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CLEO Management thanks the following corporate sponsors for their generous support:

Schedule-at-a-Glance

	Sunday 13 May	Monday 14 May	Tuesday 15 May	Wednesday 16 May	Thursday 17 May	Friday 18 May
GENERAL						
Registration	07:00–17:00	07:00–18:00	07:00–18:30	07:30–18:30	07:30–18:00	07:30–15:30
Speaker Ready Room	13:00–17:00	07:00–18:00	07:00–18:00	07:00–17:30	07:00–18:00	07:30–15:30
Coffee Breaks *on show floor		10:00–10:30 15:30–16:00	10:00–11:30 * 15:00–17:00*	10:00–11:30* 15:00–17:00*	10:00–11:30* 16:00–16:30	10:00–10:30
CLEO TECHNICAL PROGRAMMING						
Short Courses	08:30–17:30	12:30–16:30	12:00–16:00			
Technical Sessions		08:00–18:00	13:00–19:00	13:00–19:00	08:00–18:30	08:00–16:00
Special Symposium and A&T Topical Reviews		08:00–12:30	13:00–19:00	13:00–19:00	08:00–18:30	08:00–16:00
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NEW Dynamic e-Posters			11:30–13:00	11:30–13:00	11:30–13:00	
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CLEO:EXPO AND SHOW FLOOR ACTIVITIES						
CLEO:EXPO			10:00–17:00	10:00–17:00	10:00–15:00	
Poster Sessions and Free Lunches in Exhibit Hall			11:30–13:00 Free Lunch	11:30–13:00 Free Lunch	11:30–13:00 12:30–14:00 Free Lunch	
OIDA VIP Industry Leaders Speed Meetings Lunch			12:00–13:30			
CLEO Theaters I & II			10:00–17:00	10:00–17:00	10:00–14:00	
Meet the OSA Editors' Reception			15:30–17:00			
KMLabs Lunch and Learn Event				12:00–13:30		
Technology Transfer Program					10:15–13:00	
SPECIAL EVENTS						
OSAF Data Science & Career Opportunities	08:30–17:00					
OSAF Cheeky Scientist Workshop	13:00–14:00 16:00–17:00					
OIDA Executive Forum on the Exploding Role of Optics in Sensing		08:30–18:00				
OSA Technical Group Events		12:00–13:00 19:00–20:30	19:00–20:30	12:00–13:00	18:30–20:00	
Social Media 102		13:00–14:00				
Workshop: Understanding Unconscious Bias		14:00–15:30 16:00 –17:30				
Diversity & Inclusion in Optics and Photonics Reception		17:30–18:30				
Conference Reception				19:30–20:30		

Welcome to CLEO!

It is our pleasure to welcome you to CLEO 2018 in San Jose, CA. CLEO continues to be the world's premier international forum for scientific and technical optics, uniting the fields of lasers and optoelectronics by bringing together all aspects of laser technology, from basic research to industry applications. Within the scope of a single conference, CLEO provides a forum where attendees can explore new scientific ideas, engineering concepts, and emerging applications in fields such as biophotonics, optical communications, and novel light sources. While the quality of work presented remains assured by CLEO's world-renowned technical program, the conference continues to evolve with new features to enhance your experience.

CLEO offers high quality content in five core event elements:

Fundamental Science: The premier venue for discussion of basic research in optical and laser physics and related fields. Topics include modern spectroscopy, ultrafast and nonlinear light-matter interactions, quantum optics, low-dimensional optical materials, quantum information science, nanophotonics, plasmonics, and metamaterials.

Science & Innovations: World-leading scientific research and innovation in lasers, optical materials, and photonic devices. Topics include laser processing of materials, terahertz science and technologies, ultrafast optics, biophotonics, nanophotonics, fiber photonics, nonlinear optical and laser technologies, metrology, sensing, and energy-efficient "green" photonics.

Applications & Technology: Exploration of the transition of fundamental research into emerging applications and products. The scope spans innovative laser and EO components and systems and applications. This topic includes biomedical devices for diagnostics and therapeutics, high power laser systems for industry and defense, photonics instrumentation and technologies for metrology, industrial processes, environmental sensing, and energy conservation.

CLEO:EXPO: The exhibition will showcase more than 200 participating companies featuring a wide range of photonics innovations, products and services. It is expected to attract more than 4,000 attendees including researchers, engineers, and leaders from top research institutions and major businesses who represent the fastest growing markets in optics and photonics.

CLEO Theaters: This program focuses on the latest trends in the photonics marketplace and provides a forum to discuss new products and emerging technologies. All presentations and discussions are focused on the latest in photonics products and services that have been playing an important role in the industry and those that potentially hold a future business opportunity.

This year's CLEO features 5 extraordinary plenary speakers. On Tuesday morning, Nader Engheta and Vasilis Ntziachristos are our featured speakers. Engheta will describe exciting features and novel opportunities arising from light-matter interaction in metastructures, while Ntziachristos will discuss exciting recent progress in optoacoustic microscopy and its potential clinical impact. On Wednesday morning, featured speakers are Jian-Wei Pan and Sara Seager. Pan will highlight new developments that could lead to a satellite-based global quantum communication network, and Seager will discuss the dramatic advances in the discovery and characterization of exoplanets.

The International Day of Light is celebrated across the world on 16 May as the anniversary of the first successful operation of the laser in 1960 by physicist and engineer Theodore Maiman. CLEO is the perfect home to recognize this day. This conference epitomizes "how a scientific discovery can yield revolutionary benefits to society in communications, healthcare and many other fields," as quoted on the IDL site. In recognition of the International Day of Light, CLEO is excited have a third Wednesday plenary speaker, John C. Mather, Nobel Laureate, who will talk about our exploration of the universe through light waves.

The CLEO Technical Program committee maintains a rigorous peer review system that emphasizes and maintains high technical quality in all presentations. This rigorous process is made possible by the combined efforts of over 300 volunteers in 25 technical committees. In 2018, the conference features an outstanding collection of contributed paper presentations, invited speakers and tutorials. We are excited to offer more than 1300 oral presentations, 230 invited talks by some of the most respected researchers in our international community, and 23 tutorials. This year's poster sessions include an outstanding list of more than 500 posters, including a specially selected subset of posters that are dynamic E-posters. Furthermore, selected topics are highlighted in special symposia and topical reviews comprising tutorials and invited talks. Participation from industry is particularly encouraged through these topical reviews. Finally, we are pleased to offer a comprehensive short course program featuring 17 courses.

We extend our sincere thanks to the Technical Program Co-Chairs; Michael M. Mielke and Jin Ung Kang in Applications & Technology; and Stewart Aitchison and Todd Pittman in Fundamental Science, Amr S. Helmy and Shinji Yamashita in Science & Innovations for coordinating the work of our subcommittees to compile this outstanding CLEO program. We also thank Robert Fisher and Ben Eggleton, Short Course Co-Chairs, and all of the program committee members whose leadership, dedication, and hard work has been critical to maintaining the high quality of the meeting. Additionally, we would like to thank the APS Division of Laser Science, the IEEE Photonics Society, The Optical Society (OSA), and the exhibitors for their support and contributions to the meeting. Finally, we thank the OSA staff for their professional assistance and dedication in organizing this event.

We welcome you to the conference and thank you for your participation.

Peter Andersen
Technical University of Denmark, Denmark
General Chair

Zhigang Chen
San Francisco State University, USA
General Chair

Nicusor Iftimia
Physical Sciences, Inc., Germany
General Chair

Nathan Newbury
National Institute of Standards & Technology, USA
General Chair

Jessie Rosenberg
International Business Machines Corp., USA
General Chair

Jeff Shapiro
Massachusetts Institute of Technology, USA
General Chair

Conference Services

Registration

Concourse Level

Sunday, 13 May	07:00–17:00
Monday, 14 May	07:00–18:00
Tuesday, 15 May	07:00–18:30
Wednesday, 16 May	07:30–18:30
Thursday, 17 May	07:30–18:00
Friday, 18 May	07:30–15:30

CLEO:EXPO

Exhibit Hall

The CLEO:EXPO is open to all registered attendees. Visit a diverse group of companies representing every facet of the lasers and electro-optics industries. Exhibition information can be found on page 32.

Tuesday, 15 May	10:00–17:00
Wednesday, 16 May	10:00–17:00
Thursday, 17 May	10:00–15:00

Speaker and Presider Ready Room

Room 211A

All technical presentation speakers and session presiders are required to check in to the Speaker Ready Room located on the Concourse Level in Room 211A. Speakers are required to check in 24 hours before their session begins.

Session presiders should check in one to two hours prior to their session for instructions on how to use in-room equipment and check for speaker cancellations and changes. Computers will be available to review uploaded slides.

Sunday, 13 May	13:00–17:00
Monday, 14 May	07:00–18:00
Tuesday, 15 May	07:00–18:00
Wednesday, 16 May	07:00–17:30
Thursday, 17 May	07:00–18:00
Friday, 18 May	07:30–15:30

Coat and Baggage Check

Lower Lobby, Street Level

Coat and baggage check is available to conference attendees for a nominal fee.

Thursday, 17 May	07:30–22:00
Friday, 18 May	07:30–16:30

Customer Service & Information Center

Concourse Level

For questions about the program, locating sessions or general conference information, visit the Conference Information Center. Lost and Found items will be left at the Conference Information Center for 24 hours. Please put your name on all conference materials (Program Book and Short Course Notes).

There is a replacement fee for Program Books and badges.

Sunday, 13 May	13:30–17:30
Monday, 14 May	07:00–17:00
Tuesday, 15 May	08:00–17:00
Wednesday, 16 May	08:00–17:00
Thursday, 17 May	08:00–16:00

E-Center Kiosks

Concourse Level

The E-Center provides multiple viewing stations allowing attendees to check email. The E-Center Kiosks will be open during registration hours. Please limit your time on a station between 10 to 15 minutes so others may have time to check their emails. Kiosk hours will mirror Registration hours.

First Aid and Emergency Information

The First Aid room, staffed with emergency medical personnel, is located on the Exhibit Level. This room will be open during all conference hours. In the event of an emergency, please contact a security guard or a CLEO staff member. All accidents, injuries or illnesses in the San Jose Convention Center should be reported to the Public Safety Office immediately; call the office at extension 3500 from any white courtesy phone.

Wireless Access

San Jose Convention Center offers free Wi-Fi experience. To access the network just connect to the SSID, **"Wickedlyfastwifi"**, a return, SSID is easily readable.

No personal information or password needed with unlimited Wi-Fi access provided in the Convention Center.

All conference locations are in the San Jose Convention Center unless otherwise noted.

CLEO Announces CLEO KIDS - Child Care Options

This will be the first time CLEO has offered subsidized on-site childcare to attendees who want to bring their kids. We have contracted with KiddieCorp, an established childcare provider service that other conferences have used for childcare with great success.

Childcare reservations must be made 24 hours prior to date of service. Childcare services is based on space availability. Please contact Debbie Leffall at +1 916-595-7033 for reservation options.

Monday, 14 May	08:00–18:30
Tuesday, 15 May	08:00–19:30
Wednesday, 16 May	08:00–19:30
Thursday, 17 May	08:00–19:00
Friday, 18 May	08:00–16:30

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Sponsoring Societies' Booths

APS Booth

Concourse Level

Email: meetings@aps.org

Website: www.aps.org

The American Physical Society (APS) is a non-profit membership organization working to advance and diffuse the knowledge of physics through its outstanding research journals, scientific meetings, education and diversity programs, outreach, advocacy, and international activities. APS represents over 54,000 members, including physicists in academia, national laboratories, and industry in the United States and throughout the world. Throughout 2018, APS is celebrating the 125th anniversary of the Physical Review journals. Please stop by our booth near registration to learn more about APS programs, services, and world-class journals.

IEEE Photonics Society Booth & Membership Lounge

Concourse Level

Email: photonicssociety@ieee.org

Website: www.PhotonicsSociety.org

The IEEE Photonics Society is the professional home for a global network of scientists and engineers who represent the laser, optoelectronics and photonics community. The Society provides its members with professional growth opportunities, publishes journals, sponsors conferences and supports local chapter and student activities around the world. Visit the IEEE Photonics Society booth on the Concourse Level, near registration, for more information.

When you join or renew an IEEE Membership at the booth, eligible members will receive 50% off membership dues and all benefits through 31 December 2018. An IEEE Photonics Society Membership is as low as $17 USD and only $8.50 USD for students.

IEEE members are also welcome to visit the IEEE Member Lounge, sponsored by the IEEE Photonics Society. Come to the IEEE members-only lounge to relax, grab a snack and connect to the internet.

IEEE Lounge Schedule:

Monday, 14 May	10:00–16:00
Tuesday, 15 May	10:00–16:00
Wednesday, 16 May	10:00–16:00
Thursday, 17 May	10:00–14:00

IEEE Photonics Fund

The IEEE Photonics Society, in partnership with the IEEE Foundation, is proud to announce the establishment of the IEEE Photonics Fund. This fund will be used to enhance the humanitarian and educational initiatives of the Society by providing members and the photonics community with the ability to contribute directly to mission-driven imperatives, such as Humanitarian Projects, Student Resources, STEM Outreach and Diversity Initiatives.

The IEEE Photonics Society has contributed USD $100K to The IEEE Photonics Fund. Will you match us with your donation? With the establishment of this fund, you too can play a direct role in this vital work. Visit the IEEE Photonics Society booth or www.PhotonicsSociety.org for more information.

The Optical Society Booth

Exhibit Hall, #1927

Email: info@osa.org

Website: www.osa.org

Founded in 1916, The Optical Society (OSA) is the leading professional association in optics and photonics, home to accomplished science, engineering, and business leaders from all over the world.

Through world-renowned publications, meetings, and membership programs, OSA provides quality information and inspiring interactions that power achievements in the science of light. More than 21,000 OSA members, residing in over 100 countries and spanning academia, government and industry, call OSA their professional home.

Stop by to meet OSA staff, and learn more about our publications, conferences and meetings, and membership for individuals and companies.

The Optical Society Member Lounge

Concourse Level

OSA members are invited to take a brief respite from the conference at the Member Lounge. Whether it's to plan your schedule, meet up with other members or print your boarding pass, the lounge offers comfortable seating, light refreshments, coffee service and a computer/printer. In addition, take advantage of renewing your membership at 50% discount for one-year! You can renew at the OSA Member Lounge or the OSA Booth on the Exhibit Floor. This special rate is available whether you're rejoining for the first time or renewing for another year.

OSA Member Lounge Schedule:

Monday, 14 May	10:00–17:00
Tuesday, 15 May	10:00–17:00
Wednesday, 16 May	10:00–17:00
Thursday, 17 May	10:00–16:00

OSA CAM Lounge

Room 213

The Celebrating All Members (CAM) videos are an opportunity for OSA members to share their stories in 3 minutes or less about what/who inspired them to get into their field, what excites them about their current work and what OSA means to them. These short vignettes are shown on our website (osa.org/100), on social media and at some of our conferences. Stop by on Monday or Tuesday between 09:00–16:00 for a quick interview.

All conference locations are in the San Jose Convention Center unless otherwise noted.

Conference Materials

Access to Technical Digest and Postdeadline Papers

Technical attendees have *early* and *continuous* access to the CLEO:2018 Technical Digest, including the Postdeadline Papers. The Technical Digest is comprised of the two-page summaries of tutorial, invited and accepted contributed/post-deadline papers. They can be downloaded individually or by downloading daily .zip files. (.zip files are available for 60 days after the conference).

1. Visit the conference website, www.cleoconference.org.
2. Select the Access Digest Papers link on the right side of the web page.
3. Log in using the same email address and password you used to register for the meeting. You will be directed to the conference page where you will see the .zip file links at the top of the page. Please note: if you are logged in successfully, you will see your name in the upper right-hand corner.

Access is limited to Full Conference attendees only, not Exhibits Pass Plus or One-Day attendees. If you need assistance with your login information, please use the "forgot password" utility or "Contact Help" link.

The available paper summaries will be submitted to the IEEE Xplore Digital Library (www.ieeexplore.ieee.org), provided that the paper is presented by a co-author during CLEO 2018.

Poster PDFs

Authors presenting posters have the option to submit the PDF of their poster, which will be attached to their papers in OSA Publishing's Digital Library. If submitted, poster PDFs will be available three weeks after the conference. Submit your poster PDF no later than 31 May to cstech@osa.org. Your PDF should be named using your presentation number with "-1" added at the end (JTh2A.24-1.pdf.)

Short Course Notes

Notes typically include a copy of the presentation and any additional materials provided by the instructor. Each course has a unique set of notes, which are distributed on-site to registered course attendees only. Notes are not available for purchase separately from the course.

CLEO App

Manage your conference experience by downloading the CLEO App to your Smartphone or tablet.

Download the app one of three ways

1. Search for 'CLEO Conference' in the app store.
2. Go to cleoconference.org/app
3. Scan the QR code

Schedule
Search for conference presentations by day, topic, speaker or program type. Plan your schedule by setting bookmarks on programs of interest. Technical attendees can access technical papers within session descriptions.

Exhibit Hall
Search for exhibitors in alphabetical order and set a bookmark reminder to stop by their booth. Tap on the map icon within a description, and you'll find their location on the EXPO floor map. View a daily schedule of all activities occurring on the show floor.

Access Technical Digest Papers
Full technical registrants can navigate directly to the technical papers right from the CLEO mobile app. Locate the session or talk in "Event Schedule" and click on the "Download PDF" link that appears in the description .

IMPORTANT: You will need to log in with your registration email and password to access the technical papers. Access is limited to Full Conference attendees only.

Need assistance?

Contact our support team, available 24 hours a day Monday through Friday, and from 09:00 to 21:00 EDT on weekends, at +1.888.889.3069 option 1.

Android users who downloaded the app for CLEO 2017 or earlier years may need to download a new version of the app. Scan the QR code or search for 'CLEO Conference' in the Google Play Store.

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Plenary Sessions and Awards Ceremony

Plenary Session I

Tuesday, 15 May, 08:00–10:00
Grand Ballroom

Metaphotonics

Nader Engheta, *University of Pennsylvania, USA*

Materials are often used to control and manipulate photons. Metamaterials and metasurfaces are two representative classes of judiciously designed structures that provide unprecedented platforms for sculpting waves and fields. Their extreme properties lead to novel opportunities in photonics. Light-matter interaction in metastructures exhibits unusual functionalities with numerous exciting features and potential applications.

Nader Engheta is the H. Nedwill Ramsey Professor at the University of Pennsylvania. He received his PhD from Caltech. His current research activities span various areas of nanophotonics, metamaterials, nano-optics, electrodynamics, graphene optics, optical circuits, imaging and sensing inspired by eyes of animal species, and physics and engineering of light-matter interaction. His most recent awards include William Streifer Scientific Achievement Award, SPIE Gold Medal, Fellow of US National Academy of Inventors, Vannevar Bush Faculty Fellow Award, IEEE Electromagnetics Award, and URSI Balthasar van der Pol Gold Medal. He is a Fellow of OSA, APS, MRS, SPIE, IEEE, URSI, and AAAS.

Listening to Light: Advances in Optoacoustic Imaging

Vasilis Ntziachristos, *Technical University of Munich, Germany*

Optical imaging is unequivocally the most versatile and widely used visualization modality in the life sciences. Yet it has been significantly limited by photon scattering, which complicates imaging beyond a few hundred microns. Progress with fast tunable lasers, spectral techniques and advanced instrumentation have allowed the development of multi-spectral opto-acoustic tomography (MSOT) for clinical use, offering unprecedented optical imaging performance and assessment of disease pathophysiology. The talk illuminates progress with opto-acoustic macroscopy and mesoscopy and its implication toward clinical impact.

Vasilis Ntziachristos is Professor of Medicine, Professor of Electrical Engineering and Director of the Chair for Biological Imaging (CBI) at the Technical University of Munich, Director of the Institute for Biological and Medical Imaging (IBMI) at the Helmholtz Zentrum Munchen and Director of Bioengineering at the Helmholtz Pioneering Campus. He has received the Diploma in Electrical Engineering and Computer Science from the Aristotle University of Thessaloniki, Greece and the MSc and PhD degrees in Bioengineering from the University of Pennsylvania in Philadelphia. Prior to his current appointment he served as faculty at Harvard University and the Massachusetts General Hospital.

Plenary Session II & International Day of Light

Wednesday, 16 May, 08:00–10:00
Grand Ballroom

Quantum Communication Network and Future Aspects

Jian-Wei Pan, *University of Science and Technology of China, China*

Based on state of the art fiber technologies, the prevailing quantum communication technology allows practical communication in the metropolitan area. However, the distance of fiber-based quantum communications is limited due to intrinsic fiber loss. To overcome these problems, we are taking two paths in parallel: quantum repeaters and through satellite, to establish a global quantum communication network.

Jian-Wei Pan obtained his PhD degree of Experimental Physics from the University of Vienna in 1999. In 2001, he was appointed as full professor of physics by the University of Science and Technology of China (USTC). In 2011, he was elected as the academician of Chinese Academy of Sciences (CAS). In 2012, he was elected as the World Academy of Science (TWAS) Fellow. His research focuses on quantum optics, quantum information and quantum foundations. He has accomplished a series of profound achievements in experimental quantum information science. Due to his numerous progresses on quantum communication and multi-photon entanglement manipulation, quantum information science has become one of the most rapidly developing fields of physical science in China in recent years.

Mapping the Nearest Stars for Habitable Worlds

Sara Seager, *Massachusetts Institute of Technology, USA*

For thousands of years people have wondered, "Are there planets like Earth?"; "Are such planets common?"; and "Do any have signs of life?" Today, astronomers are poised to answer these ancient questions, having recently found thousands of planets that orbit nearby Sun-like stars, called "exoplanets." The presentation will share the latest advances in this revolutionary field and work to answer the question, "Are we alone?" Or put another way, where are the neighbors, and how far away are they? In a few decades of research in opto-electronics and spectroscopy, we could know an answer.

Sara Seager is a planetary scientist and astrophysicist at the Massachusetts Institute of Technology. She has pioneered many research areas in the characterization of exoplanets. Her present research focus is on the search for life by way of exoplanet atmospheric "biosignature" gases. She works on space missions for exoplanets including as: the PI of the CubeSat ASTERIA; the Deputy Science Director of the MIT-led NASA Explorer-class mission TESS; and as a lead of the Starshade Rendezvous Mission (a space-based direct imaging exoplanet discovery concept under technology development)

All conference locations are in the San Jose Convention Center unless otherwise noted.

to find a true Earth analog orbiting a Sun-like star. Among other accolades, she was elected to the US National Academy of Sciences in 2015 and is a 2013 MacArthur Fellow.

International Day of Light
16 May

Exploring the Universe at the Speed of Light

John C. Mather, *NASA's Goddard Space Flight Center, USA*

Astronomers travel the universe with imagination and observation, and most of the information arrives as light waves, showing the distant universe as it was when the light was sent out. We can now see at wavelengths ranging from over 10 meters to less than a picometer, limited only by our ingenuity and the opacity of our environment. We are beginning to learn the story of our own origins, from the expanding early universe, to the formation of galaxies, stars, and black holes, to the stellar nuclear processes producing the heavy elements of life, to the formation of planets. That history is full of catastrophic events, apparently necessary for our own existence. I will show some of the future discoveries we hope to see through NASA's James Webb Space Telescope (JWST), discuss the expanding views of the universe, and outline the technology that will lead us to deeper understanding.

John C. Mather is a Senior Astrophysicist in the Observational Cosmology Laboratory at NASA's Goddard Space Flight Center (GSFC). His research centers on infrared astronomy and cosmology. As an NRC postdoctoral fellow at the Goddard Institute for Space Studies, he led the proposal efforts for the Cosmic Background Explorer (74-76), and came to GSFC to be the Study Scientist (76-88), Project Scientist (88-98) and also the Principal Investigator for the Far IR Absolute Spectrophotometer (FIRAS) on COBE. He showed that the cosmic microwave background radiation has a blackbody spectrum within 50 ppm. As Senior Project Scientist (95-present) for the James Webb Space Telescope, he leads the science team, and represents scientific interests within the project management. He has received many awards including the Nobel Prize in Physics, 2006, for his precise measurements of the cosmic microwave background radiation using the COBE satellite. He was elected as an OSA Honorary Member in 2016.

Awards Ceremony

Tuesday, 15 May
Grand Ballroom

OSA Charles Hard Townes Medal

The Optical Society (OSA) established this medal in 1980 to honor Charles Hard Townes, whose pioneering contributions to masers and lasers led to the development of the field of quantum electronics. It is given to an individual or a group for outstanding experimental or theoretical work, discovery or invention in the field of quantum electronics.

The 2018 recipient is Peter Fritschel, Kavli Institute for Astrophysics and Space Research, Massachusetts Institute of Technology, USA, recognized for advances in quantum-limited precision measurement in the Advanced LIGO detectors, leading to the first direct detection of gravitational waves.

The Optical Society 2018 Fellows

These Fellows are being recognized at CLEO.
Visit osa.org/fellows for a complete list of 2018 Fellows.

Andrea Armani, *University of Southern California, USA*
For contributions to integrated photonics with applications in telecommunication and chemical and biological detection

Hou-Tong Chen, *Los Alamos National Laboratory, USA*
For seminal contributions to the field of metamaterials, including active metamaterials and the realization of novel electromagnetic structures at terahertz frequencies

Yu-Ao Chen, *University of Science and Technology of China, China*
For outstanding contributions on photonic quantum information and quantum simulation

Stavros Demos, *Laboratory for Laser Energetics, University of Rochester, USA*
For pioneering and sustained contributions to understanding dynamic behaviors and improved performance in optical materials for high power lasers and developing multimodal imaging and characterization methods for medical and other applications

Heike Ebendorff-Heidpriem, *University of Adelaide, Australia*
For ground breaking science contributions to the field of optical glasses and fibers

Sasan Fathpour, *CREOL, The College of Optics and Photonics, University of Central Florida, USA*
For pioneering contributions to the field of integrated photonics, particularly heterogeneous integration in silicon photonics for second- and third-order nonlinear optics and mid-infrared wavelengths applications

Almantas Galvanauskas, *Center for Ultrafast Optical Science (CUOS), EECS Department, University of Michigan, USA*
For pioneering contributions to the science and technology of ultrashort pulse and high power fiber lasers, novel fiber structures, nonlinear interactions in fibers and fiber lasers, and fiber laser beam and pulse combining

Goëry Genty, *Tampere University of Technology, Finland*
For pioneering research in the study of supercontinuum generation and nonlinear instabilities in optical fibers

Dr. Constantin Haefner, *Lawrence Livermore National Laboratory, USA*
For pioneering next generation, high average power Petawatt laser systems enabling a new arena of applications and sustained advancement of state-of-the art technologies in large-scale, high intensity, peak-power laser systems

Sivanandan S. Harilal, *Pacific Northwest National Laboratory, USA*
For pioneering contributions to the fundamentals of laser ablation, optical spectroscopy of laser ablation plumes and laser-plasma light sources

John E. Heebner, *Lawrence Livermore National Laboratory, USA*
For numerous innovations, achievements, and technical leadership in high energy laser systems and integrated optics including nonlinear optical microresonators and ultrafast light deflectors

Nicusor Iftimia, *Physical Sciences Inc., USA*
For original contributions in biomedical optics, especially pioneering the use of optical coherence tomography for interstitial tissue imaging and biopsy guidance, as well as for outstanding service to the biomedical optics community

Mona Jarrahi, *University of California, Los Angeles, USA*
For pioneering contributions to terahertz optoelectronics and microwave photonics through development of novel engineered materials, plasmonic nanostructures, and quantum well devices

Jungsang Kim, *Duke University, USA*
For research on scalable modular quantum computers and networks using trapped ions, large-scale optical switches, quantum optics with single-photon sources and detectors, and gigapixel-scale cameras

Tobias Kippenberg, *Ecole Polytechnique Federale de Lausanne, Switzerland*
For pioneering fundamental and applied research on microresonator frequency combs and cavity optomechanics

Tien-Chang Lu, *National Chiao Tung University, Taiwan*
For pioneering and outstanding contributions to wide bandgap semiconductor vertical-cavity surface-emitting lasers, light-emitting diodes, microcavity polariton lasers and surface plasmon polariton lasers

Zhenqiang Ma, *University of Wisconsin-Madison, USA*
For pioneering contributions to flexible optoelectronics and semiconductor nanomembrane based photonics

Arash Mafi, *University of New Mexico, USA*
For pioneering contributions to fundamental understanding of quantum and nonlinear behavior of optical waveguides, light propagation in disordered media, and development of Anderson localizing optical fibers

Mo Mojahedi, *Department of Electrical and Computer Engineering, University of Toronto, Canada*
For seminal contributions to the field of plasmonics and hybrid plasmonics with important applications to nano-photonics and sensing

John Nees, *University of Michigan, USA*
For contributions to the development of short pulse high rep rate laser technology as well as to the science of high intensity short pulse laser interactions with matter

Valdas Pasiskevicius, *Royal Institute of Technology (KTH), Sweden*
For substantial contributions to the development of novel applications of structured nonlinear optical materials and service to the optics community, particularly OSA

Alan B. Petersen, *Spectra-Physics, MKS Instruments, Inc., USA*
For significant and innovative contributions to the design of commercial scientific and industrial UV laser systems and for long term service to the optics community

Pepijn Pinkse, *Universiteit Twente, Netherlands*
For original and pioneering contributions in the fields of nanophotonics, quantum optics, and quantum secure authentication

Innocenzo Pinto, *University of Sannio, INFN, LVC, and KAGRA, Italy*
For fundamental contributions to thermal noise reduction in the mirror coatings of the LIGO interferometric gravitational wave detectors, and for original contributions to the science of Electromagnetics

Derryck T. Reid, *Heriot-Watt University, United Kingdom*
For the invention of two-photon autocorrelation using photodiodes and the development of frequency combs based on ultrafast optical parametric oscillators

Pascale Senellart, *Center for Nanoscience and Nanotechnology, France*
For inventing in-situ optical lithography that couples quantum dots and optical cavities with nanometric precision, realising solid-state single and entangled photon sources of unsurpassed performance that are moving quantum optics towards a scalable future

Glenn Solomon, *Joint Quantum Institute, USA*
For pioneering the development of semiconductor quantum dot optical materials and device structures for solid-state quantum optics

Kartik Srinivasan, *National Institute of Standards & Technology, USA*
For outstanding contributions to nanophotonics and quantum optics, including cavity-QED, frequency conversion, and integrated optics such as photonic crystals

Thomas Südmeyer, *Université de Neuchâtel, Switzerland*
For seminal contributions to ultrafast photonics, in particular in the area of ultrafast thin disk lasers, nonlinear frequency conversion, and optical frequency combs

Hong-Bo Sun, *Tsinghua University, China*
For pioneering contributions to the field of laser nanofabrication in both fundamental research and industrial applications, as well as ultrafast spectroscopy and their applications on deep insight into nanophotonic materials and devices

Sergei Tochitsky, *University of California, Los Angeles, USA*
For outstanding contributions to the development of high-power picosecond CO2 lasers and their applications in nonlinear optics and laser-driven particle acceleration

M. Selim Ünlü, *Boston University, USA*
For pioneering contributions in utilization of optical interference in enhanced photodetectors and biological sensing and imaging

Mu Wang, *Nanjing University and American Physical Society, China*
For original contributions in designing of metallic subwavelength microstructures to control the polarization, propagation and intensity of light, optimizing physical properties and striving for their applications in optics and opto-electric exchange

IEEE Photonics Society 2018 Fellows

Michael Krames, *Pacific Bell, USA*
For leadership in GaN-based light-emitting device physics and its commercialization

Hong-Bo Sun, *Tsinghua University, China*
For contributions to laser nanofabrication and ultrafast spectroscopy

James P. Gordon Memorial Speakership

Established in 2014 with the support of the Gordon family, The James P. Gordon Memorial Endowment funds a speakership on Quantum Information and Quantum Optics to a CLEO invited speaker. This speakership pays tribute to Dr. Gordon for his numerous high-impact contributions to quantum electronics and photonics, including the demonstration of the maser.

The recipient receives a $1,500 honorarium and their presentation will be recorded and archived in OSA's media library. The contents will serve as an educational resource for the next generation of optics and photonics leaders.

Congratulations to

Mikhail Lukin, *Harvard University, USA*

Tingye Li Innovation Prize

The Tingye Li Innovation Prize, established in 2013, honors the global impact Dr. Li made to the field of Optics and Photonics. This prize is presented to a young professional with an accepted paper that has demonstrated innovative and significant ideas and/or contributions to the field of optics. The recipient of this prize receives a $3,000 stipend, an invitation to the Chairs' Reception, and special recognition at the conference.

Congratulations to

Logan G. Wright, *Cornell University, USA*

Maiman Student Paper Competition

The Maiman Student Paper Competition honors American physicist Theodore Maiman for his demonstration of the first working laser and his other outstanding contributions to optics and photonics. It recognizes student innovation and research excellence in the areas of laser technology and electro-optics. The competition results will be announced during the meeting. The prize is endowed by a grant from HRL Laboratories LLC, the IEEE Photonics Society and the APS Division of Laser Science and is administered by the OSA Foundation.

Congratulations to our finalists:

Sheldon Kwok, *Massachusetts Institute of Technology, USA*

Nils Otterstrom, *Yale University, USA*

Dominik Peller, *University of Regensburg, Germany*

Brian Stern, *Cornell University, USA*

Incubic/Milton Chang Travel Grant

The OSA Foundation is pleased to award 10 recipients this year's Incubic/Milton Chang Student Travel Grant, endowed by Milton and Rosalind Chang. The list of recipients can viewed at www.osa.org/foundation.

Plenary Speaker Meet-n-Greet

Tuesday, 15 May, 10:15–10:45
Theater I, Exhibit Hall, #2433

Meet Nader Engheta, Vasilis Ntziachristos and Jian-Wei Pan, ask questions and network with your colleagues.

Plenary Speaker Meet-n-Greet

Wednesday, 16 May, 10:15–10:45
Theater I, Exhibit Hall, #2433

Meet John Mather and Sara Seager, ask questions and network with your colleagues.

Special Symposia

Future Directions in Terahertz Nanoscopy

Monday, 14 May, Session I: 08:00–10:00,
Session II: 10:30–12:30
Executive Ballroom 210A

Organizers
Tyler Cocker, *Universität Regensburg, Germany*
Daniel Mittleman, *Brown University, USA*

Terahertz and multi-terahertz microscopy with subwavelength spatial resolution has recently progressed from proof-of-principle demonstrations to scientific studies capable of revealing unique information. For example, the ability of terahertz nanoscopy to combine spatial resolution on the nanometer (or even sub-nanometer) scale with ultrafast temporal resolution may ultimately make it a 'killer application' for terahertz technology--one that can address scientific questions that are inaccessible via any other experimental approach. It may even be possible to obtain a comprehensive picture of nanoscale dynamics by combining cutting-edge terahertz-based techniques like near-field scanning optical microscopy and lightwave-driven scanning tunneling microscopy. Still, technical challenges remain that must be solved before the full potential of these techniques can be realized, either individually or together. In this symposium, we will discuss the latest results and future prospects of terahertz nanoscopy, as well as scientific goals for the field.

Invited Speakers

Joanna Atkin, *Univ. of North Carolina at Chapel Hill, USA*, **Towards Quantitative Conductivity Measurements with Infrared Near-Field Optical Microscopy**

Dmitri Basov, *Columbia University, USA*, **Nano-THz Imaging of Quantum Materials**

Frank Hegmann, *University of Alberta, Canada*, **Future Directions in Terahertz Scanning Tunneling Microscopy**

Pernille Klarskov Pedersen, *Brown University, USA*, **Pushing Terahertz Emission Microscopy to the Nanoscale**

Jun Takeda, *Yokohama National University, Japan*, **Nanoscale Electron Manipulation Using Phase-controlled THz Near-fields**

Multimodal and Molecular Contrast Optical Imaging

Tuesday, 15 May, Session I: 13:00–15:00,
Session II: 17:00–19:00
Salon I & II, San Jose Marriott

Organizer
Wolfgang Drexler, *Medizinische Universität Wien, Austria*

Momentary clinical medical imaging technologies are expensive and complex with limited sensitivity and specificity. Multimodal and molecular contrast optical imaging offers low-cost, non-invasive, accurate, rapid alternatives and the potential to address global medical needs. This symposium focuses on the combination of state-of-the-art optical imaging modalities to enable enhanced clinical diagnosis in a variety of medical fields. A special emphasis will be on approaches enabling molecular contrast as well as endoscopic imaging.

Tutorial Speaker
Irene Georgakoudi, *Tufts University, USA*, **Bringing Functional High Resolution Diagnostics to the Bedside Using Multimodal, Label-free, Two-photon Imaging**

Invited Speakers

Thomas Bocklitz, *IPHT Jena, Germany,* **Nonlinear Optical Endoscopy**

Audrey Bowden, *Stanford University, USA,* **Multimodal Endoscopic Bladder Imaging**

Zhongping Chen, *University of California Irvine, USA,* **Intravascular Multimodal Imaging**

Johannes de Boer, *Vrije Univ Amsterdam, Netherlands,* **Combined Optical Coherence Tompgraphy and Near Infrared Fluorescence of Cancer-specific Antibodies**

Adam de la Zerda, *Stanford University, USA,* **Molcular Imaging with Optical Coherence Tomogpraphy**

Kristen Maitland, *Texas A&M University, USA,* **Reflectance Confocal Microscopy and Fluorescence Lifetime Imaging in the Oral Cavity**

New Advances in Adaptive Optics Retinal Imaging

Wednesday, 16 May, Session I: 13:00–15:00,
Session II: 17:00–19:00
Salon VI, San Jose Marriott

Organizer
Mircea Mujat, *Physical Sciences Inc., USA*

Adaptive optics (AO) has recently achieved success in a range of high resolution retinal imaging applications in ophthalmology using instruments from flood illumination full-field retinal cameras and confocal scanning laser ophthalmoscopes (SLO) to optical coherence tomography (OCT). AO is being used as a tool to understand structural and functional aspects of vision, the elegant but complex retinal circuitry, and the dissolution of that structure, wiring and processes during the progression of disease. It has been used in direct measurements of the foveal avascular zone, retinal capillary erythrocyte and leukocyte velocity, pulsatility, and other functional dynamics. The RPE cell mosaic is being mapped in monkeys and humans and correlated to the cone mosaic. Diseases such as rod-cone dystrophy and genetic defects are confirmed and explored directly in the live eye. High-resolution retinal imaging is being applied to advanced molecular and gene therapies, both in their development and as the primary method to determine treatment efficacy at the cellular level. Systems are slowly migrating from the research lab into the clinic for use on patients with a variety of diseases and conditions. New developments such as dark-field imaging methods and OCT Angiography are clearly making their mark on ophthalmology research and practice.

Invited Speakers

Jacque Duncan, *University of California San Francisco, USA*, **Adaptive Optics Scanning Laser Ophthalmoscopy in Retinal Degenerations: New Insights in Structure and Function**

Alfredo Dubra, *Stanford University, USA,* **Adaptive Optics Scanning Light Ophthalmoscopy: Beyond Structural Imaging**

Ethan Rossi, *University of Pittsburgh, USA*, **Imaging Single Cells in the Living Eye from the Retinal Pigment Epithelium to the Ganglion Cell Layer**

Robert Zawadzki, *University of California Davis, USA*, **Progress on Functional Retinal Imaging with OCT: Recent Advancements in Measurements and Modeling of Photoreceptor Optophysiology**

Advances in Integrated Microwave Photonics

Thursday, 17 May, Session I: 14:00–16:00,
Session II: 16:30–18:3 00
Executive Ballroom 210D

Organizers
David Marpaung, *University of Twente, Netherlands*
Maurizio Burla, *ETH Zurich, Switzerland*
Jose Capmany, *Universidad Politecnica de Valencia, Spain*

The field of integrated microwave photonics explores the incorporation of photonic integration technology for the generation, processing and measurement of radio-frequency and microwave signals and is one of the fastest growing fields in signal processing. At present, the field of integrated microwave photonics has adopted significantly distinct approaches, technological tools, and focused applications compared to the recent past. A new research paradigm is to explore general purpose and programmable signal processor capable of synthesizing a multitude of on-demand signal processing tasks. On the other hand, incorporation of new technological tools such as on-chip frequency combs, opto-acoustic interactions, and plasmonics open new ways of manipulating RF signals. From the applications side, emerging concepts such as 5G communications and the Internet of Things (IoT) are expected to shape development of new systems focusing on high operating frequencies in the millimeter-waves, low power consumption, and high level of integration with electronics. This symposium emphasizes on these recent advances in integrated microwave photonics and their application to emerging massive takeover applications. It seeks for transformative ideas about the future developments field and, at the same time, attempts to bridge dialogues between device-focused and application-driven approaches.

Invited Speakers

Richard DeSalvo, *Harris Corporation, USA,* **Advanced Microwave Photonics Applications and Routes to Hybrid Integration**

Jonathan Klamkin, *Univ. of California Santa Barbara, USA,* **Integrated Microwave Photonic Component Technologies**

Juerg Leuthold, *ETH Zurich, Switzerland,* **Plasmonics for RF Photonics**

Chris Roeloffzen, *LioniX International, Netherlands,* **Integrated Microwave Photonics for 5G**

Xiaoxiao Xue, *Tsinghua University, China,* **Microcomb Engine for Microwave Photonics**

Jianping Yao, *University of Ottawa, Canada,* **Photonic Integrated Circuits for Microwave Signal Generation and Processing**

Integrated Sources of Non-Classical Light: Perspectives and Challenges

Thursday, 17 May, Session I: 14:00–16:00,
Session II: 16:30–18:30
Executive Ballroom 210C

Organizers
Marco Liscidini, *Universita degli Studi di Pavia, Italy*
Alireza Marandi, *Stanford University, USA*
John Sipe, *University of Toronto, Canada*

Parametric fluorescence in bulk crystals for generating non-classical light, such as a single photon, photon pairs, and squeezed states, has been an essential part of quantum optics for more than three decades. Recently, the use of integrated photonic structures has attracted attention as a promising strategy for generation and manipulation of non-classical states of light. This is particularly interesting because light confinement at the micro- and nano-scale can enhance the nonlinear light-matter interaction by several orders of magnitude, and the optical properties of these structures can be engineered beyond what can be achieved in bulk materials, for instance in terms of dispersion. Moreover, using integrated structures offers the promise of better stability, scalability, and lower cost, which are typical of integrated devices. Hence, "Great Expectations" have been raised for using integrated photonics toward development of scalable quantum technologies as well as extending the frontiers of light-matter interactions. Despite recent advances, the generation and control of non-classical light on a chip for the realization of practical and scalable quantum devices is still a major challenge. The goal of this symposium is to provide a forum for discussing the state-of-the-art developments in integrated photonics for generation and manipulation of non-classical light as well as major challenges and potential directions in using them toward practical quantum technologies.

Invited Speakers

Andrea Fiore, *Technische Universiteit Eindhoven, Netherlands*, **Tailoring Radiative Emission in Integrated Quantum Light Sources**

Matteo Galli, *Universita degli Studi di Pavia, Italy*, **Nonclassical Light Sources for Silicon Photonics**

Roberto Morandotti, *INRS-Energie Mat & Tele Site Varennes, Canada*, **Scalable On-chip Generation and Coherent Control of Complex Optical Quantum States**

Sven Ramelow, *Humboldt Universität zu Berlin, Germany,* **Nonlinear Quantum Optics in Si3N4 mirco-ring Resonators**

Andrey Sukhorukov, *The Australian National Univ., Australia*, **Photon-pair Generation and Quantum-classical Correspondence in Nonlinear Nanostructures**

Emerging Quantum Sensing Techniques and Applications

Friday, 18 May, Session I: 10:30–12:30,
Session II: 14:00–16:00
Executive Ballroom 210B

Organizers
Peter Humphreys, *Delft University of Technology, Netherlands*
Marina Radulaski, *Stanford University, USA*

There has been substantial recent progress in developing novel quantum sensing techniques by building on the latest developments in a diverse range of quantum optics platforms. These new sensors will enable unprecedented scientific inquiries through a combination of enhancing temporal and spatial resolutions, enabling robust and compact sensing devices and through extending the range of conditions over which signals can be detected. For instance, NV-center magnetometers can provide sub-nanometer and sub-millihertz precision, enabling sensing of individual electron spins, and have even been embedded in nanodiamonds for in-situ detection of temperatures at the sub-cellular level. Drawing on research on atomic vapors, entangled atom metrology can reduce noise 100 times below the standard quantum limit. New optomechanical devices will enable compact sensors able to detect minute variations in the gravitational field. The challenges facing this nascent field are: harnessing quantum phenomena to move sensing beyond classical boundaries, and refining these techniques to move beyond laboratory. This symposium will focus on emerging quantum sensing concepts and experiments, aiming to bring together researchers from across this new field along with potential future beneficiaries of these techniques.

Invited Speakers

Ania Bleszynski Jayich, *UCSB, USA*, **Quantum Sensing and Imaging with Diamond Spins**

Alexey Gorshkov, *Univ. of Maryland, USA*, **Optimal and Secure Measurement Protocols for Quantum Sensor Networks**

Sebastien Gleyzes, *College de France – CNRS, France*, **Quantum Metrology with Rydberg Atoms**

Lee McCuller, *MIT Kavli Institute for Astrophysics and Space Research, USA*, **The LIGO Squeezed Light Upgrade**

Morgan Mitchell, *ICFO -The Institute of Photonic Sciences, Spain*, **Quantum Sensing with Extreme-coherence Spin Ensembles**

Lasers in Accelerator Science and Technology

Friday, 18 May, Session I: 08:00–10:00,
Session II: 10:30–12:30
Executive Ballroom 210C

Organizer
Sergio Carbajo, *Stanford University and SLAC National Accelerator Laboratory, USA*

Unifying laser and accelerator physics is essential for the development of future accelerators, light sources, and other scientific instruments due to increasingly synergistic advances at the cross-section between these two fields. Laser fields are ideal agents to tailor the 6-D phase-space distribution of charged particle beams because they can imprint correlations with extremely high spatio-temporal precision. In addition to long-standing uses in photo-injectors and compact acceleration, recent laser applications to free electron laser seeding, accelerators on a chip, hybrid x-ray light sources, and more have highlighted the need for further research into laser-particle interactions. The goal of this symposium is to fill this breach and to bring experts in various aspects of this interdisciplinary field to expose present and future opportunities in laser research and development to serve accelerator technology and applications, from instrumentation requirements to science cases.

Invited Speakers

Félicie Albert, *Lawrence Livermore National Laboratory, USA*, **Light Sources from Laser Wakefield Acceleration: Development and Applications**

Jerome Faure, *LOA-ENSTA, France*, **Recent Progress on High-Repetition Rate Laser-Plasma Acceleration**

William Graves, *Arizona State University, USA*, **X-ray Laser Based on Inverse Compton Scattering**

Peter Hommelhoff, *Friedrich-Alexander-Universität Erlangen, Germany*, **Hotonics-based Laser-driven Particle Acceleration: from Proof-of-concept Structures to the Accelerator on a Chip**

Agostino Marinelli, *SLAC National Accelerator Laboratory, USA*, **Laser-shaping of Electron Beams for X-ray Free-electron Laser Applications**

Liang Jie Wong, *SIMTech, Singapore*, **Linear-Field Particle Acceleration in Free Space by Spatiotemporally Structured Laser Pulses**

CALL FOR 2019 CLEO SYMPOSIUM PROPOSALS

The 2019 CLEO Program Committee is seeking special symposium proposals for consideration from members of the optics and photonics community. Submissions should consist of timely, cutting-edge topics and/or new material in rapidly advancing areas.

Submissions need to address the following questions:

1. Why is this symposium topic important now and needed in contrast to other years?
2. Which existing topic subcommittees if any, would this topic be most aligned with?
3. Proposed invited speaker list and talk titles.

Submission Deadline: 9 July 2018 cleoconference.org/symposia

All conference locations are in the San Jose Convention Center unless otherwise noted.

Applications & Technology Topical Reviews

Photonics-enabled Quantum Technologies in Transition

Monday, 14 May, Session I: 08:00–10:00,
Session II: 10:30–12:30
Salon VI, San Jose Marriott

Organizers
Dana Anderson, *University of Colorado at Boulder, USA*
Wilhelm Kaenders, *Toptica Photonics AG & Inc., Germany*

With applications ranging from computing to navigation, quantum technology starts to make its way into the mainstream economy through both startups and well-established corporations. The evolution reflects a maturation of science and technology from novel laboratory demonstrations and prototypes to sophisticated and highly-engineered instruments. The challenges facing deployment of quantum-enabled systems are often more of a classical rather than quantum nature: Questions regarding how best to imbed quantum performance in classical systems such as for navigation and communication define a new regime for systems engineering while questions addressing size, weight, power and cost present new challenges for systems integration and manufacturing. In so many cases quantum and photonics technologies are intimately intertwined. Advances in optics and photonics technology will thus go hand-in-hand with the evolution and deployment of quantum technology. This symposium will focus on maturing quantum-enabled instruments and systems and their application in quantum information, metrology, and sensing domains. We aim to bring together researchers in both quantum-enabled classical applications such as navigation and timekeeping, and quantum applications such as quantum computing and secure communications.

Invited Speakers

David Andersen, *Rydberg Technologies, USA,* **Quantum RF electric-field Sensing with Rydberg-atom Vapors**

John Burke, *DARPA, USA*, **The Challenge of Complexity, Control, and Low Reliability in Quantum Sensors**

Tatjana Curcic, *Quantum Valley Innovations, Canada*, **From Basic Research to Quantum Technologies: Challenges and Opportunities**

Bruno Desruelle, *MUQUANS, France*, **Innovative Laser Solutions for Operational Quantum sensors**

Karl Nelson, *Honeywell, USA*, **Photonics-enabled Quantum Timing and Navigation at Honeywell**

Max Perez, *ColdQuanta, USA*, **Engineering Challenges in Commercial Photonics-enabled Quantum Technologies**

Rik van Gorsel, *id Quantique, USA,* **10 Years of Commercial Quantum Key Distribution: Engineering Achievements and Market Challenges**

Brent Young, *AOsense, USA*, **Photonics for Quantum Sensing**

Advanced Applications of Laser Radar and Remote Sensing

Tuesday, 15 May, Session I: 13:00–15:00
Wednesday, 16 May, Session II: 13:00–15:00
Theater I

Organizer
Fabio Di Teodoro, *The Aerospace Corporation, USA*

This topical review will address cutting-edge research and development of laser-based standoff sensors from a system standpoint to include new laser transmitters, detectors, and advanced sensing concepts. Examples include sensors deployed in ground, airborne and space-based platforms for reconnaissance and imaging, environmental/meteorological studies, chemical/biological detection as well as autonomous navigation. Such systems must address many technological challenges including the design, performance improvement, maturation, and qualification of suitable laser transmitters and detectors; minimization of size, weight, power consumption, and cost; increase in ruggedness and support for operation in thermo-mechanically harsh environments; and improvement of long-term reliability.

Invited Speakers

Gerald Buller, *Heriot-Watt University, UK,* **Three-Dimensional Imaging Under Extreme Conditions Using Single-Photon Counting**

Lute Maleki, *OEwaves Inc, USA*, **LiDAR for Autonomous Vehicles: Challenges and Opportunities for Photonics**

Paul McManamon, *Exciting Technology LLC, USA*

Marcos Sirota, *Sigma Space Corp, USA*, **Recent Advances in Single Photon Sensitive Mapping Lidars**

Mariano Troccoli, *Evolution Photonics Inc, USA*, **High Performance Mid-IR Devices and Applications to Gas Sensing**

Advances in Supercontinuum Technologies

Tuesday, 15 May, Session I: 13:00–15:00
Wednesday, 16 May, Session II: 13:00–15:00
Theater II

Organizer
Adam Devine, *Fianium Ltd., UK*

Advances in Supercontinuum Technologies I: Supercontinuum Generation

Almost two decades after the pivotal experiments of supercontinuum generation in photonic crystal fibers, significant advances continue to be made in the area of broadband light generation within waveguides. This topical review session will focus on recent advances and cutting edge research in supercontinuum generation technology.

Advances in Supercontinuum Technologies II: New Application Areas for Supercontinuum Light Sources

Supercontinuum broadband light sources represent a disruptive technology for traditional light sources such as xenon lamps, laser diodes and plasma driven light sources. From telecommunication to medical imaging and metrology, these light sources are enabling advances in exciting new application areas. This session will focus on new and emerging fields exploiting these broadband light sources.

Invited Speakers

David Castaneda-Castellanos, *Leica Microsystems, Germany*, **Biological Applications of Supercontinuum Lasers in Optical Light Microscopy**

Frans J.M. Harren, *Radboud Univ., Netherlands*, **Mid-infrared Supercontinuum-based Trace Gas Sensing**

Michal Lipson, *Columbia Univ., USA*, **Ultra Low Loss Waveguides for Extreme Nonlinear Optics**

Peter Moselund, *NKT Photonics Inc, Denmark,* **Supercontinuum from Labs to Factories**

Adrian Podoleanu, *Univ. of Kent, UK*, **Supercontinuum Applications in High Resolution Non Invasive Optical Imaging**

Jonathan Price, *Univ. of Southampton, UK*, **The Development of Tailored Supercontinuum Sources in Silica and Non-silica Fibers**

Peter John Rodrigo, *Technical Univ. of Denmark, Denmark*, **Mid-IR Hyperspectral Imaging of Gases Using a Supercontinuum Source and Frequency Upconversion**

John Travers, *Heriot-Watt Univ., UK*, **Ultraviolet Supercontinuum Generation in Optical Fibers**

Topical Review on Neurophotonics

Thursday, 17 May, Session I: 08:00–10:00,
Session II: 14:00–16:00
Willow Glen, San Jose Marriott

Organizers
Kishan Dholakia, *Univ. of St Andrews, UK*
Chris Xu, *Cornell Univ., USA*

Advanced neurophotonics enable recording and stimulation of a population of neurons at high spatial and temporal resolution, deep within a living, intact animal brain. Research in neurophotonics is a major part of the multibillion-dollar BRAIN Initiative, and will likely play an essential role in understanding how the brain works at the level of neural circuits, which will provide a bridge between microscopic interactions at the neuronal level and the complex computations performed at larger scales. This topical review session will focus on the development of optical tools for neuroscience and brain research.

Tutorial Speaker
Jerome Mertz, *Boston Univ., USA*, **The Challenge of Large-scale Neuronal Imaging**

Scientific and Commercial Progress in Semiconductor Laser Technology

Thursday, 17 May, Session I: 16:30–18:30
Friday, 18 May, Session II: 08:00–10:00
Willow Glen, San Jose Marriott

Organizer
Bojan Resan, *Univ. of Applied Sciences Northwestern Switzerland, Switzerland*

Semiconductor lasers continue to pave the way towards practical use in numerous applications. Many scientific ideas are on the horizon, but many challenges remain to be solved. Semiconductor lasers are a large and fruitful field and capture the largest share of the commercial laser market. We will review the recent developments in optically pumped VECSELs (semiconductor disc lasers), edge emitters, and their applications. Particular focus will be devoted to devices operating in challenging wavelength regions, efficient wavelength conversion architectures, boundaries for power scaling and ultrashort pulse generation.

Invited Speakers

Mircea Guina, *Optoelectronics Research Centre, Finland*, **Progress in VECSELs: from Gain Mirror Technology to New Applications**

Nils Hempler, *M Squared Lasers, UK*, **Commercial Semiconductor Disk Lasers**

Peter Skovgaard, *Norlase ApS, Denmark*, **New Platform for High Power IR and Visible Diode Laser Modules: Towards Yellow Wavelengths**

Time-Stretch Technology: Principles and Applications

Friday, 18 May, Session I: 10:30–12:30, Session II: 14:00–16:00
Willow Glen, San Jose Marriott

Organizers
Hongwei Chen, *Tsinghua Univ., China*
Keisuke Goda, *Univ. of Tokyo, Japan*

Optical time stretch is a method based on the exploitation of temporal dispersion for temporally stretching information-encoded ultrashort optical pulses such that the information is detected and digitized by a slow photodetector and a slow digitizer, respectively. With pulse repetition, such a measurement can be performed at a rate of MHz to GHz, allowing for fast, continuous, real-time measurements. Since it was conceived, optical time stretch has been mainly used in data acquisition for femtosecond digitization, data compression, and spectroscopy. In recent years, the method has been further studied and advanced, enabling the observation of non-repetitive and statistically rare events on ultrashort time scales such as soliton explosions, soliton molecules, optical rogue waves, and the birth of mode-locking. Furthermore, it has led to the development of ultrafast imaging, high-throughput imaging flow cytometry, ultrafast optical coherence tomography, and ultrafast surface vibrometry. This special symposium provides a forum for introducing the fundamental principles, emerging applications, and recent advances of optical time stretch as well as for discussing its technical challenges and future perspectives.

Invited Speakers

Dale Capewell, *Roguescope Technologies, USA*, **Coherent RogueScope**

Goëry Genty, *Tampere Univ. of Technology, Finland*, **Real-time Measurements of Nonlinear Instabilities in Optical Fibers**

Cheng Lei, *Univ. of Tokyo, Japan*, **Optofluidic Time-stretch Microscopy for Precision Medicine**

Ray Man, *Amonics Limited, Hong Kong*, **Studying Nonlinear Pulse Interactions using Time Stretch**

Adam C. Scofield, *Aerospace Corporation, USA*, **Demonstration of GHz-band RF Receiver and Spectrometer Using Random Speckle Patterns**

Kevin Tsia, *Univ. of Hong Kong, Hong Kong*, **Large-scale, Deep Single-cell Analysis by All-optical Laser-scanning Imaging Cytometry**

Short Courses

Short Course Chairs
Robert Fisher, *R. A. Fisher Associates, USA*
Ben Eggleton, *Univ. of Sydney, Australia*

The CLEO Short Course Program includes a range of topics at a variety of educational levels. Widely recognized experts in industry and academia lead attendees in building skills and/or achieving new insight, and the small-classroom setting provides a tremendous, interactive learning opportunity. Short Courses are an excellent opportunity to learn about new products, cutting edge technology and vital information at the forefront of the laser science and electro-optics fields.

Certificates of Attendance are available for those who register and attend a course. You may request a certificate upon completion of the online course evaluation. If you have any questions about receiving a Certificate of Attendance or completing the course evaluation, please email *shortcourses@cleoconference.org* with your name and course name(s).

Sunday, 13 May 2018

08:30–12:30

SC361: Coherent MidInfrared Sources and Applications
Instructor: Konstantin Vodopyanov; *CREOL, The College of Optics & Photonics, Univ. Central Florida, USA*

SC149: Foundations of Nonlinear Optics
Instructor: Robert Fisher, *R. A. Fisher Associates, USA*

SC466: Silicon Integrated Nanophotonics *NEW*
Instructor: Yurii A. Vlasov, *Univ. of Illinois at Urbana-Champaign, USA*

08:30–15:00

SC456: How to Start A Company
Instructor: Jes Broeng, *DTU, Denmark*, and Milton Chang, *Incubic, USA*

13:30–16:30

SC439: Attosecond Optics
Instructor: Zenghu Chang, *Univ. of Central Florida, USA*

SC403: NanoCavity Quantum Electrodynamics and Applications
Instructor: Jelena Vuckovic, *Stanford Univ., USA*

13:30–17:30

SC396: Frontiers of Guided Wave Nonlinear Optics
Instructor: Ben Eggleton, *Univ. of Sydney, Australia*

SC157: Laser Beam Analysis, Propagation, and Shaping Techniques
Instructor: James Leger, *Univ. of Minnesota, USA*

SC301: Quantum Cascade Lasers: Science, Technology, Applications and Markets
Instructor: Federico Capasso, *Harvard Univ., USA*

Monday, 14 May 2018

12:30–15:30

SC362: Cavity Optomechanics: Fundamentals and Applications of Controlling and Measuring Nano- and Micro-mechanical Oscillators with Laser Light
Instructor: Tobias Kippenberg, *Ecole Polytechnique Federale de Lausanne, Switzerland*

12:30–16:30

SC455: Integrated Photonics for Quantum Information Science and Technology
Instructor: Dirk Englund; *MIT, USA*

SC378: Introduction to Ultrafast Optics
Instructor: Rick Trebino, *Georgia Institute of Technology, USA*

Tuesday, 15 May 2018

12:00–15:00

SC410: Finite Element Modeling Methods for Photonics and Optics
Instructor: Arti Agrawal, *City Univ., UK*

SC352: Introduction to Ultrafast Pulse Shaping--Principles and Applications
Instructor: Marcos Dantus, *Michigan State Univ., USA*

SC376: Plasmonics
Instructor: Mark Brongersma, *Stanford Univ., USA*

12:00–16:00

SC270: High Power Fiber Lasers and Amplifiers
Instructor: W. Andrew Clarkson, *Optoelectronics Res. Ctr., Univ. of Southampton, UK*

SC438: Photonic Metamaterials
Instructor: Nader Engheta, *Univ. of Pennsylvania, USA*

Short Course Descriptions

Courses are listed by date and time. Complete course descriptions are available at: *www.cleoconference.org/shortcourses.*

SC361 - Coherent MidInfrared Sources and Applications

Konstantin Vodopyanov, *CREOL, The College of Optics & Photonics, Univ. Central Florida, USA*
Sunday, 13 May, 08:30–12:30

This course will make a comprehensive review of different techniques for producing coherent light in this important yet challenging spectral region. It will examine different state-of-the-art approaches from diverse areas of photonics that include: solid-state lasers based on rare-earth and transition metals, fiber lasers, semiconductor lasers (including intra- and intersubband cascade lasers), laser sources based on nonlinear optical frequency downconversion (including difference frequency generators, optical parametric oscillators, generators and amplifiers), Raman sources and others. Since the course is focused mostly on modern-day techniques, such traditional areas as carbon dioxide lasers and free electron lasers will be not be covered. Explaining fundamental principles behind a given technique will precede discussions on each topic. The course will review several emerging technologies such as supercontinuum generation in fibers and waveguides, as well as frequency combs generation. Several important mid-IR applications will be also reviewed and include molecular sensing, spectroscopy with frequency combs, and medical and military applications.

Short Course Benefits:

This course will enable you to:

- Get a clear idea of existing laser sources in the mid-IR spectral region (2-20 μm) and understand their operational principles, as well as advantages and disadvantages
- Distinguish between different operational regimes, from continuous-wave to few optical cycle pulsed operation
- Distinguish between broadband and narrow-band sources, as well as between the supercontinuum and the frequency comb regimes
- Learn about new applications of mid-IR coherent sources, from trace molecular detection and remote sensing to ultrafast spectroscopy and attosecond physics
- Identify what kind of laser source you need for your particular application

Short Course Level: Intermediate

Short Course Audience: Students, academics, researchers and engineers in various disciplines who require a broad introduction to the subject and would like to learn more about the state-of-the-art and upcoming trends in mid-infrared coherent source development and applications. Undergraduate training in either engineering or science is assumed.

SC149 - Foundations of Nonlinear Optics

Robert Fisher, *R. A. Fisher Associates, USA*
Sunday, 13 May, 08:30–12:30

This introductory and intermediate level course provides the basic concepts of nonlinear optics. Although some mathematical formulas are provided, the emphasis is on simple explanations. It is recognized that the beginning practitioner in nonlinear optics is overwhelmed by a constellation of complicated nonlinear optical effects, including second-harmonic generation, optical Kerr effect, self-focusing, self-phase modulation, self-steepening, fiberoptic solitons, chirping, stimulated Raman and Brillouin scattering, and photorefractive phenomena. It is our job in this course to demystify this daunting collection of seemingly unrelated effects by developing simple and clear explanations for how each works, and learning how each effect can be used for the modification,manipulation or conversion of light pulses. Examples will address the nonlinear optical effects that occur inside optical fibers and those that occur in liquids, bulk solids, and gases. This course will incorporate the creation of cartoons to lock in the basic concepts.

Short Course Benefits:

This course will enable you to:

- Explain and manipulate the Slowly-Varying Envelope Approximation (SVEA)
- Recognize what nonlinear events come into play in different effects
- Appreciate the intimate relationship between nonlinear events which at first appear quite different
- Discuss how a variety of different nonlinear events arise, and how they affect the propagation of light
- Describe how wavematching, phase-matching, and index matching are related
- Summarize how self-phase modulation impresses "chirping" on pulses
- Explain basic two-beam interactions in photorefractive materials
- Develop an appreciation for the extremely broad variety of ways in which materials exhibit nonlinear behavior"

Short Course Level: Beginner and Intermediate

Short Course Audience: Although we start at the very beginning of each topic, we move quite rapidly in order to grasp a deep understanding of each topic. Therefore, both beginners and intermediates will benefit greatly from this course. The material will be of interest to graduate students, to researchers, to members of the legal profession, to experts who are just transferring to this field, to managers, and to anyone else who just wants to learn how nonlinear optics works. This course, offered on Sunday Morning, will also give an excellent nonlinear optics foundation for those feeling the need so they can also take any of the following more specialized nonlinear optics courses at this CLEO conference: SC396: Frontiers of Guided Wave Nonlinear Optics; SC378: Introduction to Ultrafast Optics; SC270: High Power Fiber Lasers and Amplifiers; SC410: Finite Element Modeling Methods for Photonics and Optics; and SC352: Introduction to ultrafast pulse shaping—principles and applications.

SC466 - Silicon Integrated Nanophotonics *NEW*

Yurii A. Vlasov, *Univ. of Illinois at Urbana-Champaign, USA*
Sunday, 13 May, 08:30–12:30

Silicon photonics is a rapidly growing industry as well as an active area of advanced research. This course will focus on practical applications of advanced EM concepts to silicon photonics integrated circuits. It combines the rigorous derivation of major physical concepts like matrix optics, waveguiding, coupled mode theory, pin junctions, etc. with the applications of these knowledge towards the design of practical silicon photonic devices like passive wavelength filters, active switches and modulators for optical communications, as well as germanium photodetectors. The emphasis will be given to interaction of guided EM waves with electrical charges in pin junction that would allow participants to understand the operation and design principles of a new class of photonic devices (modulators, switches, photodetectors, etc.) based on carrier-injection/depletion in silicon/germanium integrated optics. Fabrication approaches and CMOS integration challenges will be reviewed. System-level analysis of short-reach and long-haul optical links will be analyzed that will drive the design considerations for optical transmitter and receiver subsystems and individual devices.

Short Course Benefits:

This course will enable you to:

- Get a clear idea of basic principles of integrated silicon optical devices and circuits including wavelength filters, modulators, switches, and photodetectors
- Learn about approaches to fabrication and challenges with CMOS integration of silicon integrated photonics that define the current landscape
- Understand how system-level requirements for optical communications as channel bandwidth, optical link error penalties, and power constraints, define the design considerations for subsystems and silicon photonic devices
- Understand the figures of merit for silicon photonic devices and compare various technical concepts for applications in short-reach and long-haul optical communications

Short Course Level: Beginner

Short Course Audience: Students, scientists, and engineers who are interested in learning about the rapidly developing field of silicon photonics and its impact on optical communications. Broad introduction to the subject and comprehensive review of basic concepts and the state-of-the-art trends allow beginners to take full advantage of this course with assumed undergraduate training in optical engineering or science.

SC456 - How to Start A Company

Jes Broeng[1] and Milton Chang[2], *[1]DTU, Denmark, [2]Incubic, USA*
Sunday, 13 May, 08:30–15:00

Starting a new business is one of the most rewarding experiences one can imagine. The journey from an idea to a successful company is, however, paved with challenges and puts high demands on technology, business and social skills. The upside, though, is tremendous in personal learning and potentially also in an economic sense.

This short course is aimed to help people thinking about starting their own company and provide practice-oriented tools to help aspiring entrepreneurs who have a scientific or engineering background.

To commercialize a new technology, the short course will help answer the following questions:

- How do I know I have a viable business idea?
- What to look for in co-founders?
- What financing strategy is appropriate for my kind of business?
- How to pitch and work with investors?
- How to bootstrap if all fails?

The course will include a mix of business theory and start-up experience based on a number of successful high-tech companies familiar to the scientists and engineers at CLEO. The short course will also include a workshop session, where start-up ideas from the attendees may be introduced and strengthened under the instructor's guidance. The course includes an informal networking lunch.

Short Course Benefits:

This course will enable you to:

- Recognize a potential high-tech business opportunity
- Have an understanding of different business models and to identify the right one for your start-up
- Knowledge of how investors think and how you may attract funding for a new venture
- Understand the principles to set up an effective organization
- Establish an eco-system to support your business, including lead customers and R&D partners.

Short Course Audience: This course is intended for scientists & engineers with interest in starting up their own high-tech business. This short course limited to an enrollment of 25.

SC439 - Attosecond Optics

Zenghu Chang, *Univ. of Central Florida, USA*
Sunday, 13 May, 13:30–16:30

Since the invention of lasers in 1960, various techniques such as mode-locking have been developed to push the pulse duration down first to picoseconds and then to femtoseconds, which is the oscillation period of infrared and visible light. The generation of attosecond pulses requires new methods to produce broadband coherent electromagnetic waves in the UV to X-ray range because of the lack of proper gain media. The discovery of high-order harmonic generation in high intensity laser-atom interaction at the end of 1980s paved the way. In 2001, attosecond light pulses, a train of attosecond bursts or single isolated attosecond pulses, were measured for the first time. It was accomplished by first converting the attosecond photons to photoelectrons in a combination of weak extreme ultraviolet and strong infrared fields, and then retrieve the spectral phase of the attosecond pulse by reconstructing the photoelectron spectrum. Since then, various sub-optical-cycle gating schemes such as polarization gating and Double Optical Gating have been demonstrated

to generation isolated attosecond pulses. By properly compensating the intrinsic chirp, 53 as pulses were characterized in 2017, which is so far the shorted light pulses. The new frontier in attosecond optics research is to significantly increase the photon flux and to extend the spectrum to the "water window." This course covers: (1) High harmonic generation. (2) Carrier-envelope phase of femtosecond driving lasers. (3) Semi-classical model and Strong Field Approximation. (4) Phase-matching in partially ionized media. (5) Sub-cycle gating and attosecond pulse characterization. (6) Attosecond streaking and transient absorption spectroscopy.

Short Course Benefits:

This course will enable you to:

- Specify parameters of femtosecond driving lasers that are critical to the generation of attosecond pulse trains and single isolated attosecond pulses
- Compare pros and cons of driving lasers based on Ti:Sapphire Chirped Pulse Amplification and Optical Parametric Amplifiers
- Explain the principle and techniques of locking the carrier-envelope offset frequency of femtosecond oscillators and carrier-envelope phase of amplified pulses
- Define short and long trajectories in the attosecond generation process using the Strong Field Approximation in the Lewenstein model
- Estimate the cutoff photon energy and attosecond chirp using the semi-classical model
- Calculate ionization probability of atoms in an intense laser field with the Ammosov-Delone-Krainov (ADK) tunneling rate
- Describe the principle of attosecond streak camera for characterizing attosecond pulses, as well as identify the major factors that affects the phase matching of high harmonic generation in partially ionized media

Short Course Level: Beginner (No background or minimal training is necessary to understand course material)

Short Course Audience: This short course targets senior undergraduate students, graduate students, postdoc fellows, scientists and engineers seeking to enter attosecond optics. The audience should have studied electromagnetism, optics, lasers, quantum mechanics and atomic physics at undergraduate or graduate levels. Prior knowledge of femtosecond lasers is required. Although basic theory is covered, it emphasizes on experimental aspects of attosecond optics, such as locking the carrier-envelope phase of the driving lasers and designing time-of-flight spectrometers for attosecond streak cameras.

SC403 - NanoCavity Quantum Electrodynamics and Applications

Jelena Vuckovic, *Stanford Univ., USA*
Sunday, 13 May, 13:30–16:30

Strong localization of light in nanophotonic structures leads to enhanced light-matter interaction, which can be employed in a variety of applications, ranging from improved (higher speed, lower threshold) optoelectronic devices, to biophotonics, quantum information and low threshold nonlinear optics. In particular, quantum dots in optical nanocavities are interesting as a test-bed for fundamental studies of such light-matter interaction (cavity quantum electrodynamics - QED), as well as an integrated platform for information processing. As a result of the strong field localization inside of sub-cubic wavelength volumes, they enable very large emitter-field interaction strengths (vacuum Rabi frequencies in the range of 10's of GHz – a few orders of magnitude larger than in atomic cavity QED). In addition to the study of new regimes of cavity QED, this can also be employed to build devices for quantum information processing, such as ultrafast quantum gates, nonclassical light sources, and spin-photon interfaces. Beside quantum information systems, many classical information processing devices greatly benefit from the enhanced light matter interaction in such structures; examples include all-optical switches operating at the single photon level, electro-optic modulators controlled with sub-fJ energy and operating at GHz speed, and lasers with threshold currents of 100nA.

This course will introduce cavity QED (e.g., strong and weak coupling regimes, Purcell effect, etc.), with particular emphasis on semiconductor nanocavities. We will also describe state of the art in solid state cavity QED experiments and applications.

Short Course Benefits:

This course will enable you to:

- Explain light matter interaction in optical nanostructures
- Discuss state of the art in solid state cavity QED
- Identify benefits of employing nano-cavity QED for certain applications

Short Course Level: Beginner

Short Course Audience: Scientists and engineers interested in cavity QED and nanophotonic devices in general. Some background in electromagnetics, quantum mechanics, and optoelectronics is helpful, but not required

SC396 - Frontiers of Guided Wave Nonlinear Optics

Ben Eggleton, *Univ. of Sydney, Australia*
Sunday, 13 May, 13:30–17:30

This course will review recent research and applications in the field of nonlinear guided wave optics with emphasis on both fundamentals and emerging applications. Starting from a strong foundation in the principles of nonlinear optics, we will review recent progress in emerging nonlinear optical platforms with an emphasis on the different materials, including silicon, chalcogenide, III-V semiconductors, lithium niobate, photonic crystal fibres, nanophotonic circuits and others. We will establish key figures of merit for these different material systems and a general framework for nonlinear guided wave optics with emphasis on the applications in emerging areas of science and technology. We will then review recent progress and breakthroughs in the following areas: All-optical processing, Ultra-fast optical communications, Slow light, highly nonlinear and emerging waveguides, Ultrafast measurement and pulse characterization, Frequency combs and optical clock, Optical parametric amplifiers and oscillators, Generation and applications of optical super-continuum, Nonlinear localization effects and solitons, Nonlinear optics for quantum information.

Short Course Benefits:

This course should enable the participants to:

- Get state of the art knowledge of nonlinear optics in emerging waveguides and materials
- Understand the applications of nonlinear optics in key applications
- Have a foundation of nonlinear waveguide physics for emerging applications and science

Short Course Level: Advanced Beginner

Short Course Audience: This course assumes some basic knowledge/familiarity of nonlinear optics. Individuals lacking such knowledge should consider taking SC149: Foundations of Nonlinear Optics first.

SC157 - Laser Beam Analysis, Propagation, and Shaping Techniques

James Leger; *Univ. of Minnesota, USA*
Sunday, 13 May, 13:30–17:30

The propagation and focusing properties of real laser beams are greatly influenced by beam shape, phase distortions, degree of coherence, polarization, and aperture truncation effects. The ability to understand, predict, and correct these real-world effects is essential to modern optical engineering. Attendees of this course will learn a variety of techniques for measuring and quantifying the important characteristics of real laser beams, be able to calculate the effects of these characteristics on optical system performance, and explore a variety of beam shaping techniques to optimize specific optical systems.

The course starts with a basic and intuitive description of Gaussian beam characteristics from an ideal laser. These concepts are extended to non-Gaussian beams (e.g. high-order Hermite Gaussian beams, top-hat shapes, laser arrays, and non-diffracting beams) and the relative merits of various beam shapes are discussed. The properties of optical vortex beams, cylindrical vector beams, and orbital angular momentum are then explored. Beam characterization methods such as M^2, Strehl ratio, and TDL are reviewed. Simple expressions for estimating the effects of laser aberrations and coherence on beam focusing and propagation are developed. Coupling of light into single and multi-mode fibers, as well as far-field light concentration limits are explored as real-world examples. The constant radiance theorem and étendue are employed as engineering tools to optimize optical design, and simple analytical tools are presented to estimate the effects of spatial beam shape, phase aberrations, and coherence on beam concentration. The course ends with a description of internal and external cavity beam shaping techniques using phase and polarization modulation.

Short Course Benefits:

This course will enable you to:

- Measure the quality of a laser beam using several methods
- Interpret the meaning of various laser specifications
- understand Gaussian laser beam properties from an intuitive standpoint
- Predict the propagation and focusing properties of non-ideal and aberrated laser beams
- Determine the concentration limits of a light field
- Design optimal beam concentration optics
- Compare different beam profiles for specific applications and calculate ideal peformance
- Design beam shaping optics using polarization and phase manipulation

Short Course Level: Advanced Beginner

Short Course Audience: This course is designed to provide laser engineers, optical system designers, and technical management professionals with a working knowledge of laser beam characterization, analysis, and modification. Physical and intuitive explanations of most topics are designed to make the concepts accessible to a wide range of participants.

SC301 - Quantum Cascade Lasers: Science, Technology, Applications and Markets

Federico Capasso, *Harvard Univ., USA*
Sunday, 13 May, 13:30–17:30

Quantum Cascade Lasers (QCLs) are fundamentally different from diode lasers due to their physical operating principle, which makes it possible to design and tune their wavelength over a wide range by simple tailoring of active region layer thicknesses, and due to their unipolar nature. Yet they use the same technology platform as conventional semiconductor lasers. These features have revolutionized applications (spectroscopy, sensing, etc.) in the mid-infrared region of the spectrum, where molecules have their absorption fingerprints, and in the far-infrared or so called Terahertz spectrum. In these regions until the advent of QCLs there were no semiconductor lasers capable of room temperature operation in pulsed or cw, as well high output power and stable/wide single mode tunability. The unipolar nature of QCL, combined with the capabilities of quantum engineering, leads to unprecedented design flexibility and functionality compared to other lasers. The physics of QCLs, design principles, supported by modeling, will be discussed along with the electronic, optical and thermal properties. State-of-the-art performance in the mid-ir and Terahertz will be reviewed. In particular high power CW room temperature QCLs, broadly tunable QCL, short wavelength MWIR QCLs and recent breakthroughs in THz room temperature operation will be presented. A broad range of applications (IR countermeasures, stand-off detection, chem-bio sensing, trace gas analysis, industrial process control, medical and combustion diagnostics, imaging, etc.) and their ongoing commercial development will be discussed.

Short Course Benefits:

This course will enable you to:

- Describe underlying QC Laser physics, operating principles and fundamental differences between standard semiconductor lasers and QC lasers
- Explain quantum design of the key types of QC lasers, which have entered real world applications, and how their electrical and optical properties can be tailored to optimize performance in the mid-infrared and THz regions.

- Discuss experimental device performance, including physical limits, design constraints and comparison with theory and determine device characteristics (current-voltage and light-current curves; differential and power efficiency, threshold, gain and losses; spectral behavior, single mode operation; high speed operation)
- Explain the basics of QC laser device technology: fabrication process, materials growth options
- Illustrate the basics of a chemical sensing system; discuss applications of state-of the-art mid-infrared QC lasers to sensing and present several examples of QC laser commercialization
- Discuss current and future markets of QC lasers

Short Course Level: Beginner

Short Course Audience: Graduate students; qualified undergraduates (mostly senior level) majoring in EE or physics/applied physics;researchers in industry, academia and government labs; engineers, sales reps and technical managers.

Education: Undergraduate degree or a Ph.D or pursuing a Ph.D in EE, Physics or Applied Physics, with knowledge of introductory level semiconductor devices.

SC362 - Cavity Optomechanics: Fundamentals and Applications of Controlling and Measuring Nano- and Micro-mechanical Oscillators with Laser Light

Tobias Kippenberg, *Ecole Polytechnique Federale de Lausanne, Switzerland*
Monday, 14 May, 12:30–15:30

Radiation pressure denotes the force that optical fields exert and which have wide ranging applications in both fundamental science and applications such as Laser cooling or optical tweezers. Radiation pressure can, however, also have a profound influence on micro- and nanophotonic devices, due to the fact that radiation pressure can couple optical and mechanical modes. This optomechanical coupling gives rise to a host of new phenomena and applications in force, displacement and mass sensing. This course is intended to give an introduction of the Physics and Applications of cavity optomechanics and highlight the rapid developments in this emerging field. Optomechanical coupling can be used to both cool and amplify mechanical motion and thereby allow new light driven photon clocks. Optomechanical refridgeration of mechanical modes gives insights into the quantum limits of mechanical motion. In addition, radiation pressure coupling enables new way of processing light all optically enabling optical mixers, delay lines or storage elements. Moreover, the basic limitations of optomechanical displacement measurements, due to quantum noise and practical laser phase noise limitations, will be reviewed, relevant across a wide range of sensing experiments.

The course will make contact to practical applications of optomechanics in Metrology (force sensors, mass sensors and light driven optical clocks) and review fundamental design principles of optomechanical coupling and the design of high Q mechanical oscillators. The use of finite element simulations will be covered.

Short Course Benefits:

This course will enable you to:

- Explain gradient and scattering light forces in microcavities and micromechanical systems
- Design high –Q nano-and micro- mechanical oscillators (finite element modeling, FEM)
- Discuss the fundamental limits of mechanical Q in NEMS/MEMS
- Describe of the fundamental and practical limits of displacement sensors
- Summarize Applications of optomechanics in mass and force sensing
- Explain the basic optomechanical phenomena (amplification, cooling)
- Discuss the standard quantum limit (SQL)
- Characterize radiation pressure driven oscillations in terms of fundamental oscillator metrics
- Define Phase and frequency noise of oscillators
- Know the influence of phase and amplitude noise of a wide variety of laser systems (fiber lasers, TiSa, diode lasers) in optomechanical systems

Short Course Level: Advanced Beginner

Short Course Audience: This course is intended for physicists and optical and electrical engineers desiring both focused fundamental knowledge of cavity optomechanical coupling (i.e., radiation pressure coupling of light and NEMS/MEMS) but also a view of emerging applications of this new technology. The instruction will be at a level appropriate for graduate students and will assume some basic knowledge of laser.

SC455 - Integrated Photonics for Quantum Information Science and Technology

Dirk Englund, *MIT, USA*
Monday, 14 May, 12:30–16:30

The rules of quantum mechanics enable applications that are inherently more powerful than their classical counterparts. Quantum key distribution now makes it possible to transmit information with unconditional security; quantum simulation is beginning to address problems that are intractable on classical computers; and quantum metrology techniques push the boundaries of precision measurements.

Many of these quantum technologies rely fundamentally on advanced photonics that place extremely demanding requirements on precision, efficiency, and mode complexity. Over the past decade, new generations of photonic integrated circuits have been developed to begin to address these requirements.

This course will cover basic concepts and recent progress in photonic integrated circuits technology for quantum information processing, with a focus on two primary application areas: quantum communications -- from quantum cryptography to entanglement distribution over quantum networks -- and quantum computing, including analog and digital approaches. Motivated by these applications, the course will discuss nonclassical light sources, photonic interfaces with atomic memories, high-fidelity mode transformation circuits,

nonlinear photonic quantum gates, and waveguide-integrated single photon resolving detectors.

Short Course Benefits:

This course will enable you to:

- Describe a practical quantum key distribution system, estimate performance, and identify central limitations
- Propose methods to extend the reach of quantum secure communications
- Describe the main classes of quantum communications
- Categorize the major areas of quantum computing
- Diagram quantum networks
- Design photonic integrated circuits for quantum key distribution and quantum repeaters

Short Course Level: Advanced Beginner

Short Course Audience: The course is designed for an audience interested in the key ideas and technology of photonic quantum communication and computation. It will probably be most valuable to participants who have some background in quantum information science or integrated optics and who want to better understand where the intersections of these fields and where the challenges and opportunities lie. The course should be useful for graduate students and industrial and academic researchers with an interest in applied photonic quantum technologies.

SC378 - Introduction to Ultrafast Optics

Rick Trebino, *Georgia Institute of Technology, USA*
Monday, 14 May, 12:30–16:30

Ultrafast Optics—the science and technology of ultrashort laser pulses—is one of the most exciting and dynamic fields of science. While ultrashort laser pulses seem quite exotic (they're the shortest events ever created!), their applications are many, ranging from the study of ultrafast fundamental events to telecommunications to micro-machining to biomedical imaging - to name a few. Interestingly, these lasers are readily available, and they are easy to understand. But their use requires some sophistication. This course is a basic introduction to the nature of these lasers and the pulses they generate. It will discuss the principles of their generation and amplification and describe their most common distortions in space and time and how to avoid them—or take advantage of them. In addition, it will cover the nonlinear optics of ultrashort pulses for converting pulses to almost any color, as well as the additional interesting and potentially deleterious effects nonlinear optical processes can cause. Finally, it will cover techniques for ultrashort-pulse measurement.

Short Course Benefits:

This course will enable you to:

- Explain how ultrashort-pulse lasers and amplifiers work
- Describe ultrashort pulses and their many distortions
- Use nonlinear optics to an convert ultrashort laser pulse to virtually any wavelength
- Take advantage of—or avoid—nonlinear-optical high-intensity effects
- Meaningfully measure ultrashort pulses

Short Course Level: Beginner

Short Course Audience: Any scientist or engineer interested in the science and technology of the shortest events ever created, especially those new to it.

SC410 - Finite Element Modeling Methods for Photonics and Optics

Arti Agrawal, *City Univ., UK*
Tuesday, 15 May, 12:00–15:00

Numerical modelling and simulation of optical devices and components is a key tool in improving performance by reducing time and monetary costs, design optimization and characterization as well as innovating new ideas. Both passive and active devices are modelled and optimized numerically. In some cases simulation is the only way to explore phenomena where technology is not advanced enough for fabrication. The interaction of the optical beam with physical effects such as non-linearity, stress, strain, change in refractive index due to temperature, application of electric fields etc. are now extremely important. Modelling complements experimental work perfectly and almost no research is conducted without it.

The Finite Element (FE) method is one of the most popular and powerful methods for modelling in Photonics. This short course starts with Maxwell's equations and explains the basic principles of numerical modelling and the key assumptions involved. This foundation is used to develop the FE method, including a brief tour of the mathematics. How the method can be applied to various optical devices is discussed in detail. How can physical effects be included with the FE method for modelling is considered. The course ends with an explanation of FE based beam propagation methods and how these can be used to find the evolution of the optical fields.

Some salient features of the short course include:

- Emphasis on practical application of FEM for modelling of devices
- Discussion on developing code
- Perfectly Matched Layer and Periodic boundary condition
- Generating mesh for structures, post-processing of results
- Discussion on popular commercial software such as COMSOL and how to best utilize them

Methods covered include:

- Full vector Finite Element method for modal solution
- Introduction to inclusion of physical effects with the optical model

Practical illustrations include:

- Optical fibers including photonic crystal fibers
- Si slot waveguides, nanowires and high index contrast structures
- Bent waveguides and loss
- Plasmonic waveguides

Short Course Benefits:

This course will enable you to:

- Identify and explain basic principles of numerical modelling in Photonics
- Discuss and explain Full vector Finite Element Method (FEM) for modal solutions
- Introduction to FEM with physical effects (non-linearity, stress/strain, acousto-optic, electro-optic effect etc.)
- Discuss and explain how to incorporate Perfectly Matched Layer and Periodic boundary condition
- Summarize how to generate mesh for structures and post-processing of results
- Tips on how to best utilise commercial software
- Discuss the application of the method to practical devices: nano wires, optical fibers, sensors etc.
- Identify the appropriate modeling method for their problem
- How to incorporate PML boundary conditions and write your own code

Short Course Audience: This course is intended for researchers, engineers and students who use simulation in their work in both fundamental and applied aspects of Optics and Photonics, especially for components and devices. The course is useful for members of both academic and industrial institutions. Basic background and familiarity in Optics will be sufficient.

SC352 - Introduction to Ultrafast Pulse Shaping--Principles and Applications

Marcos Dantus, *Michigan State Univ., USA*
Tuesday, 15 May, 12:00–15:00

Pulse shaping is an integral part of every femtosecond laser, and learning about pulse shaping can help us better understand dispersion, pulse characterization and pulse compression. This course begins by describing how the spectral phase affects the temporal characteristics of a femtosecond pulse with a hands-on computer simulation. The essential physics and a brief background of the development of shapers are provided. The course goes over the experimental implementation requirements and then covers some of the most salient applications of pulse shapers, among them: (a) pulse compression, (b) pulse characterization, (c) creation of two or more pulse replicas, and (d) control of nonlinear optical processes such as selective two-photon excitation and selective vibrational mode excitation (e) material processing, (f) microscopy and others. The course provides a good foundation for those wanting to explore the more fundamental aspects of light-matter interactions, and it also provides multiple examples of practical applications that are made possible by pulse shaping.

Short Course Benefits:

This course will enable you to:

- Gain a better understanding of femtosecond laser pulses and their applications
- Learn pulse shaper design principles
- Compare among different pulse shaper designs and to determine which one is best suited for a particular application
- Simulate the output pulse from a pulse shaper given a particular phase and amplitude modulation
- Predict the effect caused by introducing a simple phase such as a linear, quadratic or cubic function on a transform-limited pulse
- Learn two different approaches to creating pulse replica that can be independently controlled with attosecond precision in the time domain using the pulse shaper
- Measure the spectral phase of laser pulses using the pulse shaper itself as the measurement tool, and eliminating phase distortions to compress the output pulses
- Summarize the advantages of having an adaptive pulse shaper for controlling the output of ultrafast lasers

Short Course Level: Advanced Beginner (basic understanding of topic is necessary to follow course material)

Short Course Audience:

This course, updated yearly, is intended for everyone that uses or intends to use femtosecond laser pulses in academic research or industry. Attendees will learn how pulse shaping can greatly enhance femtosecond laser applications. No prior knowledge about pulse shaping is required.

SC376 - Plasmonics

Mark Brongersma, *Stanford Univ., USA*
Tuesday, 15 May, 12:00–15:00

Plasmonics is an exciting new field of science and technology that aims to exploit the unique optical properties of metallic nanostructures to enable routing and active manipulation of light at the nanoscale. Nanometallic objects derive these properties from their ability to support collective electron excitations, known as surface plasmons (SPs). Presently we are witnessing an explosive growth in both the number and range of plasmonics applications; it is becoming eminently clear that both new fundamental science and device technologies are being enabled by the current plasmonics revolution. The intention of this tutorial is to give the participants a fundamental background and working knowledge of the main physical ideas used in plasmonics, as well as an overview of modern trends in research and applications.

The Short Course will begin with a general overview of the field of plasmonics. This will be followed by an introduction to the basic concepts that enable one to understand and design a range of plasmonic functionalities. This part will be followed by an in-depth discussion of a range of active and passive plasmonic devices that have recently emerged. Particular attention will be given to nanometallic structures in which surface plasmons can be generated, routed, switched, amplified, and detected. It will be shown that the intrinsically small size of plasmonic devices directly results in higher operating speeds and facilitates an improved synergy between optical and electronic components. The field of plasmonics is rapidly growing and has started to provide a whole range of exciting new research and development opportunities that go well beyond chipscale components. A number of such developments will be investigated, including new types of optical sensors, solar cells, quantum plasmonic components, non-linear, and ultrafast devices. At the end of the tutorial, a critical assessment of the entire field is given and some of the

truly exciting new opportunities for plasmonics are identified. A comparison of metallic and high-index semiconductor antennas and metamaterials will be made as well.

Short Course Benefits:

This course will enable you to:

- Obtain a working knowledge of the key physical concepts used in Plasmonics that enable light manipulation at ultra small length- and time-scales
- Understand choices of different metal types, shapes, and sizes to accomplish different plasmonic functionalities
- Find out about common electromagnetic computational tools to design plasmonic structures and devices
- Get a feel for the current state of the field in terms of fundamental understanding as well as device applications
- Learn about the most recent trends and developments in research and applications

Short Course Level: Beginner

Short Course Audience: Optical engineers and scientists who are interested in learning about the rapidly emerging field of plasmonics and its potential impact.

SC270 - High Power Fiber Lasers and Amplifiers

W. Andrew Clarkson, *Optoelectronics Res. Ctr., Univ. of Southampton, UK*
Tuesday, 15 May, 12:00–16:00

Short Course Description:

Recent advances in cladding-pumped fiber lasers and amplifiers have been dramatic, leading to unprecedented levels of performance in terms of output power, efficiency, beam quality and wavelength coverage. These achievements have attracted growing interest within the community and have fueled thoughts that fiber-based sources may one day replace conventional "bulk" solid-state lasers in many application areas. The main attractions of cladding-pumped fiber sources are derived directly from their geometry, which simultaneously allows very efficient generation of coherent light and almost complete immunity from the effects of heat generation, which are so detrimental to the performance of other types of lasers.

This course aims to provide an introduction to high power fiber lasers and amplifiers, starting from the basic principles of operation and ending with examples of current state-of-the-art devices and some thoughts on future prospects. The course will cover a range of topics, including basic fiber laser and amplifier theory, spectroscopy of the relevant rare earth ions for high power devices, a discussion of the factors influencing laser and amplifier performance, fiber design and fabrication, pump sources and pump launching schemes, fiber resonator design, master-oscillator and power-amplifier configurations, linewidth control and wavelength selection, transverse mode selection, nonlinear loss processes (SBS and SRS) and their impact on performance, and heat generation and its impact on power scalability. The course will also give an overview of techniques (e.g. coherent and spectral beam combining) for further scaling of output power and provide an introduction to hybrid fiber-bulk laser schemes for scaling pulse energy.

Short Course Benefits:

This course will enable you to:

- Calculate threshold pump power and slope efficiency, and estimate the maximum output power that can be obtained from a given fiber laser oscillator or amplifier configuration
- Select the optimum pump source for a given rare earth ion transition and fiber design
- Design the pump light collection and coupling scheme and estimate the pump launch efficiency
- Specify the fiber parameters (e.g. cladding design, core size, rare earth ion concentration) required for a particular laser or amplifier configuration
- Design the fiber laser resonator and amplifier and select the operating wavelength
- Estimate thermally induced damage limit
- Estimate the power scaling limit
- Measure fiber laser performance characteristics and relate these to fiber design and resonator parameters

Short Course Level: Advanced Beginner

Short Course Audience: This course is intended for individuals with a basic knowledge of lasers and optics who wish to learn about the basic principles and capabilities of fiber lasers and amplifiers when operating at high power levels. The course will also cover some of the practical issues of operating these devices and provide an update for those wishing to learn about some of the latest developments in this rapidly advancing field.

SC438 - Photonic Metamaterials

Nader Engheta, *Univ. of Pennsylvania, USA*
Tuesday, 15 May, 12:00–16:00

Controlling electromagnetic and optical fields and waves can be achieved via materials. The wave-matter interaction can be engineered using structures made of materials with required parameters and structures with selected shapes, dimensions and sizes. Recent advances in materials science and engineering, condensed matter physics, optical materials, nanoscience and nanotechnology have made it possible to tailor materials with unusual parameters and characteristics. The field of metamaterials, along with its two-dimensional version known as metasurfaces, has seen growing interest and extensive development in recent years. Metamaterials are engineered composite structures made of subwavelength inclusions with suitable materials and proper arrangements. The compositions, arrangements, alignments, densities and distributions of these building blocks in host media provide a variety of degrees of freedom in the design of light-matter interaction with such structures. Manipulation of light at the nano-, micro-, meso- and macroscales using metamaterials and metasurfaces provides rich platforms for tailoring electromagnetic waves with desired functionalities.

In this tutorial, we will begin with the basics of electromagnetic wave interaction with material media and structures. Then the course will get into some of the specifics of the characteristics of metamaterials and metasurfaces including the dispersion properties, scattering mechanisms, effective-medium phenomena, and unconventional features of waves in

such environments. We will then discuss some of the specific topics in photonic metamaterials such as extreme-parameter metamaterials (i.e., epsilon-near-zero (ENZ), mu-near-zero (MNZ), and epsilon-and-mu-near-zero (EMNZ) structures) and their specialized wave-matter interactions, graphene metamaterials as a platform for ideas for one-atom-thick optical device concepts, optical metatronics ("lumped" nanocircuitry) and informatic metastuctures for photonic information processing and computing at the nanoscale, scattering engineering using metamaterials (such as cloaking), guided waves in metamaterials, and nonreciprocal metastructures. Various features and potential applications of these topics will also be presented and discussed. During the course, we will have interactive discussions and question-answer sessions.

Short Course Benefits:

This course will enable you to:

- Describe the basics of electromagnetic field and wave interaction with metamaterials and metasurfaces
- Explain some of the important properties of photonic metamaterials
- Discuss some of the scenarios in light-matter interaction with "extreme-parameter" metamaterials
- Describe the fundamentals of optical nanocircuits ("optical metatronics"), with potentials for information processing in nanophotonics
- Explain some of the salient features of scattering and guidance of lights in metamaterials and metasurfaces

Short Course Level: Beginner

Short Course Audience: Graduate students and senior undergraduates with EE, Physics, and Applied Physics interests; Engineers, researchers and technical managers from industry, government labs, and universities; Introductory knowledge of electromagnetics and optics is required.

Special Events

OSAF Data Science Career Opportunities

Sunday, 13 May, 08:30–17:00
Market 1, Hilton San Jose
Instructor: Roberto Reif, *Metis, USA*

Sponsored by the OSA Foundation and Milton and Rosalind Chang, this course provides an introduction to careers in data science. It incorporates interactive lectures and group exercises. By attending this course, attendees will learn how their technical skills can transition into the data science field and what a career in data science is like, understand what the field of data science is and the roles, necessary skills, and types of problems data scientists work on, and gain insight into the data science project lifecycle and outputs.

Roberto Reif is a senior data scientists at Metis. Prior to Metis, he led the signal processing team at Sensoria Inc. and was a program manager at Microsoft. He has worked on applications in the healthcare, internet of things, biomedical optics, and business intelligence. He has a PhD in Biomedical Engineering from Boston University's Biomedical Optics Laboratory and completed a senior postdoctoral research fellowship at the University of Washington's Biophotonics and Imaging Laboratory. He has co-authored several scientific publications, book chapters, and patents.

Attendance is limited to 50 people. The required registration fee of $25 includes lunch.

Hosted by: OSA Foundation

OSAF Cheeky Scientist Career Development Workshops

Sunday, 13 May, Session I: 13:00–14:00,
Session II: 16:00–17:00
Winchester 1&2, Hilton San Jose
Instructor: Isaiah Hankel, *Cheeky Scientist, USA*

Isaiah Hankel works with hundreds of graduate students and postdocs daily assisting them to transition to industry by first showing them how to present themselves as business professionals. These programs will provide you with a strong understanding of what it takes to have a tailored industry resume and how to showcase your transferrable skills.

Session Schedule

Session I: The Modern Job Search:

Using online profiles to maximize the effectiveness of the job seeking/transition process. Hiring managers use LinkedIn to determine whether they will bring in a candidate for an interview, this topic will cover all the key elements of the LinkedIn profile and how each section should be used to strategically maximize its impact. In addition, we will show candidates how to use LinkedIn algorithms to support their job search, and sell themselves to perspective employers.

Session II: Networking: An Art & Science:

This section is created based on the networking strategies of some of the most strategic networkers in the world and also goes into the science of building rapport and why this is important for the job seeking professional. While this topic tends to be popular, it seems people are still not using it effectively and thus we have detailed specific action steps job seekers can take, and specific scripts to use while networking.

Workshops are complimentary for OSA Members. There is limited space at each. RSVP online through CLEO Special Events site.

Hosted by: OSA Foundation

OIDA Executive Forum on the Exploding Role of Optics in Sensing

Monday, 14 May, 08:30–18:00
Almaden Ballroom, Hilton San Jose

This event aims to match applications leaders needing new solutions with early-stage technologies in a range of sectors, spanning consumer to industrial markets. While the ultimate activity is "matchmaking" the emphasis will be on the end-product vendors' needs and investor perspectives. The workshop will focus on segments within the field that have particular promise today, such as mobility and automation, Big Data and AI, and manufacturing issues related to these products. Some key questions for discussion will be:

- What is needed from the photonics industry? Which are the problems that optics and photonics can have the greatest impact on?
- What are the enabling technologies that have the most promise?
- What are the bottlenecks or "showstoppers" among photonics technologies today, and potential solutions?

OSA Optical Material Studies Technical Group Special Talk

Monday, 14 May, 12:00–13:00
Room 230A

Students and recent graduates are invited to join the OSA Optical Material Studies Technical Group for a special talk on potential career paths during lunch on Monday. Attendees will have the opportunity to hear from two recent graduates, one who has pursued a career in industry and one who has pursued a career in academia, who will provide insight into their current research and their career paths. An RSVP is required for this technical group event; please contact TGactivities@osa.org to register, pending availability.

Hosted by: OSA Optical Material Studies Technical Group

Workshop: Understanding Unconscious Bias

Monday, 14 May, 14:00–15:30, 16:00–17:30
Winchester 1&2, Hilton San Jose
Speaker: Sara Bendoraitis, *American Univ., USA*

Research demonstrates that we all have unconscious biases. These biases can result in best and brightest talent made to feel unwelcome, invisible, and not important to the success of the organization. This training will explore concepts and engage participants to better understand implicit bias, increase awareness and understanding the impact on organizational culture and identify ways to promote greater engagement with diversity and inclusion.

Programs are open to OSA Members. There is limited space. RSVP required through CLEO Special Events Page.

Hosted by:

Diversity & Inclusion in Optics and Photonics Reception

Monday, 14 May, 17:30–18:30
Market 1&2, Hilton San Jose

Join us for a reception to connect with the optics and photonics community to discuss diversity in the field. Come to learn, share and engage with colleagues around this important topic. Please RSVP by going to CLEO Special Events site to let us know you are attending.

Hosted by: This inclusive event has been organized by OSA, IEEE and APS

OSA Nanophotonics Technical Group 20x20 Talks

Monday, 14 May, 19:00–20:30
Room 230A

This special session hosted by OSA Nanophotonics Technical Group offers a unique platform for individuals to present their research in a creative and concise fashion that differs from the usual oral or poster session. Selected participants will showcase their research in a presentation of 20 images, in which each image is displayed for 20 seconds. Presenters will talk along to the images as the slides advance automatically. Immediately following presentations, attendees are invited to join the technical group for small reception where they can telework with colleagues over refreshments.

Hosted by:

OSA Technical Group Poster Session

Tuesday, 15 May, 19:00 – 20:30
Room 230A/B

Join the OSA Technical Groups for a series of focused poster sessions, bringing together students and colleagues for an opportunity to share their latest research findings and exchange ideas. After listening to the poster presentations and connecting with fellow attendees over refreshments, you'll have a chance to cast your vote for the best poster from each of the four participating technical groups. Among the technical groups participating this year will be the Optical Material Studies Technical Group, the Ultrafast Optical Phenomena Technical Group, the Systems and Instrumentation Technical Group and the Environmental Sensing Technical Group.

Hosted by:

Meet OSA Publishing Journal Editors Reception

Tuesday, 15 May, 15:30–17:00
Exhibit Hall #2425

Join OSA Publishing's Journal Editors for conversation and ice cream. The Editors welcome your questions, concerns, and ideas for any of OSA's Journals. Topics for discussion can include best practices when submitting a manuscript; elements of a useful manuscript review; criteria editors look for in submitted manuscripts; or the process to propose a Feature Issue topic for publication in an OSA Journal. All are welcome.

OSA Photonic Metamaterials Technical Group Tutorial on Metasurface Design and Simulation

Wednesday, 16 May, 12:00–13:00
Room 230A

Join the OSA Photonic Metamaterials Technical Group for a tutorial on metasurface design and simulation during lunch on Wednesday. This tutorial, aimed at students and new researchers, will focus on hands-on skills. Dr. Wei Ting Chen from Harvard University, with assistance from Alexander Zhu and Yao-Wei Huang, will provide an overview of metasurfaces followed by a tutorial on how to perform the simulation. An RSVP is required for this technical group event; please contact TGactivities@osa.org to register, pending availability.

Hosted by:

Conference Reception

Wednesday, 15 May, 19:30–20:30
Grand Ballroom

Enjoy a festive evening with your colleagues, while intermingling with the exhibitors and viewing the first poster session. The reception is open to all attendees and badges must be worn to enter the reception.

Sponsored by: THORLABS

Lunch at the CLEO:EXPO

Tuesday and Wednesday, 16 & 17 May, 11:30–13:00
Thursday, 18 May, 12:30–14:00
Exhibit Hall

Grab some lunch and network with exhibitors to check out their innovative products and services that can help your organization.

Emerging Trends in Nonlinear Optics – A Review of CLEO: 2018

Thursday, 17 May, 18:30 – 20:00
Room 230A

OSA Members are invited to join the OSA Nonlinear Optics Technical Group for a special panel discussion presenting the exciting and hot topics in nonlinear optics that were presented during CLEO: 2018. Short presentations from our panelists highlighting important themes from the conference will be followed by moderated question and answer sessions. Following the conclusion of the panel discussion, members are invited to join the technical group for a small reception where they can network with colleagues over refreshments. This technical group event is open to OSA Members; please contact TGactivities@osa.org to register, pending availability.

Hosted by: OSA Nonlinear Optics Technical Group

Postdeadline Paper Sessions

Thursday, 17 May, 20:00–22:00
Locations announced on the Conference Update Sheet

The Technical Program Committee has accepted a limited number of postdeadline papers for oral presentation. The purpose of postdeadline papers is to give participants the opportunity to hear new and significant materials in rapidly advancing areas.

CLEO:EXPO

Exhibit Hall

Make sure to visit the show floor which features a diverse group of companies, representing every facet of the lasers and electro-optics industries. Learn about new products, find technical and business solutions, and gain the most up-to-date perspective of the laser-related business environment. Review the list of exhibitors on the following pages to see the companies you'll meet at CLEO.

CLEO:EXPO is free of charge for all conference registrants.

Tuesday, 15 May	10:00–17:00
exhibit-only time	10:00–13:00; 15:00–17:00
Wednesday, 16 May	10:00–17:00
exhibit-only time	10:00–13:00; 15:00–17:00
Thursday, 17 May	10:00–15:00
Exhibit-only time	10:00–14:00

Exhibit Hall Rules

Children 12 and under must be accompanied by an adult at all times. Strollers are not allowed on the show floor at any time.

Neither photography nor videotaping is permitted in the Exhibit Hall. Exhibitors need to get permission from Show Management to photograph their own booths. Non-compliance may result in the surrendering of film and removal from the hall.

For further questions, visit Registration on the Concourse Level.

Exhibitors *(as of 9 April 2018)*

3DOptix
AdValue Photonics, Inc.
Advanced Research Systems
AdvR
AIP Publishing
Allied Laser Solutions
ALPAO
Alpes Lasers SA
Alpine Research Optics
Altos Photonics, Inc.
American Elements
American Institute of Physics
American Physical Society (APS)
AMPHOS, Inc.
Amplitude Laser Group
APE - Applied Physics & Electronics, Inc.
Aspen Systems - Laser Cooling
Attocube Systems, Inc.
AUREA Technology
Azur Light Systems
Boston Electronics Corporation
Bristol Instruments, Inc.
Calmar Laser, Inc.
CASTECH, Inc.
Changchun New Industries Optoelectronics Tech. Co.
Chinese Laser Press
Chromacity
Class 5 Photonics GmbH
Cobolt AB
Coherent Solutions
Coherent, Inc.
Cornell NanoScale Facility
CREOL, University of Central Florida
Crestec Corporation
Cristal Laser SA
Crystalline Mirror Solutions, GmbH
CST of America, Inc.
Cybel, LLC
Cycle GmbH
DataRay, Inc.
Daylight Solutions, Inc.
DCM Tech
Double Helix LLC
Edmund Optics, Inc.
EEOptics Corp.
EKSMA Optics
EKSPLA
Elas
Electro-Optics Technology, Inc.
Energetiq Technology, Inc.
EOSPACE, Inc.
EXFO
FASTLITE
Femtochrome Research, Inc.
few-cycle Inc.

All conference locations are in the San Jose Convention Center unless otherwise noted.

Gentec Electro-Optics, Inc.
GTAT Corp.
Hagitec Ltd
Hamamatsu Corporation
HC Photonics Corp.
Hindsight Imaging
Hiwin Corporation
HJ Optronics, Inc.
HOLOEYE Photonics AG
HTA Photomask
Ibsen Photonics A/S
IEEE Photonics Society
IMRA America, Inc.
Industrial Technology Research Institute
INNOLAS
InPhenix
Inrad Optics
Integrated Fiber Optics
IPG Photonics Corp.
IRflex Corporation
Keopsys US
KMLabs, Inc.
LaCroix Precision Optics
Laser and Engineering Technologies Cluster
Laser Focus World
Laser Quantum, Inc.
Lattice Electro Optics, Inc.
Light Conversion, Ltd.
Lighthouse Photonics
Liquid Instruments
Lumentron
Luvantix ADM Co., Ltd.
M Squared Lasers Ltd.
McPherson Inc.
Menlo Systems
Mesa Photonics, LLC
Micro Photon Devices
Mindrum Precision, Inc.
MIRTHE + Photonics Sensing Center
MKS Instruments
MPS Micro Precision Systems AG
Nanjing Ninke Photoelectric Tech., Co., Ltd.
NANOGRASS
National Energetics
National Reconnaissance Office
Newport Corporation
Nikon Corporation
NKT Photonics
Northrop Grumman Cutting Edge Optronics, Inc.
NPI Lasers
NTT Electronics Corporation
NuCrypt LLC
Nuphoton Technologies Inc.
OEwaves, Inc.
Ophir
Optiforms
OptiGrate
Optimax Systems, Inc.
OptoSigma Corporation
Optronics Co., Ltd., The
OSA - The Optical Society
Osela, Inc.
Oxford University Press
Oxide Corporation
OZ Optics
PHASICS Corp.
Photodigm, Inc.
Photon Design
Photonics Media/Laurin Publishing
Photonix Edge, LLC
Photop Technologies, Inc
Physics Today
PI (Physik Instrumente) LP
PicoQuant
Princeton Scientific Corporation
PriTel, Inc.
Pure Photonics
Quantel
Quantum Design, Inc.
Quantum Opus
Raicol Crystals Ltd.
Resolved Instruments
Sacher Lasertechnik GmbH
Sandia National Laboratories
Santec USA Corporation
Seiwa Optical America, Inc.
Shasta Crystals
SHI Cryogenics Group
SILIOS Technologies S.A.
Siskiyou Corporation
SmarAct, Inc.
Solid Sealing Technology
Specialised Imaging
Spectra Quest Lab
Spectral Energies, LLC
Spectra-Physics
SPIE: The Intl Society for Optics and Photonics
Springer
Srico, Inc.
Stable Laser Systems
STANDA
Stanford Research Systems
StellarNet, Inc.
Swabian Instruments GmbH
Swamp Optics, LLC
Synopsys, Inc.
ThermoTek, Inc.
Thorlabs
Timbercon, Inc.
Toptica Photonics, Inc.
TRUMPF Inc.
University of Arizona, College of Optical Sciences
University of Campinas (UNICAMP)
Vescent Photonics, Inc.
Vigo Systems SA
Wasatch Photonics
YSL Photonics Co., Ltd.
Zaber Technologies
Zurich Instruments

All conference locations are in the San Jose Convention Center unless otherwise noted.

CLEO:EXPO Technology Playground

Using the game card placed in your attendee bag (obtained at Registration), stop by participating exhibitor booths to hear about their products and services. They'll stamp your card; and when you've met with all of them, you'll be entered into a daily drawing to win a $100 gift card.

Exhibitors Participating:
Calmar Laser
Edmund Optics
Gentec-EO USA, Inc.
KMLabs
MKS Newport Corporation
Optimax
Optosigma
OZ Optics
Sacher Lasertechnik GmbH
Thorlabs

Exhibit Hall Coffee Breaks

The exhibit floor is the perfect place to build and maintain professional contacts, and these breaks provide ideal networking opportunities. Complimentary coffee will be served at these times:

Tuesday, 15 May	10:00–11:30 and 15:00–17:00
Wednesday, 16 May	10:00–11:30 and 15:00–17:00
Thursday, 17 May	10:00–11:30

Sponsored by THORLABS

MKS Student Lounge

#1340

All student attendees are invited to the MKS Student Lounge, co-sponsored by OSA. The lounge provides an opportunity to relax and spend time networking with other students, while enjoying complimentary, wireless internet and refreshments.

Sponsored by mks

Co-sponsored by OSA The Optical Society | 100 Since 1916

OIDA VIP Industry Leaders Speed Meetings Lunch

Tuesday, 15 May, 12:00–13:30
#2605

This session brings together Industry Executives to share their business experience with Young Professionals, Recent Graduates and Students – how they started their careers, lessons learned and using their degree in an executive position. Informal networking during lunch is followed by a transition to "speed meetings" – brief, small-group visits with each executive to discuss industry trends or career topics.

If you have any questions about this event or are a Student or Recent Graduate and interested in attending, please email vipevents@osa.org

Sponsored by GoFoton

Plenary Speaker Meet-n-Greets

Theater I, #2433

Meet CLEO Plenary speakers, ask questions and network with your colleagues.

Tuesday, 15 May 10:15–10:45
Nader Engheta and Vasilis Ntziachristos

Wednesday, 16 May 10:15–10:45
John Mather, Jian-Wei Pan and Sara Seager

Free Lunch at the CLEO:EXPO

Tuesday and Wednesday, 16 & 17 May, 11:30–13:00
Thursday, 18 May, 12:30–14:00
Exhibit Hall

Grab some lunch and network with exhibitors to check out their innovative products and services that can help your organization.

Poster Sessions

Exhibit Hall

Poster Sessions are an integral part of the Technical program. Each author is provided with a board with eight-foot-high by four-foot-wide (243cm x121cm) of usable space on which to display the summary and results of his or her paper. Authors should remain in the vicinity of their presentation board for the duration of the sessions to answer questions from attendees. Authors may set up one hour prior to their assigned session must remove their poster one hour following the session. Authors may submit their poster PDF to cstech@osa.org for publication. New this year are the Dynamic e-Posters. This new presentation method combines the richness of multimedia content of oral presentations with the personalized one-on-one interaction of posters.

Tuesday, 15 May	11:30–13:00
Wednesday, 16 May	11:30–13:00
Thursday, 17 May	11:30–13:00

All conference locations are in the San Jose Convention Center unless otherwise noted.

KMLabs Lunch & Learn Event

Wednesday, 15 May, 12:00–13:30
VIP Industry Networking, #2605

Tabletop Laser Sources at Short Wavelengths Beyond the Ultraviolet—Implementation and Application

Speaker: Henry C. Kapteyn, *Kapteyn-Murnane Laboratories Inc. and Department of Physics, Univ. of Colorado Boulder*

The recent availability of commercial tabletop-scale lasers at wavelengths in the vacuum-UV to EUV to soft x-ray spectral regions (i.e. hn~5-500 eV) presents new opportunities for next-generation optical nanometrology as well as studies of fundamental processes in materials science, chemistry, and biology. In this talk, we will discuss the enabling high-harmonic generation technology, the characteristics of the light, its applications, and what it takes to put these sources to use in your lab.

Sponsored by KMLABS LEADING IN ULTRAFAST

Technology Transfer Program

Thursday, 17 May
Theater I, #2433

The Technology Transfer Program includes a Keynote presentation, a Technology Transfer Tutorial and a Pitch Panel. The Technology Transfer Tutorial provides attendees an opportunity to learn more about the licensing process: funding, entrepreneurship, technology transfer, and intellectual property. The Pitch Panel provides entrepreneurs an opportunity to showcase their technology, explain why it's valuable and discuss the next steps to commercialization.

10:15 – 10:45 Keynote Speaker:

Ruth Houbertz, *Multiphoton Optics GmbH, Germany*

10:45 – 11:30 Tech Transfer Tutorial

Presenters:

Hossin Abdeldayem, *NASA-Goddard Space Flight Center, USA*

Newton Frateschi, *INOVA - UNICAMP, Brazil*

Yuzuru Takashima, *Univ. of Arizona, USA*

11:30 – 13:00 Pitch Panel w/ Feedback from Panelists

Pitch Panelist:

Leslie Kimerling, *Double Helix, USA*

Presenters:

Kristan Corwin, *Kansas State Univ., Department of Physics, College of Arts and Sciences, USA*

Aykutlu Dana, *Nanoeye, Inc., USA*

Pouya Dianat, *Drexel University and Nanograss Solar LLC, USA*

Lu Lan, Boston *Univ., USA*

Visit www.cleoconference.org/techtransfer for complete information.

CLEO Committees

Applications & Technology

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CLEO A&T 1: Biomedical Applications

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CLEO A&T 2: Industrial Applications

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Michael Krainak, *NASA Goddard Space Flight Center, USA*
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Manyalibo Matthews, *LLNL, USA*
Dirk Mueller, *Coherent, USA*
Jie Qiao, *RIT, USA*

CLEO A&T 3: Laser-Based Instrumentation for Measurements and Monitoring

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Giorgio Brida, *INRIM, Italy*
Peter Fendel, *Thorlabs, USA*
Kara Peters, *North Carolina State Univ., USA*
Greg Rieker, *Univ. of Colorado, USA*
Brian Simonds, *NIST, USA*
Mike Thorpe, *Bridger Photonics Inc., USA*

CLEO A&T 4: Applications in Energy & Environment

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Mark Zondlo, *Princeton Univ., USA,* Subcommittee Chair
David Bomse, *Mesa Photonics, Inc. USA*
Bernhard Buccholz, *PTB, Germany*
David Canteli, *Universidad Politecnica de Madrid, Spain*
Amir Khan, *Delaware State Univ., USA*
Jan Nekarda, *Fraunhofer ISE, Germany*
Joel Silver, *Southwest Sciences, Inc., USA*

Fundamental Science

Zhigang Chen, *San Francisco State Univ., USA,* General Chair
Jeff Shapiro, *Massachusetts Institute of Technology, USA,* General Chair
Stewart Aitchison, *Univ. of Toronto, Canada,* Program Chair
Todd Pittman, *Univ. of Maryland Baltimore County, USA,* Program Chair

FS 1: Quantum Optics of Atoms, Molecules and Solids

Tracy Northup, *Universität Innsbruck, Austria,* Subcommittee Chair
Takao Aoki, *Waseda Univ., Japan*
Daniel Felinto Pires Barbosa, *Universidade Federal de Pernambuco, Brazil*
Adam Black, *US Naval Research Laboratory, USA*
Nathalie de Leon, *Princeton Univ., USA*
Hugues de Riedmatten, *ICFO -The Institute of Photonic Sciences, Spain*
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Virginia Lorenz, *Univ. of Illinois at Chicago, USA*
Andreas Muller, *Univ. of South Florida, USA*
Marina Radulaski, *Stanford Univ., USA*

FS 2: Quantum Science, Engineering and Technology

Joshua Bienfang, *National Institute of Standards and Technology, USA,* Subcommittee Chair
Konrad Banaszek, *Uniwersytet Warszawski, Poland*
Michael Brodsky, *U.S. Army Research Laboratory, USA*
Maria Chekhova, *Max-Planck-Institut für die Physik des Lichts, Germany*
John Howell, *Univ. of Rochester, USA*
Yoon-Ho Kim, *Pohang Univ. of Science & Technology, South Korea*
Olivier Pfister, *Univ. of Virginia, USA*
Raphael Pooser, *Oak Ridge National Laboratory, USA*
Kevin Resch, *Univ. of Waterloo, Canada*
John Sipe, *Univ. of Toronto, Canada*
Martin Stevens, *National Institute of Standards & Technology, USA*
Shigeki Takeuchi, *Kyoto Univ., Japan*
Philip Walther, *Universität Wien, Austria*

All conference locations are in the San Jose Convention Center unless otherwise noted.

FS 3: Metamaterials and Complex Media

Alexey Yamilov, *Missouri Univ. of Science and Technology, USA*, Subcommittee Chair
Viktoriia Babicheva, *Georgia State Univ., USA*
Igal Brener, *Sandia National Labs, USA*
Yaron Bromberg, *The Hebrew Univ., Israel*
Yidong Chong, *Nanyang Technological Univ., Singapore*
Xu Fang, *Univ. of Southampton, UK*
Liang Feng, *Univ. of Pennsylvania, USA*
Sylvain Gigan, *Laboratoire Kastler Brossel, France*
Zubin Jacob, *Purdue Univ., USA*
Boubacar Kante, *Univ. of California San Diego, USA*
Andrei Lavrinenko, *Danmarks Tekniske Universitet, Denmark*
Junsuk Rho, *POSTECH, South Korea*
Ekatarina Shamonina, *Univ. of Oxford, UK*

FS 4: Optical Excitations and Ultrafast Phenomena in Condensed Matter

Keshav Dani, *Okinawa Institute of Science and Technology, Japan*, Subcommittee Chair
Elbert Chia, *Nanyang Technological Univ., Singapore*
Hui Deng, *Univ. of Michigan, USA*
Mackillo Kira, Univ. of Michigan, *USA*
Chih-Wei Lai, *US Army Research Laboratory, USA*
Xiaoqin Li, *Univ. of Texas at Austin, USA*
Kaihui Liu, *Peking Univ., China*
Noa Marom, *Carnegie Mellon Univ., USA*
Ilias Perakis, *Univ. of Alabama at Birmingham, USA*
Denis Seletskiy, *Univ. of Konstanz, Germany*
Mark Sherwin, *Univ. of California Santa Barbara, USA*
Diyar Talbayev, *Tulane Univ., USA*
Jerome Tignon, *CNRS - Laboratoire Pierre Aigrain, France*
Lyubov Titova, *Univ. of Alberta, USA*
Ulrike Woggon, *Technische Universität Berlin, Germany*

FS 5: Nonlinear Optics and Novel Phenomena

Mercedeh Khajavikhan, *CREOL, Univ. of Central Florida, USA*, Subcommittee Chair
Tal Carmon, *Technion Israel Institute of Technology, Israel*
Demetrios Christodoulides, *Univ. of Central Florida, USA*
Scott Diddams, *National Institute of Standards & Technology, USA*
Sara Ducci, *Université Paris Diderot, France*
Arash Mafi, *Univ. of New Mexico, USA*
Konstantinos Makris, *Univ. of Crete, Greece*
David Moss, *Swinburne Univ. of Technology, Australia*
Peter Rakich, *Yale Univ., USA*
Mikael Rechtsman, *Pennsylvania State Univ., USA*

FS 6: Nano-Optics and Plasmonics

Amit Agrawal, *National Institute of Standards and Technology, USA*, Subcommittee Chair
Andrea Baldi, *Dutch Institute for Fundamental Energy Research, Netherlands*
Palash Bharadwaj, *Rice Univ., USA*
Peter Catrysse, *Stanford Univ., USA*
Andrea Di Falco, *SUPA, Univ. of St Andrews, UK*
Monika Fleischer, *Universität Tübingen, Germany*
Hayk Harutyunyan, *Emory Univ., USA*
Ido Kaminer, *Technion Israel Institute of Technology, Israel*
Mo Mojahedi, *Univ. of Toronto, Canada*
Esther Wertz, *Rensselaer Polytechnic Institute, USA*
Wei Zhou, *Virginia Tech, USA*
Rashid Zia, *Brown Univ., USA*

FS 7: High-Field Physics and Attoscience

Michael Chini, *Univ. of Central Florida, USA*, Subcommittee Chair
Luca Argenti, *Univ. of Central Florida, USA*
Jens Biegert, *ICFO - The Institute of Photonic Sciences, Spain*
Francesca Calegari, *DESY, Hamburg, Italy*
Oren Cohen, *Technion Israel Institute of Technology, Israel*
Matthias Fuchs, *Univ. of Nebraska Lincoln, USA*
Shambhu Ghimire, *SLAC/Stanford Univ., USA*
Nobuhisa Ishii, *Institute for Solid State Physics, Japan*
Julia Mikhailova, *Princeton Univ., USA*
Arvinder Sandhu, *The Univ. of Arizona, USA*
Olga Smirnova, *Max Born Institute, Germany*
Xiaoming Wang, *Washington State Univ., USA*
Amelle Zaïr, *Kings College London, UK*

Science & Innovations

Nathan Newbury, *National Institute of Standards & Technology, USA*, General Chair
Jessie Rosenberg, *International Business Machines Corp., USA*, General Chair
Amr S. Helmy, *Univ. of Toronto, Canada*, Program Chair
Shinji Yamashita, *Univ. of Tokyo*, *Japan*, Program Chair

CLEO S&I 1: Light-Matter Interactions and Materials Processing

Tsing-Hua Her, *Univ. of North Carolina at Charlotte, USA*, Subcommittee Chair
Feng Chen, *Shandong Univ., China*
Ya Cheng, *Shanghai Institute of Optics and Fine Mechanics, China*
James Fitz-Gerald, *Univ. of Virginia, USA*
Carl Liebig, *Air Force Research Laboratory, USA*
Chih Wei Luo, *National Chiao Tung Univ., Taiwan*
Renee Sher, *Wesleyan Univ., USA*
Javier Solis, *Instituto de Óptica "Daza de Valdés," Spain*
Zijie Yan, *Clarkson Univ., USA*

CLEO S&I 2: Advanced Science and Technology for Laser Systems and Facilities

Jake Bromage, *Univ. of Rochester, USA*, Subcommittee Chair
M J Daniel Esser *Heriot-Watt Univ., UK*
Erhard Gaul, *Univ. of Texas at Austin, USA*
Max Lederer, *European XFEL, Germany*
Seong Ku Lee, *CoREeLS IBS-GIST, South Korea*
Xiaoyan Liang, *Shanghai Institute of Optics & Fine Mechanics, China*
Thomas Metzger, *TRUMPF Scientific Lasers GmbH + Co. KG, Germany*
Dimitrios Papadopoulos, *LULI, France*
Brendan Reagan, *Colorado State Univ., USA*
Clara Saraceno, *Ruhr Universität Bochum, Germany*
David Spence, *Macquarie Univ., Australia*
Thomas Spinka, *Lawrence Livermore National Laboratory, USA*

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CLEO S&I 3: Semiconductor Lasers
Mikhail Belkin, *Univ. of Texas at Austin, USA,* Subcommittee Chair
Chadwick Canedy, NRL, USA
Connie Chang, *UC Berkeley, USA*
Lan Fu, *Australian National Univ., Australia*
Nicolas Grandjean, *EPFL, Switzerland*
Qing Gu, *UT Dallas USA*
Peter Heim, *Thorlabs Quantum Electronics, USA*
Ted Masselink, *Humboldt Univ. of Berlin, Germany*
Nobuhiko Nishiyama, T*okyo Institute of Technology, Japan*
Boon Siew Ooi, *KAUST, Saudi Arabia*
Leon Shterengas, *SUNY - Stony Brook, USA*
Gottfried Strasser, *TU Vienna, Austria*
Qijie Wang, *Nanyang Technological Univ., Singapore*
Hongping Zhao, *Case Western Reserve Univ., USA*

CLEO S&I 4: Nonlinear Optical Technologies
Michelle Y. Sander, *Boston Univeristy, USA,* Subcommittee Chair
Amol Choudhary, *Univ. of Sydney, Australia*
Katia Gallo, *KTH Royal Institute of Technology, Sweden*
Shu-Wei Huang, *UCLA Engineering IV, USA*
Yoshitomo Okawachi, *Columbia Univ., USA*
Kartik Srinivasan, *National Inst of Standards & Technology, USA*
Markku Vainio, *Univ. of Helsinki, Finland*
Sergey Vasilyev, *IPG Photonics Corp., Mid-IR Lasers, USA*

CLEO S&I 5: Terahertz Science and Technologies
Matthias Hoffmann, *SLAC National Accelerator Laboratory, USA,* Subcommittee Chair
Tyler Cocker, *Universität Regensburg, Germany*
Martin Koch, *Philipps-Universität Marburg, Germany*
Juliette Mangeney, *École normale supérieure, France*
Daniel Mittleman, *Brown Univ., USA*
Tadao Nagatsuma, *Osaka Univ., Japan*
Rohit Prasankumar, *Los Alamos National Laboratory, USA*
Masayoshi Tonouchi, *Osaka Univ., Japan*
Miriam Vitiello, *Scuola Normale Superiore di Pisa, Italy*
Stephan Winnerl, *Forschungszentrum Dresden-Rossendorf, Germany*

CLEO S&I 6: Optical Materials, Fabrication and Characterization
Thomas Murphy, *Univ. of Maryland at College Park, USA*, Subcommittee Chair
Guang-Hua Duan, *Alcatel-Thales III-V Laboratory, France*
Matthew Escarra, *Tulane Univ., USA*
Frederic Gardes, *Univ. of Southampton, UK*
Juejun Hu, *Massachusetts Institute of Technology, USA*
Eiichi Kuramochi, *NTT Corporation, Japan*
Robert Norwood, *The Univ. of Arizona, USA*
Roberto Paiella, *Boston Univ., USA*
Zhipei Sun, *Aalto Yliopisto, Finland*
Frank (Fengqiu) Wang, *Nanjing Univ., China*

CLEO S&I 7: Micro- and Nano-Photonic Devices
Takasumi Tanabe, *Keio Univ., Japan,* Subcommittee Chair
Ali Adibi, *Georgia Institute of Technology, USA*
Vladimir Aksyuk, *National Institute of Standards & Technology, USA*
Paul Barclay, *Univ. of Calgary, Canada*
Daryl Beggs, *Cardiff Univ., UK*
Alfredo De Rossi, *Thales Research & Technology, France*
Dirk Englund, *Massachusetts Institute of Technology, USA*
Karen Grutter, *Univ. Technical Services, Inc., USA*
Zhihong Huang, *Hewlett Packard Laboratories, USA*
Wei Jiang, *Rutgers Univ., USA*
Jin Liu, *Sun Yat-Sen Univ., China*
Nobuyuki Matsuda, *NTT Basic Research Laboratories, Japan*
Jeremy Munday, *Univ. of Maryland at College Park, USA*
Sharon Weiss, *Vanderbilt Univ., USA*
Lan Yang, *Washington Univ. in St Louis, USA*

CLEO S&I 8: Ultrafast Optics, Optoelectronics & Applications
Christophe Dorrer, *Univ. of Rochester, USA,* Subcommittee Chair
Jose Azana, *INRS-Énergie, Matériaux et Télécommunications, Canada*
Alan Fry, *SLAC National Accelerator Laboratory, USA*
Igor Jovanovic, *Univ. of Michigan, USA*
Fumihiko Kannari, *Keio Univ., Japan*
Thomas Planchon, *Delaware State Univ., USA*
Liejia Qian, *Shanghai Jiao Tong Univ., China*
Bojan Resan, *Univ. of Applied Sciences, Switzerland*
Lawrence Shah, *Luminar Technologies, USA*
Catherine Teisset, *TRUMPF Scientific Lasers, Germany*
Andreas Vaupel, *IPG Photonics Corp, USA*
Laszlo Veisz, *Umea Univ., Sweden*
Tobias Witting, *Max-Born-Institut, Germany*

CLEO S&I 9: Components, Integration, Interconnects and Signal Processing
Weidong Zhou, *Univ. of Texas at Arlington, USA,* Subcommittee Chair
Sasan Fathpour, *CREOL, Univ. of Central Florida, USA*
Qiaoqiang Gan, *State Univ. of New York at Buffalo, USA*
Zetian Mi, *Univ. of Michigan, Ann Arbor, USA*
Richard Penty, *Univ. of Cambridge, UK*
Haisheng Rong, *Intel Corporation, USA*
Jian Wang, *Huazhong Univ. of Science and Technology, China*
Winnie Ye, *Carleton Univ., Canada*

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CLEO S&I 10: Biophotonics and Optofluidics

Andreu Llobera, *Carl Zeiss Vision GmbH, Germany,* Subcommittee Chair
Hatice Altug, *Ecole Polytechnique Federale de Lausanne, Switzerland*
Michelle Digman, *Univ. of California, Irvine, USA*
Emily Gibson, *Univ. of Colorado Boulder, USA*
Ewa Goldys, *Macquarie Univ., Australia*
Aaron Hawkins, *Brigham Young Univ., USA*
Jessica Houston, *New Mexico State Univ., USA*
Rainer Andreas Leitgeb, *Medical Univ. Vienna, Austria*
Ute Neugebauer, *Center for Sepsis Control and Care Jena, Germany*
Maria Ramos-Payan, *Instituto de Microelectronica de Barcelo, Spain*
Katarina Svanberg, *Lund Laser Centre, Sweden*

CLEO S&I 11: Fiber Photonics

Sze Yun Set, *Univ. of Tokyo, Japan,* Subcommittee Chair
Kazi Abedin, *OFS Laboratories, USA*
Shaif-Ul Alam, *Univ. of Southampton, UK*
Camille-Sophie Bres, *École polytechnique fédérale de Lausanne, Switzerland*
Neil Broderick, *Univ. of Auckland, New Zealand*
Gregory Cowle, *Lumentum, USA*
Liang Dong, *Clemson Univ., USA*
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Khanh Kieu, *The Univ. of Arizona, USA*
William Renninger, *Yale Univ., USA*
Masaki Tokurakawa, *Univ. of Electro-communications, ILS, Japan*
Kenneth Kin-Yip Wong, *Univ. of Hong Kong, Hong Kong*
Meng Zhang, *Beihang Univ., China*

CLEO S&I 12: Lightwave Communications and Optical Networks

David Geisler, *Massachusetts Institute of Technology Lincoln Lab, USA* , Subcommittee Chair
Anjali Agarwal, *Vencore Labs, USA*
Xi Chen, *Nokia Bell Labs, USA*
Francesco Da Ros, *Technical Univ. Of Denmark, Denmark*
Marija Furdek, *KTH Royal Institute of Technology, Sweden*
Vladimir Grigoryan, *Ciena Corporation, USA*
Yue-Kai Huang, *NEC Laboratories America Inc, USA*
Masayuki Matsumoto, *Wakayama Univ., Japan*
Ryan Scott, *Keysight Technologies, Inc, USA*
Yikai Su, *Shanghai Jiao Tong Univ., China*
Stylianos Sygletos, *Aston Univ., UK*

CLEO S&I 13: Active Optical Sensing

Todd Stievater, *US Naval Research Laboratory, USA,* Subcommittee Chair
Brian Brumfield, *Pacific Northwest National Laboratory, USA*
Adam Fleisher, *National Institute of Standards & Technology, USA*
Jason Guicheteau, *USA RDECOM ECBC, USA*
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Michal Nikodem, *Wroclaw Research Centre EIT+, Poland*
Ian White, *Univ. of Maryland at College Park, USA*
Michael Wojcik, *Space Dynamics Laboratory, USA*

CLEO S&I 14: Optical Metrology

Ian Coddington, *National Institute of Standards & Technology, USA,* Subcommittee Chair
E. Anne Curtis, *National Physical Laboratory, UK*
Tara Fortier, *National Institute of Standards & Technology, USA*
Jungwon Kim, *Korea Advanced Institute of Science & Technology, South Korea*
Nathan Lemke, *Air Force Research Laboratory, USA*
Marco Marangoni, *Politecnico di Milano, Italy*
Mark Notcutt, *Stable Laser Systems, USA*
Laura Sinclair, *National Institute of Standards & Technology, USA*
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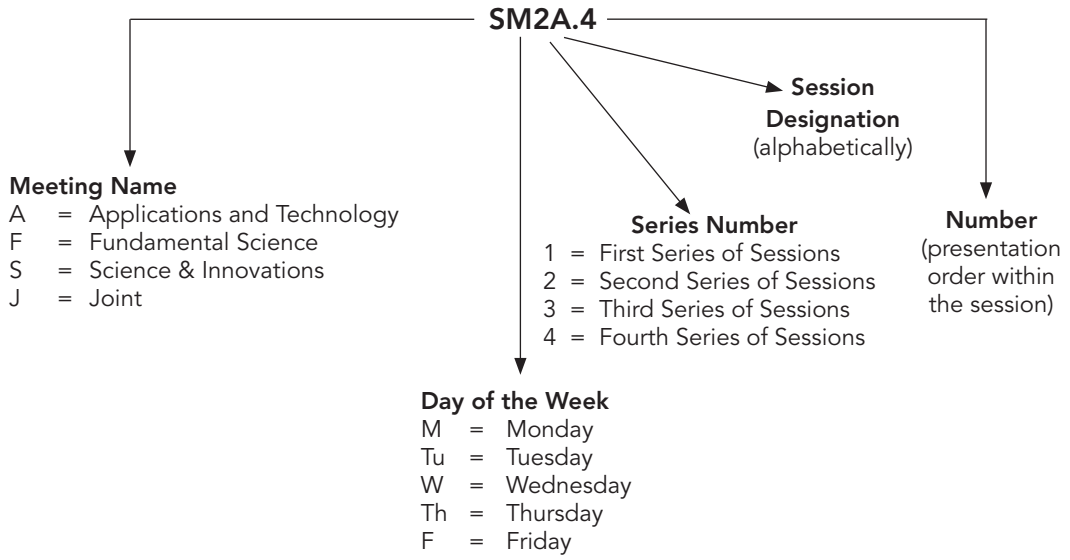
Explanation of Session/Presentation Codes



The first letter of the code designates the meeting (For instance, A=Applications & Technology, F=Fundamental Science, S=Science and Innovations, J=Joint). The second element denotes the day of the week (Monday=M, Tuesday=Tu, Wednesday=W, Thursday=Th, Friday=F). The third element indicates the session series in that day (for instance, 2 would denote the second parallel sessions in that day). Each series of sessions begins with the letter A in the fourth element and continues alphabetically through a series of parallel sessions. The number on the end of the code (separated from the session code with a period) signals the position of the talk within the session (first, second, third, etc.). For example, a presentation coded SM2A.4 indicates that this paper is part of Science and Innovations (S) and is being presented on Monday (M) in the second series of sessions (2), and is the first parallel session (A) in that series and the fourth paper (4) presented in that session.

Agenda of Sessions — Sunday, 13 May

07:00–17:00	**Registration,** *Concourse Level*
08:30–17:00	**OSAF Data Science Career Opportunities Course,** *Market 1, Hilton San Jose*
08:30–12:30	**SC149: Foundations of Nonlinear Optics** **SC361: Coherent MidInfrared Sources and Applications** **SC466: Silicon Integrated Nanophotonics**
08:30–15:00	**SC456: How to Start A Company**
13:00-14:00	**OSAF Cheeky Scientist Career Development Workshop (Session I),** *Winchester 1&2, Hilton San Jose*
13:30–16:30	**SC439: Attosecond Optics** **SC403: NanoCavity Quantum Electrodynamics and Applications**
13:30–17:30	**SC157: Laser Beam Analysis, Propagation, and Shaping Techniques** **SC301: Quantum Cascade Lasers: Science, Technology, Applications and Markets** **SC396: Frontiers of Guided Wave Nonlinear Optics**
16:00-17:00	**OSAF Cheeky Scientist Workshop (Session II),** *Winchester 1&2, Hilton San Jose*

Agenda of Sessions — Monday, 14 May

	Executive Ballroom 210A	Executive Ballroom 210B	Executive Ballroom 210C	Executive Ballroom 210D	Executive Ballroom 210E	Executive Ballroom 210F	Executive Ballroom 210G	Executive Ballroom 210H	Meeting Room 211 B/D
07:00–18:00	**Registration,** *Concourse Level*								
08:00–10:00	JM1A • Symposium on Future Directions in Terahertz Nanoscopy I	SM1B • Nonlinear and Microwave Integrated Photonics	SM1C • RF Photonic & Radio-over-fiber	SM1D • Nonlinear Resonators	FM1E • Topological Optics	FM1F • Highly Correlated and Topological States of Matter	FM1G • Quantum Photonic Devices	FM1H • Solid State Spin-Photon Interfaces	SM1I • Modulator on Integrated Platform
08:30–18:00	**OIDA Executive Forum on the Exploding Role of Optics in Sensing,** *Almaden Ballroom, Hilton San Jose*								
10:00–10:30	**Coffee Break,** *Concourse Level*								
10:30–12:30	JM2A • Symposium on Future Directions in Terahertz Nanoscopy II	SM2B • Novel Nanophotonic Structures and Devices	SM2C • Short Reach Communication	SM2D • Nonlinear Optical Phenomena	FM2E • Topological Photonics and Lasers	FM2F • Exciton-polaritons and Other Excitation in Semiconductions	FM2G • Novel Nonophotonic Light Sources	FM2H • Quantum Optics with Single Atoms	SM2I • Integrated Detectors
12:00–13:00	**OSA Optical Material Studies Technical Group Special Talk,** *Room 230A*								
12:30–13:30	**Lunch Break** *(on your own)*								
12:30–15:30	**SC362: Cavity Optomechanics: Fundamentals and Applications of Controlling and Measuring Nano- and Micro-mechanical Oscillators with Laser Light**								
12:30–16:30	**SC455: Integrated Photonics for Quantum Information Science and Technology** **SC378: Introduction to Ultrafast Optics**								
13:00–14:00	**Social Media 102,** *Market Room 1, Hilton San Jose*								
13:30–15:30	SM3A • Terahertz Nonlinear Spectroscopy	SM3B • Optical Modulators	SM3C • SDM Communications I	SM3D • Nonlinear Optics in Fibers and Waveguides	FM3E • Symmetries in Optics	FM3F • High Harmonic Generation in Solids	FM3G • Quantum Sources I	FM3H • Chiral and Topological Quantum Optics	SM3I • Optical Phase Arrays
14:00–15:30	**Workshop: Understanding Unconscious Bias,** *Winchester 1&2, Hilton San Jose*								
15:30–16:00	**Coffee Break,** *Concourse Level*								
16:00–18:00	SM4A • THz High-field Generation and Detection	SM4B • Microrings and Novel Modulation Schemes	SM4C • SDM Communication II	SM4D • Optical Meteorology Nonlinear Optical Technologies	FM4E • PT-Symmetry and Non-Hermitian Photonics	FM4F • Probing Materials with Ultrafast Electricity and Extreme Light	FM4G • Quantum Sources II	FM4H • Quantum Optics with Atomic and Molecular Ensembles	SM4I • Novel Emitters
16:00–17:30	**Workshop: Understanding Unconscious Bias,** *Winchester 1&2, Hilton San Jose*								
17:30–18:30	**Diversity & Inclusion in Optics and Photonics Reception,** *Market 1&2, Hilton San Jose*								
19:00–20:30	**OSA Nonophotonics Technical Group 20x20 Talks,** *Room 230A*								

Meeting Room 212 A/C	Meeting Room 212 B/D	Marriott, Salon I & II	Marriott, Salon III	Marriott, Salon IV	Marriott, Salon V	Marriott, Salon VI	Marriott, Willow Glen
Registration, *Concourse Level*							
AM1J • Advanced Microscopy and Imaging Techniques	SM1K • Raman Scattering and Applications	SM1L • Precision Clocks and Time Transfer	AM1M • Laser-based Advanced Manufacturing & Materials Processing	SM1N • Advanced Laser Technologies	SM1O • Fundamentals of Light-matter Interaction	AM1P • A&T Topical Review on Photonics-enabled Quantum Technologies in Transition I	FM1Q • Optical Filamentation and X-rays
OIDA Executive Forum on the Exploding Role of Optics in Sensing, *Almaden Ballroom, Hilton San Jose*							
Coffee Break, *Concourse Level*							
AM2J • Biomedical Imaging	SM2K • Fiber Sensing and Measurement	SM2L • Optical Microwave Generation	AM2M • Material Processing Lasers and Sensing Technologies	SM2N • Fiber and Wave Guide Lasers	SM2O • Light Matter Interaction in Plasmonic & Metameterials	AM2P • A&T Topical Review on Photonics-enabled Quantum Technologies in Transition II	FM2Q • Non-Hermitian and PT Photonics
OSA Optical Material Studies Technical Group Special Talk, *Room 230A*							
Lunch Break *(on your own)*							
SC362: Cavity Optomechanics: Fundamentals and Applications of Controlling and Measuring Nano- and Micro-mechanical Oscillators with Laser Light							
SC455: Integrated Photonics for Quantum Information Science and Technology **SC378: Introduction to Ultrafast Optics**							
Social Media 102, *Market Room 1, Hilton San Jose*							
FM3J • Imaging and Cloaking in Metamaterials	SM3K • Billouim Scattering and Applications	SM3L • Photonic Frequency References and Sources	FM3M • Sources and Technology for Attosecond and High-field Physics	SM3N • High Power Lasers	SM3O • Fundamentals of Laser Material Processing	AM3P • Photo-biomodulation Therapeutics	FM3Q • Topological Photonic Structure
Workshop: Understanding Unconscious Bias, *Winchester 1&2, Hilton San Jose*							
Coffee Break, *Concourse Level*							
FM4J • Fundamentals of Metamaterials	SM4K • Nonlinear Fiber Optics	SM4L • Frequency Comb Development &Technology	SM4M • Power Scaling of Ultrafast Sources	SM4N • Laser Materials	SM4O • Structured Light for Material Processing	AM4P • Biosensing Technologies	FM4Q • Valley-Hall and Active Toplogical Photonics
Workshop: Understanding Unconscious Bias, *Winchester 1&2, Hilton San Jose*							
Diversity & Inclusion in Optics and Photonics Reception, *Market 1&2, Hilton San Jose*							
OSA Nonophotonics Technical Group 20x20 Talks, *Room 230A*							

Agenda of Sessions — Tuesday, 15 May

	Executive Ballroom 210A	Executive Ballroom 210B	Executive Ballroom 210C	Executive Ballroom 210D	Executive Ballroom 210E	Executive Ballroom 210F	Executive Ballroom 210G	Executive Ballroom 210H	Meeting Room 211 B/D
07:00–18:30	**Registration,** *Concourse Level*								
08:00–10:00	**JTu1A • Plenary Session I & Awards Ceremony,** *Grand Ballroom*								
10:00–17:00	**Exhibition Open,** *Exhibit Hall*								
10:00–11:30	**Coffee Break & Exhibit Only Time,** *Exhibit Hall*								
11:30–13:00	**JTu2A • Poster Session I,** *Exhibit Hall* **Exhibit Hall Free Lunch**								
12:00–13:30	**OIDA VIP Industry Leaders Speed Meetings Lunch,** *Exhibit Hall, #2605*								
12:00–15:00	**SC352: Introduction to Ultrafast Pulse Shaping--Principles and Applications** **SC376: Plasmonics** **SC410: Finite Element Modeling Methods for Photonics and Optics**								
12:00–16:00	**SC270: High Power Fiber Lasers and Amplifiers** **SC438: Photonic Metamaterials**								
13:00–15:00	**STu3A • Quantum Photonic Technology**	**STu3B • OAM and Photodetective**	**STu3C • Advanced Short Reach and Free Space Communications**	**STu3D • Terahertz Communications**	**FTu3E • Thermal and Quantum Applications of Metasurfaces**	**STu3F • Nonlinear Integrated Photonic Platforms**	**FTu3G • Quantum Key Distribution**	**FTu3H • Quantum Optics with Solid-state Single Emitters**	**ATu3I • OCT and LIDAR**
15:00–17:00	**Coffee Break & Exhibit Only Time,** *Exhibit Hall*								
15:30–17:00	**Meet the OSA Editors Reception,** *Exhibit Hall, #2425*								
17:00–19:00	**FTu4A • Quantum Information Processing**	**STu4B • Wavelength and Phase-sensitive Integrated Devices**	**STu4C • Nonlinearity Compensation**	**STu4D • Terahertz QCLs**	**FTu4E • Quantum and Non-local Plasmonics**	**STu4F • Nonlinear Optical Phononics & Optomechanics**	**FTu4G • Continuous Variable Quantum Computing**	**FTu4H • Novel Solid State Systems for Quantum Optics**	**ATu4I • Combustion and Hypersonic Flow Diagnostics**
19:00–20:30	**OSA Technical Group Poster Session,** *230A/B*								

Meeting Room 212 A/C	Meeting Room 212 B/D	Marriott, Salon I & II	Marriott, Salon III	Marriott, Salon IV	Marriott, Salon V	Marriott, Salon VI	Marriott, Willow Glen	Theatre I	Theatre II
Registration, *Concourse Level*									
JTu1A • Plenary Session I & Awards Ceremony, *Grand Ballroom*									
Exhibition Open, *Exhibit Hall*									
Coffee Break & Exhibit Only Time, *Exhibit Hall*									
JTu2A • Poster Session I, *Exhibit Hall* **Exhibit Hall Free Lunch**									
OIDA VIP Industry Leaders Speed Meetings Lunch, *Exhibit Hall, #2605*									
SC352: Introduction to Ultrafast Pulse Shaping--Principles and Applications **SC376: Plasmonics** **SC410: Finite Element Modeling Methods for Photonics and Optics**									
SC270: High Power Fiber Lasers and Amplifiers **SC438: Photonic Metamaterials**									
ATu3J • Nano-biophotonics	**STu3K • Novel Fibers**	**JTu3L • Symposium on Multimodal and Molecular Contrast Optical Imaging I**	**STu3M • High Peak Power Lasers & Technologies**	**STu3N • Chemical Sensing**	**JTu3O • Laser Modification of Materials**	**STu3P • Precision Spectroscopy**	**STu3Q • Advances in VCSELs**	**ATu3R • A&T Topical Review on Advanced Applications of Laser Radar and Remote Sensing I**	**ATu3S • A&T Topical Review on Advances in Supercon-tinuum Technologies I**
Coffee Break & Exhibit Only Time, *Exhibit Hall*									
Meet the OSA Editors Reception, *Exhibit Hall, #2425*									
ATu4J • Medical Devices & Systems	**STu4K • Fiber Frequency Combs**	**JTu4L • Symposium on Multimodal and Molecular Contrast Optical Imaging II**	**ATu4M • Thin Film & Metrology for Laser Processing**	**STu4N • 2D Materials in Photonic Structures**	**STu4O • Laser Facilities**	**STu4P • Advanced Sensing Concepts**	**STu4Q • UV-visible Semiconduc-tor Lasers**		
OSA Technical Group Poster Session, *230A/B*									

Agenda of Sessions — Wednesday, 16 May

	Executive Ballroom 210A	Executive Ballroom 210B	Executive Ballroom 210C	Executive Ballroom 210D	Executive Ballroom 210E	Executive Ballroom 210F	Executive Ballroom 210G	Executive Ballroom 210H	Meeting Room 211 B/D
07:30–18:30	**Registration,** *Concourse Level*								
08:00–10:00	**JW1A • Plenary Session II & International Day of Light,** *Grand Ballroom*								
10:00–17:00	**Exhibition Open,** *Exhibit Hall*								
10:00–11:30	**Coffee Break & Exhibit Only Time,** *Exhibit Hall*								
11:30–13:00	**JW2A • Poster Session II,** *Exhibit Hall* **Exhibit Hall Free Lunch**								
12:00–13:00	**OSA Photonic Metamaterials Technical Group Tutorial on Metasurface Design and Simulation,** *Room 230A*								
13:00–15:00	**SW3A • Microresonator Combs**	**SW3B • Hybrid Lasers on Silicon**	**SW3C • High Capacity Transmission**	**SW3D • Terahertz Nano-imaging and Spectroscopy**	**FW3E • Frequency Combs & Precision Metrology**	**FW3F • Single-Photon Detectors**	**FW3G • Nonlinear Nano-optics**	**FW3H • Active and Tunable Metasurfaces**	**SW3I • Low-dimensional and Phase-change Materials**
15:00–17:00	**Coffee Break & Exhibit Only Time,** *Exhibit Hall*								
17:00–19:00	**SW4A • High-Q Microcavities**	**SW4B • Nitride-based Integrated Photonics**	**SW4C • Optical Switching**	**SW4D • Novel THz Techniques**	**FW4E • Quantum and Nonlinear Phenomena**	**FW4F • Beyond Qubits**	**FW4G • Plasmon-medicated Control of Light Emission**	**FW4H • Shaping Emission Using Metasurfaces**	**SW4I • Silicon Hybrid Integration**
19:30–20:30	**Conference Reception,** *Grand Ballroom*								

Meeting Room 212 A/C	Meeting Room 212 B/D	Marriott, Salon I & II	Marriott, Salon III	Marriott, Salon IV	Marriott, Salon V	Marriott, Salon VI	Marriott, Willow Glen	Theatre I	Theatre II
Registration, *Concourse Level*									
JW1A • Plenary Session II & International Day of Light, *Grand Ballroom*									
Exhibition Open, *Exhibit Hall*									
Coffee Break & Exhibit Only Time, *Exhibit Hall*									
JW2A • Poster Session II, *Exhibit Hall* **Exhibit Hall Free Lunch**									
OSA Photonic Metamaterials Technical Group Tutorial on Metasurface Design and Simulation, *Room 230A*									
SW3J • Biosensors & Photonic Devices	SW3K • Few Mode Fibers and OAM	SW3L • Fiber and Waveguide Sensing	SW3M • Beam Control & Measurement	SW3N • Few-cycle Sources	AW3O • Optical Enhancement of Photovoltaics	JW3P • Symposium on New Advances in Adaptive Optics Retinal Imaging I	SW3Q • Semiconductor Lasers for Integration	AW3R • A&T Topical Review on Advanced Applications of Laser Radar and Remote Sensing II	AW3S • A&T Topical Review on Advances in Supercontinuum Technologies II
Coffee Break & Exhibit Only Time, *Exhibit Hall*									
SW4J • Advanced Microscopy Methods	SW4K • Fiber Lasers and Amplifiers	SW4L • NIR Dual Combs	SW4M • Application of Microresonator Frequency Combs	SW4N • Ultrafast Phenomena	AW4O • Novel Laser Charaterization	JW4P • Symposium on New Advances in Adaptive Optics Retinal Imaging II	SW4Q • Novel Semiconductor Emitters		
Conference Reception, *Grand Ballroom*									

Agenda of Sessions — Thursday, 17 May

	Executive Ballroom 210A	Executive Ballroom 210B	Executive Ballroom 210C	Executive Ballroom 210D	Executive Ballroom 210E	Executive Ballroom 210F	Executive Ballroom 210G	Executive Ballroom 210H
07:30–18:00	**Registration,** *Concourse Level*							
08:00–10:00	**STh1A • Novel Structures and Devices**	**STh1B • Integrated Photonic Sensors**	**STh1C • Machine Learning for Communication**	**FTh1D • Nonlinear Metamaterials and Metasurfaces**	**FTh1E • Nonlinear Optics in Microresonator Systems**	**FTh1F • Novel Phenomena in van der Waals Heterostructure**	**FTh1G • Integrated Quantum Sources**	**FTh1H • Quantum Interference, Imaging and Spectroscopy**
10:00–15:00	**Exhibition Open,** *Exhibit Hall*							
10:15–13:00	**Technology Transfer Program,** *Exhibit Hall Theater*							
10:00–11:30	**Coffee Break & Exhibit Only Time,** *Exhibit Hall*							
11:30–13:00	**JTh2A • Poster Session III,** *Exhibit Hall*							
12:30–14:00	**Exhibit Hall Free Lunch**							
14:00–16:00	**STh3A • Photonic Crystals**	**STh3B • Networks on a Chip**	**JTh3C • Symposium on Integrated Sources of Non-Classical Light: Perspectives and Challenges I**	**JTh3D • Symposium on Advances in Integrated Microwave Photonics I**	**FTh3E • Non-diffracting and Vortex Beams**	**STh3F • Mid-IR Nonlinear Devices**	**STh3G • Quantum Information Processing on Photonic Nanostructures**	**ATh3H • Control of Quantum Optical and Opto-mechanical Systems**
16:00–16:30	**Coffee Break,** *Concourse Lobby*							
16:30–18:30	**STh4A • Waveguide Structures**	**STh4B • On-chip and Offchip Coupling Schemes**	**JTh4C • Symposium on Integrated Sources of Non-Classical Light: Perspectives and Challenges II**	**JTh4D • Symposium on Advances in Integrated Microwave Photonics II**	**FTh4E • Multimode Nonlinear Fiber Optics**	**STh4F • Optical Parametric Oscillators**	**FTh4G • Cats and Kets**	**FTh4H • Nanophotonic Emitters, Detectors and Modulators**
18:30–20:00	**Dinner Break** *(on your own)*							
18:30–20:00	**Emerging Trends in Nonlinear Optics – A Review of CLEO: 2018**							
20:00–22:00	**Postdeadline Paper Sessions,** *Location TBD*							

Meeting Room 211 B/D	Meeting Room 212 A/C	Meeting Room 212 B/D	Marriott, Salon I & II	Marriott, Salon III	Marriott, Salon IV	Marriott, Salon V	Marriott, Salon VI	Marriott, Willow Glen
Registration, *Concourse Level*								
STh1I • Novel Fabrication Methods	STh1J • OCT & Biomedical Imaging	FTh1K • Optical Near-field and Thermal Imaging	STh1L • MIR to the THz Dual Combs	FTh1M • Nonlinear Dynamics in Resonators and Fibers	STh1N • Ultrafast Applications	ATh1O • Trace Gas Detection	FTh1P • Engineering and Metrology of Thermal Radiation	ATh1Q • A&T Topical Review on Neurophotonics I
Exhibition Open, *Exhibit Hall*								
Technology Transfer Program, *Exhibit Hall Theater*								
Coffee Break & Exhibit Only Time, *Exhibit Hall*								
JTh2A • Poster Session III, *Exhibit Hall*								
Exhibit Hall Free Lunch								
STh3I • Integrated Photonic Platforms	STh3J • Optofluidics & High Throughput Florescence	STh3K • Multimode Fiber Optics	STh3L • Imaging and Ranging	FTh3M • Chirality Vortices and Topological Effects	STh3N • Ultrafast Metrology I	ATh3O • Novel Spectroscopic Approaches I	ATh3P • Sensing in Extreme Environments & Organic Optical Materials	ATh3Q • A&T Topical Review on Neurophotonics II
Coffee Break, *Concourse Lobby*								
STh4I • Mid-IR Optoelectronics	FTh4J • Random and Alternative Materials Metasurfaces	STh4K • Long Wavelength Fiber Sources	STh4L • Optical Sensing in Combustion	FTh4M • Functional Nanophotonics Using Metasurfaces	STh4N • Ultrafast Metrology II	ATh4O • Novel Spectroscopic Approaches II	ATh4P • Environmental Greenhouse Gas Sensing	ATh4Q • A&T Topical Review on Scientific and Commercial Progress in Semiconductor Laser Technology I
Dinner Break *(on your own)*								
Emerging Trends in Nonlinear Optics – A Review of CLEO: 2018								
Postdeadline Paper Sessions, *Location TBD*								

Agenda of Sessions — Friday, 18 May

	Executive Ballroom 210A	Executive Ballroom 210B	Executive Ballroom 210C	Executive Ballroom 210D	Executive Ballroom 210E	Executive Ballroom 210F	Executive Ballroom 210G	Executive Ballroom 210H
07:30–15:30	**Registration,** *Concourse Level*							
08:00–10:00	SF1A • Si Photonics	FF1B • Quantum Enhanced Measurements	JF1C • Symposium on Lasers in Accelerator Science and Technology I	FF1D • Ultrafast Spectroscopy of 2D Materials	FF1E • THz Generation and Novel Phenomena	FF1F • Spatial and Temporal Control of Light Using Metasurfaces	SF1G • Surface Emitting Lasers	FF1H • Nanophotonic Strategies for Controlling Light-Matter Interaction
10:00–10:30	**Coffee Break,** *Concourse Level*							
10:30–12:30	SF2A • Nonlinear Photonics in Integrated Structures	JF2B • Symposium on Emerging Quantum Sensing Techniques and Applications I	JF2C • Symposium on Lasers in Accelerator Science and Technology II	FF2D • THz Electrodynamics and control of Electronic Degrees of Freedom	FF2E • Novel Nonlinear Optical Materials	FF2F • Fundamental Nanophotonics: Sensing and Infrared Applications	SF2G • Mid-infrared Semiconductor Lasers	FF2H • Interference and Localization Phenomena in Complex Media
12:30–14:00	**Lunch Break** *(on your own)*							
14:00–16:00	SF3A • Integrated Photonics (III-V Heterogeneric)	JF3B • Symposium on Emerging Quantum Sensing Techniques and Applications II	FF3C • Optimization and Design of Metasurfaces	FF3D • Spectroscopy of Low Dimensional Systems	FF3E • Photon-Phonon Interactions and Cooling	FF3F • Optomechanical Interactions and Single Particle Tracking	SF3G • Quantum Cascade Lasers	FF3H • Wavefront Shaping in Complex Media

Meeting Room 211 B/D	Meeting Room 212 A/C	Meeting Room 212 B/D	Marriott, Salon I & II	Marriott, Salon III	Marriott, Salon IV	Marriott, Salon V	Marriott, Salon VI	Marriott, Willow Glen
Registration, *Concourse Level*								
SF1I • Perovskites and Organics	SF1J • Metasurfaces	SF1K • Hollow Core Fibers		AF1M • Fiber-Optic Based Sensing	SF1N • Ultrafast Mid-IR Sources		FF1P • Attosecond and X-Ray Spectroscopy	AF1Q • A&T Topical Review on Scientific and Commercial Progress in Semiconductor Laser Technology II
Coffee Break, *Concourse Level*								
SF2I • Electrooptic and Nanophotonic Materials	SF2J • Cavity Optomechanics	SF2K • Novel Fiber Technology	FF2L • Polaritons in 2D Materials	AF2M • Imaging & Microscopy	SF2N • Ultrafast Oscillators		FF2P • High-order Harmonic Generation in Solids	AF2Q • A&T Topical Review on Time-Stretch Technology: Principles and Applications I
Lunch Break *(on your own)*								
SF3I • Materials for Fiber and Solid State Lasers	SF3J • Mid IR Sensing and Optical Forces	SF3K • Mode-Locked Fiber Lasers		AF3M • Instruments and Components for Spectroscopy	SF3N • Ultrafast Pulse Manipulation		FF3P • Strong-field Physics in Solids	AF3Q • A&T Topical Review on Time-Stretch Technology: Principles and Applications II

07:00–18:00 Registration, *Concourse Level*

Executive Ballroom 210A

Joint

08:00–10:00
JM1A • Symposium on Future Directions in Terahertz Nanoscopy I
Presider: Tyler Cocker; Universität Regensburg, Germany

JM1A.1 • 08:00 Invited
Pushing Terahertz Emission Microscopy to the Nanoscale, Pernille Klarskov Pedersen[1,2], Angela C. Pizzuto[1], Hyewon Kim[1], Vicki Colvin[1], Daniel M. Mittleman[1]; [1]*Brown Univ., USA;* [2]*DTU Fotonik, Technical Univ. of Denmark, Denmark.* Using a scattering-type optical nearfield microscope the spatial resolution of Laser Terahertz Emission Microscopy (LTEM) can be improved dramatically. With this material properties can be studied optically with a resolution of only 20 nm.

JM1A.2 • 08:30 Invited
Towards Quantitative Conductivity Measurements with Infrared Near-Field Optical Microscopy, Joanna M. Atkin[1]; [1]*Chemistry, Univ of North Carolina at Chapel Hill, USA.* Mid-infrared scattering-type scanning near-field optical microscopy (s-SNOM) is a non-destructive optical method to extract nanoscale conductivity maps in semiconductors. Combined with spectroscopic analysis, we can extract quantitative local dielectric properties.

Executive Ballroom 210B

CLEO: Science & Innovations

08:00–10:00
SM1B • Nonlinear and Microwave Integrated Photonics
Presider: Richard Penty; Univ. of Cambridge, UK

SM1B.1 • 08:00
Heterogeneously Integrated InP Widely Tunable Laser and SiN Microring Resonator for Integrated Comb Generation, Keith A. McKinzie[1], Cong Wang[1], Abdullah Al Noman[1], David Mathine[2], Kyunghun Han[1], Daniel E. Leaird[1], Maria Anagnosti[2], Vikrant Lal[2], Gloria Hoefler[2], Fred Kish[2], Minghao Qi[1], Andrew M. Weiner[1]; [1]*Purdue Univ., USA;* [2]*Infinera Corporation, USA.* Optical microresonator frequency combs are inherently compact but require an external pump laser. We demonstrate heterogeneous assembly of an InP high power tunable laser and SiN microring resonator with an eye towards integrated comb generation.

SM1B.2 • 08:15
Random Quasi-Phase-Matching on a Nanophotonic Heterogeneous Silicon Chip, Ashutosh Rao[1], Tracy Sjaardema[1], Guillermo Camacho-Gonzalez[1], Amirmahdi Honardoost[1], Marcin Malinowski[1], Kenneth Schepler[1], Sasan Fathpour[1]; [1]*CREOL, Univ Central Florida, USA.* We demonstrate grating-assisted random quasi-phase-matching in unpoled thin-film lithium niobate waveguides on a silicon substrate via second-harmonic generation from near-infrared to visible wavelengths.

SM1B.3 • 08:30
Demonstration of Stimulated Raman Scattering on a Silicon Nitride Photonic Integrated Waveguide, Haolan Zhao[1,2], Stephane Clemmen[1,2], Ali Raza[1,2], Roel Baets[1,2]; [1]*Photonics Research Group, INTEC, Ghent Univ., Belgium;* [2]*Center for Nano- and Biophotonics, Ghent Univ., Belgium.* We report the first demonstration of stimulated Raman scattering (SRS) enabled by an integrated nanophotonic waveguide with CW excitations. It constitutes an important step towards all-on-a-chip Raman sensor suitable for both gas and liquid detection.

SM1B.4 • 08:45
High-Order Microwave Photonic Intensity Differentiator Based on CMOS-Compatible Micro-Combs, Xingyuan Xu[1], Jiayang Wu[1], Thach Nguyen[2], Sai T. Chu[3], Brent Little[4], Roberto Morandotti[5], Arnan Mitchell[2], David J. Moss[1]; [1]*Swinburne Univ. of Technology, Australia;* [2]*RMIT Univ., Australia;* [3]*City Univ. of Hong Kong, Hong Kong;* [4]*Chinese Academy of Science, China;* [5]*INRS-Énergie, Matériaux et Télécommunications, Canada.* We demonstrate a third-order microwave photonic intensity differentiator based on micro-combs generated by a CMOS-compatible integrated micro-ring resonator (MRR). The micro-combs serve as a multi-wavelength source, which reduced the cost, and complexity of the differentiator.

Executive Ballroom 210C

08:00–10:00
SM1C • RF Photonic & Radio-over-fiber
Presider: Masayuki Matsumoto; Wakayama Univ., Japan

SM1C.1 • 08:00
Reconfigurable Filter-free Sinc-shaped RF Photonic Filters Based on Rectangular Optical Frequency Comb, Jianqi Hu[1], Simon J. Fabbri[1], Camille-Sophie Bres[1]; [1]*École polytechnique fédérale de Lausanne, Switzerland.* We demonstrate reconfigurable sinc-shaped RF photonic filters based on rectangular optical frequency comb synthesized from cascaded modulators. Simplicity of the approach and flexibility in bandwidth for fixed free-spectral-range is shown. Phase response is also investigated.

SM1C.2 • 08:15
Noise-resistant all-optical sampling based on a temporal integrator, Zihan Geng[1,2], Deming Kong[1,2], Bill Corcoran[1,2], Arthur Lowery[1,2]; [1]*Monash Univ., Australia;* [2]*CUDOS, Australia.* We propose a novel noise-resistant all-optical sampling with temporal integration. A proof-of-concept experiment shows a receiver sensitivity improvement up to 8-dB for a 1.25 Gbaud PAM 4 signal.

SM1C.3 • 08:30 Invited
Optically Powered Radio-Over-Fiber Systems, Motoharu Matsuura[1]; [1]*Univ. of Electro-Communications, Japan.* This paper introduces recent works on optically powered radio-over-fiber systems, which drive remote antenna units by power-over-fiber without any other external power supplies. This paper also discusses the perspective on future mobile communications.

07:00–18:00 Registration, *Concourse Level*

Executive Ballroom 210D

CLEO: Science & Innovations

08:00–10:00
SM1D • Nonlinear Resonators
Presider: Yoshitomo Okawachi; Columbia Univ., USA

SM1D.1 • 08:00
Searching for New Regimes in Microresonator Frequency Combs Using a Pulsed Pump Laser, Jordan Stone[1], Daniel C. Cole[1], Scott Papp[1]; [1]*NIST, USA.* We show how microresonators driven by optical pulses enable the efficient, low-power generation of Kerr solitons and potentially open the door to new nonlinear regimes. We observe two new kinds of low-noise Kerr frequency combs.

SM1D.2 • 08:15
Tunable Insertion of Uniform-Amplitude Multiple Coherent Lines into a Kerr Frequency Comb Using Nyquist Pulse Generation, Fatemeh Alishahi[1], Peicheng Liao[1], Amirhossein Mohajerin Ariaei[1], Ahmad Fallahpour[1], Ahmed Almaiman[1], Yinwen Cao[1], Arne Kordts[2], Maxim Karpov[2], Martin Pfeiffer[2], Tobias J. Kippenberg[2], Alan E. Willner[1]; [1]*Univ. of Southern California, USA;* [2]*EPFL, Switzerland.* We experimentally achieve tunable insertion of uniform-amplitude multiple coherent lines into a Kerr frequency comb. Coherent, flat lines with spacings of 7GHz and 6GHz are inserted into the Kerr combs with FSRs of 71.7GHz and 192GHz respectively. The Nyquist pulses are compared to the theory.

SM1D.3 • 08:30
Spatial-mode-coupling-based dispersion engineering for integrated optical waveguide, Yu Li[1], Jiachen Li[1], Yuandong Huo[1], Minghua Chen[1], Sigang Yang[1], Hongwei Chen[1]; [1]*Tsinghua Univ., China.* The proposed spatial-mode-coupling-based dispersion engineering method achieves anomalous dispersion on a micro-ring resonator over a range of 25 nm with high Q of 0.8 million on the double-strip TriPleX™ waveguide platform for the first time.

SM1D.4 • 08:45
Switching Dynamics of Counter-propagating Light States in Microresonators, Leonardo Del Bino[1,2], Michael T. Woodley[1,2], Jonathan M. Silver[1], Shuangyou Zhang[1], Pascal Del'Haye[1]; [1]*National Physical Lab (NPL), UK;* [2]*CDT Applied Photonics, Heriot-Watt Univ., UK.* We present a dynamical analysis of the transition between counter-propagating light states in a nonlinear microresonator. Our results provide important information for the use of these states in optical memories and for dynamical routing in photonic circuits.

Executive Ballroom 210E

CLEO: QELS-Fundamental Science

08:00–10:00
FM1E • Topological Optics
Presider: Mikael Rechtsman; Pennsylvania State Univ., USA

FM1E.1 • 08:00
Experimental Observation of the Coupling of a Nonlinear Wave to a Topological Edge State, Arstan Bisianov[1], Mark Kremer[2], Martin Wimmer[1], Alexander Szameit[2], Ulf Peschel[1]; [1]*Inst. of Condensed Matter Theory and Optics, Friedrich Schiller Univ. Jena, Germany;* [2]*Inst. for Physics, Univ. of Rostock, Germany.* We experimentally investigate a topologically non-trivial edge state of the SSH model. In the presence of nonlinearity topological protection breaks down resulting in efficient energy transfer from a nonlinear wave to the edge state.

FM1E.2 • 08:15
Observation of Aharonov-Bohm Suppression of Optical Tunneling in Twisted Multicore Fibers, Midya Parto[1], Helena Lopez[1], Jose Enrique Antonio-Lopez[1], Juan Carlos Alvarado Zacarias[1], Mercedeh Khajavikhan[1], Rodrigo Amezcua Correa[1], Demetrios N. Christodoulides[1]; [1]*CREOL, USA.* We report the first observation of Aharonov-Bohm-like topological suppression of optical tunneling in twisted multicore fibers. Experimental results show that this effect is insensitive to imperfections, nonlinearities and mode-mixing processes, in agreement with theoretical predictions.

FM1E.3 • 08:30
Topological Lossless Optical Digitizer, Yonatan Sharabi[1], Yonatan Plotnik[1], Yonatan Nemirovski[1], Mordechai Segev[1]; [1]*Technion, Israel.* We present an optical digitizer, based on Brag reflections and nonlinear index change that restricts the output intensity to two predesigned values. This device is a manifestation of an intensity-dependent topological phase transition.

FM1E.4 • 08:45
Localization, Time-reversal, and Unidirectional Guiding of Light Pulses Using Dynamic Modulation, Momchil Minkov[1], Shanhui Fan[1]; [1]*Stanford Univ., USA.* We study a coupled-cavity waveguide in which the resonance frequency of each cavity is sinusoidally modulated in time, and demonstrate a range of interesting dynamics that can be achieved in various regimes defined by the underlying parameters.

Executive Ballroom 210F

08:00–10:00
FM1F • Highly Correlated and Topological States of Matter
Presider: Robert Kaindl; Lawrence Berkeley National Lab, USA

FM1F.1 • 08:00
Controlling electron-phonon interaction in the Bi_2Se_3 topological insulator by Dirac-plasmon engineering, Chihun In[1], Sangwan Sim[1], Beom Kim[1], Hyemin Bae[1], Hyunseung Jung[2], Woosun Jang[1], Myungwoo Son[3], Jisoo Moon[4], Maryam Salehi[4], Seung Young Seo[5], Aloysius Soon[1], Moon-Ho Ham[3], Hojin Lee[2], Seongshik Oh[4], Dohun Kim[6], Moon-Ho Jo[5], Hyunyong Choi[1]; [1]*Yonsei Univ., South Korea;* [2]*Soongsil Univ., South Korea;* [3]*Gwangju Inst. of Science and Technology, South Korea;* [4]*Rutgers Univ., USA;* [5]*Pohang Univ. of Science and Technology, South Korea;* [6]*Seoul National Univ., South Korea.* We performed the time-domain and time-resolved ultrafast THz spectroscopy on the topological insulator (TI) Bi_2Se_3 Dirac plasmons. The distinct dynamics of phonon broadening and phonon stiffening were observed when Dirac plasmon moves across the TI phonon.

FM1F.2 • 08:15
Ultrafast Photocurrent Measurements of Bulk-Conduction Induced Spin Hall Effect in the Topological Insulator Bi_2Se_3, Jekwan Lee[2], Sangwan Sim[2], Sungjun Park[2], Soohyun Park[2], Seungwan Cho[2], Sooun Lee[1], Hoil Kim[3], Jehyun Kim[4], Wooyoung Shim[1], Junsung Kim[3], Dohun Kim[4], Hyunyong Choi[2]; [1]*Materials Science & Engineering, Yonsei Univ., South Korea;* [2]*Electrical & Electronic Engineering, Yonsei Univ., South Korea;* [3]*Physics, Pohang Univ. of Science and Technology, South Korea;* [4]*Physics & Astronomy, Seoul National Univ., South Korea.* We have measured the temporally-resolved helicity-dependent photocurrent at the Bi_2Se_3 topological insulator and identified that the skew scattering induces spin Hall effect while the spin suffers Elliott-Yafet relaxation at the bulk state of the Bi_2Se_3.

FM1F.3 • 08:30 Invited
Title To Be Determined, Alessandra Lanzara[1]; [1]*Univ. of California Berkeley, USA.* TBD

07:00–18:00 Registration, *Concourse Level*

Executive Ballroom 210G	Executive Ballroom 210H	Meeting Room 211 B/D
CLEO: QELS-Fundamental Science		**CLEO: Science & Innovations**

08:00–10:00
FM1G • Quantum Photonic Devices
Presider: Joshua Bienfang; NIST, USA

FM1G.1 • 08:00
A Universal Two-Qubit Photonic Quantum Processor, Xiaogang Qiang[1,2], Xiaoqi Zhou[3,1], Jianwei Wang[1], Callum Wilkes[1], Thomas Loke[4], Sean O'Gara[1], Laurent Kling[1], Graham Marshall[1], Raffaele Santagati[1], Jingbo Wang[4], Jeremy L. O'Brien[1], Mark G. Thompson[1], Jonathan Matthews[1]; [1]*Quantum Engineering Technology Labs, Univ. of Bristol, UK;* [2]*State Key Lab of High Performance Computing, NUDT, China;* [3]*State Key Lab of Optoelectronic Materials and Technologies and School of Physics, Sun Yat-sen Univ., China;* [4]*School of Physics, The Univ. of Western Australia, Australia*. We report a universal two-qubit silicon photonic quantum processor, able to initialise, operate and analyze arbitrary two-qubit states and processes applications in quantum information processing.

FM1G.2 • 08:15
A Large-Number and Multilayer Quantum Walk using Silicon Nano-photonic Chip, Lingxiao Wan[1], Libin Yan[1], Gong Zhang[1], Jianguo Huang[1], Leong Chuan Kwek[2], Joseph F. Fitzsimons[3], Yidong Chong[1], Jiangbin Gong[2], Alexander Szameit[4], Xiaoqi Zhou[5], Man-Hong Yung[6], Xianmin Jin[7], Xiaolong Su[8], Wee Ser[1], Weibo Gao[1], Aiqun Liu[1]; [1]*Nanyang Technological Univ., Singapore;* [2]*National Univ. of Singapore, Singapore;* [3]*Singapore Univ. of Technology and Design, Singapore;* [4]*Univ. of Rostock, Germany;* [5]*Sun Yat-sen Univ., China;* [6]*Southern Univ. of Science and Technology, China;* [7]*Shanghai Jiaotong Univ., China;* [8]*Shanxi Univ., China*. We experimentally demonstrated 2D quantum walks in a Si_3N_4 chip and study how different parameters affect light distribution. Such scalable quantum device will have a promising application in the field of quantum communication and simulation.

FM1G.3 • 08:30
Monolithically Integrated Hong-Ou-Mandel Experiment in $LiNbO_3$, Kai-Hong Luo[1], Sebastian Brauner[1], Christof Eigner[1], Raimund Ricken[1], Polina Sharapova[1], Torsten Meier[1], Harald Herrmann[1], Christine Silberhorn[1]; [1]*Dept. of Physics, Univ. of Paderborn, Germany.* We implemented a fully integrated Hong-Ou-Mandel (HOM) interference circuit which comprises a qubit generation, passive routing, fast active polarization manipulation, electro-optic balanced switching, and a variable time delay based on Ti:$LiNbO_3$ waveguides.

FM1G.4 • 08:45
Investigation of Deep Learning Attacks on Nonlinear Silicon Photonic PUFs, Iskandar Atakhodjaev[1], Bryan Bosworth[1], Brian Grubel[1], Michael Kossey[1], Jesus Villalba[1], A. B. Cooper[1], Najim Dehak[1], Amy Foster[1], Mark A. Foster[1]; [1]*Johns Hopkins Univ., USA.* We demonstrate that nonlinear silicon photonic Physical Unclonable Functions (PUFs) are resistant to adversarial deep learning attacks. We find that this resistance is rooted in the optical nonlinearity of the silicon photonic PUF token.

08:00–10:00
FM1H • Solid State Spin-Photon Interfaces
Presider: Elizabeth Goldschmidt; US Army Research Lab, USA

FM1H.1 • 08:00 Invited
Spin-photon Quantum Interfaces in Solids, Mete Atature[1]; [1]*Cambridge Univ., UK.* TBD

FM1H.2 • 08:30
Frequency Control of Single Quantum Emitters in Integrated Photonic Circuits, Emma Schmidgall[1], Srivatsa Chakravarthi[1], Michael Gould[1], Ian Christen[1], Karine Hestroffer[2], Fariba Hatami[2], Kai-Mei Fu[1]; [1]*Univ. of Washington, USA;* [2]*Physics, Humboldt-Universitat zu Berlin, Germany.* We demonstrate a potential integrated-circuit architecture for quantum computation with nitrogen vacancy centers in diamond. The combination of photonic device integration and eletrodes enables both high emission rates and tuning of the emission frequency.

FM1H.3 • 08:45
Nanocavity Design for Reduced Spectral Diffusion of Solid-State Defects, Sara L. Mouradian[1], Noel Wan[1], Michael Walsh[1], Eric A. Bersin[1], Matthew Trusheim[1], Tim Schröder[2], Dirk . Englund[1]; [1]*MIT, USA;* [2]*Niels Bohr Inst., Denmark*. We report on the reduced spectral diffusion of nitrogen vacancy (NV) centers in waveguides and cavities. We also design a novel cavity that provides both high quality factor and isolation from diamond surfaces.

08:00–10:00
SM1I • Modulator on Integrated Platform
Presider: Judson Ryckman; Clemson Univ., USA

SM1I.1 • 08:00
Enhanced Polling and Infiltration of Highly-Linear Mach-Zehnder Modulators on Si/SiN-Organic Hybrid Platform, Iman Taghavi[1], Razi Dehghannasiri[1], Tianren Fan[1], Hesam Moradinejad[1], Hossein Taghinejad[1], Amir H. Hosseinnia[1], Ali Asghar Eftekhar[1], Ali . Adibi[1]; [1]*Georgia Inst. of Technology, USA.* Effective infiltration and polling of electro-optic polymer (EOP) inside world-record vertical slot of 40 nm is demonstrated for a Mach-Zehnder modulator on a hybrid Si/SiN/EOP platform with highly-linear and high-power handling performance capabilities.

SM1I.2 • 08:15
High-speed silicon-organic hybrid modulator enabled by sub-wavelength grating waveguide ring resonator, Zeyu Pan[1], Xiaochuan Xu[2], Chi-Jui Chung[1], Hamed Dalir[2], Hai Yan[1], Ke Chen[1], Yaguo Wang[1], Baohua Jia[3], Ray Chen[1]; [1]*Univ. of Texas at Austin, USA;* [2]*Omega Optics, Inc., USA;* [3]*Swinburne Univ. of Technology, Australia.* We present a high-speed modulator based on electro-optic polymer infiltrated sub-wavelength grating waveguide ring resonator. A 3-dB small signal modulation bandwidth of 41.36 GHz has been demonstrated.

SM1I.3 • 08:30
Silicon-conductive oxide nano-cavity modulator with extremely small active volume, Erwen Li[1], Qian Gao[1], Ray Chen[2], Alan X. Wang[1]; [1]*Oregon State Univ., USA;* [2]*Univ. of Texas at Austin, USA.* We design and experimentally demonstrated an ultra-compact modulator using transparent conductive oxide as the gate on 1-D silicon photonic crystal cavity. The device offers an ultra-small active volume (<0.06 μm^3) and 46 fJ/bit energy efficiency.

SM1I.4 • 08:45
100 GBd Plasmonic IQ Modulator, Wolfgang Heni[1], Benedikt Baeuerle[1], Yuriy Fedoryshyn[1], Arne Josten[1], Christian Haffner[1], Tatsuhiko Watanabe[1], David Hillerkuss[1,2], Delwin Elder[3], Larry R. Dalton[3], Juerg Leuthold[1]; [1]*ETH Zurich, Switzerland;* [2]*Huawei Technologies, Germany;* [3]*Univ. of Washington, USA.* Demonstration of a plasmonic IQ modulator operating at 100 GBd QPSK and at 32 GBd 16QAM. The device is orders of magnitude smaller than any photonic counterpart.

07:00–18:00 Registration, *Concourse Level*

Meeting Room 212 A/C

CLEO: Applications & Technology

08:00–10:00
AM1J • Advanced Microscopy and Imaging Techniques
Presider: Ilko Ilev; U.S. Food and Drug Administration , USA

AM1J.1 • 08:00 Invited
Brillouin Microscopy for cell and tissue biomechanics, Giuliano Scarcelli[1]; [1]*Univ. of Maryland at College Park, USA.* We will describe recent progress of Brillouin microscopy, an all-optical imaging modality to map mechanical properties of material based on Brillouin scattering. In ophthalmology, Brillouin microscopy is in clinical trials; at cell level, Brillouin microscopy enables characterization of intracellular elasticity.

AM1J.2 • 08:30
Excitation wavelength optimization of harmonic generation microscopy in human skin enabled by fiber-based femtosecond source tunable in 1.15-1.35 μm, Hsiang-Yu Chung[1,2], Wei Liu[1,2], Qian Cao[1,2], Rüdiger Greinert[3], Franz X. Kaertner[1,2], Guoqing Chang[1,4]; [1]*Center for Free-Electron Laser Science, DESY, Germany;* [2]*Physics, Universität Hamburg, Germany;* [3]*Skin Cancer Center Buxtehude, Germany;* [4]*The Hamburg Centre for Ultrafast Imaging, Universität Hamburg, Germany.* We demonstrate a fiber-based tunable femtosecond source covering 1.15-1.35 μm based on self-phase modulation enabled spectral selection, which allows us to optimize the excitation wavelength for harmonic generation imaging in *ex vivo* human skin.

AM1J.3 • 08:45
Study of Bacterial Inner Structures with 4π Raman Microscopy, Alejandro Diaz Tormo[1], Dmitry Khalenkow[2], Andre G. Skirtach[2], Nicolas Le Thomas[1]; [1]*Photonics Research Group, Belgium;* [2]*Dept. of Molecular Biotechnology, Ghent Univ., Belgium.* 4π Raman microscopy provides better resolution and Raman signal than standard Raman microscopy. We determine the improvement using a silicon layer and show its applicability to biological specimen for the first time.

Meeting Room 212 B/D

CLEO: Science & Innovations

08:00–10:00
SM1K • Raman Scattering and Applications
Presider: Kenneth Kin-Yip Wong; Univ. of Hong Kong, Hong Kong

SM1K.1 • 08:00
Ultrafast, High Energy, Wideband Wavelength Conversion Via Continuous Intra-pulse and Discrete Intermodal Raman Scattering, Boyin Tai[1], Lars Rishøj[1], Siddharth Ramachandran[1]; [1]*Boston Univ., USA.* We demonstrate energetic (~30nJ) ultrashort pulse wavelength conversion from ~1045-1600nm with ~38% overall efficiency, achieved by a combination of intra-pulse Raman soliton shifting and discrete, cascaded intermodal Raman scattering in a step-index multimode fiber.

SM1K.2 • 08:15
All-fiber dissipative soliton Raman laser for deep tissue multiphoton imaging, Khanh Q. Kieu[1], Orkhongua Batjargal[1], Jennifer Barton[1]; [1]*Univ. of Arizona, USA.* We propose and demonstrate an all-fiber Raman laser based on phosphosilicate fiber. It produces ~5 ps chirped dissipative soliton pulses with energy up to 8 nJ, average power of 0.3 W at 1230 nm center wavelength.

SM1K.3 • 08:30
Demonstration of a Frequency Quadrupled Tunable Soliton Self-Frequency Shifted Ultra-Short Pulse Fiber Laser with High Energy Output, Armin Zach[1], Martin Enderlein[1], Frank Lison[1], Jeffrey Nicholson[2], Man Yan[2], Patrick Wisk[2], Anthony DeSantolo[2]; [1]*TOPTICA Projects GmbH, Germany;* [2]*OFS Labs, USA.* We demonstrate a frequency quadrupled soliton self-frequency shifted femtosecond fiber laser with multiple tunable outputs in the near infrared and blue spectral range providing up to 120fs and 6nJ pulse energy.

SM1K.4 • 08:45
High Power, Ultra-Widely Tunable Wavelength, Cascaded Raman Fiber Laser, V Balaswamy[1], Santosh Aparanji[1], S Arun[1], Siddharth Ramachandran[2], V R Supradeepa[1]; [1]*Indian Inst. of Science, India;* [2]*Boston Univ., USA.* We demonstrate a high power, continuously tunable cascaded Raman fiber laser, based on filtered distributed feedback. Output powers of up to 33W is achieved with >450nm tuning from 1118nm-1575nm, bridging the Ytterbium, Erbium emission bands.

Marriott Salon I & II

08:00–10:00
SM1L • Precision Clocks and Time Transfer
Presider: Mark Notcutt; Stable Laser Systems, USA

SM1L.1 • 08:00
Real signal generation of a time scale based on an optical clock, Hidekazu Hachisu[1], Fumimaru Nakagawa[1], Yuko Hanado[1], Tetsuya Ido[1]; [1]*NICT, Japan.* Over five months, we continuously generated real signal of a time scale steered by an optical clock, showing a long-term instability of low 10^{-16} level. We also demonstrated the capability to calibrate TAI.

SM1L.2 • 08:30
Sub-picosecond resolution time-offset measurement over fiber link with asynchronous optical sampling, Abulikemu Abuduweili[1], Xing Chen[1], Jianmin Shang[3], Wanpeng Zhang[2], Cheng Ci[2], Song Yu[3], Yingxin Zhao[2], Bo Liu[2], Zhigang Zhang[1]; [1]*Peking Univ., China;* [2]*Nankai Univ., China;* [3]*Beijing Univ. of Posts and Telecommunications, China.* We demonstrate a sub-picosecond resolution time-offset measurement over l00 km long fiber using asynchronized dual-comb linear optical sampling.

SM1L.3 • 08:45
Femtosecond Synchronization through Turbulent Air Off a Quadcopter, Laura C. Sinclair[1], Hugo Bergeron[2], William C. Swann[1], Isaac Khader[1], Michael Cermak[1], Jean-Daniel Deschênes[2], Nathan R. Newbury[1]; [1]*National Inst. of Standards and Technology, USA;* [2]*Universite Laval, Canada.* We demonstrate femtosecond-level synchronization of optical oscillators connected via a moving quadcopter. Synchronization is achieved despite 20 m/s motion and 500 m pathlength changes.

07:00–18:00 Registration, *Concourse Level*

Marriott Salon III

CLEO: Applications & Technology

08:00–10:00
AM1M • Laser-based Advanced Manufacturing & Materials Processing
Presider: TBD

AM1M.1 • 08:00 Invited
Ultrafast Laser Microwelding of Optical Materials, Duncan P. Hand[1], Richard Carter[1], Robert R. Thomson[1], M J Daniel Esser[1], Michael Troughton[2], Ian Elder[2], Robert Lamb[2]; [1]*Heriot-Watt Univ., UK;* [2]*Leonardo Airborne and Space Systems, UK.* Construction of precision optical systems (e.g. lasers) involves bonding optical materials (glasses and crystals - mirrors, beamsplitters, laser crystals) to structural materials (typically metals). I will describe an ultrafast laser welding process for such applications.

AM1M.2 • 08:30
Controlling Femtosecond Laser Ablation of Germanium for Laser Polishing Applications, Lauren L. Taylor[1], Jing Xu[2], Thomas Smith[2], Michael Pomerantz[2], John Lambropoulos[2], Jie Qiao[1]; [1]*Rochester Inst. of Technology, USA;* [2]*Univ. of Rochester, USA.* Sensitivity of femtosecond laser ablation to laser parameters was investigated to evaluate controllability of germanium material removal. A processing metric was determined, enabling a method to control laser polishing with flexible combinations of laser parameters

AM1M.3 • 08:45
Process Optimization by Bursts of Ultrafast Laser Pulses and Considerations of Absorptance and Residual Heat, Beat Neuenschwander[1], Daniel J. Foerster[2], Beat Jaeggi[3,1]; [1]*Bern Univ. of Applied Sciences, Switzerland;* [2]*Institut für Strahlwerkzeuge ifsw, Univrsity of Stuttgart, Germany;* [3]*LASEA AG, Switzerland.* It will be shown that an increased absorptance of a copper surface machined with an ultrafast 3 pulse burst may be responsible for the detected increase of the specific removal rate in this case.

Marriott Salon IV

CLEO: Science & Innovations

08:00–10:00
SM1N • Advanced Laser Technologies
Presider: Erhard Gaul; Univ. of Texas at Austin, USA

SM1N.1 • 08:00
Ultrashort Pulse Laser Irradiation Tests on Silica Glass with Random Antireflective Surface Structures, Lynda E. Busse[1], Steven R. Flom[1], Jesse Frantz[1], Brandon Shaw[1], Christopher Wilson[2], Ishwar D. Aggarwal[3], Jas Sanghera[1]; [1]*US Naval Research Lab, USA;* [2]*Univ. of North Carolina at Charlotte, USA;* [3]*Sotera Defense Solutions, USA.* We show similar laser induced damage results for silica glass with and without random antireflective surface structures under high intensity fs-laser irradiation.

SM1N.2 • 08:15
High Stability Time-Lens–Based Picosecond Seed Source, Christophe Dorrer[1], Richard Brown[1]; [1]*Univ. of Rochester, USA.* The design of an optical source based on an electro-optic time lens is described. Excellent pulse-duration stability, short-term jitter, and long-term drift performance are demonstrated, making it suitable as a seed for high-energy laser systems.

SM1N.3 • 08:30
Large-Mode Optical Cavity for UV Laser Power Recycling, Yun. Liu[1], Abdurahim Rakhman[1]; [1]*Oak Ridge National Lab, USA.* A large-mode Fabry-Perot cavity has been developed for power enhancement of UV laser. Megawatt peak power has been realized inside the cavity through power recycling of 50ps/402.5MHz UV pulses operating in a 10ms/10Hz burst mode.

SM1N.4 • 08:45
Passive compensation of beam misalignment caused by air convection in thin-disk lasers, Tom Dietrich[1], Stefan Piehler[1], Christoph Röcker[1], Martin Rumpel[2], Marwan Abdou Ahmed[1], Thomas Graf[1]; [1]*Universität Stuttgart, Germany;* [2]*MarTec Photonics, Germany.* We present a new approach to passively compensate for the misalignment instabilites caused by convection of heated ambient air in front of a thin-disk laser crystal by means of exploiting the spectral dispersion of a diffractive grating-waveguide mirror.

Marriott Salon V

08:00–10:00
SM1O • Fundamentals of Light-matter Interaction
Presider: Chih Wei Luo; National Chiao Tung Univ., Taiwan

SM1O.1 • 08:00
How Conducting 2D Materials Overlayer Modify the Brewster Angle of a Substrate?, Bruno Majérus[1], Mirko Cormann[1], Nicolas Reckinger[1], Matthieu Paillet[3], Luc Henrard[1], Philippe Lambin[1], Michaël Lobet[2,1]; [1]*Univ. of Namur, Belgium;* [2]*John A. Paulson School of Engineering and Applied Sciences, Harvard Univ., USA;* [3]*Laboratoire Charles Coulomb, Univ. of Montpellier, France.* Inserting 2D conducting material between dielectrics modifies the Brewster angle. We theoretically and experimentally demonstrate this influence using mono-, bi- and trilayer graphene samples. It provides an original optical measurement of 2D materials' conductivity.

SM1O.2 • 08:15
Optomechanical coupling to ultra-high Q-factor phononic resonators on-chip at cryogenic temperatures, Prashanta Kharel[1], Yiwen Chu[1], Michael Power[1], Robert J. Schoelkopf[1], Peter T. Rakich[1]; [1]*Yale Univ., USA.* Through engineerable optomechanical coupling to bulk acoustic modes of plano-convex resonators fabricated on-chip, we demonstrate ultra-high acoustic Q-factors of 28 million (6.6 million) for phonons at high frequencies of 12.7 GHz (37.8 GHz) in quartz (silicon) at cryogenic temperatures.

SM1O.3 • 08:30 Invited
Laser Ablation by Femtosecond Synthesized Waveforms, Ci-Ling . Pan[1], Chih-Hsuan Lin[1], Chan-Shan Yang[1], Alexey Zaytsev[1]; [1]*National Tsing Hua Univ., Taiwan.* Laser ablation of polymethylmethacrylate by two-color synthesized waveforms show a dependence on the relative phase between the ω and 2ω beams, a manifestation of photoionization in the intermediate regime (Keldysh parameter $g \approx 1.5$).

Marriott Salon VI

CLEO: Applications & Technology

08:00–10:00
AM1P • A&T Topical Review on Photonics-enabled Quantum Technologies in Transition I
Presider: Wilhelm Kaenders; Toptica Photonics AG & Inc., Germany

AM1P.1 • 08:00 Invited
From Basic Research to Quantum Technologies: Challenges and Opportunities, Tatjana Curcic[1]; [1]*US Air Force Office of Scientific Res, USA.* Quantum Science research has laid foundations for many new technologies, with applications ranging from brain imaging to information security. In this talk, I will discuss challenges and opportunities accompanying the development of quantum technologies.

AM1P.2 • 08:30 Invited
Innovative Laser Solutions for Operational Quantum Sensors, Bruno Desruelle; *MUQUANS, France.* We present the innovative laser technologies developed for our Absolute Quantum Gravimeter. We describe the work we have done to develop a solution capable of meeting the demanding requirements associated to quantum manipulation of laser cooled atoms, in a compact fibered architecture.

Marriott Willow Glen

CLEO: QELS-Fundamental Science

08:00–10:00
FM1Q • Optical Filamentation and X-rays
Presider: Alexander Gaeta; Columbia University, USA

FM1Q.1 • 08:00
Precise Holographic Measurements Reveal High Electron Densities in Mid-Infrared Laser Filaments in Air, Dimitris Papazoglou[2,3], Valentina Shumakova[1], Skirmantas Ališauskas[1], Vladimir Fedorov[5,3], Audrius Pugzlys[1,4], Andrius Baltuska[1,4], Stylianos Tzortzakis[5,2]; [1]*Vienna Univ. of Technology, Austria;* [2]*Foundation for Research and Technology-Hellas, Greece;* [3]*Univ. of Crete, Greece;* [4]*Center for Physical Sciences & Technology, Lithuania;* [5]*Texas A&M Univ. at Qatar, Qatar.* We report on precise experimental measurements of the electron plasma density in plasma strings generated in air by 3.9μm laser filaments using holography. We discuss the origin and impact of the high electron densities observed.

FM1Q.2 • 08:15
Impact of Polarization on Mid-IR Air Filaments, Valentina Shumakova[1], Claudia Gollner[1], Andrius Baltuska[1,2], Vladimir Fedorov[3,4], Stylianos Tzortzakis[3,5], Alexander Voronin[6,7], Alexander Mitrofanov[6,7], Aleksei Zheltikov[6,8], Daniil Kartashov[9], Audrius Pugzlys[1,2]; [1]*Vienna Univ. of Technology, Austria;* [2]*Center for Physical Sciences & Technology, Lithuania;* [3]*Texas A&M Univ. at Qatar, Qatar;* [4]*Lebedev Physical Inst. of the Russian Academy of Sciences, Russia;* [5]*Foundation for Research and Technology-Hellas, Greece;* [6]*Lomonosov Moscow State Univ., Russia;* [7]*Russian Quantum Center, Russia;* [8]*Texas A&M Univ., USA;* [9]*Friedrich-Schiller Univ. Jena, Germany.* We report results of experimental investigation on polarization evolution and losses in linearly and circularly polarized mid-IR filaments in air under different focusing conditions.

FM1Q.3 • 08:30
Shaping Long-lived Electron Wavepackets to Create Customizable Optical Spectra, Rumen R. Dangovski[1], Nicholas Rivera[1], Marin Soljacic[1], Ido Kaminer[2]; [1]*MIT, USA;* [2]*Electrical Engineering, Technion Israel Inst. of Technology, Israel.* We introduce new shape-invariant electron wavepackets constructed via superpositions of states in the ionization continuum, enabling customizable optical emission spectra in the eV-keV range. Their shape-invariance is prolonged indefinitely in exchange for larger spatial spreads.

FM1Q.4 • 08:45
Near-infrared Filament Conductivity in Multi-Filament Regime, Milos Burger[1], Patrick J. Skrodzki[1], Igor Jovanovic[1]; [1]*Univ. of Michigan, USA.* Scaling of the electrical conductive properties of femtosecond laser filaments with energy is of significant interest. We observe that the formation of multiple filaments does not impede the increase of air conductivity with laser power.

Executive Ballroom 210A	Executive Ballroom 210B	Executive Ballroom 210C
Joint	CLEO: Science & Innovations	

JM1A • Symposium on Future Directions in Terahertz Nanoscopy I—Continued

JM1A.3 • 09:00
Bias Dependence of Laser Terahertz Emission Nanoscopy, Angela C. Pizzuto[1], Pernille Klarskov Pedersen[1,2], Daniel M. Mittleman[1]; [1]*Brown Univ., USA;* [2]*Photonics Engineering, Technical Univ. of Denmark, Denmark.* We demonstrate depletion of terahertz emission from semiconductors by applying a DC bias between a substrate and an AFM probe operating in tapping mode. The depletion is strongly dependent on the probe tapping amplitude.

JM1A.4 • 09:15
All-electronic THz Nanoscopy, Clemens Liewald[1,2], Fritz Keilmann[1]; [1]*Faculty of Physics and Center for NanoScience (CeNS), LMU Munich, Germany;* [2]*Nanosystems Initiative Munich, Germany.* We demonstrate 50-nm resolved near-field imaging at λ=500 μm for the first time, using a high-harmonic microwave circuit for emitting/detecting via free space to a standard s-SNOM, and map conductivity contrasts at near single-charge sensitivity.

JM1A.5 • 09:30 Invited
Nano-THz Imaging of Quantum Materials, Dimitri Basov[1]; [1]*Columbia Univ., USA.* We developed THz nano-spectroscopy and nano-imaging operational at liquid helium temperatures. I will discuss first low-temperature nano-imaging data for ballistic plasmonic transport in graphene, correlated oxides and cuprate high temperature superconductors.

SM1B • Nonlinear and Microwave Integrated Photonics—Continued

SM1B.5 • 09:00
A highly versatile microwave photonic filter based on an integrated optical frequency comb source, Jiayang Wu[1], Xingyuan Xu[1], Thach Nguyen[2], Sai T. Chu[3], Brent Little[4], Roberto Morandotti[5], Arnan Mitchell[2], David J. Moss[1]; [1]*Swinburne Univ. of Technology, Australia;* [2]*RMIT Univ., Australia;* [3]*City Univ. of Hong Kong, China;* [4]*Chinese Academy of Science, China;* [5]*INRS-Énergie, Matériaux et Télécommunications, Canada.* We experimentally demonstrate a highly versatile microwave photonic filter (MPF) based on Kerr optical comb generated by an integrated microring resonator (MRR). The MPF features improved Q factors, wideband tunability, and highly reconfigurable filtering shapes.

SM1B.6 • 09:15
Chaos synchronization over 50 kilometers using monolithic silicon optomechanical cavities, Jia-Gui Wu[1,2], Jaime G. Flor Flores[1], Mingbin Yu[3], Guoqiang Lo[3], Dim-Lim Kwong[3], Shukai Duan[2], Chee-Wei Wong[1]; [1]*Univ. of California, Los Angeles, Fang Lu Mesoscopic Optics and Quantum Electronics Lab, USA;* [2]*Southwest Univ., College of Electronic and Information Engineering, China;* [3]*Inst. of Microelectronics, Singapore.* High quality chaos synchronization has been experimentally achieved between micro-cavities over 50 kilometers distance. The silicon micro-cavities have been fabricated using fully CMOS-compatible processes, which makes low-cost, scalable solution for secure-communications and networks feasible

SM1B.7 • 09:30
Optical spectral shaping with MHz resolution for arbitrary RF waveform generation, Come Schnebelin[1], Hugues Guillet de Chatellus[1]; [1]*LIPhy, France.* We demonstrate a new technique of arbitrary optical spectral shaping with a MHz resolution. The system, based on a single CW laser, enables the generation of radio-frequency arbitrary waveforms with bandwidth exceeding 25 GHz.

SM1C • RF Photonic & Radio-over-fiber—Continued

SM1C.4 • 09:00
Coherently Driven Ultrafast Complex-Valued Photonic Reservoir Computing, Mitsumasa Nakajima[1], Masanobu Inubushi[2], Takashi Goh[1], Toshikazu Hashimoto[1]; [1]*NTT Device Technology Labs., Japan;* [2]*NTT Communication Science Labs., Japan.* We propose a complex-valued photonic reservoir computing system implemented using coherent detection and an all-photonic wave-forming technique, which achieves gigahertz-order processing with complex-valued inputs and outputs.

SM1C.5 • 09:15
Multi-band carrierless amplitude and phase modulation in RoF system for enhanced reliable mobile fronthaul, Li Di[1], lei deng[1], mengfan cheng[1], Songnian Fu[1], Ming Tang[1], Deming Liu[1]; [1]*Huazhong Univ. of Sci. & Tech., China.* We firstly propose to apply multi-band CAP technique in RoF system below 6GHz, and demonstrate a bidirectional 2Gbps CAP signal transmission over 25km-SSMF and 40cm-air, resulting in improved robustness to interference from existing wireless services and asynchronization among different users.

SM1C.6 • 09:30 Invited
Microwave Photonics at DARPA: Past, Present and Future, Vincent J. Urick[1]; [1]*DARPA, USA.* Microwave photonics research at DARPA is briefly reviewed. The need to focus on multi-use applications of the technology is stressed. Photonics for radio-frequency interference mitigation is identified as such an opportunity.

08:30–18:00 OIDA Executive Forum on the Exploding Role of Optics in Sensing, *Almaden Ballroom, Hilton San Jose*

10:00–10:30 Coffee Break, *Concourse Level*

Executive Ballroom 210D

CLEO: Science & Innovations

SM1D • Nonlinear Resonators—Continued

SM1D.5 • 09:00 Invited
Widely Tunable Sidebands and Optical Frequency Combs in Passive Nonlinear Resonators, Miro J. Erkintalo[1]; [1]*Univ. of Auckland, New Zealand.* We review recent results on nonlinear frequency conversion in passive resonators, focussing in particular on the generation of widely tunable parametric sidebands in Kerr microresonators and optical frequency combs in quadratically nonlinear cavities.

SM1D.6 • 09:30
Fully Integrated Chip Platform for Electrically Pumped Frequency Comb Generation, Brian Stern[1,2], Xingchen Ji[1,2], Yoshitomo Okawachi[2], Alexander L. Gaeta[2], Michal Lipson[2]; [1]*Cornell Univ., USA;* [2]*Columbia Univ., USA.* We demonstrate the first chip-based microresonator comb source consisting of a semiconductor laser integrated with a silicon nitride microresonator. For electrical powers as low as 130 mW, we generate a single-soliton comb spanning 90 nm.

SM1D.7 • 09:45
Ultra-low Power Wavelength Conversion in a Hydrogenated Amorphous Silicon Microring Resonator, Kangmei Li[1], Michael Kossey[1], Amy Foster[1]; [1]*Johns Hopkins Univ., USA.* We demonstrate ultra-low power wavelength conversion via four-wave mixing in a hydrogenated amorphous silicon microring resonator with 10-μm radius. The results show 22.8-dB conversion efficiency enhancement in the ring compared to a 3.8-mm long waveguide.

Executive Ballroom 210E

CLEO: QELS-Fundamental Science

FM1E • Topological Optics—Continued

FM1E.5 • 09:00
Topological Knotted and Tangled Solitons in Laser Media, Nikolay A. Veretenov[1,2], Sergei V. Fedorov[2,1], Nikolay N. Rosanov[1,2]; [1]*S.I. Vavilov State Optical Inst., Russia;* [2]*ITMO Univ., Russia.* Three-dimensional solitons with the topology of knots and tangles are predicted in laser media with saturable amplification and absorption. Their skeletons consist of unclosed vortex lines forming some axis, and closed ones engirdling the axis.

FM1E.6 • 09:15
Classifying Photonic Topological Phases Using Manifold Learning, Or Yair[1], Eran Lustig[1], Ronen Talmon[1], Mordechai Segev[1]; [1]*Technion Israel Inst. of Technology, Israel.* We use Manifold Learning to classify topological phases of photonic systems, from an arbitrary set of measurements without any prior knowledge or assumptions.

FM1E.7 • 09:30
Observation of Unconventionally Extended Flat-band States in Photonic Lieb Lattices, Shiqi Xia[1], Ajith Ramachandran[2], Shiqiang Xia[1], Denghui Li[1], Xiuying Liu[1], Liqin Tang[1], Daohong song[1,4], Sergej Flach[2], Zhigang Chen[1,3]; [1]*The MOE Key Lab of Weak-Light Nonlinear Photonics, TEDA Applied Physics Inst. and School of Physics, Nankai Univ., China;* [2]*Center for Theoretical Physics of Complex Systems, Inst. for Basic Science (IBS), South Korea;* [3]*Dept. of Physics and Astronomy, San Francisco State Univ., USA;* [4]*Collaborative Innovation Center of Extreme Optics, Shanxi Univ., China.* We propose and demonstrate unconventional flat-band states (compact localized lines) in photonic Lieb lattices. A simple yet effective writing technique leads to desired lattice boundaries that support linear localized modes (lines and necklaces) unrealized before.

FM1E.8 • 09:45
Experimental Realization of Photonic Topological Insulators in Synthetic Dimensions, Eran Lustig[1], Steffen Weimann[2], Yonatan Plotnik[1], Miguel Bandres[1], Alexander Szameit[2], Mordechai Segev[1]; [1]*Technion Israel Inst. of Technology, Israel;* [2]*Institut fur Physik, Universitat Rostock, Germany.* We report the first experimental realization of photonic topological insulators in synthetic dimensions.

FM1F • Highly Correlated and Topological States of Matter—Continued

FM1F.4 • 09:00
Light-induced Transient State in the Weyl Semimetal TaAs Revealed by Time-resolved Second Harmonic Generation, Nicholas Sirica[1], Yaomin Dai[1], Lingxiao Zhao[2], Genfu Chen[2], Run Yang[2], Bing Xu[2], Bing Shen[3], Ni Ni[3], Dmitry Yarotski[1], Stuart Trugman[1], Jianxiu Zhu[1], Xianggang Qiu[2], Toni Taylor[1], Rohit P. Prasankumar[1]; [1]*Los Alamos National Lab, USA;* [2]*Inst. of Physics Chinese Academy of Sciences, China;* [3]*Dept. of Physics and Astronomy, Univ. of California, Los Angeles, USA.* We performed time-resolved second harmonic generation (SHG) spectroscopy on the Weyl semimetal TaAs. These measurements reveal a potential transient photoinduced state as well as an ultrafast dependence of the SHG signal on pump polarization.

FM1F.5 • 09:15
Superconductor sandwiches: cuprate-manganite multilayers with a remarkable new ground state., Benjamin Mallett[1], Premysl Marsik[2], Jarji Khmaladze[2], Matteo Minola[3], M C. Simpson[1,4], Christian Bernhard[2]; [1]*Univ. of Auckland, New Zealand;* [2]*Physics, Fribourg Univ. , Switzerland;* [3]*Festkorperforschung, Max Plank Inst., Germany;* [4]*Dodd Walls Centre, New Zealand.* In thin-film sandwiches of a cuprate superconductor and specific manganite, the superconductor adopts a startling new ground state. THz ellipsometry and resistivity show it's granular-like, but becomes a 'normal' superconducting state in strong magnetic fields.

FM1F.6 • 09:30
Optically Induced Correlated Phase in $CaKFe_4As_4$ Superconductor, Richard H. Kim[1], William R. Meier[1], Chirag Vaswani[1], Xin Zhao[1], Xu Yang[1], Martin Mootz[2], Yongxin Yao[1], Mingyu Xu[1], Ilias E. Perakis[2], Cai-Zhuang Wang[1], Kai-Ming Ho[1], Serguei Budko[1], Paul Canfield[1], Jigang Wang[1]; [1]*Iowa State Univ., USA;* [2]*Univ. of Alabama at Birmingham, USA.* Ultrafast correlation phenomena is studied on a newly discovered, 1144-type superconductor $CaKFe_4As_4$ for the first time. Broadband spectral-temporal visualization follows distinct pair-breaking processes and reveal the build-up of a hidden quasiparticle phase with an estimated gap of ~10 meV.

FM1F.7 • 09:45
Probing Charge Density Wave Dynamics in Superconducting YBCO via Ultrafast X-Ray Scattering, Scott Wandel[1], F. Boschini[2,3], E.H. da Silva Neto[2,3], G. Welch[1], M.H. Seaberg[1], J.D. Koralek[1], G.L. Dakovski[1], W. Hettel[1], M.-F. Lin[1], S.P. Moeller[1], R. Coffee[1], Robert Kaindl[4], R. Liang[2,3], D. Bonn[2,3], W. Hardy[2,3], M.P. Minitti[1], D.G. Hawthorn[5], A. Damascelli[2,3], C. Giannetti[6], J.J. Turner[1], G. Coslovich[1]; [1]*Linac Coherent Light Source, SLAC National Accelerator Lab, USA;* [2]*Dept. of Physics and Astronomy, Univ. of British Columbia, Canada;* [3]*Quantum Matter Inst., Univ. of British Columbia, Canada;* [4]*Materials Sciences Division, Lawrence Berkeley National Lab, USA;* [5]*Dept. of Physics and Astronomy, Univ. of Waterloo, Canada;* [6]*Dept. of Mathematics and Physics, Universita Cattolica del Sacro Cuore, Italy.* We report optical pump-soft X-ray scattering probe studies of YBCO single crystals. The experiments reveal a picosecond relaxation dynamics of charge density waves, which is in turn strongly modified by the onset of superconductivity.

08:30–18:00 OIDA Executive Forum on the Exploding Role of Optics in Sensing, *Almaden Ballroom, Hilton San Jose*

10:00–10:30 Coffee Break, *Concourse Level*

Executive Ballroom 210G | Executive Ballroom 210H | Meeting Room 211 B/D

CLEO: QELS-Fundamental Science

FM1G • Quantum Photonic Devices—Continued

FM1G.5 • 09:00 Invited

Stopped and stationary light with cold atomic ensembles and machine learning., Ben C. Buchler[1]; [1]*Research School of Physics and Engineering, The Australian National Univ., Australia.* Using a cold atomic ensemble, we show the creation of bright stationary light and 87% efficient optical quantum memory. We also demonstrate the use of machine learning to maximise the optical depth of the atoms.

FM1G.6 • 09:30

Plasmon-Mediated Entanglement Dynamics, Benjamin Lawrie[1], Matthew A. Feldman[1,2], Ali Passian[1], Phil Evans[1], Matthew Chisholm[1], Jordan Hachtel[1], Richard Haglund[2], Eugene Dumitrescu[1]; [1]*Oak Ridge National Lab, USA;* [2]*Vanderbilt Univ., USA.* We explore the steady state entanglement of quantum emitters coupled to a lossy plasmonic reservoir and driven by laser or electron-beam pump fields with picosecond antibunching dynamics.

FM1G.7 • 09:45

Ultra Broadband Squeezing and Pairwise Mode-Locking of Coupled Parametric Oscillators, Leon Bello[1], Yaakov Shaked[1], Avi Pe'er[1]; [1]*Bar-Ilan Univ., Israel.* We present a source of bright and broadband, squeezed-light, using active coupling of two parametric oscillators. We demonstrate this design in a radio-frequency experiment, achieving pairwise mode-locking across the entire bandwidth between DC and the pump.

FM1H • Solid State Spin-Photon Interfaces—Continued

FM1H.4 • 09:00

Quantum dot single photon sources with ultra-low multi-photon error rate, Lukas Hanschke[1], Kevin Fischer[2], Stefan Appel[1], Daniil Lukin[2], Jonathan Finley[1], Jelena Vuckovic[2], Kai Müller[1]; [1]*Walter Schottky Institut, TU Munich, Germany;* [2]*E.L. Ginzton Lab, Stanford Univ., USA.* We demonstrate single-photon generation from self-assembled quantum dots with ultra-low multi-photon probability. While resonant excitation of a two-level system suffers from re-excitation, two-photon excitation of the biexciton state improves multi-photon errors by orders of magnitude.

FM1H.5 • 09:15

Quantum dot single photon sources transfer-printed on wire waveguides, Ryota Katsumi[1], Yasutomo Ota[2], Masahiro Kakuda[2], Satoshi Iwamoto[1,2], Yasuhiko Arakawa[1,2]; [1]*Inst. of Industrial Science, Japan;* [2]*Inst. for Nano Quantum Information Electronics, Japan.* We report quantum dot single photon sources coupled to glass-clad wire waveguides by transfer printing, which enables the heterogeneous source integration in a simple pick-and-place manner. A high waveguide coupling efficiency >60% is experimentally demonstrated.

FM1H.6 • 09:30

Highly Indistinguishable Room Temperature Single Photon Sources with Quantum Emitters in Bad Cavity Regime, Hyeongrak Choi[1], Di Zhu[1], Dirk Englund[1]; [1]*MIT, USA.* We propose room temperature indistinguishable single photon sources based on quantum emitters in solid and nanophotonic cavities. Our approach does not require ultrafast pumping as plasmonic approaches and ultra-high quality factor cavity as funneling regime.

FM1H.7 • 09:45

Near Lifetime-Limited Emitter in a Nanophotonic Waveguide, Henri T. Nielsen[1], Gabija Kirsanskė[1], Hanna Le Jeannic[1], Tommaso Pregnolato[1], Liang Zhai[1], Leonardo Midolo[1], Nir Rotenberg[1], Alisa Javadi[1], Rüdiger Schott[2], Andreas Wieck[2], Arne Ludwig[2], Matthias Löbl[3], Immo Söllner[3], Richard Warburton[3], Peter Lodahl[1]; [1]*Niels Bohr Inst., Univ. of Copenhagen, Denmark;* [2]*Lehrstuhl für Angewandte Festkörperphysik, Ruhr-Universität Bochum, Germany;* [3]*Dept. of Physics, Univ. of Basel, Switzerland.* Coherent light-matter interactions are key to a range of quantum optical technologies and experiments. We present measurements showing near-life-time limited transitions, for quantum dots embedded in nanoguides, demonstrating the robust suppression of environmental decoherence processes.

CLEO: Science & Innovations

SM1I • Modulator on Integrated Platform—Continued

SM1I.5 • 09:00

110 Attojoule-per-bit Efficient Graphene-based Plasmon Modulator on Silicon, Rubab Amin[1], Sikandar Khan[1], Cheol J. Lee[2], Hamed Dalir[3], Volker J. Sorger[1]; [1]*George Washington Univ., USA;* [2]*Korea Univ., South Korea;* [3]*Omega Optics Inc., USA.* We demonstrate a plasmonic Graphene-based electro-absorption modulator heterogeneously integrated in Silicon photonics consuming 110 aJ/bit and being 15 μm compact. We show how the plasmonic metal enables steep switching via improved contact resistance.

SM1I.6 • 09:15

Ultra-Fast Compact Plasmonic Modulator based on Adiabatic Coupled Waveguides, Rui Wang[1], Hamed Dalir[3], Farzard Koushyari[1], Xiaochuan Xu[3], Zeyu Pan[1], Shuai Sun[2], Volker J. Sorger[2], Ray Chen[1]; [1]*ECE, Univ. of Texas, Austin, USA;* [2]*ECE, The George Washington Univ. , USA;* [3]*Omega Optics, USA.* Compact plasmonic modulator based on adiabatic coupled waveguides obtains insertion loss as low as <0.1 dB with the extinction ratio exceeding 40 dB. In addition the speed of 400 GHz with footprint of 2.7 μm^2 is expected

SM1I.7 • 09:30

Microwave-to-Optical Converter based on Integrated Lithium Niobite Coupled-Resonators, Mian Zhang[1], Cheng Wang[1], Yaowen Hu[1,2], Amirhassan Shams-Ansari[1,3], Guilhem Ribeill[4], Mohammad Soltani[4], Marko Loncar[1]; [1]*John A. Paulson School of Applied and Engineering Sciences, Harvard Univ., USA;* [2]*Dept. of Physics, Tsinghua Univ., China;* [3]*Dept. of Electrical Engineering and Computer Science, Howard Univ., USA;* [4]*BBN, Raytheon, USA.* We experimentally demonstrate an efficient classical microwave-to-optical converter using coupled optical microresonators on lithium niobite with $Q = 2.7\times10^6$. We measure full-depth optical modulation with a 7 GHz microwave driving voltage V_{rms} = 70 mV.

SM1I.8 • 09:45

Nonreciprocal Modulation via Intermodal Brillouin Scattering in a Silicon Waveguide, Eric Kittlaus[1], Nils T. Otterstrom[1], Prashanta Kharel[1], Shai Gertler[1], Peter T. Rakich[1]; [1]*Yale Univ., USA.* We report non-reciprocal optical modulation and mode conversion mediated by an optically-driven acoustic wave. Through this process, we experimentally demonstrate >20 dB of nonreciprocity over a >1 nm optical bandwidth in an integrated silicon waveguide.

08:30–18:00 OIDA Executive Forum on the Exploding Role of Optics in Sensing, *Almaden Ballroom, Hilton San Jose*

10:00–10:30 Coffee Break, *Concourse Level*

CLEO: Applications & Technology

AM1J • Advanced Microscopy and Imaging Techniques—Continued

AM1J.4 • 09:00
Plasmonics Improves the Sensitivity of Smartphone Fluorescence Microscopy, Qingshan Wei[1], Guillermo Acuna[2], Seungkyeum Kim[3], Carolin Vietz[2], Derek Tseng[3], Jongjae Chae[3], Daniel Shir[3], Wei Luo[3], Philip Tinnefeld[2], Aydogan Ozcan[3]; *[1]North Carolina State Univ., USA; [2]Braunschweig Univ. of Technology, Germany; [3]Univ. of California, Los Angeles, USA.* We developed a handheld and cost-effective surface-enhanced smartphone fluorescence microscope that showed ~10-fold improvement in signal by using a thin silver film as a plasmonic substrate, enabling the detection of ~80 fluorophores per diffraction-limited spot.

AM1J.5 • 09:15
Deep Learning Microscopy: Enhancing Resolution, Field-of-View and Depth-of-Field of Optical Microscopy Images Using Neural Networks, Yair Rivenson[1], Zoltán Göröcs[1], Harun Günaydin[1], Yibo Zhang[1], Hongda Wang[1], Aydogan . Ozcan[1]; *[1]Univ. of California Los Angeles, USA.* We demonstrate the ability of deep convolutional neural networks to significantly enhance the spatial resolution, field-of-view and depth-of-field of optical microscopy images, without any hardware modification to the imaging system.

AM1J.6 • 09:30
High-resolution optical coherence tomography *in vivo* using a nano-optic endoscope, Hamid Pahlevaninezhad[1,2], Mohammadreza Khorasaninejad[2], Yao-Wei Huang[2,3], Zhujun Shi[4], Lida Hariri[1], David Adams[1], Alexander Zhu[2], Cheng-Wei Qiu[3], Federico Capasso[2], Melissa Suter[1]; *[1]Harvard Medical Shool, USA; [2]School of Engineering and Applied Science, Harvard Univ., USA; [3]Electrical and Computer Engineering, National Univ. of Singapore, Singapore; [4]Physics, Harvard Univ., USA.* This work establishes a new class of endoscopic optical imaging catheters, termed nano-optic endoscopes, that uses metalenses with the ability to modify the phase of incident light at sub-wavelength level.

AM1J.7 • 09:45
Robust Holographic Autofocusing Based on Edge Sparsity, Yibo Zhang[1], Hongda Wang[1], Yichen Wu[1], Miu Tamamitsu[1], Aydogan . Ozcan[1]; *[1]Univ. of California Los Angeles, USA.* A robust holographic autofocusing criterion based on the edge sparsity of refocused images is presented. Its performance is experimentally validated by imaging various samples with different complex-valued optical transmission functions.

CLEO: Science & Innovations

SM1K • Raman Scattering and Applications—Continued

SM1K.5 • 09:00
Power Combined, Octave-spanning, CW Supercontinuum using Standard Telecom Fiber with Output Power of 70W, Arun S[1], Vishal Choudhury[1], V Balaswamy[1], V R Supradeepa[1]; *[1]Centre for Nano Science and Engineering, Indian Inst. of Science (IISc), India.* We demonstrate a high power 70W continuous-wave supercontinuum laser using standard telecom fiber, spanning over an octave (850-1900nm). A novel, nonlinear, Raman based power-combining scheme of two independent fiber lasers is used to pump the supercontinuum.

SM1K.6 • 09:15
Multi-Wavelength Diode-Pumping of Fiber Raman Laser, Soonki Hong[1], Yutong Feng[1], Johan Nilsson[1]; *[1]Optoelectronic research centre, UK.* A fiber Raman laser pumped by two wavelength-combined multimode diode lasers at 950 nm and 976 nm generates up to 23 W of output power at a single wavelength (1020 nm) with 51% slope efficiency.

SM1K.7 • 09:30
Enhancing the Detection Sensitivity of Temporal Imaging by Distributed Raman Amplification, Lingxiao Yang[1], Sheng Wang[1,2], Chi Zhang[2], Bowen Li[1], Kenneth Kin-Yip Wong[1]; *[1]the Univ. of Hong Kong, China; [2]Wuhan National Lab for Optoelectronics,, Huazhong Univ. of Science and Technology, China.* Distributed Raman amplification is integrated into the temporal imaging system for the first time to enhance the detection sensitivity. 6.7-dB sensitivity improvement has been experimentally demonstrated for a 20-nm-bandwidth signal by a 170-mW Raman pump.

SM1L • Precision Clocks and Time Transfer—Continued

SM1L.4 • 09:00
Absolute Frequency Comb Comparisons and the Measurement of Optical Atomic Clock Transitions, Holly F. Leopardi[1,2], Josue Davila-Rodriguez[2], Jeff Sherman[2], Franklyn Quinlan[2], Scott Diddams[2,1], Tara M. Fortier[2]; *[1]Univ. of Colorado Boulder, USA; [2]NIST, USA.* We present agreement in the measurement of optical clock transition frequencies using two independent optical frequency combs to sub-millihertz levels and discuss experiments to improve the measurement instability via coherent atomic clock spectroscopy.

SM1L.5 • 09:15
Sub-mHz Spectral Purity Transfer for Next Generation Strontium Optical Atomic Clocks, Michele Giunta[1,2], Wolfgang Hänsel[1], Matthias Lezius[1], Marc Fischer[1], Ronald Holzwarth[1,2]; *[1]Menlo Systems GmbH, Germany; [2]Max Planck Inst. of Quantum Optics, Germany.* We report on a Er:fiber-based optical frequency comb transferring the stability of ultra-stable lasers from 194THz to 429THz. Sub-mHz level transfer to a fiber-delivered 698.44nm output port for future Strontium QPN-limited lattice clocks is demonstrated.

SM1L.6 • 09:30 Invited
Portable Optical Lattice Clocks, Christian Lisdat[1], Jacopo Grotti[1], Silvio Koller[1], Sofia Herbers[1], Stefan Vogt[1], Sebastian Häfner[1], Uwe Sterr[1], Stefano Origlia[2], Mysore Pramod[2], Stephan Schiller[2]; *[1]Physikalisch-Technische Bundesanstalt, Germany; [2]Heinrich-Heine-Universität Düsseldorf, Germany.* I will report on two transportable lattice clocks with strontium. The first was built by PTB and is installed in a car trailer. It was used to demonstrate 'chronometric levelling', i.e. height measurements with clocks by frequency comparisons against a reference clock via optical fibre links. The second apparatus originates from the Space Optical Clock consortium, which has the goal to prepare a space mission with an optical lattice clock. The work is supported by CRC 1128 *geo*-Q and iSOC.

08:30–18:00 OIDA Executive Forum on the Exploding Role of Optics in Sensing, *Almaden Ballroom, Hilton San Jose*

10:00–10:30 Coffee Break, *Concourse Level*

Marriott Salon III

CLEO: Applications & Technology

AM1M • Laser-based Advanced Manufacturing & Materials Processing—Continued

AM1M.4 • 09:00
Study for Black Marking of Steel with Short Pulsed and Ultrashort Pulsed Lasers, Daniel Albrecht[1], Tobias Schneider[2], Claudia Unger[1], Jürgen Koch[1], Oliver Suttmann[1], Ludger Overmeyer[1,2]; *[1]Laser Zentrum Hannover e.V., Germany; [2]Institut für integrierte Produktion Hannover gGmbH, Germany.* Black marking as micrometer scaled binary coding applied on shafts by ultrashort pulsed lasers with high contrast and without ablation as a non-contact sensor system for combined measurement of angular position and torque.

AM1M.5 • 09:15
Laser-based Fabrication of Microfluidic Devices for Porous Media Applications, Krystian L. Wlodarczyk[1], Amir Jahanbakhsh[1], Richard Carter[1], Robert R. Maier[1], Duncan P. Hand[1], Mercedes Maroto-Valer[1]; *[1]Heriot-Watt Univ., UK.* A picosecond laser is used for rapid prototyping of enclosed microfluidic devices from borosilicate glass substrates. The fabrication method and applications of these devices for the investigation of subsurface flow processes in porous media are presented.

AM1M.6 • 09:30
Ultrafast Laser Texturing on Si with Burst-mode Picosecond Laser Pulses, Iaroslav Gnilitskyi[3,1], Leonardo Orazi[1], Tommi White[2], Vitaly Gruzdev[2]; *[1]UNIMORE, Italy; [2]Dept. of Mechanical & Aerospace Engineering, Univ. of Missouri, USA; [3]NoviNano Inc., Ukraine.* Picosecond laser-induced periodic surface structures (PLIPSS) have been fabricated on surface of Si in uniform and burst-mode regimes at a high speed. The effects of burst-mode respect to uniform one are examined in term of chemical, mechanical and morphological properties.

AM1M.7 • 09:45
Influence of Laser Power and Scanning Velocity in One- and Two-Step Laser Cladding on Ultra-Thin Substrates, Tobias Gabriel[1], Florian Scherm[1], Marek Gorywoda[2], Uwe Glatzel[1]; *[1]Metals and Alloys, Univ. Bayreuth, Germany; [2]Materials Engineering, Univ. of Applied Sciences Hof, Germany.* Laser cladding on 200 µm thin substrates is a challenge due to poor heat dissipation. Successful coatings were produced using Yb fiber laser with closed-loop controlled laser power. Samples were investigated by SEM and EDS.

Marriott Salon IV

CLEO: Science & Innovations

SM1N • Advanced Laser Technologies—Continued

SM1N.5 • 09:00
In situ 3-D temperature mapping of high average power cryogenic laser amplifiers, Han Chi[1], Kristian Dehne[2], Cory Baumgarten[3], Hanchen Wang[3], Liang Yin[1], Brendan Reagan[1,2], Jorge Rocca[1,2]; *[1]Dept. of Electrical and Computer Engineering, Colorado State Univ., USA; [2]XUV Lasers, Inc, PO Box 273251, USA; [3]Dept. of Physics, Colorado State Univ., USA.* We demonstrate an accurate, in situ, noninvasive optical technique to generate 2-D and 3-D maps of the temperature profile within cryogenic amplifiers operating at high average power.

SM1N.6 • 09:15
Transition-metal-doped solid-state saturable absorbers for passively Q-switched visible Pr:YLF lasers, Hiroki Tanaka[1,2], Elena Castellano-Hernández[2], Christian Kränkel[2,3], Fumihiko Kannari[1]; *[1]Keio Univ., Japan; [2]Center for Laser Materials, Leibniz Inst. for Crystal Growth, Germany; [3]Inst. of Laser-Physics, Universität Hamburg, Germany.* We report the first visibly emitting Q-switched laser based on Co^{2+}:$Gd_3Ga_5O_{12}$ as the saturable absorber material and present a detailed characterization of the visible saturable absorption properties of various Co^{2+}-doped materials.

SM1N.7 • 09:30
Spectrally tunable, temporally shaped parametric front end to seed high-energy laser systems, Christophe Dorrer[1], Albert Consentino[1], Robert Cuffney[1], Ildar Begishev[1], Elizabeth Hill[1], Jake Bromage[1]; *[1]Univ. of Rochester, USA.* We demonstrate the generation of temporally shaped pulses at the 200-mJ level with a tuning range greater than 15 nm via parametric amplification as a high-performance alternative to Nd-doped laser systems.

SM1N.8 • 09:45
Generation of high-fidelity few-cycle pulses via nonlinear ellipse rotation in a stretched hollow-fiber compressor, Nikita Khodakovskiy[1,2], Mikhail Kalashnikov[2], Andreas Blumenstein[3,4], Peter Simon[4], Tamas Nagy[2], Melek Merve Toktamis[5], Magali Lozano[5], Brigitte Mercier[5], Rodrigo Lopez-Martens[5]; *[1]ELI-ALPS Research Inst., Hungary; [2]Max-Born-Inst., Germany; [3]Univ. of Kassel, Germany; [4]Laser-Laboratorium Göttingen e.V., Germany; [5]Laboratoire d'Optique Appliquée, France.* We report the generation of high-fidelity few-cycle pulses by nonlinear ellipse rotation in a hollow-fiber compressor. The use of flexible hollow-fiber technology and a pressure gradient enables simultaneous temporal filtering and spectral broadening with record-high efficiency.

Marriott Salon V

SM1O • Fundamentals of Light-matter Interaction—Continued

SM1O.4 • 09:00
Variable Pattern Projection via a Spatial Light Modulator for Laser Machining on Curved Surfaces, Benjamin Mills[1], Daniel Heath[1], James Grant-Jacob[1], Richard Oreffo[1], Robert Eason[1]; *[1]Univ. of Southampton, UK.* A spatial light modulator can enable precise laser machining on highly curved surfaces without the need for sample rotation, via a beam intensity profile transformation that takes into account the local gradient on the sample.

SM1O.5 • 09:15
Cavity Coupled Hexagonal Boron Nitride Emitters, Sejeong Kim[1], Minh Nguyen[1], Johannes E. Fröch[1], Milos Toth[1], Igor Aharonovich[1]; *[1]Univ. of Technology Sydney, Australia.* We present methods to integrate quantum emitters embedded in hBN to plasmonic and dielectric cavities. Precisely positioned gold nanoparticles in the vicinity of hBN flakes led to emission enhancement. Furthermore, we propose photonic crystal cavities for diverse photonic and quantum applications.

SM1O.6 • 09:30
Waveguide-coupling of pillar microcavities for efficient single quantum dot emission., Tobias Huber[1], Olivier Gazzano[1], Yichen Shuai[1], Glenn S. Solomon[1]; *[1]JQI (NIST/UMD), USA.* We demonstrate a series of pillar microcavities integrated in an optical waveguide. The structure can be used for resonant excitation and single photon emission with spatially orthogonal pump-probe geometry, or for on-chip/off-chip optical coupling.

SM1O.7 • 09:45
Utilization of self-absorption for high resolution laser induced breakdown spectroscopy, Ali Rastegari[1], Matthias Lenzner[2], Ladan Arissian[1], Jean-Claude M. Diels[1], Kristen Peterson[3]; *[1]UNM, USA; [2]Lenzner Research LLC, USA; [3]Southwest Sciences, USA.* The shock wave created by a high energy UV filament is sufficient to create a low density region in the ablation plume enabling higher resolution in laser induced breakdown spectroscopy. Isotopic selectivity is demonstrated.

08:30–18:00 OIDA Executive Forum on the Exploding Role of Optics in Sensing, *Almaden Ballroom, Hilton San Jose*

10:00–10:30 Coffee Break, *Concourse Level*

Marriott Salon VI

CLEO: Applications & Technology

AM1P • A&T Topical Review on Photonics-enabled Quantum Technologies in Transition I—Continued

AM1P.3 • 09:00 Invited

Engineering Challenges in Commercial Photonics-enabled Quantum Technologies, Max Perez[1]; *[1]ColdQuanta, Inc., USA.* As quantum technologies mature, their physical potential clarify but the practical engineering challenges remain. We describe the challenges and trade-offs made when transitioning quantum devices from the Lab to the commercial domain.

AM1P.4 • 09:30

10 years of commercial quantum key distribution: engineering achievements and market challenges, Rik van Gorsel, *id Quantique, USA.* Quantum communication needs good and reliable instrumentation. ID Quantique (IDQ) started in 2002. In order to launch our QKD system in 2007 for elections in the Swiss canton of Genève, we needed to develop the necessary instrumentation as very little existed. For example, a good NIR-SPAD (near infrared single photon avalanche photodiode detector). We have continuously been improving the detectors, so that now we have a NIR-SPAD with single digit dark count rates per second. With such a low dark count rate instrument, we have been able to show quantum key distribution through more than 300 km of high quality optical communication fiber. Our developments in electronics have paralleled the developments in single photon instrumentation. Good hardware is not enough for good technology. Quantum physics-based hardware, firmware, and QKD software needs to be integrated. It also requires the ability and flexibility to integrate new technological developments in any area of quantum communication. For example, originally systems were all-fiber. Current developments in free space communication are rapid and it is not unlikely that a reliable, robust infrastructure will mean a distributed hybrid system with a combination of free space (large distances) and wired communication (in hubs, and free space complement). Good technology is not enough for a good quantum communication network. Trust probably is the most precious element. Trust takes years to build and is very valuable to us. Trust cannot be abstract, but has to practical and verifiable. For example, our quantum random number generator (QRNG) has been time-proven, and certified by independent organizations in different countries. Current progress in quantum communication is rapid and accelerating and makes the development of solutions to technology and implementation bottlenecks more urgent. I look forward to detail both the technological achievements and discuss the constraints, including limitations by the current infrastructure, solutions to national security concerns of global quantum communication network(s), and the feasibility of cross-border partnerships, e.g. IDQ and US partners.

Marriott Willow Glen

CLEO: QELS-Fundamental Science

FM1Q • Optical Filamentation and X-rays—Continued

FM1Q.5 • 09:00

Picosecond backward-propagating lasing of atomic hydrogen via femtosecond 2-photon-excitation in a flame, PengJi Ding[1], Maria Ruchkina[1], Yi Liu[2], Andreas Ehn[1], Marcus Aldén[1], Joakim Bood[1]; *[1]Division of Combustion Physics, Dept. of Physics, Lund Univ., Sweden; [2]Univ. of Shanghai for Science and Technology, China.* We report on the observation of backward-propagating 656-nm lasing of atomic hydrogen in flame using 205-nm femtosecond laser pulses. It shows a donut-shaped spatial mode and smooth temporal profile, suggesting spatially-resolved measurements in few-millimeters resolution.

FM1Q.6 • 09:15

Few-Cycle-Culse-Driven Metasurface-Based Multi-Color X-ray Source, Gilles D. Rosolen[1], Liang Jie Wong[2], Nicholas Rivera[3], Bjorn Maes[1], Marin Soljacic[3], Ido Kaminer[4,3]; *[1]Univ. of Mons, Belgium; [2]Singapore Inst. of Manufacturing Technology, Singapore; [3]MIT, USA; [4]Technion - Israel Inst. of Technology, Israel.* We present a multi-harmonic metasurface-based hard X-ray source in which velocity-matched few-cycle laser pulses lead to output brightness enhancements of over 1000 times compared with the non-optimized case.

FM1Q.7 • 09:30

Parametric-Down Conversion of X-rays into the Optical Regime, Aviad Schori[1], Christina Bömer[2], denis borodin[1], Steve Collins[3], Blanka detlefs[4], Marco Moretti Sala[4], Shimon Yudovich[1], Sharon Shwartz[1]; *[1]Bar-Ilan Univ., Israel; [2]European XFEL, Germany; [3]Diamond Light Source, UK; [4]European Synchrotron Radiation Facility, France.* We observe parametrically down converted x-ray signal photons that correspond to idler photons at optical wavelengths. The results represent a new method for probing valence-electron charges and microscopic optical responses of crystals with atomic-scale resolution.

FM1Q.8 • 09:45

Resonance-Enhanced Harmonics From Air Plasma In The Perturbative Regime, Rostyslav Danylo[1,2], Yi Liu[1,2], Mingwei Lei[4], An Zhang[4], Qingqing Liang[1], Zhengquan Fan[1], Xiang Zhang[1], Hongbing Jiang[4], Chengyin Wu[4], Aurélien Houard[2], Vladimir Tikhonchuk[3], Qihuang Gong[4], André Mysyrowicz[2]; *[1]Shanghai Key Lab of Modern Optical System, Univ. of Shanghai for Science and Technology, China; [2]Laboratoire d'Optique Appliquée, ENSTA ParisTech, CNRS, Ecole Polytechnique, Université Paris-Saclay, France; [3]Centre Lasers Intenses et Applications, Université de Bordeaux, CEA, CNRS UMR, France; [4]State Key Lab for Mesoscopic Physics, Inst. of Modern Optics, Dept. of Physics, Peking Univ., China.* Air pumped by mid-infrared femtosecond pulses gives rise to coherent emission at 391 nm. Based on ellipticity dependence measurement and time-resolved characterization, we attribute this emission to resonance-enhanced harmonics in perturbative regime.

08:30–18:00 OIDA Executive Forum on the Exploding Role of Optics in Sensing,
Almaden Ballroom, Hilton San Jose

10:00–10:30 Coffee Break,
Concourse Level

Executive Ballroom 210A

Joint

10:30–12:30
JM2A • Symposium on Future Directions in Terahertz Nanoscopy II
Presider: Daniel Mittleman; Brown Univ., USA

JM2A.1 • 10:30 Invited
Nanoscale Electron Manipulation Using Phase-controlled THz Near-fields, Jun Takeda[1], Katsumasa Yoshioka[1], Yusuke Arashida[1], Ikufumi Katayama[1]; [1]*Yokohama National Univ., Japan.* By utilizing terahertz scanning tunneling microscopy (THz-STM) with phase-controlled THz near-fields, we could successfully implement the phase-resolved sub-cycle electron dynamics in a tunnel junction.

JM2A.2 • 11:00
Sampling the Terahertz Near-Field in Ultrafast Terahertz Scanning Tunneling Microscopy, Vedran Jelic[1], Peter H. Nguyen[1], Yang Luo[1], Daniel Mildenberger[1], Jesus A. Calzada[1], Tianwu Wang[1], Frank A. Hegmann[1]; [1]*Univ. of Alberta, Canada.* We demonstrate that 800 nm femtosecond pulses focused onto the tip of an ultrafast terahertz scanning tunneling microscope (THz-STM) can be used to sample the terahertz electric near-field at the tip apex.

JM2A.3 • 11:15
Nonlinear Plasmonic Response of Doped GaAs Nanowires Observed in s-SNIM, Denny Lang[1], Leila Balaghi[1,2], Emmanouil Dimakis[1], René Hübner[1], Susanne Kehr[3], Lukas Eng[3,2], Oleksiy Pashkin[1], Stephan Winnerl[1], Harald Schneider[1], Manfred Helm[1,3]; [1]*Helmholtz-Zentrum Dresden-Rossendorf, Germany;* [2]*cfaed - Center for Advancing Electronics Dresden, Germany;* [3]*Inst. of Applied Physics, Technische Universität Dresden, Germany.* We present nanoscopic infrared-optical investigations on highly n-type doped GaAs-based nanowires, revealing interesting nonlinear phenomena such as a pronounced redshift of the plasma resonance by the strong THz fields of a free-electron laser.

JM2A.4 • 11:30
Watching a Single Molecular Orbital Move, Dominik Peller[1], Tyler Cocker[1], Ping Yu[1], Jascha Repp[1], Rupert Huber[1]; [1]*Univ. of Regensburg, Germany.* We explore a new arena of ultrafast microscopy capturing the femtosecond motion of an individual molecule. Entering a novel, single-electron tunneling regime with lightwave-driven scanning tunneling microscopy, we resolve femtosecond vibrations of a single molecule with sub-angstrom precision.

Executive Ballroom 210B

CLEO: Science & Innovations

10:30–12:30
SM2B • Novel Nanophotonic Structures and Devices
Presider: Weidong Zhou; Univ. of Texas at Arlington, USA

SM2B.1 • 10:30 Invited
Subwavelength Engineered Metamaterial Devices for Integrated Photonics, Pavel Cheben[1]; [1]*National Research Council Canada, Canada.* Subwavelength grating (metamaterial) waveguide devices are becoming established as key building blocks for advanced integrated photonic circuits. In this talk we will present an overview and recent advances of this surging field.

SM2B.2 • 11:00
Separating Valley Excitons in a MoS_2 Monolayer at Room Temperature with a Metasurface, Liuyang Sun[1], Chun-Yuan Wang[1,2], Alexandr Krasnok[3], Junho Choi[1], Jinwei Shi[4], Andre' Zepeda[1], Shangjr Gwo[2], Chih-Kang Shih[1], Xiaoqin Li[1]; [1]*Dept. of Physics, The Univ. of Texas at Austin, USA;* [2]*Dept. of Physics, National Tsing-Hua Univ., Taiwan;* [3]*Dept. of Electrical and Computer Engineering, The Univ. of Texas at Austi, USA;* [4]*Dept. of Physics and Applied Optics Beijing Area Major Lab, Beijing Normal Univ., China.* We demonstrate that by placing a MoS_2 monolayer onto a metasurface consisting of asymmetric grooves, valley polarized excitons can be spatially separated even at room temperature.

SM2B.3 • 11:15
Broadband Waveguide Integrated Black Phosphorus Modulator for Mid Infrared Application, Ruoming Peng[1], che chen[1], mo li[1]; [1]*Univ. of Minnesota Twin Cities, USA.* The optical absorption in black phosphorus could be modulated by electric field due to the QCFK effect. We extracted the extinction coefficient from free space BP device and showed 5dB modulation would be promising for integrated device.

SM2B.4 • 11:30
Small-signal model for heterogeneous integrated graphene-silicon photonics, Dun Mao[1], Thomas M. Kananen[1], Po Dong[2], Tingyi Gu[1]; [1]*Univ. of Delaware, USA;* [2]*Nokia Bell Labs, USA.* We demonstrate directly contacted graphene-silicon *p-i-n* junction for ultrafast response. The two-dimensional junction is parameterized by fitting a small-signal model to RF response. The model extrapolates a maximum bandwidth up to 70 GHz.

Executive Ballroom 210C

10:30–12:30
SM2C • Short Reach Communication
Presider: Xi Chen; Nokia Bell Labs, USA

SM2C.1 • 10:30
2.6-km All-Fiber Orbital Angular Momentum (OAM) Multiplexing Link for Data Center Networks (DCNs) using Mode Select Coupler and Commercial SFP+ Transceivers, Yize Liang[1], XINzhou Su[1], Yifan Zhao[1], Jie Hu[1], Wei Zhou[1], Yan Luo[1], Zongyuan Huang[1], ShuHui Li[1], Jian Wang[1]; [1]*WuhanNational-Lab for Optoelectron, China.* We report an all-fiber orbital angular momentum (OAM) multiplexing transmission link over 2.6-km conventional OM-3 fiber for data center networks. OAM modes are excited, multiplexed and demultiplexed by commercial SFP+ transceivers and mode selective couplers.

SM2C.2 • 10:45
Intensity-Modulation Direct-Detection OCDM System Based on Digital Up-Conversion, Xing Ouyang[1], Cleitus Antony[1], Jian Zhao[1], Giuseppe Talli[1], Paul Townsend[1]; [1]*Tyndall National Inst. , Ireland.* We propose for the first time an OCDM for IM/DD system based on digital up-conversion for access network applications. It exhibits better resilience to impairments to chromatic-dispersion-induced fading and noise than OFDM, with ~5 dB improved receiver sensitivity at 37.5 Gbit/s line rate at 80 km.

SM2C.3 • 11:00
128 × 2 Gb/s WDM PON System with a Single TDM Time Lens Source using an AlGaAs-On-Insulator Waveguide, Pengyu Guan[1], Francesco Da Ros[1], Minhao Pu[1], Mads Lillieholm[1], Yi Zheng[1], Elizaveta Semenova[1], Pierre-Yves Bony[1], Michael Galili[1], Toshio Morioka[1], Kresten Yvind[1], Leif K. Oxenlowe[1]; [1]*DTU Fotonik, Denmark.* We demonstrate a WDM-PON transmitter based on optical Fourier transformation of a single-source TDM-PON. Using a single AlGaAs-on-insulator waveguide, 128 WDM-PON signals at 2 Gb/s are generated and transmitted over a 100-km unamplified link.

SM2C.4 • 11:30
First Demonstration of Sensitivity Improvement using APD Receiver for a 100 G Single Channel PAM4 Link, Hao Huang[1], Enis Akbaba[1], Kejia Li[1], Hatem Akel[1], Tedros Tsegaye[1], Sunil Khatana[1]; [1]*Lumentum Operations LLC, USA.* We demonstrate sensitivity improvement for 100 G single wavelength PAM4 link using an APD receiver. 2.7 dB OMA sensitivity advantage is observed as compared to a PIN receiver using the same TIA

CLEO: Science & Innovations

10:30–12:30
SM2D • Nonlinear Optical Phenomena
Presider: Amol Choudhary; Univ. of Sydney, Australia

SM2D.1 • 10:30
Power and Bandwidth Scaling of Electro-Optic Frequency Comb using Cascaded Four-Wave Mixing in a loop augmented by Tailored Optical Feedback, Roopa Prakash[1], B S Vikram[1], Nagarjun KP[1], Shankar Kumar Selvaraja[1], V R Supradeepa[1]; [1]*Centre for Nano Science and Engineering, Indian Inst. of Science, Bangalore, India.* We demonstrate power and bandwidth scaling of electro-optic frequency combs using cascaded four-wave mixing in a loop augmented by tailored optical feedback. We achieve ~98 lines in a 25GHz C-band frequency comb spanning 20nm.

SM2D.2 • 10:45
Widely-Tunable Optical Parametric Oscillation in MgF_2 Microresonators, Noel Lito B. Sayson[1], Hoan Pham[1], Karen E. Webb[1], Luke S. Trainor[2], Harald G. Schwefel[2], Stephane Coen[1], Miro J. Erkintalo[1], Stuart G. Murdoch[1]; [1]*The Univ. of Auckland, New Zealand, New Zealand;* [2]*The Univ. of Otago, New Zealand.* We present a widely-tunable microresonator optical parametric oscillator based on a high-finesse MgF_2 microdisk. The oscillator operates at low-power with output parametric sidebands discretely tunable from 1166 nm to 2226 nm.

SM2D.3 • 11:00 Invited
Generation of Quantum States in Nonlinear Whispering Gallery Resonators, Christoph Marquardt[1,2]; [1]*Max-Planck-Inst Physik des Lichts, Germany;* [2]*Univ. of Erlangen-Nuremberg, Germany.* We will review a compact and highly tunable source of photon-pairs and squeezed light based on efficient parametric down conversion in a triply resonant whispering-gallery resonator (WGR) made out of lithium niobate.

SM2D.4 • 11:30
Two-Beam Coupling in Dual-Seeded Four-Wave Mixing, Nicholas Brewer[1], Meng-Chang Wu[1], Bonnie L. Schmittberger[1], Paul D. Lett[1,2]; [1]*Univ. of Maryland, USA;* [2]*National Inst. of Standards and Technology, USA.* We observe the two-beam coupling effect in dual-seeded four-wave mixing. The effect adds excess noise to the probe seeds at frequencies below 5 MHz when both probe seed powers are over 10 μW.

CLEO: QELS-Fundamental Science

10:30–12:30
FM2E • Topological Photonics and Lasers
Presider: Mikael Rechtsman; Pennsylvania State Univ., USA

FM2E.1 • 10:30 Tutorial
Topological Photonics, Mordechai Segev[1]; [1]*Technion, Israel.* The fundamentals of the new field of Topological Photonics will be described, along with recent discoveries such as photonic topological insulators in synthetic dimensions, topological protection of quantum states, and topological insulator lasers.

Moti Segev is the Robert J. Shillman Distinguished Professor of Physics, at the Technion, Israel. He received his BSc and PhD from the Technion in 1985 and 1990. After postdoc at Caltech, he joined Princeton as Assistant Professor (1994), becoming Associate Professor in 1997, and Professor in 1999. Subsequently, Moti went back to Israel, and in 2009 was appointed as Distinguished Professor. Moti's interests are mainly in nonlinear optics, photonics, solitons, sub-wavelength imaging, lasers, quantum simulators and quantum electronics, although he finds entertainment in more demanding fields such as basketball and hiking. He has won numerous international and national awards, among them the 2007 Quantum Electronics Prize of the EPS, the 2008 Landau Prize (Israel), the 2009 Max Born Award of the OSA, and the 2014 Arthur Schawlow Prize of the APS. In 2011, he was elected to the Israel Academy of Sciences and Humanities, and in 2015 he was elected to the National Academy of Science of the USA. In 2014 Moti Segev won the Israel Prize in Physics (highest honor in Israel). However, above all his personal achievements, he takes pride in the success of his graduate students and postdocs, among them are currently 19 professors in the USA, Germany, Taiwan, Croatia, Italy, India and Israel, and many holding senior R&D positions in the industry.

FM2E.2 • 11:30
Nonlinear nanophotonics and bound states in the continuum, Luca Carletti[2], Kirill Koshelev[1,3], Costantino . De Angelis[2], Yuri S. Kivshar[1]; [1]*Nonlinear Physics Centre, Australian National Univ., Australia;* [2]*Dept. of Information Engineering, Univ. of Brescia, Italy;* [3]*ITMO Univ., Russia.* We reveal that nonlinear effects at the nanoscale can be enhanced by bound states in the continuum. We demonstrate SHG from subwavelength AlGaAs nanoantennas with record-high conversion efficiency when resonator parameters match the proper conditions.

10:30–12:30
FM2F • Exciton-polaritons and Other Excitation in Semiconductions
Presider: Vinod Menon; City University of New York, USA

FM2F.1 • 10:30
Giant AC Stark Effect in a Strongly-Coupled Light-Matter System, Dimitry Panna[1], Nadav Landau[1], Shlomi Bouscher[1], Leonid Rybak[1], Shai Tsesses[1], Sebastian Brodbeck[2], Christian Schneider[2], Sven Höfling[2], Alex Hayat[1]; [1]*Technion-Israeli Inst. of technology, Israel;* [2]*Universität Würzburg, Germany.* We present the first experimental observation of a giant non-resonant dynamic Stark effect in strongly coupled microcavity exciton-polaritons – stronger than the Rabi splitting and over an order of magnitude stronger than previous observations.

FM2F.2 • 10:45
Long-Range Transport of Organic Exciton-Polaritons Revealed by Ultrafast Microscopy, Georgi Rozenman[1,2], Katherine Akulov[1,2], Adina Golombek[1,2], Tal Schwartz[1,2]; [1]*School of Chemistry, Tel-Aviv Univ., Israel;* [2]*Center for light-matter Interaction, Tel Aviv Univ., Israel.* We directly measure micron-scale transport in organic materials, induced by strong coupling and formation of cavity polaritons. Using ultrafast microscopy we follow the motion of polaritons in real-time, finding that their propagation is surprisingly slow.

FM2F.3 • 11:00
Microcavity Exciton Polaritons with Exceptional Points Induced by Polarization-Controllable Ultrastrong Coupling, Weilu Gao[1], Xinwei Li[1], Motoaki Bamba[2,3], Junichiro Kono[1,4]; [1]*Dept. of Electrical and Computer Engineering, Rice Univ. , USA;* [2]*Dept. of Materials Engineering Science, Osaka Univ., Japan;* [3]*PRESTO, Japan Science and Technology Agency, Japan;* [4]*Dept. of Physics and Astronomy, Rice Univ., USA.* We demonstrate the existence of exceptional points in the dispersion of microcavity exciton polaritons, originating from the polarization-controlled ultrastrong coupling of 1D excitons in aligned single-chirality single-wall carbon nanotubes with microcavity photons.

FM2F.4 • 11:15
Control of coherently coupled exciton-polaritons in atomic crystals, Xiaoze Liu[1], Wei Bao[1], Quanwei Li[1], Chad Ropp[1], Yuan Wang[1,2], Xiang Zhang[1,2]; [1]*Univ. of California Berkeley, USA;* [2]*Materials Sciences Division, Lawrence Berkeley National Lab, USA.* We demonstrate, for the first time, controlled polariton emission with hybrid composition in monolayer tungsten disulfide due to robust coherent exciton-photon coupling over a broad temperature range of 110-230 K in a single cavity.

FM2F.5 • 11:30
Ultrafast Near-Field Dynamics of Polariton-Exciton in WSe_2 Slab Waveguides at Room Temperature, Michael Mrejen[1], Lena Yadgarov[1], Assaf Levanon[1], Haim Suchowski[1]; [1]*Tel Aviv Univ., Israel.* We observe the propagation of an exciton-polariton wave in a WSe2 nanometric slab. We directly visualize with unprecedented spatio-temporal resolution (50 nm, <70 fs) a strikingly slow polaritonic wave with a velocity of ~ 0.017c.

CLEO: QELS-Fundamental Science

10:30–12:30
FM2G • Novel Nonophotonic Light Sources
Presider: Mo Mojahedi; Univ. of Toronto, Canada

FM2G.1 • 10:30
Reconstructing the Scattering Matrix of Photonic Systems from Their Quasinormal Modes, Filippo Alpeggiani[1,2], Nikhil Parappurath[2], Ewold Verhagen[2], Laurens K. Kuipers[1,2]; [1]*Dept. of Quantum Nanoscience, TU Delft, Netherlands;* [2]*Center for Nanophotonics, AMOLF, Netherlands.* We demonstrate that the scattering matrix of nanophotonic systems is completely determined by their quasinormal modes and present a first-principle expansion technique which is directly applicable to an arbitrary number of modes and input-output channels.

FM2G.2 • 10:45
High harmonic plasmon generation by dressed electrons, Nicholas Rivera[1], Liang Jie Wong[2], Marin Soljacic[1], Ido Kaminer[3]; [1]*MIT, USA;* [2]*SimTECH, Singapore;* [3]*Technion Israel Inst. of Technology, Israel.* We show that high harmonics of highly spatially confined plasmons can be generated via free electrons using light intensities 10^4-10^6 times smaller than is required for an equivalent multiphoton effect in free space.

FM2G.3 • 11:00 Invited
A New Class of Light Sources Based on Electrically-Driven Optical Antennas, Claire Deeb[1]; [1]*C2N - CNRS, France.* A new class of nanoscopic light sources that are not limited by quantum states, but rather depend on the antenna architecture and the applied bias is proposed. These compact light sources, based on electrically-driven optical nanogap antennas, feature a tunable emission wavelength, a high quantum efficiency, and operate at room temperature.

FM2G.4 • 11:30
Generation of Vortex Beams using a Plasmonic Quadrumer Nanocluster, Apurv Chaitanya Nellikka[1], Pawel Wozniak[2,4], Peter Banzer[2,3], Israel De Leon[1,4]; [1]*School of Engineering and Sciences, Tecnologico de Monterrey, Mexico;* [2]*Max Planck Inst. for the Science of Light, Germany;* [3]*Inst. of Optics, Information and Photonics, Germany;* [4]*Max Planck - Univ. of Ottawa Centre for Extreme and Quantum Photonics, Canada.* We show that the interaction of tightly-focused circularly-polarized Gaussian beams with a nanoplasmonic quadrumer can generate orbital angular momentum beams in the farfield. These quadrumer can act like a nano-qplate, generating desired vortex order.

10:30–12:30
FM2H • Quantum Optics with Single Atoms
Presider: Virginia Lorenz; U. Illinois at Urbana-Champaign, USA

FM2H.1 • 10:30
Atom-mediated Spontaneous Parametric Down-conversion Using Evanescent Modes in Nonlinear Periodic Waveguides, Sina Saravi[1,4], Alexander N. Poddubny[2,3], Thomas Pertsch[1], Frank Setzpfandt[1], Andrey A. Sukhorukov[4]; [1]*Abbe Center of Photonics, Friedrich Schiller Univ. Jena, Germany;* [2]*ITMO Univ., Russia;* [3]*Ioffe Inst., Russia;* [4]*Nonlinear Physics Centre, Australian National Univ., Australia.* Relying on the bandgap modes of a nonlinear periodic waveguide, we propose the concept of atom-mediated spontaneous parametric down-conversion, where photon-pairs are only generated with a single 2-level emitter present, creating a heralded excitation mechanism.

FM2H.2 • 10:45
Towards Quantum-Enabled Flow Cytometry, Ivan A. Burenkov[1], Yu-Hsiang Cheng[1], Sergey Polyakov[2]; [1]*Joint Quantum Inst., NIST and UMD, USA;* [2]*PML, National Inst. of Standards and Technology, USA.* We enhance an optical flow cytometer with a photon-number statistics measurement. Our technique allows for an absolute measurement of biomarker concentration and proves sensitivity to a single biomarker (a colloidal quantum dot).

FM2H.3 • 11:00
Purcell-enhanced single-photon emission from an atom in a fiber-based cavity, Deepak Pandey[1], Jose Gallego[1], Tobias Macha[1], Miguel Martinez-Dorantes[1], Wolfgang Alt[1], Dieter Meschede[1]; [1]*Inst. for Applied Physics, Univ. of Bonn, Germany.* We report a sixfold Purcell broadening of a resonance line of a ${}^{87}\text{Rb}$ atom, by strongly coupling it to a single-sided fiber-based Fabry-Perot cavity which collects 90$\%$ of the enhanced single photon emission.

FM2H.4 • 11:15
A Hybrid Nanophotonic-Magnetic Chip-Based Atom Trap, Adam T. Black[1], Marcel W. Pruessner[1], Doewon Park[1], Charles T. Fancher[1], Dmitry Kozak[1], Rita Mahon[1], Mark Bashkansky[1], Fredrik K. Fatemi[2], Todd Stievater[1]; [1]*US Naval Research Lab, USA;* [2]*U.S. Army Research Lab, USA.* We report progress toward the development of a chip-based cold atom trap based on nanoscale waveguides, which incorporates a fabricated two-wire magnetic trap to assist in transferring laser-cooled atoms to the waveguides.

FM2H.5 • 11:30
Coherent Superradiance by Single Atoms, Kyungwon An[1], Junki Kim[1], Daeho Yang[1], Seunghoon Oh[1]; [1]*Seoul National Univ., South Korea.* We report cavity-mediated coherent single-atom superradiance, where single atoms with predefined correlation traverse a cavity one by one, emitting photons cooperatively with the atoms already gone through the cavity during the cavity field decay time.

CLEO: Science & Innovations

10:30–12:30
SM2I • Integrated Detectors
Presider: Zhihong Huang; Hewlett Packard Labs, USA

SM2I.1 • 10:30
High-performance InGaAs/InP photodiodes on silicon using low-temperature wafer-bonding, Qianhuan Yu[1], Ye Wang[1], Linli Xie[1], Souheil Nadri[1], Keye Sun[1], jizhao zang[1], Qinglong Li[1], Robert M. Weikle[1], Andreas Beling[1]; [1]*Univ. of Viriginia, USA.* We demonstrate back-illuminated III-V modified uni-traveling carrier photodiodes on silicon using SU-8 as the bonding layer. Responsivity at 1620nm, bandwidth, output RF power and OIP3 are 0.8A/W, 18GHz, 4dBm and 22.5dBm at 9GHz, respectively.

SM2I.2 • 10:45
Germanium Photodetector with Carrier Acceleration, De Zhou[1], Yu Yu[1], Yan Zuo[1], Xinliang Zhang[1]; [1]*Wuhan National Lab for Optoelectronics, China.* We propose and demonstrate a carrier acceleration technique, which alleviates the transit-time delay by introducing a pair of on-chip accelerative electrodes. Equivalent circuit simulation and experimental results validate the improved performance.

SM2I.3 • 11:00
100 GHz Photoconductive Plasmonic Germanium Detector, Ping Ma[1], Yannick Salamin[1], Benedikt Bäuerle[1], Alexandros Emboras[1], Yuriy Fedoryshyn[1], Wolfgang Heni[1], Bojun Cheng[1], Arne Josten[1], Juerg Leuthold[1]; [1]*Eidgenossische Tech Hochschule Zurich, Switzerland.* A compact and high-speed integrated photoconductive plasmonic photodetector is demonstrated. The proposed photodetector features a bandwidth beyond 100 GHz with an internal quantum efficiency of 36 % around 1310 nm.

SM2I.4 • 11:15
Nanostructured Fishnet Silicon Photodetector Pixels as a Fully-Contained Microspectrometer Chip, Jasper Cadusch[1], Jiajun Meng[1], Kenneth B. Crozier[1,2]; [1]*Dept. of Electrical and Electronic Engineering, Univ. of Melbourne, Australia;* [2]*School of Phyiscs, Univ. of Melbourne, Australia.* We experimentally demonstrate a microspectrometer comprising twenty silicon photodetector pixels, whose responsivities are engineered via nanostructured fishnet patterns. We computationally reconstruct the spectrum of light that illuminates the chip from the measured pixel photocurrents.

SM2I.5 • 11:30
High-speed Si plasmonic photodetector based on internal photoemission and two-photon absorption, Hidetaka Nishi[1], Tai Tsuchizawa[1], Masaaki Ono[1], Masaya Notomi[1], Hiroshi Fukuda[1], Shinji Matsuo[1]; [1]*NTT, Japan.* A Si-Al plasmonic waveguide enables detection of 1550-nm light by internal photoemission and two-photon absorption. We achieve a differential responsivity of 25 mA/W including 6-dB photonic-plasmonic coupling loss and eye openings with over 40-Gbit/s signals.

CLEO: Applications & Technology

10:30–12:30
AM2J • Biomedical Imaging
Presider: Irene Georgakoudi; Tufts Univ., USA

AM2J.1 • 10:30 Invited
Interrogating Biological Dynamics in Five Dimensions with Multispectral Optoacoustic Tomography, Daniel Razansky[2,1]; [1]*Inst. for Biological and Medical Imaging, Helmholtz Center Munich, Germany;* [2]*Faculty of Medicine, Technical Univ. of Munich, Germany.* The talk focuses on the recent advances in multi-spectral optoacoustic tomography and microscopy, an emerging new technology that attains versatile endogenous and exogenous optical absorption contrast from deep tissues with excellent spatial and temporal resolution not achievable with other bio-imaging modalities.

AM2J.2 • 11:00 Invited
Optical Coherence Polarimetry,, Martin Villiger[1]; [1]*Wellman Center for Photomedicine, USA.* Tissue polarimetry offers valuable insight into the microstructure and composition of biological samples. Recent developments enable accurate reconstruction of depth-resolved polarization properties, including vectorial birefringence, with fiber and catheter-based polarization sensitive optical coherence tomography.

AM2J.3 • 11:30
Speckle-Free Non-Invasive Imaging with Speckle-Modulating Optical Coherence Tomography, Orly Liba[1], Matthew D. Lew[1], Elliott SoRelle[1], Rebecca Dutta[1], Debasish Sen[1], Darius Moshfeghi[1], Steven Chu[1], Adam de la Zerda[1]; [1]*Stanford Univ. , USA.* Speckle-Modulating Optical Coherence Tomography (SM-OCT) is a method based on light manipulation for removing speckle noise without significant loss of resolution. By removing speckle noise, SM-OCT reveals small structures in the tissues of living animals.

CLEO: Science & Innovations

10:30–12:30
SM2K • Fiber Sensing and Measurement
Presider: Stuart Jackson; Macquarie Univ., Australia

SM2K.1 • 10:30
Self-triggered Asynchronous Optical Sampling THz Spectroscopy With a Single Bidirectional Fiber Oscillator, Robert D. Baker[2], Nezih T. Yardimci[1], Khanh Q. Kieu[2], Mona Jarrahi[1]; [1]*Dept. of Electrical & Computer Engineering, Univ. of California Los Angeles, USA;* [2]*College of Optical Sciences, Univ. of Arizona, USA.* We report a self-triggered single-laser THz spectroscopy system with no moving parts or locking electronics. The simplicity of this architecture demonstrates the possibility of portable THz spectrometers with smaller size, weight and power requirements.

SM2K.2 • 10:45
Helical Long-period Fiber Grating Written in Polarization-maintaining Fiber by CO_2-laser, Chen Jiang[1], Yunqi . Liu[1], Yunhe Zhao[1], Liang Zhang[1], Chengbo Mou[1], Tingyun Wang[1]; [1]*Shanghai Univ., China.* We propose the fabrication of helical long-period fiber grating in polarization-maintaining fiber using CO_2-laser. The polarization and sensing characteristics of the gratings were investigated experimentally.

SM2K.3 • 11:00
Frequency-Shifted Interferometry with Bidirectional Electro-Optic Modulation, Huiyong Guo[1,2], Zhou Zheng[2], Yi Liu[1,2], Zeng Xiong[2], Yiwen Ou[2], Ciming Zhou[2], Li Qian[1,2]; [1]*Univ. of Toronto, Canada;* [2]*Wuhan Univ. of Technology, China.* Efficient *bi-directional* electro-optic modulation over 2-8 GHz enables location-resolved and spectral-resolved fiber grating sensor multiplexing, achieving ~3 cm spatial resolution over 1 km sensing range using low-power incoherent broadband source without optical amplification.

SM2K.4 • 11:15
Fiber Fault Detection Using Brillouin Amplification and Two-Photon Absorption Process in Si-APD, Yosuke Tanaka[1], Masaya Nemoto[1]; [1]*Tokyo Univ of Agriculture and Technology, Japan.* We experimentally demonstrate a novel method for detecting weak reflection point in an optical fiber using Brillouin amplification and two-photon absorption process in a Si-avalanche photodiode. Weak reflection after a 20-dB attenuator is successfully observed.

SM2K.5 • 11:30
Broadband Multi-Species CARS in Gas-Filled Hollow-Core Photonic Crystal Fiber, Rinat Tyumenev[1], Barbara M. Trabold[1], Luisa Späth[1], Michael H. Frosz[1], Philip S. Russell[1]; [1]*Max Planck Inst. for Light, Germany.* We report CARS in hollow-core gas-filled PCF. The results pave the way to single-shot broadband (>4000 cm^{-1}) CARS under ambient conditions. A detection limit of 300 ppm was reached with 200 mW overall laser power.

10:30–12:30
SM2L • Optical Microwave Generation
Presider: Tara Fortier; NIST, USA

SM2L.1 • 10:30 Tutorial
Synthesizing Ultrastable Radio Waves from Light, William Loh[1]; [1]*Massachusetts Inst of Tech Lincoln Lab, USA.* The continual development of advanced laser sources with ever-increasing spectral purity gives rise to the possibility of using light as the underlying means for the generation of ultrastable radio waves. In this tutorial, we review the techniques by which laser light can be used to synthesize some of the purest forms of RF oscillation known today.

William Loh is technical staff of the Quantum Information and Integrated Nanosystems group at MIT Lincoln Laboratory. He was previously at NIST Boulder and obtained his Ph.D. from MIT. His research focuses on the interplay between photonics and electronics for the generation of precision oscillators in both the optical and RF domains.

SM2L.2 • 11:30
Reduction of Amplitude-to-Phase Conversion in Charge-Compensated Modified Uni-traveling Carrier Photodiodes, Jizhao Zang[1], Xiaojun Xie[1], Qianhuan Yu[1], Keye Sun[1], Andreas Beling[1], Joe C. Campbell[1]; [1]*Univ. of Virginia, USA.* We report optimization of charge-compensated modified unitravelling carrier photodiodes to reduce amplitude-to-phase conversion. Phase variation with photocurrent is decreased by up to 5 times.

CLEO: Applications & Technology

10:30–12:30
AM2M • Material Processing Lasers and Sensing Technologies
Presider: TBD

AM2M.1 • 10:30 Invited
Industrial Applications Enabled by Energetic Next-generation High Average Power Diode-pumped Solid-state Lasers, Craig W. Siders[1]; [1]*Lawrence Livermore National Lab, USA*. We will review the needs for next-generation applications of high-power lasers, compare with state-of-the-art technical performances, and discuss DPSSL architectures, evolved from Inertial Confinement Fusion and Inertial Fusion Energy lasers, to deliver multi-100-kW, PW-class performances.

AM2M.2 • 11:00
Normal dispersion thulium fiber for ultrafast near-2 μm fiber laser, Yuhao Chen[1], Raghuraman Sidharthan[1], Daryl Ho[1], Dingyuan Tang[1], Seongwoo Yoo[1]; [1]*Nanyang Technological Univ., Singapore*. We report fabrication of a normal dispersion thulium-doped fiber with a W-type index profile. The fiber is employed in a ring cavity to demonstrate mode-locked laser near 2 μm with a saturable absorber.

AM2M.3 • 11:15
Single-frequency Mod-hop Free Tunable 3um Laser Pumped by a 2W Diode for Isotopic Gas Sensing, Jui-Yu Lai[2,1], Hsuan-Tse Guo[2], Yu-Chen Chen[2], Cheng-Wei Hsu[2,1], Dong-Yi Wu[2], Ming-Hsien Chou[2], Shang-Da Yang[1]; [1]*Inst. of Photonics Technologies, National Tsing Hua Univ., Taiwan;* [2]*HC Photonics Corp., Taiwan*. A diode-pumped intracavity optical parametric oscillator is built to demonstrate single-frequency and mod-hop free tuning operation over 20 GHz range around 3 um. Performance is verified by measuring absorption spectrum of isotopic methane.

AM2M.4 • 11:30
Industrial GHz femtosecond amplified laser source for high efficiency laser ablation, Guillaume Bonamis[1], Konstantin Mishchik[1], Inka Manek-Hoenninger[2], Clemens Hoenninger[1], Eric Mottay[1]; [1]*Amplitude Systemes, France;* [2]*Université Bordeaux, France*. We present a new high power industrial GHz femtosecond laser. The laser source provides GHz-bursts with up to 100W average power. First ablation tests show a three times increase in ablation efficiency.

CLEO: Science & Innovations

10:30–12:30
SM2N • Fiber and Wave Guide Lasers
Presider: Thomas Spinka; Lawrence Livermore National Lab, USA

SM2N.1 • 10:30
Self-seeded high-power Mamyshev oscillator, Pavel Sidorenko[1], Walter P. Fu[1], Logan Wright[1], Frank W. Wise[1]; [1]*School of Applied and Engineering Physics, Cornell, USA*. We demonstrate an environmentally stable, self-seeded fiber oscillator based on spectral reshaping and reamplification. The oscillator delivers 140 nJ, linearly chirped pulses with 110 nm spectral bandwidth that can be compressed externally to 65 fs.

SM2N.2 • 10:45
Tunable Deep UV to UV radiation source in plasma-core fiber, Frédéric Delahaye[1], Foued Amrani[1], Benoit Debord[1,2], Luis Lemos Alves[3], Frédéric Gérôme[1,2], Fetah Benabid[1,2]; [1]*GPPMM, XLIM, UMR 7252 Univ. de Limoges, France;* [2]*Glo-Photonics, France;* [3]*Instituto de Plasmas e Fusão Nuclea, Portugal*. We report on the first tunable plasma-core fiber based DUV-UV radiation source. The emission spans over 236-450 nm range. The source is a made with microwave-driven plasma-core photonic-crystal-fiber and with a fixed beam output-coupling configuration.

SM2N.3 • 11:00
Mechanically exfoliated Rhenium disulfide onto D-shaped optical fiber for sub-300 fs EDFL mode-locking, David Steinberg[1], Juan Zapata[1], Eunézio Thoroh de Souza[1], Lúcia Saito[1]; [1]*Universidade Presbiteriana Mackenzie, Brazil*. For the first time, we present the ultrashort pulse generation of sub 300-fs mode-locked Erbium doped fiber laser using mechanically exfoliated ReS_2 deposited onto the polished surface of a D-shaped optical fiber.

SM2N.4 • 11:15
All Fiber Laser with the Gain Medium of Tm^{3+} Doped ZBLAN Fiber at 785 nm, Masoud Mollaee[1,2], Xiushan Zhu[1], kort Wiersma[2], Jie zong[2], arturo Chavez-Pirson[2], Nasser Peyghambarian[1]; [1]*Univ. of Arizona, USA;* [2]*NP Photonics, USA*. All fiber laser with about 0.5 W continuous-wave single transverse mode obtained with 0.1 %mol 3-m thulium doped fluoride fiber. Ytterbium doped fiber laser at 1125 nm was used as the pump source.

SM2N.5 • 11:30
Hybrid mode-locked 2 μm fiber laser with sub-megahertz repetition rate, Sun Do Lim[3,1], Jinhwa Gene[3], Seung Kwan Kim[3,1], Dong-il Yeom[2]; [1]*Measurement Science, Korea Univ. of Science and Technology, South Korea;* [2]*Physics, Ajou Univ., South Korea;* [3]*Physical Metrology, Korea Research Inst. of Standards and Science , South Korea*. We demonstrated a high pulse energy, hybrid mode-locked thulium-doped fiber laser with a repetition rate of 427 kHz, the lowest repetition rate at 2 μm to the best of our knowledge.

10:30–12:30
SM2O • Light Matter Interaction in Plasmonic & Metameterials
Presider: Zijie Yan; , USA

SM2O.1 • 10:30
Welding Dynamics of Plasmonic Gold Nanorods Under Femtosecond Laser Excitation, Ryan J. Suess[1], Paul Johns[2], Jawad Naciri[1], Nicholas Charipar[1], Jacob Fontana[1]; [1]*U.S. Naval Research Lab, USA;* [2]*American Society for Engineering Education Postdoctoral Fellow, U.S. Naval Research Lab, USA*. Suspensions of isolated and molecularly linked gold nanorods are investigated using time-domain spectroscopy. Unique dynamics are observed for each configuration, and indicate laser-induced concatenation of the linked nanorods occurs on picosecond timescales.

SM2O.2 • 10:45
Tuning Optical Matter Chains by Polarization Modulation, Fan Nan[1], Zijie Yan[1]; [1]*Clarkson Univ., USA*. We show that the optical binding interactions among metal nanoparticles can be tuned by modulating the polarization states of light, and the spatio-temporal stability of optical matter can be explored by introducing polarization perturbation.

SM2O.3 • 11:00 Invited
Light-Matter Interactions in Hybrid Plasmonic Systems, Stephen K. Gray[1]; [1]*Argonne National Lab, USA*. Models of quantum dots interacting with plasmonic systems show lead to optical transparencies and more general Fano resonances. The approach to the strong coupling is also discussed and, with two or more quantum dots, the possibility of quantum entanglement mediated through the plasmon arises.

SM2O.4 • 11:30
Using Planar Hyperbolic Metamaterials to Enhance Spontaneous Emission in Two-dimensional Transition Metal Dichalcogenides, Chen-An Lin[1], Cheng-Li Yu[1], Hsiang-Ting Lin[2], Chiao-Yun Chang[2], Hao-Chung Kuo[1], Min-Hsiung Shih[1,2]; [1]*Dept. of Photonics & Inst. of Electro-Optical Engineering, National Chiao Tung Univ., Taiwan;* [2]*Research Center for Applied Sciences (RCAS), Academia Sinica, Taiwan*. We designed one-dimensional planar hyperbolic metamaterials (P-HMMs) which supported high k modes and had better coupling compared to multilayers HMMs. Therefore, spontaneous emission enhancement and the strong coupling between P-HMMs and 2D materials were achieved.

CLEO: Applications & Technology

10:30–12:30
AM2P • A&T Topical Review on Photonics-enabled Quantum Technologies in Transition II
Presider: TBD

AM2P.1 • 10:30 Invited
The Challenge of Complexity, Control, and Low Reliability in Quantum Sensors, John H. Burke[1]; [1]*US Air Force Research Lab, USA.* TBD

AM2P.2 • 11:00 Invited
Photonics for Quantum Sensing, Brenton C. Young[1]; [1]*AOSense, Inc., USA.* Critical defense and civilian assets currently rely on the exquisite accuracy of atomic clocks. The rapidly expanding capabilities of quantum sensors will soon revolutionize high-accuracy navigation. AOSense is developing robust quantum technology components and systems.

AM2P.3 • 11:30 Invited
Quantum RF Electric-field Sensing with Rydberg-atom Vapors, David Andersen; *Rydberg Technologies LLC, USA.* The emergence of quantum sensor technologies is driving a paradigm shift in modern sensing and measurement instrumentation by enabling fundamentally new detection capabilities and performance metrics that are unmatched by those of traditional sensor technology. Quantum sensing of radio-frequency (RF) electric fields using Rydberg electromagnetically-induced transparency (EIT) in atomic vapors has recently been established as a viable new quantum technology, and rapid progress is being made towards practical measurement devices. In this talk I will provide an overview of the technology, from the underlying measurement method to notable recent advances, including the realization of compact sensing elements capable of broadband RF measurement for MHz to >100 GHz electric fields, and measurement ranges spanning sub-10 mV/m to >10 kV/m (120 dB dynamic range in intensity). Existing challenges in extending RF field sensitivity limits, as well as new measurement capabilities and future directions will be discussed.

CLEO: QELS-Fundamental Science

10:30–12:30
FM2Q • Non-Hermitian and PT Photonics
Presider: Yuan Wang; Univ. of Berkeley, USA

FM2Q.1 • 10:30
Non-Hermiticity-induced flat bands, Hamidreza Ramezani[1]; [1]*Univ. of Texas,Rio Grande Valley, USA.* We show increasing the non-Hermiticity in PT-symmetric Lieb lattices results in generating a robust entire flat band at the exceptional point. The obtained flat band is embedded in between dispersive bands and can be considered as BIC [1].

FM2Q.2 • 10:45
Photonic Parity-Time Symmetric Topological Edge States in a Two-Dimensional Lattice., Jiho Noh[1], Wladimir A. Benalcazar[2], Taylor L. Hughes[2], Mikael C. Rechtsman[1]; [1]*Dept. of Physics, Pennsylvania State Univ., USA;* [2]*Dept. of Physics, Univ. of Illinois at Urbana-Champaign, USA.* We propose the realization of topological edge states in two-dimensional non-Hermitian parity-time symmetric structure with C_6 symmetry. Also, we study the bulk topological invariants that explain the topological phase of the non-Hermitian Hamiltonian.

FM2Q.3 • 11:00
Non-Hermitian Topological Photonics, Bo Zhen[1], Hengyun Zhou[2], Chao Peng[2], Yoseob Yoon[2], Chia Wei Hsu[3], Keith Nelson[2], Huitao Shen[2], Liang Fu[2], John Joannopoulos[2], Marin Soljacic[2]; [1]*Univ. of Pennsylvania, USA;* [2]*MIT, USA;* [3]*Yale Univ., USA.* We present recent results in developing topological band theory for non-Hermitian systems as well our experimental discovery of two phenomena: bulk Fermi arcs and fractional topological charges in polarization, both arising from paired exceptional points.

FM2Q.4 • 11:30
Effects of non-Hermitian perturbations on Weyl Hamiltonians with arbitrary topological charges, Alexander Cerjan[1], Meng Xiao[1], Luqi Yuan[1], Shanhui Fan[1]; [1]*Stanford Univ., USA.* We provide a systematic study of non-Hermitian topologically charged systems, demonstrating that adding an arbitrary non-Hermitian perturbation transforms the Weyl points to one-dimensional exceptional contours, and can yield a topological phase transition.

Executive Ballroom 210A	Executive Ballroom 210B	Executive Ballroom 210C
Joint	**CLEO: Science & Innovations**	

JM2A • Symposium on Future Directions in Terahertz Nanoscopy II—Continued

JM2A.5 • 12:00 Invited
Future Directions in Terahertz Scanning Tunneling Microscopy, Frank A. Hegmann[1]; [1]*Physics, Univ. of Alberta, Canada*. Terahertz scanning tunneling microscopy (THz-STM) has recently enabled new approaches for exploring ultrafast dynamics in materials with sub-nanometer spatial resolution. The basic physics of THz-STM, recent developments and future directions will be discussed.

SM2B • Novel Nanophotonic Structures and Devices—Continued

SM2B.5 • 11:45
WDM Si Photonic crystal beam scanner for high-throughput parallel 3D sensing, Hiroyuki Ito[1], Tomoki Tatebe[1], Hiroshi Abe[1], Toshihiko Baba[1]; [1]*Yokohama National Univ., Japan*. We fabricated a WDM optical beam scanner consisting of thermally-controlled Si photonic crystal beam steering devices. We demonstrate the parallel scanning of light beams for the different angular ranges using four multiplexed wavelengths.

SM2B.6 • 12:15
Transfer printing of photonic nanostructures to silicon integrated circuits, Charalambos Klitis[1], Benoit Guilhabert[2], John McPhillimy[2], Stuart May[1], Ning Zhang[1], Michael J. Strain[2], Marc Sorel[1]; [1]*Univ. of Glasgow, UK;* [2]*Univ. of Strathclyde, UK*. Optical systems require the integration of technologies fabricated on different materials. We use a transfer printing technique to integrate pre-processed III-V, polymer and silicon membrane devices onto passive optical circuits with nano-metric positional accuracy.

SM2C • Short Reach Communication—Continued

SM2C.5 • 11:45
Impact of Phase-Filtering on Optical Spectral Reshaping with Microring Resonators for Directly-Modulated 4-PAM Signals, Oskars Ozolins[1], Francesco Da Ros[2], Valentina Cristofori[2], Xiaodan Pang[3,1], Aleksejs Udalcovs[1], Richard Schatz[3], Leif K. Oxenlowe[2], Sergei Popov[3], Gunnar Jacobsen[1], Christophe Peucheret[4]; [1]*RISE Acreo AB, Sweden;* [2]*DTU Fotonik, Technical Univ. of Denmark, Denmark;* [3]*KTH Royal Inst. of Technology, Sweden;* [4]*Univ Rennes, CNRS, FOTON – UMR 6082, France*. We investigate microring resonator (MRRs)-based optical spectral reshaping for directly-modulated 4-PAM signals. The phase-filtering of MRR, and consequent dispersion added to the signal, yields 120% reach increase compared to the 95% of amplitude-only filtering.

SM2C.6 • 12:00
224Gb/s Single Carrier Doubly Differential 2ASK-8PSK System without Carrier Recovery, Tingting Zhang[1], Christian Sánchez Costa[1], Mohammad A. Al-Khateeb[1], Ian Phillips[1], Andrew Ellis[1]; [1]*Aston Univ., UK*. A carrier-recovery-free 224Gb/s dual-polarization doubly differential 16-point constellation (2ASK-8PSK) is experimentally demonstrated for the first time. Utilizing 10-symbol decision feedback in the 2nd differential stage, the penalty with respect to conventional 16QAM is only 4.8dB.

12:00–13:00 OSA Optical Material Studies Technical Group Special Talk, *Room 230A*

12:30–13:30 Lunch Break *(on your own)*

12:30–15:30 SC362: Cavity Optomechanics: Fundamentals and Applications of Controlling and Measuring Nano- and Micro-mechanical Oscillators with Laser Light

12:30–16:30 SC455: Integrated Photonics for Quantum Information Science and Technology
SC378: Introduction to Ultrafast Optics

13:00–14:00 Social Media 102, *Market 1, Hilton San Jose*

CLEO: Science & Innovations

SM2D • Nonlinear Optical Phenomena—Continued

SM2D.5 • 11:45
Using Temperature to Reduce Noise in Quantum Frequency Conversion, Paulina S. Kuo[1], Jason Pelc[2], Carsten Langrock[2], M. M. Fejer[2]; *[1]NIST, USA; [2]Stanford Univ., USA.* A main source of noise in quantum frequency conversion is spontaneous Raman scattering, which can be reduced by lowering the operating temperature. We show reduction in dark count rates that agrees well with theory.

CLEO: QELS-Fundamental Science

FM2E • Topological Photonics and Lasers—Continued

FM2E.3 • 11:45
Experimental Realization of Magnetic-free Topological Insulator Laser, Miguel A. Bandres[1], Steffen Wittek[2], Gal Harari[1], Midya Parto[2], Jinhan Ren[2], Mordechai Segev[1], Demetrios N. Christodoulides[2], Mercedeh Khajavikhan[2]; *[1]Technion, Israel; [2]CREOL, USA.* We demonstrate a nonmagnetic topological insulator laser exhibiting topologically-protected transport. The topological properties of the system give rise to single mode lasing, robustness against fabrication defects, and higher slope efficiencies compared to its trivial counterpart.

FM2E.4 • 12:00
Nonlinear Unidirectional Topological States in Zigzag Arrays of Bianisotropic Dielectric Nanoparticles, Sergey S. Kruk[1], Alexey Slobozhanyuk[1], Alexander Shorokhov[2], Daria Smirnova[3], Ivan Kravchenko[4], Alexander N. Poddubny[1], Yuri S. Kivshar[1]; *[1]Australian National Univ., Australia; [2]Moscow State Univ., Russia; [3]Russian Academy of Science, Russia; [4]Oak Ridge National Lab, USA.* We generate a third-harmonic field from topological photonic edge states in zigzag arrays of silicon nanoparticles. The effect is unidirectional due to the interplay of nonlinearity and bianisotropic coupling between electric and magnetic Mie resonances.

FM2E.5 • 12:15
Complex Edge-State Phase Transitions in 1D Topological Laser Arrays, Midya Parto[1], Steffen Wittek[1], Hossein Hodaei[1], Gal Harari[2], Miguel Bandres[2], Jinhan Ren[1], Mikael Rechtsman[3], Mordechai Segev[2], Demetrios N. Christodoulides[1], Mercedeh Khajavikhan[1]; *[1]CREOL, USA; [2]Technion, Israel; [3]Pennsylvania State Univ., USA.* We report the first observation of complex lasing transitions in a topological 1D Su-Schrieffer-Heeger active array. The effect of gain saturation nonlinearities and carrier dynamics on the edge-state is investigated both theoretically and experimentally.

FM2F • Exciton-polaritons and Other Excitation in Semiconductions—Continued

FM2F.6 • 11:45
Observation of Rydberg exciton-polaritons in 2D transition metal dichalcogenides, Jie Gu[1,2], Alexandra Boehmke[1], Rian Koots[1], Vinod M. Menon[1,2]; *[1]Dept. of Physics, City College of New York, USA; [2]Dept. of Physics, The Graduate Center of City Univ. of New York, USA.* We report the strong coupling between Rydberg excitons (2S state) and cavity photons in monolayer WSe_2 with the Rabi splitting of ~ 20meV at 77K. Rydberg exciton-polaritons are crucial for solid state quantum non-linear optics.

FM2F.7 • 12:00
Dressed Excitons in Carbon Nanotubes, Kankan Cong[1], G. Timothy Noe II[1], Huaping Liu[2], Hiromichi Kataura[3], Junichiro Kono[1]; *[1]Electrical and Computer Engineering, Rice Univ., USA; [2]Inst. of Physics, Chinese Academy of Sciences, China; [3]Nanomaterials Research Inst., National Inst. of Advanced Industrial Science and Technology, Japan.* Ultrafast spectroscopy of semiconducting carbon nanotubes reveals transient modifications in the lowest exciton absorption peak. Below-gap excitation induces a blue-shift due to the optical Stark effect, while a Rabi doublet appears under resonant excitation.

FM2F.8 • 12:15
Microscopic Theory for Spatially Local Excitations in Semiconductor Nanostructures, Markus Borsch[1], Eric Martin[2], Steven T. Cundiff[2,1], Mackillo Kira[1,2]; *[1]Dept. of Electrical Engineering and Computer Science, Univ. of Michigan, USA; [2]Physics Dept., Univ. of Michigan, USA.* We develop a cluster-expansion approach further to include spatially local excitations up to two-particle correlations. Our results show that this level is needed to explain the decreasing excitation-spot size measured in resonantly excited quantum wells.

12:00–13:00 OSA Optical Material Studies Technical Group Special Talk, *Room 230A*

12:30–13:30 Lunch Break *(on your own)*

12:30–15:30 SC362: Cavity Optomechanics: Fundamentals and Applications of Controlling and Measuring Nano- and Micro-mechanical Oscillators with Laser Light

12:30–16:30 SC455: Integrated Photonics for Quantum Information Science and Technology
SC378: Introduction to Ultrafast Optics

13:00–14:00 Social Media 102, *Market 1, Hilton San Jose*

Executive Ballroom 210G	Executive Ballroom 210H	Meeting Room 211 B/D
CLEO: QELS-Fundamental Science		CLEO: Science & Innovations

FM2G • Novel Nonophotonic Light Sources—Continued

FM2G.5 • 11:45
Direct Generation of Structured Light in Metallic Nanolaser Arrays, William Hayenga[1], Midya Parto[1], Enrique Sanchez Cristobal[1], Demetrios N. Christodoulides[1], Mercedeh Khajavikhan[1]; [1]*Univ. of Central Florida, CREOL, USA.* The interplay between array geometry and the whispering galley-like modes of individual nanolasers can lead to the direct generation of structured light in nanoscale. Such nanolaser lattices emitting OAM beams are experimentally demonstrated.

FM2G.6 • 12:00
Plasmonic-assisted perovskite submicron lasers, Sangyeon Cho[2,1], Andreas C. Liapis[2], Seok-Hyun Yun[2,1]; [1]*Harvard-MIT Health Sciences and Technology, MIT, USA;* [2]*Wellman Center for Photomedicine, Massachusetts General Hospital and Harvard Medical School, USA.* We synthesized micro- and submicron particles containing $CsPbBr_3$ nanocrystals and silver nanoparticles. Optically-pumped metal-perovskite particles showed lasing, owing to high gain from perovskite and light confinement by plasmonic scattering.

FM2G.7 • 12:15
MXenes for Plasmonic and Metamaterial Devices, Zhuoxian Wang[1], Krishnakali Chaudhuri[1], Mohamed Alhabeb[2], Xiangeng Meng[1], Shaimaa Azzam[1], Alexander Kildishev[1], Young L. Kim[1], Vladimir M. Shalaev[1], Yury Gogotsi[2], Alexandra Boltasseva[1]; [1]*Purdue Univ., USA;* [2]*Drexel Univ., USA.* We explore the applications of MXenes, a new material class of growing interest, in the area of nanophotonics and plasmonics. A broadband plasmonic metamaterial absorber and a random laser device have thus been demonstrated.

FM2H • Quantum Optics with Single Atoms—Continued

FM2H.6 • 12:00
Quantum State Teleportation from a Single Ion to a Single Photon by Heralded Absorption, Jan Arenskötter[1], Stephan Kucera[1], Matthias Kreis[1], Pascal Eich[1], Philipp Müller[1], Jürgen Eschner[1]; [1]*Universität des Saarlandes, Germany.* Using a high-brightness narrowband source of $^{40}Ca^{+}$-ion-resonant entangled photon pairs at 854 nm, we teleport a qubit from the $D_{5/2}$ Zeeman sub-levels of the ion onto the polarization qubit of a single photon by heralded absorption.

FM2H.7 • 12:15
Ultrafast Rabi and Ramsey measurements with reconfigurable single-atom tweezer traps, Yunheung Song[1], Hanlae Jo[1], Han-gyeol Lee[1], Geol Moon[1], Jaewook Ahn[1]; [1]*Korean Adv Inst of Science and Tech, South Korea.* We simultaneously measured fine-structure state Rabi oscillations of rubidium atoms in reconfigurable single-atom tweezer traps driven by shaped ultrafast laser pulses, which are in a good agreement with the characterized laser beam profiles.

SM2I • Integrated Detectors—Continued

SM2I.6 • 11:45
Quantum dot micro-lasers integrated with photodetectors and optical amplifiers on (001) Si via waveguide coupling, Chen Shang[1], Yating Wan[1], Daehwan Jung[1], Justin Norman[1], MJ Kennedy[1], Di Liang[2], Chong Zhang[2], Arthur Gossard[1], John E. Bowers[1]; [1]*UCSB, USA;* [2]*HPE, USA.* We demonstrate the first integrated electrically pumped quantum dot micro-ring lasers epitaxially grown on (001) silicon. On-chip photodetection under continuous-wave excitation was achieved with a low threshold current of 3 mA.

SM2I.7 • 12:00
30-GHz graphene-on-silicon nitride waveguide photodetector, Yun Gao[1], Hon Ki Tsang[1], Chester Shu[1]; [1]*Chinese Univ. of Hong Kong, Hong Kong.* We observed 30 GHz dynamic response and 12 mA/W photoresponsivity in a graphene-on-Si_3N_4 photodetector. Our chemical vapor deposited graphene based photodetector is found to have an operating bandwidth comparable to the best pristine graphene photodetector.

SM2I.8 • 12:15
Mid-infrared waveguide integrated chalcogenide glass on black phosphorus photodetectors , Hongtao Lin[1], Skylar Deckoff-Jones[1], Derek Kita[1], Hanyu Zheng[1], Duanhui Li[1], Wei Zhang[2], Juejun Hu[1]; [1]*Dept. of Materials Science & Engineering, MIT, USA;* [2]*Key Lab of Photoelectric Materials and Devices of Zhejiang Province, Ningbo Univ., China.* The first mid-infrared waveguide integrated black phosphorus photodetector was fabricated and characterized with a responsivity of 40 mA/W at 2185 nm wavelength.

12:00–13:00 OSA Optical Material Studies Technical Group Special Talk, *Room 230A*

12:30–13:30 Lunch Break *(on your own)*

12:30–15:30 SC362: Cavity Optomechanics: Fundamentals and Applications of Controlling and Measuring Nano- and Micro-mechanical Oscillators with Laser Light

12:30–16:30 SC455: Integrated Photonics for Quantum Information Science and Technology
SC378: Introduction to Ultrafast Optics

13:00–14:00 Social Media 102, *Market 1, Hilton San Jose*

CLEO: Applications & Technology

AM2J • Biomedical Imaging—Continued

AM2J.4 • 11:45
***In vivo* Images of Rat Peripheral Cornea amd Limbus With Full-Field Optical Coherence Tomography,** Yu Tung Chen[1], Ting Way Hsu[1], Wei Li Chen[2], Sheng Lung Huang[1]; [1]*National Taiwan Univ. , Taiwan;* [2]*National Taiwan Univ. Hospital, Taiwan.* The anatomical structure of rat's peripheral cornea and limbus were delineated *in vivo* with cellular resolution. The loop-like limbal palisades of Vogt, the blood vessel, and peripheral nerve bundles in the peripheral cornea were identified.

AM2J.5 • 12:00
First Demonstration of *in vivo* Mueller Polarimetric Imaging on Human Uterine Cervix, Jérémy Vizet[1], Jean Rehbinder[1], Stanislas Deby[1], Stéphane Roussel[1], André Nazac[2], Ranya Soufan[3], Catherine Genestie[3], Christine Haie-Meder[4], Hervé Fernandez[5], François Moreau[1], Angelo Pierangelo[1]; [1]*LPICM, CNRS, Ecole Polytechnique, France;* [2]*Dept. of Obstetrics and Gynecology, Univ. Hospital Brugmann, Université Libre de Bruxelles, Belgium;* [3]*Service d'anatomie pathologique gynécologique, Institut Gustave Roussy, France;* [4]*Service de Curiethérapie,, Institut Gustave Roussy, France;* [5]*Service de Gynécologie Obstétrique, CHU de Bicêtre AP-HP, France.* A very first prototype of a Mueller polarimetric colposcope was used for *in vivo* analysis of the human uterine cervix. We believe this device of great interest to improve early detection of cervical cancer.

AM2J.6 • 12:15
Mirau Based Ti^{3+}:Al_2O_3 Spectroscopic Full-Field Optical Coherence Tomographic *in vivo* Skin Imaging, Rajendran Soundararajan[1], Ting-Wei Hsu[1], Manuel C. Delgado[1], Yanding Qin[2], Sheng Lung Huang[1]; [1]*National Taiwan Univ., Taiwan;* [2]*Inst. of Robotics and Automatic Information System, Nankai Univ., China.* Hysteresis compensated piezoelectric transducer enables precise depth-dependent spectral information extracted from the optical coherence tomography raw interferometric data. Preliminary spectral analysis shows melanin absorptions at ~285.5 THz and ~325 THz.

CLEO: Science & Innovations

SM2K • Fiber Sensing and Measurement—Continued

SM2K.6 • 11:45
Packaged Multi-core Fiber Interferometric Vibration Sensor, Joel Villatoro[1,2], J. A. Flores-Bravo[3], E. Arrospide[1], O. Arrizabalaga[1], Jose Enrique Antonio-Lopez[4], J. Zubia[1], A. Schülzgen[4], Rodrigo Amezcua Correa[4]; [1]*Univ. of the Basque Country, Spain;* [2]*IKERBASQUE, Spain;* [3]*Centro de Investigación e Innovación Tecnológica, IPN, Mexico;* [4]*CREOL, The College of Optics & Photonics, Univ. of Central Florida, USA.* We report on a packaged interferometer built with strongly-coupled multi-core optical fiber (MCF) for vibration sensing. An ultra-miniature test mass induces cyclic bending to the MCF which results in periodic shifts of the interference pattern.

SM2K.7 • 12:00
Single-shot phase measurement and fluctuation analysis of Yb-doped fiber amplifier for nanosecond pulses, Yujun Feng[1], Huaiqin Lin[1], Johan Nilsson[1]; [1]*Univ. of Southampton, UK.* We demonstrate temporal-based single-shot ns pulse characterization on a nanosecond 1064-nm Yb-doped fiber amplifier system. Both the amplitude and phase stability of bursts containing 35 1-ns pulses are measured and analyzed.

SM2L • Optical Microwave Generation—Continued

SM2L.3 • 11:45
Controllable Amplitude-to-Phase Distortion in High-Speed Photodiodes under Pulsed Illumination, Josue Davila-Rodriguez[1], Xiaojun Xie[2], Holly F. Leopardi[1], Tara M. Fortier[1], Scott Diddams[1], Joe Campbell[2], Franklyn Quinlan[1]; [1]*NIST, Time and Frequency Division, USA;* [2]*Dept. of Electrical and Computer Engineering, Univ. of Virginia, USA.* We show <-50 dB AM-to-PM conversion over a wide photocurrent range in MUTC photodiodes. By controlling the AM-to-PM coefficient minimum, we generate 15 dBm microwave power with 60 dB AM rejection onto the microwave phase.

SM2L.4 • 12:00
High-Dynamic Range Optical to Microwave Comparison with Dual-Output Mach-Zehnder Modulators, Mamoru Endo[1], Tyko D. Shoji[1], Thomas R. Schibli[1,2]; [1]*Dept. of Physics, Univ. of Colorado, USA;* [2]*JILA, NIST, and Univ. of Colorado, USA.* A high-dynamic range microwave phase noise measurement has been demonstrated with two dual-output Mach-Zehnder modulators and a cross-spectrum analyzer. The noise floor reaches the thermal limit (-186 dBc/Hz above 10-kHz offset from the carrier).

SM2L.5 • 12:15
Transportable Ultra-low Noise Photonic Microwave Synthesizer, Michele Giunta[1,2], Wolfgang Hänsel[1], Maurice Lessing[1], Matthias Lezius[1], Marc Fischer[1], Xiaopeng Xie[3], Romain Bouchand[3], Daniele Nicolodi[3], Pierre-Alaine Tremblin[4], Giorgio Santarelli[4], Abhai Joshi[5], Shubhashish Datta[5], Yann Le Coq[3], Ronald Holzwarth[1,2]; [1]*Menlo Systems GmbH, Germany;* [2]*Max-Planck-Institut für Quantenoptik, Germany;* [3]*LNE-SYRTE, Observatoire de Paris, France;* [4]*LP2N, Université de Bordeaux, France;* [5]*Discovery Semiconductors Inc., USA.* We report on a transportable photonic microwave synthesizer comprising an ultra-stable laser and a ultra-low noise frequency comb. The last acts as a frequency divider, transferring the spectral purity from the optical to microwave domain.

12:00–13:00 OSA Optical Material Studies Technical Group Special Talk, *Room 230A*

12:30–13:30 Lunch Break *(on your own)*

12:30–15:30 SC362: Cavity Optomechanics: Fundamentals and Applications of Controlling and Measuring Nano- and Micro-mechanical Oscillators with Laser Light

12:30–16:30 SC455: Integrated Photonics for Quantum Information Science and Technology
SC378: Introduction to Ultrafast Optics

13:00–14:00 Social Media 102, *Market 1, Hilton San Jose*

CLEO: Applications & Technology

CLEO: Science & Innovations

AM2M • Material Processing Lasers and Sensing Technologies—Continued

AM2M.5 • 11:45
The 5.4 kW output power of the ytterbium-doped tandem-pumping fiber amplifier, Xuejiao Wang[1], Ping Yan[1], Zehui Wang[1], Yusheng Huang[1], Jiading Tian[1], Dan Li[1], Qirong Xiao[1], Mali Gong[1]; [1]*Tsinghua Univ., China*. We present our results of a high-power tandem pumping fiber laser amplifier via optimizing the parameters. A 75 W 1080 nm seed was amplified to 5448 W successfully, along with the efficiency of 91.3%.

AM2M.6 • 12:00
Ultrafast Experimental Analysis and Comparative Performance of a Graphene Saturable Mirror at 2 µm Wavelength, Gaozhong Wang[1], Werner Blau[1], Kangpeng Wang[1]; [1]*Trinity College Dublin, Ireland*. We conducted systematic comparisons on nonlinear optical properties of graphene and that of commercial semiconductor saturable absorber mirror (SESAM) at 2 µm. Graphene shows significant advantages over the SESAM, exhibiting 50 times faster relaxation time.

AM2M.7 • 12:15
A triple quantum cascade laser based sulfur species sensor for H_2S, CH_3SH and COS in petrochemical process streams, Harald Moser[1], Johannes P. Waclawek[1], Andreas Genner[1], Christoph Gasser[1], Bernhard Lendl[1]; [1]*Vienna Univ. of Technology, Austria*. Hydrogen sulfide (H_2S), methyl mercaptan (CH_3SH) and carbonyl sulfide (COS) gas detection based on second harmonic wavelength modulation spectroscopy (2*f*-WMS) using three modulation frequency multiplexed continuous wave quantum cascade lasers (cw QCLs) tunable is presented.

SM2N • Fiber and Wave Guide Lasers—Continued

SM2N.6 • 11:45
Highly-Efficient Femtosecond-Laser-Written Waveguide Lasers at ~2 µm in Monoclinic Tm:$MgWO_4$, Esrom Kifle[3], Pavel Loiko[2], Javier Vázquez de Aldana[4], Airán Ródenas[3,5], Lizhen Zhang[1], Zhoubin Lin[1], Haifeng Lin[1], Ge Zhang[1], Valentin Petrov[6], Uwe Griebner[6], Magdalena Aguiló[3], Francesc Díaz[3], Xavier Mateos[3], Weidong Chen[1]; [1]*Fujian Inst of Res Structure of Matter, China;* [2]*ITMO Univ., Russia;* [3]*Universitat Rovira i Virgili (URV), Spain;* [4]*Univ. of Salamanca, Spain;* [5]*Istituto di Fotonica e Nanotecnologie, Italy;* [6]*Max Born Inst. for Nonlinear Optics and Short Pulse Spectroscopy, Germany*. A channel waveguide (propagation loss: ~0.1 dB/cm) laser femtosecond-laser-written in monoclinic Tm:$MgWO_4$ generated up to 320 mW slightly above 2 µm (slope efficiency up to 71%) and vibronic laser emission extending up to ~2.08 µm.

SM2N.7 • 12:00
Compact bi-direction pumped hybrid double-cladding EYDF amplifier, Xiaolei Bai[1,2], Quan Sheng[1,2], Shijie Fu[1,2], Zhaoxin Xie[1,2], Shi Wei[1,2], Jianquan Yao[1,2]; [1]*Inst. of Laser and Optoelectronics, School of Precision Instrument and Optoelectronics Engineering, Tianjin Univ., China;* [2]*Key Lab of Optoelectronic Information Science and Technology (Ministry of Education), Tianjin Univ., China*. The double-cladding EYDF with different core diameter is connected by an asymmetric cladding light striper (CLS) to realize bi-direction pumping and increase the loss of counter-propagating light. The experimental results shows that this amplifier has benefit to enhance the SBS threshold.

SM2N.8 • 12:15
Coherent Beam Combining of Seven Femtosecond Chirped-Pulse Fiber Amplifiers Using an Interfermotric Phase Measurement Technique, Anke Heilmann[1], Jérémy Le Dortz[2], Séverine Bellanger[1], Louis Daniault[1], Ihsan Fsaifes[1], Marie Antier[3], Jérôme Bourderionnet[2], Christian Larat[2], Eric Lallier[2], Arnaud Brignon[2], Eric Durand[3], Christophe Simon-Boisson[3], Jean-Christophe Chanteloup[1]; [1]*Ecole Polytechnique, France;* [2]*Thales Research & Technology, France;* [3]*Thales Optronique SAS, France*. We report on the coherent combination of seven fiber amplifiers in the femtosecond regime using an interferometric phase measurement technique. A combination efficiency of 54 % and a compressed pulse length of 225 fs were achieved.

SM2O • Light Matter Interaction in Plasmonic & Metameterials—Continued

SM2O.5 • 11:45
All-optically reconfigurable chiral metamolecules, Linhan Lin[1], Xiaolei Peng[1], Yuebing Zheng[1]; [1]*Univ. of Texas at Austin, USA*. We experimentally demonstrate the optothermal assembly of various metal and dielectric colloidal nanoparticles into chiral metamolecules with reconfigurability.

SM2O.6 • 12:00
Surface Magnon Polaritonics for Strong Magnetic Interactions with Light, Jamison M. Sloan[1], Nicholas Rivera[1], John Joannopoulos[1], Marin Soljacic[1], Ido Kaminer[2,1]; [1]*MIT, USA;* [2]*Electrical Engineering and Solid State Inst., Technion, Israel*. We propose using surface magnon polaritons, an electromagnetically dual concept to surface plasmon polaritons, to access normally very inefficient spin-flip and other magnetic spontaneous emission processes.

SM2O.7 • 12:15
Strong coupling of 2D excitons to surface lattice modes of plasmonic crystals, Sriram Guddala[1], Robert Collison[2,4], Mandeep Khatoniar[1,3], Hussai Bhokari[1], Jacob Trevino[3,4], Vinod M. Menon[1,3]; [1]*Dept. of Physics, City College, City Univ. of New York (CUNY), USA;* [2]*Dept. of Chemistry,, City College, City Univ. of New York (CUNY), USA;* [3]*PhD program in Physics, Graduate Center, City Univ. of New York (CUNY), USA;* [4]*PhD program in Chemistry, Graduate Center, City Univ. of New York (CUNY), USA*. We demonstrate strong coupling of 2D excitons in monolayer WSe_2 to surface lattice modes of a plasmonic crystal resulting in large Rabi splitting of 95 meV at room temperature.

12:00–13:00 OSA Optical Material Studies Technical Group Special Talk, *Room 230A*

12:30–13:30 Lunch Break *(on your own)*

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SC378: Introduction to Ultrafast Optics

13:00–14:00 Social Media 102, *Market 1, Hilton San Jose*

CLEO: Applications & Technology

AM2P • A&T Topical Review on Photonics-enabled Quantum Technologies in Transition II—Continued

AM2P.4 • 12:00 Invited
Photonics-enabled Quantum Timing and Navigation at Honeywell, Karl D. Nelson[1]; [1]*Honeywell Aerospace, USA.* Quantum technologies such as atom interferometry and atomic clocks are a promising pathway to more precise navigation. We show several ways in which Honeywell uses photonics as enabling technology for quantum control as we work toward putting devices in the field.

CLEO: QELS-Fundamental Science

FM2Q • Non-Hermitian and PT Photonics—Continued

FM2Q.5 • 11:45
Evanescent fields at the gain/loss interface, Radoslaw Kolkowski[1], Hanan Herzig Sheinfux[1], Shai Tsesses[2], Anna Kodanev[2], Meir Orenstein[2], Guy Bartal[2], Mordechai Segev[1]; [1]*Physics Dept., Technion - Israel Inst. of Technology, Israel;* [2]*Electrical Engineering Dept., Technion - Israel Inst. of Technology, Israel.* We experimentally investigate the branch-cut transition at Total Internal Reflection from a gain medium, and explore the ability to control the branch-cut selection by evanescent coupling of *PT*-symmetric gain/loss plasmon waves.

FM2Q.6 • 12:00
Exceptional Point Engineered Glass Slide for Microscopic Thermography, Han Zhao[1], Zhaowei Chen[2], Ruogang Zhao[2], Liang Feng[3]; [1]*Dept. of Electrical and Systems Engineering, Univ. of Pennsylvania, USA;* [2]*Dept. of Biomedical Engineering, The State Univ. of New York at Buffalo, USA;* [3]*Dept. of Materials Science and Engineering, Univ. of Pennsylvania, USA.* We demonstrate a thermosensitive glass slide with enhanced sensitivity by exploiting an optical exceptional point. The non-Hermitian exceptional point of the glass slide creates novel functionality for highly-sensitive thermal mapping compatible with conventional microscope systems.

FM2Q.7 • 12:15
Controllable Photonic Topological Insulating Chain Based on Non-Hermiticity, Kenta Takata[1,2], Masaya Notomi[1,3]; [1]*NTT Nanophotonics Center, Japan;* [2]*NTT Basic Research Labs, Japan;* [3]*Tokyo Inst. of Technology, Japan.* We determine theoretically a one-dimensional photonic insulating lattice whose bulk topology is controllable simply by tuning gain and loss. The system with four-cavity periods realizes a non-Hermiticity-induced topological transition and reconfigurable midgap topological interface states.

12:00–13:00 OSA Optical Material Studies Technical Group Special Talk, *Room 230A*

12:30–13:30 Lunch Break *(on your own)*

12:30–15:30 SC362: Cavity Optomechanics: Fundamentals and Applications of Controlling and Measuring Nano- and Micro-mechanical Oscillators with Laser Light

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SC378: Introduction to Ultrafast Optics

13:00–14:00 Social Media 102, *Market 1, Hilton San Jose*

CLEO: Science & Innovations

13:30–15:30
SM3A • Terahertz Nonlinear Spectroscopy
Presider: Andrea Markelz; Univ. at Buffalo, SUNY, USA

SM3A.1 • 13:30
Development of a THz Pump MeV Ultrafast Electron Diffraction Probe Apparatus, Ben Ofori-Okai[1], Matthias C. Hoffmann[1], Alexander H. Reid[1], Renkai Li[1], Xiaozhe Shen[1], Jie Yang[1], Su Ji Park[1], Ehren Mannenbach[1], R. Keith Jobe[1], Stephen Weathersby[1], Steve Edstrom[1], Wayne Polzin[1], Aaron Lindenberg[1], Siegfried Glenzer[1], Xijie Wang[1]; [1]*SLAC National Accelerator Lab, USA.* We demonstrate a terahertz pump-ultrafast electron diffraction probe apparatus. Using the instrument, we show that intense focused THz pulses can characterize ultrashort electron bunches.

SM3A.2 • 13:45
Scalable setup for efficient terahertz generation using a segmented tilted-pulse-front excitation, László Pálfalvi[1], György Tóth[2], Levente Tokodi[1], Zsuzsanna Mátron[1], József A. Fülöp[2,3], Gábor Almási[1,3], János Hebling[1,2]; [1]*Pecsi Tudomanyegyetem, Hungary;* [2]*MTA-PTE High-Field Terahertz Research Group, Hungary;* [3]*Szentágothai Research Centre, Hungary.* A nonlinear echelon slab structure is proposed for high-energy THz pulse generation. The most important advantage of the setup is the possibility of using plane parallel nonlinear optical crystal for producing good-quality, symmetric THz beam.

SM3A.3 • 14:00 Invited
Terahertz Strong-Field Physics without a Strong Field, Junichiro Kono[1]; [1]*Rice Univ., USA.* We discuss cooperative ultrastrong coupling of two-level systems with THz bosonic fields in two situations: a quantum Hall system interacting with high-Q cavity photons, and Er spins interacting with Fe magnons in $ErFeO_3$.

SM3A.4 • 14:30
Ultrafast Photocarrier Dynamics in Single-Layer Graphene Driven by Strong Terahertz Pulses, Ali Mousavian[1], Byounghwak Lee[1,2], Andrew D. Stickel[1], Yun-Shik Lee[1]; [1]*Physics, Oregon State Univ., USA;* [2]*Physics & Chemistry, Korea Military Academy, South Korea.* Strong THz field enhances the THz transmission of photoexcited graphene, increasing carrier scattering rates. High-field also reduces the relaxation time of the photocarriers by opening up the unoccupied states, while photoexcitation retards the relaxation process.

13:30–15:30
SM3B • Optical Modulators
Presider: Jian Wang; Huazhong Univ of Science and Technology, China

SM3B.1 • 13:30
Electrically Packaged Silicon-Organic Hybrid Modulator for Communication and Microwave Photonic Applications, Heiner Zwickel[1], Juned N. Kemal[1], Clemens Kieninger[1], Yasar Kutuvantavida[1], Matthias Lauermann[1,2], Jonas Rittershofer[1], Rastko Pajković[1], Daniel Lindt[1], Sebastian Randel[1], Wolfgang Freude[1], Christian Koos[1]; [1]*Karlsruher Institut für Technologie, Germany;* [2]*Vanguard Photonics GmbH, Germany.* We demonstrate electrical packaging of a silicon-organic hybrid (SOH) modulator. Gold traces on an Al_2O_3 substrate define the electrical connections to an IQ-modulator having a Pi-voltage of 1.5V. Signal generation up to 128Gbit/s is demonstrated.

SM3B.2 • 14:00
96 Gbit/s PAM-4 Generation using an Electro-Optic Polymer Modulator with High Thermal Stability, Shiyoshi Yokoyama[1], Guo-Wei Lu[2], Hiroki Miura[1], Feng Qiu[1], Andrew Spring[1]; [1]*Kyushu Univ., Japan;* [2]*Tokai Univ., Japan.* The thermal stability of electro-optic polymer modulators is improved using a common ridge and hybrid silicon-to-polymer waveguide-structure. It reveals excellent thermal resistance at 105°C for ~2,000 hours and generates 56Gbit/s OOK and 96Gbit/s PAM-4 successfully.

SM3B.3 • 14:15
Demonstration of Long-Term Thermal Stability of a Silicon-Organic Hybrid (SOH) Modulator at 85°C, Clemens Kieninger[1,2], Yasar Kutuvantavida[1,2], Juned N. Kemal[1], Heiner Zwickel[1], HIroki Miura[4], Sebastian Randel[1], Wolfgang Freude[1], Shiyoshi Yokoyama[3,4], Christian Koos[1,2]; [1]*Inst. of Photonics and Quantum Electronics, Karlsruhe Inst. of Technology, Germany;* [2]*Inst. of Microstructure Technology, Karlsruhe Inst. of Technology, Germany;* [3]*Inst. for Materials Chemistry and Engineering, Kyushu Univ., Japan;* [4]*Dept. of Molecular and Material Sciences, Kyushu Univ., Japan.* We demonstrate highly stable silicon-organic hybrid (SOH) modulators fulfilling Telcordia standards for high-temperature storage. We show error-free 40 Gbit/s signaling with drive voltages of 1.65 V_{PP} using a device stored at 85°C for 2700 hours.

SM3B.4 • 14:30
100-GHz Low Voltage Integrated Lithium Niobate Modulators, Cheng Wang[1], Mian Zhang[1], Xi Chen[2], Maxime Bertrand[1,3], Amirhassan Shams-Ansari[1,4], Sethumadhavan Chandrasekhar[2], Peter Winzer[2], Marko Loncar[1]; [1]*Harvard Univ., USA;* [2]*Nokia Bell Labs, USA;* [3]*Univ. of Bordeaux, France;* [4]*Dept. of Electrical Engineering and Computer Science, Howard Univ., USA.* We demonstrate monolithically integrated lithium niobate modulators consisting of sub-wavelength waveguides and velocity-matched RF transmission lines. We measure an RF V_π as low as 2.3V and an electro-optic bandwidth up to 100 GHz.

13:30–15:30
SM3C • SDM Communications I
Presider: Yikai Su; Shanghai Jiao Tong Univ., China

SM3C.1 • 13:30 Invited
Multimode and multicore fiber amplifiers for space-division multiplexed communication systems, Nicolas K. Fontaine[1], Haoshuo Chen[1], Roland Ryf[1], Juan Carlos Alvarado Zacarias[2], Zeinab Sanjabi Eznaveh[2], Jose Enrique Antonio-Lopez[2], Rodrigo Amezcua Correa[2]; [1]*Nokia Bell Labs, USA;* [2]*CREOL, Univ. of Central Florida, USA.* Multimode and multi-core fiber amplifiers must amplify all modes with uniform gain in each mode while simultaneously producing large output powers per mode (20-dBm) with low noise figures. Leaveraging the dense packing of modes, they can be built with less components than an array of single-mode fiber amplifiers. We will discuss several amplifier designs to improve these metrics.

SM3C.2 • 14:00
System Benefits of Coupled-Core Multicore Fibers with Different Coupling Lengths, Rene-Jean Essiambre[1], Roland Ryf[1], Georg F. Rademacher[2]; [1]*Nokia Corporation, USA;* [2]*Photonic Network System Lab, National Inst. of Information and Communications Technology, Japan.* We study the impact of the linear coupling length and the number of cores on the nonlinear benefit of the coupled-core multicore fiber having up to 19 cores. Coupling lengths as short as a few meters improves transmission.

SM3C.3 • 14:15
Accurate modal dispersion measurements using maximally-orthogonal Stokes vectors, Ioannis G. Roudas[1], Jaroslaw Kwapisz[1]; [1]*Montana State Univ.-Bozeman, USA.* We propose optimal launch modes minimizing the noise error in the estimation of the fiber modal dispersion vector. For a 20-mode fiber, the SNR is improved by 4 dB compared to conventional mode combinations.

SM3C.4 • 14:30
Experimental Demonstration of 400-Gbit/s Free-Space Mode-Division-Multiplexing by Varying Both Indices when using Four Laguerre-Gaussian Modes or Four Hermite-Gaussian Modes , Kai Pang[1], Haoqian Song[1], Zhe Zhao[1], Runzhou Zhang[1], Hao Song[1], Guodong Xie[1], Long Li[1], Cong Liu[1], Jing Du[1], Andreas F. Molisch[1], Moshe Tur[1], Alan E. Willner[1]; [1]*Universit of Southern California, USA.* We experimentally demonstrate a 400-Gbit/s mode-division-multiplexed free-space-optical communication link using four Laguerre-Gaussian modes or four Hermite-Gaussian modes, achieving a power penalty < 4 dB. The influence of displacement and rotation on system performance is investigated.

CLEO: Science & Innovations

13:30–15:30
SM3D • Nonlinear Optics in Fibers and Waveguides
Presider: Michelle Sander; Boston Univ., USA

SM3D.1 • 13:30
Coherent Directional Supercontinuum Generation, Yoshitomo Okawachi[1], Mengjie Yu[1,2], Jaime Cardenas[3], Xingchen Ji[3,2], Michal Lipson[3], Alexander L. Gaeta[1]; *[1]Dept. of Applied Physics and Applied Mathematics, Columbia Univ., USA; [2]School of Electrical and Computer Engineering, Cornell Univ., USA; [3]Dept. of Electrical Engineering, Columbia Univ., USA.* We present a novel approach for coherent, directional supercontinuum and cascaded dispersive waves in dispersion-engineered waveguides. Operating in the normal group-velocity-dispersion regime, we demonstrate octave-spanning spectra generated primarily to one side of the pump.

SM3D.2 • 13:45
Mid-IR Supercontinuum Generation in Ultrafast Laser Inscribed Waveguides, James Morris[2,1], Mark Mackenzie[1], Christian R. Petersen[3], Ajoy K. Kar[1], Ole . Bang[3], Henry T. Bookey[2]; *[1]Inst. of Photonics and Quantum Sciences, Heriot-Watt Univ., UK; [2]Fraunhofer Centre for Applied Photonics, UK; [3]Dept. of Photonics Engineering, DTU Fotonik, Denmark.* Supercontinuum from 2.5 to 6.5 μm has been generated in ULI waveguides pumped with femtosecond pulses centered at 4.6 μm. Dispersion measurements show the zero dispersion wavelength for the waveguides to be around 5.3 μm.

SM3D.3 • 14:00 Invited
Nonlinear Multimode Fiber Optics, Stefan Wabnitz[1,2], Katarzyna Krupa[1], Daniele Modotto[1], Alessandro Tonello[3], Alain Barthelemy[3], Vincent Couderc[3], Guy Millot[4]; *[1]Univ. of Brescia, Italy; [2]Istituto Nazionale di Ottica del Consiglio Nazionale delle Ricerche (INO-CNR), Italy; [3]XLIM, Universite de Limoges, France; [4]ICB, Universite de Bourgogne, France.* We overview recent advances in the nonlinear optics of multimode optical fibers, including ultrabroadband sideband and supercontinuum generation, Kerr and Raman beam cleanup, modal modulation instabilities, four wave mixing, and second harmonic beam cleaning.

SM3D.4 • 14:30
Adiabatic Broadband Four-Wave Mixing Frequency Conversion in Optical Fibers, Xiaoyue Ding[1], Kerrianne Harrington[2], Logan Wright[1], Wei-Zung Chang[1], Frank W. Wise[1], Tim Birks[2], Haim Suchowski[3], Jeffrey Moses[1]; *[1]School of Applied and Engineering Physics, Cornell Univ., USA; [2]Dept. of Physics, Univ. of Bath, UK; [3]Raymond and Beverly Sackler School of Physics and Astronomy, Tel Aviv Univ., Israel.* We find adiabatic four-wave mixing in optical fibers allows efficient, near-octave-spanning near-infrared to mid-infrared conversion. Simulations indicate several possible fiber platforms, extending one-to-one broadband frequency conversion both to high-repetition-rate and high-energy applications

CLEO: QELS-Fundamental Science

13:30–15:30
FM3E • Symmetries in Optics
Presider: Konstantinos Makris; Univ. of Crete, Greece

FM3E.1 • 13:30 Invited
Chirality and Nonreciprocity in Optomechanical Resonator Systems, Gaurav Bahl[1]; *[1]Univ of Illinois at Urbana-Champaign, USA.* TBD

FM3E.2 • 14:00
Spin-Glass Behavior in Nonlinear Optical Waves, Davide Pierangeli[1,2], Mariano Flammini[1], Andrea Tavani[1], Fabrizio Di Mei[1], Aharon Agranat[3], Lifu Zhang[2], Claudio Conti[1,4], Eugenio DelRe[1,4]; *[1]Università di Roma La Sapienza, Italy; [2]College of Optoelectronic Engineering, Shenzhen Univ., China; [3]Dept. of Applied Physics, Hebrew Univ. of Jerusalem,, Israel; [4]Inst. for Complex Systems, ISC-CNR, Italy.* We report the observation of replica symmetry breaking in optical wave propagation, a phenomenon that emerges from the interplay of disorder and nonlinearity and demonstrates a spin-glass phase for light.

FM3E.3 • 14:15
Interaction of Counter-Propagating Light in Microresonators: Theoretical Model and Oscillatory Regimes, Michael T. Woodley[1,2], Leonardo Del Bino[1], Jonathan M. Silver[1], Shuangyou Zhang[1], Pascal Del'Haye[1]; *[1]National Physical Lab, UK; [2]Heriot-Watt Univ., UK.* An analytical model is presented for the recently observed spontaneous symmetry breaking in nonlinear microresonators. Conditions for the symmetry breaking are obtained, and further models for sensing applications are produced, together with a stability analysis.

FM3E.4 • 14:30 Invited
Spatial coherence engineering of lasers for imaging applications, Hui Cao[1]; *[1]Applied Physics, Yale Univ., USA.* We design and build the lasers with low spatial coherence to achieve speckle-free full-field imaging. We further proposed and demonstrated a simple method to switch the spatial coherence of a laser for multimodality biomedical imaging.

13:30–15:30
FM3F • High Harmonic Generation in Solids
Presider: Mark Sherwin; Univ. of California Santa Barbara, USA

FM3F.1 • 13:30 Tutorial
Controlling Electronic Quantum Motion on Subcycle and Atomic Scales, Fabian Langer[1], Stefan Schlauderer[1], Christoph P. Schmid[1], Christoph Lange[1], Dominik Peller[1], Tyler Cocker[1], Jascha Repp[1], Johannes T. Steiner[2], Ulrich Huttner[2], Peter G. Hawkins[2], Stephan W. Koch[2], Mackillo Kira[3], Rupert Huber[1]; *[1]Univ. of Regensburg, Germany; [2]Univ. of Marburg, Germany; [3]Univ. of Michigan, USA.* Atomically strong multi-terahertz waves drive novel subcycle quantum motions of electrons, generating high-harmonics, dynamical Bloch oscillations, quasiparticle collisions etc. Lightwave-driven scanning tunneling microscopy allows us to take the first femtosecond movie of a single-molecule orbital.

Rupert Huber received his PhD from Technical University Munich in 2004. Following his postdoctoral stay as a Humboldt Fellow at Lawrence Berkeley Laboratory he led an Emmy Noether Junior Group at the University of Konstanz. He has been a full professor of physics at the University of Regensburg since 2010.

FM3F.2 • 14:30
Wannier-Bloch approach to localization in high-order harmonic generation in solids, Alexis A. Chacon[1,2]; *[1]Los Alamos National Lab, USA; [2]Quantum Optics Group, Inst. of Photonic Sciences, Spain.* High harmonic generation, HHG, in solids is a delocalized process, which is still intensely debated. Here, we develop a model what connects the well-understood HHG in atoms to the delocalization problem of HHG in solids.

CLEO: QELS-Fundamental Science

CLEO: Science & Innovations

13:30–15:30
FM3G • Quantum Sources I
Presider: Joshua Bienfang; NIST, USA

FM3G.1 • 13:30 Invited

Single photons in and out of single molecules, Vahid . Sandoghdar[1]; [1]*Max-Planck-Inst Physik des Lichts, Germany.* I shall present high-fidelity single-photon guns based on single molecules in a planar antenna. In addition, we shall discuss the use of single or handful of photons for efficient linear and nonlinear coupling to molecules.

FM3G.2 • 14:00

All-Optical Frequency Multiplexed Single-Photon Source, Chaitali Joshi[1,2], Alessandro Farsi[2], Stephane Clemmen[3], Sven Ramelow[4], Alexander L. Gaeta[2]; [1]*Cornell Univ., USA;* [2]*Applied Physics and Applied Mathematics, Columbia Univ., USA;* [3]*Universite Libre de Bruxelles, Belgium;* [4]*Humboldt-Universitat zu Berlin, Germany.* We demonstrate a scalable, low-loss fiber-based frequency multiplexed single-photon source based on efficient parametric frequency conversion. We achieve a record count rate of 4.6 × 10^4 multiplexed photons with a low $g^{(2)}(0)$ of 0.07.

FM3G.3 • 14:15

Heralded Single-photon Source Based on Intermodal Four-wave Mixing in a Few-mode Fiber,, Erik N. Christensen[1], Jesper B. Christensen[1], Søren M. Friis[1], Jacob G. Koefoed[1], Mario A. Castaneda[1], Karsten Rottwitt[1]; [1]*DTU Fotonik, Denmark.* We experimentally demonstrate a heralded single-photon source based on intermodal four-wave mixing in a step-index few-mode fiber, and measure a maximum coincidence-to-accidental ratio of 39, and a g$^{(2)}(0)$ of 0.13.

FM3G.4 • 14:30

High-visibility interference between two heralded pure-state photons without spectral filtering, Changchen Chen[1], Jeffrey H. Shapiro[1], Franco N. Wong[1]; [1]*Electrical Engineering and Computer Science, MIT, USA.* We measure 90% visibility in Hong-Ou-Mandel interference between two independent heralded single photons from pulsed spontaneous parametric downconversion with a Gaussian spectral phase-matching profile, and study its dependence on the pump spectral properties

13:30–15:30
FM3H • Chiral and Topological Quantum Optics
Presider: Tracy Northup; Univ. of Innsbruck, Austria

FM3H.1 • 13:30 Tutorial

Chiral Quantum Optics, Peter Lodahl[1]; [1]*Niels Bohr Inst., Univ. of Copenhagen, Denmark.* Nanophotonic waveguides may be engineered to constitute a one-dimensional directional photonic reservoir enabling new ways to control light-matter interaction. We review the underlying physics and potential applications of such chiral quantum interaction.

Peter Lodahl is professor at the Niels Bohr Institute, University of Copenhagen. His research focus on solid-state quantum-information processing with quantum dots. He is the recipient of an ERC consolidator/advanced grant (2010/2015), and serves as Director of the Danish National Research Foundation Center of Excellence for Hybrid Quantum Networks (Hy-Q).

FM3H.2 • 14:30

Unbiased photo-carrier transport in the quantum Hall regime, Olivier Gazzano[1], Bin Cao[1,2], Jiuning Hu[1], Tobias Grass[1], Tobias Huber[1], Dave Newell[3], Mohammad Hafezi[1,2], Glenn S. Solomon[3]; [1]*Joint Quantum Inst., USA;* [2]*Dept. of Physics, Univ. of Maryland, USA;* [3]*National Inst. of Standards and Technology, USA.* Photocurrent oscillating with respect to backgate voltage is observed in graphene in the quantum Hall regime. The relationship between edge states chirality and carrier type is explored and interplay among various processes is investigated.

13:30–15:30
SM3I • Optical Phase Arrays
Presider: Wei Jiang; Rutgers Univ., USA

SM3I.1 • 13:30

Planar-lens Enabled Beam Steering for Chip-scale LIDAR, Josue Lopez[1], Scott Skirlo[1], Dave Kharas[2], Jamison Sloan[1], Jeffrey Herd[2], Paul W. Juodawlkis[2], Marin Soljacic[1], Cheryl Sorace-Agaskar[2]; [1]*MIT, USA;* [2]*MIT Lincoln Lab, USA.* A lens-enabled chip-scale beam steering device for LIDAR is theoretically analyzed and experimentally demonstrated with azimuthal, φ_{range} = 38.8°, and polar, θ_{range} = 12.0°, beam-steering. The device allows for beam-steering at low power and low cost.

SM3I.2 • 14:00

Silicon Optical Phased Array with Grating Lobe-Free Beam Formation Over 180 Degree Field of View, Christopher T. Phare[1,2], Min Chul Shin[1], Jahnavi Sharma[1], Sohail Ahasan[1], Harish Krishnaswamy[1], Michal Lipson[1]; [1]*Electrical Engineering, Columbia Univ., USA;* [2]*Electrical and Computer Engineering, Cornell Univ., USA.* Using index-mismatched waveguides, we demonstrate the first optical phased array with half-wavelength emitter pitch. We show operation without grating lobes over an entire 180° field of view and beam formation up to 60° off-axis.

SM3I.3 • 14:15

160×160 MEMS Based 2-D Optical Phased Array, Youmin Wang[1], Guangya Zhou[2], Xiaosheng Zhang[1], Kyoungsik Yu[3], Ming C. Wu[1]; [1]*UC Berkeley, USA;* [2]*National Univ. of Singapore, Singapore;* [3]*Korea Advanced Inst. of Science & Technology, South Korea.* We present a two-dimensional ultra large aperture optical phase array (OPA) with 160×160 elements enabled with optical microelectromechanical system (MEMS). The random access beamsteering up to 4.4°×4.6° scanning range at 1550nm is demonstrated.

SM3I.4 • 14:30

Two-Dimensional Beam Steering Using Slow-Light Waveguide Deflector Array with Optical Gain, Keisuke Kondo[1], Xiaodong Gu[1], Zeuku Ho[1], Akihiro Matsutani[2], Fumio Koyama[1]; [1]*Photonics Integration System Research Center, Tokyo Inst. of Technology, Japan;* [2]*Semiconductor and MEMS Processing Center, Tokyo Inst. of Technology, Japan.* We demonstrated two-dimensional beam steering by using slow-light deflector array with large angular dispersion of 1.3°/nm and chip gain of 2 dB. We show the steering range of 38°×10°, supporting resolvable point of over 270×7.

CLEO: QELS-Fundamental Science

13:30–15:30
FM3J • Imaging and Cloaking in Metamaterials
Presider: Alexandra Boltasseva; Purdue University, USA

FM3J.1 • 13:30
Dispersion engineering of metasurfaces and its applications in the visible, Wei-Ting Chen[1], Alexander Zhu[1], Jared Sisler[1,2], Vyshakh Sanjeev[1,2], Eric Lee[1,2], Federico Capasso[1]; [1]*Harvard Univiversity, USA;* [2]*Univ. of Waterloo, Canada*. We show how to finely tune metasurface dispersion up to 2nd order terms in the visible, using coupled TiO_2 dielectric nano-pillars. We demonstrate white-light imaging and aberration-correction in lenses using these dispersion-engineered metasurfaces.

FM3J.2 • 13:45
Far-field Metamaterial Superlens, Guanghui Yuan[1], Katrine S. Rogers[2], Edward T. Rogers[3,4], Nikolay I. Zheludev[1,3]; [1]*Nanyang Technological Univ., Singapore;* [2]*School of Mathematics and Statistics, The Open Univ., UK;* [3]*Optoelectronics Research Centre and Centre for Photonic Metamaterials, Univ. of Southampton, UK;* [4]*Inst. for Life Sciences, Univ. of Southampton, UK*. We demonstrate a radically new type of metamaterial 'super-lens' that exploits the phenomenon of super-oscillations, giving a smallest hotspot size of 0.33λ and effective numerical aperture as high as 1.52 in air.

FM3J.3 • 14:00
High NA Silicon Metalens at Visible Wavelengths, Haowen Liang[1], Qiaoling Lin[1], Yin Wang[1], Qian Sun[1], Juntao Li[1]; [1]*Sun Yat-sen Univ., China*. We present a crystalline silicon based metalens with effectively low loss and high-NA in air. This metalens can be further front-immersed in high index liquids, presenting much higher NA and diffraction-limited focusing.

FM3J.4 • 14:15
High De-Magnification Hyperlens, Jingbo Sun[1], Natalia Litchinitser[1]; [1]*State Univ. of New York at Buffalo, USA*. We design and fabricate a hyperlens with a large demagnification of 3.75. We experimentally demonstrate such hyperlens' capability to compress the original patterns with feature size of 300nm down to 80nm using 405nm light.

FM3J.5 • 14:30
Subwavelength imaging of collective modes in silicon nanopillar honeycomb lattices, Siying Peng[1], Nick Schilder[2], Sophie Meuret[2], Femius Koenderink[2], Albert Polman[2], Harry Atwater[1]; [1]*Applied physics, California Inst. of Technology, USA;* [2]*Center for Nanophotonics, AMOLF, Netherlands*. We report fabrication and direct imaging of silicon Mie resonators with molecular-orbital-like bonding and anti-bonding local photonic density of states, as well as selective excitation of collective Bloch modes at specific frequencies and lattice sites.

CLEO: Science & Innovations

13:30–15:30
SM3K • Billouim Scattering and Applications
Presider: Siddharth Ramachandran; Boston Univ., USA

SM3K.1 • 13:30
Sensing Outside Polyimide-Coated Fibers Using Guided Acoustic Waves Brillouin Scattering, Hilel Hagai Diamandi[1], Yosef London[1], Gil Bashan[1], Avi Zadok[1]; [1]*Bar-Ilan Univ., Israel*. The spectra of guided acoustic waves Brillouin scattering in polyimide-coated single-mode fibers are characterized analytically and experimentally. The measurements distinguish between water and air outside coated fibers

SM3K.2 • 13:45
Fiber-optic cascaded forward Brillouin scattering seeded by backward SBS, Neisei Hayashi[1], Yosuke Mizuno[2], Nakamura Kentaro[2], Sze Y. Set[1], Shinji Yamashita[1]; [1]*The Univ. of Tokyo, Japan;* [2]*Inst. of Innovative Research, Tokyo Inst. of Technology, Japan*. We propose a novel principle for generating the cascaded forward Brillouin scattering (CFBS) using a counter-propagating pump-probe technique. The basic concept of this principle is the use of backward SBS as the seed of CFBS.

SM3K.3 • 14:00
Averaging-free Vector BOTDA assisted by a Reference Probe Lightwave, Nan Guo[1], Tao Gui[1], Chao Jin[1], Liang Wang[2], Hwa-Yaw Tam[1], Chao Lu[1]; [1]*The Hong Kong Polytechnic Univ., Hong Kong;* [2]*The Chinese Univ. of Hong Kong, Hong Kong*. We propose and experimentally demonstrate an averaging-free vector BOTDA system, which enables both distributed Brillouin gain and Brillouin phase shift detection without trace averaging. A 4m spatial resolution over 18.3 km is realized.

SM3K.4 • 14:15
Performance Enhancement for BOCDA Based on Convexity Extraction Algorithm, Bin Wang[1], Xinyu Fan[1], Zuyuan He[1]; [1]*Shanghai Jiao Tong Univ., China*. We propose an approach to enhance the performance of BOCDA by exploiting the ignored information contained on the measured data. A potentially unlimited dynamic range, as well as a fivefold-enhanced spatial resolution, has been achieved.

SM3K.5 • 14:30 Invited
Brillouin-based Optomechanics, Peter T. Rakich[1], Eric Kittlaus[1], Nils T. Otterstrom[1], Ryan O. Behunin[2], Zheng Wang[3]; [1]*Yale Univ., USA;* [2]*Physics, Northern Arizona Univ., USA;* [3]*Electrical Engineering, Univ. of Texas at Austin, USA*. We use a new class of optomechanical waveguides to we create strong stimulated Brillouin scattering in silicon. Harnessing these interactions, we create Brillouin-based RF-photonic filters, optical amplifiers, and lasers in silicon photonics, and explore new optomechanical phenomena.

13:30–15:30
SM3L • Photonic Frequency References and Sources
Presider: Laura Sinclair; NIST, USA

SM3L.1 • 13:30
Silicon-photonics-based optical frequency synthesizer , Neetesh Singh[1], Ming Xin[1], Nanxi Li[1], Diedrik Vermeulen[1], Alfonso Ruocco[1], Emir Magden[1], Katia Shtyrkova[1], Patrick Callahan[1], Christopher Baiocco[2], Erich Ippen[1], Franz X. Kaertner[1], Michael Watts[1]; [1]*MIT, USA;* [2]*SUNY polytechnic, USA*. We demonstrate silicon-photonics-based octave spanning optical frequency combs phase coherently locked to a microwave oscillator for optical frequency synthesis. This system offers capability for precision optical synthesis of CW laser over the entire C-band

SM3L.2 • 13:45
Integrated Pound-Drever-Hall Laser Stabilization System in a Standard CMOS SOI Process, Mohamad Hossein Idjadi[1], Firooz Aflatouni[1]; [1]*Univ. of Pennsylvania, USA*. The first integrated Pound-Drever-Hall stabilization system with an on-chip MZI as the frequency reference is demonstrated which suppresses the frequency noise of semiconductor lasers by more than 25 dB while occupying a 2.38 mm^2 area.

SM3L.3 • 14:00
Narrow electromagnetically induced transparencies in Rb confined large-core core inner-wall coated Kagome HC-PCFs, Ximeng Zheng[1], Maxime Delgrange[1], Jenny Jouin[2], Philippe Thomas[2], Benoit Debord[1], Frédéric Gérôme[1], Fetah Benabid[1]; [1]*GPPMM group, Xlim Research Inst., France;* [2]*SPCTS UMR CNRS 7315, Centre Européen de la Céramique, France*. We compare electromagnetically induced transparencies in large-core anti-relaxation materials inner-wall coatings Kagome HC-PCF with thermal Rb confinement in situ. A minimum transparency linewidth of ~150 KHz in OTS coated fiber was observed.

SM3L.4 • 14:15
In-situ dwell-time measurement of Rb at the inner-wall coated-surface of HC-PCF, Ximeng Zheng[1], Jenny Jouin[2], Maxime Delgrange[1], Christine Restouin[1], Benoit Debord[1], Philippe Thomas[2], Frédéric Gérôme[1], Fetah Benabid[1]; [1]*GPPMM group, Xlim Research Inst., France;* [2]*SPCTS UMR CNRS 7315, Centre Européen de la Céramique, France*. We report on a new in-situ technique to measure dwell-time of Rb at coated surfaces of the inner-wall core of Kagome HC-PCFs. Surfaces made with silica, Alumino-silicate, PDMS and OTS were measured using this technique.

SM3L.5 • 14:30
Integration of Acetylene into chip scale photonic circuits for telecom frequency referencing, Roy T. Zektzer[1], Matthew Hummon[2], Liron Stern[2], Yefim Barash[1], Noa Mazurski[1], John Kitching[2], Uriel Levy[1]; [1]*The Hebrew Univ. of Jerusalem, Israel;* [2]*Time and Frequency Division, National Inst. of Standards and Technology, USA*. We experimentally demonstrate a chip-scale integration of photonic waveguides and Acetylene for optical telecom frequency reference. The functionality of the hybrid molecular-photonic chip was demonstrated by locking a telecom laser to a molecular line.

CLEO: QELS-Fundamental Science

13:30–15:30
FM3M • Sources and Technology for Attosecond and High-field Physics
Presider: Kyung-Han Hong; MIT, USA

FM3M.1 • 13:30 Invited
Approaching the Attosecond keV X-ray Frontier , Zenghu Chang[1]; [1]*Univ. of Central Florida, CREOL, USA.* We demonstrate the generation of isolated 53-as soft X-ray pulses reaching the water window. Mid-infrared lasers centered at 2.5 to 8 μm are being developed to extend the attosecond X-rays to the keV range.

FM3M.2 • 14:00
High-flux Soft X-ray Source for Time-resolved Probing of Magnetization Dynamics in Rare-earth Ferromagnets, Guangyu Fan[1], Vincent Cardin[2], Katherine Légaré[2], Edgar Kaksis[1], Giedrius Andriukaitis[1], Bruno E. Schmidt[4], Jean-Pierre Wolf[5], François Légaré[2], Jan Luning[3], Andrius Baltuska[1], Tadas Balciunas[1,5]; [1]*Inst. of Photonics, TU Wien, Austria;* [2]*Institut national de la recherche scientifique, Canada;* [3]*Laboratoire de Chimie Physique Matière et Rayonnement, France;* [4]*few-cycle, Inc, Canada;* [5]*GAP-Biophotonics, Université de Genève , Switzerland.* We present high flux table-top 220eV HHG source driven directly by a <20fs, 10mJ, kHz Yb laser amplifier system. For the first time for a table-top system, measurement of magnetization dynamics at the N-edge at 155 eV with fs temporal resolution was demonstrated.

FM3M.3 • 14:15
Relativistic, Ultra-short Mid-infrared Pulse Generation Through Photon Frequency Downconversion in Plasmas, Zan Nie[1], Chih-Hao Pai[1], Jie Zhang[1], Xiaonan Ning[1], Jianfei Hua[1], Chaojie Zhang[2], Yipeng Wu[1], Yang Wan[1], Fei Li[1,2], Qianqian Su[1], Shuang Liu[1], Yue Ma[1], Yunxiao He[1], Zhi Cheng[1], Wei Lu[1], Hsu-Hsin Chu[3], Jyhpyng Wang[3,4], Warren B. Mori[2], Chan Joshi[2]; [1]*Tsinghua Univ., China;* [2]*Univ. of California Los Angeles, USA;* [3]*National Central Univ., Taiwan;* [4]*National Taiwan Univ., Taiwan.* Generation of relativistically intense mid-infrared pulses in the spectral range of 2-6μm with 15.5mJ pulse energy by frequency downconversion from a 800nm Ti:sapphire laser is demonstrated. The conversion efficiency is as high as 5.2%.

FM3M.4 • 14:30
Self-channeling of Terawatt-power CO_2 laser Pulses in Air, Sergei . Tochitsky[1], Eric Welch[1], Misha Polyanskiy[2], igor Pogorelsky[2], Paris Panagiotopoulos[3], Jerome Moloney[3], Chan Joshi[1]; [1]*Univ. of California Los Angeles, USA;* [2]*Accelerator Test Facility, Brookhaven National Lab, USA;* [3]*College of Optical Sciences, Univ. of Arizona, USA.* We report the first observation of Kerr self-focusing of 3 ps TW CO_2 laser pulse in atmosphere. A centimeter diameter, 30m long, 10-μm light channel containing a few Joules of energy is generated and characterized.

CLEO: Science & Innovations

13:30–15:30
SM3N • High Power Lasers
Presider: Jake Bromage; Univ. of Rochester, USA

SM3N.1 • 13:30
Power scaling end-pumped slab lasers: comparison of Tm:YLF and Tm:LuLF, Antoine Berrou[1], Daniel Morris[1], Oliver J. Collett[1], M J Daniel Esser[1]; [1]*EPS/IPAQS, Heriot-Watt Univ., UK.* High brightness diode stack end-pumped Tm:YLF and Tm:LLF slab lasers are compared under identical pump conditions in continuous-wave regime. A maximum output power of 160 W was obtained for 428 W of pump power.

SM3N.2 • 13:45
Highly stable, 54mJ Yb-InnoSlab laser platform at 0.5kW average power, Bruno E. Schmidt[1], arvid hage[2], Torsten Mans[2], François Légaré[3], Hans Jakob Wörner[4]; [1]*few-cycle Inc, Canada;* [2]*AMPHOS GmbH, Germany;* [3]*INRS-EMT, Canada;* [4]*ETH Zürich, Switzerland.* We present a compact 1.5ps, 10kHz, 54mJ Yb InnoSlab pump laser with sub-% level power stability and different output ports. 10fs seed pulses are derived via white light generation in bulk followed by subsequent compression.

SM3N.3 • 14:00 Tutorial
Current State-of-the-art in High-power Ultrafast Lasers, Peter F. Moulton[1]; [1]*Massachusetts Inst of Tech Lincoln Lab, USA.* We review the technologies, both past, present, and future that are behind operation of PW (10^{15} W)-class laser systems, survey the installations worldwide and explain their scientific and practical applications.

Peter F. Moulton is presently a Senior Staff member in the Laser Applications and Applications Group at MIT Lincoln Laboratory. He has worked in the fields of solid state lasers, nonlinear optics, and laser applications since the 1970s in industry and in Government-funded facilitie, and recently served on a National Academies study on intense, ultrafast lasers.

13:30–15:30
SM3O • Fundamentals of Laser Material Processing
Presider: Carl Liebig; Air Force Research Lab, USA

SM3O.1 • 13:30
Visible Waveguide Lasers Based on Femtosecond Laser Inscribed Cladding Waveguides in Pr:YLF Crystal, Hongliang Liu[1], Minghui Hong[2], Pengfei Wu[1], Feng Chen[3]; [1]*Nankai Univ., China;* [2]*Dept. of Electrical and Computer Engineering, National Univ. of Singapore, Singapore;* [3]*Dept. of Physics, Shandong Univ., China.* Channle waveguide in Pr:YLF has been fabricated by femtoseconld laser micromachining. π-polarized waveguide lasers at wavelengths of 605 nm and 720 nm were achieved with a pumping laser at a wavelength of 444.5 nm with a maximum output power of 66 mW with slope efficiencies of 9.5%.

SM3O.2 • 13:45
Femtosecond Laser Writing of Lithium Tantalate Crystals for Waveguide Fabrication, Hongshen Song[1], Chen Cheng[1], Ziqi Li[1], Carolina Romero[2], Javier Vázquez de Aldana[2], Feng Chen[1]; [1]*Shandong Univ., China;* [2]*Universidad de Salamanca, Spain.* We report on the direct fabrication of type I and type II waveguides in z-cut lithium tantalate crystal by varying the parameters of femtosecond laser. The waveguiding properties and reflectance spectrum of the fabricated waveguides were also characterized in this work.

SM3O.3 • 14:00 Invited
Impacts of Spatio-Temporal Coupling in Ultrashort Laser Pulses on Laser Energy Absorption by Transparent Dielectrics in Bulk Modification Regimes, Nadezhda M. Bulgakova[1], Vladimir P. Zhukov[1,2], Selçuk Aktürk[3]; [1]*HiLASE Centre, Inst. of Physics CAS, Czechia;* [2]*Inst. of Computational Technologies SB RAS, Russia;* [3]*Eğercili Mah., Turkey.* Sophisticated modeling of propagation of ultrashort laser pulses with spatio-temporal coupling through transparent medium has enabled reproducing the effect of directional asymmetry in direct laser writing and gaining a deep insight into the underlying physics.

SM3O.4 • 14:30
Influence of crystal structure on the ultrafast ionization of cubic wide-band-gap crystals by ultrashort laser pulses, Vitaly Gruzdev[1], Olga Sergaeva[1]; [1]*Univ. of Missouri-Columbia, USA.* The Keldysh photoionization-rate formula is used for arbitrary solids by neglecting their specific structure. By deriving analogs of the Keldysh formula for cubic crystals, we show that the ultrafast ionization and absorption are crystal-specific effects.

CLEO: Applications & Technology

13:30–15:30
AM3P • Photobiomodulation Therapeutics
Presider: Brian Pryor; LiteCure, USA

AM3P.1 • 13:30 Invited
Transcranial Photobiomodulation for Psychiatric Disorders: Past and Future Directions, Paolo Cassano[1,2]; [1]*Massachusetts General Hospital, USA;* [2]*Harvard Medical School, USA.* Transcranial photobiomodulation with near-infrared and red radiation for the treatment of psychiatric conditions is reviewed. While still experimental, preliminary data on the use of both laser and LED devices for brain disorders are promising.

AM3P.2 • 14:00
Optimization of Irradiation Conditions for Upconversion Nanoparticle Assisted Photobiomodulation of Neuronal Cells, Sumeyra Tek[1], Brandy A. Vincent[1], Christopher A. Baker[1], Kelly L. Nash[1]; [1]*Univ. of Texas at San Antonio, USA.* Photoluminescence from upconversion nanoparticles provides a nanoplatform for desired photochemical effects on neuron cells resulting proliferation and outgrowth with NIR light irradiation, when overcoming the unwanted heating issues by optimizing irradiation conditions.

AM3P.3 • 14:15
Optical Scattering of Structured Light, Romanus Hutchins[1], John Rogers[1], Jonathan Williams[1], Ping Yu[1]; [1]*Univ. of Missouri, USA.* Optical scattering of diffraction-free structured light beams was studied using a diffuser at the far field in a forward direction. Generated Speckle is determined by the phase difference in the structured light beams.

AM3P.4 • 14:30 Invited
Annihilation of Methicillin-Resistant *Staphylococcus Aureus* (MRSA) via Photobleaching of Staphyloxanthin, Ji-Xin Cheng[1]; [1]*Boston Univ., USA.* We report a drug-free approach to eliminate MRSA through photobleaching of staphyloxanthin, an indispensable membrane-bound antioxidant. Staphyloxanthin bleaching by low-level blue light eradicates MRSA synergistically with external or internal reactive oxygen species.

CLEO: QELS-Fundamental Science

13:30–15:30
FM3Q • Topological Photonic Structure
Presider: Liang Feng; Univ. of Pennsylvania , USA

FM3Q.1 • 13:30
Edge-State Dynamics in a One-Dimensional Topological Photonic Lattice of Multiple Quantum Numbers, Zhifeng Zhang[1], Mohammad Teimourpour[2], Jake Arkinstall[3], Mingsen Pan[4,5], Pei Miao[4,5], Henning Schomerus[3], Ramy El-Ganainy[2], Liang Feng[5]; [1]*Electrical and Systems Engineering, Univ. of Pennsylvania, USA;* [2]*Dept. of Physics and Henes Center for Quantum Phenomena, Michigan Technological Univ., USA;* [3]*Dept. of Physics, Lancaster Univ., UK;* [4]*Electrical Engineering, SUNY at Buffalo, USA;* [5]*Materials Science and Engineering, Univ. of Pennsylvania, USA.* By manipulating the couplings in a flexible topological waveguide lattice with multiple nontrivial dispersion bands, we demonstrate the independent control of edge states associated with different quantum numbers through ultrafast heterodyne measurements.

FM3Q.2 • 13:45
Weyl exceptional ring in a helical waveguide array, Alexander Cerjan[1], Sheng Huang[2], Kevin P. Chen[2], Yidong Chong[3], Mikael Rechtsman[1]; [1]*Physics, Pennsylvania State Univ., USA;* [2]*Engineering, Univ. of Pittsburgh, USA;* [3]*Physics, Nanyang Technological Univ., Singapore.* We demonstrate the existence of a topologically charged contour consisting entirely of exceptional points in a non-Hermitian helical waveguide array. We observe both protected chiral edge states and the lack of conical diffraction.

FM3Q.3 • 14:00
Topology of Photonic Time-Crystals, Eran Lustig[1], Yonatan Sharabi[1], Mordechai Segev[1]; [1]*Technion Israel Inst. of Technology, Israel.* We introduce topological phases in Photonic Time-Crystals. We show that dispersion bands, which are gapped in momentum, can have non-trivial topology, that affect the propagation of light in the temporal crystal.

FM3Q.4 • 14:15
Creation of Semi-Dirac Photons Through Topological Phase Transitions in Photonic Honeycomb Lattices, Marijana Milicevic[1], Gilles Montambaux[2], Tomoki Ozawa[3], Aristide Lemaitre[1], Luc Le Gratiet[1], Isabelle Sagnes[1], Jacqueline Bloch[1], Alberto Amo[1,4]; [1]*Centre de Nanosciences et de Nanotechnologies,CNRS, France;* [2]*Laboratoire de Physique de Solids, Univeristé Paris-Sud , France;* [3]*INO-CNR BEC Center and Dipartimento di Fisica, Università di Trento, Italy;* [4]*Université Lille, CNRS,UMR 8523, Physique des Lasers Atomes et Molécules (PhLAM), France.* Tuning the band structure of photonic Dirac materials allows engineering novel optical properties. We use photonic honeycomb lattices to tailor semi-Dirac photons that combine zero, finite and infinite effective masses.

FM3Q.5 • 14:30
Exceptional Points of Degeneracy in lossless Periodic Coupled Waveguides, Mohamed Y. Nada[1], Mohamed A. Othman[1], Filippo Capolino[1]; [1]*UCI, USA.* We present general aspects of exceptional points of degeneracy (EPD) of order 2,3, and 4, that appear also in lossless periodic waveguides. We report unconventional scaling of the quality factor in coupled resonators optical waveguides.

SM3A • Terahertz Nonlinear Spectroscopy—Continued

SM3A.5 • 14:45
Carrier Multiplication in Bismuth Investigated with Intense THz pump-THz Probe Spectroscopy, Yasuo Minami[1,2], Thang Dao[3,4], Tadaaki Nagao[3,4], Masahiro Kitajima[5], Jun Takeda[2], Ikufumi Katayama[2]; *[1]Tokushima Univ., Japan; [2]Yokohama National Univ., Japan; [3]International Center for Materials Nanoarchitectonics (WPI-MANA), National Inst. for Materials Science, Japan; [4]CREST, Japan Science and Technology Agency, Japan; [5]LxRay Co. Ltd., Japan*. By utilizing intense terahertz (THz) pump and THz probe spectroscopy, we revealed the carrier dynamics of a semi-metallic bismuth ultrathin film, originating from the THz-induced electron acceleration and a subsequent carrier multiplication process.

SM3A.6 • 15:00
Hot-Carrier Induced Photoluminescence Enhancement and Quenching in GaAs and InP Driven by Intense THz Pulses, David Purschke[1]; *[1]Univ. of Alberta, Canada*. We show how intense terahertz pulses can modulate photoluminescence lineshape and efficiency in direct gap semiconductors through hot carrier-enhancement of high energy PL and diffusion induced quenching of low energy photoluminescence. We compare these effects in the GaAs and InP.

SM3A.7 • 15:15
High-field Terahertz Switching of Plasmonic Resonance in Photoexcited Nano Antennas on GaAs , Ali Mousavian[1], Andrew D. Stickel[1], Byounghwak Lee[1,2], Yun-Shik Lee[1]; *[1]Physics, Oregon State Univ., USA; [2]Physics & Chemistry, Korea Military Academy, South Korea*. Strong terahertz pulses transiently revive the plasmonic resonance of a nano-antenna-array-patterned GaAs film, which was initially turned off by photoexcitation. The high-field THz effect has potential to ultrafast optical/THz switching in plasmonic devices.

SM3B • Optical Modulators—Continued

SM3B.5 • 14:45
20Gbps silicon lateral MOS-Capacitor electro-optic modulator, Weiwei Zhang[1], Kapil Debnath[1], Graham T. Reed[1], David J. Thomson[1], Ali Z. Khokhar[1], Callum Littlejohns[1], James Byers[1], Lorenzo Mastronardi[1], Muhammad K. Husain[1], Frederic Gardes[1], Shinichi Saito[1]; *[1]Univ. of Southampton, UK*. This work presents an experimental demonstration of a 500μm long lateral MOS-capacitor silicon modulator. A modulation efficiency ($V_\pi L_\pi$) of 1.53V-cm, moderate modulation speed of 20Gbit-s^{-1} and extinction ratio of 3.65dB have been obtained.

SM3B.6 • 15:00
Compact, High Extinction Ratio Silicon Mach-Zehnder Modulator with Corrugated Waveguides, Seyedreza Hosseini[1], Aroutin Khachaturian[2], Mircea Cătuneanu[1], Parham Porsandeh Khial[2], Reza Fatemi[2], Ali Hajimiri[2], Kambiz Jamshidi[1]; *[1]Technische Universität of Dresden, Germany; [2] California Inst. of Technology, USA*. An integrated silicon photonic MZM modulator with a slow-wave architecture to reduce Vpi *L is presented. This structure achieves an 80% enhancement in extinction ratio and has a 14GHz bandwidth with 1mm long modulator arms.

SM3B.7 • 15:15
Silicon Photonic Modulators with Coupled Electrodes, David Patel[1], Mahdi Parvizi[2], Naim Ben-Hamida[2], Michel Poulin[2], Claude Rolland[2], David V. Plant[1]; *[1]McGill Univ., Canada; [2]Ciena Corporation, Canada*. We show that differential signaling with coupled electrodes for silicon photonic modulators increases the electro-optic bandwidth in low-resistive substrates. We also show that high DC resistance of transmission lines negates the benefit of longer modulators.

SM3C • SDM Communications I—Continued

Monday, 13:30–15:30

14:00–15:30 Workshop: Understanding Unconscious Bias, *Winchester 1&2, Hilton San Jose*

15:30–16:00 Coffee Break, *Concourse Level*

16:00–17:30 Workshop: Understanding Unconscious Bias Workshop, *Winchester 1&2, Hilton San Jose*

CLEO: Science & Innovations

SM3D • Nonlinear Optics in Fibers and Waveguides—Continued

SM3D.5 • 14:45
Octave-Spanning Supercontinuum Generation in a Dispersion Managed Tapered Crystalline Silicon Core Fiber, Haonan Ren[1], Li Shen[2], Joseph Campling[1], Antoine Runge[1], Ozan Aktas[1], Thomas Hawkins[3], Peter Horak[1], John Ballato[3], Ursula J. Gibson[4], Anna C. Peacock[1]; *[1]Univ. of Southampton, UK; [2]Wuhan National Lab for Optoelectronics, Huazhong Univ. of Science and Technology, China; [3]School of Materials Science and Engineering, Clemson Univ., USA; [4]Dept. of Physics, Norwegian Univ. of Science and Technology, Norway.* We demonstrate octave spanning supercontinuum from 1.35 µm to 3 µm generated in a tapered crystalline silicon core fiber pumped at 2.4 mm using a femtosecond OPO.

SM3D.6 • 15:00
Kerr and Raman beam cleanup with supercontinuum generation in multimode microstructure fiber, Richard Dupiol[1], Katarzyna Krupa[2], Alessandro Tonello[1], Marc Fabert[1], Daniele Modotto[2], Stefan Wabnitz[2,3], Guy Millot[3], Vincent Couderc[1]; *[1]Université de Limoges, France; [2]Università degli Studi di Brescia, Italy; [3]Université Bourgogne Franche-Comté, France.* We experimentally study the interplay of Kerr and Raman beam cleanup in multimode air-silica microstructure optical fiber. The interplay of modal four-wave mixing and Raman scattering leads to high-brightness multimode supercontinuum.

SM3D.7 • 15:15
Light Sources based on Multiple Solitons in Segmented Fiber Amplifiers, Francisco R. Arteaga-Sierra[1], Aku J. Antikainen[1], Govind P. Agrawal[1]; *[1]Univ. of Rochester, USA.* We propose a novel technique to design light sources producing multiple frequency channels potentially applicable in wavelength-division multiplexing networks. The sources are based on spectral interference of solitons generated in non-uniform fiber amplifiers.

CLEO: QELS-Fundamental Science

FM3E • Symmetries in Optics—Continued

FM3E.5 • 15:00
Optical time reversal from time-dependent Epsilon-Near-Zero media, Vincenzo Bruno[1], Stefano Vezzoli[1], Daniele Faccio[1,2], Marcello Ferrara[1], Vladimir M. Shalaev[3], Clayton DeVault[4], Matteo Clerici[5], Alexandra Boltasseva[3], Thomas Roger[1], Audrius Dubietis[6]; *[1]Inst. of Photonics and Quantum Sciences, Heriot Watt Univ., UK; [2]School of Physics and Astronomy, Univ. of Glasgow, UK; [3]School of Electrical and Computer Engineering and Birck Nanotechnology Center, Purdue Univ., USA; [4]Dept. of Physics and Astronomy and Birck Nanotechnology Center, Purdue Univ., USA; [5]School of Engineering, Univ. of Glasgow, UK; [6]Dept. of Quantum Electronics, Vilnius Univ., Lithuania.* We provide an efficient surface time-reversal of the incident electric field in an ENZ material producing both phase-conjugated and negative refracted beams. The results obtained exploiting degenerate four-wave mixing show an efficiency conversion over 200%.

FM3E.6 • 15:15
Suppressing laser instabilities with microcavities exhibiting chaotic ray dynamics, Stefan Bittner[1], Hasan Yilmaz[1], Kyungduk Kim[1], Xiaonan Hu[2], Yongquan Zeng[2], Qijie Wang[2], Stefano Guazzotti[3], Sang Soon Oh[3], Ortwin Hess[3], Hui Cao[1]; *[1]Dept. of Applied Physics, Yale Univ., USA; [2]School of Electrical and Electronic Engineering, Nanyang Technological Univ., Singapore; [3]Dept. of Physics, Imperial College, UK.* We demonstrate experimentally that spatio-temporal instabilities of broad-area semiconductor lasers are strongly suppressed in microcavities with chaotic ray-dynamics. This stabilization of lasing dynamics is attributed to the modifications of the nonlinear interaction of the lasing modes.

FM3F • High Harmonic Generation in Solids—Continued

FM3F.3 • 14:45
High-Order Harmonic Generation from Solids Dressed by an Intense Terahertz Field, Haoyu Huang[1,2], Liwei Song[1,3], Nicolas Tancogne-Dejean[4,5], Nicolai Klemke[1,2], Angel Rubio[4,5], Franz X. Kaertner[1,2], Oliver Muecke[1,6]; *[1]Center for Free-Electron Laser Science CFEL, Deutsches Elektronen Synchrotron , Germany; [2]Dept. of Physics, Univ. of Hamburg, Germany; [3]State Key Lab of High Field Laser Physics, Shanghai Inst. of Optics and Fine Mechanics, Chinese Academy of Sciences, China; [4]Max Planck Inst. for the Structure and Dynamics of Matter, Germany; [5]European Theoretical Spectroscopy Facility (ETSF) , Germany; [6]The Hamburg Centre for Ultrafast Imaging CUI, Univ. of Hamburg, Germany.* Using an intense transient terahertz electric field, we observe the appearance of even-order harmonics in silicon, normally forbidden in centrosymmetric crystals. Reducing the symmetry via transient dressing might lead to ultrafast symmetry control in crystals.

FM3F.4 • 15:00
Polarimetry of THz High-Order Sideband Generation: Towards a Measurement of Berry Curvature, Darren C. Valovcin[1,2], Qile Wu[3], Shawn Mack[4], Arthur Gossard[5], Ren-Bao Liu[3], Mark S. Sherwin[1,2]; *[1]Physics, Univ. of California, Santa Barbara, USA; [2]Inst. for Terahertz Science and Technology, Univ. of California, Santa Barbara, USA; [3]Physics, The Chinese Univ. of Hong Kong, China; [4]U.S. Naval Research Lab, USA; [5]Materials, Univ. of California, Santa Barbara, USA.* Dynamical birefringence associated with high-order sideband generation is a consequence of Berry curvature of the driven material. Careful polarimetry opens the way to measuring Berry curvature in solids.

FM3F.5 • 15:15
Emission Phase of Extreme Ultraviolet High Harmonics from Bulk Crystals, Jian Lu[1], Yongsing You[1], David Reis[1,2], Shambhu Ghimire[1]; *[1]SLAC National Accelerator Lab, USA; [2]Dept. of Applied Physics, Stanford Univ., USA.* We measure the chirp in extreme ultraviolet high-harmonics from bulk MgO crystals pumped by strong near-infrared pulses using the two-color approach. By performing measurements in both reflection and transmission we separate propagation effects.

14:00–15:30 Workshop: Understanding Unconscious Bias, *Winchester 1&2, Hilton San Jose*

15:30–16:00 Coffee Break, *Concourse Level*

16:00–17:30 Workshop: Understanding Unconscious Bias Workshop, *Winchester 1&2, Hilton San Jose*

CLEO: QELS-Fundamental Science

FM3G • Quantum Sources I—Continued

FM3G.5 • 14:45
Effective $\chi^{(2)}$ in a Rb-Filled Hollow-Core Photonic Bandgap Fiber for Coherent Photon Conversion, Yun Zhao[2], Prathamesh Donvalkar[1], Chaitali Joshi[1], Bok Young Kim[2], Alexander L. Gaeta[2]; [1]*School of Applied and Engineering Physics, Cornell Univ., USA;* [2]*Dept. of Applied Physics and Applied Mathematics, Columbia Univ., USA*. We demonstrate a large effective $\chi^{(2)}$ in a rubidium-filled photonic bandgap fiber by an spontaneous parametric down conversion process. This system can be used for the coherent photon conversion scheme in quantum information processing.

FM3G.6 • 15:00
Adiabatic Fock State Generation Scheme Using Kerr Nonlinearity, Ryotatsu Yanagimoto[1], Tatsuhiro Onodera[1], Edwin Ng[1], Hideo Mabuchi[1]; [1]*Stanford Univ., USA*. We introduce a theoretical scheme for generating Fock states using a Kerr cavity by adiabatic variation of the detuning and driving field amplitude. We perform numerical calculations to determine requirements for experimental feasibility.

FM3G.7 • 15:15
Energy-entangled W-state in optical fiber, Bin Fang[1], Matteo Menotti[2], Marco Liscidini[2], John E. Sipe[3], Virginia O. Lorenz[1]; [1]*Physics, Univ. of Illinois at Urbana-Champaign, USA;* [2]*Physics, Univ. of Pavia, Italy;* [3]*Physics, Univ. of Toronto, Canada*. We demonstrate progress towards the generation of an energy-entangled three-photon W-state via spontaneous four-wave mixing in a polarization-maintaining fiber and characterize it by reduced density matrix tomography, without involving frequency conversion.

FM3H • Chiral and Topological Quantum Optics—Continued

FM3H.3 • 14:45
Pancharatnam-Berry Phase in a Condensate of Indirect Excitons, Jason R. Leonard[1], Alexander High[1], Aaron Hammack[1], Michael Fogler[1], Leonid Butov[1], Kenneth Campman[2], Arthur Gossard[2]; [1]*Dept. of Physics, Univ. of California at San Diego , USA;* [2]*Materials Dept., Univ. of California at Santa Barbara, USA*. We report on the observation of the Pancharatnam-Berry phase in a condensate of indirect excitons realized in a GaAs coupled quantum well structure. Our measurements indicate long range coherent spin transport.

FM3H.4 • 15:00
Scattering of Coherent Pulses from Quantum-Optical Systems, Kevin Fischer[1], Rahul Trivedi[1], Vinay Ramasesh[2], Irfan Siddiqi[2], Jelena Vuckovic[1]; [1]*Ginzton Lab, Stanford Univ., USA;* [2]*Dept. of Physics, Univ. of California, USA*. We develop a new computational tool and framework for characterizing the scattering of photons by energy-nonconserving Hamiltonians into unidirectional (chiral) waveguides, e.g., with coherent pulsed excitation. We demonstrate this approach for two prototypical quantum systems.

FM3H.5 • 15:15
Quantum Čerenkov radiation in weakly and strongly-coupled regimes, Charles Roques-Carmes[1], Nicholas Rivera[2], John Joannopoulos[2], Marin Soljacic[1,2], Ido Kaminer[1,3]; [1]*Research Lab of Electronics, MIT, USA;* [2]*Dept. of Physics, MIT, USA;* [3]*Technion – Israel Inst. of Technology, Dept. of Electrical Engineering, Israel*. We present the time-dependent quantum electrodynamic theory of Čerenkov radiation, which reveals orders of magnitude corrections to the decay rate from the conventional theory, as well as significant modifications to the well-established Čerenkov dispersion relation.

CLEO: Science & Innovations

SM3I • Optical Phase Arrays—Continued

SM3I.5 • 14:45
Bessel-Beam-Generating Integrated Optical Phased Arrays, Jelena Notaros[1], Christopher V. Poulton[1], Matthew Byrd[1], Manan Raval[1], Michael Watts[1]; [1]*MIT, USA*. Generation of Bessel beams using integrated optical phased arrays is proposed and experimentally demonstrated for the first time. A quasi-Bessel beam with a ~14mm Bessel length and ~30μm FWHM is generated using a splitter-tree-based architecture.

SM3I.6 • 15:00
3D integrated silicon photonic unit cell with vertical U-turn for scalable optical phase array, Yu Zhang[1], Kuanping Shang[1], Yi-Chun Ling[1], S. J. Ben Yoo[1]; [1]*Univ. of California, Davis, USA*. We demonstrate a 3D integrated silicon photonic unit cell with ultra-compact vertical U-turn interlayer coupling structures. A 120-channel folded single tile optical phase array with 2mm pitch is fabricated as a proof-of-concept.

SM3I.7 • 15:15
Broadband Imaging and Wireless Communication with an Optical Phased Array, Steven Spector[1], Benjamin F. Lane[1], Michael Watts[2], Lucas Benney[1], Justin Delva[1], Alva Hare[1], Adam Kelsey[1], Jacqueline Mlynarczyk[1,3], Ehsan Hosseini[2], Christopher Poulton[2], J P. Laine[1]; [1]*Charles Stark Draper Lab, USA;* [2]*Analog Photonics, USA;* [3]*Carderock Division, Naval Surface War Center, USA*. An optical phased array designed for broadband applications has been demonstrated. Using this architecture, imaging under natural light conditions and free space optical communications at a data rate of 10 Gbps have been achieved.

14:00–15:30 Workshop: Understanding Unconscious Bias, *Winchester 1&2, Hilton San Jose*

15:30–16:00 Coffee Break, *Concourse Level*

16:00–17:30 Workshop: Understanding Unconscious Bias Workshop, *Winchester 1&2, Hilton San Jose*

CLEO: QELS-Fundamental Science

FM3J • Imaging and Cloaking in Metamaterials—Continued

FM3J.6 • 14:45
"Invisible" Nanotextured Substrates for Quantum Optics and Microscopy, Andreas C. Liapis[1], Charles T. Black[2], Seok-Hyun Yun[1]; [1]*Wellman Center for Photomedicine, Massachusetts General Hospital, USA;* [2]*Center for Functional Nanomaterials, Brookhaven National Lab, USA*. We show that nanotextured antireflective metasurfaces, fabricated by block copolymer self-assembly, can be used to suppress the influence of the substrate in quantum optical experiments and microscopy.

FM3J.7 • 15:00
Infrared Invisibility Cloak Using Rolled Metamaterial Film, Tomo Amemiya[1], Satoshi Yamasaki[1], Toru Kanazawa[1], Zhichen Gu[1], Daisuke Inoue[1], Atsushi Ishikawa[2], Nobu Nishiyama[1], takuo tanaka[3], Tatsuhiro Urakami[4], Shigehisa Arai[1]; [1]*Tokyo Inst. of Technology, Japan;* [2]*Okayama Univ., Japan;* [3]*RIKEN, Japan;* [4]*Mitsui Chemicals, Inc., Japan*. We propose and demonstrate a method of making an infrared (~60 THz) invisibility cloaking device by simply rolling a metamaterial film around an object that we want to hide.

FM3J.8 • 15:15
Electrically Controllable Reconfiguration of Terahertz Meta-Atoms into Meta-Molecules, Hyunseung Jung[1], Jaemok Koo[2], Wonwoo Lee[3], Moon Sung Kang[2], Hojin Lee[1,3]; [1]*School of Electronic Engineering, Soongsil Univ., South Korea;* [2]*Dept. of Chemical Engineering, Soongsil Univ., South Korea;* [3]*Dept. of Information Communication, Materials, and Chemistry Convergence Technology, Soongsil Univ., South Korea*. We report structural methodology for electrically switchable terahertz metamaterials between atom- and molecule-states by using limited conductance variation of graphene bridges. Based on experimental verification, we confirmed 39% of wide resonance tuning of terahertz metamaterials.

CLEO: Science & Innovations

SM3K • Billouim Scattering and Applications—Continued

SM3K.6 • 15:00
Suppression of Stimulated Brillouin Scattering using Off-Axis Twisted Core Fiber, Kazi S. Abedin[1], Raja Ahmad[1], Kenneth Feder[1], David DiGiovanni[1]; [1]*OFS Labs, USA*. We propose a method of suppression of Brillouin scattering by using offset-core twisted fiber. A 5.2dB increase in SBS-threshold is observed by offsetting the fiber-core from center by 35µm and winding in a 45mm spool.

SM3K.7 • 15:15
Opto-Mechanical Time-Domain Reflectometry: Distributed Sensing Outside the Cladding of Standard Fiber, Gil Bashan[1], Hilel Hagai Diamandi[1], Yosef London[1], Eyal Preter[1], Avi Zadok[1]; [1]*Bar-Ilan Univ., Israel*. Distributed sensing of liquids outside the cladding of standard, unmodified fiber is demonstrated, with 3 km range and 100 m resolution. Guided light remains confined to the core. Measurements rely on fiber opto-mechanics.

SM3L • Photonic Frequency References and Sources—Continued

SM3L.6 • 14:45
Characterization of Large-Area Crystalline Coatings for Next-Generation Gravitational Wave Detectors, Garrett Cole[1,2], Christoph Deustch[2], David Follman[1], Paula Heu[1], Tobias Zederbauer[2], Ashish Rai[2], Dominic Bachmann[2], Alexander von Finck[3], Sven Schröder[3], Philip Koch[4], Harald Lück[4]; [1]*Crystalline Mirror Solutions LLC, USA;* [2]*Crystalline Mirror Solutions GmbH, Austria;* [3]*Fraunhofer Inst. for Applied Optics and Precision Engineering (IOF), Germany;* [4]*Albert Einstein Inst. (AEI) Hannover, Max Planck Inst. for Gravitational Physics, Germany*. Through in-depth optical characterization including thickness uniformity and optical scatter measurements, we demonstrate that large-area crystalline coatings are a promising alternative to ion-beam sputtered multilayers for low-noise mirrors employed in next-generation gravitational wave detectors.

SM3L.7 • 15:00
All-Fiber Delay Line-Based Repetition-Rate Stabilization, Dohyeon Kwon[1], Jungwon Kim[1]; [1]*Korea Advanced Inst of Science & Tech, South Korea*. We demonstrate all-fiber repetition-rate stabilization method with 10^{-14}-level frequency instability and 1-fs-level integrated timing jitter over 1-s using all-fiber Michelson interferometer with compactly packaged 10-km-long fiber delay.

14:00–15:30 Workshop: Understanding Unconscious Bias, *Winchester 1&2, Hilton San Jose*

15:30–16:00 Coffee Break, *Concourse Level*

16:00–17:30 Workshop: Understanding Unconscious Bias Workshop, *Winchester 1&2, Hilton San Jose*

CLEO: QELS-Fundamental Science

FM3M • Sources and Technology for Attosecond and High-field Physics—Continued

FM3M.5 • 14:45
Efficient laser wakefield acceleration by using mid-infrared pulses, Eiji J. Takahashi[1], Shin-ichi Masuda[3], Eisuke Miura[2]; *[1]RIKEN, Japan; [2]National Inst. of Advanced Industrial Science and Technology, Japan; [3]Photon Pioneers Center, Osaka Univ., Japan.* We discuss the feasibility of an efficient laser wakefield acceleration driven by an intense mid-infrared pulse. TW-scale 1.5 μm laser pulse can improve the number of accelerated electrons as an order of magnitude, compared with that driven by a Ti:sapphire laser (0.8 μm).

FM3M.6 • 15:00
Ultrafast electron emission assisted by grating-coupled propagating surface plasmons in the mid-IR range, Kengo Takeuchi[1], Tomoya Mizuno[1], Keisuke Kaneshima[1], Nobuhisa Ishii[1], Teruto Kanai[1], Jiro Itatani[1]; *[1]The Univ. of Tokyo, Japan.* We observed propagating-surface plasmon-assisted photoemission from a grating irradiated by mid-IR laser pulses by measuring the incidence-angle dependence of photoelectron spectra. The results reveal that emitted electrons are further accelerated by locally enhanced electric fields.

FM3M.7 • 15:15
Phase-Dependent Dielectric Laser Acceleration of 99keV Electrons with Symmetrically Driven Silicon Dual Pillar Gratings, Kenneth Leedle[1], Dylan S. Black[1], Yu Miao[1], Karel Urbanek[1], Andrew Ceballos[1], Huiyang Deng[1], James S. Harris[1], Olav Solgaard[1], Robert L. Byer[1]; *[1]Stanford Univ., USA.* We present phase-dependent laser acceleration and deflection of electrons using a symmetrically driven silicon dual pillar grating. We demonstrate cosh accelerator modes and sinh deflecting modes at gradients of 200 MeV/m over 15 um distance.

CLEO: Science & Innovations

SM3N • High Power Lasers—Continued

SM3N.4 • 15:00
High Average Power Type II Frequency Doubling with a Predelay for Pulse Compression and Peak Intensity Enhancement, Sabrina Beyer[1,2], Christian Grebing[1], Marcel Schultze[1], Knut Michel[1], Georg Korn[3], Thomas Metzger[1]; *[1]TRUMPF Scientific Lasers GmbH + Co. KG, Germany; [2]Fakultaet für angewandte Naturwissenschaften und Mechatronik, Munich Univ. of Applied Sciences, Germany; [3]Extreme Light Infrastructure - Beamlines, Czechia.* Fourfold pulse compression from 840 fs to 192 fs was obtained by inserting a time delay between the ordinary- and extraordinary fundamental pulses prior to type II frequency doubling in a BBO crystal. Despite a conversion efficiency of 26 %, an increase of peak power of nearly 20 % was achieved.

SM3N.5 • 15:15
Gas Lens in kW-Class Thin-Disk Lasers, Francesco Saltarelli[1], Andreas Diebold[1], Ivan J. Graumann[1], Clara J. Saraceno[1,2], Christopher R. Phillips[1], Ursula Keller[1]; *[1]ETH Zurich, Switzerland; [2]Ruhr Universität Bochum, Germany.* We measured, for the first time, a gas-lens effect accounting for 33% of the total disk thermal lensing. By helium flooding the laser, we obtain optimal beam quality (M2<1.10) over a 70% broader power range.

SM3O • Fundamentals of Laser Material Processing—Continued

SM3O.5 • 14:45
Femtosecond laser writing of 3-D NLO structures in glass, Carl M. Liebig[1], Jonathan Goldstein[1], Sean McDanniel[1,2], Douglas Krein[1,3], Gary Cook[1]; *[1]Air Force Research Lab, USA; [2]Leidos, USA; [3]General Dynamics Information Technology, USA.* Femtosecond laser pulses have been used to precipitate 3-dimensional $LiNbO_3$ structures in supersaturated glass for second harmonic generation (SHG). Measurements for successive layers with parallel and antiparallel optical axes compare nicely with calculations.

SM3O.6 • 15:00
Wavelength-Dependent Coupling of Ultrafast Filaments to Solid Surfaces, Milos Burger[1], Patrick J. Skrodzki[1], John Nees[1], Igor Jovanovic[1]; *[1]Univ. of Michigan, USA.* Plasma luminosity is essential to remote sensing based on filament-induced breakdown spectroscopy. We present the measurements of dynamics and luminosity of plasmas produced by 0.4, 0.8, and 2.0 μm filaments on a copper surface.

SM3O.7 • 15:15
Time-Resolved Surface Microscopy of Single Shot Few-Cycle Pulse Laser Ablation of Single Layer TiO_2 Thin Films, Noah Talisa[1], Kevin Werner[1], Enam Chowdhury[1]; *[1]Dept. of Physics, The Ohio State Univ., USA.* The dynamics of the few-cycle pulse laser ablation process of a single layer TiO_2 thin film from 6 ps to 1.1 ns after a single pulse hits the surface are studied using time-resolved microscopy.

Monday, 13:30–15:30

14:00–15:30 Workshop: Understanding Unconscious Bias, *Winchester 1&2, Hilton San Jose*

15:30–16:00 Coffee Break, *Concourse Level*

16:00–17:30 Workshop: Understanding Unconscious Bias Workshop, *Winchester 1&2, Hilton San Jose*

AM3P • Photobiomodulation Therapeutics—Continued

AM3P.5 • 15:00
Controlled laser biochemistry in room-temperature polar liquids by ultrashort laser pulses, Vitaly Gruzdev[1], Dmitry Korkin[2], Brian P. Mooney[3,4], Jesper F. Havelund[5,6], Ian M. Møller[6], Jay J. Thelen[3]; *[1]Univ. of Missouri-Columbia, USA; [2]Dept. of Computer Science, Bioinformatics and Computational Biology Program, Worcester Polytechnic Inst., USA; [3]Dept. of Biochemistry, Bond Life Sciences Center, Univ. of Missouri, USA; [4]Charles W Gehrke Proteomics Center, Univ. of Missouri, USA; [5]Dept. of Biochemistry and Molecular Biology, Univ. of Southern Denmark, Denmark; [6]Dept. of Molecular Biology and Genetics, Aarhus Univ., Denmark.* Traditional laser methods to control chemical modifications of biomolecules are not applicable under biologically relevant conditions. We report controlled modifications of peptides and insulin by femtosecond laser in water, methanol, and acetonitrile at room temperature.

AM3P.6 • 15:15
Parylene Photonic Waveguide Arrays: A Platform for Implantable Optical Neural Implants, Jay W. Reddy[1]; *[1]Carnegie Mellon Univ., USA.* We demonstrate compact, low-loss (<10dB/cm) Parylene-C waveguide arrays in a flexible, biocompatible, polymer platform suitable for implantable neural probes. Mechanisms of optical loss are investigated and fabrication techniques to reduce propagation loss in the optical waveguides are presented.

FM3Q • Topological Photonic Structure—Continued

FM3Q.6 • 14:45
All-dielectric topological meta-optics, Alexey Slobozhanyuk[3,4], Alena Shchelokova[3,4], Xiang Ni[1,2], Hossein Mousavi[5,1], Daria Smirnova[1], Pavel Belov[3], Andrea Alù[5], Yuri S. Kivshar[4], Alexander B. Khanikaev[1,2]; *[1]City College of New York, USA; [2]Physics, Graduate Center of CUNY, USA; [3]ITMO Univ., Russia; [4]Australian National Univ., Australia; [5]Univ. of Texas at Austin, USA.* We present all-dielectric resonant structured surfaces for the realization of lossless compact photonic topological metadevices. We demonstrate spin-Hall effect of light for spin-polarized topological edge states through proof-of-concept near-field spectroscopy measurements.

FM3Q.7 • 15:00
Photonic Chern insulator through homogenization of an array of particles, Meng Xiao[1], Shanhui Fan[1]; *[1]Standford Unversity, USA.* We propose a route towards creating a photonic Chern insulator through homogenization with an array of gyromagnetic cylinders. The non-trivial band topology of such a system is independent of the lattice structure.

FM3Q.8 • 15:15
Experiments on topological nodal chains, Qinghui Yan[1,2], Rongjuan Liu[1], Zhongbo Yan[3], Boyuan Liu[1], Hongsheng Chen[2], Zhong Wang[3], Ling Lu[1]; *[1]Inst. of Physics, Chinese Academy of Sciences, China; [2]College of Information Science and Electronic Engineering, Zhejiang Univ., China; [3]Inst. for Advanced Study, Tsinghua Univ., China.* We theoretically predicted and experimentally verified mirror-protected nodal chains in a metallic-mesh photonic crystal at microwave frequencies. The bulk states were detected through angle-resolved transmission and drumhead surface states were mapped out by field scans.

14:00–15:30 Workshop: Understanding Unconscious Bias, *Winchester 1&2, Hilton San Jose*

15:30–16:00 Coffee Break, *Concourse Level*

16:00–17:30 Workshop: Understanding Unconscious Bias Workshop,
Winchester 1&2, Hilton San Jose

CLEO: Science & Innovations

16:00–18:00
SM4A • THz High-field Generation and Detection
Presider: Masayoshi Tonouchi; Osaka Univ., Japan

SM4A.1 • 16:00
Terahertz Wave Generation from Water, Yiwen E[1], Qi Jin[1], Kaia Williams[1], Jianming Dai[2], Xicheng Zhang[1,3]; *[1]Univ. of Rochester, USA; [2]Tianjin Univ. of China, China; [3]Capital Normal Univ., China*. Terahertz wave generation from liquid water has been experimentally demonstrated by focusing femtosecond laser pulses in a water film, which shows that the signal of water is 1.8 times stronger than that of ambient air.

SM4A.2 • 16:15
Simultaneous generation and compression of broadband terahertz pulses in aperiodically poled crystals, Koustuban Ravi[1,2], Franz X. Kaertner[1,2]; *[1]MIT, USA; [2]Ultrafast optics and X-rays, Center for free electron lasers, Germany.* A non-uniform sequence of pump pulses in aperiodically poled crystals is shown to generate transform-limited terahertz pulses. Tunable, compressed terahertz output with single-stage conversion efficiencies > 2% and pulse energies ~ 10 mJ are predicted.

SM4A.3 • 16:30
Scaling of THz Generation in DSTMS to High Repetition Rates, Matthew Windeler[1,2], Katalin Mecseki[1], Franz Tavella[1], Matthias C. Hoffmann[1]; *[1]SLAC National Accelerator Lab, USA; [2]Queen's Univ., Canada*. We explore the scaling behavior of THz generation through optical rectification in DSTMS as function of repetition rate from 100 Hz to 200 kHz. We observe a strong drop-off in conversion efficiency above 10 kHz.

SM4A.4 • 16:45
Segmented Terahertz driven device for ultrashort electron acceleration, compression, focusing and streaking, Dongfang Zhang[1], Arya Fallahi[1], Michael Hemmer[1], Xiaojun Wu[1], Moein Fakhari[1], Yi Hua[1], Huseyin Cankaya[1], Anne-Laure Calendron[1], Luis Zapata[1], Nicholas H. Matlis[1], Franz X. Kaertner[1]; *[1]DESY, Germany.* We present a novel THz based device (STEAM) capable of performing multiple high-field operations of electron acceleration, compression, focusing and streaking.

SM4A.5 • 17:00 Invited
Developments and Applications of Echelon-Based Single-shot Terahertz Spectroscopy, Ben Ofori-Okai[1], Stephanie Teo[2], Christopher Werley[3], Zhijiang Chen[1], Samuel Teitelbaum[1], Brandon Russell[4], Matthias C. Hoffmann[1], Keith Nelson[5], Siegfried Glenzer[1]; *[1]SLAC National Accelerator Lab, USA; [2]Samsung Research America, USA; [3]Q-State Biosciences, USA; [4]Univ. of Michigan, USA; [5]MIT, USA.* We present recent advancements in echelon-based single-shot terahertz spectroscopy for broadband spectroscopic applications. We also apply an echelon-based scheme to study photo-induced changes in correlated electron materials and warm dense matter.

16:00–18:00
SM4B • Microrings and Novel Modulation Schemes
Presider: Jian Wang; Huazhong Univ of Science and Technology, China

SM4B.1 • 16:00
Plasmonic-Organic Hybrid Modulators for Optical Interconnects beyond 100G/λ, Benedikt Baeuerle[1], Wolfgang Heni[1], Yuriy Fedoryshyn[1], Arne Josten[1], Christian Haffner[1], Tatsuhiko Watanabe[1], Delwin Elder[2], Larry R. Dalton[2], Juerg Leuthold[1]; *[1]ETH Zurich, Switzerland; [2]Dept. of Chemistry, Univ. of Washington, USA.* We demonstrate a short-reach optical interconnect with a plasmonic intensity modulator. Data rates of 56 GBd PAM-4 and 100 GBd PAM-2 are demonstrated over 2 km and 1 km SSMF with direct detection at 1544nm.

SM4B.2 • 16:15
Electrically-Induced Absorption Silicon-Plasmonic Modulator with 70nm Bandwidth, Qian Gao[1], Erwen Li[1], Alan X. Wang[1]; *[1]Oregon State Univ., USA.* We present an electrically-induced absorption plasmonic modulator on silicon platform with 3 μm length using transparent conductive oxide filled in Au slot waveguide. We experimentally demonstrated 1.5dB/μm extinction ratio over 70 nm optical bandwidth

SM4B.3 • 16:30 Invited
Commercializing Silicon Microring Resonators: Technical Challenges and Potential Solutions, Po Dong[1], Argishti Melikyan[1], Kwangwoong Kim[1]; *[1]Nokia Bell Labs, USA.* Silicon microrings can find a wide range of applications in optical interconnects and communications. However, their resonant wavelengths are extremely sensitive to fabrication and temperature variations. Here we review possible solutions to address this challenge.

SM4B.4 • 17:00
112-Gb/s PAM-4 using Integrated Germanium on Silicon Franz Keldysh Modulator, Yeyu Tong[1], Zhouyi Hu[2], Xinru Wu[1], Jie Liu[1], Chun-Kit Chan[2], Chester Shu[1], Hon Ki Tsang[1]; *[1]Electronic Engineering, Chinese Univ. of Hong Kong, Hong Kong; [2]Information Engineering, The Chinese Univ. of Hong Kong, Hong Kong.* We evaluate the performance of 112-Gb/s PAM-4 modulation using integrated Ge electro-absorption modulator operating at 1622 nm. Using pre-equalization with 25-GHz bandwidth limited arbitrary waveform generator we demonstrated 1-km fiber transmission at 112 Gb/s.

16:00–18:00
SM4C • SDM Communication II
Presider: Ryan Scott; Keysight Technologies Inc., USA

SM4C.1 • 16:00
Crosstalk Impact on a 535 Tb/s 172 km Transmission Using a Homogeneous 19-Core Multicore Fiber, Ruben S. Luis[1], Benjamin Puttnam[1], Georg F. Rademacher[1], Yoshinari Awaji[1], Naoya Wada[1]; *[1]National Inst Information & Comm Tech, Japan.* We show the feasibility of a 535 Tb/s link with 172.8 km reach using a 19-core homogeneous multicore fiber. We demonstrate an average crosstalk penalty below 0.25 dB, enabling the transmission of 115x24.5 Gbaud PDM-64QAM signals in the C-band.

SM4C.2 • 16:15
Modal Crosstalk Mitigated IM/DD Mode-Multiplexed Transmission Based on Pilot Assisted Least Square Algorithm, Qianwu Zhang[1], Fang Wang[1], Qingqing Huang[1], Haoshuo Chen[2], Nicolas K. Fontaine[2], Roland Ryf[2], Minwen Liu[1], Jian Chen[1]; *[1]Shanghai Univ., China; [2]Nokia Bell Labs, USA.* We experimentally demonstrate mode group crosstalk mitigation in IM/DD mode-multiplexed OFDM transmission using pilot assisted least square algorithm. Transmission performance is improved through mitigating the crosstalk between the LP01 and LP11 mode groups.

SM4C.3 • 16:30 Invited
Modulation and Detection for Multicore Superchannels with Correlated Phase Noise, Erik Agrell[1], Arni Alfredsson[1], Benjamin Puttnam[2], Ruben S. Luis[2], Georg Rademacher[2], Magnus Karlsson[3]; *[1]Dept. of Electrical Engineering, Chalmers Univ. of Technology, Sweden; [2]Photonic Network System Lab, NICT, Japan; [3]Dept. of Microtechnology and Nanoscience, Chalmers Univ. of Technology, Sweden*. SDM fibers offer new opportunities and challenges for joint transmitter and receiver processing. We review multidimensional modulation and detection theory, describe algorithms for phase tracking and detection over spatial superchannels, and present some experimental results.

SM4C.4 • 17:00
7×149 Gbit/s PAM4 Transmission over 1 km Multicore Fiber for Short-Reach Optical Interconnects, Oskars Ozolins[1], Xiaodan Pang[2,1], Aleksejs Udalcovs[1], Rui Lin[2,3], Joris Van Kerrebrouck[4], Lin Gan[3], Lu Zhang[2], Ming Tang[3], Songnian Fu[3], Richard Schatz[2], Urban Westergren[2], Gunnar Jacobsen[1], Deming Liu[3], Weijun Tong[5], Guy Torfs[4], Johan Bauwelinck[4], Jiajia Chen[2], Sergei Popov[2], Xin Yin[4]; *[1]RISE Acreo AB, Sweden; [2]KTH Royal Inst. of Technology, Sweden; [3]Huazhong Univ. of Science and Technology, China; [4]INTEC, Ghent Univ. – imec, Belgium; [5]Yangtze Optical fiber and Cable Joint Stock Limited Company, China*. We transmit 80 Gbaud/λ/core PAM4 signal enabled by 1.55 μm EML over 1 km 7-core fiber. The solution achieves single-wavelength and single-fiber 1.04 Tbit/s post-FEC transmission enhancing bandwidth-density for short-reach optical interconnects.

CLEO: Science & Innovations

16:00–18:00
SM4D • Optical Metrology Nonlinear Optical Technologies
Presider: Michelle Sander; Boston Univ., USA

SM4D.1 • 16:00
High rep-rate, high peak power 1450 nm laser source based on optical parametric chirped pulse amplification, Pengfei Wang[1], Yanyan Li[1], Wenkai Li[1], Hongpeng Su[1], Yujie Peng[1], Yuxin Leng[1]; [1]*Shanghai Inst of Optics & Fine Mechanics, China*. A high peak power 1450 nm laser running at 100 Hz repetition rate is demonstrated, which can generate 20 mJ energy and 60 fs pulse width, corresponding the peak power of more than 0.3 terawatt.

SM4D.2 • 16:15
Near-infrared to visible upconversion detection for active imaging using a broadband pump laser, Romain Demur[1,2], Arnaud Grisard[1], Eric Lallier[1], Loic Morvan[1], Luc Leviandier[1], Nicolas Treps[2], Claude Fabre[2]; [1]*Thales Research & Technology, France;* [2]*Laboratoire Kastler Brossel, UPMC-Sorbonne universités, CNRS, ENS-PSL Research Univ., France*. Upconversion is a promising technique to increase sensitivity in active imaging. Using a pump laser with a wide spectrum, the field of view of our system is increased with image characteristics compatible with practical applications.

SM4D.3 • 16:30
Intra-cavity Self-illuminated Image Up-conversion System based on SHG in a Compact Laser, Adrian J. Torregrosa[1], Haroldo Maestre[1], Maria Luisa Rico[2], Juan Capmany[1]; [1]*Universidad Miguel Hernandez, Spain;* [2]*Universidad de Alicante, Spain*. We present a compact laser for image up-conversion from infrared to visible based on intra-cavity SHG by type-II phase matching. Reflected images by Nd^{3+}:YVO_4 laser illumination at 1342 are intra-cavity frequency-doubled into a KTP crystal.

SM4D.4 • 16:45
Mid-Infrared (6 - 10 μm) upconversion in $LiInS_2$ using 1064 nm CW pump, Ajanta Barh[1], Lasse Høgstedt[2], Peter Tidemand-Lichtenberg[1], Christian Pedersen[1]; [1]*Technical Univ. of Denmark (DTU), Denmark;* [2]*NLIR Aps, Denmark*. For the first time wide-band mid-infrared (6-10 μm) frequency upconversion in a $LiInS_2$ crystal is obtained using a 1064 nm pump. The absorption spectrum of polystyrene is characterized using a near-infrared grating and a Si-CCD.

SM4D.5 • 17:00
Optical Companding, Yunshan Jiang[1], Bahram Jalali[1]; [1]*Univ. of California Los Angeles, China*. We introduce a new nonlinear analog optical computing concept that compresses the signal's dynamic range and realizes non-uniform quantization that reshapes and improve the signal-to-noise ratio in the digital domain.

CLEO: QELS-Fundamental Science

16:00–18:00
FM4E • PT-Symmetry and Non-Hermitian Photonics
Presider: Stefan Rotter; Technische Universität Wien, Austria

FM4E.1 • 16:00
Manipulation and detection of optical coherence in non-conservative PT photonic structures, Kai Wang[1,2], Sergey V. Suchkov[1], James Titchener[1], Steffen Weimann[2], Demetrios N. Christodoulides[3], Alexander Szameit[2], Andrey A. Sukhorukov[1]; [1]*Nonlinear Physics Centre, RSPE, Australian National Univ., Australia;* [2]*Inst. for Physics, Rostock Universitat, Germany;* [3]*CREOL, The College of Optics and Photonics, Univ. of Central Florida, USA*. We predict a periodic variation of the coherence between optical modes in parity-time symmetric photonic structures, and demonstrate experimentally reversible purification of fully spatially incoherent input light state propagating along coupled conservative and lossy waveguides.

FM4E.2 • 16:15
Extreme dynamics near exceptional points, QI ZHONG[1,2], Konstantinos Makris[3], Ramy El-Ganainy[1,2]; [1]*Dept. of Physics, Michigan Technological Univ., USA;* [2]*Henes Center for Quantum Phenomena, Michigan Technological Univ., USA;* [3]*Dept. of Physics, Univ. of Crete, Greece*. We investigate the extreme dynamics of non-Hermitian photonic systems near higher order exceptional points (EP) and we show that the maximum possible power amplification follows a power-law dependence on the order of the EP.

FM4E.3 • 16:30
Unidirectional Light Generation in PT-symmetric Microring Lasers, Jinhan Ren[1], Midya Parto[1], Steffen Wittek[1], Mohammad Parvinnezhad Hokmabadi[1], Demetrios N. Christodoulides[1], Mercedeh Khajavikhan[1]; [1]*CREOL UCF, USA*. At resonance, mircoring resonators tend to support two counter-propagating degenerate modes. By incorporating S-bend chiral elements in each resonator, unidirectional single mode lasing below and above PT-symmetry breaking point is experimentally demonstrated.

FM4E.4 • 17:00
Saturation-Induced Perfect Absorbers, Ali Kazemi Jahromi[1], Ayman Abouraddy[1]; [1]*Univ. of Central Florida, CREOL, USA*. We introduce a new regime of optical absorption where increasing the incoming intensity – equivalently inducing optical saturation – leads to the enhancement of total absorption in a device, and always reaches 100% at a critical value.

16:00–18:00
FM4F • Probing Materials with Ultrafast Electricity and Extreme Light
Presider: Rupert Huber; Universität Regensburg, Germany

FM4F.1 • 16:00
Quantum Coherent Transverse and Longitudinal Control for Attosecond Shaping of Free Electron Beams, Armin Feist[1], Katharina E. Priebe[1], Christopher Rathje[1,3], Thomas Rittmann[1], Sergey V. Yalunin[1], Thorsten Hohage[2], Sascha Schäfer[1,3], Claus Ropers[1]; [1]*4th Physical Inst., Univ. of Göttingen, Germany;* [2]*Inst. for Numerical and Applied Mathematics, Univ. of Göttingen, Germany;* [3]*Inst. of Physics, Univ. of Oldenburg, Germany.* We demonstrate coherent control of free-electron momentum states in the longitudinal and transverse dimensions, including a temporal shaping of electron densities. A novel quantum state reconstruction scheme is employed to measure attosecond electron pulse trains.

FM4F.2 • 16:30
Investigation of Trap States and Their Dynamics in Hybrid Organic-inorganic Mixed Cation Perovskite Films Using Time Resolved Photoemission Electron Microscopy, Andrew Winchester[1], Christopher Petoukhoff[1], Mojtaba Abdi-Jalebi[2], Zahra Andaji-Garmaroudi[2], Vivek Pareek[1], E Laine Wong[1], Julien Madeo[1], Michael Man[1], Samuel D. Stranks[2], Keshav M. Dani[1]; [1]*Femtosecond Spectrocopy Unit, Okinawa Inst. of Science and Technology , Japan;* [2]*Cavendish Lab, Univ. of Cambridge, UK*. We use time-resolved photoemission electron microscopy to investigate hybrid organic perovskite thin films. We observe heterogeneous trap state densities varying on the nanometer scale. Further, we study the photo-excited carrier dynamics within these nanoscale regions.

FM4F.3 • 16:45
Nanoscale Magnetic Imaging using High-Harmonic Radiation, Sergey Zayko[1], Ofer Kfir[1,2], MIchael Heigl[3], Murat Sivis[1], Manfred Albrecht[3], Claus Ropers[1,4]; [1]*IV. Physical Inst. – Solids and Nanostructures, Univ. of Göttingen, Germany;* [2]*Solid State Inst. and Physics Dept., Technion – Israel Inst. of Technology, Israel;* [3]*Inst. of Physics, Univ. of Augsburg, Germany;* [4]*International Center for Advanced Studies of Energy Conversion (ICASEC), Univ. of Göttingen, Germany.* We demonstrate high-resolution magneto-optical imaging using circularly-polarized high-harmonic radiation. We quantitatively map amplitude and phase of the x-ray magnetic circular dichroism at the Co M-edge using coherent diffractive imaging.

FM4F.4 • 17:00
Ultrafast X-ray Diffraction Reveals a Soft-Mode Driven Reversal of Polarity in Ferroelectrics, Christoph Hauf[1], Antonio-Andres Hernandez Salvador[1], Marcel Holtz[1], Michael Woerner[1], Thomas Elsaesser[1]; [1]*Max-Born-Inst., Germany.* Transient charge density maps of photoexcited ferroelectric ammonium sulfate are determined by femtosecond x-ray diffraction. We observe a previously unknown soft-mode that induces a transient reversal of the full macroscopic electric polarization.

CLEO: QELS-Fundamental Science

CLEO: Science & Innovations

16:00–18:00
FM4G • Quantum Sources II
Presider: Joshua Bienfang; NIST, USA

FM4G.1 • 16:00
Frequency entanglement swapping, Sofiane Merkouche[1], Valerian Thiel[2], Alex O. Davis[2], Brian J. Smith[1,2]; [1]*Univ. of Oregon, USA;* [2]*Univ. of Oxford, UK*. Entanglement swapping of spectrally-entangled photons is experimentally demonstrated. Idler photons from independent entangled pairs are jointly detected after a beamsplitter and frequency filters, projecting the signal photons onto a frequency-bin singlet state.

FM4G.2 • 16:15
Hong-Ou-Mandel interference in the frequency domain using linear optical components, Poolad Imany[1], Ogaga D. Odele[1], Mohammed S. Al Alshaykh[1], Hsuan-Hao Lu[1], Daniel E. Leaird[1], Andrew M. Weiner[1]; [1]*Purdue Univ., USA*. We demonstrate a Hong-Ou-Mandel interference pattern in the frequency domain with an electro-optic phase modulator and programmable pulse shapers, using energy-time entangled photons.

FM4G.3 • 16:30
Parallel Characterization of Two-Qubit Frequency-Bin Entanglement, Ogaga D. Odele[1], Poolad Imany[1], Daniel E. Leaird[1], Andrew M. Weiner[1]; [1]*Purdue Univ., USA*. We examine multiple sets of frequency bins exhibiting two-dimensional entanglement in parallel using pulse shapers and electro-optic phase modulation. With this technique, we also demonstrate the retrieval of the dispersion constant of a single-mode fiber.

FM4G.4 • 16:45
Shaping photon-pairs time-frequency correlations in inhibited-coupling hollow-core fibers, Martin Cordier[1], Adeline Orieux[2], Benoit Debord[3], Frédéric Gérôme[3], Alexandre Gorse[4], Matthieu Chafer[3], Eleni Diamanti[2], Philippe Delaye[5], Fetah Benabid[3], Isabelle Zaquine[1]; [1]*Telecom ParisTech, France;* [2]*LIP6, France;* [3]*XLIM, France;* [4]*GloPhotonics, France;* [5]*Laboratoire Charles Fabry, France*. We experimentally show how multiband dispersion properties of inhibited-coupling hollow-core fibers allow to control the spectral correlations of photon pairs generated through four-wave-mixing in a fiber filled with non-linear gas.

FM4G.5 • 17:00
Generation of NIR correlated photon pairs in optical nano-fibers, Jin-Hun Kim[1], Yong Sup Ihn[1], Heedeuk Shin[1], Yoon-Ho Kim[1]; [1]*Pohang Univ of Science & Technology, South Korea*. We report the generation of near-IR (NIR) nondegenerate correlated photon pairs in an 13-cm-long optical nano-fiber (ONF). The coincidence-to-accidental ratio (CAR), 400 has been achieved at a very low average pump power of 70 μW

16:00–18:00
FM4H • Quantum Optics with Atomic and Molecular Ensembles
Presider: Adam Black; US Naval Research Lab, USA

FM4H.1 • 16:00
Synthetic Two-dimensional Spin-orbit Coupling in Ultracold Fermi Gases, Jing Zhang[1]; [1]*Shanxi Univ., China*. We report the experimental realization of 2D spin-orbit coupling in ultracold 40K Fermi gases using three lasers, each of which dresses one atomic hyperfine spin state.

FM4H.2 • 16:15
Strong Low-Frequency Squeezed Light from Dual-Seeded Four-Wave Mixing, Meng-Chang Wu[1], Nicholas Brewer[1], Bonnie L. Schmittberger[1], Paul D. Lett[1,2]; [1]*Univ. of Maryland, College Park, USA;* [2]*National Inst. of Standards and Technology, USA*. We have obtained -7 dB of intensity-difference squeezing below 15 Hz via four-wave mixing in a rubidium vapor. This was accomplished by locking the laser and using two seed beams to balance the power.

FM4H.3 • 16:30
Sub-Shot Noise Stimulated Raman Spectroscopy with Parametric Homodyne Detection, Yoad H. Michael[1], Michael Rosenbluh[1], Avi Pe'er[1]; [1]*Bar-Ilan Univ., Israel*. We present a method for Raman spectroscopy based on nonlinear phase detection in SU(1,1) interferometer. This method utilizes squeezed light to eliminate the noise associated with the stimulated Raman interactions and enhance the Raman gain.

FM4H.4 • 16:45
Experimental demonstration of Rabi Oscillations produced by adiabatic pulse due to initial atomic coherence, Zhenhuan Yi[1], Xingchen Zhao[1], Zhiguo Wang[1,2], Tao Peng[1], Anatoly A. Svidzinsky[1], Hichem Eleuch[1], Marlan Scully[1,3]; [1]*Texas A&M Univ., USA;* [2]*Xi'an Jiaotong Univ., China;* [3]*Baylor Univ., USA*. We experimentally demonstrate that initial atomic coherence yields Rabi oscillations in a two-level system driven by an adiabatic pulse. This method can be used to achieve Quantum Amplification by Superradiant Emission of Radiation (QASER) in atomic vapors.

FM4H.5 • 17:00
Spatial Multiplexing of Atom-Photon Entanglement Sources , Zhongxiao Xu[1], Long Tian[1], Shujing Li[1], Hai Wang[1]; [1]*Shanxi Univ., China*. We build a multiplexed light-matter interface and then demonstrate a ~sixfold (~fourfold) probability increase in generating entangled atom-photon (photon-photon) pairs. The measured compositive Bell parameter for the multiplexed interface is 2.49±0.03 and a memory lifetime of up to ~51 μs.

16:00–18:00
SM4I • Novel Emitters
Presider: Yasutomo Ota; Univ. of Tokyo, Japan

SM4I.1 • 16:00
Accelerating Emission dynamics in Perovskites Plasmonic Nanolasers, Sui Yang[1], Wei Bao[1], Xiaoze Liu[1], Jeongmin Kim[1], Rongkuo Zhao[1], Yuan Wang[1], Xiang Zhang[1]; [1]*Univ. of California Berkeley, USA*. Slow exciton recombination in recent emerging perovskite semiconductors brings a fundamental limitation for nanophotonic devices. Here we demonstrate a perovskite nanolaser under hybrid plasmonic confinement with dramatically accelerated emission dynamics via a scalable solution process.

SM4I.2 • 16:15
Electron beam-induced tunable radiation from silicon-only structures in the near-infrared, Charles Roques-Carmes[1], Steven E. Kooi[2], Aviram Massuda[1], Aun Zaidi[1], Yi Yang[1], Yujia Yang[1], Karl K. Berggren[1], Ido Kaminer[1,3], Marin Soljacic[4,1]; [1]*Research Lab of Electronics, MIT, USA;* [2]*Inst. for Soldier Nanotechnologies, USA;* [3]*Dept. of Electrical Engineering, Technion - Israel Inst. of Technology, Israel;* [4]*Dept. of Physics, MIT, USA*. We experimentally demonstrate the generation of tunable radiation from silicon-only periodic structures in the near-infrared. Spontaneous emission from low-energy electrons is recorded in a modified scanning electron microscope, matching our theoretical predictions.

SM4I.3 • 16:30
Inverse Design for Single-Mode Waveguide Coupling of Electrically Injected Optical Antenna Based NanoLED, Nicolas M. Andrade[1], Sean M. Hooten[1], Seth Fortuna[1], Kevin Han[1], Eli Yablonovitch[1], Ming C. Wu[1]; [1]*EECS, Univ. of California, Berkeley, USA*. We propose a broadband and efficient structure for single-mode spontaneous emission coupling of an electrically-injected slot antenna based nanoLED. Using FDTD simulations and inverse design, we achieved 93% waveguide coupling and 50.77% spontaneous emission coupling.

SM4I.4 • 16:45
Deep Ultraviolet Smith-Purcell Radiation, Yu Ye[1], Fang Liu[1], Mengxuan Wang[1], Yidong Huang[1]; [1]*Tsinghua Univ., China*. We demonstrated high order Smith-Purcell radiation in deep ultraviolet wavelength region. Having free electrons passing through a slot in a 2μm-long two-dimensional Aluminum grating, the radiation with wavelength as short as 237nm has been derived.

SM4I.5 • 17:00
Hybrid Metallo-Dielectric Structure for Spontaneous Emission Enhancement, Sean M. Hooten[1], Nicolas Andrade[1], Seth Fortuna[1], Kevin Han[1], Ming C. Wu[1], Eli Yablonovitch[1]; [1]*UC Berkeley, USA*. The rate of spontaneous emission can be enhanced using either a metallic antenna or a dielectric cavity. Here we adapt elements of both types for a novel metallo-dielectric structure that exhibits ultra-low mode volume, V_eff = 4.53e-6 (lambda)^3.

CLEO: QELS-Fundamental Science

16:00–18:00
FM4J • Fundamentals of Metamaterials
Presider: Mikhail Noginov; Norfolk State Univ., USA

FM4J.1 • 16:00
Epsilon-Near-Zero Systems for Quantum Optics Applications, Larissa Vertchenko[1], Nika Akopian[1], Andrei V. Lavrinenko[1]; *[1]Technical Univ. of Denmark, Denmark.* We propose Epsilon-Near-Zero materials to facilitate the interaction between distant quantum emitters by employing the supercoupling effect and form what we call an ENZ network for quantum applications. We show that such systems present very low losses and are able to coherently transmit radiation.

FM4J.2 • 16:15
Broadband Epsilon Near Zero Conducting Oxide Absorbers Fabricated by Atomic Layer Deposition, Long Tao[1], Aleksei Anopchenko[1], Sudip Gurung[1], Catherine Arndt[1], Jason Myers[2], Ho Wai H. Lee[1,3]; *[1]Baylor Univ, USA; [2]Optical Sciences Division, U.S. Naval Research Lab, USA; [3]The Inst. for Quantum Science and Engineering, Texas A&M Univ., College Station, USA.* We demonstrate an excitation of broadband epsilon-near-zero resonance in multi-layer conducting oxides grown by atomic layer deposition. Absorption bandwidth (>90%) of 214 nm for Berreman-mode and 294 nm for ENZ-mode in NIR region is realized.

FM4J.3 • 16:30
Hyperbolic modes of a metal-dielectric interface., Evgenii E. Narimanov[1]; *[1]Purdue Univ., USA.* The inherent mobility of free electrons leads to the formation of hyperbolic layers at any high-quality metal-dielectric interface, which support new surface waves with longer propagation distance and stronger field confinement, at the same time.

FM4J.4 • 16:45
Variable Environmental Index Spectroscopy in Metamaterials, Wei-Yi Tsai[1,2], Vassili Savinov[1], Jun-Yu Ou[1], Din Ping Tsai[3,2], Nikolay I. Zheludev[1,4]; *[1]Univ. of Southampton, UK; [2]Dept. of Physics, National Taiwan Univ., Taiwan; [3]Research Center for Applied Sciences, Academia Sinica, Taiwan; [4]Centre for Disruptive Photonic Technologies, Nanyang Technological Univ., Singapore.* By immersing metamaterial nanostructures into liquids with different refractive indices, we obtain valuable information on role of different multipoles in their electromagnetic response. Applications to detection of anapole modes are discussed.

FM4J.5 • 17:00
Optoelectronic Plasmonic Metamaterials with a Quantum Cascade Structure, Yezhezi M. Zhang[1], Wentao Fan[1], Alex Y. Song[1,2], Deborah Sivco[1,3], Claire F. Gmachl[1]; *[1]Princeton Univ., USA; [2]Stanford Univ., USA; [3]Trumpf Photonics Inc., USA.* Through transmission and reflection measurements, we show that optical properties are preserved when a quantum cascade structure is incorporated into a plasmonic semiconductor metamaterial with negative refraction.

CLEO: Science & Innovations

16:00–18:00
SM4K • Nonlinear Fiber Optics
Presider: Anna Peacock; Univ. of Southampton, UK

SM4K.1 • 16:00 Invited
Mid-IR Supercontinuum Sources using Double Cascading, Ole . Bang[1,2], Christian R. Petersen[1], Peter Moselund[2], Laurent Brilland[3]; *[1]DTU Fotonik, Technical Univ. of Denmark, Denmark; [2]NKT Photonics A/S, Denmark; [3]SelenOptics, France.* Supercontinuum generation in softglass fibers can offer a spatially coherent source covering the spectral region 1-12 um. However, it requires to control double supercontinuum cascading in a setup with 3 or more vastly different fibers.

SM4K.2 • 16:30
A Watt-level Supercontinuum Source from a Fiber-laser-pumped Fluoroindate Fiber Spanning 750 nm to 5 μm, Sijing Liang[1], Lin Xu[1], Qiang Fu[1], David Shepherd[1], David Richardson[1], Shaif-Ul Alam[1]; *[1]Optoelectronics Research Centre, Univ. of Southampton, UK.* Supercontinuum generation from 750 nm to 5 μm, with an output power of 1.76 W and a 3-dB spectral-bandwidth of 1870 nm, was achieved by pumping a 10-m-long fluoroindate-fiber with a 2-μm picosecond fiber MOPA.

SM4K.3 • 16:45
Normal-Dispersion Fiber Optical Parametric Chirped-Pulse Amplification, Walter P. Fu[1], Frank W. Wise[1]; *[1]Cornell Univ., USA.* We demonstrate normal-dispersion fiber optical parametric chirped-pulse amplification pumped with high-power, chirped pulses and seeded with continuous-wave light. We generate 47 nJ, 1310 nm idlers compressible to 210 fs, and anticipate further energy scaling.

SM4K.4 • 17:00
Megawatt peak power femtosecond source at 1.3 μm based on self-phase modulation enabled spectral selection, Hsiang-Yu Chung[1,2], Liwei Song[1,3], Wei Liu[1,2], Qian Cao[1,2], Franz X. Kaertner[1,2], Guoqing Chang[1,4]; *[1]Center for Free-Electron Laser Science, DESY, Germany; [2]Physics, Universität Hamburg, Germany; [3]State Key Lab of High Field Laser Physics, Shanghai Inst. of Optics and Fine Mechanics, Chinese Academy of Sciences, China; [4]The Hamburg Centre for Ultrafast Imaging, Germany.* We demonstrate a megawatt peak power femtosecond source at 1.3 μm based on self-phase modulation enabled spectral selection by pumping optical fibers with negative group-velocity dispersion.

16:00–18:00
SM4L • Frequency Comb Development & Technology
Presider: Jungwon Kim; Korea Advanced Inst of Science & Tech, South Korea

SM4L.1 • 16:00
Operating an Optical Frequency Comb Using a 5-W Handheld USB Charger, Paritosh Manurkar[1], Edgar Perez[1], Daniel Hickstein[1], David R. Carlson[1], Jeff Chiles[1], Daron Westly[2], Esther Baumann[1], Scott Diddams[1], Nathan R. Newbury[1], Kartik Srinivasan[2], Scott Papp[1], Ian R. Coddington[1]; *[1]NIST Boulder, USA; [2]NIST Gaithersburg, USA.* We present a 100-MHz frequency comb that can be fully stabilized using less than 5 W of electrical power. We demonstrate full repetition-rate and offset-frequency stabilization while powering the comb with a handheld USB charger.

SM4L.2 • 16:15
CEO Stabilization of a Fiber Laser by Cross Gain Modulation, Kutan Gurel[1], Stephane Schilt[1], Thomas Südmeyer[1]; *[1]Universite de Neuchatel, Switzerland.* We present the first CEO stabilization of a fiber laser by cross gain modulation. A low-power CW-laser modulates the fiber gain, achieving 40-times larger modulation bandwidth than standard pump-current control. A tight CEO lock is demonstrated.

SM4L.3 • 16:30
All-fiber-based mode-filtering technique with high side-mode suppression ratio and high multiplication factor, Yoshiaki Nakajima[1,2], Akiko Nishiyama[1,2], Takuya Hariki[1,2], Kaoru Minoshima[1,2]; *[1]Univ. of Electro-Communications, Japan; [2]ERATO MINOSHIMA IOS Project, Japan.* All-fiber-based mode filtering technique is developed for repetition rate multiplication of fiber-based frequency comb with multiplication factor of 11. Record high side-mode suppression ratio of approximately 40 dB is achieved with 536.0-MHz repetition-rate fiber-based mode-filtered-comb.

SM4L.4 • 16:45
Injection Locking-Based Tunable Repetition-Rate Multiplication of Mode-Locked Lasers, Chan-Gi Jeon[1], Jungwon Kim[1]; *[1]Korea Advanced Inst of Science & Tech, South Korea.* We demonstrate all-fiber repetition-rate multiplication of mode-locked laser based on injection-locked slave laser. The fundamental repetition-rate of 78.4 MHz can be multiplied by a factor of 13 to 102 (1-GHz to 8-GHz).

SM4L.5 • 17:00
Carrier-envelope-offset locking of 25-GHz EOM comb based on a free-running CW Laser Diode, Atsushi Ishizawa[1], Tadashi Nishikawa[2], Kazutaka Hara[1,2], Kenichi Hitachi[1], Tetsuomi Sogawa[1], Hideki Gotoh[1]; *[1]NTT Basic Research Labs, Japan; [2]Tokyo Denki Univ., Japan.* We demonstrate a carrier-envelope-offset (CEO)-locked electro-optics-modulation (EOM) comb with 25-GHz mode spacing at telecommunications wavelengths. The mode spacing of the CEO-locked EOM comb—the widest ever reported—is achieved with a free-running CW laser diode.

CLEO: Science & Innovations

16:00–18:00
SM4M • Power Scaling of Ultrafast Sources
Presider: Tobias Witting; Max-Born-Inst., Germany

SM4M.1 • 16:00 Invited
Isolated Pulse Parametric Frequency Conversion under Burst-Mode Pumping, Andrius Baltuska[1], Edgar Kaksis[1], Ignas Astrauskas[1], Tobias Flöry[1], Giedrius Andriukaitis[1], Pavel Malevich[1], Tadas Balciunas[1], Audrius Pugzlys[1]; [1]*Photonics Inst., TU Wien, Austria.* Burst-mode regenerative amplifiers permit substantial energy and average-power scaling of pump lasers. We demonstrate advantages of parametric burst-to-single-pulse up- and down-conversion in the generation of optical harmonics and in multicolor pumping of long-wave parametric amplifiers.

SM4M.2 • 16:30
High-Energy Soliton Dynamics in Gas-Filled Hollow Capillary Fibers, John C. Travers[1], Teodora Grigorova[1], Federico Belli[1]; [1]*Heriot-Watt Univ., UK.* We show that soliton dynamics scale to millijoule energies and terrawatt peak powers in simple hollow capillary fibers. We numerically model sub-femtosecond pulse self-compression, and experimentally demonstrate high-brightness µJ-scale ultraviolet (125-330 nm) pulse generation.

SM4M.3 • 16:45
High power hollow-core fiber compression of Yb lasers as ideal drivers for HHG, Vincent Cardin[2,1], Young-Gyun Jeong[2], Guangyu Fan[3], Tadas Balciunas[3], Riccardo Piccoli[2], Denis Ferachou[2,1], Jens Limpert[4], Steffen Hädrich[6], Roberto Morandotti[2], Hans Jakob Wörner[5], Luca Razzari[2], François Légaré[2], Andrius Baltuska[3], Bruno E. Schmidt[1]; [1]*few-cycle Inc, Canada;* [2]*INRS-EMT, Canada;* [3]*TU Wien, Austria;* [4]*Inst. of Applied Physics, Abbe Center of Photonics, Friedrich-Schiller-Univ. Jena, Germany;* [5]*ETH Zürich, Switzerland;* [6]*Active Fiber Systems GmbH, Germany.* We present recent achievements of single stage hollow-core fiber compression as HHG driving sources enabling: large compression factors (x24), highest output energies of 10mJ and operation at >100W of average power with generally >70% efficiency.

SM4M.4 • 17:00 Invited
High Power Ultrashort Amplifiers Based on Yb Doped Single Crystal Fibers, Patrick Georges[1], Fabien Lesparre[1,2], Jean-Thomas Gomes[1], Xavier Delen[1], Igor Martial[2], Julien Didierjean[2], Frédéric Druon[1], François Balembois[1]; [1]*Laboratoire Charles Fabry, Institut d'Optique Graduate School - CNRS, France;* [2]*Fibercryst, France.* We will present the advantages of the single-crystal-fiber (SCF) concept and review the main results obtained in ultrashort multi-stages Yb:YAG SCF amplifiers for high average power (100W) and high energy (mJ) regimes using Divided-Pulse-Amplification technic.

16:00–18:00
SM4N • Laser Materials
Presider: Clara Saraceno; Ruhr Universität Bochum, Germany

SM4N.1 • 16:00 Invited
Novel Solid-state Laser Materials, Christian Kraenkel[2,1]; [1]*Institut für Laser-Physik, Universität Hamburg, Germany;* [2]*Center for Laser Materials, Leibniz Inst. for Crystal Growth, Germany.* Novel materials enable unprecedented laser performance in the visible and near-infrared spectral range. $Tb^{3+}LiLuF_4$ delivers watt-level output in the green and yellow and the first cw $Er:Sc_2O_3$ laser emits 0.28 W at 2856 nm.

SM4N.2 • 16:30
Efficient and Broadly Tunable Eye-Safe Laser Operation in a Single Crystal of Tm-Doped Strontium Fluoride (Tm:SrF_2), Alberto Sottile[1,2], Eugenio Damiano[2,3], Martina Rabe[4], Rainer Bertram[4], Detlef Klimm[4], Mauro Tonelli[1,2]; [1]*NEST, Istituto Nanoscienze - CNR, Italy;* [2]*Dipartimento di Fisica, Università di Pisa, Italy;* [3]*Dipartimento di Scienze Fisiche, della Terra e dell'Ambiente – Sez. di Fisica, Università di Siena, Italy;* [4]*IKZ – Leibniz-Institut für Kristallzüchtung, Germany.* We report on the growth, spectroscopic characterization, and first laser operation in this material, with a slope efficiency of 50% at 2015 nm. The laser was also continuously tunable between 1840 and 2020 nm.

SM4N.3 • 16:45
Q-switched Cryogenic Ho:YAG Laser, Miftar Ganija[1], Alexander Hemming[2], Nikita Simakov[2], Neil Carmody[2], Peter Veitch[1], John Haub[2], Jesper Munch[1]; [1]*Univ. of Adelaide, Australia;* [2]*Cyber and Electronic Warfare Division, Defence Science & Technology Group, Australia.* We describe the first power scalable Q-switched, cryogenically cooled, resonantly-pumped, Ho:YAG laser. The output energy was extracted from a confocal resonator with a single-pass pump geometry. Pulsed operation at higher average powers will be reported.

SM4N.4 • 17:00
Electrooptic Active Q switching at the 2 µm Wavelength Range using KLTN:Cu Crystals, Salman Noach[1], Rotem Nahear[2,1], Yehuda Vidal[2], Aharon J. Agranat[2]; [1]*Jerusalem College of Technology, Israel;* [2]*The Hebrew Univ. of Jerusalem, Israel.* An actively Q switched Tm:YLF laser operating at 1880 nm, generating 5 mJ, 34 nsec pulse duration is presented. Q switching was done by an electrooptic 2 mm long KLTN crystal driven at 3.6 kV/cm.

16:00–18:00
SM4O • Structured Light for Material Processing
Presider: Tsing-Hua Her; Univ of North Carolina at Charlotte, USA

SM4O.1 • 16:00 Tutorial
Creation of Structured Materials with Optical Vortices, Takashige Omatsu[1,2]; [1]*Chiba Univ., Japan;* [2]*Molecular Chirality Research Center, Chiba Univ., Japan.* We review optical vortex materials processing, in which the orbital angular momentum twists materials irradiated by optical vortices to establish chiral structured materials on the nano-/micro-scale. Also, we address recent progress concerning the optical vortex sources for materials processing.

Prof. Omatsu has been pioneering structured materials fabrication by optical vortex illumination. He published over 150 journal papers. He is serving as a deputy editor of Optics Express, and a director of photonics division, Japan Society of Applied Physics (JSAP). He was elected a OSA fellow and a JSAP fellow.

SM4O.2 • 17:00
Acceleration of Micro-Hole Drilling by an Azimuthally Polarized Laser Beam under Tight Focusing Condition, Shugo Matsusaka[1], Yuichi Kozawa[1], Shunichi Sato[1]; [1]*Inst. of Multidisciplinary Research for Advanced Materials, Tohoku Univ., Japan.* We examined the laser micro-hole drilling using radially and azimuthally polarized beams for various types of metallic thin plates. We observed remarkable reduction of drilling time for the tight focusing of an azimuthally polarized beam.

Marriott Salon VI

CLEO: Applications & Technology

16:00–18:00
AM4P • Biosensing Technologies
Presider: Ilko Ilev; U.S. Food and Drug Administration , USA

AM4P.1 • 16:00 Invited
Miniature Biomedical Optical Sensors and Imaging Systems, Ofer Levi[1]; [1]*Univ. of Toronto, Canada*. Miniature integrated optical systems for sensing and imaging can be portable, enabling long-term studies in living tissues. We present our miniature sensitive optical sensors and imaging systems for Lab-on-a-chip and in vivo imaging applications.

AM4P.2 • 16:30
Electric Field Sensing with Graphene Optoelectronics for Action Potential Detection, Jason Horng[1,2], Halleh B. Balch[1], Allister McGuire[3], Feng Wang[1], Bianxiao Cui[3]; [1]*Univ. of California Berkeley, USA;* [2]*Physics, Univ. of Michigan, Ann Arbor, USA;* [3]*Chemistry, Stanford Univ., USA*. Graphene, exhibiting field-dependent optical absorption, offers great opportunities for action potential sensing for bioelectric researches. We demonstrate two novel schemes of graphene opto-electronic realizing high voltage sensitivity and large bandwidth electric field imaging techniques.

AM4P.3 • 16:45
Remote Photonic Sensing of Vocal Cords Vibrations, Nisan Ozana[1], Adi Primov-Fever[2], Michael Wolf[2], Zeev Zalevsky[1]; [1]*Faculty of Engineering and the Nano Technology Center, Bar Ilan Univ., Israel;* [2]*ENT Dept., Sheba Medical Center, Tel-Hashomer, Israel, and Sackler School of Medicine, Tel-Aviv Univ., Israel*. The ability to remotely extract vibrations from specific locations on the vocal cords using time varied speckle patterns is innovative. The first step towards characterization of spatial and temporal vocal cords vibrations remotely is presented.

AM4P.4 • 17:00
Self-powered Ultrasensitive Glucose Detection Based on Graphene Multi-Heterojunctions, Cheng Han Chang[1], Wei-Ju Lin[1], Yu-Ming Liao[1], Han-Yi Chou[1], Yang-Fang Chen[1]; [1]*National Taiwan Univ. , Taiwan*. A highly sensitive glucose biosensor based graphene/ZnO/p-Si heterojunctions is demonstrated. Its sensing mechanism makes use of the large variation in the Fermi energy of graphene at the presence of glucose molecules, resulting in a superb detection sensitivity.

Marriott Willow Glen

CLEO: QELS-Fundamental Science

16:00–18:00
FM4Q • Valley-Hall and Active Toplogical Photonics
Presider: Xiaobo Yin; Univ. of Colorado at Boulder, USA

FM4Q.1 • 16:00
Chirality-locked valley polarization in photonic graphene, Yuan Li[1], Yong Sun[1,2], Yunhui Li[1], Haitao Jiang[1], Zhigang Chen[2,3], Hong Chen[1]; [1]*MOE Key Lab of Advanced Micro-Structured Materials, School of Physics Science and Engineering, Tongji Univ., China;* [2]*Dept. of Physics and Astronomy, San Francisco State Univ., USA;* [3]*MOE Key Lab of Weak-Light Nonlinear Photonics, TEDA Applied Physics Inst. and School of Physics,, Nankai Univ., China*. We demonstrate experimentally chirality-locked valley polarization in photonic graphene. A point source without chirality excites two inequivalent (K, K') valleys equally, whereas a chiral source selectively excites only one preferred valley depending on its chirality.

FM4Q.2 • 16:15
Observation of Valley-based Transport for Valley-pseudospin Polarized Photonic Edge State, Yuhao Kang[1,2], Xiaojun Cheng[1,2], Xiang Ni[3,2], Alexander B. Khanikaev[3,2], Azriel Z. Genack[1,2]; [1]*Queens College, CUNY, USA;* [2]*Physics, The Graduate Center of the City Univ. of New York, USA;* [3]*The City College of the City Univ. of New York, USA*. We demonstrate the photonic valley-pseudospin polarized edge state experimentally. The contrast between transmission spectra demonstrates the conservation of valley degree of freedom at the Y-junction between domains emulating quantum valley-Hall and spin-Hall effects.

FM4Q.3 • 16:30
Experimental demonstration of valley-Hall topological photonic crystal at telecommunication wavelengths, Mikhail I. Shalaev[1], Wiktor Walasik[1], Natalia Litchinitser[1]; [1]*Buffalo State SUNY, USA*. We experimentally demonstrate silicon-based topological valley-Hall photonic crystals operating at near-infrared frequencies. Robust and reflection-less light propagation around sharp turns is demonstrated. This work is an important step towards integrated topological photonics.

FM4Q.4 • 16:45
Valley Waves Sorting and Routing Based on Photonic Topological Insulators, Kueifu Lai[2,1], Yang Yu[1], Yuchen Han[1], Fei Gao[3], Baile Zhang[3], Gennady Shvets[1]; [1]*Cornell Univ., USA;* [2]*Dept. of Physics, Univ. of Texas at Austin, Austin, USA;* [3]*Nanyang Technological Univ., Singapore*. We experimentally demonstrate a platform based on valley-spin locked propagation at heterogeneous photonic topological insulator interfaces. This platform is capable of sorting valley waves and routing it to desired destinations by topology switching.

FM4Q.5 • 17:00
Electrically Reconfigurable Topological Bound-state Laser Array, Ruizhe Yao[1], Hang Li[1], Jun Ding[2], Chi-sen Lee[1], Hualiang Zhang[1], Wei Guo[1]; [1]*Univ. of Massachusetts Lowell, USA;* [2]*East China Normal Univ., China*. We demonstrate a topological bound-state laser array in a Su-Schrieffer-Heeger array with topological defect. It is shown experimentally that the phase transition exists between the topological bound and bulk state lasing by adjusting the gain.

CLEO: Science & Innovations

SM4A • THz High-field Generation and Detection—Continued

SM4A.6 • 17:30
Single-Shot Electro-Optic Measurement of Mid-Infrared Pulses, Michael Kozina[1], Matthias C. Hoffmann[1]; [1]*Linac Coherent Light Source, SLAC National Accelerator Lab, USA.* We generate temporally chirped white light through self-phase-modulation in glass. By mixing the white light with ultrafast mid-infrared pulses in GaSe via the electro-optic effect, we observe the phase of the mid-infrared light via spectrally resolving the electro-optic signal.

SM4A.7 • 17:45
Single-shot spectral measurement of THz radiation from elliptically focused two-color laser filamentation in air, Yung Jun Yoo[1,2], Zheqiang Zhong[1], Ki-Yong Kim[1]; [1]*Univ. of Maryland, USA;* [2]*Thorlabs Imaging Systems, USA.* We report a single-shot method to measure the spectrum of THz radiation emitted from two-color laser filamentation in air. This method does not require multi-shot pump-probe scanning, and it is invulnerable to shot-to-shot laser fluctuation.

SM4B • Microrings and Novel Modulation Schemes—Continued

SM4B.5 • 17:15
Fast and Ultra-compact Multi-channel All-optical Switches Based on Silicon Photonic Crystal Nanobeam Cavities, Dong Gaonenng[1], Wentao Deng[1], Xinliang Zhang[1]; [1]*Wuhan National Lab of Optoelectronic & School of Optical and Electronic Information, Huazhong Univ. of Science and Technology, China.* By performing blue-detuned filtering on the output signal light, we achieve multi-channel all-optical switches with a processing density of 320 Tb/s/mm^2, which is the highest processing density shown in silicon based multi-channel switches.

SM4B.6 • 17:30
Monolithically Integrated Stokes Vector Modulator Based on Quantum-Confined Stark Effect, Mohiyuddin Kazi[1], Samir Ghosh[1], Masakazu Sugiyama[1], Takuo Tanemura[1], Yoshiaki Nakano[1]; [1]*Univ. of Tokyo, Japan.* We demonstrate a monolithically integrated Stokes vector modulator using quantum-confined Stark effect in a simple straight-line configuration. Efficient polarization modulation over Poincaré sphere is observed by applying reverse-bias voltages to MQW-based polarization-dependent phase modulators.

SM4B.7 • 17:45
InP Based Mach Zehnder Modulators With Ultra-low Vπ, Ye Liu[1], Quanan Chen[1], Xiang Ma[1], Wei Sun[1], Gongyuan Zhao[1], Gonghai Liu[1], Qiaoyin Lu[1], Weihua Guo[1]; [1]*Wuhan National Lab. For Optoelectronics, China.* We designed and fabricated Mach-Zehnder Modulators (MZMs) with 0.65V V_π based on InP substrate. And the expected bandwidth is >60GHz with a coplanar waveguide electrode (CPW) structure.

SM4C • SDM Communication II—Continued

SM4C.5 • 17:15
MCF-Enabled Self-Homodyne 16/64QAM Transmission for SDM Optical Access Networks, Aleksejs Udalcovs[1], Xiaodan Pang[2,1], Oskars Ozolins[1], Rui Lin[2], Lin Gan[3], Richard Schatz[2], Anders Djupsjöbacka[1], Jonas Mårtensson[1], Ming Tang[3], Songnian Fu[3], Deming Liu[3], Weijun Tong[4], Jiajia Chen[2], Sergei Popov[2], Gunnar Jacobsen[1]; [1]*RISE Acreo AB, Sweden;* [2]*KTH Royal Inst. of Technology, Sweden;* [3]*Huazhong Univ. of Science and Technology, China;* [4]*Yangtze Optical Fiber and Cable Joint Stock Limited Company, China.* We experimentally demonstrate a 28-Gbaud circular and square 16/64QAM transmission over a 33.6-km long seven-core fiber with the LO passed through one of the cores for self-homodyne coherent detection employing a low-complexity digital signal processing.

17:30–18:30 Diversity & Inclusion in Optics and Photonics Reception, *Market 1&2, Hilton San Jose*

19:00–20:30 OSA Nonophotonics Technical Group 20x20 Talks, *Room 230A*

CLEO: Science & Innovations

SM4D • Optical Metrology Nonlinear Optical Technologies—Continued

SM4D.6 • 17:15
Nonlinear Dielectric Metasurfaces for Wavefront Control, Lei Wang[1], Sergey S. Kruk[1], Kirill Koshelev[1], Ivan Kravchenko[2], Barry Luther-Davies[1], Yuri S. Kivshar[1]; [1]*Australian National Univ., Australia;* [2]*Oak Ridge National Lab, USA.* We demonstrate Si-based metasurfaces for third-harmonic generation of an arbitrary wavefront. The nonlinear metasurfaces produce phase gradients within a full 0--2π phase range. We achieve 92% diffraction efficiency of the nonlinear wavefront control.

SM4D.7 • 17:30
Giant nonlinear frequency shift in epsilon-near-zero aluminum zinc oxide thin films, Enrico Giuseppe Carnemolla[1], Vincenzo Bruno[1], Lucia Caspani[2], Matteo Clerici[3], Stefano Vezzoli[1], Thomas Roger[1], Clayton DeVault[4], Jongbum Kim[5,4], Amr Shaltout[4,6], Vladimir M. Shalaev[4], Alexandra Boltasseva[4], Daniele Faccio[1,3], Marcello Ferrara[1]; [1]*Heriot Watt Univ., IPAQS, UK;* [2]*Strathclyde Univ., UK;* [3]*Univ. of Glasgow, UK;* [4]*Purdue Univ., USA;* [5]*Univ. of Maryland, USA;* [6]*Stanford Univ., USA.* Degenerate pump/probe experiments have been performed on aluminum zinc oxide thin films at their epsilon-near-zero wavelength. A remarkable spectral shift of the reflected beam is reported to be approximately twice the pulse bandwidth.

CLEO: QELS-Fundamental Science

FM4E • PT-Symmetry and Non-Hermitian Photonics—Continued

FM4E.5 • 17:15
PT-Symmetric Microring Laser Gyroscope, Jinhan Ren[1], Gal Harari[2], Absar U. Hassan[1], Weng Chow[3], Mohammad Soltani[4], Mohammad Parvinnezhad Hokmabadi[1], Demetrios N. Christodoulides[1], Mercedeh Khajavikhan[1]; [1]*CREOL UCF, USA;* [2]*Physics Dept. and Solid State Inst., Technion, Israel;* [3]*Sandia National Labs, USA;* [4]*Raytheon BBN Technologies, USA.* A new scheme for ultrasensitive micro-ring laser gyroscopes based on the physics of exceptional points is proposed. In such systems, the sensitivity to low rotation rates can be enhanced by several orders of magnitude.

FM4E.6 • 17:30
Multi-dimensional synthetic space and state measurement with spectral photonic lattices, Kai Wang[1], James Titchener[1], Bryn Bell[2], Alexander S. Solntsev[3,1], Dragomir N. Neshev[1], Benjamin J. Eggleton[2], Andrey A. Sukhorukov[1]; [1]*Nonlinear Physics Centre, Research School of Physics and Engineering, The Australian National Univ., Australia;* [2]*Centre for Ultrahigh Bandwidth Devices for Optical Systems (CUDOS), Inst. of Photonics and Optical Science (IPOS), School of Physics, Univ. of Sydney, Australia;* [3]*School of Mathematical and Physical Sciences, Univ. of Technology Sydney, Australia.* We propose and experimentally realize spectral photonic lattices with pump-induced frequency couplings, which can emulate multi-dimensional dynamics with synthetic gauge fields and enable single-shot measurement of the signal phase and coherence.

FM4E.7 • 17:45
Single Mode Supersymmetric Laser Array, Mohammad Parvinnezhad Hokmabadi[1], Sanaz Faryadras[1], Ramy El-Ganainy[2], Demetrios N. Christodoulides[1], Mercedeh Khajavikhan[1]; [1]*Univ. of Central Flordia, USA;* [2]*Michigan Technological Univ., USA.* Multimode emission adversely affects phased-locked laser arrays resulting in chaotic behaviors. Utilizing optical supersymmetry, we experimentally demonstrate a single mode laser array where a superpartner array eliminates undesired higher order transverse modes.

FM4F • Probing Materials with Ultrafast Electricity and Extreme Light—Continued

FM4F.5 • 17:15
Fourier-transform inelastic x-ray scattering: A new kind of gas-phase vibrational spectroscopy, Matthew Ware[1,2], James Glownia[3], Adi Natan[2,3], James Cryan[2,3], Phillip Bucksbaum[1,2]; [1]*Stanford Univ., USA;* [2]*PULSE, USA;* [3]*SLAC, USA.* We use the temporal Fourier transform of time-resolved x-ray scattering, known as Fourier-transform inelastic x-ray scattering (FT-IXS), to examine the harmonic, anharmonic, and dissociative dynamics of molecular iodine. This method can directly extract dissociation velocities.

FM4F.6 • 17:30
Ultrafast Separation of Photoexcited Electron Cloud, E Laine Wong[1], Andrew Winchester[1], Michael Man[1], Vivek Pareek[1], Julien Madeo[1], Keshav M. Dani[1]; [1]*OIST, Japan.* Separation of photoexcited electron cloud is induced on a homogeneous GaAs surface via the exploitation of intensity variation within the photoexcitation beam. We show that the rate of separation can be controlled by tuning the photoexcitation intensity.

FM4F.7 • 17:45
Ultrafast quantum interference control of photocurrents beyond the perturbative regime, Rodrigo A. Muniz[2], Kai Wang[2], Steven T. Cundiff[2], John E. Sipe[1], Mackillo Kira[2]; [1]*Univ. of Toronto, Canada;* [2]*Univ. of Michigan, USA.* We explore the use of high-intensity ultrashort lightwave waveforms for quantum interference control of photocurrents in semiconductor quantum wells. We analyze the quantum interference between nonlinear optical absorption processes in real time.

17:30–18:30 Diversity & Inclusion in Optics and Photonics Reception, *Market 1&2, Hilton San Jose*

19:00–20:30 OSA Nonophotonics Technical Group 20x20 Talks, *Room 230A*

CLEO: QELS-Fundamental Science

FM4G • Quantum Sources II—Continued

FM4G.6 • 17:15
Real-time spectral characterization of a photon pair source using a chirped supercontinuum seed, Jennifer Erskine[1,2], Duncan England[2], Connor Kupchak[1,2], Ben Sussman[2,1]; [1]*Univ. of Ottawa, Canada;* [2]*National Research Council, Canada*. We perform joint spectral intensity measurements by studying stimulated four wave mixing in a birefringent fiber photon pair source. Seeding the process with a chirped supercontinuum beam, measurements are acquired in as little as 5 s.

FM4G.7 • 17:30
Quantum interferometry through cascading broadband entanglement sources, Arash Riazi[1], Chang j. Chen[1], Eric Y. Zhu[1], Alexey Gladyshev[3], Peter Kazansky[2], John E. Sipe[1], Li Qian[1]; [1]*Univ. of Toronto, Canada;* [2]*Univ. of Southampton, UK;* [3]*Russian Academy of Sciences, Russia*. We demonstrate broadband (~100nm) quantum interference in telecom frequencies in an all-fiber system with cascaded SPDC sources. Its applications in dispersion metrology and quantum state engineering are also demonstrated.

FM4G.8 • 17:45
A Compact All-fiber Polarization-Entangled Photon Source Pumped by a Laser Diode, Chang j. Chen[1], Arash Riazi[1], Eric Y. Zhu[1], Alexey Gladyshev[2], Mili Ng[3], Peter Kazansky[4], Li Qian[1]; [1]*Univ. of Toronto, Canada;* [2]*Russian Academy of Sciences, Russia;* [3]*Oz Optics, Canada;* [4]*Univ. of Southampton, UK*. We demonstrate a compact, all-fiber broadband polarization-entangled photon source pumped by a cw Fabry-Perot laser diode. Robust and stable operation yields a concurrence of 0.966 +- 0.015 and a fidelity to $\ket{\Psi^+}$ of 98.1 +- 0.8%

FM4H • Quantum Optics with Atomic and Molecular Ensembles—Continued

FM4H.6 • 17:15
Wavevector-multiplexed and memory-enabled source of multimode nonclassical light, Michal Parniak[1], Michal Dabrowski[1], Mateusz Mazelanik[1], Adam Leszczynski[1], Michal Lipka[1], Wojciech Wasilewski[1]; [1]*Univ. of Warsaw, Poland*. We demonstrate a quantum memory based on cold atomic ensemble generating and storing nonclassical light in 665 modes. With novel spin-wave manipulation techniques our system surfaces as a universal platform for quantum state preparation.

FM4H.7 • 17:30
Establishing and storing of quantum entanglement among three Rubidium atomic ensembles, Xiaojun Jia[1]; [1]*Shanxi Univ., China*. Tripartite entanglement of optical modes is mapped into three distant atomic ensembles to establish entanglement of atomic spin waves via electromagnetically-induced-transparency light-matter interaction. Then the stored atomic entanglement is transferred into a tripartite entangled state.

FM4H.8 • 17:45
Entanglement Generation in Green Fluorescent Proteins, Siyuan Shi[1], Kim F. Lee[1], Prem Kumar[1]; [1]*Northwestern Univ., USA*. We demonstrate generating polarization-entangled state through spontaneous four-wave mixing in enhanced green fluorescent proteins. We report coincident-to-accidental ratio of ~145 and entangled state fidelity of ~94% for the generated photon pairs.

CLEO: Science & Innovations

SM4I • Novel Emitters—Continued

SM4I.6 • 17:15
Lasing in Si_3N_4-Organic Hybrid (SiNOH) Spiral Resonators , Daria Kohler[2,1], Sentayehu Fetene Wondimu[2,1], Lothar Hahn[2], Isabel Allegro[2], Matthias Blaicher[2,1], Wolfgang Freude[1], Christian Koos[2,1]; [1]*Inst. of Photonics and Quantum Electronics, Karlsruhe Inst. of Technology, Germany;* [2]*Inst. of Microstructure Technology, Karlsruhe Inst. of Technology, Germany.* We demonstrate lasing in optically pumped hybrid devices that combine passive Si_3N_4 waveguides with active organic cladding materials. Si_3N_4-organic hybrid (SiNOH) lasers lend themselves to low-cost integration and parallel read-out of large-scale sensor arrays.

SM4I.7 • 17:30 Invited
Physics and Applications of Active High-Q Microcavities,, Jean-Baptiste Ceppe[1,2], Vincent Huet[1], Michel Mortier[3], Philippe Rochard[1], Ariel Levenson[4], Kamel Bencheikh[4], Alejandro Yacomotti[4], Patrice Féron[1], Yannick Dumeige[1]; [1]*Université de Rennes, CNRS, Institut FOTON, France;* [2]*IR-CICA (CNRS USR 3380) - PhLAM (CNRS UMR 8523), France;* [3]*IRCP, Chimie ParisTech, France;* [4]*C2N, France*. High-quality factor whispering gallery mode microcavities doped with rare earth materials are used i) to study the dynamical and noise properties of micro-lasers and ii) to demonstrate slow-light effects in miniaturized devices.

17:30–18:30 Diversity & Inclusion in Optics and Photonics Reception, *Market 1&2, Hilton San Jose*

19:00–20:30 OSA Nonophotonics Technical Group 20x20 Talks, *Room 230A*

CLEO: QELS-Fundamental Science

FM4J • Fundamentals of Metamaterials—Continued

FM4J.6 • 17:15
Controlling Cherenkov Angles with Resonance Transition Radiation, Xiao Lin[1], Sajan Easo[2], Yichen Shen[3], Hongsheng Chen[4], Baile Zhang[1], John Joannopoulos[3], Marin Soljacic[3], Ido Kaminer[3]; [1]*Physics and Applied Physics, Nanyang Technological Univ., Singapore;* [2]*Particle Physics Dept., Rutherford-Appleton Lab (STFC), UK;* [3]*Physics, MIT, USA;* [4]*Zhejiang Univ., China.* We propose a new mechanism using the constructive interference of resonance transition radiation from photonic crystals to generate Cherenkov radiation into controllable Cherenkov angles with high sensitivity to any desired range of velocities.

FM4J.7 • 17:30
Time Domain Modeling of Bi-Anisotropic Homogenized Media with Analytical Dispersion, Ludmila J. Prokopeva[1], Zhaxylyk A. Kudyshev[1], Alexander Kildishev[1]; [1]*Purdue Univ., USA.* We present a bi-anisotropic (BA) homogenization technique combined with derivation of the analytical dispersion of BA parameters. This formulation enables time domain modeling of the BA homogenized media and allows characterizing the geometry of the nanostructure with the dispersion parameters.

FM4J.8 • 17:45
The Superlight Inverse Doppler Effect, Xihang Shi[1], Xiao Lin[1], Ido Kaminer[2], Fei Gao[1], Zhaoju Yang[1], John Joannopoulos[2], Marin Soljacic[2], Baile Zhang[1]; [1]*Nanyang Technological Univ., Singapore;* [2]*Physics, MIT, USA.* An inverse Doppler frequency shift of light, i.e., superlight inverse Doppler effect, is shown possible even in homogeneous media with positive-refractive index, contrary to the status quo ante. We show an example with graphene plasmons.

CLEO: Science & Innovations

SM4K • Nonlinear Fiber Optics—Continued

SM4K.5 • 17:15
High-peak-power, high-efficiency, frequency doubled and quadrupled Thulium fiber laser, Lin Xu[1], Sijing Liang[1], Qiang Fu[1], David Shepherd[1], David Richardson[1], Shaif-Ul Alam[1]; [1]*Univ. of Southampton, UK.* We report frequency doubling and quadrupling of a short-pulsed (~80 ps) thulium-doped fiber laser, generating 976-nm and 488-nm wavelengths with peak powers of 34 kW and 10 kW, at conversion efficiencies of 75% and 22%, respectively.

SM4K.6 • 17:30
Phase-preserving Multilevel Amplitude Regeneration in Conjugate Nonlinear-Optical Loop Mirror Pair, Feng Wen[1,2], Mariia Sorokina[1], Christos P. Tsekrekos[1], Yong Geng[2], Xingyu Zhou[2], Baojian Wu[2], Kun Qiu[2], Sergei K. Turitsyn[1], Stylianos Sygletos[1]; [1]*Aston Inst. of Photonic Technologies, UK;* [2]*Univ. of Electronic Science and Technology of China, China.* We propose a conjugate nonlinear-optical loop mirror pair scheme (Conj-NOLM) for phase-preserving multilevel amplitude regeneration, by cascading two identical NOLMs with an intermediate phase conjugation stage. Q^2-factor improvements of 2.42dB are achieved for 16-QAM signals.

SM4K.7 • 17:45
Fundamental Limits to Duration and Bandwidth of Temporal Cavity Solitons due to Raman Scattering, Yadong Wang[1], Miles Anderson[1], Stephane Coen[1], Stuart Murdoch[1], Miro J. Erkintalo[1]; [1]*Univ. of Auckland, New Zealand.* We theoretically and experimentally show that stimulated Raman scattering destabilizes temporal cavity solitons at large pump-cavity detunings. Significantly, the identified instability imposes fundamental limits on the duration and bandwidth of temporal CSs.

SM4L • Frequency Comb Development & Technology—Continued

SM4L.6 • 17:15
Frequency Comb Stabilization of a 50-fs Thin-Disk Laser Oscillator Operating in a Strongly SPM-broadened Regime, Norbert Modsching[1], Clément Paradis[1], Pierre Brochard[1], Nayara Jornod[1], Kutan Gurel[1], Christian Kränkel[2,3], Stephane Schilt[1], Valentin J. Wittwer[1], Thomas Südmeyer[1]; [1]*Laboratoire Temps-Fréquence, Institut de Physique, Université de Neuchâtel, Switzerland;* [2]*Center for Laser Materials, Leibniz Inst. for Crystal Growth, Germany;* [3]*Inst. of Laser-Physics, Univ. of Hamburg, Germany.* An Yb:LuO thin-disk laser generating 50-fs pulses at 4-W average output power and 50-MW intracavity peak power is CEO stabilized with 200-mrad integrated phase noise. Effects of repetition-rate stabilization onto the CEO noise are discussed.

SM4L.7 • 17:30
Fully Stabilized Optical Frequency Comb from a Semiconductor Disk Laser, Dominik Waldburger[1], Aline S. Mayer[1], Cesare Alfieri[1], Jacob Nürnberg[1], Adrea R. Johnson[2,3], Xingchen Ji[4,5], Alexander Klenner[2], Yoshitomo Okawachi[2], Michal Lipson[4], Alexander L. Gaeta[2], Ursula Keller[1]; [1]*Inst. for Quantum Electronics, ETH Zürich, Switzerland;* [2]*Dept. of Applied Physics and Applied Mathematics, Columbia Univ., USA;* [3]*School of Applied and Engineering Physics, Cornell Univ., USA;* [4]*Dept. of Electrical Engineering, Columbia Univ., USA;* [5]*School of Electrical and Computer Engineering, Cornell Univ., USA.* We demonstrate pulse repetition rate and carrier-envelope offset (CEO) frequency stabilization of a gigahertz SESAM-modelocked VECSEL. The CEO-detection is enabled by lowpower supercontinuum generation in a silicon-nitride waveguide without external pulse amplification.

17:30–18:30 Diversity & Inclusion in Optics and Photonics Reception, *Market 1&2, Hilton San Jose*

19:00–20:30 OSA Nonophotonics Technical Group 20x20 Talks, *Room 230A*

SM4M • Power Scaling of Ultrafast Sources—Continued

SM4M.5 • 17:30
Two-dimensional, Eight-beam Combination of Ultrashort Pulses Using Two Diffractive Optics, Tong Zhou[1], Qiang Du[1], Tyler Sano[1], Russell Wilcox[1], Wim Leemans[1]; [1]*Lawrence Berkeley National Lab, USA.* We demonstrate beam combination of eight 120fs pulses, using a diffractive optic pair. This highly scalable technique preserves input pulse width, and achieves 89.5% combining efficiency, limited by the diffractive optic.

SM4M.6 • 17:45
Cavity Phase Measurement via Modulated Impulse Response for Coherent Temporal Pulse Stacking, Yawei Yang[1], Jay Dawson[2], Lawrence Doolittle[1], Qiang Du[1], Almantas Galvanauskas[3], Gang Huang[1], Tong Zhou[1], Russell Wilcox[1], Wim Leemans[1]; [1]*Lawrence Berkeley National Lab, USA;* [2]*Lawrence Livermore National Lab, USA;* [3]*Univ. of Michigan, USA.* We have temporally combined 25 equal-amplitude pulses using four cavities, stabilizing cavity round-trip phase by measuring the response to a probe pulse train. Energy enhancement of 18.4 is maintained within 1% RMS.

SM4N • Laser Materials—Continued

SM4N.5 • 17:15
Radiation Balanced Thin Disk Lasers, Zhou Yang[1], Alexander Albrecht[1], Junwei Meng[1], Mansoor . Sheik-Bahae[1]; [1]*Univ. of New Mexico, USA.* We demonstrate the first radiation balanced thin disk lasers. Ytterbium-doped YLF and YAG thin disks are pumped by a fiber laser in multipass geometry and an InGaAs/GaAs VECSEL in intracavity geometry.

SM4N.6 • 17:30
Q-switched Laser Oscillation in Micro-Domain Controlled Yb:FAP Anisotropic Laser Ceramics, Yoichi Sato[1], Jun Akiyama[1], Takunori Taira[1]; [1]*Inst. for Molecular Science, Japan. Using polycrystalline Yb^{3+}-doped fluoroapatite (Yb:FAP), we investigated quantum mechanics for orientation-control of microdomains in anisotropic laser ceramics with 4f-electrons of RE^{3+}-ion. Kilowatt-level sub-ns laser pulses were generated with the extraction density of 0.34 J/cm^3.*

SM4N.7 • 17:45
Inversion caused spectral phase shift in a broadband Ti:Sapphire amplifier at room and cryogenic temperatures, Roland Nagymihály[1], Huabao Cao[1], Peter Jojart[1], Viktor Zuba[2], Mikhail Kalashnikov[1,3], Adam Borzsonyi[1,2], Vladimir V. Chvykov[1], Karoly Osvay[1]; [1]*ELI-HU Non-Profit Ltd., Hungary;* [2]*Dept. of Optics and Quantum Electronics, Univ. of Szeged, Hungary;* [3]*Max Born Inst. for Nonlinear Optics and Short Pulse Spectroscopy, Germany.* Spectral phase shift of ultrabroadband pulses due to inversion was measured along the two axes of Ti:Sapphire at room and cryogenic temperatures. Results are crucial for CEP stabilization and compression of high energy few-cycle pulses.

SM4O • Structured Light for Material Processing—Continued

SM4O.3 • 17:15
Surface Relief Structuring via Multiple Pulse Femtosecond Ablation using an Intensity Spatial Light Modulator, Benjamin Mills[1], Daniel Heath[1], Rupert Bapty[1], Taimoor Rana[1], Behrad Gholipour[1], James Grant-Jacob[1], Robert Eason[1]; [1]*Univ. of Southampton, UK.* Subtractive femtosecond laser machining using multiple pulses with different spatial intensity profiles on the same position on a sample enables surface relief structuring with up to 60 layers, 330nm spatial resolution, 3μm maximum depth.

SM4O.4 • 17:30
Two-photon induced 'super-resolution' single-armed relief in azo-polymer film, Keigo Masuda[1], Shogo Nakano[1], Yoshinori Kinezuka[1], Mitsuki Ichijo[1], Ryo Shinozaki[1], Katsuhiko Miyamoto[1,2], Takashige Omatsu[1,2]; [1]*Chiba Univ., Japan;* [2]*Molecular chirality research center, Chiba Univ., Japan.* We present the formation of a 'super-resolution' single-armed chiral relief in an azo-polymer film through a two-photon absorption process by the illumination of circularly polarized picosecond optical vortex pulses.

SM4O.5 • 17:45
STED-inspired Laser Lithography Based on Spirothiopyran Chromophores, Patrick Mueller[1,2], Larissa Hammer[3], Rouven Mueller[3], Eva Blasco[3], Christopher Barner-Kowollik[3,4], Martin Wegener[1,2]; [1]*Inst. of Nanotechnology, Karlsruhe Inst. of Technology, Germany;* [2]*Inst. of Applied Physics, Karlsruhe Inst. of Technology, Germany;* [3]*Macromolecular Architectures, Inst. of Technical Chemistry and Polymer Chemistry, Karlsruhe Inst. of Technology, Germany;* [4]*School of Chemistry, Physics, and Mechanical Engineering, Queensland Univ. of Technology, Australia.* We present a photoresist based on the photochromic spirothiopyran moiety capable of creating free-standing 3D structures and offering an inhibition channel, which potentially allows for STED-inspired sub-diffraction laser lithography. Reversible inhibition and linewidth narrowing are demonstrated.

17:30–18:30 Diversity & Inclusion in Optics and Photonics Reception, *Market 1&2, Hilton San Jose*

19:00–20:30 OSA Nonophotonics Technical Group 20x20 Talks, *Room 230A*

AM4P • Biosensing Technologies—Continued

AM4P.5 • 17:15
Multifunctional Optophoresis for Biomolecular Detection by Using Integrated Silicon Photonic Waveguide Arrays, Zhenyu Li[1,2], Haitao Zhao[2], Gong Zhang[2], Yanyu Chen[2], Jianguo Huang[2], qihua xiong[2], Aiqun Liu[2]; [1]*Peking Univ., China;* [2]*Nanyang Technological Univ., Singapore*. A multifunctional optophoresis for biomolecular detection in integrated silicon photonic chip is demonstrated. Sample fractionation part is to avoid contamination and reduce interference. Signal is enhanced 5 more times after integrating sensors with waveguide arrays.

AM4P.6 • 17:30
Trapping and Optical Identification of Microparticles in a Liquid with a Functional Optical Fiber Probe, Fredrik Laurell[1], Sebastian Etcheverry[1], Walter Margulis[1]; [1]*Kungliga Tekniska Hogskolan, Sweden*. A fiber probe traps single micrometer-particles by fluid suction into a hollow microstructure and enables optical identification by the fluorescence light collected in a fiber core. The probe finds applications in life-science and environmental monitoring.

AM4P.7 • 17:45
All-fiber, Portable, Online Raman Biosensor with Enhancement of Signal Excitation and Collection Efficiency, Qian Chu[1], Guanghui Wang[1], Zhiqiang Jin[1], Jie Tan[1], Hao Cai[1], Bo Lin[2], Xuping Zhang[1]; [1]*Nanjing Univ., China;* [2]*China Academy of Electronics and Information Technology, China*. We demonstrate an all-fiber online Raman biosensor with enhancement of signal excitation and collection efficiency by inserting a gold-coated-fiber-tip reflector into the mental-lined capillary for transmission mode collection, which provides nearly 2 times of enhancement.

FM4Q • Valley-Hall and Active Toplogical Photonics—Continued

FM4Q.6 • 17:15
Topological Hybrid Silicon Microlasers, Han Zhao[1], Pei Miao[2,3], Mohammad H. Teimourpour[4], Simon Malzard[5], Ramy El-Ganainy[4], Henning Schomerus[5], Liang Feng[2]; [1]*Dept. of Electrical and Systems Engineering, Univ. of Pennsylvania, USA;* [2]*Dept. of Materials Science and Engineering, Univ. of Pennsylvania, USA;* [3]*Dept. of Electrical Engineering, The State Univ. of New York at Buffalo, USA;* [4]*Dept. of Physics and Henes Center for Quantum Phenomena, Michigan Technological Univ., USA;* [5]*Dept. of Physics, Lancaster Univ., UK*. We present an active topological hybrid silicon microlaser array respecting the charge-conjugation symmetry. The created symmetry favors the lasing of a protected zero-mode, where robust single-mode laser action prevails even with intentionally introduced perturbations.

FM4Q.7 • 17:30
Robust Radiation from Photonic Topological Insulators, Yaakov Lumer[1], Nader Engheta[1]; [1]*Electrical and Systems Engineering, Univ. of Pennsylvania, USA*. We numerically demonstrate how a photonic topological insulator can be exploited to feed an antenna array, resulting in robust radiation performance free from unwanted interferences, mutual coupling and matching challenges among feed points.

FM4Q.8 • 17:45
Robust non-reciprocal lasing in topological cavities of arbitrary geometries, Babak Bahari[1], Abdoulaye Ndao[1], Felipe Vallini[1], Abdelkrim El Amili[1], Yeshaiahu Fainman[1], Boubacar Kante[1]; [1]*Univ. of California San Diego, USA*. We present non-reciprocal topological cavities operating at telecommunication wavelengths. The unidirectional stimulated emission has an isolation ratio of about 10 dB between the output ports.

17:30–18:30 Diversity & Inclusion in Optics and Photonics Reception, *Market 1&2, Hilton San Jose*

19:00–20:30 OSA Nonophotonics Technical Group 20x20 Talks, *Room 230A*

07:00–18:30 Registration, *Concourse Level*

08:00–10:00 JTu1A • Plenary Session I & Awards Ceremony, *Grand Ballroom*

10:00–17:00 Exhibition Open, *Exhibit Hall*

10:00–11:30 Coffee Break & Exhibit Only Time, *Exhibit Hall*

Exhibit Hall

11:30–13:00 JTu2A • Poster Session I

JTu2A.1
Cladding Waveguides in Aminoacid Crystal: Fabrication and Second Harmonic Generation, Gustavo Almeida[1], Renato Martins[1], Jonathas Siqueira[1], Juliana Almeida[1], Jose J. Rodrigues Jr.[2], Cleber R. Mendonca[1]; *[1]USP - Instituto de Fisica de Sao Carlos, Brazil; [2]Physics Dept., Federal Univ. of Sergipe, Brazil.* Cladding waveguides were inscribed in L-threonine aminoacid crystals by fs-laser pulses. Guided second harmonic generation was observed at 390 nm, with an efficiency of 1.3%(MW cm^2)$^{-1}$. Such results open new opportunities in organic nonlinear photonics.

JTu2A.2
Optothermal Nanoscissors for Versatile Low-Power Patterning of Atomic-Thin Two-Dimensional Materials, Jingang Li[1], Linhan Lin[1,2], Xiaolei Peng[1], Yuebing Zheng[1,2]; *[1]Materials Science & Engineering Program, The Univ. of Texas at Austin, USA; [2]Dept. of Mechanical Engineering, The Univ. of Texas at Austin, USA.* We report a new technique - optothermal nanoscissors - to achieve fast, on-demand and arbitrary patterning of different atomic-thin two-dimensional materials using the highly localized plasmonic heating effect.

JTu2A.3
Laser Direct Writing of Waveguides in Flexible Glass and Ultrafast Visualization of Its Dynamics via Time-Resolved Interferometry, Garima C. Nagar[1], Dennis Dempsey[1], James Sutherland[2], Rostislav Grynko[1], Bonggu Shim[1]; *[1]BINGHAMTON UNIV., USA; [2]Corning Incorporated, USA.* Waveguides are inscribed onto flexible Corning Willow™ glass using femtosecond laser pulses. Interferometric phase imaging is used to elucidate the fabrication process by measuring dynamically-evolving plasma densities on ultrashort time scales.

JTu2A.4
Femtosecond-Laser Ablation of Monolayer Tungsten Diselenide (WSe2) on Sapphire, Yu-Ling Chen[1], Ya-Hsin Tseng[1], Yen-Chun Chen[1], Wen-Hao Chang[1], Tsing-Hua Her[2], Chih Wei Luo[1]; *[1]National Chiao Tung Univ., Taiwan; [2]Dept. of Physics and Optical Science, The Univ. of North Carolina at Charlotte, USA.* Near-IR femtosecond laser ablation of monolayer tungsten diselenide WSe_2 on sapphire is demonstrated. The ablation threshold is found low (below 10 mJ/cm^2), due to its low dimensionality and weak coupling to substrates. Substrate-dependent ablation threshold is predicted and will be discussed.

JTu2A.5
Femtosecond Laser- Colorized ITO Films for Blue Light Attenuation and Image Screening, Ya-Hsin Tseng[1], Hung Yang[1], Chih Wei Luo[1]; *[1]National Chiao Tung Univ., Taiwan.* Laser-colorized ITO films are fabricated using femtosecond laser annealing. The fluence-dependent nanostructures on ITO significantly attenuate blue light, which are suited to eye protection and the screening of images behind ITO for information security.

JTu2A.6
Free-Space Optical Switching of GST Phase-Change Thin Films via 1550 nm Light, Gary A. Sevison[1,4], Joshua Burrow[1], Andrea Aboujaoude[2], Matthew Mircovich[3], Andrew Sarangan[1], Josh Hendrickson[4], Imad Agha[1,3]; *[1]Electro-Optics, Univ. of Dayton, USA; [2]Electrical and Computer Engineering, Univ. of Dayton, USA; [3]Physics, Univ. of Dayton, USA; [4]Sensors Directorate, Air Force Research Lab, Wright-Patterson AFB, USA.* We experimentally demonstrate free-space phase change of Germanium Antimony Telluride (GST), switching between the amorphous and hexagonal crystalline states utilizing telecom-band laser pulses.

JTu2A.7
Graphene/III-V Hybrid Diode Optical Modulator, Ruizhe Yao[1], Bowen Zheng[1], Hyun Kum[2], Yunjo Kim[2], Sanghoon Bae[2], Jeehwan Kim[2], Hualiang Zhang[1], Wei Guo[1]; *[1]Univ. of Massachusetts Lowell, USA; [2]MIT, USA.* We demonstrate a graphene/III-V hybrid diode optical modulator working over a large frequency range from NIR to THz. The hybrid diode is achieved by heterogeneous integration of graphene and III-V heterostructures by remote epitaxy growth.

JTu2A.8
Long-lived Quantum Emitters in hBN-WSe_2 Van-Der-Waals Heterostructures, Jakob Wierzbowski[1], Malte Kremser[1], Christian Straubinger[1], florian sigger[1], Julian Klein[1], Michael Kaniber[1], Kai Müller[1], Jonathan Finley[1]; *[1]Walter Schottky Institut - TU München, Germany.* We present a significant linewidth narrowing (12.5 %) of free excitons in hBN encapsulated TMDs and localized (< 350 nm) single-photon emitters with long lifetimes of ~18 ns in hBN/WSe_2 heterostructures.

JTu2A.9
Mode-switching phenomena in periodic InGaN-based hexagon microcavity array, Chia-Yen Huang[1], Tsu-Ying Tai[1], Jing-Jie Lin[1], Tsu-Chi Chang[1], Che-Yu Liu[1], Kuo-Bin Hong[1], Tien-Chang Lu[1], Hao-Chung Kuo[1]; *[1]Dept. of Photonics, NCTU, Taiwan.* The lasing behavior of InGaN-based microcavity array was strongly relevant to the excitation area. The stronger rod-to-rod optical interaction between the fundamental axial mode resulted its dominance in the collective lasing behavior.

JTu2A.10
Frequency-Doubled Wafer-Fused 638 nm VECSEL with an Output Power of 5.6 W, Emmi L. Kantola[1], Tomi Leinonen[1], Antti Rantamäki[1], Mircea D. Guina[1], Vladimir Iakovlev[2], Alexei Sirbu[2]; *[1]ORC, Tampere Univ. of Technology, Finland; [2]RTI-Research SA, Switzerland.* We report on a frequency doubled vertical-external-cavity surface-emitting laser emitting 5.6 W at 635 nm. The cavity employed a wafer-fused AlInGaAs/InP-AlAs/GaAs gain mirror in a V-shaped configuration. The heatsink temperature was 20 °C.

JTu2A.11
VCSEL Amplifier with High Power and Narrow Divergence Applying a Folded Waveguide Layout, Mizuki Morinaga[1], Xiaodong Gu[1], Keisuke Shimura[1], Masanori Nakahama[1], Fumio Koyama[1]; *[1]Tokyo Inst. of Technology, Japan.* We demonstrated a compact VCSEL amplifier with a folded waveguide layout. Light propagation and amplification are realized in all 8 arms of the waveguide. Output power of 330mW and narrow divergence of 0.1° were obtained.

JTu2A.12
1.5 μm GaInAsP Stripe Laser Comparison Between InP Substrate and Directly Bonded InP/Si Substrate, Gandhi Kallarasan Periyanayagam[1], Naoki Kamada[1], Yuya Onuki[1], Kazuki Uchida[1], Hirokazu Sugiyama[1], Xu Han[1], Natsuki Hayasaka[1], Masaki Aikawa[1], Kazuhiko Shimomura[1]; *[1]Sophia Univ., Japan. Crystal growth on the Si substrate for 1.5 μm GaInAsP stripe laser diode has been demonstrated via MOVPE and successfully achieved the lasing operation in the pulse regime. We have compared the lasing characteristics between directly bonded InP/Si substrate and InP substrate as a reference.*

JTu2A.13
A Large Area Monolayer WS_2 Laser Based on Surface-Emitting Heterostructure Photonic Crystal Cavities, Xiaochen Ge[1], Momchil Minkov[2], Xiuling Li[3], Shanhui Fan[2], Weidong Zhou[1]; *[1]Univ. of Texas at Arlington, USA; [2]Electrical Engineering, Stanford Univ., USA; [3]Electrical and Computer Engineering, Univ. of Illinois Urbana-Champaign, USA.* An optically pumped continuous wave room temperature operation monolayer WS_2 laser is presented. The cavity is formed around Γ point above lightline in a large area heterostructure photonic crystal slab for energy efficient surface emission.

JTu2A.14
High-Power DBR-Free Membrane Semiconductor Disk Lasers, Zhou Yang[1], David Follman[2], Alexander Albrecht[1], Paula Heu[2], Garrett Cole[2], Mansoor . Sheik-Bahae[1]; *[1]Univ. of New Mexico, USA; [2]Crystalline Mirror Solutions LLC, USA.* We compare the performance of DBR-free membrane semiconductor disk lasers (SDLs) with single and dual SiC intracavity heatspreaders. A record output power of 16.1 W is achieved and a fluorescence-based temperature characterization technique is demonstrated.

JTu2A.15
Demonstration of 1-um-band Si-Photonics-Based Quantum Dot Heterogeneous Tunable Laser, Atsushi Matsumoto[1], Kouichi Akahane[1], Toshimasa Umezawa[1], Naokatsu Yamamoto[1], Hirohito Yamada[2], Tomohiro Kita[2]; *[1]NICT, Japan; [2]Tohoku Univ., Japan.* We present a Si-photonics-based quantum dot heterogeneous tunable lasers in the 1-mm band. Optical devices using Si-photonics-based PIC in the 1-mm band probably have not been reported yet.

11:30–13:00 JTu2A • Poster Session I

JTu2A.16
Generation of Cylindrical Vector Beams from Vertical-Cavity Surface-Emitting Laser with Optical Feedback, Yuki Nara[1], Yuichi Kozawa[1], Shunichi Sato[1]; [1]*Inst. of Multidisciplinary Research for Advanced Materials, Tohoku Univ., Japan*. We demonstrated the direct and selective generation of radially and azimuthally polarized beams from a VCSEL which was optically feedbacked from an external cavity including a birefringent lens to select polarization.

JTu2A.17
Frequency-Doubled VECSEL Employing a Volume Bragg Grating for Linewidth Narrowing, Emmi L. Kantola[1], Jussi-Pekka Penttinen[1], Tomi Leinonen[1], Sanna Ranta[1], Mircea D. Guina[1]; [1]*ORC, Tampere Univ. of Technology, Finland*. We report on a frequency-doubled VECSEL emitting at 512.6 nm. The laser spectrum was narrowed with a Volume Bragg Grating and the intracavity frequency-doubling was achieved with a periodically poled MgO-doped lithium niobate.

JTu2A.18
Tunable External Cavity Quantum Cascade Laser using Intra-cavity Out-coupling, Yohei Matsuoka[1], Sven Peters[2], Mykhaylo P. Semtsiv[1], W. T. Masselink[1]; [1]*Humboldt Univ. of Berlin, Germany;* [2]*Sentech Instruments GmbH, Germany*. We describe an external-cavity quantum cascade laser with an intra-cavity out-coupling optical configuration. We achieved more than twice the output power compared to the Littrow design, while keeping the tunability.

JTu2A.19
Suppressing High Order Transverse Modes in Broad-Area Quantum Cascade Lasers, Ron Kaspi[1], Chi Yang[1], Sanh Luong[1], Timothy Bate[1], Chunte Lu[1], Timothy C. Newell[1], Don Gianardi[1]; [1]*Directed Energy Directorate, Air Force Research Lab, USA*. Intracavity lateral constrictions and distributed loss through metallic sidewalls are two distinct methods that provide preferential losses to the high order transverse modes in broad-ridge quantum cascade lasers and increase brightness.

JTu2A.20
Simultaneous Oscillation of Two-Color Laser Lights from a GaAs/AlGaAs Coupled Multilayer Cavity, Yasuo Minami[1], Xiangmeng Lu[1], Naoto Kumagai[2], Ken Morita[3], Takahiro Kitada[1]; [1]*Tokushima Univ., Japan;* [2]*National Inst. of Advanced Industrial Science and Technology, Japan;* [3]*Chiba Univ., Japan*. We succeeded in simultaneous two-color laser oscillation from a GaAs/AlGaAs coupled multilayer cavity by current injection at room temperature. The simultaneous lasing was confirmed by detecting SFG generated by the two color laser lights.

JTu2A.21
Optical gain characterization of nano-ridge amplifiers epitaxially grown on a standard Si wafer, Yuting Shi[1], Bernardette Kunert[2], Marina Baryshnikova[2], Marianna Pantouvaki[2], Joris Van Campenhout[2], Dries VanThourhout[1,2]; [1]*INTEC, UGent, Belgium;* [2]*Imec, Belgium*. With this paper, the authors report optical gain characterization of InGaAs/GaAs nano-ridge amplifierss epitaxially grown on a standard 300-mnm Si wafer, by varying strip length (VSL) method. The measured material gain is ~ 4000 cm-1, which is comparable with conventional GaAs materia

JTu2A.22
Demonstration of A Novel Two-Section DFB Laser, Gonghai Liu[1], Gongyuan Zhao[1], Weihua Guo[1], Qiaoyin Lu[1]; [1]*Huazhong Univ. of Science & Technol, China*. TS-DFB laser containing an unbiased reflection section that has the same MQWs and grating pitch as the gain section, has 0.38 mW/mA slope efficiency, outstanding single mode yield and wavelength controlling reliability.

JTu2A.23
Free-standing III-V Semiconductor Microdisk Laser Particles, Andreas C. Liapis[1], Nicola Martino[1], Sheldon Kwok[1], Paul Dannenberg[1], Dong-Hoon Jang[2], Yong-Hee Lee[2], Seok-Hyun Yun[1]; [1]*Wellman Center for Photomedicine, Massachusetts General Hospital, USA;* [2]*Dept. of Physics, Korea Advanced Inst. of Science and Technology (KAIST), South Korea*. Semiconductor microdisks can be detached from their substrate and used as free-standing laser ``particles'' exhibiting room-temperature single-mode lasing. Silica-coated laser particles embedded in hydrogels display sub-nm linewidths and sub-20-pJ thresholds.

JTu2A.24
The Effect of Temperature on the Dynamical States of a Time Delayed Mid-infrared Quantum Cascade Oscillator, Olivier Spitz[1,2], Jiagui Wu[3,4], Sudeep Khanal[5], Mathieu Carras[2], Benjamin Williams[5], Chee Wei Wong[3], Frédéric Grillot[1,6]; [1]*Télécom ParisTech, France;* [2]*mirSense, France;* [3]*Fang Lu Mesoscopic Optics and Quantum Electronics Lab, Univ. of California Los Angeles, USA;* [4]*College of Electronics and Information Engineering, Southwest Univ., China;* [5]*Electrical and Computer Engineering, Univ. of California Los Angeles, USA;* [6]*Center for High Technology Materials, Univ. of New-Mexico, USA*. Carrier-to-photon lifetime ratio is a key parameter in the non-linear dynamics study of quantum cascade lasers under external optical feedback. We experimentally investigate the influence of temperature on this parameter and hence on chaotic behaviors.

JTu2A.25
Temperature Dependence of Electrically Injected Quantum-Dot Photonic-Crystal Surface-Emitting Lasers, Ming-Yang Hsu[1], Gray Lin[1], Yu-Chen Chen[1], Chien-Hung Pan[2]; [1]*National Chiao Tung Univ., Taiwan;* [2]*Truelight Corporation, Taiwan*. We have simplified fabrication of electrically injected quantum-dot photonic-crystal surface-emitting lasers and demonstrated lasing emissions at 1313 nm. Excellent threshold temperature characteristics was exhibited in range of 20~45 ^{0}C with characteristics temperature of almost infinity.

JTu2A.26
Design Optimization for Semiconductor Lasers with High-Order Surface Gratings having Multiple Periods, Gaurav Jain[1], Michael J. Wallace[1], Qiaoyin Lu[2], Wei-Hua Guo[2], John F. Donegan[1]; [1]*School of Physics and CRANN, Trinity College Dublin, Ireland;* [2]*Wuhan National Lab for Optoelectronics, Huazhong Univ. of Science and Technology, China*. A ridge waveguide multi period structure within 37th order surface grating semiconductor laser is presented. These gratings allow wide tuning over the C-band while allowing for low threshold and high SMSR.

JTu2A.27
GaSb-based 2.7μm laser diode with GaAs top cladding, Timothy Bate[1], Chunte Lu[1], Robert Palomino[1], Chi Yang[1], Timothy C. Newell[1], Sanh Luong[1], Ron Kaspi[1]; [1]*Directed Energy Directorate, Air Force Research Lab, USA*. GaSb-based ~2.7μm diode lasers were grown with highly mismatched GaAs top clad using MBE. Only ~27% reduction in slope efficiency was observed, with peak power >300mW at room temperature, despite fully relaxed clad.

JTu2A.28
High performance GaSb superluminescent diodes for tunable light source at 2 μm and 2.55 μm, Nouman Zia[1], Jukka Viheriälä[1], Eero Koivusalo[1], Antti Aho[1], Soile Suomalainen[1], Mircea D. Guina[1]; [1]*Optoelectronics research centre Tampere, Finland*. We report on GaSb–based superluminescent diodes emitting an output power of 70 mW at 2 μm and the first demonstration of 2.55μm SLD with mW-level output power at room temperature for compact gas sensors.

JTu2A.29
Enhanced Performance of 450 nm GaN Laser Diodes with an Optical Feedback for High bit-rate Visible Light Communication, Md. Hosne Mobarok Shamim[1], Mohamed Shemis[1], Chao Shen[2], Hassan Oubei[2], Tien Khee Ng[2], Boon S. Ooi[2], Mohammed Khan[1]; [1]*King Fahd Univ. of Petroleum & Mine, Saudi Arabia;* [2]*King Abdullah Univ. of Science and Technology, Saudi Arabia*. First report on significant performance improvement of 450 nm blue edge-emitting laser in terms of optical linewidth (~6.5 times), modulation bandwidth (~16%) and SMSR (~7.4 times) by employing self-injection locking scheme.

JTu2A.30
Coupling in Densely Integrated Metallo-dielectric Nanolasers, Suruj Deka[1], Si Hui Pan[1], Qing Gu[2], Yeshaiahu Fainman[1], Abdelkrim El Amili[1]; [1]*Electrical and Computer Engineering, Univ. of California, San Diego, USA;* [2]*Electrical Engineering, Univ. of Texas, USA*. We demonstrated coupling between two metallo-dielectric nanolasers using three-dimensional finite-element method simulations. Splits in resonant wavelength and quality factor were observed due to bonding and anti-bonding states. To prevent coupling, cavity resonances were slightly detuned.

JTu2A.31
Stabilization and jitter reduction in mode-locked quantum dash lasers by asymmetric dual-loop optical feedback , Haroon Asghar[1,2], Ehsan Sooudi[1,2], John McInerney[1,2]; [1]*Univ. College Cork, Ireland;* [2]*Tyndall National Inst., Ireland*. A novel asymmetric dual-loop configuration suppresses parasitic noise-resonances when single- and dual-loop optical feedback is used to stabilize mode-locked quantum-dash lasers at 1550 nm. Conditions for optimum suppression are determined and compared with published theory.

JTu2A.32
QoT estimation for Unestablished Lightpaths Using Artificial Neural Networks, Min Zhang[1], Dong Fu[1], Bo Xu[1], Baojian Wu[1], Kun Qiu[1]; [1]*Univ of Electronic Science & Tech China, China*. Estimating the quality of transmission (QoT) for lightpaths is crucial for reducing provisioned margins. We investigate an artificial neural network framework to estimate the QoT of unestablished lightpaths considering interference effects and optical monitoring uncertainties .

JTu2A.34
Coherent Free-space/Fiber L-band Optical Communication using Self-Injection Locked InAs/InP Quantum-dash Laser, Mohamed Shemis[1], Emad Alkhazraji[1,2], Muhammed Talal Khan[1], Amr Ragheb[3], Maged Esmail[3], Habib Fathallah[4,5], Saleh Alshebeili[3,4], Mohammed Zahed Khan[1]; [1]*Optoelectronics Research Lab, Electrical Engineering Dept., Saudi Arabia;* [2]*Dept. of Electrical and Electronics Engineering Technology, Jubail Industrial College, Saudi Arabia;* [3]*KACST-TIC in Radio Frequency and Photonics for the e-Society, Saudi Arabia;* [4]*Electrical Engineering Dept., King Saud Univ., Saudi Arabia;* [5]*Computer Dept. of the College of Science of Bizerte, Univ. of Carthage, Tunisia*. Demonstration of mid-L-band (~1602–1613nm) broadly tunable self-injection locked quantum-dash laser diode is reported with ~11nm tunability and ~30dB SMSR. Record 168(176) Gb/s DP-QPSK transmission over 10km SMF (16m FSO) link is achieved at ~1610nm.

JTu2A.35
Phase Noise of Diode Laser Frequency Comb and its Impact in Coherent Communication Systems, Mustafa A. Al-Qadi[1], Govind Vedala[1], Rongqing Hui[1]; [1]*Univ. of Kansas, USA*. Phase noise performance of QD-based diode laser comb sources in coherent communication systems is reported. The performance results show that much higher linewidths can be tolerated compared to single frequency lasers, like DFB, due to unique phase noise characteristics.

11:30–13:00 JTu2A • Poster Session I

JTu2A.36
Single-stage Phase-sensitive Amplifier Based Quadrature De-multiplexer for De-aggregating QAM Signals into In-phase and Quadrature Components, Jiabin Cui[1], Guo-Wei Lu[2,3], Hongxiang Wang[1], Lin Bai[1], Yuefeng Ji[1]; *[1]State Key Lab of Information Photonics and Optical Communications, School of Information and Communication Engineering, Beijing Univ. of Posts and Telecom., China; [2]Inst. of Innovative Science and Technology, Tokai Univ., Japan; [3]National Inst. of Information and Communications Technology (NICT), Japan.* A single-stage phase-sensitive amplifier based quadrature de-multiplexer is proposed and validated for de-aggregating QAM signals into in-phase and quadrature components with wavelength and polarization preserved. A 10Gbaud 16QAM/64QAM is successfully de-aggregated into two PAM4s/PAM8s.

JTu2A.37
Few-Mode EDFA Based All-Optical Relaying System for Atmospheric Channels, Shanyong Cai[1], Zhiguo Zhang[1], Xue Chen[1]; *[1]Beijing Univ of Posts & Telecom, China.* We present a scheme of all-optical relaying system based on few-mode erbium-doped fiber amplifier (EDFA) to resist turbulence for atmospheric channels with improved bit error rate.

JTu2A.38
Dual-phase-conjugation Coded Digital Multicarrier Transmission for Long-haul Coherent Optical Systems, Takahiro Kodama[1], Masanori Hanawa[1]; *[1]Yamanashi Univ., Japan.* A dual phase-conjugated multicarrier DP-QPSK system for chromatic dispersion and nonlinear tolerant transmission has been demonstrated. We show Q-factor improvement by balancing a nonlinear distortion over 10000 km SMF transmission with 6-dB worst case PDL.

JTu2A.39
512-Gbit/s PAM-4 Signals Direct-Detection using Silicon Photonics Receiver with Volterra Equalization, Yung Hsu[1], Chun-Yen Chuang[1], Liang-Yu Wei[1], Chi-Wai Chow[1], Xinru Wu[2], Hon Ki Tsang[2], Jyehong Chen[1], Chien-Hung Yeh[3]; *[1]National Chiao Tung Univ., Taiwan; [2]Dept. of Electronic Engineering, The Chinese Univ. of Hong Kong, Hong Kong; [3]Dept. of Photonics, Feng Chia Univ., Taiwan.* A 400-Gbit/s Ethernet (GbE) pulse-amplitude-modulation-4 (PAM-4) over 10-km single-mode-fiber (SMF) transmission direct-detected by an integrated silicon-photonics-receiver satisfying the IEEE P802.3bs requirement; and its feasibility to support 512-Gbit/s were illustrated.

JTu2A.40
2-Gbit/s Visible Light Modulation Using GaN-Based Photonic Crystal Light-Emitting Diodes without Pre- and Post- Emphasis, Zi-Xuan You[1], Tung-Ching Lin[1], Yu-Feng Yin[1], Yung-Tsan Chen[1], Hsuan-Yun Kao[1], Cheng-Yi Huang[1], Yu-Hong Lin[1], Jian-Jang Huang[1]; *[1]National Taiwan Univ. , Taiwan.* Recently, GaN based light-emitting diodes (LEDs) have become a promising candidate for visible light communication (VLC). In this work, we demonstrated 2-Gbit/s data rate transmission using GaN-based LEDs with photonic crystal (PhC) structure.

JTu2A.41
Set-Partitioned QAM Fast-OFDM with Real-Valued Orthogonal Circulant Matrix Transform Pre-Coding, Zhouyi Hu[1], Jian Zhao[2], Yang Hong[1], Shuang Gao[1], Chun-Kit Chan[1], Lian-Kuan Chen[1]; *[1]The Chinese Univ. of Hong Kong, Hong Kong; [2]Tyndall National Inst. and Univ. College Cork, Ireland.* We propose SP-QAM based Fast-OFDM with a novel real-valued OCT pre-coding scheme for IM/DD systems. For 19.76-Gbit/s 20-km transmission, the proposed scheme achieves 3.5-dB sensitivity improvement and higher filtering tolerance over conventional PAM Fast-OFDM.

JTu2A.42
Multi-Format and Low-Complexity Carrier Phase Estimation Scheme Based on Linear Approximation for Elastic Optical Networks, Yang Tao[1], Chen Shi[2], Xue Chen[1], Liqian Wang[1], Huan Chen[1]; *[1]Beijing Univ of Posts & Telecom, China; [2]Iowa State Univ., USA.* We propose an innovative multi-format CPE scheme outperforming existing CPEs in both performance and complexity for *m*-QAM formats in elastic optical networks. Simulation and experimental results demonstrate its effectiveness, flexibility and excellent linewidth tolerance.

JTu2A.43
Towards 400Gb/s Data Center Interconnect Using Coherent Detection with Higher-Order QAM Formats, Xuan He[1], Yang Yue[1], Qiang Wang[1], Andre Vovan[1], Jon Anderson[1]; *[1]Juniper Networks, USA.* We experimentally studied the capacity-reach matrix for single-carrier high baud rate x-QAM signals in unamplified link. We show that 400Gbit/s (64GBd 16-QAM) can be achieved over 80 km link, potentially for data center interconnect application.

JTu2A.44
Machine Learning Enabling Traffic-Aware Dynamic Slicing for 5G Optical Transport Networks, Chuang Song[1], min Zhang[1], Xuetian Huang[2], Yueying Zhan[3], Danshi Wang[1], Min Liu[1], Yanhong Rong[1]; *[1]State Key Lab of Information Photonics and Optical Communications, Beijing Univ. of Posts and Telecom., China; [2]China Telecom Corporation, China; [3]Technology and Engineering Center for Space Utilization, Chinese Academy of Science (CAS), China.* We demonstrate a machine-learning-based traffic-aware approach for dynamic network slicing in optical networks. Experimental results indicate that the proposed framework achieves 96% traffic prediction accuracy, 49% blocking reduction and 29% delay reduction compared with conventional solutions.

JTu2A.45
Silicon Photonic Deserialization for Energy Efficient Links, Nathan Abrams[1], Robert Polster[1], Michail Oikonomou[1], Liang Yuan Dai[1], Keren Bergman[1]; *[1]Columbia Univ., USA.* We develop a novel optical deserialization system in silicon photonics to reduce electrical deserialization power consumption and improve receiver sensitivity. Results demonstrate a path to increasing receiver sensitivity by 2.5 dB with improved modulators.

JTu2A.46
Reduced Complexity Interleaved Multi-Carrier CDMA for Passive Optical Networks, Abdallah M. Abdelaziz[1], Mostafa Khalil[1], mohamed El-Shimy[1], Masoud Alghoniemy[1], Hossam M. Shalaby[1,2]; *[1]Electrical Engineering, Alexandria Univ., Egypt; [2]Egypt-Japan Univ. of Science and Technology (E-JUST), Egypt.* A reduced complexity interleaved multi-carrier CDMA technique is proposed for passive optical networks (PONs). The proposed technique provides performance improvement compared to traditional O-OFDMA with less complexity than MC-CDMA.

JTu2A.47
RSOP Equalization through an Extend Kalman Filter Scheme in Stokes Vector Direct Detection System, Qisong Shang[1], Zibo Zheng[1], Nan Cui[1], Nannan Zhang[1], Wenbo Zhang[1], Hengying Xu[1,2], Xianfeng Tang[1], Lixia Xi[1], Xiaoguang Zhang[1]; *[1]Beijing Univ of Posts & Telecom, China; [2]Liaocheng Univ., China.* A new scheme for RSOP equalization in Stokes Vector Direct Detection (SV-DD) is proposed. The scheme is using Extended Kalman Filter (EKF) to tracking and compensation, which has a good performance in fast dynamic RSOP.

JTu2A.48
Cost-effective Demultiplexing Scheme for Two PDM-PAM4 Joint IM/DD Links Utilizing Stokes Receiver, Yan Pan[1], Lianshan Yan[1], Anlin Yi[1], Lin Jiang[1], Wei Pan[1], Bin Luo[1]; *[1]Southwest Jiaotong Univ., China.* We propose a cost-effective demultiplexing scheme for two PDM-PAM4 signals in IM/DD system based on a single Stokes receiver. About 1-dB power penalty is observed after 25-km NZDSF transmission at 160-Gbit/s data rate.

JTu2A.49
Fine and Coarse Tunability over a Continuous 8.1-ns Delay Range with Access to Multiple Possible Delays using a Frequency Comb, Ahmed Almaiman[1], Yinwen Cao[1], Amirhossein Mohajerin Ariaei[1], Fatemeh Alishahi[1], Ahmad Fallahpour[1], Dmitry Starodubov[1], Kaiheng Zou[1], Peicheng Liao[1], Changjing Bao[1], Shlomo Zach[2], Nadav Cohen[2], Moshe Tur[2], Alan E. Willner[1]; *[1]Univ. of Southern California, USA; [2]School of Electrical Engineering, Tel Aviv Univ., Israel.* A continuous delay range of 8.1 ns is achieved with simultaneous access to four different delays. Our system's penalty is ~2 dB for a 10 Gbaud QPSK signal. We also add a HNLF to convert one of the delays to the original wavelength, adding ~ 0.3 dB penalty.

JTu2A.50
A Cost-Effective demodulator for the Next Generation of Optical Access Networks Receivers, Ana R. Bastos[1], Ali Shahpari[1], Luís D. Carlos[2], Mário Lima[1], Paulo S. Andre[1], Maria R. Ferreira[2]; *[1]Instituto de Telecomunicacoes, Portugal; [2]CICECO, Portugal.* We introduce a cost-effective organic-inorganic hybrid photonic integrated circuit suitable for coherent access networks and demonstrate a 3.5±0.3 dB power penalty, relatively to back-to-back, for 20 Gb/s QPSK transmission over 40 km of G.652 fiber.

JTu2A.51
Programmable sub-harmonic optical clock recovery based on dispersion-induced inverse temporal self-imaging, Jinwoo Jeon[1], Reza M. Qartavol[1], James van Howe[2], Jose Azana[1]; *[1]INRS-Energie Materiaux et Telecom, Canada; [2]Dept. of Physics and Astronomy, Augustana College, USA.* We propose and experimentally demonstrate the first design of a fiber-optics programmable base/sub-harmonic optical clock recovery circuit, involving a phase modulator and linear dispersion, in which the rate division factor can be electrically reconfigurable.

JTu2A.52
Impact of differential group-velocity dispersion on intermodal four-wave mixing in few-mode fibers, Georg Rademacher[1], Ruben S. Luis[1], Benjamin Puttnam[1], Hideaki Furukawa[1], Yoshinari Awaji[1], Naoya Wada[1], Ryo Maruyama[2], Kazuhiko Aikawa[2]; *[1]National Inst of Information & Comm Tech, Japan; [2] Fujikura Ltd, Japan.* We investigate the impact of differential group-velocity dispersion between modes of a few-mode fiber on intermodal four-wave mixing. We find that differences of the chromatic dispersion lead to a reduced bandwidth with full phase-matching.

JTu2A.53
Enhancing the Performance of an Optical High-Order QAM Communication Channel by Adding Correlated Data to Robust Neighboring Channels in a Heterogeneous Network, Yinwen Cao[1], Kaiheng Zou[1], Ahmed Almaiman[1], Amirhossein Mohajerin Ariaei[1], Changjing Bao[1], Peicheng Liao[1], Fatemeh Alishahi[1], Ahmad Fallahpour[1], Alan E. Willner[1]; *[1]Univ. of Southern California, USA.* An enhanced high-order QAM communication using data correlation with neighboring channels is demonstrated. The effectiveness of this approach is verified by using 10-Gbaud 4/16/64/256-QAM channels in simulation and 5/10-Gbaud 16-QAM channels in experiment.

JTu2A.54
Single-Source Duplex High-Speed FSO Communications Using Electro-Optic Modulator-Based MRR, Xianglian Feng[1], Hexin Jiang[1], Zhihang Wu[1], Tianshu Wang[2], Hongwei He[1], Shiming Gao[1]; *[1]Zhejiang Univ., China; [2]Changchun Univ. of Science and Technology, China.* A single-source 10 Gb/s duplex free-space optical communication is demonstrated using electro-optic modulator-based modulating retro-reflector. The power penalty is <2.3 (8.0) dB for downlink DPSK (uplink OOK) signal at 1×10^{-3} BER in an atmospheric cell.

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JTu2A.55
Nyquist-WDM Super-Channel Using an On-Chip Frequency Comb enabled by a Silicon Dual-drive MZM, Jiachuan Lin[1], Yelong Xu[1], Hassan Sepehrian,[1], Leslie A. Rusch[1], Wei Shi[1]; *[1]Université Laval, Canada.* We experimentally generate a 20 GHz spaced 5-line comb using a silicon modulator, with good performance to support 16Gbaud 32QAM and 20Gbaud 16QAM, aggregating net rates of 667 Gb/s and 747 Gb/s.

JTu2A.56
Terabit optical OFDM data transmission carried by coherent Kerr soliton frequency comb lines, Xiatao Huang[1], Yong Geng[1], Wenwen Cui[1], Yun Ling[1], Xingwen Yi[1], Baojian Wu[1], Kun Qiu[1], Shu-Wei Huang[3], Chee Wei Wong[2], Heng Zhou[1]; *[1]Univ of Electronic Science & Tech China, China; [2]Univ. of California, Los Angeles,, USA; [3]Dept. of Electrical, Computer, and Energy Engineering, Univ. of Colorado, Boulder, USA.* We demonstrate seamless multiplexing of 180-channel optical-orthogonal-frequency-division-multiplexing utilizing dissipative Kerr soliton microcomb aided by sinc-pulse modulation. Mutual coherence among Kerr comb lines is exploited for the first time to achieve 6.885 Tb/s data transmission.

JTu2A.57
2^{14} (=16,384) Level Intensity Modulation at 10 Gbaud for Y-00 Quantum Stream Cipher, Ken Tanizawa[1], Fumio Futami[1]; *[1]Tamagawa Univ., Japan.* Coarse-to-fine driving of an MZI is proposed for multilevel intensity modulation beyond a resolution limit of a D/A converter. We demonstrate noise masking with record-high 2^{14} (=16,384) intensity levels in 10-Gbaud Y-00 quantum stream cipher.

JTu2A.58
192-Gbit/s PAM-4 Optical Interconnect using Mode-Division Multiplexing, Yung Hsu[1], Xinru Wu[2], Chun-Yen Chuang[1], Chi-Wai Chow[1], Hon Ki Tsang[2], Jyehong Chen[1], Chien-Hung Yeh[3]; *[1]National Chiao Tung Univ., Taiwan; [2]Dept. of Electronic Engineering, The Chinese Univ. of Hong Kong, Hong Kong; [3]Dept. of Photonics, Feng Chia Univ., Taiwan.* 192-Gbit/s pulse-amplitude-modulation-4 (PAM-4) signal transmission for on-chip optical interconnects using mode-division-multiplexing (MDM) is experimentally investigated. 3 channels are successfully mode multiplexed and de-multiplexed satisfying the forward-error correction (FEC) requirement.

JTu2A.59
Third-Order Nonlinear Optical Coefficients of Si and GaAs in the Near-Infrared Spectral Region, Joel M. Hales[2,3], San-Hui Chi[1], Taylor Allen[1], Sepehr Benis[4], Natalia Munera[4], Joseph W. Perry[1], Dale McMorrow[2], David J. Hagan[4], Eric W. Van Stryland[4]; *[1]Georgia Inst. of Technology, USA; [2]Naval Research Lab, USA; [3]Sotera Defense Solutions, USA; [4]Univ. of Central Florida, USA.* The third-order optical nonlinearities of Si and GaAs have been characterized throughout the near-infrared spectral region (1.1-2 um) using multiple ultrafast spectroscopic techniques. These results have been independently confirmed at two different Labs.

JTu2A.60
Stable, high-average-power, narrow-linewidth source at 2.1 µm pumped at 1.064 µm, Biplob K. Nandy[2], Hanyu Ye[2], Chaitanya Kumar Suddapalli[1,2], Majid Ebrahim-Zadeh[2,3]; *[1]Radiantis, Spain; [2]ICFO-The Inst. of Photonic Sciences, Spain; [3]Institucio Catalana de Recerca i Estudis Avancats (ICREA), Passeig Lluis Companys 23, Spain.* We report stable, narrow-bandwidth operation of nanosecond degenerate OPO at 2.1 µm, for the first time, generating >2 W of average power in good beam-quality (M^2<3.7) and passive power-stability of 0.6% rms over 1 hour.

JTu2A.61
Compact Femtosecond Optical Parametric Oscillator Based on an Integrated Fibre Retroreflector, Callum F. O'Donnell[1,2], Chaitanya Kumar Suddapalli[1], Therese Paoletta[2], M. Ebrahim-Zadeh[2]; *[1]Radiantis, Spain; [2]ICFO - Institut de Ciencies Fotoniques, Spain.* We report a compact femtosecond optical parametric oscillator based on MgO:PPLN, incorporating an integrated-mirror, single-mode fibre-feedback loop, generating up to 50 mW across 1128-1243 nm and 1358-1600 nm, and exhibiting interesting spectral features.

JTu2A.62
Broadband Comb Upconversion in an Apodized Step-Chirped PPLN Waveguide for the Quantum Memories, Susu He[1], Yoo Seung Lee[1], Hao Liu[1], Jinghui Yang[1], Chee Wei Wong[1]; *[1]UCLA, USA.* We present theoretical modeling and characteristics of an apodized step-chirped ppLN waveguide for efficient and uniform broadband upconversion from 1580-nm comb to ~984-nm comb with a 3dB bandwidth of 48.6-nm to interface with rare-earth solid-state quantum memories.

JTu2A.63
Four-Wave Mixing in Highly Nonlinear Chalcogenide Glass-in-Silica Waveguides, Moshe Katzman[1], Dvir Munk[1], Mirit Hen[1], Arik Bergman[1], Mark Oksman[1], Yuri Kaganovskii[1], Michael Rosenbluh[1], Avi Zadok[1]; *[1]Bar-Ilan Univ., Israel.* Highly nonlinear waveguides are fabricated through deposition of chalcogenide glass into pre-patterned trenches in a silica cladding. No processing of the chalcogenide glass is required. Four-wave mixing is demonstrated with nonlinear coefficient of 6.5±1 $[W*m]^{-1}$.

JTu2A.64
All-optical Wavelength Conversion of Phase-encoded Signals in Silicon-rich Silicon Nitride Waveguides, Cosimo Lacava[1], Stuart May[2], David Richardson[1], Graham T. Reed[1], Marc Sorel[2], Periklis Petropoulos[1]; *[1]Univ. of Southampton, UK; [2]Univ. of Glasgow, UK.* We show the design and characterization of a silicon-rich silicon nitride-based all-optical wavelength converter, for phase-encoded signals. We demonstrate successful conversion of a 40 Gb/s 16-QAM signal with negligible penalty and no-signs of TPA.

JTu2A.65
Millijoule single-cycle angularly dispersed optical parametric amplifier, Xiao Zou[2,1], Houkun Liang[2], Shizhen Qu[2,1], Kun Liu[2,1], Cheng Liu[2,1], Qijie Wang[1], Ying Zhang[2]; *[1]Nanyang Technological Univ., Singapore; [2] Singapore Inst. of Manufacturing Technology, Singapore.* We propose an angularly dispersed optical parametric amplifier to compensate the phase mismatch over 1.3-4.1 µm, and generate carrier-envelope phase stable, millijoule, ~1.1 cycle pulses centered at 2 µm wavelength.

JTu2A.66
Controlling Brillouin-Induced Optical Delay via Four-Wave-Mixing Bragg Scattering, Ning Zhang[1], Xuelei Fu[2], Jie Liu[1], Chester Shu[1]; *[1]The Chinese Univ. of Hong Kong, Hong Kong; [2]School of Information Engineering, Wuhan Univ. of Technology, China.* To rapidly tune the Brillouin-induced optical delay, we perform vector sum of Brillouin-delayed pulse with non-delayed pulse through four-wave-mixing (FWM) Bragg scattering. Output pulse delay is effectively amplified and tuned by controlling FWM pump power.

JTu2A.67
Tunable, Multi-Milliwatt, Continuous-Wave Difference-Frequency-Generation Across 4.6-4.7 µm Based on Orientation-Patterned GaP, Kavita Devi[1], Anuja Padhye[1], Peter G. Schunemann[2], M. Ebrahim-Zadeh[1,3]; *[1]ICFO -The Inst. of Photonic Sciences, Spain; [2]BAE Systems, Inc., USA; [3]Institucio Catalana de Recerca i Estudis Avancats (ICREA), Spain.* We report the first realization of tunable continuous-wave difference-frequency generation across 4608-4694 nm in OP-GaP, with maximum power of 43 mW at 4608 nm and passive power stability of 2.5% rms (1.5 mins), in good beam quality.

JTu2A.68
Characterization of the Impact of β_2 and β_3 in Four-Wave Mixing Optical Time Lenses using Input-Output Cross-Correlations, Frederik Klejs[1], Mads Lillieholm[1], Michael Galili[1], Leif K. Oxenlowe[1]; *[1]DTU, Denmark.* We propose the use of input-output cross correlations to quantify the performance of four-wave mixing time lenses with dispersion-induced degradation. The impact of dispersion variations is investigated.

JTu2A.69
Stable UV-extended Supercontinuum Generation in Bulk Material by Picosecond Pulses, Veselin Aleksandrov[1,2], Anton Trifonov[1,2], Velizar Stoyanov[1], Kaloyan Georgiev[1], Ivan C. Buchvarov[1]; *[1]Physics Dept., Sofia Univ. "St. Kliment Ohridski", Bulgaria; [2]IBPhotonics Ltd., Bulgaria.* Stable UV-extended supercontinuum generation by self-action of picosecond pulses in bulk materials is demonstrated. The stability and spectral properties of the continuum show a strong dependence on the focusing parameters in 120-mm long CaF_2 rod.

JTu2A.70
Harmonic Generation In Cascaded Raman Fiber Lasers, Santosh Aparanji[1], V Balaswamy[1], S Arun[1], V R Supradeepa[1]; *[1]Indian Inst. of Science, India.* We report the surprising observation of visible harmonics in an infrared cascaded Raman fiber laser. A transition from 2nd to 3rd harmonic is seen with increasing locally propagating wavelengths, which we attribute to Cherenkov-type phase-matching.

JTu2A.71
Characterization of linear and nonlinear carrier generation in silicon nano-waveguides at 1550 nm, Andres Gil-Molina[1,2], Ivan A. Aldaya[1,3], Julian L. Pita[2], Lucas Gabrielli[2], Hugo Fragnito[1,4], Paulo C. Dainese[1]; *[1]Inst. of Physics, Univ. of Campinas, Brazil; [2]School of Electrical Engineering, Univ. of Campinas, Brazil; [3]State Univ. of Sao Paulo, Brazil; [4]Mackgraphe, Mackenzie Presbyterian Univ. , Brazil.* We characterize the generation of free-carriers in a silicon strip nano-waveguide at 1550nm performing pump-and-probe measurements. Compared with bulk silicon, we identified a higher effective two-photon absorption coefficient and a significant carrier-generation via single-photon absorption.

JTu2A.72
Characterization of Ultra-High-Q Si_3N_4 Micro-Ring Resonators with High-Precision Temperature Control, Paul Kaufmann[1], Xingchen Ji[2], Kevin Luke[2], Alexander L. Gaeta[3], Michal Lipson[2], Sven Ramelow[1]; *[1]Institut für Physik, Humboldt Universität zu Berlin, Germany; [2]Dept. of Applied and Engineering Physics, Columbia Univ., USA; [3]Dept. of Applied Physics and Applied Mathematics, Columbia Univ., USA.* We observe ultra-high Q-factors in Si_3N_4 micro-ring resonators exceeding 2×10^6 at 850 nm. We characterize them with a novel method harnessing high-precision temperature scanning and determine their thermal tuning coefficient with an uncertainty of only 4 MHz/K.

JTu2A.73
PbO-based ultrafast fiber lasers, Yufeng Song[1], Chenyang Xing[1], Yunxiang Chen[1], Han Zhang[1]; *[1]Shenzhen Univ., China.* A novel 2D material PbO was used as saturable absorber in a fiber laser. Passive mode locking pulse was as short as 850 fs. Passive Q-switching pulse is repetition tunable from 20kHz-50kHz. This finding suggests that PbO could be developed as a device in the applications of optical communication.

JTu2A.74
Measurement of Constant Power Contours for Dissipative Kerr Solitons, Xinbai Li[2,1], Boqiang Shen[2], Heming Wang[2], Ki Youl Yang[2], Xu Yi[2], Qifan Yang[2], Zhiping Zhou[1], Kerry Vahala[2]; *[1]Peking Univ., China; [2]Applied physics and materials science, California Inst. of Technology, USA.* Dissipative Kerr solitons are generated within an existence region of pumping power versus cavity-pump detuning frequency. By comparing modeling with measurement in microcavities, the contours of constant soliton power are studied within this existence region.

11:30–13:00 JTu2A • Poster Session I

JTu2A.75
Adaptive Wavefront Contrlol for Optimized Coherent Raman Multi-sideband Generation, Mariia Shutova[1], Anton Shutov[1], Jonathan Thompson[1], Alexandra A. Zhdanova[1], Alexei V. Sokolov[1]; [1]*Inst. for Quantum Science and Engineering, Dept. of Physics and Astronomy, Texas A&M Univ., USA.* We demonstrate that the wavefront optimization algorithm with feedback loop allows the extension of the total bandwidth of coherent Raman sidebands towards UV wavelengths, which will provide broader bandwidths for subcycle UV-VIS-NIR pulse synthesis.

JTu2A.76
Breather solitons dynamics and period-doubling transitions in 19 GHz microresonator frequency combs, Wenting Wang[1], Abhinav K. Vinod[1], Jinghui Yang[1], Mingbin Yu[2], Dim-Lim Kwong[2], Chee Wei Wong[1]; [1]*Univ. of California, Los Angeles, USA;* [2]*Inst. of Microelectronics, Singapore.* We observed breather soliton dynamics and period-doubling transitions in 19 GHz dispersion-engineered dissipative microresonator frequency combs. The low-noise comb breather frequency is deterministically controlled via effective pump detuning with 18 kHz/MHz slope efficiencies.

JTu2A.77
Hybrid Silicon-Nitride / Polymer Waveguide for Nonlinear-Optics Applications, Subrata Das[1], Brett R. Wenner[2], Jeffery W. Allen[3], Monica S. Allen[3], Michael Vasilyev[1]; [1]*Univ. of Texas at Arlington, USA;* [2]*Air Force Research Lab Sensors Directorate, USA;* [3]*Air Force Research Lab Munitions Directorate, USA.* We describe a hybrid silicon-nitride / polymer slot waveguide for generation of second harmonic of a 1550 nm beam. Modal phase-matching and optimized geometry yield order-of-magnitude improvement over a channel waveguide.

JTu2A.79
Efficient tuning of second-harmonic generation in a lithium niobate nanophotonic waveguide, Rui Luo[1], Yang He[1], Hanxiao Liang[1], Mingxiao Li[1], Qiang Lin[1]; [1]*Univ. of Rochester, USA.* We report flexible spectral tuning of second-harmonic generation in a lithium niobate nanophotonic waveguide, with a thermal tuning slope of 0.84 nm/K for a telecom pump, by utilizing the significant thermo-optic birefringence of lithium niobate.

JTu2A.80
Distributed Monitoring of Cascaded Four-Wave Mixing due to Kerr and Opto-Mechanical Nonlinearities, Hilel Hagai Diamandi[1], Yosef London[1], Gil Bashan[1], Avi Zadok[1]; [1]*Bar-Ilan Univ., Israel.* Distributed monitoring of cascaded four-wave processes along an optical fiber is performed using a multi-tone optical time-domain reflectometry setup. The interplay between Kerr nonlinearity and guided acoustic waves Brillouin scattering is observed.

JTu2A.81
Continuous-Time Electro-Optic PLL with Decimated Optical Delay/Loss and Spur Cancellation for LIDAR, Jahnavi Sharma[1], Sohail Ahasan[1], Christopher T. Phare[1], Michal Lipson[1], Harish Krishnaswamy[1]; [1]*Electrical Engineering, Columbia Univ., USA.* Current EO-PLLs for laser chirp modulation require large, lossy delay waveguides in an MZI to detect chirp slope. EO-PLLs, and electronic control loops generally, are dominantly digital. A new analog EO-PLL breaks the trade-off between chirp bandwidth and MZI delay, reducing area and loss by 10x.

JTu2A.82
Absorption-enhanced Imaging through Scattering Medium, Mehbuba Tanzid[1], Ashok Veeraraghavan[1], Naomi Halas[1]; [1]*Rice Univ., USA.* Using carbon-black absorbers, we show 80% image resolution-enhancement in isotropic polystyrene medium, compared to only 8% in a forward-scattering-medium. Subsequently, by increasing imaging wavelength from visible to NIR, resolution-enhancement for the forward-scattering-medium is increased (4×).

JTu2A.83
A Compact and Portable Laser Radioactive Decontamination System Using a Fiber Laser and a Polygon Scanner, Yu-Chieh Lin[1], Yen-Yin Lin[1], An-Chung Chiang[1]; [1]*National Tsing Hua Univ., Taiwan.* We designed a compact and portable laser radioactive decontamination system using a fiber laser and a polygon scanner. By varying the spinning speed of the polygon mirror, we achieved a processing speed exceeding 88500 mm/s.

JTu2A.84
Level-set Fabrication Constraints for Gradient-based Optimization of Optical Devices, Dries Vercruysse[1,2], Logan Su[1], Rahul Trivedi[1], Neil V. Sapra[1], Alexander Y. Piggott[1], Jelena Vuckovic[1]; [1]*Stanford Univ., USA;* [2]*KU Leuven, Belgium.* When designing integrated optical devices, fabrication constraints need to be satisfied. We present an analytical constraint for level-set parameterizations that limits the gap/feature size and can be combined with higher order gradient-based optimization algorithms.

JTu2A.85
Kerr-comb generation in a dispersion engineered coupled thin silicon nitride microresonators, Ali Eshaghian Dorche[1], Ali Asghar Eftekhar[1], Ali. Adibi[1]; [1]*Georgia Inst. of Technology, USA.* We numerically demonstrate the first wideband Kerr-comb generation at telecommunication wavelength (1550 nm) using thin silicon nitride platform based on coupled-resonator for dispersion engineering.

JTu2A.86
Silicon Nitride Grating Couplers with High Efficiency and Wide Bandwidth, Chi Xu[1], Mercedeh Khajavikhan[1], Patrick LiKamWa[1]; [1]*Creol, Univ. of Central Florida, USA.* A grating coupler for coupling vertically emitted laser light into planar silicon nitride waveguides is presented. The waveguide coupling efficiency was measured at 30% with a 3-dB bandwidth of 100 nm using an optical fiber.

JTu2A.87
Long-Term Stable Operation of Coherent Ising Machine for Cloud Service, Toshimori Honjo[1], Takahiro Inagaki[1], Kensuke Inaba[1], Takuya Ikuta[1], Hiroki Takesue[1]; [1]*NTT Basic Research Labs, Japan.* A 24-hour stable operation of a coherent Ising machine, an Ising model solver based on a network of degenerate optical parametric oscillators, was successfully demonstrated. The average success probability of computation exceeds 94%.

JTu2A.88
Sub-500 fs pulses from a hybrid architecture for high energy lasers, Damien Sangla[1], Pierre Sevillano[1], Jean-Gabriel Brisset[1], Magali Durand[1], Olivier Alexaline[1], Antoine Courjaud[1]; [1]*Amplitude Systemes, France.* An hybrid architecture for high energy laser is presented, based on Yb:CaF2 regenerative amplifier and Yb:YAG thin-disk multipass amplifier at room temperature delivering pulses 74 mJ with a 450 fs duration at 100 Hz.

JTu2A.89
Multiplexed static FBG strain sensors by dual-comb spectroscopy with a free running fiber laser, Jingjing Guo[1], Yihang Ding[1], Xiaosheng Xiao[1], Lingjie Kong[1], Changxi Yang[1]; [1]*Tsinghua Univ., China.* We demonstrate a novel FBG sensor system by dual-comb spectroscopy with a single fiber laser cavity, which enables interrogation of multiplexed FBG strain sensors with 0.5 με resolution in a large dynamic range of 520 με.

JTu2A.90
Laser induced thermomechanical cracking for fatigue life determination of coated steel, Jeffrey Warrender[1], Gregory Vigilante[1]; [1]*US Army, ARDEC RDECOM, USA.* A pulsed Yb fiber laser was used to irradiate steel coated with chromium to induce thermomechanical cracks; the resultant part showed a reduced fatigue life. This provides a path to accelerated fatigue tests.

JTu2A.91
Ti/TaN Bilayer for Efficient Injection and Reliable AlGaN Nanowires LEDs, Davide Priante[1], Bilal Janjua[2], Aditya Prabaswara[1], Ram Chandra Subedi[1], Rami Elafandy[1], Sergei Lopatin[1], Dalaver Anjum[1], Chao Zhao[1], Tien Khee Ng[1], Boon S. Ooi[1]; [1]*KAUST, Saudi Arabia;* [2]*Univ. of Toronto, Canada.* Reliable operation of UV AlGaN-based nanowires-LED at high injection current was realized by incorporating a Ti-pre-orienting/TaN-diffusion-barrier bilayer, thus enhancing external quantum efficiency, and resolving the existing device degradation issue in group-III-nanowires-on-silicon devices.

JTu2A.92
High efficiency continuous-wave Ti:sapphire laser, Tomoki Kanetake[1], Kesuke Hayashi[1], Motoki Morioka[1], Shunji Kataoka[1], Hiroki Kadoya[1], Toru Sato[1], Naoya Nakajima[1], Fumihiro Sugiki[1], Ryo Kobayashi[1], Sakae Kawato[1]; [1]*Univ. of Fukui, Japan.* Highest efficiencies of CW-Ti:sapphire laser were obtained by using the high gain architecture. The maximum optical-to-optical conversion efficiency and slope efficiency are 31.7% and 41.9% for the incident pump power, respectively.

JTu2A.93
Hotspot Detection in Integrated Circuits by Two-photon-fluorescence-based Thermal Microscope, Ming-Che Chan[1], Guan-Yu Zhuo[2], ZuPo Yang[1]; [1]*Inst. of Photonic System, Taiwan;* [2] *Inst. of Medical Science and Technology, National Sun Yat-sen Univ., No. 70, Lienhai Rd, Taiwan.* For thermal images and related hotspot diagnosis on integrated circuits (ICs) during operation, we present a high temporal, spatial, and temperature resolution thermal microscope based on the thermal-optical properties of R6G thin film.

JTu2A.94
Full ocular biometry through dual-depth whole-eye optical coherence tomography, Hyung-Jin Kim[1], Minji Kim[1], Min Gyu Hyeon[1], Youngwoon Choi[1], Beop-Min Kim[1]; [1]*Korea Univ., South Korea.* There are important geometric parameters in a human eye including three major axes and two angles between them. It is known that identification of those parameters may be helpful when performing some ophthalmic surgeries. We propose a new method to measure them using dual-depth whole-eye OCT.

JTu2A.95
Diffraction-free, Self-reconstructing Bessel beam generation using thermal nonlinear optical effect, qian Zhang[1], xue m. cheng[1], zhaoyu ren[1], hao w. chen[1], bo he[1], ying Zhang[2], jintao bai[1]; [1]*Northwest Univ., China;* [2]*School of Science, Engineering Univ. of PAP, China.* We propose a method to generate Bessel beam based on thermal nonlinear optical effect without the restriction to the laser wavelength. And the beam generated demonstrates superior non-diffraction and self-reconstruction properties.

JTu2A.96
Optical System for Multi-Channel Real-Time PCR, Sangheon Kim[1,2], Sunjak Choi[1,3], Yeji Lee[1,3], Sangyoon Jung[3], Minhyoung Jung[3], Jieun Baek[3], Hyeonuk Sim[3], Donghyun Kang[3], Junho Lee[1]; [1]*Korea Electronics Technology Inst., South Korea;* [2]*Korea Univ., South Korea;* [3]*Gachon Univ., South Korea.* Optical module for multi-channel real-time PCR detection system is designed and implemented. By using hyperspectral band-pass filter integrated on CMOS photo sensor, Multi-channel optical fluorescence excitation and detection system are realized in experiments.

11:30–13:00 JTu2A • Poster Session I

JTu2A.97
Optical fluorescence to assess abnormal tryptophan metabolic activity in brain samples from Alzheimer's patients, Laura Sordillo[1,2], Lin Zhang[1], Lingyan Shi[1,3], Vidyasagar Sriramoju[1], Peter Sordillo[1], Robert Alfano[1,2]; [1]*physics and electrical engineering, CCNY, USA;* [2]*electrical engineering, grove school of engineering, USA;* [3]*chemistry, columbia Univ., USA.* Brain samples from Alzheimer's patients and aged-matched controls were studied using label-free fluorescence. Increased tryptophan metabolite to tryptophan ratios were seen in the hippocampus and Brodmann's area 9 in Alzheimer's patients as compared to normal.

JTu2A.98
Dermis-simulating phantom for noninvasive blood glucose sensing with OCT, Guoqing Yang[1], Xiaotian S. Yao[1,2], Ya Su[1], Suling Liu[1], Ting Feng[1], Lei Chen[1], Hongjie Wang[1], Wenping Li[1]; [1]*Hebei Univ., China;* [2]*General Photonics Corporation, USA.* We developed a tissue phantom to mimic the optical properties of dermis layer and expect that it may serve as a useful tool to evaluate and standardize the theoretical model of noninvasive blood glucose sensing.

JTu2A.99
SVM Based Automatic Classification of Human Stomach Cancer with Optical Coherence Tomography Images, Site Luo[1], Yingwei fan[1], Hao Liu[2], Huikai Xie[3], Peng Li[4], Hongen Liao[1], Li Huo[1], Xin An[5]; [1]*Tsinghua Univ., China;* [2]*South China Medical Univ., China;* [3]*Dept. of Electrical and Computer Engine, Univ. of Florida, USA;* [4]*Shenzhen Moptim Imaging Technique , China;* [5]*Foshan Optomedic Technologies, China.* Classification is carried out by SVM and human with 1539 normal and 1567 cancerous OCT images. Accuracy, sensitivity and specificity of human are 82.8%, 73.9%, 93.5%, and that of SVM are 91.3%, 95.3%, 87.2%.

JTu2A.100
Quantitative Analysis of Keratinocytes in Human Skin Using Full-Field Optical Coherence Tomography, Chia-Kai Chang[1], Sheng Lung Huang[1]; [1]*National Taiwan Univ., Taiwan.* The three-dimensional spatial distribution and morphometry of the keratinocytes of *in vivo* human skin are analyzed quantitatively using the full-field optical coherence tomography. The depth dependent volume and ellipticity of the keratinocyte nuclei are extracted.

JTu2A.101
In Depth Flow Inspection based on Spatial Analysis of Dynamic Laser Speckle, Mark Golberg[2], Ran Califa[2], Sagi Polani[2], Javier G. Monreal[2], Zeev Zalevsky[2]; [2]*ContinUse Biometrics Ltd., Israel.* A novel optical approach based on statistical analysis of spatial laser speckle pattern for tissue in-depth flow characteristics is presented. Properties such as flow orientation and speed can be estimated. In-vitro experimental results are demonstrated

JTu2A.102
Laser Speckle Contrast Imaging under the breaking ergodicity conditions for intravital visualization of brain vasculature, Anton U. Sdobnov[1], Alexander Bykov[1], Vyacheslav Kalchenko[2], Guillaume Molodij[2], Alexey Popov[1], Igor Meglinski[1]; [1]*Univ. of Oulu, Finland;* [2]*Weizmann Inst. of Science., Israel.* In current study, the laser speckle contrast imaging has been considered at different ergodicity conditions with a final aim of accurate and valid quantitative assessment and intravital visualization of brain vasculature and blood flow.

JTu2A.103
Endoscopic optical coherence tomography probe with large scan range, Site Luo[1], Donglin Wang[2], Hao Liu[3], Hui Zhao[4], Huikai Xie[5], Li Huo[1]; [1]*Tsinghua Univ., China;* [2]*School of Physics and Electronic Engineering, Zhengzhou Univ. of Light Industry, China;* [3]*South China Medical Univ., China;* [4]*Foshan Optomedic Technologies, China;* [5]*Dept. of Electrical and Computer Engine, Univ. of Florida, USA.* a novel miniature endoscopic OCT probe with a diameter of 2.5 mm, scan a large range of 6 mm based on electric-thermal microelectromechanical system (MEMS) and C-lens.

JTu2A.104
Label Free Imaging of Endogenous Chromophore in Biological Tissues with High Speed Photothermal Microscopy, Jun Miyazaki[1], Yuya Ishikawa[1], Takayoshi Kobayashi[2]; [1]*Wakayama Univ., Japan;* [2]*Advanced Ultrafast Laser Research Center, The Univ. of Electro-Communications, Japan.* A high-sensitivity and high-speed photothermal microscope wad developed with a new detection scheme. The system demonstrates label free imaging of endogenous chromophores in brain and skeletal muscle with the image acquisition time of 0.76 s.

JTu2A.105
Seed-Based Hemodynamic Connectivity Mapping to Analyze the Effect of Hemi-Parkinson's Disease using NIR Imaging , Seung-ho Paik[1], Sedef Erdogan[1], Zeph Phillips[1], Young-Kyu Kim[1], Kang-Il Song[2], Sunghee Park[2], Youngwoon Choi[1], Inchan Youn[2], Beop-Min Kim[1]; [1]*Bio-convergence Engineering, Korea Univ., South Korea;* [2]*Korea Inst. of Science and Technology, Biomedical Research Inst., South Korea.* A single camera near infrared hemodynamic imaging system was developed to analyze the effects hemi-Parkinson's disease on the functional organization of the brain using seed-based connectivity mapping during resting state.

JTu2A.106
Suture Maps Based on Structural Enhanced Imaging Endoscope for Laparoscopic Robotic Surgery, Hanh N. Le[1], Shuwen Wei[1], Simon Leonard[1], Justin Opfermann[2], Axel Krieger[3], Jin U. Kang[1]; [1]*Johns Hopkins Univ. , USA;* [2]*Children's National Health System, USA;* [3]*Univ. of Maryland, USA.* A detection method for cutting scheme in 3D is proposed to assist robotic surgical manipulation, leading to an automatic suturing suggestion mapping.

JTu2A.107
Lens-less Micro-endoscopy through highly scattering media, Omer Wagner[1], Aditya Pandya[2], Yoav Chemla[3], Hadar Pinhas[1], Irina Schelkanova[2], Asaf Shamoon[1], Yossi Mandel[3], Alexandre Douplik[2], Zeev Zalevsky[1]; [1]*engineering, Bar-Ilan Univ., Israel;* [2]*Physics, Ryerson Univ. , Canada;* [3]*Faculty of Life Sciences, School of Optometry and Visual Science, Bar Ilan Univ., Israel.* We demonstrate a setup based on lensless, minimally invasive micro-endoscope to image biological samples through scattering medium. We present in-vitro results of Polydimethylsiloxane micro-channels filled with Hemoglobin covered by intralipid mimicking epidermis of human skin.

JTu2A.108
Compressive OCT based on spectral domain random encoding, Xuan Liu[1], Yahui Wang[1]; [1]*New Jersey Inst. of Technology, USA.* We developed and validated a compressive OCT system based on spectral domain random encoding that achieves random modulation of OCT signal for hardware compressive sampling and allows information beyond Nyquist limit to be extracted.

JTu2A.109
High Pulse Energy Supercontinuum Laser for Photoacoustic Detection and Identification of Lipids in the 1650-1850 nm Wavelength Region, Manoj Kumar Dasa[1], Christos Markos[1], Michael Maria[2,1], Ivan Bravo Gonzalo[1], Christian R. Petersen[1], Deepak Jain[1], Peter Moselund[2], Ole . Bang[1,2]; [1]*Technical Univ. of Denmark, Denmark;* [2]*NKT Photonics, Denmark.* Lipids are highly coveted for the interrogation of fatal chronic diseases. We propose cost-efficient high pulse energy supercontinuum source, using telecom range diode laser and standard optical fiber for photoacoustic detection and identification of lipids.

JTu2A.110
Longitudinal Control of Topological Charge and Polarization of Attenuation-Resistant OAM Modes, Ahmed Dorrah[1], Mateus Corato-Zanarella[2,3], Michel Zamboni-Rached[2], Mo Mojahedi[1]; [1]*Dept. of Electrical and Computer Engineering, Univ. of Toronto, Canada;* [2]*School of Electrical Engineering, Univ. of Campinas, Brazil;* [3]*Dept. of Electrical Engineering, Columbia Univ., USA.* We experimentally demonstrate non-diffracting and attenuation-resistant beams with orbital angular momentum (OAM) and whose topological charge and polarization can be controlled independently along the beam's axis. This can address many challenges in micromanipulation and optical communications.

JTu2A.111
Dispersion Control in Silicon Oxide Wedge Microdisks, Laís Fujii dos Santos[1], Marvyn Inga[1], Jorge H. Soares[1], Thiago P. Alegre[1], Gustavo S. Wiederhecker[1]; [1]*Unicamp, Brazil.* We demonstrate the generation of optical frequency combs by engineering the dispersion of a small radius (100 microns) thin wedge microcavity. The phase-matching of the excitation taper is also employed to inhibit avoided-crossings.

JTu2A.112
Investigation of the Effect of Stimulated Raman Scattering on Parametric Pumping of Microring Resonators, Mohammed S. Al Alshaykh[1], Daniel E. Leaird[1], Andrew M. Weiner[1]; [1]*Purdue Univ., USA.* We numerically investigate the effect of stimulated Raman scattering on parametric pumping of microring resonators. Furthermore, we re-derive the LLE for a generalized pump including a FSR mismatch term to determine the locking range.

JTu2A.113
Extremely Bright THz Radiation from Two-color Filamentation of Mid-infrared Laser Pulses, Vladimir Fedorov[1,2], Stylianos Tzortzakis[1,3]; [1]*Texas A & M Univ. at Qatar, Qatar;* [2]*P.N. Lebedev Physical Inst. of the Russian Academy of Sciences, Russia;* [3]*Inst. of Electronic Structure and Laser (IESL), Foundation for Research and Technology - Hellas (FORTH), Greece.* We show numerically that two-color filamentation of mid-infrared 3.9μm laser pulses allows one to generate THz pulses of multi-millijoule energies and extreme conversion efficiencies, with electric and magnetic fields of GV/cm and kT level, exceeding by far any available quasi-DC field source today.

JTu2A.114
Size Dependent Ultra-low Upconverted Lasing Threshold in $CsPbBr_3$ Perovskites Quantum Dots, Gabriel Nagamine[1], Jaqueline O. Rocha[1], Luíz G. Bonato[1], Ana Flávia Nogueira[1], Carlos Henrique B. Cruz[1], Lazaro Padilha[1]; [1]*Universidade Estadual de Campinas, Brazil.* We report on the size dependent of up-converted lasing threshold for $CsPbBr_3$ perovskite quantum dots, excited via two-photon absorption, showing threshold as low as 1.6 mJ/cm^2 under femtosecond excitation.

JTu2A.115
Negative Irradiance-Dependent Nonlinear Refraction in Single-Layer Graphene, Giorgos Demetriou[2,1], Ajoy K. Kar[2], Fabio Biancalana[2], Eitan Abraham[3], Wei Ji[4], Yu Wang[5]; [1]*Inst. of Photonics, Strathclyde Univ., UK;* [2]*Inst. of Photonics and Quantum Sciences, School of Engineering and Physical Sciences, Heriot-Watt Univ., UK;* [3]*Inst. of Biological Chemistry, Biophysics and Bioengineering, School of Engineering and Physical Sciences, Heriot-Watt Univ., UK;* [4]*Dept. of Physics, National Univ. of Singapore, Singapore;* [5]*State Key Lab of Multiphase Complex Systems, Inst. of Process Engineering, Chinese Academy of Sciences, China.* We show that single-layer graphene presents negative irradiance-dependent nonlinear refraction. We discriminate between a low-irradiance regime, where the conventional Kerr effect applies and a high-irradiance regime where the nonlinear refraction becomes irradiance-dependent.

11:30–13:00 JTu2A • Poster Session I

JTu2A.116
THz Pulse Generation from CSP and ZGP by Tilted Pulse Front Scheme, Wenchao Qiao[1], Huseyin Cankaya[1], Anthony Hartin[1], Peter G. Schunemann[2], Kevin Zawilski[2], Nicholas H. Matlis[1], Franz X. Kaertner[1]; *[1]DESY, Germany; [2]BAE System, USA.* We report single-cycle THz-pulse generation with a 2 µm laser in $CdSiP_2$ and $ZnGeP_2$ using the tilted-pulse-front scheme and compare with LiNbO3. Initial conversion efficiencies for both crystals are promising relative to $LiNbO_3$.

JTu2A.117
Experimental Investigation of All-optical Dynamic Photonic Bandgap Control in an All-solid Tellurite Photonic Bandgap Fiber, Tonglei Cheng[1], Shunta Tanaka[1], Takenobu Suzuki[1], Yasutake Ohishi[1]; *[1]ofmlab, Japan.* All-optical dynamic photonic bandgap control by optical Kerr effect is investigated in an all-solid double-clad tellurite photonic bandgap fiber. This is the first demonstration of all-optical dynamic PBG control in optical fibers.

JTu2A.118
Tunable Backward THz-Wave Parametric Oscillation Using a Periodically Poled Lithium Niobate, Kouji Nawata[1], Yu Tokizane[1], Yuma Takida[1], Hiroaki Minamide[1]; *[1]RIKEN, Japan.* We demonstrated tunable backward terahertz-wave parametric oscillation using a slant-stripe-type periodically poled lithium niobate with a poling period of 53 µm. A novel noncollinear phase-matching scheme, quasi-collinear phase-matching condition, produces the wide tunability.

JTu2A.119
Buffering optical topological data using passive Kerr resonators, Bruno Garbin[1], Julien Fatome[2], Yadong Wang[1], François Léo[3], Gian-Luca Oppo[4], Stuart G. Murdoch[1], Miro J. Erkintalo[1], Stephane Coen[1]; *[1]The Dodd-Walls Centre for Photonic and Quantum Technologies, Dept. of Physics, The Univ. of Auckland, New Zealand; [2]Laboratoire Interdisciplinaire Carnot de Bourgogne (ICB), UMR 6303 CNRS, Université de Bourgogne Franche-Comté, France; [3]OPERA-photonique, Université Libre de Bruxelles, Belgium; [4]SUPA and Dept. of Physics, Univ. of Strathclyde, UK.* We experimentally demonstrate the existence of dissipative polarization domain walls, in a normally dispersive Kerr resonator. Through deterministic manipulation of the laser driving the resonator, we achieve systematic excitation and locking of the domain walls.

JTu2A.120
Frequency Comb Generation in Crack-free CMOS Si-photonics Compatible Si_3N_4 Microresonator Chip, Ayman N. Kamel[1], Houssein El Dirani[2], Marco Casale[2], Sébastien Kerdiles[2], Carole Socquet-Clerc[2], Minhao Pu[1], Leif K. Oxenlowe[1], Kresten Yvind[1], Corrado SCIANCALEPORE[2]; *[1]Danmarks Tekniske Universitet, Denmark; [2]Univ. Grenoble Alpes, CEA-LETI Minatec, France.* We present frequency comb generation in crack- and annealing-free Si_3N_4 microresonator chips fabricated using novel CMOS Si-photonics compatible processing.

JTu2A.121
THz Emissions from Air-Plasmas Created by Mid- and Far-Infrared Two-Color Femtosecond Pulses, Alisee Nguyen[1], Luc Bergé[1], Pedro González de Alaiza Martínez[2], Illia Thiele[2], Stefan Skupin[3]; *[1]CEA, DAM, DIF, France; [2]Univ. Bordeaux - CNRS - CEA, Centre Lasers Intenses et Applications, UMR 5107, France; [3]Institut Lumière Matière, UMR 5306 Université Lyon 1 - CNRS, Université de Lyon, France.* We study THz emission by two-color femtosecond filaments in air using mid- to far-infrared pump wavelengths. 3D numerical simulations show that 10.6-µm laser pulses can produce THz fields with unequaled mJ energies and GV/m amplitudes.

JTu2A.122
Deterministic Single Soliton Formation and Manipulation in Anomalous Dispersion Microresonators via Parametric , Jinghao Wong[1], Minming Zhang[2], Deming Liu[1]; *[1]Huazhong Univ. of Science and Technology, China; [2]Huazhong Univ. of Science and Technology, China.* We propose a novel method for the deterministic transition from multiple solitons to a single soliton in anomalous dispersion microresonators via parametric seeding. Then the temporal position of the single soliton are flexibly manipulated.

JTu2A.123
Ten-Fold Enhancement in the Small Signal Modulation of Differentially Pumped Coupled Quantum Well Lasers, Yannis Kominis[1], Vassilios I. Kovanis[2], Tassos Bountis[3]; *[1]National Technical Univ. of Athens, Greece; [2]Physics, Nazarbayev Univ., Kazakhstan; [3]Mathematics, Nazarbayev Univ., Kazakhstan.* We unexpectedly found theoretically a 10-fold enhancement in the small signal modulation response of differentially pumped coupled quantum well lasers due to the existence of novel stable asymmetric phase-locked states under differential pumping.

JTu2A.124
Optical Meta-Molecules for Non-Hermitian Photonics, Yannis Kominis[1], Vassilios I. Kovanis[2], Tassos Bountis[3]; *[1]National Technical Univ. of Athens, Greece; [2]Physics, Nazarbayev Univ., Kazakhstan; [3]Mathematics, Nazarbayev Univ., Kazakhstan.* A photonic dimer consisting of two optically coupled lasers is dissected as an optical meta-molecule for non-Hermitian photonic applications. Spectral signatures of exceptional points and Hopf bifurcations are shown for generic asymmetric configurations.

JTu2A.125
Ultrafast Mid-infrared Non-Perturbative Nonlinear Optics in Polycrystalline Zinc Selenide, Kevin Werner[1], Noah Talisa[1], Brian Wilmer[2], Laura Vanderhoef[3], Aaron Schweinsberg[4], Christopher Wolfe[3], Anthony Valenzuela[3], Enam Chowdhury[1]; *[1]Dept. of Physics, The Ohio State Univ., USA; [2]SURVICE Engineering, USA; [3]Weapons and Materials Research Directorate, U.S. Army Research Lab, USA; [4]Oak Ridge Inst. For Science and Education, USA.* Strong-field MIR laser-solid interactions have recently generated great interest. Harmonic continuum was generated in ZnSe with MIR pulses. Power scaling of the harmonics was non-perturbative with conversion efficiency as high as 26%.

JTu2A.126
Near-infrared to Mid-infrared wavelength conversion by chalcogenide suspended-core fiber, Kenshiro Nagasaka[1], Tong Hoang Tuan[1], Nguyen Phuoc Trung Hoa[1], Morio Matsumoto[2], Shigeki Cho[2], Takenobu Suzuki[1], Yasutake Ohishi[1]; *[1]Research Center for Advanced Photon Technology, Toyota Technological Inst., Japan; [2]Furukawa Denshi Co., Ltd., Japan.* We experimentally demonstrated mid-infrared wavelength conversion using a chalcogenide suspended-core fiber pumped with a pico-second pulse.

JTu2A.127
Highly Coherent Mid-Infrared Supercontinuum Spanning From 1.8-10 µm Pumped By A 2-µm Laser, Hoa P. Nguyen[1], Kenshiro Nagasaka[1], Hoang Tuan Tong[1], Takenobu Suzuki[1], Yasutake Ohishi[1]; *[1]Toyota Technological Inst., Japan.* We simulated a 2-step supercontinuum generation with tellurite and chalcogenide fibers pumped by a 2 µm femto second laser. The output SC expands from 1.8 to 10 µm with coherence of unity all over the spectrum.

JTu2A.128
Four-Wave Mixing in a Silicon Self-Pumped Ring Resonator., Micol Previde Massara[1], Federico Sabattoli[1], Matteo Galli[1], Daniele Bajoni[2]; *[1]Dept. of Physics, Univ. of Pavia, Italy; [2]Dipartimento di Ingegneria Industriale e dell'Informazione, Univ. of Pavia, Italy.* We report on four-wave mixing in a silicon micro-ring resonator using a self-pumping scheme instead of an external laser. We study the correlation of the emitted photons.

JTu2A.129
Consideration on a mechanism of pure circular polarization electroluminescence in a lateral spin-LED, Hiro Munekata[1], Nozomi Nishizawa[1]; *[1]Tokyo Inst. of Technology, Japan.*
A mechanism that the spin axis of minority-spin electrons is converted into majority spin axis with a relatively strong CP light field in the event of radiative recombination in an active layer is addressed.

JTu2A.130
Epsilon Near-Zero Nonlinear Optical Measurements of Titanium Nitride Thin Films, Manuel R. Ferdinandus[1,2], Jamie Gengler[2], Nathaniel Kinsey[3], Augustine Urbas[2]; *[1]Air Force Inst. of Technology, USA; [2]Air Force Research Lab, USA; [3]Virginia Commonwealth Univ., USA.* Using the optical beam deflection method we measure the transient optical nonlinearity of titanium nitride thin films deposited at 350° and 800° C around their respective epsilon near-zero wavelengths.

JTu2A.131
Engineered quasi-phase matching for conversion efficiency optimization of coupled $X^{(2)}$ processes, Cheng-Wei Hsu[1], Jui-Yu Lai[1], Shang-Da Yang[1]; *[1]National Tsing Hua Univ., Taiwan.* We propose an algorithm to optimize the efficiency of coupled $X^{(2)}$ processes in an aperiodic optical superlattice, achieving record high efficiency of frequency tripling. Feasibility is confirmed by controlled experiment with three different design methods.

JTu2A.132
Sub-Cycle Light Bullets in the Long-Wavelength Infrared, Rostislav Grynko[1], Garima Nagar[1], Bonggu Shim[1]; *[1]Binghamton Univ., USA.* Carrier-resolved unidirectional pulse propagation equations are used to model mid- and long-wavelength infrared laser filamentation in ZnSe, revealing a novel propagation regime where sub-cycle light bullets propagate stably with a critical dependence on plasma.

JTu2A.133
Second Harmonic Generation from UV to Visible in KDP Single-crystalline Fibers, Kam Sing . Wong[1]; *[1]Hong Kong Univ of Science & Technology, Hong Kong.* Second harmonic generation (SHG) from UV to visible in KDP single-crystal fiber without the need of angle or temperature tuning is demonstrated. This wide SHG tunability is attributed to the unique automatic 'quasi-random' phase matching.

JTu2A.134
Non-Resonant Enhancement of Second-harmonic Generation from Metal Nanoislands Coated with Dielectric Layers, Kalle O. Koskinen[1], Sergey Scherbak[2,3], Semyon Chervinskii[2,4], Andrey Lipovskii[2,3], Martti Kauranen[1]; *[1]Lab of Photonics, Tampere Univ. of Technology, Finland; [2]Inst. of Physics, Nanotechnology and Telecommunication, Peter the Great St. Petersburg Polytechnic Univ., Russia; [3]Dept. of Physics and Technology of Nanostructures, St. Petersburg Academic Univ., Russia; [4]Inst. of Photonics, Univ. of Eastern Finland, Finland.* Second-harmonic generation from gold nanoisland films increases with the dielectric TiO_2 coating thickness. This occurs although the plasmon resonance shifts away from the second-harmonic wavelength, due to enhanced non-resonant local fields at the fundamental wavelength.

11:30–13:00 JTu2A • Poster Session I

JTu2A.135
Detection of Orbital Angular Momentum Superposition States in Optical Vortices, Mariia Shutova[1], Alexandra A. Zhdanova[1], Alexei V. Sokolov[1]; *[1]Inst. for Quantum Science and Engineering, Dept. of Physics and Astronomy, Texas A&M Univ., USA.* Orbital angular momentum (OAM) transfer through nonlinear processes such as coherent Raman generation often distorts the original spatial mode of light, resulting in OAM superposition states. We characterize such modes and quantify their distortion by astigmatic focusing of the laser beam.

JTu2A.136
Second Harmonic Radiation from Rectangular Gold Antenna: Far-field Contributions of Different Nonlinear Polarizations, Kyungwan Yoo[1], Simon F. Becker[2], Martin Silies[2], Sunkyu Yu[1], Christoph Lienau[2], Namkyoo Park[1]; *[1]Seoul National Univ., South Korea; [2]Carl von Ossietzky Universität, Germany.* We investigate the second harmonic generation from rectangular gold antenna. By comparing measurement and hydrodynamic model based calculation, we show different contributions of each nonlinear polarization to second harmonic radiation.

JTu2A.137
Anomalous Trapping of Temporal Cavity Solitons by Amplitude Modulated Driving Fields, Ian Hendry[1], Wei Chen[1,2], Yadong Wang[1], Julien Javaloyes[3], Gian-Luca Oppo[4], Stephane Coen[1], Stuart Murdoch[1], Miro J. Erkintalo[1]; *[1]Univ. of Auckland, New Zealand; [2]National Univ. of Defense Technology, China; [3]Univ. of the Balearic Islands, Spain; [4]Univ. of Strathclyde, UK.* We report a systematic study of cavity soliton motion in the presence of amplitude modulated driving fields. We show that, contrary to conventional wisdom, cavity solitons are trapped to particular values of the driving field.

JTu2A.138
Design of a GaInP/AlGaInP electrically-driven photon-pair source near 1.3-micrometer wavelengths, Xiaoya Xie[1], Xiaoming Chi[1], Kaiyu Cui[2], Xiaolong Hu[1]; *[1]Tianjin Univ., China; [2]Electronic Engineering, Tsinghua Univ., China.* We present our design of an electrically-driven device based on a GaInP/AlGaInP quantum well and a Bragg-reflection waveguide to generate photon pairs near 1.3-micrometer wavelengths through internal spontaneous parametric down-conversion.

JTu2A.139
Enhanced Free-space Coupling to Whispering-gallery-mode Resonators by Accelerating Beams, Xu Liu[1], yi hu[1], Fang Bo[1], Zhenzhong Hao[1], Zhigang Chen[1], Jingjun Xu[1]; *[1]The MOE Key Lab of Weak-Light Nonlinear Photonics, TEDA Applied Physics Inst. and School of Physics, Nankai Univ., China.* We propose free-space coupling to whispering-gallery-mode resonators via accelerating beams propagating along a semi-circle, and demonstrate nearly three-fold enhancement in coupling efficiency as compared with conventional Gaussian beams.

JTu2A.140
Towards the Manipulation of Relativistic Laguerre-Gaussian Laser Pulse, Cheonha Jeon[1], Seong Geun Lee[1,2], Hwang Woon Lee[1], Jae Hee Sung[1,3], Seong Ku Lee[1,3], Il Woo Choi[1,3], Chang Hee Nam[1,2]; *[1]Center for Relativistic Laser Science, Inst. for Basic Science, South Korea; [2]Dept. of Physics and Photon Science, Gwangju Inst. of Science and Technology, South Korea; [3]Advanced Photonics Research Inst., Gwangju Inst. of Science and Technology, South Korea.* The effect of Laguerre-Gaussian beam compare to Gaussian beam on the characteristics of laser driven proton beams is presented using 150 TW beam. The LG beam experiment with the 4 PW laser is being conducted.

JTu2A.141
Collapsing dynamics of elliptic-symmetry vector optical fields with hybrid states of polarization, Dan Wang[1], Yue Pan[1], Jiaqi Lyu[1], PingPing Li[1], GuiGeng Liu[1], MengQiang Cai[1], YongNan Li[1], ChengHou Tu[1], HuiTian Wang[1,2]; *[1]Nankai Univ., China; [2]NanjingUniv., China.* The eccentricity of the spatial polarization distribution provides a new degree of freedom to achieve the controllable collapse. The coupling between the intensity and polarization affects the nonlinear dynamic properties of the structured optical fields.

JTu2A.142
Simultaneous generation of 1D and 2D Airy beams and their frequency doubling characteristics, Raghwinder S. Grewal[1], Anirban Ghosh[1], Goutam K. Samanta[1]; *[1]Physical Research Lab, India.* We report on simultaneous generation of high power, 1D and 2D Airy beam using a pair of concave and convex cylindrical lenses in a novel experimental scheme and studied their frequency doubling characteristics.

JTu2A.143
Coherent Mid-infrared Supercontinuum Generation using Rib Waveguide Pumped with Femtosecond Laser, Than Singh Saini[1], Nguyen Phuoc Trung Hoa[1], Kenshiro Nagasaka[1], Xing Luo[1], Tong Hoang Tuan[1], Takenobu Suzuki[1], Yasutake Ohishi[1]; *[1]Research Center for Advanced Photon Technology, Toyota Technological Inst., Japan.* Coherent mid-infrared supercontinuum spectrum spanning 1.2 to 7.2 μm has been reported using an As_2Se_3-chalcogenide rib waveguide pumped with 200 fs laser pulses of a moderately low peak power of 2.5 kW at 2.8 μm.

JTu2A.144
Electromagnenic Ghost Waves., Evgenii E. Narimanov[1]; *[1]Purdue Univ., USA.* Anisotropic dielectrics support ghost waves that combine properties of propagating and evanescent fields. Similarly to negative index media, these modes can grow exponentially through the transparent anisotropic material, leading to dramatic enhancement of local intensity.

JTu2A.145
Light-Actuated Electrohydrodynamics in Plasmonic Nanofluids, Luat Vuong[1,2], James McQuade[1], Vera Zarubin[1], Heriberto Vasquez[1]; *[1]Queens College of CUNY, USA; [2]Graduate Center, CUNY, USA.* The light-actuated electrohydrodynamics in plasmonic nanofluids represent harvestable exergy in an open system. Here we demonstrate thermoelectric responses and analyze the energy conversion. Future efforts will require scrutiny of the negative-Soret-coefficient thermophoretic dynamics.

JTu2A.146
Quantum Spectroscopy with Extreme Nonlinear Effects, Benjamin J. Girodias[1], Mackillo Kira[1]; *[1]Univ. of Michigan, USA.* We present a new method to study extreme nonlinearities with quantum spectroscopy. Our spectroscopy approach increases the sensitivity to detect nonlinearities by an order of magnitude while remaining robust against experimental noise.

JTu2A.147
Ultra-efficient and stable EO dendrimers containing supramolecular homodimers of dipolar semifluorinated aromatics, JieYun Wu[1], Bo Wu[1], Wen Wang[1], Kin S. Chiang[1,2], Alex K. Jen[3], Jingdong Luo[3]; *[1]Univ of Science and Tech of China, China; [2]electronic engineering, City Univ. of Hong Kong, Hong Kong; [3]Chemistry, City Univ. of Hong Kong, Hong Kong.* We demonstrated the supramolecular homodimerization of semifluorinated dipolar aromatics to self-assemble electro-optic dendrimers. The self-assembled dendritic films showed large electro-optic coefficients (248 pm/V) and excellent temporal stability (>95%) after 1000 h.

JTu2A.148
Precision generation and control of dissipative Kerr solitons with suppressed cavity thermal disturbance, Yong Geng[1], Wenwen Cui[1], Yun Ling[1], Baojian Wu[1], Kun Qiu[1], Chee-Wei Wong[2], Heng Zhou[1]; *[1]Univ. of Electronic Science and Technology of China, China; [2]Univ. of California, Los Angeles, USA.* Dissipative Kerr soliton formation with unprecedented detuning control precision is demonstrated using an auxiliary-laser-heating method to suppress cavity thermal disturbance. New existence region of dissipative Kerr soliton in low pump power regime is originally discovered.

JTu2A.149
Resonance-enhanced nonlinear optical effects in strong-field ionized nitrogen molecules, Jinping Yao[1], Wei Chu[1], Zhaoxiang Liu[1], Bo Xu[1], Jinming Chen[1], Ya Cheng[1,2]; *[1]State Key Lab of High Field Laser Physics, Shanghai Inst. of Optics and Fine Mechanics, Chinese Academy of Sciences, China; [2]State Key Lab of Precision Spectroscopy, East China Normal Univ., China.* We report on lasing actions and extraordinary supercontinuum generation in strong-field ionized nitrogen molecules. It was revealed that these unexpected emissions result from a series resonant nonlinear optical processes in molecular ions.

JTu2A.150
Spatio-Spectral Structures in High Harmonic Generation Driven by a High Repetition Rate OPCPA at 1.55 μm, Gaëtan Jargot[1,6], Aura Gonzalez[2], Philippe Rigaud[1], Antoine Comby[3], Olivier Sublemontier[4], Michel Bougeard[5], Thierry Ruchon[5], Marc Hanna[1], Patrick Georges[1]; *[1]Institut d'Optique, Laboratoire Charles Fabry, France; [2]Amplitude Laser Group, France; [3]CELIA, France; [4]NIMBE, CEA, France; [5]CEA, LIDyL, France; [6]Fastlite, France.* We investigate the spatio-spectral properties of high-harmonic generation driven by an optical parametric chirped pulse amplifier at 1.55 μm wavelength operating at 125 kHz. Ring-like structures are observed and explained by the transverse atomic-induced phase.

JTu2A.151
Progress towards a high acquisition rate attosecond pump-probe beamline, Federico J. Furch[1], Tobias Witting[1], Felix Schell[1], Dominik Hoff[2], Chih-Hsuan Lu[3,4], Peter Šušnjar[1], Fabio Cavalcante[5], Carmen Menoni[5], Claus P. Schulz[1], Gerhard G. Paulus[2], A. H. Kung[3,4], Marc J. Vrakking[1]; *[1]Max Born Inst., Germany; [2]Helmholtz-Institut Jena Institut für Optik und Quantenelektronik, Friedrich-Schiller-Universtiät, Germany; [3]National Tsin Hua Univ., Taiwan; [4]Inst. of Atomic and Molecular Sciences, Academia Sinica, Taiwan; [5]Dept. of Electrical and Computer Engineering, Colorado State Univ., USA.* The development of an attosecond pump-probe beamline based on a 100 kHz laser system is presented. Results on high harmonic generation, pulse shortening towards the single-cycle limit and single-shot carrier-envelope phase characterization are discussed.

JTu2A.152
Circularly Polarized High Harmonic Generation from Chiral Molecules, Yoichi Harada[1], Eisuke Haraguchi[1], Keisuke Kaneshima[1], Taro Sekikawa[1]; *[1]Hokkaido Univ., Japan.* Circularly polarized high harmonic generation from a chiral molecule was found to depend both on the chirality and on the rotating direction of the circularly polarized counter-rotating two-color driving laser fields.

JTu2A.153
Time-resolved ARPES Based on 8-fs High-harmonic Source in the Extreme Ultraviolet Region, Kento Toume[1,2], Katsuya Oguri[1], Hiroki Mashiko[1], Keiko Kato[1], Yoshiaki Sekine[1], Hiroki Hibino[3], Akira Suda[2], hideki gotoh[1]; *[1]NTT Basic Research Labs, NTT Corporation, Japan; [2]Faculty of Science and Technology, Tokyo Univ. of Science, Japan; [3]School of Science and Technology, Kwansei Gakuin Univ., Japan.* We demonstrate time-resolved ARPES based on the 27th harmonic pulse with sub-10-fs duration. The measurement for the initial stage of carrier photoexcitation near the Dirac point of graphite confirms duration of 8 fs.

11:30–13:00 JTu2A • Poster Session I

JTu2A.154
Reconstructing band structure of a crystalline solid from drive-laser-intensity dependence of a single harmonic produced by intraband current, Peiyu Xia[1], Faming Lu[1], Teruto Kanai[1], Nobuhisa Ishii[1], Jiro Itatani[1]; *[1]Inst. for Solid State Physics, The Univ. of Tokyo, Japan.* We propose and numerically simulate all-optical reconstruction of band structure from drive-laser–intensity dependence of a single harmonic produced from crystalline solids. This method assumes that a low-order harmonic is mainly produced by intraband current.

JTu2A.155
Energy scaling of soft-x-ray high harmonics driven by a loosely-focused TW-scale mid-infrared pulse, Kataro Nishimura[1,2], Yuxi Fu[2], Akira Suda[1], Katsumi Midorikawa[2], Eiji J. Takahashi[2]; *[1]Tokyo Univ. of Science, Japan; [2]RIKEN Center for Advanced Photonics, Japan.* We establish an energy-scaling strategy of high-order harmonic driven by a loosely focused mid-infrared pulse. Using a 4-cm Ne gas cell with a 3.5-m laser focusing length, soft x-ray harmonics beyond 200 eV are clearly enhanced by phase-matching effect.

JTu2A.156
High-order Harmonic Generation in Femtosecond laser-Micromachined Devices, Anna Gabriella Ciriolo[1], Rebeca Martinez Vazquez[1], Gabriele Crippa[1], Davide Faccialà[1], Matteo Negro[1], Michele Devetta[1], Diogo Pereira Lopes[1], Aditya Pusala[1], Caterina Vozzi[1], Roberto Osellame[1], Salvatore Stagira[1]; *[1]Dipartimento di Fisica, Politecnico di Milano, IFN-CNR, Italy.* We demonstrate the generation of high-order harmonics in a fused-silica chip produced by femtosecond laser micromachining. This achievement paves the way for the miniaturization of HHG applications from large-scale Labs to microstructures.

JTu2A.157
A Time-preserving Ultra-narrow-bandwidth Multilayer-mirror Monochromator for Extreme Ultraviolet Pulses, Yudong Yang[1,2], Julia Hengster[3,4], Tanja Neumann[3,4], Roland E. Mainz[1,3], Oliver Muecke[1,2], Franz X. Kaertner[1,3], Thorsten Uphues[3,4]; *[1]Center for Free-Electron Laser Science CFEL, Deutsches Elektronen-Synchrotron DESY, Germany; [2]The Hamburg Centre for Ultrafast Imaging CUI, Univ. of Hamburg, Germany; [3]Dept. of Physics, Univ. of Hamburg, Germany; [4]Center for Free-Electron Laser Science CFEL, Universität Hamburg, Germany.* We present a multilayer-mirror-based monochromator providing ultra-narrow bandwidth and compact footprint for easy integration into HHG-based or FEL sources. The bandwidth ($\Delta E<0.5eV$, $E_c=\sim 91eV$) of the monochromator is characterized experimentally in a HHG-based source.

JTu2A.158
Generation of Few-Cycle UV pulses Synchronized with Attosecond XUV Pulses, Vincent Wanie[2,1], Mara Galli[3,1], Erik Månsson[4,1], Mattea C. Castrovilli[5,1], François Légaré[2], Fabio Frassetto[6], Luca Poletto[6], Mauro Nisoli[3,1], Francesca Calegari[4,1]; *[1]Inst. for Photonics and Nanotechnologies CNR-IFN, Italy; [2]Institut National de la Recherche Scientifique, Canada; [3]Dept. of Physics, Politecnico di Milano, Italy; [4]Center for Free-Electron Laser Science, DESY, Germany; [5]Inst. for the Structure of Matter CNR-ISM, Italy; [6]Inst. for Photonics and Nanotechnologies CNR-IFN, Italy.* Few-femtosecond UV and isolated attosecond pulses were implemented into a Mach-Zender like interferometer. The ultraviolet light is obtained via frequency up-conversion of few-optical-cycle NIR pulses in a gas medium to achieve an optimal temporal resolution.

JTu2A.159
Scaling and Spectral Structure of Relativistic High-Order-Harmonic Generation, Matthew Edwards[1], Julia Mikhailova[1]; *[1]Princeton Univ., USA.* We develop scaling models for the behavior of relativistic high-order-harmonic generation, showing how the spectrum, attosecond pulse intensity, and the formation of secondary pulses depend on a simplified set of parameters.

JTu2A.160
THz Emission by Underdense Relativistic Plasma, Jeremy Dechard[1], Arnaud Debayle[1], Xavier Davoine[1], Laurent Gremillet[1], Luc Bergé[1]; *[1]CEA-DAM, DIF, France.* Terahertz emissions by gas-based relativistic plasmas created by two-color laser pulses are investigated. PIC simulations reveal that coherent transition radiation driven by wakefield-accelerated electrons is the dominant process, compared to photocurrents, and they yield unprecedented THz energies.

JTu2A.161
Investigation of the waveguide generated by UV filamentation, Ali Rastegari[1], Chengyong Feng[1,2], Jean-Claude M. Diels[1]; *[1]UNM, USA; [2]Lab for Laser Energetics, Univ. of Rochester, USA.* The waveguides generated by UV filaments in different focusing schemes have been investigated using the shadowgraphy technique. It was observed that these waveguides have a transverse width of the order of 400mm.

JTu2A.162
MEMS-Based Fast Tunable Laser, Alvaro Jimenez Galindo[2,1], Sebastian Schmidtmann[1], Herve Tatenguem Fankem[1], Tobias Milde[1], Christian Aßmann[1], Guillermo Carpintero del Barrio[2], Joachim Sacher[1]; *[1]Sacher Lasertechnik GmbH, Germany; [2]Electronic Technology, Universidad Carlos III de Madrid, Spain.* MEMS-based tunable diode lasers inherit the benefits of conventional ECDLs while improving the tuning speed. These lasers are here presented with an example and measurements are shown of the spectral characterization of these devices together with switching speed and stability experimental results.

JTu2A.163
A high energy sapphire-cooled multi-slab Nd:glass amplifier, Wenfa Huang[1], Tingrui Huang[1], Jiangfeng Wang[1], Xinghua Lu[1], Dajie Huang[1], Wei Fan[1], Xuechun Li[1]; *[1]SIOM, China.* We present amplification results for a sapphire-cooled multi-slab Nd:glass amplifier, an output energy of 562 mJ at 1 Hz with energy stability of 0.39% RMS was achieved.

JTu2A.164
210 W kHz-linewidth linearly-polarized all-fiber single-frequency MOPA laser, Changsheng Yang[1], Xianchao Guan[1], Shanhui Xu[1], Zhongmin Yang[1]; *[1]South China Univ. of Technology, China.* An all-fiber high-power kHz-linewidth linearly-polarized Yb^{3+}-doped single-frequency MOPA laser is experimentally demonstrated with a stable CW output power of >210 W and a laser linewidth of <9 kHz.

JTu2A.165
Dual-Pulse Passively Q-switched Microchip Laser for Two-Color Tandem THz-Wave Pulse Generation, Toshiyuki Ikeo[1], Yuma Takida[2], Kouji Nawata[2], Yasuhiro Higashi[1], Hiroaki Minamide[2]; *[1]Ricoh Company, LTD, Japan; [2]RIKEN, Japan.* Two-color, tandem THz-wave pulses are generated from an injection-seeded THz-wave parametric generator driven by a dual-pulse passively Q-switched microchip laser whose center frequency difference is 11 GHz within a single excitation cycle.

JTu2A.166
High Energy Pulse Compression by a Solid Medium, Seong Ku Lee[1,2], Je Yoon Yoo[1], Ji In Kim[1,3], Yeong Gyu kim[1,3], Jin Woo Yoon[1,2], Hwang Woon Lee[1], Jae Hee Sung[1,2], Chang Hee Nam[1,3]; *[1]CoREeLS IBS-GIST, South Korea; [2]APRI, GIST, South Korea; [3]Dept. of Physics and Photon Science, GIST, South Korea.* A high energy pulse with the energy of 3.5 J was spectrally broadened by a supercontinuum generation and it was recompressed from 31 fs to 14.5 fs by the dispersion compensation.

JTu2A.167
Bound States of Solitons in a Spatiotemporal Mode-locked Multimode Fiber Laser, Huaqiang Qin[1], Xiaosheng Xiao[1], Pan Wang[1]; *[1]Tsinghua Univ., China.* We report on experimental observation of bound states of solitons in a spatiotemporal mode-locked multimode fiber laser.

JTu2A.168
Multi-mJ, high efficiency, picosecond deep ultraviolet source, Pierre Sevillano[1], Jean-Gabriel Brisset[1], Magali Durand[1], Benoit Tropheme[1], Antoine Courjaud[1]; *[1]Amplitude systemes, France.* We report a 4.1 mJ, 100 Hz, ~1.7 ps DUV laser at 257.5 nm from a frequency-quadrupled Yb-YAG chirped-pulse amplifier. An infrared-to-DUV conversion efficiency of ~20% is achieved with a good beam quality.

JTu2A.169
Laser performance of RE^{3+}:YAG Double-Clad Crystalline Fiber Waveguides, Da Li[1], Huai-chuan Lee[1], Stephanie K. Meissner[1], Helmuth E. Meissner[1]; *[1]Onyx Optics, Inc, USA.* We report on laser performance and modeling of Yb:YAG and Tm:YAG double-clad crystalline fiber waveguide for high power applications, with 53.6% slope efficiency and 27.5-W output for Yb:YAG, and 31.6% and 46.7-W for Tm:YAG.

JTu2A.170
Development of an Auxiliary OPCPA Beamline for the Vulcan PW Laser Facility., Ian O. Musgrave[1], Alexis Boyle[1], Robert Clarke[1], John Collier[1], Marco Galimberti[1], Cristina Hernandez-Gomez[1], Pedro Oliviera[1], Waseem Shaikh[1], Adam Wyatt[1]; *[1]Science & Technology Facilities Council, UK.* In this paper we present our plans for an auxiliary OPCPA beamline for the Vulcan PW laser facility. It will be capable of delivering 30J <30fs in combination with the existing beams.

JTu2A.171
Wavefront Degradation of a 200 TW Laser from Heat-Induced Deformation of In-Vacuum Compressor Gratings, Vincent Leroux[1,2], Spencer Jolly[1,2], Matthias Schnepp[1], Timo Eichner[1], Sören Jalas[1], Manuel Kirchen[1], Philipp Messner[1], Christian Werle[1], Paul Winkler[1], Andreas R. Maier[1]; *[1]Center for Free-Electron Laser Science, Germany; [2]Institue of Physics of the ASCR, ELI-Beamlines project, Czechia.* We report laser wavefront degradation of a 200 TW laser from heat absorbed by the in-vacuum compressor gratings, while scanning laser energy and rep-rate. Laser induced damages are investigated.

JTu2A.172
Q-switched optical vortex pulses generated by the coherent superposition of off-axis modes in an azimuthal symmetry breaking laser resonator, YuanYao Lin[1]; *[1]National Sun Yat-Sen Univ., Taiwan.* Optical vortex pulse trains are generated by the superposition of coherently phase-locked off-axis laser beamlets resonating independently in an unconventional azimuthal symmetry breaking optical resonator bumped by conventional diode laser without critical beam shaping.

JTu2A.173
Radially polarized and wavelength switchable mode locking Yb-doped fiber laser, Fan Shi[1], Yiping Huang[1], Teng Wang[1], Fufei Pang[1], Tingyun Wang[1], Xianglong Zeng[1]; *[1]Shanghai Univ., China.* We experimentally demonstrated the generation of radially polarized and wavelength switchable mode locking pulse at a 1 mm spectral region by using a broadband few mode coupler in a Nonlinear Polarization Rotation fiber ring cavity.

11:30–13:00 JTu2A • Poster Session I

JTu2A.174
Carbon Nanoparticles as an Optical Modulator for Passively Q-switched Fiber Laser, Huizi Li[1], Jie Ma[1], Mengying Zhang[1], Jun Wang[1], Dingyuan Tang[1], Seongwoo Yoo[1]; [1]*Nanyang Technological Univ., Singapore*. We present the first demonstration of carbon nanoparticles (CNP) as an optical modulator to generate short laser pulses. An ytterbium-doped fiber ring cavity is successfully Q-switched with CNPs prepared in-house via a simple flame synthesis.

JTu2A.175
10 kHz, 10 ns, 13.4 mJ Burst-mode MOPA Nd:YAG Based Frequency-tripled Source at 355 nm, Wentao Wu[1], XuDong Li[1], Renpeng Yan[1], Deying Chen[1]; [1]*Harbin Inst. of Technology, China*. We demonstrated a Nd:YAG based Q-switched burst-mode MOPA laser with ultraviolet output by nonlinear harmonic generation. Single-pulse energy of 13.4 mJ at 355 nm, 10 kHz was obtained. The pulse width reached 10 ns.

JTu2A.176
Gaussian-shaped pulses oscillation of gain-switched Cr:ZnSe laser pumped with nanosecond pulses, Masaki Yumoto[1], Norihito Saito[1], Satoshi Wada[1]; [1]*RIKEN, Japan*. We demonstrated Gaussian-shaped pulses oscillation of gain-switched nanosecond Cr:ZnSe laser based on numerical and experimental research. The Gaussian-shaped pulses with pulse width of 56 ns were obtained without any Q-switch devices inside the laser cavity.

JTu2A.177
Extra-cavity amplification of the digital laser modes using Nd: YAG amplifier, Teboho Bell[1]; [1]*CSIR National Laser Centre, South Africa*. In this paper, we demonstrate experimentally how the laser output power of higher-order $LG_{p,l}$ modes generated from the digital laser is amplified by using an extra-cavity Nd: YAG amplifier. Amplification of 42% was realized.

JTu2A.178
Transverse Stimulated Raman Scattering Induced Large Aperture KDP Coating Damages of SG-II Facility, Shunxing Tang[1], Yajing Guo[1], Qing Jiang[1], Lin Yang[1], Baoqiang Zhu[1]; [1]*SIOM, China*. Coating damage of large aperture KDP crystal on SG-II laser facility is observed. A simulation model is setup, and it indicates that TSRS can induce energy lose and coating damage in large aperture KDP crystals.

11:30–13:30 Exhibit Hall Free Lunch

12:00–13:30 OIDA VIP Industry Leaders Speed Meetings Lunch, *Exhibit Hall, #2605*

12:00–15:00 SC352: Introduction to Ultrafast Pulse Shaping--Principles and Applications
SC376: Plasmonics
SC410: Finite Element Modeling Methods for Photonics and Optics

12:00–16:00 SC270: High Power Fiber Lasers and Amplifiers
SC438: Photonic Metamaterials

CLEO: Science & Innovations

13:00–15:00
STu3A • Quantum Photonic Technology
Presider: Jonathan Matthews; University of Bristol UK

STu3A.1 • 13:00 Invited

Scaling Quantum Photonic Technologies, Mark G. Thompson[1]; [1]*Quantum Engineering Technology Labs, H. H. Wills Physics Lab & Dept. of Electrical and Electronic Engineering, Univ. of Bristol, UK*. Silicon Quantum Photonics has emerged as a promising approach to realizing complex large-scale quantum photonic circuits. Here we overview recent developments presenting circuits comprising hundreds of photonic components integrated into single coherent quantum systems.

STu3A.2 • 13:30 Invited

Multi-photon Quantum Boson-sampling Machines, Chaoyang Lu[1]; [1]*Univ of Science and Technology of China, China*. We develop single-photon sources that simultaneously combines high purity, efficiency, and indistinguishability. We demonstrate entanglement among ten single photons. We construct high-performance multi-photon boson sampling machines to race against classical computers to reach the goal of quantum computational supremacy.

13:00–15:00
STu3B • OAM and Photodetective
Presider: Richard Penty; Univ. of Cambridge, UK

STu3B.1 • 13:00 Tutorial

Advances in Components and Integrated Devices for OAM-Based Systems, Alan E. Willner[1]; [1]*Univ. of Southern California, USA*. This tutorial will highlight various types of compact components that might be important for future deployment of optical systems based on beams carrying orbital-angular-momentum. Such elements may include: generators, (de) multiplexers, detectors, filters, and fibers.

Alan Willner is the Sample Chair at USC. He received: Member US National Academy of Eng., Int'l Fellow UK Royal Academy of Eng., IEEE Eric Sumner Award, NSF Presidential Faculty Fellows Award from White House, IET JJ Thomson Medal, Packard Foundation Fellowship, OSA Forman Eng. Excellence Award, and SPIE President's Award. He was co-chair National Academies' Committee on Optics and Photonics; president OSA; president IEEE Photonics Society; and CLEO general co-chair.

13:00–15:00
STu3C • Advanced Short Reach and Free Space Communications
Presider: David Geisler; Massachusetts Inst of Tech Lincoln Lab, USA

STu3C.1 • 13:00

50 Gb/s Transmission over Uncompensated Link up to 20 km Exploiting DSP-Free Direct-Detection, Francesco Fresi[1,2], Mohamed Morsy-Osman[3], Enrico Forestieri[1,2], Marco Secondini[1,2], Fabio Cavaliere[4], David V. Plant[3], Stephane Lessard[5], Luca Poti[2]; [1]*TeCIP Inst., Scuola Sant'Anna, Italy;* [2]*PNTLab, CNIT, Italy;* [3]*Photonics System Group, Electrical and Computer Engineering Dept., McGill Univ., Canada;* [4]*Ericsson, Italy;* [5]*Ericsson Canada, Canada*. We experimentally transmit 50Gb/s over 20km uncompensated SMF with a conventional DSP-free OOK direct detection receiver, exploiting combined amplitude phase shift codes. A simplified implementation based on analog electronics is also validated at 50Gb/s.

STu3C.2 • 13:15

Carrier Regeneration Assisted Kramers-Kronig Detection of an Independent Sideband Signal, Qiulin Zhang[1], Chester Shu[1]; [1]*Chinese Univ. of Hong Kong, Hong Kong*. We experimentally demonstrate Kramers-Kronig detection of an independent sideband (ISB) signal by Brillouin amplifying a weak pilot tone at the receiver side. A 30Gbit/s ISB signal with mixed modulation formats is successfully transmitted over 80 km.

STu3C.3 • 13:30 Invited

The Kramers--Kronig Receiver: a Coherent Receiver Based on Intensity Detection and Phase Recovery, Antonio Mecozzi[1], Cristian Antonelli[1], Mark Shtaif[2]; [1]*Univ. of L'Aquila, Italy;* [2]*School of Electrical Engineering, Tel Aviv Univ., Israel*. We review the operation principles and the various implementations of the Kramers--Kronig receiver. We will show that this receiver permits to extract the full complex envelope of the optical field by simple intensity detection.

CLEO: Science & Innovations

13:00–15:00
STu3D • Terahertz Communications
Presider: Tyler Cocker; Universität Regensburg, Germany

STu3D.1 • 13:00 Tutorial

100s Gigabit/s THz Communication, Leif K. Oxenlowe[1], Michael Galili[1], Darko Zibar[1], Toshio Morioka[1], Hao Hu[1], Francesco Da Ros[1], Pengyu Guan[1], Shi Jia[1], Xiaodan Pang[2], Oskars Ozolins[2], Xianbin Yu[3], Gunnar Jacobsen[2], Sergei Popov[4]; [1]*DTU Fotonik, Denmark;* [2]*ACREO RISE, Sweden;* [3]*College of Information Science and EE, Zhejiang Univ., China;* [4]*KTH, Sweden*. This paper gives an overview of recent progress on the topic of using around 0.4 THz carriers for communications. Experimental demonstrations will be described, and concepts and pros&cons of various system-platforms discussed.

Leif Katsuo Oxenløwe, Ph.D. 2002 from DTU, is Professor of Photonic Communication Technologies, group leader of the High-Speed Optical Communications group at DTU Fotonik, and Centre Leader of the DNRF Centre of Excellence SPOC. He has authored or co-authored more than 350 peer reviewed publications.

CLEO: QELS-Fundamental Science

13:00–15:00
FTu3E • Thermal and Quantum Applications of Metasurfaces
Presider: Zubin Jacob; Purdue Univ., USA

FTu3E.1 • 13:00 Invited

Metafilms for Large Scale Thermal Management, Xiaobo Yin[1]; [1]*Univ. of Colorado Boulder, USA*. Scalably procued optical metamaterial thin films could enable advance applications including passive radiative cooling. We will discuss the advancement in radiative cooling metafilms and other applications of metafilms in food-energy-water system (FEWS).

FTu3E.2 • 13:30

Near-field Thermo-photovoltaic Platform, Gaurang Bhatt[1], Samantha Roberts[1], Raphael St-Gelais[3], Tong Lin[1], Aseema Mohanty[1], Bo Zhao[2], Jean-Michel Hartmann[4], Shanhui Fan[2], Michal Lipson[1]; [1]*Columbia Univ., New York, USA, USA;* [2]*Electrical Engineering, Stanford Univ., USA;* [3]*Mechanical Engineering, Univ. of Ottawa, Canada;* [4]*CEA - Laboratoire d'Électronique des Technologies de l'Information (LETI), France*. We demonstrate a platform for heat-to-electricity conversion based on near-field radiative heat transfer. The platform is based on tens-of-μm long suspended micro-heaters at >400deg.C, placed <100nm away from a room temperature photodetector.

FTu3E.3 • 13:45

Aligned and Packed Single-Wall Carbon Nanotubes as Hyperbolic Thermal Emitters, Weilu Gao[1], Chloe Doiron[1], Xinwei Li[1], Junichiro Kono[1,2], Gururaj Naik[1]; [1]*Dept. of Electrical and Computer Engineering, Rice Univ. , USA;* [2]*Dept. of Physics and Astronomy, Rice Univ., USA*. We demonstrate a broadly tunable, polarized and selective thermal emitter from highly aligned and densely packed single-wall carbon nanotubes (SWNCTs) operating at 700 °C, originating from their optical topological transition.

CLEO: Science & Innovations

13:00–15:00
STu3F • Nonlinear Integrated Photonic Platforms
Presider: Kartik Srinivasan; NIST, USA

STu3F.1 • 13:00

Low Loss Silicon-Rich Silicon Nitride for Nonlinear Optics, Zhichao Ye[1], Attila Fulop[1], Óskar B. Helgason[1], Peter A. Andrekson[1], Victor Torres-Company[1]; [1]*Microtechnology and Nanoscience, Chalmers Univ. of Technology, Sweden*. We demonstrate low loss (~ 0.4 dB/cm) silicon-rich silicon nitride waveguides and high Q microresonators (Q, ~ 10^6) featuring broadband anomalous dispersion. Microresonator combs are generated for the first time in this emerging material platform.

STu3F.2 • 13:15

Harmonic Generation in Silicon Rich Nitride Photonic Crystal Cavities, Marco Clementi[1], Kapil Debnath[2,3], Moïse Sotto[2], Thalía Domínguez Bucio[3], Marco Liscidini[1], Daniele Bajoni[1], Frederic Gardes[3], Matteo Galli[1]; [1]*Dipartimento di Fisica, Università di Pavia, Italy;* [2]*Faculty of Physical Sciences and Engineering, Univ. of Southampton, UK;* [3]*Optoelectronics Research Centre, Univ. of Southampton, UK*. We demonstrate the cavity-enhanced second and third harmonic generation in silicon rich nitride 2D photonic crystal resonators under low-power continuous-wave excitation. Results show high generation efficiencies and suggest the absence of two-photon absorption.

STu3F.3 • 13:30

On-chip second order nonlinear generation in lithium niobate photonic crystal nanocavity, Haowei Jiang[1,2], Hanxiao Liang[3], Rui Luo[2], Xianfeng Chen[1], Yuping Chen[1], Qiang Lin[3,2]; [1]*School of Physics and Astronomy, Shanghai Jiao Tong Univ., China;* [2]*Inst. of Optics, Univ. of Rochester, USA;* [3]*Dept. of Electrical and Computer Engineering, Univ. of Rochester, USA*. We report the first observation of the second harmonic generation and the sum frequency generation in the one-dimensional lithium niobate photonic crystal nanocavity.

STu3F.4 • 13:45

Integrated Thin-film Lithium-Niobate Waveguides on Silicon for Second-Harmonic Generation Pumped at 1875 nm, Saeed Khan[1], Marcin Malinowski[1], Jean-Etienne Tremblay[2], Ashutosh Rao[1], Guillermo Camacho-Gonzalez[1], Ricardo Bustos Ramirez[1], Michael E. Plascak[1], Kathleen Richardson[1], Peter Delfyett[1,3], Ming C. Wu[2], Sasan Fathpour[1,3]; [1]*CREOL, The College of Optics and Photonics, Univ. of Central Florida, USA;* [2]*Dept. of Electrical Engineering and Computer Sciences, Univ. of California, USA;* [3]*Dept. of Electrical and Computer Engineering, Univ. of Central Florida, USA*. A thin-film periodically-poled lithium niobate (PPLN) on silicon wavelength converter is demonstrated for application in carrier-envelope offset stabilization. Supercontinuum generation, amplified at about 1900 nm wavelength, is used to generate second harmonic generation.

CLEO: QELS-Fundamental Science

13:00–15:00
FTu3G • Quantum Key Distribution
Presider: Michael Brodsky; U.S. Army Research Lab, USA

FTu3G.1 • 13:00 Invited

Handheld Quantum Key Distribution, Gwenaelle Melen[1,2], Peter Freiwang[1], Jannik Luhn[1], Tobias Vogl[3], Markus Rau[4], Wenjamin Rosenfeld[1], Harald Weinfurter[1,5]; [1]*Faculty of Physics, Univ. of Munich, Germany;* [2]*Walter Schottky Inst., Technical Univ. Munich, Germany;* [3]*Centre for Quantum Comp. and Comm. Technology, Australian National Univ., Australia;* [4]*Qutools GmbH, Germany;* [5]*Max-Planck Inst. for Quantum Optics, Germany.* Using integrated optics enabled us to miniaturize QKD optics and to demonstrate handheld QKD. The robust device could be integrated with classical free space communication systems for links in metropolitan areas and to flying platforms.

FTu3G.2 • 13:30

Integrated Chip for Continuous-variable Quantum Key Distribution using Silicon Photonic Fabrication, Gong Zhang[1], Lin Cao[2], Jing Yan Haw[3], Xiaojun Jia[4], Xiaolong Su[4], Leong Chuan Kwek[5], Joseph F. Fitzsimons[5,6], Ping Koy Lam[3], Xiaoqi Zhou[7], Weibo Gao[8], Jiangbin Gong[9], Yidong Chong[8], Alexander Szameit[10], Wee Ser[1], Ai-Qun Liu[1]; [1]*School of Electrical and Electronic Engineering, Nanyang Technological Univ., Singapore;* [2]*School of Electronics Engineering and Computer Science, Peking Univ., China;* [3]*Research School of Physics and Engineering, The Australian National Univ., Australia;* [4]*Inst. of Opto-Electronics, Shanxi Univ., China;* [5]*Centre for Quantum Technologies, National Univ. of Singapore, Singapore;* [6]*Singapore Univ. of Technology and Design, Singapore;* [7]*State Key Lab of Optoelectronic Materials and Technologies and School of Physics, Sun Yat-Sen Univ., China;* [8]*School of Physical & Mathematical Sciences, Nanyang Technological Univ., Singapore;* [9]*Dept. of Physics and Centre for Computational Science and Engineering, National Univ. of Singapore, Singapore;* [10]*Inst. for Physics, Univ. of Rostock, Germany.* A continuous-variable quantum key distribution system based on silicon photonic chip is designed and tested. A proof-of-principle test shows the secure key-rate can reach 1.92 Mbit/s at 0 km and 37 kbit/s at 45 km distance.

FTu3G.3 • 13:45

High-rate Time-bin Quantum Key Distribution Using Quantum-controlled Measurement, Nurul T. Islam[1], Charles Lim[3], Clinton Cahall[1], Bing Qi[2], Jungsang Kim[1], Daniel J. Gauthier[4]; [1]*Duke Univ., USA;* [2]*Oak Ridge National Lab, USA;* [3]*National Univ. of Singapore, Singapore;* [4]*The Ohio State Univ., USA.* We realize a time-bin qudit-based quantum key distribution system that uses two-photon interference for measuring the phase-basis states, allowing us to generate a secret key at a megabits-per-second rate.

13:00–15:00
FTu3H • Quantum Optics with Solid-state Single Emitters
Presider: Peter Lodahl; Univ. of Copenhagen, Denmark

FTu3H.1 • 13:00

Two-photon Bundles from a Single Two-level System, Lukas Hanschke[1], Kevin Fischer[2], Jakob Wierzbowski[1], Tobias Simmet[1], Constantin Dory[2], Jonathan Finley[1], Jelena Vuckovic[2], Kai Müller[1]; [1]*Walter Schottky Institut, TU München, Germany;* [2]*E. L. Ginzton Lab, Stanford Univ., USA.* Resonantly excited two-level systems are well-known as single-photon emitters. Here, we demonstrate the generation of two-photon bundles from a single quantum two-level transition in a self-assembled InAs quantum dot.

FTu3H.2 • 13:15

A Solid State Source of Photon Triplets based on Quantum Dot Molecules, Milad Khoshnegar[3,4], Tobias Huber[1,2], Ana Predojević[2], Dan Dalacu[5], Maximilian Prilmüller[2], Jean Lapointe[5], Xiaohua Wu[5], Philippe Tamarat[6], Brahim Lounis[6], Philip Poole[5], Gregor Weihs[4,2], Hamed Majedi[3,7]; [1]*Joint Quantum Inst., Univ. of Maryland & NIST, USA;* [2]*Institut für Experimentalphysik, Universität Innsbruck, Austria;* [3]*Dept. of Electrical and Computer Engineering, Univ. of Waterloo, Canada;* [4]*Inst. for Quantum Computing, Univ. of Waterloo, Canada;* [5]*National Research Council of Canada, Canada;* [6]*LP2N Institut d'Optique and CNRS, Université Bordeaux, France;* [7]*Waterloo Inst. for Nanotechnology, Univ. of Waterloo, Canada.* We present a triple cascade recombination and sequential emission of three photons with strong correlations from a quantum dot molecule. We record 65.62 photon triplets per minute under continuous-wave pumping, surpassing rates of earlier reported sources.

FTu3H.3 • 13:30 Invited

A quantum knitting machine generating on demand cluster states of entangled photons, David . Gershoni[1]; [1]*Technion Israel Inst. of Technology, Israel.* Repeated timed excitations of a quantum dot confined electronic spin is used to entangle the polarization of the emitted photons with that of the precessing spin and thereby also with the polarizations of the previously emitted photons

CLEO: Applications & Technology

13:00–15:00
ATu3I • OCT and LIDAR
Presider: Peter Fendel; Thorlabs Inc, USA

ATu3I.1 • 13:00 Invited

High-Speed Coherent and Incoherent Monitoring of Laser Processing: from Closed-Loop Keyhole Welding to Additive Manufacturing, James M. Fraser[1]; [1]*Queen's Univ. at Kingston, Canada.* In-process monitoring capable of fully resolving high-power laser processing has long been the goal of advanced manufacturing. We have achieved kHz-rate micron-resolution morphology and temperature monitoring and applied it to welding and selective laser melting.

ATu3I.2 • 13:30

Signal Reconstruction in SS-OCT using Compressed Sensing, Takuma Shirahata[1], Shinji Yamashita[1]; [1]*Univ. of Tokyo, Japan.* We applied compressed sensing to SS-OCT for the first time. We use dispesion-tuned fiber laser for non-uniform k-space sampling. We achieved the same resolution and less noise of PSF with less sampling .

ATu3I.3 • 13:45

Spatially-offset optical coherence tomography, Mingzhou Chen[1], Josep Mas[1], Kishan Dholakia[1]; [1]*School of Physics and Astronomy, Univ. of St. Andrews, UK.* We introduce a new geometry of spatially-offset optical coherence tomography (SO-OCT) to improve signal detection and reveal structural information from depth in the presence of strongly scattering layers.

Meeting Room 212 A/C

CLEO: Applications & Technology

13:00–15:00
ATu3J • Nanobiophotonics
Presider: Andrea Armani; Univ. of Southern California, USA

ATu3J.1 • 13:00 Invited
Interferometric Microscopy for Detection and Visualization of Biological Nanoparticles, M. Selim Ünlü[1]; [1]*Boston Univ., USA.* The sensitive detection and quantitative measurement of biological nanoparticles, such as viruses and exosomes, is of growing importance. We present a label-free optical biosensing method based on interferometric reflectance imaging to detect and characterize individual biological nanoparticles.

ATu3J.2 • 13:30
Broadband Fluorescence Enhancement and Ultrasensitive DNA Detection Using Plasmonic Open-Ring Nanoarrays, Akash Kannegulla[1], Ye Liu[1], Bo Wu[1], Li-Jing Cheng[1]; [1]*Oregon State Univ., USA.* Silver open-ring nanostructures were designed for broadband fluorescence enhancement of quantum dots (QDs) and molecular beacons. The plasmon-enhanced fluorescence permits high signal-to-noise ratio yielding a ~300fM detection limit, superior to those on plane silver surfaces.

ATu3J.3 • 13:45
Spatial frequency projection super resolution imaging, Randy A. Bartels[1], Keith Wernsing[1], Patrick Stockton[1], Jeff Field[1], Jeff Squier[2]; [1]*Colorado State Univ., USA;* [2]*Physics, Colorado School of Mines, USA.* Spatial Frequency Modulated Imaging (SPIFI) with nonlinear excitation is shown to enable super-resolved imaging of specimens via real or virtual state contrast. Extension of 1D enhancement to 2D through inverse domain tomography is discussed.

Meeting Room 212 B/D

CLEO: Science & Innovations

13:00–15:00
STu3K • Novel Fibers
Presider: Misha Sumetsky; Aston Univ., UK

STu3K.1 • 13:00 Invited
Towards in-fiber Silicon Photonics, Anna C. Peacock[1]; [1]*Univ. of Southampton, UK.* This paper reviews recent advances in the fabrication and application of silicon optical fibers. Particular focus is placed on novel materials and device designs that facilitate integration with standard fiber systems.

STu3K.2 • 13:30
Nearly diffraction limited beam qualities in an Anderson localizing optical fiber, Behnam Abaie[1], Mostafa Peysokhan[1], Jian Zhao[2], Jose Antonio-Lopez[2], Rodrigo Amezcua Correa[2], A. Schülzgen[2], Arash Mafi[1]; [1]*Univ. of New Mexico, USA;* [2]*Univ. of Central Florida, CREOL, USA.* Nearly diffraction limited beams are demonstrated in a disordered optical fiber. High quality beams with M2~1 are obtained at various transverse positions across the output facet of the fiber.

STu3K.3 • 13:45
Deep-Learning-Based Imaging through Glass-Air Disordered Fiber with Transverse Anderson Localization, JIAN ZHAO[1], Yangyang Sun[1], Zheyuan Zhu[1], Donghui Zheng[2], Jose Enrique Antonio-Lopez[1], Rodrigo Amezcua Correa[1], Shuo Pang[1], A. Schülzgen[1]; [1]*CREOL, College of Optics and Photonics, Univ. of Central Florida, USA;* [2]*School of Electronic and Optical Engineering, Nanjing Univ. of Science and Technology, China.* We demonstrate for the first time that deep neural networks (DNNs) can be trained to recover images transported through a 90 cm-long silica-air disordered optical fiber at variable working distances without any distal optics.

Marriott Salon I & II

Joint

13:00–15:00
JTu3L • Symposium on Multimodal and Molecular Contrast Optical Imaging I
Presider: Wolfgang Drexler, Medizinische Universität Wien, Austria

JTu3L.1 • 13:00 Invited
Molcular Imaging with Optical Coherence Tomogpraphy, Adam de la Zerda[1]; [1]*Stanford Univ., USA.* We developed nanoparticles that produce strong spectral OCT signal, which we use to visualize molecular information in live animals, including key lymphatic markers and tumor-associated macrophages moving about a brain tumor of a live mouse.

JTu3L.2 • 13:30 Invited
Reflectance Confocal Microscopy and Fluorescence Lifetime Imaging in the Oral Cavity, Kristen C. Maitland[1], Taylor Hinsdale[1], Rodrigo Cuenca[1], Bilal H. Malik[1], Yi-Shing L. Cheng[2], John Wright[2], Javier A. Jo[1]; [1]*Biomedical Engineering, Texas A&M Univ., USA;* [2]*College of Dentistry, Texas A&M Univ. Health Science Center, USA.* Confocal microscopy provides high resolution optical sectioning of epithelial tissue, but with limited field of view. Fluorescence lifetime imaging is employed for macroscopic guidance with biochemical contrast to complement the microscopic morphologic imaging of reflectance confocal microscopy.

Marriott Salon III	Marriott Salon IV	Marriott Salon V
CLEO: Science & Innovations		Joint

13:00–15:00
STu3M • High Peak Power Lasers & Technologies
Presider: Thomas Spinka; Lawrence Livermore National Lab, USA

STu3M.1 • 13:00
PW-class Laser Operation at 3.3 Hz and High Contrast Ultra-intense λ=400 nm Beamline, Shoujun Wang[1], Yong Wang[1], Alex Rockwood[2], Bradley Luther[3], Reed Hollinge[1], Alden Curtis[1], Chase Calvi[2], Carmen Menoni[1,3], Jorge Rocca[1,2]; *[1]Electrical and Computer Engineering Dept., Colorado State Univ., USA; [2]Physics Dept., Colorado State Univ., USA; [3]Chemistry Dept., Colorado State Univ., USA.* We demonstrated 0.85PW, 30fs pulses at a repetition rate of 3.3Hz from a Ti:Sapphire laser. Ultra-high contrast λ=400 nm fs pulses were generated with > 40% efficiency and focused to an intensity of 6.5×10^{21}W/cm^2.

STu3M.2 • 13:30
Hybrid OPCPA/Glass 10 PW Laser at 1 Shot a Minute, Erhard W. Gaul[1], Gilles Cheriaux[1], roman antipenkov[2], Frantysek Batysta[2], Ted borger[1], Gavin Friedman[1], Jonathan T. greene[2], axel jochmann[1], daniel kramer[2], bedrich rus[2], pavel trojek[2], stepan vyhlidka[2], todd ditmire[1]; *[1]National Energetics, USA; [2]Extreme Light Infrastructure-Beamlines, Czechia.* The 10PW OPCPA/glass laser under construction for ELI-Beamlines will exhibit output pulses delivered every minute with an energy of 1.5kJ within 150fs duration. We will show results of the sub-sections as well as output performances.

STu3M.3 • 13:45
First Intense, phase controlled, few cycle laser sources in the ELI Attosecond Facility, Karoly Osvay[1], Adam Borzsonyi[1], Dimitris Charalambidis[1], Eric Cormier[1], Lajos Fulop[1], Mikhail Kalashnikov[1], Christos Kamperidis[1], Balint Kiss[1], Rodrigo Lopez-Martens[1], Giuseppe Sansone[1], Zoltan Varallyay[1], Katalin Varju[1]; *[1]ELI-ALPS, Hungary.* Laser systems operating in the 100W average power regime provide ELI-ALPS with TW-to-PW peak power pulses for generation of single and few cycle light sources from THz to XUV for basic and applied researches.

13:00–15:00
STu3N • Chemical Sensing
Presider: Erik Emmons; ECBC, USA

STu3N.1 • 13:00
Gas Sensing Using Heterogeneously Integrated Quantum Cascade Lasers on Silicon, Christopher C. Evans[1], Alexander Spott[2], Charles D. Merritt[3], William W. Bewley[3], Igor Vurgaftman[3], Chul Soo Kim[3], Jerry R. Meyer[3], Joel M. Hensley[1], John E. Bowers[2], Michael B. Frish[1]; *[1]Physical Sciences Inc., USA; [2]Univ. of California, Santa Barbara, USA; [3]Naval Research Lab, USA.* We demonstrate tunable diode-laser absorption spectroscopy (TDLAS) gas sensing near 4.8 μm using a distributed-feedback quantum cascade laser heterogeneously integrated on a silicon-on-nitride-on-insulator platform. This platform enables sensors operating at wavelengths up to 6.7 μm.

STu3N.2 • 13:15
Line-locked Cavity Ring-Down Faraday Rotation Spectroscopy with High Repetition Rate, Jakob Hayden[2], Jonas Westberg[1], Charles L. Patrick[1], Bernhard Lendl[2], Gerard Wysocki[1]; *[1]Dept. of Electrical Engineering, Princeton Univ., USA; [2]Inst. of Chemical Technologies and Analytics, Technische Universitaet Wien, Austria.* We present a line-locked cavity ring-down Faraday rotation spectrometer for trace gas detection of oxygen. The system reaches a ring-down rate of 8-10 kHz and a noise-equivalent angle of ~9×10^{-10} rad/√Hz.

STu3N.3 • 13:30
Ultrashort-Pulse LIBS for Detecting Airborne Metal Particles from Energetic Material Reactions, Morgan O'Neil[1], Nicholas Niemiec[1], Andrew Demko[1], Eric Petersen[1], Waruna Kulatilaka[1]; *[1]Texas A&M Univ., USA.* Ultrashort-pulse, femtosecond-duration laser-induced breakdown spectroscopy (fs-LIBS), has been demonstrated for enhanced detection of metal particles such as Al, Pb, Cu, and Hg, released to the gas phase during energetic material reactions.

STu3N.4 • 13:45
Standoff detection of bulk and trace elements using laser-induced fluorescence of laser ablation plumes, Sivanandan S. Harilal[1], Brian Brumfield[1], Mark Phillips[1]; *[1]Pacific Northwest National Lab, USA.* We demonstrate 10 m standoff analysis of bulk and trace elements in laser-produced plasmas using tunable laser-induced fluorescence (LIF). LIF of laser-ablation plumes provides emission enhancement, higher spectral resolution in comparison with thermally-excited emission.

13:00–15:00
JTu3O • Laser Modification of Materials
Presider: Renee Sher; Wesleyan Univeristy, USA

JTu3O.1 • 13:00
Mechanism of Single-pulse Ablative Generation of Laser-induced Periodic Surface Structures, Iaroslav Gnilitskyi[2,1], Maxim Shugaev[3], Tommi White[4], Leonid Zhigilei[3]; *[1]UNIMORE, Italy; [2]NoviNano Inc., Ukraine; [3]Univ. of Virginia, USA; [4]Univ. of Missouri, USA.* Experimental and computational analysis of the mechanisms of ablative LIPSS formation is reported. The results of large-scale molecular dynamics simulation performed for Cr target reveal a complex interplay of material removal and redistribution in the course of spatially modulated ablation.

JTu3O.2 • 13:15
Self-organized nanogratings induced by femtosecond laser pulse direct writing in optical fibers, Jiafeng Lu[1], Qin Li[3], Ye Dai[3], Yali Zhang[1], Chunhua Wang[1], Fufei Pang[1], Tingyun Wang[1], Xianglong Zeng[1,2]; *[1]Key Lab of Specialty Fiber Optics and Optical Access Networks, Joint International Research Lab of Specialty, Fiber Optics and Advanced Communication, Shanghai Univ., China; [2]Shanghai Inst. for Advanced Communication and Data Science, Shanghai Univ., China; [3]Dept. of Physics, Shanghai Univ., China.* Self-organized nanogratings induced by femtosecond laser pulse direct writing are demonstrated in optical fibers. The results reveal strong anisotropic birefringence of nanogratings. Depolarization and retardation of nanograting are investigated through analyzing Mueller matrices method.

JTu3O.3 • 13:30
Spectrally tunable Airy beam generation using cholesteric liquid crystals, Matthew S. Mills[1], Ben Kowalski[1,2], Vincent Tondiglia[1,2], Kyungmin Lee[1,2], Aubrey Steele[1,2], Timothy White[1], Dean Evans[1]; *[1]RXA, AFRL, USA; [2]Azimuth Corporation, USA.* We demonstrate spectrally tunable Airy beams via a chiral Bragg reflector. Specifically, we photo-align a cholesteric liquid crystal such that it conditionally imparts a cubic phase dependent on voltage applied across the sample.

JTu3O.4 • 13:45
Photopolymerization differences by using nanosecond and picosecond laser pulses, Evaldas Stankevicius[1]; *[1]FTMC, Lithuania.* Formation of polymeric pillars by using laser interference lithography will be compared for nanosecond and picosecond laser pulses. The experimental results will be explained by dynamics of laser-excited radicals.

CLEO: Science & Innovations

13:00–15:00
STu3P • Precision Spectroscopy
Presider: Marco Marangoni; Politecnico di Milano, Italy

STu3P.1 • 13:00
Erbium-Fiber-Based Visible Astro-Comb with 42-GHz Mode Spacing, Sho Okubo[1], Keisuke Nakamura[1], Malte Schramm[1], Hiroki Yamamoto[2], Jun Ishikawa[1], Feng-Lei Hong[2], Ken Kashiwagi[1], Kaoru Minoshima[3], Hironori Tsutsui[4], Eiji Kambe[4], Hideyuki Izumiura[4], Hajime Inaba[1]; [1]*National Metrology Inst. of Japan, Japan;* [2]*Yokohama National Univ., Japan;* [3]*Univ. of Electro-Communications, Japan;* [4]*Okayama Astrophysical Observatory, NAOJ, Japan*. We developed an erbium-fiber-based astro-comb with 42-GHz spacing and wavelength coverage from 500 to 520 nm to calibrate a high dispersion spectrograph for radial velocity measurements and observed the comb spectrum at Okayama astrophysical observatory.

STu3P.2 • 13:15
Ultra-Broadband, Infrared Astro-Comb Generation, Tilo Steinmetz[2], Yuanjie Wu[2], Rafael Probst[2], Heinar Hoogland[2,3], Matthäus Halder[2], Peter Adel[2], Olaf Mandel[2], Sascha Donath[2], Johanna Adelung[2], Ronald Holzwarth[2,1]; [1]*Max-Planck-Institut für Quantenoptik, Germany;* [2]*Menlo Systems GmbH, Germany;* [3]*Lehrstuhl für Laserphysik, Friedrich-Alexander-Universität, Germany.* We present a concept for spectral broadening of an Er:fiber based astronomical frequency comb to cover more than two octaves ranging from 0.45 µm to at least 2.4 µm.

STu3P.3 • 13:30 Invited
Measuring Temperature with Atoms and Molecules, Gar-Wing Truong[1], Sarah Scholten[1], Faisal Karim[1], James Anstie[1], Chris Perrella[1], Philip Light[1], Dong Wei[2], Eric May[3], Tom Stace[4], Andre N. Luiten[1]; [1]*Univ. of Adelaide, Australia;* [2]*Xi'an Univ., China;* [3]*Univ. of Western Australia, Australia;* [4]*Univ. of Queensland, Australia*. We have developed atomic and molecular spectrometers that deliver quantum-limited measurements of the absorption lineshape. We use this to deduce the temperature of the gas and thereby measure Boltzmann's constant with high precision and uncertainty.

13:00–15:00
STu3Q • Advances in VCSELs
Presider: Connie Chang-Hasnain; Univ. of California Berkeley , USA

STu3Q.1 • 13:00 Invited
Recent Progress in GaSb-based VCSELs with Emission Wavelengths up to 4 µm, Ralf Meyer[1], G.K. Veerabathran[1], A. Andrejew[1], S. Sprengel[1], M.-C. Amann[1]; [1]*TU Munich, Germany.* The wavelength of commercially InP-based VCSELs is limited to 2.3µm. Applying type-II active regions allowed the fabrication of devices emitting at 2.5µm. Adapting this concept to GaSb, even wavelengths of up to 4µm were achieved.

STu3Q.2 • 13:30
High-Speed Modulation of 1.55-µm VCSELs with Spin Polarization Modulation, Nobuhide Yokota[1], Kunpei Nisaka[1], Hiroshi Yasaka[1], Kazuhiro Ikeda[2]; [1]*Tohoku Univ., Japan;* [2]*National Inst. of Advanced Industrial Science and Technology, Japan.* We investigate a novel high-speed direct modulation scheme of InAlGaAs VCSELs using optical spin injection and modulation. A wide 3-dB bandwidth drastically enhanced by the birefringence of VCSEL is demonstrated in both calculations and experiments.

STu3Q.3 • 13:45
Precise Two-step Growth of 940-nm VCSEL on a GaAsP-capped DBR Wafer, Jiaxing Wang[1], Jonas Kapraun[1], Emil Kolev[1], Jipeng Qi[1], Kevin Cook[1], Connie J. Chang-Hasnain[1]; [1]*Univ. of California Berkeley, USA.* We report a 2-step growth for 940-nm VCSELs on DBRs capped by a novel protective GaAsP layer, desorbed during the secondary growth including laser region to yield precise high quality VCSELs with sub-mA threshold.

CLEO: Applications & Technology

13:00–15:00
ATu3R • A&T Topical Review on Advanced Applications of Laser Radar and Remote Sensing I
Presider: TBD

ATu3R.1 • 13:00 Invited
TBD, McManamon Paul[1]; [1]*Exciting Technology LLC, USA.* TBD

ATu3R.2 • 13:30
High-Performance Integrated Optical Phased Arrays for Chip-Scale Beam Steering and LiDAR, Christopher V. Poulton[1], Peter Russo[1], Erman Timurdogan[1], Michael Whitson[1], Matthew Byrd[1], Ehsan Hosseini[1], Benjamin Moss[1], Zhan Su[1], Diedrik Vermeulen[1], Michael Watts[1]; [1]*Analog Photonics, USA.* We present high-performance integrated optical phased arrays and LiDAR on diffusive targets for the first time at 25m with velocity extraction. This work shows the promise for optical phased arrays in solid-state LiDARs.

ATu3R.3 • 13:45
Vernier Transceiver Architecture for Side-Lobe-Free and High-Entendue LiDAR, Sergio Pinna[1], Bowen Song[1], Larry A. Coldren[1], Jonathan Klamkin[1]; [1]*Electrical and Computer Engineering, Univ. of California Santa Barbara, USA.* Vernier-based LiDAR transceiver for high side-modesuppression optical phased arrays is proposed and investigated. This architecture enables side-lobe-free 180° viewing angle with multiple-wavelength waveguide spacing thereby easing fabrication requirements.

13:00–15:00
ATu3S • A&T Topical Review on Advances in Supercontinuum Technologies I: Supercontinuum Generation
Presider: Adam Devine; Fianium Ltd., UK

ATu3S.1 • 13:00 Invited
Ultra Low Loss Waveguides for Extreme Nonlinear Optics, Michal Lipson[1]; [1]*Columbia Univ., USA.* TBD

ATu3S.2 • 13:30 Invited
Ultraviolet Supercontinuum Generation in Optical Fibers, John C. Travers[1], Teodora Grigorova[1], Federico Belli[1]; [1]*Heriot-Watt Univ., UK.* We review the physics and techniques for the extension of multi-octave near-infrared pumped supercontinuum generation to the deep ultraviolet in solid-core photonic-crystal fibers (200 nm) and the vacuum-ultraviolet in gas-filled hollow-core fibers (113 nm).

CLEO: Science & Innovations

STu3A • Quantum Photonic Technology—Continued

STu3A.3 • 14:00
Enhanced Silicon Single-photon Avalanche Diode Based on Light Trapping, Kai Zang[1], Xiao Jiang[2,3], Yijie Huo[1], Tianzhe Zheng[2,3], Yueyang Fei[2,3], Xun Ding[2,3], Matthew Morea[1], Muyu Xue[4], Ching-Ying Lu[1], Theodore I. Kamins[1], Qiang Zhang[2,3], Jian-Wei Pan[2,3], James S. Harris[1,4]; [1]*Electrical Engineering, Stanford Univ., USA;* [2]*Hefei National Lab for Physical Sciences at Microscale and Dept. of Modern Physics, Univ. of Science and Technology of China, China;* [3]*CAS center for Excellence and Synergetic Innovation Center in Quantum Information and Quantum Physics, Univ. of Science and Technology of China, China;* [4]*Materials Science and Engineering, Stanford, USA.* We present a nano-structured light-trapping Si SPAD with improved detection efficiency, without sacrificing jitter distribution or dark count rate. The design can be adopted for CMOS-compatible SPAD image sensors and silicon photomultipliers.

STu3A.4 • 14:15
Metallic Nano-Rings for Efficient, Broadband Light Extraction from Solid-State Single-Photon Sources, Oliver J. Trojak[1], Christopher Woodhead[2], Jin Dong Song[3], Robert Young[2], Luca Sapienza[1]; [1]*Dept. of Physics and Astronomy, Univ. of Southampton, UK;* [2]*Physics Dept., Lancaster Univ., UK;* [3]*Center for Opto-Electronic Materials and Devices Research, Korea Inst. of Science and Technology, South Korea.* Metallic nano-rings deposited on the sample surface, centered around single InAs/GaAs quantum dots, enhance the brightness of the emission up to ×20, further enhanced by ×10 by epoxy solid-immersion lenses, in a scalable broadband device.

STu3A.5 • 14:30 Invited
CMOS Photonic Circuits for Trapped Ion Quantum Computing and Molecular Sensing, Rajeev Jagga Ram[1]; [1]*MIT, USA.* Photonic integrated circuits for UV and visible light offer a scalable approach to the classical optics and electronics required for large-scale trapped-ion quantum information processing as well as for self-contained lab-on-a-chip systems for molecular diagnostics.

STu3B • OAM and Photodetective—Continued

STu3B.2 • 14:00
Demonstration of Chip-to-Chip Communication Based on Ultra-Compact Orbital Angular Momentum (de)Multiplexers, Shimao Li[1], Zhichao Nong[1], Xiong Wu[1], Wen Yu[1], Mingbo He[1], Yuntao Zhu[1], Shengqian Gao[1], Jie Liu[1], Zhaohui Li[1], Liu Liu[2], Si-Yuan Yu[1], Xinlun Cai[1]; [1]*Sun Yat-sen Univ., China;* [2]*South China Normal Univ., China.* In this work we demonstrate chip-to-chip orbital angular momentum (OAM) multiplexing transmission using a pair of ultra-compact silicon integrated (de)multiplexer. Four OAM beams were multiplexed and then were demultiplexed by the devices.

STu3B.3 • 14:15
Multi-octave image-reject mixer with large suppression of mixing spurs based on balanced photodetectors, Wenjuan Chen[1], Dan Zhu[1], Shilong Pan[1]; [1]*Nanjing Univ Aeronautics & Astronautics, China.* A multi-octave photonic image-reject mixer is proposed based on two balanced photodetectors and an optical hybrid. More than 60-dB image rejection and mixing spurs suppression are realized simultaneously over a wide frequency range.

STu3B.4 • 14:30
100GHz Balanced Photodetector Module, Patrick Runge[1], Gan Zhou[1], Tobias Beckerwerth[1], Shahram Keyvaninia[1], Sven Mutschall[1], Angela Seeger[1], Robert Klötzer[1], Sebastian Wünsch[1], Greta Ropers[1]; [1]*Fraunhofer Institut, Germany.* We demonstrate a 100GHz balanced photodetector module. Regarding the bandwidth the module exceeds all other state of the art balanced modules. The module focuses on next generation optical networks with 112GBaud and operates in C-band and L-band.

STu3B.5 • 14:45
Zero-bias Photovaractor with 60 GHz Resonant Network for Optically Modulated Scatterer (OMS) Application, Jesse S. Morgan[1], Jizhao Zang[1], Keye Sun[1], Bassem Tossoun[1], Joe C. Campbell[1], Andreas Beling[1]; [1]*Univ. of Virginia, USA.* We report a zero-bias photovaractor flip-chip bonded to a coplanar-waveguide resonant network for use as a probe designed to measure near-field characteristics of antennas operating at 60 GHz.

STu3C • Advanced Short Reach and Free Space Communications—Continued

STu3C.4 • 14:00
Large Scale Optical Interconnection Using Kerr Frequency Comb and Direct-Detection Kramers-Kronig Receiver, Mingyue Zhu[1], Yong Geng[1], Xingwen Yi[2,1], Jing Zhang[1], Heng Zhou[1]; [1]*Univ. of Electronic Science and Technology of China, China;* [2]*School of Electronics and Information Technology, Sun Yat-Sen Univ., China.* We demonstrate large scale optical interconnection using Kerr frequency comb within 1540-1560 nm wavelength. An optical SSB-PAM-4 signal with total bitrate of 325-Gb/s (13×25 Gb/s) are successfully transmitted over 80-km SSMF by a Kramers-Kronig receiver.

STu3C.5 • 14:15
A Phase Retrieval Method Using Dispersion for Direct Detection of Biased QAM Signals, Masayuki Matsumoto[1]; [1]*Wakayama Univ., Japan.* Phase retrieval using dispersion in direct-detection receiver for biased Nyquist 16QAM signals is numerically examined. Processing error can be small at high bias power ratio. The continuous wave acting as a bias can be located within the signal spectrum.

STu3C.6 • 14:30
112 Gb/s PAM-4 Signal Transmission Over 80 km SSMF with Digital CD Pre-compensation Enabled SPM Mitigation, Xiang Li[1], Fan Gao[2], Ming Luo[1], Jianqiang Li[3], Songnian Fu[2]; [1]*WRI, China;* [2]*HUST, China;* [3]*BUPT, China.* We demonstrate single-lane 112 Gb/s PAM-4 signal over 80 km SSMF by digital CD pre-compensation. Thanks for the residual positive CD enabled SPM mitigation, simplified Volterra filter equalizer secures BER below the 7% HD-FEC threshold.

STu3C.7 • 14:45
Directly Modulated Laser Transmitters for Scalable Multi-rate DPSK Communications, David O. Caplan[1], P. S. Bedrosian[1], Jade P. Wang[1], Barry R. Romkey[1], Mark L. Stevens[1], Clement Burton[1], Andrew Horvath[1], Scott A. Hamilton[1]; [1]*MIT Lincoln Lab, USA.* We present a new approach for generating multi-rate burst-mode DPSK waveforms using time and frequency-windowed directly modulated laser transmitters. Near-theoretical performance is demonstrated over a wide range of data rates using a WDM-scalable implementation.

15:00–17:00 Coffee Break & Exhibit Only Time, *Exhibit Hall*

15:30–17:00 Meet the OSA Editors Reception, *Exhibit Hall, #2425*

CLEO: Science & Innovations

STu3D • Terahertz Communications—Continued

STu3D.2 • 14:00
Channel Characteristics for Terahertz Wireless Communications, Jianjun Ma[1], Rabi Shrestha[1], Lothar Moeller[2], Daniel M. Mittleman[1]; [1]*School of Engineering, Brown Univ., USA;* [2]*New Jersey Inst. of technology, USA.* We investigate channel performances for indoor terahertz (THz) wireless links with carrier frequencies at 100, 200, 300 and 400 GHz. We demonstrate error-free data links using both line-of-sight and non-line-of-sight configurations.

STu3D.3 • 14:15
Seamless connection between high-speed THz-wave and optical signals with high spectral efficiency, Koichi Takiguchi[1]; [1]*Dept. of Electrical and Electronic Engineering, Ritsumeikan Univ., Japan.* I report seamless connection between THz-wave and optical signals. A 40 Gbit/s THz-wave signal, which was generated from an optical signal shaped with a Nyquist-filter, was flexibly converted into an optical signal through an optical-modulator.

STu3D.4 • 14:30
Terahertz-to-Optical Conversion Using a Plasmonic Modulator, Sandeep Ummethala[1,2], Tobias Harter[1,2], Kira Köhnle[1,2], Sascha Muehlbrandt[1,2], Yasar Kutuvantavida[1,2], Juned N. Kemal[2], Jochen Schaefer[3], Hermann Massler[4], Axel Tessmann[4], Suresh Kumar Garlapati[5], Andreas Bacher[1], Lothar Hahn[1], Martin Walther[4], Thomas Zwick[3], Sebastian Randel[2], Wolfgang Freude[2], Christian Koos[1,2]; [1]*Inst. of Microstructure Technology, Karlsruhe Inst. of Technology, Germany;* [2]*Inst. of Photonics and Quantum Electronics, Karlsruhe Inst. of Technology, Germany;* [3]*Inst. of Radio Frequency Engineering and Electronics, Karlsruhe Inst. of Technology, Germany;* [4]*Fraunhofer Inst. for Applied Solid State Physics , Germany;* [5]*Inst. of Nanotechonology, Karlsruhe Inst. of Technology, Germany.* We show a THz plasmonic modulator with flat frequency response from 40 MHz to 0.325 THz and employ it to demonstrate THz-to-optical conversion of a 30 Gbit/s signal on a 0.294 THz carrier.

STu3D.5 • 14:45
Monolithically Integrated THz Transceiver for 1550 nm Excitation, Robert Kohlhaas[1], Simon Nellen[1], Lars Liebermeister[1], Steffen Breuer[1], Bjoern Globisch[1]; [1]*Fraunhofer Heinrich Hertz Inst., Germany.* We present a monolithically integrated transceiver based on InGaAs:Fe for THz TDS in reflection geometry. With 70 dB signal-to-noise ratio and 5 THz bandwidth, the transceiver is a competitive alternative to individual THz modules.

CLEO: QELS-Fundamental Science

FTu3E • Thermal and Quantum Applications of Metasurfaces—Continued

FTu3E.4 • 14:00
Dirac-Maxwell correspondence: Spin-1 bosonic topological insulator, Todd F. Van Mechelen[1], Zubin Jacob[1]; [1]*Purdue Univ., USA.* We introduce photonic Dirac monopoles and strings, proving the existence of a spin-1 bosonic topological phase for light. Fundamentally different from pseudo-spin-1/2 based photonic crystals, we discover quantized spin in symmetry protected helical edge states of continuous media.

FTu3E.5 • 14:15
Generating Entanglement of Spin and Orbital Angular Momentum by Metasurfaces, Tomer Stav[1], Arkady Faerman[2], Elhanan Maguid[2], Dikla Oren[1], Vladimir Kleiner[2], Erez Hasman[2], Mordechai Segev[1]; [1]*Physics, Technion, Israel;* [2]*Mechanical Engineering, Technion, Israel.* We design an experiment that uses a highly efficient dielectric metasurface to create entanglement on a single photon. The spin-orbit interaction mediated by the metasurface entangles the polarization and orbital angular momentum degrees of freedom.

FTu3E.6 • 14:30
Angular Momentum Contribution of Topologically Structured Darkness, Samuel N. Alperin[1], Mark E. Siemens[1]; [1]*Univ. of Denver, USA.* We explain the discrepancy between the fractional winding number of a generating spiral phase optic with the OAM of the resulting beam, and demonstrate the first direct measurement of intrinsic OAM of fractional vortex beams.

FTu3E.7 • 14:45
Broadband Control of Topological Nodes in Electromagnetic Fields, Alex Y. Song[1], Peter B. Catrysse[1], Shanhui Fan[1]; [1]*Stanford Univ., USA.* The topological nodes in electromagnetic waves are shown to bound to a symmetry plane in a dielectric structure over a broad wavelength range. As an implication, broadband hiding of objects can be realized.

CLEO: Science & Innovations

STu3F • Nonlinear Integrated Photonic Platforms—Continued

STu3F.5 • 14:00
A gallium arsenide nonlinear platform on silicon, Lin Chang[1], Xiaowen Guo[1], Daryl Spencer[2], Jeff Chiles[2], Abijith Kowligy[2], Nima Nader[2], Daniel Hickstein[2], MJ Kennedy[1], Andreas Boes[1], Nicolas Volet[1], Scott Diddams[2], Scott Papp[2], John E. Bowers[1]; [1]*Univ. of California Santa Barbara, USA;* [2]*National Inst. of Standards and Technology, USA.* A nonlinear platform using gallium arsenide (GaAs) waveguides cladded with SiO_2 has been demonstrated on silicon substrates. It is suitable for efficient nonlinear applications. Second harmonic generation (SHG) with record-high efficiency of 38,000% $W^{-1}cm^{-2}$ has been achieved.

STu3F.6 • 14:30
Supercontinuum generation in angle-etched diamond waveguides, Pawel Latawiec[1], Amirhassan Shams-Ansari[1,4], Yoshitomo Okawachi[2], Vivek Venkataraman[1,3], Mengjie Yu[2], Haig Atikian[1], Gary Harris[4], Nathalie Picque[5], Alexander L. Gaeta[2], Marko Loncar[1]; [1]*Harvard Univ., USA;* [2]*Columbia Univ., USA;* [3]*Indian Inst. of Technology, India;* [4]*Howard Univ., USA;* [5]*Max Plank Inst. for Quantum Optics, Germany.* On-chip supercontinuum generation in visible is demonstrated experimentally in angle-etched diamond waveguides. The output spectrum spans from 670-920 nm in response to a 100 femtosecond pulse input at 15 mW average power and 80 MHz repetition rate.

STu3F.7 • 14:45
Enhanced four-wave mixing in graphene oxide coated waveguides, Yunyi Yang[1], Jiayang Wu[1], Xingyuan Xu[1], Sai T. Chu[2], Brent Little[3], Roberto Morandotti[4], Baohua Jia[1], David J. Moss[1]; [1]*Swinburne Univ. of Technology, Australia;* [2]*City Univ. of Hong Kong, China;* [3]*Chinese Academy of Science, China;* [4]*INRS-Énergie, Matériaux et Télécommunications, Canada.* We experimentally demonstrate enhanced four-wave mixing (FWM) in an integrated waveguide coated with graphene oxide (GO). Owing to the high Kerr nonlinearity of GO and strong mode overlap, we achieve ~9.5-dB enhancement in FWM conversion efficiency.

15:00–17:00 Coffee Break & Exhibit Only Time, *Exhibit Hall*

15:30–17:00 Meet the OSA Editors Reception, *Exhibit Hall, #2425*

CLEO: QELS-Fundamental Science

CLEO: Applications & Technology

FTu3G • Quantum Key Distribution—Continued

FTu3G.4 • 14:00
Experimental Demonstration of a 10-Mbit/s Quantum Link using Data Encoding on Orthogonal Laguerre-Gaussian Modes, Kai Pang[1], Cong Liu[1], Guodong Xie[1], Yongxiong Ren[1], Zhe Zhao[1], Runzhou Zhang[1], Yinwen Cao[1], Jiapeng Zhao[1], Long Li[1], Haoqian Song[1], Hao Song[1], Moshe Tur[2], Robert Boyd[3], Alan E. Willner[1]; *[1]Universit of Southern California, USA; [2]Tel Aviv Univ., Israel; [3]Univ. of Rochester, USA*. We experimentally investigate the performance of a quantum communication link using Laguerre-Gaussian (LG) modes with different radial indices. Quantum symbol error rate (QSER) <5% is achieved at an encoding rate of 10 Mbits/s.

FTu3G.5 • 14:15
Experimental Quantum Key Distribution at 1.3 Gbit/s Secret-Key Rate over a 10-dB-Loss Channel, Zheshen Zhang[2,1], Changchen Chen[2], Quntao Zhuang[2], Jane E. Heyes[2], Franco N. Wong[2], Jeffrey H. Shapiro[2]; *[1]The Univ. of Arizona, USA; [2]Research Lab of Electronics, Massachuestts Inst. of Technology, USA*. We demonstrate quantum key distribution at 1.3-Gbit/s secret-key rates over a 10-dB-loss channel. By transmitting many photons per bit with multi-mode encoding our protocol overcomes channel loss to achieve gigabit-per-second rates without compromising security.

FTu3G.6 • 14:30
Birefringent Interferometry for Quantum Key Distribution, Amos Martinez[1], Bernd Fröhlich[1], James F. Dynes[1], Andrew W. Sharpe[1], Winci Tam[1], Alan Plews[1], Marco Lucamarini[1], Zhiliang Yuan[1], Andrew Shields[1]; *[1]Toshiba UK, UK*. We report quantum key distribution using an all-fiber, highly birefringent interferometer to implement the BB84 protocol. With this approach, we demonstrate point-to-point operation over 15.5 km drop fiber and an 8-port passive optical network splitter.

FTu3G.7 • 14:45
Entanglement loss and recovery due to arbitrarily oriented polarization dependent loss for telecom band photon pairs., Daniel E. Jones[1], Brian T. Kirby[1], Michael Brodsky[1]; *[1]US Army Research Lab, USA*. Interplay of residual fiber birefringence and modal loss impairs propagation of polarization entangled photons in fibers. We introduce an illustrative Stokes space model of the effect, verify it experimentally, and demonstrate a simple compensating scheme.

FTu3H • Quantum Optics with Solid-state Single Emitters—Continued

FTu3H.4 • 14:00
Colossal Photon Bunching Driven by Phonon Recombination Dynamics, Matthew A. Feldman[1,2], Eugene Dumitrescu[2], Denzel Bridges[3], Matthew Chisholm[4], Roderick Davidson[1,2], Phil Evans[2], Jordan Hachtel[5], Anming Hu[3], Raphael C. Pooser[2], Richard Haglund[1], Benjamin Lawrie[2]; *[1]Dept. of Physics and Astronomy, Vanderbilt Univ., USA; [2]Quantum Information Science Group, Oak Ridge National Lab , USA; [3]Mechanical Engineering, Univ. of Tennessee, USA; [4]Material Science and Technology Division, Oak Ridge National Lab, USA; [5]Center for Nanophase Materials Science, Oak Ridge National Lab, USA*. We report photon bunching $g^{(2)}(0) \approx 49$ due to phonon sidebands in spectrally filtered cathodoluminescence from NV centers in diamond. The result is consistent with fast, phonon-mediated recombination dynamics, and supported by a stochastic model.

FTu3H.5 • 14:15
Strong Cavity Enhancement of Spontaneous Emission from Silicon-Vacancy Centers in Diamond , Jingyuan Linda Zhang[1], Shuo Sun[1], Michael J. Burek[2], Constantin Dory[1], Yan-Kai Tzeng[3], Kevin Fischer[1], Yousif Kelaita[1], Konstantinos Lagoudakis[1], Marina Radulaski[1], Zhu-Xun Shen[3,5], Nicholas Melosh[4,5], Steven Chu[3,6], Marko Loncar[2], Jelena Vuckovic[1]; *[1]E. L. Ginzton Lab, Stanford Univ., USA; [2]School of Engineering and Applied Sciences, Harvard Univ., USA; [3]Dept. of Physics, Stanford Univ., USA; [4]Geballe Lab for Advanced Materials, Stanford Univ., USA; [5]Stanford Inst. for Materials and Energy Sciences, SLAC National Accelerator Lab, USA; [6]Dept. of Molecular and Cellular Physiology, Stanford Univ., USA*. We demonstrate strong enhancement of spontaneous emission of a single silicon-vacancy (SiV^-) center in diamond embedded in a monolithic optical cavity, with 10-fold lifetime reduction and 42-fold enhancement in emission intensity under resonant condition.

FTu3H.6 • 14:30
Reducing phonon-induced decoherence of solid-state artificial atoms with cavity quantum electrodynamics, Pascale Senellart[1], Alexia Auffeves[2], Thomas Grange[2], Carlos Anton[1], Niccolo Somaschi[1], Lorenzo De Santis[1], Aristide Lemaitre[1], Guillaume Coppola[1], Valerian Giesz[1]; *[1]CNRS-Center for Nanoscience and Nanotechnology, France; [2]CNRS-, Institut Néel, France*. We show how cavity quantum electrodynamics can be used to strongly suppress phonon-assisted emission from solid-state artificial atoms such as semiconductor quantum dots. This results in substantially enhanced performances in single-photon sources

FTu3H.7 • 14:45
A solid-state single photon filter, Pascale Senellart[1], Lorenzo De Santis[1], Carlos Anton[1], Alexia Auffeves[2], Bogdan Reznychenkov[2], Niccolo Somaschi[1], Guillaume Coppola[1], Aristide Lemaitre[1], Andrew White[3], Loic Lanco[1]; *[1]CNRS-Center for Nanoscience and Nanotechnology, France; [2]CNRS-Institut Néel, France; [3]Univ. of Queensland, Australia*. A single semiconductor quantum dot in a microcavity is shown to filter single photon Fock states. The device presents a non-linearity threshold of 0.3 photons and strongly suppresses the multi-photon components of an incident coherent beam.

ATu3I • OCT and LIDAR—Continued

ATu3I.4 • 14:00
Synthetic-Wavelength-Based Dual-Comb Interferometry for High-Speed and High-Precision Distance Measurement, Zebin Zhu[1], Kai Ni[2], Qian Zhou[2], Guanhao Wu[1,2]; *[1]Dept. of Precision Instrument, Tsinghua Univ., China; [2]Division of Advanced Manufacturing, Graduate School at Shenzhen, Tsinghua Univ., China*. We propose a dual-comb ranging system based on synthetic-wavelength interferometry. It can realize absolute distance measurement with ~2.7m ambiguity range, ~3nm precision within ~10ms averaging time.

ATu3I.5 • 14:15
Speckle mitigation in laser Doppler vibrometry based on a compact silicon photonics chip, Yanlu Li[1,2], Jinghao Zhu[1,2], Matthieu Duperron[3], Peter O'Brien[3], Ralf Schüler[5], Soren Aasmul[4], Mirko de Melis[4], Roel Baets[1,2]; *[1]Photonics Research Group, Ghent Univ.-imec, Belgium; [2]Center for Nano- and Biophotonics,, Ghent Univ., Belgium; [3]Tyndall National Inst., Ireland; [4]Medtronic Bakken Research Center, Netherlands; [5]SIOS Messtechnik GmbH, Germany*. A compact six-beam homodyne laser Doppler vibrometry (LDV) system is realized based on a silicon-on-insulator (SOI) photonic integrated circuit. We demonstrate a speckle mitigation method by averaging signals from the six channels.

ATu3I.6 • 14:30
High spatial resolution LIDAR for detection of cracks on tunnel surfaces, Takeharu Murakami[1], Norihito Saito[1], Yuichi Komachi[1], Takashi Michikawa[1], Michio Sakashita[1], Shigeru Kogure[1], Kiwamu Kase[1], Satoshi Wada[1], Katsumi Midorikawa[1]; *[1]RIKEN, Japan*. We developed a high resolution LIDAR to detect cracks on a concrete placed 5 m away. The LIDAR can detect cracks with 200 μm width which is difficult to detect by existing remote inspections.

15:00–17:00 Coffee Break & Exhibit Only Time, *Exhibit Hall*

15:30–17:00 Meet the OSA Editors Reception, *Exhibit Hall, #2425*

ATu3J • Nanobiophotonics—Continued

ATu3J.4 • 14:00
A Nanoplasmonic Sensor Fabricated by Laser Interference Lithography (LIL) for Immunoglobulin Detection, Chi-Chen Lin[1], Jian-Fu Luo[1], Lon A. Wang[1], Nien-Tsu Huang[1]; [1]*National Taiwan Univ., Taiwan*. We fabricated a nanoplasmonic sensor using laser interference lithography (LIL) for label-free biomolecule sensing. This sensor is able to achieve 236 nm/RIU sensitivity and has high uniformity over a large area (~ 1 cm^2).

ATu3J.5 • 14:15
High-throughput holographic monitoring of nanoparticle degradation for drug delivery applications, Aniruddha Ray[1], Shuoran Li[1], Tatiana Segura[1], Aydogan . Ozcan[1]; [1]*Univ. of California, Los Angeles, USA*. We present computational holographic imaging methods for high-throughput quantification of nanoparticle degradation for drug delivery applications. These techniques enable accurate monitoring of the dynamics of nanocarrier degradation over a large field-of-view.

ATu3J.6 • 14:30
Semiconductor Laser Particles in Biological Cells, Sheldon J. Kwok[2,1], Nicola Martino[2], Andreas C. Liapis[2], Sarah Wu[1], Sarah Forward[2], Seok-Hyun Yun[2,1]; [1]*MIT, USA;* [2]*Wellman Center for Photomedicine, Massachusetts General Hospital, USA*. We develop a method for fabricating biocompatible, semiconductor laser particles for integration into biological systems. Micron-sized laser particles coated with a passivating silica shell are readily and safely uptaken by several cell lines *in vitro*.

ATu3J.7 • 14:45
Sub-nano-Tesla, Shield-less, Field Compensation-Free Inelastic Wave Mixing Magnetometry for Bio-magnetism, Lu Deng[1], Yvonne Y. Li[2], Feng Zhou[1], Eric Y. Zhu[3], Edward W. Hagley[1]; [1]*NIST, USA;* [2]*Dana-Farber Cancer Inst., Harvard Medical School, USA;* [3]*Univ. of Toronto, Canada*. We report an inelastic-wave-mixing-enhanced Zeeman-coherence atomic magnetometry scheme that results in sub-nT magnetic field detection at human-body temperatures without employing magnetic field shielding, field compensation, and RF-modulation spectroscopy.

STu3K • Novel Fibers—Continued

STu3K.4 • 14:00
Demonstration the single mode performance of all-solid large mode area center-sunken cladding-trench fiber, Liu YeHui[1], Fangfang Zhang[1], Nan zhao[1], Haiqing Li[1], Luyun Yang[1], Nengli Dai[1], Jinyan Li[1], Wang Yibo[1]; [1]*Huazhong Univ of Science and Technology, China*. We report a novel center-sunken and cladding-trenched Yb-doped fiber. A 456 W laser output was observed in a MOPA structure. The laser slope efficiency was measured to be 79% and the M^2 was 1.17.

STu3K.5 • 14:15
115 W Large-mode-area Multi-core Fiber Laser with All Solid Structure, Junhua Ji[1], Raghuraman Sidharthan[1], Xiaosheng Huang[1], Jichao Zang[1], Daryl Ho[1], Yehuda Benudiz[2], Udi Ben Ami[2], Amiel Ishaaya[2], Seongwoo Yoo[1]; [1]*The Photonics Inst., Nanyang Technological Univ., Singapore;* [2]*Dept. of Electrical and Computer Engineering, Ben-Gurion Univ. of the Negev, Israel*. We demonstrate a multicore Yb-doped fiber laser with an all-solid large-core fiber fabricated in-house and an external Talbot resonator for mode selection. 115W output power with an overall 61% slope efficiency was achieved.

STu3K.6 • 14:30
Low Quantum Defect Fiber Lasers via Yb-Doped Multicomponent Fluorosilicate Optical Fiber, Nanjie Yu[1], Maxime Cavillon[2], Courtney Kucera[2], Thomas Hawkins[2], John Ballato[2], Peter Dragic[1]; [1]*Univ. of Illinois Urbana Champaign, USA;* [2]*Center for Optical Materials Science and Engineering Technologies, Clemson Univ., USA*. A low quantum defect (QD <1.5%) fiber laser based on an Yb-doped multicomponent fluorosilicate optical fiber is presented. Modeling results indicate that the fiber laser is scalable and that QD values below 1% are feasible.

JTu3L • Symposium on Multimodal and Molecular Contrast Optical Imaging I—Continued

JTu3L.3 • 14:00 Invited
Multimodal Endoscopic Bladder Imaging, Audrey Bowden[1]; [1]*Stanford Univ., USA*. TBD

JTu3L.4 • 14:30 Invited
TBD, Zhongping Chen[1]; [1]*Univ. of California Irvine, USA*. TBD

15:00–17:00 Coffee Break & Exhibit Only Time, *Exhibit Hall*

15:30–17:00 Meet the OSA Editors Reception, *Exhibit Hall, #2425*

CLEO: Science & Innovations

Joint

STu3M • High Peak Power Lasers & Technologies—Continued

STu3M.4 • 14:00 Invited
High-resolution Hyperspectral Imaging based on Liquid-crystal Cells, Aurelie Jullien[1], Remy Pascal[1], Umberto Bortolozzo[2], Nicolas Forget[2], Stefania Residori[1]; [1]*INPHYNI - CNRS - UNS, France;* [2]*FASTLITE, France*. A compact, integrable and low-cost hyperspectral imaging device is proposed. It relies on cascaded liquid-crystal cells dynamically driven, calibrated through broadband spectral interferometry. 6 nm spectral resolution is demonstrated over 400–1000 nm.

STu3M.5 • 14:30
Pulse-Compressor Grating-Alignment Tolerances for Varied Geometries and Bandwidths, Benjamin Webb[1], Mark J. Guardalben[1], Christophe Dorrer[1], Sara Bucht[1], Jake Bromage[1]; [1]*Lab for Laser Energetics, Univ. of Rochester, USA*. The effects of pulse compressor grating misalignment on pulse duration and focusability are simulated in *FRED* and *MATLAB* to specify tolerances over a broad range of design parameters.

STu3M.6 • 14:45
Variable Astigmatism Corrector for High-Power Lasers, Seung-Whan Bahk[1], Brian Kruschwitz[1], Amy Rigatti[1], Jim Oliver[1], Jake Bromage[1]; [1]*Univ. of Rochester, USA*. We present a variable astigmatism corrector whose magnitude and sign in the astigmatism can be deterministically adjusted without separate wavefront measurement. The experimental results agree well with the calculation.

STu3N • Chemical Sensing—Continued

STu3N.5 • 14:00
Rapid Scanning Cavity Ring-down Spectrometer for the Precision Measurement of $^{13}C/^{12}C$ for CO_2 in Air, Adam J. Fleisher[1], Hongming Yi[1], Abneesh Srivastava[1], Hodges Joseph[1]; [1]*NIST, USA*. We report a dual-wavelength rapid scanning spectrometer with < 0.1 % measurement reproducability for $^{3}C/^{12}C$ isotope ratios in air. Initial evaluations of accuracy were performed using gas samples with known $\delta^{13}C$.

STu3N.6 • 14:15
High-Speed Line-Locked Heterodyne Phase Sensitive Dispersion Spectroscopy, Pedro Martín-Mateos[1], Jakob Hayden[1], Bernhard Lendl[1], Pablo Acedo[1]; [1]*Universidad Carlos III de Madrid, Spain*. We present a method for high-speed optical gas analysis based on an line-locked HPSDS system that enables data output rates that are unmatched by any directly comparable optical gas detection and analysis technique.

STu3N.7 • 14:30
Backscatter Absorption Gas Imaging with a Narrow-Linewidth Picosecond Optical Parametric Oscillator, Guillaume Walter[1], Jean-Baptiste Dherbecourt[1], Jean-Michel Melkonian[1], Myriam Raybaut[1], Didier Henry[1], Cyril Drag[2], Antoine Godard[1]; [1]*ONERA - The French Aerospace Lab, France;* [2]*Laboratoire de Physique des Plasmas, France*. Backscatter absorption gas imaging of nitrous oxide at atmospheric pressure is carried out with a narrow-linewidth OPO tunable over 215 nm around 3.82 µm in 130 ms. This setup is promising for multi-species gas-leak detection.

STu3N.8 • 14:45
Optical Cavity Mode Measurements at Hz-Level Precision With a Comb-Based VIPA Spectrometer, Grzegorz A. Kowzan[1], Dominik Charczun[1], Agata Cygan[1], Ryszard S. Trawinski[1], Daniel Lisak[1], Piotr Maslowski[1]; [1]*Nicolaus Copernicus Univ. , Poland*. We present cavity mode width and frequency measurements over 60-cm^{-1} range at Hz-level precision. We utilize a near-infrared frequency comb and a VIPA spectrometer to retrieve absorption and dispersion of a CO-N_2 sample in a high-finesse cavity.

JTu3O • Laser Modification of Materials—Continued

JTu3O.5 • 14:00 Invited
Laser Hyperdoping Silicon for Infrared Optoelectronics,, Jeffrey Warrender[1]; [1]*US Army, ARDEC RDECOM, USA*. Silicon may be laser hyperdoped with transition metals above the equilibrium solubility. I will describe this process and the optical and optoelectronic properties of layers fabricated with it, emphasizing the most promising hyperdopant, gold.

JTu3O.6 • 14:30
Evaluating carrier lifetimes in laser hyperdoped silicon using terahertz spectroscopy, Senali Dissanayake[1], Philippe Chow[2], Shao Qi Lim[3], Matthew Wilkins[4], Eduard Dumitrescu[4], Wenjie Yang[3], Quentin Hudspeth[2], Jacob Krich[4], Jim Williams[3], Jeffrey Warrender[2], Renee Sher[1]; [1]*Dept. of Physics, Wesleyan Univeristy, USA;* [2]*U.S. Army ARDEC - Benet Labs, USA;* [3]*Research School of Physics and Engineering, The Australian National Univ., Australia;* [4]*Dept. of Physics, Univ. of Ottawa, Canada*. Silicon doped with gold at supersaturated concentrations is promising for infrared photodetectors and photovoltaic applications. Ion implantation followed by pulsed laser processing creates high quality hyperdoped material, and we investigate material properties using terahertz spectroscopy.

JTu3O.7 • 14:45
Silicon nanofibers formed at room temperature following laser irradiation of silicon in SF6, Jeffrey Warrender[1], Quentin Hudspeth[1], Philippe Chow[1], Stephen Bartolucci[1], Joshua Maurer[1]; [1]*US Army, ARDEC RDECOM, USA*. Silicon nanofibers were observed to form after several months at room temperature following laser irradiation of silicon in SF6 in an aluminum chamber.

15:00–17:00 Coffee Break & Exhibit Only Time, *Exhibit Hall*

15:30–17:00 Meet the OSA Editors Reception, *Exhibit Hall, #2425*

CLEO: Science & Innovations

STu3P • Precision Spectroscopy—Continued

STu3P.4 • 14:00
Broadband Complex Refractive Index Spectroscopy via Measurement of Cavity Modes, Alexandra C. Johansson[1], Lucile Rutkowski[1], Anna Filipsson[1], Thomas Hausmaninger[1], Gang Zhao[1,2], Ove Axner[1], Aleksandra Foltynowicz[1]; *[1]Umeå Univ., Sweden; [2]Shanxi Univ., China.* We retrieve high precision absorption and dispersion spectra of the $3v_1+v_3$ band of CO_2 from direct measurement of cavity transmission modes using an optical frequency comb and a mechanical Fourier transform spectrometer with sub-nominal resolution.

STu3P.5 • 14:15
Application of Cavity-Enhanced Comb-Based Fourier-Transform Spectroscopy to Line Shape Study of Carbon Monoxide in Argon, Akiko Nishiyama[2,1], Grzegorz Kowzan[2], Dominik Charczun[2], Vinicius S. Oliveira[3], Axel Ruehl[3,4], Ingmar Hartl[3], Kaoru Minoshima[1], Ryszard S. Trawinski[2], Piotr Maslowski[2]; *[1]Univ. of Electro-Communications, Japan; [2]Inst. of Physics, Faculty of Physics, Astronomy and Informatics, Nicolaus Copernicus Univ. in Torun, Poland; [3]Deutsches Elektronen-Synchrotron (DESY), Germany; [4]Leibniz Univ. Hannover, QUEST-Leibniz-Research School, Inst. for Quantum Optics, Germany.* We performed measurements of overtone band of CO using cavity-enhanced Fourier-transform spectrometer with sub-nominal resolution. The system's performance allows to study collisional effects not described by the Voigt profile and precise determination of line parameters.

STu3P.6 • 14:30
CO_2 Line Parameter Retrieval Beyond the Voigt Profile Using Comb-Based Fourier Transform Spectroscopy, Alexandra C. Johansson[1], Anna Filipsson[1], Lucile Rutkowski[1], Piotr Maslowski[2], Aleksandra Foltynowicz[1]; *[1]Umeå Univ., Sweden; [2]Nicolaus Copernicus Univ. , Poland.* We measure absorption spectra of the CO_2 $3v_1+v_3$ band at 1.57 μm using optical frequency comb Fourier transform spectroscopy with sub-nominal resolution and retrieve line shape parameters using multiline fitting with the speed-dependent Voigt profile.

STu3Q • Advances in VCSELs—Continued

STu3Q.4 • 14:00
36 Gb/s Error Free Modulation of 850nm Monolithic Injection Locked VCSEL Arrays, Harshil Dave[1], Peicheng Liao[2], Stewart Fryslie[3], Zihe Gao[1], Bradley J. Thompson[1], Alan E. Willner[2], Kent D. Choquette[1]; *[1]Univ. of Illinois, USA; [2]Electrical Engineering, Univ. of Southern California, USA; [3]Freedom Photonics, USA.* We report direct modulation of 2x1 proton-implanted index-confined photonic crystal coherently-coupled VCSEL array operating error free at 36 Gb/s. The high-speed modulation is attributed to modulation-bandwidth enhancement.

STu3Q.5 • 14:15
Air-Cavity Dominated HCG-VCSEL with a Wide Continuous Tuning, Jonas Kapraun[1], Jipeng Yi[1], Jiaxing Wang[1], Philippe Tingzon[2], Kevin Cook[1], Emil Kolev[1], Larry Coldren[3], Connie J. Chang-Hasnain[1]; *[1]Dept. of Electrical Engineering and Computer Sciences and Tsinghua-Berkeley Shenzhen Inst., UC Berkeley, USA; [2]Univ. of the Philippines – Diliman, Philippines; [3]Electrical and Computer Engineering, UC Santa Barbara, USA.* We present continuously tuned emission of 940-1000 nm wavelength from an electrically-pumped VCSEL without top DBR layers via an electrostatically controlled HCG mirror. Large tuning range results from a high optical intensity in the air cavity.

STu3Q.6 • 14:30
Novel Oxide Spacer High-Contrast Grating VCSELs, Kevin T. Cook[1], Jipeng Qi[1], Jiaxing Wang[1], Neil Cabello[2,1], Connie J. Chang-Hasnain[1,3]; *[1]Univ. of California, Berkeley, USA; [2]Univ. of the Philippines Diliman, Philippines; [3]Tsinghua-Berkeley Shenzhen Inst., China.* VCSELs using high-contrast grating mirrors defined by wet oxidation of an AlGaAs spacer layer are demonstrated. The devices, operating near 960nm, have threshold current as low at 0.6mA and peak power as high as 1mW.

STu3Q.7 • 14:45
Control and Simulation of Coherent Array Modes in Vertical Cavity Laser Arrays, Bradley J. Thompson[1], Zihe Gao[1], Harshil Dave[1], Stewart Fryslie[2], Katherine Lakomy[1], Kent D. Choquette[1]; *[1]Univ. of Illinois, USA; [2]Freedom Photonics, USA.* A 3x1 vertical-cavity surface-emitting laser array is resonantly tuned to multiple coherent modes. Experimental near-field and far-field coherent modes profiles are characterized and simulated. The center element bias demonstrates control of the coherent mode.

CLEO: Applications & Technology

ATu3R • A&T Topical Review on Advanced Applications of Laser Radar and Remote Sensing I—Continued

ATu3R.4 • 14:00 Invited
Recent Advances in Single Photon Sensitive Mapping Lidars, Jacobo Marcos Sirota[1], John Degnan[1], Joshua Gluckman[1], Ed Leventhal[1], Spencer Disque[1]; *[1]Sigma Space Corp, USA.* Latest developments in single-photon-sensitive based mapping systems are presented, including detection, timing, intensity measurement, multi-photon bias correction, and near real time processing techniques. Performance is evaluated from data collected in a variety of urban and natural landscapes.

ATu3S • A&T Topical Review on Advances in Supercontinuum Technologies I: Supercontinuum Generation—Continued

ATu3S.3 • 14:00 Invited
The Development of Tailored Supercontinuum Sources in Silica and Non-silica Fibers, Jonathan H. Price[1], Sijing Liang[1], Lin Xu[1], Qiang Fu[1], Yongmin Jung[1], Krzysztof P. Herdzik[1,2], Sumeet Mahajan[2], David Shepherd[1], David Richardson[1], Shaif-Ul Alam[1]; *[1]Optoelectronics Research Centre, Univ. of Southampton, UK; [2]Inst. for Life Sciences, Univ. of Southampton, UK.* Applications such as bio-imaging and mid-IR sensing demand tailored sources often using different fibers as their basis. A review of source development work using silica and non-silica fibers will be presented with relevant underpinning concepts.

ATu3S.4 • 14:30 Invited
Supercontinuum from Labs to Factories, Peter Moselund[1], Patrick Bowen[1], Magalie Bondu[1], Lucy Hooper[2], Adam Devine[2]; *[1]NKT Photonics Inc, Denmark; [2]NKT Photonics UK, UK.* We review recent trends in supercontinuum research and the challenges involved in maturing supercontinuum from being a cutting edge lab instrument replacing exotic lasers to an industrially mature light source in its own right.

15:00–17:00 Coffee Break & Exhibit Only Time, *Exhibit Hall*

15:30–17:00 Meet the OSA Editors Reception, *Exhibit Hall, #2425*

CLEO: QELS-Fundamental Science

17:00–19:00
FTu4A • Quantum Information Processing
Presider: Michael Brodsky; U.S. Army Research Lab, USA

FTu4A.1 • 17:00 Tutorial

Large Scale Quantum Simulations Using Ultracold Atomic Gases in Optical Lattices, Immanuel Bloch[1,2]; [1]*Quantum Many-Body Systems Division, Max-Planck-Institut fur Quantenoptik, Germany;* [2]*Physics, Ludwig Maximilians Univ., Germany.* Large scale quantum simulations in computationally intractable regimes offer the opportunity to address fundamental problems across different fields of science. I will introduce the field of atomic quantum simulations with ultracold atoms.

Immanuel Bloch is scientific director at the Max Planck Institute of Quantum Optics (Garching) and professor at the Ludwig-Maximilians-University (Munich). His scientific work is among the most highly cited in the field of quantum physics and has helped to open the new interdisciplinary research field of quantum simulations.

FTu4A.2 • 18:00

Quantum vs. Optical Annealing: Benchmarking the OPO Ising Machine and D-Wave, Ryan Hamerly[2,1], Takahiro Inagaki[3], Peter L. McMahon[4,1], Davide Venturelli[5], Alireza Marandi[4], Tatsuhiro Onodera[4], Edwin Ng[4], Eleanor Rieffel[5], M. M. Fejer[4], Shoko Utsunomiya[1], Hiroki Takesue[3], Yoshihisa Yamamoto[6]; [1]*National Inst. for Informatics, USA;* [2]*Research Lab of Electronics, MIT, USA;* [3]*NTT Basic Research Labs, Japan;* [4]*Applied Physics, Stanford Univ., USA;* [5]*NASA Ames Research Center, USA;* [6]*Japan Science and Technology Agency, Japan.* We benchmark the OPO-based Coherent Ising Machine (CIM) against the D-Wave quantum annealer for Ising problems up to size N=200. The CIM exhibits exponential speedup relative to D-Wave for Ising problems with dense connectivity.

CLEO: Science & Innovations

17:00–19:00
STu4B • Wavelength and Phase-sensitive Integrated Devices
Presider: Haisheng Rong; Intel, USA

STu4B.1 • 17:00

MEMS-Actuated 8x8 Silicon Photonic Wavelength-Selective Switches with 8 Wavelength Channels, Tae Joon Seok[1,2], Jianheng Luo[2], Zhilei Huang[2], Kyungmok Kwon[2], Johannes Henriksson[2], John Jacobs[3], Lane Ochikubo[3], Richard Muller[2], Ming C. Wu[2]; [1]*Gwangju Inst. of Science and Technol, South Korea;* [2]*EECS, Univ. of California, Berkeley, USA;* [3]*TSI Semiconductors, USA.* We report on a fully integrated 8x8 silicon photonic MEMS wavelength-selective switch with 8 wavelength channels on a 9.7mm x 6.7mm chip. Total on-chip loss including switches and echelle grating mux/demux is 13.3 dB.

STu4B.2 • 17:30

CMOS-Compatible Optical Phased Arrays with Monolithically-Integrated Erbium Lasers, Jelena Notaros[1], Nanxi Li[1,2], Christopher V. Poulton[1], Zhan Su[1], Matthew Byrd[1], Emir Magden[1], Michael Watts[1]; [1]*MIT, USA;* [2]*Harvard Univ., USA.* An electronically-steerable integrated optical phased array powered by an on-chip erbium-doped laser is experimentally demonstrated. This system represents the first demonstration of a rare-earth-doped laser monolithically integrated with an active CMOS-compatible silicon photonics system.

STu4B.3 • 17:45

Silicon Photonic 50GHz Wavelength (De)Multiplexer with Low Crosstalk and Flat Passband, Liangshun Han[1], Bill P. Kuo[1], Motohiko Eto[1], Ana Pejkic[1], Jin Zhang[1], Nikola Alic[1], Stojan Radic[1]; [1]*Dept. of Electrical and Computer Engineering, Univ. of California, San Diego, USA.* We demonstrated an eight-channel flat-topped wavelength (de)multiplexer with 50GHz channel spacing on a SOI chip. The measured crosstalk is < −26.0 dB at central wavelengths of the channels and 1-dB bandwidth is 33.0 GHz.

STu4B.4 • 18:00

Reconfigurable Mode (De)multiplexer with Integrated Thermo-Optic Long-Period Grating and Y-junction, Wei ke Zhao[1], Jing Feng[1], Kaixin Chen[1], Kin S. Chiang[2]; [1]*Univ of Electronic Science & Tech China, China;* [2]*City Univ. of Hong Kong, China.* We demonstrate reconfigurable mode (de) multiplexing with an integrated thermo-optic long-period grating and an asymmetric Y-junction. Our fabricated device achieves a mode selectivity >12 dB over the C+L band with a switching power of 198 mW.

17:00–19:00
STu4C • Nonlinearity Compensation
Presider: Vladimir Grigoryan; Ciena Corporation, USA

STu4C.1 • 17:00

Nonlinearity Compensation for Dual-Polarization Signals using Optical Phase Conjugation in a Silicon Waveguide, Francesco Da Ros[1], Edson P. da Silva[1], Andrzej Gajda[2], Pawel M. Kaminski[1], Valentina Cristofori[1], Anna Peczek[3], Andreas Mai[2], Klaus Petermann[4], Lars Zimmermann[2], Leif K. Oxenlowe[1], Michael Galili[1]; [1]*DTU Fotonik, Denmark;* [2]*IHP, Germany;* [3]*IHP Solutions , Germany;* [4]*TU Berlin, Germany.* Improvements in signal-to-noise ratio (1.2 dB) and transmission reach (16 %) are demonstrated for dual-polarization WDM 16-QAM signals through nonlinearity compensation by optical phase conjugation in a silicon waveguide with a lateral p-i-n diode.

STu4C.2 • 17:15

Experimental Comparison of Probabilistic Shaping with online PMF Optimization and Mid-link OPC, Metodi Yankov[1,2], Francesco Da Ros[1], Edson P. da Silva[1], Michael Galili[1], Leif K. Oxenlowe[1]; [1]*DTU Fotonik, Denmark;* [2]*Fingerprint Cards ApS, Denmark.* Gains offered by mid-link OPC and probabilistic shaping are compared in a dispersion-managed link with 64QAM input. Probabilistic shaping is optimized online and tailored to the specific channel and transceiver conditions, including the OPC stage.

STu4C.3 • 17:30

Polarization-Division-Multiplexed Nonlinear Frequency Division Multiplexing, Tao Gui[1,2], Wasyhun A. Gemechu[1,3], Jan-Willem Goossens[1,4], Mengdi Song[1], Stefan Wabnitz[3], Mansoor I. Yousefi[1], Hartmut Hafermann[4], Alan Pak Tao Lau[2], Yves Jaouen[1]; [1]*LTCI, Telecom ParisTech, Université Paris-Saclay, France;* [2]*Photonics Research Centre, Dept. of Electrical Engineering, The Hong Kong Polytechnic Univ., China;* [3]*Dipartimento di Ingegneria dell'Informazione, Università di Brescia, Italy;* [4]*Mathematical and Algorithmic Sciences Lab, Paris Research Center, Huawei Technologies France SASU, France.* We experimentally demonstrate dual-polarization nonlinear frequency division multiplexing using the continuous spectrum in 1680 km of normal dispersion fiber at a burst rate of 128Gbit/s. The DGD penalties are shown to be negligible.

STu4C.4 • 18:00

Polarization Division Multiplexing for Nonlinear Fourier-Based Transmission Schemes, Stella Civelli[1,2], Jaroslaw E. Prilepsky[2], Marco Secondini[1], Sergei K. Turitsyn[2]; [1]*Tecip, Scuola Superiore Sant'Anna, Italy;* [2]*Aston Inst. of Photonic Technologies, Aston Univ., UK.* A polarization-division multiplexing transmission scheme based on the nonlinear Fourier transform is considered. A new dual-polarization processing technique with reduced complexity, providing 1dB performance improvement, is introduced.

CLEO: Science & Innovations

17:00–19:00
STu4D • Terahertz QCLs
Presider: Kaushik Sengupta; Princeton Univ., USA

STu4D.1 • 17:00
Octave-spaced on-chip THz frequency combs, Andres Forrer[1], Markus Rösch[1], Mattias Beck[1], Jérôme Faist[1], Giacomo Scalari[1]; [1]*ETH Zurich, Switzerland*. Latest results on frequency combs based on THz quantum cascade lasers will be presented including the monolithic integration of octave-spaced combs at 2.3 THz and 4.6 THz

STu4D.2 • 17:15
Terahertz Dual-Comb Spectroscopy Using Quantum Cascade Laser Frequency Combs, Jonas Westberg[1], Lukasz A. Sterczewski[1,2], Yang Yang[3], David Burghoff[3], Qing Hu[3], Gerard Wysocki[1]; [1]*Dept. of Electrical Engineering, Princeton Univ., USA;* [2]*Faculty of Electronics, Wroclaw Univ. of Science and Technology, Poland;* [3]*MIT, USA*. We demonstrate THz dual comb spectroscopy of molecular samples using dispersion compensated quantum cascade lasers. The system achieves an optical bandwidth of ~150 GHz at 2.9 THz and is used to measure ammonia in gas phase.

STu4D.3 • 17:30 Invited
THz Quantum Cascade Lasers and Combs, Mattias Beck[1], Martin Franckie[1], Lorenzo Bosco[1], Giacomo Scalari[1], Jérôme Faist[1]; [1]*Inst. for Quantum Electronics, ETH Zurich, Switzerland*. Recent developments of THz QCLs based on two-well and four-well active regions will be presented. The two-well structure demonstrated lasing up to 192K. The lasing spectrum of the four-well design spans over a bandwidth of 1.9 THz suitable for comb operation over a spectral bandwidth of 1.1 THz.

STu4D.4 • 18:00
Continuous frequency tuning of Y-branched terahertz quantum cascade lasers with photonic lattice, Iman Kundu[1], Paul Dean[1], Alexander Valavanis[1], Joshua R. Freeman[1], Mark Rosamond[1], Lianhe Li[1], Yingjun Han[1], Edmund H. Linfield[1], Alexander G. Davies[1]; [1]*Univ. of Leeds, UK*. We report electrically-controlled continuous frequency tuning over ~20 GHz by exploiting the additive Vernier tuning effect in a THz QCL based on a longitudinally-coupled Y-branched waveguide.

CLEO: QELS-Fundamental Science

17:00–19:00
FTu4E • Quantum and Non-local Plasmonics
Presider: Henri Lezec; NIST, USA

FTu4E.1 • 17:00
Engineering Infrared Quantum Fluctuations to Generate Light from UV through Gamma Rays, Nicholas Rivera[1], Liang Jie Wong[2], John Joannopoulos[1], Marin Soljacic[1], Ido Kaminer[3]; [1]*MIT, USA;* [2]*SimTECH, Singapore;* [3]*Technion Israel Inst. of Technology, Israel*. We show that plasmonic vacuum fluctuations can lead to a passive radiation source at UV to gamma ray energies. Its per-electron power is comparable to synchrotrons with a 1 Tesla field and is density-of-states tunable.

FTu4E.2 • 17:15
Nonlinear and Quantum-Light Scattering from Gold Nanorods, Theodore B. Norris[1], Miao-bin Lien[1], Benjamin Girodias[1], Ji-Young Kim[1], Zhen Xu[1], Heather George[1], You-Chia Chang[1], Myung-Geun Han[2], Yimei zhu[2], John Schotland[1], Nicolas Kotov[1], Mackillo Kira[1]; [1]*Univ. of Michigan, USA;* [2]*Brookhaven NL, USA*. We study the spectral dependence of the scattered light from Au nanorods illuminated by 50-fs pulses resonant with the longitudinal plasmon, and determine the origin of the scattering in terms of the plasmon modes. We project the expected spectrum under illumination from a squeezed optical pump.

FTu4E.3 • 17:30 Invited
Functional Quantum-Plasmonic Metamaterials/ Metasurfaces and Maximizing the Lorentz Nonlinearity, Reuven Gordon[1], Ghazal Hajisalem[1], Dao Xiang[1], Esmaeil Rahimi[1]; [1]*Univ. of Victoria, Canada*. We present two approaches to achieve massive changes in the optical properties of plasmonic metasurfaces by making use of quantum effects. We also demonstrate ways of maximizing the Lorentz nonlinearity beyond hydrodynamic contributions.

FTu4E.4 • 18:00
Strong Coupling of Excitons, Plasmonic and Photonic Modes in Organic-dye-doped Nanostructures, Ruwen Peng[1], Kun Zhang[1], Mu Wang[1]; [1]*Nanjing Univ., China*. We demonstrate experimentally hybrid strong couplings among molecular excitons, plasmonic and photonic modes in the organic-dye-doped nanostructures. And multiple hybrid polariton bands are observed, which may achieve potential applications on multimode polariton lasers and optical spectroscopy.

CLEO: Science & Innovations

17:00–19:00
STu4F • Nonlinear Optical Phononics & Optomechanics
Presider: Amol Choudhary; Univ. of Sydney, Australia

STu4F.1 • 17:00 Tutorial
Stimulated Brillouin Scattering: Then and Now, Elsa M. Garmire[1]; [1]*Dartmouth College, USA*. Stimulated Brillouin scattering (SBS) is embedded today in a variety of optical systems: advanced lasers, sensors, microwave signal processors, scientific instrumentation and opto-mechanical systems. Optical fibers and micro-resonators generate useful SBS.

Elsa Garmire is retired from Dartmouth College as Professor and Dean of Engineering. Member of National Academy of Engineering, IEEE and OSA Fellow, she studied semiconductor nonlinear optics at USC. As MIT graduate student, she reported the first SBS in liquids; now is writing a book on nonlinear optical technology.

STu4F.2 • 18:00
Brillouin Filtering with Enhanced Noise Performance and Linearity Using Anti-Stokes Interactions, Amol Choudhary[1], Yang Liu[1], David Marpaung[1], Benjamin Eggleton[1]; [1]*Univ. of Sydney, Australia*. The anti-Stokes component of a stimulated Brillouin scattering interaction enabled low-power and high-resolution bandpass filtering, with improvements in linearity and signal-to-noise ratio of upto 3dB and 8dB, respectively when compared to using the Stokes component.

CLEO: QELS-Fundamental Science

CLEO: Applications & Technology

17:00–19:00
FTu4G • Continuous Variable Quantum Computing
Presider: Martin Stevens; NIST, USA

FTu4G.1 • 17:00
On-Chip Continuous Variable Squeezing, Jasmin D. Meinecke[2], Genta Masada[3,4], Takahiro Serikawa[3], Jeremy L. O'Brien[1], Akira Furusawa[3]; [1]*Centre for Quantum Photonics, Univ. of Bristol, UK;* [2]*Max-Planck-Inst. for Quantum Optics, Germany;* [3]*Dept. Applied Physics, The Univ. of Tokyo, Japan;* [4]*Quantum ICT Research Inst., Tamagawa Univ., Japan.* We perform a squeezing transformation for continuous variable input states using a measurement-based scheme on chip. Implementing this fundamental transformation is an important building block for fully integrated continuous variable quantum information processing.

FTu4G.2 • 17:15
Multiphoton Hong-Ou-Mandel Interferometry with Entangled Photon-Subtracted States, Omar S. Magana Loaiza[1], Roberto Leon[2], Armando Perez-Leija[3], Alfred U'ren[2], Kurt Busch[3], Adriana E. Lita[1], Sae Woo Nam[1], Richard Mirin[1], Thomas Gerrits[1]; [1]*NIST, USA;* [2]*Universidad Nacional Autonoma de Mexico, Mexico;* [3]*Max-Born-Institut, Germany.* We demonstrate generation of entangled photon-subtracted states and manipulation of their quantum fluctuations. The flexibility of our technique allows us to explore Hong-Ou-Mandel interferometry with mesoscopic states that resemble systems of entangled lasers.

FTu4G.3 • 17:30
Low-Latency Digital Feedforward for Universal Continuous-Variable Quantum Computation in Time Domain, Atsushi Sakaguchi[1], Hisashi Ogawa[1], Masaya Kobayashi[1], Shigenari Suzuki[1], Hidehiro Yonezawa[2], Elanor Huntington[3], Shuntaro Takeda[1], Jun-ichi Yoshikawa[1], Akira Furusawa[1]; [1]*Dept. of Applied Physics, School of Engineering, Univ. of Tokyo, Japan;* [2]*Centre for Quantum Computation and Communication Technology, School of Engineering and Information Technology, Univ. of New South Wales, Australia;* [3]*College of Engineering and Computer Science, The Australian National Univ., Australia.* We demonstrate a programmable optical quantum gate with a 25ns-latency digital feedforward. Such a flexible, stable, and fast feedforward enables large-scale universal continuous-variable quantum computation in time domain.

FTu4G.4 • 17:45
Scalable and Universal Quantum Computing with Continuous-Variable Gate Sequence in a Loop-Based Architecture, Shuntaro Takeda[1,2], Akira Furusawa[1]; [1]*Dept. of Applied Physics, The Univ. of Tokyo, Japan;* [2]*JST, PRESTO, Japan.* We propose a scalable scheme for optical quantum computing using continuous-variable quantum gates in a loop-based architecture. This architecture offers a universal gate set for both qubits and continuous variables with almost minimum resources.

FTu4G.5 • 18:00 Invited
Continuous-variable Quantum Computing: Scalable Designs and Fault Tolerance, Nicolas Menicucci[1]; [1]*Physics, RMIT Univ., Australia.* Continuous-variable (CV) cluster states are multimode-squeezed states that are resource states for measurement-based quantum computation. I will discuss recent experimental advances in producing large-scale CV cluster states and how to use them for fault-tolerant quantum computation.

17:00–19:00
FTu4H • Novel Solid State Systems for Quantum Optics
Presider: Marina Radulaski; Stanford Univ., USA

FTu4H.1 • 17:00
Formation of quantum emitter arrays in hexagonal Boron Nitride at room temperature, Nicholas Proscia[1,2], Zav Shotan[1], Harishankar Jayakumar[1], Prithvi Reddy[3], Michael Dollar[1], Audrius Alkauskas[4], Marcus Doherty[3], Carlos Meriles[1,2], Vinod M. Menon[1,2]; [1]*CUNY City College of New York, USA;* [2]*Physics, CUNY Graduate Center, USA;* [3]*Laser Physics Centre, Australian National Univ., Australia;* [4]*Center for Physical Science and Technology, Lithuania.* Room temperature quantum emitter arrays are created in hexagonal Boron Nitride (hBN) by deterministic activation via strain engineering on a nanopillar substrate. Emitters are localized at pillar edges where the hBN film undergoes maximum strain.

FTu4H.2 • 17:15
Lead-Related Quantum Emitters in Diamond, Matthew Trusheim[1], Noel Wan[1], Girish Malladi[2], Kevin Chen[1], Benjamin Lienhard[1], Hassaram Bakhru[2], Dirk . Englund[1]; [1]*Electrical Engineering and Computer Science, MIT, USA;* [2]*College of Nanoscale Science and Engineering, Univ. at Albany-State Univ. of New York, USA.* We investigate the optical properties of quantum emitters formed in diamond after the implantation of Pb and subsequent high-temperature annealing. We find narrow-band emission in two spectral ranges, indicating multiple classes of Pb-related color centers.

FTu4H.3 • 17:30 Invited
A Photonic Link for Donor Spin Qubits in Silicon, Stephanie Simmons[1]; [1]*Simon Fraser Univ., Canada.* This talk presents an approach to scale up donor spin qubits in silicon using the built-in, spin-selective, strong electric dipole (optical) transitions of singly-ionized double donors. This photonic link could enable photonic cavity-QED at 4.2K.

FTu4H.4 • 18:00
Miniaturizing Rare-Earth Ion Microwave to Optical Transducers, John G. Bartholomew[1], Jake Rochman[1], Jonathan Kindem[1], Tian Zhong[1], Ioana Craiciu[1], Andrei Ruskuc[1], Andrei Faraon[1]; [1]*Caltech, USA.* We present the development of an on-chip rare-earth ion architecture that integrates planar microwave elements and photonic structures to realize coherent microwave to optical transduction.

17:00–19:00
ATu4I • Combustion and Hypersonic Flow Diagnostics
Presider: Brian Simonds; National Inst. of Standards and Tech, USA

ATu4I.1 • 17:00
Spatially-resolved hydrogen atom detection in flames using backward lasing, Maria Ruchkina[1], PengJi Ding[1], Andreas Ehn[1], Marcus L.E. Alden[1], Joakim Bood[1]; [1]*Lund Univ., Sweden.* We report on an experimental demonstration of spatially-resolved detection of atomic hydrogen in flames using a single-ended configuration. The lasing signal in a backward direction is obtained by two-photon pumping with 205-nm femtosecond laser pulses

ATu4I.2 • 17:15 Invited
Translating Novel Optical Diagnostics to Air Force–Relevant Systems, James R. Gord[1]; [1]*Air Force Research Lab, USA.* Measurements with lasers and optics are often ideal for characterizing nonreacting and reacting flows, including those in aero propulsion systems. Approaches based on ultrashort-pulse and burst-mode lasers, especially for multidimensional, high-speed imaging, will be explored.

ATu4I.3 • 17:45
Spatially Resolved Raman Spectra of Diffusion Flame via Compressive Sensing, David J. Starling[1], Joseph Ranalli[1]; [1]*Univ. College, Penn State Univ., USA.* We simulate compressive sensing on spatially resolved Raman scattering measurements of a highly strained diffusion flame. Simulations agree with prior data, enabling the use of lower cost sensors in a simplified form of the experiment.

ATu4I.4 • 18:00
Hypersonic Flow Velocity Measurements Using FLEET, Laura Dogariu[2,3], Arthur Dogariu[1], Mike Smith[4], Eric Marineau[4], Richard B. Miles[2,1]; [1]*Princeton Univ., USA;* [2]*Plasma TEC, Inc., USA;* [3]*Speckodyne Corp., USA;* [4]*AEDC White Oak, USA.* We developed and applied a Femtosecond Laser Electronic Excitation Tagging (FLEET) system to nonintrusive flow velocity measurements in a large scale hypersonic wind tunnel. Freestream and boundary layer velocity measurements are compared with model predictions.

CLEO: Applications & Technology

17:00–19:00
ATu4J • Medical Devices & Systems
Presider: Ilko Ilev; U.S. Food and Drug Administration , USA

ATu4J.1 • 17:00 Invited
Machine Learning and Computation Enabled Microscopy and Sensing for Point-of-Care Medicine and Global Health, Aydogan . Ozcan[1]; [1]*Univ. of California Los Angeles, USA.* We review some of our recent progress on mobile microscopy, sensing and diagnostics technologies that utilize computational photonics and machine learning approaches to address point-of-care medicine and global health related applications.

ATu4J.2 • 17:30 Invited
Progress in the Development of All-Solid-State Coherent Sources in the Mid-IR above 5 µm for Surgical Applications, Valentin Petrov[1]; [1]*Max Born Inst., Germany.* I will review the state-of-the-art and the recent progress in all-solid-state parametric frequency down-conversion devices for achieving high pulse energy and average power in the 5 to 8 µm spectral range interesting for medical applications.

ATu4J.3 • 18:00
Microlens-Stabilized Laser Arrays for Short-Pulse, Speckle-Free Imaging, Austin W. Steinforth[1], José A. Rivera[1], J G. Eden[1]; [1]*Univ of Illinois at Urbana-Champaign, USA.* Microlens-stabilized laser arrays were constructed using solid-state and liquid gain media. Arrays comprised of more than 1,200 beams illuminated motile biological specimens, producing speckle-free video with 15 nanosecond exposure per frame.

CLEO: Science & Innovations

17:00–19:00
STu4K • Fiber Frequency Combs
Presider: Masaki Tokurakawa; Univ. of Electro-communications,ILS, Japan

STu4K.1 • 17:00
Fast phase locking of a 750-MHz Yb:fiber laser frequency comb using a high-speed piezo-transducer, Yuxuan Ma[1,2], Bo Xu[1,3], Hirotaka Ishii[1], Fei Meng[2], Yoshiaki Nakajima[1,3], Thomas R. Schibli[4], Isao Matsushima[1,3], Zhigang Zhang[2], Kaoru Minoshima[1,3]; [1]*Dept. of Engineering Science, Graduate School of Informatics, The Univ. of Electro-Communications, Japan;* [2]*State Key Lab of Advanced Optical Communication System and Networks, School of Electronics Engineering and Computer Science, Peking Univ., China;* [3]*Japan Science and Technology Agency, ERATO Intelligent Optical Synthesizer (IOS) Project, Japan;* [4]*Dept. of Physics, Univ. of Colorado at Boulder, USA.* We demonstrate a 750-MHz-spaced Yb:fiber frequency comb phase locked to a narrow linewidth CW laser by a single stack PZT actuator. Low phase noise and high stability were achieved by the fast phase locking.

STu4K.2 • 17:15
Generation of 250-MHz electro-optic frequency comb for Doppler-limited spectroscopy, Wang Shuai[1], Xinyu Fan[1], Bingxin Xu[1], Zuyuan He[1]; [1]*Shanghai Jiao Tong Univ., China.* We proposed a cascaded modulation method for electro-optic frequency comb generation. With this method, electro-optic frequency combs with 250-MHz line spacing covering 4,000 teeth were generated, which enable Doppler-limited spectroscopy.

STu4K.3 • 17:30 Invited
Precision Measurements with Ultra-Low Noise Frequency Combs, Wolfgang Hänsel[1], Michele Giunta[1,2], Katja Beha[1], Matthias Lezius[1], Maurice Lessing[1], Marc Fischer[1], Ronald Holzwarth[1,2]; [1]*Menlo Systems GmbH, Germany;* [2]*Max-Planck Inst. of Quantum Optics, Germany.* The advent of long-term stable ultra-low noise (ULN) frequency combs opens new prospects for precision measurements. We characterize the stability of such ULN combs and present dual-comb precision spectroscopy of molecules and cavities.

STu4K.4 • 18:00
All-Polarization-Maintaining Dual-Comb Fiber Laser with Nonlinear Amplifying Loop Mirror, Yoshiaki Nakajima[1,2], Yuya Hata[1], Kaoru Minoshima[1,2]; [1]*Univ. of Electro-Communications, Japan;* [2]*IOS Project, Japan.* We demonstrate an all-polarization-maintaining dual-comb fiber laser with nonlinear-amplifying-loop-mirror for realizing simple and robust dual-comb spectroscopy using two mutually coherent combs with slightly different repetition rates emitted from the laser cavity without complex servo system.

Joint

17:00–19:00
JTu4L • Symposium on Multimodal and Molecular Contrast Optical Imaging II
Presider: Wolfgang Drexler; Medizinische Universität Wien, Austria

JTu4L.1 • 17:00 Tutorial
Bringing Functional High Resolution Diagnostics to the Bedside Using Multimodal, Label-free, Two-photon Imaging, Irene Georgakoudi[1], Dimitra Pouli[1], Zhiyi Liu[1], Mihaela Balu[2], Bruce Tromberg[2]; [1]*Tufts Univ., USA;* [2]*Univ. of California at Irvine, USA.* Changes in optical metabolic signals related to the intensity, lifetime and spatial localization of endogenous fluorescence are associated with alterations in specific biosynthetic and bioenergetic cellular pathways, which can serve as diagnostic and therapeutic targets.

Irene Georgakoudi is a Professor of Biomedical Engineering at Tufts University. Her work focuses on the understanding and exploitation of endogenous fluorescence and scattering signals in two-photon microscopy to extract highly quantitative, functional information regarding cellular metabolism and matrix biomechanics. She is an OSA and AIMBE fellow.

JTu4L.2 • 18:00 Invited
Combined Optical Coherence Tompgraphy and Near Infrared Fluorescence of Cancer-specific Antibodies, Johannes de Boer[1]; [1]*Vrije Univ Amsterdam, Netherlands.* Optical coherence tomography provides structural and functional information of in vivo tissue but lacks molecular contrast. We demonstrate combined endoscopic OCT and immuno-fluorescence targeting a human colon cancer cell line metabolized in a mouse model.

CLEO: Applications & Technology

17:00–19:00
ATu4M • Thin Film & Metrology for Laser Processing
Presider: TBD

ATu4M.1 • 17:00 Invited
Laser Annealing of Thin Si Films for Displays and Other Applications, James S. Im[1]; [1]*Columbia Univ., USA.* In this talk, we will (1) discuss deciphering the currently utilized excimer-laser annealing (ELA) process, and (2) present a newly developed ultra-high-frequency fiber-laser-based crystallization approach, which is referred to as the spot-beam crystallization (SBC) method.

ATu4M.2 • 17:30
Improved Performance & Thermal Stability in Plasmonic Films with Thinner Adhesion & Capping Layers, William M. Abbott[1], Christopher P. Murray[1], Chuan Zhong[1], Christopher M. Smith[1], David McCloskey[1], John F. Donegan[1]; [1]*School of Physics, Crann & Amber, Trinity College Dublin, Ireland.* Ultrathin (≥0.5 nm) adhesion and capping layers were used to inhibit dewetting in 50 nm Au thin films. A 1500x stability enhancement was found over standard 2 nm adhesion Ti layers used in HAMR.

ATu4M.3 • 17:45
Roughness measurements of Al and Cu particles in Laser-Induced forward transferring process, Mohammad Hossein Azhdast[1], Hans Joachim Eichler[1], Klaus-Dieter Lang[2], Veronika Glaw[2], Martin Kossatz[3]; [1]*Technical Univ. of Berlin, Germany;* [2]*IZM Fraunhofer, Germany;* [3]*PacTech GMBH, Germany.* Cu and Al particles were optimized to create thin films by laser direct transfer on Si-wafer substrate with minimal measured roughness; Cu-LIFT results are especially promising at high repetition rates and minimal pulse energy.

ATu4M.4 • 18:00
Tracking the Morphology Evolution of 3D Selective Laser Melting *in situ* using Inline Coherent Imaging., Tristan G. Fleming[1], Stephen Nestor[1], Mark Boukhaled[1], Troy Allen[1], Nathan Smith[1], James Fraser[1]; [1]*Queen's Univ., Canada.* We demonstrate the utility of inline coherent imaging, an interferometric imaging technique, in monitoring 3D selective laser melting additive manufacturing builds. Interlayer morphology is demonstrated to be a promising candidate for real-time process control.

CLEO: Science & Innovations

17:00–19:00
STu4N • 2D Materials in Photonic Structures
Presider: Luca Sapienza; Univ. of Southampton, UK

STu4N.1 • 17:00 Invited
Nanoscale Optical Field Topology, from Fascination to Application, Laurens K. Kuipers[1]; [1]*Quantum Nanoscience, Kavli Inst. of Nanoscience Delft, Netherlands.* We investigate the distribution of phase singularities and observe their life-long fidelity or promiscuity. We exploit optical spin-momentum locking to create a deterministic interface between valley spin in a 2D material and plasmon propagation direction.

STu4N.2 • 17:30
Monolayer Semiconductor Surface-Emitting Lasers Using 2D Dark Plasmonic Cavities, Chun-Yuan Wang[2,1], Jinwei Shi[4], Soniya S. Raja[1], Chun-An Chen[6], Xin-Quan Zhang[6], Chih-Kang Shih[2], Hyeyoung Ahn[5], Yi-Hsien Lee[6], Shangjr Gwo[1,3]; [1]*Dept. of Physics, National Tsing-Hua Univ., Taiwan;* [2]*Dept. of Physics, Univ. of Texas at Austin, USA;* [3]*National Synchrotron Radiation Research Center, Taiwan;* [4]*Dept. of Physics, Beijing Normal Univ., China;* [5]*Dept. of Photonics, National Chiao-Tung Univ., Taiwan;* [6]*Dept. of Materials Science and Engineering, National Tsing-Hua Univ., Taiwan.* We demonstrated a low-threshold lasing from a monolayer gain medium which is made possible due to 2D feedback mechanism via strong exciton-SPP coupling in both real space and a wide range of momentum space.

STu4N.3 • 17:45
Coupling of Photonic Fano Resonances with MoS_2 Excitons for Enhanced Light Emission and Optical Modulation, Xingwang Zhang[1], Nicolas Biekert[1], Shinhyuk Choi[1], Carl H. Naylor[2], Chawina De-Eknamkul[1], Wenzhuo Huang[1], Xiaorui Zheng[1], Dake Wang[1], A. T. Charlie Johnson[2], Ertugrul Cubukcu[1]; [1]*Univ. of California, San Diego, USA;* [2]*Univ. of Pennsylvania, USA.* We demonstrate unidirectional enhanced photoluminescence from a monolayer MoS_2 via Fano resonances in dielectric photonic crystals. The Fano resonances can also be dynamic controlled by optical and electrical tuning of the MoS_2 refractive index.

STu4N.4 • 18:00
Dynamics of Valley-Polarized Exciton-Polaritons in Monolayer MoS_2, Yen-Jung Chen[1], Itamar Balla[2], Hadallia Bergeron[2], Lei Liu[1], Mark C. Hersam[2], Nathaniel P. Stern[1]; [1]*Physics and Astronomy, Northwestern Univ., USA;* [2]*Materials Science & Engineering, Northwestern Univ., USA.* We investigate the dynamics of valley-polarized exciton-polaritons in monolayer MoS_2 embedded in a planar dielectric microcavity. We demonstrate both theoretically and experimentally that valley polarization of exciton-polaritons can be tuned with cavity parameters.

17:00–19:00
STu4O • Laser Facilities
Presider: Thomas Metzger; TRUMPF Scientific Lasers GmbH + Co. KG, Germany

STu4O.1 • 17:00
Towards Sub-2 cycle, Several-TW, 1kHz OPCPA System Based on Yb:KGW and Nd:YAG Lasers, Tomas Stanislauskas[1], Ignas Balciunas[1,2], Rimantas Budriunas[1,2], Jonas Adamonis[3], Szabolcs Toth[4], Adam Borzsonyi[4], Karoly Osvay[4], Andrejus Michailovas[3], Gediminas Veitas[1], Darius Gadonas[1]; [1]*Light Conversion Ltd., Lithuania;* [2]*Laser Research Center, Vilnius Univ., Lithuania;* [3]*Ekspla Ltd., Lithuania;* [4]*ELI-HU Nonprofit Ltd., Hungary.* We investigate nonlinear crystal type multiplexing as means of increasing the bandwidth of a parametric amplification system pumped at 532nm. Experimental results and numerical simulations indicate that sub-2 cycle pulse durations and multi-mJ pulse energies will be possible using BBO and LBO.

STu4O.2 • 17:15
Efficient and Wavelength Tunable Extreme-ultraviolet Light Source Used for Tr-ARPES, Zhiqiang Ni[1], Zhonghui Nie[1], Jian Tu[1], Yao Li[1], Xuezhong Ruan[1], Liang He[1], Edmond Turcu[1], Yongbing Xu[1]; [1]*Nanjing Univ., China.* Efficient and wavelength tunable extreme-ultraviolet source is developed through high harmonic generation by a frequency doubled Ti:sapphire and a monochromator with off-plane mount single grating. Photon flux of 1.2 x 10^{11} photons/s is achieved at 21.7 eV.

STu4O.3 • 17:30 Invited
Performance of the 20 fs, 4 PW Ti:Sapphire Laser at CoReLS, Chang Hee Nam[2,1]; [1]*Gwangju Inst of Science & Technology, South Korea;* [2]*Center for Relativistic Laser Science, Inst. for Basic Science, South Korea.* One of two petawatt Ti:Sapphire laser beamlines at CoReLS was upgraded to a high-contrast, 4 PW, 20 fs laser with a repetition rate of 0.1 Hz and its performance has been tested for multi-GeV electron acceleration.

STu4O.4 • 18:00
Highly-stable, 1 kHz, 200 mJ, 1.1 ps laser optically synchronized to a photocathode laser for inverse Compton scattering, Kyung-Han Hong[1,2], Sandro Klingebiel[3], Knut Michel[3], Thomas Metzger[3], Darius Gadonas[4], Karolis Neimontas[4], Vytautas Sinkevicius[4], Lucian Hand[4], Andrey Senin[4], Mark R. Holl[2], William Graves[2]; [1]*RLE, MIT, USA;* [2]*Physics and Bio-design Inst., Arizona State Univ., USA;* [3]*TRUMPF Scientific Lasers GmbH + Co. KG, Germany;* [4]*Light Conversion, Lithuania.* We demonstrate a highly-stable, 1 kHz, 200 mJ, 1.1 ps, 1030 nm laser with good beam quality as an inverse-Compton-scattering driver, optically synchronized with 33-fs rms jitter to a photocathode laser that triggers electron beams.

17:00–19:00
STu4P • Advanced Sensing Concepts
Presider: Adam Fleisher; NIST, USA

STu4P.1 • 17:00
Slow Light Imaging Spectroscopy with a Passive Atomic Filter , Arthur Dogariu[1], Richard B. Miles[1,2]; [1]*Princeton Univ., USA;* [2]*Texas A&M Univ., USA*. We demonstrate time delayed imaging with slow light using high positive dispersion of a passive atomic gas. This filter allows for imaging of Raman, Rayleigh, and Thomson scattering without the need of a spectrometer.

STu4P.2 • 17:15
Wide-Range Tunable Refractometer Based on Orbital Angular Momentum of Light, Ahmed Dorrah[1], Michel Zamboni-Rached[2], Mo Mojahedi[1]; [1]*Dept. of Electrical and Computer Engineering, Univ. of Toronto, Canada;* [2]*School of Electrical Engineering, Univ. of Campinas, Brazil*. We experimentally demonstrate a programmable refractive index sensor utilizing orbital angular momentum of light where the sensitivity, resolution, and dynamic range can be controlled in real-time, thus addressing many challenges in refractometry and remote sensing.

STu4P.3 • 17:30
Coherent Spatiotemporal Phase Control by Combining Optical Frequency Combs and Optical Vortices, Akifumi Asahara[1,2], Satoru Shoji[1,2], Ken-ichi Kondo[1,2], Yue Wang[1,2], Kaoru Minoshima[1,2]; [1]*Univ. of Electro-Communications, Japan;* [2]*JST, Intelligent Optical Synthesizer, Japan*. "Optical vortex comb" is proposed, that enables coherent spatiotemporal phase control by combining optical frequency combs with optical vortices. The applicability is demonstrated through experiments on optical ring lattice control and optical tweezers.

STu4P.4 • 17:45
Nanoscale isotopic imaging and trace analysis by extreme ultraviolet laser ablation mass spectrometry, Carmen S. Menoni[1], Tyler Green[1], Ilya Kuznetsov[1], Weilun Chao[2], Jorge Rocca[1], Andrew Duffin[3]; [1]*Colorado State Univ., USA;* [2]*Center for X-Ray Optics, Lawrence Berkeley Lab, USA;* [3]*Pacific Northwest National Lab, USA*. Extreme ultraviolet laser ablation mass spectrometry isotopic imaging and analysis with 80 nm spatial resolution are demonstrated.

STu4P.5 • 18:00
Development of a Miniature Laser-induced Fluorescence Sensor Module used for Unmanned Aerial Vehicles, Supriya nagpal[1], Prakash Adhikari[1], William P. Williams[3], Gary L. Windham[2], Gerald A. Matthews[2], Aiunbold O. Gombojav[1]; [1]*Physics and Astronomy, Mississippi State Univ., USA;* [2]*USDA-ARS, Mississippi state univerisity, USA;* [3]*USDA-ARS, Mississippi State Univ., USA*. A versatile sensor module based on laser-induced fluorescence is constructed. The results demonstrate its ability to investigate stress in vegetation. Module is mounted on a quadcopter and flown with pre-planned missions making the task autonomous.

17:00–19:00
STu4Q • UV-visible Semiconductor Lasers
Presider: Boon Ooi; King Abdullah Univ of Sci & Technology, Saudi Arabia

STu4Q.1 • 17:00 Tutorial
III-Nitride Lasers – Challenges and Approaches to Expand the Emission Wavelength into the UV, Thomas Wunderer[1]; [1]*Palo Alto Research Center, USA*. In this tutorial we will review III-Nitride-based laser technology, discuss materials challenges using high band gap semiconductors, and present different approaches and tricks to overcome these barriers (i.e., polarization doping, e-beam excitation and frequency multiplication).

Thomas Wunderer is a Senior Member of Research Staff at the Palo Alto Research Center, CA with a PhD in EE from Ulm University, Germany. Since joining PARC in 2010, he has led various R&D projects developing novel optoelectronic materials, devices and sub-systems (incl. UV lasers for DARPA LUSTER, CMUVT).

STu4Q.2 • 18:00 Invited
Recent progress in GaN-based Vertical-Cavity Surface-Emitting Lasers Having Dielectric Distributed Bragg Reflectors, Hiroshi Nakajima [1], Jugo Mitomo[1], Kentaro Fujii[1], Masayuki Tanaka[1], Masamichi Ito[1], Maho Ohara[1], Noriko Kobayashi[1], Hideki Watanabe[1], Tatsushi Hamaguchi[1], Rintaro Koda[1], Hironobu Narui[1]; [1]*Sony Corporation, Japan*. The recent progress in GaN-based vertical-cavity surface-emitting lasers (VCSELs) having dielectric distributed Bragg reflectors, including the device characteristics of GaN-based VCSELs with a newly proposed cavity structure incorporating an atomically smooth curved mirror, is overviewed.

CLEO: QELS-Fundamental Science

FTu4A • Quantum Information Processing—Continued

FTu4A.3 • 18:15
Finding Non-Classical States that do not Generate Entanglement at a Beam Splitter, Aaron Z. Goldberg[1], Daniel James[1]; [1]*Univ. of Toronto, Canada.* A common way to generate modal entanglement uses beam splitters. We find a set of non-classical states that are not entangled by beam splitters. This is crucial for understanding entanglement generation for, e.g., boson sampling.

FTu4A.4 • 18:30
High speed device-independent quantum random number generation without detection loophole, Yang Liu[1], Xiao Yuan[1,2], Ming-Han Li[1], Weijun Zhang[3], Qi Zhao[2], Jiaqiang Zhong[4], Yuan Cao[1], Yu-Huai Li[1], Luo-Kan Chen[1], Tianyi Peng[2], Yu-Ao Chen[1], Cheng-Zhi Peng[1], Sheng-Cai Shi[4], Zhen Wang[3], Lixing You[3], Xiongfeng Ma[2], Jingyun Fan[1], Qiang Zhang[1], Jian-Wei Pan[1]; [1]*Univ. of Science and Technology of China, China;* [2]*Tsinghua Univ., China;* [3]*Shanghai Inst. of Microsystem and Information Technology, Chinese Academy of Sciences, China;* [4]*Purple Mountain Observatory and Key Lab of Radio Astronomy, Chinese Academy of Sciences, China.* We report an experimental study of device-independent quantum random number generation based on an detection-loophole free Bell test with entangled photons. After considering fluctuations and applying hashing, we achieve a random bit rate of 114 bits/s, with a failure probability less than 1E-5.

FTu4A.5 • 18:45
Two-Photon N-Party Quantum Secret Sharing, Warren P. Grice[1], Joseph M. Lukens[1], Nicholas A. Peters[1], Brian Williams[1]; [1]*Oak Ridge National Lab, USA.* We describe a multi-party quantum secret sharing protocol utilizing two-photon entangled states in which the source is one of the secret sharing participants. It is experimentally easier to realize than methods using GHZ states.

CLEO: Science & Innovations

STu4B • Wavelength and Phase-sensitive Integrated Devices—Continued

STu4B.5 • 18:15
Genetically optimized on-chip wideband ultracompact reflectors and Fabry–Pérot cavities, Zejie Yu[1], Haoran Cui[1], Xiankai Sun[1]; [1]*The Chinese Univ. of Hong Kong, Hong Kong.* We propose a new scheme for on-chip reflectors on the prevalent thin-film-on-insulator platform by using genetic algorithm optimization and experimentally demonstrated devices with footprint of 2.16μm×2.16μm and reflectivity >85% in the wavelength range of 1440-1640nm.

STu4B.6 • 18:30
Scalable Optical Phased Array with Sparse 2D Aperture, Reza Fatemi[1], Aroutin Khachaturian[1], Ali Hajimiri[1]; [1]*California Inst. of Technology, USA.* A scalable OPA with sparse 2D aperture is presented, achieving the highest reported grating-lobe-free FOV-to-beamwidth ratio (16°/0.8°). A PWM generator chip is designed to drive compact phase shifters with row-column layout to reduce power consumption.

STu4B.7 • 18:45
Experimental Realization of Floquet Engineered Topological Phase in Periodically-Curved Waveguide Arrays, Chaoshi Zhang[1], Q.Q. Cheng[1], Yiming Pan[2], Huaiqiang Wang[3], Tao Li[3], Shining Zhu[3]; [1]*Univ. of Shanghai for Science and Technology, China;* [2]*Tel Aviv Univ., Israel;* [3]*Nanjing Univ., China.* A photonic Floquet simulator was designed to investigate the engineered topological phase in a periodically-driven Su-Schrieffer-Heeger model. Experimentally, we firstly observed a new periodically-driven end state (π-mode), which only exists in special Floquet gauges.

STu4C • Nonlinearity Compensation—Continued

STu4C.5 • 18:15
Experimental Demonstration of Fiber-Nonlinearity Cancellation by Photonic Homodyne Down-Conversion in Conjugated-Paired Radio-on-Fiber System, Takahide Sakamoto[1], Guo-Wei Lu[2], Naokatsu Yamamoto[1]; [1]*National Inst of Information & Comm Tech, Japan;* [2]*Tokai univ., Japan.* We experimentally demonstrate fiber nonlinearity cancellation using photonic homodyne down conversion in conjugated-paired radio-on-fiber (C-RoF) system. 20-km SMF transmission of 156-Mb/s BPSK-C-RoF is demonstrated, naturally cancelling nonlinear phase shift without using digital signal processing.

STu4C.6 • 18:30
Signal-to-Idler Conversion Penalty in AlGaAs-on-Insulator Wavelength Converter, Pawel M. Kaminski[1], Francesco Da Ros[1], Edson P. da Silva[1], Minhao Pu[1], Metodi Yankov[1], Elizaveta Semenova[1], Kresten Yvind[1], Leif K. Oxenlowe[1], Søren Forchhammer[1], Michael Galili[1]; [1]*DTU Fotonik, Denmark.* A wavelength converter based on AlGaAsOI waveguide is characterized by varying the input signal quality. Signal-to-idler conversion penalty is measured in terms of effective received SNR, and trade-offs between penalty and converted signal quality are outlined.

19:00–20:30 OSA Technical Group Poster Session, *Room 230A/B*

CLEO: Science & Innovations

STu4D • Terahertz QCLs—Continued

STu4D.5 • 18:15
Amplitude Stabilization of a Terahertz Quantum Cascade Laser with an External Metamaterial Amplitude Modulator, Binbin Wei[1], Stephen J. Kindness[1], Nikita Almond[1], Robert Wallis[1], Yuqing Wu[1], Yuan Ren[2], Philipp Braeuninger-Weimer[3], Stephan Hofmann[3], Harvey Beere[1], David Ritchie[1], Riccardo Degl'Innocenti[4]; [1]*Cavendish Lab, Univ. of Cambridge, UK;* [2]*Purple Mountain Observatory, Chinese Academy of Sciences, China;* [3]*Dept. of Engineering, Univ. of Cambridge, UK;* [4]*Dept. of Engineering, Lancaster Univ., UK*. We demonstrate amplitude stabilization of a terahertz quantum cascade laser with a graphene loaded split-ring-resonator array, the transmission of which can be tuned to compensate the laser power fluctuation with a PID loop.

STu4D.6 • 18:30
Graphene Saturable Absorbers at Terahertz Frequency from Liquid Phase Exfoliation of Graphite, Leonardo Viti[4], Vezio Bianchi[1], Tian Carey[2], Lianhe Li[3], Edmund H. Linfield[3], Alexander G. Davies[3], Alessandro Tredicucci[5], Duhee Yoon[2], Panagiotis Karagiannidis[2], Lucia Lombardi[2], Flavia Tomarchio[2], Andrea Carlo Ferrari[2], Felice Torrisi[2], Miriam S. Vitiello[4]; [1]*Scuola Normale Superiore, Italy;* [2]*Cambridge Graphene Center, Univ. of Cambridge, UK;* [3]*School of Electronic and Electrical Engineering, Univ. of Leeds, UK;* [4]*Nanoscience, CNR, Italy;* [5]*Fisica, Università di Pisa, Italy.* We report on the development of terahertz (THz) saturable-absorbers exploiting printable graphene inks. The achieved 80% transparency modulation at 3.5 THz makes these devices potential candidates as passive components for THz solid-state lasers.

STu4D.7 • 18:45
Experimental Demonstration of 16dB Isolation at Room Temperature on a Magnetoplasmonic One-Way Mirror Exploiting THz Cyclotron Resonances in Narrow Gap Semiconductors, Oleksandr Stepanenko[2], Tomáš Horák[2,1], Jan Chochol[3,5], Kamil Postava[3,4], Jean-François Lampin[2], Mathias Vanwolleghem[2]; [1]*Universite de Lille 1, France;* [2]*THz Photonics, CNRS IEMN, France;* [3]*Nanotechnology Center, Technical Univ. Ostrava, Czechia;* [4]*IT4Innovations National Supercomputing Center, Czechia;* [5]*Dept. of Electrical and Computer Engineering, Dalhousie Univ., Canada*. We demonstrate experimentally a nonreciprocal magnetoplasmonic mirror that achieves room temperature isolation with a rejection rate of 16dB by combining the THz plasma frequency of intrinsic small-gap InSb with its strong THz cyclotron effects. At typical THz QCL temperatures this goes up to 25dB.

CLEO: QELS-Fundamental Science

FTu4E • Quantum and Non-local Plasmonics—Continued

FTu4E.5 • 18:15
Cooperative coupling of hot alkali vapors to surface plasmon: Towards room temperature quantum plasmonics with atomic media, Yoel Sebbag[1], Pankaj Arora[1], Yefim Barash[1], Uriel Levy[1]; [1]*Applied Physics, The Hebrew Univ. of Jerusalem, Israel, Israel*. We demonstrate cooperative coupling between hot vapors and surface plasmons with three-fold Purcell factor enhancement. Our result can be regarded as a major step in the quest for room temperature quantum plasmonics with atomic media.

FTu4E.6 • 18:30
Ultrabright Room-Temperature Emission from Single Plasmon-Enhanced Nitrogen-Vacancy Centers in Diamond, Simeon Bogdanov[1], Mikhail Y. Shalaginov[1,2], Alexei S. Lagutchev[1], Chin-Cheng Chiang[1], Deesha Shah[1], Alexander S. Baburin[3,4], Ilya A. Ryzhikov[3,5], Ilya A. Rodionov[3,4], Alexandra Boltasseva[1], Vladimir M. Shalaev[1]; [1]*Purdue Univ., USA;* [2]*Massachussets Inst. of Technology, USA;* [3]*FMNS REC, Bauman Moscow State Technical Univ., Russia;* [4]*Dukhov Research Inst. of Automatics, Russia;* [5]*Inst. for Theoretical and Applied Electromagnetics RAS, Russia*. We report unprecedentedly bright emission from single nitrogen-vacancy centers in nanodiamonds placed in gaps between a metal film and randomly dispersed metal nanoparticles. The detected fluorescence intensity reaches up to 50 million photons per second.

FTu4E.7 • 18:45
Photonic Crystal Slab Nanocavities from Bulk Single-Crystal Diamond, Noel Wan[1], Sara L. Mouradian[1], Dirk Englund[1]; [1]*MIT, USA*. We report on the fabrication of high-*Q* diamond photonic crystal (PC) slab cavities near the optical transition of the NV center. This process, which allows the production of 2D PC slabs directly on bulk diamond, significantly extends the toolbox for controlling light-matter interactions in diamond.

CLEO: Science & Innovations

STu4F • Nonlinear Optical Phononics & Optomechanics—Continued

STu4F.3 • 18:15
Electro-Opto-Mechanical Radio-Frequency Oscillator in a Multi-Core Fiber, Yosef London[1], Hilel Hagai Diamandi[1], Gil Bashan[1], Avi Zadok[1]; [1]*Bar-Ilan Univ., Israel*. An electro-opto-mechanical feedback loop is established across two cores of a multi-core fiber. Guided acoustic waves are stimulated into single-mode oscillations at 369 MHz with 400 Hz linewidth. Threshold behavior and spectral narrowing are observed.

STu4F.4 • 18:30
Raman-Dominant Supercontinuum Generation in Nitrogen-Filled Hollow-Core Negative Curvature Fiber Pumped by Picosecond Laser, Yingying Wang[1], Shoufei Gao[1], Pu Wang[1]; [1]*Beijing Univ. of Technology, China*. We present a novel scheme of supercontinuum generation in nitrogen-filled hollow-core negative-curvature fiber pumped by a 532 nm picosecond laser. 250 nm to 1200 nm supercontinuum is generated with total energy of tens microjoule.

19:00–20:30 OSA Technical Group Poster Session, *Room 230A/B*

CLEO: QELS-Fundamental Science

FTu4G • Continuous Variable Quantum Computing—Continued

FTu4G.6 • 18:30 Invited

Quantum Computing using Squeezed Light, Christian Weedbrook[1]; [1]*Xanadu, Canada*. Integrated photonics based on squeezed light offers a way to build a highly scalable, room temperature and energy efficient quantum computer. We will discuss the advances we are making here at Xanadu based on this exciting architecture.

FTu4H • Novel Solid State Systems for Quantum Optics—Continued

FTu4H.5 • 18:15

^{171}Yb:YVO for Nanoscale Quantum Interfaces, Jonathan Kindem[1], John G. Bartholomew[1], Jake Rochman[1], Tian Zhong[1], Charles W. Thiel[2], Philip J. Woodburn[2], Rufus L. Cone[2], Andrei Faraon[1]; [1]*Caltech, USA;* [2]*Physics, Montana State Univ., USA*. We report on the optical and spin coherence properties of ^{171}Yb:YVO at cryogenic temperatures. Our results indicate this material is promising for nanoscale quantum memories, microwave-to-optical transduction, and optically addressable single ions.

FTu4H.6 • 18:30

Narrowing of Electromagnetically Induced Transparency in an Inhomogeneously Broadened Solid-State Atomic Ensemble, Haoquan Fan[1,2], Elizabeth A. Goldschmidt[1,2]; [1]*USA Army Research Lab, USA;* [2]*Joint Quantum Inst., Univ. of Maryland, USA*. We study electromagnetically induced transparency (EIT) in an inhomogeneously broadened solid-state ensemble of europium atoms. We observe agreement with theoryincluding narrowing of the EIT linewidth as a function of the inhomogeneous width.

FTu4H.7 • 18:45

All-Optical Control of Long-lived Spin Coherences in Rare Earth Doped Nanoparticules, Diana Serrano[1], Jenny Karlsson[1], Alexandre Fossati[1], Alban Ferrier[1], Philippe Goldner[1]; [1]*Institut de Recherche de Chimie Paris, PSL Research Univ., Chimie ParisTech, CNRS, France*. We measured nuclear spin coherence lifetimes up to several milliseconds in Eu^{3+} doped Y_2O_3 nanoparticles using all-optical techniques. Combined with narrow optical linewidths, this opens the way to nanoscale light-atom-spin interfaces at the quantum level.

CLEO: Applications & Technology

ATu4I • Combustion and Hypersonic Flow Diagnostics—Continued

ATu4I.5 • 18:15

Intra-pulse Cavity Enhanced Measurements of Carbon Monoxide in a Rapid Compression Machine, Ehson Nasir[1], Aamir Farooq[1]; [1]*Clean Combustion Research Center, King Abdullah Univ. of Science and Technology, Saudi Arabia*. A laser absorption sensor for CO concentration was developed for a rapid compression machine using a pulsed QCL near 4.89 um. Cavity enhancement reduced minimum detection limit down to 2.4 ppm. Off-axis alignment and rapid intrapulse down-chirp resulted in effective suppression of cavity noise.

19:00–20:30 OSA Technical Group Poster Session, *Room 230A/B*

CLEO: Applications & Technology

ATu4J • Medical Devices & Systems—Continued

ATu4J.4 • 18:15
Portable Diagnostic for Malaria Detection in Low-Resource Settings, Samantha McBirney[1], Dongyu Chen[1], Alexis Scholtz[2], Bernard Chen[1], Andrea M. Armani[1]; *[1]Univ. of Southern California, USA; [2]Johns Hopkins Univ., USA.* We have designed a novel device to identify malaria in both symptomatic and asymptomatic populations by detecting the presence of hemozoin. Here, we detect clinically relevant concentrations of β-hematin, a synthetic mimic of hemozoin.

ATu4J.5 • 18:30
Improved Spot Formation through Flexible Multimode Fiber Using a Partial Reflector, Ruo Yu Gu[1], Elaine Chou[1], Cory Rewcastle[2], Ofer . Levi[2], Joseph Kahn[1]; *[1]Stanford Univ., USA; [2]Univ. of Toronto, Canada.* We describe a method for improving the formation of a spot of light at the distal end of a flexibly perturbed multimode fiber by attaching a structured partial reflector to the distal end.

ATu4J.6 • 18:45
Intracellular Doppler Imaging Clinical Trials in Personalized Cancer Care, David D. Nolte[1,2], Zhe Li[1], Honggu Choi[1], Michael Childress[1], Shadia Jalal[3], John Turek[1,2]; *[1]Purdue Univ., USA; [2]Animated Dynamics Inc., USA; [3]Indiana Univ. School of Medicine, USA.* Clinical trials of biodynamic digital holography of cancer biopsies identify patients resistant to chemotherapy with 90% accuracy. Translation of this biomedical optical technology to the clinic may transform personalized cancer care.

CLEO: Science & Innovations

STu4K • Fiber Frequency Combs—Continued

STu4K.5 • 18:15
Wavelength Tunable Narrow Linewidth Comb Using Soliton Self-frequency Shift and Spectral Compression Technique, Nozomu Ohta[1], Lei Jin[1], Yoichi Sakakibara[2], Emiko Omoda[2], Hiromichi Kataura[2], Norihiko Nishizawa[1]; *[1]Nagoya Univ., Japan; [2]AIST, Japan.* 1.6-1.9 um wavelength tunable comb with spectral width of 4 nm was demonstrated using wavelength tunable soliton pulse and comb profile fiber. High SNR of 37 dB was confirmed for generated comb by beat measurement.

STu4K.6 • 18:30
10 W, sub-100 fs Fiber Amplifier Based on a Self-referenced 750-MHz Yb:fiber Laser Frequency Comb, Bo Xu[1,2], Yuxuan Ma[1,3], Hirotaka Ishii[1], Fei Meng[3], Isao Matsushima[1,2], Zhigang Zhang[3], Kaoru Minoshima[1,2]; *[1]The Univ. of Electro-Communications, Japan; [2]ERATO Intelligent Optical Synthesizer (IOS) Project, Japan Science and Technology Agency, Japan; [3]State Key Lab of Advanced Optical Communication System and Networks, Peking Univ., China.* We developed a polarization maintained Yb:fiber amplifier based on the self-referenced 750-MHz Yb:fiber laser frequency comb. 10 W average power and sub-100 fs pulse were achieved without deteriorating the high coherence of the comb.

Joint

JTu4L • Symposium on Multimodal and Molecular Contrast Optical Imaging II—Continued

JTu4L.3 • 18:30 Invited
On the Road to Optical Biopsy Based on Multimodal Imaging, Thomas Bocklitz[1]; *[1]IPC, Univ. Jena, Germany.* Optical multimodal imaging techniques feature a huge potential as non-invasive optical biopsy and diagnostic tool. These applications require fiber based measurements and image analysis for artefact removal and tissue diagnostics, which are presented herein.

19:00–20:30 OSA Technical Group Poster Session, *Room 230A/B*

CLEO: Applications & Technology

ATu4M • Thin Film & Metrology for Laser Processing—Continued

ATu4M.5 • 18:15
De-Multiplexed Multiwavelength Light Interferometry, Vala Fathipour[1], Zain Zaidi[1], Connie J. Chang-Hasnain[1]; *[1]EECS, Univ. of California Berkeley, USA.* A new ranging technique is proposed using multi-wavelength laser interferometry with wavelength de-multiplexed detectors to alleviate the range-resolution trade-off inherent in many contemporary ranging techniques. We demonstrate 3-mm range and 10-nm resolution with two-wavelengths.

ATu4M.6 • 18:30
Embedding Distributed Temperature and Strain Optical Fiber Sensors in Metal Components Using Additive Manufacturing, Ran Zou[1], Xuan Liang[1], Aidong Yan[1], Mohan Wang[1], Paul Ohodnicki[2], Albert To[1], Kevin P. Chen[1]; *[1]Univ. of Pittsburgh, USA; [2]National Energy Technology Lab, U.S. Dept. of Energy, USA.* A standard telecom-grade single-mode optical fiber was protected and embedded into IN718 components by nickel electroplating to provide distributed real-time temperature and strain sensing in metal additive manufacturing applications with 5 mm spatial resolution.

ATu4M.7 • 18:45
Self-Mixing Vibrometer has picometer sensitivity by exploiting the FM Channel, Silvano Donati[1], Michele Norgia[2]; *[1]Universita degli Studi di Pavia, Italy; [2]DEIB, Politecnico di Milano, Italy.* By converting the FM modulation of a self-mixing interferometer into an amplitude signal, we demonstrate a noise-equivalent-displacement (NED) of 1.3-pm/√Hz, two order of magnitude better than AM channel or a normal interferometer.

CLEO: Science & Innovations

STu4N • 2D Materials in Photonic Structures—Continued

STu4N.5 • 18:15
Circular Polarized Emission of Tungsten Diselenide (WSe2) Atomic Layers with Plasmonic Metasurface, Hsiang-Ting Lin[1,2], Chiao-Yun Chang[1], Pi-Ju Cheng[1], Ming-Yang Li[1,3], Chia-Chin Cheng[3], Shu-Wei Chang[1,2], Lain-Jong Li[3], Chih-Wei Chu[1], Min-Hsiung Shih[1,2]; *[1]Research Center for Applied Sciences, Academia Sinica, Taiwan; [2]Dept. of Photonics and Inst. of Electro-Optical Engineering, National Chiao Tung Univ., Taiwan; [3]Physical Science and Engineering Division, King Abdullah Univ. of Science and Technology, Saudi Arabia.* A circularly polarized light emitting device with ultrathin geometry were demonstrated by integrating WSe2 atomic layers with plasmonic chiral metasurfaces and achieve more than 25% circular dichroism.

STu4N.6 • 18:30
Bright Electroluminescence from Back-Gated WSe_2 P-N Junctions Using Pulsed Injection, Kevin Han[1], Seth Fortuna[1], Matin Amani[1], Sujay Desai[1], Der-Hsien Lien[1], Geun Ho Ahn[1], Eli Yablonovitch[1], Ali Javey[1], Ming C. Wu[1]; *[1]Univ. of California Berkeley, USA.* We demonstrate bright electroluminescence in WSe_2 monolayers using pulsed injection, without the use of split gates, chemical doping, or heterostructures. Electroluminescence quantum efficiency approaches that of photoluminescence, indicating efficient exciton formation with injected carriers.

STu4N.7 • 18:45
Giant Electro-Refractive Modulation of Monolayer WS_2 Embedded in Photonic Structures, Ipshita Datta[1], Sang Hoon Chae[1], Gaurang R. Bhatt[1], James Hone[1], Michal Lipson[1]; *[1]Columbia Univ., USA.* We electrically tune the index of refraction of a monolayer WS_2 index that is integrated on a SiN photonic structure by up to 3%. The loss of WS_2 is electro-statically tuned by less than 0.2 % at 1550 nm.

STu4O • Laser Facilities—Continued

STu4O.5 • 18:15
Compact Photo-Injector and Laser-Heater Drive Laser for the European X-ray Free Electron Laser Facility, Lutz Winkelmann[1], Maik Frede[2], Christian Mohr[1], Hongwei Chu[1], Chen Li[1], Peng Li[1,3], Uwe Grosse-Wortmann[1], Frank Brinker[1], Ingmar Hartl[1], Bastian Schulz[2]; *[1]DESY, Germany; [2]neoLASE GmbH, Germany; [3]IMRA America, USA.* We present a drive laser for the photo-injector of the European XFEL, which delivers up to 25 µJ, ~6 ps, 266 nm pulses at 4.5 MHz repetition frequency in 600 µs long bursts with 0.6 % rms energy instability.

STu4O.6 • 18:30 Invited
Status and Development of High Average Power Lasers at HiLASE, Michal Chyla[1], Martin Divoky[1], Martin Smrz[1], Jiri Muzik[1], Amani Reza[1], Pawel Sikocinski[1], Liyuan Chen[1], Patricie Severova[1], Ondrej Novak[1], Hana Turcicova[1], Michal Vyvlecka[1], Lukas Roskot[1], Jaroslav Huynh[1], Siva Nagisetty[1], Jitka Cernohorska[1], Huang Zhou[1], Alina Pranovich[1], Jan Pilar[1], Ondrej Slezak[1], Magdalena Sawicka-Chyla[1], Venkatesan Jambunathan[1], Akira Endo[1], Antonio Lucianetti[1], Danijela Rostohar[1], Paul Mason[2], Jonathan Phillips[2], Klaus Ertel[2], Saumyabrata Banerjee[2], Jodie Smith[2], Thomas Butcher[2], Mariastefania De Vido[2], Cristina Hernandez-Gomez[2], Chris Edwards[2], John Collier[2], Tomas Mocek[1]; *[1]HiLASE Centre, Inst. of Physics ASCR v.v.i., Czechia; [2]CALTA, Rutherford Appleton Lab, UK.* HiLASE facility focuses on development of high average power pulsed lasers with picosecond and nanosecond laser pulses. Current status of 1kW/100J multislab and 500W/5mJ thin-disk lasers and future plans of the HiLASE facility are presented.

19:00–20:30 OSA Technical Group Poster Session, *Room 230A/B*

STu4P • Advanced Sensing Concepts—Continued

STu4P.6 • 18:15
High-speed Ultra-broadband Fourier-transform CARS Spanning over 3,000 cm^{-1}, Junko Omachi[1], Kazuki Hashimoto[2,3], Takuro Ideguchi[3,4]; *[1]Inst. for Photon Science and Technology, The Univ. of Tokyo, Japan; [2]Aeronautical Technology Directorate, Japan Aerospace Exploration Agency, Japan; [3]Dept. of Physics, The Univ. of Tokyo, Japan; [4]PRESTO, Japan Science and Technology Agency, Japan*. We demonstrate ultra-broadband rapid-scan Fourier-transform coherent anti-Stokes Raman scattering spectroscopy spanning over 3,000 cm^{-1} at a scan rate of 24,000 spectra/s with a 6-fs mode-locked laser.

STu4P.7 • 18:30
Real-time Detection of Scaling on Reverse Osmosis Membranes with Raman Spectroscopy, Omkar D. Supekar[1], Joseph J. Brown[1], Alan R. Greenberg[1], Juliet Gopinath[2,3], Victor Bright[1]; *[1]Dept. of Mechanical Engineering, Univ. of Colorado Boulder, USA; [2]Dept. of Electrical, Computer, and Energy Engineering, Univ. of Colorado Boulder, USA; [3]Dept. of Physics, Univ. of Colorado Boulder, USA*. We demonstrate real-time, local detection of the onset of scaling, in addition to chemical quantification, in a reverse osmosis separation system using confocal Raman microscopy. The results show consistent scalant detection.

STu4P.8 • 18:45
Single and double-quantum multidimensional coherent spectroscopy using frequency combs, Bachana Lomsadze[1], Steven T. Cundiff[1]; *[1]Univ. of Michigan, USA*. We present a novel experimental approach of multidimensional coherent spectroscopy using frequency combs. We demonstrate its capabilities for probing weak many-body interactions as well as its applications for rapid and high resolution chemical sensing.

STu4Q • UV-visible Semiconductor Lasers—Continued

STu4Q.3 • 18:30
Direct Pulse Position Modulation of a 410 nm Semipolar GaN Laser Diode for Space Optical Communications, Joseph M. Fridlander[1], Changmin Lee[1], James Speck[1], Steven DenBaars[1], Jonathan Klamkin[1]; *[1]UCSB, USA*. A semipolar GaN laser was characterized for space optical communications, achieving a peak power of 160 mW. Periodic and random M-ary pulse position modulation sequences with pulse widths of 5 ns and 10 ns were demonstrated.

STu4Q.4 • 18:45
High Power, High Efficiency Red Laser Diode Structures Grown on GaAs and GaAsP Metamorphic Superlattices, Steven Ruder[2,1], Tom Earles[2,1], Christian Galstad[2], Michael Klaus[2], Don Olson[2], Luke J. Mawst[1]; *[1]Univ. of Wisconsin - Madison, USA; [2]Compound Photonics, USA*. Red laser diodes were fabricated on GaAs and GaAsP metamorphic-superlattice-substrates. The tensile strained QW on GaAs emitted 45% PCE, 638nm, TM-polarized light at 880mW CW. The compressively strained QW on the metamorphic structure emitted 639nm TE-polarized light with T_0=90K and T_1=300K.

19:00–20:30 OSA Technical Group Poster Session, *Room 230A/B*

07:30–18:30 Registration, *Concourse Level*

08:00–10:00 JW1A • Plenary Session II & International Day of Light, *Grand Ballroom*

10:00–17:00 Exhibition Open, *Exhibit Hall*

10:00–11:30 Coffee Break & Exhibit Only Time, *Exhibit Hall*

Exhibit Hall

11:30–13:00 JW2A • Poster Session II

JW2A.1
Tuning Effective Fiber Radius Variation of SNAP Structures With a Femtosecond Laser, Yu Qi[1], Shen Fangcheng[1], Xu Zuowei[1], Haoran Cao[1], Misha Sumetsky[2], Shu Xuewen[1]; *[1]Huazhong Univ. of Science and Technology, China; [2]Aston Univ., UK.* It is shown that the nanoscale radius variation of the optical fiber can be effectively tuned by introducing variable internal pressure into an optical fiber with a femtosecond laser.

JW2A.2
90 Gb/s PAM4 and OOK Optical Signal Generation by Using the Dual-arm-drive Silicon Mach-Zehnder Modulator, Sizhu Shao[1,2], Jianfeng Ding[1], Lingchen Zheng[1,2], Lei Zhang[1], Xin Fu[1], Lin Yang[1,2]; *[1]Inst. of Semiconductors, CAS, China; [2]Univ. of Chinese Academy of Sciences, China.* In this paper, the 90 Gb/s PAM4 and OOK optical signal generation by using a dual-arm-drive silicon Mach-Zehnder modulator is demonstrated. The OOK optical signal generation with speed up to 110 Gb/s is also demonstrated.

JW2A.3
An On-Chip Integrated Dual-Functional Modulator-Detector for Optical Communication, SHUAI SUN[1], Ruoyu Zhang[1], Jiaxin Peng[1], Vikram Narayana[1], Hamed Dalir[2], Tarek El-Ghazawi[1], Volker J. Sorger[1]; *[1]George Washington Univ., USA; [2]Omega Optics, Inc., USA.* We propose a novel integrated broadband hybrid photonic-plasmonic device termed MODetector featuring dual light modulation and detection. With 10 dB extinction ratio and 0.8 dB insertion loss for modulation and 0.7 W/A responsivity for detection.

JW2A.4
Highly-efficient, ultra-broadband and polarization insensitive graphene-silicon based electro-absorption modulator, Yin Xu[1,2], Feng Li[2,3], Jinhui Yuan[3,4], Zhe Kang[3], Chao Mei[3,4], Xianting Zhang[3], P. K. A. Wai[3]; *[1]Dept. of Electrical Engineering, The Hong Kong Polytechnic Univ., China; [2]Hong Kong Polytechnic Univ. Shenzhen Research Inst., China; [3]Dept. of Electronic and Information Engineering, The Hong Kong Polytechnic Univ., China; [4]State Key Lab of Information Photonics and Optical Communications, Beijing Univ. of Posts and Telecommunications, China.* We propose a highly-efficient, ultra-broadband and polarization-insensitive electro-absorption modulator based on a multilayer graphene-silicon waveguide. A modulation efficiency of ~2.21 dB/um is obtained for both polarizations within a bandwidth covering from E to U bands.

JW2A.5
Gold based plasmonic stripes co-integrated with low loss Si_3N_4 platform in aqueous environment, Athanasios Manolis[1,2], George Dabos[1,2], Dimitra Ketzaki[1,2], Evangelia Chatzianagnostou[1,2], Dimitris Tsiokos[1,2], Laurent Markey[3], Jean Claude Weeber[3], Alain Dereux[3], Anna-Lena Giesecke[4], Caroline Porschatis[4], Bartos Chmielak[4], Nikos Pleros[1,2]; *[1]Aristotle Univ. of Thessaloniki, Greece; [2]Center for Interdisciplinary Research and Innovation, Greece; [3]Laboratoire Interdisciplinaire Carnot de Bourgogne, France; [4]AMO GmbH, Advanced Microelectronic Center Aachen (AMICA), Germany.* We demonstrate a butt-coupled interface between LPCVD Si_3N_4 and gold based plasmonic waveguides in aqueous environment, exhibiting 2.3dB coupling loss and 75μm propagation length at 1550nm, towards future employment in biosensing applications.

JW2A.6
Novel Polarization Beam Splitter with High Fabrication Tolerance, Nicolas M. Abadia Calvo[1,2], Md Ghulam Saber[2], Qiaoyin Lu[1], Wei-Hua Guo[1], David V. Plant[2], John F. Donegan[1]; *[1]Trinity College Dublin, Canada; [2]McGill Univ., Canada.* A highly fabrication tolerant polarization beam splitter is presented. The fabrication tolerances are relaxed by adjusting two voltages. Experiments show on-chip losses of 3.5 dB and extinction ratio of 15 dB at C-band.

JW2A.7
Application of High-reflectivity Non-periodic Sub-wavelength Gratings with Small-angle Beam-steering Ability in Fabry-Perot Cavity, Shuai Zhang[1], Xiaofeng Duan[1], Gongqing Li[1], Kai Liu[1], Yongqing Huang[1], Xiaomin Ren[1]; *[1]Beijing Univ. of Posts and Telecommunications, China.* An axisymmetric high-reflectivity non-periodic sub-wavelength gratings (SWGs) with small-angle beam-steering ability for reflected light is presented, and it brings a new characteristic of flexibly controlling the width of oscillation optical field for the improved Fabry-Perot (F-P) cavity.

JW2A.8
Ultra-broadband 3dB power splitter based on silicon slot waveguide, Yuguang Zhang[2,1]; *[1]State Key Lab of Optical Communication Technologies and Networks, Wuhan Research Inst. of Posts and Telecommunications, China; [2]National Information Optoelectronics Innovation Center, China.* We present the design of the ultra-broad bandwidth 3dB splitter based on silicon slot waveguide. The bandwidth of the proposed splitter is simulated as large as 600 nm, with the insertion loss less than 1dB.

JW2A.9
Design of an Ultra-Small Footprint Graphene-based Silicon Photonic Bandgap Modulator, Giannino Dziallas[2,1], Lars Zimmermann[1], Klaus Petermann[2]; *[1]IHP GmbH, Germany; [2]Inst. of High-Frequency and Semiconductor System Technologies, Technical Univ. of Berlin, Germany.* We propose a novel design of an ultra-small footprint silicon photonic. The device length is 6 μm and with 1 V_{pp} the modulator should attain 15 dB extinction due to the photonic bandgap microcavity.

JW2A.10
Ultrafast shifted-core coaxial nano-emitter with tunable Q factor, Xi Li[1], Qing Gu[1]; *[1]Univ. of Texas at Dallas, USA.* We numerically demonstrate a III-V single mode shifted-core coaxial nano-emitter featuring a Purcell factor larger than 600 and tunable Q factor.

JW2A.11
Silicon-Based Nanophotonic Topological Insulators, Kasper E. Lund[1,2], Chirag M. Patil[1], Søren Stobbe[1,2]; *[1]The Niels Bohr Inst., Univ. of Copenhagen, Denmark; [2]Fotonik, Technical Univ. of Denmark, Denmark.* We present the design and fabrication of nanophotonic topological insulators based on photonic crystals. Our work extends recent a proposal silicon photonics in the telecom c-band while taking realistic fabrication parameters into account.

JW2A.12
Demonstration of microring-based WDM-compatible mode-division multiplexing on a silicon chip, Shuang Zheng[1], Xiaoping Cao[1], Jian Wang[1]; *[1]Wuhan National Lab for Optoelectr, China.* Based on silicon chip, we design and fabricate a mode-division (de)multiplexer in conjunction with wavelength-division multiplexing (WDM) by using three single-mode microring resonators. The on-chip device exhibits low mode crosstalk around the wavelength of 1540 nm.

JW2A.13
A 3-Micron-Radius Bend for SOI TE_0/TE_1 Multiplexing, Min Teng[1], Abdullah Al Noman[1], Yun Jo Lee[1], Ziyun Kong[1], Minghao Qi[1]; *[1]Purdue Univ., USA.* We propose a 3-micron-radius, TE_0/TE_1 multiplexed 90-degree bend that numerically exhibits 0.8 dB bending loss and 20 dB crosstalk suppression over 30nm bandwidth on an silicon-on-insulator platform. An S-bend shows >37 dB colorless crosstalk suppression.

JW2A.14
Ultra-compact on-chip mode exchange device using inverse-designed silicon metasurface, Hao Jia[1,2], Ting Zhou[1,2], Xin Fu[1,2], Lin Yang[1,2]; *[1]Inst Semiconductors, CAS, China; [2]College of Materials Science and Opto-Electronic Technology, Univ. of Chinese Academy of Sciences, China.* We propose and demonstrate an ultra-compact mode exchange device with high efficiency. It is 4×1.6 μm in size and can realize mode exchange between TE_0 and TE_1. Characterization shows its optical bandwidth covers C-band.

JW2A.15
Extending Modulation Bandwidth of SOI Thermo-Optic Phase Shifters Through Digital Pre-Emphasis, Sungwon Chung[1], Hossein Hashemi[1]; *[1]Univ. of Southern California, USA.* We demonstrate a digital pre-emphasis technique for extending the modulation bandwidth of a thermo-optic phase shifter in silicon-on-insulator (SOI) CMOS. The electrical input to the phase shifter is pre-emphasized, increasing 3-dB optical modulation bandwidth 6.3 times from 8.1 kHz to 50.7 kHz.

JW2A.16
Encapsulated Silicon Nitride Nanobeam Cavity for Nanophotonics using Layered Materials, Taylor K. Fryett[1], Yueyang Chen[1], James Whitehead[1], Zane Peycke[1], Xiaodong Xu[1], Arka Majumdar[1]; *[1]Univ. of Washington, USA.* The fragile nature of floating membrane resonators poses a serious problem for constructing a hybrid photonics platform. To overcome this challenge, we design and demonstrate encapsulated silicon nitride nanobeams and demonstrate coupling to layered materials.

JW2A.17
Magnitude and Sign Control of Index-Antiguided Coupling, Zihe Gao[1], Dominic Siriani[2], Kent D. Choquette[1]; *[1]Univ of Illinois at Urbana-Champaign, USA; [2]Cisco Systems, USA.* We show the first theoretical analysis of the coupling coefficient in passive index-antiguided coupling. Both magnitude and sign of the coupling coefficient are controlled by the inter-element distance and index, enabling novel photonic applications.

11:30–13:00 JW2A • Poster Session II

JW2A.18
Design of a Low-threshold Mid-IR Silicon Raman Laser, Behsan Behzadi[1], Ravinder K. Jain[1], Mani Hossein-Zadeh[1,2]; [1]*Center for High Technology Materials, USA;* [2]*ECE, Univ. of New Mexico, USA.* We present the design and performance of an integrated all-silicon continuous-wave Mid-IR Raman laser with an estimated threshold power < 100 μW generating a single line with a linewidth < 10 MHz at 3.278 μm.

JW2A.19
Chip-Integrated Plasmonic Flat Optics for Mid-infrared Polarization Detection, Jing Bai[1], Chu Wang[1], Xiahui Chen[1], Ali Basiri[1], Chao Wang[1], Yu Yao[1]; [1]*Arizona State Univ., USA.* We present theoretical modeling and experimental demonstration of MIR polarization detection based on monolithically chip-integrated plasmonic metasurefaces. Our technique enables full Stokes Parameters detection for arbitrary polarized states of light in MIR wavelengths.

JW2A.20
Subwavelength grating waveguide based cladding-modulated Bragg reflector in bulk CMOS, Cheng-Tse Tang[1], Tse-Hung Chen[1], Tzu-Hsiang Yen[1], Yung-Jr Hung[1]; [1]*National Sun Yat-sen Univ., Taiwan.* A SWG-based cladding-modulated Bragg reflector implemented in bulk CMOS enables a lower propagation loss (< 30 dB/cm), a higher extinction ratio (24.5 dB) and a less-sensitive temperature coefficient (29.4 pm/°C) as compared to strip-based counterpart.

JW2A.21
Nanoscale Fingerprinting with Hyperbolic Metamaterials, Zhengyu Huang[1], Evgenii E. Narimanov[2], Theodore B. Norris[1]; [1]*Electrical Engineering and Computer Science, Univ. of Michigan, USA;* [2]*Electrical and Computer Engineering, Purdue Univ., USA.* We develop a new concept for optical sub-wavelength discrimination of nanostructures positioned on a hyperbolic metamaterial surface using only far-field measurements of the spectral scattered intensity.

JW2A.22
Integrated Optical Power Equalizer Based on a Dual-Polarization Micro-Ring Resonator, Xingyuan Xu[1], Jiayang Wu[1], Thach Nguyen[2], Sai T. Chu[3], Brent Little[4], Roberto Morandotti[5], Arnan Mitchell[2], David J. Moss[1]; [1]*Swinburne Univ. of Technology, Australia;* [2]*RMIT Univ., Australia;* [3]*City Univ. of Hong Kong, Hong Kong;* [4]*Chinese Academy of Science, China;* [5]*INRS-Énergie, Matériaux et Télécommunications, Canada.* We demonstrate an optical power equalizer based on a dual-polarization micro-ring resonator. By controlling the light polarization, a large loss tunable range from –29.3 dB to 30 dB of the equalizer is experimentally achieved.

JW2A.23
A dual-drive DAC-less silicon PAM-4 optical modulator for 100 Gb/s data transmission at C-band, Lingchen Zheng[1,2], Jianfeng Ding[1], Sizhu Shao[1,2], Lei Zhang[1], Xin Fu[1], Lin Yang[1,2]; [1]*Inistitute of semiconductor,CAS, China;* [2]*Univ. of Chinese Academy of Sciences, China.* A DAC-less silicon PAM-4 optical modulator which is driven by two binary electrical signals is demonstrated. A mathematical analysis for the modulation chirp is established. The device can work at 100 Gb/s.

JW2A.24
High Fidelity MMI Excitation Patterns for Optofluidic Multiplexing, Matthew Stott[1], Vahid Ganjalizadeh[2], Maclain Olsen[1], Marcos Orfila[1], Johnny McMurray[1], Erik Hamilton[1], Holger Schmidt[2], Aaron Hawkins[1]; [1]*Brigham Young Univ., USA;* [2]*Univ. of California, Santa Cruz, USA.* High fidelity interference patterns from multimode interference waveguides are needed for multiplexed optofluidic biosensors. Spot pattern fidelity can be optimized by careful design of the single-mode waveguides used to excite the multimode waveguides.

JW2A.25
Experimental Demonstration of Low Temperature Sensitivity SiN Interleaver, Yinglu Zhang[1], Jinsong Xia[1]; [1]*Wuhan National Lab for Optoelectronics, China.* We experimentally demonstrate a low temperature sensitivity SiN interleaver. The FSR is 1.65 nm. The 1-dB bandwidth is 0.62 nm. The crosstalk is less than -15 dB from 1522 nm to 1549 nm. In the temperature from 25°C to 70°C, the temperature sensitivity is within ±7 pm/°C.

JW2A.26
Apodization techniques for side-lobes suppression in silicon photonics waveguide gratings, Chia-Ju Yu[1], Tzu-Hsiang Yen[1], You-Cheng Lu[1], Bing-Hao Shih[1], Yung-Jr Hung[1]; [1]*National Sun Yat-sen Univ., Taiwan.* We demonstrate c-band and o-band silicon waveguide gratings with a side-lobe suppression ratio of 36.6 and 27.1 dB, respectively, by modulating the corrugation width or grating offset with apodization function while remaining zero-dc effective index change.

JW2A.27
Silicon Nitride Integrated All-optical Switch Assisted by Graphene, Ciyuan Qiu[1], Yuxing Yang[1], Chao Li[1], Yifang Wang[1], Kan Wu[2], Jianping Chen[1]; [1]*Shanghai Jiao Tong Univ., China;* [2]*Shanghai Jiao Tong Univ., China.* An all-optical switch near 1550nm is realized on a graphene-on-silicon nitride (Si_3N_4) integrated platform with thermo-optic effect. A fast switching time of 253ns is obtained due to the high thermal conductivity of graphene.

JW2A.28
Experimental demonstration of a polarization diversity broadband orbital angular momentum modes emitter, Zhou Nan[1], Shuang Zheng[1], Xiaoping Cao[1], Shengqian Gao[2], Shimao Li[2], Mingbo He[2], Xinlun Cai[2], Jian Wang[1]; [1]*Wuhan National Lab for Optoelectr, China;* [2]*State Key Lab of Optoelectronic Materials and Technologies and School of Physics and Engineering, Sun Yatsen Univ., China.* We simulate, fabricate and demonstrate the silicon-based polarization multiplexing broadband orbital angular momentum (OAM) generator. The generated x-pol OAM_{+1}, x-pol OAM_{-1}, y-pol OAM_{+1} and y-pol OAM_{-1} show maximum purity of 0.91, 0.89, 0.92 and 0.92.

JW2A.29
Light Sources for Neuromorphic Computing, Sonia M. Buckley[1], Jeffrey Chiles[1], Adam McCaughan[1], Richard Mirin[1], Sae Woo Nam[1], Jeffrey Shainline[1]; [1]*NIST, USA.* We have demonstrated electrically-injected waveguide-coupled LEDs based on W centers in silicon for neuromorphic computing. We analyze the sources of loss in these LEDs and simulate new designs for scalable, waveguide-coupled devices with several orders of magnitude higher efficiency.

JW2A.30
1550 nm AlGaInAs MQWs 10-channel Laser Array for Optical Interconnects, Mingjin Wang[1], Hailing WANG[1], Ranzhe Meng[1], Aiyi Qi[1], Wan-hua Zheng[1]; [1]*CAS Inst. of Semiconductors, China.* A 10-channel laser array with 3-nm wavelength spacing is presented. The output-power of 20 mW, SMSR of higher than 30 dB, and efficient slope of 0.224 mW/mA for each laser within the array are achieved.

JW2A.31
All-Optical Intensity Modulation in Polymer Waveguides Doped with Si Quantum Dots, Aleksandrs Marinins[1], Aleksejs Udalcovs[2], Oskars Ozolins[2], Xiaodan Pang[2], Jonathan G. Veinot[3], Gunnar Jacobsen[2], Ilya Sychugov[1], Jan Linnros[1], Sergei Popov[1]; [1]*KTH, Sweden;* [2]*RISE Acreo AB, Sweden;* [3]*Univ. of Alberta, Canada.* We demonstrate all-optical intensity modulation in integrated PMMA optical waveguides doped with silicon quantum dots. The 1550 nm probe signal is absorbed by free carriers excited in silicon quantum dots with 405 nm pump light.

JW2A.32
Compact Optomechanical Phase Shifter for Visible Light Integrated Photonics, Bruno Figeys[1], Rita Van Hoof[1], Pieter Neutens[1], Bert Du Bois[1], Guilherme Brondani Torri[1], Simone Severi[1], Xavier Rottenberg[1]; [1]*imec, Belgium.* This paper reports on the development of a CMOS compatible capacitively actuated optomechanical phase shifter for visible light, demonstrated on a 200mm PECVD SiN photonic platform. The phase shifting was demonstrated using Mach-Zehnder interferometers.

JW2A.33
Wideband Kerr-comb near visible spectrum in coupling-engineered thin Silicon nitride resonators, Ali Eshaghian Dorche[1], Ali Asghar Eftekhar[1], Ali . Adibi[1]; [1]*Georgia Inst. of Technology, USA.* We present wideband Kerr-comb generation from 650 nm to 1200 nm in a thin silicon-nitride (SiN) platform enabled by enhanced power transfer through the dispersive wave using a dispersion-engineered over-etched SiN waveguide and a coupled-resonator structure.

JW2A.34
On-Chip Adiabatic Couplers for Broadband Quantum-Polarization State Preparation, Yen-Hung Chen[1], Hung-Pin Chung[1], Kuang-Hsu Huang[1], Kai Wang[2], Sung-Lin Yang[1], Shih-Yuan Yang[1], Chun-I Sung[1], Alexander S. Solntsev[2,3], Andrey A. Sukhorukov[2], Dragomir N. Neshev[2]; [1]*National Central Univ., Taiwan;* [2]*The Australian National Univ., Australia;* [3]*Univ. of Technology Sydney, Australia.* We present a unique wavelength-dependent polarization splitter based on asymmetric adiabatic couplers designed for integration with type-II spontaneous parametric-down-conversion sources. The system can be used for preparing different quantum polarization-path states over a broad band.

JW2A.35
Thermal tuning of Brillouin resonance in free standing silicon nanowire, Paul Tiebot[1,2], Raphaël Van Laer[1,3], Dries Van-Thourhout[1,2]; [1]*Photonics Research Group, Ghent Univ.-imec , Belgium;* [2]*Center for Nano and Biophotonics (NB-Photonics),, Ghent Univ., Belgium;* [3]*Ginzton Lab, Dept. of Applied Physics, Stanford Univ., , USA.* We have demonstrate the thermal tuning of the Brillouin resonance in silicon nanowire waveguides using cross phase modulation detection. We also investigate possible use of this effect for locally mapping the width of an extended waveguide.

JW2A.36
Microring Resonator Based Compact On-chip Phase Tuner, Hwaseob Lee[1], Thomas M. Kananen[1], Ranojoy Bose[2], Raymond Beausoleil[2], Tingyi Gu[1]; [1]*Univ. of Delaware, USA;* [2]*Hewlett-Packard Labs, USA.* We study the mode-splitting microring resonators for compact and efficient phase tuners. Through optimization of inter-modal and ring-waveguide coupling, 72.535 ps group delay and 1.4208 rad phase shift with 5.83 dB loss are achieved.

JW2A.37
Near-field flat focusing mirrors using a metallic subwavelength grating on top of a plasmonic waveguide, Yu-Chieh Cheng[1], Bo-Zhi Huang[1], Juei-Hung Tsai[1], Yu-Ching Chuang[1]; [1]*Dept. of Electro-Optical Engineering, National Taipei Univ. of Technology, Taiwan.* Flat focusing mirrors without any optical axis have been studied by metallic subwavelength gratings on top of a plasmonic waveguide. The principle is based on an anomalous lateral displacement, leading to a near-field focusing.

JW2A.38
Linewidth-adjustable bandpass filter based on silicon cladding-modulated waveguide moiré Bragg gratings, Tzu-Hsiang Yen[1], Bing-Hao Shih[1], Nai-Wen Cheng[1], Yung-Jr Hung[1]; [1]*National Sun Yat-sen Univ., Taiwan.* We demonstrate linewidth-adjustable (0-1 nm) narrow bandpass filters using silicon cladding-modulated waveguide moiré Bragg gratings. The passband linewidth is controlled by the number of crossovers and the corrugation width of the moiré grating.

11:30–13:00 JW2A • Poster Session II

JW2A.39
Ge-on-Si wavelength division multiplexing components near 4.7 μm, Aditya Malik[1], Eric J. Stanton[1], Junqian Liu[1], Alexander Spott[1], John E. Bowers[1]; [1]*Electrical and Computer Engineering, Univ. of California Santa Barbara, USA.* Wavelength division multiplexing components based on Ge-on-Si waveguides are presented for operation near 4.7 μm wavelength. Transmission characteristics of 1×1 and 2× MZIs (35 dB extinction) and AWGs (25.7 dB cross-talk) are reported.

JW2A.40
Polarization Rotator in Low Index Contrast Substrates for Mid-Infrared Photonic Integration, Swapnajit Chakravarty[1], Jason Midkiff[1], Chi-Jui Chung[2], Ali Rostamian[2], Joel Guo[2], Ray Chen[2,1]; [1]*Omega Optics, Inc, USA;* [2]*Electrical and Computer Engineering, Univ. of Texas at Austin, USA.* We demonstrate polarization rotators in low index contrast InGaAs-InP material system to enable monolithic integration of quantum cascade lasers and detectors with slotted photonic crystal waveguide gas sensors in the molecular fingerprint region from l=3-15mm

JW2A.41
Low Loss Etchless Photodefined Polymer Optical Waveguides, Julie I. Frish[1], Kyung-Jo Kim[1], Roland Himmelhuber[1], Sasaan Showghi[1], Robert A. Norwood[1]; [1]*Univ. of Arizona, USA.* Etchless photodefined polymer optical waveguides are created through direct-write lithography and commercially available materials. Bypassing wet development provides benefits to optical chip-to-chip devices. At 1550nm telecommunication wavelengths optical propagation loss is less than 1 dB/cm.

JW2A.42
A Dispersion-Compensated Transmitter for All-Pass Radio over Fiber Link with Simultaneous Dispersion Induced Power Fading and Phase Distortion Elimination, Guanyu Han[1], Haojie Wang[1], Shangyuan Li[1], Xiaoxiao Xue[1], Xiaoping Zheng[1], Bingkun Zhou[1]; [1]*Tsinghua National Lab for Information Science and Technology, Dept. of Electronic Engineering, Tsinghua Univ., China.* A dispersion-compensated transmitter for the all-pass RoF link is demonstrated. CD-induced power fading and phase distortion are simultaneously eliminated with the bandwidth up to 25-GHz after 40-km SMF transmission. The SFDR is improved by 13.3-dB.

JW2A.43
Generation of Optical Single Sideband OFDM Using a Silicon Microring IQ modulator, Yelong Xu[1], Mingyang Lyu[1], Jiachuan Lin[1], Leslie A. Rusch[1], Wei Shi[1]; [1]*Université Laval, Canada.* Optical single-sideband (SSB) OFDM signal is experimentally generated by a silicon microring IQ modulator. 24 Gb/s SSB 8-QAM OFDM is successfully achieved with a BER well below the FEC limit.

JW2A.44
Electro-Optic Aperiodically Poled Lithium Niobate Directional Couplers, Yen-Hung Chen[1], Hung-Pin Chung[1], Shih-Yuan Yang[1], Sung-Lin Yang[1], Tsai-Yi Chien[1], Kuang-Hsu Huang[1]; [1]*National Central Univ., Taiwan.* We report the first aperiodically alternating-Δβ directional couplers whose switching behavior can be engineered in great freedom. The fabrication tolerance/working bandwidth of the novel coupler can be increased by 2.7/2.4 times over a conventional coupler.

JW2A.45
Fano Resonance Assisted Tunable Microwave Photonic Phase Shifter in Loaded Ring Resonator, Awanish Pandey[1], Shankar Kumar Selvaraja[1]; [1]*Indian Inst. of Science, India.* We demonstrate photonics assisted RF-phase shifter based on an internally loaded ring resonator exhibiting Fano resonance. A phase shift of 0°-172° has been achieved with a power penalty of 0-4.1 dB for 10 GHz (21-31 GHz) of bandwidth.

JW2A.46
Integrated Power Splitters for Mode-Multiplexed Signals, Yuanhang Zhang[1], Mohammed Al-Mumin[3], Huiyuan Liu[1], Chi Xu[1], Lin Zhang[2], Patrick L. LiKawWa[1], Guifang Li[1]; [1]*Univ. of Central Florida, CREOL, USA;* [2]*Tianjin Univ., China;* [3]*College of Technological Studies, Kuwait.* An on-chip non-center-feed MMI power splitter for mode-multiplexed signals is proposed and experimentally demonstrated for the first time.

JW2A.47
An Ultra-Compact Colorless Dual-Mode 3 dB Power Splitter Based on Axisymmetrical Subwavelength Structure, Weijie Chang[1], Luluzi Lu[1], Deming Liu[1], Minming Zhang[1]; [1]*Huazhong Univ. of Science and Tech, China.* A novel ultra-compact colorless dual mode power splitter using inverse design method is proposed and experimentally demonstrated with low crosstalk < 20 dB and a footprint of only 2.88 × 2.88 um^2.

JW2A.48
Hybrid Silicon Waveguides for Photonic Quantum Circuits Integrating Quantum State Generation and Manipulation, Lingjie Yu[1], Renduo Qi[1], Wei Zhang[1], Yidong Huang[1]; [1]*Tsinghua Univ., China.* We propose a hybrid silicon waveguide structure for photonic quantum circuits, in which biphoton states are generated in the strip waveguide section and manipulated in the shallow-ridge waveguide section.

JW2A.49
Verilog-A Compact Modeling and Simulation of AWGR based All-to-All Optical Interconnects, Kaiqi Zhang[1], Xian Xiao[1], Yu Zhang[1], S. J. Ben Yoo[1]; [1]*Univ. of California Davis, USA.* We construct a Verilog-A compact module for all-to-all optically interconnected system. A physics-based model of a cyclic AWGR generate simulation results, which are compared to the measured data of an actual AWGR.

JW2A.50
An Optical Parallel Multiplier Using Nanophotonic Analog Adders and Optoelectronic Analog-to-Digital Converters, Yuuki Imai[1], Tohru Ishihara[1], Hidetoshi Onodera[1], Akihiko Shinya[2], Shota Kita[2], Kengo Nozaki[2], Kenta Takata[2], Masaya Notomi[2]; [1]*Kyoto Univ., Japan;* [2]*NTT Basic Research Labs, Japan.* We proposes an architecture of an optical parallel multiplier based on an optical analog addition. With optoelectronic circuit simulation, we show that the optical multiplier is more than three times faster than the CMOS multiplier.

JW2A.51
Microwave Waveform Generation via Discrete Fourier Transform of Modulated Optical Pulse Train, Qijie Xie[1], Chester Shu[1]; [1]*Chinese Univ. of Hong Kong, Hong Kong.* A new scheme of microwave waveform generation is experimentally demonstrated utilizing envelope detection of optical waveform generated from discrete Fourier transform of modulated optical pulse trains. Programmable triangular and rectangular microwave waveforms are synthesized.

JW2A.52
High-Power Integrated Indium Phosphide Transmitter for Free Space Optical Communications, Hongwei Zhao[1], Sergio Pinna[1], Bowen Song[1], Ludovico Megalini[1], Simone Brunelli[1], Larry Coldren[1], Jonathan Klamkin[1]; [1]*UC Santa Barbara, USA.* An integrated indium phosphide transmitter is demonstrated for free space optical communications. The transmitter tunes from 1521 nm to 1565 nm, demonstrates performance up to 5 Gbps, and includes an output high-power semiconductor optical amplifier.

JW2A.53
Photonic Microwave Frequency Identification System with a Thermally Tunable Silicon Microring, Xu Wang[1], Feng Zhou[1], Yuhan Yao[1], Xi Xiao[2], Jianji Dong[1], Xinliang Zhang[1]; [1]*Wuhan National Lab for Optoelectronics, China;* [2]*Wuhan Research Inst. of Posts & Telecommunications, State Key Lab of Optical Communication Technologies and Networks, China.* A photonic microwave frequency identification system with a thermally tunable silicon microring is proposed and experimentally demonstrated. The system has excellent performance of wide operating bandwidth of 1-30 GHz, high resolution of 375 MHz and multi-frequency measurement capability.

JW2A.54
Machine learning and Silicon Photonic Sensor for Complex Chemical Components Determination, Hui Zhang[1], Muhammad F. Karim[1], Shaonan Zheng[1,2], Hong Cai[2], Yuan Dong Gu[2], Shoushun Chen[1], Hao Yu[3], Ai Qun Liu[1]; [1]*School of Electrical and Electronic Engineering, Nanyang Technological Univ., Singapore 639798, Singapore;* [2]*Inst. of Microelectronics, A*STAR, Singapore 117685, Singapore;* [3]*Dept. of Electrical and Electronic Engineering, Southern Univ. of Science and Technology, China 518055, China.* We propose an integrated microring resonator sensing system based on Backward-Propagation Neural Networks (BPNN)-Adaboost algorithm to predict component fraction in binary liquid mixtures. A minimum absolute error of 0.0023 and mean squared error of 0.000345 is achieved by this training model.

JW2A.55
Integrated Photodiodes for On-chip Semiconductor Optical Amplifier gain measurement, Agnes A. Verdier[1,2], Alexandre Garreau[1], Karim Mekhazni[1], Carmen Gomez[1], Hélène Debrégeas[1], Hélène Carrère[2], Romain Brenot[1]; [1]*III-V Lab, Nokia Bell Labs, France;* [2]*LPCNO - INSA Toulouse, France.* Two photodiodes are integrated on a semiconductor optical amplifier (SOA) for on-chip measurement of the gain. Coupled waveguides drive fraction of light into photodiodes for gain calculation from photocurrents ratio. The method can easily be implemented in SOA inside photonic integrated circuits.

JW2A.56
Optical frequency comb generation and microwave synthesis with integrated cascaded silicon modulators, Si Qi Liu[1], Kan Wu[1], Linjie Zhou[1], Xu Xiao[1], Yiming Zhong[1], Jianping Chen[1]; [1]*Shanghai Jiao Tong Univ., China.* An optical frequency comb with 15 lines, 5 GHz spacing and 6 dB flatness is generated by two cascaded silicon Mach-Zehnder modulator and phase modulator. We also demonstrate microwave synthesis using the generated frequency comb.

JW2A.57
Monolithic 1310nm 1Gb/s Optical Receiver with Schottky Photodiode in 40nm Bulk CMOS, Wouter Diels[1], Michiel Steyaert[1], Filip Tavernier[1]; [1]*Katholieke Universiteit Leuven, Belgium.* We present an optical receiver with integrated Schottky photodiode in a standard 40nm bulk CMOS process, suitable for 1310nm communication. The low-noise analog front-end enables receiving 1Gb/s data rates at 3.3dBm sensitivity.

JW2A.58
Side-lobe Level Reduction in Two-dimensional Optical Phased Array Antennas, Julian L. Pita[1], Ivan A. Aldaya[2,3], Octavio Santana[2], Luis Araujo[2], Paulo C. Dainese[2], Lucas Gabrielli[1]; [1]*DECOM - FEEC, UNICAMP, Brazil;* [2]*DEQ - IFGW, UNICAMP, Brazil;* [3]*São João da Boa Vista, UNESP, Brazil.* We experimentally demonstrate that by arranging the array elements according to Fermat's spiral, the side lobe level of an 8-element SOI-array is reduced by 0.9 dB. Additional experiments show a 6.9 dB reduction for 64-elements.

JW2A.59
Broadband efficient coupled-cavity electro-optic modulators based on Q engineering for RF photonics applications, Hayk Gevorgyan[1], Anatol Khilo[1], Milos Popovic[1]; [1]*Boston Univ., USA.* We propose a coupled-cavity electro-optic modulator, with tailored supermode Q-factors, for efficient RF-to-optical upconversion of broadband signals. It promises 20-30dB improvement over single-ring modulators and 10-20dB over the state-of-the-art for broadband modulation in high-Q cavities.

JW2A.60
Fully-Automated Grating Coupler Design Through Adjoint Optimization, Logan Su[1], Rahul Trivedi[1], Neil V. Sapra[1], Alexander Y. Piggott[1], Dries Vercruysse[1,2], Jelena Vuckovic[1]; [1]*Stanford, USA;* [2]*Physics, KU Leuven, Belgium.* By leveraging adjoint optimization, we develop an efficient algorithm for designing 1D grating couplers for different functionalities without any human input and use it to design a fiber-to-chip blazed grating with under 0.18 dB loss.

11:30–13:00 JW2A • Poster Session II

JW2A.61
Increasing the Sensitivity-Bandwidth Product of Dual Resonant FSR Electro-Optic Modulators Using a Ring Resonator with Waveguide-Coupled Feedback, Yoo Seung Lee[1], Sang-Shin Lee[2], Chee Wei Wong[1]; [1]*UCLA , USA;* [2]*Electronic Engineering, Kwangwoon Univ., South Korea.* Dual resonant free-spectral-range RF-optic modulators using ring and feedback waveguide have been first proposed and theoretically analyzed to increase the sensitivity–bandwidth product. The sensitivity–bandwidth products are up to 2.5 times larger than conventional sing ring resonator modulator.

JW2A.62
A monolithic integrated InP few-mode transmitter, Zhaosong Li[1,2], Dan Lu[1], Yiming He[1,2], Xuliang Zhou[1], Lingjuan Zhao[1,2], Jiaoqing Pan[1,2]; [1]*Inst. of Semiconductors, CAS, China;* [2]*College of Materials Science and Opto-Electronic Technology, Univ. of Chinese Academy of Sciences, China.* A monolithic integrated InP few-mode transmitter comprising of two directly modulated lasers and a mode converter-multiplexer based on multimode interference coupler was designed and demonstrated. 2×10 Gbps two modes generation and modulation was realized.

JW2A.63
Optimizing Recirculating-Frequency-Shifter performance with Semiconductor Optical Amplifier gain assistance, Xiaoxi Wang[1], Shayan Mookherjea[1]; [1]*Electrical and Computer Engineering, Univ. of California, San Diego, USA.* We show that nonlinear effects—including four wave mixing in chip-based semiconductor optical amplifier gain—impose limits to the wavelength spacing of combs in Recirculating-Frequency-Shifters (RFS), but can be mitigated by operating SOA in deeper saturation.

JW2A.64
Dispersion-engineered high quality lithium niobate microring resonators, Yang He[1], Hanxiao Liang[1], Rui Luo[1], Qiang Lin[1]; [1]*Univ. of Rochester, USA.* We report dispersion-engineered lithium niobate microring resonators with optical Q above one million. In particular, we observed anomalous group-velocity dispersion for all three cavity mode families, with values around -0.5 ps^2/m.

JW2A.65
An Efficient Approach to Characterize Low Loss Waveguides Using Bragg Gratings, Yi-Wen Hu[1], Yang Zhang[1], Pradip Gatkine[1], Joss Bland-Hawthorn[2], Sylvain Veilleux[1], Mario Dagenais[1]; [1]*Univ. of Maryland, USA;* [2]*Univ. of Sydney, Australia.* An efficient approach to measure waveguide loss is developed using record-high Q (>1×10^6) Bragg grating cavities. Our demo sample's loss is evaluated as 0.24 dB/cm, whereas the measurement limit is estimated as 0.001 dB/cm.

JW2A.66
Low Crosstalk Bent Multimode Waveguide for On-chip Mode-Division Multiplexing Interconnects, Xinru Wu[1,2], Wen Zhou[1], Duanni Huang[2], Zeyu Zhang[2], Yi Wang[1], John E. Bowers[2], Hon K. Tsang[1]; [1]*The Chinese Univ. of Hong Kong, Hong Kong;* [2]*Univ. of California, Santa Barbara, USA.* A 90° multimode bent waveguide with a bending radius of 20 μm is proposed and experimentally demonstrated to have - 23 dB crosstalk level over 60 nm optical bandwidth for the three supported quasi-TE modes.

JW2A.67
A Sub-Sampling Time-Interleaved Photonic Analog-to-Digital Converter Based on an Optoelectronic Oscillator, Huanfa Peng[1], Rui Guo[1], Huayang Du[1], Yongchi Xu[1], Cheng Zhang[1], Jingbiao Chen[1], Zhangyuan Chen[1]; [1]*Peking Univ., China.* A sub-sampling time-interleaved photonic analog-to-digital converter based on an optoelectronic oscillator is demonstrated. A sampling rate of 20GS/s, analog bandwidth of 8GHz and ENOB of 4.6bits are realized with a test signal of 21.5GHz single-tone.

JW2A.68
Tagging Electronic ICs using Silicon Nitride Photonic Physical Unclonable Functions, Hongcheng Sun[1], Milad Alemohammad[1], Bryan Bosworth[1], A. B. Cooper[1], Mark A. Foster[1], Amy Foster[1]; [1]*Johns Hopkins Univ. , USA.* We demonstrate an on-chip photonic physical unclonable function using integrated evanescently coupled multimode spiral waveguides formed in silicon nitride with rich spectral features and validate it for use in an identification tagging application for electronic ICs.

JW2A.69
Pattern enhancement of high speed data modulation through saturating SOA-integrated EAM, Yi-Jen Chiu[1], Rih-You Chen[1]; [1]*National Sun Yat-Sen Univ., Taiwan.* An optical modulation scheme by saturating SOA-integrated EAM is used for enhancing high-speed optical waveform. The saturation conditions on devices will have complemental carrier dynamics, thus leading to significant improvement of extinction ratio and also signal-to-noise ratio.

JW2A.70
Geometric Loss Reduction in Tight Bent Waveguides for Silicon Photonics, Makoto Nakai[2,1], Tsuyoshi Nomura[1], Sung-Won Chung[2], Hossein Hashemi[2]; [1]*Toyota Central R&D Labs., INC, Japan;* [2]*Viterbi School of Engineering, Univ. of Southern California, USA.* A bent waveguide with a Clothoid shape whose width is adjusted along the curvature is demonstrated. The loss is less than 0.04 dB for a single S-shape bend with a bend radius of 1.6 um.

JW2A.71
Superchannel Engineering with Microresonator Combs, Óskar B. Helgason[1], Attila Fulop[1], Jochen Schröder[1], Peter A. Andrekson[1], Andrew M. Weiner[2], Victor Torres-Company[1]; [1]*Dept. of Microtechnology and Nanoscience, Chalmers Univ. of Technology, Sweden;* [2]*School of Electrical and Computer Engineering, Purdue Univ., USA.* We study segmenting the available bandwidth of a WDM system into microcombdriven superchannels. This solution improves the power per line while using a fraction of the pump power, making it potentially more favorable for integration.

JW2A.72
Fiber to Chip Fusion Splicing for Robust, Low Loss Optical Coupling, Juniyali Nauriyal[1], Jaime Cardenas[1], Meiting Song[1], Raymond Yu[1]; [1]*Univ. of Rochester, USA.* We present a novel method of optical coupling to permanently attach a fiber to a chip using fusion splicing. As proof-of-concept, we achieve 3dB loss per facet between a silicon-nitride chip and a cleaved fiber.

JW2A.73
Photonic Microwave Channelization Based on Frequency Shifted Feedback Laser and Delayed Coherent Detection, Wenhui Hao[1], Yitang Dai[1], Feifei Yin[1], Yue Zhou[1], Jianqiang Li[1], Kun Xu[1]; [1]*Beijing Univ. of Posts and Telecoms, China.* We present a microwave channelizer implemented by frequency shifted feedback laser and I/Q demodulation. The mixing of pulse and its own delay generates a tunable radio frequency local oscillation which can be used for channelization.

JW2A.74
Mode identification for ultra high-Q terahertz whispering-gallery modes, Dominik W. Vogt[1], Rainer Leonhardt[1]; [1]*Univ. of Auckland, New Zealand.* We report on the identification of terahertz whispering-gallery modes using the phase information from coherent continuous-wave spectroscopy. The demonstrated WGM has an ultra high quality factor of 1.5x10^4 at 0.62THz.

JW2A.75
Graphene Anti-dot Arrays with Self-aligned Gold Disks for Enhanced Excitation of Terahertz Surface Plasmons, Licheng Xiao[1], Xianglong Miao[1], Geng Li[1], Peter Q. Liu[1]; [1]*Electrical Engineering, Univ. at Buffalo, The State Univ. of New York, USA.* A periodic graphene anti-dot array integrated with self-aligned gold disks for enhancing interactions between terahertz graphene surface plasmons and incident light is demonstrated. Experimental results show enhancement of the resonant transmission modulation by ~3 times.

JW2A.76
Efficient Design of Diffractive THz Lenses for Aberration Rectified Focusing via Modified Binary Search Algorithm, Sourangsu Banerji[1], Ashish Chanana[1], Hugo Condori[1], Ajay Nahata[1], Berardi Sensale-Rodriguez[1]; [1]*Univ. of Utah, USA.* We experimentally demonstrate thin, error tolerant, and aberration corrected 3D printed diffractive 1D and 2D THz lenses for focusing THz beams with *NA* > 0.25 and an average efficiency greater than 75% (for all cases). Our work has relevance to THz lens design, and in general,THz imaging systems.

JW2A.77
Ultrashort Pulsed-Laser Fabrication of Silicon Moth-Eye Structures for Terahertz Anti-Reflection, Haruyuki Sakurai[1], Natsuki Nemoto[1], Kuniaki Konishi[1], Yuki Sakurai[1], Nobu Katayama[1], Tomotake Matsumura[1], Junji Yumoto[1], Makoto Kuwata-Gonokami[1]; [1]*The Univ. of Tokyo, Japan.* We fabricate moth-eye anti-reflection structures for the terahertz region on high-resistivity silicon substrates by ultrashort pulsed-laser ablation. We demonstrate 1.4 times increased THz yield from Mg:LN by using the moth-eye structure as an output coupler

JW2A.78
Discovery of Phase-matched Stimulated Polariton Scattering near 4 THz in Lithium Niobate, Yen-Chieh Huang[1], Yu Chung Chiu[1], Tsong Dong Wang[3], Gang Zhao[2]; [1]*National Tsing Hua Univ., Taiwan;* [2]*Inst. of Heavy Ion Physics, China;* [3]*Chung-Shan Inst. of Science and Technology, Taiwan.* We report highly efficient stimulated polariton scattering near 4 THz with a parametric gain overtaking the well-known one near 1.8-THz in lithium niobate by using an off-axis parametric oscillator resonating the THz wave.

JW2A.79
Nano-electrode photomixer free from low-temperature-grown semiconductors for THz detection, Kiwon Moon[1], Il-Min Lee[1], Eui Su Lee[1], Kyung Hyun Park[1]; [1]*ETRI, South Korea.* By manipulating local photocarrier dynamics by means of field enhancement and plasmonic enhanced absorption harnessed by nano-electrode, we demonstrate the photo-conductive detection of continuous-wave THz radiations without using low-temperature-grown optoelectronic materials.

JW2A.80
Generation of Intense Terahertz Pulses with Longitudinal Electric fields, Mizuho Matoba[1], Natsuki Nemoto[1], Natsuki Kanda[1,2], Kuniaki Konishi[1], Junji Yumoto[1], Makoto Kuwata-Gonokami[1]; [1]*The Univ. of Tokyo, Japan;* [2]*RIKEN Center for Advanced Photonics, RIKEN, Japan.* We demonstrate a method for converting broadband intense terahertz Gaussian beams into Hermite-Gaussian 01 beams, based on a specially designed prism. The generated longitudinal electric fields by focusing them were observed to be 36 kV/cm.

JW2A.81
High-field Terahertz Pulses Generated in an HMQ-TMS Organic Crystal Pumped by an Amplified Ytterbium Laser, Andrea Rovere[1], Young-Gyun Jeong[1], Riccardo Piccoli[1], Seung-Heon Lee[2], Seung-Chul Lee[2], O-Pil Kwon[2], Mojca Jazbinsek[3], Roberto Morandotti[1,4], Luca Razzari[1]; [1]*INRS-Energie Materiaux et Telecom, Canada;* [2]*Ajou Univ., South Korea;* [3]*Zurich Univ. of Applied Science, Switzerland;* [4]*National Research Univ. of Information Technologies, Russia.* High-peak-electric-field THz pulses (>200 kV/cm) can be efficiently generated in a recently developed organic crystal pumped by a femtosecond ytterbium laser in a collinear configuration.

11:30–13:00 JW2A • Poster Session II

JW2A.82
Ferroelectric Metasurfaces for THz Wave Manipulation, Jingyul Tian[1,2], Fredrik Laurell[1], Valdas Pasiskevicius[1], Min Qiu[2], Hoon Jang[1]; [1]*Dept. of Applied Physics, Royal Inst. of Technology, KTH, Sweden;* [2]*College of Optical Science and Engineering, Zhejiang Univ., China.* We propose ferroelectric metasurfaces based on $KTiOPO_4$ and demonstrate the fabrication procedures. It will provide a versatile platform for THz wave manipulation and open up new possibilities to monolithically combine it with THz generation.

JW2A.83
Anti-reflection coating design for metallic terahertz metamaterials, Matteo Pancaldi[2,1], Ryan Freeman[3], Matthias Hudl[1], Matthias C. Hoffmann[4], Sergei Urazhdin[3], Paolo Vavassori[2], Stefano Bonetti[1]; [1]*Stockholm Univ., Sweden;* [2]*CIC nanoGUNE, Spain;* [3]*Emory Univ., USA;* [4]*SLAC National Accelerator Lab, USA.* We demonstrate a silicon-based, single-layer anti-reflection coating that suppresses the reflectivity of metals at near-infrared frequencies, enabling optical probing of nanoscale structures embedded in highly reflective surroundings, paving the way for table-top studies on such systems.

JW2A.84
Terahertz Antireflection Metasurfaces and Application in Narrow Bandpass Filters, Hou-Tong Chen[1], Chun-Chieh Chang[1], Li Huang[2], John Nogan[3]; [1]*Los Alamos National Lab, USA;* [2]*Harbin Inst. of Technology, China;* [3]*Sandia National Labs, USA.* Here we demonstrate bilayer metasurfaces for narrow, dual and broadband terahertz antireflection on a silicon surface. By stacking multiple metasurfaces, we realize narrow bandpass terahertz filters with an extremely clean background.

JW2A.85
Coupled Microring Resonator Lattices as Periodically-Driven Floquet Topological Insulators, Shirin Afzal[1], Vien Van[1]; [1]*Electrical and Computer Engineering, Univ. of Alberta, Canada.* We show that 2D coupled microring lattices represent systems with periodic Hamiltonian and are thus natural structures for realizing photonic Floquet topological insulators. Their topological equivalence to arrays of periodically-coupled waveguides is also established.

JW2A.86
Dispersion engineering with plasmonic nanostructures for enhanced surface plasmon resonance sensing, P. Arora[1], Eliran Talker[1], Noa Mazurski[1], Uriel Levy[1]; [1]*Dept. of Applied Physics, The Hebrew Univ. of Jerusalem, Israel.* We experimentally demonstrate plasmonic resonance narrowing via dispersion engineering using plasmonic nanogratings placed on top of thin metal coated prism. The enhancement in Q factor, combined with strong field localization is attractive for sensing applications.

JW2A.87
Lossless Edge States Protected by PT-Symmetric Phase, Xiang Ni[1,2], Daria Smirnova[2], Alexander N. Poddubny[3,4], Daniel Leykam[5], Yidong Chong[5], Alexander Khanikaev[2,1]; [1]*Graduate Center of CUNY, USA;* [2]*City College of New York, USA;* [3]*Australian National Univ., Australia;* [4]*ITMO Univ., Russia;* [5]*Nanyang Technological Univ., Singapore.* Parity-time (PT) symmetric interfaces between amplifying and lossy crystals support dissipationless edge states exhibiting gapless spectra in complex band structure if exceptional points (EPs) of edge states exist, which is verified by rigorous full-wave simulations in PT-symmetric photonic graphene

JW2A.88
Billion-times Enhanced 3rd Order Nonlinear Susceptibility Based on Non-resonant Mesoscopic Crystal, Taeyong Chang[1], Jonghwa Shin[1]; [1]*KAIST, South Korea.* We propose a broadband enhancement scheme of optical nonlinearity with mesoscopically structured material. The one billion enhancement is larger than any previous result. The nonlinear susceptibility tensor components can be individually tuned and 18 different crystal classes can be realized.

JW2A.89
Ghost Resonance in Light Scattering., Sanjay Debnath[1], Evgenii E. Narimanov[1]; [1]*Purdue Univ., USA.* We demonstrate the presence of ghost resonance in optical scattering from dielectric systems, and develop the theoretical description of this effect.

JW2A.90
Temporal Metamaterials with Non-Foster Networks, Yasaman Kiasat[1], Victor Pacheo-Pena[1], Brian Edwards[1], Nader Engheta[1]; [1]*Univ. of Pennsylvania, USA.* We theoretically explore instantaneous time mirrors (ITM) for real-time amplification of electrometric wave using non-Foster networks to engineer the required dispersion. Our analytical and numerical results demonstrate various salient features of this phenomenon.

JW2A.91
Hyperbolic Metamaterials for Quantum Dot Emission Enhancement- Effects of Unit Cell Thickness and Light Outcoupling, Akash Kannegulla[1], Bo Wu[1], Ye Liu[1], Yi-Chieh Wang[1], Li-Jing Cheng[1]; [1]*Oregon State Univ., USA.* We investigated how the unit cell thickness of multilayer hyperbolic metamaterials affects the enhancement of quantum dot emission. A facile outcoupling approach was demonstrated to improve the emission using a large-area nanoparticle-based photonic crystal.

JW2A.92
Slow-light Si-wire Waveguide with Metamaterial, Satoshi Yamasaki[1], Tomohiro Amemiya[1], Zhichen Gu[1], Junichi Suzuki[1], Keisuke Masuda[1], Hibiki Kagami[1], Nobu Nishiyama[1], Shigehisa Arai[1]; [1]*Tokyo Inst. of Technology, Japan.* We propose a novel slow-light Si-wire waveguide using metamaterials, which can be easily integrated with other Si photonics devices, and the group index of more than 40 was obtained in both theoretical and experimental investigations.

JW2A.93
Free-space Optical Mach-Zehnder Modulator based on Two Cascaded Metasurfaces, Nasim Mohammadi Estakhri[1], Nader Engheta[1]; [1]*Univ. of Pennsylvania, USA.* An approach to realize Mach-Zehnder type modulators in free-space is presented. Modulation is based on the relative distance between two parallel gradient metasurfaces. We numerically study the device performance and discuss its potential applications.

JW2A.94
Control of Electric and Magnetic Resonances in Nanoparticle Metasurfaces, Viktoriia Babicheva[1], Andrey Evlyukhin[2,3]; [1]*College of Optical Sciences, Univ. of Arizona, USA;* [2]*Laser Zentrum Hannover e.V, Germany;* [3]*ITMO Univ., Russia.* We study collective multipole resonances in plasmonic and dielectric nanoparticle arrays. Because of the lattice multipole resonance overlap, the transmission and reflection can be tuned in a given spectral range choosing an appropriate array periodicity.

JW2A.95
Plasmonic Tuning of Effective Phase Transition Temperature and Electrical Conductivity, James Frame[1], Wanaka Kubo[2,3], Xu Fang[1]; [1]*Dept. of Electronics and Computer Science, Univ. of Southampton, UK;* [2]*Dept. of Electrical and Electronic Engineering, Tokyo Univ. of Agriculture and Technology, Japan;* [3]*Metamaterials Lab, RIKEN, Japan.* Thermo-plasmonic engineering at the nanoscale can control material properties at the macroscopic scale. We demonstrate utilising plasmonic resonance to tune the effective phase transition temperature and electrical conductivity of vanadium oxide thin films

JW2A.96
Engineering Optical Emission of Sub-diffraction Hyperbolic Metamaterial Resonators, Kaijun Feng[1], Galen Harden[1], Deborah Sivco[2], Anthony Hoffman[1]; [1]*Univ. of Notre Dame, USA;* [2]*Princeton Univ., USA.* We develop an electrodynamic model for sub-diffraction hyperbolic metamaterial resonators using the modified long wave approximation and verify it via experiment and simulations. We investigate engineering the resonator *Q*, photon loss and far-field pattern.

JW2A.97
A new method to obtain the phase for designing highly efficient metasurface devices: Local Phase Method, Liyi Hsu[1], Matthieu Dupre[1], Abdoulaye Ndao[1], Boubacar Kante[1]; [1]*Electrical and Computer Engineering, Univ. of California San Diego, USA.* Recently, metasurfaces have attracted significant attention. However, the approach assumes that neighboring elements are identical. We propose a method accounting for near-field coupling with different neighbors. The proposed local phase method paves the way to highly efficient metasurface devices.

JW2A.98
Second Harmonic Generation in Geometric-Phase Resonant Dielectric Metasurfaces, Jonathan Bar-David[1], Uriel Levy[1]; [1]*Hebrew Univ. of Jerusalem, Israel.* We explore the second harmonic generation from resonant dielectric metasurfaces. We experimentally demonstrate that second harmonic radiation intensity and emission patterns can be controlled by metasurface structure and meta-atom symmetries.

JW2A.99
Complex Birefringence with Dielectric Metasurfaces for Non-conventional Polarisation Control, Shaun Lung[1], Kai Wang[1], Andrey A. Sukhorukov[1]; [1]*Nonlinear Physics Centre, Research School of Physics and Engineering, The Australian National Univ., Australia.* We establish that complex birefringence can be efficiently realised with all-dielectric metasurfaces without utilising material losses, enabling new regimes of polarisation control for enhanced measurements and unconventional interference for classical and quantum light.

JW2A.100
Double-Layer USRRs for a Thin Terahertz-Wave Phase Shifter with High Transmission, Zhengli Han[1], Seigo Ohno[2], Yu Tokizane[1], Kouji Nawata[1], Takashi Notake[1], Yuma Takida[1], Hiroaki Minamide[1]; [1]*Riken, Japan;* [2]*Tohoku Univ., Japan.* Double-layer un-split ring resonators (USRRs) with film metamaterial was developed for a thin THz-wave phase shifter (48μm-thick) with high transmission and polarization independent properties. The film size of 5cm×5cm enables large THz optical components.

JW2A.101
Metasurfaces with wavelength-controlled functions, Zhujun Shi[1], Mohammadreza Khorasaninejad[1], Yao-Wei Huang[1], Charles Roques-Carmes[1], Vyshakh Sanjeev[1], Alexander Zhu[1], Wei-Ting Chen[1], Michele Tamagnone[1], Kundan Chaudhary[1], Cheng-Wei Qiu[2], Federico Capasso[1]; [1]*Harvard Univ., USA;* [2]*National Univ. of Singapore, Singapore.* We demonstrate single-layer metasurfaces with controllable multi-wavelength functions. A multiwavelength achromatic metalens for red, yellow, green and blue light, and metasurfaces generating focused beams with different orbital angular momentum states are designed and fabricated.

JW2A.102
The Chirality of Exceptional Points – An Experimental Investigation, Samlan C.T.[1], Nirmal K. Viswanathan[1]; [1]*Univ. of Hyderabad, India.* Behavior of exceptional points (EPs) in biaxial crystal is experimentally investigated, as the system is taken from *absorption-dominated* regime to *chirality-dominated*, using conoscopic Stokes polarimetry. The resulting chirality-mediated helical trajectory of the EP is reported.

JW2A.103
Position Selective Beam Shaping in Mid-Infrared Regime by All-Dielectric Metasurfaces, Boris Desiatov[1], Marko Loncar[1]; [1]*Harvard, USA.* We demonstrate the design, fabrication and experimental characterization of a dielectric metasurfaces acting as a position selective computer generated hologram operating at mid infrared wavelength of 4.5 micron.

11:30–13:00 JW2A • Poster Session II

JW2A.104
Difference-Frequency Generation and Frequency Up-Conversion with Polaritonic Nonlinear Metasurfaces, Yingnan Liu[1], Jongwon Lee[2], Stephen March[1], Nishant Nookala[1], Daniele Palaferri[1], Omri Wolf[3], Igal Brener[3], Seth Bank[1], Mikhail A. Belkin[1]; [1]*The Univ. of Texas at Austin, USA;* [2]*2School of Electrical and Computer Engineering, Ulsan National Inst. of Science and Technology, South Korea;* [3]*Sandia National Labs, USA.* We report difference-frequency generation in nonlinear metasurfaces based on coupling of electromagnetic nanocavity modes with intersubband nonlinearities in semiconductor heterostructures. Nonlinear susceptibility of 2.7×10^5pm/V and the conversion efficiency of 0.13% were measured.

JW2A.105
Influence of geometry on speed of phase-change in GST-based nanorods, Andrea Aboujaoude[1], Joshua Burrow[1], Josh Hendrickson[2], Imad Agha[1], Andrew Sarangan[1], Joseph W. Haus[1]; [1]*Univ. of Dayton, USA;* [2]*Air Force Research Lab, USA.* We investigate how patterning phase-change materials into nanorods influences the speed of phase-change through a modification of temporal dynamics of heating/cooling. It is shown that a 10-fold improvement over bulk geometry can be achieved.

JW2A.106
Mode hybridization in lattice induced transparency for polarization-insensitive THz metasurfaces, Joshua Burrow[1], Riad Yahiaoui[2], Andrew Sarangan[1], Jay Mathews[1], Imad Agha[1], Thomas Searles[2]; [1]*Univ. of Dayton, USA;* [2]*Dept. of Physics & Astronomy, Howard Univ., USA.* We demonstrate multiple lattice-induced transparencies by decoupling the first-order lattice mode achieving a measured Q factor of 40 and support measurements with numerical calculations revealing bright dipole resonances.

JW2A.107
Revisitation of ZnO random lasers toward optical security, Seung Ho Choi[1], Young Jin Yoo[2], Jung Woo Leem[1], Jong Heon Lee[2], Young Min Song[2], Young L. Kim[1]; [1]*Purdue Univ., USA;* [2]*GIST, South Korea.* Random lasing with localized modes, governed by the inherent randomness and uncertainty, are genuinely stochastic with high entropy. Such optical chaos generated from ZnO random lasers could be used for healthcare encryption and security applications.

JW2A.108
Pseudocanalization Regime for Surface Waves, Taavi Repän[1], Andrey Novitsky[1], Morten Willatzen[1], Andrei V. Lavrinenko[1]; [1]*DTU Fotonik, Technical Univ. of Denmark, Denmark.* Magnetic properties can be used to reverse phase advancing in the pseudocanalization regime of hyperbolic metamaterials. However, practical implementations of required μ-negative media are challenging. Here we reveal analogous effect for the electromagnetic surface waves in non-magnetic materials.

JW2A.109
Dynamically Tunable, Vanadium Dioxide Huygens Source Metasurfaces, Yaping Ji[1], Adam Ollanik[1], Mason Belue[2], Matthew D. Escarra[1]; [1]*Tulane Univ., USA;* [2]*Univ. of Arkansas, USA.* An active vanadium dioxide Huygens source metasurface offering >85% near-infrared transmittance modulation over the first 10% of the metal-insulator transition is demonstrated. The fabricated vanadium dioxide Huygens source nanoantennas exhibit experimental results similar to the model.

JW2A.110
Multimodal Parity Conversion in Supersymmetric Optical Potentials for Controlling Random Waves, Sunkyu Yu[1], Xianji Piao[1], Choonlae Cho[1], Namkyoo Park[1]; [1]*Seoul National Univ., South Korea.* Utilizing isospectral and global parity conversion in supersymmetric transformation, we demonstrate multimodal switching with high throughput and isolation. We show that the collective multimode manipulation in supersymmetric harmonic potentials allows random wave switching.

JW2A.111
Metagrating holograms with ultra-wide incident angle tolerances and high diffraction efficiencies, Zi-Lan Deng[1], Junhong Deng[2], Guo Ping Wang[3], Xing Cheng[2], Guixin Li[2], Xiangping Li[1]; [1]*Jinan Univ., China;* [2]*Southern Univ. of Science and Technology, China;* [3]*Shenzhen Univ., China.* High-performance meta-holograms are experimentally demonstrated in a near-unity-efficiency metagrating platform without any size or shape variation of the meta-atoms, which is robust against large incident angles, and sustains high diffraction efficiency in a broadband.

JW2A.112
Toroidal Response of Asymmetric Metasurfaces with Multiple High Q-Factor Resonances, Riad Yahiaoui[1], Sirak M. Mekonen[1], Joshua A. Burrow[2], Pheona Williams[1], Andrew Sarangan[2], Imad Agha[2], Jay Mathews[2], Thomas Searles[1]; [1]*Howard Univ., USA;* [2]*Univ. of Dayton, USA.* We report numerical simulations and experimental investigations of a planar asymmetric terahertz metamaterials exhibiting toroidal response. By inducing symmetry breaking, multiple Fano-like resonances arise in 0.1-2.5 THz frequency range with extremely high Q-factor.

JW2A.113
Manipulation Of The Propagation Of Light In Tunable Nonlinear Bragg Mirrors With Embedded Quantum Wells, Evgeny Sedov[1,2], Irina Sedova[2], Igor Chestnov[2], Sergey Arakelian[2], Alexey Kavokin[1,3]; [1]*Univ. of Southampton, UK;* [2]*Vladimir State Univ., Russia;* [3]*. St. Petersburg State Univ., Russia.* The specially designed nonlinear semiconductor structure with embedded quantum wells possesses a tunable hyperbolic dispersion. We revealed dynamical regimes for localized polariton wave packets resulting from competition of the hyperbolic dispersion and the repulsive nonlinearity

JW2A.114
A Novel Photonic Structure with a Nodal Line of Dirac Cones and a Photonic Topological Insulator that Emerges from it, Ran A. Gladstein Gladstone[1], Gennady Shvets[1]; [1]*Cornell Univ., USA.* We propose a 2D photonic structure with a nodal line of Dirac cones. We then perturb the structure to open a band gap and reveal topologically protected edge states that also support localized slow light.

JW2A.115
X-ray created metamaterials: applications to metal-free structural colors with full chromaticity spectrum and 80 nm spatial resolution., Marcella Bonifazi[1], Valerio Mazzone[1], Andrea Fratalocchi[1]; [1]*King Abdullah Univ of Sci & Technology, Italy.* We created new types of metamaterials by hard X-rays possessing high fluency. We discuss applications in structural colors that show full spectrum of Cyan, Yellow, Magenta, Black (CYMK), realized in transparent dielectrics with 80 nm resolution.

JW2A.116
In-situ Visualization of Multiple Filament Competition Dynamic of Femtosecond Laser, Qi PengFei[1]; [1]*Nankai Univ., China.* The visualization of multiple filamentation competition has been realized performing the three-photon fluorescence. The random changes of multiple filamentation are first observed directly and visually, which can be well explained by a simplified model.

JW2A.117
Laser Absorption and Scaling Behavior in Powder Bed Fusion Additive Manufacturing of Metals, Jianchao Ye[1], Alexander M. Rubenchik[1], Michael F. Crumb[1], Gabe Guss[1], Manyalibo J. Matthews[1]; [1]*Lawrence Livermore National Lab, USA.* The effect of powder bed thickness and laser beam diameter on laser absorptivity is studied using micro-calorimetry. Dimensionless analysis is utilized to consolidate multiple influence factors into a single parameter for comparison between materials and laser parameters.

JW2A.118
Measuring quantum efficiency and background absorption of an Ytterbium-doped ZBLAN fiber, Mostafa Peysokhan[1], Behnam Abaie[1], Esmaeil Mobini[1], Saeid Rostami[1], Arash Mafi[1]; [1]*Univ. of New Mexico, USA.* Laser-induced temperature modulation spectrum (LITMoS) test is performed for an Ytterbium-doped ZBLAN fiber. The quantum efficiency and the background absorption are extracted from the cooling efficiency curve of the LITMoS test.

JW2A.119
Raman Nonlinearity Influence On Temporal Pulse Dynamics And Supercontinuum Generation Under Filamentation In YAG Crystal, Kirill Lvov[1,2], Sergey Y. Stremoukhov[1,2], Fedor Potemkin[1]; [1]*M.V. Lomonosov Moscow State Univ., Russia;* [2]*National Research Center "Kurchatov Inst.", Russia.* We report an asymmetric Raman-initiated temporal splitting and spectrum transformation of intense 200 fs laser pulses with normal (1.24 μm) and anomalous (1.9 μm) group velocity dispersion in YAG crystal.

JW2A.120
Librations in Water Nanodroplets Confined in DOPC Reverse Micelles, Giulia Folpini[1], Torsten Siebert[1,4], Michael Woerner[1], Thomas Elsaesser[1], Stephane Abel[2], Damien Laage[3,5]; [1]*Max-Born-Institut fuer Nichtlineare Optik und Kurzzeitspektroskopie, Germany;* [2]*I2BC, Universite Paris-Saclay, France;* [3]*Departement de Chemie, Ecole Normale Superieure, France;* [4]*Dept. of Physics, Freie Universität Berlin, Germany;* [5]*Sorbonne Universite, France.* We study the librational absorption spectra of water nanodroplets in reverse micelles by time-domain THz spectroscopy: an additional feature at 830 cm-1 is assigned by molecular dynamics simulations to water molecules bonded to phosphate heads.

JW2A.121
Ultrafast pulse generation in the mid-infrared via modulated emissivity, Yuzhe Xiao[1], Nicholas Charipar[2], Alberto Pique[2], Mikhail Kats[1]; [1]*Univ. of Wisconsin-Madison, USA;* [2]*Naval Research Lab, USA.* We demonstrate that mid-infrared pulses can be generated by fast emissivity modulation of semiconductors. Ultrafast visible-frequency pulses were used to pump intrinsic unpatterned silicon and gallium arsenide, resulting in nanosecond-scale thermally emitted pulses.

JW2A.122
Calculating Terahertz Near-fields in the Scanning Tunneling Microscope Junction, Peter H. Nguyen[1], Vedran Jelic[1], Graham Hornig[1], Rathje Christopher[2], Frank A. Hegmann[1]; [1]*Univ. of Alberta, Canada;* [2]*4th Physical Inst., Univ. of Gottingen, Germany.* A finite-element-method model of the terahertz scanning tunneling microscope experiment is built to simulate the propagation and coupling of THz pulses to the STM junction. Simulations are compared with analytical calculations.

JW2A.123
Optical response of crystals with effective models, Rodrigo A. Muniz[1,2], Jin-Luo Cheng[3], John E. Sipe[1], Mackillo Kira[2]; [1]*Univ. of Toronto, Canada;* [2]*Univ. of Michigan, USA;* [3]*Changchun Inst. of Optics, fine Mechanics and Physics, Chinese Academy of Sciences, China.* We present a scheme of using effective models to efficiently compute optical properties of crystals. The dynamics equations depend only on gauge-invariant quantities, and we avoid introducing a position operator.

JW2A.124
Single Exciton Optical Gain in $CsPbBr_3$ Nanocrystals Uncovered by 2D Electronic Spectroscopy, Wei Zhao[1], Zhengyuan Qin[2], Chunfeng Zhang[2], Xingcan Dai[1], Min Xiao[3,2]; [1]*Dept. of Physics, Tsinghua Univ., China;* [2]*National Lab of Solid State Microstructures, School of Physics, and Collaborative Innovation Center of Advanced Microstructures, Nanjing Univ., China;* [3]*Dept. of Physics, Univ. of Arkansas, USA.* We study the gain mechanism of $CsPbBr_3$ colloidal nanocrystals using 2D electronic spectroscopy. Optical gain in single-exciton regime has been observed in fluence-dependent measurements, indicating the promising potential for applying perovskite nanocrystals in laser technology.

11:30–13:00 JW2A • Poster Session II

JW2A.125
Radiative and Nonradiative Recombination Coefficients of InAs/InAlAs Core-shell Nanowires, Xinxin Li[1,2], Kailing Zhang[1,2], Fatima Toor[2,3], John Prineas[1,2], Julian Treu[4], Lukas Stampfer[4], Gregor Koblmüller[4]; [1]*Physics and Astronomy, Univ. of Iowa, USA;* [2]*Optical Science and Technology Center, Univ. of Iowa, USA;* [3]*Electrical and Computer Engineering, Univ. of Iowa, USA;* [4]*Physik Dept., Walter Schottky Institut of Technische Universitat Munchen, Germany.* Ultrafast and external quantum efficiency measurements were performed on InAs/InAlAs core-shell nanowires. Rates of different recombination mechanisms were determined, and the carrier densities ranges at which each dominates, an important consideration for design of devices

JW2A.126
Plasmon-Induced Hot Electron Transfer in Ag-$CsPbBr_3$ Hybrid Nanocrystals, Xinyu Huang[1], Hongbo Li[2], Chunfeng Zhang[1], Zhenda Lu[2], Min Xiao[1,3]; [1]*National Lab of Solid State Microstructures, School of Physics, and Collaborative Innovation Center of Advanced Microstructures, Nanjing Univ., China;* [2]*National Lab of Solid State Microstructures, College of Engineering and Applied Sciences, Collaborative Innovation Center of Advanced Microstructures and Research Center for Environmental Nanotechnology (ReCENT), Nanjing Univ., China;* [3]*Dept. of Physics, Univ. of Arkansas, USA.* We demonstrate plasmon-induced hot-electron transfer in Ag-$CsPbBr_3$ hybrid nanocrystals. Using transient absorption spectroscopy, we have observed the highly efficient transfer hot electrons from metal Ag to semiconductor $CsPbBr_3$ in a timescale of sub-100 fs.

JW2A.127
Ultrafast Optical Response Due to Nonlocal Interaction between Light and Excitons in ZnO Thin Films, Masayoshi Ichimiya[1,3], Takuya Matsuda[2], Takashi Kinoshita[2], Takuya Takahashi[1], Masaaki Nakayama[4], Hajime Ishihara[1,2], Masaaki Ashida[1]; [1]*Osaka Univ., Japan;* [2]*Osaka Prefecture Univ., Japan;* [3]*The Univ. of Shiga Prefecture, Japan;* [4]*Osaka City Univ., Japan.* Ultrafast optical response in ZnO thin films has been investigated by the transient grating method. Sub-picosecond radiative recombination caused by radiation-induced interaction between two multipole-type excitons was observed between nano- and micro-scale.

JW2A.128
Transient Electronic Anisotropy in Normal State of Overdoped $NaFe_{1-x}Co_xAs$ Superconductors, Shenghua Liu[1], Chunfeng Zhang[1], Xiaoyong Wang[1], Min Xiao[1]; [1]*Nanjing Univ., China.* We observe anisotropic electronic response in the tetragonal phase of $NaFe_{1-x}Co_xAs$ superconductors by using polarization-dependent pump-probe spectroscopy, which can be scribed as a result of nematic fluctuation driven by an orbital order.

JW2A.129
Carrier Relaxation Dynamics of InGaN/GaN Dot-in-Nanowires, Heather George[1], Yong-Ho Ra[2], Zetian Mi[1,2], Theodore B. Norris[1]; [1]*EECS, Univ. of Michigan, USA;* [2]*Electrical and Computer Engineering, McGill Univ., Canada.* Carrier relaxation was investigated for InGaN/GaN dot-in-nanowires using femtosecond pump-probe in transmission 400nm pump/white light probe. Though bright emitters, the localization of states contributes to relaxation rates which are faster than expected.

JW2A.130
Ultrashort molecular dynamics and flame temperature measurements by hybrid fs/ps CARS spectroscopy, Xia Yuanqin[1], Zhibin Zhang[1], Sheng Zhang[1], Yang Zhao[1], Guozhong Hou[1]; [1]*Harbin Inst. of Technology, China.* We research the molecular dynamics by hybrid femtosecond/picosecond coherent anti-Stokes Raman scattering (fs/ps CARS), and utilize the single-laser-shot CPP (chirped Probe Pulse) fs CARS signals of N_2 to get the temperature information.

JW2A.131
Terahertz Carrier Dynamics in Epitaxial Layered ε-InSe, Wei Lu[1], Zhibin Yang[2,3], Jianhuan Hao[2,3], Dong Sun[1,4]; [1]*International Center for Quantum Materials, School of Physics, Peking Univ., China;* [2]*Dept. of Applied Physics, The Hong Kong Polytechnic Univ., Hung Hom, China;* [3]*The Hong Kong Polytechnic Univ. Shenzhen Research Inst., China;* [4]*Collaborative Innovation Center of Quantum Matter, China.* Relaxation of optically excited quasiparticles in ε-InSe is studied by employing ultrafast optical-pump THz-probe spectroscopy. The excited quasiparticles enhance the THz absorption and relax by three processes which occur in few to hundreds of picoseconds.

JW2A.132
Natural Lineshapes by Projecting Multidimensional Spectra, Geoffrey M. Diederich[1], Mark E. Siemens[1]; [1]*The Univ. of Denver, USA.* We take one-dimensional data along arbitrary directions in the *t*-*t* plane of a multidimensional coherent spectroscopy experiment to obtain projections in the w_t-w_t plane, allowing faster data collection and insight into the meaning of lineshapes.

JW2A.133
Dynamic Terahertz Response in the Dirac Semimetal Cd_3As_2 Induced by Ultrafast Optical Excitation, Wei Lu[1], Jiwei Ling[2], Faxian Xiu[2], Dong Sun[1,3]; [1]*International Center for Quantum Materials, School of Physics, Peking Univ., China;* [2]*State Key Lab of Surface Physics and Dept. of Physics, Fudan Univ., China;* [3]*Collaborative Innovation Center of Quantum Matter, China.* Hot electron relaxation and coupling in Cd_3As_2 is studied by employing ultrafast time-domain THz spectroscopy. The excited carriers enhance the absorption of THz and relax in ps-time scales, the cooling rules consistent with mid-IR spectroscopy.

JW2A.134
Ultrafast Time-Resolved Photocurrent Measurement of Carrier Escape Dynamics in Anisotropic ReS_2, Hyemin Bae[1], Sangwan Sim[1,2], Taeyoung Kim[1], Doeon Lee[1], Dong-Hwi Kim[2,3], Gwangmook Kim[1], Wooyoung Shim[1], Moon-Ho Jo[3,2], Hyunyong Choi[1]; [1]*Yonsei Univ., South Korea;* [2]*Inst. for Basic Science, South Korea;* [3]*POSTECH, South Korea.* We report the two-pulse time-resolved photocurrent measurements in a group VII ReS_2. The absence of bias dependence on the photocurrent recovery implies that the escape time of photoexcited carrier is much faster than electron-hole recombination.

JW2A.135
The Influence of hBN on the Pump-dependent Time-evolution of Monolayer Photoluminescence in WSe_2, Jan Kuhnert[1], Lorenz M. Schneider[1], Sina Lippert[1], Dylan Renaud[1], Obafunso Ajayi[2], Young Duck Kim[2], Wolfram Heimbrodt[1], James Hone[2], Arash Rahimi-Iman[1]; [1]*Faculty of Physics and Material Science Center, Philipps Universität Marburg, Germany;* [2]*Dept. of Mechanical Engineering, Columbia Univ., USA.* We present the influence of hBN buffer layers on the power-dependent time-evolution of the photoluminescence in monolayer WSe_2 on different substrates. An even greater influence is observed when the excitonic Mott transition regime is reached.

JW2A.136
Exciton Dynamics in WSe_2 Monolayers for Different Stacking Schemes Involving h-BN, Lorenz M. Schneider[1], Jan Kuhnert[1], Dylan Renaud[1], Saleh Firoozabadi[1], Obafunso Ajayi[2], Young Duck Kim[2], Wolfram Heimbrodt[1], James Hone[2], Arash Rahimi-Iman[1]; [1]*Philipps-Universität Marburg, Germany;* [2]*Dept. of Mechanical Engineering, Columbia Univ., USA.* We present a comparison of tungsten-diselenide monolayers in different stacking configurations with hBN and $MoSe_2$. A pronounced red-shift is observed when the monolayer is supported or encapsulated by hBN. Furthermore, the excitonic annihilation rate changes.

JW2A.137
The H2020 Project CLONETS: Clock Services over Opticlafibre Networks in Europe, Josef Vojtech[1], Jan Radil[1], Vladimir Smotlacha[1], Radek Velc[1], Przemyslaw Krehlik[2], Lukasz Sliwczynski[2], Mauro Campanella[3], Davide Calonico[4], Cecilia Clivati[4], Filippo Levi[4], Ondrej Číp[5], Simon Rerucha[5], Ronald Holzwarth[6], Maurice Lessing[6], Sarah Saint-Jalm[6], Fabiola Camargo[7], Bruno Desruelle[7], Jean Lautier-Gaud[7], Elizabeth Laier English[8], Jochen Kronjäger[8], Peter Whibberley[8], Eva Bookjans[9], Paul-Eric Pottie[9], Philip Tuckey[9], Tomáš Müller[10], Jiri Stefl[10], Pawel Nogas[11], Robert Urbaniak[11], Artur Binczewski[12], Wojbor Bogacki[12], Krzysztof Turza[12]; [1]*CESNET, Czechia;* [2]*AGH Univ. of Science and Technology, Poland;* [3]*Consortium GARR, Italy;* [4]*Istituto Nazionale di Ricerca Metrologica, Italy;* [5]*Inst. of Scientific Instruments of the ASCR, v.v.i. (ISI), Czechia;* [6]*Menlo Systems, Germany;* [7]*Muquans, France;* [8]*National Physical Lab, UK;* [9]*LNE-SYRTE, Observatoire de Paris, PSL Research Univ., CNRS, Sorbonne Universite, France;* [10]*OPTOKON, a.s., Czechia;* [11]*Piktime Systems sp. z o.o., Poland;* [12]*Poznan Supercomputing and Networking Center, Poland.* Time and frequency transfer based on optical fiber links techniques have demonstrated excellent performances. CLONETS is EU project intended to accelerate transfer of related technologies, in order to prepare deployment of technology for sustainable network providing high-performance clock services.

JW2A.138
Commissioning of a Fully-Automated, Pulsed Optical Timing Distribution System at Dalian Coherent Light Source, Haynes P. Cheng[1], Kemal Shafak[1], Anan Dai[1], Johann Derksen[1], Andrej Berlin[1], Erwin Cano[1], Zhichao Chen[2], Hongli Ding[2], Dariush Forouher[1], Zhigang He[2], Xiaoqing Liu[3], Wahid Nasimzada[1], Mathias Neuhaus[1], Philipp Schiepel[1], Eduard Seibel[1], Yuhuan Tian[2], Bo Liu[3], Guorong Wu[2], Franz X. Kaertner[4,5]; [1]*Cycle GmbH, Germany;* [2]*State Key Lab of Molecular Reaction Dynamics, Dalian Inst. of Chemical Physics, China;* [3]*Shanghai Inst. of Applied Physics (SINAP), China;* [4]*Deutsches Elektronen Synchrotron (DESY), Germany;* [5]*Center for Free Electron Laser Science (CFEL), Germany.* We present latest results from the commissioning of China's first multi-link pulse-based optical timing distribution system (TDS). A fully-automated control system, and polarization-maintaining fiber links enable reliable, 24/7 operation of the TDS at user's facility.

JW2A.139
Sub-Shot-Noise Absorption Imaging with a Hybrid Detection Scheme, Javier Sabines-Chesterking[1], Alex McMillan[1], Paul-Antoine Moreau[2], Sebastian Knauer[1], Eric Johnston[1], Siddarth Joshi[1,3], John Rarity[1], Jonathan Matthews[1]; [1]*Univ. of Bristol, UK;* [2]*Univ. of Glasgow, UK;* [3]*Austrian Academy of Sciences, Austria.* We demonstrate a scanning microscopy system for high resolution, sub-shot-noise absorption imaging. A genuine quantum advantage of factor 1.66 in information gained per probe photon, relative to an ideal classical measurement, is demonstrated.

JW2A.140
A Step Forward the Determination of the Anomalous Dispersion on the Er^{3+} in the Telurite Glass., Luis H. Andrade[1], Ana Paula Langaro[1], Ana Kely Rufino[1], Alex Cesar Pereira Rocha[1], Claudio Y. Morassuti[1], Junior R. Silva[1], Sandro Lima[1]; [1]*UEMS, Brazil.* We report the anomalous dispersion and group refractive index (n_g) of the Er^{3+}: tellurite glass measured by Windowed Fourier Transform from interferometric measurements and compared with the dispersion calculated from absorption spectra by known Kramers-Kroing relations.

11:30–13:00 JW2A • Poster Session II

JW2A.141
Photo-acoustic sensing with fiber-based optical frequency comb cavity, Takeo Minamikawa[1,2], Takashi Masuoka[1,2], Takashi Ogura[1], Yoshiaki Nakajima[3,2], Yoshihisa Yamaoka[4], Kaoru Minoshima[3,2], Takeshi . Yasui[1,2]; [1]*Tokushima Univ., Japan;* [2]*JST, ERATO Intelligent Optical Synthesizer Project, Japan;* [3]*Univ. of Electro-Communications, Japan;* [4]*Saga Univ., Japan.* We proposed a novel photo-acoustic sensing employing an optical-frequency-comb. We utilized an optical-frequency-comb cavity as an acoustic wave sensor, and successfully demonstrated the detection of ultrasound that generated by the laser irradiation on sample.

JW2A.142
A Simplistic Method to Generate Highly Flat Optical Frequency Combs, Thanh Tuan Tran[2,1], Minje Song[3,1], Minhyup Song[1], Dongsun Seo[2]; [1]*Electronics and Telecommunications Research Inst., South Korea;* [2]*Dept. of Electronics, Myongji Univ., South Korea;* [3]*School of Electronics Engineering, Kyungpook National Univ., South Korea.* We demonstrate a simplistic scheme to generate highly flat optical frequency combs. Our results show the spectral flatness within 1 dB for 35 taps and 1.5 dB for 55 taps, where a DP-MZM is combined with 2 and 3 phase modulators, respectively

JW2A.143
Evolution and Performance of High-Speed A-Scan based on Real-Time Optical Spectrum Fourier Transformation, Fabio Falconi[2], Yongwoo Park[3], Jose Azana[4], Antonella Bogoni[1], Antonio Malacarne[1]; [1]*Scuola Superiore Sant'Anna, Italy;* [2]*CNIT, Italy;* [3]*Automated Precision Inc., USA;* [4]*INRS-EMT, Institut National de la Recherche Scientifique, Canada.* Advances on a recently proposed approach to obtain reflectivity profiles have been reported. The method has been successfully applied to a 150 μm thick transparent polyvinyl chloride layer. System performance and optimization have been discussed

JW2A.144
Femtosecond Laser-based Atmospheric Frequency Transfer Using Single Electronic Phase Compensator, Dong Hou[1], Danian Zhang[1], Fuyu Sun[1], Jie Tian[2], Haoyuan Lu[3], Jianye Zhao[3]; [1]*Univ. of Elect. Sci. and Tech. of China, China;* [2]*China Academy of Engineering Physics, China;* [3]*Peking Univ., China.* We demonstrate a femtosecond laser-based atmospheric radio-frequency transfer with a single electronic phase compensator over 100 m free-space link. The root-mean-square timing fluctuation of transferred microwave signal is about 490 fs within 5000 s.

JW2A.145
Dispersive Tunable Laser Spectroscopy with Ultrahigh Spectral Resolution, Bin Wang[1], Xinyu Fan[1], Wang Shuai[1], Zuyuan He[1]; [1]*Shanghai Jiao Tong Univ., China.* We propose a dispersive spectroscopy with ultrahigh spectral resolution based on an ultra-linearly swept laser. A measurement bandwidth of 98 GHz and a spectral resolution of 11 kHz are achieved without using costly mode-locked laser.

JW2A.146
Refractive-index-sensing RF comb using intra-cavity multi-mode interference fiber sensor, Ryo Oe[1], Kosuke Nagai[1], Takeo Minamikawa[1], Shuji Taue[2], Hideki Fukano[2], Yoshiaki Nakajima[3], Kaoru Minoshima[3], Takeshi Yasui[1]; [1]*Tokushima Univ., Japan;* [2]*Okayama Univ., Japan;* [3]*The Univ. of Electro-Communications, Japan.* We demonstrate refractive index (RI) measurement of liquid sample based on RI/RF conversion in fiber comb cavity including multi-mode interference fiber sensor. RI resolution of 6.6×10^{-6} is achieved at a measurement time of 0.1 s

JW2A.147
Auto-Start Mechanism of a Polarization-Multiplexed Dual-Frequency Femtosecond Fiber Laser, Rongqing Hui[1], Govind Vedala[1]; [1]*Univ. of Kansas , USA.* Mechanism of dual-frequency-combs coexistence in a polarization-multiplexed all-PM femtosecond fiber laser is presented. Balance between mode-locking conditions of the two combs is essential to minimize differential phase change caused by pump power variation.

JW2A.148
Radiation Pressure Assisted Acousto-Optical Transducer, Ke Huang[1], Mani Hossein-Zadeh[1]; [1]*Univ. of New Mexico, USA.* We study the acousto-optical response of the optomechanical resonators in subthreshold regime and demonstrate that the reduced damping due to radiation pressure can be used for high sensitivity detection of acoustic waves.

JW2A.149
Phase Correlation Between Lines of Electro-Optical Frequency Combs, Lars Lundberg[1], Mikael Mazur[1], Attila Fulop[1], Victor Torres-Company[1], Magnus Karlsson[1], Peter A. Andrekson[1]; [1]*Chalmers Univ. of Technology, Sweden.* Simultaneous measurement of the phase noise from 49 electro-optical frequency comb lines show a correlation of over 99.99% between lines. Additionally, the phase noise difference between line pairs is correlated, verifying theoretical predictions.

JW2A.150
Fluorescence Double Resonance Optical pumping spectrum and its application for frequency stabilization in Millimeter scale vapor cell, Eliran Talker[1], Liron stern[1], Alex Naiman[1], Uriel Levy[1]; [1]*Hebrew Universit Of Jeruaslem, Israel.* We introduce the approach of fluorescence double resonance optical pumping, demonstrate its superior contrast compare with the conventional double resonance optical pumping, and use it for locking at telecom wavelength in mm scale vapor cell.

JW2A.151
Absolute Frequency of Cesium Atom $6S_{1/2}$-$6D_{3/2}$ Doppler-free Two-photon Transition, Ting-Ju Chen[1], Jeng-En Chen[1], Tze-Wei Liu[1,2], Hsin-Hung Yu[1], Ko-Han Chen[1], Ya-Fen Hsiao[2], Ying-Cheng Chen[2], Wang-Yao Cheng[1]; [1]*Physical Dept., National Central Univ., Taiwan;* [2]*Inst. of atomic and molecular science, Academia Sinica, Taiwan.* We determined the absolute frequency of ^{133}Cs $6S_{1/2}$-$6D_{3/2}$ two-photon transition, our novel scheme enabled the resolution to address the nuclear magnetic octupole.

JW2A.152
Frequency dissemination over 1000 km optical fiber with 10^{-21} frequency instability, Xing Chen[1], Jianmin Shang[2], Dongxing Wang[2], Cheng Ci[3], Wanpeng Zhang[3], Bo Liu[3], Hong Wu[3], Song Yu[2], Zhigang Zhang[1]; [1]*Peking Univ., China;* [2]*Beijing Univ. of Posts and Telecommunications, China;* [3]*Nankai Univ., China. We demonstrate a frequency transfer scheme for over 1000 km optical fiber link with mode locked pulse train as the frequency carrier. The fractional frequency instability was measured as 2.75e10^{-15}/s and 3.91e10^{-21}/120000 s.*

JW2A.153
Dual-comb spectroscopy of methan based on an Erbium dual-comb fiber laser, Jie Chen[1], Xin Zhao[1], Yuehan Wu[1], Ting Li[1], Ruliu Wang[1], Qian Li[1], Siyao Yin[1], Jiansheng Liu[1], Zheng Zheng[1,2]; [1]*School of Electronic and Information Engineering, Beihang Univ., China;* [2]*Collaborative Innovation Center of Geospatial Technology, China.* Dual-comb spectroscopy measurement of methan absorption around 1650nm is demonstrated using a dual-wavelength Erbium mode-locked fiber laser, which illustrates the capability of such single-cavity dual-comb sources to cover spectral range well beyond their initial bandwidth.

JW2A.154
Self-controlled Stabilization of a Passively Phase-locked Er:Fiber Frequency Comb, Andreas Liehl[1], David Fehrenbacher[1], Philipp Sulzer[1], Markus Ludwig[1], Felix Ritzkowsky[1], Alfred Leitenstorfer[1], Denis Seletskiy[1,2]; [1]*Univ. of Konstanz, Germany;* [2]*École Polytechnique de Montréal, Canada.* We demonstrate optical linewidth narrowing and simultaneous repetition rate stabilization of an Er:fiber frequency comb passively phase-locked by ultrabroadband difference frequency mixing. Optical self-control is performed using the original comb from the master oscillator.

JW2A.155
Real-time multi-wavelength digital holography using line-by-line spectral shaping of optical frequency comb, Masatomo Yamagiwa[1,2], Takeo Minamikawa[1,2], Isao Morohashi[3], Norihiko Sekine[3], Iwao Hosako[3], Hirotsugu Yamamoto[2,4], Takeshi . Yasui[1,2]; [1]*Tokushima Univ., Japan;* [2]*JST, ERATO MINOSHIMA Intelligent Optical Synthesizer (IOS), Japan;* [3]*National Inst. of Information and Communications Technology, Japan;* [4]*Utsunomiya Univ., Japan.* Mode-resolved spectrum in optical frequency comb (OFC) is manipulated by a combination of a 2D spectral disperser with a spatial light modulator. The resulting mode-manipulated OFC is effectively applied for real-time multi-wavelength digital holography.

JW2A.156
High-Sensitivity Doppler-Free Optical-Optical Double-Resonance Dual-Comb Spectroscopy, Akiko Nishiyama[1,2], Ken'ichi Nakagawa[1], Hiroyuki Sasada[3,2], Atsushi Onae[4,2], Yoshiaki Nakajima[1,2], Kaoru Minoshima[1,2]; [1]*Univ. of Electro-Communications, Japan;* [2]*Japan Science and Technology Agency (JST), Erato Minoshima Intelligent Optical Synthesizer (IOS) Project, Japan;* [3]*Dept. of Physics, Faculty of Science and Technology, Keio Univ., Japan;* [4]*National Metrology Inst. of Japan (NMIJ), National Inst. of Advanced Industrial Science and Technology (AIST), Japan.* We demonstrate background-free detection schemes in optical-optical double-resonance dual-comb spectroscopy to improve measurement sensitivity. The dual-comb employing modulation spectroscopy and fluorescence detection achieved 4 and 925 times higher SNR than normal dual-comb setup, respectively.

JW2A.157
Free-running, Femtosecond Dual-Comb MIXSEL for Spectroscopy of Acetylene, Jacob Nuernberg[1], Cesare Alfieri[1], Zaijun Chen[2], Dominik Waldburger[1], Matthias Golling[1], Nathalie Picque[2], Ursula Keller[1]; [1]*Inst. of Quantum Electronics, ETH Zurich, Switzerland;* [2]*Max-Planck Inst. of Quantum Optics, Germany.* We present dual-comb spectroscopy on acetylene performed with one single free-running modelocked integrated external-cavity surface-emitting laser (MIXSEL). Two intracavity birefringent crystals reduce the difference in repetition rate and solve aliasing issues for broad optical spectra.

JW2A.158
Quantum Interference Control of Injected Photocurrent in an AlGaAs Waveguide, Kai Wang[1], Rodrigo A. Muniz[2], John E. Sipe[2], Steven T. Cundiff[1]; [1]*physics, Univ. of michigan, USA;* [2]*physics, Univ. of Toronto, Canada.* We measured the directional photocurrent induced by quantum interference between two- and three-photon absorption in a semiconductor (AlGaAs) waveguide, which allows the design of compact devices for comb offset frequency measurements.

JW2A.159
Determination of the offset frequency of a broadband frequency comb generated in a waveguide-type periodically poled lithium niobate crystal, Kazumichi Yoshii[1,2], Junia Nomura[1,2], Kaho Taguchi[1], Yusuke Hisai[1,2], Feng-Lei Hong[1,2]; [1]*Yokohama National Univ., Japan;* [2]*JST, Erato, Minoshima Intelligent Optical Synthesizer Project, Japan.* We generate a broadband frequency comb using a WG-PPLN and measure the offset frequency of the comb by using a frequency-stabilized laser at 532 nm. The visible comb is generated through $\chi^{(2)}$ process.

11:30–13:00 JW2A • Poster Session II

JW2A.160
A Computational Correction Method for Dual-comb Interferometry, Zebin Zhu[1], Kai Ni[2], Qian Zhou[2], Guanhao Wu[1,2]; *[1]Dept. of Precision Instrument, Tsinghua Univ., China; [2]Division of Advanced Manufacturing, Graduate School at Shenzhen, Tsinghua Univ., China.* We present a post-correction algorithm for dual-comb interferometry that can compensate the carrier phase noise and timing jitter of interferograms. One-hertz linewidth, ~1 ns timing jitter, and 0.4 rad precision of carrier phase are demonstrated.

JW2A.161
Compact GHz Frequency Comb from an Ultrafast Solid-State Laser with Cost-Efficient 3D-Printed Plastic Cavity Base, Sargis Hakobyan[1], Pierre Brochard[1], Valentin J. Wittwer[1], Kutan Gurel[1], Stephane Schilt[1], Thomas Südmeyer[1]; *[1]Laboratoire Temps-Fréquence, Switzerland.* We present a GHz mode-locked laser with a 3D-printed cavity base resulting in substantial noise reduction from the previous use of traditional opto-mechanical mounts. Additionally, the repetition rate is stabilized to a low-noise optically-derived 15-GHz signal.

JW2A.162
Frequency-sweeping interferometry utilizing optical frequency comb and Fourier transform phase retrieving, Weipeng Zhang[1], Haoyun Wei[1], Yan Li[1]; *[1]Tsinghua Univ., China.* A precise 3D surface measurement method for large stepped structures without height ambiguity is proposed based on optical frequency comb referenced frequency-sweeping interferometry and Fourier transformed fractional phase retrieval. Samples of from 1 to 1000 microns were measured.

JW2A.163
A High Performance Clock Laser for Two-Photon Frequency Stabilized Optical Clocks, Matthew S. Bigelow[1], Kyle W. Martin[1], Gretchen Phelps[2], Nathan D. Lemke[2]; *[1]Applied Technology Associates dba ATA, USA; [2]Space Vehicles Directorate, Air Force Research Lab, USA.* We describe a simple high-performance all-fiber atomic-line clock laser constructed from commercial off-the-shelf (COTS) components. This laser, based on a frequency-doubled telecom laser, has significantly lower frequency noise compared to direct diode lasers.

JW2A.164
Development and Qualification of UHV-Compatible, Micro-Integrated Optical Setups for Cold Atom Applications, Marc Christ[1], Achim Peters[1], Markus Krutzik[1]; *[1]Humboldt-Universität zu Berlin, Germany.* We present a tool for rapid prototyping and qualification of (electro-) optical components and adhesive integration techniques for micro-integrated assemblies operating in ultra-high vacuum environments.

JW2A.165
Optical Frequency Comb Faraday Rotation Spectroscopy, Alexandra C. Johansson[1], Jonas Westberg[2], Gerard Wysocki[2], Aleksandra Foltynowicz[1]; *[1]Umeå Univ., Sweden; [2]Princeton Univ., USA.* By combining Faraday rotation spectroscopy with an optical frequency comb Fourier transform spectrometer, we measure background- and calibration-free spectra of the entire Q- and R-branches of the fundamental band of nitric oxide at 1850-1920 cm^{-1}.

JW2A.166
Tunable lower-RIN Brillouin fiber ring laser for BOTDA sensing, Diego Marini[1], Leonardo Rossi[1,3], Filippo Bastianini[2], Gabriele . Bolognini[1]; *[1]CNR, IMM Inst., Bologna, Italy; [2]Sestosensor s.r.l., Italy; [3]Università degli Studi di Bologna, Italy.* In this work we characterize a lower-RIN Brillouin ring-laser technology for Brillouin optical time-domain analysis (BOTDA) sensing. The developed tunable pump-probe light allows for efficient BOTDA over 10 km fiber with 10mε/0.5°C temperature-strain resolutions.

JW2A.167
Multi-point Acoustic Sensing System Using Coherent Phase Detection, Jingyi Wang[1], Fan Ai[1], Yuezhen Sun[1], Hao Li[1], Xiangpeng Xiao[1], Zhijun Yan[1], Deming Liu[1], Qizhen Sun[1]; *[1]School of Optical and Electronic Information, National Engineering Lab for Next Generation Internet Access System, Huazhong Univ. of Science and Technology, China.* A multi-point acoustic sensing system with capacity up to 248 is proposed. The sensitivity of -131.5dB ±1.5dB re 1rad/μPa in 2.4k-6kHz is achieved in a prototype system with graphene diaphragm based fiber sensors.

JW2A.168
Fiber Optical Sensor for Methane Detection Based on Metal-Organic Framework/Silicone Polymer Coating, Rongtao Cao[1], Hangjun Ding[1], Zhaoqiang Peng[1], Ki-Joong Kim[2], Paul Ohodnicki[2], Aidong Yan[1], Kevin P. Chen[1]; *[1]Univ. of Pittsburgh, USA; [2]National Energy Technology Lab, USA.* A multimode fiber methane sensor made of polymer/metal-organic framework coated cladding is presented with a low detection limit of 1% (v/v). The detailed sensing mechanism is also analyzed in this paper.

JW2A.169
High-resolution and Large-capacity DBR Fiber Laser Accelerometer Network, Tao Liu[1], Dongdong Lv[1], Yiyang Luo[1], Zhijun Yan[1], Kai Wang[2], Chengqiang Li[2], Deming Liu[1], Qizhen Sun[1]; *[1]Huazhong Univ of Science and Technology, China; [2]The 38th Research Inst. of CETC, China.* We demonstrate a highly sensitive DBR fiber laser acceleration sensor network with a resolution of 17.86 $ng/Hz^{1/2}$ and accuracy of 10^{-6} g. The sensing capacity is increased to 128 by utilizing the hybrid multiplexing technique.

JW2A.170
Ultra Sensitive Long Period Fiber Gratings Based Sensor for Detection of Adulterator in Ethanol, Krishnendu Dandapat[1], Indrajeet Kumar[2], Saurabh M. Tripathi[1,2]; *[1]Physics, Indian Inst. of Technology Kanpur, India; [2]Centre for Lasers and Photonics, Indian Inst. of Technology Kanpur, India.* Using extremely sensitive dual-resonance long-period-fiber-gratings operating close to their turnaround-wavelength, we demonstrate a sensor for accurate and quantitative detection of adulterator in ethanol. Our sensor can detect methanol concentration as small as 0.1% in ethanol.

JW2A.171
Fast Reading of Fiber Bragg Grating Sensors with a Locked Non-Dithered Tunable Laser, Pedro Martín-Mateos[1], Oscar Elias Bonilla-Manrique[1], Pablo Acedo[1], Jose A. Garcia-Souto[1]; *[1]Universidad Carlos III de Madrid, Spain.* We propose a fast reading FBG laser-locked architecture that provides a single output, a wavelength range only limited by the tuning capabilities of the laser and an operation speed only restricted by the servo controller.

JW2A.172
Cost Effective Dual-Polarization Interferometric Fiber Optic Gyroscope with Ultra-Simple Configuration, Fangyuan Chen[1], Yulin Li[1], Rongya Luo[1], Fang Ben[1], Dong He[1], Chao Peng[1], Zhengbin Li[1]; *[1]School of Electronics Engineering and Computer Science, Peking Univ., China.* A cost effective and ultra-simple dual-polarization interferometric fiber optic gyroscope utilizing single-mode components was proposed and tested, which achieves an overall bias instability below 2×10^{-2} °/h and a scale factor nonlinearity below 100 ppm.

JW2A.173
Pico-strain Resolution Fiber Grating Sensor with Ultralow Probe Power and Tunable Sensitivity, Shuangxiang Zhao[1], Qingwen Liu[1], Jiageng Chen[1], Zuyuan He[1]; *[1]State Key Lab of Advanced Optical Communication Systems and Networks, Shanghai Jiao Tong Univ., China.* We present here a novel interrogation method for Er^{+}-doped fiber grating sensor with pε resolution, ultralow probe power, large tunable strain sensitivity and capability of multiplexed, static and dynamic sensing.

JW2A.174
Multichannel Fiber Bragg Grating for Temperature Field Monitoring, Wei Zhang[1], Adenowo Gbadebo[2], Zhikun Xing[1], Desheng Jiang[3], Deming Liu[1], Zhijun Yan[1], Qizhen Sun[1]; *[1]National Engineering Lab for Next Generation Internet Access System, Huazhong Univ. of Science and Technology, China; [2]Aston Inst. of Photonic Technologies, Aston Univ., UK; [3]National Engineering Lab for Fiber Optic Sensing Technology, Wuhan Univ. of Technology, China.* We demonstrated a multichannel FBG based temperature field sensor, in which the grating was designed by pre-compensation layer peeling method. Such system could achieve a real time temperature field monitoring with 3mm high spatial resolution.

JW2A.175
Demonstration of a Plasmo-Thermomechanical Radiation Detector with Si_3N_4 Waveguide Optical Readout Circuit, Qiancheng Zhao[1], Mohammad W. Khan[1], Parinaz Sadri-Moshkenani[1], Regina Ragan[1], Filippo Capolino[1], Ozdal Boyraz[1]; *[1]Univ. of California, Irvine, USA.* A plasmo-thermomechanical radiation detector based on suspended nano-antennas with a Si_3N_4 waveguide optical readout circuit has been demonstrated. The responsivity and noise equivalent power of the detector are measured to be $3.954 \times 10^{-3} \mu m^2/\mu W$ and $3.01 \mu W/\sqrt{Hz}$, respectively.

JW2A.176
Surface Plasmon Resonator Biosensor Spatial Phase Sensitivity Enhancement through Optical Fiber Low Coherence Interferometry, Shih-Hsiang Hsu[1], Hsun-Yuan Hsu[1], Chung-Hsuan Chen[1], Meng-Syuan Jian[1]; *[1]National Taiwan Univ of Science & Tech, Taiwan.* The spatial phase sensitivity on the effective reaction length using optical fiber low coherence interferometry demonstrates 10.4-rad/μM, 34 times more enhancement than the polarized light phase characterization from spectral interferometry based surface plasmon resonance biosensors.

JW2A.177
Ppb-level Detection of Acetylene based on QEPAS Using a Power Amplified Diode Laser, Yufei Ma[1], Yao Tong[1], Ying He[1], Xin Yu[1], Frank Tittel[2]; *[1]Harbin Inst. of Technology, China; [2]Rice Univ., USA.* An ultra-high sensitive C_2H_2-QEPAS sensor using an EDFA amplified diode laser was demonstrated. The 33.2 ppb detection sensitivity verified that the design of the reported QEPAS method demonstrated significantly enhanced sensor performance.

JW2A.178
Remote, distributed gas sensor based on FEW-QEPAS, Ying He[1], Yufei Ma[1], Yao Tong[1], Xin Yu[1], Frank Tittel[2]; *[1]Harbin Inst. of Technology, China; [2]Rice Univ., USA.* A remote, distributed gas sensing using fiber evanescent wave quartz-enhanced photoacoustic spectroscopy (FEW-QEPAS) technique was demonstrated. A 3 km single mode fiber with multiple tapers was employed to perform long distance, distributed gas measurements.

JW2A.179
Temperature Sensor Using Fluid-Filled Negative Curvature Fibers, Chengli Wei[1], Joshua Young[1], Curtis R. Menyuk[2], Jonathan Hu[1]; *[1]Dept. of Electrical and Computer Engineering, Baylor Univ., USA; [2]Dept. of Computer Science and Electrical Engineering, Univ. of Maryland, Baltimore County, USA.* We propose a new temperature sensor based on fluid-filled negative curvature fibers. The temperature sensitivity increases from 0.8 nm/°C to 2.5 nm/°C when the refractive index of the fluid increases from 1.30 to 1.42.

11:30–13:00 JW2A • Poster Session II

JW2A.180
Multi-functional cellulose fiber decorated with plasmonic Au nanoparticles for colorimetry and SERS assay, Qian Yu[2], Xianming Kong[2], Yibo Ma[3], Alan X. Wang[1]; [1]*Oregon State Univ., USA;* [2]*College of Chemistry, Chemical Engineering and Environment Engineering, Liaoning Shihua Univ., China;* [3]*Aalto Univ., Finland.* We fabricated a multi-functional sensor through decorating Au nanoparticles on cellulose fibers. The solid colorimetry and surface-enhanced Raman scattering sensing for water and malachite green were achieved on this device.

JW2A.181
An Optical Microwave Generator based on Stimulated Brillouin Scattering with Fine Tunability, Juanjuan Yan[1], Aihu Liang[1]; [1]*Beihang Univ., China.* In this optical microwave generator, the lower sideband of CS-DSB modulated laser is shifted using SBS in a fiber. Microwaves from 14.67GHz to 30.67GHz are generated by beating the shifted sideband and the upper sideband.

JW2A.182
Strong-field laser initiated H_2 roaming chemistry and the formation of H_3^+ from organic molecules, Nagitha Ekanayake[1], Muath Nairat[1], Travis Severt[2], Peyman Feizollah[2], Bethany Jochim[2], Balram Kaderiya[2], Farzaneh Ziaee[2], Kurtis Borne[2], Kanaka Raju Pandiri[2], Kevin Carnes[2], Daniel Rolles[2], Artem Rudenko[2], Itzik Ben-Itzhak[2], Nicholas Weingartz[1], Benjamin Farris[1], Benjamin Levine[1], James Jackson[1], Marcos Dantus[1,3]; [1]*Dept. of Chemistry, Michigan State Univ., USA;* [2]*J. R. Macdonald Lab, Dept. of Physics, Kansas State Univ., USA;* [3]*Dept. of Physics, Michigan State Univ., USA.* H_2 roaming has been recently implicated in H_3^+ production when certain organic molecules interact with a strong-field laser. Mechanistic details and femtosecond time-resolved dynamics of H_3^+ formation were obtained on a series of alcohols.

11:30–13:00 Exhibit Hall Free Lunch

12:00–13:00 OSA Photonic Metamaterials Technical Group Tutorial on Metasurface Design and Simulation, *Room 230A*

CLEO: Science & Innovations

13:00–15:00
SW3A • Microresonator Combs
Presider: Miro Erkintalo; Univ. of Auckland, New Zealand

SW3A.1 • 13:00
Gallium Phosphide Microresonator Frequency Combs, Dalziel Wilson[2,1], Simon Hönl[2], Katharina Schneider[2], Paul Seidler[2], Miles H. Anderson[1], Tobias J. Kippenberg[1]; [1]*Inst. of Physics (IPHYS), École Polytechnique Fédérale de Lausanne (EPFL), Switzerland;* [2]*Quantum Technologies, IBM Research, Zurich, Switzerland.* We demonstrate the first microresonator frequency combs in GaP, a III-V semiconductor transparent above 549 nm. High Kerr nonlinearity (>10^{-18} m^2/W) yields a 10-mW parametric threshold and 100-nm-wide combs with THz spacing, centered at 1550 nm.

SW3A.2 • 13:15
Low Power Generation of Broadband Single Kerr Solitons in Silicon Nitride Resonators, Travis C. Briles[1], Su-Peng Yu[1], Kartik Srinivasan[2], Scott Diddams[1], Scott Papp[1]; [1]*Time and Frequency Division, National Inst. of Standards and Technology, USA;* [2]*Center for Nanoscale Science and Technology, National Inst. of Standards and Technology, USA.* We report the generation of broadband, single soliton frequency combs with dual dispersive waves in 1 THz and 333 GHz FSR silicon nitride microresonators using an on-chip pump-power as low as 12 mW.

SW3A.3 • 13:30
Quasi-phase matched multispectral Kerr frequency comb, Shu-Wei Huang[1], Jinghui Yang[2], Abhinav K. Vinod[2], Mingbin Yu[3], Dim-Lim Kwong[3], Chee-Wei Wong[2]; [1]*Electrical, Computer & Energy Engineering, Univ. of Colorado, Boulder, USA;* [2]*Univ. of California, Los Angeles, USA;* [3]*Inst. of Microelectronics, Singapore.* We demonstrate a new type of Kerr frequency comb with expanded parametric range, where the momentum conservation is ensured by azimuthal modulation of the cavity dispersion. A coherent multispectral frequency comb covering telecommunication O, C, L, and 2 μm bands is observed and characterized.

SW3A.4 • 13:45
Synchronization of coupled microresonator frequency combs, Jae K. Jang[1], Alexander Klenner[1], Xingchen Ji[1,2], Yoshitomo Okawachi[1], Michal Lipson[1], Alexander L. Gaeta[1]; [1]*Columbia Univ., USA;* [2]*Cornell Univ., USA.* We experimentally demonstrate passive synchronization of microresonator-based optical frequency combs. By injecting a small fraction of the light from one microresonator to the other, we frequency-lock two combs separated by over 20 m.

13:00–15:00
SW3B • Hybrid Lasers on Silicon
Presider: Tae Joon Seok; Gwangju Inst. of Science and Technol, South Korea

SW3B.1 • 13:00 Invited
Quantum Dot Photonic Integrated Circuits on Silicon, John E. Bowers[1], Arthur Gossard[1], Daehwan Jung[1], Justin Norman[1], Yating Wan[1]; [1]*Univ. of California Santa Barbara, USA.* Quantum dot lasers, amplifiers, modulators and photodetectors epitaxially grown on Si ar°e promising for photonic integrated circuits on silicon. Laser performance is improving rapidly. This represents a significant stride toward efficient, scalable, and reliable III-V lasers on on-axis Si substrates for photonic integrate circuits that are fully compatible with CMOS foundries.

SW3B.2 • 13:30
Hybrid Integration of Solid-State Quantum Emitters with a Silicon Chip, Jehyung Kim[1,2], Shahriar Aghaeimeibodi[2], Christopher Richardson[3], Richard Leavitt[3], Dirk . Englund[4], Edo Waks[2]; [1]*UNIST, South Korea;* [2]*Univ. of Maryland, USA;* [3]*Lab for Physical Sciences, USA;* [4]*MIT, USA.* Scalable quantum photonic systems require integrated single photon sources with photonic devices. We demonstrate hybrid integration of solid-state quantum dots to a silicon photonic device and perform Hanbury-Brown and Twiss experiments on the silicon chip with integrated quantum emitters.

SW3B.3 • 13:45
Design Principles for Heterogeneously Integrated III-V-on-Silicon Microdisk Unidirectional Singlemode Lasers, Bo Xue Tan[1], Kaiyi WU[1], Yu Zhang[2], Andrew W. Poon[1]; [1]*Hong Kong Univ of Science & Technology, Hong Kong;* [2]*Univ. of California, Davis, USA.* We unfold the design principles for heterogeneously integrated III-V-on-silicon microdisk unidirectional singlemode lasers. Our simulations suggest hybrid modes between the vertically coupled III-V and silicon microdisks of different radii. Our experiments reveal unidirectional singlemode lasing.

13:00–15:00
SW3C • High Capacity Transmission
Presider: Yue-Kai Huang; NEC Labs America Inc, USA

SW3C.1 • 13:00
PM-64QAM Coherent Optical Communications Using a Dark-Pulse Microresonator Frequency Comb, Attila Fulop[1], Mikael Mazur[1], Abel Lorences-Riesgo[1,2], Pei-Hsun Wang[3], Yi Xuan[3,4], Daniel E. Leaird[3], Minghao Qi[3,4], Peter A. Andrekson[1], Andrew M. Weiner[3,4], Victor Torres-Company[1]; [1]*Photonics Lab, Chalmers Univ. of Technology, Sweden;* [2]*IT-Instituto de Telecomunicações, Portugal;* [3]*School of Electrical and Computer Engineering, Purdue Univ., USA;* [4]*Birck Nanotechnology Center, Purdue Univ., USA.* Dark-pulse microresonator combs exhibit efficient pump-to-comb power conversion. Using on-chip pump powers of 21 dBm, we show 20-channel PM-64QAM-based data transmission. These results represent the highest-order modulation format encoded onto any integrated comb.

SW3C.2 • 13:30
Experimental Investigation of Roll-off Factor and Channel Spacing for >400Gb/s Coherent Optical Systems, Qiang Wang[1], Yang Yue[1], Xuan He[1], Andre Vovan[1], Jon Anderson[1]; [1]*Juniper Networks Inc., USA.* Residual skew in coherent transmitter degrades system performance. To increase tolerance to the transmitter skew, roll-off factor of Nyquist pulse shaping, channel spacing are optimized for >400Gb/s coherent optical communications systems

SW3C.3 • 13:45
Mapping options of 4D constant modulus format for multi-subcarrier modulation, Keisuke Kojima[1], Kieran Parsons[1], Toshiaki Koike-Akino[1], David S. Millar[1]; [1]*Mitsubishi Electric Research Labs, USA.* We investigate three options of 4D constant modulus modulation format in terms of pairing complementary amplitude signals for multi-subcarrier modulation. Nonlinear transmission simulations indicate these options are almost equally effective, and much better than the conventional modulation format.

CLEO: Science & Innovations

13:00–15:00
SW3D • Terahertz Nano-imaging and Spectroscopy
Presider: Pernille Klarskov Pedersen; Brown Univ., USA

SW3D.1 • 13:00
Terahertz-Pulse-Induced Patterning on the Nanoscale with Terahertz Scanning Tunneling Microscopy, Vedran Jelic[1], Daniel Mildenberger[1], Peter H. Nguyen[1], Tianwu Wang[1], Frank A. Hegmann[1]; *[1]Univ. of Alberta, Canada*. We demonstrate that ultrafast terahertz pulses focused onto the tip of scanning tunneling microscope (THz-STM) can be used to pattern structures on a silicon surface via field-assisted removal of surface atoms.

SW3D.2 • 13:15
THz Near-Field Nanoscopy at 25 Nanometer Spatial Resolution, Max Eisele[1], Andreas Huber[1], Tobias Gokus[1]; *[1]neaspec GmbH, Germany*. We combine terahertz time-domain spectroscopy with near-field microscopy to achieve extreme sub-wavelength spatial resolution (<25nanometer) in the far-infrared spectral range. We apply our technology to investigate the carrier concentrations in semiconductor devices and single-layer graphene.

SW3D.3 • 13:30
Scattering-type Scanning Near-field Optical Microscope Operating in the Terahertz Regime, Xinzhong Chen[1], Jiawei Zhang[1], Ryan Mescall[1], Mengkun Liu[1]; *[1]Stony Brook Univ., USA*. We demonstrate a home-built terahertz (THz) scattering-type scanning near-field optical microscope (s-SNOM) system and systematically study the THz response of various common lab materials with ~50 nm spatial resolution. The modeling of the THz near-field response will be discussed.

SW3D.4 • 13:45
Reflection type scanning laser terahertz near-field spectroscopy and imaging system for bio-applications, Kosuke Okada[1], Kazunori Serita[1], Iwao Kawayama[1], Hironaru Murakami[1], Masayoshi Tonouchi[1]; *[1]Osaka Univ. , Japan*. We developed a reflection type scanning laser THz near-field spectroscopy and imaging system and evaluated its basic performance. We found that this system has huge potential for high-resolution, high-sensitive and high-speed biological measurements.

CLEO: QELS-Fundamental Science

13:00–15:00
FW3E • Frequency Combs & Precision Metrology
Presider: Scott Diddams; NIST, USA

FW3E.1 • 13:00
Octave-spanning dual comb spectroscopy in the molecular fingerprint region, Henry Timmers[1], Abijith Kowligy[1], Alex Lind[1], Flavio Cruz[1], Nima Nader[1], Myles Silfies[2], Thomas Allison[2], Gabriel Ycas[1], Peter G. Schunemann[3], Scott Papp[1], Scott Diddams[1]; *[1]NIST, USA; [2]Physics Dept., Stony Brook Univ., USA; [3]BAE Systems, USA*. We present a scheme for generating super-octave, long-wave infrared combs in the molecular fingerprint region using intra-pulse difference frequency generation in an orientation patterned GaP crystal. We demonstrate high resolution dual-comb spectroscopy in methanol vapor.

FW3E.2 • 13:15
Origin of clustered frequency combs in Kerr microresonators, Hoan Pham[1], Noel L. Sayson[1], Karen E. Webb[1], Luke S. Trainor[2], Harald G. Schwefel[2], Stephane Coen[1], Miro J. Erkintalo[1], Stuart G. Murdoch[1]; *[1]Univ. of Auckland, New Zealand; [2]Physics, Univ. of Otago, New Zealand*. We identify the physical mechanism responsible for the generation of clustered frequency combs in optical microresonators. This theory is validated by experimentally measuring the coherence of such clustered combs in a MgF2 monolithic microresonator.

FW3E.3 • 13:30 Invited
Brillouin Lasers Based on Ultra-low Loss Silicon Nitride Waveguides, Dan J. Blumenthal[1], Sarat Guvandarapu[1], Debapam Bose[1], Grant Huffman[1], Taran Huffman[1], Ryan Buhunin[3], Peter T. Rakich[2]; *[1]Univ. of California, Santa Barbara, USA; [2]Yale Univ., USA; [3]Northern Arizona Univ., USA*. We describe a new class of integrated, ultra-low phase noise Brillouin laser. Leveraging new laser dynamics in very-high Q Si_3N_4 waveguide resonators, record low linewidths and noise in cascaded-order operation, with potential operation across the visible to infrared, can be achieved.

13:00–15:00
FW3F • Single-Photon Detectors
Presider: Martin Stevens; NIST, USA

FW3F.1 • 13:00
Fractal superconducting nanowire single-photon detectors with low polarization sensitivity, Chao Gu[1], Xiaoming Chi[1], Yuhao Cheng[1], Julien Zichi[2], Nan Hu[1], Xiaojian Lan[1], Kai Zou[1], Shufan Chen[1], Zuzeng Lin[1,2], Val Zwiller[2], Xiaolong Hu[1]; *[1]Tianjin Univ., China; [2]Dept. of Applied Physics, Royal Inst. of Technology (KTH), Sweden*. We demonstrated a fractal superconducting nanowire single-photon detector and achieved 42% device efficiency and 1.04 polarization sensitivity. The low polarization sensitivity can be maintained for higher-order spatial modes in few-mode optical fibers.

FW3F.2 • 13:15
Photon-Number Resolution in Conventional Superconducting Nanowire Single-photon Detectors: Experimental Demonstration, Clinton T. Cahall[1], Kathryn L. Nicolich[2], NURUL T. ISLAM[1], Gregory P. Lafyatis[1], Aaron J. Miller[3], Daniel J. Gauthier[2], Jungsang Kim[1,4]; *[1]Duke Univ., USA; [2]The Ohio State Univ., USA; [3]Quantum Opus, LLC., USA; [4]IonQ, Inc., USA*. We present the first experimental evidence of photon number resolution in a conventional superconducting nanowire single-photon detector. The photon-number-dependent resistance reflected in the rise-time of output pulses is detected using a wideband, low-noise read-out circuit.

FW3F.3 • 13:30
WSi superconducting nanowire single photon detector with a temporal resolution below 5 ps, Boris A. Korzh[1], Qing-Yuan Zhao[2], Simone Frasca[1], Di Zhu[2], Edward Ramirez[1], Eric A. Bersin[1,2], Marco Colangelo[2], Andrew Dane[2], Andrew Beyer[1], Jason Allmaras[1], Emma Wollman[1], Karl K. Berggren[2], Matthew Shaw[1]; *[1]Jet Propulsion Lab, USA; [2]MIT, USA*. Through the use of an impedance matched taper, be we demonstrate a reduction of the noise jitter in WSi SNSPDs to a level below the intrinsic effects, resulting in full-width at half-maximum values of 4.8 ps for 532 nm and 10.3 ps for 1550 nm single photons.

FW3F.4 • 13:45
Concept of quantum timing jitter and non-Markovian limits in single photon detection, Li Ping Yang[1], Hong Xing Tang[2], Jacob Zubin[1]; *[1]Dept. of Electric and Computer Engineering, Purdue Univ., USA; [2]Dept. of Electrical Engineering, Yale Univ., USA*. We propose the concept of quantum timing jitter in single-photon detection, based on the observation of a finite rise time in the quantum probabilistic signal transduction (absorption). We also place a fundamental limit on this quantum jitter.

CLEO: QELS-Fundamental Science

13:00–15:00
FW3G • Nonlinear Nano-optics
Presider: Bo Zhen; Univ. of Pennsylvania, USA

FW3G.1 • 13:00
Enhanced Second-Harmonic Generation in Broken Symmetry III-V Semiconductor Metasurfaces driven by Fano resonance, Polina Vabishchevich[1,2], Sheng Liu[1,2], Michael Sinclair[1], Gordon A. Keeler[1], Gregory M. Peake[1], Igal Brener[1,2]; [1]*Sandia National Labs, USA;* [2]*Center for Integrated Nanotechnologies, Sandia National Labs, USA*. We use broken symmetry III-V semiconductor Fano metasurfaces to substantially improve the efficiency of second-harmonic generation (SHG) in the near infrared, compared to SHG obtained from metasurfaces created using symmetrical Mie resonators.

FW3G.2 • 13:15
Second-harmonic generations in a plasmonic two-wire transmission-line, Tzu-Yu Chen[1], Julian Obermeier[2], Fan-Cheng Lin[1], Jer-Shing Huang[3], Markus Lippitz[2], Chen-Bin Huang[1]; [1]*National Tsing Hua Univ., Taiwan;* [2]*Univ. of Bayreuth, Germany;* [3]*Leibnitz Inst., Germany.* A plasmonic two-wire transmission-line is experimentally used for SHG despite of material and geometric symmetries. The resulting SHGs are only coupled into the asymmetric mode. This characteristic is explained through surface nonlinear polarization calculations.

FW3G.3 • 13:30
Collective nonlinear optical effects in plasmonic nanohole ensembles of different rotational symmetries, Godofredo S. Bautista[1], Christoph Dreser[2,3], Xiaorun Zang[1], Dieter Kern[2,3], Martti Kauranen[1], Monika Fleischer[2,3]; [1]*Lab of Photonics, Tampere Univ. of Technology, Finland;* [2]*Inst. for Applied Physics, Univ. of Tübingen, Germany;* [3]*Center for Light-Matter-Interaction, Sensors and Analytics LISA+, Univ. of Tübingen, Germany.* We use cylindrical vector beams to investigate second-harmonic generation from rotationally symmetric arrangements of plasmonic nanoholes. The second-harmonic efficiency is shown to depend strongly on collective interactions between the nanoholes.

FW3G.4 • 13:45 Invited
Nonlinear Wave Mixing in Semiconductor Nanoantennas and Metasurfaces, Dragomir N. Neshev[1]; [1]*Australian National Univ., Australia.* We demonstrate how ultra-small dielectric nanoantennas ordered in a metasurface can enable enhanced light-matter interaction for efficient nonlinear wave-mixing and in particular, to enhance the sum-frequency generation and spontaneous parametric down conversion.

13:00–15:00
FW3H • Active and Tunable Metasurfaces
Presider: Kevin MacDonald; Univ. of Southampton, UK

FW3H.1 • 13:00
Electrical Tuning of Dielectric Metasurfaces at Visible Frequencies Facilitated by Photoalignment of Liquid Crystals, Chengjun Zou[1], Andrei Komar[2], Stefano Fasold[1], Alexander Muravsky[3], Anatoli Murauski[3], Thomas Pertsch[1], Dragomir N. Neshev[2], Isabelle Staude[1]; [1]*Inst. of Applied Physics, Abbe Center of Photonics, Friedrich Schiller Univ. Jena, Germany;* [2]*Nonlinear Physics Centre, Research School of Physics and Engineering, The Australian National Univ., Australia;* [3]*Inst. of Chemistry of New Materials, National Academy of Sciences of Belarus, Belarus.* We experimentally demonstrate the use of photoalignment materials for liquidcrystal based electrical tuning of resonant silicon metasurfaces with a 67% modulation depth at visible frequencies.

FW3H.2 • 13:15
Continuous Angle Beam Steering Using Spatiotemporal Frequency-Comb Control in Dielectric Metasurfaces, Amr Shaltout[1], Konstantinos Lagoudakis[1], Jorik van de Groep[1], Soo Jin Kim[1], Jelena Vuckovic[1], Vladimir M. Shalaev[2], Mark Brongersma[1]; [1]*Stanford Univ., USA;* [2]*Purdue Univ., USA.* Experimental laser beam steering is demonstrated using light-matter interaction between frequency-comb source and silicon based metasurface. Continuous angular scanning of 25^0 is successfully achieved over a time interval of 10 ps

FW3H.3 • 13:30
Active Frequency Modulation of Metamaterial/Graphene Optoelectronic Device Using Coupled Resonators , Stephen J. Kindness[1], Nikita Almond[1], Robert Wallis[1], Binbin Wei[1], varun kamboj[1], Philipp Braeuninger-Weimer[1], Stephan Hofmann[1], Harvey Beere[1], David Ritchie[1], Riccardo Degl'Innocenti[2]; [1]*Univ. of Cambridge, UK;* [2]*Lancaster Univ., UK.* We present continuous frequency modulation of a metamaterial resonance by selective damping of coupled resonators using electrostatically gated graphene. A frequency tuning range >150 GHz is achieved at 1.5 THz making this device suitable for use as an electrically tunable frequency modulator.

FW3H.4 • 13:45
Dielectric Metasurfaces for Optical Communications and Spatial Division Multiplexing, Sergey S. Kruk[1], Filipe Ferreira[2], Naoise Mac-Suibhne[2], Christos Tsekrekos[2], Ivan Kravchenko[3], Andrew Ellis[2], Dragomir N. Neshev[1], Sergei K. Turitsyn[2], Yuri S. Kivshar[1]; [1]*Australian National Univ., Australia;* [2]*Aston Univ., UK;* [3]*Oak Ridge National Lab, USA.* We employ passive dielectric metasurfaces with near-unity transmission to engineer spatial mode profiles for both mode modulation and multiplexing in optical communications. The broadband response of the metasurface covers S, C, and L telecommunication bands.

CLEO: Science & Innovations

13:00–15:00
SW3I • Low-dimensional and Phase-change Materials
Presider: Matthew Escarra; Tulane Univ., USA

SW3I.1 • 13:00 Tutorial
Phase Change Photonics for Neuromorphic Computing and Information Displays, Harish Bhaskaran[1]; [1]*Univ. of Oxford, UK.* In this talk, I shall discuss recent developments in phase change photonics, specifically as it relates to on-chip photonics for memory applications as well as applications in emerging areas of computing. I shall talk about how this generic architecture can be applied to a range of functional materials in photonics. The optoelectronic functionality of these devices ("mixed-mode") will also be explored, and specific applications in displays will be briefly introduced.

Harish's research interests are broadly in the area of Nanoscale Engineering, and recently has focused on the use of accumulative materials to create photonic brain-inspired or neuromorphic computing, display applications and ways to manufacture them. He is currently the Professor of Applied Nanomaterials at Oxford, where he holds the EPSRC Fellowship in Manufacturing and leads the £3.1 million Wearable and Flexible Technologies Collaboration (www.waftcollaboration.org), which includes 15 industrial partners. He is the co-founder, and director (currently serving in an Executive capacity as Chief Scientific Officer) of Bodle Technologies Limited, a displays spin-out emerging out of research done in his laboratory at Oxford.

CLEO: Science & Innovations

13:00–15:00
SW3J • Biosensors & Photonic Devices
Presider: Nien-Tsu Huang, National Taiwan Univ., Taiwan

SW3J.1 • 13:00 Invited
Point-of-Care Technologies for Infectious Diseases and Nutritional Deficiencies, David Erickson[1]; [1]*Cornell Univ., USA.* In this talk I will discuss some of the technologies and approaches to enable point-of-care diagnostics for vitamin and micronutrient deficiencies and infectious disease related cancers like Kaposi's Sarcoma.

SW3J.2 • 13:30
Laser Emission Microscopy: A Novel Tool for High-contrast Cancer Screening with Nuclear Biomarkers, YU-CHENG CHEN[1], Xiaotian Tan[1], Qiushu Chen[1], Xudong Fan[1]; [1]*Biomedical Engineering, Univ. of Michigan, USA.* We developed a scanning laser-emission microscope capable of mapping lasing emission from nuclear biomarkers in both frozen and paraffin-embedded human tissues, which may open a new field in bioimaging with unprecedented contrast for cancer screening, immunodiagnosis, and cell biology.

13:00–15:00
SW3K • Few Mode Fibers and OAM
Presider: Shaif-Ul Alam; Univ. of Southampton, UK

SW3K.1 • 13:00
Robustness of OAM fiber modes to geometric perturbations, Zelin Ma[1], Gautam Prabhakar[1], Patrick Gregg[2], Siddharth Ramachandran[1]; [1]*Boston Univ., USA;* [2]*Finisar, USA.* We experimentally demonstrate that pure OAM fiber modes are highly robust to out-of-plane bend perturbations in contrast to their vector counterparts (HE/EH) that mix completely, because geometric (Pancharatnam) phase accumulation varies with OAM content.

SW3K.2 • 13:15
Measurement of the Orbital Angular Momentum Spectrum in Twisted Coreless Photonic Crystal Fiber, Paul Roth[1], Gordon K. L. Wong[1], Ramin Beravat[1], Clarissa M. Harvey[1], Michael H. Frosz[1], Rafal Sopalla[1], Philip S. Russell[1]; [1]*Max-Planck-Inst Physik des Lichts, Germany.* We present a technique for measuring the phase and amplitude distribution of the light guided in a twisted coreless photonic crystal fiber (or indeed any fiber), enabling full characterization of the orbital angular momentum states.

SW3K.3 • 13:30
All Fiber Orbital Angular Momentum Light Generation and Propagation Using Graded-Index Few Mode Fiber, Jiulin Gan[1], Xiaobo Heng[1], Zhishen Zhang[1], Zhongmin Yang[1]; [1]*South China Univ. of Technology, China.* The special designed graded-index few mode fiber can support orbital angular momentum (OAM) light propagation. Stable OAM light generation and propagation using all fiber fused mode selective coupler with 100nm bandwidth has been experimental demonstrated.

SW3K.4 • 13:45
Towards High-Q Microwave Photonic Passband Filters using Few Mode Fibers with Cascaded Long Period Grating Mode Converters, Daniel Nickel[1], Bryan Haas[1]; [1]*Naval Research Lab, USA.* We demonstrate single source microwave photonic finite impulse response filters with coherence-free operation and the potential for arbitrarily high numbers of filter taps using few mode fibers with cascaded long period grating mode converters.

13:00–15:00
SW3L • Fiber and Waveguide Sensing
Presider: Todd Stievater; US Naval Research Lab, USA

SW3L.1 • 13:00
High-resolution, dynamic fiber Bragg grating sensing base on dual-comb spectroscopy with a single fiber laser, Xin Zhao[1], Qian Li[1], Siyao Yin[1], Jie Chen[1], Zheng Zheng[1,2]; [1]*School of Electronic and Information Engineering, Beihang Univ., China;* [2]*Collaborative Innovation Center of Geospatial Technology, China.* Enabled by a dual-comb fiber laser, real-time interrogation of fiber Bragg grating's spectral response is realized using the dual-comb spectroscopy scheme. kHz sampling speed and pm accuracy are simultaneously achieved with a simple fiber-optic setup.

SW3L.2 • 13:15
Ultrahigh-Resolution and High-Dynamic-Range Strain Sensing by Time-of-Flight Detection with Femtosecond-Laser Pulses, Xing Lu[2], Shuangyou Zhang[1], Dohyeon Kwon[1], Chan-Gi Jeon[1], Bo Liu[3], Haifeng Liu[3], Jungwon Kim[1], Kebin Shi[2]; [1]*Korea Advanced Inst of Science & Tech, South Korea;* [2]*Peking Univ., China;* [3]*Nankai Univ., China.* We demonstrate a new strain sensing method by time-of-flight detection with femtosecond-laser pulses. Strain resolution of 18 pε/Hz$^{1/2}$ at 1-Hz and 1.9 pε/Hz$^{1/2}$ at 3-kHz is demonstrated with large dynamic range of >159 dB at 3-kHz.

SW3L.3 • 13:30
Coherent Brillouin Random Fiber Laser for Application in Phase-sensitive Optical Time Domain Reflectometry, Liang Zhang[1], Yuan Wang[1,2], Yanping Xu[1], Song Gao[1], Dapeng Zhou[1], Liang Chen[1], Xiaoyi Bao[1]; [1]*Dept. of physics, Univ. of Ottawa, Canada;* [2]*Inst. of Optoelectronic Technology, China Jiliang Univ., China.* We report the experimental demonstration of a new fashion of a coherent Brillouin random fiber laser enabled by distributed Rayleigh feedback for distributed acoustic sensor based on phase-sensitive optical time domain reflectometry.

SW3L.4 • 13:45
Porous Silicon Photonics at Unity Confinement Factors for Surface Adlayer Biosensing Applications, Gabriel Allen[1,2], William Delaney[1], Judson Ryckman[1]; [1]*Clemson Univ., USA;* [2]*Western Michigan Univ., USA.* We report a porous silicon photonics platform that addresses the evanescent limitations of guided wave surface adlayer biosensors. Devices are realized through an inverse fabrication process and ultra-high sensitivity to small molecule adlayers is demonstrated.

CLEO: Science & Innovations

CLEO: Applications & Technology

13:00–15:00
SW3M • Beam Control & Measurement
Presider: Seung-Whan Bahk; Univ. of Rochester, USA

SW3M.1 • 13:00
Elegant Laser Resonator Modes with OAM, Alfonso I. Jaimes-Nájera[1], Sabino Chávez-Cerda[1]; [1]*INAOE, Mexico.* Siegman introduced the elegant beams and proved that they are not eigenmodes of spherical resonators. We demonstrate that by superposing a finite number of elegant Laguerre-Gauss beams we can generate eigenmodes of spherical resonators.

SW3M.2 • 13:15
Novel Method for Generating High Purity Vortex Modes, Robin T. Uren[1], Stephen Beecher[1], Callum Smith[1], William A. Clarkson[1]; [1]*Univ. of Southampton, UK.* A scheme for generating Laguerre-Gaussian vortex modes using a novel astigmatic mode converter based on spherical mirrors is described. A simple method for characterizing mode purity is employed to confirm the benefits of this scheme.

SW3M.3 • 13:30
Optical vortex parametric laser with a versatile orbital angular momentum, Shungo Araki[1], Roukuya Mamuti[1], Kensuke Suzuki[1], Shigeki Nishida[1], Katsuhiko Miyamoto[1,2], Takashige Omatsu[1,2]; [1]*Chiba Univ., Japan;* [2]*Molecular chirality research center, Chiba Univ., Japan.* We present a tunable optical vortex parametric oscillator with versatile OAM. The OAM mode with a designated topological charge within the range of -1~3 was selectively generated by simply shortening or extending the cavity.

SW3M.4 • 13:45
High-resolution and compact vortex mode sorters based on a spiral transformation, Yuanhui Wen[1], Ioannis Chremmos[1,2], Yujie Chen[1], Jiangbo Zhu[3], Yanfeng Zhang[1], Siyuan Yu[1,3]; [1]*Sun Yat-sen Univ., China;* [2]*Hellenic Electricity Distribution Network Operator S. A., Greece;* [3]*Univ. of Bristol, UK.* We put forward a more generalized spiral transformation for vortex mode sorting with better separation between adjacent modes. We confirm this theoretical prediction with a compact vortex mode sorter fabricated on a thin quartz plate.

13:00–15:00
SW3N • Few-cycle Sources
Presider: Takao Fuji; National Inst.s of Natural Sciences, Japan

SW3N.1 • 13:00
A Robust Two-color-field Driven Hollow-core Fiber Compressor, Yudong Yang[1,2], Liwei Song[1,3], Fabian Scheiba[1,2], Giulio M. Rossi[1,2], Roland E. Mainz[1,4], Shaobo Fang[1], Oliver Muecke[1,2], Franz X. Kaertner[1,4]; [1]*Center for Free-Electron Laser Science CFEL, Deutsches Elektronen-Synchrotron DESY, Germany;* [2]*The Hamburg Centre for Ultrafast Imaging CUI, Univ. of Hamburg, Germany;* [3]*State Key Lab of High Field Laser Physics, Shanghai Inst. of Optics and Fine Mechanics, Chinese Academy of Sciences, China;* [4]*Dept. of Physics, Univ. of Hamburg, Germany.* We present a robust two-color-field driven hollow-core-fiber compressor. The ~1mJ HCF output covers 300 nm to 950 nm supporting sub-cycle transform-limited pulses with ~2.1fs duration. The spectral phase is characterized with two-dimensional spectral shearing interferometry.

SW3N.2 • 13:15
33-fold pulse compression down to 1.5 cycles in a 6-m-long hollow-core fiber, Young-Gyun Jeong[1], Riccardo Piccoli[1], Denis Ferachou[1,2], Vincent Cardin[1], Michael Chini[3], Steffen Hädrich[4], Jens Limpert[5,6], Roberto Morandotti[1,7], François Légaré[1], Bruno E. Schmidt[2], Luca Razzari[1]; [1]*INRS-EMT, Canada;* [2]*few-cycle Inc., Canada;* [3]*Dept. of Physics and CREOL, Univ. of Central Florida, USA;* [4]*Active Fiber Systems GmbH, Germany;* [5]*Inst. of Applied Physics, Abbe Center of Photonics, Friedrich-Schiller-Univ. Jena, Germany;* [6]*Fraunhofer Inst. for Applied Optics and Precision Engineering, Germany;* [7]*National Research Univ. of Information Technologies, Mechanics and Optics, Russia.* We demonstrate 33-fold pulse compression employing a 6-m-long hollow-core fiber and chirped mirrors. 1 mJ, 170 fs pulses at 1030 nm are compressed to 0.65 mJ, 5.1 fs, corresponding to 1.5 optical cycles.

SW3N.3 • 13:30
2.5 Cycle Pulses Obtained With Self Compression At 1.8 µm In Antiresonant Waveguides, Rudrakant Sollapur[1], Bruno E. Schmidt[2], Philippe Lassonde[3], Shoufei Gao[4], Yingying Wang[4], Pu Wang[4], François Légaré[3], Christian Spielmann[1,5]; [1]*Friedrich Schiller Univ. Jena, Germany;* [2]*few-cycle Inc., Canada;* [3]*INRS-EMT, Canada;* [4]*Inst. of Laser Engineering, Beijing Univ. of Technology, China;* [5]*Helmholtz Inst. Jena, Germany.* We report on 2.5 cycle pulse compression from 60 to 15 fs at 1800 nm in the fundamental mode of an Ar-filled low-loss antiresonant hollow-core fiber by pumping close to strand-resonance and zero dispersion wavelength.

SW3N.4 • 13:45
Compression of a Yb:KGW Laser with Multi-Plate and Hollow-Core Fiber Compressors, John E. Beetar[1], Shima Gholam Mirzaeimoghadar[1], Michael Chini[1,2]; [1]*Physics, Univ. of Central Florida, USA;* [2]*CREOL, The College of Optics and Photonics, Univ. of Central Florida, USA.* We investigate the potential of multi-plate and hollow-core fiber-based pulse compressors to generate few-cycle pulses from a moderately high energy (400 µJ) and average power (20 W) Yb:KGW laser with 280 fs input duration.

13:00–15:00
AW3O • Optical Enhancement of Photovoltaics
Presider: TBD

AW3O.1 • 13:00
Efficiency Increasing of Single-Junction GaAs Solar Cells Coated with Species of NIR Up-Conversion Phosphors Layer on Front-Side Surface by Spin-On Film Deposition, Jhih-Ciang Chen[1], Wen-Jeng Ho[1], Zong-Xian Lin[1], Wen-Bin Bai[1], Guan-Yu Chen[1], Hao-Xiang Zhang[1], Jheng-Jie Liu[1], Hung-Pin Shiao[2]; [1]*National Taipei Univ. of Technology, Taiwan;* [2]*Win Semiconductor Corp., Taoyuan, Taiwan, R.O.C. , Taiwan.* This study demonstrates high-efficiency (23.72%) single-junction GaAs solar cell coated with species of NIR up-conversion phosphors layer on the front-side surface by spin-on-film deposition, compared to 19.36% efficiency of the reference single-junction GaAs solar cell.

AW3O.2 • 13:15
HIT Solar Cell Performance Enhancement with Luminescent Down Shifting Phenomenon, Albert Lin[1], Chien Y. Huang[1], Parag Parashar[1], Hao-Ming Chou[1], Yi-Shiuan Lin[1], Ming-Hsuan Kao[2], Shih-Wei Chen[2], Chang-Hong Shen[2], Jia-Min Shieh[2], Tzu-Yu Chen[1], Chien-Chung Lin[3], Peichen Yu[1], Hao-Chung Kuo[1]; [1]*National Chiao Tung Univ., Taiwan;* [2] *National Nano Device Labs (NDL), Taiwan;* [3]*Inst. of Photonic System, National Chiao Tung Univ., Taiwan.* Luminescent down-shifting (LDS) phenomenon has been employed to enhance the HIT solar cell efficiency. The efficiency and J_{SC} are increased by 2.3% and 11.5% respectively. External quantum efficiency (EQE) data supports our claim.

AW3O.3 • 13:30
Spectrum Splitting Micro-Concentrator Assembly for Laterally-arrayed Multi-Junction Photovoltaic Module, Duanhui Li[1], Rui-Tao Wen[2], Rushabh Shah[1], Xueying Zhao[1], Haoquan Zhang[3], Eugene A. Fitzgerald[1], David J. Perreault[3], Jurgen Michel[1], Juejun Hu[1], Tian Gu[1]; [1]*Dept. of Materials Science and Engineering, MIT, USA;* [2]*Materials Research Lab, MIT, USA;* [3]*Dept. of Electrical Engineering and Computer Science, MIT, USA.* We demonstrate a novel spectrum-splitting module for integration with laterally-arrayed multi-bandgap micro-scale solar cells. The high-efficiency, low-cost, and low-profile design potentially enables significant improvement on solar module performance and reduction of energy production costs.

AW3O.4 • 13:45
Flexible Integrated Concentrators for Scalable High-Power Generation from Colloidal Quantum Dot Solar Cells, Yida Lin[1], Garrett Ung[1], Botong Qiu[1], Susanna Thon[1]; [1]*Johns Hopkins Univ., USA.* We fabricated economical and scalable compact concentrators using PDMS integrated with QD solar cells. The lenses deliver short circuit currents up to 20 times and powers up to 10 times that of bare solar cells.

Joint

13:00–15:00
JW3P • Symposium on New Advances in Adaptive Optics Retinal Imaging I
Presider: TBD

JW3P.1 • 13:00 Invited
Adaptive Optics Scanning Light Ophthalmoscopy: Beyond Structural Imaging, Alfredo Dubra[1]; [1]*Stanford Univ., USA.* Here we will first review demonstrations of imaging retinal function at the cellular scale using adaptive optics ophthalmoscopy, and then, we will discuss their potential clinical applications.

JW3P.2 • 13:45 Invited
Imaging Single Cells in the Living Eye from the Retinal Pigment Epithelium to the Ganglion Cell Layer, Ethan A. Rossi[1]; [1]*Ophthalmology, Univ. of Pittsburgh, USA.* Rapid advances in adaptive optics ophthalmoscopy have allowed additional cell classes to be imaged in the living eye, offering great promise for the study of diseases such as glaucoma and age-related macular degeneration. This presentation will cover some of these and discuss the challenges that remain for widespread clinical deployment.

JW3P.3 • 14:30

CLEO: Science & Innovations

13:00–15:00
SW3Q • Semiconductor Lasers for Integration
Presider: Kiyoul Yang; Stanford Univ.

SW3Q.1 • 13:00
Room-Temperature Electrically Pumped InP-based Laser Directly Grown on on-axis (001) Silicon, Si Zhu[1], Bei Shi[1], Qiang Li[1], Kei May Lau[1]; [1]*Hong Kong Univ of Science & Technology, Hong Kong.* We report the first InAlGaAs/InP multi-quantum-well lasers grown on (001) silicon by MOCVD. Lasing near 1.5 μm was achieved with a J_{th} = 3.3 kA/cm^2 and a high T_0 of 133 K.

SW3Q.2 • 13:15
Highly Improved Reliability of Low Threshold 1.3 μm III/V Quantum Dot Laser Epitaxially Grown on On-axis Si, Daehwan Jung[1], Robert Herrick[2], Justin Norman[1], Catherine Jan[2], Neil Caranto[2], Alfredo Torres[1], Yating Wan[1], Arthur Gossard[1], John E. Bowers[1]; [1]*UCSB, USA;* [2]*Intel Corp., USA.* InAs quantum dot Fabry-Perot lasers grown on on-axis (001) Si demonstrate record-low continuous-wave threshold current of 4.8 mA as well as excellent device reliability with extrapolated lifetimes more than ten million hours at 35 °C.

SW3Q.3 • 13:30
Quadruple reduction of threshold current density for micro-ring quantum dot lasers epitaxially grown on (001) Si , Yating Wan[1], Daehwan Jung[1], Justin Norman[1], Kaiyin Feng[1], Aip Dagli[1], Arthur Gossard[1], John E. Bowers[1]; [1]*UCSB, USA.* A quadruple reduction of threshold current density was achieved for electrically pumped quantum-dot microrings epitaxially grown on (001) silicon. This was enabled by a low threading dislocation density GaAs buffer layer and a smoothed etching sidewall.

CLEO: Applications & Technology

13:00–15:00
AW3R • A&T Topical Review on Advanced Applications of Laser Radar and Remote Sensing II
Presider: Fabio Di Teodoro; Raytheon SAS

AW3R.1 • 13:00 Invited
LiDAR for Autonomous Vehicles: Challenges and Opportunities for Photonics, Lute Maleki[1]; [1]*Sensors, GM/Cruise, USA.* Autonomous vehicles are arguably the most impactful technology since the advent of the Internet. In this talk challenges and opportunities of LiDAR that pertain to Photonics Technology will be discussed.

AW3R.2 • 13:30
Comparison of cavity enhanced Faraday rotation techniques for oxygen detection, Charles L. Patrick[1], Jonas Westberg[1], Gerard Wysocki[1]; [1]*Princeton Unviersity, USA.* Two cavity enhanced Faraday rotation spectroscopic techniques are compared by detection of oxygen around 762 nm. Both techniques demonstrate sensitivities in the 1e-9 rad/√Hz range and inherent advantages of the two techniques are discussed.

AW3R.3 • 13:45
Navigation Doppler Lidar for autonomous ground, aerial, and space vehicles, Farzin Amzajerdian[1], Glenn D. Hines[1], Diego F. Pierrottet[2], Bruce W. Barnes[1], Larry B. Petway[1], John M. Carson[3]; [1]*NASA Langley Research Center, USA;* [2]*Coherent Applications, USA;* [3]*NASA Jonson Space Center, USA.* A Doppler lidar instrument has been developed and demonstrated for providing critical vector velocity and altitude/range data for autonomous precision navigation. Utilizing advanced component technologies, this lidar can be adapted to different types of vehicles.

13:00–15:00
AW3S • A&T Topical Review on Advances in Supercontinuum Technologies II: New Application Areas for Supercontinuum Light Sources
Presider: Adam Devine

AW3S.1 • 13:00 Invited
Supercontinuum Applications in High Resolution Non Invasive Optical Imaging, Adrian G. Podoleanu[1], Ole Bang[2], Peter Moselund[3]; [1]*Univ. of Kent, Canterbury, UK;* [2]*Technical Univ. of Denmark, Denmark;* [3]*NKT Phptonics, Denmark.* Progress will be presented in adapting supercontinuum sources to optical coherence tomography and photoacoustic applications with emphasis on signal processing procedures customised to alleviate noise and take full advantage of the large bandwidth of the supercontinuum

AW3S.2 • 13:30 Invited
Mid-infrared Supercontinuum-based Trace as Sensing , Frans J. M. Harren[1]; [1]*Radboud Univ., Netherlands.* An overview will be given on mid-infrared supercontinuum sources combined with sensitive spectroscopic methods, to trace molecular gases for applications such as food spoilage reduction and high-sensitivity sensing for a safer atmospheric environment.

SW3A • Microresonator Combs—Continued

SW3A.5 • 14:00
Generation of Multiple Side Lines around Kerr Comb Lines by a Second Pump Coupled into the Soliton Resonance, Peicheng Liao[1], Changjing Bao[1], Kaiheng Zou[1], Arne Kordts[2], Lin Zhang[3], Maxim Karpov[2], Martin Pfeiffer[2], Ahmed Almaiman[1], Yinwen Cao[1], Fatemeh Alishahi[1], Amirhossein Mohajerin Ariaei[1], Ahmad Fallahpour[1], Moshe Tur[4], Tobias J. Kippenberg[2], Alan E. Willner[1]; *[1]Univ. of Southern California, USA; [2]Ecole Polytechnique Federale de Lausanne, Switzerland; [3]School of Precision Instrument and Opto-electronics Engineering, China; [4]Tel Aviv Univ., Israel.* We demonstrate the generation of multiple side lines around Kerr comb lines by injecting a second pump into the soliton resonance. The side lines around each comb lines have relatively high power and are stable.

SW3A.6 • 14:15
Direct Generation of Solitons with a Reversed Soliton Step in a Microresonator Pumped by a Phase-Modulated Laser, Daniel C. Cole[1], Jordan Stone[1], Scott Papp[1]; *[1]NIST Boulder, USA.* We demonstrate direct generation of Kerr-microresonator solitons with measured 100 percent success rate using an increasing-frequency scan of a phase-modulated pump laser. A reversed soliton step is observed. The phase modulation controls the solitons' properties.

SW3A.7 • 14:30
Raman comb generation through broadband gain in a silica microresonator, Ryo Suzuki[1], Akihiro Kubota[1], Atsuhiro Hori[1], Shun Fujii[1], Takasumi Tanabe[1]; *[1]Keio Univ., Japan.* We study the dynamics of Raman comb formation in silica rod microresonators. We generated a Raman comb with a smooth spectral envelope and observed the center wavelength transition by controlling the detuning and coupling strength.

SW3A.8 • 14:45
Efficient Mid-Infrared Dispersive Wave Generation in Dispersion-Engineered Si_3N_4 Waveguides Pumped at 2 µm, Eirini Tagkoudi[1], Davide Grassani[1], Hairun Guo[2], Clemens Herkommer[2], Tobias J. Kippenberg[2], Camille-Sophie Bres[1]; *[1]Ecole Polytechnique Fédérale de Lausanne (EPFL), Photonic Systems Lab (PHOSL), Switzerland; [2]Ecole Polytechnique Fédérale de Lausanne (EPFL), Lab for Photonics and Quantum Measurements (LPQM), Switzerland.* We demonstrate efficient generation of mid-infrared dispersive wave at 3.5 µm in a Si_3N_4 waveguide pumped by a 2090nm femtosecond mode-locked fiber laser. The 8% maximum efficiency allows for a milliwatt-level average power mid-infrared pulse.

SW3B • Hybrid Lasers on Silicon—Continued

SW3B.4 • 14:00
CMOS-Compatible Tunable Vernier Ring Laser using Erbium Doped Waveguide on a Silicon Photonics Platform, Nanxi Li[1,2], Diedrik Vermeulen[1,3], Zhan Su[1,3], Emir Magden[1], Alfonso Ruocco[1], Neetesh Singh[1], Jelena Notaros[1], Ming Xin[1], Christopher Poulton[1,3], Erman Timurdogan[1,3], Christopher Baiocco[4], Michael Watts[1]; *[1]Research Lab of Electronics, MIT, USA; [2]John A. Paulson School of Engineering and Applied Science, Harvard Univ., USA; [3]Analog Photonics, USA; [4]College of Nanoscale Science and Engineering, Univ. at Albany, USA.* We demonstrate the first silicon photonic tunable laser with integrated erbium-doped Al_2O_3 waveguides. The laser is designed to have Vernier ring structure for wide tuning operation. It has a 0.23cm^2 footprint and 1.6mW output power.

SW3B.5 • 14:15
Low Cost 100 Gbps Multicore VCSEL Based Transmitter Module Platform, Teng LI[1], Sander Dorrestein[2], Wouter Soenen[3], Chenhui Li[1], Ripalta Stabile[1], Xin Yin[3], Oded Raz[1]; *[1]Eindhoven Univ. of Technology, Netherlands; [2]TE Connectivity, Netherlands; [3]Ghent Univ., Belgium.* We demonstrate a flexible printed circuit board platform for a 100 Gbps VCSEL based transmitter with direct light launching into a multi-core-fiber using a 3D glass interposer as fan-out Error free operation is demonstrated.

SW3B.6 • 14:30
Silicon Waveguide Coupled III-V Nanowire Lasers with Epitaxial Gain Control, Thomas Stettner[2,1], Tobias Kostenbader[2], Daniel Ruhstorfer[2,1], Jochen Bissinger[2,1], Andreas Thurn[2], Hubert Riedl[2], Michael Kaniber[2,1], Gregor Koblmüller[2,1], Jonathan J. Finley[2,1]; *[1]Nanosystems Initiative Munich (NIM), Schellingstr. 4, Germany; [2]Walter Schottky Institut and Physik Dept., Technische Universität München, Germany.* We demonstrate lasing from individual GaAs-based NWs integrated onto Si ridge waveguides. In addition, proof-of-principle coupling emission to the Si WG is shown, with propagation distances of the lasing mode exceeding > 60 µm.

SW3B.7 • 14:45
Microwave Spectral Characteristics of the Three-Section Distributed Feedback Lasers, Chun-Hong Chen[1], Fu-Chun Hsiao[2], Yao-Zhong Dong[3], Yueh-Lin Chan[2], Yi-Hsun Chen[2], Yu-Ming Huang[2], Shun Chieh Hsu[2], Chung-Ping Huang[3], Chien-Chung Lin[2]; *[1]College of Photonics, Inst. of Imaging and Biomedical Photonics, National Chiao-Tung Univ., Taiwan; [2]College of Photonics, Inst. of Photonic System, National Chiao-Tung Univ., Taiwan; [3]College of Photonics, Inst. of Lighting and Energy Potonics, National Chiao-Tung Univ., Taiwan.* The three-section DFB lasers are used for RF signal generation. With an extra section, it can tune the RF peak frequency farther than the two-section one, and can also simultaneously generate two single-mode RF signals.

SW3C • High Capacity Transmission—Continued

SW3C.4 • 14:00 Tutorial
Scaling Disparities in Optical Communications – And How to Resolve Them, Peter J. Winzer[1]; *[1]Nokia Bell Labs, USA.* Decades of consistent traffic growth suggest that optical transmission capacities will soon be unable to support demands. New transmission technologies will be needed, based on massive array integration across spatial and wavelength multiplexing dimensions.

Peter Winzer has contributed to many aspects of optical communications and networking, high-speed transmission, and spatial multiplexing to overcome network scalability problems. He has amply published and patented and is actively involved within IEEE and OSA. He is a Highly Cited Researcher, a Fellow of Bell Labs, IEEE, and OSA, and a Member of the NAE.

15:00–17:00 Coffee Break & Exhibit Only Time, *Exhibit Hall*

CLEO: Science & Innovations

SW3D • Terahertz Nano-imaging and Spectroscopy—Continued

SW3D.5 • 14:00 Invited

Terahertz Light Fingerprints Biomolecular Dynamics, Yanting Deng[1], Mengyang Xu[1], Katherine Niessen[1], Deepu Koshy George[1], Andrea G. Markelz[1]; *[1]Physics, Univ. at Buffalo, SUNY, USA.* This talk will discuss the limitations of standard THz spectroscopic methods, and how THz polarization techniques can be used to both fingerprint specific biomolecules and reveal their biologically important changes. I will also discuss challenges that must be addressed to fully realize THz light's impact on the biomedical community.

SW3D.6 • 14:30

Control of Spoof Localized Surface Plasmons Using Terahertz Near-field Microscope, Takashi Arikawa[1], Shohei Morimoto[1], Tomoki Hiraoka[1], François Blanchard[2], Kyosuke Sakai[3], Keiji Sasaki[3], Koichiro Tanaka[1,4]; *[1]Kyoto Univ., Japan; [2]Dept. of Electrical Engineering, École de Technologie Superieure (ÉTS) Montréal, Canada; [3]Research Inst. for Electronic Science, Hokkaido Univ., Japan; [4]Inst. for Integrated Cell-Material Sciences, Kyoto Univ., Japan.* We performed time-resolved terahertz near-field imaging of a gold disk with sub-wavelength periodic grooves and successfully observed spoof localized surface plasmons. A selective excitation method is also demonstrated with orbital angular momentum of light.

SW3D.7 • 14:45

Depth-enhanced terahertz reflection imaging with Bessel beam generated by 3D-printed diffractive element, Liting Niu[1], Qiao Wu[1], Kejia Wang[1], Zhengang Yang[1], Jinsong Liu[1]; *[1]Huazhong Univ. of Science and Techn, China.* We propose a depth-enhanced terahertz reflection imaging system with Bessel beam generated by 3D-printed diffractive element. For testing the imaging quality of this system, a resolution chart is imaged at different transverse planes.

CLEO: QELS-Fundamental Science

FW3E • Frequency Combs & Precision Metrology—Continued

FW3E.4 • 14:00

Electro-optic Frequency Comb Generation in Ultrahigh-Q Integrated Lithium Niobate Micro-resonators, Mian Zhang[1], Cheng Wang[1], Brandon Buscaino[2], Amirhassan Shams-Ansari[1,3], Joseph Kahn[2], Marko Loncar[1]; *[1]John A. Paulson School of Applied and Engineering Sciences, Harvard Univ., USA; [2]E. L. Ginzton Lab, Dept. of Electrical Engineering, Stanford Univ., USA; [3]Dept. of Electrical Engineering and Computer Science, Howard Univ., USA.* We generate an electro-optic frequency comb in an integrated lithium niobate ultrahigh-Q microresonator. The comb has more than 250 lines with a line spacing of ~ 25 GHz in the telecom L-band.

FW3E.5 • 14:15

Direct Kerr-frequency-comb atomic stabilization, Liron Stern[1], Jordan Stone[1], Songbai Kang[1], Daniel C. Cole[1], John Kitching[1], Scott A. Diddams[1], Scott Papp[1]; *[1]Time and Frequency Division, National Inst. for Standards and Technology, USA.* We experimentally demonstrate direct Kerr-microresonator frequency-comb atomic spectroscopy, utilizing a cascaded two-photon 1529-nm transition in a rubidium micro-machined vapor cell. The demonstration is a path for compact atomic frequency references and multiphoton comb-atom interactions.

FW3E.6 • 14:30

Shaping Harmonic Frequency Combs in Quantum Cascade Lasers, Marco Piccardo[1], Paul Chevalier[1], Benedikt Schwarz[2], Yongrui Wang[3], Dmitry Kazakov[1,4], Noah A. Rubin[1], Sajant Anand[5], Enrique A. Mejia[6], Michele Tamagnone[1], Feng Xie[7], Kevin Lascola[7], Alexey Belyanin[3], Federico Capasso[1]; *[1]Harvard Univ., USA; [2]TU Wien, Austria; [3]Texas A&M Univ., USA; [4]ETH Zurich, Switzerland; [5]Wake Forest Univ., USA; [6]Univ. of Texas at Austin, USA; [7]Thorlabs Quantum Electronics, USA.* Controlling the spacing of self-starting harmonic frequency combs in QCLs by design of fundamental laser parameters is arduous. New ways to shape such combs by means of original electrical, optical and radiofrequency techniques are presented.

FW3F • Single-Photon Detectors—Continued

FW3F.5 • 14:00

A Primary Radiation Standard Based on Quantum Nonlinear Optics, Samuel Lemieux[1], Enno Giese[1], Robert Fickler[1], Maria Chekhova[2], Robert Boyd[1,3]; *[1]Univ. of Ottawa, Canada; [2]Max Planck Inst. for the Science of Light, Germany; [3]Univ. of Rochester, USA.* We introduce spontaneous parametric down-conversion as a light source for intensity calibration of spectrometers solely based on physical principles. The response function of the spectrometer obtained with our technique agrees with the one measured with a NIST-traceable calibration lamp.

FW3F.6 • 14:15

Measuring single photons to bright light with a logarithmic optical detector, Johannes Tiedau[1], Evan Meyer-Scott[1], Thomas Nitsche[1], Sonja Barkhofen[1], Christine Silberhorn[1], Tim J. Bartley[1]; *[1]Integrated Quantum Optics Group, Applied Physics, Univ. of Paderborn, Germany.* We explore the behaviour of a loop detection scheme above the saturation region of single photon detectors. This enables us to measure single photon states and up to 309 nW power with the same device.

FW3F.7 • 14:30

Sub-nanosecond Temporally Resolved Imaging with a Single Pixel Camera, Steven Johnson[1], Matthew Edgar[1], David Phillips[2], Miles Padgett[1]; *[1]Univ. of Glasgow, UK; [2]Univ. of Exeter, UK.* Single pixel cameras with temporal resolution can produce 3D images. We present a single pixel camera that has a temporal resolution of 200 picoseconds, enabling us to resolve the modes from a few-mode optical fibre.

FW3F.8 • 14:45

Harnessing Quantum Wave Nature of Individual Electrons for Single Photon Detection, Yang Zhang[1], Yang Wu[2], Xiaoxin Wang[3], Eric R. Fossum[3], Rahul Kumar[2], Jifeng Liu[3], Gregory Salamo[2], Shui-Qing Yu[1]; *[1]Dept. of Electrical Engineering, Univ. of Arkansas, USA; [2]Dept. of Physics, Univ. of Arkansas, USA; [3]Thayer School of Engineering, Dartmouth College, USA.* We propose and examine theoretically a new type of photodetector that senses THz single photons by the wavefunction change of a single electron confined in a quantum dot. A possible readout scheme is also presented.

15:00–17:00 Coffee Break & Exhibit Only Time, *Exhibit Hall*

CLEO: QELS-Fundamental Science

CLEO: Science & Innovations

FW3G • Nonlinear Nano-optics—Continued

FW3G.5 • 14:15
Plasmon Enhanced Third-Harmonic Generation with Graphene Nanoribbons, Irati Alonso Calafell[1], Lee Rozema[1], David Alcaraz[2], Frank H. Koppens[2], Philip Walther[1]; [1]*Univ. of Vienna, Austria;* [2]*ICFO, Spain*. Graphene's strong third-order nonlinearity could allow single-photon level interactions. Using third-harmonic generation, we characterize this nonlinearity over a wide wavelength range (1-4um). We study a further plasmon enhancement by resonantly pumping graphene nanoribbons.

FW3G.6 • 14:30
Structured Light for Selective Third-Harmonic Generation in Subwavelength Resonators, Elizaveta V. Melik-Gaykazyan[1], Sergey S. Kruk[2], Maria del R. Camacho Morales[2], Lei Xu[2], Mohsen Rahmani[2], Khosro Zangeneh Kamali[2], Aristeidis Lamprianidis[2], Andrey Miroshnichenko[3], Andrey Fedyanin[1], Dragomir N. Neshev[2], Yuri S. Kivshar[2]; [1]*Faculty of Physics, Lomonosov Moscow State Univ., Russia;* [2]*Nonlinear Physics Centre, Australian National Univ., Australia;* [3]*School of Engineering and Information Technology, Univ. of New South Wales, Australia*. We study the third-harmonic generation in subwavelength silicon particles supporting Mie-type optical modes. By tailoring the vectorial structure of the pumping light, we selectively excite electric or magnetic multipoles, also controlling the induced nonlinear response.

FW3H • Active and Tunable Metasurfaces—Continued

FW3H.5 • 14:00 Invited
Active and Nonlinear Metasurfaces: From Graphene-Integrated to Photon-Accelerating Semiconductor Nanostructures, Gennady Shvets[1]; [1]*Cornell Univ., USA*. Amplitude and phase shaping of infrared light on a nanosecond scale using graphene-integrated plasmonic metasurfaces will be described. The concept of a Photon-Accelerating Metasurface enabling simultaneously broadband and efficient nonlinear light generation will be introduced

FW3H.6 • 14:30
A Reprogrammable Photonic Meta-platform, Kaichen Dong[2,1], Sukjoon Hong[2,3], Yang Deng[2], He Ma[1], Jiachen Li[1], Xi Wang[2], Junyeob Yeo[2,4], Letian Wang[2], Shuai Lou[2], Kyle Tom[2,5], Kai Liu[1], Zheng You[1], Yang Wei[1], Costas P. Grigoropoulos[2], Jie Yao[2,5], Junqiao Wu[2,5]; [1]*Tsinghua Univ., China;* [2]*Univ. of California, Berkeley, USA;* [3]*Hanyang Univ., South Korea;* [4]*Kyungpook National Univ., South Korea;* [5]*Lawrence Berkeley National Lab, USA*. We present an all-solid, reprogrammable meta-platform, which can be rapidly (re)programmed into nearly arbitrary photonic devices by writing/erasing patterns on it. The writing is performed with a low-power laser, and the erasing utilizes global cooling.

FW3H.7 • 14:45
Reflectance Modulation of Metasurface Coupled to Intersubband Transitions using Voltage Controlled Quantum Tunneling, Raktim Sarma[1], Salvatore Campione[1], Michael Goldflam[1], Loan Te[2], Mike Lange[2], Joshua Shank[1], Michael Wanke[1], Jinhyun Noh[3], Peide Ye[3], Igal Brener[1]; [1]*Sandia National Labs, USA;* [2]*Northrop Grumman Corporation, USA;* [3]*Purdue Univ., USA*. We demonstrate a fundamentally new approach of using voltage controlled quantum tunneling for modulating optical response of a metasurface coupled to intersubband transitions in semiconductor quantum wells.

SW3I • Low-dimensional and Phase-change Materials—Continued

SW3I.2 • 14:00
Adaptive thermal camouflage based on phase-changing material GST, Yurui Qu[1], Qiang Li[1], Lu Cai[1], Meiyan Pan[1], Pintu Ghosh[1], Kaikai Du[1], Min Qiu[1]; [1]*Zhejiang Univ., China*. An adaptive thermal camouflage device incorporating phase-changing material Ge2Sb2Te5 (GST) is experimentally demonstrated. Near-perfect thermal camouflage can be achieved continuously for the background temperature ranging from 30 °C to 50 °C.

SW3I.3 • 14:15
Non-Local Detection and Electric Modulation of Valley-Coupled Spin Photocurrents in WSe_2-Bi_2Se_3 Heterostructure Device, Minji Noh[1], Soonyoung Cha[1], Jehyun Kim[2], Jangyup Son[2], Hyemin Bae[1], Doeon Lee[1], Hoil Kim[3], Jekwan Lee[1], Hoseung Shin[1], Sangwan Sim[1], Seung Hoon Yang[4], Sooun Lee[1], Gangtae Jin[3], Moon-Ho Jo[3], Wooyoung Shim[1], Chul-Ho Lee[4], Junsung Kim[3], Dohun Kim[2], Hyunyong Choi[1]; [1]*Yonsei Univ., South Korea;* [2]*Seoul National Univ., South Korea;* [3]*POSTECH, South Korea;* [4]*Korea Univ., South Korea*. We perform a non-local circular photogalvanic measurement and directly generate the valley-coupled spin currents from WSe_2 to Bi_2Se_3 topological insulators. Our WSe_2-Bi_2Se_3 heterostructure offers a new optoelectronic platform toward the electrically-controllable valley-spin degree of freedom.

SW3I.4 • 14:30
Strain dependent optical helicity in monolayer WSe2, Jinkang Lim[1], Zhangji Zhao[1], Jin Ho Kang[1], Jiahui Huang[1], Xiangfeng Duan[1], Ali Javey[2], Chee Wei Wong[1], hyungjin kim[2]; [1]*Univ. of California Los Angeles, USA;* [2]*Electrical Engineering, Univ. of California, Berkeley, USA*. We investigate optical helicity of chemical vapor deposition (CVD) grown monolayer WSe2 samples on fused silica substrates with/without a strain control. 38 (18) % of helicity for the strain controlled (uncontrolled) sample is measured at 77 K.

SW3I.5 • 14:45
Spectroscopic signature of interlayer coupling in Black phosphorus-graphite heterostructure, Zhonghui Nie[1], Hanwen Wang[2], Weilai Liu[2], Xiaoping Liu[1], Yongbing Xu[1], Yi Shi[1], Zheng Han[2], Frank (Fengqiu) Wang[1]; [1]*Nanjing Univ., China;* [2]*IMR, Chinese Academy of Sciences, China.* We reveal a pump-polarization-dependent spectroscopic signature of interlayer coupling in a black phosphorus-graphite heterostructure by probing its ultrafast photo-response. The angle-resolved transients provide new insights into the interfacial carrier dynamics in this emerging hybrid system.

15:00–17:00 Coffee Break & Exhibit Only Time, *Exhibit Hall*

CLEO: Science & Innovations

SW3J • Biosensors & Photonic Devices—Continued

SW3J.3 • 14:00
Random Lasing Action in All-Marine Based Materials, Wei-Ju Lin[1], Shih-Yao Lin[1], Cheng Han Chang[1], Yu-Ming Liao[1], Tai-Yuan Lin[2], Yang-Fang Chen[1]; [1]*National Taiwan Univ. , Taiwan;* [2]*Inst. of Optoelectronic Sciences, National Taiwan Ocean Univ., Taiwan.* Towards the sustainable development, optoelectronic devices with biodegradability and biocompatibility have been a desirable but challenging issue for years. In this study, an all-biomaterial random laser device based on all-marine elements has been demonstrated.

SW3J.4 • 14:15
Dense-Wavelength-Division Laser Micro-Particles: Fabrication and Imaging in Tissues, Nicola Martino[1,2], Sheldon J. Kwok[1,3], Jiamin Wu[1], Andreas C. Liapis[1,2], Sun-Joo Jang[1,2], Seok-Hyun Yun[1,2]; [1]*Wellman Center for Photomedicine, Massachusetts General Hospital, USA;* [2]*Dept. of Dermatology, Harvard Medical School, USA;* [3]*MIT, USA.* Small laser cavities embedded in biological systems are a novel contrast agent for biomedical research. Here we demonstrate the fabrication of highly multiplexed laser particles that can be imaged in tissue.

SW3J.5 • 14:30
Enhanced Fluorescence Spectroscopy and Imaging Immunoassay using Biological Photonic Crystals, Kenny Squire[1], Xianming Kong[1], Paul Leduff[1], Gregory Rorrer[1], Alan X. Wang[1]; [1]*Oregon State Univ., USA.* Utilizing natural photonic crystals, diatoms, we developed immunoassay with efficiently enhanced fluorescence signals. Testing on standard antibody-antigen models achieved unprecedented detection limits of 10^{-16} M and 10^{-14} M using fluorescence spectroscopy and fluorescence imaging respectively.

SW3J.6 • 14:45
Sub-5-nm-nanogap Metasurface for Record-breaking Surface Enhanced Infrared Absorption Spectroscopy, Dengxin Ji[1], Alec R. Cheney[1], Nan Zhang[1], Haomin Song[1], Jun Gao[1], Xie Zeng[1], Haifeng Hu[1], Suhua Jiang[1], Zongfu Yu[1], Qiaoqiang Gan[1]; [1]*State Univ. of New York at Buffalo, USA.* We developed a metamaterial super absorber with sub-5-nanometer gaps and demonstrated its application for record-breaking surface enhanced infrared absorption spectroscopy using its extremely enhanced localized field.

SW3K • Few Mode Fibers and OAM—Continued

SW3K.5 • 14:00 Invited
Optical fiber designs for MIMO-less SDM, Sophie LaRochelle[1], Alessandro Corsi[1], Reza Mirzaei-Nejad[1], Lixian Wang[1], Xun Guan[1], Jun Ho Chang[1], Jiachuan Lin[1], Leslie Rusch[1]; [1]*COPL, Universite Laval, Canada.* We examine polarization maintaining elliptical core fiber designs for space-division-multiplexing (SDM) in short reach links. Linearly polarized vector modes simplify polarization Mux/Demux and MIMO-less transmission is achieved. We discuss scalability of the approach.

SW3K.6 • 14:30
Intermodal Modulation Instability and Four-Wave Mixing in Graded-Index Few-Mode Fibers, Abdelkrim Bendahmane[1], Richard Dupiol[1,2], Katarzyna Krupa[3], Alessandro Tonello[2], Julien Fatome[1], Marc Fabert[2], Bertrand Kibler[1], Thibaut Sylvestre[4], Alain Barthelemy[2], Vincent Couderc[2], Stefan Wabnitz[1,3], Guy Millot[1]; [1]*Laboratoire ICB, UMR CNRS 6303, Université Bourgogne Franche-Comté, France;* [2]*XLIM, UMR CNRS 7252, Université de Limoges, France;* [3]*Università degli Studi di Brescia, Italy;* [4]*Institut FEMTO-ST, Université Bourgogne Franche-Comté, France.* By controlling pump modes injected in the normal dispersion regime of few-mode graded index optical fiber, we investigated intermodal noise-seeded modulation instability and generation of highly-detuned cascaded intermodal four-wave mixing sidebands.

SW3L • Fiber and Waveguide Sensing—Continued

SW3L.5 • 14:00 Invited
Thermo-refractive noise at high frequency: Beyond the conventional model, Nicolas Le Thomas[1], Ali Raza[1], Roel Baets[1]; [1]*Ghent Univ., Belgium.* The detection limit of Raman sensors based on waveguides is restricted by a background that exhibits an unconventional exponential decay at high frequency. We discuss a new model that reveals the origin of this background.

SW3L.6 • 14:30
E-beam-lithography free plasmonic slot waveguides for on-chip Raman spectroscopy, Ali Raza[1], Michiel V. Daele[1], Pieter Wuytens[1], Jolien Dendooven[1], Christophe Detavernier[1], Stephane Clemmen[1], Roel Baets[1]; [1]*Ghent Univ., Belgium.* We present nanoplasmonic slot-waveguides interfaced to dielectric photonic waveguides and capable of strongly enhancing Raman scattering. Their e-beam-free fabrication can be scaled to volume manufacturing and makes the plasmonic structure, hence the Raman spectra, reproducible.

SW3L.7 • 14:45
Dynamic Optical Fringe Suppression for Silicon Photonic Sensors, Chu Teng[1], Eric J. Zhang[2], Chi Xiong[2], Yifeng Chen[1], Jonas Westberg[1], William Green[2], Gerard Wysocki[1]; [1]*Princeton Univ., USA;* [2]*IBM Thomas J. Watson Research Center, USA.* We present a new fringe mitigation method based on Fourier decomposition of background optical fringe patterns. Application to a silicon photonic on-chip sensor show order of magnitude improved concentration retrieval stability.

15:00–17:00 Coffee Break & Exhibit Only Time, *Exhibit Hall*

CLEO: Science & Innovations

CLEO: Applications & Technology

SW3M • Beam Control & Measurement—Continued

SW3M.5 • 14:00 Invited

Hartmann Wavefront Sensors for Advanced LIGO, Peter Veitch[1], Aidan Brooks[2], Won Kim[1], Jesper Munch[1], David Ottaway[1]; *[1]Univ. of Adelaide, Australia; [2]LIGO Lab, USA.* The operation and sensitivity of the Advanced LIGO gravitational wave detector are degraded by absorption-induced wavefront distortion. We describe the use of ultra-sensitive Hartmann wavefront sensors to tune detector operation and optimize sensitivity.

SW3M.6 • 14:30

Improved Spatially Dithered Beam Shapers Using Direct Binary Search, Christophe Dorrer[1], Jie Qiao[2]; *[1]Univ. of Rochester, USA; [2]Rochester Inst. of Technology, USA.* Direct binary search is used to optimize spatially dithered distributions of transparent and opaque pixels for beam shaping, improving the performance of spatial gain precompensation for laser systems, and wavefront metrology by optical differentiation.

SW3M.7 • 14:45

Amplification of Incoherent and Coherently Coupled Higher Order Modes in a HO:YAG Single Crystal Fiber, Yuan Li[1], Wenzhe Li[1], Keith Miller[1], Eric G. Johnson[1], Subhabrata Bera[2], Craig Nie[2], James A. Harrington[2]; *[1]Clemson Univ., USA; [2]Rutgers Univ., USA.* The simultaneous excitation and amplification of two higher order modes (HOMs) are demonstrated in a Ho:YAG single crystal fiber (SCF) amplifier for both incoherent and coherent mode combing.

SW3N • Few-cycle Sources—Continued

SW3N.5 • 14:00

Greater than 50x solid-state compression of 1030 nm Yb:based laser pulses to single-cycle duration, Chih-Hsuan Lu[1,2], Wei-Hsin Wu[1], Shiang-He Kuo[1], Shang-Da Yang[1], Ming-Chang Chen[1], A. H. Kung[1,2]; *[1]National Tsing Hua Univ., Taiwan; [2]Inst. of Atomic and Molecular Sciences, Academica Sinica, Taiwan.* 170 fs pulses of a 1030 nm Yb-based laser system has been compressed to 3.1 fs at below a single carrier cycle following spectral broadening in a two-stage multiple thin plates arrangement

SW3N.6 • 14:30

Near single-cycle laser pulses at high average power and high repetition rate from an all-solid-state setup, Tobias Witting[1], Chih-Hsuan Lu[2,3], Federico J. Furch[1], A. H. Kung[2,3], Marc J. Vrakking[1]; *[1]Max-Born-Inst., Germany; [2] Inst. of Photonics Technologies, Taiwan; [3]Inst. of Atomic and Molecular Sciences, Taiwan.* We demonstrate pulse compression of a high average power 100 kHz NOPCPA laser system with an all solid state setup. Using multiple thin quartz plates we achieve near-single cycle pulses with an average power of over 10 W with excellent long term power and CEP stability.

SW3N.7 • 14:45

Generation of sub-two-cycle, CEP-stable, high-energy, 3.5-μm pulses by multiple-plate pulse compression, Peiyu Xia[1], Faming Lu[1], Teruto Kanai[1], Nobuhisa Ishii[1], Jiro Itatani[1]; *[1]Inst. for Solid State Physics, The Univ. of Tokyo, Japan.* We demonstrate multiple-plate compression of femtosecond pulses in the mid-infrared region. Using YAG and two Si plates, 1.80-optical-cycle, CEP-stable, intense pulses (21.0 fs, 45 μJ, 3.5 μm) has been obtained with octave-spanning spectrum.

AW3O • Optical Enhancement of Photovoltaics—Continued

AW3O.5 • 14:00 Invited

Progress Toward Stationary Concentrator Photovoltaics, Peter Kozodoy[1], John Lloyd[1], Michael Pavilonis[1], Chadwick Casper[1], Kevin Schneider[1], William McMahon[2], Christopher Gladden[1]; *[1]Glint Photonics, Inc., USA; [2]National Renewable Energy Lab, USA.* We present an overview of our research on stationary high-concentration photovoltaic panels with internal micro-tracking. Utilizing multijunction cells, these modules offer the potential for high energy production per unit area at low cost.

AW3O.6 • 14:30

Analysis of an Anti-reflecting Nanowire Transparent Electrode for Solar Cells, Zhexin Zhao[1], Ken X. Wang[1], Shanhui Fan[1]; *[1]Ginzton Lab, Stanford Univ., USA.* We investigate a nanowire transparent electrode that also functions as an anti-reflection coating for solar cells. To provide physical insights into this broadband anti-reflection, we introduce a generalized Fabry-Perot model.

AW3O.7 • 14:45

Experimental Demonstration of 28.2% Thermophotovoltaic Conversion Efficiency, Zunaid Omair[1,2], Gregg Scranton[1,2], Luis Pazos-Outon[1], Myles Steiner[3], Per Peterson[4], John Holzrichter[5], Eli Yablonovitch[1,2]; *[1]Electrical Engineering and Computer Science, Univ. of California at Berkeley, USA; [2]Materials Science Division, Lawrence Berkeley National Lab, USA; [3]National Renewable Energy Lab, USA; [4]Nuclear Engineering, Univ. of California at Berkeley, USA; [5]Physical Insight Associates, USA.* Efficient luminescence extraction enables us to use the photovoltaic band gap as the spectral filter for thermophotovoltaics. Using this concept, we demonstrate a 28.2% conversion efficiency, higher than the previously reported value for the range of the emitter temperature (700C -1250C) used.

15:00–17:00 Coffee Break & Exhibit Only Time, *Exhibit Hall*

Joint

JW3P • Symposium on New Advances in Adaptive Optics Retinal Imaging I—Continued

Simultaneous Multi-Channel AOSLO Imaging for Visualizing Inner Retina Structures, Mircea Mujat[1], Yang Lu[1], Gopi Maguluri[1], Nicusor Iftimia[1], R. Daniel Ferguson[1]; [1]*Physical Sciences Inc., USA*. A new detection scheme was demonstrated for multiple channels simultaneous imaging that provides isotropic images of inner retina structures free of directionality artifacts. The channels can be combined to reveal additional structural and functional details.

CLEO: Science & Innovations

SW3Q • Semiconductor Lasers for Integration—Continued

SW3Q.4 • 14:00
III-V-on-Silicon Filtered Feedback Discretely Tunable Laser with Nanosecond Switching Times, Sören Dhoore[1,2], Abdul Rahim[1,2], Gunther Roelkens[1,2], Geert Morthier[1,2]; [1]*Photonics Research Group, Belgium;* [2]*Center for Nano- and Biophotonics, Belgium*. We demonstrate nanosecond fast wavelength switching with a heterogeneously integrated III-V-on-silicon four-channel filtered feedback tunable laser. High-speed direct modulation at 12.5 Gbit/s of each wavelength channel is achieved.

SW3Q.5 • 14:15
Electrically Pumped Hybrid III-V/Si Photonic Crystal Surface Emitting Lasers with Buried Tunnel-Junction, Shih-Chia Liu[1], Deyin Zhao[1], Carl Reuterskiöld-Hedlund[2], Mattias Hammar[2], Weidong Zhou[1]; [1]*Univ. of Texas at Arlington, USA;* [2]*Dept. of Electronics, KTH-Royal Inst. of Technology, Sweden*. We report here an electrically pumped hybrid III-V/Si photonic crystal surface emitting laser (PCSELs) on silicon with a buried tunnel-junction (BTJ). RT CW single mode operation was achieved at 1504 nm for a 80x80 um2 laser.

SW3Q.6 • 14:30
An MMI-based Tunable Laser for Integrated Photonic Circuits, Ludovic Caro[1,2], Mohamad Dernaika[1,3], Frank Peters[1,2]; [1]*Tyndall National Inst., Ireland;* [2]*Physics Dept., Univ. College Cork, Ireland;* [3]*Electrical and Electronic Engineering Dept., Univ. College Cork, Ireland*. A single mode, tunable semiconductor laser is presented for the L band. This facetless, regrowth-free laser shows a tuning range extending from 1564nm to 1611nm, with side-mode suppression ratio values over 30dB.

SW3Q.7 • 14:45
Tunable self-injected Fabry-Perot laser diode coupled to an external high-Q Si_3N_4/SiO_2 micro-ring resonator, Yu Li[1], Yuanjue Zhang[1], Minghua Chen[1], Hongwei Chen[1], Sigang Yang[1]; [1]*Tsinghua Univ., China*. We demonstrate a self-injection locking of Fabry-Perot laser diode with narrow linewidth of 8 kHz. The laser has output power of 7 dBm and SMSR of 45 dB with wavelength switchable range of 17 nm.

CLEO: Applications & Technology

AW3R • A&T Topical Review on Advanced Applications of Laser Radar and Remote Sensing II—Continued

AW3R.4 • 14:00 Invited
Three-Dimensional Imaging Under Extreme Conditions Using Single-Photon Counting, Gerald S. Buller[1], Abderrahim Halimi[1], Aurora Maccarone[1], Rachael Tobin[1], Peter Connolly[1], Zoe Greener[1], Yoann Altmann[1], Aongus McCarthy[1]; [1]*Heriot-Watt Univ., UK*. Picosecond single-photon timing has been used for depth profiling under extreme environmental conditions, Depth imaging has been examined in a variety of scenarios including multi-kilometer range, in underwater conditions and in the presence of obscurants.

AW3R.5 • 14:30 Invited
High Performance Mid-IR Devices and Applications to Gas Sensing, Mariano Troccoli[1], Pietro Patimisco[2], Angelo Sampaolo[2], Vincenzo Spagnolo[2]; [1]*Evolution Photonics Inc, USA;* [2]*Dipartimento di Fisica, PolySense Lab - Univ. and Politecnico of Bari, Italy*. Manufacturing and deployment of high performance mid-IR devices for demanding sensing applications requires a high degree of control over development and manufacturing of components that can be packaged in a ruggedized, reliable and compact instrument.

AW3S • A&T Topical Review on Advances in Supercontinuum Technologies II: New Application Areas for Supercontinuum Light Sources—Continued

AW3S.3 • 14:00 Invited
Biological applications of Supercontinuum lasers in Optical light microscopy, David Castaneda-Castellanos[1]; [1]*Leica Microsystems, Germany*. The integration of a supercontinuum laser in a confocal microscope allows the imaging of biological samples with unprecedented flexibility in confocal and superresolution modes as well as broad applications in precise single molecule lifetime measurements.

AW3S.4 • 14:30 Invited
Mid-IR hyperspectral imaging of gases using a supercontinuum source and frequency upconversion, Peter John Rodrigo[1], Peter Tidemand-Lichtenberg[1], Lasse Høgstedt[2], Laurent Huot[1,3], Christian Pedersen[1]; [1]*DTU Fotonik, Denmark;* [2]*NLIR, Denmark;* [3]*NKT Photonics, Denmark*. We experimentally demonstrate hyperspectral imaging of different gas species by using an all-fiber broadband mid-IR supercontinuum source for illumination and a frequency upconversion based system for detection.

15:00–17:00 Coffee Break & Exhibit Only Time, *Exhibit Hall*

CLEO: Science & Innovations

17:00–19:00
SW4A • High-Q Microcavities
Presider: Zhihong Huang; Hewlett Packard Labs, USA

SW4A.1 • 17:00
Achieving Topological Photonics in a Synthetic Space with Dynamically Modulated Ring Resonators, Luqi Yuan[1], Meng Xiao[1], Qian Lin[1], Shanhui Fan[1]; [1]*Stanford Univ., USA.* We implement the two-dimensional Haldane model in the synthetic frequency space in a system composed of several ring resonators undergoing dynamic modulation. It provides a route towards nonreciprocal topological photonics in a miniaturized structure.

SW4A.2 • 17:15
High Q Integrated Photonic Microresonators on 3C SiC-on-Insulator Platform, Tianren Fan[1], Hesam Moradinejad[1], Xi Wu[1], Ali Asghar Eftekhar[1], Ali Adibi[1]; [1]*Georgia Inst. of Technology, USA.* We report for the first time the fabrication of high-Q SiC resonators on a 3C SiC-on-insulator platform (with no undercutting) formed using direct wafer bonding. We demonstrate Q of 42,000 for a 20 μm radius microdonut resonator with a great potential for higher Qs by chemical-mechanical polishing.

SW4A.3 • 17:30 Invited
Measurements of Thermodynamical Noise and Drift in Mesoscale Cavities with Quality Factors in Excess of 1 Billion, J. Lim[1], A. A. Savchenkov[2], W. Liang[2], W. Wang[1], A. Matsko[2], L. Maleki[2], C. W. Wong[1]; [1]*Mesoscopic Optics and Quantum Electronics Laboratory, University of California, USA;* [2]*OEwaves Inc., USA.* We describe the measured noise and drift characteristics of ultrahigh-Q microresonator-stabilized lasers at the thermodynamical limits, achieving a sub-25-Hz linewidth and 32-Hz Allan deviation. Random-walk noise statistics, along with cross-polarization mode temporal correlations, are demonstrated.

17:00–19:00
SW4B • Nitride-based Integrated Photonics
Presider: Weidong Zhou; Univ. of Texas at Arlington, USA

SW4B.1 • 17:00 Invited
III-Nitride Integrated Photonics: Prospects and Challenges, Mohammad Soltani[1]; [1]*Raytheon BBN Technologies, USA.* An integrated photonic platform made of III-Nitrides with their wide bandgap and unique optical/electronic properties enables promising applications over a broad spectral range from ultraviolet to infrared. We review the progress/challenges of developing such platforms.

SW4B.2 • 17:30
Narrow-linewidth, tunable external cavity diode lasers through hybrid integration of quantum-well/quantum-dot SOAs with Si_3N_4 microresonators, Yeyu Zhu[1], Siwei Zeng[1], Xiaolei Zhao[1], Yunsong Zhao[1], Lin Zhu[1]; [1]*Clemson Univ., USA.* We demonstrate hybridly integrated narrow-linewidth, tunable diode lasers via edge coupling. The silicon nitride photonic integrated circuit performs as the tunable external cavity, whereas the gain medium is provided by a quantum-well/quantum-dot semiconductor optical amplifier.

SW4B.3 • 17:45
An unreleased MEMS actuated silicon nitride resonator with bidirectional tuning, Hao Tian[1], Bin Dong[1], Michael Zervas[2], Tobias J. Kippenberg[2], Sunil Bhave[1]; [1]*OxideMEMS Lab, Purdue Univ., USA;* [2]*École Polytechnique Fédérale de Lausanne (EPFL), Switzerland.* A silicon nitride photonic resonator is tuned by integrating a piezoelectric MEMS actuator above the resonator. Bidirectional tuning is achieved by controlling voltage polarity and judicious placement of the actuator above the ring.

17:00–19:00
SW4C • Optical Switching
Presider: David Geisler; Massachusetts Inst of Tech Lincoln Lab, USA

SW4C.1 • 17:00
Hybrid Flow Switched Network with an Arbitrarily Reconfigurable Optical Switch, Gregory Steinbrecher[2,1], Vincent W. Chan[1], Dirk Englund[1], Scott A. Hamilton[2]; [1]*MIT, USA;* [2]*MIT Lincoln Lab, USA.* We present a hybrid network based on an integrated photonic switch capable of arbitrary single- and multi-cast transformations. We show bandwidth and latency improvements in a multi-switch network under load from one to several flows.

SW4C.2 • 17:15
On-Chip Switching of Mode- and Polarization-Multiplexed Signals with a 748-Gb/s/λ (8 × 93.5-Gb/s) Capacity, Qingming Zhu[1], Yong Zhang[1], Yu He[1], Shaohua An[1], Ciyuan Qiu[1], Xuhan Guo[1], Yikai Su[1]; [1]*Shanghai Jiao Tong Univ., China.* We experimentally demonstrate an on-chip optical switching scheme for mode- and polarization-multiplexed signals. A quadrupled switching capacity of 748 Gb/s/λ is achieved by routing eight 93.5-Gb/s data channels on two modes and two polarizations.

SW4C.3 • 17:30
Experimental Demonstration of 64-Port Thin-CLOS Architecture for All-to-All Optical Interconnects, Xian Xiao[1], Roberto Proietti[1], Kaiqi Zhang[1], Gengchen Liu[1], Hongbo Lu[1], Jeff Messig[2], S. J. Ben Yoo[1]; [1]*Univ. of California, Davis, USA;* [2]*Enablence Technologies, Inc., USA.* We designed, assembled, and experimentally demonstrated a 64-port wavelength-routing Thin-CLOS system in a 1U rack using four 32×32 AWGRs. BER measurements show error-free performance under the worst-case intra-band crosstalk scenario.

SW4C.4 • 17:45
OpenFlow-Control of an OAM-Based Two-Layer Switch Supporting 100Gb/s Real Data-Traffic, Mirco Scaffardi[1], Muhammad N. Malik[1,2], Francesco Paolucci[2], Emma Lazzeri[2], Ning Zhang[3], Charalambos Klitis[3], Andrea Sgambelluri[2], Martin Lavery[3], Filippo Cugini[1], Marc Sorel[3], Antonella Bogoni[2]; [1]*CNIT, Italy;* [2]*Scuola Superiore Sant'Anna, Italy;* [3]*Univ. of Glasgow, UK.* A two-layer orbital angular momentum and wavelength based switch is presented and characterized up to 100Gb/s with coherent polarization-multiplexed real data traffic. The switch is successfully reconfigured by applying an OpenFlow based SDN control plane.

CLEO: Science & Innovations

17:00–19:00
SW4D • Novel THz Techniques
Presider: Ben Ofori-Okai; SLAC National Accelerator Lab, USA

SW4D.1 • 17:00 Invited
THz silicon systems on chip: A Moore-Maxwell Approach, Kaushik Sengupta[1]; [1]*Princeton Univ., USA*. In this talk, we will highlight new design methodologies to enable future chip-scale THz architectures in silicon that are multi-functional, programmable and can enable efficient THz technology diversity of applications in sensing, imaging and communication

SW4D.2 • 17:30
Plasmonic Heterodyne Terahertz Spectrometry, Mona Jarrahi[1], Ning Wang[1], Semih Cakmakyapan[1]; [1]*Univ. of California Los Angeles, USA*. We demonstrate a new class of terahertz spectrometers that use plasmonic photomixers as frequency downconverters to offer quantum-level sensitivity at room temperature. We demonstrated double-sideband noise temperatures of 120-270 K over 0.1-2 THz.

SW4D.3 • 17:45
Shaping Terahertz Beams with High-efficiency All-dielectric Metasurfaces, Cheng Zhang[1], Ashish Chanana[2], Wenqi Zhu[1], Henri Lezec[1], Ajay Nahata[2], Amit K. Agrawal[1]; [1]*NIST, USA;* [2]*Univ. of Utah, USA*. We demonstrate high-efficiency (>70%) all-dielectric Terahertz metasurfaces operating in the transmission mode. Example devices include high numerical-aperture (NA≈0.9) meta-lenses as well as cylindrical vector beam generator.

CLEO: QELS-Fundamental Science

17:00–19:00
FW4E • Quantum and Nonlinear Phenomena
Presider: Roberto Morandotti; INRS-Energie Mat & Tele Site Varennes, Canada

FW4E.1 • 17:00
High-efficiency Broadband Single-photon Frequency Upconversion, Huiqin Hu[1], Jianhui Ma[1], Yu Chen[1], Xiuliang Chen[1], Haifeng Pan[1], E Wu[1]; [1]*East China Normal Univ., China*. We demonstrate broad bandwidth single-photon upconversion of femtosecond pulses at telecom wavelength in periodically poled lithium niobate (PPLN) bulk with high conversion efficiency by pumping with a broad bandwidth laser.

FW4E.2 • 17:15
Experimental Demonstration of an Optical-Coherence Converter, Chukwuemeka Okoro[1], Hasan E. Kondacki[2], Ayman Abouraddy[2], Kimani C. Toussaint[1]; [1]*Univ of Illinois at Urbana-Champaign, USA;* [2] *CREOL, The College of Optics & Photonics, USA*. By treating coherence as a shareable resource between multiple degrees of freedom (DoFs), we experimentally demonstrate a reversible exchange of coherence between polarization and spatial DoFs using only unitary transformations.

FW4E.3 • 17:30 Invited
Single Photon Quantum Frequency Conversion as Tool for Quantum Networks, Christoph Becher[1]; [1]*Fachbereich Physik, Universität des Saarlandes, Germany.* We demonstrate that quantum frequency down-conversion of single photons can be used to interface stationary quantum bits with telecom photons. The preservation of polarization-entanglement and indistinguishability allows for connecting quantum bits across a quantum network.

17:00–19:00
FW4F • Beyond Qubits
Presider: John Sipe; Univ. of Toronto, Canada

FW4F.1 • 17:00
Temporal-Mode Selective Measurement and Purification of Quantum Light, John M. Donohue[1], Vahid Ansari[1], Markus Allgaier[1], Linda Sansoni[1], Georg Harder[1], Jonathan Roslund[2], Nicolas Treps[2], Benjamin Brecht[3,1], Christine Silberhorn[1]; [1]*Integrated Quantum Optics, Paderborn Univ., Germany;* [2]*Laboratoire Kastler Brossel, UPMC, CNRS, ENS-PSL, CC74, France;* [3]*Clarendon Lab, Dept. of Physics, Univ. of Oxford, UK*. We employ dispersion-engineered sum-frequency generation to perform temporal-mode selective measurements on quantum light, provably manipulating the structure of multimode downconverted light and demonstrating spectral-phase sensitive seven-dimensional time-frequency quantum state tomography.

FW4F.2 • 17:15
On-chip Entangled D-level Photon States – Scalable Generation and Coherent Processing, Michael Kues[1], Christian Reimer[1], Piotr Roztocki[1], Luis Romero Cortés[1], Stefania Sciara[1], Benjamin Wetzel[1], Young Zhang[1], Alfonso Cino[2], Sai T. Chu[3], Brent E. Little[4], David J. Moss[5], Lucia Caspani[6], Jose . Azana[1], Roberto Morandotti[1]; [1]*INRS-EMT, Canada;* [2]*Dept. of Energy, Information Engineering and Mathematical Models, Univ. of Palermo, Italy;* [3]*City Univ. of Hong Kong, Dept. of Physics and Material Science, China;* [4]*State Key Lab of Transient Optics and Photonics, Xi'an Inst. of Optics and Precision Mechanics, China;* [5]*Swinburne Univ. of Technology, Centre for Micro Photonics, Australia;* [6]*Inst. of Photonics, Dept. of Physics, Univ. of Strathclyde, UK*. Exploiting a micro-cavity-based quantum frequency comb, we demonstrate the on-chip generation of high-dimensional entangled quantum states with a Hilbert-space dimensionality larger than 100, and introduce a coherent control approach relying on standard telecommunications components.

FW4F.3 • 17:30
Stimulated Emission Tomography of Hyperentangled States, Mario A. Ciampini[1], Andrea Geraldi[1], Valeria Cimini[1], John E. Sipe[2], Chiara Macchiavello[3], Marco Liscidini[3], Paolo Mataloni[1]; [1]*Physics, Università Roma La Sapienza, Italy;* [2]*Physics, Univ. of Toronto, Canada;* [3]*Università degli Studi di Pavia, Italy.* We demonstrate the generation of states hyperentangled in polarization and path by non-degenerate spontaneous down conversion. We characterize them by quantum state tomography and stimulated emission tomography.

FW4F.4 • 17:45
High-dimensional Entanglement Distribution and Einstein-Podolsky-Rosen Steering Over Deployed Fiber, Catherine Lee[1,2], Darius Bunandar[2], Margaret Pavlovich[1], Matthew E. Grein[1], Ryan Murphy[1], Scott A. Hamilton[1], Dirk . Englund[2], P. Ben Dixon[1]; [1]*Lincoln Lab, USA;* [2]*MIT, USA*. We demonstrate the generation of high-dimensional time-frequency entangled photon pair states and the preservation of entanglement after transmission across a 42-km telecom fiber by violating a high-dimensional Einstein-Podolsky-Rosen steering inequality.

CLEO: QELS-Fundamental Science

17:00–19:00
FW4G • Plasmon-medicated Control of Light Emission
Presider: TBD

FW4G.1 • 17:00
Self-aligned Fabrication of Microscale Electron Column Array using Plasmonic Enhanced Photoemission, Zhidong Du[1], Ye Wen[1], Liang Pan[1]; [1]*Purdue Univ., USA.* Microcolumns are important for parallel electron-beam lithography because of their compactness. A large array of electrostatic microcolumns is numerically optimized for our recent surface plasmon enhanced photoemission sources and demonstrated using a self-aligned fabrication process.

FW4G.2 • 17:15
Fundamental limits on spontaneous emission and energy loss of free electrons, Yi Yang[1], Aviram Massuda[1], Charles Roques-Carmes[1], Steven E. Kooi[1], Thomas Christensen[1], Steven Johnson[1], John Joannopoulos[1], Owen Miller[2], Ido Kaminer[1], Marin Soljacic[1]; [1]*MIT, USA;* [2]*Yale Univ., USA.* We derive and experimentally validate limits of electron radiation and energy loss. We show slow electrons generate stronger radiation than relativistic ones at subwavelength separations and bound states in the continuum enable order-of-magnitude radiation enhancement.

FW4G.3 • 17:30
The Role of Surface Roughness in Plasmonically Assisted Internal Photoemission Schottky Photodetectors, Meir Y. Grajower[1], Uriel Levy[1], Jacob Khurgin[2]; [1]*Dept. of Applied Physics, The Benin School of Engineering and Computer Science, The Center for Nanoscience and Nanotechnology, Hebrew Univ. of Jerusalem, Israel;* [2]*Dept. of Electrical and Computer Engineering, Johns Hopkins Univ., USA.* We describe the positive roll of roughness in enhancing the efficiency of internal photoemission. We show that roughness provides momentum relaxation enabling the transmission of energetic electrons through the Schottky barrier between metal and silicon.

FW4G.4 • 17:45
Large radiative emission rate of deep ultraviolet emitter with hyperbolic metamaterial structure, Kun-Ching Shen[1,2], Chiieh Hsieh[1], Yuh-Jen Cheng[1], Din Ping Tsai[1,2]; [1]*Academia Sinica, Research Center for Applied Sciences, Taiwan;* [2]*National Taiwan Univ. , Taiwan.* A large radiative emission rate of ultraviolet emitter with hyperbolic metamaterials was demonstrated, where a hybridized plasmon coupling is formed and provides a new path of the photon and thus boosts the radiative rate.

17:00–19:00
FW4H • Shaping Emission Using Metasurfaces
Presider: Gennady Shvets; Cornell Univ., USA

FW4H.1 • 17:00
Manipulating Smith-Purcell Radiation Polarization with Metasurfaces, Yujia Yang[1], Charles Roques-Carmes[1], Ido Kaminer[1], Aun Zaidi[1], Aviram Massuda[1], Yi Yang[1], Steven E. Kooi[1], Karl K. Berggren[1], Marin Soljacic[1]; [1]*MIT, USA.* Swift electrons moving closely to a periodic structure can generate far-field radiation. The radiated light is usually polarized in the direction of electron propagation. We have demonstrated manipulation of this polarization with properly designed metasurfaces.

FW4H.2 • 17:15
Vortex radiation from a single emitter, Renmin Ma[1]; [1]*Peking Univ., China.* We propose a metamaterial engineered chiral plasmonic nanocavity (CPN) that, for the first time to our knowledge, can twist single emitter radiation to vortex beams with controllable topological charge.

FW4H.3 • 17:30
Spectral and spatial shaping of Smith-Purcell radiation, Roei Remez[1], Niv Shapira[1], Charles Roques-Carmes[2], Romain Tirole[2,3], Yi Yang[2], Yossi Lereah[1], Marin Soljacic[2], Ido Kaminer[2,4], Ady Arie[1]; [1]*School of Electrical Engineering, Fleischman Faculty of Engineering, Tel Aviv Univ., Israel;* [2]*Research Lab of Electronics, MIT, USA;* [3]*Dept. of Physics, Faculty of Natural Sciences, Imperial College London, UK;* [4]*Dept. of Electrical Engineering, Technion-Israel Inst. of Technology, Israel.* The Smith-Purcell effect is observed when an electron beam passes in the vicinity of a periodic structure. We propose a method to shape the spatial and spectral far-field radiation using complex periodic and aperiodic gratings.

FW4H.4 • 17:45
Strong Coupling of Dye Molecules and Cavities: Beyond First Excited State Resonances, Ekembu K. Tanyi[1], Erin Harrison[2,3], Cansu On[1], Mikhail A. Noginov[1]; [1]*Center of Materials Research, Norfolk State Univ., USA;* [2]*Dept. of Psychology and Brain Science, Univ. of Delaware, USA;* [3]*Center of Materials Research, Summer Research Program, Norfolk State Univ., USA.* In example of Fabry-Perot cavities filled with dye molecules, we studied a range of strong coupling phenomena in complex systems with multiple exciton and optical resonances, bringing applications of these exciting systems one step closer.

CLEO: Science & Innovations

17:00–19:00
SW4I • Silicon Hybrid Integration
Presider: Shota Kita; Nippon Telegraph & Telephone Corp, Japan

SW4I.1 • 17:00 Invited
Monolithic Integration of 1.3 μm III-V Quantum-Dot Lasers on Si for Si Photonics, Huiyun Liu[1]; [1]*Univ. College London, UK.* Quantum-dot (QD) lasers directly grown on Si are the prospective candidate to realize on-chip optical sources for Si photonics. In this paper, the recent progress made in field of Si-based QDs lasers are discussed.

SW4I.2 • 17:30
A Deuterium-Passivated Amorphous Silicon Platform for Stable Integrated Nonlinear Optics, Peter Girouard[1], Lars H. Frandsen[1], Michael Galili[1], Leif K. Oxenlowe[1]; [1]*DTU Fotonik, Denmark.* We report a method to create amorphous silicon waveguides passivated with deuterium and demonstrate stability under moderate continuous-wave power. The waveguides have nonlinear properties comparable to hydrogenated amorphous silicon.

SW4I.3 • 17:45
Gain Characterization and Parameter Extraction of 1.3 μm InAs Quantum Dot Lasers on Silicon, Zeyu Zhang[1], Daehwan Jung[1], Justin Norman[1], Pari Patel[1], Arthur Gossard[1], John E. Bowers[1]; [1]*UCSB, USA.* We report the current and wavelength dependence of gain and transparency current for a variety of quantum dot laser structures. The dependence on number of quantum dot layers and templates for growth are reported.

CLEO: Science & Innovations

17:00–19:00
SW4J • Advanced Microscopy Methods
Presider: Emily Gibson; Univ. of Colorado at Boulder, USA

SW4J.1 • 17:00 Invited
Longitudinal Intravital Multi-Photon Imaging of the Femoral Marrow Based on an Implanted GRIN Microendoscope, Raluca Niesner[1]; [1]*DRFZ, Berlin, Germany.* The development of mechano-optical systems which enable highly resolved, dynamic imaging of the bone marrow of long bones is mandatory to understand patho-physiologic phenomena within this important organ. Here we present a longitudinal intravital microendoscopic technology based on GRIN optics to image one and the same region of the mouse femoral bone marrow over up to 158 days.

SW4J.2 • 17:30
Experimental Demonstration of Double Moiré Structured Illumination Microscopy, Doron Shterman[1], Bergin Gjonaj[1], Guy Bartal[1]; [1]*Electrical Engineering, Technion - Israel Inst. of Technology, Israel.* ~ 4 fold resolution enhancement is demonstrated experimentally, with respect to a low NA capabilities, utilizing a novel Double Moiré Structured Illumination Microscopy (DM-SIM) scheme

SW4J.3 • 17:45
Stimulated emission depletion microscopy with polarization-maintaining fiber, Brendan M. Heffernan[1], Stephanie A. Meyer[2], Diego Restrepo[5], Mark E. Siemens[4], Emily A. Gibson[2], Juliet Gopinath[3,1]; [1]*Univ. of Colorado, Boulder, USA;* [2]*Bioengineering, Univ. of colorado, denver, USA;* [3]*Electrical, Computer, and Energy Engineering, Univ. of colorado, boulder, USA;* [4]*Physics and Astronomy, Denver Univ., USA;* [5]*Cell and Developmental Biology, Univ. of colorado, denver, USA.* Sub-diffraction limited fluorescent images using a fiber-based stimulated emission depletion (STED) microscope are reported. Both excitation and depletion beams are transported through polarization-maintaining fiber and a lateral resolution of 100nm has been achieved.

17:00–19:00
SW4K • Fiber Lasers and Amplifiers
Presider: Gregory Cowle; Lumentum, USA

SW4K.1 • 17:00
Femtosecond Laser Pulse Generation from Picosecond Laser Source with Self-Similar Amplification, Huanyu Song[1], Wei Chen[1], Youjian Song[1], Minglie Hu[1], Bowen Liu[1]; [1]*Tianjin Univ., China.* We demonstrated femtosecond laser pulse generation from a self-similar amplifier with picosecond laser which delivers ~8-ps pulses with ~0.9-nm bandwidth. The system outputs 87-fs pulses at 30-MHz repetition rate with 4.5-W average power.

SW4K.2 • 17:15
Generation of Wavelength-Tunable Picosecond Pulses with Polarization-Maintaining Yb Figure-Nine Laser for Stimulated Raman Scattering Microscopy, Takuya Asai[1], Hironobu Yoshimi[1], Jingwen Shou[1], Toshiro Fujita[1], Yasuyuki Ozeki[1]; [1]*The Univ. of Tokyo, Japan*. We present an environmentally stable, high-speed wavelength-tunable laser system with a tunability of >280 cm^{-1}. This laser is synchronized to a picosecond Ti:sapphire laser to demonstrate video-rate hyperspectral stimulated Raman imaging of polymer beads.

SW4K.3 • 17:30
Nonlinear Characterization of a Kilowatt-class Amplifier Based on Laser Gain Competition, Brian Anderson[1], Nader A. Naderi[1], Angel Flores[1]; [1]*AFRL, USA.* The scalability of dual wavelength laser gain competition for the design of beam combinable, high power fiber amplifiers is analyzed by characterizing the nonlinear phase accumulated due to self and cross-phase modulation.

SW4K.4 • 17:45
Cladding-Pumped Hybrid Single-and Higher-Order-Mode (HOM) Amplifier, Kazi S. Abedin[1], Raja Ahmad[1], Anthony DeSantolo[1], Jeffrey Nicholson[1], Paul Westbrook[1], Clifford Headley[1], David DiGiovanni[1]; [1]*OFS Labs, USA.* We demonstrate a cladding-pumped hybrid-amplifier for low-power input seed-signals, by concatenating single-mode and HOM Yb-fibers. An 115mW average-power pulsed-source (8ns, 250kHz) was amplified to 52W output, using a 120W, 975nm multimode-pump, yielding 57% slope-efficiency.

17:00–19:15
SW4L • NIR Dual Combs
Presider: Jérôme Genest, Université Laval, Canada

SW4L.1 • 17:00 Invited
Length, Time, and Frequency Metrology with Dual Frequency Combs, Katja Beha[1], Wolfgang Hänsel[1], Michele Giunta[1,2], Florian Pollinger[3], Tobias Meyer[3], Ulli Angermüller[1], Matthias Lezius[1], Ronald Holzwarth[1,2]; [1]*Menlo Systems GmbH, Germany;* [2]*Max Planck Inst. of Quantum Optics, Germany;* [3]*Physikalisch-Technische Bundesanstalt, Germany.* We present two applications of dual-comb spectroscopy: Real-time precision ranging and high-resolution spectroscopy of acetylene. The measurement system consists of two ultra-low noise optical frequency combs.

SW4L.2 • 17:30
High-speed ultra-broadband dual-comb spectroscopy using electro-optics, David R. Carlson[1], Dan Hickstein[1], Scott Diddams[1], Scott Papp[1]; [1]*Time & Frequency Division, NIST, USA.* Using 10-GHz electro-optic frequency combs and photonic-waveguide supercontinuum, we demonstrate dual-comb spectroscopy across 120 THz of bandwidth in the near infrared with a 32 kHz interferogram refresh rate.

SW4L.3 • 17:45
Hybrid dual comb spectroscopy with largely dissimilar FSR, Hao Liu[1], Shu-Wei Huang[2,1], Jinghui Yang[1], Mingbin Yu[3], Dim-Lim Kwong[3], Chee-Wei Wong[1]; [1]*UCLA , USA;* [2]*Univ. of Colorado, Boulder, USA;* [3]*The Inst. of Microelectronics, Singapore.* We report a novel hybrid dual comb by combining two frequency combs with 19.5GHz and 250MHz repetition rates, respectively, which retains high spectral resolution and large spectral range simultaneously, proved by preliminary characterizations.

CLEO: Science & Innovations

17:00–19:00
SW4M • Application of Microresonator Frequency Combs
Presider: Yoshitomo Okawachi; Columbia Univ., USA

SW4M.1 • 17:00
Soliton Microcombs at Gigahertz-Repetition-Rates, Myoung-Gyun Suh[1], Kerry Vahala[1]; [1]*California Inst. of Technology, USA.* Soliton microcombs with repetition rates as low as 1.86 GHz are demonstrated. Low repetition rate frequency combs are important in spectroscopy and relax requirements on comb processing electronics.

SW4M.2 • 17:15
Deterministic single soliton generation via mode-interaction in microresonators, Chengying Bao[1], Yi Xuan[1], Daniel E. Leaird[1], Stefan Wabnitz[2], Minghao Qi[1], Andrew M. Weiner[1]; [1]*Purdue Univ., USA;* [2]*Università di Brescia and INO-CNR, Italy.* We show that a strong mode-interaction in microcavities can trigger single soliton Kerr combs deterministically. The soliton number tends to be reduced to 1 to decrease the nonlinear loss into mode-interaction induced Cherenkov radiation.

SW4M.3 • 17:30
On-Chip Kerr Frequency Comb Generation in Lithium Niobate Microresonators, Cheng Wang[1], Mian Zhang[1], Rongrong Zhu[1,2], Han Hu[1,2], Hongsheng Chen[2], Marko Loncar[1]; [1]*Harvard Univ., USA;* [2]*Zhejiang Univ., China.* We demonstrate Kerr frequency comb generation in high quality factor, dispersion engineered lithium niobate microresonators. The generated combs span over 250 nm in the telecommunication wavelength range.

SW4M.4 • 17:45
Thermally self-stabilized single dissipative Kerr soliton in optical microresonator, Zhe Kang[1], Feng Li[1], Jinhui Yuan[1], Xianting Zhang[1], P. K. A. Wai[1]; [1]*Hong Kong Polytechnic Univ., Hong Kong.* We deterministically excited thermally self-stabilized single dissipative Kerr soliton in a microresonator using an energetic trigger pulse. The soliton automatically balances the thermal perturbation and is stabilized without any active thermal compensation.

17:00–19:00
SW4N • Ultrafast Phenomena
Presider: Lawrence Shah; Luminar Technologies, Inc., USA

SW4N.1 • 17:00
Electric-field induced second-harmonic generation of femtosecond laser pulses in atmospheric air, Gunter Steinmeyer[1,2]; [1]*Max Born Inst., Germany;* [2]*Inst. of Physics, Humboldt-Universität, Germany.* We demonstrate frequency-doubling of an amplified femtosecond laser with electric-field induced second-harmonic generation in air. The method promises application with unattenuated terawatt lasers and offers wavelength conversion beyond the ultraviolet limit of nonlinear crystals.

SW4N.2 • 17:30
Phase Lock in Four-Wave Raman Mixing in the Ultraviolet Region, Yoshifumi Mori[1], Totaro Imasaka[1]; [1]*Kyushu Univ., Japan.* Raman emissions generated by four-wave mixing in hydrogen were coherently phased against the probe beam emitting at 267 nm by molecular phase modulation induced by a two-color pump beam emitting at 800/1200 nm.

SW4N.3 • 17:45
Demonstration of Subluminal and Superluminal Group Velocities of Diffraction-Free Space-Time Light Sheets in Free Space, Hasan E. Kondakci[1], Ayman Abouraddy[1]; [1]*CREOL, Univ. of Central Florida, USA.* We report on an experimental study to control the group velocity of diffraction-free space-time light sheets propagating in free space. We demonstrate pulsed light sheets with speeds exceeding 30c and going below 0.5c. We also show space-time light sheets with negative group velocity.

CLEO: Applications & Technology

17:00–19:00
AW4O • Novel Laser Charaterization
Presider: Paul Williams; NIST, USA

AW4O.1 • 17:00
Process-oriented adaptive optics control method in the multi-pass amplifiers, Qiao Xue[1]; [1]*Research Center of Laser Fusion, China.* We propose and demonstrate the process-oriented adaptive optics wavefront control method. The experiments validate that the novel approach can effectively prevent the beam quality from worsening and ensure the successful reality of multi-pass amplification.

AW4O.2 • 17:15
Multiplexed Two-color Phase-and-amplitude Characterization of Harmonic Up-conversion in OAM Beams using Ptychography, Yuka Esashi[1], Bin Wang[1], Nathan Brooks[1], Kevin Dorney[1], Chen-Ting Liao[1], Carlos Hernandez-Garcia[2], Henry Kapteyn[1], Daniel Adams[1], Margaret Murnane[1]; [1]*Univ. of Colorado at Boulder, USA;* [2]*Universidad de Salamanca, Spain.* We present high-resolution, simultaneous two-color phase-and-amplitude characterization of 2nd harmonic up-conversion in OAM beams by ptychography. We measure topological charge conservation during 2nd harmonic generation process, which can be extended to high-order harmonic upconversion.

AW4O.3 • 17:30
Beam Quality Factor Analysis of On-Wafer Vertical Cavity Surface Emitting Lasers, Kirk A. Ingold[1], Joshua Tate[1], Joshua B. Groen[1], Brian Souhan[1], James Raftery[1]; [1]*Photonics Research Center, USA Military Academy, USA.* We report on a method for analyzing the beam quality factor of on-wafer vertical cavity surface emitting lasers (VCSEL) leading to an M^2 min-max for each measured device due to asymmetry in the beam profile.

AW4O.4 • 17:45
Polarimetry Using Graphene-Integrated Anisotropic Metasurface, Minwoo Jung[1], Shourya Dutta-Gupta[2], Gennady Shvets[3]; [1]*Dept. of Physics, Cornell Univ., USA;* [2]*Materials Science and Metallurgical Engineering, Indian Insitiute of Technology Hyderabad, India;* [3]*School of Applied and Engineering Physics, Cornell Univ., USA.* We have demonstrated polarimetry using an anisotropic metasurface on gate-tunable monolayer graphene as an electro-optic modulator. Operating by electric gate-tuning, our device measures polarization ellipse of mid-infrared light and successfully distinguishes two circular polarization states.

Joint

17:00–19:00
JW4P • Symposium on New Advances in Adaptive Optics Retinal Imaging II
Presider: TBD

JW4P.1 • 17:00 Invited
Adaptive Optics Scanning Laser Ophthalmoscopy in Retinal Degenerations: New Insights in Structure and Function, Jacque Duncan[1]; [1]*Ophthalmology, Univ. of California San Francisco, USA.* Retinal degenerations cause progressive death of photoreceptors. Imaging photoreceptors in eyes with retinal degeneration yields insights into how genetic mutations affect photoreceptor structure and function. High-resolution images can provide sensitive measures of photoreceptor survival.

JW4P.2 • 17:45 Invited
Progress on functional retinal imaging with OCT: recent advancements in measurements and modeling of photoreceptor optophysiology., Robert J. Zawadzki[1,2]; [1]*Ophthalmology & Vision Science, Univ. of California Davis, USA;* [2]*Cell Biology and Human Anathomy, Univ. of California Davis, USA.* I will review recent advances in the development of Optical Coherence Tomography based retinal imaging systems in the context of its applications to study light-induced functional responses of the retina.

CLEO: Science & Innovations

17:00–19:00
SW4Q • Novel Semiconductor Emitters
Presider: Qing Gu; The Univ. of Texas at Dallas, USA

SW4Q.1 • 17:00
Demonstration of Electrically Injected Parity-Time- Symmetric Microring Lasers, William Hayenga[1], Enrique Sanchez Cristobal[1], Hipolito Garcia-Gracia[1], Midya Parto[1], Hossein Hodaei[1], Jinhan Ren[1], Patrick LiKamWa[1], Demetrios N. Christodoulides[1], Mercedeh Khajavikhan[1]; [1]*Univ. of Central Florida, CREOL, USA.* Single-mode lasing is demonstrated in an electrically injected coupled microring arrangement at telecommunication wavelengths by exploiting the unique physics associated with parity-time-symmetry.

SW4Q.2 • 17:15
Electro-Optical Bistability in Semiconductor Laser , Curtis Wang[1], Milton Feng[1], Nick Holonyak, Jr.[1]; [1]*Electrical Engineering, Univ. of Illinois at Urbana-Champai, USA.* Optical bistability in a single semiconductor transistor laser are realized and demonstrated based on the modulation of cavity photon density via the base quantum-wells for photon-generation and collector intra-cavity photon assisted tunneling for photon-absorption.

SW4Q.3 • 17:30 Invited
Optimized photonics: from on-chip nonclassical light sources to circuits, Jelena Vuckovic[1]; [1]*Stanford Univ., USA.* Quantum emitters in semiconductors, such as quantum dots and color centers, have been used to demonstrate nonclassical light sources with high purity, indistinguishability, and efficiency. Further improvements can be achieved by employing photonics optimization techniques.

CLEO: Science & Innovations

SW4A • High-Q Microcavities—Continued

SW4A.4 • 18:00
High Q AlGaAs-On-Sapphire Microresonators, Yi Zheng[1], Minhao Pu[1], Hitesh K. Sahoo[1], Elizaveta Semenova[1], Kresten Yvind[1]; [1]*Technical Univ. of Denmark, Denmark*. We demonstrate an AlGaAs-on-sapphire (AlGaAsOS) microresonator with intrinsic quality factor(Q) as high as 460,000 and investigate the thermal property of this platform. The realization of the AlGaAsOS platform opens new prospects for AlGaAs devices applications in the mid-infrared wavelength range.

SW4A.5 • 18:15
Droplet-Induced Optical Resonator in a Silica Microcapillary, Tabassom Hamidfar[2,1], Kirill Tokmakov[2], Brian Mangan[3], Robert Windeler[3], Artemiy Dmitriev[4,2], Dashiell Vitullo[2], Pablo Bianucci[1], Misha . Sumetsky[2]; [1]*Concordia Univ., Canada;* [2]*Aston Univ., UK;* [3]*OFS Labs, USA;* [4]*Univ. of Birmingham, UK*. We show that light circulating in a silica microcapillary can be fully localized by evanescent coupling to a water droplet forming a high Q-factor microresonator. The discovered phenomenon suggests an advanced method for microfluidics sensing.

SW4A.6 • 18:30
Differential Tuning of Coupled SNAP Microresonators on a Capillary Surface, Dashiell L. Vitullo[1], Sajid Zaki[1], Gabriella Gardosi[1], Brian Mangan[2], Robert Windeler[2], Michael Brodsky[3], Misha . Sumetsky[1]; [1]*Aston Univ., UK;* [2]*OFS Labs, USA;* [3]*U. S. Army Research Lab, USA*. We fabricate two coupled SNAP microresonators on the surface of a capillary fiber and demonstrate fine differential tuning near the resonance anticrossing point by heating with a nonuniformly-etched metal wire positioned inside the capillary.

SW4A.7 • 18:45
Phase-locked Two-Color Soliton Microcombs, Gregory Moille[1,2], Qing Li[1,2], Sangsik Kim[3], Kartik Srinivasan[1]; [1]*CNST, National Inst. of Standards and Technology, USA;* [2]*Maryland NanoCenter, Univ. of Maryland, USA;* [3]*Dept. of Electrical and Computer Engineering, Texas Tech Univ., USA*. We design a dispersion-engineered Si_3N_4 microresonator to support two-color soliton states. The directly-pumped 1550 nm soliton is phase-locked to a second color whose center wavelength can be tailored between 750 nm to 3000 nm.

SW4B • Nitride-based Integrated Photonics—Continued

SW4B.4 • 18:00
Dispersion Engineering of High-Q Si_3N_4 Microdisk Resonators, Kaiyi Wu[1], Andrew W. Poon[1]; [1]*HKUST, Hong Kong*. We demonstrate Si_3N_4 waveguide-coupled microdisk resonators with a loaded Q-factor of 2.4×10^6 at 1550 nm. We tailor the cavity dispersion by increasing the Si_3N_4 microdisk thickness and using a thin oxide cladding.

SW4B.5 • 18:15
Long-Range Static and Dynamic Thermal Crosstalk in Silicon-Nitride (SiNx) Photonic Integrated Circuits, Siva Yegnanarayanan[1], Ryan Maxson[1], Cheryl Sorace-Agaskar[1], Dave Kharas[1], Paul W. Juodawlkis[1]; [1]*Massachusetts Inst of Tech Lincoln Lab, USA*. We experimentally investigate long-range (> 1-mm) static and dynamic thermal crosstalk in a silicon-nitride photonic integrated circuit (PIC) platform and identify a thermal crosstalk floor that depends strongly on modulation frequency and buried oxide thickness.

SW4B.6 • 18:30
High-Quality Hybrid Double-layer-Silicon on Silicon Nitride Platform for Integrated Photonic Applications, Tianren Fan[1], Hesam Moradinejad[1], Amir H. Hosseinnia[1], Xi Wu[1], Ali Asghar Eftekhar[1], Ali . Adibi[1]; [1]*Georgia Inst. of Technology, USA*. We demonstrate a hybrid double-layer-crystalline-silicon on silicon nitride platform formed by a two-step of bonding process. We report high Q of 400,000 for a 40 μm radius microresonator in the platform using evanescent coupling between different layers.

SW4B.7 • 18:45
Polarization-Independent Silicon Nitride 3-dB Coupler for Potential Matrix Switches Application, Jijun Feng[1], Xiaoyu Sun[1], Ryoichi Akimoto[2], Heping Zeng[3]; [1]*Univ. of Shanghai for Sci.&Technol., China;* [2]*National Inst. of Advanced Industrial Science and Technology, Japan;* [3]*East China Normal Univ., China*. A polarization-independent 3-dB coupler was experimentally demonstrated with a 580-nm-thick, 700-nm-wide Si_3N_4 waveguide. By consisting a MZI structure, both TE and TM light can output from the cross port, confirming the polarization-independent performance of the device.

SW4C • Optical Switching—Continued

SW4C.5 • 18:00
Optically switched 56 GBd PAM-4 using a hybrid InP-TriPleX integrated tunable laser based on silicon nitride micro-ring resonators, Colm Browning[1], Marco Ruffini[2], Yi Lin[1], Roelof Timens[3], Douwe Geuzebroek[3], Chris Roeloffzen[3], Dimitri Geskus[3], Ruud Oldenbeuving[3], Rene Heideman[3], Youwen Fan[4], Klaus Boller[3], Liam Barry[1]; [1]*Dublin City Univ. , Ireland;* [2]*Trinity College Dublin, Ireland;* [3]*LioniX International, Netherlands;* [4]*Univ. of Twente, Netherlands*. Tunable lasers are key elements for switching fabrics in future datacenter networks. Experimental results show transmission of 56 GBd PAM-4 data in a switching environment using an integrated silicon nitride micro-ring resonator based tunable laser.

SW4C.6 • 18:15
On-chip 2×2 four-mode global optical mode switch, Ting Zhou[1,2], Lin Yang[1,2], Hao Jia[1,2], Shanglin Yang[1,2], Jianfeng Ding[1], Xin Fu[1,2], Lei Zhang[1,2]; [1]*Inistitute of semiconductor,CAS, China;* [2]*College of Materials Science and Opto-Electronic Technology, Univ. of Chinese Academy of Sciences, China*. We proposed a general architecture for on-chip global optical mode switching. A silicon thermo-optic 2×2 four-mode optical switch capable of performing the global optical mode switching functionality is experimentally demonstrated.

19:30–20:30 Conference Reception, *Grand Ballroom*

CLEO: Science & Innovations

SW4D • Novel THz Techniques—Continued

SW4D.4 • 18:00
Terahertz Light Amplification by Current-Driven Plasmon Instabilities in Graphene, Stephane Boubanga-Tombet[1], Deepika Yadav[1], Wojciech Knap[2], Vyacheslav Popov[3], Taiichi Otsuji[1]; *[1]RIEC, Tohoku Univ., Japan; [2]Lab Charles Coulomb, Univ. of Montpellier and CNRS, France; [3]Kotelnikov Inst. of Radio Engineering and Electronics (Saratov Branch), Russian Academy of Sciences, Russia*. This paper reports on room-temperature frequency tunable terahertz light amplification by current-driven plasmon instabilities produced in a graphene metasurface implemented in an asymmetric dual-grating-gate graphene field effect transistor.

SW4D.5 • 18:15
Fast Differential Absorption Measurement with Self-Frequency-Switched Double Terahertz-Wave Pulse, Yuma Takida[1], Toshiyuki Ikeo[2], Kouji Nawata[1], Yasuhiro Higashi[2], Hiroaki Minamide[1]; *[1]RIKEN, Japan; [2]RICOH COMPANY, LTD, Japan*. We demonstrate fast differential absorption measurement by using self-frequency-switched double terahertz (THz)-wave pulse with 11-GHz center frequency difference and 200-μs time interval. Our system is capable of detecting the THz-wave differential absorption signal every 20 milliseconds.

SW4D.6 • 18:30
Active high-Q dielectric terahertz supercavities, Hansong Han[1,2], Longqing Cong[1,2], Yogesh Srivastava[1,2], Bo Qiang[3,2], Mikhail Rybin[5,4], Wenxiang Lim[1,2], Qijie Wang[3], Yuri S. Kivshar[6,5], Ranjan Singh[1,2]; *[1]School of Physical and Mathematical Science, Nanyang Technological Univ., Singapore; [2]Centre for Disruptive Photonic Technologies,The Photonics Inst., Nanyang Technological Univ., Singapore; [3]Nanyang Technological Univ., School of Electrical and Electronic Engineering & The Photonics Inst., Singapore; [4]Ioffe Inst., Russia; [5]Dept. of Nanophotonics and Metamaterials, ITMO Univ., Russia; [6]Nonlinear Physics Center, Australian National Univ., Australia*. We report the observation of extremely high-quality factors in all-dielectric subwavelength terahertz metasurfaces. We further demonstrate an active ultrafast switching of the high-Q resonances via direct optical excitation of the supercavities.

SW4D.7 • 18:45
Extraordinary Optical Reflection and Giant Goos-Hänchen Effect from a Periodic Array of Thin Metal Plates, Wei Zhang[1], Rajind Mendis[1], Aaron Charous[1], Masaya Nagai[2], Daniel M. Mittleman[1]; *[1]School of Engineering, Brown Univ., USA; [2]Graduate School of Engineering Science, Osaka Univ., Japan*. We theoretically and experimentally study the optical properties of a periodic array of thin metal plates at THz frequencies. Narrow extraordinary optical reflection resonances and a giant Goos-Hänchen effect are observed in the structure.

CLEO: QELS-Fundamental Science

FW4E • Quantum and Nonlinear Phenomena—Continued

FW4E.4 • 18:00
Wavefront Analysis of White-light Supercontinuum, Emma Kueny[1,2], Anne-Laure Calendron[1,3], Xavier Levecq[4], Nadezda Varkentina[4], Joachim Meier[1,2], Franz X. Kaertner[1,2]; *[1]Deutsches Elektronen Synchrotron (DESY), Germany; [2]Dept. of Physics, Universität Hamburg, Germany; [3]The Hamburg Centre for Ultrafast Imaging, Universität Hamburg, Germany; [4]Imagine Optic, France*. The characterization of the wavefront of a white-light supercontinuum generated by sub-picosecond pulses in YAG at 1030 nm shows a good quality and little dependence on the wavelength.

FW4E.5 • 18:15
Noise-seeded Backward Stimulated Raman Scattering in Gas-filled Hollow-Core Fibers, Manoj K. Mridha[1], David Novoa[1], Philip S. Russell[1]; *[1]Russell Division, Max Planck Inst. for the Science of Light, Germany.* We study, experimentally and theoretically, noise-seeded backward SRS in gas-filled hollow-core fibers. The spatio-temporal dynamics of the Raman coherence makes the backward Stokes signal stronger than the forward, despite a low backward/forward gain ratio.

FW4E.6 • 18:30
Tailor-made Raman-resonant four-wave-mixing processes and their applications to optical devices, Masayuki Katsuragawa[1,2], Chiaki Ohae[1,2], Jian Zheng[1], Masaru Suzuki[1], Kaoru Minoshima[1,2]; *[1]Univ. of Electro-Communications, Japan; [2]ERATO, MINOSHIMA Intelligent Optical Synthesizer Project, JST, Japan*. We theoretically and experimentally show the tailor-made Raman-resonant four-wave-mixing process. We also demonstrate an attractive application of this tailored nonlinear frequency mixing as an optical device, namely, nonlinear Mach-Zehnder interferometer in the frequency domain.

FW4E.7 • 18:45
Pressure-Tunable Third Harmonic Generation in Tapered Solid-Core Fiber, Jonas Hammer[1,2], Riccardo Pennetta[1], Philip S. Russell[1,2], Nicolas Y. Joly[1,2]; *[1]Max-Planck Inst., Germany; [2]Univ. of Erlangen-Nuremberg, Germany.* Third-harmonic phase-matching in tapered silica fiber is tuned by introducing a high pressure gas around the taper waist. This offers a new means of achieving precise control over the dispersion in tapered fibers.

FW4F • Beyond Qubits—Continued

FW4F.5 • 18:00
Demonstration of Adaptive Optics Compensation for Emulated Atmospheric Turbulence in a Two-Orbital-Angular-Momentum Encoded Free-Space Quantum Link at 10 Mbits/s, Cong Liu[1], Kai Pang[1], Yongxiong Ren[1], Jiapeng Zhao[2], Guodong Xie[1], Yinwen Cao[1], Hao Song[1], Zhe Zhao[1], Haoqian Song[1], Long Li[1], Runzhou Zhang[1], Jing Du[1], Seyed M. Rafsanjani[2], Guillaume Labroille[3], Pu Jian[3], Dmitry Starodubov[1], Robert Boyd[2], Moshe Tur[4], Alan E. Willner[1]; *[1]Univ. of Southern California, USA; [2]The Inst. of Optics, Univ. of Rochester, USA; [3]CAILabs, France; [4]School of Electrical Engineering, Tel Aviv Univ., Israel*. We experimentally demonstrate adaptive-optics compensation of emulated atmospheric turbulence for an OAM-based quantum communication link with a classical Gaussian beam used as probe. The turbulence-induced quantum-symbol-error-rate is reduced by ≈ 76% with the compensation.

FW4F.6 • 18:15
Detection of Orbital Angular Momentum of Light Using Cavity Optomechanics, Hamidreza Kaviani[1,2], Marcelu Wu[1,2], Aaron Hryciw[2,3], Roohollah Ghobadi[1], Sonny Vo[4], David Fattal[4], Paul E. Barclay[1,2]; *[1]Inst. for Quantum Science and Technology, Univ. of Calgary, Canada; [2]NRC-National Inst. for Nanotechnology, Canada; [3]nanoFAB, Univ. of Alberta, Canada; [4]Leia Inc., USA*. We introduce a nanoscale cavity-optomechanical device for non-destructively measuring the orbital angular momentum of light (OAM) by detecting torque on a subwavelength grating. The device can measure the torque produced by a change $\Delta l = 1$ in OAM from a beam with power $P_{min} \sim 2$ mW at T=4 k.

FW4F.7 • 18:30
Single-shot measurement of the orbital-angular-momentum spectrum of light, Girish Kulkarni[1], Rishabh Sahu[1], Omar Magana-Loaiza[2], Robert Boyd[2], Anand Jha[1]; *[1]Indian Inst. of Technology, Kanpur, India; [2]Univ. of Rochester, USA*. We propose a single-shot scheme to measure the orbital-angular-momentum (OAM) spectrum of a partially coherent field. We first test the scheme for a known field, and then use it to measure the OAM spectrum of the signal-idler field from parametric down-conversion with Schmidt number K=82.1

FW4F.8 • 18:45
Generation and Detection of 256 Photonic Quantum States Using Deformable-Mirror-Based Adaptive Optics and Its Application to Quantum Secure Authentication, Naoto Namekata[1], Masahito Ohya[1], Jun Nishikawa[2], Shuichiro Inoue[1]; *[1]Nihon Univ., Japan; [2]National Astronomical Observatory of Japan, Japan*. 90-dimentional and spatially phase-modulated quantum states were generated and detected using deformable-mirror-based adaptive optics. The number of controllable states was increased up to 256, which enabled us to demonstrate a quantum secure authentication.

19:30–20:30 Conference Reception, *Grand Ballroom*

CLEO: QELS-Fundamental Science

FW4G • Plasmon-medicated Control of Light Emission—Continued

FW4G.5 • 18:00
Plasmon Enhanced Upconversion in Water-Dispersible Metal-Insulator-Metal Nanostructures, Ananda Das[1], Chenchen Mao[1], Suehyun Cho[1], Wounjhang Park[1]; *[1]CU Boulder, USA.* We present results on enhanced upconversion of $NaYF_4$: Er^{3+}, Yb^{3+} nanoparticles using a metal-insulator-metal structure that can eventually be dispersed in solution. Enhancement of 1200x in photoluminescence and 3.8x in energy transfer rate is observed.

FW4G.6 • 18:15
Inhibition of the Concentration Quenching of HITC Dye in Nonlocal Plasmonic Environments, Srujana Prayakarao[1], Samantha R. Koutsares[1], Carl E. Bonner[1], Mikhail A. Noginov[1]; *[1]Norfolk State Univ., USA.* The long-range inhibition of the luminescence concentration quenching in heavily doped HITC:PMMA polymeric films in the vicinity of lamellar hyperbolic metamaterials and metallic surfaces is tentatively explained in terms of the strong exciton-plasmon coupling.

FW4G.7 • 18:30
Manipulation of Quenching and Strong Coupling via Detuned Nanoantenna-Microresonator Hybrid Systems, Burak Gurlek[1,2], Vahid Sandoghdar[1,2], Diego Martín-Cano[1]; *[1]Max Planck Inst. for the Science of Light, Germany; [2]Friedrich Alexander Univ. Erlangen—Nuremberg, Germany.* We show that a broadband Fabry-Perot cavity can control the radiative and nonradiative channels of an emitter next to a nanoantenna and assist the emitter to enter into strong coupling regime.

FW4G.8 • 18:45
Modification of Photoluminescence via Strong Coupling of Vibronic Transitions in Organic Molecules to Surface Plasmons, Rahul Deshmukh[1,2], Paulo Marques[1], Anurag Panda[3], Stephen R. Forrest[3], Vinod M. Menon[1,2]; *[1]City College of New York, USA; [2]Physics, The Graduate Center of the City Univ. of New York, USA; [3]Univ. of Michigan, USA.* We demonstrate redistribution of the spectral intensities of the luminescence associated with different vibronic transitions in organic molecule, Diindenoperylene through strong coupling of excitons to surface plasmons.

FW4H • Shaping Emission Using Metasurfaces—Continued

FW4H.5 • 18:00
Optical Power Limiting from Plasmonic Metasurfaces Coupled to Intersubband Transitions, Nishant Nookala[1], Peter Chang[1], Dimitrios Sounas[1], Omri Wolf[2], Stephen March[1], Seth Bank[1], Igal Brener[2], Andrea Alù[1], Mikhail A. Belkin[1]; *[1]Univ. of Texas at Austin, USA; [2]Sandia National Labs, USA.* We report power limiting metasurfaces based on saturable absorption of the intersubband transition in n-doped multi-quantum wells. Experimentally, we note a 20% decrease in reflectivity with an increase of the pump intensity.

FW4H.6 • 18:15
Directional Spontaneous Emission of Dye on Top of Silver Grating Metasurface, Ekembu K. Tanyi[1], Soheila Mashhadi[1], Sahana Bhattacharyya[2], Tal Galfsky[2], Vinod M. Menon[2], Evan Simmons[3], Viktor A. Podolskiy[3], Natalia Noginova[1], Mikhail A. Noginov[1]; *[1]Center for Materials Research, NSU, USA; [2]City College of New York, USA; [3]Univ. of Massachusetts, USA.* We have observed double crescent patterns in the TE polarized spontaneous emission of rhodamine 6G dye deposited onto silver grating metasurface. It originates from the surface wave characterized by the effective index of refraction n=1.03.

FW4H.7 • 18:30
Graphene Metamaterials for Intense, Tunable and Compact EUV and X-Sources, Andrea Pizzi[1], Gilles D. Rosolen[2], Liang Jie Wong[3], Rasmus Ischebeck[4], Marin Soljacic[5], Thomas Feurer[6], Ido Kaminer[7,5]; *[1]Dept. of Applied Science and Technology, Politecnico di Torino, Italy; [2]Micro and Nanophotonic Materials Group, Univ. of Mons, Belgium; [3]Singapore Inst. of Manufacturing Technology, Singapore; [4]Paul Scherrer Inst. (PSI), Switzerland; [5]Dept. of Physics, MIT, USA; [6]Inst. of Applied Physics, Univ. of Bern, Switzerland; [7]Dept. of Electrical Engineering, Technion – Israel Inst. of Technology, Israel.* We present a bright X-ray source based on free electron-plasmon interactions inside graphene metamaterials, showing with *ab initio* simulations how the structure scales up the intensity and the tunability of the source.

FW4H.8 • 18:45
Shaping InAs quantum dot photoluminescence using GaAs nanoresonator arrays, Aleksandr Vaskin[1], Sheng Liu[2], Matthias Zilk[1], Benjamin Leung[2], Miao-Chan Tsai[2], Yuanmu Yang[2], Polina Vabishchevich[2], Xiaowei He[3], Younghee Kim[3], Nicolai F. Hartmann[3], Sadhvikas Addamane[4], Gordon A. Keeler[2], George Wang[2], Han Htoon[3], Stephen Doorn[3], Ganesh Balakrishnan[4], Thomas Pertsch[1], Michael Sinclair[2], Igal Brener[2,5], Isabelle Staude[1], Stefano Fasold[1]; *[1]Inst. of Applied Physics, Friedrich Schiller Univ., Germany; [2]Sandia National Labs, USA; [3]Center for Integrated Nanotechnologies, Los Alamos National Lab, USA; [4]Center for High Technology Materials, Univ. of New Mexico, USA; [5]Center for Integrated Nanotechnologies, Sandia National Labs, USA.* We study photoluminescence from arrays of GaAs nanoresonators incorporating self-assembled InAs quantum dots. We experimentally observe spectral and spatial reshaping of the quantum dot photoluminescence by the resonant nanostructure.

CLEO: Science & Innovations

SW4I • Silicon Hybrid Integration—Continued

SW4I.4 • 18:00 Invited
A Hybrid SiN-QDOT Platform for Visible Photonics, Dries VanThourhout[1], Lukas Elsinger[1], Yunpeng Zhu[1], Weiqiang Xie[1], Ivo Tanghe[1], Suzanne Bisschop[2], Vignesh Chandrasekaran[2], Pieter Geiregat[2], Edouard Brainis[2], Zeger Hens[2]; *[1]Photonics Research Group, Ghent Univ. / IMEC, Belgium; [2]Physics and Chemistry of Nanostructures, Ghent Univ., Belgium.* We developed a hybrid SiN-QDOT platform by embedding quantum dots in a SiN waveguide. Low loss waveguiding, high modal gain and lasing from mikrodisk and DFB-type devices was demonstrated.

SW4I.5 • 18:30
Seed-Layer Free Cerium-Doped Terbium Iron Garnet on Non-Garnet Substrates for Photonic Isolators, Karthik Srinivasan[1], Thomas E. Gage[2], Bethanie J. Stadler[1,2]; *[1]Electrical and Computer Engineering, Univ. of Minnesota, USA; [2]Chemical Engineering and Materials Science, Univ. of Minnesota, USA.* Novel seed-layer free cerium-doped terbium iron garnet with high gyrotropy is grown on non-garnet substrates for integration with photonics integrated circuits, whose performance can be tuned by varying the dopant concentration and annealing parameters.

SW4I.6 • 18:45
O-band and C/L-band emission of InAs QDs monolithically grown on Ge and U-shape Si (001) platform, Ting Wang[1]; *[1]Inst. of Physics, CAS, China.* Here, the C/L-band light emission (1.53 μm-1.63 μm) of InAs/$In_{0.25}Ga_{0.75}As$ quantum dots (QDs) epitaxially grown on both Ge (001) and on-axis U-shape Si (001) substrates by molecular beam epitaxy are reported.

19:30–20:30 Conference Reception, *Grand Ballroom*

SW4J • Advanced Microscopy Methods—Continued

SW4J.4 • 18:00
Localized Plasmonic Structured Illumination Microscopy, Anna Bezryadina[1], Junxiang Zhao[1], Zhaowei Liu[1]; [1]*Electrical and Computer Engineering, Univ. of California San Diego, USA.* Localized plasmonic structured illumination microscopy (LPSIM) has tremendous ability to improve resolution of fluorescent microscopy. We analyzed and tested new approach to push resolution limit significantly below 50nm for wide-field of view high-speed biological imaging.

SW4J.5 • 18:15
Three-photon fluorescence microscopic imaging by a compact Er-doped fiber laser at 1.6 μm, Jiqiang Kang[1], Cihang Kong[1], Pingping Feng[1], Can Li[1], Zhichao Luo[1,2], Edmund Y. Lam[1], Kevin K. Tsia[1], Kenneth Kin-Yip Wong[1]; [1]*Univ. of Hong Kong, Hong Kong;* [2]*South China Normal Univ., China.* We report a high energy pulse generation scheme for three-photon fluorescence microscopy (3PM) by leveraging an L-band Er-doped fiber laser and chirped pulse amplifier. 3PM imaging is demonstrated on a mouse kidney slice.

SW4J.6 • 18:30
Adaptively Scanned Compressive Multiphoton Microscopy, Milad Alemohammad[1], Jaewook Shin[1], Mark A. Foster[1]; [1]*Johns Hopkins Univ., USA.* A depth sectioning, compressive multiphoton microscope based on spatio-temporal focusing of patterned fs-laser pulses has been demonstrated. Adaptive fluorescence sampling is used to achieve random access imaging across a wide field of view.

SW4J.7 • 18:45
Electrowetting Prism for Scanning in Two-photon Microscopy, Omkar D. Supekar[2], Baris N. Ozbay[1], Mo Zohrabi[3], Philip D. Nystrom[2], Gregory L. Futia[1], Diego Restrepo[4], Emily A. Gibson[1], Juliet Gopinath[3,5], Victor Bright[2]; [1]*Dept. of Bioengineering, Univ. of Colorado Anschutz Medical Campus, USA;* [2]*Dept. of Mechanical Engineering, Univ. of Colorado Boulder, USA;* [3]*Dept. of Electrical, Computer, and Energy Engineering, Univ. of Colorado Boulder, USA;* [4]*Dept. of Cell and Developmental Biology, Univ. of Colorado Anschutz Medical Campus, USA;* [5]*Dept. of Physics, Univ. of Colorado Boulder, USA.* We have demonstrated an electrowetting prism as a lateral scanning element for a 2-photon excitation microscope. We show imaging of mouse hippocampal neurons, with a field of view of 130 × 130 μm^2.

SW4K • Fiber Lasers and Amplifiers—Continued

SW4K.5 • 18:00
110 W High-Efficiency Er-Nanoparticle-Doped Fiber Laser, Huaiqin Lin[1], Colin Baker[2], Zhimeng Huang[1], Shankar Pidishety[1], Yutong Feng[1], E. Joseph Friebele[3], Ashley Burdett[4], Dan Rhonehouse[2], Brandon Shaw[2], Jas Sanghera[2], Johan Nilsson[1]; [1]*Optoelectronics Research Centre, Univ. of Southampton, UK;* [2]*Naval Research Lab, USA;* [3]*KeyW Corp, USA;* [4]*Univ. Research Foundation, USA.* An Er-nanoparticle-doped fiber laser cladding-pumped at 975 nm generates 110 W at 1605 nm with 40.6% slope efficiency and M^2~7. High Er-concentration (4×10^{25} ions/m^3) and pump brightness allows for adequate pump absorption even without Yb-codoping.

SW4K.6 • 18:15
1.3kW Single-mode All-fiber MOPA Based on Low-NA Trench-assisted Ytterbium-doped Fiber, Fangfang Zhang[1], Yehui Liu[1], Lei Liao[1], Yingbin Xing[1], Jinyan Li[1,2]; [1]*Wuhan National Lab for Optoelectronics (WNLO), Huazhong Univ. of Science and Technology, China;* [2]*School of Optical and Optoelectronic Information, Huazhong Univ. of Science and Technology, China.* A newly designed and fabricated trench-assisted low-NA (~0.04) fiber was reported. An output power up to 1.3kW with $M^2 < 1.1$ was achieved in an all-fiber MOPA based on the fabricated low-NA fiber.

SW4L • NIR Dual Combs—Continued

SW4L.4 • 18:00
Free-running, All-fiber Dual Electro-optic Frequency Comb System for the Precision Spectroscopy and Sensing of $H^{13}CN$, Philippe Guay[1,2], Jérôme Genest[1], Adam J. Fleisher[2]; [1]*Université Laval, Canada;* [2]*National Inst. for Standards and Technology, USA.* We demonstrate precision spectroscopy of $H^{13}CN$ where successive interferograms were phase-corrected in post-processing, averaged, and normalized to yield the complex transmission spectrum of several transitions within the $2\nu_3$ band centered near λ = 1545 nm.

SW4L.5 • 18:15
Low-Noise Dual-Comb Platform Based on Mode-Locked Lasers in a Multi-Waveguide Chip, Nicolas Bourbeau Hebert[1], David Lancaster[2], George Chen[2], Jérôme Genest[1]; [1]*Université Laval, Canada;* [2]*Univ. of South Australia, Australia.* We analyze the frequency noise of a free-running dual-comb source based on two adjacent waveguide lasers in the same glass chip. We demonstrate high rejection of environmental noise and an exceptionally low frequency noise floor.

SW4L.6 • 18:30
Dual Comb Spectroscopy with Free-Running Bidirectional Mode-Locked Laser at 1.9 μm, Md Imrul Kayes[1], Nurmemet Abdukerim[1], Alexandre Rekik[1], Martin Rochette[1]; [1]*McGill Univ., Canada.* We demonstrate a dual-comb spectrometer based on a free-running mode-locked laser that operates bidirectionally at 1.9 μm. Since both signals are emitted from a common cavity, the mutual coherence requirement for dual-comb spectroscopy is satisfied.

SW4L.7 • 18:45
Broadband Cavity-Enhanced Dual-Comb Spectroscopy of Multiple Trace Gas Species, Nazanin Hoghooghi[1], Robert Wright[1], William C. Swann[2], Ian R. Coddington[2], Nathan R. Newbury[2], Gregory B. Rieker[1]; [1]*Univ. of Colorado Boulder, USA;* [2]*National Inst. of Standard and Technology, USA.* We report compact and broadband near infrared cavity-enhanced dual-comb spectroscopy (CE-DCS) with 60 nm transmitted bandwidth and pathlength enhancement factor of 11,000 for CE-DCS. Simultaneous trace detection of four gas species is demonstrated.

19:30–20:30 Conference Reception, *Grand Ballroom*

CLEO: Science & Innovations

SW4M • Application of Microresonator Frequency Combs—Continued

SW4M.5 • 18:00
Dual-cavity scanning comb spectroscopy, Mengjie Yu[1,2], Yoshitomo Okawachi[1], Chaitanya Joshi[1], Xingchen Ji[2,3], Michal Lipson[3], Alexander L. Gaeta[1]; [1]*Applied Physics and Mathematics, Columbia Univ., USA;* [2]*Electrical Engineering, Cornell Univ., USA;* [3]*Electrical Engineering, Columbia Univ., USA.* We present a novel approach for microresonator-based gas-phase spectroscopy without use of an external laser source. The absorption spectrum of acetylene is measured with high spectral resolution using an integrated heater in a fiber-microresonator dual-cavity scheme.

SW4M.6 • 18:15
Counter-propagating soliton frequency microcombs, Qifan Yang[1], Xu Yi[1], Ki Youl Yang[1], Kerry Vahala[1]; [1]*California Inst. of Technology, USA.* Counter-propagating dissipative Kerr solitons are generated in a single silica microresonator. A relative soliton rate-locking phenomenon is observed and it provides dual-comb pulse streams with different repetition rates and a high-level of mutual coherence.

SW4M.7 • 18:30
Spatially-Multiplexed Solitons in Optical Microresonators, Erwan Lucas[1], Grigory Lihachev[2,3], Michael Gorodetsky[2,3], Tobias J. Kippenberg[1]; [1]*Ecole Polytechnique Fédérale de Lausanne, Switzerland;* [2]*Physics, Moscow State Univ., Russia;* [3]*Russian Quantum Center, Russia*. We simultaneously create stable solitons in up to three distinct mode families of a single crystalline MgF_2 microresonator. The resulting Kerr combs are mutually coherent and have distinct repetition rates and are thus well suited for dual-comb applications.

SW4N • Ultrafast Phenomena—Continued

SW4N.4 • 18:00
Self-Healing Property of Space-Time Light Sheets, Hasan E. Kondakci[1], Ayman Abouraddy[1]; [1]*CREOL, Univ. of Central Florida, USA.* We experimentally demonstrate self-healing of diffraction-free space-time light sheets propagating through one-dimensional beam blocks. Diffraction-free space-time beams are produced by introducing hyperbolic correlations in their spatio-temporal spectra.

SW4N.5 • 18:15
Mid-IR Ultrafast Carrier Dynamics in Black Phosphorus Observed Above and Below the Bandgap, Yigit Aytac[1], Martin Mittendorff[1], Thomas E. Murphy[1]; [1]*Univ. of Maryland , USA.* We employ pump-probe measurements to study the carrier dynamics in layers of black phosphorus. By tuning the probe wavelength above and below the bandgap we unambiguously quantify the interband and intraband transitions and relaxation rates.

SW4N.6 • 18:30
The Picoseconds Structure of Ultrafast Rogue Waves, Moti Fridman[1]; [1]*Bar Ilan Univ., Israel.* We suggest a new mechanism for ultrafast rogue waves in fiber lasers. We claim that ultrafast patterns arise from the non-instantaneous relaxation of the saturable absorber together with the polarization mode dispersion of the cavity.

SW4N.7 • 18:45
Single Shot Magnetization Reversal of Micron Size Magnetic Domains in a Pt/Co/Pt Ferromagnetic Stack, Mircea Vomir[1], Michèle Albrecht[1], Gilles Versini[1], Jean-Yves Bigot[1]; [1]*Université de Strasbourg and CNRS, France.* We show that the magnetization reversal of a Pt/Co/Pt ferromagnetic stack can be triggered by a single femtosecond laser pulse if the switched spot is comparable to the size of the intrinsic magnetic domains.

CLEO: Applications & Technology

AW4O • Novel Laser Charaterization—Continued

AW4O.5 • 18:00
Metasurface-integrated Fully CMOS-compatible Phase Gradient Photodetector, Evgeniy Panchenko[1], Lukas Wesemann[1], Timothy Davis[1], Daniel Gomez[2], Ann Roberts[1]; [1]*The Univ. of Melbourne, Australia;* [2]*RMIT Univ., Australia.* Here we present a fully CMOS compatible photodetector with embedded plasmonic metasurfaces capable of detecting a local phase gradient. This device could form the basis of novel wavefront sensing systems for imaging, communications and astronomy.

AW4O.6 • 18:15
Impacting Factors in Linewidth Measurement of Single-Frequency Lasers, Songsong Sun[1], Yong Wang[1], Wei Yan[1]; [1]*Laser Research Inst., Qilu Univ of Technology(Shandong Academy of Sciences), China.* Linewidth measurement of single-frequency laser using self-heterodyne method is studied. 1/f noise and the noise caused by double Rayleigh scattering in delayed fiber can affect the shape of linewidth, which introduces inaccuracy in linewidth measurement.

AW4O.7 • 18:30
Experimental Access to the Instantaneous Spectrum of MEMS-Based Swept Source, John O. Gerguis[2], Yasser Sabry[1,3], Diaa Khalil[1,3]; [1]*Faculty of Engineering , Egypt;* [2]*Faculty of Engineering, Egypt;* [3]*Si-Ware Systems, Egypt.* This work presents a novel technique for measuring the spectral response of high-speed swept laser using the convolution between this spectrum and a reference filter. The method is successfully used to characterize MEMS-based swept source

19:30–20:30 Conference Reception, *Grand Ballroom*

Joint

JW4P • Symposium on New Advances in Adaptive Optics Retinal Imaging II—Continued

JW4P.3 • 18:30
Multimodality Imaging Guided Retichoroidal Neovascularization in a Rabbit Model, Phuc Nguyen[2,1], Yannis M. Paulus[2,1], Xueding Wang[1,3], Yanxiu Li[2,1], Wei Zhang[1,4]; [1]*Univ. of Michigan, USA;* [2]*Dept. of Ophthalmology and Visual Sciences, Kellogg Eye Center, USA;* [3]*Dept. of Biomedical Engineering, USA;* [4]*Dept. of Radiology, Unviersity of Michigan, USA*. The current study presents a novel multimodal photoacoustic microscopy (PAM), optical coherence tomography (OCT), and fluorescein angiography (FA) molecular imaging system to diagnose wet aged related macular degeneration (AMD) at an earlier stage.

CLEO: Science & Innovations

SW4Q • Novel Semiconductor Emitters—Continued

SW4Q.4 • 18:00
Development of Efficient Electrically Pumped Nanolasers based on InAlGaAs Tunnel Junction, Cheng-Yi Fang[1], Felipe Vallini[3], Abdelkrim El Amili[3], Antti Tukiainen[2], Jari Lyytikäinen[2], Mircea D. Guina[2], Yeshaiahu Fainman[3]; [1]*Materials Science and Engineering Program, UC San Diego, USA;* [2]*Optoelectronic Research Centre, Tampere Univ. of Technology, Finland;* [3]*Dept. of Electrical & Computer Engineering, U C San Diego, USA*. We propose and experimentally demonstrate a metallo-dielectric nanolasers utilizing an InAlGaAs tunnel junction for efficient carrier injection, which reduce the complexity when optimizing the metal contact, and reduces the device resistance.

SW4Q.5 • 18:15
Electrically Pumped Metallic Coaxial Nanolasers, Enrique Sanchez Cristobal[1], William Hayenga[1], Hipolito Garcia-Gracia[1], Mohammad Parvinnezhad Hokmabadi[1], Patrick LiKamWa[1], Mercedeh Khajavikhan[1]; [1]*CREOL, USA*. We present our progress towards the realization of room temperature current-injected coaxial nanolasers. Laser action is demonstrated in a subwavelength coaxial resonator up to a temperature of 140 K.

SW4Q.6 • 18:30
Synchronized Narrow Linewidth Laser and High Quality Microwave Signal Generation using Optically Mutual-Injection-Locked DFB Lasers with Optoelectronic Feedback, Guangcan Chen[1,2], Dan Lu[1,2], Song Liang[1,2], Lu Guo[1,2], Wu Zhao[1,2], Lingjuan Zhao[1,2]; [1]*CAS Inst. of Semiconductors, China;* [2]*College of Materials Science and Opto-Electronic Technology, Univ. of Chinese Academy of Sciences, China*. Synchronized dual-wavelength narrow-linewidth laser and high-quality microwave signal generation is demonstrated using mutual-injection-locked DFB lasers with optoelectronic feedback. Two synchronized lasers with linewidth down to kHz and beating frequency of 23.3 GHz is realized.

SW4Q.7 • 18:45
Mode Locking at THz Repetition Frequencies using Lasers with Phase Shifted Sampled Gratings, Lianping Hou[1], Song Tang[1], Bin Hou[1], John Marsh[1]; [1]*Univ. of Glasgow, UK*. Mode-locking at repetition frequencies of 800 GHz and 1 THz is reported in pi-phase-shifted sampled grating distributed-Bragg-reflector (DBR) lasers. The effective coupling coefficient of the phase-shifted gratings is twice that of conventional sampled grating DBRs.

19:30–20:30 Conference Reception, *Grand Ballroom*

07:30–18:00 Registration, *Concourse Level*

Executive Ballroom 210A	Executive Ballroom 210B	Executive Ballroom 210C

CLEO: Science & Innovations

08:00–10:00
STh1A • Novel Structures and Devices
Presider: Takasumi Tanabe; Keio Univ., Japan

STh1A.1 • 08:00
3D-Printed Ultra-Broadband Highly Efficient Out-of-Plane Coupler for Photonic Integrated Circuits, Matthias Blaicher[1], Muhammad R. Billah[1], Tobias Hoose[1], Philipp-Immanuel Dietrich[1], Andreas Hofmann[1], Sebastian Randel[1], Wolfgang Freude[1], Christian Koos[1]; [1]*Karlsruhe Inst. of Technology, Germany.* We demonstrate a 3D printed ultra-broadband and highly efficient out-of-plane coupler for photonic integrated circuits. The coupling efficiency at 1550 nm is −0.8 dB with a 1 dB bandwidth exceeding 100 nm.

STh1A.2 • 08:15
Broadband Mode Router Based on Three-Dimensional Mach-Zehnder Interferometer and Waveguide Branches, Quandong Huang[1], Yunfei Wu[1], Wei Jin[1], Kin S. Chiang[1]; [1]*City Univ. of Hong Kong, Hong Kong.* We demonstrate a broadband mode router based on integrating a 3D thermo-optic Mach-Zehnder interferometer and a 3D mode demultiplexer. The device can dynamically route four spatial modes of a few-mode waveguide into four single-mode waveguides.

STh1A.3 • 08:30
Multiresonant Optical Response in Quasi-3D Multilayer Metal-Insulator-Metal Nanoplasmonic Crystals, Junyeob Song[1], Wonil Nam[1], Wei Zhou[1]; [1]*Virginia Tech, USA.* Quasi-3D multilayer Metal-Insulator-Metal (MIM) nanoplasmonic crystals sitting on dielectric nanopillar arrays show unique multiresonant optical response from localized and delocalized surface plasmon modes both in far-field and near-field.

STh1A.4 • 08:45
Compact Narrow-Linewidth Integrated Laser Based on Low-Loss Silicon Nitride Ring Resonator, Brian Stern[1,2], Xingchen Ji[1,2], Avik Dutt[1,2], Michal Lipson[2]; [1]*Cornell Univ., USA;* [2]*Columbia Univ., USA.* We demonstrate an integrated silicon nitride/III-V laser leveraging the narrowband backreflection of a high-Q microring resonator for output coupling and feedback. We measure a 13 kHz linewidth with 1.7 mW output power around 1550 nm.

08:00–10:00
STh1B • Integrated Photonic Sensors
Presider: Qiaoqiang Gan; State Univ. of New York at Buffalo, USA

STh1B.1 • 08:00
Mid-infrared (MIR) Mach-Zehnder Silicon Modulator at 2μm Wavelength based on Interleaved PN Junction, Wanjun Wang[1], Zecen Zhang[1], Xin Guo[1], Jin Zhou[1], Sia Jia B. Xu[1], Mohamed S. Rouifed[1], Chongyang Liu[1], Callum Littlejohns[1,2], Graham T. Reed[2], Hong Wang[1]; [1]*Nanyang Technological Univ., Singapore;* [2] *Optoelectronics Research Centre,Univ. of Southampton, UK.* In this paper, a MIR silicon modulator operating at 2 μm wavelength is experimentally demonstrated. The modulator shows 9.7 GHz 3-dB electro-optic bandwidth at $V_{bias=}$ -3V. We also present optical modulation at 12.5 Gb/s.

STh1B.2 • 08:15
Methane Absorption Spectroscopy with a Hybrid III-V Silicon External Cavity Laser, Eric J. Zhang[1], Laurent Schares[1], Jason S. Orcutt[1], Yves Martin[1], Chi Xiong[1], Marwan Khater[1], Tymon Barwicz[1], William Green[1]; [1]*IBM T. J. Watson Research Center, USA.* We present line-scanned methane absorption spectroscopy at 1656.5 nm using a multi-section hybrid III-V silicon external-cavity laser. The laser demonstrates > 2 nm tunability and single-mode operation with SMSR > 50 dB for high-resolution spectroscopy.

STh1B.3 • 08:30
Widely Tunable III-V-on-silicon Vernier Lasers Operating in the 2.3 μm Wavelength Range, Ruijun Wang[1], Stephan Sprengel[2], Gerhard Boehm[2], Roel Baets[1], Markus Amann[2], Gunther Roelkens[1]; [1]*Photonics Research Group, Ghent Univ.-imec, Belgium;* [2]*Walter Schottky Institut, Technische Universität München, Germany.* We report widely tunable III-V-on-silicon lasers with more than 40 nm tuning range near 2.35 μm wavelength. By combining two lasers with different distributed Bragg reflectors, a tuning range of more than 70 nm is achieved.

08:00–10:00
STh1C • Machine Learning for Communication
Presider: Francesco Da Ros; DTU Fotonik, Denmark

STh1C.1 • 08:00 Invited
Learning of Laser Dynamics using Bayesian Inference , Darko Zibar[1], Christian Schaeffer[2], Jesper Mork[1]; [1]*Danmarks Teknishe Universitet, Denmark;* [2]*Helmut-Schmidt-Universität, Germany.* Techniques from Bayesian machine learning and digital coherent detection are applied to perform frequency noise characterization Significant advantage of the presented techniques are high-sensitivity and direct access to the uncertainty of the frequency noise measurement.

STh1C.2 • 08:30
Complex Neural Network Equalization of Optical SSB PAM-4 Signal in Direct-Detection Kramers-Kronig Receiver, hao ying[1], Mingyue Zhu[1], Stylianos Sygletos[2], Xingwen Yi[1,3], Jing Zhang[1], Xiatao Huang[1]; [1]*Univ. of Electronics Science & Tech, China;* [2]*Aston Inst. of Photonic Technologies,, Aston Univ., UK;* [3]*School of Electronics and Information Technology, Sun Yat-Sen Univ., China.* We propose a complex neural network equalizer in a Kramers-Kronig receiver to process the complex signals. Improved performance is demonstrated in a transmission of 56-Gb/s optical SSB PAM-4 signal over 800-km SSMF.

STh1C.3 • 08:45
Joint Estimation of IQ Phase and Gain Imbalances Using Convolutional Neural Networks on Eye Diagrams, Stefano Savian[1,2], Jùlio Diniz[1], Alan Pak Tao Lau[3], Faisal Nadeem Khan[3], Simone Gaiarin[1], Rasmus Thomas Jones[1], Darko Zibar[1]; [1]*Fotonik, DTU, Denmark;* [2]*Computer Science, The Free Univ. of Bozen-Bolzano, Italy;* [3]*Electrical Engineering, The Hong Kong Polytechnic Univ., Hong Kong.* A machine learning-based low-cost monitoring technique for transmitter IQ phase and gain imbalances is proposed. Simulations with formats up to NRZ-64QAM (28 GBd) show 95%-confidence estimation within 1.5° for phase and 0.06 for gain imbalances.

07:30–18:00 Registration, *Concourse Level*

Executive Ballroom 210D

Executive Ballroom 210E

Executive Ballroom 210F

CLEO: QELS-Fundamental Science

08:00–10:00
FTh1D • Nonlinear Metamaterials and Metasurfaces
Presider: Rafael Piestun; Univ. of Colorado at Boulder, USA

FTh1D.1 • 08:00
Nonlinear Tunability and Mechanical Actuation in Photonically Doped ENZ Metasurfaces, Ehsan Nahvi[1], Inigo Liberal[1,2], Nader Engheta[1]; [1]*Univ. of Pennsylvania, USA;* [2]*Public Univ. of Navarra, Spain*. Built upon the photonic doping concept we introduced recently [Science 355, 1058 (2017)], we numerically demonstrate how nonlinearity of the single dielectric rod and its mechanical actuation enable tunability of transmission through Epsilon-Near-Zero (ENZ) metasurfaces

FTh1D.2 • 08:15
Nonlinear Manifestations of Photon Acceleration in Rapidly Evolving Semiconductor Metasurfaces, Maxim R. Shcherbakov[1], Kevin Werner[2], Zhiyuan Fan[1], Noah Talisa[2], Enam Chowdhury[2], Gennady Shvets[1]; [1]*Cornell Univ., USA;* [2]*The Ohio State Univeristy, USA*. We report an experimental observation of photon acceleration in mid-infrared semiconductor metasurfaces manifested as blue-shifted third harmonic generation at carrier frequencies of up to 3.1ω.

FTh1D.3 • 08:30 Invited
Nonlinear Optics on Demand, Haim Suchowski[1]; [1]*Tel Aviv Univ., Israel*. Nonlinear metasurfaces expand the possibilities of optical response resulting in intriguing and rich optical phenomena. Recent advances in controlling the generation and understanding of optical nonlinearities via single and collective metasurfaces designs will be presented.

08:00–10:00
FTh1E • Nonlinear Optics in Microresonator Systems
Presider: Scott Diddams; NIST, USA

FTh1E.1 • 08:00 Invited
Nonlinear and Quantum Optics within Whispering Gallery Mode Resonators, Harald G. Schwefel[1,2], Luke S. Trainor[1,2], Alfredo Rueda[3], Florian Sedlmeir[3]; [1]*Univ. of Otago, New Zealand;* [2]*Dodd-Walls Centre for Photonics and Quantum Technology, New Zealand;* [3]*Max Planck Inst. for the Science of Light, Germany.* I present the current state of nonlinear and quantum optics within WGM resonators with particular emphasis on frequency conversion. This includes electro-optic microwave to optics transduction as well as parametric photon triplet generation.

FTh1E.2 • 08:30
Polarization Effects and Nonlinear Mode Coupling in Kerr Microresonators, Tobias Hansson[1], Martino Bernard[1], Stefan Wabnitz[1,2]; [1]*Dipartimento di Ingegneria dell'Informazione, Università degli Studi di Brescia, Italy;* [2]*CNR-INO, Italy.* We model optical frequency comb generation in the presence of nonlinear polarization effects. We make an in-depth study of the modulational instability and demonstrate the appearance of novel types of instabilities and frequency comb states.

FTh1E.3 • 08:45
Type-1 and type-2 satellites in Kerr frequency combs, Jinghui Yang[1], Shu-Wei Huang[2], Zhenda Xie[3], Mingbin Yu[4], Dim-Lim Kwong[4], Chee-Wei Wong[1]; [1]*Electrical Engineering, Univ. of California, Los Angeles, USA;* [2]*Electrical, Computer & Energy Engineering, Univ. of Colorado, Boulder, USA;* [3]*Nanjing Univ., China;* [4]*Inst. of Microelectronics, Singapore.* We report Kerr frequency combs with two types of satellites, enabled by multiple phase matching in microcavities. Satellite comb clusters at ≈ 1.3 mm and 2.0 mm regimes are simultaneously generated with the central comb, with a demonstrated high external conversion efficiency reaching up to 30dB.

08:00–10:00
FTh1F • Novel Phenomena in van der Waals Heterostructure
Presider: Steven Cundiff; Univ. of Michigan, USA

FTh1F.1 • 08:00
Room-temperature optoelectronic detection of valley-locked spin photocurrent in WSe_2-graphene-$Bi2Se_3$ heterostructures, Soonyoung Cha[1], Minji Noh[1], Je-hyun Kim[2], Jangyup Son[2,3], Hyemin Bae[1], Doeon Lee[1], Hoil Kim[4], Jekwan Lee[1], Hoseung Shin[1], Sangwan Sim[1], Seunghoon Yang[5], Chul-Ho Lee[5], Moon-Ho Jo[6,7], Junsung Kim[4], Dohun Kim[2], Hyunyong Choi[1]; [1]*Yonsei Univ., South Korea;* [2]*Seoul National Univ., South Korea;* [3]*Univ. of Illinois at Urbana-Champaign, USA;* [4]*Postech, South Korea;* [5]*Korea Univ., South Korea;* [6]*Center for artifical low dimensional electronics systems, Inst. for Basic Science, South Korea;* [7]*Division of Advanced Materials Science, POSTECH, South Korea.* Using a lateral WSe_2-graphene-$Bi2Se_3$ heterostructure, we generate the valley-locked spin photocurrent in ion-liquid gated WSe_2 transistor by the circular photogalvanic effect and extract the spin-polarized current in the Bi_2Se_3 topological insulator using the spin-momentum locking.

FTh1F.2 • 08:15
Probing Charge Transfer States in Polymer:Fullerene – MoS_2 van der Waals Heterostructures, Christopher Petoukhoff[1], Damien Voiry[2], Ibrahim Bozkurt[2], Manish Chhowalla[2], Keshav M. Dani[1]; [1]*Femtosecond Spectroscopy Unit, Okinawa Inst. of Science and Technology, Japan;* [2]*Materials Science and Engineering, Rutgers Univ., USA.* Using transient absorption spectroscopy, we observe the formation of long-lived charge transfer states in polymer:fullerene – MoS_2 van der Waals heterostructures at sub-picosecond timescales.

FTh1F.3 • 08:30 Invited
2D Magnets and Heterostructures, Xiadong Xu[1]; [1]*Univ. of Washington, USA.* Since the discovery of graphene, the family of two-dimensional (2D) materials has grown to encompass a broad range of electronic properties. However, until recently 2D crystals with intrinsic magnetism were still lacking. In this talk, I will describe our recent magneto-optical spectroscopy experiments on van der Waals magnets, chromium(III) iodide CrI_3, and their heterostructures with other non-magnetic 2D materials.

07:30–18:00 Registration, *Concourse Level*

Executive Ballroom 210G

CLEO: QELS-Fundamental Science

08:00–10:00
FTh1G • Integrated Quantum Sources
Presider: John Sipe; Univ. of Toronto, Canada

FTh1G.1 • 08:00
Spectrally Unentangled Photon Pairs from Microring Resonators using Pump-pulse Tailoring, Jesper B. Christensen[1], Jacob G. Koefoed[1], Colin McKinstrie[1], Karsten Rottwitt[1]; [1]*Technical Univ. of Denmark, Denmark.* We show that a tailored pump-pulse spectrum can be used to completely eliminate spectral correlation in photon pairs generated from spontaneous four-wave mixing in nonlinear microring resonators.

FTh1G.2 • 08:15
Photonic Crystal Waveguides As Integrated Sources of Counterpropagating Factorizable Photon Pairs, Sina Saravi[1], Thomas Pertsch[1], Frank Setzpfandt[1]; [1]*Abbe Center of Photonics, Friedrich Schiller Univ. Jena, Germany.* We show that counterpropagating phase-matching reached in photonic crystal waveguides, without periodic poling, can be used in spontaneous parametric down-conversion to engineer the generation of photon pairs factorizable in the spectral degree of freedom.

FTh1G.3 • 08:30
Visible-Telecom Photon Pair Generation with Silicon Nitride Nanophotonics, Xiyuan Lu[1], Qing Li[1], Gregory Moille[1], Anshuman Singh[1], Daron Westly[1], Kartik Srinivasan[1]; [1]*NIST, USA.* We demonstrate a silicon nanophotonic chip that generates high-quality, narrowlinewidth photon pairs that link the visible and telecommunications bands. This device has potential for use in communication and entanglement of remote quantum systems

FTh1G.4 • 08:45
High CAR and low $g^{(2)}(0)$ of 1.55 μm entangled photon-pairs generated by a silicon microring resonator, Chaoxuan Ma[1], Malhar Jere[1], Xiaoxi Wang[1], Shayan Mookherjea[1]; [1]*Univ. of California, San Diego, USA.* Silicon microring photon-pair and heralded single-photon generation is reported with a spectral brightness of $1.6x10^8$ pairs/s/GHz/mW^2, achieving record CAR > 12,000 and heralded second-order self-correlation $g^{(2)}(0)$ < 0.006. Franson interferometry was used to verify time-energy entanglement.

Executive Ballroom 210H

08:00–10:00
FTh1H • Quantum Interference, Imaging and Spectroscopy
Presider: Sergey Polyakov; NIST, USA

FTh1H.1 • 08:00
Sub-cycle Control of Optical Response by Using a Terahertz Excitonic Dressed State, Hideki Hirori[1], Kento Uchida[1], Tomohito Otobe[2], Toshimitsu Mochizuki[3], Changsu Kim[4], Masahiro Yoshita[4], Koichiro Tanaka[1], Akifumi Akiyama[4], L. N. Pfeiffer[5], K. W. West[5]; [1]*Kyoto Univ., Japan;* [2]*Kansai Photon Science Inst., Japan;* [3]*National Inst. of Advanced Industrial Science and Technology, Japan;* [4]*Univ. of Tokyo, Japan;* [5]*Princeton Univ., USA.* We observed optical absorption strengths modulated on a sub-cycle timescale in a GaAs quantum well in the presence of a multi-cycle terahertz driving pulse using a near-infrared probe pulse.

FTh1H.2 • 08:15
Stern-Gerlach Effect for Photons, Aviv Karnieli[1], Ady Arie[2]; [1]*Raymond and Beverly Sackler School of Physics and Astronomy, Tel Aviv Univ., Israel;* [2]*School of Electrical Engineering, Iby and Aladar Fleischman Faculty of Engineering,, Tel Aviv Univ., Israel.* We demonstrate theoretically the existence of a Stern-Gerlach effect for single photons in a quadratic nonlinear medium. The new effect enables the spatial separation of orthogonal frequency superposition states and might open new possibilities for the manipulation of bichromatic qubits.

FTh1H.3 • 08:30
Few Photons Correlation Measurement of a Thermally Populated Cavity, Francesca F. Settembrini[1], Ileana-Cristina Benea-Chelmus[1], Jérôme Faist[1]; [1]*ETH Zürich, Switzerland.* In the THz range, correlation measurements have been implemented exploiting electrooptic sampling and femtosecond pulses. We present the field correlation measurement of few photons populating the modes of a cavity (nonlinear crystal) at room temperature.

FTh1H.4 • 08:45
Interfering Photons in Orthogonal States, Alexander Jones[2,1], Adrian Menssen[1], Helen Chrzanowski[1], Valery Shchesnovich[3], Ian Walmsley[1]; [1]*Univ. of Oxford, UK;* [2]*Imperial College London, UK;* [3]*Federal Univ. of ABC, Brazil.* Here we show that multi-particle quantum interference still occurs even when some of the particles involved are in orthogonal states. We experimentally demonstrate this with four photons.

Meeting Room 211 B/D

CLEO: Science & Innovations

08:00–10:00
STh1I • Novel Fabrication Methods
Presider: Roberto Paiella; Boston Univ., USA

STh1I.1 • 08:00
Photonic Damascene process with reflow step for ultra-smooth Si_3N_4 waveguides, Martin Pfeiffer[1], Junqiu Liu[1], Tiago Morais[1], Bahareh Ghadiani[1], Tobias J. Kippenberg[1]; [1]*Ecole Polytechnique Federale de Lausanne, Switzerland.* We present ultra-smooth silicon nitride waveguides fabricated by the photonic Damascene process extended with a novel reflow step. This leads to record Q-factors for tightly confining waveguides with anomalous dispersion.

STh1I.2 • 08:15
Single-Step Fabrication of Multispectral Filter Arrays Using Grayscale Lithography and Metal-Insulator-Metal Geometry, Calum Williams[1], George S. Gordon[1], Timothy D. Wilkinson[1], Sarah E. Bohndiek[2]; [1]*Dept. of Engineering, Univ. of Cambridge , UK;* [2]*Dept. of Physics, Univ. of Cambridge, UK.* Metal-insulator-metal geometries can provide optical transmission filtering, with peak wavelength dependent on insulator thickness. Using grayscale electron beam lithography to control insulator thickness, we fabricate multispectral filter arrays, whereby dose determines wavelength

STh1I.3 • 08:30 Invited
Silicon and Germanium based Waveguide Platforms for the Long Wave Infrared, Milos Nedeljkovic[1], Jordi Soler Penades[1], Alejandro Sánchez-Postigo[2], J. Gonzalo Wangüemert Pérez[2], Alejandro Ortega-Moñux[2], Robert Halir[2], Pavel Cheben[3], Iñigo Molina-Fernández[2], Vinita Mittal[1], Ganapathy S. Murugan[1], Ali Z. Khokhar[1], Callum Littlejohns[1], Yolanda Xu[1], Zhibo Qu[1], Ahmed Osman[1], Wei Cao[1], Lewis G. Carpenter[1], Corin Gawith[1], James S. Wilkinson[1], Goran Mashanovich[1]; [1]*Univ. of Southampton, UK;* [2]*Universidad de Malaga, Spain;* [3]*National Research Council of Canada, Canada.* We report on low-loss light propagation at mid-infrared wavelengths above 7 μm in a) suspended silicon waveguides with metamaterial claddings, and b) germanium-on-silicon waveguides. These waveguides enable new sensing circuits for this wavelength range.

07:30–18:00 Registration, *Concourse Level*

Meeting Room 212 A/C

CLEO: Science & Innovations

08:00–10:00
STh1J • OCT & Biomedical Imaging
Presider: Raluca Niesner; Charité-Univ. Medicine Berlin, USA

STh1J.1 • 08:00 Tutorial
Case Studies in Bringing Biophotonics Devices from Concept to Medical Product, Dennis L. Matthews[1]; [1]*Univ. of California Davis, USA*. In this presentation, I will review the history of development for a couple of technologies that we have brought from the idea stage to a successful commercial product (superresolution Structured Illumination Microscope) or about to be a product (Personal Blood Count Monitor). I will also describe a couple of other projects which haven't yet reached a product status or that failed to reach such a status. My lecture is meant to provide examples of successful and not-so-successful strategies and some lessons learned. Biophotonics is a relatively mature field of research with lots of successful technology development, but the translation to the marketplace, especially in clinical medicine, has been limited. I will provide some insight into this situation along with some predictions of a bright future for the adoption of biophotonics technologies into various market sectors including medicine.

Dennis Matthews, Ph.D., is the Emeritus Director of the NSF Center for Biophotonics Science and Technology, and the previous Associate Director for Biomedical Technology for the Integrated Cancer Center at the University of California at Davis. He is an emeritus professor in the UC Davis Department of Neurological Surgery and a member of the Biomedical Engineering, Applied Sciences and Clinical Sciences Graduate Groups. He is also a previous Program Leader and Division Leader at Lawrence Livermore National Laboratory. He is the co-founder and Chief Scientist of the Tahoe institute for Rural Healthcare Research, the Univ of CA Biophotonics Alliance and the Biophotonics4Life Worldwide Consortium. He is also the sole proprietor of LifeLight Resources LLC, a biophotonics-based consulting company. He has also recently become the Chief Science and Operations Officer in a radar-based heart monitoring startup company called Cardiac Motion LLC. While he is credited for inventing and developing x-ray wavelength lasers at Lawrence Livermore National Laboratory, Dr. Matthews' continuing interest is in the translation and commercialization of new physical science and engineering technologies for grand challenges in medicine and the life sciences. His current interests are in developing optical, RF and x-ray technologies for disease diagnosis and treatment. He is a Fellow of the American Physical Society, the Society of Photo and Industrial Engineers and the Optical Society. He has more than 295 publications and >30 patents and is the co-editor of the Journal of Biophotonics. Dr. Matthews is credited for raising more than $225M in grant and investor funds in his career, helping create 14 startup companies.

Meeting Room 212 B/D

CLEO: QELS-Fundamental Science

08:00–10:00
FTh1K • Optical Near-field and Thermal Imaging
Presider: Chengjun Zou; Friedrich Schiller Univ. Jena, Germany

FTh1K.1 • 08:00
Nanoscale Field Mapping of Interfering Beams from Nomarski Prism Using Photo-Induced Force Microscopy, Mohsen Rajaei[1], Mohammad Kamandi[1], Mohammad Albooyeh[1], Mina Hanifeh[1], Filippo Capolino[1], Hemantha K. Wickramasinghe[1]; [1]*Univ. of California, Irvine, USA*. We map the near-field distribution of a linearly-polarized light transmitting through a Nomarski prism. We show how translating the prism changes the near-field profile. This setup has potential applications in phase detection of molecular responses.

FTh1K.2 • 08:15
Enantio-specific Detection of Chirality at Nanoscale Using Photo-induced Force, Mohammad Kamandi[1], Mohammad Albooyeh[1], Mohsen Rajaei[1], Jinwei Zeng[1], Caner Guclu[1], Mehdi Veysi[1], Hemantha K. Wickramasinghe[1], Filippo Capolino[1]; [1]*Univ. of California, Irvine, USA*. We propose a high-resolution scanning-tip microscopy technique for enantio-specific detection of nanoscale samples (down to sub-100-nm size) by measuring the photo-induced force exerted on an achiral probe in the vicinity of a chiral sample, under circularly polarized excitation beams.

FTh1K.3 • 08:30
High Coupling Efficiency Adiabatic Near-field Transducer for HAMR, Chuan Zhong[1], Patrick Flanigan[1], Nicolás Abadía[1], Brian D. Jennings[1], Frank Bello[1], Gwenael Atcheson[1], Jing Li[1], Jian-Yao Zheng[1], Richard Hobbs[1], David McCloskey[1], John F. Donegan[1]; [1]*Trinity College Dublin, Ireland*. The literature reports NFT with size below 1 micron are found to be thermo-mechanically unstable and low coupling efficiency. We demonstrate a 6 μm long adiabatic taper. A maximum coupling efficiency of 90.8% is achieved.

FTh1K.4 • 08:45
Cryogenic Near-Field Imaging and Spectroscopy at the 10-Nanometer-Scale, Max Eisele[1], Andreas Huber[1], Tobias Gokus[1]; [1]*neaspec GmbH, Germany*. We extend conventional near-field microscopy at ambient conditions to the cryogenic temperature range (<10-300Kelvin). We will present first nano-optical measurements on semiconductor samples and single-layer materials highlighting the novel insights attainable by our cryo-neaSNOM.

Marriott Salon I & II

CLEO: Science & Innovations

08:00–10:00
STh1L • MIR to the THz Dual Combs
Presider: Ian Coddington; NIST, USA

STh1L.1 • 08:00
Mid-Infrared Frequency Comb Generation with In-Line Frequency Stabilization, Alexander Lind[1,2], Abijith Kowligy[1], Henry Timmers[1], Nima Nader[3], Flavio Cruz[1], Gabriel Ycas[3], Scott Papp[1], Scott Diddams[1,2]; [1]*Time and Frequency, NIST, USA;* [2]*Physics, Univ. of Colorado, Boulder, USA;* [3]*Applied Physics, NIST, USA*. We demonstrate a simple mid-infrared comb source via intra-pulse difference frequency generation in periodically poled lithium niobate crystals. This technique generates an offset frequency beat in the mid-infrared, which we use for comb stabilization.

STh1L.2 • 08:15
Mid-Infrared Dual-Comb Spectroscopy of Liquid-Phase Samples using Attenuated Total Reflectance, Daniel I. Herman[1,2], Gabriel Ycas[1], Fabrizio Giorgetta[1], Eleanor Waxman[1], Esther Baumann[1], Ian R. Coddington[1], Nathan R. Newbury[1]; [1]*NIST, USA;* [2]*Physics, Univ. of Colorado at Boulder, USA*. Mid-infrared dual-comb spectroscopy (DCS) is performed on liquid isopropanol from 3.0-3.75 μm with a 1.5-second acquistion time. This experiment is a first step towards viewing liquid-phase reactions in real time using DCS.

STh1L.3 • 08:30 Invited
Dual THz Comb Spectroscopy, Takeshi . Yasui[1,2]; [1]*Tokushima Univ., Japan;* [2]*JST, ERATO MINOSHIMA Intelligent Optical Synthesizer, Japan*. We combine dual-comb spectroscopy with spectrally interleaving in terahertz (THz) region, enabling us to achieve the spectral sampling interval equal to linewidth of the comb tooth in the low-pressure gas spectroscopy in THz region.

07:30–18:00 Registration, *Concourse Level*

Marriott Salon III

CLEO: QELS-Fundamental Science

08:00–10:00
FTh1M • Nonlinear Dynamics in Resonators and Fibers
Presider: Arash Mafi; Univ. of New Mexico, USA

FTh1M.1 • 08:00
10-GHz Femtosecond Degenerate Optical Parametric Oscillator, Richard A. McCracken[1], Yuk Shan Cheng[1], Derryck T. Reid[1]; [1]*Heriot-Watt Univ., UK.* We report a synchronously pumped degenerate optical parametric oscillator (DRO) with a 90-nm bandwidth at 1.634 µm, producing 400-mW average power femtosecond pulses at 10 GHz, the highest repetition frequency femtosecond DRO demonstrated to date.

FTh1M.2 • 08:15
Exotic Nonlinear Effects by Inserting a Low Finesse Resonator in a Mode-Locked Laser Cavity, James Hendrie[1], Ning Hsu[1], Jean-Claude M. Diels[1], Matthias Lenzner[2], Ladan Arissian[1]; [1]*Univ. of New Mexico, USA;* [2]*Lenzner Research LLC, USA.* Intracavity comb multiplication is demonstrated by inserting a low finesse resonator in a mode-locked laser.
Control of the comb in frequency and repetition rate is demonstrated.

FTh1M.3 • 08:30
Accelerating nonlinear interactions in tapered multimode fibers, Mohammad Amin Eftekhar[1], Zeinab Sanjabi Eznaveh[1], Jose Enrique Antonio-Lopez[1], Helena E. Lopez Aviles[1], Sepehr Benis[1], Miroslav Kolesik[2], A. Schülzgen[1], Frank W. Wise[3], Rodrigo Amezcua Correa[1], Demetrios N. Christodoulides[1]; [1]*CREOL, Univ. of Central Florida, USA;* [2]*College of Optical Sciences, The Univ. of Arizona, USA;* [3]*School of Applied and Engineering Physics, Cornell Univ., USA.* We theoretically and experimentally demonstrate that the processes of multimode soliton fission and dispersive wave generation in parabolic-index multimode fibers are substantially altered when the rate of intermodal nonlinear interactions is progressively increased during propagation.

FTh1M.4 • 08:45
Phase Conjugation in OAM fiber modes via Stimulated Brillouin Scattering, Gautam Prabhakar[1], Xiao Liu[1], Jeffrey Demas[1], Patrick Gregg[1], Siddharth Ramachandran[1]; [1]*Boston Univ., USA.* We report the first demonstration of phase conjugation in OAM fiber modes via SBS. Acoustic and optical angular-momentum selection rules facilitate this even for monomode launch, in contrast to the traditional need for multimode inputs.

Marriott Salon IV

CLEO: Science & Innovations

08:00–10:00
STh1N • Ultrafast Applications
Presider: Christophe Dorrer; Univ. of Rochester, USA

STh1N.1 • 08:00 **Tutorial**
THz Driven Accelerators and X-ray Sources, Franz X. Kaertner[1,2]; [1]*Center for Free-Electron Laser Science, Deutsches Elektronen Synchrotron, Germany;* [2]*Physics Dept., Universität Hamburg, Germany.* Approaches towards a linear THz accelerator technology are discussed. Theoretical and first experimental results on laser based high energy THz generation, guns, accelerators as well as compact X-ray sources based on these devices are presented.

Franz Kärtner heads the Ultrafast Optics and X-rays Group at the Center for Free-Electron Laser Science at DESY and is Professor of Physics at University of Hamburg. Within an ERC Synergy Grant, he and colleagues pursue Terahertz acceleration and coherent X-ray sources. He is a fellow of OSA and IEEE.

Marriott Salon V

CLEO: Applications & Technology

08:00–10:00
ATh1O • Trace Gas Detection
Presider: Paul Williams; NIST, USA

ATh1O.1 • 08:00
Optical re-injection in Off-Axis Integrated Cavity Output Spectroscopy, modelling and experiments, Faisal Nadeem[1], Julien Mandon[1], Simona M. Cristescu[1], Frans J. M. Harren[1]; [1]*Radboud Univ., Netherlands.* A 3-D ray-tracing model is developed, to model reinjection in Off-Axis Cavity Enhanced Spectroscopy. Modelling and experiments demonstrate, at near-IR laser wavelengths, a 38-times enhancement, corresponding to a NEAS of 1.1×10^{-9} cm^{-1} $Hz^{-1/2}$

ATh1O.2 • 08:15
Detection of Trace Amounts of Volatile Organic Compounds via Laser-Induced Condensation, Valentina Shumakova[1], Mary Matthews[2], Tadas Balciunas[2], Skirmantas Ališauskas[1], Elise Schubert[2], Audrius Pugzlys[1,3], Andrius Baltuska[1], Jerome Kasparian[2], Jean-Pierre Wolf[2]; [1]*Vienna Univ. of Technology, Austria;* [2]*Université de Genève, Switzerland;* [3]*Center for Physical Sciences & Technology, Lithuania.* Laser-induced condensation allows to detect volatile organic compounds with concentrations below 1 ppb. Lab experiments and comparison with quantitative photo-ionization detection measurements were performed. The method is sensitive to excitation wavelength in 1.6-2.0 µm range.

ATh1O.3 • 08:30
Mid-Infrared Photothermal Interferometric Gas Sensing in Hollow-Core Optical Fibers, Chenyu Yao[1], Zhili Li[2], Fan Yang[3], Wei Jin[3], Wei Ren[1]; [1]*The Chinese Univ. of Hong Kong, Hong Kong;* [2]*Univ. of Electronic Science and Technology-Zhongshan Inst., China;* [3]*The Hong Kong Polytechnic Univ., Hong Kong.* We developed a photothermal interferometry-based trace gas sensor by coupling a mid-infrared pump laser and a near-infrared probe laser into a hollow-core optical fiber.

ATh1O.4 • 08:45
Parts-Per-Billion Carbon Monoxide Sensing in Silicon-on-Sapphire Mid-Infrared Photonic Crystal Waveguides, Ali Rostamian[2], Joel Guo[2], Swapnajit Chakravarty[1], Chi-Jui Chung[2], Duy Nguyen[1], Ray Chen[2,1]; [1]*Omega Optics, Inc, USA;* [2]*Electrical and Computer Engineering, Univ. of Texas at Austin, USA.* We experimentally detect 3 ppm carbon monoxide via optical absorbance in a 1mm long slotted photonic crystal waveguide in silicon-on-sapphire at wavelength l= 4.55mm. Feasibility of low ppb sensing will be shown by design modifications.

07:30–18:00 Registration, *Concourse Level*

Marriott
Salon VI

CLEO: QELS-Fundamental Science

08:00–10:00
FTh1P • Engineering and Metrology of Thermal Radiation
Presider: Gururaj Naik; Rice Univ., USA

FTh1P.1 • 08:00 Tutorial
Nanophotonic Control of Thermal Radiation for Energy Applications, Shanhui Fan[1]; [1]*Stanford Univ., USA.* The ability to control thermal radiation plays a fundamentally important role in a wide range of energy technology. Nanophotonic structures provide enhanced capabilities for controlling thermal radiation, which is leading to new energy applications.

Shanhui Fan is a Professor of Electrical Engineering and the Director of the Ginzton Laboratory, at Stanford University. He received his Ph. D in 1997 from Massachusetts Institute of Technology (MIT). His research interests are in fundamental physics of nanophotonic structures, and their applications in energy and information technology.

Marriott
Willow Glen

CLEO: Applications & Technology

08:00–10:00
ATh1Q • A&T Topical Review on Neurophotonics I
Presider: Chris Xu; Cornell Univ., USA

ATh1Q.1 • 08:00 Tutorial
The Challenge of Large-scale Neuronal Imaging, Jerome C. Mertz[1]; [1]*Boston Univ., USA.* Fast, large-scale, volumetric, in-vivo neuronal imaging has long been a challenge for microscopists. I will discuss some of the issues involved and review various strategies to address this challenge.

Jerome Mertz is currently a professor of Biomedical Engineering at Boston University. His interests are in the development and applications of novel optical microscopy techniques for biological imaging. He is also author of a textbook entitled Introduction to Optical Microscopy.

CLEO: Science & Innovations

STh1A • Novel Structures and Devices—Continued

STh1A.5 • 09:00
Spectral Engineering Based on Mode Splitting in Integrated Cascaded Sagnac Loop Reflectors, Jiayang Wu[1], Tania Moein[1], Xingyuan Xu[1], David J. Moss[1]; [1]*Swinburne Univ. of Technology, Australia.* We propose and experimentally demonstrate mode splitting in integrated cascaded Sagnac loop reflectors (SLRs). By changing the number and reflectivity of the SLRs, rich filtering characteristics for spectral engineering are experimentally achieved and show good agreement with theory.

STh1A.6 • 09:15
Integrated Amorphous Silicon-Aluminum Long-Range Surface Plasmon Polaritons (LR-SPP) Waveguides, Boaz Sturlesi[1], Meir Grajower[1], Noa Mazurski[1], Uriel Levy[1]; [1]*the Hebrew Univ. of Jerusalem, Israel.* We demonstrate Long Range Surface Plasmon Polaritons waveguide with aluminum embedded in amorphous silicon. It operates in the telecom band and is compatible with backend CMOS process. Transmission and near field measurement results are reported.

STh1A.7 • 09:30
Radiation-Free, Sub-Wavelength Optical Resonator based on All-Evanescent Confinement in a High-Index Core Material, Imbert Wang[1], Milos Popovic[1]; [1]*Electrical Engineering, Boston Univ., USA.* We propose a radiation-free dielectric nanocavity with all-evanescent confinement, based on perfect mode-matching and minimal use of negative permittivity. A record-low mode volume within high-index core material, supporting high-Q(Q/V), may enable efficient active nanophotonic components.

STh1A.8 • 09:45
Interface Passivation for Realizing High Efficiency Direct Band Gap Emission from Ge MOS Tunneling Diode, Min Xie[1], Yi Zhao[1]; [1]*Zhejiang Univ., China.* We demonstrated room temperature Ge surface-emitting diode with 1.5-1.6 um strong infrared emission using a metal/graphene/high-k/interface layer (IL)/*n*-Ge MOS tunneling structure, without introducing strain or extra-doping.

STh1B • Integrated Photonic Sensors—Continued

STh1B.4 • 09:00
Monolithic Integration of Quantum Cascade Laser, Quantum Cascade Detector and Slotted Photonic Crystal Waveguide for Absorbance Sensing from l=3-15mm, Swapnajit Chakravarty[1], Jason Midkiff[1], Ali Rostamian[2], Joel Guo[2], Ray Chen[2,1]; [1]*Omega Optics, Inc, USA;* [2]*Electrical and Computer Engineering, Univ. of Texas at Austin, USA.* We demonstrate monolithic integration of quantum cascade laser and detector and slotted photonic crystal waveguide on a single epitaxial heterostructure for on-chip slow light enhanced absorption sensing. Designs can cover l=3-15mm wavelengths without wafer bonding.

STh1B.5 • 09:15
Demonstration of 2-μm on-chip two-mode division multiplexing using tapered directional coupler-based mode (de) multiplexer, Shuang Zheng[1], Meng Huang[1], Xiaoping Cao[1], Lulu Wang[1], Zhengsen Ruan[1], Li Shen[1], Jian Wang[1]; [1]*Wuhan National Lab for Optoelectr, China.* We design and fabricate a four-mode division (de)multiplexer for chip-scale optical data transmission in 2 μm waveband for the first time. The on-chip device exhibits low mode crosstalk and wide bandwidth over the wave band.

STh1B.6 • 09:30
Coupled Resonator Optical Waveguide Filter Based on Sagnac Loop Mirrors, Renyou Ge[1], Xinlun Cai[1]; [1]*Sun Yat-Sen Univ., China.* We designed and fabricated a novel coupled resonator optical waveguide filter based on Sagnac loop mirrors on silicon-on-insulator platform. We can achieve extinction ratio of >50 dB by tuning reflections of the Sagnac loop mirrors.

STh1B.7 • 09:45
Quantum cascade multi-spectral laser with integrated beam combiner on silicon, Eric J. Stanton[1], Alexander Spott[1], Jon Peters[1], Michael Davenport[1], Nicolas Volet[1], Aditya Malik[1], Junqian Liu[1], Charles D. Merritt[2], William W. Bewley[2], Igor Vurgaftman[2], Chul Soo Kim[2], Jerry R. Meyer[2], John E. Bowers[1]; [1]*Univ. of California Santa Barbara, USA;* [2]*Code 5613, Naval Research Lab, USA.* A multi-spectral quantum cascade laser is demonstrated on SOI, emitting at 4.6–4.7 μm with an integrated multiplexer. Low-loss spectral beam combining to a single-mode waveguide efficiently scales the output power.

STh1C • Machine Learning for Communication—Continued

STh1C.4 • 09:00
Performance Improvement of Nyquist DP-16QAM Over 600km System Using ANN-enhanced Post-equalization, C P. Tsekrekos[1], Christian Sánchez Costa[1], Mohammad A. Al-Khateeb[1], Feng Wen[1], Oleg Sidelnikov[2], Stylianos Sygletos[1]; [1]*Inst. of Photonic Technologies, Aston Univ., UK;* [2]*Inst. of Computational Technologies, Russia.* Performance improvement of up to 1.2 dB in Q^2-factor is experimentally demonstrated in single-carrier dual-polarization 2×28-Gbaud 16QAM 6×100 km EDFA-amplified transmission with digital post-equalization enhanced with an artificial neural network.

STh1C.5 • 09:15
Affinity propagation clustering for blind nonlinearity compensation in coherent optical OFDM, Elias Giacoumidis[1], Ivan A. Aldaya[2], Jinlong Wei[3], Christian Sánchez Costa[4], Hichem Mrabet[5], Liam Barry[1]; [1]*Dublin City Univ. , Ireland;* [2]*Univ. of Campinas, Brazil;* [3]*Huawei Technologies Düsseldorf GmbH, Germany;* [4]*Aston Univ., UK;* [5]*Saudi Electronic Univ., Saudi Arabia.* The first blind nonlinear equalizer using affinity propagation (AP) clustering is experimentally demonstrated for single-channel and WDM CO-OFDM. AP outperforms fuzzy-logic c-means clustering and digital-back propagation for both QPSK and 16-QAM formats.

10:00–15:00 Exhibition Open, *Exhibit Hall*

10:15–13:00 Technology Transfer Program, *Exhibit Hall Theater*

10:00–11:30 Coffee Break & Exhibit Only Time, *Exhibit Hall*

CLEO: QELS-Fundamental Science

FTh1D • Nonlinear Metamaterials and Metasurfaces—Continued

FTh1D.4 • 09:00
Field- and Carrier-Induced Nonlinear Metamaterials, Mohammad Taghinejad[1], Wenshan Cai[1]; *[1]Georgia Inst. of Technology, USA.* We explore active and nonlinear plasmonic metamaterials by leveraging the field-induced disruption of the inversion symmetry for second-order optical processes, and exploiting the hot-carrier-induced perturbation of the dielectric permittivity for ultrafast all-optical modulation.

FTh1D.5 • 09:15
Asymmetric Light Transport at Nonlinear Metasurfaces, Nir Shitrit[1], Jeongmin Kim[1], David Barth[1], Hamidreza Ramezani[1], Yuan Wang[1], Xiang Zhang[1,2]; *[1]Univ. of California at Berkeley, USA; [2]Materials Sciences Division, Lawrence Berkeley National Lab, USA.* We report asymmetric transport of free-space light at nonlinear metasurfaces and the derivation of the nonlinear generalized Snell's laws. Asymmetric transport at metasurfaces opens a new paradigm for ultrathin lightweight optical devices with one-way operation.

FTh1D.6 • 09:30
Homogenization and Nonlinearity Enhancement of 2D Graphene-Based Metasurfaces, Jian Wei You[1], Nicolae C. Panoiu[1]; *[1]EEE, Univ. College London, UK.* A general homogenization technique is developed to study the optical properties of 2D graphene-based metasurfaces. The results show the effective nonlinear susceptibilities of graphene metasurfaces can be enhanced by more than two orders of magnitude.

FTh1D.7 • 09:45
Structural Second Order Nonlinearity in Metamaterials, Brian Wells[2,1], Anton Y. Bykov[3], Giuseppe Marino[3], Mazhar Nasir[3], Anatoly Zayats[3], Viktor A. Podolskiy[1]; *[1]Univ. of Massachusetts Lowell, USA; [2]Dept. of Physics, Univ. of Hartford, USA; [3]Dept. of Physics, Kings College London, UK.* We demonstrate that second harmonic generation in plasmonic nanowire composites can be described by an effective bulk χ^2 susceptibility which depends on the geometry of the composite, and present an analytical description of this phenomenon

FTh1E • Nonlinear Optics in Microresonator Systems—Continued

FTh1E.4 • 09:00
Dynamics of Coupled Microresonator-Based Degenerate Optical Parametric Oscillators, Jae K. Jang[1], Yoshitomo Okawachi[1], Alexander L. Gaeta[1]; *[1]Columbia Univ., USA.* We theoretically study a network of microresonator-based chi(3) degenerate optical parametric oscillators (DOPO's). We investigate the influence of coupling on the global oscillation condition and show that the system can emulate the Ising model.

FTh1E.5 • 09:15
Mid-wavelength Infrared Supercontinuum Generation Spanning 1.4 Octaves in a Silicon-Germanium Waveguide, Milan Sinobad[2,1], Christelle Monat[1], Barry Luther-Davies[3], Pan Ma[3], Stephen Madden[3], David J. Moss[4], Arnan Mitchell[2], Regis Orobtchouk[1], Salim Boutami[5], Jean-Michel Hartmann[5], Jean-Marc Fedeli[5], Christian Grillet[1]; *[1]Lyon Inst. of Nanotechnology, France; [2]School of Engineering, RMIT Univ., Australia; [3]Laser Physics Centre, Australian National Univ., Australia; [4]Centre for Microphotonics, Swinburne Univ. of Technology, Australia; [5]CEA-Leti, France.* We report mid-wavelength infrared supercontinuum generation, from 2.6 to 7.3 μm, in a CMOS compatible low loss silicon-germanium waveguide pumped using a tunable OPA laser delivering ~200 fs pulses at 4.15 μm.

FTh1E.6 • 09:30
Dissipative Kerr Soliton States in Hybridized Microresonator Modes, Maxim Karpov[1], Martin Pfeiffer[1], Junqiu Liu[1], Anton Lukashchuk[1], Tobias J. Kippenberg[1]; *[1]Lab. of Photonics and Quantum Measuremen, Switzerland.* We experimentally demonstrate that the formation of dissipative Kerr soliton states can be achieved in hybridized microresonator modes by exploring their strong local anomalous group velocity dispersion, enabling arbitrary center wavelength operation.

FTh1E.7 • 09:45
Dynamics of laser with an integrated nonlinear waveguide, A. Aadhi[1], Michael Kues[2,3], Anton V. Kovalev[2], Piotr Roztocki[1], Christian Reimer[1], Young Zhang[1], Toa Wang[1], Sai T. Chu[5], David J. Moss[6], Zhiming Wang[4], Evgeny A. Viktorov[2], Roberto Morandotti[1,2]; *[1]INRS EMT, Canada; [2]ITMO Univ., Russia; [3]Univ. of Glasgow, UK; [4]Inst. of Fundamental and Frontier Sciences, Univ. of Electronic Science and Technology of China, China; [5]City Univ. of Hong Kong, Hong Kong; [6]Swinburne Univ. of Technology, Australia.* Exploiting a single figure-eight laser configuration that uses a highly nonlinear on-chip spiral waveguide, we experimentally demonstrate several mode-locking dynamics. We adjust the mode-locking pulse profiles in a controlled manner by varying the polarization.

FTh1F • Novel Phenomena in van der Waals Heterostructure—Continued

FTh1F.4 • 09:00
Designer Photocurrents, Perry T. Mahon[2], Rodrigo A. Muniz[3,1], John E. Sipe[2]; *[1]Univ. of Toronto, Canada; [2]Dept. of Physics, Univ. of Toronto, Canada; [3]Univ. of Michigan, USA.* Using transition metal dichalcogenides as an example, we show that the coherent control of injected carriers via 2- and 3-photon absorption processes leads to controllable, highly localized carrier distributions in the Brillouin zone.

FTh1F.5 • 09:15
Enhanced Luminescence of MoS_2, WS_2 and WSe_2, Direct Band Gap Semiconductor Heterostructures, Jin-Kyu So[1], Shoujun Zheng[1], Fucai Liu[2], Zheng Liu[2], Nikolay I. Zheludev[1,3], Hong Jin Fan[1,4]; *[1]Centre for Disruptive Photonic Technologies, TPI, SPMS, Nanyang Technological Univ., Singapore; [2]School of Materials Science and Engineering, Nanyang Technological Univ., Singapore; [3]Optoelectronics Research Centre & Centre for Photonic Metamaterials, Univ. of Southampton, UK; [4]Division of Physics and Applied Physics, School of Physical and Mathematical Sciences, Nanyang Technological Univ., Singapore.* We introduce van der Waals heterostructures to amplify the otherwise negligible cathodoluminescence from monolayer transition metal dichalcogenides, which allowed to visualize the nanoscale variation of strain and photonic modes in the monolayer on engineered surfaces.

FTh1F.6 • 09:30
Suppression of Excitonic Absorption by Thickness Variation in Few-layer GaSe, Arne Budweg[1], Dinesh Yadav[1,2], Alexander Grupp[1], Alfred Leitenstorfer[1], Maxim Trushin[1,3], Fabian Pauly[1,2], Daniele Brida[1]; *[1]Dept. of Physics and Center for Applied Photonics, Univ. of Konstanz, Germany; [2]Okinawa Inst. of Science and Technology Graduate Univ., Japan; [3]Centre for Advanced 2D Materials, National Univ. of Singapore, Singapore.* We study the optical absorption of GaSe via sensitive differential transmission measurements while controlling the sample thickness with individual layer precision. Below a critical value of eight layers, suppression of the excitonic transitions is observed.

FTh1F.7 • 09:45
Photon Correlation of Photoluminescence Emission of a Monolayer WS_2, Jiahui Huang[1], Ibrahim Sarpkaya[2], Jinkang Lim[1], Sung-Joon Lee[1], Xiangfeng Duan[1], Chee Wei Wong[1], Han Htoon[2]; *[1]Univ. of California, Los Angeles, USA; [2]Los Alamos National Lab, USA.* We observed the photon bunching of photoluminescence emission from a Tungsten disulfide monolayer by photon correlation measurements. The mixture of spectral diffusion and thermal light emission is considered to explain the bunching signature.

10:00–15:00 Exhibition Open, *Exhibit Hall*

10:15–13:00 Technology Transfer Program, *Exhibit Hall Theater*

10:00–11:30 Coffee Break & Exhibit Only Time, *Exhibit Hall*

Executive Ballroom 210G

Executive Ballroom 210H

Meeting Room 211 B/D

CLEO: QELS-Fundamental Science

CLEO: Science & Innovations

FTh1G • Integrated Quantum Sources—Continued

FTh1G.5 • 09:00
Indistinguishable Photon-Pairs from Pure and Bright Silicon Micro-ring Resonator Sources, Imad Faruque[1], Daniel M. Llewellyn[1], Yunhong Ding[2,3], Stefano Paesani[1], Raffaele Santagati[1], Damien Bonneau[1], Gary Sinclair[1], Davide Bacco[2,3], Karsten Rottwitt[2,3], Leif K. Oxenlowe[2,3], Jeremy O'Brien[1], Jianwei Wang[1], John Rarity[1], Mark G. Thompson[1]; [1]*Univ. of Bristol, UK;* [2]*Dept. of Photonics Engineering, Technical Univ. of Denmark, Denmark;* [3]*Center for Silicon Photonics for Optical Communication (SPOC), Technical Univ. of Denmark, Denmark*. We report on-chip interference fringes of very high visibility 89% from heralded single photons from separate ultra-bright silicon micro-ring resonator sources as 4-fold coincidences. The reconfigurable chip is also used to measure multipair fringes and conditional $g^{(2)}(0)$ of single photons.

FTh1G.6 • 09:15
Percolation Based Cluster State Generation by Photon-Mediated Entanglement, Mihir Pant[1], Hyeongrak Choi[1], Saikat Guha[2], Dirk Englund[1]; [1]*MIT, USA;* [2]*Optical Sciences, Univ. of Arizona, USA*. We present an architecture for creating large entangled cluster states for quantum computing and simulation with nitrogen vacancy centers in diamond within the experimentally demonstrated coherence time using percolation theory.

FTh1G.7 • 09:30
Generation and Manipulation of Multi-Photon Entangled States on a Silicon Photonic Device, Daniel M. Llewellyn[1], Yunhong Ding[2,3], Imad Faruque[1], Stefano Paesani[1], Raffaele Santagati[1], Jake Kennard[1], Davide Bacco[2,3], Karsten Rottwitt[2,3], Leif K. Oxenlowe[2,3], Jeremy L. O'Brien[1], Jianwei Wang[1], Mark G. Thompson[1]; [1]*Univ. of Bristol, UK;* [2]*Dept. of Photonics Engineering, Technical Univ. of Denmark, Denmark;* [3]*Center for Silicon Photonics for Optical Communication, Technical Univ. of Denmark, Denmark*. We experimentally demonstrate the generation and manipulation of entangled photons-pairs from an array of bright and pure photon micro-ring sources, and realise the teleportation of unknown quantum states on a reconfigurable silicon photonic quantum device.

FTh1G.8 • 09:45
Integrated silicon nitride time-bin entanglement circuits, Xiang Zhang[1], Bryn A. Bell[1], Andri Mahendra[1], Chunle Xiong[1], Philip Leong[1], Benjamin J. Eggleton[1]; [1]*Univ. of Sydney, Australia*. Time-bin entangled states are generated and analyzed in an integrated silicon nitride chip. Quantum state tomography indicates 91% fidelity to the ideal state, demonstrating its potential for applications in quantum communication networks.

FTh1H • Quantum Interference, Imaging and Spectroscopy—Continued

FTh1H.5 • 09:00
Randomness Extraction From Chsh Violation Without Fair Sampling Assumptions With A Continuous Wave Source, Alessandro Cerè[1], Lijiong Shen[1,2], Jianwei Lee[1], Le Phuc Thinh[1], Jean-Daniel Bancal[3], Valerio Scarani[1], Christian Kurtsiefer[1,2]; [1]*Centre for Quantum Technologies, NUS, Singapore;* [2]*Dept. of Physics, National Univ. of Singapore, Singapore;* [3]*Dept. of Physics, Univ. of Basel, Switzerland*. We demonstrate a detection loophole-free Bell violation using a photonic system based on a continuous wave source, and show that it allows to increase the randomness generation rate compared to pulsed systems.

FTh1H.6 • 09:15
Quantum Interference in a Room Temperature InAs/InP Quantum Dot Semiconductor Optical Amplifier, Igor Khanonkin[1], Akhilesh K. Mishra[1], Ouri Karni[2], Johann P. Reithmaier[3], Gadi Eisentein[1]; [1]*Technion- Israel Inst. of Technology, Israel;* [2]*Stanford Univ., USA;* [3]*Univ. of Kassel, Germany.* Ramsey interference were observed in an inhomogeneously broadened InAs/InP quantum dot semiconductor optical amplifier operating at room temperature. The imprint of the Ramsey fringes on pulse intensity, phase and temporal position were demonstrated.

FTh1H.7 • 09:30
Quasimomentum Distribution and Free Expansion of an Anyonic Gas, Tena Dubček[1], Bruno Klajn[1], Robert Pezer[2], Hrvoje Buljan[1], Dario Jukić[3]; [1]*Dept. of Physics, Faculty of Science, Univ. of Zagreb, Croatia;* [2]*Faculty of Metallurgy, Univ. of Zagreb, Croatia;* [3]*Faculty of Civil Engineering, Univ. of Zagreb, Croatia*. We point out that the momentum distribution is not a proper observable for anyons in two dimensions. We define the quasimomentum distribution as the asymptotic single-particle density after free expansion (time-of-flight measurements), as a means to measure the anyonic statistics.

STh1I • Novel Fabrication Methods—Continued

STh1I.4 • 09:00
In-situ "Point-and-Shoot" Fabrication of Metallic Rings for Mid-IR/Visible Sensing , Bharath Bangalore Rajeeva[1], Zilong Wu[1], Andrew F. Briggs[1], Palash V. Acharya[1], Vaibhav Bahadur[1], Seth Bank[1], Yuebing Zheng[1]; [1]*The Univ. of Texas at Austin, USA*. We utilize "point-and-shoot" strategy to achieve single-step fabrication of silver ring arrays from its precursor ink within spatially-constrained environments. We further utilize the substrates to demonstrate dual-mode sensing in mid-IR and visible regimes.

STh1I.5 • 09:15
Template assisted dewetting of optical glasses for large area, flexible and stretchable all dielectric metasurfaces, Tapajyoti Das Gupta[1], Louis Martin-Monier[1], Arthur Lebris[1], Wei Yan[1], Tùng Nguyen[1], Alexis Page[1], Yunpeng Qu[1], fabien sorin[1]; [1]*Ecole Polytechnique Federale de Lausanne, Switzerland*. We propose for the first time template-assisted dewetting of high-index chalcogenide glasses for low-cost manufacturing of all-dielectric metasurfaces on large-area flexible and stretchable substrates.

STh1I.6 • 09:30
Centimeter-scale Superfine 3D Printing, Wei Chu[1], Yuanxin Tan[1], Jintian Lin[1], Jinping Yao[1], Ya Cheng[1,2]; [1]*Shanghai Inst of Optics & Fine Mechanics, China;* [2]*School of Physics and Materials Science, East China Normal Univ., China*. We present a method based on simultaneous spatiotemporal focusing (SSTF) of the femtosecond laser pulses that enables to fabricate 3D structures on the centimeter scale with TPP. Several Centimeter-scale structures were fabricated using this method.

STh1I.7 • 09:45
On-demand lens fabrication by liquid phase molding with gallium and Polydimethylsiloxane, Keisuke Nakakubo[1], Hiroaki Nomada[1], Hiroaki Yoshioka[1], Kinichi Morita[2], Yuji Oki[1]; [1]*Kyushu Univ., Japan;* [2]*Ushio.Inc, Japan*. A new on-demand lens fabrication with gallium molding was proposed and demonstrated. A convex and concave surface of liquid gallium is transferred to Polydimethylsiloxane. The curvature can be controlled between ±0.37 mm^{-1}

10:00–15:00 Exhibition Open, *Exhibit Hall*

10:15–13:00 Technology Transfer Program, *Exhibit Hall Theater*

10:00–11:30 Coffee Break & Exhibit Only Time, *Exhibit Hall*

Meeting Room 212 A/C

CLEO: Science & Innovations

STh1J • OCT & Biomedical Imaging—Continued

STh1J.2 • 09:00
Multimodal deep tissue imaging using Wavelength Modulated Spatially Offset Raman Spectroscopy and Optical Coherence Tomography, Mingzhou Chen[1], Josep Mas[1], Lindsey H. Forbes[2], Melissa Andrews[3], Kishan Dholakia[1]; [1]*School of Physics and Astronomy, Univ. of St Andrews, UK;* [2]*Scho, Univ. of St Andrews, UK;* [3]*Biological Sciences, Univ. of Southampton, UK.* We demonstrate a multimodal system integrating optical coherence tomography (OCT) with wavelength modulated spatially offset Raman spectroscopy. This has the capability to detect co-registered Raman and OCT signals from targets deeply embedded in tissue.

STh1J.3 • 09:15
Non-Iterative Holographic Image Reconstruction and Phase Retrieval Using a Deep Convolutional Neural Network, Yair Rivenson[1], Yibo Zhang[1], Harun Günaydin[1], Da Teng[1], Aydogan Ozcan[1]; [1]*Univ. of California Los Angeles, USA.* We demonstrate a non-iterative holographic image reconstruction and phase retrieval framework based on deep learning. After its training, a deep convolutional neural network rapidly recovers phase and amplitude images of specimen from a single hologram.

STh1J.4 • 09:30
Chip-Based Frequency Combs for High-Resolution Optical Coherence Tomography, Xingchen Ji[1,2], Alexander Klenner[1], Xinwen Yao[1], Yu Gan[1], Alexander L. Gaeta[1], Christine Hendon[1], Michal Lipson[1]; [1]*Columbia Univ., USA;* [2]*Cornell Univ. , USA.* We present a source for OCT based on chip-scale microresonators for sub-micrometer axial resolution and deep tissue penetration. Using the microresonators, we acquire OCT images of human tissue and show compatibility with standard OCT systems.

STh1J.5 • 09:45
High-throughput 3D Tracking of Sperm Locomotion Reveals Head Spin and Flagellar Beating Patterns, Mustafa Daloglu[1], Wei Luo[1], Faizan Shabbir[1], Francis Lin[1], Kevin Kim[1], Inje Lee[1], Jiaqi Jiang[1], Wenjun Cai[1], Vishwajith Ramesh[1], Mengyuan Yu[1], Aydogan Ozcan[1]; [1]*Univ. of California, Los Angeles, USA.* Dual-view on-chip holographic imaging enabled high-throughput tracking of the complete 3D locomotion of bovine sperms, including the translational and rotational (i.e., spin) motion of the sperm head and the 3D beating of the flagellum.

Meeting Room 212 B/D

CLEO: QELS-Fundamental Science

FTh1K • Optical Near-field and Thermal Imaging—Continued

FTh1K.5 • 09:00
Sum rules & power–bandwidth limits to near-field optical response, Hyungki Shim[1,2], Lingling Fan[1,3], Steven Johnson[4], Owen Miller[1]; [1]*Dept. of Applied Physics and Energy Sciences Inst., Yale Univ., USA;* [2]*Dept. of Physics, Yale Univ., USA;* [3]*School of Physics and National Lab of Solid State Microstructures, Nanjing Univ., China;* [4]*Dept. of Mathematics, MIT, USA.* We not only derive a sum rule for near-field optical response integrated over all frequencies, but also establish a general framework yielding a geometry-independent limit on bandwidth-averaged response, which we call the power–bandwidth limit.

FTh1K.6 • 09:15
Imaging of Ultra-Confined Phonon Polaritons in Hexagonal Boron Nitride on Gold, Antonio Ambrosio[2,3], Michele Tamagnone[1], Kundan Chaudhary[1], Luis Jauregui[3], Philip Kim[3], William L. Wilson[2], Federico Capasso[1]; [1]*School of Engineering and Applied Sciences, Harvard Univ., USA;* [2]*Center for Nanoscale Physics, Harvard Univ., USA;* [3]*Dept. of Physics, Harvard Univ. , USA.* We investigated infrared phonon polariton on thin hexagonal boron nitride flakes on gold. We successfully imaged ultraslow guided modes in both restrahlen bands, using photo-induced force microscopy and scattering type near field scanning optical microscopy

FTh1K.7 • 09:30
Ultrasensitive localization of plasmonic nanoparticles by dual optical lock-in interferometric imaging and photothermal excitation, Seweryn Morawiec[1], Patrycjusz Stremplewski[2,1], Maciej Wojtkowski[2,1], Ireneusz Grulkowski[1]; [1]*Inst. of Physics, Nicolaus Copernicus Univ., Poland;* [2]*Inst. of Physical Chemistry, Polish Academy of Sciences, Poland.* Dual optical lock-in (DOLI) interferometric imaging method allowing for simultaneous detection of scattering and absorption depth profiles is proposed and used for highly sensitive localization of gold nanorods in colloidal solution via photothermal excitation.

FTh1K.8 • 09:45
Thermoreflectance Imaging of Optically Pumped Gap Plasmon Structures, Di Wang[1,2], Kerry Maize[1,2], Maowen Song[2,3], Alexandra Boltasseva[1,2], Vladimir M. Shalaev[1,2], Ali Shakouri[1,2], Alexander Kildishev[1,2]; [1]*Electrical and Computer Engineering, Purdue Univ., USA;* [2]*Birck Nanotechnology Center, Purdue Univ., USA;* [3]*Key Lab of Optoelectronic Technology and Systems of Education Ministry of China, Chongqing Univ., China.* We developed a fast, high-resolution thermoreflectance imaging-based technique to map the temperature distribution of gap plasmon structures subject to laser irradiation, and observed 120 K temperature rise with 3 mW/μm^2 irradiance.

Marriott Salon I & II

CLEO: Science & Innovations

STh1L • MIR to the THz Dual Combs—Continued

STh1L.4 • 09:00
Dual-comb spectroscopy in the spectral fingerprint region using OPGaP optical parametric oscillators, Oguzhan Kara[1], Luke Maidment[1], Tom Gardiner[2], Peter G. Schunemann[3], Derryck T. Reid[1]; [1]*Heriot-Watt Univ., UK;* [2]*National Physical Lab (NPL), UK;* [3]*BAE Systems, Inc., USA.* Dual-comb spectroscopy using OPGaP optical parametric oscillators is demonstrated with cross-correlation-based spectral averaging to obtain high-fidelity spectra of H_2O and CH_4 at approximately 0.3 cm^{-1} resolutions from 1285–1370 cm^{-1} and 1500–1585 cm^{-1}.

STh1L.5 • 09:15
Quantum Cascade Laser-based Dual-Comb Spectroscopy in the Mid-infrared, Jonas Westberg[1], Lukasz A. Sterczewski[1,2], Filippos Kapsalidis[3], Yves Bidaux[3], Johanna Wolf[3], Mattias Beck[3], Jérôme Faist[3], Gerard Wysocki[1]; [1]*Dept. of Electrical Engineering, Princeton Univ., USA;* [2]*Faculty of Electronics, Wroclaw Univ. of Science and Technology, Poland;* [3]*Institut für Quantenelektronik, ETH Zürich, Switzerland.* We demonstrate sub-millisecond response time dual-comb spectroscopy using quantum cascade lasers by measurements of Bromomethane and Freon 134a around 7.7 μm. The system achieves a noise-equivalent absorption of <1x10^{-3} Hz$^{-1/2}$ and an optical bandwidth of ~25 cm^{-1}.

STh1L.6 • 09:30
Massively Parallel Detection of Trace Molecules in a Mixture With An Ultra-Broadband Mid-IR Subharmonic Dual Comb, Andrey Muraviev[1], Viktor O. Smolski[2], Zachary E. Loparo[1], Konstantin L. Vodopyanov[1]; [1]*Univ. of Central Florida, CREOL, USA;* [2]*Mid-Infrared Lasers, IPG Photonics, USA.* We use a pair of highly-coherent GaAs subharmonic OPOs with instantaneous span 3.1-5.5 μm to demonstrate fast acquisition of 350,000 mode-resolved spectral data points and perform parallel detection in a mixture of 22 molecular species

10:00–15:00 Exhibition Open, *Exhibit Hall*

10:15–13:00 Technology Transfer Program, *Exhibit Hall Theater*

10:00–11:30 Coffee Break & Exhibit Only Time, *Exhibit Hall*

Marriott Salon III

CLEO: QELS-Fundamental Science

FTh1M • Nonlinear Dynamics in Resonators and Fibers—Continued

FTh1M.5 • 09:00
Harmonic dissipative soliton resonance passively mode-locked fiber laser, Georges Semaan[1], Alioune Niang[1], Mohamed Salhi[1], François Sanchez[1]; [1]*Laboratoire de Photonique d'Angers, France*. We experimentally demonstrate for the first time a harmonic mode-locked dissipative soliton resonance square pulses fiber oscillator. High energy stable pulses up to the 13th order of harmonic have been obtained without wave-breaking.

FTh1M.6 • 09:15
Diverse Solitons Interactions in the Formation of Dissipative Optical Soliton Molecules, Junsong Peng[1], Heping Zeng[1]; [1]*East China Normal Univ., China*. Using real-time measurement techniques, we firstly unveil four nonlinear stages in the build-up of soliton molecules in an ultrafast fiber laser, which are modulation instability, mode locking, soliton fission and diverse solitons interactions.

FTh1M.7 • 09:30
Demonstration of Spatial Riemann Waves and Inviscid Burgers'Equation Dynamics in Nonlinear Optics, Domenico Bongiovanni[1], Benjamin Wetzel[2], Yi Hu[3], Pengzhen Yang[3], Yujie Qiu[3], Jingjun Xu[3], Stefan Wabnitz[5], Zhigang Chen[4,3], Roberto Morandotti[1]; [1]*INRS, Canada;* [2]*School of Mathematical and Physical Sciences, Univ. of Sussex, UK;* [3]*TEDA Applied Physics Inst. and School of Physics, Nankai Univ., China;* [4]*Dept. of Physics & Astronomy, San Francisco State Univ., USA;* [5]*Dipartimento di Ingegneria dell'Informazione, Università degli Studi di Brescia, Italy*. We report on observation of spatial Riemann wave dynamics in a nonlinear m-cresol/nylon thermal solution, obtained by properly tailoring the initial optical beam. Experimental results show controllable steepening and shock formation, in good agreement with theory.

FTh1M.8 • 09:45
Observation of a Period-doubling Dynamics of the Modulation Instability Induced Temporal Pattern in a Dispersion Oscillating Fiber-ring Cavity, Francois Copie[1], Matteo Conforti[2], Alexandre Kudlinski[1], Stefano Trillo[3], Arnaud Mussot[1]; [1]*PhLAM, France;* [2]*CNRS, France;* [3]*Dept. of Engineering, Univ. of Ferrara, Italy*. We provide a clear demonstration of a period-doubling phenomenon associated to the modulation instability in dispersion oscillating fiber cavities. This has been done by performing roundtrip-to-roundtrip measurements of the temporal pattern generated through the instability.

Marriott Salon IV

CLEO: Science & Innovations

STh1N • Ultrafast Applications—Continued

STh1N.2 • 09:00
1 MHz Ultrafast Cascaded VUV Generation in Negative Curvature Hollow Fibers, Sterling J. Backus[1]; [1]*KMLabs, USA*. We demonstrate 3 tier cascaded harmonic generation to 9th harmonic (115nm) of 1040nm in a negative curvature hollow fiber filled with Xenon gas at a 1MHz repetition rate.

STh1N.3 • 09:15
High Photon Flux XUV Source Driven by Few Cycle Pulses from a Bandwidth-Optimized High Energy Yb-Doped Fiber Amplifier at 1.03 µm, Aura I. Gonzalez[2,1], Loïc Lavenu[2,3], Florent Guichard[3], Yoann Zaouter[3], Patrick Georges[2], Marc Hanna[2], Thierry Ruchon[4]; [1]*Amplitude Technologies, France;* [2]*Laboratoire Charles Fabry, Institut d'Optique Graduate School, France;* [3]*Amplitude Systemes, France;* [4]*LIDYL, CEA, CNRS, Université Paris-Saclay, France*. We report on the advantage of high harmonic generation XUV source driven by a high repetition rate few-cycle ytterbium-doped fiber-laser. We achieve a photon energy cutoff of 140 eV with photon flux of 10^{12} photons/s/eV.

STh1N.4 • 09:30
Photon-Induced Near-Field and Far-Field Electron Microscopy, Kangpeng Wang[1], Giovanni M. Vanacore[2], Enrico Pomarico[2], Ivan Madan[2], Gabriele Berruto[2], Francisco Javier García de Abajo[3,4], Ido Kaminer[1], Fabrizio Carbone[2]; [1]*Faculty of Electrical Engineering, Technion - Israel Inst. of Technology, Israel;* [2]*École Polytechnique Fédérale de Lausanne (EPFL), Switzerland;* [3]*The Barcelona Inst. of Science and Technology, Spain;* [4]*ICREA - Institució Catalana de Recerca i Estudis Avançats, Spain*. We present developments in the technique of photo-induced near-field electron microscopy (PINEM). We image the electron interaction with a far-field plane wave reflected from a mirror, and with the near-field resonance of a plasmonic nanowire.

STh1N.5 • 09:45
Ultrafast spectro-temporal analyzer for the multi-scale laser dynamics studies, Ying Yu[1], Bowen Li[1], Xiaoming Wei[2], Chi Zhang[3], Kevin K. Tsia[1], Kenneth Kin-Yip Wong[1]; [1]*Univ. of Hong Kong, Hong Kong;* [2]*California Inst. of Technology, USA;* [3]*Huazhong Univ. of Science and Technology, China*. We propose a real-time optical spectro-temporal analyzer (ROSTA), which simultaneously provides single-shot temporal and spectral information for multiple time-scale radiance. By using ROSTA, new complex dynamic phenomena during the birth of passive mode-locking is observed.

Marriott Salon V

CLEO: Applications & Technology

ATh1O • Trace Gas Detection—Continued

ATh1O.5 • 09:00
A new Method to Determine the Resonance Frequency in QEPAS, Philipp Breitegger[1], Benjamin Lang[1], Alexander Bergmann[1]; [1]*TU Graz, Austria*. We present a novel method to determine the resonance frequency and Q factor of a quartz tuning fork (QTF) in quartz-enhanced photoacoustic spectroscopy (QEPAS) in a few seconds. A CHIRP modulates a laser diode.

ATh1O.6 • 09:15
GaSb Diode Lasers for QEPAS Sensor Applications, Tobias Milde[1], Morten Hoppe[1,2], Herve Tatenguem Fankem[1], Wolfgang Schade[3], Joachim Sacher[1]; [1]*Sacher Lasertechnik GmbH, Germany;* [2]*Technische Hochschule Mittelhessen, Germany;* [3]*Technische Universität Clausthal, Germany*. Newly developed tunable single mode laser diodes based on GaSb material system in the wavelength range 1.6 µm ≤ λ ≤ 4 µm are combined with the QEPAS technique for trace gas detection.

ATh1O.7 • 09:30
Fiber Laser Intracavity Quartz-Enhanced Photoacoustic Gas Sensor, Qiang Wang[1], Zhen Wang[1], Pietro Patimisco[2], Angelo Sampaolo[2], Vincenzo Spagnolo[2], Wei Ren[1]; [1]*The Chinese Univ. of Hong Kong, Hong Kong;* [2]*Politecnico di Bari , Italy*. We report a novel photoacoustic trace gas sensor by using a custom-designed quartz tuning fork inside a fiber ring laser cavity for sensitive gas detection with a large dynamic range.

ATh1O.8 • 09:45
Sub-Parts-Per-Trillion Sensitivity in Trace Gas Detection by Cantilever-Enhanced Photo-Acoustic Spectroscopy, Teemu Tomberg[1], Markku M. Vainio[1,2], Tuomas Hieta[3], Lauri Halonen[1]; [1]*Dept. of Chemistry, Univ. of Helsinki, Finland;* [2]*Lab of Photonics, Tampere Univ. of Technology, Finland;* [3]*Gasera Ltd., Finland*. We report a simple cantilever-enhanced photoacoustic detector, which reaches exceptionally good sensitivity in trace gas detection of hydrogen fluoride by using a highly stable narrow-linewidth optical parametric oscillator at 2.476 µm.

10:00–15:00 Exhibition Open, *Exhibit Hall*

10:15–13:00 Technology Transfer Program, *Exhibit Hall Theater*

10:00–11:30 Coffee Break & Exhibit Only Time, *Exhibit Hall*

Marriott Salon VI

CLEO: QELS-Fundamental Science

FTh1P • Engineering and Metrology of Thermal Radiation—Continued

FTh1P.2 • 09:00
Demonstration of On-Chip Thermocouple Photodetector in Infrared Regime through Field Enhancement by Plasmonic Nano Focusing, Orian Keneth[1], P. Arora[1], Noa Mazurski[1], Uriel Levy[1]; [1]*Applied Physics, Hebrew Univ. of Jerusalem, Israel.* On-chip thermocouple photodetector is realized for near infrared regime. Conversion of electromagnetic field to heat was performed through plasmonic mode which leads to joule heating at the metal. The responsivity of the device is 32±1mV/W.

FTh1P.3 • 09:15 Invited
Thermal Homeostasis and Hybrid Optothermal Logic, Michelle L. Povinelli[1], Ahmed Morsy[1], Shao-Hua Wu[1], Mingkun Chen[1], Michael Barako[2], Vladan Jankovic[2], Philip W. Hon[2], Luke Sweatlock[2]; [1]*Univ. of Southern California, USA;* [2]*NG Next, Northrop Grumman Corporation, USA.* We exploit the co-design of optical and thermal properties for microphotonic applications. We design a material that passively regulates its temperature by switching on/off its thermal emission. We experimentally demonstrate a hybrid optothermal logic device.

FTh1P.4 • 09:45
Single-molecule Thermometry by Carbon Nanotube Excitons Coupled to Plasmonic Nanocavities, Yue Luo[1,4], Ehsaneh D. Ahmadi[1], Kamran Shayan[1,4], Yichen Ma[1,4], Kevin S. Mistry[2], Changjian Zhang[3], James Hone[3], Jeffrey L. Blackburn[2], Stefan Strauf[1,4]; [1]*Dept. of Physics, Stevens Inst. of Technology, USA;* [2]*National Renewable Energy Lab, USA;* [3]*Dept. of Mechanical Engineering, Columbia Univ., USA;* [4]*Center for Quantum Science and Engineering, USA.* In a unique interplay of excitons, phonons, and plasmons, we demonstrate plasmonic thermometry at the single-molecule level by detecting the plasmonically induced heat from SWCNT excitons coupled to plasmonic nanocavity arrays.

Marriott Willow Glen

CLEO: Applications & Technology

ATh1Q • A&T Topical Review on Neurophotonics I—Continued

ATh1Q.2 • 09:00
Ultrasonic Guiding and Steering of Light in Scattering Tissue , Matteo Giuseppe Scopelliti[1], Maysam Chamanzar[1]; [1]*Carnegie Mellon Univ., USA.* We present a novel technique for guiding and steering photons in multiply scattering brain tissue by using ultrasound waves to sculpt refractive index contrast profiles that define and control the trajectory of light within tissue.

ATh1Q.3 • 09:30
Spectral Multiplexing of Optogenetic Switch by Stimulated Emission Depletion Quenching, Alexei Goun[1]; [1]*Princeton Univ., USA.* We demonstrate that stimulated emission depletion quenching allows for higher fidelity control of optogenetic switching

ATh1Q.4 • 09:45
Attojoule Modulators for Photonic Neuromorphic Computing, Rubab Amin[1], Jonathan George[1], Jacob Khurgin[2], Tarek El-Ghazawi[1], Paul R. Prucnal[3], Volker J. Sorger[1]; [1]*George Washington Univ. , USA;* [2]*Johns Hopkins Univ., USA;* [3]*Princeton Univ., USA.* We show how the nonlinear transfer function of electrooptic modulators enables vector matrix multiplications of photonic neural networks. Here the modulators energy-per-bit function and signal-to-noise ratio are critical factors impacting system performance.

10:00–15:00 Exhibition Open, *Exhibit Hall*

10:15–13:00 Technology Transfer Program, *Exhibit Hall Theater*

10:00–11:30 Coffee Break & Exhibit Only Time, *Exhibit Hall*

11:30–13:00 JTh2A • Poster Session III

JTh2A.1
Limits on manipulating conditional photon statistics of lasers via interference and post-selections, Kang-Hee Hong[1], Jisung Jung[2], Young-Wook Cho[2], Sang-Wook Han[2], Sung Moon[2], Kyunghwan Oh[3], Yong-Su Kim[2], Yoon-Ho Kim[1]; [1]*Pohang Univ of Sci & Tech (POSTECH), South Korea;* [2]*Korea Inst. of Science and Technology (KIST), South Korea;* [3]*Yonsei Univ., South Korea.* Recently it has been reported that photon anti-bunching can be obtained via interference of lasers. We provide counter-evidence by theoretical analysis on the limits of manipulating conditional photon statistics of lasers via interference and post-selections.

JTh2A.2
Photon-Pair State Engineering in Raman-Mediated Four-Wave Mixing, Kai B. Shinbrough[1], Bin Fang[1], Yanting Teng[1], Yujie Zhang[1], Offir Cohen[1], Virginia O. Lorenz[1]; [1]*Univ. of Illinois Urbana-Champaign, USA.* Towards delayed-choice generation of single photons in pure quantum states, we measure and model the purity of Stokes photons scattered from sapphire, measuring a maximum purity of 0.99±0.03 and high quantum correlation with anti-Stokes photons.

JTh2A.3
Mechanically Tunable Photonic Crystal Cavity with High Quality Factor and Small Mode Volume, Xiruo Yan[1,2], Jingda Wu[1,2], Ryan Watt[1], Megan Nantel[1], Lukas Chrostowski[2,3], Jeff Young[1,2]; [1]*Physics and Astronomy, Univ. of British Columbia, Canada;* [2]*Stewart Blusson Quantum Matter Inst., Canada;* [3]*Electrical and Computer Engineering, Univ. of British Columbia, Canada.* A fractured planar photonic crystal microcavity is designed to be mechanically tunable while maintaing a quality factor of >1x10^5, and a mode volume ~0.3 $(\lambda/n)^3$. Its optomechanical coefficient is ~15GHz/nm, at mid-IR wavelengths.

JTh2A.4
Sorting Laguerre-Gaussian modes by radial quantum number, Yiyu Zhou[1], Mohammad Mirhosseini[1], Dongzhi Fu[1,2], Jiapeng Zhao[1], Seyed Mohammad Hashemi Rafsanjani[1], Alan E. Willner[3], Robert Boyd[1,4]; [1]*The Inst. of Optics, Univ. of Rochester, USA;* [2]*Key Lab for Quantum Information and Quantum Optoelectronic Devices, Dept. of Applied Physics, Xi'an Jiaotong Univ., China;* [3]*Dept. of Electrical Engineering, Univ. of Southern California, USA;* [4]*Dept. of Physics, Univ. of Ottawa, Canada.* An efficient sorter based on the fractional Fourier transform is realized to detect the radial quantum number of the Laguerre-Gaussian modes. The reported scheme can, in principle, have unit efficiency and no cross-talk.

JTh2A.5
Sub-Poissonian Twin-Beam Correlations at Blue and Red Wavelengths from Four-Wave Mixing, Jason D. Mueller[4,1], Alex McMillan[1], Paul-Antoine Moreau[3], Javier Sabines-Chesterking[1], John Rarity[1], Peter J. Mosley[2], Jonathan Matthews[1]; [1]*Quantum Engineering Technology Labs, Univ. of Bristol, UK;* [2]*Centre for Photonics and Photonic Materials, Univ. of Bath, UK;* [3]*School of Physics and Astronomy, Univ. of Glasgow, UK;* [4]*Quantum Engineering Centre for Doctoral Training, Univ. of Bristol, UK.* We demonstrate sub-Poissonian intensity correlations of twin beams at short wavelengths: 442nm and 665nm. The beams are generated via four-wave mixing in photonic crystal fiber, measured with a CCD camera.

JTh2A.6
Towards a Waveguide-based Single Photon Detector for Integrated Quantum Photonics Platforms, Salih Yanikgonul[1,2], Jun Rong Ong[3], Victor Leong[1], Leonid Krivitskiy[1]; [1]*Advanced Concepts and Nanotechnology, Data Storage Inst. (DSI) of A*STAR, Singapore;* [2]*Centre for Disruptive Photonic Technologies, Nanyang Technological Univ., Singapore;* [3]*Electronics and Photonics, Inst. of High Performance Computing, Singapore.* We design a waveguide-based Geiger-mode silicon single-photon avalanche diode (SPAD), optimized for visible wavelengths. We simulate photon detection efficiency and timing jitter with 2D Monte Carlo simulator for SPADs with different widths and bias voltages.

JTh2A.7
Ghost Imaging with Paired X-ray Photons, Aviad Schori[1,2], Denis Borodin[1,2], Kenji Tamasaku[2], Sharon Shwartz[1,2]; [1]*Bar-Ilan Univ., Israel;* [2]*RIKEN SPring-8 Center, Japan.* We observed of ghost imaging with parametrically down-converted x-ray photons pairs. We reconstructed the image of slits with nominally zero background levels. Our procedure can lead to the observation of quantum phenomena at x-ray wavelengths.

JTh2A.8
Photon-Number Resolution in Conventional Superconducting Nanowire Single-Photon Detectors: Theoretical Predictions, Kathryn Nicolich[1], Clinton T. Cahall[2], Nurul T. Islam[3], Gregory P. Lafyatis[1], Jungsang Kim[2,4], Daniel J. Gauthier[1]; [1]*Dept. of Physics, Ohio State Univ., USA;* [2]*Dept. of Electrical and Computer Engineering, Duke Univ., USA;* [3]*Dept. of Physics, Duke Univ., USA;* [4]*IonQ Inc., USA.* We demonstrate theoretically that a conventional single-pixel superconducting nanowire single-photon detector can resolve photon number by sensing changes in the rising edge of the electrical readout pulse

JTh2A.9
Passive State Preparation in Continuous Variable Quantum Key Distribution , Bing Qi[1], Phil Evans[1], Warren Grice[1]; [1]*Oak Ridge National Lab, USA.* We propose a passive continuous-variable quantum key distribution scheme, where Alice splits the output of a thermal source into two spatial modes, measures one locally and transmits the other mode to Bob after applying attenuation.

JTh2A.10
Security verification for vacuum fluctuation based quantum random number generator, Arne Kordts[1], Cosmo Lupo[2], Dino Solar[1], Tobias Gehring[1], Ulrik L. Andersen[1]; [1]*Danmarks Tekniske Universitet, Denmark;* [2]*Univ. of York, UK.* We demonstrate a gigahertz source of verifiable quantum random numbers based on homodyne detection of the vacuum state. Using a whitening filter, we generate iid samples with a potential randomness rate of 20Gbit/s.

JTh2A.11
Multipartite Quantum Entanglement and Quantum Correlation from cascaded Four-wave Mixing Processes with spatial multiplexing, Jietai Jing[1], Shuchao Lv[1], Kai Zhang[1], Wei Wang[1], Hailong Wang[1], Jun Xin[1], Leiming Cao[1], Sijin Li[1], Li Wang[1], Jinjian Du[1]; [1]*East China Normal Univ., China.* Four-wave mixing (FWM) process with spatial multiplexing is a promising candidate for building quantum network. We experimentally investigate multipartite quantum correlation and theoretically study multipartite quantum entanglement from cascaded FWM processes.

JTh2A.12
1.064-μm-band Up-conversion Single-photon Detector, Fei Ma[1], Ming-Yang Zheng[2], Quan Yao[3], Xiu-Ping Xie[2], Qiang Zhang[1,3], Jian-Wei Pan[1]; [1]*Hefei National Lab for Physical Sciences at Microscale and Dept. of Modern Physics, Univ. of Science and Technology of China, China;* [2]*Shandong Inst. of Quantum Science and Technology Co., Ltd., China;* [3]*Jinan Inst. of Quantum Technology, China.* We demonstrate an up-conversion single-photon detection at 1.064-μm band using a PPLN waveguide. By employing two kinds of filtering schemes, we achieve the detection efficiency of 32.5% and 38% with noise count rate of 45 cps and 700 cps respectively.

JTh2A.13
Performance Improvement of Discrete-Modulation Continuous-Variable Quantum Key Distribution by Using the Machine-Learning-Based Detector, Jiawei Li[1], Duan Huang[1], Cailang Xie[1], Ling Zhang[1], Ying Guo[1]; [1]*School of Information Science and Engineering, Central South Univ., China.* The discrete-modulation continuous-variable quantum key distribution is proposed using the machine-learning-based detector to preprocess the signal before the reconciliation, which would mitigate the burden of error correction reconciliation and further improve the system performance.

JTh2A.14
Generation of Multi-mode NOON States with Arbitrary N, Lu Zhang[1], Kam Wai C. Chan[1]; [1]*Univ. of Oklahoma, USA.* We present three methods of generating multi-mode NOON states with arbitrary photon number using either coherent states or Fock states along with single photons. Generation probabilities are calculated to show their efficiencies.

JTh2A.15
Experimental Demonstration of a 20-Mbit/s per Channel Free-Space Bi-directional Quantum Communication Link Using Orbital-Angular-Momentum Encoding and Multi-Port Mode Converters, Cong Liu[1], Kai Pang[1], Hao Song[1], Guodong Xie[1], Jiapeng Zhao[2], Yongxiong Ren[1], Haoqian Song[1], Zhe Zhao[1], Runzhou Zhang[1], Long Li[1], Jing Du[1], Seyed Rafsanjani[2], Guillaume Labroille[3], Pu Jian[3], Robert Boyd[2], Moshe Tur[4], Alan E. Willner[1]; [1]*Univ. of Southern California, USA;* [2]*The Inst. of Optics, Univ. of Rochester, USA;* [3]*CAILabs, France;* [4]*School of Electrical Engineering, Tel Aviv Univ., Israel.* We experimentally demonstrate a free-space, bi-directional quantum communication link encoded by two OAM states using multi-port mode converters. We achieve a quantum-symbol-error-rate of ≈ 0.058 for each channel at 20 Mbit/s/channel when OAM mode-spacing is 4.

JTh2A.16
Spectral Resolution of Second-Order Coherence of Broadband Biphotons, Ashutosh Rao[1], Nima Nader[2], Thomas Gerrits[2], Martin J. Stevens[2], Omar S. Magana Loaiza[2], Guillermo Camacho-Gonzalez[1], Jeffrey Chiles[2], Amirmahdi Honardoost[1], Marcin Malinowski[1], Richard Mirin[2], Sasan Fathpour[1]; [1]*CREOL, Univ Central Florida, USA;* [2]*NIST, USA.* We spectrally resolve the second-order coherence of biphoton pairs using a time-of-flight fiber spectrometer. Spectrally resolved coincidence-to-accidental ratios of over 300 are measured using a thin-film lithium niobate waveguide source on a silicon chip.

JTh2A.17
One-Way Noise Measurement of Deployed Optical Fiber for Quantum Networks Using Mode-Locked Lasers, Helena Zhang[1,2], Matthew E. Grein[3], Scott A. Hamilton[3], Issac Chuang[2,1]; [1]*Research Lab of Electronics, MIT, USA;* [2]*Dept. of Physics, MIT, USA;* [3]*Lincoln Lab, MIT, USA.* One-way noise across a 42-km deployed optical fiber link is measured using two different techniques employing referenced mode-locked lasers. We compare the two techniques and assess their suitability for stabilizing the fiber for quantum networks.

JTh2A.18
Determinating Full Parameters of U-Matrix for Reconfigurable Boson Sampling Circuits using Machine Learning, Lingxiao Wan[1], Hui Zhang[1], Jianguo Huang[1], Gong Zhang[1], Leong Chuan Kwek[2], Joseph F. Fitzsimons[3], Yidong Chong[1], Jiangbin Gong[2], Alexander Szameit[4], Xiaoqi Zhou[5], Man-Hong Yung[6], Xianmin Jin[7], Xiaolong Su[8], Wee Ser[1], Weibo Gao[1], Aiqun Liu[1]; [1]*Nanyang Technological Univ., Singapore;* [2]*National Univ. of Singapore, Singapore;* [3]*Singapore Univ. of Technology and Design, Singapore;* [4]*Univ. of Rostock, Germany;* [5]*Sun Yat-sen Univ., China;* [6]*Southern Univ. of Science and Technology, China;* [7]*Shanghai Jiaotong Univ., China;* [8]*Shanxi Univ., China.* A method of tuning a reconfigurable silicon photonic circuit into an arbitrary unitary operator with machine learning was proposed to bypass the traditional phase-voltage calibration process and make the prediction of applied heating voltage directly.

JTh2A.19
Performance analysis of d-dimensional quantum cryptography with mode-dependent diffraction, Jiapeng Zhao[2], Mohammad Mirhosseini[1], Yiyu Zhou[2], Seyed Mohammad Hashemi Rafsanjani[2], Yongxiong Ren[3], Nicholas Steinhoff[4], Glenn Tyler[4], Robert Boyd[2]; [1]*California Inst. of Technology, USA;* [2]*Univ. of Rochester, USA;* [3]*Univ. of Southern California, USA;* [4]*The Optical Science Company, USA.* We analyze the degraded performance of QKD that results from mode-dependent diffraction in spatial-mode-encoded QKD systems. A pre-compensation method is proposed to solve this problem without sacrificing the security.

11:30–13:00 JTh2A • Poster Session III

JTh2A.20
Quantum temporal imaging and gravitational wave detection, Dmitri Horoshko[2,1], Giuseppe Patera[2], Mikhail I. Kolobov[2]; [1]*B. I. Stepanov Inst. of Physics, NASB, Belarus;* [2]*CNRS, UMR 8523 - PhLAM, Univ. of Lille, France*. We study the quantum field evolution in a temporal imaging system, including the vacuum noise due to finite time aperture. We show how the gravitational wave detector signal can be transmitted to a higher frequency.

JTh2A.21
Purification of Photon Subtraction from Continuous Squeezed Light by Filtering, Jun-ichi Yoshikawa[1], Warit Asavanant[1], Akira Furusawa[1]; [1]*Univ. of Tokyo, Japan*. We show that Schrödinger cat states, generated by photon subtraction from squeezed states with conventional continuous-wave methods, have an inherent impurity. Furthermore, we show that the impurity is arbitrarily suppressed by optical filtering.

JTh2A.22
Quantum-Classical Transmission on Single Wavelength, Rupesh Kumar[1], Adrian Wonfor[2], Richard V. Penty[2], Ian White[2]; [1]*Quantum Communication Hub, UK;* [2]*Univ. of Cambridge, UK*. We demonstrate, for the first time, simultaneous generation, transmission and reception of quantum signals and classical signals on a single wavelength. 61.6kbps Quantum key and 590kbps classical data rates are estimated.

JTh2A.23
Quantum monitored long-distance secure optical network, Yupeng Gong[1], Rupesh Kumar[2], Adrian Wonfor[1], Richard V. Penty[1], Ian White[1]; [1]*Univ. of cambridge, UK;* [2]*Univ. of York, UK*. We report a method for monitoring physical layer attacks in optical fiber communication using a modulated quantum signal. This system utilizes the quantum noise of the quadrature components of coherent states to monitor fiber links with quantum sensitivity.

JTh2A.24
High-Speed Quantum Key Distribution with Wavelength-Division Multiplexing on Integrated Photonic Devices, Alasdair Price[1,2], Philip Sibson[1], Chris Erven[1], John Rarity[1], Mark G. Thompson[1]; [1]*Centre for Quantum Photonics, Univ. of Bristol, UK;* [2]*Quantum Engineering Centre for Doctoral Training, Univ. of Bristol, UK*. We experimentally implement a compact and practical solution for wavelength-division multiplexed quantum key distribution using integrated photonics. This increases secret key rates and allows for greater operational flexibility to meet network user requirements.

JTh2A.25
Quantum-Enhanced Optomechanical Magnetometry, Jan Bílek[1], BeiBei Li[2], Ulrich B. Hoff[1], Lars Madsen[2], Stefan Forstner[2], Varun Prakash[2], Clemens Schäfermeier[1], Tobias Gehring[1], Warwick Bowen[2], Ulrik L. Andersen[1]; [1]*Technical Univ. of Denmark, Denmark;* [2]*The Univ. of Queensland, Australia*. Quantum-enhanced measurements of magnetic fields are experimentally demonstrated using a microcavity optomechanical magnetometer and squeezed states of light. We attain an improvement of the magnetic field sensitivity of 20% using 2.2dB phase-squeezed states.

JTh2A.26
Breaking up the Anapole: or How to Separate Toroidal and Electric Dipole Excitations in Matter, Vassili Savinov[1], Wei-Yi Tsai[1,2], Din Ping Tsai[3,2], Nikolay I. Zheludev[1,4]; [1]*Univ. of Southampton, UK;* [2]*Dept. of Physics, National Taiwan Univ., Taiwan;* [3]*Research Center for Applied Sciences, Academia Sinica, Taiwan;* [4]*Centre for Disruptive Photonic Technologies, Nanyang Technological Univ., Singapore*. Increasing interest in electrodynamics and spectroscopy of toroidal excitations in matter has initiated a discussion on independent physical significance of toroidal and electric dipole excitations. Here we introduce three Gedanken-Experiments that reveal their fundamental differences.

JTh2A.27
On-Chip Electro-Mechanical Routing of Single Photons from an Embedded Quantum Emitter, Zofia K. Bishop[1], Andrew P. Foster[1], Benjamin Royall[1], Christopher Bentham[1], Ed Clarke[2], Maurice S. Skolnick[1], Luke R. Wilson[1]; [1]*Physics and Astronomy, The Univ. of Sheffield, UK;* [2]*Electronic and Electrical Engineering, The Univ. of Sheffield, UK*. We demonstrate on-chip routing of single photons using a III-V semiconductor-based electro-mechanical system with embedded quantum dots. Switching is achieved by electro-mechanical actuation of an integrated directional coupler.

JTh2A.28
Certification of high-dimensional entanglement and Einstein-Podolsky-Rosen steering with quantum memory, Mateusz Mazelanik[1], Michal Dabrowski[1], Michal Parniak[1], Adam Leszczynski[1], Michal Lipka[1], Wojciech Wasilewski[1]; [1]*Univ. of Warsaw, Poland*. We experimentally generate a spatially-entangled state using a Raman multimode quantum memory setup and characterize it with the entropic EPR-steering inequality. We obtain genuine violation of 1.06 ± 0.05 bits and certify entanglement of formation of at least 0.70 ± 0.04 ebits.

JTh2A.29
Ultrafast leakage suppression in weakly nonlinear atomic qubits, Hanlae Jo[1], Yunheung Song[1], Jaewook Ahn[1]; [1]*Korean Adv Inst of Science and Tech, South Korea*. We propose and experimental demonstrate ultrafast coherent control scheme for leakage transition suppression through inducing destructive interference of constituent two-photon pathways in a three-level system of atomic rubidium, without disturbing resonant two-level qubit subspace operations.

JTh2A.30
Fiber-Integrated Single Photon Devices with High Efficiency and Directional Emission, Changmin Lee[1], Mustafa A. Buyukkaya[1], Edo Waks[1,2]; [1]*Univ. of Maryland, USA;* [2]*Joint Quantum Inst., Univ. of Maryland and National Inst. of Standard and Technology, USA*. Fiber-integrated single photon device based on quantum dot nanobeam and fiber taper is proposed and calculated. Total collection efficiency of 88% is achieved into one arm of fiber taper. Broadband and robust operation of the system is also confirmed.

JTh2A.31
Improving Squeezed Vacuum Generation via Spatial Mode Shaping in Hot Rb Vapor, Irina Novikova[1], Mi Zhang[1], Melissa A. Guidry[1], Eugeniy Mikhailov[1], R N. Lanning[2], Zhihao Xiao[2], Jonathan P. Dowling[2]; [1]*College of William & Mary, USA;* [2]*Physics, Louisiana State Univ., USA*. Achievable squeezed vacuum may be limited by contamination of the output fields with higher-order spatial modes. Squeezing can be improved by multipass interactions with a less optically-dense medium or by spatial tailoring of the input.

JTh2A.32
An 8-branch optical frequency comb for laser frequency stabilization and measurement in optical lattice clocks, Yusuke Hisai[1,2], Daisuke Akamatsu[2], Takumi Kobayashi[2], Sho Okubo[2], Hajime Inaba[2], Kazumoto Hosaka[2], Feng-Lei Hong[1], Masami Yasuda[2]; [1]*Yokohama National Univ., Japan;* [2]*National Metrology Inst. of Japan, National Inst. of Advanced Industrial Science and Technology, Japan*. We have developed an 8-branch fiber comb for frequency stabilization and measurement of multiple lasers. Seven lasers used in the Sr and Yb optical lattice clocks are frequency stabilized or measured using the developed comb.

JTh2A.33
Spatially-resolved spin manipulation using ac-Stark effect., Adam Leszczynski[1], Mateusz Mazelanik[1], Michal Parniak[1], Michal Dabrowski[1], Michal Lipka[1], Wojciech Wasilewski[1]; [1]*Inst. of Experimental Physics, Facul, Poland*. We used a Zeeman-like ac-Stark shift to perform spatially-resolved rotations of spins in cold rubidium. Using SLM we extended coherent spins oscillations time and imprinted comb-like patterns on the atomic ensemble.

JTh2A.34
Charging Dynamics of Single InGaAs Quantum Dots under Resonant Excitation, Gary R. Lander[1], Samantha D. Isaac[1], Disheng Chen[1], Glenn S. Solomon[2], Edward Flagg[1]; [1]*West Virginia Univ., USA;* [2]*Joint Quantum Inst., National Inst. of Standards and Technology, USA*. We investigate the rates of charge fluctuation in single quantum dots under resonant excitation, with additional modulated low-power above-band excitation. Time-resolved fluorescence is fit using stretched/compressed exponentials, indicating a continuum of relaxation and charging rates.

JTh2A.35
Integrated Photonic Platform for Scalable Ion-Qubits towards Quantum Information Networking, Youngmin M. Kim[1], Shahriar Aghaeimeibodi[1], Edo Waks[1]; [1]*Univ. of Maryland, USA*. We propose a SiN photonic platform where ion-qubits can be effectively coupled to polarization insensitive photonic circuits. Our approach aims to improve scalability of ion-qubit system via integration with photonic devices which could form a base architecture for realizing a quantum network.

JTh2A.36
Dissipation-enhanced optomechanically induced transparency, Yong-Chun Liu[1], Cuicui Lu[2], Li You[1]; [1]*Tsinghua Univ., China;* [2]*Qian Xuesen Lab of Space Technology, China*. We find that dissipation can be utilized as a resource to enhance optomechanically induced transparency in the unresolved sideband regime. This positive effect of dissipation holds potential for applications including high-precision measurements and slow light.

JTh2A.37
Highly Directional Single Photon Source Based on Nitrogen Vacancy Centers, Niko Nikolay[1], Boaz Lubotzky[2], Alexander Dohms[1], Hamza Abudayyeh[2], Nikola Sadzak[1], Florian M. Böhm[1], Bernd Sontheimer[1], Ronen Rapaport[2], Oliver Benson[1]; [1]*Humboldt-Universität zu Berlin, Germany;* [2]*Hebrew Univ. of Jerusalem, Israel*. A stable single photon device consisting of a nitrogen vacancy center coupled to a bulls-eye grating will be presented. Beside the highly directional emission pattern, we will report on the functionalization technique using electrostatic forces.

JTh2A.38
Nitrogen-Vacancy Based Spectroscopy and Control of the Local Paramagnetic Spin Bath in Nitrogen-15 Delta-Doped Diamond, Florian M. Böhm[1], Nikola Sadzak[1], Claudia Widmann[2], Christoph Nebel[2], Oliver Benson[1]; [1]*Humboldt-Universität zu Berlin, Germany;* [2]*Fraunhofer-Institut für Angewandte Festkörperphysik, Germany.* We present the spectroscopy of the local paramagnetic spin bath in nitrogen-15 delta-doped (111) diamond using single shallow nitrogen-vacancy centers as sensors and probe the spin bath dynamics with double spin resonance schemes.

JTh2A.39
Towards Light Storage and Retrieval from a Solid-State Atomic Ensemble at the Single-Photon Level, Kumel Kagalwala[1], Elizabeth A. Goldschmidt[2], Sergey Polyakov[3,1], Alan Migdall[3,1]; [1]*Joint Quantum Inst., UMCP, USA;* [2]*US Army Research Labs, USA;* [3]*National Inst. of Standards and Technology, USA*. We report progress towards the implementation of a quantum memory in a rare-earth ion-doped crystal. Toward that goal, we demonstrate a narrowband spectral filter for our memory, and measure the optical correlations.

JTh2A.40
Observation of plasmonic enhanced EIT and velocity selective optical pumping measurements with atomic vapor, Eliran Talker[1], P. Arora[1], Yefim Barash[1], Liron stern[1], Uriel Levy[1]; [1]*Dept. of Applied Physics,, 91904, Israel, The Benin School of Engineering and Computer Science, The Center for Nanoscience and Nanotechnology, The Hebrew Univ. of Jerusalem, Israel*. We demonstrate theoretically and experimentally for the first time nanoscale plasmonic enhanced electromagnetically induced transparency and velocity selective optical pumping effects in miniaturized integrated quantum plasmonic device for D_2 transitions in rubidium with V-type system

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JTh2A.41
Probing dipole-dipole interaction at cold-atom density range using optical two-dimensional coherent spectroscopy, Shaogang Yu[1,2], Michael Titze[1], XiaoJun Liu[2], Hebin Li[1]; *[1]Dept. of physics, Florida International Univ., USA; [2]Wuhan Inst. of Physics and Mathematics, Chinese Academy of Sciences, China.* We experimentally demonstrate that the dipole-dipole interaction in a potassium vapor at cold atom density can be observed using optical 2D coherent spectroscopy. This paves the way to implement 2D spectroscopy in cold atoms.

JTh2A.42
Coherent Population Trapping in Cs-filled Kagome Hollow Core Fibers, Marcelo A. Gouveia[1,2], Thomas Bradley[1], Mohsin Haji[2], Natalie Wheeler[1], Yong Chen[1], Seyed Sandoghchi[1], David Richardson[1], Patrick Gill[2], Marco Petrovich[1]; *[1]Optoelectronics Research Centre, UK; [2]Quantum Metrology Inst., National Physical Lab, UK.* We report for the first time Coherent Population Trapping (CPT) in Cs-filled Kagome Hollow Core Fibers. Dark resonance contrasts of up to 9 % and linewidths as narrow as 1.8 MHz were observed.

JTh2A.43
Novel nonlinear collective effects in hybrid quantum systems: relaxation to negative temperatures, William Munro[1,2], Yusuke Hama[2], Kae Nemoto[2]; *[1]NTT Basic Research Labs, Japan; [2]National Inst. of Informatics, Japan.* Nonlinear systems are known to exhibit interesting and important phenomena that have profoundly changed our technological landscape. They can now be explored in quantum hybrid systems and here we discuss novel effects such as superradiance induced negative temperature relaxation in such systems.

JTh2A.44
Spontaneous and Stimulated Emission from Quantum Optical Systems, Rahul Trivedi[2,1], Kevin Fischer[2], Shanshan Xu[3], Shanhui Fan[2], Jelena Vuckovic[2]; *[1]Stanford Univ., USA; [2]Electrical Engineering, Stanford , USA; [3]Physics, Stanford, USA.* We develop a method based on the input-output formalism to analyze stimulated emission of photons by a low-dimensional quantum optical system into 1D loss channels (e.g. waveguides) or a spatial continuum (e.g. free space, photonic crystals).

JTh2A.45
Channeling of Spontaneous Emission from an Atom into the Fundamental and Higher-Order Modes of a Vacuum-Clad Ultrathin Optical Fiber, Fam Le Kien[1], Sahar Hejazi[1], Thomas Busch[1], Viet Giang Truong[1], Sile Nic Chormaic[1]; *[1]Okinawa Inst of Sci and Tech Grad Univ, Japan.* We study spontaneous emission from a multilevel atom into the fundamental and higher-order modes of a vacuum-clad ultrathin optical fiber. We examine the dependencies of the rate on the type of modes, the position of the atom, and the fiber radius.

JTh2A.46
Photostable Single-Photon Emission from Organic Nanocrystals, Sofia Pazzagli[1,2], Pietro Lombardi[2,3], Daniele Martella[3], Maja Colautti[3], Bruno Tiribilli[4], Francesco Cataliotti[1,2], Costanza Toninelli[2,3]; *[1]Dept. of Physics and Astrophysics, Univ. of Florence, Italy; [2]National Inst. of Optics, INO-CNR, Italy; [3]European Lab for Nonlinear Spectroscopy (LENS), Italy; [4]Inst. of Complex Systems, ISC-CNR, Italy.* We report on organic nanocrystals doped with tunable concentration of fluorescent molecules, grown with an easy and inexpensive method and performing as bright and photostable single-photon sources at both room and cryogenic temperatures.

JTh2A.47
Exceptional Points in Passive Plasmonic Nanostructure for Sensing, Jun-Hee Park[1], Ashok Kodigala[1], Abdoulaye Ndao[1], Boubacar Kante[1]; *[1]Univ. of California San Diego, USA.* We propose a passive plasmonic nanostructures sensor operated at an exceptional point (EP), that fundamentally shift more than conventional resonances and will pave the way to highly sensitive plasmonic devices.

JTh2A.48
Spin Hall Effect from Achiral Nanohole Arrays, Chao Liu[1], Xiaoyu Guo[1], H C. Ong[1]; *[1]Chinese Univ. of Hong Kong, Hong Kong.* We continuously steer the propagation direction of the degenerate (-1,±1) surface plasmon on circular nanohole arrays under an elliptical polarization. The directionality has been attributed to the coherent control of the dark and bright modes.

JTh2A.49
Angular sensitivity of PT-symmetric optical lattices, Konstantinos Makris[1], Stylianos Miliotis[2], Ioannis Komis[1]; *[1]Univ. of Crete, Greece; [2]Inst. for Theoretical Physics, Vienna Univ. of Technology, Austria.* We investigate the sensitivity of the diffraction pattern in PT optical lattices near exceptional points. We examine the range of excitation angles, in one and two-dimensional lattices, that leads to the maximum sensitivity.

JTh2A.50
Surface Emitting Plasmonic Laser with Distributed Feedback, Ekembu K. Tanyi[3], Soheila Mashhadi[3], Cansu On[3,2], Md Omar Faruk[3], Erin Harrison[1,2], Mikhail A. Noginov[3,2]; *[1]Univ. of Delaware, USA; [2]Summer Research Program, Center for Materials Research, NSU, USA; [3]Center for Materials Research, NSU, USA.* We have demonstrated the novel low-threshold surface-emitting plasmonic laser and explained its performance in terms of the distributed feedback mechanism, providing a new degree of freedom to the laser design.

JTh2A.51
Hybrid-plasmonic gold coated GaAs nanowire lasers, Fatemesadat Mohammadi[1], Mykhaylo Lysevych[2], Hoe Tan[2], Chennupati Jagadish[2], Martin Fraenzl[3], Hans Peter Wagner[1]; *[1]Dept. of Physics, Univ. of Cincinnati, USA; [2]Dept. of Electronic Materials Engineering, The Australian National Univ., Australia; [3]Dept. of Physics, Univ. of Leipzig, Germany.* Hybrid plasmonic lasing from zinc doped GaAs nanowires which were coated with a 10 nm thick granular gold layer was observed. The result suggests that hybrid-plasmonic lasing is achievable despite of a non-continuous metal surface.

JTh2A.52
Tunable Random Lasing Emissions by Manipulating Plasmonic Coupling Strengths on Flexible Substrates, TingWei Yeh[1], ChunYang Chou[1], ZuPo Yang[2], Nguyen Thi Bich Hanh[1], YungChi Yao[1], Meng-Tsan Tsai[3,4], Hao-Chung Kuo[5], Ya-Ju Lee[1]; *[1]National Taiwan Normal Univ., Taiwan; [2]National Chiao-Tung Univ., Taiwan; [3]Chang Gung Univ., Taiwan; [4]Chang Gung Memorial Hospital, Taiwan; [5]National Chiao Tung Univ., Taiwan.* We experimentally demonstrated flexible random lasers fabricated on the PET substrate with tunable emissions. Lasing wavelength is blue-shifted with the bending strains exerted on the PET, and the maximum shift of ~15 nm was achieved.

JTh2A.53
Optical properties of graphene flakes and organic molecules, Rodrigo A. Muniz[1], Zaheen S. Sadeq[1], John E. Sipe[1]; *[1]Univ. of Toronto, Canada.* We compute the electronic states of graphene flakes and organic molecules including electron correlations beyond the mean field level. We analyze the linear and nonlinear optical properties of these systems and discuss their implications.

JTh2A.54
Highly Sensitive Refractive Index Sensing with Silicon-Based Dielectric Metasurfaces, Adam Ollanik[1], Matthew D. Escarra[1]; *[1]Tulane Univ., USA.* We design and simulate microfluidic refractive index sensors based on optical dielectric metasurfaces comprised of resonant silicon nanoantennas. Sensitivity as high as $<10^{-7}$ RIU is modeled; experimental realization is in progress with biomarker of interest.

JTh2A.55
Highly Compact Structure for Near-total Absorption in a Graphene Monolayer in the Visible, Amirreza Mahigir[1], Georgios Veronis[1]; *[1]Louisiana State Univ., USA.* We propose a highly compact structure consisting of a subwavelength grating covered with a graphene monolayer to achieve near-total absorption in the graphene monolayer in the visible without the need for thick multilayer dielectric mirrors.

JTh2A.56
Tunable plasmonic subwavelength grating using electrically controlled conductive oxide, Erwen Li[1], Qian Gao[1], Alan X. Wang[1]; *[1]Oregon State Univ., USA.* We design and experimentally demonstrate an electrically tunable plasmonic subwavelength grating at telecommunication wavelength based on a metallic subwavelength slit array coupled with a Si/SiO_2/ITO semiconductor-oxide-metal (MOS) capacitor, achieving 32%-56% transmission-reflection modulation.

JTh2A.57
Generation of Surface Plasmon Polaritons in Graphene-Semiconductor Structure with Distributed Feedback, Igor O. Zolotovskii[1], Yuliya S. Dadoenkova[1], Aleksei S. Kadochkin[1], Sergey G. Moiseev[1]; *[1]Ulyanovsk State Univ, Russia.* We have shown the possibility of surface plasmon polaritons generation in a waveguiding system containing semiconductor film and graphene single-layer.

JTh2A.58
Scanning Light-Diffracted Microscopy, Hira Farooq[1], Sueli Skinner-Ramos[1], Luis Grave de Peralta[1]; *[1]Physics and Astronomy, Texas Tech Univ., USA.* We simulated and experimentally demonstrated a novel subwavelength resolution microscopy technique by illuminating the sample with the hollow-cone of light produced by a ring-shaped condenser and scanning the diffracted light using a slit.

JTh2A.59
Generation of Prescribed Optical Orbital Angular Momentum Spectrum with Spiral Polarization Modulation, Chenhao Wan[1], Xiahui Tang[1], Yingxiong Qin[1], Yu Xiao[1], Qiwen Zhan[2]; *[1]Huazhong Univ. of Science & Technology , China; [2]Dept. of Electro-Optics and Photonics, Univ. of Dayton, USA.* We report a method to generate prescribed optical orbital angular momentum (OAM) spectrum with spiral polarization modulation. The generated OAM spectrum contains 11 OAM states of equal intensity and various linear polarization angles.

JTh2A.60
High Q Si Slot Waveguide Ring Resonators for Gas Sensing Application, Yuki Tomono[1], Hiromasa Shimizu[1]; *[1]Tokyo Univ. of Agri. and Tech., Japan.* We fabricated Si slot waveguide ring resonators having Q factor of 2.5x104. Based on the resonance characteristics, refractive index sensitivity Dn of 1x10-5 was theoretically estimated by the difference of transmitted optical intensity at the resonance wavelength.

JTh2A.61
Determination of Complex Hermitian and Anti-Hermitian Interaction Constants from a Coupled System via Coherent Control, Xiaoyu Guo[1], Zhaolong Cao[1], H C. Ong[1]; *[1]The Chinese Univ. of Hong Kong, Hong Kong.* We devise a new method to determine the complex Hermitian and anti-Hermitian coupling constants from a coupled system via coherent control. The method is verified numerically and experimentally on various photonic and electronic systems.

JTh2A.62
Integrated Plasmonic Waveguide at the Mid-Infrared, Bingqing Zhu[1], Wen Zhou[1], Hon Ki Tsang[1]; *[1]Chinese Univ. of Hong Kong, Hong Kong.* We demonstrate an integrated plasmonic waveguide fabricated on the silicon-on-insulator platform at the mid-infrared range. Experimentally, the metal-insulator-metal mode propagation loss is 1.16 dB/μm, and the Si-to-SPP mode converter loss is 4.1 dB/interface.

JTh2A.63
Excitation Light-Induced Anisotropies in LSP-Enhanced SHG from Au Nanoprisms, Atsushi Sugita[1], Hirofumi Yogo[1], Shohei Hamada[1], Atsushi Ono[1], Yoshimasa Kawata[1]; *[1]Shizuoka Univ., Japan.* We report excitation light-induced anisotropies in polarized SHG for Au nanoprisms at LSP resonances. The anisotropies were pronounced more in higher excitation powers. The phenomena were explained by taking account of 2nd and 4th-order nonlinearities.

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JTh2A.64
Graphene Plasmonic in-Plane Cherenkov Radiation, Jin Tao[1], Lin Wu[1], ZiChen Liu[1], Quan You[1], Qi Yang[1], Guoxing Zheng[2]; *[1]State Key Lab of Optical Communication Technologies and Networks, Wuhan Research Inst. of Posts & Telecommunications, China; [2]Wuhan Univ., China.* We theoretically study the Cherenkov plasmonic radiation in/parallel graphene plane by a moving electron, which provides a versatile, tunable mechanism for plasmonic chenrenkov effect in active integrated photonic applications.

JTh2A.65
Graded-Index Plasmonic Nanoparticles: Light Scattering Characteristics and Peculiarities, Dimitrios Tzarouchis[1], Ari Sihvola[1]; *[1]Aalto Univ., Finland.* Light scattering by subwavelength spheres exhibiting a radially inhomogeneous permittivity are presented. The theoretical model for power-law, exponential, and Drude-like inhomogeneous profiles are discussed, generalizing the concept of polarizability for graded-index nanoparticles.

JTh2A.66
Multifrequency Near Field Scanning Optical Microscopy (MF-SNOM), Hadar Greener[1], Michael Mrejen[1], Uri Arieli[1], Haim Suchowski[1]; *[1]Tel Aviv Univ., Israel.* We introduce a novel excitation and detection scheme in near-field optical microscopy based on a multifrequency method. Using this method, we experimentally demonstrate enhanced sensitivity, implying improved spatial resolution in optical measurements.

JTh2A.67
Thermal Scan of Metal Based Metasurface and Evidence of Circular Dichroism and Optothermal Anisotropy, Grigore Leahu[1], Alessandro Belardini[1], Emilija Petronijevic[1], Roberto Li Voti[1], Concita Sibilia[1], Tiziana Cesca[2], Giovanni Mattei[2]; *[1]Univ degli Studi di Roma La Sapienza, Italy; [2]Università di Padova, Italy.* Photothermal and photoacoustic techniques are utilized to explore the thermal properties of metal based metasurfaces. We experimentally evidence the role of the symmetry in the heat transport and its relation with the optical circular dichroism.

JTh2A.68
Electric Field Enhancement by Two-scale Structure, Mahsa Darvishzadeh Varcheie[1], William John Thrift[1], Mohammad Kamandi[1], Regina Ragan[1], Filippo Capolino[1]; *[1]Univ. of California Irvine , USA.* We propose a novel multi-length-scale architecture for giant electric field enhancement. We investigate the capability of our structure to boost the electric field analytically and using full-wave simulations and verify our results with surface-enhanced Raman spectroscopy experiment.

JTh2A.69
Plasmonic enhancement and control of optical nonlinearity in monolayer WS_2, Wei-Yun Liang[1], Hyeyoung Ahn[1], Yungang Sang[2], Yanrong Wang[2], Jinwei Shi[2], Soniya S. Raja[3], Yi-Hsien Lee[4], Shangjr Gwo[5]; *[1]National Chiao Tung Univ., Taiwan; [2]Dept. of Physics and Applied Optics, Beijing Normal Univ., China; [3]Inst. of NanoEngineering and MicroSystems, National Tsing Hua Univ., Taiwan; [4]Dept. of Materials Science and Engineering, National Tsing Hua Univ., Taiwan; [5]Dept. of Physics, National Tsing Hua Univ., Taiwan.* A giant SHG enhancement is achieved from monolayer-WS_2 incorporated onto 2D plasmonic metasurfaces (Ag-nanogroove-grating) in resonance with the excitonic resonance of monolayer-WS_2. An optical encoding technique is demonstrated based on plasmonic manipulation of SHG polarization.

JTh2A.70
Integrated resonant units of metasurface for broadband efficiency and phase modulation, Ren Jie Lin[1], Hui-Hsin Hsiao[2], Yu Han Chen[1], Bo Han Chen[1], Pin Chieh Wu[3], Yi-Chieh Lai[1], Shuming Wang[4], Din Ping Tsai[1,3]; *[1]Dept. of Physics, National Taiwan Univ., Taiwan; [2]Graduate Inst. of Biomedical Optomechatronics, Taipei Medical Univ., Taiwan; [3]Research Center for Applied Sciences, Academia Sinica, Taiwan; [4]School of Physics, Nanjing Univ., China.* Integrated-resonant units (IRUs) provide additional degree of freedom to control the phase compensation and enhance the conversion efficiency over a broad bandwidth of light. In this work, we demonstrated achromatic metalens in visible range and broadband versatile polarization generator.

JTh2A.71
Enhanced Harmonic Generation in Metal-Insulator-Metal Nanostructures, Mallik Mohd Raihan Hussain[1], Zhengning Gao[2], Domenico de Ceglia[3], Maria A. Vincenti[4], Andrew Sarangan[1], Imad Agha[1], Michael Scalora[5], Parag Banerjee[2,6], Joseph Haus[1]; *[1]Dept. of Electro-Optics and Photonics, Univ. of Dayton, USA; [2]Inst. of Materials Science and Engineering, Washington Univ., USA; [3]Dept. of Information Engineering, Univ. of Padova, Italy; [4]Dept. of Information Engineering, Univ. of Brescia, Italy; [5]Charles M. Bowden Research Lab, US Army AMRDEC, USA; [6]Dept. of Mechanical Engineering & Materials Science, Washington Univ., USA.* We experimentally observed no change in second-harmonic signal and an enhancement of the third-harmonic signal from metal-insulator-metal nanostructures, which are consistent with the nonlinear photon-assisted electron tunneling current flowing through them.

JTh2A.72
Scattering near-field mid-infrared microscopy using self-mixing in quantum cascade lasers, Mingzhou Jin[1], Mikhail A. Belkin[1]; *[1]Univ. of Texas at Austin, USA.* We demonstrated scattering near-field mid-infrared imaging via the self-mixing in a quantum cascade laser used as both a light source and a detector. The experimental setup and preliminary results on gold/sapphire samples are presented.

JTh2A.73
Strong Mode Coupling and High-Q Supercavity Modes in Subwavelength Dielectric Resonators, Kirill Koshelev[1,3], Andrey Bogdanov[1,2], Sergey Gladyshev[1], Zarina Sadrieva[1], Mikhail Rybin[1,2], Kirill Samusev[1,2], Mikhail Limonov[1,2], Yuri S. Kivshar[1,3]; *[1]Dept. of Nanophotonics and Metamaterials, ITMO Univ., Russia; [2]Ioffe Inst., Russia; [3]Nonlinear Physics Centre, Australian National Univ., Australia.* We reveal that isolated subwavelength dielectric resonators support states with giant Q-factors similar to bound states in the continuum formed via destructive interference between strongly coupled eigenmodes and characterized by singularities of the Fano parameters

JTh2A.74
Hybrid Metal-Dielectric Metasurfaces For Refractive Index Sensing, Debdatta Ray[1], T.V Raziman[1], Christian Santschi[1], Andreas Tittl[1], Dordaneh Etezadi[1], Hatice Altug[1], Olivier Martin[1]; *[1]EPFL, Switzerland, Switzerland.* The utilization of a hybrid metal-dielectric metasurface for sensing is demonstrated experimentally. We show how the hybridization between the different modes supported by the structure determines the overall sensitivity of the system.

JTh2A.75
Optimization of Titanium Nitride Films using Plasma Enhanced Atomic Layer Deposition, Ray R. Secondo[1], Vitaliy Avrutin[1], Umit Ozgur[1], Nathaniel Kinsey[1]; *[1]Virginia Commonwealth Univ., USA.* We investigate the quality of atomic layer deposited Titanium nitride thin films and find metallicity close to high quality sputtered films on both sapphire and silicon for a deposition temperature of 375°C.

JTh2A.76
InGaAs/InP Multi-quantum-well Nanowires Directly Grown on SOI Substrates and Optical Property Characterizations, Mengqi Wang[1,2], Zhibo Li[1,2], Xuliang Zhou[1,2], Yajie Li[1,2], Pengfei Wang[1,2], Hongyan Yu[1,2], Wei Wang[1,2], Jiaoqing Pan[1,2]; *[1]Inst. of Semiconductors, Chinese Academy of Sciences, China; [2]College of Materials Science and Opto-Electronic Technology, Univ. of Chinese Academy of Sciences, China.* InGaAs/InP MQW nanowires were directly grown on SOI substrates by ART technique. Multiple characterizations which applied to reveal the material quality and optical properties, had proved that such MQW nanowire was capable of an active waveguide cavity for potential photonic applications.

JTh2A.77
Yb-doped Large-Mode-Area Al-P-Silicate Laser Fiber fabricated by MCVD, Arindam Halder[1], Lin Di[1], Andrey A. Umnikov[1], N. J. Rámirez-Martínez[1], Martín M. Núñez-Velázquez[1], Pranabesh Barua[1], Shaif-Ul Alam[1], Jayanta K. Sahu[1]; *[1]Univ. of Southampton, UK.* We demonstrate an efficient ytterbium-doped alumino-phospho-silicate low-NA fiber fabricated by modified solution-doping process that shows continuous-wave laser efficiency of 81%. In ps-MOPA, the fiber provides 35kW peak power with repetition-rate 1.46MHz, and average power 9.1W.

JTh2A.78
Hybrid h-BN/Graphene/h-BN Silicon Device for Electro-optic Modulation , Tianren Fan[1], Amir H. Hosseinnia[1], Hesam Moradinejad[1], Ali Asghar Eftekhar[1], Ali . Adibi[1]; *[1]Georgia Inst. of Technology, USA.* We integrate hexagonal boron nitride (h-BN)-encapsulated graphene on top of a compact silicon microdisk resonator for modulation applications. We demonstrate reduced graphene resistance through h-BN encapsulation and showed active tuning of the optical mode through voltage-gated graphene.

JTh2A.79
Investigation of High Temperature Photoluminescence Efficiency from InGaN/GaN MQWs , Abbas F. Sabbar[1], Syam Madhusoodhanan[1], Sattar Al-Kabi[1], Binzhong Dong[2], Jiangbo Wang[3], Shui-Qing Yu[1], Zhong Chen[1]; *[1]1Dept. of Electrical Engineering, Univ. of Arkansas, Fayetteville, USA; [2]HC SemiTek , China; [3]HC SemiTek, China.*Temperature and power dependent photoluminescence (PL) measurements from InGaN/GaN MQWs, which was grown on a sapphire substrate were performed to extract the PL efficiency.

JTh2A.80
Numerical Characterization of Monolayer Ink-Jet Printed Polystyrene Lattice, Ray R. Secondo[1], Karam Nashwan Al-Milaji[1], Tse Nga Ng[2], Hong Zhao[1], Nathaniel Kinsey[1]; *[1]Virginia Commonwealth Univ., USA; [2]Univ. of California San Diego, USA.* We investigate the color of polystyrene metasurfaces printed via a novel dual-droplet ink-jet technique resulting in a closely-packed hexagonal formation through self-assembly. Simulations, Mie Theory, and Bragg Diffraction calculations are utilized for spectra validation.

JTh2A.81
Highly Transparent Organic Microdisk Cavity in Visible Range by the Ink-jet Printing Method, Taku Takagishi[1], Hiroaki Yoshioka[1], Shintaro Mitsui[1], Yuya Mikami[1], Naoya Nishimura[2], Yuji Oki[1]; *[1]Kyushu Univ., Japan; [2]Nissan chemical industries, ltd, Japan.* We experimentally demonstrated the fabrication and the fundamental lasing evaluation of a printed microdisk cavity by focusing on a fluorinated spherical polymer FZ-001 to achieve a microdisk with small absorption loss in the visible range.

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JTh2A.82
Stable, inkjet printed temperature- and humidity-resistant black phosphorus for ultrafast lasers, Xinxin Jin[1], Guohua Hu[2], Meng Zhang[1], Yuwei Hu[1], Qing Wu[1], T Albrow-Owen[2], R Howe[2], T Wu[2], Zheng Zheng[1], Tawfique Hasan[2]; [1]*Beihang Univ., China;* [2]*Cambridge Graphene Centre, UK*. We demonstrate an inkjet-printed temperature- and humidity-resistant black phosphorus saturable absorber, enabling stable continuous mode-locking over 210 hours. Our work highlights the potential of BP-based devices for photonic applications operating under challenging environmental conditions.

JTh2A.83
Inkjet-printed optically uniform transition metal dichalcogenide saturable absorbers, Qing Wu[1], Guohua Hu[2], Meng Zhang[1], Xinxin Jin[1], Yuwei Hu[1], Ting Li[1], T Albrow-Owen[2], R Howe[2], T Wu[2], Zheng Zheng[1], Tawfique Hasan[2]; [1]*Beihang Univ., China;* [2]*Cambridge Graphene Centre, UK*. We report self-starting mode-locking in all-fiber erbium-doped lasers utilizing inkjet-printed transition metal dichalcogenide saturable absorbers, exhibiting highly optical uniformity, with <5% standard deviations.

JTh2A.84
Single Crystal Growth of $BaGa_4S_7$ and $BaGa_4Se_7$ by the Horizontal Gradient Freeze Technique, Peter G. Schunemann[1], Kevin Zawilski[1]; [1]*BAE Systems Inc, USA*. Horizontal gradient freeze growth in transparent furnaces yields extremely favorable crystallization of high-optical quality barium thiogallate and sellenogallate: two new nonlinear optical crystals with wide band gaps, deep infrared transparency, and moderately high nonlinear coefficients.

JTh2A.85
Auger Recombination in Mid-Infrared Active Regions, Kenneth J. Underwood[1], Andrew F. Briggs[2], Scott D. Sifferman[2], Seth Bank[2], Juliet Gopinath[1]; [1]*Univ. of Colorado at Boulder, USA;* [2]*Dept. of Electrical and Computer Engineering, Univ. of Texas at Austin, USA*. We study strain effects on Auger recombination in GaInAsSb/GaSb multiple quantum well structures emitting ~3 mm, using differential reflection pump-probe and photoluminescence spectroscopy; results suggest increasing strain decreases Auger and increases radiative recombination strength.

JTh2A.86
Novel spectroscopic transparent/scattering material for 260/280nm ultraviolet optical detection, Keisuke Nakakubo[1], Junfeng Zhu[1], Yuya Mikami[1], Kinichi Morita[2,1], Hiroaki Yoshioka[1], Yuji Oki[1]; [1]*Kyushu Univ., Japan;* [2]*Ushio.Inc, Japan*. Novel type of wavelength filter was proposed and demonstrated. Polydimethylsiloxane was mixed with CaF_2 particles. This scattering material of 30wt% provided transparency at specified wavelength of 259 nm and 278nm.

JTh2A.87
Enhanced Spontaneous Emission of Quantum Emitters in the Vicinity of TiN Thin Films, Shaimaa I. Azzam[1], Motoharu Saito[2], Shunsuke Murai[2], Satoshi Ishii[3], Katsuhisa Tanaka[2], Alexander Kildishev[1]; [1]*Purdue Univ., USA;* [2]*Kyoto Univ., Japan;* [3]*National Inst. for Materials Science, Japan*. We report on the enhancement of spontaneous emission from organic dyes on top of TiN films. Up to 200-fold Purcell enhancement is achieved. The proposed structures are modeled in the time domain and validated experimentally.

JTh2A.88
Dissolvable and Recyclable Random Lasers, Shih-Yao Lin[1], Yu-Ming Liao[1], Hung-I Lin[1], Wei-Ju Lin[1], Yang-Fang Chen[1], Tai-Yuan Lin[2], Wei-Cheng Liao[1], Yuan-Fu Huang[1], Ying-Chih Lai[3], Zhaona Wang[4], Xiaoyu Shi[4], Cheng-Han Chang[1]; [1]*National Taiwan Univ., Taiwan;* [2]*National Taiwan Ocean Univ., Taiwan;* [3]*National Chung Hsing Univ., Taiwan;* [4]*Beijing Normal Univ., China*. The dissolvable and recyclable random laser can be dissolved in water, accompanying the decay of emission intensity and the increment in lasing threshold. It can be reused after deionized treatment, exhibiting reproducibility with recycling processes.

JTh2A.89
All Inorganic Perovskite Quantum Dots Hybrid Green Light-Emitting Diode with Stable Performance, Chung-Ping Yu[3], Meng-Ting Chung[1], Tzu-Yu Chen[2], Yu-Ming Huang[3], Chung-Ping Huang[5], Shu-Hsiu Chang[4], Shun Chieh Hsu[3], Teng-Ming Chen[1], Hao-Chung Kuo[2], Chien-Chung Lin[3]; [1]*Dept. of Applied Chemistry, National Chiao-Tung Univ., Taiwan;* [2]*Inst. of Electro-Optical Engineering, National Chiao-Tung Univ., Taiwan;* [3] *Inst. of Photonic System, National Chiao-Tung Univ., Taiwan;* [4]*Inst. of of Imaging and Biomedical Photonics, National Chiao-Tung Univ., Taiwan;* [5] *Inst. of Lighting and Energy Photonics, National Chiao-Tung Univ., Taiwan*. A silica-coated inorganic perovskite quantum dot hybrid light-emitting diodes is aged continuously in high and low light intensity conditions. Both blue and ultra-violet-pumped samples showed stable performances up to 104 hours.

JTh2A.90
Planar Focusing Element Based on Scattering Structures in a Dielectric Waveguide, Brian D. Jennings[1], David McCloskey[1], Alexander Krichevsky[2], Christopher Wolf[2], Frank Bello[1], Ertuğrul Karademir[1], John F. Donegan[1]; [1]*Univ. of Dublin Trinity College, Ireland;* [2]*Western Digital Corporation, USA*. Focusing elements in integrated optics are required for localised high intensities and coupling between certain components. Here, a focusing element is designed using analytical approximations, simulated using FDTD and characterised using far-field optical imaging. Focusing below λ/2 is predicted.

JTh2A.91
KW-level Yb/Ce-codoped Aluminosilicate Fiber Fabricated by Chelate Precursor Doping Technique, Yuwei Li[1], Huan Zhan[1], Kun Peng[1], Shuang Liu[1], Xiaolong Wang[1], Li Ni[1], Shihao Sun[1], Jiali Jiang[1], Lei Jiang[1], Juan Yu[1], Jianjun Wang[1], Feng Jing[1], Aoxiang Lin[1]; [1]*China Academy of Engineering Physics, China*. By chelate precursor doping technique, an Yb/Ce-codoped aluminosilicate fiber was fabricated and reported. The fiber showed excellent laser stability at 1850W for over 500 minutes with small power degradation of <1.04%.

JTh2A.92
Linear and Nonlinear Optical Response of Monolayer Two-dimensional Transition Metal Dichalcogenide $MoSe_2$ and WSe_2, Yanxiao Sun[1], Boyang Zhao[2], jintao bai[1], Yang Bai[1], Jiming Zheng[1]; [1]*Northwest Univ., China;* [2]*Xi'an Jiaotong Univ., China*. Linear and nonlinear optical properties of CVD-fabricated monolayer $MoSe_2$ and WSe_2 are studied, which showed nonlinear saturable absorption, reverse saturable absorption and two photon absorption. Band structure of the materials are investigated by simulation and experiments.

JTh2A.93
Fiber fuse in GeAsSe photonic crystal fiber and its impact on undamaged segment, Sida Xing[1], Svyatoslav Kharitonov[1], Jianqi Hu[1], Camille-Sophie Bres[1]; [1]*École polytechnique fédérale de Lausanne, Switzerland*. We observe, for the first-time, fiber fuse in non-silica fiber. Images of the photonic crystal fiber show smooth discrete voids in the solid core region. Significant dispersion modifications of the undamaged fiber section are measured.

JTh2A.94
Electric Field Control of the Ferro-paraelectric Phase Transition in Cu:KTN Crystals, Xin Zhang[1,2], Hongliang Liu[1,2], Zhuan Zhao[1,2], Xuping Wang[3], Pengfei Wu[1,2]; [1]*Key Lab of Optical Information Science and Technology, Ministry of Education, Inst. of Modern Optics, Nankai Univ., China;* [2]*Tianjin Key Lab of Optoelectronic Sensor and Sensing Network Technology, China;* [3]*Advanced Materials Inst., Shandong Academy of Sciences, China*. We demonstrate an efficient ferro-paraelectric phase transition in Cu-doped $KTa_{1-x}Nb_xO_3$ crystals using AC electric fields. The dynamic process is probed by a laser beam and characterized by a microscope and an X-ray diffractometer.

JTh2A.95
Raman determination of the rate of α-chymotrypsin-catalyzed reaction, Irina Shpachenko[1], Nikolay Brandt[1], Andrey Chikishev[2]; [1]*Lomonosov Moscow State Univ., Russia;* [2] *International Laser Center of Moscow State Univ. , Russia*. We apply the method of Raman spectroscopy to the study of enzyme kinetics. It is shown that Raman spectroscopy data can be used for calculation of chemical reaction rates and catalytic activity of α-chymotrypsin.

JTh2A.96
Characterization of the Photonic Response in Nitzschia Filiformis Phytoplankton, Yannick D'Mello[1], Dan Petrescu[1], James Skoric[1], Melissa Campbell[1], Mark Andrews[1], David V. Plant[1]; [1]*McGill Univ., Canada*. The optical response of the phytoplankton species *Nitschia filiformis*, specifically its silica shell, is investigated by correlating SEM, AFM, SNOM, and HSI microscopy techniques. Our results demonstrate its behavior as a passive optical device.

JTh2A.97
Double-clad hypocycloid core-contour Kagome hollow-core photonic crystal fiber, Frédéric Delahaye[1], Martin Maurel[1,2], Matthieu Chafer[1,2], Foued Amrani[1], Benoit Debord[1,2], Frédéric Gérôme[1,2], Fetah Benabid[1,2]; [1]*GPPMM, XLIM, UMR 7252 Univ. de Limoges, France;* [2]*GloPhotonics, France*. We report on the design and fabrication of the first double-clad hypocycloid core-contour Kagome fiber optimized for guidance in air-core at 1μm via Inhibited-Coupling and in a cladding silica ring via total-internal-reflection.

JTh2A.98
Ultrasound Sensing with a Photonic Crystal Slab, Eric Y. Zhu[1], Cory Rewcastle[1], Raanan Gad[1], Li Qian[1], Ofer . Levi[1]; [1]*Univ. of Toronto, Canada*. We experimentally demonstrate a compact architecture for ultrasound sensing based upon a photonic crystal slab (PCS) fabricated on top of a thin mechanically pliable silicon membrane. A noise-equivalent pressure of 2.0 kPa (0.072 kPa/rt Hz) at 5 MHz is observed.

JTh2A.99
Optical Trapping of Living Bacteria in 2D Hollow Photonic Crystal Cavities, Rita Therisod[1], Manon Tardif[2,3], Pierre Marcoux[4], Emmanuel Picard[3], Emmanuel Hadji[3], David Peyrade[2], Romuald Houdré[1]; [1]*Institut de Physique, Ecole Polytechnique Fédérale de Lausanne (EPFL), Switzerland;* [2]*CNRS -LTM - Micro and Nanotechnologies for Health, Univ. Grenoble Alpes, France;* [3]*CEA-INAC-PHELIQS-SINAPS, Univ. Grenoble Alpes, France;* [4]*CEA-LETI-DTBS-SBSC-LCMI/LBAM, Univ. Grenoble Alpes, France*. We report on the optical trapping of seven types of living bacteria in 2D hollow photonic crystal cavities. The possibility of distinction of bacteria via the interaction effects with the trapping field will be discussed.

JTh2A.100
Optofluidic SERS in a Microcapillary Coated with a Graphene Oxide/Gold Nanorod Nanocomposite, Pilar Gregory Vianna[1], Daniel Grasseschi[1], Sergio Domingues[1], Christiano de Matos[1]; [1]*MackGraphe – Graphene and Nanomaterials Research Center, Mackenzie Univ., Brazil*. We demonstrate a re-usable microcapillary fiber with a graphene oxide/gold nanorod nanocomposite inner coating for optofluidic SERS. Rhodamine detection is performed with <1sec integration times down to 10^{-9}M in samples of few hundreds of nanoliters.

JTh2A.101
3D Hydrodynamic Focusing for Optofluidics Using a Stacked Channel Design , Erik Hamilton[1], Joel G. Wright[1], Matthew Stott[1], Jennifer A. Black[2], Holger Schmidt[2], Aaron Hawkins[1]; [1]*Brigham Young Univ., USA;* [2]*Univ. of California, Santa Cruz, USA*. We present a 3D hydrodynamic focusing design suitable for optofluidic devices allowing planar fabrication and velocity independent particle focusing. Simulations are presented and fabrication outlined with evidence that stacked SU8 layers are suitable building blocks.

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JTh2A.102
Triple Fluorescence SPIM Using a Single Camera Detection, Israel Rocha[1], Jacob Licea-Rodriguez[1], Alfredo Figueroa[1], Meritxell Riquelme[1]; [1]*CICESE Ensenada, Mexico*. Three color SPIM is performed using three sequential cw-lasers pulsed trains in the excitation synchronized with the acquisition frame rate of a single camera. Multicolor images of living hyphae of *Neurospora crassa* are acquired.

JTh2A.103
Effect of Viscosity on Fluorescence Lifetime Measured Using Flow Cytometry, Faisal H. Alturkistany[1], Kapil Nichani[1], Wenyan Li[1], Jessica P. Houston[1]; [1]*New Mexico State Univ., USA*. The effect of viscosity on Dronpa-3 fluorescence protein kinetics is studied using time resolved flow cytometry (TRFC). Phasor analysis and Förster Hoffman relation analysis provide the basis of studying intracellular viscosity in high throughput manner.

JTh2A.104
Mode and sensing properties of the deformed microdroplet, Meng Zhang[1], Jiansheng Liu[1], Weifeng Cheng[2], Jiangtao Cheng[2], Hongwen Zhou[1], Haitao Liu[1], Jie Chen[1], Qing Wu[1], Yuhang Wan[1], Zheng Zheng[1]; [1]*Beihang Univ., China;* [2]*Virginia Tech, USA*. The resonant mode along meridian of a deformed droplet on a hydrophilic substrate with different contact angle CA is investigated. A relatively large Q ~ 2000 and a sensitivity S ~ 550 nm/ RIU can still be achieved even with CA down to 1500.

JTh2A.105
Hyperspectral and multimodal CARS microscopy of structured endogenous biomolecules in *Euglena gracilis*, Joel T. Tabarangao[1], Jeremy G. Porquez[1], Aaron D. Slepkov[1]; [1]*Trent Univ., Canada*. Using hyperspectral CARS and SHG microscopies we image and fingerprint an intriguing biomolecule in phototrophic *Euglena gracilis*. The large CARS signal strength of this endogenous biomolecule opens new opportunities in label-free, live biological imaging.

JTh2A.106
Imaging of 3D Molecular Orientations by Polarization-Controlled Coherent Raman Microscopy, Young J. Lee[1]; [1]*NIST, USA*. A new optical imaging method determines the 3D angles of molecular orientation by concurrent polarization analysis of multiple Raman modes. Theoretical description and data analysis results of a high-density polyethylene film will be presented.

JTh2A.107
Flexible Mid-infrared Photonic Chips for Real-time and Label-Free Biochemical Detection, Pao T. Lin[1]; [1]*Texas A&M Univ., USA*. Chip-scale biomedical chemical sensors were demonstrated using mid-Infrared flexible aluminum nitride waveguides. Ethanol and water real-time detection was conducted by measuring waveguide light at λ=2.7 μm corresponding to the characteristic -OH absorption.

JTh2A.108
All-optical wavelength-tunable narrow-linewidth fiber laser, Yujia Li[1], Tao Zhu[1], Shihong Huang[1], Lei Gao[1], Tianyi Lan[1], Yulong Cao[1]; [1]*Chongqing Univ., China*. We propose an optical-controlled wavelength-tunable narrow-linewidth fiber laser based on graphene's optical-thermal effect, which has the properties of wavelength fast-scanning, low to ~750 Hz linewidth, wavelength stability of 0.4 pm and so on.

JTh2A.109
Spatially Gain-Tailored Fiber Raman Laser Cladding-Pumped by Multimode Disk Laser at 1030 nm, Yutong Feng[1], Sheng Zhu[1], Soonki Hong[1], Huaiqin Lin[1], Pranabesh Barua[1], Jayanta K. Sahu[1], Johan Nilsson[1]; [1]*Univ. of Southampton, UK*. A spatially gain-tailored fiber Raman laser with Ge-doped core and P-doped inner cladding generates 46 W of instantaneous power at 1084 nm with 64% slope efficiency when cladding-pumped by a 1030-nm quasi-cw multimode disk laser.

JTh2A.110
Numerical Analysis on the Influence of Photo Darkening Heating Induced Phase Distortion on Fiber Coherent Combining CPA Scheme, Yujun Feng[1], Betty M. Zhang[1], Johan Nilsson[1]; [1]*Univ. of Southampton, UK*. We use numerical simulations to investigate the effects of photodarkening (PD) on single-channel and coherently combined Yb-doped Fiber CPA Systems. The system design optimizing for the lossy fiber caused by PD at ending of life shows improvements on both pulse compression and combining efficiency.

JTh2A.111
Generation of Octave Spanning Spectra Directly from a Fiber Oscillator with Self-Similar Pulse Evolution, Ankita N. Khanolkar[1], Chunyang Ma[3], Andy Chong[1,2]; [1]*Electro Optics and Photonics, Univ. of Dayton, USA;* [2]*Dept. of Physics, Univ. of Dayton, USA;* [3]*Electronic Science and Enigineering, Jilin Univ., China*. A mode-locked fiber laser with a strong self-similar evolution in a gain segment and spectral broadening in a photonic crystal fiber was simulated to generate nearly octave spanning spectra.

JTh2A.112
Stable microwave signal generation from PM dual-wavelength single-frequency Er-doped DBR fiber laser utilizing superimposed FBGs, Yubin Hou[1], Qian Zhang[1], Shuxian Qi[1], Xian Feng[1], Pu Wang[1]; [1]*Beijing Univ. of Technology, China*. We demonstrate a PM dual-wavelength single-frequency Er-doped DBR fiber laser as a stable microwave generation source. The beat frequency of the dual-wavelength is 28.4474 GHz with the linewidth less than 0.3 kHz.

JTh2A.113
Spatial-Mode Switchable Ring Fiber Laser Based on Low Crosstalk Few-mode Fiber and Mode MUX/DEMUX, Yu Yang[1], Juhao Li[1], Fang Ren[2], Jinglong Zhu[1], Yongqi He[1], Zhangyuan Chen[1], Zhengbin Li[1]; [1]*Peking Univ., China;* [2]*Univ. of Science and Technology Beijing, China*. A spatial-mode switchable ring fiber laser based on low mode-crosstalk few-mode fiber and mode multiplexer/demultiplexer (MUX/DEMUX) is proposed. We experimentally demonstrate that output lasing mode can be switched among the three lowest-order LP modes.

JTh2A.114
Efficient Frequency Doubling of an Ytterbium-Doped Fiber Ring Laser Using an Internal Enhancement Cavity, Stanislav K. Vassilev[1], William A. Clarkson[1]; [1]*Optoelectronics Research Centre, UK*. A novel fiber laser geometry incorporating an internal resonant enhancement cavity to generate visible output via second harmonic generation is presented. Preliminary experiments using an Yb-fiber gain medium yielded 17W of single-mode output at 540nm.

JTh2A.115
Generation and Amplification of First Order OAM with Fused Taper Coupler, Jianxiang Wen[1]; [1]*Shanghai Univ., China*. We demonstrated a vortex beams coupler which can generate at range of 1480 – 1640 nm and built up an all-fiber vortex amplification system, which is of the higher gain and better flatness of OAM.

JTh2A.116
All-fiber Laser Source at 1.7 μm for Photoacoustic Microscopy in Lipid Detection, Nan Chen[1], Can Li[1], Bowen Li[1], Kenneth Kin-Yip Wong[1]; [1]*The Univ. of Hong Kong, China*. Multi-wavelength all-fiber laser source in 1.7-μm regime combining parametric oscillation and thulium-doped fiber amplification is reported. Its high flexibility facilitates itself of high performance in high-speed OR-PAM for lipid detection in the first overtone wavelength.

JTh2A.117
Distributed Measurement of Bending-Induced Birefringence in Single-Mode Fibers with PA-OFDR, Yanling Shang[1], Ting Feng[1], Xichen Wang[1], Anton Khomenko[2], James Chen[2], Xiaotian S. Yao[1,2]; [1]*Hebei Univ., China;* [2]*General Photonics Corporation, USA*. We demonstrate the distributed bending-induced birefringence measurement in single-mode fibers with high spatial resolution using a polarization-analyzing optical frequency domain reflectometry. The bending-induced birefringence coefficient of 5.499×10^{-10} m^2 is accurately obtained.

JTh2A.118
Implementation of linearly-polarized LP_{01} modes to any azimuthally-orientated LP_{11} modes conversion, lipeng feng[1], Yan Li[1], Sihan Wu[1], Xinglin Zeng[1], Wei Li[1], Rongsheng Chen[2], Jifang Qiu[1], Xiaobin Hong[1], Ian P. Giles[2], Jian Wu[1]; [1]*Beijing Univ. of Posts and telecom, China;* [2] *Phoenix Photonics, UK*. We propose a scheme that converts fundamental modes of different polarization to asymmetrical spatial modes of different orientation, of utility in exchange data between preceding PDM and rising MDM optical networks.

JTh2A.119
Multiplexed mode-locked fiber laser emitting dissipative and conventional solitons, Bowen liu[1], Yiyang Luo[1], Yang Xiang[1], Zhijun Yan[1], Yingxiong Qin[1], Qizhen Sun[1], Xiahui Tang[1]; [1]*Huazhong Univ of Science and Technology, China*. We report a bidirectional passively mode-locked fiber laser supporting both dissipative and conventional soliton emission in different propagating directions. Moreover, broadband wavelength-tunable solitons, dual-wavelength solitons and wavelength-tunable noise-like pulses are respectively obtained.

JTh2A.120
High Peak Power Single-Frequency Amplifier Based on a Er-Yb Doped Polarization Maintaining LMA Fiber, Anne Durécu[1], Pierre Bourdon[1], François Gustave[1], Hermance Jacqmin[1], Julien Le Gouët[1], Laurent Lombard[1]; [1]*ONERA, France*. We report on single-frequency fiber amplifiers based on PM Er-Yb doped P_2O_5-Al_2O_3-SiO_2 fibers. Peak power up to 700W at 1545nm for 730ns pulse duration was obtained with a good beam quality and a 17dB PER.

JTh2A.121
Bidirectional, Er-doped, Dual-comb Fiber Laser with Carbon Nanotube Polyimide Film, Shuto Saito[1], Lei Jin[1], Yoichi Sakakibara[2], Emiko Omoda[2], Hiromichi Kataura[2], Norihiko Nishizawa[1]; [1]*Nagoya Univ., Japan;* [2]*AIST, Japan*. Bi-directional, Er-doped dual comb fiber laser was demonstrated using polyimide film dispersed with single wall carbon nanotube. Difference of repetition frequency was temporally stable and it could be tuned continuously by pump power control.

JTh2A.122
Directly modified single mode fiber as an intermodal interferometer based on single femtosecond-laser induced line, Pengcheng Chen[1], Shu Xuewen[1]; [1]*Huazhong Univ. of Sci. & Tech., China*. We demonstrate a novel Mach-Zehnder interferometer based on a single femtosecond-laser induced positive refractive index-modified line created in the core of a single-mode fiber. The device is extremely simple in structure and very efficient in manufacturing.

JTh2A.123
Dispersion Engineering Analysis of Er-Fiber Based Comb Amplification in All-Fiber Configuration, Ken Kashiwagi[1,2], Hajime Inaba[1,2]; [1]*National Inst. of Advanced Industrial Science and Technology, Japan;* [2]*JST, ERATO, MINOSHIMA Intelligent Optical Synthesizer (IOS), Japan*. We experimentally and numerically investigated dispersion engineering of amplification of erbium-fiber based comb. Spectral narrowing in a fiber amplifier increased the effective gain and enhanced the peak power at fiber-based dispersion compensator output.

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JTh2A.124
Super-resolution electro-optic dual-comb spectroscopy, Wang Shuai[1], Xinyu Fan[1], Bingxin Xu[1], Zuyuan He[1]; [1]*Shanghai Jiao Tong Univ., China*. We demonstrate an electro-optic dual-comb spectroscopy with 1-MHz spectral resolution. By using quasi-integer-ratio multiheterodyne approach, 36000 electro-optic comb lines were well resolved with an increased measurement speed of 3000.

JTh2A.125
Design of a Dual-Channel Modelocked Fiber Laser that Avoids Multi-Pulsing, Xianting Zhang[1], Shaokang Wang[2], Feng Li[1], Curtis R. Menyuk[2], P. K. A. Wai[1]; [1]*Dept. of Electronic and Information Engineering, The Hong Kong Polytechnic Univ., Hong Kong;* [2]*Dept. of Computer Science and Electrical Engineering, Univ. of Maryland Baltimore County, USA*. Multi-pulsing competes with multi-channel modelocking in fiber lasers and can suppress it. We study the conditions to achieve stable dual-channel modelocking, and we propose a design that avoids multi-pulsing.

JTh2A.126
Rogue waves in an ultrafast fiber laser under chaotic dissipative soliton buildup regime, Zhichao Luo[1,2], Jiqiang Kang[1], Meng Liu[2], Can Li[1], Cihang Kong[1], Kenneth Kin-Yip Wong[1]; [1]*Univ. of Hong Kong, Hong Kong;* [2]*South China Normal Univ., China*. We report on the observation of optical rogue waves (RWs) in a net-normal dispersion fiber laser during the chaotic dissipative soliton buildup process. These findings indicate a promising approach for optical RW generation.

JTh2A.127
Optical Computing Based on Recirculating Frequency Shifter, Zhiqiang Qin[1], Qizhuang Cen[1], Yitang Dai[1], Feifei Yin[1], Kun Xu[1]; [1]*Beijing Univ. of Posts and Telecommunications, China*. Optical computing is an effective technique to accelerate the computing process. Here, an optical computing scheme based on recirculating frequency shifter is proposed and experimentally demonstrated. Matrix multiplication can be realized based on our scheme.

JTh2A.128
High Damage Threshold Semiconductor Saturable Absorber Mirror for Fiber Lasers, Yan Wang[1], Nan Lin[2], Wanli Gao[1], Huanyu Song[3], Minglie Hu[3], Haiming Li[4], Wenxia Bao[4], Xiaoyu Ma[2], Zhigang Zhang[1]; [1]*Peking Univ., China;* [2]*Inst. of semiconductors, Chinese Academy of Sciences, China;* [3]*Tianjin Univ., China;* [4]*LZ Lasers, China*. We demonstrate a high damage threshold semiconductor saturable absorber mirror for mode-locked fiber lasers, with a damage threshold of 9.5 mJ/cm^2, a modulation depth of 11.5%, a saturation fluence of 39.3 mJ/cm^2, an ISA coefficient of 6.3×10^2 mJ/cm^2.

JTh2A.129
Fabrication of Low Loss Low-NA Highly Yb-doped Aluminophosphosilicate Fiber for High Power Fiber Lasers, Raghuraman Sidharthan[1], Serene Huiting Lim[2], Kang Jie Lim[2], Daryl Ho[1], Chun Ho Tse[1], Junhua Ji[1], Huizi Li[1], Yue Men Seng[1], Song Liang Chua[2], Seongwoo Yoo[1]; [1]*Nanyang Technological Univ., Singapore;* [2]*DSO National Labs, Singapore*. We report fabrication and characterization of photodarkening-suppressed highly Yb-doped step-index fibers. The fiber contains 2.9wt% of Yb and has background loss of ~10dB/km. The fiber generates >100 W laser output power with 75% slope efficiency.

JTh2A.130
An Er Fiber Laser Generating Multi-Milliwatt Picosecond Pulses with Nearly Shot-Noise-Limited Intensity Noise, Hironobu Yoshimi[1], Kazuhiko Sumimura[2], Yasuyuki Ozeki[1]; [1]*The Univ. of Tokyo, Japan;* [2]*Kokyo Inc., Japan*. We demonstrate a polarization-maintaining fiber laser generating 8.4-ps pulses at 40 MHz with an average power of ~5 mW. Its intensity noise is measured to be only 2.4-dB higher than the shot noise limit.

JTh2A.131
Localization of light and transport of infrared optical image in a tellurite optical fiber with transversely-disordered refractive index profile, Hoang Tuan Tong[1], Shunei Kuroyanagi[1], Kenshiro Nagasaka[1], Takenobu Suzuki[1], Yasutake Ohishi[1]; [1]*Toyota Technological Inst., Japan*. By numerical calculations and experiments, we demonstrate that tellurite optical fibers with transverse-disordered refractive index profile can be used to obtain the localization of light and to transport infrared optical images at 1.55 mm.

JTh2A.132
All-Polarization-Maintaining One- and Two-Stage Holmium-doped Fiber Amplifiers at 2051 nm, Robert E. Tench[1], Clement Romano[1,2], Jean-Marc Delavaux[1], Benoit Cadier[3], Thierry Robin[3], Arnaud Laurent[3]; [1]*Cybel, LLC, USA;* [2]*Institut Telecom/Paris Telecom Tech, France;* [3]*IXBlue Photonics, France*. We report the performance of one- and two-stage single clad polarization-maintaining (PM) Ho-doped fiber amplifiers (HDFAs) at λ_s = 2051 nm, pumped at $\lambda_p \approx$ 1950 nm. We show that the Ho-doped fiber has a slope efficiency η = 70 %, and demonstrate an output power P_{out} of 3.5 W and a gain G = 43 dB.

JTh2A.133
Cladding Pumped EDFAs with Annular Erbium Doping, Charles Matte-Breton[1], Haoshuo Chen[2], Nicolas K. Fontaine[2], Roland Ryf[2], René-Jean Essiambre[2], Younès Messaddeq[1], Sophie LaRochelle[1]; [1]*Université Laval, Canada;* [2]*Nokia Bell Labs, USA*. We present simulation, fiber design and experimental characterization of a cladding pumped EDFA with erbium doping in the cladding. The approach is of interest for future development of multi-core EDFAs with increased saturation output power.

JTh2A.134
Gain-Switched Thulium-Doped Fiber Laser with Electrically Tuning at 1690-1765 nm, Can Li[1], Nan Chen[1], Zhichao Luo[1,2], Kenneth Kin-Yip Wong[1]; [1]*Univ. of Hong Kong, Hong Kong;* [2]*Guangzhou Key Lab for Special Fiber Photonic Devices and Applications, South China Normal Univ., China*. We demonstrate a gain-switched thulium-doped fiber laser with electrically tuning at 1690-1765 nm. Stable laser pulse with duration of 190 ns, average power of 654 mW, and pulse energy of 2.2 μJ is achieved.

JTh2A.135
Dual Pumping Scheme for Efficient 4 μm Operation of a Ho:InF$_3$ Glass Fiber Laser, Richard S. Quimby[1]; [1]*Worcester Polytechnic Inst., USA*. Numerical modeling shows that pumping a Ho-doped fluoroindate fiber laser at both 910 and 2100 nm will give a cw output at 4100 nm with a slope efficiency of ~17% .

JTh2A.136
Fiber-based Picosecond Source with Variable Transform Limited Linewidth and Flexible Repetition Rate, Daniel Kiefer[1], Thomas Walther[1]; [1]*TU Darmstadt, Laser and Quantum Optics, Germany*. We present a 1028-nm master oscillator power amplifier system generating transform limited pulses with adjustable duration (250 and 735 ps) and repetition rate (1 and 10 MHz).

JTh2A.137
Off-resonance long-period fiber gratings and spin-optics response, Moti Fridman[1]; [1]*Bar Ilan Univ., Israel*. We investigated the spectral response of strong long-period fiber gratings (LPFGs) and found an off-resonance spectral response including a spin-optics coupling between polarization and modes for asymmetric LPFGs.

JTh2A.138
Probabilistic Phase Control for Coherent Beam Combining, Henrik Tuennermann[1], Akira Shirakawa[1]; [1]*Univ. of Electro-Communications, Japan*. Using probabilistic phase control, we realize coherent beam combining without using explicit modulation or polarization for error signal generation. Furthermore, the technique allows fusing multiple types of sensor data.

JTh2A.139
Polarization-maintaining, dual-wavelength, dual-comb mode-locked fiber laser, Ruliu Wang[1], Xin Zhao[1], Weinan Bai[1], Jie Chen[1], Zheng Zheng[1,2]; [1]*School of Electronic and Information Engineering, Beihang Univ., China;* [2]*Collaborative Innovation Center of Geospatial Technology, China*. A self-starting, dual-wavelength, dual-comb mode-locked fiber laser based on all polarization-maintaining parts and a carbon nanotube modelocker is demonstrated, and dual-wavelength operation is realized through spatial filtering facilitated by waveplates in the cavity.

JTh2A.140
Timing Stabilization of Solid-State Yb-Based Laser System, Stefano Valente[1,2], Anne-Laure Calendron[1,3], Joachim Meier[1], Emma Kueny[1,2], Huseyin Cankaya[1,2], Nicholas H. Matlis[1], Giovanni Cirmi[1,3], Franz X. Kaertner[1,2]; [1]*Center for Free Electron Laser Science,Deutsches Elektronen Synchrotron (DESY), Germany;* [2]*Dept. of Physics, Univ. of Hamburg, Germany;* [3]*The Hamburg Centre for Ultrafast Imaging, Univ. of Hamburg, Germany*. We present a tight optical timing stabilization to 10 fs RMS jitter between two compressed branches of a sub-picosecond Yb based laser system operating at 1 kHz

JTh2A.141
Extension of the Stable Operation of an all Polarization Maintaining Mode-Locked Fiber Laser, Hanieh Afkhamiardakani[1], Mehran Tehrani[1], Jean-Claude M. Diels[1]; [1]*Univ. of New Mexico, USA*. We present an all-polarization maintaining mode-locked fiber laser at 1532 nm with enhanced stability by cooling of the carbon nanotube saturable absorber. The laser output power ranges from 50uW to 200uW depending on the cooling.

JTh2A.142
Pulse-Chirp Instability and Issues for Its Measurement, Rana Jafari[1], Rick Trebino[1]; [1]*Georgia Inst. of Technology, USA*. Pulses often possess random amounts of linear chirp. We find that SPIDER cannot detect this variation, yielding instead a shorter, flat-phase, coherent artifact. SHG FROG can and provides a better estimate of the average pulse.

JTh2A.143
Ultrafast Broadband Photodetectors Based on Three-Dimensional Dirac Semimetal Cd_3As_2, Jiawei Lai[1], Qinsheng Wang[1], Cai-Zhen Li[2], Shaofeng Ge[1], Jin-Guang Li[2], Wei Lu[1], Xuefeng Liu[1], Junchao Ma[1], Da-Peng Yu[2,3], Zhi-Min Liao[2,3], Dong Sun[1,3]; [1]*International Center for Quantum Materials, School of Physics, Peking Univ., China;* [2]*State Key Lab for Mesoscopic Physics, School of Physics, Peking Univ., China;* [3]*Collaborative Innovation Center of Quantum Matter, China*. In this work, we report the realization of an ultrafast broadband photodetector based on Cd_3As_2 with a high sensitivity, high responsivity and high speed (~145 GHz) over a broad wavelength range.

JTh2A.144
Ultralow-Noise and Agile Microwave Synthesizer Based on a Femtosecond Mode-Locked Fiber Laser, Juan Wei[1,2], Dohyeon Kwon[1], Shilong Pan[2], Jungwon Kim[1]; [1]*Korea Advanced Inst of Science & Tech, South Korea;* [2]*Nanjing Univ. of Aeronautics and Astronautics, China*. We demonstrate a microwave synthesizer based on a mode-locked fiber laser and all-fiber photonics, which outputs 9-11 GHz signals with integrated timing jitter of 7.6-fs to 9.1-fs [integration bandwidth: 10 Hz-10 MHz] and frequency switching time of 135-ns.

JTh2A.145
Simplified Pre-Characterization of Chirped Pulses in Single-shot Supercontinuum Spectral Interferometry, Dinhduy Vu[1], Dogeun Jang[1], Ki-Yong Kim[1]; [1]*Univ. of Maryland at College Park, USA*. We develop a method to pre-characterize a chirped pulse in single-shot supercontinuum spectral interferometry (SSSI). In this method, the spectral phase of both modulated (probe) and unmodulated (reference) pulses can be determined simultaneously.

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JTh2A.146
Optical Repetition Rate Locking of Ultrafast SESAM-Based Yb-Doped All-Fiber Oscillator for High Intensity OPCPA Systems, Karolis Madeikis[1,2], Karolis Viskontas[1], Rokas Danilevicius[1,2], Tadas Bartulevicius[1,2], Laurynas Veselis[1,2], Andrejus Michailovas[1,2], Nerijus Rusteika[1,2]; [1]*Ekspla Ltd., Lithuania;* [2]*Dept. of Laser Technology, State research Inst. Center for Physical Sciences and Technology, Lithuania.* We demonstrate all-fiber ultrafast SESAM-based optically repetition rate locked oscillator concept designed for high intensity OPCPA systems. Pump induced refractive index change in the active erbium fiber for precise delay line was tested.

JTh2A.147
Femtosecond laser delivery and coupling via dual hollow-core anti-resonant fiber, Xiaosheng Huang[1], Seongwoo Yoo[1], Dingyuan Tang[1], Jie Ma[1]; [1]*Nanyang Technological Univ., Singapore.* We design, fabricate and characterize dual hollow-core anti-resonant fibers (DHAFs) that function as air core fiber couplers. The applications of DHAFs in fiber laser and ultrafast pulse delivery and power coupling are demonstrated.

JTh2A.148
Dual-comb spectrally encoded confocal microscopy, Pingping Feng[1], Jiqiang Kang[1], Sisi Tan[1], Xi Zhou[2], Chi Zhang[2], Kenneth Kin-Yip Wong[1]; [1]*The Univ. of Hong Kong, Hong Kong;* [2]*Huazhong Univ. of Science and Technology, China.* We report a dual-comb spectrally encoded confocal microscopy (DC-SECM) at 3-MHz frame rate and 8.8-μm resolution. Comparing with mode-locked laser based SECM, DC-SECM features with lower detection bandwidth and higher power efficiency.

JTh2A.149
An aberration-free ultrafast optical oscilloscope with large temporal window, Liao Chen[1], Yuhua Duan[1], Xi Zhou[1], Chi Zhang[1], Xinliang Zhang[1]; [1]*Huazhong Univ. of Science and Technology,, Wuhan National Lab for Optoelectronics & School of Optical and Electronic Information, China.* We report an aberration-free ultrafast optical oscilloscope based on the time-to-frequency conversion. It achieves 430-fs temporal resolution over 14-ns temporal window, which represents the largest record-length-to-resolution ratio (3.2×10^4) of any single-shot-capable ultrafast oscilloscope.

JTh2A.150
High-Speed "Multi-Grid" Pulse-Retrieval Algorithm for Frequency-Resolved Optical Gating, Rana Jafari[1], Rick Trebino[1]; [1]*Georgia Inst. of Technology, USA.* We improved the FROG-algorithm convergence speed for complex pulses using a "multi-grid" technique. We achieved a factor of ~7 improvement for cross-correlation FROG for pulses with time-bandwidth products from 40 to 90.

JTh2A.151
Ultrafast Coherent Hole Transfer in Non-Fullerene OPV Blends, Rui Wang[1], Chunfeng Zhang[1], Zhiguo Zhang[2], Yongfang Li[2], Xiaoyong Wang[1], Min Xiao[1,3]; [1]*National Lab of Solid State Microstructures, School of Physics, and Collaborative Innovation Center of Advanced Microstructures, Nanjing Univ., China;* [2]*Beijing National Lab for Molecular Science, CAS Key Lab of Organic Solids, Inst. of Chemistry, Chinese Academy of Science, China;* [3]*Dept. of Physics, Univ. of Arkansas, USA.* We study the ultrafast hole transfer process in the OPV blends of J71/ITIC utilizing two-dimensional electronic spectroscopy. The results show coherent vibronic coupling plays a critical role in ultrafast hole transfer process.

JTh2A.152
Mode-Locked all-fiber laser using Two-Dimensional Perovskite in C and L band, Seongjin Hong[1], ferdinand ledee[2], Jaedoek Park[3], Sanggwon Song[1], Dong-il Yeom[3], Emmanuelle Deleporte[2], Kyunghwan Oh[1]; [1]*Yonsei Univ., South Korea;* [2]*Université Paris-Sud, France;* [3]*Ajou Univ., South Korea.* Using two-dimensional (2D) hybrid organic-inorganic (C6H5C2H4NH3)2PbI4 perovskite thin film as an in-line saturable absorber, we experimentally demonstrate an all-fiber mode-locked laser with 381 fs in both C and L band.

JTh2A.153
Scaling of High Repetition Rate Mode-Locked Tm-doped Fiber Lasers, Junjie Zeng[1], Ahmet E. Akosman[1], Michelle Y. Sander[1,2]; [1]*Electrical and Computer Engineering, Boston Univ., USA;* [2]*Materials Science and Engineering, Boston Univ., USA.* Scaling of a compact linear soliton mode-locked Tm-doped fiber lasers with repetition rates of 531.9 MHz, 704.3 MHz, and 969.0 MHz with transform limited pulse durations down to 358 fs is demonstrated.

JTh2A.154
Compact High Average Power High Energy CPA Laser System Based on Yb Fiber Seeder and Yb:YAG Amplifier, Laurynas Veselis[1,2], Tadas Bartulevicius[1,2], Karolis Madeikis[1,2], Rokas Danilevicius[1,2], Andrejus Michailovas[1,2], Nerijus Rusteika[1,2]; [1]*R&D, Ekspla Ltd, Lithuania;* [2]*Dept. of Laser Technology, Center for Physical Sciences and Technology, Lithuania.* We presented a compact sub-ps high average power (20 W) and energy (100 μJ) laser based on the matched pair of chirped fiber Bragg grating and chirped volume Bragg grating for pulse stretching and compression.

JTh2A.155
Soliton molecule vibration in mode-locked fiber lasers, Yiyang Luo[1], Yang Xiang[1], Tao Liu[1], Bowen liu[1], Zhijun Yan[1], Yingxiong Qin[1], Qizhen Sun[1], Xiahui Tang[1]; [1]*Huazhong Univ of Science and Technology, China.* Atom-like behaviors make the bound solitons akin to molecules. Here, we report on the experimental observation of soliton molecule vibration in mode-locked fiber lasers with time-stretch technique to deepen our understanding of soliton complexes.

JTh2A.156
Four-Prism-Pumped All-Gold-Mirror Femtosecond Optical Parametric Oscillator Based on an Yb-doped Fiber Laser, Jun Zhao[1], Jintao Fan[1], Chenglin Gu[1], Wu Liu[1], Chingyue Wang[1], Ming-lie Hu[1]; [1]*Tianjin Univ., China.* We report a four-prism-pumped all-gold-mirror idler resonant optical parametric oscillator (OPO) driven by an Yb-fiber femtosecond laser. The idler is tuned from 2560-4180 nm, with the corresponding signal covering 1380-1825 nm.

JTh2A.157
Generation of a CEO-stabilized optical frequency comb with programmable sub-MHz FSR using spectral self-imaging, Mohamed Seghilani[1], Xiao-Zhou Li[1], Reza M. Qartavol[1], Luis Romero Cortés[1], Jose . Azana[1]; [1]*INRS-EMT, Canada.* We demonstrate a low noise, CEO-stabilized optical frequency comb (OFC) with a programmable sub-MHz FSR through suitable temporal phase modulation of a 250-MHz OFC. The method preserves the energy and the full bandwidth of the input OFC.

JTh2A.158
21-fs Kerr-lens Mode-locked Yb:$CaYAlO_4$ Laser, Jie Ma[2,1], Xiaodong Xu[2], Deyuan Shen[2], Dingyuan Tang[1]; [1]*Nanyang Technological Univ., Singapore;* [2]*Jiangsu Normal Univ., China.* We experimentally demonstrated the generation of 5.87-optical-cycle pulses from a Kerr-lens mode-locked Yb:$CaYAlO_4$ (Yb:CYA) laser. Pumped by a 976 nm fiber laser, stable ultrashort pulses with a repetition rate of ~114 MHz were obtained around 1077 nm.

JTh2A.159
Continuous Generation of Ultrafast Arbitrary Optical Waveform with a Repetition Rate exceeding 100 THz, Chiaki Ohae[1,2], Trivikramarao Gavara[1], Kaoru Minoshima[1,2], Masayuki Katsuragawa[1,2]; [1]*Univ. of Electro-Communications, Japan;* [2]*JST, ERATO, MINOSHIMA Intelligent Optical Synthesizer, Japan.* We generate the five phase-locked harmonics having an exact integer frequency ratio 1ω, 2ω, 3ω, … with a controlled carrier-envelope-phase. We also demonstrate the continuous generation of ultrafast optical amplitude waveforms with a repetition rate exceeding 100 THz.

JTh2A.160
Dissipative Kerr Soliton mode-locking and breather states in 19 GHz Si_3N_4 microresonator, Wenting Wang[1], Abhinav K. Vinod[1], Jinghui Yang[1], Mingbin Yu[2], Dim-Lim Kwong[2], Chee-Wei Wong[1]; [1]*Mesoscopic Optics and Quantum Electronics Lab, Univ. of California, Los Angeles, USA;* [2]*Technology and Research (A*STAR), Inst. of Microelectronics, Singapore.* We observed chaotic state, breather comb, and dissipative Kerr soliton (DKS) with repetition rate of 19 GHz in dispersion-managed Si_3N_4 microresonator. The DKS pulse train is characterized by SHG noncollinear autocorrelator and frequency-resolved optical gating.

JTh2A.161
Multiplexed Signal Recovery for Ultrafast Waveform Measurement, Daniel J. Kane[1]; [1]*Mesa Photonics, LLC, USA.* We demonstrate a combined optical and electronic system for measuring optical waveforms at bandwidths up to 2 THz. The technique uses sonogram decomposition of the waveform to reduce the optical bandwidth to levels measurable with current electronics.

JTh2A.162
Tightly Synchronized Two-color Femtosecond Source Based on Low-noise SPM-enabled Spectral Selection, Yi Hua[1], Gengji Zhou[1], Wei Liu[1], Franz X. Kaertner[1], Guoqing Chang[1]; [1]*Center for Free-Electron Laser Science, DESY, Germany.* We demonstrate that SPM-enabled spectral selection generates low noise high-energy wavelength tunable femtosecond pulses that exhibit sub-fs relative timing jitter and therefore are tightly synchronized to the source laser pulse.

JTh2A.163
Temporal Super-Resolution, Moti Fridman[1]; [1]*Bar Ilan Univ., Israel.* We investigated the resolution limits of time-lenses and developed a super-resolution technique in the time domain based on localization microscopy algorithm, demonstrating an improved resolution by a factor of two.

JTh2A.164
Phase Lock in Four-Wave Raman Mixing in the Near-Infrared Region, Yuta Nakano[1], Totaro Imasaka[2]; [1]*Dept. of Applied Chemistry, Graduate School of Engineering, Kyushu Univ., Japan;* [2]*Division of International Strategy, Center of Future Chemistry,, Kyushu Univ., Japan.* The Raman emission generated by four-wave mixing was verified to be coherently phased against the pump beams, suggesting the generation of an ultrashort optical pulse train by superimposing the Raman emission and the pump beams.

JTh2A.165
Ultralarge Dispersion of Microwave Signals, Jilong Li[1], Yan Zheng[1], Yitang Dai[1], Feifei Yin[1], Kun Xu[1]; [1]*Beijing Univ of Posts & Telecom, China.* We propose and demonstrate a novel microwave signal processing scheme to achieve ultralarge dispersion amounts approaching 10 ns/GHz. We achieve this by magnifying limited optical dispersion amounts (around 32.3 ps/nm) 390,000 times

JTh2A.166
Progress Towards Full Stabilization of an Injection Locked 10GHz Chip-Scale Mode-Locked Laser on InP, Michael E. Plascak[2], Ricardo Bustos Ramirez[2], Marcin Malinowski[2], Jean-Etienne Tremblay[1], Ashish Bhardwaj[3], Gloria Hoefler[3], Sasan Fathpour[2], Ming C. Wu[1], Peter Delfyett[2]; [1]*Dept. of Electrical Engineering and Computer Science, Univ. of California at Berkeley, USA;* [2]*CREOL, The College of Optics & Photonics, Univ. of Central Florida, USA;* [3]*Infinera Corporation, USA.* Repetition rate stabilization of an injection locked chip-scale mode-locked laser and progress towards carrier envelope offset frequency stabilization using chalcogenide waveguides for supercontinuum generation and a bulk PPLN for second harmonic generation are presented.

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JTh2A.167
Harmonic Injection Locking for a Direct Optical to RF Link, Ricardo Bustos Ramirez[2], Michael E. Plascak[2], Ashish Bhardwaj[1], Gloria Hoefler[1], Fred Kish[1], Peter Delfyett[2]; [1]*Infinera Corporation, USA;* [2]*CREOL, The College of Optics and Photonics, USA.* We demonstrate a chip-scale direct optical to RF link, that down-converts 60GHz optical frequency combs to 10GHz, using harmonic multi-tone injection locking. A minimum injection power of 10μW and locking bandwidth of 4.3MHz is observed.

JTh2A.168
Photonic Measurement of Broadband Microwave Bursts, Yihan Li[1], Naoya Kuse[1], Martin E. Fermann[2]; [1]*IMRA America, Inc., BRL, USA;* [2]*IMRA America, Inc., USA.* We report a photonic-assisted system for broadband microwave burst measurements. By deploying a dual coherent electro-optical comb and optical storage, wavelength and time-division multiplexings are enabled simultaneously to offer broad bandwidth and fast acquisition speed.

JTh2A.169
4D Pulse Shaping of Discretized Beam Arrays, Wei Liu[1], Joseph Robinson[1], Alan Fry[1], Sergio Carbajo[1]; [1]*Stanford Univ. SLAC National Accelerator, USA.* We report on a novel ultrafast laser architecture capable of generating 4D arbitrarily distributed beams based on an array of coherently combined fibers, each containing femtosecond pulses with controlled intensity, wavefront, and polarization vector distribution.

JTh2A.170
Spectrally sampled second-harmonic interferometric autocorrelation for 3.5 fs pulse measurement, Heng-Jia Liu[1], An-Chia Hsu[1], Chung-Lo Chen[1], Shang-Da Yang[1]; [1]*National Tsing Hua Univ., Taiwan.* We demonstrate that two interferometric autocorrelation traces obtained by sampling two second-harmonic tones around the carrier would be sufficient to algebraically retrieve the spectral phase of a 3.5 fs pulse.

JTh2A.171
Directly Determining the Coefficient of Thermal Expansion of High-power Light-emitting Diodes by Optical Coherence Tomography, TingWei Yeh[1], Chun-Yang Chou[1], Chun-Ying Huang[2,3], YungChi Yao[1], YiKai Haung[1], Meng-Tsan Tsai[4,5], Ya-Ju Lee[1]; [1]*National Taiwan Normal Univ., Taiwan;* [2]*Univ. of Washington, USA;* [3]*National Chi Nan Univ., Taiwan;* [4]*Chang Gung Univ., Taiwan;* [5]*Chang Gung Memorial Hospital, Taiwan.* We used optical coherence tomography to measure CTE of high-power LEDs encapsulated in polystyrene resin. This work validates OCT can provide an alternative way to directly and nondestructively determine spatially resolved CTE of packaged LEDs.

JTh2A.172
A Fast, Accurate and Widely Applicable Computer Algorithm for Estimating Layer Number of Two-Dimensional Materials, Seungwan Cho[1], Jekwan Lee[1], Soohyun Park[1], Hyemin Bae[1], Minji Noh[1], Beom Kim[1], Chihun In[1], Seung Hoon Yang[2], Sooun Lee[3], Seung Young Seo[4], Jehyun Kim[5], Chul-Ho Lee[2], Wooyoung Shim[3], Moon-Ho Jo[4,6], Dohun Kim[5], Hyunyong Choi[1]; [1]*Electrical and Electronic Engineering, Yonsei Univ., South Korea;* [2]*KU-KIST Graduate School of Converging Science and Technology, Korea Univ., South Korea;* [3]*Dept. of Materials Science and Engineering, Yonsei Univ., South Korea;* [4]*Dept. of Materials Science and Engineering, Pohang Univ. of Science and Technology, South Korea;* [5]*Dept. of Physics and Astronomy, Seoul National Univ., South Korea;* [6]*Center for Artificial Low Dimensional Electronic Systems, Inst. for Basic Science, South Korea.* We present a computer algorithm for layer number estimation of few-layered two-dimensional materials. Based on the optical contrast method, this algorithm analyzes an optical microscope image in a few seconds with high accuracy over 90%.

JTh2A.173
Characterizing Chromatic Dispersion of Multiple Few-Mode Fibers Using Bidirectional OTDR Technique, Huiyuan Liu[2,1], Haoshuo Chen[2], Jiaxiong Li[2], Nicolas K. Fontaine[2], Roland Ryf[2], Guifang Li[1]; [1]*Univ. of Central Florida, USA;* [2]*Nokia Bell Labs, USA.* We use bidirectional OTDR technique to measure effective areas of two LP modes at four discrete wavelengths in cascaded few-mode fibers, with the help of mode-selective photonic lanterns, and calculate the chromatic dispersion.

JTh2A.174
The Reliability Assessment of Interferometric Fiber Optical Gyroscopes Based on Bayesian Estimation, Kun Ma[1], Jing Jin[1], Jing Ma[1], Ningfang Song[1]; [1]*Beihang Univ., China.* With the combination of priori distribution and likelihood function, the joint posterior distribution of interferometric fiber optical gyroscopes (IFOGs) is obtained based on Bayesian estimation and the reliability of IFOGs is assessed.

JTh2A.175
Using Two-Photon Absorption Pulsed-Laser Excitation to Simulate Radiation Effects in Microelectronics, Joel M. Hales[1,2], Ani Khachatrian[1,2], Stephen Buchner[1], Nicolas J. Roche[1], Jeffrey Warner[1], Veronique Ferlet-Cavrois[3], Dale McMorrow[1]; [1]*Naval Research Lab, USA;* [2]*Sotera Defense Solutions, USA;* [3]*European Space Agency, Netherlands.* By accurately characterizing and simulating the charge deposited in a device using two-photon absorption, this laser-based approach is used for quantitatively predicting radiation effects induced by heavy-ion excitation.

JTh2A.176
Study on Improved Object Identification by Using a Fused Image from Hyper-Spectral IR Images, Do-Hwi Kim[1], Changwon Kim[1], Kuk-Il Han[1], Jun-Hyuk Choi[1], Tae-Kuk Kim[1]; [1]*Chung Ang Univ., South Korea.* We developed a method for fusion of hyper-spectral IR images by emphasizing the feature points determined from the gray scale analysis. The proposed image fusion method resulted in an increased contrast up to 46% as compared to the previous methods.

JTh2A.177
Simultaneous Identification of Size and Complex Refractive Index of a Single Microbead via Mie Scattering, Benjamin Mills[1], James Grant-Jacob[1], Bharat Pant[1], Daniel Heath[1], Peter Horak[1], Matthew Loxham[1], Robert Eason[1]; [1]*Univ. of Southampton, UK.* The comparison of a single experimental diffraction pattern with simulations produced using Mie theory enables the precise and simultaneous determination of size and complex refractive index of a polystyrene microbead. Results agree with tabulated values.

JTh2A.178
An broadband terahertz metamaterial filter based on multiplexed metallic bar resonators, Zi jie Dai[1], Jing Yang[2], Qiang Su[1], Pengfei Qi[1], Dan Lu[1], Cheng Gong[1], Lu Sun[1], Weiwei Liu[1]; [1]*Nankai Univ., China;* [2]*Shanghai Inst. of Applied Physics, China.* An ultrabroad terahertz metamaterial filter based on multiplexed metallic bar resonators is designed and fabricated. The bandwidth of terahertz filter can be significantly broadened by the multiplexed configurations.

JTh2A.179
Broadband Wavelength Tunable Mode-Locked Tm-Doped Fiber Laser Based on Carbon Nanotubes, Bo Fu[1], Syed Hussain[1], Giancarlo Soavi[1], Baicheng Yao[1], Daniel Popa[1], Andrea Ferrari[1]; [1]*Cambridge Graphene Centre, UK.* We report a broadband tunable Tm-doped fiber laser mode-locked by carbon nanotubes. The wavelength tunability is achieved by introducing a polarization-maintaining isolator and two polarization controllers and the tunable range is up to 60 nm.

JTh2A.180
A Raman Spectroscopy and Optical Microscopy System for Studies at Low Temperatures and High Magnetic Fields, Todd Sayles[1]; [1]*Quantum Design, USA.* We present an optical probe for the PPMS for temperatures from 1.8 to 350 K and magnetic fields up to 16 T with XYZ motion control and integrated camera for fluorescence, Raman spectroscopy, and microscopy

JTh2A.181
Generation of wavelength- and orbital-angular-momentum-tunable vortex beam in Yb:CALGO laser, Yijie Shen[1], Mali Gong[1]; [1]*Tsinghua Univ., China.* A dual-off-axis pumping scheme is presented to generate orbital-angular-momentum (OAM) beam in Yb:CALGO laser. The wavelength-tunable width about 10 nm and the OAM-tunable range from ±1h to ±15h, controlled by the off-axis-displacements and pump power.

JTh2A.182
Ultra-Thin Films with Eu^{3+} Ions for Probing Effects of Local Environment , Alexis D. Bullock[1,2], Marvin c. Clemmons[1,2], Mohammad Shahabuddin[1,2], Soheila Mashhadi[1], Chi Yang[1,2], Carl E. Bonner[1,2], Natalia Noginova[1,2]; [1]*Center of Materials Research, USA;* [2]*Material Science and Engineering, Norfolk State Univ., USA.* Ultra-thin films of $Eu(TTA)_3$(L1a) have been fabricated by Langmuir-Blodgett technique on plasmonic and dielectric substrates and used to probe the effect of local environment on magnetic dipole emission and charge transfer processes.

JTh2A.183
A Novel Scheme Based on Composite Frame and Correlation for OTN Fiber Link In-Service Monitoring, Jinhao Du[1], Yan Zhang[1], Zhiliang Ren[2], Xue Chen[1]; [1] *Beijing Univ. of Posts and Telecommunications, China;* [2]*ZTE Corporation, China.* Using correlation technique and composite frame formed by OTN OSC channel and M sequence, we demonstrate an in-service monitoring scheme for OTN fiber link, which has the benefit of large dynamic range and without waveform distortion in service signal.

JTh2A.184
Real-time loop gain and bandwidth measurement of phase-locked loop for mode-locked laser in full frequency range, Dong Hou[1], Jie Tian[2], Fuyu Sun[1], Qingsong Bai[1], Haoyuan Lu[3], Jianye Zhao[3]; [1]*Univ. of Elect. Sci. and Tech. of China, China;* [2]*Inst. of Electronic Engineering-CAEP, China;* [3]*Peking Univ., China.* We demonstrate a technique for directly and real-timely measuring the loop gain and bandwidth of a phase-locking loop for mode-locked laser in full frequency range. The agreement of measurement and theoretical calculation proves the validity.

JTh2A.185
Precision visible comb from an Er fiber laser, Antoine Rolland[1], Peng Li[1], Marco Cassinerio[1], Jie Jiang[1], Martin E. Fermann[1]; [1]*IMRA, USA.* We report a highly coherent octave spanning visible optical frequency comb from a doubled Er fiber laser. The fractional residual instability is lower than 6x10^(-18) at 1s and reaches 3x10^(-20) after 1000 s of averaging time.

JTh2A.186
High-performance and cost-effective C-OTDR employing polarization independent coherent detection, Yan Zhao[1], Yang Tao[1], Ke Yan[1], Zhiliang Ren[2], Xue Chen[1]; [1]*State Key Lab of Information Photonics and Optical Communications, Beijing Univ. of Posts and Telecommunications, China;* [2]*ZTE corporation, China.* We propose a novel C-OTDR scheme which not only achieves large dynamic range but also solves the problem of polarization dependence. Simulation and experimental results demonstrate its feasibility and potentiality in ultra-long fiber link monitoring.

JTh2A.187
Non-mechanical Beam-steer Lidar System Based on Swept-laser Source, Yuyao N. Zhai[1], qingwen liu[1], Zuyuan He[1], He Li[1], Dian Chen[1]; [1]*Shanghai Jiao Tong Univ., China.* We have proposed a non-mechanical beam-steer lidar system, in which laser sweeps to realize 1-D beam steering and ranging simultaneously. Steering resoluiton of 0.19° over 3.3° and distance resolution of 1.8mm over 1m is achieved.

11:30–13:00 JTh2A • Poster Session III

JTh2A.188
Computation of Refractive Index and Optical Parameters for Stretched Polymer Films, KEUMCHEOL KWAK[1], Jung-Gu Lim[1,2], Jang-Kun Song[1]; [1]*Sungkyunkwan Univ., South Korea;* [2]*Advanced Materials R&D Center, Dongwoo Fine Chem. Co., Ltd.,, South Korea*. We report a theoretical calculation process without empirical databases to predict the refractive index, including wavelength dispersions and optical retardation of stretched polymer films using polarizability tensor, molecular volume for periodic units of polymers.

JTh2A.189
Dual-chirped OPA based pumping source for generation multicycle tunable terahertz pulses, Gyorgy Toth[2], József A. Fülöp[1], Máté Baditz[2], János Hebling[2]; [1]*MTA-PTE High-Field THz Research Group, Hungary;* [2]*Inst. of Physics, Univ. of Pécs, Hungary.* The superposition of signal and idler in dual-chirped OPA is proposed to produce intensity-modulated pulses with constant period. The modulation period can be tuned by changing the chirp and/or the delay between pump and signal.

JTh2A.190
Single-cycle attosecond pulse generation by Thomson scattering of terahertz pulses, Gyorgy Toth[2], Zoltan Tibai[2], Ashutosh Sharma[3], József A. Fülöp[1,3], János Hebling[2]; [1]*MTA-PTE High-Field THz Research Group, Hungary;* [2]*Inst. of Physics, Univ. of Pécs, Hungary;* [3]*ELI-ALPS, ELI-Hu Nkft., Hungary.* Single-cycle attosecond pulses can be generate by Thomson scattering of terahertz pulses on ultrathin electron layers, produced by a laser-plasma wakefield accelerator. According to our calculations, the energy can achieve more than 1 nJ.

JTh2A.191
Efficient semiconductor source of multicycle terahertz pulses using intensity-modulated pump, Gyorgy Toth[2], Pryo S. Nugraha[2], Mátyás I. Mechler[2], Gergo Krizsán[2], Gyula Polónyi[2], János Hebling[2], József A. Fülöp[1]; [1]*MTA-PTE High-Field THz Research Group, Hungary;* [2]*Inst. of Physics, Univ. of Pécs, Hungary.* Up to 5% conversion efficiency is predicted by numerical simulations for optimized GaP contact-grating THz sources based on optical rectification. Easy control of multicycle THz waveforms is enabled by a flexible dual-chirped OPA pump source.

JTh2A.192
A Continuously Tunable Optical Filter System in Broad Spectral Range, Mi-Yun Jeong[1]; [1]*Gyeongsang National Univ., South Korea.* Optical notch and band pass filter systems with continuous fine tuning resolution in broad spectral range are realized by combining left- and right-handed cholesteric liquid crystal wedge cells.

JTh2A.193
Nano-membrane based Plasmonic Devices for Surface-Enhanced Infrared Absorption Gas Sensing, Xinyuan Chong[1], Yujing Zhang[1], Ki-joong Kim[2], Erwen Li[1], Paul Ohodnicki[2], Chih-hung Chang[1], Alan X. Wang[1]; [1]*Oregon State Univ., USA;* [2]*National Energy Technology Lab, USA.* Surface-enhanced infrared absorption for gas sensing is still not successful due to the intrinsically weak light-matter interaction. Herein, we demonstrate a plasmonic device integrated with metal-organic framework on Si_3N_4 membrane substrate for CO_2 sensing.

JTh2A.194
Detection of O18 and D Isotopes in Water Vapor using a Fiber-Coupled Tunable Diode Laser Absorption Spectroscopy Multi-Pass Cell, Allan S. Chang[1], Ate Visser[1], Erik Oerter[1], Tiziana Bond[1]; [1]*Lawrence Livermore National Lab, USA.* We have demonstrated detection of water isotopologues (H16OH, H18OH and HDO) by a compact fiber-coupled tunable diode laser absorption spectroscopy setup. The measured results agree well with HITRAN simulation.

JTh2A.195
28Gbps PAM4 60GHz Radio over Fiber System by Injection Locking Two-Tone Light to Directly-Modulated Laser, Guo-Wei Lu[1,2], Ruben S. Luis[2], Hiroyuki Toda[3], Jiabin Cui[4], Takahide Sakamoto[2], Hongxiang Wang[4], Yuefeng Ji[4], Naokatsu Yamamoto[2]; [1]*Tokai Univ., Japan;* [2]*National Inst. of Information and Communication Technology, Japan;* [3]*Doshisha Univ., Japan;* [4]*Beijing Univ. of Posts and Telecommunications, China.* A 28Gbps PAM4 60GHz radio-over-fiber system is proposed and experimentally demonstrated by injection locking a two-tone light to a directly-modulated laser. Experimental results show negligible power penalty for the obtained PAM4 after the injection locking.

JTh2A.196
Visible to Mid-infrared Supercontinuum Generation Using a Gas-filled Hollow-core Fiber, MD Selim Habib[1], Christos Markos[2], A. Isa Adamu[2], Jose Enrique Antonio-Lopez[1], Rodrigo Amezcua Correa[1]; [1]*CREOL, Univ. of Central Florida, USA;* [2]*Dept. of Photonics Engineering, Technical Univ. of Denmark, Denmark.* Broadband supercontinuum generation spanning 0.58-5.0 μm is numerically presented using a Xe-filled nested hollow-core anti-resonant fiber under 7 bar pressure, pumped at 3 μm with 100 fs pulses and 15 μJ pulse energy.

12:30–14:00 Exhibit Hall Free Pizza Lunch

CLEO: Science & Innovations

14:00–16:00
STh3A • Photonic Crystals
Presider: Kengo Nozaki; NTT Basic Research Labs, Japan

STh3A.1 • 14:00
CMOS-Compatible High-Q Photonic Crystal Cavities, Delphin Dodane[1], Jérôme Bourderionnet[1], Sylvain Combrié[1], Alfredo De Rossi[1]; [1]*Thales Research & Technology, France.* All-Solid Cladding Photonic Crystal Cavities have been fabricated in CMOS foundry. A recent design concept resulted into a measured Q-factor of 0.6 million ($4.1x10^5$ in average). Statistical analysis leads to an estimate of the fabrication disorder of 1.2 nm.

STh3A.2 • 14:15
High-Contrast Resonance Excitation in Photonic Crystal Nanobeams via Side-Coupling and Wave-Vector Matching, Francis Afzal[1], Sami Halimi[1], Sharon M. Weiss[1]; [1]*Vanderbilt Univ., USA.* Photonic crystal nanobeams engender exceptional high Q/V devices but suffer broadband signal loss off-resonance and low on-resonance transmission. We demonstrate drastically improved transmission metrics without compromising Q-factor using side-coupled excitation with optical momentum matching.

STh3A.3 • 14:30 Invited
InP Membrane Photonic Crystal Fano Devices, Kresten Yvind[1], Yi Yu[1], Dagmawi Bekele[1], Thorsten S. Rasmussen[1], Aurimas Sakanas[1], Andrey Marchevsky[1], Kristoffer S. Mathiesen[1], Hitesh K. Sahoo[1], Luisa Ottaviano[1], Elizaveta Semenova[1], Jesper Mork[1]; [1]*DTU Fotonik, Technical Univ. of Denmark, Denmark.* Membrane photonic crystals offer many possibilities for designing small energy efficient devices like switches and lasers. We will present theoretical and experimental results on devices based on Fano resonances in photonic crystals.

STh3A.4 • 15:00
Lasing in a topological photonic crystal nanocavity, Yasutomo Ota[1], Ryota Katsumi[1], Katsuyuki Watanabe[1], Satoshi Iwamoto[1], Yasuhiko Arakawa[1]; [1]*Univ. of Tokyo, Japan.* We report lasing oscillation in a zero-dimensional edge state formed at the boundary of two photonic crystal nanobeams with distinct band topologies. The topological origin of the nanocavity mode ensures a single mode operation.

14:00–16:00
STh3B • Networks on a Chip
Presider: Ruijun Wang; Ghent Univ.-imec, Belgium

STh3B.1 • 14:00 Invited
Microring Weight Banks for Neuromorphic Silicon Photonics, Alexander Tait[1], Thomas Ferreira de Lima[1], Mitchell Nahmias[1], Bhavin Shastri[1], Paul R. Prucnal[1]; [1]*Princeton Univ., USA.* Research in photonic information processing has experienced a recent resurgence. Microring weight banks enable reconfigurable neural network approaches on silicon photonics. We discuss the latest results in neuromorphic silicon photonic networks and microring weight banks.

STh3B.2 • 14:30
Thermally Tunable III-V Photonics Architecture for Coherent Nonlinear Optical Circuits, Marina Radulaski[1,2], Ranojoy Bose[2], Tho Tran[2], Thomas Van Vaerenbergh[2], David Kielpinski[2], Raymond Beausoleil[2]; [1]*Stanford Univ., USA;* [2]*Hewlett Packard Enterprise, USA.* We develop a thermally tunable hybrid photonics architecture integrating GaAs photonic crystal cavities, SiN_x grating couplers and waveguides, and chromium microheaters. We demonstrate external signal coupling to frequency-synchronized microcavities connected by a bus waveguide.

STh3B.3 • 14:45
Design, Fabrication and Demonstration of a Chip-Scale Reconfigurable Photonic Signal Processor, Xiaoping Cao[1], Shuang Zheng[1], Yun Long[1], Yan Luo[1], Li Shen[1], Jian Wang[1]; [1]*WNLO, China.* Inspired by electronic Field Programmable Gate Arrays, we experimentally demonstrate a reconfigurable hexagonal mesh processor based on silicon platform. Assisted by tunable Mach–Zehnder couplers, numerous topologies and functions can be implemented with favorable performances.

STh3B.4 • 15:00
Reconfigurable Silicon Photonic Signal Processor Based on the SCOW Resonant Structure, Liangjun Lu[1], Lin Shen[1], linjie zhou[1], Jianping Chen[1]; [1]*Shanghai Jiao Tong Univ., China.* We propose a reconfigurable silicon photonic signal processor composed of three stages of self-coupled optical waveguide (SCOW) resonators. The processor can be configured to ring resonator and MZI-based optical filters.

Joint

14:00–16:00
JTh3C • Symposium on Integrated Sources of Non-Classical Light: Perspectives and Challenges I
Presider: Marco Liscidini; Università degli Studi di Pavia, Italy

JTh3C.1 • 14:00 Invited
Photon-pair Generation and Quantum-classical Correspondence in Nonlinear Nanostructures, Andrey A. Sukhorukov[1]; [1]*Nonlinear Physics Centre, RSPE, The Australian National Univ., Australia.* We present theoretical and experimental advances towards efficient photon-pair generation through spontaneous parametric down-conversion in nonlinear nanostructures and metasurfaces, enabling quantum entanglement engineering at sub-wavelength scale for photon generation with tailored polarization and spatial correlations.

JTh3C.2 • 14:30
Photon Pair Generation on a Silicon Chip Using Nanophotonic Periodically-Poled Lithium Niobate Waveguides, Ashutosh Rao[1], Nima Nader[2], Martin J. Stevens[2], Thomas Gerrits[2], Omar S. Magana Loaiza[2], Guillermo Camacho-Gonzalez[1], Jeffrey Chiles[2], Amirmahdi Honardoost[1], Marcin Malinowski[1], Richard Mirin[2], Sasan Fathpour[1]; [1]*CREOL, Univ Central Florida, USA;* [2]*NIST, USA.* We present a new class of photon pair sources on a silicon chip. The source is based on nanophotonic periodically poled lithium niobate waveguides and presents MHz rate pair generation.

JTh3C.3 • 14:45
A Nanophotonic Platform Integrating Quantum Memories and Single Rare-earth Ions, Tian Zhong[1,2], Jonathan Kindem[1], Jake Rochman[1], John G. Bartholomew[1], Andrei Faraon[1]; [1]*California Inst. of Technology, USA;* [2]*Univ. of Chicago, USA.* We demonstrate a quantum nanophotonic platform integrating on-chip quantum memories and optically addressable single rare-earth ions. We show near-transform-limited, high-purity single photon emissions from individual rare-earth ions.

JTh3C.4 • 15:00 Invited
Tailoring radiative emission in integrated quantum light sources, Andrea Fiore[1], Daniele Pellegrino[1], Michele Cotrufo[1], Ewold Verhagen[1,2], Robert Johne[3], Maurangelo Petruzzella[1], Francesco Pagliano[1], Frank van Otten[1]; [1]*Dep. Applied Physics, Eindhoven Univ. of Technology, Netherlands;* [2]*AMOLF, Netherlands;* [3]*Max Planck Inst. for the Physics of Complex Systems, Germany.* An approach to the real-time control of the exciton-photon interaction rate in solid-state systems will be discussed. It enables the temporal shaping of single photons and the coherent coupling of excitons and phonons.

Joint

14:00–16:00
JTh3D • Symposium on Advances in Integrated Microwave Photonics I
Presider: José Capmany; Universidad Politecnica de Valencia, Spain and David Marpaung; University of Twente, Netherlands

JTh3D.1 • 14:00 Invited
Advanced Microwave Photonics Applications and Routes to Hybrid Integration, Richard DeSalvo[1], Anthony Klee[1], Charles Middleton[1], Kristina Bagnell[1], Elliott Grafer[1], Alex Cramer[1]; [1]*Harris Corporation, USA*. We review recent advances in microwave photonic systems for wideband spectral awareness and down-conversion. Progress is shown toward hybrid integration of these systems with the latest chip-scale technologies to reduce SWaP and improve performance.

JTh3D.2 • 14:30 Invited
Integrated Microwave Photonics for 5G, Chris Roeloffzen[1], Ilka Visscher[1], Caterina Taddei[1], Dimitri Geskus[1], Ruud Oldenbeuving[1], Jörn Epping[1], Roelof Timens[1], Paul van Dijk[1], René Heideman[1], Marcel Hoekman[1], Robert Grootjans[1], Laurens Bliek[2], Sander Wahls[2], Michel Verhaegen[2]; [1]*LioniX International, Netherlands;* [2]*Delft Center for Systems and Control, Delft Univ. of Technology, Netherlands*. This paper describes the design, fabrication, packaging, testing and automated tuning of an integrated 1x4 optical beamforming network. It consists of hybridly integrated InP and TriPleX chips, where end-facet coupling is used for optical interfacing.

JTh3D.3 • 15:00
Fast and Broadband SOI Photonic Integrated Microwave Phase Shifter, Giovanni Serafino[1], Claudio Porzi[1], Marc Sans[2], Fabio Falconi[3], Sergio Pinna[1], Vito Sorianello[3], John Mitchell[2], Marco Romagnoli[3], Antonella Bogoni[1,3], Paolo Ghelfi[3]; [1]*TeCIP, Scuola Superiore Sant'Anna, Italy;* [2]*Dept. of Electronic and Electrical Engineering, Univ. College London, UK;* [3]*National Photonics Labs, CNIT, Italy*. An integrated silicon-on-insulator microwave photonic phase shifter based on an optical deinterleaver and a reverse-biased pn-junction waveguide providing broadband phase shift up to more than 400° with fast reconfiguration time of 1 ns is demonstrated.

CLEO: QELS-Fundamental Science

14:00–16:00
FTh3E • Non-diffracting and Vortex Beams
Presider: Zhigang Chen; San Francisco State Univ., USA

FTh3E.1 • 14:00
Spatiotemporal diffraction-free pulsed beams in free-space of the Airy and Bessel type, Nikolaos K. Efremidis[1,2]; [1]*Univ. of Crete, Greece;* [2]*Inst. of Applied and Computational Mathematics, Foundation for Research and Technology - Hellas (FORTH), Greece*. We find new classes of optical spatio-temporal waves with one transverse direction that propagate in space-time in a diffraction-free fashion. These waves take the form of Airy, Bessel, and modified Bessel functions.

FTh3E.2 • 14:15
Observation of a Bessel beam soliton, Mariano Flammini[1], Giuseppe Di Domenico[1,2], Davide Pierangeli[1,3], Fabrizio Di Mei[1], Aharon Agranat[4], Eugenio DelRe[1,5]; [1]*Dept. of Physics, Univ. of Rome "La Sapienza", Italy;* [2]*Center for Life Nano Science@Sapienza, Istituto Italiano di Tecnologia, Italy;* [3]*Collaborative Innovation Center for Optoelectronic Science & Technology, College of Optoelectronic Engineering-Shenzhen Univ., China;* [4]*Dept. of Applied Physics, Hebrew Univ. of Jerusalem, Israel;* [5]*ISC-CNR, Universita di Roma "La Sapienza", Italy*. We have demonstrated experimentally and numerically that a Bessel-Beam propagating in a strongly self-focusing medium undergoes relevant dynamics along the propagation axis that ultimately cause it to self-trap into a periodic breather.

FTh3E.3 • 14:30
Nonlinear Optical Conversion of Photon Spin to Orbital Angular Momentum, Alex M. Wilhelm[1], David Schmidt[1], Charles Durfee[1]; [1]*Colorado School of Mines, USA*. We demonstrate, to our knowledge, the first optical spin-to-orbital angular momentum conversion using second harmonic generation in underdense plasmas, enabling the generation of arbitrary orbital angular momentum beams using a single focusing optic.

FTh3E.4 • 14:45
Demonstration of pseudospin-to-orbital angular momentum conversion in photonic graphene, Xiuying Liu[1], Dao-Hong Song[1,2], Shiqi Xia[1], Zhixuan Dai[1], Liqin Tang[1], Jingjun Xu[1], Zhigang Chen[1,3]; [1]*The MOE Key Lab of Weak-Light Nonlinear Photonics, TEDA Applied Physics Inst. and School of Physics, Nankai Univ., China;* [2]*Collaborative Innovation Center of Extreme Optics, Shanxi Univ., China;* [3]*Dept. of Physics and Astronomy, San Francisco State Univ., USA*. Momentum-matched selective excitation of two sublattices with vortex beams leads to direct observation of pseudospin-dependent conical diffraction and topological charge transformation, including spin-orbital angular momentum conversion arising from inherent degree-of-freedom in photonic graphene.

FTh3E.5 • 15:00
Tunable Vortex Beam, Singly-Resonant Ultrafast Optical Parametric Oscillator., Varun Sharma[1], S. C. Kumar[2], G. K. Samanta[1], M. Ebrahim-Zadeh[2,3]; [1]*Photonic Sciences Lab., Physical Research Lab, India;* [2]*ICFO-Institut de Ciencies Fotoniques, Spain;* [3]*Institucio Catalana de Recerca i Estudis Avancats (ICREA), Spain*. We demonstrate the direct transfer of pump vortex mode to the idler beam in a singly- resonant optical parametric oscillator, generating ultrafast vortex beam of order as high as l=3, tunable across 1109-1209 nm.

CLEO: Science & Innovations

14:00–16:00
STh3F • Mid-IR Nonlinear Devices
Presider: Shu-Wei Huang; Univ. of Colorado at Boulder, USA

STh3F.1 • 14:00
Suspended-Si waveguides for spectral engineering of mid-IR frequency combs, Nima Nader[1], Jeff Chiles[1], Abijith Kowligy[2], Henry Timmers[2], Sae Woo Nam[1], Scott Diddams[2], Richard Mirin[1]; [1]*Applied Physics Division, NIST, USA;* [2]*Time and Frequency measurement Division, NIST, USA*. Suspended-silicon waveguides are used for broadband mid-IR supercontinuum with low input power. Pumped with 100 fs, 3 µm pulses, these devices extend the mid-IR comb coverage across 126 THz from 1.74 µm to 6 µm.

STh3F.2 • 14:15
Picosecond fiber-laser-pumped widely tunable, narrow-linewidth, high-peak-power, mid-infrared OP-GaAs OPA, Qiang Fu[1], Lin Xu[1], Sijing Liang[1], David Shepherd[1], David Richardson[1], Shaif-Ul Alam[1]; [1]*Optoelectronics Research Centre, UK*. We demonstrate a narrow-linewidth, mid-infrared OP-GaAs cascaded OPG-OPA with a widely tunable output of 2552-2960 nm (signal) and 5733-8305 nm (idler), and with a maximum peak power of 11.1 kW (signal) and 4.5 kW (idler).

STh3F.3 • 14:30 Invited
Chalcogenide-based devices for mid-infrared waveguide photonics, Martin Rochette[1]; [1]*McGill Univ., Canada*. This talk will feature recent achievements of the Nonlinear Photonics Group at McGill Univ. towards the fabrication of chalcogenide-based mid-infrared optical fiber components such as nonlinear gain media, optical fiber couplers and optical filters.

STh3F.4 • 15:00
Octave-Spanning Mid-Infrared Supercontinuum Generation and Self-Compression in $\chi^{(2)}$-Structured Rb-Doped KTP, Anne-Lise Viotti[1], Robert Lindberg[1], Andrius Zukauskas[1], Rimantas Budriunas[3,2], Dainius Kucinskas[3,2], Tomas Stanislauskas[2], Carlota Canalias[1], Fredrik Laurell[1], Valdas Pasiskevicius[1]; [1]*Royal Inst. of Technology, Sweden;* [2]*Light Conversion, Lithuania;* [3]*Vilnius Univ. Laser Research Center, Lithuania*. We experimentally demonstrate octave-spanning supercontinuum generation and nonlinear pulse compression, down to sub-20-fs, in periodically poled Rb-doped KTP. The results of a detailed numerical study provide excellent agreement with the experiments.

CLEO: Science & Innovations

14:00–16:00
STh3G • Quantum Information Processing on Photonic Nanostructures
Presider: Mark Thompson;University of Bristol, UK

STh3G.1 • 14:00 Tutorial
Recent Advances in Quantum Information Science Using Quantum Optical Systems, Mikhail Lukin[1]; [1]*Harvard Univ., USA.* We will discuss a new scientific interface between quantum optics, many-body physics, nanophotonics and quantum information science. Examples include manipulating arrays of individually trapped cold neutral atoms and atom-like emitters in diamond.

Mikhail Lukin received the Ph.D. degree from Texas A&M University in 1998. He has been a Professor of Physics at Harvard since 2004, where he is currently a co-Director of Harvard-MIT Center for Ultracold Atoms. His research interests include quantum optics, quantum metrology, nanophotonics, and quantum information science.

STh3G.2 • 15:00
Silicon on Silicon Carbide Ring Resonators for Coupling to Color Centers, Chuting Wang[1], Evan Miyazono[1], Ioana Craciu[1], Jake Rochman[1], Jonathan Kindem[1], Tian Zhong[1], John G. Bartholomew[1], Andrei Faraon[1]; [1]*California Inst. of Technology, USA.* We present hybrid crystalline-silicon (c-Si) ring resonators on top of 4H silicon carbide with measured quality factor ~9600 for coupling to spin qubits like divacancies and Cr ions for future applications in quantum information networks.

CLEO: Applications & Technology

14:00–16:00
ATh3H • Control of Quantum Optical and Opto-mechanical Systems
Presider: Thomas Purdy; NIST, USA

ATh3H.1 • 14:00
Spin-Photon Interface Controlled Optical Switching in a Nanobeam Waveguide, Tim Schröder[1], Alisa Javadi[1], Dapeng Ding[1], Martin Hayhurst Appel[1], Sahand Mahmoodian[1], Matthias Löbl[2], Immo Söllner[2], Rüdiger Schott[2], Camille Papon[1], Tommaso Pregnolato[1], Søren Stobbe[1], Leonardo Midolo[1], Andreas Wieck[3], Arne Ludwig[3], Richard Warburton[2], Peter Lodahl[1]; [1]*Niels Bohr Inst., Denmark;* [2]*Dept. of Physics, Univ. of Basel, Switzerland;* [3]*Ruhr Universität Bochum, Germany.* We demonstrate a single InGaAs quantum dot electron spin controlled photon switch in a nanobeam waveguide with 4-fold switching ratio, a spin-state preparation fidelity of 96%, and a lifetime T_1 approaching 5 μs.

ATh3H.2 • 14:15
Electromechanically Tunable Diamond Color Centers Coupled to Nanophotonic Waveguides, Bartholomeus J. Machielse[1], Michael J. Burek[2], Srujan Meesala[2], Cleaven Chia[2], Young-Ik Sohn[2], Haig Atikian[2], Linbo Shao[2], Smarak Maity[2], Mikhail Lukin[1], Marko Loncar[2]; [1]*Dept. of Physics, Harvard Univ., USA;* [2]*John A Paulson School of Engineering and Applied Sciences, Harvard Univ., USA.* We present a platform for the generation and high-efficiency collection of indistinguishable photons from spatially separated silicon-vacancy (SiV) color centers by use of waveguide-coupled nanoelectromechanical systems (NEMS).

ATh3H.3 • 14:30
Spectral Tuning of Multiple Germanium Vacancy Centers in Diamond with Mechanical Strain, Smarak Maity[1], Linbo Shao[1], Young-Ik Sohn[1], Srujan Meesala[1], Bartholomeus J. Machielse[1], Edward Bielejec[2], Marko Loncar[1]; [1]*Harvard Univ., USA;* [2]*Sandia National Labs, USA.* We experimentally demonstrate spectral tuning of the optical transitions of the germanium vacancy (GeV) center using strain in a diamond microcantilever. The GeV shows a large strain susceptibility on the order of PHz/strain. Spectral alignment of two initially spectrally separated GeVs is achieved.

ATh3H.4 • 14:45
Quantum Measurement of Membrane's Vibration, Jiteng Sheng[1], Xinrui Wei[1], Shuhui Wu[1], Haibin Wu[1]; [1]*East China Normal Univ., China.* We demonstrate that the sub-shot-noise measurement of membrane's displacement can be realized with the cooperation of membrane-based interferometer and quantum correlated light. This provides a new strategy to study cavity optomechanics with squeezed light.

ATh3H.5 • 15:00
Quantum Optomechanics with Ultracoherent Soft–Clamped Resonators, Junxin Chen[1], Massimiliano Rossi[1], David Mason[1], Yeghishe Tsaturyan[1], Yannick Seis[1], Albert Schliesser[1]; [1]*Niels Bohr Inst., Denmark.* Soft–clamped mechanical resonators realise quality factors Q~10^9 and quantum cooperativities C_q~60 already in a moderate cryogenic environment (e.g. a 4.2 K flow cryostat). This enables both sideband and feedback cooling to the mechanical quantum ground state.

CLEO: Science & Innovations

14:00–16:00
STh3I • Integrated Photonic Platforms
Presider: Tian Gu; MIT, USA

STh3I.1 • 14:00
Highly Nonlinear Gallium Nitride Waveguides, Erik Stassen[1], Minhao Pu[1], Elizaveta Semenova[1], Evgeniy Zavarin[2], Wsevolod Lundin[2], Kresten Yvind[1]; [1]*Technical Univ. of Denmark, Denmark;* [2]*Ioffe Inst., Russia.* We demonstrate a high effective nonlinearity in high refractive-index-contrast gallium nitride waveguides by performing four-wave mixing characterization. The intrinsic material nonlinearity (n2) of gallium nitride is extracted at telecom wavelengths.

STh3I.2 • 14:15
InGaN-ZnSnN$_2$ Quantum Wells for High Efficiency Light Emitters Beyond Green, Md Rezaul Karim[1], Hongping Zhao[1,2]; [1]*Dept. of Electrical and Computer Engineering, The Ohio State Univ., USA;* [2]*Dept. of Materials Science and Engineering, The Ohio State Univ., USA.* A novel quantum well design based on InGaN-ZnSnN$_2$ structures is promising to address the existing challenge to realize high performance InGaN based visible light emitters emitting beyond green spectral regime (3-order enhancement in spontaneous emission).

STh3I.3 • 14:30
Four-Wave Mixing in a High-Q Aluminum Oxide Microcavity on Silicon, Henry C. Frankis[1], Zhan Su[2,3], Nanxi Li[2,5], Emir Magden[2,4], Mengyuan Ye[1], Michael Watts[2,3], Jonathan Bradley[1,2]; [1]*McMaster Univ., Canada;* [2]*MIT, USA;* [3]*Analog Photonics, USA;* [4]*Koç Univ., Turkey;* [5]*Harvard Univ., USA.* We demonstrate *Q* factors of > 10^6 and parametric frequency conversion in Al_2O_3 micro-trench resonators co-integrated with Si_3N_4 waveguides on silicon. Under 1550-nm pumping we show oscillation at wavelengths ranging from 1135 to 2445 nm

STh3I.4 • 14:45
Arbitrary Vertical Low-Loss Waveguides in Deposited Oxide of Optical Interposers for Low-Loss 3D Photonic Packaging, Yi-Chun Ling[1], Yu Zhang[1], S. J. Ben Yoo[1]; [1]*Univ. of California, Davis, USA.* We first demonstrate a low-loss flexible 3D waveguide on deposited oxide cladding for 3D photonic packaging using ultrafast laser inscription. Waveguide propagation loss, excess bending loss and coupling loss to SiN waveguide were characterized.

STh3I.5 • 15:00
Four-Wave Mixing in a Multi-Layer SiN$_x$/a-Si:H Photonic Chip, Michael Kossey[1], Kangmei Li[1], Hongcheng Sun[1], Amy Foster[1]; [1]*Johns Hopkins Univ., USA.* We demonstrate four-wave mixing (FWM) in a-Si:H waveguides in a multi-layer integrated photonic chip. The a-Si:H waveguides are accessed through interlayer couplers from waveguides composed of SiN$_x$ and exhibit 0.45±0.05 dB loss per transition.

CLEO: Science & Innovations

14:00–16:00
STh3J • Optofluidics & High Throughput Florescence
Presider: Andreu Llobera; Carl Zeiss Vision GmbH, Germany

STh3J.1 • 14:00 Invited
Light Controlled Cellular Surgery and Intracellular Delivery, Pei-Yu Chiou[1]; [1]*Univ. of California Los Angeles, USA.* Delivery of large-sized extracellular cargo into live cells has been a major technical barrier. Here, we present an optofluidics platform for high efficiency delivery of cargo of size up to micrometers into mammalian cells.

STh3J.2 • 14:30 Invited
Optofluidic Platforms for Applications in Cancer Research, Alexandre Brolo[1], America Palacios[1], Karolina Papera Valente[1]; [1]*Univ. of Victoria, Canada.* We will describe a microfluidic chip designed to study the diffusion of nanoparticles in cancer tissues. We will also demonstrate an optical trap to study the effect of radiation on cancer cells by Raman scattering.

STh3J.3 • 15:00
Frequency Doubled High Speed Fluorescence Lifetime Imaging, Sebastian Karpf[1], Bahram Jalali[1]; [1]*Univ. of California, Los Angeles, USA.* We present high speed fluorescence lifetime imaging in the visible enabled by broadband frequency-doubling of the SLIDE technique (1P-SLIDE). Fluorescence Lifetime imaging at 88 million pixels per second is demonstrated.

14:00–16:00
STh3K • Multimode Fiber Optics
Presider: Sophie LaRochelle; Universite Laval, Canada

STh3K.1 • 14:00 Tutorial
Multimode Nonlinear Fiber Optics: New perspectives, opportunities & challenges, Siddharth Ramachandran[1]; [1]*Boston Univ., USA.* Multimode fibers experience intra- and inter-modal nonlinear interactions, facilitating new degrees of design freedom as well as nonlinear effects not seen in single mode systems. We review the physics and applications of this emerging platform.

Dr. Siddharth Ramachandran started his scientific career as a Member of Technical Staff at Bell Laboratories in 1998, followed by continuing, in 2002, with its fiber-optics-related spin-off, OFS Laboratories. In 2010, he moved back to academics and is now a Professor in the Department of Electrical Engineering at Boston University.

STh3K.2 • 15:00
Multimode random fiber laser for speckle free imaging, Rui Ma[1], Yun Jiang Rao[1], Wei Li Zhang[1], Bo Hu[1]; [1]*Univ of Electronic Science & Tech China, China.* It is the first time that a multi transverse mode random fiber laser with high radiance and low coherence is used for speckle-free imaging, which is ideal for wide field or high-speed imaging applications.

14:00–16:00
STh3L • Imaging and Ranging
Presider: Waruna Kulatilaka; Texas A&M Univ., USA

STh3L.1 • 14:00 Invited
Deep Learning Smart Microscope, Bahram Jalali[1], Ata Mahjoubfar[1], Claire L. Chen[1]; [1]*Univ. of California Los Angeles, USA.* We describe a microscope featuring artificial intelligence (AI), time stretch, quantitative phase imaging and optofluidics. Capturing images at 50 GigaPixels per seconds, the system has shown record performance in classification of cancer in blood.

STh3L.2 • 14:30
Speckle-based wavelength measurement at femtometer resolution using a multimode fibre, Mingzhou Chen[1], Graham D. Bruce[1], Kishan Dholakia[1]; [1]*School of Physics and Astronomy, Univ. of St Andrews, UK.* We demonstrate an approach to accurately measure the wavelength of light at femtometer resolution using the speckle output from a multimode fibre. Our approach can be used to measure a single wavelength, or distinguish between two wavelengths co-propagating through the fibre.

STh3L.3 • 14:45
Dual-Comb Microscopy for Scanless Confocal Phase Imaging, Eiji Hase[1,2], Shuji Miyamoto[1,2], Takahiko Mizuno[1,2], Takeo Minamikawa[1,2], Hirotsugu Yamamoto[3,2], Takeshi . Yasui[1,2]; [1]*Tokushima Univ., Japan;* [2]*JST, ERATO MINOSHIMA Intelligent Optical Synthesizer, Japan;* [3]*Utsunomiya Univ., Japan.* Two-dimensional image pixels of a sample are encoded onto optical frequency comb modes via spectral encoding, and the resulting mode-resolved amplitude and phase spectra are used to decode full-field confocal and phase images without scanning.

STh3L.4 • 15:00
Subwavelength Optical Focusing in Scattering Media with Optically Detectable Magnetic Resonance, Donggyu Kim[1,2], Dirk . Englund[3,2]; [1]*Dept. of Mechanical Engineering, MIT, USA;* [2]*Research Lab of Electronics (RLE), MIT, USA;* [3]*Dept. of Electrical Engineering and Computer Science, MIT, USA.* We introduce a new wavefront shaping technique guided by optically detectable magnetic resonance (ODMR). We present subwavelength light focusing in scattering media with our ODMR-guided wavefront shaping, which paves the way for subwavelength quantum sensing in deep-tissue.

Marriott Salon III

CLEO: QELS-Fundamental Science

14:00–16:00
FTh3M • Chirality Vortices and Topological Effects
Presider: Amr Shaltout; Purdue Univ., USA

FTh3M.1 • 14:00
Disorder Topological Defects Induce Photonic Phase Transition, Bo Wang[1], Elhanan Maguid[1], Michael Yannai[1], Arkady Faerman[1], Vladimir Kleiner[1], Erez . Hasman[1]; [1]*Technion-Israel Inst. of Technology, Israel.* We report on the observation of photonic phase transition emerging from disorder topological defects in geometric phase metasurfaces. Low defect concentration induces isolated vortices, whereas high disorder leads to a random vortex interaction.

FTh3M.2 • 14:15
Topological photonic crystals in the visible: design and angle-resolved characterization of the bulk and edge states, Siying Peng[1], Nick Schilder[2], Xiang Ni[3], Sophie Meuret[2], Hugo Doeleman[2], Toon Coenen[2,4], Femius Koenderink[2], Alexander Khanikaev[3], Andrea Alù[5], Harry Atwater[1], Albert Polman[2]; [1]*Applied physics, California Inst. of Technology, USA;* [2]*Center for Nanophotonics, AMOLF, Netherlands;* [3]*Dept. of Electrical Engineering, City Univ. of New York, USA;* [4]*Delmic B.V., Netherlands;* [5]*Dept. of Electrical and Computer Engineering, Univ. of Texas at Austin, USA.* We fabricated and characterized photonic crystals with topological bulk states and pseudo-time-reversal-symmetry protected helical edge states in the visible regime. With a 30kV electron beam, we excite cathodoluminescence in the nanostructured material and derive photonic band structures.

FTh3M.3 • 14:30
Metasurfaces and Ultrafast Dynamics for High Angular Momentum Compound Optical Fileds, Grisha Spektor[1], Deirdre Kilbane[2], Anna-Katharina Mahro[3], Michael Hartelt[3], Eva Prinz[3], Martin Aeschlimann[3], Meir Orenstein[1]; [1]*Technion Israel Inst. of Technology, Israel;* [2]*School of Physics, Univ. College Dublin, Ireland;* [3]*Dept. of Physics, Univ. of Kaiserslautern, Germany.* Employing unique metasurface-based plasmonic generators and an ultrafast probing technique, we experimentally demonstrate plasmonic vortex compounds carrying arbitrary orbital angular momentum. These can be used for functional near-field shaping and sculpting of optical potentials.

FTh3M.4 • 15:00
Controlling the topology of plasmonic vortex lattices, Shai Tsesses[1], Kobi Cohen[1], Evgeny Ostrovsky[1], Bergin Gjonaj[1,2], Guy Bartal[1]; [1]*Technion-Israeli Inst. of technology, Israel;* [2]*Medical Sciences, Albanian Univ., Albania.* We experimentally demonstrate creation of two-dimentional plasmonic vortex lattices, while controlling the lattice topology. These lattices could drive many nanophotonic applications and bear an uncanny similarity to recently observed magnetic skyrmion lattices.

Marriott Salon IV

CLEO: Science & Innovations

14:00–16:00
STh3N • Ultrafast Metrology I
Presider: Gunter Steinmeyer; Max Born Inst., Germany

STh3N.1 • 14:00
Spatio-temporal characterization of few-cycle laser pulses by SEA-F-SPIDER and time-domain ptychography, Tobias Witting[1], Federico J. Furch[1], Marc J. Vrakking[1]; [1]*Max-Born-Inst., Germany.* We review the self-referenced spatio-temporal characterization of few-cycle laser pulses. In particular we show results obtained from high average power NOPA based laser systems using the single-shot SEA-F-SPIDER technique and spatially multiplexed time-domain ptychography.

STh3N.2 • 14:15
Spatio-temporal Characterization and Optimization of a 200-kHz OPCPA Laser System, Sara Mikaelsson[1], Miguel Miranda[1], Anne Harth[1,2], Chen Guo[1], Thomas Binhammer[3], Yu-Chen Cheng[1], Arthur Losquin[1], Christoph Heyl[1,4], Alexander Pape[3], Jan Ahrens[3], Oliver Prochnow[3], Uwe Morgner[5], Anne L'Huillier[1], Cord Arnold[1]; [1]*Dept. of Physics, Lund Univ., Sweden;* [2]*Max-Plank-Institut für Kernphysik, Germany;* [3]*Laser Quantum, Germany;* [4]*JILA, USA;* [5]*Institut of Quantum Optics, Germany.* We present measurements on a few cycle OPCPA laser chain where due to careful characterization and compensation of the spectral phase and spatio-temporal couplings, we are able achieve efficient HHG with very low pulse energy.

STh3N.3 • 14:30
Characterization of Spatiotemporal Coupling with a Hyperspectral Hartmann Wavefront Sensor, Christophe Dorrer[1], Seung-Whan Bahk[1]; [1]*Univ. of Rochester, USA.* A broadband optical source is directly characterized using a Hartmann wavefront sensor implemented with a custom hyperspectral camera, yielding the accurate experimental characterization of radial group delay and pulse-front tilt.

STh3N.4 • 14:45
Spectrally-Resolved, Single-Shot Wavefront Sensing of Broadband High-Harmonic Sources, Matthijs Jansen[2,1], Lars Freisem[2,1], Denis Rudolf[2,1], Kjeld S. Eikema[1,2], Stefan Witte[2,1]; [1]*Physics and Astronomy, Vrije Universiteit Amsterdam, Netherlands;* [2]*Advanced Research Center for Nanolithography, Netherlands.* A novel grating-based Hartmann-type wavefront sensor is developed and used to measure wavefronts of nine high-harmonics at 25-49 nm wavelength simultaneously. Pulse front tilts of the high-harmonic beam are measured in a single exposure.

STh3N.5 • 15:00 Invited
Temporal Imaging in Three Dimensions, Moti Fridman[1]; [1]*Bar-Ilan Univ., Israel.* We adopted the concept of three-dimensional (3D) imaging into the time domain, providing a new dimension in temporal optics. We demonstrated depth imaging in time and developed the concept of non-flat signals.

Marriott Salon V

CLEO: Applications & Technology

14:00–16:00
ATh3O • Novel Spectroscopic Approaches I
Presider: Brian Simonds; NIST, USA

ATh3O.1 • 14:00
Longwave Infrared Lidar Based on Parametric Sources for Standoff Detection of Gaseous Chemicals, Julie Armougom[1], Jean-Michel Melkonian[1], Myriam Raybaut[1], Jean-Baptiste Dherbecourt[1], Guillaume Gorju[1], Antoine Godard[1], Riaan Stuart Coetzee[2], Valdas Pasiskevicius[2], Jírí Kadlčák[3]; [1]*ONERA - The French Aerospace Lab, France;* [2]*Dept. of Applied Physics, Royal Inst. of Technology, Sweden;* [3]*CBRN Protection Division, Military Research Inst., Czechia.* We report on a longwave infrared lidar, tailored for detection of chemical warfare agents in the gaseous phase. The emitter is based on single-frequency 2 µm parametric oscillator/amplifier systems followed by a ZnGeP2 downconversion stage.

ATh3O.2 • 14:15
Towards Broadband Multi-species Trace Gas Detection Using a Mid-infrared Supercontinuum Source, Qing Pan[1], Khalil E. Jahromi[1], Ali Abbas[1], Amir Khodabakhsh[1], Simona M. Cristescu[1], Frans J. M. Harren[1]; [1]*Radboud Univ., Netherlands.* We present mid-infrared trace gas sensing based on a supercontinuum source combined with direct absorption spectroscopy and sum-frequency upconversion, showing broadband detection with a 10^{-4} $Hz^{-1/2}$ noise equivalent absorbance sensitivity.

ATh3O.3 • 14:30
Infrared metrology using visible photons, Anna Paterova[1,2], Hongzhi Yang[1], Chengwu An[1], Dmitry Kalashnikov[1], Leonid Krivitskiy[1]; [1]*Data Storage Inst., Singapore;* [2]*School of EEE, Nanyang Technological Univ., Singapore.* We exploit the nonlinear interference of correlated photons to demonstrate a new infrared metrology technique using detection of visible photons. The technique applies to infrared spectroscopy, optical coherence tomography, and imaging.

ATh3O.4 • 14:45
Self-heterodyne and dual-comb spectroscopy using acousto-optic frequency combs, Vicente Duran[1], Leo Djevarhidjian[1], Come Schnebelin[1], Kanagaraj Nithyanandan[1], Samir Kassi[1], Guillaume Mejean[1], Daniele Romanini[1], Hugues Guillet de Chatellus[1]; [1]*LIPhy, France.* We demonstrate that repetitive frequency shifts of a CW laser in an acousto-optic modulator generate frequency combs with > 1000 mutually coherent lines. We report self-heterodyne interferometry with 500-kHz resolution, and precise dual-comb molecular spectroscopy.

ATh3O.5 • 15:00
An FPGA Based Algorithm to Study and Characterize Gas Mixtures: CH_4/CO_2 Case Study, Fatemeh Yazdandoust[1], Herve Tatenguem Fankem[1], Tobias Milde[1], Alvaro Jimenez[1], Joachim Sacher[1]; [1]*Sacher Lasertechnik GmbH, Germany.* This study reports on the development and validation of a real-time algorithm, for measuring the peak area of molecular transitions. The proposed algorithm is then successfully used to characterize a gas mixture of CH_4/CO_2 in different proportions.

CLEO: Applications & Technology

14:00–16:00
ATh3P • Sensing in Extreme Environments & Organic Optical Materials
Presider: David Bomse; Mesa Photonics, LLC, USA

ATh3P.1 • 14:00
HO_2 Detection in a Photolysis Reactor Using Faraday Rotation Spectroscopy, Chu Teng[1], Chao Yan[1], Aric Rousso[1], Timothy Chen[1], Yiguang Ju[1], Gerard Wysocki[1]; [1]*Princeton Univ., USA.* We perform Faraday rotation spectroscopy at 7.2 μm to quantify HO_2 formation from the reaction between excited singlet $O(^1D)$ atoms and C_2H_2. A digitally balanced detection scheme is employed to suppress spectral interferences from diamagnetic C_2H_2.

ATh3P.2 • 14:15
Criegee Intermediates Dynamic Analysis based on Dual Optical Frequency Combs Spectrometer, Haoyuan Lu[1], Dawei Li[2], Jy Zhao[1], Peng Zuo[3]; [1]*School of Electronics Engineering and Computer Science, Peking Univ., China;* [2]*Biomedical engineering Dept., Johns Hopkins Univ., USA;* [3]*College of environment sciences and engineering, Peking Univ., China.* We propose a Fourier transform spectrometer based on dual optical frequency comb structure. The spectrum resolution can reach 0.001 nm with 71.5 microseconds time resolution. It can be used for precisely analyzing the spectrum dynamic process of Criegee intermediates.

ATh3P.3 • 14:30 Invited
Single-particle fluorescence detection of biological particles in the atmosphere, Anne Perring[1,2]; [1]*Chemical Sciences Division, NOAA Earth System Research Lab, USA;* [2]*Cooperative Inst. for Research in Environmental Sciences, Univ. of Colorado, Boulder, USA.* Single-particle fluorescence sensors, such as the Wide-Band Integrated Bioaerosol Sensor (WIBS), allow real-time detection of atmospheric primary biological particles. In this talk I discuss instrumental and methodological developments and present key findings from ambient studies.

ATh3P.4 • 15:00
Ultrafast Laser Enhanced Rayleigh Backscattering on Silica Fiber for Distributed Sensing under Harsh Environment, Mohan Wang[1], Mohamed Zaghloul[1], Sheng Huang[1], Aidong Yan[1], Shuo Li[1], Ran Zou[1], Paul Ohodnicki[2], Michael Buric[2], Ming-Jun Li[3], David Carpenter[4], Joshua Daw[5], Kevin P. Chen[1]; [1]*Univ. of Pittsburgh, USA;* [2]*National Energy Technology Lab, USA;* [3]*Corning Research and Development Corporation, USA;* [4]*MIT Nuclear Reactor Lab, USA;* [5]*Idaho National Lab, USA.* This paper reports an ultrafast laser processing method to improve the high temperature stability, radiation resilience, and measurement sensitivity in silica optical fiber distributed temperature sensing with optical frequency domain reflectometry (OFDR).

14:00–16:00
ATh3Q • A&T Topical Review on Neurophotonics II
Presider: TBD

ATh3Q.1 • 14:00
An Active Visible Nanophotonics Platform for Sub-Millisecond Deep Brain Neural Stimulation, Aseema Mohanty[1,2], Qian Li[3], Mohammad Amin Tadayon[1], Gaurang R. Bhatt[1], Euijae Shim[1], Xingchen Ji[1,2], Jaime Cardenas[4,1], Steven A. Miller[1], Adam Kepecs[3], Michal Lipson[1]; [1]*Columbia Univ., USA;* [2]*Cornell Univ., USA;* [3]*Cold Spring Harbor Lab, USA;* [4]*Univ. of Rochester, USA.* We demonstrate the first visible-range nanophotonic switch network and create an implantable probe for in-vivo deep-brain stimulation. The probe enables stimulation patterns of single neurons with the timing and spatial precision to decode animal behavior.

ATh3Q.2 • 14:30
Energy-Efficient and High-Throughput Nanophotonic Neuromorphic Computing, Mohammadamin Nazirzadeh[1], Mohammadsadegh Shamsabardeh[1], S. J. Ben . Yoo[1]; [1]*Univ. of California Davis, USA.* High-efficient bio-inspired nanophotonic neuromorphic computing is discussed. Using reconfigurable photonic interconnects combined by optical 2D and 3D integrated circuits, more than 500× improvement in energy consumption is predicted compared to the state-of-the-art implementations of SNNs.

ATh3Q.3 • 14:45
Liquid-level Sensor Using Optical Microfiber Probe, Junjie Wang[1], Yanpeng Li[1], Lingduo Li[1], Wei Zhang[1], Zhijun Yan[1], Qizhen Sun[1], Deming Liu[1]; [1]*School of Optical and Electronic Information, National Engineering Lab for Next Generation Internet Access System, Huazhong Univ. of Science and Technology, China.* A liquid-level sensor using reflective optical microfiber probe as the sensing element is proposed and experimentally demonstrated. By monitoring the reflection wavelength shift, an ultra-high liquid-level sensitivity of ~153.5 nm/mm is achieved.

ATh3Q.4 • 15:00
Third Harmonic Generation Microscopy for Label-free Human Brain Imaging, Sandeep Chakraborty[1], Hao-Cheng Gao[1], Chen-Tung Yen[1], Hsin-Yi Huang[2], Chi-Kuang Sun[1]; [1]*National Taiwan Univ., Taiwan;* [2]*Pathology, National Taiwan Univ. Hospital, Taiwan.* Third harmonic generation microscopy (THG) was used for high-resolution label-free human brain imaging. The THG images of human brain tissues show neuronal soma, dendrites, and lipofuscin in gray matter while myelinated axons in white matter.

CLEO: Science & Innovations

Joint

STh3A • Photonic Crystals—Continued

STh3A.5 • 15:15
Slow Light Dispersion Engineering of Active Photonic Crystal Cavities for Compact and Integrated Mode-Locked Lasers, Malik Kemiche[1], Jérémy Lhuillier[1], Thomas Wood[1], Aziz Benamrouche[1], Philippe Regreny[1], Radoslaw Mazurczyk[1], Pedro Rojo-Romeo[1], Xavier Letartre[1], Ségolène Callard[1], Christelle Monat[1]; [1]*INL - CNRS UMR5270 - Ecole Centrale de Lyon, France.* We realize compact active photonic crystal cavities for miniaturized chip-based pulsed lasers. We experimentally validate our approach relying on slow-light dispersion engineering for sustaining the intended regular comb of modes from a 30µm long cavity.

STh3A.6 • 15:30
Transmission Experiments on Photonic-Crystal Waveguides With a Symmetry-Protected Dirac Point, Chirag M. Patil[1], Xiaoyan Zhou[1], Morten Herskind[1], Kasper E. Lund[1,2], Søren Stobbe[1,2]; [1]*Niels Bohr Inst., Denmark;* [2]*DTU Fotonik, Denmark.* Slow-light photonic-crystal waveguides suffer from Anderson localization and propagation losses due to fabrication imperfections. Here we investigate a novel photonic system exhibiting a symmetry-protected two-dimensional Dirac-point feature and observe a >50-fold group-velocity slowdown.

STh3A.7 • 15:45
Complete photonic bandgaps in supercell photonic crystals, Alexander Cerjan[1], Shanhui Fan[1]; [1]*Stanford Univ., USA.* We develop a class of supercell photonic crystals supporting complete photonic bandgaps based on breaking spatial symmetries. One member of this class supports a complete bandgap for $n_{high}/n_{low}=2.1$ the lowest known index-contrast ratio in 2D.

STh3B • Networks on a Chip—Continued

STh3B.5 • 15:15
Inter Symbol Interference Correction Based on Zero-forcing Equalization for Time Interleaved Photonic Analog to Digital Converter, Zhengtao Jin[1], Guiling Wu[1], Cheng Wang[1], Jianping Chen[1]; [1]*Shanghai Jiao Tong Univ., China.* A zero-forcing equalization based inter symbol interference correction method is proposed to overcome the limitation to single-channel sampling rate for the finite backend electric bandwidth in TIPADCs. The correction method is verified experimentally.

STh3B.6 • 15:30
Crosstalk-aware Calibration for Fast and Automated Functionalization of Photonic Integrated Switch Fabrics, Yishen Huang[1], Qixiang Cheng[1], Keren Bergman[1]; [1]*Columbia Univ., USA.* Intelligent calibration technique coordinating thermo- and electro-optic phase shifters for simultaneous phase-error and power-imbalance corrections is first introduced, capable of determining driving conditions for optimized crosstalk across entire photonic switch without built-in power monitors.

STh3B.7 • 15:45
All-optical Ternary Content Addressable Memory (T-CAM) Cell for ultra-fast Address Look-ups in Router Applications, George Mourgias-Alexandris[1], Christos Vagionas[1], Apostolos Tsakyridis[1], Pavlos Maniotis[1], Nikos Pleros[1]; [1]*Dep. of Informatics, Aristotle Univ. of Thessaloniki, Greece.* We experimentally demonstrate the first all-optical Ternary Content Addressable Memory (T-CAM) cell based on two monolithic integrated InP Flip-Flops and a SOA-MZI XOR-gate, achieving 10Gb/s error-free operation during Content-Addressing and Write functionalities.

JTh3C • Symposium on Integrated Sources of Non-Classical Light: Perspectives and Challenges I—Continued

JTh3C.5 • 15:30
Diamond Color Center Integration with a Silicon Carbide Photonics Platform, Marina Radulaski[1], Yan-Kai Tzeng[1], Jingyuan Linda Zhang[1], Hitoshi Ishiwata[1], Konstantinos Lagoudakis[1], Constantin Dory[1], Kevin Fischer[1], Yousif Kelaita[1], Shuo Sun[1], Peter Maurer[1], Kassem Alassaad[2], Gabriel Ferro[2], Zhu-Xun Shen[1], Nicholas Melosh[1], Steven Chu[1], Jelena Vuckovic[1]; [1]*Stanford Univ., USA;* [2]*Univ. of Lyon, France.* We develop hybrid microresonators composed of the color center-rich nanodiamonds and silicon carbide microdisks fabricated on a silicon wafer. We demonstrate up to five-fold resonant enhancement of diamond silicon-vacancy and chromium-related color center emission.

JTh3C.6 • 15:45
Covalent Defects of Carbon Nanotubes: Room Temperature, 1.5 µm Single Photon Emitters for Integrated Photonics, Han Htoon[1]; [1]*Center for Integrated Nanotechnologies, Los Alamos National Lab, USA.* We demonstrate room-T single photon emission at 1.55 µm telecommunication wavelength with 99% single-photon purity and the shot-noise limited emission stability from covalently-introduced aryl sp^3 defect sites of single-wall carbon nanotubes.

16:00–16:30 Coffee Break, *Concourse Lobby*

Joint

JTh3D • Symposium on Advances in Integrated Microwave Photonics I—Continued

JTh3D.4 • 15:15
Automated Initialization of Reconfigurable Silicon-Nitride (SiN_x) Filters, Siva Yegnanarayanan[1], Ryan Maxson[1], Cheryl Sorace-Agaskar[1], Dave Kharas[1], Gregory Steinbrecher[1], Paul W. Juodawlkis[1]; [1]*Massachusetts Inst of Tech Lincoln Lab, USA.* We demonstrate automated initialization of tunable optical filters consisting of an initial feed-forward step followed by iterative feedback. Rapid convergence is demonstrated on high-order all-pass-filter (APF) structures in a silicon-nitride photonic integrated circuit (PIC).

JTh3D.5 • 15:30 Invited
Integrated Microwave Photonic Component Technologies, Jonathan Klamkin[1], Yuan Liu[1], Bowen Song[1], Fengqiao Sang[1], Brandon Isaac[1]; [1]*Univ. of California Santa Barbara, USA.* Key integrated microwave photonic component technologies are presented including low-loss waveguide true time delays for optical signal processing functions and high-performance hybrid integrated active devices.

CLEO: QELS-Fundamental Science

FTh3E • Non-diffracting and Vortex Beams—Continued

FTh3E.6 • 15:15
Landau-Zener-Bloch oscillations and valley-dependent vortex generation in photonic graphene, Yong Sun[1,2], Daniel Leykam[3,4], Stephen Nenni[1], Daohong Song[5], Hong Chen[2], Y. D. Chong[4,6], Zhigang Chen[1,5]; [1]*Dept. of Physics and Astronomy, San Francisco State Univ., USA;* [2]*MOE Key Lab of Advanced Micro-Structured Materials, School of Physics Science and Engineering, Tongji Univ., China;* [3]*Center for Theoretical Physics of Complex Systems, Inst. for Basic Science, South Korea;* [4]*Division of Physics and Applied Physics, School of Physical and Mathematical Sciences, Nanyang Technological Univ., Singapore;* [5]*MOE Key Lab of Weak-Light Nonlinear Photonics, TEDA Applied Physics Inst. and School of Physics, Nankai Univ., China;* [6]*Centre for Disruptive Photonic Technologies, Nanyang Technological Univ., Singapore.* We observe Bloch oscillations and Landau-Zener-tunneling at Dirac points in photonic graphene. The non-adiabatic wave dynamics depend anisotropically on the direction of an applied index gradient, resulting in imperfect Landau-Zener-tunneling and valley-dependent vortex generation.

FTh3E.7 • 15:30
Launching Electromagnetic Donuts: Non-transverse electromagnetic pulses, Apostolos Zdagkas[1], Parik Moitra[1], Oleksander Buchnev[1], Nikitas Papasimakis[1], Nikolai I. Zheludev[1,2]; [1]*Univ. of Southampton, UK;* [2]*Nanyang Technological Univ., Singapore.* We demonstrate experimentally for the first time the generation of electromagnetic "Flying Donuts", few-cycle pulses of toroidal topology with non-separable spatial and temporal structure, and discuss applications in the study of anapole excitations in matter.

FTh3E.8 • 15:45
Generation of Vector Vortex Beam From Doubly-Resonant Nanosecond Optical Parametric Oscillator., Varun Sharma[3], S. C. Kumar[1], A Aadhi[3], H. Ye[1], G. K. Samanta[3], M. Ebrahim-Zadeh[1,2]; [1]*ICFO-Institut de Ciencies Fotoniques, Spain;* [2]*Institucio Catalana de Recerca i Estudis Avancats (ICREA), Spain;* [3]*Photonic Sciences Lab, Physical Research Lab, India.* We demonstrate a novel experimental scheme to generate tunable vector vortex beam directly from an optical parametric oscillator (OPO). Using a nanosecond doubly-resonant OPO, we produce vector vortex beam tunable across 964-990 nm.

CLEO: Science & Innovations

STh3F • Mid-IR Nonlinear Devices—Continued

STh3F.5 • 15:15
Generation of coherent mid-IR light by parametric four-wave mixing in alkali vapor, Yoel Sebbag[1], Yefim Barash[1], Uriel Levy[1]; [1]*Applied Physics, The Hebrew Univ. of Jerusalem, Israel, Israel.* We demonstrate the generation of coherent mid-infrared light at 5.23 μm in hot rubidium vapor by parametric four wave mixing. Different regimes of competition between amplified spontaneous emission and four wave mixing are observed.

STh3F.6 • 15:30
Generation of high power, higher order, continuous-wave optical vortices tunable in the mid-IR wavelength ranges, A. Aadhi[1], Varun Sharma[1], G. K. Samanta[1]; [1]*Physical Research Lab, India.* We report on direct transfer of vortices at near-IR to the mid-IR wavelengths using a dual-crystal singly-resonant optical parametric oscillator producing vortices of order up to l=6 and power of 6 W across 2270-3560 nm.

16:00–16:30 Coffee Break, *Concourse Lobby*

CLEO: Science & Innovations

STh3G • Quantum Information Processing on Photonic Nanostructures—Continued

STh3G.3 • 15:15
Single-Photon Detection by Cavity-Assisted All-Optical Gain, Christopher L. Panuski[1], Mihir Pant[1], Mikkel Heuck[2], Dirk . Englund[1]; *[1]Dept. of Electrical Engineering and Computer Science, MIT, USA; [2]Dept. of Photonics Engineering, Technical Univ. of Denmark, Denmark.* Considering the free-carrier dispersion effect at the limit of a single photoexcited charge carrier pair suggests the possibility of realizing single-photon detection through a high-*Q*/*V* semiconductor cavity.

STh3G.4 • 15:30
Switching radiative processes via mode field modulation, Daniele Pellegrino[1], Francesco Pagliano[1,2], Armando Genco[1], Maurangelo Petruzzella[1,2], Frank van Otten[1], Andrea Fiore[1]; *[1]Eindhoven Univ. of Technology, Netherlands; [2]nanoPHAB, Netherlands.* We experimentally demonstrate the control over the emission of quantum dots embedded in photonic molecules via mode field modulation. By locally changing the cavity frequencies we control, and even suppress, spontaneous emission.

STh3G.5 • 15:45
Chiral quantum optics in hot vapor cladded waveguide, Roy T. Zektzer[1], Eliran Talker[1], Yefim Barash[1], Noa Mazurski[1], Uriel Levy[1]; *[1]The Hebrew Univ. of Jerusalem, Israel.* We demonstrate a strong magneto optic effect in chip scale integrated atomic cladded waveguides. Chiral effects and non-reciprocity of the integrated waveguide-atomic vapor system is observed. Possible applications such as isolators are discussed

CLEO: Applications & Technology

ATh3H • Control of Quantum Optical and Opto-mechanical Systems—Continued

ATh3H.6 • 15:15
Elastic Strain Engineering for Exceptional Mechanical Coherence, Nils Johan Engelsen[1], Amir Ghadimi[1], Sergey A. Fedorov[1], Mohammad J. Bereyhi[1], Ryan Schilling[1], Dalziel Wilson[2,1], Tobias J. Kippenberg[1]; *[1]Physics, École polytechnique fédérale de Lausanne, Switzerland; [2]IBM Research , Switzerland.* We utilized strain engineering combined with soft-clamping to realize exceptionally high Q Si_3N_4 nanomechanical oscillators. The quality factors (>400 million) and Q×f products (approaching 10^{15} Hz) are both unprecedented for any room temperature mechanical oscillator.

ATh3H.7 • 15:30
Frequency Conversion of a Quantum Dot Single-Photon Source on a Nanophotonic Chip, Anshuman Singh[1,2], Qing Li[1,2], Jin Liu[3], Xiyuan Lu[1,2], Christian Schneider[4], Sven Höfling[4], Kartik Srinivasan[1]; *[1]NIST-CNST, USA; [2]Maryland NanoCenter, Univ. of Maryland College Park, USA; [3]School of Physics, Sun-Yat Sen Univ., China; [4]Technische Physik, Universitat Wurzburg, Germany.* We report frequency conversion of single photons from a quantum dot using four-wave-mixing Bragg scattering in a Si_3N_4 microring. We measure an on-chip conversion efficiency >10%, and frequency-converted light that is antibunched with $g^{(2)}(0) < 0.5$.

ATh3H.8 • 15:45
Single-Photon-Level Interface for Linking Sr^+ Transition at 422nm with The Telecommunications C-band, Thomas A. Wright[1], Robert J. Francis-Jones[1], Corin Gawith[3], Jonas N. Becker[2], Patrick Ledingham[2], Ian Walmsley[2], Benjamin Brecht[2], Joshua Nunn[1], Peter J. Mosley[1]; *[1]Univ. of Bath, UK; [2]Univ. of Oxford, UK; [3]Univ. of Southampton, UK.* We present a single-stage bi-directional interface capable of linking Sr^+ trapped ion qubits emitting single photons at 422 nm with the telecoms C-band. We achieve external up(down) conversion efficiencies of 9.4%(1.1%).

CLEO: Science & Innovations

STh3I • Integrated Photonic Platforms—Continued

STh3I.6 • 15:15
GaP-On-Insulator as a Platform for Integrated Photonics, Simon Hönl[1], Katharina Schneider[1], Pol Welter[1], Yannick Baumgartner[1], Herwig Hahn[1], Lukas Czornomaz[1], Dalziel Wilson[1], Paul Seidler[1]; *[1]IBM Research -- Zurich, Switzerland.* We present a complete process flow for fabrication of integrated GaP-on-insulator photonic devices via direct wafer bonding of epitaxial films. High-fidelity patterning enables a range of applications, such as waveguide resonators and photonic crystal cavities.

STh3I.7 • 15:30
A Widely Tunable Vernier Filter on a Ge-on-SOI Platform for Sensing Applications, Sanja Radosavljevic[1], Nuria Teigell Beneitez[1], Andrew Katumba[1], Muhammad Muneeb[1], Michael Vanslembrouck[1], Bart Kuyken[1], Gunther Roelkens[1]; *[1]Universiteit Gent, Belgium.* We present a Vernier tunable racetrack resonator filter on Ge-on-SOI, with 110nm FSR at 5μm. The racetrack has a Q-factor of 20000 and side-peak suppression >20dB, sufficient for wavelength selection in an external cavity laser.

STh3I.8 • 15:45
Silicon nitride metalenses for unpolarized high-NA visible imaging, Zhi-Bin Fan[1], Zeng-Kai Shao[1], Ming-Yuan Xie[1], Xiao-Ning Pang[1], Wen-Sheng Ruan[1], Fu-Li Zhao[1], Yu-Jie Chen[1], Si-Yuan Yu[1], Jianwen Dong[1]; *[1]Sun Yat-Sen Univ., China.* We experimentally demonstrate the high-NA silicon nitride metalenses with centimeter aperture and micro size in visible region, fabricated by 695-nm-thick hexagonal silicon nitride arrays. The potential application of wide viewing-angle functionality has also been shown.

16:00–16:30 Coffee Break, *Concourse Lobby*

CLEO: Science & Innovations

STh3J • Optofluidics & High Throughput Florescence—Continued

STh3J.4 • 15:15
A Novel Cell and Particle Sorting Approach Based on Fluorescence Dynamics, Jianzhi Li[1], Jessica P. Houston[1]; [1]*New Mexico State Univ., USA.* Fluorescence activated cell sorting (FACS) is an approach that is based solely on detection of the amount of fluorescence emitted. We advance FACS with a unique phase mixing approach to enable separation based on fluorescence dynamics.

STh3J.5 • 15:30
Microfluidic Diatomite Analytical Devices for Ultra-Sensitive Detection of Hazardous Chemicals, Xianming Kong[1], Kenny Squire[1], Alan X. Wang[1]; [1]*Oregon State Univ., USA.* We report microfluidic diatomite analytical devices (μDADs), which consist of highly porous photonic crystal biosilica microchannels, as an innovative lab-on-a-chip platform to detect hazardous chemicals with the sensitivity down to ppb level.

STh3J.6 • 15:45
Optical Lattice-Based Cell Guiding and Stretching Using Integrated Vertical Multimode-Interference Waveguides, Zhanshi Yao[1], Andrew W. Poon[1]; [1]*Hong Kong Univ. of Sci. and Tech., Hong Kong.* We report our recent progress in optical lattice-based cell guiding and stretching using integrated SU8-filled vertically embedded multimode-interference waveguides. We obtain a throughput of ~6 cells/s for the deformability characterization of rabbit red blood cells.

STh3K • Multimode Fiber Optics—Continued

STh3K.3 • 15:15
Imaging Beyond a Multimode Fibre with Time of Flight Depth Information, Daan Stellinga[1], David Phillips[2], Matthew Edgar[1], Sergey Turtaev[3,4], Tomáš Čizmár[3,4], Miles Padgett[1]; [1]*Univ. of Glasgow, UK;* [2]*Univ. of Exeter, UK;* [3]*Univ. of Dundee, UK;* [4]*Leibniz Inst. of Photonic Technology, Germany.* Imaging through a multimode fibre can be achieved using a DMD. Using a Q-switched laser we extend this to include the time of flight as a first step towards 3D imaging though a fibre.

STh3K.4 • 15:30
Time-Domain Interference of Nonlinearly Interacting Spatial Modes in a Multimode Fiber, Sai Kanth Dacha[1], Thomas E. Murphy[1]; [1]*Univ. of Maryland at College Park, USA.* The study of nonlinear optics in multimode fibers has gathered considerable interest recently. We report experimental observation of time-domain interference between nonlinearly interacting co-polarized spatial modes of a graded-index multimode fiber at 1550nm.

STh3K.5 • 15:45
Mode Scrambler Using CO_2-laser Inscribed Long-period Gratings, Yunhe Zhao[1], Haoshuo Chen[2], Nicolas K. Fontaine[2], Jiaxiong Li[2], Roland Ryf[2], Yunqi . Liu[1]; [1]*Shanghai Univ., China;* [2]*Bell labs, Nokia, USA.* We demonstrate a mode scrambler using CO_2-laser inscribed long-period gratings for mixing 3 spatial modes. The mode-dependent loss and modal transfer matrices versus wavelength are characterized using a swept-wavelength interferometer.

STh3L • Imaging and Ranging—Continued

STh3L.5 • 15:15
Controlled Transmission Through Highly Scattering Media Using Semi-Definite Programming as a Phase Retrieval Computation Method, Moussa N'Gom[1]; [1]*Univ. of Michigan, USA.* An SLM in a simple optical setup is used to generate a random wavefronts. The transmitted speckle patterns are acquired on a camera. The semi-definite algorithm allows computation of the complex transmission matrix of the system. Arbitrary intensity profiles can then be generated.

STh3L.6 • 15:30
One-shot three-dimensional imaging with a paired filter and chirped-frequency combs, Takashi Kato[1,2], Megumi Uchida[1,2], Yurina Tanaka[1,2], Kaoru Minoshima[1,2]; [1]*The Univ. of Electro-Communications, Japan;* [2]*JST, ERATO MINOSHIMA Intelligent Optical Synthesizer (IOS), Japan.* One-shot three-dimensional imaging with chirped-frequency comb interferometry was demonstrated using 2D spectral imaging technique with a paired spectral filter. Non-scanning image measurement of a target 3D surface profile with 120-pixels square area was demonstrated.

STh3L.7 • 15:45
Overcoming the Coherence Distance Barrier in Long-Range FMCW LIDAR, Taehwan Kim[1], Pavan Bhargava[1], Vladimir Stojanovic[1]; [1]*UC Berkeley, USA.* Coherence distance has been considered as a hard limit for FMCW LIDAR range. We show laser characterization and a detection algorithm tailored to laser properties can significantly improve the accuracy, extending the range beyond coherence distance.

16:00–16:30 Coffee Break, *Concourse Lobby*

FTh3M • Chirality Vortices and Topological Effects—Continued

FTh3M.5 • 15:15
Giant intrinsic chiro-optical activity in planar nanostructures, Alexander Y. Zhu[1], Wei-Ting Chen[1], Aun Zaidi[1], Yao-Wei Huang[1], Mohammadreza Khorasaninejad[1], Vyshakh Sanjeev[3], Cheng-Wei Qiu[2], Federico Capasso[1]; [1]*Harvard Univ., USA;* [2]*National Univ. of Singapore, Singapore;* [3]*Univ. of Waterloo, Singapore.* We demonstrate near-unity circular dichroism in planar dielectric nanostructures, with approximately 90% of the incident light of the chosen helicity being transmitted at normal incidence at 540nm. Such strong intrinsic chiral behavior exists due to the excitation of giant higher-order multipoles.

FTh3M.6 • 15:30
Microscopic Origin of the Chiroptical Response of Plasmonic Media, Matthew Davis[1,2], Jay Lee[1], Henri Lezec[2], Amit K. Agrawal[2,3]; [1]*Syracuse Univ., USA;* [2]*Center for Nanoscale Science and Technology, USA;* [3]*Maryland Nanocenter, USA.* Plasmonic systems hold potential for amplifying chiroptical signals of molecular systems, however a comprehensive understanding of this effect does not exist. We discuss the common origin of chiroptical response in two-dimensional and three-dimensional plasmonic systems.

FTh3M.7 • 15:45
A chiral waveguide directional coupler using transition metal dichalcogenide monolayers, Zhili Yang[1], Edo Waks[1]; [1]*Univ. of Maryland, College Park, USA.* We demonstrated an on-chip broadband input-polarization-dependent directional coupler with a directionality of 0.3 based on coupling between a glide-plane photonic crystal waveguide and WSe_2 monolayers.

STh3N • Ultrafast Metrology I—Continued

STh3N.6 • 15:30
Spatio-temporally wideband ultrafast imaging, Cihang Kong[1], Xiaoming Wei[1,2], Kevin K. Tsia[1], Kenneth Kin-Yip Wong[1]; [1]*Univ. of Hong Kong, Hong Kong;* [2]*Dept. of Medical Engineering, California Inst. of Technology, USA.* We present a 10's-MHz imaging system through a simple spatio-temporally sweeping unit which is constructed with incremental optical fibers. It is demonstrated that this imaging modality can be performed over an ultrawide wavelength range, i.e., 500-2000 nm.

STh3N.7 • 15:45
Cascading Nonlinearity Inside a Spectrometer (CaNIS) for Ultrashort Pulse Diagnostics, Ning Hsu[1], Luke Horstman[1], Jean-Claude M. Diels[1]; [1]*Univ. of New Mexico, USA.* An ultrashort pulse is characterized by using spectra only. Second harmonic and cascading spectra are manipulated with a grating spectrometers to determine the original pulse's spectral phase, and hence achieve complete field reconstruction.

ATh3O • Novel Spectroscopic Approaches I—Continued

ATh3O.6 • 15:15
Wavelength calibration of high-performance spectrometers with a stabilized optical comb from an ultrafast semiconductor disk laser, Antoine Jallageas[1], Jacob Nuernberg[2], Cesare Alfieri[2], Dominik Waldburger[2], Sandro M. Link[2], Florian Emaury[2], Jacques Morel[1], Ursula Keller[2]; [1]*Federal Institut of Metrology METAS, Switzerland;* [2]*Inst. of Quantum Electronics, ETH Zurich, Switzerland.* We demonstrate for the first time that a fully stabilized ultrafast semiconductor disk laser is a suitable tool to perform wavelength calibration of high-performance spectrometers, opening new possibilities for wider and more accurate instruments calibrations.

ATh3O.7 • 15:30
Noise Correlation Spectroscopy for spectroscopic measurements of low energy modes, Giorgia Sparapassi[1], Jonathan O. Tollerud[1], Filippo Glerean[1], Daniele Fausti[1,2]; [1]*Università degli Studi di Trieste, Italy;* [2]*Elettra Sincrotrone Trieste S.C.p.A., Italy.* Noise Correlation Spectroscopy (NCS) is a technique exploiting statistical correlations imprinted onto spectral components of shaped ultrashort light pulses by a light-matter inelastic scattering process, in order to measure low energy eigenmodes of a material.

16:00–16:30 Coffee Break, *Concourse Lobby*

ATh3P • Sensing in Extreme Environments & Organic Optical Materials—Continued

ATh3P.5 • 15:15
Passive radiative cooling structure with vivid colors, Gil Ju Lee[1], Hyun Myung Kim[1], Yeong Jae Kim[1], Young Min Song[1]; [1]*GIST, South Korea*. A colored passive radiative cooler can widen the applicability of passive cooling strategy. This photonic structure is based on 1D structure/thermal emitter polymer and can be easily fabricated by metal/dielectric deposition and polymer coating.

ATh3P.6 • 15:30
Observation of Coherent Perfect Absorption in Resonant Organic Materials, Ali Kazemi Jahromi[1], Lorelle N. Pye[1], Soroush Shabahang[1], Massimo Villinger[1], Joshua Perlstein[1], Ayman Abouraddy[1]; [1]*Univ. of Central Florida, CREOL, USA*. By judiciously devising mirror reflectivities of a cavity containing an absorber, we experimentally demonstrate coherent perfect absorption in a resonant organic dye, even though the material's intrinsic absorption significantly varies across the dye absorption bandwidth.

ATh3P.7 • 15:45
Silk is a natural metamaterial for self-cooling: An oxymoron?, Seung Ho Choi[1], Zahyun Ku[2], Seong-Ryul Kim[3], Kwang-Ho Choi[3], Augustine Urbas[2], Young L. Kim[1]; [1]*Purdue Univ., USA;* [2]*Air Force Research Lab, USA;* [3]*National Inst. of Agricultural Sciences, South Korea*. As light transmittance in silk is suppressed by Anderson localization, its reflectance is drastically enhanced. A further combination with the high emissivity from the biomolecules of silk in infrared radiation results in passive radiative cooling.

ATh3Q • A&T Topical Review on Neurophotonics II—Continued

ATh3Q.5 • 15:30
Identification of Biomarker (L-2HG) in Real Human Brain Glioma by Terahertz Spectroscopy, Yan Peng[1], Wanqing Chen[1], Yiming Zhu[1]; [1]*Univ of Shanghai for Science & Tech, China*. L-2-Hydroxyglutaric acid disodium salt (L-2HG), a unique biomarker in glioma, has been detected effectively in real human brain glioma by THz time-domain spectroscopy (THz-TDS), which is especially meaningful for the diagnose and treatments of glioma.

ATh3Q.6 • 15:45
Neurite Outgrowth and Retraction Caused by Combined Optical and Chemical Stimulations, Yu-Chiu Kao[1], Yu-Cing Liao[1,2], Chau-Hwang Lee[1,2]; [1]*Research Center for Applied Sciences, Academia Sinica, Taiwan;* [2]*Inst. of Biophotonics, National Yang-Ming Univ., Taiwan*. We demonstrated that a 473 nm light spot caused neurite retraction of a neuroblastoma cell; while a 650 nm light spot on soma plus a myosin II inhibitor stimulated the neurite re-growth effectively.

16:00–16:30 Coffee Break, *Concourse Lobby*

CLEO: Science & Innovations

Joint

16:30–18:30
STh4A • Waveguide Structures
Presider: Ali Adibi; Georgia Inst. of Technology, USA

STh4A.1 • 16:30
High-Density Photonic Chip with All-Dielectric Metamaterials, Sangsik Kim[1,2], Saman Jahani[2,3], Jonathan Atkinson[3], Justin Wirth[2], Farid Kalhor[2,3], Abdullah Al Noman[2], Ward Newman[2,3], Prashant Shekhar[3], Kyunghun Han[2], Vien Van[3], Raymond G. Decorby[3], Lukas Chrostowski[4], Minghao Qi[2], Zubin Jacob[2,3]; [1]*Electrical and Computer Engineering, Texas Tech Univ., USA;* [2]*Electrical and Computer Engineering, Purdue Univ., USA;* [3]*Electrical and Computer Engineering, Univ. of Alberta, Canada;* [4]*Electrical and Computer Engineering, Univ. of British Columbia, Canada.* We present an extreme skin-depth (e-skid) waveguide scheme, whose evanescent field is suppressed significantly. We demonstrate it on a monolithic silicon chip, reducing the waveguide crosstalk and bending loss for a high-density photonic chip integration.

STh4A.2 • 16:45
Fast adiabatic mode evolution based on geometry-induced suppression of nearest-mode crosstalk, Josep Fargas Cabanillas[1], Milos Popovic[1]; [1]*Dept. of Electrical and Computer Engineering, Boston Univ., USA.* A new degree of freedom in the design of adiabatic mode-evolution structures allows dramatic length reduction while maintaining the characteristic large bandwidth and insensitivity, leading to a 10x shorter ultrabroadband, low-loss 2x2 3dB coupler design

STh4A.3 • 17:00
Curvature Control in a Segmented Beam Expander -Emergence of a Semi-lens, Siamak Abbaslou[1], Robert Gatdula[1], Ming Lu[2], Aaron Stein[2], Wei Jiang[1]; [1]*Rutgers Univ., USA;* [2]*Brookhaven National Lab, USA.* We introduce direct curvature control in optimizing a segmented beam expander that maintains width continuity. Unexpectedly, the optimization algorithm yields a structure with abrupt width discontinuity. Spatial phase analysis reveals the emergence of a semi-lens.

STh4A.4 • 17:15
Double-Inverse Tapers for Efficient Light Coupling with Arbitrary Polarization, Junqiu Liu[1], Arslan Raja[1], Martin Pfeiffer[1], Clemens Herkommer[1], Hairun Guo[1], Michael Zervas[1,2], Michael Geiselmann[1,2], Tobias J. Kippenberg[1]; [1]*EPFL, Switzerland;* [2]*LIGENTEC SA, Switzerland.* Efficient light coupling to integrated photonic devices is vital. We present novel, double-inverse tapers, which can achieve optimum coupling with arbitrary polarization. Reduced lithography requirement makes the double-inverse tapers promising for operation at near-IR and visible wavelengths.

STh4A.5 • 17:30
On-Chip Polarization Control Using Augmented Low Index Guiding Platform, Xiao Sun[1], J. Stewart Aitchison[1], Mo Mojahedi[1]; [1]*Univ. of Toronto, Canada.* The Augmented Low-index Guiding Waveguide can confine the two orthogonal polarization modes in different layers. We present our recent theoretical and experimental results on several polarization manipulation devices enabled by such a platform.

16:30–18:30
STh4B • On-chip and Offchip Coupling Schemes
Presider: Qiaoqiang Gan; State Univ. of New York at Buffalo, USA

STh4B.1 • 16:30
On-chip optical interconnect on silicon by transfer printing, Lei Liu[1], Ruggero Loi[1], Brendan Roycroft[1], James O'Callaghan[1], John Justice[1], Antonio Jose Trindade[2], Stephen Kelleher[2], Agnieszka Gocalinska[1], Kevin Thomas[1], Emanuele Pelucchi[1], Christopher A. Bower[2], Brian Corbett[1]; [1]*Tyndall National Inst., Ireland;* [2]*X-Celeprint Limited, Ireland.* On-chip optical interconnects consisting of transfer-printed micro-LEDs and photodiodes are presented. Static and dynamic data transmission and bi-directional interconnect are demonstrated. The results show the potential for cost-effective and small form-factor on-chip opto-isolators.

STh4B.2 • 16:45
Optical Equalization Using Spatial Phase Manipulation for VCSEL-MMF Based Links, Chenyu Liang[1], Wenjia Zhang[1], Shun Yao[2,3], Qing Wang[2,3], Zuyuan He[1]; [1]*Shanghai Jiaotong Univ., China;* [2]*Inst. of Laser Engineering, Beijing Univ. of Technology, China;* [3]*Sino-semiconductor Photonics Integrated Circuit Co., Ltd.,, China.* We propose an optical equalization scheme for VCSEL and MMF based link by using spatial phase manipulation. Over 2-dB power penalty improvement is achieved by experiment for 25-Gb/s 300m transmission.

STh4B.3 • 17:00
Fabrication Constrained Inverse Design of a 3-channel Wavelength Demultiplexer, Alexander Y. Piggott[1], Logan Su[1], Neil V. Sapra[1], Jan Petykiewicz[1], Jelena Vuckovic[1]; [1]*Stanford Univ., USA.* We have implemented an automated nanophotonic design algorithm with fabrication constraints. This was used to demonstrate a compact 3-channel wavelength demultiplexer with a channel spacing of 40nm, insertion loss <2.29dB, and under 10.7dB crosstalk.

STh4B.4 • 17:15
Ultra-broadband Compact Adiabatic Coupler in Silicon-on-Insulator for Joint Operation in the C- and O-Bands, Heba Tamazin[1], Eslam Elfiky[1], Yun Wang[1], Yannick D'Mello[1], David Patel[1], Amar Kumar[1], David V. Plant[1]; [1]*McGill Univ., Canada.* An ultra-broadband, compact adiabatic coupler in silicon-on-insulator platform is presented. It has 70 µm coupling length and a splitting ratio of 3±0.8 dB over bandwidth > 160 nm measured jointly in the C- and O-bands.

STh4B.5 • 17:30
Direct coupling between 2D-PDA and triangular/square shape aligned MCF for universal SDM photoreceiver, Toshimasa Umezawa[1], Takahide Sakamoto[1], Atsushi Kanno[1], Naokatsu Yamamoto[1], Tetsuya Kawanishi[1,2]; [1]*National Inst of Information & Comm Tech, Japan;* [2]*Waseda Univ., Japan.* We successfully achieved the high coupling efficiencies and alignment tolerances between a newly developed 10-GHz 32-pixel two dimensional photodetector array (2D-PDA) and triangular- and square-shape-aligned multi-core fiber (MCF) for universal SDM photoreceivers.

16:30–18:30
JTh4C • Symposium on Integrated Sources of Non-Classical Light: Perspectives and Challenges II
Presider: Alireza Marandi, USA

JTh4C.1 • 16:30 Invited
Nonclassical Light Sources for Silicon Photonics, Matteo Galli[1]; [1]*Universita degli Studi di Pavia, Italy.* silicon photonics has rapidly become the platform of choice for on-chip integration of high performing photonic devices, now extending their functionalities to quantum-based applications. We review recent progress in this growing field and highlight the challenges that need to be overcome to make quantum photonics a reliable and widespread technology.

JTh4C.2 • 17:00 Invited
Scalable On-chip Generation and Coherent Control of Complex Optical Quantum States, Piotr Roztocki[1], Michael Kues[1,3], Christian Reimer[1], Luis Romero Cortés[1], Stefania Sciara[1,4], Benjamin Wetzel[1,5], Young Zhang[1], Alfonso Cino[4], Sai T. Chu[6], Brent E. Little[7], David J. Moss[8], Lucia Caspani[9], Jose . Azana[1], Roberto Morandotti[1,2]; [1]*INRS-Energie Mat & Tele Site Varennes, Canada;* [2]*National Research Univ. of Information Technologies, Mechanics and Optics, Russia;* [3]*Univ. of Glasgow, UK;* [4]*Univ. of Palermo, Italy;* [5]*Univ. of Sussex, UK;* [6]*City Univ. of Hong Kong , China;* [7]*Xi'an Inst. of Optics and Precision Mechanics, Chinese Academy of Science, China;* [8]*Swinburne Univ. of Technology, Australia;* [9]*Univ. of Strathclyde, UK.* Integrated quantum frequency combs provide access to multi-photon and high-dimensional entangled states, and their control via standard telecommunications components, and can thus open paths for reaching the state complexities required for meaningful quantum information science.

JTh4C.3 • 17:30
Monolithic Source of Entangled Photons with Integrated Pump Rejection, Cale M. Gentry[1], Omar S. Magana Loaiza[2], Mark T. Wade[1], Fabio Pavanello[1], Thomas Gerrits[2], Sen Lin[3], Jeffrey Shainline[2], Shellee Dyer[2], Sae Woo Nam[2], Richard Mirin[2], Milos Popovic[4,1]; [1]*Univ. of Colorado Boulder, USA;* [2]*National Inst. of Standards and Technology, USA;* [3]*Univ. of California Berkeley, USA;* [4]*Boston Univ., USA.* We demonstrate a photon pair source with pump rejection filter on a *single* CMOS chip. Cascaded microring-based filters exhibit >95 dB pump extinction, providing a raw visibility in time-energy entanglement of 81.4% ± 2.3%.

Executive Ballroom 210D

Joint

16:30–18:30
JTh4D • Symposium on Advances in Integrated Microwave Photonics II
Presider: Maurizio Burla; ETH Zurich, Switzerland and David Marpaung; University of Twente, Netherlands

JTh4D .1 • 16:30 Invited
Photonic Integrated Circuits for Microwave Signal Generation and Processing, Jianping Yao[1]; [1]*Univ. of Ottawa, Canada.* Silicon photonic integrated circuits (PICs) for the implementation of microwave photonic systems to perform functions including microwave signal processing based on a reconfigurable grating, and microwave signal generation based on an optoelectronic oscillator are disused.

JTh4D .2 • 17:00 Invited
Microcomb Engine for Microwave Photonics, Xiaoxiao Xue[1], Xiaoping Zheng[1], Andrew M. Weiner[2]; [1]*Tsinghua Univ., China;* [2]*Purdue Univ., USA.* We review recent advances in microcomb generation for microwave photonic applications including microwave generation, programmable signal processing, and true-time-delay beamforming. The key challenges and future research opportunities are also discussed.

JTh4D .3 • 17:30
Injection Locking of Dissipative Kerr Solitons, Wenle Weng[1], Erwan Lucas[1], Hairun Guo[1], Grigory Lihachev[2,3], Valery Lobanov[2], Michael Gorodetsky[2,3], Tobias J. Kippenberg[1]; [1]*EPFL, Switzerland;* [2]*Russian Quantum Center, Russia;* [3]*Faculty of Physics, M.V. Lomonosov Moscow State Univ., Russia.* We report a radio frequency injection locking technique with amplitude modulation of pump laser for suppressing fluctuations of the repetition rate of a microresonator-based dissipative Kerr soliton frequency comb.

Executive Ballroom 210E

CLEO: QELS-Fundamental Science

16:30–18:30
FTh4E • Multimode Nonlinear Fiber Optics
Presider: Arash Mafi; Univ. of New Mexico, USA

FTh4E.1 • 16:30 Invited
Spatiotemporal Phenomena in Multimode Fibers, Frank W. Wise[1]; [1]*Cornell Univ., USA.* New phenomena observed recently in multimode optical fibers will be reviewed, and their relevance to applications will be discussed.

FTh4E.2 • 17:00
Universal Entropic Response of Nonlinear Multimode Optical Systems, Fan Wu[1], Absar U. Hassan[1], Mohammad Amin Eftekhar[1], Demetrios N. Christodoulides[1]; [1]*Univ. of Central Florida, USA.* We show that the mode occupancies in nonlinear multimode optical systems follow a universal behavior that tends to maximize the system's entropy at steady-state. This thermodynamic response occurs irrespective of the type of nonlinearities involved.

FTh4E.3 • 17:15
Intermodal Raman Scattering of Ultrashort Pulses in Multimode Fibers, Aku J. Antikainen[1], Boyin Tai[2], Lars Rishøj[2], Siddharth Ramachandran[2], Govind P. Agrawal[1,2]; [1]*Univ. of Rochester, USA;* [2]*Boston Univ., USA.* We study numerically the competition between intramodal and intermodal Raman scattering of ultrashort pulses in a multimode fiber. Considerable pulse energy can be transferred between different modes depending on the extent of group velocity matching.

FTh4E.4 • 17:30
Nonlinear Wave Collapse in Coupled Fiber Systems, Andre Luiz M. Muniz[1], Martin Wimmer[1], Arstan Bisianov[1], Demetrios N. Christodoulides[2], Roberto Morandotti[3], Ulf Peschel[1]; [1]*Friedrich-Schiller-Universität Jena, Germany;* [2]*Univ. of Central Florida, College of Optics and Photonics, USA;* [3]*Énergie, Matériaux et Télécommunications, Institut national de la recherche scientifique, Canada.* We experimentally demonstrate nonlinear wave collapse at mW-power levels in a genuine 1D system formed by coupled optical fibers. Based on time-multiplexing we realize an effective two-dimensional lattice and observe strong nonlinearly driven field compression.

Executive Ballroom 210F

CLEO: Science & Innovations

16:30–18:30
STh4F • Optical Parametric Oscillators
Presider: Markku Vainio; Univ. of Helsinki, Finland

STh4F.1 • 16:30
HVPE of Orientation-Patterned Gallium Phosphide (OP-GaP) with Novel Quasi-Phasematched Device Structures, Peter G. Schunemann[1], Daniel J. Magarrell[1], Leonard A. Pomeranz[1]; [1]*BAE Systems Inc, USA.* We report the successful growth and fabrication of engineered quasi-phasematched grating structures - parallel gratings, tandem gratings, linear- and curved fan gratings, and chirped gratings - in the new nonlinear optical semiconductor OP-GaP.

STh4F.2 • 16:45
Efficient Backward-Wave Optical Parametric Oscillator with 500 nm-periodicity PPRKTP, Riaan Stuart Coetzee[1], Andrius Zukauskas[1], Carlota Canalias[1], Valdas Pasiskevicius[1]; [1]*Royal Inst. of Technology (KTH), Sweden.* Backward-wave OPO with forward mid-infrared idler and backward signal generation is demonstrated in 500-μm-periodicity PPRKTP. The output energy of 2.39mJ and efficiency of 46.4% is obtained. This design has potential for broad tunability in mid-infrared.

STh4F.3 • 17:00 Invited
Optical Parametric Oscillation in Random Polycrystalline $\chi^{(2)}$ Medium, Konstantin L. Vodopyanov[1], Qitian Ru[1], Nathaniel Lee[1], Xuan Chen[1], Kai Zhong[2], Sergey Vasilyev[3], Mike Mirov[3], Sergey Mirov[3,4]; [1]*Univ. of Central Florida, CREOL, USA;* [2]*College of Precision Instrum. and Optoel. Eng., Tianjin Univ., China;* [3]*Mid-Infrared Lasers, IPG Photonics , USA;* [4]*Dept. of Physics, Univ. of Alabama at Birmingham, USA.* We demonstrate the first OPO based on random phase matching. The OPO was based on ZnSe ceramic pumped by 62-fs, λ=2.35-μm Cr:ZnS laser pulses, had 90-mW pump threshold and produced an ultra-broad spectrum spanning 3-7.5 μm.

STh4F.4 • 17:30
Half-watt average power compact femtosecond source with a bandwidth of 3–8 μm based on subharmonic GaAs OPO, Viktor O. Smolski[1], Sergey Vasilyev[1], Igor Moskalev[1], Mike Mirov[1], Qitian Ru[2], Andrey Muraviev[2], Peter G. Schunemann[3], Sergey Mirov[1,4], Valentin Gapontsev[5], Konstantin L. Vodopyanov[2]; [1]*IPG Photonics, USA;* [2]*Univ. of Central Florida, CREOL, USA;* [3]*BAE Systems, USA;* [4]*Univ. of Alabama at Birmingham, USA;* [5]*IPG Photonics, USA.* High-power (0.5 W) mid-IR output suitable for ultra-broadband frequency comb generation was produced in a subharmonic GaAs optical parametric oscillator that was synchronously pumped by a compact 0.9 GHz, 6 W femtosecond Cr:ZnS (2.35μm) MOPA.

CLEO: QELS-Fundamental Science

16:30–18:30
FTh4G • Cats and Kets
Presider: Martin Stevens; NIST, USA

FTh4G.1 • 16:30
Experimental Test of Bell's Inequality for Temporal Orders, Giulia Rubino[1], Lee Rozema[1], Francesco Massa[1], Mateus Araujo[1], Magdalena Zych[2], Caslav Brukner[1], Philip Walther[1]; *[1]Univ. of Vienna, Austria; [2]Univ. of Queensland, Australia.* Bell's inequality has been violated using different physical systems, but never for the temporal order between events. Here we present such a Bell inequality and experimentally violate it by entangling the temporal order between events.

FTh4G.2 • 16:45
A Four-Photon Graph State Generator in Silicon, Jeremy C. Adcock[1], Caterina Vigliar[1], Raffaele Santagati[1], Joshua W. Silverstone[1], Mark G. Thompson[1]; *[1]Univ. of Bristol, UK.* We present a four-photon, four-qubit graph state generator in Silicon quantum photonics, achieving, for the two and four qubit cases respectively, fidelities of 0.931 ± 0.004 and 0.62 ± 0.04, and a visibility of 0.85 ± 0.03.

FTh4G.3 • 17:00
A Broadband All-Fiber SU(1,1) Interferometer, Joseph M. Lukens[1], Raphael C. Pooser[1,2], Nicholas A. Peters[1,3]; *[1]Oak Ridge National Lab, USA; [2]Dept. of Physics, Univ. of Tennessee, USA; [3]Bredesen Center, Univ. of Tennessee, USA.* We describe an SU(1,1) interferometer based on highly nonlinear optical fiber, attaining >97% peak interference visibility and >90% visibility over a 554 GHz optical band.

FTh4G.4 • 17:15
Rabi-like Oscillations in Photon Pair Correlations, Steven Rogers[1], Austin Graf[1], Usman Javid[1], Qiang Lin[1]; *[1]Univ. of Rochester, USA.* We have produced a new quantum coherence phenomenon via photon generation within ultra-high-Q silicon microdisks. The Rayleigh-scattering-induced strong coupling of counterpropagating modes leads to Rabi-like oscillations in the biphoton second-order coherence.

FTh4G.5 • 17:30 Invited
Schrödinger Cats for Quantum Internet, Alexander I. Lvovsky[2,1], Alexander Ulanov[2], Demid Sychev[2], Anastasia A. Pushkina[2,1], Egor Tiunov[2], Valery Novikov[2]; *[1]Univ. of Calgary, Canada; [2]Russian Quantum Center, Russia.* We generate and characterize an entangled state between qubits encoded in single-photon polarizations and superpositions of opposite-amplitude coherent states. We demonstrate its application for exchanging quantum information between discrete- and continuous-variable encodings of quantum information.

16:30–18:30
FTh4H • Nanophotonic Emitters, Detectors and Modulators
Presider: Cheng Zhang; NIST, USA

FTh4H.1 • 16:30
Bypassing Loss in Plamsonic Modulators, Christian Haffner[1], Daniel Chelladurai[1], Yuriy Fedoryshyn[1], Arne Josten[1], Benedikt Baeuerle[1], Wolfgang Heni[1], Tatsuhiko Watanabe[1], Tong Cui[1], Bojun Cheng[1], Soham Saha[2], Delwin Elder[3], Larry R. Dalton[3], Alexandra Boltasseva[2], Vladimir M. Shalaev[2], Nathaniel Kinsey[4], Juerg Leuthold[1]; *[1]ETH Zurich, Switzerland; [2]School of Electrical & Computer Engineering and Brick Nanotechnology Center, Purdue Univ., USA; [3]Dept. of Chemistry, Univ. of Washington, USA; [4]Electrical and Computer Engineering, Virginia Commonwealth Univ., USA.* We show that Ohmic losses in plasmonic modulators can be bypassed by using a resonant scheme. This enables the first modulator that unites low-loss, high-speed, compact footprint and low-electrical energy consumption.

FTh4H.2 • 17:00
Electro–Absorption Waveguide Modulator Performance, Rubab Amin[1], Jacob Khurgin[2], Volker J. Sorger[1]; *[1]The George Washington Univ., USA; [2]Johns Hopkins Univ., USA.* A holistic analysis for waveguide-based electro-absorption modulators demonstrates that all materials with direct interband absorption show comparable performance from the fundamental point of view. Only reducing the effective waveguide area can lead to reduced switching energy and wide bandwidth.

FTh4H.3 • 17:15
High responsivity and bias-free graphene photodetector with nano-grating contact electrodes, Mona Jarrahi[1], Semih Cakmakyapan[1]; *[1]Univ. of California Los Angeles, USA.* We present a high responsivity and bias-free graphene photodetector with responsivity levels as high as 225 mA/W at 800 nm wavelength, which uses nano-grating contact electrodes to enhance optical absorption and photocarrier extraction.

FTh4H.4 • 17:30 Invited
Integrated Quantum Optics: From Emitters to Detectors, Val Zwiller[1]; *[1]Technische Universiteit Delft, Netherlands.* We develop quantum devices to generate quantum states of light with semiconductor quantum dots, superconducting single photon detectors and on-chip circuits to filter and route light.

CLEO: Science & Innovations

16:30–18:30
STh4I • Mid-IR Optoelectronics
Presider: Frank (Fengqiu) Wang; Nanjing Univ., China

STh4I.1 • 16:30 Invited
Epitaxy-free Direct Bandgap GeSn Materials and Devices for Facile 3D Photonic Integration, Jifeng Liu[1], Xiaoxin Wang[1]; *[1]Dartmouth College, USA.* We present direct bandgap GeSn crystallized on dielectric layers at <450 °C with room-temperature photoluminescence, ~0.1 ns transient optical gain >4000/cm at λ=2100-2350 nm, and a photoconductive responsivity of ~10 mA/W @1V at λ=2180 nm.

STh4I.2 • 17:00
Systematic Study of $Ge_{0.89}Sn_{0.11}$ Photodiodes for Low-Cost Shortwave Infrared Imaging, Huong Tran[1], Thach Pham[1], Wei Du[2], Yang Zhang[1], Seyed Ghetmiri[3], Perry Grant[1,6], Joshua Grant[1], Greg Sun[4], Richard Soref[4], Joe Margetis[5], John Tolle[5], Baohua Li[6], Mansour Mortazavi[3], Shui-Qing Yu[1]; *[1]Univ. of Arkansas, USA; [2]Wilkes Univ., USA; [3]Univ. of Arkansas Pine Bluff, USA; [4]Univ. of Massachusetts Boston, USA; [5]ASM, USA; [6]Arktonics, USA.* The characteristics $Ge_{0.89}Sn_{0.11}$ photodiodes were systematically investigated. A cutoff wavelength of 2.65 μm at 300 K and the peak detectivity of 4.3×10^9 Jones at 77 K were achieved. An infrared imaging of an object was demonstrated using the single Ge0.89Sn0.11 photodiode.

STh4I.3 • 17:15
Dilute-Bismide Alloys for GaSb-based Mid-Infrared Semiconductor Lasers, Scott D. Sifferman[1], Marcin Motyka[2], Andrew F. Briggs[1], Kenneth J. Underwood[3], Kyle M. McNicholas[1], Robert Kudrawiec[2], Juliet Gopinath[3,4], Seth Bank[1]; *[1]Microelectronics Research Center, Univ. of Texas at Austin, USA; [2]Wroclaw Univ. of Technology, Poland; [3]Dept. of Physics, Univ. of Colorado Boulder, USA; [4]Dept. of Electrical, Computer and Energy Engineering, Univ. of Colorado Boulder, USA.* Incorporation of bismuth into III-V emitters typically results in dramatically reduced luminescence efficiency. We present type-I dilute-bismide III-V quantum wells exhibiting enhanced photoluminescence near 4 μm, suggesting a viable route to extend diode laser emission.

STh4I.4 • 17:30
Direct Bandgap Type-I GeSn Quantum Well toward Si-based Optoelectronics, Perry C. Grant[2,1], Joe Margetis[3], Yiyin Zhou[2,1], Wei Dou[1], Grey Abernathy[1], Andrian Kuchuk[1], Wei Du[4], Seyed Ghetmiri[5], Baohua Li[2], John Tolle[3], Jifeng Liu[6], Greg Sun[7], Richard Soref[7], Mansour Mortazavi[5], Shui-Qing Yu[1]; *[1]Univ. of Arkansas, USA; [2]Arktonics LLC., USA; [3]ASM, USA; [4]Wilkes Univ., USA; [5]Univ. of Arkansas-Pine Bluff, USA; [6]Darthmouth College, USA; [7]Univ. of Massachusetts-Boston, USA.* GeSn single quantum well on relaxed GeSn and Ge buffered Si substrate was investigated. The direct bandgap well and type-I band alignment were achieved, which were confirmed by calculation and photoluminescence studies.

CLEO: QELS-Fundamental Science

16:30–18:30
FTh4J • Random and Alternative Materials Metasurfaces
Presider: Otto Muskens; Univ. of Southampton, UK

FTh4J.1 • 16:30
Tunable topology of photonic systems based on transparent conducting oxides, Zhaxylyk A. Kudyshev[1], Alexander Kildishev[1], Alexandra Boltasseva[1], Vladimir M. Shalaev[1]; [1]*Purdue, USA*. Here we show that by integrating transparent conducting oxides with a photonic waveguide array it is possible to realize ultrafast control over topology of photonic system. This precise control is highly important for topologically protected memory devices and quantum communication applications.

FTh4J.2 • 16:45
Chip-scale atomic diffractive optical elements, Liron Stern[1], Douglas Bopp[1], Vincent N. Maurice[1], John Kitching[1]; [1]*Time & Frequency Division, National Inst. of Standards and Technology (NIST), USA*. We experimentally explore the spatial and spectral response of a chip-scale hybrid atomic-dielectric grating. Spectral control of the diffracting orders mediated by the atomic vapor paves the path to a variety of novel atomic-controlled diffractive-optical-elements.

FTh4J.3 • 17:00
Gain tunable all-dielectric metasurfaces incorporating III-V semiconductors, Hang Li[1], Ruizhe Yao[1], Jun Ding[2], Wei Guo[1], Hualiang Zhang[1]; [1]*Univ. of Massachusetts Lowell, USA;* [2]*School of Information and Science Technology, East China Normal Univ., China*. In this work, we present a tunable all-dielectric metasurface based on III-V semiconductors (InGaAs/GaAs). Active amplitude tuning of reflected optical wave using the proposed metasurface has been demonstrated through both numerical simulation and experiment.

FTh4J.4 • 17:15
III-V semiconductor metasurface as the optical metamixer, Polina Vabishchevich[1], Sheng Liu[1], Aleksandr Vaskin[2], John Reno[1,3], Gordon A. Keeler[1], Michael Sinclair[1], Isabelle Staude[2], Igal Brener[1,3]; [1]*Sandia National Labs, USA;* [2]*Inst. of Applied Physics, Abbe Center of Photonics, Friedrich-Schiller-Univ. Jena, Germany;* [3]*Center for Integrated Nanotechnologies, Sandia National Labs,, USA*. In this work, we experimentally demonstrate simultaneous occurrence of second-, third-, fourth-harmonic generation, sum-frequency generation, four-wave mixing and six-wave mixing processes in III-V semiconductor metasurfaces with spectra spanning from the UV to the near-IR.

FTh4J.5 • 17:30
High-efficiency and low-loss dielectric metasurfaces on a gallium nitride platform, Naresh K. Emani[1], Egor Khaidarov[1,2], Ramon Paniagua-Dominguez[1], Yuan Hsing Fu[1], Vytautas Valuckas[1], Shunpeng Lu[2], Xueliang Zhang[2], Swee Tiam Tan[2], Hilmi Volkan Demir[2,3], Arseniy Kuznetsov[1]; [1]*Data Storage Inst., Singapore;* [2]*Nanyang Technological Univ., Singapore;* [3]*Bilkent Univ., Turkey*. Epitaxial GaN on sapphire is a promising material platform for low-loss, nonlinear and active metasurfaces at visible wavelengths. We experimentally demonstrate high efficiency dielectric metasurfaces with beam bending and polarization splitting functionalities on this platform.

CLEO: Science & Innovations

16:30–18:30
STh4K • Long Wavelength Fiber Sources
Presider: Camille-Sophie Bres; Ecole Polytechnique Federale de Lausanne, Switzerland

STh4K.1 • 16:30
Few-Cycle Pulse Generation from a 3 µm Fiber Laser, Robert I. Woodward[1], Darren Hudson[1], Alex Fuerbach[1], Stuart D. Jackson[1]; [1]*Macquarie Univ., Australia*. We demonstrate the generation of 70-fs pulses (~7 optical-cycles) from a mid-infrared mode-locked Ho:ZBLAN fiber laser using nonlinear compression with step-index chalcogenide fiber. Experiments are supported by numerical modelling, confirming the scalability of this approach.

STh4K.2 • 17:00
High Power Splice-less Fiber Laser at 2825 nm, Yigit O. Aydin[1], Vincent Fortin[1], Réal Vallée[1], Martin Bernier[1]; [1]*Centre d'Optique, Photonique et Laser (COPL), Université Laval, Canada*. A passively cooled 2825 nm splice-less erbium-doped fluoride fiber laser delivering 20 W output power in continuous wave operation was reported. This result represents the highest mid-IR output power obtained from a splice-less laser cavity.

STh4K.3 • 17:15
Emission Beyond 4µm and Mid-infrared Lasing from a Dy^{3+}:InF_3 Fiber, Matthew Majewski[1], Robert I. Woodward[1], Jean-Yves Carree[2], Marcel Poulain[2], Samuel Poulain[2], Stuart D. Jackson[1]; [1]*Macquarie Univ., Australia;* [2]*Le Verre Fluore, France*. We present a dysprosium-doped InF3 fiber exhibiting emission beyond 4 microns; the longest wavelength to date from a fluoride-based fiber. Laser emission around 3 µm is also demonstrated.

STh4K.4 • 17:30
Yb-doped Fiber Laser Based Coherent Mid-Infrared Frequency Comb at λ = 4.5 µm for CRDS application, Lei Jin[1], Volker Sonnenschein[1], Ryohei Terabayashi[1], Noriyoshi Hayashi[1], Shusuke Kato[1], Masahito Yamanaka[1], Hideki Tomita[1], Tetsuo Iguchi[1], Atsushi Sato[2], Kohei Nozawa[2], Kenji Yoshida[2], Norihiko Nishizawa[1]; [1]*Nagoya Univ., Japan;* [2]*Sekisui Medical Co. Ltd., Japan*. An offset free mid-infrared optical frequency comb was generated based on an Yb-doped fiber laser system with tunability of 3.9-4.7 µm. Cavity ring down spectroscopy measurement was demonstrated with QCL and MIR comb reference.

16:30–18:30
STh4L • Optical Sensing in Combustion
Presider: Brian Brumfield; Pacific Northwest National Lab, USA

STh4L.1 • 16:30 Invited
Probing Soot Formation and Chemical Evolution During Combustion, Hope A. Michelsen[1]; [1]*Sandia National Labs, USA*. There are gaps in the understanding of soot formation during combustion, which are largely attributable to a limited ability to probe relevant particle parameters during formation. This talk will describe approaches to developing appropriate diagnostics.

STh4L.2 • 17:00
Investigation of Multi-Photon Excitation Schemes for Detecting Atomic Hydrogen in Flames, Ayush Jain[1], Waruna Kulatilaka[1]; [1]*Texas A&M Univ., USA*. **Abstract:** We investigate two-photon and three-photon excitation schemes for ultrashort pulse LIF detection of atomic hydrogen in flames. Three-photon (λ=307.7nm) scheme was demonstrated successfully for the first time and various interferences effects are studied.

STh4L.3 • 17:15
CO_2 Measurement in Laminar Premixed Flames Using Heterodyne Phase-Sensitive Dispersion Spectroscopy, Zhen Wang[1], Liuhao Ma[1], Kin-Pang Cheong[1], Wei Ren[1]; [1]*The Chinese Univ. of Hong Kong, Hong Kong*. We measured CO_2 concentrations in laminar premixed flames using heterodyne phase sensitive dispersion spectroscopy by directly modulating the injection current of an interband cascade laser.

STh4L.4 • 17:30 Tutorial
Development and Application of Laser Diagnostic Techniques for Combustion Studies, Marcus L.E. Alden[1]; [1]*Dept of Physics, Lund Univ., Sweden*. The present talk will present some advancement in laser diagnostics in combustion environments. Several techniques will be described and the talk will also include new developments addressing some of the challenges in the field

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CLEO: QELS-Fundamental Science

16:30–18:30
FTh4M • Functional Nanophotonics Using Metasurfaces
Presider: Godofredo Bautista; Tampere Univ. of Technology, Finland

FTh4M.1 • 16:30
Active Tuning of Reflectance at Long Infrared Wavelengths using Strongly Coupled Metasurface-Semiconductor Hybrid Structures, Raktim Sarma[1], Salvatore Campione[1], michael goldflam[1], Joshua Shank[1], Sean Smith[1], Jinhyun Noh[2], Peide Ye[2], Michael Sinclair[1], Igal Brener[1]; [1]*Sandia National Labs, USA;* [2]*Purdue Univ., USA.* We experimentally demonstrate spectral tuning and amplitude modulation of reflectance at long infrared wavelengths using a complementary metasurface strongly coupled to an epsilon-near-zero (ENZ) mode in an ultrathin InGaAs layer with a reflecting backplane.

FTh4M.2 • 16:45
Wavelength-dependent Optical-rotation Manipulation for Active Color Display and Highly Secure Encryption, Maowen Song[1,2], Alexander Kildishev[1,3], Di Wang[1,3], Zhuoxian Wang[1,3], Yi Xuan[1], Alexandra Boltasseva[1,3], Honglin Yu[2], Vladimir M. Shalaev[1,3]; [1]*Birck Nanotechnology Center, Purdue Univ., USA;* [2]*Key Lab of Optoelectronic Technology and Systems of Education Ministry of China, Chongqing Univ., China;* [3]*School of Electrical and Computer Engineering, Purdue Univ., USA.* We present a silica coated aluminum metamirror with wavelength-dependent optical rotation effect. Excitation of localized surface plasmons maps discrete polarizations into diverse colors, broadly increasing the encoded information space.

FTh4M.3 • 17:00 Invited
Broadband Hot Electron Creation in Nanoscale Gap Plasmon Metasurfaces, Gary Wiederrecht[1]; [1]*Argonne National Lab, USA.* We report experimental and theoretical results on the use of broadband plasmonic nanopatch metasurfaces to produce large concentrations of hot electrons. Transient absorption spectroscopy enables the detection of hot electron populations and their decay pathways.

FTh4M.4 • 17:30
Ultrafast Tunable Metasurface with Transparent Conducting Oxide Antenna Array, Soham Saha[1,2], Aveek Dutta[1,2], Clayton DeVault[1,2], Vladimir M. Shalaev[1,2], Alexandra Boltasseva[1,2]; [1]*Birck Nanotechnology Center, USA;* [2]*Purdue Univ., USA.* We demonstrate large reflection and transmission modulation and femtosecond relaxation times in undoped zinc oxide films. Using these experimental results, we designed an optically tunable, terahertz-speed metasurface with a 17.4dB extinction ratio at 1.30 μm.

CLEO: Science & Innovations

16:30–18:30
STh4N • Ultrafast Metrology II
Presider: Jose Azana; INRS-Energie Materiaux et Telecom, Canada

STh4N.1 • 16:30
Deep Learning Reconstruction of Ultrashort Pulses, Tom Zahavy[1], Alex Dikopoltsev[1], Oren Cohen[1], Shie Mannor[1], Mordechai Segev[1]; [1]*Technion, Israel.* We propose and demonstrate, numerically and experimentally, the first deep neural network technique to reconstruct the amplitude and phase of ultrashort optical pulses. We anticipate that this approach will enable diagnostics of very weak pulses.

STh4N.2 • 16:45
Differential Evolution for Robust Phase Retrieval in Ultrafast Pulse Characterization, Gunter Steinmeyer[1]; [1]*Max Born Inst., Germany.* We demonstrate pulse retrieval from dispersion-scan and FROG traces using a genetic algorithm. The algorithm is extremely robust even for complex pulse shapes, resilient to noise, and can reliably compensate for spectral efficiency variations.

STh4N.3 • 17:00 Invited
Ultra-short Optical Pulses for Coherent Ultra-wide Band RF Signal Sampling, Daniel Onori[1], Filippo Scotti[1], Giovanni Serafino[2], Paolo Ghelfi[1], Antonella Bogoni[1,2]; [1]*CNIT, Italy;* [2]*Sant'Anna School of Advanced Studies, Italy.* The importance of ultra-short and stable optical pulses for ultra-wide band RF signal sampling is demonstrated through the implementation and comparison of different solutions of RF scanning receiver based on photonics.

STh4N.4 • 17:30
All-linear Phase Retrieval of a Single-soliton Kerr Comb, Ziyun Kong[1], Chengying Bao[1], Oscar Sandoval[1], Bohao Liu[1], Minghao Qi[1], Andrew M. Weiner[1]; [1]*Purdue Univ., USA.* We demonstrate all-linear phase retrieval of a single-soliton Kerr comb via dual-comb electric field cross-correlation (EFXC). This approach greatly lowers the power needed for ultrafast waveform reconstruction of optical frequency combs.

CLEO: Applications & Technology

16:30–18:30
ATh4O • Novel Spectroscopic Approaches II
Presider: Paul Williams; NIST, USA

ATh4O.1 • 16:30
High-resolution and Large Tunable Range Nanophotonic Spectrometer Using a Microring Resonator, Shaonan Zheng[1,2], Yangyang Chen[3], Hong Cai[2], Yuandong Gu[2], Zhenchun Yang[3], Y. L. Hao[3], D.L. Kwong[2], Aiqun Liu[1]; [1]*Nanyang Technological Univ., Singapore;* [2]*Inst. of Microelectronics, Singapore;* [3]*Peking Univ., China.* An integrated high-resolution on-chip spectrometer with Ge-on-Si photodetector is demonstrated. The robust spectrometer has high resolution, high compactness, low cost and CMOS-compatibility. It has high potential to be used in integrated sensing and spectroscopy systems.

ATh4O.2 • 16:45
High-resolution and Large-bandwidth On-chip Microring Resonator Cavity-enhanced Fourier-transform Spectrometer, Shaonan Zheng[1,2], Yangyang Chen[3], Hong Cai[2], Yuandong Gu[2], Aiqun Liu[1]; [1]*Nanyang Technological Univ., Singapore;* [2]*Agency for Science, Technology and Research (A*STAR), Singapore;* [3]*Peking Univ., China.* A high-resolution (0.47 nm) and large-bandwidth (150 nm) on-chip Fourier-transform spectrometer (FTS) enhanced with a microring resonator (MRR) cavity is demonstrated. It is promising to be applied in applications such as on-chip chemical and biological sensing systems.

ATh4O.3 • 17:00
Self-expanding fabricated bubble resonators used as whispering gallery modes sensors, Hongwen Zhou[1], Jiansheng Liu[1], Meng Zhang[1], Jie Chen[1], Xiaosheng Liu[1], Qing Wu[1], Zheng Zheng[1]; [1]*Beihang Univ., China.* Employing low-cost high borosilicate glass capillaries, self-expanding bubble resonator fabrication method based on air thermal expansion is demonstrated. Detected quality factor Q is as high as 10^5. 54 pm light perturbation mode shift was sensed.

ATh4O.4 • 17:15
A High-resolution Dual-microring-based Silicon Photonic Sensor using Electronic Integrated Circuit, Hui Zhang[1], Muhammad F. Karim[1], Shaonan Zheng[1,2], Hong Cai[2], Yuan Dong Gu[2], Shoushun Chen[1], Hao Yu[3], Ai qun Liu[1]; [1]*School of Electrical and Electronic Engineering, Nanyang Technological Univ., Singapore 639798, Singapore;* [2]*Inst. of Microelectronics, A*STAR, Singapore 117685, Singapore;* [3]*Dept. of Electrical and Electronic Engineering, Southern Univ. of Science and Technology, China 518055, China.* A high-resolution dual-microring based silicon photonic sensor is demonstrated with an electronic integrated circuit. For refractive index sensing in sodium chloride solution, a high sensitivity of 0.153 RIU/W and a detection limit of 0.34 μRIU are achieved.

ATh4O.5 • 17:30
Combined Laser-Induced Breakdown Spectroscopy and MIR Quantum Cascade Laser Reflectance Spectroscopy for Elemental and Molecular Characterization, Francis Vanier[1], Christian Padioleau[1], Mohamad Sabsabi[1], Alain Blouin[1]; [1]*National Research Council Canada, Canada.* We combine laser-based mid-infrared reflectance measurements using tunable quantum cascade lasers and laser-induced breakdown spectroscopy to get both the elemental and molecular compositions of a sample. Results for mineral ore characterization are shown.

CLEO: Applications & Technology

16:30–18:30
ATh4P • Environmental Greenhouse Gas Sensing
Presider: Mark Zondlo; Princeton Univ., USA

ATh4P.1 • 16:30 Invited
Bringing Laser Spectroscopy to the Deep Sea, Anna P. Michel[1]; [1]*WHOI, USA.* By coupling laser-based techniques to gas extraction techniques, gases critical for understanding ocean processes such as methane and carbon dioxide can be measured. Recent advances in oceanographic chemical sensing using laser-based techniques will be presented.

ATh4P.2 • 17:00
Compact Amplitude-Modulated, Phase-Analyzed Spectroscopy (CAMPAS) for Gas Analysis, David Bomse[1]; [1]*Mesa Photonics, LLC, USA.* Optical absorption in gases within an integrating sphere is determined by phase shifts of amplitude modulated laser light. This technique could achieve performance advantages similar to those of FM radio over AM radio.

ATh4P.3 • 17:15
Quantifying methane emissions among simulated gas wells with a dual-frequency comb spectrometer, Sean C. Coburn[1], Caroline Alden[1,2], Robert Wright[1], Esther Baumann[3], Kevin Cossel[3], Nathan R. Newbury[3], Kuldeep Prasad[4], Ian R. Coddington[3], Gregory B. Rieker[1]; [1]*Univ. of Colorado at Boulder, USA;* [2]*CIRES, USA;* [3]*NIST, USA;* [4]*NIST, USA.* We present the results of a single-blind field test assessing the capability of a dual-frequency comb spectrometer coupled with atmospheric inversion methods for detecting and quantifying methane emissions from natural gas production infrastructure.

ATh4P.4 • 17:30 Invited
Recent Advancement in Cavity Ringdown Spectroscopy in Measuring Effects of Natural Gas Industry, Tracy Tsai[1]; [1]*Picarro, USA.* Natural gas is a growing energy source, but to minimize environmental impact and safety risks, the natural gas infrastructure must be monitored for methane emissions. I will present field results collected with a cavity ring-down based spectrometer.

16:30–18:30
ATh4Q • A&T Topical Review on Scientific and Commercial Progress in Semiconductor Laser Technology I
Presider: Bojan Resan; Univ. of Applied Sciences FHNW, Switzerland

ATh4Q.1 • 16:30 Invited
Progress in VECSELs: from Gain Mirror Technology to New Applications, Mircea D. Guina[1,2]; [1]*Tampere Univ. of Technology, Finland;* [2]*VEXLUM Ltd, Finland.* We review recent progress in VECSEL technology in connection to new milestones that continue to pave the way for practical use in emerging applications. We focus on wavelength extension and applications in quantum technology, dermatology, or spectroscopy.

ATh4Q.2 • 17:00 Invited
Commercial Semiconductor Disk Lasers, Nils Hempler[1], David Paboeuf[1], Tiago Ortega[1], Robin Head[1], Walter Lubeigt[1], Gareth Maker[1], Graeme Malcolm[1]; [1]*M Squared Lasers, UK.* This paper will present the development of commercial semiconductor disk lasers undertaken at M Squared Lasers mainly for microscopy and quantum applications.

ATh4Q.3 • 17:30
First demonstration of O-band grating-assisted microcylinder surface-emitting laser, Xiang Ma[1], Quanan Chen[1], Wei Sun[1], Ye Liu[1], Gongyuan Zhao[1], Gonghai Liu[1], Qiaoyin Lu[1], Weihua Guo[1]; [1]*Wuhan National Lab for Optoelectronics, Huazhong Univ. of S && T, China.* Grating-assisted microcylinder surface-emitting laser (GAMSEL) in the O-band was demonstrated. Continuous-wave working with side-mode suppression-ratio >40dB has been realized and the output beam is radially polarized.

CLEO: Science & Innovations

STh4A • Waveguide Structures—Continued

STh4A.6 • 17:45
Large Bandwidth Waveguide Spectral Splitters Using Higher-Order Mode Evolution, Jean-Etienne Tremblay[1], Marcin Malinowski[2], Guillermo Camacho-Gonzalez[2], Sasan Fathpour[2], Ming C. Wu[1]; [1]*Univ. of California, Berkeley, USA;* [2]*CREOL, Univ. of Central Florida, USA.* Broadband spectral filters separating 1μm/2μm wavelengths of octave-spanning frequency combs have been realized using mode evolution to high-order modes. The splitters are fabricated in chalcogenide glass ($Ge_{23}Sb_7S_{70}$) and can be readily integrated with supercontinuum sources.

STh4A.7 • 18:00
Ultra-Broadband and Compact Asymmetrical Beam Splitter Enabled by Angled Sub-Wavelength Grating MMI, Eslam Elfiky[1], Yannick D'Mello[1], Yun Wang[1], Md Ghulam Saber[1], Amar Kumar[1], James Skoric[1], Alireza Samani[1], Luhua Xu[1], Rui Li[1], David Patel[1], David V. Plant[1]; [1]*McGill Univ., Canada.* We present an ultra-broadband and compact asymmetrical beam splitter using subwavelength grating based multi-mode interference coupler. We experimentally demonstrate splitting ratios from 50:50 to 90:10 over 100 nm bandwidth using a 24um x 3um design.

STh4A.8 • 18:15
Arbitrary Ratio, Wavelength-insensitive 2×2 MMI Coupler in SOI with Enhanced Fabrication Tolerance, Jin Zhang[1], Liangshun Han[1], Bill P. Kuo[1], Stojan Radic[1]; [1]*Univ. of California, San Diego, USA.* We present a new arbitrary-ratio 2x2 MMI coupler design. The design demonstrated 2.6 times lower coupling ratio variation across extended C-band, and 2.2 times ratio error reduction when subjected to ±10 nm thickness and width deviations.

STh4B • On-chip and Offchip Coupling Schemes—Continued

STh4B.6 • 17:45
Efficient coupling of ultra-high Q crystalline microresonators to integrated photonic waveguides, Miles H. Anderson[1], Nikolay Pavlov[2,5], John Jost[1], Grigory Lihachev[3,5], Junqiu Liu[1], Tiago Morais[4], Michael Zervas[4], Michael Gorodetsky[3,5], Tobias J. Kippenberg[1]; [1]*Inst. of Physics, Ecole Polytechnique Federale de Lausanne, Switzerland;* [2]*Moscow Inst. of Physics and Technology, Russia;* [3]*Faculty of Physics, M. V. Lomonosov Moscow State Univ., Russia;* [4]*LiGenTec, SA, Switzerland;* [5]*Russian Quantum Center, Russia.* We present a new integrated photonic chip solution for coupling light to ultra-high quality factor (Q) crystalline microresonators, which is in the form of an index-matching suspended silica beam-waveguide. The scheme enables coupled Q-factors exceeding 100 million near critical coupling.

STh4B.7 • 18:00
3D Photonic Structure for Plug-and-Play Fiber to Waveguide Coupling, Oscar Jimenez[1], Mohammad Amin Tadayon[1], You-Chia Chang[1], Michal Lipson[1]; [1]*Columbia Univ., USA.* We show a 3D photonic structure for passive high alignment tolerance fiber to waveguide coupling. We measured a coupling efficiency of 2.5dB+/-0.4dB from fiber to a polymeric waveguide for fiber misalignments within a 17μm diameter.

STh4B.8 • 18:15
Automated Assembly of Duplex Fiber Connectors to Photonic Chips in Standard Microelectronic Tools, Ted Lichoulas[1], Eddie Kimbrell[1], Alexander Janta-Polczynski[2], Elaine Cyr[2], Paul Fortier[2], Nicolas Boyer[2], Tymon Barwicz[3]; [1]*AFL Telecommunications, USA;* [2]*IBM, Canada;* [3]*IBM, USA.* We demonstrate self-aligned assembly of LC-terminated fibers to chips in a manner compatible with standard microelectronics assembly lines. We show -1.5dB peak transmission to chip with 0.9dB penalty over a 100nm bandwidth and all polarization.

Joint

JTh4C • Symposium on Integrated Sources of Non-Classical Light: Perspectives and Challenges II—Continued

JTh4C.4 • 17:45
Unidirectional Frequency Conversion in Silicon-based Double-Ring Microresonator, Mikkel Heuck[1], Yunhong Ding[1], Lars H. Frandsen[1], Jacob G. Koefoed[1], Jesper B. Christensen[1], Karsten Rottwitt[1]; [1]*Dept. of Photonics Engineering, Technical Univ. of Denmark, Denmark.* We experimentally study four-wave-mixing frequency conversion in two coupled silicon ring-resonators. The asymmetric super-mode structure causes highly directional conversion and enables near-unity efficiency which is important for photonic quantum information technology.

JTh4C.5 • 18:00 Invited
Nonlinear Quantum Optics in Si_3N_4 mirco-ring resonators, Sven Ramelow[1]; [1]*Humboldt Universität zu Berlin, Germany.* Si_3N_4 is a promising platform for nonlinear quantum optics. Here, I will summarize experimental results and future perspectives on implementing bright and narrowband entangled photon sources in different wavelengths regimes and realizing strong nonlinear coupling due to induced photon interaction.

18:30–20:00 Emerging Trends in Nonlinear Optics – A Review of CLEO: 2018, *Room 230A*

18:30–20:00 Dinner Break *(on your own)*

20:00–22:00 Postdeadline Paper Sessions, *Location TBD*

Joint

JTh4D • Symposium on Advances in Integrated Microwave Photonics II—Continued

JTh4D .4 • 17:45
Ultra-Compact Optical True Time Delay Lines Featuring Fishbone-Like One-Dimensional Photonic Crystal Waveguide, Chi-Jui Chung[1], Xiaochuan Xu[2], Gencheng Wang[3], Zeyu Pan[1], Ray Chen[1,2]; *[1]Dept. of Electronical and Computer Engineering, Univ. of Texas at Austin, USA; [2]Omega Optics, Inc, USA; [3]College of Information Science and Electronic Engineering and the Cyrus Tang Center for Sensor Materials and Applications,, Zhejiang Univ., China.* An ultra-compact on-chip optical true-time-delay line features the slow light enhanced fishbone-like one-dimensional photonic crystal waveguide is proposed. A delay time of 65 ps/mm which corresponds to group index of 19.47 is observed experimentally.

JTh4D .5 • 18:00 Invited
Plasmonics for RF Photonics, Juerg Leuthold[1], Yannick Salamin[1], Romain Bonjour[1], Arne Josten[1], Benedikt Baeuerle[1], Alexander Dorodny[1], Yuriy Fedoryshyn[1], Ping Ma[1], Delwin Elder[2], Larry R. Dalton[2]; *[1]ETH Zurich, Switzerland; [2]Univ. of Washington, USA.* Plasmonics is a solution to replace active photonics. If properly designed, plasmonic devices offer highly integrated circuits on a micrometer footprint with THz frequency responses. In this talk we will review opportunities for RF plasmonics

CLEO: QELS-Fundamental Science

FTh4E • Multimode Nonlinear Fiber Optics—Continued

FTh4E.5 • 17:45
Optical Trapping and Manipulation of Multiple Microparticles Using SDM Fibers, Joel A. Hernández-García[1], Amado M. Velazquez-Benitez[1], Yanín Guerra-Santillán[2], Raúl Caudillo-Viurquez[2], Jose Enrique Antonio-Lopez[3], Rodrigo Amezcua Correa[3], Juan Hernandez-Cordero[4]; *[1]CCADET-UNAM, Mexico; [2]Facultad de Ciencias, UNAM, Mexico; [3]CREOL, UCF, USA; [4]IIM, UNAM, Mexico.* We demonstrate optical trapping and dynamic manipulation of microparticles using multicore and few-mode fibers. Tuning of the input state of polarization of the trapping beam allows for particle rotation and adjustable trapping distances.

FTh4E.6 • 18:00
Analysis of Parametric Instabilities in Parabolic Multimode Fibers under High Intensity Conditions, Helena E. Lopez Aviles[1], Fan Wu[1], Zeinab Sanjabi Eznaveh[1], Mohammad Amin Eftekhar[1], Frank W. Wise[2], Rodrigo Amezcua Correa[1], Demetrios N. Christodoulides[1]; *[1]Univ. of Central Florida, USA; [2]School of Applied and Engineering Physics, Cornell Univ., USA.* We systematically study geometric parametric instabilities in parabolic multimode fibers. We show, both analytically and experimentally, that global dispersion processes and self-focusing effects can substantially affect the spectral positions and widths of the generated sidebands.

FTh4E.7 • 18:15
Mode-Resolved Control and Measurement of Nonlinear Pulse Propagation in Multimode Fibers, Zimu Zhu[1], Logan Wright[1], Joel Carpenter[2], Dan Nolan[3], Ming-Jun Li[3], Demetrios N. Christodoulides[4], Frank W. Wise[1]; *[1]Cornell Univ., USA; [2]The Univ. of Queensland, Australia; [3]Corning Incorporated, USA; [4]Univ. of Central Florida, USA.* We demonstrate use of spatial light modulators to control modal excitation and make mode-resolved measurements of nonlinear pulse propagation in multimode fiber, and present a representative experiment wherein we observe discrete Raman beam clean-up.

CLEO: Science & Innovations

STh4F • Optical Parametric Oscillators—Continued

STh4F.5 • 17:45
Femtosecond mid-IR difference-frequency generation in $BaGa_2GeSe_6$ from a 40 MHz optical parametric oscillator pumped at 1035 nm, Gero Stibenz[2], Marcus Beutler[2], Ingo Rimke[2], Valeriy Badikov[3], Dmitrii Badikov[3], Valentin Petrov[1]; *[1]Max Born Inst., Germany; [2]APE, Germany; [3]Kuban State Univ., Russia.* Mixing the signal and idler pulses near 2 µm from a femtosecond synchronously-pumped optical parametric oscillator in a $BaGa_2GeSe_6$ crystal we generate mid-IR pulses tunable up to 10 µm with 45% maximum internal quantum efficiency.

STh4F.6 • 18:00
Pulsed Optical Parametric Generation and Oscillation in Orientation-Patterned Gallium Phosphide, Hanyu Ye[1], Chaitanya Kumar Suddapalli[2], Junxiong Wei[1], Peter G. Schunemann[3], Majid Ebrahim-Zadeh[1,4]; *[1]ICFO-Institut de Ciencies Fotoniques, Spain; [2]Radiantis, Spain; [3]BAE Systems, Incorporated, USA; [4]Institucio Catalana de Recerca i Estudis Avancats (ICREA), Spain.* We report a Nd:YAG-laser-pumped pulsed OPG/OPO based on OP-GaP. The OPG and singly-resonant OPO spanning 2.8 µm-3.1 µm provide up to ~2 mW and ~20 mW idler power, respectively. Crystal thermal effects are also investigated.

STh4F.7 • 18:15
Critically Phase-Matched Deep-Infrared Femtosecond Optical Parametric Oscillator Based on $CdSiP_2$, Callum F. O'Donnell[1,2], Chaitanya Kumar Suddapalli[1], Kevin Zawilski[3], Peter G. Schunemann[3], M. Ebrahim-Zadeh[2]; *[1]Radiantis, Spain; [2]ICFO - Institut de Ciencies Fotoniques, Spain; [3]BAE Systems, USA.* We report a femtosecond optical parametric oscillator across 6654–8329 nm based on critically phase-matched $CdSiP_2$. Directly pumping with a Ti:sapphire laser, we generate 19 mW of average power in ~300-fs pulses at 80.5 MHz.

18:30–20:00 Emerging Trends in Nonlinear Optics – A Review of CLEO: 2018, *Room 230A*

18:30–20:00 Dinner Break *(on your own)*

20:00–22:00 Postdeadline Paper Sessions, *Location TBD*

CLEO: QELS-Fundamental Science

FTh4G • Cats and Kets—Continued

FTh4G.6 • 18:00
Generation of Schrodinger's cat state in an optical double sideband mode, Takahiro Serikawa[1], Jun-ichi Yoshikawa[1], Hidehiro Yonezawa[2], Timothy Ralph[3], Elanor Huntington[4]; [1]*Univ. of Tokyo, Japan;* [2]*The Univ. of New South Wales, Australia;* [3]*Univ. of Queensland, Australia;* [4]*Australian National Univ., Australia.* An optical Schrodinger's cat state is generated in 500.6MHz double sideband mode of continuous wave light. We used phase modulation to selectively subtract a photon from sideband. The reconstructed Wigner function exhibits a significant negativity of -0.088 without any correction.

FTh4G.7 • 18:15
Amplifying Schrödinger cat state with an optical parametric amplifier, Meihong Wang[1], Zhongzhong Qin[1], Miao Zhang[1], Li Zeng[1], Xiaolong Su[1], Changde Xie[1], Kunchi Peng[1]; [1]*Shanxi Univ., China*. We experimentally demonstrate the deterministic amplification of an optical Schrödinger cat state by an optical parametric amplifier. The results provide an efficient way to amplify the amplitude of an optical cat state.

FTh4H • Nanophotonic Emitters, Detectors and Modulators—Continued

FTh4H.5 • 18:00
Circularly Polarized Light Detection Based on Efficient Chip-Integrated Metasurface, Ali Basiri[1,2], Xiahui Chen[1,2], Pouya Amrollahi[3], Jing Bai[1,2], Chao Wang[1,4], Yu Yao[1,2]; [1]*School of Electrical, Computer and Energy Engineering, Arizona State Univ., USA;* [2]*The Center for Photonics Innovation, Arizona State Univ., USA;* [3]*School for Engineering of Matter, Transport & Energy, Arizona State Univ., USA;* [4]*Biodesign Center for Molecular Design & Biomimetics, Arizona State Univ., USA.* We report a hybrid metal-dielectric metasurface to realize on-chip detection of circularly polarized light at telecommunication wavelengths. Preliminary experimental results show extinction ratios close to 10 dB and efficiencies up to 90% at designed wavelengths.

FTh4H.6 • 18:15
Extraordinary Properties of Epsilon-Near-Zero and Low-Index Chalcogenide Metamaterials, Davide Piccinotti[1], Behrad Gholipour[1], Jin Yao[1], Kevin F. MacDonald[1], Brian E. Hayden[1], Nikolay I. Zheludev[1,2]; [1]*Univ. of Southampton, UK;* [2]*Nanyang Technological Univ., Singapore.* 'Laminar flow' transmission, suppression of plasmonic powerflow vortices, and absorption decreasing with increasing Joule losses can be observed in metamaterials combining plasmonic nanostructures with chalcogenide inclusions exhibiting epsilon-near-zero and sub-unitary refractive index behaviors.

CLEO: Science & Innovations

STh4I • Mid-IR Optoelectronics—Continued

STh4I.5 • 17:45
Quantum Dot Quantum Cascade Detector on Si Substrate, Jian Huang[1], Daqian Guo[2], Deng Zhuo[1], Wei Chen[1], Tinghui Wu[1], Yaojiang Chen[1], Huiyun Liu[2], Jiang Wu[2], Baile Chen[1]; [1]*SIST, ShanghaiTech Univ., China;* [2]*Dept. of Electronic and Electrical Engineering, Univ. College London, UK.* We demonstrate a quantum cascade detector monolithic grown on Si substrate for mid infrared application. Sub-monolayer dots were used as absorption region for normal incidence light detection around 6μm.

STh4I.6 • 18:00
Low-Threshold Lasing in Strained Germanium under Optical Pumping, Donguk Nam[1,4], Shuyu Bao[1], Daeik Kim[4], Chibuzo Onwukaeme[4], Shashank Gupta[2], Krishna Saraswat[2], Kwang Hong Lee[3], Yeji Kim[4], Dabin Min[4], Yongduck Jung[4], Haodong Qiu[1], Hong Wang[1], Eugene Fitzgerald[3], Chuan Seng Tan[1]; [1]*Nanyang Technological Univ., Singapore;* [2]*Stanford Univ., USA;* [3]*Singapore-MIT Alliance for Research and Technology (SMART), Singapore;* [4]*Inha Univ., South Korea.* We report the first experimental observation of low-threshold lasing in strained germanium nanowires. The lasing threshold is ~3.0 kW cm^{-2} which is more than one order of magnitude lower than the state-of-the-art germanium-tin Fabry-Perot laser.

18:30–20:00 Emerging Trends in Nonlinear Optics – A Review of CLEO: 2018, *Room 230A*

18:30–20:00 Dinner Break *(on your own)*

20:00–22:00 Postdeadline Paper Sessions, *Location TBD*

CLEO: QELS-Fundamental Science

FTh4J • Random and Alternative Materials Metasurfaces—Continued

FTh4J.6 • 17:45
Mid-infrared Magnetic Mirror Based on a Hybrid Metal/Dielectric Metasurface, Ming Ye[1], Shiqiang Li[1], Yang Gao[1], Vivek R. Shrestha[1], Kenneth B. Crozier[1]; [1]*The Univ. of Melbourne, Australia.* We propose a hybrid metal/dielectric metasurface that functions as a mid-infrared magnetic mirror. It consists amorphous silicon cuboids on gold. The physical mechanism is explained by image theory. Measured reflection spectra agree with simulations.

FTh4J.7 • 18:00
Towards Random Metasurface based Devices, Matthieu Dupre[1], Junhee Park[1], Liyi Hsu[1], Abdoulaye Ndao[1], Boubacar Kante[1]; [1]*UCSD, USA.* Using full wave simulations and a transmission matrix approach, we design and then realize random metasurface lenses with anisotropic nanorods, and show that we can obtain a diffraction limited focal spot for all polarizations.

FTh4J.8 • 18:15
Disordered Geometric Phase: Photonic Transition from Spin Hall to Random Rashba Effect, Elhanan Maguid[1], Michael Yannai[1], Arkady Faerman[1], Igor Yulevich[1], Vladimir Kleiner[1], Erez . Hasman[1]; [1]*Technion-Israel Inst. of Technology, Israel.* We report on photonic spin-symmetry breaking and unexpected optical transport phenomena arising from disordered geometric phase structures. Weak disorder induces a photonic spin Hall effect, whereas strong disorder leads to a random Rashba effect.

CLEO: Science & Innovations

STh4K • Long Wavelength Fiber Sources—Continued

STh4K.5 • 17:45
Generation of sub-100 fs pulses tunable from 1.8 to 2.0 µm from an All-fiber, All-PM Source Pumped at 1560 nm, Grzegorz J. Sobon[1], Tadeusz Martynkien[3], Karol Tarnowski[3], Pawel Mergo[2], Jaroslaw Sotor[1]; [1]*Faculty of Electronics, Wroclaw Univ. of Science and Technology, Poland;* [2]*Maria Curie-Sklodowska Univ., Poland;* [3]*Faculty of Fundamental Problems of Technology,, Wroclaw Univ. of Science and Technology, Poland.* An all-fiber, all-PM source of widely tunable (1800 – 2000 nm) ultrashort pulses seeded by an Er-doped fiber laser is presented. The system delivers sub-100 fs pulses with 400 mW average power and >8 nJ energy.

STh4K.6 • 18:00
Dual Comb Spectroscopy with a Free-Running Bi-Directional Mode-Locked Thulium FIber Laser, Joshua Olson[1], Yi-Hsin Ou[1], Ali Azarm[1], Khanh Q. Kieu[1]; [1]*Univ. of Arizona, USA.* We present a Thulium fiber laser mode-locked bi-directionally with a carbon nanotube saturable absorber and demonstrate single-shot dual-comb spectroscopy of H_2O in the short-wave infrared (SWIR) with the laser.

STh4K.7 • 18:15
15 GHz actively mode-locked fiber laser at 2 micron, Jiarong Qin[1], Ruihong Dai[1], Yafei Meng[1], Wenbin Gao[1], Yongbing Xu[1], Yao Li[1], Shining Zhu[1], Frank (Fengqiu) Wang[1]; [1]*Nanjing Univ., China.* We demonstrate a 15-GHz actively-mode-locked thulium fiber laser. The repetition-rate is improved by one order of magnitude compared with existing results and such a source can be used for 2 µm optical data-communication and processing.

STh4L • Optical Sensing in Combustion—Continued

Marcus Aldén is professor/Head of the Division of Combustion Physics at Lund University and Program director of the Swedish Centre in Combustion Science and Technology. Prof. Aldén has co-authored 395 papers and is a member of the Royal Swedish Academy of Engineering Sciences and the Royal Swedish Academy of Sciences.

18:30–20:00 Emerging Trends in Nonlinear Optics – A Review of CLEO: 2018, *Room 230A*

18:30–20:00 Dinner Break *(on your own)*

20:00–22:00 Postdeadline Paper Sessions, *Location TBD*

CLEO: QELS-Fundamental Science

FTh4M • Functional Nanophotonics Using Metasurfaces—Continued

FTh4M.5 • 17:45
Magnetic Plasmon Hybridization in Vertically Stacked Double-gap Nanocavities, Seied Ali Safiabadi Tali[1], Wei Zhou[1]; [1]*Virginia Tech, USA*. In vertically stacked double-gap nanocavities, the strong magnetic-optical interaction between magnetic plasmon modes in individual gap nanocavities can lead to new hybridized bonding and antibonding modes with a tunable splitting energy.

FTh4M.6 • 18:00
Perovskite Nanostructures and Metasurfaces Enhanced by Mie Resonances, Sergey Makarov[1], Ekaterina Tiguntseva[1], Anvar Zakhidov[3,1], Yuri S. Kivshar[2,1]; [1]*ITMO Univ., Russia;* [2]*Australian National Univ., Australia;* [3]*Univ. of Texas at Dallas, USA*. We study resonant properties of nanoantennas and nanostructured metasurfaces made of halide perovskites and demonstrate experimentally the photoluminescence enhancement near the dipolar and multipolar Mie resonances for both visible and near-infrared frequency ranges.

FTh4M.7 • 18:15
Bifunctional Gap-Plasmon Metasurfaces for Visible Light, Fei Ding[1], Rucha Deshpande[1], Sergey I. Bozhevolnyi[1]; [1]*Univ. of Southern Denmark, Denmark*. We design, fabricate and experimentally demonstrate bifunctional gap-plasmon metasurfaces for visible light, allowing simultaneous polarization-controlled unidirectional surface plasmon polariton (SPP) excitation and beam steering at normal incidence.

CLEO: Science & Innovations

STh4N • Ultrafast Metrology II—Continued

STh4N.5 • 17:45
Cross-spectrum approach for absolute timing jitter measurement of mode-locked lasers, Alexis Casanova[1,2], Benoit Tropheme[1], Antoine Courjaud[1], Giorgio Santarelli[2]; [1]*Amplitude Systemes, France;* [2]*Université de Bordeaux, France*. A combination of cross-spectral analysis and balanced optical cross-correlation techniques is proposed to access the absolute timing jitter of one laser mode-locked solid-state laser. This method gives a record jitter detection floor.

STh4N.6 • 18:00
Waveform characterization of optical pulses by plasma luminescence of gas, Nariyuki Saito[1], Nobuhisa Ishii[1], Teruto Kanai[1], Jiro Itatani[1]; [1]*Univ. of Tokyo, Japan*. We propose and demonstrate a new all-optical method to characterize an optical waveform using plasma luminescence of gas. Our technique is based on simple physics, and applicable to compact pulse diagnostics and petahertz time-domain spectroscopy.

STh4N.7 • 18:15
Intrapulse Coherence for Gauging the Quality of Passive Carrier-Envelope Phase Stabilization, Gunter Steinmeyer[1]; [1]*Max Born Inst., Germany*. The intrapulse coherence is introduced as a measure for judging a fixed phase relation between different spectral components within a laser pulse. This new criterion plays an important role for passive CEP stabilization of OPA systems.

CLEO: Applications & Technology

ATh4O • Novel Spectroscopic Approaches II—Continued

ATh4O.6 • 17:45
Identification of white powder samples using broadband coherent light in the molecular fingerprint region, Luke Maidment[1], Richard A. McCracken[1], Oguzhan Kara[1], Peter G. Schunemann[2], Derryck T. Reid[1]; [1]*Heriot-Watt Univ., UK;* [2]*BAE Systems, USA*. Stand-off Fourier-transform spectroscopy of eleven white powder samples illuminated by a broadband femtosecond source was used to construct a library of spectra, which are demonstrated to enable automated chemical detection using a simple correlation algorithm.

ATh4O.7 • 18:00
Edible Oils Sensing Setup Based on a Core-Offset Mach-Zehnder Interferometer With Single Mode Fiber, Leidy J. Cuchimaque Lugo[1], Rafael Castro-López[2], Maria E. Sosa Morales[2], Juan M. Sierra Hernandez[1], Julian M. Estudillo Ayala[1], Daniel Jauregui[1], Juan Hernandez Garcia[1], Roberto Rojas Laguna[1]; [1]*Departamento de Ingeniería Electrónica, División de Ingenierías, Campus Irapuato-Salamanca, Universidad de Guanajuato, Comunidad de Palo Blanco, Salamanca, Gto., C.P. 36885, México., Mexico;* [2]*Departamento de Alimentos, División de Ciencias de la Vida, Campus Irapuato-Salamanca, Universidad de Guanajuato, Carretera Irapuato-Silao km 9, Irapuato, Gto. 36500 México., Mexico*. Peroxides are compounds related to rancidity in oils. A peroxides index sensing setup based on a Mach-Zehnder interferometer is presented. The output power spectrum shift occurs from 1490 to1580 [nm] with sensitivity of 0.88 [nm/meq/kg].

ATh4O.8 • 18:15
Alpha Radiation Induced Luminescence in Solar Blind Spectral Region, Thomas H. Kerst[1,2], Juha Toivonen[1]; [1]*Tampere Univ. of Technology, Finland;* [2]*Helsinki Inst. of Physics, Finland*. Intense luminescence in the solar blind spectral region is produced by modifying the gas atmosphere around an alpha emitter. This enables standoff detection of alpha radiation under daylight conditions.

18:30–20:00 Emerging Trends in Nonlinear Optics – A Review of CLEO: 2018, *Room 230A*

18:30–20:00 Dinner Break *(on your own)*

20:00–22:00 Postdeadline Paper Sessions, *Location TBD*

CLEO: Applications & Technology

ATh4P • Environmental Greenhouse Gas Sensing—Continued

ATh4P.5 • 18:00
Effect of tuning characteristics of continuous wave quantum cascade laser on detection of CH_4 and N_2O in mid-IR region, May Hlaing[1,2], Mohammad A. Khan[1]; [1]*Delaware State Univ., USA;* [2]*Optical Science Center for Applied Research, USA.* We report studies of tuning characteristics and modulation properties of a distributed feedback continuous wave quantum cascade laser centered at 7.83 μm in detection of mid-IR line transitions of methane, nitrous-oxide and water-vapor.

ATh4P.6 • 18:15
Mid-infrared Photonic Chips for Real-time Gas Mixture Analysis, Pao T. Lin[1]; [1]*Texas A&M Univ., USA.* Real-time gas analysis on-a-chip was demonstrated using a mid-infrared microcavity. Optical apertures were made of ultrathin membranes using the CMOS process. CH4, CO2, and N2O were selected as analytes due to their strong absorption bands at λ = 3.25 - 3.50 μm, 4.20 - 4.35 μm.

ATh4Q • A&T Topical Review on Scientific and Commercial Progress in Semiconductor Laser Technology I—Continued

ATh4Q.4 • 17:45
Far field control of large-area surface-emitting photonic crystal quantum cascade laser, Yong Liang[1], Zhixin Wang[1], Johanna Wolf[1], Emilio Gini[1], Mattias Beck[1], Jérôme Faist[1]; [1]*ETH Zurich, Switzerland.* Large-area single-mode lasing is demonstrated within surface-emitting photonic-crystal quantum cascade lasers, at room temperature, with narrow divergence (<1°) and 175 mW peak power. Single-lobed far-field is realized by optimizing the pillar shape.

ATh4Q.5 • 18:00
Frequency Comb Formation Over the Entire Lasing Range of Quantum Cascade Lasers, Yang Yang[1], David Burghoff[1], John Reno[2], Qing Hu[1]; [1]*MIT, USA;* [2]*Sandia National Labs, USA.* By incorporating a two-section geometry featuring an electrically tunable dispersion compensator, we demonstrate terahertz quantum cascade lasers exhibiting comb operation from I_{th} to I_{max}, covering the entire bias range of lasing.

ATh4Q.6 • 18:15
Direct Measurement of the Phase Coherence of Quantum Cascade Comb Sources, Saverio Bartalini[1,2], Luigi Consolino[1], Francesco Cappelli[1], Giulio Campo[1], Iacopo Galli[1,2], Davide Mazzotti[1,2], Pablo Cancio[1,2], Giacomo Scalari[3], Jérôme Faist[3], Paolo De Natale[1,2]; [1]*CNR-INO, Italy;* [2]*ppqSense Srl, Italy;* [3]*Inst. for Quantum Electronics, ETH Zürich, Switzerland.* Thanks to a novel method for directly and simultaneously measuring the instantaneous phases of the modes of mid-infrared and THz quantum cascade lasers combs, the phase coherence of these sources is presented and discussed.

18:30–20:00 Emerging Trends in Nonlinear Optics – A Review of CLEO: 2018, *Room 230A*

18:30–20:00 Dinner Break *(on your own)*

20:00–22:00 Postdeadline Paper Sessions, *Location TBD*

07:30–15:30 Registration, *Concourse Level*

Executive Ballroom 210A

CLEO: Science & Innovations

08:00–10:00
SF1A • Si Photonics
Presider: Qiang Lin; Univ. of Rochester, USA

SF1A.1 • 08:00
High-resolution on-chip digital Fourier transform spectroscopy, Derek Kita[1], Brando Miranda[1], David Favela[1], David Bono[1], Jérôme Michon[1], Hongtao Lin[1], Tian Gu[1], Juejun Hu[1]; [1]*MIT, USA*. We experimentally demonstrate a high-resolution, on-chip digital Fourier transform (dFT) spectrometer using a reconfigurable Mach-Zehnder interferometer. The dFT architecture claims the multiplex advantage for signal enhancement, with a resolution that scales exponentially with device footprint.

SF1A.2 • 08:15
Silicon Linear Optical Logic Gates for Low-Latency Computing, Shota Kita[1,2], Kengo Nozaki[1,2], Kenta Takata[1,2], Akihiko Shinya[1,2], Masaya Notomi[1]; [1]*NTT Nanophotonics Center, Nippon Telegraph & Telephone Corp, Japan;* [2]*NTT Basic Research Labs., Nippon Telegraph and Telephone corp., Japan*. We demonstrate 3 μm-long linear optical logic gates with a bias input. The binary contrasts of AND/NOR operations can be 9.5 dB without signal attenuation. This may open up a new boundary for ultralow-latency computing.

SF1A.3 • 08:30
Microdisk-Based Full Adders for Optical Computing in Silicon Photonics, Zhoufeng Ying[1], Zheng Wang[1], Zheng Zhao[1], Shounak Dhar[1], David Pan[1], Richard Soref[2], Ray Chen[1]; [1]*The Univ. of Texas at Austin, USA;* [2]*Univ. of Massachusetts Boston, USA*. We experimentally demonstrate a two-bit thermal-optic ripple-carry full adder based on microdisk resonators in silicon photonics with the advantages of large bandwidth, low power consumption, and high scalability, paving the way to future optical computing.

Executive Ballroom 210B

CLEO: QELS-Fundamental Science

08:00–10:00
FF1B • Quantum Enhanced Measurements
Presider: Raphael Pooser; Oak Ridge National Lab, USA

FF1B.1 • 08:00
Resolution-enhanced imaging with quantum correlations, Ermes Toninelli[1], Paul-Antoine Moreau[1], Adam Mihalyi[1], Thomas Gregory[1], Matthew Edgar[1], Miles Padgett[1]; [1]*The Univ. of Glasgow, UK*. The resolution of optical systems is limited by diffraction. We exploit the spatial properties of correlated photon-pairs to reconstruct a super-resolved image made of bisectant pixel-coordinates, achieving 40% of the theoretical √2 optical resolution enhancement.

FF1B.2 • 08:15
Imaging incoherent point sources with quantum-inspired measurements, Kent Fisher[1], Hugo Ferretti[1], Edwin (Weng-Kian) Tham[1], Aephraim M. Steinberg[1,2]; [1]*Physics, Univ. of Toronto, Canada;* [2]*Canadian Inst. for Advanced Research, Canada*. We present straightforward measurements, involving only π-phase shifts and single-mode fiber coupling, to estimate the separation and relative intensities of two incoherent point sources. We show Monte Carlo results demonstrating an advantage over direct imaging.

FF1B.3 • 08:30
Super-Resolution Localization and Readout of Individual Solid State Qubits, Eric A. Bersin[1], Michael Walsh[1], Sara L. Mouradian[1], Matthew Trusheim[1], Tim Schröder[2], Dirk Englund[1]; [1]*MIT, USA;* [2]*Niels Bohr Inst., Denmark*. We demonstrate super-resolution imaging and readout of solid state defect centers. Multiple nitrogen vacancy centers within 130 nm are resolved. Simultaneous control sequences are performed to demonstrate protection of nearby NV states during readout.

Executive Ballroom 210C

Joint

08:00–10:00
JF1C • Symposium on Lasers in Accelerator Science and Technology I
Presider: Sergio Carbajo; Stanford University and SLAC National Accelerator Laboratory, US

JF1C.1 • 08:00 Invited
Photonics-based Laser-driven Particle Acceleration: from proof-of-concept structures to the accelerator on a chip, Peter Hommelhoff[1]; [1]*Physics Dept., Friedrich Alexander Univ. Erlangen-Nurnberg, Germany.* Demonstrating a photonics-based particle accelerator is the goal of the "Accelerator on a Chip International Collaboration" (ACHIP). Half way into the program, the current status is discussed.

JF1C.2 • 08:30 Invited
X-ray laser based on Inverse Compton Scattering, William Graves[1]; [1]*Arizona State Univ., USA*. A compact XFEL based on inverse Compton scattering is described. A novel method allows coherent control of the phase, bandwidth, and pulse length of the x-ray pulses, and enables multi-color experiments with precisely tunable femtosecond delays.

Executive Ballroom 210D

CLEO: QELS-Fundamental Science

08:00–10:00
FF1D • Ultrafast Spectroscopy of 2D Materials
Presider: Jigang Wang; Iowa State Univ., USA

FF1D.1 • 08:00
Spectroscopic signature of chiral phonons in 2D materials, Hanyu Zhu[1], Jun Yi[1], Ming-Yang Li[2], Jun Xiao[1], Lifa Zhang[3], Chih-Wen Yang[2], Yuan Wang[1,4], Robert Kaindl[4], Lain-Jong Li[2], Xiang Zhang[1,4]; [1]*Univ. of California Berkeley, USA;* [2]*King Abdullah Univ. of Science and Technology, Saudi Arabia;* [3]*Nanjing Normal Univ., China;* [4]*Lawrence Berkeley National Lab, USA*. The chiral phonons at the corners of the Brillouin zone in inversion asymmetric 2D atomic lattices were revealed by the circular-polarization selection rules and the spectrum of the indirect intervalence band transition.

FF1D.2 • 08:15
Homogeneous Linewidth of Encapsulated $MoSe_2$ Monolayer Revealed using Multi-dimensional Coherent Spectroscopy, Eric Martin[1], Jason Horng[1], Hanna G. Ruth[1], Eunice Paik[1], Michael-Henr Wentzel[1], Hui Deng[1], Steven T. Cundiff[1]; [1]*Dept. of Physics, Univ. of Michigan, USA*. We use a collinear multidimensional coherent spectroscopic technique to measure van der Waals structures with a nearly diffraction-limited spot size. Encapsulation by boron nitride narrows both the homogeneous and inhomogeneous linewidths of $MoSe_2$.

FF1D.3 • 08:30
Intrinsic Homogeneous Linewidth of Trions in Monolayer $MoSe_2$, Michael Titze[1], Bo Li[2], Pulickel Ajayan[2,3], Hebin Li[1]; [1]*Florida International Univ., USA;* [2]*Dept. of Materials Science and NanoEngineering, Rice Univ., USA;* [3]*Dept. of Chemistry, Rice Univ., USA*. We have measured the intrinsic homogeneous linewidth of trions in monolayer MoSe 2 using two-dimensional spectroscopy. The linewidth is 3.60 meV, corresponding to a decoherence time of 182 fs.

07:30–15:30 Registration, *Concourse Level*

Executive Ballroom 210E

CLEO: QELS-Fundamental Science

08:00–10:00
FF1E • THz Generation and Novel Phenomena
Presider: Mona Jarrahi; Univ. of California Los Angeles, USA

FF1E.1 • 08:00
Silicon nitride-based deep sub-λ slit for ultra-broadband THz coherent detection, Alessandro Tomasino[1,2], Riccardo Piccoli[1], Yoann Jestin[1], Alessandro Busacca[2], Sebastien Delprat[1], Mohamed Chaker[1], Marco Peccianti[3], Matteo Clerici[4], Luca Razzari[1], Roberto Morandotti[1,5]; *[1]INRS-EMT, Canada; [2]DEIM, Univ. of Palermo, Italy; [3]Dept. of Physics and Astronomy, Univ. of Sussex, UK; [4]School of Engineering, Univ. of Glasgow, UK; [5]National Research Univ. of Information Technologies, Russia*. We report on the characterization of a new type of CMOS-compatible device for terahertz solid-state biased coherent detection, which relies on a 1-µm-wide metallic slit embedded in a thin film of PECVD-grown silicon nitride.

FF1E.2 • 08:15
Observation of Strong THz Fields from Mid-Infrared Two-Color Laser Filaments, Anastasios D. Koulouklidis[1,2], Claudia Gollner[3], Valentina Shumakova[3], Vladimir Fedorov[2,4], Audrius Pugzlys[3,5], Andrius Baltuska[3,5], Stylianos Tzortzakis[1,2]; *[1]Inst. of Electronic Structure and Laser (IESL), Foundation for Research and Technology/Hellas (FORTH), Greece; [2]Science Program, Texas A&M Univ. at Qatar, Qatar; [3]Photonics Inst., TU Wien, Austria; [4]P. N. Lebedev Physical Inst. of the Russian Academy of Sciences, Russia; [5]Center for Physical Sciences & Technology, Lithuania*. We demonstrate, strong THz emission from two-color mid-infrared (3.9 µm) femtosecond laser filaments. The conversion efficiency approaches the percent level, at least one order of magnitude higher than the previously reported for plasma-based THz sources.

FF1E.3 • 08:30
Towards Millijoule Narrowband Terahertz Pulses Using the Chirp-and-Delay Technique, Spencer W. Jolly[1,2], Frederike Ahr[3,4], Nicholas H. Matlis[3], Vincent Leroux[1,2], Timo Eichner[1], Koustuban Ravi[5], Hideki Ishizuki[6], Takunori Taira[6], Franz X. Kaertner[3,4], Andreas R. Maier[1]; *[1]CFEL and Univ. of Hamburg, Germany; [2]ELI - Beamlines, Czechia; [3]DESY and CFEL, Germany; [4]Dept. of Physics, Univ. of Hamburg, Germany; [5]RLE, MIT, USA; [6]Laser Research Center, Inst. for Molecular Sciences, Japan*. We show generation of THz pulses of combined energy above 0.5 mJ at 0.361 THz using the chirp-and-delay technique.

Executive Ballroom 210F

08:00–10:00
FF1F • Spatial and Temporal Control of Light Using Metasurfaces
Presider: Martti Kauranen; Tampere University of Technology, Finland

FF1F.1 • 08:00
Femtosecond Pulse Shaping by Metasurfaces, Shawn Divitt[1,2], Wenqi Zhu[1,2], Cheng Zhang[1,2], Henri Lezec[2], Amit K. Agrawal[1,2]; *[1]Univ. of Maryland College Park, USA; [2]National Inst. of Standards and Technology, USA*. Metasurfaces provide extremely fine spatial control over the amplitude and phase of incident light. Here, we demonstrate shaping of <15 femtosecond ultrafast laser pulses using a metasurface as a spectral phase mask.

FF1F.2 • 08:30
A Photonic Crystal Slab Laplace Differentiator, Cheng Guo[1], Meng Xiao[1], Momchil Minkov[1], Yu Shi[1], Shanhui Fan[1]; *[1]Stanford Univ., USA*. We propose an implementation of a Laplace differentiator based on a photonic crystal slab that operates at transmission mode. Such a device may facilitate nanophotonics-based optical analog computing for image processing.

Executive Ballroom 210G

CLEO: Science & Innovations

08:00–10:00
SF1G • Surface Emitting Lasers
Presider: Eric Tournie; Univ. of Montpellier, France

SF1G.1 • 08:00
Photonic crystal diode laser arrays integrated with a phase shifter designed for narrow far-field angle, Xuyan Zhou[1], Xiaolong Ma[1], Shaoyu Zhao[1], Hongwei Qu[1], Aiyi Qi[1], Wanhua Zheng[1]; *[1]Inst. of Semiconductors,CAS, China*. Edge-emitting photonic crystal laser arrays integrated with a phase-shifter are investigated to obtain narrow far field in lateral and vertical directions. More than 500 mW/facet continuous-wave power, FWHM of 1.5°×12°, and single-lobe pattern are achieved.

SF1G.2 • 08:15
Ultrafast Quantum Dot VECSELs: Record Performance Depending on Growth Techniques, Cesare Alfieri[1], Dominik Waldburger[1], Jacob Nürnberg[1], Matthias Golling[1], Ursula Keller[1]; *[1]ETH, Switzerland*. We present the extended potentialities of quantum dots (QDs) as active media for semiconductor disk lasers. Self-assembled QDs efficiently reach the shortest sub-200-fs pulses, while submonolayer QDs deliver record output powers in continuous wave operation.

SF1G.3 • 08:30
10 W High-Power and High-Beam-Quality Pulsed Operation of Double-Hole Photonic-Crystal Surface-Emitting Lasers, Masahiro Yoshida[1], Menaka D. Zoysa[1], Kenji ishizaki[1], Yoshinori Tanaka[1], Ranko Hatsuda[1], Masato Kawasaki[1,3], Bong-Shik Song[1,2], Susumu Noda[1]; *[1]Kyoto Univ., Japan; [2]Sungkyunkwan Univ., South Korea; [3]Mitsubishi Electric Corporation, Japan*. We develop high-power, high-beam-quality photonic-crystal lasers with double-hole structures. We demonstrate broad-area coherent lasing in a circular region with a 500 µm diameter, and 10 W peak powers with very narrow far-field angles (< 0.3°).

Executive Ballroom 210H

CLEO: QELS-Fundamental Science

08:00–10:00
FF1H • Nanophotonic Strategies for Controlling Light-Matter Interaction
Presider: Haim Suchowski; Tel Aviv Univ., Israel

FF1H.1 • 08:00 Invited
New All-optical and Plasmonic Strategies for Controlling Light on a Silicon Chip, Otto L. Muskens[1], Bigeng Chen[1], Nicholas Dinsdale[1], Roman Bruck[1], David J. Thomson[1], Goran Mashanovich[1], Graham T. Reed[1], Kevin Vynck[2], Philippe Lalanne[2]; *[1]Univ. of Southampton, UK; [2]LP2N, Institut Optique d'Aquitaine, France*. We explore the integration of nanophotonic and plasmonic concepts with the silicon photonics platform. I will present hybrid plasmonic antennas on a silicon ring resonator and all-optical wavefront shaping in a multimode device.

FF1H.2 • 08:30
Beamed Light Emission near a Gradient Metasurfaces, Xiaowei Wang[1], Leonard Kogos[1], Reyhaneh Toufanian[1], Allison Dennis[1], Roberto Paiella[1]; *[1]Boston Univ., USA*. We investigate the ability of gradient metasurfaces to induce the selective emission of light with prescribed far-field properties from nearby sources. With this approach, we demonstrate off-axis unidirectional beaming of quantum-dot luminescence.

07:30–15:30 Registration, *Concourse Level*

Meeting Room 211 B/D	Meeting Room 212 A/C	Meeting Room 212 B/D	Marriott Salon III
CLEO: Science & Innovations			CLEO: Applications & Technology

08:00–10:00
SF1I • Perovskites and Organics
Presider: Thomas Murphy; Univ. of Maryland at College Park, USA

SF1I.1 • 08:00 Invited
Toward Hybrid Organic-Inorganic Perovskite Diode Lasers, Noel C. Giebink[1]; [1]*Pennsylvania State Univ., USA.* Hybrid organic-inorganic perovskites represent a promising, wavelength-tunable materials platform for a future diode laser. This talk will present progress toward this goal, including continuous-wave lasing and high-brightness perovskite light emitting diodes.

SF1I.2 • 08:30
Lasing from high-quality lead halide perovskite single crystal microparticles, Sangyeon Cho[2,1], Seok-Hyun Yun[2,1]; [1]*Harvard-MIT Health Sciences and Technology, MIT, USA;* [2]*Wellman Center for Photomedicine, Massachusetts General Hospital and Harvard Medical School, USA.* We have synthesized CsPbBr3 and CH3NH3PbBr3 single-crystal microplates with improved surface quality and obtained whispering-gallery mode lasing from a size of 2 μm. The method can produce high-quality perovskite microlasers in large quantity within minutes.

08:00–10:00
SF1J • Metasurfaces
Presider: Takasumi Tanabe; Keio Univ., Japan

SF1J.1 • 08:00
Dynamic Dielectric Metasurfaces Incorporating Phase-Change Material, Sajjad AbdollahRamezani[1], Hossein Taghinejad[1], Yashar Kiarashi Nejad[1], Ali Asghar Eftekhar[1], Ali . Adibi[1]; [1]*Georgia Inst. of Technology, USA.* We present a highly-reconfigurable metasurface with unprecedented efficiency for spatial and spectral manipulation of optical wavefronts, leveraging control over the overlapped Mie-dipolar-modes of dielectric nanorings and large refractive index tunability granted by GeSbTe phase-change material.

SF1J.2 • 08:15
MEMS-tunable dielectric metasurface lens, Ehsan Arbabi[1], Amir Arbabi[2], Seyedeh Mahsa Kamali[1], Yu Horie[1], MohammadSadegh Faraji-Dana[1], Andrei Faraon[1]; [1]*California Inst. of Technology, USA;* [2]*Electrical Engineering, Univ. of Massachusetts Amherst, USA.* We report a micro-electromechanically tunable metasurface doublet composed of a moving metasurface on a membrane and a stationary one. The doublet provides more than 180 diopters change in the optical power.

SF1J.3 • 08:30
Continuous Gradient Dielectric Metasurfaces for Non-discrete Spatial Light Manipulation, Masashi Miyata[1], Mitsumasa Nakajima[1], Toshikazu Hashimoto[1]; [1]*NTT Device Technology Labs., Japan.* We demonstrate continuous gradient metasurfaces that can form a non-discrete one-dimensional phase pattern on a surface. The capability of our approach for wavefront shaping is demonstrated in efficient and versatile optical multi-beam splitters.

08:00–10:00
SF1K • Hollow Core Fibers
Presider: Sze Set; Univ. of Tokyo, Japan

SF1K.1 • 08:00
45W 2 μm Nanosecond Pulse Delivery Using Antiresonant Hollow-core Fiber, Elizabeth M. Lee[2,1], Jiaqi Luo[2,1], Biao Sun[2], Vincent Larry Ramalingam[2,1], Xia Yu[2], Qijie Wang[1], Fei Yu[3], Jonathan C. Knight[3]; [1]*School of Electrical & Electronic Engineering, Nanyang Technological Univ., Singapore;* [2]*Precision Measurements Group, Singapore Inst. of Manufacturing Technology, Singapore;* [3]*Centre for Photonics and Photonic Materials, Dept. of Physics, Univ. of Bath, UK.* We demonstrated the highest reported transmission of 44.9W average power from a 1980nm 1.2ns source using an antiresonant hollow-core delivery fiber with good output beam quality.

SF1K.2 • 08:15
2-3 μm wavelength-range low-loss inhibited-coupling hollow-core fiber, Martin Maurel[1,2], Frédéric Delahaye[1], Foued Amrani[1], Benoit Debord[1,2], Frédéric Gérôme[1,2], Fetah Benabid[1,2]; [1]*GPPMM, Xlim, CNRS UMR 7252, Limoges Univ, France;* [2]*GLOphotonics SAS, France.* We report on ultra-broad transmission guiding large-mode area inhibited-coupling HC-PCFs. The fibers guidance spans from 500 nm to 3300 nm and exhibits losses in the range of 25-50 dB/km in the 2-3 μm wavelength range.

SF1K.3 • 08:30
1 km fiber with losses at the fundamental Rayleigh scattering limit in the green wavelength range, Matthieu Chafer[1,2], Frédéric Delahaye[1], Foued Amrani[1], Benoit Debord[1,2], Frédéric Gérôme[1,2], Fetah Benabid[1,2]; [1]*GPPMM, Xlim, CNRS UMR 7252, Limoges Univ, France;* [2]*GLOphotonics, France.* We report losses at the Rayleigh scattering limit of silica at 539 nm in a tubular HC-PCF with value of 13.8 dB/km. The fiber was drawn over 1 km with ± 0.6% fluctuation.

08:00–10:00
AF1M • Fiber-Optic Based Sensing
Presider: Gregory Rieker; Univ. of Colorado at Boulder, USA

AF1M.1 • 08:00 Invited
Optical Sensing Systems for Industrial and Medical Process Monitoring, Guido Perrone[1]; [1]*Politecnico di Torino, Italy.* The paper reviews how photonic sensors, and those based on fiber optics in particular, can enable new applications in the framework of the so-called "industry 4.0" and in the biomedical field.

AF1M.2 • 08:30
A Family of Interferometric Fiber Optic Gyroscopes for Miniaturized Satellites, Jing Jin[1], Kun Ma[1], Cai Wei[1], Linghai Kong[1]; [1]*Beihang Univ., China.* The compact interferometric fiber optical gyroscope configurations and components, efficient and reliable parameters monitoring and fault diagnosis, performances and in-orbit tests of miniaturized products for space use are presented in this paper.

07:30–15:30 Registration, *Concourse Level*

Marriott Salon IV

CLEO: Science & Innovations

08:00–10:00
SF1N • Ultrafast Mid-IR Sources
Presider: Igor Jovanovic; Univ. of Michigan, USA

SF1N.1 • 08:00
Generation of 1 mJ, 85 fs, 2.5 μm Pulses from a Cr^{2+}:ZnSe Chirped Pulse Amplifier, Lam H. Mach[1], Xiaoming Ren[1], Yanchun Yin[1], Yang Wang[1], Zenghu Chang[1]; *[1]CREOL and Dept. of Physics, Univ. of Central Florida, USA.* We demonstrate the generation of 1 mJ, 85 fs, 2.5 μm pulses with 300 nm of available bandwidth at 1 kHz of repetition rate from a Chirped Pulse Amplifier based on the Cr^{2+}:ZnSe gain medium.

SF1N.2 • 08:15
8.6 MHz Extended Cavity Cr:ZnS Chirped-pulse Oscillator, Nikolai Tolstik[1,2], Cherrie S. Lee[1], Evgeni Sorokin[3], Irina Sorokina[1,2]; *[1]Norges Teknisk Naturvitenskapelige Univ, Norway; [2]Atla Lasers AS, Norway; [3]Vienna Univ. of Technology, Austria.* We report the first extended cavity Cr:ZnS chirped-pulse oscillator mode-locked by graphene. We demonstrate 415 mW average power at 8.6 MHz repetition rate which results in 48 nJ pulse energy.

SF1N.3 • 08:30
High Energy, Few-Cycle Parametric Source Tunable in the 5-11 μm Window, Driven by an Yb Bulk CPA System, Giedre M. Archipovaite[1], Guangyu Fan[2], Pavel Malevich[2], Tan Lihao[3], Stéphane Petit[1], Jean-Christophe Delagnes[1], Eric Cormier[1], Giedrius Andriukaitis[2], Edgar Kaksis[2], Andrius Baltuska[2], Tadas Balciunas[2]; *[1]CELIA, France; [2]Vienna Univ. of Technology, Austria; [3]DSO National Labs, Singapore.* We demonstrate an efficient difference frequency generation in the 5-11 μm spectral range. A KTA-AGS based parametric source is driven by 14 mJ Yb:CPA and provides 150 μJ pulses with up to 3 μm bandwidth.

Marriott Salon VI

CLEO: QELS-Fundamental Science

08:00–10:00
FF1P • Attosecond and X-Ray Spectroscopy
Presider: Ming-Chang Chen; National Tsing Hua University, Taiwan

FF1P.1 • 08:00 Invited
Femtosecond Response of Atoms and Molecules to Ultra-Intense X-rays, Rebecca Boll[1]; *[1]European XFEL, Germany.* The interaction of heavy atoms and small molecules with very intense soft and hard X-ray FEL pulses is discussed, and comprehensive results from several recent experiments at the LCLS are presented.

FF1P.2 • 08:30
Attosecond Transient Absorption and Four-Wave Mixing with Tunable IR Pulses, Nathan Harkema[1], Jens E. Bækhøj[2], Kenneth J. Schafer[2], Mette B. Gaarde[2], Arvinder S. Sandhu[1]; *[1]Univ. of Arizona, USA; [2]Louisiana State Univ., USA.* We extend the technique of attosecond transient absorption spectroscopy by incorporating tunable IR pulses from an OPA. This technique is used to control Autler-Townes splitting and drive XUV four-wave mixing processes in Helium.

Marriott Willow Glen

CLEO: Applications & Technology

08:00–10:00
AF1Q • A&T Topical Review on Scientific and Commercial Progress in Semiconductor Laser Technology II
Presider: Bojan Resan; Univ. of Applied Sciences FHNW, Switzerland

AF1Q.1 • 08:00 Invited
New Platform for High Power IR and Visible Diode Laser Modules: Towards Yellow Wavelengths., Peter Skovgaard[1], Danny Noordegraaf[1], Mathias Christensen[1,2], Mariafernanda Vilera Suarez[1], Thomas Buss[1], Peter E. Andersen[2], Ole B. Jensen[2]; *[1]Norlase ApS, Denmark; [2]Fotonik, DTU, Denmark.* A new platform of Watt-class, visible lasers is presented. Enabled by tapered diodes and highly efficient frequency conversion, visible laser modules are realized. Such lasers are inherently robust and can be made in unusual wavelengths, such as 577 nm.

AF1Q.2 • 08:30
A Widely-Tunable High-SMSR Narrow-Linewidth Laser Heterogeneously Integrated on Silicon, Minh Tran[1], Tin Komljenovic[1], Duanni Huang[1], Linjun Liang[1], MJ Kennedy[1], John E. Bowers[1]; *[1]Univ. of California Santa Barbara, USA.* A heterogeneously-integrated widely-tunable semiconductor laser utilizing unbalanced MZI filter assisted Vernier ring resonators is demonstrated. A wavelength tuning range of 55 nm, SMSR greater than 50 dB and spectral linewidth of 50–85 kHz over this range was achieved.

Executive Ballroom 210A

CLEO: Science & Innovations

SF1A • Si Photonics—Continued

SF1A.4 • 08:45
128x128 Silicon Photonic MEMS Switch with Scalable Row/Column Addressing, Kyungmok Kwon[1], Tae Joon Seok[2], Johannes Henriksson[1], Jianheng Luo[1], Lane Ochikubo[3], John Jacobs[3], Richard Muller[1], Ming C. Wu[1]; *[1]UC Berkeley, USA; [2]Gwangju Inst. of Science and Technology, South Korea; [3]TSI Semiconductors, USA.* 128x128 silicon photonic switch with 16,384 MEMS-actuated switching elements and row/column addressing scheme have been successfully integrated on a 16x17mm^2 chip. The maximum (minimum) on-chip loss is 22.7 dB (4.8 dB).

SF1A.5 • 09:00 Invited
Monolithically Integrated Photonics with Silicon Nanoelectronics in Advanced Bulk CMOS Process Nodes for Next-Generation Systems-on-Chip, Milos Popovic[1], Fabio Pavanello[4], Amir H. Atabaki[2], Sajjad Moazeni[3], Hayk Gevorgyan[1], Jelena Notaros[4,2], Luca Alloatti[2], Mark T. Wade[4], Chen Sun[3], Seth Kruger[5], Kenaish Al Qubaisi[1], Imbert Wang[1], Bohan Zhang[1], Anatol Khilo[1], Christopher Baiocco[5], Vladimir Stojanovic[3], Rajeev Jagga Ram[2]; *[1]Boston Univ., USA; [2]MIT, USA; [3]Univ. of California Berkeley, USA; [4]Univ. of Colorado Boulder, USA; [5]SUNY Polytechnic Inst., USA.* We demonstrate microring-based, 10Gbps single-chip electronic-photonic transceivers for dense WDM links that are monolithically integrated in a new 65nm bulk-CMOS microelectronics-derivative process on 300mm wafers. The polysilicon platform includes waveguides/resonators, modulators, and sensitive avalanche photodetectors.

Executive Ballroom 210B

CLEO: QELS-Fundamental Science

FF1B • Quantum Enhanced Measurements—Continued

FF1B.4 • 08:45
Super-Resolution Quantum Imaging at the Heisenberg Limit, Manuel Unternährer[1], Bänz Bessire[1], Leonardo Gasparini[2], Matteo Perenzoni[2], André Stefanov[1]; *[1]IAP, Univ. of Bern, Switzerland; [2]Fondazione Bruno Kessler FBK, Italy.* The theory of optical centroid measurement, having shown *N*-fold spatial resolution using entangled *N*-photon states, is formulated in the framework of an imaging formalism. An exemplary experiment using photon pairs demonstrates double resolution and uses a newly developed integrated detector array.

FF1B.5 • 09:00
Direct quantum process tomography via measuring sequential weak values, Yosep Kim[1], Yong-Su Kim[2], Sang-Yun Lee[2], Sang-Wook Han[2], Sung Moon[2], Yoon-Ho Kim[1], Young-Wook Cho[2]; *[1]POSTECH, South Korea; [2]Korea Inst. of Science and Technology (KIST), South Korea.* We demonstrate measurement of the sequential weak value of two incompatible observables by making use of two-photon quantum interference. We also demonstrate direct quantum process tomography of a qubit channel using the sequential weak value.

FF1B.6 • 09:15
Quantum Measurements in weak coupling regime: from Sequential weak values to Protective measurements, Marco Genovese[1], Fabrizio Piacentini[1], Alessio Avella[1], Enrico Rebufello[1], Salvatore Virzi'[1], Ivo Degiovanni[1], Marco Gramengna[1], Giorgio Brida[1]; *[1]INRIM, Italy.* Quantum measurements in weak coupling regime represent a new interesting paradigm with significant applications both conceptual and practical. Here we present several experimental achievements exploiting weak values, and the first realization of protective measurements.

Executive Ballroom 210C

Joint

JF1C • Symposium on Lasers in Accelerator Science and Technology I—Continued

JF1C.3 • 09:00
Characterizing isolated attosecond pulses with angular streaking, Siqi Li[2,1], Zhaoheng Guo[3], R. Coffee[4,5], Kareem Hegazy[1,4], Zhirong Huang[2], Adi Natan[4], Timur Osipov[5], Dipanwita Ray[5], Agostino Marinelli[2], James Cryan[4]; *[1]Physics, Stanford Univ., USA; [2]SLAC National Accelerator Lab, USA; [3]Applied Physics, Stanford Univ., USA; [4]Stanford Pulse Inst., USA; [5]LCLS, SLAC National Accelerator Lab, USA.* We present a robust reconstruction algorithm for isolated attosecond pulses, which exploits the phase-dependent energy modulation of a photoelectron ionized in the presence of a circularly polarized laser field.

JF1C.4 • 09:15
High-repetition rate, TW-class, picosecond CO_2 laser for a variable species ion source, Jeremy Pigeon[1], Sergei Tochitsky[1], Eric Welch[1], Chan Joshi[1]; *[1]UCLA, USA.* A CO_2 laser driven, high-brightness, H, He, C, Ne ion source from a gas jet plasma is being developed. The high-repetition rate, 0.5 TW, picosecond, CO_2 laser driver is described.

Executive Ballroom 210D

CLEO: QELS-Fundamental Science

FF1D • Ultrafast Spectroscopy of 2D Materials—Continued

FF1D.4 • 08:45
Ultrafast Linewidth and Resonant Energy Dynamics of Anisotropic Excitons in Atomically Thin ReS_2, Ho-Seung Shin[1], Sangwan Sim[1,2], Doeon Lee[1], Seungwan Cho[1], Sooun Lee[3], Seung Hoon Yang[4], Wooyoung Shim[3], Chul-Ho Lee[4], Hyunyong Choi[1]; *[1]School of Electrical and Electronic Engineering, Yonsei Univ., South Korea; [2]Center for Artificial Low Dimensional Electrical Systems, Institution for Basic Science (IBS), Pohang Univ. of Science and Technology, South Korea; [3]Dept. of Materials Science and Engineering, Yonsei Univ., South Korea; [4]KU-KIST Graduate School of Converging Science and Technology, Korea Univ., South Korea.* We investigate the anisotropic exciton dynamics of bilayer ReS_2 using time-resolved pump-probe spectroscopy. In contrast to conventional 2D materials, we identify that the exciton resonance broadening strongly depends on the exciton-longitudinal optical (LO) phonon coupling.

FF1D.5 • 09:00
Direct time-domain observation of ultrafast exciton formation in monolayer MoS_2, Chiara Trovatello[1], Stefano Dal Conte[1], Giulio Cerullo[1,4], Kaiyuan Yao[2,3], Nick Borys[2], Francesco Scotognella[1,2], Ilka Kriegel[2], P. James Schuck[2,3]; *[1]Dipartimento di Fisica, Politecnico di Milano, Italy; [2]Molecular Foundry Division, Lawrence Berkeley National Lab, USA; [3]Dept. of Mechanical Engineering, Columbia Univ., USA; [4]IFN-CNR, Italy.* We study the transient optical response of monolayer MoS2 with an unprecedented temporal resolution. From the build-up dynamics of the transient signal around A/B excitonic peaks we directly extract the characteristic time-scale for exciton formation process, which ranges between 15 and 35 fs.

FF1D.6 • 09:15
Tuning Exciton-polaritons in Monolayer WS_2 Using Electrical Field Gating, Biswanath Chakraborty[1], Jie Gu[1], Mandeep Khantoniar[1], Zheng Sun[2], Vinod M. Menon[1]; *[1]The City College of New York, USA; [2]Dept. of Physics and Astronomy, Univ. of Pittsburgh, USA.* We demonstrate the tuning of the exciton-polaritons in monolayer WS_2 embedded in a microcavity via electrostatic gating at room temperature. Under high electron doping the formation of polaritons with the charged excitons is observed.

CLEO: QELS-Fundamental Science

FF1E • THz Generation and Novel Phenomena—Continued

FF1E.4 • 08:45
Excitation Wavelength Dependence of a High-Q Nanocavity-based Raman Silicon Laser, Daiki Yamashita[1], Takashi Asano[2], Susumu Noda[2], Yasushi Takahashi[1]; [1]*Osaka Prefecture Univ., Japan;* [2]*Kyoto Univ., Japan.* We investigate the excitation wavelength dependence of the laser emission from a nanocavity-based Raman silicon laser with a technique called Raman-scattering-luminescence excitation. This technique provides an overview of the Raman gain including nonlinear optical losses.

FF1E.5 • 09:00
Bloch oscillations of a free electron in a strong field, Adi Pick[1,2], Ori Reinhardt[1], Liang Jie Wong[3], Yonatan Plotnik[4], Ido Kaminer[1,4]; [1]*Electrical Engineering, Technion-Israel Inst. of Technology, Israel;* [2]*Chemistry, Technion-Israel Inst. of Technology, Israel;* [3]*Singapore Inst. of Manufacturing Technology, Singapore;* [4]*Physics, Technion-Israel Inst. of Technology, Israel.* We find that electrons in strong electromagnetic fields exhibit Bloch oscillations, in analogy to light propagation in index-gradient waveguide arrays. Our relativistic non-perturbative approach generalizes to multifrequency fields, producing rich variety of oscillations.

FF1E.6 • 09:15
Resonant harmonic generation in AlGaAs nanoantennas using cylindrical vector beams, Maria del R. Camacho Morales[1], Godofredo S. Bautista[2], Xiaorun Zang[2], Lei Xu[1], Léo Turquet[2], Andrey Miroshnichenko[1], Aristeidis Lamprianidis[1], Mohsen Rahmani[1], Dragomir N. Neshev[1], Martti Kauranen[2]; [1]*Nonlinear Physics Centre, Research School of Physics and Engineering, The Australian National Univ., Australia;* [2]*Lab of Photonics, Tampere Univ. of Technology, Finland.* We use second- and third-harmonic generation with cylindrical vector beams to investigate AlGaAs nanodisks. The nonlinear emission is found to depend strongly on the interplay between tensorial nonlinearities, focal-field symmetries and resonant multipolar excitations.

FF1F • Spatial and Temporal Control of Light Using Metasurfaces—Continued

FF1F.3 • 08:45
Broadband Achromatic Metalenses, Yu Han Chen[1], Pin Chieh Wu[2,1], Shuming Wang[3], Ren Jie Lin[1], Jia Wern Chen[1], Yi-Chieh Lai[1], Cheng Hung Chu[2], Bo Han Chen[1], Shining Zhu[3], Tao Li[3], Zhenlin Wang[3], Din Ping Tsai[1,2]; [1]*National Taiwan Univ. , Taiwan;* [2]*Research Center for Applied Sciences, Academia Sinica, Taiwan;* [3]*College of Engineering and Applied Sciences, School of Physics, Nanjing Univ., China.* We propose a design principle to realize achromatic metasurface devices which successfully eliminate the chromatic aberration over a continuous wavelength regions from 400 to 660 nm and 1200 to 1680 nm in a transmission and reflection scheme, respectively.

FF1F.4 • 09:00
Aberration Corrected Metalenses for Imaging, Sajan Shrestha[1], Adam Overvig[1], Nanfang Yu[1]; [1]*Columbia Univ., USA.* We experimentally demonstrated chromatic aberration correction in converging and diverging metalenses up to wavelength range of ~450 nm in the near-infrared by utilizing dispersion engineering of meta-units.

FF1F.5 • 09:15
Angle-multiplexed metasurfaces, Seyedeh Mahsa Kamali[1], Ehsan Arbabi[1], Amir Arbabi[2], Yu Horie[1], MohammadSadegh Faraji-Dana[1], Andrei Faraon[1]; [1]*California Inst. of Technology, USA;* [2]*UMass Amherst, USA.* We introduce angle-multiplexed metasurfaces for encoding independent wavefronts in a single metasurface under different illumination angles. As proof of concept, we demonstrate an angle-multiplexed hologram, which projects different images under normal and oblique illumination angles.

CLEO: Science & Innovations

SF1G • Surface Emitting Lasers—Continued

SF1G.4 • 09:00
Asymmetric beam generation in an on-chip 2D-pattern-projecting lasers, Kazuyoshi Hirose[1], Yoshitaka Kurosaka[1], Yu Takiguchi[1], Takahiro Sugiyama[1], Yoshiro Nomoto[1], So Uenoyama[1]; [1]*Hamamatsu Photonics K.K., Japan.* We successfully generate an asymmetric beam pattern in integrable phase-modulating surface-emitting lasers, which showed static, arbitrary, two-dimensional beam pattern from on-chip size, while symmetric beam patterns are obtained in the conventional device.

SF1G.5 • 09:15
Direct generation of Laguerre-Gaussian beam with holographical phase-modulated surface-emitting lasers, Yu Takiguchi[1], Kazuyoshi Hirose[1], Takahiro Sugiyama[1], So Uenoyama[1], Yoshiro Nomoto[1], Yoshitaka Kurosaka[1]; [1]*Hamamatsu Photonics K.K., Japan.* Holographically-designed Laguerre-Gaussian beam generation with surface emitting semiconductor lasers are demonstrated. Holographic information was inserted as resonator between the cladding layers. The Laguerre-Gaussian holograms was calculated in the form of complex-amplitude phase hologram.

CLEO: QELS-Fundamental Science

FF1H • Nanophotonic Strategies for Controlling Light-Matter Interaction—Continued

FF1H.3 • 08:45
***In situ* Real-Time Beam Monitoring with Dielectric Meta-Holograms,** Yoav Blau[1], Michal Eitan[1], Victor Egorov[1], Amir Boag[1], Yael Hanein[1], Jacob Scheuer[1]; [1]*Tel-Aviv Univ., Israel.* We propose and demonstrate novel meta-holograms for laser beam monitoring. These devices project a portion of the beam power to a screen, allowing for real-time monitoring of laser beam properties - position, astigmatism, and spot-size.

FF1H.4 • 09:00 Invited
Coherent Control of Light-matter Interactions in Standing Waves, Kevin F. MacDonald[1], Eric Plum[1], Daniele Faccio[2], Nikolay I. Zheludev[1,3]; [1]*Univ. of Southampton, UK;* [2]*Univ. of Glasgow, UK;* [3]*Nanyang Technological Univ., Singapore.* In standing wave light fields, 'coherent control' of energy exchange, in ultrathin films and metasurfaces, between incident and scattered waves leads to new technological opportunities relevant to optical data processing, spectroscopy, and nonlinear/quantum optics applications.

Meeting Room 211 B/D	Meeting Room 212 A/C	Meeting Room 212 B/D	Marriott Salon III
CLEO: Science & Innovations			CLEO: Applications & Technology

SF1I • Perovskites and Organics—Continued

SF1I.3 • 08:45
Highly Sensitive UV-Vis-NIR Inorganic Perovskite Quantum Dot Phototransistors Based on Layered Heterojunctions, Chen Zou[1], Yuyin Xi[2], Lilo D. Pozzo[2], Lih Y. Lin[1]; [1]*Electrical Engineering, Univ. of Washington, USA;* [2]*Chemical Engineering, Univ. of Washington, USA.* We report a high-performance phototransistor based on a layered heterojunction composed of all-inorganic perovskite quantum dots (IPQDs) and a narrow-bandgap conjugated polymer DPP-DTT. The device exhibits stable and excellent optoelectronic properties with broadband photodetection range.

SF1I.4 • 09:00
Low Coherence Illumination of Flexible Perovskite Random Lasers, Yu-Chi Wang[1], Yu-Heng Hong[1], Kuo-Bin Hong[1], Tsung-Sheng Kao[1], Tien-Chang Lu[1]; [1]*National Chiao Tung Univ., Taiwan.* We demonstrated that the methylammonium metal-halide perovskites can be exploited as a random laser source for the advanced speckle-free imaging. Furthermore, the lasing performance can be actively controlled via the mechanical modulation of supporting substrates.

SF1I.5 • 09:15
Highly Efficient Energy Transfer Between TMDCs and Organic Materials, Chehsuan Cheng[1], Zidong Li[1], Parag Deotare[1]; [1]*Univ. of Michigan, USA.* We demonstrate MoS2 photodetectors sensitized with highly absorbing organic j-aggregate thin films. Förster resonance energy transfer (FRET) radius of 1.649 nm was estimated across the hybrid organic-inorganic interface.

SF1J • Metasurfaces—Continued

SF1J.4 • 08:45
Large Area Tunable Alvarez Metalens via Stepper Photolithography, Shane A. Colburn[1], Alan Zhan[1], Arka Majumdar[1]; [1]*Univ. of Washington, USA.* Using inexpensive and high-throughput stepper lithography, we design and fabricate 1 cm wide tunable metalenses which exhibit a focal length change of 162%, more than 6 cm, with only 2.4 mm lateral actuation.

SF1J.5 • 09:00
Directional Plasmonic Image Sensors for Lens-Free Compound-Eye Vision, Leonard Kogos[1], Lei Tian[1], Roberto Paiella[1]; [1]*Boston Univ., USA.* We describe a novel lens-free camera technology inspired by the compound-eye vision modality that combines ultrathin plasmonic metasurfaces to enable angle-resolved photodetection with computational imaging for wide field-of-view image reconstruction.

SF1J.6 • 09:15
Intra-cavity metasurfaces for topologically spin-controlled laser modes, Elhanan Maguid[1], Ronen Chriki[2], Michael Yannai[1], Chene Tradonsky[2], Vladimir Kleiner[1], Erez . Hasman[1], Asher Friesem[2], Nir Davidson[2]; [1]*Technion-Israel Inst. of Technology, Israel;* [2]*Dept. of Physics of Complex Systems, Weizmann Inst. of Science, Israel.* We present the incorporation of a metasurface involving spin-orbit interaction phenomenon into a laser cavity paving the way for the generation of spin-controlled intra-cavity modes with different topologies.

SF1K • Hollow Core Fibers—Continued

SF1K.4 • 09:00
Hollow-Core Negative-Curvature Fiber for High Energy Pulse Delivery at UV Wavelength, Shoufei Gao[1], Yingying Wang[1], Pu Wang[1], Wei Ding[2]; [1]*Beijing Univ. of Technology, China;* [2]*Lab of Optical Physics, Inst. of Physics, Chinese Academy of Sciences,, China.* We report a UV guiding hollow-core negative-curvature fiber with loss of 0.2 dB/m at 355 nm. This fiber enables, for the first time, picosecond pulse delivery up to 160 μJ at 355 nm with no damage observed.

SF1K.5 • 09:15
Polarization Evolution in Antiresonant Hollow Core Fibers, Nikhil Jayakumar[1], Rudrakant Sollapur[1], Andreas Hoffmann[1], Teodora Grigorova[1], Alexander Hartung[2], Anka Schwuchow[2], Joerg Bierlich[2], Jens Kobelke[2], Markus Schmidt[2,3], Christian Spielmann[1,4]; [1]*Friedrich Schiller Univ. Jena, Germany;* [2]*Leibniz Inst. of Photonic Technology, Germany;* [3]*Otto Schott Inst. of Material Research, Germany;* [4]*Helmholtz Inst. Jena, Germany.* We experimentally demonstrate that the ellipticity of light exiting antiresonant hollow core fibers is a function of the input polarization which manifests as ellipticity varying with the azimuthal periodicity of the cornered core.

AF1M • Fiber-Optic Based Sensing—Continued

AF1M.3 • 08:45
Sensing applications of double hollow-core anti-resonant fiber based modal interferometer, Xiaosheng Huang[1], Seongwoo Yoo[1], Jichao Zang[1]; [1]*Nanyang Technological Univ., Singapore.* In this work, sensing application of dual hollow-core anti-resonant fibers (DHAFs) is studied. DHAF based gas pressure sensor with 40 nm/MPa ultrahigh sensitivity is demonstrated.

AF1M.4 • 09:00
Angular Dependence in Coupling Lamb Waves to Optical Fiber Guided Modes, Junghyun Wee[1], Drew Hackney[1], Kara Peters[1]; [1]*North Carolina State Univ., USA.* We investigate directional differences when coupling Lamb waves in a structure to guided modes in an optical fiber sensor for detection of the ultrasonic wave propagation through the structure.

AF1M.5 • 09:15
Multimode Interference Dynamic Light Scattering, Jose Guzman-Sepulveda[1], Aristide Dogariu[1]; [1]*CREOL, The College of Optics and Photonics, Univ. of Central Florida, USA.* We present a robust implementation of a fiber-based, single-mode, common-path interferometer assisted by multimode interference effects in which light is efficiently collected from larger coherent regions while keeping a high signal-to-noise ratio.

Marriott Salon IV

CLEO: Science & Innovations

SF1N • Ultrafast Mid-IR Sources—Continued

SF1N.4 • 09:00
An all-fiber mid-infrared (6 – 9 μm) source based on difference frequency generation in OP-GaP crystal, Jaroslaw Z. Sotor[1], Tadeusz Martynkien[1], Peter G. Schunemann[2], Pawel Mergo[3], Grzegorz J. Sobon[1]; *[1]Politechnika Wroclawska, Poland; [2]BAE Systems, Inc, USA; [3]Lab of Optical Fiber Technology, Maria Curie-Sklodowska Univ., Poland.* We present an all-fiber source generating laser pulses in the 6 – 9 μm spectral range. The developed setup is based on difference frequency generation in the OP-GaP crystal and delivers 7.4 mW at 7600 nm.

SF1N.5 • 09:15
Generation of high-energy mid-infrared pulses at 3.3 μm by dual-chirped optical parametric amplification, Yuxi Fu[1], Kataro Nishimura[1], Bing Xue[1], Akira Suda[2], Katsumi Midorikawa[1], Eiji J. Takahashi[1]; *[1]RIKEN, Japan; [2]Tokyo Univ. of Science, Japan.* We generated 31 mJ mid-infrared pulses near 3.3 μm using a dual-chirped optical parametric amplification scheme. The pulse was compressed to 70 fs. We will further increase the energy to obtain multi-TW, few-cycle mid-infrared pulses.

Marriott Salon VI

CLEO: QELS-Fundamental Science

FF1P • Attosecond and X-Ray Spectroscopy—Continued

FF1P.3 • 08:45
Attosecond Transient Absorption Spectroscopy near the $L_{2,3}$-edge of Argon, Andrew Chew[2], Nicolas Douguet[2], Coleman Cariker[2], Jie Li[2], Xiaoming Ren[2], yanchun yin[2], Luca Argenti[2], Zenghu Chang[2], Wendell Hill[1]; *[1]Physics, Univ. of Maryland, College Park, USA; [2]CREOL and Physics, Univ. of Central Florida, USA.* We present an experimental investigation of attosecond transient absorption spectroscopy near the $L_{2,3}$-edge of argon gas by using an attosecond pulse in the 240-250 eV range.

FF1P.4 • 09:00
Electron dynamics in transition metal dichalcogenides utilizing attosecond transient absorption spectroscopy, Alexander Guggenmos[1], Hung-Tzu Chang[1], Michael Zürch[1], Diana Y. Qiu[2,3], Romain Geneaux[1], Yen-Chang Chen[4,5], Xuan Wei[5], Chang-Ming Jiang[6,7], Yufeng Liang[4], Felipe H. da Jornada[2,3], Adam Schwartzberg[4], David Prendergast[4], Vincent C. Tung[5], Steven G. Louie[2,3], Daniel M. Neumark[1,6], Stephen R. Leone[1,2]; *[1]Dept. of Chemistry, Univ. of California, Berkeley, USA; [2]Dept. of Physics, Univ. of California, Berkeley, USA; [3]Materials Sciences Division, Lawrence Berkeley National Lab, USA; [4]Molecular Foundry, Lawrence Berkeley National Lab, USA; [5]School of Engineering, Univ. of California, Merced, USA; [6]Chemical Sciences Division, Lawrence Berkeley National Lab, USA; [7]Joint Center of Artificial Photosynthesis, Lawrence Berkeley National Lab, USA.* Strong enhancement of exciton binding has been observed in valence-excitons in the optical regime of 2D materials. We report direct observation of long-lived core-exciton states in transition metal dichalcogenides by attosecond transient absorption spectroscopy in the XUV.

FF1P.5 • 09:15
Optical Chirality for High Harmonic Generation, Ofer Neufeld[1,2], Oren Cohen[1,2]; *[1]Physics, Technion, Israel; [2]Solid State Inst., Technion, Israel.* We link the chirality of attosecond pulses with the chirality of the pump that drives them by extending the theory of optical chirality. We propose a chiral tricircular pump that generates tunable highly helical attopulses.

Marriott Willow Glen

CLEO: Applications & Technology

AF1Q • A&T Topical Review on Scientific and Commercial Progress in Semiconductor Laser Technology II—Continued

AF1Q.3 • 08:45
Increase in Output Power of 8 μm Quantum Cascade Spiral Cavity Superluminescent Devices by Active Region Doping, Yezhezi M. Zhang[1], Mei C. Zheng[1], Abigail R. Pitarresi[1,2], Sara Kacmoli[1], Abanti Basak[1,3], Deborah Sivco[1,4], Claire F. Gmachl[1]; *[1]Princeton Univ., USA; [2]Lafayette College, USA; [3]Univ. of California, Santa Barbara, USA; [4]Trumpf Photonics, Inc., USA.* We report on 8 μm quantum cascade superluminescent emitters. Doping in the active region contributed to higher SL power of 7.5 mW; we obtained a coherence length of ~346 μm at maximum SL power.

AF1Q.4 • 09:00
Mid-infrared saturable absorber mirror (MIR-SAM) based on Dirac semimetal thin films, Lei Huang[1], Jiarong Qin[1], Yafei Meng[1], Chunhui Zhu[1], Yao Li[1], Yongbing Xu[1], Yi Shi[1], Frank (Fengqiu) Wang[1]; *[1]Nanjing Univ., China.* We have for the first time fabricated a Dirac semimetal saturable absorber with a mirror structure. The centimeter-scale, SESAM-like device can operate across 3-5 μm, and mid-infrared pump-probe spectroscopy is used to study the nonlinear absorption characteristics.

AF1Q.5 • 09:15
Optically Pumped GeSn-edge-emitting Laser with Emission at 3 μm for Si Photonics, Wei Dou[1], Yiyin Zhou[1,7], Joe Margetis[2], Seyed Ghetmiri[3], Wei Du[4], Jifeng Liu[5], Greg Sun[6], Richard Soref[6], John Tolle[2], Baohua Li[7], Mansour Mortazavi[3], Shui-Qing Yu[1]; *[1]Univ. of Arkansas, USA; [2]ASM,LLC, USA; [3]Dept. of Chemistry and Physics, Univ. of Arkansas at Pine Bluff, USA; [4]Dept. of Electrical Engineering, Wilkes Univ., USA; [5]Thayer School of Engineering, Dartmouth College, USA; [6]Dept. of Engineering, Univ. of Massachusetts Boston, USA; [7]Arktonics, LLC, USA.* We presented optically pumped edge-emitting GeSn laser with 22.3% world-record maximum Sn content and 3 μm emission wavelength. Lasing threshold of 139 kW/cm^2 at 77 K and maximum operating temperature of 150 K were achieved.

Executive Ballroom 210A

CLEO: Science & Innovations

SF1A • Si Photonics—Continued

SF1A.6 • 09:30
Monolithically Integrated Holmium Lasers on Silicon Chips, Nanxi Li[1,2], Emir Magden[1], Zhan Su[1,3], Neetesh Singh[1], Alfonso Ruocco[1], Ming Xin[1], Matthew Byrd[1,3], Patrick Callahan[1], Jonathan Bradley[1,4], Diedrik Vermeulen[1,3], Michael Watts[1]; [1]*Research Lab of Electronics, MIT, USA;* [2]*John A. Paulson School of Engineering and Applied Science, Harvard Univ., USA;* [3]*Analog Photonics, USA;* [4]*Dept. of Engineering Physics, McMaster Univ., Canada.* We demonstrate holmium-doped DFB lasers monolithically integrated on silicon. Single mode lasing at wavelength from 2.02 to 2.10 μm with 15 mW maximum output power are reported. This work extends silicon-photonic microsystems beyond 2 μm.

SF1A.7 • 09:45
Quantum-dot nanolasers on Si photonic circuits, Alto Osada[1], Yasutomo Ota[1], Ryota Katsumi[2], Katsuyuki Watanabe[1], Satoshi Iwamoto[1,2], Yasuhiko Arakawa[1,2]; [1]*Inst. for Nano Quantum Information Electronics, The Univ. of Tokyo, Japan;* [2]*Inst. of Industrial Science, The Univ. of Tokyo, Japan.* We report the hybrid integration of quantum dot nanolasers on silicon photonic circuits using transfer printing. The pick-and-place assembly method facilitates the integration of two nanolasers on a single CMOS-processed waveguide that supports two-wavelength output.

Executive Ballroom 210B

CLEO: QELS-Fundamental Science

FF1B • Quantum Enhanced Measurements—Continued

FF1B.7 • 09:30
Distributed Quantum Sensing Using Continuous-Variable Multipartite Entanglement, Quntao Zhuang[1], Zheshen Zhang[1,2], Jeffrey H. Shapiro[1]; [1]*MIT, USA;* [2]*Dept. of Materials Science and Engineering, Univ. of Arizona, USA.* Continuous-variable multipartite entanglement, obtained from dividing a squeezed state between multiple nodes, is shown to enhance distributed field-quadrature displacement sensing. In the lossless case, its performance has Heisenberg scaling in the number of nodes.

FF1B.8 • 09:45
Manipulation of Two-Photon Interference by Entanglement, Polina Sharapova[1], Kai Hong Luo[1], Harald Herrmann[1], Matthias Reichelt[1], Torsten Meier[1], Christine Silberhorn[1]; [1]*Univ. of Paderborn, Germany.* We demonstrate that entangled states are able to significantly extend the functionality of integrated Hong-Ou-Mandel interferometers and give rise an antibunching peak and rapid oscillation fringes with twice the optical frequency in the coincidence probability.

Executive Ballroom 210C

Joint

JF1C • Symposium on Lasers in Accelerator Science and Technology I—Continued

JF1C.5 • 09:30 Invited
Linear-Field Particle Acceleration in Free Space by Spatiotemporally Structured Laser Pulses, Liang Jie Wong[1], Kyung-Han Hong[2], Sergio Carbajo[3], Arya Fallahi[4], Philippe Piot[5], Marin Soljacic[2], John Joannopoulos[2], Franz X. Kaertner[4], Ido Kaminer[6]; [1]*SIMTech, Singapore;* [2]*MIT, USA;* [3]*Stanford SLAC, USA;* [4]*CFEL, Germany;* [5]*Northern Illinois Univ., USA;* [6]*Technion, Israel.* We show that net energy transfer via linear-field forces, between a laser pulse and a bunch of multiple interacting electrons, can be realized in unbounded free space by engineering the spatiotemporal structure of light.

Executive Ballroom 210D

CLEO: QELS-Fundamental Science

FF1D • Ultrafast Spectroscopy of 2D Materials—Continued

FF1D.7 • 09:30
Ultrafast Dynamical Evolution of Anisotropic Response of Black Phosphorus under Magnetic Field, Wei Lu[1,2], Xuefeng Liu[1,2], Xiaoying Zhou[3,4], Yang Zhou[3], Chenglong Zhang[1,2], Jiawei Lai[1,2], Shaofeng Ge[1,2], M. Chandra Sekhar[1,2], Shuang Jia[1,2], Kai Chang[3], Dong Sun[1,2]; [1]*International Center for Quantum Materials, School of Physics, Peking Univ., China;* [2]*Collaborative Innovation Center of Quantum Matter, China;* [3]*SKLSM, Inst. of Semiconductors, Chinese Academy of Sciences, China;* [4]*Dept. of Physics, Hunan Normal Univ., China.* The dynamical evolution of anisotropy properties of black phosphorus (BP) under magnetic field is studied by polarization resolved mid-IR ultrafast transient reflection spectroscopy. We found magnetic field can efficiently adjust the anisotropy response of BP.

FF1D.8 • 09:45
Ultrafast quantum beats of linearly polarized excitons in two-dimensional ReS_2, Sangwan Sim[1,3], Doeon Lee[1], Artur Trifonov[2], Taeyoung Kim[1], Soonyoung Cha[1], Ji Ho Sung[3], Sungjun Cho[1], Wooyoung Shim[1], Moon-Ho Jo[3], Hyunyong Choi[1]; [1]*Yonsei Univ., South Korea;* [2]*Spin Optics Lab, Russia;* [3]*Center for Artificial Low Dimensional Electronics Systems, IBS, South Korea.* We observe quantum beats of excitons in atomically thin ReS_2. Our observation directly confirms the quantum coherence between anisotropic excitons which are linearly polarized with different orientations.

10:00–10:30 Coffee Break, *Concourse Level*

Executive Ballroom 210E

CLEO: QELS-Fundamental Science

FF1E • THz Generation and Novel Phenomena—Continued

FF1E.7 • 09:30
Optimizing the Nonlinear Optical Response of Plasmonic Metasurfaces, Yael Blechman[1], Euclides C. Almeida[1], Basudeb Sain[1], Yehiam Prior[1]; [1]*Weizmann Inst. of Science, Israel*. We demonstrate that the enhancement of nonlinear optical processes in plasmonic nanomaterials cannot be fully predicted by their linear properties.

FF1E.8 • 09:45
Probing free-carrier recombination in silicon strip nano-waveguides, Ivan A. Aldaya[1,2], Andres Gil-Molina[1,3], Julian Pita[3], Lucas Gabrielli[3], Hugo Fragnito[1,4], Paulo C. Dainese[1]; [1]*Inst. of Physics, Univ. of Campinas, Brazil;* [2]*State Univ. of Sao Paulo, Brazil;* [3]*School of Electrical Engineering, Univ. of Campinas, Brazil;* [4]*Mackgraphe, Mackenzie Presbyterian Univ. , Brazil*. We analyze recombination dynamics of photo-generated free-carriers in strip silicon nanowaveguides, revealing a highly nonlinear decay dynamics with a time-dependent lifetime ranging from 800ps at the beginning to 300ns at the end of the decay.

Executive Ballroom 210F

CLEO: QELS-Fundamental Science

FF1F • Spatial and Temporal Control of Light Using Metasurfaces—Continued

FF1F.6 • 09:30
Two-Color and 3D Phase-Amplitude Modulation Holograms, Adam C. Overvig[1], Sajan Shrestha[1], Chang Xiao[1], Changxi Zheng[1], Nanfang Yu[1]; [1]*Columbia Univ., USA*. We report a high-efficiency dielectric metasurface with continuous and arbitrary control of both amplitude and phase of one or two colors simultaneously. We numerically and experimentally demonstrate 2D and 3D holograms using such metasurfaces.

FF1F.7 • 09:45
Large-scale Metasurface Design using the Adjoint Sensitivity Technique, Mahdad Mansouree[1], Amir Arbabi[1]; [1]*Univ. of Massachusetts at Amherst, USA*. We introduce a general technique for the design of metasurfaces composed of a large number of meta-atoms that enables efficient multifunctional metasurfaces. As a proof-of-concept, we demonstrate a metalens with 0.78NA and 74% focusing efficiency.

Executive Ballroom 210G

CLEO: Science & Innovations

SF1G • Surface Emitting Lasers—Continued

SF1G.6 • 09:30
Mixed-Cation Organic-Inorganic Halide Perovskite Thin Film Surface-Emitting Laser Enabled by Excitonic Gain, Songtao Chen[1], Arto Nurmikko[1]; [1]*Engineering, Brown Univ., USA*. Cesium incorporated mixed-cation perovskite thin films are demonstrated as source of excitonic optical gain media, embedded within monolithic vertical cavity exploiting sputtered dielectric HfO_2/SiO_2 DBRs, realizing robust low threshold green lasing under optical pumping.

SF1G.7 • 09:45
A violet III-nitride vertical-cavity surface-emitting laser with a MOCVD-grown tunnel junction contact, Seunggeun Lee[1], Charles Forman[2], Changmin Lee[2], Jared Kearns[2], John T Leonard[2], Daniel Cohen[2], James Speck[2], Shuji Nakamura[1,2], Steven DenBaars[1,2]; [1]*Dept. of Electrical and Computer Engineering, Univ. of California, Santa Barbara, USA;* [2]*Materials Dept., Univ. of California, Santa Barbara, USA*. We demonstrated a violet III-nitride vertical-cavity surface-emitting laser (VCSEL) with a GaN tunnel junction (TJ) contact grown by a metal-organic chemical vapor deposition (MOCVD) technique. A peak output power of 319 uW was achieved.

Executive Ballroom 210H

CLEO: QELS-Fundamental Science

FF1H • Nanophotonic Strategies for Controlling Light-Matter Interaction—Continued

FF1H.5 • 09:30
Physical random bit generation using mesoscopic chaos in silicon optomechanical oscillators, Ciwei Luo[1], Jia-Gui Wu[1,2], Shaojie Wang[1], Yongjiao Niu[1], Jaime G. Flor Flores[2], Mingbin Yu[3], Guoqiang Lo[3], Dim-Lim Kwong[3], Shukai Duan[1], Chee-Wei Wong[2]; [1]*Southwest Univ., College of Electronic and Information Engineering, China;* [2]*Univ. of California, Los Angeles, Fang Lu Mesoscopic Optics and Quantum Electronics Lab, USA;* [3]*Inst. of Microelectronics, Singapore*. We propose a new physical random bit (PRB) generator using silicon micro-oscillator, which is configured with photonic-crystal optomechanical microcavity and fabricated with CMOS process. 200Mbit/s PRB was obtained and passed tests of NIST-SP800-22

FF1H.6 • 09:45
Nanophotonic light sails for relativistic spaceflight by high-power laser beams, Ognjen Ilic[1], Cora Went[1], Harry Atwater[1]; [1]*California Inst. of Technology, USA*. We show that designed nanophotonic structures could become multiband building-block elements of a relativistic light sail, due to their ability to achieve substantial reflectivity and low absorption in the near-IR, significant emissivity in the mid-IR, and a very low mass.

10:00–10:30 Coffee Break, *Concourse Level*

Meeting Room 211 B/D	Meeting Room 212 A/C	Meeting Room 212 B/D	Marriott Salon III
CLEO: Science & Innovations			CLEO: Applications & Technology

SF1I • Perovskites and Organics—Continued

SF1I.6 • 09:30 Invited

Patterning of Organic Micro/Nano-crystals for High-Performance Optoelectronic Devices, Jiansheng Jie[1]; [1]*Inst. of Functional Nano and Soft Materials Lab (FUNSOM), Soochow Univ., China*. Organic micro/nanocrystals (OMNCs) are promising system to construct new-generation optoelectronic devices. However, the scale-up of OMNCs for technological applications is difficult. We developed a series of simple methods to produce patterned OMNCs for device applications.

SF1J • Metasurfaces—Continued

SF1J.7 • 09:30

Bianisotropic All-dielectric Metasurfaces for Efficient Diffraction of Mid-infrared Electromagnetic Waves, Zhiyuan Fan[1], Maxim R. Shcherbakov[1], Gennady Shvets[1]; [1]*Cornell Univ., USA*. We design and experimentally demonstrate a bianisotropic all-silicon metasurface with a near unity diffraction by implementing a 4-mode interference in the far field. Resonant and non-resonant properties of the modes and interactions can be mediated by sculpting meta-atoms of the metasurface.

SF1J.8 • 09:45

Self-Aligned Nano-Transfer of Metasurface Polarimeter to an Optical Fiber Tip using UV-Curable Hybrid Polymer, Michael Juhl[1,2], Carlos Mendoza[1], J. P. Balthasar Mueller[3], Federico Capasso[3], Kristjan Leosson[1,2]; [1]*Innovation Center Iceland, Iceland;* [2]*Univ. of Iceland, Iceland;* [3]*Harvard John A. Paulson School of Engineering and Applied Sciences, USA*. We present a novel method of patterning an optical fiber facet using self-aligned nano-transfer of a gold pattern to a UV-curable hybrid polymer. We experimentally demonstrate a metasurface polarimeter on a 1550 nm single-mode fiber.

SF1K • Hollow Core Fibers—Continued

SF1K.6 • 09:30

Mode transformation in an inhibited-coupling guiding asymmetric tubular hollow fiber, Jonas H. Osório[1], Matthieu Chafer[1,2], Benoit Debord[1,2], Fabio Giovanardi[3], Martin Cordier[4], Frédéric Delahaye[1], Luca Vincetti[3], Frédéric Gérôme[1,2], Fetah Benabid[1,2]; [1]*GPPMM Group, XLIM Research Inst., Univ. of Limoges, France;* [2]*GLO Photonics, France;* [3]*Univ. of Modena and Reggio Emilia, Italy;* [4]*Télécom ParisTech, Université Paris-Saclay , France*. We report on mode transformation in an asymmetric tubular hollow fiber. We theoretically and experimentally show that LP_{01} and LP_{11} modes superposition entails an output profile with unusual spatially-separated orthogonal polarization sites.

SF1K.7 • 09:45

Low-Frequency Suppression of Classical Laser Fluctuations Using Hollow-Core Fibre, Euan Allen[1], Giacomo Ferranti[1], Dylan H. Mahler[1], Kristina Rusimova[2], Peter J. Mosley[2], Jonathan Matthews[1]; [1]*Univ. of Bristol, UK;* [2]*Univ. of Bath, UK*. We demonstrate classical laser amplitude noise suppression at 4.5 MHz using hollow-core free-boundary fibre. We attain suppression of 2.0 dB and get to within 0.2 dB of the shot-noise limit.

AF1M • Fiber-Optic Based Sensing—Continued

AF1M.6 • 09:30

Inherent Signal Distortion in Dynamic Fiber-optic Interrogators Employing Frequency Scanning, Hari D. Bhatta[1], Roy Davidi[1], Moshe Tur[1]; [1]*Tel Aviv Univ., Israel, Israel*. It is shown, theoretically and experimentally, that signal distortion is inherently present in dynamic fiber-optic strain sensing techniques, which use frequency scanning to determine the value of the measurand. The resulting harmonic distortion and ways to reduce it are described.

AF1M.7 • 09:45

Temperature-sensitivity enhancement in a tapered dual-core As_2Se_3-PMMA fiber with an antisymmetric long-period grating, Song Gao[1], Chams Baker[1], Liang Chen[1], Xiaoyi Bao[1]; [1]*Univ. of Ottawa, Canada*. We report sensitivity enhancement of temperature measurement by a factor of 4.0 based on effective group-velocity matching between the even and odd modes of a dual-core chalcogenide-PMMA taper that is inscribed with an antisymmetric long-period grating.

10:00–10:30 Coffee Break, *Concourse Level*

Marriott Salon IV

CLEO: Science & Innovations

SF1N • Ultrafast Mid-IR Sources—Continued

SF1N.6 • 09:30
High Power Offset-free Ultrafast Mid-IR Source Harnessing SPM-enabled Spectral Selection, Gengji Zhou[1,2], Franz X. Kaertner[1,2], Guoqing Chang[1,2]; [1]*CFEL,DESY, Germany;* [2]*Physics Dept., Universität Hamburg, Germany.* We demonstrate a novel fiber approach for power scaling difference-frequency-generation based ultrafast mid-IR laser sources that are tunable from 7.4 μm to 16.8 μm with up to 5.3-mW average power at 9.3 μm.

SF1N.7 • 09:45
High-Power Harmonic Frequency Comb Covering the Mid-Infrared Molecular Fingerprint Region, Christian Gaida[1], Tobias Heuermann[1,2], Martin Gebhardt[1,2], Thomas Butler[3], Daniel Gerz[4], Lenard Vamos[4], Ferenc Krausz[3,4], Jens Limpert[1,5], Ioachim Pupeza[3]; [1]*Inst. of Applied Physics, Germany;* [2]*Helmoltz-Inst. Jena, Germany;* [3]*Max Planck Inst. of Quantum Optics, Germany;* [4]*Ludwig Maximilians Univ. Munich, Germany;* [5]*Fraunhofer Inst. for Applied Optics and Precision Engineering, Germany.* We present a multi-channel, 0.1 mW/THz-level, 50 MHz-repetition-rate harmonic frequency comb covering the spectral range 18.5 – 85 THz (or 3.5 – 16 μm, or 625 – 2860 cm-1), based on intrapulse difference-frequency mixing within few-cycle, high-power 1.96 μm pulses.

Marriott Salon VI

CLEO: QELS-Fundamental Science

FF1P • Attosecond and X-Ray Spectroscopy—Continued

FF1P.6 • 09:30
Ultrafast Photo-Isomerization Dynamics Probed via Time-Resolved High-Harmonic Spectroscopy, Keisuke Kaneshima[1], Yuki Ninota[1], Taro Sekikawa[1]; [1]*Division of Applied Physics, Hokkaido Univ., Japan.* Time-resolved high-harmonic spectroscopy (TR-HHS) of the photo-isomerization dynamics of 1,3-cyclohexadiene is demonstrated. The present results show that TR-HHS can track both the electronic and the nuclear dynamics, and is useful for unveiling ultrafast photochemical reactions.

Marriott Willow Glen

CLEO: Applications & Technology

AF1Q • A&T Topical Review on Scientific and Commercial Progress in Semiconductor Laser Technology II—Continued

AF1Q.6 • 09:30
Room Temperature Operation of Directly Patterned Perovskite Distributed Feedback Light Source under Continuous-Wave Optical Pumping, Abouzar Gharajeh[1], Ross Haroldson[1], Zhitong Li[1], Jiyoung Moon[1], Balasubramaniam Balachandran[1], Walter Hu[1,2], Anvar Zakhidov[1,3], Qing Gu[1]; [1]*The Univ. of Texas at Dallas, USA;* [2]*Microelectronics Dept., Fudan Univ., China;* [3]*ITMO Univ., Russia.* We report the first directly patterned perovskite distributed feedback (DFB) resonator with a narrow amplified spontaneous emission (ASE) at pump powers as low as 0.1W/cm^2, under continuous-wave (CW) optical pumping condition at room temperature.

AF1Q.7 • 09:45
Unusual Scaling Laws for Plasmonic Nanolasers, Suo Wang[1], Xing-Yuan Wang[1], Hua-Zhou Chen[1], Yi-Lun Wang[1], Lun Dai[1], Rupert Oulton[2], Renmin Ma[1]; [1]*Peking Univ., China;* [2]*Imperial College London, UK.* We report unusual scaling laws allowing plasmonic lasers with superior performances over photonic lasers at the nanoscale, which clarifies the long-standing debate over the viability of metal confinement and feedback strategies in laser technology.

10:00–10:30 Coffee Break, *Concourse Level*

CLEO: Science & Innovations

10:30–12:30
SF2A • Nonlinear Photonics in Integrated Structures
Presider: Gregory Moille; NIST/ UMD, USA

SF2A.1 • 10:30
Quantum frequency conversion using nanophotonics, Qing Li[1,2], Anshuman Singh[1,2], Xiyuan Lu[1,2], Varun Verma[3], Richard Mirin[3], Sae Woo Nam[3], Kartik Srinivasan[1]; [1]*CNST, NIST, USA;* [2]*Univ. of Maryland, USA;* [3]*PML, NIST, USA.* We demonstrate quantum frequency conversion of photon pairs, with both pair generation and frequency conversion implemented in Si_3N_4 microrings. Quantum correlations between the signal and idler are preserved, with an on-chip conversion efficiency around 25%.

SF2A.2 • 11:00
Observation of Second Harmonic and Sum Frequency in an Optically Poled Si3N4 Waveguide, Davide Grassani[1], Adrien Billat[1], Martin Pfeiffer[2], Tobias J. Kippenberg[2], Camille-Sophie Bres[1]; [1]*Photonic System Lab (PHOSL), Ecole Polytechnique Federale de Lausanne, Switzerland;* [2]*Lab for Photonics and Quantum Measurements (LPQM), Ecole Polytechnique Federale de Lausanne, Switzerland.* Enhanced second order nonlinear processes in a Si3N4 waveguide following optically induced $\chi(2)$ is demonstrated, enabling the detection of a frequency doubled pulsed train and SFG with >-37 dB conversion efficiency for 18 W pump peak power.

Joint

10:30–12:30
JF2B • Symposium on Emerging Quantum Sensing Techniques and Applications I
Presider: TBD

JF2B.1 • 10:30 Invited
Quantum Sensing and Imaging with Diamond Spins, Ania Bleszynski Jayich[1], Alec Jenkins[1], Susanne Baumann[1], Dolev Bluvstein[1], Simon Meynell[1], Amila Ariyaratne[1]; [1]*Univ. of California Santa Barbara, USA.* The diamond nitrogen-vacancy (NV) center quantum sensor features excellent spatial resolution, sensitivity, and versatility. I discuss recent developments in NV-based imaging of condensed matter systems and ongoing developments in improving the NV center's functionality.

JF2B.2 • 11:00 Invited
Quantum Metrology with Rydberg Atoms, Sebastien Gleyzes[1], Eva-Katharina Dietsche[1], Arthur Larrouy[1], Serge Haroche[1], Jean-Michel Raimond[1], Michel Brune[1]; [1]*Laboratoire Kastler Brossel, Collège de France, CNRS, ENS-PSL Univ., Sorbonne Université, France.* I will present how we can use non-classical states of Rydberg atom to measure fast variations of the electric or magnetic field with a precision close to the Heisenberg limit.

10:30–12:30
JF2C • Symposium on Lasers in Accelerator Science and Technology II
Presider: Peter Hommelhoff, Friedrich-Alexander-Universität Erlangen, Germany

JF2C.1 • 10:30 Invited
Laser-shaping of Electron Beams for X-ray Free-electron Laser Applications, Agostino Marinelli[1]; [1]*SLAC National Accelerator Lab, USA.* From seeding to laser-based electron bunch compression, to the generation of attosecond X-ray pulses, conventional lasers are ubiquitous in X-ray free-electron laser facilities. In my talk I will give an overview of advanced XFELs schemes involving the use of high-power lasers.

JF2C.2 • 11:00
Multi-kW Average Power Thin Disk -Slab Ti:Sa Amplifiers, Vladimir V. Chvykov[1], Roland Nagymihály[1], Huabao Cao[1]; [1]*ELI-HU Non-Profit Ltd., Hungary.* Ti:Sapphire thin disc is suitable for ultrafast lasers of kWs average power, Js pulse energy. Simulations show the changing geometry of direct CWdiodes pumped amplifiers from TD to slab can improve efficiency and heating extraction.

CLEO: QELS-Fundamental Science

10:30–12:30
FF2D • THz Electrodynamics and control of Electronic Degrees of Freedom
Presider: Bachana Lomsadze; Univ. of Michigan, USA

FF2D.1 • 10:30
Coherent Terahertz Excitation of Magnons to 30 T, Gary T. Noe[1], Xinwei Li[1], Jeffrey Horowitz[1], Katsumasa Yoshioka[2], Ning Yuan[3], Maolin Xiang[3], Kai Xu[3], Zuanming Jin[3], Shixun Cao[3], Hiroyuki Nojiri[4], Ikufumi Katayama[2], Jun Takeda[2], Dmitry Turchinovich[5,6], Junichiro Kono[1]; [1]*Rice Univ., USA;* [2]*Yokohama National Univ., Japan;* [3]*Shanghai Univ., China;* [4]*Tohoku Univ., Japan;* [5]*Univ. Duisburg-Essen, Germany;* [6]*Max Planck Inst. for Polymer Research, Germany.* We have performed terahertz time-domain magneto-spectroscopy measurements on canted antiferromagnet $YFeO_3$ in pulsed high magnetic fields up to 30 T, observing coherent magnon oscillations and frequency splitting.

FF2D.2 • 10:45
Magneto –THz spectroscopy in spinel superconductors $LiTi_2O_4$ thin films, Yue Huang[1], Jie Yuan[2], Kui Jin[2], Wei Zhang[1], Kimberly Reichel[1], Daniel M. Mittleman[1]; [1]*Brown Univ., USA;* [2]*Inst. of Physics,Chinese Academy of Sciences, China.* We observed a clear superconducting gap at 2.0meV and a coherent peak in the strong spin fluctuation compounds $LiTi_2O_4$ using continues wave (CW) terahertz spectroscopy. The superconducting state was strongly suppressed by magnetic fields.

FF2D.3 • 11:00 Invited
Quantum Manipulation of Competing Phases by Terahertz Pulses, Jigang Wang[1]; [1]*Iowa State Univ., USA.* We reveal a hidden quantum phase of prethermalized, gapless electron fluid, which evolvesfollowing single-cycle, resonant terahertz quench of the SC gap above a critical fluence and implies novel organization principles beneath superconductivity.

CLEO: QELS-Fundamental Science

10:30–12:30
FF2E • Novel Nonlinear Optical Materials
Presider: David Hagan; CREOL, Univ. of Central Florida, USA

FF2E.1 • 10:30
Enhancement Mechanism of Nonlinear Optical Response of Transparent Conductive Oxides at Epsilon-Near-Zero, Sepehr Benis[1], David J. Hagan[1], Eric W. Van Stryland[1]; [1]*Univ. of Central Florida, CREOL, USA.* Transient nondegenerate nonlinear refraction of Indium Tin Oxide has been characterized in the near-infrared using femtosecond Beam-Deflection with independently tuned excitation and probe. ENZ enhancement depends more strongly on the probe wavelength than the excitation.

FF2E.2 • 10:45
Graphene Electrically Tuneable Third Harmonic Generation, Giancarlo Soavi[1], Gang Wang[1], Habib Rostami[2], David Purdie[1], Domenico De Fazio[1], Teng Ma[1], Birong Luo[1], Junjia Wang[1], Anna K. Ott[1], Duhee Yoon[1], Sean Bourelle[1], Jakob E. Muench[1], Ilya Goykhman[3], Stefano Dal Conte[4], Michele Celebrano[4], Andrea Tomadin[5], Marco Polini[5], Giulio Cerullo[4], Andrea Ferrari[1]; [1]*Cambridge Graphene Centre, Univ. of Cambridge, UK;* [2]*Nordic Inst. for Theoretical Physic, Sweden;* [3]*Electrical Engineering, Israel Inst. of Technology, Israel;* [4]*Dipartimento di Fisica, Politecnico di Milano, Italy;* [5]*Istituto Italiano di Tecnologia, Graphene Labs, Italy.* Graphene displays electrically and broadband tunable third order nonlinear susceptibility. Third harmonic generation efficiency in graphene can be tuned by two orders of magnitude by controlling the Fermi energy and the incident photon energy.

FF2E.3 • 11:00
Electrically Tunable Nonlinear Refraction and Absorption in Graphene-covered SiN Waveguides, Koen Alexander[1,2], Bart Kuyken[1,2], Dries VanThourhout[1,2]; [1]*Photonics Research Group, INTEC, Ghent Univ.-imec, Belgium;* [2]*Center for Nano- and Biophotonics (NB-Photonics), Ghent Univ., Belgium.* The real and imaginary part of the third-order nonlinearity of a gate-tunable graphene-covered SiN waveguide are measured through cross-phase and cross-amplitude modulation. A strong dependence on pump-probe detuning and Fermi energy is demonstrated.

10:30–12:30
FF2F • Fundamental Nanophotonics: Sensing and Infrared Applications
Presider: Ognjen Ilic; California Inst. of Technology, USA

FF2F.1 • 10:30
Revisiting the Photon-Drag Effect in Thin Metal Films, Jared Strait[1], Glenn Holland[1], B. Robert Ilic[1], Amit K. Agrawal[1,2], Domenico Pacifici[1,3], Henri Lezec[1]; [1]*Center for Nanoscale Science and Technology, National Inst. of Standards and Technology, USA;* [2]*Maryland NanoCenter, Univ. of Maryland, USA;* [3]*School of Engineering and Dept. of Physics, Brown Univ., USA.* We demonstrate that the sign of the photon-drag effect in smooth gold films is crucially dependent on the surface environment and contrary to the prevailing intuitive model of direct momentum transfer to free electrons.

FF2F.2 • 10:45
Plasmon Drag Effect and Opportunities for Sensing Applications , Natalia Noginova[1], Tejaswini Ronurpraful[1], Nelly Jerop[1], David Keene[1], Maxim Durach[2]; [1]*Norfolk State Univ., USA;* [2]*Georgia Southern Univ., USA.* Photoinduced voltages in profile-modulated plasmonic surfaces demonstrate sharp dependence on the incidence angle and are very sensitive to dielectric environment, which provides opportunities for applications in compact plasmonic sensors with electrical detection.

FF2F.3 • 11:00
Optical Sensing with Anderson-Localized Light, Oliver J. Trojak[1], Tom Crane[1], Luca Sapienza[1]; [1]*Dept. of Physics and Astronomy, Univ. of Southampton, UK.* We demonstrate optical sensing with Anderson-localized visible light on scalable silicon nitride photonic crystal waveguides. For a refractive index change of ≈0.38, we measure 15.2 nm wavelength shifts of an optical resonance 0.15 nm broad.

CLEO: Science & Innovations

10:30–12:30
SF2G • Mid-infrared Semiconductor Lasers
Presider: Dan Botez; Univ. of Wisconsin-Madison, USA

SF2G.1 • 10:30
Dual-comb spectroscopy with passively mode-locked interband cascade laser frequency combs, Lukasz A. Sterczewski[1,2], Jonas Westberg[1], Mahmood Bagheri[2], Clifford Frez[2], Igor Vurgaftman[3], Chadwick Canedy[3], William W. Bewley[3], Charles D. Merritt[3], Chul Soo Kim[3], Mijin Kim[4], Jerry R. Meyer[3], Gerard Wysocki[1]; [1]*Princeton Univ., USA;* [2]*Jet Propulsion Lab, California Inst. of Technology, USA;* [3]*Naval Research Lab, USA;* [4]*Sotera Defense Solutions, USA.* We demonstrate dual comb spectroscopy using free running passively mode-locked interband cascade laser frequency combs by measuring methane around 3.6 μm with 100 μs acquisition time and an instantaneous optical bandwidth of 570 GHz.

SF2G.2 • 10:45
Ring Interband Cascade Lasers, Martin Holzbauer[1], Borislav Hinkov[1], Rolf Szedlak[1], Hermann Detz[2], Robert Weih[3], Sven Höfling[4,5], Werner Schrenk[1], Erich Gornik[1], Johannes Koeth[3], Gottfried Strasser[1]; [1]*TU Wien, Austria;* [2]*Austrian Academy of Sciences, Austria;* [3]*nanoplus Nanosystems and Technologies GmbH, Germany;* [4]*Univ. of Würzburg, Germany;* [5]*Univ. of St Andrews, UK.* We present ring-shaped interband cascade lasers with light emission through the GaSb substrate. Measurements of the projected nearfields revealed a radial polarization, owing to the nature of the optical interband transitions.

SF2G.3 • 11:00 Invited
Mid-IR Optoelectronic Devices Epitaxially Grown on Silicon, Eric Tournie[1]; [1]*Univ. of Montpellier, France.* Integrated optoelectronic devices are key technologies for Si photonics. I will review recent results in show that GaSb-based mid-IR devices epitaxially grown on Si substrates which exhibit high performances and are promising candidates for future on-chip sensing solutions.

CLEO: QELS-Fundamental Science

10:30–12:30
FF2H • Interference and Localization Phenomena in Complex Media
Presider: Alexey Yamilov; Missouri Univ. of Science & Technology, USA

FF2H.1 • 10:30
Wide spectral tuning range in an Anderson localizing fiber laser, Behnam Abaie[1], Thomas Hawkins[1,2], John Ballato[2], Arash Mafi[1]; [1]*Univ. of New Mexico, USA;* [2]*Clemson Univ., USA.* Wavelength sensitivity of Anderson localized modes in a disordered optical fiber is exploited to obtain a tunable fiber laser. The lasing wavelength varies upon excitation of various localized modes across the fiber.

FF2H.2 • 10:45
Eradicated Coherent Backscattering of Anderson Localized Modes, Alex Dikopoltsev[1], Hanan Herzig Sheinfux[2,1], Mordechai Segev[1]; [1]*Technion, Israel;* [2]*ICFO, Spain.* Coherent backscattering is a recognized precursor of Anderson localization. But, we show that waves in certain types of disordered potentials can undergo Anderson localization, without exhibiting any coherent backscattering at all

FF2H.3 • 11:00 Tutorial
Wave Engineering in Complex Media, Stefan Rotter[1]; [1]*Technische Universität Wien, Austria.* I will give an overview of new concepts for engineering light waves in complex media based on shaping either their external wave-front or the spatial structure of gain and loss components inside these media.

Stefan Rotter is professor for Theoretical Physics at Vienna University of Technology (TU Wien) in Austria. After studies in Vienna and Lausanne, he worked as a postdoc at Yale. Since 2011 he runs his own group focused on waves in disordered media, non-Hermitian physics, and quantum optics.

CLEO: Science & Innovations

CLEO: QELS-Fundamental Science

10:30–12:30
SF2I • Electrooptic and Nanophotonic Materials
Presider: Tian Gu; MIT, USA

SF2I.1 • 10:30
A Breakthrough leading to A New Type of E-O Materials Electro-Elasto-Optical Properties of EEO Crystals (PMN-PT Based Relax Ferroelectric Crystals) by Special Modifications, Pengdi Han[1]; [1]*EEOptics Corp., USA*. Important findings from a systematic investigation on Electro-Elasto-Optical characterization for PMN-PT based ferroelectric crystals. The new E-O material is biaxial EEO crystal with N_g=2.564, N_m=2.558, N_p=2.545, 2V=109° and effective EO-coefficient g_c over 300~600pm/V and V_p less than 100V.

SF2I.2 • 10:45
Periodic Poling of Ion-Sliced X-Cut Magnesium Oxide Doped Lithium Niobate Thin Films, Jonathan T. Nagy[1], Ronald M. Reano[1]; [1]*The Ohio State Univ., USA*. We fabricate and periodically pole 700 nm thick ion-sliced x-cut magnesium oxide doped lithium niobate thin films. Uniform domains with 50% duty cycle are imaged by piezo-response force microscopy.

SF2I.3 • 11:00
Ultrahigh-Q Lithium Niobate Microring Resonator, Mian Zhang[1], Cheng Wang[1], Rebecca Cheng[1,2], Amirhassan Shams-Ansari[1,3], Marko Loncar[1]; [1]*John A. Paulson School of Applied and Engineering Sciences, Harvard Univ., USA;* [2]*Dept. of Physics, Brown Univ., USA;* [3]*Dept. of Electrical Engineering and Computer Science, Howard Univ., USA*. We demonstrate ultralow loss monolithic integrated lithium niobate photonic platform consisting of dry-etched subwavelength waveguides. We show microring resonators with a quality factor of 10^7 and waveguides with propagation loss as low as 2.7 dB/m.

10:30–12:30
SF2J • Cavity Optomechanics
Presider: Karen Grutter; Univ. of Maryland at College Park, USA

SF2J.1 • 10:30
Optomechanically Mediated Wavelength Conversion in Diamond Microdisks, Matthew Mitchell[1,2], David P. Lake[1,2], Paul E. Barclay[1,2]; [1]*Inst. for Quantum Science & Tech., Canada;* [2]*NRC - National Inst. for Nanotechnology, Canada*. Optomechanically mediated wavelength conversion in a single-crystal diamond microdisk operating in the resolved sideband regime is demonstrated. Frequency down-conversion is demonstrated with an expected internal conversion efficiency of ~ 45%.

SF2J.2 • 11:00
Diamond Optomechanical Crystals at Cryogenic Temperatures, Cleaven Chia[1], Srujan Meesala[1], Nayera El-Sawah[1,2], Bartholomeus J. Machielse[3], Michael J. Burek[1], Marko Loncar[1]; [1]*John A. Paulson School of Engineering and Applied Sciences, Harvard Univ., USA;* [2]*Univ. of Waterloo, Canada;* [3]*Dept. of Physics, Harvard Univ., USA*. We investigate the properties of optomechanical crystals (OMCs) fabricated in single-crystal diamond in a cryogenic environment (T ~ 5K). We demonstrate high mechanical Q-factors (> 100,000) from localized OMC mechanical modes at 5 & 8 GHz, a 30x improvement from room temperature.

10:30–12:30
SF2K • Novel Fiber Technology
Presider: Sze Set; Univ. of Tokyo, Japan

SF2K.1 • 10:30 Invited
SNAP: Subangstrom Precise and Ultralow Loss Nanophotonic Platform, Misha Sumetsky[1]; [1]*Aston Univ., UK*. The review of fundamentals, recent results, and prospects of Surface Nanoscale Axial Photonics (SNAP), which includes ultralow-loss slow light delay lines and buffers, tunable, optomechanical and optofluidic microresonators, microlasers, and frequency comb generators, is presented.

SF2K.2 • 11:00
Harmonic SNAP Bottle Microresonators Produced via Tapering of Optical Fibers, Dashiell L. Vitullo[1], Gabriella Gardosi[1], Sajid Zaki[1], Kirill Tokmakov[1], Michael Brodsky[2], Misha . Sumetsky[1]; [1]*Aston Univ., UK;* [2]*U.S. Army Research Lab, USA*. We demonstrate fabrication of SNAP microresonators with parabolic profiles via fiber tapering with a laser-heated microfurnace. The developed method enables simple and convenient fabrication of prospective frequency comb generators and miniature dispersionless SNAP delay lines.

10:30–12:30
FF2L • Polaritons in 2D Materials
Presider: Peter Liu; Sandia National Labs Albuquerque, USA

FF2L.1 • 10:30
Valley-controlled directional coupling to plasmonic nanowire modes, Su-Hyun Gong[1,2], Filippo Alpeggiani[1,2], Beniamino Sciacca[2], Erik C. Garnett[2], Laurens K. Kuipers[1,2]; [1]*Delft Univ. of Technology, Netherlands;* [2]*AMOLF, Netherlands*. We demonstrate the valley(spin)-dependent directional emission of transition metal chalcogenides (TMDs) into plasmonic eigenstates of a silver nanowire through spin-orbit coupling of light.

FF2L.2 • 10:45
Topological Valley Transport of Infrared Plasmons on a Nanoscale in Metagate-tuned Graphene, Minwoo Jung[2], Zhiyuan Fan[1], Gennady Shvets[1]; [1]*School of Applied and Engineering Physics, Cornell Univ., USA;* [2]*Dept. of Physics, Cornell Univ., USA*. We propose a electrically tunable plasmonic platform for valleytronics---a monolayer graphene with its chemical potential controlled by a periodically structured metagate. Topologically protected edge states show reflection-free propagation around sharp corners.

FF2L.3 • 11:00
Inducing Indirect Optical Transitions Using Graphene Plasmons, Yaniv Kurman[1], Nicholas Rivera[2], Thomas Christensen[2], Shai Tsesses[1], Meir Orenstein[1], Marin Soljacic[2], John Joannopoulos[2], Ido Kaminer[1,2]; [1]*Electrical Engineering, Israel Inst. of Technology, Israel;* [2]*Physics, MIT, USA*. We show that graphene placed near a quantum-well induces a pronounced shift in the emission\absorption frequency. The high momenta of graphene plasmons reaches the electron's momenta, enabling indirect optical transitions and inducing structural nonlocal properties.

Marriott Salon III

CLEO: Applications & Technology

10:30–12:30
AF2M • Imaging & Microscopy
Presider: Kara Peters; North Carolina State Univ., USA

AF2M.1 • 10:30
Broadband spectral-focusing CARS of pharmaceutical drugs, Jeremy G. Porquez[1], Aaron D. Slepkov[1]; [1]*Trent Univ., Canada.* We apply supercontinuum-Stokes-based spectral-focusing CARS hypermicroscopy for chemical identification and 3D imaging of pharmaceutical powder samples. A wide spectral scan range, combined with facile epi-detection, allows for strong progress toward quantitative drug assaying with CARS.

AF2M.2 • 10:45
Distributed Pulsation Waveform Inspection to Radial Artery with Shadow Moiré fringe, Chun-Hsiung Wang[1], Yu-Hsiang Hsu[1], Shu-Sheng Lee[2], Wen-Jung Wu[1], Chih-Kung Lee[1]; [1]*National Taiwan Univ., Taiwan;* [2]*National Taiwan Ocean Univ., Taiwan.* A non-invasive full-field arterial-induced skin vibration inspection system is developed based on Shadow Moiré, 2D Continuous Wavelet Transform and Region of Interest techniques. Pulsation profiles obtained can be used for potential diagnostic use.

AF2M.3 • 11:00
Deep tissue, wide-field multiphoton imaging using TEMPPIX, Adria Escobet-Montalban[1], Roman Spesyvtsev[1], Mingzhou Chen[1], Wardiya Afshar[2], Melissa Andrews[3], Simon Herrington[4], Michael Mazilu[1], Kishan Dholakia[1]; [1]*School of Physics and astronomy, Univ. of St andrews, Univ. of St Andrews, UK;* [2]*School of Medicine, Univ. of St. Andrews, UK;* [3]*Biological Sciences, Univ. of Southampton, UK;* [4]*Inst. of Genetics and Molecular Medicine, Univ. of Edinburgh, UK.* We demonstrate a new approach, temporal focusing microscopy with single-pixel detection (TEMPPIX), for wide-field multiphoton imaging through scattering media without any *a priori* knowledge or requirement to determine the properties of the media.

Marriott Salon IV

CLEO: Science & Innovations

10:30–12:30
SF2N • Ultrafast Oscillators
Presider: Bojan Resan; Univ. of Applied Sciences FHNW, Switzerland

SF2N.1 • 10:30
Sub-100 fs pulse generation from a Tm,Ho:CALYO laser mode-locked by a GaSb-based SESAM at ~2043 nm, Yongguang Zhao[2,1], Yicheng Wang[2], Xuzhao Zhang[3], Xavier Mateos[3], Zhongben Pan[4,2], Pavel Loiko[5], Wei Zhou[1], Xiaodong Xu[1], Xu Jun[6], Deyuan Shen[1], Soile Suomalainen[7], Antti Härkönen[7], Mircea D. Guina[7], Uwe Griebner[2], Valentin Petrov[2]; [1]*Jiangsu Normal Univ., Germany;* [2]*Max-Born-Inst. for Nonlinear Optics and Ultrafast Spectroscopy, Germany;* [3]*Universitat Rovira i Virgili (URV), Spain;* [4]*China Academy of Engineering Physics, China;* [5]*ITMO Univ., Russia;* [6]*Tongji Univ., China;* [7]*Tampere Univ. of Technology, Finland.* We report on the first sub-100-fs mode-locked Ho^{3+}-laser in the 2-μm spectral range. The disordered co-doped Tm,Ho:$CaYAlO_4$ (Tm,Ho:CALYO) crystal produced pulses as short as 87 fs with 27-mW average output power at 80.45-MHz repetition rate.

SF2N.2 • 10:45
Sub-120 fs Kerr-lens Mode-locked Tm:Sc_2O_3 Laser In-band pumped by an Er;Yb fiber MOPA, Masaki Tokurakawa[1], Eisuke Fujita[1], Christian Kraenkel[2,3]; [1]*Univ. of Electro-communications,ILS, Japan;* [2]*Zentrum für Lasermaterialien, Leibniz-Institut für Kristallzüchtung,, Germany;* [3]*Institut für Laser-Physik, Universität Hamburg, Germany.* We demonstrate a Kerr-lens mode-locked Tm:Sc_2O_3 laser in-band pumped by a 1611 nm Er-fiber laser. 115 fs pulses with 42.6 nm spectral bandwidth are obtained. The output power and repetition rate are 420 mW and 95 MHz, respectively.

SF2N.3 • 11:00 Invited
Frontiers in Ultrafast Thin-Disk Laser Oscillators, Clément Paradis[1], Norbert Modsching[1], Maxim Gaponenko[1], François Labaye[1], Valentin J. Wittwer[1], Thomas Südmeyer[1]; [1]*Laboratoire Temps-Fréquence, Université de Neuchâtel, Switzerland.* Ultrafast thin-disk lasers continue achieving higher average powers and pulse energies than other oscillator technologies. We discuss performance scaling and the ongoing race towards shorter durations, which recently resulted in 30-fs from Yb-based thin-disk lasers.

Marriott Salon VI

CLEO: QELS-Fundamental Science

10:30–12:30
FF2P • High-order Harmonic Generation in Solids
Presider: Alexis Chacon; Los Alamos National Lab , USA

FF2P.1 • 10:30 Tutorial
High Harmonics from Solids and Gases., Paul B. Corkum[1,2]; [1]*Univ. of Ottawa, Canada;* [2]*National Research Council of Canada, Canada.* Experiments and models show that intense light irradiating transparent solids or gases creates a sequence of harmonics extending to photon energies >1 keV in gases and >H29 in solids. The same process creates attosecond pulses.

Corkum holds a Canada Research Chair at the University of Ottawa and directs the Joint NRC/University of Ottawa Attosecond Science Laboratory. He is a member of the Royal Societies of London and of Canada, also a foreign member of the US National Academy of Science and of the Austrian Academy of Science.

Marriott Willow Glen

CLEO: Applications & Technology

10:30–12:30
AF2Q • A&T Topical Review on Time-Stretch Technology: Principles and Applications I
Presider: Hongwei Chen; Tsinghua University, China

AF2Q.1 • 10:30 Invited
Real-time Measurements of Nonlinear Instabilities in Optical Fibers, Piotr Ryczkowski[1], Mikko Närhi[1], Cyril Billet[2], Jean-Marc Merolla[2], John M. Dudley[2], Goëry Genty[1]; [1]*Tampereen Teknillinen Yliopisto , Finland;* [2]*Institut FEMTO ST, France.* We review recent advances in the real-time characterization of instabilities in nonlinear fiber optics systems. In particular, we show how these techniques can provide novel insight into the dynamics of ultrafast complex optical systems.

AF2Q.2 • 11:00 Invited
Demonstration of GHz-band RF receiver and spectrometer using random speckle patterns, Adam Scofield[1]; [1]*The Aerospace Corporation, USA.* We report experimental demonstrations of compressive sensing with photonic systems in which the measurement matrices are implemented using speckle in multimode waveguides. We calibrate by measuring a dictionary of single frequency RF sinusoids.

CLEO: Science & Innovations

SF2A • Nonlinear Photonics in Integrated Structures—Continued

SF2A.3 • 11:15
Broadband parametric down-conversion in an X-cut lithium niobate microresonator, Rui Luo[1], Haowei Jiang[1,2], Steven Rogers[1], Hanxiao Liang[1], Yang He[1], Qiang Lin[1]; [1]*Univ. of Rochester, USA;* [2]*Shanghai Jiao Tong Univ., China.* We report spontaneous parametric down-conversion with a bandwidth of about 400 nm in a high-Q lithium niobate microdisk resonator. The broadband feature is enabled by cyclic phase matching in an X-cut microresonator.

SF2A.4 • 11:30
Four-Wave Mixing in GaN Waveguides, Dvir Munk[1], Moshe Katzman[1], Ohad Westreich[3,2], Moran Bin Nun[2], Yedidya Lior[2], Noam Sicron[3], Yossi Paltiel[2], Avi Zadok[1]; [1]*Bar-Ilan Univ., Israel;* [2]*Hebrew Univ., Israel;* [3]*Soreq NRC, Israel.* Four-wave mixing at 1550 nm wavelength is demonstrated in a GaN ridge waveguide for the first time. A nonlinear coefficient of 1.6±0.45 $[W*m]^{-1}$ is measured. The nonlinear parameter of GaN is estimated as 3.4±1e-18 $[m^2/W]$.

SF2A.5 • 11:45
CMOS-compatible, low-loss deuterated silicon nitride photonic devices for optical frequency combs, Jeff Chiles[1], Nima Nader[1], Daniel Hickstein[1], Su Peng Yu[1], Travis C. Briles[1], David R. Carlson[1], Hojoong Jung[1], Jeffrey Shainline[1], Scott A. Diddams[1], Scott Papp[1], Sae Woo Nam[1], Richard Mirin[1]; [1]*NIST, USA.* We demonstrate plasma-deposited (temperature < 300°C), deuterated silicon nitride waveguides with 0.22 dB/cm propagation loss at λ = 1552 nm. Pumping at λ = 1560 nm, we obtain a 550 nm-bandwidth Kerr-microcomb and octave-spanning supercontinuum.

Joint

JF2B • Symposium on Emerging Quantum Sensing Techniques and Applications I—Continued

JF2B.3 • 11:30
Atomic Force Microscopy Beyond the Standard Quantum Limit, Benjamin Lawrie[1], Raphael C. Pooser[1]; [1]*Quantum Information Science Group, Oak Ridge National Lab, USA.* We explore the impact of quantum noise reduction on force microscopy for broadband off-resonant materials characterization by integrating a multi-spatial-mode squeezed state as the readout field in a commercially available microscope.

JF2B.4 • 11:45
Quantum Enhanced Joint Multi-Parameter Measurement, Jiamin Li[1], Yuhong Liu[1], Liang Cui[1], Nan Huo[1], Xiaoying Li[1], Z.Y. Ou[2,1]; [1]*Tianjin Univ., China;* [2] *Indiana Univ.-Purdue Univ. Indianapolis, USA.* We study simultaneously measure the multiple non-commuting observables by using the SU(1,1) nonlinear interferometer, and show that joint measurement of each non-commuting observables can achieve a sensitivity beating the standard quantum limit.

JF2C • Symposium on Lasers in Accelerator Science and Technology II—Continued

JF2C.3 • 11:15
Laser Heater Shaping for Microbunching Instability Suppression in Free Electron Lasers, Nikolas Liebster[1,2], Jingyi Tang[1,2], Zhirong Huang[1,2], Daniel Ratner[1,2], Wei Liu[1,2], Sharon Vetter[1,2], Sergio Carbajo[1,2]; [1]*SLAC National Accelerator Lab, USA;* [2]*Stanford Univ., USA.* We present two laser heater shaping solutions based on Laguerre-Gaussian and discrete beamlet array distributions that significantly outperform current microbunching instability suppression approaches in free-electron lasers

JF2C.4 • 11:30 Invited
Light Sources from Laser Wakefield Acceleration: Development and Applications., Félicie Albert[1]; [1]*Lawrence Livermore National Lab, USA.* This talk reviews x-ray and gamma-ray sources driven by laser wakefield acceleration. They provide broadband radiation from keV to MeV energies, and can be used for applications in high energy density science.

CLEO: QELS-Fundamental Science

FF2D • THz Electrodynamics and control of Electronic Degrees of Freedom—Continued

FF2D.4 • 11:30
Ultrafast Semiconducting to Metallic Terahertz Responses in the Topological Insulator Bi_2Se_3, Seungmin Lee[1], Sangwan Sim[1], Jisoo Moon[2], Soonyoung Cha[1], Hoseung Shin[1], Soohyun Park[1], Woosun Jang[3], Myungwoo Son[4], Hyunseung Jung[5], Seung Young Seo[6], Aloysius Soon[3], Moon-Ho Ham[4], Hojin Lee[5], Moon-Ho Jo[6,7], Seongsik Oh[2], Hyunyong Choi[1]; [1]*School of Electrical and Electronic and Engineering, Yonsei Univ., South Korea;* [2]*Dept. of Physics and Astronomy, Rutgers, The State Univ. of New Jersey, USA;* [3]*Dept. of Materials Science and Engineering, Yonsei Univ., South Korea;* [4]*School of Materials Science and Engineering, Gwangju Inst. of Science & Technology (GIST), South Korea;* [5]*School of Electronic Engineering, Soongsil Univ., South Korea;* [6]*Dept. of Materials Science and Engineering, Pohang Univ. of Science and Technology (POSTECH), South Korea;* [7]*Division of Advanced Materials Science, Pohang Univ. of Science and Technology (POSTECH), South Korea.* We present the photoinduced terahertz responses of topological insulators Bi_2Se_3. The photoconductance sign is determined by the competition between the topological surface state and the bulk response in *n*-type, *p*-type and bulk-insulating Bi_2Se_3.

FF2D.5 • 11:45
Formation Dynamics of Indirect Excitons and Electron Hole Droplets in InSb, Xu Yang[1,2], Chirag Vaswani[1,2], Xin Zhao[1,2], Yongxin Yao[1,2], Cai-Zhuang Wang[1,2], Kai-Ming Ho[1,2], Jigang Wang[1,2]; [1]*Iowa State Univ., USA;* [2]*Ames Lab, USA.* Direct band-gap semiconductor InSb is studied under intense electric fields leading to impact ionization followed by intervalley scattering. Further, fast formation of indirect excitons and Electron Hole Droplets(EHDs) is shown by time-resolved conductivity measurements.

CLEO: QELS-Fundamental Science

FF2E • Novel Nonlinear Optical Materials—Continued

FF2E.4 • 11:15
Nanophotonic Waveguides for Extreme Nonlinear Optics, Dan Hickstein[1], David R. Carlson[1], Abijith Kowligy[1], Scott Domingue[2], Matt Kirchner[2], Henry Timmers[1], Nima Nader[1], Alex Lind[1], Hairun Guo[3], Clemens Herkommer[3], Tobias J. Kippenberg[3], Margaret Murnane[4,2], Henry Kapteyn[4,2], Scott Papp[1,5], Scott A. Diddams[1,5]; *[1]NIST, USA; [2]KM-Labs, USA; [3]Ecole Polytechnique Federale de Lausanne , Switzerland; [4]JILA - Univ. of Colorado and NIST, USA; [5]Physics, Univ. of Colorado, USA.* We demonstrate nanophotonic waveguides for mid-infrared supercontinuum generation and high-harmonic generation. The waveguide geometry enables phase-matching of harmonic generation to higher-order modes. Simulations reveal how periodic poling enables harmonic generation through a cascaded mechanism.

FF2E.5 • 11:30
Photorefraction quenching in high quality $LiNbO_3$ photonic crystal nanocavities, Hanxiao Liang[1], Rui Luo[1], Mingxiao Li[1], Yang He[1], Haowei Jiang[1]; *[1]Univ. of Rochester, USA.* We report extremely strong cavity tuning by photorefraction in $LiNbO_3$ photonic crystal nanocavities, with a tuning rate up to ~84 MHz/photon. In particular, we report for the first time intriguing quenching of photorefraction in these devices.

FF2E.6 • 11:45
Broadband mid-infrared frequency combs in quasi-phase-matched lithium niobate waveguides, Abijith Kowligy[1], Alex Lind[1,2], Henry Timmers[1], Dan Hickstein[1], David R. Carlson[1], Nima Nader[3], Flavio Cruz[1], Gabriel Ycas[3], Scott Papp[1], Scott Diddams[1]; *[1]Time and Frequency Division, NIST, USA; [2]Dept. of Physics, Univ. of Colorado, USA; [3]Applied Physics Division, NIST, USA.* We experimentally demonstrate broadband mid-infrared (3–5 mm) frequency combs in quasi-phase-matched lithium niobate waveguides leveraging cascaded-$c^{(2)}$ supercontinuum generation and difference-frequency generation pumped by an Er:fiber laser.

FF2F • Fundamental Nanophotonics: Sensing and Infrared Applications—Continued

FF2F.4 • 11:15
Narrowband Plasmonic Metamaterial Absorber Integrated Pyroelectric Detectors Towards Infrared Gas Sensing, Xiaohao Tan[1], Junyu Li[1], Ao Yang[1], Huan Liu[1], Fei Yi[1,2]; *[1]School of Optical and Electronic Information, Huazhong Univ. of Science and Technology, China; [2]Shenzhen R & D Center of Huazhong Univ. of Science and Technology, China.* We proposed using narrowband absorption filter integrated lithium tantalite (LT) based pyroelectric detector array as spectroscopic sensor for NDIR gas sensing. Measured absorption spectra of the narrowband absorber and calculated thermal responses are provided.

FF2F.5 • 11:30
Sub-wavelength field enhancement in mid-IR: Photonics vs Plasmonics vs Phononics, Tengfei Li[1], Vivek Nagal[2], David Gracias[2], Jacob Khurgin[1]; *[1]Electrical and Computer Engineering, Johns Hopkins Univ., USA; [2]Chemical and Biomolecular Engineering, Johns Hopkins Univ., USA.* We compare different means for the mid-infrared light enhancement on sub-wavelength scale. Depending on whether the magnitude of the bandwidth of enhancement is important, metallic or phononic structures are preferable.

FF2F.6 • 11:45
Metal-insulator-metal Metamaterial Absorbers with Optical Absorption Tailored by Embedded Phonons, Junyu Li[1], Rulei Gan[1], Huan Liu[1], Fei Yi[1,2]; *[1]School of Optical and Electronic Information, Huazhong Univ. of Science and Technology, China; [2]Shenzhen R & D Center of Huazhong Univ. of Science and Technology, China.* We demonstrated that the coupling of the plasmonic resonances of gold nanodisk antennae and naonrod antennae with the optical phonons in the dielectric spacer such as SiO_2, Si_3N_4 and PDMS can broaden the absorption band.

CLEO: Science & Innovations

SF2G • Mid-infrared Semiconductor Lasers—Continued

SF2G.4 • 11:30
InP-based Quantum Cascade Lasers Monolithically Integrated onto Si and GaAs Substrates, Rowel Go[1], H. Krysiak[2], M. Fetters[2], Pedro Figueiredo[1], Matthew Suttinger[1], Jason Leshin[1], X. M. Fang[2], Joel Fastenau[2], D. Lubyshev[2], Amy Liu[2], A. Eisenbach[2], M. Furlong[2], Arkadiy Lyakh[1]; *[1]Univ. of Central Florida, USA; [2]IQE, USA.* Operation of InP-based quantum cascade lasers (QCL) processed from structures grown on 6-inch Si and GaAs substrates with metamorphic buffers are reported. Results pave the way for the development of ultra-compact Si-based platforms comprising QCLs.

SF2G.5 • 11:45
Monolithic integration of mid-infrared quantum cascade lasers coupled with passive InGaAs waveguides, Seungyong Jung[2,1], Daniele Palaferri[1], Jiaming Xu[1], Feng Xie[3], Yae Okuno[3], Christopher Pinzone[3], Kevin Lascola[3], Mikhail A. Belkin[1]; *[1]Univ. of Texas at Austin, USA; [2]TransWave Photonics, LLC, USA; [3]Thorlabs Quantum Electronics , USA.* We experimentally demonstrate lasing and mode coupling of mid-infrared quantum cascade lasers monolithically integrated with passive InGaAs waveguides for integrated-photonics applications. A waveguide-coupled device produced 30 mW peak power with J_{th}=3.5 kA/cm^2 at room-temperature.

CLEO: QELS-Fundamental Science

FF2H • Interference and Localization Phenomena in Complex Media—Continued

CLEO: Science & Innovations

CLEO: QELS-Fundamental Science

SF2I • Electrooptic and Nanophotonic Materials—Continued

SF2I.4 • 11:15
Foundry-compatible Hybrid Silicon / Lithium Niobate Electro-Optic Modulator, Peter Weigel[1], Jie Zhao[1], Douglas Trotter[2], Dana Hood[2], John Mudrick[2], Christina Dallo[2], Andrew Pomerene[2], Andrew Starbuck[2], Christopher DeRose[2], Anthony Lentine[2], Shayan Mookherjea[1]; [1]*Univ. of California San Diego, USA;* [2]*Applied Microphotonic Systems, Sandia National Labs, USA.* A foundry-compatible hybrid silicon-lithium niobate electro-optic modulator with an optical bandwidth greater than 6 GHz is presented. Wafer-scale photolithography processing is used to fabricate silicon features before bonding to a 600 nm lithium niobate film.

SF2I.5 • 11:30
Measurement of Nonlinear Refractive Index of Solids in the Mid-Infrared, Gauri Patwardhan[1,2], Jared Ginsberg[2], M. Mehdi Jadidi[2], Xiaohui Gao[2], Alexander L. Gaeta[2]; [1]*Applied and Engineering Physics, Cornell Univ., USA;* [2]*Applied Physics and Applied Mathematics, Columbia Univ., USA.* We report experimental measurements of nonlinear refractive index of solids in the mid-infrared. Here we present our results for fused silica at wavelength of 2.3 and 3.5 um, and for silicon at 2.3 um.

SF2I.6 • 11:45
Super Absorbing Nano-gap Metasurface With Sub-5-nm Gaps for Extreme Light Confinement, Dengxin Ji[1], Alec R. Cheney[1], Nan Zhang[1], Haomin Song[1], Jun Gao[2], Xie Zeng[1], Haifeng Hu[3], Suhua Jiang[2], Zongfu Yu[4], Qiaoqiang Gan[1]; [1]*Univ. at Buffalo, USA;* [2]*Fudan Univ., China;* [3]*Northeastern Univ., China;* [4]*Univ. of wisconsin-madison, USA.* We report a metamaterial super absorber structure with sub-5-nm gaps fabricated using atomic layer deposition processes for extreme light confinement. Light trapping efficiency of 81% is experimentally demonstrated at mid-infrared wavelengths.

SF2J • Cavity Optomechanics—Continued

SF2J.3 • 11:15
High Harmonic Generation Via an Electro-Optomechanical Oscillator, Turker Beyazoglu[1], Clark T. Nguyen[1]; [1]*UC Berkeley, USA.* We present an Electro-Opto-Mechanical Oscillator achieving 270 harmonics from a 37-MHz mechanical oscillation, more than 2x larger in harmonic number and 1000x higher in frequency compared to the previous mark. This is achieved by producing large oscillation amplitude with a unique device design

SF2J.4 • 11:30
NEMS with Co-Localized Optical and Electric Forces, Marcel W. Pruessner[1], Doewon Park[1], Dmitry Kozak[1], Todd Stievater[1], William Rabinovich[1]; [1]*US Naval Research Lab, USA.* Recently, there has been significant interest in nano-electro-mechanics (NEMS). By co-localizing optical and electric actuation, enhanced functionality can be achieved. We demonstrate NEMS-cavity tuning using electric forces and NEMS-resonance excitation using optical forces.

SF2J.5 • 11:45
Reconfigurable Optical Circulator In An Optomechanical Microresonator, Zhen Shen[1], Yan-Lei Zhang[1], Yuan Chen[1], Fang-Wen Sun[1], Xu-Bo Zou[1], Guang-Can Guo[1], Chang-Ling Zou[1], Chun-Hua Dong[1]; [1]*Univ. of Science and Technology of China, China.* We experimentally demonstrate a reconfigurable non-reciprocal device with alternative functions as either a circulator or a directional amplifier via optomechanically induced coherent photon-phonon conversion or gain.

SF2K • Novel Fiber Technology—Continued

SF2K.3 • 11:15 Invited
Ultra-low Loss Silica Core Fiber for Long Haul Transmission, Yoshiaki Tamura[1], Hirotaka Sakuma[1], Yoshinori Yamamoto[1], Takemi Hasegawa[1]; [1]*Sumitomo Electric Industry,, Japan.* We review recent advances in optical fiber technologies that realize ultra-low losses as low as 0.142 dB/km including pure-silica core and reduction of microscopic density fluctuation.

SF2K.4 • 11:30
Integration of High-performance Optoelectronic Nanowire-based Devices at Optical Fiber Tips, Wei Yan[1], Tapajyoti Das Gupta[1], Inès Richard[1], Fabien Sorin[1]; [1]*Ecole Polytechnique Federale de Lausanne, Switzerland.* We establish a facile and robust approach to integrate high-performance semiconducting nanowire-based optoelectronic devices at optical fiber tips. The multi-functional fibers exhibit excellent optical and optoelectronic properties, leading to unique applications in fluorescence imaging.

FF2L • Polaritons in 2D Materials—Continued

FF2L.4 • 11:15
Ultrafast and energy-efficient all-optical modulator based on deep-subwavelength graphene-loaded plasmonic waveguides, Masaaki Ono[1,2], Masanori Hata[2,3], Masato Tsunekawa[2,3], Kengo Nozaki[1,2], Hisashi Sumikura[1,2], Masaya Notomi[1,2]; [1]*Nanophotonics Center, NTT Corporation, Japan;* [2]*NTT Basic Research Labs, NTT Corporation, Japan;* [3]*Dept. of Physics, Tokyo Inst. of Technology, Japan.* We have demonstrated ultracompact all-optical modulators by deep-subwavelength graphene-loaded plasmonic waveguides (60 x 40 nm^2), and achieved an ultrafast response time (2.2 ps) with a substantially small consumption energy (155 fJ) for the first time.

FF2L.5 • 11:30
Graphene-induced tunable Lamb shifts beyond atomic fine structure, Cyuan-Han Chang[1], Nicholas Rivera[1], John Joannopoulos[1], Marin Soljacic[1], Ido Kaminer[1,2]; [1]*Dept. of Physics, MIT, USA;* [2]*Dept. of Electrical Engineering, Israel Inst. of Technology, Israel.* We show that highly tunable atomic energy levels can be achieved by exploiting plasmonic Lamb shifts. The shifts can be larger than fine-structure shifts and potentially larger than the Coulomb interactions at certain Fermi energies.

FF2L.6 • 11:45
Broadband Negative Refraction of Hyperbolic Highly Squeezed Graphene Plasmons, Jing Jiang[1], Xiao Lin[1], Yi Yang[2], Ido Kaminer[3], Marin Soljacic[3], Baile Zhang[1]; [1]*Nanyang Technological Univ., Singapore;* [2]*Electrical Engineering and Computer Science, MIT, USA;* [3]*Physics, MIT, USA.* The array of graphene nanoribbons provides a versatile platform to enable all-angle negative refraction of hyperbolic highly squeezed graphene plasmons in a broad bandwidth.

AF2M • Imaging & Microscopy—Continued

AF2M.4 • 11:15
FPGA-based high-speed real-time line-scan imager via Fourier spectrum acquisition, Tianhua Fang[1], Jiajie Teng[1], Hongwei Chen[1], Qiang Guo[1], Minghua Chen[1], Sigang Yang[1], Shizhong Xie[1]; [1]*Tsinghua Univ., China*. A FPGA-based high-speed real-time line-scan imager with Fourier spectrum acquisition is demonstrated, which allows image acquisition at a frame rate of 400 kHz in real-time and the imaging data processing with only microseconds delay.

AF2M.5 • 11:30
Wide-Field Surface-Enhanced Raman Scattering from Ferroelectrically Defined Au Nanoparticle Microarrays for Optical Sensing, Nebras Alattar[2,3], Rusul M. Al-Shammari[1], Michele Manzo[4], Katia Gallo[4], Brian Rodriguez[1], James Rice[1]; [1]*School of Physics, Univ. College Dublin, Ireland;* [2]*School of biosystems & food engineering, Univ. College Dublin, Ireland;* [3]*Laser and Optoelectronics Engineering Dept., Univ. of Technology, Iraq;* [4]*Royal Inst. of Technology, Sweden*. The acquisition-time in optical sensors using SERS is vital value. Wide-field SERS is used to perform high-density of hot-spots of GNPs photodeposition on a periodically-proton-exchanged-$LiNbO_3$ which, leads to increase the sensitivity at ultralow probe concentrations $<10^{-9}$–10^{-13}M

AF2M.6 • 11:45
A hyperspectral camera based on ghost imaging via sparsity constraints with a flat-field grating, Liu S. Ying[1,2]; [1]*Shanghai Inst of Optics and Fine Mech, China;* [2]*Univ. of Chinese Academy of Sciences, China*. We propose a hyperspectral camera based on ghost imaging via sparsity constraints with a flat-field grating, which can greatly improve spectral resolution and optimize the measurement matrix according to optical fields with different wavelengths.

SF2N • Ultrafast Oscillators—Continued

SF2N.4 • 11:30
Discrete similariton regime for energy scaling of modelocked thin-disk lasers, F. Ömer Ilday[2], Martin Hoffmann[1], Clara J. Saraceno[1]; [1]*Ruhr Universität Bochum, Germany;* [2]*Bilkent Univ., Turkey*. We investigate energy scaling of modelocked thin-disk lasers via modelocking regimes which are more tolerant in terms of maximum nonlinearity than soliton modelocking. Our numerical results show promise for mJ-level pulse energies without requiring vacuum.

SF2N.5 • 11:45
Kerr-Lens Mode-Locked Yb:Lu_2O_3 Ceramic Thin-Disk Laser, Shotaro Kitajima[1], Akira Shirakawa[1], Hideki Yagi[2], Takagimi Yanagitani[2]; [1]*Univ. of Electro-communications, Japan;* [2]*Konoshima Chemical Co., Ltd., Japan*. The first Kerr-lens mode-locked Yb:Lu_2O_3 ceramic thin-disk laser was demonstrated. The shortest pulse duration was 177 fs with 3.2 W output power. The output power of 17 W with 588 fs pulses was also demonstrated.

FF2P • High-order Harmonic Generation in Solids—Continued

FF2P.2 • 11:30
High-harmonic generation from crystalline silicon driven by sub-cycle mid-infrared pulses, Hideto Shirai[1], Fumitoshi Kumaki[1,2], Yutaka Nomura[1,2], Takao Fuji[1,2]; [1]*Inst. for Molecular Science, Japan;* [2]*The Graduate Univ. for Advanced Studies (SOKENDAI), Japan*. Carrier-envelope phase controlled sub-cycle mid-infrared pulses generated through two-color filamentation have been applied for high harmonic generation from crystalline silicon membrane. The high harmonic spectrum reaches the ultraviolet region.

FF2P.3 • 11:45
Polarimetry of High Harmonics in Bulk Crystals, Yongsing You[1], Eric Cunningham[1], Christian Rödel[1], David Reis[1], Shambhu Ghimire[1]; [1]*SLAC National Lab, USA*. We measure the polarization of extreme ultravilet high-harmonics from a MgO crystal pumped by strong infrared laser pulses. We find that the polarization depends strongly on crystal orientation and harmonic order.

AF2Q • A&T Topical Review on Time-Stretch Technology: Principles and Applications I—Continued

AF2Q.3 • 11:30 Invited
Studying Nonlinear Pulse Interactions using Time Stretch, Ray Man[1], Mary Fung[1], Kevin Lui[1], K.S. Tsang[1]; [1]*Amonics Ltd, Hong Kong*. Single shot measurements unveil valuable information about laser performance. We report characterization of ultrafast optical system using the first commercial time stretch instrument.

CLEO: Science & Innovations

SF2A • Nonlinear Photonics in Integrated Structures—Continued

SF2A.6 • 12:00
Stability of cnoidal wave frequency combs in microresonators, Zhen Qi[1], Shaokang Wang[1], José Jaramillo-Villegas[2], Minghao Qi[2], Andrew M. Weiner[2], Giuseppe D'Aguanno[3], Curtis R. Menyuk[1]; *[1]Univ. of Maryland Baltimore County, USA; [2]Purdue Univ., USA; [3]Univ. of Texas at Austin, USA*. We determine the regions in the parameter space of microresonators where cnoidal waves (Turing rolls) are stable; solitons are included as a special limit. Conditions to obtain broadband frequency combs are identified.

SF2A.7 • 12:15
Non-Hermiticity in Weakly Coupled Semiconductor Laser Arrays, Zihe Gao[1], Matthew T. Johnson[2], Harshil Dave[1], Bradley J. Thompson[1], Kent D. Choquette[1]; *[1]Univ of Illinois at Urbana-Champaign, USA; [2]USA Air Force Academy, USA*. Coupled semiconductor laser arrays are naturally non-Hermitian optical systems. We show that in a weakly coupled semiconductor laser array, the control for gain/loss is dominated by the nonlinearities, rather than simply following the pump profile.

Joint

JF2B • Symposium on Emerging Quantum Sensing Techniques and Applications I—Continued

JF2B.5 • 12:00
Optomechanical Quantum Thermometry, Thomas Purdy[1], Robinjeet Singh[1,2], Nikolai Klimov[1,2], Zeeshan Ahmed[1], Karen Grutter[1,4], Kartik Srinivasan[1], Jacob Taylor[1,3]; *[1]NIST, USA; [2]Joint Quantum Inst., USA; [3]JQI and QuICS, USA; [4]Lab for Physical Sciences, USA*. We demonstrate quantum-backaction-noise-calibrated Brownian motion thermometry as a metrological application of quantum optomechanics. We present recent work as well as on-going efforts to enhance the bandwidth, sensitivity, and range of these devices.

JF2B.6 • 12:15
Quantum-Enhanced Ultrasound Detection with Plasmonic Sensors, Ashok Kumar[1], Mohammadjavad Dowran[1], Benjamin Lawrie[2], Raphael C. Pooser[2], Alberto M. Marino[1]; *[1]Univ. of Oklahoma, USA; [2]Oak Ridge National Lab, USA*. We implement a quantum-enhanced plasmonic sensor with a 56% sensitivity enhancement with respect to the shot-noise limit when used to detect ultrasound waves. The sensor is probed with twin beams with 9dB of intensity-difference squeezing.

JF2C • Symposium on Lasers in Accelerator Science and Technology II—Continued

JF2C.5 • 12:00 Invited
Recent Progress on High-Repetition Rate Laser-Plasma Acceleration , Jerome Faure[1,2]; *[1]Laboratoire d'Optique Appliquée, France; [2]Ecole Polytechnique, France*. We have used kHz single cycle laser pulses in order to resonantly drive a plasma wakefield, resulting in the acceleration of relativistic electron beams with 5 MeV energies and >20 pC/shot charges. Simulations indicate that the electron bunch duration can be as short as 1 femtosecond, making this source unique for probing structural dynamics on ultrafast time scales.

CLEO: QELS-Fundamental Science

FF2D • THz Electrodynamics and control of Electronic Degrees of Freedom—Continued

FF2D.6 • 12:00
Vacuum Bloch-Siegert Shift in Landau Polaritons with Ultrahigh Cooperativity, Xinwei Li[1], Motoaki Bamba[2], Qi Zhang[3], Saeed Fallahi[4], Geoff Gardner[4], Weilu Gao[1], Minhan Lou[1], Katsumasa Yoshioka[5], Michael J. Manfra[4], Junichiro Kono[1,6]; *[1]Dept. of Electrical and Computer Engineering, Rice Univ., USA; [2]Dept. of Material Engineering Science, Osaka Univ., Japan; [3]Argonne National Labs, USA; [4]Dept. of Physics and Astronomy, Purdue Univ., USA; [5]Dept. of Physics, Yokohama National Univ., Japan; [6]Dept. of Physics and Astronomy, Rice Univ., USA*. Terahertz spectroscopy of Landau polaritons reveals a shift induced by the ultrastrong coupling of cyclotron-orbiting electrons with the counter-rotating component of the vacuum fluctuation field, evidencing the breakdown of the rotating wave approximation.

FF2D.7 • 12:15
Ultrafast THz Fingerprints of Large Polaron Formation in Lead-Halide Perovskites, Eugenio L. Cinquanta[1,2], Daniele Meggiolaro[3,4], Marina Gandini[5], Edoardo Mosconi[2,4], Silvia Motti[5], Marcelo Alcocer[1], Cristian Manzoni[2], Caterina Vozzi[2], Annamaria Petrozza[5], Filippo De Angelis[3,4], Salvatore Stagira[1]; *[1]Politecnico di Milano, Italy; [2]CNR-IFN, Italy; [3]CNR-ISM, Italy; [4]IIT, Italy; [5]IIT, Italy.* Ultrafast Thz spectroscopy combined with DFT calculations demonstrates the formation of large polaron in $CsPbPr_3$ nanocrystals. Our results explain their fascinating dielectric properties that makes hybrid perovskites a promising platform for next-generation high-performances optoelectronics devices.

12:30–14:00 Lunch Break *(on your own)*

CLEO: QELS-Fundamental Science

FF2E • Novel Nonlinear Optical Materials—Continued

FF2E.7 • 12:00
Optical Magnetic Force Induces Molecular Rotations, Tuan M. Trinh[1], Krishnandu Makhal[1], Elizabeth Dreyer[1], Stephen Rand[1]; *[1]Univ. of Michigan, USA.* Optical interactions involving both electric and magnetic fields in two-photon scattering can stimulate molecular librations/rotations, via torque-enhanced magnetic transitions. Here we report ultrafast observations of magneto-electrically-induced vibrations and rotations

FF2F • Fundamental Nanophotonics: Sensing and Infrared Applications—Continued

FF2F.7 • 12:00
Surface-Enhanced Infrared Absorption Spectroscopy via Coaxial Zero-Mode Resonators with Sub-10-nm Gaps, Daehan Yoo[1], Daniel A. Mohr[1], Ferran Vidal-Codina[2], Aurelian John-Herpin[3], Minsik Jo[4,5], sunghwan Kim[4,5], Joseph Matson[6], Joshua D. Caldwell[6], Ngoc-Cuong Nguyen[2], Luis Martin-Moreno[7,8], Jaime Peraire[2], Hatice Altug[3], Sang-Hyun Oh[1]; *[1]Dept. of Electrical and Computer Engineering, Univ. of Minnesota, USA; [2]Dept. of Aeronautics and Astronautics, MIT, USA; [3]Inst. of BioEngineering, École Polytechnique Fédérale de Lausanne , Switzerland; [4]Dept. of Physics, Ajou Univ., South Korea; [5]Dept. of Energy Systems Research, Ajou Univ., South Korea; [6]Dept. of Mechanical Engineering, Vanderbilt Univ., USA; [7]Instituto de Ciencia de Materiales de Aragón, Spain; [8]Departamento de Física de la Materia Condensada, CSIC-Universidad de Zaragoza, Spain.* We demonstrate high-contrast infrared absorption spectroscopy on ultrathin protein films enabled by coaxial nanogap resonators, where light can be efficiently coupled with vibrational modes of proteins at the zeroth-order Fabry-Perot resonance condition.

FF2F.8 • 12:15
Generating Spin Current from Mid Infrared Plasmonic Metamaterial Absorbers, Satoshi Ishii[1], Ken-ichi Uchida[1], Thang Dao[1], Yoshiki Wada[1], Eiji Saitoh[2], Tadaaki Nagao[1]; *[1]National Inst. for Materials Science, Japan; [2]Tohoku Univ., Japan.* Wavelength selective spin current is generated in the mid infrared rage by combining plasmonic metamaterial absorbers with platinum/yttrium-iron-garnet spintronic devices. The wavelength selectivity is attributed to the plsmonic resonance of the metamaterial absorber.

CLEO: Science & Innovations

SF2G • Mid-infrared Semiconductor Lasers—Continued

SF2G.6 • 12:00
External cavity GaSb-based cascade diode lasers with tuning range of 280 nm centered near 3.13 µm., Meng Wang[1], Tao Feng[1], Takashi Hosoda[1], Gela Kipshidze[1], Jiang Jiang[1], Leon Shterengas[1], Gregory Belenky[1]; *[1]Stony Brook Univ., USA.* Cascade type-I quantum well GaSb-based laser heterostructures with broad optical gain demonstrated tuning from 2.99 to 3.27 µm (above 35 meV) in Littrow external cavity configuration. The devices generated up to 5 mW of the narrow spectrum output power in continuous wave regime at room temperature

SF2G.7 • 12:15
Pure Amplitude or Frequency Modulation of a Quantum Cascade Laser by Use of an Integrated Heater, Atif Shehzad[1], Pierre Brochard[1], Renaud Matthey[1], Alfredo Bismutto[2], Stephane Blaser[2], Tobias Gresch[2], Richard Maulini[2], Antoine Muller[2], Thomas Südmeyer[1], Stephane Schilt[1]; *[1]Univ. of Neuchatel, Switzerland; [2]Alpes Lasers, Switzerland.* We present pure amplitude and frequency modulation realized electrically in a quantum cascade laser (QCL) equipped with an integrated heater (IH), achieved by simultaneously modulating the QCL and IH currents with proper amplitudes and phases.

CLEO: QELS-Fundamental Science

FF2H • Interference and Localization Phenomena in Complex Media—Continued

FF2H.4 • 12:00
Diffusion in Translucent Media, Azriel Z. Genack[1,2], Zhou Shi[1,3]; *[1]Queens College of the City Univ. of New York, USA; [2]Physics, The Graduate Center of the City Univ. of New York, USA; [3]Chiral Photonics, USA.* We show in optical measurements and simulations that the scaling of transmission, intensity profiles of transmission eigenchannels, and the statistics of transmission eigenvalues are the same in translucent and opaque media.

FF2H.5 • 12:15
High-Quality Confinement of Visible Light in Disordered Photonic Crystal Waveguides in the Anderson-Localized Regime, Oliver J. Trojak[1], Tom Crane[1], Luca Sapienza[1]; *[1]Dept. of Physics and Astronomy, Univ. of Southampton, UK.* We demonstrate Anderson localization of visible light in silicon nitride photonic crystal waveguides. We measure photoluminescence resonances due to disorder-induced light localization showing quality factors of ≈10 000 that exceed engineered 2D photonic crystal cavities.

12:30–14:00 Lunch Break *(on your own)*

CLEO: Science & Innovations

CLEO: QELS-Fundamental Science

SF2I • Electrooptic and Nanophotonic Materials—Continued

SF2I.7 • 12:00
Engineering the Coupling Between the Berreman Mode and Nanobar Antennas in Epsilon-near-zero Materials, Owen Dominguez[2], Leland J. Nordin[1], Daniel Wasserman[1], Anthony Hoffman[2]; [1]*Electrical and Computer Engineering, Univ. of Texas at Austin, USA;* [2]*Electrical Engineering, Univ. of Notre Dame, USA.* We design, fabricate and characterize the coupling between nanobar antennas and optical modes on epsilon-near-zero thin AlN films. Reflection measurements and simulations indicate that the interaction can be controlled via incident angle and antenna length.

SF2I.8 • 12:15
Memetic Algorithm Optimization of Thin-film Photonic Structures for Thermal and Energy Applications, Yu Shi[1], Wei Li[1], Aaswath Raman[1], Shanhui Fan[1]; [1]*Electrical Engineering, Stanford Univ., USA.* We present an effective thin-film optimization method using the memetic algorithm for thermal and energy applications. This method rigorously treats broadband material dispersion and produces structures with superior performances than their counterparts in the literature.

SF2J • Cavity Optomechanics—Continued

SF2J.6 • 12:00
Integrated Brillouin microcavity laser with sub-milliwatt threshold, Ki Y. Yang[1], Boqiang Shen[1], Heming Wang[1], Qifan Yang[1], Xu Yi[1], Seung Hoon Lee[1], Dong Yoon Oh[1], Kerry Vahala[1]; [1]*California Inst. of Technology, USA.* A Brillouin laser featuring an ultra-high-Q silica cavity monolithically integrated with a silicon-nitride waveguide is demonstrated. The device features a sub-milliwatt threshold pump power and provides high-coherence output for on-chip sources, gyroscopes, and microwave generation

SF2J.7 • 12:15
Electromechanically Induced Brillouin Scattering in AlN Optomechanical Waveguides, Qiyu Liu[1], Huan Li[1], mo li[1]; [1]*Univ. of Minnesota, USA.* We experimentally demonstrate electromechanically induced Brillouin scattering in a photonic waveguide fabricated on aluminum nitride thin film, and show single sideband modulation due to the non-reciprocal acousto-optic phase matching conditions.

SF2K • Novel Fiber Technology—Continued

FF2L • Polaritons in 2D Materials—Continued

FF2L.7 • 12:00
Indirect excitons in van der Waals heterostructures at room temperature, Erica V. Calman[1], Michael Fogler[1], Leonid Butov[1], Sheng Hu[2], Artem Mishchenko[2], Andre Geim[2]; [1]*UC San Diego, USA;* [2]*Univ. of Manchester, UK.* Indirect excitons (IXs) are observed at room temperature in a van der Waals MoS_2/hBN heterostructure. IX lifetimes are orders of magnitude longer than direct exciton lifetimes and IX energy is controllable by voltage.

FF2L.8 • 12:15
Coupling Single Defect Emissions From 2-Dimensional Semiconductors into Long-Range Propagating Gap Plasmons in Metal-Insulator-Metal Waveguides, Subhojit Dutta[1], Tao Cai[1], Edo Waks[1]; [1]*Inst. for Research in Electronics and Applied Physics, Univ. of Maryland, College Park, USA.* We demonstrate coupling of single defect emissions from the 2-D transition metal dichalcogenide (TMDC), Tungsten diselenide (WSe_2) into propagating surface plasmon modes in lithographically fabricated silver-air-silver, metal-insulator-metal (MIM) waveguides.

12:30–14:00 Lunch Break *(on your own)*

CLEO: Applications & Technology

AF2M • Imaging & Microscopy—Continued

AF2M.7 • 12:00
Increasing the Speed of CCD-based Thermoreflectance Imaging: An Experimental and Theoretical Demonstration, Mark Hallman[1], Kyle Allison[1], Johanna Hardin[2], Ami Radunskaya[2], Janice A. Hudgings[1]; [1]*Physics and Astronomy Dept., Pomona College , USA;* [2]*Mathematics Dept., Pomona College, USA.* To increase the speed of thermoreflectance imaging, we derive detailed statistical models of both the conventional imaging algorithm and our proposed higher speed technique, and we experimentally confirm both the models and resulting speed enhancement.

AF2M.8 • 12:15
High-Resolution and Real-Time W-Band Imaging Radar Based on Photonics for Security Check, Shaowen Peng[1], Shangyuan Li[1], Xuedi Xiao[1], Dexin Wu[1], Xiaoxiao Xue[1], Xiaoping Zheng[1]; [1]*Tsinghua National Lab for Information Science and Technology, Dept. of Electronic Engineering, Tsinghua Univ., China.* We present a photonics-based W-band imaging radar for non-cooperative and non-contact security check with a two-dimension imaging resolution of ~1.9cm × ~1.6cm and an image frame rate of 200 fps.

CLEO: Science & Innovations

SF2N • Ultrafast Oscillators—Continued

SF2N.6 • 12:00
Nonlinear-Mirror Modelocked 323-fs Thin-Disk Oscillator, Francesco Saltarelli[1], Andreas Diebold[1], Ivan J. Graumann[1], Christopher R. Phillips[1], Ursula Keller[1]; [1]*ETH Zurich, Switzerland.* We present the first nonlinear-mirror modelocked thin-disk laser, delivering 21 W at 323 fs pulse duration. This opens a new chapter for the nonlinear-mirror technique which, until now, only modelocked few-ps bulk oscillators.

SF2N.7 • 12:15
Repetition-Rate Stabilized 10-GHz Straight-Cavity SESAM-Modelocked Yb:CALGO Laser, Léonard M. Krüger[1], Aline S. Mayer[1], Christopher R. Phillips[1], Valentin J. Wittwer[2], Olga Razskazovskaya[2], Thomas Südmeyer[2], Ursula Keller[1]; [1]*ETH Zurich, Switzerland;* [2]*Univ. of Neuchatel, Switzerland.* We present a repetition-rate stabilized SESAM-modelocked 10-GHz Yb:CALGO laser using a self-defocussing straight-cavity that suppresses Q-switching and delivered 171 fs pulses at 1.44 W, and even 104 fs at 0.81 W with a dispersion-compensating output coupler.

CLEO: QELS-Fundamental Science

FF2P • High-order Harmonic Generation in Solids—Continued

FF2P.4 • 12:00
Observation of selection rules for circularly polarized high harmonics from a solid, Nariyuki Saito[1], Peiyu Xia[1], Faming Lu[1], Nobuhisa Ishii[1], Teruto Kanai[1], Jiro Itatani[1]; [1]*Univ. of Tokyo, Japan.* We report on the observation of selection rules for circularly polarized high harmonics from solids driven by single-color circularly polarized mid-infrared pulses. Our result offers a novel way to produce circularly polarized short wavelength light.

FF2P.5 • 12:15
A real space perspective of high harmonic generation in crystalline solids, Harshit Lakhotia[1], Minjie Zhan[1], Hee-Yong Kim[1], Eleftherios Goulielmakis[1]; [1]*Max Planck Inst. of Quantum Optics, Hans-Kopfermann-Str. 1 D-85748, Garching, Germany.* We present a real space picture for high harmonic generation in solids. We studied the crystal orientation dependence of extreme ultraviolet high harmonics in MgF_2.

CLEO: Applications & Technology

AF2Q • A&T Topical Review on Time-Stretch Technology: Principles and Applications I—Continued

AF2Q.4 • 12:00
Ultrafast Optical Sampling Spectroscopy Based on Dispersive Fourier Transformation, Srikamal Soundararajan[1], Lin Yang[1], Lingze Duan[1]; [1]*Univ. of Alabama in Huntsville, USA.* Time-wavelength optical sampling combines ultrafast optical sampling and dispersive Fourier transform and has been demonstrated for real-time absorption spectroscopy with a low-pressure C_2H_2 sample.

AF2Q.5 • 12:15
Dynamic Dispersion via Acousto-Optic Angular Excitation of Multimode Waveguides, Jacky Chan[1], Sebastian Karpf[1], Bahram Jalali[1]; [1]*Univ. of California, Los Angeles, USA.* To enable tunable temporal engineering in optical communications and processing systems, we integrate RF and wavelength control of mode excitation angle in a multimode waveguide. Dynamic tunability of dispersion is demonstrated over 1.27 ns and 40 nm of optical bandwidth.

12:30–14:00 Lunch Break *(on your own)*

CLEO: Science & Innovations

14:00–16:00
SF3A • Integrated Photonics (III-V Heterogeneric)
Presider: Ali Adibi; Georgia Inst. of Technology, USA

SF3A.1 • 14:00
Room temperature lasing from InP/InGaAs nano-ridges at telecom-bands, Yu Han[1], Chao Ma[2], Wai Kit Ng[2], Qiang Li[1], Kam Sing. Wong[2], Kei May Lau[1]; [1]*Dept. of Electronic and Computer Engineering, Hong Kong Univ. of Science and Technology, Hong Kong;* [2]*Dept. of Physics, Hong Kong Univ. of Science and Technology, Hong Kong*. Densely packed InP/InGaAs nano-ridges are selectively grown on patterned (001) Si substrates. We demonstrate room temperature lasing at telecom-wavelengths under optical pumping from InGaAs QW nano-ridges transferred onto SiO_2/Si substrates.

SF3A.2 • 14:15
Graphene nano-optomechanical resonators on an integrated photonic platform, Xiang Xi[1], Zefeng Chen[1], Jingwen Ma[1], Jian-Bin Xu[1], Xiankai Sun[1]; [1]*The Chinese Univ. of Hong Kong, Hong Kong*. Graphene nano-optomechanical resonators are demonstrated for the first time on an integrated photonic platform. A flexural mode with effective mass 4.5 fg and frequency 8.1 MHz was measured in air with mechanical Q of ~28.

SF3A.3 • 14:30
Ultracompact O-E-O converter based on fF-capacitance nanophotonic integration, Kengo Nozaki[1], Shinji Matsuo[1], Takuro Fujii[1], Koji Takeda[1], Eiichi Kuramochi[1], Akihiko Shinya[1], Masaya Notomi[1]; [1]*NTT Nanophotonics Center, Japan*. A nanocavity-based modulator is closely integrated with a nano-photodetector to form an ultracompact O-E-O converter. The femto-joule energy operation proves the opto-electronic integrability with a femto-farad capacitance, for the first time.

Joint

14:00–16:00
JF3B • Symposium on Emerging Quantum Sensing Techniques and Applications II
Presider: TBD

JF3B.1 • 14:00 Invited
The LIGO Squeezed Light Upgrade, Lee McCuller[1]; [1]*MIT Kavli Inst. for Astrophysics and Space Research, USA*. Squeezed light sources are being commissioned for operation during the third observing run of advanced LIGO. I overview the implementation and optomechanical tradeoffs of continuous squeezed states for interferometers as gravitational wave observatories.

JF3B.2 • 14:30
Cavity-Enhanced Nitrogen-Vacancy Ensemble Magnetometry, Sepehr Ahmadi[1], Haitham A. R. El-Ella[1], Adam M. Wojciechowski[1], Tobias Gehring[1], Jørn O. Hansen[1], Alexander Huck[1], Ulrik L. Andersen[1]; [1]*Danmarks Teknishe Universitet, Denmark*. We demonstrate magnetic-field sensing using the intrinsic nitrogen-vacancy concentration of a single-crystal diamond placed in an optical cavity resonant with the pump field. We investigate two approaches based on fluorescence detection and pump absorption, respectively.

JF3B.3 • 14:45
Optically Levitated Torque Sensor and Ultrafast Nanomechanical Rotor, Tongcang Li[1], Jonghoon Ahn[1], Zhujing Xu[1], Jaehoon Bang[1]; [1]*Purdue Univ., USA*. We propose to optically levitate a nonspherical nanoparticle in vacuum to detect the quantum vacuum torque (Casimir torque). We have levitated nonspherical nanoparticles in vacuum and driven them to mechanically rotate at several hundred MHz.

CLEO: QELS-Fundamental Science

14:00–16:00
FF3C • Optimization and Design of Metasurfaces
Presider: Viktor Podolskiy; Univ. of Massachusetts Lowell, USA

FF3C.1 • 14:00
High Efficiency Aperiodic Metasurfaces Based on Variable Phase Shifting Element Spacing, Jiaqi Jiang[1], Thaibao Phan[1], Jonathan Fan[1]; [1]*Electrical Engineering, Stanford Univ., USA*. We report new method for designing high efficiency aperiodic metasurfaces by approximating the desired phase profile with linear sections and optimizing the spacing between subwavelength-scale phase shifter elements within each section.

FF3C.2 • 14:15
Multifunctional Silicon Metagratings, David Sell[1], Jianji Yang[1], Sage Doshay[1], Evan W. Wang[1], Thaibao Phan[1], Jonathan Fan[1]; [1]*Stanford Univ., USA*. We design highly efficient multi-functional silicon metagratings based on adjoint-based optimization and experimentally demonstrate devices exhibiting negative refraction and wavelength sorting capabilities.

FF3C.3 • 14:30
Solving Equations with Waves in Collections of Mach-Zehnder Interferometers, Mario Junior Mencagli[1], Nasim Mohammadi Estakhri[1], Brian Edwards[1], Nader Engheta[1]; [1]*Univ. of Pennsylvania, USA*. We present how waves in ensembles of Mach-Zehnder interferometers (MZIs) can be utilized to perform mathematical operations and solve integral equations with kernels that can be reconfigured by adjusting phases in such MZIs.

FF3C.4 • 14:45
Non-local computing metasurfaces performing mathematical operations, Concetto Eugenio Andrea Cordaro[1,2], Hoyeong Kwon[3], Dimitrios Sounas[3], Albert Polman[1], Andrea Alù[3]; [1]*AMOLF, Netherlands;* [2]*Universiteit van Amsterdam, Netherlands;* [3]*The Univ. of Texas at Austin, USA*. We present Si-based metasurfaces with suitably engineered spatial dispersion and non-locality that can perform even and odd mathematical operations on an input image, enabling all-analog signal processing and on-the-fly edge detection.

14:00–16:00
FF3D • Spectroscopy of Low Dimensional Systems
Presider: Rohit Prasankumar; Los Alamos National Lab, USA

FF3D.1 • 14:00
Selective Observation of Nonradiative Electronic States in Silicon-Vacancy Centers in Diamond, Christopher L. Smallwood[1], Matthew W. Day[1], Travis Autry[2,3], Geoffrey M. Diederich[4], Ronald Ulbricht[2,3], Tim Schröder[5], Edward Bielejec[6], Mark E. Siemens[4], Steven T. Cundiff[1,2]; [1]*Physics, Univ. of Michigan, USA;* [2]*JILA, Univ. of Colorado / NIST, USA;* [3]*Physics, Univ. of Colorado, USA;* [4]*Physics and Astronomy, Univ. of Denver, USA;* [5]*Electrical Engineering and Computer Science, MIT, USA;* [6]*Sandia National Labs, USA*. Multidimensional coherent spectroscopy measurements of SiV^- centers in diamond reveal a previously unexamined population of silicon-based defect states, which are not detected in photoluminescence and which exhibit a substantial degree of inhomogeneous broadening.

FF3D.2 • 14:15
Exploring the State Structure of Quantum Dot/Quantum Well Systems by Two-Dimensional Coherent Spectroscopy with White Pulses, Mirco Kolarczik[1], Sophia Helmrich[1], Kevin Thommes[1], Bastian Herzog[1], Nina Owschimikow[1], Ulrike K. Woggon[1]; [1]*IOAP, Technical Univ. Berlin, Germany*. Coulomb-bound states of mixed dimensionality (Crossed Excitons) are directly observed in In(Ga)As quantum dot/quantum well systems by coherent two-dimensional spectroscopy. The setup incorporates collinear geometry, inversion control by electrical carrier injection, and white supercontinuum pulses.

FF3D.3 • 14:30
Vibrational Interferometry Enables Single-Scan Acquisition of all $x^{(3)}$ Multi-Dimensional Coherent Spectral Maps, Travis Autry[1], Galan Moody[1], Corey McDonald[1,3], James M. Fraser[1,2], Richard Mirin[1], Kevin L. Silverman[1]; [1]*NIST, USA;* [2]*Queen's Univ., Canada;* [3]*Physics, Univ. of Colorado, USA*. We demonstrate a new method for multidimensional coherent spectroscopy of nanostructures. We use a heterodyne technique implemented with a confocal microscope to record the amplitude and phase of all degenerate third-order wave-mixing processes.

FF3D.4 • 14:45
Sub-Cycle Effects in Carrier-Envelope-Phase-Sensitive Photoemission from Plasmonic Nanoparticles , William Putnam[1,2], Phillip D. Keathley[1], Richard Hobbs[1,3], Praful Vasireddy[1], Karl K. Berggren[1], Franz X. Kaertner[1,4]; [1]*Massachussetts Inst. of Technology, USA;* [2]*NG Next, Northrop Grumman Corp., USA;* [3]*Chemistry, Trinity College Dublin, Ireland;* [4]*Physics, Univ. Of Hamburg, Germany*. We study carrier-envelope-phase-sensitive (CEP-sensitive) photoemission from plasmonic nanoparticles illuminated with few-cycle laser pulses of varying intensity. The CEP-sensitive photocurrent exhibits antiresonant-like behavior due to competing emission from different optical half-cycles.

CLEO: QELS-Fundamental Science

14:00–16:00
FF3E • Photon-Phonon Interactions and Cooling
Presider: Peter Rakich; Yale Univ., USA

FF3E.1 • 14:00 Invited
Optical Refrigeration Advances: Solid-State Cryocoolers and Athermal Disk Laser, Mansoor . Sheik-Bahae[1], Junwei Meng[1], Zhou Yang[1], Alexander Albrecht[1], Eric Lee[1], Richard Epstein[1], Markus Hehlen[1,2]; [1]*Univ. of New Mexico, USA;* [2]*Los Alamos National Lab, USA.* Having reached record temperatures <90K in Yb:YLF, cryogenic optical refrigeration of an arbitrary load has been demonstrated for the first time. In parallel, research on radiation-balanced-lasers has led to demonstration of athermal rare-earth-doped thin-disk lasers.

FF3E.2 • 14:30
Interaction of light with thin liquid membranes , Anatoly Patsyk[1], Miguel Bandres[1], Mordechai Segev[1]; [1]*Technion-Israel Inst. of Technology, Israel.* We study the interaction of light with liquid thin soap membranes experimentally. We observe optical beams form liquid waveguides, bulges, and trigger nucleation of crystals in the membrane due to absorption and surface tension effects.

FF3E.3 • 14:45
Brillouin cooling in a linear waveguide through dispersive symmetry breaking, Nils T. Otterstrom[1], Eric Kittlaus[1], Ryan O. Behunin[2], Peter T. Rakich[1]; [1]*Applied Physics, Yale Univ., USA;* [2]*Dept. of Physics and Astronomy, Northern Arizona Univ., USA.* Here, we experimentally demonstrate Brillouin cooling in a linear waveguide for the first time. Leveraging the dispersive symmetry breaking of inter-modal Brillouin scattering, we achieve Brillouin cooling without an optical cavity or discrete acoustic modes.

14:00–16:00
FF3F • Optomechanical Interactions and Single Particle Tracking
Presider: Luca Sapienza; Univ. of Southampton, UK

FF3F.1 • 14:00
Experimental realization of Feynman's ratchet with an optically trapped microsphere, Jaehoon Bang[1], Rui Pan[2], Thai M. Hoang[1], Jonghoon Ahn[1], Christopher Jarzynski[3], Hai Tao Quan[2], Tongcang Li[1]; [1]*Purdue Univ., USA;* [2]*Peking Univ., China;* [3]*Univ. of Maryland, USA.* Feynman's ratchet is a microscopic heat engine that was proposed by Richard Feynman. Here we experimentally realize Feynman's ratchet for the first time with a colloidal particle in a feedback controlled one dimensional optical trap.

FF3F.2 • 14:15
Opto-Thermophoretic Trapping in Simple Polar Liquids, Xiaolei Peng[1], Linhan Lin[1,2], Yuebing Zheng[1,2]; [1]*Materials Science & Engineering Program and Texas Materials Inst., The Univ. of Texas at Austin, USA;* [2]*Dept. of Mechanical Engineering, The Univ. of Texas at Austin, USA.* We experimentally demonstrate opto-thermophoretic trapping of particles in several simple polar liquids with a dominant interfacial-entropy-driven force, which is determined by the surface chemistry of the particles and physical properties of the solvents

FF3F.3 • 14:30 Invited
Single Particle Tracking: Recent Advances in Methods and Applications, Christie Landes[1]; [1]*Rice Univ., USA.* The temporal resolution of single-molecule spectroscopy is limited by the frame rate of scientific cameras. We have developed a novel imaging technique to improve the temporal resolution by 20 times and to image subframe events.

CLEO: Science & Innovations

14:00–16:00
SF3G • Quantum Cascade Lasers
Presider: Seungyong Jung; Univ. of Texas at Austin, USA

SF3G.1 • 14:00 Invited
High-Power, High-Efficiency Mid-Infrared Quantum Cascade Lasers , Dan Botez[1], Jeremy D. Kirch[1], Colin Boyle[1], Kevin M. Oresick[1], Chris Sigler[1], Don F. Lindberg III[2], Thomas L. Earles[2], Luke J. Mawst[1]; [1]*Univ. of Wisconsin-Madison, USA;* [2]*Intraband, LLC, USA.* Carrier-leakage suppression and fast carrier extraction allow quantum cascade lasers to reach internal efficiencies close to fundamental limits (~ 90 %). Then, CW wallplug efficiencies ≥ 40 % and powers ≥ 10 W become possible.

SF3G.2 • 14:30
Phase Measurement of a QCL Comb in the Mid-IR, Matthew Singleton[1], Pierre Jouy[1], Mattias Beck[1], Jérôme Faist[1]; [1]*ETH Zuerich, Switzerland.* QCL combs arise through cascaded four-wave mixing, with simulations suggesting a strongly frequency modulated field. Experimentally, we show that QCL combs can possess a linear chirp, and demonstrate that the comb states are reproducible.

SF3G.3 • 14:45
Tuning the multimode dynamics of Fabry-Perot quantum cascade laser devices with optical injection, Paul Chevalier[1], Marco Piccardo[1], Sajant Anand[1,2], Enrique A. Mejia[1,3], Yongrui Wang[4], Tobias S. Mansuripur[4], Feng Xie[5], Kevin Lascola[5], Alexey Belyanin[4], Federico Capasso[1]; [1]*Harvard Univ., USA;* [2]*Dept. of Physics, Wake Forest Univ., USA;* [3]*Univ. of Texas at Austin, USA;* [4]*Dept. of Physics and Astronomy, Texas A&M Univ., USA;* [5]*Thorlabs Quantum Electronics (TQE), USA;* [6]*Pendar Technologies, USA.* With the external injection of an optical seed, we demonstrate how to control the spectrum of multimode Fabry-Perot quantum cascade lasers by reaching a watt-level single-mode emission and tunable harmonic comb regime.

CLEO: QELS-Fundamental Science

14:00–16:00
FF3H • Wavefront Shaping in Complex Media
Presider: Viktoriia Babicheva; Georgia State University, USA

FF3H.1 • 14:00
Wavefront Shaping with the Generalized Wigner-Smith Operator, Philipp Ambichl[1], Andre Brandstötter[1], Matthias Kühmayer[1], Michael Horodynski[1], Julian Böhm[2], Ulrich Kuhl[2], Stefan Rotter[1]; [1]*Technische Universität Wien, Austria;* [2]*Université Côte d'Azur, France.* We introduce a wave front shaping protocol based on a generalization of the Wigner-Smith time-delay operator. This tool is used to create light fields with desired properties at a predetermined target embedded inside a medium.

FF3H.2 • 14:15
Temporal Focusing of Total Transmission through Multimode Fibers with Random Mode Mixing, Wen Xiong[1], Chia Wei Hsu[1], Hui Cao[1]; [1]*Yale Univ., USA.* We demonstrate the temporal focusing of optical pulses through multimode fibers with strong mode mixing. The focusing efficiency varies strongly with the focus time, which can be explained by the time-dependent correlations between output channels.

FF3H.3 • 14:30
Constant Pressure Sound Waves in Non-Hermitian Disordered Media, Etienne Rivet[2], Andre Brandstötter[1], Konstantinos Makris[3], Herve Lissek[2], Stefan Rotter[1], Romain Fleury[2]; [1]*Technische Universität Wien, Austria;* [2]*EPFL, Switzerland;* [3]*Univ. of Crete, Greece.* Theory shows that waves with constant intensity can perfectly transmit through a disordered medium with a tailored distribution of gain and loss. We present the first experimental realization of this concept using an acoustic waveguide.

FF3H.4 • 14:45
Tailoring Spatial Intensity-Correlations of Speckle Patterns, Nicholas Bender[1], Hasan Yilmaz[1], Yaron Bromberg[2], Hui Cao[1]; [1]*Yale Univ., USA;* [2]*Racah Inst. of Physics, The Hebrew Univ. of Jerusalem, Israel.* We present a general framework for customizing the spatial intensity-correlations of speckle patterns without altering the spatial field-correlations. We experimentally generate speckles possessing long-range intensity-correlations by synthesizing non-Gaussian random phase patterns on a SLM.

CLEO: Science & Innovations

CLEO: Applications & Technology

14:00–16:00
SF3I • Materials for Fiber and Solid State Lasers
Presider: TBD

SF3I.1 • 14:00
5 kW 30/600Yb-doped Aluminophosphosilicate Laser Fiber, Cong Gao[1], Chengyu Li[1], Yuying Wang[1], Huan Zhan[1], Kun Peng[1], Lihua Zhang[1], Li Ni[1], Xiaolong Wang[1], Lei Jiang[1], Yuwei Li[1], Shuang Liu[1], Jianjun Wang[1], Feng Jing[1], Aoxiang Lin[1]; [1]*Laser Fusiong Research Center , China Academy of Engineering Physics, China.* A 30/600 Yb-doped aluminophosphosilicate fiber was fabricated and presented 5.17 kW laser output at 1064 nm with slope efficiency of 85.69%. Stable operation at 5 kW was demonstrated for 10 hours.

SF3I.2 • 14:15
Novel Fabrication Technique for Highly Efficient Tm-doped Fibers, Norberto J. Ramirez-Martinez[1], Martín M. Núñez-Velázquez[1], Andrey A. Umnikov[1], Jayanta K. Sahu[1]; [1]*Optoelectronics Research Centre, Univ. of Southampton, UK.* Thulium-doped aluminosilicate fiber fabricated by MCVD process combining both solution doping and gas phase. Laser characterization report a slope efficiency of ~72% with respect to launched pump power at 2069nm emission wavelength.

SF3I.3 • 14:30
Cladded Single Crystal Fibers for All-Crystalline Fiber Lasers, Brandon Shaw[1], Shyam Bayya[1], Woohong Kim[1], Jason Myers[1], Dan Rhonehouse[1], Noor Qadri[1], Charles Askins[2], John Peele[2], Rajesh Thapa[2], Dan Gibson[1], Rafael Gattass[1], Joseph Kolis[3], Brad Stadleman[3], Jas Sanghera[1]; [1]*US Naval Research Lab, USA;* [2]*Sotera Defense Solutions, USA;* [3]*Clemson Univ., USA.* We report on fabrication of crystalline cladded single crystal Yb:YAG fiber. Net gain has been demonstrated in hydrothermal grown cladded Yb:YAG fiber structures

SF3I.4 • 14:45
Hybrid mode-locked erbium-doped fiber laser with black phosphorus saturable absorber, Yuwei Hu[1], Xinxin Jin[1], Guohua Hu[2], Meng Zhang[1], Qing Wu[1], Zheng Zheng[1], Tawfique Hasan[2]; [1]*Beihang Univ., China;* [2]*Cambridge Graphene Centre, UK.* We demonstrate a self-starting erbium-doped fiber laser mode-locked by the hybrid mode-locking mechanism consisting of a nonlinear amplifying loop mirror and a black phosphorus saturable absorber, producing 100 fs pulses at 45.9 MHz repetition rate.

14:00–16:00
SF3J • Mid IR Sensing and Optical Forces
Presider: Kenneth Crozier, Australia

SF3J.1 • 14:00
Optomechanically coupled glass nanospike array on the endface of a multicore fiber, Zheqi Wang[1], Shangran Xie[1], Xin Jiang[1], Riccardo Pennetta[1], Johannes R. Koehler[1], Philip S. Russell[1]; [1]*Max Planck Inst. for the Science of Light, Germany.* We report the fabrication and characterization of an optomechanically coupled array of glass nanospikes on the endface of a germanate multicore fiber. Strong optical gradient forces drive the mechanical motion of the free-standing nanospikes.

SF3J.2 • 14:15
Soft Optical Contact Sensing based on On-Demand Drawn, High Aspect-Ratio Elastomeric Micropillars, Qiang Li[1], Jaeyoun Kim[1]; [1]*Iowa State Univ., USA.* We demonstrate on-demand fabrication of high aspect-ratio, microsphere-tipped elastomeric micropillars on various structures with uncommon geometries. A fiber optic contact sensor is realized by integrating a micropillar onto the end facet of an optical fiber.

SF3J.3 • 14:30
Controlled optical trapping and transport of a single 100 nm particle across an array of silicon nanoantennas, Zhe Xu[1], Kenneth B. Crozier[1,2]; [1]*School of Physics, Univ. of Melbourne, Australia;* [2]*Dept. of Electrical and Electronic Engineering, Univ. of Melbourne, Australia.* We experimentally demonstrate the optical trapping and transport of a single 100 nm polystyrene nanosphere across an array of silicon nanoantennas. Our device is all silicon and produces negligible local heating.

SF3J.4 • 14:45
Waveguide Polarimetry using Belinfante Forces, Vincent Ginis[1,2], Lulu Liu[1,3], Alan She[1], Federico Capasso[1]; [1]*Harvard SEAS, USA;* [2]*Applied Physics, Vrije Universiteit Brussel, Belgium;* [3]*MIT Lincoln Lab, USA.* We reveal the surprising polarization dependence of lateral forces acting on resonant Mie particles in evanescent fields. This effect can be utilized to retrieve the polarization state of light inside birefringent waveguides.

14:00–16:00
SF3K • Mode-Locked Fiber Lasers
Presider: Kazi Abedin; OFS Labs, USA

SF3K.1 • 14:00
Spectral dynamics of dual-color-soliton intracavity collision, Yuan Wei[1], Bowen Li[1], Xiaoming Wei[1,2], Ying Yu[1], Kenneth Kin-Yip Wong[1]; [1]*Univ. of Hong Kong, Hong Kong;* [2]*California Inst. of Technology, USA.* By using the dispersive Fourier transform (DFT), we unveil the collision-induced soliton spectral dynamics, which features evolving spectral fringes over the soliton main lobe, and the rebuilding of Kelly sidebands with wavelength drifting.

SF3K.2 • 14:15
Ultrafast dispersion-managed fiber laser mode-locked by black phosphorus saturable absorber, Xinxin Jin[1], Guohua Hu[2], Meng Zhang[1], Yuwei Hu[1], Qing Wu[1], T Albrow-Owen[2], R Howe[2], T Wu[2], Zheng Zheng[1], Tawfique Hasan[2]; [1]*Beihang Univ., China;* [2]*Cambridge Graphene Centre, UK.* We demonstrate an all-fiber erbium-doped laser mode-locked by an inkjet-printed black phosphorus saturable absorber, delivering 102 fs pulses with 40 nm spectral width. Our work highlights the potential of BP-based devices for future photonic technologies.

SF3K.3 • 14:30
Spatiotemporal Mode-Locking, Logan Wright[1], Demetrios N. Christodoulides[2], Frank W. Wise[1]; [1]*Cornell Univ., USA;* [2]*College of Optics and Photonics, CREOL, Univ. of Central Florida, USA.* We describe, through multiple theoretical and experimental realizations, spatiotemporal mode-locking (STML), the most general form of self-organization in optical oscillators. We discuss qualitatively new kinds of mode-locking, and routes to ultrahigh power, compact lasers.

14:00–16:00
AF3M • Instruments and Components for Spectroscopy
Presider: Kara Peters; North Carolina State Univ., USA

AF3M.1 • 14:00
Experimental Demonstration of Mid-Infrared Computational Spectroscopy with a Plasmonic Filter Array, Benjamin J. Craig[1], Vivek R. Shrestha[1], Jiajun Meng[1], Kenneth B. Crozier[1]; [1]*Univ. of Melbourne, Australia.* We demonstrate mid-infrared plasmonic filters. We experimentally determine the spectrum of a mid-infrared light source using an algorithm whose inputs are the total power transmitted by each filter and the transmission spectrum of each filter.

AF3M.2 • 14:15
Phase-type zigzag grating for suppression high order diffraction, Ziwei Liu[1,2], Tanchao Pu[1,2], Lina Shi[1], Changqing Xie[1]; [1]*Inst. of Microelectronics of CAS, China;* [2]*Univ. of Chinese Academy of Sciences, China.* We present a novel design of phase-type diffraction grating for spectrum measurement from soft x-ray to far infrared. The 0, 2n, 3n order diffractions can be suppressed and the absolute diffraction efficiency is 27.72%.

AF3M.3 • 14:30
Folded planar metasurface spectrometer, MohammadSadegh Faraji-Dana[1], Ehsan Arbabi[1], Amir Arbabi[2], Seyedeh Mahsa Kamali[1], Hyounghan Kwon[1], Andrei Faraon[1]; [1]*T. J. Watson Lab of Applied Physics, California Inst. of Technology, USA;* [2]*Electrical and Computer Engineering, Univ. of Massachusetts Amherst, USA.* We present a folded planar spectrometer based on dielectric metasurfaces operating in the near-IR range(760nm-860nm) and achieving ~1.22nm spectral resolution. The planar and compact shape makes the demonstrated spectrometer well-suited for applications requiring integrated and portable spectrometers

14:00–16:00
SF3N • Ultrafast Pulse Manipulation

Presider: Alan Fry; SLAC National Accelerator Lab, USA

SF3N.1 • 14:00
6 GHz Repetition Rate Photocathode Laser for Multi-Bunch Operation of a Relativistic Electron Gun, Chen Li[1], Lutz Winkelmann[1], Ingmar Hartl[1]; [1]*Deutsches Elektronen-Synchrotron, Germany.* We report a new photocathode laser with 6 GHz repetition rate, generated by an electro-optic modulator comb. The laser is amplified by an Yb:fiber amplifier to 10 W and will be converted to UV for photoelectron generation.

SF3N.2 • 14:15
Space-Time Control of Broadband Light in a Multimode Fiber, Bohao Liu[1], Andrew M. Weiner[1]; [1]*Purdue Univ., USA.* Strong modal dispersion of a highly multimode fiber causes a space-time scrambled output field. Using pulse shaping, impulse responses at specific output spots can be characterized and spatial-temporal focusing can be achieved.

SF3N.3 • 14:30
Generation of 1.4-fs Ultrafast Single-Cycle Pulses with a Repetition Rate Exceeding 100 THz by Arbitrarily Manipulating Amplitude and Phase, Chuan Zhang[1], Kazumichi Yoshii[1,2], Dmitry Tregubov[1], Chiaki Ohae[1,2], Masaru Suzuki[1], Kaoru Minoshima[1,2], Masayuki Katsuragawa[1,2]; [1]*The Univ. of Electro-Communications, Japan;* [2]*JST, ERATO MINOSHIMA Intelligent Optical Synthesizer Project (IOS), Japan.* We report a new optical technology which enables arbitrarily manipulating amplitudes and phases of a highly-discrete optical spectrum and its application to generating a train of 1.4-fs ultrafast pulses with a repetition-rate exceeding 100 THz.

SF3N.4 • 14:45
Carrier-Envelope Phase Control and Single-Cycle Autocorrelation in Attosecond Coherent Nanotransport, Markus Ludwig[1], Tobias Rybka[1], Felix Ritzkowsky[1], Alfred Leitenstorfer[1], Daniele Brida[1]; [1]*Univ. of Konstanz, Germany.* We employ a pair of single-cycle near-infrared pulses to control coherent transfer of single electrons between the contacts of a plasmonic nanocircuit. As a result, attosecond highly nonlinear phenomena manifest themselves at pJ pulse energies.

14:00–16:00
FF3P • Strong-field Physics in Solids

Presider: Shambhu Ghimire; SLAC National Accelerator Lab, USA

FF3P.1 • 14:00 Invited
HHG in Solids: Influence of Band Structure on Harmonic Spectral and Temporal Properties, Mette B. Gaarde[1]; [1]*Louisiana State Univ., USA.* I will discuss how the spectral and temporal properties of harmonic radiation from solids are closely connected to their band structure. I will compare predictions for yields, cutoff energies and orientation-dependence to recent experimental results.

FF3P.2 • 14:30
Disentangling surface and bulk contributions to high-harmonic generation from solids, Giulio Vampa[1], Hanzhe Liu[1], Tony F. Heinz[1], David Reis[1,2]; [1]*Stanford PULSE Inst., USA;* [2]*Dept. of Applied Physics and Photon Science, Stanford Univ., USA.* We demonstrate that surface space-charges alter the large amplitude oscillations of electron-hole pairs during high-harmonic generation from silicon, resulting in the emission of weak even-order harmonics. Our results extend surface nonlinear optics to the non-perturbative regime.

FF3P.3 • 14:45
Enhanced Solid-State High-Harmonic Generation from a Silicon Metasurface, Hanzhe Liu[1,2], Cheng Guo[3,4], Giulio Vampa[1], Jingyuan Linda Zhang[3,4], Tomas Sarmiento[4,5], Meng Xiao[4], Philip Bucksbaum[1,2], Jelena Vuckovic[3,4], Shanhui Fan[3,4], David Reis[1,3]; [1]*Stanford Pulse Inst., USA;* [2]*Physics, Stanford Univ., USA;* [3]*Applied Physics, Stanford Univ., USA;* [4]*E. L. Ginzton Lab, USA;* [5]*Electrical Engineering, Stanford Univ., USA.* We report resonantly enhanced non-perturbative high-harmonic emission by more than two orders of magnitude from a Si metasurface that possesses a Fano-like resonance resulting from a classical analog of electromagnetically induced transparency.

14:00–16:00
AF3Q • A&T Topical Review on Time-Stretch Technology: Principles and Applications II

Presider: Cheng Lei; University of Tokyo, Japan

AF3Q.1 • 14:00 Invited
Coherent RogueScope, Dale Capewell[1], Bahram Jalali[2], Mohamad Asghari[3]; [1]*RogueScope, USA;* [2]*UCLA, USA;* [3]*Loyola Marymount Univ., USA.* Photonic time stretch has enabled new scientific discoveries, and new industrial and biomedical applications. RogueScope is its first commercial product. It measures full-field optical spectra in real-time at MHz refresh rates and millions of frames record length.

AF3Q.2 • 14:30 Invited
Large-scale, Deep Single-cell Analysis by All-optical Laser-scanning Imaging Cytometry, Kevin K. Tsia[1]; [1]*The Univ. of Hong Kong , Hong Kong.* Two techniques enabling ultralarge-scale multi-scale single-cell analysis (through biophysical and biochemical phenotyping) with the unprecedented combination of imaging resolution, contrast, and speed are introduced: interferometry-free quantitative phase time-stretch imaging and free-space angular-chirp-enhanced delay (FACED) imaging.

CLEO: Science & Innovations

SF3A • Integrated Photonics (III-V Heterogeneric)—Continued

SF3A.4 • 15:00
An Aluminum Nitride Integrated Photonics Platform for the Ultraviolet to Visible Spectrum, Tsung-Ju Lu[1], Michael Fanto[2,3], Hyeongrak Choi[1], Paul Thomas[2], Jeffrey Steidle[2], Sara L. Mouradian[1], Wei Kong[1], Di Zhu[1], Hyowon Moon[1], Karl K. Berggren[1], Jeehwan Kim[1], Mohammad Soltani[4], Stefan Preble[2], Dirk . Englund[1]; [1]*Research Lab of Electronics, MIT, USA;* [2]*Microsystems Engineering, Rochester Inst. of Technology, USA;* [3]*Air Force Research Lab, USA;* [4]*Raytheon BBN Technologies, USA.* We demonstrate a wide-bandgap semiconductor photonics platform based on aluminum nitride on sapphire. We measure ring resonators with quality factor >140,000 at 638 nm and >20,000 down to 369 nm, which shows a promising path for low-loss integrated photonics in the ultraviolet and visible spectrum.

SF3A.5 • 15:15
III-V Photonic Circuits with Waveguide-Integrated LED Source and WSi Nanowire Detectors, Corey McDonald[2,1], Sonia Buckley[1], Sae Woo Nam[1], Richard Mirin[1], Galan Moody[1], Jeffrey Shainline[1], Kevin L. Silverman[1]; [1]*NIST, USA;* [2]*Physics, Univ. of Colorado Boulder, USA.* We describe the fabrication and testing of photonic circuits using a III-V LED light source coupled to waveguide-integrated WSi single photon detectors for use in advanced computing and on-chip quantum optics experiments.

SF3A.6 • 15:30
Non-volatile All-Optical Quasi-Continuous Switching in GST-on-Silicon Microring Resonators, Jiajiu Zheng[1], Amey Khanolkar[1], Peipeng Xu[2,1], Shane A. Colburn[1], Sanchit Deshmukh[3], Jason Myers[4], Jesse Frantz[4], Eric Pop[3], Nicholas Boechler[1], Arka Majumdar[1]; [1]*Univ. of Washington, Seattle, USA;* [2]*Ningbo Univ., China;* [3]*Stanford Univ., USA;* [4]*US Naval Research Lab, USA.* Based on GST-on-silicon hybrid nanophotonic integrated circuits, we demonstrate a non-volatile reprogrammable platform, where we achieve all-optical quasi-continuous tuning of microring resonators with switching extinction ratio up to 33dB by controlling a pulsed laser.

Joint

JF3B • Symposium on Emerging Quantum Sensing Techniques and Applications II—Continued

JF3B.4 • 15:00 Invited
Optimal and Secure Measurement Protocols for Quantum Sensor Networks, Alexey Gorshkov[1]; [1]*Joint Quantum Inst., USA.* We find the optimal entanglement-enhanced protocol for measuring linear combinations of the values of a field (e.g. magnetic or electric) at different spatial points. This has potential applications in chemistry, biology, medicine, geodesy, and geophysics.

JF3B.5 • 15:30 Invited
Quantum Sensing with Extreme-coherence Spin Ensembles, Morgan Mitchell[1], Silvana Palacios[1], Simon Coop[1], Pau Gomez[1], Thomas Vanderbruggen[2], Natali M. de Escobar[3], Martijn Jasperse[4]; [1]*ICFO -The Inst. of Photonic Sciences, Spain;* [2]*Koheron, Centre scientique d'Orsay, France;* [3]*Lone Star College, Univ. Park, USA;* [4]*The Univ. of Melbourne, Australia.* We demonstrate an ultra-cold magnetic spin ensemble with seemingly-unlimited coherence time. We discuss its use as an extreme magnetic sensor.

CLEO: QELS-Fundamental Science

FF3C • Optimization and Design of Metasurfaces—Continued

FF3C.5 • 15:00
Robust Design for Topology Optimized Metasurfaces, Evan W. Wang[1], David Sell[2], Jianji Yang[1], Jonathan Fan[1]; [1]*Dept. of Electrical Engineering, Stanford Univ., USA;* [2]*Dept. of Applied Physics, Stanford Univ., USA.* We implement robustness control in topology-optimized metasurfaces and show that robust metasurfaces are relatively insensitive to geometric erosion and dilation. We also explore the physical mechanisms enabling robustness through a coupled mode analysis.

FF3C.6 • 15:15
Metasurface Lenses Based on Topology-Optimized Wavelength-Scale Building Blocks, Thaibao Phan[1], David Sell[1], Jianji Yang[1], Sage Doshay[1], Jonathan Fan[1]; [1]*Stanford Univ., USA.* We develop a new technique for improving the performance of planar, high numerical aperture metamaterial lenses by combining wavelength-scale diffractive elements designed using topology optimization.

FF3C.7 • 15:30
Scaling Laws for Inverse-Designed Metadevices, Philip Camayd-Muñoz[1], Andrei Faraon[1]; [1]*California Insitute of Technology, USA.* Metasurface designs are typically limited to single functions. We use an inverse design method to optimize device performance across multiple tasks, and investigate limits on performance based on effective degrees of freedom in the system.

FF3D • Spectroscopy of Low Dimensional Systems—Continued

FF3D.5 • 15:00
All-Optical Determination of 3-Dimensional Alignment of Crystal Axis of Single Colloidal Quantum Dots for Control of Ultrafast Spin Dynamics, Pascal Gumbsheimer[1], Christopher Hinz[1], Yannic Behovits[1], Florian Werschler[1], Christian Traum[1], Denis Seletskiy[2,1], Alfred Leitenstorfer[1]; [1]*Universität Konstanz, Germany;* [2]*École Polytechnique de Montréal, Canada.* The spatial alignment of the crystallographic axes of single colloidal quantum dots is determined by purely optical means. This capability allows maximizing the Zeeman interaction in a magnetic field which is vital e.g. for efficient and ultrafast single-photon amplification.

FF3D.6 • 15:15
Probing the Influence of Shell Configurations on the Exciton Dephasing of CdSe Colloidal Quantum Dots Using Multidimensional Coherent Spectroscopy, Diogo Almeida[1], Albert Liu[1], Wan Ki Bae[3], Lazaro Padilha[2], Steven T. Cundiff[1]; [1]*Univ. of Michigan, USA;* [2]*Universidade Estadual de Campinas, Brazil;* [3]*Korea Inst. of Science and Technology, South Korea.* Using multidimensional coherent spectroscopy, measurements of exciton dephasing, acoustic phonon confinement and fine structure splitting were obtained for CdSe colloidal quantum dots with different shell configurations, enabling identification of the shell's influence over these properties.

FF3D.7 • 15:30
Evidence of Non-Markovian Dynamics in CdSe/CdZnS Colloidal Quantum Dots Revealed by 2D Coherent Spectroscopy, Albert Liu[1], Diogo Almeida[1], Wan Ki Bae[2], Lazaro Padilha[3], Steven T. Cundiff[1]; [1]*The Univ. of Michigan, USA;* [2]*Korea Inst. of Science and Technology, South Korea;* [3]*Universidade Estadual de Campinas, Brazil.* We present evidence of non-Markovian dynamics of interband coherences in CdSe/CdZnS colloidal quantum dots by using the 0-quantum 2D coherent spectroscopy technique at cryogenic temperatures.

CLEO: QELS-Fundamental Science

FF3E • Photon-Phonon Interactions and Cooling—Continued

FF3E.4 • 15:00
Investigation of solid state laser cooling in Ytterbium-doped silica fibers, Esmaeil Mobini[1], Mostafa Peysokhan[1], Behnam Abaie[1], Arash Mafi[1]; *[1]Univ. of New Mexico, USA.* The possibility of solid-state laser cooling (SSLC) in a single mode Yb-doped silica fiber is investigated. The results show that the material is a viable candidate for SSLC and radiation-balanced lasers.

FF3E.5 • 15:15
Effect of Thermal Nonlinearities on Sideband Asymmetry Measurements in Quantum Optomechanics, Itay Shomroni[1], Liu Qiu[1], Marie Ioannou[1], Daniel Malz[2], Andreas Nunnenkamp[2], Tobias J. Kippenberg[1]; *[1]EPFL, Switzerland; [2]Cavendish Lab, Univ. of Cambridge, UK.* Probing an optomechanical crystal cavity with two optical tones leads to generation of multiple asymmetric mechanical sidebands. This occurs due to nonlinear thermal effects in the cavity, that interfere with the optomechanical scattering.

FF3E.6 • 15:30
Measuring the spin-dependent lateral force in evanescent fields, Lulu Liu[1], Andrea Di Donato[1], Vincent Ginis[1,2], Simon Kheifets[1], Arman Amirzhan[1], Federico Capasso[1]; *[1]Harvard SEAS, USA; [2]Applied Physics, Vrije Universiteit Brussel, Belgium.* We report the quantitative measurement of the out-of-plane spin-dependent optical force acting on a microsphere in evanescent fields. The measurement was made via a thermally-limited floating-probe detection scheme with extreme sensitivity and high dynamic range.

FF3F • Optomechanical Interactions and Single Particle Tracking—Continued

FF3F.4 • 15:00
Synthetic Optical Anisotropy via Plasmonic Resonant Tuning of Nanorod Orientation, Huizhong Xu[1], Trevor S. Kelly[1], Pepito J. Alvaro[1], Yu-Xuan Ren[1], Chensong Zhang[1], Yinxiao Xiang[1], Zhigang Chen[1,2]; *[1]Dept. of Physics & Astronomy, San Francisco State Univ., USA; [2]TEDA Applied Physics Inst. and School of Physics, Nankai Univ., China.* We demonstrate tunable orientation of gold nanorods in colloidal suspensions via plasmonic resonant solitons. Wavelength-dependent polarizability and optical torque lead to synthetic anisotropic optical properties (birefringence and dichroism) of the nanorods along the soliton channel.

FF3F.5 • 15:15
Programmable Transport of Nanoparticles Based on a Plasmonic Metasurface, Min Jiang[1], Guanghui Wang[1], Wenhao Xu[1], Xuping Zhang[1]; *[1]Nanjing Univ., China.* Plasmonic nano-ellipses metasurface are designed for the realization of programmable two-dimensional transport of nanoparticles through rotating the polarization of an excitation beam, which can be used in lab-on-a-chip applications.

FF3F.6 • 15:30
Long-range Laser-induced Self-assembly via Plasmon Radiative Interactions and the Lorentz Force, Haojie Ji[1], Jacob Trevino[2,3], Raymond Tu[4,3], Ellen Knapp[4], Farzad Mashayek[5], Vitaliy Yurkiv[5], Luat Vuong[1,6]; *[1]Queens College of CUNY, USA; [2]Chemistry, The Graduate Center of the City Univ. of New York, USA; [3]Advanced Science Research Center of the Graduate Center at the City Univ. of New York, USA; [4]Chemical Engineering, City College of New York, USA; [5]Mechanical and Industrial Engineering, Univ. of Illinois at Chicago, USA; [6]Physics, The Graduate Center of the City Univ. of New York, USA.* We report on the light-induced formation of gold-nanoparticle chains as long as 200μm, aligned perpendicular to the illuminating linear polarization. The long-range self-assembly is shown to arise from plasmon radiation and the Lorentz force.

CLEO: Science & Innovations

SF3G • Quantum Cascade Lasers—Continued

SF3G.4 • 15:00
The Role of Spatial and Spectral Hole Burning in QCL Frequency Comb Formation, Nathan C. Henry[1], Jacob Khurgin[1]; *[1]Johns Hopkins Univ., USA.* We investigate theoretically formation of frequency comb in Quantum Cascade Lasers operating in mid-IR and THz regions and show that spectral and spatial hole burning mitigation favors pseudo-random frequency modulation format.

SF3G.5 • 15:15
Raman Emission From An Electrically Pumped Phonon Polariton Laser, Keita Ohtani[1], Lorenzo Bosco[1], Mattias Beck[1], Martin Franckie[1], Camille Ndebeka-Bandou[1], Jérôme Faist[1]; *[1]ETH Zurich, Switzerland.* We demonstrate an electrically pumped laser that generates phonon polaritons. The emission also appears directly on a Raman spectrum measurement exhibiting a Stokes and anti-Stokes component with the expected shift of 48meV.

SF3G.6 • 15:30
Surface-Emitting Terahertz Quantum-Cascade Laser with 170 mW Output Power in a Single Lobed Beam, Yuan Jin[1], Liang Gao[1], Ji Chen[1], Chongzhao Wu[1], John Reno[2], Sushil Kumar[1]; *[1]Lehigh Univ., USA; [2]Sandia National Labs, USA.* A fourth-order Bragg grating scheme is developed to achieve single-lobed emission and increased radiative efficiencies from surface-emitting semiconductor lasers. Record-high peak output power of 170mW is demonstrated for a single-mode 3.4THz quantum-cascade laser at 62K.

CLEO: QELS-Fundamental Science

FF3H • Wavefront Shaping in Complex Media—Continued

FF3H.5 • 15:00 Invited
Adaptive Wave-front shaping in Linear and Nonlinear Complex Media , Omer Tzang[1], Antonio Caravaca-Aguirre[1], Kelvin Wagner[1], Rafael . Piestun[1]; *[1]Univ. of Colorado Boulder, USA.* We present wave-front-shaping (WFS) methodologies for controlling light propagation in complex nonlinear media. We demonstrate linear and nonlinear photoacoustic feedback for focusing through scattering media and control nonlinear interactions along multimode fibers.

FF3H.6 • 15:30
Coherent Injection of Light into Lossy Micro-Porous Scattering Medium, Alexey G. Yamilov[1], Raktim Sarma[2], Vladislav Yakovlev[3], Hui Cao[2]; *[1]Missouri Univ of Science & Technology, USA; [2]Yale Univ., USA; [3]Texas A&M Univ., USA.* We demonstrate a possibility of efficient injection of light into scattering lossy medium by coupling to eigenchannels confined to a micro-pore. Evidence of enhanced injection past absorption length is obtained in wave-front shaping experiments.

SF3I • Materials for Fiber and Solid State Lasers—Continued

SF3I.5 • 15:00
Crystal growth, spectroscopy and femtosecond laser performance of Tm,Na:CNGG disordered garnet crystal, Zhongben Pan[1,2], Yicheng Wang[1], Yongguang Zhao[1,3], Hualei Yuan[2], Xiaojun Dai[2], Huaqiang Cai[2], Ji Eun Bae[4], Sun Young Choi[4], Fabian Rotermund[4], Xavier Mateos[5], Josep Maria Serres[5], Pavel Loiko[6], Uwe Griebner[1], Valentin Petrov[1]; *[1]Max-Born-Inst. for Nonlinear Optics and Short Pulse Spectroscopy, Germany; [2]Inst. of Chemical Materials, China Academy of Engineering Physics, China; [3]Jiangsu Key Lab of Advanced Laser Materials and Devices, Jiangsu Normal Univ., China; [4]Dept. of Physics, Korea Advanced Inst. of Science and Technology (KAIST), South Korea; [5]5Física i Cristal lografia de Materials i Nanomaterials (FiCMA-FiCNA)-EMaS, Dept. Química Física i Inòrganica, Universitat Rovira i Virgili (URV), Campus Sescelades, Spain; [6]ITMO Univ., Russia.* We report on the crystal growth, spectral properties, and mode-locked laser operation of Tm,Na:CNGG, generating pulses as short as 84 fs at ~2018 nm using single-walled carbon nanotubes as a saturable absorber.

SF3I.6 • 15:15
Reduced loss in SiGe-core optical fibers, Trygve Sørgård[1], Korbinian Mühlberger[2], Wu Wei[1], Xiong Yang[2], Thomas Hawkins[3], John Ballato[3], Fredrik Laurell[2], Michael Fokine[2], Ursula J. Gibson[1,2]; *[1]Norges Teknisk Naturvitenskapelige Univ, Norway; [2]Applied Physics, KTH, Sweden; [3]Clemson Univ., USA.* We investigate CO_2 laser processing of SiGe-core glass fibers, and show that homogeneous, low optical loss cores can be made. Coaxial Ge-rich centers within the semiconductor cores can also be fabricated.

SF3I.7 • 15:30
Efficient High Power Yellow Tb^{3+}:$LiLuF_4$ Laser, Elena Castellano-Hernández[1], Maksim Dzemesh[4], Hiroki Tanaka[2], Christian Kränkel[1,3]; *[1]Leibniz Inst. for Crystal Growth, Germany; [2]Dept. of Electronics and Electrical Engineering, Keio Univ., Japan; [3]Inst. of Laser-Physics, Univ. of Hamburg, Germany; [4]Center for Optical Materials and Technologies, Belarusian National Technical Univ., Belarus.* We report on yellow Tb^{3+}:$LiLuF_4$ solid-state lasers. Under 2.1 W of 2ω-OPSL-pumping at 486.2 nm the laser delivers 0.45 W of cw output at a wavelength of 587.5 nm and a slope efficiency of 23%

SF3J • Mid IR Sensing and Optical Forces—Continued

SF3J.5 • 15:00
Thin-Film Magnetless Faraday Rotators for Heterogeneously Integrated On-Chip Optical Isolators, Miguel Levy[1], Dolendra Karki[1], Vincent Stenger[2], Andrea Pollick[2]; *[1]Michigan Technological Univ., USA; [2]Srico, Inc, USA.* This article describes the processing, characterization, and transfer of 26 µm-thick by 480 µm-long iron-garnet Faraday rotator films onto semiconductor substrates. Insertion losses below 0.1 dB and extinction ratios of -30 dB are achieved. No magnets are needed.

SF3J.6 • 15:15
Mid-Infrared Silicon-on-Sapphire Polarization Rotator, Joel Guo[2], Ali Rostamian[2], Swapnajit Chakravarty[1], Hai Yan[2], Chi-Jui Chung[2], Elham Heidari[2], Ray Chen[2,1]; *[1]Omega Optics, Inc, USA; [2]Electrical and Computer Engineering, Univ. of Texas at Austin, USA.* We experimentally demonstrate mid-infrared polarization rotators in silicon-on-sapphire at wavelength l= 4.55mm to enable integration of quantum cascade lasers and detectors with slotted photonic crystal waveguide gas sensors. Polarization selective grating couplers are also demonstrated.

SF3J.7 • 15:30
Mid-infrared integrated photonic elements and efficient couplers on fusion-bonded, suspended silicon membranes, Jeff Chiles[1], Nima Nader[1], Scott A. Diddams[1], Sae Woo Nam[1], Richard Mirin[1]; *[1]NIST, USA.* Using all-silicon fusion-bonded membrane waveguides, we demonstrate efficient input/output couplers with 1.8 dB loss at λ = 3.06 µm, 1×2 power splitters (Y- and MMI-type), 25 µm bends, and 0.35 dB transitions to fusion-sealed micro-channels.

SF3K • Mode-Locked Fiber Lasers—Continued

SF3K.4 • 15:00
Figure-9 Fiber Laser with Phase Bias by Frequency Shifter, Yuki Shirakura[1], Koji Takiguchi[1], Shinji Yamashita[1], Sze Y. Set[1]; *[1]The Univ. of Tokyo, Japan.* We propose a novel figure-9 fiber laser using a frequency shifter to produce phase bias. Mode-locking operation is successfully archived, and arbitrary phase bias can be produced by changing the frequency shift.

SF3K.5 • 15:15
Reduction of Intensity Noise in Mode-Locked Er-Fiber Oscillators and Amplifiers by Optical Bandpass Filtering, Dohyun Kim[1], Shuangyou Zhang[1], Jungwon Kim[1]; *[1]Korea Advanced Inst of Science & Tech, South Korea.* Relative-intensity-noise (RIN) of <-140 dB/Hz over broad offset frequency (20 Hz – 1 MHz) of mode-locked Er-fiber oscillator output is demonstrated by optical bandpass filtering. Optical filtering also reduces the Er-doped fiber amplifier output RIN by ~10-dB.

SF3K.6 • 15:30
Gate controllable and stabilized ultrafast fiber lasers based on graphene, Baicheng Yao[1], Giancarlo Soavi[1], Teng Ma[1], Xiao Zhang[1], Bo Fu[1], Duhee Yoon[1], Syed Hussain[1], Antonio Lombardo[1], Daniel Popa[1], Andrea Ferrari[1]; *[1]Cambridge graphene center, Univ. of Cambridge, UK.* We report an all-fiber graphene-based gate tunable saturable absorber, dispersion controller and electrical feedback accepter, for mode-locked lasers, enabling tunable repetition rate up to 348 GHz, with minimized supermode noise <-50 dB and timing jitter <6.62×10^{-17} s.

AF3M • Instruments and Components for Spectroscopy—Continued

AF3M.4 • 15:00
Impact of Tapered Nano-Slits Grating on The Optical Enhancement of Photo-Sensing Devices, Ahmad A. Darweesh[1], Stephen Bauman[1], Joseph Herzog[1]; *[1]Univ. of Arkansas, USA.* A nano-grating structure with a 5nm slit and 15 nm thickness was simulated. Optical enhancement, which can be harnessed to improve photo-sensing devices such as photodetectors and biosensors, was calculated for various tapered nanoslits.

AF3M.5 • 15:15
Wavefront Aberration Compensation Method to Fabricate Large Gratings with Low Spacing Error Using Broad-beam Scanning Exposure, Yuxuan Zhao[1], Lijiang Zeng[1]; *[1]Tsinghua Univ., China.* A wavefront aberration compensation method is proposed to reduce the spacing error accumulation in broad-beam scanning exposure. A 200 mm × 100 mm grating with a spacing error of 0.07 λ was fabricated.

AF3M.6 • 15:30
Goddard Laser for Absolute Measurement of Radiance for Instrument Calibration in the Ultraviolet to Short Wave Infrared, Brendan McAndrew[1], Joel McCorkel[1], Timothy Shuman[2], Barbara Zukowski[3], Aboubakar Traore[4], Michael Rodriguez[5], Steven Brown[6], John Woodward[6]; *[1]NASA Goddard Space Flight Center, USA; [2]Fibertek, USA; [3]Ball Aerospace, USA; [4]NASA Langley Research Center, USA; [5]Sigma Space Corporation, USA; [6]NIST, USA.* A description of the Goddard Laser for Absolute Calibration of Radiance, a tunable, narrow linewidth spectroradiometric calibration tool, and results from calibration of an earth science satellite instrument from ultraviolet to short wave infrared wavelengths.

CLEO: Science & Innovations

SF3N • Ultrafast Pulse Manipulation—Continued

SF3N.5 • 15:00
Three-octave-wide Phase-stable Seeding Scheme for Parallel Parametric Waveform Synthesizers, Roland E. Mainz[1,2], Giulio M. Rossi[1,2], Yudong Yang[1,2], Oliver Muecke[1,2], Giovanni Cirmi[1,2], Franz X. Kaertner[1,2]; *[1]Center for Free-Electron Laser Science, Deutsches Elektronen-Synchrotron DESY, Germany; [2]Univ. of Hamburg, Physics Dept. and The Hamburg Centre for Ultrafast Imaging, Germany.* We present a three-octave-wide phase-stable seeding scheme using separate supercontinua in bulk driven by a CEP-stable laser and its second harmonic to provide optimized seeds for each spectral channel of a parallel parametric waveform synthesizer.

SF3N.6 • 15:15
Flexible Width Nyquist Pulse Based on a Single Mach-Zehnder Modulator, Jianqi Hu[1], Simon J. Fabbri[1], Camille-Sophie Bres[1]; *[1]EPFL, Switzerland.* We present a Nyquist pulse generation technique based on a single Mach-Zehnder modulator driven by a multi-harmonic electrical signal. The direct control of the RF components yields a range of 10 GHz sinc-shaped pulse train.

SF3N.7 • 15:30
On-the-fly Recovery of Arbitrary Waveforms from In-band Noise by Linear Coherent Spectral Energy Re-distribution, Benjamin G. Crockett[1], Luis Romero Cortés[1], Jose . Azana[1]; *[1]INRS, Canada.* We introduce a novel concept for in-band noise mitigation applicable to non-repetitive events, through linear spectral and temporal phase control. We demonstrate recovery of broadband optical waveforms, with unknown characteristics, buried under noise.

CLEO: QELS-Fundamental Science

FF3P • Strong-field Physics in Solids—Continued

FF3P.4 • 15:00
Controlling High Harmonic Generation in Tailored Semiconductors, Marco Taucer[1,3], Murat Sivis[2,3], Giulio Vampa[1,3], Kyle Johnston[1,3], André Staudte[1,3], Andrei Naumov[1,3], David Villeneuve[1,3], Claus Ropers[2], Paul B. Corkum[1,3]; *[1]Univ. of Ottawa, Canada; [2]Georg-August Univ., Germany; [3]National Research Council of Canada, Canada.* Here, we use nanofabrication tools to demonstrate the potential to tailor semiconductor targets for high harmonic generation. Morphology and local composition can localize light fields and enhance emission, which can be used to realize new high harmonic devices.

FF3P.5 • 15:15
Strong-Field Polarization-State Control of Higher Harmonics Generated in Crystalline Solids, Nicolai Klemke[1,2], Nicolas Tancogne-Dejean[3,4], Giulio M. Rossi[1,2], Yudong Yang[1,2], Roland E. Mainz[1,2], Giuseppe Di Sciacca[1], Eliza Casandruc[1], Angel Rubio[3,4], Franz X. Kaertner[1,2], Oliver Muecke[1,5]; *[1]Center for Free-Electron Laser Science CFEL, Deutsches Elektronen Synchrotron DESY, Germany; [2]Physics Dept., Univ. of Hamburg, Germany; [3]Max Planck Inst. for the Structure and Dynamics of Matter, Germany; [4]European Theoretical Spectroscopy Facility (ETSF), Germany; [5]The Hamburg Centre for Ultrafast Imaging, Germany.* We demonstrate that the polarization states of higher harmonics emitted from crystalline solids (here silicon, quartz) are determined by both crystal symmetry and nonperturbative dynamics, opening the door to strong-field control of the harmonics' polarization states.

FF3P.6 • 15:30
Anisotropic Polarization Dependent High Harmonic Generation in the Ferroelectric Crystal $BaTiO_3$, Shima Gholam Mirzaeimoghadar[1], Erin Crites[1], John E. Beetar[1], Aiping Chen[3], Michael Chini[1,2]; *[1]Physics, Univ. of Central Florida, USA; [2]CREOL, the College of Optics and Photonics, Univ. of Central Florida, USA; [3]Center for Integrated Nanotechnologies, Los Alamos National Lab, USA.* We generate high-order harmonics from femtosecond mid-IR pulses in ferroelectric $BaTiO_3$ crystals. We find that odd and even harmonics' intensity and polarization behave differently when rotating the input polarization with respect to the crystal axes.

CLEO: Applications & Technology

AF3Q • A&T Topical Review on Time-Stretch Technology: Principles and Applications II—Continued

AF3Q.3 • 15:00 Invited
Optofluidic Time-stretch Microscopy for Precision Medicine, Cheng Lei[1], Yasuyuki Ozeki[2], Keisuke Goda[1]; *[1]Dept. of Chemistry, The Univ. of Tokyo, Japan; [2]Dept. of Electrical Engineering and Information Systems, The Univ. of Tokyo, Japan.* We present the principle of optofluidic time-stretch microscopy and its application to precision medicine. Its ability to perform multiparametric image-based profiling of numerous single cells enables biomedical data mining with the help of machine learning.

AF3Q.4 • 15:30
Introduction to Time-folded Optics; Spatial Compression of Paraxial Optics Using Time, Barmak Heshmat[1], Matthew Tancik[1], Guy Satat[1], Ramesh Raskar[1]; *[1]MIT, USA.* We exploit the high time resolution of ultrafast imaging sensors to fold and modify the imaging optics of the camera. We demonstrate an order of magnitude compression in lens –sensor distance using a time-folded design.

CLEO: Science & Innovations

SF3A • Integrated Photonics (III-V Heterogeneric)—Continued

SF3A.7 • 15:45
A multifunctional micro-electro-opto-mechanical (MEOM) platform based on phase-transition materials, Xi Wang[1], Kaichen Dong[1,2], Hwan Sung Choe[1,2], Huili Liu[1,2], Shuai Lou[1], Kyle Tom[1,2], Hans Bechtel[4], Zheng You[3], Junqiao Wu[1,2], Jie Yao[1,2]; *[1]Univ. of California, Berkeley, USA; [2]Materials Sciences Division, Lawrence Berkeley National Lab, USA; [3]Dept. of Precision Instrument, Tsinghua Univ., China; [4]Advanced Light Source Division, Lawrence Berkeley National Lab, USA.* We demonstrate a new MEOM multifunctional platform activated by the structural phase transition of an embedded vanadium dioxide layer. Its diverse stimuli and > 50% optical modulation depth over a broad wavelength range promise versatile applications.

Joint

JF3B • Symposium on Emerging Quantum Sensing Techniques and Applications II—Continued

CLEO: QELS-Fundamental Science

FF3C • Optimization and Design of Metasurfaces—Continued

FF3D • Spectroscopy of Low Dimensional Systems—Continued

FF3D.8 • 15:45
A Near Deterministic Plasmonic Quantum Zeno Gate using Graphene Nanoribbons, Irati Alonso Calafell[1], Joel Cox[2], Milan Radonjic[1], José Ramón Martínez Saavedra[2], Javier García de Abajo[2], Lee Rozema[1], Philip Walther[1]; *[1]Univ. of Vienna, Austria; [2]ICFO, Spain.* The scalability of photonic quantum-computation is limited by the low success probability of two-qubit logic gates. We propose a root-SWAP gate based on graphene nanoribbons, where the strong two-plasmon absorption boosts its success above 90%.

CLEO: QELS-Fundamental Science

FF3E • Photon-Phonon Interactions and Cooling—Continued

FF3E.7 • 15:45
Observation of stimulated Brillouin scattering and Brillouin frequency comb generation in diamond, Zhenxu Bai[1,2], Robert J. Williams[1], Ondrej Kitzler[1], Soumya Sarang[1], Richard P. Mildren[1]; *[1]Macquarie Univ., Australia; [2]Harbin Inst. of Technology, China.* We report evidence for stimulated Brillouin scattering in diamond using an intense Raman-generated intracavity pump. Configurations are described for producing a single Stokes line and a Brillouin frequency comb containing up to the 22 orders spaced over 1.55 THz.

FF3F • Optomechanical Interactions and Single Particle Tracking—Continued

FF3F.7 • 15:45
All-optical Light Control in Dielectric Bilayer Optical Surfaces via Optomechanical Interaction, Carol Bibiana Rojas Hurtado[1], Johannes Dickmann[1], Walter Dickmann[2], Thomas Siefke[3], Stefanie Kroker[1,2]; *[1]Physikalisch-Technische Bundesanstalt, Germany; [2]Technische Universität Braunschweig, Germany; [3]Friedrich-Schiller-Univ. Jena, Germany.* We propose a bilayer Gamma-shape grating structure as a novel nano-optomechanical system promising for all-optical modulation in a frequency range of a few MHz up to a few 100 MHz.

CLEO: Science & Innovations

SF3G • Quantum Cascade Lasers—Continued

SF3G.7 • 15:45
Difference-Frequency Generation Terahertz Quantum Cascade Lasers with Surface Grating Outcouplers, Jae Hyun Kim[1], Seungyong Jung[1], Yifan Jiang[1], Kazuue Fujita[2], Masahiro Hitaka[2], Akio Ito[2], Tadataka Edamura[2], Mikhail A. Belkin[1]; *[1]Univ. of Texas at Austin, USA; [2]Hamamatsu Photonics K.K., Japan.* We report terahertz quantum cascade laser sources based on intra-cavity difference-frequency generation processed into double-metal waveguides with surface-grating outcouplers. Over 112 μW of peak power output is produced at room temperature at 1.9 THz.

CLEO: QELS-Fundamental Science

FF3H • Wavefront Shaping in Complex Media—Continued

FF3H.7 • 15:45
Broadband perfect transmission through non-Hermitian disordered media, Konstantinos Makris[1], Andre Brandstotter[2], Stefan Rotter[2]; *[1]Univ. of Crete, Greece; [2]Inst. for Theoretical Physics, Vienna Univ. of Technology, Austria.* We examine the resonance properties of a novel type of waves, the constant-intensity (CI) waves in one-dimensional non-Hermitian disordered media. Such CI waves propagate perfectly through a scattering landscape without any reflection.

CLEO: Science & Innovations

SF3I • Materials for Fiber and Solid State Lasers—Continued

SF3I.8 • 15:45
Direct generation of a 'bottle beam' from an end-pumped Nd:YVO_4 laser with second-harmonic generation, Jung-Chen Tung[1], Yuan-Yuan Ma[1], Yung-Fu Chen[2], Kai-Feng Huang[2], Takashige Omatsu[1]; *[1]Chiba Univ., Taiwan; [2]National Chiao Tung Univ., Taiwan.* We have demonstrated, for the first time, the generation of an optical 'bottle beam' with a 'zero-intensity' region surrounded by three-dimensional bright regions from an intra-cavity frequency-doubled Nd:YVO_4 laser with a nearly hemispherical cavity configuration.

SF3J • Mid IR Sensing and Optical Forces—Continued

SF3J.8 • 15:45
Long-Wave Infrared Germanium-on-Silicon Waveguides Beyond 10 µm, Dmitry Kozak[1], Todd H. Stievater[1], Rita Mahon[1], Marcel W. Pruessner[1], William S. Rabinovich[1]; *[1]US Naval Research Lab, USA.* We show low-loss propagation in germanium-on-silicon (GOS) waveguides from 6.85 µm to 11.25 µm. The loss is as low as a few dB/cm at a wavelength of 10 µm for both the quasi-TE_{00} and quasi-TM_{00} modes.

SF3K • Mode-Locked Fiber Lasers—Continued

CLEO: Applications & Technology

AF3M • Instruments and Components for Spectroscopy—Continued

AF3M.7 • 15:45
Peculiarities of near-room-temperature thermal-emission measurements using FTIR spectroscopy, Yuzhe Xiao[1], Alireza Shahsafi[1], Patrick Roney[1], Chenghao Wan[1], Graham Joe[1], Zhaoning Yu[1], Jad Salman[1], Mikhail Kats[1]; *[1]Univ. of Wisconsin-Madison, USA.* We investigated the impact of multi-source background emission on thermal-emission measurements using FTIR spectroscopy. We found that a backward-emitting background in the interferometer can lead to partial or total cancellation of the measured thermal emission.

SF3N • Ultrafast Pulse Manipulation—Continued

FF3P • Strong-field Physics in Solids—Continued

FF3P.7 • 15:45
Wannier-Stark Localization in Bulk Gallium Arsenide Induced by Extreme Mid-Infrared Fields, Johannes Bühler[1], Christian Schmidt[1], Alexander-Cornelius Heinrich[1], Jonas Allerbeck[1], Reinold Podzimski[2], Daniel Berghoff[2], Torsten Meier[2], Wolf G. Schmidt[2], Christian Reichl[3], Werner Wegscheider[3], Daniele Brida[1], Alfred Leitenstorfer[1]; [1]*Dept. of Physics and Center for Applied Photonics, Univ. of Konstanz, Germany;* [2]*Dept. of Physics and Center for Optoelectronics and Photonics Paderborn, Univ. of Paderborn, Germany;* [3]*Solid State Physics Lab, ETH Zurich, Switzerland.* Sub-cycle transmission measurements of bulk gallium arsenide biased by intense mid-infrared transients reveal a strong blue-shift of the optical absorption when the peak electric field reaches 10 MV/cm, indicating 2D-localization of electronic wave functions.

AF3Q • A&T Topical Review on Time-Stretch Technology: Principles and Applications II—Continued

AF3Q.5 • 15:45
High-resolution time-stretch microscopy based on asynchronous optical sampling, Xi Zhou[1], Xin Dong[1], Jiqiang Kang[2], Liao Chen[1], Chi Zhang[1], Kenneth Kin-Yip Wong[2], Xinliang Zhang[1]; [1]*Wuhan National Lab for Optoelectronics,, China;* [2]*Dept. of Electrical and Electronic Engineering, The Univ. of Hong Kong, Hong Kong.* We propose and demonstrate an ultrafast time-stretch microscopy based on asynchronous optical sampling (ASOPS) with 92-MHz sampling rate and 10-kHz frame rate, and this microscopy achieves 2.3-μm lateral resolution leveraging 1.9-MHz acquisition bandwidth.

Key to Authors and Presiders

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