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

Lower Level 21B

08:00–10:00
JTu1A • Joint Plenary Session I

JTu1A.1 • 08:00 Plenary
Multi-modality Remote Sensing Data Acquisition and Analysis for High Throughput Phenotyping, Melba Crawford[1]; [1]*Purdue University, USA.* Sensing technologies ranging from RGB cameras to hyperspectral imaging and LiDAR are rapidly gaining popularity for field-based high throughput phenotyping applications on airborne and ground-based platforms. In addition to direct measurements of traditional phenotypes such as height, these sensors potentially provide surrogate measurements for plant structural characteristics (e.g. leaf count and leaf area index) and chemistry (e.g. photosynthesis, and plant stress). Opportunities and challenges associated with acquisition, processing, and analysis of high resolution RGB, VNIR/SWIR hyperspectral data, and discrete return LiDAR data acquired from UAVs for plant breeding experiments focused on advancing sorghum varieties for biofuels will be outlined. Results from multi-modality, multi-temporal predictive modeling of complex phenotypes such as biomass using data driven machine learning and biophysical models will also be presented in the context of feature extraction and learning with limited training data. Opportunities to exploit transfer learning across scales will also be discussed.

JTu1A.2 • 09:00 Plenary
Chip-Based Comb Spectroscopy, Alex Gaeta[1]; [1]*Columbia University, USA.* The ability to generate optical frequency combs in microresonators at milliwatt power levels offers the promise for high-precision spectroscopic instruments in highly robust, compact, and portable platforms.

10:00–10:30 Coffee Break, *Lower Level (by 21B)*

Lower Level 21C

Optics and Photonics for Sensing the Environment

10:30–12:30
ETu2A • Mobile and Remote Environmental Sensing
Presider: Lukas Emmenegger, EMPA, Switzerland

ETu2A.1 • 10:30 Invited
MIRA: A New, Ultrasensitive Middle Infrared Laser-Based "Lab in a Lunchbox", James Scherer[1], Joshua Paul[1], Jerome Thiebaud[1], Stephen So[1]; [1]*Aeris Technologies, Inc, USA.* A new ultrasensitive, lunchbox sized, middle infrared laser-based commercial gas sensor platform is described, with examples of monitoring of key pollutants (CO, HCHO) and GHG's (CH4, N2O) with 1ppb accuracy in a variety of field applications.

ETu2A.2 • 11:00
Comparison of solar light measurements from diffusing, focusing and bare optical fiber probes, Gabriel P. Lachance[1], Ruohui Wang[1], Warwick F. Vincent[2], Simon Thibault[1], Sophie LaRochelle[1]; [1]*Center for Optics, Photonics and Lasers (COPL), Université Laval, Canada;* [2]*Center for Northern Studies (CEN), Université Laval, Canada.* We measured solar light transmitted through ice and snow cover with fiber optic probes, and examined the benefits and trade-offs of using diffusers and optics to reduce signal variations due to non-uniform illumination.

Lower Level 21D

Fourier Transform Spectroscopy

10:30–12:30
FTu2B • Measurements of the Earth's Atmosphere: Instrument Development, Observations and Calibration
Presider: Christoph Englert, US Naval Research Laboratory, USA

FTu2B.1 • 10:30 Invited
IASI-NG: an Innovative Wide Field Infrared Remote Sensing FTS for Meteorology, Atmospheric Chemistry and Climate Monitoring , Frederic Bernard[1,2]; [1]*Centre National d'Etudes Spatiales, France;* [2]*Airbus Defence and Space SAS, France.* IASI-NG is a new space instrument based on an innovative wide field Mertz compensated FTS to improve both radiometric and spectral performances. We present the design of the instrument, required critical technologies and development status.

FTu2B.2 • 11:00
Calibration Validation of the GOES-16 Advanced Baseline Imager (ABI) with the High-Altitude Aircraft Based Scanning High-resolution Interferometer Sounder (S-HIS), Joe Taylor[1], David Tobin[1], Henry Revercomb[1], Fred Best[1], Ray Garcia[1], Robert Knuteson[1], Michelle Feltz[1], Frank Padula[2], Steve Goodman[2]; [1]*Univ. of Wisconsin-Madison, USA;* [2]*NESDIS, NOAA, USA.* A summary of the GOES-16 Advanced Baseline Imager (ABI) radiometric calibration validation assessment conducted using the Scanning High-resolution Interferometer Sounder (S-HIS) during the 2017 GOES-16 calibration validation campaign is presented.

Lower Level 21A

Hyperspectral Imaging and Sounding of the Environment

10:30–12:30
HTu2C • Hyperspectral Aquatic Remote Sensing
Presider: Michael Yetzbacher, Naval Research Laboratory, USA

HTu2C.1 • 10:30 Invited
Thinking Like a Data Scientist: Phytoplankton Functional Type Algorithms and Hyperspectral Imagery, Sherry Palacios[2,1], Raphael M. Kudela[3]; [1]*Biospheric Sciences, NASA Ames Research Center, USA;* [2]*Bay Area Environmental Research Inst., USA;* [3]*Ocean Sciences, Univ. of California - Santa Cruz, USA.* Data science methods in engineering may inform hyperspectral ocean color algorithm development. We explore interface of data science and ocean color remote sensing, and lessons learned, to improve efficiencies in hyperspectral algorithm development.

HTu2C.2 • 11:00 Invited
Airborne Calibration and Validation Instrumentation for Current and Next Generation Satellite Ocean Color Observations, Liane S. Guild[1], John Morrow[2], Raphael M. Kudela[3], Jeffrey Myers[7], Sherry Palacios[4], Juan Torres-Perez[5], Kendra Negrey[6], Stephen Dunagan[1], Roy R. Johnson[1], Meloë Kacenelenbogen[1]; [1]*Earth Science Division, NASA Ames Research Center, USA;* [2]*Biospherical Instruments, Inc., USA;* [3]*Ocean Sciences Dept., Univ. of California Santa Cruz, USA;* [4]*Bay Area Environmental Research Inst., USA;* [7]*Universities Space Research Association, USA.* NASA airborne missions over Monterey Bay demonstrated above- and in-water calibration and validation measurements supporting a combined sensor approach (imaging spectrometer, microradiometers, and sunphotometer) for coastal ocean color observations.

Lower Level 21B

Optical Sensors

10:30–12:30
STu2D • Optical Chemical and Biological Sensors I
Presider: Paul Pellegrino, US Army Research Laboratory, USA

STu2D.1 • 10:30 Invited
Combining a Minimally Invasive Injectable Hydrogel Sensor with a Non-invasive Wearable Device for Human Performance and Health Management, Natalie Wisniewski[1]; [1]*Profusa, Inc., USA.* Hypoxia can severely impact pilots at extreme altitudes or during rapid transitions in altitude. We explore novel soft, injectable microsensors that non-invasively report data to continuously track tissue oxygenation, enabling real-time monitoring of pilot performance.

STu2D.2 • 11:00 Invited
Microsystems for Measuring Oxygen Using Tissue Integrated Phosphorescence-Based Soft Sensors, Kristina Rivera[2], Vladimir Pozdin[1], James Dieffenderfer[1], Natalie Wisniewski[3], Alper Bozkurt[1], Michael Angelo-Anthony Daniele[1,2]; [1]*Electrical & Computer Engineering, North Carolina State Univ., USA;* [2]*Biomedical Engineering, North Carolina State Univ. / Univ. of North Carolina at Chapel Hill, USA;* [3]*Profusa, Inc., USA.* Continuous monitoring of oxygen inside both the human body and engineered human tissues can be achieved *via* real-time phosphorescence lifetime spectroscopy of integrated sensors. Photonic sensors and flexible, spectroscope patches are discussed.

Lower Level 21C

Optics and Photonics for Sensing the Environment

ETu2A • Mobile and Remote Environmental Sensing—Continued

ETu2A.3 • 11:15 Invited

Novel Gas Analyzers Based on Cavity Enhanced Laser Absorption Spectroscopy, Douglas S. Baer[1]; [1]*ABB-Los Gatos Research Inc, USA.* This presentation reviews recent advances in the development and deployment of measurement systems for quantification of atmospheric trace gases and pollutants, industrial process monitoring, and localization of natural gas leaks while driving and flying.

ETu2A.4 • 11:45

Diode-Laser-Based Micro-Pulse Differential Absorption Lidar (DIAL) for Thermodynamic Profiling of the Lower Troposphere, Catharine E. Bunn[1], Kevin Repasky[2,3], Robert Stillwell[3], Matthew Hayman[3], Scott Spuler[3]; [1]*Physics Dept., Montana State Univ., USA;* [2]*Electrical & Computer Engineering Dept., Montana State Univ., USA;* [3]*Earth Observing Lab, National Center for Atmospheric Research, USA.* Micro-pulse differential absorption lidar have demonstrated humidity, calibrated aerosol, and temperature profiling capabilities. These instruments have the potential to fulfill the thermodynamic profiling needs for research and data assimilation.

ETu2A.5 • 12:00 Invited

Applications of Mobile Air Pollution Monitoring to Guide Environmental Policy, Ramon Alvarez[1]; [1]*Environmental Defense Fund, USA.* TI will describe two distinct collaborative research programs that rely on mobile air pollution monitoring to quantify methane emissions from the US oil and gas industry and characterize fine-scale spatial patterns of urban air pollution.

Lower Level 21D

Fourier Transform Spectroscopy

FTu2B • Measurements of the Earth's Atmosphere: Instrument Development, Observations and Calibration—Continued

FTu2B.3 • 11:15

A 3D Space-ground Atmospheric Observation System, Ren Chen[1,2], Cong Gao[1,3], Lei Liu[4], Jianwen Hua[1,2], Lei Ding[1,2]; [1]*Shanghai Inst. of Technical Physics, Chinese Academy of Sciences, China;* [2]*Key Lab of Infrared System Detection and Imaging Technology, Chinese Academy of Sciences, China;* [3]*Univ. of Chinese Academy of Sciences, China;* [4]*College of Meteorology and Oceanography, National Univ. of Defense Technology, China.* This paper introduced a three-dimensional(3D) Space-ground atmospheric observation system, which is based on interference optics technology. It is used to detect the three-dimensional distribution and change of atmospheric temperature and humidity.

FTu2B.4 • 11:30 Invited

Atmospheric Carbon Dioxide and Methane Observations by GOSAT and GOSAT-2, Yukio Yoshida[1], Haruki Oshio[1], Yu Someya[1], Hirofumi Ohyama[1], Akihide Kamei[1], Isamu Morino[1], Osamu Uchino[1], Makoto Saito[1], Hibiki Noda[1], Tsuneo Matsunaga[1]; [1]*NIES, Japan.* Atmospheric carbon dioxide and methane have been observed from space by Fourier transform spectrometer onboard Greenhouse gases Observing SATellite (GOSAT) and its successor, GOSAT-2. The retrieval method and observation results will be introduced.

FTu2B.5 • 12:00

Comparisons of Nitrogen Dioxide Profiles from the Atmospheric Chemistry Experiment Fourier Transform Spectrometer (ACE-FTS) and Stratospheric Aerosol and Gas Experiment (SAGE) III, Kaley A. Walker[1], Patrick E. Sheese[1], Chris D. Boone[2], David E. Flittner[3], Robert Damadeo[3]; [1]*Univ. of Toronto, Canada;* [2]*Univ. of Waterloo, Canada;* [3]*NASA Langley Research Center, USA.* This paper will compare NO_2 data from the Atmospheric Chemistry Experiment Fourier Transform Spectrometer (ACE-FTS) with correlative data from the new Stratospheric Aerosol and Gas Experiment III on the International Space Station (SAGE III/ISS).

Lower Level 21A

Hyperspectral Imaging and Sounding of the Environment

HTu2C • Hyperspectral Aquatic Remote Sensing—Continued

HTu2C.3 • 11:30

Algorithms and Sensor Design Considerations for Retrieving Bottom Depth and Type in Shallow Coral Reef Environments, Wesley Moses[1], Steven Ackleson[1]; [1]*Naval Research Lab, USA.* The spatial and spectral resolutions and signal-to-noise ratio of a sensor affect parameter retrieval accuracy. We discuss algorithms and sensor design considerations for retrieving bottom characteristics in shallow reef environments.

HTu2C.4 • 11:45

A new perspective on coral reefs: COral Reef Airborne Lab, Eric Hochberg[1]; [1]*Bermuda Inst. of Ocean Sciences, Bermuda.* Through airbrone hyperspectral imaging, CORAL provides the first large-scale, high-density, uniform data set describing coral reef condition across Florida, Hawaii, the Mariana Islands, Palau, and sections of the Great Barrier Reef.

HTu2C.5 • 12:00

A Review On Hyperspectral Remote Sensing Studies Of Coral Reefs, Sumisha Velloth[1], Raghavendra S. Mupparthy[2], Sudhakar Maruthadu[1]; [1]*CMLRE Ministry of Earth Sciences, India;* [2]*Ministry of Earth Sciences, NCMRWF, India.* The study reviews recent work on coral reefs using hyperspectral remote sensing data. Classifies literatures into two categories: satellite platforms and in situ.Compared various atmospheric correction schemes,techniques for various requirements.

Lower Level 21B

Optical Sensors

STu2D • Optical Chemical and Biological Sensors I—Continued

STu2D.3 • 11:30

Reversible Protein Carbonylation In-Vivo Biosensor, Roman Kostecki[1], Bin Zhang[2], Abdeljalil El Habti[3], Azim Arman[1], Mark Hutchinson[1], Penny Tricker[3], Delphine Fleury[3], Roger Narayan[2], Heike Ebendorff-Heidepriem[1]; [1]*ARC Centre of Excellence for Nanoscale BioPhotonics (CNBP), The Univ. of Adelaide, Australia;* [2]*Joint Dept. of Biomedical Engineering, Univ. of North Carolina and North Carolina State Univ., USA;* [3]*ARC ITRH Wheat Hub, School of Agriculture, Food and Wine, The Univ. of Adelaide, Australia.* We show preliminary results of an optical fiber based reversible in-vivo biosensor for understanding redox balance within living systems. The biosensor measured protein carbonyls (oxygen metabolism marker) in pig-skin, live mouse, and wheat plant.

STu2D.4 • 11:45

Photoacoustic Gas Detection with Electronic and Optical Microphones, Oscar E. Bonilla Manrique[1], Marta Ruiz Llata[1], José-Antonio A. Garcia-Souto[1], Julio-Enrique A. Posada-Roman[1]; [1]*Universidad Carlos III de Madrid, Spain.* A photoacoustic gas system has been implemented for comparison of the performance of an electronic and an optical microphone as acoustic sensors. Results show a minimum detectable pressure of 79.5 $\mu Pa/Hz^{1/2}$ for the optical microphone.

STu2D.5 • 12:00

Spatially Resolved Diffuse Reflectance Spectroscopy of Tumor and Normal Excised Human Colon with Thin Film Si Sensors, Benjamin A. LaRiviere[1], Katherine Garman[1], N. Lynn Ferguson[1], Deborah Fisher[1], Nan Jokerst[1]; [1]*Duke Univ., USA.* Spatially resolved diffuse reflectance spectroscopy of normal and cancerous ex-vivo human colon tissue using a thin film Si photodiode array sensor is presented as a step toward the realization of in-vivo endoscopic spectral tissue characterization.

Lower Level 21C	Lower Level 21D	Lower Level 21A	Lower Level 21B
Optics and Photonics for Sensing the Environment	Fourier Transform Spectroscopy	Hyperspectral Imaging and Sounding of the Environment	Optical Sensors

ETu2A • Mobile and Remote Environmental Sensing—Continued

FTu2B • Measurements of the Earth's Atmosphere: Instrument Development, Observations and Calibration—Continued

FTu2B.6 • 12:15
Digitally Calibrated Broadband Gases Absorption Spectral Measurements, Xinyi Chen[1], Weipeng Zhang[1], Haoyun Wei[1], Yan Li[1]; [1]*Tsinghua Univ., China*. A calibration algorithm was studied for the processing of spectral data in dual-comb spectroscopy. A mode-resolved spectrum was obtained over the full spectral range of the comb with a Hertz linewidth of RF comb mode.

HTu2C • Hyperspectral Aquatic Remote Sensing—Continued

STu2D • Optical Chemical and Biological Sensors I—Continued

STu2D.6 • 12:15
Porous Silicon Fabry–Pérot Interferometer Highly Sensitive Detection of Mycotoxins in Field Crops, Ilana Freidman[2], Giorgi Shtenberg[1]; [1]*Volcani Center, Israel;* [2]*Life Sciences, Bar Ilan Univ., Israel.* Oxidized porous silicon nanostructures,Fabry-Pérot thin film,is synthesized and used as optical transducer element for the detection and quantification of Fumonisin B1 and is monitored by reflective interferometric Fourier transform spectroscopy.

12:30–13:30 Career Transition: Research <---> Development<---> Manufacturing Lunch and Learn, *Lower Level Pre-Function Area*

12:30–13:30 Lunch on Your Own

Lower Level 21C

Optics and Photonics for Sensing the Environment

13:30–15:30
ETu3A • New Techniques for Laser Sensing
Presider: Vasanthi Sivaprakasam, US Naval Research Laboratory, USA

ETu3A.1 • 13:30 Invited
Advances in mid-IR Cavity Enhanced Photoacoustic and Photothermal Trace Gas Sensing, Jakob Hayden[1], Johannes P. Waclawek[1], Bernhard Lendl[1]; [1]*Technische Universität Wien, Austria.* Resent advances and developments regarding laser based mid-IR gas sensors based on cavity enhanced – quartz enhanced photoacoustic spectroscopy (QEPAS) as well as interferometric cavity assisted photothermal spectroscopy (ICAPS) are reported.

ETu3A.2 • 14:00
LDLS Powered Tunable Light Source for Advance Sensor Characterization, Xiaohua Ye[1]; [1]*Energetiq, USA.* Tunable light source powered by a laser-driven light source (LDLS) was presented for the application of image-sensor evaluations. Experimental results of spectral flux stability, FWHM bandwidths, repeatability, and flexibility are discussed.

ETu3A.3 • 14:15
Graphene Based Double Ring Label-Free Terahertz Sensor with High Sensitivity, Fatemeh Ghaedi Vanani[2], Alireza Fardoost[2], reza safian[1]; [1]*Imec, USA;* [2]*CREOL, The College of Optics and Photonics, USA.* In our proposed structure, deformation of the normal double waveguide mode into photonic-plasmonic confined super mode by curving the waveguide into a small ring is exploited to increase the sensitivity of the terahertz label-free sensor.

ETu3A.4 • 14:30
A Dual-polarization Rayleigh Backscatter Model for Phase-sensitive OTDR Applications, Sterenn Guerrier[1], Christian Dorize[1], Elie Awwad[1], Jérémie Renaudier[1]; [1]*Nokia Bell Labs, France.* A dual-polarization model of Rayleigh backscattering for telecom fibers is developed. The noise standard deviation over distance estimated from phase-OTDR simulation matches experimental results when accounting for the laser source phase noise.

ETu3A.5 • 14:45
Broadband Mid-Infrared Spectroscopy using a Virtually Imaged Phased Array , Diana M. Bailey[1], Adam Fleisher[1]; [1]*Material Measurement Lab, National Inst. of Standards and Technology, USA.* We report a dispersive frequency comb spectrometer for broadband mid-infrared spectroscopy of N_2O and SF_6 with absorbance noise of 3×10^{-3} in 1.2 s integration time.

ETu3A.6 • 15:00 Invited
Free-running Optical Frequency Combs for Remote Sensing, Jérôme Genest[1]; [1]*Universite Laval, Canada.* Software correction algorithms allow using free-running frequency combs in remote sensing applications. One recent example is the spectroscopy of methane's R and Q branches with a broadband, rugged, and compact chip-based dual-comb system.

Lower Level 21A

Hyperspectral Imaging and Sounding of the Environment

13:30–15:15
HTu3B • Image Processing, Algorithm Development, and Applications I
Presider: Wesley Moses, Naval Research Laboratory, USA

HTu3B.1 • 13:30 Invited
The Eightfold Paths to Clairvoyant Fusion, Alan Schaum[1]; [1]*US Naval Research Lab, USA.* A practical methodology called clairvoyant fusion can be used to build robust detection algorithms from elementary ones. We describe several of the method's interpretations and illustrate their use in multi- and hyperspectral imaging applications.

HTu3B.2 • 14:00 Invited
Bayesian Methods for Remote Coastal Measurement Using Imaging Spectroscopy, David Thompson[1]; [1]*Imaging Spectroscopy, Jet Propulsion Lab, California Inst. of Technology, USA.* Bayesian model inversion methods are a powerful tool for analyzing imaging spectrometer data. This talk highlights an Optimal Estimation (OE) methodology from recent work which demonstrates closed uncertainty accounting for coastal and inland waters.

HTu3B.3 • 14:30
Multispectral Imaging for Detection of Adulterants in Turmeric Powder, G.W. K. Prabhath[1], Wele Gedara C. Bandara[1], Dissanayake Walawwe Sahan Chinthana B. Dissanayake[1], Herath Mudiyanselage V. Herath[1], Gunawath Mudiyanselage R. Godaliyadda[1], Mervyn P. Ekanayake[1], Dhanushika Demini[2], Terrence Madhujith[2]; [1]*Dept. of Electrical and Electronic Engineering, Univ. of Peradeniya, Sri Lanka;* [2]*Dept. of Food Science and Technology, Univ. of Peradeniya, Sri Lanka.* Ultraviolet-visible-near infrared (UV-vis-NIR) multispectral imaging and multivariate statistical analysis methods were used to identify the adulteration level of turmeric powder available in the market.

HTu3B.4 • 14:45
Material Identification Using Fuzzy-Classification of High Resolution Hyperspectral Imagery of an Urban Area, Meghana Paranjape[1], François Cavayas[1]; [1]*Univ. of Montreal, Canada.* This project identifies urban surface materials using high-resolution hyperspectral data, compared to reference spectra from spectral libraries by using a fuzzy classification that incorporates both the shape and distance of spectral signatures.

HTu3B.5 • 15:00
Tridimensional Convolutional Sparse Coding of Spectral Images, CRISOSTOMO A. BARAJAS-SOLANO[1], Hans Y. Garcia[1], Juan M. Ramirez[1], Henry Arguello[1]; [1]*UIS, Colombia.* This work proposes a 3D framework for convolutional sparse coding of spectral images using dictionary learning. This scheme was tested within a denoising scheme, improving the state-of-the-art's representation approach by up to 5dB of PSNR.

Lower Level 21B

Optical Sensors

13:30–15:30
STu3C • Optical Chemical and Biological Sensors II
Presider: Paul Pellegrino, US Army Research Laboratory, USA

STu3C.1 • 13:30 Invited
Micro-interferometers on chip for sensing applications, Yisbel Marin[1], Philippe Velha[1], Stefano Faralli[1], Fabrizio Di Pasquale[1], Claudio J. Oton[1]; [1]*Scuola Superiore Sant'Anna, Italy.* We present an overview on integrated micro-interferometers on chip, with a special focus on silicon photonics. Some recent results are described, which include applications for optical fiber sensing and chemical sensing.

STu3C.2 • 14:00 Invited
Enhanced Sensitivity Subwavelength Grating Waveguides for Silicon Photonics Sensing Applications, J. Gonzalo Wangüemert-Pérez[1], Abdel H. Hadij-ElHouati[1], Alejandro Sánchez-Postigo[1], Jonas Leuermann[1,2], Daniel Pereira-Martín[1], José-Manuel Luque-González[1], Pavel Cheben[3], Danxia Xu[3], Jens H. Schmid[3], Jiri Ctyroky[4], Jordi Soler-Penadés[5], Milos Nedeljkovic[5], Goran Z. Mashanovich[5], Alejandro Ortega-Moñux[1], Robert Halir[1,2], Iñigo Molina-Fernández[1,2]; [1]*Málaga Univ., Spain;* [2]*Bionand Center for Nanomedicine and Biotechnology, Spain;* [3]*National Research Council Canada, Canada;* [4]*Inst. of Photonics and Electronics, Czechia;* [5]*Optoelectronics Research Centre, UK.* In this work we will review the enormous potential of subwavelength grating waveguides for sensing applications in the near and mid-infrared bands, demonstrating the capability to engineer the mode profile to maximize the light-matter interaction.

STu3C.3 • 14:30
Inline Characterization of Microfluidic APTES Functionalization for SOI Ring Resonator Biosensors, Laura Kasper[1], Christoph Kratz[2], Jürgen Bruns[1], Rudolf Volkmer[3], Karsten Hinrichs[2], Klaus Petermann[1]; [1]*Technische Universität Berlin, Germany;* [2]*Leibniz Institut für analytische Wissenschaften, Leibniz Gemeinschaft, Germany;* [3]*Institut für Medizinische Immunologie, Charité - Universitätsmedizin, Germany.* SOI biosensors afford a linkage of biological moieties at the inorganic surface. This paper presents an inline microfluidic approach to functionalize SOI ring resonators by reducing effects of physisorption and 3D-networks.

STu3C.4 • 14:45
Microring Resonator Biosensor Sensitivity Enhancement through Higher Order Interferograms, Feng-Chang Chien[1], Shih-Hsiang Hsu[1], Chou-Yun Hsu[1]; [1]*National Taiwan Univ of Science & Tech, Taiwan.* The MRR sensitivity on influenza DNA is enhanced by 1.5 times through round-trip ring-down waveforms interrogated with two-stage MZ interferometer and demonstrates 14.5 μm/μM and 9.7 μm/μM, respectively, for the first and second order interferograms.

STu3C.5 • 15:00
A Miniaturized Non-Dispersive Infrared CO2 Sensor Based On a 2D Integrating Cylinder, Xiaoning Jia[1], Günther Roelkens[1], Roel Baets[1], Joris Roels[2]; [1]*Ghent Univ., Belgium;* [2]*Melexis Technologies NV, Belgium.* We propose a novel, miniaturized NDIR CO2 sensor based on a 2D integrating cylinder, realized using deep RIE and wafer bonding on silicon. The sensor has a detection limit down to ~ 250ppm, with a small footprint of only ~ 5mm by 5mm.

STu3C.6 • 15:15
Withdrawn

15:30–16:00 Coffee Break, *Lower Level (by 21B)*

Lower Level 21C

Optical Sensors

16:00–17:30
STu4A • Laser-Based Sensors I
Presider: Kwang Jo Lee, Kyung Hee University, South Korea

STu4A.1 • 16:00 Invited
Femtosecond Laser-Based Time-of-Flight (TOF) Sensors, Jungwon Kim[1]; [1]*Korea Advanced Inst of Science & Tech, Korea (the Republic of).* A new class of high-speed, high-resolution and multi-functional time-of-flight sensor is demonstrated using electro-optic sampling of phase-locked microwaves with femtosecond optical pulses. A ~1-nm resolution is obtained in 14-ms averaging time.

STu4A.2 • 16:30 Invited
Laser-based Remote Sensing of Atmospheric Carbon Dioxide, Mark A. Stephen[1]; [1]*NASA Goddard Space Flight Center, USA.* NASA-Goddard is developing a high-fidelity space-based remote sensor for atmospheric CO_2. We report on a the instrument architecture and performance and the technology developments for a low earth orbiting instrument.

STu4A.3 • 17:00
A Grating Interferometer based High-Sensitivity Acoustic Sensor Packaged with Optoelectronic Readout Module, Mengying Zhang[1,2], Zhenjun Ma[1,3], Ran Gao[1], Zhi-mei Qi[1], Xingdong Liang[2]; [1]*State Key Lab of Transducer Technology, Inst. of Electronics, Chinese Academy of Sciences, China;* [2]*Science and Technology on Microwave Imaging Lab, Inst. of Electronics, Chinese Academy of Sciences, China;* [3]*School of Electronic, Electrical and Communication Engineering, Univ. of Chinese Academy of Sciences, China.* An acoustic sensor based on grating interferometer has been developed. The interference structure was made of glass and packaged with the optoelectronic readout module. The acoustic sensor achieved high-sensitivity and high-quality response.

Lower Level 21D

Fourier Transform Spectroscopy

16:00–17:30
FTu4B • Spaceborne and Miniaturized-based FTS Developments
Presider: Kaley Walker, University of Toronto, Canada

FTu4B.1 • 16:00 Invited
Miniature Robust High-resolution Spectrometers for Future Planetary Missions, Sona Hosseini[1]; [1]*Jet Propulsion Lab, USA.* We describe the design, fabrication, and testing of compact spatial heterodyne spectrometers (SHS). The interferometer is part of the effort to develop miniature robust high-resolution spectrometers to observe low density, low temperature and angularly extended planetary targets such as cometary coma and lunar exosphere in near-ultraviolet OH fluorescence emission. The stability of the spectrometer coupled with the high optomechanical tolerances makes this new instrument very robust and suitable for applications in space missions

FTu4B.2 • 16:30
An Overview of Design Challenges and the Data Analysis Approach of the Thermospheric Wind and Temperature Instrument on the NASA ICON Mission, Christoph R. Englert[1], John Harlander[2], Charles M. Brown[1], Kenneth Marr[1], Michael H. Stevens[1], Brian J. Harding[3], Thomas J. Immel[3], Stephen B. Mende[3], Jonathan J. Makela[4]; [1]*US Naval Research Lab, USA;* [2]*Space Systems Research Corporation, USA;* [3]*Univ. of California, Berkeley, USA;* [4]*Univ. of Illinois, USA.* The MIGHTI instrument on the NASA ICON Explorer mission is currently scheduled for launch in 2019. This presentation discusses the instrument concept, design challenges and achievements, major data analysis steps, and anticipated on-orbit data.

FTu4B.3 • 16:45
Mini-MIGHTI: A Prototype Sensor for Thermospheric Red-Line (630 nm) Neutral Wind Measurements from a 6U CubeSat, John Harlander[1,2], Christoph Englert[3], Kenneth Marr[3]; [1]*Space Systems Research Corp, USA;* [2]*Physics, St Cloud State Univ., USA;* [3]*Naval Reserach Lab, USA.* A prototype sensor for measuring thermospheric red-line winds from a 6U CubeSat is described. The sensor uses a backup interferometer for the MIGHTI instrument on the NASA ICON satellite with a more limited scientific scope.

FTu4B.4 • 17:00
A Velocity Modulated Fixed-Path Michelson Interferometer for Space-Based Remote Sensing of Upper Atmospheric Neutral Winds, John Harlander[1,2], Christoph Englert[3]; [1]*Space Systems Research Corp, USA;* [2]*Physics, St Cloud State Univ., USA;* [3]*Naval Reserach Lab, USA.* A concept for measuring upper atmospheric neutral winds from a satellite platform utilizing a fixed-path Michelson interferometer is described. The concept is suitable in resource limited applications such as CubeSats.

Lower Level 21A

Hyperspectral Imaging and Sounding of the Environment

16:00–17:30
HTu4C • Image Processing, Algorithm Development, and Applications II
Presider: Saurabh Prasad, Univ. of Houston, USA

HTu4C.1 • 16:00 Invited
Challenges and Opportunities in the Far-IR Remote Sensing, Xianglei Huang[1]; [1]*Univ. of Michigan, USA.* I will first describe the technical challenges for far-IR remote sensing, then the recent works to address such issue, and the scientific questions to be answered by the far-IR remote sensing.

HTu4C.2 • 16:30 Invited
The Soil Line: Moisture-independent Soil Reflectance Spectra, William Philpot[1]; [1]*Cornell Univ., USA.* The soil line that appears in a Red-NIR scatterplot is representative of a stable, moisture-independent spectral reflectance that spans the VNIR. This has potential for refining the characterization of, and discrimination among soil types

HTu4C.3 • 17:00
Using Hyperspectral UAS Imagery to Monitor Invasive Plant Phenology, Erik A. Bolch[1], Erin L. Hestir[1]; [1]*Univ. of California, Merced, USA.* UAS based sensors provide safe on demand deployment of small hyperspectral imaging systems. Using this technology to monitor invasive plant spread and phenology will enable resource managers to respond quickly and effectively.

Lower Level 21B

Optical Sensors

16:00–17:30
STu4D • Industrial Sensing
Presider: To Be Announced

STu4D.1 • 16:00 Invited
Downhole Sensing: 177 C Are you Kidding? Jess V. Ford[1]; [1]*Weatherford International Ltd, USA.* This paper gives a short overview of oil & gas optical sensing and a case study regarding a downhole VIS-NIR photometric analyzer for crude oil characterization operating under high pressure and temperature conditions.

STu4D.2 • 16:30
Development of a Frequency-locking V-shaped Cavity Enhanced Raman Spectrometer for Simultaneous Analysis of Fault Gases, FU WAN[1], Pinyi Wang[1], Jin Hu[1], Jianxin Wang[1], Feng Zhou[1], Weigen Chen[1]; [1]*State Key Lab of Power Transmission Equipment &System Security and New Technology, China.* A frequency-locking cavity enhanced Raman spectrometer for simultaneous gases analysis was developed. Minimum detection limit of CH_4, C_2H_4, C_2H_2, C_2H_6, H_2, CO and CO_2 was 8.25, 15.50, 25.78, 14.65, 37.83, 65.12 and 44.30 (**μL**/L), respectively.

STu4D.3 • 16:45
Non-intrusive pipeline pressure monitoring with a Fiber Bragg Gratings-based sensing patch, nicolas roussel[1], romain cotillard[1], Guillaume Laffont[1], marc baque[2]; [1]*CEA Saclay, France;* [2]*Total Exploration Production, France.* A non-intrusive patch with three FBG sensors is proposed and tested for measuring a 4” gas pipeline’s internal pressure. Stable measurement over 8 days is achieved with less than one bar measuring resolution.

STu4D.4 • 17:00
Lossy Mode Resonance based Optical Fiber-Tip Moisture Sensor in Foods, Yundong Ren[1], Mucheng Li[1], Pratap Rao[1], Yuxiang Liu[1]; [1]*Worcester Polytechnic Inst., USA.* We designed, fabricated, and characterized a lossy mode resonance based optical fiber-tip moisture sensor. We experimentally demonstrated the sensor’s capability of in-situ moisture content monitoring within food samples during their drying process.

Lower Level 21C

Optical Sensors

STu4A • Laser-Based Sensors I—Continued

Lower Level 21D

Fourier Transform Spectroscopy

FTu4B • Spaceborne and Miniaturized-based FTS Developments—Continued

FTu4B.5 • 17:15
Performance Optimization Strategies for Nanophotonic Digital Fourier Transform Spectrometers, Derek Kita[1], Carlos Rios[1], Juejun Hu[1]; [1]*MIT, USA.* We present techniques for improving the performance of ultra-high resolution on-chip digital Fourier transform spectrometers. These methods enable perfect optical switching, broadband operation, large visibility, and filtering of narrowband signals.

Lower Level 21A

Hyperspectral Imaging and Sounding of the Environment

HTu4C • Image Processing, Algorithm Development, and Applications II—Continued

Lower Level 21B

Optical Sensors

STu4D • Industrial Sensing—Continued

STu4D.5 • 17:15
Broadband Infrared Gas Spectroscopy Using Quantum Cascade Laser Arrays , CHIEN-SHENG LIAO[1], Romain G. Blanchard[1], Christian Pfluegl[1], Fred Huettig[1], Masud Azimi[1], Mark F. Witinski[1], Daryoosh Vakhshoori[1]; [1]*Pendar Technologies, USA.* Using rapidly-tunable quantum cascade laser arrays, we demonstrate acquisition of absorption spectra over 50cm^{-1} with < 0.1cm^{-1} resolution and a minimum detectable absorbance of 1 × 10^{-4} over the full spectrum in < 0.5s.

17:30–19:30 Congress Reception, *Lower Level Lobby Pre-Function Area*

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

Lower Level 21B

08:00–09:00
JW1A • Joint Plenary Session II

JW1A.1 • 08:00 Plenary

High Performance Optical Phased Array LiDAR, Peter Russo[1]; [1]*Analog Photonics*. Integrated optical phased arrays provide an attractive solution to LiDAR sensors by enabling solid-state, small-form-factor systems fabricated on 300mm wafers. We present recent results including high-performance beam steering and long-range LiDAR up to almost 200m.

Lower Level 21C

Optics and Photonics for Sensing the Environment

09:00–10:00
EW2A • Laser Sensing Devices
Presider: Dennis Killinger, University of South Florida, USA

EW2A.1 • 09:00 Invited

Miniaturized Ring-Down Spectroscopy with Etalon Cancellation for Planetary Science and Other Field Applications, Bradley M. Gibson[1]; [1]*NASA Jet Propulsion Lab, USA.* A miniaturized ring-down spectrometer prototype, including novel adjacent-resonance etalon cancellation, has been developed for *in situ* planetary science. The development and performance of the spectrometer and etalon cancellation will be discussed.

EW2A.2 • 09:30

Mid-Infrared Waveguides for Volatile Organic Compounds Detection, Pao T. Lin[1]; [1]*Texas A&M Univ., USA.* Miniaturized mid-Infrared (mid-IR) photonic sensors were utilized for volatile organic compounds (VOCs) detection. The optical waveguides were fabricated by microelectronic processes.

EW2A.3 • 09:45

Asymmetrical all-organic waveguide gas sensor, Arturs Bundulis[1], Edgars Nitiss[1], Martins Rutkis[1]; [1]*Inst. of Solid State Physics, Latvia.* An all-organic waveguide sensor for volatile solver detecting was presented. Device consists of SU-8 waveguide with novel organic material used as sensitive cladding. Created device was tested in isopropanol and N_2 vapor mixture.

Lower Level 21B

Optical Sensors

09:00–10:00
SW2B • Nanoplasmon I
Presider: Frank Vollmer, University of Exeter, UK

SW2B.1 • 09:00 Tutorial

Plasmonic Biosensors: Harnessing the Enhanced Power of Light with Biosystems, Tuan Vo-Dinh[1]; [1]*Duke Univ., USA.* This tutorial lecture presents an overview of the development and applications of plasmonic biosensors. Development of various plasmonics-active platforms for surface-enhanced Raman scattering and biosensing in the author's Lab is discussed.

SW2B.2 • 09:45

Sensitivity Enhancement of Goos-Hänchen Shift Modulation Based Plasmonic Biosensing, Qingling Ouyang[1,2], Lixing Kang[1], Xuan Quyen Dinh[1], Philippe Coquet[1,3], Ken-Tye Yong[1,2]; [1]*CINTRA CNRS/NTU/THALES, Singapore;* [2]*School of Electrical and Electronic Engineering, Nanyang Technological Univ., Singapore;* [3]*Institut d'Electronique, de Microélectronique et de Nanotechnologie (IEMN), Université de Lille 1, France.* A highly sensitive surface plasmon resonance biosensor was developed based on Goos-Hänchen shift modulation. The detection limit was improved by two orders of magnitude compared with that of conventional modulation approaches.

NOTES

10:00–11:00
JW3A • Joint Poster Session I

JW3A.1
Integration of Modeling and Remote Sensing Methods for the Study of Suspended Matter in the Sea of Azov, Tatiana Shulga[1], Viacheslav Suslin[1]; [1]*Marine Hydrophysical Inst. of RAS, Russia.* The assimilation scheme allows for prediction of transport and diffusion of the bio-optical tracers from MODIS products applied the Princeton Ocean Model. Use data-assimilation made simulations a tool for filling the gaps to satellite imagery.

JW3A.3
Locally Adaptive Optical Protection Filtering For Vision Sensors , Vasily A. Ezhov[1]; [1]*GPI RAS, Russia.* The described concept of locally-adaptive optical-protection filtering provides reliable vision sensor perception of the real world objects with normal brightness in the presence of the objects with highest brightness having differing coordinates.

JW3A.5
Narrow linewidth random fiber laser based on weak grating array with a π-phase-shifted FBG, Wentao Zhang[1], Shuaijie Miao[1], Wenzhu Huang[1], Ying Song[2], Fang Li[1]; [1]*Chinese Academy of Sciences, China;* [2]*Shijiazhuang Tiedao Univ., China.* The π-phase-shifted FBG in proposed random fiber laser significantly inhibited the sub-cavity modes, emitting a narrow lasing of 225 Hz with 58 dB side-mode suppression ratio and providing a new option for high-resolution sensing.

JW3A.7
3D Flash LIDAR Simulation to Expect Deterioration under Various Weather Conditions, Han Mingon[1], Juhwan Kim[1], Haechan An[2], Yoonchan Jeong[1]; [1]*Seoul National Univ., Korea (the Republic of);* [2]*Purdue Univ., USA.* We develop a numerical model for a 3D flash LIDAR system, using a Monte Carlo method along with Kim's model and Henyey-Greenstein phase function, and exploit it for LIDAR image deterioration under various weather conditions.

JW3A.9
Incoherent Supercontinuum Light Source via an Active Highly-Nonlinear Photonic Crystal Fiber with All-Normal Dispersion for Laser-Based Sensing Applications, Kyoungyoon Park[1], Hansol Kim[1], Hanbyul Chang[1], Yoonchan Jeong[1]; [1]*Seoul National Univ., Korea (the Republic of).* We study incoherent supercontinuum generation in ytterbium-doped all-normal dispersion fibers and report that eruptive dark solitons generated by optical gain cause incoherence and spectral broadening, which can be utilized for optical sensing.

JW3A.11
NASA's next-generation airborne sunphotometer (5STAR): Engineering challenges and advances, Robert P. Dahlgren[1], Stephen Dunagan[4], Roy R. Johnson[3], Stephen Broccardo[5], Ali-Imran Tayeb[2], Conrad M. Esch[2,6]; [1]*SGE, CSUMB/NASA Ames Research Center, USA;* [2]*SGE, BAERI/NASA Ames Research Center, USA;* [3]*SGG, NASA Ames Research Center, USA;* [4]*SGE, NASA Ames Research Center, USA;* [5]*SGG, USRA/NASA Ames Research Center, USA;* [6]*EECS, UC Santa Cruz, USA.* The NASA next-generation airborne sunphotometer is subject to requirements and constraints in the optical, mechanical, electronic, thermal and aeronautic domains. This presentation summarizes engineerng challenges, tradeoffs, and advances in 5STAR.

JW3A.13
Research of vertical profile of aerosol extinction based on measured the O_4 of multi-elevation angles with MAX-DOAS, suwen li[1], fusheng MOU[1]; [1]*Huaibei Normal Univ., China.* The look-up table algorithm is studied to retrieve vertical profile of aerosol extinction based on measured the O_4 of multi-elevation angles with MAX-DOAS.

JW3A.15
Infrared laser sensors for monitoring of atmospheric pollutions using nonlinear optical coherent beams, Iwan Kityk[1], Cate Ozga[1]; [1]*Czestochowa Univ. of Technology, Poland.* It is proposed to use two coherent nanosecond laser beams for the detection of the molecules in atmosphere. It will be demonstrated how use of coherent beams may enhance the signal/noise ratio.

JW3A.17
Simple Model of Light Transmission and Reflection for a Free Standing Highly Scattering Dielectric Medium, Martin Kykta[1]; [1]*MAK Eectro Optics, USA.* Simple equations for multiple reflection and absorption in a free standing transparent dielectric medium can be efficiently transformed to account for reflection and absorption in a highly scattering medium.

JW3A.19
Degenerate four-wave mixing based temperature sensor in As2S3 PCF, N Nagarajan[1], vasantha jayakantha raja R[1]; [1]*SASTRA Univ., India.* We theoretically demonstrate a temperature sensor based on the method of degenerate FWM in As2S3 photonic crystal fiber. The sensitivity of the proposed sensor shows the Stokes shift of 5.91 nm/°C and anti-Stokes shift of -0.145 nm/°C.

JW3A.21
Novel optically coherent sensors for nonlinear optical coherent monitoring of pollutions, Iwan Kityk[1], Cate Ozga[1]; [1]*Czestochowa Univ. of Technology, Poland.* A principally novel laser sensor for monitoring of oil pollutions in water is proposed. The basic principle is based on the coexistence of coherent fundamental and doubled frequencies excited beams of nanosecond Nd:YAG laser.

JW3A.23
Oil Film Thickness Measurement by Laser Induced Spectrum Method Based on Android Platform, Zhaoshuo Tian[1], Yi Fan[1], Zongjie Bi[1], Yanchao Zhang[1], Ling Wang[1], Shiyou Fu[1]; [1]*Harbin Inst. of Technology (Weihai), China.* Oil film on water surface is excited by laser and its spectral data are transmitted wirelessly to the mobile phone via Bluetooth. Oil film thickness value and spectral curve can display on APP interface simultaneously.

JW3A.25
Optical Parametric Oscillator Based Differential Absorption Lidar foTropospheric Methane Concentration Measurement, Taieb Gasmi[1]; [1]*Saint Louis Univ-Madrid Campus, Spain, Spain.* We present a Q-switched Nd:YAG-OPO based differential absorption lidar for the detection of methane in the mid-infrared region (3.0-4.5) µm. Measurements depict urban methane measurements that exhibited diurnal fluctuations in concentration levels.

JW3A.27
Monolithic Near Infrared LED System for Plants Health Monitoring Sensors , Abdullah J. Zakariya[1], Ebraheem Sultan[2]; [1]*Ministry of Interior Kuwait, Kuwait;* [2]*Public Authority of Applied Education and Training, Kuwait.* A monolithic selectively intermixed QW LEDs emit a range of wavelengths in the near infrared spectrum from a single output. The LEDs use a single power source to produce light for plants health monitoring sensors.

JW3A.29
Sensitive fluorescence instrumentation for water quality assessment, Dániel Csösz[1], Sándor Lenk[1], Attila Barócsi[1], Tibor Lóránt Csöke[1], Szandra Klátyik[3], Diána Lázár[3], Mária Berki[4], Nóra Adányi[4], Attila Csákányi[2], László Domján[2], Gábor Szarvas[2], László Kocsányi[1], András Székács[3]; [1]*Dept. of Atomic Physics, BME, Hungary;* [2]*Optimal Optik Kft, Hungary;* [3]*Agro-Environmental Research Inst., National Agricultural Research and Innovation Centre, Hungary;* [4]*Food Science Research Inst., National Agricultural Research and Innovation Centre, Hungary.* We are developing the instrumentation for *in situ* measurement of several characteristic parameters of water quality using direct and immunofluorescence techniques. The instruments and our first results are presented.

JW3A.31
SO_2 measurement by 2F-harmonic wavelength modulation spectroscopy at 4µm and 7.4µm, Richard Kovacich[1], bahram alizadeh[1], michael lawson[1], vasili kasiutsich[1], rhys jenkins[1], jun-ichi hashimoto[2], martin lopez[1]; [1]*Servomex Group Limited, UK;* [2]*Sumitomo Electric Industries, Japan.* The measurement performance of SO_2 by second harmonic wavelength modulation spectroscopy using an interband cascade laser at 4µm is compared against using a quantum cascade laser at 7.4µm, showing differences in optical interference noise limitation.

JW3A.33
NASA's next-generation airborne sunphotometer (5STAR): science drivers and requirements, Stephen Broccardo[1], Samuel LeBlanc[2], Stephen Dunagan[3], Connor Flynn[4], Kristina Pistone[2], Jens Redemann[5], Michal Segal-Rosenhaimer[2], Meloe Kacenelenbogen[3]; [1]*USRA/NASA Ames Research Center, USA;* [2]*BAERI/NASA Ames Research Center, USA;* [3]*NASA Ames Research Center, USA;* [4]*Pacific Northwest National Lab, USA;* [5]*Univ. of Oklahoma, USA.* To realize the potential of spectrometers for airborne sunphotometry, a hybrid instrument incorporating radiometers and spectrometers is being built. This brings with it challenges in amplifier design, thermal management and stray-light control.

Lower Level 21C

Optics and Photonics for Sensing the Environment

11:00–12:30
EW4A • Particles, Particulates, and Organics
Presider: Jérôme Genest, Université Laval, Canada

EW4A.1 • 11:00 Invited
Optical Characterization of Individual Aerosol Particles, Vasanthi Sivaprakasam[1]; [1]*US Naval Research Lab, USA.* Spectroscopic studies of individual aerosol particles using Surface Enhanced Raman, polarized elastic light scattering and fluorescence measurements for broad classification and potential chemical identification of aerosols and their chemical dynamics.

EW4A.2 • 11:30
Single-Molecule Optoplasmonic Sensing of Enzyme Dynamics and Chiral Aminoacids, Frank Vollmer[1]; [1]*Univ. of Exeter, UK.* Probing single-enzymes and chiral molecules on nanosensors can lead to the next generation of bio-analytical technologies. Understanding light-matter interactions and what impacts the functionality of enzymes is crucial.

EW4A.3 • 11:45
Perfluorooctanoic (PFOA) Acid Detection in Aqueous Medium using Polyvinylidene Fluoride (PVDF) Thin Film on Optical Fiber Endface , Fairuza Faiz[1], Marlene Cran[1], Gregory Baxter[1], Stephen Collins[1], Fotios Sidiroglou[1]; [1]*Victoria Univ., Australia.* Polyvinylidene fluoride thin films were developed on optical fiber endface to detect perfluorooctanoic acid in water. Fabry-Perot interference was monitored and changes in optical path difference were measured to characterize sensor performance.

EW4A.4 • 12:00
Highly Sensitive Detection of Organic Molecules using Widely Electrically Tuneable QCLs, Lukas Emmenegger[1], Oleg Aseev[2,1], Philipp Scheidegger[1], Stéphane Blaser[3], Herbert Looser[1], Bela Tuzson[1]; [1]*EMPA, Switzerland;* [2]*Miro-Analytical, Switzerland;* [3]*Alpes Lasers, Switzerland.* Widely electrically tuneable QCLs are highly attractive for the sensitive and selective detection of organic molecules. Both high spectral resolution and broad coverage are shown for an XT-QCL providing 6-channels based on the Vernier effect.

Lower Level 21D

Fourier Transform Spectroscopy

11:00–12:30
FW4B • Far-IR Astronomy and FTS Spectroscopy: Measurements and Techniques
Presider: Sheng-Cai Shi, Purple Mountain Observatory, China

FW4B.1 • 11:00 Invited
Fourier Transform Spectroscopy with the Herschel Space Observatory Spectral and Photometric Imaging Receiver (SPIRE), Jason Glenn[1]; [1]*Univ. of Colorado at Boulder, USA.* The design, performance, and some major astronomical results of the SPIRE Fourier Transform Spectrometer will be discussed. Additionally, imminent and planned infrared and submillimeter astronomical spectrometers will be surveyed to indicate the future directions.

FW4B.2 • 11:30 Invited
THz Atmospheric Transmission Measured by FTS and Development of an On-chip Superconducting Spectrometer, Jing Li[1]; [1]*Purple Mountain Observatory, China.* This talk will present the FTS measurement results of atmospheric transmission at Dome A in Antarctic and Ali in western China and then introduce an on-chip superconducting spectrometer developed for the telescopes to be constructed there.

FW4B.3 • 12:00
Dual-comb methane spectroscopy using one Erbium-doped fiber laser, Jie Chen[1], Xin Zhao[1], Zijun Yao[1], Ting Li[1], Qian Li[1], Shuguo Xie[1], Jiansheng Liu[1], Zheng Zheng[1,2]; [1]*School of Electronic and Information Engineering, Beihang Univ., China;* [2]*Beijing Advanced Innovation Center for Big Date-based Precision Medicine, Beihang Univ., China.* Dual-comb methane spectroscopy at 1650nm is realized based on a dual-comb mode-locked fiber laser at 1560nm, which demonstrates the capability of such single-cavity, dual-comb sources to cover spectral ranges far beyond the laser emission wavelength.

FW4B.4 • 12:15
Measurement of acetone emission using a compact mid-infrared dual-comb spectrometer, Jacob Friedlein[1], Gabriel Ycas[2,1], Fabrizio R. Giorgetta[2,1], Daniel Herman[2,1], Kevin C. Cossel[1], Esther Baumann[2,1], Nathan Newbury[1], Ian R. Coddington[1]; [1]*National Inst. of Standards and Tech, USA;* [2]*Physics, Univ. of Colorado at Boulder, USA.* We present a compact, mid-infrared (MIR) dual-comb spectrometer using difference-frequency generation. The spectrometer covers 3 μm – 4 μm, within the functional group region. We demonstrate detection of acetone in a controlled-release experiment.

Lower Level 21B

Optical Sensors

11:00–12:30
SW4C • Nanoplasmon II
Presider: Filiz Yesilkoy, Ecole Polytechnique Federale de Lausanne, Switzerland

SW4C.1 • 11:00
Operating Point Correction for Mach Zehnder Interferometer-based Electro-optic E-field Sensors, James Toney[1,2], Vincent E. Stenger[1], Andrea Pollick[1], Sri Sriram[1]; [1]*SRICO, Inc., USA;* [2]*Dept. of Engineering Education, The Ohio State Univ., USA.* The response of Mach Zehnder Interferometer (MZI) electric field sensors is strongly dependent on the operating point. Techniques to compensate for sensor drift include correcting the measurement based on received optical power or harmonic analysis.

SW4C.2 • 11:15 Invited
Nanophotonic Biosensors: from Plasmonic to Dielectric Metasurfaces, Filiz Yesilkoy[1], Eduardo R. Arvelo[1], Yasaman Jahani[1], Alexander Belushkin[1], Mingkai Liu[2], Andreas Tittl[1], Yuri Kivshar[2], Hatice Altug[1]; [1]*Ecole Polytechnique Federale de Lausanne, Switzerland;* [2]*Australian National Univ., Australia.* Mobile and affordable biosensors enabling detection of disease biomarkers from small sample volumes are essential for next-generation healthcare systems.

SW4C.3 • 11:45
Fluorescence-based Multiplexed Biomolecular Systems in mm-scale Optics-free CMOS Chip: Nanoplasmonics in Embedded Electronics, Kaushik Sengupta[1], Lingyu hong[1], Hao Li[1], Haw Yang[1]; [1]*Princeton Univ., USA.* In this paper, we present a 96-sensor multiplexed fluorescence-based CMOS biosensor chip with integrated nanoplasmonic angle and scattering insensitive filters for the first time, miniaturizing the entire system into a pill-size form.

SW4C.4 • 12:00
Detection of Influenza Virus by Electrochemical Surface Plasmon Resonance Under Ptential Modulation, Aymen H. Qatamin[1]; [1]*Dept. of Physics & Astronomy, Univ. of Louisville, USA.* We report the development of a novel immunosensor- based strategy for detection of viral pathogens by incorporating a sandwich bioassay on the electrochemically-modulated SPR platform with a sensitivity in the pico-molar range for the H5N1 antigen

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12:30–13:30 Lunch on Your Own

12:30–13:30 Student & Early Career Professional Development & Networking Lunch and Learn, *Lower Level Pre-Function Area*

Lower Level 21C

Optical Sensors

13:30–15:30
SW5A • Optical Fibre I
Presider: Simon Fleming, University of Sydney, Australia

SW5A.1 • 13:30
Sensing with magnetostriction by coupling geometrical effect to an embedded fiber Bragg grating, Raúl E. Jiménez-Mejía[1], David M. Frailey[2], Chiu T. Law[2], Rodrigo Acuna[1]; [1]*Escuela de Fisica, Universidad Nacional de Colombia, Colombia;* [2]*Electrical Engineering and Computer Sciences, Univ. of Wisconsin-Milwaukee, USA.* This paper discusses the geometrical effects on the performance of a fiber optic magnetic field sensor based on a magnetostrictive composites. Experimental results for the cases under study agree with the discussed theoretical framework.

SW5A.2 • 13:45
A High-Sensitivity Magnetic Field Sensor with a Simple Structure, Riqing Lv[1], Yong Zhao[1], Shu-na Wang[1], Jun-kai Qian[1], Zi-ting Lin[1]; [1]*Northeastern Univ., China.* Ahigh-sensitivity magnetic field sensor with a single-mode-fiber structure and magnetic fluidwas presented. It could get a good response in the range of 0Gs to 30Gs and the sensitivity could be up to -4.49nm/Gs.

SW5A.3 • 14:00
Compact Fiber-Optic Pressure Sensor Based On an Externally Tunable Inter-Modal Converter, Kwang Jo Lee[1], Kyung Jun Park[2], Yung Kim[1], Donghwa Lee[1], Ilhwan Kim[1]; [1]*Kyung Hee Univ., Korea (the Republic of);* [2]*KS Photonics Inc., Korea (the Republic of).* We present a compact fiber-optic pressure sensor based on a long period fiber grating with the short length of ~1.8 cm (33 grating periods) induced by an externally tunable inter-modal converter.

SW5A.4 • 14:15
Fiber-optic Interferometric Vibration Sensor without Phase Bias induced Signal Fading, Youngwoong Kim[1], Myoung Jin Kim[1], Young Ho Kim[1], Huioon Kim[1], Byung Sup Rho[1]; [1]*Korea Photonics Technology Inst. , Korea (the Republic of).* We propose a simple fade-free fiber-optic interferometer for vibration sensing. A 90° optical hybrid based quadrature detection with subsequent π/2 phase shifting technique has shown to be fully free from the phase bias induced fading.

SW5A.5 • 14:30
Sub-cm Temperature Monitoring of 500 Weak Gratings Array Through Chirped Ultra-Short Light Pulses, Demetrio Sartiano[1], Javier Madrigal[1], Salvador Sales[1]; [1]*Inst. of Telecommunications and Multimedia Applications (iTEAM), Universitat Politècnica de València, Spain.* We developed a temperature quasi-distributed sensing system interrogating a 500 weak fiber Bragg gratings (FBGs) array of 5 meters. It was possible to sense temperature changes down to 1°C with sub-centimeter spatial resolution.

Lower Level 21D

Fourier Transform Spectroscopy

13:30–15:30
FW5B • Comb-based Spectroscopy Developments and Applications
Presider: Ian Coddington, National Inst of Standards & Technology, USA

FW5B.1 • 13:30 Invited
Nyquist-limited Fourier-transform Spectroscopy with Phase-controlled Delay Line, Takuro Ideguchi[1]; [1]*Univ. of Tokyo, Japan.* We develop a Nyquist-limited Fourier-transform spectrometer with a phase-controlled delay line. The rapid phase and group delay scanning allows us to measure interferograms in an efficient manner.

FW5B.2 • 14:00
Towards Hyperspectral Dual-Comb Imaging, Pedro Martín-Mateos[1], Guillermo Guarnizo[1]; [1]*Universidad Carlos III de Madrid, Spain.* This work describes the basics and the initial steps towards the development of a hyperspectral dual optical frequency comb imaging set-up. The first readings of dual-comb interferograms by a regular video-rate camera are demonstrated.

FW5B.3 • 14:15
A 1000x Stabler Spectrograph using an Interferometer with Crossfaded Delays, David J. Erskine[1], Eric V. Linder[2]; [1]*Lawrence Livermore National Lab, USA;* [2]*Physics Div, Lawrence Berkeley Nat Lab, USA.* We describe a data analysis strategy weighting signal components from at least two overlapping delays in an externally dispersed interferometer that reduces by 1000x the net shift in response to a wavelength drift in the disperser.

FW5B.4 • 14:30
Shot-noise-limited photodetection in dual frequency comb electric-field sampling, Abijith Kowligy[1], Alexander Lind[1], Henry Timmers[1], Flavio Cruz[1], Jens Biegert[2], Scott Diddams[1]; [1]*NIST, USA;* [2]*ICFO, Spain.* We demonstrate shot-noise-limited electric-field detection using dual frequency comb electro-optic sampling of few-cycle long-wave-infrared pulses, with the spectrum spanning 5 to 13 μm.

Lower Level 21A

Hyperspectral Imaging and Sounding of the Environment

13:30–15:00
HW5C • Effects of Clouds and Aerosols on Radiative Transfer
Presider: Ka Lok Chan, German Aerospace Center (DLR), Germany

HW5C.1 • 13:30 Invited
The Impact of Partly Cloudy Skies on Remote Sensing Data Products, Robert L. Sundberg[1]; [1]*Spectral Sciences Inc., USA.* We examine the effects of partly cloudy skies on the retrieval of spectral remote sensing products. Shadowing and scattering from clouds spectrally alter the ground illumination which complicates retrieval of accurate data products.

HW5C.2 • 14:00 Invited
Impact of Broken Clouds on Trace Gas Spectroscopy From Low Earth Orbit, Sebastian Schmidt[1], Steven Massie[1], Graham Feingold[2]; [1]*Univ of Colorado/LASP, USA;* [2]*ESRL, NOAA, USA.* We explain the observed high bias of carbon dioxide retrieved from passive spectroscopy (OCO-2) in presence of broken clouds with three-dimensional spectroscopic radiative transfer calculations.

HW5C.3 • 14:30
Quantifying Cloud Radiative Effects with Overlying Aerosol using Hyperspectral Transmitted Light, Samuel E. LeBlanc[1,2], Jens Redemann[3], Connor Flynn[4], Michal Segal-Rosenhaimer[1,2], Meloë Kacenelenbogen[2], Kristina Pistone[1,2], Sebastian Schmidt[5], Hong Chen[5], Sabrina Cochrane[5]; [1]*Bay Area Environmental Research Inst., USA;* [2]*NASA Ames Research Center, USA;* [3]*School of Meteorology, Oklahoma Univ., USA;* [4]*Pacific Northwest National Lab, USA;* [5]*Lab for Atmospheric and Space Physics, Univ. of Colorado at Boulder, USA.* Aerosol overlying clouds increase uncertainty of standard remotely sensed properties. We present results of a hyperspectral-based retrieval technique to obtain cloud properties, and its calculated radiative effect, from cloud-transmitted light.

Lower Level 21B

Optical Sensors

13:30–15:30
SW5D • Nanoplasmon III
Presider: Filiz Yesilkoy, Ecole Polytechnique Federale de Lausanne, Switzerland

SW5D.1 • 13:30 Invited
Single-molecule Sensing Mediated by Localized Plasmon Resonances, Peter Zijlstra[1], Rachel Armstrong[1], Michael Beuwer[1], Matej Horacek[1], Yuyang Wang[1]; [1]*Eindhoven Univ. of Technology, Netherlands.* I will outline recent advances in the plasmon-enhanced detection of single molecules and their application toward single-molecule biosensing and single-molecule biophysical studies.

SW5D.2 • 14:00
Snapshot Hyperspectral Imaging of Plasmonic Nanoelectrode Dissolution, Sean Collins[1], Alexander Al-Zubeidi[1], Benjamin Hoener[1], Wenxiao Wang[1], Silke Kirchner[1], Seyyed Ali Hosseini Jebeli[1], Anneli Joplin[1], Wei-Shun Chang[1], Stephan Link[1], Christy Landes[1]; [1]*Rice Univ., USA.* We demonstrate the role of hot holes in dissolution of individual gold nanorods with millisecond time resolution using snapshot hyperspectral imaging. The results provide insights into hot-hole processes with relevance to photocatalytic sensing.

SW5D.3 • 14:15
Improving the performance of LSPR sensors by composite plasmonic nanostructures, Steven Larsen[1], Yiping Zhao[1]; [1]*Univ. of Georgia, USA.* Combining nanosphere lithography and co-deposition, we demonstrate that the sensitivity of localized surface plasmon sensors is not only determined by the size, shape, and separation of the nanostructures, but also by its dielectric function.

SW5D.4 • 14:30
Plasmofluidic Nanoporous Gold Membrane for Ultrasensitive Raman Spectroscopy , Xiangchao Zhu[1], Pallavi Daggumati[2], Erkin Seker[2], Ahmet A. Yanik[1,3]; [1]*Electrical and Computer Engineering, Univ. of California, USA;* [2]*Electrical and Computer Engineering, Univ. of California, USA;* [3]*California Inst. for Quantitative Biosciences (QB3), USA.* A label-free and ultrasensitive surface-enhanced Raman spectroscopy technique based on suspended plasmonic nanoporous structures is demonstrated. Drastically enhanced local fields and optofluidic analyte delivery is used to enhance detection limits.

Lower Level 21C

Optical Sensors

SW5A • Optical Fibre I—Continued

SW5A.6 • 14:45
Application of High-Sensitivity Fiber Optic Microphone for On-line Detection of Electromagnetic Vibration Noise of Contactor Relays, Zhi-mei Qi[1]; [1]*Chinese Academy of Sciences (CAS), China.* Fabry-Perrot interferometer based fiber optic microphones with high sensitivity and high thermal stability have been successfully used for detection of weak electromagnetic vibration noise in the on-line quality control process of contactor relays.

SW5A.7 • 15:00
Investigating Physiological Signals in the Rat Brain with Optical Fiber Probe, Wen-Ju Pan[1], Xiaodi Zhang[1], Behnaz Yousefi[1], Taylor Bolt[1], Jacob Billings[1], Seung Yup Lee[1], Erin Buckley[1], Shella Keilholz[1]; [1]*Emory Univ., USA.* The physiological activities in the rat cortex were recorded/evaluated with fiber probe. Despite different pulse frequencies, the cardiac/respiratory pulse powers show correlated dynamics in slow fluctuation, suggesting common modulation mechanism.

Lower Level 21D

Fourier Transform Spectroscopy

FW5B • Comb-based Spectroscopy Developments and Applications—Continued

FW5B.5 • 14:45
Broadband, High-sensitive Spectroscopy by Adaptive Cavity Enhanced Dual-Comb Spectroscopy, Weipeng Zhang[1], Haoyun Wei[1], Xinyi Chen[1], Yan Li[1]; [1]*Tsinghua Univ., China.* A novel adaptive cavity enhanced dual-comb spectroscopy was proposed, achieving broadband measurement with no compromise of sensitivity, accuracy, resolution. A one-point comb-cavity coupling scheme achieving distortion-free broadband measurement.

FW5B.6 • 15:00
Acousto-Optic Comb Fourier Transform Spectrometer, Stephanie L. Swartz[1], Kelvin H. Wagner[1]; [1]*Electrical, Computer, and Energy Engineering, Univ. of Colorado at Boulder, USA.* We present an acousto-optic comb Fourier transform spectrometer that uses radiofrequency encoded optical pulses to produce an asymmetric interferogram with a complex comb Fourier transform for measuring transmission spectrums in the near-IR.

FW5B.7 • 15:15
Absolute-frequency THz dual-comb instrument: a scalable and high-resolution spectrometer based on electro-optic comb generation, Pedro Martín-Mateos[1], Borja Jerez[1], Andrés Betancur[1], Cristina de Dios[1], Pablo Acedo[1]; [1]*Universidad Carlos III de Madrid, Spain.* We present a compact and robust absolute-frequency THz dual-comb spectrometer based on electro-optic modulators that provides ultra-narrow linewidth teeth, a total control over both central and repetition frequencies and a high measurement speed.

Lower Level 21A

Hyperspectral Imaging and Sounding of the Environment

HW5C • Effects of Clouds and Aerosols on Radiative Transfer—Continued

HW5C.4 • 14:45
A Gas Absorption Parameterization Model for Hyperspectral Shortwave Radiative Transfer Computations, Jiachen Ding[1], Ping Yang[1], Michael King[3], Steven Platnick[2], Kerry Meyer[2], Chenxi Wang[4]; [1]*Texas A&M Univ., USA;* [2]*NASA Goddard Space Flight Center, USA;* [3]*Lab for Atmospheric & Space Physics, Univ. of Colorado, USA;* [4]*Univ. of Maryland, USA.* A regression-based gas absorption parameterization method is developed. T This method can be applied in fast hyperspectral shortwave radiative transfer computations because of its computational efficiency and accuracy.

Lower Level 21B

Optical Sensors

SW5D • Nanoplasmon III—Continued

SW5D.5 • 14:45
Hydrogen Detection with Plasmonic Palladium-coated Tilted Fiber Bragg Gratings, Alvaro Gonzalez-Vila[1], Shunshuo Cai[1,2], Tuan Guo[2], Christophe Caucheteur[1]; [1]*Univ. of Mons, Belgium;* [2]*Jinan Univ., China.* Surface plasmon resonance excitation is achieved with palladium-coated tilted fiber Bragg gratings. The sensors are able to detect hydrogen leaks at concentrations way below the lower explosive limit of the gas.

SW5D.6 • 15:00 Invited
Artificial Chirality Evolution in Micro-/nanoscale 3D Plasmonic Metamaterials, Junsuk Rho[1]; [1]*POSTECH, Korea (the Republic of).* In this talk, I will discuss recent effort making bottom-up approached 3D chiral metamaterials, which could be used for further practical applications such as sensing.

15:30–16:00 Coffee Break, *Lower Level (by 21B)*

Lower Level 21C

Optics and Photonics for Sensing the Environment

16:00–17:30
EW6A • Atmospheric Gases and Clouds
Presider: Michelle Bailey, NIST, USA

EW6A.1 • 16:00 Invited
Laser Heterodyne Radiometry for Remote Sensing of Atmospheric Gases, David Bomse[1], Jared E. Tso[1], John H. Miller[2]; [1]*Mesa Photonics, LLC, USA;* [2]*Chemistry, George Washington Univ., USA.* A passive remote sensor for atmospheric retrievals of O_2, CO_2 and CH_4 has been developed based on laser heterodyne radiometry using diode lasers operating at wavelengths between 1278 and 1650 nm as local oscillators.

EW6A.2 • 16:30
Efficient Multi-Event Localization from Rayleigh Backscattering in Phase-Sensitive OTDR Systems, Elie Awwad[1], Christian Dorize[1], Jérémie Renaudier[1]; [1]*Nokia Bell Labs, France.* We introduce a phase-OTDR multi-resolution approach to localize mechanical events through telecom fibers. Perturbations are first coarsely localized from a subset of high-reflecting backscatters, followed by a low complexity localization refinement

EW6A.3 • 16:45
Gas Leak Detection, Localization and Imaging Using Compressed Domain Sensing and Processing, Lenore McMackin[1], Matthew A. Herman[1], Leif G. Fredin[2], Keith Jamison[2]; [1]*InView Technology Corporation, USA;* [2]*Amethyst Research Incorporated, USA.* An inexpensive, narrowband mid-IR camera built on the computational Compressed Domain architecture implements a selective low-volume data sampling strategy and utilizes a novel resonant cavity detector to demonstrate automated methane leak detection.

EW6A.4 • 17:00 Invited
Lidar Cloud Detection with Fully Convolutional Networks, Erol Cromwell[1], Donna Flynn[1]; [1]*Pacific Northwest National Lab, USA.* We present a novel approach for segmenting lidar imagery into geometric time-height cloud locations with a fully convolutional network. We show the model achieves higher levels of cloud identification compared to the MPLCMASK algorithm.

Lower Level 21A

Hyperspectral Imaging and Sounding of the Environment

16:00–17:30
HW6B • Characterization of Hyperspectral Measurements
Presider: Emmett Ientilucci , Rochester Institute of Technology, USA

HW6B.1 • 16:00 Invited
Background Estimation in Multispectral Imagery, James Theiler[1], Amanda Ziemann[1]; [1]*Los Alamos National Lab, USA.* A machine learning framework is employed for estimating the background spectrum at a pixel of interest using pixel values in an annular neighborhood of that pixel.

HW6B.2 • 16:30 Invited
Multispectral Terrestrial LiDAR: Improving Active Spectral Sensing of Low Reflectance Targets, Sanna M. Kaasalainen[1], Tuomo Malkamäki[1]; [1]*Navigation and positioning, Finnish Geospatial Research Inst., Finland.* The calibration of multispectral LiDAR intensity is still challenging because the measurement has to be optimized for simultaneous 3D measurement. We present first results of improved LiDAR waveform sampling for retrieval of low reflectance values.

HW6B.3 • 17:00
Assessing the Spectral Signal-to-noise Ratio of Hyperspectral Cameras for Ocean Color Sensing, Ryan E. O'Shea[1,2], Samuel Laney[2], Jennie Rheuban[2]; [1]*MIT, USA;* [2]*Woods Hole Oceanographic Institution, USA.* We assessed the signal-to-noise ratio (SNR) of a drone-deployable hyperspectral camera for water quality parameter estimation. We also developed a model to assess the SNR of comparable sensors in a range of sensing scenarios.

Lower Level 21B

Optical Sensors

16:00–17:30
SW6C • Laser-Based Sensing II
Presider: Peter Dragic, Univ. of Illinois at Urbana-Champaign, USA

SW6C.1 • 16:00 Invited
Time-stretch LiDAR, Bahram Jalali[1]; [1]*Univ. of California Los Angeles, USA.* We demonstrate the first wavelength-sweeping time-of-flight LiDAR enabled by discrete time-stretch and achieve non-mechanical scanning at ~MHz line rate with foveated imaging.

SW6C.2 • 16:30
Withdrawn

SW6C.3 • 16:45
Optical Light Shift for Vector Vapor Magnetometry, Janet W. Lou[1], Seth Meiselman[1], Geoffrey A. Cranch[1]; [1]*Naval Research Lab, USA.* The optical frequency of the light shift effect for an optically-pumped vapor vector magnetometer is shown to cause an angular error when it is tuned near the absorption resonance, countering the benefit of higher response.

SW6C.4 • 17:00
Magnetic field sensor based on FBG and magnetostrictive composites of Terfenol-D with oriented magnetic domains , Juan David Lopez Vargas[1], Alex Dante[1], Talitha Trovão[1], Roberto Wu Mok[1], César Cosenza de Carvalho[1], Regina Célia da Silva Barros Allil[1], Fabricio Borghi[2], Marcello M. Werneck[1]; [1]*Photonics and Instrumentation Lab (LIF), Federal Univ. of Rio de Janeiro (UFRJ), Brazil;* [2]*Physics Inst., UFRJ, Magnetic Nanomaterials Lab, Brazil.* This paper presents a study of magnetostrictive composites for magnetic field sensing with FBG and Terfenol-D. Experimental results show that orientation of magnetic domains with permanent magnets promoted an improved linearity of the sensor response.

SW6C.5 • 17:15
Simultaneous Perturbation of 3D Printed Long-Period Fiber Grating Devices for Controllable Resonant Wavelengths, Ravivudh Khun-in[1], Masahiro Takagi[1], Yuji Usuda[1], Apichai Bhatranand[2], Hideki Yokoi[1]; [1]*Shibaura Inst. of Technology, Japan;* [2]*King Mongkut's Univ. of Technology Thonburi, Thailand.* Resonant wavelengths from the simultaneous perturbation by 3D printed long-period fiber grating devices with different periods are observed. Both LPFG devices give resonant spectrums separately as same as ones from individual perturbation does.

18:00–18:45 Dinner on Your Own

18:45–20:00 JW7A • Postdeadline Session

Lower Level 21C	Lower Level 21D	Lower Level 21A	Executive Ballroom 210G
Optics and Photonics for Sensing the Environment	Fourier Transform Spectroscopy	Hyperspectral Imaging and Sounding of the Environment	Optical Sensors

07:00–17:30 Registration

08:00–10:00
ETh1A • Applied Spectral Sensing
Presider: Adam Fleisher, NIST, USA

ETh1A.1 • 08:00
Temperature Measurement of Macro and Micro Diffusion Flame by Digital Holographic Interferometry using Volume Phase Holographic Grating, vivek rastogi[1], Shilpi Agarwal[1], varun kumar[1], Chandra Shakher[1]; [1]*Indian Inst. of Technology, Delhi, India.* This paper presents the measurement of temperature of macro and micro diffusion flame by digital holographic interferometry (DHI) using volume phase holographic grating (VPHG). VPHG will remove stray light and coherent noise from the interferogram.

ETh1A.2 • 08:15
Mid-Wave Infrared Subsurface CO_2 Monitor with Isotopic Discrimination, Keith Jamison[1], Leif G. Fredin[1], Andrew J. Milder[1], Kevin Repasky[2]; [1]*Amethyst Research, Inc., USA;* [2]*Montana State Univ., USA.* A sensor to monitor sequestered CO_2 with the ability to differentiate between natural and anthropogenic CO_2 is presented. This sensor is critical to ensure that sequestered gases are not re-entering the atmosphere.

ETh1A.3 • 08:30 Invited
Open-Path Ammonia Measurements on the NASA DC-8 Aircraft Using a Fiber-coupled, Quantum Cascade Laser, Mark A. Zondlo[1]; [1]*Princeton Univ., USA.* An airborne-based, open-path ammonia instrument has been developed for the NASA DC-8 aircraft that uses a fiber-coupled, quantum cascade laser. The flight performance and design characteristics will be demonstrated when sampling fire and agricultural plumes.

ETh1A.4 • 09:00
Fabrication of Ultra-Weak Fiber Bragg Grating (UWFBG) in Single-Mode Fibers through Ti-Doped Silica Outer Cladding for Distributed Acoustic Sensing, Jingyu Wu[1], Zhaoqiang Peng[1], Mohan Wang[1], Rongtao Cao[1], Mingjun Li[2], Hongqiao Wen[3], Hu Liu[4], Kevin P. Chen[1]; [1]*Univ. of Pittsburgh, USA;* [2]*Corning, USA;* [3]*Wuhan Univ. of Technology, China;* [4]*Beihang Univ., China.* UWFBG was fabricated in single-mode fiber through Ti-Doped Silica Outer Cladding using KrF 248-nm excimer laser for phase-sensitive distributed acoustic sensing (DAS). This paper suggests a new approach to produce sensing fibers for DAS.

ETh1A.5 • 09:15
Role of Metal Coating Parameters on the Reflective Long Period Grating Spectrum, Sohel Rana[1], Harish Subbaraman[1], Nirmala Kandadai[1]; [1]*Boise State Univ., USA.* The role of metal coating length and coating coverage on the spectrum of a reflective long period grating is presented.

08:00–09:30
HTh1B • Remote Sensing of Atmospheric Pollutants
Presider: Ping Yang, Texas A&M Univ., USA

HTh1B.1 • 08:00 Invited
Using AIRS Hyperspectral Observations To Optimize Dust Refractive Index in Infrared Spectrum, Jun Wang[1], Yi wang[1]; [1]*Univ. of Iowa , USA.* Climate models lack accurate dust refractive index measurements for estimating radiative forcing. AIRS hyperspectral observations are used to optimize dust refractive index in infrared spectrum via integration of PCA and inverse modelling techniques.

HTh1B.2 • 08:30 Invited
Hyperspectral Imaging and Sounding of the Environment, Yingying Ma[1]; [1]*Wuhan Univ., China.* Haze episodes often occur during wintertime in Central China. The presentation reports the different characteristic of haze pollution and their influences on radiative transfer over Central China using hyperspectral satellite and ground observations.

HTh1B.3 • 09:00
Hyperspectral ground based and satellite measurements of tropospheric NO_2 and HCHO over Eastern China, Ka Lok Chan[1], Zhuoru Wang[1], Klaus-Peter Heue[1]; [1]*German Aerospace Center (DLR), Germany.* We present long term observations of atmospheric nitrogen dioxide (NO2) and formaldehyde (HCHO) in Nanjing and the reconstruction of NO_2 and HCHO spatial distribution over the Yangtze River Delta during summer and winter time.

HTh1B.4 • 09:15
Combining co-located multispectral VIS-SWIR polarimetry and UV-NIR hyperspectral imagery to simultaneously retrieve aerosol and ocean color properties from remote sensing: case studies for airborne RSP and GCAS observations obtained during the NAAMES campaign., Jacek Chowdhary[1,5], Snorre Stamnes[2], Minwei Zhang[3], Priscilla Kienteca Lange[2], Chuanmin Hu[4], Brian Cairns[5]; [1]*Columbia Univ., USA;* [2]*NASA LRC, USA;* [3]*Univ. of South Florida, USA;* [5]*NASA GISS, USA.* Co-located airborne measurements obtained during the NAAMES campaign of multispectral polarized radiance from RSP and of hyperspectral radiance from GCAS are used to retrieve aerosol properties and hyperspectral water-leaving radiance in the VIS.

08:00–10:00
STh1C • Micro and Nano-Engineered Sensors
Presider: Peter Zijlstra, Eindhoven University of Technology, Netherlands

STh1C.1 • 08:00 Invited
Optical Fiber and Plasmonic Based Sensors for Trapping and Imaging Applications, Sile Nic Chormaic[1]; [1]*Okinawa Inst of Science & Technology, Japan.* In this work, our recent progress on different optical sensing platforms for trapping and imaging applications will be presented, ranging from fiber bundle probes, through nanostructured optical nanofibers to plasmonic nanohole arrays.

STh1C.2 • 08:30 Invited
Flexible Fiber Sensors for Health-Monitoring, Fei Xu[1]; [1]*Nanjing Univ., China.* An attachable and flexible smart sensor consisting of a hybrid microfiber device is demonstrated as an ultrasensitive and wearable photonic sensor for continuous and close health-monitoring.

STh1C.3 • 09:00 Invited
Mode Modulation in Microbottle Cavities and Its Sensing Applications, Fuxing Gu[1]; [1]*Univer. of Shanghai for Science and Tech, China.* Based on gain and loss engineering approach, we realize single-whispering-gallery-mode lasing in polymer bottle microresonators and then demonstrate stretchable strain sensing and temperature sensing devices.

08:00–17:30
OIDA Forum on Optics in Autonomy

08:30–08:35
Welcome Remarks & Opening Comments

08:35-09:05
Keynote: The View from an OEM—CEO of Guangzhou Automotive Company (GAC) R&D Center Silicon Valley
One of the largest automotive manufacturers in the world shares its views on LIDAR and other optical sensors in ADAS & autonomous driving. What are the use cases and necessary functionalities for these sensors in Level 3 and Level 4 autonomy, and what requirements are there for cost & reliability?

Introduction: Rob Murano, *II-VI Incorporated*

Jin Shang, *GAC, Guangzhou Automotive Corp*

09:05–10:15
Panel 1: Investment and Market Perspectives
Investments by corporations and the venture capital world will continue to feed an increasingly diverse set of applications for mobility, autonomy, and robotics. It is creating new systems and service opportunities, driving new opportunities for semiconductors, optics and AI software. Our speakers will share their perspectives on riding these waves.

Moderator: John Dexheimer, *Lightwave Advisors, Inc.*

Alexei Andreev, *Autotech Ventures*
The perspective of a Physicist VC : The forefront of Driving Transportation technologies and business models.

Anand Joshi, *Tractica*
Tracking the evolution of autonomous machines and applications—the roadmap and challenges and implications for the optical sector

Yvonne Lutsch, *Robert Bosch Venture Capital*
The perspective of a corporate VC : Where's the action and why we invest

10:15–10:30 Break

Lower Level 21C

Optics and Photonics for Sensing the Environment

ETh1A • Applied Spectral Sensing—Continued

ETh1A.6 • 09:30
Thermal Infrared Laser Heterodyne Radiometer based on a Wavelength Modulated External Cavity Quantum Cascade Laser, Pedro Martín-Mateos[1], Andreas Genner[2], Harald Moser[2], Bernhard Lendl[2]; [1]*Universidad Carlos III de Madrid, Spain;* [2]*Inst. of Chemical Technologies and Analytics, Austria.* A novel laser heterodyne radiometer based on a wavelength modulated external cavity quantum cascade laser featuring calibration free-operation, large signal to noise ratio and a high suitability for wideband spectral measurements is presented.

ETh1A.7 • 09:45
Assessing Uncertainty in Remote Sensing Reflectance Derived from Multiple Above-Water Hyperspectral Radiometers for Ocean Color Analysis, Wonkook Kim[1,4], Jeong-Eon Moon[1], Scott Freeman[2], Jianwei Wei[3], Zhehai Shang[3], Antonio Mannino[2]; [1]*Korea Ocean Satellite Center, Korea Inst. of Ocean Science and Technology, Korea (the Republic of);* [2]*Ocean Ecology Lab, National Aeronautics and Space Administration, USA;* [3]*School for the Environment, Univ. of Massachusetts Boston, USA;* [4]*Pusan National Univ., Korea (the Republic of).* This study assessed the uncertainty in remote sensing reflectance derived from the four widely-used hyperspectral above-water radiometers. The results showed that the uncertainty varies by radiometers, ranging from 10 % to 30 %.

Lower Level 21A

Hyperspectral Imaging and Sounding of the Environment

HTh1B • Remote Sensing of Atmospheric Pollutants—Continued

Lower Level 21B

Optical Sensors

STh1C • Micro and Nano-Engineered Sensors—Continued

STh1C.4 • 09:30 Invited
Intensities Fluctuations in Single-Molecule Surface-Enhanced Raman Scattering, Alexandre Brolo[1]; [1]*Univ. of Victoria, Canada.* SERS intensity fluctuations are observed when a small number of molecules interacts to metallic nanostructures. We will discuss the origin of those fluctuations and demonstrate how they can be explored for different applications.

Executive Ballroom 210G

OIDA Forum on Optics in Autonomy

OIDA Forum on Optics in Autonomy—Continued

NOTES

10:00–11:00
JTh2A • Joint Poster Session II

JTh2A.2
Intrusion Even Positioning Algorithm based on LMD-ICA for φ-OTDR Fiber Optic Sensors , Yuzhao Ma[1], Wantong Zhang[1], Xinglong Xiong[1]; [1]*Civil Aviation Univ. of China, China.* In the paper we proposed an algorithm based on the LMD-ICA, in order to improve the performance of the intrusion event positioning of theφ-OTDR fiber optic perimeter security system.

JTh2A.4
A Novel Idea to Discriminate Strain and Temperature Variations of Fiber Bragg Grating Sensor, Sanjib Sarkar[1], Varsha Suresh[1], Mehdi Shadaram[1]; [1]*Univ. of Texas at San Antonio, USA.* Wavelength variation of fiber Bragg grating sensor is caused by strain and temperature. We propose a method to discriminate between these two parameters by measuring full width half maxima at different strain and temperature values.

JTh2A.6
Early Detection of Subclinical Mastitis in Dairy Cows based on Porous Silicon Fabry–Pérot Lab-on-a-Chip Device, Nofar Pinker[2], Giorgi Shtenberg[1]; [1]*Volcani Center, Israel;* [2]*Biotechnology, Food and Environment, the Hebrew Univ., Israel.* Oxidized porous silicon nanostructures, Fabry-Pérot thin film, is synthesized and used as optical transducer element for early detection of bovine mastitis utilizing specific predicting biomarkers.

JTh2A.8
Withdrawn

JTh2A.10
Fiber Optic Surface Plasmon Resonance Temperature Sensor Based on Hollow Core Fiber, Siyu E[1], Yanan Zhang[1], Yong Zhao[1]; [1]*Northeastern Univ., China.* A new fiber optic surface plasmon resonance temperature sensor based on hollow core fiber was proposed and experimentally demonstrated. The proposed sensor has high sensitivity, small size, good stability, and excellent application potential.

JTh2A.12
Towards Versatile Folded Microfibers: Folded versus Straight Configuration on Hydrophilic and Hydrophobic Substrates, Alexandra Blank[1], Moti Fridman[2], Yoav Linzon[1]; [1]*Tel Aviv Univ., Israel;* [2]*Bar-Ilan Univ., Israel.* We present durable in-liquid operation with near-infrared light transmitted through fused optical microknot fibers. The persistent detection of transmission resonances in volatile liquids is experimentally demonstrated in various configurations.

JTh2A.14
Optimizing Contact Area Geometry and Taper Composition in Microknot Resonators, Alexandra Blank[1], Yoav Linzon[1]; [1]*Tel Aviv Univ., Israel.* We present a comprehensive numerical study of microstructures defined on adiabatic tapered fibers. A practical recipe for the experimental realization of the significant Q-factor values improvement in microknot resonators is demonstrated.

JTh2A.16
Simultaneous Measurement of Temperature and Strain with Multipoint Sensing Characteristics, Seong-Yong Jeong[1], Sang-Jin Choi[2], Jae-Kyung Pan[1]; [1]*Chonbuk National Univ., Korea (the Republic of);* [2]*korea instiute of geoscience and mineral resources, Korea (the Republic of).* We propose and experimentally demonstrate the fiber optic sensor (FOS) combined with the strain free fiber Bragg grating (FBG) and the intensity-based FOS for multipoint sensing of the temperature and the strain simultaneously.

JTh2A.18
Withdrawn

JTh2A.20
SPR Based Optical Biosensor for Acetylcholine Utilizing Enzyme Entrapped Ta_2O_5 Nanoflowers Assembly Encapsulated in Chitosan and rGO Matrix, Ravi Kant[1], Banshi D. Gupta[1]; [1]*Indian Inst. of Technology, Delhi, India.* SPR based fiber optic biosensor for acetylcholine is reported utilizing enzyme entrapped Ta_2O_5 nanoflowers encapsulated in chitosan and rGO matrix as sensing surface. Sensor operates in 0–8 μM range with detection limit 73 nM.

JTh2A.22
Flexible AlN Photonic Sensor Chips , Pao T. Lin[1]; [1]*Texas A&M Univ., USA.* Miniaturized photonic sensors were demonstrated using mechanical bendable aluminum nitride waveguides. The sensor is bendable because it has a thickness less than 30 µm that significantly decreases the strain.

JTh2A.24
Glass Substrate Inspection Using Swept-Source Optical Coherence Tomography, Seungsu Lee[1], Seungsoo Hong[1], Jeongkyun Na[1], Hansol Kim[1], Yoonchan Jeong[1]; [1]*Seoul National Univ., Korea (the Republic of).* We demonstrate a novel industrial application of optical coherence tomography (OCT) for glass substrate inspection. We developed an all-fiberized Fourier-domain mode locking swept source and successfully measured multiple layers of glass substrate.

JTh2A.26
Optical Real-time Oxygen Monitoring in 2D Tissues , Nuria Lopez Ruiz[1], Dahiana Mojena[1], Cristina Lopez-Serrano[1], Jose Luis Jorcano[1], Pablo Acedo[1]; [1]*Universidad Carlos III de Madrid, Spain.* An optical sensor based on porphyrin is used to monitor oxygen concentration in 2D cell cultures. The fluorescence intensity in the membrane determines cell densities and monitors the existence of discontinuities in a 2D tissue.

JTh2A.28
Influence of the Thermal Effect on the DTS Calibration, Luis Silva[1], Jorge Samatelo[1], Marcelo Segatto[1], Maria J. Pontes[1]; [1]*UFES, Brazil.* In this study it will be shown that the sensitivity variability of the detected signal with the temperature leads to significant error in the accuracy of the DTS systems.

JTh2A.30
Axial localization at the quantum limit using imaging, Jaroslav Rehacek[1], Bohumil Stoklasa[1], Martin Paur[1], Dominik Koutny[1], Zdenek Hradil[1], Luis L. Sanchez-Soto[2,3]; [1]*Univerzita Palackeho v Olomouci, Czechia;* [2]*Departamento de Optica, Universidad Complutense, Spain;* [3]*Max Planck Inst. fur der Physik des Lichts, Germany.* We investigate the fundamental limits for object axial position estimation using the quantum Fisher information. Placing an intensity position detector into a proper place out of the image plane enables detection attaining those limits.

JTh2A.32
Subway tunnel intrusion detection based on fiber optic seismic sensor array, Wentao Zhang[1], Gaoran Guo[1], Jiantao Huang[2], Wenzhu Huang[1], Fang Li[1], Yanliang Du[3]; [1]*Chinese Academy of Sciences, China;* [2]*Shenzhen Academy of Disaster Prevention and Reduction, China;* [3]*Shijiazhuang Tiedao Univ., China.* A three-component fiber optic seismic sensor array is installed in subway tunnel for intrusion detection. The interrogation of the sensors is phase generation carrier (PGC). The field test is carried out in Shenzhen Metro.

JTh2A.34
Four-Layered Sensor Chip for Wavelength-based Surface Plasmon Resonance Biosensor, Azharul Alom[1], Briliant A. Prabowo[1], Ying-Feng Chang[1], Kou-Chen Liu[1]; [1]*Chang Gung Univ., Taiwan.* In this study, we designed a four-layered (Al/Au/Ag/Au) sensor chip for surface plasmon resonance (SPR) biosensor and demonstrated that the structure shows a better performance than conventional SPR chip in our system.

Lower Level 21C

Optical Sensors

11:00-12:00
STh3B • Applied Spectral Sensing
Presider: To Be Announced

STh3B.1 • 11:00 Invited
Stand-off Detection of Minerals in the Long-wave Infrared, Tanya Myers[1], [1]Pacific Northwest National Laboratory, United States. We have used a longwave infrared (7.7 - 11.8 µm) imaging spectrometer to measure spectra for 24 solid materials, including minerals, mixtures and background materials at a stand-off distance of 14 m. Prior to the experiment, all 24 samples were measured in the laboratory using a Fourier transform infrared spectrometer (FTIR) equipped with a gold-coated IR integrating sphere; these spectra formed the reference library. Results using various statistical methods such as classical least squares (CLS) and multivariate curve resolution (MCR) were applied to demonstrate the utility of using laboratory reference spectra for field detection.

STh3B.2 • 11:30 Invited
Environmental and Industrial Trace Gas Sensing Using Quantum Cascade Lasers, Lukas Emmenegger[1]; [1]*EMPA, Switzerland.* Mid-IR spectroscopy using QCLs allows sensitive, selective, and fast detection of trace gases. Recent developments, including dual-wavelength QCLs, create tantalizing options for compact, multi-species analysis in industrial and environmental applications.

Lower Level 21B

Optical Sensors

11:00–12:30
STh3A • Optical Fibre Sensors II
Presider: Daniele Tosi, Nazarbayev University, Kazakhstan

STh3A.1 • 11:00 Invited
Distributed Bragg Reflector Fiber Lasers for Acoustic Sensing, Gary Miller[1], Kyla Hallam[2]; [1]*US Naval Research Lab, USA;* [2]*Swarthmore College, USA.* Distributed Bragg reflector fiber laser-based sensors require careful design of both the laser and sensing transducer. Through simulations and experimentation, acoustic sensors employing extended cavity lasers were fabricated and characterized for their acceleration and acoustic responses.

STh3A.2 • 11:30
High spatial-resolution, dynamic interrogation of a large identical weak fiber Bragg grating sensor array base on dual-comb spectroscopy with one fiber laser, Xin Zhao[1], Jianjun Yang[1], Xinyue Zhang[1], Qian Li[1], Jiansheng Liu[1], Hongfeng Shao[1], Zheng Zheng[1,2]; [1]*School of Instrumentation Science & Optoelectronics Engineering, Beihang Univ., China;* [2]*Beijing Advanced Innovation Center for Big Date-based Precision Medicine, Beihang Univ., China.* Enabled by a simple fiber-optic setup, interrogation of large identical weak FBG arrays can be realized using the dual-comb spectroscopy scheme. Unique performance including high spatial/spectral resolution and fast sampling rate is achieved.

STh3A.3 • 11:45
A four-core optical fiber twist sensor, Zane Meyer[1], Mehmet N. Inci[2], Lynne A. Molter[1]; [1]*Engineering, Swarthmore College, USA;* [2]*Physics, Bogazici Univ., Turkey.* The degree of twist of an unknown material is determined without direct observation of the angle, by embedding a four-core optical fiber in it, then measuring the phase shift of the fiber's interferogram.

STh3A.4 • 12:00
Fast Dynamic Strain Measurement in the Spallation Mercury Target Using Fiber-Optic Sensors, Yun Liu[1], Bing Qi[1], Cary Long[1], Drew Winder[1], Mark Wendel[1]; [1]*Oak Ridge National Lab, USA.* We report measurement of fast dynamic strains produced by high energy proton pulses in the mercury target of the Spallation Neutron Source using single-mode fiber-optic interferometric sensors and quadrature phase-shifted optical demodulation scheme.

STh3A.5 • 12:15
Optical Fiber Acoustic Emission Sensor for GIS Partial Discharge Detection, Guoming MA[1], Hong-yang ZHOU[1], Meng ZHANG[1], Cheng-rong LI[1], Bo-yuan CUI[2], Yu-yi WU[2]; [1]*North China Electric Power Univ., China;* [2]*CHINA ELECTRIC POWER RESEARCH INST., China.* Optical fiber acoustic emission sensor was optimized to enhance the sensitivity of partial discharge detection in GIS. Amplitude of the signal detected by the proposed system was 525% higher than that of conventional system.

12:30–13:30 Lunch on Your Own

Executive Ballroom 210G

OIDA Forum on Optics in Autonomy

OIDA Forum on Optics in Autonomy—Continued

10:30–12:15
Panel 2: Optics and Imaging in Autonomy—Accelerating Breadth and Depth
As radar and IMUs before, optical components and systems are entering the mainstream of autonomy—from on-board optics to off-the-shelf automotive grade cameras, computational and AI engines, adaptive lighting, TOF building blocks, and LIDAR systems. What does the future look like?

Moderator: Rob Murano, *II-VI Incorporated*

Carl Conti, *Spatial Integrated Systems (SIS)*

Scott Davis, *Analog Devices*

Alex Kormos, *Veoneer*

Amit Mehta, *North American Lighting*

12:15-13:30 Networking Lunch

Lower Level 21B

Optical Sensors

13:30–15:30
STh4A • Optical Fibre Sensors III
Presider: George Chen, University of South Australia, Australia

STh4A.1 • 13:30 Invited
Brillouin Optical Correlation-Domain Reflectometry: State-of-the-Art and Future Challenges, Yosuke Mizuno[1], Kohei Noda[1], Heeyoung Lee[1], Kentaro Nakamura[1]; [1]*Tokyo Inst. of Technology, Japan.* We present the current status and future issues of Brillouin optical correlation-domain reflectometry, the fiber-optic distributed sensing technique with single-end-access operation, high spatial resolution, random accessibility, and cost efficiency.

STh4A.2 • 14:00 Invited
Multiplexing Techniques and Applications in Fiber-optic Spatially Resolved Sensing Networks, Daniele Tosi[1,2], Carlo Molardi[1], Wilfried Blanc[3], Carlos Marques[4], Salvador Sales[5]; [1]*Nazarbayev Univ., Kazakhstan;* [2]*Lab of Biosensors and Bioinstruments, National Lab Astana, Kazakhstan;* [3]*INPHYNI–CNRS UMR, Université Côte d'Azur, France;* [4]*4Instituto de Telecomunicações, Universidade de Aveiro, Portugal;* [5]*iTEAM, Universidad Politecnica de Valencia, Spain.* This work presents techniques for parallel multiplexing using specialty fibers in distributed sensing. Applications in biomedical engineering are also discussed, such as temperature 2D/3D rendering, shape sensing, and refractive index detection.

STh4A.3 • 14:30
Spatial Resolution Improvement of Discriminative and Distributed Measurement of Temperature/Strain with PMF using Intensity-Modulated Correlation-Domain Technique, Youhei Okawa[1], Rodorigo K. Yamashita[2], Masato Kishi[3], Kazuo Hotate[1]; [1]*Toyota Technological Inst., Japan;* [2]*Furukawa Electric Corporation, Japan;* [3]*Kougakuin Univ., Japan.* We analyzed reflection spectrum of Brillouin dynamic grating localized by intensity-modulated BOCDA technique. Then, we proposed newly modulation technique achieving better spatial resolution for discriminative temperature/strain sensing using PMF.

STh4A.4 • 14:45
Trans-jacket inscription of robust FBG sensors for directional and distributed strain measurement, Tommy T. Boilard[1], Steeve Morency[1], Younès Messaddeq[1], Richard Fortier[2], François Trépanier[3], Martin Bernier[1]; [1]*Center for Optics, Photonics, and Lasers (COPL), Université Laval, Canada;* [2]*Center for Northern Studies, Université Laval, Canada;* [3]*TeraXion Inc., Canada.* We report trans-jacket femtosecond laser inscription of an array of 18 FBGs distributed over 70 nm with a single uniform phase-mask by controlling the applied strain to the fiber during laser writing.

STh4A.5 • 15:00
High Temperature and γ-ray Radiation Effects on Regenerated Fiber Bragg Grating, Thomas Blanchet[1], Simon Nehr[1], rudy desmarchelier[1], adriana morana[2], andrei goussarov[3], aziz boukenter[2], youcef ouerdane[2], emmanuel marin[2], sylvain girard[2], Guillaume Laffont[1]; [1]*CEA Saclay, France;* [2]*Univ-Lyon Lab Hubert Curien (LabHC) CNRS UMR 5516, France;* [3]*SCK CEN—Belgian Nuclear Research Center, Boeretang 200, Belgium.* We investigate the combined effects of γ-rays and high temperatures on regenerated FBGs. Such irradiation conditions induce a shift of their Bragg wavelengths of less than 20 pm (equivalent to a temperature error of 2°C).

STh4A.6 • 15:15
Dynamic Readout of a Fiber Bragg Grattings Serial Array based on All Electro-optical Dual Optical Frequency Comb, Dragos A. Poiana[1], José-Antonio Garcia-Souto[1], Julio-Enrique Posada-Roman[1], Pablo Acedo[1]; [1]*Univ. Carlos III of Madrid, Spain.* We present the readout process of two low reflectivity FBG sensors based on a multimode multiheterodyne source generated with a continuous wave laser. We read two independent Fiber Bragg Grating sensors with different Bragg wavelengths.

15:30–16:00 Coffee Break, *Lower Level (by 21B)*

Executive Ballroom 210G

OIDA Forum on Optics in Autonomy

OIDA Forum on Optics in Autonomy—Continued

13:30–14:30
Panel 3: The Vehicle as a Data Center: Next-Generation On-Board Computing & *Communications*
The vision for autonomous vehicles of all types is on a path to equip highly autonomous vehicles with hundreds of sensors in the future that generate massive and rich datasets. Our speakers will address what infrastructure is required to integrate all this data, and to make consistent and safe decisions within timeframes required in a given environment that is variable and often unpredictable. We will hear from leading edge players on: (1) the state-of-the-art on-board communications networking and integration of multi-sensors in the computing architectures to come, (2) latency issues and how and when solutions will enable the bandwidth needed; (3) the role of on-board vs. cloud, 5G wireless and V2X networks, and the implications for imaging and optical sensor players.

Moderator: John Dexheimer, *Lightwave Advisors, Inc.*

Amir Bar-Niv, *Aquantia*

Byron Hill, *TE Connectivity*

14:30–15:30
Panel 4: Driving down costs: The Manufacturability Challenges for the Optical Supply Chain
With so many potential applications and technologies in the market, the question remains how to drive down manufacturing costs in volume production. What are the manufacturing challenges for systems and components vendors? What's the tool kit for cost reduction and scaling volume and meeting reliability needs? What are the limits, and what is good enough? How do you trust a partner?

Andrew Rickman, *Rockley Photonics*

Arlon Martin, *Samtec*

15:30–16:00 Break

Lower Level 21B

Optical Sensors

16:00–17:30
STh5A • Optical Fibre Sensors IV
Presider: Yosuke Mizuno, Tokyo Institute of Technology, Japan

STh5A.1 • 16:00 Invited
Polyurethane Optical Fibre Sensors, Simon C. Fleming[1], Maryanne Large[1], Alessio Stefani[1,2]; [1]*Inst. of Photonics and Optical Science, School of Physics, Univ. of Sydney, Australia;* [2]*DTU Fotonik, Technical Univ. of Denmark, Denmark.* Optical fiber sensors drawn from polyurethane are demonstrated. Polyurethane's Young's Modulus is orders of magnitude lower than traditional optical fiber materials, permitting more sensitive optical detection of mechanical perturbations.

STh5A.2 • 16:30 Invited
Sensitized Light Pipes: Multimode Fibers Empowered by Skew Rays, George Y. Chen[1], David Lancaster[1]; [1]*Univ. of South Australia, Australia.* Skew rays can increase the sensitivity of evanescent-wave-based sensors mainly through a larger number of total internal reflections and circular coverage. We review our recent progress in this research area and discuss future directions.

STh5A.3 • 17:00
A Compact FBG-based Toroidal Magnetostrictive Current Sensor with Reduced Mass of Terfenol-D, Alex Dante[1], Juan David Lopez Vargas[1], Talitha Trovão[1], Roberto Wu Mok[1], César Cosenza de Carvalho[1], Regina Célia da Silva Barros Allil[1], Marcello M. Werneck[1]; [1]*Univ. of Rio de Janeiro - UFRJ, Brazil.* This paper presents a novel fiber optic current sensor based on FBG and Terfenol-D that employs only 5.6 grams of the alloy for monitoring of currents of up to 650 A_{rms} in high-voltage transmission lines.

STh5A.4 • 17:15
Athermal Optical Fibers for Sensing Applications, Peter D. Dragic[1], Maxime Cavillon[2], Courtney Kucera[2], Joshua Parsons[2], Thomas Hawkins[2], John Ballato[2]; [1]*Univ of Illinois at Urbana-Champaign, USA;* [2]*Clemson Univ., USA.* Progress toward athermal optical fibers for sensing is discussed. The first subset are fibers whose Brillouin frequency shift is independent of temperature. The second are those where the optical path length is independent of temperature.

Executive Ballroom 210G

OIDA Forum on
Optics in Autonomy

OIDA Forum on Optics in Autonomy—Continued

16:00–17:30
Panel 5: The Evolution of LIDAR in Transportation: Opportunities for Non-Auto Applications and Deployment Progress in Auto
Auto is a massive market for LIDAR, as investment and firms continue to pursue a multi-billion dollar market. Yet other applications are also opportunities for large and near term pursuit. How are some of the leaders allocating resources? Will leaders broaden offerings to have an array of solutions—different wavelengths, powers, form factors, lifetimes and channel strategies? What do they need for the supply chain to execute on their upstream customers targets?

Moderator: Sabbir Rangwala, *Patience Consulting, LLC*

Akram Benmbarek, *Aeye*

Craig Cocchi, *Blackmore*

Raffi Mardirosian, *Ouster*

Malcom Minty, *Gener8*

17:30-19:00 Networking Reception
Please join your speakers and fellow attendees for food and drinks after the OIDA Forum.

Key to Authors and Presiders

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