#RAPID2018

2018 RAPID

Research and Applications of Photonics in Defense

22-24 August

Hilton Sandestin Beach Golf Resort

Miramar Beach, FL, USA

GENERAL CHAIRS

Jeffery Allen, Ph.D. (Air Force Research Laboratory)

Monica Allen, Ph.D. (Air Force Research Laboratory)

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IEEE

IEEE Photonics Society

PROGRAM – AT – A – GLANCE

Wednesday, 22 August	**8:00am – 6:00pm - Registration Coral Ballroom Foyer**
Room:	**Coral Ballroom A/B/C/D**
1:00pm-3:30pm	**Plenary & Keynote Session** **Session Chair:** Emily A. Doucette, *Air Force Research Laboratory, FL, USA* **1:00pm - 1:10pm Welcome Address:** Michael Eismann, *Air Force Research Laboratory, OH, USA* **1:10pm - 1:35pm Opening Remarks:** Stephen Welby, *Executive Director and Chief Operating Officer of the IEEE, NJ, USA* **1:35pm - 2:10pm Keynote:** Richard Joseph, *Chief Scientist of the United States Air Force, Washington, D.C., USA* **2:10pm - 2:45pm Plenary I:** Ray O. Johnson, *Bessemer Venture Partners, VA, USA* **2:45pm -3:20pm Plenary II:** Chennupati Jagadish, *Australian National University, Camberra, Australia*
3:30pm-4:00pm	**Break – Coral Ballroom Foyer**
4:00pm-6:00pm	**STEM Session** **Session Chair:** Brian Mitchell, *Air Force Research Laboratory, FL, USA* **4:00pm-4:05pm**: Opening Remarks **4:05pm - 4:35pm Keynote Speaker:** Paul Hsu, *Total Parts Plus, FL, USA* **4:35pm - 5:40pm:** STEM Presentations *Students from the Florida State Science & Engineering Fair and the International Science & Engineering Fair* **5:40pm - 6:00pm:** Panel Discussion
6:00pm-7:30pm	**Meet & Greet Reception: Photonics Workforce Development for Technicians & Veterans – Emerald E** **Session Chair:** Lauren Mecum, *IEEE Photonics Society, NJ, USA* **Keynote Speaker:** Chrysanthos Panayiotou, *LASER-TEC, FL, USA*

Thursday, 23 August	**8:00am – 6:00pm - Registration & Exhibits Coral Ballroom Foyer**					
Room:	**Coral Ballroom A**	**Coral Ballroom B**	**Coral Ballroom C**	**Coral Ballroom D**	**Heron**	**Theater**
8:00am-8:30am	**ThA1:** **Track 1 (ETP):** Enabling Technologies in Photonics **Session Chairs:** A. Gracia & M. Allen **Keynote:** Ben Eggleton	**ThB1:** **Track 2 (MMAP):** Materials and Manufacturing for Advanced Photonics **Session Chairs:** R. Pachter & M. Filler **Keynotes:** Ruth Pachter & Michael Filler	**ThC1:** **Track 3 (OEDDIP)**: Optical Emitter/Detector Devices and Integrated Photonics **Session Chairs:** R. Rapp & D. Wasserman **Keynote:** Robert Magnusson	**ThD1:** **Track 4 (OMPSP):** Optical Metamaterials, Plasmonics and Subwavelength Photonics **Session Chairs:** J. Allen & J. Caldwell **Keynote:** Nader Engheta	**ThE1:** **Track 5 (PDS):** Photonics for Defense Systems **Session Chairs:** R. Orgusaar & M. Schmitt **Keynote:** Dalma Novak	9:00am-11:00am **ThF2:** Tutorial I **Session Chair:** C. McCartan **Speakers:** Aaron Maxwell Andrews & Jacob Dodson
8:30am–10:30am	**ThA2**: Microwave Optics and RF Photonics **Session Chairs:** B. Braaten & B. Eggleton	**ThB2**: Novel Materials for Photonics **Session Chairs:** J. Boeckl & W. Zhou	**ThC2**: Integrated Photonics and Optical Devices **Session Chairs:** R. Magnusson & A. Majumdar	**ThD2**: Plasmonic Devices and Applications **Session Chairs:** M. Allen & J. Guo	**ThE2**: EO/IR/LADAR **Session Chairs:** C. Keyser & S. Marlow	
10:30am - 12:30pm	**ThA3**: Epitaxial Growth, Fabrication and Characterization **Session Chairs:** S. Krishna & D. Jelinek	**ThB3**: Nonlinear Materials and Phenomena **Session Chairs:** S. Guha & I. Lima	**ThC3**: Lasers/Emitters **Session Chairs:** D. Wasserman & F. Grillot	**ThD3**: Optical Metamaterials Based Devices and Applications **Session Chairs:** J. Allen & G. Shvets	**ThE3**: Instrumentation and Control for Test and Evaluation **Session Chairs:** M. Johnson & R. Orgusaar	
12:30pm – 1:30pm	**Women in Photonics / Women in Science and Engineering Luncheon – Emerald E** **Session Chair:** Mary Kinsella, *Air Force Research Laboratory, OH, USA* **Keynote Speaker:** Elisabetta Jerome, *Air Force Test Center, FL, USA*					
1:30pm–3:30pm	**ThA4**: Devices and Systems for Sensors **Session Chairs:** B. Stadler & M. Schmitt	**ThB4**: Scalable Manufacturing and Rapid Prototyping for Photonics **Session Chairs:** C. Tabor & M. Filler	**ThC4**: UV Optoelectronics **Session Chairs:** M. Gerhold & R. Collazo	**ThD4**: Optical Metasurfaces and Applications **Session Chairs:** A. Urbas & M. Kats	**ThE4**: Enabling Tools for Testing Rapidly Evolving EO/IR Systems **Session Chairs:** A. Keipert & J. Vosatka	2:00pm-4:00pm **ThF4:** Tutorial II **Session Chair:** C. McCartan **Speakers:** Jason Foley & Janet Wolfson
3:30pm - 5:30pm	3:30pm-5:15pm **ThA5**: Position, Navigation and Time Technologies **Session Chairs:** M. Miller & D. Bevly	**ThB5:** Semiconductor Materials and Quantum Nanoscience **Session Chairs:** K. Eyink & P. Deotare	**ThC5**: Optical Detectors and Focal Plane Arrays **Session Chairs:** J. Cleary & J. Duran	**ThD5**: Dynamic Control of Self-assembled Plasmonic Nanostructures **Session Chair:** J. Fontana & J. Valentine	**ThE5**: Displays, Holography and Projection **Session Chairs:** R. Rapp & F. Kiamilev	
5:30pm-6:00pm	**ETP Panel Discussion** **Session Chairs:** A. Gracia & M. Allen	**MMAP Panel Discussion** **Session Chairs:** R. Pachter & M. Filler	**OEDDIP Panel Discussion** **Session Chairs:** R. Rapp & D. Wasserman	**OMPSP Panel Discussion** **Session Chairs:** J. Allen & J. Caldwell	**PDS Panel Discussion** **Session Chairs:** R. Orgussar & M. Schmitt	
7:00pm-9:00pm	**Welcome Reception – Barefoot's Deck**					

Friday, 24 August	**8:00am - 3:00pm - Registration & Exhibits Coral Ballroom Foyer**					
Room:	**Coral Ballroom A**	**Coral Ballroom B**	**Coral Ballroom C**	**Coral Ballroom D**	**Heron**	**Theater**
8:00am-8:30am	**FA1:** **Track 6 (HMB):** Human State Measurement and Biosensing **Session Chairs:** R. Naik & B. Wenner **Keynote:** Rajesh Naik	**FB1:** **Track 7 (OIST):** Optical Imaging and Sensing Technology **Session Chairs:** M. Eismann & R. Magnusson **Keynote:** M. Eismann	**FC1:** **Track 8 (BBT):** Bioinspired and Bioprincipic Technologies **Session Chair &** **Keynote:** Ric Wehling	**FD1**: **Track 9 (NPNMAP):** Novel Phenomena and New Materials for Advanced Photonics **Session Chairs:** D. Basov & Y. Abate **Keynote:** Dmitri Basov	**FE1:** **Track 10 (ANP):** Advanced Nanophotonics Platforms **Session Chair:** H. Harutyunyan **Keynote:** Alexandra Boltasseva	9:00am-11:00am **FF2:** Tutorial III **Session Chair:** C. McCartan **Speakers:** Sanjay Krishna & Robert Magnusson
8:30am–10:30am	**FA2**: Biosensing Methods **Session Chairs:** J. Chavez & M. Palma	**FB2**: Spectral, Polarimetric, and Multimodal Imaging **Session Chair:** M. Eismann & M. Kudenov	**FC2**: Bioinspired Optical Technologies **Session Chairs:** T. Cronin & F. Reininger	**FD2**: Quantum Sensing and Spintronics **Session Chair:** M. Flatte	**FE2:** Ultrafast and Nonlinear Nanophotonics **Session Chairs:** H. Harutyunyan & J. Boeckl	
10:30am–12:30pm	**FA3**: Materials and Devices for Biosensing **Session Chair:** B. Wenner	**FB3**: Blast/Shock Wave Imaging and Spectroscopic Techniques **Session Chairs:** C. Mai & A. Diggs	**FC3**: Bioinspired Sensors **Session Chairs:** G. Belusic & M.A. Massie	**FD3**: Two-Dimensional Materials **Session Chair:** J. Hone	**FE3**: High Refractive Index Enabled Nanophotonics **Session Chairs**: J. Schuller & J. Caldwell	
12:30pm–1:30pm	**Professional Development Tutorial Lunch & Learn - Emerald E** **Session Chair:** Stanley Ikpe, *NASA Langley Research Center, VA, USA* **Keynote Speaker:** Linda Stacy, *LivingBluPrints, MA, USA*					
1:30pm–3:30pm	1:30pm-3:15pm **FA4**: Human State Measurement **Session Chair:** J. Christensen	**FB4**: Terahertz Photonics **Session Chairs:** G. Goldsmith II & M. Kim	**FC4**: Biobased Signal and Information Processing I **Session Chairs:** G. Barrows & P. Abshire	**FD4:** Topological Insulators and Photonics **Session Chair:** N. Fang	**FE4**: Emerging Material Platforms for Plasmonics **Session Chairs:** A. Boltasseva & S. Law	2:00pm-4:00pm **FF4:** Tutorial IV **Session Chair:** C. McCartan **Speakers:** Brian Mitchell & Claron Ridge
3:30pm – 5:30pm	3:30pm-5:15pm **FA5**: Human Analyst Augmentation **Session Chairs:** G. Burnett & A. Ephrem	**FB5**: Target Detection and Pattern Recognition **Session Chairs:** M. Burfeindt & D. Gray	3:30pm-4:45pm **FC5:** Biobased Signal and Information Processing II **Session Chair:** R. Wehling	**FD5**: Modeling and Simulation for Advanced Photonics **Session Chairs:** R. Pachter & S. Trendafilov	**FE5**: Active Plasmonics and Nanophotonics **Session Chairs:** A. Agrawal & P. Bharadwaj	
5:30pm-6:00pm	**HMB Panel Discussion** **Session Chairs:** R. Naik & B. Wenner	**OIST Panel Discussion** **Session Chairs:** M. Eismann & R. Magnusson	**BBT Panel Discussion** **Session Chair:** R. Wehling	**NPNMAP Panel Discussion** **Session Chair:** Dmitri Basov	**ANP Panel Discussion** **Session Chair:** H. Harutyunyan	

THANK YOU FOR ATTENDING THE FIRST ANNUAL RAPID CONFERENCE,
WE LOOK FORWARD TO SEEING YOU NEXT YEAR!

Welcome to the IEEE RAPID at Hilton Sandestin Beach and Golf Resort & Spa!

Welcome to the first IEEE Research and Applications of Photonics in Defense Conference (RAPID) held here at the beautiful Hilton Sandestin Beach Golf Resort & Spa located in the Heart of Florida's Emerald Coast on the Gulf of Mexico!

The IEEE RAPID conference aims to bring together government, academia and industry in a global forum to present new fundamental basic research, innovative technologies and build collaborations to solve critical security and defense challenges.

This international conference will be broad in scope covering such areas as electromagnetics, device physics, optics and photonics, algorithms, and test and evaluation to name a few. With the breadth of topics covered, this conference seeks to attract diverse participation and collaboration from academia, industry, defense and government agencies that will promote security interests with opportunities to increase technical depth and breadth as well as networking with peers. In a world where technology is rapidly changing, collaborations and multidisciplinary work is the only way to solve research challenges and foster the next generation of scientific discovery.

This meeting is intended to be a premier international forum for the exchange of ideas on the state-of-the-art in research, focused on Photonics. Through a range of technical and social activities, it will provide the opportunity to interact with the world's leading experts in Photonics from academia, industry, and government.

Attendees can participate in two evening social events: a "Meet & Greet" on Wednesday with LASER-TEC veterans and the Welcome Reception outside Thursday evening on the Barefoot's Deck. To inspire young minds to cultivate interests in light-based sciences, RAPID will also have a STEM Session on Wednesday to showcase the work of local students. This session was devised to demonstrate how a photonics and optics career can be made part of their future. We hope our technical attendees participate with encouragement.

In addition, there will be special networking lunches: Thursday there is a joint Women in Photonics (WiP) and Women in Science and Engineering (WiSE) event, and Friday a Professional Development "Lunch & Learn" Tutorial, sponsored by the IEEE Young Professionals program.

There are many great events to attend at this first time conference; we hope you take advantage of everything RAPID has to offer!

Monica Allen
Co-Chair
Air Force Research Laboratory, FL, USA

Jeffery Allen
Co-Chair
Air Force Research Laboratory, FL, USA

2018 ORGANIZING COMMITTEE

Co-Chairs

Monica Allen
Jeffery Allen

Committee Members

Yohannes Abate
Pamela Abshire
Mark Adams
Amit Agrawal
Geoff Barrows
Dmitri Basov
Gregor Belušič
David M. Bevly
Palash Bharadwaj
John Boeckl
Alexandra Boltasseva
Ben Braaten
Matthew Burfeindt
Gregory M. Burnett
Joshua Caldwell
Jorge Chavez Benavides
James Christensen
Justin W. Cleary
Ramón Collazo
Thomas W. Cronin
Parag Deotare
Angela Diggs
Emily A. Doucette
Benjamin Eggleton
Michael Eismann
Adrienne Ephrem
Kurt Eyink
Nicholas Fang
Michael Filler
Michael Flatte
Jake Fontana
Gregory Garrett
Thomas K. Gaylord
George "Buddy" Goldsmith
Alex Gracia
David Gray
Frederic Grillot
Shekhar Guha
Junpeng Guo
Hayk Harutyunyan
James Hone
Capt Derek R. Jelinek
Mike Johnson
Mikhail Kats
Andreas Keipert
Christian Keyser
Fouad Kiamilev
Mary E. Kinsella
Sanjay Krishna
Mike Kudenov
Stephanie Law
Ivan Lima
Robert Magnusson
Chi Mai
Arka Majumdar
Seongsin Margaret Kim
Steve Marlow
Mark Massie
Mikel M. Miller
Brian "Mitch" Mitchell
Rajesh R. Naik
Robert Orgusaar
Ruth Pachter
Matteo Palma
Stanley Pau
Ron Rapp
Francis Reininger
Andrew Sarangan
Mark Schmitt
Gennady Shvets
Brian Stadler
Christopher Tabor
Jennifer Lindy Talley
Simeon Trendafilov
Augustine Urbas
Jason Vosatka
Dan Wasserman
Martin "Ric" Wehling
Ric Wehling
Brett Wenner
Caryn Whitney
Weidong Zhou

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General Information

Registration Hours

The IEEE RAPID Registration will be located in the **Coral Ballroom Foyer**.

Registration and Speaker Check-in will be open during the following hours:

Wednesday, 22 August	8:00AM – 6:00PM
Thursday, 23 August	8:00AM – 6:00PM
Friday, 24 August	8:00AM – 3:00PM

Speaker & Session Chair Check-in

To ensure that all sessions proceed smoothly, all speakers and session chairs must report to the IEEE Photonics Society Speaker/Session check-in directly after you pick up your registration materials located in the **Coral Ballroom Foyer**.

Exhibitor Schedule

IEEE Photonics Society thanks each of the 2018 Exhibitors of the IEEE RAPID.

Exhibit times are as follows:

Wednesday, 22 August	(set-up)	9:00AM – 12:00PM
Wednesday, 22 August		12:00PM – 5:00PM
Thursday, 23 August		8:00AM – 5:00PM
Friday, 24 August		8:00AM – 5:00PM

*Exhibits & coffee breaks are located in Coral Ballroom Foyer.

Special Events

Plenary & Keynote (Coral Ballroom A/B/C/D)

Wednesday, 22 August- 1:00pm – 3:30pm
Session Chair: Emily Doucette
Welcome Address: Michael Eismann
Opening Remarks: Stephen Welby
Keynote: Richard Joseph
Plenary I: Ray O. Johnson
Plenary II: Chennupati Jagadish

STEM Session (Coral Ballroom A/B/C/D)

Wednesday, 22 August- 4:00pm – 6:00pm
Session Chair: Brian Mitchell
Keynote Speaker: Paul Hsu
STEM Presentations
Panel Discussion

Women in Photonics / Women in Science and Engineering Luncheon (Emerald E)
*Registration is required
Thursday, 23 August- 12:30pm – 1:30pm
Session Chair: M. Kinsella
Keynote Speaker: Elisabetta Jerome

Professional Development Tutorial Lunch & Learn (Emerald E)
*Registration is required
Friday, 24 August- 12:30pm – 1:30pm
Session Chair: S. Ikpe
Keynote Speaker: Linda Stacy

Social Events

Meet & Greet Reception: Photonics Workforce Development for Technicians & Veterans (Emerald E)
Wednesday, 22 August- 6:00pm – 7:30pm
Session Chair: L. Mecum
Keynote Speaker: Chrysanthos Panayiotou

Welcome Reception (Barefoot's Deck)
Thursday, 23 August- 7:00pm – 9:00pm

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An R &D Funding Program - The National Reconnaissance Office's Director's Innovation Initiative (DII) invests in advanced technologies, fosters innovation, and provides seed funding to push the boundaries of technology to dramatically improve our overhead reconnaissance capabilities. It presents an opportunity for developers not traditionally associated with the National Reconnaissance Office to participate in building the NRO of the
21st Century.

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Tech-X Corporation develops simulation software for electromagnetics and plasma applications, developed during many years of academic research, government consulting and commercial development. Our package VSim for Electromagnetics provides highly accurate solutions for design and analysis of electromagnetic cavities and waveguides, photonic devices (integrated photonic circuits, sensors, crystals, fibers, OPAs) and antennas using Time Domain algorithms. These algorithms handle complex 3D metallic and dielectric shapes and allow simulations of computationally large devices encompassing hundreds of wavelengths in all directions. VSim proved to scale to hundreds of thousands cores and model grids of tens of billion cells. In addition to FDTD we provide methods for finding propagating modes and calculating figures of merit in frequency domain, such as S parameters.

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UltraComm develops Digital and RF photonic components for harsh environment and high reliability applications. These applications require components to operate through wide temperature ranges, shock, vibration, condensation, chemicals, and/or radiation.

UltraComm specializes in challenging engineering tasks: high-speed mixed-signal circuit design, packaging for high fidelity electrical and optical coupling, and testing at the wafer and component level.

SPONSORS

Final Program

1:00 pm–3:30 pm **Coral Ballroom a/B/C/D**
Session Wa1 **Plenary & Keynote Session**
Session Chair Emily A. Doucette, *Air Force Research Laboratory, FL, USA*

1:00 pm–1:10 pm

Welcome addr ess, Michael Eismann, *Air Force Research Laboratory, OH, USA*

1:10 pm–1:35 pm

Opening Remarks, Stephen Welby, *Executive Director and Chief Operating Officer of the IEEE, NJ, USA*

1:35 pm–2:10 pm ***(Keynote)***

Wa1.1 **Keynote addr ess,** Richard Joseph, *Chief Scientist of the United States Air Force, Washington, DC, USA*

2:10 pm–2:45 pm ***(Plenary)***

Wa1.2 **Plenary I: Innovation for a Secure Future,** Ray O. Johnson, *Bessemer Venture Partners, VA, USA*

The global security environment has become increasingly complex; threats range from terrorism to global nuclear war. The US and its allies met previous existential threats with technological and geopolitical innovation. It is again time to increase all aspects of innovation to meet these global challenges.

2:45 pm–3:20 pm ***(Plenary)***

Wa1.3 **Plenary II: Semiconductor Nanowires for Optoelectronics applications,** Chennupati Jagadish, *Australian National University, Canberra, Australia*

Growth of nanowires and control of diameter, composition and shape and their influence on optical and electrial properties will be presented. Results on nanowire lasers, nanowire laser integration for flexible electronics, THz detectors and use of nanowire scaffolds for engineering neuronal networks will be discussed.

3:30 pm–4:00 pm

Break

4:00 pm–6:00 pm **Coral Ballroom a/B/C/D**

Session Wa2 **STEM**

Session Chair Brian Mitchell, *Air Force Research Laboratory, FL, USA*

4:00 pm–4:35 pm

Wa2.1 Opening & Keynote: Preparing Students for Careers of Global Demand, Paul Hsu, *Total Parts Plus, Fort Walton Beach, FL, USA*

4:35 pm–5:40 pm

STEM Presentations, *Students from the Florida State Science & Engineering Fair and the International Science & Engineering Fair*

5:40 pm - 6:00 pm

STEM Panel Discussion

6:00 pm–7:30 pm **Emerald E**

Meet & Greet Reception: Photonics Workforce Development for Technicians & Veterans

Session Chair Lauren Mecum, *IEEE Photonics Society, NJ, USA*

6:00 pm–7:30 pm

Keynote Speaker: Chrysanthos Panayiotou, *LASER-TEC, FL, USA*

Track 1: Enabling Technologies in Photonics (ETP)

8:00 am–8:30 am **Coral Ballroom a**

Session Tha1 **Enabling Technologies in Photonics**

Session Chairs Monica Allen, *Air Force Research Laboratory, FL, USA*
Alex Gracia, *Air Force Research Laboratory, FL, USA*

8:00 am–8:30 am ***(Keynote)***

Tha1.1 Enabling Technologies in Photonics, Benjamin Eggleton, *University of Sydney, Sydney, NSW, AU*

This track will address enabling technologies for photonics. Topics include: microwave optics and RF photonics, higher level devices and integrated systems for photonics, and position navigation and time technologies, as well novel fabrication and characterization methods that enable advanced functionality in photonics.

8:30 am–10:30 am **Coral Ballroom a**

Session Tha2 **Microwave Optics and RF Photonics**

Session Chairs Benjamin Braaten, *North Dakota State University, ND, USA*
Benjamin Eggleton, *University of Sydney, Australia*

8:30 am–9:00 am ***(Invited)***

Tha2.1 applications of Micr owave Photonic Processing, Richard DeSalvo, Anthony Klee, Charles Middleton, Kristina Bagnell, Elliott Grafer, Alex Cramer, *Harris Corporation, Palm Bay, FL, USA*

We review recent advances in microwave photonic processors for full spectrum awareness and frequency translation. Hybrid integration progress for these systems is shown along with the latest waveguide and chip-scale technologies to reduce size, weight and power and improve performance.

9:00 am–9:30 am ***(Invited)***

Tha2.2 Integrated Photonics for RF-Photonic Phased-array Radar System, Weimin Zhou, *US Army Research Laboratory, Adelphi, MD, USA,* Stephen Anderson, *US Army Research Laboratory, Adelphi, MD, USA and Rensselaer Polytechnic Institute, Troy, NY, USA,* Lingjun Jiang, Z. Rena Huang, *Rensselaer Polytechnic Institute, Troy, USA,* Karen Grutter, *US Army Research Laboratory, Adelphi, MD, USA and University of Maryland, College Park, MD, USA,* and Olukayode Okusaga, *Johns Hopkins University, Laurel, MD, USA*

We discuss some potential benefits of using integrated RF-photonic devices/circuits in a phased-array-Radar system. A viable simple solution is proposed for a low-cost, RF-photonic multi-beams beamformer that meets both transmitting and receiving RF-system specifications/requirements. Proof-of-concept experiments and chip-scale integrated-photonics subsystem development will also be discussed.

9:30 am–10:00 am ***(Invited)***

Tha2.3 New Trends in Photonics for Radar and LIDaR Systems, Daniel Dolfi, Loic Morvan, Vincent Crozatier, Oriane Lelievre, Ghaya Baili, Perrine Berger, Jerome Bourderionnet, Alfredo De Rossi, Sylvain Combrie, Ines Ghorbel, Patrick Feneyrou, Aude Martin, Luc Leviandier, Pascale Nouchi, and Arnaud Brignon, *Thales Research & Technology, Palaiseau, France*

Photonics appears as a disruptive technology for multifunction radar and lidar systems. Both systems benefit from the wide frequency bandwidth offered by photonics providing advanced functions such as waveform generation or adaptive filtering. We will review these capabilities and the impact of PICs on performances.

10:00 am–10:15 am

Tha2.4 On Using Micron-Sized Silver Coated Particles to Control the Electromagnetic Response of a Metamaterial with Complementary Split Ring Resonators and Wires in a host Dielectric, Jerika Cleveland, Benjamin D. Braaten, *North Dakota State University, Fargo, ND, USA,* Monica Allen, Jeffery Allen, *Air Force Research Laboratory, Eglin Air Force Base, FL, USA*, and Brett Wenner, *Air Force Research Laboratory, Wright-Patterson Air Force Base, OH, USA*

Micron-sized conducting particles that columnize along the magneto-static field lines are used to implement the wires in a traditional split ring resonator/wire metamaterial unit-cell configuration. It is shown that the impedance of the metamaterial can be effectively changed from 1 GHz–20 GHz by controlling the particle columns.

10:15 am–10:30 am

Tha2.5 applications of Stimulated Brillouin Scattering in Micr owave Photonic Links, Anthony Klee, Alex Cramer, Elliott Grafer, Micah Jenkins, Joseph Devenport, Charles Middleton, and Richard DeSalvo, *Harris Corporation, Palm Bay, FL, USA*

We review recent progress in applying stimulated Brillouin scattering to microwave photonic links in multiple signal processing contexts. Dynamic bandpass filters, high selectivity notch filters, and wideband phase shifters are demonstrated. These developments promise to advance the state of the art in wideband microwave systems.

10:30 am–12:30 pm **Coral Ballroom a**

Session Tha3 **Epitaxial Growth, Fabrication and Characterization**

Session Chairs Sanjay Krishna, *Ohio State University, OH, USA*
Derek Jelinek, *Air Force Research Laboratory, FL, USA*

10:30 am–11:00 am ***(Invited)***

Tha3.1 GaSb-Based II-VI Semiconductors for application in Next-Generation Infrar ed Detectors, Wen Lei, Yongling Ren, Imtiaz Madni, Renjie Gu, Gilberto A. Umana-Membreno, Jarek Antoszewski, and Lorenzo Faraone, *University of Western Australia, Perth, Australia*

In this work, we will review our recent effort on developing GaSb-based II-VI semiconductors (mainly HgCdTe/CdTe and HgCdSe epitaxial materials grown on GaSb substrates) for making next generation infrared detectors with features of lower cost and larger array format size.

11:00 am–11:30 am ***(Invited)***

Tha3.2 Next-Generation Tunneling Based III-Nitride Visible and Ultraviolet Emitters, Yuewei Zhang, Zane Jamal-Eddine, Fatih Akyol, and Siddharth Rajan, *Ohio State University, Columbus, OH, USA*

This presentation will discuss next-generation III-Nitride optoelectronic devices based on interband tunneling. We will first discuss the design of wide band gap tunnel junctions using heterostructure and polarization engineering. We will then discuss the application of tunnel junctions in visible and ultraviolet emitters.

11:30 am–11:45 am

Tha3.3 au:Ga alloyed Clusters to Enhance al Contacts to p-T ype GaN, Andrew Klump, Biplab Sarkar, *North Carolina State University, Raleigh, NC, USA,* Pramod Reddy, *Adroit Materials, Inc., Raleigh, NC, USA,* Mathew Hayden Breckenridge, Felix Kaess, *North Carolina State University, Raleigh, NC, USA,* Ronny Kirste, Seiji Mita, *Adroit Materials, Inc., Raleigh, NC, USA,* Erhard Kohn, Ramon Collazo, and Zlatko Sitar, *North Carolina State University, Raleigh, NC, USA*

Deposition, annealing, and subsequent removal of Au on p-type GaN films reduced the resistivity of subsequently deposited Al metal contacts. The reduction is explained by formation of Au:Ga alloys which remove Ga from the surface, and create Ga-vacancies that surround the electrically active alloy clusters.

11:45 am–12:00 pm

Tha3.4 Electrical and Structural Characterization of Si Implanted homoepitaxially Gr own alN, M. Hayden Breckenridge, Luis Hernandez-Balderrama, Andrew Klump, *North Carolina State University, Raleigh, NC, USA,* Pramod Reddy, James Tweedie, Ronny Kirste, *Adroit Materials, Inc., Cary, NC, USA,* Ramon Collazo, and Zlatko Sitar, *North Carolina State University, Raleigh, NC, USA*

AlN is an attractive material for UV optoelectronics and high-power device applications; however, obtaining high n-type conductivity is still a challenge. Ion implantation may provide an avenue to realize electrical conductivities suitable for device operation. A novel annealing procedure to recover lattice damage is presented.

12:00 pm–12:15 pm

Tha3.5 Side Wall Passivation of LWIR P-Type Superlattice Detectors Using atomic Layer Deposition, Teressa Specht, *Ohio State University, Columbus, OH, USA,* Stephen Myers, *SK Infrared, Columbus, OH, USA,* Theodore J. Ronningen, Alireza Kazemi, David Hollingshead, *Ohio State University, Columbus, OH, USA,* Earl Fuller, *SK Infrared, Columbus, OH, USA*, and Sanjay Krishna, *Ohio State University, Columbus, OH, USA*

This work demonstrates the use of aluminum oxide passivation on the mesa sidewall of long-wave infrared p-type superlattice photodetectors applied by atomic layer deposition. The surface leakage current of the passivated photodetectors was reduced by an order of magnitude over the unpassivated photodetectors.

12:15 pm–12:30 pm

Tha3.6 high-Power , high-SFDR, heter ogeneously Integrated III-V on Si MZI Modulators, Paul A. Morton, Michael J. Morton, *Morton Photonics, West Friendship, MD, USA,* Chong Zhang, *University of California at Santa Barbara, Santa Barbara, CA, USA,* Jacob B. Khurgin, *Johns Hopkins University, Baltimore, MD, USA,* Jon Peters, *University of California at Santa Barbara, Santa Barbara, CA, USA,* Christopher D. Morton, *Morton Photonics, West Friendship, MD, USA*, and John E. Bowers, *University of California at Santa Barbara, Santa Barbara, AL, USA*

Heterogeneously integrated III-V/Si MZI modulators measured at high optical power levels demonstrate applicability for high SFDR analog fiber-optic links without an optical amplifier. Optical power up to 100 mW injected into the modulator shows no degradation in linearity, demonstrating 110 dB.Hz$^{2/3}$ typical SFDR.

12:30 pm–1:30 pm **Emerald E**

Session WiP **Women in Photonics / Women in Science and Engineering Luncheon**

Session Chair Mary Kinsella, *Air Force Research Laboratory, OH, USA*

12:30 pm–1:30 pm ***(Lunch Presentation)***

WiP **Women in Science & Engineering – Choosing Freedom Over Equality and Other Controversial Thoughts,** Elisabetta Jerome, *Air Force Test Center, Eglin Air Force Base, FL, USA*

Should 50% of scientists and engineers be women? Today only 8% of mechanical engineers are women. Is that an inequality we need to fix? What does equality even mean? What should it look like? These and other thought provoking questions will be posed and discussed.

1:30 pm–3:30 pm **Coral Ballroom a**

Session Tha4 **Devices and Systems for Sensors**

Session Chairs Brian Stadler, *Air Force Research Laboratory, OH, USA*
Mark Schmitt, *Air Force Research Laboratory, OH, USA*

1:30 pm–2:00 pm ***(Invited)***

Tha4.1 Integrated Magnetoelectric Sensors, Nian Sun, *Northeastern University, Boston, MA, USA*

I will cover the recent progress on integrated magnetoelectric sensors and antennas. These magnetoelectric sensors are the most sensitive nanoscale magnetometers. These acoustically actuated magnetoelectric antennas are ultra-compact with 1/10~1/100 the size of conventional antennas, with excellent impedance matching and ground plane immunity. These magnetoelectric sensors have enormous impacts.

2:00 pm–2:30 pm ***(Invited)***

Tha4.2 Unlimited Beam-Bandwidth-Product Multifunctional RF arrays, Dennis Prather, *University of Delaware, Newark, DE, USA*

An RF-phased-array-antenna design that uses spatially-coherent optical up-conversion to perform an analog-spatial Fourier transform on all received RF signals simultaneously and prior to digital processing is presented. This enables broadband-multifunctional operation with unlimited beam-bandwidth-product and massive beam-space-processing in real-time and at the speed of light.

2:30 pm–2:45 pm

Tha4.3 Field Trial of 95-Ghz Fr equency-Modulated Continuous-Wave Radar System Driven by Radio Over Fiber Techniques, Atsushi Kanno, Naokatsu Yamamoto, *National Institute of Information and Communications Technology, Tokyo, Japan,* Sevia Mahdaliza Idrus, Nor Hisham Khamis, *Universiti Teknologi Malaysia, Johor Bharu, Malaysia,* Kei Akama, Tetsuya Kawanishi, *Waseda University, Tokyo, Japan,* Nobuhiko Shibagaki, and Kenichi Kashima, *Hitachi Kokusai Electric Inc., Tokyo, Japan*

Millimeter-wave radar system connected to an optical synthesizer is evaluated at outdoor fields in tropical weather conditions. Maximum range and its resolution are evaluated at the field. Polarization imaging by the perpendicular antenna configuration is also performed in 95-GHz bands.

2:45 pm–3:00 pm

Tha4.4 Micro-Cavity Fiber-Optic Pressure Sensor with Graphene Diaphragm, Ivan Avrutsky, Pooja Thakur, Qingsong Cui, *Wayne State University, Detroit, MI, USA,* Corneliu Rablau, *Kettering University, Flint, MI, USA*, and Mark Ming-Cheng Cheng, *Wayne State University, Detroit, MI, USA*

Micro-cavity fiber-optic pressure sensor with exfoliated graphene diaphragm is fabricated and tested. Analytical modeling indicates that pursuing ultra-thin diaphragm may not be necessary while non-trivial geometry of the cavity and reduced strain of the diaphragm help increasing the responsivity of the sensor.

3:00 pm–3:15 pm

Tha4.5 Microchip Terahertz Frequency Electro-Optic Phase Modulation, Ingrid Wilke, Alexander K. Turnbull, Waleed M. Mansha, Kefei Wu, and Mona Hella, *Rensselaer Polytechnic Institute, Troy, NY, USA*

The feasibility of ultrafast optical modulation (300–500 GHz) using silicon microchips is discussed. Results of electric field concentrators, transistor amplifier and oscillator simulations are presented. The modulation of 1.55 microns laser light traveling through $LiNbO_3$ is calculated and device performance is described.

3:15 pm–3:30 pm

Tha4.6 Rotation Measurements with a Passive Resonant Gyroscope Based on hollow Cor e Fiber, Alexia Ravaille, *Thales Avionics, Chatellerault, France,* Gilles Feugnet, *Thales Research and Technology, Palaiseau, France,* Fabien Bretenaker, *CNRS, Orsay, France,* Benoit Debord, *GloPhotonics, Limoges, France,* Georges Humbert, and Fetah Benabid, *University of Limoges, Limoges, France*

We present rotation measurements with a Kagome Hollow Core Fiber based passive resonant gyroscope. We describe the lock-in phenomenon with two configurations to probe the cavity, one of them allowing to stronghly reduce the lock-in. We will comment on their limitations due to biases.

3:30 pm–5:15 pm **Coral Ballroom a**

Session Tha5 **Position, Navigation and Time Technologies**

Session Chairs Mikel Miller, *IS4S, FL, USA*
David Bevly, *Auburn University, AL, USA*

3:30 pm–4:00 pm ***(Invited)***

Tha5.1 LIDaR-Based Navigation for GPS-Denied Missions, Andrey Soloviev, *QuNav, Mary Esther, FL, USA*

Images created by light detection and ranging sensors (lidars) provide a viable alternative for maintaining robust PNT capabilities in GPS-degraded and denied environments. This talk will review main principles of lidar-based PNT systems. Navigation performance will be characterized using experimental results for various mission scenarios.

4:00 pm–4:30 pm ***(Invited)***

Tha5.2 Image aided Navigation Techniques for autonomous Vehicles, Michael Veth, *Veth Research Associates, LLC, Niceville, FL, USA*

A critical component of autonomous vehicle design is the navigation system which is required to provide a robust solution over a wide-range of operating environments. In this presentation, we explore the concepts and technology associated with developing Bayesian image-aided navigation systems for autonomous vehicles.

4:30 pm–4:45 pm

Tha5.3 Sky Polarization azimuth Sensing System, David B. Chenault, Todd Aycock, and Amy Kransteuber, *Polaris Sensor Technologies, Inc., Huntsville, AL, USA*

Accurate PNT is critical to the warfighter but is subject denial of GPS. SkyPASS calculates absolute heading to 4 milliradians or better by measuring the sky's polarization. SkyPASS enables reliable far-target location, weapons aiming and emplacement, vehicle navigation and surveying regardless of GPS accessibility.

4:45 pm–5:00 pm

Tha5.4 a Photonics-Based Broadband RF Spectrum analysis and Geolocation System, Kristian D. Merkel, James T. Jackson, Ryan M. Price, Wm. Randall Babbitt, Craig Benko, Scott H. Bekker, Kevin N. Winn, Colton R. Stiffler, Alex J. Woidtke, Jon Oset, Aaron S. Traxinger, Jylissa Salveson, Michael D. Chase, Peter B. Sellin, *S2 Corporation, Bozeman, MT, USA,* R. Krishna Mohan, and Zeb W. Barber, *Montana State University, Bozeman, MT, USA*

Testing of a broadband photonics-based spectrum analyzer and coherent correlator for RF emitter geolocation using time-difference of arrival is presented. Emitters including frequencyhoppers and spread spectrum signals with bandwidths from 10-500 MHz covering 12–22 GHz band were located with a typical <1 ft^2 precision.

5:00 pm–5:15 pm

Tha5.5 Toward a Scalable Photonic Tightly Coupled array for 5G applications, Victoria A. Carey, *University of Delaware, Newark, DE, USA,* Matthew R. Konkol, *Phase Sensitive Innovations, Inc., Newark, DE, USA,* Shouyuan Shi, *University of Delaware, Newark, DE, USA,* Christopher A. Schuetz, *Phase Sensitive Innovations, Inc., Newark, DE, USA,* and Dennis W. Prather, *University of Delaware, Newark, DE, USA*

We present a tightly coupled array excited by a 1 × 4 array of high-power photodiodes bonded directly to the antenna dipoles. This fabrication approach defines a path toward scalable, monolithic solutions for mmW applications. The proposed antenna exhibits high radiation efficiency between 15 and 65 GHz.

5:30 pm–6:00 pm **Coral Ballroom a**

ETP Panel Discussion

Session Chairs Alex Gracia, *Air Force Research Laboratory, FL, USA*
Monica Allen, *Air Force Research Laboratory, FL, USA*

7:00 pm–9:00 pm **Barefoot's Deck**

Welcome Reception

Track 2: Materials and Manufacturing for advanced Photonics (MMaP)

8:00 am–8:30 am **Coral Ballroom B**

Session ThB1 **Materials and Manufacturing for advanced Photonics**

Session Chairs Ruth Pachter, *Air Force Research Laboratory, OH, USA*
Michael Filler, *Georgia Tech, GA, USA*

8:00 am–8:30 am ***(Keynote)***

ThB1.1 Emerging Materials and Manufacturing Directions in Photonics, Ruth Pachter, *Air Force Research Laboratory, Wright-Patterson Air Force Base, OH, USA* and Michael Filler, *Georgia Institute of Technology, AL, USA*

We overview emerging materials for innovative directions in photonics applications, for example, for quantum photonics or nonlinear optics. Advanced materials will be discussed, e.g. metallic and semiconducting nanostructures, bulk materials and thin films, and oxides. Scalable manufacturing and rapid prototyping for photonics will be outlined.

8:30 am–10:30 am **Coral Ballroom B**

Session ThB2 **Novel Materials for Photonics**

Session Chairs John Boeckl, *Air Force Research Laboratory, OH, USA*
Weidong Zhou, *University of Texas at Arlington, TX, USA*

8:30 am–9:00 am ***(Invited)***

ThB2.1 Towards On-Silicon Photonics with Graphene on Silicon Carbide, Francesca Iacopi, University of Technology Sydney, Sydney, Australia

Graphene from hetero-epitaxial silicon carbide on silicon is an appealing material system for integrated nanophotonics, as it would combine high confinement and low-loss plasmonic properties onto a silicon platform. We demonstrate a promising approach to this scope.

9:00 am–9:30 am ***(Invited)***

ThB2.2 III-V Strain Layer Superlattice Based Band Engineered a valanche Photodiodes, Sid Ghosh, *Raytheon Company, El Segundo, CA, USA*

InAs/GaSb Strain Layer Superlattice (SLS) material system has emerged as a potential material for advanced infrrared detectors The talk will discuss the evolution of superlattice based avalanche photodiodes and some of the recent results on the work being done at Raytheon on SWIR avalanche photodiodes.

9:30 am–10:00 am ***(Invited)***

ThB2.3 Digital alloy Gr owth of Low-Noise a valanche Photodiodes, Seth R. Bank, *University of Texas at Austin, Austin, TX, USA,* Joe C. Campbell, *University of Virginia, VA, USA,* Scott J. Maddox, Ann Kathryn Rockwell, *University of Texas at Austin, Austin, TX, USA,* Maddy E. Woodson, Min Ren, Andrew Jones, *University of Virginia, VA, USA,* Stephen March, *University of Texas at Austin, Austin, TX, USA,* Jiyuan Zheng, and Yuan Yuan, *University of Virginia, VA, USA*

We describe the molecular beam epitaxial growth, characterization, and device performance of conventional, staircase, and photoconductive avalanche photodetectors grown with AlInAsSb digital alloys. In particular, this is the first low-noise III-V avalanche photodiode alloy family and offers flexibility necessary to achieve staircase avalanche photodiode operation.

10:00 am–10:30 am ***(Invited)***

ThB2.4 advanced Single Photon Detector arrays for Imaging applications, Dennis Delic, *Defence Science and Technology Group, Australia*

There are many Defence applications which require electro-optical sensor technologies for detection, tracking and discrimination of distant objects. Of interest is a sensor called a Single Photon Avalanche Diode (or SPAD for short), which is a type of solid-state photo-detector that is designed and biased.

10:30 am–12:30 pm **Coral Ballroom B**

Session ThB3 **Nonlinear Materials and Phenomena**

Session Chairs Shekhar Guha, *Air Force Research Laboratory, OH, USA*
Ivan Lima, *North Dakota State University, ND, USA*

10:30 am–11:00 am ***(Invited)***

ThB3.1 Mid-IR Femtosecond Extreme Non-Linearity in Materials, Enam Chowdhury, *Ohio State University, Columbus, OH, USA*

11:00 am–11:30 am ***(Invited)***

ThB3.2 Optical Parametric Oscillation in Random Polycrystalline $\chi^{(2)}$ Medium, Qitian Ru, Nathaniel Lee, Xuan Chen, *University of Central Florida, Orlando, FL, USA,* Kai Zhong, *University of Central Florida, Orlando, FL, USA and Tianjin University, Tianjin, China,* Sergey Vasilyev, Mike Mirov, *IPG Photonics–Mid-Infrared Lasers, Birmingham, AL, USA,* Sergey B. Mirov, *IPG Photonics–Mid-Infrared Lasers, Birmingham, AL, USA and University of Alabama at Birmingham, Birmingham, AL, USA*, and Konstantin L. Vodopyanov, *University of Central Florida, Orlando, FL, USA*

We demonstrate the first OPO based on random phase matching. The OPO was based on ZnSe ceramic pumped by 62-fs, λ = 2.35-μm Cr:ZnS laser pulses, had 90-mW pump threshold and produced an ultra-broad spectrum spanning 3–7.5 μm.

11:30 am–11:45 am

ThB3.3 analysis of Raman Scattering and Four -Wave Mixing in Ch $_4$ Filled hollow-Cor e Photonic Crystal Fiber, Christian Keyser, *Air Force Research Laboratory Munitions Directortae, Eglin Air Force Base, FL, USA* and Gregory Smail, *University of Michigan, Ann Arbor, MI, USA*

We numerically investigate stimulated Raman scattering and four-wave mixing in CH_4 filled inhibited-coupling hollow-core photonic crystal fiber. Analysis indicates that four-wave mixing can be an aid or hindrance in wavelength conversion depending on whether the first or second Stokes order is desired.

11:45 am–12:00 pm

ThB3.4 Comparison of Digital Back-Propagation with Nonlinear Fourier Transform and Split-Step Fourier for Nonlinear Mitigation in Optical Fiber Systems, Ivan T. Lima Jr., *North Dakota State University, Fargo, ND, USA*

This study shows that digital back-propagation with nonlinear Fourier transform is significantly less efficient than split-step Fourier to mitigate nonlinear distortions in optical fibers, since the nonlinear spectrum describes the entire nonlinear evolution that is much longer than the propagation distances in the nonlinear regime.

12:00 pm–12:30 pm *(Invited)*

ThB3.5 Nonlinear Integrated Photonics: Progress and Prospects, Robert Norwood, *University of Arizona, AZ, USA*

We will discuss how advances in integrated photonics in III-V and Si-based materials, combined with progress in both semiconductor and fiber-based light sources, have resulted in a renaissance in nonlinear integrated photonics that will now be driven by bringing advanced nonlinear optical materials to these platforms.

12:30 pm–1:30 pm **Emerald E**

Session WiP **Women in Photonics / Women in Science and Engineering Luncheon**

Session Chair Mary Kinsella, *Air Force Research Laboratory, OH, USA*

12:30 pm–1:30 pm *(Lunch Presentation)*

WiP **Women in Science & Engineering – Choosing Freedom Over Equality and Other Controversial Thoughts,** Elisabetta Jerome, *Air Force Test Center, Eglin Air Force Base, FL, USA*

Should 50% of scientists and engineers be women? Today only 8% of mechanical engineers are women. Is that an inequality we need to fix? What does equality even mean? What should it look like? These and other thought provoking questions will be posed and discussed.

1:30 pm–3:30 pm **Coral Ballroom B**

Session ThB4 **Scalable Manufacturing and Rapid Prototyping for Photonics**

Session Chairs Christopher Tabor, *Air Force Research Laboratory, OH, USA*
Michael Filler, *Georgia Tech, GA, USA*

1:30 pm–2:00 pm ***(Invited)***

ThB4.1 Scalable Directed Self-assembly of Metamaterials fr om Nanoparticles, Eric Furst, *University of Delaware, Newark, DE, USA*

Colloidal and nanoparticle self-assembly is a promising approach to the scalable nanomanufacture of advanced functional materials that control the transport of light, heat, and chemical species. In this talk, I will discuss the use of directed self-assembly using external electric and magnetic fields.

2:00 pm–2:30 pm ***(Invited)***

ThB4.2 Synthesized Silicon Nanostructures for Optical Switches and Thz Electr onics, James F. Cahoon, *University of North Carolina at Chapel Hill, Chapel Hill, NC, USA*

Synthetic control over the sub-10 nm composition and shape of degenerately-doped silicon creates precisely-designed nanostructures that exhibit plasmon resonances for mid-IR metatronics, tunable scattering dark states for optical switches, and electron ratcheting for GHz-THz rectification, zero turn-on diodes, and long-wavelength energy harvesting.

2:30 pm–3:00 pm ***(Invited)***

ThB4.3 additive Manufacturing Using Optical Fiber for Photonics applications, Edward Kinzel, John Hosteler, Jason Johnson, *Missouri University of Science and Technology, Rolla, MO, USA,* Jonathan Goldstein, *Air Force Research Laboratory, AL, USA,* Richard Brow, Douglas Bristow, and Robert Landers, *Missouri University of Science and Technology, Rolla, MO, USA*

High quality optical fiber is deposited by feeding it into the intersection of a CO_2 laser beam and substrate. The laser power, feed rate, and scan speed can be adjusted to print smooth 3D glass forms or isolated free-standing optical fiber with photonic applications.

3:00 pm–3:15 pm

ThB4.4 Colloidal Germanium Inks for 3D Printed Semiconductors, Meghan McLeod, *UES, Inc., Dayton, OH, USA* and Christopher Tabor, *Air Force Research Laboratory, Wright-Patterson Air Force Base, OH, USA*

We report the synthesis of monodispersed transition metal doped Ge nanoparticles that can be readily utilized as inks for additive manufacturing. The investigation of electro-optic properties reported tunable electrical conductivities with additional increases upon light exposure. Thermal and photonic sintering techniques were also compared.

3:15 pm–3:30 pm

ThB4.5 Scalable Production of Functionally-Encoded Nanowires for applications in Photonics, Maritza Mujica, Victor Breedveld, Sven H. Behrens, and Michael A. Filler, *Georgia Institute of Technology, Atlanta, GA, USA*

We demonstrate how particle stabilized double emulsion droplets prepared by simple batch emulsification can be used to generate microreactors for the scalable production of functionally-encoded semiconductor nanowires for applications in large-scale photonics (e.g., large-area absorbers/emitters/detectors, tunable thermal radiation coatings).

3:30 pm–5:30 pm **Coral Ballroom B**

Session ThB5 Semiconductor Materials and Quantum Nanoscience

Session Chairs Kurt Eyink, *Air Force Research Laboratory, OH, USA*
Parag Deotare, *University of Michigan, MI, USA*

3:30 pm–4:00 pm ***(Invited)***

ThB5.1 Nonlinear Optoelectronic Measurements in Novel Quantum Materials, Qiong Ma, *Massachusetts Institute of Technology, Cambridge, MA, USA*

We introduce low energy, nonlinear optoelectronic measurements as a highly symmetry sensitive way to study the quantum geometry, topology and correlated behavior of the low energy electron states in a wide range of novel metallic/semimetallic materials.

4:00 pm–4:30 pm ***(Invited)***

ThB5.2 Spin-assisted Spectr oscopy for Characterization of Solid-State Qubits, Diana Prado Lopes Aude Craik, Andrew Greenspon, Xingyu Zhang, *Harvard University, Cambridge, MA, USA,* Pauli Kehayias, *Harvard-Smithsonian Center for Astrophysics, Cambridge, MA, USA,* Erik Bauch, Jennifer Schloss, Connor Hart, *Harvard University, Cambridge, MA, USA,* Ronald Walsworth, *Harvard-Smithsonian Center for Astrophysics, Cambridge, MA, USA,* and Evelyn Hu, *Harvard University, Cambridge, MA, USA*

A new class of photonic materials has recently emerged, featuring fluorescent defects with exceptional spin-dependent optical properties. We present an integrated system that allows us to isolate and characterize the spectroscopic signatures of these defects, enabling the identification and optimization of promising solid-state qubit candidates.

4:30 pm–4:45 pm

ThB5.3 Improving the Conductivity Limits in Si Doped al Rich alGaN, Pramod Reddy, *Adroit Materials, Inc., Cary, NC, USA,* Shun Washiyama, Mathew H. Breckenridge, Andrew Klump, Qiang Guo, Felix Kaess, *North Carolina State University, Raleigh, NC, USA,* Ronny Kirste, *Adroit Materials, Inc., Cary, NC, USA,* Biplab Sarkar, *North Carolina State University, Raleigh, NC, USA,* James Tweedie, Seiji Mita, *Adroit Materials, Inc., Cary, NC, USA,* Ramon Collazo, and Zlatko Sitar, *North Carolina State University, Raleigh, NC, USA*

We report point defect control of two primary compensating defects in AlGaN: CN and V_{III} + nSi_{Al}, based on their dependence on chemical potentials. Reasonable control over the knee behavior of the conductivity and the low doping limit in $Al_{0.65}Ga_{0.35}N$ thin films grown on sapphire is achieved.

4:45 pm–5:00 pm

ThB5.4 Optical Properties of Titanium Dioxide–Vanadium Dioxide Multilayer Thin-Film Structures, Rudra Gnawali, Partha P. Banerjee, Joseph W. Haus, *University of Dayton, Dayton, OH, USA,* Victor Reshetnyak, *National University of Kyiv, Kyiv, Ukraine,* and Dean R. Evans, *Air Force Research Laboratory, Wright-Patterson Air Force Base, OH, USA*

The objective of this work is to investigate the electromagnetic (EM) propagation properties of titanium dioxide (TiO_2)-vanadium dioxide (VO_2) multilayer thin film structures during the phase transition cold-VO_2 to hot-VO_2. Berreman matrix is used to explore the propagation properties of thin film structures.

5:00 pm–5:15 pm

ThB5.5 Multimode Scanning Near-Field Photoluminescence Spectroscopy of InGaN Quantum Wells, Saulius Marcinkevičius, Mounir Mensi, Ruslan Ivanov, *KTH Royal Institute of Technology, Kista, Sweden,* Leah Y. Kuritzky, Steven P. DenBaars, Shuji Nakamura, and James S. Speck, *University of California, Santa Barbara, CA, USA*

Multimode scanning near-field photoluminescence spectroscopy was developed and applied to study carrier localization and dynamics in m-plane InGaN quantum wells. The study showed that localized hole states maintain properties of extended bands, radiative and nonradiative carrier lifetimes are spatially nonuniform, and hole diffusion is anisotropic.

5:15 pm–5:30 pm

ThB5.6 a Scalable Low-Cost Manufacturing to hybridize Infrar ed Detectors with Si Read-Out Circuits, Pouya Dianat, *Drexel University, Philadelphia, PA, USA*

A manufacturing method for infrared imagers is described, avoiding costly flip-chip bonding. LWIR type-II superlattice films were removed from substrate and attached to non-native silicon host by VanderWaals forces. Devices, processed on transferred films, showed dark current of J_{dark} = 8.8 mA/cm^2, QE = %55, and cut-off of 16.2 microns at 77 K.

5:30 pm–6:00 pm **Coral Ballroom B**

MMaP Panel Discussion

Session Chairs Ruth Pachter, *Air Force Research Laboratory, OH, USA*
Michael Filler, *Georgia Tech, GA, USA*

7:00 pm–9:00 pm **Barefoot's Deck**

Welcome Reception

Track 3: Optical Emitter/Detector Devices and Integrated Photonics (OEDDIP)

8:00 am–8:30 am **Coral Ballroom C**

Session ThC1 **Optical Emitter/Detector Devices and Integrated Photonics**

Session Chairs Ronald Rapp, *Air Force Research Laboratory, FL, USA*
Daniel Wasserman, *University of Texas at Austin, TX, USA*

8:00 am–8:30 am ***(Keynote)***

ThC1.1 Optical Emitter/Detector Devices and Integrated Photonics, Robert Magnusson, *University of Texas–Arlington, Arlington, TX, USA*

We review integrated photonics including pertinent emitter and detector concepts. We discuss devices and materials enabling imaging and sensing platforms. Topics including silicon photonics, subwavelength structures, nanolasers and emitters, detectors and focal plane arrays, UV optoelectronics, and design and fabrication methods are addressed.

8:30 am–10:30 am **Coral Ballroom C**

Session ThC2 **Integrated Photonics and Optical Devices**

Session Chairs Robert Magnusson, *University of Texas at Arlington, TX, USA*
Arka Majumdar, *University of Washington, WA, USA*

8:30 am–9:00 am ***(Invited)***

ThC2.1 Si/SiO_2 Interlayer Coupler Based on Cylindrical Resonant Cavities, Congshan Wan, Thomas K. Gaylord, and Muhannad S. Bakir, *Georgia Institute of Technology, Atlanta, GA, USA*

A grating-assisted-cylindrical-resonant-cavities (GARC) coupler consisting of three cavities and made of Si/SiO_2 is designed. An interlayer optical coupling efficiency of 71% for TE polarization at 1.55 μm is simulated.

9:00 am–9:15 am

ThC2.2 Wideband Mid-IR Semiconductor Resonant Reflectors, Daniel Carney and Robert Magnusson, *University of Texas at Arlington, Arlington, TX, USA*

Mid-IR resonant reflectors are presented offering wideband polarized and unpolarized responses. Devices are fabricated from durable and commercially available IR transparent semiconductor materials, offering the possibility of rugged and economical opto-electronic integration.

9:15 am–9:30 am

ThC2.3 Full Spectrum Millimeter-Wave Modulation in Thin-Film LiNbO3, Andrew J. Mercante, Shouyuan Shi, *University of Delaware, Newark, DE, USA,* Peng Yao, *Phase Sensitive Incorporated, Newark, DE, USA,* and Dennis W. Prather, *University of Delaware, Newark, DE, USA*

We present a crystal ion sliced (CIS) $LiNbO_3$ phase modulator that demonstrates functionality across the entire millimeter wave spectrum. A shallow rib waveguide supports a single transverse electric (TE) optical mode, and a Au coplanar waveguide (CPW) supports the modulating radio frequency (RF) mode.

9:30 am–9:45 am

ThC2.4 Design of a high-Q Raman amplifier with Guided-Mode Resonant Gratings, Ren-Jie Chen, Yeong Hwan Ko, Jae Woong Yoon, and Robert Magnusson, *University of Texas at Arlington, Arlington, TX, USA*

We propose a Raman amplifier with one dimensional guided-mode resonant gratings with silicon-on-quartz. We provide an initial design based on nanopatterned c-Si films. Raman spectrum separation will be presented by two resonant modes with proper spectral and angular tuning.

9:45 am–10:00 am

ThC2.5 Strong-Coupling of Emitters to Different Grating Coupled Plasmonic Modes, M. Csete, E. Tóth, A. Török, B. Bánhelyi, and T. Csendes, *University of Szeged, Szeged, Hungary*

Strong-coupling between organic emitters and plasmonic modes supported by multilayers consisting of wavelength-scaled gratings was inspected. Although, the split is larger on the lower branch of originally short-range modes, the modes characteristic is more strongly modified on the upper branch of originally long-range modes.

10:00 am–10:15 am

ThC2.6 Thin-Film Silicon Nitride on Electro-Optic Materials for a Novel Modulator ar chitecture, Christopher J. Cullen, Janusz Murakowski, Shouyuan Shi, and Dennis W. Prather, *University of Delaware, Newark, DE, USA*

This paper introduces integration of silicon nitride onto electro-optic (EO) materials to realize novel RF-photonic modulators. The introduction of silicon nitride to EO material enables novel modulator relying on modifying its index ellipsoid. Design, fabrication, and experimental demonstration of such a modulator is presented.

10:15 am–10:30 am

ThC2.7 Robustness of Second-harmonic Generation in a hybrid SiN / Polymer Waveguide, Subrata Das, *University of Texas at Arlington, Arlington, TX, USA,* Brett R. Wenner, *Air Force Research Laboratory Sensors Directorate, Wright-Patterson Air Force Base, OH, USA,* Jeffery W. Allen, Monica S. Allen, *Air Force Research Laboratory Munitions Directorate, Eglin Air Force Base, FL, USA*, and Michael Vasilyev, *University of Texas at Arlington, Arlington, TX, USA*

We design a hybrid silicon-nitride / polymer slot waveguide that employs modal phase-matching for generation of second harmonic of a 1550 nm beam, with an order-of-magnitude improvement over a channel waveguide. The performance is not degraded by waveguide bending with radius down to ~150 mm.

10:30 am–12:30 pm **Coral Ballroom C**

Session ThC3 Lasers/Emitters

Session Chairs Daniel Wasserman, *University of Texas at Arlington, TX, USA*
Frederic Grillot, *Télécom ParisTech, France*

10:30 am–11:00 am ***(Invited)***

ThC3.1 Long-Wavelength, Mid-Infrared Lasers and Superluminescence Emitters, Claire Gmachl, *Princeton University, Princeton, NJ, USA*

Quantum Cascade emitters are powerful light sources for the mid-infrared region of the spectrum. In the long-wavelength, lambda >12um, spectral region, however, performance (as measured in power efficiency and temperature behavior) drops significantly. We review causes and strategies of mitigation for this long-wavelength performance drop-off.

11:00 am–11:30 am ***(Invited)***

ThC3.2 Phase Locking Quantum Cascade Lasers for high Power Coherent IR Sources, Timothy Newell, *Air Force Research Laboratory, Albuquerque, NM, USA,* Athanasios Gavrielides, *University of New Mexico, Albuquerque, NM, USA*, Ron Kaspi, and Chunte Lu, *Air Force Research Laboratory, Albuquerque, NM, USA*

Passive phase locking via Talbot cavity coupling along with feedback dynamics in mid-infrared quantum cascade lasers is investigated. We find that the QCL shows good mode stability and a resistance to feedback induced instabilities. The objective is a stable >20 W coherent source for IR applications.

11:30 am–11:45 am

ThC3.3 Mono-Output Monolithic Tri-Wavelength QW LED, Abdullah J. Zakariya, *Saad Al-Abdullah Academy for Security Sciences, Kuwait City, Kuwait*

A monolithic tri-wavelength LED device with a multi-power control ports and a mono-output is proposed as single source for RGB color displays. The LED consists of a monolithic selectively intermixed QW structure emitting three independently controlled wavelengths of 805 nm, 787 nm and 772 nm simultaneously or individually.

11:45 am–12:00 pm

ThC3.4 Nanosecond Mid-Infrared Pulse Generation Via Modulated Thermal Emission, Yuzhe Xiao, *University of Wisconsin-Madison, Madison, WI, USA,* Nicholas A. Charipar, Alberto Piqué, *Naval Research Laboratory, Washington, DC, USA*, and Mikhail A. Kats, *University of Wisconsin-Madison, Madison, WI, USA*

We demonstrated that mid-infrared pulses can be generated by fast emissivity modulation of semiconductors. Ultrafast visible-frequency pulses were used to pump intrinsic unpatterned silicon and gallium arsenide. The ultrafast free-carrier dynamics in these materials lead to nanosecond-scale pulsed thermal emission.

12:00 pm–12:15 pm

ThC3.5 Design Challenges for Mid-UV Laser Diodes, Qiang Guo, *North Carolina State Univeristy, Raleigh, NC, USA,* Ronny Kirste, Pramod Reddy, Seiji Mita, *Adroit Materials, Inc., Cary, NC, USA,* Ramon Collazo, and Zlatko Sitar, *North Carolina State University, Raleigh, NC, USA*

An optimized 270 nm UV laser structure is proposed with a predicted turn-on current density of 5 kA/cm^2. The possible loss mechanisms are discussed, including p-GaN contact layer absorption, impact of a graded AlGaN layer on hole injection, and loss due to Mg doping.

12:15 pm–12:30 pm

ThC3.6 Improving Density and Efficiency of Infrared Projectors, Miguel Hernandez, *University of Delaware, Newark, DE, USA,* Edwid Koerperick, *Firefly Photonics, Iowa City, IA, USA,* Peyman Barakhshan, Garrett Ejzak, Kassem Nabha, *University of Delaware, Newark, DE, USA,* John Prineas, *Firefly Photonics, Iowa City, IA, USA*, and Fouad Kiamilev, *University of Delaware, Newark, DE, USA*

Infrared scene projectors using LEDs instead of resistor arrays are a new technology that is gaining popularity within the infrared projection community. This paper describes an approach to increase the density and efficiency of LED arrays using the .18 transistor technology.

12:30 pm–1:30 pm **Emerald E**

Session WiP **Women in Photonics / Women in Science and Engineering Luncheon**

Session Chair Mary Kinsella, *Air Force Research Laboratory, OH, USA*

12:30 pm–1:30 pm ***(Lunch Presentation)***

WiP **Women in Science & Engineering – Choosing Freedom Over Equality and Other Controversial Thoughts,** Elisabetta Jerome, *Air Force Test Center, Eglin Air Force Base, FL, USA*

Should 50% of scientists and engineers be women? Today only 8% of mechanical engineers are women. Is that an inequality we need to fix? What does equality even mean? What should it look like? These and other thought provoking questions will be posed and discussed.

1:30 pm–3:30 pm **Coral Ballroom C**

Session ThC4 **UV Optoelectronics**

Session Chairs Gregory Garrett
Ramon Collazo, *North Carolina State University, NC, USA*

1:30 pm–2:00 pm ***(Invited)***

ThC4.1 Recent Breakthroughs in alGaN-Based UV Light Emitters, R. Kirste, S. Mita, *Adroit Materials, Inc., Cary, NC, USA,* Q. Guo, B. Sarkar, F. Kaess, *North Carolina State University, Raleigh, NC, USA,* J. Tweedie, *Adroit Materials, Inc., Cary, NC, USA,* R. Collazo, *North Carolina State University, Raleigh, NC, USA,* and Z. Sitar, *North Carolina State University & Adroit Materials, Inc., Raleigh & Cary, NC, USA*

AlGaN-based technology developed on single crystalline AlN substrates offers a pathway to UVC laser diodes. Extended defect an point defect control has enabled LD structures with lasing threshold as low as 3 kW/cm^2 for wavelengths from 237 to 280 nm.

2:00 pm–2:30 pm ***(Invited)***

ThC4.2 The Growth of Vertically Conducting algan heter ostructures on Patterned GaN Substrates, Andrew Allerman, Mary Crawford, Greg Pickrell, Andrew Armstrong, Vincent Abate, Michael Smith, and Karen Cross, *Sandia National Laboratories, Albuquerque, NM, USA*

We present laser diode emission at 352 nm from ridge waveguide structures fabricated from AlGaN alloys overgrown on patterned AlGaN/AlN/sapphire templates. To overcome the high lateral resistance of front-contacted lasers we will discuss the growth of AlGaN alloys on patterned, conducting HVPE GaN substrates.

2:30 pm–3:00 pm ***(Invited)***

ThC4.3 III-Nitride heter ostructures and Nanostructures Grown by Molecular Beam Epitaxy: Breaking the Efficiency Bottleneck of Deep Ultraviolet Photonics, Zetian Mi, *University of Michigan, Ann Arbor, Ann Arbor, MI, USA*

Recent advances of AlGaN nanostructures and heterostructures grown by molecular beam epitaxy, including the realization of efficient p-type conduction and surface-emitting UV laser diodes will be presented. Their prospects in breaking the efficiency bottleneck of deep UV LEDs and in integrated photonics will be discussed.

3:00 pm–3:30 pm ***(Invited)***

ThC4.4 Semiconductor UV Lasers – Conventional and Exotic appr oaches, Thomas Wunderer, *Palo Alto Research Center, Palo Alto, CA, USA*

PARC's Laser Diode technology offers Watt-level optical output in the UV-A spectral band. For AlGaN lasers in the UV-B and UV-C bands, challenges related to p-type doping necessitate advanced heterostructure designs that include polarization doping. A platform technology based on electron-beam excitation will be described.

3:30 pm–5:30 pm **Coral Ballroom C**

Session ThC5 Optical Detectors and Focal Plane arrays

Session Chairs Justin Cleary, *Air Force Research Laboratory, OH, USA*
Joshua Duran, *Air Force Research Laboratory, OH, USA*

3:30 pm–4:00 pm ***(Invited)***

ThC5.1 antimonide Based Infrar ed Detectors and Focal Plane arrays, Sanjay Krishna, *Ohio State University, Columbus, OH, USA*

I will describe some of the material science and device physics of the 6.1A family of semiconductors (InAs,GaSb and AlSb) which has the ability to engineer the bandstructure to obtain designer band-offsets.We will discuss superlattice based avalanche photodiodes and dielectric resonators to increase the SNR.

4:00 pm–4:30 pm ***(Invited)***

ThC5.2 Band Structure and Device Engineering of InGaas/InasSb Infrar ed Photodetectors, Josh Duran, *Air Force Research Laboratory, Wright-Patterson Air Force Base, OH, USA*

Strained-layer superlattice infrared photodetectors made from a variety of III-V material systems have proven utility for engineering bandgaps and heterostructures tailored to an application. We explore the InGaAs/InAsSb material system and highlight the wider design trade space afforded by greater flexibility in strain balancing.

4:30 pm–5:00 pm ***(Invited)***

ThC5.3 Microwave Based Lifetime Measurements and analysis for Detector Materials, Eric Shaner, Clark Kadlec, Michael Goldflam, Ed Bielejec, *Sandia National Laboratories, Albuquerque, NM, USA,* Preston Webster, *Air Force Research Laboratory, NM, USA,* Evan Anderson, Sam Hawkins, John Klem, and Jin Kim, *Sandia National Laboratories, Albuquerque, NM, USA*

We will present an overview of microwave based lifetime measurements for detector materials including basic parameter extraction, wafer level diagnostics, and a recently developed system for in situ study of materials in a radiation environment.

5:00 pm–5:15 pm

ThC5.4 Room Temperature GaasSb array Photodetectors, Ziyuan Li, *Australian National University, Canberra, Australia,* Simeon Trendafilov, Monica Allen, Jeffery Allen, *Air Force Research Laboratory, Eglin Air Force Base, FL, USA,* Ahmed Alabadla, Qian Gao, *Australian National University, Canberra, Australia,* Xiaoming Yuan, *Australian National University, Canberra, Australia and Central South University, Hunan, China,* Inseok Yang, *Australian National University, Canberra, Australia,* Philippe Caroff, *Australian National University, Canberra, Australia and Delft University of Technology, Delft, The Netherlands,* Hark Hoe Tan, Chennupati Jagadish, and Lan Fu, *Australian National University, Canberra, Australia*

GaAsSb nanowire arrays were grown by gold-seeded metalorganic vapor phase epitaxy (MOVPE) and fabricated into photodetector devices. The array photodetectors operate at room temperature with tunable resonance peaks varying with the array geometry. These devices are promising for multispectral photodetector applications.

5:15 pm–5:30 pm

ThC5.5 Electrical Readout of Carrier Dynamics in Micro-Scale Infrared Materials, S. Dev, Y. Wang, K. Kim, *University of Texas at Austin, Austin, TX, USA,* M. Zamiri, *University of Wisconsin, Madison, WI, USA,* S. Hawkins, E. Shaner, J. Kim, *Sandia National Laboratories, Albuquerque, NM, USA,* J. Allen, M. Allen, *Air Force Research Laboratory, Eglin Air Force Base, FL, USA,* S. Krishna, *Ohio State University, Columbus, OH, USA,* E. Tutuc, and D. Wasserman, *University of Texas at Austin, Austin, TX, USA*

We present a technique, Micro-Scale Microwave Resonator Time Response (μ-MRTR), capable of measuring photo-excited carrier lifetimes in micro-scale material volumes using a resonant microwave circuit with direct electrical readout. We demonstrate a ~105 improvement in sensitivity when compared to traditional lifetime measurement techniques.

5:30 pm–6:00 pm **Coral Ballroom C**

OEDDIP Panel Discussion

Session Chairs Ronald Rapp, *Air Force Research Laboratory, FL, USA*
Daniel Wasserman, *University of Texas at Austin, TX, USA*

7:00 pm–9:00 pm **Barefoot's Deck**

Welcome Reception

Track 4: Optical Metamaterials, Plasmonics and Subwavelength Photonics (OMPSP)

8:00 am–8:30 am **Coral Ballroom D**

Session ThD1 Optical Metamaterials, Plasmonics and Subwavelength Photonics

Session Chairs Jeffery Allen, *Air Force Research Laboratory, FL, USA*
Joshua Caldwell, *Vanderbilt University, TN, USA*

8:00 am–8:30 am ***(Keynote)***

ThD1.1 Metaphotonics: Where Do We Go from her e?, Nader Engheta, *University of Pennsylvania, Philadelphia, PA, USA*

With rapid growth and extensive development of the field of photonic metamaterials in the past two decades, in this talk we will forecast possible paths this field may be taking and how the future of our field may look like in the years to come.

8:30 am–10:30 am **Coral Ballroom D**

Session ThD2 **Plasmonic Devices and applications**

Session Chairs Monica Allen, *Air Force Research Laboratory, FL, USA*
Junpeng Guo, *University of Alabama in Huntsville, AL, USA*

8:30 am–9:00 am ***(Invited)***

ThD2.1 Limiting Optical Diodes, Mikhail Kats, *University of Wisconsin–Madison, Madison, WI, USA*

We the explore the use of phase-transition materials integrated into nanophotonic structures for applications in unidirectional optical limiters (limiting optical diodes). These devices can be very thin, and can function at low input powers without a lot of field enhancement, resulting in broadband operation.

9:00 am–9:30 am ***(Invited)***

ThD2.2 Tunable Plasmonic and Dielectric Metasurfaces, Harry Atwater, *California Institute of Technology, Pasadena, CA, USA*

Tunable nanoscale antenna arrays are bringing metasurfaces to life as dynamically active devices. Electrical tuning of the carrier density in conducting oxides, transition metal nitrides and two-dimensional materials enables active antenna arrays with gate-tunable amplitude, phase and polarization modulation for absorption, radiative emission and scattering.

9:30 am–10:00 am ***(Invited)***

ThD2.3 ENZ Optical Modulator, Ting Luk, Michael Wood, *Sandia National Laboratories, Albuquerque, NM, USA*, and Yuanmu Yang, *Tsinghua University, Beijing, China*

The potential of using Epsilon-near-zero materials as optical modulator had been recognized because charge depletion or accumulation can produce large index change and fast response. Results of compact gigahertz optical modulator device on silicon waveguide and ultrafast femtosecond polarization modulation will be presented.

10:00 am–10:15 am ***(Invited)***

ThD2.4 Plasmon Field Effect Transistor for Visible to Near IR Detection, Seongman Cho, Mark Ciappesoni, *University of Miami, Miami, FL, USA,* Monica Allen, Jeffery Allen, *Air Force Research Laboratory, Eglin Air Force Base, FL, USA,* Kevin Leedy, Brett Wenner, *Air Force Research Laboratory, Wright-Patterson Air Force Base, OH, USA*, and *Sung Jin Kim, University of Miami, Miami, FL, USA*

We present plasmon FET with various gold nanostructures for controlled spectral response from visible to near IR. Experimental data show the exponentially increased detection loss as the volume of nanostructure increases. Finally, we demonstrate a plasmon FET that can detect energy from visible to telecommunication wavelengths.

10:15 am–10:30 am ***(Invited)***

ThD2.5 Dielectrophoretic Nanoparticle Propellant Injection with Plasmonic acceleration,
Jaykob Maser, *Missouri University of Science and Technology, Rolla, MO, USA,* and Joshua Rovey, *University of Illinois at Urbana-Champaign, Urbana, IL, USA*

We analyze the influence that the injection rate of nanoparticle propellant, fed by dielectrophoretic forcing, has on the thrust profile of a plasmonic-based, small-satellite propulsion system. Thrust is achieved by inducing motion on net-neutral nanoparticles by the application of a plasmon generated non-uniform electromagnetic field.

10:30 am–12:30 pm **Coral Ballroom D**

Session ThD3 Optical Metamaterials Based Devices and applications

Session Chairs Jeffery Allen, *Air Force Research Laboratory, FL, USA*
Gennady Shvets, *Cornell University, NY, USA*

10:30 am–11:00 am ***(Invited)***

ThD3.1 actively-T unable Metasurfaces Based on Semiconductors and Metals,
Gennady Shvets, *Cornell University, Ithaca, NY, USA*

In this talk, I will describe metasurfaces that rely on free carriers for controlling their optical responses. Active nanophotonic structures are the Photon-Accelerating Semiconductor Infrared Metasurfaces (PASIM) that can be used to control light propagation through self-consistent generation of electron-hole pairs will be discussed.

11:00 am–11:30 am ***(Invited)***

ThD3.2 Nanostructured Diamond Optics for high Power Laser applications,
Haig Avedis Atikian, *Harvard University, Cambridge, MA, USA*

High average power lasers place a significant thermal load on typical optical components based on multilayer thin-film coatings. We present a novel solution, where nanostructured transmissive and reflective optics are etched from bulk diamond substrates, creating optical elements with exceptionally high laser induced damage thresholds.

11:30 am–11:45 am

ThD3.3 Electrically Tunable Thz Polarization Conversion in Liquid Crystal Metamaterials,
Elizabath Philip, Sharmistha Pal, Hancheng Shen, M. Zeki Gungordu, Sina Soleymani, Patrick Kung, and Seongsin Margaret Kim, *University of Alabama, Tuscaloosa, AL, USA*

We report a dynamically tunable, LC incorporated MM device capable of achieving linear to elliptical polarization conversion of THz wave. By further optimizing the LC thickness and modifying the bias voltage, the device can completely convert the incident linear polarization to circularly polarized light.

11:45 am–12:00 pm

ThD3.4 Perfect Diffraction Using all-Dielectric Bianisotr opic Metagratings, Zhiyuan Fan, Maxim R. Shcherbakov, *Cornell University, Ithaca, NY, USA,* Monica Allen, Jeffery Allen, *Air Force Research Laboratory, Eglin Air Force Base, FL, USA,* Brett Wenner, *Air Force Research Laboratory, Wright-Patterson Air Force Base, OH, USA*, and Gennady Shvets, *Cornell University, Ithaca, NY, USA*

Bianisotropic metamolecules supporting multiple resonances of appropriate symmetry can be used to assemble a perfectly diffractive metagrating, where all but one transmission/reflection channel is suppressed due to radiated field interference. We design, fabricate and characterize such a metagrating on a silicon-on-insulator platform for mid-infrared wavelengths.

12:00 pm–12:15 pm

ThD3.5 Implementing Photonic Crystals, Instead of Metamaterials, in the Media of Transformation Optics-Based Devices, S. Jamilan, G. Semouchkin, E. Semouchkina, *Michigan Technological University, Houghton, MI, USA*

Extending Transformation Optics in optical range is challenging because of losses in metamaterials. We propose, instead, to use dielectric photonic crystals capable of supporting superluminal wave propagation and realizing spatial dispersion of refractive index values. Implementing these materials in cylindrical invisibility cloaks is demonstrated.

12:15 pm–12:30 pm

ThD3.6 Characterizing Meta-Lens Performance as a Function of Refractive Index, Elyas Bayati, Alan Zhan, Shane Colburn, and Arka Majumdar, *University of Washington, Seattle, WA, USA*

Several materials with different refractive indices have been used to create meta-lenses. In this paper, we analyze the role of material refractive indices in the performance of a meta-lens. We employ both forward and inverse design methodologies to perform our analysis.

12:30 pm–1:30 pm **Emerald E**

Session WiP **Women in Photonics / Women in Science and Engineering Luncheon**

Session Chair Mary Kinsella, *Air Force Research Laboratory, OH, USA*

12:30 pm–1:30 pm ***(Lunch Presentation)***

WiP **Women in Science & Engineering – Choosing Freedom Over Equality and Other Controversial Thoughts,** Elisabetta Jerome, *Air Force Test Center, Eglin Air Force Base, FL, USA*

Should 50% of scientists and engineers be women? Today only 8% of mechanical engineers are women. Is that an inequality we need to fix? What does equality even mean? What should it look like? These and other thought provoking questions will be posed and discussed.

1:30 pm–3:30 pm **Coral Ballroom D**

Session ThD4 **Optical Metasurfaces and applications**

Session Chairs Augustine Urbas, *Air Force Research Laboratory, OH, USA*
Mikhail Kats, *University of Wisconsin, WI, USA*

1:30 pm–2:00 pm ***(Invited)***

ThD4.1 Ultrathin Dielectric Metasurfaces for Manipulating Visible Light, Daniel Lopez, Haogang Cai, David Czaplewski, Karim Ogando, Alex Martinson, David Gosztola, and Liliana Stan, *Argonne National Laboratory, Lemont, IL, USA*

A new methodology to implement single-layer multi-wavelength metasurfaces is presented. These metasurfaces employ ultrathin dielectric resonators (thickness << wavelength) to locally manipulate the transmission of light. We validate the potential of the proposed approach by demonstrating achromatic meta-lenses for diffraction-limited focusing in the visible band.

2:00 pm–2:30 pm ***(Invited)***

ThD4.2 Unique Properties of 3D Infrared Metamaterials, D. Bruce Burckel, *Sandia National Laboratories, Albuquerque, NM, USA*

We have recently demonstrated membrane projection lithography (MPL) as a fabrication technique capable of creating meta-films with complex lattice+basis geometries with 3D unit cells, meta-atoms and spatial arrangements. Here we show that 3D meta-atoms possess unique coupling/excitation mechanisms which can add functionality to metamaterial applications.

2:30 pm–3:00 pm ***(Invited)***

ThD4.3 Plasmonic Metamaterials 2.0: New applications for Metasurfaces & 4D Photonics, Vladimir Shalaev, *Purdue University, West Lafayette, IN, USA*

The fields of nanophotonics and plasmonics enabled unprecedented ways to control the flow light at the nanometer scaleIn this presentation, novel emerging plasmonic concepts and material platforms will be discussed with the focus on practical photonic technologies for sensing, quantum optics, bio-medical and energy applications.

3:00 pm–3:15 pm

ThD4.4 Thermally Tunable Far-Infrared Metasurfaces Enabled by $Ge_2Sb_2Te_5$ Phase-Change Material, Riad Yahiaoui, *Howard University, Washington, DC, USA,* Joshua A. Burrow, Gary Sevison, Andrew Sarangan, Jay Mathews, Imad Agha, *University of Dayton, Dayton, OH, USA,* Augustine M. Urbas, *Air Force Research Laboratory, Wright-Patterson Air Force Base, OH, USA*, and *Thomas A. Searles, Howard University, Washington, DC, USA*

We demonstrate a tunable far-infrared metasurface device featuring an analogue of electromagnetically induced transparency (EIT) and a thin layer of temperature-driven phase change material, $Ge_2Sb_2Te_5$. The EIT originates from near-field coupling of bright and quasi-dark resonances resonating at nearly the same frequency with contrasting linewidths.

3:15 pm–3:30 pm

ThD4.5 Fourier-Transform Pulse Shaping with Metasurfaces, Shawn Divitt, Wenqi Zhu, Cheng Zhang, *National Institute of Standards and Technology, Gaithersburg, MD, USA and University of Maryland, College Park, MD, USA,* Henri J. Lezec, *National Institute of Standards and Technology, Gaithersburg, MD, USA,* and Amit Agrawal, *National Institute of Standards and Technology, Gaithersburg, MD, USA and University of Maryland, College Park, MD, USA*

Metasurfaces offer a unique opportunity in ultrafast pulse shaping: a large array of small pixels. This feature enables control over individual frequency comb lines from pulsed lasers with low repetition rates. We present our recent results in shaping of sub-15 femtosecond pulses using metasurfaces.

3:30 pm–5:30 pm **Coral Ballroom D**

Session ThD5 Dynamic Control of Self-assembled Plasmonic Nanostructures

Session Chairs Jake Fontanta, *Naval Research Laboratory, Washington, DC, USA*
Jason Valentine, *Vanderbilt University, AL, USA*

3:30 pm–3:50 pm ***(Invited)***

ThD5.1 Interface of Physics and Biomedicine: The Next Big Thing is at the Nanoscale, Giuseppe Strangi, *Case Western University, Cleveland, OH, USA*

3:50 pm–4:10 pm ***(Invited)***

ThD5.2 Third Order Nonlinear Optics in Self-assembled Gold Metasurfaces, Anderson Gomes, *Universidade Federal de Pernambuco, Recife, Brazil*

Self-assembled gold metasurfaces, composed of a monolayer of quasi-hexagonally close packed gold nanospheres on glass substrate were studied using femtosecond on-resonance (~800 nm) and off-resonance (1500 nm) excitation sources. Besides enhanced optical nonlinearities, an off-resonance ~2ps response time and a violation of Miller's rule were revealed.

4:10 pm–4:30 pm ***(Invited)***

ThD5.3 Ultrafast Optical Pulses for Characterising and Shaping Nanomaterials, Ventsislav Valev, *Univeristy of Bath, Bath, UK*

Due to their power-law dependence on optical near-fields, nonlinear optical techniques are excellent probes for plasmonic nanomaterials. For the best nonlinear signal, illumination intensity should be just below the sample damage threshold. Above, the optical probes become useful tools, for shaping materials at the nanoscale.

4:30 pm–4:50 pm ***(Invited)***

ThD5.4 Tunable Optical Properties of Polymer-Grafted Gold Nanoparticle assemblies, Kyoungweon Park, Jason Streit, Andrew Tibbits, Dhriti Nepal, Richard Vaia, *Air Force Research Laboratory, Wright-Patterson Air Force Base, OH, USA*

Precisely tailored polymer grafted gold nanoparticles are fabricated via varying size and shape of gold nanoparticles and organic corona structure. By modulating the subsequent processing conditions, we demonstrate to fabricate nano-architectures comprised of organized assemblies of polymer-grafted plasmonic nanoparticles with tunable structural and optical properties.

4:50 pm–5:10 pm ***(Invited)***

ThD5.5 Emerging Materials for Dynamic Photonics, Marina Leite, *University of Maryland, College Park, MD, USA*

Dynamic tunability has been a 'holy grail' objective in nanophotonics because it enables reconfigurability. Mg and MgO form an ideal platform for zero-power reconfigurable photonics as they vanish in water. We demonstrate transient devices ranging from color pixels to nanostructures with dynamic LSPR for encryption.

5:10 pm–5:30 pm ***(Invited)***

ThD5.6 Nonreciprocal Nanophotonics with Dielectric and Plasmonic Metasurfaces, Jennifer Dionne, *Stanford University, Stanford, CA, USA*

We introduce two new nanophotonic designs for nonreciprocal transmission of near infrared light within subwavelength optical paths. Compared to existing schemes, these platforms enable time-reversal-symmetry breaking for arbitrary free-space and modal optical inputs in a simple, robust materials platform.

5:30 pm–6:00 pm **Coral Ballroom D**

OMPSP Panel Discussion

Session Chairs Jeffrey Allen, *Air Force Research Laboratory, FL, USA*
Josh Caldwell, *Vanderbilt University, TN, USA*

7:00 pm–9:00 pm **Barefoot's Deck**

Welcome Reception

Track 5: Photonics for Defense Systems (PDS)

8:00 am–8:30 am **her on**
Session ThE1 **Photonics for Defense Systems**
Session Chairs Robert Orgusaar, *Air Force Research Laboratory, FL, USA*
Mark Schmitt, *Air Force Research Laboratory, OH, USA*

8:00 am–8:30 am ***(Keynote)***

ThE1.1 Photonics for Defense Systems – Opening Remarks, Dalma Novak, Rod Waterhouse, *Pharad, LLC, Hanover, MD, USA*

Photonic technology provides enhanced capabilities, performance improvements, and design flexibility for a variety of RF/microwave systems. Its signal remoting and distribution capabilities, along with advanced processing functionalities, offer the potential for increased insertion into military platforms. This talk introduces some defense applications of photonics.

8:30 am–10:30 am **her on**
Session ThE2 **EO/IR/LaDaR**
Session Chairs Christian Keyser, *Air Force Research Laboratory, FL, USA*
Steve Marlow, *Air Force Research Laboratory, FL, USA*

8:30 am–9:00 am ***(Invited)***

ThE2.1 advanced Infrar ed Target acquisition Systems, Ronald Driggers, *Universityof Central Florida, Orlando, FL, USA*

There are many advances in infrared components to include small pitch infrared focal planes, digital readout integrated circuits, multiband detectors, and flat optics. How are the advances best used in infrared target acquistion systems? We review some of these advances and provide concepts for system optimization.

9:00 am–9:30 am ***(Invited)***

ThE2.2 LIDa R Development at NaSa Langley Research Center for Vehicle Navigation and Landing in GPS Denied Environments, Diego F. Pierrottet, *Coherent Applications, Inc., Hampton, VA, USA,* Farzin Amzajerdian, Glenn D. Hines, Bruce W. Barnes, Larry B. Petway, *NASA Langley Research Center, Hampton, VA, USA*, and John M. Carson III, *NASA Johnson Space Center, Houston, TX, USA*

NASA missions for human or robotic landings on planetary bodies require precision state navigation estimates obtained from sensing modalities that are self-contained, and applicable to GPS-denied environments. The Navigation Doppler Lidar meets these requirements by providing precision velocity vectors and altitude data.

9:30–9:45 am

ThE2.3 Single-Pulse Mueller Matrix Polarimeter Laboratory Demonstration, Christian Keyser, *Air Force Research Laboratory, Eglin Air Force Base, FL, USA,* Khanh Nguyen, *Torch Technologies, Shalimar, FL, USA,* Arielle Adams, *Engility Corp., Shalimar, FL, USA*, and Richard Martin, *Air Force Institute of Technology, Wright-Patterson Air Force Base, OH, USA*

Motivated by a desire to reduce CSWAP, yet maintain high scan speed, we numerically and experimentally explore a new scanning LADAR architecture that employs temporal multiplexing to enable Mueller matrix measurement for each point in a scene with a single ns-scale illumination laser pulse.

9:45 am–10:00 am

ThE2.4 Increased Spectral Sampling with Temporally Multiplexed Raman Waveform LaDaR, Luke Ausley, Christian Keyser, *Air Force Research Laboratory, Eglin Air Force Base, FL, USA*, and Richard Martin, *Air Force Institute of Technology, Wright-Patterson Air Force Base, OH, USA*

We present a novel multispectral LADAR architecture that may enable enhanced object discrimination or identification with lower cost, size, weight, and power than current multispectral LADAR systems. Several temporally multiplexed architectures, which leverage stimulated Raman scattering in hollow-core fibers, are analyzed and show significant promise.

10:00 am–10:15 am

ThE2.5 MEMS-Based Low SWaP Solutions for Multi/hyperspectral Infrar ed Sensing and Imaging, Jorge Silva, Hemendra Kala, Dhirendra Kumar Tripathi, K. K. M. B. Dilusha Silva, Mariusz Martyniuk, Adrian Keating, Gino Putrino, and Lorenzo Faraone, *University of Western Australia, Perth, Australia*

A MEMS-based tunable filter platform is presented for multi/hyper-spectral sensing/imaging at SWIR, MWIR or LWIR wavelengths. Large-area SWIR filters have surface flatness < 15 nm with excellent optical uniformity, and narrow-band filters using air as the low index medium demonstrate spectral linewidths of $\delta \lambda/\lambda < 2\%$.

10:15 am–10:30 am

ThE2.6 Optical Transmittance and Reflectance of Lanthanum Nickelate at Telecommunication Frequencies, Todd Schumann, Jacob Neff, Shayla Breedlove, Henry Zmuda, Yong-Kyu Yoon, *University of Florida, Gainesville, FL, USA,* David Look, Kevin Leedy, *Air Force Research Laboratory, Wright-Patterson Air Force Base, OH, USA,* Monica Allen, and Jeffery Allen, *Air Force Research Lab, Eglin Air Force Base, FL, USA*

The optical properties of lanthanum nickelate (LNO) films grown by chemical solution decomposition on sapphire substrates were measured and extracted. The relatively low imaginary part of the dielectric function indicates that LNO may perform well in plasmonic applications at traditional telecommunication frequencies.

10:30 am–12:30 pm **her on**
Session ThE3 **Instrumentation and Control for Test and Evaluation**
Session Chairs Michael Johnson, *SKI, FL, USA*
Robert Orgusaar, *Air Force Research Laboratory, FL, USA*

10:30 am–11:00 am ***(Invited)***

ThE3.1 What Causes Disagreement Between Models and Measurements of Imaging System Performance?, Daniel LeMaster, *Air Force Research Laboratory, Wright-Patterson Air Force Base, OH, USA*

NIIRS is a widely applied measure of image quality and the GIQE is an established method of predicting NIIRS. We present two cases where NIIRS ratings made by analysts do not match GIQE predictions and explore the factors that may explain these discrepancies.

11:00 am–11:15 am

ThE3.2 Miniature Fiber Laser Microphones with Graphene Diaphragms, Shaolin Liao, *Argonne National Laboratory, Lemont, IL, USA and Illinois Institute of Technology, Chicago, IL, USA,* Thomas Wong, Zi Wang, Rong Wang, Elwin Clutter, *Illinois Institute of Technology, Chicago, IL, USA*, and Hual-Te Chien, *Argonne National Laboratory, Lemont, IL, USA*

We have developed a novel type of Fiber Laser Microphone (FLM) based on miniature Distributed Bragg Reflectors/Distributed Feedback Bragg (DBR/DFB) fiber lasers with graphene as diaphgrams, i.e., the graphene-FLM. We carried out laboratory measurement of the graphene-FLM with acoustic frequency up to 10 kHz.

11:15 am–11:30 am

ThE3.3 End to End Testing of IRLED Projectors, Peyman Barakhshan, Miguel Hernandez, Kassem Nabha, Casey Campbell, Jeffrey Volz, Aaron Landwehr, Rebekah Houser, Fouad Kiamilev, *University of Delaware, Newark, DE, USA,* Russell J. Ricker, Sydney Provence, John P. Prineas, and Thomas F. Boggess, *University of Iowa, Iowa City, IA, USA*

In 2014, our team built the world's first infrared LED scene projector. This system is called the SLEDS projector, and has been thoroughly tested and evaluated at numerous user facilities. New and upgraded versions of the SLEDS projector have been developed.

11:30 am–11:45 am

ThE3.4 Counter Directional Optical Network Using Ribbon Fiber, John Mazurowski, *Pennsylvania State University, Freeport, PA, USA*

This ring network incorporates a common source module and nodes. The nominal number of nodes equals the number of fibers in the physical layer. Transmission requires connecting a transmission fiber with a receiving fiber and modulating the signal, which then travels in the reverse direction.

11:45 am–12:00 pm

ThE3.5 analysis of Multibeam WDM-FSO System in Various Weather Conditions, Achintya Murali, Prabu K, *Vellore Institute of Technology, Bangalore, India*

This project aims to analyse the use of multibeam technology in enduring the effect of multiple weather conditions on the FSO link by comparing it with the single beam technology. Mathematical models for each of the weather patterns have been compared and chosen for this.

12:00 pm–12:15 pm

ThE3.6 Toward a Packetized Display Protocol ar chitecture for IRLED Projector Systems, Aaron Landwehr, Andrea Waite, Tyler Browning, Christopher Jackson, Rebekah Houser, Hamzah Ahmed, and Fouad Kiamilev, *University of Delaware, Newark, DE, USA*

Traditional display protocols have limitations in terms of fixed frame rates, high bandwidth requirements, and precise control over the display of frames. We propose a novel scalable packetized display protocol architecture incorporating dynamic frame rates, high speed capabilities, and dynamic synchronization to bridge performance gaps.

12:15 pm–12:30 pm

ThE3.7 Compact Ultra-Low-Noise Photonic Microwave Synthesizer, Michele Giunta, *Menlo Systems GmbH, Martinsried, Germany and Max-Planck-Institut fur Quantenoptik, Garching, Germany,* Maurice Lessing, Wolfgang Hänsel, Matthias Lezius, Marc Fischer, Ronald Holzwarth, *Menlo Systems GmbH, Martinsried, Germany,* Jason Reeves, *Menlo Systems Inc., Newton, NJ, USA,* Xiaopeng Xie, Yann Le Coq, *Observatoire de Paris, Paris, France*, and Giorgio Santarelli, *Université de Bordeaux 1, Talence, France*

An ultra-low-noise photonic microwave synthesizer based on a compact frequency comb is transferring the spectral purity of an ultra-stable-laser down to a 12 GHz carrier with residual phase noise of –115 dBc/Hz at 1 Hz and –170 dBc/Hz at 10 kHz from the microwave carrier.

12:30 pm–1:30 pm **Emerald E**

Session WiP **Women in Photonics / Women in Science and Engineering Luncheon**

Session Chair Mary Kinsella, *Air Force Research Laboratory, OH, USA*

12:30 pm–1:30 pm ***(Lunch Presentation)***

WiP **Women in Science & Engineering – Choosing Freedom Over Equality and Other Controversial Thoughts,** Elisabetta Jerome, *Air Force Test Center, Eglin Air Force Base, FL, USA*

Should 50% of scientists and engineers be women? Today only 8% of mechanical engineers are women. Is that an inequality we need to fix? What does equality even mean? What should it look like? These and other thought provoking questions will be posed and discussed.

1:30 pm–3:30 pm **her on**

Session ThE4 **Enabling Tools for Testing Rapidly Evolving EO/IR Systems**

Session Chairs Andreas Keipert, *46 TW, FL, USA*
Jason Vosatka, *46 TW, FL, USA*

1:30 pm–2:00 pm ***(Invited)***

ThE4.1 Cyber Physical Systems T&E, Michael Deis, *Ohio University, Beavercreek, OH, USA*

Advancing cyber technologies are making T&E more complex. This complexity is forcing two realities together: how do we address cyber security for aging weapons systems and how do we bake cyber into new systems? More importantly, how do we provide T&E to support these extremes?

2:00 pm–2:10 pm ***(Invited)***

ThE4.2 Future Needs in Photonics: a T&E Perspective, Andreas Keipert, *Miramar Beach, FL, USA*

2:10 pm–2:30 pm ***(Invited)***

ThE4.3 Free-Space RF Confined Guiding with Laser Filaments, Shermineh Rostami, *Florida Institute of Technology, FL, USA*

Filament induced plasma waveguides can be engineered for free-space EM wave guiding. The efficiency of these structures are strongly dependent on their spatial arrangement and relative phase. The stability and properties of these structures will be discussed, from a single wire to a multi-channel design.

2:30 pm–2:45 pm

ThE4.4 Metal-assisted Chemical Etching of β-Ga $_2O_3$ and Textured MSM Photodetectors with Enhanced Responsivity, Xiuling Li, *University of Illinois, Urbana, IL, USA,*

β-Ga_2O_3 is an emerging material that has started to attract unprecedented attention in the wide bandgap semiconductor community, and holds great promise for next generation power electronics and solar blind optoelectronics. Anti-reflection micro and nanostructure texturing of semiconductor surfaces offers proven advantages in efficient light management for photovoltaic...

2:45 pm–3:00 pm

ThE4.5 Modular System ar chitecture as a Foundation for Rapid IRSP Development, Rebekah Houser, Hamzah Ahmed, Kassem Nabha, and Fouad Kiamilev, *University of Delaware, Newark, DE, USA*

Infrared scene projectors based on superlattice light emitting diodes (SLEDs) have evolved relatively rapidly over the past decade. Much of this development has been enabled by the design of a flexible support system for driving the SLEDs. This paper describes the system and its benefits.

3:00 pm–3:15 pm

ThE4.6 Improved MWIR LED arrays on Si Substrates for Scene Projectors, S. R. Bank, K. M. McNicholas, R. H. El-Jaroudi, A. K. Rockwell, *University of Texas at Austin, Austin, TX, USA,* T. Golding, R. Droopad, J. Shao, W. K. Jamison, G. Wicks, and G. Savich, *Amethyst Research Inc., Ardmore, OK, USA*

Recent progress incorporating record boron concentrations in coherent direct-bandgap BGaAs films on GaAs, we have been investigating the growth of BGaAs on GaP. The transition to GaP substrates provides a straightforward avenue for epitaxial incorporation of direct-gap BGa(In)As layers with silicon via commercially available GaP-on-silicon.

3:15 pm–3:30 pm

ThE4.7 Modular Carrier Board and Package for Infrared LED arrays, Tianne L. Lassiter, Jonathan Dickason, Garrett A. Ejzak, Zackary Marks, Andrea Waite, and Fouad E. Kiamilev, *University of Delaware, Newark, DE, USA*

Infrared scene projector (IRSPs) are critical laboratory tools for setup, calibration, and testing of infrared imaging systems. Projectors are progressing to handle higher resolution, faster frame rates and improvement in thermal performance. This work highlights the cryostat design and how this effects the systems hardware.

3:30 pm–5:30 pm **her on**

Session ThE5 Displays, holography and Pr ojection

Session Chairs Ronald Rapp, *Air Force Research Laboratory, FL, USA*
Fouad Kiamilev, *University of Delware, DE, USA*

3:30 pm–4:00 pm ***(Invited)***

ThE5.1 Improved Quantum Efficiency in alGaInSb/Inas Superlattices for Mid-Infrared Optoelectronics, John Prineas, Cassandra Bogh, Aaron Muhowski, Katrina Schrock, Andrew Muellerleile, Jonathon Olesberg, and Michael Flatté, *University of Iowa, Iowa City, IA, USA*

Several mid-infrared superlattices with different material combinations have been designed and grown by molecular beam epitaxy. An ultrafast technique has been refined with CW measurements to obtain superlattice A, B, C recombination coefficients and quantum efficiency. Promising results on AlGaInSb/InAs and other superlattices are presented.

4:00 pm–4:25 pm ***(Invited)***

ThE5.2 Light Emitting arrays for high Temperature Scene Projection, Michael MacDougal, Jon Geske, *Attollo Engineering, LLC, Camarillo, CA, USA,* Arkadiy Lyakh, and Pedro Figueiredo, *University of Central Florida, Orlando, FL, USA*

Attollo Engineering will discuss development efforts toward light emitting arrays for scene projectors to achieve high temperatures. These include MWIR light emitting diodes, single-color lasers, and two-color lasers. Attollo will present device data and the impact of using these devices in scene projector systems.

4:25 pm–4:50 pm ***(Invited)***

ThE5.3 Quantum Dots for Multi-Band Infrared Scene Projector, Zhitao Kang, J. Christopher James, Brent Wagner, Zhiqun Lin, Young Jun Yoon, Cheng-Hsin Lu, Yajing Chang, *Georgia Tech Research Institute, Atlanta, GA, USA,* Hisham Menkara, and Christopher Summers, *PhosphorTech Corporation, Kennesaw, GA, USA*

Recent work is presented on the development of a dual-color MWIR display suitable for scene projection using a combination of quantum dot (QD) technology and commercial LCDs. PbSe QDs were prepared using colloidal techniques and evaluated in a proof of concept VIS-to-IR LCD.

4:50 pm–5:15 pm ***(Invited)***

ThE5.4 Infrared Scene Projector Based on Vertically aligned Carbon Nanotubes, Raul Fainchtein, *Johns Hopkins University, Baltimore, MD, USA*

Feasibility, advantages and status of IR scene projectors based on vertically-aligned, carbon nanotubes will be presented. VACNTs absorb all incoming light, heat up and emit broadband infrared radiation as ideal Planck blackbodies at the surface temperature. VACNT IRSPs emit at wavelengths between 2–22 μm, frame rates >500 Hz and apparent temperatures >800 K.

5:15 pm–5:30 pm

ThE5.5 Improving Density and Efficiency of Infrared Projectors, Miguel Hernandez, *University of Delaware, Newark, DE, USA,* Edwid Koerperick, *Firefly Photonics, Iowa City, IA, USA,* Peyman Barakhshan, Garrett Ejzak, Kassem Nabha, *University of Delaware, Newark, DE, USA,* John Prineas, *Firefly Photonics, Iowa City, IA, USA,* and Fouad Kiamilev, *University of Delaware, Newark, DE, USA*

Infrared scene projectors using LEDs instead of resistor arrays are a new technology that is gaining popularity within the infrared projection community. This paper describes an approach to increase the density and efficiency of LED arrays using the .18 transistor technology.

5:30 pm–6:00 pm **her on**

PDS Panel Discussion

Session Chairs Robert Orgusaar, *Air Force Research Laboratory, FL, USA*
Mark Schmitt, *Air Force Research Laboratory, OH, USA*

7:00 pm–9:00 pm **Barefoot's Deck**

Welcome Reception

9:00 am–11:00 am **Theater**
Session ThF2 **Tutorial I**
Session Chair Chris McCartan, *AFRL/RWMFS, FL, USA*

9:00 am–10:00 am ***(Tutorial)***

ThF2.1 Tutorial for IEEE-RaPID 2018 on Quantum Cascade Lasers (QCL), Quantum Cascade Detectors (QCD), and Quantum Cascade Laser Detectors (QCLD), Aaron M. Andrews, *Technische Universtät Wien, Vienna, Austria*

Quantum cascade lasers (QCL) are unipolar intersubband lasers where the lasing energy, extraction, and injection are designed through band gap engineering. As a result, QCLs can emit high-power coherent radiation from 3-300 μm. This broad spectrum covers the MIR and THz chemical fingerprint regions and...

10:00 am–11:00 am ***(Tutorial)***

ThF2.2 Packaging Photonics & Electronics for harsh Mechanical Envir onments, Jacob Dodson, *Air Force Reserach Laboratory, Eglin Air Force Base, FL, USA,*

This tutorial will introduce quantitative methods useful for the design and evaluation of high-g electronics and photonics; specifically loadings that result from a sudden change in velocity (velocity shock, >50 ft/s). Emphasis will be placed on the mechanical and thermal aspects of the design process.

12:30 pm–1:30 pm **Emerald E**
Session WiP **Women in Photonics / Women in Science and Engineering Luncheon**
Session Chair Mary Kinsella, *Air Force Research Laboratory, OH, USA*

12:30 pm–1:30 pm ***(Lunch Presentation)***

WiP Women in Science & Engineering – Choosing Freedom Over Equality and Other Controversial Thoughts, Elisabetta Jerome, *Air Force Test Center, Eglin Air Force Base, FL, USA*

Should 50% of scientists and engineers be women? Today only 8% of mechanical engineers are women. Is that an inequality we need to fix? What does equality even mean? What should it look like? These and other thought provoking questions will be posed and discussed.

2:00 pm–4:00 pm **Theater**
Session ThF4 **Tutorial II**
Session Chair Chris McCartan, *AFRL/RWMFS, FL, USA*

2:00 pm–3:00 pm ***(Tutorial)***

ThF4.1 Support Opportunities in Defense R&D, Jason Foley, *EOARD (European Office of Aerospace R&D), Ruislip, UK*

This tutorial presentation will begin with an overview of U.S. Department of Defense programs (both funded and unfunded) that support defense research at domestic and international institutions. This will be followed by an informal panel discussion with representatives from various U.S. defense research funding organizations.

3:00 pm–4:00 pm ***(Tutorial)***

ThF4.2 Work Life Balance, Janet Wolfson, *Air Force Research Laboratory, AL, USA*

How do you balance your dream job with your dream life? What happens if your dream job turns out to not be what you thought it was? This session will cover the challenges of pursuing your dreams and the choices we make between our career and personal life.

7:00 pm–9:00 pm **Barefoot's Deck**

Welcome Reception

Track 6:human State Measur ement and Biosensing (hMB)

8:00 am–8:30 am **Coral Ballroom a**

Session Fa1 **human State Measur ement and Biosensing**

Session Chairs Rajesh Naik, *Air Force Research Laboratory, OH, USA*
Brett Wenner, *Air Force Research Laboratory, OH, USA*

8:00 am–8:30 am ***(Keynote)***

Fa1.1 **Wearable Technologies for human Performance and health,** Rajesh R. Naik, *Air Force Research Laboratory, Wright-Patterson Air Force Base, OH, USA*

Wearable sensing technologies can be used for monitoring the health and performance of our warfighters, to assess operator readiness and be an enabler for human-machine teaming. Challenges reamin with the implementation of wearables in a military domain to include device robustness, data analytics and augmentation strategies.

aerospace, automotive and national security.

8:30 am–10:30 am **Coral Ballroom a**

Session Fa2 **Biosensing Methods**

Session Chairs Jorge Chavez-Benavides, *Air Force Research Laboratory, OH, USA*
Matteo Palma, *Queen Mary, University of London, UK*

8:30 am–9:00 am ***(Invited)***

Fa2.1 **Nanophotonic Biosensor Platforms for Ultrasensitive and Multiplex analysis at the Point-of-Care,** Laura Lechuga, *Catalan Institute of Nanoscience and Nanotechnology, Barcelona, Spain*

Motivated by beneficts as user-friendly, multiplexing capabilities and higher sensitivities, nanophotonic biosensors are an excellent alternative to traditional techniques. We use innovative designs of nanointerferometric biosensors and lab-on-chip integration. We have demonstrated their extreme sensitive and selective detection of disease biomarkers directly in un-treated fluids.

9:00 am–9:30 am ***(Invited)***

Fa2.2 **Exploiting Biology-Inspired Electrochemical Sensing in the Measurement and Control of Specific Molecular Targets Directly in the Living Body,** Netz Arroyo, *Johns Hopkins University School of Medicine, Baltimore, MD, USA*

Electrochemical, aptamer-based (E-AB) sensors support the continuous, real-time measurement of specific molecules in situ in the body. Exploiting this ability, I describe here efforts to couple E-AB sensing with closed-loop control to achieve feedback-controlled drug delivery directly in live animals.

9:30 am–10:00 am ***(Invited)***

Fa2.3 **Factors in Biomarker Sensor Development for human Performance and Pr otection,** Steve Kim, Michael Brothers, Yen Ngo, *Air Force Research Laboratory, Wright-Patterson Air Force Base, OH, USA,* Ahmad Islam, *Materials & Manufacturing Directorate, Wright-Patterson Air Force Base, OH, USA,* Trung Do, *Air Force Research Laboratory, Wright-Patterson Air Force Base, OH, USA,* Ari Nicolini, *Materials & Manufacturing Directorate, Wright-Patterson Air Force Base, OH, USA,* Jorge L. Chavez, Jennifer Martin, Claude Grigsby, *Air Force Research Laboratory, Wright-Patterson Air Force Base, OH, USA,* Benji Maruyama, Lawrence Drummy, *Materials & Manufacturing Directorate, Wright-Patterson Air Force Base, OH, USA,* and Rajesh Naik, *Air Force Research Laboratory, Wright-Patterson Air Force Base, OH, USA*

Human performance monitoring and health protection requires precise chemical and biochemical sensing. The biomarker detection in physiologically relevant media faces significant challenges from chemical interference and environmental extremity. This presentation will provide an in-depth look on the factors governing in the biomarker sensor development.

10:00 am–10:30 am ***(Invited)***

Fa2.4 **Carbon Nanostructures hybrids for Multiplexed Sensing and Single-Molecule Investigations,** Matteo Palma, *Queen Mary University of London, London, UK*

The rapid development of nanoscale biosensors combining nanomaterials and biological components offers great opportunities for biomarkers' detection. We developed different nanohybrid platforms via the controlled in-solution assembly of aptamers, proteins or semiconductor nanocrystals on individual carbon nanotubes employed as either transducer elements or nanoelectrodes for single-molecule investigations.

10:30 am–12:30 pm **Coral Ballroom a**

Session Fa3 **Materials and Devices for Biosensing**

Session Chair Brett Wenner, *Air Force Research Laboratory, OH, USA*

10:30 am–11:00 am ***(Invited)***

Fa3.1 **Sensing Electronics on Ultra-Thin Nanocellulose Sheets,** Jonathan D. Yuen, Scott A. Walper, Dan Zabetakis, Michael A. Daniele, David A. Stenger, and Banahalli R. Ratna

We will describe our ongoing work on the development of sensing electronics on microns-thin bacterial nanocellulose for human monitoring applications. We have developed an ultra-thin electronic decals that measure human body temperature and perform pulse oximetry.

11:00 am–11:30 am ***(Invited)***

Fa3.2 **Pathogen Sensing and Identification Using a Smartphone,** Brian Cunningham, Rashid Bashir, *University of Illinois at Urbana-Champaign, Urbana, IL, USA,* David Hirschberg, *University of Washington at Tacoma, Tacoma, WA, USA,* Fu Sun, Akid Ornob, *University of Illinois at Urbana-Champaign, Urbana, IL, USA,* and David Nash, *private veterinary practice*

Using a smartphone camera in conjunction with a handheld cradle and credit-card format microfluidic cartridge, we demonstrate 30-minute, 8× multiplexed detection, identification, and quantification of viral and bacterial infectious pathogens, using an isothermal nucleic acid amplification assay in a single droplet test sample.

11:30 am–11:45 am

Fa3.3 **Electronic Terahertz Wave Gas Spectroscopy Systems,** Aniket Tekawade, Tim E. Rice, Matthew A. Oehlschlaeger, Muhammad Waleed Mansha, Kefei Wu, Mona M. Hella, Yueliang Lu, Aparna Gupta, and Ingrid Wilke, *Rensselaer Polytechnic Institute, Troy, NY, USA*

The potential of terahertz wave electronics for non-intrusive atmospheric and industrial gas sensing is explored. Measurements are reported for pure acetonitrile, methanol, and ethanol vapors at 5 and 10 Torr and for methanol dilute in air (0.75–3.0 mol %) at a pressure of 500 Torr.

11:45 am–12:00 pm

Fa3.4 **Neuropeptide y Binding Dynamics Quantified with Nanophotonic Resonant Sensors,** Kyu Lee, Robert Magnusson, *University of Texas at Arlington, Arlington, TX, USA,* Brett R. Wenner, *Air Force Research Laboratory, Wright-Patterson Air Force Base, OH, USA,* Jeffery W. Allen, and Monica S. Allen, *Air Force Research Laboratory, Eglin Air Force Base, FL, USA*

Nanostructured resonant sensors are used to record peptide binding dynamics. We quantify anti-NPY binding to NeutrAvidin and protein G and then NPY binding to anti-NPY. We report resonant wavelength shift of 160 pm for 8 μg/ml NPY with a detection limit of 1 μg/ml.

12:00 pm–12:15 pm

Fa3.5 **Interdigitated Micro Electrode array Dielectr ophoretic System for Label-Free Multi-Parameter-Based Cell Detection,** Vidura Jayasooriya and Dharmakeerthi Nawarathna, *North Dakota State University, Fargo, ND, USA*

Circulating Tumor Cells have recognized as a promising biomarker for detection of cancer. However, there is no robust method to isolate CTCs in low-cost and label free manner. To address this need, we have demonstrated multi parameter based cell detection that is applicable for CTC.

12:15 pm–12:30 pm

Fa3.6 **Performance of Nanoscale UV Light Sources vs. Thin Film LEDs,** Babak Nikoobakht, Robin Hansen, and Yuqin Zong, *National Institutes of Standards and Technology, Gaithersburg, MD, USA*

Nanoscale light-emitting-diodes or nanolasers are of technological interest in miniaturized applications such as low-size-weight and power high-definition displays or on-chip electro-optical platforms for sensing or communication. We report the first generation of a linear array of nanoscale light sources on a-chip and their novel properties.

12:30 pm–1:30 pm **Emerald E**

Professional Development Tutorial Lunch & Learn

Session Chair Stanley Ikpe, *NASA Langley Research Center, VA, USA*

12:30 pm–1:30 pm

Keynote Speaker: Linda Stacy, *LivingBluPrints, MA, USA*

1:30 pm–3:15 pm **Coral Ballroom a**

Session Fa4 **human State Measur ement**

Session Chair James Christensen, *Air Force Research Laboratory, OH, USA*

1:30 pm–2:00 pm ***(Invited)***

Fa4.1 **Cognitive State Change Detection through Multispectral Sensing,** Anil Raj, *Florida Institute for Human and Machine Cognition, Pensacola, FL, USA*

Changes in human cognitive state arise through the complex interactions of mulitple biological (neural, hormonal, hemodynamic, etc.) systems in repsonse to external and internal perturbations and manifests as a multivariate (behavioral, task performance, psychophysiologic, etc.) response. Reliable and robust characterization and tracking of cognitive state, therefore, warrants the use of an integrated, multisensor, multispectral approach.

2:00 pm–2:15 pm

Fa4.2 **Towards army Relevant Sensing with Integrated Molecularly Imprinted Polymer Photonic (IMIPP) Devices,** Mikella E. Farrell, Ellen L. Holthoff, Justin R. Bickford, Pak S. Cho, Matthew B. Coppock, and Paul M. Pellegrino, *US Army Research Lab, Adelphi, MD, USA*

Highlights recent ARL work developing MIP-based photonic sensing chip. This sensor has applications for threat detection, including current known and emerging hazards, and chemical and biological material via target specific sensing, concentrating and filtering.

2:15 pm–2:30 pm

Fa4.3 Optofluidic and Electrochemical Nanoslits for Rapid Measurement of Receptor Binding to Neuropeptides, Nathan S. Swami, Walter B. Varhue, *University of Virginia, Charlottesville, VA, USA,* and Chiafu Chou, *Academia Sinica, Taipei, Taiwan*

A nanoscale optofluidic and electrochemical platform for screening receptors based on binding to neuropeptide targets is reported. The nanoslit structures dramatically reduce the diffusion length of analytes, thereby enhancing collision frequencies with receptors and enabling rapid measurement of chemical binding constants, with minimal diffusional dependence.

2:30 pm–2:45 pm

Fa4.4 high Throughput and Low-Cost Detection of Short Nucleic acid Biomarkers in Serum Using Dielectrophoretic Biosensor, Logeeshan Velmanickam, Ivan T. Lima Jr., and Dharmakeerthi Nawarathna, *North Dakota State University, Fargo, ND, USA*

Short circulating nucleic acid molecules such as microRNA and DNA are recognized as potential biomarkers for early detection of diseases such as cancer. To efficiently quantify these biomarkers in serum, we have utilized dielectrophoresis to selectively concentrate and quantify the fluorophore labeled target biomarker molecules.

2:45 pm–3:00 pm

Fa4.5 Plasmonic Sensing of Neuropeptide y and Orexin a with Gold Nanoparticles on Flexible Plastic Substrates, Rejeana Cary, Jamison Reifsteck, Ian Bruzas, *University of Cincinnati, Cincinnati, OH, USA,* Jorge Chavez Benavides, *USAF AFMC 711 HPW/RHXBC, OH, USA,* and Laura Sagle, *University of Cincinnati, Cincinnati, OH, USA*

In order to diagnose post-traumatic stress disorder, two biomarkers, Neuropeptide Y and Orexin A are often monitored. Our goal is to use gold nanoparticles on plastic substrates to have flexible, portable, sensitive sensors for in-field monitoring of these biomarkers in a non-invasive manner.

3:00 pm–3:15 pm

Fa4.6 Wide Subwavelength Grating Waveguide Sensitivity, Justin Bickford, *US Army Research Laboratory, Adelphi, MD, USA,* Pak S. Cho, *General Technical Services, LLC, Wall Township, NJ, USA,* Mikella E. Farrell, Ellen L. Holthoff, Matthew B. Coppock, and Paul M. Pellegrino, *US Army Research Laboratory, Adelphi, MD, USA*

Grating waveguide structures have the opportunity to greatly improve integrated photonic sensor sensitivity. We have examined the impact of wide subwavelength grating waveguide geometries on sensor performance. We present the progress of our design exploration and compare performance to existing slot and strip waveguide structures.

3:30 pm–5:15 pm **Coral Ballroom a**

Session Fa5 **human analyst augmentation**

Session Chairs Greg Burnett, *Air Force Research Laboratory, OH, USA*
Adrienne Ephrem, *Air Force Research Laboratory, OH, USA*

3:30 pm–4:00 pm ***(Invited)***

Fa5.1 **a human-in-the-Loop Monitoring via a hybrid Brain-Computer Interface Based on Electroencephalography and Functional Transcranial Doppler Ultrasound,** Ervin Sejdic, Aya Khalaf, Murat Akcakaya, *University of Pittsburgh, Pittsburgh, PA, USA*

To boost the performance of hybrid brain computer interfaces, we advance the state of the art by introducing a novel system that measures electrical brain activity as well as cerebral blood flow velocity using electroencephalography and functional transcranial Doppler ultrasound, respectively.

4:00 pm–4:30 pm ***(Invited)***

Fa5.2 **Ongoing Research in Operational Telemedicine at the Tactical Edge,** Thomas R. Bigott, *Telemedicine and Advanced Technology Research Center (TATRC), Fort Detrick, MD, USA*

The U.S. Army Medical and Materiel Command, Telemedicine and Advanced Technology Research Center thorugh its' Operational Telemedicine Laboratory focuses on researching and developing advanced technologies for the Combat Medic while at the Point of Injury and while en route to Theater advanced medical treatment facilities.

4:30 pm–4:45 pm

Fa5.3 **Biosensor for Pancreatic Cancer Biomarker Based on Dielectrophoresis and Image Processing,** Fleming Dackson Gudagunti, Logeeshan Velmanickam, Dharmakeerthi Nawarathna, and Ivan T. Lima Jr., *North Dakota State University, Fargo, ND, USA*

We demonstrate a label-free method to detect the concentration of pancreatic cancer biomarker CA 19-9 by combining dielelectrophoresis and image processing to measure the frequency-dependent group velocity of functionalized polystyrene microspheres due to the gradient of electric field produced by an interdigitated microstructured electrode.

4:45 pm–5:15 pm ***(Invited)***

Fa5.4 **Metrics for Comparison of Polarimetric and Thermal Target to Background Contrast,** David Chenault, A. Hagewood, M. Roche, J. Vaden, *Polaris Sensor Technologies, Inc., AL, USA*

Comparison of the contrast improvement of polarimetric signatures to that of thermal signatures of the same scene has proved problematic due to the nature, the offset and range, of the data. We present a survey of metrics and their response on several representative data sets.

5:30 pm–6:00 pm **Coral Ballroom a**

hMB Panel Discussion

Session Chairs Rajesh Naik, *Air Force Research Laboratory, OH, USA*
Brett Wenner, *Air Force Research Laboratory, OH, USA*

Track 7:Optical Imaging and Sensing Technology (OIST)

8:00 am–8:30 am **Coral Ballroom B**
Session FB1 **Optical Imaging and Sensing Technology**
Session Chairs Michael Eismann, *Air Force Research Laboratory, OH, USA*
Robert Magnusson, *University of Texas at Arlington, TX, USA*

8:00 am–8:30 am ***(Invited)***

FB1.1 air Force S&T Directions in Optical Imaging and Sensing Technology, Michael Eismann, *Air Force Research Laboratory, USA*

As an introduction to the Optical Imaging and Sensing Technology track, this presentation provides an overview of the future capability trends for optical imaging and sensing, some specific Air Force Research Laboratory research directions and implications where new research developments are needed.

8:30 am–10:30 am **Coral Ballroom B**
Session FB2 **Spectral, Polarimetric, and Multimodal Imaging**
Session Chairs Michael Eismann, *Air Force Research Laboratory, OH, USA*
Michael Kudenov, *North Carolina State University, NC, USA*

8:30 am–8:55 am ***(Invited)***

FB2.1 advances in hyperspectral Sensors and Phenomenology for army applications, Jason Zeibel, *Night Vision and Electronic Sensors Directorate, Fort Belvoir, VA, USA*

This paper examines some of the new class of available hyperspectral sensors from a military sensing point of view, as well as the algorithms, phenomenology, and processing required to produce actionable information from hyperspectral imaging for today's warfighter.

8:55 am–9:20 am ***(Invited)***

FB2.2 IR Polarization for Natural Clutter Suppression, Francis Pantuso, Collin Bright, Richard Harr, Michael Polcha, Aaron LaPointe, *Night Vision and Electronic Sensors Directorate, Fort Belvoir, VA, USA*

IR Polarization can help find man-made objects in scenes primarily made up of natural environment. A model was developed to predict and explain results in short range, on-the-move situations. Test results show that Polarization contrast nearly always exceeds radiance contrast and generally suppresses background clutter.

9:20 am–9:40 am ***(Invited)***

FB2.3 IR Polarimetry: Sensors and applications, David Chenault, *Polaris Sensor Technologies, Inc., Huntsville, AL, USA*

Recent developments in infrared polarimetric sensors are demonstrating substantially improved performance in small packages. We present an overview of the latest including uncooled, cooled, and two-color IR systems as well as SWIR and rotating element systems. We also show representative results from recent tests.

9:40 am–10:00 am ***(Invited)***

FB2.4 Modulated Polarimeters for Space Situational awareness, Scott Tyo, Andrey Alenin, Israel Vaughn, and Jiawei Song, *University of New South Wales, Canberra, Australia*

Monitoring unresolved space objects is an important task in space situational awareness. This paper will present methods to extend the bandwidth of modulated optical polarimeters to detect, track, and monitor unresolved space objects based on differences in their optical scattering properties.

10:00 am–10:30 am ***(Invited)***

FB2.5 Photonics Research at the Naval Research Laboratory, Craig Hoffman, *National Research Laboratory, Washington, DC, USA*

10:30 am–12:30 pm **Coral Ballroom B**

Session FB3 **Blast/Shock Wave Imaging and Spectroscopic Techniques**

Session Chairs Matthew Burfeindt, *Air Force Research Laboratory, FL, USA*
David Gray, *Air Force Research Laboratory, FL, USA*

10:30 am–11:00 am ***(Invited)***

FB3.1 Prompt Optical Spectral Signatures of high Explosives, Nick Glumac, *University of Illinois, Urbana, IL, USA*

Recent work at the University of Illinois, examining the time-resolved optical spectroscopy of the breakout event from a high explosive detonation into air is presented. Spectral signatures in the ultraviolet, visible, and near-infrared regions are examined, and implications for detonation modeling are discussed.

11:00 am–11:30 am ***(Invited)***

FB3.2 Laser-Based Diagnostics for Measuring Gas-Phase Temperature and Species, James Gord, *Air Force Research Laboratory/RQTC, Wright-Patterson Air Force Base, OH, USA*

Advanced measurement techniques that exploit lasers and optics have become well-established tools for characterizing reacting flows. Approaches based on linear and nonlinear spectroscopies will be explored, especially those involving hyperspectral sources, ultrashort-pulse lasers, and burst-mode lasers with emphasis on data acquisition at kHz-to-MHz rates.

11:30 am–11:45 am

FB3.3 Recent Developments Using Background Oriented Schlieren with a Plenoptic Camera, Jenna N. Klemkowsky, Christopher J. Clifford, Brian S. Thurow, *Auburn University, Auburn, AL, USA,* William M. Kunzler, and Daniel R. Guildenbecher, *Sandia National Laboratories, Albuquerque, NM, USA*

Plenoptic BOS has been introduced as a single-camera technique used to observe three-dimensional density gradients in a flow field. With the ability to generate focused BOS images, two experiments are used to demonstrate the qualitative and quantitative capabilities of plentopic BOS in different experimental configurations.

11:45 am–12:00 pm

FB3.4 Mhz-Rate Measur ements of Time-Resolved Species Concentrations in Shock heated Chemical Weapon Simulants, Sneha Neupane, Samuel Barak, Erik Ninnemann, Zachary Loparo, Owen Pryor, and Subith Vasu, *University of Central Florida, Orlando, FL, USA*

In this study, shock-heated decomposition kinetics study of triethyl phosphate (TEP), a simulant of chemical weapon Sarin-GB, was carried out in a shock tube. Mid-infrared, time-resolved laser absorption spectroscopy was used to measure the concentrations of CO, a key intermediate species, behind reflected shock waves.

12:00 pm–12:15 pm

FB3.5 Shocks Sensing by Fiber Bragg Gratings and a 100 Mhz Dynamic Dispersive Interrogator, Y. Barbarin, A. Lefrançois, B. Rougier, F. Sinatti, O. Lassalle, A. Osmont, and J. Luc, *CEA Dam, Gramat, France*

A multi-channels high resolution dispersive interrogator with at a high sampling rate has been developed to measure shocks pressure levels by Fiber Bragg Gratings (FBGs). Two FBG orientations are compared numerically and experimentally. The first one is along the cylindrical target axis, thus the grating spectrum is blue shifted. The second orientation is perpendicular to the target axis and the grating spectrum is red shifted. The interrogator uses a femtosecond laser source to cover the C+L band spectrum. The source repetition rate (100 MHz) fixes the spectra acquisition rate. The wavelengths are basically converted to time using a long telecom fiber. The time-multiplexed spectra are recorded with 400 points by a fast oscilloscope (40 GSa/s). The experimental setup is a Tin plate impact on a pmMA target performed in a 35-mm single-stage gas gun. An impact at 510 m/s generates a pressure level of 1.69 GPa during 5 µs. The performance of the dynamic interrogator and the wavelength shifts in the two FBG configurations are discussed.

12:15 pm–12:30 pm

FB3.6 Khz–Mhz Rate Laser -Based Tracking of Particles and Product Gases for Multiphase Blast Fields, Daniel Lauriola, Mateo Gomez, Mikhail N. Slipchenko, Steven F. Son, Terrence R. Meyer, *Purdue University, West Lafayette, IN, USA,* Sukesh Roy, *Spectral Energies, LLC, Dayton, OH, USA,* and James R. Gord, *Air Force Research Laboratory, Wright-Patterson Air Force Base, OH, USA*

An imaging system for analysis of particle fields and product gases in a multiphase blast is proposed. The approach combines a kHz-MHz-rate burst-mode laser with particle image velocimetry (PIV) or tomographic feature tracking velocimetry (FTV) to resolve flowfields over a wide range of time scales.

12:30 pm–1:30 pm **Emerald E**

Professional Development Tutorial Lunch & Learn

Session Chair Stanley Ikpe, *NASA Langley Research Center, VA, USA*

12:30 pm–1:30 pm

Keynote Speaker: Linda Stacy, *LivingBluPrints, MA, USA*

1:30 pm–3:30 pm **Coral Ballroom B**

Session FB4 **Terahertz Photonics**

Session Chairs George Goldsmith, *Air Force Research Laboratory, FL, USA*
Margaret Kim, *University of Alabama, AL, USA*

1:30 pm–2:00 pm ***(Invited)***

FB4.1 **Room-Temperature Thz Quantum Cascade Laser Sources Based on Intra-Cavity Difference-Frequency Mixing with Improved Outcoupling Efficiency,** Mikhail Belkin, *University of Texas, TX, USA*

An order of magnitude improvement in THz outcoupling efficiency is achieved in THz quantum cascade laser sources based on intra-cavity difference-frequency generation by transferring devices to high-resistivity silicon substrates. Broadly-tunable emission in 1-5THz range is demonstrated with the peak THz power output over 0.25 mW.

2:00 pm–2:30 pm ***(Invited)***

FB4.2 **harnessing Light-Metasurface Interactions for Enabling Technologies,** Abul Azad, *Los Alamos National Laboratory, Los Alamos, NM, USA*

Ultrathin metasurface allows unprecedented control of electromagnetic waves by enabling resonant interactions between incident light photons and subwavelength resonators. We demonstrated many designer electromagnetic phenomena including perfect absorption, linear polarization conversion, flat lenses, and ultrafast switching, using metasurfaces in the terahertz spectral window.

2:30 pm–3:00 pm ***(Invited)***

FB4.3 **advanced ThZ Plasmonic Devices,** Nezih Pala, *Florida International University, Miami, FL, USA*

We report on numerical and experimental investigations of THz plasmonic devices and structures based on metals, dielectrics and novel materials such as graphene. These devices can be used resonant detection, fast modulation and switching and precise filtering of THz radiation for various applications.

3:00 pm–3:30 pm ***(Invited)***

FB4.4 **hybrid Graphene/Semiconductor Technology for Terahertz Communications,** Josep Miquel Jornet, *University at Buffalo, Buffalo, NY, USA*

In this presentation, the latest developments towards designing, fabricating and experimentally characterizing a hybrid graphene/semiconductor plasmonic front-end for Terahertz communications will be discussed. Emphasis will be given to the key components of the front-end, namely, the on-chip THz plasmonic source, phase modulator, and antenna.

3:30 pm–5:30 pm **Coral Ballroom B**

Session FB5 **Target Detection and Pattern Recognition**

Session Chairs Chi Mai, *Air Force Research Laboratory, FL, USA*
Angela Diggs, *Air Force Research Laboratory, FL, USA*

3:30 pm–4:00 pm ***(Invited)***

FB5.1 **Designing Empirical Lab Experiments for SaR-a TR,** Michael A. Saville, Jacob D. Compaleo, Heather L. Judd, *Wright State University, Dayton, OH, USA,* and Paul Sotirelis, *Air Force Research Laboratory, Wright-Patterson Air Force Base, OH, USA*

Automatic target recognition (ATR) experiments often rely on expensive simulation data or measurements in an anechoic chamber limiting opportunity for ad hoc experiments. Here, we present recent work towards ad hoc ATR experimentation at Ka-band with a non-anechoic test site and quasi near-field ISAR configuration.

4:00 pm–4:30 pm ***(Invited)***

FB5.2 **Doppler-Only Imaging,** Margaret Cheney, *Colorado State University, Fort Collins, CO, USA*

This presentation outlines a radar imaging approach using a transmitted waveform consisting of a single frequency tone. Included are: a) the mathematical model for the radar signal, b) the image formation formula, and c) analysis of the associated image resolution.

4:30 pm–4:45 pm

FB5.3 **Forward-Looking InSaR Pr ocessing for Moving Target Imaging,** Matthew J. Burfeindt, *Air Force Research Laboratory, Eglin Air Force Base, FL, USA*

We present an optimization-based interferometric synthetic aperture radar (InSAR) technique for jointly estimating a target's shape and velocity vector based on a forward-looking data collection. We describe the mathematical formulation, apply it to simulated data, and evaluate performance by comparing estimates to truth.

4:45 pm–5:00 pm

FB5.4 **k-Space Tomography for Spatial-Spectral Mapping,** Conor J. Ryan, Dylan D. Ross, Janusz Murakowski, Garrett J. Schneider, Dennis W. Prather, *University of Delaware, Newark, DE, USA,* and Christopher A. Scheutz, *Phase Sensitive Innovations, Inc., Newark, DE, USA*

Simultaneous detection of radio waves' frequency and angle of arrival is achieved by coherent optical processing. This technique uses a fiber length dispersion array coupled to a distributed antenna array to provide unique CCD-captured interferograms for computational tomographic reconstruction of the radio frequency signal environment.

5:00 pm–5:15 pm

FB5.5 Deep Learning for Compressive Infrared and hyperspectral Machine Vision, J. Chen, Y. Xu, L. Liyang, and K. F. Kelly, *Rice University, Houston, TX, USA*

We examine methods to realize efficient means of compressive convolution neural networks using an optical modulator as the first layer in the neural network algorithm combined with a few pixel detector therefore enabling high-resolution machine vision in infrared and hyperspectral imaging.

5:15 pm–5:30 pm

FB5.6 analytical BER Performance of a LDPC Coded OFDM FSO with Optical Intensity Modulation and a Direct Detection Receiver, Bobby Barua and S. P. Majumder, *Bangladesh University of Engineering and Technology, Dhaka, Bangladesh*

In this paper we provide an analytical approach to evaluate the performances of LDPC coded OFDM FSO communication system with the effect of strong atmospheric turbulence. Analytical observation shows that LDPC coded OFDM system in FSO provides 12 to 15 dB improvements over uncoded system.

5:30 pm–6:00 pm **Coral Ballroom B**
OIST Panel Discussion
Session Chairs Michael Eismann, *Air Force Research Laboratory, OH, USA*
Robert Magnusson, *University of Texas at Arlington, TX, USA*

Track 8: Bioinspired and Bioprincipic Technologies (BBT)

8:00 am–8:30 am **Coral Ballroom C**
Session FC1 Bioinspired and Bioprincipic Technologies
Session Chair Ric Wehling, *Air Force Research Laboratory, FL, USA*

8:00 am–8:30 am ***(Keynote)***

FC1.1 Why Should Engineers Be Interested in Vision in animals, Especially arthr opods?, Ric Wehling, *Air Force Research Laboratory, Wright-Patterson Air Force Base, OH, USA*

Nature provides an astonishing array of approaches to the vision problem: extracting information vital for life processes from the electromagnetic radiation field. Our human-engineered optical systems designs could benefit by considering the knowledge being discovered in these systems.

8:30 am–10:30 am **Coral Ballroom C**

Session FC2 **Bioinspired Optical Technologies**

Session Chairs Thomas Cronin, *University of Maryland, Baltimore County, MD, USA*
Francis Reininger, *Spectral Imaging Laboratory, CA, USA*

8:30 am–9:00 am ***(Invited)***

FC2.1 Bioinspired Micro-Optics and applications to Imaging Polarimetry, Stanley Pau, *University of Arizona, Tucson, AZ, USA*

Study of structural colors has led to optical filter designs using liquid crystal polymer that has microscopic structure similar to exoskeleton of many animals. The optical filters are utilized in novel multi-spectral and polarization cameras with applications in medical imaging, remote sensing, surveillance, and metrology.

9:00 am–9:30 am ***(Invited)***

FC2.2 Dynamic Materials Inspired by Cephalopods, Alon Gorodetsky, *University of California, Irvine, Irvine, CA, USA*

Cephalopods have been studied for many years due to their stunning camouflage displays and complex behavioral patterns. More recently, these marine invertebrates have emerged as models for novel adaptive materials and systems. Within this context, our laboratory has developed cephalopod-inspired camouflage systems with unique capabilities.

9:30 am–10:00 am ***(Invited)***

FC2.3 Biomimicry of Insect Eyes and Wings, Doekele Stavenga, *University of Groningen, Groningen, The Netherlands*

Insects apply a plethora of photonical methods to optimize their vision and coloration. I will discuss how the study of insect compound eyes have inspired applications. Examples will be moth eyes, particularly their corneal nipple arrays, and butterfly wing scales, notably of the blue Morpho's.

10:00 am–10:30 am ***(Invited)***

FC2.4 The Biophotonics of Open-Ocean animals: anti-Reflective Coatings, Super -Black Skins, and Transparent Interiors, Sonke Johnsen, *Duke University, Durham, NC, USA*

The extreme predation in the open ocean and lack of hiding spaces has led to remarkable innovations in biophotonics. This talk, via several case studies, shows the clever ways in which the inhabitants of this world manipulate light, many of which have technological parallels.

10:30 am–12:30 pm **Coral Ballroom C**

Session FC3 **Bioinspired Sensors**

Session Chairs Gregor Belusic, *ULjubljana, Slovenia*
Mark Massie, *Raytheon, FL, USA*

10:30 am–11:00 am ***(Invited)***

FC3.1 **Bio-Inspired Mechanosensors,** Miao Yu, *University of Maryland, College Park, MD, USA*

Various efforts on the development of bio-inspired mechanosensors at the Sensors and Actuators Laboratory (SAL) of the University of Maryland will be discussed, including bio-inspired acoustic sensors and air flow sensors. These sensors will benefit tracking, navigation, and flight control of autonomous flight systems.

11:00 am–11:30 am ***(Invited)***

FC3.2 **Infrared Biologically-Inspired Imaging Sensors–a Review,** Mark Massie, *Raytheon Vision Systems, Goleta, CA, USA*

After Cal Tech developed the Silicon Retina in 1985, Mr. Massie has been involved in developing infrared imaging sensors that mimic the function of biological imaging sensors. A technology review will be given covering massively parallel analog domain neuromorphic imagers to dynamically-programmable multi-foveal tracking sensors.

11:30 am–12:00 pm ***(Invited)***

FC3.3 **Bioinspired Sensors for Underwater Geolocalization,** Viktor Gruev, Missael Garcia, Sam Powell, Nan Cui, and Tyler Davis, *University of Illinois at Urbana-Champaign, Urbana, IL, USA*

We have mimicked the visual system of the mantis shrimp by monolithically integrating pixelated spectral-polarization filters with an array of vertically stacked photodetectors. These sensors are used for underwater geolocalization with 30km sensitivity by recording the in-water polarization field.

12:00 pm–12:30 pm ***(Invited)***

FC3.4 **Local Motion Sensor, Curvace artificial Compound Eye and M2aPIX Retina: Fr om Sensors Design to Robotics application,** Franck Ruffier, *CNRS–Aix Marseille University (ISM–Biorobotics), Marseille, France*

12:30 pm–1:30 pm **Emerald E**

Professional Development Tutorial Lunch & Learn

Session Chair Stanley Ikpe, *NASA Langley Research Center, VA, USA*

12:30 pm–1:30 pm

Keynote Speaker: Linda Stacy, *LivingBluPrints, MA, USA*

1:30 pm–3:30 pm **Coral Ballroom C**

Session FC4 **Biobased Signal and Information Processing I**

Session Chairs Geoff Barrows, *Centeye, Inc., Washington, DC, USA*
Pamela Abshire, *University of Maryland, MD, USA*

1:30 pm–2:00 pm ***(Invited)***

FC4.1 Pamela Abshire, *University of Maryland, College Park, MD, USA*

2:00 pm–2:30 pm ***(Invited)***

FC4.2 **Visual Guidance of Polarotactic horseflies,** Gregor Belušič, Marko Ilić, Andrej Meglič, *University of Ljubljana, Ljubljana, Slovenia,* and Martin F. Wehling, *Air Force Research Laboratory, Eglin Air Force Base, FL, USA*

Horseflies are unique among insects for using the detection of linearly polarized reflections to seek their victims. We analyzed the physiological basis for their visual guidance and verified our findings with behavioral tests. We explain how horsefly attack is gudied by multiple segregated visual channels.

2:30 pm–2:45 pm

FC4.3 **Gaussian-Based Filters for Elementary Motion Detection Delay Element,** Geoffrey Brooks, *Florida State University Panama City, Panama City, FL, USA*

Proposed here is using the delays inherent in natural Gaussian-based information pathways for HR-EMD delay element. Since such pathways are known to exist in duality in natural systems, a combination of dual EMDs is proposed as an alternate approach for precision in image velocity estimation.

2:45 pm–3:00 pm

FC4.4 **Spatially-Variant Photonic Crystals and Possible applications,** Noel P. Martinez, Manuel Martinez, *University of Texas at El Paso, El Paso, TX, USA,* Jimmy E. Touma, Joshua K. Lentz, *Air Force Research Laboratory, Eglin Air Force Base, FL, USA,* Stephen M. Kuebler, *University of Central Florida, Orlando, FL, USA,* and Raymond C. Rumpf, *University of Texas at El Paso, El Paso, TX, USA*

Spatially-variant photonic crystals (SVPCs) are a new concept in photonics that provide new optical properties and an extraordinary means for multiplexing functions and incorporating bio-inspired randomness and materials. In the present work, planar SVPCs based on self-collimation are investigated.

3:00 pm–3:15 pm

FC4.5 **Novel Bio-Inspired Infrared Imager with On Chip Object Computation,** P. McCarley, *Air Force Research Laboratory, Eglin Air Force Base, FL, USA,* and J. Caulfield, *Cyan Systems, Santa Barbara, CA, USA*

We report on a novel infrared imager that utilizes on ROIC spatial and temporal processing that conducts motion computation on the FPA. Our work is motivated by biological vision which has enabled the ability to persistently track objects within the sensor's field of regard.

3:15 pm–3:30 pm

FC4.6 Diamond Meta-Surfaces for high Power Laser applications, Alexander Muhr, Daniel Twitchen, and Henk de Wit, *Element Six Technologies US Corp., Santa Clara, CA, USA*

Optical quality single crystal and polycrystalline diamond have been established as excellent materials for high power laser applications. Diamond windows are typically performance limited by thin film optical coatings. Replacing thin film coatings with anti-reflective metasurfaces greatly increases laser induced damage threshold and overall durability.

3:30 pm–4:45 pm **Coral Ballroom C**

Session FC5 Biobased Signal and Information Processing II

Session Chair Ric Wehling, *Air Force Research Laboratory, FL, USA*

3:30 pm–4:00 pm ***(Invited)***

FC5.1 a Dynamically-Positioned, Time-Domain Winner-Take-all Cir cuit for Spike-Based Path Planning, Timmer Horiuchi, *University of Maryland, College Park, MD, USA*

4:00 pm–4:15 pm

FC5.2 Nearest Neighbor anomaly Detector for Passively augmented LaDaR, J. Brown, R. Roberts, *Tallahassee, FL, USA*, C. Welsh, C. Keyser, and C. Saludez, *Eglin Air Force Base, FL, USA*

4:15 pm–4:45 pm ***(Invited)***

FC5.3 Neuromorphic Computing with Mixed analog-Digital Chips, Kwabena Boahen, *Stanford University, Stanford, CA, USA*

As transistors scale down to a few nanometers, heterogeneity and stochasticity increase. This deleterious trend may be combated by combining analog computation, which degrades gracefully, with digital communication, which is error-correcting—a paradigm the brain employs to harness its nanoscale ion-channels' heterogeneous expression and stochastic behavior.

5:30 pm–6:00 pm **Coral Ballroom C**

BBT Panel Discussion

Session Chair Ric Wehling, *Air Force Research Laboratory, FL, USA*

Track 9: Novel Phenomena and New Materials for advanced Photonics (NPNMaP)

8:00 am–8:30 am **Coral Ballroom D**

Session FD1 **Novel Phenomena and New Materials for advanced Photonics**

Session Chairs Dmitri Basov, *Columbia University, NY, USA*
Yohannes Abate, *University of Georgia, GA, USA*

8:00 am–8:30 am ***(Keynote)***

FD1.1 **Nano-Optical Phenomena in Quantum Materials,** Dmitri Basov, *Columbia University, New York, NY, USA*

Quantum materials exemplify some of the most profound concepts in condensed matter physics including topology, macroscopic quantum orders and intertwined degrees of freedom. I will discuss recent nano-optical experiments aimed at elucidating and harnessing these concepts for controlling light at the nano-scale.

8:30 am–10:30 am **Coral Ballroom D**

Session FD2 **Quantum Sensing and Spintronics**

Session Chair Michael Flatte, *University of Iowa, IA, USA*

8:30 am–9:00 am ***(Invited)***

FD2.1 **Local Manipulation and Characterization of Spin and Magnetization Dynamics,** P Chris Hammel, *Ohio State University, Columbus, OH, USA,* Vidya Bhallamudi, *Indian Institute Technoloby Madras, Chennai, India,* Shane White, William Ruane, Carola Purser, Brendan McCullian, and Chris Wolfe, *Ohio State University, Columbus, OH, USA*

We discuss manipulation and high spatial resolution measurement of magnetization dynamics at the nanoscale. We measure spin transport out of magnetically confined spin waves with a cantilever-mounted micromagnetic tip and optically detect spin dynamics using NV centers in diamond.

9:00 am–9:30 am ***(Invited)***

FD2.2 **Single Photon Detection Using Chromophores and Nitrogen Vacancies in Diamond,** N. J. Harmon, *University of Iowa, Iowa City, IA, USA*

Some molecular chromophores not only change shape upon photon absorption but also their electric dipole moment by up to several Debye. We develop a model where the dipole moment change is detected by a nitrogen vacancy center implanted near the surface of a nearby diamond.

9:30 am–9:45 am

FD2.3 **Plasmonic Structure Integrated Superconducting Nanowire Single-Photon Detectors for Transfering Specific Quantum Information,** M. Csete, A. Szenes, B. Tóth, G. Szabó, B. Bánhelyi, and T. Csendes, *University of Szeged, Szeged, Hungary*

Superconducting nanowire single-photon detectors integrated with plasmonic structures and optimized to maximize the absorptance (A-SNSPD), the polarization contrast (P-SNSPD), and the product of them without (AP-SNSPD) and with (APC1/APC3) absorptance criterion proves that the most efficient read-out of encoded quantum information is possible via APC-SNSPDs.

9:45 am–10:00 am

FD2.4 SiV Diamond Color Center Fluorescence Improvement via Silica-Silver Core-Shell Nanoresonators, M. Csete, A. Szenes, D. Vass, G. Szabó, B. Bánhelyi, and T. Csendes, *University of Szeged, Szeged, Hungary*

SiV color centers fluorescence is significantly improved via optimized monomer and dimer silica-silver core-shell nanoresonator configurations in diamond. Elliptical nanoresonators outperform the spherical counterparts both in monomers and dimers due to the achievable excitation enhancement, moreover simultaneous excitation and emission coupling is realizable via dimers.

10:00 am–10:15 am

FD2.5 Electronic Structure and Quantum Optics of Carbon Nanotube Defects, Han Htoon, *Los Alamos National Laboratory, Los Alamos, NM, USA*

I will review our recent low temperature PL, and quantum optics experiments on individual, covalent defect states of carbon nanotubes and discuss their impacts on quantum information science and technologies.

10:15 am–10:30 am

FD2.6 Strong Photon antibunching in Weakly Nonlinear Two-Dimensional Exciton-Polaritons, Albert Ryou, David Rosser, *University of Washington, Seattle, WA, USA,* Abhi Saxena, *Indian Institute of Technology, Delhi, India,* Taylor Fryett, and Arka Majumdar, *University of Washington, Seattle, WA, USA*

A scalable, deterministic array of single photon nonlinearities holds great potential for fundamental physics and technology. We theoretically explore a hybrid light-matter platform, marrying an atomically thin 2D-material to a photonic crystal cavity. By patterning the monolayer into different sizes, we demonstrate strong photon antibunching.

10:30 am–12:30 pm **Coral Ballroom D**

Session FD3 **Two-Dimensional Materials**

Session Chair James Hone, *Columbia University, NY, USA*

10:30 am–11:00 am ***(Invited)***

FD3.1 2D Semiconductor Quantum Optoelectronics, Xiaodong Xu, *University of Washington, Seattle, WA, USA*

Two-dimensional (2D) semiconductor (e.g. MoSe2, WSe2) is an emerging platform for developing new optoelectronics at atomically thin limit. In this talk, I will present the progress in optically and electrically driven single emitters based on 2D semiconductors and heterostructures, and their integration with nano-photonic cavities.

11:00 am–11:30 am ***(Invited)***

FD3.2 Next Generation Photonics Based on 2D Materials, Michal Lipson, *Columbia University, New York, NY, USA*

Two dimensional materials such as monolayer transition metal dichalcogenides (TMD) are expected to have large changes in their optical sheet conductivity by controlling their carrier densities. We demonstrate a platform for waveguide-integrated phase modulators in the near-infrared regime based on Tungsten disulphide (WS_2) gating.

11:30 am–12:00 pm ***(Invited)***

FD3.3 Nanoimaging and Nano-FTIR of Muscovite Mica, Alireza Fali, *University of Georgia, Athens, GA, USA,* Sampath Gamage, *Linköping University, Norrköping, Sweden,* Marquez Howard, *University of Georgia, Athens, GA, USA,* Kirill Bolotin, *Free University of Berlin, Berlin, Germany,* and Yohannes Abate, *University of Georgia, Athens, GA, USA*

Muscovite type mica is an inorganic material most commonly used in various electronic devices. We use the near-field imaging and nano-FTIR techniques to investigate the properties of mica exfoliated on different substrates. In order to support experimental results, we use a theoretical model and simulation.

12:00 pm–12:15 pm

FD3.4 Optical Nano-Imaging of 2D Transition Metal Dichalcogenides, Sharad Ambardar and Dmitri V. Voronine, *University of South Florida, Tampa, FL, USA*

Two-dimensional transition metal dichalcogenides (TMDs) are the materials of recent interest in many applications. We performed tip-enhanced photoluminescence (TEPL) and tip-enhanced Raman Scattering (TERS) imaging with spatial resolution of few nanometers on various TMDs (MoS_2, WS_2, $MoSe_2$, WSe_2), alloys and heterostructures revealing detailed nanoscale features.

12:15 pm–12:30 pm

FD3.5 Compressive hyperspectral Micr oscopy of Nanomaterials, Y. Xu, J. Chen, L. Liyang, K. F. Kelly, *Rice University, Houston, TX, USA*

We applied compressive sensing theory to hyperspectral microscopy so that the combination of compressive light modulation with sparse reconstruction algorithms enhances the SNR and allows for rapid acquisition of the full spectrum at every pixel and demonstrate its utility in analyzing a variety of nanomaterials.

12:30 pm–1:30 pm **Emerald E**

Professional Development Tutorial Lunch & Learn

Session Chair Stanley Ikpe, *NASA Langley Research Center, VA, USA*

12:30 pm–1:30 pm

Keynote Speaker: Linda Stacy, *LivingBluPrints, MA, USA*

1:30 pm–3:30 pm **Coral Ballroom D**

Session FD4 **Topological Insulators and Photonics**

Session Chair Nicholas Fang, *Massachusetts Institute of Technology, MA, USA*

1:30 pm–2:00 pm ***(Invited)***

FD4.1 **Quantum Inspired Integrated Photonics,** Liang Feng, *University of Pennsylvania, Philadelphia, PA, USA*

Quantum mechanics and photonics share mathematical equivalence. Hence, photonics has become an ideal platform to explore some exotic quantum concepts. Here, I will present our recent efforts in demonstrating quantum inspired photonics on an integrated platform, such as non-Hermitian and topological photonics for novel applications.

2:00 pm–2:30 pm ***(Invited)***

FD4.2 **Topological Light Sources,** Boubacar Kante, *University of California, San Diego, San Diego, CA, USA*

This talk will discuss the demonstration of the first Bound state In Continuum laser that can beam coherent light in prescribed directions and the demonstration of the first topological laser that non-reciprocally couples stimulated emission to selected waveguide outputs, a long searched optical functionality.

2:30 pm–2:45 pm ***(Invited)***

FD4.3 **hyperspectral Time-Domain Terahertz Nano Imaging,** N. Aghamiri, *University of Georgia, Athens, GA, USA,* F. Huth, A. Huber, *Neaspec GmbH, Munich, Germany,* R. Hillenbrand, *CIC nanoGUNE and UPV/EHU, San Sebastian, Spain and Basque Foundation of Science, Bilboa, Spain,* and Y. Abate, *University of Georgia, Athens, GA, USA*

We demonstrate hyperspectral imaging of the charge carrier profiles of doped precharacterized SRam arrays in the THz frequency range 13 cm^{-1}–60 cm^{-1} using a s-SNOM. We are able to map free carrier concentration in range of 10^{16} cm^{-3}–10^{20} cm^{-3} with broadband THz source.

2:45 pm–3:00 pm

FD4.4 **Resonant Ultrathin Infrared Detectors Enabling high Quantum Efficiency ,** David W. Peters, Jin K. Kim, Paul Davids, Anna Tauke-Pedretti, Paul S. Davids, Michael D. Goldflam, Michael B. Sinclair, Joel R. Wendt, Larry K. Warne, Salvatore Campione, Aaron J. Pung, Michael G. Wood, Evan M. Anderson, Patrick S. Finnegan, Charles R. Alford, Phillip H. Weiner, Torben R. Fortune, Wesley T. Coon, and Samuel D. Hawkins, *Sandia National Laboratories, Albuquerque, NM, USA*

We demonstrate thinned resonant longwave infrared detectors with quantum efficiencies of over 60% in the longwave infrared. This improvement over unthinned detectors is made possible by a nanoantenna that confines the incident optical energy in a reduced volume compared to traditional detector architectures.

3:00 pm–3:15 pm

FD4.5 Near-Field Photocurrent Mapping of MoS2-Based Device at Nanoscale, Rugang Geng and Yohannes Abate, *University of Georgia, Athens, GA, USA*

Utilizing scattering-type scanning near-field optical microscopy (s-SNOM) with electrical read-out, we have demonstrated the ability of mapping optical and electronic properties of MoS_2-based devices at length scales of tens of nanometers.

3:15 pm–3:30 pm

FD4.6 2D Material Printing for Cavity Integration, Xiaochen Ge, Zhonghe Liu, and Weidong Zhou, *University of Texas at Arlington, Arlington, TX, USA*

By using an automatic assembly platform, precise control of the transfer printing process in preparation of 2D materials is realized. Cavity enhanced photoluminescence is achieved after transferring monolayer WS_2 onto photonic crystals.

3:30 pm–5:30 pm **Coral Ballroom D**

Session FD5 **Modeling and Simulation for advanced Photonics**

Session Chairs Ruth Pachter, *Air Force Research Laboratory, OH, USA*
Simeon Trendafilov, *Air Force Research Laboratory, FL, USA*

3:30 pm–4:00 pm ***(Invited)***

FD5.1 Wave Propagation in Time-Modulated Metamaterials, Andrea Alu, *CUNY Advanced Science Research Center, New York, NY, USA*

In this talk, we will describe the unusual propagation properties in metamaterials with suitably tailored spatio-temporal modulations. We show how modulation can induce arbitrarily slow wave propagation and non-reciprocal transport, opening new avenues towards the quest of controlling and taming electromagnetic waves with metamaterials.

4:00 pm–4:30 pm ***(Invited)***

FD5.2 Optics of hybrid Nanomaterials: Fr om Collective Resonances to Nonlinear Spectroscopy, Maxim Sukharev, *Arizona State University, Mesa, AZ, USA*

I'll discuss modeling aspects of various optical phenomena at exciton-plasmonic interfaces using Maxwell-Bloch equations in one, two, and three dimensions. I'll show that such systems may exhibit collective exciton resonances. Nonlinear optical phenomena such as thrid harmonic generation and photon echo spectroscopy will be discussed.

4:30 pm–5:00 pm ***(Invited)***

FD5.3 Optical Response of Two-Dimensional Nanostructures by Theoretical Prediction, Ruth Pachter and Jie Jiang, *Air Force Research Laboratory, Wright-Patterson Air Force Base, OH, USA*

We predict significantly red-shifted single-photon emitters for 2D WSe_2 having experimentally observed rotational defects, as based on a validated approach. Furthermore, to develop materials having tunable optical absorption and nonlinear optical response, we computationally demonstrate exciton modulation by variation of 2D hybrid organic-inorganic perovskites' constituents.

5:00 pm–5:15 pm

FD5.4 **To Etch or Not To Etch,** Simeon Trendafilov, Monica Allen, Jeffery Allen, *Air Force Research Laboratory, Eglin AFB, FL, USA,* Young Jun Yoon, Yihuang Chen, Cynthia Rivaldo Gomez, and Zhiqun Lin, *Georgia Institute of Technology, Atlanta, GA, USA*

Monocrystalline metallic nanoparticles are preferable for plasmonic applications, but grow preferably in polyhedral shapes which deviate from the pervasive spherical shape. Our simulations show that dimers of octahedral Au nanoparticles have higher field enhancement in the gap compared to dimers of spherical Au nanoparticles.

5:15 pm–5:30 pm

FD5.5 **Enhanced Quantum Efficiency and Reduction of Reflection for MSM Photodetectors with Nano-Structured Surface,** Ekaterina Ponizovskaya-Devine, Hilal Cansizoglu, Yan Gao, Cesar Perez, Toshishige Yamada, Aly F. Elrefaie, M. Saif Islam, and Shih-Yuan Wang, *UC Davis, Davis, CA, USA*

The photon trapping nano-structures help to enhance quantum efficiency and reduce reflection for MSM photodetector that allows fast Si photodetectors at wavelength 800–950 nm. The nanostructure consist of micro holes reduces reflection and bends normally incident light into the lateral modes in the absorbing layer.

5:30 pm–6:00 pm **Coral Ballroom D**
NPNMaP Panel Discussion
Session Chair Dmitri Basov, *Columbia University, NY, USA*

Track 10:advanced Nanophotonics Platforms (aNP)

8:00 am–8:30 am **her on**
Session FE1 **advanced Nanophotonics Platforms**
Session Chair Hayk Harutyunyan, *Emory University, GA, USA*

8:00 am–8:30 am ***(Keynote)***

FE1.1 **Opening Remarks,** Alexandra Boltasseva, *AL, USA*

Recent years have seen dramatic growth in the field of nanophotonics including breakthrough developments in both fundamental science of light and novel optical materials. New device concepts range from nanoscale photonic circuitry and subwavelength-resolution imaging to optical metasurfaces that are expected to impact information technology, healthcare, energy, manufacturing, aerospace, automotive and national security.

8:30 am–10:30 am **her on**

Session FE2 **Ultrafast and Nonlinear Nanophotonics**

Session Chairs Hayk Harutyunyan, *Emory University, GA, USA*
John Boeckl, *Air Force Research Laboratory, OH, USA*

8:30 am–9:00 am ***(Invited)***

FE2.1 **Topologically-Engineered Flat-Surface Metamaterials for the Far- & Near-Field Nanophotonics,** Svetlana V. Boriskina, *Massachusetts Institute of Technology, Cambridge, MA, USA*

The overarching idea is the development of smart nanophotonic structures with flat surfaces, which are designed based on the topological engineering of the nano-structured material bulk, provide uniform signal enhancement over large surface areas, and can be fabricated by high-throughput additive techniques without the need for nano-patterning.

9:00 am–9:30 am ***(Invited)***

FE2.2 **Ultrafast all-Optical Modulation of Light with hot-Carrier Plasmonics,** Wenshan Cai, *Georgia Institute of Technology, Atlanta, GA, USA*

Sub-picosecond all-optical modulation of the intensity, phase, and polarization of light is demonstrated by leveraging the ultrafast generation and transport of hot-electrons, incorporated into a metamaterial absorber. Accurate control over the modulation depth and operating wavelength is achievable via rational design and excitation schemes.

9:30 am–10:00 am ***(Invited)***

FE2.3 **Infrared and active Photonics Using Nanoantennas and Metasurfaces,** Otto Muskens, *University of Southampton, Southampton, UK*

I will present topics in infrared active plasmonics, including new meta-surface thermal coatings for radiative cooling of spacecraft and satellites exploiting metal-oxide plasmonics, picosecond switching of antennas on vanadium dioxide using plasmonic hotspots, and hybrid photonic plasmonic resonators on silicon photonics exploiting coherent perfect absorption.

10:00 am–10:30 am ***(Invited)***

FE2.4 **Plasmonically-Coupled Nanowire Sensors,** Diana Huffaker, *Cardiff University, Wales, UK*

Plasmonically-coupled nanowire sensors have potential to compete with bulk state of art. Nanoscale assembly overcomes strain for integration and optimization. Plasmonic-coupling reduces device volume, substantially reducing dark current. The small footprint increases electric field profile for extremely low noise operation. We will discuss recent demonstration.

10:30 am–12:30 pm **Room: Ballroom**
Session FE3 **High Refractive Index Enabled Nanophotonics**
Session Chairs John Schuller, *University of California, Santa Barbara, CA, USA*
Joshua Caldwell, *Vanderbilt University, TN, USA*

10:30 am–11:00 am ***(Invited)***

FE3.1 **Resonant Semiconductor Nanostructures for Optoelectronics,** Mark Brongersma, *Stanford University, Stanford, CA, USA*

Semiconductor nanostructures are at the heart of electronic devices and systems. When properly sized and shaped, they can also support strong optical resonances that are capable of boosting light-matter interaction over bulk materials and afford new optoelectronic functionalities.

11:00 am–11:30 am ***(Invited)***

FE3.2 **Dynamic all-Dielectric Metasurfaces,** Jason Valentine, *Vanderbilt University, Nashville, TN, USA*

In this talk, I will discuss our recent efforts to develop dynamic metasurfaces based on all- dielectric resonators. Several modulation techniques will be covered including phase change media and carrier injection with an emphasis on structures possessing concentrated field profiles.

11:30 am–12:00 pm ***(Invited)***

FE3.3 **Ultrawide Thermal Tuning of Semiconductor Metasurface Resonators,** Tomer Lewi, *Bar Ilan University, Tel Aviv, Israel*

Exploiting high-index semiconductors with large thermo-optic response combined with high-Q resonances, we demonstrate dynamic tuning of metasurface resonators by several linewidths with small temperature gradients. We describe ongoing efforts to exploit these phenomena in reconfigurable nanophotonic meta-devices such as metafilters and phase shifters.

12:00 pm–12:15 pm

FE3.4 **Electromagnetic Responses from Planar arrays of Dielectric Nano-Disks at Overlapping Dipolar Resonances,** N. Gandji, G. Semouchkin, and E. Semouchkina, *Michigan Technological University, Houghton, MI, USA*

Periodic arrays of dielectric nano-disk resonators are investigated to clarify the nature of their electromagnetic responses, in particular, the relation of light transmission to Kerker's conditions at overlapping dipolar resonances. It is concluded that periodicity and inter-resonator coupling define the observed responses.

12:15 pm–12:30 pm

FE3.5 achr omatic Subwavelength Grating Micro Lens for Linear Polarized Incidence, Mao Ye, *University of Michigan-Dearborn, Dearborn, MI, USA,* Vishva Ray, *University of Michigan, Ann Arbor, MI, USA,* and Yasha Yi, *University of Michigan-Dearborn, Dearborn, MI, USA*

Chromatic behavior is an important drawback for emerging planar subwavelength micro lens. In this work, a subwavelength grating lens is designed, similated, fabricated and characterized under linearly polarized incidence with achromatic behavior across the whole visible wavelength.

12:30 pm–1:30 pm **Emerald E**

Professional Development Tutorial Lunch & Learn

Session Chair Stanley Ikpe, *NASA Langley Research Center, VA, USA*

12:30 pm–1:30 pm

Keynote Speaker: Linda Stacy, *LivingBluPrints, MA, USA*

1:30 pm–3:30 pm **her on**

Session FE4 Emerging Material Platforms for Plasmonics

Session Chairs Alexandra Boltasseva, *Purdue University, IN, USA*
Stephanie Law, *University of Delaware, DE, USA*

1:30 pm–2:00 pm ***(Invited)***

FE4.1 Novel Silicon-Compatible Plasmonic Materials, Luca Dal Negro, *Boston University, Boston, MA, USA*

We present our work on the development of transparent conductive materials compatible with silicon technology. We discuss the fabrication and characterization of Indium Silicon Oxide and Titanium Oxynitrides and demonstrate tunable Epsilon-Near-Zero (ENZ) behavior. These materials provide opportunities to engineer plasmon-enhanced nanostructures and metamaterial devices.

2:00 pm–2:15 pm

FE4.2 Topological Insulator Thin Films as Terahertz Plasmonic Materials, Theresa Ginley, Yong Wang, Zhengtianye Wang, and Stephanie Law, *University of Delaware, Newark, DE, USA*

The surfaces of topological insulators contain two-dimensional massless Dirac electrons. In topological insulator thin films, electrons on the top and bottom surfaces couple. Plasmons can be excited using these coupled electrons and show resonances in the terahertz with exceptionally large mode indices and long lifetimes.

2:15 pm–2:30 pm

FE4.3 Synthesis and Characterizations of Plasmonic Nanoparticles: Large Plain au and au/T iO_2 Core-Shell Nanoparticles, Young Jun Yoon, Yihuang Chen, Cynthia Rivaldo Gomez, *Georgia Institute of Technology, Atlanta, GA, USA,* Monica Allen, Jeffrey Allen, *Air Force Research Laboratory, Eglin Air Force Base, FL, USA,* and Zhiqun Lin, *Georgia Institute of Technology, Atlanta, GA, USA*

Two distinct approaches to synthesizing spherical, monodisperse, and large (>40 nm) gold nanoparticles are reported. The first approach involves synthesizing monodisperse gold octahedrons followed by selective etching of the vertices. The second approach exploits the nanoreactor strategy for gold nanoparticles and the related core-shell nanoparticles.

2:30 pm–2:45 pm

FE4.4 Impact of Interface Quality on the Strength of Volume Plasmon Polaritons in Semiconductor hyperbolic Metamaterials, Patrick Sohr, Dongxia Wei, and Stephanie Law, *University of Delaware, Newark, DE, USA*

Semiconductor hyperbolic metamaterials (HMMs) are designer materials that can support the propagation of large wavevector light through volume plasmon polariton (VPP) modes. We investigated the impact of interface quality on the strength and quality factor of these VPP modes using Fourier Infrared Spectroscopy.

2:45 pm–3:00 pm

FE4.5 Improving Transfer Efficiency of Molecular Photonic Wires on DNa Scaffolds, Sebastián A. Díaz, William P. Klein, *US Naval Research Laboratory, Washington, DC, USA,* Sean M. Oliver, *George Mason University, Fairfax, VA, USA,* David A. Hastman, *US Naval Research Laboratory, Washington, DC, USA and University of Maryland, College Park, MD, USA,* Susan Buckhout-White, Mario G. Ancona, Paul D. Cunningham, Joseph S. Melinger, *US Naval Research Laboratory, Washington, DC, USA,* Patrick M. Vora, *George Mason University, Fairfax, VA, USA,* and Igor L. Medintz, *US Naval Research Laboratory, Washington, DC, USA*

DNA-based assemblies provide a simple and economical preparation method for molecular photonic wires (structures that capture and direct light with high efficiencies), through precise positioning of the molecular transfer components. Multiple variables were studied to optimize these FRET based molecular photonic wires.

3:00 pm–3:30 pm *(Invited)*

FE4.6 New Materials and Designs for Nano- & Topo-Photonics, Vladimir Shalaev, *Purdue University, West Lafayette, IN*

3:30 pm–5:30 pm **her on**
Session FE5 **active Plasmonics and Nanophotonics**
Session Chairs Amit Agrawal, *NIST, CO, USA*
Palash Bharadwaj, *Rice University, TX, USA*

3:30 pm–4:00 pm ***(Invited)***

FE5.1 **Nanoplasmonics: how to a void the Loss,** Jacob Khurgin, *Johns Hopkins University, Baltimore, MD, USA*

Plasmonic techniques promise to reduce the footprint, latency and power consumption of photonic devices and circuits but this promise is frustrated by large ohmic loss inherent to metals. To what degree and how this loss can be mitigated is the subject of this presentation.

4:00 pm–4:30 pm ***(Invited)***

FE5.2 **highly Efficient Excitation of Plasmons acr oss (Molecular) Tunneling Junctions,** Christian Nijhuis, *National University of Singapore, Singapore*

To integrate plasmonics with nano-eletronics, plasmonic-electronic transducers are needed. I will discuss our recent progress in the development of tunnel junctions based on self-assembled monolayers (Sams) and metal oxides and how we apply them as electrical excitation sources of plasmons.

4:30 pm–4:45 pm

FE5.3 **Electrical Driving of Plasmonic Optical a ntennas,** Ali Mojibpour and Palash Bharadwaj, *Rice University, Houston, TX, USA*

We present a light emitting plasmonic tunnel junction in which plasmonic nanoparticles are driven by the shot noise of a direct electrical current. This scheme provides a spectral tunability beyond that of the previous reports.

4:45 pm–5:00 pm

FE5.4 **Monolithic Doped-Semiconductor Platform for Optical Devices in the Infrared,** Raymond Wambold, Jad Salman, *University of Wisconsin–Madison, Madison, WI, USA,* Martin Hafermann, Jura Rensberg, *Friedrich Schiller University Jena, Jena, Germany,* Chenghao Wan, Bradley S. Gundlach, *University of Wisconsin–Madison, Madison, WI, USA,* Carsten Ronning, *Friedrich Schiller University Jena, Jena, Germany,* and Mikhail A. Kats, *University of Wisconsin–Madison, Madison, USA*

The ability to control light in the infrared is central to improving sensing, spectroscopy, communication, and directed-energy technologies. In this presentation, we demonstrate a platform for flat optical devices based on selectively doped semiconductors for monolithic diffractive, plasmonic, and gradient-index devices in the infrared.

5:00 pm–5:30 pm ***(Invited)***

FE5.5 Surface Plasmon Polariton Laser Based on a Metallic Trench Fabry-Perot Resonator, Henri Lezec, *National Institute of Standards and Technology, Gaithersburg, MD, USA*

We demonstrate ultra-narrow linewidth, room-temperature, visible-frequency surface plasmon lasing by leveraging an open Fabry-Perot cavity formed by a flat Ag surface coated with optically pumped gain medium and orthogonally bound by a pair of Ag sidewalls, opening the way to high figure-of-merit refractive index sensing.

5:30 pm–6:00 pm **her on**
aNP Panel Discussion
Session Chair Hayk Harutyunyan, *Emory University, GA, USA*

9:00 am–11:00 am **Theater**
Session FF2 Tutorial III
Session Chair Chris McCartan, *AFRL/RWMFS, FL, USA*

9:00 am–10:00 am ***(Tutorial)***

FF2.1 Physics and Technology of Photonic Infrared Detectors, Sanjay Krishna, *Ohio State University, Columbus, OH, USA*

This tutorial will be divided into three parts. We will discuss the phenomenology in the infrared that drive applications, antimonide based infrared detectors that have made significant advances in the past and the next generation infrared imaging designs with enhanced functionality in the pixel.

10:00 am–11:00 am ***(Tutorial)***

FF2.2 Principles and applications of Resonant Metasurfaces, Robert Magnusson, *University of Texas–Arlington, Arlington, TX, USA*

We review principles and applications of nanophotonic devices based on fundamental electromagnetic resonance effects in thin periodic films. We discuss design methods and review typical fabrication processes. Representative devices include single-layer wideband reflectors, nonfocusing spatial filters, nanogrid reflectors and polarizers, and resonant biosensors.

12:30 pm–1:30 pm **Emerald E**
Professional Development Tutorial Lunch & Learn
Session Chair Stanley Ikpe, *NASA Langley Research Center, VA, USA*

12:30 pm–1:30 pm

Keynote Speaker: Linda Stacy, *LivingBluPrints, MA, USA*

2:00 pm–4:00 pm **Theater**
Session FF4 **Tutorial IV**
Session Chair Chris McCartan, *AFRL/RWMFS, FL, USA*

2:00 pm–3:00 pm ***(Tutorial)***

FF4.1 **STEM Session: Why We Need STEM, What We Get Wrong, how Do We Fix It,** Brian Mitchell, *Air Force Research Laboratory, Eglin Air Force Base, FL, USA*

The term STEM has become so ubiquitous that we've lost sight of how important it is to our lives. We're also missing out on a lot of really smart kids, but there's hope. We can find the talent, close the gaps and save the world.

3:00 pm–4:00 pm ***(Tutorial)***

FF4.2 **helium Dr oplet Mediated Cluster assembly as a Tool to Probe the Limits of Energy Storage in Metastable Nanomaterials,** Claron Ridge, *Air Force Research Laboratory/RWME, Eglin Air Force Base, FL, USA*

The recent efforts of our laboratory have been focused on helium droplet mediated deposition as a tool to synthesize novel materials in a pre-reactive, metastable state. We have fabricated a range of materials varying composition, cluster size, stoichiometry, and cluster film thickness.

END OF PROGRaM

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