OSA Light, Energy and the Environment Congress

05–08 November 2018

Resort World Sentosa Convention Center
Singapore

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# Program Committees

## Congress Chair
Kenneth Baldwin, Australian National University, Australia

## Local Organizing Chair
Armin Aberle, Solar Energy Research Institute of Singapore, Singapore

## Fourier Transform Spectroscopy (FTS)
Frans J. Harren, Radboud Universiteit Nijmegen, Netherlands, Program Chair
Sheng-Cai Shi, Purple Mountain Observatory, China, Program Chair
Kaley Walker, University of Toronto, Canada, Program Chair
Ian Coddington, NIST, USA
Christoph Englert, US Naval Research Laboratory, USA
Erik Kretschmer, Karlsruher Institut für Technologie, Germany
Hiroshi Matsuo, National Astronomical Observatory Japan, Japan
Isamu Morino, NIES, Japan
Scott Paine, Harvard-Smithsonian Center for Astrophysics, USA
Luca Palchetti, Istituto Nazionale di Ottica, Italy
Aldona Wiacek, Saint Mary’s University, USA

## Hyperspectral Imaging and Sounding of the Environment (HISE)
Akihiko Kuze, Japan Aerospace Exploration Agency, Japan, Program Chair
Mark Wenig, Ludwig-Maximilians-Universität, Germany, Program Chair
Michael Yetzbacher, US Naval Research Laboratory, USA, Program Chair
States Myoung-Hwan Ahn, Ewha Womans University, South Korea
Eric Bucselá, SRI International, Inc., USA
Miran Bürmen, University of Ljubljana, Slovenia
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Stuart Phinn, University of Queensland, Australia
Peter Pilewskie, University of Colorado at Boulder, USA
Shanshan Wang, Fudan University, China
Heli Wei, Anhui Institute of Optics Fine Mechanics, China

## Optics and Photonics for Energy & the Environment (E2)
Adam Fleisher, NIST, USA, Program Chair
Aleksandra Foltynowicz, Umea University, Sweden, Program Chair
Wilfred Walsh, National University of Singapore, Singapore, Program Chair
Jong Chow, Australian National Univ., Australia
Phil DeCola, Sigma Space, USA
Melanie Emmenegger, EMPA, Switzerland
Vanda Grubišić, National Center for Atmospheric Research, USA
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Gregory Rieker, University of Colorado at Boulder, USA
Vincenzo Spagnolo, Politecnico di Bari, Italy
Jean-Pierre van Helden, Leibniz Institute for Plasma Science & Technology, Germany
Jonas Westberg, Princeton University, USA
Azer Yalin, Colorado State University, USA

## Optics in Solar Energy (SOLAR)
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Serena Fen Lin, National University of Singapore, Singapore, Program Chair
Olindo Isabella, Technische Universiteit Delft, Netherlands, Program Chair
Klaus Jaeger, Helmholtz-Zentrum Berlin, Germany, Program Chair
Jos Haverkort, Technische Universiteit Eindhoven, Netherlands
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Wahed Muhammad, National University of Singapore, Singapore
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Bonna Newman, ECN Solar Energy, Netherlands
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Noren Pan, MicroLink Devices Inc., USA
Rudi Santbergen, Technische Universiteit Delft, Netherlands
Rolf Stangl, Solar Energy Research Institute of Singapore, Singapore
Hairen Tan, University of Toronto, Canada
Liu Xiaogang, National University of Singapore, Singapore
Xiaodan Zhang, Nankai University, China

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Hanwei Gao, Florida State University, USA, Program Chair
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Tze Chien Sum, Nanyang Technological University, Singapore
Harun Tüysüz, Max-Planck-Institut für Kohlenforschung, Germany

OSA SENSORS AND SENSING CONGRESS
25 – 27 June 2019
San Jose McEnery Convention Center
San Jose, California, USA

SAVE THE DATE
osa.org/SensingOPC

TOPICAL MEETINGS
- Fourier Transform Spectroscopy
- Hyperspectral Imaging and Sounding of the Environment
- Optical Sensors
- Optics and Photonics for Sensing the Environment

Collocated with sensors expo & conference
General Information

Online Access to Technical Digest

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2. Select the “Access digest papers” link on the right hand navigation.
3. Log in using your email address and password used for registration. You will be directed to the conference page where you will see the .zip file link at the top of this page.
   [Note: if you are logged in successfully, you will see your name in the upper right-hand corner.]

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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 Inglis, 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.

Access to the Wireless Internet

OSA has provided complimentary wireless internet for all Congress attendees. Use the information below to log in.

Network - MICWIFI@RWS
Password - Rwsmice2018
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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*Exhibitor*  
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URL: www.seris.sg

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Explanation of Session Codes

Meeting Name
E = E2  
F = FTS  
H = HISE  
O = SOLAR  
S = SSL  

Day of the Week
M = Monday  
Tu = Tuesday  
W = Wednesday  

Series Number
1=First Series of Sessions  
2=Second Series of Sessions  

Session Designation  
(alphabetically)  

Number  
(Presentation order within the session)  

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  
Keynote papers are noted with Keynote  

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## Agenda of Sessions — Monday, 5 November

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

### 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

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

29 July – 1 August 2019
Hyatt Regency San Francisco Airport
Burlingame, California, USA

**SAVE THE DATE**
osa.org/PhotonicsOPC

### TOPICAL MEETINGS
- Integrated Photonics Research, Silicon and Nano-photronics
- Novel Optical Materials and Applications
- Optical Devices and Materials for Energy
- Photonic Networks and Devices
- Signal Processing in Photonic Communications
## Agenda of Sessions — Wednesday, 7 November

<table>
<thead>
<tr>
<th>Time</th>
<th>Session 1</th>
<th>Session 2</th>
<th>Session 3</th>
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</tr>
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<tbody>
<tr>
<td>08:00–17:00</td>
<td>Registration, Leo Foyer, Level 1</td>
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<tr>
<td>08:30–10:00</td>
<td>JW1A • Keynote Session II, Leo 1&amp;2</td>
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<tr>
<td>10:00–10:30</td>
<td>Coffee Break/Exhibits, Leo Foyer</td>
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<tr>
<td>10:30–12:30</td>
<td>EW2A • New Techniques for Sensing the Environment</td>
<td>FW2B • Satellite Measurements of the Earth’s Atmosphere: Instrumentation and Calibration Techniques</td>
<td>HW2C • Radiative Transfer and Hyperspectral Sensing (ends at 12:00)</td>
<td>SW2D • Advanced Design, Measurement, and Fabrication (ends at 11:30)</td>
</tr>
<tr>
<td>12:30–13:30</td>
<td>Lunch, Leo Foyer</td>
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<tr>
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<td>Coffee Break/Exhibits, Leo Foyer</td>
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<tr>
<td>16:00–16:30</td>
<td>Post Deadline Presentations I</td>
<td>Post Deadline Presentations II</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16:45–18:45</td>
<td>FW5A • Measurements of the Earth’s Atmosphere: Validation and Instrument Advances</td>
<td>HW5B • Hyperspectral Imaging of Aerosol and Trace Gases II (ends at 18:00)</td>
<td>OW5C • Multi-Junction Solar Cells</td>
<td></td>
</tr>
</tbody>
</table>

### 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
CALL FOR PAPERS:
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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Akihiko Kuze, Japan Aerospace Exploration Agency, Japan
Qihua Xiong, Nanyang Technological University, Singapore

For more information, visit the Feature Issues section of ao.osa.org or oe.osa.org.
### Optics and Photonics for Energy & the Environment

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<tr>
<td>10:00-12:00</td>
<td>EM2A</td>
<td>Industrial Monitoring I: Energy and Power</td>
<td>Presider: Jonas Westberg; Princeton Univ., USA</td>
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<tr>
<td>10:00-10:30</td>
<td>EM2A.1</td>
<td>10:00 Tapered multi-mode optical fiber sensor to detect petrol adulteration, Vinod K. Singh¹; '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 fabrication using tapered multi-mode fiber (MMF). The maximum sensitivity of 123 nW/N is obtained.</td>
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<tr>
<td>10:15-10:45</td>
<td>EM2A.2</td>
<td>10:15 Broadband fluorescence from green-synthesized carbon dots, Venkata Siva Gummadi¹, Somesh Sabat¹, Vijayan C¹; 'Indian Inst. of Technology Madras, India; 'Gangadhahr 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.</td>
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<tr>
<td>10:45-11:20</td>
<td>EM2A.3</td>
<td>10:30 Preliminary Study of Distributed Fiber Optic Sensing Technologies in Hydraulic Machinery, Can Yao, Xingyang Huang, Pingyu Zhu, Camille Bres¹, Luc Thévenaz¹; 'Ecole Polytechnique Federale de Lausanne, Switzerland; 'WinIO, Switzerland; '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.</td>
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<tr>
<td>11:20-12:00</td>
<td>EM2A.4</td>
<td>10:45 A Novel Route to Plastics Recycling via Unique, Background-free, Micro-scale Photonic Markers, Bryce S. Richards¹, Dmitry Busko¹, Guoyuan Gao¹, Damien Hudvy¹, Ian Howard¹, Andrey Turshatov¹; '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.</td>
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### Optics Transform Spectroscopy

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<td>10:00-12:00</td>
<td>FM2B</td>
<td>Dual Comb and miniaturized-based FTS developments</td>
<td>Presider: Frans J. Harren; Radboud Universiteit Nijmegen, Netherlands</td>
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<tr>
<td>10:00-10:30</td>
<td>FM2B.1</td>
<td>10:00 A chip based dual frequency-comb Fourier spectrometer, David G. Lancaster¹; 'Physics &amp; 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.</td>
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<tr>
<td>10:30-11:00</td>
<td>FM2B.2</td>
<td>10:30 Trace Gas Detection Using a MEMS-Based Portable Fourier Transform Infrared Spectrometer, Kunyu Chai¹, Hongchi Ji¹, Xiaoxuan Dong¹, Chuan Huang¹, Lei Jiang¹, Huikai Xie²; 'Engineeering Research Center of Optical Instrument and System, Univ. of Shanghai for Science and Technology, China; 'IWO Technology Co., China; 'Honeywell Integrated Technology, China; '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.</td>
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<td>11:00-11:30</td>
<td>FM2B.3</td>
<td>10:45 Open Path MIR DCS for Chemical Detection, Gabrielly Cardoso¹, Fabrizio Gorrgetta¹, Kevin Cassel¹, Eleanor Waxman¹, Esther Baumann¹, Nathan R. Newbury¹, Ian R. Goddington¹; 'NSF, 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 VOCs such as acetone even in the presence of water vapor interference.</td>
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### Hyperspectral Imaging and Sounding of the Environment

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<td>10:00-11:45</td>
<td>HM2C</td>
<td>Hyperspectral Sensing of Land and Water</td>
<td>Presider: Michael Yetzbacher; US Naval Research Lab, USA</td>
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<tr>
<td>10:00-10:30</td>
<td>HM2C.1</td>
<td>10:00 Calibration and validation of optical EO sensors' relevance to non-renewable resources environmental monitoring, Cindy C. Ong¹; 'Energy, CSIRO, Australia. Our standoff sensor platform is based on two mutually-stable mode-locked waveguide lasers integrated into the same glass chip. The system provides a robust and high-resolution molecular spectroscopic capability.</td>
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<tr>
<td>10:30-11:00</td>
<td>HM2C.2</td>
<td>10:30 Eruptions from UV to TIR: multispectral high-speed imaging of explosive volcanic activity, Jacopò Teduccio¹, Poirogiorgi Scarlato¹, Elisabetta Del Bello¹, Giancarlo Tamburello¹, Damien Gaudin¹; 'Istituto Nazionale di Geofisica e Vulcanologia, Italy; 'Istituto Nazionale di Geofisica e Vulcanologia, Italy; '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 plume dynamics and gas/fraction ratios at the seconds and centimeter scales.</td>
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<td>11:00-11:30</td>
<td>HM2C.3</td>
<td>10:45 Open Path MIR DCS for Chemical Detection, Gabrielly Cardoso¹, Fabrizio Gorrgetta¹, Kevin Cassel¹, Eleanor Waxman¹, Esther Baumann¹, Nathan R. Newbury¹, Ian R. Goddington¹; 'NSF, 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 VOCs such as acetone even in the presence of water vapor interference.</td>
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### Optics in Solar Energy

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<td>10:00-11:45</td>
<td>OM2D</td>
<td>PV beyond Silicon</td>
<td>Presider: Serena Fen Lin; National University of Singapore, Singapore</td>
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<tr>
<td>10:00-10:30</td>
<td>OM2D.1</td>
<td>10:00 Light trapping: From Silicon to III-V Solar Cells, Nicholas J. Elek-Daukes¹; 'School of Photovoltaic &amp; 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.</td>
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<tr>
<td>10:30-11:00</td>
<td>OM2D.2</td>
<td>10:30 Optical Anisotropy and Photovoltaic Performance of N-Si/Organic Heterojunction HOT Solar Cells, Hajime Shirai¹, A.T.M. Saiful Islam¹, Koki Kawamura¹, Ryo Ishikawa¹, Satoshi Unu, 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.</td>
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<td>11:00-11:30</td>
<td>OM2D.3</td>
<td>10:45 2D Tungsten Disulfide Sheets for Ultralight, Flexible Photovoltaics, Sayan Roy¹, Peter Bermel¹; '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.</td>
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**Light, Energy and the Environment Congress • 5-8 November 2018**
### Pisces 1

**Optics and Photonics for Energy & the Environment**

**EM2A • Industrial Monitoring I:**

**Energy and Power—Continued**

- **EM2A.5 • 11:00**
  - Invited
  - Photoacoustic H2S Gas Sensor for SF6 Decomposition Analysis in an Electric Power System, Lei Dong, Xukun Yin, Hongpeng Wu, Liantuan Xiao, Suotang Jia, Shari Univ., China. A photoacoustic hydrogen sulfide (H2S) gas sensor for sulfur hexafluoride (SF6) decomposition analysis in an electric power system was developed. A detection limit of 109 ppb was achieved.

### 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, Tatsuyuki Takechi, Takayuki Kimura, Kansai Univ., Japan. The dual-comb spectroscopic method was applied to the measurement of a thin-film standard sample.

### 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, Helen E. Brindley, Juliet C. Pickering, Stuart Fox, Axell Wellpott, Cathryn Fox, Alan Last, Chann Harlou, Dept. of Physics, Imperial College London, UK. A study on far-infrared up-welling radiances measurements over Greenland has yielded the first estimates of the emissivity of ice and snow in this spectral region. It describes the complexity of undertaking such work and what the future holds.

### Pisces 4

**Optics in Solar Energy**

**OM2D • PV beyond Silicon—Continued**

- **OM2D.6 • 11:15**
  - Invited

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**EM2A.6 • 11:30**

Diagnosing the vibrational excitation kinetics of CO2 for renewable energy storage, Richard Engeln1, Bart Klarennaar1, Ana Sofia Molina-Candas1, Maria Grafulovicic1, Richard van de Sanden1, Oliver Guatella1, Eindhoven Univ. of Technology, Netherlands; 2Ecole Polytechnique-CNRS, France; 3Ecole Polytechnique, Portugal; 4DIFFER, 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 CO2 and the reduction of CO2 to CO in a pulsed glow discharge.

**FM2B.5 • 11:30**

Mid-infrared Dual-comb Spectroscopy in An Electrical Discharge, Amir Khodabakhsh1, Julien Mandon1, Qing Pan1, Muhammad Ali Abbas1, Frans J. M. Harren1, 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 (ns scale) and also monitoring the relaxation process of methane excited states (μs scale).

**FM2B.6 • 11:45**

Direct Mid-Infrared Frequency Comb Spectroscopy of Nitrocarburizing Plasma Processes, Norbert Lang, Alexander Puth, Sarah-Johanna Klose1, Grzegorz Kowzan, Stephan Hamann, Juergen Roepcke, Piotr Maslowski, Jean-Pierre H. van Helden, Leibniz Inst. for Plasma Science & Technology, Germany. 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, CH3, and NH3.

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**12:00–13:00 Lunch, Leo Foyer**
On the Chemical Kinetics of HO gas in a Cold Atmospheric Plasma Jet, Sarah-Johanna Klose1, Michele Gianella2, Stephan Reuter1, Press Sioned3, Ana Loury Aguila1, Katherine Manfred1, Ansgar Schmidt-Bleker1, Grant Ritchie2, Jean-Pierre H. van Helden1, Leibniz Inst. for Plasma Science & T, Germany; 2Dept. of Atmospheric and Space Physics, Univ. of Colorado at Boulder, USA; 3Dept. of Mechanical and Aerospace Engineering, Princeton Univ., USA. HO gas 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 concentration is in good agreement with the measurements.

Development of Reflective Spatially Heterodyne Spectrometers for Spaceflight Applications from the Extreme UV to Near IR, Walter M. Harris1, Jason Corliss1, 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.

Accurate Soiling Ratio Determination with Incident Angle Modifier for PV Modules, Olimdo Isabella1,2, 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.
Monday, 5 November

**EM3A.1 • Sensing of Plasma & Combustion Environments—Continued**

Laser dispersion spectroscopy for combustion diagnostics, Wei Ren,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.3 • 14:00**

Sub-orbital demonstration of the Spatial Heterodyne Observations of Water (SHOW) instrument from NASA’s high-altitude ER-2 remote science airplane, Jeffery A. Langille1, Daniel Letros1, Adam Bourassa1, Brian Solheim1, Fabien Dupont2, Doug Degenest1, Daniel Zawadski1, Univ. of Saskatchewan, Canada; 2ABB Inc, Canada. The Spatial Heterodyne Observations of Water instrument (SHOW) is a lim-bounding 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.

**EM3A.5 • 14:30**

Parameter Estimation Using Wavelength Modulation Spectroscopy Temperature Measurements and Approximate Bayesian Computation, Jason D. Christopher1, Daniel Petrykowski1, Torrey R. Hayden1, Caelan Lapointe1, Nicholas T. Wimer1, Siddharth P. Nigam1, Ian Grooms1, Peter E. Hamlington1, Gregory B. Rieker1, 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 Agarwal1, Chandra Shakti1, IIDD, 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 capable of measuring temperature of a large size flame to micro size flame.

**FM3B.1 • Measurements of the Earth and the Earth’s Atmosphere: Satellite and Airborne Systems—Continued**

Progress and recent developments of the GLORIA infrared limb imager, Eri Kretschmer1, 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.2 • 14:30**

A Hyperspectral Camera for Remote Sensing based on a Birefringent Ultrastable Common-Path Interferometer, Antonio Ferré1,2, Barbara Elza Nogueira de Faria1,3, Danielle Ferreira1, Dario Poli1,2, Daniela Comelli2, Gianluca Antonio Perri2,4, Valentina2, Giulio Cerullo2,1, Cristian Manzoni1,2,1,1, IFN-CNR, Italy; 2Dipartimento di Fisica, Politecnico di Milano, Italy; 3Departamento de Fisica, Universidade Federal de Minas Gerais, Brazil; 4NIREOS 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.

**FM3B.3 • 14:45**

Spectrally resolved radiative observations of the Earth in the Far-Infrared using the Tropospheric Airborne Fourier Transform Spectrometer (TAFTS), Jan E. Murray1, Juliet C. Pickering1, Helen E. Brindley1, Stuart Fox1, Peter Ade1, Carole Tucker1, Cathryn Fox1, Chawn Harlow1, Alan Last1, Imperial College London, UK; 2UK National Centre for Earth Observation, UK; 3Met Office, UK; 4Cardiff 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.

**FM3B.4 • 14:00**

Pre-Launch Activity for Flight model of HSUI hyper-spectral sensor onboard International Space Station, Jun Tanii1, Akira Iwasaki1, Osamu Kashimura1, Yoshihiko Ito1, Japan Space Systems, Japan; 2Univ. of Tokyo, Japan; 3NEC Corporation, Japan. HSUI 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.

**FM3B.5 • 14:00**

Impact of Fabrication Parameters on the Self-cleaning Performance of Hot-embossed Fluoropolymer Films for Photovoltaic Modules, Aiman Roulizer1,2,3, Stephan Dottermusch4, Felix Vüllers1, Mayra N. Kavalenka1, Markus Gutmann1,2, Marc Schneider1,2, Efthymios Klimapetis1, Ulrich W. Paetzold1, Hendrik Hölscher1, Bryce S. Richards1, Karlsruhe Institute 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.

**FM3B.7 • 14:30**

Fast Extraction of Performance Parameters for Photovoltaic Module using Electroluminescence Imaging Technique, Amit S. Rupali2,3, Jian Wei Ho1, Yin Zhang1, Srinath Nalluri1, Armin G. Aberle1,2, Solar Energy Research Inst. of Singapore, Singapore; 3National 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.

**FM3C.1 • Recent Advances in Hyperspectral Instruments, Analysis, and Algorithms I—Continued**

Compact Integrated Fused Snapshot Imaging Spectrometers for Environmental Imaging Applications, Tomasz Tkaczyk1, David Alexander1, Ye Wang1, Jason Dwight1, Razvan Stoian1, Shuna Cheng1, Michal Pawlowski1, 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.

**FM3C.2 • 14:00**

A Hyperspectral Camera for Remote Sensing based on a Birefringent Ultrastable Common-Path Interferometer, Antonio Ferré1,2, Barbara Elza Nogueira de Faria1,3, Danielle Ferreira1, Dario Poli1,2, Daniela Comelli2, Gianluca Antonio Perri2,4, Valentina2, Giulio Cerullo2,1, Cristian Manzoni1,2,1, IFN-CNR, Italy; 2Dipartimento di Fisica, Politecnico di Milano, Italy; 3Departamento de Fisica, Universidade Federal de Minas Gerais, Brazil; 4NIREOS 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.

**FM3C.3 • 14:30**

Compact Fused Snapshot Imaging Spectrometers for Environmental Imaging Applications, Tomasz Tkaczyk1, David Alexander1, Ye Wang1, Jason Dwight1, Razvan Stoian1, Shuna Cheng1, Michal Pawlowski1, 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.
Graphene energy storage devices, Baohua Jia1; 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.

Systematic study on the interaction between graphene and visible-light responsive photocatalysts, Hassan Samie1, Ali A. Saffazagh-Alavi1, Naimeh Nasiri2, Bastian Meier1; CPOC, Amirkabir Univ. of Technology, Iran; Photocatalytic Synthesis Group, MESA+ Inst. for Nanotechnology, Univ. of Twente, Netherlands; Sharif Univ. of Technology, Iran. The basic mechanisms of interfacial interaction, charge transfer/separation and subsequently their influence on the photocatalytic activity of ZnV2O6/graphene nanocomposites were comprehensively studied.

Revisiting Broadband Reflection Suppression by Mie Scatterers: the Role of Electromagnetic Duality, Eugenia Sliwinska1,2, Aimi Abebasi1,2, Derk Bätzner1, Carsten Rockstuhl2,3, Ivan Fernandez-Corbato1,2; Meyer Burger Research AG, Switzerland; 2Dept. of Physics, Umeå Univ., Sweden; 3Inst. 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.

Influence of 2D non-uniformly gradient motheye structures for absorption improvement in solar energy harvesting, Saraswati Behera1, Mechanical Engineering, Yonsei Univ., South Korea. Non-uniform gradient 2D motheye photonic structures are studied to show more than 55% of absorption over a broad solar spectrum (350-1100 nm) and wide angle of incidence for targeted applications in solar energy harvesting.

Improved Light Trapping in Quantum Dot Solar Cells Using Double-sided Nanostucturing, Farid K. Elsehrawy1, Timo Ahola2, Tapio Niemi1, Mireia Guina1, Federica Cappelluti1; Dept. of Electronics and Telecommunications, Politecnico di Torino, Italy; 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.

Precision beyond the Voigt profile using optical frequency comb dual-comb phase spectroscopy, Helge Rustowski1,2, Laura C. Johansson1, Jonas Westberg1,2; Uppsala University, Sweden; 2Inst. of Nanoscience and Physics, Astronomy and Technology, Poland. We present optical frequency comb Fourier transform spectroscopy of the entire CO2 band at 5.3–5.4 µm by the background- and calibration-free dual-comb phase spectroscopy technique. The phase spectrum of methane is coherently averaged for 11 s and fit using a model developed for this purpose.

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. The dual-comb spectroscopy is demonstrated for the first time.

We present recently obtained high performance planar comb Faraday rotation spectroscopy measurements using optical frequency comb Faraday rotation spectroscopy technique. 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.

We report high performance planar comb Faraday rotation spectroscopy measurements using optical frequency comb Faraday rotation spectroscopy technique. 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.

Optical Frequency Comb Faraday Rotation Spectroscopy, Jonas Westberg1,2, Alexander C. Johansson1, Gerard Wysocki1, Aleksandra Foltynowicz1, Dept. of Electrical Engineering, Princeton Univ., USA; 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. The phase spectrum of methane is coherently averaged for 11 s and fit using a model developed for this purpose.

Cavity-enhanced dual-comb phase spectroscopy, Nazanin Haghgoohi1, Robert Wright1, William Swaminathan1, Ian Coddington1,2, Aimi Abebasi1,2; Meyer Burger Research AG, Switzerland; 2Inst. of Nanoscience and Physics, Astronomy and Technology, Poland. We present optical frequency comb Fourier transform spectroscopy of the entire CO2 band at 5.3–5.4 µm by the background- and calibration-free dual-comb phase spectroscopy technique. The phase spectrum of methane is coherently averaged for 11 s and fit using a model developed for this purpose.

Invited: Dual-frequency Comb Spectroscopy for Dynamic, High-pressure Combustion Systems, Ryan Cole1, Nazanin Haghgoohi1, Anthony Draper1, Robert Wright1, Jeffrey Mohr2, Andrew Zdanowicz2, Anthony Marchese1, Gregory B. Rieker1; Univ. of Colorado Boulder, USA; 2Colorado 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.

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. The phase spectrum of methane is coherently averaged for 11 s and fit using a model developed for this purpose.

Invited: Atmospheric Correction of Airborne Hyperspectral Remote Sensing Data for Inland Water Applications, Sandip Banerjee1, Palarivastu Sharmugam2,1; 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.

Recent Advances in AERI Data Processing: Real-time Quality Control and Real-time Thermodynamic Retrievals, Jonathan Gero1, David Turner2, Raymond Garcia1, Coda Phillips1, Alex Diebold1, Denny Hackel1, Matthew Westphall1, Univ. of Wisconsin-Madison, USA; 2ESRL, 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.

Improving the Full Waveform Digitizing in an Eight Channel Portable Hyperspectral Lidar, Tuomo Mäkäläinen1, Sanna Kaasalainen1, Julian Ilincis1, Pinnash Geophysical 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.
Realization of Colors and Patterns for Inkjet-Printed Perovskite Solar Cells, Stefan Schliske1, Florian Mathes1,2, Dmitriy Busko1, Noah Strube1,2, Tobias Rödlmeier1,2, Uli Lemmer1, Ulrich W. Paetzold1, Gerardo Hernandez-Sosa1, Efthymios Klimapas1, Bryce S. Richards1, Karlsruhe Inst. of Technology, Germany; InnovationLab GmbH, Germany; 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.

A Novel Rapid Scanning Fourier Transform Spectrometer for the Measurement of Electron Cyclotron Emission in a Plasma Fusion Reactor, David A. Naylor1, Brad Gom1, Sudhakar Gunuganti2, Trevor Fulton2, Hitoshi Pandy2, Vinay Kumar3, Univ. of Lethbridge, Canada; ‘Blue Sky Spectroscopy’, Canada; ITR-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.

Time-domain Measurement of the Complex Chiro-Optical Susceptibility via Fourier-Transform Spectroscopy using an Ultra-stable Common-path Interferometer, Fabrizio Preda1,2, Antonio Penn1,2, Julien Reault1, Cristian Manzoni1, Soumen Gosh1, Jan Helbing2, Giulio Cerullo1,2, Dario Poll2,1; Politecnico di Milano, Italy; NIREOS s.r.l., Italy; Università Bern, Switzerland; 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.

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 Inglis, 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
Joint

LEO Foyer

09:30–10:30

JT2A • Poster Session with Coffee Breaks and Exhibits

JT2A.1 Variability InTransient Climate Response InThe MPI Grand Ensemble And Its RelationTo The Radiative Effect Of Sea Ice Loss, Andrew E. Dessler1;2, Texas A&M Univ, USA. Transient climate response (TCR) is one way to measure sensitivity of the Earth’s climate to increased 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. Bazhanov1,2; ‘PC “SPI "Geofizika-Kosmos”, Russia. The report presents the composition, technical characteristics and design of scientific equipment, as well as the 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. Bazhanov1,2; ‘PC “SPI "Geofizika-Kosmos”, Russia. Design of optical system, containing two mirror off-axis telescope and Offner spectrometer with freeform mirror usage is presented in this paper. For off-axis design, Wolfram© 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 Yan1, Bin Chai1, Xiaodan Zhang1, Ying Zhao1, Xiaodan Zhang1, Nan Guo1,5; 1PC “SPI "Geofizika-Kosmos”, Russia. The design and fabrication of the AR coatings with an antireflection layer in perovskite/silicon tandem solar cells. The PP-MDMS layer exhibit a higher average haze ratio (H) mainly originated from the uneven random distribution.

JT2A.5 Sunlight Harvesting System for Simultaneous use of Room Indoor Lighting and Water Heating, Mayank Gupta1,2; 1PC “SPI "Geofizika-Kosmos”, Russia. We present the implementation of triple layer antireflection coatings helps to reduce front reflection and allows improvement of absorbance ~0.2% efficiency of n-FAB solar cells.

JT2A.6 Light Trapping Enhancement in Perovskite/Silicon Tandem Solar Cells via Optimized PDMS as an Antireflective Layer, Hufan Hou1,2, Can Han1,2, Li1; 1Univ. of Tokyo, Japan; 2 Key Lab of Environmental Optics and Technology, Chinese Academy of Sciences, China. We studied Shingling module reliability and found that ECA quality could influence the module reliability. This work focuses on the influence of the bubbles in the ECA on the reliability of module.

JT2A.7 Design of Smart Cooling System for Solar Panel on Performance Efficiency with Internet of Things (IoT), Lay-Theng Tan1; 1School 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 Russo1,2, Francesco Di Giambenedetto1, Matteo Monti1,2, Davide De Maio1,2, Francesco Di Giamberardino1,2, Matteo Monti1,2, An optical system was designed and driven by a shape memory alloy (SMA) actuator. Lenses could collect the solar energy to heat the SMA to realize a mechanical motion and switch the system phase.

JT2A.9 Angle-Selection with Sub-Unity Index in Solar Cells, Ken Xinyue Wang1; 1Huazhong Univ of Science and Technology, Anhui Inst. of Optics and Fine Technology, Anhui Inst. of Optics and Fine Technology, China. A series of experiments have been carried out to characterize the instrument performance and the detection limit of HOx.

JT2A.10 ECA (Electrical Conductive Adhesive) Induced Failure On Shingling Module, Juan Wang1,2, Ziqiu Guo1,2, Hao Jin1,2, Zieyong Jinkosolar Co., Ltd, China. We studied Shingling module reliability and found that ECA quality could influence the module reliability. This work focuses on the influence of the bubbles in the ECA on the reliability of module.

JT2A.11 Solar Energy Actuated Optical Mechanism, Li Hui1,2, Hongxu Xu1,2, Masatoshi Ishikawa1; 1Univ. of Tokyo, Japan; 2 Faculty of Science and Technology of China, China. The active optical system was designed and driven by a shape memory alloy (SMA) actuator. Lenses could collect the solar energy to heat the SMA to realize a mechanical motion and switch the system phase.

JT2A.12 Retrieval optical parameters of atmospheric particles based on active DOAS, Suwen Li1,2, Huabei 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, Sew Yee Lim1,2, Cheryl Suwen Law1,2, Abel Santos1; 1Univ. of Adelaide, Australia; 2Univ. of Science and Technology of China, China. The photonic efficiency of this composite material improves photocatalytic performance of a rationally designed nanoporous anodic alumina gradient-index filters functionalized with photocative titanium dioxide. The photonic efficiency of this composite material improves photocatalytic performance of a rationally designed nanoporous anodic alumina gradient-index filters functionalized with photocative titanium dioxide. The photonic efficiency of this composite material improves photocatalytic performance of a rationally designed nanoporous anodic alumina gradient-index filters functionalized with photocative titanium dioxide.

JT2A.14 Application of Nano-TiO2 Coating in a Rooftop Hydroponic Farming System, Lay-Theng Tan1,2; 1Republic Polytechnic, Singapore. This paper presents the effectiveness of nano-TiO2 coating in 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, Niu Li1,2, Huaqiao Gu1,2, Jingguo Liu1,2, Minxia Gao1,2, Jiaojiao Zhang1,2, Tonghui Yu1,2, Ying Chen1,2; 1 Key Lab of Environmental Optics and Technology, Anhui Inst. of Optics and Fine Mechanics, Chinese Academy of Sciences, China; 2Nanjing Tech Univ, China. The inorganic compounds in PM2.5 aerosols were measured using ATR-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 HOx by A FAGE Instrument, Yihu Xu1,2, Renhu Hu1,2, Pinhua Xie1,2, Hao Chen1,2, Fengyang Wang1,2, Zhiyan Li1,2, Huawei Jin1,2, Anhui Inst of Optics and Fine Mechanics, China; 1School of Environmental Science and Optoelectronic Technology, Univ. of Science and Technology of China, China. An instrument for measuring atmospheric HOx has been developed by FAGE technique. A series of experiments have been carried out to characterize the instrument performance and the detection limit of HOx.

JT2A.17 OH radical field observation based on Fluorescence Assay by Gas Expansion technique, Fengyong Wang1,2, Renshi Hu1,2, Hao Chen1,2, Pinhua Xie1,2, Yihu Xu1,2, Zhiyan Li1,2, Huawei Jin1,2; 1Anhui Inst of Optics and Fine Mechanics, Chinese Academy of Sciences, China; 2Univ. 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 N2O Using an External-Cavity Quantum Cascade Laser, Faisal Nadeem1,2, Amir Khodabakhsh1,2, Julien Mandon1, Simona Cristescu1,2, Faisal J. M. Harren1; 1Radboud 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.
Tuesday, 6 November

**JT2A.19** Optical Monitoring of N$_2$O in a Nocturnal Tropospheric Chemical Reaction Process using Quantum Cascade Laser, Weidong Chen$^{1}$, Université du Littoral, France. A spectroscopic instrument based on an external cavity quantum cascade laser was developed to optically monitor N$_2$O in the ppb-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$^{1}$, Université du Littoral, France. An mid-infrared laser heterodyne radiometer was 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, Changying Zhao$^{1}$, Boxiang Wang$^{1}$, Jinshi Gao$^{1}$, Shaoqiang Chen$^{1}$, Junhao Chu$^{1}$, Xiobin Hu$^{1}$, A Frequency Comb, and the Tunable Frequency-Division Multiplexing Fabry-Perot Interferometer (T-FDMPFI), Japan. The aim is to reduce forecast uncertainty by introducing a lock-in detection in dual-comb spectroscopy.

**JT2A.22** Interference-free Measurements of Environmental NO$_2$ by Laser Photoacoustic Spectroscopy, Weidong Chen$^{1}$, Université 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-Equalized Solution-Processed Pure-Inorganic Lead Halide Perovskite, Xinri Zhang$^{1}$, Huafeng Shi$^{1}$, University 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 Guo$^{1}$, Huaqin Wang$^{1}$, Wei Wan$^{1}$, Fajun Yu$^{1}$, Jinguo Liu$^{1}$, Liang Li$^{1}$, Anhui Inst Optics & Fine Mech, CAS, China. A 90° scattering on absorption in disordered media is developed. The system uses the classic 90° particle size measurement technique, which has a high sensitivity and precision.

**JT2A.25** Dependent Scattering Effect on Light Absorption in Random Media, Boxiang Wang$^{1}$, Shaoqiang Chen$^{1}$, Junhao Chu$^{1}$, Xiobin Hu$^{1}$, A Frequency Comb, and the Tunable Frequency-Division Multiplexing Fabry-Perot Interferometer (T-FDMPFI), Japan. 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$^{1}$, Kyoko Shibuya$^{1}$, Akifumi Asahara$^{2}$, Takanori Minamikawa$^{1}$, Kazuo Minoshima$^{2}$, Takeda Yasui$^{1}$, Tohoku University, Japan; JST, ERATO MINOSHIMA Intelligent Optical Synthesizers, Japan; 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$^{1}$, Rufeng Kan$^{1}$, 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. Hoppler$^{1}$, Tobias Kölling$^{1}$, Felix Gödde$^{1}$, Manuel Gutleber$^{1}$, Marek Jacobs$^{2}$, Tobias Zinner$^{1}$, Berhard Mayer$^{1}$, Ludwig Maximilian University of Munich, Germany; Deutsches Zentrum für Luft- und Raumfahrt, Institut für Physik der Atmosphäre, Germany. We present a 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 Reflective Index Spectroscopy of Entire Molecular Bands Using a Frequency Comb, Alexandra C. Johansson$^{1}$, Thomas Hausermann$^{2}$, Gang Zhao$^{3}$, Dve Aaren$^{1}$, Alexandra C. Johansson$^{1}$, a Frequency Comb, and the Tunable Frequency-Division Multiplexing Fabry-Perot Interferometer (T-FDMPFI), Italy; 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.30** Study of defects in Sb$_2$Se$_3$ 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 Sb$_2$Se$_3$ solar cells were studied in detail by admittance measurements. Correlations of defects properties to the performance of the solar cells have been discussed.
Optics in Solar Energy

10:30–12:15

1STD • Perovskite and Metal Halide Emitters

Presider: Qihua Xiong; Nanyang Technological Univ., Singapore

ST3D 1 • 11:00

Invited

Stability Enhancement in Perovskite Light-Emitting Materials, Zhi Xuan Tan1; 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.

OT3C 1 • 10:30

On the near-infrared parasitic absorption in large-area monoPoly™ silicon solar cells, Shubham Duttagupta2, Naomi Nadakumaran1, John Rodriguez1; Solar Energy Research Inst. of Singapore (SERIS), National Univ. of Singapore (NUS), Singapore. Crystalline silicon (c-Si) solar cells with monofoil poly-silicon-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. Lai1, Chuan Seng Tan1, Fun Chong Ang1, Zhi Ming Kam1, Armin G. Aberle1, Ying Huang1; 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 CHEN1, Xia Yan1, Frida Bin Suhami1, Lin Zhang1, Xinmin Gong1, Xinya Zhang1, Shubham Duttagupta2; SERIS, National Univ. of Singapore, Singapore; 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 Jsc of n-Fab cells increased by -4mA/cm2, and over 9% bifacial factor achieved.

OT3C 4 • 11:30

Small-area p-type PERC Silicon Solar Cells for Tandem Applications, Maung Thway2, Tanyun-an Liu1, Mei Huang1, Gangming Ke1, Xin Rin Ng2; Balaji Nagaranjan1, Xia Yan1, Shubham Duttagupta2, Rolf Stangl1, Soo Jin Chua1, Armin G. Aberle1, Serena Fen Lin1; Solar Energy Research Inst. of Singapore, Singapore; 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 4-inch-wide solar cells fabricated using industrial tools.

ST3D 3 • 11:00

Invited

Arrays of Multi-Color Emitting Cesium Lead Halide Perovskite Nanocrystals and Efficient White Light Generation by Tailored Anion Exchange Reactions and Electrohydrodynamic Jet Printing, Yemiha Attilats1, liker Turan2, Ahmet Faruk Yagiz1, Emre Beskazak1, Serdar Onsen1, Eren Mutlugun1; Abdullah Gul Univ., Turkey; 1Univ., 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.
ET3A.5 • 11:45
Detection of atmospheric boundary layer height based on the Scheimpflug Lidar technique, Mei L. Li1, Lihan Zhang2, Liang Mei3, Da-lian 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 Qiu1, Hayun Xiu2, Chao Yu3, Chong Wang4, Xiantang Dou5, 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 Wu1,2, Jinshao Wang3, Jintao Liu4, Bingyi Liu5, Haiyun Xia1, Chao Yu1, Ocean Univ. of China, China; 1Lab 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.

FT3B.5 • 12:00
Excitation-Emission Fluorescence Spectroscopy with Single Molecule Sensitivity Using a Common-Path Interferometer, Antonio Penna1,2, Fabrizio Predis3,4, Juergen Hauer2, Erling Thyrhaug1, Stefan Krause1, Tom Vočk1, Giulio Cerullo1,2, Dario Polli5,4, Fakultät für Chemie, Technische Universität München, Germany; 1Photonics Inst., Austria; 2Nanoscience Center, Denmark; 3NIREOS s.r.l., Italy; 4Politecnico 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.

OT3C.5 • 11:45
Mie resonators as rear-side light trapping structures in planar crystalline silicon solar cells, Alexander N. Spraker1,2, Michael Pollard2, Peter Pechalla3, Ralf B. Wehrspohn1,2, Inst. of Physics, Martin Luther Univ. Halle, Germany; 1School of Photovoltaic and Renewable Energy Engineering, Univ. of New South Wales, Australia; 2Fraunhofer IWS, Germany. Mie resonances of high-refractive index nanostructures provide strong and spectrally broadband scattering. In this numerical work, we investigate the feasibility of amorphous silicon nanodisks at the planar rear side of crystalline silicon solar cells for light trapping.

OT3C.6 • 12:00
Explicit Determination of the Current Loss Mechanisms in Textured Si Solar Cells, Hiroki Fujiiwara1,2,1-1 Yanagidori, 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.

ST3D.5 • 12:15
Efficient Perovskite Light-Emitting Diodes via Interface and Composition Engineering, Jingbi You1, 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).
imagery of a cotton field, Omer Sapir1,3, Iftach ET4A.4 • 14:30
Artium Dashuta1,2, Yield of a Breeding Process, Melon Recognition in UAV Images to Estimate Liang Mei1; Iftach Klapp 1; Heejoo Choi1, Dae Wook Kim1, Chuan Luo 1, Eunmo Kang 1, YoungSik Kim 1, Alonzo Espinoza1, Paul Winkler1, Cameron Perl1, Guanghao Chen 1, Braden Smith 1, Adley Gin 1, performed on a near-ground path in urban area has been developed for real time monitoring A dual-wavelength Scheimpflug lidar system segmentation enables recognizing outbursts dictionary learning with variational method city, Israel.

ET4A.1 • 13:30
MEMS-based imaging LIDAR, Yuzuru Takashima1, Brandon Hellman1, Joshua Rodriguez1, Guang Hao Chen1, Braden Smith1, Adley Gin1, Alonzo Espinoza1, Paul Winkler1, Cameron Perl1, Chuan Luo1, Eunmo Kang1, Young Sik Kim1, Heejoo Choi1, Dae Wook Kim1; 1Univ. 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, Arnut Dashuta1, Iftach Klapp1, 1ARO-Volcani Center, Israel; 2Electrical Eng., Tel Aviv University, 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 Mi-scattering Scheimpflug lidar for particle size measurements, Zheng Kang1,2, Teng Ma1, Liang Mei1, 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 macromolecules in aerial imagery of a cotton field, Omer Sapir1,3, Iftach Klapp1, Anela Niv1, Michal Axelrod1, Nir Sochen1, 1ARO-Volcani Center, Israel; 2The Israel Cotton Board Ltd, Israel; 3Applied Math, Tel Aviv University, Israel. A novel algorithm combining sparse dictionary learning with variational method segmentation enables recognizing outbursts of macromolecules in cotton field images taken from a drone.

OT4C.1 • 13:30
Bringing Light to Solar Absorbers: Nano- and Microoptical Concepts for Chalcopyrites and Beyond, Martina Schmid1,2, Phillip Manley1, Guanghao Yei1, Universitat Duisburg-Essen, Germany; 3Heinrich-Zentrum Berlin, Germany. The improved incoupling of light to solar absorbers is shown via the examples of light concentration on Cu(InGa)Se2, micro cells, SiOx nanoparticles on CdS, and nanostructures on top of silicon photoelectrodes.

OT4C.4 • 14:30
InterfaceModification in Type-II ZnCdSe/ZnCdTe QDs for High Efficiency Intermediate Band Solar Cells, Vasilios Deligiannis1, Siddharth Dhomkar1, Marcel Claro1, Igor L. Kuskovsky4, Maria Tamargo1,2; 1The City College of New York, USA; 2The Graduate Center of the City Univ. of New York, USA; 3The Graduate Center of the City Univ. of New York, USA; 4Physics, Queens College, CUNY, USA. A new growth sequence of ZnCdSe/ZnCdTe 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.
Towards, Multi-purpose system for spatial and hyperspectral sampling of crop from a moving platform, Or Arad; Iftach Klapp; ARO-Volcani Center, Israel; '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 ~3 times higher than standard aerial survey.

Design rules for birefringent lateral shearing interferometers. Yann Ferrec; Hervé Sauzet; Armande Pola Fossi; Nicolas Guérineau; Office Nat’l d’Etudes et Rech. Aérospatiales, France; Laboratoire Charles Fabry, Institut d’Optique Graduate School, France. Birefringent lateral shearing interferometers may be key elements for compact hand etendue imaging static FTS. We developed a tool to simulate propagation in a stack of birefringent plates, and established design rules for such interferometers.

A FTS system for on-line analysis of the raw materials of cement, Rong Hu; Xu Liang; Wengqin Liu; Jianguo Liu; Jing jin; Weifeng Yang; Yuhao Wang; Univ. of Science and Technology of China, China; Key Lab of Environmental Optics and Technology, Antun 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.

We developed a tool to simulate propagation in a stack of birefringent plates, and established design rules for such interferometers.

We describe a Fourier Transform Spectroscopy (FTS) system for on-line analysis of the raw materials of cement, Rong Hu; Xu Liang; Wengqin Liu; Jianguo Liu; Jing jin; Weifeng Yang; Yuhao Wang; Univ. of Science and Technology of China, China; Key Lab of Environmental Optics and Technology, Antun 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.

Design rules for birefringent lateral shearing interferometers. Yann Ferrec; Hervé Sauzet; Armande Pola Fossi; Nicolas Guérineau; Office Nat’l d’Etudes et Rech. Aérospatiales, France; Laboratoire Charles Fabry, Institut d’Optique Graduate School, France. Birefringent lateral shearing interferometers may be key elements for compact hand etendue imaging static FTS. We developed a tool to simulate propagation in a stack of birefringent plates, and established design rules for such interferometers.
**ET5A.1 • 16:00 Invited**

Multi-species DIAL remote gas detection using nested cavity optical parametric oscillators, Julie Armougou1, Thomas Hamoudi2, Jean-Baptiste Dherbecourt1, Jean-Michel Melkanian1, Antoine Godard1, Myram Raybaut1, OPPT, Onera, The French Aerospace Lab, France. Multi-species 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 multi-species DIAL.

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**ET5A.2 • 16:30**

QCL Absorption Spectroscopy for Lightweight and Multi-Species Environmental Applications, Lukas Emmenegger1, Badruin Stanicki1, Manuel Graf1, Philipp Scheidegger2, Morten Hundt3, Jerome Faist1, Filippos Kapasidias1, Herbert Looser1, Mehran Shahmohammadi2, Béla Tuzson1, EMPA, Switzerland; 2ETHZ, 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.

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**ET5A.3 • 16:45 Invited**

Laser spectroscopy for the monitoring of radioactive emissions from nuclear facilities, Pauline Guiond1, MIKES Metrology, VTT Technical Research Centre of Finland Ltd, Finland; 2Dankook Univ., South Korea. The use of lasers as detection tools for the measurement of radioactive emissions from nuclear facilities is highly promising. This session will present recent developments and applications of laser-based spectroscopy for this purpose.

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**ET5B.1 • 16:00 Invited**

The Tropospheric Emission Spectrometer: From Discovery Mission to Earth System Sounding, Kevin W. Bowman1, 2Jet Propulsion Lab, USA; 3Joint 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.

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**ET5B.2 • 16:30**

Investigating N2O produced in the mesosphere–lower thermosphere and its transport to the middle atmosphere, Patrick E. Shrieve1, Kyle A. Walker2, Chris D. Boone1, Monika Andersson3, Daniel Marsh1, Christopher Kelly2, Wuhu Feng3, Martin Chipperfield4, and John Plane5. N2O is a powerful greenhouse gas and a precursor to the formation of ozone-depleting halogen compounds. This paper will describe a comprehensive study of N2O production and transport in the mesosphere–lower thermosphere.

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**ET5B.3 • 16:45**

An Application of Extractive FTIR for Monitoring Greenhouse Gas Emissions, Chuling Deng1, Jingjing Tang1, Mingqiang Gao1, Xiaoping Liu1, and Yanga Shi1. This paper presents a novel application of extractive FTIR spectroscopy for the monitoring of greenhouse gas emissions, focusing on the extraction and analysis of CO2 and CH4 from complex environments.

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**ET5B.4 • 17:00 Invited**

IASI satellite observations: best-of 2017-2018, Sarah Saffred1, Cathy Clerbaux2, Anne Boyard2, Maya George2, Juliette Hadji-Lazaro2, Viatte Camille2, Lieven Clarisse1, Martin Van Damme1, Pierre-Francois Coheur2, LATMOS-IPSL, Paris, France; 3ULB, Belgium. This talk presents the latest results of the IASI instruments: we talk about what can be achieved in terms of pollutants monitoring, such as ozone, carbon monoxide, ammonia, sulfur dioxide, and we show the skin temperature product and the urban heat islands detected by IASI.

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**OTSC.1 • 16:00 Invited**

Using Machine Learning to Rapidly Diagnose the Root Causes of Underperformance in Early-Stage Solar Cells, Torinio Buonassisi1, Martin-Luther Univ. Halle, Germany. 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.

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**OTSC.2 • 16:30**

Rigorous Wave-Optical Simulation of Photon Recycling in Nanostuctured Perovskite Solar Cells, Stefan Nana1, Raphael Schmager1, Aimi Abas2, Muluneh Abebe1, Guillaume Gozard1, Ulrich W. Paetzold1, Carsten Rockstuhl2, Karlruhe Inst. of Technology, Germany. We present a rigorous optical simulation of photon recycling in a nanostuctured perovskite layer stack resembling a solar cell. Relevant emission characteristics such as the fraction of recycled light and far-field angular spectrum are deduced.

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**ST5D.1 • 16:00 Invited**

New Applications of Organic LEDs in Biophotonics, Caroline Murawski1, Andreas Mischok1, Chongmin Keum1, Dinesh Kumar2, Stefan F. Pulver1, Malte C. Gather1, Univ. of St Andrews, UK; 2Kurt 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.

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**ST5D.2 • 16:30**

Dynamic Photometric System for Solid State Lighting to Preserve the Dark Sky, Rohan Nag2,3; Lighting Application Design, Regent Lighting, India; 4Lighting 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.

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**ST5D.3 • 16:45**

LED-based Extended White Light Source to Reduce the Heating Effect on YAG:Ce3+ Phosphor, Atul K. Dubey1, Mayank Gupta1, Virenda Kumar1, Dalip S. Mehra1, VIT Delhi, India. We report an extended white light source containing a small cylindrical acrylic diffuser coated with YAG:Ce3+ phosphor and excited by blue LED. This design supports remote phosphor coating technique to prevent quenching of YAG:Ce3+.
<table>
<thead>
<tr>
<th>Session</th>
<th>Title</th>
</tr>
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<tbody>
<tr>
<td>ETSA.4 • 17:15</td>
<td>On-line monitoring of heavy metals in industrial wastewater by laser induced breakdown spectroscopy, Nan J. Zhao, Key Lab of Environmental Optics and Technology, Anhui Inst of Optics and 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.</td>
</tr>
<tr>
<td>ETSA.5 • 17:30</td>
<td>Planar Bragg grating sensor for the detection of CFC-11, Maiko Girschikofsky, Dimitrij Ryvlin, Applied Laser and Photonics Group, Univ. of Applied Sciences Aschaffenburg, Germany; (^1)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.</td>
</tr>
<tr>
<td>FTSB.5 • 17:30</td>
<td>Open-Path Fourier Transform Infrared (OP-FTIR) Spectroscopic Measurements of Atmospheric Composition, Aldana Wiaczek, Taiwan Gray, Morgan Mitchell, Cameron Powell, Ian Ashpole, (^2)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.</td>
</tr>
<tr>
<td>FTSB.6 • 17:45</td>
<td>A new method to estimate emission strength for point source with Onboard Solar Occultation Flux-Fourier Transform Infrared Spectroscopy System, Xin Han, Xiangxian Xin Han, (^2)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.</td>
</tr>
<tr>
<td>STSD.5 • 17:15</td>
<td>Micro-photoluminescence Measurements and Analysis of Low Efficiency in Green Light-Emitting Diodes, (^1)Gwangju Inst. of Science &amp; 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.</td>
</tr>
</tbody>
</table>
Recent Advances in Flexible Electronics, Wei Huang, 1,2 Shaarxi 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.

Advances and Advantages of the Fourier Transform Spectrometer (FTS) for infrared remote sensing in support of Numerical Weather Prediction (NWP) and establishing a longterm record of climate trends, Henry E. Rosecomb, 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.

Solar Irradiance Variability: Current Understanding from Observations and Future Directions for Model Improvements, Odelle M. Coddington, 1, Judith Lean, 2 Peter Pilewskie, 1 Martin Gerken, 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.

Temperature Dependence of Raman Linewidth on Wide Bandgap Semiconductor GaN by Micro-Raman Spectroscopy from RT up to 573K. We have evaluated the line broadening of E2 at high temperatures in GaN by Micro-Raman Spectroscopy. We have also evaluated the line broadening of E2 at high temperatures in GaN by Micro-Raman Spectroscopy. We have also evaluated the line broadening of E2 at high temperatures in GaN by Micro-Raman Spectroscopy.

Third-order nonlinearity by the plasmon-induced inverse Faraday effect, Chol-Song Ri, 1 Song-Jin Im, 1 Ji-Song Paek, 1, Kum-Song Ho, 1 Joachim Hermann, 1 Kim Il-Sung Univ., North Korea. 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.

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

Room 1
Optics and Photonics for Energy & the Environment

Room 2
Fourier Transform Spectroscopy

Room 3
Hyperspectral Imaging and Sound of the Environment

Room 4
Solid-state Lighting

FW2B.1 • 10:30
Geostationary Interferometric Infrared Sounder (GIIRS) for Chinese Meteorological Satellites (FY-4A and beyond), Lei Ding, 1 Jianwen Hua, 1 Changesi Han, 2 Liwei Sun, 2 Zhang Wang, 2 Xiangyang Liu, 1 Shanghai Inst. of Technical Physics CAS, China; 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 introduced. The specification, design and performance of this payload are introduced while the upcoming features of the next one are shown here.

HW2C.1 • 10:30
Solar Irradiance Variability: Current Understanding from Observations and Future Directions for Model Improvements, Odelle M. Coddington, 1 Judith Lean, 2 Peter Pilewskie, 1 Martin Gerken, 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.

HW2C.2 • 10:30
A Fast Hyperspectral Radiative Transfer Model, Jiachen Ding, Ping Yang, Michael King, 1 Steven Platnick, 2 Kerry G. Meyer, 2 Texas A&M Univ., USA; 2 NASA Goddard Space Flight Center, USA. A fast hyperspectral radiative transfer model is developed for applications to hyperspectral atmospheric and oceanic remote sensing in the VNIR-regime. Gaseous absorption and multiple scattering with full polarization are considered in the model.
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, Jingyan Li 1, Luyun Yang 1, Haoming Li 1, Jinggang Feng 1, Nengli Dai 1, Yi Wang 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
Trace Gas Spectroscopy on a Chip with Mid-Infrared Photonic Waveguides, Jana Jagerská 1, Marek Vlk 1, Vinita Mittal 2, Senthil Murugan 2, Jonna 2, Martina Vrbáková 1, 1Dept. of Molecular and Biophysics, Aristotle University of Thessaloniki, Greece; 2ORC, Univ. of Southampton, UK. The potential for trace gas detection in mid-infrared (MIR) applications is demonstrated using specially designed MIR waveguides and on-chip pre-concentration of target gases. MIR sources are used to produce a high density of MIR photons in the waveguides, which are then used to detect target trace gases with ultra-high sensitivities.

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. Haren 1, 1Dept. 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 control of agricultural products.

EW2A.6 • 12:15
Interband Cascade Laser-based Dual-Comb Spectroscopy for Methane Sensing, Jonas Westberg 1, Lukasz A. Sterczewski 2, Mahmood Bagheri 1, Clifford Frez 2, Igor Vurgaftman 3, Chadwick L. Canedy 4, William Belew 2, Charles D. Metz 1, Chul Soo Kim 5, Mijn Kim 5, Jerry R. Meyer 2, Gerard Wysocki 2, 1Dept. of Electrical Engineering, Piscataway, NJ, USA; 2Naval Research Lab, USA; 3KeyW Corp, USA. We demonstrate methane and hydrogen chloride measurements around 3.6 µm using dual-comb spectroscopy with a free running interband cascade laser frequency comb 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
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, 1Space Science and Engineering Center, Univ. of Wisconsin-Madison, USA. A model of the potential polarization induced calibration bias is presented, along with details of the model parameter determination, and the predicted impact of the correction on the calibrated radiances.

FW2B.4 • 12:00
A Highly Accurate Correction for Self-Apodization Effects on Fourier Transform Spectrometer Spectra, Jonathan Gero 1, Henry E. Revercomb 1, David Tobin 1, Robert Knuteson 1, 1Univ. of Colorado, Boulder, USA; 2Lawrence Berkeley National Lab, USA; 3Lab for Atmospheric and Space Physics, USA; 4Univ. of Colorado, Boulder, USA; 5Science Systems and Applications, Inc, USA; 6Univ. of Illinois at Urbana-Champaign, USA. We demonstrate a highly accurate correction for self-apodization in Fourier transform spectrometers, which is critical for accurate retrieval of atmospheric properties from remote sensing data.

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 Lu 1, 1NASA 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
Unraveling Earth’s Climate Change Mysteries from Space: What do we need from our measurements?, Yolandia Sheal 1, Daniel Feldman 2, Peter Filewski 1, Sheng-Ying Lai 1, Seiji Kato 1, Larry Di Girolamo 6, Bruce Wielicki 1, 1NASA Langley Research Center, USA; 2Lawrence Berkeley National Lab, USA; 3Lab for Atmospheric and Space Physics, USA; 4Univ. of Colorado, Boulder, USA; 5Science Systems and Applications, Inc, USA; 6Univ. 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 images, Dorukalp Durmus 1, Wendy Davis 1, 1Univ. of Sydney, Australia. Visual experiments were conducted to quantify blur acceptability in projection systems using complex images. Results show a statistically significant (99% confidence) increase in blur perception when the circle of confusion increases 3%.
Optics and Photonics for Energy & the Environment

13:30–15:30
FW3A • Fundamental Measurements for Energy & the Environment
Presider: Gregory Rieker; Univ. of Colorado at Boulder, USA

FW3A.1 • 13:30
Re- vibrational analysis of ammonia at 6.2 µm using high-precision cavity ring-down spectroscopy, Sanchi Maithani1, Nahijit Maity2, Mithun Pal3, Manik Pradhan1; 1S 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 a high-resolution and high-sensitive molecular spectroscopic study of ammonia molecule in the spectral region covering 6.0-6.3 µm.

FW3A.2 • 13:45
Accurate Optical Measurements of Stable and Radioactive Carbon Isotopologues of CO2, Adam J. Fleisher1, David A. Long1, Hongming Yi1, Qingnan Liu2, Zachary D. Reed1, Joseph T. Hodgkins2, Mithun Pal1; 1NIST, USA. We report the cavity ring-down spectroscopy of 13C, 12C isotopologues of CO2 in the near- and mid-infrared, measurements which yielded accurate transition intensities, mole fraction determinations, and isotope ratios.

FW3A.3 • 14:00
Transition Frequency Measurements of the 2v, 6v Manifold of Methane, Yang Lei1,2, Hong Lin2, Xiaofang Feng1, Jintao Zhang1, Tsinghua Univ., China; 2National Inst. of Metrology, China.

FW3A.4 • 14:15
Experimental 1.5-1.6 µm Water Line List at 1950 K, Lucile Rutkowski1, Aleksandra C. Johansson1, Amir Khodabakhsh1, Aleksandra A. Kyubenis2, Nikolai F. Zobov1, Oleg L. Polyansky2, Sergey Yurchenka1, Florian M. Schmidt3, Nicholas Lyons1, Kyung-Jo Kim1, Robert A. Norwood6; 1Harvard-Smithsonian Center for Astrophysics, USA; 2Synhelion SA, Switzerland.

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
The SPICA Safari Fourier Transform Spectrometer, David A. Naylor1, Brad Gorn2, Ian Veenendaal3, Dennis van Loon4, Willem Jellema4, Peter Reissl5; 1SRON Netherlands Inst. for Space Research, Netherlands; 2Kapteyn Astronomical Institute, Netherlands; 3ABB, Switzerland; 4Synhelion SA, Switzerland.

13:30–15:30
FW3C • Hyperspectral Imaging of Aerosol and Trace Gases I
Presider: Ka Lok Chan; DLR Oberpfaffenhofen Aerospace Center, Germany

FW3C.1 • 13:30
Fine Boundary Layer Characteristics in China in Association with Aerosol Pollution, Jianping Guo1; 1State Key Lab of Severe Weather, Chinese Academy of Meteorological Science, China.

Hyperspectral Imaging and Sounding of the Environment

13:30–15:30
FW3D • Solar Concentrators
Presider: Karin Hinzer; Univ. of Ottawa, Canada

FW3D.1 • 13:30
Concentrating solar thermal power: challenges and opportunities, and the importance of solar field optical quality, Joe Coventry1,2; 1Australian National Univ., Australia; 2Synhelion SA, Switzerland.

13:30–15:30
FW3D.2 • Solar Concentrators
Presider: Gregory Rieker; Univ. of Colorado at Boulder, USA

FW3D.3 • 14:15
Silicone optical elements for cost-effective solar concentration, Sifang Cui1; 1Silicone 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.
Investigation on the potential gas standard of CO₂ based on cavity ring-down spectroscopy, Hong Lin¹, Hai Lin¹, Hai Wu¹, Xiaojun Feng¹, Jianao Zhang¹. National Institute of Metrology, China. The potential gas standard of CO₂ based on cavity ring-down spectroscopy is discussed. The CO₂ standard is a comprehensive solution to the measurement of trace gases in industrial applications.

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.

High-Sensitivity Raman Spectrum Detection, Nanofocusing with Silver-Coated Fiber Tip for Reaction Spectroscopy in a Multi-Pass Photolysis Reactor. The current setup enables line-locked rotational spectroscopy, radicals using wavelength modulated Faraday Rotation Spectroscopy, and cavity-enhanced DOAS (CE DOAS) measurements to produce constant concentration maps of Munich and Hong Kong.

We report measurements of NO₂ and NO₃ using cavity ring-down spectroscopy, Investigation on the potential gas standard of CO₂ based on cavity ring-down spectroscopy, Hong Lin¹, Hai Lin¹, Hai Wu¹, Xiaojun Feng¹, Jianao Zhang¹. National Institute of Metrology, China. The potential gas standard of CO₂ based on cavity ring-down spectroscopy is discussed. The CO₂ standard is a comprehensive solution to the measurement of trace gases in industrial applications.

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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 Martín-Mateos, Cristina de Dios; Pablo Acevedo, 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, Dylan Millet, Kelley Wells, Vivienne Payne, Shanshan Yu, Thomas Pagano, Annmarie Eldering, 1Jet 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.
CO$_2$ and CH$_4$ observations by the thermal infrared band of GOSAT/TANSO-FTS and GOSAT-1/TANSO-FTS-2; Nakato Saitoh, Ryooi Imazu, Kei Shomii, Akihiko Kuze, Masakatsu Nakajima, Yosuke Niwa, Toshinobu Machida, Yosuke Sawa, Hidekazu Matsueda, Kazuhiro Tsuibo, Aki Tsutota; Center for Environmental Remote Sensing, Chiba Univ., Japan; Atmosphere and Ocean Research Inst., The Univ. of Tokyo, Japan; Japan Aerospace Exploration Agency, Japan; National Inst. for Environmental Studies, Japan; Atmospheric Research 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.

Long-term Validation for the Atmospheric Chemistry Experiment Fourier Transform Spectrometer (ACE-FTS), Kaley A. Walker, Patrick E. Sheese, Jianheng Zou, Chris D. Boone; Univ. of Toronto, Canada; 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.

Philippines TCCON Project: One-year Measurement Results and Future, Isamu Morino, Vokarev A. Velazco, Akhiro Horii, Osamu Uchino, Hirofumi Oyama, Tetsu Saka, Yoshinori Izuura, Tomohiro Nagai, Gerry Bagias, Yukio Yoshida, Matthias Kiehl, Beata Bukosa, Nicholas M. Deutscher, Jenny A. Fisher, David W. Griffith; NES, Japan; Centre for Atmospheric Chemistry, Univ. of Wollongong, Australia; Oscar M. Lopez Center for Climate Change Adaptation and Disaster Risk Management Foundation, Philippines; Meteorological Research Inst., Japan; Univ. of the Philippines, Philippines; California Inst. of Technology, USA. We present results of one-year of measurements, some interesting phenomena like CO$_2$ and CH$_4$ enhancements, and comparisons with satellite data at Bungus TCCON site in the Philippines, as well as activities involving participation in aircraft observation campaigns such as EMERG-Asia and NASA CAMP2Ex.

Greenhouse Gas Column Measurements by Ground-Based FTIR, Hirofumi Oyama, Kei Shomii, Nobuhito Kikuchi, Isamu Morino, Akhiro Horii, Tsuneo Matsumaga; National Inst. for Environmental Studies, Japan; 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 FTIRs.
FW5A • 18:15
Imaging FTS Elegant Breadboard for Atmospheric Missions, Fabien Dupont¹, Frederic Grandmont¹, Stephane Lantagne¹, Martin Larouche¹, Louis Jacques¹, Danny Lebreux¹, Kaley A. Walker¹, Ray Nassar³; ¹ABB Inc, Canada; ²Univ. of Toronto, Canada; ³ECCC, 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 Buijs¹, Frederic Grandmont¹, Jean-Francois Lavigne¹; ¹ABB 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.
Key to Authors and Presiders

A

Abass, Aimi - JM4A.3, OTSC.2
Abbas, Muhammad Ali - FM2B.5
Abebe, Muluneh - OTSC.2
Abedzade, Farshad - ST4D.2
Aberle, Armin G.- OM3D.5, OT3C.2, OT3C.4, OWSC.2
Acedo, Pablo - JW4A.2
Ade, Peter - FM3B.6
Agarwal, Shilpi - EM3A.6
Ahmadpanahi, Hamed - OTSC.3
Aho, Timo - JM4A.5
Albrecht, Steve - OT5C.5
Alexander, David - HM3C.5
Altermann, Fabian - OM2D.6
Altintas, Yemilia - ST3D.3
Ammann, M. C - ST4D.4
Ambrosetti, Gianluca - OW3D.2
Andersson, Monika - FT5B.2
Ang, Pun Chong - OT3C.2
Anttu, Nicklas - OT4C.2
Arad, Or - ET4A.5
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