OSA Light, Energy and the Environment Congress

05–08 November 2018

Resort World Sentosa Convention Center
Singapore

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Special Events

Accelerating the Deployment of Renewables in Southeast Asia Special Panel

Monday, 5 November, 17:30–19:00
Leo 1&2

Moderator: Kenneth Baldwin, Director, *ANU Energy Change Institute, Australian National University, Australia*

Panelists:

Christophe Inglin, Managing Director, *Energetix Pte Ltd., Singapore*

Edwin Khew, Chairman, *Sustainable Energy Association of Singapore (SEAS), Singapore*

Alan Khor, Head of Engineering, *Procurement & Construction, Cleantech Solar, Singapore*

Eicke Weber, *Berkeley Education Alliance for Research in Singapore, Singapore*

Thomas White, *Australian National University, Australia*

SERIS Local Lab Tours

Thursday, 8 November
09:00–13:00

The local host of OSA Light, Energy and the Environment Congress, the Solar Energy Research Institute of Singapore (SERIS, NUS) is pleased to organize local guided tours to SERIS' laboratories and facilities located at both the National University of Singapore (NUS), and Cleantech One (CTO) on the morning of 8 Nov 2018, as part of OSA's local site visit program. Pre-registration for the SERIS guided lab tours is required for logistic arrangement. Registration confirmation will be on first-come, first-served basis.

Plenary Speaker

Eicke R. Weber, *Berkeley Education Alliance for Research in Singapore, Singapore*

Photovoltaics Moving into the Terawatt Age

Global PV production capacity will soon reach 100-120 GWp/a, doubling the production volume of 2016. More than 90% of the global PV market is crystalline Silicon technology. New approaches for higher efficiencies will be discussed, including heterojunctions, such as low-cost III/V or Perovskite layers on silicon.

Biography: Eicke R. Weber is Director/CEO of the Berkeley Education Alliance for Research in Singapore (BEARS). Till 2016, he served as Director of the Fraunhofer Institute for Solar Energy Systems ISE and Professor of Physics at the Albert-Ludwigs-University of Freiburg, Germany. Weber studied Physics at the University of Cologne, Germany, where he obtained his doctorate in 1976 and his habilitation in 1983.

Prof. Weber's research is concerned with Materials Science of semiconductors, especially for photovoltaic applications. He was visiting professor at the Tohoku University in Sendai (1990), and at the Kyoto University in Kyoto, Japan (2000). In 1994 he received an Alexander von Humboldt Senior Scientist Award. In 2006 he received the Award of Merit from former German President Horst Kohler. In June 2013, Prof. Weber was honored with the SolarWorld Einstein Award. In January 2014, he received the Zayed Future Energy Prize from the Crown Prince of the United Arab Emirates on behalf of Fraunhofer ISE. He served as founding president of the German Energy Storage Association BVES (2012-16) and is a member of the German Academy of Science and Engineering (acatech).

Keynote Speakers

David Crisp, *Jet Propulsion Laboratory, California Institute of Technology, USA*

Measuring Atmospheric Carbon Dioxide from the NASA Orbiting Carbon Observatory-2 (OCO-2)

NASA's OCO-2 spacecraft has returned observations of atmospheric carbon dioxide (CO2) since September 2014. These data are being used to study the processes emitting CO2 into the atmosphere and those absorbing it at the surface.

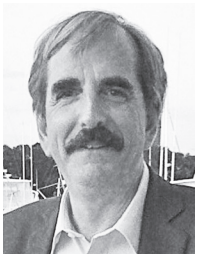
Biography: David Crisp is an atmospheric physicist at the Jet Propulsion Laboratory (JPL), California Institute of Technology. He is currently serving as the Science Team Leader for NASA's Orbiting Carbon Observatory-2 (OCO-2) mission and the soon-to-be-launched OCO-3 mission. He is also a member of the Science Team for the Earth Ventures Geostationary Carbon Cycle Observatory (GeoCarb), a member of the European Copernicus CO2 Mission Advisory Group and the Greenhouse Gas Lead for the Committee on Earth Observation Satellites (CEOS) Atmospheric Composition Virtual Constellation (AC-VC).

Iouli E. Gordon, *Harvard-Smithsonian Center for Astrophysics, USA*

HITRAN2016 and Beyond: Reference Molecular Spectroscopy in the XXI Century

The most recent edition of the HITRAN spectroscopic database (HITRAN2016) will be presented at the meeting including new and improved data and structure, efficient web interface at www.hitran.org, and the HITRAN Application Programming Interface (HAPI).

Biography: Iouli Gordon is a physicist at the Harvard-Smithsonian Center for Astrophysics in Cambridge, USA. He is the director of the HITRAN and HITEMP projects (www.hitran.org). HITRAN and HITEMP are molecular spectroscopic databases which constitute an international reference standard for the spectroscopic parameters of major absorbers of light in planetary atmospheres. Dr. Gordon led the efforts towards the assembly, validations and public release of the HITRAN2016 database and associated tools. Dr. Gordon obtained his Diploma in Engineering Physics at the Moscow Institute of Physics and Technology, Russia (1999), MSc in Physics at the University of Toronto, Canada (2001), and PhD at the University of Waterloo, Canada (2006). His research interests focus on laboratory and theoretical molecular spectroscopy of atmospheric and astrophysical interest, use of available spectroscopic information to construct databases, and development of the tools for enhancing data accessibility and effectiveness of scientific collaborations.



Hank Revercomb, *University of Wisconsin-Madison, Space Science and Engineering Center, USA*

Innovation in Optical Materials Design to Manufacture for Driving High Performance Photovoltaics Cost-Effectively

For global observing systems that require a significant number of individual spacecraft and sensors, it is highly advantageous to have observations that are sensor independent with respect to spectral properties and instrument responsivity. FTS sensors are especially well suited to achieving this goal.

Biography: Hank Revercomb, director of the UW-Madison, Space Science and Engineering Center (SSEC) for the last 17 years, has carried on the SSEC traditions established by Professor V. E. Suomi. He has been a leader in using radiation measurements to study the atmospherics of the earth and other planets. Specialties include: high spectral resolution instrumentation for atmospheric remote sensing and spectroscopy, operational infrared sounders, climate observing systems, and net flux observations of Venus and Jupiter.

Wei Huang, *Northwestern Polytechnic University, China*

Recent Advances in Flexible Electronics

In the past decades, organic optoelectronics has made great progress both in fundamental studies and commercial applications because of their excellent properties, such as solution processable, printable, flexible, low-cost and able to be made at large area.

Biography: Huang Wei is one of the earliest and most renowned scholars in the research of polymer light-emitting diodes (PLEDs) and has great reputation in the field of organic optoelectronics research in international community. His current research interests include organic/plastic/flexible electronics, bioelectronics, nanomaterials, nanoelectronics, and polymer chemistry. In the area of organic optoelectronics and flexible electronics, he has made a large amount of systematic and innovative achievements and has published more than 700 papers as the first author or corresponding author in Nature Materials, Nature Photonics, Nature Nanotechnology, Nature Communications, Advanced Materials, Journal of the American Chemical Society, Angewandte Chemie-International Edition, Chemical Reviews, etc., with over 37,000 citations (ISI Web of Knowledge) and an H-index of 99.

He is the most cited Researchers in the field of material science and chemistry. His contributions to these disciplines have led to wide-ranging publications that address both fundamental and more applied topics, and that place him amongst the 1% most highly cited materials/chemistry/informatics scientists in the world (ISI Highly Cited Scientist). He is editor-in-Chief of npj Flexible Electronics and editorial board member of top international journals such as Advanced Materials, Advanced Electronic Materials, Progress in Polymer Science, etc. He has held over 200 patents which are granted in USA, Singapore and China. Additionally, Professor Huang has published several academic books, such as Organic Optoelectronics, Bio-optoelectronics, Introduction to Organic Light-Emitting Materials and Devices, etc.

Tom White, *The Australian National University, Australia*

Perovskite-silicon Tandem Solar Cells: Progress, Challenges and Opportunities

Tandem solar cells that combine emerging perovskite materials with conventional silicon photovoltaic technology have the potential to boost silicon cell efficiencies well beyond their practical and theoretical efficiency limits. This presentation will review recent progress on perovskite-silicon tandem solar cells, the current research challenges, and the exciting opportunities presented by this technology.

Biography: Tom White is currently an Associate Professor in the Research School of Engineering at the Australian National University, Canberra. He completed a PhD in Physics at the University of Sydney in 2006, followed by three years as a research fellow at the University of St Andrews, UK, studying nanophotonic enhancement of light-matter interactions. Since 2011, Dr. White's main research focus has been photovoltaics; initially on nanophotonic light-trapping; and more recently on the development of high efficiency perovskite solar cells and perovskite-silicon tandems. He has published more than 90 journal papers on topics including electromagnetic theory, photonic crystals, nonlinear optics, optical engineering for solar cells and novel photovoltaic materials.

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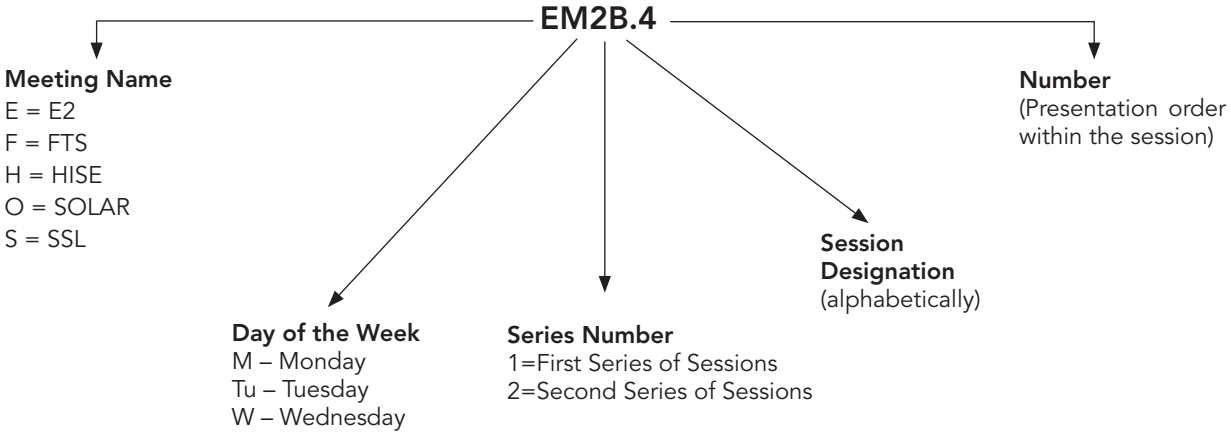
Explanation of Session Codes



The first letter of the code designates the meeting. The second element denotes the day of the week . The third element indicates the session series in that day (for instance, 1 would denote the first sessions in that day). Each day begins with the letter A in the fourth element and continues alphabetically through the parallel session. The lettering then restarts with each new series. The number on the end of the code (separated from the session code with a period) signals the position of the talk within the session (first, second, third, etc.).

For example, a presentation coded EM2B.4 indicates that this paper is being presented as part of the EUV meeting on Monday (M) in the second series of sessions (2), and is the second parallel session (B) in that series and the fourth paper (4) presented in that session.

Invited papers are noted with Invited

Plenary papers are noted with Plenary

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Agenda of Sessions — Monday, 5 November

	Pisces 1	Pisces 2	Pisces 3	Pisces 4
	E2	FTS	HISE	SOLAR
07:30–18:00	**Registration,** *Leo Foyer, Level 1*			
08:30–09:30	**JM1A • Plenary Session,** *Leo 1&2*			
09:30–10:00	**Coffee Break/Exhibits,** *Leo Foyer*			
10:00–12:00	**EM2A • Industrial Monitoring I: Energy and Power**	**FM2B • Dual Comb and Miniaturized-based FTS Developments**	**HM2C • Hyperspectral Sensing of Land and Water** (ends at 11:45)	**OM2D • PV Beyond Silicon** (ends at 11:45)
12:00–13:00	**Lunch,** *Leo Foyer*			
13:00–15:00	**EM3A • Sensing of Plasma & Combustion Environments**	**FM3B • Measurements of the Earth and the Earth's Atmosphere: Satellite and Airborne Systems**	**HM3C • Recent Advances in Hyperspectral Instruments, Analysis, and Algorithms I**	**OM3D • PV Modules and Characterization**
15:00–15:30	**Coffee Break/Exhibits,** *Leo Foyer*			
15:30–17:30	**JM4A • Solar Energy and Energy Storage (E2/SOLAR)** (ends at 17:15)	**FM4B • Comb-based Spectroscopy**	**HM4C • Recent Advances in Hyperspectral Instruments, Analysis, and Algorithms II** (ends at 16:30)	
17:30–19:00	**Accelerating the Deployment of Renewables in Southeast Asia Special Panel,** *Leo 1&2*			

Conference Abbreviations

E2 Optics and Photonics for Energy & the Environment
FTS Fourier Transform Spectroscopy
HISE Hyperspectral Imaging and Sounding of the Environment
SOLAR Optics in Solar Energy
SSL Solid-state Lighting

Agenda of Sessions — Tuesday, 6 November

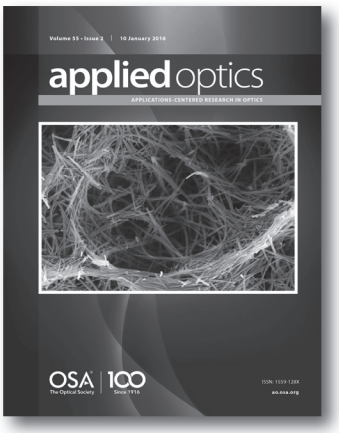
	Pisces 1	Pisces 2	Pisces 3	Pisces 4
	E2	FTS	SOLAR	SSL
08:00–18:00	**Registration,** *Leo Foyer, Level 1*			
08:30–09:30	**JT1A • Keynote Session I,** *Leo 1&2*			
09:30–10:30	**JT2A • Poster Session with Coffee Break/Exhibits,** *Leo Foyer*			
10:30–12:30	**ET3A • Atmospheric Sensing of Clouds & Aerosols**	**FT3B • Far-IR Observatories and FTS Spectroscopy**	**OT3C • Silicon PV Technology**	**ST3D • Perovskite and Metal Halide Emitters** (ends at 12:45)
12:30–13:30	**Lunch,** *Leo Foyer*			
13:30–15:30	**ET4A • Photonics & Imaging of the Environment and Agriculture**	**FT4B • Comb-based and Other Spectroscopic Applications**	**OT4C • Nano-Structures for Solar Cells**	**ST4D • VCELs and Other Lasers** (ends at 15:45)
15:30–16:00	**Coffee Break/Exhibits,** *Leo Foyer*			
16:00–18:00	**ET5A • Industrial Monitoring II: Environmental Sensing**	**FT5B • Measurements of the Earth's Atmosphere: Satellite and Ground-based Systems**	**OT5C • Theory and Modeling** (ends at 17:45)	**ST5D • LED Design, Applications, and Testing** (ends at 17:30)
18:00–19:30	**Conference Reception,** *Leo 3&4*			

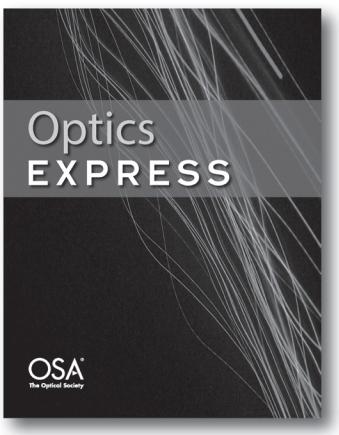
Agenda of Sessions — Wednesday, 7 November

	Pisces 1	Pisces 2	Pisces 3	Pisces 4
	E2	FTS	HISE	SSL / SOLAR
08:00–17:00	**Registration,** *Leo Foyer, Level 1*			
08:30–10:00	**JW1A • Keynote Session II,** *Leo 1&2*			
10:00–10:30	**Coffee Break/Exhibits,** *Leo Foyer*			
10:30–12:30	**EW2A • New Techniques for Sensing the Environment**	**FW2B • Satellite Measurements of the Earth's Atmosphere: Instrumentation and Calibration Techniques**	**HW2C • Radiative Transfer and Hyperspectral Sensing** (ends at 12:00)	**SW2D • Advanced Design, Measurement, and Fabrication** (ends at 11:30)
12:30–13:30	**Lunch,** *Leo Foyer*			
13:30–15:30	**EW3A • Fundamental Measurements for Energy & the Environment**	**FW3B • Far-IR Observatories: Satellite Measurements** (ends at 15:15)	**HW3C • Hyperspectral Imaging of Aerosol and Trace Gases I**	**OW3D • Solar Concentrators**
15:30–16:00	**Coffee Break/Exhibits,** *Leo Foyer*			
16:00–16:30		**Post Deadline Presentations I**	**Post Deadline Presentations II**	
16:45—18:45		**FW5A • Measurements of the Earth's Atmosphere: Validation and Instrument Advances**	**HW5B • Hyperspectral Imaging of Aerosol and Trace Gases II** (ends at 18:00)	**OW5C • Multi-Junction Solar Cells**

Key to Conference Abbreviations

E2 Optics and Photonics for Energy & the Environment
FTS Fourier Transform Spectroscopy
HISE Hyperspectral Imaging and Sounding of the Environment
SOLAR Optics in Solar Energy
SSL Solid-state Lighting





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Light, Energy and the Environment 2018 Joint Feature Issue

Submission Opens: 1 December 2018
Submission Deadline: 7 January 2019

Optics Express and *Applied Optics* welcome submissions for a joint Feature Issue comprising expanded papers from the 2018 OSA Light, Energy and the Environment Congress. This special issue will include expanded papers covering the following topical meetings:

- Fourier Transform Spectroscopy (FTS)
- Hyperspectral Imaging and Sounding of the Environment (HISE)
- Optics and Photonics for Energy & the Environment (E2)
- Optics in Solar Energy (SOLAR)
- Solid-State Lighting (SSL)

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OSA The Optical Society 100 Since 1916

08:00–09:30
JM1A • Plenary

JM1A.1 • 08:30 Plenary

Photovoltaics Moving into the Terawatt Age, Eicke R. Weber[1]; [1]*Berkeley Education Alliance for Research , Singapore.* In the last few years, PV electricity became cost-competitive with electricity produced by conventional sources. Global PV production capacity will reach in the next 2-3 years 100-120 GWp/a, doubling the production volume of 2016, soon bringing global PV installations into the Terawatt range. A key factor for this growth will be continuous technology advances aimed at higher efficiencies at reduced cost. In addition, cell efficiency will be even more important than lowest cost, to optimize energy harvest from a given area. Crystalline Silicon technology currently represents more than 90% of the global PV market. This technology is approaching a ceiling of 29% efficiency for a single-bandgap semiconductor. New approaches for higher efficiencies require heterojunctions, and several approaches will be discussed. These include heterojunctions on silicon, allowing to combine well-established large-scale Silicon PV technology with new technologies, such as low-cost III/V or Perovskite layers.

09:30–10:00 Coffee Break/Exhibits, *Leo Foyer*

Pisces 1

Optics and Photonics for Energy & the Environment

10:00–12:00
EM2A • Industrial Monitoring I: Energy and Power
Presider: Jonas Westberg; Princeton Univ., USA

EM2A.1 • 10:00
Tapered multi-mode optical fiber sensor to detect petrol adulteration, Vinod K. Singh[1]; [1]*Indian Institute of Technology, Dhanbad, India.* In the present manuscript an intensity modulated optical fiber sensor has been reported to detect petrol adulteration. The sensor has been fabricated using tapered multi-mode fiber (MMF). The maximum sensitivity of 123 nW/% is obtained.

EM2A.2 • 10:15
Broadband fluorescence from green-synthesized carbon dots, Venkata Siva Gummaluri[1], Somesh Sabat[2], Vijayan C[1]; [1]*Indian Inst. of Technology Madras, India;* [2]*Gangadhar Meher Univ., India.* Visible broadband fluorescence from green-synthesized carbon dots is demonstrated. Intermixing of carbon dot samples results in broadband fluorescence covering the visible spectrum. The results indicate carbon dots as green materials for designing white light sources.

EM2A.3 • 10:30
Preliminary Study of Distributed Fiber Optic Sensing Technologies in Hydraulic Machinery, Can Yao[1], Xingxing Huang[2], PingYu Zhu[3], Camille Bres[1], Luc Thévenaz[1]; [1]*Ecole Polytechnique Federale de Lausanne, Switzerland;* [2]*WinGD, Switzerland;* [3]*GuangZhou Univ., China.* This paper includes a preliminary study of bringing innovative and promising distributed optical fiber sensing technologies to strain monitoring of hydraulic machinery.

EM2A.4 • 10:45
A Novel Route to Plastics Recycling via Unique, Background-free, Micro-scale Photonic Markers, Bryce S. Richards[1], Dmitry Busko[1], Guojun Gao[1], Damien Hudry[1], Ian Howard[1], Andrey Turshatov[1]; [1]*Karlsruhe Inst. of Technology, Germany.* This work demonstrates the development of novel up-conversion (UC) and down-shifting (DS) micro-scale photonic markers for the unique fluorescent labelling of polymers to realize both high-yield and high-purity recycled product.

Pisces 2

Fourier Transform Spectroscopy

10:00–12:00
FM2B • Dual Comb and miniaturized-based FTS developments
Presider: Frans J. Harren; Radboud Universiteit Nijmegen, Netherlands

FM2B.1 • 10:00 Invited
A chip based dual frequency-comb Fourier spectrometer, David G. Lancaster[1]; [1]*Laser Physics & Photonics Devices Lab, Univ. of South Australia, Australia.* Our standalone dual-comb platform is based on two mutually-stable mode-locked waveguide lasers integrated into the same glass chip. The inherent low phase-noise of the system provides a robust and high-resolution molecular spectroscopic capability.

FM2B.2 • 10:30
Trace Gas Detection Using a MEMS-Based Portable Fourier Transform Infrared Spectrometer, Junyu Chai[1,2], Hongzhi Jia[1], Xiaoxuan Dong[2], Chuang Huang[3], Lei Jiang[3], Huikai Xie[4,2]; [1]*Engineering Research Center of Optical Instrument and System, Univ. of Shanghai for Science and Technology, China;* [2]*WiO Technology Co., China;* [3]*Honeywell Integrated Technology, China;* [4]*Univ. of Florida, USA.* A portable Fourier transform infrared spectrometer has been developed based on a piston-scanning MEMS mirror. It is successfully applied for gas detection and a low gas concentration down to 100 ppm has been detected.

FM2B.3 • 10:45
Open Path MIR DCS for Chemical Detection, Gabriel ycas[1], Fabrizio Giorgetta[1], Kevin Cossel[1], Eleanor Waxman[1], Esther Baumann[1], Nathan R. Newbury[1], Ian R. Coddington[1]; [1]*NIST, USA.* We demonstrate MIR-DCS across a 1-km open-air path probing the C-H stretch region around 3.2 µm. We show sensitivity to VOC's such as acetone even in the presence of water vapor interference.

Pisces 3

Hyperspectral Imaging and Sounding of the Environment

10:00–11:45
HM2C • Hyperspectral Sensing of Land and Water
Presider: Michael Yetzbacher; US Naval Research Lab, USA

HM2C.1 • 10:00 Invited
Calibration and validation of optical EO sensors relevance to non-renewable resources environmental monitoring, Cindy C. Ong[1]; [1]*Energy, CSIRO, Australia.* Earth Observation (EO) satellite data are the single most important and richest source of environmental information for Australia and are used for a wide range of applications including their use for non-renewable resources environmental monitoring. This talk will focus on calibration and validation of EO optical data illustrated with case histories on their relevance for regulatory compliance.

HM2C.2 • 10:30 Invited
Eruptions from UV to TIR: multispectral high-speed imaging of explosive volcanic activity, Jacopo Taddeucci [1], Piergiorgio Scarlato[1], Elisabetta Del Bello[1], Giancarlo Tamburello[2], Damien Gaudin[1,3]; [1]*Istituto Nazionale di Geofisica e Vulcanologia, Italy;* [2]*Istituto Nazionale di Geofisica e Vulcanologia, Italy;* [3]*LMU Univ. of Munich, Germany.* Explosive volcanic eruptions eject a mixture of rock/magma fragments and gases. Ground-based eruption imaging, combining thermal infrared, high-speed visible, and ultraviolet videos, can parameterize ejection dynamics and gas/fragment ratios at the seconds and centimeter scales.

Pisces 4

Optics in Solar Energy

10:00–11:45
OM2D • PV beyond Silicon
Presider: Serena Fen Lin; National University of Singapore, Singapore

OM2D.1 • 10:00 Invited
Light trapping: From Silicon to III-V Solar Cells, Nicholas J. Ekins-Daukes[1]; [1]*School of Photovoltaic & Renewable Energy Engineering, UNSW Sydney, Australia.* Light trapping has been long established in silicon but only recently employed for III-V solar cells. To achieve efficient silicon tandem solar cells, light trapping in both are likely to be necessary.

OM2D.2 • 10:30
Optical Anisotropy and Photovoltaic Performance of N-Si/Organic Heterojunction HOT Solar Cells, Hajime Shirai[2,1], A.T.M. Saiful Islam[2,1], Koki Kawamura[2,1], Ryo Ishikawa[2,1]; [1]*Saitama Univ., Japan;* [2]*Graduate School of Science and Engineering, Saitama Univ., Japan.* We represent the state-of-art of solution-processed PEDOT:PSS/n-Si heterojunction solar cell. The effect of optical anisotropy of PEDOT:PSS on the photovoltaic performance is demonstrated together with the junction property at PEDOT:PSS/n-Si interface.

OM2D.4 • 10:45
2D Tungsten Disulfide Sheets for Ultralight, Flexible Photovoltaics, Sayan Roy[1], Peter Bermel[1]; [1]*Purdue Univ., USA.* 2D nanomaterials have potential to cut the weight of photovoltaics by more than a factor of 100. Here, we explore the potential for tungsten disulfide to serve as a platform for high-efficiency, flexible photovoltaic devices.

Pisces 1

Optics and Photonics for Energy & the Environment

EM2A • Industrial Monitoring I: Energy and Power—Continued

EM2A.5 • 11:00 Invited

Photoacoustic H_2S Gas Sensor for SF_6 Decomposition Analysis in an Electric Power System, Lei Dong[1], Xukun Yin[1], Hongpeng Wu[1], Liantuan Xiao[1], Suotang Jia[1]; *[1]Shanxi Univ., China.* A photoacoustic hydrogen sulfide (H_2S) gas sensor for sulfur hexafluoride (SF_6) decomposition analysis in an electric power system was developed. A detection limit of 109 ppb was achieved.

EM2A.6 • 11:30 Invited

Diagnostics to study the vibrational excitation kinetics of CO_2 for renewable energy storage, Richard Engeln[1], Bart Klarenaar[1], Ana Sofia Morillo-Candas[2], Maria Grofulovic[3], Richard van de Sanden[4,1], Olivier Guaitella[2]; *[1]Eindhoven Univ. of Technology, Netherlands; [2]Ecole Polytechnique-CNRS, France; [3]Instituto Superior Tecnico, Portugal; [4]DIFFER, Netherlands.* Time-resolved in situ FTIR spectroscopy and spatiotemporally resolved in situ Raman spectroscopy are used to study the excitation and relaxation of the vibrations of CO_2 and the reduction of CO_2 to CO in a pulsed glow discharge.

Pisces 2

Fourier Transform Spectroscopy

FM2B • Dual Comb and miniaturized-based FTS developments—Continued

FM2B.4 • 11:00 Invited

Dual-comb spectroscopic Ellipsometry, Takeshi Yasui[1,2]; *[1]Tokushima Univ., Japan; [2]JST, ERATO, Minoshima Intelligent Optical Synthesizer, Japan.* Mode-resolved optical-comb spectrum of amplitude and phase, acquired by dual-comb spectroscopy, is applied for polatization-modulation-free, high-precision spectroscopic ellipsometery. Effictiveness of the proposed method is demonstrated in the measurement of a thin-film standard sample.

FM2B.5 • 11:30

Mid-infrared Dual-comb Spectroscopy in An Electrical Discharge, Amir Khodabakhsh[1], Julien Mandon[1], Qing Pan[1], Muhammad Ali Abbas[1], Frans J. M. Harren[1]; *[1]Dept. of Molecular and Laser Physics, Radboud Univ., Netherlands.* We present time-resolved mid-infrared dual-comb spectroscopy of methane in an electrical discharge. The system is capable of detecting the discharge products (ms scale) and also monitoring the relaxation process of methane exited states (µs scale).

FM2B.6 • 11:45

Direct Mid-Infrared Frequency Comb Spectroscopy of Nitrocarburizing Plasma Processes, Norbert Lang[1], Alexander Puth[1], Sarah-Johanna Klose[1], Grzegorz Kowzan[2], Stephan Hamann[1], Juergen Roepcke[1], Piotr Maslowski[2], Jean-Pierre H. van Helden[1]; *[1]Leibniz Inst. for Plasma Science & Technology, Germany; [2]Inst. of Physics, Astronomy and Informatics, Nicolaus Copernicus Univ., Poland.* We report on mid-infrared broadband direct frequency comb spectroscopy as a novel plasma diagnostic applied to spectroscopic investigations of plasma nitrocarburizing processes. We discuss the parameter-dependent behavior of species like HCN, CH_4, and NH_3.

Pisces 3

Hyperspectral Imaging and Sounding of the Environment

HM2C • Hyperspectral Sensing of Land and Water—Continued

HM2C.3 • 11:00 Invited

Far-Infrared emissivity of ice and snow: Resolving the paucity of observational data, Jon E. Murray[1], Helen E. Brindley[1], Juliet C. Pickering[1], Stuart Fox[2], Axell Wellpott[3], Cathryn Fox[2], Alan Last[1], Chawn Harlow[2]; *[1]Dept. of Physics, Imperial College London, UK; [2]UK Meteorology Office, UK; [3]Facility for Airborne Atmospheric Measurements, UK.* Far-Infrared up-welling radiance measurements over Greenland have yielded the first estimates of the emissivity of ice and snow in this spectral region. I describe the complexity of undertaking such work and what the future holds.

HM2C.4 • 11:30

Plant-species identification from only near-surface and internal reflectance spectroscopic data regardless of zenith and azimuth angles, Hanyue Kang[1], Natsumi Kawashima[1], Tomoya Kitazaki[1], Sora Mizutani[1], Ichirou Ishimaru[1]; *[1]Kagawa Univ., Japan.* Any plant species may be distinguished from only two basic spectroscopic data obtained by the orthogonal polarized light illumination method. We demonstrate its viability by obtaining separately the near-surface and internal-reflected light from plant leaves.

Pisces 4

Optics in Solar Energy

OM2D • PV beyond Silicon—Continued

OM2D.5 • 11:00

An optical study of back contacted CIGS solar cells, Nasim Rezaei[1], Olindo Isabella[1], Zeger Vroon[2], Miro Zeman[1]; *[1]Delft Univ. Of Technology, Netherlands; [2]TNO-Brightlands Materials Center, Netherlands.* An optical investigation of ultra-thin CIGS solar cells and guidelines for elimination of optical losses is presented. Then, a novel back contacted structure for CIGS solar cells is suggested and optimized for best implied photocurrent density.

OM2D.6 • 11:15 Invited

Probing the Microstructure of Methylammonium Lead Iodide Solar Cells, Tobias Leonhard[1,2], Holger Röhm[1], Alexander Schulz[1,2], Susanne Wagner[2,3], Fabian Altermann[3], Wolfgang Rheinheimer[3], Michael J. Hoffmann[2,3], Alexander Colsmann[1,2]; *[1]Light Technology Inst., Karlsruhe Inst. of Technology, Germany; [2]Material Research Center for Energy Systems, Karlsruhe Inst. of Technology, Germany; [3]Inst. for Applied Materials – Ceramic Materials and Technologies, Karlsruhe Inst. of Technology, Germany.* Using electron backscattered diffraction, we report on the crystal orientation in methylammonium lead iodide thin-films with sub-micrometer resolution. The crystal orientation correlates with the orientation of the ferroelectric polarization as investigated by piezoresponse force microscopy.

12:00–13:00 Lunch, *Leo Foyer*

Pisces 1

Optics and Photonics for Energy & the Environment

13:00–15:00
EM3A • Sensing of Plasma & Combustion Environments
Presider: Hong Lin; National Inst. of Metrology, China

EM3A.1 • 13:00 Invited
Time-resolved dual-comb spectroscopy of laser induced plasmas, R. Jason Jones[1]; [1]*Univ. of Arizona, USA.* We demonstrate time-resolved dual-comb spectroscopy to track the evolution of multiple atomic and ionic species following laser ablation of solids. The approach promises improved plasma characterization and detection confidence in the analysis of solid materials.

EM3A.2 • 13:30
Spectroscopic investigations of plasma nitriding processes using an active screen made of carbon in a model reactor, Juergen Roepcke[1], Stephan Hamann[1], Lukas Kusyn[2], Igor Burlacov[3], Anke Dalke[3], Heinz-Joachim Spies[3], Horst Biermann[3]; [1]*INP-Greifswald, Germany;* [2]*Masaryk Univ., Czechia;* [3]*TU Bergakademie Freiberg, Germany.* H_2-N_2 plasmas were investigated spectroscopically in an active screen nitriding reactor to study the usage of a carbon screen without any additional gaseous carbon precursor.

EM3A.3 • 13:45
On the Chemical Kinetics of HO_2 in a Cold Atmospheric Plasma Jet, Sarah-Johanna Klose[1], Michele Gianella[2], Stephan Reuter[1,3], Press Sioned[2], Ana Lawry Aguila[2], Katherine Manfred[2], Ansgar Schmidt-Bleker[1], Grant Ritchie[2], Jean-Pierre H. van Helden[1]; [1]*Leibniz Inst. for Plasma Science & T, Germany;* [2]*Dept. of Chemistry, Univ. of Oxford, UK;* [3]*Dept. of Mechanical and Aerospace Engineering, Princeton Univ., USA.* HO_2 is detected in the effluent of an atmospheric pressure plasma jet by cavity ring-down spectroscopy. A reaction kinetics model describing the pathways that determine the HO_2 concentration is in good agreement with the measurements.

Pisces 2

Fourier Transform Spectroscopy

13:00–15:00
FM3B • Measurements of the Earth and the Earth's Atmosphere: Satellite and Airborne Systems
Presider: Aldona Wiacek; Saint Mary's Univ., USA

FM3B.1 • 13:00 Invited
A Miniaturized Limb Sounder Utilizing a Spatial Heterodyne Spectrometer for the Observation of the Molecular Oxygen Atmospheric Band, Martin Kaufmann[1,2], Friedhelm Olschewski[2], Klaus Mantel[3], Gordon Shepherd[4], Brian Solheim[4], Tom Neubert[1], Michael Deiml[1,6], Jilin Liu[1,2], Qiuyu Chen[1,2], Oliver Wroblowski[1,2], Martin Riese[1,2], Ralf Koppmann[2], Jinjun Shan[4], Heinz Rongen[1], Denis Fröhlich[1], Geshi Tang[5]; [1]*Forschungszentrum Jülich, Germany;* [2]*Univ. of Wuppertal, Germany;* [3]*Max-Planck-Inst. for the Science of Light, Germany;* [4]*York Univ., Canada;* [5]*Aerospace Flight Dynamics Lab, China;* [6]*OHB System AG, Germany.* A CubeSat-sized limb sounder utilizing a Spatial Heterodyne Spectrometer for the detection of the O2 Atmospheric A-Band is presented. The purpose of the instrument is to measure vertical profiles of temperature in the middle atmosphere.

FM3B.2 • 13:30
Withdrawn

FM3B.3 • 13:45
Development of Reflective Spatial Heterodyne Spectrometers for Spaceflight Applications from the Extreme UV to Near IR, Walter M. Harris[1], Jason Corliss[1]; [1]*Univ. of Arizona, USA.* A RSHS is an interferometric technique with broad applicability for remote sensing of diffuse emissions. We report on Lab, field, and spaceflight development of RSHS for narrow and broadband applications from the EUV to NIR.

Pisces 3

Hyperspectral Imaging and Sounding of the Environment

13:00–15:00
HM3C • Recent Advances in Hyperspectral Instruments, Analysis, and Algorithms I
Presider: Akihiko Kuze; Japan Aerospace Exploration Agency, Japan

HM3C.1 • 13:00 Invited
Extremely compact hyperspectral cameras of visible and infrared lights for environmental measurements, Ichirou Ishimaru[1], Natsumi Kawashima[1], Hanyue Kang[1], Tomoya Kitazaki[1], Kosuke Nogo[1], Wei Qi[1]; [1]*Kagawa Univ., Japan.* We developed the palm-size 2D-type and beans-size 1D-type Hyperspectral cameras for environmental measurements. To visualize broad-area plankton or chlorophyll distributions using drones, the light-source color correlation method, what was based on polarization, was proposed.

HM3C.2 • 13:30 Invited
An Overview of CLARREO Pathfinder and the On-Orbit Calibration Methodology, Paul C. Smith[1], Peter Pilewskie[1], Greg Kopp[1], Bruce Wielicki[2], Constantine Lukashin[2]; [1]*Lab. for Atmospheric and Space Physics, Univ. of Colorado at Boulder, USA;* [2]*NASA Langley Research Center, USA.* CLARREO Pathfinder is a NASA mission to investigate the performance of a highly-accurate hyperspectral imager (350-2300 nm, 0.3% uncertainty) from the International Space Station. The HyperSpectral Imager for Climate Science (HySICS) is cross-calibrated on-orbit via direct measurements of the solar spectral irradiance. It will acquire climate-needed spectral imagery and enable intercalibration of other on-orbit sensors (CERES, VIIRS) through coincident measurements of angle matched Earth scenes.

Pisces 4

Optics in Solar Energy

13:00–15:00
OM3D • PV Modules and Characterization
Presider: Nicholas Ekins-Daukes; Univ. of New South Wales, Australia

OM3D.1 • 13:00 Invited
Title to be Determined, Jizhong Yao[1]; [1]*Microquanta, China.* To be determined

OM3D.2 • 13:30
Visual Appearance of Effectively Transparent Contacts for Solar Windows, Lucas Myers[2], Pim Venderbosch[2], Chris van de Stadt[2,1], Harry Atwater[1], Rebecca Saive[2]; [1]*California Inst. of Technology, USA;* [2]*Univ. of Twente, Netherlands.* We explore the visual aspects of effectively transparent contacts – triangular microscale silver grids that mitigate shading losses – for use in solar windows. The distortion of view is investigated by ray optical computations and experiments.

OM3D.3 • 13:45
Accurate Soiling Ratio Determination with Incident Angle Modifier for PV Modules, Olindo Isabella[1]; [1]*PVMD, Delft Univ. of Technology, Netherlands.* This paper proposes an empirical equation to determine the soiling ratio (SR) at any instant of time of the day based on the Sun's angle of incidence (AOI) on the module and a midday SR.

Pisces 1

Optics and Photonics for Energy & the Environment

EM3A • Sensing of Plasma & Combustion Environments—Continued

EM3A.4 • 14:00 Invited

Laser dispersion spectroscopy for combustion diagnostics, Wei Ren[1]; [1]*The Chinese Univ. of Hong Kong, Hong Kong.* Dispersion spectroscopy has drawn extensive attention in recent years due to its advantages of immunity to laser power fluctuations and large dynamic range. We demonstrate in situ temperature and species measurements in flames using heterodyne phase-sensitive dispersion spectroscopy.

EM3A.5 • 14:30

Parameter Estimation using Wavelength Modulation Spectroscopy Temperature Measurements and Approximate Bayesian Computation, Jason D. Christopher[1], Daniel Petrykowski[1], Torrey R. Hayden[1], Caelan Lapointe[1], Nicholas T. Wimer[1], Siddharth P. Nigam[1], Ian Grooms[1], Peter E. Hamlington[1], Gregory B. Rieker[1]; [1]*Univ. of Colorado Boulder, USA.* We use approximate Bayesian computation (ABC) to estimate parameters in a 3D high-temperature turbulent buoyant jet large-eddy simulation (LES). Wavelength modulation spectroscopy (WMS) provides reference temperature measurements. Parameters provide close agreement between simulation and experiment.

EM3A.6 • 14:45

Measurement of Temperature and Temperature Profile of Micro Flame using Circular Grating Talbot Interferometer, Shilpi Agarwal[1], Chandra Shakher[1]; [1]*IDDC, Indian Inst. of Technology Delhi, India.* We have investigated the Talbot interferometer to measure the temperature and temperature profile of an axisymmetric micro flame. This system is s capable of measuring temperature of a large size flame to micro size flame.

Pisces 2

Fourier Transform Spectroscopy

FM3B • Measurements of the Earth and the Earth's Atmosphere: Satellite and Airborne Systems—Continued

FM3B.4 • 14:00 Invited

Sub-orbital demonstration of the Spatial Heterodyne Observations of Water (SHOW) instrument from NASA's high-altitude ER-2 remote science airplane, Jeffery A. Langille[1], Daniel Letros[1], Adam Bourassa[1], Brian Solheim[1], Fabien Dupont[2], Doug Degenstein[1], Daniel Zawada[1]; [1]*Univ. of Saskatchewan, Canada;* [2]*ABB Inc, Canada.* The Spatial Heterodyne Observations of Water instrument (SHOW) is a limb-sounding satellite prototype that is being developed to provide high spatial resolution measurements of water vapour in the upper troposphere and lower stratosphere region. In 2017, SHOW flew several flights on NASA's ER-2 airplane, allowing for sub-orbital demonstration of the measurement technique. Here, we present the results from the measurement campaign and examine the sampling capabilities of the instrument.

FM3B.5 • 14:30

Progress and recent developments of the GLORIA infrared limb imager, Erik Kretschmer[1]; [1]*Karlsruher Institut für Technologie , Germany.* GLORIA has been deployed on multiple missions since 2011 with over 500 flight hours on airborne platforms. We give an overview of demonstrated capabilities and some example scientific results and look ahead on coming projects.

FM3B.6 • 14:45

Spectrally resolved radiative observations of the Earth in the Far-Infrared using the Tropospheric Airborne Fourier Transform Spectrometer (TAFTS), Jon E. Murray[1], Juliet C. Pickering[1], Helen E. Brindley[1,2], Stuart Fox[3], Peter Ade[4], Carole Tucker[4], Cathryn Fox[3], Chawn Harlow[3], Alan Last[3]; [1]*Imperial College London, UK;* [2]*UK National Centre for Earth Observation, UK;* [3]*Met Office, UK;* [4]*Cardiff Univ., UK.* The Far-Infrared contributes up to 50% of the radiative emission from Earth to space, however, FIR observations are lacking. Satellite instruments are proposed or set for deployment, we discuss the practicalities of supporting these missions with TAFTS.

Pisces 3

Hyperspectral Imaging and Sounding of the Environment

HM3C • Recent Advances in Hyperspectral Instruments, Analysis, and Algorithms I—Continued

HM3C.3 • 14:00 Invited

Pre-Launch Activity for Flight model of HISUI hyperspectral sensor onboard International Space Station, Jun Tanii[1], Akira Iwasaki[2], Osamu Kashimura[1], Yoshiyuki Ito[3]; [1]*Japan Space Systems, Japan;* [2]*Univ. of Tokyo, Japan;* [3]*NEC Corporation, Japan.* HISUI hyperspectral sensor to be mounted on International Space Station obtains the earth's images of 185 bands from the visible to shortwave-infrared wavelength region with the ground sampling distance of 20x31 meters. Pre-launch evaluation activities of a Flight Model are reported.

HM3C.4 • 14:30

A Hyperspectral Camera for Remote Sensing based on a Birefringent Ultrastable Common-Path Interferometer, Antonio Perri[2,4], Bárbara Elza Nogueira de Faria[3], Danielle Ferreira[3], Dario Polli[2,4], Daniela Comelli[2], Gianluca Valentini[2,1], Giulio Cerullo[2,1], Cristian Manzoni[1,2]; [1]*IFN-CNR, Italy;* [2]*Dipartimento di Fisica, Politecnico di Milano, Italy;* [3]*Departamento de Física, Universidade Federal de Minas Gerais, Brazil;* [4]*NIREOS S.R.L., Jamaica.* We introduce a compact Fourier-transform hyperspectral camera based on an ultrastable birefringent interferometer. The camera has broad spectral coverage and resolution, wide angular acceptance, high sensitivity and short acquisition time. Example spectral images are presented.

HM3C.5 • 14:45

Compact Integral Filed Snapshot Imaging Spectrometers for Environmental Imaging Applications, Tomasz Tkaczyk[1], David Alexander[1], Ye wang[1], Jason Dwight[1], Razvan Stoian[1], Shuna Cheng[1], Michal Pawlowski[1]; [1]*Rice Univ., USA.* Imaging techniques e.g. field slicing and mapping, fiber re-organization techniques to rapidly acquire multi-dimensional data are discussed. They allow recording and display of spectral, polarization and in general 3D+ environmental data in a snapshot mode.

Pisces 4

Optics in Solar Energy

OM3D • PV Modules and Characterization—Continued

OM3D.4 • 14:00

Impact of Fabrication Parameters on the Self-cleaning Performance of Hot-embossed Fluoropolymer Films for Photovoltaic Modules, Aiman Roslizar[1], Stephan Dottermusch[1], Felix Vüllers[1], Maryna N. Kavalenka[1], Markus Guttmann[1], Marc Schneider[1], Efthymios Klampaftis[1], Ulrich W. Paetzold[1], Hendrik Hölscher[1], Bryce S. Richards[1]; [1]*Karlsruhe Inst. of Technology, Germany.* Photovoltaic (PV) module soiling can be overcome through passive self cleaning top covers. This work investigates hot-embossing microtextured fluorinated ethylene propylene films to obtain superhydrophobic surfaces exhibiting the dual functionality of self cleaning and anti-reflection properties.

OM3D.5 • 14:15

Fast Extraction of Performance Parameters for Photovoltaic Module using Electroluminescence Imaging Technique, Amit S. Rajput[1,2], Jian Wei Ho[1], Yin Zhang[1], Srinath Nalluri[1], Armin G. Aberle[2,1]; [1]*Solar Energy Research Inst. of Singapore, Singapore;* [2]*National Univ. of Singapore, Singapore.* A fast extraction method, based on electroluminescence (EL) imaging technique, is introduced to quantitatively estimate the electrical performance parameters of individual solar cells within the photovoltaic (PV) module.

OM3D.6 • 14:30 Invited

Modulated Photoluminescence Technique for Solar Cell Characterisation, Kwan Bum Choi[1], Jian Wei Ho[1]; [1]*Solar Research Inst. of Singapore , Singapore.* Modulated photoluminescence technique is used to measure the effective carrier lifetime of metalized and non-metallized silicon solar cell samples, by using intensity modulated illumination and measuring its phase difference to the photoluminescence from the sample.

15:00–15:30 Coffee Break/Exhibits, *Leo Foyer*

Pisces 1

Optics and Photonics for Energy & the Environment

15:30–17:15
JM4A • Solar Energy and Energy Storage (E2/SOLAR)
Presider: Klaus Jaeger; Helmholtz-Zentrum Berlin, Germany

JM4A.1 • 15:30 Invited
Graphene energy storage devices, Baohua Jia[1]; [1]*Swinburne Univ. of Technology, Australia.* We demonstrate high-performance planar supercapacitors by direct light printing technique. By controlling the nanometric pore size of graphene, the surface area and the mean ionic path can be optimized, which led to supercapacitor performance exceeding the state-of-the-art.

JM4A.2 • 16:00
Systematic study on the interaction between graphene and visible-light responsive photocatalysts, Hassan Sameie[1,2], Ali A. Sabbagh Alvani[1], Naimeh Naseri[3], Bastian Mei[2]; [1]*CPRC, Amirkabir Univ. of Technology, Iran;* [2]*Photocatalytic Synthesis Group, MESA+ Inst. for Nanotechnology, Univ. of Twente, Netherlands;* [3]*Sharif Univ. of Technology, Iran.* The basic mechanisms of interfacial interaction, charge transfer/separation and subsequently their influence on the photocatalytic activity of ZnV_2O_6/graphene nanocomposites were comprehensively studied.

JM4A.3 • 16:15
Revisiting Broadband Reflection Suppression by Mie Scatterers: the Role of Electromagnetic Duality, Evgeniia Slivina[1,2], Aimi Abass[2], Derk Bätzner[1], Carsten Rockstuhl[2,3], Ivan Fernandez-Corbaton[2]; [1]*Meyer Burger Research AG, Switzerland;* [2]*Inst. of Nanotechnology, Karlsruhe Inst. of Technology, Germany;* [3]*Inst. of Theoretical Solid State Physics, Karlsruhe Inst. of Technology, Germany.* The physics behind broadband reflection suppression that high index dielectric nanoparticle arrays can provide is revisited. We demonstrate that antireflective properties are inherently connected to how equal the effective magnetic and electric responses are.

JM4A.4 • 16:30
Influence of 2D non-uniformly gradient motheye structures for absorption improvement in solar energy harvesting, Saraswati Behera[1]; [1]*Mechanical Engineering, Yonsei Univ., South Korea.* Non-uniformly gradient 2D motheye photonic structures are studied to show more than 85% of absorption over a broad solar spectrum (350-1100 nm) and wide angle of incidence for targeted applications in solar energy harvesting.

JM4A.5 • 16:45
Improved Light Trapping in Quantum Dot Solar Cells Using Double-sided Nanostructuring, Farid K. Elsehrawy[1], Timo Aho[2], Tapio Niemi[2], Mircea Guina[2], Federica Cappelluti[1]; [1]*Dept. of Electronics and Telecommunications, Politecnico di Torino, Italy;* [2]*Lab of Photonics, Tampere Univ. of Technology, Finland.* We investigate light trapping in thin-film quantum dot solar cells employing front and back side nanostructuring for antireflection and diffraction, respectively. Simulation results demonstrate a large improvement of the effective quantum dot optical absorption.

Pisces 2

Fourier Transform Spectroscopy

15:30–17:30
FM4B • Comb-based Spectroscopy
Presider: Ian Coddington; NIST, USA

FM4B.1 • 15:30 Invited
Precision beyond the Voigt profile using optical frequency comb Fourier transform spectroscopy, Lucile Rutkowski[1,2], Alexandra C. Johansson[1], Anna Filipsson[1], Piotr Maslowski[3], Aleksandra Foltynowicz[1]; [1]*Fysikhuset Plan 4, Umea Universitet, Sweden;* [2]*Univ. of Rennes, France;* [3]*Nicolaus Copernicus Univ., Inst. of Physics, Astronomy and Informatics, Poland.* We present optical frequency comb Fourier transform spectroscopy of the entire CO_2 band at 1.57 μm with high enough signal-to-noise ratio to outreach the limit of validity of the Voigt profile.

FM4B.2 • 16:00
Cavity-enhanced dual-comb phase spectroscopy, Nazanin Hoghooghi[1], Robert Wright[1], Wiliam Swann[2], Ian R. Coddington[2], Gregory B. Rieker[1]; [1]*Univ. of Colorado Boulder, USA;* [2]*national Inst. of standards and technology, USA.* Broadband cavity-enhanced dual-comb phase spectroscopy is demonstrated for the first time. The phase spectrum of methane is coherently averaged for 11 s and fit using a model developed for this purpose.

FM4B.3 • 16:15
Optical Frequency Comb Faraday Rotation Spectroscopy, Jonas Westberg[1], Alexandra C. Johansson[2], Gerard Wysocki[1], Aleksandra Foltynowicz[2]; [1]*Dept. of Electrical Engineering, Princeton Univ., USA;* [2]*Dept. of Physics, Umeå Univ., Sweden.* We present measurements of the entire Q- and R-branches of the fundamental band of nitric oxide at 5.2 – 5.4 μm by the background- and calibration-free optical frequency comb Faraday rotation spectroscopy technique.

FM4B.4 • 16:30 Invited
Dual-frequency Comb Spectroscopy for Dynamic, High-pressure Combustion Systems, Ryan Cole[1], Nazanin Hoghooghi[1], Anthony Draper[1], Robert Wright[1], Jeffrey Mohr[2], Andrew Zdanowicz[2], Anthony Marchese[2], Gregory B. Rieker[1]; [1]*Univ. of Colorado Boulder, USA;* [2]*Colorado State Univ., USA.* We present recent results using dual-comb spectroscopy to measure temperature in dynamic high-pressure environments. Signal processing and other optimization approaches greatly increase the time-resolution in order to capture fast transient events.

Pisces 3

Hyperspectral Imaging and Sounding of the Environment

15:30–16:30
HM4C • Recent Advances in Hyperspectral Instruments, Analysis, and Algorithms II
Presider: Akihiko Kuze; Japan Aerospace Exploration Agency, Japan

HM4C.1 • 15:30
Design of a fast dual band hyper-spectral imager with wide field of view for airborne application, Seo Hyun Kim[1]; [1]*Hanwha system, South Korea.* We present a new fast and wide FOV dual band hyper-spectral imager for airborne application. To satisfy the high SNR requirement, we have analyzed system, detector and optics. We have established WFE budget to get high spectral resolution with a good MTF, and designed the high efficiency optics.

HM4C.2 • 15:45
Atmospheric Correction of Airborne Hyperspectral Remote Sensing Data for Inland Water Applications, Sandip Banerjee[1], Palanisamy Shanmugam[1]; [1]*Indian Inst. of Technology, Madras, India.* This study focuses on atmospheric correction of airborne AVIRIS-NG data and estimation of Chlorophyll-a in inland water bodies with implications for water quality monitoring and assessment.

HM4C.3 • 16:00
Recent Advances in AERI Data Processing: Real-time Quality Control and Real-time Thermodynamic Retrievals, Jonathan Gero[1], David Turner[2], Raymond Garcia[1], Coda Phillips[1], Alex Diebold[1], Denny Hackel[1], Matthew Westphall[1]; [1]*Univ. of Wisconsin-Madison, USA;* [2]*ESRL, NOAA, USA.* The Atmospheric Emitted Radiance Interferometer (AERI) measures downwelling thermal infrared radiance from the atmosphere. Recent development of real-time quality control and thermodynamic retrievals transform the AERI into a vastly more valuable tool for atmospheric science.

HM4C.4 • 16:15
Improving the Full Waveform Digitizing in an Eight Channel Portable Hyperspectral Lidar, Tuomo Malkamäki[1], Sanna Kaasalainen[1], Julian Ilinca[1]; [1]*Finnish Geospatial Research Inst., Finland.* In this paper, we present a robust field design and an improved pulse sampling scheme for our renewed hyperspectral LIDAR. This design allows field measurements of very low reflectance targets, enabling a range of novel applications.

Pisces 1

Joint Optics and Photonics for Energy & the Environment/ Optics in Solar Energy

JM4A • Solar Energy and Energy Storage (E2/SOLAR)—Continued

JM4A.6 • 17:00
Realization of Colors and Patterns for Inkjet-Printed Perovskite Solar Cells, Stefan Schlisske[1,2], Florian Mathies[1,2], Dmitry Busko[1], Noah Strobel[1,2], Tobias Rödlmeier[1,2], Uli Lemmer[1], Ulrich W. Paetzold[1], Gerardo Hernandez-Sosa[1,2], Efthymios Klampaftis[1,3], Bryce S. Richards[1]; *[1]Karlsruhe Inst. of Technology, Germany; [2]InnovationLab GmbH, Germany; [3]Nanotechnology and Advanced Materials Lab., Technological-Educational Inst. of Western Greece, Greece.* We demonstrate colored perovskite solar cells (PSC) that combine the flexibility of inkjet printing with luminescent down-shifting (LDS) layers. Via LDS, many colors can be realized for only a small reduction (~17%) in conversion efficiency.

Pisces 2

Fourier Transform Spectroscopy

FM4B • Comb-based Spectroscopy—Continued

FM4B.5 • 17:00
A Novel Rapid Scanning Fourier Transform Spectrometer for the Measurement of Electron Cyclotron Emission in a Plasma Fusion Reactor, David A. Naylor[1], Brad Gom[2], Sudhakar Gunuganti[2], Trevor Fulton[2], Hitesh Pandya[3], Vinay Kumar[3]; *[1]Univ. of Lethbridge, Canada; [2]Blue Sky Spectroscopy, Canada; [3]ITER-India, Inst. for Plasma Research, India.* Measurements of electron cyclotron emission provide a powerful diagnostic tool for fusion plasmas. We present the design of, and preliminary results from, a novel, rapid scanning, high throughput, Fourier transform spectrometer capable of meeting the challenging ECE fusion diagnostic requirements.

FM4B.6 • 17:15
Time-domain Measurement of the Complex Chiro-Optical Susceptibility via Fourier-Transform Spectroscopy using an Ultra-stable Common-path Interferometer, Fabrizio Preda[1,2], Antonio Perri[1,2], Julien Rehault[3], Cristian Manzoni[1], Soumen Gosh[1], Jan Helbing[4], Giulio Cerullo[1,2], Dario Polli[1,2]; *[1]Politecnico di Milano, Italy; [2]NIREOS s.r.l., Italy; [3]Universität Bern, Switzerland; [4]Univ. of Zurich, Switzerland.* We introduce a novel, compact and low-cost instrument to measure the broadband optical activity of molecules. It employs a birefringent common-path polarization-division interferometer and combines time-domain Fourier-transform detection with heterodyne amplification.

Pisces 3

Hyperspectral Imaging and Sounding of the Environment

HM4C • Recent Advances in Hyperspectral Instruments, Analysis, and Algorithms II—Continued

Leo 1&2

17:30–19:00
Accelerating the Deployment of Renewables in Southeast Asia Special Panel

Urgent action is required to limit global warming. Rapidly developing Southeast Asia, with a population of 600 million, needs to deploy vast amounts of renewable energies to keep carbon emissions under control. In this timely panel discussion, experts from universities, solar companies and government agencies will share their views on how to accelerate the deployment of renewables in Southeast Asia. Aspects covered range from technology & engineering to economics and policies.

Moderator: Kenneth Baldwin, Director, *ANU Energy Change Institute, Australian National University, Australia*

Panelists:
Christophe Inglin, Managing Director, *Energetix Pte Ltd, Singapore*
Edwin Khew, Chairman, *Sustainable Energy Association of Singapore (SEAS), Singapore*
Alan Khor, Head of Engineering, Procurement & Construction, *Cleantech Solar, Singapore*
Eicke Weber, *Berkeley Education Alliance for Research in Singapore, Singapore*
Thomas White, *Australian National University, Australia*

08:30–09:30
JT1A • Keynote I
Presider: Serena Fen Lin, National University of Singapore, Singapore

JT1A.1 • 08:30 Keynote

Perovskite-silicon Tandem Solar Cells: Progress, Challenges and Opportunities, Thomas P. White[1]; [1]*Research School of Engineering, Australian National Univ., Australia.* This presentation will review recent highlights and current challenges in the development of high efficiency perovskite-silicon tandem solar cells, and identify pathways for reaching efficiencies of 30% and beyond through optical, material and device engineering.

JT1A.2 • 09:00 Keynote

Measuring Atmospheric Carbon Dioxide from the NASA Orbiting Carbon Observatory-2 (OCO-2), David Crisp[1]; [1]*Jet Propulsion Lab, California Inst. of Technology, USA.* NASA's OCO-2 spacecraft has returned observations of atmospheric carbon dioxide (CO_2) since September 2014. These data are being used to study the processes emitting CO_2 into the atmosphere and those absorbing it at the surface.

Joint

LEO Foyer

09:30–10:30
JT2A • Poster Session with Coffee Breaks and Exhibits

JT2A.1
Variability In Transient Climate Response In The MPI Grand Ensemble And Its Relation To The Radiative Effect Of Sea Ice Loss, Andrew E. Dessler[1]; [1]*Texas A&M Univ, USA.* Transient climate response (TCR) is one way to measure sensitivity of the Earth's climate to increasing greenhouse gases. We find that the radiative impact of sea ice plays a key role in TCR uncertainty.

JT2A.2
Space experiment "Climate" on the Russian segment of the ISS and its scientific equipment, Yuri V. Bazhanov[1]; [1]*PC "SPI "Geofizika-Kosmos", Russia.* The report presents the composition, technical characteristics and design of scientific equipment, as well as scientific tasks of the Space experiment "Climate" related to the study of the Earth's atmosphere.

JT2A.3
Design and Fabrication of hyperspectral systems with freeform optical elements, Yuri V. Bazhanov[1]; [1]*PC "SPI "Geofizika-Kosmos", Russia.* Design of optical system, containing two-mirror off-axis telescope and Offnerspectrometer with freeform mirror usage is presented in this paper. For of such mirrors "uVo" manufacturing software can be used, allowing fabrication of freeform elements using conventional 3 axis diamond turning machines.

JT2A.4
Design of Triple Layer Antireflection Coatings (ARC) for Industrial Bifacial *n*FAB Solar Cells, Xia Yan[1], Ning Chen[1], Firdaus Bin Suhaimi[1], Xinxin Gong[2], Lin Zhang[2], Xinyu Zhang[2], Shubham Duttagupta[1]; [1]*National Univ. of Singapore, Singapore;* [2]*Jinko Solar, China.* High efficiency solar cells need to make better use of solar spectrum. The implementation of triple layer antireflection coatings helps to reduce front reflection and allows improvement of absolute ~0.2% efficiency of *n*FAB solar cells.

JT2A.5
Sunlight Harvesting System for Simultaneous use of Room Indoor Lighting and Water Heating, Mayank Gupta[1], Atul K. Dubey[1], Virendra Kumar[1], Dalip S. Mehta[1]; [1]*IIT Delhi, India.* Utilizing the broad spectrum of Sunlight we present Fresnel lens and single axis tracking based sunlight harvesting system for Indoor lighting and water heating. Sunlight is guided through POF bundle coupled with light diffusing acrylic rod for illumination.

JT2A.6
Light Trapping Enhancement in Perovskite/Silicon Tandem Solar Cells via Optimized PDMS as an Antireflective Layer, Fuhua Hou[1], Can Han[1], Lingling Yan[1], Biao Shi[1], Yi Ding[1], Yuelong Li[1], Ying Zhao[1], Xiaodan Zhang[1]; [1]*Nankai Univ., China.* Three random-pyramid texture PDMS were designed as an antireflection layer in perovskite/silicon tandem solar cells. The P2-PDMS layer exhibit a higher average haze ratio (H) mainly originated from the uneven random distribution.

JT2A.7
Design of Smart Cooling System for Solar Panel on Performance Efficiency with Internet of Things (IoT), Lay-Theng Tan[1]; [1]*School of Engineering, Republic Polytechnic, Singapore.* This paper provides integrated solutions to improve the energy efficiency of solar panel. It is achieved by incorporating a cost-efficient, propulsive and intelligent water cooling system using Raspberry Pi. It also provides cleaning function to remove the dirt on the panel.

JT2A.8
Performances of a CPC Collector Inside in a High Vacuum Flat Panel, Roberto Russo[1], Francesco Di Giamberardino[2], Matteo Monti[2], Carmine D'Alessandro[2,1], Davide De Maio[2,1], Marilena Musto[3], Vittorio G. Palmieri[2]; [1]*National Research Council of Italy, Italy;* [2]*TVPSolar SA, Switzerland;* [3]*Dipertimento di Ingegneria dell'Informaizone, Università di Napoli, Italy.* We present the performances of CPC collector designed and optimized to be placed inside high vacuum panels. Results will be compared with performances of a high vacuum flat panel equipped with the best available absorber.

JT2A.9
Angle-Selection with Sub-Unity Index in Solar Cells, Ken Xingze Wang[1]; [1]*Huazhong Univ of Science and Technology, China.* Angle selection/restriction modifies the emission cone of and can improve the limiting efficiency and reduce the material cost for solar cells. This can be realized using a material with an effective sub-unity refractive index.

JT2A.10
ECA (Electrical Conductive Adhesive) Induced Failure On Shingling Module, Juan Wang[1], Zhiqiu Guo[1], Hao Jin[1]; [1]*Zhejiang Jinkosolar Co.,Ltd., China.* We studied Shingling module reliability and found that ECA quality could induce module failure. This work focuses on the influence of the bubbles in the ECA on the reliability of module.

JT2A.11
Solar Energy Actuated Optical Mechanism, Lihui Wang[1], Hongjin Xu[1], Masatoshi Ishikawa[1]; [1]*Univ. of Tokyo, Japan.* An optical system was designed and driven by a shape memory alloy (SMA) actuator. Lenses could collect the solar energy to heatthe SMA to realize a mechanical motion and switch the system phase.

JT2A.12
Retrieval optical parameters of atmospheric particles based on active DOAS, Suwen Li[1]; [1]*Huaibei Normal Univ., China.* The active differential optical absorption spectroscopy (DOAS) is developed to measure the optical parameters of atmospheric particles, combining two light paths. With the extinction coefficient, the number size distribution from 0.1μm to 1.25μm was retrieved by a step function.

JT2A.13
Enhanced Visible Light Photocatalysis in Titanium Dioxide-Functionalized Nanoporous Anodic Alumina Photonic Crystals, Siew Yee Lim[1], Cheryl Suwen Law[1], Abel Santos[1]; [1]*Univ. of Adelaide, Australia.* Herein, we demonstrate the enhanced photocatalytic performance of a rationally designed nanoporous anodic alumina gradient-index filters functionalized with photoactive titanium dioxide. The photonic efficiency of this composite material improves photocatalytic reactions by 'slow photon' effect.

JT2A.14
Application of Nano-TiO2 Coating in a Rooftop Hydroponic Farming System, Lay-Theng Tan[1]; [1]*Republic Polytechnic, Singapore.* This paper focuses on the effectiveness of nano-TiO_2 coating on the solar glass in absorbing Ultra-Violet (UV) to improve the plant's growth in a rooftop hydroponics farm system. The parameters to assess the plant growth are diameter/length of the leaf, fresh/dry mass, and moisture content.

JT2A.15
Analysis of the inorganic compounds in PM2.5 aerosols in Zhengzhou using ATR-FTIR method, Xiuli Wei[1], Huaqiao Gui[1], Jianguo Liu[1], minguang gao[1], jiaoshi zhang[1], tongzhu yu[1], ying chen[1]; [1]*Key Lab of Environmental Optics and Technology, Anhui Inst. of Optics and Fine Mechanic, Chinese Academy of Sciences, China.* The inorganic compounds in PM2.5 aerosols were measured using a FTIR spectroscopy before Chinese New Year in 2014 in Zhengzhou city, China. Combined the data of gaseous pollutants (NO2 and SO2) and the air back trajectories to analyze the effect of transport.

JT2A.16
The Measurement of HO_2 by A FAGE Instrument, Yihui Wang[2,1], Renzhi Hu[1], Pinhua Xie[1], Hao Chen[1], Fengyang Wang[1], Zhiyan Li[1], Huawei Jin[1]; [1]*Anhui Inst.of Optics and Fine Mechanics, China;* [2]*School of Environmental Science and Optoelectronic Technology, Univ. of Science and Technology of China, China.* An instrument for measuring atmospheric HO_2 has been developed by FAGE technique. A series of experiments have been carried out to characterize the instrument performance and the detection limit of HO_2.

JT2A.17
OH radical field observation based on Fluorescence Assay by Gas Expansion technique, Fengyang Wang[1,2], Renzhi Hu[1], Hao Chen[1], Pinhua Xie[1], Yihui Wang[1,2], Zhiyan Li[1,2], Huawei Jin[1,2]; [1]*Anhui Inst. of Optics and Fine Mechanics, Chinese Academy of Sciences, China;* [2]*Univ. of Science and Technology of China, China.* OH radical has an important role in atmosphere, as it is involved in many tropospheric chemical reactions. This paper presents a tropospheric OH radical detection instrument based on Fluorescence Assay by Gas Expansion technique.

JT2A.18
Detection of N_2O Using An External-Cavity Quantum Cascade Laser, Faisal Nadeem[1], Amir Khodabakhsh[1], Julien Mandon[1], Simona Cristescu[1], Frans J. M. Harren[1]; [1]*Radboud Univ., Netherlands.* We developed an EC-QCL-based spectrometer around 8 μm for detection of nitrous oxide. Using wavelength modulation spectroscopy and 2nd harmonic detection, a minimum detection limit of 15 ppbv is achieved in less than 10 s.

LEO Foyer

JT2A • Poster Session—Continued

JT2A.19
Optical Monitoring of N_2O_5 in a Nocturnal Tropospheric Chemical Reaction Process using Quantum Cascade Laser, Weidong Chen[1]; *[1]Universite du Littoral, France.* A spectroscopic instrument based on an external cavity quantum cascade laser was developed for optical monitoring of dinitrogen pentoxide (N_2O_5) at the ppbv-level in a nocturnal tropospheric chemical reaction process in an atmospheric simulation chamber.

JT2A.20
Laser Heterodyne Radiometry for Ground-based Monitoring of GHGs in the Atmospheric Column, Weidong Chen[1]; *[1]Universite du Littoral, France.* An mid-infrared laser heterodyne radiometer was been developed for ground-based remote measurements of greenhouse gases (GHGs) in the atmospheric column.

JT2A.21
Precision Two-Photon-Excitation Spectroscopy of Atomic and Molecular Rydberg States, Kenneth G. Baldwin[1], Mitsuhiko Kono[3], Brian J. Orr[2], Yabai He[2]; *[1]Australian National Univ., Australia; [2]Dept. of Physics and Astronomy, Macquarie Univ., Australia; [3]Senri International School of Kwansei Gakuin, Japan.* A tunable, narrowband laser system, developed for high-resolution ultraviolet spectroscopy of atoms and molecules and previously applied to two-photon excitation of rare-gas atoms, now offers prospects for new measurements of atmospheric molecules such as oxygen.

JT2A.22
Interference-free Measurements of Environmental NO_2 by Laser Photoacoustic Spectroscopy, Weidong Chen[1]; *[1]Universite du Littoral, France.* A photoacoustic spectroscopy based NO_2 sensor was developed for measurement of ambient NO_2 with a sensitivity of about 0.4 ppb (SNR=1) in 1 min, which was validated with side-by-side measurements using a referenced NOx analyzer.

JT2A.23
Phase Transformation in Size-Evolved Solution-Processed Pure-Inorganic Lead Halide Perovskite, Xinhai Zhang[1], Huafeng Shi[1]; *[1]Southern Univ. of Sci. & Tech. , China.* We report the crystal structure phase transformation phenomenon occur in size-evolution of solution-processed pure-inorganic lead halide perovskite.

JT2A.24
Development of a fiber-optic particle size measurement system based on dynamic light scattering technique, Huaqiao Gui[1,2], Huanqin Wang[3], Wei Wan[3], Fajun Yu[3], Jianguo Liu[1,2], Liang Lü[4]; *[1]Anhui Inst Optics & Fine Mech, CAS, China; [2]CAS Center for Excellence in Regional Atmospheric Environment, Chinese Academy of Sciences, China; [3]State Key Lab of Transducer Technology, Chinese Academy of Sciences, China; [4]Key Lab of Opto-Electronic Information Acquisition and Manipulation of Ministry of Education, Anhui Univ., China.* In this paper, a fiber-optic particle size measurement system based on dynamic light scattering(DLS) is developed. The system uses the classic 90° particle size measurement technique, which has high sensitivity and precision.

JT2A.25
Dependent Scattering Effect on Light Absorption in Random Media, Boxiang Wang[1], Changying Zhao[1]; *[1]Shanghai Jiao Tong Univ., China.* We examine the effect of dependent scattering on absorption in disordered media consisting of highly scattering scatterers. The present work is of practical importance in modeling light absorptance in random media, for applications like solar energy concentration, micro/nanofluids, etc.

JT2A.26
Use of Lock-in Detection in Dual-Comb Spectroscopy, Hidenori Koresawa[1,2], Kyuki Shibuya[1,2], Akifumi Asahara[3,2], Takeo Minamikawa[1,2], Kaoru Minoshima[3,2], Takeshi Yasui[1,2]; *[1]tokushima Univ., Japan; [2]JST, ERATO MINOSHIMA Intelligent Optical Synthesizer, Japan; [3]The Univ. of Electro-Communications, Japan.* We present a method to selectively measure a mode-resolved spectrum of optical frequency comb at a specific frequency by introducing a lock-in detection in dual-comb spectroscopy.

JT2A.27
Measurement of atmospheric column concentration of CO_2 using near infrared laser heterodyne radiometer, Hao Deng[1], Chenguang Yang[1], Zhenyu Xu[1], Ruifeng Kan[1]; *[1]Anhui Inst of Optics Fine Mechanics, China.* A near infrared laser heterodyne radiometer has been developed for measuring atmospheric column concentration of CO_2. The results have been compared with that of ground-based fourier transform spectrometer in Hefei and show good agreement.

JT2A.28
3D Cloud Microphysics by Combining the Hyperspectral Imaging Spectrometer specMACS with Active Remote Sensing Instruments, Lucas C. Höppler[1], Tobias Kölling[1], Felix Gödde[1], Manuel Gutleben[2], Marek Jacob[1], Tobias Zinner[1], Bernhard Mayer[1]; *[1]Ludwig Maximilian University of Munich, Germany; [2]Deutsches Zentrum für Luft- und Raumfahrt, Institut für Physik der Atmosphäre, Germany.* A new hyperspectral imaging spectrometer makes it possible to combine information from lidar, radar, and microwave radiometer. 3D clouds with measured micro- and macrophysical quantities are then created. The aim is to reduce forecast uncertainties in the future.

JT2A.29
Cavity-Enhanced Complex Refractive Index Spectroscopy of Entire Molecular Bands Using a Frequency Comb, Alexandra C. Johansson[1], Lucile Rutkowski[1], Anna Filipsson[1], Thomas Hausmaninger[1], Gang Zhao[1,2], Ove Axner[1], Aleksandra Foltynowicz[1]; *[1]Umea Universitet, Sweden; [2]Inst. of Laser Spectroscopy, Shanxi Univ., China.* We demonstrate broadband calibration-free complex refractive index spectroscopy of entire molecular bands by direct measurement of transmission modes of a Fabry-Perot cavity using frequency comb-based Fourier transform spectrometer with sub-nominal resolution.

JT2A.30
Time- and Frequency-Resolved Fluorescence with a Single TCSPC Detector via Fourier-Transform Spectroscopy, Antonio Perri[1,2], Fabrizio Preda[1,2], John Gaida[3], Andrea Farina[1], Cosimo D'Andrea[1], Giulio Cerullo[1,2], Dario Polli[1,2]; *[1]Politecnico di Milano, Italy; [2]NIREOS s.r.l., Italy; [3]4th Physical Inst., Germany.* We introduce a broadband single-pixel time-resolved fluorescence spectrometer comprising an ultra-stable common-path interferometer based on birefringence and a single-pixel time-resolved detector. It shows better sensitivity, throughput and spectral/temporal resolution than commercial instruments.

JT2A.31
A Comparison of two sampling and processing methods in FT-IR Spectrometer, Yan Li[1], Jingjing Tong[1], minguang gao[1], Jun Chen[1], Xiangxian Li[1], Sheng Li[1], Yaping Wang[1], Xin Han[1], Chuling Deng[1], Jiangting Wu[1], Jianguo Liu[1]; *[1]Anhui Inst of Optics Fine Mechanics, China.* The laser triggered sampling method and the fourier interpolative sampling method based on the Brault algorithm are compared. The results show that the fourier interpolative sampling method has lower detection limit and better detection accuracy.

JT2A.32.
Study of defects in Sb2Se3 solar cells via admittance spectroscopy, Xiaobo Hu[1]; Jiahua Tao[1]; Shaoqiang Chen[1]; Junhao Chu[1]; *East China Normal University, China.* Defects properties in Sb2Se3 solar cells were studied in detail by admittance measurements. Correlations of defects properties to the performance of the solar cells have been discussed.

Pisces 1

Optics and Photonics for Energy & the Environment

10:30–12:30
ET3A • Atmospheric Sensing of Clouds & Aerosols
Presider: Iftach Klapp; ARO-Volcani Center, Israel

ET3A.1 • 10:30
Vertical Characteristics of Aerosols in Lower Troposphere during a Haze Episode in Hinterland of YRD, Jie Wang[1,2], Tianshu Zhang[1], Wenqing Liu[1], Jianguo Liu[1], Xueping Wan[2]; [1]*Key Lab of Environmental Optics and Technology, Anhui Inst. of Optics and Fine Mechanics, China;* [2]*Wuxi CAS Photonics Co. Ltd, China*. Vertical characteristics and mechanisms of pollution in lower troposphere in Hinterland of YRD region was studied with a profile-analysis method. Lidar was proved to be an effective tool for the further study of complex pollution in China.

ET3A.2 • 10:45
A low cost sky-scanning device as centralized sensor for real-time light control in building management application, Marshal Maskarenj[1], Rangan Banerjee[1], Prakash C. Ghosh[1]; [1]*Indian Inst. of Technology Bombay, India*. A low-cost LDR-based angular sky-luminance measurement device is proposed as a centralized sensor for predicting real-time illuminance distribution in building interiors over a wide district, for application in centralized light control.

ET3A.3 • 11:00 Invited
Monitoring of climate-change related aerosol by laser absorption spectroscopy, Weidong Chen[1]; [1]*Laboratoire de Physicochimie de l'Atmosphère, Universite du Littoral Côte d'Opale, France*. We will present our recent developments and applications of laser-based spectroscopic instruments to monitoring of climate-change related aerosols, which involve photoacoustic spectroscopy (PAS) and broadband cavity enhanced absorption spectroscopy (BBCEAS).

ET3A.4 • 11:30
Optical and Geometrical Properties of Cirrus Clouds over the Tibetan Plateau Measured by Lidar and Radiosonde Sounding at the Summertime in 2014, Guangyao Dai[1], Songhua Wu[1,2], Xiaoquan Song[1,2], Liping Liu[3]; [1]*Ocean Univ. of China, China;* [2]*Lab for Regional Oceanography and Numerical Modeling, Qingdao National Lab for Marine Science and Technology, China;* [3] *Lab of Severe Weather, Chinese Academy of Meteorological Science, China*. Optical and geometrical characteristics of the cirrus over Naqu, the Tibetan Plateau were determined with lidar and radiosonde. The temperature dependences of the cirrus characteristics were analyzed. The formation of cirrus clouds was investigated.

Pisces 2

Fourier Transform Spectroscopy

10:30–12:30
FT3B • Far-IR Observatories and FTS Spectroscopy
Presider: Sheng-Cai Shi; Purple Mountain Observatory, China

FT3B.1 • 10:30 Invited
Progress Towards a Far-Infrared Spatial/Spectral Interferometry Lab Testbed Instrument, Locke D. Spencer[1], Chris Benson[1], Jeremy P. Scott[1], Geoffrey R. Sitwell[1], Adam Sundberg[1], Vince F. Weiler[1], David A. Naylor[1]; [1]*Physics & Astronomy, Univ. of Lethbridge, Canada*. Characterization results are presented for a double-Fourier spatial/spectral Lab interferometer. This instrument is a testbed platform for developing imaging techniques, data processing algorithms, and component characterization for space-based astronomical applications in the far-infrared.

FT3B.2 • 11:00
Atmospheric Windows from Dome-A Antarctica for High Angular Resolution Terahertz Astronomy, Hiroshi Matsuo[1], Sheng-Cai Shi[2], Scott Paine[3], Qijun Yao[2], Zhenhui Lin[2]; [1]*National Astronomical Observatory Japan, Japan;* [2]*Purple Mountain Observatory, China;* [3]*Smithonian Astrophysical Observatory, USA*. FTS measurements of atmospheric transmission spectra from Dome A revealed numerous windows throughout terahertz frequencies, and their stabilities are analyzed. Terahertz telescopes and HBT-type intensity interferometry can be used for high angular resolution terahertz astronomy.

FT3B.3 • 11:15
Terahertz Atmospheric Transmission Measured at Ali with a Fourier Transform Spectrometer, Wei MIAO[1], Zhenhui Lin[1], Sheng Li[1], Ming Yao[1], Bowen Fan[1], Yue Geng[1], Shaoliang Li[1], Qijun Yao[1], Shengcai Shi[1]; [1]*Purple Mountain Observatory, China*. We report measurements of the atmospheric transmission of Tibet's Ali at 0.75-15 THz with a Fourier transform spectrometer from 2 December 2017 to 30 April 2018. The details of the measurement results will be presented.

FT3B.4 • 11:30 Invited
Dual-Comb Electric Field Sampled Infrared Spectroscopy, Scott A. Diddams[1]; [1]*NIST, USA*. We generate bright, super-octave infrared combs in the molecular fingerprint region using intra-pulse difference frequency generation. Dual-comb electro-optic sampling is used to map the full infrared electric field with temporal dynamic range of 10^6.

Pisces 3

Optics in Solar Energy

10:30–12:30
OT3C • Silicon PV Technology
Presider: Olindo Isabell; Technische Universiteit Delft, Netherlands

OT3C.1 • 10:30 Invited
On the near-infrared parasitic absorption in large-area monoPoly™ silicon solar cells, Shubham Duttagupta[2], Naomi Nandakumar[1], John Rodriguez[1]; [2]*Solar Energy Research Inst. of Singapore (SERIS), National Univ. of Singapore (NUS), Singapore*. Crystalline silicon (c-Si) solar cells with monofacial polysilicon-based passivated contacts (monoPoly cells) may have high parasitic absorption at near-infrared (NIR) wavelengths. In this work, we show that NIR absorption can be significantly suppressed in monoPoly cells such that it is comparable to standard reference cells.

OT3C.2 • 11:00
Rear-side dielectric passivation: Optical design considerations to fabricate higher efficiency industrial *p*-type mc-Si *PERC* solar cells, Donny J. Lai[1], Chuan Seng Tan[1], Pun Chong Ang[1], Zhi Ming Kam[1], Armin G. Aberle[1], Ying Huang[1]; [1]*SERIS, Singapore*. Higher reflectance of rear-side dielectric passivation stack, at the wavelength of the laser source used for ablation, reduces laser-induced damage and improves open-circuit voltage of the *PERC* solar cells.

OT3C.3 • 11:15
Improvement in bifaciality of Industrial *n*FAB Solar Cells by Alkaline Treatment, Ning CHEN[1], Xia Yan[2], Firdaus Bin Suhaimi[1], Lin Zhang[2], Xinxin Gong[2], Xinyu Zhang[2], Shubham Duttagupta[1]; [1]*SERIS, National Univ. of Singapore, Singapore;* [2]*Zhejiang Jinko Solar Co. Ltd., , China*. We introduced alkaline treatment for the rear side of bifacial solar cells to improve rear side optical performance. With additional alkaline treatment, rear J_{sc} of *n*FAB cells increased by ~4mA/cm^2, and over 96% bifacial factor achieved.

OT3C.4 • 11:30
Small-area p-type PERC Silicon Solar Cells for Tandem Applications, Maung Thway[1,2], Tianyuan Liu[1], Mei Huang[1], Cangming Ke[1], Xin Ren Ng[1,2], Balaji Nagarajan[1], Xia Yan[1], Shubham Duttagupta[1], Rolf Stangl[1], Soo Jin Chua[2], Armin G. Aberle[1,2], Serena Fen Lin[1]; [1]*Solar Energy Research Inst. of Singapore, Singapore;* [2]*National Univ. of Singapore, Singapore*. Due to the small area of thin-film top cell candidates, the fabrication of small-area p-type silicon passivated emitter and rear cells (PERC) is investigated by scaling down from 6-inch-wide solar cells fabricated using industrial tools.

Pisces 4

Solid-state Lighting

10:30–12:45
ST3D • Perovskite and Metal Halide Emitters
Presider: Qihua Xiong; Nanyang Technological Univ., Singapore

ST3D.1 • 10:30 Invited
Luminescent Low-Dimensional Organic Metal Halide Hybrids, Biwu Ma[1,2]; [1]*Chemistry and Biochemistry, Florida State Univ., USA;* [2]*Materials Science and Engineering Program, Florida State Univ. , USA*. In this talk, I will discuss our work on the development of photoactive organic metal halide hybrids with low dimensional structures at the molecular level, which can act as emitters for efficient light emitting diodes.

ST3D.2 • 11:00 Invited
Stability Enhancement in Perovskite Light-Emitting Materials, Zhi Kuang Tan[1]; [1]*National Univ. of Singapore, Singapore*. Perovskite semiconductors have demonstrated strong luminescence and good color performance in light-emitting devices. However, they degrade upon exposure to moisture and heat, which limits their practical application. In this talk, we will discuss several new approach towards enhancing the stability of perovskite materials, and demonstrate their application in functional devices.

ST3D.3 • 11:30
Arrays of Multi-Color Emitting Cesium Lead Halide Perovskite Nanocrystals and Efficient White Light Generation by Tailored Anion Exchange Reactions and Electrohydrodynamic Jet Printing, Yemliha Altintas[1], Ilker Torun[2], Ahmet Faruk Yazici[1], Emre Beskazak[1], Serdar Onses[2], Evren Mutlugun[1]; [1]*Abdullah Gul Univ., Turkey;* [2]*Univ., Erciyes, Turkey*. We employ highly efficient and narrow band emitter Cesium-lead-halide perovskite nanocrystals, optimized by the anion exchange method, for efficient white light generation by patterning multiple lines of different colors via proposed electrohydrodynamic jet printing.

Pisces 1

Optics and Photonics for Energy & the Environment

ET3A • Atmospheric Sensing of Clouds & Aerosols—Continued

ET3A.5 • 11:45
Detection of atmospheric boundary layer height based on the Scheimpflug Lidar technique, Mei L. Li[1], Lishan Zhang[1], Liang Mei[1]; [1]*Dalian Univ. of Technology, China.* A Scheimpflug lidar system based on the Scheimpflug principle has been developed to measure vertically the aerosol backscattering intensity, and the covariance wavelet transform (CWT) method is developed to calculate the ABL height.

ET3A.6 • 12:00
1.5 μm cloud lidars based on single photon detectors, Jiawei Qiu[1], Haiyun Xia[1], Chao Yu[1], Chong Wang[1], Xiankang Dou[1]; [1]*Univ of Science and Technology of China, China.* Two 1.5 μm cloud lidars based on single-photon detectors are demonstrated. One is a polarization lidar using a superconducting nanowire single photon detector. The other equipped a multimode fiber coupled InGaAs/InP single photon detector.

ET3A.7 • 12:15
A UAV-borne Compact Coherent Doppler Lidar for Marine Boundary Layer Wind Remote Sensing, Songhua Wu[1,2], Qichao Wang[1], Jintao Liu[1], Bingyi Liu[1,2], Kailin Zhang[1]; [1]*Ocean Univ. of China, China;* [2]*Lab for Regional Oceanography and Numerical Modeling, Qingdao National Lab for Marine Science and Technology, China.* A compact UAV-borne pulsed coherent Doppler lidar was developed for the wind in marine atmospheric boundary layer. The paper presents the lidar design and the flight campaign at Hailing Island, South China Sea in 2016.

Pisces 2

Fourier Transform Spectroscopy

FT3B • Far-IR Observatories and FTS Spectroscopy—Continued

FT3B.5 • 12:00
Excitation-Emission Fluorescence Spectroscopy with Single Molecule Sensitivity Using a Common-Path Interferometer, Antonio Perri[5,4], Fabrizio Preda[5,4], Juergen Hauer[1,2], Erling Thyrhaug[1], Stefan Krause[3], Tom Vosch[3], Giulio Cerullo[5,4], Dario Polli[5,4]; [1]*Fakultät für Chemie, Technische Universität München, Germany;* [2]*Photonics Inst., Austria;* [3]*Nanoscience Center, Denmark;* [4]*NIREOS s.r.l., Italy;* [5]*Politecnico di Milano, Italy.* We demonstrate the use of a simple and highly stable common-path interferometer based on birefringence to measure fluorescence excitation-emission maps with sensitivity down to the single molecule level via a Fourier-transform approach.

FT3B.6 • 12:15
Dual-THz-Comb Spectroscopy Using Wavelength-Multiplexed Mode-Locked Fiber Laser, Kazuki Nitta[1,2], Chen Jie[3,1], Tatsuya Mizuguchi[1,2], Guqing Hu[3,1], Zheng Zheng[3], Takeshi . Yasui[1,2]; [1]*Tokushima Univ., Japan;* [2]*JST, ERATO MINOSHIMA Intelligent Optical Synthesizer, Japan;* [3]*Beihang Univ., Japan.* We demonstrate dual-THz-comb spectroscopy using a wavelength-multiplexed mode-locked fiber laser. While greatly reducing its size, complexity, and cost, the proposed system maintains the spectroscopic performance comparable to a system equipped with dual stabilized fiber lasers.

Pisces 3

Optics in Solar Energy

OT3C • Silicon PV Technology—Continued

OT3C.5 • 11:45
Mie resonators as rearside light trapping structures in planar crystalline silicon solar cells, Alexander N. Sprafke[1,2], Michael Pollard[2], Peter Piechulla[1], Ralf B. Wehrspohn[1,3]; [1]*Inst. of Physics, Martin Luther Univ. Halle, Germany;* [2]*School of Photovoltaic and Renewable Energy Engineering, Univ. of New South Wales, Australia;* [3]*Fraunhofer IMWS, Germany.* Mie resonances of high-refractive index nanostructures provide strong and spectrally broadband scattering. In this numerical work, we investigate the feasibility of amourphous silicon nanodisks at the planar rear side of crystalline silicon solar cells for light trapping.

OT3C.6 • 12:00 Invited
Explicit Determination of the Current Loss Mechanisms in Textured Si Solar Cells, Hiroyuki Fujiwara[1]; [1]*1-1 Yanagido, Gifu Univ., Japan.* In this contribution, the explicit characterization of the current losses in the state-of-the-art textured Si solar cells based on a new and yet simple optical simulation technique will be presented.

Pisces 4

Solid-state Lighting

ST3D • Perovskite and Metal Halide Emitters—Continued

ST3D.4 • 11:45 Invited
Efficient Perovskite Light-Emitting Diodes *via* Interface and Composition Engineering, Jingbi You[1]; [1]*Inst. of Semiconductors, Chinese Academy of Sciences, China.* Perovskite materials exhibit high photoluminescence quantum yield (PLQY, greater than 90% in solution for nanocrystals) and high color purity with narrow emission line-widths less than 20 nm, which make them as a good candidate material for efficient light-emitting diodes (LEDs).

ST3D.5 • 12:15 Invited
Perovskite Light-Emitting Diodes based on Solution-Processed, Self-Organized Multiple Quantum Wells, Jianpu Wang[1]; [1]*Nanjing Tech Univ., China.* Solution-processed light-emitting diodes (LEDs) are attractive for applications in low-cost, large-area lighting sources and displays. Organometal halide perovskites can be processed from solutions at low temperatures to form crystalline direct-bandgap semiconductors with intriguing optoelectronic properties.

12:30–13:30 Lunch in Foyer, *Leo Foyer*

Pisces 1

Optics and Photonics for Energy & the Environment

13:30–15:30
ET4A • Photonics & Imaging of the Environment and Agriculture

Presider: Jean-Pierre van Helden; Leibniz Inst. for Plasma Science & Technology, Germany

ET4A.1 • 13:30 Invited

MEMS-based Imaging LIDAR, Yuzuru Takashima[1], Brandon Hellman[1], Joshua Rodriguez[1], Guanghao Chen[1], Braden Smith[1], Adley Gin[1], Alonzo Espinoza[1], Paul Winkler[1], Cameron Perl[1], Chuan Luo[1], Eunmo Kang[1], YoungSik Kim[1], Heejoo Choi[1], Dae Wook Kim[1]; [1]*Univ. of Arizona, USA.* Micro Electro Mechanical System (MEMS) is a pathway for high performance yet cost effective Time-of-Flight based LIDARs while satisfying trade-offs in performances, such as field-of-view, angular and range resolution, scanning speed and power consumption.

ET4A.2 • 14:00

Melon Recognition in UAV Images to Estimate Yield of a Breeding Process, Artium Dashuta[1,2], Iftach Klapp[1]; [1]*ARO-Volcani Center, Israel;* [2]*Electrical Eng., Tel Aviv Univercity, Israel.* We propose an algorithmic pipeline for automated yield tracking from images of a melon field captured by a drone. Gathering exact yield statistics automatically saves on an otherwise labor-intensive task.

ET4A.3 • 14:15

Feasibility studies of a dual-wavelength Mie-scattering Scheimpflug lidar for particle size measurements, Zheng Kong[1], Teng Ma[1], Liang Mei[1]; [1]*Dalian Univ. of Technology, China.* A dual-wavelength Scheimpflug lidar system has been developed for real time monitoring of atmospheric particles. Field campaigns were performed on a near-ground path in urban area of Dalian city for 6 days to study particle sizes.

ET4A.4 • 14:30

Segmentation of macrophomina in aerial imagery of a cotton field, Omer Sapir[1,3], Iftach Klapp[1], Ariela Niv[2], Michal Axelrod[2], Nir Sochen[3]; [1]*ARO-Volcani Center, Israel;* [2]*The Israel Cotton Board Ltd, Israel;* [3]*Applied Math, Tel Aviv Univercity, Israel.* A novel algorithm combining sparse dictionary learning with variational method segmentation enables recognizing outbursts of macrophomina in cotton field images taken from a drone.

Pisces 2

Fourier Transform Spectroscopy

13:30–15:30
FT4B • Comb-based and Other Spectroscopic Applications

Presider: Scott Paine; Harvard-Smithsonian Ctr for Astrophysics, USA

FT4B.1 • 13:30 Invited

Multi-comb technique for metrological applications with coherent control of optical pulse train, Kaoru Minoshima[1,2], Akifumi Asahara[1,2]; [1]*1-5-1 Chofugaoka, Univ. of Electro-Communications, Japan;* [2] *JST, ERATO MINOSHIMA Intelligent Optical Synthesizer (IOS), Japan.* Tailoring relative carrier envelope phase and repetition frequency in the multi-comb source were utilized for versatile coherent control of optical pulse train. Rapid polarization-modulated pulse train and optical vortex comb were experimentally demonstrated.

FT4B.2 • 14:00

An Ultrafast Electro-Optic Dual Comb for Linear and Nonlinear Spectroscopy, David Carlson[1], Daniel Hickstein[1], Scott A. Diddams[1,2], Scott Papp[1,2]; [1]*NIST, USA;* [2]*Univ. of Colorado, USA.* We report on 10-GHz electro-optic frequency-comb technology with broad bandwidth enabled by nanophotonic supercontinuum. We demonstrate high-speed, dual-comb linear spectroscopy on various gases and coherent anti-Stokes Raman spectroscopy on various solids.

FT4B.3 • 14:15

Open-Path Dual Frequency Comb Spectroscopy Applied to Source Quantification, Eleanor Waxman[1], Kevin Cossel[1], Fabrizio Giorgetta[1], Eli Hoenig[1], Gar-Wing Truong[1], Wiliam Swann[1], Ian R. Coddington[1], Nathan R. Newbury[1]; [1]*NIST, USA.* We combine a guassian plume model with dual-comb spectrometer (DCS) data to quantify both a localized leak, by measuring to a flying retroreflector, and distributed traffic carbon emissions, by differential path measurements over a city.

FT4B.4 • 14:30 Invited

Massively parallel sensing of trace molecules and their isotopologues with broadband subharmonic mid-infrared frequency combs, Konstantin L. Vodopyanov[1]; [1]*Univ. of Central Florida, CREOL, USA.* We use a pair of highly-coherent GaAs subharmonic OPOs with instantaneous span 3.1-5.5 µm to demonstrate fast acquisition of 350,000 mode-resolved spectral data points and perform parallel detection in a mixture of 22 molecular species.

Pisces 3

Optics in Solar Energy

13:30–15:30
OT4C • Nano-Structures for Solar Cells

Presider: Peter Bermel; Purdue Univ., USA

OT4C.1 • 13:30 Invited

Bringing Light to Solar Absorbers: Nano- and Microoptical Concepts for Chalcopyrites and Beyond, Martina Schmid[1,2], Phillip Manley[2], Guanchao Yin[2]; [1]*Universität Duisburg-Essen, Germany;* [2]*Helmholtz-Zentrum Berlin, Germany.* The improved incoupling of light to solar absorbers is shown via the examples of light concentration on Cu(In,Ga)Se_2 micro cells, SiO_2 nanoparticles underneath ultrathin Cu(In,Ga)Se_2 and TiO_2 nanostructures on top of silicon photoelectrodes.

OT4C.2 • 14:00 Invited

Resonant and non-resonant absorption and scattering of light in III-V semiconductor nanowire arrays, Nicklas Anttu[1]; [1]*Dept. of Electronics and Nanoengineering, Aalto Univ., Finland.* III-V semiconductor nanowire arrays show promise for both single-junction and tandem solar cells. We discuss how resonant and non-resonant optical effects can be used for designing and optimizing the performance in such applications.

OT4C.3 • 14:30

Interface Modification in Type-II ZnCdSe/Zn(Cd)Te QDs for High Efficiency Intermediate Band Solar Cells, Vasilios Deligiannakis[1,3], Siddharth Dhomkar[1], Marcel Claro[1], Igor L. Kuskovsky[4,3], Maria Tamargo[1,2]; [1]*The City College of New York, USA;* [2]*The Graduate Center of the City Univ. of New York, USA;* [3]*The Graduate Center of the City Univ. of New York, USA;* [4]*Physics, Queens College, CUNY, USA.* A new growth sequence of ZnCdSe/Zn(Cd)Te QDs is developed, so to avoid formation of a parasitic strain inducing ZnSe interfacial layer. This allows for simplified intermediate band solar cell device that yields higher quality material.

Pisces 4

Solid-state Lighting

13:30–15:45
ST4D • VCELs and Other Lasers

Presider: Caroline Murawski; Univ. of St. Andrews, UK

ST4D.1 • 13:30 Invited

An emerging field of nanocrystal optoelectronics: all-colloidal nanocrystal lasers of quantum dots to wells, Vino Prabakaran[1]; [1]*NTU Singapore , Singapore.* Solution-processed semiconductor nanocrystals have attracted great interest in photonics including color conversion and enrichment in quality lighting and display backlighting. Optical properties of these colloidal nanocrystals can be conveniently controlled by tailoring their shape, composition, and size in an effort to realize high-performance light generation and lasing.

ST4D.2 • 14:00

Spherical Approximation for combination of Mechanical Deformation & Optical Path Difference thermal lenses in Nd: YAG slab amplifier, ehsan tanhaee[1,3], Mohamad Mahdi Majidof[1,4], Seyed Hassan Nabavi[2], Farshad Abedzade[1], Mohana Najafy[1], Seyedsasan Seyedzamani[5]; [1]*Iranian National Center for Laser Scienc, Iran;* [2]*Nano Lab, Tarbiat Modares Univ., Iran;* [3]*Photonic Dept., Nano Lab, Tehtan Univ., Iran;* [4]*Shahidbeheshti Univ., Iran;* [5]*Elmosanat Univ., Iran.* We pave the way for preconception of thermal lens by amalgamation of Mechanical Deformation and Optical Path Difference via Spherical Approximation with analytical and experimental results at Nd:YAG slab amplifier up to 420W pump power.

ST4D.3 • 14:15 Invited

Carrier Dynamics and Lasing with Colloidal Quantum Wells, Matthew A. Pelton[1]; [1]*Univ. of Maryland, Baltimore County, USA.* The dynamics of carriers in colloidal semiconductor nanocrystals are central to their applicability in light-emitting devices and lasers. Semiconductor nanoplatelets, or colloidal quantum wells, support unique and promising carrier dynamics, particularly reduced Auger recombination.

Pisces 1

Optics and Photonics for Energy & the Environment

ET4A • Photonics & Imaging of the Environment and Agriculture—Continued

ET4A.5 • 14:45
Towards, Multi-purpose system for spatial and hyperspectral sampling of crop from a moving platform, Or Arad[1,2], Iftach Klapp[1]; [1]*ARO-Volcani Center, Israel;* [2]*Electro-Optics Eng., Ben Gurion Univ., Israel.* We present a design of a low cost hyperspectral imaging system based on Risley prism LOS steering, demonstrating the system's performances and limitations. Results show spatial resolution ~5 times higher than standard aerial survey.

ET4A.6 • 15:00 Invited
Produce Sorting by NIR Spectrometry, Zeev Schmilovitch[1]; [1]*Agricultural Research Organization, Israel.* The objective of the present study is to evaluate the feasibility of implanting NIR mini-spectrometers in the commercial sorting line manufactured by Eshet Eilon (Israel), and to develop the suitable NIR module.

Pisces 2

Fourier Transform Spectroscopy

FT4B • Comb-based and Other Spectroscopic Applications—Continued

FT4B.5 • 15:00
A FTS system for on-line analysis of the raw materials of cement, Rong Hu[1], Xu liang[2], Wenqing Liu[2], Jianguo Liu[2], ling jin[2], Weifeng Yang[2], Yuhao Wang[1]; [1]*Univ. of Science and Technology of China, China;* [2]*Key Lab of Environment Optics and Technology, Anhui Inst. of Optics and Fine Mechanics, Chinese Academy of Sciences, China.* We describe a Fourier Transform Spectroscopy (FTS) system for on-line analysis of the raw materials of cement to determine five key oxides in the cement samples.

FT4B.6 • 15:15
Design rules for birefringent lateral shearing interferometers, Yann Ferrec[1], Hervé Sauer[2], Armande Pola Fossi[1], Nicolas Guérineau[1]; [1]*Office Natl d'Etudes Rech Aerospatiales, France;* [2]*Laboratoire Charles Fabry, Institut d'Optique Graduate School, France.* Birefringent lateral shearing interferometers may be key elements for compact *high étendue* imaging static FTS. We developed a tool to simulate propagation in a stack of birefringent plates, and established design rules for such interferometers.

Pisces 3

Optics in Solar Energy

OT4C • Nano-Structures for Solar Cells—Continued

OT4C.4 • 14:45
Engineering Efficient, Broadband Upconversion Core/Rod/Emitter Semiconductor Nanostructures, Eric Y. Chen[1], Jill M. Cleveland[1], Christopher C. Milleville[1], Kyle R. Lennon[1], Jing Zhang[1], James Bork[1], Joshua M. Zide[1], Matthew F. Doty[1]; [1]*Univ. of Delaware, USA.* We characterize upconversion (UC) photoluminescence (PL) in semiconductor quantum dot/rod/emitter nanostructures using one- and two-color cw excitation. We engineer improvements in UC quantum efficiency to 3% of the PL emission efficiency.

OT4C.5 • 15:00 Invited
IR-Emitting quantum dots for luminescent solar concentrators, Zhi Kuang Tan[1]; [1]*National Univ. of Singapore, Singapore.* Luminescent solar concentrator (LSC) is a promising technology for building-integrated photovoltaics. This talk will cover the synthetic methodology of heavy-metal free IR emitting quantum dots, specifically designed for LSC applications. The new quantum dots possess broad absorption across the entire visible spectrum, and emits in the IR, making then neutral colored and useful for solar windows.

Pisces 4

Solid-state Lighting

ST4D • VCELs and Other Lasers—Continued

ST4D.4 • 14:45
Effect of enhanced Rayleigh scattering on the random fiber laser efficiency, Can Yao[1], Camille Bres[1], Luc Thévenaz[1]; [1]*Ecole Polytechnique Federale de Lausanne, Switzerland.* The effect of Rayleigh scattering enhancement in an optical fiber on the random fiber laser efficiency is investigated, and the effect of different corresponding fiber loss is also studied.

ST4D.5 • 15:00 Invited
Robust Organic Emitters as Gain Media for Organic Lasers, Wen-Young Lai[1]; [1]*Nanjing Univ. of Posts and Telecommunications, China.* Organic semiconductors have found various applications in optoelectronic devices, such as organic light-emitting diodes (OLEDs), organic field-effect transistors (OFETs) and organic photovoltaic cells (OPVs).

ST4D.6 • 15:30
Non-destructive Photo-modulated Reflectance Study of GaInAsSb-based VCSEL, Grace M. Chai[1], Jeff Hosea[2], Natasha Fox[2], Konstanze Hild[2], A. B. Ikyo[2], M. C Amann[3], S. J. Sweeney[2]; [1]*Univ. of Southampton, Malaysia, Malaysia;* [2]*Advanced Technology Inst., Univ. of Surrey, UK;* [3]*Walter Schottky Institut, Germany.* Temperature dependent photoreflectance on 2.3μm GaInAsSb-based vertical cavity surface emitting laser (VCSEL) structures were performed and show that the room temperature quantum well-cavity mode energy offset is 21meV; thermally-tuning into resonance at 220±2K.

15:30–16:00 Coffee Break/Exhibits, *Leo Foyer*

Pisces 1

Optics and Photonics for Energy & the Environment

16:00–18:00
ET5A • Industrial Monitoring II: Environmental Sensing
Presider: Lucile Rutkowski; Inst. of Physics of Rennes, France

ET5A.1 • 16:00 Invited

Multispecies DIAL remote gas detection using nested cavity optical parametric oscillators, Julie Armougom[1], Thomas Hamoudi[1], Jean-Baptiste Dherbecourt[1], Jean-Michel Melkonian[1], Antoine Godard[1], Myriam Raybaut[1]; [1]*DPHY, Onera, The French Aerospace Lab, France.* Multispecies remote gas detection is of prime interest for environmental monitoring to security applications. We present here widely-tunable optical parametric sources, based on specific amplified nested-cavity optical parametric oscillator architectures, implemented for multispecies DIAL.

ET5A.2 • 16:30

QCL Absorption Spectroscopy for Lightweight and Multi–Species Environmental Applications, Lukas Emmenegger[1], Badrudin Stanicki[1], Manuel Graf[1], Philipp Scheidegger[1], Morten Hundt[1], Jerome Faist[2], Filippos Kapsalidis[2], Herbert Looser[1], Mehran Shahmohammadi[2], Béla Tuzson[1]; [1]*EMPA, Switzerland;* [2]*ETHZ, Switzerland.* MIR spectroscopy using QCLs allows sensitive, selective, and fast detection of trace-gases. Recent developments, including dual-wavelength QCLs and segmented circular optical cells, create tantalizing options for drone-based and multi-species environmental analysis.

ET5A.3 • 16:45 Invited

Laser spectroscopy for the monitoring of radioactive emissions from nuclear facilities, Guillaume Genoud[1]; [1]*MIKES Metrology, VTT Technical Research Centre of Finland Ltd., Finland.* Mid-infrared cavity ring-down spectroscopy is applied to the detection of long-lived radioisotopes. A high sensitivity is achieved while providing on-line measurement capabilities, which is not possible with currently used techniques such as liquid scintillation counting. Examples related to the detection of radiocarbon will be presented, as it is one of the main sources of radioactive gas emissions in nuclear facilities, where it can be released in the form of carbon dioxide or methane.

Pisces 2

Fourier Transform Spectroscopy

16:00–18:00
FT5B • Measurements of the Earth's Atmosphere: Satellite and Ground-based Systems
Presider: Isamu Morino; NIES, Japan

FT5B.1 • 16:00 Invited

The Tropospheric Emission Spectrometer: From Discovery Mission to Earth System Sounding, Kevin W. Bowman[1,2]; [1]*Jet Propulsion Lab, USA;* [2]*Joint Inst. for Regional Earth System Science and Engineering, Univ. of California, Los Angeles, USA.* The Tropospheric Emission Spectrometer (TES) was launched in 2004 and decommissioned in February 2018. We show how TES measurements have altered our understanding of atmospheric composition and its relationship to the Earth System.

FT5B.2 • 16:30

Investigating N_2O produced in the mesosphere – lower thermosphere and its transport to the middle atmosphere, Patrick E. Sheese[1], Kaley A. Walker[1], Chris D. Boone[2], Monika Andersson[3], Daniel Marsh[4], Christopher Kelly[5], Wuhu Feng[5], Martyn Chipperfield[5], John Plane[5]; [1]*Univ. of Toronto, Canada;* [2]*Univ. of Waterloo, Canada;* [3]*Finnish Meteorological Inst., Finland;* [4]*National Center for Atmospheric Research, USA;* [5]*Univ. of Leeds, UK.* This paper will describe Atmospheric Chemistry – Experiment Fourier Transform Spectrometer (ACE-FTS) N_2O measurements in the middle atmosphere along with its production mechanisms and long-term variation. Comparisons with model N_2O simulations will also be discussed.

FT5B.3 • 16:45

An Application of Extractive FTIR for Monitoring Greenhouse Gas Emissions, Chuling Deng[1,2], Jingjing Tong[1], Minguang Gao[1], Xiangxian Li[1], Yan Li[1], Jianguo Shi[1], Yueqin Li[1]; [1]*Key Lab of Environmental Optics and Technology, Anhui Inst. of Optics and Fine Mechanics, China;* [2]*Univ. of Science and Technology of China, China.* The greenhouse gas emissions CO_2,CH_4,along with the pollutant CO were continually monitored with extractive FTIR.The results show that extractive FTIR is a direct,reliable and effective method of greenhouse gas monitoring.

FT5B.4 • 17:00 Invited

IASI satellite observations: best-of 2017-2018, Sarah Safieddine[1], Cathy Clerbaux[1], Anne Boynard[1], Maya George[1], Juliette Hadji-Lazaro[1], Viatte Camille[1], Lieven Clarisse[2], Martin Van Damme[2], Pierre-Francois Coheur[2]; [1]*LATMOS-IPSL, Paris, France;* [2]*ULB, Belgium.* This talk presents the latest results of the IASI instruments: we talk about what can be achieved in terms of ollutants monitoring, such as ozone, carbon monoxide, ammonia, sulfur dioxide, and we show the skin temperature product and the urban heat islands detected by IASI.

Pisces 3

Optics in Solar Energy

16:00–17:45
OT5C • Theory and Modeling
Presider: Alexander Sprafke; Martin-Luther Univ. Halle, Germany

OT5C.1 • 16:00 Invited

Using Machine Learning to Rapidly Diagnose the Root Causes of Underperformance in Early-Stage Solar Cells, Tonio Buonassisi[1]; [1]*Singapore-MIT Alliance for Research & Technology, Singapore.* We use Bayesian inference in combination with rapid non-destructive current-voltage testing to infer performance-limiting bulk and interface properties in early-stage solar cell devices, directing our process-optimization bandwidth more efficiently.

OT5C.2 • 16:30

Rigorous Wave-Optical Simulation of Photon Recycling in Nanostructured Perovskite Solar Cells, Stefan Nanz[1], Raphael Schmager[1], Aimi Abass[1], Muluneh Abebe[1], Guillaume Gomard[1], Ulrich W. Paetzold[1], Carsten Rockstuhl[1]; [1]*Karlsruhe Inst. of Technology, Germany.* We present a rigorous optical simulation of photon recycling in a nanostructured perovskite layer stack resembling a solar cell. Relevant emission characteristics such as the fraction of recycled light and far-field angular spectrum are deduced.

OT5C.3 • 16:45

Distinguishing Fabry-Perot from guided resonances in thin periodically-textured silicon absorber., Hamed Ahmadpanahi[1], Robin Vismara[1], Olindo Isabella[1], Miro Zeman[1]; [1]*TUDelft, Netherlands.* Total electric field in a periodic thin-film structure is described by its Fourier coefficients. These coefficients can be used to calculate the share of different resonances in total absorption in the structure.

OT5C.4 • 17:00

3D Numerical Analysis of Enhanced Localized Surface Plasmon Resonance via AuNPs/ZnONRs Hybrid Structure, So Yun Lee[1], Jae Ryoun Youn[1], Young Seok Song[2]; [1]*Seoul National Univ., South Korea;* [2]*Dankook Univ., South Korea.* Enhanced localized surface plasmon resonance (LSPR) is investigated by utilizing AuNPs/ZnONRs hybrid nanostructure. The structure is selected based on the numerical prediction which confirms the synergistic effects of AuNPs/ZnONRs for enhancing LSPR-induced photophysical processes.

Pisces 4

Solid-state Lighting

16:00–17:30
ST5D • LED Design, Applications, and Testing
Presider: Zhi Kuang Tan; National Univ. of Singapore, Singapore

ST5D.1 • 16:00 Invited

New Applications of Organic LEDs in Biophotonics, Caroline Murawski[2,1], Andreas Mischok[1], Changmin Keum[1], Dinesh Kumar[1], Stefan R. Pulver[1], Malte C. Gather[1]; [1]*Univ. of St Andrews, UK;* [2]*Kurt Schwabe Inst., Germany.* Here, we demonstrate the successful application of organic light-emitting diodes in optogenetics to control neurons in fruit fly larvae and explore their further use as a light source in fluorescence microscopy.

ST5D.2 • 16:30

Dynamic Photometric System for Solid State Lighting to Preserve the Dark Sky, Rohan Nag[1,2]; [1]*Lighting Application Design, Regent Lighting, India;* [2]*Lighting Application Design, GE Lighting, India.* Inability of meeting dark-sky compliance with the use of a static photometry system in lighting fixtures demands the development and use of a dynamic photometric system which can switch between predefined and transitional photometry

ST5D.3 • 16:45

LED-based Extended White Light Source to Reduce the Heating Effect on YAG:Ce^{+3} Phosphor, Atul K. Dubey[1], Mayank Gupta[1], Virendra Kumar[1], Dalip S. Mehta[1]; [1]*IIT Delhi, India.* We report an extended white light source containing a small cylindrical acrylic diffuser coated with YAG:Ce^{+3} phosphor and excited by blue LED. This design supports remote phosphor coating technique to prevent quenching of YAG:Ce^{+3}.

ST5D.4 • 17:00

Colloidal Quantum Dot White LEDs, Devanshi Arora[1]; [1]*ECE, SRM IST, India.* ColloidalQDs have highQY&tunable electronic prop,used for efficient solidstate lightsources:host material effect supress-liquidstate integration in LEDs. Max QY(RG) emit QDs optimize synth.parameter&integrated efficient QDs-QY:blueLED die in liq.&integration-2&6fold~incorp.QDs in$(C_2H_6OSi)_n$film&cpp.

Pisces 1

Optics and Photonics for Energy & the Environment

ET5A • Industrial Monitoring II: Environmental Sensing—Continued

ET5A.4 • 17:15
On-line Monitoring of Heavy Metals in Industrial Wastewater by Laser Induced Breakdown Spectroscopy, Nan J. Zhao[1]; [1]*Key Lab of Environmental Optics and Technology, Anhui Inst of Optics Fine Mechanics,Chinese Academy of Sciences, China.* A method of heavy metals determination in industrial wastewater based on laser induced breakdown spectroscopy technique was studied, the on-line system with graphite enrichment automatically and plasma spatial confinement detection were developed and field applied.

ET5A.5 • 17:30
Planar Bragg Grating Sensor for the Detection of CFC-11, Maiko Girschikofsky[1], Dimitrij Ryvlin[2], Siegfried R. Waldvogel[2], Ralf Hellmann[1]; [1]*Applied Laser and Photonics Group, Univ. of Applied Sciences Aschaffenburg, Germany;* [2]*Inst. of Organic Chemistry, Johannes Gutenberg Univ. Mainz, Germany.* We demonstrate the fabrication of a highly sensitive opto-chemical sensor system based on cyclodextrin derivative functionalized planar Bragg gratings for an online in-situ detection and measurement of the environmentally harmful propellant trichlorofluoromethane in real-time.

ET5A.6 • 17:45
Application of FBG sensors in tokamak tungsten divertor component for strain and temperature monitoring, Xingli Wang[1,2], Wanjing Wang[1], Qiang Li[1], Chunyi Xie[1], Guang-Nan Luo[1,2]; [1]*Inst. of Plasma Physics, Chinese Academy of Science, China;* [2]*Science Island Branch of Graduate School, Univ. of Science & Technology of China, China.* FBG has been applied to fusion field and used to monitor surface strain and temperature of tokamak tungsten divertor component under baking and high heat flux tests, respectively. This is a summary of the works.

Pisces 2

Fourier Transform Spectroscopy

FT5B • Measurements of the Earth's Atmosphere: Satellite and Ground-based Systems—Continued

FT5B.5 • 17:30
Open-Path Fourier Transform Infrared (OP-FTIR) Spectroscopic Measurements of Atmospheric Composition, Aldona Wiacek[1], Taylor Gray[1], Morgan Mitchell[1], Cameron Power[1], Ian Ashpole[1]; [1]*Environmental Science, Saint Mary's Univ., Canada.* We describe the deployment of an OP-FTIR spectrometer over a very long atmospheric path (550 m one-way), highlighting some challenges and technical solutions under these measurement conditions, which are representative of newest satellite footprints.

FT5B.6 • 17:45
A new method to estimate emission strength for point source with Onboard Solar Occultation Flux–Fourier Transform Infrared Spectroscopy System, Xin Han[1], Xiangxian Li[1], Minguang Gao[1], Jingjing Tong[1], Jun Chen[1], Chuling Deng[1]; [1]*Anhui Inst. of Optics and Fine Mechanics, Chinese Academy of Scie nces, China.* A novel method that combines the FTIR-SOF with Gaussian dispersion model is developed for estimate the emission strength of pollutant gases, mainly volatile organic compounds(VOCs) from point sources in industry plants.

Pisces 3

Optics in Solar Energy

OT5C • Theory and Modeling—Continued

OT5C.5 • 17:15
Light management with sinusoidal nanotextures, Klaus Jaeger[1,2], Phillip Manley[1,2], David Eisenhauer[1], Philipp Tockhorn[1], Johannes Sutter[1], Martin Hammerschmidt[2], Sven Burger[2], Steve Albrecht[1], Christiane Becker[1]; [1]*Helmholtz-Zentrum Berlin für Materialien und Energie, Germany;* [2]*Zuse Inst. Berlin, Germany.* Nanoimprint lithography can be used to fabricate sinusoidal nanotextures on a large scale. We present optical and numerical results for sinusoidal nanotextures in two types of solar cells: thin film c-Si and perovskite-silicon tandem solar cells.

OT5C.6 • 17:30
Optimal Two-Dimensional Bravais Lattice for Wavelength-Scale Photon Management in Solar Cells, Ken Xingze Wang[1]; [1]*Huazhong Univ of Science and Technology, China.* Many photon management techniques use the square lattice in solar cells. With theory and simulations, we demonstrate the optimality of the triangular lattice among all Bravais lattices for antireflection, light trapping, and open-circuit voltage enhancement.

Pisces 4

Solid-state Lighting

ST5D • LED Design, Applications, and Testing—Continued

ST5D.5 • 17:15
Micro-photoluminiscence Measurements and Analysis of Low Efficiency in Green Light-Emitting Diodes, Sang Youp Yim[1]; [1]*Gwangju Inst. of Science &Technology, South Korea.* Light-emitting diodes suffer low efficiency in the green region, a phenomenon known as the green gap. We performed micro-photoluminescence measurements and analysis of the carrier generation/annihilation mechanism which give insight into the green gap problem.

18:00–19:30 Conference Reception, *Leo 3&4*

08:30–10:00
JW1A • Keynote II
Presider: Qihua Xiong, Nanyang Technological University, Singapore

JW1A.1 • 08:30 Keynote
HITRAN2016 and Beyond: Reference Molecular Spectroscopy in the XXI Century, Iouli Gordon[1], Laurence Rothman[1], Roman Kochanov[1], Yan Tan[1], Christian Hill[2]; [1]*Harvard-Smithsonian Center for Astrophysics, USA;* [2]*IAEA, Austria.* The most recent edition of the HITRAN spectroscopic database (HITRAN2016) will be presented at the meeting including new and improved data, structure, efficient web interface at www.hitran.org, and the HITRAN Application Programming Interface (HAPI).

JW1A.2 • 09:00 Keynote
Recent Advances in Flexible Electronics, Wei Huang[1]; [1]*Shaanxi Inst. of Flexible Electronic, Northwestern Polytechnic Univ., China.* In the past decades, organic optoelectronics has made great progress both in fundamental studies and commercial applications because of their excellent properties, such as solution processable, printable, flexible, low-cost and able to be made at large area. Our recent work is devoted to the development of high-performance organic semiconductors for optoelectronics. We will present our recent advancement on rational molecular design of organic semiconductors for light-emitting diodes, lasers, memories, chemo-/biosensors, and latest research results about ultralong organic phosphorescence, light-emitting perovskite and color display technologies.

JW1A.3 • 09:30 Keynote
Advances and Advantages of the Fourier Transform Spectometer (FTS) for infrared remote sensing in support of Numerical Weather Prediction (NWP) and establishing a longterm record of climate trends, Henry E. Revercomb[1]; [1]*Univ. of Wisconsin-Madison, USA.* For global observing systems that require a significant number of individual spacecraft and sensors, it is highly advantageous to have observations that are sensor independent with respect to spectral properties and instrument responsivity. FTS sensors are especially well suited to achieving this goal.

10:00–10:30 Coffee Break/Exhibits, *Leo Foyer*

Room 1

Optics and Photonics for Energy & the Environment

10:30–12:30
EW2A • New Techniques for Sensing the Environment
Presider: Lukas Emmenegger; EMPA, Switzerland

EW2A.1 • 10:30 Invited
Photonics, Sperm and the Environment, Miriam C. Simpson[1,2]; [1]*Photon Factory, Univ. of Auckland, New Zealand;* [2]*The Dodd Walls Centre for Photonic and Quantum Technologies, New Zealand.* Our research in laser-driven sorting of sperm by sex is being commercialised through spin-out Engender Technologies. It may not be obvious, but this photonic technology will deliver significant environmental benefits, as well as economic ones.

EW2A.2 • 11:00
A White Random Laser: A First Step Towards Angle-free Laser Illumination, Yu-Ming Liao[1], Wei-Cheng Liao[1], Shu-Wei Chang[1], Cheng-Fu Hou[2], Chia-Tse Tai[1], Min-Hsuan Wu[1], Yun-Tzu Hsu[1], Rou-Jun Chou[1], Tai-Yuan Lin[2], Yang-Fang Chen[1]; [1]*Physics, National Taiwan Univ., Taiwan;* [2]*Inst. of Optoelectronic Sciences, National Taiwan Univ., Taiwan.* The hope of next-generation illuminants goes on random laser. Random laser is naturally endowed with two key superiorities, namely, laser-level intensity and broad-angular emissions, which are mutually exclusive in thermal light sources, light-emitting-diodes, and lasers.

Room 2

Fourier Transform Spectroscopy

10:30–12:30
FW2B • Satellite Measurements of the Earth's Atmosphere: Instrumentation and Calibration Techniques
Presider: Kaley Walker; Univ. of Toronto, Canada

FW2B.1 • 10:30 Invited
Geostationary Interferometric Infrared Sounder (GIIRS) for Chinese Meteorological Satellites (FY-4A and beyond), Lei Ding[1,2], Jianwen Hua[1,2], Changpei Han[1,2], Liwei Sun[1,2], Zhanhu Wang[1,2], Xiangyang Li[1,2]; [1] *Shanghai Inst of Technical Physics CAS, China;* [2]*Key Lab of Infrared System Detection and Imaging Technology, CAS, China.* The first high-spectral-resolution advanced IR sounder on board a geostationary weather satellite, FY-4's GIIRS, is mentioned. The specification, design and performance of this payload are introduced while the upcoming features of the next one are shown here.

FW2B.2 • 11:00 Invited
FTS and FTS-2 Onboard Japanese GOSAT Earth Observation Satellite Series, Tsuneo Matsunaga[1], Isamu Morino[1], Yukio Yoshida[1], Makoto Saito[1], Hibiki Noda[1], Hirofumi Oyama[1], Akihide Kamei[1], Fumie Kawazoe[1], Shamil Maksyutov[1], Tatsuya Yokota[1], Akihiko Kuze[2], Hiroshi Suto[2], Masakatsu Nakajima[2], Ryoichi Imasu[3]; [1]*National Inst for Environmental Studies, Japan;* [2]*JAXA, Japan;* [3]*The Univ. of Tokyo, Japan.* Greenhouse gases Observing SATellite (GOSAT) and its successor, GOSAT-2, are Japanese earth observation satellites for greenhouse gas measurement from space using Fourier transform spectrometers. Instrument specifications, together with GOSAT achievements and GOSAT-2 expectations, will be introduced.

Room 3

Hyperspectral Imaging and Sounding of the Environment

10:30–12:00
HW2C • Radiative Transfer and Hyperspectral Sensing
Presider: Ping Yang; Texas A&M Univ., USA

HW2C.1 • 10:30 Invited
Solar Irradiance Variability: Current Understanding from Observations and Future Directions for Model Improvements, Odele M. Coddington[1], Judith Lean[2], Peter Pilewskie[1], Martin Snow[1], Greg Kopp[1], Erik Richard[1], Tom Woods[1], Matthew DeLand[3], Sergey Marchenko[3]; [1]*LASP/Univ. of Colorado Boulder, USA;* [2]*Naval Reseach Lab, USA;* [3]*Science Systems and Applications, Inc., USA.* We describe spectral and time-dependent variations in solar irradiance, discuss their implications for Earth science, and summarize ongoing work in developing the next generation of observationally-consistent models of solar irradiance variability.

HW2C.2 • 11:00
A Fast Hyperspectral Radiative Transfer Model, Jiachen Ding[1], Ping Yang[1], Michael King[3,1], Steven Platnick[2], Kerry G. Meyer[2]; [1]*Texas A&M Univ., USA;* [2]*NASA Goddard Space Flight Center, USA;* [3]*Univ. of Colorado, USA.* A fast hyperspectral radiative transfer model is developed for applications to hyperspectral atmospheric and oceanic remote sensing in the UV-NIR regime. Gaseous absorption and multiple scattering with full polarization are considered in the model.

Room 4

Solid-state Lighting

10:30–11:30
SW2D • Advanced Design, Measurement, and Fabrication
Presider: Matthew Pelton; Univ. of Maryland, Baltimore County, USA

SW2D.1 • 10:30
Highly performant organic top-emitting light-emitting diodes (OLEDs) by solution process, Yolande Murat[1], Hannes Lüder[1], Martina Gerken[1]; [1]*Integrated Systems and Photonics, Faculty of Engineering, Germany.* This works aims to develop an inverted top-emitting solution-processed OLED. The early results obtained are promising to achieve similar efficiencies than bottom-emitting solution-processed OLED structures.

SW2D.2 • 10:45
Temperature Dependence of Raman Linewidth on Wide Bandgap Semiconductor GaN by Micro-Raman Imaging and *Ab-initio* Calculations in High-temperatures, Jun Suda[1]; [1]*Chukyo Univ., Japan.* Raman images of GaN have been measured by Micro-Raman Spectroscopy from RT up to 573K. We have evaluated the line broadening of E_2 mode in GaN in high temperatures by *Ab-initio* calculations.

SW2D.3 • 11:00
Third-order nonlinearity by the plasmon-induced inverse Faraday effect, Chol-Song Ri[1], Song-Jin Im[1], Ji-Song Pae[1], Kum-Song Ho[1], Joachim Herrmann[2]; [1]*Kim Il-Sung Univ., North Korea;* [2]*Max-Born-Inst. for Nonlinear Optics and Short Pulse Spectroscopy, Germany.* We theoretically predict a new type of third-order nonlinearity of surface plasmon polaritons by the plasmon-induced inverse Faraday effect in planar magnetoplasmonic structures.

Pisces 1

Optics and Photonics for Energy & the Environment

EW2A • New Techniques for Sensing the Environment—Continued

EW2A.3 • 11:15
Pulsed laser Q-switched by graphene on silicon waveguide and ultra-low self-start threshold power realization, Shaodong Hou[1], Guoqin Liu[1], Jinyan Li[1], Luyun Yang[1], Haiqing Li[1], Jinggang Peng[1], Nengli Dai[1], Yi Wang[1]; [1]*Huazhong Univ of Science and Technology, China.* A pulsed fiber laser Q-switched by graphene laying on silicon waveguide is firstly demonstrated. Patterned transfer technology is firstly utilized for pulsed lasing. The power triggering saturable absorption is calculated to be as low as 0.11mW.

EW2A.4 • 11:30 Invited
Trace Gas Spectroscopy on a Chip with Mid-Infrared Photonic Waveguides, Jana Jagerská[1], Marek Vlk[1], Vinita Mittal[2], Senthil Murugan Ganapathy[2]; [1]*Physics and Technology, UiT The Arctic Univ. of Norway, Norway;* [2]*ORC, Univ. of Southampton, UK.* Mid-infrared (MIR) laser absorption spectroscopy in combination with specially designed photonic waveguides and on-chip pre-concentraiton can realize sensitive and selective trace gas sensors with detection limits in ppb range.

EW2A.5 • 12:00
Mid-infrared Spectroscopy Using Supercontinuum Sources: Towards Field Applications, Amir Khodabakhsh[1], Qing Pan[1], Khalil Eslami Jahromi[1], Frans J. M. Harren[1]; [1]*Dept. of Molecular and Laser Physics, Radboud Univ., Netherlands.* We present our recent results in the development of mid-infrared spectroscopy systems based on supercontinuum sources for two different field applications: airborne monitoring of atmospheric pollutants and field quality control of agricultural products.

EW2A.6 • 12:15
Interband Cascade Laser-based Dual-Comb Spectroscopy for Methane Sensing, Jonas Westberg[1], Lukasz A. Sterczewski[1,2], Mahmood Bagheri[2], Clifford Frez[2], Igor Vurgaftman[3], Chadwick L. Canedy[3], William Bewley[3], Charles D. Merritt[3], Chul Soo Kim[3], Mijin Kim[4], Jerry R. Meyer[3], Gerard Wysocki[1]; [1]*Dept. of Electrical Engineering, Princeton Univ., USA;* [2]*Jet Propulsion Lab, USA;* [3]*Naval Research Lab, USA;* [4]*KeyW Corp, USA.* We demonstrate methane and hydrogen chloride measurements around 3.6 µm using dual-comb spectroscopy with free running interband cascade laser frequency combs and a 76 m astigmatic Herriott multipass cell.

Pisces 2

Fourier Transform Spectroscopy

FW2B • Satellite Measurements of the Earth's Atmosphere: Instrumentation and Calibration Techniques—Continued

FW2B.3 • 11:30 Invited
An Analysis and Correction of Polarization Induced Calibration Errors for the Cross-track Infrared Sounder (CrIS) Sensor, Joe Taylor[1], Henry E. Revercomb[1], David Tobin[1]; [1]*Space Science and Engineering Center, Univ. of Wisconsin-Madison, USA.* A model of the potential polarization induced calibration bias is presented for the CrIS instrument, along with details of the model parameter determination, and the predicted impact of the correction on the calibrated radiances.

FW2B.4 • 12:00 Invited
A Highly Accurate Correction for Self Apodization Effects on Fourier Transform Spectrometer Spectra, Jonathan Gero[1], Henry Revercomb[1], David Tobin[1], Robert Knuteson[1], Joe Taylor[1]; [1]*1225 W. Dayton St., Univ. of Wisconsin, USA.* A complex Spectral Kernel is defined that expresses the effect of self-apodization induced line shape changes on the ideal Fourier transform integral relationship between spectra and interferograms. Results from the Cross-track Interferometer Sounder (CrIS) are used to demonstrate improved accuracy over the standard processing approach.

Pisces 3

Hyperspectral Imaging and Sounding of the Environment

HW2C • Radiative Transfer and Hyperspectral Sensing—Continued

HW2C.3 • 11:15
Exploring Information Content of Hyperspectral Remote Sensing Data, Xu Liu[1]; [1]*NASA Langley Research Center, USA.* We present a Principal Component-based Radiative Transfer Model (PCRTM) and a retrieval algorithm that can be used to effectively explore the information content of the hyperspectral remote sensing data from infrared to solar spectral regions.

HW2C.4 • 11:30 Invited
Unraveling Earth's Climate Change Mysteries from Space: What do we need from our measurements?, Yolanda Shea[1], Daniel Feldman[2], Peter Pilewskie[3,4], Lusheng Liang[5], Seung-Hee Ham[5], Seiji Kato[1], Larry Di Girolamo[6], Bruce Wielicki[1]; [1]*NASA Langley Research Center, USA;* [2]*Lawrence Berkeley National Lab, USA;* [3]*Lab for Atmospheric and Space Physics, USA;* [4]*Univ. of Colorado, Boulder, USA;* [5]*Science Systems and Applications, Inc, USA;* [6]*Univ. of Illinois at Urbana-Champaign, USA.* This talk will review our work on understanding the measurement uncertainty, information content, and retrieval stability needs from Earth-reflected radiation measurements at top-of-atmosphere to obtain an unambiguous assessment of Earth's changing climate.

Pisces 4

Solid-state Lighting

SW2D • Advanced Design, Measurement, and Fabrication—Continued

SW2D.4 • 11:15
Visual clarity and blur acceptability in complex illuminated images, Dorukalp Durmus[1], Wendy Davis[1]; [1]*Univ. of Sydney, Australia.* Visual experiments were conducted to quantify blur acceptability in projection systems illuminating complex images. Results show a statistically significant (99 % confidence) increase in blur perception when the circle of confusion increases 3 %.

12:30–13:30 Lunch, *Leo Foyer*

Pisces 1

Optics and Photonics for Energy & the Environment

13:30–15:30
EW3A • Fundamental Measurements for Energy & the Environment

Presider: Gregory Rieker; Univ. of Colorado at Boulder, USA

EW3A.1 • 13:30
Ro-vibrational analysis of ammonia at 6.2μm using high-precision cavity ring-down spectroscopy, Sanchi Maithani[1], Abhijit Maity[1], Mithun Pal[1], Manik Pradhan[1]; [1]*S.N.Bose National Center for Basic Sciences, India.* We developed a cavity ring-down spectroscopy system utilizing a room-temperature, mode-hop-free, continuous wave external-cavity quantum cascade laser for high-resolution and high-sensitive molecular spectroscopic study of ammonia molecule in the spectral region covering 6.0-6.3 μm.

EW3A.2 • 13:45
Accurate Optical Measurements of Stable and Radioactive Carbon Isotopogolues of CO_2, Adam J. Fleisher[1], David A. Long[1], Hongming Yi[1], Qingnan Liu[1], Zachary D. Reed[1], Joseph T. Hodges[1]; [1]*NIST, USA.* We report the cavity ring-down spectroscopy of ^{14}C, ^{13}C and ^{12}C isotopologues of CO_2 in the near- and mid-infrared, measurements which yielded accurate transition intensities, mole fraction determinations, and isotope ratios.

EW3A.3 • 14:00
Transition Frequency Measurements of the $2\nu_3$ R6 Manifold of Methane, Yang Lei[1,2], Hong Lin[2], Xiaojuan Feng[2], Jintao Zhang[1,2]; [1]*Tsinghua Univ., China;* [2]*National Inst. of Metrology, China.* The $2\nu_3$ R6 manifold of methane is important for remote sensing. The positions of 96 lines in this manifold were determined by both Lamb-dip spectroscopy and linear absorption spectroscopy using a cavity ring-down spectrometer.

EW3A.4 • 14:15
Experimental 1.5-1.6 μm Water Line List at 1950 K, Lucile Rutkowski[1], Alexandra C. Johansson[1], Amir Khodabakhsh[1], Aleksandra A. Kyuberis[2], Nikolai F. Zobov[2], Oleg L. Polyansky[3], Sergey Yurchenko[3], Florian M. Schmidt[4], Jonathan Tennyson[3], Aleksandra Foltynowicz[1]; [1]*Umea Universitet, Sweden;* [2]*Inst. of Applied Physics, Russian Academy of Sciences, Russia;* [3]*Dept. of Physics and Astronomy, Univ. College London, UK;* [4]*Thermochemical Energy Conversion Lab, Umeå Universitet, Sweden.* We demonstrate a high-temperature water absorption spectrum measured in a flame using cavity-enhanced frequency comb-based Fourier transform spectroscopy. The retrieved transition intensities and frequencies are assigned using the POKAZATEL line list.

Pisces 2

Fourier Transform Spectroscopy

13:30–15:15
FW3B • Far-IR Observatories: Satellite Measurements

Presider: Hiroshi Matsuo; National Astronomical Observatory Japan, Japan

FW3B.1 • 13:30 Invited
The SPICA SAFARI Fourier Transform Spectrometer, David A. Naylor[1], Brad Gom[1], Ian Veenendaal[1], Dennis van Loon[2], Willem Jellema[2], Peter Roelfsema[2], Kees Wafelbakker[2], Alain Cournoyer[3], Frederic Grandmont[3]; [1]*Univ. of Lethbridge, Canada;* [2]*SRON, Netherlands;* [3]*ABB, Canada.* The high resolution spectroscopic mode of the SPICA SAFARI instrument will be achieved using a Martin-Puplett interferometer. The key science and technology requirements of the spectrometer will be reviewed and the current instrumental concept presented.

FW3B.2 • 14:00
Simulating the Retrieval of Astronomical Spectra from the SPICA SAFARI Post Dispersed Fourier Transform Spectrometer, Ian Veenendaal[1], David A. Naylor[1], Trevor Fulton[1], Brad Gom[1]; [1]*Physics and Astronomy, Univ. of Lethbridge, Canada.* The SPICA mission will employ ultra sensitive superconducting detectors. In this case the mulitplex disadvantange of Fourier transform spectroscopy dictates the use of a post dispersed, diffraction grating detection system. The challenges of reconstructing astronomical spectra will be reviewed.

FW3B.3 • 14:15
The SAFARI far-infrared instrument for the SPICA space telescope, Willem Jellema[1,2], Dennis van Loon[3], David A. Naylor[4], Peter Roelfsema[1,2]; [1]*SRON Netherlands Inst. for Space Research, Netherlands;* [2]*Kapteyn Astronomical Inst., Netherlands;* [3]*SRON Netherlands Inst. for Space Research, Netherlands;* [4]*Univ. of Lethbridge, Canada.* Utilizing a novel post-dispersed Martin-Puplett FTS scheme and very sensitive TES detector arrays, the SAFARI instrument will provide unprecedented sensitivity and spectroscopic capabilities for astronomy in the far-IR window of 34-230 μm onboard the SPICA space telescope.

Pisces 3

Hyperspectral Imaging and Sounding of the Environment

13:30–15:30
HW3C • Hyperspectral Imaging of Aerosol and Trace Gases I

Presider: Ka Lok Chan; DLR Oberpfaffenhofen Aerospace Center, Germany

HW3C.1 • 13:30 Invited
Fine Boundary Layer Characteristics in China in Association with Aerosol Pollution, Jianping Guo[1]; [1]*State Key Lab of Severe Weather, Chinese Academy of Meterological Science, China.* The spatio-temporal distribution of boundary layer height (BLH) using radiosonde measurements. Also presented is the features of temperature inversion (TI). BLH and TI are linked to aerosol pollution due to its radiative effect.

HW3C.2 • 14:00 Invited
Satellite Remote Sensing of Ozone Profile and Tropospheric Ozone from Nadir-viewing Backscattered Ultraviolet Measurements: OMI and Beyond, Xiong Liu[1], Kelly Chance[1], Juseon Bak[1], Pawan K. Bartia[2], Zhaonan Cai[3], Sachiko Hayashida[4], Guanyu Huang[5], Robert J. Spurr[6], Kang Sun[7], Kai Yang[8]; [1]*Harvard-Smithsonian Center for Astrophysics, USA;* [2]*NASA Goddard Space Flight Center, USA;* [3]*Inst. of Atmospheric Physics, China;* [4]*Nara Women's Univ., Japan;* [5]*Environmental and Health Sciences, Spelman College, USA;* [6]*RT Solutions, Inc., USA;* [7]*Univ. at Buffalo, SUNY, USA;* [8]*Atmospheric and Oceanic Science, Univ. of Maryland, College Park, USA.* We present our OMI ozone profile and tropospheric ozone retrieval algorithm, retrieval characterization, data product and validation, application, and update for the next version. Methods to improve sensitivity to lower tropospheric ozone retrievals are reviewed.

Pisces 4

Optics in Solar Energy

13:30–15:30
OW3D • Solar Concentrators

Presider: Karin Hinzer; Univ. of Ottawa, Canada

OW3D.1 • 13:30 Invited
Concentrating solar thermal power: challenges and opportunities, and the importance of solar field optical quality, Joe Coventry[1]; [1]*Australian National Univ., Australia.* Concentrating solar thermal power is a promising renewable technology because of its inherent thermal storage, but is being challenged strongly by alternatives such as PV with pumped hydro and batteries. Achieving cost targets (e.g. Sunshot 0.06 USD/kWh) requires new technologies that operate at higher temperature than current state-of-the-art. The strong influence that heliostat optical quality has on solar receiver efficiency at such temperatures is demonstrated.

OW3D.2 • 14:00
Solar concentrating dishes based on elastic and elasto-plastic membranes, Fabian Dähler[1], Gianluca Ambrosetti[2], Javier Montoya-Zegarra[1], Konrad Schindler[1], Aldo Steinfeld[1]; [1]*ETH Zurich, Switzerland;* [2]*Synhelion SA, Switzerland.* The ability of pressurized membranes to approximate a paraboloid of revolution is investigated. The optical performance of different membrane materials is analyzed computationally and experimentally, showing concentrations of up to 3070 suns.

OW3D.3 • 14:15
Silicone optical elements for cost-effective solar concentration, Sifang Cui[1], Nicholas Lyons[1], Kyung-Jo Kim[1], Robert A. Norwood[1]; [1]*Univ. of Arizona, USA.* Silicone optical elements are demonstrated for a concentrated photovoltaic system. These components show over 96% transmission through most of the solar spectrum and excellent temperature stability. Unique moldability enables cost-effective and complex shape production.

Pisces 1

Optics and Photonics for Energy & the Environment

EW3A • Fundamental Measurements for Energy & the Environment—Continued

EW3A.5 • 14:30
Investigation on the potential gas standard of CO_2 based on cavity ring-down spectroscopy, Hong Lin[1], Hailin Huo[1], Hai Wu[1], Xiaojuan Feng[1], Jintao Zhang[1]; [1]*National Inst. of Metrology, China*. The potential gas standard of CO_2 based on cavity ring-down spectroscopy is discussed. The(300013)<-(00001) R10e and R12e lines are measured to obtain the concentration which has a relative uncertainty of 0.21% and a 0.05% relative difference from the gravimetric method.

EW3A.6 • 14:45
HO_2 Radical Measurements in a Photolysis Reactor using Line-Locked Faraday Rotation Spectroscopy, Chu Teng[1], Chao Yan[1], Hongtao Zhong[1], Aric Rousso[1], Timothy Chen[1], Jonas Westberg[1], Yiguang Ju[1], Gerard Wysocki[1]; [1]*Princeton Univ., USA*. We report measurements of HO_2 radicals using wavelength modulated Faraday Rotation Spectroscopy in a multi-pass photolysis reactor. The current setup enables line-locked measurements to improve sensitivity and time resolution compared to the line-scanning system.

EW3A.7 • 15:00
Nanofocusing with Silver-Coated Fiber Tip for High-Sensitivity Raman Spectrum Detection, Wending Zhang[1], Min Liu[1], Fanfan Lu[1], Shuhai Liang[1], Ligang Huang[2], Ting Mei[1]; [1]*Northwestern Polytechnical Univ., China*; [2]*Chongqing Univ., China*. Nanofocusing was achieved at apex of a silver-coated fiber tip internally excited via radially vector beam, and then the tip was adopted to examine Raman spectrum of probe analytes with high activity.

EW3A.8 • 15:15
Quantum Noise Limited Trace Gas Cavity Enhanced Polarization Spectroscopy, Yajie Guan[1], Jiahao Dong[1], Chathura P. Bandutunga[1], Roland Fleddermann[1], Timothy T. Lam[1], Malcolm B. Gray[2], Jong H. Chow[1]; [1]*Australian National Univ., Australia*; [2]*National Measurement Inst., Australia*. We present a new molecular trace gas absorption spectroscopy architecture and its recent progress. It uses optical cavity polarization states for an ultra-sensitive absorption readout, and achieves shot noise limited performance.

Pisces 2

Fourier Transform Spectroscopy

FW3B • Far-IR Observatories: Satellite Measurements—Continued

FW3B.4 • 14:30
The Herschel/SPIRE Spectral Feature Finder: Updated Feature Catalogues, Jeremy P. Scott[1], Locke D. Spencer[1], Chris Benson[1], David A. Naylor[1], Ivan Valtchanov[2], Rosalind Hopwood[2], Natalia Hladczuk[2]; [1]*Univ. of Lethbridge, Canada*; [2]*European Space Astronomy Centre, Herschel Science Centre, Spain*. We present an analysis of the updated publicly available Herschel SPIRE spectral Feature Finder data products, focusing primarily on mapping observations, radial velocity estimates, and neutral carbon detection.

FW3B.5 • 14:45 Invited
Compact dual-comb systems: From precision spectroscopy to satellite ranging, Ronald Holzwarth[1]; [1]*Am Klopferspitz 19a, Menlo Systems GmbH, Germany*. Abstract not available.

Pisces 3

Hyperspectral Imaging and Sounding of the Environment

HW3C • Hyperspectral Imaging of Aerosol and Trace Gases I—Continued

HW3C.3 • 14:30
Using NO_2 Satellite Observations to Support Satellite-based CO_2 Emission Estimates of Cities and Power Plants, Gerrit Kuhlmann[1], Valentin Clément[2], Oliver Fuhrer[3], Julia Marshal[6], Grégoire Broquet[4], Yasjka Meijer[5], Armin Löscher[5], Dominik Brunner[1]; [1]*Empa, Swiss Federal Labs for Materials Science and Technology, Switzerland*; [2]*Center for Climate Systems Modelling, ETH Zürich, Switzerland*; [3]*Federal Office of Meteorology and Climatology, MeteoSwiss, Switzerland*; [4]*Laboratoire des Sciences du Climat et de l'environnement, France*; [5]*ESA ESTEC, Netherlands*; [6]*Max Planck Inst. for Biogeochemistry, Germany*. We created synthetic CO_2 and NO_2 satellite observations and compared various methods for estimating anthropogenic CO_2 emissions. The NO_2 observations increased the number of detected CO_2 plumes and reduced mean bias and scatter of the emission estimates making an NO_2 instrument a valuable addition.

HW3C.4 • 14:45
Using a Combination of CE and LP DOAS to Capture Citywide patterns of NO2 Concentrations, Ying ZHU[1], Mark Wenig[1]; [1]*LMU, Germany*. In our study we developed an algorithm that combines stationary long-path Differential Optical Absorption Spectroscopy (LP DOAS) and cavity-enhanced DOAS (CE DOAS) measurements to produce consistent concentrations maps of Munich and Hong Kong.

HW3C.5 • 15:00
Aerosol Profile Retrieval from a High-altitude MAX-DOAS Measurement using a Parameterized Look-up Table Method, Zhuoru Wang[1], Ka Lok Chan[1], Klaus-Peter Heue[1], Matthias Wiegner[2]; [1]*German Aerospace Center (DLR), Germany*; [2]*Meteorological Inst., Ludwig-Maximilians-Universität (LMU), Germany*. We present the first aerosol profile retrieval for high-altitude MAX-DOAS measurement on the Alps (Environmental Research Station Schneefernerhaus (~2650 m a.s.l.), Germany) using the parameterized look-up table method of O_4 absorption.

HW3C.6 • 15:15
Inter-comparison of Hyper Spectral Radiance and GHG data between space-borne FTS and grating spectrometers, Takahiro Kawashima[1], Akihiko Kuze[2], Kei Shiomi[2], Hiroshi Suto[2], Fumie Kataoka[1]; [1]*RESTEC, Japan*; [2]*Japan Aerospace Exploration Agency, Japan*. To demonstrate the effectiveness of monitoring greenhouse gases and air quality from space, we matched-up and inter-compared hyper spectral radiances of solar-reflected light and thermal emission and GHG dataset measured by space-borne FTS and grating spectrometers.

Pisces 4

Optics in Solar Energy

OW3D • Solar Concentrators—Continued

OW3D.4 • 14:30
Photogrammetric Measurement and Alignment of Radiation Modules in a High-Flux Solar Simulator, Johannes J. Pottas[1], Mustafa Habib[1], Wojciech Lipinski[1]; [1]*Australian National Univ., Australia*. A novel method using close-range photogrammetry was developed and evaluated to conduct spatial measurements of the as-built geometry of a high-flux solar simulator. Spatial measurements were used to align radiation modules to a target.

OW3D.5 • 14:45
Application of a Compound Parabolic Concentrator to a Multi-Source High-Flux Solar Simulator, Lifeng Li[1], Bo Wang[1], Johannes J. Pottas[1], Jose Zapata[1], Wojciech Lipinski[1]; [1]*The Australian National Univ., Australia*. This study investigates optical characteristics of compound parabolic concentrators (CPCs) coupled to multi-source high-flux solar simulators using Monte Carlo ray-tracing modelling. Application of a CPC results in increased flux magnitude and uniformity on target surfaces.

OW3D.6 • 15:00
Optical Design of a Heliostat Field for a High-Temperature Receiver–Reactor, Lifeng Li[1], John Pye[1], Wojciech Lipinski[1]; [1]*The Australian National Univ., Australia*. This study investigates the geometrical and optical characteristics of a high concentration ratio heliostat field, with an optional compound parabolic concentrator. The field is designed for application in a high-temperature redox thermochemical energy storage system.

OW3D.7 • 15:15
Design and Fabrication of Thin-Film Silicon-Based Selective Solar Absorbers, Zhiguang Zhou[1], Hao Tian[1], Urcan Guler[1], Vladimir Shalaev[1], Thomas Hymel[2], Yi Cui[2], Peter Bermel[1]; [1]*Purdue Univ., USA*; [2]*Stanford Univ., USA*. The efficiency of solar absorbers at capturing heat can be improved dramatically using spectral selectivity. Applying this concept to thin-film silicon increases thermal transfer efficiencies over 60% at 595 °C under moderate solar concentrations.

15:30–16:00 Coffee Break/Exhibits, *Leo Foyer*

16:00–16:30
JW4A • Postdeadline Presentations I

JW4A.1 • 16:00
Standoff Detection of RDX, TNT, and HMX Using Femtosecond Filament Induced Breakdown Spectroscopy, Abdul K. Shaik; Venugopal R. Soma; *ACRHEM, India.* Femtosecond filaments were employed for the first time, to the best of our knowledge, to investigate the explosive molecules RDX, TNT and HMX in standoff mode (~6.5m/~8m) using filament induced breakdown spectroscopy (FIBS) technique.

JW4A.2 • 16:15
Multi-octave Spanning, Absolute Frequency, High Resolution THz Dual-Comb Spectrometer Based on Electro-Optic Modulators: First Spectroscopic Measurements, Borja Jerez; Andres Betancur; Pedro Martin-Mateos; Cristina de Dios; Pablo Acedo; *Universidad Carlos III de Madrid, Spain.* First results on a new approach to obtain compact THz dual-comb spectrometers based on Electro-Optic modulators are reported. Two different schemes are evaluated with the objective of obtaining a practical solution for THz spectroscopy.

16:00–16:30
JW4B • Postdeadline Presentations II

JW4B.1 • 16:00
Satellite Observations of Isoprene from the Thermal Infrared Imaging Spectrometer: from Cross-track Infrared Sounder towards a Next Generation of Global Observing System, Dejian Fu[1]; Dylan Millet[2]; Kelley Wells[2]; Vivienne Payne[1]; Shanshan Yu[1]; Thomas Pagano[1]; Annmarie Eldering[1]; *[1]Jet Propulsion Lab, USA; [2] University of Minnesota, USA.* We will present retrievals of atmospheric isoprene directly from the CrIS satellite observations, and an instrument concept "Infrared Composition Atmospheric Sounder" - a next-generation global observing system crafted for quantifying atmospheric volatile organic compounds

JW4B.2 • 16:15
Optical Design of Visible and Short-wave Infrared Common-Aperture Imaging Spectrum System, Linlin Pei; *Chinese Academy of Science, China.* In this paper, we design a common-aperture imaging spectrum system. We choose reflective lenses as the main structure, and three refractive lenses to correct axial aberrations. The system is just 260mm in length. The image quality is good.

Pisces 2

Fourier Transform Spectroscopy

16:45–18:45
FW5A • Measurements of the Earth's Atmosphere: Validation and Instrument Advances

Presider: Erik Kretschmer; Karlsruher Institut für Technologie, Germany

FW5A.1 • 16:45 Invited

CO_2 and CH_4 observations by the thermal infrared band of GOSAT/TANSO-FTS and GOSAT-1/TANSO-FTS-2, Naoko Saitoh[1], Ryoichi Imasu[2], Kei Shiomi[3], Akihiko Kuze[3], Masakatsu Nakajima[3], Yosuke Niwa[4], Toshinobu Machida[4], Yousuke Sawa[5], Hidekazu Matsueda[5], Kazuhiro Tsuboi[5], Aki Tsuruta[6]; [1]*Center for Environmental Remote Sensing, Chiba Univ., Japan;* [2]*Atmospherere and Ocean Research Inst., The Univ. of Tokyo, Japan;* [3]*Japan Aerospace Exploration Agency, Japan;* [4]*National Inst. for Environmental Studies, Japan;* [5]*Meteorological Research Inst., Japan;* [6]*Finnish Meteorological Inst., Finland.* We have validated CO_2 and CH_4 data retrieved from TIR band of GOSAT/TANSO-FTS based on comparisons with aircraft observations. The accuracy of GHG measurements by TIR bands of GOSAT-2/TANSO-FTS-2 are expected to be much improved.

FW5A.2 • 17:15

Long-term Validation for the Atmospheric Chemistry Experiment Fourier Transform Spectrometer (ACE-FTS), Kaley A. Walker[1], Patrick E. Sheese[1], Jiansheng Zou[1], Chris D. Boone[2]; [1]*Univ. of Toronto, Canada;* [2]*Univ. of Waterloo, Canada.* This paper will describe the current validation results for the Atmospheric Chemistry Experiment Fourier Transform Spectrometer (ACE-FTS) with a focus on long-term validation efforts and overall mission status for this instrument.

FW5A.3 • 17:30

Philippines TCCON Project: One-year Measurement Results and Future, Isamu Morino[1], Voltaire A. Velazco[2,3], Akihiro Hori[1], Osamu Uchino[1], Hirofumi Oyama[1], Tetsu Sakai[4], Toshiharu Izumi[4], Tomohiro Nagai[4], Gerry Bagtasa[5], Yukio Yoshida[1], Matthäus Kiel[6], Beata Bukosa[2], Nicholas M. Deutscher[2], Jenny A. Fisher[2], David W. Griffith[2]; [1]*NIES, Japan;* [2]*Centre for Atmospheric Chemistry, Univ. of Wollongong, Australia;* [3]*Oscar M. Lopez Center for Climate Change Adaptation and Disaster Risk Management Foundation, Philippines;* [4]*Meteorological Research Inst., Japan;* [5]*Univ. of the Philippines, Philippines;* [6]*California Inst. of Technology, USA.* We present results of one-year of measurements, some interesting phenomena like CO and CH_4 enhancements, and comparisons with satellite data at Burgos TCCON site in the Philippines, as well as activities involving participation in aircraft observation campaigns such as EMeRGe-Asia and NASA CAMP2Ex.

FW5A.4 • 17:45 Invited

Greenhouse Gas Column Measurements by Ground-Based FTS, Hirofumi Oyama[1], Kei Shiomi[2], Nobuhiro Kikuchi[2], Isamu Morino[1], Akihiro Hori[1], Tsuneo Matsunaga[1]; [1]*National Inst. for Environmental Studies, Japan;* [2]*Japan Aerospace Exploration Agency, Japan.* Ground-based high-resolution Fourier transform spectrometer (FTS) and portable FTS have been used for column measurements of greenhouse gases. We present measurement campaigns for quantifying CO_2 emission from a large point source with two portable FTSs.

Pisces 3

Hyperspectral Imaging and Sounding of the Environment

16:45–18:00
HW5B • Hyperspectral Imaging of Aerosol and Trace Gases II

Presider: Cindy Ong; CSIRO Energy Technology, Australia

HW5B.1 • 16:45

Monitoring Greenhouse Gases Emission from Different Source Sectors with an Angstrom Spectral Resolution Imaging Spectrometer Suite, Akihiko Kuze[1], Hiroshi Suto[1]; [1]*Japan Aerospace Exploration Agency, Japan.* We used an imaging spectrometer suite to measure CO_2, CH_4, and NO_2 with a Å spectral resolution to estimate flux from different source sectors. An airplane campaign over greater Nagoya detected CO_2 and CH_4 enhancement.

HW5B.2 • 17:00 Invited

Title to be Determined, Jianguo Liu[1]; [1]*Anhui Inst Optics & Fine Mech, CAS, China.* Abstract not available.

HW5B.3 • 17:30 Invited

NO_2 Gridded Monitoring and Emission Flux Estimation by a Novel Mobile Two-axis DOAS Instrument, Pinhua Xie[1]; [1]*Anhui Inst. of Optics Fine Mechanics, China.* The temporal and spatial varication of pollutants and emission sources are important ways to understand regional pollution. To investigate the distribution characteristics and identify sources rapidly, a novel mobile two-axis differential optical absorption spectroscopy (DOAS) instrument has been developed, which receives the scatted light with two elevation angle telescopes (90°, 30°) by setting two shutters to switch the optical paths to spectrometer respectively.

Pisces 4

Optics in Solar Energy

16:45–18:45
OW5C • Multi-Junction Solar Cells

Presider: Martina Schmid; Universität Duisburg-Essen, Germany

OW5C.1 • 16:45 Invited

Advanced optics for silicon based tandem solar cells and modules, Jan C. Goldschmidt[1], Benedikt Bläsi[1], Jan Benick[1], Alexander J. Bett[1], Romain Cariou[1], Ludmila Cojocaru[2], Frank Feldmann[1], Hubert Hauser[1], Oliver Höhn[1], Ralph Müller[1], Patricia S. Schulze[1], Nico Tucher[2], Karl Wienands[2], Kristina Winkler[1], Frank Dimroth[1], Martin Hermle[1], Stefan W. Glunz[1,2]; [1]*Fraunhofer Inst Solare Energie Systeme, Germany;* [2]*Dept. of Sustainable Systems Engineering INATECH, Freiburg Univ., Germany.* Our experiments and simulations show how advanced optical elements (front-side texturing, rear-side photonic elements) improve the overall efficiency in III-V and perovskite on silicon multi-junction solar cells leading to record efficiencies and high energy yield.

OW5C.2 • 17:15

Laser-fired-contact Silicon Solar Cells for Perovskite/Silicon Tandem Applications, Xinhang Li[1,2], Armin G. Aberle[1,2], Fen Lin[1]; [1]*SERIS, Singapore;* [2]*Dept. of Electrical and Computer Engineering, National Univ. of Singapore, Singapore.* In this work, laser-fired-contact (LFC) *p*-type silicon wafer solar cells are investigated as an option for low-temperature metalized bottom cells in perovskite/silicon tandem applications.

OW5C.3 • 17:30

Energy Yield Modelling of Wide Bandgap Perovskite-Based Tandem Solar Modules, Malte S. Langenhorst[1], Jonathan Lehr[2], Benjamin Sautter[1], Raphael Schmager[1], Uli Lemmer[2,1], Bryce S. Richards[1,2], Ulrich W. Paetzold[1,2]; [1]*Inst. of Microstructure Technology, Karlsruhe Inst. of Technology, Germany;* [2]*Light Technology Inst., Karlsruhe Inst. of Technology, Germany.* In this work, major loss mechanisms in the complex architecture of wide bandgap perovskite-based tandem solar modules are quantified using detailed energy yield modelling based on realistic meteorological data and rigorous optical and electrical simulations.

OW5C.4 • 17:45

Preparation of flexible GaInP/GaAs/GaInAs Inverted metamorphic (IMM) solar cell based on Electroplating Technology, Junhua Long[1,2], Meng Xiao[2], Xinping Huang[2], Ming Tan[2], Zhiwei Xing[1,2], Wenxian Yang[1,2], Xuefei Li[2], Yuanyuan Wu[2], Shulong Lu[2]; [1]*School of Nano Technology and Nano Bionics, Univ. of Science and Technology of China, China;* [2]*Key Lab of Nanodevices and Applications, Suzhou Inst. of Nano-Tech and Nano-Bionics, Chinese Academy of Sciences, China.* GaInP/GaAs/GaInAs IMM flexible solar cell has been fabricated by electroplating 20μm thick copper on the p-type contact metal as the supported thin film, which has an efficiency of 33.13% at one sun under the AM1.5G illumination.

Pisces 2

Fourier Transform Spectroscopy

FW5A • Measurements of the Earth's Atmosphere: Validation and Instrument Advances—Continued

FW5A.5 • 18:15
Imaging FTS Elegant Breadboard for Atmospheric Missions, Fabien Dupont[1], Frederic Grandmont[1], Stephane Lantagne[1], Martin Larouche[1], Louis Jacques[1], Danny Lebreux[1], Kaley A. Walker[2], Ray Nassar[3]; [1]*ABB Inc, Canada;* [2]*Univ. of Toronto, Canada;* [3]*ECCC, Canada*. The IFTS instrument is designed to image CO2, CH4 and O2 in the atmosphere by observing spectra of reflected shortwave infrared (SWIR) and near infrared (NIR) solar radiation. We present the IFTS Elegant Breadboard.

FW5A.6 • 18:30
High Performance spectro-imagery in LEO with an Imaging FTS, Henry Buijs[1], Frederic Grandmont[1], Jean-Francois Lavigne[1]; [1]*ABB Inc., Canada*. Time constraints associated with high orbital speed in low earth orbit have been preventing instrument builder to recommend the IFTS approach for earth observation. ABB has a novel approach that overcomes the main technical challenges.

Pisces 3

Hyperspectral Imaging and Sounding of the Environment

HW5B • Hyperspectral Imaging of Aerosol and Trace Gases II—Continued

Pisces 4

Optics in Solar Energy

OW5C • Multi-Junction Solar Cells—Continued

OW5C.6 • 18:00
Triple Junction GaAs High Efficiency Epitaxial Lift-Off Solar Cells, Noren Pan[1], Drew Cardwell[1]; [1]*MicroLink Devices Inc, USA*. MicroLink Devices has developed flexible, lightweight, high efficiency III-V inverted metamorphic multi-junction (IMM) solar cells. The solar cells are lifted off from the GaAs substrate and they have achieved an NREL-certified efficiency of 37.75% AM1.5G 1-Sun.

OW5C.5 • 18:15 Invited
High Efficiency Photovoltaics: Ways to Push the Efficiencies Further, Karin Hinzer[1]; [1]*Electrical Engineering, Univ. of Ottawa, Canada*. To bring higher efficiencies to photovoltaics, present integrated architectures such as multijunction solar cells must include new materials and designs. We present new architectures such as multi-segments, nanostructures and junction materials.

Key to Authors and Presiders

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