Final Program

MONDAY, 9 JULY 2018

8:00 am–8:30 am **Kohala Promenade**

Breakfast

8:30 am–10:00 am **Waikoloa 1**

Session MA1 **Thermal and Germanium Optical Sources I**

Session Chair Alexei Chelnokov, *CEA Leti, Grenoble, Rhone-Alpes, France*

8:30 am–8:45 am

Welcome and Introductions to the IMIP, Alexei Chelnokov, *CEA Leti, Grenoble, Rhone-Alpes, France*

8:45 am–9:15 am ***(Invited)***

MA1.1 Selective Thermal Emitters Based on Photonic Crystals, Takashi Asano, Takuya Inoue, and Susumu Noda, *Kyoto University, Kyoto, Kyoto, Japan*

We have demonstrated narrowband mid-infrared thermal emitters by combining intersubband transition in multiple quantum wells (MQWs) and band-edge resonant effects of two-dimensional photonic crystal slabs. Ultrafast modulation (~MHz) of thermal emission has been realized by changing the electron density of MQWs using applied electric field.

9:15 am–9:30 am

MA1.2 Optical Tunneling Based Radiative Cooling, Jin-Woo Cho, Yoon Jeong Shin, and Sun-Kyung Kim, *Kyunghee University, Yongin, South Korea*

Here, we design and fabricate cavities-based radiative coolers in which high emissivity is achieved over the full range of mid-infrared wavelengths. By using these radiative coolers, we observe a temperature drop 8 K for a heating Si substrate with an initial temperature at 340 K.

9:30 am–10:00 am ***(Invited)***

MA1.3 Group-IV Epitaxial QDs as Light Emitters for Si Photonics, Moritz Brehm, Martyna Grydlik, Lukas Spindlberger, Patrick Rauter, Thomas Fromherz, and Friedrich Schäffler, *Johannes Kepler University Linz, Linz, Oberosterreich, Austria*

We demonstrate CMOS-compatible lasing from epitaxially-grown Ge quantum dots (QDs) in defect-free crystalline Si. Upon Ge ion-implantation into the QD, point-defects states form at which electrons are strongly confined, leading to optically-direct transitions. These defect-enhanced QDs exhibit shortened carrier lifetimes and negligible PL-quenching above room-temperature.

8:30 am–10:00 am **Kohala 2**

Session MC1 **Topological Lasers and Emitters I**

Session Chair Mikael C. Rechtsman, *Penn State University, University Park, PA, USA*

8:30 am–9:15 am ***(Plenary)***

MC1.1 Experimental Realization of Magnetic-Free Topological Insulator Lasers, Mordechai Segev, Miguel A. Bandres, Gal Harari, *Technion, Haifa, Tel Aviv, Israel,* Steffen Wittek, Demetrio N. Christodoulides, and Mercedeh Khajavikhan, *University of Central Florida, Orlando, FL, USA*

We present the fundamentals of the recently invented topological insulator lasers.

9:15 am–9:45 am ***(Invited)***

MC1.2 Topological Source of Quantum Light, Sunil Mittal and Mohammad Hafezi, *University of Maryland, College Park, College Park, MD, USA*

We present a topological source of quantum light, that is, heralded single photons and correlated photon pairs, implemented using spontaneous four-wave mixing in a coupled ring resonator system. We show that the topological robustness of source manifests as robustness in the spectrum of generated photons.

9:45 am–10:00 am

MC1.3 Tunable Orbital Angular Momentum Microring Laser, Jinhan Ren, William Hayenga, Midya Parto, Fan Wu, Demetrios N. Christodoulides, and Mercedeh Khajavikhan, *University of Central Florida, Orlando, FL, USA*

We demonstrate a microring laser generating vortex beams with topological charge. By implementing a chiral S-bend element inside the active ring and a second-order grating structure around the sidewall, this system could effectively down-convert the large order whispering gallery mode to on-demand OAM values.

8:30 am–10:00 am **Kohala 3**

Session MD1 **Networks & Applications**

Session Chair Michael Brodsky, *US Army Research Laboratory, USA*

8:30 am–9:00 am ***(Invited)***

MD1.1 Quantum Connections, Rodney Van Meter, *Keio University, Fujisawa, Kanagawa, Japan*

Real-world operation of quantum repeater networks will require a protocol for establishing connections between two nodes. Such connections require choosing a path, deciding how many rounds of purification are necessary, and more. Such decisions also depend on the planned use of the generated entanglement.

9:00 am–9:30 am ***(Invited)***

MD1.2 Cryptographic and Non-Cryptographic Network Applications and Their Optical Implementations, Juan Miguel Arrazola, Ashutosh Marwah, Benjamin Lovitz, *University of Waterloo, Waterloo, Ontario, Canada,* Dave Touchette, and Norbert Lütkenhaus, *University of Waterloo, Waterloo, Ontario, Canada and Perimeter Institute for Theoretical Physics, Waterloo, Ontario, Canada*

We report on optical realizations of other cryptographic and non-cryptographic protocols that demonstrate a quantitative advantage of quantum communication. These include the comparison of data and a scheduling algorithm.

9:30 am–10:00 am ***(Invited)***

MD1.3 Quantum Interference Enables Constant-Time Information Processing, Magdalena Stobińska, *University of Warsaw, Warsaw, Poland*

We report a one-step computation of a fractional Kravchuk-Fourier transform well-suited to finite string processing. Unlike its previous demonstrations, the architecture shown here involves only one gate resulting in constant-time processing. The gate exploits a generalized Hong-Ou-Mandel effect, the basis for quantum-photonic information applications."

8:30 am–10:00 am **Kohala 4**
Session ME1 **QOPO Plenary**
Session Chair Stephan Reitzenstein, *Technische Universität Berlin, Berlin, Germany*

8:30 am–8:45 am

Opening Remarks, Stephan Reitzenstein, *Technische Universität Berlin, Berlin, Germany*

8:45 am–9:30 am ***(Plenary)***

ME1.1 ENTROPY INSIGHTS: From Lasers and Bose Condensates to Acceleration Radiation and Black Hole Emissions, Marlan O. Scully, *Texas A&M University, College Station, TX, USA, Princeton University, Princeton, NJ, USA and Baylor University, Waco, TX, USA*

Einstein's study of entropy of light resulted in the photon concept. Studies of the entropy of: laser light and its relation to Bose condensate ("the atom laser") and the entropy of a beam of atoms falling into a black hole yield interesting insights.

9:30 am–10:00 am ***(Invited)***

ME1.2 Single-Layer Coupled Quantum Dot Lattices, James J. Coleman, *University of Texas at Dallas, Richardson, TX, USA*

Previous work on inverted quantum dot structures has shown that the crystal-like periodicity introduces potentially useful changes in the energy band structure including sharp, high-density states above the ground state. We explore this for two dimensions and consider possible ways to extend it to three.

8:30 am–10:00 am **King's 3**

Session MF1 **SDM Transmission I**

Session Chair Benjamin J. Puttnam, *NICT, KOGANEI, Tokyo, Japan*

8:30 am–9:15 am ***(Tutorial)***

MF1.1 SDM Research Activities within the EXAT Initiative, Yoshinari Awaji, *NICT, Koganei, Tokyo, Japan*

EXAT initiative started on 2008 as study group to propose future R&D plan of optical networks. Three major subjects of multi-core fiber, multi-mode control, and multi-level modulation were promoted in several national projects. The latest results of these project and academic activities were reviewed.

9:15 am–9:45 am ***(Invited)***

MF1.2 Joint Phase Tracking for Multicore Transmission with Correlated Phase Noise, Arni F. Alfredsson, Erik Agrell, Henk Wymeersch, *Chalmers University of Technology, Gothenburg, Sweden,* Benjamin J. Puttnam, and Ruben S. Luís, *NICT, Koganei, Tokyo, Japan*

Space-division multiplexed transmission over multicore fibers offers potential for joint-core processing to compensate for correlated phase noise. We review methods that take advantage of the phase-noise correlation across cores and assess their benefits in terms of transmission reach and pilot-rate requirements.

9:45 am–10:00 am

MF1.3 Impact of Intercore Crosstalk on Achievable Information Rates, Daniel J. Elson, *UCL (University College London), London, England, UK,* Benjamin J. Puttnam, Georg Rademacher, Ruben S. Luis, *NICT, Koganei, Tokyo, Japan,* Eric Sillekens, Lidia Galdino, Domaniç Lavery, *UCL (University College London), London, England, UK,* Yoshinari Awaji, Naoya Wada, *NICT, Koganei, Tokyo, Japan,* and Polina Bayvel, *UCL (University College London), London, England, UK*

We investigate the impact of intercore crosstalk in a 7-core fiber on signal to noise ratio and achievable information rates for PDM-QPSK, PDM-16QAM, and PDM-64QAM formats. The achievable rate is reduced by 8%, 5.4% and 1.5%, at a crosstalk of 25.6 dB/100 km respectively.

10:00 am–10:30 am **Kohala Promenade**

Coffee Break

10:30 am–12:00 pm **Waikoloa 1**

Session MA2 **Thermal and Germanium Optical Sources II**

Session Chair Osamu Nakatsuka, *Nagoya University, Nagoya, Aichi, Japan*

10:30 am–11:00 am ***(Invited)***

MA2.1 Strained Ge Micro-Laser Using Metallic Heat Sink, Moustafa El Kurdi, *C2N CNRS/UPSud, Orsay, Ile-de-France, France,* Anas Elbaz, *C2N/UPSud-STMicroelectronics, Ile-de-France, France,* Abdelhanin Aassime, Sebastien Sauvage, Xavier Checoury, *C2N/UPSud, Ile-de-France, France,* Isabelle Sagnes, *C2N/UPSud, Marcoussis, Ile-de-France, France,* Charles Baudot, Frédéric Boeuf, *STMicroelectronics, Rhone-Alpes, France,* and Philippe Boucaud, *C2N/UPSud, Ile-de-France, France*

Ge-dielectric-metal stacking heterostructures is shown to address the issue of strain engineering and thermal management in Ge microcavities. Up to 1.7% of biaxial strain is reached in Ge microdisks with Al pedestal. Efficient temperature cooling of the Ge-disks allows low-temperature lasing under CW optical pumping.

11:00 am–11:30 am ***(Invited)***

MA2.2 Gain/Loss Spectroscopy of Direct Band Gap Germanium from Strained Micro Bridges, Hans Sigg, *Paul Scherrer Institut (PSI), Villigen, Aargau, Switzerland*

Strain enhancement by under etching of micro bridges enables to create on a wafer base Ge and related Sn-based alloys with a direct band gap. We explore their gain/loss properties via photo luminescence emission scattered from an all enclosing high-Q optical cavity.

11:30 am–12:00 pm ***(Invited)***

MA2.3 Highly Strained Germanium Nanowire Lasers Under Optical Pumping, Donguk Nam, Shuyu Bao, *Nanyang Technological University, Singapore, Singapore,* Daeik Kim, Chibuzo Onwukaeme, *Inha University, Incheon, Kyonggi-do, Republic of Korea,* Shashank Gupta, Krishna Saraswat, *Stanford University, Stanford, CA, USA,* Kwang Hong Lee, *Singapore-MIT Alliance for Research and Technology (SMART), Singapore, Singapore,* Yeji Kim, Dabin Min, Yongduck Jung, *Inha University, Incheon, Kyonggi-do, Republic of Korea,* Haodong Qiu, Hong Wang, *Nanyang Technological University, Singapore, Singapore,* Eugene Fitzgerald, *Singapore-MIT Alliance for Research and Technology (SMART), Singapore, Singapore*, and Chuan Seng Tan, *Nanyang Technological University, Singapore, Singapore*

The integration of miniaturized group IV lasers into CMOS architecture holds the key to the realization of photonic-integrated circuits. In this talk, we present the first experimental observation of low-threshold lasing in strained germanium nanowires with an optical pumping threshold density of ~3.0kW/cm^2.

10:30 am–12:00 pm **King's 2**
Session MB2 **MLSDN Plenary**
Session Chair Qunbi Zhuge, *Shanghai Jiao Tong University, China*

10:30 am–11:15 am ***(Plenary)***

MB2.1 Applications of Machine Learning in Network Design, Optimization and Analysis, Anurag Sharma, *Google LLC, CA, USA*

Cross-layer network design and optimization are starting to use machine learning algorithms to achieve higher efficiencies in the network planning. This talk will present various applications of Machine Learning that are being explored in the Network Design and Optimization of Google's backbone cross-layer network.

11:15 am–12:00 pm ***(Plenary)***

MB2.2 Intelligent Physical Layer Designs for Software-Defined Optical Networks, David Plant, *McGill, Ontario, Canada*

We review software-defined coherent transceiver designs that enable reach and spectral efficiently optimization. We also discuss performance monitoring using coherent transceivers as a means of extracting key network telemetry information.

10:30 am–12:00 pm **Kohala 2**
Session MC2 **PT-Symmetric Non-Hermitian Photonics**
Session Chair Mordechai Segev, *Technion, Haifa, Tel Aviv, Israel*

10:30 am–11:15 am ***(Plenary)***

MC2.1 Parity-Time and Other Symmetries in Optics and Photonics, Demetrios Christodoulides, *University of Central Florida, Olando, FL, USA*

The prospect of exploiting both optical gain and loss has been recently suggested as a means to control light transport. By harnessing parity-time-symmetric notions, novel structures and devices with counter-intuitive properties can be envisioned, potentially enabling new possibilities in the field of optics and photonics.

11:15 am–12:00 pm ***(Keynote)***

MC2.2 Non-Hermitian and Topological Electromagnetics: Synthetic Dimensions, and Robust Wireless Power Transfer, Shanhui Fan, *Stanford University, Stanford, CA, USA*

We discuss our recent works in non-hermitian and topological electromagnetics. We show that nonlinear parity-time symmetry system can be used to achieve robust wireless power transfer. We also consider topological effects in systems exhibiting synthetic dimensions, and in the scattering matrices of optical devices.

10:30 am–12:00 pm **Kohala 3**

Session MD2 **Quantum Repeater Implementations**

Session Chair Vladimir Malinovsky, *US Army Research Laboratory, USA*

10:30 am–11:00 am ***(Invited)***

MD2.1 Development of a Functional Quantum Repeater Node with Two Species of Alkali Atoms, Mark Saffman, Matthew Ebert, Garrett Hickman, Trent Graham, Xiaoyu Jiang, and Cody Poole, *University of Wisconsin-Madison, Madison, WI, USA*

We will report on progress towards functional quantum network nodes that utilize two atomic species to implement quantum memory with long coherence times, local quantum processing for error correction, and an efficient interface between local quantum memory and photonic qubits.

11:00 am–11:30 am ***(Invited)***

MD2.2 Towards a Global Quantum Network, Nikolai Lauk and Christoph Simon, *University of Calgary, Calgary, Alberta, Canada*

A global quantum network would enable many practical application, such as secure communication and computation. Two possible ways for realizing of such a network are discussed: entanglement distribution via satellite links and a proposal for quantum repeater that exploits the existent optical telecommunication infrastructure.

11:30 am–12:00 pm ***(Invited)***

MD2.3 Quantum Interfaces with Trapped Ions: Routes to Scalability, Tracy Northup, Dario Fioretto, Konstantin Friebe, Moonjoo Lee, Klemens Schüppert, Markus Teller, Rainer Blatt, *University of Innsbruck, Innsbruck, Tirol, Austria*

Optical cavities provide a coherent interface between photons, which transport quantum information, and ions, which are a promising platform for quantum computing. We discuss error protection based on decoherence-free subspaces and photon shaping for quantum state transfer, towards the goal of scaling up quantum networks.

10:30 am–12:10 pm **Kohala 4**

Session ME2 **Lasers**

Session Chair Stephan Reitzenstein, *Technische Universität Berlin, Berlin, Germany*

10:30 am–11:00 am ***(Invited)***

ME2.1 Toward the Smallest Possible Lasers and Resonators, Yong-Hee Lee, *Korea Institute of Advanced Study, Seoul, South Korea*

The evolution of small lasers, from VCSEL to photonic crystal laser and 1-D nanobeam laser, is reviewed. Recent efforts on the ultra-low threshold small lasers are discussed. The potentials and limits of the very small metallic lasers and resonators will also be addressed.

11:00 am–11:30 am ***(Invited)***

ME2.2 Quantum Noise in Nanolasers with Few Emitters, Jesper Mork, *Technical University of Denmark, Kgs. Lyngby, Hovedstaden, Denmark*

The quantum noise of nanolasers containing discrete emitters, e.g. semiconductor quantum dots, is analyzed. In particular, the role of the spontaneous emission beta-factor, Purcell enhancement and the number of emitters is discussed, Analytical expressions for the intensity noise are derived and compared to stochastic simulations.

11:30 am–11:50 am

ME2.3 Scaling Towards Efficient Monolayer WS_2 Photonic Crystal Lasers, Xiaochen Ge, *University of Texas at Arlington, Arlington, TX, USA,* Momchil Minkov, *Stanford University, Stanford, CA, USA,* Xiuling Li, *University of Illinois Urbana-Champaign, Urbana, IL, USA,* Shanhui Fan, *Stanford University, Stanford, CA, USA,* and Weidong Zhou, *University of Texas at Arlington, Arlington, TX, USA*

We report continued scaling in laser cavity and gain medium towards potential few photon sources. Performance of an optically pumped continuous wave room temperature operation monolayer WS_2 laser will be discussed, based on a heterostructure photonic crystal cavity for efficient light extraction and surface-emission.

11:50 am–12:10 pm

ME2.4 New Lasing Regimes of High-β Nanolasers, Frederik Lohof, Roy Barzel, *University of Bremen, Bremen, Germany,* Paul Gartner, *National Institute of Materials Physics, Bucharest-Măgurele, Romania,* and Christopher Gies, *University of Bremen, Bremen, Germany*

We identify new lasing regimes of high-β nanolasers with extended gain media. There, coherent emission can occur after the typical threshold non-linearity in the I-O-curve due to increased spontaneous emission. We present room temperature lasing in III-nitride nanobeam cavities as an example for this regime.

10:30 am–12:00 pm **King's 3**

Session MF2 **SDM Components I**

Session Chair Jochen Schroder, *Chalmers University of Technology, Gothenburg, Sweden*

10:30 am–11:00 am ***(Invited)***

MF2.1 Multi-Plane Light Conversion for High Spatial Mode Counts, Joel Carpenter, *University of Queensland, Queensland, Australia*

In general, the number of phase plates required of a multi-plane light conversion device scales with the total number of spatial modes. We present work on designing devices capable of operating on large numbers of spatial modes in a more scalable fashion.

11:00 am–11:30 am ***(Invited)***

MF2.2 Remote Mode-Forming over Multimode Fiber for Endoscopic Imaging and Beam Steering, Haoshuo Chen, *Nokia Bell Labs, Holmdel, NJ, USA*

We demonstrate mode-forming over multimode fiber without access to the remote end, needed for endoscopic imaging and beam steering. Reflective spatial pilots and transmitter-side MIMO enable uncoupled spatial and polarization modes at the remote end.

11:30 am–11:45 am

MF2.3 6th Mode-Group Multiplexer for Intra-Mode Transmission over 50-µm GI-Multimode Fiber, Steffen Wittek, *University of Central Florida, Orlando, FL, USA,* Roland Ryf, Nicolas K. Fontaine, Haoshuo Chen, *Nokia Bell Labs, Holmdel, NJ, USA,* Juan Carlos Alvarado-Zacarias, *University of Central Florida, Orlando, FL, USA,* Jiaxiong Li, *Nokia Bell Labs, Holmdel, NJ, USA,* Jose Enrique Antonio-Lopez, *University of Central Florida, Orlando, FL, USA,* Mark Capuzzo, Rose Kopf, Al Tate, Hugo Safar, Cristian Bolle, *Nokia Bell Labs, Providence, NJ, USA,* David T. Neilson, Ellsworth Burrows, Kwangwoong Kim, *Nokia Bell Labs, Holmdel, NJ, USA,* Marianne Bigot, Adrian Amezcua-Correa, Pierre Sillard, *Parc des Industries Artois Flandres, Billy Berclau, Haisnes, France,* Joel Carpenter, *University of Queensland, Brisbane, Australia,* and Rodrigo Amezcua-Correa, *University of Central Florida, Orlando, FL, USA*

We show mode-multiplexed transmission over the 6th mode group of a 50-um graded-index multimode fiber using a multi-plane light conversion device, for transmission distances up to 90 km.

11:45 am–12:00 pm

MF2.4 Asymmetric Y-Junction based Reconfigurable Optical Mode-Division Multiplexing on Silicon, Gencheng Wang, Tingge Dai, Bei Chen, Xiaoqing Guo, Yuehai Wang, Hui Yu, and Jianyi Yang, *Zhejiang University, Hangzhou, China*

We designed and fabricated a novel reconfigurable optical mode-division multiplexer based on asymmetric Y-junction. Extinction ratios are larger than ~15dB over the C band for both states when switching the outputs by heating the narrow arm of Y-junction. The maximum insertion loss is ~1.5 dB.

12:00 pm–1:30 pm

Lunch Break (on own)

1:30 pm–3:00 pm **Waikoloa 1**

Session MA3 **(Si)GeSn Devices I**

Session Chair Buwen Cheng, *Chinese Academy of Sciences, Beijing, China*

1:30 pm–2:00 pm ***(Invited)***

MA3.1 Tunnel Injection into Group IV Semiconductors and Its Application to Light-Emitting Devices, Caterina J. Clausen, Inga A. Fischer, Niklas Hoppe, *University of Stuttgart, Stuttgart, Germany,* Roman Koerner, *Philips Photonics, Ulm, Germany,* Michael Oehme, Daniel Schwarz, and Jörg Schulze, *University of Stuttgart, Germany*

We present experimental results on using tunnel injection of electrons in Germanium diodes on Silicon substrates for light emission, the Zener-Emitter. Through tunneling and applying a controlled bias, electrons can be injected into the direct conduction band valley. We discuss the usage for optoelectronic devices.

2:00 pm–2:45 pm ***(Plenary)***

MA3.2 Development of SiGeSn Technique Towards Integrated Mid-Infrared Photonics Applications, Wei Dou, Yiyin Zhou, Thach Pham, Perry Grant, Shui-Qing Yu, *University of Arkansas, Fayetteville, AR, USA,* Wei Du, *Wilkes University, Wilkes-Barre, PA, USA,* Joe Margetis, John Tolle, *ASM, Phoenix, AZ, USA,* Seyed Ghetmiri, Aboozar Mosleh, Mansour Mortazavi, *University of Arkansas at Pine Bluff, AR, USA,* Greg Sun, Richard Soref, *University of Massachusetts at Boston, Boston, MA, USA,* Huong Tran, Yiyin Zhou, Perry Grant, and Baohua Li, *Arktonics, LLC, Fayetteville, AR, USA*

SiGeSn technique has been investigated, ranging from material growth to the device demonstration including lasers and photodetectors. The maximum Sn composition of 22.3% was achieved, while the operation wavelength of devices is up to 3 μm, indicating the great potential applications in integrated mid-infrared photonics.

2:45 pm–3:00 pm

MA3.3 Observation of Amplified Spontaneous Emission in GeSn Waveguides at Room Temperature, J. Mathews, Z. Li, Y. Zhao, *University of Dayton, Dayton, OH, USA,* J. D. Gallagher, *Arizona State University, Tempe, AZ, USA,* D. Lombardo, I. Agha, *University of Dayton, Dayton, OH, USA,* J. Kouvetakis, and J. Menéndez, *Arizona State University, Tempe, AZ, USA*

Room temperature amplified spontaneous emission at mid-IR has been observed from optically pumped GeSn waveguides on Si. For higher pump power, emission spectrum indicates the direct band to indirect band emission intensity ratio increases and the peak value increases non-linearly due to the material gain.

1:30 pm–3:00 pm **King's 2**

Session MB3 **Applications of ML in Optical Networks I**

Session Chair Reza Nejabati, *Bristol, UK*

1:30 pm–2:00 pm ***(Invited)***

MB3.1 Application of Artificial Intelligence Techniques in Optical Networks, Javier Mata, Ignacio de Miguel, Ramón J. Durán, Noemí Merayo, *Universidad de Valladolid, Valladolid, Spain,* Sandeep Kumar Singh, Admela Jukan, *Technische Universität Carolo-Wilhelmina zu Braunschweig, Braunschweig, Germany,* and Mohit Chamania, *ADVA Optical Networking, Berlin, Germany*

We provide an overview of artificial intelligence techniques and their use in optical communication systems and networks with the aim of improving performance. Areas of application include optical transmission, performance monitoring, quality of transmission monitoring, as well as optical network planning and operation.

2:00 pm–2:30 pm ***(Invited)***

MB3.2 Management and Control of Multi-Vendor Transport Networks Supporting Machine Learning Applications, Stephane St.-Laurent, Omer Faruk Yilmaz, Onur Turkcu, Biao Lu, Matthew L. Mitchell, and Parthiban Kandappan, *Infinera Corporation, USA*

We demonstrate a framework for automated service management and optical power control over a multi-vendor transport network using a Layer-0 SDN controller. We then propose key machine learning applications on this open network model and discuss their implications.

2:30 pm–3:00 pm ***(Invited)***

MB3.3 Roles of Machine Learning in Network Management Evolutions, Michiaki Hayashi, *KDDI Research, Inc., Tokyo, Japan*

Machine Learning (ML) assists network management to evolve from reactive to proactive one. The paper shows examples where ML plays the roles. Infrastructure built with merchant silicon is further enhancing the roles. ML is expected to help predict serious anomalies and maintain automated business process.

1:30 pm–3:00 pm **Kohala 2**

Session MC3 **Active Nanophotonics**

Session Chair Shaya Fainman, *University of California, San Diego, San Diego, CA, USA*

1:30 pm–2:15 pm ***(Keynote)***

MC3.1 Some Recent Results in Active Nano-Photonics, Marin Soljacic, *Massachusetts Institute of Technology, Cambridge, MA, USA*

I will present some of our recent results in the field of nano-photonics, including novel phenomena in light sources, and neural networks.

2:15 pm–2:45 pm ***(Invited)***

MC3.2 Photonic Crystal Membrane Lasers for Energy Efficient 3D Integrated Photonics, Weidong Zhou, *University of Texas at Arlington, Arlington, TX, USA*

Recent advances in photonic crystal membrane lasers will be reviewed for energy efficient 3D integrated photonics on silicon. I will discuss laser cavity scaling towards attojoule optoelectronics, with focus on buried tunnel junction InP lasers and low index contrast photonic crystal cavity single sheet lasers.

2:45 pm–3:00 pm

MC3.3 Unidirecional Scattering of a Single Sphere-Gap-Cone Hybrid Nanoantenna, Y. Sun, S. V. Makarov, and D. A. Zuev, *ITMO University, Saint Petersburg, Russia*

Here we numerically study the optical properties of a novel hybrid sphere-gap-cone nanostructure. Simulations related to scattering cross section and electric fields are presented to show strong magnetic and electric response in the visible range. Besides, this novel nanostructure demonstrates unidirectional scattering in magnetic resonance.

1:30 pm–3:00 pm **Kohala 3**

Session MD3 Quantum Repeaters

Session Chair Barry C. Sanders, *University of Calgary, Calgary, Alberta, Canada*

1:30 pm–2:00 pm ***(Invited)***

MD3.1 WITHDRAWN

2:00 pm–2:30 pm ***(Invited)***

MD3.2 Quantum Multiplexing as a Resource Saver in Quantum Networks, William J. Munro, *NTT BRL, Atsugi, Kanagawa, Japan,* Nicolo Lo Piparo, and Kae Nemoto, *National Institute of Informatics, Tokyo, Japan*

In this presentation we introduce the concept of quantum multiplexing as an essential ingredient in quantum repeater networks. We show how the quantum multiplexing of photonic system allows for a significant improvement in establishing entangled pairs over a quantum repeater network.

2:30 pm–3:00 pm ***(Invited)***

MD3.3 Universal Optical Modules for Quantum Network, Kae Nemoto, *National Institute of Informatics, Tokyo, Japan and Graduate University for Advanced Studies (Sokendai), Tokyo, Japan,* Michael Hanks, *Graduate University for Advanced Studies (Sokendai), Tokyo, Japan, and National Institute of Informatics, Tokyo,*Nicoló Lo Piparo, *National Institute of Informatics, Tokyo, Japan,* and William Munro, *NTT Corporation, Kanagawa, Japan and National Institute of Informatics, Tokyo, Japan*

We describe how a quantum network can be built from a simple device which consists of only a few elements. Such a device can be considered as a module for universal quantum networks and can be realized with a single NV-center and an optical cavity.

1:50 pm–3:00 pm **Kohala 4**
Session ME3 **Quantum Emitters**
Session Chair Frank Jahnke, *University of Bremen, Bremen, Germany*

1:50 pm–2:20 pm ***(Invited)***

ME3.1 Multiphoton Quantum States from Semiconductor Sources, Gregor Weihs, *University of Innsbruck, Innsbruck, Tirol, Austria*

We will present our results on advanced quantum states of light for quantum communication. With individual and coupled semiconductor quantum dots, we produce photon pairs hyperentangled in polarization and time-bin for increased efficiency protocols and photon triplet states, which form the basis for multi-party interaction.

2:20 pm–2:40 pm

ME3.2 WITHDRAWN

2:40 pm–3:00 pm

ME3.3 The Importance of Correlation Effects in Cavity-QED Systems, Christopher Gies, *University of Bremen, Bremen, Germany*

In my talk I will discuss different realizations of semi-conductor cavity-QED systems in which correlation effects play a defining role. In all cases, the enhanced light-matter interaction – one of the hallmarks of optoelectronic nanostructures – is the driving force that fosters correlations.

1:30 pm–3:00 pm **King's 3**
Session MF3 **Multi-Mode Fiber Modelling**
Session Chair Ivana Gasulla, *Universitat Politecnica de Valencia, Spain*

1:30 pm–2:00 pm ***(Invited)***

MF3.1 Propagation Effects in Fibers for Space-Division Multiplexing, Cristian Antonelli, Antonio Mecozzi, *University of L'Aquila, L'Aquila, Abruzzi, Italy,* Ori Golani, and Mark Shtaif, *Tel Aviv University, Tel Aviv, Israel*

We review the modelling of multi-mode propagation in fibers for Space-Division Multiplexing (SDM). We address specifically the study of random mode coupling, modal dispersion, mode-dependent loss, and nonlinear distortions, as well as the impact of their interplay on system performance and characterization.

2:00 pm–2:30 pm ***(Invited)***

MF3.2 Models for Mode Coupling Dynamics for Mode-Division Multiplexing, Karthik Choutagunta and Joseph M. Kahn, *Stanford University, Stanford, CA, USA*

Environmental perturbations cause rapid fluctuations in the channel matrix of mode-division multiplexing systems, necessitating adaptive MIMO signal processing at the receiver. We present rigorous and low-complexity channel models to describe mode coupling dynamics and use them to evaluate the tracking performance of adaptive MIMO equalizers.

2:30 pm–3:00 pm ***(Invited)***

MF3.3 Recent Developments in Modal Analysis of Elliptical Waveguides, Aku Antikainen, *University of Rochester, Rochester, NY, USA,* René-Jean Essiambre, *Nokia Bell Labs, Holmdel, NJ, USA*, and Govind P. Agrawal, *University of Rochester, Rochester, NY, USA*

We present an overview on a recently developed novel mathematical method to determine the transverse modes of elliptical waveguides. The method is based on a perturbation expansion and avoids the numerical issues of the traditional Mathieu function treatment without compromising generality or versatility.

3:00 pm–3:30 pm **Kohala Promenade**

Coffee Break

3:30 pm–5:00 pm **Waikoloa 1**
Session MA4 (Si)GeSn Devices II
Session Chair Mitsuru Takenaka, *University of Tokyo, Tokyo, Japan*

3:30 pm–4:15 pm ***(Plenary)***

MA4.1 (Si)GeSn-Based Light Sources – Challenges and Chances, Nils von den Driesch, *Forschungszentrum Juelich; RWTH Aachen, Juelich, Nordrhein-Westfalen, Germany,* Daniela Stange, Denis Rainko, *Forschungszentrum Juelich, Juelich, Nordrhein-Westfalen, Germany,* Giovanni Capellini, *IHP, Frankfurt Oder, Brandenburg, Germany,* Zoran Ikonic, *University of Leeds, Leeds, England, UK,* Jean-Michel Hartmann, *Univ. Grenoble Alpes, Grenoble, Rhone-Alpes, France,* Siegfried Mantl, *Forschungszentrum Juelich, Juelich, Nordrhein-Westfalen, Germany,* Hans Sigg, *Paul Scherrer Institut (PSI), Villigen, Aargau, Switzerland,* Jeremy Witzens, *RWTH Aachen, Aachen, Nordrhein-Westfalen, Germany,* Detlev Grützmacher, and Dan Buca, *Forschungszentrum Juelich, Juelich, Nordrhein-Westfalen, Germany*

We will discuss the formation of heterostructure light emitters based on group IV Si-Ge-Sn alloys. Confinement of carriers and their separation from defects in SiGeSn/GeSn double heterostructures and multi quantum wells leads to improved lasing thresholds and is a viable paths towards future integrated emitters.

4:15 pm–4:45 pm ***(Invited)***

MA4.2 Mid-IR GeSn/SiGeSn-Based Lasers and Photodiodes, A. Chelnokov, N. Pauc, M. Bertrand, Q. M. Thai, J. Chrétien, R. Khazaka, J. Aubin, *Univ. Grenoble Alpes, Grenoble, France,* F. Armand-Pilon, H. Sigg, *Paul Scherrer Institut (PSI), Villigen, Switzerland,* J.-M. Hartmann, V. Calvo, and V. Reboud, *Univ. Grenoble Alpes, Grenoble, France*

We describe our latest results on optically pumped GeSn lasers: microdiscs, photonic crystals, parabolic corner cubes. Thresholds and maximal operating temperatures (230 K) are improved using step-graded GeSn epi buffers, SiGeSn claddings, and controlled mechanical strain in the structures. We also show our first GeSn photodiodes.

4:45 pm–5:00 pm

MA4.3 Cavity-Enhanced Electroluminescence from GeSn p-i-n Diode on Silicon-on-Insulator Substrate, Bo-Jun Huang and Guo-En Chang, *National Chung Cheng University, Chiayi County, Taiwan*

We report cavity-enhanced direct band electroluminescence from GeSn p-i-n diodes on silicon-on-insulator substrates. A Fabry-Perot cavity was created between the buried oxide layer and the deposited oxide layer to enhance electroluminescence from the GeSn active layer.

3:30 pm–5:00 pm **King's 2**

Session MB4 **Performance Monitoring**

Session Chair Guoxiu Huang, *Fujitsu Laboratories Ltd., Kanagawa, Japan*

3:30 pm–4:00 pm ***(Invited)***

MB4.1 Machine Learning-Assisted Optical Performance Monitoring in Fiber-Optic Networks, Faisal Nadeem Khan, Qirui Fan, Chao Lu, and Alan Pak Tao Lau, *Hong Kong Polytechnic University, Hong Kong*

We review machine learning (ML)-based optical performance monitoring (OPM) techniques in optical communications. Recent applications of ML-assisted OPM in different aspects of fiber-optic networking including cognitive fault detection and management, network equipment failure prediction, and dynamic planning and optimization of software-defined networks are also discussed.

4:00 pm–4:30 pm ***(Invited)***

MB4.2 Machine Learning Techniques in Optical Physical-Layer Monitoring, Takahito Tanimura, *Fujitsu Laboratories Ltd., Kawasaki, Japan*

We review applications of machine learning to extract physical-layer status of optical networks from their sensory information. After pointing out representation in learning process, we demonstrate an end-to-end learning framework in optical monitoring by convolutional neural networks with asynchronously-sampled data right after intradyne coherent detection.

4:30 pm–5:00 pm ***(Invited)***

MB4.3 Machine Learning Based Noise Estimation in Optical Fiber Communication Networks, Seb J. Savory and F. J. Vaquero Caballero, *University of Cambridge, Cambridge, England, UK*

We discuss a machine learning based approach to jointly estimating both linear and nonlinear noise contributions in an optical fiber communication link. We will expound the rational for utilizing machine learning for this problem, before discussing current progress and then concluding with future research directions.

3:30 pm–5:00 pm **Kohala 2**

Session MC4 **Topological Photonics and Weyl Points**

Session Chair Yidong Chong, *Nanyang Technological University, Singapore*

3:30 pm–4:00 pm ***(Invited)***

MC4.1 Photonic Weyl Points at Optical Frequencies, Mikael C. Rechtsman, *Penn State University, University Park, PA, USA*

Here I present the observation of optical Weyl points in a laser-written waveguide array structure. By demonstrating a topological transition in the 2D Floquet dispersion of the waveguide array, I will show that a Weyl point arises in the full 3D photonic crystal band structure.

4:00 pm–4:30 pm ***(Invited)***

MC4.2 Embedded Photonic Topological Insulators, Miguel Bandres and Mordechai Segev, *Technion, Haifa, Tel Aviv, Israel*

We show that, counterintuitive, it is possible to control the properties of photonic topological insulators by tailoring defects. In the extreme case, a lattice of defects inside a topological insulator creates a totally new topological insulator.

4:30 pm–4:45 pm

MC4.3 Electromagnetic Scattering Laws in Weyl Systems, Ming Zhou, Lei Ying, *University of Wisconsin–Madison, Madison, WI, USA,* Ling Lu, *Chinese Academy of Sciences, Beijing, China,* Lei Shi, Jian Zi, *Fudan University, Shanghai, China*, and Zongfu Yu, *University of Wisconsin–Madison, Madison, WI, USA*

We show that the unique dispersions of Weyl systems can decouple the scattering cross section from the well-known wavelength limit. Extremely large resonant scattering cross section can be obtained at any wavelength.

4:45 pm–5:00 pm

MC4.4 Investigation of Tunable Dirac Cones in Two Dimensional Plasma Photonic Crystals, Benjamin Wang and Mark Cappelli, *Stanford University, Stanford, CA, USA*

We present finite difference time domain (FDTD) simulations of the response of a two-dimensional plasma photonic crystal to incident TE electromagnetic waves that span regions both above and below the plasma frequency and investigate the Dirac cone dispersion with double degeneracy near X.

3:30 pm–5:15 pm **Kohala 1**

Session MG4 **Lasing in Non-Hermitian and PT-Symmetric Systems**

Session Chair Lan Yang, *Washington University, USA*

3:30 pm–4:00 pm ***(Invited)***

MG4.1 Non-Hermitian Modes of Phased Microcavity Laser Arrays, Zihe Gao and Kent D. Choquette, *University of Illinois at Urbana-Champaign, Urbana, IL, USA*

Coupled semiconductor arrays are inherently non-Hermitian optical systems. We use a comprehensive coupled rate equation analysis to elucidate the unique properties of coherent 2 × 1 photonic crystal VCSEL arrays.

4:00 pm–4:30 pm ***(Invited)***

MG4.2 Non-Hermitian Coupled Waveguide Lasers, Wei Guo, *University of Massachusetts Lowell, Lowell, MA, USA*

4:30 pm–4:45 pm

MG4.3 Experimental Realization of Supersymmetric Laser, Mohammad P. Hokmabadi, William Hayenga, Jinhan Ren, Enrique Sanchez Cristobal, Sanaz Faryadras, *University of Central Florida, Orlando, FL, USA,* Ramy El-Ganainy, *Michigan Technological University, Houghton, MI, USA*, Demetrios N. Christodoulides, and Mercedeh Khajavikhan, *University of Central Florida, FL, USA*

A multimode, chaotic, and broadband emission is an undesired characteristic of laser arrays which is an adverse effect of supermodes in coupled waveguides. Employing optical supersymmetry, we experimentally demonstrate single mode lasing in arrays of supersymmetric lasers where a superpatner array eliminates undesired lasing modes.

4:45 pm–5:15 pm ***(Invited)***

MG4.4 Non-Hermitian Photonics Via an Optical Meta-Molecule, Vassilios Kovanis, *Nazarbayev University, Astana, Kazakhstan*

We will cover recent theoretical work on how to build and dissect the new photonic-meta-atom of the non-Hermitian photonics that consists of two optically coupled gain blocks individually addressed so that pump inhomogeneities can induce the gain and loss requirements.

3:30 pm–5:00 pm **Kohala 3**

Session MD4 **Quantum Key Distribution**

Session Chair Gregory S. Kanter, *NuCrypt, LLC, Evanston, IL, USA*

3:30 pm–4:00 pm ***(Invited)***

MD4.1 **Quantum Key Distribution Network and Its Applications,** Akio Tajima, Takashi Kondoh, Takao Ochi, *NEC Corporation, Kawasaki, Japan,* Mikio Fujiwara, *National Institute of Information and Communications Technology, Tokyo, Japan,* Ken-ichiro Yoshino, Hiromi Iizuka, Toshio Sakamoto, *NEC Corporation, Kawasaki, Japan,* Akihisa Tomita, *Hokkaido University, Sapporo, Japan,* Shione Asami, *NEC Corporation, Kawasaki, Japan*, and Masahide Sasaki, *National Institute of Information and Communications Technology, Tokyo, Japan*

We present the fundamental architecture and functions of quantum key distribution (QKD) network that support multiple applications. As applications on the QKD network, we introduce a quantum key distribution-advanced encryption standard (QKD-AES) hybrid system and an encrypted smartphone system.

4:00 pm–4:15 pm

MD4.2 **Coexistence of Continuous Variable Quantum Key Distribution and 7 × 12.5 Gbit/s Classical Channels,** Tobias A. Eriksson, *National Institute of Information and Communications Technology, Tokyo, Japan,* Takuya Hirano, Motoharu Ono, *Gakushuin University, Tokyo, Japan,* Mikio Fujiwara, *National Institute of Information and Communications Technology, Tokyo, Japan,* Ryo Namiki, *Gakushuin University, Tokyo, Japan,* Ken-ichiro Yoshino, Akio Tajima, *NEC Corporation, Kawasaki, Japan,* Masahiro Takeoka, and Masahide Sasaki, *National Institute of Information and Communications Technology, Tokyo, Japan*

We study coexistence of CV-QKD and 7 classical 12.5 Gbit/s on-off keying channels in WDM transmission over the C-band. We demonstrate key generation with a distilled secret key rate between 20 to 50 kbit/s in experiments running continuously over 24 hours.

4:15 pm–4:30 pm

MD4.3 **Measurement of Fiber-Induced One-Way Noise Over Deployed Optical Links for Quantum Networks,** Helena Zhang, Matthew E. Grein, Scott A. Hamilton, and Isaac Chuang, *Massachusetts Institute of Technology, Cambridge, MA, USA*

Noise imparted to an optical signal propagating along a 42-km deployed optical fiber link is measured using two different techniques employing referenced mode-locked lasers. We compare the two techniques and assess their suitability for stabilizing the deployed fiber link for quantum networks.

4:30 pm–5:00 pm ***(Invited)***

MD4.4 Security Level and Information Flow in a Quantum Key Distribution Network, Xiongfeng Ma, Hongyi Zhou, and Kefan Lv, *Tsinghua University, Beijing, China*

We present a framework of quantum networks, including a communication scheme of the highest security level with sufficient keys and a key management scheme realizing a maximum information flow with limited keys. Meanwhile, we briefly report the recent field tests of quantum key distribution networks.

3:30 pm–5:10 pm **Kohala 4**

Session ME4 Lasers and Quantum Emitters I

Session Chair **James J. Coleman,** *University of Texas at Dallas, Richardson, TX, USA*

3:30 pm–4:00 pm ***(Invited)***

ME4.1 Advances in UV Single Photon Sources, Yasuhiko Arakawa, Mark Holmes, and Munetaka Arita, *University of Tokyo, Tokyo, Japan*

We discuss single ultraviolet (UV) photon sources using GaN-based quantum dots (QDs). A nanowire QD realized a giant binding energy of biexciton, resulting in UV single photon emission above room temperature. Emission of a high-purity UV single photon from an interface-fluctuation QD was also demonstrated.

4:00 pm–4:30 pm ***(Invited)***

ME4.2 Telecom Wavelength Nanophotonic Elements for Quantum Communication, Mohamed Benyoucef and Johann Peter Reithmaier, *University of Kassel, Kassel, Germany*

An overview is given on recent progress of InP-based quantum dots and photonic elements addressing the 1.55 μm wavelength range for far distance fiber-based quantum optical communication. Specific growth and fabrication techniques as well as fundamental physical quantum properties are discussed

4:30 pm–4:50 pm

ME4.3 WITHDRAWN

4:50 pm–5:10 pm

ME4.4 Optimized Access-Time Scheduling in Quantum Networks Using Realistic Quantum Memories, Siddhartha Santra, *US Army Research Laboratory, Adelphia, MD, USA,* Liang Jiang, *Yale University, New Haven, CT, USA*, and Vladimir S. Malinovsky, *US Army Research Laboratory, Adelphia, MD, USA*

We propose a novel schedule for entanglement swapping which allows two orders of magnitude increase in long-distance entanglement generation rate using current state-of-art quantum memories. The schedule suggests that nested networks should rapidly reset lower level memories and wait longer before resetting higher nesting levels.

3:30 pm–4:30 pm **King's 3**

Session MF4 **Spatial Diversity and Quantum Systems**

Session Chair Sergio Leon Saval, *University of Sydney, Sydney, New South Wales, Australia*

3:30 pm–4:00 pm ***(Invited)***

MF4.1 **Multimode Fibers for Quantum-Secure Communication**, Lyubov V. Amitonova, Tristan B. H. Tentrup, Ivo M. Vellekoop, Pepijn W. H. Pinkse, *University of Twente, Enschede, The Netherlands*

Multimode fibers support a multitude of transverse optical modes. These modes are mixed by the fiber. By complex wavefront shaping through the multimode fiber, we can undo this mixing, making it possible to communicate through the fiber even at very low light levels.

4:00 pm–4:30 pm ***(Invited)***

MF4.2 **Control Over the Transverse Structure of Light at the Single-Photon Level,** D. Cruz-Delgado, *Universidad Nacional Autónoma de México, Mexico City, México,* J. C. Alvarado-Zacarias, *University of Central Florida, Orlando, FL, USA,* H. Cruz-Ramirez, *Universidad Nacional Autónoma de México, Mexico City, México,* J. E. Antonio-Lopez, *University of Central Florida, Orlando, FL, USA,* S. G. Leon-Saval, *University of Sydney, Sydney, New South Wales, Australia*, R. Amezcua-Correa, *University of Central Florida, Orlando, FL, USA*, and A. B. U'Ren, *Universidad Nacional Autónoma de México, Mexico City, México,*

We demonstrate control over the structure of light at the single-photon level, particularly deterministic transverse mode conversion in a passive optical device. This demonstration is based on a fiber-based spontaneous four wave mixing photon-pair source and a mode-selective photonic lantern spatial multiplexer.

7:00 pm–9:00 pm **Grand Promenade**

Session MP **Welcome Reception & Poster Session**

Session Chair Nicolas Fontaine, *Nokia Bell Labs, USA*

7:00 pm–9:00 pm

MP1 **Widely Tunable, High-Q Two-Dimensional Photonic Crystal Cavities for cQED Applications,** Jingda Wu, Xiruo Yan, Ryan C. Watt, Megan K. T. Nantel, Lukas Chrostowski, and Jeff F. Young, *University of British Columbia, Vancouver, BC, Canada*

A fractured planar photonic crystal cavity is designed so that its resonant frequency can be mechanically tuned over a range of tens of nanometers while maintaining a quality factor in excess of 100,000. Experimental data validates the tuning capability, in lower Q cavities.

MP2 **The Lateral Growth of GeSn Layer on Si Substrate by MBE Method,** Chuanbo Li, Shuai Feng, *Minzu University of China, Beijing, China,* Chunlai Xue, Buwen Cheng, *Chinese Academy of Sciences, Beijing, China*

The lateral growth of GeSn alloy strips were grown on Si by Sn self-catalyzed method by MBE. The growth of GeSn strips are also studied on pattered substrate. We will discuss the growth mechanism and the impact factors on the materials.

MP3 **Power-Dependent Responsivity of Ge/GeSn/Ge Heterostructure Photodiodes,** Elaheh Ghanati, *University of Dayton, Dayton, OH, USA,* Gary Sevison, *University of Dayton, Dayton, OH, USA and Air Force Research Laboratory, Wright-Patterson AFB, OH, USA,* Chaio Chang, Hao-Cheng Lin, Hung-Hsiang Cheng, Li Hui, *National Taiwan University, Taipei, Taiwan, China,* Joshua Hendrickson, *Air Force Research Laboratory, Wright-Patterson AFB, OH, USA,* Richard Soref, Greg Sun, *University of Massachusetts, Boston, MA, USA*, and Jay Mathews, *University of Dayton, Dayton, OH, USA*

Responsivity of Ge/GeSn/Ge a heterostructure photodiode was measured and compared to a theoretical model. The responsivity of the device was found to decrease with increasing power from a pulsed laser, and the responsivity showed a peak at 1600 nm.

MP4 **Optical Characteristics of Narrow Band Gap InAs/InAsSb Superlattices,** A. Khoshakhlagh, L. Höglund, D. Z. Ting, A. Soibel, and S. D. Gunapala, *California Institute of Technology, Pasadena, CA, USA*

To optimize the InAs/InAsSb SL based materials and improve the device performance at longer wavelengths, detailed study of mechanisms limiting the lifetime in these SLs is needed. In this presentation, the temperature dependence of the minority carrier lifetime in a LW InAs/InAsSb SL is reported.

MP5 **Modelling Waveguide-Integrated Superconducting Nanowire Single Photon Detectors at Short-Wave Infrared,** Benjamin Slater, Mack H. Johnson, Lawrence Rosenfeld, Joshua Silverstone, Mark G. Thompson, and Döndü Sahin, *University of Bristol, Bristol, England, UK*

We report on the first integrated superconducting nanowire single photon detectors (SNSPDs) that are optimised for short-wave infrared photons at 2.1 μm. The SNSPDs presented in this work are one of the building blocks of quantum information processing with silicon, beyond infrared.

MP6 **An Integrated Smart Temperature Control System for Microring Resonators,** Yuewen Hu, *Tianjin University, Tianjin, China,* Beiju Huang, Xurui Mao, *Chinese Academy of Sciences, Beijing, China,* Zan Zhang, *Chang'an University, Xi'an, China,* Luhong Mao, *Tianjin University, Tianjin, China*, and Hongda Chen, *Chinese Academy of Sciences, Beijing, China*

An integrated temperature control system was designed for microring resonators. It includes a high sensitive temperature sensor, a target temperature calibration circuit and a heater control circuit. It can simplify user settings and compensate process error, which may enhance the practicality of microring resonators.

MP7 **Quantum Efficiency Enhancement of Mid Infrared Photodetectors with Photon Trapping Micro-Structures,** Ekaterina Ponizovskaya Devine, Hilal Cansizoglu, Yang Gao, Soroush Ghandiparsi, Cesar Perez, Hasina H. Mamtaz, H. Raniee, and M. Saif Islam, *University of California, Davis, Davis, CA, USA*

The study propose to use the photon trapping micro-structures to enhance quantum efficiency of the mid infrared photodetectors. The micro-structure that is consist of micro holes reduces reflection and bends the near normally incident light into the lateral modes in the absorbing layer.

MP8 **Process Control in Additive Manufacturing with 3-Dimensional Thermography,** Marc Preissler, Chen Zhang, and Gunther Notni, *Technische Universität Ilmenau, Ilmenau, Germany*

This work presents a method for a heterogeneous sensor fusion of thermography and 3-dimensional informations to monitor an additive manufacturing process. The combined data represent informations about every manufactured layer and offer a possibility to evaluate and qualify the manufacturing process.

MP9 **Application of Ledoit-Wolf Covariance Estimator to Active EM Signal Detection,** Benjamin Robinson, *Air Force Research Laboratory, Dayton, OH, USA*

A central problem in problems involving active EM illumination is adaptive high-dimensional covariance estimation for detection. In this work we propose an adaptive matched filter that is empirically more powerful than the rank-constrained maximum-likelihood estimator's in cases of low sample support and Gaussian interference statistics.

MP10 **A Negative Responsivity MoS_2 Quantum Dots and Graphene based Photodetector,** Amulya Nemoori, *Indian Institute of Technology-BHU, Varanasi, India,* Himanshu Mishra, Vijay Kumar Singh, Anchal Srivastava, *Banaras Hindu University, Varanasi, India,* and Amritanshu Pandey, *Indian Institute of Technology-BHU, Varanasi, India*

The Hydrothermally fabricated MoS_2-QDs based visible light detector on graphene /SiO_2/Si is reported. The fabricated device has shown a negative responsivity. This reduction in current is mainly attributed due to Pauli-Blocking and Electrostatic field set up by the induced charges under visible light range.

MP11 **LED Light System for Effective Cultivation Process,** Abdullah J. Zakariya, *Saad Al-Abdullah Academy for Security, Sciences, Ministry of Interior, Kuwait,* and Eshaq Mulla, *Ministry of Electric and Water, Kuwait*

A monolithic far infrared tri-wavelength LED system is proposed and fabricated. The device consists of selectively intermixed QW LED structure emitting wide range of independently controlled wavelengths. The LED system provides an effective method for efficient plant growth process using a single device light source.

MP12 **Quantum Repeaters Based on Two-Species Trapped Ions,** Sreraman Muralidharan, Siddhartha Santra, *US Army Research Laboratory, Adelphi, MD, USA,* Liang Jiang, *Yale University, New Haven, CT, USA*, Christopher Monroe, *University of Maryland, College Park, MD, USA*, and Vladimir S. Malinovsky, *US Army Research Laboratory, Adelphi, MD, USA*

We analyze performance of two-species trapped ions quantum repeater where one ion acts as a communication qubit that can be entangled to photon and the other as quantum memory. Dependence of quantum key generation rates on several crucial parameters is demonstrated.

MP13 **Time-Domain Measurement of Continuous-Variable Entanglement Using Temporally Shaped Local Oscillator Pulses,** Ami Shinjo, *Gakushuin University, Tokyo, Japan,* Yujiro Eto, *National Institute of Advanced Industrial Science and Technology, Ibaraki, Japan*, and Takuya Hirano, *Gakushuin University, Tokyo, Japan*

We generated entanglement that satisfied EPR-Reid criterion in the time domain measurement with pulsed light source and waveguides. To improve temporal mode-matching efficiency between entangled beams and local oscillator (LO) beams, we shortened the duration of the LO pulses.

MP14 Quantum Photonic Device Characteristics for Long Distance Cellular Applications, M. P. Chitra, M. Premkumar, M. Arun, and Daphne Jenson, *Panimalar Institute of Technology, Chennai, Tamil Nadu, India*

This paper outlines quantum photonic device performance such as gallium arsenide(GaAs) light emitting diode (GaAsLED) for long distance cellular applications. It requires effective signal transmission to aid with quantum photonic devices such as LED which can provide effective and efficient photons transmission between base stations.

MP15 Photon-Mediated Energy Transfer in Coherent Microcavity Laser Arrays, Zihe Gao and Kent D. Choquette, *University of Illinois, Urbana, IL, USA*

Coherently coupled 2 × 1 vertical cavity laser arrays are shown to exhibit unchanged near-field intensity profile with unequal current injection and associated far-field beam steering. The energy transfer to maintain equal near-field intensity between the cavities is shown to be consistent with parity-time symmetry.

MP16 On-Chip Readily Integrable Spectrally Uniform Single Quantum Dot Based Single Photon Source Array and Their Excitonic and Electronic Properties: Towards Quantum Optical Circuits, Jiefei Zhang, Swarnabha, *University of Southern California, Los Angeles, CA, USA,* Siyuan Lu, *IBM Thomas J. Watson Research Center, Yorktown Heights, NY, USA*, and Anupam Madhukar, *University of Southern California, Los Angeles, CA, USA*

We report on an approach to realizing on-chip quantum optical circuits (QOC) based on spectrally uniform ordered array of single quantum dots (SQDs) as single photon source. The quantum dot excitonic structure and photon emission properties have been studied to assess their potential for QOCs.

MP17 First-Order Mode Compact Focusing Grating Coupler for SOI Interconnect, Omnia M. Nawwar, *Egypt-Japan University of Science and Technology (E-JUST), Alexandria, Egypt,* Hossam M. H. Shalaby, *Egypt-Japan University of Science and Technology (E-JUST), Alexandria, Egypt and Alexandria University, Alexandria, Egypt,* and Ramesh K. Pokharel, *Graduate School of Information Science and Electrical Engineering, Fukuoka, Japan*

Compact on-chip grating coupler for first-order TE-like mode in a strip waveguide is proposed. The grating coupler is used in mode-division multiplexing (MDM) systems to couple light from a single-mode fiber to desired on-chip mode without the need of intermediate mode converters.

MP18 Multi-Band Analyses of Beam Dynamics in Disordered PT-Symmetric Optical Lattices, Xiankun Yao and Xueming Liu, *Zhejiang University, Hangzhou, China*

The method of multi-band eigenstate analyses has been used to investigate the beam dynamics in disordered PT-symmetric lattices. We found that the higher-order band components of beams are more immune to the disorder, which is proved by the beam evolutions.

TUESDAY, 10 JULY 2018

8:00 am–8:30 am **Kohala Promenade**

Breakfast

8:30 am–10:00 am **Waikoloa 1**
Session TuA1 **(Si)GeSn Devices III**
Session Chair Shui-Qing (Fisher) Yu, *University of Arkansas, AR, USA*

8:30 am–9:00 am ***(Invited)***

TuA1.1 GeSn-Based Nano-Electronic and Photonic Devices, Xiao Gong, *National University of Singapore, Singapore*

We discuss recent progress in GeSn-based advanced transistors, including various key process modules such as formation of gate stack and S/D contact as well as the multi-gate transistors enabled by the GeSnOI substrate. We would also cover various GeSn-based photodetectors for SWIR applications.

9:00 am–9:30 am ***(Invited)***

TuA1.2 GeSn Short-Wave Infrared Photodetectors by MBE, Buwen Cheng, *Chinese Academy of Sciences, Beijing, China and University of Chinese Academy of Sciences, Beijing, China,* Zhi Liu, *Chinese Academy of Sciences, Beijing, China,* Fan Yang, Jun Zheng, Chunlai Xue, *Chinese Academy of Sciences, Beijing, China and University of Chinese Academy of Sciences, Beijing, China,* Chuanbo Li, *Minzu University of China, Beijing, China,* Yuhua Zuo, *Chinese Academy of Sciences, Beijing, China and University of Chinese Academy of Sciences, Beijing, China,* Guangze Zhang, *Chinese Academy of Sciences, Beijing, China*, and Qiming Wang, *Chinese Academy of Sciences, Beijing, China and University of Chinese Academy of Sciences, Beijing, China,*

GeSn with a tunable bandgap extends the application of Si photonics to short-wave infrared region. The fabrication of GeSn PIN photodetectors and GeSn-graphene heterostructure photodetector will be introduced. Some results such as imaging by using a GeSn 20 × 20 pixel detector array will also be reported.

9:30 am–10:00 am ***(Invited)***

TuA1.3 Design and Modeling of SiGeSn Lasers: From Modeling Experiments to Future Device Concepts, Jeremy Witzens, *RWTH Aachen, Aachen, Nordrhein-Westfalen, Germany*

8:30 am–10:00 am **King's 2**

Session TuB1 **Multilayer Optical Networks**

Session Chair Raul Muñoz, *CTTC, Castelldefels, Catalonia, Spain*

8:30 am–9:00 am ***(Invited)***

TuB1.1 Cross Layer, Spectrum Aware Planning at Scale, Abishek Gopalan, Satyajeet Singh Ahuja, Sri Bala, Vinayak Dangui, and Gaya Nagarajan, *Facebook, USA*

We touch several aspects and design considerations involved in planning for Facebook's global production topology. We discuss how we optimize across layers (IP and Optical) and the role of spectrum awareness in this process. We highlight how we cope with demand uncertainty in equipment placement.

9:00 am–9:30 am ***(Invited)***

TuB1.2 Machine Learning Aided Orchestration in Multi-Tenant Networks, Carlos Natalino, Muhammad Rehan Raza, *KTH Royal Institute of Technology, Kista, Sweden,* Ahmad Rostami, *Deutsche Bahn AG, Germany,* Peter Öhlen, *Ericsson Research, Kista, Sweden,* Lena Wosinska, and Paolo Monti, *KTH Royal Institute of Technology, Kista, Sweden*

Software-defined networking enables operators to efficiently share their transport network infrastructure resources among different tenants, a concept known as network slicing. This paper presents an orchestration strategy based on reinforcement learning used to slice optical connectivity resources while serving concurrently mobile and cloud tenants.

9:30 am–10:00 am ***(Invited)***

TuB1.3 AI-Assisted Knowledge-Defined Multilayer Optical Networks, Zuqing Zhu, Siqi Liu, Baojia Li, Wei Lu, *University of Science and Technology of China, Hefei, China*

We discuss the system design to realize artificial intelligence assisted knowledge-defined cross-layer orchestration in IP over elastic optical networks. Deep learning is introduced in the control plane (CP) for traffic analysis and prediction, and consistently provides suggestions to the CP for achieving future-friendly traffic routing.

8:30 am–10:00 am **Kohala 2**

Session TuC1 **Topological Lasers and Emitters II**

Sessin Chair Sunil Mittal, *University of Maryland, College Park, College Park, MD, USA*

8:30 am–9:00 am ***(Invited)***

TuC1.1 **Topological Lasing with Polaritons,** Philippe St-Jean, Valentin Goblot, Élizabeth Galopin, Aristide Lemaître, *Université Paris-Sud, Marcoussis, Ile-de-France, France,* Tomoki Ozawa, *Université Libre de Bruxelles, Bruxelles, Brussels Hoofdstedelijk Gewest, Belgium,* Luc LeGratiet, *Université Paris-Sud, Marcoussis, Ile-de-France, France,* Isabelle Sagnes, *C2N/UPSud, Marcoussis, Ile-de-France, France,* Jacqueline Bloch, *Université Paris-Sud, Marcoussis, Ile-de-France, France,* and Alberto Amo, *Université de Lille, Marcoussis, Ile-de-France, France*

Polaritons, light-matter quasiparticles in semiconductor microcavities, offer a versatile photonic platform for exploring topological physics in the nonlinear regime. Recently, we demonstrated lasing in topological edge states of 1D lattices, and generation of coherent light with optically-tunable orbital angular momentum in photonic molecules.

9:00 am–9:30 am ***(Invited)***

TuC1.2 **Topological Lasers and Condensates,** Henning Schomerus, *Lancaster University, England, UK*

I describe how to enhance topological photonic systems via effects such as gain, loss and nonlinearities that do not have an electronic counterpart. This leads to a topological mechanism of mode selection, formation of compactons in flat-band condensates, and topological excitations in lasers.

9:30 am–10:00 am ***(Invited)***

TuC1.3 **TBD,** Boubacar Kante, *University of California, San Diego, San Diega, CA, USA*

9:00 am–10:00 am **Kohala 3**

Session TuD1 **Quantum Sensing**

Session Chair Tracy Northup, *University of Innsbruck, Innsbruck, Tirol, Austria*

9:00 am–9:30 am ***(Invited)***

TuD1.1 **Compressive Quantum Sensing,** John C. Howell, *Hebrew University of Jerusalem, Yerushalayim, Israel*

I will show how combining digital signal processing with quantum techniques can be used to overcome space bandwidth products in imaging, find Fourier amplitudes in coherent imaging, perform low-light level LIDAR and obtain ultra-high dimensional full light fields.

9:30 am–10:00 am ***(Invited)***

TuD1.2 Quantum Sensor Networks, Alexey V. Gorshkov, *University of Maryland/NIST, College Park, MD, USA*

Entangling quantum sensors can dramatically increase their sensitivity. We will show how entanglement in a network of quantum sensors can be used to optimally measure a spatially inhomogeneous field. We will also extend our results to sensing the field with a multi-port interferometer.

8:30 am–10:00 am **Kohala 4**

Session TuE1 Applications

Session Chair Gregor Weihs, *University of Innsbruck, Innsbruck, Tirol, Austria*

8:30 am–9:00 am ***(Invited)***

TuE1.1 Coherent Ising Machine – Optical Neural Network Operating at the Quantum Limit, Yoshihisa Yamamoto, *Japan Science and Technology Agency, Tokyo, Japan*

We will present the basic concept, operational principle and observed performance of a novel computing machine based on the network of degenerate optical parametric oscillators. The developed machine has 2048 qubits with all-to-all connections and is now available as a cloud system via internet.

9:00 am–9:30 am ***(Invited)***

TuE1.2 Lightwave-Driven Quasiparticles and Qubit Valleytronics, Mackillo Kira, *Ann Arbor, MI, USA*

Extremely strong lightwaves are demonstrated to transport quasiparticles much faster than scattering occurs, making electronic quantum interferences and flipping a qubit in a WSe2 monolayer controllable. A first-principles many-body quantum theory is presented to quantitative explain the related extreme nonlinear experiments.

9:30 am–10:00 am ***(Invited)***

TuE1.3 Scalable Quantum Photonics Using Quantum Dots, Edo Waks, *University of Maryland, College Park, MD, USA,* Shuo Sun, Jehyung Kim, *University of Maryland, College Park, MD, USA and National Institute of Standards and Technology, College Park, MD, USA,* Christopher Richardson, Richard Leavitt, *University of Maryland, College Park, MD, USA,* and Glenn Solomon, *University of Maryland, College Park, MD, USA and National Institute of Standards and Technology, College Park, MD, USA and National Institute of Standards and Technology, Gaithersburg, MD, USA*

I will describe our latest progress towards developing quantum photonic devices using quantum dots. I will show how a single spin in a quantum dot can act as a quantum transistor for photons, and discuss how these devices can be scaled to larger systems.

8:30 am–10:00 am **King's 3**

Session TuF1 **Multi-Mode Imaging**

Session Chair Joel Carpenter, *University of Queensland, Queensland, Australia*

8:30 am–9:00 am ***(Invited)***

TuF1.1 Microscopy and Optical Manipulation Through Multimode Fibres, Sergey Turtaev, Ivo T. Leite, *Leibniz-Institute of Photonic Technology, Jena, Germany,* Martin Siler, Tomáš Tyc, *Institute of Scientific Instruments of the ASC, Brno, Jihomoravsky kraj, Czech Republic*, and Tomas Cizmar, *Leibniz-Institute of Photonic Technology, Jena, Germany*

The lecture will introduce the utilization of multimode fibres for deep tissue imaging inside living animal models as well as the exploitation of highly specialised optical fibre probes for advanced bio-photonics applications including optical manipulation.

9:00 am–9:30 am ***(Invited)***

TuF1.2 Image Transport Through Anderson Localization, Arash Mafi, *University of New Mexico, Albuquerque, NM, USA*

Anderson localization has been a subject of intense research for sixty years. It is highly desirable to harness its curious and interesting properties in practical applications. I will survey recent advances in this direction by using this phenomenon for high-quality image transport in optical fibers.

9:30 am–9:45 am

TuF1.3 Holographic Optical Tweezers at the Tip of a Needle, Ivo T. Leite, Sergey Turtaev, *Leibniz Institute of Photonic Technology, Jena, Germany,* Xin Jiang, *Max Planck Institute for the Science of Light, Erlangen, Germany,* Martin Šiler, *Institute of Scientific Instruments of the Czech Academy of Sciences, Brno, Czech Republic,* Alfred Cuschieri, *University of Dundee, Dundee, Scotland, UK,* Philip St. J. Russell, *Max Planck Institute for the Science of Light, Erlangen, Germany*, and Tomáš Čižmár, *Leibniz Institute of Photonic Technology, Jena, Germany*

Fibre-based optical tweezers typically rely on engineered fibre terminations yielding limited flexibility in number and positioning of trap sites. Here, we demonstrate holographic optical tweezers delivered by a lensless, high-NA multimode fibre with full positioning control of multiple tweezers independently and in all directions.

9:45 am–10:00 am

TuF1.4 Near-IR to Mid-IR Supercontinuum Generation for High-Order Modes Using AsSe Multimode Fiber, Ning Wang, Md Selim Habib, Fei Jia, Guifang Li, Rodrigo Amezcua-Correa, *University of Central Florida, Orlando, FL, USA*

We investigate the supercontinuum generation of the first four LP modes in an AsSe multimode fiber. Numerical results show that the supercontinuum spectra spanning from near-IR to mid-IR of high-order spatial modes are broader than that of the fundamental mode.

10:00 am–10:30 am **Kohala Promenade**

Coffee Break

10:30 am–12:00 pm **Waikoloa 1**
Session TuA2 **(Si)GeSn Material Properties I**
Session Chair Dan Buca, *Forschungszentrum Juelich, Juelich, Germany*

10:30 am–11:00 am ***(Invited)***

TuA2.1 Developing Sn-Containing Group-IV Alloys for Mid-Infrared Sensing, Bruce Claflin, *Air Force Research Laboratory, Wright-Patterson AFB, OH, USA,* Gordon Grzybowski, Stephanie Chastang, *KBRwyle, Wright-Patterson AFB, OH, USA*, and Arnold Kiefer, *Air Force Research Laboratory, Wright-Patterson AFB, OH, USA*

We report on CVD growth as well as structural, electrical and optical characterization of Sn-containing group-IV alloy films over a range of alloy compositions. The impact of buffer layers on growth is evaluated. Annealing studies show improvements in film crystallinity and strain relaxation.

11:00 am–11:30 am ***(Invited)***

TuA2.2 CMOS-Compatible MIR and SWIR Imagers and Detectors: A Materials Perspective, Simone Assali, Anis Attiaoui, Étienne Bouthillier, Jérôme Nicolas, and Oussama Moutanabbir, *Ecole Polytechnique de Montreal, Montreal, Quebec, Canada*

The high production cost has been a major obstacle in the development of MIR devices, which remain out of the reach of the civilian market. This work will outline strategies to circumvent this technological roadblock using emerging CMOS-compatible materials to implement MIR and SWIR devices.

11:30 am–12:00 pm ***(Invited)***

TuA2.3 Engineering Optoelectronic Properties of High-Sn-Content GeSn, GeSiSn, and SiSn Thin Films, Osamu Nakatsuka, Masashi Kurosawa, Masahiro Fukuda, Mitsuo Sakashita, Wakana Takeuchi, and Shigeaki Zaima, *Nagoya University, Nagoya, Japan*

GeSn-related group-IV semiconductors have attracted much attention for optoelectronic applications. We have been developing the crystal growth technology of GeSn, GeSiSn, and SiSn thin films with strain engineering to overstep thermal-equilibrium limitation. Heterostructure engineering has been investigated for energy-band design to improve the optoelectronic performances.

10:30 am–12:00 pm **King's 2**

Session TuB2 **Applications of ML in Optical Networks II**

Session Chair Omer Faruk Yilmaz, *Infinera Corporation, USA*

10:30 am–11:30 am ***(Tutorial)***

TuB2.1 Using Machine Learning in Communication Networks, David Cote, *Ciena, Gatineau, Quebec, Canada*

We will review how the machine learning concepts – data, algorithms, infrastructure and applications – can apply to communication networks. Then we will present results from concrete applications: detection of abnormal network elements, deep learning of optical fiber parameters and reinforcement learning of bandwidth allocation.

11:30 am–12:00 pm ***(Invited)***

TuB2.2 Deeply Programmable and Machine-Learning Assisted Optical Network, Reza Nejabati, *Bristol, UK*

10:30 am–12:00 pm **Kohala 2**

Session TuC2 **Non-Hermitian Resonances and Optical Transport**

Sessin Chair Demetrio Christodoulides, *University of Central Florida, Orlando, FL, USA*

10:30 am–11:00 am ***(Invited)***

TuC2.1 Generalized Reflectionless Transmission in Photonic Structures via Gain-Loss Engineering, A. Douglas Stone, William Sweeney, and Chia-Wei Hsu, *Yale University, New Haven, CT, USA*

Reflectionless perfect transmission resonances in hermitian structures require parity symmetry and are bidirectional. We show that in non-hermitian structures such resonances are unidirectional and are generically achievable without PT symmetry via gain-loss engineering. Moreover perfect mode conversion can also be achieved in a similar fashion.

11:00 am–11:30 am ***(Invited)***

TuC2.2 Non-Hermitian Wave Transport with Applications to Photonic Limiters, Tsampikos Kottos, *Wesleyan University, Middletown, CT, USA*

Optical limiters transmit low-level radiation while blocking high-level electromagnetic signal. Typical limiters absorb the high-level incident radiation – an operation that causes overheating and destruction. We present a class of non-Hermitian photonic limiters which are self-protected from overheating effects induced via high-level incident electromagnetic radiation.

11:30 am–12:00 pm ***(Invited)***

TuC2.3 Non-Hermitian Wave Control in Scattering Disordered Media, K. G. Makris, *University of Crete, Heraklion, Greece,* A. Brandstötter, S. Rotter, *Vienna University of Technology, Vienna, Austria*

In the framework of non-Hermitian and PT-symmetric photonics, we show how complete wave control can be achieved inside a disordered scattering system, by precise gain/loss engineering. In particular, perfect transmission, unidirectional invisibility and focusing are examined in detail. Possible experimental implementations are also are discussed.

10:30 am–12:00 pm **Kohala 3**

Session TuD2 **Spectral and Temporal Entanglement Manipulation**

Session Chair **Marco Bellini,** *Istituto Nazionale di Ottica – CNR, ITALY, Sesto Fiorentino (Florence), Toscana, Italy*

10:30 am–11:00 am ***(Invited)***

TuD2.1 Temporal Multiplexing: The Tool of Our Time, Paul Kwiat, *University of Illinois at Urbana-Champaign, Savoy, IL, USA*

Scalable quantum networks rely on distribution of entanglement between nodes. The requisite quantum repeaters in turn require simultaneous presence of at least two photons for the entanglement-swapping Bell state analysis. Here we discuss the large enhancements that can be obtained by incorporating low-loss temporal multiplexing.

11:00 am–11:30 am ***(Invited)***

TuD2.2 Experiments with Frequency Entangled and Frequency Encoded Photons, Andrew Weiner, *Purdue University, West Lafayette, IN, USA*

We investigate frequency bin entanglement of photon pairs generated via either spontaneous four wave mixing in silicon nitride microresonators or spectrally filtered spontaneous parametric down-conversion. Topics include entanglement in >2 dimensions, low light level dispersion measurement, and a simple frequency domain Hong-Ou-Mandel demonstration.

11:30 am–12:00 pm ***(Invited)***

TuD2.3 Hong-Ou-Mandel Interference and Deterministic Control of Two-Qubit Correlations for Spectral Gubits, Hsuan-Hao Lu, *Purdue University, West Lafayette, IN, USA,* Joseph Lukens, Nicholas A. Peters, Brian Williams, *Oak Ridge National Laboratory, Oak Ridge, TN, USA,* Andrew Weiner, *Purdue University, West Lafayette, IN, USA*, and Pavel Lougovski, *Oak Ridge National Laboratory, Oak Ridge, TN, USA*

Optical fiber enables photonic quantum telecommunications in the lowest-loss frequency windows which promise to support many parallel frequency channels. As a step towards leveraging the available bandwidth, we experimentally demonstrate Hong-Ou-Mandel interference between different frequency modes and frequency-encoded quantum correlation control.

10:30 am–12:00 pm **Kohala 4**

Session TuE2 **Resonators and Si Photonics**

Session Chair Gadi Eisensterin, *Technion, Hefa, Israel*

10:30 am–11:00 am ***(Invited)***

TuE2.1 Soliton Microcomb Physics and Applications, Kerry J. Vahala, *California Institute of Technology, Pasadena, CA, USA*

The physics of dissipative Kerr solitons in high-Q micro cavities is reviewed including discussion of Raman effects and counter-propagating soliton behavior. Demonstrations of dual-comb spectroscopy and optical LIDAR using soliton microcombs are presented. Work towards compact optical clocks and synthesizers is also discussed.

11:00 am–11:20 am

TuE2.2 An On-Chip Homodyne Detector for Measuring Quantum States, Giacomo Ferranti, Francesco Raffaelli, Dylan H. Mahler, Philip Sibson, Jake E. Kennard, Alberto Santamato, Gary Sinclair, Damien Bonneau, Mark G. Thompson, and Jonathan C. F. Matthews, *University of Bristol, Bristol, England, UK*

We present the first silicon-integrated homodyne detector suitable for characterising quantum states of light travelling in a silicon waveguide. We report high-fidelity quantum state tomography of coherent states. The device was also used to generate random numbers at a speed of 1.2 Gbps.

11:20 am–11:40 am

TuE2.3 Comparative Analysis of Classical and Quantum Plasmons in Graphene Nanostructures, Jian Wei You and Nicolae C. Panoiu, *University College London, London, England, UK*

We investigate the physical properties of classical and quantum plasmons in graphene nanostructures using finite-difference time-domain computations and time-dependent density functional theory, respectively. The results show that the optical properties of quantum plasmons are markedly different from those of classical ones, both qualitatively and quantitatively.

11:40 am–12:00 pm

TuE2.4 Enhanced Photon Detection Efficiency of Silicon Single Photon Avalanche Photodetectors Enabled by Photon Trapping Structures, Cesar Bartolo Perez, Hilal Cansizoglu, Yang Gao, Soroush Ghandiparsi, Ahmed S. Mayet, *University of California, Davis, Davis, CA, USA,* Ekaterina Ponizovskaya, Aly F. Elrefaie, *University of California, Davis, Davis, CA, USA and W&WSens Devices, Inc., Los Altos, CA, USA* Shih-Yuan Wang, *W&WSens Devices, Inc., Los Altos, CA, USA*, and M. Saif Islam, *University of California, Davis, Davis, CA, USA*

Silicon single photon avalanche photodetectors with photon trapping structures demonstrate absorption improvement from 800 nm to 1100 nm, and with a response time of 28 ps, opening the possibility to improve their photon detection efficiency, with low time jitter and low dark count rate.

10:30 am–11:45 am **King's 3**

Session TuF2 **SDM Transmission II**

Session Chair Jochen Schroder, *Chalmers University of Technology, Gothenburg, Sweden*

10:30 am–11:00 am ***(Invited)***

TuF2.1 Coupled-Core and Multi-Mode Fiber Transmission, Roland Ryf, Nicolas K. Fontaine, and Haoshuo Chen, *Nokia Bell Labs, Holmdel, NJ, USA*

We present the latest progress in coherent MIMO based transmission over multimode and coupled-core fibers. Particular we will show results for mode-multiplexed transmission over 36 spatial modes of a graded-index multimode fiber and long distance transmission results up to 12000 km over 4-core coupled-core fiber.

11:00 am–11:30 am ***(Invited)***

TuF2.2 Few-Mode Multi-Core Fiber Technologies for Repeated Dense SDM Transmission, T. Sakamoto, *NTT Corporation, Tsukuba, Ibaraki, Japan,* K. Saitoh, *Hokkaido University, Hokkaido, Japan,* S. Saitoh, *Fujikura Ltd., Chiba, Japan,* K. Shibahara, *NTT Corporation, Yokosuka, Kanagawa, Japan,* M. Wada, Y. Abe, A. Urushibara, *NTT Corporation, Tsukuba, Ibaraki, Japan,* K. Takenaga, *Fujikura Ltd., Chiba, Japan,* T. Mizuno, *NTT Corporation, Yokosuka, Kanagawa, Japan,* T. Matsui, *NTT Corporation, Tsukuba, Ibaraki, Japan,* K. Aikawa, *Fujikura Ltd., Chiba, Japan,* Y. Miyamoto, *NTT Corporation, Yokosuka, Kanagawa, Japan,* and K. Nakajima, *NTT Corporation, Tsukuba, Ibaraki, Japan*

We introduce the high spatial density few-mode multi-core fiber (FM-MCF) design for repeated space division multiplexed transmission. We clarify the 6-mode 7-core structure is beneficial for reducing the splice induced differential modal loss, and report the repeated 100-km transmission using our 6-mode MCF and EDFA.

11:30 am–11:45 am

TuF2.3 Investigation of Higher Order Modulation Formats for Few-Mode Fiber SDM Transmission Systems, Georg Rademacher, Ruben S. Luís, Benjamin J. Puttnam, Hideaki Furukawa, Yoshinari Awaji, *NICT, Koganei, Tokyo, Japan,* Ryo Maruyama, Kazuhiko Aikawa, *Fujikura Ltd., Sakura, Chiba, Japan*, and Naoya Wada, *NICT, Koganei, Tokyo, Japan*

We investigate the use of higher order modulation formats in few-mode fiber transmission systems. We demonstrate transmission of up to 256-quatrature amplitude modulation at 24.5 GBaud over 30~km three-mode fiber

12:00 pm–1:30 pm

Lunch Break (on own)

1:30 pm–3:00 pm **Waikoloa 1**
Session TuA3 **(Si)GeSn Material Properties II**
Session Chair Wei Du, *Wilkes University, Wilkes-Barre, PA, USA*

1:30 pm–2:00 pm ***(Invited)***

TuA3.1 Thermal Stability of GeSn and SiGeSn Layers, Giovanni Capellini, *IHP, Frankfurt Oder, Brandenburg, Germany*

In this talk we present a thorough investigation of the effect of thermal annealing on the strain plastic relaxation and Sn segregation in GeSn and GeSiSn layers grown by CVD or MBE on Ge/Si virtual substrates.

2:00 pm–2:45 pm ***(Plenary)***

TuA3.2 Si-Ge-Sn Semiconductors and Related (Si,Ge)5-2y(III-V)y Systems, John Kouvetakis, *Arizona State University, Tempe, AZ, USA*

The talk reviews epitaxial synthesis and device fabrication of Ge-Si-Sn alloys using ultra-low temperature stoichiometric reactions of high-order germanium hydrides. The talk also introduces a closely-related class of new semiconductors comprising diamond-like structures based on Si or Ge parent lattices incorporating isolated III-V donor-acceptor pairs.

2:45 pm–3:00 pm

TuA3.3 Temperature Dependent Dielectric Function and Critical Points of Bulk Ge Compared to α-Sn on InSb, C. Emminger, R. Carrasco, N. Samarasingha, F. Abadizaman, and S. Zollner, *New Mexico State University, Las Cruces, NM, USA*

The temperature dependence of the dielectric function of Ge is investigated in a spectral range from 0.5 to 6.3 eV between 10 and 738 K. Structures occurring in the infrared region of α-Sn on InSb are compared to the absorption edge of Ge.

1:30 pm–3:00 pm **King's 2**
Session TuB3 **Access Networks**
Session Chair Seb J. Savory, *University of Cambridge, Cambridge, England, UK*

1:30 pm–2:00 pm ***(Invited)***

TuB3.1 SDN Control and Monitoring of SDM/WDM and Packet Transport Networks for 5G Fronthaul/Backhaul, R. Muñoz, J. M. Fàbrega, R. Vilalta, M. Svaluto Moreolo, R. Martínez, Ramon Casellas, *Centre Tecnològic de Telecomunicacions de Catalunya (CTTC/CERCA), Barcelona, Spain,* N. Yoshikane, T. Tsuritani, and I. Morita, *KDDI Research, Inc., Saitama, Japan*

This paper presents optical (SDM/WDM) and packet transport solutions for 5G fronthaul/backhaul and the hierarchical Transport SDN control and monitoring architecture. It dynamically provides multiple spectral-spatial super-channels and packet flows, and monitors the signal quality degradation of the optical super-channels and the aggregated packet traffic.

2:00 pm–2:30 pm ***(Invited)***

TuB3.2 From Central Office Cloudification to Optical Network Disaggregation, Marco Ruffini, *University of Dublin, Trinity College, Dublin, Ireland*, and Daniel C. Kilper, *University of Arizona, Tucson, AZ, USA*

This talk discusses how the novel concept of a cloud-based Central Office blurs the distinction between access, metro and data centre networks. We show how this scenario provides new use cases for dynamic and disaggregated optical networking and opportunities for machine learning integration.

2:30 pm–3:00 pm ***(Invited)***

TuB3.3 Machine-Learning-Based Prediction and Optimization of Mobile Metro-Core Networks, Rodolfo Alvizu, *Politecnico di Milano, Milan, Italy and SWAN networks, Milan, Italy,* Sebastian Troia, *Politecnico di Milano, Milan, Italy*, Guido Maier, and Achille Pattavina, *Politecnico di Milano, Milan, Italy and SWAN networks, Milan, Italy*

1:30 pm–3:00 pm **Kohala 2**

Session TuC3 Non-Reciprocal and Topological Phenomena in Photonics

Session Chair Bo Zhen, *University of Pennsylvania, Philadelphia, PA, USA*

1:30 pm–2:00 pm ***(Invited)***

TuC3.1 Chiral and Nonreciprocal Photonics in Optomechanical Resonator Systems, Seunghwi Kim, Donggyu Sohn, JunHwan Kim, *University of Illinois at Urbana-Champaign, IL, USA,* Jacob Taylor, *Joint Center for Quantum Information and Computer Science, Gaithersburg, MD, USA,* Gaurav Bahl, *University of Illinois at Urbana-Champaign, Urbana, IL, USA*

We show that time-reversal symmetry (TRS) can be broken in any dielectric using optomechanics, without topological or magneto-optic materials. Using such optomechanical TRS-breaking, we demonstrate dynamical suppression of disorder induced scattering for light and sound, as well as acoustically pumped optical nonreciprocity.

2:00 pm–2:30 pm ***(Invited)***

TuC3.2 Demonstration of a Bi-Anisotropic Meta-Waveguide Quantum Hall Analog, Steven M. Anlage, *University of Maryland, College Park, MD, USA*

We construct a quantum Hall (QH) analog bi-anisotropic meta-waveguide (BMW) structure that breaks time-reversal invariance. By utilizing magnetized ferrites, the interface of the QH/Quantum-Spin-Hall (QSH) regions should show uni-directional propagation. We demonstrate a 4-port circulator based on a composite QSH and QH BMW structure.

2:30 pm–3:00 pm ***(Invited)***

TuC3.3 Entangled States of Topological Modes in Nanophotonics, Andrea Blanco-Redondo, Bryn Bell, *University of Sydney, New South Wales, Australia,* Dikla Oren, *Technion Israel Institute of Technology, Hefa, Israel,* Mordechai Segev, *Technion, Haifa, Tel Aviv, Israel*, and Benjamin Eggleton, *University of Sydney, New South Wales, Australia*

We experimentally study topological protection of biphoton states in nanophotonic lattices of coupled silicon waveguides. The biphotons generated within the lattice have spatial entanglement due to quantum interference. When they couple to topological defect modes their wavefunction becomes near-separable and certain aspects are protected.

1:30 pm–3:00 pm **Kohala 1**

Session TuG3 **Active Nanophotonics**

Session Chair Mark Stockman, *Georgia State University, USA*

1:30 pm–2:00 pm ***(Invited)***

TuG3.1 Dynamics of Nanoscale Light Emitters, Y. Fainman, S. H. Pan, S. Deka, Q. Gu, A. El Amili, and F. Vallini, *University of California, San Diego, La Jolla, CA, USA*

We discusses nanoscale metal-dielectric-semiconductor resonant gain geometries confined in three dimensions used to create a new type of light emitters. When these emitters are driven in a pulsed regime, dynamic hysteresis is observed and characterized. Coupling between two metallo-dielectric nanolasers results in splitting the resonance.

2:00 pm–2:30 pm ***(Invited)***

TuG3.2 Electrooptic Activation Function for MAC-per-Attojoule Photonic Neuromorphic Computing, Jonathan George, Armin Mehrabian, Rubab Amin, Tarek El-Ghazawi, *George Washington University, Washington, DC, USA,* Jacob Khurgin, *Johns Hopkins University, Baltimore, MD, USA,* Paul Prucnal, *Princeton University, Princeton, NJ, USA*, and Volker Sorger, *George Washington University, Washington, DC, USA*

We show how the nonlinear transfer function of electrooptic modulators enables vector matrix multiplications for energy-efficient photonic neural networks. Here the modulators energy-per-bit function and sensitivity to noise are critical factors impacting system performance towards delivering MAC-per-attojoule performance.

2:30 pm–2:45 pm

TuG3.3 Pt/Al_2O_3 Multilayer Films as High-Temperature Thermal Emitters, Tae Il Lee, Youngsuk Nam, and Sun-Kyung Kim, *Kyunghee University, Yongin, South Korea*

One-dimensional metal/dielectric hyperbolic metamaterials have a great potential for broadband thermal emitters in thermophotovoltaics due to their wavelength-dependence phase transition between dielectric and metal. In this study, we report broadband Pt/Al_2O_3 thermal emitters with a high-temperature stability up to 1450 K.

2:45 pm–3:00 pm

TuG3.4 Scalable AWGR-Based All-to-All Optical Interconnects with 2.5 D/3 D Integrated Optical Interposers, Xian Xiao, Yu Zhang, Roberto Proietti, and S. J. B. Yoo, *University of California, Davis, Davis, CA, USA*

This paper investigates AWGR-based optical interposers for scalable hierarchical all-to-all interconnects. First, we analyzed the crosstalk requirements for AWGR. Second, we presented a hierarchical all-to-all architecture that can scale beyond 100,000 nodes. Finally, we presented our work-in-progress on 1.6 Tb/s SiPh interposer design and fabrication.

1:30 pm–3:00 pm **Kohala 3**

Session TuD3 Quantum Metrology

Session Chair Vladimir Malinovsky, *US Army Research Laboratory, USA*

1:30 pm–2:00 pm *(Invited)*

TuD3.1 Reinforcement Learning for Quantum Metrology via Quantum Control, Seyed Shakib Vedaie, Pantita Palittapongarnpim, *University of Calgary, Calgary, Alberta, Canada*, and Barry C. Sanders, *University of Calgary, Calgary, Alberta, Canada and Canadian Institute for Advanced Research, Toronto, Ontario, Canada*

We develop reinforcement learning as a tool for classical and quantum control, which we treat in a unified framework. Our reinforcement-learning approach yields robust quantum metrology policies that beat the standard quantum limit.

2:00 pm–2:30 pm *(Invited)*

TuD3.2 Operational Wave-Particle Duality in Multi-Path Interferometers, Janos A. Bergou, Mark Hillery, Emili Bagán Capella, *Hunter College of the City University of New York, NY, USA,* and John Calsamiglia Costa, *Universitat Autònoma de Barcelona, Barcelona, Spain*

We present a tight duality relation for n-path interferometers via resource theory of coherence. Discrimination games provide operational meaning. Players guess the path of the particle in ‘Ways’, and the phase shifts in the paths in ‘Phases’. Duality emerges as constraint on the winning probabilities.

2:30 pm–3:00 pm *(Invited)*

TuD3.3 Spectral Densities for Quantum Networks and Implications for Quantum Darwinism, Barry M. Garraway, *University of Sussex, Brighton, England, UK*

This work shows the connection between some types of simple quantum network and a spectral density for the communication channel. Recent work which examined the phenomenon of Quantum Darwinism for a sub-divided channel will also be presented.

1:30 pm–3:00 pm **Kohala 4**

Session TuE3 **Lasers and Quantum Emitters II**

Session Chair Johann Peter Reithmaier, *University of Kassel, Kassel, Germany*

1:30 pm–2:00 pm ***(Invited)***

TuE3.1 Thresholdless Lasing in Single-Atom Superradiance, Kyungwon An, *Seoul National University, Seoul, South Korea*

Contrary to the conventional approach of maximizing the so-called beta factor for thresholdless lasing, we utilized collective interaction of phase-aligned atomic dipoles in a high-Q cavity to demonstrate thresholdless lasing even with a beta factor of 0.03 in the setting of the single-atom superradiance.

2:00 pm–2:20 pm

TuE3.2 Active Optical Systems with Novel Metal Brightness Amplifiers, Maxim V. Trigub and Gennadiy S. Evtushenko, *V.E. Zuev Institute of Atmospheric Optics SB RAS, Tomsk, Russia and Tomsk Polytechnic University, Tomsk, Russia*

The system with a brighntenss amplifiers can be used for development the new method of information obtaining. It can be available to observe the modern fast processes in the region of high energy fluxes with matter. The new type of an active filters are presented.

2:20 pm–2:40 pm

TuE3.3 A Charge-Tunable Quantum Dot Deep in the Strong Coupling Regime of Cavity QED, Daniel Najer, Immo Söllner, Matthias C. Loebl, Daniel Riedel, Benjamin Petrak, Sebastian Starosielec, *University of Basel, Basel, Switzerland,* Vincent Dolique, *Univ Lyon, Univ Claude Bernard, Villeurbanne, France and Univ Lyon, Univ Claude Bernard, Lyon, France,* Sascha R. Valentin, Ruediger Schott, Andreas D. Wieck, Arne Ludwig, *Ruhr-Universität Bochum, Bochum, Germany*, and Richard J. Warburton, *University of Basel, Basel, Switzerland*

We present high-cooperativity (C up to 140) strong coupling of a charge-tunable InAs quantum dot embedded in a tunable Fabry-Pérot microcavity (Q = 500,000). Via second-order correlation measurements we show high single-photon purity in the photon-blockade regime and pronounced vacuum Rabi oscillations in the photon-induced tunneling regime.

2:40 pm–3:00 pm

TuE3.4 Coherent Polariton States in ZnO Nano- and Microstructures, Tom Michalsky, Marcel Wille, Evgeny Krüger, Chris Sturm, Marius Grundmann, and Rüdiger Schmidt-Grund, *Leipzig University, Leipzig, Germany*

We present a survey on types of coherent states, which we have observed in bare and functionalized ZnO nano- and microwire cavities. These cover energetically tunable coherent emission by electron-hole plasma lasing, doubly stimulated exciton-phonon scattering, and propagating exciton-polariton Bose-Einstein condensates, including Bogoliubov-like excitations.

1:30 pm–3:00 pm **King's 3**

Session TuF3 **SDM Transmission III**

Session Chair Roland Ryf, *Nokia Bell Labs, Holmdel, NJ, USA*

1:30 pm–2:00 pm ***(Invited)***

TuF3.1 Design of Multi-Core and Coupled-Core Fibers, Tetsuya Hayashi, *Sumitomo Electric Industries, Ltd., Yokohama, Japan*

This talk will review the design factors of multi-core fibers, which include basic properties of the uncoupled multi-core fibers, and recent advances on the understanding on the random coupling in the coupled multi-core fibers.

2:00 pm–2:30 pm ***(Invited)***

TuF3.2 An Overview on Recent Advancement with Joint Packet and Circuit Switched Networks Using Homogeneous Multicore Fibers, Ruben S. Luis, *NICT, Koganei, Tokyo, Japan*

2:30 pm–3:00 pm ***(Invited)***

TuF3.3 10 Pbit/s Transmission Using Space-Division-Multiplexing, Itsuro Morita, Daiki Soma, and Takehiro Tsuritani, *KDDI Research, Fujimino, Saitama, Japan*

Space-division-multiplexing is a promising technology to increase a system capacity drastically and the highest capacity in a single optical fiber has reached to 10 Pbit/s recently. In this paper, we will review 10.16 Pbit/s transmission experiment using 6-mode 19-core fiber.

3:00 pm–3:30 pm **Kohala Promenade**

Coffee Break

3:30 pm–5:00 pm **Waikoloa 1**

Session TuA4 **Group IV Integration**

Session Chair Jeremy Witzens, *RWTH Aachen, Aachen, Nordrhein-Westfalen, Germany*

3:30 pm–4:00 pm ***(Invited)***

TuA4.1 Components for Integrated Ge on Si for Mid-Infrared Photonic Sensors, Kevin Gallacher, Ross W. Millar, Ugnė Griškevičiūtė, *University of Glasgow, Glasgow, UK,* Marco P. Fischer, Aaron Riede, *University of Konstanz, Konstanz, Germany,* Jacopo Frigerio, *Politecnico di Milano, Como, Italy,* Leonetta Baldassarre, *Sapienza Universitá di Roma, Rome, Italy,* Giovanni Pellegrini, *Politecnico di Milano, Milano, Italy,* Alfred Leitenstorfer, Daniele Brida, *University of Konstanz, Konstanz, Germany,* Giovanni Isella, *Politecnico di Milano, Como, Italy,* Michele Ortolani, *Sapienza Universitá di Roma, Rome, Italy,* Paolo Biagioni, *Politecnico di Milano, Milano, Italy*, and Douglas J. Paul, *University of Glasgow, Glasgow, UK*

Components for mid-infrared chip-scale sensors are reviewed including loss measurements of Ge-on-Si waveguides between 8 and 10.5 μm wavelength. Third-harmonic generation is demonstrated using Ge nano-antennas. Such components are essential for a Ge-on-Si mid-infrared platform technology for healthcare, security and environmental sensing applications.

4:00 pm–4:30 pm ***(Invited)***

TuA4.2 Ge-on-Insulator Platform for Mid-Infrared Integrated Photonics, M. Takenaka and S. Takagi, *University of Tokyo, Tokyo, Japan*

A Ge-on-insulator wafer formed by wafer bonding can provide a photonic integrated circuit platform operating at mid-infrared wavelengths. In addition to passive waveguide components including bends, MMI coupler, ring resonators, and grating couplers, carrier-injection optical modulators have been demonstrated on the Ge-on-insulator platform.

4:30 pm–5:00 pm ***(Invited)***

TuA4.3 Silicon and Germanium Suspended Waveguides for the Mid-Infrared, A. Osman, J. Soler Penades, *University of Southampton, Southampton, UK,* A. Sanchez-Postigo, *Universidad de Malaga, Malaga, Spain,* Y. Wu, Z. Qu, *University of Southampton, Southampton, UK,* J. G. Wanguemert-Perez, A. Ortega-Monux, R. Halir, *Universidad de Malaga, Malaga, Spain,* P. Cheben, *National Research Council Canada, Ottawa, Canada,* I. Molina-Fernandez, *Universidad de Malaga, Malaga, Spain,* M. Nedeljkovic, *University of Southampton, Southampton, UK,* and G. Z. Mashanovich, *University of Southampton, Southampton, UK and University of Belgrade, Belgrade, Serbia*

We have demonstrated low loss light propagation in suspended silicon and suspended germanium waveguide platforms. Both rib and subwavelength grating designs have been fabricated and characterised at a wavelength as long as 7.7 micrometers.

3:30 pm–5:00 pm **King's 2**

Session TuB4 **Transmission and Photonics**

Session Chair Takahito Tanimura, *Fujitsu Laboratories Ltd., Kawasaki, Kanagawa, Japan*

3:30 pm–4:00 pm ***(Invited)***

TuB4.1 Applications of Intelligent Coherent Transceivers in Software-Defined Elastic Optical Networks, Bo Zhang, *Beijing University of Posts and Telecommunications, Beijing, China and McGill University, Montréal, Québec, Canada,* Qunbi Zhuge, *McGill University, Montréal, Québec, Canada and Shanghai Jiao Tong University, Shanghai, China,* Xingyu Zhou, *McGill University, Montréal, Québec, Canada,* Ru Zhang, Xiangjun Xin, *Beijing University of Posts and Telecommunications, Beijing, China*, and David V. Plant, *McGill University, Montréal, Québec, Canada*

We review the application of intelligent coherent bandwidth-variable transceiver (BVT) with flexibilities in both bandwidth and spectral efficiency (SE) in software-defined elastic optical networks (SD-EONs). Machine learning techniques can be adopted to configure BVTs in diverse and dynamic optical networks.

4:00 pm–4:30 pm ***(Invited)***

TuB4.2 Polarization Dependent Loss Monitor and Compensation for Digital Coherent Transmission System, Guoxiu Huang, *Fujitsu Ltd., Kawasaki, Japan,* Yuichi Akiyama, *Fujitsu Laboratories Ltd., Kawasaki, Japan,* Shoichiro Oda, *Fujitsu Ltd., Kawasaki, Japan,* Hisao Nakashima, *Fujitsu Laboratories Ltd., Kawasaki, Japan*, and Takeshi Hoshida, *Fujitsu Ltd., Kawasaki, Japan*

We demonstrate a new proposal of polarization-dependent-loss compensation with digital-signal-processing based on Mueller matrix monitor technology. The experimental results show high Q improvement of 1.6dB for a polarization-dependent-loss of 5dB.

4:30 pm–4:45 pm

TuB4.3 Neuro-MMI: A Hybrid Photonic-Electronic Machine Learning Platform, Nicholas Soures, Jeffrey Steidle, Stefan Preble, and Dhireesha Kudithipudi, *Rochester Institute of Technology, Rochester, NY, USA*

We demonstrate a hybrid electronic-photonic feedforward neural network which exploits interference patterns in a Multimode Interference coupler (neuro-MMI). The proposed neuro-MMI's accuracy is statistically equivalent to state-of-the-art networks. Neuro-MMI serves as a blueprint for a class of high-performance neuromorphic networks that can solve cognitive tasks.

4:45 pm–5:00 pm

TuB4.4 Extreme Mobile Broadband Tier-II Fronthaul Network Enabled by a New DNN Machine Learning Framework, Qi Zhou, Mu Xu, *Georgia Institute of Technology, Atlanta, GA, USA,* Peng-Chun Peng, *National Taipei University of Technology, Taipei, Taiwan, China*, and Gee-Kung Chang, *Georgia Institute of Technology, Atlanta, GA, USA*

We propose a new DNN framework for the next-generation mobile fronthaul network supporting tier-II enhanced mobile broadband. The mobile fronthaul network integrates the GPU for efficient resource-saving machine learning. In addition, the framework can achieve over 30% relative capacity improvement.

3:30 pm–5:00 pm **Kohala 2**

Session TuC4 **Novel Concepts in Topological Photonics I**

Session Chair Sahin K. Ozdemir, *Pennsylvania State University, University Park, PA, USA*

3:30 pm–4:00 pm ***(Invited)***

TuC4.1 Parity-Time-Symmetric Optics, Extraordinary Momentum and Spin in Evanescent Waves,and the Quantum Spin Hall Effect of Light, Franco Nori, *RIKEN, Saitama, Japan and University of Michigan, Ann Arbor, MI, USA*

I will cover:

Bliokh, Bekshaev, Nori, Extraordinary momentum and spin in evanescent waves, *Nature Communications* **5**, 3300 (2014).

Bliokh, Smirnova, Nori, Quantum Spin Hall Effect of Light, *Science* **348**, 1448–1451 (2015).

Bliokh, Nori, Transverse and Longitudinal Angular Momenta of Light, *Physics Reports* **592**, 1–38 (2015).

4:00 pm–4:30 pm ***(Invited)***

TuC4.2 Solids in Ultrafast Strong Fields: Topological Attosecond Phenomena, Mark I. Stockman, *Georgia State University, Atlanta, GA, USA*

We present our latest theoretical results on graphene and other two-dimensional solids such as transitional metal dichalcogenides. These materials in the reciprocal space are characterized by nontrivial topological properties. These materials in a strong ultrashort pulse field exhibits induced chirality and a significant valley polarization.

4:30 pm–5:00 pm ***(Invited)***

TuC4.3 Magnetic Dirac Cones, Yidong Chong, *Nanyang Technological University, Singapore*

3:30 pm–5:00 pm **Kohala 1**

Session TuG4 **Non-Hermitian Resonances and Beam Dynamics**

Session Chair Tsampikos Kottos, *Wesleyan University, Middletown, CT, USA*

3:45 pm–4:00 pm

TuG4.1 Exceptional Points in the Dispersion of Optically Anisotropic Planar Microcavities, Steffen Richter, *ELI Beamlines, Dolní Břežany, Czech Republic,* Jesús Zúñiga-Pérez, Christiane Deparis, *Université Côte d'Azur, Valbonne, France,* Lukas Trefflich, Heinrich-Gregor Zirnstein, Chris Sturm, Bernd Rosenow, Marius Grundmann, and Rüdiger Schmidt-Grund, *Universität Leipzig, Leipzig, Germany*

When incorporating anisotropic materials, planar microcavities can give rise to exceptional points, i.e. propagation directions along which two otherwise polarization-split photonic modes degenerate in energy and broadening. They are non-Hermitian degeneracies revealing complex-square-root topology and chiral eigenstates. We show computations and experiments on ZnO-based microcavities.

4:00 pm–4:30 pm ***(Invited)***

TuG4.2 TBD, Ziad Musslimani, *Florida State University, FL, USA*

4:30 pm–5:00 pm ***(Invited)***

TuG4.3 Pseudospin/Valley-Mediated Phenomena in Staggered Photonic Lattices, Zhigang Chen, *Nankai University, Tianjin, China and San Francisco State University, San Francisco, CA, USA*

We present a few examples of pseudospin-mediated phenomena, including pseudospin-orbital angular-momentum conversion and chirality-locked vortex generation. We focus on nonlinear beam dynamics in a staggered honeycomb (and Lieb) lattice, and discuss the possibility to achieve nonlinear topological states along the interface between two staggered lattices.

3:30 pm–5:00 pm **Kohala 3**

Session TuD4 **Enabling Photonic Technologies**

Session Chair John C. Howell, *Hebrew University of Jerusalem, Jerusalem, Israel*

3:30 pm–4:00 pm ***(Invited)***

TuD4.1 Quantum Light State Engineering and Entanglement Generation by Multimode Photon Addition, Marco Bellini, Nicola Biagi, Luca Salvatore Costanzo, and Alessandro Zavatta, *Istituto Nazionale di Ottica, Florence, Italy and University of Firenze, Florence, Italy*

One can entangle distinct field modes by the delocalized addition of a single photon. We present recent experiments on the characterization of entanglement created by adding single photons between modes initially containing light states of different sorts and sizes.

4:00 pm–4:30 pm ***(Invited)***

TuD4.2 Multiplexing: Moving Real-World Single-Photon Sources Toward the Ideal, Alan Migdall, *University of Maryland, MD, USA and National Institute of Standards and Technology, Gaithersburg, MD, USA*

Individual single photon sources, as implemented, offer performance far from the ideal. Multiplexing can turn those imperfect sources into a system much closer to the ideal single-photon source. Since first suggested, many multiplexing schemes have proposed and implemented. We review the progress in this field.

4:30 pm–5:00 pm ***(Invited)***

TuD4.3 Low-Loss High-Speed Fiber-Optic Switch for Quantum State Manipulation, K. F. Lee and G. S. Kanter, *NuCrypt, LLC, Evanston, IL, USA*

We demonstrate a fiber-based photonic switch that is fast (sub ns), low loss (1 dB), low noise, and operates in the 1550 nm band. The switch operation is characterized and potential applications are discussed.

3:30 pm–5:20 pm **Kohala 4**
Session TuE4 **Active Media**
Session Chair Christopher Gies, *University of Bremen, Bremen, Germany*

3:30 pm–4:00 pm ***(Invited)***

TuE4.1 Optical Properties of Atomically Thin Semiconductors Based on Transition Metal Dichalcogenides for Applications in Nanophotonics, Frank Jahnke, *University of Bremen, Bremen, Germany*

Atomically thin semiconductors have been recently used as a novel active material in nanolasers, single-photon sources and detectors. Based on a microscopic theory, we analyze optical properties of excitons, trions, biexcitons, high-density plasma excitations and the realizations of nanostructures using strain and dielectric band-structure engineering.

4:00 pm–4:30 pm ***(Invited)***

TuE4.2 Photonic Integration and Quantum Coherence Phenomena, Ann Catrina Coleman, *University of Texas at Dallas, Richardson, TX, USA*

There is great interest in “artificial atoms” for demonstrating quantum optics effects in semiconductor heterostructures. By using photonic integration techniques to achieve bandgap engineering in semiconductor waveguides is it possible to use these quantum coherence effects for performing storage and nonlinear optics?

4:30 pm–4:50 pm

TuE4.3 Observation of Bloch-Siegert Shift in an Atomically Thin Crystal, Edbert J. Sie, *Massachusetts Institute of Technology, Cambridge, MA, USA and Stanford University, Stanford, CA, USA,* C. H. Lui, *University of California, Riverside, CA, USA,* Yi-Hsien Lee, *National Tsing-Hua University, Hsinchu, Taiwan,* Liang Fu, Jing Kong, and Nuh Gedik, *Massachusetts Institute of Technology, Cambridge, MA, USA*

Coherent interactions with off-resonance light can lead to the optical Stark shift and Bloch-Siegert shift of an electronic energy level. The latter has so far eluded direct observation in solids. Here we observed a large Bloch-Siegert shift in a two-dimensional material system WS2.

4:50 pm–5:20 pm *(Invited)*

TuE4.4 Theory of Steady State Superradiance: Collective Forces, Quantum Limited Metrology, and Ultra-Stable Light, Murray Holland, *University of Colorado Boulder, Boulder, CO, USA*

Ultrastable "clock" atoms when employed as an active medium in a laser-like system could potentially form the basis for producing coherent light of extreme frequency stability. The coherence limits with realistic experimental parameters appear to be competitive with the most ultrastable lasers developed to date.

3:30 pm–5:00 pm **King's 3**

Session TuF4 **Astrophotonics**

Session Chair Sergio Leon Saval, *University of Sydney, Sydney, New South Wales, Australia*

3:30 pm–4:15 pm *(Tutorial)*

TuF4.1 Adaptive Optics and the Search for Life on Exoplanets, Olivier Guyon, *National Astronomical Observatory of Japan, National Institutes of Natural Sciences, USA*

Most large astronomical telescopes are now equipped with Adaptive Optics (AO) to provide real-time correction of atmospheric turbulence, delivering ~10× to 100× improvement in angular resolution. One of their most challenging goal is to enable high contrast imaging of exoplanets orbiting nearby stars.

4:15 pm–4:45 pm *(Invited)*

TuF4.2 Nulling Interferometry in Astronomy with Integrated Photonics, Barnaby Norris, *University of Sydney, Sydney, New South Wales, Australia,* Simon Gross, Alex Arriola, *Macquarie University, Sydney, New South Wales, Australia,* Tiphaine Lagadec, *University of Sydney, Sydney, New South Wales, Australia,* Nick Cvetojevic, *Obervatory of Paris, Ile-de-France, France,* Thomas Gretzinger, *Macquarie University, Sydney, New South Wales, Australia,* Nemanja Jovanovic, *California Institute of Technology, Pasadena, CA, USA,* Jon Lawrence, *Australian Astronomical Observatory, New South Wales, Australia*, and Peter Tuthill, *University of Sydney, Sydney, New South Wales, Australia*

Integrated photonic devices incorporating waveguides and couplers are enabling new astronomical instruments to detect and image planets around distant stars. These interferometers allow the light from extra-solar planets to be disentangled from the glare of their host star and the phase-scrambling from Earth's turbulent atmosphere.

4:45 pm–5:00 pm

TuF4.3 Liquid-Crystal and MEMS Modulators for Beam-Shaping Through a Multimode Fibre, Sergey Turtaev, Ivo T. Leite, and Tomas Cizmar, *Leibniz-Institute of Photonic Technology, Jena, Germany*

Side-by-side comparison of the performance of digital micromirror device and liquid crystal spatial light modulator as leading technologies for wavefront shaping through a multimode fibre.

WEDNESDAY, 11 JULY 2018

8:00 am–8:30 am **Kohala Promenade**

Breakfast

8:30 am–10:00 am **Waikoloa 1**

Session WA1 **Modulators and Optical Combs for Sensing**

Session Chair Giovanni Capellini, *IHP, Frankfurt Oder, Brandenburg, Germany*

8:30 am–9:00 am ***(Invited)***

WA1.1 **Silicon and Germanium Mid-Infrared Optical Modulators,** W. Cao, M. Nedeljkovic, *University of Southampton, Southampton, England, UK,* C. G. Littlejohns, *University of Southampton, Southampton, England, UK and Nanyang Technological University, Singapore,* T. Li, Z. Zhou, *Peking University, Beijing, China,* F. Y. Gardes, D. J. Thomson, G. T. Reed, *University of Southampton, Southampton, England, UK, and* G. Z. Mashanovich, *University of Southampton, Southampton, England, UK and University of Belgrade, Belgrade, Serbia*

We report design, fabrication and characterisation of mid-infrared modulators, including an SOI modulator at ~2 μm, operating at 20 Gb/s, the fastest Si mid-IR modulator reported to date. We also describe modulators in Si and Ge operating at 3.8 μm with a modulation depth >30 dB.

9:00 am–9:15 am

WA1.2 **Mid-Infrared Electro-Absorption Optical Modulation in GeSn Photodiodes on Silicon,** Jun-Han Lin and Guo-En Chang, *National Chung Cheng University, Chiayi, Taiwan, China*

We report mid-infrared optical modulation in GeSn photodiodes on silicon. The incorporation of Sn into Ge shrinks the direct bandgap energy, redshifting the absorption edge to longer wavelengths and enabling electro-absorption optical modulation based on Franz-Keldysh effect in the mid-infrared range.

9:15 am–9:45 am ***(Invited)***

WA1.3 **Silicon-Microresonator-Based Mid-Infrared Comb Spectroscopy,** Yoshitomo Okawachi, *Columbia University, New York, NY, USA*

Recently there have been significant developments in microresonator-based frequency comb technology for applications including spectroscopy, precision metrology, and communications. Here we describe our recent results on chip-based combs in the mid-infrared. Using our silicon-chip-based source, we demonstrate dual-comb spectroscopy and tunable direct comb spectroscopy.

9:45 am–10:00 am

WA1.4 Interband Cascade (IC) Optical Frequency Combs, Mahmood Bagheri, Clifford Frez, *California Institute of Technology, Pasadena, CA, USA,* Igor Vurgaftman, *Naval Research Laboratory, Washington, DC, USA,* Mathieu Fradet, Ivan Grudinin, *California Institute of Technology, Pasadena, CA, USA,* Chadwick L. Candey, William W. Bewley, Charles D. Merritt, Chulsoo Kim, *Naval Research Laboratory, Washington, DC, USA,* Siamak Forouhar, *California Institute of Technology, Pasadena, CA, USA*, and Jerry R. Meyer, *Naval Research Laboratory, Washington, DC, USA*

We demonstrate an electrically-driven frequency comb whose sub-picosecond pulses span more than 1 THz of spectral bandwidth centered near 3.6 micro-meter. This is achieved by passively mode locking an interband cascade laser with gain and saturable absorber sections monolithically integrated on the same chip.

8:30 am–10:00 am **King's 2**

Session WB1 **Network Optimization**

Session Chair Christine Tremblay, *École de Technologie Supérieure, Montreal, Quebec, Canada*

8:30 am–9:00 am ***(Invited)***

WB1.1 Machine Learning Techniques for Workload-Performance Optimized Networking, Keren Bergman, Yiwen Shen, Yishen Huang, Min Yee Teh, and Qixiang Cheng, *Columbia University, New York, NY, USA*

Techniques in machine learning (ML) are powerful enablers for the implementation of intelligent and robust optical interconnects in next generation data center networks. We cover methodologies that leverage both ML and reconfigurable photonic switching to enable networks optimized for various traffic workloads and maximized performance.

9:00 am–9:30 am ***(Invited)***

WB1.2 TBD, Vinayak Dangui, *Facebook, USA*

For an automated optical network, the following are key elements: (1) streamlined API to network elements, (2) optimized telemetry parameters, and (3) predictive maintenance framework. We present how these components enable automation in Facebook's network through the application of machine learning.

9:30 am–10:00 am ***(Invited)***

WB1.3 Maximizing Capacity via Channel Power Optimization under Energy Constraints, Jose Krause Perin, Ian Roberts, and Joseph M. Kahn, *Stanford University, Stanford, CA, USA*

A fundamental question arises in designing terrestrial and submarine optical systems: what is the channel power that maximizes capacity per fiber given an energy constraint? We solve this optimization problem including EDFA physics, Kerr nonlinearity, and energy constraints, either as optical or electrical power constraints.

8:30 am–10:00 am **Kohala 2**

Session WC1 **Non-Hermitian, Topological, and Non-Reciprocal Phenomena in Photonics and Optomechanics**

Session Chair Sahin K. Ozdemir, *Pennsylvania State University, Unversity Park, PA, USA*

8:30 am–9:00 am ***(Invited)***

WC1.1 Experimental Demonstrations of Topological Adiabatic Transport Around Exceptional Points, Jack Harris, Haitan Xu, Luyao Jiang, *Yale University, New Haven, CT, USA,* and David Mason, *Niels Bohr Institute, Sjelland, Denmark*

We describe experiments demonstrating the topological character of adiabatic transport around an exceptional point. An optomechanical device to used to realize a system of non-Hermitian oscillators that can easily be tuned in situ. We show topological operations on degenerate as well as nondegenerate oscillator pairs.

9:00 am–9:30 am ***(Invited)***

WC1.2 Topologically-Protected Optomechanics, Zheng Wang, *University of Texas at Austin, Austin, TX, USA*

Topologically protected photonic modes provide several unique opportunities to optomechanics and optical manipulation that are difficult to realize in conventional optical waveguides. Optomechanics also offers new ways of realizing topologically non-trival states at optical frequencies.

9:30 am–10:00 am ***(Invited)***

WC1.3 Non-Hermitian Physics of Optomechanical Cavities, Mohammad Ali Miri, *University of Texas at Austin, Austin, TX, USA,* Freek Ruesink, John Mathew, Ewold Verhagen, *AMOLF, Amsterdam, The Netherlands*, and Andrea Alu, *University of Texas at Austin, Austin, TX, USA*

The interplay of dynamical coupling between optical and mechanical degrees of freedom, dissipation, and nonlinear frequency mixing processes, makes optomechanical cavities a unique platform for investigating non-Hermitian effects. Here, opportunities for realizing the conditions of parity-time-symmetry, and breaking optical reciprocity will be discussed.

8:30 am–9:00 am **Kohala 4**

Session WE1 **Invited Joint with QN & QOPO**

Session Chair Marlan Scully, *Texas A&M University, College Station, TX, USA*

8:30 am–9:00 am ***(Invited)***

WE1.1 Scalable Quantum Information Processing with Photons and Atoms, Jian-Wei Pan, *University of Science and Technology of China, Hefei, Anhui, China*

Quantum information are emerging by combining coherent manipulation of quantum systems and information technology, which enables secure quantum cryptography, super-fast quantum computing, improving measurement precision, to beat classical limits. This presentation will highlight a few of progresses along quantum information processing with photons and atoms.

9:00 am–10:00 am **Kohala 3**
Session WD1 **Space Communications**
Session Chair Michael Brodsky, *US Army Research Laboratory, USA*

9:00 am–9:30 am ***(Invited)***

WD1.1 Satellite-Earth Quantum Communication: Modeling Daytime Free-Space Atmospheric Channels and Interfaces, Mark T. Gruneisen, *Air Force Research Laboratory, Kirtland AFB, NM, USA*, and Michael B. Flanagan, *Leidos, Albuquerque, NM, USA*

Daytime sky radiance easily overwhelms quantum signals transmitted over satellite-to-Earth quantum channels. Recent demonstrations of satellite-Earth quantum communication were performed under nighttime conditions to avoid this problem. Restricting the ground terminal field of view (FOV) is an effective technique for spatially filtering sky noise.

9:30 am–10:00 am ***(Invited)***

WD1.2 Towards Quantum Communications with Satellites, Thomas Jennewein, *University of Waterloo, Waterloo, Ontario, Canada*

Satellite based quantum communications will enable long distances, or even global quantum networking. I present recent results towards implementing the Canadian Quantum Satellite Mission, including laboratory tests of the payload components and its demonstration for a quantum link between a ground station and an aircraft

9:00 am–9:50 am **Kohala 4**
Session WE2 **AMO/OE Interface I**
Session Chair Marlan Scully, *Texas A&M University, College Station, TX, USA*

9:00 am–9:30 am ***(Invited)***

WE2.1 Rigorous Tests of Bell's Inequality and Beyond, W. Rosenfeld, K. Redeker, R. Garthoff, T. van Leent, T. Hummel, P. Koschmieder, D. Burchardt, and H. Weinfurter, *Ludwig-Maximilians-Universität, München, Germany*

We present a rigorous test of Bell's inequality using Rb atoms entangled over a large distance in combination with fast and efficient atomic state measurements. Further we discuss its future perspectives and potential applications in device-independent or self-testing scenarios.

9:30 am–9:50 am

WE2.2 Many-Body Physics with Spin States of Rydberg Atoms, Svetlana A. Malinovskaya and Elliot Pachniak, *Stevens Institute of Technology, Hoboken, NJ, USA*

Rydberg atoms trapped in an optical trap are used to study the collective spin properties of ultracold atoms. Interaction Hamiltonian of collective spin states of Rydberg atoms were explored in triatomic chains. The characteristics of entangled crystalline states were observed using quantum control methodology.

9:00 am–10:00 am **King's 3**

Session WF1 **Properties of Multi-Mode Systems**

Session Chair Rodrigo Amezcua Correa, *University of Central Florida, Orlando, FL, USA*

9:00 am–9:30 am ***(Invited)***

WF1.1 **Seamless Wireless/Optical MIMO Transmission via Radio-Over-FMF,** Nikolaos-Panteleimon Diamantopoulos, *Osaka University, Osaka, Japan and NTT Corporation, Kanagawa, Japan,* Yuki Yoshida, *National Institute of Information and Communications Technologies (NICT), Tokyo, Japan*, and Ken-ichi Kitayama, *Graduate School for the Creation of New Photonics Industries (GPI), Hamamatsu, Japan and National Institute of Information and Communications Technologies (NICT), Tokyo, Japan*

The recently proposed radio-over-few-mode-fiber, hybrid-SDM-MIMO system using millimeter-waves in the W-band and combined MIMO-DSP is reviewed, towards seamless wireless/optical massive-MIMO systems for 5G RAN and beyond.

9:30 am–9:45 am

WF1.2 **Optimization of the Mode-Dependent Signal Delay Method for the Measurement of Modal Dispersion,** I. Roudas and J. Kwapisz, *Montan State University, Bozeman, MT, USA*

The mode-dependent signal delay method can be used to estimate the modal dispersion vector of multimode fibers. We compute optimal launch modes minimizing the noise error in this estimate. The electronic SNR is improved asymptotically by almost 6 dB compared to conventional mode combinations.

9:45 am–10:00 am

WF1.3 **Properties of a Partially Coherent Beam Generated at the Output of a Stationary Multimode Fiber,** Anatoly Efimov, *Los Alamos National Laboratory, Los Alamos, NM, USA*

Spatial coherence properties of light at the output of a step-index multimode fiber excited with a spatially coherent broadband source are described. Their relationship to speckle contrast values measured through averaging over two different ensembles – fiber bends and twists and external diffuser – are elucidated.

10:00 am–10:30 am **Kohala Promenade**

Coffee Break

10:30 am–12:00 pm **Waikoloa 1**

Session WA2 **III-V and IV Integration for Optical Sensing**

Session Chair Douglas J. Paul, *University of Glasgow, Glasgow, Scotland, UK*

10:30 am–10:45 am

WA2.1 GaN/AlGaN Photovoltaic Quantum Well Infrared Photodetector at 2.3 µm, Ben Dror, Piotr M. Mensz, *Technion-Israel Institute of Technology, Haifa, Israel,* Akhil Ajay, Catherine Bougerol, Eva Monroy, *Université Grenoble-Alpes, Grenoble, France*, Meir Orenstein and Gad Bahir, *Technion-Israel Institute of Technology, Haifa, Israel*

We present a novel GaN/AlGaN Photovoltaic Quantum Well Infrared Photodetector operating at room temperature with peak response at 2.3 µm. The peak responsivity, measured at front 45° illumination configuration at 110 K is 870 µA/W at –1 V bias and 255 µA/W at zero bias

10:45 am–11:15 am ***(Invited)***

WA2.2 Miniaturization Challenges in Mid-IR Chemical Sensing: The MIRPHAB Pilot Line Approach, Sergio Nicoletti, *Université Grenoble-Alpes, Grenoble, France*

Mid-IR is the paradigm for silicon photonic because of the potential in spectroscopy, chemical sensing, security and industry applications. The challenges of the miniaturization is discussed to address cost, size and power consumption. This approach is pursued by MIRPHAB, offering access for sensing devices prototyping.

11:15 am–11:45 am ***(Invited)***

WA2.3 Quantum Cascade Lasers Integration on Silicon and Related Integrated Photonics, Mathieu Carras, Mickael Brun, *mirSense, France,* Jean-Marc Fedeli, Jean-Guillaume Coutard, Laurent Duraffourg, *Université Grenoble-Alpes, Grenoble, France,* Gregory Maisons, Guillaume Aoust, *mirSense, France,* Sergio Nicoletti, *Université Grenoble-Alpes, Grenoble, France,* and Johan Abautret, *mirSense, France*

Bringing mid-IR laser light on silicon open the possibility of compact cost effective gas sensing. mirSense and CEA-LETI have developed silicon fab compatible processes for heterogeneous and hybrid quantum cascade lasers integration and advance mid-IR functionalities on the silicon like waveguiding, wavelength combination, photoacoustic detection.

11:45 am–12:00 pm

WA2.4 Compact Integrated Photonic Components for Lambda = 3–15 micron, Swapnajit Chakravarty, Jason Midkiff, *Omega Optics Inc., Austin, TX, USA,* Kyoungmin Yoo, Chi-Jui Chung, Ali Rostamian, *University of Texas at Austin, Austin, TX, USA,* and Ray T. Chen, *Omega Optics Inc., Austin, TX, USA and University of Texas at Austin, Austin, TX, USA*

Compact sub-wavelength waveguide bends with sub-50 micron bend radius and compact polarization rotators are designed for on-chip sensing applications from 3–15 micron wavelength range in the InGaAs material platform. Experimental results will be presented.

10:30 am–12:00 pm **King's 2**

Session WB2 **Telemetry and Learning**

Session Chair Zuqing Zhu, *University of Science and Technology of China, Hefei, Anhui, China*

10:30 am–11:00 am ***(Invited)***

WB2.1 Machine Learning Techniques for Estimating the Quality of Transmission of Lightpaths, Christine Tremblay and Sandra Aladin, *École de Technologie Supérieure, Montreal, Quebec, Canada*

We discuss the use of machine learning (ML) techniques for estimating the quality of transmission (QoT) of lightpaths in coherent uncompensated WDM links and show the potential benefits of cognitive QoT estimation tools through a comparative performance analysis of ML-based classifiers using synthetic BER data.

11:00 am–11:30 am ***(Invited)***

WB2.2 Cognitive Heterogeneous Multi-Domain Networks with Hierarhical Learning, S. J. B. Yoo, *University of California, Davis, CA, USA*

11:30 am–12:00 pm ***(Invited)***

WB2.3 Intelligent Optical Spectrum Analyzer using Support Vector Machine, Danshi Wang, Min Zhang, Jin Li, Yu Xin, Jianqiang Li, Mengyuan Wang, and Xue Chen, *Beijing University of Posts and Telecommunications, Beijing, China*

A machine learning-based intelligent optical spectrum analyzer is proposed to perform center wavelength detection and OSNR calculation for QPSK signals. The good performance and fast speed are obtained, especially for SVM, achieving the optimal accuracy (100%) and the least test time (<0.34 s).

10:30 am–12:00 pm **Kohala 2**

Session WC2 **Exceptional Points in Optics and Photonics**

Session Chair Demetrio Christodoulides, *University of Central Florida, Orlando, FL, USA*

10:30 am–11:00 am ***(Invited)***

WC2.1 Explore Exceptional Points in Whispering-Gallery-Mode Optical Resonators, Lan Yang, *Washington University, USA*

11:00 am–11:30 am ***(Invited)***

WC2.2 Exceptional Points in Whispering-Gallery Microcavities, Jan Wiersig, Chang-Hwan Yi, and Julius Kullig, *Otto-von-Guericke-Universität Magdeburg, Magdeburg, Germany*

We introduce three different mechanisms for the formation of exceptional points in whispering-gallery microcavities based on weak deformation or perturbation of the cavity's boundary. Sensors using exceptional points for enhanced sensitivity are discussed.

11:30 am–12:00 pm ***(Invited)***

WC2.3 Exceptional Points in Optical and Optomechanical Systems, Sahin K. Ozdemir, *Pennsylvania State University, University Park, PA, USA*

Physical systems can be brought to exceptional points by engineering their loss/gain profile and coupling to other systems. I will present our progress towards a better understanding of optical processes and optomechanical interactions at exceptional points for realizing photonic and phononic devices with novel functionalities.

10:30 am–12:00 pm **Kohala 3**
Session WD2 **High-Dimensional Entanglement**
Session Chair Kae Nemoto, *NII, Tokyo, Japan*

10:30 am–11:00 am ***(Invited)***

WD2.1 Creating and Using Multi-Partite Entanglement, Jacob Taylor, *Joint Center for Quantum Information and Computer Science, Gaithersburg, MD, USA,* Xingyao Wu, Daniel Carney, and Minh Tran, *QuICS, MD, USA*

We consider protocols that use entanglement between distant systems to accomplish three main tasks: a specific approach to blind computation that uses minimal network resources and can be implemented in current architectures; multi-party data hiding and retrieval; and testing entanglement channels.

11:00 am–11:30 am ***(Invited)***

WD2.2 Long-Distance Quantum Teleportation and High-Dimensional Entanglement Distribution Over Optical Fiber, Hiroki Takesue and Takuya Ikuta, *NTT Corporation, Atsugi, Japan*

We present two technologies for advanced quantum communication systems. The first is quantum teleportation over 100 km of fiber using highly-efficient superconducting single photon detectors. The second is generation and long-distance distribution of high-dimensional time-bin entanglement, which was enabled by using cascaded delay interferometers.

11:30 am–12:00 pm ***(Invited)***

WD2.3 Quantitatively Witnessing Exceptionally Large High-Dimensional Entanglement in Photon Pairs, James Schneeloch and Gregory A. Howland, *Air Force Research Laboratory, Rome, NY, USA*

We develop new uncertainty relations that efficiently quantify entanglement in high-dimensional and continuous-variable systems using the experimental data of correlations between pairs of complementary observables. We predict that over 10 ebits of entanglement can be verified between SPDC photon pairs.

10:30 am–12:20 pm **Kohala 4**
Session WE3 **AMO/OE Interface II**
Session Chair Ann Catrina Coleman, *University of Texas at Dallas, Richardson, TX, USA*

10:30 am–11:00 am ***(Invited)***

WE3.1 Quantum Coherent Effects in Room Temperature InAs/InP Quantum Dot Optical Amplifiers, Gadi Eisensterin, *Technion, Hefa, Israel*

We describe how the use of ultra-short pulses can sub statute for cryogenic temperatures for induction and measuring quantum coherent phenomena in room temperature quantum dot gain media. Rabi oscillation, coherent control, Ramsey fringes and photon echoes have been demonstrated.

11:00 am–11:30 am ***(Invited)***

WE3.2 WITHDRAWN

11:30 am–11:50 am

WE3.3 Quantum-Optical Spectroscopy of a Two-Level System Using an Electrically Driven Micropillar Laser as Resonant Excitation Source, Sören Kreinberg, Tomislav Grbešic, Max Strauß, Alexander Carmele, *Technische Universität Berlin, Berlin, Germany,* Martin Kamp, Christian Schneider, Sven Höfling, *Julius-Maximilians-Universität Würzburg, Würzburg, Germany,* Xavier Porte, and Stephan Reitzenstein, *Technische Universität Berlin, Berlin, Germany*

Quantum nanophotonics has become focuses on the development of cavity-enhanced microlasers and on-demand quantum light sources delivering single photons or entangled photon pairs on-demand. Here, we synergistically join the two important subfields by demonstrating resonant excitation of a solid-state two-level system by high-beta microlaser.

11:50 am–12:10 pm

WE3.4 Two Examples of Application of Optoelectronic Analytical Techniques in AMO Systems, Weng W. Chow, *Sandia National Laboratories, NM, USA*

Sometimes, similarities between AMO and semiconductor experiments allow optoelectronicdevice theoretical or modeling techniques to be used in AMO systems. This talk presents two examples. One involves atomtronics (devices based on Bose-Einstein condensation). The second involves calculation of T2 in NV centers in diamond.

12:10 pm–12:20 pm

Closing Remarks, Stephan Reitzenstein, *Technische Universität Berlin, Berlin, Germany*

10:30 am–12:00 pm **King's 3**

Session WF2 **Nonlinear Spatial Diverse Systems**

Session Chair Ivana Gasulla, *Universitat Politecnica de Valencia, Spain*

10:30 am–11:00 am ***(Invited)***

WF2.1 Toward Multi-kW Femtosecond Fiber Lasers Based on Mutlicore Fibers, Jens Limpert, *Friedrich-Schiller-Universität Jena, Jena, Germany and Helmholtz-Institute Jena, Jena, Germany and Fraunhofer Institute for Applied Optics and Precision Engineering, Jena, Germany*

The achievements and the potential of coherent pulse addition as a performance scaling approach of ultrafast laser systems will be reviewed. Active multicore arrangements pursue that concept in a most compact way. First very promising results will be presented.

11:00 am–11:30 am ***(Invited)***

WF2.2 Thermodynamics of Nonlinear Multimode Fibers, Demetrios Christodoulides, *University of Central Florida, Orlando, FL, USA*

We show that the mode occupancies in nonlinear multimode optical systems follow a universal behavior that tends to maximize the system's entropy at steady-state. This thermodynamic response occurs irrespective of the type of nonlinearities involved.

11:30 am–12:00 pm ***(Invited)***

WF2.3 Intermodal Nonlinear Optics in Step-Index Fibers, Siddharth Ramachandran, *Boston University, MA, USA*

We review the nonlinear properties of the large subset of modes in step-index optical fibers that are, counter-intuitively, resistant to linear mode mixing. We discuss how this characteristic of these modes results in unique nonlinear optical transformations with no free-space or single-mode waveguide analogues.

12:00 pm–1:30 pm

Lunch Break (on own)

1:30 pm–3:00 pm **Kohala 2**

Session WC3 **Topological Phenomena in Non-Hermitian Systems**

Session Chair Zhigang Chen, *Nankai University and San Francisco State University, CA, USA*

1:30 pm–2:00 pm ***(Invited)***

WC3.1 Topological Photonics in Open Systems, Bo Zhen, *University of Pennsylvania, Philadelphia, PA, USA*

Recently, much success has been achieved in studying topological photonics in closed and lossless systems. Here, I will discuss a few new topological phenomena we have observed in optical systems with open boundary conditions and their applications in optoelectronic devices.

2:00 pm–2:30 pm ***(Invited)***

WC3.2 Exceptional Points and Generalized Bulk Edge-Correspondence of PT-Symmetric Topological Domain Walls, Xiang Ni, Daria Smirnova, *City College of New York, New York, NY, USA,* Alexander Poddubny, *Lead Research Scientist, Saint Petersburg City, Russia,* Daniel Leykam, *Institute for Basic Science, Korea, Singapore,* Yidong Chong, *Nanyang Technological University, Singapore*, and Alexander Khanikaev, *City College of New York, New York, NY, USA*

We demonstrate that the non-Hermitian parity-time symmetric interfaces formed between amplifying and lossy crystals support dissipationless edge states. These states exhibit gapless spectra in the complex band structure interconnecting complex-valued bulk bands as long as exceptional points of edge states exist.

2:30 pm–3:00 pm ***(Invited)***

WC3.3 Manipulating Edge Modes and Flat Bands Using Non-Hermitian Coupling, Daniel Leykam, *Institute for Basic Science, South Korea*

I will discuss how non-Hermitian coupling – hopping accompanied by amplification or attenuation – qualitatively changes the behaviour of familiar photonic lattice models of topological phases and dispersionless flatbands. The resulting asymmetric edge states and non-diffracting bulk states may be observed using microring resonator lattices.

1:30 pm–3:00 pm **Kohala 1**

Session WG3 **Novel Platforms for Topological Photonics**

Session Chair Yidong Chong, *Nanyang Technological University, Singapore*

1:30 pm–2:00 pm ***(Invited)***

WG3.1 Progress in Three-Dimensional Topological Photonics, Ling Lu, *Chinese Academy of Sciences, Beijing, China*

I will present the recent experiments on ideal Weyl points and nodal chains in metallic photonic crystals at microwave frequencies. The relevant implications of the results and future directions will also be discussed.

2:00 pm–2:30 pm ***(Invited)***

WG3.2 Photonic Topological Structures at Optical Frequencies, Ganapathi Subramania, *Sandia National Laboratories, USA*

Topological photonic structures possess topologically protected photonic modes that can propagate unidirectionally without scattering and can exhibit extreme photonic density of states (PDOS). We present recent work towards implementation and measurement of topological photonic behavior in semiconductor based nanophotonic structures for optical frequency chip-scale implementation.

2:30 pm–3:00 pm ***(Invited)***

WG3.3 Towards All-Dielectric Topological Photonics, Xiao Hu, *National Institute for Materials Science, Ibaraki, Japan*

We propose a way to realize topological photonic crystal purely by dielectrics. We identify a pseudospin in photonic bands from the quasi orbital angular momentum in honeycomb structure, and derive the photonic version of quantum spin Hall effect. I will discuss recent experiments and perspectives.

1:30 pm–3:00 pm **Kohala 3**

Session WD3 Quantum Photonic Circuits

Session Chair Andrew Weiner, *Purdue University, West Lafayette, IN, USA*

1:30 pm–2:00 pm ***(Invited)***

WD3.1 Room-Temperature High-Speed Control of Quantum Emitters Using Metamaterials and Plasmonics, Simeon I. Bogdanov, *Purdue University, West Lafayette, IN, USA,* Mikhail Y. Shalaginov, *Massachusetts Institute of Technology, Cambridge, MA, USA,* Oksana Makarova, Chin-Cheng Chiang, Alexei Lagutchev, Alexandra Boltasseva, and Vladimir M. Shalaev, *Purdue University, West Lafayette, IN, USA*

Plasmonic nanostructures and metamaterials allow to reach unique regimes of interaction between quantum emitters and confined optical modes. We utilize this confinement to achieve enhancement of quantum emission over more than 100 THz bandwidth, very high directionality and unprecedented brightness in room-temperature quantum emitters.

2:00 pm–2:15 pm

WD3.2 Proposal to Generate Robust Entanglement Between Distant Superconducting Qubits Mediated Via Telecom Photons, Sourabh Kumar, Nikolai Lauk, and Christoph Simon, *University of Calgary, Calgary, Alberta, Canada*

We propose a robust scheme to generate entanglement between distant superconducting qubits (SQs), mediated via telecom photons travelling in optical fibers. This could be useful for establishing a cloud-based distributed quantum computing architecture, enabling powerful and secure computation and communication tasks.

2:15 pm–2:30 pm

WD3.3 Quantum Optical Networks Using a Single Mie Resonance of On-Chip Dielectric Light Manipulating Elements and Their Scalable Integration with Quantum Dot Single Photon Sources, Swarnabha Chattaraj, Jiefei Zhang, *University of Southern California, Los Angeles, CA, USA,* Siyuan Lu, *University of Southern California, Los Angeles, CA, USA and IBM Thomas J. Watson Research Center, Yorktown Heights, NY, USA*, and Anupam Madhukar, *University of Southern California, Los Angeles, CA, USA*

We present an approach to scalable on-chip quantum optical networks comprising array of mesa-top-single-quantum-dots(MTSQDs) as single photon sources integrated with dielectric building block based light manipulating elements that enhance MTSQD emission rate, direct, propagate, phase-shift, split and recombine the emitted photons for quantum information processing.

2:30 pm–3:00 pm ***(Invited)***

WD3.4 Wide-Bandgap Integrated Photonic Circuits for Nonlinear Interactions and Interfacing with Quantum Memories, Michael Fanto, *Rochester Institute of Technology, Rochester, NY, USA and Air Force Research Laboratory, Rome, NY, USA,* Tsung-Ju Lu, Hyeongrak Choi, *Massachusetts Institute of Technology, Cambridge, MA, USA,* Paul Thomas, John Serafini, *Rochester Institute of Technology, Rochester, NY, USA,* Christopher Tison, *Florida Atlantic University, Boca Raton, FL, USA,* Jeffrey Steidle, Stefan Preble, *Rochester Institute of Technology, Rochester, NY, USA,* Mohammad Soltani, *Raytheon BBN Technologies, Cambridge, MA, USA,* Dirk Englund, *Massachusetts Institute of Technology, Cambridge, MA, USA,* Paul Alsing, and Kathy-Anne Soderberg, *Air Force Research Laboratory, Rome, NY, USA*

We demonstrate a wide-bandgap semiconductor photonics platform based on aluminum nitride (AlN). This platform opens up new possibilities in UV-Vis integrated quantum optics with trapped ions or atom-like color centers in solids, as well as classical applications including nonlinear optics.

1:30 pm–3:15 pm **King's 3**

Session WF3 **SDM Components II**

Session Chair **Ruben S. Luis,** *NICT, Koganei, Tokyo, Japan*

1:30 pm–2:00 pm ***(Invited)***

WF3.1 Multimode and Coupled-Core Fiber Amplifier, J. Enrique Antonio-Lopez, Z. Sanjabi Eznaveh, J. Carlos Alvarado-Zacarias, *University of Central Florida. Orlando, FL, USA,* Pierre Sillard, Adrian Amezcua-Correa, Cedric Gonnet, Marianne Bigot-Astruc, *Prysmian Group, Haisnes, France,* Nicolas K. Fontaine, Roland Ryf, Haoshuo Chen, *Nokia Bell Labs, Holmdel, NJ, USA,* Axel Schülzgen, and Rodrigo Amezcua-Correa, *University of Central Florida. Orlando, FL, USA*

We report recent advances in multimode-and coupled-core fiber amplifiers for SDM. The amplifiers gain goes up to 20dB, operating at low mode-dependent-loss. Adequate fibers design and pumping configuration allows for exploiting multiple benefits of these two approaches making them suitable for employment in transmission links.

2:00 pm–2:30 pm ***(Invited)***

WF3.2 Recent Technologies on Multicore EDFA, Ryuichi Sugizaki, *Furukawa Electric Co., Ltd., Ichihara, Chiba, Japan*

MC-EDFA is expected as one of the key component for SDM systems. Its possibilities and abilities to enable high-capacity, low power consumption and cost reduction are summarized. Also, recent reports utilizing MC-EDFA are introduced.

2:30 pm–3:00 pm ***(Invited)***

WF3.3 Components for Multi-Core Fiber Transmission Systems based on Long Period Gratings, Ana Maria Rocha, Telmo Almeida, Rogério Nunes Nogueira, *Instituto de Telecomunicações, Aveiro, Portugal*, and Margarida Facão, *University of Aveiro, Aveiro, Portugal*

The realization of a cost and energy efficient SDM transmission systems based on Multicore fibers (SDM-MC) will require the development of several compatible components. In this paper, we discuss the viability of using LPGs in MCFs to develop different components for SDM-MC transmission systems.

3:00 pm–3:15 pm

WF3.4 Cladding-Pumped Coupled-Core EDFA, Juan Carlos Alvarado-Zacarias, *University of Central Florida, Orlando, FL, USA,* Nicolas K. Fontaine, Haoshuo Chen, *Nokia Bell Labs, Holmdel, NJ, USA,* Jose Enrique Antonio-Lopez, *University of Central Florida, Orlando, FL, USA,* Roland Ryf, *Nokia Bell Labs, Holmdel, NJ, USA,* Steffen Wittek, *University of Central Florida, Orlando, FL, USA,* Hirotaka Sakuma, Takemi Hasegawa, Tesuya Nakanishi, Tetsuya Hayashi, *Sumitomo Electric Industries, Ltd., Yokohama, Kanagawa, Japan,* and Rodrigo Amezcua-Correa, *University of Central Florida, Orlando, FL, USA*

We demonstrate a 4-core cladding-pumped EDFA for coupled-core transmission, the amplifying fiber is designed to have mode coupling between cores for better overlap of pump and signal wavelengths. Mode dependent gain variation of less than 4 dB was obtained.

3:00 pm–3:30 pm **Kohala Promenade**

Coffee Break

3:30 pm–4:30 pm **Kohala 2**

Session WC4 **Novel Concepts in Topological Photonics II**

Session Chair Alexander Khanikaev, *City College of New York, New York, NY, USA*

3:30 pm–4:00 pm ***(Invited)***

WC4.1 Anomalous Floquet Insulators, Netanel Lindner, *Technion, Israel*

4:00 pm–4:30 pm ***(Invited)***

WC4.2 Photon Spin in New Phases of Matter, Todd Van Mechelen and Zubin Jacob, *Purdue University, West Lafayette, IN, USA*

We report on the discovery of a new topological phase of matter where the bosonic nature of the photon (spin-1) plays a central role. Our theory utilizes a new framework called the Dirac-Maxwell correspondence and a magneto-electric coupling which is spatially and temporally dispersive.

3:30 pm–4:30 pm **Kohala 3**

Session WD4 **QIS at U.S. Army Research Laboratory**

Session Chair William Munro, *NTT BRL, Atsugi, Kanagawa, Japan*

3:30 pm–4:00 pm ***(Invited)***

WD4.1 Optimizing Entanglement Distribution Rates for Quantum Networks, Vladimir Malinovsky, *US Army Research Laboratory, USA*

4:00 pm–4:30 pm ***(Invited)***

WD4.2 Entanglement Recovery by Manipulating Photonic Quantum States in Optical Fibers, Michael Brodsky, Brian Kirby, and Daniel Jones, *US Army Research Laboratory, USA*

We show both theoretically and experimentally how far and how reliably polarization entangled photons could be distributed over fiber-optic telecom networks. We demonstrate that two major polarization effects – polarization dependent loss and polarization mode dispersion could be compensated non-locally.

4:00 pm–5:00 pm **King's 3**

Session WF4 **Panel Discussion: SDM and Beyond – An Opportunity for Cross-Disciplinary Research**

Session Chair Jochen Schroder, *Chalmers University of Technology, Gothenburg, Sweden*

4:00 pm–5:00 pm

Panel Discussion: SDM and Beyond – An Opportunity for Cross-Disciplinary Research, Jochen Schroder, *Chalmers University of Technology, Gothenburg, Sweden*

END OF PROGRAM