Advanced Photonics Congress

Integrated Photonics Research, Silicon, and Nanophotonics

Novel Optical Materials and Applications

Optical Devices and Materials for Solar Energy and Solid-state Lighting

Photonic Networks and Devices

Signal Processing in Photonic Communications

29 July–1 August 2019

Burlingame, California, USA

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Special Events

Congress Reception

Monday, 29 July 2019, 18:30–20:00
Grand Peninsula D

Join us for a Culinary Tour of San Francisco at the Congress Reception. Tickets for this event are included in the registration fee for Technical Attendees. Additional guest tickets can be purchased for US $75 at Registration.

Student and Early Career Professional Development & Networking Lunch and Learn

Tuesday, 30 July, 12:30–14:00
Bayside Room

This program will provide a unique opportunity for students and early career professionals, who are close to finishing or who have recently finished their doctorate degree, to interact with experienced researchers. Key industry and academic leaders in the community will be matched for each student based on the student's preference or similarity of research interests. Students interested in all career paths – from those seeking an academic position, to those wishing to start a technology business, to those interested in government/public service, to those looking to translate their benchwork skills to product development – are encouraged to apply. Students will have an opportunity to discuss their ongoing research and career plans with their mentor, while mentors will share their professional journey and provide useful tips to those who attend. Lunch will be provided.

This workshop is complimentary for OSA Members and space is limited. Not all who apply will be able to attend due to space limitations and priority will be given to those who have most recently or are close to graduation.

Hosted by: OSA Foundation

Hands-on Introduction to Data Analytics and Machine Learning in Optical Networks

Wednesday, 31 July, 12:30–14:00
Bayside Room

Organizers: Carlos Natalino Silva and Marija Furdek, *KTH Royal Institute of Technology, Sweden*

In this workshop/tutorial, the audience will be guided through the first steps necessary for applying data analytics and machine learning to optical networks. We will begin with a brief introduction to the fundamentals of data analytics and machine learning. We will then focus on representative optical networking use cases suitable for the application of machine learning. Using the available development tools (e.g., Jupyter Lab), the attendees will be encouraged to explore a previously defined dataset using their laptops. The workshop will enable the participants to perform data importing and selection (e.g., removing samples with missing features), as well as visualizing the dataset characteristics. Normalization techniques will be discussed and applied to the dataset. Then, the attendees will explore the correlation between the different features of the dataset. An unsupervised learning algorithm will be applied to the dataset, followed by a supervised learning algorithm that will build upon the information learned from the unsupervised approach. The tutorial will be concluded with an interactive discussion on the remaining challenges and ideas for extensions.

Space is limited. To ensure your spot in this workshop, please RSVP online at osa.org/PhotonicsOPC under the Program & Topics tab. Lunch will be provided.

Congress Banquet
(Separate Fee Required)

Wednesday, 31 July, 18:30–20:30
Domenico Winery, San Carlos, CA

Enjoy your evening with your fellow colleagues at the Congress Banquet held at the Domenico Winery in the cask room amid the aromas of wine aging in French oak barrels. This boutique winery specializes in "Cal-Italia" varietals such as Primitivo, Barbera, and Sangiovese. Come enjoy a glass of wine and a delicious meal with your colleagues! Tickets can be purchased for US $85 at Registration.

OSA Advanced Photonics Congress Exclusive Discounted Tours

Tower Tours is pleased to offer an exclusive discount on sightseeing tours and activities in and around San Francisco for all 2019 Advanced Photonics Congress attendees! All tours include complimentary shuttle service from the Hyatt Regency San Francisco Airport Hotel.

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* Discount code is valid only for travel dates: 2-3 August 2019; complimentary hotel shuttle service is provided from Hyatt Regency San Francisco Airport; Promo Code is applicable to tours listed only.

General Information

Congress Wireless Internet

OSA is pleased to offer complimentary wireless internet services throughout the meeting space at the hotel for all attendees and exhibitors.

SSID: @Hyatt_Meeting
Password: Photonics2019

Registration

Grand Peninsula Foyer EFG Side

Sunday, 28 July	15:00–18:00
Monday, 29 July	07:00–18:00
Tuesday, 30 July	07:30–17:30
Wednesday, 31 July	07:30–17:30
Thursday, 1 August	07:30–14:00

Exhibits and Coffee Breaks

Monday, 29 July–Thursday, 1 August
Grand Peninsula D

The 2019 Advanced Photonics Congress Exhibit Hall is open to all registered attendees. Visit a diverse group of companies representing every facet of optics. Coffee breaks and the joint poster session will be held with exhibits from Monday–Thursday.

Monday 29 July	10:00–10:30	Exhibit Hall Opening and Networking Coffee Break with Exhibitors
	16:00–16:30	Networking Coffee Break with Exhibitors
	18:30–20:00	Congress Reception
Tuesday 30 July	10:00–10:30	Networking Coffee Break with Exhibitors
	16:00–18:00	Joint Poster Session and Networking Coffee Break with Exhibitors
Wednesday 31 July	10:00–10:30	Networking Coffee Break with Exhibitors
	16:00–16:30	Networking Coffee Break with Exhibitors
Thursday 1 August	10:00–10:30	Networking Coffee Break with Exhibitors

About OSA Publishing's Digital Library

Registrants and current subscribers can access all of the meeting papers, posters and postdeadline papers on OSA Publishing's Digital Library. The OSA Publishing's Digital Library is a cutting-edge repository that contains OSA Publishing's content, including 16 flagship, partnered and co-published peer reviewed journals and 1 magazine. With more than 304,000 articles including papers from over 640 conferences, OSA Publishing's Digital Library is the largest peer-reviewed collection of optics and photonics.

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Full Technical Attendees have both early and free continuous access to the digest papers through OSA Publishing's Digital Library. To access the papers go to osa.org/PhotonicsOPC and click on Access Proceedings. As access is limited to Full Technical Congress Attendees only, you will be asked to validate your credentials by entering the same login email address and password provided during the Congress registration process.

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Poster Presentation PDFs

The PDFs of select poster presentations will be available two weeks after the Congress. While accessing the papers in OSA Publishing's Digital Library look for the multimedia symbol.

Congress Updates

All technical program changes will be communicated in the onsite update sheet. This sheet contains the latest information as of 22 July. Changes after 22 July will be posted onsite near Registration and on the Advanced Photonics Congress App.

Anti-harassment Policy and Code of Conduct

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

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

- use the online portal osa.org/IncidentReport or email **CodeOfConduct@OSA.org**.
- contact any OSA staff member

The Optical Society invites all people to use the restroom that aligns with their gender identity. For anyone who would like to use a gender-neutral restroom, we have worked with the facility to identify the restroom between Bayside A and Sandpebble A for that purpose.

Plenary Speakers

Monday, 29 July, 08:00–10:00
Grand Peninsula EF

The OSA 2019 Advanced Photonics Congress Plenary Session will feature prominent speakers from a variety of disciplines related to the congress.

Empowering Flexible and Scalable High Performance Architectures with Embedded Photonics

Keren Bergman, *Columbia University, USA*

The explosive growth in data analytics applications that rely on machine and deep learning techniques are seismically changing the landscape of high performance architectures. Driven by these applications, systems' performance is increasingly bottlenecked by the energy and communications costs of interconnecting the numerous heterogeneous compute and memory resources. Recent advances in integrated silicon photonics offer the opportunity of embedding optical connectivity that directly delivers high off-chip communication bandwidth densities with low power consumption. This talk will review these advances and introduce the concept of embedded photonics for addressing data-movement challenges in high-performance systems. Beyond alleviating the bandwidth/energy bottlenecks, embedded photonics can enable new disaggregated architectures that leverage the distance independence of optical transmission. We will discuss how the envisioned modular system interconnected by a unified photonic fabric can be flexibly composed to create custom architectures tailored for specific applications.

Keren Bergman is the Charles Batchelor Professor of Electrical Engineering at Columbia University where she also serves as the Scientific Director of the Columbia Nano Initiative. Professor Bergman received a BS from Bucknell University in 1988, and a MS in 1991 and a PhD in 1994 from the Massachusetts Institute of Technology all in electrical engineering. At Columbia, Bergman leads the Lightwave Research Laboratory encompassing multiple cross-disciplinary programs at the intersection of computing and photonics. Bergman serves on the Leadership Council of the American Institute of Manufacturing (AIM) Photonics leading projects that support the institute's silicon photonics manufacturing capabilities and Datacom applications. She is the recipient of the 2016 IEEE Photonics Engineering Award and is a Fellow of The Optical Society (OSA) and IEEE.

Next-generation Space-based Laser Communications

Bryan Robinson, *MIT Lincoln Lab, USA*

Recent successful demonstrations have proven that free-space optical communications (FSOC) are possible and capable of exceeding the performance of traditional radio frequency space communications links. Rapid advancement of optical communications technology, driven by developments in the fiber telecommunications industry, will enable revolutionary future space communications systems. This plenary presentation will review the current state of the art for free-space optical communications and discuss efforts underway to provide new operational capabilities.

Bryan Robinson is the associate leader of the Optical Communications Technology Group at MIT Lincoln Laboratory. For the past decade, Dr. Robinson has led efforts to develop and demonstrate free-space laser communications systems. He was the lead systems engineer for the Lunar Laser Communications Demonstration (2009-2014), where he helped architect the laser communication system, oversaw development of the space and ground terminals, and led the system operations for NASA's first successful demonstration of high-rate laser communications from space. Today he leads a variety of follow-on efforts to develop enabling laser communications capabilities for future near-Earth and deep-space missions, including NASA's human exploration efforts on the International Space Station and the upcoming Orion Crew Exploration Vehicle.

A New Era for Solar Electricity

Sarah Kurtz, *University of California Merced and NREL, USA*

The solar electricity industry has grown so big that it is now bumping up against limits of growth: In 2017, the net expansion of solar electricity generating capacity was greater than the combined net growth of fossil fuel and nuclear electricity generating capacity. As the industry works through a turning point, the technology continues to mature, with the optical design of solar cells becoming increasingly important.

Sarah Kurtz obtained her doctorate in 1985 from Harvard University and has worked since then at the National Renewable Energy Laboratory, in Golden, Colorado. She is known for her contributions to developing multijunction, GaInP/GaAs solar cells, supporting the Concentrator Photovoltaic (PV) industry, and, more recently, her work with PV performance and reliability. Her work has been recognized with a jointly received Dan David Prize in 2007 and the Cherry Award in 2012. She has now moved to the University of California Merced, where she is excited to be a small part of California's adoption of renewable energy.

Tutorial Speakers

Novel Optical Materials and Applications (NOMA)

Measuring Everything You've Always Wanted to Know about a Light Pulse
Monday, 29 July, 14:00–15:00
Sandpebble AB

Rick Trebino, *Georgia Institute of Technology, USA*

This tutorial will review techniques (and their issues) for measuring ultrashort laser pulses in time and space, including simple methods for measuring the complete spatio-temporal electric field of an arbitrary, potentially complex light pulse.

Rick Trebino received his BA from Harvard in 1977 and his PhD from Stanford in 1983. After twelve years at Sandia National Laboratories in Livermore, California, he accepted a Chair in Ultrafast Optical Physics at Georgia Tech, where he currently studies ultrafast optics, specifically pulse measurement, and online optics education. He is the inventor of the well-known frequency-resolved-optical-gating (FROG) technique, as well as elegant devices for the complete spatiotemporal measurement of arbitrary pulses. He has received numerous prizes for his research and teaching and is a Fellow of the OSA, the APS, the AAAS and the SPIE.

Emerging Material Platforms: Design Approaches for Nanophotonic Devices
Wednesday, 31 July, 08:00–09:00
Sandpebble AB

Alexandra Boltasseva, *Purdue University, USA*

Emerging nanophotonic materials will be discussed including transparent conducting oxides, semimetals, 2-D and trans-dimensional materials such as graphene and MXenes. Topology optimization and machine learning for photonic design will be mentioned.

Alexandra Boltasseva is a Professor of ECE at Purdue University. She is a 2018 Blavatnik National Award for Young Scientists Finalist, 2013 MRS Outstanding Young Investigator, 2013 IEEE Photonics Society Young Investigator, and the MIT Technology Review Top Young Innovator (TR35). She is an OSA member, SPIE Fellow and *Optical Materials Express* Editor-in-Chief.

Signal Processing in Photonic Communications (SPPCom)

Keynote Speaker

Miniaturization of Quantum Systems
Wednesday, July 31, 08:00–09:00
Grand Peninsula F

Alexander Ling, *Centre for Quantum Technologies, Singapore*

Driven by an interest in deploying quantum communication systems, attention is being paid to the considerations of Size, Weight and Power. How small should we make the first systems for deployment? Dr. Ling will discuss this from a systems perspective, and provide some examples from my own work in putting entangled light sources onboard nanosatellites.

Alexander Ling has been a Principal Investigator at the Centre for Quantum Technologies in Singapore since 2010. He leads a team that aims to bring quantum instruments out of the lab and into field deployment. His team has deployed instruments in diverse environments, ranging from Singapore's urban fibre networks to satellites in space. Alexander received his PhD from the National University of Singapore, and has worked at the National Institute of Standards and Technology in the United States.

Tutorial Speaker

Quantum Key Distribution
Wednesday, 31 July, 09:00–09:40
Grand Peninsula F

Qiang Zhang, *University of Science and Technology of China, China.*

In this talk, Professor Zhang will briefly review the experimental progress in solving the challenges, especially focusing on the new experiment in quantum repeater and twin field QKD.

Qiang Zhang is a Professor of Physics at the University of Science and Technology of China (USTC). Qiang received his PhD at USTC in 2001. Then he spent about five year at Stanford University as a postdoc fellow. In 2011, he returned to USTC as a professor. Dr. Zhang has primarily worked on experimental quantum optics and quantum information. He has published 78 articles in peer-reviewed journals, including 3 in Nature, 8 in Nature sub-journals, and 22 in PRL(X). He has delivered 25 invited talks in international conferences.

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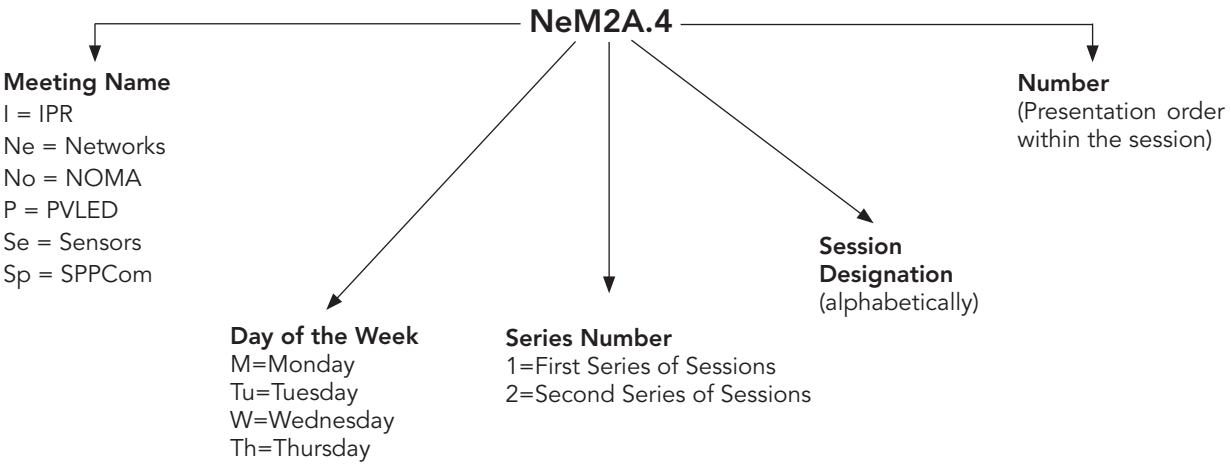
Explanation of Session Codes



The first section of the code designates the meeting (I = IPR, Ne = Networks, No = NOMA, P = PVLED, Sp = SPPCom). The second element denotes the day of the week (M=Monday, T=Tuesday, W=Wednesday, Th=Thursday). The third element indicates the session series in that day (for instance, 1 would denote the first parallel sessions in that day). Each day begins with the letter A in the fourth element and continues alphabetically through a series of parallel sessions. The lettering then restarts with each new series. The number on the end of the code (separated from the session code with a period) signals the position of the talk within the session (first, second, third, etc .) . For example, a presentation coded NeM2A .4 indicates that this paper is part of the Networks topical meeting (Ne) and is being presented on Monday (M) in the second series of sessions (2), and is the first parallel session (A) in that series and the fourth paper (4) presented in that session.

Invited papers are noted with Invited

Tutorial papers are noted with Tutorial

Keynote paper is noted with Keynote

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Agenda of Sessions — Monday, 29 July

	Grand Peninsula G	Sandpebble Room AB	Sandpebble Room CD	Grand Peninsula E	Grand Peninsula F
	IPR	NOMA	PVLED	Networks	SPPCom
07:00–18:00	**Registration,** *Grand Peninsula Foyer*				
08:00–10:00	**JM1A • Introductory Remarks and Plenary Session,** *Grand Peninsula EF*				
10:00–10:30	**Networking Coffee Break with Exhibitors,** *Grand Peninsula D*				
10:30–12:30	**IM2A • Lasers and Sources**	**NoM2B • Polymers and Nonlinear Materials**	**PM2C • Space, Cooling and Other Energy/Optics**	**NeM2D • Free-space Optical and Satellite Communications**	**SpM2E • Nonlinear Optics** *(ends at 12:00)*
12:30–14:00	**Lunch** *(on own)*				
14:00–16:00	**IM3A • Integrated Devices and Circuits**	**NoM3B • Nonlinear Materials and Devices**	**PM3C • LED 1**	**NeM3D • Devices and Transmission 1**	**SpM3E • Optical Signal Processing** *(ends at 15:45)*
16:00–16:30	**Networking Coffee Break with Exhibitors,** *Grand Peninsula D*				
16:30–18:00	**IM4A • Microwave Photonics and Optical Phased Arrays**	**NoM4B • Novel Glass Applications**	**PM4C • Pervoskite PV**	**NeM4D • Devices and Transmission 2** *(ends at 17:45)*	**SpM4E • Networks and Transceiver Technology**
18:30–20:00	**Congress Reception,** *Grand Peninsula D*				

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Key to Conference Abbreviations

IPR	Integrated Photonics Research, Silicon and Nanophotonics
NETWORKS	Photonic Networks and Devices
NOMA	Novel Optical Materials and Applications
PVLED	Optical Devices and Materials for Solar Energy and Solid-state Lighting
SPPCom	Signal Processing in Photonics Communications

Agenda of Sessions — Tuesday, 30 July

	Grand Peninsula G	Sandpebble Room AB	Sandpebble Room CD	Grand Peninsula E	Grand Peninsula F
	IPR	NOMA	PVLED	Networks	SPPCom
07:30–17:30	**Registration,** *Grand Peninsula Foyer*				
08:00–10:00	**IT1A • Frequency Combs 1**	**NoT1B • Materials for Solar/LED Applications**	**PT1C • Thin-film Solar Materials** *(starts at 08:30 and ends at 09:45)*	**NeT1D • Network Management and Operation**	**SpT1E • Access Networks** *(starts at 09:00 and ends at 09:45)*
10:00–10:30	**Networking Coffee Break with Exhibitors,** *Grand Peninsula D*				
10:30–12:30	**IT2A • Frequency Combs 2 and Resonators**	**NoT2B • Biomimetic and Biocompatible Optical Materials**	**PT2C • LED 2**	**NeT2D • Access, Metro and Transport Network Evolution**	**SpT2E • Digital Signal Processing 1**
12:30–14:00	**Lunch** *(on own)*				
	Student and Early Career Professional Development & Networking Lunch and Learn, *Bayside Room*				
14:00–16:00	**IT3A • Photodetectors and Sensing**	**NoT3B • Metamaterials and Metasurfaces 1**	**PT3C • Liquid-phase Solar Materials** *(ends at 15:00)*	**NeT3D • High-performance Networks**	**SpT3E • Digital Signal Processing 2** *(ends at 15:45)*
16:00–18:00	**JT4A • Poster Session and Networking Coffee Break with Exhibitors,** *Grand Peninsula D*				
19:00–21:00	**Evening Session: A Light in Digital Darkness; Optical Wireless Communications to Connect the Unconnected,** *Grand Peninsula EF*				

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Agenda of Sessions — Wednesday, 31 July

	Grand Peninsula G	Sandpebble Room AB	Sandpebble Room CD	Bayside Room	Grand Peninsula EF
	IPR	NOMA	PVLED	NOMA	Symposium
07:30–17:30	**Registration,** *Grand Peninsula Foyer*				
08:00–10:00	**IW1A • Optomechanics and Nanophotonics**	**NoW1B • Metamaterials and Metasurfaces 2**	**PW1C • LED 3** *(starts at 08:30)*		**QtW1E • Quantum Technologies 1**
10:00–10:30	**Networking Coffee Break with Exhibitors,** *Grand Peninsula D*				
10:30–12:30	**IW2A • Photonic Computing and Emerging Technologies** *(ends at 13:00)*	**NoW2B • Two-dimensional Materials**	**PW2C • Modeling, Bifacial, Solar Resource, BIPV**	**NoW2D • Glass Materials and Applications** *(ends at 12:00)*	**QtW2E • Quantum Technologies 2**
12:30–14:00	**Lunch** *(on own)*				
	Workshop: Hands-on Introduction to Data Analytics and Machine Learning in Optical Networks, *Bayside Room*				
14:00–16:00	**IW3A • III-V Integration**	**NoW3B • Phase-change and Metamaterials** *(ends at 15:45)*	**PW3C • Materials and Techniques**		**QtW3E • Quantum Technologies 3**
16:00–16:30	**Networking Coffee Break with Exhibitors,** *Grand Peninsula D*				
16:30–18:00	**Postdeadline Paper Session,** *Grand Peninsula EF*				
18:30–20:30	**Congress Banquet,** *Domenico Winery, San Carlos, CA*				

Key to Conference Abbreviations

IPR	Integrated Photonics Research, Silicon and Nanophotonics
NETWORKS	Photonic Networks and Devices
NOMA	Novel Optical Materials and Applications
PVLED	Optical Devices and Materials for Solar Energy and Solid-state Lighting
SPPCom	Signal Processing in Photonics Communications

Agenda of Sessions — Thursday, 1 August

	Grand Peninsula G	Sandpebble Room AB	Sandpebble Room CD	Grand Peninsula E	Grand Peninsula F
	IPR	NOMA	PVLED/IPR	Networks	SPPCom
07:30–14:00	**Registration,** *Grand Peninsula Foyer*				
08:00–10:00	**ITh1A • Silicon Photonic Integrated Circuits (Si PICs)**	**NoTh1B • Plasmonics and Metamaterials**	**PTh1C • III-V PV and Phosphors** *(starts at 08:30)*	**NeTh1D • Network Telemetry, Data Analytics and Visualization**	**SpTh1E • Transmission 1** *(starts at 08:30)*
10:00–10:30	**Networking Coffee Break with Exhibitors,** *Grand Peninsula D*				
10:30–12:30	**ITh2A • Quantum and Nonlinear Photonics**	**NoTh2B • Two-dimensional Materials and Nanomaterials**	**ITh2C • Modulators** *(starts at 11:00)*	**NeTh2D • Heterogeneous and Distributed Photonic Networks** *(ends at 12:00)*	**SpTh2E • Transmission 2** *(ends at 12:15)*
12:30–14:00	**Lunch** *(on own)*				
14:00–16:00	**ITh3A • Biophotonics and Sensing**	**NoTh3B • Active Materials and Metamaterials**	**ITh3C • Photonic Technologies** *(ends at 15:30)*	**NeTh3D • Devices and Transmission 3**	**SpTh3E • Freespace Optics and Visible Light Communication**

Key to Conference Abbreviations

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NETWORKS	Photonic Networks and Devices
NOMA	Novel Optical Materials and Applications
PVLED	Optical Devices and Materials for Solar Energy and Solid-state Lighting
SPPCom	Signal Processing in Photonics Communications

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Optical Devices and Materials for Solar Energy and Solid-State Lighting Feature Issue

Submission Opens: 1 October 2019
Submission Deadline: 1 November 2019

This Feature Issue, to be published in the *Energy Express*-dedicated section of *Optics Express*, will cover the latest developments in nanophotonics and advanced materials for the next generation of photovoltaic (PV) solar cells and light emitting diodes (LEDs).

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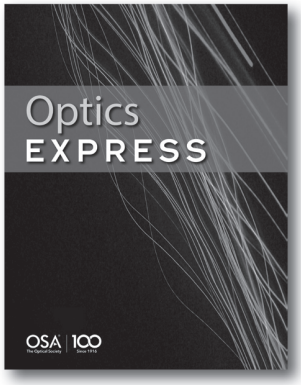

FEATURE ISSUE GUEST EDITORS

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Grand Peninsula G	Sandpebble Room AB	Sandpebble Room CD
Integrated Photonics Research, Silicon and Nanophotonics	Novel Optical Materials and Applications	Optical Devices and Materials for Solar Energy and Solid-state Lighting

07:00–18:00 Registration, *Grand Peninsula Foyer*

08:00–10:00 JM1A • Introductory Remarks and Plenary Session, *Grand Peninsula EF*

10:00–10:30 Networking Coffee Break with Exhibitors, *Grand Peninsula D*

10:30–12:30
IM2A • Lasers and Sources
Presider: Matteo Clerici; Univ. of Glasgow, UK

IM2A.1 • 10:30 Invited
Integrated Ultra-narrow Linewidth Lasers and their Applications, Daniel J. Blumenthal; *Univ. of California Santa Barbara, USA.* A new class of integrated stimulated Brillouin scattering laser will be described and application to chip-scale systems including data center communications, atomic clocks, optical gyros and microwave synthesis.

IM2A.2 • 11:00 Invited
Light Extraction from Nano-photonic Structures on LED Pumped-luminescent Converters, Alan L. Lenef[1], Luca Dal Negro[2,3], Sean Gorsky[2], Wesley Britton[2], Ran Zhang[1,2], Madis Raukas[1]; *[1]Technology Innovation, OSRAM Opto-Semiconductors, USA; [2]Department of Electrical and Computer Engineering, Boston Univ., USA; [3]Materials Science and Engineering, Boston Univ., USA.* We review physical limits and promise of nanostructure arrays to generate directed, sub-Lambertian emission for automotive and related applications. We present theoretical and experimental results, emphasizing the physics of light extraction.

IM2A.3 • 11:30 Invited
Extended Open Cavities for Polaritonic Devices and Exciton-polariton Condensation: Low Threshold for Non-linear Emission with Low Quantum Efficiency Emitters, Jaime G. Rivas, Mohammad Ramezani; *Applied Physics, Technische Universiteit Eindhoven, Netherlands.* Periodic arrays of nanoparticles supporting localized surface plasmons allow the control of electromagnetic fields over large areas and define open cavities where strong coupling to excitons and exciton-polariton condensation can be realized.

IM2A.4 • 12:00
Optofluidic Distributed Feedback Dye Laser Using Corrugated Sidewall Structure, Jennifer Black, Tyler T. Sano, Sarah Mitchell, Holger Schmidt; *Univ. of California Santa Cruz, USA.* An optofluidic distributed feedback laser is demonstrated with a threshold fluence of in a polydimethylsiloxane device. The cavity is comprised of a corrugated sidewall structure filled with a Rhodamine 6G ethylene glycol solution.

IM2A.5 • 12:15
Monolithic Integration of Widely-tunable DBR and DFB Lasers with One-step Grating Formation, Victoria Rosborough[1], Fengqiao Sang[1], Joseph Fridlander[1], Hongwei Zhao[1], Bowen Song[1], Simone Tommaso Suran Brunelli[1], Jeffrey R. Chen[2], Mark A. Stephen[2], Larry A. Coldren[1], Jonathan Klamkin[1]; *[1]Univ. of California Santa Barbara, USA; [2]NASA Goddard Space Flight Center, USA.* We demonstrate the integration of widely-tunable sampled-grating DBR (SGDBR) and DFB lasers on indium phosphide. The SGDBR laser exhibits a 36-nm tuning range with >36-dB SMSR and the DFB laser an SMSR of 51.6 dB.

10:30–12:30
NoM2B • Polymers and Nonlinear Materials
Presider: Lynda Busse; US Naval Research Laboratory, USA

NoM2B.1 • 10:30 Invited
Patterning Conjugated Polymers for Applications in Optics and Electronic Devices, Adam Moule[1], Ian Jacobs[1,2], Zaira Itzel Bedolla Valdez[1], Jun Li[1], Tucker Murrey[1], Goktug Gonel[1]; *[1]Univ. of California Davis, USA; [2]Cambridge Univ., UK.* Device applications of organic semiconductors are currently limited by the absence of a patterning technology that is equivalent to photo-lithography. We present methods to layer and pattern organic semiconductors with diffraction limited resolution.

NoM2B.2 • 11:00 Invited
Hybrid Organic/Inorganic Integrated Photonics, Andrea M. Armani, Jinghan He, Andre Kovach, Hyungwoo Choi; *Univ. of Southern California, USA.* By grafting oriented monolayers of small molecules on the surface of optical resonators, we have improved the nonlinear performance of the devices. Numerous nonlinearities including Stokes/Anti-Stokes generation are observed.

NoM2B.3 • 11:30 Invited
Shaping of Photo-active Materials by 3D Printing, Alberto Portone[1], Francesca D'Elia[2], Luigi Romano[2], Adam Szukalski[1], Francesca Matino[1], Filippo Fabbri[1], Luana Persano[1], Dario Pisignano[3], Andrea Camposeo[1]; *[1]Istituto Nanoscienze CNR, Italy; [2]Scuola Normale Superiore, Italy; [3]Università di Pisa, Italy.* We report on the development of advanced 3D printing technologies specifically designed for photo-active materials. 3D systems with photoluminescence, optical gain, and photochromic and nonlinear optical properties are demonstrated.

NoM2B.4 • 12:00
Transparent Wearable 3D Touch: Self-generated Multiscale Structure Engineered by Laser-induced Thermal Gradient, Kyun Kyu Kim, Seung Hwan Ko; *Seoul National Univ., South Korea.* We report a transparent and flexible 3D touch which operates in a single device with the assistance of multiscale structures and a nanowire percolation network.

NoM2B.5 • 12:15
Probing the 3D-conjugated LUMOs of Silsesquioxanes with Light Scattering, Krishnandu Makhal, Tuan Minh Trinh, Stephen C. Rand; *Univ. of Michigan, USA.* Cross-polarized light scattering in silsesquioxane (SSQ) molecules probes the azimuthal variation of intramolecular potentials. SSQ molecules with small and large cage interiors reveal variations in the sphericity of orbital shapes for the first time.

10:30–12:30
PM2C • Space, Cooling and Other Energy/ Optics
Presider: Sarah Kurtz; Univ. of California Merced, USA

PM2C.1 • 10:30 Invited
Space PV, Michael Kelzenberg; *California Inst. of Technology, USA.* Abstract not available.

PM2C.2 • 11:00 Invited
Passive Sub-ambient Daytime Radiative Cooling, Bikram Bhatia, Arny Leroy, Yichen Shen, Lin Zhao, Marin Soljacic, Evelyn Wang; *Massachusetts Inst. of Technology, USA.* We propose and experimentally demonstrate a directional approach to reject solar radiation and an optically-selective thermally-insulating emitter cover that minimizes parasitic losses that can lead to high-performance daytime radiative coolers.

PM2C.3 • 11:30 Invited
Technologies for Rooftop and Building-integrated CPV, Noel C. Giebink; *Electrical Engineering, Penn State Univ., USA.* Recent advances in microtracking CPV will be presented, including a proof-of-concept system that achieves 30% efficiency in outdoor testing and a CPV skylight that harvests direct, but transmits diffuse sunlight for building-integrated applications.

PM2C.4 • 12:00
The Role of Etendue and Ratchets in Spectral Conversion and Multi-color Emission, Andreas Pusch, Nicholas J. Ekins-Daukes; *UNSW Sydney, Australia.* Spectral conversion can increase solar cell efficiency. We explain the thermodynamics of spectral conversion and the role of etendue and electronic ratchets. We also discuss the potential of spectral converters for tunable-color light emitting diodes.

PM2C.5 • 12:15
III-V Vertical Nanowires Grown on Si by Template-assisted Selective Epitaxy for Tandem Solar Cells, Noelia Vico Trivino[1], Philipp Staudinger[1], Nicolas Bologna[1,2], Heike Riel[1], Kirsten Moselund[1], Heinz Schmid[1]; *[1]IBM Research-Zurich, Switzerland; [2]Electron Microscopy Center, Empa, Switzerland.* We demonstrate a growth approach that enables connecting III-V nanowires, with precise control of shape, position and size by standard Si nanofabrication techniques, to a bottom silicon solar cell for the next generation of photovoltaics.

Grand Peninsula E

Photonic Networks and Devices

Grand Peninsula F

Signal Processing in Photonics Communications

07:00–18:00 Registration, *Grand Peninsula Foyer*

08:00–10:00 JM1A • Introductory Remarks and Plenary Session, *Grand Peninsula EF*

10:00–10:30 Networking Coffee Break with Exhibitors, *Grand Peninsula D*

10:30–12:30
NeM2D • Free-space Optical and Satellite Communications
Presider: David Geisler; Massachusetts Inst. of Tech Lincoln Lab, USA

NeM2D.1 • 10:30 Invited
NASA Optical Communication Strategy and Technology, Michael A. Krainak, Donald M. Cornwell; *NASA, USA*. We discuss NASA's next decade program for deployment of space-flight optical communication satellites and ground stations. Key technology includes integrated photonics, optical phased arrays, pointing-tracking systems, and photon-counting detectors.

NeM2D.2 • 11:00
Narrowband Optical Filtering with Wide Angular Acceptance for Free-space Optical Communications, Katia Shtyrkova, Igor Gaschits, David O. Caplan; *MIT Lincoln Laboratory, USA*. We demonstrate improved angular acceptance for low-loss narrowband optical filtering for high-sensitivity photon-counting free-space applications. Using a silicon etalon, a GHz-class passband with 230% greater low-loss angular acceptance is achieved.

NeM2D.3 • 11:30
Liquid Crystal Tunable Beam Steering for Free-space Optical Communications, Francisco Algorri[1], Noureddine Bennis[2], Dimitris Zografopoulos[3], Virginia Urruchi[1], Przemyslaw Morawiak[2], Leszek Jaroszewicz[2], Jose Manuel Sanchez-Pena[1]; *[1]UC3M, Spain; [2]New Technologies and Chemistry Faculty, Poland; [3]Consiglio Nazionale delle Ricerche, Istituto per la Microelettronica e Microsistemi (CNR-IMM), Italy.* In this work it is proposed a LC beam steering that overpass the typical LC phase modulators, it has a very simple voltage control is lighter and smaller than previous proposals.

NeM2D.4 • 11:45
Free-space Optical Communication for Spacecraft and Satellites, including CubeSats in Low Earth Orbit (LEO), Peter M. Goorjian; *NASA Ames Research Center, USA*. A static system is described, and computed results for it are shown for laser beam transmissions from a Cubstat in low Earth orbit. This system can replace current architectures which use dynamical systems (moving parts).

NeM2D.5 • 12:00 Invited
Free-space Laser Communication: Coming Soon to a Satellite Near You, Thomas Wood; *LGS Innovations, USA*. Compared to conventional radio, free-space optical links offer much higher bandwidth and freedom from spectrum licensing constraints. Recent progress shows it likely will be widely deployed in space soon for Government and commercial constellations.

10:30–12:00
SpM2E • Nonlinear Optics
Presider: Koji Igarashi; Osaka Univ., Japan

SpM2E.1 • 10:30 Invited
Optical Poling of Silicon Nitride Waveguides for Enhanced Effective χ(2), Camille-Sophie Brès, Edgars Nitiss; *École Polytechnique Fédérale de Lausanne, Switzerland*. In this talk, we will cover recent work on optically inducing second order nonlinearity in silicon nitride waveguides and the characterization of the effect.

SpM2E.2 • 11:00
Aggregation of OOK Signals for Modulation Format Conversion to 8QAM Signal Using XPM and XGM, Tomoki Amano, Hiroki Kishikawa, Nobuo Goto; *Tokushima Univ., Japan*. All-optical OOK to 8QAM conversion is numerically simulated by using nonlinear devices. We also evaluate the conversion by BER as a function of OSNR, EVM as a function of the OOK and QPSK signal power.

SpM2E.3 • 11:15
Electrical Control of Coherent Brillouin Interaction Based Induced Transparency, Siva Shakthi A, Ravi Pant; *IISER Thiruvananthapuram, India*. We report the electrical control of coherent Brillouin interaction based electromagnetically induced transparency resonances in the microwave domain using single mode fiber. We show extinction of about 30 dB from 10 GHz to 40 GHz

SpM2E.4 • 11:30 Invited
Combinatorial Optimization with a Network of Degenerated Optical Parametric Oscillators, Takahiro Inagaki[1], Kensuke Inaba[1], Toshimori Honjo[1], Koji Enbutsu[2], Takeshi Umeki[2], Ryoichi Kasahara[2], Hiroki Takesue[1]; *[1]NTT Basic Research Laboratories, Japan; [2]NTT Device Technology Laboratories, Japan*. We report a coherent Ising machine based on 2,048 networked degenerate optical parametric oscillators with all-to-all connectivity. The machine can simulate large-scale Ising model and obtain good solutions for the optimization of 2,000-node graphs.

12:30–14:00 Lunch *(on own)*

Grand Peninsula G

Integrated Photonics Research, Silicon and Nanophotonics

14:00–16:00
IM3A • Integrated Devices and Circuits
Presider: Meer Nazmus Sakib; Intel Labs-Photonics Research, USA

IM3A.1 • 14:00 Invited
System-on-a-Chip Photonic Integrated Circuits Enabling C+L Band 57.6 Tbps Capacity Long Haul Links, Thomas Frost, Gloria Hoefler, Payam Abolghasem, Lee Dardis, Abdou Diba, Bryan Ellis, Ryan Going, Xian Xu, Ales Kumpera, Scott Corzine, Sanjeev Murthy, Matthias Kuntz, Jianping Zhang, Parmijit Samra, Vikrant Lal, Don Pavinski, Tim Butrie, Jeffrey Rahn, Steve Sanders, Vince Dominic, Peter Evans, Mehrdad Ziari, Fred Kish; *Infinera Corporation, USA*. We present multi-channel monolithically integrated InP based photonic integrated circuits emitting in both the C and L bands with 200 Gbps transmission per wavelength, enabling long haul links with up to 57.6 Tbps capacity.

IM3A.2 • 14:30 Invited
Parameter Extraction, Variability Analysis and Yield Prediction of the Photonic Integrated Circuits, Umar Khan[1,2], Yufei Xing[1,2], Wim Bogaerts[1,2]; [1]*Photonics Research Group, Ghent Univ. - IMEC, Belgium;* [2]*Center of Nano and Biophotonics, Belgium*. We discuss the complete workflow from the extraction of behavioral and fabricated geometry parameters using optical measurements to a decomposition of spatial variability and ultimately to the layout-aware yield prediction of *PICs*.

IM3A.3 • 15:00
Electronic/Photonic Design Automation (EPDA) for InP-Photonic Integrated Circuit Process Design Kit, Yuchun Zhou[1], Ashish Bhardwaj[1], John Mason[1], Wai Leong[1], Shawn Luna[1], Stefan Wolf[1], Thomas Vallaitis[1], Adam James[1], Pablo Mena[2], Enrico Ghillino[2], Rob Scarmozzino[2], Gloria Hoefler[1], Fred Kish[1]; [1]*Infinera Corporation, USA;* [2]*Synposys Inc., USA*. A state-of-the-art process design kit for an InP photonic integrated circuit foundry using electronic photonic design automation environment is discussed. Automated design tools are used to design PICs using data-driven models.

IM3A.4 • 15:15
Improved Power-handling of OEO Conversion on a Generic Photonic Integration Platform, Peter L. Tønning, Martijn J. Heck; *Aarhus Univ. Dep. of Engineering, Denmark*. Improved power-handling of optical-electrical-optical conversion structures purely by circuit design within a commercially available photonic integration platform. This conversion is achieved with no electrical RF-input.

Sandpebble Room AB

Novel Optical Materials and Applications

14:00–16:00
NoM3B • Nonlinear Materials and Devices
Presider: Mikhail Kats; Univ. of Wisconsin-Madison, USA

NoM3B.1 • 14:00 Tutorial
Measuring Everything You've Always Wanted to Know about a Light Pulse, Rick Trebino; *Georgia Inst. of Technology, USA*. I will review techniques (and their issues) for measuring ultrashort laser pulses in time and space, including simple methods for measuring the complete spatio-temporal electric field of an arbitrary, potentially complex light pulse.

NoM3B.2 • 15:00
Graphene Oxide for Enhanced Nonlinear Optics in Integrated Waveguides, Jiayang Wu[1], Yunyi Yang[1], Xingyuan Xu[1], Yang Qu[1], Linnan Jia[1], Yuning Zhang[1], Yao Liang[1], Sai T. Chu[3], Brent Little[2], Roberto Morandotti[4], Baohua Jia[1], David J. Moss[1]; [1]*Swinburne Univ. of Technology, Australia;* [2]*Chinese Academy of Science, China;* [3]*City Univ. of Hong Kong, China;* [4]*INRS, Canada*. We experimentally demonstrate enhanced Kerr optical nonlinearities of waveguides integrated with layered graphene oxide (GO) films. Up to ~9.5-dB enhancement of four-wave mixing conversion efficiency is achieved for a waveguide with 2 layers of GO.

NoM3B.3 • 15:15
Measurement of Wavelength and Temperature Dependent Refractive Index of GaSb, Jean Wei, Joel Murray, Charles Reyner, Shekhar Guha; *US Air Force Research Laboratory, USA*. Temperature-dependent refractive index values of GaSb were measured at wavelengths between 1.7 and 9.8 micrometers, over a temperature range of 81 to 400 K. A temperature dependent Sellmeier equation was obtained.

Sandpebble Room CD

Optical Devices and Materials for Solar Energy and Solid-state Lighting

14:00–16:00
PM3C • LED 1
Presider: Seunghyup Yoo; Korea Advanced Inst of Science & Tech, South Korea

PM3C.1 • 14:00 Invited
Efficient Perovskite Optoelectronic Devices: Carrier Kinetics and Efficiency Modelling, Dawei Di[1,2]; [1]*Zhejiang Univ., China;* [2]*Univ. of Cambridge, UK*. We demonstrate perovskite–polymer bulk heterostructure LEDs exhibiting external quantum efficiencies of up to 20.1%. The kinetics of excited-state carriers is studied. Besides, we present our progress in the modelling of new solar cell structures.

PM3C.2 • 14:30
***In silico* Discovery of Emitters and Charge Transporters for Organic Light-Emitting Diodes,** Hironori Kaji; *Kyoto Univ., Japan*. Recently, remarkable progress has been made in the development of organic LEDs. Here, we show our recent results on thermally activated delayed fluorescence, multiscale charge transport simulation, and dynamic nuclear polarization-NMR.

PM3C.3 • 14:45
Realization of Stretchable OLEDs through the Stacked Structure of Stress Relief Layer and Stretchable Platform, Taehyun Kim, Hyeonwoo Lee, Seunghee Lee, Seunghyup Yoo; *Korea Advanced Inst. of Science and Technology, South Korea*. The stress relief layer is an effective method to fabricated stretchable OLEDs with minimal compromise in performance. Stretchable OLEDs fabricated by this method have very little change in efficiency even when interconnectors are stretched 140%.

PM3C.4 • 15:00 Invited
Efficient Light-emitting Diodes Based on Colloidal Metal-halide Perovskite Nanoparticles, Tae-Woo Lee; *Seoul National Univ., South Korea*. We report ligand-engineered perovskite nanoparticles (NPs) based on methylammonium (MA) and formamidinium (FA) cations beyond quantum size and highly efficient perovskite NP light-emitting diodes (LEDs).

Grand Peninsula E

Photonic Networks and Devices

14:00–16:00
NeM3D • Devices and Transmission 1
Presider: Wolfgang Freude; Karlsruhe Inst. of Technology, Germany

NeM3D.1 • 14:00 Invited
Single Wavelength Intensity-modulation and Direct Detection at 500 Gb/s, Xi Chen; *Nokia Bell Labs, USA.* Abstract not available.

NeM3D.2 • 14:30 Invited
Low-complexity Kramers-Kronig Receivers and their Applications, Sebastian Randel; *KIT-IPQ, Germany.* Abstract not available.

NeM3D.3 • 15:00
10 Gb/s Data Transmission over 30 km Using a 1.5 μm Widely Tunable Directly Modulated InGaAsP DBR Laser, Daibing Zhou, Song Liang, Guangcan Chen, Wu Zhao, Dan Lu, Lingjuan Zhao, Wei Wang; *Inst Semiconductors, CAS, China.* We report 10 Gb/s data transmission over 30 km using a packaged two-section InGaAsP distributed Bragg reflector (DBR) laser. The tunable DBR laser has a wavelength tuning range over 12 nm.

NeM3D.4 • 15:15
Nanophotonics Based Residue Number System, Shuai Sun, Jiaxin Peng, Tarek El-Ghazawi, Volker J. Sorger; *George Washington Univ., USA.* We design a nanophotonic RNS arithmetic by spatially shifting the input relative to the outputs, where the moduli are represented by the number of waveguides, which can be used for functional analysis of convolutional neural networks.

Grand Peninsula F

Signal Processing in Photonics Communications

14:00–15:45
SpM3E • Optical Signal Processing
Presider: Koji Igarashi; Osaka Univ., Japan

SpM3E.1 • 14:00 Invited
GHz-speed Tracking of the Frequency Spectrum of Complex Continuous Waveforms through Photonic Analog Processing, Saikrishna Reddy Konatham, Reza Maram, José Azaña; *INRS-EMT, Canada.* We demonstrate real-time dynamic Fourier analysis of complex GHz-bandwidth microwave waveforms, including multiple evolving frequency bands, by mapping the full spectrogram along the time domain using a simple photonic sampling and dispersion scheme.

SpM3E.2 • 14:30
Noise-tolerance Evaluation for Optical 8QAM Coded Label Recognition Circuit, Tumendemberel Surenkhorol, Hiroki Kishikawa, Nobuo Goto; *Tokushima Univ., Japan.* A waveguide-type label recognition circuit is proposed for optical 8QAM coded signal. The proposed method is operable for both of the maximum and minimum output detection cases for which the noise tolerance evaluation is investigated.

SpM3E.3 • 14:45
Dual Channel Wideband Microwave Photonic Switch Exploiting Single Mode Fiber Based Fano Resonance, Siva Shakthi A, Ravi Pant; *IISER Thiruvananthapuram, India.* We report the first demonstration of high resolution dual-channel wideband microwave photonic switch from 1-11GHz with extinction >30dB exploiting Fano resonance based on stimulated Brillouin scattering in single-mode fibre.

SpM3E.4 • 15:00 Invited
Optical Signal Processing and Sensing in Parametric Devices, Ana Pejkic, Stojan Radic; *Univ. of California San Diego, USA.* Optical signal processing and sensing at a few photon level is now possible in parametric devices due to progress in longitudinal dispersion engineering. Amplifier design and performance is reviewed and results are summarized.

Grand Peninsula G

Integrated Photonics Research, Silicon and Nanophotonics

IM3A • Integrated Devices and Circuits—Continued

IM3A.5 • 15:30
Electro-optically Tunable Modified Racetrack Resonator in Hybrid Si_3N_4-$LiNbO_3$, Abu Naim Rakib Ahmed[1], Shouyuan Shi[1], Jack Manely[1], Peng Yao[2], Dennis Prather[1]; [1]*Univ. of Delaware, USA;* [2]*Phase Sensitive Innovations, USA*. We experimentally demonstrate the first Si_3N_4-$LiNbO_3$ hybrid electro-optic tunable racetrack resonator with the modified electrode to enhance the modulation efficiency. The measured tunability and the intrinsic Q are 2.8 pm/V and 8×10^6 respectively.

IM3A.6 • 15:45
Shallow-angle Grating Coupler for Vertical Emission from Indium Phosphide Devices, Keisuke Kojima[1,2], Toshiaki Koike-Akino[1], Mohammad Tahersima[1], Kieran Parsons[1], Thomas Meissner[2], Bowen Song[2], Jonathan Klamkin[2]; [1]*Mitsubishi Electric Research Labs, USA;* [2]*Electrical and Computer Engineering Dept, Univerisity of California Santa Barbara, USA*. We propose a long period grating in an indium phosphide waveguide for redirecting the guided mode to a downward angle targeting hybrid integration with silicon waveguides. A simulated end-to-end coupling efficiency of 58% is obtained.

Sandpebble Room AB

Novel Optical Materials and Applications

NoM3B • Nonlinear Materials and Devices—Continued

NoM3B.4 • 15:30
Broad Band Ultrafast Response Vertical Phototransistors Based on Perovskite / Quantum Dot Hybird, Yating Zhang, TengTeng Li, Yifan Li, Hongliang Zhao, Qingyan Li, Zhiliang Chen, Yu Yu, Lufan Jin, Jianquan Yao; *Tianjin Univ., China*. Vertical field effect phototransistors (VFEpTs) based on methylammonium lead halide perovskite / PbS quantum dot (QD) hybrid were design and fabricated. VFEpTs exhibit an broadband and ultrafast photoresponse, as well as a high photoresponsivity .

NoM3B.5 • 15:45
Cavity Mode between Two Dielectric Bragg Reflectors for Refractive Index Sensing, Samir Kumar[1,2]; [1]*Department of Physics, Hotilal Ramnath College Amnour, India;* [2]*Department of Physics, Jai Prakash Univ. Chapra, India*. A simple method of refractive index sensor is proposed using dielectric Bragg reflectors. The refractive index sensor is based on the cavity modes formed in an analyte (cavity) region sandwiched between dual dielectric Bragg reflectors.

Sandpebble Room CD

Optical Devices and Materials for Solar Energy and Solid-state Lighting

PM3C • LED 1 —Continued

PM3C.5 • 15:30 Invited
Efficient, Color Tunable, and Flexible Thin Film Perovskite Light Emitting Devices, Lianfeng Zhao, Barry P. Rand; *Princeton Univ., USA*. We discuss metal halide perovskite LEDs exceeding 17% EQE, with improved stability and flexible as organic electronic thin films. We also show stabilized mixed halide (I and Br) and mixed Pb-Sn films to tune emission from the green to near infrared.

16:00–16:30 Networking Coffee Break with Exhibitors, *Grand Peninsula D*

Grand Peninsula E

Photonic Networks and Devices

NeM3D • Devices and Transmission 1—Continued

NeM3D.5 • 15:30 Invited
Membrane-based DMLs-on-Si for Energy-efficient 400GbE SDM Transmission, Nikolaos Panteleimon Diamantopoulos[1], Kota Shikama[1], Hidetaka Nishi[1], Takuro Fujii[1], Takashi Matsui[2], Takaaki Kakitsuka[1], Hiroshi Fukuda[1], Kazuhide Nakajima[2], Shinji Matsuo[1]; [1]*NTT Device Technology Labs, NTT, Japan;* [2]*NTT Access Networks Service Systems Labs, NTT, Japan.* We present our recent achievements regarding short-reach 400-Gb/s links and optical data-center interconnections using our energy-efficient membrane-based III/V-on-Si directly-modulated lasers and space-division multiplexing over multi-core fiber.

Grand Peninsula F

Signal Processing in Photonics Communications

SpM3E • Optical Signal Processing—Continued

SpM3E.5 • 15:30
High-speed Electro-optic Equalizer for Data Center Interconnects, Rishab Maheshwari, Rakesh Ashok, Shivangi Chugh, Shalabh Gupta; *IIT Bombay, India.* We propose a PIC based equalizer for intra-data center interconnects that uses a modified sign-sign LMS algorithm. Simulation results for a 2 km SSMF 50 Gbps IM/DD link have been presented.

16:00–16:30 Networking Coffee Break with Exhibitors, *Grand Peninsula D*

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Grand Peninsula G

Integrated Photonics Research, Silicon and Nanophotonics

16:30–18:00
IM4A • Microwave Photonics and Optical Phased Arrays
Presider: Alan Lenef; Osram Opto Semiconductor, USA

IM4A.1 • 16:30 Invited
Advanced Photonic Components for Microwave Photonics Applications, Milan L. Mashanovitch; *Freedom Photonics, USA.* Abstract not available.

IM4A.2 • 17:00 Invited
Integrated Optical Phased Arrays: LiDAR, Augmented Reality, and Beyond, Jelena Notaros[1], Milica Notaros[1], Manan Raval[1], Christopher V. Poulton[1], Matthew J. Byrd[1], Nanxi Li[1,2], Zhan Su[1], Emir Salih Magden[1], Erman Timurdogan[1], Thomas Dyer[3], Christopher Baiocco[3], Taehwan Kim[4], Pavan Bhargava[4], Vladimir Stojanovic[4], Michael Watts[1]; [1]*Research Laboratory of Electronics, Massachusetts Inst. of Technology, USA;* [2]*John A. Paulson School of Engineering and Applied Science, Harvard Univ., USA;* [3]*Colleges of Nanoscale Science and Engineering, State Univ. of New York Polytechnic Inst., USA;* [4]*Department of Electrical Engineering and Computer Science, Univ. of California Berkeley, USA.* Recent integrated optical phased array architectures, results, and applications will be reviewed, including laser integration, CMOS-electronics integration, near-field focusing, quasi-Bessel-beam generation, and visible-light holographic projection.

IM4A.3 • 17:30
Calibration-free Si-SiN Optical Phased Array, Sarvagya Dwivedi, Hemant Tyagi, Aleksandrs Marinins, Tangla David Kongnyuy, Sarp Kerman, Jon Kjellman, Bruno Figeys, Mathias Prost, Sandeep Saseendran, Philippe Soussan, Marcus Dahlem, Xavier Rottenberg, Roelof Jansen; *IMEC, Belgium.* We present a calibration-free OPA leveraging low phase error in a SiN feeding network to feed a dense 64-element Si array. The 0.47° × 0.4° divergence spot is unambiguously wavelength steered for more than 10°.

IM4A.4 • 17:45
Integrated Optical Phased Array Butterfly Architecture for Independent Amplitude and Phase Control, Jelena Notaros, Matthew J. Byrd, Manan Raval, Michael Watts; *Research Laboratory of Electronics, Massachusetts Inst. of Technology, USA.* A scalable two-dimensional integrated optical phased array architecture with cascaded butterfly-shaped pixels is introduced. This novel architecture enables compact, in-line independent amplitude and phase control with power recycling.

Sandpebble Room AB

Novel Optical Materials and Applications

16:30–18:00
NoM4B • Novel Glass Applications
Presider: Ishwar Aggarwal; Univ. of North Carolina at Charlotte, USA

NoM4B.1 • 16:30 Invited
Designing Chalcogenide Materials for Visible Photonics, Robert Simpson; *Singapore Univ. of Technology and Design, Singapore.* Abstract not available.

NoM4B.2 • 17:00 Invited
Supercontinuum Generation in the Near and Mid-infrared Using Soft-glass Fibers, Goëry Genty[1], Zahra Eslami[1], Amarnath Ghosh[2], Thibault Sylvestre[2], Mariusz Klimczak[3], Ryszard Buczynski[3], John Dudley[2]; [1]*Tampere Univ., Finland;* [2]*Université Bourgogne Franche-Comté, France;* [3]*Inst. of Electronic Materials Technology, Poland.* We review recent progress in the generation of broadband supercontinuum light sources using soft-glass based optical fibers.

NoM4B.3 • 17:30 Invited
Sulfur- and Selenium-based Polymers for Infrared Optics and Photonics, Robert A. Norwood; *Univ. of Arizona, USA.* Ultra-high refractive index polymers based on elemental sulfur and selenium have been developed. The high refractive indices (1.7-2.1) and transparency in the MWIR provide the opportunity for advances in low-cost bulk optics and integrated photonics.

Sandpebble Room CD

Optical Devices and Materials for Solar Energy and Solid-state Lighting

16:30–18:00
PM4C • Perovskite PV
Presider: Dawei Di; Zhejiang Univ., China

PM4C.1 • 16:30 Invited
Highly Efficient and Stable Perovskite-silicon Tandem Solar Cells, Caleb Boyd[2,1], Jixian Xu[1,3], Kevin Bush[4], James Raiford[5], Rongrong Cheacharoen[6], Michael McGehee[1,3]; [1]*Univ. of Colorado Boulder, USA;* [2]*Materials Science and Engineering, Stanford Univ., USA;* [3]*National Renewable Energy Lab, USA;* [4]*Swift Solar, USA;* [5]*Chemical Engineering, Stanford Univ., USA;* [6]*Metallurgy and Materials Science Research Inst., Chulalongkorn Univ., Thailand.* We describe the development of novel perovskite active layers and sputter-buffer layers for perovskite-silicon tandems with efficiencies surpassing 25% that pass a variety of IEC standard stability tests.

PM4C.2 • 17:00
Improving Monolithic Perovskite/Silicon Tandem Solar Cells from an Optical Viewpoint, Klaus Jaeger[1,2], Marko Jost[1], Johannes Sutter[1], Philipp Tockhorn[1], Eike Köhnen[1], David Eisenhauer[1], Phillip Manley[1,2], Steve Albrecht[1], Christiane Becker[1]; [1]*Helmholtz-Zentrum Berlin, Germany;* [2]*Zuse Inst. Berlin, Germany.* Perovskite/silicon tandem solar cells are the most promising concept for a future photovoltaic technology. We report on recent progress from an optical viewpoint and disucss how we achieved more than 25% device efficiency.

PM4C.3 • 17:15
Nanophotonic Perovskite Thin-film Solar Cells by Thermal Nano-imprint Lithography, Raphael Schmager, Ihteaz M. Hossain, Yidenekachew J. Donie, Fabian Schackmar, Guillaume Gomard, Bryce S. Richards, Ulrich W. Paetzold; *Karlsruhe Inst. of Technology, Germany.* Direct texturing of the perovskite absorber layer with a facile thermal nano-imprint lithography process, enables the great opportunity to tune and enhance the absorptance of perovskite solar cells by coupling incident light to the quasi-guided modes

PM4C.4 • 17:30 Invited
Interface Manipulation in Solution Processed Hybrid Perovskite Solar Cells, Gang Li; *Hong Kong Polytechnic Univ., Hong Kong.* Perovskite solar cells (PSCs) is a promising photovoltaic technology. This paper summarizes our works of (a) Perovskite/HTL interface tuning; and (b) Efforts on novel solution processed tin oxide nanostructures as electron transport layer for PSCs.

18:30–20:00 Congress Reception, *Grand Peninsula D*

Grand Peninsula E

Photonic Networks and Devices

16:30–17:45
NeM4D • Devices and Transmission 2
Presider: Marco Fiorentino; Hewlett Packard Enterprise, USA

NeM4D.1 • 16:30 Invited
Ultra-stable Integrated Lasers and Low-cost, Low-energy Coherent Data Center Interconnects, Daniel J. Blumenthal; *Univ. of California Santa Barbara, USA*. In this talk, we describe FRESCO, an approach to bring highly coherent WDM Terabit links inside the data center without the need for DSPs and other power consuming technologies.

NeM4D.2 • 17:00
Power Optimization for Datacenter Optical Transmitters, Sergio Pinna, Sarvagya Dwivedi, Larry A. Coldren, Clint Schow, Jonathan Klamkin; *Univ. of California Santa Barbara, USA*. Power allocation is investigated for a non-repeated/non-amplified datacenter networks. A mathematical model is constructed for the optical eye amplitude in a power constrained case, and the effectiveness of the model is demonstrated experimentally.

NeM4D.3 • 17:15 Invited
Subwavelength Metamaterial Nanophotonic Waveguide Devices, Pavel Cheben; *National Research Council, Canada*. Subwavelength grating metamaterial structures are becoming established as fundamental building blocks for the silicon photonics integrated devices. In this invited talk we will present an overview of our recent advances in this surging field.

Grand Peninsula F

Signal Processing in Photonics Communications

16:30–18:00
SpM4E • Networks and Transceiver Technology
Presider: David Hillerkuss; Huawei Technologies, Germany

SpM4E.1 • 16:30 Invited
White Boxes in Optical Networks: An Operator's Viewpoint, Andrew Lord; *Applied Research, BT, UK*. Where and what kind of whitebox technology will appear in telecom operator networks and what benefits will it bring?

SpM4E.2 • 17:00 Invited
InP Transceivers for Terabit Coherent Optical Communications Systems, Daniel Tauber, Robert Griffin; *Lumentum, Inc, USA*. We review high performance, highly integrated InP coherent optics that have enabled bandwidth growth from 100 to 600 Gigabits per second (Gbps) per wavelength when incorporated with CMOS DSP chips.

SpM4E.3 • 17:30 Invited
InP-based Coherent PICs for 100 Gbaud Operation, Ryan Going, Stefan Wolf, Robert Maher, Pavel Studenkov, Vikrant Lal, Huan-Shang Tsai, Scott Corzine, Jiaming Zhang, Babak Behnia, Carlo Di Giovanni, Thomas Vallaitis, Jeanne Yan, John Osenbach, Matthias Kuntz, Thomas Frost, Hossein Mousavi, Stefano Porto, Sanketh Buggaveeti, Hossein Hodaei, Zhenxing Wang, Xian Xu, Peter Evans, Jeffrey Rahn, Tim Butrie, Mehrdad Ziari, David Welch, Fred Kish; *Infinera Corporation, USA*. We present our progress in developing InP-based coherent Transmitter (Tx) and Receiver (Rx) Photonic Integrated Circuits (PIC) for 100 Gbaud transmission, enabling future multi-Tb/s optical engines.

18:30–20:00 Congress Reception, *Grand Peninsula D*

Grand Peninsula G

Integrated Photonics Research, Silicon and Nanophotonics

Sandpebble Room AB

Novel Optical Materials and Applications

Sandpebble Room CD

Optical Devices and Materials for Solar Energy and Solid-state Lighting

07:30–17:30 Registration, *Grand Peninsula Foyer*

08:00–10:00
IT1A • Frequency Combs 1
Presider: Shamsul Arafin; Ohio State Univ., USA

IT1A.1 • 08:00 Invited

Infrared Optical Frequency Comb Generation with Nonlinear Ultrafast Photonics, Scott Diddams; *NIST, USA.* We report the generation and spectroscopic application of optical frequency combs spanning 2-27 mm using ultrafast nonlinear optics in quasi-phase-matched $LiNbO_3$ and GaP waveguides and crystals, as well as dispersion-engineered suspended Si waveguides.

IT1A.2 • 08:30 Invited

Sub-harmonic and Harmonic Synchronization of Kerr Frequency Combs, Jae K. Jang[1], Alexander Klenner[1], Xingchen Ji[1,2], Chaitanya Joshi[1,2], Yoshitomo Okawachi[1], Michal Lipson[1], Alexander L. Gaeta[1]; *[1]Columbia Univ., USA; [2]Cornell Univ., USA.* We describe our recent work on the synchronization of microresonator-based Kerr frequency combs. By utilizing microresonators of various sizes, we can extend our synchronization technique to the sub-harmonic and harmonic regimes.

IT1A.3 • 09:00

Dual-pumped Kerr Cavity Soliton Based Synchronous All-optical Buffer: Raman Resilience, Arkadev Roy[2], Raktim Haldar[1], Shailendra K Varshney[1]; *[1]E&ECE Department, IIT Kharagpur, India, Indian Inst. of Technology Kharagpur, India; [2]Electrical Engineering, California Inst. of Technology, USA.* In this work, we numerically show that dual-pumped Kerr microresonator exhibits resilience against the stimulated Raman scattering and self-steepening phenomena that creates a favorable condition for effectively realizing Raman free optical systems.

IT1A.4 • 09:15

Millimeter-wave Synthesizer Based on Microresonator Soliton Dual-comb Photomixing, Jizhao Zang[1], Travis C. Briles[1], Jesse Morgan[2], Su-peng Yu[1], Andreas Beling[2], Scott Papp[1]; *[1]Univ. of Colorado Boulder/NIST, USA; [2]Univ. of Virginia, USA.* We propose a tunable millimeter-wave synthesizer design based on microresonator soliton dual-comb photomixing. The generated 50-500 GHz signal is expected to reproduce the stability of a microwave reference clock.

08:00–10:00
NoT1B • Materials for Solar/LED Applications
Presider: Jason Myers; US Naval Research Laboratory, USA

NoT1B.1 • 08:00 Invited

The Pursuit of Novel Phosphors for the Next Generation of LED Lighting, Jakoah Brgoch, Ya Zhuo; *Univ. of Houston, USA.* The development of phosphors for next-generation high power LED lighting requires a unique approach for materials discovery. Our research employs machine learning and computation to identify new luminescent materials guiding our synthetic efforts.

NoT1B.2 • 08:30 Invited

Understanding the Origin of Green Photoluminescence in Low-dimensional Lead Halide Perovskites, Jiming Bao[1], Zhaojun Qin[1], Shen-yu Dai[1], Chong Wang[2], Xinghua Su[3], Guoying Feng[4], Zhiming Wang[5], Viktor Hadjiev[1], Yanan Wang[5]; *[1]Univ. of Houston, USA; [2]Yunnan Univ., China; [3]Chang'an Univ., China; [4]Sichuan Univ., China; [5]Univ. of Electronic Science and Technology of China, China.* We discuss the controversy and challenges of the origin of green luminescence centers in 2D $CsPb_2Br_5$ and 0D Cs_4PbBr_6 and suggest several new experimental techniques to resolve the controversy and identify their underlying nature.

NoT1B.3 • 09:00 Invited

Investigating the Optical and Electrical Properties of Two-dimensional Organic-inorganic Hybrid Perovskite Multiple Quantum Wells via Electroabsorption Spectroscopy Studies, Eric Amerling, Luisa Whittaker-Brooks; *Univ. of Utah, USA.* Two-dimensional (2D) organic–inorganic hybrid perovskites have strong spin-orbit coupling (SOC) leading to the Rashba splitting effect. In this talk, we will explain how doping affects exciton and free-carriers in 2D perovskite thin films.

08:30–09:45
PT1C • Thin-film Solar Materials
Presider: Giulia Tagliabue; Swiss Federal Inst. of Technology, Switzerland

PT1C.1 • 08:30 Invited

Atomically-thin Photovoltaics: Progress and Prospects, Deep Jariwala; *Electrical and Systems Engineering, Univ. of Pennsylvania, USA.* I will present demonstration of unity light absorption in sub-15 nm thick semiconductors and photovoltaic devices with record quantum efficiencies. Ongoing work on application of two-dimensional materials in photovoltaics will be presented.

PT1C.2 • 09:00 Invited

Upconversion Performance Enhancement in Real 1D Photonic Crystals: Simulation, Experiment and Perspectives for Photovoltaics, Clarissa L. Hofmann[1,2], Emil H. Erkisen[3], Deniz U. Yazicioglu[1], Stefan Fischer[4], Benedikt Bläsi[1], Christian Reitz[5], Bryce S. Richards[2,6], Jan Christoph Goldschmidt[1]; *[1]Fraunhofer Inst. for Solar Energy Systems ISE, Germany; [2]Inst. of Microstructure Technology (IMT), Karlsruhe Inst. of Technology KIT, Germany; [3]Department of Physics and Astronomy, Aarhus Univ., Denmark; [4]Department of Materials Science and Engineering, Stanford Univ., USA; [5]Karlsruhe Nano Micro Facility, Karlsruhe Inst. of Technology KIT, Germany; [6]Light Technology Inst. (LTI), Karlsruhe Inst. of Technology KIT, Germany.* We investigate photonic effects of optimized 1D photonic structures on embedded upconverting core-shell nanoparticle layers in a thorough comparison of simulation and experiment regarding parameters relevant for photovoltaic applications.

Grand Peninsula E

Photonic Networks and Devices

Grand Peninsula F

Signal Processing in Photonics Communications

07:30–17:30 Registration, *Grand Peninsula Foyer*

08:00–10:00
NeT1D • Network Management and Operation
Presider: Marija Furdek; Chalmers Tekniska Hogskola, Sweden

NeT1D.1 • 08:00 Invited
Path Computation and Topology Description Scheme for Consistently Supporting Heterogeneous Optical Node Structures, Kiyo Ishii[1], Atsuko Takefusa[2], Shu Namiki[1], Tomohiro Kudoh[3]; [1]*National Inst. of Advanced Industrial Science and Technology, Japan;* [2]*National Inst. of Informatics, Japan;* [3]*The Univ. of Tokyo, Japan*. A physical network topology description scheme where individual optical switching functionalities are specified in a mathematically exact manner is presented. The applicability of the proposed scheme is evaluated through path computations.

NeT1D.2 • 08:30 Invited
Configuration and Monitoring of the Optical Physical Layer Using Software-defined Tools, Yuliya Verbishchuk[1,3], Cormac J. Sreenan[3], Fatima C. Garcia Gunning[1,2]; [1]*Tyndall National Inst., Ireland;* [2]*Physics, Univ. College Cork, Ireland;* [3]*Computer Science, Univ. College Cork, Ireland.* In this paper we discuss the need for implementation of SDN-based elements and tools towards disaggregated physical layer devices for optimum management of resources.

NeT1D.3 • 09:00 Invited
End-to-end Network Slicing and Orchestration in 5G Infrastructures with SDM-based Fronthaul, Giacomo Bernini, Marco Capitani, Giada Landi, Gino Carrozzo; *Nextworks, Italy.* 5G services drive an evolution of network infrastructures towards optical technologies for more capacity, flexibility, and agile network slicing. The paper proposes a slicing and orchestration framework operating 5G infrastructures with SDM fronthaul

09:00–09:45
SpT1E • Access Networks
Presider: Naoki Suzuki; Mitsubishi Electric Corporation, Japan

SpT1E.1 • 09:00 Invited
Digital Signal Processing in Optical Access Systems, Dora van Veen, Vincent Houtsma; *Nokia Bell Labs, USA.* We analyze the introduction of DSP in optical access. We review the specific requirements of PON and compare performance and feasibility of solutions with and without DSP for cost-effectively increasing the bit-rate in PON.

Grand Peninsula G

Integrated Photonics Research, Silicon and Nanophotonics

IT1A • Frequency Combs 1—Continued

IT1A.5 • 09:30
Self-healing Micro-combs, Hualong Bao[1], Juan S. Totero Gongora[2], Maxwell Rowley[3], Luana Olivieri[4], Sai T. Chu[5], Brent E. Little[6], Roberto Morandotti[7,8], David J. Moss[9], Marco Peccianti[10], Alessia Pasquazi[11]; *[1]Univ. of Sussex, UK; [5]City Univ. of Hong Kong, China; [6]Xi'an Inst. of Optics and Precision Mechanics, Chinese Academy of Science, China; [7]NRS-EMT, Canada; [8]Inst. of Fundamental and Frontier Sciences, Univ. of Electronic Science and Technology of China, China; [9]Centre for Microphotonics, Swinburne Univ. of Technology, Australia.* We demonstrate a scheme for generating micro-combs by embedding a micro-cavity in a fibre-laser cavity. The addition of an all-pass, fibre-based filter produces a periodical spectral-phase modulation which stabilises the comb for long fibre amplifiers

IT1A.6 • 09:45
Microwave and RF Applications Based on Kerr Micro-combs, Jiayang Wu[1], Xingyuan Xu[1], Mengxi Tan[1], Thach Nguyen[2], Yang Qu[1], Linnan Jia[1], Yuning Zhang[1], Sai T. Chu[3], Brent Little[4], Roberto Morandotti[5], Arnan Mitchell[2], David J. Moss[1]; *[1]Swinburne Univ. of Technology, Australia; [2]RMIT Univ., Australia; [3]City Univ. of Hong Kong, China; [4]Chinese Academy of Science, China; [5]INRS, Canada.* We present our recent progress on microwave and RF applications based on integrated Kerr micro-combs, including adaptive photonic RF filters with 80 taps, photonic RF filters via bandwidth scaling, and broadband photonic microwave mixer.

Sandpebble Room AB

Novel Optical Materials and Applications

NoT1B • Materials for Solar/LED Applications—Continued

NoT1B.4 • 09:30 Invited
In Situ Measurement of the Excited State Dynamics of Evolving Materials Systems, Kelly S. Wilson, Morgan L. Sosa, Madelyn N. Scott, Cathy Y. Wong; *Univ. of Oregon, USA.* Single-shot transient absorption and linear absorption measure excited state dynamics and electronic structure in situ during the formation of a pseudoisocyanine film. A model used to fit the absorption spectra reveals evolving aggregate structure.

Sandpebble Room CD

Optical Devices and Materials for Solar Energy and Solid-state Lighting

PT1C • Thin-film Solar Materials—Continued

PT1C.3 • 09:30
Optimizing Tm^{2+}-doped Dihalide Thin Film Luminescent Solar Concentrators, Evert P. Merkx, Erik van der Kolk; *Technische Universiteit Delft, Netherlands.* Local property-mapping of gradient thin films of MI_2:x% Tm^{2+} (M=Ca,Sr), where *x* and film thickness vary, is used to optimize for LSC use. Tm^{2+} absorbs the entire visible spectrum and emits at 1140 nm.

10:00–10:30 Networking Coffee Break with Exhibitors, *Grand Peninsula D*

NOTES

Grand Peninsula E

Photonic Networks and Devices

NeT1D • Network Management and Operation—Continued

NeT1D.4 • 09:30 Invited
Machine-learning-aided Service Provisioning in Multi-domain Optical Networks, Roberto Proietti, Xiaoliang Chen, Gengchen Liu, S.J. Ben Yoo; *Univ. of California Davis, USA*. This paper discusses testbed experiments and algorithms for machine-learning-aided service provisioning in multi-domain optical networks. Experimental results of hierarchical learning for QoT estimation of end-to-end lightpaths and a multi-agent DRL-based RMSA algorithm are presented.

Grand Peninsula F

Signal Processing in Photonics Communications

SpT1E • Access Networks—Continued

SpT1E.2 • 09:30
Dynamic Bandwidth Allocation Algorithms for NG-PON2 to Support 5G Fronthaul Services, Aziza Zaouga[1,2], Amaro de Sousa[2], Monia Najjar[1], Paulo P. Monteiro[2]; [1]*Communication Systems Laboratory (SysCom), Communication Systems Laboratory (SysCom), National Engineering School of Tunis (ENIT), Univ. of Tunis El Manar (UTM), Tunisia;* [2]*Instituto de Telecomunicações, Universidade de Aveiro, Portugal*. In this work, we propose DBA algorithms for NG-PON2 access networks to support both 5G fronthaul services and data services guaranteeing the 5G fronthaul latency requirements and maximizing data service throughput.

10:00–10:30 Networking Coffee Break with Exhibitors, *Grand Peninsula D*

Grand Peninsula G

Integrated Photonics Research, Silicon and Nanophotonics

10:30–12:30
IT2A • Frequency Combs 2 and Resonators
Presider: Judith Su; Univ. of Arizona, USA

IT2A.1 • 10:30 Invited

Nanophotonic Supercontinuum Based Mid-infrared Dual-comb Spectroscopy, Hairun Guo[1,5], Wenle Weng[1], Junqiu Liu[1], Fan Yang[2], Wolfgang Hänsel[3], Camille-Sophie Brès[4], Luc Thévenaz[2], Ronald Holzwarth[3], Tobias Kippenberg[1]; *[1]LPQM, Swiss Federal Inst. of Technology Lausanne (EPFL), Switzerland; [2]GFO, Swiss Federal Inst. of Technology Lausanne (EPFL), Switzerland; [3]Menlo Systems GmbH, Germany; [4]PHOSL, Swiss Federal Inst. of Technology Lausanne (EPFL), Switzerland; [5]Key Laboratory of Specialty Fiber Optics and Optical Access Networks, Shanghai Univ., China.* We demonstrate an approach to dual-comb spectroscopy, based on dispersion engineered and broadband supercontinuum generation in photonic integrated nonlinear waveguides, and driven by low-noise fiber-laser combs, which covers the range 2800-3600cm^{-1}.

IT2A.2 • 11:00 Invited

Laser Cavity-solitons in Micro-resonators, Alessia Pasquazi[1], Hualong Bao[1], Andrew Cooper[1], Luigi Di Lauro[1], Marco Peccianti[1], Sai T. Chu[2], Brent Little[2], Gian-Luca Oppo[3], Roberto Morandotti[4], David J. Moss[5], Benjamin Wetzel[1], Juan Sebastian Totero Gongora[1]; *[1]Univ. of Sussex, UK; [2]City Univ. of Hong Kong, Hong Kong; [3]SUPA and Department of Physics, Univ. of Strathclyde, Glasgow, UK; [4]INRS-EMT, Canada; [5]8 Centre for Microphotonics, Swinburne Univ. of Technology, Australia.* We report the observation of temporal laser cavity-solitons in a system comprising an optical micro-cavity nested in a fibre laser.

IT2A.3 • 11:30 Invited

Kerr-microresonator Frequency Combs with Tantalum-pentoxide Nanophotonics, Scott Papp; *National Inst of Standards & Technology, USA.* Abstract not available.

IT2A.4 • 12:00

High Fineness Tunable Optoelectronic Oscillator Based on SiO_2 Optical Waveguide Ring Resonator, Shengkun Li[2,1], Yongqiu Zheng[1], Jiamin Chen[1], Yuejin Zhao[2]; *[1]North Univ. of China, China; [2]Beijing Inst. of Technology, China.* A novel approach to obtain fine tunable optoelectronic oscillators based on SiO_2 optical waveguide ring resonator (OWRR) is proposed. Fine control of 20kHz frequency steps has been realized by shifting resonant frequency locking points of the OWRR.

IT2A.5 • 12:15

Thermo-optical Pulsing in a Microresonator Filtered Fiber-laser, Maxwell Rowley[1], Benjamin Wetzel[2,1], Luigi Di Lauro[1], Juan Sebastian Totero Gongora[1], Hualong Bao[1], Jonathan Silver[3], Leonardo Del Bino[3], Pascal Del' Haye[3], Marco Peccianti[1], Alessia Pasquazi[1]; *[1]Univ. of Sussex, UK; [2]Xlim Research Inst., France; [3]National Physical Laboratory (NPL), UK.* We demonstrate a hybrid microresonator-fiber-laser scheme with pulsed output at microsecond period, with pulse dynamics driven by complex interactions between the nonlinear thermo-optical effect and non-instantaneous gain response.

Sandpebble Room AB

Novel Optical Materials and Applications

10:30–12:30
NoT2B • Biomimetic and Biocompatible Optical Materials
Presider: Woei Ming Lee; Australian National Univ., Australia

NoT2B.1 • 10:30 Invited

Dynamic Materials Inspired by Cephalopods, Alon Gorodetsky; *Univ. of California Irvine, USA.* Cephalopods have captivated the imagination of both the general public and scientists alike, emerging as exciting models for novel materials and systems. In this reagrd, we have developed cephalopod-inspired materials with unique functionalities.

NoT2B.2 • 11:00 Invited

Organic Light Actuators for Non-genetic Optical Stimulation, Guglielmo Lanzani, Giuseppe M. Paternò; *Center for Nano Science and Technology, Istituto Italiano di Tecnologia, Italy.* Although optogenetics is a great tool to induce light sensitivity to living organism, its invasiveness limits real applications. Here, I describe alternative approaches aimed at NON-genetically inducing sensitivity in cells and organism.

NoT2B.3 • 11:30 Invited

Soft Matter and Biological Lasers, Matjaz Humar[1,2]; *[1]Department of Condensed Matter Physics, Jozef Stefan Inst., Slovenia; [2]Faculty of Mathematics and Physics, Univ. of Ljubljana, Slovenia.* Lasers were made from soft and biological materials. These lasers have been inserted into cells and tissues to perform a number of functions including tagging of cells, intracellular sensing, diagnostics and novel imaging methods.

NoT2B.4 • 12:00

Light Scattering Spectroscopy Combined with Principal Component Analysis for Animal Species Identification in Historical Parchments, Angel Martin Fernandez Alvarez, Alexandre Mayer, Olivier Deparis; *Univ. of Namur, Belgium.* Light scattering spectroscopic data from historical parchments were processed according to different PCA schemes, leading to reliable optical fingerprints. This method enabled animal species identification without resorting to molecular analysis.

NoT2B.5 • 12:15

Fabrication of Gabor Filtering Photosensors Using the Printing Patterns of Bacteriorhodopsin, Katsuyuki Kasai[1], Hiroyuki Hasegawa[2], Yoshiko Okada-Shudo[3], Shukichi Tanaka[1], Akira Otomo[1]; *[1]National Inst of Information & Comm Tech, Japan; [2]Shimane Univ., Japan; [3]The Univ. of Electro-Communications, Japan.* Bacteriorhodopsin is an attractive photosensitive biomaterial. Its patterns can be obtained via an inkjet printing method. We fabricated Gabor filtering photosensors by layering inkjet patterns, and their sensing characteristics were investigated.

Sandpebble Room CD

Optical Devices and Materials for Solar Energy and Solid-state Lighting

10:30–12:30
PT2C • LED 2
Presider: Clarissa Hofmann; Fraunhofer Inst Solare Energie Systeme, Germany

PT2C.1 • 10:30 Invited

GaN High-power Lasers for Solid-state Lighting, Guillaume Lheureux, Shlomo Mehari, Daniel Cohen, Philip Chan, Haojun Zhang, Kareem Hamdy, Caroline Reilly, Ryan Anderson, Emet Zeitz, Ram Seshadri, Tal Margalith, Claude Weisbuch, James S. Speck, Steven P. DenBaars, Shuji Nakamura; *Materials, Univ. of California Santa Barbara, USA.* We discuss the use of GaN high-power laser diode in general lighting applications. After reviewing the laser diode achievements; the phosphors materials, the optical design and the possible performances of these devices are discussed.

PT2C.2 • 11:00 Invited

Stationary Adjustable Luminaires via Optical Beam Steering, John Lloyd, Peter Kozodoy, Christopher Gladden, Andrew Kim; *Glint Photonics Inc., USA.* Adjustable luminaires deliver targeted light in countless illumination scenarios. The high brightness and surface emission characteristic of LED light sources enable new optical design of adjustable luminaires to include beam steering.

PT2C.3 • 11:30

Transparent Nanophosphor Films for Efficient White-light Generation, Gabriel S. Lozano-Barbero, Elena Cabello-Olmo, Dongling Geng, Hernán Míguez; *Instituto de Ciencia de Materiales de Sevilla, Consejo Superior de Investigaciones Científicas, Spain.* Herein we demonstrate highly transparent white-light-emitting coatings of tunable shade with photoluminescence quantum yields above 35% by a sequential stacking of optical quality layers made of Eu^{3+}- and Dy^{3+}-doped rare-earth nanocrystals.

PT2C.4 • 11:45

Foamed Polymer/Quantum Dots Composite Films with Enhanced Photoluminescence Efficiency, Shudong Yu[1,2], Benjamin Fritz[2], Dominik Theobald[2], Siegbert Johnsen[2], Dmitry Busko[2], Bryce S. Richards[2], Marc Hippler[2], Gabriele Wiegand[2], Yong Tang[1], Zongtao Li[1], Uli Lemmer[2], Hendrik Hölscher[2], Guillaume Gomard[2]; *[1]South China Univ. of Technology, China; [2]Karlsruhe Inst. of Technology, Germany.* We use the CO_2 foaming method to control the introduction of pores in polymer/quantum dots light converting films, whose photoluminescence efficiency is improved owing to an efficient light management scheme.

PT2C.5 • 12:00

Impact of Surface Reflectance on Spectral Optimization for Melanopic Illuminance and Energy Efficiency, Dorukalp Durmus; *Pacific Northwest National Laboratory, USA.* Although surfaces impact melanopic response, they are not considered in optimization studies. Calculations with iteratively-generated narrowband LED combinations show that reflectance in short wavelengths has a large impact on melanopic illuminance.

PT2C.6 • 12:15

How Useful is Photochemical Upconversion for Lighting Applications?, Laszlo Frazer; *ARC Centre of Excellence in Exciton Science, School of Chemistry, Monash Univ., Australia.* Triplet-triplet annihilation photochemical upconversion is a method of converting light to a higher frequency. We show theoretically that photochemical upconversion can be applied to Watt-scale lighting.

Grand Peninsula E

Photonic Networks and Devices

10:30–12:30
NeT2D • Access, Metro and Transport Network Evolution
Presider: Fatima Garcia Gunning; Tyndall National Institute, Ireland

NeT2D.1 • 10:30 Invited
Scaling the Next Generation Broadband Access Networks with Super-PON, Cedric F. Lam; *Google, USA*. We present the design, deployment and the standardization of a TWDM Super-PON fiber access network with 50km transmission distance and 768 users on a single fiber strand from the central office (CO).

NeT2D.2 • 11:00 Invited
Full PON Virtualisation Supporting Multi-tenancy beyond 5G, Nima Afraz, Frank Slyne, Marco Ruffini; *CONNECT, Univ. of Dublin Trinity College, Ireland*. In this paper, we introduce a virtualization technique to enable fully customizable resource sharing for Passive Optical Networks. We provide a summary of the concept, economic challenges and implementation.

NeT2D.3 • 11:30 Invited
How the Metro Network Evolves in the MEC Era, Qingya She[2], Qiong Zhang[1]; [1]*Fujitsu Laboratories of America Inc., USA*; [2]*Fujitsu Network Communications, USA*. As multi-access edge computing (MEC) is emerging in telecom metro networks, we analyze its impact on IP over WDM metro network architectures, as well as central office nodal architectures, based on future metro traffic patterns.

NeT2D.4 • 12:00 Invited
Designing Ultra-reliable 5G-ready Transport Networks, Bodhisattwa Gangopadhyay, João Pedro, Nuno Borges; *Infinera, Portugal*. Exponential traffic growth with stringent SLA built upon heavily interconnected backbone and heterogeneous infrastructure is 5G reality. A hybrid control plane policy providing augmented resiliency for such networks is the focus of this paper.

Grand Peninsula F

Signal Processing in Photonics Communications

10:30–12:30
SpT2E • Digital Signal Processing 1
Presider: Hany Elgala; State Univ. of New York at Albany, USA

SpT2E.1 • 10:30 Invited
Digital Predistortion Techniques for Ultra-high Symbol Rates, Ginni Khanna[1], Bernhard Spinnler[2], Erik De Man[2], Norbert Hanik[1]; [1]*Technische Universität Munchen, Germany*; [2]*Infinera, Germany*. An adaptive digital pre-compensation scheme to jointly compensate for the linear and non-linear effects for high baud rate and higher order modulation formats optical transmitters is discussed.

SpT2E.2 • 11:00 Invited
Nonlinearity Compensation Techniques Using Machine Learning, Stylianos Sygletos; *Aston Univ., UK*. We discuss the potential of dynamic neural networks to provide mitigation of nonlinear impairments in long haul transmission systems and we compare their performance and computational efficiency against conventional digital back propagation methods.

SpT2E.3 • 11:30
Autoencoder Model for OFDM-based Optical Wireless Communication, Priti Pachpande, Monette Khadr, Hesham Hussien, Hany Elgala, Dola Saha; *Univ. at Albany, USA*. An orthogonal frequency division multiplexing based Autoencoder model for optical wireless communication is implemented. Symbol-error performance demonstrates the viability of using neural networks and deep learning techniques in OWC systems.

SpT2E.4 • 11:45
Detecting Underwater Laguerre Gaussian Modes Using a Convolutional Neural Network, Abderrahmen Trichili, Chaouki Ben Issaid, Yujian Guo, Tien Khee Ng, Boon S. Ooi, Mohamed-Slim Alouini; *King Abdullah Univ of Sci & Technology, Saudi Arabia*. We propose the use of a convolutional neural network (CNN) to detect single and superpositions of Laguerre Gaussian modes in an underwater environment which will open the doors towards fast and reliable underwater optical wireless communications.

SpT2E.5 • 12:00
Emission Spectrum Denoising Algorithm for Microlasers-based Neurotransducers, Maurizio Manzo, Ibrahim L. Ibrahim L. Olokodana; *Univ. of North Texas, USA*. Emission spectra from microlasers are noisy due to the presence of higher order optical modes and first order missing modes. Here, the proposed algorithm eliminates the noise and reconstructs the missing peaks.

SpT2E.6 • 12:15
Free Space Optical Coprocessor for Image Processing and Convolution Neural Network, Mario Miscuglio, Zibo Hu, Jonathan George, Zhizhen Ma, Volker J. Sorger; *George Washington Univ., USA*. Convolution Neural Networks are artificial networks able to extract features from large dataset by spatial filtering. Here we propose an optical coprocessor able to perform large image filtering and convolutions, outperforming current architectures.

12:30–14:00 Student and Early Career Professional Development & Networking Lunch and Learn, *Bayside Room*

12:30–14:00 Lunch *(on own)*

Grand Peninsula G

Integrated Photonics Research, Silicon and Nanophotonics

14:00–16:00
IT3A • Photodetectors and Sensing
Presider: Heayoung Yoon; Univ. of Utah, USA

IT3A.1 • 14:00 Invited
1310 nm High-speed All-silicon Waveguide Photodetectors for Low-cost Photonic Integration, Meer Nazmus Sakib[1], Hao Li[2], Ranjeet Kumar[1], Hasitha Jayatilleka[1], Ganesh Balamurugan[2], James Jaussi[2], Haisheng Rong[1], Bryan Casper[2]; *[1]Intel Labs- Photonics Research, USA; [2]Intel Labs, USA.* We present an all-silicon waveguide photodetector co-packaged with a 28-nm CMOS TIA. At 1310nm datacom wavelength, we demonstrate an optical signal detection at 40 Gb/s with an open eye diagram and SNR of 10.

IT3A.2 • 14:30 Invited
Silicon Nanowires for Photonics, Photovoltaics and Sensing, Maria J. Lo Faro[1,2], Priolo Francesco[1,3], Dario Morganti[1,2], Antonio A. Leonardi[1,2], Paolo Musumeci[1], Barbara Fazio[2], Alessia Irrera[2]; *[1]Dept. of Physics and Astronomy "E.Majorana", Univ. of Catania, Italy; [2]CNR IPCF, Italy; [3]CNR IMM, Italy.* Si nanowires are promising building blocks for future nanoscale devices. The combination of their high aspect-ratio and quantum effects allows the realization of ultrasensitive of label-free optical biosensors with novel perspectives in photonics.

IT3A.3 • 15:00
Up to 1700nm Broadband High-efficiency Surface-illuminated Ge/Si Photodiode with Microhole Array, Soroush Ghandiparsi[1], Aly F. Elrefaie[1,2], Ahmed S. Mayet[1], Cesar Bartolo-Perez[1], Hilal Cansizoglu[1], Yang Gao[1], Ekaterina P. Devine[2], Taha Landolsi[3], Hasina H. Mamtaz[1], Hossein Rabiee-Golgir[1], Toshishige Yamada[4], Shih-Yuan Wang[2], M. Saif Islam[1]; *[1]Univ. of California Davis, USA; [2]W&Wsens, USA; [3]Department of Computer Science and Engineering, American Univ. of Sharjah, United Arab Emirates; [4]Electrical Engineering, Baskin School of Engineering, Univ. of California Santa Cruz, USA.* We demonstrate a 10Gb/s CMOS-compatible surface-illuminated Ge/Si Photodiode integrated with photon-trapping microhole arrays with broadband high efficiency up to 1700nm. The Ge/Si photodiode has >80% and >73% EQE at 1310nm and 1550nm, respectively.

IT3A.4 • 15:15
A Single Photon Detector with an Amorphous/Crystalline Silicon Heterointerface, Lujiang Yan, Mohammad Abu Raihan Miah, Jiayun Zhou, Yong Zhang, Yuhwa Lo; *University of California San Diego, USA.* We demonstrate a single photon detector of dual gain sections design with internal control. At 100MHz, it shows over 11% single photon detection efficiency, sub-nanosecond self-recovery time, low excess noise with only 8.5V bias.

Sandpebble Room AB

Novel Optical Materials and Applications

14:00–16:00
NoT3B • Metamaterials and Metasurfaces 1
Presider: Mikhail Kats; Univ. of Wisconsin-Madison, USA

NoT3B.1 • 14:00 Invited
High Q Metasurfaces for Nonlinear Free-space Optics, Jennifer Dionne, Mark Lawrence, David Barton, Elissa Klopfer, Jefferson Dixon; *Stanford Univ., USA.* We show how high-Q modes can be generated within dielectric metasurfaces, opening new possibilities for nonlinear freespace nanophotonics. We utilize these nonlinear metasurfaces for nanoscale nonreciprocity and neuromorphic nanophotonic networks.

NoT3B.2 • 14:30 Invited
Manipulating and Imaging Quantum Light with Dielectric Metasurfaces, Andrey A. Sukhorukov; *Nonlinear Physics Centre, Research School of Physics and Engineering, Australian National Univ., Australia.* We present theoretical and experimental results demonstrating non-classical multi-photon interferences at the subwavelength scale in dielectric metasurfaces, enabling tailored manipulation and measurement of multi-photon quantum states.

NoT3B.3 • 15:00 Invited
Enhanced Optical Nonlinearities in All-dielectric Metasurfaces, Polina Vabishchevich[1,2], Aleksandr Vaskin[3], Sadhvikas Addamane[4], Nicholas Karl[1,2], Sheng Liu[1,2], Andrei Sharma[4], Ganesh Balakrishnan[4], John L. Reno[1,2], Gordon A. Keeler[1], Michael Sinclair[1], Isabelle Staude[3], Igal Brener[1,2]; *[1]Sandia National Laboratories, USA; [2]Center for Integrated Nanotechnologies, Sandia National Laboratories, USA; [3]Inst. of Applied Physics, Abbe Center of Photonics, Friedrich Schiller Univ., Germany; [4]Center for High Technology Materials (CHTM), Univ. of New Mexico, USA.* We demonstrate simultaneous generation of second-, third-, fourth-harmonic, sum-frequency, four-wave and six-wave mixing processes in III-V semiconductor metasurfaces and show how to tailor second harmonic generation via crystal orientation.

Sandpebble Room CD

Optical Devices and Materials for Solar Energy and Solid-state Lighting

14:00–15:00
PT3C • Liquid-phase Solar Materials
Presider: Michael Kelzenberg; California Inst. of Technology, USA

PT3C.1 • 14:00 Invited
The Role of Organic Optoelectronics in Wearable Medical Devices, Ana Arias, Yasser Khan, Donggeon Han, Adrien Pierre, Jonathan Ting; *University of California Berkeley, USA.* We have demonstrated a flexible and printed sensor array composed of organic light-emitting diodes and organic photodiodes, which senses reflected light from tissue to determine the oxygen saturation.

PT3C.2 • 14:30 Invited
Plasmonic Hot Holes: Fundamentals and Devices, Giulia Tagliabue[1], Joseph DuChene[2], Harry Atwater[2]; *[1]EPFL, Switzerland; [2]Applied Physics and Material Science, Caltech, USA.* Photoelectrochemical, photoelectrical and ultra-fast pump-probe studies elucidate the generation and dynamics of plasmonic hot-holes and suggest new opportunities for hot-carrier optoelectronic devices.

Grand Peninsula E

Photonic Networks and Devices

14:00–16:00
NeT3D • High-performance Networks
Presider: Marco Ruffini; Univ. of Dublin Trinity College, Ireland

NeT3D.1 • 14:00 Invited
Candidate Technologies for High-capacity Optical Communication Systems, Lidia Galdino, Daniel Semrau, Polina Bayvel; *Univ. College London, UK.* The practicalities in designing high-capacity optical communication systems are described. With a given perspective on the present and future technologies, we cover the transceiver design and optical amplifier technologies to maximize fiber capacity.

NeT3D.2 • 14:30 Invited
Spatial Channel Cross-connect (SXC) Architectures and Their Enabling Technologies for Future Spatial Channel Networks (SCNs), Masahiko Jinno; *Kagawa Univ., Japan.* We discuss two types of spatial channel cross-connect architectures based on sub-matrix-switches, core selective switches, and their enabling technologies for spatial channel networks in the forthcoming spatial division multiplexing abundant era.

NeT3D.3 • 15:00 Invited
Optical Multi-band Networks: Maximizing Lifetime of Deployed Fiber Infrastructure, Johannes Fischer[4], Pablo Wilke Berenguer[4], Behnam Shariati[4], Antonio Napoli[1], Erwan Pincemin[2], Alessio Ferrari[5], Vittorio Curri[5], Nelson Costa[3], João Pedro[3]; *[1]Infinera, Germany; [2]Orange Labs, France; [3]Infinera Unipessoal Lda, Portugal; [4]Fraunhofer Inst. for Telecommunications Heinrich-Hertz-Inst.,, Germany; [5]Politecnico di Torino, Italy.* Optical multi-band networks provide an option for scaling the capacity of single-mode fiber with the continuously increasing demand. Achievable capacities are reviewed and challenges to realize them in deployed systems are highlighted.

Grand Peninsula F

Signal Processing in Photonics Communications

14:00–15:45
SpT3E • Digital Signal Processing 2
Presider: Koji Igarashi; Osaka Univ., Japan

SpT3E.1 • 14:00 Invited
ADC and DAC: State of the Art and Technology Trends, Tomislav Drenski; *Socionext Europe GmbH, UK.* Technology trends for high speed ADC & DAC and their ASIC implementation in optical transport/access, starting from Ultra Long Haul to Short Reach transmissions are shown. New requirement for 5G applications are reviewed and possible solutions given.

SpT3E.2 • 14:30 Invited
Flexible and Low-power Probabilistic Shaping for Fiber-optic Communications, Tsuyoshi Yoshida[1,2], Naoki Suzuki[1]; *[1]Mitsubishi Electric Corporation, Japan; [2]Graduate School of Engineering, Osaka Univ., Japan.* Deep probabilistic shaping with coarse base constellation leads to significant increase of power consumption and fiber nonlinear degradation. We show potentials of flexible probabilistic shaping with multiple and granular base constellations.

SpT3E.3 • 15:00 Invited
Dimensions Grading Optimization of Orthogonal Volterra DPD Based on Signal-projection, Hananel Faig, Eyal Wohlgemuth, Yaron Yoffe, Dan Sadot; *Ben-Gurion Univ. of the Negev, Israel.* An efficient grading method for dimensions-reduced digital pre-distorter based on orthogonal Volterra series for band-limited nonlinear components is proposed. The method is based on a combination of dimension variance and signal-projection.

Integrated Photonics Research, Silicon and Nanophotonics

Novel Optical Materials and Applications

Optical Devices and Materials for Solar Energy and Solid-state Lighting

IT3A • Photodetectors and Sensing—Continued

IT3A.5 • 15:30
Integrated Graphene Plasmonic Slot Photodetector with High Responsivity, Zhizhen Ma, Kazuya Kikunaga, Shuai Sun, Rubab Amin, Mario Miscuglio, Volker J. Sorger; *George Washington Univ., USA.* We demonstrated an ultra-narrow (15 nm) plasmonic slot photodetector using graphene demonstrating an external responsivity of 0.67 A/W. Tuning the gating for graphene a strong short-channel was found to increase the photo-to-dark current-ratio.

IT3A.6 • 15:45
Ultra-low Capacitance, High-speed Integrated Waveguide Photodiodes on InP, Bassem Tossoun, Jesse Morgan, Andreas Beling; *Univ. of Virginia, USA.* We demonstrate integrated waveguide modified uni-traveling carrier (MUTC) photodiodes with dark currents as low as 5 nA at -1 V, capacitance of 1.8 fF, 0.26 A/W external responsivity, and a 3-dB bandwidth of 85 GHz.

NoT3B • Metamaterials and Metasurfaces 1—Continued

NoT3B.4 • 15:30
Realization of Topology-optimized Multilayer Metasurfaces, Evan W. Wang[1], Thaibao Phan[1], David Sell[2], Jonathan A. Fan[1]; *[1]Department of Electrical Engineering, Stanford Univ., USA; [2]Department of Applied Physics, Stanford Univ., USA.* Multilayer metasurfaces promise extraordinary electromagnetic control beyond those achievable with single layer devices. We discuss methods for the practical design and fabrication of multilayer metasurfaces.

NoT3B.5 • 15:45
Optical Properties of Hybrid Carbon Flakes and their Dependence on Fabrication Parameters, Muhammad Abdullah T. Butt[1,8], Martin Neugebauer[1,2], Antonino Calà Lesina[3,4], Lora Ramunno[3,7], Pierre Berini[3,4], Thomas Bauer[5], Daria Mamonova[6], Alina Manshina[6], Peter Banzer[1,2], Gerd Leuchs[1,2]; *[1]Max Planck Inst. for Sci of Light, Germany; [2]Inst. of Optics, Information and Photonics, FAU, Germany; [3]Department of Physics, Univ. of Ottawa, Canada; [4]School of Electrical Engineering and Computer Science, Univ. of Ottawa, Canada; [5]Department of Quantum Nanoscience, Delft Univ. of Technology, Netherlands; [6]Inst. of Chemistry, St. Petersburg State Univ., Russian Federation; [7]Univ. of Ottawa Centre for Extreme and Quantum Photonics, Max Planck Center, Canada; [8]Optical Materials and Systems, School of Advance Optical Technologies, Germany.* We investigate the effects of fabrication parameters on optical properties of carbon flakes. We use microscopic Müller matrix measurement technique to experimentally investigate different samples of carbon flakes.

NeT3D • High-performance Networks—Continued

NeT3D.4 • 15:30 Invited
Latency Control in Deterministic and Dynamic Networks, Nihel D. Benzaoui; *NOKIA, France*. We present Deterministic Dynamic Network as a solution for 5G Edge Cloud and show how we control latency to ensure end-to-end deterministic performance of only tens of microseconds latency and tens of nanoseconds jitter per-application

SpT3E • Digital Signal Processing 2—Continued

SpT3E.4 • 15:30
Modulation Format Independent Joint Polarization Demultiplexing and IQ Imbalance Compensation, Marwa Kazdoghli Lagha[1], Pascal Scalart[1], Christophe Peucheret[2], Robin Gerzaguet[1], Laurent Bramerie[2]; *[1]Univ Rennes, CNRS, IRISA, France; [2]Univ Rennes, CNRS, FOTON-UMR 6082, France*. We propose a new joint Tx-IQ imbalance compensation and polarization demultiplexing algorithm for arbitrary M-QAM coherent systems. Evaluated metrics demonstrate its effectiveness as a blind approach compared to cascaded CMA and BASS algorithms.

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16:00–18:00
JT4A • Joint Poster Session
Networking Coffee Break with Exhibitors

JT4A.1
Birefringent Laser Pulse Shaper Generating Arbitrarily Optimal Temporal Output Pulse Profiles, Abde Rezzaq Halassi[1], Rachid Hamdi[1,2], Badr-Eddine Benkelfat[2]; [1]*Laboratoire des Télécommunications, Algeria;* [2]*SAMOVAR, Télécom SudParis, CNRS, Institut Polytechnique de Paris, France*. We demonstrate a birefringent pulse shaper generating arbitrarily optimal temporal pulse profiles. The optogeometrical shaper parameters are obtained by a resolution of generalized nonlinear equation system based on time-domain Jones matrix formalism

JT4A.2
Frequency Offset Stabilization for Frequency Combs Using Electro-optic Modulators, Daniel Bodenmüller, Jose C. Boggio, Martin M. Roth; *Leibniz-Institut für Astrophysik Potsdam , Germany*. Frequency offset locking of two lasers by means of a digital controller was performed using two different methods. The frequency instability at an average time of 1 s was below 1 kHz.

JT4A.3
On Performing Complete Stokes Polarimetry Using only One Liquid Crystal, Muhammad Abdullah T. Butt; *NanoOptics group, School of Advance Optical Technologies, Germany*. We analyze the implementation of complete stokes polarimetry, exploiting the dependence of electric voltage on retardance of liquid crystal. The method ensures no rotation of liquid crystal retarder, to avoid any beam movement during stokes analysis.

JT4A.4
Robust Couplers Designed by Fast Quasiadiabatic Elimination, Hung-Ching Chung, Jheng-Yi Sie, Shuo-Yen Tseng; *National Chung kung Univ., Taiwan*. We propose robust waveguide couplers by combining adiabatic elimination and the fast quasiadiabatic dynamics. The new fast quasiadibatic elimination (FAQUEL) coupler is short and have good robustness against wavelength and fabrication variations.

JT4A.5
Infrared Emission from ZnO codoped Er:ZrO_2 Thin Films, José L. Clabel[1], Gaston Lozano Calderon[1], Victor Garcia[2], Euclydes Marega[1]; [1]*Instituto de Física de São Carlos - Universidade de São Paulo (IFSC-USP), Brazil;* [2]*Departamento de Física - Universidad Nacional Mayor de San Marcos (DF-UNMSM)), Peru*. We investigated the effect of ZnO concentration on structural and optical properties of Er:ZrO_2 thin films grown using electron beam physical vapor deposition. The photoluminescence and $^4I_{13/2}\rightarrow{}^4I_{15/2}$ lifetime was measured with 980 nm excitation.

JT4A.6
SDN for Passive Optical Networks and Passive Optical Ethernet, Yuxin (Eugene) Dai[1], Wei Dai[2]; [1]*Senior Consultant, USA;* [2]*Appfolio, USA*. This paper first introduces the concept of Passive Optical Ethernet. Then constructs a foundation for developing a unified SDN model for Passive Optical Network and Passive Optical Ethernet.

JT4A.7
Infrared Mirror Coating to Improve Efficiency in Solar Thermal Energy Applications, Daniela De Luca[1,2], Carmine D'Alessandro[1,2], Davide De Maio[1,2], Emiliano Di Gennaro[1], Marilena Musto[1], Giuseppe Rotondo[1], Roberto Russo[2]; [1]*Univ. of Naples "Federico II", Italy;* [2]*CNR, Italy*. In high vacuum solar flat thermal panel, the heat losses are mainly due to emitted radiation. Photon recycling, obtained through optimized infrared mirror coating deposited on glass, can improve thermal efficiency and increase operating temperatures.

JT4A.8
Theoretical Analysis and Design of a High Bandwidth SiNx on SOI Grating Coupler for Communications Applications, Albert Djikeng; *Univ. of Texas at San Antonio, USA*. Asymmetric grating trenches and optimization of grating dimensions of a SiNx on silicon-on-insulator (SOI) grating coupler are examined with results of 28.57 nm 1dB bandwidth and a maximum coupling efficiency of 49.77%.

JT4A.9
Near-field Scanning Optical Microscopy of Luminescent Nanostructured Semiconductors, Laszlo Frazer[1], Heyou Zhang[2], Chun Kiu Ng[3], Pegah Maasoumi[2], Jacek Jasieniak[3], Paul Mulvaney[2], Alison Funston[1]; [1]*ARC Centre of Excellence in Exciton Science, School of Chemistry, Monash Univ., Australia;* [2]*ARC Centre of Excellence in Exciton Science, School of Chemistry, The Univ. of Melbourne, Australia;* [3]*ARC Centre of Excellence in Exciton Science, Department of Materials Science and Engineering, Monash Univ., Australia*. The ability to image nanostructures with far-field visible light optics is limited by diffraction. We use Near-field Scanning Optical Microscopy (NSOM/SNOM) to increase resolution of luminescence imaging, while avoiding radiation damage.

JT4A.10
Purification, Synthesis, Crystal Growth and Optical Spectroscopy of Pr^{3+} Doped $CsPbCl_3$ Perovskite Crystals for Photonic Applications, Uwe H. Hommerich[1], Lanijah Flagg[1], AlAmin Kabir[1], Althea Bluiett[2], Sudhir Trivedi[3]; [1]*Hampton Univ., USA;* [2]*Dept. of Chemisty, Geology, Physics, Elizabeth City State Univ, USA;* [3]*Brimrose Technology Corporation, USA*. We report on the purification, synthesis, crystal growth and spectroscopy Pr^{3+} doped $CsPbCl_3$ perovskite bulk crystals for photonic applications. The Pr: CsPbCl3 exhibited infrared emission at 1625nm, 2450nm and 4450 nm under pumping at ~1500 nm.

JT4A.11
Withdrawn

JT4A.12
Theoretical Analysis of Waveguide Mode Profiles Obtained by the Source-added Transfer Matrix Method in Organic Light-emitting Diodes, Jiyong Kim[1], Kyoung-Youm Kim[2], Jungho Kim[1]; [1]*Dept. of Information Display, Kyung Hee Univ., South Korea;* [2]*Dept. of Electrical Engineering, Sejong Univ., South Korea*. We calculate the spatial profile of optical waveguide modes based on the source-added transfer matrix method inside organic light-emitting diodes. The effect of the dipole source on waveguide mode profiles is investigated.

JT4A.13
Enhanced Magnetic Circular Dichroism in Graphene Oligomers at Low Static Magnetic Fields, Jian Q. Liu; *Jiujiang Univ., China*. Giant magnetic circular dichroism (MCD) is promising for nanophotonic devices. We numerically demonstrate that MCD is enhanced three times larger than reported method based on the resonance of electric dipole plasmonic mode.

JT4A.14
Broadband TiO_2 Dielectric Metamaterial Absorber, Tian Lan, Pinwei Liu, Xiaomei Chen; *School of Optics and Photonics, Beijing Inst. of Technology, China*. In this paper, we demonstrate a broadband, polarization-insensitive, and omnidirectional metamaterial absorber which is relatively easy to fabricate. This device exhibits absorption above 90% in the wavelength range from 639 nm to 1339 nm.

JT4A.15
Flexible Optical and Wireless Testbed for 5G and Beyond Communication Systems, Paulo P. Monteiro[2,1], Alimi I. Ajewale[2], Fernando Guiomar[2], Abel L. Riesgo[2], Akeem Mufutau[2,1], Atílio Gameiro[2,1]; [1]*Universidade de Aveiro, Portugal;* [2]*Instituto de Telecomunicações, Portugal*. In this paper, we report ORCIP, a flexible and software-defined testbed for realistic 5G system evaluation. The testbed offers the underlying platform for the testing of different fixed-mobile convergence solutions.

JT4A.16
Irradiance Pattern Model of LED at Short Distances, Ivan Moreno; *Universidad Autonoma de Zacatecas, Mexico*. LEDs are used in many applications where intense irradiation is necessary, but current radiation models are only for far-field. We propose a mathematical model for the spatial distribution of irradiance of LEDs at near working distances.

JT4A.17
2-Input/3-Input All-optical Switchable AND/NOR Logic Gate, Akira Nabeyama[1], Kosuke Komatsu[2], Gou Hosoya[3], Hiroyuki Yashima[3]; [1]*Department of Management Science, Faculty of Engineering, Tokyo Univ. of Science, Japan;* [2]*Department of Management Science, Graduate School of Engineering, Graduate School of Tokyo Univ. of Science, Japan;* [3]*Department of Information and Computer Technology, Tokyo Univ. of Science, Japan*. We propose a 2-input/3-input all-optical switchable AND/NOR logic gate. We perform a simulation to confirm that the output signal quality does not depend on the logical operators and the number of inputs.

JT4A.18
Polarization Switching Characteristics of Light Emission in Deep-ultraviolet AlGaN/AlN Quantum Well Structures with Anisotropic Strains, Seoung-Hwan Park[1], Jongmyeong Kim[3], Euijoon Yoon[3], Doyeol Ahn[2]; [1]*Department of Electronics Engineering, Catholic Univ. of Daegu, South Korea;* [2]*Department of Electrical and Computer Engineering, Univ. of Seoul, South Korea;* [3]*Department of Materials Science and Engineering, Seoul National Univ., South Korea*. The anisotropic strain effects on optical properties of UV AlGaN/AlN QWs were investigated. The peak intensity significantly increases with an anisotropic strain. A polarization switching from TE to TM polarization depends on the strain relaxation.

JT4A.19
Two-step Conversion of PbSe Thin Films to Perovskites, Sa'ar Peled[1,2], Maayan Perez[1,2], Yuval Golan[1,2]; [1]*Materials Engineering, Ben Gurion Univ., Israel;* [2]*Ilse Katz Inst. for Nanoscale Science and Technology, Israel*. In this work we present successful conversion of PbSe thin films to PbI_2 and subsequently to $MAPbI_3$ and explain the effect of the conversion parameters on the resulting perovskite films.

JT4A.20
Recognizing Network Activity Based on Hierarchical Clustering in Optical Networks, Anurag Prakash, Subrat Kar; *IIT Delhi, India*. We review the hierarchical clustering method to provide low-rank parametric embeddings of network activity patterns. Since optical parameters exhibit spatial and temporal locality, we create dendrogram clustering representation for such an embedding.

JT4A.21
SHG of Quasistatic Origin from Extreme Nano-scaled Heterodimers, Maya H. Shor[1,2], Avi Niv[1,2]; [1]*Ben-Gurion Univ. of the Negev, Israel;* [2]*Solar Energy and Environmental Physics, Ben-Gurion Univ. of the Negev, Israel*. We show experimentally that SHG from gold-silver nanodimers is qualitatively different from the prediction of known theory. Consequently, we propose a quasi-static interaction model that is relevant to extreme nano-sized objects at hand.

16:00–18:00
JT4A • Joint Poster Session
Networking Coffee Break with Exhibitors

JT4A.22
Investigation of 1-D Quasi-periodic Photonic Crystal Based Sensor for Detection of Hemoglobin, Bipin K. Singh[1], Vipul Rastogi[1], Praveen C. Pandey[2]; [1]*Department of Physics, Indian Inst. of Technology Roorkee, India;* [2]*Department of Physics, Indian Inst. of Technology (BHU) Varanasi, India*. We investigate the detection of different concentrations of Hemoglobin in 1-D quasi-periodic photonic crystals by infiltrating samples in defect layer. The significant shift in sensing dips is analyzed for different concentrations and parameters.

JT4A.23
Enhanced Optical Absorption in Thin Film Gaas Solar Cells with Double Al Nanoparticle System, Gurjit Singh, S S. Verma; *Sant longowal Inst. of engg. & tech, India*. The effect of single and double Al nanoparticle array on absorption of thin film GaAs solar cells is investigated by FDTD method. Plasmonic action of double array yields a maximum absorption enhancement factor of 1.74.

JT4A.24
Withdrawn

JT4A.25
Light-slice: Evaluation of Slice-ability-based RMCSA Algorithms in SDM-EON, Yue Wang, Vinod Vokkarane; *ECE Department, Univ. of Massachusetts Lowell, USA*. We investigate the potential of using SDM-EON to handle exhaustion of current network resources. We propose to utilize the combination of Slice-ability and Best-Fit RMCSA algorithm to decrease spectrum fragmentation due to contiguity constraint.

JT4A.26
Analysis of the Surface Recombination Influence on Organic Solar Cell J-V Curve, Ali R. Khalf[1], Jovana P. Gojanovic[1], Natasa A. Cirovic[1], Monirul Islam[2], Sandra Zivanovic[2], Petar Matavulj[1]; [1]*School of Electrical Engineering, Serbia;* [2]*Louisiana Tech Univ., USA*. We suggest the SML (Small Medium Large) surface recombination velocity approach to systemize the analysis of its influence on organic solar cell J-V curve. The ITO/PEDOT:PSS/P3HT:ICBA device was analyzed and its J-V curve was reproduced.

19:00–21:00 Evening Session: A Light in Digital Darkness; Optical Wireless Communications to Connect the Unconnected
Grand Peninsula EF

Grand Peninsula G

Integrated Photonics Research, Silicon and Nanophotonics

Sandpebble Room AB

Novel Optical Materials and Applications

07:30–17:30 Registration, *Grand Peninsula Foyer*

08:00–10:00
IW1A • Optomechanics and Nanophotonics
Presider: Lucia Caspani; Univ. of Strathclyde, UK

IW1A.1 • 08:00 Invited

Electromechanical Brillouin Scattering in Integrated Optomechanical Waveguides, Mo Li, Qiyu Liu, Huan Li; *Univ. of Washington, USA.* We demonstrate electromechanically excited Brillouin scattering in integrated, piezoelectric optomechanical waveguides. Acoustic phonons of 16 GHz are excited with transducers to scatter counter-propagating photons into the anti-Stokes sideband.

IW1A.2 • 08:30 Invited

Synthetic Magnetic Fields for Phonons and Photons through Optomechanical Interactions, Javier Del Pino[1], Ewold Verhagen[1], John P. Mathew[1], Robert Duggan[2], Andrea Alù[2,3]; [1]*FOM Inst. for Atomic and Molecular Physics (AMOLF), Netherlands;* [2]*Department of Electrical and Computer Engineering, The Univ. of Texas at Austin, USA;* [3]*Photonics Initiative, Advanced Science Research Center, USA.* We demonstrate synthetic magnetic fields for both light and sound via radiation pressure. We show how optomechanical interactions and suitable symmetry breaking enable non-reciprocal phononic transport and polarization control for photons on a chip.

IW1A.3 • 09:00

Towards Optical Manipulation on a Chip, John Canning; *Univ. of Technology Sydney, Australia.* Hoovering of optical water using an optical tractor on an SPR excited sputtered gold (Au) surface is demonstrated. Direct visual observation shows accumulation of water towards optical light passing through a gold layered metal film.

IW1A.4 • 09:15

Simulating Travelling Waves in Large 3D Whispering Gallery Mode Resonators Decorated with Plasmonic Nanoparticles, Lei Chen[1,2], Cheng Li[1], Yu-min Liu[2], Judith Su[1], Euan McLeod[1]; [1]*Univ. of Arizona, USA;* [2]*Beijing Univ. of Posts and Telecommunication, China.* Nanostructures can improve the performance of high-Q whispering gallery mode (WGM) resonators. Here we use a new simulation method capable of handling travelling waves in large 3D WGM systems to design a free space coupler.

IW1A.5 • 09:30

High Efficiency Metasurface Design Based on Deep Generative Models, Jiaqi Jiang[1], David Sell[2], Jonathan A. Fan[1]; [1]*Department of Electrical Engineering, Stanford Univ., USA;* [2]*Department of Applied Physics, Stanford Univ., USA.* We show that generative neural networks can train from images of periodic topology-optimized metasurfaces to produce high-efficiency, topologically complex devices, served as a new design tool to facilitate metasurface design.

IW1A.6 • 09:45

Multi-spectral SWIR PbS Quantum Dot Pixels Realized Using Transfer Printing, Nayyera Mahmoud[1,2], Willem Walravens[3,2], Robin Petit[4], Michiel Van Daele[4], Christophe Detavernier[4], Zeger Hens[3,2], Gunther Roelkens[1,2]; [1]*Information Technology, Photonics Research Group, Ghent Univ.-IMEC, Belgium;* [2]*Center for Nano and Biophotonics, Ghent Univ.-imec, Belgium;* [3]*Inorganic chemistry, Physics and Chemistry of Nanostructures (PCN) Group, Ghent Univ., Belgium;* [4]*Conformal Coating of Nanomaterials (CoCooN), Ghent Univ., Belgium.* We report on the transfer-printing-based integration of PbS QD pixels for multi-spectral imaging in the short-wave infrared. As a proof-of-concept, 8 multi-spectral pixels each consisting of 4 QD photodetectors operating in the SWIR are demonstrated.

08:00–10:00
NoW1B • Metamaterials and Metasurfaces 2
Presider: Mikhail Kats; Univ. of Wisconsin-Madison, USA

NoW1B.1 • 08:00 Tutorial

Emerging Material Platforms: Design Approaches for Nanophotonic Devices, Alexandra Boltasseva; *Purdue Univ., USA.* Emerging nanophotonic materials will be discussed including transparent conducting oxides, semimetals, 2-D and trans-dimensional materials such as graphene and MXenes. Topology optimization and machine learning for photonic design will be mentioned.

NoW1B.2 • 09:00 Invited

Integrated Dichroic Filtering for Octave-spanning Silicon Photonics, Emir Salih Magden; *Electrical and Electronics Engineering, Koc Univ., Turkey.* Broadband filters with sharp roll-offs are essential for flexibly handling optical signals in integrated photonic platforms. Here, recent developments on novel silicon photonic structures with octave-wide multiplexing capabilities will be reviewed.

NoW1B.3 • 09:30

Mid-infrared Hyperbolic Plasmons in Aligned Carbon Nanotube Metamaterials, Shangjie Yu[1], John A. Roberts[2], Po-Hsun Ho[3], Stefan Schoeche[4], Abram L. Falk[3], Jonathan A. Fan[1]; [1]*Electrical Engineering, Stanford Univ., USA;* [2]*Applied Physics, Stanford Univ., USA;* [3]*IBM T.J. Watson Research Center, USA;* [4]*J.A. Woollam Co., Inc., USA.* A tunable mid-infrared hyperbolic metamaterial is demonstrated based on aligned carbon nanotube films. The hyperbolic dispersion of the plasmon modes is clearly shown through the experimental and theoretical studies of various nanopatterned films.

NoW1B.4 • 09:45

Manipulating Fano Coupling in All-dielectric Meta-molecules, Linhan Lin, Xiaolei Peng, Yuebing Zheng; *Univ. of Texas at Austin, USA.* We demonstrate the all-optical assembly of dielectric Fano metamolecules in the opto-thermoelectric trap with both reconfigurability and tunability.

10:00–10:30 Networking Coffee Break with Exhibitors, *Grand Peninsula D*

Sandpebble Room CD

Optical Devices and Materials for Solar Energy and Solid-state Lighting

Grand Peninsula EF

Symposium

07:30–17:30 Registration, *Grand Peninsula Foyer*

08:30–10:00
PW1C • LED 3
Presider: Guillaume Lheureux; University of California Santa Barbara, USA

PW1C.1 • 08:30 Invited
White OLEDs for Displays and General Lighting, Junji Kid[1], Takayuki Chib[1]; *Frontier Center for Organic Materials Science, Yamagata Univ., Japan.* Today, a variety of OLED display products are on the market. White OLEDs are considered to be the general lighting of next generation. Recent progress in white OLEDs will be discussed.

PW1C.2 • 09:00 Invited
Gallium Nitride Nanostructures: From Multi-color Micro LEDs to High Efficiency Solar Fuel Production, Zetian Mi, Xianhe Liu, Srinivas Vanka, Baowen Zhou; *Univ. of Michigan, USA.* We demonstrate multi-color micro LEDs monolithically integrated on a single chip by using InGaN nanocrystals. These nanostructures can also enable one-step generation of chemical fuels directly from sunlight, water, and carbon dioxide.

PW1C.3 • 09:30
Low- and High-index Self-assembled Nanopillars as Light Outcoupling Elements in Organic Light Emitting Diodes, Yidenekachew J. Donie[1,2], Lorenz Graf Van Reventlow[1,3], Jan B. Preinfalk[1], Somayeh Moghadamzadeh[1], Jocelyn Van Leeuwen[1], Tsvetelina Merdzhanova[4], Karsten Bittkau[4], Ulrich W. Paetzold[1,2], Alexander Colsmann[1,3], Uli Lemmer[1,2], Guillaume Gomard[1,2]; *[1]Light Technology Inst., Karlsruhe Inst. of Technology (KIT), Germany; [2]Inst. of Microstructure Technology, KIT, Germany; [3]Material Research Center for Energy Systems, KIT, Germany; [4]IEK5 – Photovoltaik, Forschungszentrum, Germany.* We report on the development of phase-separated, disordered nanopillars that are integrated as corrugated or as planarized light scattering layers for the outcoupling of waveguide and substrate modes in organic light emitting diodes.

PW1C.4 • 09:45
Down-conversion Based Near-infrared Organic Light-emitting Diodes with High Efficiency and Low Roll-off, Woochan Lee, Jinouk Song, Jaehyeok Park, Seunghyup Yoo; *Korea Advanced Inst. of Science and Technology, South Korea.* Efficient near-infrared organic light-emitting diodes are proposed based on a down-conversion method using phosphors. The proposed devices exhibit external quantum efficiency as high as 14% at the wavelength longer than 700nm with low roll-off.

08:00–10:00
QtW1E • Quantum Technologies 1
Presider: David Hillerkuss; Huawei Technologies, Germany

QtW1E.1 • 08:00 Keynote
Miniaturization of Quantum Systems, Alexander Ling; *Centre for Quantum Technologies, Singapore.* Driven by an interest in deploying quantum communication systems, attention is being paid to the considerations of Size, Weight and Power. How small should we make the first systems for deployment? I will discuss this from a systems perspective, and provide some examples from my own work in putting entangled light sources onboard nanosatellites.

QtW1E.2 • 09:00 Tutorial
Quantum Key Distribution, Qiang Zhang; *Univ. of Science and Technology of China, China.* Quantum key distribution can provide information theoretical security which could not be achieved by classical communication. Imperfect device and channel loss are two main obstacles to its deployment. Here, in this talk, I shall brief review the experimental progress in solving the challenges, especially focusing on the new experiment in quantum repeater and twin field QKD.

QtW1E • 09:40
Panel Discussion

10:00–10:30 Networking Coffee Break with Exhibitors, *Grand Peninsula D*

Grand Peninsula G

Integrated Photonics Research, Silicon and Nanophotonics

10:30–13:00
IW2A • Photonic Computing and Emerging Technologies

Presiders: Luca Dal Negro; Boston Univ., USA and Anna Tauke-Pedretti; Sandia National Laboratories Albuquerque, USA

IW2A.1 • 10:30 Invited

Accelerating the Development of Emerging Photonics Technologies through Microsystem Applications, Gordon A. Keeler; *DARPA, USA*. Photonics investments at DARPA/MTO seek revolutionary microsystem solutions to communications, sensing, and metrology challenges through innovation in materials, components, and integration. This talk highlights results from recent program efforts.

IW2A.2 • 11:00 Invited

Machine-learning-assisted Topology Optimization for Refractory Photonics, Alexandra Boltasseva, Zhaxylyk Kudyshev, Alexander Kildishev, Vladimir Shalaev; *Purdue Univ., USA*. We expand metasurface design methodology to a global optimization space by advancing topology optimization via artificial-intelligence-assisted algorithms and design efficient refractory photonics for thermophotovoltaics.

IW2A.3 • 11:30 Invited

InP Photonic Circuit for Deep Neural Networks, Bin Shi, Nicola Calabretta, Ripalta Stabile; *Technische Universiteit Eindhoven, Netherlands*. We perform weight addition of four 10 Gbit/s channels employing a photonic integrated indium phosphide chip based on semiconductor optical amplifier technology. We demonstrate classification of classes of Iris flowers with an accuracy of 91.6%.

IW2A.4 • 12:00

Ultra-high Resolution and Broadband Chip-scale Speckle Enhanced Fourier-transform Spectrometer, Uttam Paudel; *The Aerospace Corporation, USA*. We report on a chip-scale silicon-on-insulator (SOI) hybrid optical spectrometer that combines speckles and discrete Fourier transform technology to achieve an ultra-high resolution spectral resolution (<150 MHz) across 10 nm bandwidth.

Sandpebble Room AB

Novel Optical Materials and Applications

10:30–12:30
NoW2B • Two-dimensional Materials

Presider: Woei Ming Lee; Australian National Univ., Australia

NoW2B.1 • 10:30 Invited

Two-dimensional Semiconductors for Atomically-thin Opto-electronics, Deep Jariwala; *Univ. of Pennsylvania, USA*. I will present recent computational and experimental advances on enhancing light-matter interactions in two-dimensional materials and their heterostructures for making opto-electronic devices and present strategies for exploting thier tunability

NoW2B.2 • 11:00 Invited

Second Harmonic Generation and Electroluminescence in 2D Semiconductors, Thomas Mueller, Lukas Mennel, Matthias Paur, Aday Molina-Mendoza; *Vienna Univ. of Technology, Austria*. Optical second harmonic generation in strained two-dimensional semiconductors and electroluminescence from multi-particle exciton complexes in these materials will be discussed.

NoW2B.3 • 11:30 Invited

Ge2Sb2Te5 Integrated Silicon Photonics, Arka Majumdar[1], Jiajiu Zheng[1], Peipeng Xu[2], Jonathan Doylend[3]; *[1]Univ. of Washington, USA; [2]Ningbo Univ., China; [3]Intel, USA*. Based on the non-volatile GST-on-silicon photonics platform, we demonstrate compact (~30 μm), low-loss (~1dB), and broadband (over 30 nm with crosstalk < −10 dB) 1 × 2 and 2 × 2 photonic directional coupler switches.

NoW2B.4 • 12:00

Silicon Microring Resonator Integrated $MoTe_2$ Photodetector, Rishi Maiti, Chandraman Patil, Rohit Hemnani, Volker J. Sorger; *George Washington Univ., USA*. Here we demonstrate a TMD-based photodetector heterogeneously integrated into a silicon photonics microcavity. The photodetector shows high photoresponsivity (~0.1 A/W) with a low dark current at 1550 nm.

Sandpebble Room CD

Optical Devices and Materials for Solar Energy and Solid-state Lighting

10:30–12:30
PW2C • Modeling, Bifacial, Solar Resource, BIPV

Presider: Klaus Jaeger; Helmholtz-Zentrum Berlin, Germany

PW2C.1 • 10:30 Invited

Ray Tracing of Complete Solar Cell Modules, Malte Ruben Vogt[1], Robert Witteck[1], Timo Gewohn[1], Henning Schulte-Huxel[1], Carsten Schinke[2,1], Karsten Bothe[1], Rolf Brendel[1,2]; *[1]Institue for Solar Energy Research in Hamelin(ISFH), Germany; [2]Leibniz Universität Hannover, Germany*. We use the Daidalos-Cloud module ray tracer to quantify optical losses in a PERC+ cell module in three different spectrally resolved irradiance conditions. In mean annual irradiation conditions 8.6 mA/cm^2 are lost, in contrast to 7.6 mA/cm^2 in STC.

PW2C.2 • 11:00

Comparison of FMM, FEM and FDTD for Absorption Modeling of Nanostructured Solar Cells and Photodetectors, Nicklas Anttu[1], Henrik Mäntynen[1], Toufik Sadi[1], Antti Matikainen[1], Jari Turunen[2], Harri Lipsanen[1]; *[1]Aalto Yliopisto, Finland; [2]Univ. of Eastern Finland, Finland*. We compare FMM, FEM and FDTD for absorption modeling. We discuss optimum choice of modeling method for varying nanostructures, enabling solar cell and photodetector design optimization that would be impossible with a suboptimal method choice.

PW2C.3 • 11:15

Module to Array Design for Bifacial Photovoltaics, Peter Bermel, Yubo Sun; *Purdue Univ., USA*. Here, I discuss the potential for designing bifacial photovoltaic modules to balance electrical and optical losses using interdigitated back contacts, and then extend this concept to the bifacial panel arrays.

PW2C.4 • 11:30

Experimental Study of the Spectral and Angular Solar Irradiance, Shweta Pal[1], Rebecca Saive[1,2]; *[1]Univ. of Twente, Netherlands; [2]California Inst. of Technology, USA*. We propose an experimental procedure to measure spectro-angular solar irradiance for optimization of bifacial solar power plants. Our data shows strong spectro-angular irradiance variations dependent on location, surroundings and cloud coverage.

PW2C.5 • 11:45

Performance of Solar Cells under Spectro-angular Solar Irradiance, Shweta Pal, Roland Adelerhof, Rebecca Saive; *Universiteit Twente, Netherlands*. Performance of solar cells is usually determined under AM 1.5 conditions rarely existing at power plant sites. We present the dependence of solar cell output on the spectro-angular solar irradiance.

PW2C.6 • 12:00

Planar Light Guide Concentrators for Building Integrated Photovoltaics, Eryn A. Fennig, Greg Schmidt, Duncan T. Moore; *Univ. of Rochester, USA*. A light guide alternative to Fresnel lenses for building integrated photovoltaic systems is discussed. The design studies resulting in the final manufactured prototypes are reviewed and prototype testing results are reported.

Bayside Room

Novel Optical Materials and Applications

10:30–12:00
NoW2D • Glass Materials and Applications
Presider: Brandon Shaw; US Naval Research Laboratory, USA

NoW2D.1 • 10:30 Invited
Designing Dispersion in Infrared-transparent Glasses, J. David Musgraves; *Rochester Precision Optics, USA.* This presentation will discuss methods for intelligent design of glasses with desired dispersion profiles for use in infrared optical systems.

NoW2D.2 • 11:00 Invited
Chalcogenide Glasses and Fibers for Infrared Applications, Catherine Boussard-Pledel, Shou Cui, Claire Fourmentin, David Le Coq, Bruno Bureau; *Universite de Rennes I, Rennes, France.* Optical sensors based on chalcogenide glass fibers transparent in the mid infrared (MIR) spectral range from 2 to 16 µm (4000 to 625 cm-1) have been developed in order to analyse biological and chemical samples.

NoW2D.3 • 11:30
Fabrication of Broadband Anti-reflective Surface on Fused Silica from Visible to SWIR Spectral Band, Rajendra Joshi, Greg J. Gbur, Menelaos K. Poutous; *Univ of North Carolina at Charlotte, USA.* A reactive-ion etching process, can be optimized to fabricate an angle of incidence independent, anti-reflective, random-structured novel material; and can be tailored to shift the nearly perfect transmissive waveband through it from Visible to SWIR.

NoW2D.4 • 11:45
Ultra-sharp Single-crystalline Nano Probes for Near-field Applications, Duc Huy Nguyen[1], Yu-Wei Liu[1], Jung-Tse Huang[2], Jian-Zhi Huang[2], Chien-Chih Lai[1,2]; [1]*Physics, National Dong Hwa Univ., Taiwan;* [2]*Opto-Electronic Engineering, National Dong Hwa Univ., Taiwan.* We present how an effective fiber drawing process followed by low-cost and controllable etching enables atomically smooth YAG crystal fiber, producing high-crystallinity, defect-free, and ultra-sharp tapered probes with apexes down to 1.5 nm

Grand Peninsula EF

Symposium

10:30–12:30
QtW2E • Quantum Technologies Part 2
Presider: David Hillerkuss; Huawei Technologies, Germany

QtW2E.1 • 10:30 Invited
Optimized Quantum Photonics, Jelena Vuckovic; *Stanford Univ., USA.* We present our recent progress on developing high quality qubits based on color centers in diamond and silicon carbide, combined with powerful optimized photonic structures providing efficient optical interfaces and interconnects.

QtW2E.2 • 10:50 Invited
Ultra-low Loss Waveguide Platforms for Integration of Quantum Circuits, Daniel J. Blumenthal; *Univ. of California Santa Barbara, USA.* In this talk we review work in ultra-low loss silicon nitride and related waveguide technology and the prospects and challenges to integrate sources, detectors, switches and other functions that can operate in the quantum regime.

QtW2E.3 • 11:10 Invited
Commercialization of QKD, Ilmran Khan[1], Christoph Marquardt[2]; *InfiniQuant, Germany; Max Planck Institute for the Science of Light, Germany.* InfiniQuant is a startup project at the Max Planck Institute for the Science of Light, Erlangen, Germany. In this presentation we will share our experience in commercializing a second generation quantum technology: quantum key distribution.

QtW2E.4 • 11:30 Invited
SKR Improvement for an Entanglement Assisted BB84 System Using Adaptive Optics on an FSO Link, John Gariano, Ivan B. Djordjevic; *Univ. of Arizona, USA.* Implementing QKD systems over FSO channels can suffer due to time-varying channel degradations. To reduce the channel degradations use of adaptive optics to compensate for atmospheric turbulence is studied in a 30 km maritime channel.

QtW2E.5 • 11:50 Invited
High-dimensional Quantum Communication in Optical Fibres Using Spatial States, Leif Katsuo Oxenløwe; *Technical Univ. of Denmark, Denmark.* This talk will describe our recent work using various degrees of freedom of light to establish high-dimensional quantum communication links, such as orbital angular momentum, spatial position in multi-core fiber, and differential phase and time.

QtW2E • 12:10
Panel Discussion

Grand Peninsula G

Integrated Photonics Research, Silicon and Nanophotonics

IW2A • Photonic Computing and Emerging Technologies—Continued

IW2A.5 • 12:15
Quantum Coherence Enhanced Graphene Spaser, Lakshitha Kumarapperuma, Malin Premaratne; *Monash Univ., Australia*. We demonstrate the possibility of significantly enhancing the output characteristics of a plasmonic nano-laser (spaser) made of a graphene plasmonic resonator and 3-level gain chromophores by using a coherent electric field to control the dynamics.

IW2A.6 • 12:30 Invited
Materials Aspects of Disordered Self-assembled Structures, Cefe Lopez; *Consejo Superior de Inv Cientificas, Spain*. Self-assemmbled structures are intrinsically disordered. Therefore it no surprise that supressing disorder to improve performance will encounter many difficulties. Where surprise lurks is in the difficulty to produce disorder entirely averting order.

Sandpebble Room AB

Novel Optical Materials and Applications

NoW2B • Two-dimensional Materials—Continued

NoW2B.5 • 12:15
Optical Characteristics of Hybrid-nanostructures Using 2D Semiconductors and Applications to Photo-triggered Field-effect-transistors and Sensitive Photodetectors, Jinsoo Joo[1], Cheol-Joon Park[1], Hyeon Jung Park[1], Taeho Noh[1], Kwang-Sup Lee[2], Jeongyong Kim[3]; [1]*Korea Univ., South Korea;* [2]*Hannam Univ., South Korea;* [3]*Sungkyunkwan Univ., South Korea*. Optical properties for 2D MoS_2 hybridized with organic semiconductors or perovskite $CsPbBr_3$ are studied. Photo-triggered MoS_2/rubrene transistors are controlled by gate-bias. Photoresponsivity of MoS_2 device is enhanced by hybridization with $CsPbBr_3$.

Sandpebble Room CD

Optical Devices and Materials for Solar Energy and Solid-state Lighting

PW2C • Modeling, Bifacial, Solar Resource, BIPV—Continued

PW2C.7 • 12:15
Enhanced Multi-layer Lens-let Array for Extreme Angle Solar Collection, Rakan E. Alsaigh[1], Ralf Bauer[2], Martin P. Lavery[1]; [1]*Univ. of Glasgow, UK;* [2]*Univ. of Strathclyde, UK*. Deployment of solar panels on the side of buildings leads to very-low collection-efficiency. We present an enhanced multi-layer lens-let array that increases the daily generated power at near vertical deployment by a factor of 4.783.

12:30–14:00 Lunch *(on own)*

12:30–14:00 Workshop: Hands-on Introduction to Data Analytics and Machine Learning in Optical Networks, *Bayside Room*

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Bayside Room	Grand Peninsula EF
Novel Optical Materials and Applications	Symposium

12:30–14:00 Lunch *(on own)*

12:30–14:00 Workshop: Hands-on Introduction to Data Analytics and Machine Learning in Optical Networks, *Bayside Room*

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Grand Peninsula G

Integrated Photonics Research, Silicon and Nanophotonics

14:00–16:00
IW3A • III-V Integration
Presider: Masahiro Nada; NTT, Japan

IW3A.1 • 14:00 Invited
A Heterogeneously-integrated III-V/Silicon Interferometric Widely Tunable Laser, Guan-Lin Su[1], Meer Nazmus Sakib[2], John Heck[2], Haisheng Rong[2], Ming C. Wu[1]; [1]*Univ. of California Berkeley, USA;* [2]*Intel Corporation, USA.* A heterogeneously-integrated III-V/silicon three-cavity-arm interferometric tunable laser which tunes continuously across 30 nm in the O-band with high side-mode suppression ratios (> 40 dB) and a peak wall-plug efficiency of 16.7% is reported.

IW3A.2 • 14:30 Invited
Integrated AlGaAs Devices for Non-linear Applications, Marc Sorel[1], Stuart May[1], John McPhillimy[2], Charalambos Klitis[1], Benoit Guilhabert[2], Michael Kues[1], Martin Dawson[2], Michael Strain[2], Matteo Clerici[1]; [1]*Univ. of Glasgow, UK;* [2]*Univ. of Strathclyde, UK.* Heterogeneous integration of AlGaAs-on-insulator has great potential for nonlinear optics. This talk will explore chip-scale bonding and transfer printing techniques for integrated photonic chips for second- and third-order non-linear applications.

IW3A.3 • 15:00 Invited
III-nitride Nanocrystal Laser Diodes and Integrated Photonics, Zetian Mi[1], Xianhe Liu[1], Yi Sun[1], David Laleyan[1], Mohammad Soltani[2]; [1]*Univ. of Michigan, USA;* [2]*Raytheon BBN Technologies, USA.* We demonstrate high performance III-nitride nanocrystal surface emitting laser diodes operating in the visible and UV spectra, as well as high Q microring resonators using single crystal aluminum nitride in the UV, visible and near-infrared.

IW3A.4 • 15:30
III-V Compound Avalanche Photodiodes on Silicon, Yuan Yuan[1], Daehwan Jung[2], Keye Sun[1], Jiyuan Zheng[1], Andrew Jones[1], John Bowers[2], Joe C. Campbell[1]; [1]*Univ. of Virginia, USA;* [2]*Univ. of California, USA.* We demonstrate the first III-V avalanche photodiodes grown directly on silicon by heteroepitaxy. The InGaAs/InAlAs APD exhibits gain > 20, low dark current, quantum efficiency > 40%, and low excess noise (k value ~0.2).

IW3A.5 • 15:45
High-Responsivity Photodiodes Heterogeneously Integrated on Silicon Nitride Waveguides, Qianhuan Yu[1], Nan Ye[1], Junyi Gao[1], Keye Sun[1], Linli Xie[1], Kartik Srinivasan[2], Michael Zervas[3], Gabriele Navickaite[3], Michael Geiselmann[3], Andreas Beling[1]; [1]*Univ. of Virginia, USA;* [2]*National Inst. of Standards and Technology, USA;* [3]*LIGENTEC, Switzerland.* We demonstrate photodiodes on Si_3N_4 waveguides with record-high external (internal) responsivities of 0.68A/W (0.8A/W) and 0.24A/W (0.6A/W) at 1550nm and 1064nm. Balanced photodiodes have low dark current of 10nA, 7GHz bandwidth, and over 40 dB CMRR.

Sandpebble Room AB

Novel Optical Materials and Applications

14:00–15:45
NoW3B • Phase-change and Metamaterials
Presider: Arka Majumdar; Univ. of Washington, USA

NoW3B.1 • 14:00 Invited
Phase Changing Correlated Oxides for Photonics, Shriram Ramanathan; *Purdue Univ., USA.* We will discuss insulator-metal transitions in correlated oxides, e.g VO2, NbO2 and perovskites that are of interest to emerging photonic devices.

NoW3B.2 • 14:30 Invited
Reconfigurable Infrared Flat Optics with Novel Phase Change Materials, Vladimir Liberman[1], Yifei Zhang[2], Mikhail Shalaginov[2], Carlos Rios[2], Paul Robinson[1], Christopher Roberts[1], Kevin Tibbetts[1], Myungkoo Kang[3], Kathleen Richardson[3], Juejun Hu[2], Jeffrey Chou[1]; [1]*Lincoln Laboratory, Massachusetts Inst. of Technology, USA;* [2]*Massachusetts Inst. of Technology, USA;* [3]*Univ. of Central Florida, USA.* We report on pixelated, switchable devices based on novel chalcogenide phase change materials, Ge-Sb-Se-Te, transparent from 1.5 to >15 microns, with appplications in integrated photonics and hyperspectral imaging, enabled by reconfigurable elements.

NoW3B.3 • 15:00
Decoupling of Temperature and Thermal Radiation, Alireza Shahsafi[1], Patrick Roney[1], You Zhou[2], Zhen Zhang[3], Chengzi Huang[3], Yuzhe Xiao[1], Chenghao Wan[1], Raymond Wambold[1], Jad Salman[1], Zhaoning Yu[1], Jiarui Li[4], Jerzy Sadowski[5], Riccardo Comin[4], Shriram Ramanathan[3], Mikhail A. Kats[1]; [1]*Univ. of Wisconsin-Madison, USA;* [2]*Harvard Univ., USA;* [3]*Purdue Univ., USA;* [4]*Massachusetts Inst. of Technology, USA;* [5]*Brookhaven National Laboratory, USA.* We show that the well-known relationship between temperature and thermal radiation can be decoupled in a fully passive and reversible way using the phase transition of samarium nickelate.

NoW3B.4 • 15:15
Switchable Vanadium Dioxide Kerker Metasurface, David Woolf[1], Koushik Ramadoss[2], Justin Brown[1], Shriram Ramanathan[2], Joel Hensley[1]; [1]*Physical Sciences, Inc., USA;* [2]*School of Materials Engineering, Purdue Univ., USA.* We developed a switchable filter by incorporating vanadium dioxide (VO_2) into a metasurface that obeys the Kerker condition. By varying the temperature of the VO_2, the filter switches between broadly transparent and notch filter states.

NoW3B.5 • 15:30
Liquid Crystal Active Metasurface for Ultra-selective Wavelength Switching, Francisco Algorri[1], Dimitris Zografopoulos[2], Antonio Ferraro[2], Virginia Urruchi[1], Romeo Beccherelli[2], Jose Manuel Sanchez-Pena[1]; [1]*UC3M, Spain;* [2]*Consiglio Nazionale delle Ricerche, Istituto per la Microelettronica e Microsistemi, Italy.* A novel wavelength selective switch is proposed and demonstrated. This new configuration avoid the use of grating and lenses, as a result, a very compact and lightweight ultra-selective wavelength switch can be obtained.

16:00–16:30 Networking Coffee Break with Exhibitors, *Grand Peninsula D*

16:30–18:00 Postdeadline Paper Session, *Grand Peninsula EF*

18:30–20:30 Congress Banquet, *Domenico Winery, San Carlos, CA*

Sandpebble Room CD

Optical Devices and Materials for Solar Energy and Solid-state Lighting

14:00–16:00
PW3C • Materials and Techniques
Presider: Rebecca Saive; Universiteit Twente, Netherlands

PW3C.1 • 14:00 Invited
Broadband-transparent Conducting Oxides for Efficient Solar Cells: Case of Zirconium-doped Indium Oxide, Monica Morales-Masis[1], Laura Schmengler[1], Yury Smirnov[1], Riemer Kuik[1], Erkan Aydin[2], Stefaan De Wolf[2]; *[1]Univ. of Twente, Netherlands; [2]King Abdullah Univ. of Science and Technology (KAUST), Saudi Arabia*. Broadband-transparent conducting oxides are key to avoid parasitic absorption in solar cells. We show that Zr-doped In_2O_3 grown by both sputtering and pulsed laser deposition tackle these requirements allowing improved efficiencies in photovoltaics.

PW3C.2 • 14:30 Invited
Singlet Fission: Current Challenges and Spectroscopy, Murad Tayebjee[1], Samuel Sanders[2], Elango Kumarasamy[3], Amir Asadpoordarvish[1], Andrew Pun[1], Daniel Niesner[3], Matthew Sfeir[4], Luis Campos[3], Dane McCamey[1]; *[1]UNSW Sydney, Australia; [2]Harvard Univ., USA; [3]Columbia Univ., USA; [4]City Univ. of New York, USA*. Singlet fission, an exciton multiplication process, can augment existing solar cell technologies. We explore the current challenges facing the research field and how optical and magnetic resonance spectroscopies can help identify promising materials.

PW3C.3 • 15:00
Superhydrophobic Self-cleaning Cover Sheets for Photovoltaic Modules, Aiman Roslizar, Stephan Dottermusch, Hendrik Hölscher, Ulrich W. Paetzold, Bryce S. Richards; *Karlsruhe Inst. of Technology, Germany*. Multifunctional top-covers for photovoltaic modules were fabricated, via hot-embossing of both random and periodic microtextures into superhydrophobic textured fluoropolymers, demonstrating both self-cleaning and anti-reflective properties.

PW3C.4 • 15:15
Angle-dependent Pump-probe Differential Transient Absorption Spectroscopy as a Novel Technique to Examine Surface Properties of Semiconductor Nanostructures, Vikas Pendem, Pratim Saha, Tarni Aggarwal, Shonal Chouksey, Ankit Udai, Swaroop Ganguly, Dipankar Saha; *Indian Inst. of Technology Bombay, India*. We describe a non-destructive optical technique to probe semiconductor surfaces using ultrafast pump-probe transient absorption spectroscopy (TAS). Angle-dependent TAS decouples surface and bulk differential absorptions to measure surface dynamics.

PW3C.5 • 15:30
Fabrication of Nearly-hyperuniform Disordered Substrates for Photonic Applications, Alexander N. Sprafke[1], Peter Piechulla[1], Ralf B. Wehrspohn[1,2], Stefan Nanz[3], Aimi Abass[3], Carsten Rockstuhl[3]; *[1]Inst. of Physics, Martin Luther Univ. Halle-Wittenberg, Germany; [2]Fraunhofer Inst. IMWS, Germany; [3]Inst. of Theoretical Solid State Physics, Karlsruhe Inst. of Technology, Germany*. A method is presented to fabricate large-scale 2D colloidal patterns of correlated disorder for photonic applications. Easy-to-access parameters allow to tune the structure factor and tailor light scattering of the disordered structures on demand.

PW3C.6 • 15:45
High-efficiency, High-temperature, Air-stable Cu, Mn and Fe Oxides Nanoparticles-pigmented Silicone Solar Selective Coatings via Hot Spray-coating Method, Can Xu, Eldred Lee, Xiaoxin Wang, Jifeng Liu; *Dartmouth College, USA*. We report Cu, Mn and Fe oxides nanoparticles-pigmented silicone solar selective coatings on Inconel substrates via hot spray-coating. It owns high-temperature resistance and improved thermal efficiency for future concentrating solar power systems.

Grand Peninsula EF

Symposium

14:00–16:00
QtW3E • Quantum Technologies 3
Presider: David Hillerkuss; Huawei Technologies, Germany

QtW3E.1 • 14:00 Invited
QKD and its Application in Future Telecoms Networks, Andrew Lord; *BT Innovate and Design, UK*. Abstract not available.

QtW3E.2 • 14:20 Invited
Challenges in Parallel Operation of Quantum Key Distribution and Data Transmission, Tobias A. Eriksson[1,2], Takuya Hirano[3], Georg Rademacher[1], Benjamin J. Puttnam[1], Ruben Luis[1], Mikio Fujiwara[1], Ryo Namiki[3], Yoshinari Awaji[1], Masahiro Takeoka[1], Naoya Wada[1], Masahide Sasaki[1]; *[1]National Inst of Information & Comm Tech, Japan; [2]Department of Applied Physics, Royal Inst. of Technology (KTH), Sweden; [3]Department of Physics, Gakushuin Univ., Japan*. We discuss impairments and design of fiber links supporting co-propagation of quantum key distribution and classical signals.

QtW3E.3 • 14:40 Invited
A Long-term Secure Data Transmission and Storage Network Based on Quantum Key Distribution, Akihisa Tomita; *Hokkaido Univ., Japan*. Integration of secret sharing and Quantum key distribution is proposed to provide network functions of transmission, storage, and processing; guarantees long term security to be a infrastructures supporting high-quality, efficient and safe society.

QtW3E.4 • 15:00 Invited
Pushing Boundaries of Quantum Secured Networking: Towards a Fully Dynamic Quantum Secured Optical Network, Reza Nejabati; *Univ. of Bristol, UK*. Abstract not available.

QtW3E.5 • 15:20 Invited
The Madrid Quantum Network: A Quantum-classical Integrated Infrastructure, Vicente Martin[1], Alejandro Aguado[1], Pedro Salas[1], Angel Luis Sans[1], Juan Pedro Brito[1], Diego Rafael López[2], Victor López[2], Antonio Pastor[2], Jesus Folgueira[2], Hans Hermann Brunner[3], Stefano Bettelli[3], Chi-Hang Fred Fung[3], David Hillerkuss[3], Lucian Cornelius Comandar[3], Dawei Wang[3], Andreas Poppe[3], Momtchil Peev[3]; *[1]Univ. Politecnica de Madrid, Spain; [2]Telefónica Investigación y Desarrollo, Spain; [3]Huawei Technologies Duesseldorf GmbH, Germany*. We report on the Madrid Quantum Network, designed to demonstrate that a telecommunications network can also host quantum communications in a unified, logical and physical infrastructure.

QtW3E • 15:40
Panel Discussion

16:00–16:30 Networking Coffee Break with Exhibitors, *Grand Peninsula D*

16:30–18:00 Postdeadline Paper Session, *Grand Peninsula EF*

18:30–20:30 Congress Banquet, *Domenico Winery, San Carlos, CA*

Grand Peninsula G	Sandpebble Room AB	Sandpebble Room CD
Integrated Photonics Research, Silicon and Nanophotonics	Novel Optical Materials and Applications	Optical Devices and Materials for Solar Energy and Solid-state Lighting

07:30–14:00 Registration, *Grand Peninsula Foyer*

08:00–10:00
ITh1A • Silicon Photonic Integrated Circuits (Si PICs)
Presider: Benjamin Yang; Georgia Tech Research Inst., USA

ITh1A.1 • 08:00 Invited
Laser Integration Technologies for Silicon Photonics, Jonathan Klamkin, Lei Wang, Bei Shi, Simone Tommaso Suran Brunelli, Hongwei Zhao, Bowen Song; *Univ. of California Santa Barbara, USA.* Heteroepitaxy of III-V materials on silicon for laser integration is reported. State-of-the-art templates and indium arsenide quantum dots are realized by metalorganic chemical vapor deposition, demonstrating potential for large-scale integration.

ITh1A.2 • 08:30 Invited
Classical and Quantum Integrated Silicon Photonics, Lorenzo Pavesi; *Universita degli Studi di Trento, Italy.* Silicon Photonics is a platform to integrate classical as well as quantum photonics. Here we discuss an optical switches for telecom, a compact biosensor for screening toxins, a quantum random number generator and a source of heralded single photons.

ITh1A.3 • 09:00 Invited
Overview of Silicon Photonics Components for Commercial DWDM Applications, M. Ashkan Seyedi, Jared Hulme, Peng Sun, Thomas Van Vaerenbergh, Xiaoge Zheng, Geza Kurczveil, Zhihong Huang, Di Liang, Marco Fiorentino, Ray Beausoleil; *Hewlett Packard Enterprise, USA.* This paper presents an overview of the work done by Hewlett Packard Labs on high bandwidth, scalable and cost-effective interconnect solution. We outline the proposed link architecture, review components and discuss co-packaged form factors.

ITh1A.4 • 09:30
Wideband 1×8 Silicon Optical Demultiplexer Based on Point-symmetric Cascade Mach-Zehnder Interferometers, Seok-Hwan Jeong; *PETRA, Japan.* We propose and demonstrate wideband operating 1×8 (de)multiplexer by adopting point-symmetric Mach-Zehnder optical couplers in the multistage delayed interferometers over >100-nm range in O-band regime.

ITh1A.5 • 09:45
Refractive Index Engineering Inside Silicon by Infrared Laser Pulses of Different Pulse Durations in the Picosecond Regime, Andong Wang, Amlan Das, Olivier Uteza, David Grojo; *CNRS, France.* We report on the refractive index engineering inside silicon bulk by picosecond infrared lasers. Different responses are observed depending on the pulse durations. This represents a critical step for prototyping 3D silicon photonics microdevices.

08:00–10:00
NoTh1B • Plasmonics and Metamaterials
Presider: Jonathan Fan; Stanford Univ., USA

NoTh1B.1 • 08:00 Invited
Active Control of Plasmonic Enhanced Light Emission, Yu-Jung Lu[1,2]; [1]*Academia Sinica, Taiwan;* [2]*Physics, National Taiwan Univ., Taiwan.* We report modulation of the spontaneous emission and lasing in a TiN/SiO_2/Ag gated plasmonic heterostructures that modifying the local density of optical states in the vicinity of the quantum dots.

NoTh1B.2 • 08:30 Invited
Exceptional Photonics, Liang Feng; *Univ. of Pennsylvania, USA.* I will present our work on exceptional nanophotonics, creating and utilizing "quantum" exceptional points on-a-chip to enable new photonics functionality including an orbital angular momentum microlaser, a low-power optical switch, microscopic thermal sensing, etc.

NoTh1B.3 • 09:00 Invited
Plasmonic Nano-electro-mechanical Systems: From Local Motion Sensing to Powering Mechanical Oscillation, Vladimir Aksyuk[1], Brian Roxworthy[2]; [1]*Physical Measurement Laboratory, National Institute of Standards and Technology, USA;* [2]*US Naval Research Laboratory, USA.* We fabricate localized plasmon resonators with nanometer scale mechanically-tunable gaps between noble metals. Integrated into plasmomechanical systems, they locally couple static and dynamic optical, electrical, mechanical, and thermal responses.

NoTh1B.4 • 09:30
Chiral Properties of Light in Material Systems, J. Enrique Vazquez-Lozano, Alejandro Martínez; *Universitat Politècnica de València, Spain.* Motivated by recent theoretical results concerning dynamical properties of light in dispersive media, we present a complete derivation for the optical chirality accounting also for losses; thus being applicable to metamaterials and plasmonic systems.

NoTh1B.5 • 09:45
Spectral Self-tuning of the Ultrashort Pulse During Propagation in Al:Zno/Zno Metamaterial at the Epsilon Near Zero Spectral Point, Priscilla Kelly, Lyuba Kuznetsova; *San Diego State Univ., USA.* Numerical FDTD study shows that initial 100 fs Gaussian pulse with central frequency beyond epsilon-near-zero point experiences spectral self-tuning during propagation in Al:ZnO/ZnO. The resulting spectral shift depends strongly on optical loss.

08:30–10:00
PTh1C • III-V PV and Phosphors
Presider: Peter Bermel; Purdue Univ., USA

PTh1C.1 • 08:30 Invited
Understanding the Performance of Mechanically Stacked Tandem Solar Cells with Different Interconnection Architectures, Emily Warren[1], William McMahon[1], Pauls Stradins[1], Kaitlyn VanSant[1], Michael Rienaecker[2], Robby Peibst[2], Adele Tamboli[1]; [1]*NREL, USA;* [2]*ISFH, Germany.* Three-terminal (3T), mechanically stacked tandem solar cells based on IBC Si subcells provide a compelling platform for tandem cell integration. This talk will discuss the design, operating principle, and interconnection options for 3T tandems.

PTh1C.2 • 09:00 Invited
Thermophotonic Energy Transfer in Optically Coupled III-V Light Emitting Diodes and Photovoltaic Cells, Vilgaile Dagyte, Ivan Radevici, Toufik Sadi, Jani Oksanen; *Aalto Univ., Finland.* We present progress towards high power electroluminescent cooling - the net cooling of an LED where photons carry out more energy than provided by electrical bias. For this, we use optically coupled III-V LED and PD structures.

PTh1C.3 • 09:30
Nanophotonics Tunes Rare-earth Nanophosphor Emission, Elena Cabello-Olmo, Dongling Geng, Gabriel S. Lozano-Barbero, Hernán Míguez; *Instituto de Ciencia de Materiales de Sevilla, Consejo Superior de Investigaciones Científicas, Spain.* Current lighting technology is built on phosphors. However, their large crystal size impedes the tuning, optimization, or manipulation of emitted light. Herein we show this can be achieved combining nanophosphors and nanophotonic architectures

PTh1C.4 • 09:45
Optical Thermometer Based on Thermal Shift of Charge-transfer-band Luminescence in $Gd_2O_2S:Eu^{3+}$ Phosphors, Ngei Katumo, Guojun Gao, Felix Laufer, Bryce S. Richards, Ian A. Howard; *Karlsruhe Inst. of Technology, Germany.* The thermal shift of charge-transfer-band luminescence from $Gd_2O_2S:Eu^{3+}$ phosphors is used to realize a smartphone-based optical thermometer. Use of the smartphone camera is possible via the long-lived luminescence with a high quantum yield.

10:00–10:30 Networking Coffee Break with Exhibitors, *Grand Peninsula D*

Grand Peninsula E

Photonic Networks and Devices

Grand Peninsula F

Signal Processing in Photonics Communications

07:30–14:00 Registration, *Grand Peninsula Foyer*

08:00–10:00
NeTh1D • Network Telemetry, Data Analytics and Visualization
Presider: Nihel Benzaoui; Nokia Corporation, France

NeTh1D.1 • 08:00 Invited
Analytics-driven Network Management, Mohit Chamania[1], Xiaomin Chen[2]; [1]*ADVA Optical Networking, Germany;* [2]*Nantong Univ., China*. This paper presents a network management architecture that can effectively integrate inputs from various analytics frameworks to manage network and service lifecycles, along with some open research challenges for autonomous network management.

NeTh1D.2 • 08:30 Invited
Physical-layer Visualization and Analysis toward Efficient Network Operation by Deep Neural Networks, Takahito Tanimura, Yuichi Akiyama, Takeshi Hoshida; *Fujitsu Limited, Japan*. We discuss digital coherent receiver-based physical layer information visualization, which utilizes machine learning techniques such as neural networks to provide useful information to network operators for the better operational decision.

NeTh1D.3 • 09:00 Invited
Data Analytics for Re-dimensioning of SDM Links in Spectrally-spatially Flexible Optical Networks, Krzysztof Walkowiak[1], Roza Goscien[1], Adam Wlodarczyk[1], Piotr Lechowicz[1], Miroslaw Klinkowski[2]; [1]*Wroclaw Univ. of Science and Technology, Poland;* [2]*National Inst. of Telecommunications, Poland.* We focus on spectrally-spatially flexible optical networks and analyze benefits of adjusting the number of active spatial modes in network links using various metrics based on data analytics with the goal to maximize the served traffic.

NeTh1D.4 • 09:30 Invited
Achieving Low-latency H2M Communications through Predicting Bandwidth Demand: A Comparative Study of Statistical Prediction and Machine Learning Techniques, Elaine Wong, Lihua Ruan; *Electrical and Electronic Engineering, Univ. of Melbourne, Australia*. Bandwidth demand prediction is crucial in reducing uplink latency of human-to-machine traffic in future converged networks. A comprehensive review of existing statistical prediction and state-of-the-art machine learning techniques is presented.

08:30–10:00
SpTh1E • Transmission 1
Presider: Maria Vasilica Ionescu; Nokia Bell Labs France, France

SpTh1E.1 • 08:30 Invited
Frequency Comb Based High-spectral Efficiency Transmission, Mikael Mazur[1], Jochen B. Schröeder[1], Abel L. Riesgo[2], Magnus Karlsson[1], Peter A. Andrekson[1]; [1]*Chalmers Tekniska Hogskola, Sweden;* [2]*Instituto de Telecomunicações (IT), Portugal.* We review our work on high spectral efficiency frequency comb-based superchannels using shared optical pilot tones combined with digital signal processing. The coherence of frequency combs is exploited to minimize the pilot tone overhead.

SpTh1E.2 • 09:00
Overlapping Estimation Based on DBSCAN Algorithm in Nyquist-WDM Systems, Jhon J. Granada Torres[1], Neil G. Gonzalez[2]; [1]*Universidad de Antioquia, Colombia;* [2]*Universidad Nacional de Colombia, Colombia*. We propose a method to estimate the percentage of overlapping between optical channels based on DBSCAN algorithm applied to received symbols. We experimentally verified this method in a 3×16-Gbaud 16QAM Nyquist-WDM system.

SpTh1E.3 • 09:15
KNN-based Demodulation in Gridless Nyquist-WDM Systems Affected by Interchannel Interference, Alejandro Escobar Pérez[1], Jhon J. Granada Torres[1], Neil G. Gonzalez[2]; [1]*Universidad de Antioquia, Colombia;* [2]*Universidad Nacional de Colombia, Colombia*. We propose a digital demodulation technique based on KNN algorithm for 16-QAM signals affected by interchannel interference in gridless scenarios. We experimentally verified this technique in a 3×16-Gbaud 16QAM Nyquist-WDM system.

SpTh1E.4 • 09:30 Invited
Towards FPGA Emulation of Fiber-optic Channels for Deep-BER Evaluation of DSP Implementations, Erik Börjeson, Christoffer Fougstedt, Per Larsson-Edefors; *Chalmers Univ. of Technology, Sweden.* We introduce an FPGA-based fiber-optic channel emulator, including both AWGN and carrier phase noise, which can be used to perform deep-BER simulations of DSP implementations and accurately evaluate DSP implementation penalties.

10:00–10:30 Networking Coffee Break with Exhibitors, *Grand Peninsula D*

Grand Peninsula G

Integrated Photonics Research, Silicon and Nanophotonics

10:30–12:30
ITh2A • Quantum and Nonlinear Photonics
Presider: Akihisa Tomita; Hokkaido Univ., Japan

ITh2A.1 • 10:30 Invited
Highly Entangled Photon Pairs from Semiconductor Quantum Dots, Christian Schimpf, Armando Rastelli; *Johannes Kepler Universität Linz, Germany.* We report here on semiconductor quantum dots capable of emitting highly entangled photon pairs, on the conditions required to achieve high degree of indistinguishability, and on the implementation of photonic quantum teleportation.

ITh2A.2 • 11:00 Invited
Efficient Parametric Source of Non Classical Light Based on a Photonic Crystal Cavity, Gabriel Marty[2,1], Sylvain Combrié[1], Fabrice Raineri[2,3], Alfredo De Rossi[1]; *[1]Thales Research and Technology, France; [2]Centre de Nanosciences et de Nanotetchnologies, CNRS, Université Paris Saclay, Palaiseau, France, France; [3]Université Paris Diderot, Sorbonne Paris Cit, 75205 Paris, France, France.* Efficient (-6 dB) parametric conversion is achieved in Photonic Crystal Cavities by compensating disorder-induced spectral misalignement . Spontaneous Four Wave Mixing up to 20 pW is detected with pump power about 0.1 mW.

ITh2A.3 • 11:30
Broadband Electric-field-induced Second Harmonic Generation in a Silicon Waveguide, Manan Raval, Neetesh Singh, Alfonso Ruocco, Michael Watts; *Research Laboratory of Electronics, Massachusetts Inst. of Technology, USA.* We demonstrate group-velocity-matched electric-field-induced second harmonic generation in silicon ridge waveguides with a broad conversion bandwidth of 80nm for a 2.48μm pump wavelength and a maximum efficiency of 112±13%W^{-1} using 200fs pump pulses.

ITh2A.4 • 11:45
D-dimensional Frequency-time Entangled Cluster States with On-chip Frequency Combs, Michael Kues[1], Christian Reimer[2], Stefania Sciara[3], Piotr Roztocki[3], Mehedi Islam[3], Luis Romero Cortés[3], Yanbing Zhang[3], Bennet Fischer[3], Sébastien Loranger[4], Raman Kashyap[4], Alfonso Cino[5], Sai T. Chu[6], Brent E. Little[7], David J. Moss[8], Lucia Caspani[9], William J. Munro[10], José Azaña[3], Roberto Morandotti[3]; *[1]Hannover Center for Optical Technologies, Leibniz Univ. Hannover, Germany; [2]John A. Paulson School of Engineering and Applied Sciences, Harvard Univ., USA; [3]INRS-EMT, Canada; [4]Polytechnique Montreal, Canada; [5]Univ. of Palermo, Italy; [6]City Univ. of Hong Kong, Hong Kong; [7]Chinese Academy of Science, China; [8]Swinburne Univ., Australia; [9]Strathclyde Univ., UK; [10]National Inst. of Informatics, Japan.* We realize the on-chip generation of time-frequency hyper-entangled states, and converted them via a deterministic controlled gate into d-level cluster states. For detection, we developed a d-level cluster witness and showed a high noise tolerance.

Sandpebble Room AB

Novel Optical Materials and Applications

10:30–12:30
NoTh2B • Two-dimensional Materials and Nanomaterials
Presider: Jason Myers; US Naval Research Laboratory, USA

NoTh2B.1 • 10:30 Invited
Piezo-phototronic Effect in Scalably-nanomanufactured 2-D Piezoelectric Semiconductors for Smart Optoelectronics, Wenzhuo Wu; *Purdue Univ., USA.* Piezo-phototronic Effect in Scalably-nanomanufactured 2-D Piezoelectric Semiconductors for Smart Optoelectronics

NoTh2B.2 • 11:00 Invited
Bandgap and Interface Engineering of Two-dimensional Layered Semiconductors, Anlian Pan; *Hunan Univ., China.* In this talk, we report our recent progress on the band gap and interface engineering of 2D atomically thin layered semiconductors, and demonstrate some interesting optical properties and device applications of these novel 2D nanostructures.

NoTh2B.3 • 11:30 Invited
Excitons in Atomically Thin 2D Materials and Heterostructures, Tony Heinz; *Stanford Univ., USA.* Abstract not available.

Sandpebble Room CD

Integrated Photonics Research, Silicon and Nanophotonics

11:00–12:30
ITh2C • Modulators
Presider: Sarvagya Dwivedi; Univ. of California Santa Barbara, USA

ITh2C.1
Withdrawn

ITh2C.2 • 11:00 Invited
A Strong Pockels Effect in Integrated Photonic Circuits, Felix Eltes, Jean Fompeyrine, Stefan Abel; *IBM Research - Zurich, Switzerland.* We enable a new class of electro-optic components based on a strong Pockels effect (>900pm/V) in photonic integrated circuits. Integration concepts and examples of high-speed electro-optic modulators and ultra-low power tuning elements are discussed.

ITh2C.3 • 11:30
Compact Double Graphene Layer Modulators in Dielectric Waveguides, Arif Gungor, Nadir Dagli; *Univ. of California Santa Barbara, USA.* Simple and low-cost electro absorption modulators in low loss Si_3N_4/SiO_2 platform containing two graphene layers are fabricated. 100 micron long devices demonstrate about 3 dB absorption change, which agrees well with the calculations.

ITh2C.4 • 11:45
Mach-Zehnder ITO Modulator on SOI, Rubab Amin[1], Rishi Maiti[1], Caitlin Caferno[1], Zhizhen Ma[1], Mohammad Tahersima[1], Yigal Lilach[2], Dilan Ratnayake[2], Hamed Dalir[3], Volker J. Sorger[1]; *[1]George Washington Univ., USA; [2]Nanofabrication and Imaging Center, George Washington Univ., USA; [3]Omega Optics Inc., USA.* We demonstrate a monolithically integrated compact ITO electro-optic modulator in silicon on insulator photonics based on a Mach-Zehnder interferometer featuring a high-performance half-wave voltage and active device length product of $V_\pi L$ = 0.59 Vmm.

Grand Peninsula E

Photonic Networks and Devices

10:30–12:00
NeTh2D • Heterogeneous and Distributed Photonic Networks
Presider: David Caplan; MIT Lincoln Lab, USA

NeTh2D.1 • 10:30 Invited
Optical Solutions for Next-generation Wireless Networks, Benjamin Imanilov, Michael Sauer, Andrey Kobyakov; *Corning Inc., USA*. We review evolution of in-building radio access networks (RAN) from early distributed antenna systems to 5G RAN and analyze the role of optical solutions in realistic system deployments.

NeTh2D.2 • 11:00 Invited
Microwave Photonics for a Radar Network, Leonardo Lembo[2,3], Salvatore Maresca[2], Giovanni Serafino[2,1], Filippo Scotti[1], Antonio Malacarne[2], Paolo Ghelfi[1], Antonella Bogoni[1,2]; [1]*CNIT, Italy;* [2]*TeCIP, Sant'Anna School of Advanced Studies, Italy;* [3]*Naval Research Center CSSN, Italian Navy, Italy.* The benefits of photonics-based fully coherent radar networks are analyzed. The first photonics-based coherent 2x2 MIMO radar network has been implemented and tested in real environments confirming the potential of photonics in overcoming RF issues

NeTh2D.3 • 11:30 Invited
5G Transport Networks: Capacity, Latency and Cost, Jiajia Chen[2,1]; [1]*KTH Royal Inst. of Technology, Sweden;* [2]*Chalmers Univ. of Technology, Sweden*. We summarize recent research on 5G transport networks addressing challenges on capacity, service migration and techno-economics brough by cloud radio access networks, diverse usage scenarios and heterogeneous deployments, respectively.

Grand Peninsula F

Signal Processing in Photonics Communications

10:30–12:15
SpTh2E • Transmission 2
Presider: Mikael Mazur; Chalmers Tekniska Hogskola, Sweden

SpTh2E.1 • 10:30 Invited
Challenges in Subsea Transmission Systems, Maria Vasilica Ionescu; *Nokia Bell Labs, France*. This paper examines the capacity evolution in subsea optical transmission systems and presents the specific challenges faced in sustaining growth in future systems, particularly under cost and electrical power constraints.

SpTh2E.2 • 11:00 Invited
Substantial Capacity Increase via Optimized Power/Bit Allocation in Spatially Multiplexed Power-limited Submarine Systems, Jose Krause Perin[1], Joseph M. Kahn[1], John Downie[2], Jason Hurley[2], Kevin Bennett[2]; [1]*Stanford Univ., USA;* [2]*Corning, Inc., USA*. We show how to optimize the channel bit/power allocation in submarine systems under an electrical power constraint. Our design strategy increases the theoretical link capacity by up to 70% compared to a recently proposed system.

SpTh2E.3 • 11:30 Invited
Low-complexity PDL-resilient Signaling Design, Arnaud Dumenil, Elie Awwad, Cyril Measson; *Nokia Bell Labs, France*. Building on recent works on PDL-resilience, we show how to derive optimal and practically-efficient low-complexity multidimensional signaling. Analytic arguments provide optimized unitary transforms of multiplexed square QAM as a function of the PDL.

Grand Peninsula G

Integrated Photonics Research, Silicon and Nanophotonics

ITh2A • Quantum and Nonlinear Photonics—Continued

ITh2A.5 • 12:00
Generation and Detection of Photon Pairs at 2.080 µm by Spontaneous Parametric Down Conversion in a PPLN Crystal, Shashi Prabhakar[1], Taylor Shields[1], Damian Powell[1], Gregor Taylor[1], Dmitry Morozov[1], Mehdi Ebrahim[1], Michael Kues[1,2], Lucia Caspani[3], Corin Gawith[4], Robert Hadfield[1], Matteo Clerici[1]; *[1]Univ. of Glasgow, UK; [2]Hannover Center for Optical Technologies, Leibniz Univ. Hannover, Germany; [3]Inst. of Photonics, Department of Physics, Univ. of Strathclyde, UK; [4]Covesion Ltd. & Optoelectronics Research Centre, Univ. of Southampton, UK.* We report the generation and detection of photon pairs at 2.080 µm. We characterized the coincidence to accidental ratio for a source with potential applications in integrated quantum optics, away from the Silicon two-photon absorption.

ITh2A.6 • 12:15
Time-resolved Nonlinear Ghost Imaging, Luana Olivieri, Juan Sebastian Totero Gongora, Vittorio Cecconi, Robyn Tucker, Luke Peters, Alessia Pasquazi, Marco Peccianti; *Univ. of Sussex, UK.* We propose a new type of THz Ghost-Imaging technique combining nonlinear pattern generation and time-resolved single-pixel measurements. Our approach allows to reconstruct the morphology and spectrum of the sample with deep subwavelength resolution.

Sandpebble Room AB

Novel Optical Materials and Applications

NoTh2B • Two-dimensional Materials and Nanomaterials—Continued

NoTh2B.4 • 12:00
Indium Tin Oxide Metatronic Circuit Board for Analog Computing, Mario Miscuglio, Joseph Crandall, Shuai Sun, Yaliang Gui, Volker J. Sorger; *George Washington Univ., USA.* Analog processors provide an equivalent model for complex problems. Here, we propose a nano-optics metatronic approach based on EpsilonNearZero circuit, which provides accurate solution for Laplace differential equation similarly to a resistive mesh.

NoTh2B.5 • 12:15
Numerical Calculations of Band Shifting and Permittivity of Silver-based Bi-metallic Alloys, Min-Hsueh Chiu[1], Jia-Han Li; *National Taiwan Univ., Taiwan.* The operating frequency of the plasmonic devices can be tuned by the materials. In this work, we simulate the silver-based bi-metallic alloys and discuss the effects of band shifting on permittivity.

Sandpebble Room CD

Integrated Photonics Research, Silicon and Nanophotonics

ITh2C • Modulators—Continued

ITh2C.5 • 12:00
From the Backscattering to the Reactive Coupling, Stefano Biasi[1], Fernando Ramiro-Manzano[2], Mher Ghulinyan[3], Iacopo Carusotto[4], Lorenzo Pavesi[1]; *[1]Univ. of Trento, Italy; [2]Instituto de Tecnologia Quimica, Spain; [3]Centre for Materials and Microsystem, Fondazione Bruno Kessler, Italy; [4]Physics, INO-CNR BEC Center and Department of Physics, Univ. of Trento, Italy.* We use the knowledge of the complex field to study experimentally the inter-mode coupling. Reducing the mutual dependence of the parameters we confirm the key-role of a reactive inter-mode coupling reported in [Phys.Rev 90.053811, J.Phys.B 42,215401]

ITh2C.6 • 12:15
Integrated Visible-light Liquid-crystal Variable-tap Amplitude Modulator, Milica Notaros, Jelena Notaros, Manan Raval, Michael Watts; *Massachusetts Inst. of Technology, USA.* An integrated visible-light liquid-crystal variable-tap amplitude modulator is proposed and experimentally shown. The device leverages liquid-crystal birefringence to vary the coupling between two waveguides and enable compact, low-power modulation.

12:30–14:00 Lunch *(on own)*

Grand Peninsula E

Photonic Networks and Devices

Grand Peninsula F

Signal Processing in Photonics Communications

SpTh2E • Transmission 2—Continued

SpTh2E.4 • 12:00
Zero Forcing Pre-compensation Technique for Multi-core Fiber Transmission System, Akram A. Abouseif, Ghaya Rekaya-Ben Othamn, Yves Jaouen; *LTCI, Telecom ParisTech, France*. We propose pre-compensation to enhance the multi-core fiber performance. The proposed solution avoids the feedback estimation of the channel by applying mathematical channel model. The pre-compensation offers close performance to the Gaussian channel

12:30–14:00 Lunch *(on own)*

Grand Peninsula G

Integrated Photonics Research, Silicon and Nanophotonics

14:00–16:00
ITh3A • Biophotonics and Sensing
Presider: Noelia Vico Triviño; IBM, Switzerland

ITh3A.1 • 14:00 Invited
Terahertz Spectrometry through Photomixing, Mona Jarrahi; *UCLA, USA.* We present a heterodyne terahertz spectrometer that utilizes plasmonic photomixing to offer quantum-level sensitivities at room temperature, for the first time, through a flexible platform capable of operating over 0.1-5 THz frequency band.

ITh3A.2 • 14:30 Invited
Photonic Integrated Inertial Sensors, Suraj Bramhavar, Dave Kharas, Paul Juodawlkis; *MIT Lincoln Laboratory, USA.* We demonstrate a chip-scale photonic platform that integrates photonic circuits with large mechanical structures at the wafer-scale. The platform can be used to realize chip-scale inertial sensors with performance exceeding traditional MEMS devices.

ITh3A.3 • 15:00 Invited
Imaging Flow Cytometer and Image-guided Cell Sorter, Yuhwa Lo; *Univ. of California San Diego, USA.* We discuss techniques that integrate microscopy and flow cytometer cell sorter into a single system. Both 2D and 3D images of individual cells are obtained in real time for cell calssification and isolation for downstream molecular analysis.

Sandpebble Room AB

Novel Optical Materials and Applications

14:00–16:00
NoTh3B • Active Materials and Metamaterials
Presider: Woei Ming Lee; Australian National Univ., Australia

NoTh3B.1 • 14:00 Invited
Engineering III-V Nanowires for Optoelectronics: From Visible to Terahertz, Hannah Joyce[1], Chawit Uswachoke[1], Stephanie Adeyemo[1], Srabani Kar[1], Djamshid Damry[2], Kun Peng[2], Michael Johnston[2], Jennifer Wong-Leung[3], Hoe Tan[3], Chennupati Jagadish[3]; *[1]Univ. of Cambridge, UK; [2]Univ. of Oxford, UK; [3]Australian National Univ., Australia.* We describe how optimized growth processes and contact-free electrical characterization techniques are accelerating the development of III–V nanowire-based optoelectronic devices with new and enhanced performance.

NoTh3B.2 • 14:30 Invited
Control Architectures for Coherent Phase Photonics, Artur Davoyan; *Univ. of California Los Angeles, USA.* As the complexity of optical systems grows novel system level functions emerge. In this talk I will discuss our recent work on understanding and controlling emergent phenomena in coherent phase optical systems and meta-structures.

NoTh3B.3 • 15:00
Tunable Metasurface Based on Silicon Doped Indium Oxide, Hongwei Zhao[1], Ran Zhang[2], Hamid Chorsi[1], Wesley Britton[2], Yuyao Chen[2], Prasad P. Iyer[1], Jon Schuller[1], Luca Dal Negro[2], Jonathan Klamkin[1]; *[1]Univ. of California Santa Barbara, USA; [2]Boston Univ., USA.* A tunable metasurface based on silicon doped indium oxide has been investigated. The amplitude of reflected light was actively tuned with a gate bias, demonstrating 57% reflectance change and 366 nm of resonance wavelength shift.

NoTh3B.4 • 15:15
Nanomanipulation of Colloidal Particles via Optothermally-gated Photon Nudging, Jingang Li, Yaoran Liu, Yuebing Zheng; *The Univ. of Texas at Austin, USA.* We report an all-optical technique for versatile nanomanipulation and assembly of various colloidal particles on a solid substrate by harnessing both photothermal effects and optical scattering forces.

Sandpebble Room CD

Integrated Photonics Research, Silicon and Nanophotonics

14:00–15:30
ITh3C • Photonic Technologies
Presider: Ripalta Stabile; Technische Universiteit Eindhoven, Netherlands

ITh3C.1 • 14:00 Invited
Tilted Structures for Angle-selective Thermal Emission, Peter Bermel, Zhiguang Zhou, David Kortge; *Purdue Univ., USA.* Thermal emission of flat materials typically follows Lambert's law, spanning a wide range of angles. Here, we present the principles underlying selective emission over asymmetric ranges of angles, and specific designs to achieve this behavior.

ITh3C.2 • 14:30
Compact Silicon TE-pass Polarizer Using Rib Waveguide Adiabatic Bends with Side Gratings, Humaira Zafar[3], Anatol Khilo[2], Marcus Dahlem[1]; *[1]IMEC, Belgium; [2]Boston Univ., USA; [3]Khalifa Univ., United Arab Emirates.* We propose and demonstrate a broadband silicon TE-pass polarizer at 1550 nm based on partially-etched waveguide adiabatic S-bends and side gratings, with high TM extinction (>30 dB) and low TE insertion loss (<0.25 dB).

ITh3C.3 • 14:45
Two-colour Terahertz Generation from a Quasi-2D System, Juan Sebastian Totero Gongora[1], Luke Peters[1], Jacob Tunesi[1], Matteo Clerici[2], Alessia Pasquazi[1], Marco Peccianti[1]; *[1]EPic Laboratory, Univ. of Sussex, UK; [2]Ultrafast Nonlinear Optics Lab, Univ. of Glasgow, UK.* We demonstrate the generation and control of Terahertz radiation from two-colour excitation of a semiconductor interface. Such a purely optical process is enabled by the tight confinement of the interacting fields in a quasi-2D region.

ITh3C.4 • 15:00
Ultra-compact Bragg-assisted Silicon Photonics Orbital Angular Momentum Emitter, Fabrizio Gambini[1], Yuan Liu[1], Bowen Song[1], Hongwei Zhao[1], Victoria Rosborough[1], Fengqiao Sang[1], Philippe Velha[2], Stefano Faralli[2], Jonathan Klamkin[1]; *[1]Univ. of California Santa Barbara, USA; [2]Scuola Superiore Sant'Anna, Italy.* An ultra-compact microring-based Orbital Angular Momentum (OAM) emitter is demonstrated for free-space optical communications. The device relaxes the fabrication constraints and enables fast OAM switching and multiple OAM modes at the same wavelength.

ITh3C.5 • 15:15
High-power Low-beam-divergence InP-based Coupled Ridge-waveguide Laser Arrays Emitting at 2.1µm, Zhong-Kai Zhang, Hong-Yu Chai, Yun-Yun Ding, ZunRen Lv, Xiao-Guang Yang, Tao Yang; *Inst. of Semiconductors,CAS, China.* We report on the InP-based coupled ridge-waveguide laser arrays with chirped structure and bilateral lossy regions, emitting at 2.1µm. High output power of 521mW and a far-field distribution with a dominant central lobe were achieved.

Grand Peninsula E

Photonic Networks and Devices

14:00–16:00
NeTh3D • Devices and Transmission 3
Presider: Nick Parsons; HUBER+SUHNER Polatis, Inc, UK

NeTh3D.1 • 14:00 Invited
The Scalability of Silicon Photonics for Optical Networks, Po Dong; *Nokia Bell Labs, USA.* Silicon photonics offers superior scalability in terms of integration level and energy efficiency, two key metrics to obtain sustainable capacity growths in telecom, datacom, and chip-scale interconnects. We illustrate these advantages by describing novel devices.

NeTh3D.2 • 14:30 Invited
Polarization Independent and Ultra-broadband Silicon Photonics for Future Networks, Timo Aalto; *VTT Technical Research Center of Finland, Finland.* Abstract not available.

NeTh3D.3 • 15:00
Polarization-shift Keying Using Low-coherence Sources, Mark D. Feuer, Mario V. Bnyamin, Xin Jiang; *College of Staten Island, USA.* Polarization-shift keying offers multi-dimensional signaling for systems using low-coherence sources. Non-Gaussian noise distributions are found to enable low bit-error rates up to at least 10Gsym/s when broad source bandwidths are used.

NeTh3D.4 • 15:15 Invited
Optimization of Modulation Formats for Improved Quality of Transmission, Olga Vassilieva, Inwoong Kim, Tadashi Ikeuchi; *Fujitsu Laboratories of America Inc., USA.* We review the different candidates of modulation formats (from fixed to tunable) for improved network resource utilization and discuss how they can assist in achieving high capacity gains with precise knowledge of quality of transmission.

Grand Peninsula F

Signal Processing in Photonics Communications

14:00–16:00
SpTh3E • Freespace Optics and Visible Light Communication
Presider: Hany Elgala; State Univ. of New York at Albany, USA

SpTh3E.1 • 14:00 Invited
Impact of Variable Field of View in Indoor Visible Light Communications Networks, Thomas Little[1], Iman Abdalla[1], Michael B. Rahaim[2]; *[1]Boston Univ., USA; [2]Engineering, Univ. of Massachusetts at Boston, USA.* We describe and evaluate a dynamic field of view receiver for increasing coverage and SNR in medium access for a dense network of overhead optical access points.

SpTh3E.2 • 14:30
Deep Learning Based Optical Camera Communications, Ian Walter, Monette H. Khadr, Hany Elgala; *Electrical and Computer Engineering, Univ. at Albany, USA.* A deep convolutional autoencoder (C-AE) for end-to-end adoption of orthogonal frequency division multiplexing (OFDM) based optical camera communications (OCC) is proposed and the feasibility of the neural network (NN) is verified by simulations.

SpTh3E.3 • 14:45
Open Source Visible-light Communication (VLC) System for Ultra-low Latency Optical Wireless Links in ITS, Marco Seminara[2], Tassadaq Nawaz[1], Stefano Caputo[3], Francesco S. Cataliotti[2,4], Lorenzo Mucchi[3], Jacopo Catani[1,2]; *[1]CNR-INO National Inst. of Optics of CNR, Italy; [2]LENS, Italy; [3]Univ. of Firenze, DINFO - Information Engineering Dept., Italy; [4]Univ. of Firenze, Physics and Astronomy Dept., Italy.* We developed an open-source VLC decode-and-relay transceiver with sub-ms latency for intelligent transportation systems. Range and speed performances are tested in a realistic setting, using a regulated LED traffic-light as optical information source.

SpTh3E.4 • 15:00 Invited
Advanced Physical Layer Design for Li-fi in the Industrial Internet of Things, Malte Hinrichs, Pablo Wilke Berenguer, Ronald Freund, Volker Jungnickel; *Fraunhofer HHI, Germany.* An energy efficient physical layer (PHY) employing pulsed modulation and simultaneous transmission enabling reliable Li-Fi networks for industrial applications. Essential PHY components are laid out and tested in a simulated manufacturing cell.

Grand Peninsula G

Integrated Photonics Research, Silicon and Nanophotonics

ITh3A • Biophotonics and Sensing—Continued

ITh3A.4 • 15:30
Ultra-sensitive and Selective Biomolecular Detection Using Frequency-locked Microtoroid Optical Resonators, Judith Su; *Univ. of Arizona, USA*. We used frequency locked microtoroid optical resonators to detect attomolar concentrations of Alzheimer's biomarkers. In addition, we present methods to improve the sensitivity and selectivity these sensors.

ITh3A.5 • 15:45
Subwavelength Grating Bimodal Waveguide for Refractive Index Sensing, Luis Torrijos Morán, Jaime García-Rupérez; *Biophotonics, Nanophotonics Technology Center - UPV, Spain*. Periodic subwavelength structures supporting two TE modes are presented as high performance sensors with bulk and surface sensitivities of 1375.5nm/RIU and 6.138nm/nm, respectively. A complete theoretical study is provided by numerical simulations.

Sandpebble Room AB

Novel Optical Materials and Applications

NoTh3B • Active Materials and Metamaterials—Continued

NoTh3B.5 • 15:30
Surface Terahertz Emission from 2D-flakes Micro-junctions, Luke Peters, Jacob D. Tunesi, Sean Ogilvie, Juan Sebastian Totero Gongora, Matthew Large, Alessia Pasquazi, Alan Dalton, Marco Peccianti; *Univ. of Sussex, UK*. We consider the passive modulation of the surface field at a junction between semiconductors and 2D-materials. We experimentally demonstrate that this boosts the optical-to-terahertz conversion efficiency beyond that of benchmark surface emitters.

NoTh3B.6 • 15:45
Terahertz Time-dependent Random Metamaterials, Jacob D. Tunesi[1], Luke Peters[1], Juan Sebastian Totero Gongora[1], Alessia Pasquazi[1], Andrea Fratalocchi[2], Marco Peccianti[1]; [1]*Univ. of Sussex, UK;* [2]*King Abdullah Univ. of Science and Technology, Saudi Arabia*. Plasmonic metamaterials enable access to extremely nonlinear regimes with remarkable full-field control. We theoretically and experimentally demonstrate a novel form of photo-induced semiconducting Time-Dependent metamaterial at THz frequencies.

Sandpebble Room CD

Integrated Photonics Research, Silicon and Nanophotonics

ITh3C • Photonic Technologies—Continued

NOTES

Grand Peninsula E

Photonic Networks and Devices

NeTh3D • Devices and Transmission - 3—Continued

NeTh3D.5 • 15:45
Mitigation of Spectral Slicing Penalty Using Binary Polarization-shift Keying, Mark D. Feuer, Mario V. Bnyamin, Xin Jiang; *College of Staten Island, USA.* Polarization-shift keying (PolSK) is shown theoretically and experimentally to improve performance of optical links based on spectrally-sliced sources. BER floors observed with on-off keying (OOK) at 5 Gb/s are eliminated when 2-PolSk is used.

Grand Peninsula F

Signal Processing in Photonics Communications

SpTh3E • Freespace Optics and Visible Light Communication—Continued

SpTh3E.5 • 15:30
Influence of Angular Deflection on Mode Sorting with Adaptive Compensation for Beams Carrying Orbital Angular Momentum, Hiroki Kishikawa, Noriyuki Sakashita, Nobuo Goto; *Tokushima Univ., Japan.* We propose a method of adaptive compensation for angular deflection of orbital angular momentum beam on high resolution mode sorting. The sorting performance measured by crosstalk is effectively reduced for lateral angular deflection.

SpTh3E.6 • 15:45
8-ary OAM Shift Keying for FSO Link with Atmospheric Turbulence, Munkhbayar Adiya, Hiroki Kishikawa, Nobuo Goto; *Tokushima Univ., Japan.* We propose an 8-ary orbital angular momentum shift keying technique for free-space optical communication with atmospheric turbulence to improve tolerance to noise and phase distortion by atmospheric turbulence.

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Key to Authors and Presiders

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