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

[List of sponsors images and logos]

Conference on Lasers and Electro-Optics®
# Schedule-at-a-Glance

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<th>Sunday 5 May</th>
<th>Monday 6 May</th>
<th>Tuesday 7 May</th>
<th>Wednesday 8 May</th>
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<td>Registration</td>
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<td>Speaker Ready Room</td>
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<td>Coffee Breaks</td>
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<td><strong>CLEO TECHNICAL PROGRAMMING</strong></td>
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<td>Short Courses</td>
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<td>Technical Sessions</td>
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<tr>
<td>Special Symposium and A&amp;T Topical Reviews</td>
<td>08:00–16:00</td>
<td>13:00–19:00</td>
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<td>CLEO Workshops</td>
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<td>Plenary Sessions</td>
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<td>Posters and Dynamic e-Posters</td>
<td>11:30–13:00</td>
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<td>Postdeadline Paper Sessions</td>
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<tr>
<td><strong>CLEO:EXPO AND SHOW FLOOR ACTIVITIES</strong></td>
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<td>CLEO:EXPO</td>
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<td>Unopposed EXPO-Only Time</td>
<td>11:30–13:00</td>
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<td>Poster Sessions and Free Lunches in Exhibit Hall</td>
<td>11:30–13:00</td>
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<td>CLEO Theaters I &amp; II</td>
<td>10:00–17:00</td>
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<td>Meet OSA Publishing Journal Editors Ice Cream Social</td>
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<td>Technology Transfer Program</td>
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<td><strong>SPECIAL EVENTS</strong></td>
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<td>Pride in Photonics: LGBTQ+ &amp; Ally Workshop</td>
<td>09:00–13:00</td>
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<td>Be Part of the Solution: Preventing and Responding to Harassment</td>
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<td>OSA Presentation Feedback Program</td>
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<td>Navigate Your Leadership Trajectory for Senior Leaders</td>
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<td>Resumes, Linkedin, and Networking (with Cheeky Scientist)</td>
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<td>Social Media in 2019 Panel Discussion</td>
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<td>Deliberate Mentoring to Advance Your Career: Special Flash Mentoring</td>
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<td>Professional Development for Busy Professionals</td>
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<td>Diversity and Inclusion Reception</td>
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<td>OSA Technical Group Events</td>
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*on show floor*
Welcome to CLEO!

It is our pleasure to welcome you to CLEO 2019 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 electro-optics 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, quantum computing, advanced imaging, 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, lasers and systems for industrial materials processing, and optical instrumentation and technologies for remote sensing, process monitoring, environmental sensing, and energy generation.

**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 6 extraordinary plenary speakers. On Tuesday morning, Mial Warren, Naomi Halas, and Chris Xu are our featured speakers. Warren will describe the history, motivation and technologies for LIDAR sensors in automobiles. Halas will discuss metallic nanoparticles and their useful properties for applications ranging from cancer therapy to chemical production. Xu will show how ultrafast lasers enable non-invasive monitoring of brain activity in live animals. On Wednesday morning, the featured speaker is Chris Monroe, who will describe quantum computing with atoms and the critical role for lasers and optics in this field.

The **2018 Nobel Prize in Physics** was awarded to three optics pioneers “for groundbreaking inventions in the field of laser physics.” One half of the Prize went to Arthur Ashkin “for the optical tweezers and their application to biological systems.” The other half of the Prize went jointly to Gérard Mourou and Donna Strickland “for their method of generating high-intensity, ultra-short optical pulses.” CLEO 2019 is the perfect occasion to recognize these breakthroughs with the inclusion of plenary presentations by these Nobel Laureates on Wednesday. We will present a brief video interview with Ashkin. Strickland will highlight the development of chirped pulse amplification (CPA) and its enablement of new types of laser-matter interactions. Mourou will discuss the generation and application of extreme light for investigating fundamental physics at sub-femtosecond time scales and beyond exawatt peak power.

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 27 technical committees. In 2019, the conference features more than 1,145 oral presentations, 182 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 360 posters, including a specially selected subset of posters that are dynamic E-posters. Furthermore, selected topics are highlighted in special symposia and topical reviews that include tutorials and invited talks. Participation from industry is particularly encouraged through these topical reviews. We are pleased to offer a comprehensive short course program featuring 22 courses, including new courses for 2019 in laser radar, quantum optics, and VCSELs.

Finally, CLEO has a new feature in the 2019 program: topical workshops to address timely and important subjects that are not covered by traditional presentations. The workshops are open to all conference registrants and are intended to be more open and interactive discussions between panelists and audience. The workshop topics are

- Beyond Awareness: What Actions Can Be Taken to Improve Diversity in STEM?
- Will Quantum Computing Actually Work?!
- What Will Be the Largest Commercial Application for Optical Frequency Combs in 10 Years?
We extend our sincere thanks to the Technical Program Co-Chairs, Jin Ung Kang and Stephanie Tomasulo in Applications & Technology, Natalia Litchinitser and Sergey Polyakov in Fundamental Science, and Tara Fortier and Christophe Dorrer in Science & Innovations, for coordinating the work of our subcommittees to compile this outstanding CLEO program. We also thank Robert Fisher and Konstantin Vodopyanov, 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.
Conference Services

Registration
Concourse Level

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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 30.

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Speaker and Presider Ready Room
Room 111

All technical presentation speakers and session presiders are required to check in to the Speaker Ready Room located on the Lower Level in Room 111. 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.

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Coat and Baggage Check
Concourse Level

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

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CLEO Information Center
Concourse Level

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

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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 McEnery 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 McEnery Convention Center offers free Wi-Fi experience. To access the network just connect to the SSID “WickedlyFastWifi”.

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

CLEO Announces CLEO KIDS - Child Care Options

CLEO will offer subsidized on-site childcare to attendees who want to bring their kids.

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All conference locations are in the San Jose Convention Center unless otherwise noted.
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. Please stop by our booth near registration to learn more about APS programs, services, and our new fully open access broad scope journal Physical Review Research.

IEEE Photonics Society Booth & Membership Lounge
Concourse Level
Email: photonicsociety@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, to learn more about IEEE programs, services, and our new fully open access broad scope journal Physical Review Research.

IEEE Lounge Schedule:

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IEEE Photonics Speaker & Volunteer Database

More Diverse Voices Need to Be Heard. To grow our community, the IEEE Photonics Diversity Oversight Committee has created a speaker database where members and volunteers can actively sign up and be called upon to serve within their technical and/or professional subject areas. Chairs and volunteer leaders use this database to recruit for invited talks, keynotes, panels, news stories, and councils.

Visit the IEEE Photonics Society booth on the CLEO Concourse Level, near registration, to sign-up!

IEEE Women in Photonics Travel Grant Program

The IEEE Women in Photonics initiative has established a travel grants program to encourage early career participation and gender inclusivity at its conferences and workshops. The grant funds within this program are intended to be used for travel, lodging expenses and registration to an IEEE Photonics sponsored event. Since gender is not binary, this program is inclusive for people of all genders to apply. However, applicants must be active supporters in the community for gender awareness and/or volunteers of the Women in Photonics program.

Visit the IEEE Photonics Society booth on the CLEO Concourse Level, near registration, to learn more on how to apply!

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, Booth 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, industry resources, membership and professional development programs, OSA provides quality information and inspiring interactions that power achievements in the science of light. 350,000 professionals in over 175 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.

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

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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 from Monday to Wednesday between 09:00–17:00 for a quick interview.

Code of Conduct

All CLEO guests, attendees, and exhibitors are subject to the Code of Conduct policy, the full text of which is available at cleoconference.org/codeofconduct. Conference management reserves the right to take any and all appropriate actions to enforce the Code of Conduct, up to and including ejecting from the conference individuals who fail to comply with the policy.

If you wish to report bullying, discrimination, or harassment you have witnessed or experienced, you may do so through the following methods:

- use the online portal osa.org/IncidentReport (or email CodeOfConduct@OSA.org)
- contact any CLEO staff member
Conference Materials

Access to Technical Digest and Postdeadline Papers

Technical attendees have early and continuous access to the CLEO: 2019 Technical Digest, including the Postdeadline Papers. The Technical Digest is comprised of the two-page summaries of tutorial, invited and accepted contributed/postdeadline papers. They can be downloaded individually or by downloading daily .zip files. (.zip files are available for 60 days after the conference).

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 2019.

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 24 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 available on your mobile device or in your web browser.

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 booth number at the top of the 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 expanded 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.
Plenary Sessions and Awards Ceremony

Plenary Session I
Tuesday, 7 May, 08:00–10:00
Grand Ballroom

Imaging Deeper and Faster: Watching the Brain in Action with Ultrafast Lasers
Chris Xu, Professor, School of Applied and Engineering Physics, The Mong Family Foundation Director, Cornell Neurotech – Engineering, Cornell University, USA

Brain research is a multi-disciplinary endeavor, and inspires the development of innovative measurement tools. By pushing the boundaries of imaging depth and speed, nonlinear optical microscopy enables large-scale, non-invasive monitoring of brain activity in live animals, and is poised to play a major role in understanding how brains work.

Chris Xu is Professor of Applied and Engineering Physics, Cornell University. He is the founding co-director of Cornell Neurotech, and the director of Cornell NeuroNex Hub, an NSF funded center for developing and disseminating neuro-technology. His current research areas are biomedical imaging and fiber optics. Prior to Cornell, he was a member of technical staff at Bell Laboratories, developing fiber optic communication systems. He received his PhD in Applied Physics from Cornell University, and contributed to the early development of multiphoton microscopy. He is a Fellow of The Optical Society, and a fellow of the National Academy of Inventors. He has 32 patents granted or pending.

Plasmonics: Putting Light to Work from the Dipole Up
Naomi J. Halas, Stanley C. Moore Professor of Electrical and Computer Engineering, Professor of Physics, Chemistry, and Bioengineering, Rice University, USA

Metallic nanoparticles, well-known for their vibrant color, have become a central tool in the nanoscale manipulation of light. Their resonant illumination gives rise to intense, local photothermal heating and hot electron generation, properties that are useful in applications ranging from prostate cancer therapy to photocatalysis for producing useful chemicals.

Naomi Halas is the Stanley C. Moore Professor of Electrical and Computer Engineering and Professor of Physics, Chemistry, and Bioengineering at Rice University. She was the first person to demonstrate that the shape of plasmon-supporting metallic nanoparticles determines their color. She pursues studies in nanophotonics with applications in biomedicine, optoelectronics, chemical sensing, solar water treatment and plasmonic photocatalysis. She has more than 300 refereed publications and more than 20 issued patents. She is a member of the National Academy of Engineering, the National Academy of Sciences, the American Academy of Arts and Sciences and fellow of the National Academy of Inventors.

Plenary Session II and Awards
Wednesday, 8 May, 08:00–10:00
Grand Ballroom

A LIDAR in Every Garage — The Race for Automotive Optical Sensor Supremacy
Mial Warren, Vice President of Technology, TriLumina Corp., USA

Mial Warren will present a review of the history, motivation and technologies for LIDAR sensors in automobiles. There is a multi-billion-dollar race to integrate complex, high-performance optoelectronic systems into the world’s largest industry. Warren will explain the unique performance specifications that have been emerging from the automotive industry and how they drive the technology.

Mial Warren is a former DMTS at Sandia National Laboratories, where he did research on vertical-cavity surface-emitting laser (VCSEL) technology, diffractive optical element design and fabrication, micro-optical system integration and nanophotonics. He retired from Sandia in 2012 to join a venture-capital funded start up in Albuquerque, New Mexico. He is currently Vice President of Technology for TriLumina Corporation, where he is leading the development of high-power VCSEL arrays and near-infrared illumination modules for automotive LIDAR and 3D time-of-flight imaging applications.

Quantum Computing with Atoms
Christopher Monroe, Distinguished University Professor & Bice Sechi-Zorn Professor, University of Maryland, and Chief Scientist, IonQ, Inc., USA

Quantum computers offer hope for attacking problems that are beyond the capability of any possible conventional information processor. Individual atoms are the highest quality components for a scalable quantum computer, with unmatched coherence properties and reconfigurable circuits that are “wired” with laser beams. Monroe will speculate on the future of this field and the critical role lasers and optics will play.

Christopher Monroe is a leading atomic physicist and quantum information scientist. He demonstrated the first quantum gate realized in any system at NIST in the 1990s, and at the University of Michigan and University of Maryland, he discovered new ways to scale trapped ion qubits and simplify their control with semiconductor chip traps, simplified lasers and photonic interfaces for long-distance entanglement. He received the American Physical Society I. I. Rabi Prize and the Arthur Schawlow Laser Science Prize, and has been elected into the National Academy of Sciences. He is Co-founder and Chief Scientist at IonQ in College Park, Maryland.

All conference locations are in the San Jose Convention Center unless otherwise noted.
2018 Nobel Laureates in Physics

Video Presentation: Reflections on Optical Tweezers and the 2018 Nobel Prize in Physics
Nobel Laureate Arthur Ashkin

Passion for Extreme Light
Gérard Mourou, École Polytechnique, France

Extreme-light laser is a universal source providing a vast range of high energy radiations and particles along with the highest field, highest pressure, temperature and acceleration. It offers the possibility to shed light on some of the remaining unanswered questions in fundamental physics like the genesis of cosmic rays with energies in excess of 1020 eV or the loss of information in black-holes. Using wake-field acceleration, some of these fundamental questions can be studied in the laboratory. In addition, extreme-light enables study of the structure of vacuums and particle production in “empty” space, which is one of the field’s ultimate goals, reaching into the fundamental QED and possible QCD regimes.

Gérard Mourou is Professor Haut-Collège at the École Polytechnique. He is also the A.D. Moore Distinguished University Emeritus Professor of the University of Michigan. He received his undergraduate education at the University of Grenoble (1967) and his PhD from University Paris VI in 1973. He has made numerous contributions to the field of ultrafast lasers, high-speed electronics and medicine. But his most important invention, demonstrated with his student Donna Strickland while at the University of Rochester is the laser amplification technique known as Chirped Pulse Amplification (CPA). CPA revolutionized the field of optics, opening new branches like attosecond pulse generation, nonlinear QED and compact particle accelerators. It extended the field of optics to nuclear and particle physics. In 2005, Mourou proposed a new infrastructure, the Extreme Light Infrastructure (ELI), which is distributed over three pillars located in the Czech Republic, Romania and Hungary. He also pioneered the field of femtosecond ophthalmology that relies on a CPA femtosecond laser for precise myopia corrections and corneal transplants. Over a million such procedures are now performed annually. Mourou is member of the US National Academy of Engineering, and a foreign member of the Russian Science Academy, the Austrian Sciences Academy and the Lombardy Academy for Sciences and Letters. He is Chevalier de la Légion d’honneur and was awarded the 2018 Nobel Prize in Physics with his former student Donna Strickland.

Donna Strickland is one of the recipients of the Nobel Prize in Physics 2018 for co-inventing Chirped Pulse Amplification with Gérard Mourou, her PhD supervisor at the time of the discovery. She earned her PhD in optics from the University of Rochester and her BEng from McMaster University. She was a research associate at the National Research Council Canada, a physicist at Lawrence Livermore National Laboratory and a member of technical staff at Princeton University. In 1997, she joined the technical staff of the University of Waterloo, where her ultrafast laser group develops high-intensity laser systems for nonlinear optics investigations. She is a recipient of a Sloan Research Fellowship, a Premier’s Research Excellence Award and a Cottrell Scholar Award. She served as the president of The Optical Society (OSA) in 2013 and is an OSA Fellow.

Awards and Honors
Tuesday, 7 May
Grand Ballroom

OSA Frederic Ives Medal/Jarus W. Quinn Prize
Eli Yablonovitch, Univ. of California Berkeley, USA

Recognized for diverse and deep contributions to optical science including photonic crystals, strained semiconductor lasers, and new record-breaking solar cell physics.

The Optical Society’s highest honor, this award recognizes overall distinction in optics.

The medal was established in 1928 to honor Frederic Ives for his pioneering contributions to color photography, three-color process printing, and other branches of applied optics. The prize was added in recognition of Jarus W. Quinn’s 25 years of service as OSA’s first Executive Director.

Generating High-intensity, Ultrashort Optical Pulses
Donna Strickland, Univ. of Waterloo, Canada

With the invention of lasers, the intensity of a light wave was increased by orders of magnitude over what had been achieved with a light bulb or sunlight. This much higher intensity led to new phenomena being observed, such as violet light coming out when red light went into the material. After Gérard Mourou and Strickland developed chirped pulse amplification, also known as CPA, the intensity again increased by more than a factor of 1,000 and it once again made new types of interactions possible between light and matter. The two developed a laser that could deliver short pulses of light that knocked electrons off their atoms. This new understanding of laser-matter interactions led to the development of new machining techniques that are used in laser eye surgery and micromachining of glass used in cell phones.

Donna Strickland is one of the recipients of the Nobel Prize in Physics 2018 for co-inventing Chirped Pulse Amplification with Gérard Mourou, her PhD supervisor at the time of the discovery. She earned her PhD in optics from the University of Rochester and her BEng from McMaster University. She was a research associate at the National Research Council Canada, a physicist at Lawrence Livermore National Laboratory and a member of technical staff at Princeton University. In 1997, she joined the technical staff of the University of Waterloo, where her ultrafast laser group develops high-intensity laser systems for nonlinear optics investigations. She is a recipient of a Sloan Research Fellowship, a Premier’s Research Excellence Award and a Cottrell Scholar Award. She served as the president of The Optical Society (OSA) in 2013 and is an OSA Fellow.

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OSA Charles Hard Townes Medal Recipient

Alexander Gaeta, Columbia Univ., USA
Recognized for seminal contributions to chip-based nonlinear photonics, nonlinear optics in photonic crystal fibers, and nonlinear propagation of ultrashort laser pulses.

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 Optical Society 2019 Fellows

These OSA Fellows are being recognized at CLEO.
Visit osa.org/fellows for a complete list of 2019 Fellows.

Jiming Bao, Univ. of Houston, USA
For contributions to semiconductor and metallic nanostructures and their applications in nanophotonics and solar energy harvesting.

Pierre Berini, Univ. of Ottawa, Canada
For scientific achievements that have led to remarkable new insights in the field of nanophotonics, including pioneering contributions to surface plasmon photonics.

Paul Campagnola, Univ. of Wisconsin-Madison, USA
For advancing nonlinear optical microscopy for biological applications, focusing on Second Harmonic Generation imaging of diseased states and multiphoton excited polymerization for fabricating tissue engineered scaffolds.

Ji-Xin Cheng, Boston Univ., USA
For outstanding contributions to invention and development of label-free optical spectroscopic imaging technologies with groundbreaking applications to biology, medicine and materials science.

Richard N. Claytor, Fresnel Technologies Inc, USA
For entrepreneurial leadership, product innovation, and commercialization of optical products, particularly high-quality Fresnel lenses with wide practical applicability in optical systems such as the passive infrared motion detectors ubiquitous in security and lighting control.

Jay W. Dawson, Lawrence Livermore National Laboratory, USA
For leadership, innovations, and contributions to the understanding of fiber laser power scaling limits, development of spectrally selective fiber waveguiding structures for Nd3+ fibers, and lasers for future accelerators.

Shengwang Du, Hong Kong Univ. of Science and Technology, Hong Kong
For pioneering contributions in photon-atom quantum interaction, including generation and manipulation of narrowband biphotons, observation of optical precursors, and realization of nontraditional quantum heat engines.

Liang Feng, Univ. of Pennsylvania, USA
For outstanding pioneering scientific contributions to the field of non-Hermitian photonics and its applications in integrated nanophotonics and optoelectronics.

Amr S. Helmy, Univ. of Toronto, Canada
For pioneering contributions in utilizing chi 2 nonlinearities in semiconductors for classical and quantum applications.

Ronald Holzwarth, Menlo Systems GmbH, Germany
For having a pivotal role in the realisation and commercialisation of optical frequency combs.

Sheng-Lung Huang, National Taiwan Univ., Taiwan
For contributions to glass-clad crystalline fiber based lasers and broadband light sources for optical coherence tomography.

M. Saif Islam, Univ. of California Davis, USA
For distinguished contributions to the field of photodetectors, particularly highly sensitive ultra-fast photodetectors enabled by photon-trapping micro and nanostructures for data and telecommunication.

Mackillo Kira, Univ. of Michigan, USA
For pioneering contributions to the theory of semiconductor quantum optics.

Kei May Lau, Hong Kong Univ. of Science and Technology, Hong Kong
For exceptional contributions to hetero-epitaxy of III-V on silicon by MOCVD for photonic devices.

Anne Matsuura, Intel Corporation, USA
For exceptional contributions to the support and advancement of optical sciences and technologies, through the development of national and international activities of government, industry, and academic institutions.

Richard Mirin, National Institute of Standards and Technology, USA
For outstanding contributions to semiconductor quantum dot devices and quantum optics.

Teri W. Odom, Northwestern Univ., USA
For pioneering contributions to multi-scale plasmonic nanostructures and nanophotonics.

Taiichi Otsuji, Tohoku Univ., Japan
For pioneering contributions to terahertz emission and detection exploiting two-dimensional plasmonic and electronic systems with semiconductor nano- and hetero-structures.

Geoff Pryde, Griffith Univ., Australia
For pioneering developments and advancements in photonic quantum information science, photonic entanglement-enhanced metrology, and the study of quantum measurement.

David A. Reis, Stanford Univ. and SLAC National Accelerator Laboratory, USA
For pioneering achievements in ultrafast and strong-field phenomena in solids including discovery of solid-state high-harmonic generation, contributions to x-ray nonlinear optics, and invention of a novel femtosecond x-ray scattering method to probe phonon dispersion.

Kent Rochford, SPIE, USA
For innovative technical leadership in multiple scientific disciplines of highly advanced optical metrology, especially for the US National Institute of Standards and Technology.

Shyh-Chiang Shen, Georgia Institute of Technology, USA
For the development and advancement of compound semiconductor optoelectronic devices and integrated circuits.
Laura Waller, Univ. of California Berkeley, USA
For pioneering contributions in computational imaging

Daniel Wasserman, Univ. of Texas at Austin, USA
For contributions to the development of novel sources, detectors, and optical materials operating in the mid-infrared wavelength range

Edward A. Whittaker, Stevens Institute of Technology, USA
For important contributions to laser spectroscopy for sensitive detection of molecules, and extraordinary editorial service to Optics Letters

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 Univ., 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.

This year’s recipient can be viewed at www.osa.org/gordon

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.

Recipients can be viewed at www.osa.org/Tingye

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.

Finalists can be viewed at www.osa.org/maiman

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 be viewed at www.osa.org/foundation.

Awards and Honors Presented Elsewhere at CLEO

OSA Esther Hoffman Beller Medal
Rick Trebino, Georgia Institute of Technology, USA
For pioneering educational optics practices, including the only textbook on ultrashort-pulse measurement, innovative short courses, and the creation of high-quality graduate and undergraduate optics lectures that are shared freely with students and instructors worldwide.

The medal was established in 1993 by the estate of Esther Hoffman Beller. It is presented for outstanding contributions to education in optical science and engineering. Consideration is given to outstanding teaching and/or original work in optics education that enhances the understanding of optics.

OSA Nick Holonyak Jr. Award
Fumio Koyama, Tokyo Institute of Technology, Japan
For seminal contributions to VCSEL photonics and integration.

The award was established in 1997 to honor Nick Holonyak Jr., who has made distinguished contributions to the field of optics through the development of semiconductor based light emitting diodes and semiconductor lasers. It is given to an individual who has made significant contributions to optics based on semiconductor-based optical devices and materials, including basic science and technological applications

The Bernard J. Couillaud Prize
The OSA Foundation (OSAF) and Coherent, Inc. have partnered to create the Bernard J. Couillaud Prize. The Prize provides the opportunity for an early-career professional to pursue a compelling and innovative project that has the potential to make a meaningful and positive impact on the science and applications of ultrafast lasers. One early career professional will receive a merit-based award which includes a $20,500 USD prize and $5,000 USD in travel expenses.

This year’s winner can be viewed at osa.org/couillaud.

All conference locations are in the San Jose Convention Center unless otherwise noted.
THE OPTICAL SOCIETY CONGRATULATES
2018 Paul F. Forman Team Engineering Excellence Award Winner
Adaptive Optics Facility on the Very Large Telescope (VLT) at
European Southern Observatory’s Paranal Observatory

The team is recognized for equipping one of the 8-m Unit Telescopes at ESO’s Paranal Observatory in Chile with an Adaptive Optics Laser Guide Star Facility, providing exquisite images to the unique 3-D spectrograph MUSE and near-infrared imager HAWK-I.

Congratulations to the team:

Jose Antonio Abad
Matteo Accardo
Emmanuel Aller-Carpentier
Jose-Luis Alvarez
Paola Amico
Javier Argomedo
Robin Arsenault
Pedro Baksai
Juan Beltran
Thomas Bierwirth
Domenico Bonaccini Calia
Pierre Bourget
Stéphane Brillant
Bernard Buzzoni
Giorgio Calderone
Gianluca Chiozzi
Mauro Comin
Ralf Conzelmann
Bernard Delabre
Diego Del Valle
Robert Donaldson
Dario Dorigo
Mark Downing
Michel Duchateau
Philippe Duhoux
Christophe Dupuy
Enrico Fedrigo
Gert Fischer
Christophe Frank
Eloy Fuenteescua
Fernando Gago
Juan Carlos Guerra
Ivan M. Guidolin
Stéphane Guisard
Pablo Gutierrez-Cheetham
Ronald Guzman
Wolfgang Hackenberg
Pierre Haguenaer
Andreas Haemerl
Peter Hammersley
George Hau
Volker Heinz
Pascale Hibon
Ronald Holzloehner
Stefan Huber
Norbert Hubin
Lieselotte Jochum
Paul Jolley
Andreas Jost
Lothar Kern
Mario Kiekebusch
Jean-Paul Kirchbauer
Johann Kolb
Harald Kuntzschner
Paolo La Penna
Miska Le Louarn
Samuel Leveque
Steffan Lewis
Jean-Louis Lizon
Pierre-Yves Madec
Antonio Manescau-Hernandez
Steward McClay
Leander Mehrgan
Ivan Munoz
Sylvain Oberti
Juan Carlos Palacio
Jerome Paufique
Lorenzo Pettazzi
Thomas Pfommer
Jean-Francois Pirard
Dan Popovic
Marco Quattri
Jutta Quentin
Christian Ramirez
Javier Reyes
Rob Ridings
Pierre Sansgasset
Marc Sarazin
Babak Sedghi
Fernando Selman
Christian Soenke
Heiko Sommer
Stefan Stroebele
Marcos Suarez Valles
Mirko Todorovic
Sebastien Tordo
Javier Valenzuela
Ignacio Vera
Elise Vernet
Joël Daniel Roger Vernet
Dominika Wylezalek
Gérard Zins

Call for 2019 Nominations!
Deadline: 10 July
osa.org/FormanTeamAward
Workshops

New this year are the CLEO Workshops. These sessions provide interactive learning environments and are open to all conference registrants.

The format is intended to be less formal than a technical session or symposium so as to enable open discussion between panelists and the audience to address technical and strategic questions for which there is no clear consensus.

Will Quantum Computing Actually Work?!  
Monday, 6 May; 18:30–20:00  
Room 210A

The realization of a large-scale quantum computer represents the holy grail for quantum researchers and for those hoping to harness the power of quantum entanglement. Far beyond practical limits of classical computing, quantum computers potentially enable the simulation of all quantum processes in nature, and have profound and immediate practical applications, most famously in cryptography. After decades of painstaking research on small-scale laboratory devices, there has been a recent, dramatic ramping up of commercial interest, spanning boutique companies to tech giants.

This workshop aims to address the question currently on the minds of many — is large-scale, fault-tolerant, universal quantum computing a realistic possibility?

Organizers
Ben Eggleton, Univ. of Sydney, Australia  
Tara Fortier, National Institute of Standards & Technology, USA  
Andrew Wilson, National Institute of Standards & Technology, USA

Panelists
Jerry Chow, IBM Corp., USA  
Mikhail Lukin, Harvard Univ., USA  
Christopher Monroe, Univ. of Maryland, Joint Quantum Institute & IQC Inc., USA  
Robert Schoelkopf, Yale Univ., USA  
Andrew Steane, Univ. of Oxford, UK  
Jelena Vuckovic, Stanford Univ., USA  
Birgitta Whaley, UC Berkeley, USA

What Will Be the Largest Commercial Application for Optical Frequency Combs in 10 Years?  
Monday, 6 May; 18:30–20:00  
Room 210B

More than 15 years ago, a committee at CLEO was formed to capture research on precision optical measurement primarily enabled by the development of optical frequency combs. Since their first demonstration in 2000, optical frequency combs have seen rapid changes in laser technology, expansion of applications, and industry interest. This workshop seeks a discussion from experts in government, academia and industry on what the commercial future holds for this versatile technology.

Organizers
Fabrizio Giorgetta, National Institute of Standards & Technology, USA  
Tara Fortier, National Institute of Standards & Technology, USA

Moderator
Fabrizio Giorgetta, National Institute of Standards & Technology, USA

Panelists
Ronald Holzwarth, Menlo Systems GmbH, Germany  
Ursula Keller, ETH Zürich, Switzerland  
Seung-Woo Kim, KAIST, South Korea  
Nate Newbury, National Institute of Standards & Technology, USA  
Nathalie Picqué, Max Planck Institute of Quantum Optics, Germany  
Stojan Radic, University of California San Diego, USA  
Felix Rohde, TOPTICA Photonics AG, Germany

Beyond Awareness: What Actions Can Be Taken to Improve Diversity in STEM?  
Wednesday, 8 May, 10:30–12:00  
Exhibit Hall Theater II

In the hard sciences, women and minorities have seen slower improvements in representation compared to fields such as medicine and law. Information on how to improve this representation in STEM is also difficult to find. This workshop brings together leaders of professional organizations and subject matter experts to discuss policies and actions that can improve gender, racial, LGBTQI and disability diversity within the physics, engineering and optics communities.

Organizers
Arti Agrawal, University of Technology Sydney, Australia  
Ben Eggleton, University of Sydney, Australia  
Tara Fortier, National Institute of Standards & Technology, USA  
Christina Willis, Consultant, USA

Panelists
Liz Rogan, CEO, The Optical Society  
Kent Rochford, CEO, the International Society for Optics and Photonics  
Kate Kirby, CEO, American Physical Society  
Doug Razzano, Executive Director, Institute of Electrical and Electronics Engineers  
Meg Urry, Yale Univ., USA
Special Symposia

Symposium on High Average Power Ultrafast Lasers: Trends, Challenges & Applications
Monday, 6 May, Session I: 8:00–10:00; Session II: 10:30–12:30; Session III: 13:30–15:30
Executive Ballroom 210E

Organizers
Thomas Metzger, Trumpf Scientific Lasers, Germany
Clara Saraceno, Ruhr Universität Bochum, Germany
Thomas Spinka, Lawrence Livermore National Laboratory, USA

Invited Speakers
Cristina Hernandez-Gomez, STFC Rutherford Appleton Laboratory, UK
High peak power, high average power lasers at the CLF and their potential applications
Norman Hodgson, Coherent Inc., USA
Industrial Ultrafast Lasers - Systems, Processing Fundamentals, and Applications

Clemens Hönninger, Amplitude, France
Industrial kilowatt femtosecond lasers: potentialities and challenges

Jerome Kasparian, Univ. of Geneva, Switzerland
Multi-Wavelength Laser Control of High-Voltage Discharges: From the Laboratory to Säntis Mountain

Ursula Keller, ETH Zurich, Switzerland
Recent Advances in SESAM-modelocked High-power Thin Disk Lasers

Andreas Maier, Univ. of Hamburg, Germany
Towards Stable Laser-Plasma Electron Acceleration

Dirk Sutter, TRUMPF Laser GmbH, Germany
High Power and High Energy Ultrafast Disk Lasers for Industrial Applications

Takunori Taira, Institute for Molecular Science, Japan
High Average Power Ultrafast Lasers: Large Aperture Quasi-phase Matched Nonlinear Devices

Johannes Weitenberg, Max-Planck-Institut für Quantenoptik, Germany
Nonlinear Pulse Compression at High Average Power Based on Multi-pass Cells

Symposium on Nonreciprocal Photonics
Monday, 6 May, Session I 10:30–12:30; Session II: 13:30–15:30
Executive Ballroom 210B

Organizers
Pascal Del Haye, National Physical Laboratory, UK
Lan Yang, Washington Univ., USA
Ewold Verhagen, AMOLF, Netherlands

Nonreciprocal photonics has been a rapidly growing research field in recent years. This is motivated by a strong demand for nonreciprocal elements in upcoming generations of integrated optical circuits. In particular, the increasing complexity of photonic circuits and their combination with chip-based laser sources requires new optical elements, e.g. for efficient optical isolators and circulators. On the fundamental physics side, research on optical nonreciprocity has led to many new insights on interaction of light with complex media, optomechanical systems and nonlinear materials. This special symposium aims to provide a forum for discussing the various different means of achieving optical nonreciprocity as well as related applications. This includes nonreciprocity and unidirectional transmission phenomena based on Kerr nonlinearity, optomechanical systems, metamaterials, integrated magneto-optical devices, PT symmetric systems, Brillouin scattering, topological protection, spin-orbit coupling and through other nonlinear optical effects. Beyond the fundamental physics of optical nonreciprocity, this symposium also addresses applications of nonreciprocity e.g. for sensors, integrated photonic circuits and in laser systems.

Invited Speakers
Andrea Alu, CUNY Advanced Science Research Center, USA
Nonreciprocal and Topological Photonics

Benjamin Eggleton, Univ. of Sydney, Australia
Brillouin Based non-Reciprocal Functions for On-chip Optical Signal Processing

Tsampikos Kottos, Wesleyan Univ., USA
Utilizing Floquet Engineering for the Design of Non-reciprocal Transport

Caroline Ross, Massachusetts Institute of Technology, USA
Magneto-optical Garnets for Nonreciprocal Integrated Photonics

Edo Waks, Univ. of Maryland at College Park, USA
Topological Quantum Photonics

All conference locations are in the San Jose Convention Center unless otherwise noted.
**Symposium on Machine Learning Photons: Where Machine Learning and Photonics Intersect**

**I**

**Monday, 6 May Session I: 13:30–15:30**

Salon I & II, Marriott

**Organizers**
Zongfu Yu, Univ. of Wisconsin Madison, USA
Darko Zibar, Danmarks Tekniske Universitet, Denmark
Shanhui Fan, Stanford Univ., USA
Bahram Jalali, Univ. of California Los Angeles, USA
Marin Soljačić, Massachusetts Institute of Technology, USA

Over the past 5 years, tremendous progress has been made in machine learning. Its impact has started to emerge across a broad range of fields. Photonics is one of them. This symposium will highlight recent progress at the intersection of photonics and machine learning. Various methods such as deep learning, Bayesian inference, Monte Carlo Markov Chain and Gaussian processes will be addresses on how they can provide new paths for solving the most critical problems in various fields in photonics. For example, deep learning points to new inverse design approach for complex photonic structures while Bayesian inference offers detection methods that can operate at the quantum limit. Combination of deep learning with time stretched measurements has been highly successful in biological cell analysis at extreme throughput. Unlike optimization-driven approaches that require expensive computation, machine learning leverages on learning form the data. Photonics also provides exciting opportunities for all optical implementation of various machine learning techniques. There are also many other exciting developments in microscopy, quantum communication, sensing, bio-medical image recognition, optical communication and opto-mechanics that have benefited from machine learning.

**Invited Speakers**

Wenshan Cai, Georgia Institute of Technology, USA
Wenshan Cai, Georgia Institute of Technology, USA
Generative Model for the Inverse Design of Photonic Nanostructures

Folkert Horst, International Business Machines Corp., Switzerland
Integrated Photonics for Neural Network Acceleration

Paul Prucnal, Princeton Univ., USA
Multiwavelength Neuromorphic Photonics

**Symposium on Intense-field Nonlinear Optics & High Harmonic Generation in Nanoscale**

**Materials I**

**Tuesday, 7 May; Session I: 13:00–15:00;**

Session II: 17:00–19:00

Salon I & II, Marriott

**Organizers**
Marko Loncar, Harvard Univ., USA
Maxim Shcherbakov, Cornell Univ., USA
Gennady Shvets, Cornell Univ., USA

Nanomaterials are driving many research fields in photonics, from spectroscopy to microscopy, from sensing to telecommunication. Importantly, they can enhance light-matter interactions and funnel optical fields into hot spots, spawning applications in nonlinear optics. They have also shown enormous potential for non-perturbative nonlinear optics and high-harmonic generation, producing intense extreme-ultra high-power laser applications. This symposium will review and discuss the recent progress in light-matter interactions on an ultra-intense scale, such as nonlinear frequency conversion and generation of high harmonics, assisted by novel nanostructures and metamaterials. We also solicit contributed papers that advance the field of high-intensity light-matter interactions on the nanoscale.

**Invited Speakers**

Pierre Berini, Univ. of Ottawa, Canada
Enhancement of Nonlinear Processes by Surface Plasmons

Igal Brener, Sandia National Laboratories, USA
Extreme Nonlinear Optics With Dielectric Metasurfaces

Andrey Fedyanin, Lomonosov Moscow State Univ., Russia
Optical Harmonic Generation in Nonlinear All-dielectric Nanoantennas and Metasurfaces

David Reis, Stanford Univ., USA
High-harmonic Generation from Bulk to Engineered Solids

Koichiro Tanaka, Kyoto Univ., Japan
Extreme nonlinear optics in two dimensional materials

**Symposium on Quantum Information in Time-Frequency Domain**

**Tuesday, 7 May, Session I: 13:00–15:00;**

Session II: 17:00–19:00

Executive Ballroom 210A

**Symposium Organizers**

Pavel Lougovski, Oak Ridge National Laboratory, USA
Michael G. Raymer, Univ. of Oregon, USA
Brian J. Smith, Univ. of Oregon, USA
Andrew M. Weiner, Purdue Univ., USA

There has been significant experimental progress in encoding and manipulating quantum information using light’s spectral-temporal degrees of freedom. From electro-optics to nonlinear optics — a range of technologies has been utilized to prepare, control and characterize qubits and demonstrate quantum logic. Spectral encoding is naturally compatible with optical fiber networks, amenable to massive parallelization, and valuable for scaling up quantum memories. Spectral beam splitters, based both on optical nonlinearities and electro-optic modulation, have been demonstrated recently. For spectral-temporal encoding, which can be used to store large amounts of information in a single photon, quantum pulse gates based on mixing single photons with shaped control fields have allowed state discrimination of orthogonal time-frequency pulsed modes (temporal modes). Considerable advances have also been made in generating entangled frequency combs from bulk sources and on-chip by using microring resonators, opening new avenues for quantum information processing with qubits. These novel techniques and methods can be combined and readily utilized for applications in quantum networking, computing, key distribution, and classical optical information processing. The aim of this symposium is to bring together researchers from across machine learning.
these research fields and to expose others to the exciting new opportunities offered by spectral-temporal encoding of light.

Invited Speakers
Benjamin Brecht, Universität Paderborn, Germany
Tailored Generation, Manipulation, and Application of Photonic Temporal Modes
Joseph Lukens, Oak Ridge National Laboratory, USA
Quantum Information Processing with Frequency-bin Qubits: Progress, Status, and Challenges
Olivier Pfister, Univ. of Virginia, USA
Generation of scalable cluster states in the quantum optical frequency comb
Valérian Thiel, Univ. of Oxford, UK
Full Single and Two Photon Spectral Mode-function Reconstruction
Nicolas Treps, Sorbonne Université, France
Tailored Non-Gaussian Multimode States of Quantum Light

Symposium on Space-borne Quantum Sensors
Tuesday, 7 May, 13:00–15:00
Executive Ballroom 210G

Symposium Organizers
Matthew Hummon, National Institute of Standards and Technology, USA
Jeff Sherman, National Institute of Standards and Technology, USA

Governments, industry leaders and academic researchers are pursuing and funding the development of quantum technology with renewed intensity. While research into quantum information and exotic quantum states captures headlines, systems which leverage quantum properties of light and matter to enable and enhance measurements of physical quantities are just as likely to broadly alter our technological landscape. Quantum sensors enable measurement of acceleration, rotation, magnetic- and electric-field, temperature, chemical content, low-light intensity, length, time, and frequency — often with high stability and inherent calibration to primary standards. Space missions often impose unique and extreme requirements on sensor technology, and therefore often serve as catalysts for guiding new technologies out of the laboratory and into viable commercial application. Several such missions featuring quantum sensors are scheduled to launch in coming years. This symposium will focus on opportunities and technical challenges related to space-borne quantum sensors, and empirical lessons garnered from recently completed missions.

Invited Speakers
Sergio Mottini, Thales Alenia Space, Italy
Atom Interferometry for Space-Borne Sensors
Cheng-Zhi Peng, Univ. of Science and Technology of China, China
Quantum Science Experiments with Micius Satellite
Evan Salim, ColdQuanta Inc., USA
Enabling Technologies for Space-Based Quantum Systems
Robert James Thompson, Jet Propulsion Laboratory, USA
The Coolest Spot in the Universe: Early results from the Cold Atom Laboratory Mission Aboard the International Space Station

Symposium on Coupling Artificial Atoms to Nano- and Opto-mechanical Systems
Wednesday, 8 May, Session I: 13:00–15:00;
Session II: 17:00–19:00
Executive Ballroom 210A

Symposium Organizers
Paul Barclay, Univ. of Calgary, Canada
Hailin Wang, Univ. of Oregon, USA

This symposium will focus on recent experimental and theoretical advances on coupling artificial atoms, such as defect centers and quantum dots, to nanomechanical or optomechanical resonators. These hybrid quantum systems bring together concepts and techniques from different disciplines — optics and atomic physics, nanophotonics, nanomechanics and quantum information science — and allow spin control of mechanical motion as well as mechanical control of the spin states. Quantum control of both spin and mechanical degrees of freedom in these systems can enable potential applications in quantum information processing such as phononic or phononic-photonic quantum networks, as well as quantum transducers for quantum networking.

Invited Speakers
David Awschalom, Univ. of Chicago, USA
Quantum Control of Spins in Silicon Carbide with Photons and Phonons
Yiwen Chu, Yale Univ., USA
Creating Quantum States of Sound with Superconducting Qubits
Gregory Fuchs, Cornell Univ., USA
Spin and Orbital Resonance Driven by a Mechanical Resonator
Mark Kasperczyk, Univ. of Basel, Switzerland
Toward Novel Coherence Protection and Sensing Techniques: Closed Counter Interaction Using a Single Spin
Peter Rabl, Technische Universität Wien, Austria
Phonon Networks with SiV Centers in Diamond Waveguides

All conference locations are in the San Jose Convention Center unless otherwise noted.
Symposium on Machine Learning Photons: Where Machine Learning and Photonics Intersect II & III
Friday, 10 May Session II: 10:30–12:30; Session III:14:00-16:00
Executive Ballroom 210F

Organizers
Zongfu Yu, University of Wisconsin Madison, USA
Darko Zibar, Danmarks Tekniske Universitet, Denmark
Shanhui Fan, Stanford University, USA
Bahram Jalali, University of California Los Angeles, USA
Marin Soljačić, Massachusetts Institute of Technology, USA

Over the past 5 years, tremendous progress has been made in machine learning. Its impact has started to emerge across a broad range of fields. Photonics is one of them. This symposium will highlight recent progress at the intersection of photonics and machine learning. Various methods such as deep learning, Bayesian inference, Monte Carlo Markov Chain and Gaussian processes will be addresses on how they can provide new paths for solving the most critical problems in various fields in photonics. For example, deep learning points to new inverse design approach for complex photonic structures while Bayesian inference offers detection methods that can operate at the quantum limit. Combination of deep learning with time stretched measurements has been highly successful in biological cell analysis at extreme throughput. Unlike optimization-driven approaches that require expensive computation, machine learning leverages on learning form the data. Photonics also provides exciting opportunities for all optical implementation of various machine learning techniques. There are also many other exciting developments in microscopy, quantum communication, sensing, bio-medical image recognition, optical communication and opto-mechanics that have benefited from machine learning.

Invited Speakers
Hou-Man Chin, Danmarks Tekniske Universitet, Denmark
Phase Compensation for Continuous Variable Quantum Key Distribution

Tyler Hughes, Stanford Univ., USA
Training of Photonic Neural Networks through In Situ Backpropagation

Bahram Jalali, Univ. of California Los Angeles, USA
Deep Imaging Cytometry

Aydogan Ozcan, Univ. of California Los Angeles, USA
Deep Learning in Optical Microscopy and Image Reconstruction

Marin Soljačić, Massachusetts Institute of Technology, USA
Ken Xingze Wang, Huazhong Univ. of Science and Technology, China
Object Recognition with Optical Coherence

Tom Zahavy, Technion, Israel
Deep Learning Reconstruction of Ultrashort Laser Pulses and Ptychographic Data from Ambiguous Measurements
Applications & Technology Topical Reviews

A&T Topical Review on Flat Optics
Monday, 6 May: Session I 13:30–15:30;
Session II: 16:00–18:00
Meeting Room 212 A/B

Organizer
Federico Capasso, Harvard Univ., USA

Flat Optics I: Physics of metasurfaces and their applications: Metasurfaces enable an unprecedented platform to explore light-matter interaction. This session covers aspects of interesting fundamental topics in metasurfaces, including but not limited to zero index materials, dispersion engineering, ultrafast dynamics, nonreciprocity, nonlinearity and quantum metasurfaces.

Invited Speakers
Mikhail Belkin, Univ. of Texas at Austin, USA
Nonlinear metasurfaces for power limiting
Yuri Kivshar, Australian National Univ., Australia
Nonlinear and topological dielectric metasurfaces
Vladimir M. Shalaev, Purdue Univ., USA
Metasurfaces for Synchrotron radiation generation and ultrafast beam steering

Flat Optics II: Metasurface optical components: Metasurfaces enable the redesign of optical components into thin, planar and multifunctional elements, promising a major reduction in footprint and system complexity as well as the introduction of new optical functions. This session will focus on metasurface-based optical devices and systems for a wide range of applications and will include high-performance components designed by inverse methods.

Invited Speakers
Wei Ting Chen, Harvard Univ., USA
Dispersion-engineered and Polarization-insensitive Metasurfaces for Broadband Achromatic Optics
Jonathan Fan, Stanford Univ., USA
AI-assisted Design of Topologically Complex Metasurfaces
Byoungho Lee, Seoul National Univ., USA
Metasurface Devices for AR/VR

Tuesday, 7 May: 13:00–15:00
Wednesday, 8 May: 13:00–15:00
Theater II

Organizers
Will Conley, Cymer, USA
Jae Won Hahn, Yonsei Univ., South Korea

The successful integration of design, layout, imaging solutions and advances in process technologies continue to provide viable working solutions to continue the advancement of Logic and Memory technologies. This topical review will highlight recent advances in design layout to on wafer imaging to on wafer final etch of circuitry. Areas of interest include layout ground rules, use of machine learning throughout the design, verification cycle and the application to imaging solutions through pupil and mask optimization (SMO). Insight into metrology issues, Scanner/source (laser) improvements and the integration of etch processes will be reviewed.

Invited Speakers
Will Conley, Cymer LLC, USA
Quantifying Improvements in Field to Field and Wafer to Wafer CD Variation from Laser Bandwidth Variation
Yuri Granik, Mentor Graphics, USA
Compensation of Optical Distortions in IC Fabrication
Jae W Hahn, Yonsei University, South Korea
Nanoscale Three-dimensional Patterning with Plasmonic Lithography
Patrick Naulleau, Lawrence Berkeley National Labs, USA
Extending EUV to the High-NA EUV Regime
Robert Socha, ASML, USA
Reduction and Control of Edge Placement Error at the 5nm node Through a Holistic Approach
Yoen Sik Jung, KAIST, South Korea
Nanopatterning of Things: from Metals, Oxides to Quantum Dots

A&T Topical Review on Progress in the Semiconductor Laser Technology
Tuesday, 7 May; 13:00–15:00;
Wednesday, 8 May; 13:00–15:00
Theater I

Organizer
Edik Rafailov, Aston Univ., UK

For over half a century, laser technology has undergone a technological revolution. These technologies, particularly semiconductor lasers have reached mature stage and transformed from a fundamental area of research into emerging applications and products. This topical Review meeting will present recent progress in the development of novel light sources in a broad wavelength range along with their applications (ie lighting, sensing, biophotonics etc).
Invited Speakers
Richard Hogg, Glasgow Univ., UK
Photonic Crystal Surface Emitting Lasers
Sven Höfling, Univ. of Würzburg, Germany
Interband Cascade Devices for sensing
Takeo Kageyama, QD Laser Ltd, Japan
Semiconductor Lasers for Next-generation Applications
Mike Leszczynski, Institute of High Pressure Physics Warsaw, Poland
Material issues in GaN-based Laser Diode Manufacturing

A&T Topical Review on Silicon Photonics
Thursday, 9 May; Session I: 14:00-16:00, Session II: 16:30-18:30
Meeting Room 211 A/B

Organizers
Long Chen, Acacia Communications, USA
Amy Foster, Johns Hopkins Univ., USA

Over the past few decades, silicon photonics technology has matured from one-off demonstrations on optical tables to commercial products in applications generally involving information transfer. The advancement of the field is a result of many fantastic demonstrations by the research community (academic, government, and industry) as well as the establishment of several silicon photonic foundries where researchers can share real estate in multi-project wafers to manufacture prototype silicon photonic devices up to the sub-system level of integration. The maturity of the field and the increased accessibility of the manufacturing have resulted in a very exciting and application-diverse field of silicon photonics. In this topical review, we will highlight work being done all over the field of silicon photonics with diverse fabrication approaches and application space. We will highlight ongoing efforts at all levels of technology readiness, from basic science to commercial products. Many silicon-based platforms including crystalline, poly-, and amorphous silicon, silicon nitride, silicon germanium, silicon-rich nitride, and silicon oxynitride will be highlighted.

Invited Speakers
Chris Doerr, Acacia Communications, Inc., USA
Coherent Silicon Photonic Devices for Communication and Sensing
David Moss, Swinburne Univ. of Technology, Australia
RF, Microwave and Communications Applications of Microcombs
Alex Wright, Ayar Labs, Inc., USA
Monolithic Silicon optoelectronics with Standard CMOS Processes
Graham Reed, Univ. of Southampton, UK
Silicon Photonics
Linjie Zhou, Shanghai Jiao Tong Univ., China
Silicon Photonic Phased Arrays
Short Courses

Short Course Chairs

Robert Fisher, R. A. Fisher Associates, USA
Konstantin Vodopyanov; CREOL, The College of Optics & Photonics, Univ. Central Florida, USA

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 attendees who register, attend, and complete the course evaluation. If you have any questions about receiving the course evaluation or your Certificate of Attendance upon completion, please email shortcourses@cleoconference.org with your name, Short Course number(s) and inquiry.

Sunday, 5 May 2019

08:30–12:30

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

SC456: How to Start a Company
Jes Broeng, Danmarks Tekniske Universitet, Denmark

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

SC479: Basics of Quantum Optics for Quantum-Enabled Technologies NEW
Bahaa Saleh, CREOL, Univ. of Central Florida, USA

13:30–17:30

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

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

Fabio Di Teodoro, Raytheon, USA

SC481: Fundamentals and Applications of VCSELs NEW
Kent Choquette, Univ. of Illinois, USA

Monday, 6 May 2019

08:30–12:30

SC270: High Power Fiber Lasers and Amplifiers
W. Andrew Clarkson, Univ. of Southampton, UK

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

SC361: Coherent Mid-IR Light: Generation and Applications
Konstantin Vodopyanov, CREOL, Univ. of Central Florida, USA

Fabio Di Teodoro, Raytheon, USA

SC481: Fundamentals and Applications of VCSELs NEW
Kent Choquette, Univ. of Illinois, USA

13:30–17:30

Tobias Kippenberg, École polytechnique fédérale de Lausanne, Switzerland

SC376: Plasmonics
Mark Brongersma, Stanford Univ., USA

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

SC476: QCL and QCL Combs NEW
Jérôme Faist, ETH Zürich, Switzerland

Tuesday, 15 May 2018

10:30–13:30

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

10:30–14:30

SC403: NanoCavity Quantum Electrodynamics and Applications
Jelena Vučković, Stanford Univ., USA

SC410: Finite Element Modeling Methods for Photonics and Optics
Arti Agrawal, Univ. of Technology Sydney, Australia

SC424: Optical Terahertz Science and Technology
David G. Cooke, McGill Univ., Canada

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

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

SC149: Foundations of Nonlinear Optics
Robert Fisher, R. A. Fisher Associates, USA
Short Course Level: Beginner and Intermediate

This 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, fiber optic 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.

SC157: Laser Beam Analysis, Propagation and Shaping Techniques
James Leger, Univ. of Minnesota, USA
Short Course Level: Advanced Beginner

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 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.

SC270: High Power Fiber Lasers and Amplifiers
W. Andrew Clarkson, Univ. of Southampton, UK
Short Course Level: Advanced Beginner

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 — so detrimental to the performance of other types of lasers.

SC352: Introduction to Ultrafast Pulse Shaping — Principles and Applications
Marcos Dantus, Michigan State Univ., USA
Short Course Level: Beginner and Advanced Beginner

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, (d) control of nonlinear optical processes such as selective two-photon excitation and selective vibrational mode excitation, (e) material processing and (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.

SC361: Coherent Mid-infrared Sources and Applications
Konstantin Vodopyanov, CREOL, Univ. of Central Florida, USA
Short Course Level: Intermediate

This course reviews different techniques to produce coherent light in the important yet challenging mid-IR spectral region (approximately 2–20 μm). It examines, in great detail, a variety of state-of-the-art approaches from diverse areas of photonics: solid-state lasers based on rare-earth and transition metals, fiber lasers, semiconductor lasers (including intra- and intersubband cascade lasers), nonlinear-optical frequency conversion (including difference frequency generators, optical parametric oscillators, and amplifiers), Raman converters and others. The course assesses several emerging technologies such as supercontinuum generation in microresonators, waveguides, and fibers, as well as frequency comb generation. The course examines the most important applications of the mid-IR, such as spectroscopic sensing and imaging, nano-IR imaging, ultrafast interactions, medical and defense applications, plasmonics, extreme nonlinear optics (including attosecond science), particle acceleration and other applications.

Tobias Kippenberg, École polytechnique fédérale de Lausanne, Switzerland
Short Course Level: Beginner

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 refrigeration 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 limi-
tions 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.

SC376: Plasmonics
Mark Brongersma, Stanford Univ., USA
Short Course Level: Beginner

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. Nanomaterials 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 course 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.

SC378: Introduction to Ultrafast Optics
Rick Trebino, Georgia Institute of Technology, USA
Short Course Level: Beginner

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, their applications are many — ranging from the study of ultrafast fundamental events to telecommunications to micro-machining to biomedical imaging. The 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.

SC396: Frontiers of Guided Wave Nonlinear Optics
Ben Eggleton, Univ. of Sydney, Australia
Short Course Level: Advanced Beginner

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 fibers, 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, ultrafast 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 supercontinuum, nonlinear localization effects and solitons, nonlinear optics for quantum information.

SC403: NanoCavity Quantum Electrodynamics and Applications
Jelena Vučković, Stanford Univ., USA
Short Course Level: Beginner

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. Besides quantum information systems, many classical information processing devices greatly benefit from the enhanced light matter interaction in such structures. The 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.

SC410: Finite Element Modeling Methods for Photonics and Optics
Arti Agrawal, Univ. of Technology Sydney, Australia

The Finite Element (FE) method is one of the most popular and powerful methods for modeling in photonics. The course starts with Maxwell’s equations and explains the basic principles of numerical modeling 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 modeling 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.

SC424 - Optical Terahertz Science and Technology
David G. Cooke, McGill Univ., Canada
Short Course Level: Intermediate

The purpose of this short course is to introduce time-domain optical techniques based on femtosecond lasers for generating, manipulating and detecting light in the 0.1 – 10 THz region, and demonstrate how this interesting part of the spectrum can be used to improve our understanding of materials. I will discuss THz imaging and sensing applications that are driving the development of this technology and discuss new physics that can be probed with short pulses of THz light.

All conference locations are in the San Jose Convention Center unless otherwise noted.
SC438: Photonic Metamaterials  
Nader Engheta, Univ. of Pennsylvania, USA  
Short Course Level: Beginner

The course will begin with the basics of electromagnetic wave interaction with material media and structures and discuss 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-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 informative metastructures for photonic information processing and computing at the nanoscale, scattering engineering using metamaterials (such as cloaking), guided waves in metamaterials and nonreciprocal metastructures.

SC455 - Integrated Photonics for Quantum Information Science and Technology  
Dirk Englund; MIT, USA  
Short Course Level: Advanced Beginner

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.

SC456: How to Start a Company  
Jes Broeng, Danmarks Tekniske Universitet, Denmark

Starting a new business is a rewarding experience. However, the journey from an idea to a successful company is paved with challenges and puts high demands on technology, business and social skills. The upside is tremendous in personal learning and potentially also economically. The 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 course will help answer questions such as how to know if you have a viable business idea; what to look for in cofounders; and what financing strategy is appropriate for my kind of business.

SC466: Silicon Integrated Nanophotonics  
Jérôme Faist, ETH Zürich, Switzerland

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, wave-guiding, coupled mode theory, pin junctions, etc., with the applications of this knowledge toward the design of practical silicon photonics 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.

SC475: Metasurface Flat Optics NEW  
Federico Capasso, Harvard Univ., USA  
Short Course Level: Beginner, Advanced Beginner, Intermediate

The course is focused on metasurfaces: sub-wavelength-scale artificially structured metal-dielectric surfaces and upon their applications. Metasurfaces enable the redesign of optical components into thin, planar and multifunctional elements. This leads to a major reduction in thickness, in footprint and in system complexity, simplifying optical alignment and aberration control. As well, this leads to the introduction of new optical functions, thus circumventing the limitations of refractive and conventional diffractive optics. Design, fabrication and measurements of metalenses, holograms, multifunctional metasurfaces and waveplates will be covered with particular emphasis on polarization optics. Applications such as imaging, AR/VR, miniature spectrometers, polarimetry and fiber optics will be discussed.

SC476: QCL and QCL Combs NEW  
Jérôme Faist, ETH Zürich, Switzerland  
Short Course Level: Intermediate

The first section of this course will discuss the fundamental physical principles behind the operation of a quantum cascade laser. This will entail the models used to describe the electronic states, as well as a discussion of the key scattering mechanism. We will then describe the various active region architectures and their respective advantages. An emphasis will also be given on the fundamental limits of quantum cascade laser structures. The second part of the lecture will discuss the engineering of single mode and broad gain devices. Beside external cavity, multi-wavelength and other Vernier

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devices will be discussed as some of the key applications of QCLs. The third and final part of the lecture will address the optical frequency comb quantum cascade laser. It will start by describing the physics behind the comb formation, the Maxwell-Bloch modeling of the QCL combs. The various techniques used to correct the group velocity dispersion of the device will next be discussed. It will then describe the various characterization techniques, as well as some of the emerging applications in broadband time-resolved mid-infrared spectroscopy.

SC478: Microresonator-based Optical Frequency Comb and Photonic Waveguide Supercontinuum Sources NEW
Tobias Kippenberg, École polytechnique fédérale de Lausanne, Switzerland
Short Course Level: Beginner
Optical frequency combs have revolutionized frequency metrology and spectroscopy over the last two decades. Recent advances have allowed generating optical frequency combs in compact optical microresonators using parametric interactions. This course will provide an introduction to the numerical simulation and design, operation principles and measurement techniques of micro-resonator frequency combs. It will cover the formation of dissipative temporal solitons, and discuss how such states can be numerically simulated using the Lugiato Lefever equation. The course will discuss the similarities to soliton-related phenomena known in supercontinuum generation, and will study basics of supercontinuum generation in integrated photonic waveguides, as recently studied. The course will moreover discuss applications of soliton micro-combs in ranging, communications and spectroscopy, and outline the state of the art.

SC479: Basics of Quantum Optics for Quantum-enabled Technologies NEW
Bahaa Saleh, CREOL, Univ. of Central Florida, USA
Short Course Level: Beginner
This course will begin with a brief overview of the basic quantum principles — superposition, uncertainty, non-cloneability and entanglement—highlighting the essence of the “quantum advantage” that has led to the emerging quantum technology leap. The “mixed analog-digital” nature of the quantum bit (qbit) and its role in quantum computing will be introduced, and the distinction between entanglement and ordinary correlation will be clarified. This will be followed by the application of these general quantum principles to light: demonstrating the inherent uncertainty in the optical amplitude, phase, quadrature components and photon number; noting bounds on the uncertainty product dictated by the Heisenberg principle and their manipulation by “squeezing”; and summarizing the photon statistics associated with various quantum states of light.

SC481: Fundamentals and Applications of VCSELs NEW
Kent Choquette, Univ. of Illinois, USA
Short Course Level: Beginner
This course will review the principles of operation and technological advances of vertical cavity surface emitting lasers (VCSELs). The course will begin with an overview of microcavity laser fundamentals and will include discussions of semiconductor optical gain, Fabry-Perot resonators, electron and photon confinement and the properties of VCSEL emission. The second half of the course will overview the major application areas of VCSELs and will include digital modulation, both incoherent and coherent high power 2-dimensional array performance, and various examples of optical sensing. Specific examples of infrared and visible VCSEL performance will be included as well as the commercial VCSEL manufacturing landscape.
Special Events

Pride in Photonics: LGBTQ+ & Ally Workshop
Sunday, 5 May; 9:00–13:00
University Room, Hilton San Jose

The aim for this workshop is to:
- Provide a safe space for LGBTQI+ people, allies and diversity advocates;
- Create a welcoming atmosphere for collaboration and technical dissemination;
- Discuss best practices in LGBTQI+ equality, diversity and inclusion.

The program will consist of technical talks, personal journey stories, best practice take-aways, a panel and open networking time. Again, this is an inclusive event, so all members of the community are encouraged to attend, including LGBTQI+ and diversity allies.

Note that this workshop will be a safe space for collaboration and sharing. The organizers recognize and respect that some individuals may not be “out” in this space, therefore confidentiality is a priority and a code of conduct for the workshop will be made available in advance and addressed at the event.

Sponsored by

Be a Part of the Solution: Preventing and Responding to Harassment
Sunday, 5 May; 14:00–15:30 and 16:00–17:30
University Room, Hilton San Jose

CLEO is committed to providing an environment that is conducive to the free and robust exchange of scientific ideas. This requires that all participants be treated with equal consideration and respect. With this in mind, CLEO is offering this session to help provide members with the skills needed to make this a reality throughout our community. The program will examine different forms of harassment, The Bystander Effect, and Ally Skills. This session is open to all conference attendees, but space is limited.

Sponsored by

OSA Presentation Feedback Program
Monday, 6 May; 11:00–12:00
University Room, Hilton San Jose

Join us for an interactive session focused on providing an effective conference talk or poster. Conference presentations are an important aspect of communicating cutting-edge research. In this workshop we will discuss some key elements of giving an effective conference talk. This will be followed by an interactive session where individual feedback to your slides would be provided by the moderators and by your peers. So, please bring along your laptop with your conference presentation or any other technical talk.

Navigate Your Leadership Trajectory for Senior Leaders
Monday, 6 May; 11:00–12:30
Salon VI, San Jose Marriott

In this interactive session you will:
1. Reflect on both the impact and the opportunity of having both mentors and sponsors in your life
2. Evaluate best practices and internal strategies to elevate others while expanding your personal leadership capabilities and brand
3. Understand and build a business case for mentoring and sponsorship to drive ROI + diversity, retention, knowledge transfer and engagement

What’s Next in Integrated Optics – Hot Topics at CLEO: 2019
Monday, 6 May 2019; 12:30–13:30
Room 230A

Join the OSA Integrated Optics Technical Group for a panel discussion during lunch on Monday. Our featured presenters will give their perspective on the exciting research that will be presented at CLEO 2019, followed by a moderated question and answer session. This event is an excellent opportunity to hear from experts in the field on exciting new areas in integrated optics. Panelists include Michal Lipson, Columbia University; Marko Loncar, Harvard University; and Jelena Vuckovic, Stanford University. Please contact TGactivities@osa.org to register, pending availability.

Hosted by

All conference locations are in the San Jose Convention Center unless otherwise noted.
Savvy scientists must increasingly engage with social media. It is how and where we share information—with friends, colleagues, acquaintances and any and everyone else. The co-sponsors of CLEO 2019 are hosting a Social Media Career Session to explore the benefits of leveraging social media for advancement. We will explain how anyone at any stage in their career can use social media to influence and grow. You will learn best practices and gain practical takeaways enabling you to optimize your "social" footprint and personal brand.

Please refer to Program Update Sheet for Panelists.

Hosted by OSA Foundation

Social Media in 2019 Panel Discussion
Monday, 6 May; 13:00–14:00
University, Hilton San Jose

Organizers:
Andrea Armani, Univ. of Southern California, USA
Benjamin Eggleton, Univ. of Sydney, Australia

Learn more how to select the career path that's right for you and the top 20 industry jobs that PhDs are getting into. Make sure you are prepared to get the salary you deserve as well as making sure you standout among the sea of candidates. Join Cheeky Scientists as we guide you through the process of getting a job in industry!

Resumes, Linkedin, and Networking (with Cheeky Scientist)
Monday, 6 May; 13:00–14:00 and 16:00–17:00
University Room, Hilton San Jose

Diversity and Inclusion Reception
Monday, 6 May; 17:30–18:30
Winchester Room

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.

Sponsored by

Lasers for Attosecond 2.0
Monday, 6 May; 18:30–20:00
Room 230A

Join the OSA Short Wavelength Sources and Attosecond/High Field Physics Technical Group for a special session on the next generation of laser technology that will support the field of attosecond science in the coming decades. Our featured presenters will be discussing both current and upcoming technology for the next generation of femtosecond lasers. Following the conclusion of these presentations, attendees are invited to join the technical group for a small reception where they can network with colleagues over refreshments. Please contact TGactivities@osa.org to register, pending availability.

Hosted by OSA Short Wavelength Sources and Attosecond/High Field Physics Technical Group

Meet OSA Publishing Journal Editors Ice Cream Social
Tuesday, 7 May, 15:00–16:30
Exhibit Hall, Networking Zone, Booth 2605

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.

Hosted by The Optical Society Since 1916

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CLEO • 5–10 May 2019 27
OSA Senior Member Reception
Tuesday, 7 May; 17:30–18:30
OSA Member Lounge, Concourse Level
Join us for a reception with other OSA Senior Members, and future OSA Senior Members to learn about this distinction, its benefits, application process and deadline while networking with colleagues from around the world. Get Involved Today!

OSA Technical Group Poster Session
Tuesday, 7 May; 19:00–20:30
Grand Ballroom 220C
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.

Conference Reception
Wednesday, 8 May, 19:00–20:30
Grand Ballroom 220B/C
Enjoy a festive evening with your colleagues. The reception is open to all attendees and badges must be worn to enter the reception.

Sponsored by THORLABS

Emerging Trends in Nonlinear Optics – A Review of CLEO
Thursday, 9 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. 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 only; please contact TGactivities@osa.org to register, pending availability.

Hosted by OSA Nonlinear Optics Technical Group

Postdeadline Paper Sessions
Thursday, 9 May, 20:00–22:00
Locations announced on the 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.

Seminar: VirtualLab Fusion Technology and Applications: Interferometry, Microscopy and Fiber Coupling
Friday, 10 May; 09:00–16:00
Room 214
Speaker: Site Zhang, PhD, CTO, LightTrans International UG
Discover the Fast Physical Optics concept with VirtualLab Fusion by means of seminar modules on technology and different applications. You will learn how to use non-sequential field tracing to configure and model various interferometric setups; setting up of modern microscopes and how to perform fully vectorial imaging simulations; using physical optics for fiber coupling efficiency analysis and design of high-NA coupling systems.

Hosted by OSA Technical Groups

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

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 26 March 2019)

3DOptix
AdValue Photonics, Inc.
Advanced Research Systems
AdvR
AIP Publishing
Allied Laser Solutions
Alpine Research Optics
Altos Photonics, Inc.
American Physical Society (APS)
Amplitude Laser Group
APE - Applied Physics & Electronics Inc.
asphericon Inc.
Atseva LLC
Attocube Systems, Inc.
AUREA Technology
Azur Light Systems
Beam Engineering for Advanced Measurements Co.
Boston Electronics Corporation
Bristol Instruments, Inc.
Calmar Laser, Inc.
Carmel Instruments
CASTECH, Inc.
Changchun BoXin Photoelectric Co., Ltd.
Changchun New Industries Optoelectronics Tech. Co.
Chinese Laser Press
Class 5 Photonics GmbH
Cobolt by HUBNER Photonics
Coherent, Inc.
ColdQuanta, Inc.
CRC Press – Taylor & Francis Group
CREOL, University of Central Florida
CrystaLaser LC
Crystalline Mirror Solutions
Cybel, LLC
Cycle GmbH
DataRay, Inc.
Dausinger + Giesen GmbH
DRS Daylight Solutions, Inc.
Edmund Optics, Inc.
EKSMA Optics
EKSPLA
Electro-Optics Technology, Inc.
Energetiq Technology Inc.
EOSPACE, Inc.
Epner Technology, Inc.
Eulitha AG
EXFO
FASTLITE
Femtochrome Research, Inc.

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few-cycle
Gentec Electro-Optics, Inc.
GTAT Corp.
Hagtec Co.
Hamamatsu Corporation
HILLTOP Technology Lab., Inc.
Hinds Instruments, Inc.
Hitronics Technologies, Inc.
Hiwin Corporation
HOLOEYE Photonics AG
Hong Kong University of Science and Technology
HTA Photomask
Ibsen Photonics A/S
IEEE Photonics Society
IMEC
IMRA America, Inc.
INNOLAS
Inrad Optics
IPG Photonics Corp.
IRflex Corporation
IXBLUE
Jasper Display Corp.
KMLabs, Inc.
Knight Optical
Kphotonics, LLC
LaCroix Precision Optics
Laser Focus World
Laser Quantum, Inc.
Lattice Electro Optics, Inc.
Light Conversion
Lighthouse Photonics
LightTrans International UG
Liquid Instruments
Luvantix ADM Co., Ltd.
M Squared Lasers Ltd.
Menlo Systems
Mesa Photonics, LLC
Microphoton Devices
MKS Instruments
NKT Photonics
NM Laser Products
Northrop Grumman Cutting Edge Optronics, Inc.
NPI Lasers
Nuphoton Technologies Inc.
O埃waves, Inc.
OPOTEXK, Inc.
Optelligent, LLC
OptiGrate Corporation
Optimax Systems, Inc.
OptoSigma Corporation
Optronics Co., Ltd., The

OSA – The Optical Society
OSA Member Lounge
Osela, Inc.
Oxide Corporation
OZ Optics
PHASICS Corp.
Photodigm, Inc.
Photon Design
Photon Force Ltd
Photonics Media/Laurin Publishing
Photop Technologies, Inc
PI (Physik Instrumente) LP
PicoQuant
Princeton Scientific Corporation
PriTel, Inc.
Quantel Laser by Lumibird
Quantum Design, Inc.
Quantum Opus
RAM Photonics, LLC
Sacher Lasertechnik GmbH
Sandia National Laboratories
SaNoor Technologies
Santec USA Corporation
Seiwa Optical America, Inc.
SILIOS Technologies S.A.
Siskiyou Corporation
SmarAct, Inc.
Solid Sealing Technology
Specialised Imaging
Spectrolight, Inc.
SPIE: The Intl Society for Optics and Photonics
Springer
Stable Laser Systems
STANDA
StellarNet, Inc.
Swamp Optics, LLC
Synopsys, Inc.
Teledyne Judson Technologies
ThermoTek, Inc.
Thorlabs
Tianjin University
Timbercon, Inc.
Toptica Photonics, Inc.
TRUMPF Inc.
Universal Quantum Devices
Vescent Photonics, Inc.
Wuhan National Lab for Optoelectronics
YSL Photonics Co., Ltd.
Zaber Technologies
Zurich Instruments

All conference locations are in the San Jose Convention Center unless otherwise noted.
Beyond Awareness: What Actions Can Be Taken to Improve Diversity in STEM
Wednesday, 8 May, 10:30–12:00
Exhibit Hall Theater II

Organizers
Arti Agrawal, University of Technology Sydney, Australia
Ben Eggleton, University of Sydney, Australia
Tara Fortier, National Institute of Standards & Technology, USA
Christina Willis, Consultant, USA
Andrew Wilson, National Institute of Standards & Technology, USA

In the physical sciences, women and minorities have seen slower improvements in representation compared to fields such as medicine and law. Information on how to improve this representation in STEM is also difficult to find. This workshop brings together leaders of professional organizations and subject matter experts to discuss policies and actions that can improve gender, racial, LGBTQI and disability diversity within the physics, engineering and optics communities.

Panelists
Kate Kirby, Chief Executive Officer, American Physical Society
Doug Razzano, Executive Director, IEEE Photonics Society
Kent Rochford, Chief Executive Officer, SPIE
Elizabeth A. Rogan, Chief Executive Officer, The Optical Society

Please refer to Update Sheet for moderator information.

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:

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<td>Wednesday, 8 May</td>
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<tr>
<td>Thursday, 8 May</td>
<td>10:00–11:30</td>
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Sponsored by

MKS Student Lounge
Booth 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

OIDA VIP Industry Leaders Speed Meetings Event
Tuesday, 7 May, 12:00–13:30
Exhibit Hall, Networking Zone, Booth 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 trooney@osa.org.

Sponsored by

Plenary Speaker Meet-n-Greets
Tuesday, 7 May & Wednesday, 8 May, 10:15–10:45
Exhibit Hall, Networking Zone, Booth 2605

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

Quantum Information Science and Technology Initiatives
Tuesday, 7 May, 10:30–12:00
Exhibit Hall Theater I

Organizer
Sergey Polyakov, National Institute of Standards and Technology, USA

Nationally-driven research initiatives in quantum information science and technology have grown as quickly as the fields themselves in recent years. This panel will explore the state of the research, the initiatives, and the potential international competitiveness, and cooperation that comes with them.

Panelists:
Marissa Giustina, Google, USA
David Lang, The Optical Society, USA
Christopher Monroe, University of Maryland, College Park, USA
Cheng-Zhi Peng, University of Science and Technology of China, China
Michael Raymer, University of Oregon, USA
Carl Williams, National Institute of Standards and Technology, USA

Free Lunch at the CLEO:EXPO
Tuesday and Wednesday, 7 & 8 May, 11:30–13:00
Thursday, 9 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.

All conference locations are in the San Jose Convention Center unless otherwise noted.
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 and must remove their poster one hour following the session. Authors may submit their poster PDF to cstech@osa.org for publication. The Dynamic e-Posters presentation method combines the richness of multimedia content of oral presentations with the personalized one-on-one interaction of posters.

| Tuesday, 7 May | 11:30–13:00 |
| Wednesday, 8 May | 11:30–13:00 |
| Thursday, 9 May | 11:30–13:00 |

Market Trends: Opportunities in Optics and Photonics
Tuesday, 7 May, 15:30–17:00
Exhibit Hall Theater I

Organizer
Tom Hausken, OIDA, USA

This presentation will review the current state and upcoming opportunities for the optics and photonics industry with respect to revenues, product areas, and regions. It will provide a quantitative look at recent performance, and examples of promising markets going forward.

New Commercial Trends in Mid-Infrared Sensing – From Nano-Photonics to Stand-Off Detection
Wednesday, 8 May, 10:30–12:00
Exhibit Hall Theater I

Organizer
Bernadeta A. Wysocka, Princeton University, USA

Panelists from industry, government laboratories and academia will discuss novel technologies leveraging infrared sensing for material science, biomedical imaging and chemical detection. The speakers will discuss established technologies and market opportunities in a variety of applications such as industrial process monitoring, bio-medical and pharmaceutical industry, and security. Please consider attending the event, listen and interact with leaders in the mid-infrared sensing community, and share your ideas in an open discussion.

Moderator
Gerard Wysocki, Associate Professor of Electrical Engineering, Princeton University

Technology Transfer Program

The Technology Transfer Program includes a Keynote presentation, a Technology Transfer Tutorial and a Pitch Panel. The tutorial speaker provides attendees more information 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. In addition, these organizations will feature their license-ready technologies at tabletop displays in the exhibit hall.

Keynote Talk
Thursday, 9 May, 10:15–10:45
Exhibit Hall Theater I

Keynote Speaker
Tim Day, VP and GM, DRS Daylight Solutions

Technology Transfer Tutorial
Thursday, 9 May, 10:45–11:15
Exhibit Hall Theater I

Tutorial Speaker
Dr. Eugene R. Cochran III, PhD, Senior Commercialization Manager, Oak Ridge National Laboratory

Pitch Panel with Feedback from Panelists
Thursday, 9 May, 11:15–12:30
Exhibit Hall Theater I

Panelists:
Kei May Lau, PhD, Chair Professor, Hong Kong University of Science and Technology, Hong Kong
Rachel Grange, PhD, Leader of the Optical Nanomaterial Group, ETH Zurich, project PolarNon, USA
Manish D. Kulkarni, PhD, Chief Executive Officer, Netra Systems, USA
Max Perez, Senior Engineer & Business Development, ColdQuanta Ltd., USA

Judging Panel:
Robert Mandra, Managing Director, RSM Advisors, USA
Sujatha Ramanujan, PhD, Managing Director, Nextcorps’ Luminate, USA
CLEO Committees

Applications & Technology
Peter Andersen, Danmarks Tekniske Universitet, Denmark, General Chair
Michael M. Mielke, Iridion Laser, USA, General Chair
Jin Ung Kang, Johns Hopkins Univ., USA, Program Chair
Stephanie Tomasulo, US Naval Research Laboratory, USA, Program Chair

A&T 1: Biomedical Applications
Ilkay U. U. Food and Drug Administration, USA, Subcommittee Chair
Utkarsh Sharma, Volk Optical Inc., USA, Subcommittee Chair
Andrea Armani, Univ. of Southern California, USA
Brian Cullum, Univ. of Maryland Baltimore County, USA
Qiyan Fang, McMaster Univ., Canada
Irene Georgakoudi, Tufts Univ., USA
Thomas Huser, Universität Bielefeld, Germany
Beop-Min Kim, Korea Univ., South Korea
Xingde Li, Johns Hopkins Univ., USA
Yuji Matsuura, Tohoku Univ., Japan
David Nolte, Animated Dynamic Inc., USA
Aydogan Ozcan, Univ. of California Los Angeles, USA
Brian Pryor, LiteCure, USA
Sean Wang, B&W Tek Inc, USA
Yicong Wu, NIH National Institute of Biomedical Imaging & Bioengineering, USA

A&T 2: Industrial Applications
Nicolas Falletto, Electro Scientific Industries, Inc., USA, Subcommittee Chair
Jie Qiao, Rochester Institute of Technology, USA, Subcommittee Chair
David Grojo, CNRS, France
Michael Krainak, NASA Goddard Space Flight Center, USA
Manyalibob Matthews, Lawrence Livermore National Laboratory, USA
Peter Moselund, NKT Photonics Inc, Denmark
Dirk Mueller, Coherent Inc., USA
Roberto Osellame, Istituto di Fotonica e Nanotecnologie, Italy
Hong-Bo Sun, Tsinghua Univ., China

A&T 3: Laser-Based Instrumentation for Measurements and Monitoring
Gregory Rieker, Univ. of Colorado at Boulder, USA, Subcommittee Chair
Brian Simonds, National Institute of Standards and Technology, USA, Subcommittee Chair
Alexandra Artusio-Glimpse, National Inst of Standards & Technology, USA
Fabio Di Teodoro, Raytheon SAS, USA
Christopher Goldenstein, Purdue Univ., USA
Peter Fendel, Thorlabs Inc, USA
Kara Peters, North Carolina State Univ., USA
Steven Wagner, Technische Universität Darmstadt, Germany
Azer Yalin, Colorado State Univ., USA

A&T 4: Applications in Energy & Environment
Mark Zondlo, Princeton Univ., USA, Subcommittee Chair
Daniel Law, Boeing, USA, Subcommittee Chair
David Bomse, Mesa Photonics, LLC, USA
Mohammad Khan, Delaware State Univ., USA
Joel Silver, Southwest Sciences Inc., USA

Fundamental Science
Ben Eggleton, Univ. of Sydney, Australia, General Chair
Irina Novikova, College of William & Mary, USA, General Chair
Natalia Litchinitser, Univ. at Buffalo, USA, Program Chair
Sergey Polyakov, National Institute of Standards & Technology, USA, Program Chair

FS 1: Quantum Optics of Atoms, Molecules and Solids
Tracy Northup, Universität Innsbruck, Austria, Subcommittee Chair
Takao Aoki, Waseda Univ., Japan
Adam Black, US Naval Research Laboratory, USA
Nathalie de Leon, Princeton Univ., USA
Elizabeth Goldschmidt, US Army Research Laboratory, USA
Peter Humphreys, Technische Universität Delft, Netherlands
Rudolph Kohn, Space Dynamics Laboratory, USA
Lucas Lamata, Universidad del País Vasco, Spain
Virginia Lorenz, Univ. of Illinois at Urbana-Champaign, USA
Pavel Lougovski, Oak Ridge National Laboratory, USA
Marina Radulaski, Stanford Univ., USA
Glenn Solomon, Joint Quantum Institute, USA

FS 2 Quantum Information and Communication
Joshua Nunn, Univ. of Oxford, UK, Subcommittee Chair
Michael Brodsky, U.S. Army Research Laboratory, USA
Maria Chekhova, Max-Planck-Inst Physik des Lichts, Germany
Eleni, Diamanti, Universite Pierre et Marie Curie, France
Thomas Gerrits, National Inst of Standards & Technology, USA
Steve Koltzhammer, Imperial College, UK
Peter Mosley, Univ. of Bath, UK
Valentina Parigi, Laboratoire Kastler Brossel, France
Fabrizio Piacentini, INRIM, Italy
Polina Sharapova, Univ. of Paderborn, Germany
John Sipe, Univ. of Toronto, Canada
Philip Walther, Universitat Wien, Austria

FS 3: Quantum Photonics
Joshua Bienfang, National Inst of Standards & Technology, USA, Subcommittee Chair
Guillaume Bachelier, Institut NÉEL, CNRS, France
Sara Ducci, Université Paris Diderot, France
John Howell, Hebrew Univ. of Jerusalem, Israel
Yuping Huang, Stevens Institute of Technology, USA
Jungsang Kim, Duke Univ., USA
Marco Liscidini, Università degli Studi di Pavia, Italy
Mirko Lobino, Griffith Univ., Australia
Raphael Pooser, Oak Ridge National Laboratory, USA
Stefan Francis Preble, Rochester Institute of Technology, USA
Alexander Sergienko, Boston Univ., USA
Martin Stevens, National Inst of Standards & Technology, USA
Andrey Sukhorukov, Australian National Univ., Australia

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FS 4: Optical Excitations and Ultrafast Phenomena in Condensed Matter
Denis Seletskiy, Polytechnique Montréal, Canada, Subcommittee Chair
Elbert Chia, Nanyang Technological Univ., Singapore
Mackillo Kira, Univ. of Michigan, USA
Chih-Wei Lai, The MITRE Corporation, USA
Kaihui Liu, Peking Univ., China
Ilias Perakis, Univ. of Alabama at Birmingham, USA
Mark Sherwin, Univ. of California Santa Barbara, USA
Julia Stähler, Fritz-Haber-Institut der Max-Planck-Gesellschaft, Germany
Diyar Talbayev, Tulane Univ., USA
Vasily Temnov, IMMM CNRS 6283 Le Mans, France
Jerome Tignon, Ecole Normale Superieure Paris and Sorbonne Univ., France
Lyubov Titova, Worcester Polytechnic Institute, USA
Ulrike Woggon, Technische Universität Berlin, Germany
Luyi Yang, Univ. of Toronto, Canada
Liuyan Zhao, Univ. of Michigan, USA

FS 5: Nonlinear Optics and Novel Phenomena
Mercedeh Khajavikhan, CREOL, Univ. of Central Florida, USA, Subcommittee Chair
Andrea Blanco-Redondo, Univ. of Sydney, Australia
Daniel Brunner, CNRS - FEMTO-ST, France
Demetrios Christodoulides, Univ. of Central Florida, USA
Scott Diddams, National Institute of Standards & Technology, USA
Mona Jarrahi, Univ. of California Los Angeles, USA
Arash Mafi, Univ. of New Mexico, USA
Konstantinos Makris, Univ. of Crete, Greece
Alireza Marandi, California Institute of Technology, USA
 Sahin Ozdemir, Pennsylvania State Univ., USA
Peter Rakich, Yale Univ., USA
Mikael Rechtsman, Pennsylvania State Univ., USA
Bo Zhen, Univ. of Pennsylvania, 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
Hayk Harutyunyan, Emory Univ., USA
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
Shambhu Ghimire, SLAC/Stanford Univ., USA
Nobuhisa Ishii, Institute for Solid State Physics, Japan
Alexandra Landsman, ETH Zürich, Switzerland
Guillaume Laurent, Auburn Univ., USA
Julia Mikhailova, Princeton Univ., USA
Avrinder Sandhu, Univ. of Arizona, USA
Emma Springate, STFC Rutherford Appleton Laboratory, UK
Xiaoming Wang, Washington State Univ., USA

FS 8: Metamaterials and Complex Media
Zubin Jacob, Purdue Univ., USA, Subcommittee Chair
L. Jay Guo, Univ. of Michigan, USA
Yongmin Liu, Northeastern Univ., USA
Ori Katz, Hebrew Univ. of Jerusalem, Israel
Rajesh Menon, Univ. of Utah, USA
Sushil Mujumdar, Tata Institute of Fundamental Research, India
Ward Newman, Univ. of Alberta, Canada
Junsuk Rho, POSTECH, South Korea
Alessandro Saldarino, Univ. of Kansas, USA
Riccardo Sapienza, Imperial College London, UK
Justin Song, Nanyang Technological Univ., Singapore
Sergei Tretyakov, Aalto Yliopisto, Finland
Martijn Wubs, Danmarks Tekniske Universitet, Denmark

Science & Innovations
Sterling Backus, Kavli-Illini Nano Sciences Institutes, USA, General Chair
Michal Lipson, Columbia Univ., USA, General Chair
Tara Fortier, National Inst of Standards & Technology, USA, Program Chair
Christophe DorrER, Univ. of Rochester, USA, Program Chair

S&I 1: Light-Matter Interactions and Materials Processing
Tsing-Hua Her, Univ. of North Carolina at Charlotte, USA, Subcommittee Chair
NadezhdA Bulgakova, HiLASE, Institute of Physics ASCR, Czech Republic
Maria Kandyla, National Hellenic Research Foundation, Greece
Edward Kinzel, Missouri Univ. of Sci. and Tech., USA
Carl Liebig, Air Force Research Laboratory, USA
Chih Wei Luo, National Chiao Tung Univ., Taiwan
Takashi Omatsu, Chiba Univ., Japan
Renee Sher, Wesleyan Univ., USA
Zijie Yan, Clarkson Univ., USA

S&I 2: Laser Systems and Facilities
Jake Bromage, Univ. of Rochester, USA, Subcommittee Chair
Lynda Busse, US Naval Research Laboratory, USA
Erhard Gaul, Univ. of Texas at Austin, USA
Aurélie Jullien, INL - INPHYNI, CNRS, UNS, France
Max Lederer, European XFEL, Germany
Seong Ku Lee, APRI, GIST, South Korea
Xiaoyan Liang, Shanghai Institute of Optics & Fine Mechanics, China
Dimotrios Papadopoulos, LULI, France
Clara Saraceno, Ruhr Universität Bochum, Germany
Emily Sistrunk Link, Lawrence Livermore National Laboratory, USA
David Spence, Macquarie Univ., Australia
Lutz Winkelmann, DESY, Germany

All conference locations are in the San Jose Convention Center unless otherwise noted.
CLEO • 5-10 May 2019
S&I 3: Semiconductor Lasers
Mikhail Belkin, Univ. of Texas at Austin, USA, Subcommittee Chair
Chadwick Canedy, Naval Research Laboratory, USA
Connie Chang-Hasnain, Univ. of California Berkeley, USA
Lan Fu, Australian National Univ, Australia
Nicolas Grandjean, Ecole polytechnique federale de Lausanne, Switzerland
Qing Gu, The Univ. of Texas at Dallas, USA
Peter Heim, Thorlabs Inc., USA
Nobu Nishiyama, Tokyo Institute of Technology, Japan
Günther Roelkens, Universiteit Gent – imec, Belgium
Leon Shterengas, Stony Brook Univ., USA
Qijie Wang, Nanyang Technological Univ., Singapore

CLEO S&I 4: Nonlinear Optical Technologies
Michelle Y. Sander, Boston University, USA, Subcommittee Chair
Jaime Cardenas, Univ. of Rochester, USA
Amol Choudhary, Univ. of Sydney, Australia
Kavita Devi, Indian Institute of Technology (IIT), India
Miro Erkintalo, Univ. of Auckland, New Zealand
Katie Gallo, KTH Royal Institute of Technology, Sweden
Shu-Wei Huang, Univ. of Colorado at Boulder, USA
Brandon Shaw, US Naval Research Laboratory, USA
Youjian Song, Tianjin Univ., China
Dawn Tan, Singapore Univ. of Technology & Design, Singapore
Markku Vainio, Helsingin Yliopisto, 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
Mattias Beck, ETH Zürich, Switzerland
Tyler Cocker, Michigan State Univ., USA
Martin Koch, Philipps Universitat Marburg, Germany
Juliette Mangeney, Laboratoire Pierre Aigrain, France
Daniel Mittleman, Brown Univ., USA
Tadao Nagatsuma, Osaka Univ., Japan
Pernille Pedersen, Aarhus Universitet, Denmark
Minah Seo, Korea Institute of Science & Technology, South Korea
Miriam Vitiello, Scuola Normale Superiore di Pisa, Italy

CLEO S&I 6: Optical Materials, Fabrication and Characterization
Roberto Paiella, Boston Univ., USA, Subcommittee Chair
Jiming Bao, Univ. of Houston, USA
Matthew Escarré, Tulane Univ., USA
Frederic Gardes, Univ. of Southampton, UK
Tingyi Gu, Univ. of Delaware, USA
Eiichi Kuramochi, NTT Corporation, Japan
Lih Lin, Univ. of Washington, USA
Oana Malis, Purdue Univ., USA
Alejandro Manjavacas, Univ. of New Mexico, USA
Richard Osgood, Columbia Univ., USA
Zhipei Sun, Aalto Yliopisto, Finland

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
Karen Grutter, Univ. of Maryland at College Park, USA
Tobias Herr, Swiss Cent for Electronics and Microtech, Switzerland
Zhihong Huang, Hewlett Packard laboratories, USA
Jin Liu Sun, Yat-Sen Univ., China
Nobuyuki Matsuda, Tohoku Univ., Japan
Yasutomo Ota, Univ. of Tokyo, Japan
Harish Subbaraman, Boise State Univ., USA
Sharon Weiss, Vanderbilt Univ., USA
Lan Yang, Washington Univ. in St Louis, USA

CLEO S&I 8: Ultrafast Optics & Applications
Igor Jovanovic, Univ. of Michigan, USA, Chair, Subcommittee Chair
Alan Fry, SLAC National Accelerator Laboratory, USA
Cristina Hernandez-Gomez, STFC Rutherford Appleton Laboratory, UK
Fumihiko Kannari, Keio Univ., Japan
Thomas Planchnon, Delaware State Univ., USA
Liejia Qian, Shanghai Jiao Tong Univ., China
Bojan Resan, Univ. of Applied Sciences FHNW, Switzerland
Lucia Saito, Universidade Presbiteriana Mackenzie, Brazil
Lawrence Shah, Luminar Technologies, Inc., USA
Catherine Teisset, TRUMPF Scientific Lasers, Germany
Andreas Vaupel, IPG Photonics Corp, USA
László Veisz, Max-Planck-Institut für Quantenoptik, Sweden
Tobias Witting, Max-Born-Institute, Germany

CLEO S&I 9: Photonic Integration
Qiaoqiang Gan, State Univ. of New York at Buffalo, USA, Subcommittee Chair
Ozdal Boyraz, Univ. of California Irvine, USA
Jonathan Bradley, McMaster Univ., Canada
Martin Cryan, Univ. of Bristol, UK
Zetian Mi, Univ. of Michigan, USA
Richard Penty, Univ. of Cambridge, UK
Haisheng Rong, Intel Corporation, USA
Laurent Schaere, IBM, USA
Jian Wang, Huazhong Univ. of Science and Technology, China
Alan Wang, Oregon State Univ., USA
Shumin Xiao, Harbin Institute of Technology, China
Winnie Ye, Carleton Univ., Canada
Beibei Zeng, Los Alamos National Laboratory, USA

CLEO S&I 10: Biophotonics and Optofluidics
Jessica Houston, New Mexico State Univ., USA, Subcommittee Chair
Hatrice Altug, Ecole polytechnique federale de Lausanne, Switzerland
Emily Gibson, Univ. of Colorado Denver, USA
Vernita Gordon, Univ. of Texas at Austin, USA
Aaron Hawkins, Brigham Young Univ., USA
Rainer Leitgeb, Medical Univ. Vienna, Austria
Jakub Nedbal, King’s College London, UK
Ute Neugebauer, Center for Sepsis Control and Care Jena, Germany
Raluca Niesner, Charité-Univ. Medicine Berlin, Germany
John Rasmussen, Univ. of Texas Health Science Center, USA

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Sze Yun Set, Univ. of Tokyo, Japan, Subcommittee Chair
Kazi Abedin, OFS Laboratories, USA
Rodrigo Amezcu Correa, Univ. of Central Florida—CREOL, USA
Camille-Sophie Brès, École polytechnique fédérale de Lausanne, Switzerland
Neil Broderick, Univ. of Auckland, New Zealand
Guoqing Chang, Beijing National Laboratory for Condensed Matter Physics, China
Maria Chernysheva, Aston Univ., UK
Julien Fatome, Université de Bourgogne, France
Takehi Hasegawa, Sumitomo Electric Industries Ltd., Japan
Stuart Jackson, Macquarie Univ., Australia
Li Qian, Univ. of Toronto, Canada
William Renninger, Univ. of Rochester, 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
Xi Chen, Nokia Bell Labs, USA
Nan Chi, Fudan Univ., China
Francesco Da Ros, DTU Fotonik, Denmark
Mihaela Dinu, LGS Innovations LLC, USA
Marija Furdek, KTH Royal Institute of Technology, Sweden
Vladimir Grigoryan, Ciena Corporation, USA
Magnus Karlsson, Chalmers Tekniska Hogskola, Sweden
Masayuki Matsumoto, Wakayama Univ., Japan
Giovanni Milione, NEC Laboratories America Inc, USA
Ryan Scott, Keysight Technologies Inc., USA

CLEO S&I 13: Active Optical Sensing
Todd Stievater, US Naval Research Laboratory, USA, Subcommittee Chair
Brian Brumfield, Pacific Northwest National Laboratory, USA
Denis Donlagic, Uniwerza v Mariboru, Slovenia
Erik Emmons, Edgewood Chemical and Biological Center, USA
Gamani Karunasiri, Naval Postgraduate School, USA
Waruna Kulatilaka, Texas A&M Univ., USA
Nicolas Le Thomas, Université de Bourgogne, France
Andrey Muraviev, CREOL, Univ. of Central Florida, USA
Eric Zhang, IBM T. J. Watson Research Center, USA

CLEO S&I 14: Optical Metrology
Laura Sinclair, National Inst of Standards & Technology, USA, Subcommittee Chair
Florian Adler, Tiger Optics, USA
Ladan Arissian, Univ. of Ottawa, Canada
Aurélien Coillet, Université de Bourgogne, France
Flavio Cruz, Universidade Estadual de Campinas, USA
E. Anne Curtis, National Physical Laboratory, UK
Pascal Del’Haye, National Physical Laboratory, UK
HaiFeng Jiang, National Time Sevice Center, China
Nathan Lemke, Air Force Research Laboratory, USA
Takeshi Yasui, Tokushima Univ., Japan

CLEO S&I 15: Quantum and Atomic Sensors, and their Applications
Andre Luiten, Univ. of Adelaide, Australia, Subcommittee Chair
Eisuke Abe, Keio Univ., Japan
Warwick Bowen, Univ. of Queensland, Australia
Susannah Jones, Dstl, UK
Shau-Yu Lan, Nanyang Technology Univ., Singapore
Franck Pereira dos Santos, SYRTE, France
Qudsia Quraishi, US Army Research Laboratory, USA
Erling Reis, Univ. of Strathclyde, Scotland
James Schaffer, Univ. of Oklahoma, USA
Susan Schima, NIST, USA
Benjamin Sussman, National Research Council Canada, Canada

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Craig Arnold, Princeton Univ., USA
Sterling J. Backus, Kapteyn-Murnane Labs., USA
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Jessie Rosenberg, IBM TJ Watson Research Center, USA
Yuri Vlasov, IBM TJ Watson Research Center, USA

APS/Division of Laser Science
Nicholas Bigelow, Univ. of Rochester, USA
Rohit Prasankumar, Los Alamos National Laboratory, USA

Ex-Officio
Peter Andersen, Danmarks Tekniske Universitet, Denmark
Christophe Dorrer, Univ. of Rochester, USA
Ben Eggleton, Univ. of Sydney, Australia
Tara Fortier, National Institute of Standards & Technology, USA
Amr Helmy, Univ. of Toronto, Canada
Jin Kang, Johns Hopkins Univ., USA
Mercedeh Khajavikhan, CREOL, Univ. of Central Florida, USA
Michal Lipson, Columbia Univ., USA
Natalia Litchinitser, Univ. at Buffalo, USA
Michael M. Mielke, Iridion Laser, USA
Tracy Northup, Univ. at Buffalo, USA
Craig Arnold, Kapteyn-Murnane Labs., USA

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CLEO Budget Committee
Craig Arnold, *Princeton Univ.*, USA
Kent Choquette, *Univ. of Illinois at Urbana-Champaign*, USA
Douglas M. Razzano, *IEEE Photonics Society*, USA
Kristan Corwin, *Kansas State Univ.*, USA
Kate Kirby, *American Physical Society*, USA
Rohit Prasankumar, *Los Alamos National Laboratory*, USA
Elizabeth A. Rogan, *The Optical Society*, USA

Joint Council on Applications
Eric Mottay, *Amplitude Systemes, France*, Chair
Wilhelm G. Kaenders, *Toptica Photonics Inc, Germany*
Amy Eskilson, *Inrad Optics*, USA
Peter Fendel, *Thorlabs Inc.*, USA
Klaufe Klein, *Coherent, Inc.*, USA
Tyler Morgus, *Thorlabs Inc.*, USA
Rick Plympton, *Optimax Systems*, USA
Carsten Thomsen, *NKT Photonics, Denmark*
Mark Tolbert, *Toptica Photonics*, USA
Chris Wood, *Insight Photonic Solutions*, USA
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, 5 May

<table>
<thead>
<tr>
<th>Time</th>
<th>Location</th>
<th>Description</th>
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<tbody>
<tr>
<td>07:30–17:30</td>
<td>Registration, Concourse Level</td>
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</table>
SC456: How to Start a Company (Jes Broeng, Danmarks Tekniske Universitet, Denmark)  
SC466: Silicon Integrated Nanophotonics (Yuri A. Vlasov, University of Illinois at Urbana-Champaign, USA)  
SC479: Basics of Quantum Optics for Quantum-Enabled Technologies (Bahaa Saleh, CREOL, University of Central Florida, USA) |
| 09:00–13:00 | Pride in Photonics: LGBTQ+ & Ally Workshop, University Room, Hilton San Jose |
| 13:30–17:30 | SC157: Laser Beam Analysis, Propagation, and Shaping Techniques (James Leger, University of Minnesota, USA)  
SC396: Frontiers of Guided Wave Nonlinear Optics (Ben Eggleton, University of Sydney, Australia)  
SC475: Metasurface Flat Optics: A New Paradigm for Optical Components Design and Manufacturing (Federico Capasso, Harvard University, USA) |
| 14:00–15:30 | Be a Part of the Solution: Preventing and Responding to Harassment, University Room, Hilton San Jose |
| 14:30–17:30 | SC478: Microresonator based Optical Frequency Comb and Photonic Waveguide Supercontinuum Sources (Tobias Kippenberg, École polytechnique fédérale de Lausanne, Switzerland) |

New This Year: Workshops

These sessions provide interactive learning environments and are open to all conference registrants.

**Will Quantum Computing Actually Work?!**
Monday, 6 May; 18:30–20:00  
Room 210A

**What Will Be the Largest Commercial Application for Optical Frequency Combs in 10 Years?**
Monday, 6 May; 18:30–20:00  
Room 210B

**Beyond Awareness: What Actions Can Be Taken to Improve Diversity in STEM?**
Wednesday, 8 May, 10:30–12:00  
Exhibit Hall Theater II
<table>
<thead>
<tr>
<th>Time</th>
<th>Executive Ballroom 210A</th>
<th>Executive Ballroom 210B</th>
<th>Executive Ballroom 210C</th>
<th>Executive Ballroom 210D</th>
<th>Executive Ballroom 210E</th>
<th>Executive Ballroom 210F</th>
<th>Executive Ballroom 210G</th>
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<td>07:00–</td>
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<td>08:00–</td>
<td>FM1A • Quantum Optomechanics &amp; Transduction</td>
<td>FM1B • Topological Photonics I</td>
<td>FM1C • Novel Phenomena in Classical Nano-Optics</td>
<td>FM1D • Coherent Phenomena in Coupled Resonator Networks</td>
<td>JM1E • Symposium on High Average Power Ultrafast Lasers: Trends, Challenges &amp; Applications I</td>
<td>SM1F • Optical Clocks</td>
<td>SMTG • Ultra-High Capacity Transmission Techniques &amp; SDM</td>
<td>SM1H • Plasmonics for Manipulation &amp; Sensing</td>
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<tr>
<td>08:30–</td>
<td>SC270: High Power Fiber Lasers and Amplifiers (W. Andrew Clarkson, Optoelectronics Research Center, University of Southampton, UK)</td>
<td>SC352: Introduction to Ultrafast Pulse Shaping - Principles and Applications (Marcos Dantus, Michigan State University, USA)</td>
<td>SC361: Coherent Mid-IR Light: Generation and Applications (Konstantin Vodopyanov, The College of Optics &amp; Photonics, University of Central Florida, USA)</td>
<td>SC476: QCL and QCL Combs (Jérôme Faist, ETH Zürich, Switzerland)</td>
<td>SC477: Laser Radar and Remote Sensing: An Application-oriented Introduction (Fabio Di Teodoro, Raytheon, USA)</td>
<td>SC481: Fundamentals and Applications of VCSELs (Kent Choquette, University of Illinois, USA)</td>
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<td>11:00–</td>
<td>OSA Presentation Feedback Program, University Room, Hilton San Jose</td>
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<td>11:00–</td>
<td>Navigate Your Leadership Trajectory for Senior Leaders, Salon VI, San Jose Marriott</td>
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<td>12:30–</td>
<td>Lunch Break (on your own)</td>
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<td>12:30–</td>
<td>What’s Next in Integrated Optics - Hot Topics at CLEO: 2019, Room 230A</td>
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<td>13:00–</td>
<td>Social Media in 2019 Panel Discussion, University Room, Hilton San Jose</td>
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<td>13:00–</td>
<td>Resumes, LinkedIn, and Networking (with Cheeky Scientist), University Room, Hilton San Jose</td>
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<td>13:30–</td>
<td>SC362: Cavity Optomechanics: Fundamentals and Applications (Tobias Kippenberg, École polytechnique fédérale de Lausanne, Switzerland)</td>
<td>SC376: Plasmonics (Mark Brongersma; Stanford University, USA)</td>
<td>SC378: Introduction to Ultrafast Optics (Rick Trebino, Georgia Institute of Technology, USA)</td>
<td>SC476: QCL and QCL Combs (Jérôme Faist, ETH Zürich, Switzerland)</td>
<td>SC477: Laser Radar and Remote Sensing: An Application-oriented Introduction (Fabio Di Teodoro, Raytheon, USA)</td>
<td>SC481: Fundamentals and Applications of VCSELs (Kent Choquette, University of Illinois, USA)</td>
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<td>14:30–</td>
<td>Deliberate Mentoring to Advance Your Career: Special Flash Mentoring Session, Guadalupe Room, Marriott</td>
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<td>16:00–</td>
<td>Resumes, LinkedIn, and Networking (with Cheeky Scientist), University, Hilton San Jose</td>
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<td>16:00–</td>
<td>Professional Development for Busy Professionals, Salon VI, San Jose Marriott</td>
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<td>16:00–</td>
<td>FM4A • Quantum Nanophotonics I: Plasmonics &amp; Quantum Dots</td>
<td>FM4B • Topological Photonics II</td>
<td>FM4C • New Systems for Quantum Communications</td>
<td>FM4D • Excitons in Condensed Matter Systems</td>
<td>SML • High-Average Power Laser Systems</td>
<td>SM4E • Precision Spectroscopy</td>
<td>SM4G • Access &amp; Radio Over Fiber</td>
<td>SM4H • Advanced Optical Technologies for Cells and Tissues</td>
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<td>17:30–</td>
<td>Diversity and Inclusion Reception, Winchester Room, Hilton San Jose</td>
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<td>18:30–</td>
<td>Lasers for Attosecond 2.0, Room 230A</td>
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<td>10:00–</td>
<td>AM1I • Photobiomodulation Therapeutics</td>
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<td>12:30–</td>
<td>Navigate Your Leadership Trajectory for Senior Leaders, Salon VI, San Jose Marriott</td>
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<td>13:30–</td>
<td>Coffee Break, Concourse Level</td>
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<td>13:30–</td>
<td>SC270: High Power Fiber Lasers and Amplifiers (W. Andrew Clarkson, Optoelectronics Research Center, University of Southampton, UK)</td>
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<td>13:30–</td>
<td>SC352: Introduction to Ultrafast Pulse Shaping - Principles and Applications (Marcos Dantus, Michigan State University, USA)</td>
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<td>13:30–</td>
<td>SC361: Coherent Mid-IR Light: Generation and Applications (Konstantin Vodopyanov, The College of Optics &amp; Photonics, University of Central Florida, USA)</td>
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<td>13:30–</td>
<td>SC481: Fundamentals and Applications of VCSELs (Kent Choquette, University of Illinois, USA)</td>
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<td>13:30–</td>
<td>AM2I • Applied Biophotonic Microscopy &amp; Imaging</td>
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<td>13:30–</td>
<td>SM2J • Optical Computing &amp; Resonator Applications</td>
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<td>13:30–</td>
<td>AM2K • Environmental &amp; Atmospheric Sensing II</td>
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<td>13:30–</td>
<td>SM2L • Fiber Devices</td>
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<td>13:30–</td>
<td>FM2M • Random Numbers &amp; Entanglement</td>
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<td>13:30–</td>
<td>SM2N • Enhanced Cavities for Sensing and Interferometry</td>
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<td>13:30–</td>
<td>SM2O • Micro &amp; Nano Fabrication</td>
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<td>14:30–</td>
<td>OSA Presentation Feedback Program, University Room, Hilton San Jose</td>
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<td>14:30–</td>
<td>Navigate Your Leadership Trajectory for Senior Leaders, Salon VI, San Jose Marriott</td>
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<td>15:30–</td>
<td>AM3I • Biomedical Imaging</td>
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<td>15:30–</td>
<td>SM3J • Silicon Photonics</td>
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<td>15:30–</td>
<td>AM3K • A&amp;T Topical Review on Flat Optics I</td>
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<td>15:30–</td>
<td>SM3L • Fiber Amplifiers</td>
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<td>15:30–</td>
<td>SM3N • Novel Optoelectronic Devices</td>
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<td>15:30–</td>
<td>SM3O • Guided Wave Nonlinear Devices</td>
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<td>16:00–</td>
<td>Deliberate Mentoring to Advance Your Career: Special Flash Mentoring Session, Guadalupe Room, Marriott</td>
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<td>16:00–</td>
<td>Resumes, Linkedin, and Networking (with Cheeky Scientist), University Room, Hilton San Jose</td>
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<td>16:00–</td>
<td>Coffee Break, Concourse Level</td>
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<td>16:00–</td>
<td>AM4I • Nanobiophotonics</td>
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<td>16:00–</td>
<td>SM4J • Light Emission &amp; Detection</td>
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<td>16:00–</td>
<td>AM4K • A&amp;T Topical Review on Flat Optics II</td>
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<td>16:00–</td>
<td>SM4L • Specialty Fibers</td>
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<td>16:00–</td>
<td>FM4M • Solid State High Harmonic Generation</td>
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<td>16:00–</td>
<td>SM4N • Surface Emitting Lasers</td>
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<td>16:00–</td>
<td>SM4O • Nonlinear Phonon Interactions</td>
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<td>16:00–</td>
<td>Diversity and Inclusion Reception, Winchester Room, Hilton San Jose</td>
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<td>17:00–</td>
<td>Lasers for Attosecond 2.0, Room 230A</td>
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<td>17:30–</td>
<td>NEW Workshop 2: Will Quantum Computing Actually Work? Room 210A</td>
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<td>17:30–</td>
<td>NEW Workshop 3: What Will be the Largest Commercial Application for Optical Frequency Combs in 10 Years?, Room 210B</td>
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### Agenda of Sessions — Tuesday, 7 May

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<tr>
<th>Time</th>
<th>Executive Ballroom 210A</th>
<th>Executive Ballroom 210B</th>
<th>Executive Ballroom 210C</th>
<th>Executive Ballroom 210D</th>
<th>Executive Ballroom 210E</th>
<th>Executive Ballroom 210F</th>
<th>Executive Ballroom 210G</th>
<th>Executive Ballroom 210H</th>
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<tr>
<td>07:00–18:30</td>
<td>Registration, Concourse Level</td>
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<td>08:00–10:00</td>
<td>Joint Plenary Session, Grand Ballroom 220A</td>
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<tr>
<td>10:00–17:00</td>
<td>Exhibit Open (10:00–17:00), Coffee Break (10:00–11:30), Exhibit Halls 1-3, Coffee Break Sponsored by COHERENT THOR LASERS</td>
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<td>10:30–12:00</td>
<td>Quantum Information Science and Technology Initiatives, Exhibit Hall Theater I</td>
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<td>10:30–13:30</td>
<td>SC455: Integrated Photonics for Quantum Information Science and Technology (Dirk Englund, MIT, USA)</td>
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<td>10:30–14:30</td>
<td>SC403: NanoCavity Quantum Electrodynamics and Applications (Jelena Vučković, Stanford University, USA), SC410: Finite Element Modeling Methods for Photonics and Optics (Arti Agrawal, City University, UK), SC424: Optical Terahertz Science and Technology (David G. Cooke, McGill University, Canada), SC438: Photonic Metamaterials (Nader Engheta, University of Pennsylvania, USA)</td>
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<td>11:30–13:00</td>
<td>Poster Session I &amp; Lunch, Exhibit Halls 1-3</td>
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<td>12:00–13:30</td>
<td>OIDA VIP Industry Leaders Speed Meeting Event, Booth 2605, Sponsored by Coherent THOR LASERS</td>
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<td>13:00–15:00</td>
<td>JTu3A • Symposium on Quantum Information in Time-Frequency Domain I, FTu3B • PT Symmetry &amp; Exceptional Points, FTu3C • Polaritonic Interactions in Transition Metal Dichalcogenide, FTu3D • Tailored Light-Matter Interactions, STu3E • High Peak-Power Lasers &amp; Technologies I, STu3F • Terahertz Sensing &amp; Devices, JTu3G • Symposium on Space-borne Quantum Sensors, STu3H • Biophotonics &amp; Optofluidics</td>
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<td>15:00–17:00</td>
<td>Coffee Break and Exhibit Only Time, Exhibit Halls 1-3, Sponsored by COHERENT THOR LASERS</td>
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<td>15:00–16:30</td>
<td>Meet the OSA Publishing Journal Editors Ice Cream Social, Networking Zone, Booth 2605</td>
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<td>15:30–17:00</td>
<td>OIDA: Market Trends: Opportunities in Optics and Photonics, Exhibit Hall Theater I</td>
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<td>17:00–19:00</td>
<td>JTu4A • Symposium on Quantum Information in Time-Frequency Domain II, FTu4B • Manipulation of Symmetries in Optics, FTu4C • Nanophotonic Platforms for Optical Computing &amp; Deep Learning, FTu4D • Thermal Photonics, STu4E • High Peak-Power Laser &amp; Technologies II, STu4F • Terahertz Spectroscopy, STu4G • Miniaturizing Quantum Technology, STu4H • Innovations in Machine Learning &amp; Microscopy</td>
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<td>17:30–18:30</td>
<td>OSA Senior Member Reception, OSA Member Lounge, Concourse Level</td>
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<td>19:00–20:30</td>
<td>OSA Technical Group Poster Session, Grand Ballroom 220C</td>
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<td>Meeting Room 211 A&amp;B</td>
<td>Meeting Room 211 C&amp;D</td>
<td>Meeting Room 212 A&amp;B</td>
<td>Meeting Room 212 C&amp;D</td>
<td>Marriott Salon I &amp; II</td>
<td>Marriott Salon III</td>
<td>Marriott Salon IV</td>
<td>Theater I</td>
<td>Theater II</td>
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<td><strong>OSA Technical Group Poster Session</strong>, <strong>19:00–17:30</strong></td>
<td><strong>OIDA: Market Trends: Opportunities in Optics and Photonics</strong>, <strong>15:30–15:00</strong></td>
<td><strong>Meet the OSA Publishing Journal Editors Ice Cream Social</strong>, <strong>15:00–14:30</strong></td>
<td><strong>Coffee Break and Exhibit Only Time</strong>, <strong>17:00</strong></td>
<td><strong>Poster Session I &amp; Lunch</strong>, <strong>13:00–11:30</strong></td>
<td><strong>Quantum Information Science and Technology Initiatives</strong>, <strong>Exhibit Hall Theater I</strong></td>
<td><strong>SC455: Integrated Photonics for Quantum Information Science and Technology (Dirk Englund, MIT, USA)</strong></td>
<td><strong>Registeration, Concourse Level</strong></td>
<td><strong>Joint Plenary Session, Grand Ballroom 220A</strong></td>
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<td><strong>Exhibit Open (10:00–17:00), Coffee Break (10:00–11:30), Exhibit Halls 1-3</strong>, <strong>Coffee Break Sponsored by COHERENT</strong></td>
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<td><strong>SC438: Photonic Metamaterials (Nader Engheta, University of Pennsylvania, USA)</strong></td>
<td><strong>SC445: Optical Materials and Devices (Dirk Englund, MIT, USA)</strong></td>
<td><strong>SC455: Integrated Photonics for Quantum Information Science and Technology (Dirk Englund, MIT, USA)</strong></td>
<td><strong>SC465: Applications of Optics and Photonics in Information Technology I</strong></td>
<td><strong>SC475: Applications of Optics and Photonics in Information Technology II</strong></td>
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<td><strong>SC465: Applications of Optics and Photonics in Information Technology I</strong></td>
<td><strong>SC475: Applications of Optics and Photonics in Information Technology II</strong></td>
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**OSA Technical Group Poster Session, Grand Ballroom 220C**
## Agenda of Sessions — Wednesday, 8 May

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<thead>
<tr>
<th>Time</th>
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<th>Session Details</th>
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<tbody>
<tr>
<td>07:30–18:30</td>
<td>Executive Ballroom 210A</td>
<td>Registration, Concourse Level</td>
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<td>08:00–10:00</td>
<td>Executive Ballroom 210B</td>
<td>Joint Plenary Session, Grand Ballroom 220A</td>
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<tr>
<td>10:00–17:00</td>
<td>Executive Ballroom 210C</td>
<td>Exhibit Open (10:00–17:00), Coffee Break (10:00–11:30), Exhibit Halls 1-3</td>
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<tr>
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<td>Executive Ballroom 210D</td>
<td>MIRTHE: New Commercial Trends in Mid-Infrared Sensing – From Nano-Photonics to Stand-Off Detection, Exhibit Hall Theater I</td>
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<td>Executive Ballroom 210E</td>
<td>Beyond Awareness: What Actions Can Be Taken to Improve Diversity in STEM, Exhibit Hall Theater II</td>
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<tr>
<td>10:30–12:00</td>
<td>Executive Ballroom 210F</td>
<td>Poster Session II &amp; Lunch, Exhibit Halls 1-3</td>
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<tr>
<td>11:30–13:00</td>
<td>Executive Ballroom 210G</td>
<td>Coffee Break &amp; Dessert (Exhibit Only Time), Exhibit Halls 1-3 Sponsored by COHERENT, THORLABS</td>
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<tr>
<td>13:00–15:00</td>
<td>Executive Ballroom 210H</td>
<td>Universal Quantum Devices, Product Showcase, Exhibit Hall Theater I</td>
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<td>15:00–17:00</td>
<td>Executive Ballroom 210B</td>
<td>Sandia National Laboratory, Product Showcase, Exhibit Hall Theater I</td>
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<td>15:30–16:00</td>
<td>Executive Ballroom 210D</td>
<td>Class 5, Product Showcase, Exhibit Hall Theater I</td>
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<td>16:30–17:00</td>
<td>Executive Ballroom 210C</td>
<td>Conference Reception, Grand Ballroom Sponsored by THORLABS</td>
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<tr>
<td>17:00–19:00</td>
<td>JW3A • Sym on Coupling Artificial Atoms to Nano- &amp; Opto-mechanical Systems I</td>
<td>JW4B • Chip-scale Nonlinear Optics, JW4C • Professional Development Session I, JW4D • Chirality, PT Symmetry, &amp; Exceptional Points, JW4E • Ultrafast Pulse Manipulation, SWAF • Terahertz Sources &amp; Communication, SW4G • Optical Frequency Synthesis &amp; Microwave Generation</td>
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<tr>
<td>19:00–20:30</td>
<td>Executive Ballroom 210A, 210B</td>
<td>Coffee Break &amp; Dessert (Exhibit Only Time), Exhibit Halls 1-3 Sponsored by COHERENT, THORLABS</td>
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CLEO • 5–10 May 2019
**CLEO • 5–10 May 2019**

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<td>MIRTHE: New Commercial Trends in Mid-Infrared Sensing – From Nano-Photonics to Stand-Off Detection, Exhibit Hall Theater I</td>
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<td>AW4I • Medical Devices &amp; Systems</td>
<td>SW4J • Design &amp; Simulation of Micro- &amp; Nano-photonic Devices</td>
<td>AW4K • Lidar</td>
<td>SW4L • Optical Detection of Vapors or Hazardous Environments</td>
<td>FW4M • Advanced Techniques &amp; Applications in Ultrafast Spectroscopy</td>
<td>SW4N • High Power &amp; Narrow Linewidth Lasers</td>
<td>SW4O • Short-Reach Communication Technologies</td>
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<td>08:00–10:00</td>
<td>FTh1A • Exploiting Quantum Degrees of Freedom</td>
<td>FTh1B • Ultrafast Nonlinear Phenomena</td>
<td>FTh1C • Hot-electron Enabled Plasmonics &amp; Optical Vortices</td>
<td>FTh1D • Entanglement Sources</td>
<td>STh1E • Mid-IR Lasers</td>
<td>STh1F • Chip-Scale Trace-Gas Sensing</td>
<td>STh1G • Frequency Comb Spectroscopy</td>
<td>STh1H • Optical Resonance-Based Devices</td>
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<td>10:00–11:30</td>
<td>Exhibit Open (10:00–15:00), Coffee Break (10:00–11:30), Exhibit Halls 1–3</td>
<td>Coffee Break Sponsored by COHERENT THORLABS</td>
<td>Technology Transfer Program, Exhibit Hall Theater I</td>
<td>Technology Transfer Program: Keynote, Exhibit Hall Theater I</td>
<td>Technology Transfer Program: Tutorial Talk, Exhibit Hall Theater I</td>
<td>Technology Transfer Program: Pitch Panel, Exhibit Hall Theater I</td>
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<td>11:30–13:00</td>
<td>Poster Session III, Exhibit Halls 1-3</td>
<td>Lunch, Exhibit Halls 1-3</td>
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<td>14:00–16:00</td>
<td>FTh3A • Gateways to Quantum Information Processing</td>
<td>FTh3B • Tailorable Phenomena in Optical Fibers</td>
<td>FTh3C • Emission &amp; Detection of Thermal Radiation</td>
<td>FTh3D • Quantum Photonics: Generation &amp; Manipulation</td>
<td>STh3E • Ultrafast Parametric Sources I</td>
<td>STh3F • Nonlinear THz Phenomena</td>
<td>STh3G • Precision Timing &amp; Optical Time Transfer</td>
<td>STh3H • Modulation &amp; Switching</td>
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<td>16:00–16:30</td>
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<td>16:30–18:30</td>
<td>FTh4A • New Protocols in Quantum Communications</td>
<td>FTh4B • Non-Diffractive &amp; Vortex Beams</td>
<td>FTh4C • Advanced Nanophotonic Platforms for Spectroscopy &amp; Sensing</td>
<td>FTh4D • Beyond Photon Pairs</td>
<td>STh4E • Ultrafast Parametric Sources II</td>
<td>STh4F • Interaction of Strong THz Fields with Condensed Matter Systems</td>
<td>STh4G • Optomechanics</td>
<td>STh4H • Optical Driven Photonics</td>
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**Registration, Concourse Level**

- ATh3I • A&T Topical Review on Silicon Photonics I
- STh3J • Emerging Nonlinear Platforms
- ATh3K • Trace Species Sensing
- STh3L • Multi-Mode Fiber Phenomena I
- FTh3M • Metasurfaces
- STh3N • Hybrid Integration with Si Photonics
- STh3O • 2D Materials

**Coffee Break, Concourse Level**

- ATh4I • A&T Topical Review on Silicon Photonics II
- STh4J • Applications of Lasers & Microcombs
- ATh4K • Sources & Techniques for Industrial Monitoring
- STh4L • Multi-Mode Fiber Phenomena II
- FTh4M • Hyperbolic Photonics Media
- STh4N • High-Speed Optical Interconnects
- STh4O • Epitaxial Materials & Strain Engineering


**Dinner Break (on your own)**

**Postdeadline Paper Sessions, Location Announced in Update Sheet**
### Agenda of Sessions — Friday, 10 May

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<td>08:00–10:30</td>
<td>FF1A • Single-Photon Detection</td>
<td>FF1B • Time Varying Metasurfaces</td>
<td>FF1C • Attosecond &amp; High Field Sources</td>
<td>FF1D • Solitons in Microresonators</td>
<td>SF1E • Ultrafast Applications</td>
<td>FF1F • Machine Learning &amp; Quantum Exotica</td>
<td>SF1G • Devices for Communications</td>
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<td>10:30–12:30</td>
<td>FF2A • Photonic Crystals &amp; Periodic Nano Optics</td>
<td>FF2B • Linear/Non-Linear Metasurfaces</td>
<td>FF2C • Attosecond Pulse Generation &amp; Characterization</td>
<td>FF2D • Frequency Comb &amp; Supercontinuum Generation</td>
<td>SF2E • Ultrafast Phenomena</td>
<td>JF2F • Symposium on Deep-learning Photons: Where Machine Learning &amp; Photonics Intersect II</td>
<td>SF2G • Laser-Based Diagnostics for Material Processing</td>
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<td>14:00–16:00</td>
<td>FF3A • Single-Photon Collection &amp; Characterization</td>
<td>FF3B • Disordered Media</td>
<td>FF3C • Attosecond Dynamic Imaging</td>
<td>FF3D • Nonlinear &amp; Quantum Effects</td>
<td>SF3E • Ultrafast Oscillators</td>
<td>JF3F • Symposium on Deep-learning Photons: Where Machine Learning &amp; Photonics Intersect III</td>
<td>SF3G • Laser-Based 2D/3D Micro- &amp; Nano-fabrication</td>
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<td>SF3N • Modulators, Phase Arrays &amp; Photodetectors</td>
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We demonstrate dissipation dilution engineering on an optomechanical system, Dynamical gauge fields for phonons in a FM1A.2 • 08:15 Albert Schliesser 1,2; Tobias J. Kippenberg1; Ecole Polytechnique Fédérale de Lausanne, Switzerland; 2IBM Research — Zürich, Switzerland. We demonstrate dissipation dilution engineering techniques for ultralow dissipation mechanical resonators. The SiN nanobeam shows quality factors (Q) as high as 800 million and Qτ exceeding 10^{16} Hz—both records at room temperature.

FM1A.1 • 08:00 Ultralow Dissipation Mechanical Resonators for Quantum Optomechanics, Nils Johan Engelsen 1, Sergey A. Fedorov1, Amir H. Ghadimi1, Mohammad J. Bereyhi1, Alberto Beccai1, Ryan Schilling1, Dalziel J. Wilson2, Tobias J. Kippenberg2; “Ecole Polytechnique Fédérale de Lausanne, Switzerland; 2IBM Research — Zürich, Switzerland. We demonstrate dissipation dilution engineering techniques for ultralow dissipation mechanical resonators. The SiN nanobeam shows quality factors (Q) as high as 800 million and Qτ exceeding 10^{16} Hz—both records at room temperature.

FM1B.1 • 08:00 Spin-Preserving Chiral Photonic Crystal Mirror, Behrooz Sernani1,2, Jeremy Flannery3, Zhenghao Ding1, Rubayet Al Maruf4, Michal Bajc5; 1ECT, Univ of Waterloo, Canada; 2first for Quantum Computing, Canada. We report on experimental realization of a chiral photonic-crystal structure which exhibits extreme intrinsic chira-optical activity. Formation of quasi-bound-states-in-continuum allows selective reflection of the circular polarization states of light and uncomventionally preserves the handedness.

FM1B.2 • 08:15 Dynamical gauge fields for phonons in an optomechanical system, Javier Del Pino1, John P. Mathew1, Ewold Verhagen1; AMOLF, Netherlands. We demonstrate a synthetic gauge field for phonon transport in a nano-optomechanical platform. Employing time-modulated radiation pressure forces, we demonstrate nonreciprocal nanomechanical phase transfer. We show how this enables new classes of phononic topological insulators.

FM1C.1 • 08:00 Brightness Theorems for Nanophotonics, Hanwen Zhang1, Cha Wei Hsu1, Owen Miller1; Yale Univ., USA. We present non-photonic “brightness theorems”, a set of power-concentration bounds that generalize their ray-optical counterparts, and motivate the concept of “wave étendue”. We show their ramifications in the design of metasurfaces and waveguide combiners.

FM1C.2 • 08:15 The Meaning and Use of Phase in Sub-wavelength Scattering, Zhean Shen1, Aristide Dogariu1; Univ of Central Florida, CREOL, USA. We show that the influence of evanescent wave is preserved in the phase of far field as an energetic time delay during scattering. We demonstrate the capability for sub-wavelength sensing by far-field phase measurements.

FM1D.2 • 08:30 Mode-Dependent Coupling and Vectorial Optical Vortices in Metallic Nanolaser Arrays, Midya Parto1, William Hayenga2, Demetrios N. Christodoulides3, Mingsen Pan4,5, Han Zhao1, Meng Xiao1, Shan-hui Fan1; 1Stanford Univ., USA. We find upper bounds to near-field optical response, for any material over any bandwidth. We apply this approach to CDOS, a photon-entanglement measure, and derive the first general bounds to near-field optical response, for any material over any bandwidth. We apply this approach to CDOS, a photon-entanglement measure, and derive the first general bounds to near-field optical response, for any material over any bandwidth.
High average power ultrafast lasers: large aperture quasi-phase matched nonlinear devices, Takunori Tana1,2, Hideki Ishizuki1,1Inst. for Molecular Science, Japan; 2Laser-Driven Electron-Acceleration Technology Group, Japan. Large aperture (LA) quasi-phase matched (QPM) nonlinear devices have been developed for functional wavelength conversion without catastrophic damages. The LA-QPM Mg-doped LiNbO3 and Quartz offer the artificial nonlinear short pulse lasers in high power region.

Optical Atomic Clocks: From International Timekeeping to Gravity Potential Measurement, Helen Margolis1, Heiner Denker2, Christian Voigt3,4, Ludger Timmer2, Jacopo Grott1, Silvio Koller1, Stefan Vogt1, Sebastian Haefner1, Uwe Sterr1, Christian Utschal1, Antoine Rolland1, Fred baynes1, Michel Zampaolo1, Pierre Thoumany1, Marco Pizocaro1, Benjamin Rauf6,7, Filippo Bregolin6,7, Anna Tampellini6,7, Piero Barbieri6,7, Massimo Zucco1, Giovanni Costanzo1, Cecilia Civati1, Filippo Levi1, Davide Calonico1, National Physical Lab, UK; 2Leibniz Universität Hannover, Germany; 3Physikalisch-Technische Bundesanstalt, Germany; 4GFZ German Research Centre for Geosciences, Germany; 5Laboratoire Souterrain de Modane, France; 6Istituto Nazionale di Ricerca Metrologica, Italy; 7Politecnico di Torino, Italy. We discuss the relation between atomic clocks and gravity from two perspectives: gravity potential measurements for optical clock comparisons and contributions to international timescales and, conversely, the measurement of gravity potential differences using optical clocks.

Mode-Multiplexed Transmission with Crosstalk Mitigation Using Amplified Spontaneous Emission (ASE), Yetian Huang1, Haozhao Chen1, Hanzi Huang1, Yingxiong Song1, Zhengxuan Li1, Nicolas K. Fontaine1, Roland Ryf2, Juan Carlos Alvarado Zacarias3,4,5, Nicola Bell Labs, USA; 2CREOL, The Univ. of Central Florida, USA; 3E. L. Grinton Lab, Stanford Univ., USA; 4Photoacoustic Lab, Chalmers Univ. of Technology, Sweden. We present latest advances in multimode fibers and components for mode-multiplexed transmission. In particular, we will review large mode count mode-multiplexer and characterization techniques for multimode components and provide a summary of the latest transmission results.
Molecularly-targeted cancer therapy based on antibody-photonsensitizer conjugates. By breaking cancer cells combined with immuno-activation, NIR-PIT activates anti-cancer immunity resulting in curing local and distant metastatic cancers without recurrence.

SM1J.2 • 08:30 On-chip Wavefront Shaping with High Contrast Dielectric Metamaterials, Zi Wang, Tianjian Li, Anishkumar Soman, Tingyi Gu; Dept. of Electrical and Computer Engineering, Univ. of Delaware, USA. Compact and lossless on-chip high-contrast transmit-array is experimentally demonstrated on a standard SOI substrate. The integrated metamaterials has a focal spot size of 0.38λ, transmission of 94%, and focusing efficiency of 71%.

AM1K.2 • 08:30 Methane Leak Detection Using Chirped Laser Dispersion Spectroscopy, Yifeng Chen, Michael Sokolud, James McSpire, Rui Wang, Nathanael Liu, Mark A. Zondlo, Gerard Wysoki; Electrical Engineering, Princeton Univ., USA; Civil and Environmental Engineering, Princeton Univ., USA. We present a real-time chirped laser dispersion spectrometer capable of distinguishing path-averaged methane leaks 0 to 8 ppm above the ~2ppm background methane level using low reflectivity (down to 0.01%) surfaces 50 m away.
We report the interfacing of an integrated solid-state single-photon source and integrat-
tics, high rate three-photon coalescence, Carlos Antonio Solanas1,2, Guillaume Coppola1, Juan Carlos
Adelmer
arm Harouri1,2, Niccolò Somaschi1, Andrea Crespi1,3, Isabelle
Sagres1,2, Aristide Lemaire1,2, Loïc Lanco1,2, Roberto Osellame4,5, Fabio Sciarrino2, Pascale Serellati1,2, CNRS Center
of Nanosciences and Nanotechnology, France; 2Universite Paris-Sud, Universite Paris-Saclay, France; 3Dipartimento
di Fisica, Sapienza Universita di Roma, Italy; 4Institute of Quantum Electronics, ETH Zurich, Switzerland;
5Consiglio Nazionale delle Ricerche Istituto di Fotonica e Nanotecnologie, Italy; 6Dipartimento di Fisica, Politecnico di
Milano, Italy; 7Universita Paris Diderot, France. We report the interfacing of an integrated solid-state single-
photons with an on-chip beamsplitter confirms the single-
photon nature of the emission.

Quantum-dot single-photon source on a CMOS-processed silicon waveguide, Ryota Katsumi,
Yasutomo Ota2, Alto
Shemer1, Gil Bashan1, Hilel H. Diamandi1, Yosef London1, Christopher Richardson1, Richard Leavitt1, Marko Loncar2, Edo
Waks1, Univ. of Maryland, USA; 2Harvard Univ., USA; 3Ulsan National Inst. of Science and Technology, South Korea (the Republic of). We demonstrate integration of telecom quantum dots with lithium niobate photonics using a pick-and-place technique. Second order photon correlation measurement performed with an on-chip beamsplitter confirms the single-photon nature of the emission.

Integration of Quantum Emitters with Lithium Niobate Pho-
tonics, Shahriar Aghaeimeibodi1, Boris Desiatov2, Je-Hyung
Kim1, Chang-Min Lee1, Mustafa Buyukkaya1, Aziz Karasahin1, Christopher Richardson1, Richard Leavitt1, Marko Loncar2, Edo
Waks1, 1Univ. of Maryland, USA; 2Harvard Univ., USA; 3Ulsan National Inst. of Science and Technology, South Korea (the Republic of). We demonstrate integration of telecom quantum dots with lithium niobate photonics using a pick-and-place technique. Second order photon correlation measurement performed with an on-chip beamsplitter confirms the single-photon nature of the emission.

We demonstrate integration of telecom quantum dots with lithium niobate photonics using a pick-and-place technique. Second order photon correlation measurement performed with an on-chip beamsplitter confirms the single-photon nature of the emission.

We experimentally demonstrate active three-dimensional (3D) imaging at a range of up to 21.6 km in daylight by constructing a high-efficiency single-photon LiDAR system and developing a long-range-tailored computational algorithm.

Using a Broadband Swept-ECQCL, Standoff 250m Open-path Detection of Chemical Plumes
SM1N.3 • 08:30
Javier García de Abajo is an ICREA Research Professor at ICFO (Barcelona), where he leads the Nanophotonics Theory group. He is Fellow of APS and OSA and has co-authored 370+ articles with 25,000+ citations (WoK h index 78) in the different aspects of surface science, nanophotonics, and electron microscope spectroscopies.
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<tr>
<td>FM1A.4</td>
<td>Nonlinear Imaging of Topological Edge States in Dielectric Metasurfaces</td>
<td>Executive Ballroom 210C</td>
<td>08:45</td>
<td>Daria Smirnova, Sergey S. Kuk, Daniel Leykam, Elizaveta V. Melik-Gaykazyan, Duk-yong Choi, Yuri S. Kivshar</td>
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Theodor W. Hänsch 1, Reinhart Poprawe 2; Alan Fry 1, Franz Tavella 1; Sartorius 2, Akira Ozawa 1, Thomas Udem 1, at 1.75 µm with a round, the OPCPA produced 106 W, centered wavelengths spanning 1.5 – 2.0 µm. At maxi-scaling of OPCPA in KTA at signal center...

We explore average power...
AM1L.4 • 09:09

Label-Free Quantitative Classification of Cancer Cells Measured by Interferometric Phase Microscopy, Natan T. Shaked1, Tel-Aviv Univ., Israel. I will present our latest advances in label-free quantitative imaging flow cytometry for cancer cell classification using external and portable interferometric microscopes, where the metastatic potential of the cells is detected.

AM1L.4 • 09:15

Cell deformation and assessment with tunable “tug-of-war” optical tweezers, Yi Liang1,2, Yinxiao Xiang1,2, Josh Lasrnstein1, Anna Bezrada1a,1, Zhigang Chen1,3,4, Xiaoyi Zhao1,2, Yinxiao Xiang1,3,4, Josh Lasrnstein1, Anna Bezrada1a,1, Zhigang Chen1,3,4. 1Tel-Aviv University, Israel; 2Guangxi Key Lab for Nanomaterials and Related Technology, Guangxi University, China; 3MOE Key Lab of Weak-Light Physical Science and Technology, Guangxi Materials and Related Technology, School of Physics and Engineering, Zhejiang University, China; 4EPD, Singapore University of Technology and Design, Singapore.

AM1L.5 • 09:15

Using an Integrated Silicon Emitter to Generate Two Coaxial Orbital-Angular-Momentum Beams with Tunable Mode Orders and Broad Bandwidth, Hao Song1,2, Zhe Zhao1, Runzhou Zhang1,3, Jing Du1, Haoqian Song1,3, Long Li1, Kai Pang1, Cong Liu2, Ahmed Almaiman1,2, Robert Bock1,2, Moshe Tur3,4, Alan E. Willner1,2. 1Tel-Aviv University, Israel; 2MOE Key Lab of Weak-Light Nonlinear Photonics, TEDA Applied Physics Inst. and School of Physics, Nankai University, China; 3Dept. of Physics and Astronomy, Dept. of Physics and Astronomy, University of Southern California, USA; 4EPD, Singapore University of Technology and Design, Singapore.

AM1L.5 • 09:15

Simultaneous Two- and Three-photon Imaging of Multilayer Neural Activities with Remote Focusing, Aaron Mok1, Tianyu Sim1,2, Tianyu Sim1,2, Aaron Mok1, Tianyu Sim1,2, Tianyu Sim1,2. 1EPD, Singapore University of Technology and Design, Singapore; 2Inst. of Materials Research and Engineering, A*STAR (Agency for Science, Technology and Research), Singapore.

AM1J.3 • 08:45

Achromatic Subwavelength Grating Lens at Visible Bandwidths, Hao Ye1, Ray Vahala2, Ya Sha Yi1, Univ. of Michigan, USA. The polarization insensitive achromatic micro lens covering the whole visible wavelength is demonstrated that can cover 250 nm of visible bandwidths (from 435 nm to 685 nm) with focal shift less than 5%.

AM1J.4 • 09:00

Optical spatial differentiator based on subwavelength high-contrast gratings, Weijiang Zhang1, Zheewo Dong1, Jingnan Xu1,2, Xuan Ly2, Xiaorui Deng1, Shanghui Jia1,2, Guangxi Key Lab. of Novel Energy and Engineering, Kunming University of Science and Technology, China; 2Guangxi Key Lab. of Novel Energy and Engineering, Kunming University of Science and Technology, China; 3Department of Physics and Astronomy, University of Southern California, USA.

AM1J.5 • 09:15

Using an Integrated Silicon Emitter to Generate Two Coaxial Orbital-Angular-Momentum Beams with Tunable Mode Orders and Broad Bandwidth, Hao Song1,2, Zhe Zhao1, Runzhou Zhang1,3, Jing Du1, Haoqian Song1,3, Long Li1, Kai Pang1, Cong Liu2, Ahmed Almaiman1,2, Robert Bock1,2, Moshe Tur3,4, Alan E. Willner1,2. 1Tel-Aviv University, Israel; 2MOE Key Lab of Weak-Light Nonlinear Photonics, TEDA Applied Physics Inst. and School of Physics, Nankai University, China; 3Dept. of Physics and Astronomy, Dept. of Physics and Astronomy, University of Southern California, USA; 4EPD, Singapore University of Technology and Design, Singapore.

AM1K.3 • 08:45

Mid-IR Laser Spectrometer for Balloon-borne Lower Stratospheric Water Vapor Measurements, Manuel Graf1,2, Philipp Scheidegger1,2, Herbert Looser1, Badruden Stanic1, Thomas Peter3, Lukas Emmenegger1, Béla Tuzson1, Empa, Switzerland; 2IAC, ETH, Switzerland. A lightweight instrument has been developed to measure water vapor up to the lower stratosphere aboard meteorological balloons. The sensor relies on a segmented circular multipass cell which is especially suited for mobile field applications.

AM1K.4 • 09:00

Imaging Technique for In Situ Cloud Characterization, Andrei B. Vakhtin1,2, Lev N. Manukin3,2, Rossreira Bogachev1,2, Manuel Graf1,2, Herbert Looser1, Badruden Stanic1, Thomas Peter3, Lukas Emmenegger1, Béla Tuzson1, Empa, Switzerland; 2IAC, ETH, Switzerland. We present a novel remote focusing interferometric optical system that allows simultaneous imaging of 3D cloud properties and aerosols without moving mechanical components.

AM1K.5 • 09:15

Development of a Compact CO2 Instrument for Small Aerial Platforms, Anthony Gomez1, Joel A. Silver1. 1Southwest Sciences Inc., USA. A new compact CO2 measuring instrument for small aerial platforms is presented. It is based on a fiber laser and optical scheme that provides simultaneous measurement of CO2 and water vapor concentration.

AM1K.6 • 09:15

Rapid and Continuously Tunable Narrow Linewidth Fiber Source Based on a SOA and a Linearly Chirped Bragg Grating, Xiao Yang1,2, Robert Lindberg1, Walter Margulis1,2, Krister Fridjh1, Fredrik Laurell1, John R. Huth1, Chao Li2, Xiao Yang1,2, Robert Lindberg1, Walter Margulis1,2, Krister Fridjh1, Fredrik Laurell1, John R. Huth1, Chao Li2. 1University of Michigan, USA; 2R-DEX System, Inc., USA; 3Tel Aviv University, Israel.

AM1K.6 • 09:15

Longitudinal Modes in Random Feedback Fiber Lasers, Pedro Torabet1, Luis J. Herrera1, Guilherme P. Temporão1, Jean Pierre von der Weid1,2,1. 1PUC-Rio, Brazil. An SOA-based random fiber laser is experimentally demonstrated to exhibit multimode operation dominated for high SOA currents. Single mode prevails only near the threshold current. Mode lifetime of ~1 ms and 6 kHz linewidth were measured.

AM1M • 10:00

Label-Free Quantitative Classification of Cancer Cells Measured by Interferometric Phase Microscopy, Natan T. Shaked1, Tel-Aviv Univ., Israel. I will present our latest advances in label-free quantitative imaging flow cytometry for cancer cell classification using external and portable interferometric microscopes, where the metastatic potential of the cells is detected.
CLEO: QELS-Fundamental Science

FM1M • Single-Photon Sources—Continued

Coherent Coupling of Single Molecules to a Chip-Based Optical Circuit, Dominik Rastenbacher1, Alexey Shkarin1, Jan Renger1, Tobias Utkil1, Stephan Götzinger1,2, Yehid Sandoghdar1,2, Max Planck Inst. for the Science of Light, Germany; Friedrich-Alexander Univ. Erlangen-Nürnberg, Germany. We present the coherent coupling of single dye molecules to subwavelength waveguides (nanoguides) and microresonators made of TiO$_2$ on a chip. Integrated electrodes allow us to tune several molecules into resonance via the Stark effect.

FM1M.5 • 09:00

Controlled Assembly of an Ultrafast Single-Photon Source, Oksana Makarova1, Simeon Bogdanov1, Xiaohui Xu2, Deesha Shah1, Alexander Baburin1, Ilya Rykhlikov1, Soham Saha1, Ilya Ryzhikov2, Alexander Kildishev1, Alexandr Boltasseva1, Vladimir M. Shalaev1, Purdue Univ., USA; FMNS REC, Bauman Moscow State Technical Univ., Russia. We demonstrate a technique for highly controllable assembly of single-photon sources coupled to plasmonic nanoantennas with optimal emitter positioning on the nanoscale, resulting in fluorescence decay rates beyond 10 GHz in single nitrogen-vacancy centers.

FM1M.6 • 09:15

Spin Coherence in Single NV Centers Coupled to Controlably Assembled Nanopatch Antennas, Simeon Bogdanov1, Oksana Makarova1, Alexey Kildishev1, Deesha Shah1, Chun-Cheng Chang1, Alexander Baburin1, Ilya Rykhlikov1, Soham Saha1, Ilya Ryzhikov2, Alexander Boltasseva1, Vladimir M. Shalaev1, Purdue Univ., USA; FMNS REC, Bauman Moscow State Technical Univ., Russia; Dushkov Research Inst. of Automatics, Russia. We transfer a pre-characterized nanodiamond with a single electron spin into a nanoscale nanophotonic circuit onto an epitaxial silver substrate and deterministically couple it to a nanopatch antenna. The NV retains its coherent spin dynamics in this process.

FM1M.7 • 09:30

Tailoring Nanophotonic Frequency Converters for Quantum Dots Single-Photon Sources, Anshuman Singh1,2, Qing Li1,2, Shunfa Liu1, Ying Yu1,2, Christian Schneider1, Sven Hoffing1, John Lawall1, Varun B. Verma2, Robert P. Min1, Sae Woo Nam1, Jin Lu1, Kartik Sinivasan1, Physical Measurement Lab, National Inst. of Standards and Technology, USA; Maryland NanoCenter, Univ. of Maryland, College Park, USA; Electrical and Computer Engineering, Carnegie Mellon Univ., USA; School of Electronics and Information Technology, Sun-Yat Sen Univ., China; Technische Physik, Univ. of Würzburg, Germany; School of Physics and Astronomy, Univ. of St. Andrews, UK. We demonstrate the suitability of silicon nanophotonic frequency converters for use with quantum dot single-photon sources. Preservation of photon statistics, operation across a 840-980 nm input wavelength band, and tunable wavelength shifts are shown.

SM1N • Open-path Sensing & Free-electron Lasers—Continued

Experimental Demonstration of Enhanced Accuracy of Beam Radial Displacement and Azimuthal Rotation Measurements using Enhanced Gradient of a Beam Composed of Multiple Orbital-Angular-Momentum modes, Jing Du1, Zhe Zhao1, Guodong Xie2, Runzhou Zhang4, Long Li2, Haoqian Song1, Kai Pang1, Cong Liu1, Hao Song1, Masai Tur1, Sholomo Zach1, Nadav Cohen1, Alan E. Willner1, USC, USA; Tel Aviv Univ., Israel. We experimentally demonstrate beam radial displacement and azimuthal rotation angle measurements using the intensity gradient of multiple OAM modes. Compared with a Gaussian beam or a beam carrying two opposite OAM modes, using multiple OAM modes can improve the measurement accuracy.

SM1N.6 • 09:15

A Compact, Low Loss Integrated Continuous-Time Electro Optic PPL with Maximum Range of 3.3 m, Shoh Ahasan1, Ali Binae1,2, Christopher T. Phare1, Michael Lipson1, Harish Krishnaswamy1, Columbia Univ., USA. We present a Continuous Time ElectroOptic PPL which not only breaks the fundamental trade-off between chirp bandwidth and Mach-Zender interferometer (MZI) delay but also completely eliminates spurs from the PPL. Laser output using single-sideband SSB and harmonic rejection (HR) mixing.

SM1O • Van der Waals Heterostructures—Continued

Near ultraviolet light emission in hexagonal boron nitride based van der Waals heterostructures, Sanghoon Chae1, Donggea Seo1, Gungiu Cad1, Xiaong Huang2, Er-Min Shih3, Takashi Tanguchi1, Kenji Watanabe1, Junyoung Kwow1, Gwan-Hyoung Lee4, Cory R. Dean1, David Schimminovich1, Irving P. Herman1, Heon-jin Choi1, Iaonnis Kymissis1, Young Duck Kim1, James Hong1, Columbia Univ., USA; Dept. of Materials Science and Engineering, Yonsei Univ., South Korea (the Republic of), National Inst. for Materials Science, Japan; Dept. of Physics, Kyung Hee Univ., South Korea (the Republic of). We demonstrate light emitting devices consisting of graphene layers separated and with thin hexagonal boron nitride (hBN) with additional hBN encapsulation. At high bias through two graphene layer, thin hBN produce near ultraviolet (NUV) light emission at 394 nm.

SM1O.3 • 09:15

A low-power optoelectronic memory device based on MoS$_2$/BN/graphene heterostructure, Hongzh signatures, Shuhaos Qin1, Annan Wang1,2, Frank Pandolfo1, Wang1, Nanjing Univ., China. A low-power optoelectronic memory device is demonstrated by charge trapping in a MoS$_2$/BN/graphene heterostructure. The miniaturized structure, large current switching ratio (~6×10$^5$) and fast read/write speed (50 ms) suggest its potential in integrated non-volatile storage cell.
FM1A • Quantum Optomechanics & Transduction—Continued

FM1A.7 • 09:45
Toward Microwave-to-Optical Conversion using Erbium Doped Crystals and Integrated Resonators, Jake Rochman¹, John Bartholomew¹, Ioana Craiciu¹, Chuting Wang¹, Tian Xie¹, Jonathan Kindem¹, Keith Schwab¹, Andrei Farson¹; 'Caltech, USA. We present progress towards a bidirectional coherent microwave-to-optical photon converter using an ensemble of rare-earth ions coupled to integrated photonic and microwave resonators.

FM1B • Topological Photonics I—Continued

FM1B.6 • 09:45
Coupled Degenerate Parametric Oscillators Towards Photonic Coherent Ising Machine, Yoshitomo Okawachi¹, Mengjie Yu², Xingchen Ji³, Jae K. Jang¹, Michal Lipson¹, Alexander Gaeta¹; 'Columbia Univ., USA; 'Cornell Univ., USA. We demonstrate on-chip coupling between degenerate parametric oscillators (OPOs) in two different silicon nitride microresonators. The system offers potential towards creating a network of OPOs for the realization of a photonic coherent Ising machine.

FM1C • Novel Phenomena in Classical Nano-Optics—Continued

FM1C.7 • 09:45
Absence of frequency ranges of unidirectional propagation in nonreciprocal plasmonics, Siddharth Buddhiraju¹, Yu Shi¹, Alex Song¹, Casey Wojcik¹, Momchil Minkov¹, Ian Williamson¹, Avik Dutta¹, Shanhui Fan¹; 'Stanford Univ., USA. Surface plasmon-polaritons at a metal-dielectric interface are believed to support a unidirectional frequency range under a magnetic field, where a violation of the time-bandwidth constraint is possible. We show that such unidirectionality is nonphysical.

FM1D • Coherent Phenomena in Coupled Resonator Networks—Continued

FM1D.6 • 09:45
Coupled Degenerate Parametric Oscillators Towards Photonic Coherent Ising Machine, Yoshitomo Okawachi¹, Mengjie Yu², Xingchen Ji³, Jae K. Jang¹, Michal Lipson¹, Alexander Gaeta¹; 'Columbia Univ., USA; 'Cornell Univ., USA. We demonstrate on-chip coupling between degenerate parametric oscillators (OPOs) in two different silicon nitride microresonators. The system offers potential towards creating a network of OPOs for the realization of a photonic coherent Ising machine.

08:30–12:30  SC270: High Power Fiber Lasers and Amplifiers (W. Andrew Clarkson, Optoelectronics Research Center, University of Southampton, UK)

SC352: Introduction to Ultrafast Pulse Shaping - Principles and Applications (Marcos Dantus, Michigan State University, USA)

SC361: Coherent Mid-IR Light: Generation and Applications (Konstantin Vodopyanov, The College of Optics & Photonics, University of Central Florida, USA)

SC477: Laser Radar and Remote Sensing: An Application-oriented Introduction (Fabio Di Teodoro, Raytheon, USA)

SC481: Fundamentals and Applications of VCSELs (Kent Choquette, University of Illinois, USA)

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

11:00–12:00  OSA Presentation Feedback Program, University Room, Hilton San Jose

11:00–12:00  Navigate Your Leadership Trajectory for Senior Leaders, Salon VI, San Jose Marriott
JM1E.5 • 09:45
Compact, high-efficiency, ultrafast 2-cycles sources at 1030 nm, Florent Guichard*, Loic Lavenu†, Michele Natile‡, Xavier Delen**, Yo-ann Zaouter†, Marc Hanna*, Patrick Georges*, *Amplitude Laser Group, France; †Laboratoire Charles Fabry, France. We present a dual-stage nonlinear compression scheme generating 6.8 fs pulses, with a transmission of 61%. The system’s compactness, stability, and average power makes it ideally suited to drive high photon flux XUV sources through HHG.

SM1F.6 • 09:45
Absolute frequency measurement of molecular iodine hyperfine transition at 534 nm with a femtosecond optical comb, Feihu Cheng*, Ke Deng*, Kui Liu*, Hongli Liu*, Jie Zhang*, Zehuang Lu‡; †School of Physics, Huazhong Univ. of Science and Technology, China. We report absolute frequency measurements of the a21 component of the rovibrational transition of molecular iodine R(53)31-0 transitions at 534 nm by modulation transfer spectroscopy with an optical frequency comb.

SM1F • Optical Clocks—Continued
SM1G • Ultra-High Capacity Transmission Techniques & SDM—Continued
SM1H • Plasmonics for Manipulation & Sensing—Continued

JM1E • Symposium on High Average Power Ultrafast Lasers: Trends, Challenges & Applications I—Continued

SM1G.5 • 09:45
JM1E.5 • 09:45
Compact, high-efficiency, ultrafast 2-cycles sources at 1030 nm, Florent Guichard*, Loic Lavenu†, Michele Natile‡, Xavier Delen**, Yo-ann Zaouter†, Marc Hanna*, Patrick Georges*, *Amplitude Laser Group, France; †Laboratoire Charles Fabry, France. We present a dual-stage nonlinear compression scheme generating 6.8 fs pulses, with a transmission of 61%. The system’s compactness, stability, and average power makes it ideally suited to drive high photon flux XUV sources through HHG.

SM1F.6 • 09:45
Absolute frequency measurement of molecular iodine hyperfine transition at 534 nm with a femtosecond optical comb, Feihu Cheng*, Ke Deng*, Kui Liu*, Hongli Liu*, Jie Zhang*, Zehuang Lu‡; †School of Physics, Huazhong Univ. of Science and Technology, China. We report absolute frequency measurements of the a21 component of the rovibrational transition of molecular iodine R(53)31-0 transitions at 534 nm by modulation transfer spectroscopy with an optical frequency comb.

SM1F.6 • 09:45
High Color Conversion Efficiency for Monolayer WSe2 Using Plasmonic Metasurface, Cheng-Yuan Chen†, Chen-An Lin†, Hsiang-Ting Lin†, Chiao-Yun Chang‡, Hao-Chung Kuo*, Min-Hsiung Shih‡; †National Chiao Tung Univ., Taiwan; ‡Academia Sinica, Taiwan. Color conversion is a potential answer to enhancing the spontaneous emission of transition metal dichalcogenide (TMDC) atomic layer. Therefore, our experiment utilized silver nanodisk to manipulate the color conversion effect between WSe2 and quantum dots.

08:30–12:30 SC270: High Power Fiber Lasers and Amplifiers (W. Andrew Clarkson, Optoelectronics Research Center, University of Southampton, UK)
SC352: Introduction to Ultrafast Pulse Shaping - Principles and Applications (Marcos Dantus, Michigan State University, USA)
SC361: Coherent Mid-IR Light: Generation and Applications (Konstantin Vodopyanov, The College of Optics & Photonics, University of Central Florida, USA)
SC477: Laser Radar and Remote Sensing: An Application-oriented Introduction (Fabio Di Teodoro, Raytheon, USA)
SC481: Fundamentals and Applications of VCSELs (Kent Choquette, University of Illinois, USA)

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

11:00–12:00 OSA Presentation Feedback Program, University Room, Hilton San Jose
11:00–12:00 Navigate Your Leadership Trajectory for Senior Leaders, Salon VI, San Jose Marriott
AM1I.6 • 09:45
Laser versus radiofrequency catheter ablation of myocardium, Karina S. Lithvinova1, Maria Chernyshova1, Igor Kudelin1, Sergei Khalimanenko1, Francisco Leyva2,3; 1Aston Medical Research Inst., Aston Univ., UK; 2Leibniz Inst. of Photonic Technology, Germany; 3Queen Elisabeth Hospital, UK. Cardiac ablation is a procedure for heart rhythm problems correction. Laser can create controlled irreversible myocardial lesions without craters formation. We confirmed laser produced similar lesions as RF, without undesirable effects on the ventricular walls.

SM1J.7 • 09:45
One-chip Integrated Near-field Thermophotovoltaic Devices Using Intermediate Transparent Substrates, Takuya Inoue1, Takaaki Koyama2, Dongyeon D. Kang1, Takashi Asano1, Susumu Noda1,2; 1Photonics and Electronics Science and Engineering Center, Kyoto Univ., Japan; 2Dept. of Electronic Science and Engineering, Kyoto Univ., Japan. We develop one-chip near-field thermophotovoltaic devices, where thin-film thermal emitters (>1000K) and solar cells are integrated to the top and bottom of intermediate substrates with a sub-wavelength gap (<150nm), realizing 10-fold enhancement in the photocurrent.

AM1K.6 • 09:45
Multi-Species Environmental Gas Sensing Using Drone-Based Fourier-Transform Infrared Spectroscopy, Marius Rutkauskas1, Martin Asenov2, Subramanian Ramamoorthy2,3, Derryck Reid1; 1Heriot-Watt Univ., UK; 2Informatics Forum, Univ. of Edinburgh, UK. We report a broadband FTIR spectrometer integrated with an autonomous UAV enabling quantitative aerial surveys of multiple gas species simultaneously with a demonstrated sensitivity of 37 ppm and an estimated noise-limited performance of 18 ppm.

08:30–12:30  SC270: High Power Fiber Lasers and Amplifiers (W. Andrew Clarkson, Optoelectronics Research Center, University of Southampton, UK)
SC352: Introduction to Ultrafast Pulse Shaping - Principles and Applications (Marcos Dantus, Michigan State University, USA)
SC361: Coherent Mid-IR Light: Generation and Applications (Konstantin Vodopyanov, The College of Optics & Photonics, University of Central Florida, USA)
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10:00–10:30  Coffee Break, Concourse Level

11:00–12:00  OSA Presentation Feedback Program, University Room, Hilton San Jose

11:00–12:00  Navigate Your Leadership Trajectory for Senior Leaders, Salon VI, San Jose Marriott

1. Electrical and Computer Engineering, Univ. of California, Los Angeles, USA; 2. California NanoSystems Inst., Univ. of California, Los Angeles, USA; 3. Material and Science Engineering, Univ. of California, Los Angeles, USA; 4. Chemistry and Biochemistry, Univ. of California, Los Angeles, USA. We conducted confocal micro-photoluminescence spectroscopy to scan a WS2-WSe2 lateral heterostructure sample using oil emerged microscopy method. We observed enhanced PL lines at the edges of WSe2 and spatially enhanced PL at tip of the v-shaped areas.

09:45 • SM1O.5 Deeply-submicron confocal photoluminescence spectroscopy and edge recombination in WS2-WSe2 lateral heterostructure monolayer crystals.
**Joint CLEO: QELS-Fundamental Science**

**Executive Ballroom 210A**

10:30–12:30

**FM2A • Quantum Optics of Atoms and Molecules**

*President: Rudolph Kohn; Space Dynamics Laboratory, USA*

**FM2A.1 • 10:30**

Entanglement Between a Photonic Time-Bin Qubit and a Collective Atomic Spin Excitation, *Pau Ferrera*, *Georg Heinze*, *Hugues de Riedmatten* & *I-CFO - The Institute of Photonic Sciences, Spain; 2ICREA-Institució Catalana de Recerca i Estudis Avançats, Spain*. Light-matter entanglement combines the long-distance transmission advantage of photonic qubits with the storage and processing capabilities of atomic qubits. In this work we used a laser-cooled atomic cloud to generate entanglement between photonic time-bin qubits and atomic spin excitations.

**FM2A.2 • 10:45**

Configurable Beam Splitting of Single Photon in Cold Atoms, *Yeleng Mei*, *Xianxin Guo*, *Shengwang Du*; *1the Hong Kong Univ of Sci & Tech, Hong Kong*. We demonstrate a dynamically configurable beam splitter (BS) for single photon wavepacket via electromagnetically-induced-transparency storage in cold atoms. This quantum-memory based controllable BS may have applications in a quantum information processing network.

**FM2A.3 • 11:00**

Spectral Compression of Narrowband Single Photons with a Near Resonant Cavity, *Mathias Seidler*, *X. Jie Yeo*, *Andrea Cere*; *1Christian Kuntsiefer; 21National Univ. of Singapore, Singapore; 2Centre for Quantum Technologies, NUS, Singapore*. We compress the spectrum of narrowband heralded single photons generated by four-wave mixing in cold $^{87}$Rb atoms using a near-resonant cavity as dispersion medium, without reducing the brightness and almost matching the atomic linewidth.

**Executive Ballroom 210B**

10:30–12:30

**JM2B • Symposium on Nonreciprocal Photonics I**

**JM2B.1 • 10:30**

Nonreciprocal and topological photonics, *Andrea Ali*; *1CUNY Advanced Science Center; 21CUNY Graduate Center, USA*. In this talk, we will overview our recent progress in inducing strong nonreciprocal responses in nonphoton devices and metasurfaces, and the role of their symmetry breaking features in the realization of topological photonic metamaterials.

**JM2B.2 • 11:00**

Direct Observation of Topological Edge States in Silicon Photonic Crystals, *Nikhil Parappurath*; *Filippo Alpeggiani*, *L. Kapers*, *Ewold Verhagen*; *1Center for Nanophotonics, AMOLF, Netherlands; 2Dept. of Quantum Nanoscience, Kavli Inst. of Nanoscience, Delft Univ. of Technology, Netherlands*. We directly observe the states of topological photonic crystals at telecom wavelengths. Using the states’ intrinsic radiation, we measure dispersion, loss, pseudospin, and spin-spin scattering. We image spin-selective unidirectional propagation around sharp corners and junctions.

**Executive Ballroom 210C**

10:30–12:15

**FM2C • Nonlinear Nano-Optics**

**FM2C.1 • 10:30**

Nonlinear Nanoimaging of Ultrafast Coherent Dynamics of Graphene, *Tao Jiang*; *1Gary Deng*, *2Vasily Kruktsou*, *3Michael Tokman*, *4Andrey Alu*; *1Dept. of Physics, 2Dept. of Chemistry, and JILA, Univ. of Colorado, USA; 3Inst. of Applied Physics, Russian Academy of Sciences, Russia; 4Dept. of Physics and Astronomy, Texas A&M Univ., USA*. Using femtosecond adiabatic plasmonic nanofocusing, we image graphene in broadband four-wave mixing, revealing spatial heterogeneity, 6 fs coherent dynamics, and a long range spatial nonlocality.

**FM2C.2 • 11:00**

Efficient four wave mixing and low-loss in-coupling in hybrid gap plasmonic waveguides, *Nicholas A. Gusken*; *Michael Nielsen*, *Ngoc Nguyen*, *Xingyuan Shi*, *Paul Dichl*, *Stefan Maeir*, *Rupert Oulton*; *1Physics, Imperial College London, UK*. We show efficient four-wave-mixing over µm length-scales with a signal-to-idler conversion efficiency of 1% enabled by strong non-linearities and highly confined fields. Furthermore, we demonstrate low-loss in-coupling into nanometer gaps with an efficiency of 80%.

**FM2C.3 • 11:45**

Tailoring Second Harmonic Diffraction in GaAs Metasurfaces via Crystal Orientation, *Polina Vabishchevich*; *Aleksandr Vaskin*, *Sadhvikas Addamane*, *Sheng Liu*, *Andrei P. Sharon*, *Ganesh Balakrishnan*, *John Reno*; *1Physics, Imperial College London, UK; 2Dept. of Physics and Astronomy, Texas A&M Univ., USA*. We use GaAs metasurfaces with (111) crystal orientation to channel the second harmonic generation (SHG) into the zero-diffraction order that is suppressed for SHG obtained from GaAs metasurfaces with (100) orientation.

**Executive Ballroom 210D**

10:30–12:30

**FM2D • Ultrafast Optical Processes in Topological Materials**

**FM2D.1 • 10:30**

Topological Materials, *Allan H. MacDonald*; *1Univ. of Texas at Austin, USA*. Topological materials, including Chern (quantum Hall) insulators and quantum spin Hall and quantum valley Hall insulators in two dimensions and topological semimetals in three dimensions have a number of distinct optical properties. My tutorial will discuss how these can be used to identify new topological materials, and how they might be valuable for applications.

**Executive Ballroom 210E**

**FM2D.2 • 11:00**

Topological Materials: Promise and Challenges, *Allan H. MacDonald*; *1Univ. of Texas at Austin, USA*. Topological materials, including Chern (quantum Hall) insulators and quantum spin Hall and quantum valley Hall insulators in two dimensions and topological semimetals in three dimensions have a number of distinct optical properties. My tutorial will discuss how these can be used to identify new topological materials, and how they might be valuable for applications.
We describe the current performance achieved at the CLF for increasing average power Ultrafast Lasers at the CLF and Their Potential Applications. We present the basic concepts and technology of diamond nanoprobes and provide illustrations of nanoscale imaging of magnetism and currents.

An outdoor evaluation of 1-Gbps optical wireless communication using AlGaN-based LED in 280-nm band, Yuki Yoshida, Kazunobu Kojima, Masaki Shiraishi, Yoshinari Awaji, Atsushi Kanno, Naokatsu Yamamoto, Shigefusa Chichibu, Akira Hirano, Masamichi Ipommatani, National Inst of Information & Comm Tech, Japan; Inst. for Multidisciplinary Research for Advanced Materials, Tohoku Univ., Japan; UV Craftory Co. Ltd., Japan. The performance of solar-blind optical wireless communication using AlGaN-based LED at 280 nm-band was evaluated experimentally over a 1.5-m outdoor Line-of-Sight channel. Even under the summer sun, 1.18-Gbps error-free transmission was achieved.

An absolute distance measurement scheme incorporating SNSPD receiver unit under turbulence-induced fading conditions, Hiroto Ivanov, Erich Leitgeb, Gert Freiberger; Graz Univ. of Technology, Austria. Performance of a deep space FSO-link incorporating SNSPD parametrized with deadtime, QE and N-array measurement with a very simple fiber-optic environment with a much longer ambiguity range for real-time measurement without precise environmental sensing. The experimental result demonstrates 46 nm precision with 0.1 s coherent averaging and achieves an accuracy of the order of ~10−7.

We present a two-color dual-comb ranging (TC-DCR) system without precise environmental sensing. Jeerwan Shinari Awaji, Atsushi Kanno, Naokatsu Yamamoto, Shigefusa Chichibu, Akira Hirano, Masamichi Ipommatani; National Inst of Information & Comm Tech, Japan; Inst. for Multidisciplinary Research for Advanced Materials, Tohoku Univ., Japan; UV Craftory Co. Ltd., Japan. The performance of solar-blind optical wireless communication using AlGaN-based LED at 280 nm-band was evaluated experimentally over a 1.5-m outdoor Line-of-Sight channel. Even under the summer sun, 1.18-Gbps error-free transmission was achieved.

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### AM2I.1 • 10:30
Towards Anatomical Profiling of Intact Bones with Tissue Clearing, Custom Microscopy and Algorithms, Alan Greenbaum, 1Joint Dept. of Biomedical Engineering, North Carolina State Univ., USA; 2Joint Dept. of Biomedical Engineering, UNC Chapel Hill, USA. Bones are complex and vital organs, nevertheless, investigating biological phenomena in the bones is challenging due to their opacity. Bone-CLARITY, a method to render bones transparent allows 3D imaging and analysis of whole mice bone.

### AM2I.2 • 11:00
Adding Dimensions to Intravital Imaging, Scott E. Fraser. Intravital imaging provides a key bridge between molecular & cellular data. To address the compromises in live imaging, we are combining 2-photon light-sheet microscopes for 4D imaging with new multispectral analysis tools to permit rapid and unambiguous 5D analyses of multiplex-labeled specimens.

### SM2J.1 • 10:30
Photonic Reservoir Computing in Silicon Photonics, Peter Bienstman, 1Ghent Univ., INTEC, Belgium. Photonic Reservoir Computing is a brain-inspired information processing paradigm that is especially suited for a hardware implementation in photonics. We will present our latest results on a number of applications, ranging from telecom equalization to biological cell sorting.

### SM2J.2 • 11:00
All-photon in-memory computing based on phase-change materials, Carlos Ríos, 1MIT (MIT), USA; 2Univ. of Oxford, UK; 3Univ. of Münster, Germany; 4Univ. of Exeter, UK; 5IBM Zürich, Switzerland. We experimentally demonstrate, for the first time, co-located data storage and processing (i.e. in-memory computing) on an integrated photonic platform based on nonvolatile phase-change materials.

### AM2K.1 • 10:30
Active and Passive Greenhouse Gas Profiling in the Atmosphere Using Near Infrared Tunable Diode Lasers, Houston Miller, D. Michelle Bailey, Monica M. Flores, David Bomser, 1Chemistry, George Washington Univ., USA; 2Mesa Photonics, USA. The development of two laser-based sensors for horizontal and vertical profiling of greenhouse gas levels in the atmosphere including an auto-aligning, open-path instrument and a new variant on laser heterodyne radiometry are presented.

### AM2K.2 • 11:00
Simultaneous DIAL, IPDA and point sensor measurements of the greenhouse gases, CO$_2$, and H$_2$O, David Plusquellec, 1DUR, Germany; 2Physical Measurement Lab, NIST, Boulder, USA; 3Material Measurements Lab, NIST, Gaithersburg, USA. Rapid scan IPDA and DIAL systems have been developed based on phase modulators for tuning and hybrid counting systems for detection. The performance of these systems has been evaluated through comparisons with point sensor measurements.
Using Photons to Generate Certified Randomness, Peter Bierhorst1,2; 1Univ. of Colorado at Boulder, USA. A photonic loophole-free Bell experiment is generating random numbers impossible to predict by any agent that cannot send signals faster than the speed of light. This resource has applications in secure communication.

Interferometric quantum random number generation on chip, Thomas Roger1,2, Innocenzo De Marco3,4, Taiqiu Paraiso1, Davide Marango1, Zhihui Yuan1, Andrew Shield1,2, Peter Bierhorst1; 1Fraunhofer Inst. for Applied Optics and Precision Engineering IOF, Germany, 2School of Electronic and Electrical Engineering, Univ. of Leeds, UK. We demonstrate an on-chip, high-speed quantum random number generator based on the interference of two gain-switched pulsed lasers. FPGA-based electronics allows for real-time processing, providing 8 Gbps random numbers passing all the NIST tests.

Quantum random number generation (QRNG) by phase diffusion process in a gain-switched semiconductor laser - new insights, Brigitta Septriani1,2, Oliver de Vries1, Markus Graefel1,2, Fraunhofer Inst. for Applied Optics and Precision Engineering IOF, Germany. A parametric study of QRNG employing phase diffusion in gain-switched DFB laser diode is presented. New theoretical findings on the maximal raw data rate and explanations on advantage of pulsed regime over cw are given.

Chipscale Soliton Micro-combs, Tobias J. Kippenberg1,2, Inst. of Physics, Swiss Federal Inst. of Technology (EPFL), Switzerland. This tutorial will review the fundamental operational principles and latest development in the field of soliton microresonator frequency combs (micro-combs), which utilize spatio-temporal self organization of light in the form of dissipative solitons. Such microcombs provide chipscale and broadband frequency combs, that have been applied to frequency synthesis, LIDAR, astrophysical spectrometer calibration as well as dual comb based ranging and spectroscopy techniques.

Birefringent Photonic Crystal for High Efficiency Polarization Beam Splitting, Ehsan Orsbouie1, Azad Siahmakoun1, Hossein Alisafaee1,2, 1Physics and Optical Engineering, Rose-Hulman Inst. of Technology, USA. We have modeled and fabricated a birefringent photonic crystal using only TiO2. The device demonstrates high efficiency for splitting the polarization states of incident light. The fabrication is done using oblique-angle deposition.

Curvature-controlled Fabrication of Polymer Nanolens Array, Qiang Li1,2; 1Iowa State Univ., USA. We demonstrate curvature-controlled fabrication of arrayed nanolenses via UV-assisted modification of photopolymer's material characteristics and elastomer-based nanoimprint. By varying the UV-dose, the f/# of the 500 nm-diameter nanolens was varied from 1.2 to 10.0.

High-quality Nanometric Quantum Source: Epitaxially Grown Diamond Nano-pyramids with Silicon-Vacancy Centers, Tzach Jaffe1,2, Nina Felger1, Lior Gal1, Lior Korinblum1, Cyril Popov1,2, Johann Peter Reithmaier1,2, Meir Orenstein1; 1Dept. of Electrical Engineering, Technion Israel Inst. of Technology, Israel, 2Inst. of Nanostructure Technologies and Analytics, Univ. of Kassel, Germany. We present a deterministic template-assisted bottom-up process for creating high-quality nanoscale diamond pyramids incorporating optically active silicon vacancy centers (SiV). We achieved deterministic nano-localization and an extraction efficiency enhancement of 4 compared to bulk diamond.

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A Single Shot Measurement of Atomic Coherence in a Thermal Ensemble of Atoms, Anil W. Laskar1, Nihanka Singh1, Pratik Adhikari1, Anuradha S. Mukherjee1, Saikat Ghosh1; Physics, Indian Inst. of Technology, Kanpur, India. We demonstrate a single shot measurement technique to quantify ground state coherence in atomic system. The quantifier identifies the transition from EIT to Autler-Townes regime. Furthermore, we demonstrate phase coherent control and freezing coherence against decoherence.

Turning an Organic Molecule into a Coherent Two-Level Quantum System using a Tunable Fabry-Perot Microcavity, Daqing Wang1, Hrishikesh Kelkar1, Stephan Götzinger1, Vahid Sandoghdar1,2; Nonlinear Physics Centre, Australian National Univ., Australia; 2Faculty of Physics, Lomonosov Moscow State Univ., Russia; 3ITMO Univ., Russia; Dept. of Physics, South Korea Univ., South Korea (the Republic of). We employ doughnut-shaped cylindrical vector beams to observe the enhanced second-harmonic generation from individual subwavelength AlGaAs nanoparticles which support both electric and magnetic multipolar Mie-type resonances at the fundamental and double frequencies.

Raman Scattering Beyond the Master Equation: Photon-Matter Correlations and Statistics, Kai B. Shinbrough1, Yanting Teng1, Bin Fang1, Virginia O. Lorenz1, Offir Cohen1; 1Univ. of Illinois at Urbana-Champaign, USA. We present 1D and 3D models that take into account Stokes-photon-excitation pair correlations in Raman scattering, revealing non-trivial dependence of the photon statistics on linewidth, dispersion and collection angle.

Utilizing Floquet Engineering for the Design of Non-reciprocal Transport, Tsampikos Kottos1, Wesleyan Univ., USA. We present a framework that lays out the rules under which a periodic driving induces nonreciprocal transport. The method unveils the role of an extended Hilbert space where non-reciprocal Floquet networks can be engineered.

Boosting LSP-enhanced SHG from Au nanoparticles by using NLO polymers, Atsushi Sugita1, Takumi Makiyama1, Hikaru Sato1, Atsushi Ono1, Wataru Inami1, Yoshimasa Kawata1; 1Shizuoka Univ., Japan. LSP-enhanced SHG from Au nanoparticles surrounded by NLO polymers is presented. Nearly 50-fold increases in LSP-enhanced SHG signals compared to pristine Au nanoparticles are discussed in terms of plasmon-exciton two-photon resonances and molecule-to-metal charge transfer.

Metal-Dielectric Nanodimers with Hybridized Resonances Probed by Second-Harmonic Polarization, Claude Renaud1, Lang Lukas1, Frayyuk Kristina1, Maria Timpolkova1, Mikhail Petrov1, Filip Knisafer1, Ivan Mukhin1, Flavia Timpu1, Yuri S. Kivshar1, Rachel Grange1; 1ETH Zurich, Switzerland; 2ETH Zurich, Switzerland; 3ITMO Univ., Russia; 4Australian National Univ., Australia. We fabricate hybrid nanodimers made of gold and barium titanate nanoparticles by a pick-and-place technique. By overlapping their resonances, we achieve 100-times enhancement of the second-harmonic signal at the hybridized mode while reshaping its polarization.

Ultrafast Photocurrents in the Weyl Semimetal TaAs: Nicholas Sirica1, Ra’anan Tolbey1, Dmitry Yarotski1, Pam Bowman1, Stuart Trugman1, Jian-Xin Zhu1, Yaomin Dai1, Abul Azad1, Ni Ni1, Xianggang Qiu1, Antoinette Taylor1, Rohit Prasankumar1; Center for Integrated Nanotechnology, USA; 1Inst. of Physics Chinese Academy of Science, China. Terahertz emission from TaAs reveals highly directional, ultrafast photocurrents whose origin is intrinsically due to crystal structure. This is illustrated by unraveling the polarization dependence, directionality, and intrinsic timescales underlying photocurrent generation and decay.
Towards Stable Laser-Plasma Electron Acceleration, Andreas R. Maier¹, Univ. of Hamburg, Germany. Driven by a highly stable laser system, the LUX accelerator combines expertise in plasma and conventional accelerator technology. We report on the generation of few-nm undulator radiation and stable operation of the LUX plasma accelerator.

Creating Highly Coherent NV Centers in Diamond, Ania Bleszynski Jayich¹, Claire McLellan¹, Tim Eichhorn¹, Simon Meynell¹, Univ. of California Santa Barbara, USA. The diamond NV center is a powerful platform for diverse quantum applications. We present novel NV formation techniques, using CVD diamond growth and tunable electron irradiation, that optimize the quantum properties of NV spin ensembles.

SM2G.4 • 11:30 Hybrid Femtocell-Attocell Optical Links for High-Speed Indoor Wireless Network, Spencer Liverman¹, Siyuan Chen¹, Arun Natarajan¹, Trushikriya Nguyen¹, Alan X. Wang¹, Oregon State Univ., USA. A dual channel indoor optical link is presented consisting of a 100Mbps wide-angle femtocell and a 1.5Gbps line-of-sight attocell. Wavelength multiplexing is used to eliminate interference between the two spatially overlapped optical links.

SM2G.5 • 11:45 Optical Broadcasting for Wide Field-of-View Bidirectional Indoor Optical Wireless Communications, Feng Feng¹, Paramir Sangwongngam¹, Hyunchae Chun¹, Graham Faulker¹, Dominic O’Brien¹, Univ. of Oxford, UK. We demonstrate point-to-multipoint optical wireless upstream and downstream data transmission at 12.5Gbps between a novel holographic beam steering base station with ±30° FOV and two nomadic terminals that use mirror-based steering with ±50° FOV.

SM2H.4 • 11:15 All-optical Hilbert transform with optical frequency comb for one-shot three-dimensional imaging, Takashi Kato¹, Megumi Uchida¹, Yurina Tanaka¹, Kaoru Minoshima¹, The Univ. of Electro-Communications, Japan; JST, ERATO MINOSHIMA Intelligent Optical Synthesizer (IOS), Japan. A novel all-optical Hilbert transform with precise relative carrier-phase and envelope control utilizing frequency control of an optical frequency comb is reported. One-shot three-dimensional imaging of a surface profile demonstrated 200-square-pixels resolution and µm-level uncertainty.

SM2H.5 • 11:30 Cascade-Linked Multi-Synthetic-Wavelength Digital Holography Using Line-by-Line Spectral Shaping Optical Frequency Comb, Takeshi Yasui¹, Masatomo Yamagiwa¹, Takeo Minamikawa¹, Isao Moroshita¹, Noriko Sekine¹, Iwao Hosako¹, Hirotsugu Yamamoto¹, Tokushima Univ., Japan; JST, ERATO MINOSHIMA Intelligent Optical Synthesizer, Japan; National Inst. of Information and Communications Technology, Japan; Utsunomiya Univ., Japan. Line-by-line spectral shaping of a 10-GHz optical frequency comb (OFC) is used for cascade-linked multi-synthetic-wavelength digital holography. The proposed method enables the real-time 3D shape measurement with wide axial dynamic range.

SM2H.6 • 11:45 Depth thermography enabled by precise thermal-emission measurements, Yuzhe Xiao¹, Chengshao Wan¹, Alinee Shaha¹, Jad Salem¹, Mikhail Kat¹, Univ. of Wisconsin-Madison, USA. We developed and experimentally demonstrated a depth-thermography technique based on infrared thermal emission that enables the extraction of temperatures beneath the surface of an object.

Concurrent sessions are grouped across four pages. Please review all four pages for complete session information.
Holographic Reconstruction with Brightfield Microscopy Contrast using Cross-Modality Deep Learning, Yilin Luo1, Yichen Wu1, Guvnant Chaudhari1, Yair Rivenson1, Ayfer Calis1, Kevin Haan1, Aydogan Ozcan1,2.

1Electrical and Computer Engineering Dept., Univ. of California, Los Angeles, California, USA; 2Colorado School of Mines, USA.

We characterize silicon photonic microring resonators specifically designed with low Quality Factors (Q) to operate with high linearity measured over a range of 1.44 volts suitable for microring-based high resolution optical matrix multiplier architectures.

SM2J.4 • 11:30
Photicon Crystal Design with Mix and Match Unit Cells for Mode Manipulation, Sami I. Halimi1, Zhongxuan Fu2,3, Francis O. Atzal2, Joshua Allen1, Shuren Hu1, Sharon M. Weiss1,2.

2Dept. of Electrical Engineering and Computer Science, Vanderbilt Univ., USA; 3Interdisciplinary Graduate Program in Materials Science, Vanderbilt Univ., USA, 4State Key Lab of Information Photonics and Optical Communications, Beijing Univ. of Posts and Telecommunications, China.

We report simulations and experimental measurement of a photonic crystal designed with mix and match unit cells. Our results enable extreme mode manipulation and potentially phase and amplitude modification using non-traditional unit cell shapes.

SM2K.3 • 11:30
Label-free Bio-aerosol Sensing Using On-Chip Holographic Microscopy and Deep Learning, Yichen Wu1, Ayfer Calis1, Yi Luo1, Cheng Chen1, Maxwell Lutton1, Yair Rivenson1, Xing Lin1, Hatice Geylan Koydemir1, Yibo Zhang1, Hongda Wang1, Zoltan Goricai1, Aydogan Ozcan1.

1Univ. of California Los Angeles, USA. We present automated and label-free bio-aerosol sensing using a portable and cost-effective device, enabled by on-chip digital holographic microscopy and deep-learning.

SM2L.3 • 11:15
Fabrication of Near-Field Optical Fiber Probes Through Focused Ion Beam, Karen Sloyan1, Henrik Melkonyan1, Matteo Chiesa1, Marcus Dahlem2,3, Khalifa Univ., United Arab Emirates; InterUniv. Microelectronics Center (IMEC), Belgium. We describe a procedure to fabricate a near-field optical fiber probe using focused ion beam milling. The method allows to control the fiber taper angle for better throughput, and the taper length for mechanical robustness.

SM2L.4 • 11:30
Low-Loss Ring-Core Fiber Supporting 4 Mode Groups, Heyun Tan1, Juneezi Zhang1, Jie Liu1, Lei Shen1, Guoxuan Zou1, Rui Zhang1, Yaping Liu1, Lei Zhang1, Siyan Yu1.

1School of Electronics and Information Engineering, State Key Lab of Optoelectronic Materials and Technologies, Sun Yat-sen Univ., China; 2School of Physics, State Key Lab of Optoelectronic Materials and Technologies, Sun Yat-sen Univ., China; 3State key Lab of Optical Fiber and Cable Manufacture technology, Yantze Optical Fiber and Cable Joint Stock Limited Company, China; 4Photonics Group, Merchant Venturers School of Engineering, Univ. of Bristol, UK. A ring-core fiber with a novel modulated-reflective-index profile is reported, whose low attenuation (~0.2 dB/km) and low inter-mode-group coupling coefficient (<36 dB/km for adjacent high-order mode groups), both setting records for a ring-core fiber.
Symmetrical Bell state preparation and measurement without a third party. Yong-Su Kim\textsuperscript{1,2}, Tanumoy Pramanik\textsuperscript{1}, Young-Wook Cho\textsuperscript{1}, Ming Yang\textsuperscript{1}, Sang-Wook Han\textsuperscript{1}, Sang-Yun Lee\textsuperscript{1}, Min-Sung Kang\textsuperscript{1}, Sung Moon\textsuperscript{1,2}; \textsuperscript{1}South Korea Inst. of Science & Technology, South Korea (the Republic of); \textsuperscript{2}South Korea Univ. of Science and Technology, South Korea (the Republic of); \textsuperscript{2}Anhui Univ., China. We present a linear optical Bell state preparation and measurement schemes without photon-photon interaction at an optical element. Unlike the standard schemes, it can be symmetrically divided into two parties without a third party.

Frequency Comb phase-locked cavity ringdown spectroscopy, Zachary D. Reed\textsuperscript{1}, Joseph Hodges\textsuperscript{1}; \textsuperscript{1}NIST, USA. We present a frequency comb phase-locked cavity ringdown spectrometer capable of arbitrary frequency steps with 1 kHz absolute frequency accuracy, and demonstrate determination of molecular line positions with better than 40 kHz accuracy.

Light-Directed Nanomanipulation of Colloidal Particles in Ambient Environments, Jingang Li\textsuperscript{1}, Yaoran Liu\textsuperscript{1}, Yuebing Zheng\textsuperscript{1}; \textsuperscript{1}The Univ. of Texas at Austin, USA. We report an all-optical technique for the versatile nanomanipulation of various colloidal particles under ambient conditions by harnessing both photothermal effects and optical forces.

Violating Bell inequalities with entangled optical frequency combs and multi-pixel homodyne detection, William N. Plick\textsuperscript{1}, Francesco Arzani\textsuperscript{1}, Nicolas Treps\textsuperscript{2}, Damian Markham\textsuperscript{2}, Eleni Diamanti\textsuperscript{2}; \textsuperscript{1}Univ. of Dayton, USA; \textsuperscript{2}Sorbonne Universites, France. We theoretically investigated using continuous-variable Bell-type inequalities in a multiparty configuration using an optical parametric oscillator which has been synchronously-pumped with a frequency comb. We find violation is possible.

Attenuated Total Reflectance Dual-Comb Spectroscopy of an Organic Liquid-Phase Chemical Reaction, Daniel I. Herman\textsuperscript{1,2}, Eleanor Waxman\textsuperscript{1}, Gabriel Ycas\textsuperscript{1,2}, Fabrizio R. Giorgetta\textsuperscript{1,2}, Nathan R. Newbury\textsuperscript{1}, Ian Coddington\textsuperscript{1}; \textsuperscript{1}NIST, USA; \textsuperscript{2}Physics, Univ. of Colorado Boulder, USA. A mid-infrared dual-comb spectrometer coupled to an attenuated total reflectance cell is used to monitor the hydration of mesityl oxide (MO) into diacetone alcohol (DAA). Our method provides real-time concentrations for MO and DAA.

Improvement of lasing threshold of ink-jet printed polymeric microdisk cavity by precise controlled wet etching, Taku Takagishi\textsuperscript{1}, Hiroaki Yoshioka\textsuperscript{1}, Yuya Mikami\textsuperscript{1}, Naoya Nishimura\textsuperscript{1}, Yuki Oki\textsuperscript{1}, Kyushu Univ., Japan; \textsuperscript{2}Nissan Chemical Corporation, Japan. With well-controlled wet etching process, under-cut structure of ink-jet printed microdisk was successfully formed and we succeeded in lowering the lasing threshold by 10 times, compared with the one on a substrate.
### Quantum Few-body Dynamics of Rydberg-atom entanglements, Hanlae Jo, Yunheung Song, Minhyuk Kim, Jaewook Ahn; demonstrate interferometric implementation of Rydberg-atom quantum simulators, or entangled Rydberg atom clusters, using Lindblad equations with control parameters including spontaneous emission, stochastic atom loss, and laser phase noise.

### Interferometric implementation of Rydberg-atom entanglements, Hanlae Jo, Yunheung Song, Minhyuk Kim, Jaewook Ahn; Physics, South Korea Advanced Inst of Science & Tech, South Korea (the Republic of). We propose and experimentally verify the quantum dynamics of small-scale Rydberg-atom quantum simulators, or entangled Rydberg atom clusters, using Lindblad equations with control parameters including spontaneous emission, stochastic atom loss, and laser phase noise.
AM2I • Applied Biophotonic Microscopy & Imaging—Continued

AM2I.5 • 12:00
Computation-enabled Lensless Imaging & Deep-Brain Microscopy, Brian Rodriguez1, Zhimeng Pan1, Ruopeng Guo1, Naveen Nagarajan1, Kyle Jenks1, Mario Capocelli1, Jason Shepard1, Rajesh Menon1; ‘Univ. of Utah, USA. We show imaging using only a CMOS image sensor, and fluorescence microscopy inside the mouse brain using a surgical needle and an image sensor, both enabled by computation including machine learning.

AM2I.6 • 12:15
Enhancing Resolution in Coherent Microscopy Using Deep Learning, Tairan Liu1, Kevin Haan1, Yibo Zhang1, Aydogan Ozcan1; ‘Univ. of California Los Angeles, USA. A generative adversarial network (GAN) based super-resolution framework is presented. This deep learning-based framework is capable of enhancing the resolution of coherent imaging systems in both pixel size-limited and diffraction-limited microscopy systems.

SM2J • Optical Computing & Resonator Applications—Continued

SM2J.6 • 12:00
Ultrahigh-Q single cell slotted nanocavity operated in water, Eiichi Kuramochi1, Theo Martel1, Shota Kita1, Hideaki Taniyama1, Akihiko Shinya1, Masaya Nomoto1; ‘NTT Corporation, Japan. By tuning 30 or more holes, H1 slotted nanocavities with theoretical Q exceeding 10^6 and mode volume smaller than 0.03 (λ/2π)^3 in water were designed. A Q factor exceeding 10^4 was measured in ultrapure water.

AM2K • Environmental & Atmospheric Sensing II—Continued

AM2K.5 • 12:00
MIRA: A New, Ultrasonic, Middle Infra-red Laser-Based Gas Analyzer for Environmental Monitoring Applications. James J. Scherer1, Joshua B. Paul1, Jerome Theibrault1, and Stephen So1. ‘Aeris Technologies, Inc., USA. A new, ultrasensitive lunchbox-sized middle infrared laser-based commercial gas sensor is described, with examples of monitoring key pollutants (CO, HCHO), greenhouse gases (CH4, N2O) with ppb accuracy levels in a variety of field applications.

SM2L • Fiber Devices—Continued

SM2L.6 • 12:00
The thermal sensitivity of optical path length in standard single mode fibers down to cryogenic temperatures, Wenwu Zhu1,2, Meng Ding1, Mingshan Zhao1, David Richardson1, Radan Slavik1; ‘Dalian Univ. of Technology, China; ‘Optoelectronics Research Centre, Univ. of Southampton, UK. We measured the thermal sensitivity of SMF-28 fiber in the range -190°C - 25°C and measured a > 3-fold decrease for uncoated fiber towards the lowest measured temperature and far higher sensitivities for coated and jacketed fibers.
FM2M.6 • 12:00
Withdrawn

FM2M.7 • 12:15
Verifying Multi-Partite Entanglement with a Few Detection Events, Lee Rozema1, Valeria Saggio1, Aleksandra Dimic1, Chiara Greganti1, Philip Walther1, Borivoje Dalic1; 1Univ. of Vienna, Austria, 2Univ. of Belgrade, Serbia. We introduce a new entanglement-verification method and use it to experimentally verify the entanglement in a photonic six-qubit cluster state, created at telecommunication wavelengths, by detecting only 20 copies of the quantum state.

SM2N.4 • 12:00
Trace Gas Sensing through Purcell-Enhanced Raman Scattering in Pressurized Microcavities, Juan S. Gomez Velaz1, Andreas Muller1; 1Univ. of South Florida, USA. Minimally long microcavities were constructed for Purcell-enhanced Raman scattering in gases at up to 12 bar pressure. A linear emission rate confirms pressure broadening remains exceeded by the cavity linewidth, making pressurization beneficial.

SM2N.5 • 12:15
Near-Infrared Continuous-Filtering Vernier Spectroscopy in a Flame, Chuang Lu1, Francisco Senna Vieira1, Florían M. Schmidt2, Aleksandra Foltynowicz1; 1Dept. of Physics, Umeå Univ., Sweden; 2Dept. of Applied Physics and Electronics, Umeå Univ., Sweden. A continuous-filtering Vernier spectrometer based on an Er fiber femtosecond laser was developed to acquire broadband H2O and OH spectra in a premixed CH4/air flame with 25 ms time resolution and percent precision on concentrations retrieval.

SM2N.6 • 12:00
High Quality Factor PECVD Si3N4 Ring Resonators Compatible with CMOS Process, Xingchen Ji1,2, Samantha Roberts1, Michal Lipson1; 1Columbia Univ., USA; 2Cornell Univ., USA. We demonstrate high-confinement Si3N4 resonators with intrinsic quality factor more than 1 million using standard PECVD process. We show that by addressing scattering, the loss at 1.6 μm can be as low as 0.4 dB/cm.

SM2O.6 • 12:15
Fabrication of High-Q, High-Confinement 4H-SiC Microring Resonators by Surface Roughness Reduction, Yi Zheng1, Minhao Pu1, Ailun Yi2, Ayman N. Kamel1, Martin R. Henriksen3, Asbjørn A. Jørgensen3, Xin Ou2, Haiyan Ou1; 1Technical Univ. of Denmark, Denmark; 2Inst. of Microsystem and Information Technology, Chinese Academy of Sciences, China; 3Niels Bohr Inst., Univ. of Copenhagen, Denmark. We improve the Q of SiC microring resonators with a sub-micron cross-sectional dimension by a factor of six by reducing surface roughness. We achieve a high Q (~73,000) for such a device with anomalous dispersion.

12:30–13:30 Lunch Break (on your own)

12:30–13:30 What’s Next in Integrated Optics – Hot Topics at CLEO: 2019, Room 230A

13:00–14:00 Resumes, LinkedIn, and Networking (with Cheeky Scientist), University Room, Hilton San Jose

13:00–14:00 Social Media in 2019 Panel Discussion, University Room, Hilton San Jose

SC376: Plasmonics (Mark Brongersma; Stanford Univ., USA)
SC378: Introduction to Ultrashort Optics (Rick Trebino, Georgia Institute of Technology, USA)
SC476: QCL and QCL Combs (Jérôme Faist, ETH Zürich, Switzerland)
FM3A • 13:30 Voltage controlled fine-structure splitting of single photon emitters in a two-dimensional semiconductor, Chitradee Chakraborty1, Nicholas Jungwirth1, Gregory Fuchs2, Nick Vamivakas3, 4Electrical Engineering and Computer Science, MIT, USA; 5Materials Science, Univ. of Rochester, USA; 6School of Applied and Engineering Physics, Cornell Univ., USA; 7The Inst. of Optics, Univ. of Rochester, USA. We report on the modulation of the fine-structure splitting (FFS) of quantum dot-like emitters in a two-dimensional semiconductor. Voltage-controlled suppression of the electron-hole exchange interaction features a 40% increase in circular polarization with decreasing FFS.

FM3A • 13:45 Generation of quantum light in a photon-number superposition, Carlos Antón Solana2, Juan Carlos Loredo1, Bogdan Reznychenko1, 2Paul Hilaren3, Abdelmounam Harouri2, Clement Millet1, Helene Olivier1, 2Nicolaos Samasis1, Lorenzo de Santos1, 2Aristide Lemaitre1, Isabelle Sagnes1, 2Loic Lanco1, Denis Alexia Aufeves1, 2Olivier Krebs1, 2Pascale Seظلiet1, 2CNRS Center of Nanosciences and Nanotechnology, France; 3Université Paris-Sud, Université Paris-Saclay, France; 4CNRS Institut Néel, France; 5Univ. Grenoble Alpes, France; 6Quandela, SAS, France; 7Université Paris Diderot, France. We generate highly pure quantum states of light in a coherent superposition of zero, one, and two photons. Such states are generated by coherently driving electrically-controlled 2D-microcavity devices with resonant laser pulses.

FM3A • 14:00 A Charge-Tunable Quantum Dot Strongly Coupled to a Nanophotonic Cavity, Zhouchen Luo1, Allan S. Bracker1, Dan Gamm1, Edo Waks1, 2Naval Research Lab, USA; 3Inst. for Research in Electronics and Applied Physics, Univ. of Maryland, USA. We report for the first time a strong interface between a charge tunable quantum dot spin and a microcavity embedded in a p-i-n-i-n diode structure, which enables control and stabilization of quantum dots changing state.

FM3B • 13:30 Invited Brillouin Based Non-reciprocal Functions for On-chip Optical Signal Processing, Benjamin J. Eggleton1, 2Univ. of Sydney, Australia. Stimulated Brillouin Scattering is an efficient opto-mechanical process that generates a sound-wave in an optical waveguide; the direction of the travelling sound wave breaks time-reversal symmetry, enabling non-reciprocity, the basis of isolators and circulators.

FM3B • 13:45 Polariton Meta-Optics with Phase-Change Materials, Michele Tamagnone1, Kundan Chaudhary1, Xinhuo Yin1, Christina Spagels1, Jianli Li1, Stefano Oscurato1, 2Noah Rubin1, Luis Jaugue1, 2Philip Kim1, 3James Edgar1, 2Antonio Ambrosio1, 2Federico Capasso1, 2Harvard University, USA; 3Kansas State Univ., USA. We created polariton meta-materials in heterostructures formed by hBN and GeSbTe and characterized them with SNOM. The meta-materials are created switching the phase of GeSbTe below hBN from amorphous to crystalline, focusing hBN phonon polaritons.

FM3C • 13:45 All-dielectric Deep Ultraviolet Metasurfaces, Cheng Zhang1, Shihan Dutt1, Qingbin Fan2, Wenqi Zhu2, Amit K. Agrawal2, Ting Xu2, Hui Leezec1, 2NIST, USA. We propose the first technique to directly measure the band structures of synthetic lattices, and experimentally demonstrate it in a modulated ring resonator. We also realize long-range couplings, photon gauge potentials and nonreciprocal bands.

FM3D • 13:45 Two-dimensional THz Spectroscopy of Exchange Interactions in Rare-earth Doped Garnets, Shovan Pal1, Christian Tschuschke1, Amadee Bortis2, Takuya Sato1, Manfred Fiebig1, 2Dept. of Materials, ETH Zurich, Switzerland; 2Dept. of Physics, Kyoto Univ., Japan. We study the correlation dynamics of the complex exchange interaction between the rare-earth and the transition metal in a garnet using two-dimensional terahertz spectroscopy. The THz resonance resembles a convolution of the exchange mode with electron transfer between the Kramer’s doublet.
The architectures of industrial ultrafast lasers are being reviewed and their performance compared. Ablations rates as a function of pulse duration (0.4 – 19 ps), wavelength and pulse fluence are presented and the main industrial applications are discussed.
Implementation and Characterization of a Compact Multiphoton Endoscope with Large Field of View Working at 1700 nm, Farhad Akhoudi1, Yukin Giril, Nasser Peyghambarian1; 1Univ. of Arizona, USA. The implementation and characterization of a compact multi-photon endoscope is presented. A miniscule objective lens with a long working distance is used. We utilized a 1700 nm wavelength femtosecond laser to increase penetration depth.

Reconstruction of Multiple-Scattering Complex Media by Iterative Optical Diffraction Tomography, Shengli Fan1, Seth D. Smith-Dryden1, Guangfu Li1, Bahaa Saleh1,2; CREOL, The College of Optics & Photonics, USA. We demonstrated the reconstruction of complex media beyond the weakly-scattering regime using iterative diffraction tomography. The accuracy and efficiency of the iterative reconstruction are numerically demonstrated.

Optoacoustic Imaging Beyond the Diffraction Limit, X Luis Dean-Ben1, Daniel Ranzanyski1; 1Univ. and ETH Zurich, Switzerland. The talk focuses on novel super-resolution optoacoustic approaches enabling imaging beyond the diffraction limit, such as localization tomography of flowing particles, non-linear bleaching effects, dynamic speckle excitation and waveform shaping.

New Physics and Applications with Metasurfaces, Vladimir M. Shalaev1,2; Purdue Univ./Brick Nanotechnology, USA. Via in-plane optical phase control, metasurfaces serve as an illustration platform for new physical phenomena including ultrafast beam steering, optical switching, synchrotron radiation, and new applications such as multiplexed color display and efficient thermo-photovoltaic generation.

AM3J.1 • 13:30
Monolithically Integrated InP-on-Si Microdisk Lasers with Room-Temperature Operation, Svenja Mauhe1, Philipp Staudinger1, Noelia Vico Trivino1, Mariyana Sousa1, Thilo Stöferle1, Heinz Schmid1, Kirsten E. Moselund1; IBM Research Zurich, Switzerland. We present the first monolithic integration of InP microdisk room-temperature lasers on silicon by template-assisted-selective-epitaxy and compare their performance with previously demonstrated GaAs microdisk lasers. InP allows for future integration of QWs for the NIR.

SM3J.2 • 13:45
Waveguide-Integrated Dielectric Laser Particle Accelerators Through the Inverse Design of Photonics, Neel Sapra1, Kiyoul Yang1, Dries Vercruysse1,2, Logan Su1, Jelena Vuckovic1; 1Ginzton Lab, Stanford Univ, USA; 2Dept. of Physics, KU Leuven, Belgium. We apply the inverse design methodology to waveguide-integrated dielectric laser particle accelerators. These accelerators are optimized to maximize the acceleration gradient. The designs have been fabricated on a silicon-on-insulator platform and experimentally characterized.

New Concepts in Silicon Photonics: From Optical Communications to the Brain, Joyce K. Poon1,2; 1Univ. of Toronto, Canada; 2Max Planck Inst. for Microstructure Physics, Germany. I will present monolithically integrated multi-level silicon nitride-on-silicon photonic platforms that support 3D integrated photonic devices and circuits for telecommunications, and our recent efforts to extend this work to realize neurophotonic implants for brain activity mapping.

AM3K.1 • 13:30
High NA Free-Space Focusing Using a Metasurface-Integrated Photonic Platform for Atom Trapping, Alexander Yulysz1,2, Wenqi Zhu1,2, Cheng Zhang1,2, Daron Westley1,2, Henri Leze1, Amit K. Agrawal1,2, Vladimir Akimov1,2; 1IREAP, Univ. of Maryland, USA; 2PML, National Inst. of Standards and Technology, USA. We report a compact, general photonic-to-free-space coupling via integrating metasurfaces with planar photonics. Demonstrated collimated beam projection and high numerical aperture focusing at long distance may enable trapping and interrogating atoms in chip-scale systems.

Invited Tutorial
Coherent Combination of Fiber Amplified Femtosecond Pulses, Jens Limpert1; 1Friedrich-Schiller-Universität Jena, Germany. The presentation will review the basics, achievements and newest developments of coherent combination of amplified femtosecond pulses, a concept which has already out-performed single aperture femtosecond laser systems and which allows for a scaling to unprecedented performance levels.

Jens Limpert received his M.S in 1999 and Ph.D in Physics from the Friedrich Schiller University of Jena in 2003. His research interests include high power fiber lasers in the pulsed and continuous-wave regime, in the near-infrared and visible spectral range. He is author or co-author of more than 350 peer-reviewed journal papers in the field of laser physics. His research activities have been awarded with the WIT-Award in 2006, an ERC starting grant in 2009 and an ERC consolidator grant in 2013. Jens Limpert is founder of the Active Fiber Systems GmbH a spin-off from the University Jena and the Fraunhofer-IOF Jena.
13:30–15:30
Presider: To Be Announced

JM3M.1 • 13:30 Invited
Integrated Photonics for Neural Network Acceleration, Folkert Horst1; IBM Research - Zurich, Switzerland. We will present our work on an analog integrated optical processor for the acceleration of Backpropagation Algorithm based training of Artificial Neural Networks.

SM3N • Novel Optoelectronic Devices

SM3N.1 • 13:30 Self-suspended Single-mode Microdisk Lasers, Wanwoo Nah1, Matthieu Dupre2, Abdoulaye Ndao1, Ashok Kodigala1, Boubacar Kante1; Univ. of California San Diego, USA. We report subwavelength microdisk resonators suspended in air by connecting bridges. By optimizing the bridge configuration, we numerically and experimentally demonstrate mode selection and single mode microdisk lasers operating at near-infrared wavelength.

SM3N.2 • 13:45 Bending-induced tunable threshold in random laser, Ya-Ju Lee1, Ting-Wei Yeh1, Zu-Po Yang1, Yung-Chi Yao1, Chen-Yu Chang1, Meng-Tsan Tsai1, Jinn-Kong Sheu2; National Taiwan Normal Univ., Taiwan; 2Inst. of Photonic System, National Chiao-Tung Univ., Taiwan. We investigate the transport mean free path of emitted photons within disordered scatterers tunable by bending substrates, thereby creating a light source able to be operated above and below threshold for desirable spectral emissions.

SM3N.3 • 14:00 Autaptic Circuits of Integrated Laser Neurons, Hsu-Tung Peng1, Thomas Ferreira de Lima1, Mitchell A. Nahmias1, Alexander N. Tal1, Bhavin J. Shastri1, Paul R. Prucnal1; Princeton Univ., USA; 2Physics, Queen’s Univ., Canada; 3National Inst. of Standard Technology, USA. The presence of autapses in neural networks enables complex temporal dynamics and information storage. We experimentally demonstrated feedback dynamics in an integrated laser neuron, which provides a proof-of-principle demonstration of cascadability and stable recurrent memory.

SM3O • Guided Wave Nonlinear Devices

SM3O.1 • 13:30 Invited
Integrated Lithium Niobate Photonics and Applications, Marko Loncar1; 2; Harvard Univ., USA; 3HyperLight Corporation, USA. I will present ultra-low loss thin film lithium niobate photonics platform that enables realization of high-Q optical cavities, efficient electro-optic modulators, and broad frequency combs. Applications in telecommunications, micro-wave-photonics, and quantum photonics will be discussed.

SM3O.2 • 14:00 Ultrabroadband Nonlinear Optics in Dispersion Engineered Periodically Poled Lithium Niobate Waveguides, Marc Jankowski1, Carsten Langrock1, Boris Desiatov2, Alireza Marandi3, Cheng Wang2, Mian Zhang2, Christopher Phillips4, Marko Loncar2, Martin Fejer1; 1Stanford Univ., USA; 2John A. Paulson School of Engineering and Applied Sciences, Harvard Univ., USA; 3Caltech, USA; 4Dept. of Physics, Inst. of Quantum Electronics, ETH Zurich, Switzerland. We experimentally demonstrate the first generation of dispersion-engineered periodically poled lithium niobate (PPLN) waveguides. These waveguides achieve ultra-broadband second-harmonic generation (SHG) and multi-octave supercontinuum generation (SCG) with record-low pulse energies.
FM3A • Quantum Nanophotonics I: Plasmonics & Quantum Dots—Continued

FM3A.4 • 14:15
Spin-Selective AC Stark Shifts in a Charged Quantum Dot, Tristan A. Wilkinson1, Dillon Cottrill1, Josh Cramlet1, Cole Maurer1, Collin Flood1, Allan S. Bracker1, Dan Gammon2, Edward B. Flagg1, West Virginia Univ., USA; 2Naval Research Lab, USA. We demonstrate a spin-selective modification to the energy structure of a charged quantum dot using the AC Stark effect. This mechanism offers a potentially rapid, reversible, and coherent control of the energy structure.

FM3A.5 • 14:30
Tutorial Quantum Nanophotonics: Manipulating Photons at the Subwavelength Regime, Gabriel Molina-Terriza1,2,1 IKERBASQUE, Basque Foundation for Science, Spain; 2Materials Physics Center (CSIC-UPV/EHU), Spain. I will give an overview of quantum nanophotonics. I will focus on the control of the quantum correlations of light and its applications to interacting with nanoparticles: single photon, entangled and squeezed states.

FM3A.4 • 14:15
Quantum Nanophotonics: Manipulating Photons at the Subwavelength Regime, Gabriel Molina-Terriza1,2,1 IKERBASQUE, Basque Foundation for Science, Spain; 2Materials Physics Center (CSIC-UPV/EHU), Spain. I will give an overview of quantum nanophotonics. I will focus on the control of the quantum correlations of light and its applications to interacting with nanoparticles: single photon, entangled and squeezed states.

FM3B • Symposium on Nonreciprocal Photonics II—Continued

FM3B.3 • 14:15
Spontaneous Symmetry Breaking Based Near-Field Sensing with a Micromesona totor, Andreas Svela1,3, Jonathan M. Silver1,4, Leonardo Del Bino1,3, George Ghalanos1,2, Niall Moroney1,3, Michael T. M. Woodley1,4, Shuangyou Zhang1, Michael Vanner1,3, Pascal DelHaye4,1 National Physical Lab, UK; 2Blackett Lab, Imperial College London, UK; 3Heriot-Watt Univ., UK; 4City, Univ. of London, UK. The nonlinear Kerr effect causes spontaneous symmetry breaking in bi-directionally pumped whispering gallery mode resonators, providing a system highly sensitive to external perturbations. We demonstrate symmetry-breaking-enhanced near-field sensing within a microresonator’s evanescent field.

FM3B.4 • 14:30
Invited Magnetooptical Garnets for Nonreciprocal Integrated Photonics, Caroline Ross4, Takan Fakih1, Yan Zhang2, Qiangyang Du3, Lukas Beran1, Stana Tzaduri4, Martin Vesi1, Lei Bi2, Juejun Hu1, MIT, USA; 2Univ. of Electronic Science and Technology of China, China; 3Charles Univ., Czechia. The magnetooptical figure of merit of polycrystalline Bi, Ce- and Tb-substituted yttrium iron garnet films on silicon and the performance of integrated TM and TE isolators based on both ring resonators and Mach-Zehnder interferometers with garnet cladding are described.

FM3B.5 • 14:30
Tutorial Quantum Nanophotonics: Manipulating Photons at the Subwavelength Regime, Gabriel Molina-Terriza1,2,1 IKERBASQUE, Basque Foundation for Science, Spain; 2Materials Physics Center (CSIC-UPV/EHU), Spain. I will give an overview of quantum nanophotonics. I will focus on the control of the quantum correlations of light and its applications to interacting with nanoparticles: single photon, entangled and squeezed states.

FM3C • Functional Nanophotonics Using Metasurfaces—Continued

FM3C.4 • 14:30
High-Q resonance train in a plasmonic metasurface, Md Saad-Bin-Abam1, Orad Reshef1, Mikko J. Huttunen1, Graham Colorow1, Brian Sullivan1, Jean-Michel Menard1, Ksenia Dolgaleva1,2, Robert W. Boyd1,3, School of Electrical Engineering and Computer Science, Univ. of Ottawa, Canada; 3The Inst. of Optics and Dept. of Physics and Astronomy, Univ. of Rochester, USA; 3Dept. of Physics, Univ. of Ottawa, Canada. We experimentally demonstrate a plasmonic surface that supports a series of high-quality-factor (Q > 100) surface lattice resonances. These resonances are enabled by tuning the thickness of the top-cladding layer to confine higher order diffraction-orders.

FM3C.5 • 14:45
Nanoplasmonic Metamaterial Devices as Electrically Switchable Perfect Mirrors and Perfect Absorbers, Debabrata Sikdar1,2, Ye Ma1, Anthony Kucernak1, Joshua Edel1, Alexei Kornyshev1, Imperial College London, UK; 2EEE, Indian Inst. of Technology guwahati, India. We introduce nanoplasmonic meta-material devices — electrically-switchable between perfect- mirror/absorber states — based on voltage-controlled assembly/disassembly of gold nanoparticles on silver films. These are investigated using effective-medium-theory, verified with simulations and experiments.

FM3D • Ultrafast Coherent Spectroscopy—Continued

FM3D.4 • 14:15
Ultrafast Analysis and Control of Sub-Nanosecond Intraband Coherence in Single CdSe/ZnSe Quantum Dots, Christian Traum1, Philipp Henzler1, David Nabben1, Matthias Holtkemper1, Doris E. Zechler1, Tilmann Kuhn1,2, Denis Seletsky1,3, Alfred Leitenstorfer1, Dept. of Physics and Center for Applied Photonics, Univ. of Konstanz, Germany; 2Solid State Theory, Univ. of Munster, Germany; 3Dept. of Engineering Physics, Polytechnique Montréal, Canada. Excited trion triplet states are studied with two-color femtosecond resolution monitoring induced absorption into charged biexciton levels. Quantum beats of single-electron wave packets with sub-nanosecond dephasing are found and controlled by pump and probe polarizations.

FM3D.5 • 14:30
Polarization-Selective Excitation of Triplet State Coherences in CBrI3 Perovskite Nanocrystals, Albert Lu1, Diogo B. Almeida2, Luiz Bonato1, Gabriel Nagamine1, Luiz Zagone2, Ana F. Nogueira2, Lazaro A. Padilha2, Steven T. Cundill3, Univ. of Michigan, USA; 2Materials Physics Center (CSIC-UPV/EHU), Spain. We study CBrI3 perovskite nanocrystals using polarization-resolved 2D coherent spectroscopy at cryogenic temperatures. Coherences involving triplet exciton states are revealed and characterized, including inter-triplet coherences with dephasing times on the picosecond timescale.

FM3D.6 • 14:45
Ultrafast Carrier Dynamics in Graphite Studied by Visible/Multi-Thz 2D Spectroscopy, Jonas Allerbeck1, Laurents Spitzner2, Takayuki Kunihara1, Alfred Leitenstorfer1, Daniele Brida1, Dept. of Physics and Center for Applied Photonics, Univ. of Konstanz, Germany; 3Physics and Materials Science Research Unit, Université du Luxembourg, Luxembourg. Two-dimensional spectroscopy employing an asymmetric scheme with visible excitation and multi-Thz readout is applied to study ultrafast carrier dynamics in graphite, enabling phase sensitive investigation of correlations between high- and low-energy excitations.

I am an Ikerbasque Research Professor leading the Quantum Nanophotonics Laboratory in the Materials Physics Center (Spain). I obtained my PhD in 2002. Since then, my research is focused on the spatial properties of light, such as the angular momentum, and applications to Quantum Information, Nanophotonics and Optical levitation.
Monday, 13:30–15:30

Executive Ballroom 210E

JM3E • Symposium on High Average Power Ultrafast Lasers: Trends, Challenges & Applications III—Continued

SM3F • Hot Topics in Quantum Sensing—Continued

SM3G • Data Center Lightwave Communications—Continued

SM3H • Fundamentals of Ultrafast Light Matter Interaction—Continued

Concurrent sessions are grouped across four pages. Please review all four pages for complete session information.
AM3I.4 • 14:30  Invited
Second Harmonic Generation Probes of Human Ovarian Cancer, Paul J. Campagnola1, Eric Rontzcher1, Manish Patankar1, Kirby Campbell1, ’Univ. of Wisconsin-Madison, USA. We use Second Harmonic Generation microscopy to characterize extracellular matrix changes in human ovarian cancers. Texture analysis and polarization resolved techniques differentiate a spectrum of tumors based on alterations in fibrillar organization and supramolecular structure.

SM3J.5 • 14:45
Experimental demonstration of rapid adiabatic couplers, Josep Fargas Cabanillas1, Kayk Harutyunyan1, Anatal Khilo1, Milos Popovic1, ’ECE, Boston Univ., USA. We experimentally demonstrate rapid adiabatic coupling (RAC), a novel design concept that harnesses the benefits and avoids the disadvantages of adiabatic photonic structures. The 31um long 2x2 coupler shows 3±0.3dB splitting over 130nm bandwidth.

SM3L.3 • 14:45
Pre-Chirp Managed Amplification of Circularly Polarized Pulses Using Chirped Mirrors for Pulse Compression, Hangdong Huang2, Yao Zhang2, Hao Teng2, Shaoqiang Fang2, Junli Wang2, Jianglei Zhu2, Guoqing Chang2, Zhiyi Wei2, ’Chinese Academy of Sciences, China; ’Xi dian Univ., China. We demonstrate an Yb-fiber based pre-chirp managed amplification system that amplifies circularly polarized pulses. Using chirped mirrors as the highly efficient (98%) compressor, the system emits 50-MHz, 42-fs pulses with 83-W average power.

AM3K.3 • 14:15
Reconfigurable mid-infrared optical elements using phase change materials, Xinghui Yin1, Christina Spagere1, Michele Tamagnone1, Kundan Chaudhary1, Stefano Osscaro1, Jiahui Li2, Ruoping Li2, Noah Rubin2, Luis Jauregui1, Philip Kim1, James Edgar2, Antonio Ambrosio1, Federico Capasso2; 1Harvard Univ., USA; 2Chemical Engineering, Kansas State Univ., USA. Reconfigurable optical elements using the phase change material Ge,Sb,Te are demonstrated for freely propagating light as well as phonon polaritons in hexagonal boron nitride.

SM3J.4 • 14:30
Efficient Telecom-to-Visible Spectral Translation Using Silicon Nanophotonicics, Xiyuan Lu2, Gregory Mollie1, Qiing Li1,2, Daron Westley1, Ashotosh Rao1,2, Su-Peng Yu1, Travis C. Bries1, Scott B. Papp1, Kartik Srinivasan1; ’NIST, USA; ’Univ. of Maryland College Park, USA; ’Carnegie Mellon Univ, USA. We demonstrate efficient spectral translation of a continuous-wave optical signal across 250 THz using cavity-enhanced four-wave mixing on a silicon nanophotonicics chip, with up to 12.8 % photon number efficiency achieved for sub-mW pump power.

SM3L.2 • 14:30
100-W Average-Power Femtosecond Fiber Laser System with Variable Parameters for Rapid Optimization of Laser Processing, Dai Yoshitomi1, Hideyuki Takada1, Kenji Torizuka1, Yoei Kobayashi1; ’Natl Inst of Adv Industrial Sci & Tech, Japan; ’Inst. Solid State Physics, Univ. Tokyo, Japan. We developed a femtosecond fiber-laser system delivering an average power up to 100 W with wide variability of parameters: pulse duration, pulse energy, number of pulses, and repetition rate for rapid optimization of laser processing.

AM3K.4 • 14:30  Invited
Nonlinear and topological meta-optics and metasurfaces, Yuri S. Kivshar1,2; ’Australian National Univ., Australia; ’ITMO Univ., Russia. This talk will summarize the major concepts of all-dielectric Mie-resonant meta-optics, including nanophasic structures and metasurfaces. It will present also recent advances from my groups in Canberra and St. Petersburg on dielectric nanophotonics as well as nonlinear and topological metasurfaces.

AM3L.3 • 14:45
Pre-Chirp Managed Amplification of Circularly Polarized Pulses Using Chirped Mirrors for Pulse Compression, Hangdong Huang2, Yao Zhang2, Hao Teng2, Shaoqiang Fang2, Junli Wang2, Jianglei Zhu2, Guoqing Chang2, Zhiyi Wei2, ’Chinese Academy of Sciences, China; ’Xi dian Univ., China. We demonstrate an Yb-fiber based pre-chirp managed amplification system that amplifies circularly polarized pulses. Using chirped mirrors as the highly efficient (98%) compressor, the system emits 50-MHz, 42-fs pulses with 83-W average power.
Concurrent sessions are grouped across four pages. Please review all four pages for complete session information.

Monday, 13:30–15:30
Marriott 
Salon I & II
CLEO: Science & Innovations
Marriott 
Salon III
Marriott 
Salon IV
Joint


SM3N • Novel Optoelectronic Devices—Continued

SM3O • Guided Wave Nonlinear Devices—Continued

SM3N.4 • 14:15
Blue Superluminescent Diodes with GHz Bandwidth Exciting Perovskite Nanocrystals for High CRI White Lighting and High-Speed VLC, Abdullah Al-atawii1,2, Jorge A. Holguin-Lerma1, Chun Hong Kang1, Chao Shen1, Ibrahim Durusmi1, Luftan Sinat12, Abdulrahman albadri1, Ahmad Alyamani1, Tien Khee Ng1, Osman Bak1, Boon S. Ooi1; 1King Abdullah Univ of Sci & Technology, Saudi Arabia; 2National Center for Nanotechnology, King Abdulaziz City for Science and Technology, Saudi Arabia; 3Quantum Solutions LLC, Saudi Arabia. A 442-nm GaN-based superluminescent diode (SLD) is demonstrated with a GHz modulation bandwidth and a linewidth of 7 nm. When use for exciting CsPbBr3-perovskite nanocrystal-phosphor, warm-white light with a high CRI of 91 was achieved.

SM3O.3 • 14:15
Quadratic Cavity Soliton Optical Frequency Combs, Tobias Hansson1,2, P. Parra-Rivas3, F. Leo1, M. Bernard1, L. Gelens1, Stefan Walen12; 1Linkoping Univ., Sweden; 2Univ. of Brescia, Italy; 3Free Univ. of Brussels, Belgium; 3Sapienza Università di Roma, Italy; 4Univ. of Leuven, Belgium. We theoretically demonstrate, in the absence of a temporal walk-off, the existence of both bright and dark coherent cavity soliton optical frequency combs in a dispersive second-harmonic generation cavity system.

SM3N.5 • 14:30
Wideband Self-injection-locked Green Tunable Laser Diode, Md. Hosne Mobarok Shamim1, Tien Khee Ng1, Boon S. Ooi1, Mohammad Zahed Mustafa Khan1; 1King Fahd Univ. of Petroleum & Mine, Saudi Arabia; 2Computer, Electrical and Mathematical Sciences and Engineering (CEMSE) division, King Abdullah Univ of Science & Technology (KAUST), Saudi Arabia. A wideband tunability of 6.53 nm with appreciable SMSR (>10 dB) and linewidth (~0.1 nm) is demonstrated from a simple and low-cost tunable self-injection locked InGaN/GaN green laser based external-cavity system, for the first time.

SM3O.4 • 14:30
Frequency comb generation in a continuous-wave pumped second-order nonlinear waveguide resonator, Zeina Abdallah1, Michael Stetfzky1, Ville Ulvila1, Christine Silberhorn1; 1Lab of Photonics, Tampere Univ. of Technology, Finland; 2Integrated Quantum Optics, Applied Physics, Paderborn Univ., Germany; 3Molecular Science, Dept. of Chemistry, Univ. of Helsinki, Finland; 4VTT Technical Research Centre of Finland Ltd, Finland. Optical frequency comb generation has been experimentally studied using an integrated system based on a lithium niobate waveguide resonator featuring a strong quadratic nonlinearity. Our theoretical model shows good agreement with the experimental results.

SM3O.5 • 14:45
Wafer-scale GaAs-on-insulator Waveguide Platform for Diverse Nonlinear Processes, Eric J. Stanton1, Jeff Chiles1, Nima Nader1, Sae Woo Nam1, Richard P. Mirin1; 1Applied Physics Division, National Inst. of Standards and Technology, USA. We detail a 76 mm wafer-bonding process for high-yield GaAs-on-insulator waveguides. Second-harmonic generation waveguides are designed with 120 W−1cm−2 conversion efficiency, and a microresonator is demonstrated with a 180,000 quality factor.

SM3N.6 • 14:45
12.5-GHz InP Quantum Dot Monolithically Mode-Locked Lasers Emitting at 740 nm, Zhibao Li1, Samuel Shutt1, Craig Allford1, Andrey Krav1, Peter Smowton1; 1School of Physics and Astronomy, Cardiff Univ., UK; 2Univ. of Sheffield, UK. Monolithic InP/GaInP quantum dot passively mode-locked lasers, designed using gain and absorption measurements, are realised for the first time, emitting at 740 nm with 12.5 GHz repetition frequency.
14:30–16:00 Deliberate Mentoring to Advance Your Career: Special Flash Mentoring Session, Guadalupe Room, San Jose Marriott

15:30–16:00 Coffee Break, Concourse Level

16:00–17:00 Resumes, Linkedin, and Networking (with Cheeky Scientist), University Room, Hilton San Jose

16:00–17:30 Professional Development for Busy Professionals, Salon VI, San Jose Marriott
Joint

JM3E • Symposium on High Average Power Ultrafast Lasers: Trends, Challenges & Applications III—Continued

JM3E.4 • 15:00
1 MHz Ultrafast High Order Cascaded VUV Generation in Negative Curvature Hollow Fibers, Jessica Ramirez1, David Couch2, Daniel Hickstein1, Mathew Kirchner1, Henry Kapteyn1, Margaret M. Murnane1, Sterling J. Backus1,2. XOM Labs, USA; 2JILA, Univ. of Colorado, USA. We demonstrate cascaded harmonic generation to 9th harmonic (115nm) of 1040nm by combining the fundamental and SHG in a negative curvature hollow fiber filled with Xenon gas.

SM3F • Hot Topics in Quantum Sensing—Continued

SM3F.5 • 15:00 • Invited
Point Source Atom Interferometry for Inertial Navigation and Precision Measurements, Yun-Jih Chen1,2, Azadeh Vasey1, John Kitching1, Elizabeth A. Donley1, National Inst. of Standards and Technology, USA; 1Univ. of Colorado, USA. We evaluate the technique of point source atom interferometry as a relatively simple approach for building an atom interferometer gyroscope. A sensitivity evaluation for simultaneous measurements of acceleration, rotation, and rotation angle will be presented.

SM3G • Data Center Lightwave Communications—Continued

SM3G.4 • 15:00
8-ary Stokes-Vector Signal Generation and Transmission Employing a Simplified Transmitter, Samir Ghosh1, Shota Ishimura2, Takahiro Suganuma3, Taku Tamura4, Yoshiaki Nakano5; KDDI Research, Inc., Japan; 1School of Engineering, The Univ. of Tokyo, Japan. We experimentally demonstrate a simple straight-line configuration of Stokes vector modulator with two cascaded phase modulators. Three-dimensional 8-ary Stokes vector modulated signal is generated at 30 Gb/s and transmitted over a 50-km dispersion-compensated single-mode fiber.

SM3G.5 • 15:15
Iterative Block Decision Feedback Equalization for IM/DD-OCDM System to Mitigate CD-Induced Fading, Xing Ouyang1, Giuseppe Talli1, Paul Townsend1, John Kitching1, Elizabeth A. Donley1, National Inst. of Standards and Technology, USA; 1Univ. of Colorado, USA. We propose an IM/DD-OCDM system with IB-DFE algorithm to mitigate chromatic dispersion-induced fading and the results confirm that the BER performance can be improved by up to three orders of magnitude by compensating the fading effect.

SM3H • Fundamentals of Ultrafast Light Matter Interaction—Continued

SM3H.4 • 15:00
Femtosecond-laser ablation of monolayer molybdenum disulfide (MoS2) on sapphire, Joel M. Solomon1, Hsin-Yu Yao2, Li-Syuan Lu3, Wen-Hao Chang3, Tsing-Hua Her1, Dept. of Physics and Optical Science; 1The Univ. of North Carolina at Charlotte, USA; 2Dept. of Physics, National Tsing Hua Univ., Taiwan; 3Dept. of Electrophysics, National Chiao Tung Univ., Taiwan. Single-shot femtosecond laser ablation of monolayer molybdenum disulfide is demonstrated. An ablation threshold was found 0.9 nJ/μm2, which is too low for two-photon photoionization alone. We show that surface defects and avalanche ionization are important.

SM3H.5 • 15:15
Femtosecond Laser Ablation of Monolayer Graphene with Analysis of the Structural Deformations, Andres Vasquez1, Mohammad Alaghemandi1, Junjie Zeng2, Panagis Samoli3, Adam Sapp4, Sahar Shafizadeh5, Michelle Y. Sanders1; 1Boston Univ., USA. Experimental femtosecond laser ablation of graphene at a high repetition rate of 80 MHz with moderate pulse energies up to 27.5 nJ is analyzed and structural deformations studied by reactive molecular dynamics simulations.
AM3I.5 • 15:00
Ultra-high-resolution single input state polarization-sensitive OCT with polarization distortion correction, Qiaozhou Xiong1, Nanshuo Wang1, Xinyu Liu1, Si Chen1, Shufen Chen1, Haitao Liang1, Linbo Liu1,2; 1School of Electrical and Electronic Engineering, Nanyang Technological Univ., Singapore; 2School of Chemical and Biomedical Engineering, Nanyang Technological Univ., Singapore. In an ultra-high-resolution single input PS-OCT, we proposed a method for correcting polarization distortion caused by Quarter-wave plate (QWP) and spectrometers' roll-off mismatch. The method yielded better estimation of polarization properties especially in weakly birefringent samples.

AM3I.6 • 15:15
Fast Two-snapshot Structured Illumination for Wide-field Two-photon Microscopy with Enhanced Axial Resolution and Signal-to-noise Ratio, Yunlong Meng1, Wei Lin1, Jialong Chen1, Chenglin Li1, Shih-Chi Chen1; 1Dept. of Mechanical and Automation Engineering, The Chinese Univ. of Hong Kong, Hong Kong. We have developed a fully adaptive fast two-snapshot structured illumination algorithm for fast data acquisition and image reconstruction, which can be used in wide-field two-photon microscopy with enhanced axial resolution (~1.25x) and signal-to-noise ratio.

SM3I.5 • 15:00
Efficient Conversion to Very High Order Modes in Silicon Waveguides, Utsav D. Dave1, Michal Lipson1; 1Electrical Engineering, Columbia Univ., USA. We demonstrate robust mode conversion up to the 12th higher order mode in silicon waveguides by using an optimized adiabatic directional coupler and using subwavelength waveguides. The conversion efficiency is better than -1.5 dB over a 75 nm bandwidth and tolerating ±30 nm fabrication variations.

SM3I.6 • 15:00
Efficient Conversion to Very High Order Modes in Silicon Waveguides, Utsav D. Dave1, Michal Lipson1; 1Electrical Engineering, Columbia Univ., USA. We demonstrate robust mode conversion up to the 12th higher order mode in silicon waveguides by using an optimized adiabatic directional coupler and using subwavelength waveguides. The conversion efficiency is better than -1.5 dB over a 75 nm bandwidth and tolerating ±30 nm fabrication variations.

SM3I.7 • 15:15
SOI Optical Add-Drop Multiplexers Using Apodized Spiral Contra-Directional Couplers, Mustafa Hammood1, Stephen Lin1, Ajay Mistry1, Minglei Ma1, Lukas Chrostowski1, Nicolas Jaeger1; 1Univ. of British Columbia, Canada. We use long, spiral contra-directional couplers (contra-DCs) to make optical add-drop filters with 30 dB extinction ratios and 12.2 nm bandwidths, and avoid some of the effects caused by fabrication non-uniformities in long, straight contra-DCs.

SM3L.5 • 15:15
All-fiber polarization maintaining Thulium doped amplifier seeded by coherent polarized supercontinuum, Anupamaa Rampur1,2, Grzegorz Stepniowski1, Dominik Dobrakowski1,2, Yuriy Stepanenko3, Alexander Heidt4, Thomas Feurer4, Mariusz Klimczak2,1; 1Inst. of Electronic Materials Technology, Poland; 2Faculty of Physics, Univ. of Warsaw, Poland; 3Laser Center, Inst. of Physical Chemistry, Polish Academy of Sciences, Poland; 4Inst. of Applied Physics, Univ. of Bern, Switzerland. Coherently seeded, broadband ultrastable thulium fiber amplifier is demonstrated. Its architecture comprises only polarization-maintaining fibers. Preliminary results show amplification of 2 nJ, 5.5 ps long, 100 nm (3dB) pulses centered at 1900 nm before recompression.
Concurrent sessions are grouped across four pages. Please review all four pages for complete session information.

**Monday, 13:30–15:30**

**Marriott Salon I & II**

**Joint**

**JM3M • Symposium on Deep-learning Photons: Where Machine Learning & Photonics Intersect I—Continued**

**JM3M.4 • 15:00**

Optimization of Nonlinear Nanophotonic Media for Artificial Neural Inference, Erfan Khoram1, Ang Chen1, Dianjing Liu1, Qi-Qi Wang1, Ming Yuan3, Zongfu Yu1; 1Univ. of Wisconsin-Madison, USA; 1MIT, USA; 1Columbia Univ., USA. We show optical waves passing through a nanophotonic medium can perform artificial neural computing. Such a medium exploits linear and nonlinear scatterers to realize complex input-output mapping far beyond the capabilities of traditional nanophotonic devices.

**JM3M.5 • 15:15**

PhaseStain: Deep Learning-based Histological Staining of Quantitative Phase Images, Yair Rivenson1, Tairan Liu1, Zhensong Wei1, Kevin de Haan1, Yibo Zhang1, Aydogan Ozcan1; 1Univ. of California Los Angeles, USA. We demonstrate a digital staining framework that transforms quantitative phase images of label-free tissue sections to match the brightfield microscopy images of the same sections, after histological staining. Inference of multiple tissue-stain combinations is demonstrated.

**Marriott Salon III**

**CLEO: Science & Innovations**

**SM3N • Novel Optoelectronic Devices—Continued**

**SM3N.7 • 15:00**

Dual-wavelength operation of the GaSb-based diode lasers with asymmetric coupled quantum wells, Jiang Jiang1, Leen Sheregesha1, Takashi Hosoda1, Aaron Stein1, Alexey Belyanin1, Gela Kipshidze1, Gregory Belenky1; 1Stony Brook Univ., USA; 1Center for Functional Nanomaterials, Brookhaven National Lab, USA; 1Physics, Texas A&M Univ., USA. The DBR diode lasers with asymmetric tunnel coupled quantum wells having built-in resonant second order nonlinearity were designed and fabricated. The devices can generate comparable power in two bands near 2 μm separated by ~13 meV as required for intracavity difference frequency generation.

**SM3N.8 • 15:15**

Optically-feedbacked mode-locked laser diode for tunable narrow-linewidth photonic millimeter-wave generation, Huan Wang1, Lu Guo1, Wu Zhao1, Guangcan Chen1, Dan Lu1, Lingjuan Zhao1; 1Inst. of Semiconductors, Chinese Academy of Science, China. A tunable narrow-linewidth photonic millimeter-wave generation scheme is demonstrated by using a mode-locked laser diode with optical feedback. Photonic mode beating signal tunable from 420GHz to 2930GHz with a linewidth of several kHz is obtained.

**Marriott Salon IV**

**SM3O • Guided Wave Nonlinear Devices—Continued**

**SM3O.6 • 15:00**

Direct Mode-Frequency Control for Nonlinear Optics in Photonic-Crystal Ring Resonators, Su-Peng Yu1, Hoojung Jung1, Travis C. Bifles2, David Carlson3, Gregory Moille2; 1Stony Brook Univ., USA; 1Center for Nanoscale Science and Technology, NIST Gaithersburg, USA. We demonstrate that photonic-crystal modulation enables individual mode-frequency shifting in ring resonators, and high quality factor. Simulation predicts frequency-comb generation in normal-dispersion resonators and spontaneous pulse formation in both dispersion types.

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**14:30–16:00**

**Deliberate Mentoring to Advance Your Career: Special Flash Mentoring Session, Guadalupe Room, San Jose Marriott**

**15:30–16:00**

**Coffee Break, Concourse Level**

**16:00–17:00**

**Resumes, Linkedin, and Networking (with Cheeky Scientist), University Room, Hilton San Jose**

**16:00–17:30**

**Professional Development for Busy Professionals, Salon VI, San Jose Marriott**
FM4A.1 • 16:00 Quantum Nanophotonics II: Diamond & Boron Nitride
President: Glenn Solomon; Joint Quantum Initiative, USA

FM4A.2 • 16:10 Optical Characterization of Single Tin-Vacancy Emitters in Diamond Nanopillars, Alison E. Ruger1, Constantin Dory1, Shuo Sun1, Jelena Vuckovic1, 2Stanford Univ., USA. We characterize the optical and spin properties of tin-vacancy centers isolated in diamond nanopillars. We measure spectrometer-limited linewidths <1 GHz, a strong polarization dependence of the emission, and Zeeman splitting behavior consistent with previous theoretical predictions.

FM4A.3 • 16:30 Control and Stabilization of Nitrogen-Vacancy Centers in Photonic Circuits, Kai-Mei Fu1, 2Univ. of Washington, USA. We present our results integrating near-surface nitrogen-vacancy NV centers into gallium phosphide (GaP) photonic circuits toward photon-mediated spin-spin entanglement.
SM4E 1 16:00
Joule-class 500 Hz Cryogenic Yb:YAG Chirped Pulse Amplifier, Luis E. Zapata, Simon Schweistal, Jello Thesinga, Collette Zapata, Matthias Schaut, Liu Yihou, Mikhail Pergament, Franz Kortner, Center for Free Electron Laser Science, Germany; Dept. of Physics & The Hamburg Center for Ultrafast Imaging, Univ. of Hamburg, Germany. A cryogenic Yb:YAG composite-thin-disk laser driver has demonstrated long-term stable operation at 500 Hz with 1-joule 20-ns pulses. Results with chirped pulses will be presented. Joule-level pulses at 500 Hz compressible to 5 ps are expected.

SM4F 1 16:00 Tutorial
Challenging QED with atomic Hydrogen, Thomas Udem, Lothar Maisenbacher, Axel Beyer, Vitaly Andreev, Alexey Grinin, Arthur Matevev, Ksenia Khabarova, Nikolai Kolachevsky, Randolph Pohl, Dylan Tost, Theodor Hansch, Max-Planck-Institut für Quantenoptik, Germany. Testing theories means to compare precise measurements with theoretical predictions. I will describe where we stand with quantum electrodynamics by verifying calculations of energy levels in atomic hydrogen.

SM4G 1 16:00
A Timing-synchronization-free WDM-compatible Colorless DRoF Uplink System for 5G Mobile Fronthaul employing Gold Sequence Multiplexing, Jih-Heng Yan, Chao-Wei Wang, Kai-Hsiang Lin, Kai-Ming Feng, National Tsing Hua Univ., Taiwan. A Timing-synchronization-free WDM-compatible Colorless DRoF Uplink for 5G Mobile Fronthaul employing Gold sequence multiplexing is experimentally demonstrated. Both signals at different wavelengths with total 6-Gb/s throughput are retrieved without timing synchronization or WDM demultiplexing.

SM4H 1 16:00
Intelligent Image-Activated Cell Sorting and Beyond, Yasuyuki Ozeki, Nao Nitta, Takeaki Sugimura, Akhiro Isazaki, Hi-dehara Mikami, Dino Di Carlo, Yoichiro Hooshkavar, Sotaro Uemura, Kisesuke Goda, Univ. of Tokyo, Japan, Japan Science and Technology Agency, Japan; Univ. of California, Los Angeles, USA, Nara Inst. of Science and Technology, Japan. We present a groundbreaking machine intelligence technology called “intelligent image-activated cell sorting” that achieves high-throughput image-triggered sorting of single cells by integrating high-speed fluorescence microscopy, cell focusing, cell sorting, and deep learning.

SM4E 2 16:30
High Power and Average Power Yb-doped Tapered Fiber Amplifiers, Konstantin K. Bobkov, Andrey E. Levchenko, Vladimir V. Velimskii, Tatiana A. Kochergina, Svetlana Alekhina, Mikhail Bubnov, Denis Lipatov, Fiber Optics Research Center RAS, Russia; Inst. of High Purity Substances of the RAS, Russia. Yb-doped tapered fiber amplifiers delivering picosecond pulses with high peak power (550 kW) and high average power (44 W) is presented.

SM4F 2 16:30
A Timing-synchronization-free WDM-compatible Colorless DRoF Uplink System for 5G Mobile Fronthaul Employing Gold Sequence Multiplexing, Jih-Heng Yan, Chao-Wei Wang, Kai-Hsiang Lin, Kai-Ming Feng, National Tsing Hua Univ., Taiwan. A Timing-synchronization-free WDM-compatible Colorless DRoF Uplink for 5G Mobile Fronthaul employing Gold sequence multiplexing is experimentally demonstrated. Both signals at different wavelengths with total 6-Gb/s throughput are retrieved without timing synchronization or WDM demultiplexing.

SM4G 2 16:30
Portable Imaging Flow-cytometer Using Deep Learning-based Holographic Image Reconstruction, Zoltan Gorocs, Miu Tama-mitsu, Vittorio Bianco, Patrick Wolff, Shou-nak Roy, Koyoshi Shindo, Kyriillos Yanni, Yichen Wu, Hatice Ceylan Koydemir, Trinity College Dublin, Ireland. We demonstrate an RoF system with a simplified RRU, by employing a remote uplink downconversion and downlink wavelength reuse. An error-free transmission of 64-QAM UF-OFDM signals over 12 km of fiber is also shown.

SM4H 2 16:30
Cellular Imaging Flow-cytometer Cell Sorting and Beyond, Yasuyuki Ozeki, Nao Nitta, Takeaki Sugimura, Akhiro Isazaki, Hitoshi Ikami, Dino Di Carlo, Yoichiro Hooshkavar, Sotaro Uemura, Kisesuke Goda, Univ. of Tokyo, Japan, Japan Science and Technology Agency, Japan; Univ. of California, Los Angeles, USA, Nara Inst. of Science and Technology, Japan. We present a groundbreaking machine intelligence technology called “intelligent image-activated cell sorting” that achieves high-throughput image-triggered sorting of single cells by integrating high-speed fluorescence microscopy, cell focusing, cell sorting, and deep learning.

Thomas Udem studied physics at the University of Giessen and at the University of Washington. In 1997 he got his PhD from the University of Munich (LMU). After a short post doc at the NIST Boulder he returned Munich to become a research fellow MPQ and since 2016 professor at LMU.
AM4I.1 • 16:00
Wide-field magnetic imaging of sub-50 nm ferromagnetic nanoparticles for time-resolved biophysical-mechanical orientation measurements, Zeeshawn Kazi1, Isaac Shelby1, Nicholas Brunelle1, Hideyuki Watanabe1, Kohei M. Itoh1, Paul Wiggins1, Kai-Mei Fu1; 1UW Physics Dept., USA; 2Electrical Engineering, Univ. of Washington, USA; 3Bioengineering, Univ. of Washington, USA; 4Electronics and Photonics Research Inst., National Inst. of Advanced Industrial Science and Technology (AIST), Japan; 5School of Fundamental Science and Technology, School of Fundamental Science and Technology, Japan; 6Spintronics Research Center, Keio Univ., Japan. We present the use of individual carbon nanotubes for generating and manipulation of photons on a chip.

AM4I.2 • 16:15
Nanoplasmonic Interferometric Sensor for Multiplex Detection of MMP-9 and TIMP-1, Yifeng Qian1, Yu-Han Ho2, Sushil Kumar1, Anirudh Ray1, Xuanhong Cheng1, Filbert Bartoli1; 1Electrical and Computer Engineering Dept., Lehigh Univ., USA; 2Shanghai Industrial µTechnology Research Inst., China; 3Bioengineering Dept., Lehigh Univ., USA. The secretion of MMP-9 and TIMP-1 was detected simultaneously using a nanoplasmonic interferometric sensor. Dynamic and multiplexed sensing of two secretory proteins suggests the biosensor holds good promise for cell function analysis.

AM4I.3 • 16:30
Holographic Microscopy with Acoustic Modulation for Detection of Nano-sized Particles and Pathogens in Solution, Anvrdra Ray1, Muhammad A. Khalid1, Andrejus Demcenko1, Mustafa Dalgat1, Derek Tseng1, Julien Reboud1, Jonathan Cooper1, Aydogan Ozcan1; 1Univ. of California, USA; 2Univ. of Glasgow, UK. We present a method for the detection of nanoparticles in solution using an acoustically actuated holographic microscope. This type of microscopy can be used for high-throughput biosensing applications, e.g., detection of viruses in a liquid.

AM4J.1 • 16:00 • Invited
Single-carbon-nanotube Photonics and Optoelectronics, Yuchiro K. Kato1; RIKEN, Japan. Single-walled carbon nanotubes exhibit telecom-band emission at room temperature and can be directly synthesized on silicon substrates. Here we discuss the use of individual carbon nanotubes for generating and manipulation of photons on a chip.

AM4J.2 • 16:30 • Invited
Graphene-Based Transparent Photodetector Array for Multiplane Imaging, Dehui Zhang1, Zhen Xu1, Zhengyu Huang1, Audrey Rose Gutierrez2, Il Yong Chun1, Cameron J. Blocker1, Gong Cheng1, Zhe Liu1, Jeffrey A. Fessler1, Zhaohui Zhong1, Theodore B. Norris1; 1Univ. of Michigan, USA. We report a transparent photodetector array using graphene as both the active pixel and interconnect material. We demonstrate imaging at multiple focal planes with these arrays. Further applications of position tracing will also be discussed.

AM4K.1 • 16:00 • Invited
Dispersion-engineered and Polarization-insensitive Metasurfaces for Broadband Achromatic Optics, Wei-Ting Chen1, Federico Capasso1; 1Harvard Univ., USA. Chromatic aberrations are challenging to correct. We show dispersion-tailed and polarization-insensitive metasurfaces comprising anisotropic nanofins that can correct the chromatic aberrations in lens systems (from singlet lenses to sophisticated microscope objectives) with unprecedented compactness.

AM4K.2 • 16:30 • Invited
Metasurface Devices for AR/VR, Byoungho Lee1, Gun-Yeol Lee1, Jong-Young Hong1; 1Electrical and Computer Engineering, Seoul National Univ., South Korea (the Republic of). We introduce recent achievements on metasurface optical applications. In particular, metasurface holography with full complex-amplitude holograms and metalens for augmented reality display with large viewing angles are discussed and their outlook is also discussed.

SM4L.1 • 16:00 • Invited
Hybrid Fibers for Dispersion Management at 1 μm, Swetlana Alshekina1, Mikhail Yashkov2, Mikhail Salganskiii3, Denis Lipatov2, Liudmila Iskhakova1, Mikhail Bubnov1, Alexei Guryanov2, Mikhail Likhachev1; Fiber Optics Res. Ctr the RAS, Russia; 2Inst. of High Purity Substances of the Russian Academy of Sciences, Russia. Hybrid fibers with high (60-400 ps/nm·km) anomalous dispersion at 1.06 μm were developed. Utilization of such fibers allowed us to fabricate femtosecond all-fiber master oscillator and nonlinear chirped pulses compressor (Pout>3 kW).

SM4L.2 • 16:30
Efficient High-power Single-mode Yb Three-level Cladding-pumped All-solid Photonic Bandgap Fiber Lasers at ~978nm, Turghun Matniyaz1, Wensong Li1, Monica Kalichevsky-Dong1, Thomas Hawkins1, Joshua Parsons1, Guancheng Gu3, Liang Dong1; 1Clemson Univ., USA; 2Dept. of Electronic Engineering, Xiamen Univ., China; 3Coherent/Nufern, USA. We report an efficiency of 62.7% with regard to the launched pump from a Yb cladding-pumped fiber laser at ~978nm. ~84W with an M2 of 1.11/1.12 was achieved, a significant improvement from a flexible fiber.
**FM4M.1 • 16:00**

High Harmonic Generation in Reflection and Transmission from Gallium Arsenide, Nobuhisa Ishii, Peiyu Xia, Changsu Kim, Faming Lu, Teruto Kanai, Hidetoshi Akima, Jiro Itatani; Inst. for Solid State Physics, Japan. High harmonic generation in reflection and transmission from gallium arsenide is investigated using femtosecond infrared pulses. Harmonic spectra obtained in both geometries show drastic difference with each other, indicating significant contribution of nonlinear propagation.

**FM4M.2 • 16:15**

Modeling Harmonic Generation in Polycrystalline ZnSe, Michael Hastings, Kevin Werner, Aaron Schewensberg, Brian L. Wilner, Drake Austin, Christopher Wolfe, Trenton Ersley, Laura Vanderhoeft, Anthony Valenzuela, Enam Chowdhury, Jerome V. Moloney, Miroslav Koliesik; College of Optical Sciences, Univ. of Arizona, USA; Dept. of Physics, The Ohio State Univ., USA; Oak Ridge Inst. for Science and Education, USA; SURVICE Engineering, USA; Weapons and Materials Research Directorate, U.S. Army Research Lab, USA; Sensors and Electromagnetic Devices Directorate, U.S. Army Research Lab, USA. High harmonic generation in polycrystalline ZnSe is modeled as an effective medium. The non-perturbative behavior observed experimentally was recreated, showing that an effective model captures the underlying physics.

**FM4M.3 • 16:30**

Dipole Phase of High-harmonics from Crystals, Yongsing You; Stanford Univ., USA. Abstract not available.

**SM4N.1 • 16:00**

Blue and Ultraviolet Vertical-cavity Surface-emitting Lasers, Aya Haglund, Michael Bergmann, Filip Hjort, Ehsan Hashemi, Jørgen Bengtsson, Johan Gustavsson; Chalmers Univ. of Technology, Sweden. We will summarize state-of-the-art results in III-nitride-based vertical-cavity surface-emitting lasers (VCSELs) for blue and ultraviolet emission, including our schemes for optically guided devices and our approach for UV-VCSELs with double dielectric distributed Bragg reflectors.

**SM4N.2 • 16:30**

Beam Pattern Projecting On-Chip Lasers at Visible Wavelength, Yoshihata Kurosaka, Kazuyoshi Hinose, Akio Ito, Masahiro Hitaka, Akira Higuchi, Takahiro Suyama, Yu Takiguchi, Yoshiro Nomoto, Soh Uenoyama, Tadatakai Edamura; Hamamatsu Photonics, Japan. We have successfully demonstrated pattern projecting semiconductor lasers at the red wavelength, for the first time. The two-dimensional pattern was directly emitted on the screen, at the red wavelength, without any lens or scanning system.

**SM4N.3 • 16:30**

Arbitrary Optical Waveform Generation by Nonlinear Frequency-to-Time Conversion, Daniel E. Mittelberger, Ryan Murr, Mathew Hamamoto, Matthew Prantil; Lawrence Livermore Natl Lab, USA. We propose and demonstrate a novel method of arbitrary optical temporal patterning for generation of long (330 ps) unchirped waveforms with picosecond features. The method is based on frequency-to-time conversion of an imposed spectral pattern.
Week of 7–10 May 2019

FM4A • Quantum Nanophotonics II—Diamond & Boron Nitride—Continued

FM4A.4 • 16:45
Photic bands in 230 space groups, Ling Li, Haruki Watanabe1,2,3,3, Inst. of Physics, Chinese Academy of Sciences, China; 2Dept. of Applied Physics, Univ. of Tokyo, Japan. We present the symmetry constraints on photonic bands for all 230 space groups with time-reversal symmetry. The results of minimum band connectivities provide useful design insights for photonic crystals, metamaterials, and topological lattices.

FM4A.5 • 17:15
Tuning of Quantum Emitters in Hexagonal Boron Nitride, Noah Mendelson1, Niko Nikolay1,2,3, Zai-Quan Xu1, Tong Toan Tran1, Nikola Sazdak1,2, Florian Bohm1,2, Bernd Sontieder1,1, Oliver Koschnick1,2,2, Miros Toh1,1, Igor Aharonovich1,1, Univ. of Technology Sydney, Australia; 2AG NANOoptik, Humboldt Universi-

FM4B • Topological Photonics II—Continued

FM4B.4 • 16:45
Integrated photonic devices for measure-

FM4B.5 • 17:00
Field Trial of Long Distance Quantum Key Distribution with Polarization Encoding Through Installed Aerial Fibre, Dong-Dong Li1,2,3, Song Gao1, Guo-Chun Liu1,2,3, Li Xue1,2,3, Li-Wei Wang1,2,3, Chang-Bin Lu1,2,3, Yao Xiang1,2,3, Zhi-Yan Zhao1,2,3, Long-Chuan Yan1,2,3, Zhi-Yu Chen1,2,3, Jiannong Liu1,2,3,4, Quantum Cnt, China; 2Univ. of Science and Technology of China, China; 3State Grid Information & Telecommunication Co., Ltd., China; 4Quantum Cnt (Beijing), China. We experimentally demonstrate quantum key distribution with polarization encoding through installed aerial fibre link. The fast vibration of polarization is compensated with a homemade feedback module. The key rate reaches 2 kbps over 68-km-long fiber.

FM4B.6 • 17:15
Non-scattering Systems for Field Localiza-

FM4B.7 • 17:30
Towards Experimental Implementation of Quantum-Enabled Bandwidth and Power Efficient Communications, Ivan A. Burenov1,2, M. V. Jablon1,2, Driss El Idrissi1, Abbdella Batty1, Sergey V. Polyakov1,2, Joint Quantum Inst., USA; 3INT, USA; 4Physics, Queen's Univ., Canada. We experimentally demonstrate diagonalization of a 3x3 Hamiltonian using continuous-wave laser pulses. We observe the revival of the eigenstates of the system at time intervals of the order of a nanosecond. The time evolution of the system is monitored by the detection of the transmitted light.

FM4C • New Systems for Quantum Communications—Continued

FM4C.4 • 16:45
Integrated photonic devices for measure-

FM4C.5 • 17:00
Field Trial of Long Distance Quantum Key Distribution with Polarization Encoding Through Installed Aerial Fibre, Dong-Dong Li1,2,3, Song Gao1, Guo-Chun Liu1,2,3, Li Xue1,2,3, Li-Wei Wang1,2,3, Chang-Bin Lu1,2,3, Yao Xiang1,2,3, Zhi-Yan Zhao1,2,3, Long-Chuan Yan1,2,3, Zhi-Yu Chen1,2,3, Jiannong Liu1,2,3,4, Quantum Cnt, China; 2Univ. of Science and Technology of China, China; 3State Grid Information & Telecommunication Co., Ltd., China; 4Quantum Cnt (Beijing), China. We experimentally demonstrate quantum key distribution with polarization encoding through installed aerial fibre link. The fast vibration of polarization is compensated with a homemade feedback module. The key rate reaches 2 kbps over 68-km-long fiber.

FM4C.6 • 17:15
Entangled Photon Transmission from a Quantum Dot over Loop-back Fiber in Cambridge Network, Zi-Heng Xiang1,2,3, Jan Huwe1, R. Mark Stevenson1, Joanna Sopczak1, Martin Ward1, Ian Fanner1,2, Steven T. Cundiff1, Alexander Szameit1,1, Haruki Watanabe1,2,3,1, Song Gao1, Guo-Chun Liu1,2,3,1, Li Xue1,2,3,1, Li-Wei Wang1,2,3,1, Chang-Bin Lu1,2,3,1, Yao Xiang1,2,3,1, Zhi-Yan Zhao1,2,3,1, Long-Chuan Yan1,2,3,1, Zhi-Yu Chen1,2,3,1, Jiannong Liu1,2,3,1,4, Quantum Cnt, China; 2Univ. of Science and Technology of China, China; 3State Grid Information & Telecommunication Co., Ltd., China; 4Quantum Cnt (Beijing), China. We experimentally demonstrate quantum key distribution with polarization encoding through installed aerial fibre link. The fast vibration of polarization is compensated with a homemade feedback module. The key rate reaches 2 kbps over 68-km-long fiber.

FM4C.7 • 17:30
Toward Experimental Implementation of Quantum-Enabled Bandwidth and Power Efficient Communications, Ivan A. Burenov1,2, M. V. Jablon1,2, Driss El Idrissi1, Abbdella Batty1, Sergey V. Polyakov1,2, Joint Quantum Inst., USA; 3INT, USA; 4Physics, Queen's Univ., Canada. We experimentally demonstrate diagonalization of a 3x3 Hamiltonian using continuous-wave laser pulses. We observe the revival of the eigenstates of the system at time intervals of the order of a nanosecond. The time evolution of the system is monitored by the detection of the transmitted light.
SM4E • High-Average Power Laser Systems—Continued

SM4E.3 • 16:45
Towards a Joule-Class Ultrafast Thin-Disk Based Amplifier at Kilohertz Repetition Rate, Clemens Herkommer1,2, Peter Krötz1, Sandra Klingebiel1, Christoph Wandt1, Dominik Bauer1, Knut Michel1, Reinhard Kienberger1, Thomas Metzger1; TRUMPF Scientific Lasers GmbH & Co. KG, Germany; 2Physik Dept., Technische Universität München, Germany; TRUMPF Laser GmbH, Germany. We report on the development of a thin-disk based multipass amplifier operating at 1 kHz repetition rate. The chirped pulse amplifier delivers 600 mJ pulses before compression. A Joule-class laser source with sub-ps pulse durations is currently under construction using further amplifier stages.

SM4E.4 • 17:00
Invited Laser Technologies for PW-Class Peak Power at Multi-kW Average Power, Thomas Spinka1, David Alessi1, Andrew J. Bayramian1, Kyle Chesnut1, Alvin Erlandson1, Thomas Galvin1, David Gibson1, Brendan Reagan1, Craig Siders1, Emily F. Sistrunk1, Constantin Spinka1,2, Lawrence Livermore National Lab, USA; 1Physics and Astronomy, Univ. of California - Irvine, USA; 2Physik Dept., Technische Universität München, Germany; TRUMPF Laser GmbH, Germany. We present multi-kW average power, PW-class peak power short pulse (≤150 fs) high rep-rate (≥10 Hz) laser designs based on Nd:glass and Ti:YLF, and explore progress on technologies that promise to enable or enhance their capabilities.

SM4F • Precision Spectroscopy—Continued

SM4F.2 • 17:00
Frequency-comb-referenced phase spectroscopy measures plasmonic dynamics with picometre resolution, Arnh D. Nguyen1, Byung Jee Chun1, Young-Jin Kim1; Nanyang Technological Univ. (NTU), Singapore. A 1.94Å dynamic motion of plasmonic nanohole array was measured with a 1.67 pm resolution using a frequency comb as the light source. This frequency-comb-referenced plasmonic phase spectroscopy could provide high speed, high resolution, and traceability to a time standard.

SM4F.3 • 17:15
Metamaterial infrared refractometer for detecting broadband complex refractive index of liquid material, Hibiki Kagami1, Tomo Arumyja1, Makoto Tanaka1, Kaisuke Masuda1; Nobi Nishiyama1, Shigehisa Arai1; Tokyo Inst. of Technology, Japan. We developed a metamaterial refractometer for detecting broadband infrared complex refractive index of liquid materials. Using the device, the complex infrared refractive index of PMMA from 40 to 120 THz was measured for the first time.

SM4F.4 • 17:30
Real-time Reference for Frequency-shifted Fourier-transform Spectrometers using an Arbitrary-wavelength CW Reference Laser, Eric Martin1,2, Christopher L. Smallwood3,1; Torben L. Purz1, Hanna G. Ruth1, Steven T. Cundiff1,2; 1Univ. of Michigan, USA; 2Monstr Sense Technologies, USA; 3Dept. of Physics and Astronomy, San Jose State Univ., USA. Frequency-shifted interferometers enable significant reduction of the measurement noise in Fourier-transform spectrometry and distance metrology. We demonstrate a real-time solution for referencing these interferometers with nanometer precision using an arbitrary-wavelength CW reference laser.

SM4G • Access & Radio Over Fiber—Continued

SM4G.4 • 16:45
Quasicoherent Receivers for Access Networks Using Fullwave Rectification BasedEnvelope Detection, Varghese A. Thomas1, Siddharth Varughese1, Stephen E. Ralph1; 1Georgia Inst. of Technology, USA. We demonstrate a novel quasicoherent receiver architecture based on envelope detection employing fullwave rectification. Signalings rates of up to 18 Gbaud (PAM-2) were experimentally achieved using low receiver bandwidths and low received powers.

SM4H • Advanced Optical Technologies for Cells and Tissues—Continued

SM4H.3 • 16:45
Deciphering Bioengineered Tissues Functional Properties with Label-free Optical Techniques, Laura Marzuoli1,2, Univ. of California Davis, USA. We present studies demonstrating fluorescence lifetime techniques as a means for monitoring the recellularization processes in vascular constructs grown in bioreactors and for assessing changes in bioengineered cartilage functional properties during matrix maturation.

SM4H.4 • 17:15
Determining Metabolic Changes Associated with Tamoxifen Treatment and Resistance in Breast Cancer, Jessica P. Houston1, Kevin D. Houston1, David Rodriguez1, Yan Zheng1, 1New Mexico State Univ., USA. Autofluorescence lifetimes of endogenous NAD(P)H are altered when breast cancer cells are treated with tamoxifen and is distinguishable when comparing tamoxifen sensitive and resistant breast cancer cells.

SM4H.5 • 17:30
Ultrasimanother-assisted In Situ 3D Optical Imaging And Manipulation: Challenges And Opportunities To Access Deep Tissue, Matteo Giuseppe Scopelliti1, Yasin Karimi1,2, Maysamee Chamanzari1, Carnegie Mellon Univ., USA. We demonstrate that non-invasive ultrasound can be used to sculpt reconfigurable 3D optical patterns within tissue for light delivery (optical stimulation) and light collection (imaging) deep into the medium.
### AM4J.4 • 16:45
Torsional Shear Stress Sensing Using Elliptically-Shaped Nanopillar Light-Emitting Diodes

**By Thomas Stettner**

This talk demonstrates an approach for detecting shear stress using elliptically-shaped nanopillar light-emitting diodes (ELD) embedded in a shear stress sensor. The ELDs are designed to exhibit enhanced optical properties under torsional shear stress, allowing for the detection of shear-induced strain. The sensor design and experimental results will be presented, showcasing the potential of this technology for monitoring shear stress in various applications.

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### AM4J.5 • 17:00
Mapping Nanoscale Dynamics and Features Throughout Entire Mammalian Cells by 3D Single-Molecule Tracking and 3D Super-Resolution Imaging

**By Anna-Karin Gustavsson**

The presentation will focus on demonstrating how 3D single-molecule tracking and super-resolution imaging can be combined to investigate the dynamics of nanoscale features throughout entire mammalian cells. This work provides insights into the complex cellular environment and opens new avenues for understanding cellular processes at a nanoscale level.

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### AM4J.6 • 17:30
Comparison of Substrate-dependent SERS Chemical-enhancement Effects in Au and Ag for Compositional Analysis of Single-stranded DNA

**By Phuong H. Nguyen**

This talk will compare the chemical enhancement effects of Au and Ag substrates on the SERS spectra of single-stranded DNA. The results from this study will aid in the development of more effective SERS substrates for DNA analysis, offering improved sensitivity and selectivity in DNA detection applications.

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### SM4J.3 • 16:45
A hybrid nanowire photo-detector integrated in a silicon photonic crystal, Masato Takiguchi

**By Gregor Koblmueller**

This presentation will introduce a novel hybrid nanowire photo-detector that is integrated into a silicon photonic crystal. The design combines the benefits of both photonic crystal and nanowire technologies, leading to enhanced optical performance and sensitivity in photodetection applications.

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### SM4J.4 • 17:00
Vertically Stacked Silicon Nanowire Photodetectors for Spectral Detection, Jiajun Meng

**By Kenneth Crozier**

The talk will discuss vertically stacked silicon nanowire photodetectors designed for spectral detection applications. These devices demonstrate improved spectral response and sensitivity compared to traditional photodetector designs, making them suitable for advanced spectral detection tasks.

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### SM4J.5 • 17:15
Spectrally selective detection with In$_2$O$_3$/n-Si radial heterojunction nanowire photodiodes, Han-Don Um

**By Daniel Ruhstorfer**

This presentation will present spectrally selective detection capabilities of radial heterojunction nanowire photodiodes made from In$_2$O$_3$/n-Si. The selective detection properties are demonstrated, offering potential applications in narrowband filtering and optical sensing.

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### SM4J.6 • 17:30
Tuning Lasing Emission towards Long Wavelengths in GaAs-In$_{0.1}$Al$_{0.9}$As Core-Multishell Nanowires, Thomas Stettner

**By Paul J. Schmiedeke**

The talk will focus on the tuning of lasing emission wavelengths in GaAs-In$_{0.1}$Al$_{0.9}$As core-multishell nanowires. By controlling the composition and structure of these nanowires, it is possible to tune the emission towards longer wavelengths, expanding the applicability of these materials in optoelectronic devices.
FM4A • Quantum Nanophotonics II: Diamond & Boron Nitride—Continued

FM4B • Topological Photonics II—Continued

FM4C • New Systems for Quantum Communications—Continued

FM4D • Excitons in Condensed Matter Systems—Continued

FM4B.8 • 17:45 Observation of corner states in topological photonic crystal slabs, Xiaodong Chen1, Wei-Min Deng1, Fu-Long Shi1, Jian-Wen Dong1; 1Sun Yat-Sen Univ., China. With the near-field scanning measurement, we show the observation of in-gap corner states in topological photonic crystal slabs which consist of periodic dielectric rods on a perfect electric conductor.

FM4C.8 • 17:45 Symmetrical Clock Synchronization with Time-Correlated Photon Pairs, Jianwei Lee1, Lijiong Shen1,2, Alessandro Cerè1, James Troupe1, Antia Lamas-Linares1, Christian Kurtsiefer1; 1Centre for Quantum Technologies, Singapore; 2Physics, National Univ. of Singapore, Singapore; 1Applied Research Labs, USA, 4Texas Advanced Computing Center, USA. We demonstrate a distance-independent clock synchronization protocol, using counter-propagating photons from spontaneous parametric down-conversion pair sources, secure against symmetric-delay attacks. With rates of 200 coincidences/s, we record a precision of 51ps over 100s.

FM4D.7 • 17:45 Gate-tunable terahertz emission at oxide interfaces via ultrafast spin-to-charge current conversion, Qi Zhang1, Deshun Hong1, Changjiang Liu1, Richard Schaller1, Dillon Fong1, Anand Bhattacharya1, Haidan Wen1; 1Argonne National Lab, USA. We demonstrate gate-tunable spintronic terahertz (THz) emission at the interface of LaAlO3 / SrTiO3 due to ultrafast spin-to-charge current conversion. The soft phonon mode of SrTiO3 is also observed in the emitted THz spectra.

17:30–18:30 Diversity and Inclusion Reception, Winchester Room, Hilton San Jose

18:30–20:00 Lasers for Attosecond 2.0, Room 230A

18:30–20:00 NEW Workshop 2: Will Quantum Computing Actually Work?, Room 210A
NEW Workshop 3: What Will be the Largest Commercial Application for Optical Frequency Combs in 10 Years?, Room 210B
SM4E.6 • 17:45
Deep Learning for Real-Time Modeling of High Repetition Rate, Short Pulse CPA Laser Amplifier, Sandrine I. Herriot1, Thomas Galvin1, Brenda Ng1, Emily Sistrunk Link1, Shawn Betta2, Craig Siders3, Thomas Spinke4, Daniel Smith1, Sachin Talathi1, Wade Williams1, Constantin Haefer1; 1LLNL, USA; 2Unknown, USA; 3UC Irvine, USA. Real-time feedback loop of kHz repetition rate, high intensity laser sets new challenges to the traditional modeling concept. We present a deep learning approach to model amplification and laser-induced damage in CPA laser system enabling high speed analysis above tens of kHz.

SM4F.5 • 17:45
Calibration-free Wavelength Measurement with Sub-femtometer Resolution Based on All-fiber Rayleigh Speckles, Wang Shuai1, Zhaopeng Zhang1, Xinyu Fan1, Bin Wang1, Zuyuan He1; 1Shanghai Jiao Tong Univ., China. We propose an ultra-high resolution wavelength measurement approach with all-fiber based system. By extracting the Rayleigh speckles of a single mode fiber, we achieve a spectral resolution of 0.3 fm in optical frequency measurement.

SM4H.6 • 17:45
Nanophotonic Neural Probes for in vivo Light Sheet Imaging, Wesley D. Sacher1, Xinyu Liu1, Ilan Felts Almog2, Thomas Lordello2, Fu-Der Chen2, Homeira Moradi-Chameh2, Azadeh Nadian2, Michael Chang1, Trevor Fowler1, Taufik Valiante3,4, Andres M. Lozano5,6, Laurent Moreaux1, Joyce K. Poon2,3, Michael L. Roukes1; 1Division of Physics, Mathematics, and Astronomy, California Inst. of Technology, USA; 2Dept. of Electrical and Computer Engineering, Univ. of Toronto, Canada; 3Max Planck Inst. for Microstructure Physics, Germany; 4Krembil Research Inst., Canada; 5Division of Neurosurgery, Dept. of Surgery, Toronto Western Hospital, Univ. of Toronto, Canada. We present implantable silicon neural probes with nanophotonic waveguide routing networks and grating emitters for light sheet imaging. Fluorescein beam profiles, fluorescent bead imaging, and fluorescence brain imaging in vivo are presented.
AM4I • Nanobiophotonics—Continued

AM4I.7 • 17:45
Point-of-Care Multiplexing Assay for Dengue Using Barcoded Fluorescent Microspheres, Ryan X. Yuan1, Srishti Garg1, Anupriya Gopalsamy1, Frederic Follouë2, Sachdev Sidhu1, James Dou1, J. Stewart Archison1; 1Dept. of Electrical & Computer Engineering, Univer. of Toronto, Canada; 2Banting and Best Dept. of Medical Research and Dept. of Medical Genetics, Univer. of Toronto, Canada; 3ChipCare, Canada. Chromatic dispersion is utilized to separate fluorescent signals in different fluorescent dyes. The fluorescence intensity of allophycocyanin is used as the barcode fluorophore for specific biomarkers, enabling a four-plex biomarker detection.

SM4J • Light Emission & Detection—Continued

SM4J.7 • 17:45
50 Gb/s PAM4 Low-Voltage Si-Ge Avalanche Photodiode, Binhao Wang1, Xiaoge Zeng1, Di Liang1, Marco Fiorentino1, Wayne Sorin1, Raymond Beau-soleil1; 1Hewlett Packard Enterprise, USA. We demonstrate a 50 Gb/s PAM4 operation of an integrated Si-Ge APD with low breakdown voltage of -10 V. The receiver has achieved -17 dBm optical input power at 50 Gb/s PAM4 with a bit error rate of 2.4×10-4.

AM4K • A&T Topical Review on Flat Optics II—Continued

AM4K.5 • 17:45
Programmable metamaterials & metasurfaces for ultra-compact multi-functional photonics, Apratim Majumder1, Sourangsu Banerji1, Kazumasa Miyagawa1, Monjurul Meem1, Mark Mondol2, Berardi Sensale Rodriguez1, Rajesh Menon1; 1Univ. of Utah, USA; 2MIT, USA. We demonstrate the design and experimental verification of several examples of programmable metamaterials and metasurfaces. Such devices offer the advantage of high-density integration and versatility.

17:30–18:30 Diversity and Inclusion Reception, Winchester Room, Hilton San Jose

18:30–20:00 Lasers for Attosecond 2.0, Room 230A

18:30–20:00 NEW Workshop 2: Will Quantum Computing Actually Work?, Room 210A
NEW Workshop 3: What Will be the Largest Commercial Application for Optical Frequency Combs in 10 Years?, Room 210B
FM4M • Solid State High Harmonic Generation—Continued

**FM4M.7 • 17:45**
Enhancement of Harmonic Generation in Gases Using an All-Dielectric Metasurface, Jared S. Ginsberg¹, Adam C. Overvig¹, M. M. Jadidi¹, Stephanie Malek¹, Gauri Patwardhan¹, Nicolas Swenson¹, Nanfang Yu¹, Alexander Gaeta¹; ¹Applied Physics and Applied Mathematics, Columbia Univ., USA. We design and fabricate a dielectric metasurface for enhancing harmonic generation from gases with mid-infrared pulses. We observe third-harmonic generation in Ar at pump intensities as low as $1.8 \times 10^{12} \text{W/cm}^2$.

SM4N • Surface Emitting Lasers—Continued

**SM4N.7 • 17:45**
Energy-Efficient VCSELs for 200+ Gb/s Optical Interconnects, Gunter Larisch¹, Ricardo Rosales¹, James A. Lott¹, Dieter Bimberg²; ¹Bimberg Chinese-German Center for Green, China; ²Technische Universität Berlin, Germany. Vertical-cavity surface-emitting lasers for 200+ Gbit/s single fiber data transmission systems emitting at 850 nm, 880 nm, 910 nm, and 940 nm are presented showing a heat-to-bit-rate energy efficiency of 240 fJ/bit.

17:30–18:30  Diversity and Inclusion Reception, Winchester Room, Hilton San Jose

18:30–20:00  Lasers for Attosecond 2.0, Room 230A

18:30–20:00  NEW Workshop 2: Will Quantum Computing Actually Work?, Room 210A
NEW Workshop 3: What Will be the Largest Commercial Application for Optical Frequency Combs in 10 Years?, Room 210B
11:30–13:00  JTu2A • Poster Session I and Lunch

JTu2A.1  Response of Porcine Articular Cartilage to Irradiation by an Ultrafast, Burst-Mode Laser, Thomas W. Dzelzains1, Sabrina Hammour1, Robert Marjerink2, Lothar Lilge1, Margarette Akens1, Omer Iliday1, Hamit Kayacigil1, Seydi Yavas1, Sahre Karamuk1, Melissa Prickaerts1, Kailas Cassidy1, Ahmad Golarse1, Virginius Barzdziuk1, Techna Inst., Univ. Health Network, Canada; 2Princess Margaret Cancer Centre, Univ. Health Network, Canada; 3Inst. of Electronics-BAS, Bulgaria; 4Physics, Univ. Of Toronto, Canada; 5Medical Biophysics, Univ. of Toronto, Canada; 6Chemical ad Physical Sciences, Univ. of Toronto Mississauga, Canada. Plasma-mediated ablation by ultrafast pulses is generally considered to be a material-independent process. We show that, in certain circumstances, this assumption may be invalid. Physical processes involved and the impact on applications are discussed.

JTu2A.2  Ultra-short Laser Texturing of Biomimetic Hybrid Thin film Coatings from Natural Polymers and Their Ceramic Composites for Cellular Guidance, Albena Daskalova1, Irina Bliznakova1, Anton Trifonov1, Lilija Angelova1, Heidi Diedler2, Ivan Buchvarov1, Inst. of Electronics-BAS, Bulgaria; 3Faculty of Physics, St. Kliment Ohridski Univ. of Sofia, Bulgaria; 4Dept. of Basic Medical Sciences, Ghent Univ., Belgium. The goal of this study was to combine the osteogenic properties of biopolymers with good mechanical properties of ceramics to design improved implant interface and investigate the effect of laser texturing on surface characteristics of chitosan (CH)/Hydroxyapatite (HA)/ZrO2 composite biofilms.

JTu2A.3  Multivariate Machine Learning Approaches for Data Fusion: Behavioral and Neuroimaging (Functional Near Infra-Red Spectroscopy) Datasets, Amir H. Gandjbakhche1, Hadis Dashtestani1, National Inst. of Health, USA. Coupling behavioral with neuroimaging datasets promises to provide insight into medical data analyses. Here, we investigate the relation between psychiopathic traits and brain activity captured by functional near-infra-red spectroscopy during a moral judgment task.

JTu2A.4  Multifocal Compensative Sensing Spectral Domain Optical Coherence Tomography Based on Bessel Beam, Luying Yi1, Liqun Sun1, Tsinghua Univ., China. We present a method CS-MB-SDOCT, which combines multifocal Bessel beam spectral-domain optical coherence tomography (MB-SDOCT) and compressive sensing (CS) to increase the imaging depth using a spectrometer with lower spectral resolution.

JTu2A.5  An Absorbance Spectrum Estimation-based Accurate Colorization Method for Holographic Imaging of Pathology Slides, Tairan Liu1, Yibo Zhang1, Yujia Huang1, Da Teng1, Yinxu Bian1, Yichen Wu1, Yair Rivenson1, Aydogan Ozcan1, Univ. of California Los Angeles, USA. We present an accurate-color holographic imaging method for pathology slide samples based on absorbance spectrum estimation of histochemical stains, which improves the color accuracy and reduces the required number of illumination wavelengths.

JTu2A.6  Corneal imaging with extended imaging range using dual spectrometer high-resolution SD-OCT, Lulu Wang1, 2NTU, Singapore. A dual-spectrometer SD-OCT system with extended imaging range, high spatial resolution was demonstrated for pig corneal imaging ex vivo. Spectra from the two spectrometers are combined to achieve a 3.4 mm maximum depth range with an axial and lateral resolution of 1.86 µm(n=1.38) and 1.96 µm.

JTu2A.7  Generation of surface plasmonic resonance mode on highly ordered diverse conformation of Au nanostructures, Hyerin Song1, Heesang Ahn1, Seunghun Lee1, Yuxiang Yang1, Yuxiang Yang1, Xiyou He1, Jinrih Huh1, Jietao Liu1, Xiaopeng Shao1, Xiandian Univ., China. We developed a method to realize color imaging through the scattering media based on triple correlation technique. This method enables color imaging through the scattering without the wavefront shaping technique and deconvolution technique.

JTu2A.8  Improving the Temporal Resolution of Speckle based Remote Phonocardiogram Sensing via Laser Modulation, Nisan Ozana1, Zeer Markman1, Ran Califa1, Zeev Zalevsky1, Bar Ilan Univ., Israel, 2Continue Biometrics, Israel. We present a method for remote phonocardiogram sensing which employs temporal modulation of the illumination laser. This method yields a significant enhancement of the temporal bandwidth of the captured speckle image sequence, thus improving performance.

JTu2A.9  Smart Carbon Fiber Sensing Systems Applied to Biomechanics, Jose R. Galvão1, Tatila Bastos1, Carlos Zamarreno2, John Canning1, Cicero Martelli1, Jean Carlos Cardoza da Silva1, 2Federal Univ. of Technology – Pr, Brazil, 3Univ. of Navarra, Pamplona, Spain, 4Univ. of Technology Sydney, Australia. This paper presents three applications of carbon fiber reinforced polymer with integrated FBG sensor systems in biomechanics. In vivo tests were performed showing that the sensors are robust for the different applications.

JTu2A.10  Color imaging through the scattering media, Lei Zhu1, Yuxiang Yang1, Jietao Liu1, Xiaopeng Shao1, Xiandian Univ., China. We developed a method to realize color imaging through the scattering media based on triple correlation technique. This method enables color imaging through the scattering without the wavefront shaping technique and deconvolution technique.

JTu2A.11  Flat-top Supercontinuum Generation Based on Electro-optic Optical Frequency Comb, Minje Song1, Sang-Pil Han1, Sungil Kim1, Minhyup Song2, Kyungpook National Univ., South Korea (the Republic of); 2Electronics and Telecommunications Research Inst., South Korea (the Republic of). We demonstrate the optical frequency comb based supercontinuum (OFC-SC) with flatness using the pulse shaping technique and the dispersion compensation. Furthermore, we achieve the short pulse width with electro-optic OFC-SC.
In-situ laser fabrication to reduce eccentricity errors in optical encoders, Robin Hahn1, Christof Pruss1, Martina Dambrowski1, Mai Gerngross1, Matthias Schimrer2, Christian Kreisel2, Bernd Sommer2, David Hopp1, Christian Schneider1, Mathias Wenzel1, Wolfgang Osten2, 1Inst. of Applied Optics, Germany; 2Allresist GmbH, Germany; 3Assyst Lasertechnik GmbH, Germany; 4Sision GmbH, Germany; 5Sick Stegmann GmbH, Germany. Rotational encoders are of high importance of nowadays robotic systems. We present a technique for laser based post assembly fabrication, increasing the accuracy, decreasing the alignment effort and giving the possibility of an increased flexibility.

A depth information acquisition method through 3D printed optical components, Joshua Davidson1, Jianan Zhang1, Tim Kan1, Ram Narayanan1, 1Penn State, USA. This paper proposes a method for preparing 3D printed surfaces as commercial quality optical components. Utilizing Formlabs’ 3Sick Stegmann GmbH, Germany. In-situ laser fabrication to reduce eccentricity errors in optical encoders, Robin Hahn1, Christof Pruss1, Martina Dambrowski1, Mai Gerngross1, Matthias Schimrer2, Christian Kreisel2, Bernd Sommer2, David Hopp1, Christian Schneider1, Mathias Wenzel1, Wolfgang Osten2, 1Inst. of Applied Optics, Germany; 2Allresist GmbH, Germany; 3Assyst Lasertechnik GmbH, Germany; 4Sision GmbH, Germany; 5Sick Stegmann GmbH, Germany. Rotational encoders are of high importance of nowadays robotic systems. We present a technique for laser based post assembly fabrication, increasing the accuracy, decreasing the alignment effort and giving the possibility of an increased flexibility.

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Trapped ion slow light: first photonic interaction between a photon from an ion and neutral atoms, John M. Hanneke1, James Siverns2, Qudisa Qurashi1, 1Joint Quantum Inst., USA; 2Inst. for Research in Electronics and Applied Physics, USA; 3US Army Research Lab, USA. Hybrid quantum systems will enable practical implementation of quantum-memory based photonic networking. Using quantum frequency conversion, we slow photons emitted from 133Ba+ using warm 87Rb vapor, demonstrating the first hybrid interaction between ion-emanated photons and neutral atoms.

Measurements of Frequency-Resolved Third-Order Correlations in Quantum Dot Resonance Fluorescence, Yamil A. Nieves1, Andreas Muller1, 1Univ. of South Florida, USA. We investigated the three-photon spectrum of quantum dot resonance fluorescence, revealing significantly more pronounced photon antibunching at the Mollow triplet sidebands and more strongly correlated emission through virtual states than at second order.

Upper Bound on the Duration of Quantum Jumps, Mathias A. Seidel1, Alessandro Cere1, Ricardo Gutierrez-Jauregui1, Rocío Jauregui1, Christian Kurselief1, 1National Univ. of Si- ngapore, Singapore; 2Instituto de Física, UNAM, Mexico; 3Inst. for Quantum Science and Engineering, Texas A&M Univ., USA. We estimate the time scale of quantum jumps from the time correlation of photon pairs generated from a cascade decay in a cold cloud of 10B. We find an upper bound of 21±11 ps.

Experimental observation of multi-atom Dicke states in an atomic vapor using optical 2D coherent spectroscopy, Shaogang Yu1, Michael Titzer1, Yifu Zhu1, Xiaojun Liu1, Hebin Li1, 1Wuhan Inst. of Physics & Mathematics, China; 2Florida International Univ., USA. We report the first observation of two-, three-, four-, five-, six-, and seven-atom Dicke states in an atomic vapor using optical multi-quantum D2 coherent spectroscopy. This has significant implications in the studies of many-body physics.

Characterization of the Superhyperfine Interaction in 171Yb:YVO4, Yao Qi Huan2, Jonathan Kindem1, John G. Bartholomew3, Andrei Faraci2, 1Kavli Nanoscience Inst. and Thomas J. Watson, Sr. Lab, of Applied Physics, California Inst. of Technology, USA; 2Inst. for Quantum Information and Matter, California Inst. of Technology, USA. We computationally characterize the hyperfine energy structure of 171Yb:YVO4 and compare predicted holeburning spectra and coherence times with experimental data. Our simulation can almost the same as the initial protocol with a trusted source.

Quantum Capacitors for Electronic Read-out in Spin-based Quantum Information Processing, Foyua Dianal1, Bahram Nabet1, 1Drexel Univ., USA. Quantum capacitors are demonstrated due to gauging of quantum energy states, which provide an unprecedented electronic read-out for spintronic systems applied in quantum information processing.

BB84 and DDPS-QKD experiments using one polarization-insensitive measurement setup with a countermeasure against detector blinding and control attacks, Muatza M. Alhussein1, Kyo Inoue2, Titas Gertus1, 1National Taiwan Univ., Taiwan; 2NTT Basic Research Labs, NTT Corporation, Japan. This paper demonstrates phase-encoding BB84-based QKD experiments with active basis selection using one interferometer with no phase and polarization controls, unlike conventional BB84-QKD experiments. A countermeasure against detector blinding attack is also implemented.
JTu2A.34
Generating polarization-entangled photon pairs in domain-engineered InAs quantum dots, Hao S. Koo, Varun B. Verma, Thomas Gerrits, Sae Woo Nam, Richard P. Minnir, Information Technology Lab, NIST, USA; 2Physical Measurement Lab, National Inst. of Standards and Technology, USA. Using a periodically poled LiNbO3 crystal that is doped-engineered for two simultaneous type-II down-conversion processes, we demonstrated polarization-entangled photon-pair generation.

JTu2A.35
Converting Position Correlation into Polarization Entanglement, Chithrabhanu Penumaggati, Alexander Lohmann, Alexander Ling 1, 'Centre for quantum technologies, India; 2Physics, National Univ. of Singapore, Singapore. The photons pairs generated by parametric down conversion of a laser beam have inherent position and momentum correlations. We generate bright, high fidelity polarization entangled photons by manipulating the position correlations using a Mach-Zehnder interferometer.

JTu2A.36
Bright Beams of Intensity Difference Squeezed Light for Mach-Zehnder interferometer, Remy W. Spuris, Nicholas R. Brewer, Meng-Chang Wu 1, Paul D. Lett. 'Joint Quantum Inst., The Univ. of Maryland, USA; 2Joint Quantum Inst., National Inst. of Standards and Technology, USA; 3Inst. of Physical Science and Technology, The Univ. of Maryland, USA. We present a method for using bright beams of intensity difference squeezed light to perform sub-shot-noise imaging. The intensity correlated twin beams are generated by four wave mixing in rubidium vapour.

JTu2A.37
Detection of 10 dB vacuum squeezing at 1064 nm by balanced homodyne detectors with a common mode rejection ratio more than 80 dB, Chien-Ming Wu, Shu-Rong Wu, Yi-Ru Chen, Hsin-Chung Wu, Ray-Kuang Lee, 'National Taiwan Hua Univ., Taiwan. Quantum noise reduction up to 10 dB is observed, with the help of our home-made balanced homodyne detector (BHD), characterized with a Common Mode Rejection Ratio (CMRR) more than 80 dB.

JTu2A.38
Realization of optical isolator at room temperature in miniaturized vapor cell using light induced atomic desorption, Elinar Talke, P. Avor, Mark Dikopaltsev, Ueli Levy, Dept. of Applied Physics, The Hebrew Univ. Jerusalem, Israel; 2RAFAEL, Science Center, Rafael Ltd, Haifa,Israel. A compact, on-chip atomic optical isolator using light induced atomic desorption technique is demonstrated. A millimeter size fabricated vapor cell integrated with small permanent magnets of ~ 300 Gauss is used to realize an atomic optical isolator at room temperature.

JTu2A.39
GHz Photon-number-resolving Detection with InGaAs/InP APD, Yan Liang, Zhihe Liu, Qilai Fei, 'Physics, National Univ. of Singapore, Singapore. The photons pairs generated by parametric down conversion of a laser beam have inherent position and momentum correlations. We generate bright, high fidelity polarization entangled photons by manipulating the position correlations using a Mach-Zehnder interferometer.

JTu2A.40
Design and Production of Femtosecond Laser Writable Borate-based Glasses for Photonic Devices, Antonio Dias, Francisco Muñoz, Pedro Moreno-Zarate, Julia Atienzar 1, Ana Urbieta 4, Paloma Fernandez 4, Marina Garcia 1, Mandeep Khatoniar 1,4, Nicholas Menon 4,1, 'Physics, Graduate Center, USA; 2Physics, National Inst. of Standards and Technology, USA. We demonstrate the generation of entangled photon pairs via type-I/0-parametric down conversion in ultra-thin lithium niobate in which momentum between the pump photon and daughter photons is not conserved.

JTu2A.41
Generating polarized entanglement from a variable atomic geometry, Kristen Holthaus, coworkers at Indiana Univ., USA. We theoretically and experimentally investigate the ‘hidden’ property of quantum steerability. In particular, we find that there are initially unsteerable states which can reveal the steerability by using local filtering operations on individual quantum systems.

JTu2A.42
Design and Production of Femtosecond Laser Writable Borate-based Glasses for Photonic Devices, Antonio Dias, Francisco Muñoz, Pedro Moreno-Zarate, Julia Atienzar 1, Ana Urbieta 4, Paloma Fernandez 4, Marina Garcia 1, Mandeep Khatoniar 1,4, Nicholas Menon 4,1, 'Physics, Graduate Center, USA; 2Physics, National Inst. of Standards and Technology, USA, We demonstrate the generation of entangled photon pairs via type-I/0-parametric down conversion in ultra-thin lithium niobate in which momentum between the pump photon and daughter photons is not conserved.

JTu2A.43
Non-phase Matched Spontaneous Parametric Down Conversion in Ultra-thin Lithium Niobate, Cameron S. Okoth 1, Saturdays. Tomas Santiago 1, Andrea Cavanna 1, Maria Chekhova 1, 'Max-Planck Inst. for the Science of Light, Germany; 2Physics, Univ. Erlangen-Nuremberg, Germany. We report the generation of entangled photon pairs via type-I/0-parametric down conversion in ultra-thin lithium niobate in which momentum between the pump photon and daughter photons is not conserved.

JTu2A.44
Observing the quantum Cavendish cat with a nondestructive weak measuring device, Josep Kom, Dang-Gillim, Yong-Su Kom, Sang-Yun Lee, Sang-Wook Han, Sung Moon, Yoon-Ho Kim, Young-Woo Cho, 'South Korea Inst. of Science & Technology, South Korea; 2Pohang Univ. of Science and Technology (POSTECH), South Korea (the Republic of). In this work, we report the experimental observation of the quantum Cavendish cat effect with a nondestructive weak measuring device. A quantum pointer after the weak quantum measurement indicates that the polarization can be found at the path the photon did not take.

JTu2A.45
Realization of optical isolator at room temperature in miniaturized vapor cell using light induced atomic desorption, Elinar Talke, P. Avor, Mark Dikopaltsev, Ueli Levy, Dept. of Applied Physics, The Hebrew Univ. Jerusalem, Israel; 2RAFAEL, Science Center, Rafael Ltd, Haifa,Israel. A compact, on-chip atomic optical isolator using light induced atomic desorption technique is demonstrated. A millimeter size fabricated vapor cell integrated with small permanent magnets of ~ 300 Gauss is used to realize an atomic optical isolator at room temperature.

JTu2A.46
High-Resolution Mid-Infrared Spectral Reconstruction using a Wavelength Consistent Filter, Bao L. Yao, Benjamin J. Craig, Qiaojun Meng, Vivek R. Shrestha, Jasper Cadusch, Kenneth Crozier, 'Univ. of Melbourne, Australia. We demon- strate mid-infrared computational spectroscopy using an array of coaxial aperture filters. We experimentally determine material transmission spectra using an algorithm whose in- puts are the transmission spectra and the power transmitted through each filter.

JTu2A.47
Selective Delamination of Thin Films from Ceramic Surfaces Using a Subwavelength Coaxial Aperture Array, Chiara Pompilio, Muniyat Rafa, Ya Cheng 1,4, Tao Lu 1, 2State Key Lab of Preci- sion Spectroscopy, East China Normal Univ., China; 3Dept. of Electrical and Computer Engineering, Univ. of Victoria, Canada; 3State Key Lab of High Field Laser Physics, Shanghai Inst. of Optics and Fine Mechanics, China; 4XXL–The Extreme Opto-electromechanics Lab, East China Normal Univ., China. We demonstrate an electrically tunable ultrahigh-Q optome- chanical device (mechanical Q ~ 2 x 10^11) for the mechanical mode at 100.32 MHz by monolithically integrating an on-chip lithium niobate microresonator (optical Q ~ 10^11) with a pair of in-plane microelectrodes.

JTu2A.48
Selective polarization of the quantum information. To see this, imagine a quantum system. There are initially unsteerable states which can reveal the steerability by using local filtering operations on individual quantum systems.

JTu2A.49
Monolithic integration of an electrically tunable ultrahigh- Q opticalmechanical device, Zhiwei Fang 1, Sanaul Haque, Jintian Lin3, Rongbo Wu 3, Jianhao Zhang 3, Min Wang 1,4, Munyat Rafa, Ya Cheng 1,4, Tao Lu 1, 2State Key Lab of Preci- sion Spectroscopy, East China Normal Univ., China; 3Dept. of Electrical and Computer Engineering, Univ. of Victoria, Canada; 3State Key Lab of High Field Laser Physics, Shanghai Inst. of Optics and Fine Mechanics, China; 4XXL–The Extreme Opto-electromechanics Lab, East China Normal Univ., China. We demonstrate an electrically tunable ultrahigh-Q optome- chanical device (mechanical Q ~ 2 x 10^11) for the mechanical mode at 100.32 MHz by monolithically integrating an on-chip lithium niobate microresonator (optical Q ~ 10^11) with a pair of in-plane microelectrodes.

JTu2A.50
Laser-Induced-Modification Raman Spectroscopy for Prob- ing Microscopic Structural Variation Beyond Conventional Techniques: CZTSe as an Example, Qi Cong, Yong Zhang, 1UNC-Charlotte, USA. Laser-induced-modification Raman spectroscopy coupled with high spatial resolution and high-temperature capability is demonstrated to obtain additional structure information beyond what the conven- tional techniques offer, revealing microscopic scale variation between similarly small alloys.

JTu2A.51
Graphene-coated Suspended Metallic Nanostructures for Fast and Sensitive Optomechanical Infrared Detection, Mohammad Wahiduzzaman Khan, 1Physics, National Inst. of Standards and Technology, USA. We have found enhanced absorptance resulting in increased sensitivity and faster operation owing to graphene’s extrapo- larization and thermal properties.

JTu2A.52
Room Temperature Control of Valley Coherence in Bilayer WSx, exciton Polaritons, Mandeep Khatoniar 1,4, Nicholas Yama, 1,2, Argh Ghaszaryan, Sanaul Haque, 1,2, Qizhong Li, 1,2, Yong-Su Kim, 1,2, Dong-Gil Im, 1,2, Young-Wook Cho 1,2, 'South Korea Inst. of Science & Technology, South Korea; 2Physics, National Inst. of Standards and Technology, USA. We demonstrate the generation of entangled photon pairs via type-I/0-parametric down conversion in ultra-thin lithium niobate in which momentum between the pump photon and daughter photons is not conserved.

JTu2A.53
Laser-Induced-Modification Raman Spectroscopy for Prob- ing Microscopic Structural Variation Beyond Conventional Techniques: CZTSe as an Example, Qi Cong, Yong Zhang, 1UNC-Charlotte, USA. Laser-induced-modification Raman spectroscopy coupled with high spatial resolution and high-temperature capability is demonstrated to obtain additional structure information beyond what the conven- tional techniques offer, revealing microscopic scale variation between similarly small alloys.

JTu2A.54
Room Temperature Control of Valley Coherence in Bilayer WSx, exciton Polaritons, Mandeep Khatoniar 1,4, Nicholas Yama, 1,2, Argh Ghaszaryan, Sanaul Haque, 1,2, Qizhong Li, 1,2, Yong-Su Kim, 1,2, Dong-Gil Im, 1,2, Young-Wook Cho 1,2, 'South Korea Inst. of Science & Technology, South Korea; 2Physics, National Inst. of Standards and Technology, USA. We demonstrate the generation of entangled photon pairs via type-I/0-parametric down conversion in ultra-thin lithium niobate in which momentum between the pump photon and daughter photons is not conserved.
Scattered Complex Laguerre-Gaussian Spectrum to Determine the 2-D Transverse Position of a Spherical Silica Particle, Runzhou Zhang1, Hao Song 1, Zhe Zhao 1, Haoqian Guo1, Shougang Zhang 1,2, Haifeng Jiang 1,2; 1National Time Service Center, China; 2Univ. of Chinese Academy of Sciences, China. We report a proposal of developing ultrashort laser reference to multi-cavity, reducing thermal noise by averaging effect of beam size. We perform an experiment to simulate a two-cavity system and obtained the instability is 5 × 10⁻¹⁰dBs, improved by a factor of (2 from a single cavity system).

JTu2A.67
Generating a Twisted Spatiotemporal Wave Packet Using Coherent Superposition of Structured Beams with Different Frequencies, Zhe Zhao1, Runzhou Zhang, Haoqian Song1, Long Li1, Jing Du1, Cong Liu1, Kai Pang1, Ahmed Almaiman1, Robert Boyd1, Moshe Tur1, Alan E. Willner1; 1National Time Service Center, China; 2Univ. of Chinese Academy of Sciences, China. We experimentally demonstrate the superposition of different LG modes located on different frequencies to control the wave packet’s spatiotemporal structures in simulation. Dependence of its rotating helical envelope on the mode and frequency spectra is analyzed.

JTu2A.68
Development of an Actively Cooled Glass Amplifier at 1.03 μm, Bogdan Petrutia1, Vincent Begoud1,2, Bernhard Zielbauer1, Markus Roth1,2, Markus Rottler1,2, forces, CAS, China. Single-mode directly modulated distributed feedback (DFB) lasers working at 1.55-μm with high power of 160 mW output, SMSR beyond 50 dB and large bandwidth of 8.5 GHz are demonstrated.

JTu2A.93
Fast physical random bit generation using broadband chaos generated by self-phase-modulated external-cavity semiconductor laser cascaded with microsphere resonator, Ningsheng Zhang, Xiang Ren, and Pengcheng Yue. We experimentally demonstrate a broadband chaos generation using semiconductor laser subject to self-phase-modulation and microsphere resonator, and a subsequent fast physical random bit generation beyond 300-Gbps by using the broadband chaos as entropy source.

JTu2A.74
A Quantum Inhibitory Integrate and Fire Neuron based on a Single-Section Quantum-Dot Semiconductor Laser, Benelos Skontanis1,2, George Sarantoglou2, Charis Mesaritakis1,2; 1Information and Communication Systems Engineering, Univ. of the Aegean, Greece, 2Informatics & Telecommunications, National & Kapodistrian University of Athens, Greece. Numerical results concerning all optically triggered inhibitory neurons based on single-section InAs/InGaAs quantum-dot lasers are demonstrated. The devices are isomorphic to biological fire and integrate inhibitory neurons, offering precise spikes and wavelength encoding of neural signals.

Concurrent sessions are grouped across six pages. Please review all six pages for complete session information.
JTu2A.75
Vertical Metasurface integrated Cavity Surface-Emitting Lasers (VMSCELs) for collimated lasing emissions, Yiyang Xie, Peinan Ni, Qiuhua Wang, Chen Xu, Qiang Kan, Hongda Chen, Patrice Genevet, CNRS, France; Beijiang Wang, 1st Inst. of Semiconductor, China. In this work, vertical metasurface integrated cavity surface-emitting lasers (VMSCELs) have been proposed and designed into back-emitting configuration. We have demonstrated that the integration with metasurface allows the effective control of the lasing emission wavefront.

JTu2A.76
Modelling Directly Reflectivity Modulated Lasers, Guangyao Liu, Arghati Meiklyan, SJ Ben Yoo, Po Dong, Univ. of California Davis, USA; Nickia Bell Labs, USA. We present the numerical modelling of directly reflectivity modulated laser with high speed modulated mirrors in the time domain for both static and dynamic laser performance.

JTu2A.77
Controlling Light Amplification of Colloidal Quantum Dot in Actively Operating Devices, Junhong Yu, Yushant Shendre, Weon-Ayu Koh, Baqian Liu, Songyan Hou, Chaoxuan Hettiarachchi, Savas Delikanli, Pedro H. Martínez, New Mexico, USA. We have demonstrated tunable amplified spontaneous emission (ASE) threshold in a long-sought practical device. Our results open new possibilities for achieving zero-threshold and electrically pumped QD lasers.

JTu2A.78
A Gain-Embedded Meta-Mirror, Mansoor Sheikh-Bahae, Zhou Yang, Alexander R. Albrecht, David Lidzey, Univ. of New Mexico, USA. We propose an active mirror structure based on a dielectric high-contrast grating reflector combined with optical gain. This structure is designed to be directly bonded to a thermal substrate for efficient heat removal, thus allowing semiconductor disk lasers with kW output power.

JTu2A.79
Four-Channel Hybrid Silicon Laser Array with low power consumption for on-chip optical interconnections, Hongyan Yu, Yajie Li, Chaoyang Ge, Xuliang Zhou, Guangzhao Ran, Chaoyang Ge, 2nd Inst. of Semiconductor, China; The State Key Lab for Mesoscopic Physics and School of Physics, Peking Univ., China. A four-wavelength silicon hybrid laser array with a buried ridge stripe (BRS) structure is demonstrated with a threshold current less than 10 mA and a side-mode suppression ratio higher than 40 dB at room temperature.

JTu2A.80
Polarization Stable VCSL based on Integration of Sub-wavelength Gratings with Low Reflective Index Medium, Qiuhua Wang, Yiyang Xie, Chen Xu, Guanzhong Pan, 1st CAS Inst. of Semiconductors, China; 2nd Inst. of Semiconductor, China; Beijing Univ. of Technology, China. A polarization stable VCSL was realized by etching sub-wavelength gratings structure and depositing a low refractive index layer on the surface. The fabricated VCSL is of low threshold and high polarization power ratio of 123.1.

JTu2A.81
Low Threshold Current Photonic Crystal Surface Emitting Lasers with Beam Modulation Capability, Li-Ren Chen, Han-Lun Chu, Kuo-Bin Hong, Tien-Chang Lu, Dept. of Photonics, National Chiao Tung Univ., Taiwan. We proposed a GaAs-based photonic crystal surface emitting laser with naturally formed periodic structures on the ITO top cladding layer. Low threshold current density and ability of beam modulation have been demonstrated.

JTu2A.82
Toward All MOVCOD Grown InAs/GaAs Quantum Dot Laser with Optical Gain (001) Silicon, Li, Meng, Wei Shi, Hongwei Zhao, Simone S. Brunelli, Bowen Song, Douglas Oakley, Jonathan Kläkmann, 1st Univ. of California, Santa Barbara, USA. Indium arsenide quantum dots (QDs) are demonstrated on gallium arsenide on silicon templates by metalorganic chemical vapor deposition. The template threading dislocation density is only 9.5 x 10^4 cm^-2 and the QDs are of high quality.

JTu2A.83
High-Order Phase-Matching Enabled Octave-Bandwidth Four-Wave Mixing in AlGaAs-On-Insulator Waveguides, Yong Liu, Michael Galli, Kristen Yvind, Lei K. Oxenløwe, Hao Hu, Minhao Pu, Dept. of Photonics Engineering, Tech. University, Denmark. We show in simulation an ultra-broad continuous four-wave mixing conversion band over an octave span (covering 1.1-2.5 μm wavelength range) by taking advantage of the high-order phase-matching and the ultra-high effective nonlinear coefficient of AlGaAs-on-insulator waveguides.

JTu2A.84
Avoidance of Cross-Phase Modulation in Femtosecond Stimulated Raman Scattering, Thomas Würtzweiler, Niels DANG, Carsten Fallich, 1st Inst. of Applied Physics, Germany; MEMS+ Inst. of Nanotechnology, Netherlands. The influence of cross-phase modulation on stimulated Raman scattering in the high peak power regime is investigated, resulting in optimized pulse parameters for reduced cross-phase modulation artefacts.

JTu2A.85
Evolutionary Algorithm Assisted Design of an Elliptical Focusing Build-up Cavity Avoiding the Degradation Problem in BBO, Daniel Preissler, Daniel Kiefer, Thorsten Fuhrer, Thomas Walther, Technische Universität Darmstadt, Germany. We report on the design of a novel cavity with cylindrical focusing to overcome cavity degradation effects in the generation of UV radiation using evolutionary algorithms. Experimental results show the advantages of the new set-up.

JTu2A.86
pyLL: A Fast and User Friendly Lugato-Lefever Equation Solver, Gregory Mouillé, Qing Li, Xuyuan Liu, Kartik Sirivava-sar, NIST/UMD, USA; NIST, USA. We present the development of pyLL, a freely accessible Lugato-Lefever equation solver programmed in Python and Julia and optimized for the simulation of microresonator fre-quency combs. Examples illustrating its operation and performance are presented.

JTu2A.87
Non-linear Optics and Harmonic Generation in ZnS Using Femtosecond Mid-IR Pulses Near Zero Dispersion in a Chirped Quasi-Phase Matched Crystal, Anna Ledentsova, Alexander Yamanaka, Kevlin Werner, Nesh Talaia, Laura Vanderhooft, Christopher Wolfe, Trenton Ensley, Anthony Valenzula, Exam. Chowdhury, 1st Dept. of Physics, The Ohio State Univ., USA; Materials and Manufacturing Directorate, Air Force Research Labs, USA; 4th Weapons and Materials Research Directorate, U.S. Army Research Lab, USA; Sensors and Electronics Devices Directorate, U.S. Army Research Lab, USA. Using intense 3.6 μm, 200 fs, 500 Hz laser pulses, non-linear spectral broadening, filamentation and 2nd-4th harmonic generation in ZnS (Cleartran®) with 3-4 mm propagation distance were observed. Non-linear index of Cleartran was also measured.

JTu2A.88
Above-Octave Supercontinuum Generation in a Hybrid Nonlinear Waveguide for On-Chip Cascaded Third- and Second-Order Nonlinear Optical Applications, Guillermo Fer- nando Camacho Gonzalez, Marcin Malinowski, Amiramidi Honaroost, Sasan Fathpour, CREOL, Univ. of Central Florida, USA; Dept. of Electrical and Computer Engineering, Univ. of Central Florida, USA. It is shown that over 1.25 octaves supercontinuum is attainable in a hybrid chalcogenide-glass/lithium-niobate miniaturized waveguide platform that allows cascaded third- and second-order optical nonlinearities on a monolith chip, particularly for frequency-stabilized inte-grated comb sources.

JTu2A.89
1.7-μm high-power laser generation from a thulium- optical parametric oscillator (TAOPO) for bond-selective photoacoustic microscopy, Jiawei Shi, Can Li, Kenneth Xin-Yip Wong, 1st Univ. of Hong Kong, Hong Kong. We present a high-power thulium-assisted optical parametric oscillator (TAOPO), which provides a pulse energy of 146 nJ with a duration of 2 ns at 1.7-μm window. It is a promising exciting source for bond-selective photoacoustic microscopy.

JTu2A.90
Kerr Comb Generation in Raman Effect Dominated Micro-resonators, Yanzhen Zheng, Changsheng Sun, Bing Xiong, Lai Wang, Jian Wang, Yanjun Han, Zhibiao Hao, Hongtao Li, Yi Luo, Dept. of Electronic Engineering, Tongji Univ., China. We propose a method to suppress Raman effect in microresonators by incorporating a filter structure. Numerical simulations based on Lugato-Lefever equation confirm the effectiveness of the design for soliton frequency comb generation at microwave rates.

JTu2A.91
We report on the generation of supercontinuum spanning in lead fluoride crystal, Yuxia Yang, Hongbo Cai, Meisong Liao, Yasutake Ohishi, Wanjun Bi, Xiu Li, Takenobu Suzuki, Key Lab of Materials for High Power Laser, Shanghai Inst. of Optics and Fine Mechanics, Chinese Academy of Sciences, China; Univ. of Chinese Academy of Sciences, China; Research Center for Advanced Photon Technology, Toyota Technological Inst., Japan. We report the filamentation and supercontinuum generation of femtosecond pulse in a piece of PFL crystal with high bandgap and ultra-broadband frequency window. A broadband supercontinuum spanning from 350 to 9000 nm is demonstrated.

JTu2A.92
High-power High-efficiency Second Harmonic Generation of 1342-nm Laser in LBO and PPKTP, Xingyu Cao, Qi Shen, Mei-Chen Yan, Chao Zeng, Tao Yuan, Wen-Zhuo Zhang, Xing-Can Yao, Cheng-Zhi Peng, Xiao Jiang, Yu-ao Chen, Jian-Wei Pan, Shanghai Branch, National Lab for Physical Sciences at Microscale and Dept. of Modern Physics, Univ. of Science and Technology of China, China. We present a high-efficiency extra-cavity SHG of high-power CW 1342-nm laser. By employing LBO and PPKTP, we obtained the output power up to 3.3W and 5.2W with the conversion efficiency of 57.9% and 93.8%, respectively.

JTu2A.93
Spectral Modulations in a Picosecond OPO Based on a Chirped Quasi-Phase Matched Crystal, Guillaume Walter, Jean-Baptiste Dherbecourt, Jean-Michel Melkonian, Myriam Raybaud, Cyril Dragé, Antoine Godard, Office Natl d’Etudes Rech Aerospatiales, France; Laboratoire de physique des Plasmas, France. We investigate and model spectral modulations that are specific features of OPOs based on chirped quasi-phase matched crystals. Their occurrence is related to cascaded three-wave mixing processes that are quasi-phase matched at different positions.

JTu2A.94
Deterministic Single Soliton Generation without Frequency Toning in a Graphene-FP Microresonator, Zeyu Xiao, Kan Wu, Jieangang Chen, Shanghai Jiao Tong Univ., China. A novel microresonator based on Fabry–Perot resonator and monolayer graphene has been proposed. This design allows deterministic single soliton generation without frequency tuning, and has strong robustness under frequency and timing jitter.

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**Exhibits Hall 1-3**

11:30–13:00  JTu2A • Poster Session I and Lunch
JTu2A.117 Radical mitigation of photo-darkening effect in Yb-doped fiber through deuterium treatment, Jiaming Li1, Nan Zhao1; 1South China Normal Univ., China. We report radical mitigation of photo-darkening effect in Yb-doped fibers with deuterium. After deuterium loading, the fiber did not exhibit any PD effect. Existed color centers induced by PD could also be eliminated by deuterium.

JTu2A.118 Hydrogen plasma treatment of MoS2 with graphene protection, Anishkumar Soman1, Robert A. Burke1, Qui Li1, Michael Valentini1, Eugene Zakari1, Ugochukwu Nsofor1, Steven Hege- dus1, Ujjwal Das1, Jianping Shi1; 1University of Delaware, USA; 2University of California – Riverside, USA; 3US Army Research Lab, USA; 4Instituto de Energy Conversion, USA; 5Peking Univ., China. Hydrogen plasma treatment can create defects such as sulfur vacancies in single layer MoS2. A single layer graphene’s protection can effectively reduce the defects formation as confirmed by Raman spectroscopy.

JTu2A.119 Synthesis, Spectroscopy and Efficient Laser Operation of Tm:Lu3Al5O12 Transparent Ceramics, Josep Serres2, Pavel Loiko3, Venkatesan Jambunathan1, Xavier Mateos1, Yicheng Wang1, Jiang Li5, Liza Basyrova1, Antonio Lucianetti1, Tomas Mocák4, Magdalena Aguilo2, Francesc Diaz2, Uwe Griebner1, Valentin Petrov1; 1Max Born Inst., Germany; 2Universitat Rovira i Virgili, Spain; 3ITMO Univ., Russia; 4HILASE, Czechia; 5Shanghai Inst. of Ceramics, China. Tm:Lu3Al5O12 ceramics are synthesized by solid-state reactive sintering, and their structure and spectroscopic properties are studied. A Tm:Lu3Al5O12 ceramic laser diode-pumped at 793 nm generates 3.12 W at ~2.02 μm with a slope efficiency of 60.2%.

JTu2A.120 Remote Photonic Sensing of Cerebral Hemodynamics via Spatial-Temporal Analysis of Back-Scattered Laser Light, Nisan Ozana1, Adam Noah2, Xian Zhang2, Ying Zuo1, Shengwang Du1; 1Bar Ilan Univ., Israel; 2Yale Univ., USA. The ability to remotely extract cerebral hemodynamics from specific locations on the brain using time varied speckle patterns is innovative. The first step towards remote sensing of brain activity and stroke is presented.

JTu2A.121 Effectively enhancing photon-exciton coupling via a gap whispering gallery modes, Qi Zhang1, Juanjuan Ren1, Xueke Duan1, He Hao1, Chenguang Gong1, Ying Gu1; 1Peking Univ., China. We theoretically demonstrate the coupling coefficient enhancement in cavity quantum electrodynamics system via a nanogap between a dielectric nanotoroid and a dielectric nanowire.

JTu2A.122 Efficiently Loading Cold Atomic Ensemble into an Optical Cavity with High Optical Depth, Yue Jiang1, Yefeng Mei1, Yueyang Zou1, Ying Zuo1, Shengwang Du1; 1The Hong Kong Univ. of Sci&Tech, Hong Kong. We describe a cold atom apparatus for achieving high optical depth (OD) and OD-duty cycle product by loading a dark-line 2D MOT into an optical cavity. Cavity enhanced OD can go up to 7600, with 188 times enhancement of the single-pass OD, and highest OD-duty cycle product is 1697.

JTu2A.123 Quantum-correlated Light Source from Dual-seeded Four-wave Mixing with a Diode Laser System, Meng-Chang Wu1, Nicholas R. Brewer2, Rory W. Speirs3, Bonnie L. Schmittberger1, Kevin M. Jones2, Paul D. Lett1; 1National Inst. of Standards and Technology, USA; 2Williams College, USA; 3Univ. of Maryland, College Park, USA. We have obtained broadband intensity-difference squeezing from sub 10 Hz to 20 MHz via four-wave mixing (4WM) in a rubidium vapor. This was accomplished by dual-seeding the 4WM process and using semiconductor diode lasers.

JTu2A.124 Machine Learning Applied in Reconstruction of Unitary Matrix for Quantum Computation, Hui Zhang1, Hong Cai4, Stefano Paesani2, Raffaele Santagati2, Anthony Laing1, Leong Chuan Kwek4, Ali Qiu Liu1; 1Nanyang Technological Univ., Singapore; 2Univ. of Bristol, UK; 3National Univ. of Singapore, Singapore; 4Inst. Of Microelectronics, Singapore. Optimal method are applied in characterizing and reconstructing designed unitary matrices on linear optical circuit. The scheme is based on the measurement of single-photon and two-photon statistics using coherent beams.
We present a novel method to reconstruct frequency entanglement. By controlling these modes, we can tailor quantum states and measurements for applications such as quantum state tomography or quantum metrology. The setup combines spectral shearing interferometry and measurements for applications such as quantum state tomography or quantum metrology. We demonstrate dynamical encirclement of an exceptional point in a laser cavity. By continuously varying the detuning and coupling between a pair of PT-symmetric waveguides, the laser simultaneously emits two eigenmodes, one from each facet.

A two-qudit operation on a 256-dimensional Hilbert space, Poolad Imany, Mohammed S. Alshaykh, Joseph M. Lukens, Jose A. Jaramillo-Villegas, Daniel E. Leaird, Andrew M. Weiner, Purdue Univ, USA; Oak Ridge National Lab, USA; Universidad Tecnol´ogica de Pereira, Colombia. By encoding two 16-dimensional qudits in the time and frequency degrees of freedom of a heralded single photon, we realize a deterministic photonic two-qudit SUM gate operating on a 256-dimensional Hilbert space.

Pulsed temporal modes form a high-dimensional basis for quantum information applications. We demonstrate dynamical encirclement of an exceptional point in a laser cavity. By continuously varying the detuning and coupling between a pair of PT-symmetric waveguides, the laser simultaneously emits two eigenmodes, one from each facet.

An on-chip optical Brillouin gyroscope with Earth-Rotation Rate Sensitivity, Kerry J. Vahala, Yu-Hung Lai, Myoung-Gyun Suh, California Inst. of Technology, USA. A chip-based gyroscope is demonstrated that uses counter-propagating Brillouin lasers to measure rotation as a Sagnac-induced frequency shift. Demonstration of rotation measurement below the Earth rotation rate is presented. Prospects for improved performance are discussed.

Presider: Esther Wertz, Rensselaer Polytechnic Institute, USA. In this tutorial, I will describe a variety of optical techniques that can be used to probe the unique excitation and valley physics and their ultrafast dynamics in transition metal dichalcogenides monolayers and heterostructures.

Feng Wang is an professor of physics at the university of California, Berkeley and faculty scientist at the Lawrence Berkeley National Lab. His research interests have been in ultrafast nano-optics, with special focus on low dimensional materials, including one dimensional carbon nanotubes and two-dimensional graphene and transition metal dichalcogenides.
JTu3G.1 • 13:00 Invited
Atom Interferometry for Space-Borne Sensors, Sergio Mottini1, Stefano Cesare1, Alberto Anselmi1, Linda Mandal2, Oliver Carr2, Federica Migliazzo3, Mirko Reguzzoni3, Fid Andersen2, Khulan Batsukh3, Guglielmo Tino4; 1Thales Alenia Space Italia SpA, Italy; 2European Space Agency, Netherlands; 3Politecnico di Milano, Italy; 4INFN-FI, Italy; 5INFN - Ge, Italy. The perspectives for application of atom interferometry in inertial navigation, geophysics, or tests of fundamental physics motivate the interest for the development of spaceborne quantum accelerometers and gravimeters. Technical challenges and implementation examples are presented.

JTu3G.2 • 13:30 Invited
Enabling Technologies for Space-Based Quantum Systems, Evan A. Salin1; 1ColdQuanta, Inc; USA. Quantum technologies have great potential to enable space-based applications of information science, sensing, navigation, and timekeeping. We present enabling technologies to address the technical challenges of preparing cold atom based systems for use in space.

JTu3G.3 • 14:00 Invited
The Coolest Spot in the Universe: Early results from the Cold Atom Laboratory Mission Aboard the International Space Station, Robert J. Thompson1; 1Jet Propulsion Lab, USA. The Cold Atom Lab launched to the International Space Station in May 2018, and has been operating since then as the world’s first multi-user facility for the study of ultra-cold atoms in microgravity. In this talk, I present early results from the Cold Atom Lab (CAL).

JTu3H.1 • 13:00
An Optofluidic Tweak-and-Drag Cell stretcher in a Microfluidic Channel, Zhangyi Yao1, Yinghui Chi2, Wanjuan Pan3, Hong Kong University of Science and Technology, Hong Kong. We report an optofluidic tweak-and-drag cell stretcher in a microfluidic channel. We distinguish healthy and glutathione-hydrated treated rabbit red blood cells based on their different mechanical deformations at a cell-stretching throughput of ~1.2 cells.

JTu3H.2 • 13:15
Optofluidic Platform with Integrated Optical Waveguides and Sample Preparation for Digitalized Detection of Nucleic Acid Targets, Aadhari Jain1, Gopikrishnan G. Meena1, Alexander Stambaugh1, Jean Patterson1, Aaron Hawkins1, Holger Schmidt2, 1University of California, Santa Cruz, USA; 2Brigham Young University, USA; 3Texas Biomedical Research Institute, USA. An architecture of sensitive solid-core and liquid-core optical waveguides are integrated with a pneumatic valve array on a single optofluidic platform to enable specific capture, labeling and detection of single nucleic acid strands using barcode fluorescence reporters.

JTu3H.3 • 13:30
Bend-Insensitive Through Fiber Stimulated Emission Depletion (STED) Imaging of HELA Cells, Brendan M. Heffernan1, Stephanie A. Meyer1, Diego Restrepo2, Mark Siemens1, Emily A. Gibson2, Juliet T. Gopinath1; 1University of Colorado Anschutz Medical Campus, USA; 2University of Colorado Boulder, USA; 3Biogelengieering, University of Colorado Anschutz Medical Campus, USA. A single optofluidic platform to enable specific capture, labeling and detection of single nucleic acid strands using barcode fluorescence reporters. We demonstrate, for the first time, STED images of biological samples where fluorescence has been collected through the same fiber used to transport excitation and depletion light (through-fiber imaging). We also quantitatively demonstrate fiber-bending-independent resolution.

JTu3H.4 • 13:45
Single Particle Detection Enhancement with Wavelet-based Signal Processing Technique, Vahid Ganjalizadeh1, Gopikrishnan G. Meena1, Matthew Stott2, Holger Schmidt2; 1University of California, Santa Cruz, USA; 2Electrical and Computer Engineering, Brigham Young University, USA. Chip-based single molecule detection requires ultra-sensitive devices and robust signal processing methods. A new wavelet-based signal processing method is introduced that improves detection and error rates on an optofluidic platform by 2x and 3x, respectively.

JTu3H.5 • 14:00 Tutorial
Wavefront Shaping – the Threading of Light Through Scattering Media, Changhuei Yang1, 1California Inst. of Technology, USA. Wavefront shaping has been an active research area over the past decade. Its ability to control light transmission through or into a scattering medium has significant biophotonics, computing, imaging, encryption and other applications. In this tutorial, I will go through the various optical components involved in wavefront shaping – feedback iteration, phase conjugation, optical memory effects, guide star strategies, speckle correlations, etc. I will also survey the use of wavefront shaping in biophotonics. Finally, I will also examine two recent and surprising developments in wavefront shaping. The first is the intentional combination of wavefront shaping and a controlled scattering medium to create novel optical system – in effect, turning scattering from a ‘foe’ to a ‘friend’ for wavefront shaping. The second is the complete dropping of phase characterization in a new class of ‘wavefront shaping’ methods.

continued on page 116
Novel Material Platforms for Resonator Kerr Combs, Andrea M. Armani; Univ. of Southern California, USA. Resonators are an emerging platform for generating Kerr combs. By attaching a range of different nanomaterials to the surface of optical resonators, we demonstrate a new approaches for fabricating high performance frequency combs.

Andrea Armani received her BA in physics from the University of Chicago and her PhD in applied physics from Caltech. She is currently the Ray Irani Chair in Engineering and Materials Science at the University of Southern California. She is also the Director of the W. M. Keck Photonics Cleanroom as well as the soon to open John D. O'Brien Nanofabrication Laboratory, USA.

Ultra-low-noise Laser, Integrated Si3N4 Soliton Microcomb Driven by a Compact

Andrea Armani

1Univ. of California, Santa Barbara (UCSB), USA; 2JST, ERATO MINOSHIMA Intelligent Optical Synthesizer (IOS) Project, Japan. We demonstrate an all-polarization-maintaining, polarization-multiplexed mode-locked Er-fiber laser with nonlinear amplifying loop mirror that generates two mutually coherent frequency combs with slightly different repetition rates at same center wavelength without nonlinear spectral broadening.

Femtosecond pulses generated from a compact all-polarization-maintaining (PM) Ytterbium-doped fiber laser, Wu Zhichao1,2, Yujun Feng1, SongNian Fu1, Ming Tang1, Deming Liu1, Jonathan Price2, Johan Nilsson3; (Huazhong Univ of Science and Technology, China; Univ. of Southampton, UK. We demonstrate femtosecond dissipative solitons generated from an all-PM Ytterbium-doped fiber laser. The simplified fiber ring cavity has been shown to reliably self-start and provides a route to a robust platform for future development.

Dispersions in 46 nm was achieved around zero dispersion region. We investigated dispersion management of polarization-multiplexed, polarization-maintained Er-fiber laser with nonlinear amplifying loop mirror that generates two mutually coherent frequency combs with slightly different repetition rates at the same center wavelength without nonlinear spectral broadening.
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13:00–15:00
JTu3M • Symposium on Intense-field Nonlinear Optics & High Harmonic Generation in Nanoscale Materials I
Presider: To Be Announced

JTu3M.1 • 13:00 • Invited
Extreme Nonlinear Optics With Dielectric Metasurfaces, Igal Brener 1, 2, Sandia National Labs Livermore, USA. We have used dielectric metasurfaces made from direct bandgap semiconductor materials to generate high harmonics and nonlinear mixing simultaneously, without the need of phase matching. Inclusion of broken-symmetry designs and quantum heterostructures can lead to even higher efficiency.

JTu3M.2 • 13:30 • Invited
Enhancement of Nonlinear Processes by Surface Plasmons, Pierre Berini 1, 2, Univ. of Ottawa, Canada. Nonlinear processes using nanoscale metallic structures are of strong interest due to their ability to enhance local fields and engineer the optical density of states. We discuss various nonlinear processes that exploit these effects.

JTu3M.3 • 14:00
Coherent Control of the Non-instantaneous Response of Plasmonic Nanostructures, Eyal Bahr 1, 2, Uri Arieli 1, 2, Haim Suchowski 1, 2, 3, Condenst Matter Physics, Tel Aviv Univ., Faculty of Exact Sciences, Israel; 2, Condensed Matter Physics, Faculty of Exact Sciences, Tel Aviv Univ., Israel; 3, The Center for Light Matter Interaction, Faculty of Exact Sciences, Tel Aviv Univ., Israel. We experimentally demonstrate coherent control of the non-linear response of resonant nanostructures beyond the weak-field regime. Furthermore, we develop a novel theoretical approach capturing the induced nonlinearities of shaped ultrafast pulses with resonant nanostructured media.

JTu3M.4 • 13:45
O-band InAs/GaAs Quantum Dot Micro-disk Lasers on SOI by in-situ hybrid epitaxy, Bin Zhang 1, 2, Wei W. Qi 1, 2, Ting Wang 1, Bin Zhang 1, 2, Wei W. Qi 1, 2, Ting Wang 1, Jianjun Zhang 1, Inst. of Physics, China. By implementing III-V/Si hybrid growth technique, we demonstrate the first InAs quantum-dot micro-disk laser on SOI substrates. Threshold pump power as low as 0.39 mW were achieved with the Q factor of 3900.

JTu3M.5 • 14:00
Spatially Coherent Interlayer Exciton Lasing in an Atomic-like Thin Heterostructure, Eunice Paik 1, Long Zhang 1, William Burg 1, Rahul Gogna 1, Emanuel Tutuc 1, Hui Deng 1, Univ. of Michigan, USA; 2, Univ. of Texas, USA. We demonstrate lasing in a WSe2/MoSe2 heterostructure integrated in a silicon nitride grating cavity. Signatures of lasing include sharp increase in spatial coherence and super-linear increase in the emission intensity as photon number increases above unity.

JTu3M.6 • 14:45
Integrated Silicon Photodetector in Thin Film Lithium Niobate Platform for Visible Wavelength Band, Boon S. Ooi 1, 2, King Abdullah University of Science and Technology (KAUST) in 2009, from Lehigh University (USA). His group focuses on lasers for solid-state lighting, visible-light and underwater-wireless-optical communication, and nanostructures for energy harvesting.

Boon S. Ooi (Fellow of OSA, SPIE, and IoP, Ph.D. degree from the University of Glasgow, UK, 1994) joined King Abdullah University of Science and Technology (KAUST) in 2009, from Lehigh University (USA). His group focuses on lasers for solid-state lighting, visible-light and underwater-wireless-optical communication, and nanostructures for energy harvesting.

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**Theatre I**

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<th>Time</th>
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<td>13:00–15:00</td>
<td><strong>ATu3P</strong> • A&amp;T Topical Review on Progress in the Semiconductor Laser Technology I</td>
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**ATu3P.1 • 13:00**
Double-side pumped membrane external-cavity surface-emitting laser (MECSEL) with increased efficiency emitting > 3 W in the 780 nm region. Hermann Kahle1, Hoy-My Phung1, Jussi-Pekka Penttinen1, Patrik Rajala1, Anti Tukianen1, Sanna Ranta1, Mircea Guina1; 1Optoelectronics Research Centre (ORC) - Physics, Tampere Univ., Finland. We demonstrate a double-side pumped MECSEL emitting more than 3 W of output power in the 780 nm wavelength region. The laser exhibits an efficiency as high as 34.4%.

**ATu3P.2 • 13:15**
Direct Tunneling Modulation of Semiconductor Lasers, Junyi Qu1, Milton Feng1, Nick Holonyak1; 1Univ. of Illinois at Urbana-Champaign, USA. Direct tunneling modulation of semiconductor lasers is realized experimentally in the three-terminal transistor laser through the interaction between the photon absorption by voltage-controlled intra-cavity photon-assisted tunneling and the photon generation by quantum-well recombination.

**ATu3P.3 • 13:30**
Invited Semiconductor Lasers for Next-generation Applications, Takeo Kageyama1; 1QD Laser, Inc., Japan. In this presentation, we will review emerging semiconductor laser applications which have developed remarkably in recent years, such as precision laser machining, variety of sensing, Si-photonics and retinal projection eye wear.

**ATu3P.4 • 14:00**
Invited Photonic Crystal Surface Emitting Lasers, Richard Hogg1; 1Glasgow Univ., UK. Abstract not available.

**Theatre II**

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<th>Time</th>
<th>Session Description</th>
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<tr>
<td>13:00–15:00</td>
<td><strong>ATu3Q</strong> • A&amp;T Topical Review on Advanced Design, Imaging and Process Technologies for Next Generation Semiconductors I</td>
</tr>
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**ATu3Q.1 • 13:00**
Extending EUV to the High-NA EUV Regime, Patrick Naulleau1; 1Lawrence Berkeley National Labs, USA. Abstract not available.

**ATu3Q.2 • 13:30**
Nanopatterning of Things: from Metals, Oxides to Quantum Dots, Yoen Sik Jung1; 1KAIST, South Korea. This talk will introduce deep-nanoscale fabrication technologies based on synergic combinations of self-assembly, photolithography, and transfer-printing applicable to a variety of material systems including polymers, oxides, metals, quantum nanostructures for high-performance sensors, photovoltaics, and displays.

**ATu3Q.3 • 14:00**
Quantifying Improvements in Field to Field and Wafer to Wafer CD Variation from Laser Bandwidth Variation, Will Conley1; 1Cymer LLC, USA. Abstract not available.

Concurrent sessions are grouped across six pages. Please review all six pages for complete session information.
FTu3B • PT Symmetry & Exceptional Points—Continued

FTu3B.5 • 14:15
Optical amplification at exceptional points, Qi Zhong1, Sahin K. Ozdemir2, Alexander Esfied3, A. Metelmann4, Ramy El-Ganainy1, Michiyan Technological Univ., USA; 1Pennsylvania State Univ., USA; 2Max Planck Inst. for the Physics of Complex Systems, Germany; 3Frewi Univ., Germany. We propose a new optical amplifier geometry based on exceptional points. Compared to its standard counterpart device, the proposed structure relaxes the limitation imposed by the gain-bandwidth product.

FTu3B.6 • 14:30
Breakdown of Non-Hermitian Hamiltonian for Correlated Multi-photon Transport Due to Reservoir-induced Correlation Changes, Zihao Chen1, Yao Zhou1, Jung-Tsung Shen2, 1Washington Univ. in St. Louis, USA. We present a theoretical analysis of multi-photon transport in the presence of reservoir, and unearth the breakdown of widely adopted non-Hermitian Hamiltonian descriptions in the dissipative regime due to reservoir-induced changes of correlations.

FTu3B.7 • 14:45
Non-Hermitian Engineered TCC VCSEL for LDAR Remote Sensing Technologies, Mohammad H. Teimourpour1, 2, Hamed Dalir3, Elham Heidari3, Volker J. Sorger4, Ray T. Chen5, 1Omega Optics Inc., USA; 2College of Optical Sciences, The Univ. of Arizona, USA; 3ECE Dept., Univ. of Texas at Austin, USA; 4The George Washington Univ., USA. We present the main aspects of a new approach to achieve a single mode operation in TCC-VCSEL array based on (1) increasing the spacing of the eigenfrequencies of supermodes, (2) Q-enhancing of the fundamental supermodes.

FTu3C • Polaritonic Interactions in Transition Metal Dichalcogenide—Continued

FTu3C.3 • 14:15
The Ultimate Purcell Factor in Van der Waals Heterostructures, Yaniv Kurman1, Peter Schmidt2, Frank H. Koppens3, Ido Kaminer1, 1Israel Inst. of Technology, Israel; 2ICFO-Institut de Ciencies Fotoniques, Spain; 3ICREA – Institució Catalana de Recerca i Estudis Avançats, Spain. We find what mechanisms limit fundamental light-matter interactions of plasmons confined to the atomic scale, when interfacing two-dimensional semiconductor emitters. We show how nonlocality governs the dynamics, limiting the Purcell factor yet reaching ultrastrong coupling.

FTu3C.4 • 14:30
Strong Light-Matter Interaction in Monocrystalline Gold Nanodisks Coupled to Tungsten Disulfide, Nicolas Stenger1, Mathias Gesler2, Martyn Wubs2, Sanhuo Xiao3, N. Mortensen4, 1Center for Nano Optics, Univ. of Southern Denmark, Denmark; 2Dept. of Photonics Engineering, Technical Univ. of Denmark, Denmark; 3Center for Nanostructured Graphene, Technical Univ. of Denmark, Denmark; 4Danish Inst. for Advanced Study, Univ. of Southern Denmark, Denmark. Spectroscopy on plasmonic nanodisks coupled to single and multilayer tungsten disulfide show a Rabi splitting of 108 meV and 180 meV, respectively, the highest splitting reported in transition metal dichalcogenides coupled to plasmonic nanostructures.

FTu3C.5 • 14:45
Controllable coherent plasmon-exciton interaction in MoS2 monolayer with gold nanorods through photothermal reshaping, Hu Aiqin1, 1Peking Univ., China. The plasmon-exciton interactions in an individual gold nanorod with MoS2 monolayer were investigated with single particle spectroscopy method. Based on photothermal reshaping, we in-situ tuned the surface plasmon resonance of single gold nanorod and investigate at room temperature.
Interactions—Continued

FTu3D.5 • 14:15
Optical skyrmions: a new topological state of light, Shai Tseses1, Evgeny Ostrovsky1, Kobi Cohen1, Bergin Gjonaj2, Netanel H. Lindner1, Guy Bartal1; 1Technion-Israeli Inst. of technology, Israel; 2Albanian Univ., Albania. We experimentally demonstrate a new topology for light: optical skyrmions. This discovery may allow a variety of applications, from stimulated creation of skyrmions in matter to new paradigms in optical information processing.

FTu3D.6 • 14:30
Implementing Optimal Field Configurations for Micromanipulation, Michael Horodynski1, Matthias Kühmayer1, Andre Brandstätter1, Kevin Fischer1, Ulrich Kuhl1, Stefan Rottler1; 1Inst. for Theoretical Physics, Vienna Univ. of Technology (TU Wien), Austria; 2Institut de Physique de Nice, Université Côte d’Azur, France. We demonstrate both theoretically and experimentally how to achieve wave states that are optimal for transferring momentum, torque, etc. on a target of arbitrary shape embedded in an arbitrary environment.

FTu3D.7 • 14:45
Quantum State Filtering of Dual-rail Photons with Fiberized Plasmonic Metamaterial, Salih Yanigkan1,2, Anton N. Vetyugin3, Ruixiang Guo4, Angelos Xomalis3, Giorgio Adami1, Cesare Soci1, Nikolay I. Zheludev3; 1Centre for Disruptive Photonic Technologies, Nanyang Technological Univ., Singapore; 2Advanced Concepts and Nanotechnologies, Inst. of Materials Research and Engineering, Singapore; 3Optoelectronics Research Centre & Centre for Photonic Metamaterials, Univ. of Southampton, UK. We demonstrate quantum state filtering of dual-rail photons through single-photon interference on a fiberized plasmonic metamaterial, exploiting different optical response of the metamaterial to symmetric and anti-symmetric superpositions of double-path wavefunction of single-photons.

STu3E.4 • 14:30
First commissioning results of the Apollon laser on the 1 PW beam line, Dimitrios N. Papadopoulos1; 1LULI, France. The Apollon 10 PW laser has recently demonstrated its capacity of generating >1 PW pulses with <22 fs duration. The complete commissioning results of the 1 PW beam line will be presented in this work.

STu3E.5 • 14:45
The 9.2 µm, 2 ps, Multi-Terawatt Laser at the Accelerator Test Facility (ATF) of Brookhaven National Lab, Mikhail N. Polyanskiy1, Igor V. Pogorelsky1, Marcus Babzien1, Mark A. Palner1, 1Brookhaven National Lab, USA. An overview of the 9.2 µm, 2 ps, Multi-Terawatt Laser at the Accelerator Test Facility (ATF) of the Brookhaven National Lab is presented. The first commissioning results of the laser system as well as a summary of recent progress and status are presented.

STu3E.6 • 14:30
A Luneburg Lens for the THz Region, Yasith Amarasinghe1, Daniel M. Mittleman1, Rajind Mendis1; 1Brown Univ., USA. We implement a two-dimensional Luneburg lens for the THz region using a waveguide-based artificial-dielectric technology. The lens can focus an approximately 2-cm diameter input beam at 0.162 THz to a spot size of 3.4 mm.

STu3E.7 • 14:45
Photons-based multi-spectral THz imaging using a dual-mode laser and a telecentric f-θ lens, Kwon Moon1, Il-Min Lee1, Eui Su Lee1, Kyung Hyun Park1; 1Electronics and Telecom Research Inst, South Korea (the Republic of). We propose a continuous-wave THz imaging system using a semiconductor dual-mode laser, a photonizer and a Schottky barrier diode. Through the broadband frequency tunability of the dual-mode laser, high-resolution multi-spectral THz images were obtained.
JTu3G • Symposium on Space-borne Quantum Sensors—Continued

JTu3G.4 • 14:30  Invited
Quantum Science Experiments with Micius Satellite, Cheng-Zhi Peng1,2; 1 Univ of Science and Technology of China, China; 2 Synergetic Innovation Center of Quantum Information and Quantum Physics, China. The quantum science satellite have been launched successfully in China. Utilizing this satellite, we have completed a series of quantum experiments in space. Here, I will introduce these experiments and our future plans.

Professor Yang works on microscopy and wavefront shaping. His group invented the ePetri technology and Fourier Ptychography for microscopy. His group invented optical phase conjugation technology and was the first to apply wavefront shaping into biophotonics. He is a fellow of the Coulter foundation, AIMBE, OSA and SPIE.

STu3H • Biophotonics & Optofluidics—Continued

STu3H.5 • 14:15
Femtosecond + Nanosecond Multiple Pulse Train from a Thin Disk Regenerative Amplifier, Atabak Marandi1, Florian Fink1, Joerg Neuhaus1, Mikhail Laninov1; Dausinger + Giesen GmbH, Germany. Demonstration of a regenerative amplifier with “mixed pulse trains” for micromachining: femtosecond pulses for effective ablation directly followed by nanosecond pulses for smoothening of the surface amplified within one single thin disk resonator.

ATu3I • Ultrafast Laser Processing—Continued

ATu3I.5 • 14:15
Femtosecond + Nanosecond Multiple Pulse Train from a Thin Disk Regenerative Amplifier, Atabak Marandi1, Florian Fink1, Joerg Neuhaus1, Mikhail Laninov1; Dausinger + Giesen GmbH, Germany. Demonstration of a regenerative amplifier with “mixed pulse trains” for micromachining: femtosecond pulses for effective ablation directly followed by nanosecond pulses for smoothening of the surface amplified within one single thin disk resonator.

ATu3I.6 • 14:30
Thermal damage free materials processing by using ultrashort pulse laser, Sungkwon Shin1, Jungyu Hur1, Jongkab Park1; Dausinger + Giesen GmbH, Germany. We report thermal damage free processing in Invar, polyimide, and soda-lime glass by using an ultrashort pulse laser. Experimental results and a toy model for thermal accumulation will be discussed.

ATu3I.7 • 14:45
Efficient ablation of silicon with a high power GHz femtosecond laser source, Eric Mottay1, Guillaume Bonams1,2, Konstantin M. Mishchik1, John Lopez2, Eric Audouard1, Clemens Hoenninger1, Inka Marcek-Hoening1; 1 Amplitude, France; 2 Univ. of Bordeaux, France. Ablation of silicon using high power GHz femtosecond lasers achieves specific removal rate of 2.5 mm³/min/W. Ablation morphologies are discussed in terms of thermal and non-thermal mechanisms.

15:00–16:30  Meet the OSA Publishing Journal Editors Ice Cream Social, Networking Zone Booth 2605

15:00–17:00  Coffee Break and Exhibit Only Time, Exhibit Halls 1-3
Coffee Break Sponsored by COHERENT and THORLABS

15:30–17:00  OIDA: Market Trends: Opportunities in Optics and Photonics, Exhibit Hall Theater I
STuJ.3 • 14:15
Broadband Efficient Soliton Microcombs in Pulse-Driven Photonic Microresonators, Miles H. Anderson1, Romain Bouchand1, Ewelina Olbrzud1, Junqiu Liu2, Sylvain Karlen3, Steve Lecomte4, Tobias Herr5, Tobias J. Kippenberg1; 1École Polytechnique Fédérale de Lausanne, Switzerland; 2Swiss Center for Electronics and Microtechnology (CSEM), Switzerland; 3Geneva Observatory/PlanetS, Dept. of Astronomy, Univ. of Geneva, Switzerland. Broadband single-soliton based frequency combs, with a detectable repetition rate of 28 GHz, are efficiently generated through pulse-driving of a chip-based frequency comb, with a detectable repetition rate of 28 GHz, which is achieved through injection-locking a multi-frequency laser diode to a chip-based frequency comb. This approach offers a pathway for integrated and ultra-compact microcomb source for high-sensitivity detection of low frequency Raman vibrational modes from 10 cm⁻¹ to 1500 cm⁻¹ through signal amplification in the external detection system.

STuJ.4 • 14:30
Electrically Driven Ultra-compact Photonic Integrated Soliton Microcomb, Arslan Raja1, Andrei S. Voloshin2, Hairun Guo3, Sohya E. Agafonova4; 1Oregon State Univ., USA; 2KM Labs, USA; 3Mesa Photonics, USA. We demonstrate a current-initiated soliton microcomb by injection-locking a multi-frequency laser diode to a chip-scale high-Q Si3N4 microresonator. This approach offers a pathway for integrated and ultra-compact microcomb source for high-sensitivity detection of Raman vibrational modes from 10 cm⁻¹ to 1500 cm⁻¹ through signal amplification in the external detection system.

STuJ.5 • 14:45
Long-Term Stabilization and Operation of a Soliton Micro-Comb for 9-Days, Tong Lin1, Avik Dutt1, Xingchen Ji1, Miles H. Anderson1, Andrey S. Voloshin2, Hairun Guo3, Sohya E. Agafonova4; 1Ecole Polytechnique Fédérale de Lausanne, Switzerland; 2Russian Quantum Center, Russia. We report the long-term stabilization of a soliton microcomb over 9 days of continuous operation. Using an integrated heater, the original pump-cavity detuning is maintained with a simple active feedback method.

STuK.5 • 14:15
High-Sensitivity Coherent Raman Spectroscopy with Doppler Raman, David Smith1, Jeff Field2, David Winters1, Scott Domingue1, Jesse Wilson1, Daniel Kane1, Randy Bartels1; 1Colorado State Univ., USA; 2FM Labs, USA; 3Mesa Photonics, USA. Doppler Raman spectroscopy is a novel detection scheme for impulsively stimulated Raman scattering that unlocks high-sensitivity detection of low frequency Raman vibrational modes from 10 cm⁻¹ to 1500 cm⁻¹ through signal amplification in the external detection system.

STuK.6 • 14:30
Shining the Light to Terahertz Spectroscopy of nL-Volume Biological Samples, Sergey Mitryukovsky1, Mélanie Lavancier1, Romain Peretti1, Jean-François Lampin2, Théo Hannotte1, Flavie Braud1, Emmanuel Dubois1, Goedele Roos1; 1Inst. of Micronics, Microelectronics and Nanotechnology (IEMN), CNRS/Univ. Lille, France; 2Unit of Structural and Functional Glycobiology (UGSF), CNRS/Univ. Lille, France. We present a technique allowing the confinement of a broadband terahertz pulse to a few-nL volume. The method is approved in terahertz time-domain spectroscopy study of biological samples and further perspectives are discussed.

STuK.7 • 14:45
SERS Detection of Trace Level Tetrahydrocannabinol in Body Fluid, Kundan Sivashanmugan1, Kenneth Squire1, Yong Zhu2, Fengyuan Deng1, Ji-Xin Cheng1, Siddharth Ramachandran1, 2Boston Univ., USA. We demonstrate energetic (30 nJ) dual-wavelength ultrashort-pulse sources via soliton self-mode conversion in a multimode fiber that are naturally temporally synchronized. Power fluctuations of resultant sum-frequency signals are 11.4 dB lower than conventional fiber based dual-wavelength approaches.

STuL.5 • 14:15
All-fiber dual-wavelength mode-locked laser by using low-birefringence Lyot-filter and carbon nanotube, Jiajun Zhu1, Fulin Xiang1, Pengtao Yuan1, Neisei Hayashi1, Chao Zhang1, Lei Jin2, Sze Y. Set1, Shinji Yamashita1; 1Research Center for Advanced Science and Technology, The Univ. of Tokyo, Japan. We firstly demonstrate a dual-wavelength mode-locked EDF laser by utilizing a low birefringence Lyot-filter and CNT, which delivers dual-wavelength output centers at 1532 nm and 1556 nm corresponds to the difference frequency of 3.02 THz.

STuL.6 • 14:30
Jitter-Free Multi-Wavelength Fiber Sources using Intermol- dal Solitons, Lars Risbo1, Boyin Tai1, Fengyuan Deng1, Ji-Xin Cheng1, Siddharth Ramachandran1, 2Boston Univ., USA. We demonstrate energetic (30 nJ) dual-wavelength ultrashort-pulse sources via soliton self-mode conversion in a multimode fiber that are naturally temporally synchronized. Power fluctuations of resultant sum-frequency signals are 11.4 dB lower than conventional fiber based dual-wavelength approaches.

STuL.7 • 14:45
Real-time Observation of Soliton Build-up Dynamics in Bidirectional Mode-Locked Fiber Lasers, Maria Chernycheva1, Igor Kudelin1, Srikanth Sugavanam1; 1Aston Univ., UK; 2Leibniz Inst. of Photonics Technology, Germany. By using newly emerged high precision real-time measurement technologies of spatio-temporal intensity reconstruction and dispersive Fourier transformation (DFT), we have experimentally observed the build-up dynamics of solitons in a bidirectional ultrafast fibre laser.
JTu3M • Symposium on Intense-field Nonlinear Optics & High Harmonic Generation in Nanoscale Materials I—Continued

JTu3M.4 • 14:15
Unveiling the Mechanism of Highly-efficient Nonlinear Responses from Film-coupled Plasmonic Structures, Qixin Shen1, Thang B. Hoang1, Guoce Yang1, Virginia D. Wheeler2, Maiken H. Mikkelsen1; 1Duke Univ., USA; 2USA Naval Research Lab, USA. We investigate the mechanism of highly efficient nonlinear responses from dielectric materials in a tiny gap of less than 7 nm between a gold film and metallic nanostructures, which offers potential for on-chip nonlinear devices.

JTu3M.5 • 14:30
Title to be Determined, David A. Reis1; 1Stanford Univ., USA. Abstract not available.

STu3N • Lasers on Silicon & Nanolasers—Continued

STu3N.6 • 14:15
High-temperature Continuous-wave Operation of 1.3-µm Membrane Distributed Reflector Lasers on SiC, Suguru Yamada1, Ryo Nakao1, Takuro Fuji1, Koji Takeda1, Tatsuro Hiraki1, Hitotaka Nishi1, Takashi Kikuta1, Tai Tsuchizawa1, Shinji Matsuo1; 1NTT Device Technology Labs, Japan. We demonstrate continuous-wave operation of 1.3-µm membrane distributed reflector lasers on SiC at a 130 °C stage temperature. The laser, with its large thermal conductivity and optical confinement, is promising for high-temperature operation.

STu3N.7 • 14:30
Sub-wavelength single-mode all-inorganic perovskite CsPbBr3 nanolaser, Zhengsheng Liu1, Jie Yang2, Juan Du1, Xiaohong Tang1, Yucon Leng1, Ruxin Li1; 1Shanghai Inst. of Optics and Fine Mechanics, Chinese Academy of Sciences, China; 2Chongqing Univ., China. We report the single-mode, high-quality, low-threshold picosecond pulses laser whose physical volume is only ∼0.49 Å3 (where Å is the lasing wavelength in air) from an individual all-inorganic perovskite CsPbBr3 nanocuboid.

STu3N.8 • 14:45
Measuring the Frequency Response of Metallic Nanolasers, Chi Xu1, William Hayenga1, Mercedeh Khajavikhan1, Patrick LiKamWa1; 1Univ. of Central Florida, CREOL, USA. The frequency response of metallic nanolasers are evaluated theoretically and experimentally. The predicted modulation bandwidth is ~ 289 GHz, and the experiments show an effective modulation current efficiency factor (MCEF) of ~163.8 GHz/mA1/2.

STu3O • Emerging Visible Light Communication—Continued

STu3O.3 • 14:15
Liquid-Crystal-Based Visible-Light Integrated Optical Phased Arrays, Jelena Notaros1, Milica Notaros1, Manan Raval1, Michael R. Watts1; 1MIT, USA. Liquid-crystal-based integrated optical phased arrays are proposed and experimentally demonstrated for the first time as a method for low-power and compact visible-light beam steering. Beam steering of 10.5° within ±3.5V at a 632.8nm wavelength is shown.

STu3O.4 • 14:30
Integrated-Phased-Array-Based Visible-Light Near-Eye Holographic Projector, Jelena Notaros1, Manan Raval1, Milica Notaros1, Michael R. Watts1; 1MIT, USA. An integrated-phased-array-based visible-light holographic projector is proposed as a scalable solution towards the next generation of augmented-reality head-mounted displays. A passive pixel-based architecture is developed and projection of a wire-frame cube is experimentally demonstrated.

15:00–16:30 Meet the OSA Publishing Journal Editors Ice Cream Social, Networking Zone Booth 2605

15:00–17:00 Coffee Break and Exhibit Only Time, Exhibit Halls 1-3
Coffee Break Sponsored by COHERENT and THORLABS

15:30–17:00 OIDA: Market Trends: Opportunities in Optics and Photonics, Exhibit Hall Theater I
ATu3P • A&T Topical Review on Progress in the Semiconductor Laser Technology I—Continued

ATu3P.5 • 14:30
100 GHz colliding pulse mode locked quantum dot lasers directly grown on Si for WDM application, Songtao Liu¹, Xinru Wu¹,², Justin Norman¹, Deeshan Jung¹, MJ Kennedy¹, Hon Ki Tsang³, Arthur Gossard¹, John Bowers¹; ¹Univ. of California, Santa Barbara, USA; ²The Chinese Univ. of Hong Kong, China. We demonstrate the first 100 GHz 5th harmonic colliding pulse mode locked quantum dot laser directly grown on CMOS compatible on axis (001) silicon substrate with ~ 0.9 Tb/s PAM-4 transmission capacity.

ATu3P.6 • 14:45
High repetition-rate pulse generation from SESAM-free electrically pumped VECSEL, Nikolai B. Chichkov¹, Amit Yadav¹, Tasnim Munshi¹, Ksenia Fedorova¹, Evgeny Viktorov², Edik U. Rafailov¹; ¹Aston Inst. of Photonic Technologies, Aston Univ., UK; ²Faculty of Physics and Materials Sciences Center, Philipps-Universität Marburg, Germany; ³ITMO Univ., Russia. High repetition-rate pulse generation in a SESAM-free electrically pumped VECSEL is demonstrated. The laser produces output pulses with a duration of 140 ps, pulse energy of 3.6 pJ, and repetition rate of 1.97 GHz.

15:00–16:30  Meet the OSA Publishing Journal Editors Ice Cream Social, Networking Zone Booth 2605

15:00–17:00  Coffee Break and Exhibit Only Time, Exhibit Halls 1-3
Coffee Break Sponsored by COHERENT and THORLABS

15:30–17:00  OIDA: Market Trends: Opportunities in Optics and Photonics, Exhibit Hall Theater I
Tailored Non-Gaussian Multimode States of Quantum Light, Nicolas Treps1; Laboratoire Kastler Brossel, Sorbonne Université, France. We demonstrate experimentally non-Gaussian states of light from mode-dependant photon subtraction on multimode entangled Gaussian States. We study the propagation properties of non-gaussianity within the graph, and its implications on the nature of entanglement.

Experimental Demonstration of 2D PT-Symmetric Graphene: Bulk Properties and Edge States, Mark Kremer1, Tobias Biesenthal1, Lukas Maczewsky1, Matthias Heinrich1, Ronny Thomale2, Alexander Szameit1; Inst. of Physics, Univ. of Rostock, Germany; Dept. of Physics and Astronomy, Univ. of Würzburg, Germany. We report the first realization of a two-dimensional PT-symmetric crystalline structure, based on a novel isotropic loss mechanism. By probing bulk and edge properties, we shed new light on the interplay between PT-symmetry and topology.

Bound states in the continuum through environment engineering, Alexander Cerjan1, Chia Wei Hsu 2, Mikael C. Rechtsman1; Pennsylvania State Univ., USA; Electrical Engineering, Univ. of Southern California, USA. We propose a new paradigm for realizing bound states in the continuum (BICs): engineering radiating channels in the environment. Examples include points and lines of BICs in a structure embedded in a periodic medium.

Irreversible Refractive-Index and Water-Walled Photonics, Tal Carmi1; Technion Israel Inst. of Technology, Israel. Coupling light from a tapered fiber into a resonator was recently transformed to permit coupling to rapidly-spinning resonators as well as to resonators made strictly of water. I will present recent experiments where light is transmitted in only one direction of the fiber, record finesse is observed, and water-waves exchange energy with light.

Deep Learning for Design and Retrieval of Plasmonic Nanostructures, Michael Meyr1, Izik Makel2, Ashya Nagler1, Uri Ariel1, Luiz Wall1, Haim Suchowski2; Computer Science, Tel Aviv Univ., Israel; School of Physics and Astronomy, Tel Aviv Univ., Israel. We experimentally demonstrate a novel Deep Learning method capable of retrieving subwavelength dimensions from solely far-field measurements. Moreover, it also directly addresses the inverse problem i.e. obtaining a geometry for a desired electromagnetic response.
Non-Hermitian Selective Thermal Emitters Using Hybrid Plasmonic-Photonic Resonators, Chloee F. Daron1, Gunraj V. Naik2, Electrical and Computer Engineering, Rice Univ., USA; 2Applied Physics Graduate Program, Smalley-Curl Inst., Rice Univ., USA. We experimentally demonstrate non-Hermitian physics of thermal emitters by coupling a plasmonic resonator with low losses. Our thermal emitter exhibits passive PT-symmetry while operating at 700°C.

Dual-Band Quasi-Coherent Radiative Thermal Source, Ryan Starko-Bowes1, Xueji Wang1, Jin Dai2, Ward D. Newman1, Sean Molekyte1, Limei Qi3, Aman Satija1, Ying Tiu4, Manisha Gupta1, Robert Fedosejevs5, Sandipan Pramanik6, Yi Xuan7, Zubin Jacob8, 1Birk Nanotechnology Center, Purdue Univ., USA; 2Univ. of Alberta, Canada; 3School of Electronic Engineering, Beijing Univ. of Posts and Telecommunications, China. We design, fabricate and characterize the spectral, polarization, angular and temperature dependence of a microstructured SiC thermal infrared source, achieving independent control of the frequency and polarization of thermal radiation in two spectral bands.

High-Temperature Refractory Metasurfaces For Solar Thermophotovoltaic Energy Harvesting, Chun-Chieh Chang1,2, Wilton J. Kort-Kamp1,2, John Nogari1, Ting S. Luk2, Abdul Azad1, Antoinette Taylor1, Diego A. Dalvit3, Milan Sykora4, Hou-Tong Starko-Bowes5, Xueji Wang6, Jin Dai7, Ward D. Newman8, Sean Dual-Band Quasi-Coherent Radiative Thermal Source, Ryan Starko-Bowes1, Xueji Wang1, Jin Dai2, Ward D. Newman1, Sean Molekyte1, Limei Qi3, Aman Satija1, Ying Tiu4, Manisha Gupta1, Robert Fedosejevs5, Sandipan Pramanik6, Yi Xuan7, Zubin Jacob8, 1Birk Nanotechnology Center, Purdue Univ., USA; 2Univ. of Alberta, Canada; 3School of Electronic Engineering, Beijing Univ. of Posts and Telecommunications, China. We design, fabricate and characterize the spectral, polarization, angular and temperature dependence of a microstructured SiC thermal infrared source, achieving independent control of the frequency and polarization of thermal radiation in two spectral bands.

High-Temperature Optical Metamaterials, Alexander Petrov1, Manohar Chirumamilla1, Granavee Vaidyathanathan2, Tobias Krekeler1, Matthias Graf1, Dirk Jala1, Martin Ritter1, Michael Stromer1, Manfred Eich1; 1Center for Integrated Nanotechnologies, Los Alamos National Lab, USA; 2Inst. of Electro-Optical Science and Technology, National Taiwan Normal Univ., Taiwan; 3Center for Nonlinear Studies, Los Alamos National Lab, USA; 4Theoretical Division, Los Alamos National Lab, USA; 5Center for Integrated Nanotechnologies, Sandia National Labs, USA; 6Chemistry, Life, and Earth Sciences Directorate, Los Alamos National Lab, USA; 7Chemistry Division, Los Alamos National Lab, USA. We experimentally demonstrate refractory metasurfaces for solar thermophotovoltaics (STPV) with tailored absorptance and emittance thermally stable up to at least 1200°C.

High Temperature Optical Metamaterials, Alexander Petrov1, Manohar Chirumamilla1, Granavee Vaidyathanathan2, Tobias Krekeler1, Matthias Graf1, Dirk Jala1, Martin Ritter1, Michael Stromer1, Manfred Eich1; 1Center for Integrated Nanotechnologies, Los Alamos National Lab, USA; 2Inst. of Electro-Optical Science and Technology, National Taiwan Normal Univ., Taiwan; 3Center for Nonlinear Studies, Los Alamos National Lab, USA; 4Theoretical Division, Los Alamos National Lab, USA; 5Center for Integrated Nanotechnologies, Sandia National Labs, USA; 6Chemistry, Life, and Earth Sciences Directorate, Los Alamos National Lab, USA; 7Chemistry Division, Los Alamos National Lab, USA. We experimentally demonstrate refractory metasurfaces for solar thermophotovoltaics (STPV) with tailored absorptance and emittance thermally stable up to at least 1200°C.

Design study of two-cycle bandwidth, single-color pumped OPCPA chain, Szabolcs Toth1, Tomas Stansilauskas2, Ignas Balciunas3, Rimantas Budriunas3, Gediminas Vetas3, Janos Csortos3, Adam Borszynski3, Karyol Osvey3; 1ELI-ALPS, ELI-HU Nonprofit Ltd., Hungary; 2Light Conversion Ltd., Lithuania. We study the low-energy dynamics of hydroquinone and its clathrates under pressure using terahertz time-domain spectroscopy. Transitions between different phases are observed. The absorption peaks are assigned to lattice vibrational modes using quantum-mechanical simulations.

FTu4D.1 • 17:00 Dual-Band Quasi-Coherent Radiative Thermal Source, Ryan Starko-Bowes1, Xueji Wang1, Jin Dai2, Ward D. Newman1, Sean Molekyte1, Limei Qi3, Aman Satija1, Ying Tiu4, Manisha Gupta1, Robert Fedosejevs5, Sandipan Pramanik6, Yi Xuan7, Zubin Jacob8, 1Birk Nanotechnology Center, Purdue Univ., USA; 2Univ. of Alberta, Canada; 3School of Electronic Engineering, Beijing Univ. of Posts and Telecommunications, China. We design, fabricate and characterize the spectral, polarization, angular and temperature dependence of a microstructured SiC thermal infrared source, achieving independent control of the frequency and polarization of thermal radiation in two spectral bands.

FTu4D.2 • 17:15 High-Temperature Refractory Metasurfaces For Solar Thermophotovoltaic Energy Harvesting, Chun-Chieh Chang1,2, Wilton J. Kort-Kamp3,4, John Nogari1, Ting S. Luk2, Abdul Azad1, Antoinette Taylor1, Diego A. Dalvit3, Milan Sykora4, Hou-Tong Starko-Bowes5, Xueji Wang6, Jin Dai7, Ward D. Newman8, Sean Dual-Band Quasi-Coherent Radiative Thermal Source, Ryan Starko-Bowes1, Xueji Wang1, Jin Dai2, Ward D. Newman1, Sean Molekyte1, Limei Qi3, Aman Satija1, Ying Tiu4, Manisha Gupta1, Robert Fedosejevs5, Sandipan Pramanik6, Yi Xuan7, Zubin Jacob8, 1Birk Nanotechnology Center, Purdue Univ., USA; 2Univ. of Alberta, Canada; 3School of Electronic Engineering, Beijing Univ. of Posts and Telecommunications, China. We design, fabricate and characterize the spectral, polarization, angular and temperature dependence of a microstructured SiC thermal infrared source, achieving independent control of the frequency and polarization of thermal radiation in two spectral bands.

FTu4D.3 • 17:30 High Temperature Optical Metamaterials, Alexander Petrov1, Manohar Chirumamilla1, Granavee Vaidyathanathan2, Tobias Krekeler1, Matthias Graf1, Dirk Jala1, Martin Ritter1, Michael Stromer1, Manfred Eich1; 1Center for Integrated Nanotechnologies, Los Alamos National Lab, USA; 2Inst. of Electro-Optical Science and Technology, National Taiwan Normal Univ., Taiwan; 3Center for Nonlinear Studies, Los Alamos National Lab, USA; 4Theoretical Division, Los Alamos National Lab, USA; 5Center for Integrated Nanotechnologies, Sandia National Labs, USA; 6Chemistry, Life, and Earth Sciences Directorate, Los Alamos National Lab, USA; 7Chemistry Division, Los Alamos National Lab, USA. We experimentally demonstrate refractory metasurfaces for solar thermophotovoltaics (STPV) with tailored absorptance and emittance thermally stable up to at least 1200°C.

FTu4D.4 • 18:00 Non-Hermitian Selective Thermal Emitters Using Hybrid Plasmonic-Photonic Resonators, Chloee F. Daron1, Gunraj V. Naik2, Electrical and Computer Engineering, Rice Univ., USA; 2Applied Physics Graduate Program, Smalley-Curl Inst., Rice Univ., USA. We experimentally demonstrate non-Hermitian physics of thermal emitters by coupling a plasmonic resonator with low losses. Our thermal emitter exhibits passive PT-symmetry while operating at 700°C.

FTu4E.1 • 17:00 Latest developments at Amplitude in the frame of the ELI-HU projects. PW laser at high repetition rate, Franck Falcoz1, Amplitude, France. We will present in this paper the latest development made in the frame of the ELI projects. We will focus in particular on the development of a 50J @ 532nm, 10Hz pump laser that is compatible with T:Sa or OP-CPA pumping. The technology used and the performances obtained will be presented.

FTu4E.2 • 17:15 Design study of two-cycle bandwidth, single-color pumped OPCPA chain, Szabolcs Toth1, Tomas Stansilauskas2, Ignas Balciunas3, Rimantas Budriunas3, Gediminas Vetas3, Janos Csortos3, Adam Borszynski3, Karyol Osvey3; 1ELI-ALPS, ELI-HU Nonprofit Ltd., Hungary; 2Light Conversion Ltd., Lithuania. We study the low-energy dynamics of hydroquinone and its clathrates under pressure using terahertz time-domain spectroscopy. Transitions between different phases are observed. The absorption peaks are assigned to lattice vibrational modes using quantum-mechanical simulations.

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Matt Himsworth leads the integrated atom-chip group at the University of Southampton. His PhD focused on novel cooling mechanisms using atom interferometry. After a postdoctoral position at the University of Oxford he was awarded a RAEng/EPsrc fellowship. He is a Co-I in the UK Quantum Hub for Sensors and Metrology.

### STu4G • 17:00
Challenges in Miniaturising Cold Atom Quantum Technology, Matt Himsworth,
School of Physics & Astronomy, Univ of Southampton, UK.
I will discuss the current state of the art in integrating a miniaturising magneto optical traps (MOT) for quantum technology. The tutorial will cover on MOT geometries, vacuum systems, lasers, and optical elements.

### STu4H • 17:00
Machine Learning Assisted Raman in Optofluiddics for User-Independent Biofluid Diagnostics, Emily E. Storey,
Duxuan Wu,
Amr S. Helmy,
Univ. of Toronto, Canada.
We present a self-contained microfluidic Raman device which achieves signal enhancement of several orders of magnitude and machine-learning-driven analysis which facilitates diagnostically significant biofluid composition analysis, with a physiologically relevant sensitivity below 50 μM.

### STu4H • 17:15
Cross-Modality Deep Learning Achieves Super-Resolution in Fluorescence Microscopy, Hongda Wang,
Yair Rivenson,
Yinyin Jin,
Zhensong Wei,
Ronald Gao,
Harun Gunaydin,
Laurent Bentolila,
Comert Kural,
Aydogan Ozcaci,
Univ. of California Los Angeles, USA;
Ohio State Univ., USA.
Using cross-modality deep learning, we achieved super-resolution in fluorescence microscopy and established image transformations from a lower resolution microscopy modality to a higher resolution modality, without any parameter estimation or assumptions about the imaging system.

### STu4H • 17:30
Image-Guided Microfluidic Cell Sorter with Machine Learning, Yi Gu,
Rui Tang,
Alex Zhang,
Yuanquan Han,
Yuhwa Lo,
Univ. of California San Diego, USA.
We demonstrated an image-guided cell sorter using the techniques of spatial-temporal coding for high throughput cell imaging, real-time image processing and machine learning for cell classification, and microfluidic device in a disposable cartridge for cell sorting.

### STu4I • 17:00
Femtosecond Laser decapsulation of micro-electronics Including parameter study and redeposition control, Nicholas May,
Sina Shahbabanomad,
REFINE Lab of CT, USA.
This talk presents our approaches for laser based flexible electronics manufacturing. Femtosecond laser processing has been applied to increase the efficiency of organic semiconductors and to form electrodes on flexible substrates possessing novel transparent conductors.

### STu4I • 17:15
Low-loss geometrical phase elements by ultrafast laser writing in silica glass, Yukao Li,
Masaaki Sakakura,
Lei Wang,
Yan Hao Yu,
Roks Drevinskas,
Peter G. Kazarsky,
Optoelectronics Research Centre, Univ. of Southampton, UK.
Femtosecond laser induced birefringence with negligible transmission loss in silica glass is observed. Ultra-low loss birefringent optical elements including UV retarders and geometric phase optics are demonstrated.
Enhanced photoreponse at two-micron-wavelength was achieved through the use of a photodiode structure and was characterized at an 8-inch insulating platform, USA.

Dynamic measurement of blood flow using laser speckle contrast imaging, Abhishek Rege1; Vasoptic Medical, Inc., USA. Laser speckle contrast imaging is able to noninvasively obtain blood flow information with high spatio-temporal resolution from optically accessible tissues. Such information has the potential to be useful for diagnostic and other clinical decision making.

Low threshold 1.55 µm quantum dash microring lasers, Le1, Wei Wang1, Yuan Dong1, Chuan Seng Tan1,2, Xiao Gong1, Yee-Chia Yeo1; Univ. of California Los Angeles, USA. We present a lensless time-resolved speckle imaging technique for label-free, sensitive and rapid detection of motile parasites in bodily fluids, by using the locomotion of parasites as a biomarker and contrast mechanism.

Particle-agargregation-based virus sensor, achieving a high sensitivty of ~5 viral copies per µL, Yichen Wu1, Yi Luo1, Zhensong Wei1, Hongda Wang1, Vittorio Bianco1, Bohan Zhang1, Rohan Nadkarni1, Kent Hill1, Aydogan Ozcan1; Univ. of California Los Angeles, USA. We present a lensless time-resolved speckle imaging technique for label-free, sensitive and rapid detection of motile parasites in bodily fluids, by using the locomotion of parasites as a biomarker and contrast mechanism.

Time-resolved oxygen monitoring in human breath, Charles L. Patrick1; Jonas Westberg1, Gerard Wysocki2; Princeton University, USA. A small form-factor oxygen sensor is designed for respiratory monitoring to meet specifications: form-factor, sensitivity and real-time (<0.1 %, of QO2 at 100Hz). Two designs are demonstrated based on wavelength modulation spectroscopy (WMS) and Faraday rotation spectroscopy (FRS).

Characterization of the CEO Phase Noise of an Erbium Fiber Frequency Comb, Christoph Trepp1; Thomas Puppe1, Ali Seer1, Pierre Trouard1, Felix Rohde1, Ralf Wilk1; TOPICA Photonics AG, Germany. We measure the carrier-envelope phase noise of our Er-fiber frequency comb based on difference frequency generation. Integrating from 70 mHz to 20 MHz we achieve an excellent RMS phase jitter of only 61 mrad.
Extreme nonlinear optics in two dimensional materials, Kai-chiro Tansaku: Kyoto Univ., Japan. We show recent progress of extreme non-linear optics in two dimensional materials. High-harmonic generation is confirmed not only in semiconductors but also metals under irradiation of mid-infrared femtosecond laser pulses. We found main mechanism changes according to the carrier doping status of the material.

Valleytronics on the subcycle timescale, Christoph P. Schmid1, Stefan Schläuderer1, Fabian Langer1, Martin Gmitra1, Jaroslav Fabian1, Philipp Nagler1, Tobias Kom1, Christian Schüller1, Peter Hawkes1, Johannes T. Steiner2, Ulrich Huttner2, Markus Borsch1, Benjamin Girodias1, Stephan W. Koch1, Macikila Kira1, Rupert Huber1, Univ. of Regensburg, Germany; 2Univ. of Marburg, Germany; 3 Univ. of Michigan, USA. Intense multi-terahertz waveforms drive electron-hole recollisions in monolayer WSe2 and enable subcycle switching of the valley multi-terahertz waveforms drive electron-hole recollisions in monolayer WSe2 and enable subcycle switching of the valley polariton. This dynamics manifests in high-odd-order sidebands generation and opens the door to valleytronic protocols at optical clock rates.

Ultrafast laser pulse induced topological resonance in MoS2 monolayer, Seyyedeh Azar Oliaei Motlagh1, Jian-Sheng Wu1, Vadym Apalkov1, Mark Stokman1; 1Georgia State Univ., USA. In MoS2 monolayer, we predict that a single oscillation of double-layer electron wavepacket with circular polarization creates a chiral distribution of conduction band electron population. This chirality is an effect of topological resonances in this semiconductor.

Carrier-Envelope Phase Detection with Arrays of Electrically Connected Bowtie Nanoantennas, Philip D. Keatley1, Yuja Yang1, William Putnam1, Praful Vasireddy1, Franz Kartner1, Karl Berggren1; 1Photonics Research Group, Ghent Univ. - imec, Belgium; 2Center for Free Electron Laser Science and DESY, Germany. We use arrays of electrically connected bowtie nanoantennas to detect the carrier-envelope phase of few-cycle optical pulses with noise performance close to the shot-noise limit. Our results pave the way towards low-cost, low-profile CEP monitoring and tagging.

Optomechanical Control of the State of Chip-Scale Frequency Combs, David P. Burghoff1, Ningren Han2, Filippos Kapasidis3, Nathan Henry3, Mattias Beck3, Jacob Khurgin4, Jerome Faist5, Qing Hu6, Qiang Gao6, Networking and General Chair, 1ETH Zurich, Switzerland; 2Honeywell, USA; 3Center for Nano- and Biophotonics, Belgium; 4Department of Physics, University of California, Santa Barbara, USA; 5School of Physics, Georgia Institute of Technology, USA. We describe a silicon nitride (Si3N4) optoelectronic integrated circuit (PIC) designed to deliver non-diverging 780nm free-space optical cooling beams to an 87Rb atomic magneto optical trap (MOT) via fiber coupled ultra-large-area 3.88mm x 2.08mm gratings.

Photonic Integrated Si3N4Ultra-Large-Area Grating Waveguide MOT Interface for 3D Atomic Clock Laser Cooling, Zhou1, Zecen Zhang1, Callum Littlejohns2; 1Univ. of California, USA; 2Optoelectronics Reserch Centre, Univ. of Southampton, UK. We present the first MR hybrid Si external cavity laser with a tunable range below the 2 μm mark. To the best of our knowledge, we have achieved the largest tunable range of 66 nm (1881-1947 nm) near the 2 μm wavelength in silicon photonics.

Compact, ultra-tunable InGaSb/AlGaAsSb Si external cavity laser at the Mid-Infrared (MIR), Brian1, Wanjun Wang1, Zhongliang Qiao2, Xiang Li1, Xin Guo1, Jian Zhou1, Zecen Zhang1, Callum Littlejohns2, Chongyang Liu1, Graham T. Reed1, Hong Wang1, Nanyang Technological Univ., Singapore; 1Optoelectronics Research Centre, Univ. of Southampton, UK. We present first MIR hybrid Si external cavity laser with a tunable range below the 2 μm mark. To the best of our knowledge, we have achieved the largest tunable range of 66 nm (1881-1947 nm) near the 2 μm wavelength in silicon photonics.

Neutral-atom 3D atomic clock laser cooling, Russel1, Fei Xu1, Jeremie Faist1, 1ETH Zurich, Switzerland. We present the first MIR hybrid Si external cavity laser with a tunable range below the 2 μm mark. To the best of our knowledge, we have achieved the largest tunable range of 66 nm (1881-1947 nm) near the 2 μm wavelength in silicon photonics.
JTu4A.4 • 18:30
Photonic Controlled-PHASE Gate using Dynamic Cavities and a Kerr Nonlinearity, Mikkel Heuck1,2, Kurt Jacobs3,4, Dirk R. Enlund1; 1Danmarks Tekniske Universitet, Denmark; 2Dept of Electrical Engineering and Computer Science, MIT, USA; 3Computational and Information Sciences Directorate, U.S. Army Research Lab, USA; 4Dept of Physics, Univ of Massachusetts at Boston, USA. We propose a photonic CPHASE gate based on Kerr nonlinearity and tunable cavities enabling complete absorption and re-emission of photons. Storing photons about 40 times the width of their wavepackets results in 99% gate fidelity.

JTu4A.5 • 18:45
Exploring Quantum Memory via Optically Induced Bragg Structures, Carlo Page1, Tom Weaver1, John Price1, Joshua Nunn1; 1Univ of Bath, UK; 2QOLS, Blackett Lab, Imperial College, UK. We investigate short-term light storage for quantum computing by trapping light in an optically induced Bragg grating in warm Rb vapour.

FTu4B.6 • 18:30
Controlling Optical Forces between Evansently Coupled PT-Symmetric Waveguides, Mohammad-Ali Min1,2, Michele Cotrufo1, Andrea Alu3,4; 1Queens College of CUNY, USA; 2Physics Program, The Graduate Center of CUNY, USA; 3Advanced Science Research Center of CUNY, USA. We investigate optical forces between evanescently coupled optical waveguides with balanced gain and loss. This system reveals unusual properties, most notably the emergence of a tangential stress component parallel to the direction of wave propagation.

FTu4B.7 • 18:45
Spatially locked mode in defected microring resonators, Hwaseob Lee1, Tiantian Li1, Zi Wang1, Anishkumar Soman1, Alec Scalio1, Tingyi Gu1; 1Univ. of Delaware, USA. Control of mode-splitting in a microring resonator is achieved by introducing notched scatters on its perimeter. Single step etching on SOI substrate enables the microring resonator to operate at exceptional point.

17:30-18:30  OSA Senior Member Reception, OSA Member Lounge, Concourse Level

19:00-20:30  OSA Technical Group Poster Session, Grand Ballroom 220C
Concurrent sessions are grouped across six pages. Please review all six pages for complete session information.

**Tuesday, 17:00–19:00**

**CLEO: QELS-Fundamental Science**

**Executive Ballroom 210D**

**FTu4D • Thermal Photonics—Continued**

**FTu4D.5 • 18:15**
Perfect selective emitter with far infrared photonic structure, Se-Yeon Heo1, Gil Ju Lee1, Young Min Song1; Gwangju Inst. of Science and Technol, South Korea (the Republic of). We design and fabricate metasurface radiative cooler, in which high emissivity is achieved over the full range of main transparency window. The results provide one potential route to the absorption tuning at far infrared wavelength.

**FTu4D.6 • 18:30**
Incoherent Perfect Absorption in Lossy Dielectric Media, Sanjay Debnath1, Evgenii E. Narimanov1; Purdue Univ., USA. We theoretically demonstrate perfect absorption of incoherent light in lossy anisotropic half-infinite planar dielectric structures, and uncover this effect in existing (meta)materials.

**FTu4D.7 • 18:45**
All-Dielectric Metalens Integrated with Dispersive Grism for High Spectral Resolution at Mid-Infrared Regime, Semih Cakmakyan1, Yi-Chun Ling1, Mathias Prost1, S.J.Ben You1; UCD, USA. We present a proof-of-concept beam steering device which resolves the wavelength differences at mid-infrared regime by utilizing an all-dielectric metalens structure integrated with a grism structure.

**STu4E • High-Peak-Power Laser & Technologies II—Continued**

**Executive Ballroom 210E**

**STu4E.5 • 18:15**
A methodology for designing grism stretchers for idler-based optical parametric chirped-pulse amplification systems, Sara Bucht1, Dan Haberberger1, Jake Bromage1, Dustin Froula1; ‘Lab for Laser Energetics, USA. This paper presents a method for designing grism stretchers and grating compressors that can produce near transform-limited idler pulses from OPCPA systems.

**STu4E.6 • 18:30**
Pulse Contrast Enhancement via Non-collinear Sum-Frequency Generation of the Signal and Idler of an Optical Parametric Amplifier, Eric Cunningham1, Eric Galte1, Gilliss Dyer1, Joseph Robinson1, Alan Fry1; SLAC National Accelerator Lab, USA. We improve the temporal contrast of the front end of a high-intensity laser system to better than twelve orders of magnitude using non-collinear sum-frequency generation of the signal and idler of an optical parametric amplifier.

**STu4E.7 • 18:45**
Monitoring Charge Separation Dynamics Using THz Emission Spectroscopy, Burak Guzel'turk1,4, Eric Yue Ma1,4, Guoqing Li1,4, Eric Yue Ma2,4, Tony Heinz1,4, Aaron Linderberg1,4; Materials Science and Engineering, Stanford Univ., USA; 1Dept. of Applied Physics, Stanford Univ., USA; 2Dept. of Materials Science and Engineering, North Carolina State Univ., USA; 3Stanford Inst. for Materials and Energy Sciences, SLAC, USA. We present terahertz (THz) emission spectroscopy as a means of monitoring ultrafast charge separation dynamics in layered two-dimensional heterostructures.

**Executive Ballroom 210F**

**STu4F • Terahertz Spectroscopy—Continued**

**STu4F.5 • 18:15**
Thickness-Dependent THz Emission From Ultrathin Ferromagnetic Mn3-xGa Films, Igor Ilyakov1, Nilesh Awari1,3, Sergey Kovalev1, Ciarán Fowley1, Karsten Rode2, Plamen Stamenov2, Yong Chang Lau1, Davide Berto1, Nivetha Thiagarajah2, Bertram Green1, Oguz Yildirim1, Jürgen Lindner1, Jürgen Fassbender1, Michael Cox1, Alina Deac1, Michael Gensch1; 1Helmholtz-Zentrum Dresden-Rossendorf, Germany; 2Trinity College Dublin, Ireland; 3Univ. of Groningen, Netherlands. An experimental time-domain, room-temperature study of magnetization precession in ultra-thin Mn3-xGa films excited by femtosecond laser pulses is presented. The thickness dependence of the parameters of THz waves emitted from coherently driven magnetic resonances is investigated.

**STu4F.6 • 18:30**
Incoherent Perfect Absorption in Lossy Dielectric Media, Sanjay Debnath1, Evgenii E. Narimanov1; Purdue Univ., USA. We theoretically demonstrate perfect absorption of incoherent light in lossy anisotropic half-infinite planar dielectric structures, and uncover this effect in existing (meta)materials.

**STu4F.7 • 18:45**
Monitoring Charge Separation Dynamics Using THz Emission Spectroscopy, Burak Guzel’turk1,4, Eric Yue Ma1,4, Guoqing Li1,4, Eric Yue Ma2,4, Tony Heinz1,4, Aaron Linderberg1,4; Materials Science and Engineering, Stanford Univ., USA; 1Dept. of Applied Physics, Stanford Univ., USA; 2Dept. of Materials Science and Engineering, North Carolina State Univ., USA; 3Stanford Inst. for Materials and Energy Sciences, SLAC, USA. We present terahertz (THz) emission spectroscopy as a means of monitoring ultrafast charge separation dynamics in layered two-dimensional heterostructures.

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**17:30-18:30**
**OSA Senior Member Reception, OSA Member Lounge, Concourse Level**

**19:00-20:30**
**OSA Technical Group Poster Session, Grand Ballroom 220C**
STu4G.3 • 18:30
Alkali metal condensation zones in MEMS alkali vapor cells and characterization in CPT clock, Sylvain Karlen¹, Thomas Overstolz¹, Jean Gobet¹, Jacques Haesler¹, Fabien Droz¹, Steve Lecomte¹; ¹CSEM SA, Switzerland. We fabricated MEMS vapor cells gold microdiscs, allowing the condensation of alkali metal on preferred locations without the use of a thermal gradient. Reduction of light-shift induced long-term frequency instability in CPT clock is reported.

STu4G.4 • 18:45
Nanophotonic Integration of Atomic Wavelength References, Douglas Bopp¹, John Kitching¹, Vladimir Aksyuk¹; ¹NIST, USA. Nanophotonic circuitry is interfaced to microfabricated alkali vapor cells forming a quantum sensing platform. We operate this device as a wavelength reference using several operation modes and discuss strengths and limitations of such devices.

STu4H.4 • 18:30
Multicolor Stimulated Raman and Fluorescence Imaging with High-speed Programmable Tunability, Jingwen Shou¹, Robert Oda¹,², Shunji Tanaka¹, Yasuyuki Ozeki¹; ¹Univ. of Tokyo, Japan; ²The Univ. of Hawaii, USA. We demonstrate a multispectral and multimodal microscopy which enables high-speed stimulated Raman and fluorescence imaging. Both the Raman wavenumber and the fluorescence detection wavelength of each frame can be tuned via high-speed galvanometer-driven optical filters.

STu4H.5 • 18:15
Smartphone-based cancer detection platform based on plasmonic interferometer array biochips, Xie Zeng¹, Yunchen Yang¹, Nan Zhang¹, Dengen Ji¹, Yun Wu¹, Qiaoyang Gan¹; ¹State Univ. of New York at Buffalo, USA. We develop a nanoplasmonic interferometer imaging system based on intensity modulation to detect circulating exosomal proteins in real-time with high sensitivity and low cost to enable the early detection of cancer.

STu4H.6 • 18:45
Intracellular GaN microrod laser, Minho Song¹, Hyeonjun Baek¹, Gyu-Chul Yi¹; ¹Seoul National Univ., South Korea (the Republic of); ²Heriot-Watt Univ., UK. We report fabrication of GaN microrods and their intracellular lasing characteristics for individual cell tracking and labeling application.

STu4H.7 • 18:45
All-Fiber 2 μm Amplifier Using A Normal Dispersion Thulium Fiber, Yuhao Chen¹, Shaoxiang Chen¹, Kun Liu¹, Qijie Wang¹, Dingyuan Tang¹, Seongwoo Yoo¹; ¹Nanyang Technological Univ., Singapore. Normal dispersion thulium-doped fiber was deployed in all-fiber setup to amplify pulses from a near-2-μm ultrafast fiber ring cavity and demonstrated >27 dB amplification without pulse breaking. Output pulse energy ~525nJ reported at 1852nm.

17:30-18:30  OSA Senior Member Reception, OSA Member Lounge, Concourse Level

19:00–20:30  OSA Technical Group Poster Session, Grand Ballroom 220C
STu4J: Quantum Nanostructure—Continued

STu4J.6 • 18:30
Heterogeneous integrated quantum photonic devices with single, deterministically positioned InAs quantum dots, Peter Schnauber1, Anshuman Singh1,2, Johannes Schall1, Sven Rodt2, Kartik Srivivasan2, Stephan Reitzenstein3, Marcelo I. Davanco1; 1Dept. of Electrical and Computer Engineering, Univ. of British Columbia, Canada; 2Inst. of Solid-State Physics, Technical Univ. of Berlin, Germany; 3Maryland NanoCenter, Univ. of Maryland, USA. We demonstrate integrated Si3N4 waveguides containing single-photon emitters based on single InAs quantum dots that were deterministically positioned in a GaAs nanowaveguide via a low-temperature in-situ electron-beam lithography.

ATu4K: Biosensing Technology—Continued

ATu4K.5 • 18:15
Cost-effective, CMOS-compatible, label-free biosensors using doped silicon detectors and a broadband source, Leanne Dias1, Enxiao Luan1, Hosam Shoman1, Hanshi Jayatilleka1, Sudip Shekhar1, Lukas Chrostowski2, Nicolas Jaeger2; 1Dept. of Electrical and Computer Engineering, Univ. of British Columbia, Canada. By replacing Ge-based photodetectors and tunable lasers with doped silicon photodetectors and broadband sources, we propose and demonstrate a cost-effective implementation of photonic sensors for biosensing applications.

ATu4K.6 • 18:30
Deep Learning Enables Virtual Histological Staining of Label-free Tissue Sections Using Auto-fluorescence, Yair Rivenson1, Hongda Wang1, Kevin de Haan1, Zhengsong Wei1, Aydogan Ozcan2; 1Univ. of California Los Angeles, USA. We report a data-driven method for label-free virtual histological staining of tissue sections using deep learning. This framework is successfully demonstrated by inferring multiple types of stains on different tissue types using auto-fluorescence signal.

ATu4K.7 • 18:45
Smart Mattress System Based on Interferometric Fiber Optics for Vital Signs Monitoring, Semmao Wang1, Lijiang Li1, Jingyi Wang1, Zhijun Yan1, Deming Liu1, Qizhen Sun1; 1HuaZhou Univ of Science and Technology, China. A smart mattress system is developed to monitor human vital signs. The heart rate signal and respiration signal are measured simultaneously by the system based on fiber optic Mach-Zehnder interferometer.

ATu4L: Mode-Locked Fiber Lasers II—Continued

ATu4L.5 • 18:15
Passive Elimination of Spectrally Correlated Intensity Noise in Ultrad broadband Supercontinua from Highly Nonlinear Fibers, Philipp Sulzer1, Andreas Lielh1, Kilian R. Keller1, Jel- drik Huster1, Cornelius Beck1, Alfred Leitenstorfer1; 1Dept. of Physics and Center for Applied Photonics, Univ. of Konstanz, Germany. Amplitude fluctuations of pump pulses for frequency broadening by third-order processes are found to result in strong anti-correlations of spectral output components. We exploit this information to minimize intensity noise in subsequent nonlinear conversion steps.

ATu4L.6 • 18:30
Resolving the temporal structure of noise-like pulse using a synchronized time magnifier, Bowen Li1, Jiqiang Kang1, Sheng Wang1, Ying Yu1, Pingping Feng1, Kenneth Kin-Yip Wong1; 1Univ. of Hong Kong, Hong Kong. The detailed temporal structures inside the noise-like pulses have been resolved in real time for the first time using a synchronized parametric time magnifier. Optical rogue waves have been observed under sub-ps temporal resolution.

ATu4L.7 • 18:45
Spectrally uniform discrete Fourier domain mode locked fiber laser by time domain modulation, Dongmei Huang1, Chao Shang1, Peng Li1, Xianting Zhang1, Zhaoh Cheng1, Jinhui Yuan1, Xinhuang Feng1, P. K. A. Wai1; 1The Hong Kong Polytechnic Univ., Hong Kong; 2The Hong Kong Polytechnic Univ. Shenzhen Research Inst., China; 3Jinan Univ., China. We propose and demonstrate a frequency domain linearized discrete Fourier domain mode locked laser with a rate varying pulse modulation in time domain. Discrete swept signal with an identical FSR of 100 GHz is demonstrated.
JTu4M • Symposium on Intense-field Nonlinear Optics & High Harmonic Generation in Nanoscale Materials II—Continued

JTu4M.5 • 18:15 Circular dichroism of electrons photoemitted from an emitter array of Au nanospirals, Hong Ye, Anchita Adhikari, Subir Ray, Nirmalya Ghosh, Oliver D. Mücke, Jochen Küpper, Franz Kärntner, DESY/CFEL, Germany; Univ. of Hamburg, Germany; Indian Inst. of Science Education and Research Kolkata, India; Hamburg Centre for Ultrafast Imaging, Germany. We have investigated photoemission from an emitter array of Au nanospirals on an ultrafast time scale via velocity-map-imaging spectroscopy. Circular dichroism of the velocity distribution of the emitted electrons is observed.

JTu4M.6 • 18:30 Optical Harmonic Generation in Nonlinear All-Dielectric Nanoantennas and Metasurfaces, Andrey Fedyanin, Lomonosov Moscow State Univ., Russia. We present recent experimental results of controllable optical harmonic generation in all-dielectric nanoantennas and metasurfaces fabricated from direct (silicon) and indirect (gallium arsenide) semiconductor nanoparticles possessing low-order Mie-resonances in visible and IR ranges.

STu4N • Semiconductor-Based Optical Frequency Combs—Continued

STu4N.3 • 18:15 Optical-feedback-stabilized quantum cascade laser frequency combs, Chu Teng, Jonas Westberg, Gerard Wysocki, Princeton Univ., USA. Stabilization of quantum-cascade-laser frequency combs by means of external optical feedback is presented. Experimental results suggest reduced phase-noise in the frequency comb, allowing comb operation in previously unstable regimes.

STu4N.4 • 18:30 Narrow Intrinsic Linewidth Frequency Combs from a Chip-Based Hybrid Integrated InP-Si$_3$N$_4$ Diode Laser, Jesse Mak, Albert v. Rees, Youwen Fan, Edwin J. Klein, Dimitri Geskus, Peter van der Slot, Univ. of Twente, Netherlands; Lionix International BV, Netherlands. We present a hybrid integrated InP-Si$_3$N$_4$ laser that generates frequency combs with a record-low intrinsic linewidth of 34 kHz.

STu4O • Infrared Photonics & Applications—Continued

STu4O.3 • 18:30 Interband cascade laser frequency combs for monolithic and battery driven spectrometers, Benedikt Schwartz, Johannes Hillbrand, Maximilian Beiser, Aaron M. Andrews, Gottfried Strasser, Hermann Detz, Anne Schade, Robert Wehl, Sven Höfling, CEITEC, Czechia; Univ. Würzburg, Germany; TU Wien, Austria; Nanoplus, Germany. We demonstrated a monolithic frequency comb platform based on interband cascade lasers. We show self-starting frequency combs operation utilizing the inherent gain non-linearity and exceptionally fast and sensitive room-temperature photodetection to enable on-chip multi-heterodyne detectors.

STu4O.4 • 18:45 Integrated DFB Lasers on Si$_3$N$_4$ Photonic Platform for Chip-Scale Atomic Systems, Kevin F. Gallacher, Martin Sinclair, Ross Millar, Oliver Sharp, Francesco Miranda, Gary Tement, Gordon Mills, Brendan Casey, Douglas J. Paul, Univ. of Glasgow, UK; Kelvin Nanotechnology, UK. 780 nm wavelength distributed feedback lasers have been integrated onto a Si$_3$N$_4$ photonic platform on a Si substrate and coupled into waveguides for laser locking to either a ring resonator or rubidium vacuum cell.
Concurrent sessions are grouped across six pages. Please review all six pages for complete session information.
JW2A.1 Digital Holography for Local Heat Flux Measurement Using Silicon Nanowire Arrays on Transparent and Flexible Polymer. The high order diffraction was observed by controlling their shapes of the silicon nanowire arrays.

JW2A.2 LMD-ICA Based Intrusion Even Positioning Algorithm for Fiber Optic Perimeter Security System. We present a tunable hybrid square/hollow-core optical fiber laser for intrusion detection. Single-mode lasing around 1.626μm is achieved with a side mode suppression ratio above 30dB.

JW2A.3 Hybrid Square/Rhomb-Rectangular Semiconductor Lasers for Ethylene Detection. The experimental results demonstrate that the range for detecting binary neutron star inspirals for the Advanced LIGO detector, the range for detecting binary neutron star inspirals is enhanced by a factor of 19 using this scheme.

JW2A.4 Testing of an Optomechanical Accelerometer with a High-Finesse On-Chip Microcavity. The motion of a micro resonator integrated in a silicon hemisphere Fabry-Perot microcavity is used to transduce acceleration. We present the prototype assembly and performance tests of the optomechanical accelerometer.

JW2A.5 Development of Path-integrated Remote Chirped Laser Dispersion Spectrometer with Automatic Target Tracking (TLS) using an acousto-optic tunable filter (AOTF) and a Laser-Driven Light Source (LDSL). We propose a Vehicle-borne Near infrared 3D imaging LiDAR. The experimental results demonstrate that the image of target at 120m range with 30mm resolution can be obtained when the vehicle's speed is 30km/h.

JW2A.7 Experimental demonstration of Vehicle-borne Near Infrared Three-Dimensional Quantum Imaging LiDAR. Xiao-dong Mei, Cheng-long Wang, Long Pan, Peng-xi Wang, Wen-lin Gong, Sheng-sheng Han, Univ. of Chinese Academy of Sciences, China; Key Lab for Quantum Optics and Center for Cold Atom Physics of CAS, Shanghai Inst. of Optics and Fine Machines, Chinese Academy of Sciences, China. We propose a Vehicle-borne near infrared 3D ghost imaging LiDAR. The experimental results demonstrate that the image of target at 120m range with 30mm resolution can be obtained when the vehicle's speed is 30km/h.

JW2A.8 Tunable Light Source with LDL and AOTF. Xiaohua Ye, Alex Cultier, Ron Collins, Debbie Gustafson, Huiling Zhu, Energetic Inc., USA. Performances of a tunable light source (TLS) are evaluated. Experimental results of in-band fluxes, FWHM bandwidths between 400nm and 800nm, are presented.

JW2A.9 Dual-parameter sensing based on Fano resonances from a nontransparent materials.

JW2A.10 Stokes polarimeter with polarization-dependent hologram. Hailong Zhou, Yanxian Wei, Yu Yu, Jianji Dong, Xiniang Zhang, Wuhan National Lab for Optoelectronics, China. A Stokes polarimeter is demonstrated with polarization-dependent hologram. Owing to the low demand on the pattern of hologram, our work offer an easily manufactured scheme to measure the polarization of the light.

JW2A.11 Advanced Spectrometer with Two Spectral Channels Sharing the Same BSI-CMOS Detector. Liang-Yao Chen, Kai-Yan Zhang, Yuan Yao, Er-Tao Hu, An-Qing Jiang, Yu-Xiang Zheng, Song-You Wang, Hai-Bin Zhao, Yu-Mei Yang, Osamu Yoshie, Qian Wang, Kevin P Chen, University of Pittsburgh, USA; 4 NASA Goddard Space Flight Center, USA; 5 Ball Aerospace, USA. We describe an arc-lamp based pump-probe photothermal mirror spectrophotometer to measure the spectrum of the thermal quantum yield of the surface of solid samples. We discuss advantages of the method to characterize solid nontransparent materials.

JW2A.12 Si-traceable Calibration of Suitcase SOLARIS for CLARREO Pathfinder Mission. Yigit Aytaç, Kurt T. Thomas, Brian Wen-ry, Timmy M. Shuman, Julia Barsi, Brendan McAndrew, Barbara J. Zivkovski, Amit Angal, Joel McCorkell, Science Systems and Applications, Inc., USA; 2 Biophotonic Sciences, NASA Goddard Space Flight Center, USA; 3 Fibertek, USA; 4 NASA Goddard Space Flight Center, USA; 5 Ball Aerospace, USA. NASA's high accuracy calibration system GLAMR is utilized for testing a portable, visible and near-IR version of an imaging spectrometer that is part of the CLARREO Pathfinder mission to help demonstrate that 0.3% absolute uncertainty in reflectance retrieval is achievable.

JW2A.13 Superfluorescent Laser Gravitational Wave Detector. Minchun Zhou, Zifan Zhou, Selim M. Shahrari, Northwestern Univ., USA. We propose a gravitational wave detector that uses two superfluorescent lasers. Compared to the Advanced LIGO detector, the range for detecting binary neutron star inspirals is enhanced by a factor of 19 using this scheme.

JW2A.14 Detection of Rare-Earth Elements Enhanced by Bio-Metal-Organic Frameworks (MOFs) Using UV LED. Hui Lan, Scott Crawford, Zach Splain, Thomas Bayer, Paul Omidkhoda, Ran Zou, Mohan Wang, Kevin P Chen, University of Pittsburgh, USA; 4 Dept. of Electrical and Computer Engineering, Univ. of Pittsburgh, USA; 5 U.S. Dept. of Energy, USA. Spectral characteristics of BioMOF-sensitized trace rare-earth elements dissolved in water are studied at room temperature by laser-induced fluorescence method using a 280-nm LED. This paper presents a low-cost detection scheme to extract rare-earth materials in liquid phase.

JW2A.15 White-Light Photothermal Mirror Spectrophotometer. Aristides Marciano Oalozola, Mal Hing, Delaware State Univ., USA. We describe an arc-lamp based pump-probe photothermal mirror spectrophotometer to measure the spectrum of the thermal quantum yield of the surface of solid samples. We discuss advantages of the method to characterize solid nontransparent materials.

JW2A.16 Microwave-patterned colored passive radiative cooler. Gil Ju Lee, Se-yeon Heo, Young Min Song, Guangju Inst of Science & Technology, South Korea (the Republic of). Thermal management in colored objects has been intensely attractive for a long time. The proposed scheme is based on micropatterned metal-insulator-metal with thermal emission polymers, which can reduce the temperature of colored objects.
High Efficiency InP Pillar Array Heterojunction Solar Cells, Lin Gan1, Seyed Ebrahim Hashemi Amini1, Dong-Yong Li2, Alan H. Chin3, Yue-Yang Yu2, Cun-Zheng Ning1,2; N. S. M1; to 1.341 is achieved. A high RI sensitivity of microfiber probe for refractive index sensing is proposed and experimentally demonstrated. A high RI sensitivity of microfiber probe for refractive index sensing is proposed and experimentally demonstrated.

Dynamic Range, Online Monitoring of Biogas Concentration with a Wide Dynamic Range, Yiow-Seng Pauline Tan1, Justin P. Tan1,2, Grace S. Poh1, Y-H. Tan1, Zhiyun Zhou1, K. C. Leong1, S. S. Verma1, G. G. Ng1, Y. Q. Zhong1, Y. J. Chong1, R. J. C. MacFarlane1; 1Indian Inst. of Technology, Madras, India. Online measurement of CO2, CH4, and H2O in a biogas plant using a Supercontinuum laser based off-resonant broadband photo-acoustic spectroscopy is realized. The system exhibits a wide dynamic range from ppbv - 100% concentration.

Near-infrared broadband cavity-enhanced sensor system for methane detection using a wavelet-denoising assisted Fourier-transform spectrometer, Kiyuan Zhang4, Chun-Tao Zheng5, Zhi Lu1, Qixin He1, Xiangfeng Duan3, Ed Barnard2, Chee Wei Pamela R. Goh1,2; 1Gwangju Inst of Science & Technology, South Korea; 2Department of Medical Physics, National University of Singapore. Using extremely broad-band mid-infrared pulses (3-14 µm), and a single shot spectrometer, we demonstrate the electric-field control of both valley transmissive and reflective modes of the solute and the surrounding solvent molecules.
JW2A.38 Polarization rotators generated from graphene polymer composite made by a focused ion beam, Cheng Zhao1, Qianqian Huang1, Mohammad AlAraini1, Zinan Huang1, Chengbo Mou1, Alexey Rozhov1, Sergey Sergeev1, 1Shanghai Univ., China; 2Aston Inst. of Photonic Technologies, Aston Univ., UK; 3Higher College of Technology, Oman. We have experimentally investigated the polarization dynamics of an all-fiber passively mode-locked laser based on graphene using polarimeter for the first time. By carefully adjusting polarization controllers, two types of polarization rotators are obtained.

JW2A.39 Modulation Instability of Discrete Angular Momentum in Fiber Rings, Calum Matland1,2, Fabio Bicanalana1, Daniele Faccio1,1, Heriot-Watt Univ., UK; 2School of Physics and Astronomy, Univ. of Glasgow, UK. We present an analysis of modulation instability in a ring of coupled optical fibers. Plane waves are shown to be unstable to perturbations carrying discrete angular momenta, both for normal and anomalous group velocity dispersion.

JW2A.40 High-energy 9 µm LiGaS2-based Optical Parametric Chirped-Pulse Amplifier, Shizhen Qi1, Houkun Liang1, Xiao Zhou1, Kun Liu1, Wenkai Li2, Qijie Wang1, Ying Zhang1, 1Nanyang Technological Univ., Singapore; 2Singapore Inst. of Manufacturing Technology, Singapore. We report the first LiGaS2-based mid-IR OPCPA, pumped by the 1-µm Yb:YAG laser at 10kHz. The idler pulse is centered at 9 µm, covering 7.5-10.2 µm wavelength range, with 13.8 µJ pulse energy.

JW2A.41 Paraxial Accelerating Beams along a Sharply Curved Path, Zekun Pi1, Yi Hu1, Zhigang Chen1, Jingju Xu1; 1Nankai Univ., China. Sharply accelerating beams are commonly believed to exist only under non-paraxial conditions. Here we demonstrate that paraxial accelerating beams can be designed to travel along a steep parabolic path that conventional Airy beams cannot follow.

JW2A.42 Pseudo-Magnetic Monopole and Antimonopole in PT-Symmetric Coupled Waveguides, Rosie S. Hayward1, Fabio Bicanalana1; 1Heriot-Watt Univ., UK. PT-symmetric coupled waveguides, for which the Berry curvature corresponds to a hyperbolic pseudo-magnetic monopole or antimonopole, are shown to have a purely imaginary Berry connection, which can induce gain and loss when it is non-periodic.

JW2A.43 Raman Induced Visible Stable Platicons and Breather Platicons in Microresonators, Shuyun Yao1, Chengxing Bao1, Changxi Yang1; 1Tsinghua Univ., China; 2California Inst. of Technology, USA. We numerically demonstrate that stable platicons and coherent Kerr combs can be generated via Raman assisted four wave mixing in a AIN microresonator. Raman induced breather platicon dynamics is also observed in our simulations.

JW2A.44 Mid-infrared, Idler-resonant, Picosecond OP-AsGs OPO with Wide Tunability and Good Beam Quality, Qiang Fu1, Lin Xu1, Siping Li1, Peter Sheldove1, David Shepherd1, Shaif-Ul Alam1, 1David Richardson1; 1Optoelectronics Research Centre, UK. We report an idler-resonant, watt-level, picosecond OP-AsGs OPO with a tuning range of 4394-6102 nm (idler) and 2997-3661 nm (signal), and diffraction-limited idler beam.

JW2A.45 Guiding and Routing of a Light Pulse via an Airy-like Accelerating Potential, Zhi Li1, Fong Zhang1, Xue Mu1, Yi Hu1, Zhegang Chen1, Jingju Xu1; 1Nankai Univ., China. We experimentally guiding pulse by pulse in an accelerating potential. Weak signals features with single/double peaks can be guided to co-accelerate with a self-accelerating Airy pulse in an optical fiber.

JW2A.46 Bright Conical Diffraction at the Exceptional Point of PT-and Anti-PT-Symmetric Photonic Lattices, Mogan Ghandhi1, Hamidreza Ramezan1; 1Univ. of Texas Rio Grande Valley, USA. We show that bright conical diffraction occurs at the exceptional points of 1D PT and Anti-PT-symmetric photonic lattices.

JW2A.47 Characterization of Kerr Solitons in Microresonators with Parameter Optimization and Nonlinear Fourier Spectrum, Aqiao Sheng1, Yilong Zhao1, Guangqiang He1; 1Shanghai Jiao Tong Univ., China. We investigate the influence of pump power and the number of driving modes on the soliton step and use nonlinear Fourier transform to characterize the Kerr soliton in the microresonator driven by pulses.

JW2A.48 Nucleation of Optical Vortices in the Wake of a Blockage in Free-Space Propagating Light, William G. Holtzmann1, Samuel Alpermit1; 1Mark Siemens 2,1, Alexander Kildishev1, Vladimir M. Shalaev1, Alexandra Boltasseva1; 1Purdue Univ., USA; 2Inst. of Optoelectronics, Military Univ. of Technology, Poland. We demonstrate printing of colors from blue through green, yellow, orange to red using laser photomodification of semiconducting silver films on mirror with dielectric spacer. The colors are controlled by laser fluence and exposure time.

JW2A.49 Phase Synchronization of Coupled Optical Oscillators, Mohammad Ali Minaj1, Majie Ding1; 1Queens College of CUNY, USA. The problem of creating phase synchronization between coupled optical oscillators of different individual frequencies is theoretically investigated. The synchronization coupling threshold is obtained for a dimmer as well as an array of coupled oscillators.

JW2A.50 Measurements of Resonant Kerr Self-focusing and Self-defocusing of Tunable, 4.3 µm Radiation in CO2 Gas, Jeremy Pigeon1, Dana Tovey1, Sergei Tochitsky1, Gerhardus Louw 1; 1Nankai Univ., China. We demonstrate experimentally guiding pulse by pulse in an all-fiber passively mode-locked laser based on graphene using polarimeter for the first time. By carefully adjusting polarization controllers, two types of polarization rotators are obtained.

JW2A.51 Enhancement of Third Harmonic Generation in Organically Modulated permalloy films are promising for magneto-optical applications. We show that bright conical diffraction occurs at the exceptional points of 1D PT and Anti-PT-symmetric photonic lattices.

JW2A.52 Effect of linewidth dispersion in generate four wave mixing and Kerr-comb generation, Ali Eshkafer1, Ali Adibi1; 1Georgia Inst. of Technology, USA. We report the numerical study of linewidth dispersion effect on the degenerate four-wave mixing and the corresponding Kerr-comb generation; for asymmetric linewidth difference around pumping wavelength, there is a threshold above which we see non-homogeneous response corresponding to tuning roles.

JW2A.53 Sensitivity of Parameter Estimation Near the Exceptional Point of a Non-Hermitian System, Chong Chen1, Liang Jin 2, Ren-Bao Lu1; 1Dept. of Physics, The Chinese Univ. of Hong Kong, Hong Kong; 2Dept. of Physics, Nankai Univ., China. The eigenvalue susceptibility divergence at the exceptional point (EP) stimulates the idea of high sensitivity metrology. Parameter estimation around the EPs is theoretically studied. We find that the EP bears no enhancement of the sensitivity.

JW2A.54 Large Purcell enhancement with nonreciprocal photon collection in a gap plasmon system, Fan Zhang1, Lingxiao Shan1, Xinjie Fang1, Xueke Duan1, Qihuang Gong1, Ying Gu1; 1Peking Univ., China. We achieve chiral light-emitter coupling with guided part Purcell enhancement of 1000$\times$ gamma 0.5 and the directionality of 88% in a designed hybrid gap plasmon system, which provides an efficient way for nonreciprocal quantum photon sources.

JW2A.55 Laser Color Printing on Semicontinuous Silver Films, Sarah N. Chowdhury1, Piet Ngy1, Zhiyakh Kudyshev1, Alexander Kildishev1, Vladimir M. Shalaev1, Alexandra Boltasseva1; 1Purdue Univ., USA; 2Inst. of Optoelectronics, Military Univ. of Technology, Poland. We demonstrate printing of colors from blue through green, yellow, orange to red using laser photomodification of semiconducting silver films on mirror with dielectric spacer. The colors are controlled by laser fluence and exposure time.

JW2A.56 Tunable Localized Cosine-Gauss Beam generation through polarization control, Xuesi Zhao1, Peng Zhao1, Xue Feng1, Yidong Huang1; 1Tsinghua University, China. A nano-structure on metallic film is designed and fabricated to generate Localized Cosine-Gauss Beam while the propagating direction of generated surface plasmon plamon wave by modulating the polarization of illuminating lightbeam.

JW2A.57 Ultra-compact Polarization Emitter using a Silicon Nanoantenna, Zhonglin Lin1, Wei Shi1; 1University Laval, Canada. We demonstrate an ultra-compact ($3\times 4$~$\mu m$) silicon plasmonic nanoantenna that can generate an arbitrary polarization state through breaking the geometrical symmetry. The emitted polarization state shows a weak wavelength dependence over the C-band.

JW2A.58 Using Dynamic Plasmonic Colors for Optical Cryptography, Maowen Song1,2, Di Wang1, Zhaxylyk Kudyshev1, Vladimir M. Shalaev1, Alexander Kildishev1, Pengli Univ., China; 2Chongqing Univ., China. We experimentally demonstrate an all-aluminum metasurface that generates tunable plasmonic colors depending on the polarization states of the incident and reflected light. The metasurface produces high-resolution images and can be used to encrypt arbitrary information.

JW2A.59 Plasmonic System with In-Plane Magnetic Anisotropy for Plasmon Based Magnetic Switching, Mohammad Shahabuddin1, Nataila Nogaeva1; 1Norfolk State Univ, USA. Profile-modulated permalloy films are promising for magneto-optical applications. We show that such systems demonstrate plasmonic properties and have uniaxial in-plane anisotropy, which may allow sharp magnetization switching using SAM of light.

JW2A.60 Array of Symmetric Nanohole Dimers for STTRAM Ultra-thin Layer Sensing, Parma Sadi Moshkemani1; 1Univ. of California Irvine, USA. Dimer nanohole array is designed to detect radiation effects in STTRAM multilayer thin films, facing Fano resonance highly sensitive to dielectric layer changes. Normalized figure of merit is 13.5 times larger than single nanohole array.
Using metal/dielectric multilayer boundary, molecules for over 50 times and preserve the spin states of Texas at Austin, USA. We report a design of achiral dielectric thermoplasmonic applications, a comparison of metal adhesion layers for Au films in JW2A.66 phonon polariton resonance showing near perfect infrared experimentally demonstrated a control of localized surface grating of a metal/dielectric multilayer on silicon carbide. We deliver 300 ps pulses with energy of 104 nJ at repetition Technology, China. We demonstrate a mode-locked all-PM technology, providing an alternative for the optimization of field amplifications.

JW2A.62 Strontium Niobate for Near Infrared Plasmonics, Aweek Dutta1, Dongyang Wan2, Bixing Yan2, Vladimir M. Shalaev1, Thirunimal Venkatasesan3, Alexandra Boltseva5, Purdue Univ., USA; 1National Univ. of Singapore, Singapore. We study MgO-doped SrTiO3 (SrTiO3: MgO) as an alternate material for plasmonics in the near infrared wavelength range. We demonstrate, experimentally and through numerical simulations, hybrid plasmonic-photonic resonances in a SiO2-Si nanodisk stack on SNO near technologically important telecom window.

JW2A.63 Near-Ultraviolet Dielectric Metasurfaces for Surface-Enhanced Circular Dichroism Spectroscopy and Hanau’s Preserved Reflection, Kan Yoo1, Yuebing Zheng1; The Univ of Texas at Austin, USA. We report a design of achiral dielectric metasurfaces that can enhance the circular dichroism of chiral molecules for over 50 times and preserve the spin states of light upon reflection in the near-ultraviolet region.

JW2A.64 A control of localized surface phonon polarization using metal/dielectric multilayer boundary, Satyanarayana R. Kachiraju1; UTRGV, USA. We fabricated subwavelength grating of a metal/dielectric multilayer on silicon carbide. We experimentally demonstrated a control of localized surface phonon polarization resonant showing near perfect infrared absorption at the optical phonon band of silicon carbide.

JW2A.65 A Comparison of Metal Adhesion Layers for Au Films in Thermo-Plasmonic Applications, William Abbott1, Christopher Smith1, Amanda Petford-Long3, John Chang Hong1, ZhiGang Peng1, Pu Wang1; Beijing Univ. of Technology, China. We demonstrate a mode-locked all-PM Yb-doped fiber laser using nonlinear amplitude loop mirror, delivering 300 ps pulses with energy of 104 nJ at repetition rate of 100 kHz, which can be compressed to 1.05 ps.

JW2A.66 Generation of 104 nJ, 100 kHz Pulses directly from all-Normal Dispersion all-PM Yb-fiber Laser with a Nonlinear Amplification Loop Mirror, Yuhang Shui1, Zhaochen Cheng1, Chang Hong1, Zhigang Peng1, Pu Wang1; Beijing Univ. of Technology, China. We demonstrate a mode-locked all-PM Yb-doped fiber laser using nonlinear amplifying loop mirror, delivering 300 ps pulses with energy of 104 nJ at repetition rate of 100 kHz, which can be compressed to 1.05 ps.

JW2A.67 Generation and Frequency-conversion of Optical Vortex Arrays with Controlled Intensity Distribution, SS Harshith Bachimanchi1, Goutam Samanta1; IISER Pune, India; 2Atomic, Molecular, and Optical Physics, Physical Research Lab(PRL), India. We report on the generation of high-power ultrashort optical vortex arrays of controlled intensity distribution using microlens array we have generated vortex arrays at 1064 nm and frequency-doubled into vortex arrays at new wavelength.

JW2A.68 Grating-Based Mid-Infrared Long-Pass Filter for High-Power Applications, Wolfgang Schweinberger1, Daniel Gerz1, Thomas P. Butler1, Thomas Siekle1, Martin Heusinger1, Tatiana Amotchka1, Vladimir Pervak1, Uwe Zeitner1, Joachim Pepeza2; Max Planck Institute of Quantum Optics, Germany; 2Institute of Applied Physics, Academy of Sciences, Munich, Germany; 3Fraunhofer Inst. for Applied Optics and Precision Engineering, Germany; 4Physikalisch-Technische Bundesanstalt, Germany. We present a gold-coated silicon grating which provides efficient spatial separation of a broadband mid-infrared (MIR) beam from a collinear, 30W beam of broadband near-infrared (NIR) pulses in a power-scalable and chromatic dispersion-free manner.

JW2A.69 Withdrawn

JW2A.70 Single-shot Subnano Signal Recovery by Coherent Spectral Energy Redistribution, Benjamín G. Crockett1, Luis Romero1, Thomas F. K. Mak1, Shaikinasha Reddy K1, Jose Azañ1; UNRS, Canada. We demonstrate single-shot recovery of subnano signals, completely buried under random in-band noise, through combinations of phase manipulations derived from Talbot effect theory, allowing for reconstruction of signals with a time-bandwidth-product of up to 24.

JW2A.71 Demonstration of Space-Time Wave Packets That Travel in Optical Materials at the Speed of Light in Vacuum, Basanta Bhaduri1, Murat Yessenov1, Ayman F. Abouraoud1; Univ. of Central Florida, CREOL, USA. We synthesize optical wave packets that travel in transparent non-dispersive materials (liquids, glasses, and sapphire) at the speed of light in vacuum, independently of the refractive index, by introducing carefully designed spatio-temporal field spectral correlations.

JW2A.72 High-efficiency nonlinear compression using a gas-filled multipass cell, Florent Guichard1, Loic Lavenu1, Michele Natile1, Xavier Delen1, Yoann Zeaute1, Marc Hanna1, Eric Mottay1, Patrick Georges1; AmplyLight Laser Group, France; 2Laboratoire Charles Fabry, France. We demonstrate nonlinear temporal compression of a Yb-doped fiber amplifier in a multipass-cell filled with argon. The 160µJ 275Ps pulses are compressed down to 135µJ and 33fs, corresponding to a transmission of 85%.

JW2A.73 Demonstration of Space-Time Wave Packets That Travel in Optical Materials at the Speed of Light in Vacuum, Basanta Bhaduri1, Murat Yessenov1, Ayman F. Abouraoud1; Univ. of Central Florida, CREOL, USA. We synthesize optical wave packets that travel in transparent non-dispersive materials (liquids, glasses, and sapphire) at the speed of light in vacuum, independently of the refractive index, by introducing carefully designed spatio-temporal field spectral correlations.

JW2A.74 Phase space performance of filtered optical frequency comb, Lawrence Trask1, Ricardo Bustos-Ramirez1, Michael Ptaszak1, Peter Delleytt1; Univ. of Central Florida, USA. We determined the key parameters in low phase noise performance in filtered optical frequency combs. Laser frequency fluctuation and filter passband width as well as spectral phase play a role in obtaining low timing jitter.

JW2A.75 Generation of ultra-stable 50-fs pulses directly from an Er-doped fiber oscillator, Xiaoyu Zhao1, Weiwei Fan1, Yan Feng1; Shanghai Inst. of Optics & Fine Mech., China. We report on an Er-doped fiber laser which can generate few-cycle pulses with excellent long-term stability. The all-polarization-maintaining fiber oscillator can produce 50-fs pulses with 13.6-mW average power output at 55.3-MHz repetition rate.

JW2A.76 Demonstration of calibration-free time-stretch optical coherence tomography based on high-order dispersion compensation, Basanta Bhaduri1, Marcus J. Stainbeck1,2, John A. Rogers3,满意 Chen4; Nanyang Univ., China. We synthesized hybrid photonic crystal-plasmic mesocapsules using diatom bioisica with in situ growth silver nanoparticles. The mesocapsules achieved near single-molecule sensitivity for optofluorometric sensing with five orders of magnitude higher than colloidal nanoparticles.

JW2A.77 Microfluidic Mid-Infrared Spectroscopy via Microcapsule-Based Dual-Comb Source, Mengjie Yu1, Yoshitomo Okawachi1, Austin Griffiths1, Michal Lipson2, Alexander Gaeta3,4; Columbia Univ., USA; 2Cornell Univ., USA. We present a monolithically integrated platform in a CMOS 65RFETO process for biophotonic sensing. This platform opens the pathway to the first Lab-on-Chip system with nanoplasmonic functionality and advanced electronics on a single die.

JW2A.78 Beam Shaping with Axicons for Low Multipass Optical Microscopy, Natsuka Ochiai1, Jingwen Shou1, Yusuyuki Ozeki1,2; The Univ of Tokyo, Japan. We propose a beam shaping method using two axicons for reducing optical loss in broadband microsc ope optics. We demonstrate high transmittance and high spatial resolution without sacrificing signal intensity in stimulated Raman scattering microscopy.
11:30–13:00  JW2A • Poster Session II and Lunch

JW2A.84 Withdrawn

JW2A.85 Bound States in a Harmonic Graphene-Mode-Locked Fiber Laser, Bo Fu1, Jin Li1, Zhang Cao1, Daniel Popa1; Beijing Advanced Innovation Center for Big Data-Driven Precision Medicine, Beijing Univ., China; School of Instrumentation and Optoelectronic Engineering, Beihang Univ., China; Electrical Engineering, Univ. of Cambridge, UK. A solution-processed graphene film deposited on a fiber-based connector is used for stable bound states of solitons in a harmonic mode-locked all-fiber laser at harmonics up to the 26th.

JW2A.86 104 fs mode-locked fiber laser with a MXene-based saturable absorber, Qing Wu1, Meng Zhang1, Xin Xin1, Si Chen1, Quanyu Jiang1, Xiantao Jiang1, Zheng Zheng1, Han Zhang1, Beihang Univ., China; Shenzhen Univ., China. We report an all-fiber erbium-doped laser mode-locked by a microfiber-based MXene saturable absorber, generating 104-fs pulses with 42.5-nm spectral width. Our work adds MXene to the growing catalogue of nanomaterials for future nonlinear photonics.

JW2A.87 Spatial-temporal Dynamics of Dual-Soliton States in a Multimode Fiber Laser, Yihang Ding1, Xiaosheng Xiao1, Mode-Locked Fiber Laser Design, Jianwu Chai1,2, Jin Li3, Zhang Cao2,1, Daniel Popa1; Beijing Advanced Innovation Center for Big Data-Driven Precision Medicine, Beijing Univ., China; School of Instrumentation and Optoelectronic Engineering, Beihang Univ., China; Electrical Engineering, Univ. of Cambridge, UK. A solution-processed graphene film deposited on a fiber-based connector is used for stable bound states of solitons in a harmonic mode-locked all-fiber laser at harmonics up to the 26th.

JW2A.88 1.94 GHz Passively Harmonic Mode-Locked All-Fiber Laser Using Polarization-maintaining Helical Long-period Grating, Qianqian Huang1, Chen Jiang1, Changxi Yang1, Bo Fu1,2, Jin Li3, Zhang Cao2,1, Daniel Popa1; Beijing Advanced Innovation Center for Big Data-Driven Precision Medicine, Beijing Univ., China; School of Instrumentation and Optoelectronic Engineering, Beihang Univ., China; Electrical Engineering, Univ. of Cambridge, UK. A solution-processed graphene film deposited on a fiber-based connector is used for stable bound states of solitons in a harmonic mode-locked all-fiber laser at harmonics up to the 26th.

JW2A.89 High Absorption Low NA Step Index Large-Mode-Area Fiber for High Power Ultrafast Lasers, Raghu Murman Sidharth1, Kang, Jie Lim1, Serene Huiting Lim2, Huie Li3, Yan Yan Zhou1, Junhua Ji1, Yue Men Seng1, Song Liang Chua1, Seongwoo Yoo1, Nan Yanyang Technological University, Singapore; 2DSO National Laboratories, Singapore. We report fabrication of >20dB/m cladding absorption step-index LMA fiber with low core NA (<0.07) suitable for ultra-fast fiber lasers. Above 58W output power with a slope efficiency of ~80% was demonstrated in only 0.5m fiber.

JW2A.90 Self-parametric amplification in ultrashort fibre lasers, Heping Zeng1, Junsong Peng1, East China Normal Univ., China. Self-parametric amplification is employed as a novel gain mechanism in ultrashort fibre lasers, which transfers energy from the spectral tails to the center within the laser field. The laser outputs three pulses with different spectra.

JW2A.91 Highly Sensitive Liquid Level Sensor Based on Microstructured Optical Fiber, Wei Zhang1, Fan Ai1, Zhihun Xing1, Wei Zhou1, Zhijun Yan1, Deming Liu1, Qunhe Sun1, Huazhong Univ of Science and Technology, China. A highly sensitive liquid level sensor based on microstructured optical fiber is experimentally demonstrated. The proposed sensor can achieve the fully distributed liquid level monitoring with the resolution of 74um with large detection range.

JW2A.92 All-Polarization Maintaining, Bi-directional, Er-doped, Dual-comb Fiber Laser with Single Wall Carbon Nanotube, Shuto Saito1, Masahito Yamakawa1, Youichi Sakakibara1, Eriko Omota1, Hirokihi Katsura1, Noriko Nishizawa1, Nagoya Univ., Japan; AIST, Japan. All polarization maintaining, bi-directional, Er-doped, dual-comb fiber laser using carbon nanotube polyimide film was demonstrated. Optical spectra of output pulses were almost the same, and stable soliton mode-locking operation was achieved for long term.

JW2A.93 Demonstration of the Coherent Mid-IR Supercontinuum Generation in Tapered Tellurite Fiber, Than Singh San1, Hoa P Nguyen1, Luo Xing1, Tong H Tuan1, Takanobu Suzuki1, Yasutake Ohashi1, Toyota Technological Inst., Japan. Coherent supercontinuum spectrum spanning 1.28 - 3.1 µm at -40 dB intensity level is obtained using an all-normal dispersion tapered tellurite fiber pumped by 200 fs laser pulse of peak power of 19 kW at 2.0 µm.

JW2A.94 The Impact of Saturable Absorber Recovery Time in Hybrid Mode-Locked Fiber Laser Design, Liu Jin1, Chao Zhang1, Nesei Hayashi1, Zae Y Set1, Shinji Yamashita1, Univ. of Tokyo, Japan. Saturable absorber recovery time plays an important role in a hybrid mode-locked fiber laser. Our investigation reveals that a shorter recovery time is preferred for the hybrid scheme combined with nonlinear polarization rotation.

JW2A.95 Single-aperture passive coherent beam combination of fiber lasers based on diffractive optical element, Gang Bai1,2, Hui Shen1, Meizhong Liu1, Kai Li1, Haibo Zhang1, Xiaoxia Niu1, Yi Feng1, Bing He1,3, Jun Zhou1, Shanghai Key Lab of All Solid-State Laser and Applied Techniques, Shanghai Inst. of Optics and Fine Mechanics, Chinese Academy of Sciences, China; Univ. of Chinese Academy of Sciences, China; Nanjing Inst. of Advanced Laser Technology, China. We demonstrate a single-aperture coherent beam combination with eight fiber laser beamlets using a one-dimension diffractive optical element in an all-optical feedback loop. The maximum output power is 1.5 W with near diffraction-limited beam quality.

JW2A.96 Light propagation properties of a novel tellurite hollow-core photonic crystal fiber with a single hexagonal air-hole layer, Huiping Tian1, Nobuhiko Nishihara1, Takanobu Suzuki1, Yasutake Ohashi1, Toyota Technological Inst., Japan. We experimentally demonstrated the fabrication of a novel tellurite hollow core photonic crystal fiber with a single hexagonal air-hole layer and studied its light propagation and transmission properties from 0.4 to 2.4 µm.

JW2A.97 High Repetition Rate Visible Frequency Comb Generation By Utilizing a Microring Resonator as Frequency Comb Filter, Yifeng Yang1, Bing He1,3, Jun Zhou1,3; Hong Kong Polytechnic Univ., Hong Kong; The Hong Kong Polytechnic Univ. Shenzhen Research Inst., China; City Univ. of Hong Kong, Hong Kong; Univ. of Science and Technology of China, China. We propose a new method to generate self-similar parabolic pulses in experimentally tapered multimode fibers. In such broadband amplification-free setups the input pulse can quickly acquire a parabolic profile with a high quality linear chirp.

JW2A.98 Tricomb and quadcomb generation from a multi-dimensional multiplexed fiber laser, Ting Li1, Xin Zha1, Jie Chen1, Quan Li1, Zhenhong 2,1; School of Electronic and Information Engineering, Beihang Univ., China; Beijing Advanced Innovation Center for Big Data-based Precision Medicine, China. By tapping into multiple wave-guiding dimensions in optical fiber, it is demonstrated that up to four wavelength/polarization multiplexed, asynchronous ultrashort pulse sequences can be generated with good stability from all-single-fiber, ring-cavity, mode-locked fiber laser.

JW2A.99 1-MHz, Energetic Ultrafast Source Tunable Between 940-1200 nm Using Single Wall Carbon Nanotube Pulse Fiber Laser, Bo Fu1,2, Xing Yu1, Shao Bo Fang1, Hao Teng1, Jiangfang Zhu1, Junli Wang1, Guoqing Chang1, Zhiyi Wei2,3, Xidian Univ., China; Beijing National Lab for Condensed Matter Physics, Inst. of Physics, Chinese Academy of Sciences, China; School of Physical Science, Univ. of Chinese Academy of Sciences, China. We demonstrate a 1-MHz ultrafast fiber-optic source that produces ∼100-fs pulses tunable from 940 nm to 1250 nm with up to 33μJ pulse energy. Such a source is ideal for driving multi-photon microscopy.

JW2A.100 Inclinometer Based on Optical Microfiber Probes, Junjie Wang1, Shijie Tan1, Wei Zhang1, Yanpeng Li1, Qunhe Sun1, Deming Liu1, Huazhong Univ of Science and Technology, China. An inclinometer based on optical microfiber probes is proposed and experimentally demonstrated, which is capable of measuring the tilt angle and direction simultaneously with a resolution lower than 0.0004° within ± 5°.

JW2A.101 High Resolution Tri-Phase-Shifted Fiber Bragg Grating Demodulator using Frequency Swept DFB Laser, Jiachen Chen1, Qiangwen Liu1, Zuyuan He1, Shangli Jiao1, Tong Univ., China. A tri-phase-shifted fiber Bragg grating demodulator has been proposed based on feed-forward linewidth suppression of frequency swept DFB laser. Wavelength resolution of 3.2 fm in 0.4 nm scan range is achieved in the demonstration.

JW2A.102 Discrete Fourier domain mode locked laser with a microring resonator, Dongmei Huang1, Feng Li1, Huwuo Luo1, Chao Zhang1, Nan Guo1, Jiayang Wang1, Sai Chu1, Xinhuang Feng1, P.K. A. Wai1; The Hong Kong Polytechnic Univ., Hong Kong; The Hong Kong Polytechnic Univ. Shenzhen Research Inst., China; Univ. of Science and Technology of China, China; City Univ. of Hong Kong, Hong Kong; Univ. of Science and Technology of China, China. We propose and experimentally demonstrate a discrete Fourier domain mode-locked (DFM) laser with more than 100 nm bandwidth by utilizing a microring resonator as frequency comb filter.

JW2A.103 Parabolic Pulse Generation in Totally Passive Tapered Multimode Fibers, Helena E. Lopez Alvarez1, Michael Buttolph1, Edmon C. Gonder2,3, William N. Li3,4, Rodrigo Aranceta Cortes1, Demetrios N. Christodoulides1; School of Applied and Engineering Physics, Cornell Univ., USA; CREOL, College of Optics and Photonics, Univ. of Central Florida, USA. We propose a new method to generate self-similar parabolic pulses in exponentially tapered multimode fibers. In such broadband amplification-free set-ups the input pulse can quickly acquire a parabolic profile with a high quality linear chirp.

JW2A.104 11:30–13:00  JW2A • Poster Session II and Lunch

JW2A.105 Surface-enhanced Raman scattering sensor based on soft polymer optical fibers, Jingjing Guo1,2, Yuanlu Luo1, Changxi Yang1, Lingjie Kong1, Beihang Univ., China; Shenzhen Univ., China. We present a novel SERS probes based on soft polymer optical fibers with physio-mechanical properties suitable for implantation, and demonstrate their potential applications for in-situ detection of bioanalytes.
JW2A.106
Fast M⁰ estimation for fiber beams through deep learning. Liangjin Huang, Pu Zhou, Yi An, Jinyong Peng, Liya Yang, Jun Li. National Univ. of Defense Technology, China. We have firstly utilized deep learning (DL) in M⁰ estimation for fiber beams. The simulations have proved our scheme is accurate and M⁰ can be determined within ~3 ms using a trained DL network.

JW2A.107
Fabrication and Characterization of Birefringent Bismuth and Erbium Co-Doped Photonic Crystal Fiber for Broadband Polarized Near Infrared Emission. Yushi Chiu, Yuan Tian, Desheng Fan, Gui Xiaoo, Shuon Wei, Bowen Zhang, Xinghu Fu, Zhenyu Ma, Quan Chai, Jing Ren, Jianzhong Zhang, Yanhua Luo, Gang-Ding Peng. School of Science, Harbin Engineering Univ., China; School of Electrical Engineering & Telecommunications, Univ. of New South Wales, Australia. The birefringent bismuth and erbium co-doped photonic crystal fiber (B-BEPCF) by preform stacking technology has been fabricated and characterized. Results demonstrate broadband and elliptically polarized near infrared (NIR) emission under 532 or 630 nm pumping, respectively.

JW2A.108
Suspended-core fiber based Sagnac interferometer device and sensing applications. Yu Zheng, Perry Ping Shum, Yiyang Luo, Yanyan Zhang, Zhifang Wu, Jean-Louis Auguste, Georges Humbert, COFT, School of EEE, Nanyang Technological Univ., Singapore; CINTRA, CNRS/NTU/Thales Research Alliance, Singapore; College of Information Science and Engineering, Northeastern Univ., China; College of Information Science and Engineering, Huazhao Univ., China; XJLU Research Inst., France. Optical fiber based interferometers have been used for numerous sensing applications. Here, we develop an all-fiber Sagnac interferometer device based on suspended-core fiber, which can be excellent candidates for physical or biochemical sensors.

JW2A.109
Experimental Demonstration of Highly Coherent Near to Mid-Infrared Supercontinuum Generation with All-solid Hybrid Microstructured Tellurite Fiber. Hua P. Nguyen, Tuan H. Tong, Lao Xiong, Thai Singh Saini, Takanobu Suzuki, Yasutake Oshiki, Toyota Technological Inst., Japan. A highly coherent supercontinuum spanning 1.4 to 3.3 µm was generated in an all-solid hybrid microstructured tellurite fiber pumped by a laser operating at 2 µm.

JW2A.110
Demonstration of dichroic atomic vapor laser lock in micro fabricated vapor cell using light induced atomic desorption, Eliran Talker, P. Arora, Roy Zektzer, Yefim Barash, Tae Hyun Kim, Hee Yeoun Kim, Sang-Eon Park, 1The Hebrew Univ., Jerusalem, Israel; 2North Carolina State Univ., USA; 3YuNan Univ. of Science and Technology, China; 4Huazhong Univ. of Science and Technology, China; 5XLIM Research Inst. France. We demonstrate Dichroic Atomic Vapor Laser Lock (DAVLL) using light induced atomic desorption, enabling a new quantum-enhanced atomic force microscopy suitable for broadband characterization of high-speed dynamics in materials.

JW2A.111
Optimizing the dipole trap for loading laser-cooled atoms into hollow-core fibers. Tae Hyun Kim, Hee Yeoun Kim, Sang-Eon Park, 1The Hebrew Univ., Jerusalem, Israel; 2North Carolina State Univ., USA; 3YuNan Univ. of Science and Technology, China; 4Huazhong Univ. of Science and Technology, China; 5XLIM Research Inst. France. We optimize the dipole trap for loading laser-cooled atoms into hollow-core fiber to optimize the trade-offs between the observed loss mechanisms.

JW2A.112
Coherent atomic microwave sensor, Vladislav Gergnov, Fabio da Silva, Craig Nelson, Archita Hati. Time and Frequency, NIST, USA; 2Physics, Univ. of Colorado Boulder, USA. We developed a room-temperature microwave signal atomic sensor that converts coherently a low-power microwave signal to polarization modulation of a probe light field. The sensitivity rivals that of microwave field probes based on Rydberg atoms.

JW2A.113
Efficient hyperfine optical pumping of Rb atoms in Miniaturized vapor cells, Eliran Talker, P. Arora, Mark Dikopolov, Uriel Levy. Dept. of Applied Physics, The Hebrew Univ., Jerusalem, Israel. We demonstrate the positive role of buffer gas in achieving highly efficient hyperfine-structure based optical pumping of Rubidium atoms in miniaturized vapor cells. At a pressure of 40 Torr, pumping efficiency of 85% is achieved.

JW2A.114
Sodium Magnetometry, Yan Feng, Tingwei Fan, Tianhua Zhou, 1Shanghai Inst. of Optics & Fine Mechanics, China. Magnetric resonance of sodium fluorescence is investigated and a magnetometer based on sodium vapor is demonstrated. The study is motivated by remote magnetometry with mesoscopic sodium. Results of on-sky tests are reviewed.

JW2A.115
Multiparameter Quantum Tracking of Optical Activity, Valeria Cimini, Ludovica Ruggiero, Ilaria Gianani, Marco Sbroscia, Tedia Gasper, Emanuele Roccia, Luca Mancino, Daniela Tofani, Fabio Bruni, Maria Antonietta Ricci, Marco Barbieri. Université degli studi Roma Tre, Italy. Quantum sensors can be used to monitor the dynamic of chemical processes. Here we implement a multiparameter protocol, on two different chemical reactions, robust against time-varying noise.

JW2A.116
Multiparameter Quantum Tracking of Optical Activity, Valeria Cimini, Ludovica Ruggiero, Ilaria Gianani, Marco Sbroscia, Tedia Gasper, Emanuele Roccia, Luca Mancino, Daniela Tofani, Fabio Bruni, Maria Antonietta Ricci, Marco Barbieri. Université degli studi Roma Tre, Italy. Quantum sensors can be used to monitor the dynamic of chemical processes. Here we implement a multiparameter protocol, on two different chemical reactions, robust against time-varying noise.

JW2A.117
Truncated nonlinear interferometric cantilever beam-displacement: accessible quantum sensing, Benjamin Lawrie, Jacob Beckey, Raphael C. Pooser, Oak Ridge National Lab, USA. We show that relative beam displacement measurements with two-mode squeezed light sources are identical to truncated SU(1,1) interferometers, enabling a new quantum-enhanced atomic force microscopy suitable for broadband characterization of high-speed dynamics in materials.

JW2A.118
Planar Alignment of Graphene Sheets by a Rotating Magnetic Field for Polarizer and Display Applications, Feng Lin, Guang Yang, Chao Niu, Zhaoping Liu, Zhiming Wang, Hong Kong Poly. Univ., USA; 2Rafael Ltd, Haifa, Israel. We demonstrate power enhancement of burst-mode UV (355 nm) laser with 50 ps pulse width and 402.5 MHz repetition rate. Peak intracavity power of >1.5 MW has been achieved for bunches with 10 µs at 10 Hz rate in a doubly-resonant optical cavity under high vacuum.

JW2A.119
Optimization of Chalcogenide Negative Curvature Fibers for CO₂ Laser Transmission, Chengli Wei, Curtis R. Menyuk, Jonathan Hui, Electrical and Computer Engineering, Baylor Univ., USA; 2Computer Science, Engineering and Physics, Univ. of Maryland at College Park, USA; 3Computer Science and Electrical Engineering, Univ. of Maryland, Baltimore County, USA. We study the geometry of chalcogenide negative curvature fibers with different numbers of tubes and different core diameters. We optimize the design of chalcogenide negative curvature fibers for CO₂ laser transmission.

JW2A.120
Burst-Mode Ultraviolet Laser Pulses at Megawatt Peak Power in a Doubly-Resonant Enhancement Cavity, Abdulrahim Rakham, Yunn Liu; Oak Ridge National Lab, USA. We demonstrate power enhancement of burst-mode UV (355 nm) laser with 50 ps pulse width and 402.5 MHz repetition rate. Peak intracavity power of >1.5 MW has been achieved for bunches with 10 µs at 10 Hz rate in a doubly-resonant optical cavity under high vacuum.

JW2A.121
Photonic Crystal Behavior of Nitzschia Filipponis Phytoplankton for Chlorophyll A Photosynthesis, Yannick D’Mello, Santiago Bernal, James Skoric, Dan Petruscu, Mark Andrews, David V. Plant, McGill Univ., Canada. Photonic band structures of Nitzschia Filipponis diatom frustules revealed resonances at wavelengths corresponding to both peaks in the chlorophyll A absorption spectrum. The behavior at 658 nm wavelength was investigated using near-field optical microscopy.

JW2A.122
Optimization of Chalcogenide Negative Curvature Fibers for CO₂ Laser Transmission, Chengli Wei, Curtis R. Menyuk, Jonathan Hui, Electrical and Computer Engineering, Baylor Univ., USA; 2Computer Science, Engineering and Physics, Univ. of Maryland at College Park, USA; 3Computer Science and Electrical Engineering, Univ. of Maryland, Baltimore County, USA. We study the geometry of chalcogenide negative curvature fibers with different numbers of tubes and different core diameters. We optimize the design of chalcogenide negative curvature fibers for CO₂ laser transmission.
FW3B.1 • 13:00
Second-Harmonic Diffraction from Periodically Structured MoS2 Monolayer, Franz J. Löchner1, Rajeshkumar Muppapu1, Michael Steiner1, Antony George2, Andrey Turchanin2, Thomas Pertsch2, Isabelle Staude1, Frank Setzpfandt1; 1Inst. of Physical Chemistry, Friedrich Schiller Univ. Jena, Germany; 2Fraunhofer Inst. for Applied Optics and Precision Engineering, Germany. We investigate second-harmonic generation from one-dimensional gratings in MoS2 monolayer flakes structured by focused ion beam milling, and observe diffraction orders due to nonlinear diffraction from the periodic structure.

FW3B.2 • 13:15
Non-reciprocal delay based on photon-phonon interactions on a chip, Moritz Merklen1, Birgit Stiller1, Khu Vu1, Pan Ma1, Stephen Madden1, Benjamin J. Eggleton1; The Univ. of Sydney, Australia; 1Australian National Univ., Australia. We demonstrate a non-reciprocal delay scheme based on stimulated Brillouin scattering in a planar highly nonlinear waveguide. The bandwidth of this scheme approaches a GHz, has wide frequency tunability and scales linearly with data power.

FW3B.3 • 13:30
Heterogeneous Integration of GaAs/AlGaAs Devices for Non-Linear Applications, Marc Sorel1, Stuart May1, Matteo Clerici1, Michael Kues1, Charalampos Klitis1, Michael Strain2, Stephen Madden1, Benjamin J. Eggleton1; 1The Univ. of Sydney, Australia; 2Australian National Univ., Australia. We present that the nonlinear optical conversion efficiency in LNOI ridge/rib waveguides can be improved by considering the lateral leakage at the second harmonic wavelength, enabling an improved nonlinear optical conversion efficiency of ~780% W/cm2.

FW3B.4 • 14:00
Enhanced nonlinearity in lithium niobate on insulator (LNOI) waveguides through engineering of lateral leakage, Andreas Boes1, Lin Chang1, Thach Nguyen1, Markus Knoerzer1, Jan Peters1, John Bowers2, Arnan Mitchell1, 1The Univ. of Sydney, Australia; 2Australian National Univ., Australia. We present that the nonlinear optical conversion efficiency in LNOI ridge/rib waveguides can be improved by considering the lateral leakage at the second harmonic wavelength, enabling an improved nonlinear optical conversion efficiency of ~780% W/cm2.

FW3C.1 • 13:00
Light Emission from a Waveguide Integrated MOS Tunnel Junction, Michael Doderer1, Markus Parzefall1, Andreas Joerg1, Daniel Chelladurai1, Nikola Dordevic1, Yuriy Fedoryshyn1, Amit K. Agrawal2, Henri Lezec2, Lukas Novotny2, Juerg Leuthold1, Christian Haffner1; ETH Zurich, Switzerland; 1National Inst. of Standards and Technology, USA; 2Univ. of Maryland, USA. We report on light generation via inelastic electron tunneling in a metal-oxide-semiconductor (MOS) junction that is directly integrated within a silicon photonic waveguide. We generate an optical power of 6.8 pW.

FW3C.2 • 13:15
Polariton electroluminescence in monolayer WS2, Biswanath Chakraborty1, Jie Gu1, Mandeep Khattor1, Vinod Menon1, 1Physics, The City College of New York, CUNY, USA. We demonstrate a room temperature polariton LED using monolayer WS2 embedded in a microcavity in the strong coupling regime. Electrical injection is accomplished via graphene contacts and hBN tunnel barriers integrated with the microcavity.

FW3C.3 • 13:30
Spatial and Temporal Coherence of Ultrafast Plasmon Nanolasers, Tert W. Odom1, 2Northwestern Univ., USA. This talk will describe the underlying mechanisms for coherence in two plasmonic nanolasers systems with different cavity structures: nanoparticle arrays and bowtie-shaped particles.

FW3C.4 • 14:00
Probing Electro-Magnetic Local Density of Optical States with Mixed ED-MD Emitters, Dongfang Li1,2, Sinan Karaveli1, Sebastien Cueff1,3, Wenhao Li1, Rashid Zia1, Sebastien Cuet1,2, Wenhao Li1, Rashid Zia1, 1Brown Univ., USA; 2Center for Integrated Nanotechnologies, Los Alamos National Lab, USA; 3Institut des Nanotechnologies de Lyon, France. We experimentally demonstrated that the lifetime of quantum emitters with strongly mixed electric dipole (ED) and magnetic dipole (MD) transitions can directly probe the combined electro-magnetic local density of optical states.
multi-frequency modes, forcing the resonators to mode-lock with one spatial and one modal dimensions. The topological of Technolo, Israel.

We introduce a new design for implementing the topological Haldane laser on a non-magnetic platform. Unit cells are provided for detuned nearest neighbor coupling and imaginary next-nearest neighbor coupling based on microring laser networks.

Mode-locked topological laser in synthetic dimensions, Zhaohu Liu1, Pawel Jung1,2, Mrida Parto1, Jason Leshin1, Demetrios N. Christodoulides1, Meredith Khagwakhi1, 1Univ. of Central Florida, CREOL, USA; 2Faculty of Physics, Warsaw Univ. of Technology, Poland. We introduce a new design for implementing the topological Haldane laser on a non-magnetic platform. Unit cells are provided for detuned nearest neighbor coupling and imaginary next-nearest neighbor coupling based on microring laser networks.

FW3D.3 • 13:30
Observation of Flat-band Line States in Photonic Superhoneycomb Lattices, Wenchao Yan1, Daohong Song1, Shiqi Liu1, Liqin Tang1, Yiqi Zhang1, Jingjun Xu1, Zhigang Chen1,2; 1Technion - Israel Inst. of Technol, Israel; 2Faculty of Physics, Warsaw Univ. of Technology, Poland. We introduce a new design for implementing the topological Haldane laser on a non-magnetic platform. Unit cells are provided for detuned nearest neighbor coupling and imaginary next-nearest neighbor coupling based on microring laser networks.

Fractal Waveguide Arrays Induce Maximal Anderson Localization, Jonathan Guglielmon1, Mikhail C. Rechtsman1, 1Pennsylvania State Univ., USA. In recent years, there has been great interest in using Anderson localization of flat-band lattices to eliminate interwaveguide crosstalk for imaging and telecommunications applications. We show that fractal configurations offer strict improvements on these schemes.

Realization of a Non-Quantized Square-Root Topological Insulator Based on Photonic Aharonov-Bohm Cages, Mark Kremer1, Ioannis Petrides1, Eric Meyer1, Matthias Heinrich1, Oded Zilberberg1, Alexander Sztam1; 1Inst. of Physics, Univ. of Rostock, Germany; 2Inst. for Theoretical Physics, ETH Zürich, Switzerland. We report a new type of insulator that exhibits spectral bands with nonquantized topological properties. Furthermore, a quantisation manifests itself upon squaring the Hamiltonian. We experimentally verify our claims by using photonic Aharonov-Bohm cages.

Coherent Two-Octave-Spanning Supercontinuum Generation in Lithium-Niobate Waveguides, Mengjie Yu1, Boris Desiatov1, Yoshitomo Okawachi1, Alexander Gaeta1, Marko Lončar1; 1Harvard Univ., USA; 2Applied Physics and Applied Math, Columbia Univ., USA. We demonstrate a coherent supercontinuum spanning two octaves with 35 pJ pulses in a lithium-niobate waveguide under the presence of second- and third-order nonlinear effects, which allows for detection of the carrier-envelope offset frequency on-chip.

FW3D.4 • 14:00
0.25 mW Pulsed Terahertz Radiation from Bias-Free, Telecommunication-Compatible Plasmonic Nanotriangles, Denz Turan1, Nezih Tolga Yardimci1, Mona Jarrahi1; 1Univ. of California, Los Angeles, USA. We present a bias-free, telecommunication-compatible photoconductive terahertz source, which offers radiation powers exceeding 0.25 mW, enabling time-domain terahertz spectroscopy with more than a 90 dB dynamic range over a 0.1-3.5 THz bandwidth.

FW3D.5 • 14:00
Towards a Non-magnetic Topological Haldane Laser, Yuzhou Liu1, Pawel Jung1,2, Mrida Parto1, Jason Leshin1, Demetrios N. Christodoulides1, Meredith Khagwakhi1, 1Univ. of Central Florida, CREOL, USA; 2Faculty of Physics, Warsaw Univ. of Technology, Poland. We introduce a new design for implementing the topological Haldane laser on a non-magnetic platform. Unit cells are provided for detuned nearest neighbor coupling and imaginary next-nearest neighbor coupling based on microring laser networks.

FW3D.1 • 13:00
Towards a Non-magnetic Topological Haldane Laser, Yuzhou Liu1, Pawel Jung1,2, Mrida Parto1, Jason Leshin1, Demetrios N. Christodoulides1, Meredith Khagwakhi1, 1Univ. of Central Florida, CREOL, USA; 2Faculty of Physics, Warsaw Univ. of Technology, Poland. We introduce a new design for implementing the topological Haldane laser on a non-magnetic platform. Unit cells are provided for detuned nearest neighbor coupling and imaginary next-nearest neighbor coupling based on microring laser networks.

FW3D.2 • 13:15
Sensitve Interferometric GRENOUILLE Device, Travis N. Jones1, Peter Šušnjar1, Rok Petkovšek2, Rick Trebino1; 1Georgia Inst. of Technology, USA; 2Lab for Photonics and Laser Systems, Univ. of Ljubljana, Slovenia. We present a practical, sensitive and self-referenced frequency-resolved optical gating technique for measuring picosecond pulses with femtjoule energies. We demonstrate the capability of this technique to measure a pulse with complex temporal and spectral structure.

FW3D.3 • 13:30
Application of Artificial Neural Networks to Dispersion Scan Retrievals, Sven Klemmt1, Ayhan Tajalli1, Tamas Nagy1, Uwe Morgner1,2; 1Leibniz Universität Hannover, Germany; 2Max Born Inst. for Nonlinear Optics and Short Pulse Spectroscopy, Germany. We present the phase reconstruction of ultrashort pulses from dispersion scan traces using a deep neural network. Compared to conventional algorithms, this reconstruction is more than 3000 times faster, enabling video-rate reconstructions.

FW3D.4 • 13:45
Coherent Two-Octave-Spanning Supercontinuum Generation in Lithium-Niobate Waveguides, Mengjie Yu1, Boris Desiatov1, Yoshitomo Okawachi1, Alexander Gaeta1, Marko Lončar1; 1Harvard Univ., USA; 2Applied Physics and Applied Math, Columbia Univ., USA. We demonstrate a coherent supercontinuum spanning two octaves with 35 pJ pulses in a lithium-niobate waveguide under the presence of second- and third-order nonlinear effects, which allows for detection of the carrier-envelope offset frequency on-chip.

FW3D.5 • 14:00
0.25 mW Pulsed Terahertz Radiation from Bias-Free, Telecommunication-Compatible Plasmonic Nanotriangles, Denz Turan1, Nezih Tolga Yardimci1, Mona Jarrahi1; 1Univ. of California, Los Angeles, USA. We present a bias-free, telecommunication-compatible photoconductive terahertz source, which offers radiation powers exceeding 0.25 mW, enabling time-domain terahertz spectroscopy with more than a 90 dB dynamic range over a 0.1-3.5 THz bandwidth.

FW3D.1 • 13:00
Towards a Non-magnetic Topological Haldane Laser, Yuzhou Liu1, Pawel Jung1,2, Mrida Parto1, Jason Leshin1, Demetrios N. Christodoulides1, Meredith Khagwakhi1, 1Univ. of Central Florida, CREOL, USA; 2Faculty of Physics, Warsaw Univ. of Technology, Poland. We introduce a new design for implementing the topological Haldane laser on a non-magnetic platform. Unit cells are provided for detuned nearest neighbor coupling and imaginary next-nearest neighbor coupling based on microring laser networks.
A high signal-to-noise-ratio of 30 dB were demonstrated with rates was developed. Carrier-envelope-offset beat signals with comb fiber laser that generates two high-coherence, ultra-

A dual-

Intelligent Optical Synthesizer (IOS) Project, Japan. We developed a mode-

locked Er:fiber laser containing a small optical bench with an electro-optic modulator. The bench is used to control the laser repetition frequency at a large servo bandwidth and realize narrow linewidth.

Stabilized All-Fiber-Based Mode-Filtering Technique for the Generation of a GHz-Repetition-Rate Frequency Comb, Yoshiaki Nakajima1,2, Takuya Hariki1,2, Akiko Nishiyama1,2, Kaoru Minoshima1,2, Minori Ishikawa1,2, University of Electro-Communications, Japan; 2JST, ERATO, MINOSHIMA Intelligent Optical Synthesizer (IOS) Project, Japan. An all-fiber-based mode-filtering technique is developed for generating a 1 GHz fiber-based frequency comb with a multiplicity factor of 21. A high side-mode suppression ratio of approximately 36 dB is achieved with this comb.

Broad Visible Frequency Comb with 24 GHz Mode-spacing Based on Mode-Locked Erbium-Fiber Laser, Kensuke Nakamura2, Shota Okubo2, Ken Kashigawa1,2, Hajime Inaba1,2, National Metrology Inst. of Japan, Japan; 2JST, ERATO, MINOSHIMA Intelligent Optical Synthesizer (IOS) Project, Japan. We developed a 24 GHz spacing comb based on a mode-locked Erbium fiber laser and mode-filtering technique. The broad comb spectrum in infrared region was converted to visible region by a PPLN waveguide.

High-Coherence Ultra-Broadband Dual-Comb Fiber Laser with Carrier-Envelope-Offset Frequency, Yoshiaki Nakajima1,2, Yuya Hata1,2, Yugo Kusumi1, Kaoru Minoshima2, University of Electro-Communications, Japan; 2JST, ERATO, MINOSHIMA Intelligent Optical Synthesizer (IOS) Project, Japan. A dual-comb fiber laser that generates two high-coherence, ultra-

A technique for the characterization of picosecond pulse widths is presented, based on a non-linear optical fiber loop mirror and power meter measurement. Pulse widths in the 2-10 ps range are successfully recovered with a resolution of 0.25 ps.
is used as a Tx/Rx optical antenna in LiDAR. The PC slow light waveguide electro-chemical effects, which allows ultrahigh sensitivity or (PC) devices will be presented. The PC nanolaser detects

Shrestha4, Benjamin Craig4, Matin Amani1,3, James Bullock2,1, Electrically-Tunable Graphene Metasurface, Mid-Infrared Computational Spectroscopy with an

SW3J.1 • 13:00
Photonic Crystal Devices for Sensing, Toshihiko Baba1; Yokohama National Univ., Japan. Two photonic crystal (PC) devices will be presented. The PC nanolaser detects electro-chemical effects, which allows ultrahigh sensitivity or spectral-analysis-free sensing. The PC slow light waveguide is used as a Tx/Rx optical antenna in LiDAR.

Toshihiko Baba received the Ph.D. degree from Yokohama National University in 1990. He became an associate professor and full professor in 1994 and 2005, respectively. He has presented the studies on ARROW waveguides, VCSELs, photonic crystals, Si photonics, micro/nanolasers, slow light, etc. in 200 papers with 12900 citations.

AW3K.1 • 13:00
Automotive LiDAR: Design Concepts and Challenges, Jake Li1, Hamamatsu Corporation, USA. The presentation will briefly introduce different LiDAR concepts, discusses the techniques of measuring distance with light for the automotive industry based on principles of the direct time of flight (TOF) and indirect TOF – frequency modulated continuous wave (FMCW). The discussion contains the following topics: benefits and challenges of different TOF or FMCW LiDAR concepts in the market today; overview of optical design challenges that’s key driver for development of each LiDAR concepts, as well as introducing key optical components (photodetector and light sources) for different LiDAR designs.

AW3K.2 • 13:30
Vernier Si-Photonic Phased Array Transceiver for Grating Lobe Suppression and Extended Field-of-View, Nathan Dostart1, Michael Brandt1, Bohan Zhang2, Daniel Feldkhun3, Kelvin Wagner4, Milos Popovic5,6; Electrical, Computer, and Energy Engineering, Univ. of Colorado at Boulder, USA. We present a Vernier optical phased array transceiver architecture that suppresses grating lobes and can extend the field-of-view. The first experimental demonstration shows Vernier lobe suppression by transmitting from adjacent TX and RX tiles simultaneously.

AW3K.3 • 13:45
Discrete spectral-temporal encoded LiDAR, Yunshan Jiang1, Sebastian Kapf2, Bahram Jalali3, Univ. of California Los Angeles, China. We propose the discrete spectrum-temporal LiDAR that realizes non-mechanical scanning in one dimension at 0.342MHz line rate with a single laser and a single-pixel detector. Our implementation is based on an externally modulated FDML MQOA laser.

AW3K.4 • 14:00
Compound period grating coupler for double beams generation and steering, Dachuan Wu1, Ya Sha Yi1, Wei Guo1; Univ. of Michigan, USA. We propose a compound period grating coupler by combining two component periods together to generate two outcoupling beams simultaneously. The two beams both response to the wavelength tuning, and thus approximately double the steering range.

SW3J.2 • 14:00
Mid-Infrared Computational Spectroscopy with an Electrically-Tunable Graphene Metasurface, Vivek R. Shrestha1, Benjamin Craig1, Matin Amani2,3, James Bullock2,4, Ali Javey5,6; Electrical Engineering and Computer Sciences, Univ. of California, Berkeley, Berkeley, USA; Dept. of Electrical and Electronic Engineering, The Univ. of Melbourne, Australia; Materials Sciences Division, Lawrence Berkeley National Lab, USA; School of Physics, The Univ. of Melbourne, Australia. We demonstrate graphene-plasmonic metasurfaces whose mid-infrared reflection spectra are electrically-tunable. Using measurements of the power reflected by the metasurfaces at different drive voltages, the source spectrum is computationally reconstructed by the recursive least squares method.

SW3J.4 • 14:00
Compound period grating coupler for double beams generation and steering, Dachuan Wu1, Ya Sha Yi1, Wei Guo1; Univ. of Michigan, USA. We propose a compound period grating coupler by combining two component periods together to generate two outcoupling beams simultaneously. The two beams both response to the wavelength tuning, and thus approximately double the steering range.

Congratulations on achieving a complete session review! If you have any questions or need further assistance, feel free to ask.
Evidence for Moiré Excitons in Van der Waals Heterostructures.

Maiuri1, Stefano dal Conte 1, Mattia Russo 1, Junjia Wang 2, Margherita 3, Samuel Brem 2, Malte Selig 3, Gunnar Bengtsson 3, Rupert Huber 3,

FW3M.2 • 13:15
Direct Measurement of Coherent Coupling in a MoSe2/WSe2 Heterostructure, Hanka G. Ruth1, Eric Martin1, Torben L Purz2, Pasqual Rivera3, Xiaodong Xu1, Steven T Cundiff1,

FW3M.3 • 13:30
Evidence for Moiré Excitons in Van der Waals Heterostructures, Xiaoqin Li1,3, Andrea Hendt1, Mathieu Carras1, Wolfgang Eisasser1, Frederic Grillot1,2, Telecom Paris Tech, France; 2Technische Universität Darmstadt, Germany; 3miRense, France; 4Univ. of New Mexico, USA. Quantum cascade lasers, which are known to only emit a transverse-magnetic wave under free-running operation, can output a square wave with transverse-electric emission under polarization-rotated feedback.

FW3M.4 • 14:00
Excitonic Effects in Single Layer MoS2, Probed by Broadband Two-dimensional Electronic Spectroscopy, Margherita Mauri1, Stefano dal Conte1, Mattia Russo1, Junjia Wang2, Giancarlo Saggio1, Damiu Wang1, Jianfeng Li1,3, Andrea Hendt1, Mathieu Carras1, Wolfgang Eisasser1, Frederic Grillot1,2, Telecom Paris Tech, France; 3Universite Libre de Bruxelles, Belgium.

Invited

Terahertz Metasurface Quantum-cascade Lasers: Broadband and High-power Operation, Benjamin S. Williams1, University of California Los Angeles, USA; 2University of California Los Angeles, USA. Metasurface based external cavity lasers are an attractive approach to the challenge of obtaining simultaneous high-power, tunable single-mode wavelength, and excellent beam pattern from terahertz quantum-cascade lasers.

SWM.4 • 14:00
Excitonic Effects in Single Layer MoS2, Probed by Broadband Two-dimensional Electronic Spectroscopy, Margherita Mauri, Stefano dal Conte, Mattia Russo, Junjia Wang, Giancarlo Saggio, Damiu Wang, Jianfeng Li, Andrea Hendt, Mathieu Carras, Wolfgang Eisasser, Frederic Grillot, Telecom Paris Tech, France; 2Technische Universität Darmstadt, Germany; 3miRense, France; 4Univ. of New Mexico, USA.

SWM.5 • 14:00
Modeling and Mitigation of Nonlinear Effects in Uncompensated Coherent Optical Transmission Systems, Gabriella Bosco1, Politecnico di Torino, Italy; 2Politecnico di Torino, Italy. We review recent results on analytical modeling of non-linear interference in multi-span optical systems with high-order modulation and coherent detection, and on performance gains that can be achieved through non-linearity mitigation in digital coherent receivers.
Concurrent sessions are grouped across six pages. Please review all six pages for complete session information.

**Theatre I**

**13:00–15:00**

**AW3P • A&T Topical Review on Progress in the Semiconductor Laser Technology II**

**AW3P.1 • 13:00 Invited**

DFB Interband Cascade Laser Array for Mid Infrared Spectroscopy, Sven Hoilling1, Julian Scheuermann1, Robert Wehl1, Martin Kamp1, Johannes Koeh1; "Universitat Wurzburg, Germany; 2Univ. of St Andrews, UK; 3nanoplus GmbH, Germany. We demonstrate an interband cascade laser array with multiple spectrally monomode emitters monolithically integrated on a single chip. The targeted emission wavelengths cover the mid infrared regime from around 3.3 to 3.5 microns.

**AW3P.2 • 13:30**

High Brightness Operation in Broad Area Quantum Cascade Lasers with Reduced Number of Stages, Matthew Suttinger1, Rowel Go1, Ahmad Azimi1, Enrique Sanchez2, Hong Shu2, Arkady Lyakh1; "Univ. of Central Florida, USA. Two 20 μm wide QCL structures demonstrate room temperature watt-level CW power with single lobe behavior. A figure of merit predicts broad area, fundamental mode behavior configurations for QCLs of identical wavelength and stage height.

**AW3P.3 • 13:45**

Si-based Mid-Infrared GeSn-Edge-Emitting Laser with Operating Temperature up to 260 K, Yiyin Zhou1,2, Wei Dou1, Wei Du1, Solomon Ojo1,2, Huong Tran1,2, Seyed Ghetarin1, Jifeng Liu3, Greg Sun3, Richard Sorel4, Joe Margara1, John Tolle5, Bachua Li6, Zhong Chen1, Mansour Mortazavi1, Shuqing Yu7; "Dept. of Electrical Engineering, Univ. of Arkansas, USA; "Microelectronics-Photonics Program, Univ. of Arkansas, USA; "Arkonics, LLC, USA; "Dept. of Electrical Engineering, Wilkes Univ., USA; "Dept. of Chemistry and Physics, Univ. of Arkansas at Pine Bluff, USA; "Thayer School of Engineering, Dartmouth College, USA; "Dept. of Engineering, Univ. of Massachusetts Boston, USA; "ASML, USA. We demonstrated optically pumped GeSn lasers with 20% maximum Sn content based on ridge waveguide with 5 and 20 μm ridge widths. The high operating temperature of 260 K was achieved with wider ridge device.

**AW3P.4 • 14:00 Invited**

Material Issues in GaN-based Laser Diode Manufacturing, Mike Leszczynski1,2; "Inst. of High Pressure Physics, Poland; "TopGaN, Poland. The first part of the talk will be devoted to blue and green laser diode applications: in lighting, RGB projectors, LiFi communication, quantum technologies and others. In the second part, I will present difficulties in growing AlGaN. In particular, I will focus on point- and extended-defects.

**Theatre II**

**13:00–15:00**

**AW3Q • A&T Topical Review on Advanced Design, Imaging and Process Technologies for Next Generation Semiconductors II**

**AW3Q.1 • 13:00**

Reduction and Control of Edge Placement Error at the 5nm node Through a Holistic Approach. Robert Socha1; "ASML, USA. Abstract note available.

**AW3Q.2 • 13:30**

Nanoscale Three-dimensional Patterning with Plasmonic Lithography. Jae W Hahn1; "Yonsei University, South Korea. We fabricated nano-microscale 3D structures, such as a cone, microlens array, a nanoneedle, and a multiscale structure using a plasmonic lithography system. The recent progress of the plasmonic lithography will be discussed.

**AW3Q.3 • 14:00**

Compensation of Optical Distortions in IC Fabrication. Yuri Granik1; "Mentor Graphics, USA. Abstract not available.

Concurrent sessions are grouped across six pages. Please review all six pages for complete session information.
Strain control of silicon-vacancy centers in diamond nanophotonic devices, Stefan Bagdanovic, Bartholomew Machielse, Srujan Meesala, Scarlett Gauther, Graham Joe, Michelle Chalupnik, Jeffrey Holzgrafe, Cleaven Chia, Mikhail Lukin, Marko Loncar; Harvard Univ., USA. We present a novel electromechanical platform for controlling optical transitions from spatially separated color centers in diamond waveguides. We use this technology to greatly suppress spectral diffusion and demonstrate entanglement between separate emitters.

Dynamic Control of Spontaneous Emission Rate by Optomechanical Cavity QED System, Feng Tian, Tsuji Sumikura, Eiichi Kuramochi, Masato Takiguchi, Masashi Ono, Akihiko Shinya, Masaya Notomi; Tokyo Inst. of Technology, Japan; NTT Basic Research Labs, Japan. We demonstrate all-optical control of the spontaneous-emission rate within the emission lifetime in copper-doped-silicon nanobeam optomechanical cavities via mechanical oscillation driven by repetitive laser pulses, representing the first experimental realization of optomechanical cavity QED systems.

Phonon-induced multi-color correlations in hBN single-photon emitters, Matthew Feldman, Claire Manviny, Alex Puretzky, Lucas Lindsay, Ethan Tucker, Dayrl Briggs, Philip Evans, Richard F. Haglund, Benjamin Lawrie; Oak Ridge National Lab, USA; Vanderbilt Univ., USA. We explore electron-phonon dynamics in hBN defects and observe g^{(2)}(0)=0.20 in a phonon replica and g^{(2)}(0)=0.18 between a phonon replica and the zero-phonon line, and we examine Purcell enhancement of phonon replicas with phononic cavities.

Record High Squeezing Gain and Sensitivity in InAs-based AlGaAs Parametric Amplifiers, Zhishong Yan, Haoyu He, Han Liu, Meng Lu, Osman Ahmed, Eric Chen, Yuichi Akasaka, Tadashi Ikeuchi, Anne S. Helmy; Univ. of Toronto, Canada; Fujitsu Labs of America, USA. Record squeezing, with squeezing parameter r=2.5 is measured in AlGaAs optical parametric amplifiers using an ultrafast pump centered at 775 nm. Polarization dependent squeezing and parametric gain were obtained with sub-photon per pulse amplifier sensitivity at 1550 nm regime.

Laser Beat-Wave Induced Enhancement of the Kerr Nonlinearity in Bulk GaAs at 10μm, Daniel A. Matteo, Jeremy Pigeon, Sergei Tochitsky, Ulrich Huttner, Mackillo Kiraz, Stephan W. Koch, Jerome V. Moloney, Chan Joshii; Dept. of Electrical Engineering, Univ. of California Los Angeles, USA; Dept. of Physics and Material Sciences Center, Philipps-Universität Marburg, Germany; Dept. of Electrical Engineering and Computer Science, Univ. of Michigan, USA; College of Optical Sciences, Univ. of Arizona, USA. We experimentally and theoretically demonstrate enhancement of the Kerr nonlinearity in semi-insulating GaAs through four-wave mixing of a CO/ laser beat-wave. Nonlinearity increases with decreasing beat frequency, attributed to nonlinear currents modulated by the beat-wave.

Wide Bandwidth, Nonmagnetic Linear Optical Isolators based on Frequency Conversion, Tingfei Li, Kamal Abdelsalam, Susan Pathopoulou, Jacob Khurgin; Electrical and Computer Engineering, Johns Hopkins Univ., USA; The College of Optics & Photonics, Univ. of Central Florida, USA. We propose a family of nonmagnetic optical isolators based on waveguide frequency conversion and characterized by high isolation properties, high linearity, bandwidth as high as a few THz.

Deterministic nanoprinting of single fluorescent molecules, Claudia U. Hall, Christian Hölter, Korenobu Matsuzaki, Rohner Patrik, Jan Renger, Vahid Sandoghdi, Dimos Poulikakos, Hadi Eghidi; ETH Zürich, Switzerland; Max Planck Inst. for the Science of Light, Germany. We report direct non-contact electrohydrodynamic nanodrop printing of a countable number of photostable fluorescent molecules in a host crystal of nanoscopic dimensions with single molecule specificity, high spatial resolution and deterministic dipole orientation.

Deterministic nanoprinting of single fluorescent molecules, Claudia U. Hall, Christian Hölter, Korenobu Matsuzaki, Rohner Patrik, Jan Renger, Vahid Sandoghdi, Dimos Poulikakos, Hadi Eghidi; ETH Zürich, Switzerland; Max Planck Inst. for the Science of Light, Germany. We report direct non-contact electrohydrodynamic nanodrop printing of a countable number of photostable fluorescent molecules in a host crystal of nanoscopic dimensions with single molecule specificity, high spatial resolution and deterministic dipole orientation.

Waveguide Coupling of an Integrated Nanowire Laser on Silicon with Enhanced End-Facet Reflectivity, Jochen Bissinger, Daniel Ruhstorfer, Thomas Stettner, Gregor Koblmüller, Jonathan J. Finley; Physic Dept., Walter Schottky Institut, Germany. We numerically explored the coupling characteristics and the critical interplay with the end-facet reflectivities of nanowire lasers coupled to proximal silicon-waveguides. A proper waveguide design enables high coupling efficiencies with enhanced end-facet reflectivities of ~83%.
**Executive Ballroom 210D**

**CLEO: QELS-Fundamental Science**

**FW3D.6 • 14:15**

Wideband Slow Light in a Photonic Topological Insulator, Jonathan Guglielmi1, Mikael C. Rechtsman1, Pennsylvania State Univ., USA. We demonstrate that chiral edge states can be used to generate wideband slow light. This is achieved by producing an edge state that winds many times around the Brillouin zone as it crosses the bandgap.

**FW3D.7 • 14:30**

Magnetic Gauge Field for Photons in Synthetic Dimensions by a Propagation-Invariant Photonic Structure, Liat Nemirovsky1, Moshe-Ishay Cohen1, Eran Lustig1, Mordechai Segev1; Technion, Israel. We propose a system that exhibits an effective magnetic field for photons in synthetic - dimensional, implemented by a propagation-invariant (static) potential. The spectrum of this synthetic-space system displays Landau levels.

**FW3D.8 • 14:45**

Switching light at the interface between anomalous Floquet topological insulators, Francesco Piccioli1, Lukas Maczewsky1, Mark Kremer1, Matthias Heinrich1, Alexander Szameit1; Inst. of Physics, Univ. of Rostock, Germany. We study interface states at the boundary between two Anomalous Floquet Photonic Topological Insulators and show how their interactions with an chiral edge mode can be used to switch it via the wave number.

**Executive Ballroom 210E**

**CLEO: Science & Innovations**

**SW3E • Ultrafast Metrology—Continued**

**SW3E.5 • 14:15**

Active f-to-2f interferometer for record-low jitter carrier-envelope phase locking, Ruoyu Liao1, Haochen Tian1, Tianli Feng1, Youqian Song1, Ming-he Hu1, Gunter Steinmeyer1,2,1Tianjin Univ., China; 2Max Born Inst. for Nonlinear Optics and Short Pulse Spectroscopy, Germany; 3Humboldt Universität zu Berlin, Germany. Introduction of optical gain into the infrared arm of f-to-2f interferometers is demonstrated to improve signal-to-noise ratios by > 20 dB. This opens a perspective for CEP stabilization of unstabilizable lasers.

**SW3E.6 • 14:30**

Single-shot CEP drift measurement at arbitrary repetition rate based on dispersive Fourier transform, Máté Kurucz1, Szabolcs Tóth1, Roland Flender1, Ludovit Haizer1, Balint Kis1, Benjamin Perselle2, Eric Cormier2; ELI-ALPS, Hungary; 1Centre Lasers Intenses et Applications, France. Arbitrary repetition-rate single-shot CEP drift measurement technique is achieved based on dispersive Fourier transform. The technique is validated by comparing the results to an independent measurement. Further improvement is presented allowing jitter-free CEP drift extraction.

**SW3E.7 • 14:45**

Time-domain vectorial field reconstruction of a circularly polarized harmonic from silicon using 2D spectral shearing interferometry, Fabian Scheibl1,2, Nikolai Klemke1,2,3, Oliver D. Mücke1,4, Franz Kartner1,2,3; Center for Free-Electron Laser Science CFEL, Deutsches Elektronen-Synchrotron DESY, Germany; 3Physics Dept., Univ. of Hamburg, Germany; 4Max Planck Inst. for the Structure and Dynamics of Matter, Germany; 5The Hamburg Centre for Ultrafast Imaging, Germany. A two-dimensional spectral shearing interferometry is demonstrated permitting to reconstruct vectorial optical fields with picosecond energy. As proof of principle, we retrieve the circularly polarized third-harmonic field emitted from 2-μm thin silicon driven by 2.1-μm pulses.

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15:00–17:00 **Coffee Break & Dessert (Exhibit Only Time), Exhibit Halls 1-3**

Coffee Break Sponsored by COHERENT and THORLABS

15:30–17:00 **Product Showcases, Exhibit Hall Theater I**
SW3G.6 • 14:15
Repetition-Rate Multiplication of Mode-Locked Lasers Using Harmonic Injection Locking and Gain-Saturated SOA, \textit{Chen-Gi} \textit{Jeon} \textsuperscript{1}, \textit{Xiao-Zhou} \textit{Li} \textsuperscript{1}, \textit{Shilong} \textit{Pan} \textsuperscript{1}, \textit{Jungwon} \textit{Kim} \textsuperscript{1}, \textit{South Korea Advanced Inst of Science \\& Tech, South Korea (the Republic of); \textit{Nanjing Univ. of Aeronautics and Astronautics, China}. Low-noise repetition-rate multiplication method is proposed by combining harmonic injection locking and gain-saturated SOA. A 1-GHz optical pulse train with 33-dB side-mode-suppression-ratio, 3\% modulation depth, and 6.3-fs absolute rms timing jitter (10kHz–1MHz) is demonstrated.

SW3G.7 • 14:30
Laser frequency stabilization at \( \leq 10^{-16} \) from a thermal atomic beam, \textit{Judith Olson} \textsuperscript{1}, \textit{Richard Fox} \textsuperscript{2}, \textit{Tara M. Fortier} \textsuperscript{1}, \textit{Chris Oates} \textsuperscript{1}, \textit{Andrew Ludlow} \textsuperscript{1}, \textit{Optical Frequency Measurements, National Inst. of Standards and Technology, USA}; \textit{Physics, Univ. of Colorado Boulder, USA}. We describe a system for ultra-stable laser frequency generation using Ramsey-Borde interferometry with atomic calcium. Unprecedented frequency instabilities from a thermal ensemble are demonstrated.

SW3G.8 • 14:45
An iodine-stabilized laser at the telecom wavelength using a dual-pitch PPLN waveguide, \textit{Kohei Ikeda} \textsuperscript{1}, \textit{Chaojun Chen} \textsuperscript{1}, \textit{Kazumichi Yoshii} \textsuperscript{1}, \textit{Sho Okubo} \textsuperscript{1}, \textit{Ken Kashiyagi} \textsuperscript{2}, \textit{Hajime Inaba} \textsuperscript{2}, \textit{Feng-Lei Hong} \textsuperscript{1}, \textit{Yamashita Laboratory, National Inst. of Standards and Technology, USA}; \textit{ERATO IOS, Japan}. We demonstrate third harmonic generation by coupling an ultra-thin nonlinear dielectric into the gap-mode of the plasmonic nanopatch antenna. A 10\(^{8}\)-fold enhancement is achieved relative to the bare dielectric producing up to 3\times10\(^7\) photons/s.

SW3H.6 • 14:15
Plasmonically Enhanced Nonlinear Generation via a Hybridized Nanopatch Antenna, \textit{Andrew J. Traverso} \textsuperscript{1}, \textit{Tanara M. Nebabu} \textsuperscript{2}, \textit{Virginia D. Wheeler} \textsuperscript{1}, \textit{Maiken H. Mikkelsen} \textsuperscript{1}, \textit{Physics, Duke Univ., USA}; \textit{Princeton Univ., USA}. We demonstrate enhanced second harmonic generation by coupling an ultra-thin nonlinear dielectric into the gap-mode of the plasmonic nanopatch antenna. A 10\(^{8}\)-fold enhancement is achieved relative to the bare dielectric producing up to 3\times10\(^7\) photons/s.

AW3I.6 • 14:30
Laser Ignition of Cryogenic Propellants in Space Propulsion, \textit{Robert G. Stützer} \textsuperscript{1}, \textit{Jan Deeken} \textsuperscript{1}, \textit{Justin Haral} \textsuperscript{1}, \textit{Dmitry Suslov} \textsuperscript{1}, \textit{Michael Börner} \textsuperscript{1}, \textit{Michael Oschwald} \textsuperscript{1}; \textit{German Aerospace Center, Germany}. A Q-switched laser system was applied to a research rocket combustor in order to ignite cryogenic propellants by inducing several plasma breakdown events. The optical emission was analyzed using LIBS and other techniques.

AW3I.7 • 14:45
Laser-Induced Breakdown Spectroscopy, \textit{Zhao Tianhuo} \textsuperscript{2}, \textit{Xin Li} \textsuperscript{2}, \textit{Qizhou Zhong} \textsuperscript{2}, \textit{Hong Xiao} \textsuperscript{1}, \textit{Shuwen Nie} \textsuperscript{1}, \textit{Fugang Lian} \textsuperscript{1}, \textit{Sining Sun} \textsuperscript{1}, \textit{Zhangwei Fan} \textsuperscript{1}; \textit{Academy of Opto-electronics, Chinese Academy of Sciences, China}; \textit{Academy of Opto-electronics, Univ. of Chinese Academy of Sciences, China}; \textit{Beijing GK Laser Technology Co., Ltd., China}. Laser-induced breakdown spectroscopy is used to quantitative analyze molten alloy ingredient in a 2-ton vacuum induction melt furnace. Measurements relative standard deviation of the main elements is 2–10\%, trace element (< 0.2\%) is lower than 25\%.

AW3I.8 • 14:45
On-line Quantitative Analyzing of Molten Alloy Ingredient in Industrial Vacuum Smelting Process Using Laser-Induced Breakdown Spectroscopy, \textit{Zhao Tianhuo} \textsuperscript{2}, \textit{Xin Li} \textsuperscript{2}, \textit{Qizhou Zhong} \textsuperscript{2}, \textit{Hong Xiao} \textsuperscript{1}, \textit{Shuwen Nie} \textsuperscript{1}, \textit{Fugang Lian} \textsuperscript{1}, \textit{Sining Sun} \textsuperscript{1}, \textit{Zhangwei Fan} \textsuperscript{1}; \textit{Academy of Opto-electronics, Chinese Academy of Sciences, China}; \textit{Academy of Opto-electronics, Univ. of Chinese Academy of Sciences, China}; \textit{Beijing GK Laser Technology Co., Ltd., China}. Laser-induced breakdown spectroscopy is used to quantitative analyze molten alloy ingredient in a 2-ton vacuum induction melt furnace. Measurements relative standard deviation of the main elements is 2–10\%, trace element (< 0.2\%) is lower than 25\%.

AW3I.9 • 14:45
Manufacturing—Continued

AW31 • Laser-formed Structures \\& Additive Manufacturing—Continued

AW31.5 • 14:15
Absorptivity and energy scaling associated with laser powder bed fusion additive manufacturing, \textit{Manyaliba J. Matthews} \textsuperscript{1}, \textit{Jianchao Ye} \textsuperscript{2}, \textit{Leonidas Gargalis} \textsuperscript{1}, \textit{Gabe Guss} \textsuperscript{1}, \textit{Saad Khairallah} \textsuperscript{1}, \textit{Alexander Rubenchik} \textsuperscript{1}; \textit{Lawrence Livermore National Lab, USA}; \textit{Univ. of Nottingham, UK}. In situ absorptivity measurements and finite element modeling are used to characterize energy coupling mechanisms and scaling behavior in laser powder bed fusion additive manufacturing. A universal relationship is derived that predicts melt depth and absorptivity.

AW31.6 • 14:30
On-line Quantitative Analyzing of Molten Alloy Ingredient in Industrial Vacuum Smelting Process Using Laser-Induced Breakdown Spectroscopy, \textit{Zhao Tianhuo} \textsuperscript{2}, \textit{Xin Li} \textsuperscript{2}, \textit{Qizhou Zhong} \textsuperscript{2}, \textit{Hong Xiao} \textsuperscript{1}, \textit{Shuwen Nie} \textsuperscript{1}, \textit{Fugang Lian} \textsuperscript{1}, \textit{Sining Sun} \textsuperscript{1}, \textit{Zhangwei Fan} \textsuperscript{1}; \textit{Academy of Opto-electronics, Chinese Academy of Sciences, China}; \textit{Academy of Opto-electronics, Univ. of Chinese Academy of Sciences, China}; \textit{Beijing GK Laser Technology Co., Ltd., China}. Laser-induced breakdown spectroscopy is used to quantitative analyze molten alloy ingredient in a 2-ton vacuum induction melt furnace. Measurements relative standard deviation of the main elements is 2–10\%, trace element (< 0.2\%) is lower than 25\%.
InSb Nanostructures as selective absorbers in the Short and Mid-Wave Infrared, Nicholas Collins1, Amit Solanki1, Han-Don Um1, Ruihi Huang1, Fawwaz Habbal1, *Harvard Univ., USA. We demonstrated wafer-scale integration of suspended Al0.32Ga0.68As nanophotonic waveguides on silicon substrates. Micro-ring resonators are fabricated and measured at λ = 1545 and 2305 nm, showing loaded quality factors of 740,000 and 450,000, respectively.

Hyperuniform Disordered Polarisers for the Mid-Infrared, Milan Milosevic1, Wen Zhou2, Hon Ki Tsang2, Ahmed Osman1, Stevan Stankovic1, Yanli Qi1, Ali Khokhar1, Graham T. Reed1, Goran Mihanovich1; *Zepler Inst. for Photonics and Nanoelectronics, Optoelectronics Research Centre, Univ. of Southampton, UK. A novel high-compactness electrically controlled beam-steering chip was achieved via integrating a liquid crystal optical phased array directly on a coherently coupled VCSEL array. One-dimensional beam steering was successfully realized by the chip.

Multi-order Laser Beam Steering with Digital Micro Mirror Device for High-speed LIDARs, Joshua M. Rodriguez1, Brandon Himmel1, Braden Smith1, Heejo Choi1, Dae Wook Kim1, Yuzuru Takashima1, Univ. of Arizona, USA. Multi-order DMD based beam steering enables a fast beam steering that scan rate exceeds a frame rate of DMD, over tens of KHz, by redirecting laser pulses to multiple directions within couple ms timeframe.

A High-Compactness Electrically Controlled Beam-Steering Chip, Guanzhong Pan1, Chen Xu1, Yiyang Xie1, Yibo Dong1, Qinhua Wang1, Hongda Chen1, *Beijing Univ. of Technology, China. *Inst. of Semiconductor, Chinese Academy of Sciences, China. A novel high-compactness electrically controlled beam-steering chip was achieved via integrating a liquid crystal optical phased array directly on a coherently coupled VCSEL array. One-dimensional beam steering was successfully realized by the chip.

Multi-order Laser Beam Steering with Digital Micro Mirror Device for High-speed LIDARs, Joshua M. Rodriguez1, Brandon Himmel1, Braden Smith1, Heejo Choi1, Dae Wook Kim1, Yuzuru Takashima1, Univ. of Arizona, USA. Multi-order DMD based beam steering enables a fast beam steering that scan rate exceeds a frame rate of DMD, over tens of KHz, by redirecting laser pulses to multiple directions within couple ms timeframe.

A novel nanomechanical absorption-based microscopy with unprecedented sensitivity of 16 fW/Hz1/2 is introduced with silicon nitride drum resonator. With 5-order-of-magnitudes higher sensitivity than the state-of-the-art technique, this study provides a sensitive label-free alternative for microscopy.
FW3M.1 • 14:15
Nonlinear Interaction of Rydberg Exciton-Polaritons in Two-Dimensional WSe 2. Vivek Pareek1, Bala M. Mariserla1,2, Jie Gu1,2, Lutz Waldecker1, Daniel Rhodes1, Alexandre Bohem1,1, Archana Raja1, Rian Koots1, Jie Gu1,2, Lutz Waldecker1, Daniel Rhodes1, Alexandre Bohem1,1, Archana Raja1, Rian Koots1.

FW3M.2 • 14:20
A 1 Mode, which is enhanced around the C-exciton peak. Univ. of Karnataka, India. We study exciton-exciton annihilation in atomically black phosphorus using micro-transverse absorption spectroscopy. Our results show a transition from 1D to 2D-like interactions as we increase the exciton densities.

FW3M.3 • 14:25
Strong Exciton-Coherent Phonon Coupling In Single-Layer MoS 2. Chiara Trovatello1, Henrique P. C. Miranda2, Andrea C. Ferrari3, Andrea Marini5, Ludger Wirtz6, Giulio Cerullo1,7, Davide Sangalli8, Stefano Dal Conte1,5; 1Politecnico di Milano, Italy; 2Univ. of Cambridge, UK; 3Cambridge Graphene Center, Univ. of Cambridge, UK; 4Inst. of Materials Science, Univ. of Valencia, Spain; 5Division of Ultrafast Process in Materials, Area della Ricerca di Roma 1, Italy; 6Université catholique de Louvain, Belgium; 7IFN-CNR, Italy.

FW3M.4 • 14:30
High-power edge-emitting terahertz plasmonic quantum-cascade laser. Yuan Jin1, Liang Gao1, John Reno2, Sushil Kumar1,2, John Reno2, Sushil Kumar1,2.

FW3M.5 • 14:35
Strong Exciton-Coherent Phonon Coupling In Single-Layer MoS 2. Chara Trotavello1, Henrique P. C. Miranda2, Alejandro Molina-Sánchez1,2, Rocio Borrego Varillas1, Luca Moretti1,2, Lucia Gunter1,2, Margheritta Mauri1,2, Giancarlo Soavi1,2, Andrea C. Ferrari3, Andrea Marini5, Ludger Wirtz6, Giulio Cerullo1,7, Davide Sangalli8, Stefano Dal Conte1,5; 1Politecnico di Milano, Italy; 2Inst. of Condensed Matter and Nanoscience, Université catholique de Louvain, Belgium; 3Cambridge Graphene Center, Univ. of Cambridge, UK; 4Inst. of Materials Science, Univ. of Valencia, Spain; 5Division of Ultrafast Process in Materials, Area della Ricerca di Roma 1, Italy; 6Université catholique de Louvain, Belgium; 7IFN-CNR, Italy.

FW3M.6 • 14:40
We demonstrate the formation of Rydberg exciton-polaritons in monolayer WSe 2 embedded in a microcavity and their 10X enhanced nonlinear interaction strength compared to the 15 exciton-polaritons owing to their larger size.

FW3M.7 • 14:45
Controlling the Likelihood of Extreme Pulses in a Quantum Cascade Laser with Optical Feedback and Bias Perturbation, Olivier Spitz1,2, Ja-Gui Wu1, Mathieu Carras1, Chee Wei Wong1, Frederic Grillot1,2, Télécom ParisTech, France; 1Univ. of California Los Angeles, USA; 2University of New Mexico, USA.

FW3M.8 • 14:50
Two-Dimensional WSe2, Nonlinear Interaction of Rydberg Exciton-Polaritons in Monolayer WSe2. Vivek Pareek1, Bala M. Mariserla1,2, Jie Gu1,2, Lutz Waldecker1, Daniel Rhodes1, Alexandre Bohem1,1, Archana Raja1, Rian Koots1, Jie Gu1,2, Lutz Waldecker1, Daniel Rhodes1, Alexandre Bohem1,1, Archana Raja1, Rian Koots1.

SW3N.1 • 14:15
Cascade Lasers—Continued

SW3N.2 • 14:30
High-power edge-emitting terahertz plasmonic quantum-cascade laser. Yuan Jin1, Liang Gao1, John Reno2, Sushil Kumar1,2, John Reno2, Sushil Kumar1,2.

SW3N.3 • 14:45
Strong Exciton-Coherent Phonon Coupling In Single-Layer MoS 2. Chiara Trovatello1, Henrique P. C. Miranda2, Andrea C. Ferrari3, Andrea Marini5, Ludger Wirtz6, Giulio Cerullo1,7, Davide Sangalli8, Stefano Dal Conte1,5; 1Politecnico di Milano, Italy; 2Univ. of Cambridge, UK; 3Cambridge Graphene Center, Univ. of Cambridge, UK; 4Inst. of Materials Science, Univ. of Valencia, Spain; 5Division of Ultrafast Process in Materials, Area della Ricerca di Roma 1, Italy; 6Université catholique de Louvain, Belgium; 7IFN-CNR, Italy.

SW3N.4 • 14:50
Controlling the Likelihood of Extreme Pulses in a Quantum Cascade Laser with Optical Feedback and Bias Perturbation, Olivier Spitz1,2, Ja-Gui Wu1, Mathieu Carras1, Chee Wei Wong1, Frederic Grillot1,2, Télécom ParisTech, France; 1Univ. of California Los Angeles, USA; 2University of New Mexico, USA.

SW3N.5 • 14:30
Impact of Laser Phase Noise on Nonlinear Frequency Division Multiplexing Systems, Francesco Da Ros1, Simone Gaiarin1,2, Darko Zibar1,2, DTU Fotonik, Denmark. The impact of Wiener phase noise on NFDM transmission is experimentally investigated for dual-polarization discrete NFDM systems. The results show minimal OSNR penalty in back-to-back and limited degradation for 2000-km transmission for 750-kHz and 100-kHz linewidth, respectively.

SW3N.6 • 14:45
Frequency Modulation Supported Long-haul Transmission Enabled by Nonlinear Equalization with a Low-cost DML, Shaohua Hu1, Pingping Lei1, Jing Zhang1, Yuzhong Feng1, Xingwen Yi1, Kun Qiu1; 1Univ. of Electronic Science & Tech China, China; 2Univ. of New Mexico, USA. We experimentally demonstrate an FM-supported 23 Gb/s PAM-4 coherent transmission over 2800 km SSMF utilizing a low-cost DML. The nonlinear equalizers are effective to enable the FM signal recovery.

SW3N.7 • 14:50
Impact of Laser Phase Noise on Nonlinear Frequency Division Multiplexing Systems, Francesco Da Ros1, Simone Gaiarin1,2, Darko Zibar1,2, DTU Fotonik, Denmark. The impact of Wiener phase noise on NFDM transmission is experimentally investigated for dual-polarization discrete NFDM systems. The results show minimal OSNR penalty in back-to-back and limited degradation for 2000-km transmission for 750-kHz and 100-kHz linewidth, respectively.

15:00–17:00 Coffee Break & Dessert (Exhibit Only Time), Exhibit Halls 1-3
Coffee Break Sponsored by COHERENT and THORLABS

15:30–17:00 Product Showcases, Exhibit Hall Theater I
AW3P • A&T Topical Review on Progress in the Semiconductor Laser Technology II—Continued

AW3Q • A&T Topical Review on Advanced Design, Imaging and Process Technologies for Next Generation Semiconductors II—Continued

AW3P.5 • 14:30  Invited
Development of Terahertz Quantum-Cascade Lasers for Satellite-Borne Measurement of Key Gas Species. Alexander Valavanis1, Yingjun Han1, Eleanor Nuttall1, Esam Zafar1, Diego Pardo1, Olivier Auracome1, Thomas Rawlings2, Nart Daghastani2, Ednud H. Linfield1, Brian N. Ellison2 and A. Giles Davies1; 1School of Electronic and Electrical Engineering, University of Leeds, UK, 2STFC Rutherford Appleton Laboratory, UK. We present key developments towards atmospheric chemistry studies using terahertz quantum-cascade lasers (QCLs), including ~1-cm3-scale integration of THz QCLs with waveguides and antennas using precision micromachining, and broadband multimode spectroscopy based on detector-free self-mixing.

15:00–17:00 Coffee Break & Dessert (Exhibit Only Time), Exhibit Halls 1-3
Coffee Break Sponsored by COHERENT and THORLABS

15:30–17:00 Product Showcases, Exhibit Hall Theater I
JW4A.1 • 17:00  
**Invited**  
Phonon networks with SiV centers in diamond waveguides, Peter Rabl1,2; 1TU Wien, Austria. In this talk I will discuss recent theoretical ideas for realizing controlled spin-phonon interactions and scalable phononic quantum networks with silicon-vacancy centers coupled to propagating acoustic modes in diamond waveguides.

JW4A.2 • 17:30  
**Invited**  
Creating Quantum States of Sound with Superconducting Qubits, Yiwen Chu2,1; 1Yale Univ., USA; 2Physics, ETH Zurich, Switzerland. I will describe our recent experiments involving a high frequency bulk acoustic wave resonator strongly coupled to a superconducting qubit. We use this device to demonstrate quantum operations on the system, including the creation and measurement of quantum mechanical states such as phonon Fock states.

JW4A.3 • 18:00  
**Invited**  
Quantum Control of Spins in Silicon Carbide with Photons and Phonons, David Awschalom1; 1Univ. of Chicago, USA. Isolated spins in silicon carbide are optically probed, revealing long spin coherence times and high-fidelity quantum control. Gaussian surface acoustic wave resonators mechanically drive coherent Fabi oscillations using phonons that are imaged with focused x-rays.

FW4B.1 • 17:00  
A Hybrid Dielectric-Semiconductor Resonant Nanostucture for Broadband and Efficient Second-Harmonic Generation, Rakim Sarmi1, Domenico de Ceglia2, Nishant Nookala3, Maria Antonietta Vincenti1, Salvatore Campione1, Omri Wolf1, Michael Scalora1, Mikhail A. Belkin3, Igal Brener1; 1Sandia National Labs, USA; 2Univ. of Padova, Italy; 3Univ. of Texas at Austin, USA; 4Univ. of Brescia, Italy; 5US Army AMRDEC, USA. We experimentally demonstrate a novel approach of coupling leaky-mode resonances in dielectric nanostructures to intersubband transitions in semiconductor quantum wells to realize an ultra-thin hybrid device with broadband and high second-harmonic generation efficiency.

FW4B.2 • 17:15  
Electrically Tunable Dynamic Phase Modulation Enhanced Second Harmonic Generation of Dielectric Metasurfaces, Xuexue Guo1, Yimin Ding1, Xingjie Ni1; 1Pennsylvania State Univ., USA. Taking advantage of the dynamic phase modulation arisen from the interaction of dc electrical and optical field, we create super-quadratic field dependent second-harmonic generation (SHG) with ultra-high ON/OFF ratio of 15000 on a dielectric metasurface.

FW4B.3 • 17:30  
Observation of Extraordinary SHG from All-Dielectric Nanoantennas Governed by Bound States in the Continuum, Kirill Koshelev1,2, Sergey Kruk1, Jae-Hyuck Choi3, Elizaveta V. Melik-Gaykazyan1,4, Daria Smirnova1,5, Hong-Gyu Park3, Yuri S. Kivshar1,2; 1Australian National Univ., Australia; 2Dept. of Nanophotonics and Metamaterials, ITMO Univ., Russia; 3Dept. of Physics, South Korea Univ., South Korea (the Republic of); 4Faculty of Physics, Lomonosov Moscow State Univ., Russia; 5Inst. of Applied Physics, Russia. We observe record-high efficiency of the second-harmonic generation from AlGaAs nanoantennas fabricated on a transparent substrate and pumped with structured light. The engineered nanoantennas exhibit high-quality optical resonances governed by quasi-bound states in the continuum.

FW4B.4 • 18:00  
Disorder-Robust Nonlinear Light Generation in Topological Nanostructures, Sergey S. Krul1, Alexander Poddubny2,3; 1Daria Smirnova1, Ivan Kravchenko2, Barry Luther-Davies1, Yuri S. Kivshar1; 1Australian National Univ., Australia; 2ITMO Univ., Russia; 3Oak Ridge National Lab, USA. We observe topologically nontrivial nonlinear edge states of light in zigzag arrays of silicon nanoparticles. We image the edge states via the third-harmonic generation and demonstrate their robustness against disorder and structural perturbations.
FW4D.1 • 17:00
Chiral Metasurface Optomechanics, Simone Zanotto1, Alessandro Tredicucci1,2, Daniel Navarro-Uniós1, Marco Cecchini1, Giorgio Biasiol1, Alessandro Pitarresi1,1;1 Institute of Nanoscience - CNR, Italy; 2 Universitat de Barcelona, Spain; 3 Università di Pisa, Italy, Istituto Officina dei Materiali, Italy. We report on mechanical action on light polarization, and its back-action effect, in a chiral metasurface. Our thin-film nanostructured semiconductor device may prove of relevance for fast polarization state generation and detection.

FW4D.2 • 17:30
Tunable Orbital Angular Momentum Microring Lasers Using Chiral Exceptional Points, William Hayenga1, Jinhan Ren1, Midya Parito1, Fan Wu1, Mohammad Hokmabadi2, Christian Wolff1, Ramy El-Ganainy3, N. Mortensen1,2, Demetrios N. Christodoulides1, Mercedes Khajavikhan1,1;1 Univ. of Central Florida, CCREL, USA; 2 Center for Nano Optics, Univ. of Southern Denmark, Denmark; 3 Dept. of Physics and Henes Center for Quantum Phenomena, Michigan Technological Univ., USA; 3 Danish Inst. for Advanced Stud; Univ. of Southern Denmark, Denmark. A microring laser generating tunable orbital angular momentum states via chiral exceptional points is demonstrated. An incorporated inner S-band waveguide construct provides an avenue to enforce unidirectional lasing in a predetermined manner.

FW4D.3 • 17:45
Photonic Spin Polarizer Using Phase-Cancellation Metasurface, Anir Shaltout1, Jorik van de Groep1, Yifei Wang1, Mark Brongersma1,2;1 Stanford Univ., USA. Phase-cancellation metasurfaces are introduced to attenuate the transmission of specific optical mode using destructive interference, and used to implement a broadband circular polarizer with extinction ratio of 20 using silicon based dielectric nanostructures.

FW4D.4 • 18:00
Low Loss Propagation in a Metal-clad Waveguide via PT-Symmetry Breaking, Utsav D. Dave1, Michal Lipson1,2;1 Electrical Engineering, Columbia Univ., USA. We demonstrate passive PT symmetry breaking between the spatial modes within a single SOI waveguide with metal deposited directly on top. By leveraging this effect, we show low propagation loss of < 1 dB for a 100 μm long, 10 μm wide waveguide partially covered with 100 nm thick metal.

SW4E • 17:00
Science & Innovations
Executive Ballroom 210E
SW4E.1 • 17:00
Optimization and fabrication of two-quantum well THz QCLs operating above 200 K, Martin C. Frankle1, Lorenzo Bosco1, Mattias Beck1, Elena Mavrona1, Jérôme Faist2, 1ETH Zurich, Switzerland. We present the first THz quantum cascade laser operating above 200 K. The design is based on two quantum wells per period and was optimized using a non-equilibrium Green’s function model.

SW4E.2 • 17:15
Two-Stage Nonlinear Compression of a Yb:KGW Laser Amplier to Sub-10 fs Duration, John E. Beattie1, Federico Rivas1, Shima Gholam Mirzaeimoghaddar1, Yangyang Liu1, Michael Chinn2,1;1 Univ. of Central Florida, CCREL, USA; 2 CCREL, The College of Optics and Photonics, USA. We demonstrate the nonlinear compression of pulses from a commercial Yb:KGW laser amplifier using a two-stage hollow-core fiber and multplate continuum compressor to below 9 fs duration with overall system transmission of 60%.

SW4E.3 • 17:30
Optical Thin Film Compression for Laser Induced Plasma Diagnostics, Masrur Masrur1, Jonathan Wheeler1,2, Ioan Dancu1, Riccardo Fabbrini1, Andrei Nazri1, Radu Secareanu1, Daniel Ursu1, Gabriel Cojocaru1, Razvan Ungureanu1, Deano Farinella1, Moana Pattini1, Sergey Mironov1, Septimiu Balascuta1, Domenico Dorina1, David Ros1, Razvan Dabu1, 1ELI-PL, Romania; 1JEST, France; 2 European XFEL GmbH, Germany; 3 CETAL-PW (INFLPR), Romania; 4 Univ. of California at Irvine (UCI), USA; 5 LASERIX (UPAd - LUMAT), France; 1 Federal Research Center Inst. of Applied Physics of the Russian Academy of Science (IFAPR), Russia. Zeonor thin film compressor based on self-phase modulation is presented as an ultrashort probe for a plasma diagnostics at ELI-NP. The capability of a compression factor more than two enables a probe of 10 fs.

SW4E.4 • 17:45
Relative-Phase Synchronization in a Sub-Cycle Parametric Waveform Synthesizer, Roland E. Mainz1,2, Giulio Maria Rossi1,2, Fabian Schieba2,1, Yudong Yang1,2, Giovanni Ciri si1,2, Franz Kärntner1,2;1 Center for Free-Electron Laser Science, Germany; 2 Physics Dept. and the Hamburg Centre for Ultrafast Imaging, Germany. We compare two different methods for relative phase synchronization among two channels of a parallel parametric waveform synthesizer. The achieved stability allows for reproducible high-energy sub-cycle pulses capable to generate isolated attosecond pulses without gating.

SW4E.5 • 18:00
Phase-Locked Programmable Femtosecond Pulse Bursts from a Regenerative Amplifier, Tobias Flöy1, Edgar Kaksii1, Audrius Puglys1, Audrius Baltuska1,2, Gergö Kriszán1,2, Gyula Palónyi1,2, József Fülöp3,4,1 Photonik Institut, TU Wien, Austria; 2 Center for Physical Sciences & Technology, Lithuania; 3 Inst. of Physics, Univ. of Pécs, Hungary; 4 Univ. of Geneva, Switzerland; 5 Inst. National de la Recherche Physique, Fudan Univ., China. We present a phase-locked femtosecond pulse burst source based on a titanium-sapphire regenerative amplifier. The source is capable of producing phase-locked pulse trains of more than 100 pulses with a relative phase stability better than 1° over a period of 30 minutes. The demonstration shows the potential of such sources for applications requiring synchronization of femtosecond pulse trains.
SW4G.1 • 17:00
Optically Generated 10-GHz Signal with 10 Microradian Residual Phase Instability, Takuma Nakamura1, Josue Davila-Rodriguez1, Holly Leopardi2, Jeff A. Sherman1, Tara M. Fortier1, Xiaojun Xie1, Joe C. Campbell2, Scott A. Diddams1, Franklyn Quinlan1,2, and Martin E. Fermann1; 1Dept. of Physics, Univ. of Colorado Boulder, USA; 2Dept. of Electrical and Computer Engineering, Univ. of Virginia, USA. We demonstrate ultra-stable 10-GHz generation based on single-fiber-branched Er-fiber combs. Residual rms phase fluctuations were 10 microradians at 10 s, with corresponding fractional frequency instability of $5 \times 10^{-17}$ at 1 s and $1 \times 10^{-18}$ at 200 s.

SW4G.2 • 17:30
Ultra-low noise microwave generation using carrier-envelope-offset signal of 25-GHz EOM comb, Atsushi Ishizawa1, Kenichi Hitachi2, Kazutaka Hara2, Kenya Hitomi1,2, Tomoya Akatsuka1, Tetsuomi Sagawa1, Hideki Gotoh1, and Masakazu Tanaka1; 1NTT Basic Research Labs, Japan; 2Tokyo Denki Univ., Japan. Using carrier-envelope-offset signal of a 25-GHz electro-optics-modulation comb, we demonstrated a record phase-noise reduction of a conventional signal generator and an unprecedented measurement of the absolute optical frequency at 12-order-of-magnitude accuracy without any optical reference.

SW4G.3 • 17:45
Free-running Monolithic Laser-based 8-GHz Photonic Microwave Generation, Manoj P. Kalubovilage1,2,1, Mamoru Endo2,1, Tadashi Nishikawa2,1, Atsushi Ishizawa1,2, Hitomi1,2, Hongquan Li1, David Carlson3, Scott B. Papp1,1, and NIST, USA. We experimentally and numerically demonstrate free-cycle pulse generation in chip-integrated waveguides made from silicon nitride. When these pulses seed supercontinuum generation in two-section waveguides, coherent ultraflat spectra spanning more than an octave can be realized.

SW4H.1 • 17:00
Polarization effects in silicon-nitride waveguides: Supercontinuum, carrier-envelope offset, and optical beatnotes, Lingfang Wang1,2, Hongguan Li1, David Carlson3, Scott B. Papp1,1, Leo Hollberg1,1, HEPL & Dept. of Physics, Stanford Univ., USA; 2Dept. of Optoelectronic Science and Engineering, Univ. of Electronic Science and Technology of China, China; 3School of Optical Science, Univ. of Arizona, USA. We phase lock a tunable OEO to an optically locked comb for microwave synthesis from an optical reference. We demonstrate phase locking of a tunable OEO to an optical frequency comb, and an unprecedented measurement of the absolute optical frequency at 12-order-of-magnitude accuracy without any optical reference.

SW4H.2 • 17:15
Few-cycle pulses and ultraflat supercontinuum with silicon-nitride waveguides, David R. Carlson3, Phillips Hutchison4, Daniel Hickstein1, Scott B. Papp1, and NIST, USA. We experimentally and numerically demonstrate few-cycle pulse generation in chip-integrated waveguides made from silicon nitride. When these pulses seed supercontinuum generation in two-section waveguides, coherent ultraflat spectra spanning more than an octave can be realized.

SW4H.3 • 17:30
Coherent Supercontinuum Generation in a Silicon Nitride Chip, Yoshitomo Okawachi1,1, Columbia Univ., USA; 2Advances in CMOS-compatible silicon technology opens a path towards chip-scale supercontinuum generation in silicon nitride waveguides for applications including spectroscopy, frequency metrology, and optical clocks.

SW4H.4 • 18:00
Lotus-like dual soliton generation and phase shifting of an 88 GHz high-order-mode-suppressed Si$_3$N$_4$ microring, Hao Liu1, Jinghui Yang1, Shu-Wei Huang2, Mingbin Yu3, Dim Lee Kwong1, Chee Wei Wong1, and Tien Chen1; 1Univ. of California Los Angeles, USA; 2Dept. of Electrical, Computer, and Energy Engineering, Univ. of Colorado Boulder, USA; 3Inst. of Microelectronics, A*STAR, Singapore. Here we report a unique lotus-like dual dissipative soliton spectrum generated in an 88 GHz tapered Si$_3$N$_4$ microring. The mode-locking nature is verified by both amplitude noise and FROG measurement. A continuous phase shifting of such state is successfully observed directly in frequency domain.
Inverse designed Fano resonance in Silicon microresonator. SW4J.3 • 17:30
We numerically demonstrate an on-chip full Poincaré beam emitter based on Bloch-Floquet theory. This theory can predict the splitting associated with this coupling in all the ring resonances.

Absolute Distance Measurement with Large Non-ambiguous Range by an Electro-optic Triple-comb, Xianyu Zhao1, Qu Xinghua1, Fumin Zhang1, Tianjin Univ., China. We present a multi-heterodyne interferometry for long distance measurement. The synthetic wavelengths chain can be established through triple-comb with cascaded phase modulators. The experimental results demonstrated a relative ranging precision of about 7×10⁻⁷.

An on-chip Full Poincaré Beam Emitter Based on an Optical Micro-ring Cavity, Wenbo Lin1, Yasutomo Ota1, Yasuhiko Arakawa1, Satoshi Iwamoto2, 1Inst. of Industrial Science, The Univ. of Tokyo, Japan; 2Nano-photonic Devices. We demonstrate that femtosecond laser filamentation combined with time-resolved laser-induced fluorescence spectroscopy of laser ablation plumes.

A Basic Approach for Speed Profiling of Alternating Targets with Photonic Doppler Velocimetry, Mustafa M. Bayat1, Rasul Torun1, Iman Uz Zaman1, Ozdai Boyraz1, 1Univ. of California Irvine, USA. Single tone continuous wave lidar system is utilized to construct the speed profile of an oscillating membrane by applying photonic Doppler velocimetry with amplitude-modulated light. Then short-time Fourier Transform is applied to acquire the profile.

Broadband Infrared Laser Absorption Spectroscopy of High-explosive Detonations, Mark C. Phillips1, Brian Brumfield1, Bruce E. Bernacki1, Sivanandan S. Harilal1, Joel M. Schwallier1, Nick Glumac1, 1Pacific Northwest National Lab, USA; 2Mechanical Science & Engineering, Univ. of Illinois at Urbana-Champaign, USA. We measure time-resolved absorption spectra in high-explosive detonations using an external cavity quantum cascade laser swept over the range 2050-2300 cm⁻¹. Absorption from CO₂, H₂O, N₂O, and particulates is characterized.

Detection of isotopic shifts and hyperfine structures of uranium transitions using LIF of laser ablation plumes, Sivanandan S. Harilal2, 1Univ. of Michigan, Ann Arbor, USA; 2Univ. of Nevada Las Vegas, USA. We demonstrate that femtosecond laser filamentation combined with time-resolved laser-induced fluorescence spectroscopy is viable for remote detection of uranyl fluoride, a powerful indicator of uranium enrichment activity.

Hydrodynamics and Spatio-temporal Mapping of Oxide Formation in Laser-produced U Plasmas, Patrick J. Skrodzki1, 1Univ. of Michigan, Ann Arbor, USA; 2Mechanical Science & Engineering, Univ. of Illinois at Urbana-Champaign, USA. We combine optical emission spectroscopy with hydrodynamic measurements in laser-produced uranium plasma in air to detect formation of higher uranium oxide states. Generation of uranium oxides reduces the excited atomic uranium population.
Imaging the Motion of Charge with Time-Resolved Photoemission Spectroscopy using an Ultrafast XUV Source at 21.8 eV, Yangyang Liu1, John E. Beetz1, Md M. Hosen1, Gyanendra Dhakal1, Christoph Simms1, Marc Etienne1, Firouz Kabi1, Klaus Dimitri1, Sabin Regmi1, Madhab Neupane1, Michael Chini2, Univ. of Central Florida, USA. We demonstrate a novel teraPES setup using high-order harmonic probe pulses produced from a moderately high power Yb:KGW amplifier. The surface band structure of ZrTe2P is measured using a single harmonic at 21.8 eV.

Laser cooling of semiconductors traced in the time domain, Jan F. Lippmann1, Alfred Lenieterstorfer1, Denis Seletsky2, Dept. of Physics and Center for Applied Photonics, Univ. of Konstanz, Germany; Dept. of Engineering Physics, Polytechnique Montréal, Canada. Despite tremendous progress in optical refrigeration of rare-earth-doped crystals, laser cooling in III-V semiconductors has not been demonstrated to date. Here we report first observation of cooling in GaAs/InGaP double heterostructures on a sub-nanosecond timescale.

Ultrafast Magnetic Microscopy using High-Harmonic Radiation, Sergey Zayko1, Ofer Kfir1, Michael Heigl1, Michael Lohmann1, Murat Sivas1, Manfred Albrecht1, Claus Ropers1, Univ. of Göttingen, Germany; Experimentalphysik IV, Institut für Physik, Germany; International Center for Advanced Studies of Energy Conversion (ICASEC), Univ. of Göttingen, Germany. We report ultrafast nanoscale magnetic microscopy using high-harmonic radiation, reaching 19 nm spatial resolution. The femtosecond-scale demagnetization of worm-like magnetic domains in Co/Pd multilayers is quantitatively mapped with 50 fs temporal resolution.

Continuous Wave Green Lasing at Room Temperature in Two-Dimensional Photonic Crystal Perovskite Laser, Jiaying Moon1, Masoud Ahlabakhsh1, Abouzar Ghassehi1, Ross Haroldson1, Roberta Hawkins1, Zhiting Li1, Walter Hu1,2, Anvar Zakhdov1, Qing Gu1, The Univ. of Texas at Dallas, USA; Fudan Univ., China; ITMO Univ., Russia. Direct patterning of methylammonium lead bromide (MAPbBr3) perovskite-enabled green lasing in two-dimensional photonic crystal on the Si platform, under continuous wave pumping at room temperature for the first time.

High-Power and High-Beam-Quality Photonic-Crystal Lasers, Susumu Noda1,2, Kyoto Univ., Japan. Recent progress in photonic crystal lasers is described. 10W-class high-power and high-quality (RM2=2) operation is successfully demonstrated using InGaAs/InP semiconductor systems. The extension to InGaN/GaN semiconductor systems is also discussed.

Over 2W Room Temperature Lasing On A Large Area Photonic Crystal Quantum Cascade Laser, Zhaixiang Wang1, Yong Liang1, Bo Meng1, Yanting Sun1, Giriprasad Anumukant1, Emilio Gini1, Matthias Beck1, Ilia Sergachev1, Sebastian Louroudjou1, Jérôme Fast1, Giacomo Scalari1, Inst. for Quantum Electronics, ETH Zürich, Switzerland; KTH, Sweden; FIRST Lab ETH Zürich, Switzerland; Wyss Zurich, Switzerland. We present a large-area (1.5 mm × 1.5 mm) photonic crystal quantum cascade laser, with over 2 W peak power at room temperature (289 K), and symmetrical, narrow (<1°), single-lobe surface-emitting beam.
JW4A.4 • 18:30
Quantum Acoustics with Lithium Niobate Nanocavities, Patricio Arrangoiz-Ariola1, E. Alex Wollack1, Marek Pechal1, Wentao Jiang1, Zhaoyou Wang1, Timothy McKenna1, Amir Safavi-Naeini1; Stanford Univ., USA. We couple a superconducting qubit to a piezoelectric nanomechanical resonator fabricated from thin film lithium niobate (LN). The sizeable piezoelectric coefficient of LN leads to a coupling rate $g/2\pi > 15$ MHz allowing quantum operations.

FW4B.5 • 18:15
Resonance Splitting and Enhanced Optical Nonlinearities in ITO-based Epsilon-near-zero Metasurface with Cross-shaped Nanoantennas, Cong Liu1, Kai Pang1, Karapet Manukyan1, Orad Reshef1, Yiyu Zhou1, Joel Patrow1, Anuj Pennathur1, Hao Song1, Zhe Zhao1, Runzhou Zhang1, Fatemeh Alizadeh1, Ahmad Fallahpour1, Yinwen Cao1, Ahmed Almaimani1, Jahan Davlaty1, N. Apurv Chaitanya1, Israel De Leon1, Zahra Alard2, Robert Boyd3, Moshe Tur4, Alan E. Willner1; 1Univ. of Southern California, USA; 2Univ. of Ottawa, Canada; 3Univ. of Rochester, USA; 4Tel Aviv Univ., Israel; 5Tecnológico de Monterrey, Mexico. We experimentally demonstrate a strong-coupling-induced resonance splitting in indium-tin-oxide (ITO) based epsilon-near-zero (ENZ) metasurface with cross-shaped nanoantennas. An ~11-nm blue shift of the carrier wavelength is observed for this metasurface under ~4-GW/cm² peak-power density.

FW4B.6 • 18:30
Nonlinear and electro-optical properties of epsilon near zero materials: are they all they are believed to be?, Jacob Khurgin1, Hua-Zhou Chen2, Ren-Min Ma2; 1Johns Hopkins Univ., USA; 2School of Physics, Peking Univ., China. Nonlinear and Electro-optical properties of Epsilon-near-zero (ENZ) materials and Epsilon-and-mu-near-zero (EMNZ) materials have been investigated. The ENZ enhancement was shown to be a slow light effect and EMNZ enhancement was found to be nonexistent.

JW4A.5 • 18:45
Scalable Phononic Quantum Networks of Spins in Diamond, Mark C. Kuzyk1; 1Univ. of Oregon, USA. Phononic quantum networks with alternating phononic crystal waveguides have been developed. This new architecture solves the inherent scalability problem in coupling spins with mechanical vibrations by breaking large networks into small and closed mechanical subsystems.

FW4B.7 • 18:45
Vertical emission of second and third harmonic light from GaAs nanowires below the band edge, Michael Scalora1, Jose Trulli1, Crina Cojocaru2, Maria Antonietta Vincenti2, Luca Carletti2, Domenico de Ceglia3, Costantino De Angelis3,4; 1US Army Aviation and Missile Command, USA; 2Physics Dept., Universitat Politècnica de Catalunya, Spain; 3Dept. of Information Engineering, Univ. of Brescia, Italy; 4National Inst. of Optics (INO-CNR), Italy. Using a hydrodynamic approach we predict bulk- and surface-induced second and third harmonic generation from a GaAs nanowire grating. Absorption is inhibited below the band-edge and conversion efficiencies are predicted to be 0.5% at 333nm.

19:00–20:30 Conference Reception, Grand Ballroom 220B/C
We introduce and experimentally demonstrate a novel platform to connect the concepts of Huygens’ condition and PT-symmetrical systems supporting an embedded eigenstate. In non-Hermitian PT-symmetrical systems, we construct a concept of coherent excitation can pave the way to light scattering control in an extreme fashion in non-Hermitian PT-symmetrical systems supporting an embedded eigenstate.
An optical synthesizer is devised to generate ultra-narrow erbium tunable laser,

Ming Xin, Nanxi Li, Neetesh Singh, Alfonso Ruocco, Zhan Su, Emr Salih Magden, Elena Nataros, Diedrik Vermeulen, Erich Ippen, Michael R. Watts, Franz Kärtner, EPFL, Switzerland; UNINE, Switzerland. We perform optical frequency division of an ultra-stable laser by using a crystalline-based Kerr frequency comb as a transfer oscillator. We demonstrate absolute phase noise levels of $-110$ dBc/Hz at 200-Hz offset from a 14 GHz carrier.

We experimentally study the supercontinuum generation from a highly nonlinear silica fiber with low nJ input pulse energies.

A broadband supercontinuum is generated from a thulium doped tunable laser. A 20 nm tuning range from 1544 nm to 1564 nm is achieved with $-10^{-13}$ frequency instability at 10s averaging time.

Comb-rooted synthesis of ultra-narrow multiple optical frequencies of few Hz linewidth, Byung Soo Kim, Heesuk Jung, Dong-Chel Shin, Young-Jin Kim, Seung-Woo Kim, Heterogeneous Lightwave Technologies, South Korea Advanced Inst of Science & Tech, South Korea.

An optical synthesizer is devised to generate ultra-narrow optical frequencies of a 1.0 Hz linewidth directly from a frequency comb stabilized to a high-finesse cavity.

Byung Soo Kim, Heesuk Jung, Dong-Chel Shin, Young-Jin Kim, Seung-Woo Kim, Heterogeneous Lightwave Technologies, South Korea Advanced Inst of Science & Tech, South Korea.

Observation of broadband frequency down-conversion by adiabatic four-wave mixing in optical fiber, Xiaoyue Ding, Kerianne Harrington, Dylan Heberle, Noah Flemens, Jeffrey Moses, Cornell University, USA; Dept. of Physics, Univ. of Bath, UK. We present the first experimental observation of broadband adiabatic four-wave mixing frequency conversion by using a tapered photonic crystal fiber to generate 2-μm pulses. This conversion mechanism may prove widely relevant for ultrafast optics applications.

We present the first experimental observation of broadband adiabatic four-wave mixing frequency conversion by using a tapered photonic crystal fiber to generate 2-μm pulses. This conversion mechanism may prove widely relevant for ultrafast optics applications.

Femtosecond Micromachining of Ophthalmic Hydrogels: effects of laser repetition rate on the induced phase change in the two photon and four photon absorption limit, Ruiting Huang, Wayne H. Knox, The Inst. of Optics, USA. We study and model effects of laser wavelength, repetition rate and other parameters on writing refractive index changes with a femtosecond laser in ophthalmic hydrogels.

Femtosecond Micromachining of Ophthalmic Hydrogels: effects of laser repetition rate on the induced phase change in the two photon and four photon absorption limit, Ruiting Huang, Wayne H. Knox, The Inst. of Optics, USA. We study and model effects of laser wavelength, repetition rate and other parameters on writing refractive index changes with a femtosecond laser in ophthalmic hydrogels.

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Concurrent sessions are grouped across six pages. Please review all six pages for complete session information.
FW4M • Advanced Techniques & Applications in Ultrafast Spectroscopy—Continued

FW4M.5 • 18:30
Ultrafast Spin Dynamics and Phase Competition in a Spin Vortex Crystal Superconductor, Di Cheng1,2, Joongmok Park1,2, Richard H. Kim1,2, William Meier1,2, Sergey Bud’ko1,2, Paul Canfield1,2, Martin Mojet1,2, Ilia E. Penaker1,2, Jigang Wang1,2; 1Iowa State Univ, USA; 2Ames Lab, USA. We present a frequency noise reduction in a mid-infrared quantum cascade laser achieved by stabilization to a short free-space delay line and show a decrease by more than 20 dB at 1-kHz Fourier frequency.

FW4M.6 • 18:45
Carrier Dynamics Between the Ordered and Disordered Orthorhomic Lattice Domains in Methylammonium Lead Iodide Perovskite, Michael Titze1, Chengbin Fei1, Maria Munoz1, He Wang1, Hebin Li1; 1Florida International Univ., USA; 2Physics, Univ. of Miami, USA. The carrier dynamics between the ordered and disordered orthorhomic lattice domains in methylammonium lead iodide perovskite are measured. Emission from disordered domain is visible within 250fs, accessing intermediate states inbetween and coupling to coherent phonon.

SW4N • High Power & Narrow Linewidth Lasers—Continued

SW4N.5 • 18:15
Frequency Noise Reduction in a Quantum Cascade Laser Using a Short Free-Space Delay Line, Atif Shehzad1, Pierre Brochard1, Renaud Matthey1, Thomas Sudmeyer1, Stephane Schlitz1; 1Univ. of Neuchatel, Switzerland. We present a frequency noise reduction in a mid-infrared quantum cascade laser achieved by stabilization to a short free-space delay line and show a decrease by more than 20 dB at 1-kHz Fourier frequency.

SW4N.6 • 18:30
1550 nm laser with 320 Hz Lorentzian linewidth based on semiconductor gain chip and extended Si3N4 Bragg grating, Chao Xiang1, Paul Morton2, John Bowers1; 1Dept. of Electrical and Computer Engineering, Univ. of California Santa Barbara, USA; 2Morton Photonics, USA. We demonstrate narrow linewidth lasers based on a semiconductor gain chip coupled to a Si3N4 Bragg grating. The laser demonstrates 12 mW fiber coupled output power, > 55 dB SMSR and 320 Hz Lorentzian linewidth.

SW4O • Short-Reach Communication Technologies—Continued

SW4O.6 • 18:30
Combined Probabilistic Shaping and Nyquist Pulse Shaping for PAM8 Signal Transmission in WDM Systems, Xiao Han1,2, Mingwei Yang1, Ivan B. Djordjevic1, Yang Yue1, Qiang Wang1, Zhen Qu1, Jon Anderson1; 1Juniper Networks, USA. We use the LDPC-coded probabilistically shaped PAM8 signaling combined with Nyquist pulse shaping to improve the transmission performance in a WDM system. We find that the combination of these shaping schemes offers great performance improvement.

19:00–20:30 Conference Reception, Grand Ballroom 220B/C
Christine Silberhorn is a professor at Paderborn University leading the research group “Integrated Quantum Optics”. She received several prizes, most prominently: Gottfried-Wilhelm-Leibniz-prize from the German Science Foundation (2011) and a consolidator ERC-grant (2017). Since 2013 she is member of the Leopoldina, National Academy of Science, and since 2018 OSA Fellow.
We report a dissipative soliton seeded, robust, high peak power, 1.56 MW. Gain-optimized 2.05 μm pulses at 20 mJ and 1 kHz from multi-pass Ho:YLF amplifier, Krishna Murari, Yanchun Yin, Yi Wu, Xiaoming Ren, Zenghu Chang, College of Optics and Photonics (CREOL), USA; 2Univ. of Central Florida Physics, USA. We present Ho:YLF based multi-pass amplifier emitting pulses at 20 mJ energy and 1 kHz repetition rate seeded by 3 mJ seed pulses from DC-OPA.

Selective Wavelength KGW/ Tm:YLF STh1E • 08:15

Selective Wavelength KGW/ Tm:YLF Raman Laser, Salman Noach Raman Laser,Selective Wavelength KGW/ Tm:YLF STh1E.2 • 08:15

Selective Wavelength KGW/ Tm:YLF STh1E • 08:00

Selective Wavelength KGW/ Tm:YLF Gain-optimized 2.05 μm pulses at 20 mJ and 1 kHz from multi-pass Ho:YLF amplifier, Krishna Murari, Yanchun Yin, Yi Wu, Xiaoming Ren, Zenghu Chang, College of Optics and Photonics (CREOL), USA; 2Univ. of Central Florida Physics, USA. We present Ho:YLF based multi-pass amplifier emitting pulses at 20 mJ energy and 1 kHz repetition rate seeded by 3 mJ seed pulses from DC-OPA.

Trace Gas Spectroscopy with Mid-Infrared Nanophotonic Waveguides, Marek Vlk, Henock D. Yallew, Vinita Mittal, Ganapathy Senthil Murugan, Jana Jageriska, UII The Arctic Univ. of Norway, Norway; 3Optoelectronics Research Centre Southampton, UK. We present a mid-infrared photonic waveguide platform for sensitive and selective detection of trace gases by means of tunable laser absorption spectroscopy.

Trace Gas Spectroscopy with Mid-Infrared Nanophotonic Waveguides, Marek Vlk, Henock D. Yallew, Vinita Mittal, Ganapathy Senthil Murugan, Jana Jageriska, UII The Arctic Univ. of Norway, Norway; 3Optoelectronics Research Centre Southampton, UK. We present a mid-infrared photonic waveguide platform for sensitive and selective detection of trace gases by means of tunable laser absorption spectroscopy.

We report a dissipative soliton seeded, robust, high peak power, 1.56 MW. Gain-optimized 2.05 μm pulses at 20 mJ and 1 kHz from multi-pass Ho:YLF amplifier, Krishna Murari, Yanchun Yin, Yi Wu, Xiaoming Ren, Zenghu Chang, College of Optics and Photonics (CREOL), USA; 2Univ. of Central Florida Physics, USA. We present Ho:YLF based multi-pass amplifier emitting pulses at 20 mJ energy and 1 kHz repetition rate seeded by 3 mJ seed pulses from DC-OPA.

Trace Gas Spectroscopy with Mid-Infrared Nanophotonic Waveguides, Marek Vlk, Henock D. Yallew, Vinita Mittal, Ganapathy Senthil Murugan, Jana Jageriska, UII The Arctic Univ. of Norway, Norway; 3Optoelectronics Research Centre Southampton, UK. We present a mid-infrared photonic waveguide platform for sensitive and selective detection of trace gases by means of tunable laser absorption spectroscopy.
 attending.

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Thursday, 08:00–10:00

**ATH1 • Radiative Cooling & Photovoltaics**

*President: Daniel Law; Boeing, USA*

**ATH1.1 • 08:00**

Structured Polymers for High-Performance Passive Daytime Radiative Cooling

**Speaker:** Jyotirmoy Mandal, Nanfang Yu, Yuan Yang, Columbia Univ., USA

Structured polymer coatings with exceptional solar reflectance (96-99%) and hemispherical long-wave infrared emittance (≤97%) are created using a scalable phase inversion technique. The polymer coatings exhibit excellent passive daytime radiative cooling, with a paint-like convenience.

**ATH1.2 • 08:30**

All-day Radiative Cooling Using Beam-Controlled Architectures

**Speaker:** Lyu Zhou, Haomin Song, Jian-Wei Liang, Matthew H. Singer, Ming Zhou, Edgars Stegenbergs, Nan Zhang, Tien Khee Ng, Zongfu Yu, Boon S. Ooi, Qiaoqiang Gan, State Univ. of New York at Buffalo, USA; KAUST Nanophotonics Lab, King Abdullah Univ. of Science and Technology, Saudi Arabia; Dept. of Electrical and Computer Engineering, Univ. of Wisconsin, Madison, USA. We report an inexpensive planar polydimethylsiloxane (PDMS)/metal thermal emitter in a beam-controlled architecture for all-day radiative cooling and realized ~11°C reduction compared with the ambient temperature.

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**STH1 • Nonlinear Photonics**

*President: Satoshi Iwamoto; Univ. of Tokyo, Japan*

**STH1.1 • 08:00**

Third- and Fourth-Harmonic Generation in Cascaded Periodically-Poled Lithium Niobate Ultracompact Waveguides on Silicon

**Speaker:** Qiang Lin, Hanxiao Liang, Mingxiao Li, Jingwei Ling, Qian Lin, Univ. of Rochester, USA. We report cavity-enhanced second-harmonic generation and difference-frequency generation in a high-Q lithium niobate microring resonator with modal phase matching. The second-harmonic generation efficiency is measured to be 1,500% W⁻¹.

**STH1.2 • 08:15**

Cavity-enhanced optical parametric generation in a modal-phase-matched lithium niobate microring, Rui Luo, Yang He, Hanxiao Liang, Mingxiao Li, Jingwei Ling, Qian Lin, Univ. of Rochester, USA. We report cavity-enhanced second-harmonic generation and difference-frequency generation in a hydrogen-filled kagome PCF. Raman coherence waves, prepared by a visible pump, up- or down-shift the frequency of an ultraviolet signal upon fulfillment of phase-matching conditions.

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**ATH1K • Industrial Metrology & Remote Sensing**

*President: Meng Zhang; Beihang Univ., USA*

**ATH1K.1 • 08:00**

Invited: Optical Systems for Industrial Shop Floor Surface Measurements To Improve Yield

**Speaker:** Erik L. Novak, Veeco Instruments Inc, USA. We demonstrate a novel 3D surface profile imaging method based on time-encoded structured illumination, low error 3D reconstruction of different objects can be obtained.

**ATH1K.2 • 08:30**

Highly Efficient Thresholdless Ultraviolet Frequency Conversion in H₂-filled Photonic Crystal Fiber

**Speaker:** Matthew Partridge, Rowan Curtis, Kendra Khodabandehloo, Yong Chen, Mathew Bradley, Natalie V. Wheeler, John Hayes, Ian Davidson, Seyed Reza Sandogchi, Marco N. Petrovich, Francesco Poletti, David Richardson, Radan Slavik, Optoelectronics Research Centre, UK. We demonstrate the use of a Mach-Zehnder interferometer to measure gas flow within hollow core fiber during gas pressure changes. These preliminary results demonstrate the method and indicate differences between various hollow core morphologies.
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<td><strong>FTh1M • Ultrafast Processes in Gases &amp; Solids</strong>&lt;br&gt;Presider: To Be Announced</td>
<td><strong>STh1N • Sensing &amp; Switching</strong>&lt;br&gt;Presider: Ozdal Boyraz; Univ. of California, Irvine, USA</td>
<td><strong>STh1O • Metasurfaces &amp; Nanophotonic Materials</strong>&lt;br&gt;Presider: Roberto Paiella; Boston Univ., USA</td>
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**FTh1M.1 • 08:00**<br>Self-Reinforced Optical Stability Formed by Unseeded Four-Wave Mixing with Two Pump Beams in Atomic Vapor, Erin Knutson¹, Jon D. Swaim¹, Sara Wyllie¹, Ryan T. Glasser¹; Tulane Univ., USA. We demonstrate unseeded multimode four-wave mixing wherein each created photon is correlated to exactly two others, resulting in an "optimal" four-mode output. The generated beams are spatially separated, readily allowing for use in quantum communications.

**FTh1M.2 • 08:15**<br>Laser without population inversion of nitrogen ions pumped by femtosecond pulses, Yi Liu¹,², Rostislav Danylo³, Pengji Ding⁴, Aurelien Houard⁴, Vladimir Tikhonchuk⁴, Xiang Zhang⁴, Zhengquan Fan⁴, Qingsong Liang⁴, Songlin Zhuang⁴, Luqi Yuan⁴; ¹Tulane Univ., USA; ²ENSTA Paristech, France; ³Université de Bordeaux, France; ⁴Stanford Univ., USA. We attribute the mechanism of "lasing" action of nitrogen ions pumped by femtosecond IR pulses to a laser without inversion scheme. Numerical simulations reproduce well the temporal dynamics and pressure dependence of the emission.

**FTh1M.3 • 08:30**<br>Microwave Radiation from Single and Two Color Mid-Infrared Laser Produced Plasmas in Air, Alexander C. Englesbe¹,², Robert Schwartz¹,², Anastasia Karolov¹,², Dogeon Jang³, Daniel Woodbury³, Ki-Yong Kim³, Howard Milchberg³, Remington Reid³, Adrian Lucero³, Hugh Pofahl³, Sergei Kalmykov³, Karl Krushelnick³; ¹Univ. of Michigan, USA; ²Directed Energy Directorate, Air Force Research Lab, USA; ³Univ. of Maryland, USA. Plasmas generated by focusing ultrashort laser pulses in air emit broadband microwaves. We present comparisons between the frequency spectrum of radiation from 2-70 GHz due to single and two color mid-infrared laser pulses.

**STh1N.1 • 08:00**<br>Random Fiber Gratings and Applications, Xiaoyi Bao¹; ¹Physics Dept., Univ. of Ottawa, Canada. Enhancing scattering in optical fibers by random periods can lead to broadband grating, which acts as a random distributed feedback in lasers to control the coherence for low noise. It can also create multi-parameters sensors.

**STh1O.1 • 08:00**<br>Nonlinear and Tunable Semiconductor Metasurfaces, Isabelle Staude¹; ¹Friedrich-Schiller-Univ. Jena, Germany. Resonant semiconductor metasurfaces were established as a versatile platform for manipulating light fields. This talk reviews our recent advances in the integration of optical non-linearities into such metasurfaces and on obtaining dynamic control of their optical response.

**STh1N.2 • 08:30**<br>Fingerprint mid-infrared sensing with germanium on silicon waveguides, Ugne Griskeviciute¹, Ross Millar¹, Kevin Galbraith¹, Leonetta Baldassare¹, Marc Sorel¹, Michele Ortolani¹, Douglas J. Paul¹; ¹Univ. of Glasgow, UK; ²Sapienza Univ. of Rome, Italy. Low-loss Ge-on-Si waveguides are demonstrated in the 8-14μm atmospheric transmission window for the first time, with losses reaching ~1dB/cm. Molecular fingerprint sensing is demonstrated using a polymer with absorption lines in this spectral region.

**STh1O.2 • 08:30**<br>Dynamically-tunable Plasmonic Devices Based on Phase Transition of Vanadium Dioxide, Ruwen Peng¹,², Fang-Zhou Shu¹, Ren-Hao Fan¹, Mu Wang¹; ¹Nanjing Univ., China. We have experimentally demonstrated several dynamically-tunable plasmonic devices based on phase transition of vanadium dioxide, which include dynamic color generators and dynamically-switchable polarizers. The investigations can be applied in dynamic digital displays and imaging sensors.
**FTh1A.2 • 09:00**
Measuring frequency-bin entanglement in depolarized biphoton frequency combs, Oscar Soñado2, Navin B. Lingaraju1, Pooled Ilmar1y, Daniel E. Leard1, Michael Brodsky1, Andrew M. Weiner1, 1Purdue Univ., USA; 2U.S. Army Research Lab, USA. A polarization diversity phase modulator capable of measuring frequency-bin entanglement, irrespective of polarization fluctuations and the relative orientation between the signal and idler photons, is demonstrated.

**FTh1A.3 • 09:15**
High Dimensional Quantum Key Distribution with Biphoton Frequency Combs through Energy-Time Entanglement, Murat C. Sarihan1, Kai-Chi Chang1, Xiang Cheng1, Yoo Seung Lee1, Tian Zhong1, Hongchao Zhou1, Zhenzhen Zhang1, Franco N. Wong1, Jeffrey H. Shapiro2, Chee Wei Wong1; 1Dept. of Electrical Engineering, Univ of California, Los Angeles, USA; 2Institut für Mollekulare Technologie, Ettlingen, Germany. We report on the first subcycle angle-resolved electron emission from circular and elliptical nanorings on large scales, using a novel cathodoluminescence technique in which high-resolution spectroscopy and Fourier imaging are combined.

**FTh1B • 08:45**
Experimental Nonlinear Observation of TW Laser Propagation Through a 10m Rubidium Vapor Source for Plasma Diagnostics at AWAKE, Valentina Lea1, Joshua Mood2, Gabor Demeter1, Gregory Kriehn1, Patrick Muggli1, 1California State Univ. Fresno, USA; 2Max Planck Inst. for Physics, Germany. We investigate parametric down-conversion in orientation-patterned NbN-PPLN waveguide and scalable thermal process, Paulina S. Kuo1, Peter G. Schumemann1, Mackenzie Van Camp1, Varun B. Verma1, Thomas Gerst1, Sae Woo Nam2, Richard P. Minn3, 1Information Technology Lab, NASA; 2BAE Systems, USA; 3Physical Measurement Laboratory, National Inst. of Standards and Technology, USA. We investigate parametric down-conversion in orientation-patterned GaP. Pumped at 865 nm, the signal and idler are at 1350 nm and 2400 nm, respectively.

**FTh1B • 09:00**
Subcycle band structure movie of lightwave-driven Dirac currents, Johannes Reimann1, Stefan Schlauderer1, Christoph P. Schmid1, Fabian Langer1, Sebastian Baer1, Konstantin A. Kohler1, Oleg E. Teschechenko2, Akio Kimura3, Christoph Lange1, Jens Gudd1, Ulrich Höfer1, Rupert Huber1; 1Univ. of Regensburg, Germany; 2Fachbereich Physik, Philipps-Universität, Germany; 3V.S. Sobolev Inst. of Geology and Mineralogy SB RAS, Russia. We report on the first subcycle angle-resolved photoemission study reveals how an intense terahertz field drives topologically protected Dirac currents on the surface of Bi2Te3, spin-momentum locking enables fully ballistic lightwave currents over several 100 nm.

**FTh1C • 09:00**
Full Energy-Momentum Cathodoluminescence Mapping on Circular and Elliptical Plasmonic Bullseye Antennas, Toon Coenen1, Albert Polman1, Delmic, Netherlands; 2Center for nanophotonics, AMOLF, Netherlands. We investigate cathodoluminescence emission from circular and elliptical plasmonic bullseye antennas. The emission is mapped both in energy and momentum space, using a novel cathodoluminescence technique in which high-resolution spectroscopy and Fourier imaging are combined.

**FTh1C.6 • 09:15**
Airy Plasmon Pulses investigated by Multiphoton Photoemission Electron Microscopy (PEEM), Thomas Kaiser1, Matthias Falkner1, Amit Singh1, Matthias Zilk1, Michael Steiner1, Thomas Pertsch1; 1Inst. of Applied Physics, Germany. We report on multiphoton PEEM measurements of pulsed Airy plasmons generated by a holographic grating. The diffraction-free behavior and high localization are important for generating spatio-temporal electromagnetic hotspots in ultrafast nanophotonics.

**FTh1D • 08:45**
Enhanced Control of Size and Shape of Gold Nanoparticles Produced by a Simple and Scalable Thermal Process, Nathan Ray1, Jae Hyuck Yoo1, Hoang Nguyen1, Mike Johnson1, Sal Baxamusa1, Selim Elhaadj2, Joseph Mckeown1, Manyalibo J. Matthews1, Eyal Feigenbaum1; 1Lawrence Livermore National Lab, USA. Enhanced control through sub-melting solid state differential dewetting is utilized to generate randomly oriented ensembles of nanoparticles on large scales, with controllable regulation over particle size, shape, and separation distance, ideal for large-area plasmonic applications.

**FTh1D.4 • 08:45**
Highly Directional Silicon Microring Photon Pair Source, Jeffrey A. Sterdi1, Michael Fantz1, Stefan P. Preble1, Christopher C. Tison1, Paul M. Alsing1; 1Rochester Institute of Technology, USA; 2Air Force Research Lab, USA. Silicon microrings make for compact, tunable photon-pair sources but typically suffer from an effective 50% loss. Through interferometric coupling, these sources can be highly directional, resulting an drastically improved performance.
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<th>Session</th>
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<th>Abstract</th>
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<tr>
<td>Executive Ballroom 210E</td>
<td>Mid-IR Lasers—Continued</td>
<td>08:45</td>
<td>STh1E.4</td>
<td>CO2 Laser Optically Pumped by a Tunable 4.3 μm Laser Source, Dana Tovey1, Jeremy Pigeon1, Sergio Tochitsky1, Gerhard Lounwrens1, Ilan Ben-Zvi2, Chan Joshi1, Dmitry Marchuk3,4, Michail P. Smayev4, Vladislav Likhov4, Yuri Tsyshkin3, Vladimir Fedorov3, Krishna Karki3, Evgeni Sorokin5, Irina T. Sorokina1,2; Valentin Petrov1, Xavier Mateos2; Magdalena Aguilo2, Francesc Diaz2, Alain Carolina Romero4, Javier Marangoni4, Jerzy Lisowski4, Dennis O’Hara4, Domingo Haj Columbia1,2, Idaho National Laboratory1,2; Umeå University3, Australian National University4, University of Haifa5. We report the first single-mode Cr:ZnS depressed cladding buried waveguide laser manufactured by fs direct-laser-writing in monocrystalline ZnS. Passive Q-switching by Cr2+:ZnS resulted in fundamental 1.84 μm with a slope efficiency of 69.5%. Passive Q-switching by Cr:ZnS, fabricated by fs direct-laser-writing in monocrystalline ZnS, resulted in 2.6 ns/6.9 μJ pulses.</td>
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<td>Executive Ballroom 210F</td>
<td>Chip-SCALE Trace-Gas Sensing—Continued</td>
<td>08:45</td>
<td>STh1F.3</td>
<td>Carbon Dioxide Sensing with Low-confinement High-sensitivity Mid-IR Silicon Waveguides, Flora Ottone-Briano1, Carlos Errando-Herranz1, Henrik Rödégård1, Hans Martin1, Hans Soh lstrom2, Kristinn B. Gylfason1; Micro and Nanosystems, KTH Royal Inst. of Technology, Sweden; Senseair AB, Sweden. We present a low-confinement Si chip waveguide for 4.26 μm wavelength and apply it to sense CO2 concentrations down to 0.1%. We demonstrate the highest reported waveguide sensitivity to CO2: 44% of the free-space sensitivity.</td>
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<td>Executive Ballroom 210G</td>
<td>Frequency Comb Spectroscopy—Continued</td>
<td>08:45</td>
<td>STh1G.4</td>
<td>Adaptive Sampling Terahertz Dual-Comb Spectroscopy Based on a Free-Running Single-Cavity Dual-Comb Fiber Laser, Jie Chen1,2, Koichi Nitta1,2, Xin Zhao1, Takahiko Mizuno1,2, Takeo Minamikawa1,2, Zheng Zheng1, Takeshi Yasui1,2; Tokushima Univ., Japan; 1JST, ERATO MINOSHIMA Intelligent Optical Synthesizer, Japan; 2Beihang Univ., China. Mode-resolved adaptive sampling terahertz dual-comb spectroscopy is demonstrated using a free-running wavelength-multiplexed dual-comb fiber laser, which illustrates the capability of such single-cavity dual-comb sources for high-sensitivity THz spectroscopy.</td>
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<td>Executive Ballroom 210H</td>
<td>Optical Resonance-Based Devices—Continued</td>
<td>08:45</td>
<td>STh1H.3</td>
<td>Thermo-refractive noise in silicon nitride microresonators, Guanzhu Huang1, Erwan Lucas1, Junou Lu1, Arslan Rajas, Gregory Lihachev2,3, Michael L. Gorodetsky2,3, Nils Engelsen1, Tobias J. Kippenberg1; 1Inst. of Physics (IPHY5), EPFL, Switzerland; 2Faculty of Physics, M.V. Lomonosov Moscow State Univ., Russia; 3Russian Quantum Centre, Russia. Thermodynamic noises limit the frequency stability of resonators. Here, we present the first complete characterization of thermo-refractive noise in Si$_3$N$_4$ microresonators. The measurements are in good agreement with theoretical analysis and FEM simulation of the structures.</td>
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<td>Executive Ballroom 210I</td>
<td>All-Optical Control of Pulse Storage Time and Retrieval Phase Using a Diamond Microdisk, Matthew Mitchell1, David Lake1, Paul E. Barclay1; 1Physics &amp; Astronomy, Univ. of Calgary, Canada. Enhancement of optomechanical pulse storage time is demonstrated, for the first time, in a multimode diamond microdisk cavity. Optical control of the mechanical damping rate and frequency allows &gt; 5× enhancement of the pulse storage time, and a maximum controllable pulse phase shift of ~2π.</td>
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<td>Executive Ballroom 210J</td>
<td>Frequency Comb Spectroscopy—Continued</td>
<td>09:00</td>
<td>STh1G.5</td>
<td>Time-Resolved Dual Frequency Comb Spectroscopy for Broadband Multi-Species Detection in Laser-Induced Plasmas, Caroline Lecaplain1, Yu Zhang1, Reagan R. Weeks1, Jeremy Yeak1, Sivanandan S. Harial1, Mark C. Phillips1, R. J. Jones1; 1College of Optical Sciences, Univ. of Arizona, USA; 2Physics, Univ. of Arizona, USA; 3OpticsLabs, USA; 4Pacific Northwest National Lab, USA. We present the first results using time-resolved broadband dual-comb spectroscopy in a laser-induced plasma. Preliminary results identifying multiple species in a Nd magnet will be shown.</td>
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<td>Executive Ballroom 210K</td>
<td>Optical Resonance-Based Devices—Continued</td>
<td>09:15</td>
<td>STh1H.5</td>
<td>Record High-Q Microresonators from 650 nm to 1550 nm Wavelengths on a 3C-SiC-on-Insulator Platform, Tianran Fan1, Xi Wu1, Ali Eftekhar1, Ali Adibi1; 1Georgia Inst. of Technology, USA. We report record high-Q SiC microresonators on a 3C-SiC-on-insulator platform with ultra-low (&lt;1 Å) roughness after chemical-mechanical polishing. We demonstrate Qs of 242,000 at 1550 nm, 112,000 at 780 nm, and 83,000 at 650 nm.</td>
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ATH1 • Radiative Cooling & Photovoltaics—Continued

ATH1.3 • 08:45
Boosted CO₂ Reduction Using Ultra-thin TiO₂ Photocatalyst Films on Nanocavities, Haomin Song¹, Wei Wu², Jian-Wei Liang², Partha Marti³, Omar F. Mohammed³, Boon S. Ooi¹, Dongxia Liu¹, Qiaoqiang Gan¹; ¹State Univ. of New York at Buffalo, USA; ²Dept. of Chemical & Biomolecular Engineering, Univ. of Maryland College Park, USA; ³Dept. of Electrical Engineering, King Abdullah Univ. of Science and Technology, Saudi Arabia. We created an ultra-thin film photocatalytic light absorber (UFPLA) with 2–22-nm-thick TiO₂ films. The UFPLA structure conquered the intrinsic trade-off between optical absorption and charge carrier extraction efficiency and therefore boosted CO₂ reduction efficiency.

ATH1.4 • 09:00
Silicon Solar Cells Efficiency Enhanced In NIR Band by Coating Plasmonics ITO- and UC-Phosphors-particles on Back-side Surface Using Spin-on Film Deposition, Ding-Lun Lin¹, Wen-Jeng Ho¹, Guan-Yu Chen¹, Heng-Jie Liu¹, Bao-Ying Pan¹, Ying-Lun Haung¹, Po-Yuan Ting¹, Ying-Yu Chen¹; ¹National Taipei Univ. of Technology, Taiwan. We demonstrate efficiency enhanced in NIR-band using plasmonics indium-tin-oxide (ITO) nanoparticles and up-conversion (UC)-phosphors particles on back-side of silicon solar cells. Impeccable efficiency enhancement of 17.49% was obtained, compared to the reference-cell without ITO/UC-particles.

ATH1.5 • 09:15
Ultra-Wide Field of View Lens-Let Array for Efficient Solar Collection, Rakan E. Alsaigh¹, Ralf Bauer¹, Martin P. Lavery¹; ¹Univ. of Glasgow, UK; ²Univ. of Strathclyde, UK. Efficient solar collection over a full-day is a leading challenge for photovoltaic power generation. We present a novel multi-layer lens-lot array that increases the daily collection efficiency of standard panels by a factor of 2.32.

ATH1.6 • 09:45
Efficient and Broadband Four-wave Mixing in AlGaAs Microresonator for High-speed Optical Signal Processing, Chanju Kim¹, Erik Stassen¹, Krysten Vundt¹, Minhao Pu¹; ¹DTU Fotonik, Denmark. We demonstrate four-wave mixing in GHz-linewidth AlGaAs microresonators with -10.7-dB conversion efficiency at 4-nW pump power over the telecom S-, C-, and L-bands. We achieve 57-dB resonance enhancement for microresonators supporting 10-Gbit/s signal processing.

ATH1.7 • 10:15
Regularized Phase Reconstruction for Sensing Deep Subwavelength Perturbations on Large-Scale Wafers, Jinlong Zhu¹, Jinlong Zhu¹, Bao-Ying Pan¹, Ying-Ming J. Eggleton¹; ¹The Univ. of Sydney, Australia; ²RMIT Univ., Australia; ³Australian National Univ.; ⁴Univ. of Twente, Netherlands. We present the first demonstration of backward stimulated Brillouin scattering between distinct guided optical spatial modes in an integrated multi-modal photonic circuit. This unique opto-acoustic process enables new opportunities for on-chip Brillouin signal processing technology.
We report on the generation of electronic quantum coherence in the ionized nitrogen molecules. The coherence is revealed by observing $N_2^+$ air lasing with a near-infrared laser and a delayed mid-infrared laser. The time dependence of stark shift of transitions in plasma created by 800 nm filament shows the same time dependence as the gain decay.

Electronic quantum coherence in $N_2^+$, air lasing, Jinming Chen$^1$, Jingping Yao$^1$, Haiss Zhang$^1$, Zhaoxiang Liu$^1$, Bo Xu$^1$, Wei Chu$^1$, Lingling Qiao$^1$, Zhenhua Wang$^2$, Julian Fatome$^1$, Olivier Faucher$^1$, Chengyin Wu$^1$, 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; $^2$Université de Bourgogne, France. We present the Stark shift measurement on the individual transition lines of $N_2^+$ in a pump probe configuration. The time dependence of stark shift of transitions in plasma created by 800 nm filament shows the same time dependence as the gain decay.

Energy Transmission Efficiency of Laser-induced Vortical Filaments, Milos Burger$^1$, Patrick J. Skrodzki$^1$, John Nees$^1$, Igor Jovanovic$^1$, Univ. of Michigan, USA. We performed characterization and energy transmission measurements of both ordinary and vortical ultrafast filament structures in air. The results appear to stand in favor of reduced ionization losses in the case of vortical filaments.

Stark shift and gain decay in air lasing of $N_2^+$, Ladan Aris-sian$^1$, Jean-Claude Delsi$^1$, Brian Kamer$^1$; $^1$Univ. of New Mexico, Canada. We present the Stark shift measurement on the individual transition lines of $N_2^+$ in a pump probe configuration. The time dependence of stark shift of transitions in plasma created by 800 nm filament shows the same time dependence as the gain decay.

A low power superconductor-to-optoelectronic interface, Adam McCaughan$^1$, Sonia Buckley$^1$, Varun B. Verma$^1$, Alexander N. Tait$^1$, Sue Woo Nam$^1$, Jeff Shainline$^1$; $^1$NIST, USA. We present a ultrahigh- impedance superconducting thermal switch that acts as a superconductor-to-optoelectronic interface. We demonstrated the generation of photons in a cryogenic photonic LED from a low-voltage input, detecting those photons with a waveguide-coupled detector.

A new architecture for space-and-wavelength selective switch fabrics is proposed. This class of designs built with a combination of microring-based channel-selectors and comb-aggregators completely blocks first-order in-band crosstalk enabling highly-scalable and flexible interconnect networks.

Programmable self-assembled metasurface for strong field enhancement, Tapayoti Das Gupta$^1$, Louis Martin-Monier$^1$, Arthur Lebras$^1$, Wei Yan$^1$, Tung Dang Nguyen$^1$, Alexis Page$^1$, Fabien Sorin$^1$; $^1$Material science, Ecole Polytechnique Federale de Lausanne, Switzerland. Self-assembled chalcogenide metasurfaces is proposed for low-cost manufacturing on large-area unconventional substrates. Programmed control over particle arrangement and periodicity yields strong Fano resonances, highlighting novel applications for bio-detection and second harmonic generation.

Scalable Space-and-Wavelength Selective Switch Architecture Using Microring Resonators, Qixiang Cheng$^1$, Meisam Bahadori$^1$, Madeleine Glick$^1$, Keren Bergman$^1$; $^1$Columbia Univ., USA. A new architecture for space-and-wavelength selective switch fabrics is proposed. This class of designs built with a combination of microring-based channel-selectors and comb-aggregators completely blocks first-order in-band crosstalk enabling highly-scalable and flexible interconnect networks.

Embedded dielectric metasurface based subtractive color filter on a 300mm glass wafer, Zhengji Xu$^1$, Yuan Dong$^1$, Yuan-Hung Fu$^1$, Qize Zhang$^1$, Ting Hu$^1$, Dongdong Li$^1$, Yu Li$^1$, Nanxi Li$^1$, Ying Lin$^1$, Qunying Lin$^1$, Shiyang Zhu$^1$, Navab Singh$^1$; $^1$A*STAR, Inst. of Microelectronics, Singapore. A subtractive color filters (SCFs) is firstly demonstrated on a 300mm glass wafer using CMOS-compatible fabrication process. Three transmission dips were observed at 528, 568, and 598 nm wavelengths for different SCF designs.

Ultrahigh-impedance superconducting thermal switch that acts as a superconductor-to-optoelectronic interface, NIST, USA. We present a ultrahigh-impedance superconducting thermal switch that acts as a superconductor-to-optoelectronic interface. We demonstrated the generation of photons in a cryogenic photonic LED from a low-voltage input, detecting those photons with a waveguide-coupled detector.

Bipolar low-loss Non-volatile Photonic Switches Using Phase-Change Materials, Jiajiu Zheng$^1$, Peipeng Xu$^1$, Jonathan Daylend$^1$, Arka Majumdar$^1$; $^1$Univ. of Washington, Seattle, USA. A new architecture for space-and-wavelength selective switch fabrics is proposed. This class of designs built with a combination of microring-based channel-selectors and comb-aggregators completely blocks first-order in-band crosstalk enabling highly-scalable and flexible interconnect networks.

Broadband Low-loss Non-volatile Photonic Switches Using Phase-Change Materials, Jiajiu Zheng$^1$, Peipeng Xu$^1$, Jonathan Daylend$^1$, Arka Majumdar$^1$; $^1$Univ. of Washington, Seattle, USA. Based on the non-volatile GST-on-silicon platform, we demonstrate compact (~30 µm), low-loss (~1dB), and broadband (over 30 nm with crosstalk < −10 dB) 1 x 2 and 2 x 2 photonic directional coupler switches.
FTh1A.1 • Exploiting Quantum Degrees of Freedom—Continued

High-dimensional one-way quantum computation operations with on-chip optical d-level cluster states, Christian Nemec1, Michael Kues2, Stefania Sciarra3, Piet Roztock3, Meheddi Islam4, Luis Romero Cortes5, Yaxing Zhang6, Bennet Fischer7, Sebastien Loranger1, Raman Kashyap1, Alfonso Cino8, Sai Chu9, Brent Little9, David Moss7, Lucia Michael Kues2, Stefania Sciara2, Piotr Rozandi Precision Mechanics, China; 7Swinburne Univ. of Technology, Australia; 8Univ. of Strathclyde, UK; 9NTT Basic Research Labs, Japan. We implement one-chip generation of hyper-entangled states in the time- and frequency-domain, and transform them into d-level cluster states using a deterministic controlled phase gate. We then demonstrate one-way quantum computing operations and show the state’s high tolerance towards noise.

FTh1A.5 • 09:45
Optical Information Processing with Noise-Resistant Entangled Topological States, Alexander V. Sergienko1, David Simon1,2, Shuto Osawa3,4, Boston Univ., USA; 2Stanhill College, USA. Linear-optical photonic quantum walks are used to jointly entangle polarization and winding number. This joint entanglement allows polarization entanglement-based quantum information processing tasks to be performed with high degree or error protection.

FTh1B.1 • Ultrafast Nonlinear Phenomena—Continued

Sub-millijoule, 3 μm optical parametric chirped-pulse amplifier at 10 kHz repetition rate, Xiao Zou1, Wenshu Li2, Haojun Liang3, Shizhen Qu3, Kun Liu2, Qijie Wang2, Ying Zhang2, Nanyang Technological Univ., Singapore; 2Singapore Inst. of Manufacturing Technology, Singapore. We demonstrate a 3 μm optical parametric chirped pulse amplifier with 802 μJ pulse energy, at 10 kHz repetition rate, and stable carrier-envelope phase. 73 fs pulse width is obtained with an efficient nonlinear compression.

FTh1B.6 • 09:45
Nonlinear Generation of Ultrafast beams with Classical Non-Separable States of Light, Ravi Saripalli1, Anirban Ghosh1, Apurv C. Nellikka2, Goutam Samanta1; 1Atomic, Molecular and Optical Physics Division, Physical Research Lab, India; 2Tecnologico de Monterrey, Mexico. We report on non-linear generation of ultrafast optical beams with classical non-separable states in spin and orbital angular momentum degrees of freedom with topological order as high as 24 and output power as high as 20 mW.

FTh1C.7 • 09:30
Brownian Dynamics Controlled by Phase Gradients, Cristian Hernando Acevedo1, Jose Guzman-Sepulveda1, Aristide Dogariu1; 1Univ. of Central Florida, USA. We demonstrate the effect of random forces induced by phase gradients on the dynamics of small particles. We show that subdiffusive regimes could be controlled by the topological charge of an external optical field.

FTh1D.8 • 09:45
Satellite-Borne High-Brightness Source of Entangled Photons, Yuan Cao1; 1Univ. of Science and Technology of China, China. The satellite-borne high-brightness source of polarization-entangled photons was developed and launched with the “Micius” satellite. With this source we implemented the Bell test between the satellite and the ground stations over 1200 km.
balanced lasers and radiation balanced lasers, crystals for mid-IR cryocoolers and radiation temperatures are reported. Potential of these absorption, and minimum achievable external quantum efficiency, background Ho-doped crystals is investigated, and their optical refrigeration in Tm- and Pisa, Italy. Optical refrigeration in Tm- and Pisa, Italy.

CNR, Dipartimento di Fisica, Universita di Pisa, Italy. Optical refrigeration in Tm- and Ho-doped crystals is investigated, and their

Optical refrigeration in Tm- and Pisa, Italy.

Saeid Rostami1, Azzurra Volpi1, Alexander R. Albrecht1, Mauro Tonelli2, Mansoor Sheik-Bahae1; Univ. of New Mexico, USA; 2NEST-CNR, Dipartimento di Fisica, Universita di Pisa, Italy.

Suspended Membrane InGaAs Photonic Crystal Waveguides for ammonia sensing at Lambda=6.15um., Young Min Yoo1, Jason Midkiff1, Ali Roostamian1, Swapnajit Chakravarty1, Ray T. Chen1,2; Electrical and Computer Engineering, The Univ of Texas at Austin, USA; 2Omega Optics Inc., USA. Fully suspended InGaAs waveguides devices with holey photonic crystal waveguides (HPCWs) are designed for mid-infrared sensing at labmda=6.15um in the low index contrast InGaAs-InP platform. We experimentally detect 5ppm ammonia in 1mm long suspended HPCWs.

Suspended Membrane InGaAs Photonic Crystal Waveguides for ammonia sensing at Lambda=6.15um., Young Min Yoo1, Jason Midkiff1, Ali Roostamian1, Swapnajit Chakravarty1, Ray T. Chen1,2; Electrical and Computer Engineering, The Univ of Texas at Austin, USA; 2Omega Optics Inc., USA. Fully suspended InGaAs waveguides devices with holey photonic crystal waveguides (HPCWs) are designed for mid-infrared sensing at labmda=6.15um in the low index contrast InGaAs-InP platform. We experimentally detect 5ppm ammonia in 1mm long suspended HPCWs.

Waveguide-Enhanced Raman Spectroscopy Using a Mesoporous Silica Sorbent Layer for Volatile Organic Compound (VOC) Sensing, Haolan Zhao1,2, Ali Raza1,2, Bettina Baumgartner1, Stephanie Clemmen1,2, Bernhard Lendl1, Andre Skirtach1, Roel Baets1,2; Photonics Research Group, INTEC, Gent Univ., Belgium; 1Center for Nano- and Biophotonics, Ghent Univ., Belgium; 1Inst. of Chemical Technologies and Analytics, Technische Universität Wien, Austria; 2Dept. of Molecular Biotechnology, Ghent Univ., Belgium. We report a Raman sensor for broadband vapor-phase volatile organic compounds (VOCs) based on SiN waveguides functionalized with a mesoporous silica top-cladding. A detection limit below 1000ppm is demonstrated and scaling to trace-gas-levels is discussed.

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Singular spectrum analysis for low SNR signal processing in dual-comb distance measurements, Hui Cao1, Youjian Song1, Runmin Li1, Yuepeng Li1, Ming-Lie Hu1, Chingyue Wang1; Tianjin Univ., China. We utilize singular spectrum analysis based post-processing approach to reduce distance measurement uncertainty for moving targets in dual-comb absolute ranging.

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BROADBAND VAPOR-PHASE VOLATILE ORGANIC COMPOUND (VOC) SENSOR USING A MESOPOROUS SILICA SORBENT LAYER AND WAVEGUIDE-ENHANCED RAMAN SPECTROSCOPY, Haolan Zhao1,2, Ali Raza1,2, Bettina Baumgartner1, Stephanie Clemmen1,2, Bernhard Lendl1, Andre Skirtach1, Roel Baets1,2; Photonics Research Group, INTEC, Gent Univ., Belgium; 1Center for Nano- and Biophotonics, Ghent Univ., Belgium; 1Inst. of Chemical Technologies and Analytics, Technische Universität Wien, Austria; 2Dept. of Molecular Biotechnology, Ghent Univ., Belgium. We report a Raman sensor for broadband vapor-phase volatile organic compounds (VOCs) based on SiN waveguides functionalized with a mesoporous silica top-cladding. A detection limit below 1000ppm is demonstrated and scaling to trace-gas-levels is discussed.

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New Resonance Behavior based on Bound States in the Continuum in a Silicon Photonic Waveguide Platform, Thach Nguyen1, Guanghui Ren1, Steffen Schoenhardt1, Markus Knoerzer1, Andreas Boes1, Arnar Mitchell1; School of Engineering, RMIT Univ., Australia. A new type of resonance in silicon photonics is demonstrated, achieved by coupling between a continuum of TE slab modes to a discrete TM mode of a silicon ridge to create a single sharp resonance.

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Coffee Break Sponsored by Coherent and Thorlabs

Technology Transfer Program, Exhibit Hall Theater I
### CLEO: Applications & Technology

**Meeting Room 211 A/B**

**CLEO: Science & Innovations**

**Meeting Room 211 C/D**

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**ATH11 • Radiative Cooling & Photovoltaics—Continued**

**STh1J • Nonlinear Photonics—Continued**

**ATH1K • Industrial Metrology & Remote Sensing—Continued**

**STh1L • Hollow Core Fibers—Continued**

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**ATH11.6 • 09:30**

Broadband Omni-resonant Enhancement in Near-Infrared Quantum-Efficiency of a Thin Film Amorphous Silicon Solar Cell, Massimo Villinger, Abbas Shirif, Sorosh Shabahang, Magued B. Naar, Chris Villinger, Ayman F. Aboursaddy, Univ. of Central Florida, USA. By embedding an amorphous-silicon thin-film solar cell in an omni-resonant micro-cavity, we demonstrate a broadband boost in the near-infrared optical absorption and concomitant enhancement in the quantum efficiency.

**ATH11.7 • 09:45**

Near Perfect Solar Energy Conversion for Vapor Generation, Youhai Liu, Haomin Song, Matthew H. Singer, Chenyu Li, Dengxin Ji, Lyu Zhou, Nan Zhang, Xie Zeng, Zongmin Bei, Zongfu Yu, Gaoqiang Gan, The State Univ. of New York at Buffalo, USA; Univ. of Wisconsin, USA. We demonstrate a strategy to realize ~100% efficiency for solar vapor generation by managing the energy flow, and to further enhance the evaporation by taking energy from the warmer environment.

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**STh1J.6 • 09:30**

Saturable absorption of non-linear graphene coated waveguides, Pierre Demongodin, Houssen El Dinani, Jeremy Lhullier, Malik Kemiche, Thomas Wood, Segolene Caillard, Pedro Rojo-Romeo, Corrado Sciancalepore, Christian Grillot, Christelle Monat, Institut des nanotechnologies de Lyon, France; Optics and Photonics Division, CEA-LETI, France. We investigate the saturable absorption of hybrid graphene/silicon-nitride waveguides at telecom wavelengths. By measuring the power dependent transmission of picosecond and sub-picosecond pulses, we clarify the temporal dynamics of photo-excited carriers in graphene.

**STh1J.7 • 09:45**

Cavity Enhanced Trion Emission from a Bilayer MoTe2 on Silicon, Jianxing Zhang, Dong Hou, Guangkun Guo, Jiyuan Chen, Danian Zhang, Ke Liu, Fu Yu Sun, Univ. of Electro. Sci. and Tech. of China, China; National Time Service Center, Chinese Academy of Science, China. We demonstrate a laser-based transfer of radio-frequency signal with phase compensation over 5 m underwater link. The root-mean-square timing fluctuation of the transferred RF signal is about 2.3 ps within 5000 s.

**STh1K.6 • 09:30**

Laser-based Frequency Transfer over Underwater Link with Phase Compensation, Dong Hou, Guangkun Guo, Jiyuan Chen, Danian Zhang, Ke Liu, Fu Yu Sun, Univ. of Electro. Sci. and Tech. of China, China; National Time Service Center, Chinese Academy of Science, China. We demonstrate a laser-based transfer of radio-frequency signal with phase compensation over 5 m underwater link. The root-mean-square timing fluctuation of the transferred RF signal is about 2.3 ps within 5000 s.

**STh1K.7 • 09:45**

Higher Order Bessel Beams Integrated in Time (HOBBIT) for Underwater Sensing and Metrology, Kaitlyn Morgan, Yuan Li, Wen- zhe Li, Keith Miller, Joseph Watkins, Eric Johnson, Clemson Univ., USA. This paper introduces a novel platform for coherently coupled OAM modes that can be dynamically controlled at rates in excess of 100’s kHz. Results are provided for a 512-QAM constellation composed of two OAM states.

**STh1L.5 • 09:30**

Nested-capillary anti-resonant silica fiber with mid-infrared transmission and very low bending sensitivity at 4000 nm, Manuhs Klimczak, Dominik Dobrakowski, Amar Nath Ghosh, Grzegorz Stepniekski, Dariusz Pyza, Thibaut Sylvestre, Ryszard Buczynski, Inst of Electronic Materials Technology, Poland; Faculty of Physics, Univ. of Warsaw, Poland; Institut Femto-ST, CNRS, France. Silica glass nested capillary anti-resonant fiber is reported. Transmission is measured with 150cm long sample over 1700-4200nm wavelengths, revealing a 3500-4200nm window. The fiber is bending insensitive down to 0.5cm radius over a full loop.

**STh1L.6 • 09:45**

Hollow-Core Conjoined-Tube Negative-Curvature Fiber with Loss approaching Rayleigh Scattering Limit of Silica, Shoulei Gao, Yingying Wang, Wei Ding, Yifeng Hong, Pu Wang, Beijing Univ. of Technolo- gy, China; Inst. of Physics, Chinese Academy of Science, China. We report on a hollow-core conjoined-tube negative-curvature fiber with measured transmission losses of 2.7dB/km at 1150nm and 3.8dB/km at 680nm. The loss from 653 to 706 nm approaches the Rayleigh scattering limit of silica fiber.
FTh1M • Ultrafast Processes in Gases & Solids—Continued

FTh1M.7 • 09:30
High Intensity 5th Harmonic Generation using CLBO, Siddharth Patankar1, Steven T. Yang1, Andrew J. Bayramian1, Mark W. Bowers1, Phillip S. Datte1, George F. Swadling1, Joel Stanley1, Tracy S. Budge1, James S. Ross1; Lawrence Livermore National Lab, USA. We report results from frequency conversion experiments using a 1053 nm Nd:Glass laser system and a CLBO quintupler to generate fifth harmonic (211 nm) output. A peak 211 nm intensity of 0.4 GW/cm² was measured with a fundamental drive intensity of 2.25 GW/cm²².

FTh1M.8 • 09:45
Efficient 2-W Average Power 206nm Deep-UV Generation from 100-kHz Picosecond Pulses, Benjamin Willenberg1, Fabian Brunner1, Christopher Phillips2, Ursula Keller1; ETH Zurich, Switzerland. We present a 100-kHz all-solid-state deep-ultraviolet source delivering 206nm few-picosecond pulses with 2-W average power based on non-collinear sum frequency generation, which features high conversion efficiency by pulse front tilt matching and beam flattening.

STh1N • Sensing & Switching—Continued

STh1N.6 • 09:30
Low-loss integrated photonic switch using sub-wavelength patterned phase change material, Shang Wang1, Heshan Yu1, Xiaohang Zhang1, Ichiro Takeuchi1, Mo Li1; Dept. of Electrical and Computer Engineering, Univ. of Washington, USA. We demonstrate a 1×2 switch using phase Ge-Sb-Te (GST) integrated micro-ring resonator. The device achieves a low insertion loss of less than 1 dB in both output ports and can be switched photo-thermally and electro-thermally.

STh1O • Metasurfaces & Nanophotonic Materials—Continued

STh1O.6 • 09:30
Invited
Beating the Heat via Radiative Cooling: Tales of the Saharan Silver Ant, Comet Moth Silk Fibers, and Butterfly Wings, Nanfang Yu1; Columbia Univ., USA. I will present the discovery of radiative cooling in living organisms and the development of bioinspired radiative-cooling technologies.

10:00–11:30
Exhibit Open (10:00–15:00), Coffee Break (10:00–11:30), Exhibit Halls 1–3
Coffee Break Sponsored by COHERENT and THORLABS

10:15–12:00
Technology Transfer Program, Exhibit Hall Theater I
JThA2.1 Controlling Electron Quantum Paths for Generation of Circularly Polarized High-Order Harmonics by H2; Subject to Tailored (ω, 2ω) Counter-Rotating Laser Fields, John T. Hesler1, Dmitry A. Telnov1, Shih-I Chu1; 1Dept. of Physics, National Tawan Univ., Taiwan; 2Dept. of Physics, St. Petersburgh State Univ., Russia; 3Dept. of Chemistry, Univ. of Kansas, USA. We demonstrate the ability to control the electron recollisions giving three returns per one cycle of the fundamental frequency ω using tailored bichromatic (ω, 2ω) counter-rotating circularly polarized laser fields with a molecular target.

JThA2.2 Low Energy Hollow Core Fiber Pulse Compression Using Molecular Gases, Elissa Haddad1, Reza Safaee1, Ojoon Kwon1, Adrien Leblanc1, Ricardo Piccolo1, Young-Gyu Jeong1, Heide Ibrahim2, Bruno E. Schmidt2, Roberto Monardotti2; 1Luca Razani1, François Légaré1, 2Philipp Lassonde1, 1INRS-EMT, Canada; 2ITMO Univ., Russia. We theoretically demonstrate Brunel-type gradients.

JThA2.3 Phase-matched perturbative wave-mixing in XUV region, Khuong B. Dinh1, Khoa Anh Tran1, Peter Hannaford1, Lap Dao1; 1Swinburne Univ. of Technology, Australia. We demonstrate generation of phase-matched four-wave mixing frequencies in XUV region by using a driving field and two control fields. Our findings are promising to produce an XUV quasi-continuum for attosecond pulses synthesis.

JThA2.4 Brunel harmonics generated from ionizing clusters by few-cycle laser pulses, Xiaohui Gao1, Bonggu Shim1; 1Shaoxing Univ., China; 2Binghamton Univ., USA. We measure plasma densities in laser filamentation in fused silica using single-shot time-resolved interferometry when the filament driven wavelength is varied between 1.2 and 2.3 μm. The experimental results are compared with numerical simulations.

JThA2.5 Brunel harmonics in nanostructures, Ihar Babushkin1, Liping Shi1, Ayhan Demircan1; 1Indian Institute of Technology, Hyderabad, India. We theoretically demonstrate Brunel-type harmonic generation from ionizing nano-clusters irradiated by intense few-cycle laser pulses. Mie oscillations strongly blue-shift and enhance the internal field. The resulting subcycle ionization dynamics efficiently produce broadband VUV radiation.

JThA2.6 Optimization of RF Emission from Ultra-Short Laser Pulses via Geometrical Algorithm and Deformable Mirror, Adrian Lucero1, Alexander Engelsbee1, Jennifer Elle1, Jinpu Lin1; 1John Nees1, Karl Krushelnick1; 1AFRL, USA; 2Center for Ultrafast Optical Science, Univ. of Michigan, USA. A genetic algorithm is used to drive a deformable mirror and optimize the RF emission from an ultra-short pulse plasma filament. The optimization process increases the plasma volume, linking plasma conductance to RF emission.

JThA2.7 Measurements of Plasma Densities in Laser Filamentation in Solids at Various Wavelengths Spanning From Near and Mid Infrared, Garima C. Nagar1, Dennis Dempsey2, Bonggu Shim3; 1Binghamton Univ., USA. We measure plasma densities in laser filamentation in fused silica using single-shot time-resolved interferometry when the filament driven wavelength is varied between 1.2 and 2.3 μm. The experimental results are compared with numerical simulations.

JThA2.8 Towards Precision Measurements of Radiation Reaction, Yarden Sheffer1, Morgan Lynch1, Yaron Haddad1, Ido Kaminer1; Technion - Israel Inst. of Technology, Israel. We find the long-time dynamics of charges in electromagnetic fields, revealing that charge acceleration is due to radiation rather than counter-intuitive acceleration. Using this phenomenon, we propose a method to observe radiation reaction with weak fields.

JThA2.9 Off-focus beam profile optimization for high-order harmonic generation, Jiaxin Li1, Tianyi Guo1, Jonathan White1, Matthew Weidman1, Yi Wu1, Zenghu Chang1; 1Univ. of Central Florida, USA; 2Max-Planck-Institut für Quantenoptik, Germany. Customized wavefront correction was realized by an adaptive optics system in a high-energy femtosecond system to obtain smooth beam profiles far away from focal points and boost the photon flux of high-order harmonic generation.

JThA2.10 Air-hole-type Valley Photonic Crystal Slab with Simple Triangular Lattice for Valley-contrasting Physics, Takanori Yoda1,2; 1Tokyo Institute of Technology, Japan; 2NTT Basic Research Labs, Japan. We theoretically propose a new scheme to realize a valley photonic crystal slab with simple triangular lattice. The eigenstates which are not originated from the Dirac cone can exhibit valley-contrasting physics by breaking inversion symmetry.

JThA2.11 Control the Wave-front and Polarization of Light Simultaneously with High-efficiency Meta-surfaces, Dongyi Wang1, Weifei Liu1, Shi Jun1, Qing He1, Lei Zhou1; 1Fudan Univ., China. We propose a generic strategy for designing metasurfaces to efficiently control the wave-front and polarization of light simultaneously, and realized several meta-devices to verify the concept at near-infrared frequencies, which exhibit distinct light-manipulation capabilities.

JThA2.12 Linking guided waves and surface waves via metasurface on terahertz-integrated platform, Ride Wang1, Qiang Wu1, Zixi Jia1, Yangzi Zhang1, Bin Zhang1, Wei Cai1; 1Key Lab of Weak-Light Nonlinear Photonics, Ministry of Education, TEDA Inst. of Applied Physics and School of Physics, Nankai Univ., China; 2Collaborative Innovation Center of Extreme Optics, Shanxi Univ., China; 3College of Science, Civil Aviation Univ. of China, China. We implement the conversion from terahertz guided waves to surface waves via metasurface on lithium niobate subwavelength waveguide, providing a platform for thin-layer effective detection, which provides a more pronounced sensitivity than the normal interaction.

JThA2.13 Withdrawn.

JThA2.14 Dual-wavelength Terahertz Metasurfaces Based on Geometric Phase Metasurfaces, Tailei Wang1, Hang Li1, Rensheng Xie1, Senson Av1, Shouzheng Zhu1, Guohua Zhai1, Wei Guo1, Huailiang Zhang1, Jun Ding1; 1School of Information and Science Technology, East China Normal Univ., China; 2ECE Dept., Univ. of Massachusetts Lowell, USA; 3Physics and Applied Physics Dept., Univ. of Massachusetts Lowell, USA. We proposed a novel dual-wavelength meta-atom, which could be used to independently modulate the geometric phase of the circularly polarized incident wave at two terahertz frequencies. A prototype dual-wavelength metasurfaces has been designed and verified at the terahertz regime.

JThA2.15 On-chip plasmon-induced transparency using a metastructure in THz regime, Wenjuan Zhao1, Yao Lu1, Qi Zhang1, Jiawei Qi1, Qiang Wu1, Jingyu Xu1; 1Key Lab of Weak-Light Nonlinear Photonics, Ministry of Education, TEDA Inst. of Applied Physics and School of Physics, Nankai Univ., China; 2Collaborative Innovation Center of Extreme Optics, Shanxi Univ., China. We experimentally and numerically demonstrated an investigation of plasmon-induced transparency using a meta-structure on a THz LiNbO3 chip. Aabi oscillation-like behavior at the transparency peak was obtained.

JThA2.16 Control of slow-light effect in metatmatric-loaded Si waveguide, Makoto Tanaka1, Tomo Amemiya1, Satoshi Yamasaki1, Hikbi Kagami1, Keisuke Masuda1, Nobu Nishiyama1, Shigeaki Arai1; 1Tokyo Inst. of Technology, Japan. We have demonstrated slow-light effect with the slow-down factor of >10 times in a metamaterial-loaded Si waveguide which can be easily integrated with other Si photonics devices, and proposed optical control method for that effect.

JThA2.17 Optimal Single Metagrating for Robust polarization Measurements, Nicolas Pedersen1, Kai Wang1, Yuan Wu1, John Nees1, Andrey A. Sukhorukov1; 1Nonlinear Physics Centre, Australian National Univ., Australia. We formulate a new conceptual approach for full Stokes polarization measurement with a single metagrating, and develop novel design through advanced computational optimization of individual nano-resonator properties delivering robust operation even under strong fabrication inaccuracies.

JThA2.18 Spokele Intensity Correlations Over Object Position, Qiaocon Lu1, Kevin J. Webb2; 1Purdue Univ., USA. A general theory for intensity correlations over object position allows an arbitrary object to be imaged through an amount of scatter limited by detector noise. Applications include in vivo imaging, material inspection, and environmental sensing.

JThA2.19 Spinning Radiation from Topological Insulators, Emroz Khan1, Evgenii Narimanov1; 1Purdue Univ., USA. We show that thermal radiation from a lossy topological insulator carries a nonzero average spin angular momentum.

JThA2.20 Effect of Fabry-Perot Cavities on Concentration Quenching, Samantha R. Koutsares1, Sujana Prayakara1, Devon Courtwright1, Carl Borer1, M. Noginov2; 1Norfolk State Univ., USA. We show that concentration quenching of emission of dye molecules—an energy transfer to quenching centers—is inhibited in subwavelength Fabry-Perot cavities (or metal-insulator-metal, MIM, waveguides).

JThA2.21 High Quality Resonances in Lithium Niobate Metasurfaces and Applications, Bofeng Gao1, Mengxin Ren1, Wei Wu1, Hui Hu1, Wei Cai1, Jingyu Xu1; 1School of Physics and TEDA Applied Physics Inst., Nankai Univ., China; 3School of Physics and Microelectronics, Shandong Univ., China. We experimentally demonstrate the lithium niobate meta-surfaces. High-quality structural resonances are observed in transmittance spectra. And such lithium niobate metasurfaces are proved to show vivid structural colors.

JThA2.22 Impact of Surface Recombination and Doping on Optical Gain in Semiconductor Nanostructures, Jinal K. Tapari1, Saurabh Kishen1, Kausik Naksy1, Nareesh E. Kannan1; 1Indian Institute of Technology, Hyderabad, India. We investigate the impact of surface recombination on optical gain, and show that the lasing threshold can be lowered by introducing strain and p-doping III-V material. This will make lasing in all-dielectric metasurfaces more practical.
JSTh2A.23 Non-Paraxial Polarizer Model Based on Optically Anisotropic Media Theory, Shih-Yi Zhang, Christian Hellmann1, Frank Wyrowski2, LightTrans International UG, Germany; 1Wyrowski Photonics UG, Germany; 2Applied Computational Optics Group, Friedrich Schiller Univ. Jena, Germany. We present an idealized polarizer model, based on the fields and modes in optically anisotropic media. The model is derived in the spatial-frequency domain, and the result is presented in a compact 2x2-matrix form.

JSTh2A.24 Semi-Analytic Modeling of Chiral Meta- surface Stacks, Jan Sperrhake1, Manuel Deckert1, Matthias Falkner1, Stefan Fasold1, Thomas Kaiser1, Isabelle Staude1, Thomas Pertsch1, Inst. of Applied Physics, Germany; 2Fraunhofer Institut für Applied Optics and Precision Engineering, Germany. We analyze the polarization response of a fabricated twisted nano-wire metasurface stack using a semi-analytic algorithm. This lifts the requirement for rigorous simulations when designing metasurface stacks with specific target functionalities.

JSTh2A.25 Towards High Efficiency Dynamically Tunable Metamaterials, Isaac O. Oguntoye1, Adam Ollam2, Yaping Ji1, George Z. Hatfield1, Matthew D. Escarra1, Graphene-based Metamaterials, Royal Holloway, University of London, UK. We propose a method for determination of nanoantenna transmitted phase for coupled, resonant nanoantennas in a heterogeneous array, necessary for design of metamaterials with ~90% optical efficiency. Progress toward fabricating of VO₃ nanoantennas is demonstrated.

JSTh2A.26 Graphene-based Metamaterial Tunable Phase Modulator for Mid-Infrared Beam Steering, Cheng Shi1, Isaac Luxmoore1, Geoffrey Nash1,2, College of Engineer, Mathematics and Physics, Univ. of Exeter, UK; 2EPSRC Centre for Doctoral Training in Engineering, University of Exeter, UK. We propose a design for graphene-based metamaterial tunable phase modulator, and investigate its feasibility in steering mid-infrared beams in the mid-infrared regime. Simulations show that up to 45% steering efficiency can be achieved.

JSTh2A.27 Light–to–heat conversion by optical absorption in a Si microring resonator, Toshiya Mura1, Yuya Saji1, Tetsuya Mizumoto1, Tiko Inst. of Technology, Japan. An efficient light–to–heat conversion by optical absorption in a silicon microring resonator was demonstrated. We measured a wavelength shift due to thermal-optic effect and >300 K rise in temperature with light of 6.8 mW.

JSTh2A.28 Design of Nonlinear Optical Ring Resona- tors, Ming Gong1, Hui Wu1, Univ. of Rochester, USA. We present a design methodology of nonlinear microring resonators based on iteration of matrix analysis. This new method is time/memory efficient and scalable, and can be applied to other nonlinear devices.

JSTh2A.29 Visualization of a cavity-cavity coupling at two-dimensional LO subwavelengths, Jiayang Li1, Qi Zhao1, Zheang1, Qianfei Wang1, Qiong Gu1, Jiaoqun Tang1, Jinyou Xu1, Jinqian Wang1, Shuangli Yang1, Jingjun Xu2, The Key Lab of Weak-Light Nonlinear Photonics, Ministry of Education, TEDA Inst. of Applied Physics and School of Physics, Nankai Univ, China. We have achieved a strong cavity-cavity coupling in a LN/SiO₂ subwavelength waveguide at THz frequency. The wave confinement and radiation in the waveguide-cavity structure were visualized by a phase contrast imaging system.

JSTh2A.30 Repair of pseudo time-reversal broken by topological phase transition in a photonic crystal slab, Yau Lo1, Hau Xiong1, Qiang Wu1,2, Deng Zhang1, Qi Zhang1, Ride Wang2, Wenjuan Zhao2, Jinqian Xu2, The Key Lab of Weak-Light Nonlinear Photonics, Ministry of Education, TEDA Inst. of Applied Physics and School of Physics, Nankai Univ, China. We demonstrate a repair of pseudo time-reversal broken by topological phase transition in a photonic crystal slab. By changing metamaterial struc- tures, the unidirectional topological edge states transit to bidirectional trion ones.

JSTh2A.31 Germanium photodiodes on pyramidal textur- ed surface by Metal-Assisted Chemical Etching, Minho Kim1, Sooeyong Yi1, Jeong Dong Kim1, Xin Yin1, Jun Li1, Jihye Bong1, Dong Liu1, Shih-Chia Liu1, Alexander Kvít1, Weidong Zhou2, Xudong Wang3, Zongfu Yu1, Zhenqiang Ma1, Xiuqiong Li1, Nan Yang1, Technological University, Singapore; 2ECE, Univ. of Illinois Urbana Champaign, USA; 3Univ. of Wisconsin Madison, USA; 4Univ. of Texas Arlington, USA. We demonstrate a Ge photodiode on pyramidal textured surface by Metal-Assisted Chemical Etching (MacEtch) technique. This photodiode shows both reduced dark current and enhanced responsiv- ity at near infrared (NIR) wavelength range.

JSTh2A.32 Narrowband transmission filter based on waveguide gratings, Tao-Hsiang Yen1,2, Yung-Cheng Lü1,3, Yung-Hsue Huang1,2, National Sun Yat-sen Univ., Taiwan. We demonstrate that employing waveguide gratings in a surface plasmon waveguide with Michelson interferometer is a much practical approach, as compared to Sagnac counter- part, to realize a narrowband transmission filter due to its shorter and relatively balanced connecting waveguides.

JSTh2A.33 Regular-orbit engineered momentum transformation in the mixed phase space of an asymmetric micrometric, Likun Chen1, Yan-Jun Qian1, Qihuang Gong1, Jan Wier- sig1, Yun-Feng Xiao1,2, Fekong Liu1, China; 1Shanghai Jiaotong Univ., China; 2Huawei Technologies Co. Ltd., China. We demonstrate a repair of pseudo time-reversal broken by topological phase transition in a photonic crystal slab. By changing metamaterial struc- tures, the unidirectional topological edge states transit to bidirectional trion ones.
JTh2A.44 O-Band Add-Drop Filter in Bragg-Grating-Assisted Mach-Zehnder Interferometers for CWDWM, Dominique J. Charron 1, Wei Shi 1, Laval Univ., Canada. We demonstrate a flat-top add-drop filter using silicon photonic Bragg gratings embedded in Mach-Zehnder interferometers. The device implemented using 193-nm lithography shows broad 3-dB bandwidth (>19 nm), low loss (2.3 dB) and high extinction ratio (> 32 dB).

JTh2A.45 ITQ-Mach-Zehnder Modulator on Si, Rubab Amen 1, Rishi Mati 1, Carlin Cartano 1, Zhichen Ma 1, Mohammed H. Tahersama 1, Yigal Llach 1, Dilan Ratnavayake 1, Hamed Dalir 1, Volker J. Songer 1, 1Dept. of Electrical and Computer Engineering, The George Washington Univ., USA; 2Nanofabrication and Imaging Center, George Washington Univ., USA; 3Omega Optics, Inc., USA. We demonstrate a monolithically integrated compact ITQ electro-optic modulator in silicon photonics based on a Mach-Zehnder interferometer featuring a high-performance halfwave voltage and active device length product of VJL = 0.59 V·mm.

JTh2A.46 Adiabatic transitions between supersymmetric structures as a tool to design integrated photonic devices, Gerard Queraltó 1, Alfonso Abdulrahman 1, 1Universitat Autònoma de Barcelona, Spain. We introduce adiabatic transitions between supersymmetric structures as a systematic way to engineer efficient and robust integrated photonic devices by modifying the refractive index profile along the propagation direction.

JTh2A.47 Scaling of Mode Degeneracy and Image Fidelity in a Self- Imaging Optical Resonator, Albert Ryu 1, Shane Colburn 1, Alan Zhan 1, Afra Maymand 1, 1Univ. of Illinois, USA. Nonlinear optical processing of images in a miniature self-imaging cavity holds enormous potential for optical processing and artificial neural networks. We move from the inherent trade-off between the cavity size, image amplification, and image fidelity.

JTh2A.48 Electro-optic polymer surface-normal modulator using silicon high-contrast grating resonator, Makoto Ogawara 1, Yuji Kosugi 1, Jooq Zhang 1, Yuki Okamoto 1, Boon S. Ooi 1, 1Dept. of Applied physics, Kyoto Univ., Japan; 2NTT Nanophotonics Center, Japan. A surface-normal electro-optic modulator using electro-optic polymer embedded inside a 570-nm-thick silicon high-contrast grating resonator is fabricated. With a voltage applied to silicon grating, we obtain >20% intensity modulation of the transmitted light at 30 MHz.

JTh2A.49 The role of surface passivation in integrated photonic-bandgap microcavities, Rifka Ghebrial 1, Mei Grajower 1, Joseph Shapoor 1, Noa Mazunks 1, Uriel Levy 1, 1Dept. of Applied physics, Hebrew Univ., Israel. We demonstrate the role of passivation in silicon photonics photodetectors based on defect states operating in the sub bandgap regime. Upon passivation removal, higher responsivity is obtained alongside with loss reduction, surprisingly improving over time.

JTh2A.50 Slow cooking of SNAP microresonators, Gabriella Gardosi 1, Yong Yang 1, Misha Sumetsky 1, Aston Univ., UK. We demonstrate a SNAP microresonator permanently introduced at the silica microcapillary by multi-hour heating with hot water from the inside. The discovered effect is presumably caused by water-induced irreversible processes within the micron-scale silica thickness.

JTh2A.51 Producing OAM Information Carriers Using Intersubstructured Spiral Phase Plates, Edgars Steigenburgs 1, Andrea Bertocnini 1, Abderrahman Trichili 1, Vito W. de Lemos 1, 1Georgia Inst. of Technology, USA; 2CNR Institute of Photonics and Nanotechnology, Italy. We report on small-footprint spiral phase plates for orbital angular momentum (OAM) light beam generation used in free space communication. A modal decomposition process confirms high purity of the generated beams at 1.550-μm wavelength.

JTh2A.52 Extreme Sub-wavelength Optical Confinement in Nanostructured All-dielectric Silicon Waveguides, Nazmuz Salib 1, 1Clemson Univ., USA. Novel approaches for the design of all-dielectric silicon waveguides featuring strong field enhancement and low mode confinement have been developed. Deeply subwavelength transverse characteristic, previously limited to nanophotonic waveguides, are predicted in an all-dielectric platform.

JTh2A.53 Ultrabroadband Integrated Photonic Filters for Waveguide-Based Sensing Systems, Nathan Tynidil 1, Todd H. Stievater 1, Dmitry Kozak 1, Marcel W. Pruessner 1, Scott Holmstrom 1, William Rabinovich 1, 1Naval Research Lab, USA; 2Univ. of Tula, USA. We describe the design and characterization of broadband, multi-stage waveguide lattice filters intended for integrated photonic sensing systems. The B-stage filter provides 20 dB extinction at the filter resonance adjacent to a 190-nm passband.

JTh2A.54 Configurable non-reciprocal acousto-optic modulator, Donggyu B. Sohn 1, 1Univ. of Illinois, USA. We experimentally demonstrate a reconfigurable non-reciprocal acousto-optic modulator. The directionality of mode conversion is controlled by the phase of a pair of standing acoustic waves.

JTh2A.55 Near-visible bright-soliton Kerr comb generation in dispersion-engineered lithium niobate coupled optical microresonators, Ali Eshaghi Dorche 1, Ali Eftekhar 1, Ali Adibi 1, 1Georgia Inst. of Technology, USA. We present an optimized, dispersion-engineered, air-clad, coupled lithium niobate optical-microresonator-based configuration for bright-soliton wideband (40 nm bandwidth at -70 dB bandwidth) Kerr-comb generation at the near-visible spectrum.

JTh2A.56 Bridge from Visible Light Communication to Telecommunication via Perovsky-Silicon Photonics, Ziwei Cheng 1, Danyan Li 1, 1NTT Nanophotonics Center, Japan; 2NTT Europe, Germany. We introduce adiabatic transitions between supersymmetric structures as a tool to design integrated photonic devices.

JTh2A.57 High-Mobility Transparent Conducting Oxides for Compact Epsilon-Near-Zero Silicon Photonic Phase Modulators, Michael G. Wood 1, 1Cornell University, USA. We numerically analyze the role of carrier mobility in transparent conducting oxides on epsilon-near-zero phase modulators. High-mobility materials such as cadmium oxide enable compact photonic phase modulators with a modulation figure of merit of >290 GHz.

JTh2A.58 High-signal-to-noise ratio for high-impedance load nanophotodetector towards attostep optical reception, Kengo Nozaki 1, 1NTT Nanophotonics Center, Japan. We demonstrate a signal-to-noise ratio for a photonics-crystal nano-phodetector loaded with 59-kΩ resistor revealing 30 dB higher than conventional photodetector thanks to thermal-noise suppression. Reception of ultralow optical energy of 74 aJ is theoretically expected.

JTh2A.59 RI Sensitivity of Tapered MCF Enhanced by Graphene Coating, HongXing Yu 1, 1Shanghai Jiao Tong Univ, China. We experimentally demonstrate the universal presence of the DC Kerr effect in silicon modulators and report performance trends and theoretical limits for the optical Kerr effect opto-mization with implications for both digital and analog applications.
We experimentally demonstrate all-optical clock recovery from optical NRZ-PM-QPSK and NRZ-PM-16QAM data at 10 Gb/s after 60 km fiber propagation, through injection-locking of an Erbium-doped fiber laser.

Influences of Polarization Transformation in Phase Conjugation of PM-QPSK in Non-linear SOAs, Anesh Sobhanan, Lakshmi Narayanan Venkatasubramani, Baiji Sriivasvan, Deepa Venkitesh; Indian Inst. of Technology, Madras, India. We demonstrate all-optical clock recovery from optical NRZ-PM-QPSK and NRZ-PM-16QAM data at 10 Gb/s after 60 km fiber propagation, through injection-locking of an Erbium-doped fiber laser.

Remote detection of uranium with filament ablative spectroscopy, Lauren A. Finney, Patrick J. Skrodzki, Milos Burger, John Nees, Igor Jovanovic; Univ. of Michigan, USA. We demonstrate that femtosecond filamentation can efficiently excite metallic uranium over distances on the order of 10 meters, and that characteristic uranium atomic and molecular signatures can be simultaneously detected in seconds.

Polarization-insensitive amplitude-modulation CW LIDAR, Chao Zhang, Narendra Shrestha, Thien-An Nguyen, Monireh Moayedi Pour Fard, Sriram Vishwanath; Univ. of Texas at Austin, USA; GenXComm Inc, USA. A demonstration of all-optical clock recovery from optical NRZ-PM-QPSK and NRZ-PM-16QAM data at 10 Gb/s after 60 km fiber propagation, through injection-locking of an Erbium-doped fiber laser.

Remote detection of uranium with filament ablative spectroscopy, Lauren A. Finney, Patrick J. Skrodzki, Milos Burger, John Nees, Igor Jovanovic; Univ. of Michigan, USA. We demonstrate that femtosecond filamentation can efficiently excite metallic uranium over distances on the order of 10 meters, and that characteristic uranium atomic and molecular signatures can be simultaneously detected in seconds.

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JThA2.87 Integrating Cavity Enhanced Raman Spectroscopy of Trace Gases and Bulk Compounds, Thomas Z. Moore¹, Vladislav Yakovlev², John Mason³, Edward Fry¹, Dawson Nodurft¹, Vincent Tedford¹, Kristin Favela¹, ²Southwest Research Inst., USA; ³Physics, Texas A&M Univ., USA; ²Biomedical Engineering, Texas A&M Univ., USA. The Raman spectra of trace gases and bulk compounds are measured using an integrating cavity enhanced Raman spectroscopy technique. The technique utilizes an integrating cavity formed from fumed silica providing significant Raman signal enhancement.

JThA2.88 Optoelectronic biosensing in graphene-driven fiber resonators with single-molecule sensitivity and selectivity, Baicheng Yao¹, Zhongxu Cao¹, Yu Wu¹, Teng Tan¹, Chenye Qin¹, Yuanfeng Chen¹, Yuan Gong², Zhenda Xie¹, Chengi Wei³, Jun Yang¹,². ¹Univ. of Electronic Science & Tech China, China; ²Nanjing Univ., China; ³Univ. of California, Los Angeles, USA. By implementing properties of Er fiber fibres with a graphene oxide in fiber-calibrated Fabry-Perot resonators, we demonstrate a biosensing platform. By measuring the functionalized FRET and intermode heterodyne interference, we achieve single-molecule sensitivity and selectivity for multiple target detection.

JThA2.89 Dual comb-linked cavity ring-down spectroscopy, Weipeng Zhang¹, Xinyi Chen¹, Haisong Wei¹, Yan Li¹, Tinghua Univ., China. A dual comb-linked scheme for cavity ring-down is presented, which maintained both an excellent cavity length and accurate measurement of the probing frequency. Several absorption lines of oxygen were measured.

JThA2.90 An FBG-based high-resolution Temperature Sensor through Measuring the Beat Frequency of Single-frequency Ring Fiber Laser, Liangchong Duan¹, Wei Shi¹, Haimei Zhang¹,², Xianchao Yang¹, Ying Lu¹, Jianquan Yao¹,². ¹Tianjin Univ., China; ²Tianjin Univ. of Technology, China. A high-resolution temperature sensor based on narrow-linewidth (<1 kHz) single-frequency ring fiber laser was investigated using optical heterodyne spectroscopy technology. Temperature resolution of ~5×10⁻⁸ °C was achieved in our experiment.

JThA2.91 Nuclear recoil spectroscopy in an optical trap, Alexander Malyschenkov¹,², Les Alamos National Lab, USA; ¹The Paul Scherrer Inst., Switzerland. We discuss the conditions that allow the observation of nuclear decay recoil for small particles levitated in an optical trap. We report on trapping uranium oxide particles at ambient conditions as a first experimental step.

JThA2.92 Characterization of small-scale contortions of graphene surface using an optically-coupled optical-fiber-sensor, Raja Ahmad¹,², Wing Ko¹,³, Sanket Patel¹,²,³, Paul S. Westbrook¹,². ¹OPS Labs, USA. We use spatially continuous measurements of the Bragg-wavelength of a grating in an offset-core fiber to measure continuous, sub-millimeter-scale variations in the surface of a corrugated metal surface.

JThA2.93 Wavelength Measurement of Single Photon LIDAR with Superconducting Nanowire Detectors, Gregory G. Taur¹,², Dmitri Morozov¹,³, Nathan R. Gemmell¹, Klaas H. Beaken¹,², Stephen T. Rochester¹,², Philippe G. S. F. Lee¹,²,³. ¹Univ. of Glasgow, UK; ²Univ. of Sussex, UK; ³Superconducting Nanowire Detectors, Inc., USA. Microring Resonator Biosensor Sensitivity and the Measurement of a Protein using Superconducting Nanowire Detectors.

JThA2.94 Optoelectronic stripes integrated in a silicon nitride Mach Zehnder Interferometer for high sensitivity refractometric sensors, Athanasios Maroulis¹, Evangelia Chatzanag-nostou¹,², George Dabos¹,³, Nikos Floros¹,³, Bar-tos Chimelis¹,², Anna Lena Giesekiec¹, Caroline Porschtsit¹,², Peter Cegelskis¹,², Robert Market¹,², Jean-Claude Weiber¹,², Alan Dure³,³, Dimitris Tsakonas¹,²,³, ¹National Center for Interdisciplinary Research and Innovation, Aristotle Univ. of Thessaloniki, Greece, Greece; ²AMO GmbH, Advanced Microelec-tronic Center Aachen (AMICL), Otto-Blumen-thal-Strasse, Aachen, Germany, Germany; ³Laboratoire Interdisciplinaire Carnot de Bourgogne (ICB), CNRS UMR 6303, Université de Bourgogne Franche-Comté, 21078, Dijon, France, France; ²ibAloom Ltd, 28, 28th October Avenue, Office 301, Engomi, 2414 Nicosia, Cyprus, Cyprus. We demonstrate an optoelectronic stripes integrated Mach-Zehnder interferometric refractometric sensor based on silicon nitride photonic waveguides and gold surface Plasmon Polariton waveguides. The proposed approach exhibits bulk sensitivity up to 1930 nm/RIU, holding promise for compact and ultra-sensitive interferometric sensing devices.

JThA2.95 Hydrostatic Pressure Response of Mo Coated Etched Fiber Fragg Grating Sensor in Side-Hole Packaging, Sunetha Sebastian¹,²,³, Instrumentation and Applied Physics, Indian Inst. of Science, India. We demonstrate side-hole packaged, nanolayer Molybdenum (Mo) coated etched Fiber Fragg Grating (eFFBG) as hydrostatic pressure sensor. Pressure sensitivity enhancement of nearly 2000 times is observed with such a simple, ruggedized and packaged sensor system.

JThA2.96 CO₂ Detection with Si Slot Waveguide Ring Resonators toward On-Chip Specific Gas Sensing, Yu¹,²,³, Toshihito Hamaya¹,²,³, Hiroasa Shimizu¹. ¹Tokyo Univ. of Agri. and Tech., Japan. We fabricated a Si slot waveguide ring resonator detecting CO₂ with RI difference of 1.5×10⁻⁶ and sensitivity of 3×10⁻⁹ nm/RIU. The device satisfies both detecting capability and compatibility with biolayer toward on-chip specific gas sensing.

JThA2.97 Microring Resonator Biosensor Sensitivity Enhancement through Ring-down Interferograms, Shih-Huang Hsu¹,²,³, Feng-Chang Chien¹,²,³, Chou-Yun Hsu¹,²,³. ¹National Taiwan Univ. of Science & Tech, Taiwan. The microring resonator biosensor sensitivity is enhanced by round-trip ring-down wave-forms interrogated with two-staged Mach-Zehnder interferograms through optical low-coherence interferometry. The sensitivity and resolution on influenza DNA demonstrate 49 µm/µm and 1.53 µm, respectively.

JThA2.98 Omni-Resonant Micro-Cavity Toggling Between Active and Passive Imaging, Sonuhi Shabanghi¹,²,³, Ali K. Jahromi¹,²,³, Kenneth L. Schepler¹,²,³, Ayman Abouraddy¹,²,³. ¹Univ. of Central Florida, USA; ²Harvard Medical School, Massachusetts General Hospital, USA. We have demonstrated an experimental scheme for toggling between two distinct functionalities in the same optical system: narrowband resonant filtering and broadband omniresonant transmission. Both functionalities are realized in-line in an imaging configuration.

JThA2.99 A 20-GHz Optoelectronic Oscillator Based on an Electroabsorption Modulated Laser, Siyu Zhao¹,²,³, Juqian Yan¹,²,³, Zheng Zheng¹,²,³, Beihang Univ., China. An optoelectronic oscillator based on an electroabsorption modulated laser is experimentally demonstrated. The phase noise is measured to be -110.26dBc/Hz at 10kHz offset from the carrier when the oscillation frequency is 20GHz.

JThA2.100 Single-Mode Fiber Based Pulsed-Optical Timing Link with Few-Femtosecond Precision in SwissFEL, Kemal Shafaki¹,²,³, Shaobo Fang¹,²,³, Guoqing Chang¹,²,³, Zhiyi Wei¹,²,³, Er:mm Fiber optical frequency combs, enabling the observation of nuclear decay recoil for small particles levitated in an optical trap. We report on trapping uranium oxide particles at ambient conditions as a first experimental step.

JThA2.102 Overcoming the Diffraction Limit of Optical Fiber Spectra for Monitoring Tapered Optical Fibers, Abderahem Azzoune¹,²,³, Philippe Delaye¹,², Sylve Lebrun¹,², Maha Bouhadida¹,², Gilles Pauliat¹, ²Laboratoire Charles Fabry, ²Institut d’Optique, CNRS, Univ. Paris-Saclay, France. We describe a technique that allows increasing the resolution of optical microscopes for nanofiber measurements. We demonstrated it by measuring the diam-eter of tapered fibers for radii ranging from 0.2 to 1.5 µm.

JThA2.103 Asymmetric fiber delay line interferometer based noise measurement platform for Er: fiber optical frequency combs, Haochen Tian¹,²,³, Wenka Yang¹,²,³, Deyuwen Kwon¹,²,³, Runmin Li¹,²,³, Youjian Song¹,²,³, Jingxin Wu¹,²,³, Li Tian¹,²,³, Haining Han¹,²,³, Hailong Shi¹,²,³, Huijia Yang¹,²,³, Jiexi Zhang¹,²,³, Shaojie Fang¹,²,³, Guangzhe Zhang¹,²,³, Zhiyi Wei¹,²,³, Beijing National Lab for Condensed Matter Physics, Inst. of Physics, Chinese Academy of Sciences, China; ²School of Physics and Optoelectronics Engineering, Xidian Univ., China; ³Univ. of Chinese Academy of Sciences, China. We report a precision feed-forward locking between a 1064 nm CW laser and an ultra-stable frequency comb. The relative linewidth of the 1064nm CW laser is 1.14 MHz and the stability reaches 1.5×10⁻⁷/s.

JThA2.104 Locking CW Laser to Ultra-stable Optical Frequency Comb by Feed-forward Method, Xiaodong Shao¹,²,3, Hanian Han¹,²,3, Yabei Su¹,²,3, Huibo Wang¹,²,3, Ziyu Zhang¹,²,3, Shaojie Fang¹,²,3, Guangzhe Zhang¹,²,3, Zhiyi Wei¹,²,3. We present the first results using a novel interferometric approach for a full-field and simultaneous measurement of the phase and the polarization state of a light field. The same procedure can be used for simultaneous analysis of the phase transmission and the polarization properties of a specimen.

JThA2.105 Polarization and phase shifting interferometry, Serjez Rothau¹,²,³, Klaus Mantel¹,²,³, Norbert Lindner¹,²,³, Friedrich-Alexander-Univ., Germany; ²Max Planck Inst. for the Science of Light, Germany. A novel interferometric approach for a full-field and simultaneous measurement of the phase and the polarization state of a light field is introduced. The same method can be used for simultaneous analysis of the phase transmission and the polarization properties of a specimen.

JThA2.106 Time-Resolved Dual Frequency Comb Phase Spectroscopy of Laser-Induced Plasmas, Reagan R. Weeks¹,²,³, Yu Zhang¹,²,³, Caroline Lecaplain¹,²,³, Jeffrey Yek², Siva-nandan S. Hariil¹,²,³, Mark C. Phillips¹,²,³, R. J. Jones¹,²,³, College of Optical Sciences, Univ. of Arizona, USA; ²Physics, Univ. of Arizona; USA; ³Opticalis, USA; ³Pacific Northwest National Lab, USA. We present the first results using time-resolved dual-frequency comb spectroscopy in a laser-induced plasma. It can allow for simultaneous plasma characterization as well as multi-species detection and plasma characterization.
JTh2A.107 Continuously-chirped guided mode resonance filter for low-cost near-infrared spectroscopic applications, Chuan-Ci Yin1, Chia-Wei Kao1, Chia-Wei Huang1, Yung-Ji Hung2, National Sun Yat-sen Univ., Taiwan. We demonstrate a continuously period-chirped TiO2-based guided mode resonance filter to discriminate telecom band wavelengths with a filter linewidth of 0.743 nm, thus enables on-chip spectroscopy for near-infrared light in a low-cost manner.

JTh2A.108 Three-Beam Interferometry for Dynamic and Low-Signal Measurements, Adam Ollanik1, George Z. Hartfield1, Matthew D. Escarra1, Tulane Univ., USA. We present an interferometer for the characterization of dynamic optical materials and meta-surfaces. A three-beam method provides robust measurements despite unavoidable drift. Measurements are demonstrated with a phase-change material, ultra-thin materials, and a dielectric metasurface.

JTh2A.109 Direct comb multi-heterodyne spectroscopy for rapid detection of trace gases, Jaehyun Lee1, Keunwoo Lee1, Jaevon Yang1, Young-Jin Kim2, Seung-Woo Kim3, KAIST, South Korea (the Republic of); 2School of Mechanical and Aerospace Engineering, NTU, Singapore. We perform high sensitive spectroscopic measurements by combining a single probe comb with multiple cw lasers so as to produce strong RF multi-heterodyne spectra for rapid detection of different trace gases.

JTh2A.110 A nonlinear interferometer using a designable Raman-resonant four-wave-mixing process, Jian Zheng1, Masayuki Katsuragawa1,2, 1Graduate School of Informatics and Engineering, Univ of Electro-Communications, 1-8-1, Chofu, Chofu, Tokyo 182-8585, Japan; 2JST, ERATO, MINOSHIMA Intelligent Optical Synthesizer Project, 4-1-8, Honcho, Kawaguchi, Saitama 332-0012, Japan, Japan. A new kind of nonlinear interferometer is proposed based on the arbitrary designable Raman-resonant four-wave-mixing process.

JTh2A.111 Cavity-Enhanced Direct Optical Frequency Comb Spectroscopy with Tooth-Width Limited Resolution, Dominik Chaczczyn1, Grzegorz Kowzan1, Akiko Nishiyama1, Przemyslaw Staniszewski1, Agata Cygan1, Daniel Lisak1, Ryzzad S. Traivinski1, Piotr Mlaszowski1, Inst. of Physics, Nicolaus Copernicus Univ. in Torun, Poland, We present a multimodal spectroscopic method employing optical frequency combs, optical cavities and Fourier-transform spectrometry. It allows fast and broadband measurements of both absorption and dispersion spectra as well as of dispersion and reflectivity of mirrors.

JTh2A.112 Optical frequency stability transfer using a single-branch Er:fiber frequency comb, Felix Rohde1, Thomas Puppe1, Rafał Wilk2, Burghard Lipphardt2, Uwe Steer2, Erik Bensch2, TOPPTICA Photonics AG, Germany; 2Physikalisch-Technische Bundesanstalt, Germany. We report on the frequency transfer from an ultrastable laser at 1542 nm to a clock laser at 935 nm using a single-branch commercial Er:fiber optical frequency comb.

JTh2A.113 Cost-efficient thermal tuning and stabilization system for fiber-based optical frequency combs, Aleksander Gluszek1, Arkadiusz Hudzikowski1, Jaroslaw Sobot1, Grzegorz J. Sobon1, Wroclaw Univ. of Science and Technology, Poland. We present the design of a compact, low-cost thermal stabilization system for mode-locked fiber lasers without using Peltier modules. Repetition rate tuning of 0.85 kHz per 1°C was achieved in a 100 MHz frequency comb.

JTh2A.114 High Brightness Broadband Infrared Light Source, from 0.3 to 20 Microns, Matthew J. Partlow1, Ron Collins1, Alex Culter1, Debbie Gustafson1, Steve Horne1, Dan McDaniel1, Energetiq Technology, Inc., USA. Development of broadband, high brightness Laser-Driven Light Sources (LDLS) covering the infrared spectrum (2 – 20 μm) is described. Radiation performance is compared to that of a broadband ceramic thermal emitter light source.

JTh2A.115 Orbital-Angular-Momentum Azimuthal Phase-Shift Keying via Digital Holography Through Turbulent Media, Raymond Lopez-Ros1, Usman A. Javid1, Qiang Lin1, Inst. of Optics, Univ. of Rochester, USA. We report a digital holographic technique for retrieving the OAM azimuthal phase difference of coherent beams co-propagating through turbulence. Experimental results suggest that OAM phase-shift keying schemes are feasible for large-bandwidth free-space optical communication.

JTh2A.116 The CLONETS – Clock Network Services Strategy and innovation for clock services over optical-fibre networks, Josef Vojtech1, CESNET, Czechia. Methods for long-distance time and frequency transfer over optical fibers have demonstrated excellent performances. CLONETS is a EU funded action intended to facilitate the vision of a sustainable, pan-European optical fiber network for precise time and frequency reference dissemination.

JTh2A.117 Boosting Second-Harmonic Generation in Nonlinear Metasurfaces with Bound States in the Continuum, Kirill Koshelev1,2, Andrey Bogdanov1, Yuri S. Kivshar1,2, Australian National Univ., Australia; 2Dept. of Nanophotonics and Metamaterials, ITMO Univ., Russia. We apply the concept of bound states in the continuum to nonlinear metasurfaces with a broken in-plane symmetry and realize high-Q resonances boosting dramatically the SHG efficiency via a smart asymmetry engineering.

JTh2A.118 Flat Lenses for Ultra-lightweight Long-wave-Infrared Broadband Imaging, Manjurl Meem1, Sourangsu Banerji1, Apratim Majumder1, Berardi Sensale Rodriguez1, Rajesh Menon1, Univ. of Utah, USA. We demonstrate the design and experiments for chromatic aberration rectified, high NA, polarization insensitive, diffractive flat lenses operating in the LWIR (8mm to 12mm) regime.
Repeated Multi-Qubit Readout and Feedback in a Mixed-Species Trapped-Ion Register, Karan Mehta1, Vlad Negnevitsky1, Matteo Marinelli1, Hsiang-Yu Lo1, Christa Flihanm1, Jonathan Home1, ETH Zürich, Switzerland. We measure the parity of two beryllium ion qubits by mapping the relevant operator onto an ancillary calcium qubit, utilizing multi-species entangling gates. Repeated measurement and feedback cycles allow preparation and stabilization of parity subspaces and Bell states.

Quantum Computing using MAGIC with Trapped Atomic Ions, Christof Wunderlich1, Ivan Boldin1, Hans Biegel1,2, Vedran Dunjko1, Elham Esteke2,3, Gouri Gin2, Timm Gloger2, Michael Johanning2, Delia Kaufmann1, Peter Kaufmann1, Alexander Kraft1, Bogdan Oshirenko2, Moritz Porat1, Thesaraphit Srarinrath2, Sabine Wölk3,1, Universität Siegen, Germany; University of Innsbruck, Austria; 3 Université Paris-Saclay, France; 4 Max Planck Inst. for Quantum Optics, Germany; 5 AustriAcademy of Sciences, Austria. A programmable quantum computer based on trapped ions interacting via magnetic gradient induced coupling (MAGIC) together with elements for scaling quantum computing – transport of ions and a novel trap for 2D ion arrays – are reported.

Variational Quantum Unsampling on a Programmable Nanophotonic Processor, Jacques Carolin1, Masoud Mosheni2, Jonathan Olson1, Miikka Paalblu1, Changshen Chen1, Darius Runyan2, Nicholas C. Harris4, Patrick Bouchard5, Julien Jacob1, Nathalie Bandini1, Karl Joulain2, Houssem Kallel1, Institut Langevin, ESPCI Paris, PSL Univ., CNRS, France; 2DOTA, ONERA, Université Paris-Saclay, France; 3 Centre de Nanosciences et de Nanotechnologies, CNRS, Université Paris-Sud, Université Paris-Saclay, France; 4 Lightmatter, USA; 5 Elenion Technologies, USA. We introduce the Variational Quantum Unsampling (VQU) protocol, a nonlinear quantum neural network approach for verification and inference of near-term quantum circuits outputs. We experimentally demonstrate this protocol on a quantum photonic processor.
Raman Maksimenka1, Yoann Pertot1, Olivier Nicolas Forget1, Nicolas Thiré1, High-Average-Power Mid-Infrared Sources

65 mrad RMS is reported. <0.7% rms and a single-shot CEP noise of 0.7 mrad. Over 8h, a pulse-to-pulse energy stability of 2.5 μm. With a novel pulse shaping scheme, generating pulses at 100 kHz centered at 2.5 μm.

We demonstrate a 100-kHz, 15-W, OPCPA (parametric chirped-pulse amplifier) system. The pulses were compressed to 14.4 fs. With a novel pulse shaping scheme, generating pulses at 100 kHz centered at 2.5 μm. With a novel pulse shaping scheme, generating pulses at 100 kHz centered at 2.5 μm.

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Monolithic Silicon Optoelectronics with Standard CMOS Processes, Alex Wright1,
1Univ. of Rochester, USA. Abstract not available.

We show a novel optical edge coupling between a fiber and a silicon nitride microresonator. We achieve the shortest wavelength to-date for mode-locked Kerr combs through dispersion engineering of a higher-order mode.

We present measurements and analysis of the fundamental noise in Kerr-microresonator frequency combs due to finite temperature. By exploiting the thermo-optic locking effect, we reduce the effect of these thermally-driven fluctuations on the comb coherence.

The high refractive index of heavy metal oxide glasses combined with their low processing temperatures enables new fiber concepts such as enhanced imaging core density, stable doughnut beam delivery, miniaturized imaging+sensing and intrinsic magnetic sensitivity.
Computational holographic camera with a dielectric metasurface difuser, Hyojunghun Kwon1, Elsah Arbab1, Seyyedeh M. Kamali2, M. Hommadsadegh Faraj-Dana1, Andrei Fan1; ‘California Inst. of Technology, USA. We experimentally demonstrate computational complex optical field imaging by a metasurface difuser and the speckle-correlation scattering matrix method. Thus we show that the metasurface difuser can outperform conventional scattering media in context of computational imaging.

Dielectric metasurfaces performing all-analog computing, Concetto Eugenio Andrea Cordaro1, Hoyeong Kwon2, Dimitrios Souras2, Elemio Koenderink1, Albert Polman1, Andrea Alù1, AMOLF, Netherlands; ‘Dept. of Electrical and Computer Engineering, The Univ. of Texas at Austin, USA; ‘Electrical and Computer Engineering, Wayne State Univ., USA; ‘CUNY Advanced Science Research Center, USA. We present experimental results on metasurfaces capable of performing analog image processing. Specifically, we show designs for 1st and 2nd order spatial differentiation enabling low power and real-time edge detection.

Asymmetric graphene-on-silicon nitride waveguide photodetector towards fast speed and high responsivity, Yun Gao1, Hong Xi2, Chester Shu3, ‘The Chinese Univ. of Hong Kong, Hong Kong. We demonstrate a 6-μm long asymmetric graphene-on-silicon nitride waveguide photodetector with a measured electro-optic bandwidth of 38 GHz and a responsivity of 13 mA/W at 1550 nm. Carrier dynamics in the photodetector are also analyzed.

Direct Growth of Large-area Graphene by Cross-linked Parylene Graphitization toward Photodetection, Yibo Dong1, Chuantong Cheng1, Chen Xu1, Xuru Mao2, Hyang Xie1, Guangzhong Pan1, Qihuai Wang3, Jie Sun1, ‘Beijing Univ. of Technology, China; ‘Inst. of Semiconductor, Chinese Academy of Sciences, China; ‘Fuzhou Univ., China. Large area uniform graphene was directly grown on insulating substrate by cross-linked Parylene graphitization. The as-grown graphene was used for the fabrication of graphene-Si Schottky junction photodetector with a responsivity of 275.9 mA/W.
We derive a state-dependent Germany.

We demonstrate a photonic quantum simulation of a quantum frequency processor, computing the effective interaction potential between composite particles in the Schwinger model and theoretically verifying the relation with a second transformation. The experimental field-resolved measurement allows observing the time domain response of a single plasmonic antenna in the mid-infrared. This field-resolved measurement allows observing the time domain response of a single plasmonic antenna in the mid-infrared. This field-resolved measurement allows observing the time domain response of a single plasmonic antenna in the mid-infrared. This field-resolved measurement allows observing the time domain response of a single plasmonic antenna in the mid-infrared. This field-resolved measurement allows observing the time domain response of a single plasmonic antenna in the mid-infrared. 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A high power (11 W), tunable (1.45 – 1.65 µm) OPCPA for THz generation in organic crystals, [1] Sakamoto, Y., Hisata, N., Ishikawa, Y., Kimura, K., and Takahashi, T., RIKEN, Japan. We generate infrared monocycle pulses in BBO crystals, pumped by 708-nm femtosecond pulses, producing high fields and with the potential for electron bunch compression to a few femtoseconds.


We report ultra-low ~400-attosecond-level jitter for both p-i-n and MUTC photodiodes. [3] Lee, J., Lee, M., and Moon, C., Kwansei Gakuin University, Japan.

We present experiments with high repetition rate and two satellite-to-ground laser time transfer results from testing a new dispersion-free communication network. [4] Bai, G., You, S., and Jin, Y., Science and Technology of China, China. Based on Micius satellite, we demonstrate two-satellite-to-ground laser time transfer experiments with high repetition rate and high precision. It shows the feasibility to combine time transfer network with quantum communication network.


We observe efficient optical rectification in between optical pulses and rising edges of photocurrent pulses, [6] Lee, J., Lee, M., and Moon, C., Kwansei Gakuin University, Japan. Using a high-pulse rate generated from an optical frequency comb, we combine time transfer network with quantum communication network.

We report ultra-low ~400-attosecond-level jitter for both p-i-n and MUTC photodiodes. [7] Lee, J., Lee, M., and Moon, C., Kwansei Gakuin University, Japan.

We present experiments with high repetition rate and two satellite-to-ground laser time transfer results from testing a new dispersion-free communication network. [8] Bai, G., You, S., and Jin, Y., Science and Technology of China, China. Based on Micius satellite, we demonstrate two-satellite-to-ground laser time transfer experiments with high repetition rate and high precision. It shows the feasibility to combine time transfer network with quantum communication network.

We generate narrowband terahertz emission at 15 THz from lithium niobate crystals when irradiated by femtosecond Ti:sapphire laser pulses. [9] Chung, H., Kim, J., Kang, D., Cho, J., and Kim, Y., College Park, USA.
ATH3I.3 • 14:45
Silicon Photonics External Cavity Laser with Misalignment Tolerant Multi-mode RSOA to PIC Interface, Ibrahim Ghanam1, Manuel Ackermann1, Sebastian Romero-Garcia1, Florian Merget1, Jeremy Witzens1; 1Inst. of Integrated Photonics, RWTH-Aachen Univ., Germany. We present an external cavity laser with a silicon photonics PIC coupled to an RSOA with a multimode grating coupler. Also acting as a 3-dB splitter inside a Sagnac loop, it relaxes alignment tolerances.

ATH3I.4 • 15:00
Vertically Coupled a-Si:H Multimode Interference Waveguides for Multi-layer Silicon Photonics Platform, Swat Z. Qao1, Antulio Tarazona1, Raifat Petra1,2, Ali Khokhar1, Graham T. Reed1, Anna C. Peacock1, Harold M. Chong1; 1Univ. of Southampton, UK; 2UniversitèTechnologBrunei, Brunei Darussalam. We successfully demonstrated low temperature fabrication process of vertical MMI a-Si-H waveguides for multi-layer photonic integrated circuit. Measured MMI loss of 1.97dB/MMIand vertical light coupling of TE polarization at 1550nm wavelength have been achieved.

ATH3I.5 • 15:15
Silicon Photonics, Graham T. Reed1; 1Univ. of Southampton, UK. In this paper we will discuss the use of ion implantation of Germanium into Silicon to introduce new functionality to Silicon Photonic circuits, from wafer scale testing, to device trimming and programmable photonic circuits.

ATH3I.6 • 15:30
Broadband randomly phase matched OPO using a thin 0.5-mm ZnSe ceramic and a dispersion-free cavity, Qinwu Rui1, Takki Kawamori1, Sergey Vasilev1, Sergey Minov1, Konstantin L. Vodopyanov1; 1CREOL, College of Optics and Photonics, Univ. of Central Florida, USA; 2IPG Photonics - Mid-infrared Lasers, USA; 3Dept. of Physics, Univ. of Alabama at Birmingham, USA. We used a 0.5-mm randomly-phase-matched ZnSe polycrystal pumped by femtosecond 235-nm pulses and achieved a 3.2-4-um-wide spectrum with 53-mW output power in a dispersion-free OPO cavity consisting of gold-coated mirrors and a pump injector.

ATH3K.4 • 15:00
Competing Faraday and modulation instabilities in dispersion-managed high-Q microcavities, Wenting Wang1, Jinghui Yang1, Abhinav Vinod1, Hao Liu1, Mingbin Yu2, Dim Lee Kwong1, Chee Wei Wong1; 1Univ. of California Los Angeles, USA; 2Inst. of Microelectronics, Singapore. We observed the competition between Faraday parametric instability and modulation instability in a dispersion-managed microcavity by changing the effective pump-resonance detuning. The Faraday ripple is triggered by the periodical oscillating group-velocity dispersion along the microcavity.

ATH3K.5 • 15:15
Photonic Acoustic Pulse Width Measurement using Speckle Contrast Analysis, Matan Benyamin1,2, Hadar Genish1, Ran Cafifa1,3, Nir Ozana1,2, Ariel Schwarz1, Zeev Zalevsky1,2; 1Faculty of Engineering and the Nanotechnology center, Bar Ilan Univ., Israel; 2ContinUse Biometrics, Israel. A previously demonstrated non-expensive setup for remote photonic acoustic signal detection, is extended to overcome its bandwidth limitations and obtain time-domain signal properties.

ATH3K.6 • 15:30
Methane excitation behavior as a comparison of InP, GaSb, IC and QC lasers excitation source by sensor applications, Tobias Milde1,2, Morten Hoppe1, Herve Tatanguem1, Christian Assmann1, Martin Honsberg1, Wolfgang Schade1, Joachim R. Sacher1; 1Sacher Lasertechnik GmbH, Germany; 2Technische Universitat Clausthal, Germany; 3Sensor Photonics GmbH, Germany. The MIR wavelength regime promises better gas detection possibilities than the NIR or the visible region because of the higher absorbencies simulated by HITRAN. These possibilities are tested with different lasers on TDLAS and QEPSAS.
FTh3A • Gateways to Quantum Information Processing—Continued

FTh3B • Tailorable Phenomena in Optical Fibers—Continued

FTh3C • Emission & Detection of Thermal Radiation—Continued

FTh3D • Quantum Photonics: Generation & Manipulation—Continued

FTh3B.5 • 15:45
Dynamics of photon fluid flows driven by optical pistons, Abdelkrim Bendahmane1, Gang Xu1, Matteo Conforti1, Alexandre Kudlinski1, Arnaud Mussot1, Stefano Trillo1; 1CNRS / Lille Univ., France; 2Univ. of Ferrara, Italy. We investigate the optical analogous of the piston shock problem in gas dynamics. Using fast temporal measurements, we recorded dispersive shock waves formed by the propagation of a bi-chromatic photon fluid along an optical fiber.

FTh3C.7 • 15:45
Tunable Hyperbolic Plasmons in Self-Assembled Carbon Nanotube Metamaterials, John A. Roberts1, Shang-Jie Yu2, Abram Falk3, Po-Hsun Ho3, Stefan Schoeche4, Jonathan A. Fan2; 1Dept. of Applied Physics, Stanford Univ., USA; 2Dept. of Electrical Engineering, Stanford Univ., USA; 3IBM T.J. Watson Research Center, USA; 4J.A. Woollam Co., Inc., USA. We show that self-assembled aligned carbon nanotubes are a tunable hyperbolic metamaterial using spectroscopic ellipsometry. We map the hyperbolic dispersion of plasmonic modes in aligned carbon nanotube films using transmission measurements of nanoribbon resonators.

FTh3D.5 • 15:45
High visibility Hong-Ou-Mandel interference between independent single photon sources obtained from multi-stage nonlinear interferometers, Jiamin Li1, Jie Su1, Liang Cui1, Xiaoying Li1, Z. Y. Ou1,2; 1Tianjin Univ., China; 2Indiana Univ.–Purdue Univ. Indianapolis, USA. Using spontaneous four-wave mixing in a 3-stage nonlinear interferometer for temporal mode shaping, we efficiently generate heralded single photons in single-mode, evidenced by a visibility of 90% in Hong–Ou–Mandel interference between independent sources.
Executive Ballroom 210E  Executive Ballroom 210F  Executive Ballroom 210G  Executive Ballroom 210H

CLEO: Science & Innovations

STh3E • Ultrafast Parametric Sources I—Continued

STh3F • Nonlinear THz Phenomena—Continued

STh3G • Precision Timing & Optical Time Transfer—Continued

STh3H • Modulation & Switching—Continued

STh3E.7 • 15:45
New horizons for high power broadband THz sources driven by ultrafast Yb-based thin disk laser oscillators, Jakub Drs¹, Norbert Modsching², Christian Kränkel², Valentin J. Wittwer¹, Olga Ražanskovskaya¹, Thomas Südmeyer¹; ¹Université de Neuchâtel, Switzerland; ²Center for Laser Materials, Leibniz-Institut für Kristallzüchtung, Germany. We confirm the high suitability of ultrafast thin-disk lasers for THz generation, achieving up to 0.33-mW broadband THz radiation in GaP. Moreover, we show 7-THz gapless spectrum by optimization of crystal length and pulse duration.

STh3F.5 • 15:45
Rapid and Precise Displacement Measurement Using Time-of-Flight Detection of Femtosecond Optical Pulses, Yongjin Na¹, Minji Hyun¹, Chan-Gi Jeon¹, Jungwon Kim¹; ¹South Korea Advanced Inst of Science & Tech, South Korea (the Republic of). We demonstrate high-speed and high-resolution displacement measurement method by utilizing electro-optic sampling between electrical pulses from photodetection and femtosecond optical pulses. A 5.8-nm (1.9-nm) resolution is achieved in only 50 μs (14 ms) update time.

STh3F.7 • 15:45
New horizons for high power broadband THz sources driven by ultrafast Yb-based thin disk laser oscillators, Jakub Drs¹, Norbert Modsching², Christian Kränkel², Valentin J. Wittwer¹, Olga Ražanskovskaya¹, Thomas Südmeyer¹; ¹Université de Neuchâtel, Switzerland; ²Center for Laser Materials, Leibniz-Institut für Kristallzüchtung, Germany. We confirm the high suitability of ultrafast thin-disk lasers for THz generation, achieving up to 0.33-mW broadband THz radiation in GaP. Moreover, we show 7-THz gapless spectrum by optimization of crystal length and pulse duration.

STh3G.7 • 15:45
Rapid and Precise Displacement Measurement Using Time-of-Flight Detection of Femtosecond Optical Pulses, Yongjin Na¹, Minji Hyun¹, Chan-Gi Jeon¹, Jungwon Kim¹; ¹South Korea Advanced Inst of Science & Tech, South Korea (the Republic of). We demonstrate high-speed and high-resolution displacement measurement method by utilizing electro-optic sampling between electrical pulses from photodetection and femtosecond optical pulses. A 5.8-nm (1.9-nm) resolution is achieved in only 50 μs (14 ms) update time.

STh3H.7 • 15:45
A Wideband On-Chip Radiator Driven by a Traveling-Wave Photodetector, Craig Ives¹, Behrooz Abiri², Ali Hajimiri¹; ¹California Inst. of Technology, USA; ²Auspion Inc., USA. An integrated broadband Vivaldi antenna driven by an on-chip traveling-wave photodetector is reported. The silicon photonic chip radiates between 21 and 67 GHz with -65 dBm coupled power at 44 GHz.

16:00–16:30  Coffee Break, Concourse Level
ATh3I.6 • 15:45
Electro-Optics with Gigahertz Phonons in Silicon Photonics, Raphaël Van Laer1, Rishi Patel1, Jeremy D. Witmer1, Timothy McKenna1, Amir Safavi-Naeini1; Stanford Univ., USA. We demonstrate effective piezoelectricity in silicon nanophotonic structures by breaking silicon’s inversion symmetry with an electrical bias field. The devices show promise as low-energy microwave-to-optical interfaces for use in classical and quantum communications.

STh3J.7 • 15:45
Logic Gates based on Interaction of Counterpropagating Light in Microresonators, Niall Moroney1, Leonardo Del Bino1, Michael T.M. Woodley1, Jonathan M. Silver1, George Ghalanos1, Andreas Svela1, Shuangyou Zhang1, Pascal Del’Haye1; National Physical Lab, UK; Physics, Imperial College London, UK; City, Univ. of London, UK. We demonstrate a novel optical logic gate that is mediated by the Kerr effect of counter-propagating beams in a whispering gallery mode microresonator. The universal gate A &¬ B is presented.

ATh3K.7 • 15:45
High Speed Measurements and Enhancement of QEPAS Sensitivity: Quartz Resonance Frequency Tracking, Hervé Tatenchou Fankem1, Andreas Sacher1, Morten Hoppe1, Tobias Milde1, Joachim R. Sacher1; Sacher Lasertechnik GmbH, Germany. This study reports on the development of a platform based-on a Field-Programmable Gate Arrays (FPGAs) and suitable for high speed measurements and enhancement of QEPAS sensitivity.

16:00–16:30  Coffee Break, Concourse Level
**CLEO: QELS-Fundamental Science**

**FTh3M.8 • 15:45**

Near-IR Wide Field-of-View Huygens Metalens for Outdoor Imaging Applications, Jacob Engelberg1, Chen Zhou2, Noa Mazurski1, Jonathan Bar-David1, Uriel Levy1, Anders Kristensen1; 1Applied Physics, Hebrew Univ. Jerusalem, Israel; 2Micro- and Nanotechnology, Technical Univ. of Denmark, Denmark. We present a Huygens nano-antenna based metalens, designed for outdoor photographic applications in the near-infrared. We show that good imaging quality can be obtained over a moderate ±15 degree field-of-view (FOV).

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**CLEO: Science & Innovations**

**STh3N.7 • 15:45**

Low Loss, Compact Waveguides in GaAs/Oxidized Al/GaAs Layers Directly Grown on Silicon, Prashanth Bhasker1, Chen Shang1, John Bowers1, Nadir Dagi1; 1Univ. of California, Santa Barbara, USA. Waveguides in high index contrast GaAs/Oxidized AlGaAs layers directly grown on silicon are presented. These are very similar to waveguides in Si photonics and can be the basis of very high performance photonic integration platform.

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16:00–16:30  Coffee Break, **Concourse Level**
FTh4A.1 • 16:30
Quantum Multiplexing, William Munro1,2, Nicola Lo Piccolo1, Kae Nemoto1; 1NTT Basic Research Labs, Japan; 2National Inst. for Informatics, Japan. We introduce the concept of quantum-multiplexing for quantum communication systems and repeater networks, which allows us to minimize the number of photons needed in entanglement distribution while enhancing the quality of the entangled pairs generated.

FTh4B.2 • 16:45
Coherent Propulsion with Negative-mass Fields in a Photonic Setting, Yumiao Pei1, Yi Hu1, Ping Zhang2, Chunmei Zhang3, Cibo Lou4, Christian E. Rüter5, Detlef Kip5, Demetrios N. Christodoulides6, Zhigang Chen7, Jingjun Xu7, 1Nankai Univ., China; 2Nanjing Univ., China; 3Helmholtz Schmidt Univ., Germany; 4Univ. of Central Florida, USA; 5San Francisco State Univ., USA. We demonstrate an optical self-accelerating state driven by nonlinear coherent interaction of its constituting components with opposite “mass-sign.” The coherent propulsion, highly immune to initial phase conditions, is surprisingly enhanced compared to its incoherent counterpart.

FTh4B.3 • 17:00
Engineering the Wavelength and Topological Charge of Non-Diffracting Beams Along Their Axis of Propagation, Ahmed Dorrah1, Michel Zamboni-Rached2, Mo Mojahedi3, 1Dept. of Electrical and Computer Engineering, Univ. of Toronto, Canada; 2School of Electrical and Computer Engineering, Univ. of Campinas, Brazil. We present non-diffracting structured light beams in which their wavelength and local orbital angular momentum can be changed independently and “at will” along the axis of propagation, thus opening new possibilities in laser processing, micro-manipulation, and data communications.

FTh4C.2 • 17:00
Nonspectroscopic Imaging of Vibrational Excitations as a Molecular Ruler, Thomas P. Gray1, Eric A. Muller1, Omar Khatib2, Hans Bechtel2, Markus B. Raschke1; 1Physics, Univ. of Colorado Boulder, USA; 2Advanced Light Source Division, Lawrence Berkeley National Lab, USA. We demonstrate infrared vibrational nano-spectroscopy and imaging using the evolution of vibrational marker resonances as a molecular ruler to map nanoscale crystallinity in molecular electronic materials.

FTh4D.3 • 17:00
Lithium Niobate as a Platform for Continuous Variable Quantum Optics, Mirko Lobino1, Francesco Lensini1, Jiri Janousek2, Oliver Thearle3, Matteo Villa1, Ben Haylock1, Sachin Kasture1, Liang Cui3, Hoang-Phuong Phan1, 1Aero 1Aero, Australia; 2Australian National Univ., Australia; 3Australian National Univ., Australia. We will report on the progress towards a fully integrated platform for continuous variable quantum optics in lithium niobate. Our device incorporates generation, manipulation, and detection of nonclassical state of light on a single chip.
We propose a cylindrical vector beam optical parametric oscillator, which is capable of delivering on demand vector beam tunable across 1405~1601 nm directly, with a maximum power of 614 mW at 1505 nm.

We report Yb:YAG thin-disk laser oscillator.

All-optical synapses based on silicon microcoring resonators actuated by the phase-change material Ge$_2$Sb$_2$Te$_5$. Synaptic plasticity is investigated with different resonator coupling conditions.
We review our recent work in optical frequency comb sources as the basis of novel functions including a Hilbert Transformer, first, second and third order RF transform, and characterize the phase noise of the repetition rate in the electrical-optical modulation comb is improved, allowing for more advanced applications.

A Breakthrough Industrial THz Application: Robust In-situ THz-based Paint Layer Monitoring, Deran Maas1, Andreas Frank1, Jacobus L. van Mechelen2, Corporate Research, ABB Switzerland, Switzerland. We present a THz paint analyzer for measuring wet and dry paint multilayers insensitive to surface curvatures and vibrations. The layers can be measured simultaneously with an average error smaller than 1.1 μm.

Two-phase flow monitoring with an electrical-optical probe was developed and characterized to monitor monophasic and biphasic flow in industrial environments. The probe measures the parameters of electrical conductance and mechanical strain, thereby introducing data redundancy and facilitating auto calibration.

Self-Cleaning on a Higher Order Mode in Ytterbium-Doped Multimode Fiber with Parabolic Profile, Alouine Niang1, Vincent Couderc2, Alessandro Tonello1, Katarzyna Krupa1, Mesay Addis1, Raphael Jauber- teau1, Marc Fabert1, Daniele Modotto1, Stefan Wabnitz2, Univ. of Brescia, Italy; 3Univ. of Limoges, France; 4Sapienza Università di Roma, Italy. We experimentally demonstrate polarization-dependent Kerr spatial beam self-cleaning into the LP11 mode of an Ytterbium-doped multimode optical fiber with parabolic gain and refractive index profiles.

ATh4L.2 • 16:45 Multimode Fiber Beam Self-Cleaning in the Anomalous Dispersion Regime, Yann Levantou1, Alexandre Parriaux1, Geoffroy Granger1, M. Jossert1, L. Lavaute1, D. Ga- ponov1, Marc Fabert1, Alessandro Tonello1, Katarzyna Krupa1, Agnes Desforges-Berthelemot1, Vincent Kermene1, Oleg Sidelnikov1, Guy Millot2, Sebastien Fevrier2, Stefan Wabnitz2, Vincent Couderc2, Univ. of Limoges, France; 3Univ. of Bourgogne Franche-Comte, France; 4Novae Lasers, France; 5Novosibirsk State Univ., Russia; 6Sapienza Università di Roma, Italy. We experimentally demonstrate Kerr beam self-cleaning of picosecond pulses in the anomalous dispersion regime of graded-index multimode optical fibers, with threshold power reduced by two orders of magnitude with respect to the normal dispersion regime.

Full-3D measurements of mode-locked states outline a theoretical framework to understand the multitude of new mode-locked states obtained in the telecom band is 1x10^-12 at 1s level, comparable to a bench-top commercial optical frequency synthesizer system.

We demonstrate rapid imaging using dual-microcomb interferometry. One of the soliton microcombs is spatially dispersed into two dimensions to record spatial information and the image is read out by multi-heterodyne with the second microcomb.

Continuous Optical Measurement of Dynamic Colloidal Droplets, Jose Guzman-Sepulveda1, Ruiato Wu2, Aristeid Dogariu1, Univ. of Central Florida, USA. We demonstrate the use of spatiotemporal coherence-gated light scattering for monitoring the dynamics of colloidal droplets during drying. The measurement is non-contact, non-invasive, and label-free, and permits monitoring the internal structure in optically-isolated, picoliter-sized volumes.

Spatiotemporal Mode-Locking as Multi-dimensional Optimization, Logan Wright1, Pavel Siderenko2, Zachary Ziegler1, Andrei Isichenko1, Boris Malomed2, Curtis R. Meryuk1, Demetrios N. Christodoulides1, Frank W. Wise1, Cornell Univ., USA; 2Dept. of Physical Electronics, School of Electrical Engineering, Faculty of Engineering, and the Center for Light-Matter Interaction, Tel-Aviv Univ., Israel; 3Dept. of Computer Science and Electrical Engineering, Univ. of Maryland Baltimore County, USA; 4CREOL/College of Optics and Photonics, Univ. of Central Florida, USA. We outline a theoretical framework to understand the multitude of new mode-locked states possible in multi-transverse mode resonators. Full-3D measurements of mode-locked states comprising roughly 30 modes agree with theoretical expectations.

Silicon photonics optical frequency synthesizer - SPOFS, Neetesh Singh1, Ming Xin1, Nanxi Li1, Diedrik Vermeulen1, Alfonso Ruocco1, ‘Emir Salih Magden’1, Katia Shytrova1, Patrick Callahan1, Erich Ippen1, Franz Karten1, Michael R. Watts1, MIT, USA; 2CEFL, DESY, Germany. We demonstrate a silicon photonics optical frequency synthesizer (SPOFS). The frequency instability obtained in the telecom band is 1x10^-12 at 1s level, comparable to a bench-top commercial optical frequency synthesizer system.
FTh4A • New Protocols in Quantum Communications—Continued

Genuine Counterfactual Communication with a Nanophotonic Processor, Irati Alonso Calafell1, Teodor Strömberg1, David R. Arvidsson-Shukur2, Lee A. Rozema1, Valeria Saggio1, Chiara Greganti1, Nicholas C. Harris1, Mihika Prabhu1, Jacques Carolan1, Michael Hochberg2, Tom Baehr-Jones2, Dirk R. England2, Crispin H. Barnes2, Philip Walther2; 1Univ. of Vienna, Austria, Austria; 2Univ. of Cambridge, UK; 3MIT, USA; 4Elenion Technologies, USA. In counterfactual communication particles and information can travel in opposite directions. With our high-fidelity programmable nanophotonic processor we implement the first trace-free counterfactual protocol without post-selection with a counterfactual violation as low as 2.4%.

FTh4A.4 • 17:30
1 GBaud Heterodyne Continuous Variable Quantum Key Distribution over 26 km Fiber, Max Rückmann1, Christian G. Schäffer1; 1Radio-Frequency Engineering & Photonics, Helmut-Schmidt-Univ., Germany. We experimentally demonstrate a 1 GBaud heterodyne continuous variable quantum key distribution system based on standard telecom components capable to achieve a key rate of 1.71 Mbit/s over 26 km of fiber.

FTh4B • Non-Diffractive & Vortex Beams—Continued

Abruptly Focusing X-waves: Nondiffracting Waves with Localized Disruptions, Liang Jie Wong1, Ido Kaminer2; 1SIMTech, Singapore; 2Technion, Israel. We present a family of electromagnetic wave packets with nondiffracting behavior for most of their propagation, but are capable of extremely strong focusing behavior at specified locations, enhancing their peak intensity by over 200 times.

FTh4B.4 • 17:15
Non-Gaussian Continuous-Variable Graph States, Mattia Walschaers1, Valentina Parigi1, Nicolas Treps1; 1Laboratoire Kastler Brossel, France. Mode-tunable photon subtraction is a viable method to introduce non-Gaussian features in continuous-variable graph states. Non-Gaussian properties are shown to spread up to next-to-nearest neighbours of the graph’s vertex in which the photon was subtracted.

FTh4C • Advanced Nanophotonic Platforms for Spectroscopy & Sensing—Continued

Near-Field Tomography and Spectroscopy of Surface States on a Three-Dimensional Topological Insulator, Fabian Sandner1, Fabian Mooshammer1, Markus A. Huber1, Martin Zilisberger1, Helena Weigand1, Markus Plankl1, Christian Weyrich1, Martin Lanius1, Jörg Kampmeier2, Martin Mussler2, Detlev Grützmacher1, Jessica L. Boland2, Tyler L. Cocker3, Rupert Huber1; 1Dept. of Physics, Univ. of Regensburg, Germany; 2Peter Grünberg Institut 9, Forschungszentrum Jülich, Germany; 3Dept. of Physics and Astronomy, Michigan State Univ., USA. Beside massless Dirac fermions, topological insulator surfaces can host a massive two-dimensional electron gas. Using near-field spectroscopy, we identify both of these surface states by retrieving the nanoscale dielectric function without any model assumptions.

FTh4C.4 • 17:30
Graphene Modified Plasmonic Guided Mode For CO\textsubscript{2} Detection, Thomas M. Malkani1, Arnav Malkani1, Zi Wang1, Bingjun Xu1, Tingyi Gu1; 1Univ. of Delaware, USA. We observed broadening of the plasmonic guided modes in gold nanorod arrays by a single layer graphene, which can manifest CO\textsubscript{2} detection. The plasmonic modes enhance absorption by over 35% from 729 to 621 cm\textsuperscript{-1}.

FTh4D • Beyond Photon Pairs—Continued

Graphene Modified Plasmonic Guided Mode For CO\textsubscript{2} Detection, Thomas M. Kananen1, Anishkumar Soman1, Arnav Malkani1, Zi Wang1, Bingjun Xu1, Tingyi Gu1; 1Univ. of Delaware, USA. We observed broadening of the plasmonic guided modes in gold nanorod arrays by a single layer graphene, which can manifest CO\textsubscript{2} detection. The plasmonic modes enhance absorption by over 35% from 729 to 621 cm\textsuperscript{-1}.
Concurrent sessions are grouped across four pages. Please review all four pages for complete session information.
TH4I.3 • 17:15 **Invited**
Coherent Silicon Photonic Devices for Communication and Sensing, Chris Doerr¹;
¹Acacia Communications Inc, USA.
Abstract not available.

TH4L.4 • 17:15
Diode Laser-based Film Thickness Measurement of DEF in a generic exhaust gas test bench for the investigation of SCR-relevant processes, Anna Schmidt¹, Benjamin Kühnreich¹, Matthias Jacob², Steven Wagner³; ¹Technische Universität Darmstadt, Germany.
An absorption based laser sensor for film thickness measurement of DEF in an exhaust gas test bench is presented. A wavelength pre-selection ensures that film-thicknesses could be measured without cross sensitivity to temperature or concentration.

TH4L.5 • 17:30 **Invited**
Controlling Nonlinearity in Multimode Fibers and Fast Real-Time Wave-Front Shaping, Omer Tzang¹, Eyal Niv¹, Dan Feldkhun¹, Antonio Caravaca¹, Sakshi Singh¹, Simon Labouesse¹, Kelvin Wagner¹, Rafael Piestun¹; ¹Univ. of Colorado at Boulder, USA.
We show adaptive computational control of complex and non-linear interactions in multimode fibers. We also present novel wave-front shaping methodologies that are orders of magnitude faster than other technologies, and show real-time continues operation.
FTh4M • Hyperbolic Photonics Media—Continued

FTh4M.4 • 17:15
Nano-scale Hyperbolic Metamaterial cavity system for enhanced Light-Matter interaction at Visible Frequencies, Sita Rama Krishna C. Indukuri1, Jonathan Bar-David1, Noa Mazurski1, Uriel Levy1; 1Hebrew Univ. of Jerusalem., Israel. We design and demonstrate experimentally nano-scale hyperbolic metamaterial cavities at the visible frequency to enhance the free space radiation power of quantum dots for applications in solid state light emitting devices.

FTh4M.5 • 17:30
Quantum to Classical Transitions in Multilayer Plasmonic Metamaterials, Evan L. Simmons1, Kun Li2, Andrew Briggs2, Seth Bank1, Daniel Wasserman1, Eugene Narimanov2, Viktor Padolskiy3; 1Physics, Univ. of Massachusetts Lowell, USA; 2Electrical and Computer Engineering, Univ. of Texas at Austin, USA; 3Electrical and Computer Engineering, Purdue Univ., USA. We demonstrate that classical-to-quantum transition of free electron plasma can be used to as a doping-independent parameter controlling optical topology of metamaterials and present a comprehensive description of this phenomenon.

STh4N • High-Speed Optical Interconnects—Continued

STh4N.4 • 17:30
All-Plasmonic 100 Gbd Optical Communication Link, Yannick Salamin1, Ping Ma1, Benedikt Baeuerle1, Wolfgang Heni1, Claudia Hoesabacher1, Arne Josten1, Yuriy Fedoryshyn1, Alexandros Emboras1, Delwin L. Elder1, Larry R. Dalton1, Juerg Leuthold1; 1ETH Zurich, Switzerland; 2Dept. of Chemistry, Univ. of Washington, USA. We realize an all-plasmonic optical communication link operating at 100 Gbit/s NRZ, in which the optical transmitter and receiver rely on a plasmonic-organic modulator and a plasmonic-graphene photodetector, respectively.

STh4O • Epitaxial Materials & Strain Engineering—Continued

STh4O.4 • 17:15
RF Read-Out of Minority Carrier Lifetimes in Micro-Scale Infrared Materials, Sukrit Dh1, Yinan Wang2, Kyoungwan Kim1, Marzieh Zamiri2, Clark Kadi3, Michael Goldflam4, Samuel Hawkins1, Eric Shaner1, Jin Kim5, Sanjay Krishna6, Monica Allen7, Jeffery Allen7, Emanuele Tuttic1, Daniel Wasserman1; 1Univ. of Texas at Austin, USA; 2Univ of Wisconsin, USA; 3Sandia National Labs, USA; 4Ohio State Univ., USA; 5Egl Air Force Base, USA. We present micro-scale time-resolved microwave resonator response (μ-TRMRR), a sensitive technique capable of measuring carrier lifetimes in micron-scale materials, something not typically achievable using common techniques like time-resolved photoluminescence or timeresolved microwave reflectance.

STh4O.5 • 17:30
Invited
Germanium-Tin Semiconductors for Silicon-Compatible Mid-Infrared Photonics, Simone Assali1, Anis Attiaoui1, Étienne Bouthillier1, Patrick Del Vecchio1, Aashish Kumar1, Samik Mukherjee1, Jerôme Nicolas1, Oussama Mostabbour1; 1Engineering Physics, Ecole Polytechnique de Montreal, Canada. GeSn alloys have recently been the subject of extensive investigations as a new platform to engineer the band structure in group IV semiconductors thus providing a rich playground to implement silicon-compatible photonics and optoelectronics. Herein, we discuss the growth of these metastable semiconductors and their use in silicon-compatible devices. We will also discuss the effects of strain and Sn content on the optical, electronic, and structural properties of GeSn semiconductors.
A Continuous-Variable Quantum Repeater based on Quantum Scissors, Kaushik P. Seshadreesan, Hari Krovi, Saiak Guha; 1College of Optical Sciences, Univ. of Arizona, USA; 2Quantum Engineering and Computing Physical Sciences and Systems, Raytheon BBN Technologies, USA. Using the quantum scissors operation for entanglement distillation and a single-rail Bell state projection for non-Gaussian entanglement swapping, we show a multiplexed quantum repeater scheme for continuous-variable entanglement distribution over a pure loss communication channel.

Ultrafast tunable mid-infrared higher-order optical vortex source, Varun Sharma, S Chaitanya Kumar, GoutamSamanta, M Ebrahim-Zadeh1; 1PRL Ahmedabad, India; 2Radianta, Poligon Cari Ral, 08850 Gava, Spain; 3ICFO-Institut de Ciencies Fotoniques, The Barcelona Inst. of Science and Technology, Spain; 4Instituto Catalana de Recerca i Estudis Avancats (ICREA), Spain. We report on the generation of tunable ultrafast, mid-infrared, multi-order, optical vortices from a picosecond single-resonant optical parametric oscillator in 2493-4035 nm wavelength range with an average output power of up to 800 mW.

We demonstrated a surface plasmon resonance sensor based on 2D Perovskite and Goos-Hänchen shift exhibiting sensitivity up to 900,000 um/RIU for refractive index sensing of target analytes.

We propose and demonstrate a new kind of spiral vortex beams by phase projection for non-Gaussian entanglement swapping, we show a multiplexed quantum repeater scheme for continuous-variable entanglement distribution over a pure loss communication channel.

Evolution and Conservation of Orbital Angular Momentum in Three-Dimensional Structured Light, Ahmed Dornha, Carmelo Rosales-Guzmán1,2, Andrew Forbes3, Mo Mohajedi3, 1Dept. of Electrical and Computer Engineering, Univ. of Toronto, Canada; 2School of Physics, Univ. of the Witwatersrand, South Africa. We engineer quasi 3D structured light fields in which the orbital angular momentum changes locally in both sign and magnitude along the beam’s axis and explain how such transitions occur without violating conservation of angular momentum.

Enhanced Circular Dichroism and Chiral Sensing with Bound States in the Continuum, Kirill Kozerkov1,2, Yasaman Jahani1, Andreas Tillit1, Hatice Altug1, Yuri S. Kivshar1,2; 1Australian National Univ., Australia; 2Dept. of Nanophotonics and Metamaterials, ITMO Univ., Russia; 3Bioengineering Dept., Ecole Polytechnique Federale de Lausanne, Switzerland. We reveal that optical chirality at the nanoscale can be boosted dramatically by bound states in the continuum (BIC). We predict the enhancement of chiroptical signals from nanostructures supporting quasi-BICs in mid-IR with a record-high efficiency.
StH4E.5 • 17:45 Near-single-cycle long-wave infrared pulses for coherent linear and nonlinear optics, Abijith Kowligy1, Henry Timmers1, Alexander Lind1,2, Sylvain Karlen1, Flavio C. Cruz1, Peter G. Schumemann1, Jens Biegert1, Scott A. Diddams1,2, NIST, USA; 2BAE Systems, USA; 3TFCO, Spain; 4CSEM, Switzerland. We generate and detect phase-stable, near-single-cycle long-wave-infrared pulses using intrapulse difference-frequency generation and dual frequency comb electro-optic sampling, respectively. Applications such as high-resolution, super-octave spectroscopy and parametric amplification are described.

JTh4F.4 • 17:45 Terahertz Kerr Effect in β-Alumina Ion Conductors, Andrey D. Poletayev1, Matthias C. Hoffmann1, Samuel Tettelbaum2, Mariano Trigo3, William Chueh4, Aaron Lindenberg2; 1Materials Science & Engineering, Stanford Univ., USA; 2Stanford Linear Accelerator Lab, USA. We present THz Kerr effect spectra of Na, K, and Ag β-alumina solid-state ion conductors as model systems for grid-scale battery applications. We show both a field-following response consistent with electronic polarization, and a slower relaxation consistent with translation of mobile ions.

StH4E.6 • 18:00 Octave-Spanning Mid-Infrared Intrapulse Difference Frequency Generation With A Few-Cycle Cr:ZnS Laser, Sergey Mirov1,4, Konstantin L. Vodopyanov2, Igor S. Moskalev1,4, Scott A. Diddams1,2, NIST, USA; 2BAE Systems, USA; 3TFCO, Spain; 4CSEM, Switzerland. We generate longwave mid-IR transients between 4 and 18 µm via optical parametric amplification and dual frequency comb electro-optic sampling, respectively. Applications such as high-resolution, super-octave spectroscopy and dual frequency comb electro-optic sampling, respectively. Applications such as high-resolution, super-octave spectroscopy and dual frequency comb electro-optic sampling, respectively. Applications such as high-resolution, super-octave spectroscopy and dual frequency comb electro-optic sampling, respectively.
AH4.4 • 17:45
Beam-Steering Nanophotonic Phased-Array Neural Probes, Wesley D. Sacher1, Xinyu Liu1, Fu-Der Chen2, Hameira Mordi-Chameh2, Ilan Feils Almog3, Thomas Lordello1, Michael Chang4, Azadeh Naderian1, Trevor Fowler1, Eser Segev5, Tianyuan Xue2, Sara Mahallati3, Taufik Valiante3,4, Laurent Moreaux5, Joyce K. Poont5, Michael L. Roukes1; 1Division of Physics, Mathematics, and Astronomy, California Inst. of Technology, USA; 2Dept. of Electrical and Computer Engineering, Univ. of Toronto, Canada; 3Division of Fundamental Neurobiology, Krembil Research Inst., Canada; 4Division of Neurosurgery, Univ. of Toronto, Canada; 5Max Planck Inst. for Microstructure Physics, Germany. We demonstrate the first implantable nanophotonic neural probes with integrated silicon nitride phased arrays. Coherent beam-steering is achieved in brain tissue by wavelength tuning. Beam profiles, optogenetic stimulation, and functional imaging are validated in vitro.

AH4.5 • 18:00
Optical Phased Array Beam-steering with a Large Steering Angle and a Tailored Envelope, Linjie Zhou1, Weihan Xu2, Liangjun Lu1, and Jianping Chen1; 1Shanghai Jiao Tong University, China. We demonstrate an SOI-based OPA with a curved waveguide array for inter-channel coupling suppression. The far-field diffraction pattern exhibits a plateau for inter-channel coupling suppression. The system is based on a SiN microresonator array.

STh4J • 18:00
Ultra-high-Q Crystalline Microresonator Fabricated with Computer-controlled Machining without Polishing, Shun Fuji1, Mika Fuchida1, Hikaru Amano1, Ryo Suzuki1, Yasuhiro Kakumura1, Takasumi Tanabe1, Keio Univ., Japan. We fabricated crystalline whisp-erating cavity mode microresonators with an ultra-high-Q close to 1012 without polishing by employing a computer-controlled ultra-precision machining process.

STh4K • 18:00
Acousto-Optically Modulated Quantum Cascade Laser (ADQCL) for Combustion and Detonation Thermometry, Zachary Lopez1, Kyle Thurmond1, Erik Ninnemann1, Andrew Lach1, Ahmad Armr2, Arkady Lyakh3, Subhajit S. Vasu3, 1Mechanical and Aerospace Engineering, Univ. of Central Florida, USA; 2CREOL, College of Optics and Photonics, Univ. of Central Florida, USA; 3NanoScience Technology Center, Univ. of Central Florida, USA. We demonstrate temperature measurements in shock-heated mixtures of carbon monoxide (CO) using an acousto-optically modulated quantum cascade laser. Temperatures between 900 – 1300 K were measured at rates up to 250 kHz.

STh4L • 18:00
Passive Q-switching Based on Nonlinear Effect of Multimode Interference in Tapered Fiber, Hanjie Alkhamiardakani1, Jean-Claude Diels2; 1CHTM, Univ. of New Mexico, USA. A novel method to passively Q-switch an all-PM fiber laser is presented. A tapered fiber (free standing in air) is used as a saturable absorber based on Kerr effect of multimode interference in tapered section.

18:30–20:00 Emerging Trends in Nonlinear Optics - A Review of CLEO: 2019, Room 230A
18:30–20:00 Dinner Break (on your own)
20:00–22:00 Postdeadline Paper Sessions, Location TBD
FTh4M.6 • 17:45
Development of Near-Infrared Rare Earth Doped Organic Materials for Nanophotonics Applications, Joshua K. Asane1, Alexis Bullock2, Marvin Clemmons1, Natalia Noginova1, Mikhail Noginov1; ‘Norfolk State Univ., USA. We have synthesized a series of near-infrared rare-earth doped organic materials for nanophotonics applications and studied their absorption and emission properties. The developed materials show promise as research tools and (meta)device components.

FTh4M.7 • 18:00
Spontaneous emission from a wide quantum electron, Aviv Karnieli1, Roi Remez1, Sivan Trajtenberg-Mills1, Niv Shapiro1, Ido Kaminer1, Yossi Lereah1, Ady Aris1; ‘Tel Aviv Univ., Israel. We show that the azimuthal distribution of emitted light in the Smith-Purcell interaction does not depend on the width of the electron wavefunction, thus providing direct evidence for the probabilistic interpretation of the electron wavefunction.

FTh4M.8 • 18:15
Probe the ultimate nonlocal limit of ‘threshold-free’ Cherenkov radiation, Hao Hu1, Xiao Lin1, Dongjue Liu1, Patrice Genevet2, Baile Zhang1, Yu Luo1; ‘Nanyang Technological Univ., Singapore; 2CNRS, France. Here we probe the ultimate nonlocal limit of “threshold-free” Cherenkov radiation in hyperbolic metamaterials. The nonlocality, induced by the spatial dispersion from the inhomogeneous structure and the electron screening, determines a nonzero Cherenkov threshold.

FTh4N.5 • 18:00
A 10Gb/s Optical Random-Access Memory using a saturated SOA-MZI fast Access Gate and a monolithic InP Flip-Flop, Apostolos Tsakyrakis1, Christos Vagias1, Theoni Alexoudi1, Amalia Miliou1, Nikos Plokos1; ‘Aristotle Univ. of Thessaloniki, Greece. We experimentally demonstrate an all-optical static Random-Access Memory (RAM) cell using a monolithic integrated InP Flip-Flop and a fast strongly-saturat-ed push-pull SOA-MZI Access-Gate, reporting 10Gb/s error-free Write/Read operation and the fastest RAM cell to date.

FTh4N.6 • 18:15
Silicon Photonic Single-Sideband Generation with Dual-Parallel Mach-Zehnder Modulators, Ashok Kodigala1, Michael R. Gehl1, Christopher DeRose1, Dana Hood1, Andrew T. Pomerene1, Christina Dallal1, Douglas Trotter1, Penny Moore1, Andrew Starck1, Jongmin Lee1, Grant Biedermann1, Anthony Lentine1; ‘Sandia National Labs, USA. We demonstrate the first silicon photonic single-sideband (SSB) modulator with dual-parallel Mach-Zehnder modulators (MZMs) operating near 1550 nm with a measured carrier suppression of 27 dB and at least 12 dB sideband suppression at 1 GHz.

FTh4N.7 • 18:15
Boron Alloys for GaAs-based 1.3µm Semiconductor Lasers, Rasha H. El-Jaroudi1, Kyle M. McNicholas1, Brent A. Bouslog1, Iram E. Olivares1, Rachel C. White1, Joshua McArthur1, Seth Bank1; ‘Univ. of Texas at Austin, USA. We present BGaInAs as a potential active region for 1.31µm laser sources on GaAs substrates. We demonstrate high quality BGaInAs films with high indium concentrations and multiple percent boron concentrations that emit at room temperature.

18:30–20:00 Emerging Trends in Nonlinear Optics - A Review of CLEO: 2019, Room 230A
18:30–20:00 Dinner Break (on your own)
20:00–22:00 Postdeadline Paper Sessions, Location TBD

Concurrent sessions are grouped across four pages. Please review all four pages for complete session information.
Microscopic Plasmonic Properties of Superconducting Thin Films May Enable Improved Single-Photon Detection. Karl Berggren1, MIT, USA. Superconducting thin films have a strong microwave plasmonic characteristic which enables ultra-slow microwave propagation speeds and thus complex on-chip architectures for microwave circuits. We present a novel interferometric scheme for single-photon detection that would use a superconducting-nanowire-based microwave on-chip interferometer.

Resolution for Multimode Fiber Coupling

Laou2, J Zichi3, Val Zwiller3; Univ. of Colorado Boulder, USA; 2Applied Physics, The Ohio State Univ., USA. Multimode fibers have a strong microwave plasmonic characteristic which enables ultra-slow microwave propagation speeds and thus complex on-chip architectures for microwave circuits. We present a novel interferometric scheme for single-photon detection that would use a superconducting-nanowire-based microwave on-chip interferometer.

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**Executive Ballroom 210E**

**CLEO: Science & Innovations**

08:00–10:00

**SF1E • Ultrafast Applications**

Presider: Alan Fry; SLAC, USA

Laser-based 3D Printing for Biomedical Applications, Maria Farsari¹, IIESL-FORTH, Greece. We present our most recent results into the 3D laser printing of scaffolds and biomedical implants using a series of novel functional materials.

**Table-Top XUV Sources, High Performance Nanoscale Imaging with Applications, Laser-based 3D Printing for Biomedical SF1E.2 • 08:30**

Pr

**Invited**

**SF1E • Ultrafast Applications**

Laser-based 3D Printing for Biomedical Applications, Maria Farsari¹, IIESL-FORTH, Greece. We present our most recent results into the 3D laser printing of scaffolds and biomedical implants using a series of novel functional materials.

**FF1F.1 • Machine Learning & Quantum Exotica**

Presider: Peter Mosley; University of Bath, UK

Entanglement-Enhanced Physical-Layer Classifier Using Supervised Machine Learning, Gintautas Zhuang², Zheshen Zhang³, ¹Dept. of Physics, Univ. of California, Berkeley, USA; ²Dept. of Electrical and Computer Engineering, Univ. of Arizona, USA; ³College of Optical Sciences, Univ. of Arizona, USA. We introduce physical-layer classifiers enhanced by multipartite entanglement learned through a supervised support-vector machine. The required entangled states are practical and give error probability advantage over classical schemes even in presence of loss.

**SF1F.2 • 08:15**

Quantum Photonic Neural Networks, Gregory Steinbrecher¹, Jonathan Olson¹, Dirk R. Englund¹, Jacques Carolan¹, ¹MIT, USA; ²Zapata Computing Inc., USA. We propose an architecture for next generation quantum photonic processors, which maps the features of neural networks into the quantum optical domain. Through numerical simulation we demonstrate a range of new quantum information processing tasks.

**SF1G.1 • 08:00**

Programmable Integrated Photonics: Is it the right time for Field Programmable Arrays?, Jose Capmany¹, Daniel Perez², Ivana Gasull¹, Prometheus Das Mahapatra², ¹Universidad Politècnica de Valencia, Spain. Programmable photonics is an emerging paradigm based on using a common integrated optical hardware architecture to implement multiple functions by software programming. Field Programmable Photonic Arrays enable its implementation, but is the technology ready?

**SF1G.2 • 08:30**

Bit error rate performance of bias-free operational UTC-PD for high baud rate communications up to 100 Gb/s, Toshimasa Umezawa¹, ¹National Inst of Information & Comm Tech, Japan; ²Waseda Univ., Japan. We fabricated a bias free operational high bandwidth photodetector operating over 110-GHz, and characterized the bit error performance at up to 100-Gb/s. At 90-Gb/s, BER<1×10⁻³ was confirmed without a frequency equalizer or a DSP.

**Invited**

**SF1H.1 • 08:00**

A 2.35-μm pumped subharmonic OPO reaches the spectral width of two octaves in the mid-IR, Qitan Fu¹, Peter G. Schunemann², Sergey Vasilyev³, Sergey Mirov³, ¹Konstantin L. Vodopyanov⁴, ²CREOL, College of Optics and Photonics, Univ. of Central Florida, USA; ³BAE Systems, USA; ⁴IPG Photonics - Mid-infrared Lasers, USA. We used an orientation-patterned gallophilie photopchip (OP-GaP) crystal combined with an ultrastong 2.35-μm pump (1.2W, 79 MHz, 6T) to demonstrate a subharmonic sync-pumped OPO with an instantaneous output spectrum of 3-12.5 μm.

**SF1H.2 • 08:15**

Generation of wavelength- and mode-controllable Poincaré sphere beams from a femtosecond optical parametric oscillator, Jintao Fan¹, Na Xiao¹, Jun Zhao¹, Haosen Shi, Ruoyu Liao¹, Chen Xie¹, Youjian Song¹, Minglie Hu¹, ¹Tianjin Univ., China. We report on a femtosecond optical parametric oscillator which is capable of generating on-demand arbitrary higher-order Poincaré (HOP) sphere beams tunable from 1376 to 1628 nm.

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**Concurrent sessions are grouped across four pages. Please review all four pages for complete session information.**
SF1 • Frequency-Coded Based Sensing

Presider: Aleksandra Foltynowicz
Umea University, Sweden

SF1.1 • 08:00
Mid-infrared Dual-comb Spectroscopy of Volatile Organic Compounds Across Open-air Paths, Fabrizio R. Giorgiutta1, Gabriel Ycas1, Kevin C. Cossel1, Eleanor Waxman1, Esther Baumann1, Nathan R. Newbury1, Jan Coddington1; NIST, USA. 2Physics, Univ. of Colorado, USA. Volatile organic compounds are probed across up to 1 km-long open-air paths with mid-infrared dual-comb spectroscopy. Quantitative concentrations of released acetone and isopropanol and atmospheric ethane are measured with ppm-level sensitivities.

SF1.2 • 08:30
Background-Free Mid-Infrared Absorption Spectroscopy Based on Interferometric Suppression with a Sign-Inverted Waveform, Teemu Tommy1, Andrey Muravev1, Qitan Liu1, Konstantin L. Vodopyanov1, Qiu Bin2, Joonmoong Seo1; Univ. of Central Florida, CREOL, USA. Dept. of Chemistry, Univ. of Helsinki, Finland. Using a broadband dual-comb system, we implement a new type of background-free spectroscopy based on a Michelson interferometer operating in a dark fringe. This strongly improves detection sensitivity and reduces requirements for detector dynamic range.

SF1.3 • 08:45
Automatic Interpolation of 25 GHz Mode Spacing in Dual EOM Comb Spectroscopy, Tadashi Nishikawa1, Akira Oohara1, Shohei Uda1, Atsushi Ishizawa2, Kenichi Hitachi2, Teemu Tommy1, Konstantin L. Vodopyanov1, Qiu Bin2, Joonmoong Seo1; Univ. of Helsinki, Institute of Biomedical Materials and Devices, Univ. of Technology Sydney, Australia. Hexagonal boron nitride (hBN) is an emerging layered material that plays a key role in a variety of 2D devices. Here, we demonstrate the first hBN cavity optomechanical system by integrating hBN nanobeams with silicon microdisk cavities. The system has a 0.29 pm/√Hz sensitivity to hBN nanobeam motion.

SF1J • Plasmonics, Optomechanics, & Metamaterials

Presider: Karen Grutter, Univ. of Maryland at College Park, USA

SF1J.1 • 08:00
A Few Novel Effects in Plasmonics, Marcin Soljacic1; MIT, USA. Some of our recent work in plasmonics will be presented, including novel free-electron light sources, as well as structures for enhanced light emission, and tailoring light-flow.

SF1J.2 • 08:30
Record Purcell Factor in Hybrid Plasmonic Waveguides, Yiwen Su1, Pohan Chang1, Charles Lin1, Ami S. Helmy1; Univ. of Toronto, Canada. A composite hybrid plasmonic waveguide is demonstrated to exhibit long-range propagation (0.0368μm) and subwavelength confinement simultaneously while unrestricted from structural or modal symmetry coupling conditions. Purcell factors of 1.5x10^4 were measured in traveling-wave ring-resonators.

AF1 • Structural Monitoring

Presider: Gregory Rieker; University of Colorado at Boulder, USA

AF1K.1 • 08:00
VCSEL Based FBG Sensor Network Interrogator for Lightning Stroke Testing of Airframes, Guodong Guo1, Brandon Hearley1, David Lake1, Sejeong Kim2, Milos Toth2; Cornell Univ., USA. We develop a low-power, VCSEL based FBG sensor network interrogator for high-speed measurements of thermal and mechanical induced strains in composite airframes during lightning strikes.

AF1K.2 • 08:30
Sub-nl Static Resolution Fiber Laser Sensor, Shuangxiao Zhao1, Qiangwen Lu1, Jiageng Chen1, Zuyuan He1; Shanghai Jiao Tong Univ., China. A fiber laser sensor system capable of both static and dynamic strain measurement is presented. Using Pound-Drever-Hall and injection-locking techniques, resolution of 276 ps in 1000 s and 450 fs at 1 kHz is demonstrated.

AF1K.3 • 08:45
Strain Sensitivity Enhancement by Polarization-Maintaining Fiber Bragg Gratings, Dpenkumar Barot1, Hongmei Li1,2, Victor G. Bucklew1, William H. Renninger1; Univ. of Rochester, USA. Stable broadband solitons are observed in a driven nonlinear resonator consisting of fibers with opposite signs of dispersion. Corresponding numerical simulations reveal periodic temporal stretching of the pulse, characteristic of stretched-pulse solitons in mode-locked lasers.

AF1K.4 • 08:45
Highly-Chirped Solitons in Driven Resonators, Christopher Spiess1, Qian Yang1, Victor G. Bucklew1, William H. Renninger1; Univ. of Rochester, USA. Here we investigate driven fiber resonators with large net normal dispersion and a narrowband intracavity spectral filter. A range of stable solutions are observed, including the first experimental and numerical observations of highly-chirped solitons.
SF1M.1 • 08:00

Device independent quantum information processing——from Bell inequality to fiber QKD, Qiang Zhang1; "Univ of Science and Technology of China, China. Bell experiment provides not only a way to test quantum nonlocality but also to implement quantum information independent of any device. Here, I shall introduce the recent experimental progress in loophole free Bell test and device independent quantum random number generation.

SF1N.1 • 08:00

Integrated Nanophotonic Ising Sampler, Mihika Prabhu1, Charles Roques-Carmes1, Yichen Shen1, Nicholas C. Harris1, Li Jing1, Jacques Carolan1, Ryan Hamerly2, Tom Baeher-Jones1, Michael Hochberg1, Vladimir Ceperic1, John D. Joannopoulos1, Dirk R. Englund1, Marin Soljacic1, John D. Joannopoulos1, Lightmatter, USA; 2Elenion Technologies, USA. We demonstrate an integrated silicon photonic Markov Chain Monte Carlo sampler capable of high-probability convergence to the ground state of various 4-spin Ising graphs. Robustness to getting trapped in local minima is enhanced by experimental system noise.

SF1O.2 • 08:30

High-performance X-ray Detector Based on Solution-synthesized Thin-film Perovskite, Xiangming Liu1, Zhigang Zang1, Ming Wang1, Tao Xu1, Yulong Li1, Xiaoshi Peng1, Huiyue Wei1, Zanyang Guan1, Yonggang Liu1, Feng Wang1, 1Laser Fusion Research Center, CAEP, China; 2Key Lab of Optoelectronic Technology & Systems, Chongqing Univ., China. We present a high-performance X-ray detector based on a solution-synthesized perovskite film. The sensitivity as high as 30 μC Gy⁻¹cm⁻² is realized. More importantly, the as-prepared detectors exhibit a fast photosresponse with high stability.
**Executive Ballroom 210A**

**FF1A • Single-Photon Detection—Continued**

**FF1A.4 • 09:00**
High Efficiency Planar Ge-on-Si Single-Photon Avalanche Diode Detectors, Jaro-
slav Kirdoda1, Lourdes Ferre Lin1, Kateryna Kuzmenko1,2, Peter Vines1, Zoe M. Greener2, Derek C. Dumas1, Ross Millar1, Muhammad M. Mirza1, Gerald S. Buller1, Douglas J. Paul1,2,1Univ. of Glasgow, UK; 2School of Engineer-
ing and Physical Sciences, Heriot-Watt Univ, UK. Planar Ge-on-Si single-photon avalanche
diode detectors fabricated using CMOS-compatible processing demonstrate a 38% single
photon detection efficiency at 125 K with 1310 nm wavelength illumination, exhibiting 310 ps jitter and 2+10-11 noise equivalent power.

**FF1A.5 • 09:15**
Single Photon Detectors's Timing-Jitter Quantum Description, Elie Gouzien1, Bruno
Fedrizzi1, Alessandro Zavattini,2,2Sebastien Tan-
zilli, Virginia D'Auria1, Institut de Physique de
Nice, Université Côte d'Azur, France; 2Istituto Nazionale di Ottica, Italy; 1LENs and Dept. of
Physics, Università di Firenze, Italy. We model single photon detectors by explicitly taking into account their timing-
jitter, finite efficiency and dead-time effects. Our model represents the first operational and ful-
d description of temporal limitations of those detectors.

**FF1A.6 • 09:30**
Quantum tomography of a single-photon state by photon-number parity measure-
ments, Rajveer Nehra1, Ayse Yilmaz1, Miller Eaton1, Nirjanan Sritharan1, Rehaneh Shah-
rkhollahi1, Thomas Gerrits1, Adriana Lita1, Sai
Woo Nam1, Olivier Pfister1, Univ. of Virginia, USA; 2Google, Inc., USA; 3Xanadu, Canada;
4National Inst. of Standards and Technology, USA. A single-photon state was generated by heralding cavity-enhanced spontaneous parametric downconversion in a PKTP optical parametric oscillator. The Wigner distribution was reconstructed by quantum state tomography, using photon-
number-resolving measurements with a system efficiency of 58% ±2%.

**FF1A.7 • 09:45**
Quantum illumination with x-rays, Saon Sofer1,2, Edward Striezewski1,3, Aviad Shon1,
Kenji Tamassaka1, Sharon Shwartz1,2,1Phys-
ics Dept. and Inst. of Nan, Israel; 2BKE
SPHome-8 Center, Japan. We present the experimental realization of quantum illumina-
tion with x-rays. By using entangled photons, we detected the presence of an object in a noisy environment and improved the visibility substantially compared to classical methods.

**FF1B • Time Varying Metasurfaces—Continued**

**FF1B.8 • 09:00**
Time-varying Huygens' Metadevices for Parametric Wave Controls, Mingkai Liu1, 
David Powell1,2,3, Yair Zarat1,4, Ilya Shadrivov1,4,1Australian National Univ., Australia; 2Univ.
of New South Wales, Australia. Dynamic and arbitrary control of electromagnetic waves is
challenging. We introduce time-varying Huy-
gens' metadevices for efficient parametric conversion and demonstrate experimentally that the amplitude, phase, and scattering of parametric waves can be manipulated almost arbitrarily.

**FF1B.8 • 09:15**
Broadband Switches Using Photonic Aharonov-Bohm Interferometers and Dy-
namic Modulation, Ian Williamson1, Shanhui Fan1,3, Stanford Univ., USA. We introduce an
optical switch using an Aharonov-Bohm interferometer constructed from gauge potentials in
dynamically modulated waveguides. Our results show that such a switch can have a far broader bandwidth than the conventional Mach-Zehnder interferometer.

**FF1B.8 • 09:30**
Dynamic Phase Modulation Induced Non-
reciprocity of Optical Metasurfaces, Kuenue
Guo1, Yimin Ding1, Yao Duan1, Xingjie Ni1,2, Pennsylvania State Univ., USA. By exploiting both spatial and temporal phase modulation, we experimentally demonstrate an ultrafast nonlinear metasurface with broken reciprocity at wavelengths around 860 nm. Our ap-
proach paves a way for miniaturized on-chip nonreciprocal optical components.

**FF1C • Attosecond & High Field Sources—Continued**

**FF1C.3 • 09:15**
Demonstrating a Few-pulse Attotrain from CEP-
dependent Relativistic High Harmonics, Guangmin Ma1,2, Dmitrii Komnin1,2, Anton
Borot1, William Dallan1,3, Boris Bergues1,4, Mark Aladi1, Istvan Foldes1, Jin He1, Laszlo
Veszely2,3, Sharen SoC1, Key Lab, Peking Univ.
Shenzhen Inst. & PKU-HKUST Shenzhen-
Hong Kong Institution, China; 2Center for Free-Electron Laser Science, DESY, Ger-
many; 3Max-Planck-Institut für Quantenoptik, Germany; 4Ludwig-Maximilian-Universität München, Germany; 5Wigner Research Centre for Physics, Hungarian Academy of Sciences, Hungary; 6Dept. of Physics, Umea Univ, Sweden. We present laser-wavelength-
dependent relativistic high harmonics from plasma surfaces, and use spectral interferometry to understand its generation process. The attotrain structure as well as the field-driven plasma surface motion during the process are revealed.

**FF1C.4 • 09:30**
First experimental steps toward an in situ
gauge for direct measurement of rela-
tivistic intensities, Wendell T. Hill1,2,3,4,5,6,7,
Calvin He1,2,3,4,5,6,7, Luis Rosa1,2,3,4,5,6,7,
José A. Pérez-Hernández1,2,3,4,5,6,7, Giancarlo Gatti1,2,3,4,5,6,7, Massimo de Marco1,2,3,4,
Robert Fedosejevs1,2,3,4,5,6,7, Andrew Longme1,2,3,4,5,6,7, Univ. of Maryland at College Park, USA; 2Centro de Láseres Pulsados, Spain; 3Univ. of Alberta, Canada. Nearly 50 years ago Sarachik and Schappert suggested an intensity gauge based on wavelength shifts due to relativistic Thomson scattering. We present the first preliminary experimental results exploiting these shifts to make a direct measurement of peak intensities above 1018 W/cm².

**FF1D • Solitons in Microresonators—Continued**

**FF1D.4 • 09:30**
Kerr-breather-soliton time crystals, Scott
Papp1, Daniel C. Cole1,2,1NIST, USA. We
describe Kerr-breather-soliton time crystals in which a breathing excitation is sub-har-
monically locked to the repetition frequency. Nonlinear modeling explains the behavior of soliton time crystals, and we will report on progress towards their observation.
SF1E.5 • 09:15
Hyper-spectral Microscopy with Broadband Infrared Frequency Combs, Henry Timmerse1, Abijith Kowligy1, Alexander Lind1, Nima Nader1, Jonah Shaw1, Dobryna Zalvidea2, Jens Biegert3, Scott A. Diddams1; 1Univ. of Colorado Boulder, USA; 2Inst. of Bioengineering of Catalonia, Spain; 3ICFO, Spain.

We present a new modality for infrared, hyper-spectral microscopy using dual-color, electro-optic sampling of octave-spanning infrared frequency combs. We obtain hyper-spectral images of Si test patterns on Si wafers with a spatial resolution of 12 μm.Ø.
SF11.4 • 09:00
High-resolution Dual-comb Spectroscopy with a Free-running All-fiber Laser, Lukasz A. Sterczewski,1,2 Aleksandra Przewloka,1 Wawrzyniec Kaszuba,1 Jaroslaw Sotor,1 1Faculty of Electronics, Wroclaw Univ. of Science and Technology, Poland, 2Inst. of Electronic Materials Technology, Poland. We use a 1.56 μm computationally-corrected polarization-multiplexed dual-comb laser in free-running mode to measure hydrogen cyanide at 10 Torr. The source with a repetition rate of 142.4 MHz requires only 0.35 W of electrical power.

SF11.5 • 09:15
Quantum Cascade Laser Dual-comb Spectroscopy For Multi-species Detection, Jonas Westberg,1 Lukasz A. Sterczewski,1,2 Gerard Wysoczak,1 1Princeton Univ., USA; 2Faculty of Electronics, Wroclaw Univ. of Science and Technology, Poland. Multi-species detection of analytes in gas-phase by dual-comb spectroscopy using quantum cascade laser frequency combs is demonstrated. These chip-scale, electrically-pumped, semiconductor light sources are highly appealing for portable multi-component chemical sensing systems.

SF11.6 • 09:30
GHz Dual-comb Spectroscopy with 110 μs Time Resolution, Nazann Haghgoo,1 Ryan K. Cole,1 Amanda Makowiecki,1 Gregory B. Rieker,1 Univ. of Colorado Boulder, USA. We demonstrate high-speed dual-comb spectroscopy by spectrally filtering frequency combs using two Fabry-Perot cavities. Using this system, we measured the spectrum of CO with high signal to noise in 110 μs and 1 GHz resolution.

SF11.7 • 09:45
Rapid and high-resolution multidimensional coherent spectroscopy using three frequency combs, Bachana Lomsader,1 Brad Smith,1 Steven T. Cundiff,1 1Univ. of Michigan, USA. We present a novel method, tri-comb spectroscopy, which enables the measurement of a high-resolution multidimensional coherent spectrum in 365 ms. This method has the potential to become a field-deployable device for remote-sensing applications.

SF11.8 • 09:45
High Tolerance of Metamaterial Waveguides to Fabrication Variations,Moshe Zakdar,1 Utsav D. Dave,1 Michel Lipson,1 1Columbia Univ., USA. We demonstrate that silicon metamaterial waveguides have a high tolerance to large fabrication variations. We measured only a 5% drop in the Quality factor of a resonator with a metamaterial segment compared to a 40% drop for a wire waveguide segment, with a 50 nm discontinuity.
SF1M • Fiber-Based Information Process—Continued

SF1M.4 • 09:00
Multiple Modal and Wavelength Conversion Process of a 10-Gbit/s Signal in a 6-LP-Mode Fiber, Haissu Zhang1, Marianne Bigot-Astruc1, Laurent Bigot1, Pierre Sillard2, Julien Fatome1; 1CNRS - Universite Bourgogne Franche Comté, France; 2Prysmian Group, France; 3IRCICA - Université de Lille, France. We experimentally demonstrate a simultaneous threefold modal and wavelength conversion process of a 10-Gbit/s NRZ signal in a 1.8-km long 6-LP-mode fiber. The principle of operation is based on a phase-matched intermodal four-wave mixing phenomenon.

SF1N • AI for Integrated Photonics—Continued

SF1N.4 • 09:00
Optoelectronic Quantum Capacitors for Configurable Neural Photonic Networks, Posysa Danait1, Anna Persano2, Fabio Quaranta1, Adriano Cola1, Bahram Nabet1; 1Drexel Univ., USA; 2IMM-CNR, Italy. An optoelectronic quantum capacitor is described as a memristive behaving neuron in a dynamically configurable crossbar network. Activation, weight, and bias for each neuron are dynamically controlled with light, gate voltage, and a sampling frequency, respectively.

SF1O • Perovskites—Continued

SF1O.4 • 09:00
Modulation of CH3NH3PbBr3 perovskite microcrystal morphology for WGM and F-P mode lasers, Bobo Li1; 1CUHKSZ, China. We focused on the growth of CH3NH3PbBr3 perovskite crystals with shapes of sub-circular and quasi-cubic under different temperatures for WGM and F-P mode lasers. The lasing emissions exhibit low threshold below 20 μJ/cm².

SF1O.5 • 09:15
Simultaneous Inhibition and Redistribution of Spontaneous Emission from Perovskite Photonic Crystals, Songyan Hou1,2, Teo Hang Tong Edwin1,2, Muhammad Danang Birowosuto 2, Hong Wang1,2; 1Nanyang Technological Univ., Singapore; 2CINTRA, Singapore. Here, perovskite PhC exhibits both emission rate inhibition and light energy redistribution simultaneously, as a result of light energy redistribution from 2D guided modes to vertical direction, indicating a high intrinsic light extraction efficiency.

SF1O.6 • 09:30
Quantum-confined Stark effect of lead halide perovskite quantum dots in a mixed dimensional van der Waals heterostructure, Chitraleema Chakraborty1, Hendrik Uatz2, Matthias Ginterseder2, Hyowon Moon1, Cheng Peng1, Moungi Bawendi2; 1Electrical Engineering and Computer Science, MIT, USA; 2Dept. of Chemistry, MIT, USA. We demonstrate quantum-confined Stark effect in perovskite quantum dots by employing a voltage-tunable vertically stacked van der Waals heterostructure with 2D materials. A spectral shift of 10 meV was observed for the excitation peak.

SF1N.5 • 09:15
SOA-Based Photonic Integrated Deep Neural Networks for Image Classification, Bin Shi1, Nicola Calabretta1, Ripalta Stabile1; Inst. for Photonic Integration, Eindhoven Univ. of Technology, Netherlands. We successfully demonstrate classification of three classes of Iris flowers by implementing a trained neural network on an SOA-based InP cross-connect chip. Classification accuracy of 91.6% is achieved after a fine optimization procedure.

SF1N.6 • 09:30
Towards Optical Neural Networks with Fabrication Noise Immunity, Michael Fang1,2, Sashkanth Manipatruni1, Casimir Wierzyński3, Amir Khasrowshahi4, Ian Young5; 1Physics, UC Berkeley, USA; 2Redwood Center for Theoretical Neuroscience, UC Berkeley, USA; 3AI Research, Intel, USA; 4Components Research, Intel, USA. Optical neural networks (ONNs) can provide breakthrough energy/op and latency compared to GP-GPUs/ASICs. Here we compare two different architectures of ONNs and explore the effect of the imprecision of constituent photonic components.

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

Concurrent sessions are grouped across four pages. Please review all four pages for complete session information.
10:30–12:30  
**FF2A** • Photonic Crystals & Periodic Nano Optics  
**Presider:** Sushil Mujumdar  
Tata Institute of Fundamental Research, India

**FF2A.1 • 10:30**  
High Reflection from a One-Dimensional Array of Graphene Nanoribbons, Nathan Z. Zhao, Zhexin Zhao1, Ian Williamson1, Salim Boutami1, Bo Zhao1, Shanhui Fan1; Stanford Univ., USA. We show one-dimensional plasmonic systems such as graphene nanoribbons can be used to engineer extremely large bandwidth, high reflectivity resonances. Further, we prove that the underlying concept relies upon the general observation of the lack of Chu-Harrington limit in one-dimensional systems.

**FF2A.2 • 10:45**  
Photonic Crystal Polaritons in 2D Materials, Rahul Gogna1, Long Zhang1, Hui Deng1; 1Univ. of Michigan, USA. We demonstrate the important properties of transition-metal dichalcogenides strongly coupled to one-dimensional photonic crystals, including the design considerations and dispersions, as well as the possibility for creating multi-wave-length polariton devices on a single chip.

**FF2B.1 • 10:30**  
Non-resonant Enhancement of Second-Harmonic Generation in a Dielectric Particle with a Nanostructured Nonlinear Metamaterial Shell, Joong Hwan Bahng1, Douglas Montjoy2, Saman Jahanani3, Nicholas Katol4, Alinea Marandi3; 1California Inst. of Technology, USA; 2Univ. of Michigan, Ann Arbor, USA. We demonstrate a new principle for realizing a miniaturized and scalable platform for nonlinear optics using dielectric particles with nanostructured nonlinear metamaterial shells. We show numerical and experimental results of enhanced second-harmonic generation in them.

**FF2B.2 • 10:45**  
All-Optical Tuning of Fano Resonances in Broken-Symmetry GaAs Metasurfaces , Nicholas Karl1, Polina Vabischchevich1, Sheng Liu1, Michael B. Sinclair1, Gordon Keeler1, Gregory Peake1, Igal Brener1; 1Sandia National Labs, USA; 2Center for Integrated Nanotechnologies, Sandia National Labs, USA. We demonstrate ultrafast tuning of Fano resonances in a broken symmetry III-V metasurface using optical pumping. The resonance is spectrally shifted by 10 nm under low pump fluences of < 100 µJ cm⁻².

**FF2B.3 • 11:00**  
Dielectric nanostructures with enhanced local density of states, Sandro Mignuzzi1, Javier Cambiasso1, Stefano Vezzoli1, Simon A. Hosley1, William Barnes2, Stefan Maier1, Riccardo Sapienza1; 1Imperial College London, UK; 2Exeter Univ., UK. We demonstrate all-dielectric single photon nanostructures by rational design of the local density of optical states. We unravel an inverse design route to strong emitter’s decay rate enhancements, near-unity quantum efficiency, and large bandwidth.

**FF2B.4 • 11:15**  
Controlling HHG with a Sub-Cycle mJ-Level Parametric Waveform Synthesizer, Yudong Yang1, Giulio Maria Rossi1,2, Roland E. Mainz1,2, Nicolae Tancogne-Dejean1,2, Franco Ferrari3,4, Fabian Scheiba1,2, Sandro Mignuzzi1, Michael Mahrt1,2,3,4; 1ETH Zurich, Switzerland; 2Exeter Univ., UK; 3Max Planck Inst. for the Structure and Dynamics of Matter, Germany; 4The Centre for Ultrafast Imaging, Hamburg, Germany. We demonstrate a new principle for multi-phase-matched satellite frequency comb generation with satellite clusters spanning beyond conventional phase-matching bandwidth. The evolution of the signal and idler satellites at ∼1.3 mm and 1.9 mm regimes are detailed. With proper pump parameters, the satellites can span up to one full octave.

**FF2C.1 • 10:30**  
Reduction of Laser-Intensity Correlated Noise in High-Harmonic Generation, Mikhail Volkov1, Justinas Pupeikis2, Christoph Phillip2, Fabian Schaepler1, Lukas Gallmann1, Ursula Keller1; 1ETH Zürich, Switzerland. We present a scheme for correcting the spectral fluctuations of high-harmonic radiation by monitoring the generating near-infrared pulse energy. We apply this correction in an attosecond transient absorption experiment yielding an improved confidence interval on the mean.

**FF2C.2 • 10:45**  
Temporal Coherence of Linearly and Circularly Polarized High-Harmonics from Silicon, Nicolai Klemke1,2, Polina Vabishchevich1,2, Nicolask Tancogne-Dejean1,2, Giulio Maria Rossi1,2, Nicolae Tancogne-Dejean1,2, Franco Ferrari3,4, Sandro Mignuzzi1, Michael Mahrt1,2,3,4; 1ETH Zurich, Switzerland; 2Exeter Univ., UK; 3Max Planck Inst. for the Structure and Dynamics of Matter, Germany; 4The Centre for Ultrafast Imaging, Hamburg, Germany. We experimentally investigate circularly polarized high-harmonics can be generated from solids with elliptical and circular driver polarization. We investigate the temporal coherence properties of both cases and compare them to those of linearly polarized high-harmonics.

**FF2C.3 • 11:00**  
Controlling HHG with a Sub-Cycle mJ-Level Parametric Waveform Synthesizer, Yudong Yang1,2, Giulio Maria Rossi1,2, Roland E. Mainz1,2, Fabian Scheiba1,2, Sandro Mignuzzi1, Michael Mahrt1,2,3,4; 1ETH Zurich, Switzerland; 2Exeter Univ., UK; 3Max Planck Inst. for the Structure and Dynamics of Matter, Germany; 4The Centre for Ultrafast Imaging, Hamburg, Germany. We present HHG driven with a sub-cycle centre for coherent HHG generation and characterization using a two-bit sub-cycle mJ-level parametric waveform synthesizer. The variation of the HHG spectral shape and yield as a function of the relative phase between the synthesizer channels is shown.
Harnessing Quantum Light Science for Applications in Materials and Nano Science, Margaret M. Murnane; Univ. of Colorado at Boulder, USA. High harmonic generation produces polarization-shaped extreme-ultraviolet and soft X-ray beams that can uncover the fastest charge, spin and lattice dynamics in quantum materials, and enable ultraviolet and soft X-ray beams that can demonstrate the effectiveness of unscented Kalman filter for phase noise compensation.

JF2F.1 • 10:30
Phase Compensation for Continuous Variable Quantum Key Distribution, Hou-Man Chin, Darko Zibar, Nitin Jain, Tobias Gehring, Ulrik Andersen; Technical Univ. of Denmark, Denmark. The tracking and compensation of phase noise is critical to reducing excess noise for continuous variable quantum key distribution schemes. This work demonstrates the effectiveness of unscented Kalman filter for phase noise compensation.

JF2F.2 • 11:00
Deep Learning in Optical Microscopy and Image Reconstruction, Aydogan Ozcan; Univ. of California Los Angeles, USA. We will discuss recently emerging applications of the state-of-art deep learning methods on optical microscopy and microscopic image reconstruction, which enable new transformations among different modalities of microscopic imaging, driven entirely by image data. We believe that deep learning will fundamentally change both the hardware and image reconstruction methods used in optical microscopy and sensing in a holistic manner.

JF2F.3 • 11:00
Non-Equilibrium Structural Dynamics in Laser-Driven Materials Studied with Time-Resolved Diffraction, Klaus Sokolowski-Tinten; Universität Duisburg-Essen, Germany. This talk will discuss some of our recent results on using time-resolved diffraction with femtosecond X-ray or electron pulses to investigate the non-equilibrium structural response of materials upon intense ultrashort optical excitation.

SF2G.1 • 10:30
Enanti-enrichment of Racemic Films Using Circularly Polarized Femtosecond Pulses, Katrin E. Oberhofer, Farinaz Mortashbe, Johann Riemensberger, Florian Ristow, Reinhard Kienberger, Ulrich K. Heiz; Hristo Iglev, Aras Kartouzian; Physics Dept., Technical Univ. of Munich, Germany. Catalysis Research Center, Chair of Physical Chemistry, Technical Univ. of Munich, Germany. Circularly polarized laser pulses are used to desorb chiral molecules enantioselectively from an achiral surface implicating the quantum mechanical nature of this process, moreover demonstrating a new method for enantio-enrichment and enantio-separation.

SF2G.2 • 10:45
Two Dimensional Film Printing by Blister-Based Laser-Induced Forward-Transfer, Nathan T. Goodfriend, Oleg Nerushev, Wenshuo Xu, Mitsuhiro Okada, Ryo Kitaura, Jamie Warner, Hisanori Shinohara; Alexander Bulgakov, Eleanor Campbell; 1Universität Duisburg-Essen, Germany. 2School of Chemistry, EastCHEM, UK; 3Dept. of Materials, Univ. of Oxford, UK; 4Dept. of Chemistry, Nagoya Univ., Japan; 5Konkuk Univ., South Korea (the Republic of). We report an all-optical approach for extremely efficient tuning of a high-Q niobate photonic crystal nanocavity, Photon-level tuning of a high-Q lithium niobate photonic crystal nanocavity, with a significant resonance tuning rate of 110–MHz/photon.
10:30–12:30
SF2I • High Q Cavity, Resonators Application

President: Haisheng Rong; Intel Corporation, USA

SF2I.1 • 10:30
Tunable Optomechanical Cavity Filters, Marcel W. Pfrüssner1, Doewon Park1, Brian Roxworthy1, Dmitry Koza2, Todd Stevater3, Nathan Tyndall1, William Rabinochnic1; US Naval Research Lab, USA. Cavity optomechanics enables large-scale index tuning (Δn_p). However, most demonstrations exhibited small Δn_p or have not considered optical loss at large Δn_p. We demonstrate Δn_p-tuning using gradient electric forces and analyze optomechanically-induced loss and mitigation.

SF2I.2 • 10:45
High Q resonators in the GaAs and AlGaAs on insulator platform, Lin Chang1, Andreas Boes2, Paolo Pintus2, Jon Peters2, MJ Kennedy2, Warren Jin2, Xiaowen Guo2, Supeng Yu2, Scott B. Papp2, John Bowers2,1; Univ. of California Santa Barbara, USA; 2RMIT, Austria; 3NIST, USA. We demonstrated a low loss gallium arsenide (GaAs) and aluminium gallium arsenide (AlGaAs) on insulator platform by heterogeneous integration. The ring resonators on this platform exhibit record high intrinsic quality factors above 1 × 10^10.

SF2I.3 • 11:00
Invited
Explore Whispering-gallery Resonators for a Versatile Sensor Platform, Lan Yang1,2, Chris Bofinger3, Ewelina Obrzud3,4,5, Jennifer Lomas2,6, Tobias Herr1,2,6,7,8,9, Uli Lemmer10,11, Jacob Scheuer1,2,6,7,8,9, Ewelina Rodakowicz-Becker5, François Martin Bernier1,2, Michel Piché1,2,10, Gianluca Galzerano1,4, Réal Vallée1,2, Université Laval, Canada, 3Femtum inc., Canada, 4Dipartimento di Fisica, Politecnico di Milano, Italy, 5Istituto di Fotonica e Nanotecnologie, Italy, 6Département de physique, Cégep Garneau, Canada. We present recent demonstrations of fiber oscillators and amplifiers based on erbium- and dysprosium-doped fluoride fibers that enable the generation of ultrashort pulses above 3 μm.

10:30–12:30
SF2J • Lithium Niobate & Perovskite Photonic Devices

President: Christian Reimer; HyperLight Corporation, USA

SF2J.1 • 10:30
Ultra-Low Loss Integrated Lithium Niobate Photonics in Visible Wavelengths, Boris Desiatov1, Amirhasham Shams-Ansari2, Mian Zhang2, Cheng Wang3, Marko Loncar3; Harward Univ., USA, 2HyperLight Corporation, USA, 3Dept. of Electronic Engineering, City Univ. of Hong Kong, Hong Kong. We demonstrate a low loss integrated photonic platform in lithium niobate in the visible wavelength range. We show microring resonators with a quality factor of 10^8 and gigahertz intensity modulators.

SF2J.2 • 10:45
Perovskite Micro Laser arrays using Scalable Lithography: Towards Integrated Perovskite Photonics, Ofer Bar-On1, Philipp Brenner2, Uli Lemmer2, Jacob Scheuer1,1, Felix Aiv1, Aviv1, Karlruhe Inst. of Technology, Germany. Low threshold Perovskite micro lasers are fabricated and characterized. These devices are realized using the first complete top-down lithography process of metal halide perovskites which presents a crucial step towards integrated photonic photonics.

10:30–12:30
AF2K • Spectrometers & Wavelength Metrology

President: Kara Peters; North Carolina State University, USA

AF2K.1 • 10:30
Microresonator Spectrometer Using Counter-propagating Solitons, Qi-Fan Yang1,2, Boqiang Shen1,3, Heming Wang1, Minh Tran1, Ziyu Shen2, Yiyou Yang1, Yue Wu1, Chengyong Bao1, John Bowers1, Anh-An Yen1, Jerry J. Vahala1, T. J. Watson Lab of Applied Physics, California Inst. of Technology, USA, 2Dept. of Electrical and Computer Engineering, Univ. of California, Santa Barbara, USA. A spectrometer is demonstrated using self-locked counter-propagating soliton frequency combs in a high-Q silica micro-resonator. Fast tuning laser waveforms and molecular absorption features are measured with kilohertz to MegaHertz resolution.

AF2K.2 • 10:45
All-fiber Electro-optic Frequency Comb for Near-Infrared Astronomical Spectrograph Calibration, Ewelina Obrzud1,2,3,4,5, Jennifer Lomas2,6, Tobias Herr1,2,6,7,8,9, Uli Lemmer10,11, Jacob Scheuer1,2,6,7,8,9, Ewelina Rodakowicz-Becker5, François Martin Bernier1,2, Michel Piché1,2,10, Gianluca Galzerano1,4, Réal Vallée1,2, Université Laval, Canada, 3Femtum inc., Canada, 4Dipartimento di Fisica, Politecnico di Milano, Italy, 5Istituto di Fotonica e Nanotecnologie, Italy, 6Département de physique, Cégep Garneau, Canada. We present recent demonstrations of fiber oscillators and amplifiers based on erbium- and dysprosium-doped fluoride fibers that enable the generation of ultrashort pulses above 3 μm.

AF2K.3 • 11:00
Increasing the Range and Precision of Integrated Wavemeters, Enrique Martin-Bernier1,2,3,4,5,6, Tobias Herr1,2,3,4,5,6, Thomas Herr1,2,3,4,5,6, Omer Sivertsson1,2,3,4,5,6, Victor Brasch1, Steve Lecomte1, François Martin Bernier1,2,3,4,5,6, François Pepe2,3,4,5,6, Christel Yguel5,6, Centre Suisse d’Electro-Physique et de Micro, Switzerland. We demonstrate a low-loss integrated wavemeter for astronomical spectrograph calibration is developed, capable of providing radial velocity calibration with a precision of < 10 cm/s, relevant for exoplanet searches.

AF2K.4 • 11:15
500 μm Fiber Mach-Zehnder Interferometer for Frequency Conversion, John Bowers1,2,3,4,5,6, David Bialkowski1,2,3,4,5,6, Christel Yguel5,6, Centre Suisse d’Electro-Physique et de Micro, Switzerland. We demonstrate a Mach-Zehnder interferometer with a free spectral range of 1 GHz on a single fiber. The interferometer is integrated into a tunable laser, demonstrating the potential for future all-fiber frequency comb systems.

10:30–12:30
SF2L • MID-IR Fiber Sources

President: Maria Chernysheva; Leibniz Institute of Photonic Technology, Germany

SF2L.1 • 10:30
Ultrafast mid-infrared fiber lasers beyond 3 μm, Simon Duval1,2, Yuchen Wang3, Louis-Rafael Robichaud3, Michel Olivier1, Frédéric Jobin1, Jean-Christophe Gauthier1, Pascal Paradis1, Vincent Fortin1, Paolo Laporta1, Martin Bernier1, Michel Piché1, Gianluca Galzerano1, Réal Vallée1, Université Laval, Canada. We present recent demonstrations of fiber oscillators and amplifiers based on erbium- and dysprosium-doped fluoride fibers that enable the generation of ultrashort pulses above 3 μm.

SF2L.2 • 11:00
~3.5 μm self-Q-switched Er3+:ZBLAN fiber laser stabilized by an ASE seeded pump source, Jun Liu1,2, Jiadong Wu1, Shenghua Tang1, Yu Chen1, Shufen Fan1, Shenzhen University, China. We report on a ~3.5 μm highly stable self-Q-switched Er3+:ZBLAN fiber laser based on a temporally stable ASE seeded pump source. The pulsing dynamics are carefully investigated which can help facilitate their potential applications.
Optimizing Career Paths in Optics: the Guide for Young Professionals

Career planning is very important for young professionals in optics. Different career paths are available, each with its own requirements, challenges, and rewards. We invite young professionals to hear firsthand from their more seasoned colleagues about their jobs. Practical questions on how to excel in an optics-related career will be answered. What does it take to get a foot in the door at your target workplace? How to network? Who makes hiring decisions, and how? What qualities are the most sought? What does it get not to get stuck in your career? How could your typical workday look like? What are the most common challenges in maintaining the work-life balance?

Panelists:

J. Stewart Aitchison, University of Toronto, Canada
Ben Eggleton, University of Sydney, USA
Tara Fortier, National Institute of Standards and Technology, USA
Michael Miele, Iridion Laser Inc., USA
Irina Novikova, College of William and Mary, USA
Sergey Polyakov, National Institute of Standards and Technology, USA
Stephanie Tomasulo, U.S. Naval Research Laboratory, USA

SF2N.1 • 10:30
High-Speed Photodetection and Microwave Generation in a Sub-100 mK Environment, Josue Davila-Rodriguez1, John D. Teufel1, Jose A. Aumentado1, Xiaojun Xie2, Joe C. Campbell2, Scott A. Diddams1,2, Franklin Quinlan1,2, 3NIST, USA; 2Dept. of Physics, Univ. of Colorado, USA; 3Dept. of Electrical and Computer Engineering, Univ. of Virginia, USA. We perform microwave generation via high-speed photodetection at a temperature of 20 mK. Shot noise-limited detection with high linearity was obtained, compatible with continued scaling of the control and readout of superconducting quantum information systems.

SF2N.2 • 10:45
Broadband Local Oscillator Free Photonic Microwave Mixer based on a Coherent Kerr Micro-Comb Source, Jiayang Wu1, Xingyuan Xu1, Mengxi Tan1, Thach Nguyen1, Sai Chu1, Brent Little1, Roberto Morandotti2, Arnann Mitchell2, David Moss3, 1Swinburne Univ. of Technology, Australia; 2RMIT Univ., Australia; 3City Univ. of Hong Kong, China. We demonstrate a photonic microwave mixer based on an integrated micro-comb source. We achieve an operation bandwidth of over 40 GHz with a conversion efficiency of ~6.8 dB and a spurious suppression ratio of 43.5 dB.

SF2N.3 • 11:00
Experimental Characterization of Low-Latency Multiple and Tunable Delays of Wideband Analog LFM Signal Using Concatenated Linearly Chirped and Sampled FBGs, Ahmed El-Almaian1, Yinwen Cao1, Fatemeh Alishahi1, Ahmad Farhounpouli2, Long Li1, Peicheng Liao1, Kaiheng Zou1, Shlomo Zach2, Nadav Cohen3, Moshe Tur4, Alan E. Willner1; 1Univ. of Southern California, USA; 2School of Electrical Engineering, Tel Aviv Univ., Israel. Concatenated chirped and sampled fiber Bragg gratings are used to simultaneously generate multiple wavelength-tunable delayed versions of a wide bandwidth (10GHz) analog linear-frequency-modulated (LFM) pulse. We measured peak sidemode level (PSL) > 31 dB.

SF2N.4 • 11:15
Broadband Local Oscillator Free Photonic Microwave Mixer based on a Coherent Kerr Micro-Comb Source, Jiayang Wu1, Xingyuan Xu1, Mengxi Tan1, Thach Nguyen1, Sai Chu1, Brent Little1, Roberto Morandotti2, Arnann Mitchell2, David Moss3, 1Swinburne Univ. of Technology, Australia; 2RMIT Univ., Australia; 3City Univ. of Hong Kong, China. We demonstrate a photonic microwave mixer based on an integrated micro-comb source. We achieve an operation bandwidth of over 40 GHz with a conversion efficiency of ~6.8 dB and a spurious suppression ratio of 43.5 dB.

SF2O.1 • 10:30
Electrical Characterization of Solar-Blind Deep-Ultraviolet (Al0.28Ga0.72)2O3-based Schottky Photodetectors Grown on Silicon by Pulsed Laser Deposition, Nasir Alfaraj1, Kuang-Hui Li1, Chun Hong Kang1, Davide Prante1, Laurentiu Brac1, Zalibing Guo1, Tien-Khee Ng1, Xaichang Li1, Boon S. Ooi1, King Abdul-lah Univ of Sci & Technology, Saudi Arabia. This study reports on (Al0.28Ga0.72)2O3-based ultraviolet-C Schottky metal-semiconductor-metal photodetectors with peak responsivities of 1.17 and 0.40 A/W, respectively, for an incident-light wavelength of 230 nm at 2.50 V reverse-bias.

SF2O.2 • 10:45
The Aging Study for Fine Pitch Quantum-Dot Array on LEDs, Yu-Ming Huang1, Kai-Ling Liang1, Yu-Yun Cho1, Shun-Chieh Hsu2, Wei-Hung Kuo2, Chung-Ping Huang1, Hao-Chung Kuo1, Yin-Hsiang Fan2, Chi-Chen Lin3, National Chiao-Tung Univ., Taiwan, Taiwan; 2Industrial Technology Research Inst. of Taiwan, Taiwan; 3National Chiao-Tung Univ., Taiwan. In this paper, we fabricated the photore sist mold whose pitch is smaller than 15 mm on light-emitting diode and printed two different cadmium-based quantum dots. Also, we burn-in the LED to compare their lifetime which are passed barrier film by two different methods.

SF2O.3 • 11:00
Nanoscale inspection of GaN LED devices using g(2) cathodoluminescence imaging, Toon Coenen1,2, Sophie Meuret1, Yong-Ho Ra1, Zetian Mi1, Albert Polman1, Delmic, Netherlands; 1Center for nanophotonics, AMOLF, Netherlands; 2Dept. of Electrical and Computer Engineering, McGill Univ., Canada; 3Dept. of Electrical Engineering and Computer Science, Univ. of Michigan, USA. We apply a combination of hyperspectral cathodoluminescence and g(2) imaging to bulk and nanostructured LED materials. From these measurements we extract both excited state lifetimes and the probability of excitation of a single primary electron.
Beyond the Goos–Hänchen Effect: Resonance-Induced Spatial Reshaping and Its Application in Measuring Resonance Linewidth, Wei Zhang, Aaron Charous, Masaya Nagai, Daniel M. Mittleman, Rajind Mendis, School of Engineering, Brown Univ., USA; 2Graduate School of Engineering Science, Osaka Univ., Japan. We study the spatial distribution of a beam as it interacts with a planar resonator. Our result encompasses the familiar Goos–Hänchen effect and more complicated scenarios, and can be used for measuring resonance linewidth.

Symmetry-Broken High Contrast Gratings, Adam C. Overvig, Stephanie Malek, Sajan Shrestha, Nanfang Yu, Columbia Univ., USA. We develop an exhaustive catalogue detailing the behavior of normally incident light on symmetry-broken high-contrast gratings. This provides a high-level roadmap for designing compact devices with sharp spectral features within standard nanofabrication constraints.

Optical Needle with Ultra-Small Resolution Enabled by Integrated Metamaterials, Haowen Liang, Qian Sun, Yu Hao Ren, Juntuo Li, Sun Yat-sen Univ., China. We present a metasurface composed of integrated metamaterials to achieve an optical needle with ultra-small optical resolution of 5. This metalens is promising for non-intrusive, far-field super-resolution optical imaging.

Terahertz Single-Pixel Imaging System with Electrically Tunable Metamaterial Spatial Light Modulator, Wonwoo Lee, Hyunseung Jung, Hyunwoo Jo, Moon Sung Kang, Hojin Lee, Dept. of Information Communication, Materials, and Chemistry, Soongsil Univ., South Korea (the Republic of); 2School of Electronic Engineering, Soongsil Univ., South Korea (the Republic of); 3Dept. of Chemical Engineering, Soongsil Univ., South Korea (the Republic of). We propose a novel terahertz single-pixel imaging system with active metamaterial spatial light modulator using ion-gel gating graphene. From the experimental results, we confirmed the reconstructed image was 93% of agreement with the real image.

Attosecond Pulse Generation & Characterization—Continued

Attosecond Pulse Generation & Characterization—Continued

Attosecond Pulse Generation & Characterization—Continued

Frequency Comb & Supercontinuum Generation—Continued

Overcoming Spectral Stagnation in Supercontinuum Generation, Haider Zia, Niklas M. Lupker, Tim Hellwig, Carsten Fallich, Klaus J. Boller, Westfälische Wilhelms-Universität Münster, Germany. We present a new approach that increases bandwidth of supercontinuum generation by alternating the sign of dispersion along the interaction length, bypassing mechanisms that limit bandwidth in typical approaches. The method should be particularly suited for fiber and integrated optical waveguides.

30 GHz Supercontinuum Generation for Astronomy with Efficient SIN Waveguides, Connor Friedrick, Andrew J. Metcalf, Daniel Hickstein, David R. Carlson, Wesley Brand, Kartik Sinivasan, Scott Papp, Scott A. Diddams, Physics, Univ. of Colorado at Boulder, USA; Time and Frequency, National Inst. of Standards and Technology, USA; Microsystems and Nanotechnology, National Inst. of Standards and Technology, USA. Using silicon nitride waveguides we demonstrate octave spanning spectra at a 30 GHz repetition rate with less than 20 pJ of total pulse energy at 1 um. This high efficiency supercontinuum enables broadband and robust frequency comb generation for astronomical spectrograph calibration.
Spectral Correlations of Phase Noise in Ultrabroadband Femtosecond Lasers, Andreas Leitl¹, Philipp Sulzer¹, David Fehrenbacher¹, Denis Seletsky²,³, Alfred Leitenstorfer¹; ¹Dept. of Physics and Center for Applied Photonics, Univ. of Konstanz, Germany; ²Dept. of Engineering Physics, Polytechnique Montréal, Canada. Phase noise in mode-locked Er:fiber systems shows strong correlations emerging from broadband nonlinear-optical processes. Our fundamental insights are key to maximize the quality of passively phase-stable frequency combs and single-cycle pulse trains.

Soliton explosions induced by soliton fusion in a mode-locked fibre laser, Heping Zhang¹, Junsong Peng¹; ¹East China Normal Univ., China. We reveal that soliton fusion can induce soliton explosions in a mode-locked fibre laser, using real-time measurement techniques. Two solitons differing in their central wavelengths due to chirp explode as they approach each other.

Deep Learning Reconstruction of Ultra-short Laser Pulses and Ptychographic Data from Ambiguous Measurements, Tom Zahavy¹, ²EE, Technion, Israel. We propose a deep learning approach to reconstruct ultrashort laser pulses and ptychographic data from optical measurements, based on optimization and calibration of ambiguities in the measurement system. We demonstrate, numerically and experimentally, superior performance and robustness to noise.

Measurements of Optical Nonlinearities at Mid-IR Wavelengths Using a Modified Z-Scan Technique, Manuel R. Ferdinandus¹, ²MIT, USA; ³Air Force Inst. of Technology, USA; ²Air Force Research Lab, USA. We measure the effective optical nonlinearity of polycrystalline zinc selenide and undoped silicon at mid-IR wavelengths using a variant of Z-scan technique that employs a quadrant photodiode to simplify alignment and enhance sensitivity.

Reducing Actuation Nonlinearity of MEMS Phase Shifters for Reconfigurable Photonic Circuits, Pierre Edinger¹, Carlos Errando-Herranz¹, Kristinn B. Guðfason¹; ¹Micro and Nanosystems, KTH Royal Inst. of Technology, Sweden. The low power consumption of MEMS actuators enables large-scale reconfigurable photonic circuits. However, insertion loss and actuation linearity need improvement. By simulations and experiments, we analyze the dominating design parameters affecting linearity and suggest improvements.

High-Q Microresonators Integrated with Microheaters on a 3C-SiC-on-Insulator Platform, Xi WU¹, Tianren Fan¹, Ali Eftekhar¹; ¹Georgia Inst. of Technology, USA. We demonstrate, for the first time, non-volatile tunable photonics that makes use of graphene microheaters to thermally switch large-area, low-loss phase change materials. This framework enables scalable nonvolatile integrated photonics and free-space optics applications.
SF2J.4 • 11:30
Waveguide-Coupled Disk Resonators on a Crack-Free Si$_3$N$_4$ Film with a Dense Stress Release Pattern, Kaiyi Wu$^1$, Andrew W. Poon$^1$, $^1$HKUST, Hong Kong. We deposit a crack-free 780nm-thick Si$_3$N$_4$ film on a dense stress release pattern on a 100nm silicon wafer. Our fabricated waveguide-coupled 920μm-radius Si$_3$N$_4$ disk resonator reveals a high loaded quality factor of 1.7x10$^9$.

SF2J.5 • 11:30
Self-starting lithium niobate soliton microcombs, Yang He$^1$, Qi-Fan Yang$^2$, Jingwei Ling$^1$, Rui Luo$^1$, Hanxiao Liang$^1$, Mingxia Li$^1$, Baoqiang Shen$^2$, Heming Wang$^2$, Jerry J. Vahala$^3$, Qiang Lin$^4$, $^1$Univ. of Rochester, USA; $^2$California Inst. of Technology, USA. We report soliton generation in a high-Q lithium niobate resonator. The photo-refractive effect enables self-starting mode locking and is able to produce stable single solitons on demand that feature reversible switching between soliton states.

SF2J.4 • 11:15
Integrated Electro-Optic Spectrometers on Thin-Film Lithium Niobate, Marc Reig$^1$, David Pohl$^1$, Mohammad Madi$^2$, Peter Brozter$^1$, Fabian Kaufmann$^1$, Anton Sergeyev$^1$, Urs Meier$^1$, Edoardo Alberti$^2$, Rachel Grange$^2$, ETH Zürich, Switzerland; Micron Engineering GmbH, Switzerland. We demonstrate the concept of an integrated waveguide Fourier transform spectrometer on a thin-film lithium niobate platform. The material’s electro-optic properties enable on-chip phase-modulations to overcome undersampling restrictions by shifting the evanescently probed standing wave.

SF2J.5 • 11:45
Continuous scanning of a dissipative Kerr-microresonator soliton comb by Pound-Drever-Hall locking, Naoya Kuse$^1$, Tomohiro Tetsumoto$^1$, Yi Xuan$^2$, Martin E. Ferrmann$^1$, IMRA America Inc, USA; $^2$School of Electrical and Computer Engineering, Purdue Univ., USA; $^1$Birck Nanotechnology Center, Purdue Univ., USA. We propose and demonstrate a novel technique for continuous and autonomous scanning of a dissipative Kerr-microresonator soliton comb facilitated by Pound-Drever-Hall locking.

AF2K.5 • 11:30
Scalable Bandwidth All-fiber Spectrometer using Spatial Multiplexing, Ziyi Meng$^1$, Zhenming Yu$^1$, Jiaqiang Li$^1$, Kun Xu$^1$, Beijng Univ of Posts & Telecom, China; $^1$Huazhong Univ. of Science & Technology, China; $^1$Yangtze Optical Fibre and Cable Limited Company, China. We propose and experimentally demonstrate a large bandwidth and high-resolution all-fiber speckle-based spectrometer using spatial multiplexing, which is constructed by integrating a multicore fiber (MCF) with a multimode fiber (MMF).

AF2K.6 • 11:45
Super-resolution in a compact Fourier Transform InfraRed (FT-IR) spectrometer, Erga Lifshitz$^1$, Uri Arieli$^1$, Shahar Katz$^1$, Assaf Levanon$^1$, Michael Megen$^1$, Haim Suchowski$^1$, Tel-Aviv Univ., Israel. We introduce a novel method to achieve a compact, high resolution FT-IR spectrometer. By simulation and experimental results we demonstrate that effectively increasing the size of the FT-IR by stitching different interferograms yields spectral super-resolution.

SF2L.3 • 11:15
High Power Dy-doped Fluoride Fiber Laser Operating Beyond 3 μm, Vincent Fortin$^1$, Frédéric Jobin$^1$, Maxence Larose$^1$, Martin Bernier$^1$, Réal Vallée$^1$, centre d’optique, photonique et laser (COPL), Université Laval, Canada. We demonstrate an entirely monolithic dysprosium-doped fiber laser system producing a record output power of 10 W at 3.24 μm based on in-band pumping at 2.8 μm.

AF2K.4 • 11:15
Dual Comb Assisted Spectrum-to-Time Mapping for Rapid Wavelength-encoded Tomography, Yuhua Duan$^1$, Lei Zhang$^1$, Xin Dong$^1$, Xi Zhou$^1$, Chu Zhang$^1$, Xiniang Zhang$^1$, WNLO, China. Leveraging a stimulated Brillouin scattering filter and the Vernier effect between two optical frequency combs, the wavelength-encoded depth information is time mapped and detected with low bandwidth, with both imaging range and imaging speed enhanced.

AF2K.6 • 11:30
Breaking Through the Wavelength Barrier: State-of-play on Rare-earth Ion Mid-infrared Fiber Lasers at 4-9 mm, Angela Seddon$^1$, Zhubq Tang$^1$, David Furniss$^1$, Emma Barney$^1$, Lukasz Sojka$^2$, Trevor Benson$^1$, Swamni Sujecki$^1$ $^1$, Univ. of Nottingham, UK; $^2$Wroclaw Univ. of Technology, Poland. Fiber lasing at 3.9 mm was reported in 1995, but has not yet been demonstrated at 4 mm or longer wavelengths. Rare-earth ion behavior in low optical-phonon energy hosts is appraised and host confounding issues explored.

SF2L.4 • 11:30
Continuous scanning of a dissipative Kerr-microresonator soliton comb by Pound-Drever-Hall locking, Naoya Kuse$^1$, Tomohiro Tetsumoto$^1$, Yi Xuan$^2$, Martin E. Ferrmann$^1$, IMRA America Inc, USA; $^2$School of Electrical and Computer Engineering, Purdue Univ., USA; $^1$Birck Nanotechnology Center, Purdue Univ., USA. We propose and demonstrate a novel technique for continuous and autonomous scanning of a dissipative Kerr-microresonator soliton comb facilitated by Pound-Drever-Hall locking.

AF2K.4 • 11:15
Dual Comb Assisted Spectrum-to-Time Mapping for Rapid Wavelength-encoded Tomography, Yuhua Duan$^1$, Lei Zhang$^1$, Xin Dong$^1$, Xi Zhou$^1$, Chu Zhang$^1$, Xiniang Zhang$^1$, WNLO, China. Leveraging a stimulated Brillouin scattering filter and the Vernier effect between two optical frequency combs, the wavelength-encoded depth information is time mapped and detected with low bandwidth, with both imaging range and imaging speed enhanced.
**SF2N • RF Photonics—Continued**

**SF2N.4 • 11:15** Tunable Photonic RF Bandpass Filters based on an 80 Channel Kerr Micro-Comb Source, Mengxi Tan1, Xingyuan Xu1, Jiayang Wu1, Thach Nguyen2, Sai Chu1, Brent Little1, Roberto Morandotti1, Arman Mitchell1, David Moss1; 1Swinburne Univ. of Technology, Australia; 2RMIT Univ., Australia; 3City Univ. of Hong Kong, China; 4Chinese Academy of Science, China; 5INRS-Énergie, Matériaux et Télécommunications, Canada.

We demonstrate a tunable photonic RF bandpass filter based on a Kerr micro-comb source providing 80 taps in the C-band. We achieve a wide tunable centre frequency (0.05 FSR – 0.40 FSR) and 3-dB bandwidth (0.5 – 4.6 GHz).

**SF2N.5 • 11:30** Photonic-chip based RF signal detection system with improved bandwidth and sensitivity, Zihang Zhu1,2, Moritz Merklein1,3, Duk-yong Choi1, Khu Vu1, Pan Ma1, Stephen Madden1, Benjamin J. Eggleton1; 1Inst. of Photonics and Optical Science (IPOS), School of Physics, The Univ. of Sydney, Australia; 2The Faculty of Automation & Information Engineering, Xi’an Univ. of Technology, China; 3Sydney Nano Inst. (Sydney Nano), The Univ. of Sydney, Australia; 4Laser Physics Centre, Australian National Univ., Australia.

We demonstrate on-chip RF signal detection with high sensitivity and broad bandwidth using a Brillouin opto-electronic oscillator. RF signals with power levels as low as -65dBm and a frequency range of 1.5–40 GHz are detected.

**SF2N.6 • 11:45** A Photodetector-Driven Coherent RF Array with Wide Tuning Range, Behrouz Abiri2, Craig Ives1, Ali Hajimiri1; 1California Inst. of Technology, USA; 2Auspion Inc., USA.

A sixteen-element coherent array of wideband spiral antennas driven by photodetectors is presented. The array radiates between 21 and 65 GHz, with -45 dBm of coupled power at 42 GHz.

**SF2O • Optoelectronic Materials—Continued**

**SF2O.4 • 11:15** UV Laser Resist-Mask Writing for Low-Cost Prototyping of Integrated Optical Devices, Dawson Bonneville1, Manuel Arturo Méndez-Rosales1, Henry Franks1, Jonathan D. B. Bradley1; 1Engineering Physics, Canada.

We report on UV-laser photoresist-mask writing as a tool for fabricating integrated-optical waveguides. We investigate feature width and roughness under different write settings and apply the technique to realize integrated Si3N4 waveguides and devices.

**SF2O.5 • 11:30** Optical and Electrical Properties of Phase Change Materials for High-Speed Optoelectronics, Joshua Burrow1, Pengfei Guo1, Gary A. Sevison1, Heungdong Kwon1, Christopher Perez1, Mehdi Asheghi1, Joshua R. Hendrickson1, Andrew Sarangan1, Kenneth E. Goodson1, Imad Agha1; 1Electro-Optics, Univ. of Dayton, USA; 2Sensors Directorate, Air Force Research Lab, USA; 3Mechanical Engineering, Stanford Univ., USA; 4Physics, Univ. of Dayton, USA.

By doping Ge2Sb2Te5 phase change material with tungsten, we produce material with improved electrical properties while simultaneously maintaining the optical contrast necessary for light modulation and switching.

**SF2O.6 • 11:45** Optically Re-Writable Dynamic Resistors for Optoelectronic and Reconfigurable Computing Applications, Gary A. Sevison1, Edward C. Ruff1, Joshua Burrow1, Pengfei Guo1, Joshua R. Hendrickson1, Andrew Sarangan1, Imad Agha1; 1Electro-Optics and Photonics, Univ. of Dayton, USA; 2Sensors Directorate, Wright-Patterson Air Force Research Labs, USA; 3Physics, Univ. of Dayton, USA.

By employing the phase transition properties of germanium-antimony-telluride, we demonstrate optically re-writable electronic resistors, which can be used to dynamically reconfigure hardwired electronic circuits for optoelectronic and computing applications.
**Executive Ballroom 210A**

**FF2A • Photonic Crystals & Periodic Nano Optics—Continued**

**FF2A.7 • 12:00**

*Optical Pressure on a Structured Surface, Li-Fan Yang1, Arunap Datta1, Yu-Chun Hsieh1, Xianfan Xu1, Kevin J. Webb1, Purdue Univ., USA.* We experimentally demonstrate for the first time that the optical pressure on a nanostructured surface can exceed that on a planar mirror by virtue of exploiting the third dimension and an asymmetric plasmon wave resonance.

**FF2B • Linear/Non-Linear Metasurfaces—Continued**

**FF2B.7 • 12:00**

*Helicity-Multiplexed Hologram via All-dielectric Metasurface in the Visible Domain, Muhammad Afnan Ansari1,2, Muhammad Qasim Mehmoody,3, Muhammad Hamza Waseem1,4, Inki Kim1,5, Nasir Mahmood1,4, Tauseef Taqeer1,6, Suleikha Yezzi1,6, Dansuk Rho1,6 Information Technology University of the Punjab, Lahore, Pakistan; 2, Department of Electrical and Electronic Engineering, Middle East Technical University, 06800 Ankara/Ankara, Turkey; 3, Department of Electrical Engineering, University of Engineering and Technology, Lahore 54000, Pakistan; 4, Department of Mechanical Engineering, Pohang University of Science and Technology (POSTECH), Pohang 37673, South Korea; 5, National University of Sciences and Technology (NUST), Islamabad, Pakistan; 6, Engineering Dept., University of Lahore, Lahore, Pakistan, Pakistan; 7, Department of Micro and Nanotechnology, Middle East Technical University, 06800 Ankara/Akara, Turkey, Turkey. A transmission type helicity-multiplexed metasurface hologram is demonstrated at wavelength of 633 nm using low loss hydrogenated amorphous silicon to achieve the pragmatic features of metasurfaces in the integrated photonic circuits.*

**FF2C • Attosecond Pulse Generation & Characterization—Continued**

**FF2C.6 • 12:00**

*Helicity in a Twist: Attosecond, Extreme Ultraviolet Vortex Beams with Designer Spin and Orbital Angular Momenta, Kevin Dorney1, Laura Rego2, Nathan Brooks1, Julio San Roman3, Chen-Ting Liao1, Jennifer Ellis1, Dmitry Zusin1, Christian Gentry2, Quynh L. Nguyen1, Justin Shaw1, Antonio Picón1, Luis Plaja1, Henry Kapteyn1, Margaret Murmane2, Carlos Hernandez-Garcia1, Physics, JILA - Univ. of Colorado Boulder, USA; 2, Departamento de Física Aplicada, Universidad de Salamanca, Spain; 3, Quantum Electromagnetics Division, National Inst. of Standards and Technology, USA; 4, Departamento de Química, Universidad Autonoma de Madrid, Spain. High-harmonics—and attosecond pulses—with controllable spin and orbital angular momenta (SAM and OAM) are generated for the first time. The coupled SAM-OAM conservation laws enable exquisite control over the polarization of attosecond pulse trains.*

**FF2D • Frequency Comb & Supercontinuum Generation—Continued**

**FF2D.7 • 12:00**

*Supercontinuum Generation in Titanium Dioxide Waveguides, Kamal Hammami1, Laurent Markey1, Manon Lam1, Bert Hendrickx2, John J. Gupta2,3, Auke Bobbert4, and Franziska Huber5, Lawrence Livermore National Laboratory, Livermore, California, USA. We report the design and fabrication of titanium dioxide optical waveguides optimized for supercontinuum generation in the mid-infrared. A spectrum spanning from the visible up to 2 μm is experimentally demonstrated.*

**FF2D.8 • 12:15**

*Tailoring the Dispersion of a Hybrid Chalcogenide/Silicon-Germanium Waveguide for Mid-Infrared Supercontinuum Generation, Alberto Della Torre1, Milan Sinobad1,4, Barry Luther-Davies1, Pan Ma3, Stephen Madden2, Sukanta Debbarma1, Khu Vu1, David Moss3, Arnan Mitchell4, Jean-Marc Fedeli1, and Christelle Monat1, Institut des Nanotechnologies de Lyon, France; 2, Australian National University, Australia; 3, Swinburne University of Technology, Australia; 4, CEA-LETI, France. We report mid-infrared supercontinuum generation in a silicon germanium-on-silicon waveguide. We show that the dispersion properties of the waveguide can be precisely tuned by controlling the thickness of a chalcogenide cladding layer.*

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**Executive Ballroom 210B**

**Executive Ballroom 210C**

**Executive Ballroom 210D**

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**CLEO: QELS-Fundamental Science**

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**Friday, 10:30–12:30**

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**12:30–14:00**

*Lunch Break (On Your Own)*
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<thead>
<tr>
<th>Executive Ballroom 210E</th>
<th>Executive Ballroom 210F</th>
<th>Executive Ballroom 210G</th>
<th>Executive Ballroom 210H</th>
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<tbody>
<tr>
<td><strong>CLEO: Science &amp; Innovations</strong></td>
<td><strong>Joint</strong></td>
<td><strong>CLEO: Science &amp; Innovations</strong></td>
<td><strong>Active &amp; Reconfigurable Devices—Continued</strong></td>
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<td><strong>SF2E • Ultrafast Phenomena—Continued</strong></td>
<td><strong>SF2F • Symposium on Deep-learning Photons: Where Machine Learning &amp; Photonics Intersect II—Continued</strong></td>
<td><strong>SF2G • Laser-Based Diagnostics for Material Processing—Continued</strong></td>
<td><strong>SF2H.6 • 12:00</strong></td>
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<td><strong>SF2E.4 • 12:00</strong></td>
<td><strong>SF2F.4 • 12:00</strong></td>
<td><strong>SF2G.6 • 12:00</strong></td>
<td><strong>SF2H.6 • 12:00</strong></td>
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<td>Invited</td>
<td>Attosecond Tracking of Electron Dynamics in Large Molecules, Francesca Calegari1,3, 1Deutsches Elektronen Synchrotron, Germany; 2Physics, Hamburg University, Germany. A new attosecond beamline combining 200-as XUV pulses with sub-2 fs UV pulses is presented. The application of attosecond technology for the investigation of electronic processes in bio-relevant molecules is discussed.</td>
<td>Training Deep Neural Networks for the Inverse Design of Nanophotonic Structures, Dianjing Liu1, Yixuan Tan1, Erfan Khoram1, Zongfu Yu1; 2Univ. of Wisconsin - Madison, USA. We demonstrate a tandem neural network architecture that tolerates inconsistent training instances in inverse design of nanophotonic devices. It provides a way to train large neural networks for the inverse design of complex photonic structures.</td>
<td>A sub-10 μK, dual-mode temperature stabilized microresonator, Jinkang Lim1,2, Anatoliy Savchenkov3, Yoon-Soo Jang1, Andrey B Matsko1, Chee Wei Wong1; 2Univ. of California Los Angeles, USA; 3Photonics Solutions, LGs innovations LLC, USA; 4OEwaves Inc., USA. We show a resonator long-term temperature stability of 8.53 μK after stabilization and unveil various sources that hinder the stability from reaching sub-μK in the current system.</td>
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<td><strong>SF2F.5 • 12:15</strong></td>
<td><strong>SF2F.5 • 12:15</strong></td>
<td><strong>SF2G.7 • 12:15</strong></td>
<td><strong>SF2H.7 • 12:15</strong></td>
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<td>Large-Scale Optical Neural-Network Accelerators based on Coherent Detection, Ryan Hamerly1, Alex Sludds1, Liane Bernstein1, Marin Soljacic1, Dirk R. Englund1; 2MIT, USA. We present a coherent optical neural-network accelerator based on homodyne detection that is scalable to large (N &gt; 1000) networks, and analyze the fundamental quantum limits to its energy efficiency.</td>
<td>Towards Stark Coefficient Determination in Laser-produced Uranium Plasma, Milos Burger1, Patrick J. Skrodzki1, Igor Jovanovic1, Mark C. Phillips1, Svanandan S. Harlal2, 3Univ. of Michigan, USA; 4Pacific Northwest National Lab, USA. We performed spatiotemporal diagnostics of excitation temperature and electron density of laser-induced uranium plasma. The results are prerequisite for Stark broadening and shift coefficients determination, required for accurate modeling of uranium emission spectra.</td>
<td>Design of a tapered slot waveguide dielectric laser accelerator for sub-relativistic electrons, Zhexin Zhao1, Tyler Hughes1, Si Tan1, Huiyang Deng1, Neil Sapra1, Joel England1, Jenica Vuckovic1, James Harris1, Robert Byer1, Shanhu Fan1; 2Stanford Univ., USA; 3SLAC National Accelerator Lab, USA. We design and analyze a tapered slot waveguide structure for sub-relativistic electron acceleration. The tapering scheme can be designed, through the eikonal approximation, to achieve phase synchronization with the accelerated electrons.</td>
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12:30–14:00  Lunch Break (On Your Own)
SF2J • High-Q Cavity, Resonators Application—Continued

SF2J.6 • 12:00
High-Q Resonators on Single Crystal Aluminum Nitride Grown by Molecular Beam Epitaxy, Yi Sun1, David Lalayan1, Eric Reid1, Ping Wang1, Xianhe Liu1, Ayush Pandey1, Mohammad Soltani2, Zeitan Mi3; 1Dept. of Electrical and Computer Engineering, Univ. of Michigan, USA; 2Raytheon BBN Technologies, USA. We report the demonstration of high-Q (>70,000) microring resonators at 770 nm wavelength using single crystal aluminum nitride (AlN) grown by molecular-beam epitaxy (MBE) which is a crucial growth technique enabling electronic/photonics integration with III-Nitrides.

SF2J.7 • 12:15
Control of Kerr-microresonator optical frequency comb by a dual-parallel Mach-Zehnder interferometer, Naoya Kuse1, Travis C. Briles2,3, Scott B. Papp2,3, Martin E. Ferrmann1, IMRA America Inc, USA; 2Time and Frequency Division, National Inst. of Standards and Technology, USA; 3Dept. of Physics, Univ. of Colorado, USA. We propose and demonstrate a simple technique to generate a stable dissipative Kerr comb and to control \( f_{rep} \) and \( f_{freq} \) of the comb, in which only one device, i.e. dual-parallel Mach-Zehnder interferometer is used.

SF2J.8 • 12:15
Phase-Shifted Bragg Grating Resonators in Thin-Film Lithium Niobate Waveguides, Mohammad Amin Baghban1, Katia Gallo1, Michel Dufresne1; 1KTH Royal Inst. of Technology, Sweden. We demonstrate narrowband integrated filters with 0.23 mm-long phase-shifted Bragg gratings in corrugated single-mode thin-film LiNbO\(_3\) photonic wires, achieving quality factors of 1.2×10\(^6\) and extinction ratios up to 24 dB at telecom wavelengths.

AF2K • Spectrometers & Wavelength Metrology—Continued

AF2K.7 • 12:00
Ultranarrow-band metagrating absorbers for sensing and modulation, Ansong Feng1, Zeyie Yu1, Xiankai Sun1; 1Electronics Engineering and Radiological Sciences, Univ. of Michigan, USA; 2Center for Ultrafast Optical Science, Univ. of Michigan, USA; 3Nuclear Engineering and Radiological Sciences, Univ. of Michigan, USA. Pulsed amplification at 2.7 \( \mu \)m in Er:ZBLAN LMA fibers was explored demonstrating up to 194\( \mu \)J in 9.7\( ns \), the highest short-pulse energies from these mid-IR fibers. We also measured fiber damage threshold and 650\( \mu \)J of stored energy.

AF2K.8 • 12:15
Spherical mirrors based compact multipass cell with dense astigmatic-like spot pattern, Arkadiusz Hudzikowski1, Aleksander Gluszek1, Karol Krimpek1, Jaroslav Sotor1, 1Wroclaw Univ. of Science and Techn., Poland. We propose a 2.72\( \mu \)m, 210\( \mu \)J and 650\( \mu \)J of stored energy. We also measured fiber damage threshold.

AF2K.9 • 12:15
Ultrafast Thulium-Doped Fiber Laser System at 1.8 \( \mu \)m for Multiphoton Microscopy, Yutaka Nomura1, Takao Fuji1; 1Inst. for Molecular Science, Japan; 2JST, PRESTO, Japan. An ultrafast laser system at 1.8 \( \mu \)m is developed based on thulium-doped ZBLAN fibers. The generated pulses are used in a three-photon microscope to observe the images of fluorescent beads for \(~650\) nm.
### SF2N • RF Photonics—Continued

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<tr>
<th>Session</th>
<th>Time</th>
<th>Title</th>
<th>Authors</th>
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<tbody>
<tr>
<td>SF2N.7</td>
<td>12:00</td>
<td>Brillouin-loss Enabled Noise Figure Improvement for Chip-based Tunable Microwave Photonic Filters, Yiwei Xie, Amol Choudhary, Yang Liu, David Marpaung, Khu Vu, Pan Ma, Duk-yong Choi, Stephen Madden, Benjamin J. Eggleton; 1Univ. of Sydney, Australia; 2Univ. of Twente, Netherlands; 3Australian National Univ., Australia. We compare the noise figure (NF) of chip-based tunable microwave photonic band-pass filters using stimulated Brillouin scattering (SBS) gain and loss responses, respectively. The filter using SBS loss scheme exhibits 10-dB lower NF than that using SBS gain scheme.</td>
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<td>SF2N.8</td>
<td>12:15</td>
<td>Rapid Wideband RF Subsampling and Disambiguation Using Dual Combs, Mohammed S. Al Alshaykh, Daniel E. Leard, Jason D. McKinney; 1School of Electrical and Computer Engineering, Purdue Univ., USA; 2Birck Nanotechnology Center, Purdue Univ., USA. Using two electro-optic combs with an offset in the repetition rate, we disambiguate RF signals over 20 Nyquist bands. The setup doesn’t require a pulse compression stage and can be readily integrated using existing technology.</td>
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### SF2O • Optoelectronic Materials—Continued

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<th>Session</th>
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<tr>
<td>SF2O.7</td>
<td>12:00</td>
<td>High-Performance Mid-Infrared Crystalline Bragg Mirrors at 4.5 µm, Georg Winkler, Lukas Perner, Gar-Wing Truong, Dominic Bachmann, Aline S. Mayer, Jakob Fellinginger, Tobias Zederbauer, David Follman; 1Christian Doppler Lab for Mid-IR Spectroscopy and Semiconductor Optics, Faculty Center for Nano Structure Research, Faculty of Physics, Univ. of Vienna, Austria; 2Crystalline Mirror Solutions LLC, USA; 3Crystalline Mirror Solutions GmbH, Austria. We present state-of-the-art mid-IR high-reflectivity low-loss mirrors at 4.55 µm based on substrate-transferred crystalline coatings. Transmission losses of 150 ppm and excess losses of &lt;50 ppm are demonstrated via cavity-ringdown and direct transmission measurements.</td>
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<td>SF2O.8</td>
<td>12:15</td>
<td>Nd:Y$_2$O$_3$ Transparent Ceramics: Fabrication and Laser Performance, Daniela Yin, Jun Wang, Zhi Li, Martin Richardson, Dingyuan Tang; 1Nanyang Technological Univ., Singapore; 2Univ. of Central Florida, USA. 0.6 at% Nd:Y$_2$O$_3$ transparent ceramics with high optical quality were fabricated by vacuum sintering plus hot isostatic pressing. High efficiency CW laser operation at 1.08 and 1.36 µm were demonstrated.</td>
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12:30–14:00  Lunch Break (On your Own)
FF3A.1 • 14:00
Inverse Designed Diamond Nanophotonics, Constantin Dory1, Dries Verbruggen1, Kyoung Won1, Neil Sapra1, Alisson E. Rugar1, Shuo Sun1, Danil Lukin1, Alexander Y. Piggott1, Linda Jingyuan Zhang1, Marina Radulaski2, Konstantinos Lagoudakis3, Logan Sui1, Jelena Vuckovic1;1 Stanford Univ., USA. Combining inverse design optimization methods and quasi-isotropic etching techniques, we develop compact, flexible and efficient photonic components in diamond for applications in quantum technologies.

FF3A.2 • 14:15
Waveguide-coupled Localized Excitons From a WSe$_2$ QD monolayer on a Silicon Nitride Photonic Platform, Frederic Peykins1, Chitraleena Chakrabarty1, Muhammad Muneer2, Dries Van Thourhout1, Dirk R. Englund1;1 MIT, USA; 2 ETH Zurich, Switzerland. We demonstrate the coupling of localized excitons from a WSe$_2$ QD monolayer into a silicon nitride waveguide by measuring the waveguide-coupled fluorescence, paving the way towards scalable fabrication of on-chip single photon sources.

FF3A.3 • 14:30
Deterministically coupled quantum emitters in a hexagonal Boron Nitride hybrid microcavity system, Nicholas Proscia1, Harishankar Jayakumar1, Zav Shotan1, Gabriel Lopez-Morales2, Xiaochen Ge2, Weidong Lopez-Morales1, Vinod Menon1;1 CUNY City College of New York; 2 Center for Optical Technologies, Germany. We demonstrate a hybrid microphotonic device integrating a thin film of hexagonal Boron Nitride containing quantum emitters with Si$_3$N$_4$ microdisk resonators. We deterministically drive these emitters via strain within a microdisk’s evanescent field.

FF3B.1 • 14:00
Light Propagation in Temporally Disordered Media, Yonatan Sharabi1, Eran Lustig1, Mordechai Segev1;1 Technion, Israel. We study light propagation in a medium with a homogeneous refractive index that varies randomly in time. We find that, in stark contrast to spatial disorder, temporal disorder causes exponential increase of the light intensity.

FF3B.2 • 14:15
Spatio-temporal response of random media beyond ensemble averages, Ruotao Wu1, Anisote Dogaru1;1 CREOL, USA. We demonstrate measurements of full spatio-temporal correlations between photon path lengths in highly scattering media. The dependence on the structural characteristics of the medium and the connection to memory-like phenomena are discussed.

FF3B.3 • 14:30
Memory effect of transmission eigenchannels in random media, Hasan Yilmaz1, Chia Wei Hu1, Alexey Yamalov1, Hui Cao1;1 Yale Univ., USA; 2 Dept. of physics, Missau Univ. of Science & Technology, USA. We have experimentally and numerically studied the angular memory effect of transmission eigenchannels in random media. High-transmission channels have a larger range of memory effect than any input wavefront, thus are robust against sample tilt.

FF3C.1 • 14:00
Invited: Probing Electronic Binding Potentials with Attosecond Photoelectron Wavepackets, Robert R. Jones1, Dietrich Kiesewetter1, Antoine Camper2, Stephen B. Schoun2, Pierre Agostini3, Louis F. DiMauro3;1 Univ. of Virginia, USA; 2 The Ohio State Univ., USA. We show that by looking at the polarization of photoelectron wavepackets, we can mine the coherence length of quasiparticles.

FF3C.2 • 14:30
Subcycle dynamics of ionization revealed via polarization of lowest harmonics, Ihar Babushkin1, Alvaro G. Galan1, Virgilijus Vaicaistas1, Anton H. Husakou1, Felipe Morales2, Ayhan Demircan2, Jose Andrade2, Uwe Morgner3, Misha Ivanov1;1 Max-Born Inst., Germany; 2 Inst. of Quantum Optics, Univ. of Hannover, Germany; 3 Laser Research Center, Vilnius Univ., Lithuania; Hannover Centre for optical Technologies, Germany. We show that by looking at the polarization of lowest (0th and 3d) harmonics of the atomic response it is possible to determine details of attosecond-scale ionization dynamics including ionization time and its temporal asymmetry.

FF3D.1 • 14:00
Measurement of excitation coherence lengths using multi-spatial-mode four-wave mixing, Torben L. Purz1,2, Eric Martin1, Zhaorong Wang1, Hui Deng1, Steven T. Cundiff1, Dept. of Physics, Univ. of Michigan, USA; 2 Dept. of Physics, Univ. of Goettingen, Germany. We develop a multi-spatial-mode four-wave mixing (FWM) experiment to determine the coherence length of quasiparticles. We present evidence for nonlocal effects in a microcavity polarization system that affect nonlinear optical processes such as FWM.

FF3D.2 • 14:15
Nonlinear Plasmonic Enhancement with Graphene Heterostructures, Irati Alonso Babushkin1,2,1 Max-Born Inst., Germany; 2 Inst. of Quantum Optics, Univ. of Hannover, Germany; 3 Laser Research Center, Vilnius Univ., Lithuania; Hannover Centre for optical Technologies, Germany. We show that by looking at the polarization of lowest (0th and 3d) harmonics of the atomic response it is possible to determine details of attosecond-scale ionization dynamics including ionization time and its temporal asymmetry.

FF3D.3 • 14:30
Spectral and angular dependence of the giant nonlinear refraction of Indium Tin Oxide excited at epsilon-near-zero, Sepehr Benis1, Natalia Mumen1, David J. Hagan1, Eric W. Van Stryland2;1 Univ. of Central Florida, CREOL, USA; 2 SLAC National Accelerator Laboratory, USA. We report beam-deflection measurements of indium tin oxide excited around epsilon-near-zero (ENZ), but probed far from ENZ. Nonlinear refraction is very large even far from ENZ and enhanced as the excitation is tuned through ENZ.

Executive Ballroom 210A
FF3A • Single-Photon Collection & Characterization
President: Marcelo Davanco; NIST, USA

Executive Ballroom 210B
FF3B • Disordered Media
President: To Be Announced

Executive Ballroom 210C
FF3C • Attosecond Dynamic Imaging
President: Shambhu Ghimire; SLAC National Accelerator Laboratory, USA

Executive Ballroom 210D
FF3D • Nonlinear & Quantum Effects
President: To Be Announced
SF3E.1 • 14:00
20 MW Mamyshev Oscillator featuring LMA-PCF, Wu Li1, Ruoyu Liao1, Jun Zhao1, Jiahua Cui1, Youjuan Song1, Chingyue Wang1, Minglie Hu1, Tianjin Univ., China. We demonstrate a Mamyshev oscillator featuring large-mode-area photonic crystal fibers (LMA-PCF). The laser generates over 1 μJ pulses which can be dechirped down to 41 fs, leading to pulse peak powers of ~20 MW.

SF3E.2 • 14:15
Fiber oscillator mode-locked using a novel scheme for Nonlinear Polarization Evolution in Polarization Maintaining fibers, Jan Szczepanek1, Tomasz Kardas1, Bernard Pichal1, Yuriy Stepanenko1, 1Inst. of Experimental Physics, Faculty of Physics, Univ. of Warsaw, Poland; 2Fluence sp. z o. o., Poland; 3Inst. of Physical Chemistry PAS, Poland. We present an environmentally stable ultrafast oscillator employing a novel implementation of a multi-segment All Polarization-Maintaining-Fiber Nonlinear Polarization Evolution reflective artificial Saturable Absorber. Oscillator emits 1 nJ pulses with duration of 230 fs after compression.

SF3E.3 • 14:30
Power Scaling of Ultrafast Lasers Oscillators: 350-W Output Power Sub-ps SESAM-ModeLocked Thin-Disk Laser, Francesco Saltarelli1, Ivan J. Graumann1, Lang Lukas2, Dominik Bauer2, Christopher Phillips2, Ursula Keller1, 1ETH Zurich, Switzerland; 2TRUMPF Laser GmbH, Germany. Combining vacuum operation, large pump spot, and multiple passes on the gain medium, we designed a high-power thin-disk oscillator with a record 350-W average power, 40 μJ pulses. We expect 500-W-level modelocking in the near future.

JF3F.1 • 14:30
Object Recognition with Optical Coherence, Ken Xingze Wang1, 1Huazhong Univ. of Science and Technology, China. Computer vision systems could be improved by using wave optics instead of geometrical optics. We show that some object recognition tasks are made possible by using optical coherence.

JF3F.2 • 14:15
Femtosecond-Laser-Induced Blisters in Polymer Thin Films and Application as Microlenses, Alan T. Godfrey1,2, L.N. Deepak Kallepalli1, Jesse Ratté1,2, Paul B. Corkum1,2, 1uOttawa, Canada; 2National Research Council of Canada, Canada. We present the phenomenon of blister formation by nonlinear absorption of femtosecond pulses in polyimide films, characterized by atomic force microscopy. We demonstrate a novel implementation of blisters as microlenses.

JF3F.3 • 14:30
Micron-scale ‘ink-jet’ created by optical vortex ablation, Ryosuke Nakamura1, Muneaki Iwata1, Akhiro Kaneko1, Kohei Toyoda1,2, Katsuhiko Miyamoto1,3, Chiba Univ., Japan; 1RICOH CT&P Division, Japan; 2MCR Chiba Univ., Japan. We have demonstrated the creation of a micron-scale ‘ink-jet’ by employing optical vortex laser ablation. The OAM then provides a spin of the melted ink, thereby stabilizing the formation of the ‘ink-jet’.

SF3G.1 • 14:00
Er and Yb femtosecond laser-induced melting and shaping of indium nanostructures on silicon wafers, Ali Azarm1, Nasser Peyghambarian1, Farhad Akhound1,2, Univ. of Arizona, USA. We use erbium and ytterbium femtosecond lasers to melt and shape semi-spherical nanostructures by high spatial frequency laser induced periodic surface structures into linear microstructures of 2 μm long in the direction of laser polarization.

SF3G.2 • 14:15
Femtosecond-Laser-Induced Blisters in Polymeric Films, Ayman N. Kamel1, Houssen El Dinani2, Marco Casale2, Sébastien Kerdelv1, Carole Scoquet-Clerc3, Minhtao Pu1, Leif K. Oxenløwe1, Kresten Yrind1, Jesper Lægsgaard1, Corrado Sciancalepore1, 1DTU, Denmark; 2CEA-LETI, France. We present the generation of a second harmonic wave and a clustered comb at 1 μm from a telecom wavelength pump in a dispersion engineered SiN microresonator.
SF3J.1 • 14:00
Update on BELLA Center’s Free-Electron Laser driven by a Laser-Plasma Accelerator, Fumika Isono1,2, Jeroen Van Tilborg1, Sam Barber1, Cameron Geddes1, Hai-En Tsai1, Carl Schroeder1, Wim Leemans1,2; Lawrence Berkeley National Lab, USA. We report a new S-Hz 100 TW laser, producing first electron beams (135 MeV), and built a dedicated FEL beamline, the status of which we report here.

SF3J.2 • 14:15
Laguerre-Gaussian Mode Laser Heater for Microbunching Instability Suppression in Free Electron Lasers, Jingyi Tang1, Wei Liu1, Randy Lemons1, Sharon Vetter1, Timo-thy Maxwell1, Franz-Josef Deckert1, Alberto Lutman1, Jacek Krywinski1, Gabriel Marcus1, Stefan Moeller1, Daniel Ratner1, Zhirong Huang1, Sergio Carabp2; SLAC National Accelerator Lab, USA. We report on the use of a Laguerre-Gaussian transverse mode in the LCLS laser heater resulting in better suppression of microbunching instability.

SF3J.3 • 14:30
Psychographic Characterization of an Intense High-Harmonic-seeded Femtosecond Soft-Xray Laser, Michael Zurch1,2, Frederik Tuitej1, Tobias Helk1, Julien Gautier1, Stéphane Sebban1, Christian Tuitje3, Tobias Helk3, Julien Gautier4, Stefan Möller1, Daniel Ratner1, Hai-En Tsai1, France; 1Laboratoire Barber1, 2Univ. Electronic Sci. & Tech. of China, Beijing, China; 3Laboratoire Barber1, 4Laboratoire Barber1, France. We demonstrate a non-perturbative method capable of detecting mid-infrared molecular fingerprints without the need for spectrometry. We leverage dielectric metasurfaces featuring ultra-sharp resonances at discrete frequencies, enabling us to sample absorption signatures over the mid-IR spectral range.

AF3K.1 • 14:00
Full-color, multi-plane image projection with mobile-phone flashlight & a multi-level diffraction hologram, Monjurul Meem1, Rajesh Menon1, Aaprit Majumder1; 1Univ. of Colorado at Boulder, USA. We demonstrate a directional curvature sensing using a multi-core fiber Bragg grating (FBG). The FBGs having almost the same Bragg wavelengths are discriminated by the distance measurement technique using two-photon absorption process in a Si-APD.

AF3K.2 • 14:15
Holographic Speckle-Based Authentication Paradigm, Yoav Blau1, Ofer Bar-On1, Yael Haneni1, Amir Boag1, Jacob Scheuer1, Tel Aviv Univ., Israel. An approach for a physical authentication scheme is proposed relying on the irreversibility and nonconvex nature of computer-generated holograms. This is demonstrated by proof-of-principle meta-holograms projecting uniquely speckled 2D barcode images.

AF3K.3 • 14:30
Compressive Imaging with a Stochastic Spatial Light Modulator, Jason Schaake1, Raphael C. Pooser2, Stephen Jesse4; 1The Univ. of Melbourne, Australia; 2Nonlinear Physics Centre, Research School of Physics and Engineering, Australian National Univ., Australia; 3Research School of Physics and Engineering, Australian National Univ., Australia. We present a stochastic analog spatial light modulator designed for non-optical authentication schemes. Such devices could be useful for secure documents.

SF3L.1 • 14:00
Directional Curvature Sensing Using Multicore Fiber Bragg Grating and Two-Photon Absorption Process in Si-APD, Yosuke Tanaka1, Tetsuya Abe1, Hiromasa Miyazawa2, 1Tokyo Univ of Agriculture and Technology, Japan. We demonstrate a directional curvature sensor using a multicore fiber Bragg grating (FBG). The FBGs having almost the same Bragg wavelengths are discriminated by the distance measurement technique using two-photon absorption process in a Si-APD.

SF3L.2 • 14:15
Embedded-core optical fiber for distributed pressure measurement using an autocorrelation OFDR technique, Rodrigo M. Gerosa1, Jonas H. Osindo1, Daniel Lopez-Cortes2, Cristiana M. Cordeiro2, Christiano J. de Matos2; 1Instituto de Física “Gleb Wataghin”, Universidade Estadual de Campinas, Brazil; 2MackGrape – Graphene and Nanomaterials Research Center, Mackenzie Presbyterian Univ., Brazil. We present a pressure sensor using an optical frequency domain reflectometer and a simplified microstructured fiber. High sensitivity, ease of fabrication and distributed sensing makes the proposed configuration a promising technique for pressure sensing applications.

SF3L.3 • 14:30
Dynamic coherent optical time-domain reflectometry with pulse compression, Ji Xiong1, Yue Wu1, Ziran Wang1, Yun Jiang2; 1Univ. Electronic Sci. & Tech. of China, Beijing, China. We report a novel COTDR using chirped pulse compression. By only adjusting the sweep range of the chirped pulse, the spatial resolution is changed from 5 m to 0.5 m, and dynamic strain sensing is also demonstrated.

AF3K • Imaging, Microscopy, & Specialized Detection
AF3K.1 • 14:00
Full-color, multi-plane image projection with mobile-phone flashlight & a multi-level diffraction hologram, Monjurul Meem1, Rajesh Menon1, Aaprit Majumder1; 1Univ. of Colorado at Boulder, USA. We demonstrate a directional curvature sensing using a multi-core fiber Bragg grating (FBG). The FBGs having almost the same Bragg wavelengths are discriminated by the distance measurement technique using two-photon absorption process in a Si-APD.

AF3K.2 • 14:15
Holographic Speckle-Based Authentication Paradigm, Yoav Blau1, Ofer Bar-On1, Yael Haneni1, Amir Boag1, Jacob Scheuer1, Tel Aviv Univ., Israel. An approach for a physical authentication scheme is proposed relying on the irreversible and nonconvex nature of computer-generated holograms. This is demonstrated by proof-of-principle meta-holograms projecting uniquely speckled 2D barcode images.

AF3K.3 • 14:30
Compressive Imaging with a Stochastic Spatial Light Modulator, Jason Schaake1, Raphael C. Pooser2, Stephen Jesse4; 1The Univ. of Melbourne, Australia; 2Nonlinear Physics Centre, Research School of Physics and Engineering, Australian National Univ., Australia; 3Research School of Physics and Engineering, Australian National Univ., Australia. We present a stochastic analog spatial light modulator designed for non-optical authentication schemes. Such devices could be useful for secure documents.
**Coupling Regime, Quantum Electron-Photon Entanglement in the Strong-FF3M.2 • 14:15**

Molecular Spectroscopy, Javier Aizpurua1; Quantum Approaches to Atomic-Scale Plasmon-Enhanced

Analyses are presented. The interaction between cavity-photons and electrons at arbitrary coupling strengths, and propose a road-map to approach this regime between cavity-photons and electrons at arbitrary coupling strengths, and propose a road-map to approach this regime experimentally. As an example, we explore photon-mediated entanglement of two free electrons.

**Quantum Electron-Photon Entanglement in the Strong-Coupling Regime, Ofer Kfir1, Claus Ropers1; Univ. of Göttingen, Germany.** We investigate coherent interactions between cavity-photons and electrons at arbitrary coupling strengths, and propose a road-map to approach this regime experimentally. As an example, we explore photon-mediated entanglement of two free electrons.

**Hybrid Integration of Multi-band, Tunable External-Cavity Diode Lasers for Wide-Angle Beam Steering, Yeyu Zhu1,2, Vahid Sandoghdar1,2; Univ. of Tokyo, Japan.** We demonstrate a multi-wavelength mode-locked fiber laser using synthetic single-crystal diamond as a saturable absorber which could achieve multi-wavelength output and a high-speed waveguide-integrated photodetector is demonstrated. The proposed photodetector features a measured 3 dB bandwidth of 25 GHz around 1310 nm.

**Erb- and Tm-doped mode-locked fiber laser with a broadband, microfiber-based MOF saturable absorber, Qian Zhang1, Meng Zhang1, Xinxin Jin1, Quanyu Jiang1, Xiantao Jiang2, Han Zhang2, Zheng Zheng2, Behang Univ., China; Shenzhen Univ., China. We demonstrate mode-locked pulse generation in erbium-doped and thulium-doped fiber lasers by using a microfiber-based metal–organic frameworks saturable absorber. Our results highlight the applicability of such nanomaterial as a broadband SA for ultrafast photonic applications.

**Thulium-doped mode-locked fiber laser with MXene saturable absorber, Quanyu Jiang1, Meng Zhang1, Qian Zhang2, Xinxin Jin1, Qing Wu1, Xiantao Jiang2, Han Zhang2, Zheng Zheng2, Behang Univ., China; Shenzhen Univ., China. We demonstrate an all-fiber thulium-doped mode-locked laser by using MXene as the saturable absorber, producing 2.11 ps pulses at 13.45 MHz repetition rate. Our work highlights the potential of MXene-based devices for future photonic technologies.

**Invited**

Quantum Approaches to Atomic-Scale Plasmonic Molecular Spectroscopy, Javier Aizpurua1; Mat Physics Ctr. CSIC-UPV and DIPC, Spain. The interaction between molecular excitations and plasmons can enhance and modify the spectral properties of a molecule. In this context, we address the importance of quantum effects produced by atomic-scale hot spots.
We demonstrate a Kerr-lens mode-locked Ti:sapphire laser using only three optical elements. The repetition rate of 20 GHz was achieved with the pulse duration of 120 fs.

Three-element cavity enables Kerr-lens mode-locking at 20-GHz repetition rate, Shota Kimura, Shuntaro Tanii, Yohi Kobayashi; The Univ. of Tokyo, Japan. We propose a new cavity design for a compact Kerr-lens mode-locked laser using only three optical elements. The repetition rate of 20 GHz was achieved with the pulse duration of 120 fs.

Graphene mode-locked Tm,Ho:CLNGG SF3E.6 • 15:00

We demonstrate a blue-diode pumped Kerr-Lens Mode-Locked Tm,Ho:CLNGG laser with 70-fs pulse duration, Yongguang Zhao, Weidong Chen, Valentin Petrov; Li Wang, Yicheng Wang, Zhongben Pan; Xiaojun Dai, Hualei Yuan; Norbert Modsching, Germany; 1Max-Born Inst., Germany; 2China Academy of Engineering Physics, China; 3Dept. of Physics, South Korea Advanced Inst. of Science and Technology (KAIST), South Korea (the Republic of); 4ITMO Advanced Inst. of Science and Technology, Russia; 5Instituto De Optica 'Daza De Valdes', Spain; 6Jiangsu Normal Univ., China. We report on a mode-locked Tm,Ho:CLNGG laser employing graphene as a saturable absorber. Pulses as short as 70 fs, i.e., 10 optical cycles, are generated at 2093 nm with a repetition rate of ~89 MHz.

Deep Imaging Cytometry. Yueqin Li, Alta Mahjourzad; Rahnam Jalali; Kayvan Niaz; UCLA, USA; Nantworks, USA. We describe a new implementation of our deep learning time-stretch imaging flow cytometry which avoids data pre-processing and feature extraction. The neural network classifies cancer cells by directly processing the raw temporal data.

Rapid Femtosecond Laser 3D microfabrication using Focal Field Engineering, Yan Li, Dong Yang, Lipu Liu, Hong Yang, Qihuang Gong; Peking Univ., China. We realize the single-exposure and the single-scan femtosecond laser microfabrication of 3D microstructures by the 3D focal field intensity engineering. The two rapid techniques are further integrated to fabricate a microstructure.

Microwatt-Level Soliton Frequency Comb Generation in Microresonators Using an Auxiliary Laser, Shuangyou Zhang, Jiona Iwasa, Ryo Shimizu; National Physical Lab, UK. We report a simple and robust method to generate soliton frequency combs in microresonators assisted by an auxiliary laser. Our method significantly enhances the soliton access range and enables threshold powers down to 780 microwatt.
ments with high temporal resolution. Recent

Holger Schlarb 1; Marie Kristin Czwalinna 1, Ingmar Hartl 1,

Lutz Winkelmann 1, Ingmar Hartl 1; Frank Ludwig 1, Uros Mavric 1, Jost Mueller 1,

Flexible Pulse-Shape Picosecond Front-End for XFEL Photocathode Lasers, Chen Li1,

Chen Li1,2, Chiao-Yun Chang 1, Min-Hsiung Shih1,2, Chiao-Yun Chang 1, Min-Hsiung Shih1,2,

for XFEL Photocathode Lasers, Chen Li1,2, Chiao-Yun Chang 1, Min-Hsiung Shih1,2,

optimum performance, temporally shaped laser pulses are desired. Here we present a

Feedback loop this timing error could be

electron bunch arrival time changes. With a

laser pulses were identified using balanced
drifts of the European XFEL photocathode

Accelerators, Precision Synchronization for large scale

Electrons (XFEL) require femtosecond

synchronization over kilometer distance
to carry-out complex X-ray photon experi-
ments with high temporal resolution. Recent
implementations are summarized in this talk.

Optical Chirality Tunable and Reversible
Plasmonic Chiral Metasurfaces on Flexible
PDMS Substrate, Hsiao-Ting Lin1, Yao-Yu
Hsu1,2, Chiao-Yun Chang1, Min-Hsiung Shih1,2,

SU Research Center for Applied Sciences, Ac-

ademia Sinica, Taiwan; 2Dept of Photonics and

Instr. of Electro-Optical Engineering, National
Chiao Tung Univ., Taiwan. We demonstrated a
flexible plasmonic chiral metasurface which
realized optical chirality both tunable and re-
versible. The controllable circular dichro-
ism from -25% to +30% was achieved in the
same metasurface under different stretch
situations.

Dispersion-Engineered Metasurfaces for
Aberration-Corrected Spectroscopy, Alexander Y. Zhu1, Wei-Ting Chen1, Jared
Sisler1,2, Koralos M. Yousef1,2, Eric Lee1,2,

Yao-Wei Huang1, Cheng-Wei Qu1, Federico
Capasso1,3, Harvnd Univ., USA; 3Univ. of Wa-
terloo, Canada. 4College of Biotechnology,
Miss Univ. of Science and Technology, Egypt;
5National Univ. of Singapore, Singapore. We report a miniature aberration-corrected
spectrometer comprised of dispersion-
engineered off-axis metasurface lenses. It
possesses close to diffraction-limited spot
diameters across 200 nm in the visible and has
nanometer spectral resolution, despite a 4cm
beam-propagation distance.

Metasurface-based Waveplates Demonstrated
on 300 mm Si CMOS Platform, Yuan
Dong1, Zhenggi Xu1, Jinchao Tang1, Yung-
Hsiang Fu1, Qizhe Zhong1, Vladimir Blinov1,

Ting Hu1, Yu Li1, Shiyang Zhu1, Qunying Lin1,

Ming-Hsiung Shih1,2, Chiao-Yun Chang 1, Min-Hsiung Shih1,2,

optical fingerprint region.

Time-stretch Network Analyzer for Single-
Photon Characterization of Electronic Devices,
Zhuyao Bai1, Cejo K. Lonappan1, Asad M.
Madni1, Bahram Jalali1,2, Electrical and
Computer Engineering, Univ. of California,
Los Angeles, USA. An optically-assisted
single-shot instrument with automated Tik-

Yuan Fu1, Jinchao Tong1, Yuan-

A QCL modulator based on a

Smart Photonics and Applications, Brussels,
Belgium. We demonstrate a unique 300 nm
Si CMOS platform that allows femtosecond
Timing. A drive current and detuning
response of electronic devices is

achieved near 1.6 μm-wavelength.

Sub-nanosecond Pulsed Quantum Cascade
Laser Driver, Mateusz Zbik1; WIGO System
S.A., Poland. A QCL modulator based on a

pair of pulsed HEMT transistors was designed to
test the high-speed WIGO System HgCdTe
photodetectors response time. A drive cur-
rent and optical pulse width of approximately
1A and 100ps, respectively, was achieved.

Shift Sensor Using Chiral Long-Period
Grating Written in the Double-Cladding Fi-
er, Chen Jiang1, Xiang Li1, Chengbo Mou1,

Tingyun Wang1; 2Shanghai Jiao Tong Univ., China. Here, we demonstrated a water-immersible
90-meter-long fully-integrated fiber system that allows distributed quantum magnetic sensing over
distances with a sensitivity of 63 nT Hz-1/2. Applications include remote detection of
ferrous metals, geophysics, and biosensing.
**Nanophotonic Systems—Continued**

<table>
<thead>
<tr>
<th>Session</th>
<th>Title</th>
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<tbody>
<tr>
<td>FF3M.4 • 15:00</td>
<td>Tip Enhanced Strong Coupling of a Single Emitter at Room Temperature, Molly A. May1, Kyoung-Duck Park2, Haixu Leng1, Jaron A. Kropp1, Theodosia Gougos2, Matthew Felton1, Markus B. Raschke1, 'Dept. of Physics, Dept. of Chemistry, and JILA, Univ. of Colorado Boulder, USA; 2Dept. of Physics, Univ. of Maryland, USA. We demonstrate an efficient optical amplifier that can achieve and control strong coupling to a single quantum dot under ambient conditions using tip-enhanced photoluminescence spectroscopy.</td>
</tr>
<tr>
<td>FF3N.4 • 14:45</td>
<td>Accousto-Optic Modulator based on the Integration of Arsenic Trisulfide Photonic Components with Lithium Niobate Surface Acoustic Waves, Mdshofiqulislam Khan1, Ashraf Mahmoud1, Lutong Cai1, Mohamed Mahmoud1, Tamal Mukherjee1, James Barn1, Gianluca Piazza1, 'Carnegie Mellon Univ., USA. An acousto-optic modulator formed by an Arsenic Trisulfide (As2S3) Mach-Zehnder interferometer placed inside a surface acoustic wave cavity on a Lithium Niobate (LN) wafer is demonstrated for the first time.</td>
</tr>
<tr>
<td>SF3O.6 • 14:45</td>
<td>High Power Tolerant SWCNT-BNNT Saturable Absorber for Laser Mode-Locking, Pengtao Yuan1, Zheyuan Zhang1, Shoko Yokokawa1, Yongjia Zheng2, Lei Jin1, Sze Y. Set1, Shigeo Maniyama1, Shinya Yamashita1, 'Research Center for Advanced Science and Technology, Univ. of Tokyo, Japan; 2Departments of Mechanical Engineering, The Univ. of Tokyo, Japan. We demonstrate a mode-locked fiber laser using BN-wrapped SWCNT as a high power-tolerant saturable absorber. The new saturable absorber shows a significantly higher optical damage threshold and a great potential for various high-power optical applications.</td>
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<tr>
<td>SF3O.7 • 15:00</td>
<td>Complete Photonic Bandgap in Lowest Index Contrast Inverse Rod-Connected Diamond Structured Chalcogenides, Lifeng Chen1,2, Katina Morgan1, Chung-Che Huang1, Ying-Lung Daniel Ho1, Mike P. C. Tavernel1, Daniel W. Hewak3, John G. Rarity1, 'Univ. of Bristol, UK; 2Sun Yat-Sen Univ., China; 3Univ. of Southampton, UK. We present an inverse rod-connected diamond structure showing a complete bandgap with refractive index contrast down to nsw/nse &gt; 1.9. The structures were fabricated using a low-temperature chemical vapor deposition process, via a single-inversion technique.</td>
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**Modulators, Phase Arrays & Photodetectors—Continued**

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<td>SF3N.5 • 15:00</td>
<td>Metals-enabled Low-power Solid-state 2D Beam Steering, You-Chia Chang1,2, Min-Chul Shin1, Christopher T. Phare1, Steven A. Miller1, Euijae Shim2, Michal Lipson1, 'Dept. of Photonics and Inst. of Electro-Optical Engineering, National Chiao Tung Univ., Taiwan; 2Electrical Engineering, Columbia Univ., USA. We demonstrate a platform for low-power solid-state beam steering in 2D with a single wavelength. This platform, based on a metals and a switchable emitter array, enables steering of 12.4° × 26.8° using less than 83 mW.</td>
</tr>
<tr>
<td>SF3N.5 • 15:15</td>
<td>Tapered atomic cladded nano waveguide for fine control of light-atom interaction, Roy T. Zektzer1, Noa Mazurski1, Yefim Karnieli3, Nicholas Rivera2, Ady Arie3, Ido Kaminer1; 'Israel; 2MIT, USA; 3Tel Aviv Univ., Israel. We experimentally demonstrate the chip-scale integration of tapered atomic cladded nano waveguides and rubidium atoms. The optical mode interaction volume with the atoms is controlled by the tapered nano waveguides and rubidium atoms. The optical light-atom interaction, Barash1, Uriel Levy1; 1Iowa State Univ., USA. We report a novel nano-laser, Dinh Ngo1, Mingjun Chen1, Nathan Augenbraun1, Anishkumar Soman1, Xiangyu Ma1, Thomas Kanan1, Matthew Doty1, Tingyi Gu1, 'Univ. of Delaware, USA; 2Univ. of Rochester, USA. Direct laser inscription creates waveguide structures on chalcogenide thin film. Results of GeSb2Te2, and Ge5Sb2Se3, are compared by varying laser powers and translation speeds.</td>
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**Quantum Interactions in Nanophotonic Systems**

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<td>FF3M.5 • 15:15</td>
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</tr>
</tbody>
</table>

** Integration of Nanoimprint and Silver Doping Lithography for Chalcogenide Photonic Crystal Slabs, Le Wei1, Meng Lu1, Liang Dong1; 1University of Delaware, DE; 2University of Delaware, DE. We report a novel nano-fabrication approach that combines the imprinting and silver doping lithography processes to pattern chalcogenide materials. The approach can fabricate 3D nanoscale structures in chalcogenide thin film for nanophotonic devices and sensors. |
FF3A • Single-Photon Collection & Characterization—Continued

FF3A.7 • 15:45
Direct Detection of Quantum Phase Errors in Spatially Multiplexed Transmission Channels, Kai Wang1, Falk Eilenberger2, Alexander Szameit1, Andrey A. Sukhorukov1; 1Nonlinear Physics Centre, Research School of Physics and Engineering, Australian National Univ., Australia; 2Inst. for Physics, Rostock Univ., Germany; 3Inst. of Applied Physics, Abbe Center of Photonics, Friedrich Schiller Univ., Germany; 4Center for Excellence in Photonics, Fraunhofer Inst. for Applied Optics and Precision Engineering IOF, Germany. We introduce a protocol for direct detection of arbitrary continuous phase errors in transmission of multi-photon spatially entangled quantum states, and present a design and experimental evidence for its realization in an integrated photonic circuit.

FF3B • Disordered Media—Continued

FF3B.8 • 15:45
A Novel Phase-Map to Increase the Efficiency of Random Metasurfaces, Hadiseh Nasari1, Matthieu Dupré1, Boubacar Kanté1; 1Dept. of Electrical and Computer Engineering, Univ. of California San Diego, USA. We report on using a statistical approach to obtain a novel phase-map addressing the near-field coupling between elements and improving the efficiency of random metasurfaces compared to the conventional ones designed by periodic phase-map.

FF3C • Attosecond Dynamic Imaging—Continued

FF3D • Nonlinear & Quantum Effects—Continued

FF3D.8 • 15:45
Withdrawn
SF3E • Ultrafast Oscillators—Continued

SF3F • Symposium on Deep-learning Photons: Where Machine Learning & Photonics Intersect III—Continued

SF3G • Laser-Based 2D/3D Micro- & Nano-fabrication—Continued

SF3H • Microresonator Frequency Combs—Continued

**Executive Ballroom 210E**

**Executive Ballroom 210F**

**Executive Ballroom 210G**

**Executive Ballroom 210H**

**CLEO: Science & Innovations**

**Joint**

**CLEO: Science & Innovations**

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**Friday, 14:00–16:00**

**SF3E.7 • 15:45**

Direct Printing of Gold Nano-Particles by Laser Induced Dewetting. Jae Hyuck Yoo1, Nathan Ray1, Hoang Nguyen1, Mike Johnson1, Sal Baxamusa1, Selim Elhadj2, Joseph Mckeown1, Manyalibo J. Matthews1, Eyal Feigenbaum1; LLNL, USA. Arbitrary patterns, consisting of sub-wavelength sized nano particles, are developed by laser induced dewetting of ultrathin gold films (e.g., 5, 7.5, and 10 nm). We demonstrate that the light induced local temperature determines the resulting dewetting structures.

**SF3F.7 • 15:45**

Broadband High-Resolution Scanning of Soliton Micro-Combs. Tong Lin1, Avik Dutt1, Xingchen Ji1, Chaitanya Joshi1, Alexander Gaeta1, Michal Lipson1; Columbia Univ., USA. We demonstrate continuous scanning of a single soliton micro-comb over 88 GHz with an instantaneous linewidth of 60 kHz. We show such a system can acquire spectra of HCN with a high spectral-resolution.

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**SF3G.7 • 15:45**

Direct Printing of Gold Nano-Particles by Laser Induced Dewetting. Jae Hyuck Yoo1, Nathan Ray1, Hoang Nguyen1, Mike Johnson1, Sal Baxamusa1, Selim Elhadj2, Joseph Mckeown1, Manyalibo J. Matthews1, Eyal Feigenbaum1; LLNL, USA. Arbitrary patterns, consisting of sub-wavelength sized nano particles, are developed by laser induced dewetting of ultrathin gold films (e.g., 5, 7.5, and 10 nm). We demonstrate that the light induced local temperature determines the resulting dewetting structures.
SF3I • Lasers for Accelerators—Continued

SF3I.7 • 15:45
High-sensitivity X-ray Optical Cross-Correlator for Next Generation Free-Electron Lasers, Stefan Droste1, Lingjia Shen1, Vaughn E. White1, Elizabeth Diaz-Jacobo1, Ryan Coffee1, Sloan Zohar1, Alexander Reid1, Franz Tavella1, Michael P. Minitti1, Joshua Turner1, Karl Gumerlock1, Alan Fry1, Giacomo Coslovich1; 1SLAC / Stanford, USA. We designed a novel X-ray arrival time monitor that cross-correlates X-ray and 1550 nm optical pulses. We exploit an interferometric detection scheme and etalon effects in thin-film Germanium to achieve unprecedented high sensitivity to soft X-rays.

SF3J • Metasurface & Plasmonic Structures—Continued

SF3J.7 • 15:45
Direct laser writing of optical field concentrators based on chirped three-dimensional photonic crystals, Vygantas Mizeikis1, Zeki Hayran2, Hamza Kurt2, Mirbek Turduev2, Darius Galievicius3, Margirdas Malinauskas3, Saulius Juodkazis3, Kestutis Staliunas4; 1Research Inst. of Electronics, Shizuoka Univ., Japan; 2TOBB Univ. of Economics and Technology, Turkey; 3TED Univ., Turkey; 4Vilnius Univ., Lithuania; 3Swansea Univ. of Technology, Australia; 4Institució Catalana de Recerca i Estudis Avancats, Spain. 3D chirped photonic crystals for applications as electromagnetic field concentrators at optical frequencies were fabricated using Direct Laser Write technique, their optical properties and functionality were characterized experimentally.

AF3K • Imaging, Microscopy, & Specialized Detection—Continued

AF3K.8 • 15:45
Ultrafast UV Metal–Semiconductor–Metal Photodetector Based on AlGaN with a Response Time Below 20 ps, Yiming Zhao1; 1Lab for Laser Energetics, USA. AlGaN UV photodetectors were fabricated with micrometer scale metal–semiconductor–metal structures and tested with an ultrafast 263-nm laser. The best performance devices showed a fast response time of below 20 ps and dark currents below 10 pA.

SF3L • Fiber Sensing—Continued

SF3L.7 • 15:45
Intensity-Interrogated Refractive Index Sensor Based on Exposed-Core Multicore Fiber Mach-Zehnder Interferometer, Shaoxiang Duan1, Bo Liu1, Hao Zhang1, Xu Zhang1, Hailong Liu1, Jixuan Wu1, Yuan Yao1; 1Inst. of Modern Optics, Nankai Univ., China; 2School of Electronics and Information Engineering, China. A temperature-insensitive intensity-interrogated fiber sensor based on exposed-core multicore fiber for refractive index (RI) measurement is demonstrated by etching a seven-core fiber. The RI sensitivity of -287.252 dB/RIU is experimentally achieved.
**FF3M • Quantum Interactions in Nanophotonic Systems—Continued**

**Friday, 14:00–16:00**

**FF3M.7 • 15:45**

Goos-Hänchen shift in edge-reflections of two-dimensional surface polaritons, Ji-Hun Kang1, Sheng Wang1, Feng Wang2; 1Dept. of Physics, Univ. of California Berkeley, USA; 2Dept. of Physics and Astronomy, Seoul National Univ., South Korea (the Republic of). We introduce an analytic model describing the reflection of two-dimensional surface polaritons at an abrupt edge, and reveal that induced evanescent waves during the reflection leads to a Goos-Hänchen phase shift of π/4 in edge-reflections.

**SF3N • Modulators, Phase Arrays & Photodetectors—Continued**

**SF3N.7 • 15:45**

Luneburg Lens for Wide-Angle Chip-Scale Optical Beam Steering, Samuel Kim1, Jamison Sloan1, Josue López1, Dave Kharas2, Jeffrey Herd1, Suraj Bramhavar1, Paul Juodawlkis1, George Barbastathis1, Steven Johnson1, Sorace-Agaskar Cheryl1, Marin Soljacic1; 1MIT, USA. We present a design for a planar generalized Luneburg lens for use in a chip-scale optical beam steering device. The device has a theoretical in-plane field of view of 160° with no off-axis aberrations.

**SF3O • Saturable Absorber Materials & Chalcogenides—Continued**

**SF3O.8 • 15:45**

Growth and Characterization of PbGa2GeSe6: A New Quaternary Chalcogenide Nonlinear Crystal for the Mid-IR, Valeriy V. Badikov2, Dmitrii Badikov2, Li Wang1, Galina S. Shevyrdyaeva1, Vladimir L. Panyutin1, Anna A. Fintisova1, Svetlana G. Sheina2, Valentin Petrov1; 1Max Born Inst., Germany; 2Kuban State Univ., Russia. Non-centrosymmetric crystals of PbGa2GeSe6, grown in large sizes and with good optical quality, are used to characterize its linear (transmission, dispersion, and birefringence) and nonlinear (second order susceptibility) optical properties.