Light, Energy and the Environment 2016 Congress Program

14–17 November 2016
Kongresshalle am Zoo
Leipzig, Germany

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Welcome to the 2016 Light, Energy and the Environment Congress

This comprehensive Congress features six topical meetings that have been collocated to provide attendees a wide range of opportunities to explore the use of optical and photonic approaches to monitor energy usage and the effects energy production has on the environment. Over the next four days we hope to foster timely information exchange between several of the disciplines involved in energy production usage, cost, and environmental and efficiency management. With exciting Plenary and Keynote speakers, stimulating presentations, networking opportunities, and open discussions, the Congress aims to promote the generation of new ideas between researchers, engineers, and managers as we examine the frontiers in the development of optical technologies for energy production, transport, and use.

Fourier Transform Spectroscopy (FTS) focuses on the latest advances in instrumentation and applications of FTS to astronomy and astrophysics, atmospheric science and remote sensing, laboratory spectroscopy, analytical chemistry, bio-medicine, and a variety of industrial applications. Attendees can also expect 47 oral, 12 poster and 13 invited talks covering a range of topics. Jérôme Faist, *ETH Zurich, Switzerland,* is featured as FTS' keynote talk on *Quantum-cascade Laser Frequency Combs and Their Application to Dual-comb Spectroscopy*.

Hyperspectral Imaging and Sounding of the Environment (HISE) seeks innovations in hyperspectral instrumentation and data analysis methods, to study geophysical and atmospheric phenomena, and to advance capabilities for anomaly- and signature-based detection. The scope of HISE continues to expand as hyperspectral measurement and detection systems proliferate. These provide unprecedented opportunities to monitor and understand our planetary system. Fusing hyperspectral observations with other sensing modalities shows great scientific potential and promises enhanced discrimination capabilities. Hyperspectral remote sensing over scales ranging from regional to global, and object/event-oriented to climatological are of interest. All relevant passive, active, imaging, and sounding hyperspectral and related remote sensing programs, technologies, missions, field campaigns, signal processing, applications, validation approaches, basic research are welcome. Additionally, research is solicited that addresses the use of current and future measurements for providing products useful for rapid response efforts to phenomena such as downed aircraft, volcanoes, floods, changes in land cover, snow/ice cover, and treaty violations; also atmospheric events such as biomass burning, tropical storms, trace gases, and heavy aerosol events. Attendees can also expect 22 oral, 5 poster and 14 invited talks covering a range of topics. Keynote speaker Stephen Tjemkes, *EUMETSAT, Germany,* will speak on *Mtg-irs: The Instrument, Its Products and Current User Readiness Activities.*

The **Optical Nanostructures and Advanced Materials for Photovoltaics (PV**) meeting brings together experts in nanophotonics, materials science and photovoltaics to discuss the latest developments in nanophotonic enhancement and nanostructured materials for the next generation of solar cells. This meeting covers all aspects of novel materials and optical nanostructures for photovoltaic applications, from surface textures and diffraction gratings through to emerging topics such as plasmonics, nanowires, quantum dots, and perovskites, among many more. Organizers have assembled an exciting program of 22 invited, 28 contributed oral and 10 contributed poster presentations this year. PV's keynote talk *Optical Properties of Industrially Mass-produced Crystalline Silicon Solar Cells and Prospects for Improvements* will be given by Pietro Altermatt, *Trina Solar Limited, China.*

Optics and Photonics for Energy & the Environment (E2) focuses on monitoring and controlling the generation of energy and its impact on the environment. The conference will showcase optical techniques and instrumentation used in monitoring, sensing, and transmitting information relating to energy and the environment. It will bring together people from industry, university, and government to address environmental impacts of energy production and policies to guide its management. Special emphasis will be on sensor devices for energy, environment, and pollution monitoring, energy usage and transmission (including smart grid technology), and energy efficiency in industry. Attendees can also expect 15 oral, 5 poster and 14 invited talks covering a range of topics. Michael Hardesty, *University of Colorado/NOAA, USA,* will speak on *Lidar Techniques and Applications for Improving Wind Energy Production and Characterizing Pollution from Fossil Fuel-based Energy Generation* as keynote presenter.

The **Optics for Solar Energy (SOLAR)** meeting focuses on optical science and its applications to solar energy conversion, mainly in the areas of solar thermal, concentrating photovoltaics and new-type solar cell such as perovskite solar cell, two dimensional semiconductor devices, organic solar cell, nano-structured semiconductor solar cell and so on, but not limited on the above mentioned novel type SOLAR technology. The program will highlight presentations spanning technology, public policy and finance with 8 invited talks and 5 oral presentations and 1 poster presentation. The SOLAR program features keynote presenter Christian Sattler, *German Aerospace Center, Germany, to speak on Solar Fuels: Specific Requirements for Solar Concentrator Systems.*

Solid-State Lighting (SSL) focuses on new materials and new devices for lighting, including their manufacture and lighting policy. The conference includes all aspects of solid-state lighting, from new materials development and device physics to the design of efficient lighting optics. The meeting features 19 invited, 17 oral, and 10 poster presentations. The SSL meeting keynote presentation *Solid-State Lighting: Opportunities and Challenges* will be given by Klaus Streubel, *Osram Licht AG, Germany*.

The Congress features plenary speaker Shuji Nakamura, *Univ. of California Santa Barbara, USA*. Prof. Nakamura will speak on *The Invention of High Efficient Blue LEDs and Future Lighting* on Monday, 14 November.

In addition to the multitude of exciting technical content, this year's Congress features a multitude of educational, networking, and social events to ensure all congress participants have ample time to engage in important discussions and critical knowledge-sharing. Join us on the evening of Monday, 14 November, for the Congress Welcome Reception at the Leipzig Zoo and Tuesday, 15 November, for the Congress Banquet at Altes Landratsamt. Additionally, an Industry Panel Discussion is scheduled for Tuesday, 15 November, and features a panel on renewable energy to discuss perspectives from politics, research, and industry.

We hope you will join us at all these events and that you enjoy your time in Leipzig.

Committees

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Andreas Tünnermann, *Fraunhofer IOF*, Germany, General Chair
Ralf B. Wehrspohn, *Fraunhofer IMWS*, Germany, General Chair
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Hiroshi Matsuo, *National Astronomical Observatory Japan*, Japan
Luca Palchetti, *Istituto Nazionale di Ottica (CNR)*, Italy
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Hiroyuki Sasada, *Keio Univ.*, Japan
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Carole Tucker, *Cardiff Univ.*, UK
Kaley Walker, *Univ. of Toronto*, Canada

Hyperspectral Imaging and Sounding of the Environment (HISE)

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Michael Yetzbacher, *Naval Research Laboratory*, USA

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Chairs

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Chairs

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Solid-State Lighting (SSL)

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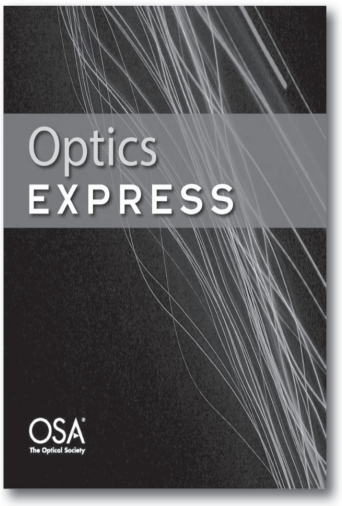
Call for Papers: Feature Issue
LIGHT, ENERGY, AND THE ENVIRONMENT 2016

Submission Opens: 1 December 2016
Submission Deadline: 15 January 2017



This Feature Issue, to be published in the *Energy Express* dedicated section of *Optics Express*, will include expanded papers covering the following topical meetings from the 2016 Light, Energy, and the Environment Congress:

- Fourier Transform Spectroscopy
- Hyperspectral Imaging and Sounding of the Environment
- Optics and Photonics for Energy and the Environment
- Optical Nanostructures and Advanced Materials for Photovoltaics
- Optics for Solar Energy
- Solid-State Lighting

FEATURE ISSUE EDITORS

Jiangguo Liu, *Anhui Institute of Optics and Fine Mechanics, China*

Locke Spencer, *University of Lethbridge, Canada*

Alexander Sprafke, *Martin-Luther University Halle, Germany*

Jianxin Tang, *Soochow University, China*

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For more information, visit the Feature Issues section of oe.osa.org.

General Information

Congress Wireless Internet

OSA is pleased to offer complimentary wireless services throughout the meeting space at the Kongresshalle am Zoo for all attendees.

Network: **OSA**

Username: **OSA100**

Password: **Energy2016**

Registration

South Foyer, Kongresshalle am Zoo

Sunday, 13 November	15:00–18:00
Monday, 14 November	08:00–12:30 13:30–18:00
Tuesday, 15 November	08:00–12:00 16:00–18:00
Wednesday, 16 November	08:00–12:00 13:30–18:00
Thursday, 17 November	08:00–12:00 13:30–16:00

Networking and Coffee Breaks

Monday, 14 November – Thursday, 17 November
Großer Saal, Kongresshalle am Zoo

Light, Energy and the Environment networking and coffee breaks are open to all Congress attendees.

Monday, 14 November	10:00–10:30	Networking and Coffee Break
	16:00–16:30	Networking and Coffee Break
Tuesday, 15 November	10:00–10:30	Networking and Coffee Break
Wednesday, 16 November	10:00–10:30	Networking and Coffee Break
	16:00–17:30	Joint Poster Session and Coffee Break
Thursday, 17 November	10:00–10:30	Networking and Coffee Break
	16:00–16:30	Networking and Coffee Break

About OSA Publishing's Digital Library

Registrants and current subscribers can access all of the congress papers and posters on OSA Publishing's Digital Library. The OSA Publishing's Digital Library is a cutting-edge repository that contains OSA Publishing's content, including 16 flagship, partnered and co-published peer-reviewed journals and 1 magazine. With more than 240,000 articles including papers from over 450 conferences, OSA Publishing's Digital Library is the largest peer-reviewed collection of optics and photonics.

Online Access to the Technical Digest

Full Technical Attendees have both early and free continuous access to digest papers through OSA's digital library, OSA Publishing's Digital Library. To access the papers, go to www.osa.org/EnergyOPC and select the **"Access digest papers"** essential link on the right hand navigation. As access is limited to Full Technical Conference Attendees only, you will be asked to validate your credentials by entering the same login email address and password provided during the Conference registration process. If you need assistance with your login information, please use the "forgot password" utility or "Contact Help" link.

Poster Presentation PDFs

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

OSA Foundation Travel Grant

We are pleased to announce the OSA Foundation Travel Grant recipients for 2016 Light, Energy and Environment Congress. The OSA Foundation Student Travel Grant Program is designed to provide career development opportunities by assisting students who wish to attend conferences and meetings. The grants are given to students working or studying science in qualifying developing nations so they can attend OSA-managed technical meetings and conferences. Congratulations to the following individuals:

- Orhan Torun, *Haccettepe Univ., Turkey*
- Zaifa Yang, *Beijing Technology and Business Univ., China*

Special Events

Congress Welcome Reception

Monday, 14 November, 18:30–20:30
Mekong Event Space - Leipzig Zoo

Attend the 2016 Light, Energy and the Environment Congress Welcome Reception in the unique Mekong event space of the famous Gondwanaland. Meet with colleagues from around the world and enjoy light hors d'oeuvres. This event is complimentary for technical attendees - non-technical attendees and guest tickets are available for $55 USD each.

Plenary and Keynote Sessions

Monday, 14 November – Thursday, 17 November, 08:30–10:00
Weißer Saal, Kongresshalle am Zoo

The Light, Energy and the Environment Congress will feature 1 Plenary Speaker and 3 Joint Keynote Sessions. For more information on the plenary and keynote presentations, see page 9 of the program.

The Fraunhofer Center for Silicon Photovoltaics (CSP)

Tuesday, 15 November 2016, 13:30–16:30

Ticket Fee: $15 USD per person

70 person maximum capacity.

Registration will be available onsite at the congress on a first come first serve basis.

Round-trip transportation will be provided from the Kongresshalle am Zoo. Bus will depart at 13:30 and return by 16:30.

The Fraunhofer CSP conducts applied research into silicon crystallization, wafer production, solar cell characterization and module technology, developing in the process new technologies, production processes and product concepts along the entire photovoltaic value chain.

The Center's work is focused on the assessment of the reliability of solar cells and modules under laboratory and operating conditions as well as electrical, optical, mechanical and microstructural material and component characterization. Focusing its activities in this way enables the Center to develop measurement methods, devices and production process for components and materials which are based on an understanding of failure mechanisms and offer increased levels of reliability.

Its portfolio of research activities in the field of photovoltaics is complemented by research into renewable hydrogen production and the storage and utilization of this gas, in particular the development, characterization and testing of new materials for fuel cells and electrolyzers, as well as the simulations and economic feasibility studies of decentralized photovoltaic electrolysis systems.

The Fraunhofer CSP is a joint initiative of the Fraunhofer Institute for Microstructure of Materials and Systems IMWS and the Fraunhofer Institute for Solar Energy Systems ISE.

Leibniz Institute for Tropospheric Research (TROPOS)

Tuesday, 15 November 2016, 13:30–16:30

Ticket Fee: $10 USD per person

40 person maximum capacity.

Registration will be available onsite at the congress on a first come first serve basis.

Round-trip transportation will be provided from the Kongresshalle am Zoo. Bus will depart at 13:30 and return by 16:15.

The Leibniz Institute for Tropospheric Research (TROPOS) is member of the Leibniz Association, which connects 88 independent research institutions of Germany. The task of TROPOS is the research on tropospheric aerosols and clouds.

Tropospheric aerosols and clouds play a central role in the coupled system men-environment-climate. The corresponding processes are highly complex and a successful research requires strong cooperation between different scientific fields.

TROPOS is an internationally leading institution aiming at application oriented basic research on aerosols and clouds and their interactions. TROPOS monitors, understands and models the physical and chemical processes of tropospheric aerosols and clouds from the molecular and micro-scale to long-range transports into polluted regions of various strengths. TROPOS is the contact for politics, society and science in the impact-fields health and climate.

TROPOS consists of 4 research departments: Experimental Aerosol and Cloud Microphysics, Remote Sensing of Atmospheric Processes, Modeling of Atmospheric Processes, and Atmospheric Chemistry. Often optical methods and techniques are applied within the experiments.

After a short introduction to TROPOS, the offered tour through TROPOS will stop at four stations (groups):

1. Ground-based remote sensing activities: aerosol lidars (Dietrich Althausen)
2. In-situ measurements of aerosol properties: calibration lab for measurements of optical particle properties (Alfred Wiedensohler)
3. Cloud-chamber: experimental setup to investigate cloud microphysical processes including the use of optical techniques for detection (Frank Stratmann)
4. The LEAK chamber (Leipziger Aerosolkammer): photochemical investigations of atmospheric processes including secondary organic aerosol formation using optical excitations (Olaf Böge)

Industry Panel Discussion

Tuesday, 15 November, 17:30–19:00
Weißer Saal, Kongresshalle am Zoo

Renewable energy systems are finally on a global economic rise, exceeding combined new build fossil generation for the first time in 2015. Still there is a long way to go, as renewable energies (including hydro) contribute less than a quarter of the worldwide overall energy capacity. In this panel discussion, we will hear different perspectives from politics, research and industry on the status and future of renewable energies and approaches to accelerate market penetration.

Munib Amin, *RWE International SE, Germany*

Michael Bauer, *Calyxo GmbH, Germany*

Hans-Josef Fell, *Energy Watch Group, Germany*

Jung-Ho Lee, *Hanyang Univ., Korea*

Facilitated by Kenneth Baldwin, *ANU Energy Change Inst., Australia*

Congress Banquet

Tuesday, 15 November, 19:00–21:30
Altes Landratsamt

Ticket fee: $65 USD per person

Join your colleagues for a special evening banquet at the Altes Landratsamt, only a few steps away from all conference hotels. After a welcome beverage and opening remarks, enjoy a lavish dinner buffet in a historical setting. Purchase your ticket within registration.

Joint Poster Session

Wednesday, 16 November, 16:00–17:30
Großer Saal, Kongresshalle am Zoo

Poster presentations offer an effective way to communicate new research findings and provide a venue for lively and detailed discussion between presenters and interested viewers. This Congress features 44 poster presentations.

Plenary and Keynote Speakers

Plenary Session

Monday, 14 November, 8:30–10:00
Weißer Saal, Kongresshalle am Zoo

The Invention of High Efficient Blue LEDs and Future Lighting

Shuji Nakamura, *Univ. of California Santa Barbara, USA*

In 1970's and 80's, an efficient blue and green light-emitting diodes (LED) were the last missing elements for solid-state display and lighting technologies due to the lack of suitable materials. By that time, III-nitride alloys was regarded the least possible candidate due to various "impossible" difficulties. However, a series of unexpected breakthroughs in 1990's totally changed people's view angle. Finally, the first high efficient blue LEDs were invented and commercialized at the same time of 1993. Nowadays, III-nitride-based LEDs have become the most widely used light source in many applications. The LED light bulbs are more than ten times efficient than incandescent bulb, and they last for 50 years! At their current adoption rates, by 2020, LEDs can reduce the world's need for electricity by the equivalent of nearly 60 nuclear power plants.

Bio: Shuji Nakamura is from Ehime, Japan. He obtained his B.E., M.S., and Ph.D. degrees in Electrical Engineering from the Univ. of Tokushima, Japan. He joined Nichia Chemical Industries Ltd. in 1979. He spent a year at the Univ. of Florida as a visiting research associate in 1988, and started the research of blue LEDs using group-III nitride materials the following year. In 1993 and 1995, he developed the first group-III nitride-based blue/green LEDs. He also developed the first group-III nitride-based violet laser diodes (LDs) in 1995. He has received a number of awards, including the MRS Medal Award (1997), the IEEE Jack A. Morton Award, the British Rank Prize (1998) and the Benjamin Franklin Medal Award (2002). He was elected as a member of the US National Academy of Engineering (NAE) in 2003, received the Finnish Millennium Technology Prize in 2006, the Prince of Asturias Award from Spain in 2008, the Harvey Prize of Israel Inst. of Technology in 2010, and the Nobel Prize in Physics in 2014. Since 2000, he is a professor in the Materials Department of the Univ. of California Santa Barbara. He holds more than 200 patents and has published more than 400 papers in this field.

Keynote Sessions

Keynote Session I

Tuesday, 15 November, 08:30–10:00
Weißer Saal, Kongresshalle am Zoo

Quantum-cascade Laser Frequency Combs and Their Application to Dual-comb Spectroscopy

Jérôme Faist, *ETH Zurich, Switzerland*

Quantum cascade lasers have recently demonstrated the capability of operating as optical frequency combs in the mid-infrared and terahertz with high optical power (>100mW). Self-detected dual comb operation and dual-comb spectroscopy were recently demonstrated.

Bio: Jérôme Faist was born in Geneva, and obtained his Bachelor and Ph.D. in Physics, in the group of Prof. F.-K Reinhart from the Swiss Institute of Technology in Lausanne in 1985, 1989 respectively. After a post-doc in IBM Rueschlikon (89-91), he joined F. Capasso's group in Bell Laboratories in 1991 where he worked first as a post-doc and then as a Member of Technical Staff. From 1997 to 2007, he was professor in the physics institute of the University of Neuchâtel. In 2007, he became professor in the institute for quantum electronics of the ETH Zurich.

His central role in the invention and first demonstration of the quantum cascade (QC) laser in 1994 was recognised by the IEE premium (1995), the IEEE/LEOS William Streifer award (1998), the Michael Lunn award (1999), the ISCS "Young scientist award" (1999), and the Swiss National Latsis Prize (2003). His present interests are the development of high performance QC lasers in the Mid and Far-infrared and the physics of coherence in intersubband transitions in the presence of strong magnetic fields.

Mtg-irs: The Instrument, Its Products and Current User Readiness Activities

Stephen Tjemkes, *EUMETSAT, Germany*

This paper gives an overview of the Infrared Sounder mission, its planned products and the current activities to prepare the envisaged user community for the MTG-IRS era.

Keynote Session II

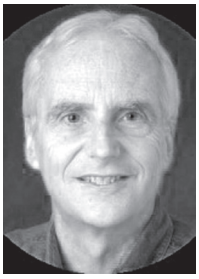
Wednesday, 16 November, 08:30–10:00
Weißer Saal, Kongresshalle am Zoo

Solar Fuels: Specific Requirements for Solar Concentrator Systems

Christian Sattler, *German Aerospace Center, Germany*

The production of fuels by concentrated solar radiation is an option for efficient large scale processes. The radiation can either be used to replace fossil fuels for heating established processes like steam or dry reforming of methane. Or at higher temperature to drive thermochemical cycles for water or CO_2 splitting into hydrogen, oxygen and CO. Presently most of the technologies are developed with high flux solar simulators. However some scale-up demonstrations on solar towers have been operated. The concentrator systems, mainly heliostat fields, are similar to installations for power production. However the chemical reactions require a different heating regime. Therefore a special optics and control systems have to be developed to achieve the very high temperatures necessary to carry out thermochemical cycles constantly and homogeneously in the whole solar receiver. The presentation will give an overview of the concentrating solar fuel production processes. It will give insight in how to design the required heliostat fields, secondary optics, and control systems.

Bio: Prof. Dr. Christian Sattler is head of the Department of Solar Chemical Engineering of the German Aerospace Center's Institute of Solar Research. He is also professor for solar fuel production at the Technical University of Dresden. The main area of his work is the production of fuels especially hydrogen by solar thermo- and photochemical processes. He serves as vice president of the research association N.ERGHY a member of the European Joint Technology Initiative for Fuel Cells and Hydrogen and is the national representative to tasks of the IEA's SolarPACES and Hydrogen Implementing Agreements.



Lidar Techniques and Applications for Improving Wind Energy Production and Characterizing Pollution from Fossil Fuel-Based Energy Generation

Michael Hardesty, *Univ. of Colorado Boulder; NOAA, USA*

This paper describes the use of Doppler and differential absorption lidar (DIAL) remote sensing techniques to enhance wind energy production and investigate air pollution and greenhouse gas emissions from burning of fossil fuel.

Bio: R. Michael Hardesty is a Senior Research Scientist and Associate Director for Environmental Observations, Modeling and Forecasting with the Cooperative Institute for Research in Environmental Sciences at the University of Colorado Boulder. His current research interests are focused on the development and application of lidar techniques for investigating dynamical and chemical processes in the atmosphere. Prior to joining CIRES, he was Program Leader for Optical Remote Sensing for the National Oceanic and Atmospheric Administration (NOAA) in Boulder. Over the course of his career he has worked to advance technology and demonstrate use of lidar to measure winds, turbulence and transport from boundary layer to global scales. He is currently co-chair of the US Working Group on Space-Based Lidar Winds and serves as a US Observer to the European Space Agency's Aeolus Mission Advisory Group. Michael is a Fellow of the Optical Society of America and the American Meteorological Society.

Keynote Session III

Thursday, 17 November, 08:30–10:00
Weißer Saal, Kongresshalle am Zoo

Solid State Lighting: Opportunities and Challenges

Klaus Streubel, *Osram Licht AG, Germany*

LEDs have become the dominating light source in many applications such as mobile devices, displays or laptop computers. They also play a significant role in the area of general lighting. In this presentation we will discuss the success stories of LEDs in lighting, the challenges and the opportunities in future solid state lighting systems.

Bio: As Senior Vice President and head of Corporate Innovation of Osram Licht AG in Munich, Dr. Klaus Streubel is responsible for the global research and pre-development activities in the company. Klaus has held a position as head of Corporate Innovation at Osram since August 2009.

Dr. Streubel spent two years as a post doc at the Swedish Institute of Microelectronics in Stockholm, and began his professional career in 1993 when he took a permanent position at the Royal Institute of Technology (KTH) in Stockholm, where he received a lecturer certificate and was appointed as adjunct professor. In 1997, he moved from academic to industrial research and joined Mitel Semiconductors in Järfälla, Sweden, and in 1999 Osram Opto Semiconductors in Regensburg, Germany.

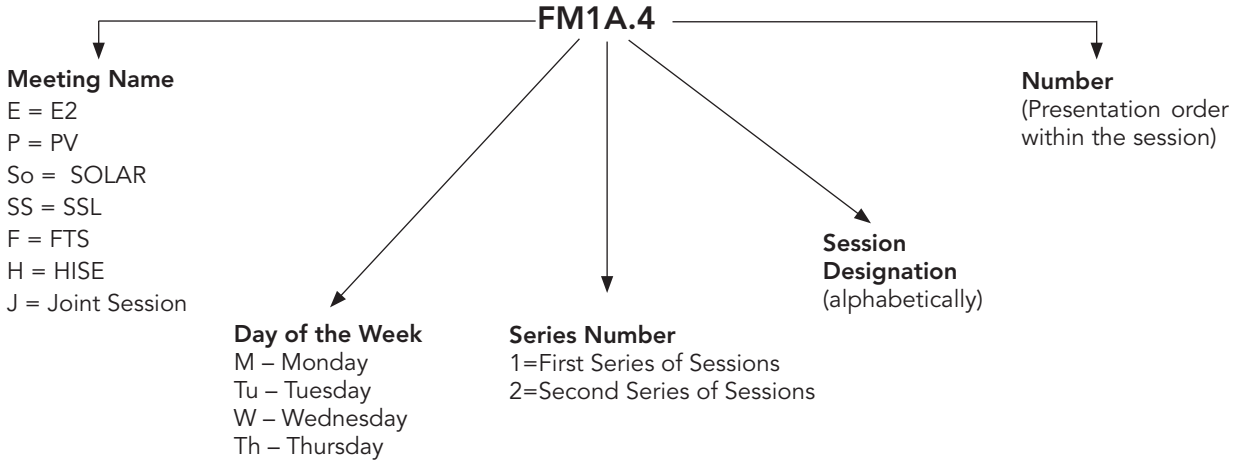
Optical Properties of Industrially Mass-produced Crystalline Silicon Solar Cells and Prospects for Improvements

Pietro Altermatt, *Trina Solar Limited, China*

The optical properties of mass-produced crystalline Si solar cells are reviewed and the requirements and constraints for their improvements by modern optical methods are outlined from the perspective of one of the largest manufacturers.

Bio: Pietro P. Altermatt's main area of research has been the development of physical models for the numerical simulation of crystalline silicon solar cells and testing devices. Of equal interest to him is the application of these models to simulation strategies tailored to research, development and mass production. When Pietro worked at UNSW from 1993 until 2002, the UNSW high-efficiency cells were ideally suited for setting up generally valid physical models, because they suffered from very few non-ideal losses. When Pietro set up a modelling group at the Leibniz University Hannover (Germany) in 2005, the models were extended to industrially fabricated solar cells, working in close collaboration with the industry. Now, such simulations form the quantitative basis for improvement strategies in the PV industry, predicting the optimum device design, the necessary production equipment, and the feasible silicon material.

Explanation of Session Codes



The first letter of the code designates the meeting (E = E2, P = PV, So = Solar, SS = SSL, F = FTS, H = HISE, J = Joint). The second element denotes the day of the week (M=Monday, Tu-Tuesday, W=Wednesday, Th=Thursday). The third element indicates the session series in that day (for instance, 1 would denote the first parallel sessions in that day). Each day begins with the letter A in the fourth element and continues alphabetically through a series of parallel sessions. The lettering then restarts with each new series. The number on the end of the code (separated from the session code with a period) signals the position of the talk within the session (first, second, third, etc.). For example, a presentation coded FM1A.4 indicates that this paper is part of the FTS topical meeting (F) and is being presented on Monday (M) in the first series of sessions (1), and is the first parallel session (A) in that series and the fourth paper (4) presented in that session.

Invited papers are noted with Invited

Plenary papers are noted with Plenary

Keynote papers are noted with Keynote

Agenda of Sessions — Sunday, 13 November

15:00–18:00	**Registration,** *South Foyer*

Monday, 14 November

	Goethe-Saal	Telemann-Saal	Leibniz-Saal	Schiller-Saal	Händel-Saal	Lessing-Saal
	E2	PV	SOLAR	SSL	FTS	HISE
08:00–12:30 13:30–18:00	**Registration,** *South Foyer*					
08:30–10:00	**JM1A • Plenary Session - Shuji Nakamura,** *Weißer Saal*					
10:00–10:30	**Networking and Coffee Break,** *Großer Saal*					
10:30–12:30	**EM2A • Optics and Photonics in Solar and Wind Energy** (ends at 12:00)	**PM2B • General and Crystalline PV I**		**SSM2C • LED Devices**	**FM2D • Far-IR Observatories**	**HM2E • Recent Advances in Hyperspectral Instruments and Analysis**
12:30–14:00	**Lunch** *(on your own)*					
14:00–16:00	**EM3A • Infrared Spectroscopy in Gas Monitoring** (ends at 15:45)	**PM3B • Thin-film PV**	**SoM3C • CSP Applications I** (ends at 15:45)	**SSM3D • LED Materials and Process** (ends at 15:30)	**FM3E • Airbourne Instruments and Measurements of the Earth and Earth's Atmosphere**	**HM3F • Radiative Transfer and Hyperspectral Sensing** (ends at 15:45)
16:00–16:30	**Networking and Coffee Break,** *Großer Saal*					
16:30–18:30	**EM4A • Remote Sensing Techniques to Measure Trace Gases, Particulates and Aerosols I**	**PM4B • Perovskite PV I**		**SSM4C • OLED Materials**	**FM4D • Frequency Combs I**	**HM4E • Hyperspectral Imaging of Trace Gases**
18:30–20:30	**Congress Welcome Reception,** *Leipzig Zoo, Mekong Event Space*					

Agenda of Sessions — Tuesday, 15 November

	Goethe-Saal	Telemann-Saal	Leibniz-Saal	Schiller-Saal	Händel-Saal	Lessing-Saal
	E2	PV	SOLAR	SSL	FTS	HISE
08:00–12:00 16:00–18:00	**Registration,** *South Foyer*					
08:30–10:00	**JTu1A • Keynote Session I,** *Weißer Saal*					
10:00–10:30	**Networking and Coffee Break,** *Großer Saal*					
10:30–12:30	**ETu2A • Optics and Photonics in Combustion Diagnostics**	**PTu2B • Nanowires and Quantum Dots** (ends at 11:45)	**SoTu2C • Innovative Approaches** (ends at 12:15)	**SSTu2D • Solid-State Light Systems** (ends at 12:15)	**FTu2E • Nano- and Micro-spectroscopy and Imaging**	**HTu2F • Hyperspectral Sensing of Cloud and Aerosol Properties**
12:30–16:30	**Free Afternoon**					
13:30–16:30	**Local Tour (fee required),** *The Fraunhofer Center for Silicon Photovoltaics (CSP)*					
13:30–16:30	**Local Tour (fee required),** *Leibniz Institute for Tropospheric Research (TROPOS)*					
16:30–17:30	**ETu3A • Laser-based Instruments and Techniques**	**PTu3B • Perovskite PV II and Organic PV**			**FTu3C • Far infrared Measurements of Earth's Atmosphere**	**HTu3D • Advances in Algorithims for Hyperspectral Sensing** (starts at 17:00)
17:30–19:00	**Industry Panel Discussion,** *Weißer Saal*					
19:00–21:30	**Congress Banquet** (Ticket Required), *Altes Landratsamt*					

Agenda of Sessions — Wednesday, 16 November

	Goethe-Saal	Telemann-Saal	Leibniz-Saal	Schiller-Saal	Händel-Saal	Lessing-Saal
	E2	PV	SOLAR	SSL	FTS	HISE
08:00–12:00 13:30–18:00	**Registration,** *South Foyer*					
08:30–10:00	**JW1A • Keynote Session II,** *Weißer Saal*					
10:00–10:30	**Networking and Coffee Break,** *Großer Saal*					
10:30–12:30	**EW2A • Lidar in Dust and Aerosol Observation**	**PW2B • Multi-juntion Solar Cells**	**SoW2C • CSP and PV Applications** (ends at 12:15)	**SSW2D • OLED Optics & Emitter Orientation**	**FW2E • Femtosecond Laser & Combs**	**HW2F • Hyperspectral Sensing of Climate Change I** (ends at 11:45)
12:30–14:00	**Lunch** *(on your own)*					
14:00–16:00	**EW3A • Remote Sensing Techniques to Measure Trace Gases, Particulates and Aerosols II** (ends at 15:30)	**PW3B • Advanced Numerics and CI(G)S PV**		**SSW3C • Applications of Solid-State Light Sources**	**FW3D • Laboratory Spectroscopy (Including at Synchrotron Facilities)**	**HW3E • Hyperspectral Sensing of Climate Change II: The Far-infrared and Earth Surface Properties**
16:00–17:30	**JW4A • Joint Poster Session and Coffee Break,** *Großer Saal*					
17:30–18:30		**PW5A • Light Management in Solar Modules and New Approaches**		**SSW5B • OLED Device Physics**	**FW5C • FTS Instruments in Astrophysics**	**HW5D • Atmospheric Measurements with Infrared Hyperspectral Sensing**

Agenda of Sessions — Thursday, 17 November

	Goethe-Saal	Telemann-Saal	Leibniz-Saal	Schiller-Saal	Händel-Saal	Lessing-Saal
	E2	PV	SOLAR	SSL	FTS	HISE
08:00–12:00 13:30–16:00	**Registration,** *South Foyer*					
08:30–10:00	**JTh1A • Keynote Session III,** *Weißer Saal*					
10:00–10:30	**Networking and Coffee Break,** *Großer Saal*					
10:30–12:30		**PTh2A • Ordered and Disordered Structures for Light Management**		**SSTh2B • Flexible OLEDs** (ends at 12:15)	**FTh2C • Interferometer Design (Including Miniaturized Spectrometers)**	
12:30–14:00	**Lunch** *(on your own)*					
14:00–16:00		**PTh3A • Crystalline PV II** (ends at 15:45)			**FTh3B • Frequency Combs II**	
16:00–16:30	**Networking and Coffee Break,** *Großer Saal*					
16:30–18:30		**PTh4A • Novel Fabrication Methods and Applications**			**FTh4B • Spaceborne Instruments and Measurements of the Earth and Earth's Atmosphere**	

08:00–12:30, 13:30–18:00 Registration, *South Foyer*

Weißer Saal

Joint

08:30–10:00
JM1A • Plenary Session
Presider: Kenneth Baldwin; Australian National Univ., Australia

JM1A.1 • 08:45 Plenary
The Invention of High Efficient Blue LEDs and Future Lighting, Shuji Nakamura[1]; [1]*Dept. of Materials, Univ. of California Santa Barbara, USA.* In 1970's and 80's, an efficient blue and green light-emitting diodes (LED) were the last missing elements for solid-state display and lighting technologies due to the lack of suitable materials. By that time, III-nitride alloys was regarded the least possible candidate due to various "impossible" difficulties. However, a series of unexpected breakthroughs in 1990's totally changed people's view angle. Finally, the first high efficient blue LEDs were invented and commercialized at the same time of 1993. Nowadays, III-nitride-based LEDs have become the most widely used light source in many applications. The LED light bulbs are more than ten times efficient than incandescent bulb, and they last for 50 years! At their current adoption rates, by 2020, LEDs can reduce the world's need for electricity by the equivalent of nearly 60 nuclear power plants. The history of the invention of blue LED and future lighting will be described.

10:00–10:30 Networking and Coffee Break, *Großer Saal*

Goethe-Saal

Optics and Photonics for Energy & the Environment (E2)

Telemann-Saal

Optical Nanostructures and Advanced Materials for Photovoltaics (PV)

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

10:30–12:00
EM2A • Optics and Photonics in Solar and Wind Energy
Presider: Andreas Fix; German Aerospace Center, Germany

EM2A.1 • 10:30 Invited
Earth Observation Based Cloud, Aerosol, and Irradiance Information for Applications in Solar Energy Generation, Marion Schroedter-Homscheidt[1]; [1]*Earth Observation Center, DLR, Germany.* The use of solar energy has strongly increased. Electricity grid operations has to adapt and operators of utility scale solar energy power plants need monitoring and forecasts of irradiances. Earth observation helps in these tasks.

EM2A.2 • 11:00 Invited
Diode Laser Applications for Wind Energy, Peter John Rodrigo[1], Christian Pedersen[1]; [1]*DTU Fotonik, Denmark.* Our work on the use of diode lasers for wind sensing applications (i.e. wind turbine control) is described in this summary. Very briefly, we review the key results we have achieved to date on diode laser based lidars for the wind energy industry.

10:30–12:30
PM2B • General and Crystalline PV I
Presider: Ralf Wehrspohn; Fraunhofer IWM Halle, Germany

PM2B.1 • 10:30 Invited
How the Optical Properties of a Solar Cell Influence its Performance - From the Efficiency Limits to Real Devices, Uwe Rau[1]; [1]*Juelich Research Center, USA.* The contribution shows how the properties of real world photovoltaic devices are physically linked to the idealized situation defined by the Shockley-Queisser efficiency limit and how differences between real devices and the limitis can be measured. The preeminent role of optics in the definition of a detailed balance theory beyond Shockley-Queisser is highlighted.

PM2B.2 • 11:00 Invited
Physical Scaling Laws of Nanophotonics: Case Photon Conversion, Shuai Sun[1], Mohammad Tahersima[1], Volker J. Sorger[1], Ke Liu[1]; [1]*George Washington Univ., USA.* We show that nanophotonic device performance scales non-monotonically with critical length and define the metric to assess the quality of photodetector and conversion processes. Furthermore, we discus an example of a 2D material-based solar cell.

08:00–12:30, 13:30–18:00 Registration, *South Foyer*

Weißer Saal

Joint

08:30–10:00
JM1A • Plenary Session
Presider: Kenneth Baldwin; Australian National Univ., Australia

JM1A.1 • 08:45 Plenary
The Invention of High Efficient Blue LEDs and Future Lighting, Shuji Nakamura[1]; [1]*Dept. of Materials, Univ. of California Santa Barbara, USA.* In 1970's and 80's, an efficient blue and green light-emitting diodes (LED) were the last missing elements for solid-state display and lighting technologies due to the lack of suitable materials. By that time, III-nitride alloys was regarded the least possible candidate due to various "impossible" difficulties. However, a series of unexpected breakthroughs in 1990's totally changed people's view angle. Finally, the first high efficient blue LEDs were invented and commercialized at the same time of 1993. Nowadays, III-nitride-based LEDs have become the most widely used light source in many applications. The LED light bulbs are more than ten times efficient than incandescent bulb, and they last for 50 years! At their current adoption rates, by 2020, LEDs can reduce the world's need for electricity by the equivalent of nearly 60 nuclear power plants. The history of the invention of blue LED and future lighting will be described.

10:00–10:30 Networking and Coffee Break, *Großer Saal*

Schiller-Saal

Solid-State Lighting (SSL)

10:30–12:30
SSM2C • LED Devices
Presider: Jiangeng Xue; Univ. of Florida, USA

SSM2C.1 • 10:30 Invited
Gallium Nitride Structured Illumination Light Sources, Martin D. Dawson[1]; [1]*Univ. of Strathclyde, UK.* We review recent developments in GaN LED arrays interfaced to CMOS as the basis of pattern-programmable light sources. Applications in visible light communications, object location and tracking, and control of autonomous systems are described.

SSM2C.2 • 11:00
Spatially Superposed Pulse Amplitude Modulation Using a Chip-scale CMOS-Integrated GaN LED Array, Alexander D. Griffiths[1], Johannes Herrnsdorf[1], Jonathan J. McKendry[1], Robert Henderson[2], Harald Haas[2], Erdan Gu[1], Martin D. Dawson[1]; [1]*Univ. of Strathclyde, UK;* [2]*Univ. of Edinburgh, UK.* We present a highly compact system capable of generating discrete optical wireless data signals from logic inputs, suitable for pulse amplitude modulation (PAM) transmission, in visible light communication (VLC).

SSM2C.3 • 11:15 Invited
High-efficiency Organic-inorganic Perovskite Light-emitting Diodes, Tae-Woo Lee[1]; [1]*Seoul National University, Korea.* Abstract not available.

Händel-Saal

Fourier Transform Spectroscopy (FTS)

10:30–12:30
FM2D • Far-IR Observatories
Presider: Carole Tucker; Cardiff Univ., UK

FM2D.1 • 10:30 Invited
Dome-A THz/Far-infrared Fourier Transform Spectrometer and Its Results, Sheng-Cai Shi[1], Scott Paine[2]; [1]*Chinese Academy of Sciences, China;* [2]*Smithsonian Astrophysical Observatory, USA.* In the terahertz and far-infrared (FIR) band, from approximately 0.3 THz to 15 THz (1 mm to 20 μm), the pure rotation band of water vapor renders the terrestrial atmosphere opaque over nearly all of the Earth's surface. Early radiometric measurements below 1 THz at Dome A (80° 22′ S, 77° 21′ E), the highest point of the cold and dry Antarctic ice sheet, suggest that it may offer the best possible access to the terahertz and FIR band from the ground. In this talk we will introduce a Fourier transform spectrometer (FTS) deployed to Dome A for the measurement of atmospheric transmission from 20 μm to 350 μm wavelength. Also some measurement results will be presented.

FM2D.2 • 11:00
Line Asymmetry in Herschel SPIRE FTS Spectra, David A. Naylor[1], Gibion Makiwa[1], Ian Veenendaal[1], Jeremy Scott[1], Locke D. Spencer[1]; [1]*Univ. of Lethbridge, Canada.* The SPIRE instrument on the Herschel Space Observatory employed an imaging FTS. The instrumental line shape exhibited a slight asymmetry, constant throughout the mission and virtually independent of wavelength, both suggesting an instrumental origin.

FM2D.3 • 11:15
The Herschel SPIRE Spectral Feature Finder, Rosalind Hopwood[1], Ivan Valtchanov[2], Locke D. Spencer[3], Jeremy Scott[3], Gibion Makiwa[3], Trevor Fulton[3,4], Gavin Noble[1], Chris S. Benson[3], Nichola Marchili[7], Edward Polehampton[5,3], David A. Naylor[3], Nanyao Lu[6]; [1]*Physics, Imperial College, UK;* [2]*Herschel Science Centre, European Space Astronomy Centre, European Space Agency, Spain;* [3]*Univ. of Lethbridge, Canada;* [4]*Blue Sky Spectroscopy, Canada;* [5]*RAL Space, Rutherford Appleton Laboratory, UK;* [6]*NASA Herschel Science Center, California Inst. of Technology, USA;* [7]*IAPS-INAF, Italy.* We present an algorithm to automatically find and fit features in all SPIRE-FTS spectra. Searchable spectral line and continuum feature catalogues and "quick-look" postcards have been produced for public distribution via the Herschel public TWiki.

Lessing-Saal

Hyperspectral Imaging and Sounding of the Environment (HISE)

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

10:30–12:30
HM2E • Recent Advances in Hyperspectral Instruments and Analysis
Presider: Mark Wenig, LMU; Germany

HM2E.1 • 10:30 Invited
The Earth Polychromatic Imaging Camera on the Deep Space Climate Observatory, Alexander Cede[1,2]; [1]*NASA Goddard Space Flight Center, USA;* [2]*SciGlob, USA.* The Earth Polychromatic Imaging Camera takes images of the Earth in 10 ultraviolet and visible channels. This paper gives an overview of the optical design, calibrations performed, and corrections applied to obtain corrected count rates.

HM2E.2 • 11:00
A Push-broom Computational Spectral Imager, Jianwei Wang[1,2]; [1]*AOE, China;* [2]*Beihang Univ., China.* This paper shows a push-broom computational spectral imager with high resolution and SNR by equipping the spectrometer with hadamard-mask array and least squares-based algorithm for digital processing. Results of outfield experiments are reported.

HM2E.3 • 11:15 Invited
Characterization and Airborne Deployment of specMACS, a Multipurpose Hyperspectral Cloud and Sky Imager, Florian Ewald[2,1], Tobias Kölling[2], Andreas Baumgartner[3], Tobias Zinner[2], Bernhard Mayer[2]; [1]*Inst. of Atmospheric Physics, German Aerospace Center, Germany;* [2]*Meteorological Inst., Ludwig Maximilians Univ., Germany;* [3]*Remote Sensing Technology Inst., German Aerospace Center, Germany.* The new spectrometer of the Munich Aerosol Cloud Scanner (specMACS) is a multipurpose hyperspectral cloud and sky imager designated, but is not limited to investigations of cloud–aerosol interactions in Earth's atmosphere.

Goethe-Saal

Optics and Photonics for Energy & the Environment (E2)

Telemann-Saal

Optical Nanostructures and Advanced Materials for Photovoltaics (PV)

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

EM2A • Optics and Photonics in Solar and Wind Energy—Continued

EM2A.3 • 11:30 Invited

Lidar Investigation of Wind Turbine Wake Characteristics under Different Surface Roughness, Songhua Wu[1], Xiaochun Zhai[1]; [1]*Ocean Univ. of China, China.* A scanning Coherent Doppler Lidar (CDL) were employed for elucidating main features of turbine wakes under different surface roughness. Field experiments were performed in the onshore and offshore wind parks from 2013 to 2015.

PM2B • General and Crystalline PV I—Continued

PM2B.3 • 11:30 Invited

Towards Dopant-free Silicon Photovoltaics, Stefaan De Wolf[1]; [1]*King Abdullah University of Science and Technology, Saudi Arabia.* Silicon solar cells classically use impurity doping to extract photogenerated carriers. However, this brings along optoelectronic losses, limiting ultimate device performance. We discuss new, dopant-free high-efficiency device fabrication approaches.

PM2B.4 • 12:00
Withdrawn.

PM2B.5 • 12:15
Imprinted Nanostructures for Light Management in Crystalline Silicon Thin-film Solar Cells on Glass, David Eisenhauer[1], Grit Köppel[1], Klaus Jaeger[1], Bernd Rech[1], Christiane Becker[1]; [1]*Helmholtz-Zentrum Berlin Mat & Energie, Germany.* We present various imprinted nanostructures for light management in liquid-phase crystallized silicon thin-film solar cells enabling both, increased j_{sc} by enhanced absorption and excellent electronic material-quality with V_{oc} values above 640 mV.

12:30–14:00 Lunch *(on your own)*

Schiller-Saal	Händel-Saal	Lessing-Saal
Solid-State Lighting (SSL)	Fourier Transform Spectroscopy (FTS)	Hyperspectral Imaging and Sounding of the Environment (HISE)

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

SSM2C • LED Devices—Continued

SSM2C.4 • 11:45
Transfer Printed Multi-color Integrated Devices for Visible Light Communication Applications, Katherine J. Rae[1], Enyuan Xie[1], Caroline Foucher[1], Benoit Guilhabert[1], Ricardo Ferreira[1], Dandan Zhu[2], David Wallis[2], Colin Humphreys[2], Rachel Oliver[2], Erdan Gu[1], Nicolas Laurand[1], Martin D. Dawson[1]; [1]*Inst. of Photonics, UK;* [2]*Univ. of Cambridge, UK.* Integrated multi-color devices for visible light communication applications are fabricated by transfer printing blue-emitting GaN light emitting diodes (LEDs) onto a green-emitting LED array and a colloidal quantum dot color-converter structure.

SSM2C.5 • 12:00 Invited
High Performance Perovskite Light-emitting Diodes, Jianpu Wang[1]; [1]*Nanjing Tech Univ., China.* Abstract not available.

FM2D • Far-IR Observatories—Continued

FM2D.4 • 11:30
Neutral Carbon Detection in the SPIRE Spectral Feature Finder, Jeremy Scott[1], Locke D. Spencer[1], Rosalind Hopwood[2], Ivan Valtchanov[3], Chris S. Benson[1]; [1]*Univ. of Lethbridge, Canada;* [2]*Physics, Imperial College, UK;* [3]*Herschel Science Centre, European Space Astronomy Centre, European Space Agency, Spain.* Due to its proximity to the adjacent 12CO(7-6) rotational transition, neutral-carbon emission detection in SPIRE FTS spectra with the automated feature finder is difficult. We discuss methods of reliable C[I] detection under these circumstances.

FM2D.5 • 11:45
Effects of Spacecraft Pointing Errors on Future Astronomical Far-infrared Fourier Transform Spectrometers, David A. Naylor[1], Ian Veenendaal[1], Brad Gom[1]; [1]*Univ. of Lethbridge, Canada.* Future far-infrared space astronomy missions will feature cryogenically cooled telescopes that will enable over 100x increase in sensitive over previous missions. The effects of pointing errors on FTS observations in this environment are discussed.

FM2D.6 • 12:00 Invited
Post-dispersed FTS Spectroscopy on SPICA-Safari, Willem Jellema[1]; [1]*SRON, Netherlands.* The SPICA-Safari instrument, currently being proposed as an ESA M5 mission, requires line sensitivities of order 10-19 W/m2 (5σ-1hr) between 34-230 μm. In this paper we will give an overview of the mission and instrument. In particular we will present a cryogenic post-dispersed Martin-Puplett Interferometer scheme, utilizing extremely sensitive TES detector arrays, to implement a high-resolution mode ($R \approx 10^3$-10^4), offering unprecedented spectroscopic observing capabilities in the far-IR.

HM2E • Recent Advances in Hyperspectral Instruments and Analysis—Continued

HM2E.4 • 11:45
Direct Three-Dimensional Point Spread Function Measurement for Spectral-spatial Interdependence Error Assessment of Imaging Spectrometers, Jurij Jemec[1], Franjo Pernuš[1,2], Boštjan Likar[1,2], Miran Bürmen[1,2]; [1]*Faculty of electrical engineering, Slovenia;* [2]*SENSUM, Computer Vision Systems, Slovenia.* Characterization of spectral-spatial interdependence related error in the images acquired with an imaging spectrometer requires a 3D PSF measurement. In this contribution we introduce a 3D PSF measurement setup and demonstrate the error assessment.

HM2E.5 • 12:00
Multispectral and Hyperspectral CAOS Camera, Nabeel A. Riza[1], Juan Pablo La Torre[1]; [1]*Univ. College Cork, Ireland.* Proposed is the multispectral and hyperspectral CAOS camera. This camera simultaneously and independently detects image information for two different spectral bands providing special features such as extremely high dynamic range.

HM2E.6 • 12:15
Investigation of Noise Sources in Upconversion Based Infrared Hyperspectral Imaging, Louis M. Kehlet[2,1], Peter T. Lichtenberg[1], Pablo Beato[2], Christian Pedersen[1]; [1]*DTU Fotonik, Denmark;* [2]*Haldor Topsoe A/S, Denmark.* Noise sources in infrared hyperspectral imaging based on nonlinear frequency upconversion are investigated. The effects on the spectral and spatial content of the images are evaluated and methods of combating them are suggested.

12:30–14:00 Lunch *(on your own)*

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Essential Links

Goethe-Saal

Optics and Photonics for Energy & the Environment (E2)

Telemann-Saal

Optical Nanostructures and Advanced Materials for Photovoltaics (PV)

Leibniz-Saal

Optics for Solar Energy (SOLAR)

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

14:00–15:45
EM3A • Infrared Spectrosocpy in Gas Monitoring
Presider: Jianguo Liu; Anhui Inst Optics & Fine Mech, CAS, China

EM3A.1 • 14:00 Invited
GLORIA - 3D Sounding of the Atmosphere Using Air-Borne Imaging Fourier Spectrometry in the Mid Infrared, Johannes Orphal[1]; [1]*Karlsruhe Inst. of Technology, Germany.* Abstract not available.

EM3A.2 • 14:30 Invited
Industrial Air Pollution Monitoring by Active and Passive Fourier Transform Infrared Spectroscopy, Liang Xu[1], Jianguo Liu[1], Wenqing Liu[1], Lin Jin[1], Minguang Gao[1], Rong Hu[1], Shubin Ye[1], Yakai Li[1], Yang Hu[1]; [1]*Anhui Inst. of Optics and Fine Mechanics, Chinese Academy of Sciences, China.* Both active and passive techniques, such as open path FTIR, White cell based FTIR and Solar Occultation Flux FTIR were presented and the quantitative algorithm to retrieve the object gas concentration was also discussed.

EM3A.3 • 15:00 Invited
Dual-Comb Spectroscopy for GHG Quantification, Ian R. Coddington[1], Gar-Wing Truong[1], Eleanor M. Waxman[1], Kevin C. Cossel[1], Paul J. Schroeder[2], Sean Coburn[2], Robert J. Wright[2], Fabrizio Giorgetta[1], William Swann[1], Gregory B. Rieker[2], Nathan R. Newbury[1]; [1]*Applied Physics, NIST, USA;* [2]*Mechanical Engineering, Univ. of Colorado, USA.* Near-infrared frequency-comb spectroscopy is a powerful tool with which to measure concentrations of gasses relevant to combustion and atmospheric monitoring (CO_2, CH_4, H_2O, HDO) over meter and kilometer scale paths.

14:00–16:00
PM3B • Thin-film PV
Presider: Alexander Sprafke; Martin Luther Univ. Halle, Germany

PM3B.1 • 14:00 Invited
Light Management in Photovoltaic Devices: a Case of Thin-film Silicon Solar Cells, Hitoshi Sai[1]; [1]*Natl Inst of Adv Industrial Sci & Tech, Japan.* Our recent research activities on thin-film silicon solar cells are reviewed from the view point of light management. Periodically textured substrates play a key role in high-efficiency microcrystalline silicon solar cells.

PM3B.2 • 14:30 Invited
Effective Methods for Performance Promotion of Silicon-based Thin Film Solar Cells, Xiaodan Zhang[1]; [1]*Nankai Univ., China.* We present our latest progress in adopting effective electrical and optical controls to improve the performance of silicon based thin-film solar cells.

PM3B.3 • 15:00 Invited
Withdrawn.

14:00–15:45
SoM3C • CSP Applications I
Presider: Reiner Buck; German Aerospace Center, Germany

SoM3C.1 • 14:00 Invited
Field Aperture Optics and their Effect on Optimal Scheduling of Solar Thermal Power Plants with Thermal Energy Storage, Jeff Cumpston[1], Alexander Mitsos[1]; [1]*RWTH Aachen Univ., Germany.* Energy storage scheduling is optimised for a CST tower plant for two values of heliostat optical error. Different storage schedules are observed between these cases. Optimal scheduling reduces losses associated with poor optics.

SoM3C.2 • 14:30 Invited
Backward-gazing Method for Measuring Heliostat Shape Errors, Mathieu Coquand[1], Cyril Caliot[1], François Henault[2]; [1]*CNRS, France;* [2]*Institut de Planétologie et d'Astrophysique de Grenoble, France.* A numerical evaluation of a new backward gazing method with cameras located near the receiver is proposed to characterize the slopes and wavefront errors of heliostats using the radial profile of the Sun's radiative intensity.

SoM3C.3 • 15:00 Invited
High-flux Solar Simulator Technology, Roman Bader[1], Gaël Levêque[2], Sophia Haussener[2], Wojciech Lipinski[1]; [1]*Australian National Univ., Australia;* [2]*Ecole Polytechnique Fédérale de Lausanne, Switzerland.* High-flux solar simulators provide intense radiation beams, suitable for high-temperature, high-heating rate testing of various energy conversion and materials technologies, for example receivers and reactors for concentrating solar thermal processes and thermal protection systems of space vehicles. This talk provides an overview of simulator designs, devices and characteristics, and discusses pertinent optical and technological aspects.

Schiller-Saal	Händel-Saal	Lessing-Saal
Solid-State Lighting (SSL)	Fourier Transform Spectroscopy (FTS)	Hyperspectral Imaging and Sounding of the Environment (HISE)

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

14:00–15:30
SSM3D • LED Materials and Process
Presider: Tae-Woo Lee; Seoul National University, Korea

SSM3D.1 • 14:00 Invited
Unlocking the Efficiency Potential of Metal Halide Preovskite Light Emitting Devices, Ross A. Kerner[1], Zhengguo Xiao[1], Barry P. Rand[1]; [1]*Princeton Univ., USA.* We explore the use of metal halide perovskites for light emitting diode (LED) applications. Through improvements in film formation that yield rms roughness <1 nm, we demonstrate green and red perovskite LEDs with external quantum efficiencies >9%.

SSM3D.2 • 14:30 Invited
Colloidal Quantum Dots for Quality Lighting, Hilmi Volkan Demir[1]; [1]*Bilkent Universitesi, Turkey.* Abstract not available.

SSM3D.3 • 15:00
Synthesis and Luminescence Properties of $Ba_3Lu(PO_4)_3:Sm^{3+}$, Zaifa Yang[1], Denghui Xu[1], Jiayue Sun[1]; [1]*Beijing Technology and Business Univ., China.* Novel $Ba_3Lu(PO_4)_3:Sm^{3+}$ phosphors were prepared by solid-state reaction. The results of X-ray diffraction, photoluminescence spectra and decay time spectra suggest that it might be a promising reddish-orange emitting phosphor used in w-LEDs.

SSM3D.4 • 15:15
Nanophotonics for Color Conversion in Solid-State Lighting, Gabriel Lozano[1]; [1]*Inst. of Materials Science of Seville, Spanish National Research Council, Spain.* Herein, we discuss the opportunities that large area metallic or dielectric photonic nanostructures offer to mold the emission properties of color converters, such as fluorescent dyes or nanocrystals, employed in solid-state lighting.

14:00–16:00
FM3E • Airborne Instruments and Measurements of the Earth and Earth's Atmosphere
Presider: Kaley Walker; Univ. of Toronto, Canada

FM3E.1 • 14:00 Invited
The Spatial Heterodyne Observations of Water (SHOW) Instrument for High Resolution Profiling in the Upper Troposphere and Lower Stratosphere, Adam E. Bourassa[1], Jeff Langille[1], Brian Solheim[1], Doug Degenstein[1], Fabien Dupont[2]; [1]*Univ. of Saskatchewan, Canada;* [2]*ABB, Canada.* The Spatial Heterodyne Observations of Water (SHOW) instrument is a prototype Canadian satellite instrument specifically designed to make high spatial resolution measurements of water vapor in the upper troposphere and lower stratosphere through vertical imaging of the limb scattered sunlight in a near infrared vibrational absorption band. The spatial heterodyne approach provides sufficient spectral resolution and signal-to-noise performance such that when combined with a multiple scattering forward model and a non-linear inversion, the SHOW measurements can be used to tomographically reconstruct the two dimensional water vapour distribution, i.e. in altitude along the satellite track. Here we present the motivation for the measurement, the instrument concept, prototype specifications and results from simulated measurements and retrievals.

FM3E.2 • 14:30
Spatial Heterodyne Spectrometer for Observation of Water (SHOW) Aboard the ER-2 Aircraft: Overview of the Instrument., Fabien Dupont[1], Frederic Grandmont[1], Simon Paradis[1], Louis Jacques[1], Adam E. Bourassa[2], Brian Solheim[2], Doug Degenstein[2], Kevin Walsh[3], Mike Kapitzke[3]; [1]*ABB Inc, Canada;* [2]*Univ. of Saskatchewan, Canada;* [3]*NASA Armstrong Flight Research Center, USA.* SHOW is designed to vertically resolve water profiles from limb scattered sunlight in the atmosphere. We present the technical design of the prototype that is accommodated for test flight on the NASA Lockheed ER-2 aircraft.

FM3E.3 • 14:45 Invited
Five Years of GLORIA Flights: Results and Lessons Learnt, Felix Friedl-Vallon[1]; [1]*Karlsruher Institut fuer Technologie, Germany.* The presentation gives an overview of scientific capabilities demonstrated and technical improvements achieved during five years of operation of the airborne imaging infrared limb sounder GLORIA.

FM3E.4 • 15:15
Characterization of Large Area Calibration Blackbodies for the Imaging FTS GLORIA, Anne Kleinert[1], Albert Adibekyan[2], Andreas Ebersoldt[1], Berndt Gutschwager[2], Christian Monte[2], Friedhelm Olschewski[3], Marco Schulz[2], Oliver Wroblowski[4]; [1]*Karlsruhe Inst. of Technology, Germany;* [2]*Physikalisch-Technische Bundesanstalt, Germany;* [3]*Univ. of Wuppertal, Germany;* [4]*Forschungszentrum Jülich, Germany.* GLORIA is an imaging infrared FTS measuring atmospheric limb emission spectra from aircraft. For radiometric calibration it uses two on-board blackbodies. Accuracy and homogeneity of these blackbodies are characterized and traced to ITS-90.

14:00–15:45
HM3F • Radiative Transfer and Hyperspectral Sensing
Presider: Martin Mlynczak; NASA Langley Research Ctr, USA

HM3F.1 • 14:00
Influence of Low Mass-density Particles and Temperature-dependent Refractive Index on Hyper-spectral Forward Calculations, Patrick G. Stegmann[1], Ping Yang[1]; [1]*Texas A&M Univ., USA.* The present work uses the Community Radiative Transfer Model to assess the influence of complex particle shapes, including snowflakes, in hyper-spectral calculations. Also considered will be the temperature-dependence of the refractive-index of ice.

HM3F.2 • 14:15 Invited
A Fast Hyperspectral Radiative Transfer Model, Ping Yang[1], Jiachen Ding[1], Patrick G. Stegmann[1], Bingqiang Sun[1], George Kattawar[1], Steven Platnick[2], Kerry Meyer[3], Chenxi Wang[4]; [1]*Texas A&M Univ., USA;* [2]*NASA Goddard Space Flight Center, USA;* [3]*Goddard Earth Sciences Technology and Research, Morgan State Univ., USA;* [4]*Univ. of Maryland, USA.* We develop a fast absorption calculation method used in the hyperspectral radiative transfer model for the PACE mission. The model will serve as a TOA radiance and reflectance simulator for remote sensing applications of PACE.

HM3F.3 • 14:45
Fast Correlated K-distributions Generation for the Acceleration of MATISSE Radiative Transfer, Laurence Croizé[1], Jean Pierro[1], Thierry Huet[1], Luc Labarre[1]; [1]*DOTA, ONERA, France.* MATISSE V3 will be a major release with new radiative transfer core. To accelerate the k-distributions generation step, a new code was developed and allows this generation three order of magnitude faster than before.

HM3F.4 • 15:00
Hyperspectral Imaging in Tropical Environments, A D. Cropper[1], David C. Mann[1], T J. Ross[1]; [1]*Raytheon, USA.* This paper presents analytical results demonstrating the effects of tropical environment atmospheric conditions on the system NESR/SNR of Long Standoff Airborne Hyperspectral Imaging systems based on a Raytheon developed E2E System Performance Model.

HM3F.5 • 15:15 Invited
Clairvoyant Fusion Solutions to Composite Spectral Detection Problems, Alan Schaum[1]; [1]*US Naval Research Laboratory, USA.* Ignorance of the values of some model parameters makes optimal likelihood ratio tests (LRTs) inapplicable to nontrivial spectral detection problems. We describe a methodology for fusing LRTs to create robust solutions to such problems.

Goethe-Saal	Telemann-Saal	Leibniz-Saal
Optics and Photonics for Energy & the Environment (E2)	Optical Nanostructures and Advanced Materials for Photovoltaics (PV)	Optics for Solar Energy (SOLAR)

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

EM3A • Infrared Spectrosocpy in Gas Monitoring—Continued

EM3A.4 • 15:30
Using Passive Remote Sensing in the Short Wave Infrared to Quantify Methane and CO_2 Point Source Emissions, Heinrich Bovensmann[1]; [1]*Univ. of Bremen, FB 1, Germany.* The paper will present most recent achievements using satellite and airborne passive remote sensing of atmospheric concentrations of the greenhouse gases Methane (CH_4) and CO_2 to quantify point source emissions of both gases.

PM3B • Thin-film PV—Continued

PM3B.4 • 15:30
Back Contacted $BaSi_2$ Thin-film Solar Cells: An Optical Analysis, Robin Vismara[1], Olindo Isabella[1], Miro Zeman[1]; [1]*Delft Univ. of Technology, Netherlands.* We present an investigation of the optical performance of back contacted $BaSi_2$ solar cells. We determine the optimal geometrical configuration and analyze benefits and drawback of such architectures.

PM3B.5 • 15:45
On Accurate Simulations of Thin-film Solar Cells With a Thick Glass Superstrate, Klaus Jaeger[1,2], Martin Hammerschmidt[2], Grit Köppel[1], Sven Burger[2], Christiane Becker[1]; [1]*Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Germany;* [2]*Zuse Inst. Berlin, Germany.* The air-glass interface significantly affects the reflectivity of nanotextured layer stacks on thick glass superstrates. We estimate this effect with an a posteriori approach applied to results obtained with FEM. Further, we give experimental proofs.

SoM3C • CSP Applications I—Continued

SoM3C.4 • 15:30
Radiative and Convective Transport in Solar Volumetric Receivers, Maya Livshits[1], Abraham Kribus[1]; [1]*Tel-Aviv Univ., Israel.* Optimization of solar volumetric absorbers for high-temperature CSP involves complex interactions of radiative transport vs. convection. Candidate structures are analyzed, and paths are identified to high efficiency >90% at temperatures >1000°C.

16:00–16:30 Networking and Coffee Break, *Großer Saal*

NOTES

Schiller-Saal	Händel-Saal	Lessing-Saal
Solid-State Lighting (SSL)	Fourier Transform Spectroscopy (FTS)	Hyperspectral Imaging and Sounding of the Environment (HISE)

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

SSM3D • LED Materials and Process—Continued

SSM3D.5 • 15:45
Withdrawn.

FM3E • Airborne Instruments and Measurements of the Earth and Earth's Atmosphere—Continued

FM3E.5 • 15:30
Integration of Infrared Focal Plane Array Detectors in the GLORIA Imaging FTS, Erik Kretschmer[1], Jörn Ungermann[2], Thomas Latzko[1]; [1]*Institut für Meteorologie und Klimaforschung, Karlsruher Institut für Technologie, Germany;* [2]*Institut für Energie und Klimaforschung - Stratosphäre, Forschungszentrum Jülich, Germany.* The five years of deployment of the GLORIA iFTS has taught us a great deal about the combination of imaging and FTS systems. The detector related effects, their impact and their mitigation are presented.

FM3E.6 • 15:45
Relief Computation from Images of a Fourier Transform Spectrometer for Interferogram Correction, Clara Barbanson[1], Andrés Almansa[2], Yann Ferrec[1], Pascal Monasse[3]; [1]*ONERA - DOTA, France;* [2]*TSI, Telecom Paristech, Cyprus;* [3]*Ecole des Ponts Paristech, France.* A method to extract digital elevation models of the ground from the images of an airborne Fourier transform spectrometer is presented. Such information allows to construct accurate interferograms in non-flat areas, where they are otherwise flawed.

HM3F • Radiative Transfer and Hyperspectral Sensing—Continued

16:00–16:30 Networking and Coffee Break, *Großer Saal*

NOTES

Goethe-Saal

Optics and Photonics for Energy & the Environment (E2)

Telemann-Saal

Optical Nanostructures and Advanced Materials for Photovoltaics (PV)

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

16:30–18:30
EM4A • Remote Sensing Techniques to Measure Trace Gases, Particulates and Aerosols I
Presider: Arthur Dogariu; Princeton Univ., USA

EM4A.1 • 16:30 Invited
25 Years of Atmospheric Lidar Measurements in Antarctica, Marcel Snels[1], Francesco Cairo[1], Federico Fierli[1], Mauro De Muro[1], Terry Deshler[2]; [1]*ISAC-CNR, Italy;* [2]*Atmospheric Science, Univ. of Wyoming, USA*. A statistical comparison between PSC observations observed by ground- and satellite based lidars around McMurdo is presented. PSC lidar observations are compared to climate model predictions and balloon borne OPC measurements at McMurdo.

EM4A.2 • 17:00 Invited
ACTRIS (Aerosols, Clouds, and Trace Gases Research InfraStructure Network) Network, Doina Nicolae[1]; [1]*National Inst. for Optoelectronics, Romania*. Abstract not available.

16:30–18:30
PM4B • Perovskite PV I
Presider: Olindo Isabella; Technische Universiteit Delft, Netherlands

PM4B.1 • 16:30 Invited
Optoelectronic Transient Probes of the Mechanism Underlying Hysteresis in Hybrid Perovskite Solar Cells, Piers Barnes[1]; [1]*Imperial College London, UK*. Transient photovoltage and photocurrent measurements coupled show that the migration of ionic defects can explain hysteresis in perovskite solar cells. We further show that the ionic migration appears present even in cells with minimal hysteresis.

PM4B.2 • 17:00
Monolithic Perovskite Silicon Tandem Solar Cells with Advanced Optics, Jan C. Goldschmidt[1], Alexander J. Bett[1], Martin Bivour[1], Benedikt Bläsi[1], Johannes Eisenlohr[1], Markus Kohlstädt[1], Seunghun Lee[1], Simone Mastroianni[1], Laura Mundt[1], Markus Mundus[1], Paul Ndione[3], Christian Reichel[1], Martin Schubert[1], Patricia S. Schulze[1], Nico Tucher[1], Clemens Veit[1], Welmoed Veurman[1], Karl Wienands[2], Kristina Winkler[1], Uli Würfel[1], Stefan W. Glunz[1,2], Martin Hermle[1]; [1]*Fraunhofer Inst. for Solar Energy Systems, Germany;* [2]*Albert-Ludwigs-Univ., Faculty of Engineering, Ghana;* [3]*National Renewable Energy Laboratory, USA*. For high efficiency monolithic perovskite silicon tandem solar cells, we develop low-temperature processes for the perovskite top cell, rear-side light trapping, optimized perovskite growth, transparent contacts and adapted characterization methods.

PM4B.3 • 17:15
Nanophotonic Electrodes for Perovskite Thin-film Solar Cells, Ulrich W. Paetzold[1,2], Weiming Qiu[2], Robert Gehlhaar[2], David Cheyns[2], Jef Poortmans[2,3]; [1]*Inst. of Microstructure Technology, Karlsruhe Inst. of Technology, Germany;* [2]*imec, Belgium;* [3]*ESAT, Katholieke Universiteit Leuven,, Belgium*. We report on the development and implementation of nanophotonic front electrodes for perovskite thin-film solar cells. An improvement in power conversion efficiency is demonstrated and explained based on three-dimensional electromagnetic simulations.

Schiller-Saal	Händel-Saal	Lessing-Saal
Solid-State Lighting (SSL)	Fourier Transform Spectroscopy (FTS)	Hyperspectral Imaging and Sounding of the Environment (HISE)

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

16:30–18:30
SSM4C • OLED Materials

Presider: Seunghyup Yoo; Korea Advanced Inst of Science & Tech, Korea

SSM4C.1 • 16:30 Invited

High Efficiency Phosphorescent, TADF and Fluorescent OLEDs, Jang-Joo Kim[1]; [1]*Seoul National Univ., Korea.* Abstract not available.

SSM4C.2 • 17:00

Highly Efficient Sky-Blue Fluorescence from Organic Light Emitting Diode Utilizing Mixed Cohost system for Thermally Actively Delayed Fluorescence Emitter, Jinwon Sun[1], Jang-Joo Kim[1]; [1]*Seoul National Univ., Korea.* The mixed cohost system have been developed for a highly efficient blue fluorescent OLED approaching high EL efficiency of 21.8% doped with a TADF emitter.

16:30–18:30
FM4D • Frequency Combs I

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

FM4D.1 • 16:30 Invited

Dual Comb Outdoor Spectroscopy for Complex Molecular Response Retrieval, Esther Baumann[1], Fabrizio Giorgetta[1], Gregory B. Rieker[1], William Swann[1], Laura C. Sinclair[1], Ian R. Coddington[1], Gar-Wing Truong[1], Kevin C. Cossel[1], Eleanor M. Waxman[1], Nathan R. Newbury[1]; [1]*National Inst of Standards & Technology, USA.* Trace gas concentration is measured across a turbulent open-air path. Using the appropriate dual-comb configuration, phase and absorbance spectra are simultaneously obtained. Decoherence caused by turbulence is estimated and corrected for.

FM4D.2 • 17:00

Broadband Dual-comb Spectroscopy with a Polarization-multiplexed, Dual-comb Fiber Laser, Ya Liu[1,2], Xin Zhao[1], Bofeng Zhao[1], Zijun Yao[1], Guoqing Hu[1], Takeshi . Yasui[3,4], Zheng Zheng[1,2]; [1]*School of Electronic and Information Engineering, Beihang Univ., China;* [2]*Collaborative Innovation Center for Geospatial Technology, China;* [3]*Inst. of Technology and Science, Tokushima Univ., Japan;* [4]*JST, ERATO, MINOSHIMA Intelligent Optical Synthesizer Project, Japan.* Dual-comb spectroscopy using a free-running, polarization-multiplexed mode-locked fiber laser is demonstrated, which can measure the response of a high-Q microring resonator with several-picometer-wide spectral features over a >3THz spectral range.

FM4D.3 • 17:15

Electro-Optic Dual Optical Frequency Combs: New Architectures and Opportunities Beyond Spectroscopy, Pedro Martín-Mateos[1], Pablo Acedo[1]; [1]*Universidad Carlos III de Madrid, Spain.* The rapid evolution of Electro Optic Dual Comb spectrometer design is detailed, from the new architectures for extra operation robustness and immunity to external factors, to techniques for spectral coverage enhancement and signal processing methods.

16:30–18:30
HM4E • Hyperspectral Imaging of Trace Gases

Presider: Miran Bürmen; Faculty of Electrical Engineering, Slovenia

HM4E.1 • 16:30 Invited

Applying the OMI NO_2 Retrieval Algorithm to Estimate the Production Efficiency of Lightning NOx, Eric Bucsela[1], Kenneth Pickering[2], Dale Allen[3], Robert Holzworth[4], Nickolay Krotkov[2], Edward Celarier[5,2], Lok Lamsal[5,2], William Swartz[6,2], Sergey Marchenko[7,2]; [1]*SRI International, Inc., USA;* [2]*NASA Goddard Space Flight Center, USA;* [3]*Univ. of Maryland, USA;* [4]*Univ. of Washington, USA;* [5]*GESTAR, USA;* [6]*Applied Physics Laboratory, Johns Hopkins Univ., USA;* [7]*Science Systems and Applications, Inc., USA.* The Ozone Monitoring Instrument (OMI) on board the NASA Aura satellite was launched into sun-synchronous low-earth orbit in 2004. Its hyperspectral measurements have been an invaluable tool in determining trace-gas concentrations in the troposphere and stratosphere. Nitrogen dioxide (NO2) has a particularly prominent absorption signature in the violet and near-UV regions of the OMI spectrum. This signature can be exploited in retrievals of column amounts of NO2 attributable to both natural and anthropogenic sources. We outline the OMI NO2 retrieval algorithm and demonstrate its utility for inferring NOx (NO + NO2) amounts due to lightning. Lightning is the dominant source of NOx in the free troposphere, and most estimates of the concentration of lightning NOx (LNOx) require knowledge of the amount of this species produced per lightning flash. We present the largest spatial- and temporal-scale investigation of LNOx to date that combines satellite-based NOx estimates and lightning flash data. The study comprises five northern-hemisphere (NH) summers, including much of the mid-latitude regions in North America and Asia and adjacent waters. NO2 measurements are converted to LNOx and compared with flashes preceding OMI overpass by 2 hours. The flash counts are derived from ground-based World Wide Lightning Location Network (WWLLN) data that are adjusted for detection efficiency. We find reasonable correlation between the number of lightning flashes and the amount of LNOx produced and estimate mean efficiencies for the production of LNOx in various NH regions. Overall results indicate mole/flash values near the low end of those reported in previous LNOx studies, as well as a possible dependence of production efficiency on flash rate. These findings have potential implications in the chemistry of upper tropospheric trace gases and the global NOx budget.

HM4E.2 • 17:00

Analysis of Temporal and Spatial Patterns of OMI NO2 Data, Annette M. Schütt[1], Gerrit Kuhlman[2], Ying ZHU[1], Mark O. Wenig[1]; [1]*Ludwig- Maximiliansuniversität, Germany;* [2]*EMPA, Switzerland.* Different sources of NO2 emissions are identified by analyzing annual and weekly cycles of different cities and areas in Europe and in North America using NO2 vertical column densities retrieved from the Ozone Monitoring Instrument.

HM4E.3 • 17:15

Far-Infrared Spectroscopy of Water Vapor: Results from Deployment of FIRST to Cerro Toco and Requirements for Future Experiments in Extremely Dry Environments, Jeffrey Mast[1], Martin G. Mlynczak[2], David Kratz[2], Richard Cageao[2], David G. Johnson[2], David Turner[3], Eli Mlawer[4]; [1]*SSAI, USA;* [2]*NASA Langley Research Center, USA;* [3]*NOAA, USA;* [4]*AER, USA.* Radiative transfer measurements in extremely dry environments offer fundamental tests of water vapor spectroscopy. For such studies instrument and water vapor input to radiative transfer models need to be known to within 2%.

Goethe-Saal

Optics and Photonics for Energy & the Environment (E2)

Telemann-Saal

Optical Nanostructures and Advanced Materials for Photovoltaics (PV)

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

EM4A • Remote Sensing Techniques to Measure Trace Gases, Particulates and Aerosols I—Continued

EM4A.3 • 17:30
Water Vapor Mixing Ratio Measured by Lidar at the Tibetan Plateau and Qingdao, Guangyao Dai[1], Songhua Wu[1]; [1]*Ocean Univ. of China, China.* A Raman lidar was deployed successively for the measurements of water vapor mixing ratio (WVMR) at Qingdao and the Tibetan Plateau. From these observations, the corresponding developments of WVMR at Qingdao and Naqu were analysed.

EM4A.4 • 17:45 Invited
Withdrawn.

EM4A.5 • 18:15
Upconversion-based Lidar Measurements of Atmospheric CO_2, Andreas Fix[1], Lasse Høgstedt[2], Christian Pedersen[2], Peter T. Lichtenberg[2], Martin Wirth[1]; [1]*German Aerospace Center, Germany;* [2]*Department of Photonics Engineering, Technical Univ. of Denmark, Denmark.* The return signal of an integrated path differential absorption lidar for atmospheric CO_2 measurements at 1572nm was shifted to 635nm by upconversion technology, detected by a photomultiplier tube, and compared to a conventional InGaAs detector.

PM4B • Perovskite PV I—Continued

PM4B.4 • 17:30
Robust Interface Engineering for High-performance and Stable Inverted Planar Perovskite Solar Cells via Both Poly(2-ethyl-2-oxazoline) Nanodots, Leiming Xu[1], Wei Chen[1], Zhubing He[1]; [1]*South Univ. of Science and Tech., China.* A low cost, chemical stable, solution processing, thermal treatment free PEOz was found to improve the performance of perovskite solar cells dramatically by band-alignment between PCBM and silver owingto electron extraction enhancement.

PM4B.5 • 17:45
Numerical Optical Optimization of Planar Monolithic Perovskite-silicon Tandem Solar Cells, Klaus Jaeger[1], Steve Albrecht[1], Lars Korte[1], Bernd Rech[1]; [1]*Helmholtz-Zentrum Berlin, Germany.* We present a numerical layer-thickness optimization of planar perovskite-silicon tandem solar cells in order to maximize the achievable photocurrent density. Results were obtained with the transfer-matrix method and the simulated annealing algorithm.

PM4B.6 • 18:00
Ultrafast Electrochemical Fabrication of Multicomponent Photovoltaic Materials, Feng Zhou[1], Hong Liu[1], Xinwei Wang[1], Wenzhong Shen[1]; [1]*Physics and Astronomy, Shanghai Jiao Tong Univ., China.* In this work, we represent a novel ultrafast and controllable electrochemical fabrication method for multi-component photovoltaic materials such as perovskites. The as-fabricated solar cell has exhibited good performance and high stability.

PM4B.7 • 18:15
Novel Insight into the Function of $PC_{61}BM$ in Efficient Planar Perovskite Solar Cells, Lin Fan[1], Yi Ding[1], Biao Shi[1], Changchun Wei[1], Dekun Zhang[1], Jiangsheng Xie[2], Xuegong Yu[2], Baojie Yan[1], Junhui Liang[1], Ying Zhao[1], Xiaodan Zhang[1]; [1]*Nankai Univ., China;* [2]*Zhejiang Univ., China.* We introduced a $PC_{61}BM$ layer between the compact TiO_2 layer and the perovskite absorber, which forms a porous precursor film, and thus promotes uniform perovskite films with large grain size and improves the device efficiency.

18:30–20:30 Congress Welcome Reception, *Leipzig Zoo, Mekong Event Space*

NOTES

Schiller-Saal	Händel-Saal	Lessing-Saal
Solid-State Lighting (SSL)	Fourier Transform Spectroscopy (FTS)	Hyperspectral Imaging and Sounding of the Environment (HISE)

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

SSM4C • OLED Materials—Continued

SSM4C.3 • 17:30 Invited

Effects of Charge-exciton and Exciton-exciton Interactions on the Efficiency of OLEDs – Experimental and Advanced Modelling Studies, Reinder Coehoorn[1], Le Zhang[1], Harm van Eersel[2], Peter Bobbert[1]; [1]*Eindhoven Univ. of Technology, Netherlands;* [2]*Simbeyond B.V., Netherlands.* At high brightness, exciton-exciton and exciton-charge interactions reduce the efficiency of OLEDs. Advanced molecular-scale modeling studies and experiments have been used to quantify these processes and to develop optimal material designs.

SSM4C.4 • 18:00 Invited

Degradation Phenomena in Wide Band-gap Organic Electroluminescent Materials, Hany Aziz[1], Yingjie Zhang[1], Qi Wang[1], Hyeonghwa Yu[1], Yong Joo Cho[1]; [1]*Univ. of Waterloo, Canada.* The limited stability of OLEDs utilizing wide band-gap materials, such as blue-emitting phosphorescent devices, continues to be a challenge for wider commercialization. Results from our investigations of the underlying mechanisms will be presented.

FM4D • Frequency Combs I—Continued

FM4D.4 • 17:30

Dense Spectral Sampling Dual-comb Spectroscopy through Pseudo-Random Phase Modulation of the Probe Comb, Nicolas Bourbeau-Hébert[1], Vincent Michaud-Belleau[1], Sébastien Magnan-Saucier[1], Jean-Daniel Deschênes[1], Jérôme Genest[1]; [1]*Universite Laval, Canada.* We introduce an efficient and simple technique to reduce the mode spacing of a frequency comb. We use such a densified comb in multiheterodyne configuration to characterize a microresonator displaying resonances that are otherwise unresolved.

FM4D.5 • 17:45

Near-Infrared Fourier Transform Cavity-Enhanced Optical Frequency Comb Spectroscopy, Amir Khodabakhsh[1], Lucile Rutkowski[1], Alexandra C. Johansson[1], Piotr Maslowski[2], Florian M. Schmidt[1], Aleksandra Foltynowicz[1]; [1]*Umea Universitet, Sweden;* [2]*Nicolaus Copernicus Univ., Poland.* Using Fourier transform-based cavity-enhanced optical frequency comb spectroscopy around 1.57 μm we measure high precision low pressure spectra of the $3\nu_1+\nu_3$ band of CO_2 and high temperature H_2O and OH spectra in a premixed methane/air flat flame.

FM4D.6 • 18:00 Invited

Fourier Transform Optical Frequency Comb Spectroscopy with Resolution Beyond the Optical-path-difference Limit, Piotr Maslowski[1]; [1]*Inst. of Physics, Faculty of Physics, Astronomy and Informatics, Nicolaus Copernicus Univ., Poland.* The resolution limit of Fourier transform spectrometry is overcome when spectrometer's optical path difference is matched to optical frequency comb's line spacing. Then instrumental-lineshape-free broadband molecular spectra are measured precisely.

HM4E • Hyperspectral Imaging of Trace Gases—Continued

HM4E.4 • 17:30

Citywide Measurements of NO2 Concentrations in Munich Using a Combination of Mobile and Stationary Spectroscopic Measurement Techniques, Ying Zhu[1], Gerrit Kuhlman[2], Ka Lok Chan[1], Sebastian Donner[3], Annette M. Schütt[1], Thomas Wagner[3], Mark O. Wenig[1]; [1]*LMU, Germany;* [2]*EMPA, Switzerland;* [3]*Chemistry, Max-Planck-Institut , Germany.* We performed 2 weeks of measurements in Munich to capture the spatial variability on NO2 using a combination of different spectroscopic instruments. We present first results of NO2 concentration maps derived from the mobile measurements.

HM4E.5 • 17:45

Studies on Spectrally Dependent CLARREO IR Instrument Calibration Requirement, Xu Liu[1]; [1]*NASA Langley Research Center, USA.* In this paper, we present a study quantifying the spectrally dependent radiometric calibration requirements for the CLARROE IR instrument in order to accurately determine climate trend of atmospheric temperature and moisture profiles.

HM4E.6 • 18:00 Invited

High Resolution Mapping of Urban NO2 Distributions Using Airborne Remote Sensing, Michel Van Roozendael[1]; [1]*Inst d'Aeronomie Spatiale de Belgique, Belgium.* Tropospheric NO2 columns have been derived from hyperspectral APEX observations over Berlin and the three largest Belgian cities at the resolution of 80x60 m2. We discuss the retrieval methodology and potential applications for source identification.

18:30–20:30 Congress Welcome Reception, *Leipzig Zoo, Mekong Event Space*

NOTES

08:00–12:00, 16:00–18:00 Registration, *South Foyer*

Weißer Saal

Joint

08:30–10:00
JTu1A • Keynote Session I

JTu1A.1 • 08:30 Keynote
Quantum-cascade Laser Frequency Combs and Their Application to Dual-comb Spectroscopy, Jérôme Faist[1]; [1]*ETH Zurich, Switzerland.* QCLs have recently demonstrated the capability of operating as optical frequency combs in the mid-infrared and terahertz with high optical power (>100mW). Self-detected dual comb operation and dual-comb spectroscopy were recently demonstrated.

JTu1A.2 • 09:15 Keynote
Mtg-irs: The Instrument, Its Products and Current User Readiness Activities, Stephen Tjemkes[1]; [1]*EUMETSAT, Germany.* This paper gives an overview of the Infrared Sounder mission, its planned products and the current activities to prepare the envisaged user community for the MTG-IRS era.

10:00–10:30 Networking and Coffee Break, *Großer Saal*

Goethe-Saal

Optics and Photonics for Energy & the Environment (E2)

Telemann-Saal

Optical Nanostructures and Advanced Materials for Photovoltaics (PV)

Leibniz-Saal

Optics for Solar Energy (SOLAR)

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

10:30–12:30
ETu2A • Optics and Photonics in Combustion Diagnostics
Presider: Frans J. Harren; Radboud Universiteit Nijmegen, Netherlands

ETu2A.1 • 10:30 Invited
Photons, Electrons, and Ions: Detective Work in Combustion Chemistry Research, Katharina Kohse-Hoinghaus[1], Andreas Brockhinke[1]; [1]*Universitat Bielefeld, Germany.* Primary energy consumption remains dependent on fossil fuels, driving research towards efficient and cleaner combustion processes. *In-situ* diagnostics will contribute to a fundamental understanding of the chemically complex combustion reactions.

ETu2A.2 • 11:00 Invited
On Recent Progress in Plasma Diagnostics and Trace Gas Detection Using Infrared Laser Techniques, Juergen Roepcke[1]; [1]*INP-Greifswald, Germany.* Chemical sensing using mid infrared laser absorption spectroscopy in the molecular fingerprint region which contains strong absorption features of a variety of species has been established as powerful diagnostic tool for molecular gases and plasmas.

10:30–11:30
PTu2B • Nanowires and Quantum Dots
Presider: Jan Goldschmidt; Fraunhofer Inst. Solare Energie Systeme, Germany

PTu2B.1 • 10:30 Invited
Quantifying Losses and Thermodynamic Limits in Nanophotonic Solar Cells, Erik C. Garnett[1]; [1]*Center for Nanophotonics, FOM Inst. AMOLF, Netherlands.* Integrating sphere microscopy is used to measure quantitative absorption, photoluminescence, external quantum efficiency and internal quantum efficiency along a single InP nanowire solar cell.

PTu2B.2 • 11:00 Invited
Application and Physics of Type-II Submonolayer Quantum Dots as an Active Medium for Intermediate Band Solar Cells, Igor Kuskovsky[1]; [1]*City Univ. of New York, USA.* We present growth and characterization of vertically correlated submonolayer type-II ZnCdTe/ZnCdSe quantum dots suitable for fabricating intermediate band solar cells. An actual p-i-n structure, lattice matched to InP, will be described.

10:30–12:15
SoTu2C • Innovative Approaches
Presider: Reiner Buck, German Aerospace Center, Germany

SoTu2C.1 • 10:30 Invited
Electrowetting-controlled Optofluidic Window Shelter for Building Natural Daylighting, Jiangtao Cheng[1]; [1]*Virginia Tech, USA.* In this paper we report a novel optofluidic window shelter system for natural daylighting in buildings. The implementation of the optofluidic system is based on electrowetting-on-dielectric enabling full range solar tracking and sunlight steering.

SoTu2C.2 • 11:00 Invited
3D Nano-architectures on Si Platforms for Opto-electronic Device Concepts such as Optical Sensors, Solarcells and Light Emitting Devices, Silke Christiansen[1], Sebastian Schmitt[1], George Sarau[1]; [1]*Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Germany.* The success integration of new, 3-D nano-architectures into devices such as sensors, solarcells, light emitting diodes (LEDs) a.o. on a silicon (Si) platform requires new approaches towards fabrication and characterisation.

08:00–12:00, 16:00–18:00 Registration, *South Foyer*

Weißer Saal

Joint

08:30–10:00
JTu1A • Keynote Session I

JTu1A.1 • 08:30 Keynote
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JTu1A.2 • 09:15 Keynote
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10:00–10:30 Networking and Coffee Break, *Großer Saal*

Schiller-Saal

Solid-State Lighting (SSL)

10:30–12:15
SSTu2D • Solid-State Light Systems
Presider: Andreas Bräuer; Fraunhofer Institut IOF, Germany

SSTu2D.1 • 10:30 Invited
Connected Lighting Solutions for the Cities of Tomorrow, Berit Wessler[1]; [1]*Osram GmbH, Germany.* After the paradigm shift towards LED Lighting, the lighting industry is now facing an even bigger disruption with the introduction of connected smart lighting and beyond lighting solutions that will impact life in future cities.

SSTu2D.2 • 11:00 Invited
How Digitalization of SSL Changes the World of Lighting, Horst Rudolph[1]; [1]*TRILUX Group, Germany.* LED has shown enormous growth rates in the past due to energy efficiency. The lighting industry now enters the next step of disruption by making light digital. How to survive between new customer needs and increasing competition?

Händel-Saal

Fourier Transform Spectroscopy (FTS)

10:30–12:30
FTu2E • Nano- and Micro- spectroscopy and Imaging
Presider: Juliet Pickering; Imperial College London, UK

FTu2E.1 • 10:30 Invited
Committing SINS: Ultra-broadband Synchrotron Infrared Nano-spectroscopy and Imaging, Hans Bechtel[1], Eric A. Muller[2,3], Robert L. Olmon[2,3], Omar Khatib[1,2], Michael C. Martin[1], Markus B. Raschke[2,3]; [1]*Advanced Light Source, Lawrence Berkeley National Laboratory, USA;* [2]*Departments of Physics and Chemistry, Univ. of Colorado, Boulder, USA;* [3]*JILA, Univ. of Colorado and National Inst. of Standards and Technology, USA.* Synchrotron infrared nano-spectroscopy (SINS) provides sensitive vibrational chemical contrast with < 25 nm spatial resolution, enabling investigations of nanoscale surface phenomena that were previously impossible to study with infrared techniques.

FTu2E.2 • 11:00
Enhanced Sensitivity of Nano-FTIR Spectroscopy, Bernd Kaestner[1], Peter Hermann[1], Gerhard Ulm[1], Arne Hoehl[1], Piotr Patoka[2], Georg Ulrich[2], Eckart Rühl[2]; [1]*Physikalisch-Technische Bundesanstalt, Germany;* [2]*Physikalische und Theoretische Chemie, Freie Universitaet Berlin, Germany.* Nano-FTIR spectroscopy enables surface characterization at nanometer scale using broadband infrared radiation. We will report on the effect of spectral filtering to significantly enhance the sensitivity of this method.

FTu2E.3 • 11:15
FTIR Imaging and Spectroscopy with Six Decades Spatial Dynamic Range, Christophe Sandt[1], Stephane Lefrancois[1], Alexandre Dazzi[2], Hans Bechtel[3], Honghua Yang[4], Craig Prater[4], Rosario Brunetto[5], Mustafa Kansiz[6], Ferenc Borondics[1]; [1]*Synchrotron Soleil, France;* [2]*Laboratoire de Chimie Physique, Université Paris-Sud, France;* [3]*Advanced Light Source Division, Lawrence Berkeley National Laboratory, USA;* [4]*Anasys Instruments, USA;* [5]*Institut d'Astrophysique Spatiale, CNRS, France;* [6]*Agilent Technologies, Australia.* The SMIS beamline allows a multitechnique and multiscale approach to FTIR studies. The newest developments and capabilities, including nanoscale measurements and large area imaging, the fastest growing fields in synchrotron FTIR will be reviewed.

Lessing-Saal

Hyperspectral Imaging and Sounding of the Environment (HISE)

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

10:30–12:30
HTu2F • Hyperspectral Sensing of Cloud and Aerosol Properties
Presider: Manfred Wendisch; Universitat Leipzig, Germany

HTu2F.1 • 10:30 Invited
Analysis of the Vertical Distribution of the Thermodynamic Phase in Tropical Deep-convective Clouds, Evelyn Jäkel[1], Manfred Wendisch[1], Florian Ewald[2,3], Tobias Kölling[2]; [1]*Leipzig Inst. for Meteorology, Univ. of Leipzig, Germany;* [2]*Meteorological Inst., Ludwig-Maximilians-Univ. Munich, Germany;* [3]*Inst. of Atmospheric Physics, German Aerospace Center, Germany.* Vertical profiles of the cloud thermodynamic phase of tropical deep-convective clouds were investigated based on airborne cloud side observations performed with an imaging spectroradiometer system during the ACRIDICON-CHUVA experiment.

HTu2F.2 • 11:00
Directional, Horizontal Inhomogeneities of Cloud Optical Thickness Fields Retrieved from Ground-Based and Airborne Spectral Imaging, Michael Schäfer[1], Elke Bierwirth[1], André Ehrlich[1], Evelyn Jäkel[1], Frank Werner[1,2], Manfred Wendisch[1]; [1]*Univ. of Leipzig, Leipzig Inst. for Meteorology, Germany;* [2]*Univ. of Maryland, Joint Center for Earth Systems Technology, USA.* Cloud optical thickness fields, retrieved from solar spectral radiance measurements are used to investigate directional, horizontal cloud inhomogeneities with scalar 1D inhomogeneity parameters, 2D auto-correlation functions and 2D Fourier analysis.

HTu2F.3 • 11:15
The Cirrus Coupled Cloud-radiation Experiment-II, Jon E. Murray[1], Stuart Fox[2], Sebatian O'Shea[4], Jenna Thornton[3], Jamie Trembath[5], Jacob Fugal[6], Juliet C. Pickering[1], Cathryn Fox[2], Jennifer Brooke[2], Chawn Harlow[2], Keith Bower[4], Joseph Ulanowski[3], Anthony Baran[2], Helen Brindley[1], Georg Ritter[3], Alan Last[1]; [1]*Imperial College London, UK;* [2]*UK Meteorological Office, UK;* [3]*Hertfordshire Univ., UK;* [4]*Manchester Univ., UK;* [5]*Facility for Airborne Atmospheric Measurements, UK;* [6]*Univ. of Mainz, Germany.* A cirrus study has been undertaken during the second Cirrus Cloud-Radiation Experiment field campaign based in Prestwick, Scotland. We report on a case study describing the radiation and microphysics measurements and cloud modelling work.

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

ETu2A • Optics and Photonics in Combustion Diagnostics—Continued

ETu2A.3 • 11:30
Ultra-large Amplitude Wavelength Modulation Spectroscopy, Torrey R. Hayden[1]; [1]*Univ. of Colorado at Boulder, USA.* We demonstrate the extension of wavelength modulation spectroscopy (WMS) to ultra-large modulation depths by using a fast-scanning MEMS laser. We perform measurements of CO_2 in air at the highest to-date density for a WMS measurement.

ETu2A.4 • 11:45
A Tunable Diode Laser Absorption Based Velocity Sensor for Local Field in Hypersonic Flows, Zhenyu Xu[1], Ruifeng Kan[1], Jun Ruan[1], Lu Yao[1], Xueli Fan[1], Jianguo Liu[1]; [1]*Anhui Inst Optics & Fine Mech, CAS, China.* A new structure TDLAS velocity sensor for local hypersonic flow field and data processing method is presented. Schlieren images of the probe in wind tunnel tests show TDLAS measurement is barely influenced by shock layers.

ETu2A.5 • 12:00 Invited
Gas-Phase and Combustion Diagnostics by Infrared Laser-induced Grating Spectroscopy, Johannes Kiefer[1], Anna-Lena Sahlberg[2], Dina Hot[2], Marcus Alden[2], Zhongshan Li[2]; [1]*Universitat Bremen, Germany;* [2]*Lund Univ., Sweden.* Infrared laser-induced grating spectroscopy is a powerful method for the detection of molecules in atmospheric and combustion chemistry by exploiting their fundamental vibrations. This work discusses potentials and limitations of the method.

PTu2B • Nanowires and Quantum Dots—Continued

PTu2B.3 • 11:30
Simulation of Absorption Enhancement and Optical Modes in CIS Nanocrystal Embedded Photonic Crystal Designs, Stephan Dottermusch[1], Aina Quintilla[1], Guillaume Gomard[1], Ulrich W. Paetzold[1], Bryce S. Richards[1]; [1]*KIT, Germany.* Photonic crystals can be utilized for absorption enhancement in thin film solar cells. Numerical simulations were performed for optimizing structural parameters of photonic crystals embedded in CIS nanocrystal fabricated using a novel method.

SoTu2C • Innovative Approaches—Continued

SoTu2C.3 • 11:30 Invited
Optical Gain and Loss Mechanisms in Photovoltaic Modules, Jens Schneider[1]; [1]*Fraunhofer Center for Silicon Photovoltaics CSP, Germany.* Solar module power can exceed cell power when optical gains exceed optical losses. In this presentation an overview on optical gain and loss mechanisms is given and opportunities for improvement are discussed.

SoTu2C.4 • 12:00
Reduced Graphene Oxide: A Promising Solid-state Electron Mediator for Solar Oxygen Evolution, Hassan Sameie[1], Ali A. Sabbagh Alvani[1], Naimeh Naseri[2]; [1]*Color and Polymer Research Center (CPRC), Amirkabir Univ. of Technology, Iran;* [2]*Department of Physics, Sharif Univ. of Technology, Iran.* We believe that reduced graphene oxide sheets can promote the photogenerated charge separation and electron transport in photoanodes for O_2 evolution in photoelectrochemical cells because of their unique 2D carbon structure.

12:30–16:30 Free Afternoon

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

SSTu2D • Solid-State Light Systems—Continued

SSTu2D.3 • 11:30 Invited

Large Area Intelligent Efficient High Quality Solid-State Lighting, Rolando Ferrini[6], Oscar Fernandez[6], Stephan Junger[1], Kimmo Keränen[2], Leire Barruetabeña[3], Adrian von Mühlenen[4], Thierry Dreyfus[5]; [1]*Fraunhofer IIS, Germany;* [2]*VTT, Finland;* [3]*Gaiker, Spain;* [4]*BASF Schweiz AG, Switzerland;* [5]*Regent Lighting AG, Switzerland;* [6]*CSEM SA, Switzerland*. This communication will present the main results of the European project LASSIE-FP7, whose objective is to implement large-area intelligent SSL modules with high efficiency and high lighting quality, while assessing their environmental footprint.

SSTu2D.4 • 12:00

Development and Evaluation of Colour Control Interfaces for LED Lighting, Wenye Hu[1], Wendy Davis[1]; [1]*Faculty of Architecture, Design and Planning, Univ. of Sydney, Australia*. For spectrally tunable LED lighting, a model for converting device-specific control signals, such as DMX settings, to chromaticity coordinates was used in an experiment evaluating the usability of different colour control interfaces.

FTu2E • Nano- and Micro- spectroscopy and Imaging—Continued

FTu2E.4 • 11:30

Withdrawn.

FTu2E.5 • 11:45

Attenuated Total Reflection FTIR Microspectroscopy at the Australian Synchrotron, Mark Tobin[1], Keith R. Bambery[1], Danielle E. Martin[1], Ljiljana Puskar[2], David A. Beattie[3], Elena P. Ivanova[4], Song-Ha Nguyen[4], Hayden K. Webb[4], Jitraporn Vongsvivut[1]; [1]*Australian Synchrotron, Australia;* [2]*Helmholtz-Zentrum für Materialien und Energie GmbH, Germany;* [3]*Univ. of South Australia, Australia;* [4]*Swinburne Univ. of Technology, Australia*. ATR FTIR microspectroscopy enables the analysis of samples with lateral resolution greater than is possible by transmission FTIR. ATR accessories have been developed for the study of materials with multilayer coatings and fine surface structures.

FTu2E.6 • 12:00

Time-dependent Water Uptake in s Polymer Model Coating Visualised by FTIR Microscopy Using a Focal Plane Array Detector, Petra M. Ebbinghaus[1]; [1]*Max-Planck-Institut für Eisenforschung, Germany*. Progress of the delamination front during cathodic delamination was imaged by FTIR microscopy. Delamination experiments were carried out using H_2O and D_2O-based electrolytes. Inhomogeneous propagation of the delamination front was observed.

FTu2E.7 • 12:15

Holographic Fourier Transform Spectroscopy of Biosamples, Georgy S. Kalenkov[1], Sergey G. Kalenkov[2], Alexander E. Shtanko[3]; [1]*Microholo Ltd, Russia;* [2]*Univ. of mechanical engineering, Russia;* [3]*Moscow State Technical Univ., Russia*. New approach of holographic microspectroscopy is suggested. Point to point spectra of a microobject are derived from hyperspectral holograms registered in uncoherent, wideband radiation. Method is applicable for label free, weakly absorbing tissues.

HTu2F • Hyperspectral Sensing of Cloud and Aerosol Properties—Continued

HTu2F.4 • 11:30

Airborne Hyperspectral Observations of Aerosols, Clouds and Radiation in the Southeast Atlantic – First Results from NASA's Oracles Campaign, Jens Redemann[1], Samuel LeBlanc[2], Connor Flynn[3], Michal Segal-Rozenhaimer[2], Yohei Shinozuka[2], Roy Johnson[1], Stephen Dunagan[1], Beat Schmid[3], Meloe Kacenelenbogen[2], Kristina Pistone[4], Sebastian Schmidt[5], Sabrina Cochrane[5], Peter Pilewskie[5], Warren Gore[1], Robert Wood[6], Paquita Zuidema[7]; [1]*NASA Ames Research Center, USA;* [2]*BAER Inst., USA;* [3]*PNNL, USA;* [4]*NASA ARC/USRA, USA;* [5]*LASP - Univ. of Colorado, USA;* [6]*Univ. of Washington, USA;* [7]*Univ. of Miami, USA*. NASA's ORACLES campaign aims to understand key parameters and processes driving the interactions of biomass burning aerosols with clouds over the South Atlantic. We describe first results from two hyperspectral instruments deployed in ORACLES-2016.

HTu2F.5 • 11:45 Invited

The Shortwave Spectral Signature of Cloud Spatial Structure – a New Observable for Cloud Remote Sensing, Sebastian Schmidt[2,3], Graham Feingold[1], Shi Song[2], Sabrina Cochrane[2,3], Hong Chen[2,3]; [1]*ESRL, NOAA, USA;* [2]*ATOC, Univ. of Colorado, USA;* [3]*LASP, Univ. of Colorado, USA*. We show that cloud morphology manifests itself as spectral signatures in radiance and irradiance observations, and argue that this connection may pave the way for improved estimates of cloud-aerosol radiative effects from space.

HTu2F.6 • 12:15

Ship Borne Rotating Shadow Band Radiometer Observations for the Determination of Multi Spectral Irradiance Components and Direct Sun Products for Aerosol, Jonas Witthuhn[1], Hartwig Deneke[1], Andreas Macke[1], Germar Bernhard[2]; [1]*TROPOS, Germany;* [2]*Biospherical Instruments Inc., USA*. Introducing a 19 channel rotating shadow band radiometer as a possible means to provide automated irradiance and aerosol observations from a ship under the framework of OCEANET. Presenting initial evaluation and performance compared to AERONET.

12:30–16:30 Free Afternoon

Goethe-Saal

Optics and Photonics for Energy & the Environment (E2)

Telemann-Saal

Optical Nanostructures and Advanced Materials for Photovoltaics (PV)

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

16:30–17:30
ETu3A • Laser-based Instruments and Techniques
Presider: Johannes Kiefer; Universitat Bremen, Germany

ETu3A.1 • 16:30 Invited
Laser-based Trace Gas Detection in Life Science, Frans J. M. Harren[1]; [1]*Radboud Universiteit Nijmegen, Netherlands.* Abstract not available.

ETu3A.2 • 17:00
Likelihood based Wavelength Selection for Sorting Metals by Laser-induced Breakdown Spectroscopy, Hyemin Jang[1], Sungho Shin[1], Sungho Jeong[1], Euiseok Hwang[1]; [1]*School of Mechatronics, Gwangju Inst. of Science and Technology (GIST), Korea.* Likelihood based wavelength selection is proposed for efficient classification of metals by laser-induced breakdown spectroscopy. Copper alloys are evaluated with the 10 selected points from 12,288 and classified much faster with fewer errors.

ETu3A.3 • 17:15
Dissemination Of Precise Radio-frequency References For Environmental Sensing Over Long-Haul Optical-fiber Networks, Kenneth G. Baldwin[1], Yabai He[3], Brian Orr[2], Bruce Warrington[3], Andre Luiten[4], Peter Mirtschin[5], Tasso Tzioumis[5], Chris Phillips[5], Guido Aben[6], Thomas Newlands[6], Tim Rayner[6]; [1]*Australian National Univ., Australia;* [2]*Macquarie Univ., Australia;* [3]*National Measurement Inst., Australia;* [4]*Univ. of Adelaide, Australia;* [5]*CSIRO, Australia;* [6]*AarNet, Australia.* Optical-fiber networks, compensated for path-length fluctuations, enable long-distance dissemination of a radio-frequency signal for precise spectroscopic calibration at remote sites in environmental, industrial and energy-monitoring applications.

16:30–17:30
PTu3B • Perovskite PV II and Organic PV
Presider: Ulrich Paetzold; IMEC, Germany

PTu3B.1 • 16:30 Invited
Halide Perovskites—An Emerging Class of Optoelectronic Materials, Hanwei Gao[1]; [1]*Florida State Univ., USA.* Solution-processed halide perovskites have shown their promises in a variety of optoelectronic applications, from solar cells, light emitting diodes, to photodetectors. This new class of optoelectronic materials exhibit superb optical and electrical properties such as long diffusion length, high carrier mobility, strong optical absorption, and tunable bandgap. Despite the successful demonstrations reported so far, perovskite-based devices with high performance and stability still remain challenging. Our work has been focused on creating halide perovskites for electrically-driven LEDs. We found that the morphology of the materials, either nanostructured or microcrystalline, plays important role in both optical and electrical properties. With optimized morphology, perovskite-based LEDs with high brightness and external quantum efficiencies have been achieved. The approaches to control and manipulate crystallization of halide perovskite may also be applicable to the development of other optoelectronic applications such as solar cells.

PTu3B.2 • 17:00 Invited
Advanced Nanomaterials for Enhancing the Performance and Stability of Organic Solar Cells, Dong Chan Lim[1]; [1]*Korea Inst. of Materials Science, Korea.* We have incorporated Au38 nanocluster consist of 38 Au atoms on inverted organic PV. Based on the energy transfer effect, the highest performing OPV, ~20% increased in the efficiency, fabricated.

17:30–19:00 Industry Panel Discussion, *Weißer Saal*
Moderator: Kenneth Baldwin, Australian National Univ., Australia

19:00–21:30 Congress Banquet, *Altes Landratsamt*

Fourier Transform Spectroscopy (FTS)

Hyperspectral Imaging and Sounding of the Environment (HISE)

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

16:30–17:30
FTu3C • Far Infrared Measurements of the Earth's Atmosphere
Presider: Erik Kretschmer; Karlsruher Institut für Technologie, Germany

FTu3C.1 • 16:30
The Far Infrared FTS for the FORUM Mission, Luca Palchetti[1], Monica Olivieri[2], Carlo Pompei[2], Demetrio Labate[2], Helen Brindley[3], Gianluca Di Natale[1], Giovanni Bianchini[1]; [1]*Istituto Nazionale di Ottica (CNR), Italy;* [2]*Leonardo-Finmeccanica, Italy;* [3]*Imperial College London, UK.* A wide-band FTS has been designed to perform the spectral observation of the entire infrared Earth's outgoing emission, including the far infrared portion, for the FORUM space mission.

FTu3C.2 • 16:45
Retrieval of Antarctic Cirrus Cloud Micro-physics from Measurements of Far Infrared Spectral Radiance, Gianluca Di Natale[1], Luca Palchetti[1], Giovanni Bianchini[1], Massimo Del Guasta[1]; [1]*Istituto Nazionale di Ottica - CNR, Italy.* A retrieval method for cirrus clouds was applied to the measurements of spectral radiance performed by the REFIR-PAD Fourier spectroradiometer over the Antarctic Plateau at Dome C.

FTu3C.3 • 17:00
Two Years of Spectrally-resolved Measurements of the Antarctic Downwelling Atmospheric Radiance Within the COMPASS Project, Giovanni Bianchini[1], Gianluca Di Natale[1], Massimo Del Guasta[1], Luca Palchetti[1]; [1]*INO-CNR, Italy.* Atmospheric emitted radiance, provided by a FT spectroradiometer installed at Concordia Station, Antarctica in the framework of the COMPASS project has been analyzed providing a characterization of the Antarctic troposphere in the 2014-2016 period.

FTu3C.4 • 17:15
The Absolute Radiance Interferometer (ARI) for the CLARREO Pathfinder: Instrument Status and Demonstrated Performance, Joe Taylor[1], Henry E. Revercomb[1], Fred A. Best[1], P. J. Gero[1], David C. Tobin[1], Robert O. Knuteson[1], Doug Adler[1], Claire Pettersen[1], Jeff Wong[1], Mark Schwarz[1], Henry Buijs[2], Frederic Grandmont[2], John A. Dykema[3]; [1]*Space Science and Engineering Center (SSEC), Univ. of Wisconsin-Madison, USA;* [2]*ABB-Bomem Inc, Canada;* [3]*Harvard Univ., USA.* The infrared Absolute Radiance Interferometer prototype instrument was developed for NASA's Climate Absolute Radiance and Reflectivity Observatory (CLARREO), and brought to a Technical Readiness Level of 6. The current status of the ARI is presented.

17:00–17:30
HTu3D • Advances in Algorithms for Hyperspectral Sensing
Presider: Martin Mlynczak; NASA Langley Research Ctr, USA

HTu3D.2 • 17:00
Using k-way Normalized Cuts to Integrate LiDAR and Hyperspectral Imagery for Segmentation, Orhan Torun[1], Seniha Esen Yuksel[1]; [1]*Hacettepe Univ., Turkey.* We propose a new affinity matrix for the Ncut algorithm that takes into account both the hyperspectral and LiDAR data for segmentation. Our results show that the segmentation is much more accurate and can distinguish objects better than a plain Ncut.

HTu3D.3 • 17:15
Informed Source Separation of Atmospheric and Surface Contributions in Hyperspectral Imagery using Non-Negative Matrix Factorization, Logan A. Wright[1], Odele Coddington[1], Peter Pilewskie[1]; [1]*Univ. of Colorado at Boulder, USA.* Informed Non-negative Matrix Factorization is a numerical tool that can be tailored to separate atmospheric and surface contributions to hyperspectral imagery by using prior knowledge of signal spectral shape, magnitude and spatial abundance.

17:30–19:00 Industry Panel Discussion, *Weißer Saal*
Moderator: Kenneth Baldwin, Australian National Univ., Australia

19:00–21:30 Congress Banquet, *Altes Landratsamt*

All technical papers are currently available for online download.
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08:00–12:00, 13:30–18:00 Registration, *South Foyer*

Weißer Saal

Joint

08:30–10:00
JW1A • Keynote Session II

JW1A.1 • 08:30 Keynote
Solar Fuels: Specific Requirements for Solar Concentrator Systems, Christian Sattler[1]; [1]*German Aerospace Center, Germany.* The production of fuels by concentrated solar radiation is an option for efficient large scale processes. The radiation can either be used to replace fossil fuels for heating established processes like steam or dry reforming of methane. Or at higher temperature to drive thermochemical cycles for water or CO_2 splitting into hydrogen, oxygen and CO. Presently most of the technologies are developed with high flux solar simulators. However some scale-up demonstrations on solar towers have been operated. The concentrator systems, mainly heliostat fields, are similar to installations for power production. However the chemical reactions require a different heating regime. Therefore a special optics and control systems have to be developed to achieve the very high temperatures necessary to carry out thermochemical cycles constantly and homogeneously in the whole solar receiver. The presentation will give an overview of the concentrating solar fuel production processes. It will give insight in how to design the required heliostat fields, secondary optics, and control systems.

JW1A.2 • 09:15 Keynote
Lidar Techniques and Applications for Improving Wind Energy Production and Characterizing Pollution from Fossil Fuel-Based Energy Generation, Michael Hardesty[2,1]; [1]*Chemical Sciences Division, NOAA, USA;* [2]*CIRES, Univ. of Colorado Boulder, USA.* This paper describes the use of Doppler and differential absorption lidar (DIAL) remote sensing techniques to enhance wind energy production and investigate air pollution and greenhouse gas emissions from burning of fossil fuel.

10:00–10:30 Networking and Coffee Break, *Großer Saal*

Goethe-Saal

Optics and Photonics for Energy & the Environment (E2)

Telemann-Saal

Optical Nanostructures and Advanced Materials for Photovoltaics (PV)

Leibniz-Saal

Optics for Solar Energy (SOLAR)

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10:30–12:30
EW2A • Lidars in Dust and Aerosol Observation
Presider: Arthur Dogariu; Princeton Univ., USA

EW2A.1 • 10:30 Invited
The Asian Dust and Aerosol Lidar Observation Network (AD-Net), Nobuo Sugimoto[1], Tomoaki Nishizawa[1], Atsushi Shimizu[1], Yoshitaka Jin[1]; [1]*National Inst for Environmental Studies, Japan.* Asian dust and air pollution aerosols are continuously observed at ~20 locations in East Asia using polarization sensitive multi-wavelength lidars. The data from the network are processed and published in near real-time.

EW2A.2 • 11:00 Invited
Withdrawn.

10:30–12:30
PW2B • Multi-junction Solar Cells
Presider: Ning Dai, Chinese Academy of Sciences, China

PW2B.1 • 10:30 Invited
Tandem Solar Cells with Infrared-tuned Silicon Bottom Cells, Zhengshan (Jason) Yu[1], Mehdi Leilaeioun[1], Kathryn Fisher[1], mathieu boccard[1], Zachary Holman[1]; [1]*Arizona State Univ., USA.* We modify silicon heterojunction solar cells for the near-infrared spectrum and reduced generation rate that they experience in tandems, with a focus on the front transparent conductive oxide layer and rear reflector.

PW2B.2 • 11:00 Invited
Advanced Photon Management in Printed High-efficiency Multijunction Solar Cells, Xing Sheng[1]; [1]*Tsinghua Univ., China.* Firstly, we demonstrate four-junctions, four-terminal solar cells with measured efficiencies of 43.9% at concentrations exceeding 1000 suns. Secondly, we present a printed MJ cell architecture with advanced photo-recycling capabilities.

10:30–12:15
SoW2C • CSP and PV Applications
Presider: Ranga Pitchumani; Virginia Tech, USA

SoW2C.1 • 10:30 Invited
Novel Optical Collection Method for Concentrating Solar Power, Boubacar Kante[1]; [1]*Univ. of California, San Diego, USA.* Abstract not available.

SoW2C.2 • 11:00
Metamaterial-silicon Anti-reflection Waveguide Model for Solar Cells, Houria Hamouche[1,2], Mohammed Shabat[3], Daniel Schaadt[4]; [1]*Centre de Développement des Energies Re, Algeria;* [2]*Département de Physique, Ecole Normale Supérieure , Algeria;* [3]*The Islamic Univ. of Gaza., Palestine, State of;* [4]*Inst. of Energy Research and Physical Technologies., Germany.* Transfer matrix method was applied to analyze the optical properties of a metamaterial antireflection coating structure for silicon solar cells for several angles of incidence. The numerical results highlighted an enhancement of the absorption power.

SoW2C.3 • 11:15
Hybrid Perovskite Thin Films as Highly Efficient Luminescent Solar Concentrators, Christine Hoffman[1], Katerina Nikolaidou[1], Boaz Ilan [1], Sayantani Ghosh[1]; [1]*Univ. of California, USA.* High refractive index and broad absorption spectrum theoretically make perovskites ideal for luminescent solar concentrators. Monte Carlo simulations show that perovskites perform better than CdSe/CdTe quantum dots.

08:00–12:00, 13:30–18:00 Registration, *South Foyer*

Weißer Saal

Joint

08:30–10:00
JW1A • Keynote Session II

JW1A.1 • 08:30 Keynote
Solar Fuels: Specific Requirements for Solar Concentrator Systems, Christian Sattler[1]; [1]*German Aerospace Center, Germany.* The production of fuels by concentrated solar radiation is an option for efficient large scale processes. The radiation can either be used to replace fossil fuels for heating established processes like steam or dry reforming of methane. Or at higher temperature to drive thermochemical cycles for water or CO_2 splitting into hydrogen, oxygen and CO. Presently most of the technologies are developed with high flux solar simulators. However some scale-up demonstrations on solar towers have been operated. The concentrator systems, mainly heliostat fields, are similar to installations for power production. However the chemical reactions require a different heating regime. Therefore a special optics and control systems have to be developed to achieve the very high temperatures necessary to carry out thermochemical cycles constantly and homogeneously in the whole solar receiver. The presentation will give an overview of the concentrating solar fuel production processes. It will give insight in how to design the required heliostat fields, secondary optics, and control systems.

JW1A.2 • 09:15 Keynote
Lidar Techniques and Applications for Improving Wind Energy Production and Characterizing Pollution from Fossil Fuel-Based Energy Generation, Michael Hardesty[2,1]; [1]*Chemical Sciences Division, NOAA, USA;* [2]*CIRES, Univ. of Colorado Boulder, USA.* This paper describes the use of Doppler and differential absorption lidar (DIAL) remote sensing techniques to enhance wind energy production and investigate air pollution and greenhouse gas emissions from burning of fossil fuel.

10:00–10:30 Networking and Coffee Break, *Großer Saal*

Schiller-Saal

Solid-State Lighting (SSL)

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

10:30–12:30
SSW2D • OLED Optics & Emitter Orientation
Presider: Russell Holmes; Univ. of Minnesota Twin Cities, USA

SSW2D.1 • 10:30 Invited
Enhance Light Out-coupling of OLEDs: Low-Index Active Materials and Horizontal Dipole Emitters, Chung-Chih Wu[1], Wei-Kai Lee[1], Min Jiao[1], Chun-Yang Lu[1]; [1]*National Taiwan Univ., Taiwan.* We report that judicious use of low-index active organic materials and transparent electrodes in OLEDs, together with preferentially horizontal dipole emitter, can effectively enhance optical coupling both into substrate and directly into air.

SSW2D.2 • 11:00
Enhanced Light Coupling of White Organic LED Using Sub-anode High Index Grids, Dirk Michaelis[1], Christoph Wächter[1], Thomas Wehlus[2], Andreas F. Rausch[2], Frank Fuchs[1], Lorenz Stürzebecher[1], Torsten Harzendorf[1], Norbert Danz[1], Andreas Bräuer[1]; [1]*Fraunhofer IOF, Germany;* [2]*OSRAM OLED GmbH, Germany.* Periodic arrays of high refractive index structures are arranged below the anode of a white, bottom-emitting Organic LED. Significant enhancement of the emission into air and substrate is achieved without introducing pronounced chromatic effects.

SSW2D.3 • 11:15
Accurate Modeling of Outcoupling from OLEDs: Volumetric versus Flat Internal Scattering Layers, Amos Egel[1], Dominik Theobald[1], Yidenekachew J. Donie[1], Jan B. Preinfalk[1], Guillaume Gomard[1], Uli Lemmer[1]; [1]*Karsruhe Inst. of Technology, Germany.* We use the T-matrix formalism to compute light outcoupling through disordered internal scattering layers in OLEDs. The method can be used for particle-based volumetric scattering layers and for flat photonic layers based on nano-cylinders.

Händel-Saal

Fourier Transform Spectroscopy (FTS)

10:30–12:30
FW2E • Femtosecond Laser & Combs
Presider: Adam Fleisher; National Inst of Standards & Technology, USA

FW2E.1 • 10:30 Invited
Broadband Fourier-Transform Pump-Probe Spectroscopy and Stimulated Raman Scattering Microscopy at Megahertz Modulation Frequencies, Fabrizio Preda[1], Aurelio Oriana[1], Julien Réhault[1], Sandro De Silvestri[1], Giulio Cerullo[1], Dario Polli[1]; [1]*Politecnico di Milano, Italy.* We introduce a common-path birefringent interferometer to perform Fourier-transform spectroscopy combined with lock-in detection at 20-MHz frequency. We apply it for broadband pump-probe spectroscopy and stimulated Raman scattering microscopy.

FW2E.2 • 11:00
Ultra-broadband Dual-comb Coherent Anti-Stokes Raman Spectroscopy, Pei-Ling Luo[1,2], Ming Yan[1,2], Theodor Hänsch[1,2], Nathalie Picque[1,2]; [1]*Max-Planck-Institut fur Quantenoptik, Germany;* [2]*Fakultät für Physik, Ludwig-Maximilians-Universität München, Germany.* Dual-comb coherent Raman spectra span Raman shifts from 300 to 3300 cm^{-1}. They are measured within less than 100 µs at a resolution of 8 cm^{-1}.

FW2E.3 • 11:15
Dual-comb Nonlinear Raman Spectroscopy of Broad Molecular Bands, Gwenaelle Mélen[1], Ming Yan[1], Pei-Ling Luo[1], Theodor Hänsch[1,2], Nathalie Picque[1,2]; [1]*Max-Planck Inst. for Quantum Optics, Germany;* [2]*Fakultät für Physik, Ludwig-Maximilians-Universität München, Germany.* Highly-multiplex coherent anti-Stokes Raman spectra are measured within a short recording time (µs scale) and a high refresh rate (several kHz) on a single photodetector with two femtosecond frequency combs of strongly different repetition rates.

Lessing-Saal

Hyperspectral Imaging and Sounding of the Environment (HISE)

10:30–11:30
HW2F • Hyperspectral Sensing of Climate Change I
Presider: Elmar Csaplovics; Technische Universität Dresden, Germany

HW2F.1 • 10:30 Invited
Observing Climate Change with Both Shortwave and Longwave Hyperspectral Satellite Instrumentation, Daniel R. Feldman[1], William D. Collins[1,2], Yolanda Shea[3], Newton Nguyen[1], Xu Liu[3], Bruce Wielicki[3]; [1]*Climate Sciences, Lawrence Berkeley National Laboratory, USA;* [2]*Earth and Planetary Science, Univ. of California-Berkeley, USA;* [3]*NASA Langley Research Center, USA.* We have modeled changes in top-of-atmosphere spectra from 0.3 to 50 µm, highlighting the spectral signatures of climate change that emerge on annual to centennial time-scales, thereby guiding upcoming satellite observational priorities.

HW2F.2 • 11:00 Invited
On the Use of Hyperspectral Observations in Climate Studies: Unveiling a Hidden Dimension, Xianglei Huang[1]; [1]*Univ. of Michigan, USA.* This talk summarizes a few studies in my research group that utilized spectral information in the hyperspectral radiances to test and diagnose global climate models, demonstrating the non-traditional use of such spectrally resolved observations.

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

EW2A • Lidars in Dust and Aerosol Observation—Continued

EW2A.3 • 11:30
Central Asian Dust Experiment (CADEX): First Year Lidar Observations, Julian Hofer[1], Dietrich Althausen[1], Sabur Abdullaev[2], Abduvosit Makhmudov[2], Bakhron Nazarov[2], Georg Schettler[3], Ronny Engelmann[1], Holger Baars[1], Bernd Heinold[1], Konrad Müller[1], Khanneh Wadinga Fomba[1]; [1]*Leibniz Inst. for Tropospheric Research, Germany;* [2]*Physical Technical Inst. of the Academy of Science of Tajikistan, Tajikistan;* [3]*GFZ German Research Centre for Geosciences, Germany.* Tajikistan and Central Asia suffer from climate change and the potential role of dust needs to be investigated. The Central Asian Dust Experiment conducts first lidar measurements in Tajikistan.

EW2A.4 • 11:45
Central Asian Dust Experiment (CADEX) and Comparison of Lidar Ratios of Asian and Saharan Dust, Dietrich Althausen[1], Sabur Abdullaev[2], Julian Hofer[1], Abduvosit Makhmudov[2], Konrad Müller[1], Khanneh Wadinga Fomba[1], Bernd Heinold[1], Georg Schettler[3], Bakhron Nazarov[2], Nasridin Minikulov[2]; [1]*Inst. for Tropospheric Research, USA;* [2]*S.U.Umarov Physical-Technical Inst., Academy of Sciences of Republic of Tajikistan, Tajikistan;* [3]*Helmholtz Centre - German Research Centre for Geosciences, Germany.* We report about first aerosol lidar measurements at Dushanbe, Tajikistan (Central Asia) during our Central Asian Dust EXperiment (CADEX) project and compare the low lidar ratios of Asian dust with the values of Saharan dust.

EW2A.5 • 12:00
Monitoring Dust Storms Over the Persian Gulf and the Oman Sea by Using CALIPSO Recordings, Hamid Reza Khalesifard[1], Farizeh Bayat[1]; [1]*Physics Department and Center for Research in Climate Change and Global warming, Inst for Advanced Studies in Basic Sci, Iran.* Integrated attenuated backscatter, aerosol optical depth and particulate depolarization ratio, from the recordings of the CALIPSO satellite, have been used for monitoring dust events over the Persian Gulf, Oman and Arab seas.

EW2A.6 • 12:15
Polly ^{NET}: An Emerging Network of Automated Raman-polarization Lidars for Continuous Aerosol Profiling, Holger Baars[1], Thomas Kanitz[1,2], Ronny Engelmann[1], Dietrich Althausen[1], Birgit Heese[1], Albert Ansmann[1], Ulla Wandinger[1]; [1]*Remote sensing, Leibniz Inst. for Tropospheric Research (TROPOS), Germany;* [2]*ESTEC, European Space Agency, Netherlands.* A global vertically resolved aerosol data set covering more than 10 years of observations at more than 20 measurement sites has been achieved from portable, remote-controlled multiwavelength-polarization-Raman lidars (Polly) within Polly^{NET}.

PW2B • Multi-junction Solar Cells—Continued

PW2B.3 • 11:30 Invited
Multifunctional Antireflection Coatings for High-efficient Light Harvesting in Photovoltaic Devices, Weijie Song[1]; [1]*Ningbo Inst. of Material Technology and Engineering, Chinese Academy of Sciences, China.* We developed multifunctional AR coatings based on hollow silica-silica nanocomposites. The AR coatings could suppress the reflection and achieve the light trapping in micromorph solar cells. The current mismatch of subcells was also improved.

PW2B.4 • 12:00 Invited
Optical Simulation of Multi-junction Solar Cells, R. Santbergen[1], Ryota Mishima[2], Tomomi Meguro[2], Takashi Suezaki[2], Masashi Hino[2], Hisashi Uzu[2], Gensuke Koizumi[2], Johan Blanker[1], Kenji Yamamoto[2], Miro Zeman[1]; [1]*Photovoltaic Materials and Devices Laboratory, Delft Univ. of Technology, Netherlands;* [2]*Photovoltaic & Thin Film Device Research Laboratories, Kaneka Corporation, Japan.* We introduce our optical model for solar cell design. It is especially suitable for optimization of light-trapping schemes in multi-junction devices. We illustrate this for triple junction thin-film silicon and for perovskite/c-Si tandem solar cells.

SoW2C • CSP and PV Applications—Continued

SoW2C.4 • 11:30
Optical Loss Analyses and Energy Yield Modelling of Perovskite/silicon Multijunction Solar Cells, Ulrich W. Paetzold[1,2], Robert Gehlhaar[2], Jeffrey Tait[2], Weiming Qiu[2], Joao Bastos[2], Maarten Debucquoy[2], Manoj Jaysankar[2], Tom Aernouts[2], Jef Poortmans[2,3]; [1]*Karlsruhe Inst. of Technology, USA;* [2]*imec, Belgium;* [3]*ESAT, Katholieke Universiteit Leuven,, Belgium.* We perform optical loss analyses and energy yield modelling of perovskite/silicon multijunction solar cells to elucidate the superiority of different architectures, e.g., 4-terminal solar cells and 2-terminal solar cell.

SoW2C.5 • 11:45 Invited
Cloud Detection and Motion Estimation Using Fisheye Cameras for Nowcasting of Beam Radiation Variability in Concentrating Solar Thermal Systems, Jose Zapata[1], Jacob Buddee[1], Yuxin Liu[1], Geoff Barton[1]; [1]*The Australian National Univ., Australia.* Concentrating solar thermal systems experience severe operating transients when clouds obstruct the collector field. This presentation offers an overview of ground based nowcasting research activities at the Australian National Univ..

12:30–14:00 Lunch *(on your own)*

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

SSW2D • OLED Optics & Emitter Orientation—Continued

SSW2D.4 • 11:30
Bragg Scattering of Non-radiative Modes in Red Top-emitting Organic Light Emitting Diodes with Variation of Cavity Length, Paul-Anton Will[1], Elisabeth Schwarz[1], Cornelius Fuchs[1], Simone Lenk[1], Sebastian Reineke[1]; *[1]Dresden Integrated Center for Applied Physics and Photonic Materials (IAPP) and Inst. for Applied Physics, Germany.* The spectral radiant intensity and external quantum efficiency of red top-emitting organic light emitting diodes with integrated one dimensional periodic gratings is studied in dependence of the cavity length with comparison to optical simulations.

SSW2D.5 • 11:45
Precise Determination of The Molecular Orientation in Organic Thin Films by Angular Resolved Photoluminescence Spectroscopy, Christian Hänisch[1], Cornelius Fuchs[1], Simone Lenk[1], Sebastian Reineke[1]; *[1]Dresden Integrated Center for Applied Physics and Photonic Materials (IAPP) and Inst. of Applied Physics, Germany.* We present a refined procedure of determining the anisotropy coefficient of organic films via angular resolved photoluminescence spectroscopy considering measurement instabilities and an appropriate modelling of finite thick emission layers.

SSW2D.6 • 12:00
Understanding and Predicting the Orientation of Heteroleptic And Homoleptic Phosphors in Organic Light-emitting Materials, Tobias D. Schmidt[1], Matthew Jurow[2], Thomas Lampe[1], Peter Djurovich[2], Mark Thompson[2], Wolfgang Brütting[1]; *[1]Augsburg Univ., Germany; [2]Univ. of Southern California, USA.* Non-isotropic transition dipole orientation can enhance the efficiency of OLEDs. Therefore, we analyzed the underlying mechanism by combining the use of different deposition techniques as well as iridium-complexes with special physical properties.

SSW2D.7 • 12:15
Orientation of OLED Emitter Molecules Revealed by XRD, Caroline Murawski[2,1], Chris Elschner[2], Simone Lenk[2], Sebastian Reineke[2], Malte C. Gather[2,1]; *[1]School of Physics and Astronomy, Univ. of St Andrews, UK; [2]Dresden Integrated Center for Applied Physics and Photonic Materials, Technische Universität Dresden, Germany.* Thin films of the phosphorescent emitters $Ir(ppy)_3$ and $Ir(ppy)_2(acac)$ are investigated by GIXRD and GIWAXS. Both molecules form crystalline grains and exhibit a preferred orientation that is pertained even when doped into a host.

FW2E • Femtosecond Laser & Combs—Continued

FW2E.4 • 11:30
Application of Dual-comb Spectroscopy to Doppler-free High-resolution Spectroscopy of Rubidium, Akiko Nishiyama[1,2], Satoru Yoshida[1,2], Yoshiaki Nakajima[1,2], Hiroyuki Sasada[3,2], Ken'ichi Nakagawa[1], Atsushi Onae[4,2], Kaoru Minoshima[1,2]; *[1]The Univ. of Electro-Communications, Japan; [2] Japan Science and Technology Agency (JST), ERATO MINOSHIMA Intelligent Optical Synthesizer (IOS) Project, Japan; [3]Keio Univ., Japan; [4] National Metrology Inst. of Japan (NMIJ), National Inst. of Advanced Industrial Science and Technology (AIST), Japan.* Optical-optical double-resonance spectroscopy with a CW pump laser and dual-comb technique were demonstrated. We obtained the fully resolved hyperfine spectra of rubidium, and the absolute frequencies of the spectra were determined precisely.

FW2E.5 • 11:45
Dual Frequency Comb Spectroscopy of High Temperature Water Vapor: Absorption Model Development for Combustion Sensors, Paul J. Schroeder[1], Jinyu Yang[1], Fabrizio Giorgetta[2], William Swann[2], Ian R. Coddington[2], Nathan R. Newbury[2], Gregory B. Rieker[1]; *[1]Univ. of Colorado Boulder, USA; [2]National Inst. of Standards and Technology, USA.* Absorption linestrength and lineshape parameters are extracted from measurements of pure water absorption between 6800 and 7200cm^{-1} from room temperature to 1300K using a dual frequency comb spectrometer with point spacing of 0.0033cm^{-1}.

FW2E.6 • 12:00
Real-time Phase Correction for High-SNR Fieldable Dual-Comb Spectroscopy, Fabrizio R. Giorgetta[1], Gabriel Ycas[1], Esther Baumann[1], Gar-Wing Truong[1], Kevin C. Cossel[1], Eleanor M. Waxman[1], Ian R. Coddington[1], William Swann[1], Nathan R. Newbury[1]; *[1]National Inst of Standards & Technology, USA.* We discuss the significance of coherent averaging and real-time phase correction to dual-comb spectroscopy. A digital real-time phase correction implementation for high-SNR averaging is presented.

FW2E.7 • 12:15
Development of Precise Polarization Measurement System Using Dual-comb Spectroscopy, Kana A. Sumihara[1], Sho Okubo[2], Makoto Okano[1], Hajime Inaba[2], Shinichi Watanabe[1]; *[1]Keio Univ., Japan; [2]NMIJ, AIST, Japan.* We develop a method to precisely determine the polarization state of each comb tooth by a combination of dual-comb spectroscopy and rotating compensator polarimetry. This method is useful for measuring birefringent and dichroic materials.

HW2F • Hyperspectral Sensing of Climate Change I—Continued

HW2F.3 • 11:30
Towards the Thin Ice Clouds in the Far-InfraRed Experiment (TICFIRE), Quentin Libois[1], Jean-Pierre Blanchet[1], Christian Proulx[2], Liviu Ivanescu[1], Ludovick S. Pelletier[1]; *[1]Univ. of Quebec in Montreal, Canada; [2]INO, Canada.* Ground and airborne measurements were performed in the Arctic with the Far-InfraRed Radiometer (FIRR), as a technology demonstration for the satellite mission TICFIRE which aims at studying opticallythin ice clouds in the polar regions.

12:30–14:00 Lunch *(on your own)*

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

14:00–15:30
EW3A • Remote Sensing Techniques to Measure Trace Gases, Particulates and Aerosols II

Presider: Jianguo Liu; Anhui Inst Optics & Fine Mech, CAS, China

EW3A.1 • 14:00 Invited

Optical Airborne Leak Survey for Gas Pipelines, Matthias Ulbricht[1], Sebastian Dietrich[1], Andreas Hoffstädt[1], Axel Scherello[2]; [1]*ADLARES GmbH, Germany;* [2]*Open Grid Europe GmbH, Germany.* A sensitive airborne infrared DIAL system was developed for the detection of leaks in high pressure natural gas pipelines. The system was certified according to DVGW guidelines.

EW3A.2 • 14:30

Multi-Species Trace Gas Analysis with Dual-section DFB-QCLs, Morten Hundt[1], Martin J. Süess[2], Béla Tuzson[1], Philipp Scheidegger[1], Herbert Looser[3], Jérôme Faist[2], Lukas Emmenegger[1]; [1]*Empa, Switzerland;* [2]*ETH Zürich, Switzerland;* [3]*FHNW, Switzerland.* Dual-DFB-QCLs are promising light sources for multi-species laser spectrometers. We demonstrate combination of several dual-wavelength QCLs to measure concentrations of the environmentally most important gases in a compact laser spectrometer.

EW3A.3 • 14:45

Hydrogen Backward Lasing in Atmospheric Air for Remote Detection, Arthur Dogariu[1], Tat Loon Chng[1], Richard Miles[1]; [1]*Princeton Univ., USA.* We present atomic hydrogen backwards lasing in ambient air. The 656nm stimulated emission follows two-photon excitation of atomic hydrogen obtained from dissociation of water or other H-containing molecule, allowing for standoff optical gas detection.

EW3A.4 • 15:00

Laser-based Hydrogen Sulfide Detection at Atmospheric Pressure using Wavelength Modulation Spectroscopy, Dorota Stachowiak[1], Piotr Jaworski[1], Gerard Wysocki[2], Michal P. Nikodem[1]; [1]*Wroclaw Research Centre EIT+, Poland;* [2]*Princeton Univ., USA.* Application of wavelength modulation spectroscopy to H_2S detection at atmospheric pressure is discussed. Cross-interference with CO_2 transitions is analyzed. Detection limit below 1 ppmv/Hz$^{1/2}$ is obtained using a setup with a multipass cell.

EW3A.5 • 15:15

Testing and Validation of a Micro-pulse, Differential Absorption Lidar (DIAL) for Measuring the Spatial and Temporal Distribution of Water Vapor in the Lower Atmosphere, Scott M. Spuler[1], Tammy Weckwerth[1], Kevin Repasky[2], Matthew Hayman[1], Amin Nehrir[3]; [1]*National Center for Atmospheric Research, USA;* [2]*Montana State Univ., USA;* [3]*NASA Langley Research Center, USA.* A compact, field-deployable, micro-pulse DIAL for measuring water vapor in the lower troposphere has been developed and validated at field campaigns. Details of the intercomparisons and improvements since the field studies are discussed.

EW3A.6 • 15:30

Calibrating Uncooled Micro-bolometer FPA by Lenses, Shahar Papini[1,2], Iftach Klapp[1], Nir Sochen[2]; [1]*Agricultural Research Organization, Israel;* [2]*Dept. of Applied Mathematics, Tel Aviv Univ., Israel.* Micro-bolometer based thermal focal plane array is very attractive for radiometric imaging. We introduce a new method, to perform on site calibration of unknown spatially dependent drift and gain thermal images for this goal.

14:00–16:00
PW3B • Advanced Numerics and CI(G)S PV

Presider: Klaus Jaeger; Helmholtz-Zentrum Berlin, Germany

PW3B.1 • 14:00 Invited

A Fourier Scattering Model Without Paraxial Error, Franz-Josef Haug[1]; [1]*Ecole Polytechnique Federale de Lausanne, Switzerland.* A Fourier-model is used to describe light scattering in solar cells with textured surfaces. For the large angles obtained with typical micro-textures, paraxial errors become noticeable and a non-paraxial formulation is presented.

PW3B.2 • 14:30 Invited

Direct Laser Written Nanophotonics for Embedded CIS Nanocrystal Solar Cells, Stephan Dottermusch[1], Aina Quintilla[1], Guillaume Gomard[1], Douglas Pernik[2], Vikas Reddy[2], Brian Korgel[2], Ulrich W. Paetzold[1], Bryce S. Richards[1]; [1]*Karlsruhe Inst. of Technology, Germany;* [2]*Department of Chemical Engineering, The Univ. of Texas at Austin, USA.* Printing of nanocrystal-based inks as a solar cell absorber layer is demonstrated to infiltrate photonic crystals structures created by two-photon direct laser writing. Absorption enhancement is shown in optical measurement and simulations.

PW3B.3 • 15:00 Invited

Multi-resonant Absorption for Ultrathin Solar Cells, Stéphane Collin[1,2]; [1]*Center for Nanoscience and Nanotechnology (CNRS), France;* [2]*Institut Photovoltaïque d'Ile-de-France (IPVF), France.* We show that multiresonant absorption can exceed the lambertian light-trapping limit. We present a simple theoretical model, numerical examples, and our latest experimental results with record efficiency achieved for 200nm-thick GaAs solar cells.

PW3B.4 • 15:30

Enhanced Light Management in Cu(In,Ga)Se $_2$ Solar Cells by Structured Rear Contacts, Enrico Jarzembowski[1], Thomas Schneider[1], Bodo Fuhrmann[2], Hartmut Leipner[2], Wolfgang Fränzel[1], Roland Scheer[1]; [1]*Martin Luther Univ. Halle, Germany;* [2]*Interdisciplinary center of material science, Martin-Luther-Universität, Germany.* An intermediate SiO_2 layer with periodical openings was prepared between the absorber and back contact of a CIGSe solar cell. The enhanced absorption through this layer was investigated experimentally and using RCWA simulations.

PW3B.5 • 15:45

Optical Analysis of Dielectric Spacers for Quenching Mo Losses in CIGS Solar Cells, Nasim Rezaei[1], Olindo Isabella[1], Miro Zeman[1]; [1]*Delft Univ. of Technology, USA.* The influence of a dielectric layer between Molybdenum and CIGS on the performance of CIGS solar cells is investigated. Using optical simulations, thickness and dielectric constant of such dielectric spacer are evaluated.

16:00–17:30 JW4A • Joint Poster Session and Coffee Break, *Großer Saal*

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

14:00–16:00
SSW3C • Applications of Solid-State Light Sources
Presider: Berit Wessler; Osram GmbH, Germany

SSW3C.1 • 14:00 Invited
LED Light Sources Using Arrayed Microprojectors for Structured Illumination, Peter Schreiber[1], Stephanie Fischer[1], Peter Dannberg[1]; [1]*Fraunhofer IOF, Germany.* LED-illuminated structured light sources with shortest system length are realized using arrayed microprojectors. Flux scaling requires array area enlargement only. Large depth of focus enables projection onto strongly tilted or curved screens.

SSW3C.2 • 14:30 Invited
OLED Lighting in Automotive Applications, Werner Thomas[1]; [1]*AUDI AG, Germany.* The presentation will address the challenges of using OLED lighting in automotive applications. The current status of OLED technology as well as the future perspective of OLED technology in automotive lighting will be highlighted.

SSW3C.3 • 15:00 Invited
OLEDs Exceeding 1000 cd/A Current Efficiency, Uli Lemmer[1]; [1]*Karlsruhe Inst. of Technology, Germany.* Abstract not available.

SSW3C.4 • 15:30 Invited
Biomedical Applications of Visible and UV Solid State Lighting, Paul M. Petersen[1]; [1]*DTU Fotonik, Denmark.* The talk reviews how visible and UV solid state lighting in the future may be used in biomedical applications such as cancer therapy, disinfection of specific bacteria, and improved health by using light-induced enhancement of vitamin D.

14:00–16:00
FW3D • Laboratory Spectroscopy (Including at Synchrotron Facilities)
Presider: Mark Tobin; Australian Synchrotron, Australia

FW3D.1 • 14:00 Invited
Pushing the Limits Toward High Resolution and Time Resolved Thz Measurements Using Coherent Synchrotron Radiation, Pascale Roy[1]; [1]*Synchrotron SOLEIL, France.* Recently, a high power source of THz radiation was made scientifically available: coherent synchrotron radiation (CSR). This intense and stable source clearly lead to the development of new applications including terahertz spectroscopy at the nsec rate without the need for a pump probe technique, as well as ultra-high resolution spectroscopy based on heterodyne mixing technique.

FW3D.2 • 14:30
Coherent Synchrotron Radiation for THz Electron Paramagnetic Resonance in Materials and Protein Research, Alexander Schnegg[1], Joscha Nehrkorn[1], Karsten Holldack[1]; [1]*Helmholtz Zentrum Berlin, Germany.* Fourier Transform THz EPR based on coherent synchrotron radiation is presented as a unique tool to extract electronic and magnetic properties in high spin transition metal ions in catalytic compounds, single molecule magnets and proteins.

FW3D.3 • 14:45
Epitaxial Phase Change Materials Probed by Single Cycle THz Pulses of Coherent Synchrotron Radiation, Karsten Holldack[1]; [1]*Helmholtz-Zentrum Berlin, Germany.* A THz-probe spectroscopy scheme with laser-induced single cycle pulses of coherent synchrotron radiation is devised at BESSY II and used to reveal the dynamic THz response in epitaxial grown phase change materials (GST) upon fs-laser excitation.

FW3D.4 • 15:00 Invited
Metamaterial and Quasi-optic Devices for THz Spectroscopy and Their Applications, Carole Tucker[1]; [1]*Cardiff Univ., UK.* Abstract not available.

FW3D.5 • 15:30
High Resolution Fourier Transform Spectrometry of Astrophysically Important Elements from IR to VUV, Juliet C. Pickering[1], Christian Clear[1], Florence Liggins[1], Maria T. Belmonte[1], Anne P. Thorne[1]; [1]*Imperial College London, UK.* Modern astronomical spectrographs require accurate high resolution atomic data for interpretation of many astrophysical spectra. The Imperial College laboratory astrophysics program using high resolution Fourier Transform spectrometry is described.

FW3D.6 • 15:45
Analysis of the Product Gas Composition in Pyrolysis Processes of Single Wood Particles Using FTIR Spectroscopy, Norbert Lang[1], Stephan Hamann[1], Alba Dieguez-Alonso[2], Juergen Roepcke[1], Jean-Pierre van Helden[1]; [1]*INP Greifswald, Germany;* [2]*EVUR, TU Berlin, Germany.* FTIR spectroscopy has been applied time-resolved to analyse the product gas composition of a single pyrolysing wood particle in a special particle reaction chamber in close vicinity of the particle surface.

14:00–16:00
HW3E • Hyperspectral Sensing of Climate Change II: The Far-infrared and Earth Surface Properties
Presider: Michael Yetzbacher; Naval Research Laboratory, USA

HW3E.1 • 14:00 Invited
Far-IR Spectral Observations of the Earth's Longwave Radiation and Their Role in Climate Studies, Luca Palchetti[1], Giovanni Bianchini[1], Gianluca Di Natale[1], Samuele Del Bianco[2], Simone Ceccherini[2]; [1]*Istituto Nazionale di Ottica (CNR), Italy;* [2]*Istituto di Fisica Applicata Nello Carrara (CNR), Italy.* Far-IR spectral measurements of the Earth's longwave emission can be used to improve the characterization of the radiative effects of water vapor, cirrus clouds and surface properties.

HW3E.2 • 14:30
The Hyperspectral Soil Line: a Preliminary Description, William Philpot[1], Jia Tian[1]; [1]*Cornell Univ., USA.* The hyperspectral "soil line" describes the change in brightness of reflected light due to water-enhanced absorption by soil. Thus, the location and orientation of the soil line represents soil reflectance in the 450-950 nm range.

HW3E.3 • 14:45
Estimating Far Infrared Surface Emissivity over Greenland from the Tropospheric Airborne Fourier Transform Spectrometer (TAFTS), Helen Brindley[1], Jon E. Murray[1], Chawn Harlow[2], Alan Woolley[3], Stuart Fox[2], Alan Last[1], Juliet C. Pickering[1]; [1]*Imperial College London, UK;* [2]*UK Meteorological Office, UK;* [3]*Facility for Atmospheric Airborne Measurements, UK.* We report on efforts to obtain observationally based estimates of far-infrared surface emissivity over snow and ice. We highlight one flight from the CIRCCREX-COSMICS airborne campaign over Greenland during March 2015.

HW3E.4 • 15:00
Sea Surface Emissivity, Temperature and Atmospheric Measurements from the M-AERI During the ACAPEX Campaign, Jonathan Gero[1], Matthew H. Westphall[1], Robert O. Knuteson[1], Nicholas Nalli[2], William L. Smith[1]; [1]*Univ. of Wisconsin, USA;* [2]*I. M. Systems Group, USA.* The M-AERI is a robust, accurate seagoing Fourier transform spectrometer measuring thermal emission spectra from the sea surface and marine atmosphere. Ocean skin temperature and emissivity retrievals are presented from the recent ACAPEX campaign.

HW3E.5 • 15:15
A Hybrid Global Surface Spectral Emissivity Dataset for Hyperspectral Radiance Simulator and Climate/weather Models, Xianglei Huang[1], Xiuhong Chen[1], Daniel Zhou[2], Xu Liu[2]; [1]*Univ. of Michigan, USA;* [2]*NASA Langley Research Center, USA.* We use first-principle calculation as well as available observations of surface spectral emissivities to develop a global dataset suitable for the simulator of hyperspectral radiances as well as for the climate and weather models.

HW3E.6 • 15:30 Invited
Simultaneous Retrieval of Cloud and Snow Properties Using Airborne Spectral Solar Remote Sensing, André Ehrlich[1], Manfred Wendisch[1]; [1]*Univ. of Leipzig, Germany.* Spectral cloud reflectivity is analyzed to separate the influence of clouds and snow on the reflected radiation. A method will be presented to obtain simultaneous estimates of cloud optical thickness, cloud particle and snow grain size.

16:00–17:30 Joint Poster Session and Coffee Break, *Großer Saal*

16:00–17:30
JW4A • Joint Poster Session

JW4A.1
High Bandwidth (11-22) Semipolar LEDs for Visible Light Communications, Brendan Roycroft[1], Zhiheng Quan[1], Silvino Presa[1], Vanduc Dinh[1], John Justice[1], Mahbub Akhter[1], Pleun Maaskant[1], Peter Parbrook[1], Brian Corbett[1]; [1]*Tyndall National Inst., Univ. College Cork, Ireland*. The limited electro-optic bandwidths in the green spectral region for c-plane LEDs is overcome by using the (11-22) plane where we demonstrate a bandwidth of 500 MHz at 490 nm and signalling to 1 Gbps.

JW4A.2
Laser-excited 580nm AlGaInP Nanomembrane for Visible Light Communications, Miguel F. Leitao[1], Caroline Foucher[1], Mohamed Islim[2], Liang Yin[2], Benoit Guilhabert[1], Andrey Krysa[3], Stefan Videv[2], Enyuan Xie[1], Erdan Gu[1], Harald Haas[2], Nicolas Laurand[1], Martin D. Dawson[1]; [1]*Inst. of Photonics, U. Strathclyde, UK;* [2]*Univ. of Edinburgh, UK;* [3]*Univ. of Sheffield , UK*. A blue-to-yellow (580nm) AlGaInP multi-quantum-well nanomembrane color-converter for use in GaN-based laser diode visible light communication (VLC) is presented. Preliminary tests using OFDM demonstrate free-space data transmission rates of 180 Mb/s.

JW4A.3
Restoration of the Photochemically Degraded Watercolour Pigments Using a LED Based Light Source, Andrius Petrulis[1], Pranciškus Vitta[1], Jurga Bagdzeviciene[3], Jurate Senvaitiene[4], Rimantas Vaicekauskas[2]; [1]*Inst. of Applied Research, Vilnius Univ., Lithuania;* [2]*Department of Computer Science, Vilnius Univ., Lithuania;* [3]*Pranas Gudynas Centre for Restoration, Lithuania;* [4]*Department of Applied Chemistry, Vilnius Univ., Lithuania*. The artwork illumination requires special lighting to prevent a photochemical damage. Reflectance spectrums were measured of the UV-degraded 25 watercolour pigments and an optimal solid-state light source was modelled for this specific colour set.

JW4A.4
Circular Polarization Phenomena in Chiral Nano-optical Devices, Philipp Gutsche[1], Raquel Mäusle[1], Sven Burger[1,2]; [1]*Computational Nano Optics, Zuse Inst. Berlin, Germany;* [2]*JCMwave GmbH, Germany*. We report on theory and numerics of optical chirality within helical metamaterials. Generation of electromagnetically chiral near-fields is observed. These provide new approaches for tailoring polarization-sensitive emission of lighting devices.

JW4A.5
Maskless Integration of Nano Lens Arrays (NLAs) on Inverted Top Emitting Organic Light Emitting Diodes (TEOLEDs) for High Light Extraction Efficiency, Young-Sam Park[1], Kyung-Hoon Han[2], Doo-Hee Cho[1], Jonghee Lee[1], Yoon-Jay Han[2], Nam Sung Cho[1], Byoung-Gon Yu[1], Jang-Joo Kim[2], Jeong-Ik Lee[1]; [1]*ETRI, Korea;* [2]*Seoul National Univ., Korea*. We report enhancement of light extraction efficiency of inverted TEOLEDs by maskless integration of submicron sized N,N′-Di(1-naphthyl)-N,N′-diphenyl-(1,1′-biphenyl)-4,4′-diamine (NPB) NLAs, formed by controlling wettability of NPB on top electrode.

JW4A.6
Efficiency of Emitters Showing Thermally Activated Delayed Fluorescence Analyzed via a Rate Model for Recombination Processes and Intersystem Crossing, Karla Roszeitis[1], Paul Kleine[1], Reinhard Scholz[1], Simone Lenk[1], Sebastian Reineke[1]; [1]*Dresden Integrated Center for Applied Physics and Photonic Materials (IAPP) and Inst. for Applied Physics, Germany.* This work combines a time-resolved luminescence analysis with quantum chemical calculations of rates occurring in thermally activated delayed fluorescence emitters. A computational setup estimates the suitability of molecules as efficient emitters.

JW4A.7
Effect of Temperature-dependent Carrier Recombination on the Efficiency Droop in InGaN/GaN Single Quantum Well (SWQ) Light Emitting Diode (LED) Chips, Hung Q. Pham [1], Chen J. Chen[1], Shiun F. Hwu[1], Bich H. Nguyen[2]; [1]*National Central Univ., Taiwan;* [2]*Mechanical, Nong Lam Univ., Vietnam.* The electrical and thermal behaviors of LED are systematically investigated using a numerical method. The focus is on how the temperature-dependent carrier recombination induces an efficiency droop. The thermal effect enhances the efficiency droop.

JW4A.8
Tetrapodal ZnO Particles for Substrate Mode Scattering in Flexible Organic Light-Emitting Diodes, Matthias Bremer[1], Ala Cojocaru[2], Iris Hölken[2], Ingo Paulowicz[2], Markus Köpke[1], Rainer Adelung[1], Hartmut Schmidt-Niepenberg[2], Martina Gerken[1]; [1]*Christian-Albrechts-Universtät zu Kiel, Germany;* [2]*FUMT R&D Functional Materials GmbH, Germany.* A thin polymer foil containing tetrapodal zinc oxide microparticles for volume scattering is produced. This foil is used as bendable substrate for an organic light-emitting diode.

JW4A.9
Organic Light-emitting Diodes for Optogenetic Stimulation of *Drosophila* Larvae, Caroline Murawski[1], Andrew Morton[1], Ifor D. Samuel[1], Stefan R. Pulver[2], Malte C. Gather[1]; [1]*School of Physics and Astronomy, Univ. of St Andrews, UK;* [2]*School of Psychology and Neuroscience, Univ. of St Andrews, UK*. Optogenetics is an emerging method in biology that enables controlling neurons with light. We use organic light-emitting diodes to stimulate neurons in *Drosophila* larvae and investigate subsequent behavioral changes at different light intensities.

JW4A.10
Photosynthetic Panel, Using Ions Transport through Permeable Membrane, Irradiating Carotenoids., Richard Castillo[1]; [1]*ESPOCH, Ecuador.* This Panel was built using the ions transport, providing a electrical potential that can be collected or measured reaching 0.142 V obtained through irradiation of the carotenoids contain in carrot extract with his absorption specter.

JW4A.11
Using Collocated VIIRS Observations for CrIS Scene Characterization toward Extending Data Utilization, Likun Wang[1], Yong Han[2]; [1]*ESSIC, Univ. of Maryland, USA;* [2]*NOAA/NESDIS/STAR, USA*. A collocation method to collocate VIIRS within CrIS is developed. The potential application of how the sub-pixel inhomogeneous scene features derived collocated VIIRS pixels impact on CrIS radiance data quality are presented.

JW4A.12
Scanning Micro-resonator Direct-comb Spectroscopy, Alessio Gambetta[2,1], Marco Cassinerio[3], Davide Gatti[1], Paolo Laporta[2,1], Gianluca Galzerano[1,2]; [1]*Istituto di Fotonica e Nanotecnologie - CNR, Italy;* [2]*Dipartimento di Fisica, Politecnico di Milano, Italy;* [3]*IMRA America Inc., USA*. We report on a novel direct comb spectroscopy method based on a scanning Fabry-Pérot microresonator resolving the mode structure of an optical frequency comb at 1.54 µm with a resolution of 20 MHz in a single-scan optical bandwidth up to 1 THz.

JW4A.13
Fourier-transform-based Noise-immune Cavity-enhanced Optical Frequency Comb Spectroscopy, Alexandra C. Johansson[1], Amir Khodabakhsh[1], Lucile Rutkowski[1], Aleksandra Foltynowicz[1]; [1]*Umea Univ., Sweden*. We describe the principles and implementation of Fourier-transform-based cavity-enhanced optical frequency comb spectroscopy that uses phase modulation at the cavity free spectral range frequency to achieve high sensitivity over broad spectral range.

JW4A.14
Structural Dynamics Study of Hydration Shells on n-Ge(100) in Aqueous Solution with Electrochemical Control, Fang Niu[1], Andreas Erbe[1,2]; [1]*Max-Planck Institut füer Eisenforschung, Germany;* [2]*Norwegian Univ. of Science and Technology, Norway.* Structural changes of the hydration shell of surfaces in aqueous solution are studied using attenuated total reflection infrared spectroscopy, under different electrode potentials and consequently different states of the solid/liquid interface.

JW4A.15
Fourier Transform and Vernier Spectroscopy with a Mid-infrared Optical Frequency Comb, Amir Khodabakhsh[1], Venkata Ramaiah-Badarla[1], Lucile Rutkowski[1], Alexandra C. Johansson[1], Kevin F. Lee[2], Jie Jiang[2], Christian Mohr[2], Martin E. Fermann[2], Aleksandra Foltynowicz[1]; [1]*Umea Universitet, Sweden;* [2]*IMRA America, Inc., USA*. We present a versatile frequency comb spectroscopy system based on a doubly resonant optical parametric oscillator tunable between 3–5.4 µm and two detection methods: a Fourier transform spectrometer and a continuous-filtering Vernier spectrometer.

JW4A.16
Modifying a Commercial FTS for Operation at Cryogenic Temperatures, Ian Veenendaal[1], David A. Naylor[1]; [1]*Univ. of Lethbridge, Canada.* A cryogenic FTS is being developed at the Univ. of Lethbridge based on a commercial rotary arm system. Measurement of optical path difference is accomplished using a fiber-fed laser interferometer system internal to the cryostat.

JW4A.17
Color Tuning of $GdVO_4$:Dy^{3+} Nanophosphor via Photonic Multilayers, Dongling Geng[1]; [1]*Inst. of Materials Science of Seville, Spanish National Research Council, Spain*. The photoluminescence spectrum of GdVO4:Dy3+ nanocrystals is strongly modulated in tunable spectral ranges from blue to yellow using photonic multilayers in which the nanophosphor is integrated as an optical dopant.

JW4A.18
Brilliant Infrared Radiation from the IRIS Beamline, Ljiljana Puskar[1], Eglof Ritter[2], Ulrich Schade[1], Emad F. Aziz[1,3]; [1]*Helmholtz-Zentrum Berlin für Materialien, Germany;* [2]*Experimentelle Biophysik, Humboldt-Universität zu Berlin, Germany;* [3]*Fachbereich Physik, Freie Universität Berlin, Germany.* The HZB operates the IRIS beamline, dedicated to the in-house energy materials research and the broad-field research of external users. This paper reports on the current status, performance and the latest application of the beamline.

JW4A.19
Automated Redshift Estimating Algorithm Using the SPIRE Spectral Feature Finder, Jeremy Scott[1], Locke D. Spencer[1], Rosalind Hopwood[2], Ivan Valtchanov[3], Chris S. Benson[1]; [1]*Univ. of Lethbridge, Canada;* [2]*Physics, Imperial College, UK;* [3]*Herschel Science Centre, European Space Astronomy Centre, European Space Agency, Spain*. The Herschel/SPIRE automated spectral feature finder uses a pattern seeking, S/N filtering algorithm along with a robust flagging system to find 12CO emission lines and estimate corresponding source velocities with multiple uncertainty metrics.

JW4A.20
On-sky Validation of the Herschel/SPIRE Automated Feature Finder Using Source Radial Velocity Estimates, Chris S. Benson[1], Locke D. Spencer[1], Jeremy Scott[1], Rosalind Hopwood[2], Ivan Valtchanov[3]; [1]*Univ. of Lethbridge, Canada;* [2]*Physics, Imperial College, UK;* [3]*Herschel Science Centre, European Space Astronomy Centre, European Space Agency, Spain*. The Herschel/SPIRE team has developed an automated spectral-line fitter as part of its data archive. This tool is validated by comparing source velocities from the line-fitter with known/external velocities for a variety of on-sky targets.

JW4A.21
Stacking the Dark-sky Calibration Observations of the Herschel/SPIRE IFTS: searching for lines in all the wrong places, Locke D. Spencer[1], Ivan Valtchanov[2], Rosalind Hopwood[3], Edward Polehampton[4,1], Trevor R. Fulton[5,1], Jeremy Scott[1], Chris S. Benson[1]; [1]*Univ. of Lethbridge, Canada;* [2]*Herschel Science Centre, European Space Astronomy Centre, European Space Agency, Spain;* [3]*Physics, Imperial College, UK;* [4]*RAL Space, Rutherford Appleton Laboratory, UK;* [5]*Blue Sky Spectroscopy, Canada*. Every Herschel/SPIRE Imaging FTS observation was accompanied by an equal or greater length observation of the same dark-sky on the same observation day. We present the stacking of these dark sky observations in search of faint spectral features.

JW4A.22
Quantitative Evaluation of the Object Color without Influence from the Light Source Color under Unstructured Environment - A Background Correction Method Using Polarization Properties, Satsuki Hosono[1], Kengo Aizawa[1], Tsubasa Saito[1], Mizuho Okada[1], Kosuke Nogo[1], Natsumi Kawashima[1], Kuninao Tada[1], Ichiro Ishimaru[1]; [1]*Kagawa Univ., Japan*. The proposed apparatus can be used outdoors because of its high portability. Our proposed correction method can measure the color of objects without being influenced by the light source color by using the polarization properties.

JW4A • Joint Poster Session—Continued

JW4A.23
Bad Pixels Correction in Interference-modulated Images Based on Data Reconstruction and Restoration, Jun Cao[1], Yan Yuan[1], Lijuan Su[1], Qian Li[1]; [1]*Beihang Univ., China.* A correction method based on data reconstruction and restoration applied to interference-modulated images acquired with Fourier Transform Imaging Spectrometers are introduced. Simulations are done to discussed and demonstrated the proposed method.

JW4A.24
Reconstruction of NO_2 Spatial Distributions Basing on Scanning Multi-axis DOAS Somography, Suwen Li[1]; [1]*School of Physics and Electronic Information, Huaibei Normal Univ., China.* A method was developed to reconstruct spatial distributions of NO_2 emission of industrial chimneys basing on timing scanning MAX-DOAS system, combining computed tomography. Visual spatial distribution of NO_2 concentrations was formed.

JW4A.25
OFS Quasi-distributed Transducer for Wind Blade Monitoring, Luis Rodriguez-Cobo[1], Antonio Quintela[1], Joseba Aramburu[2], Jose M. Lopez-Higuera[1]; [1]*Universidad de Cantabria, Spain;* [2]*Aeroblade SL, Spain.* Employing FBG based transducers, a full-scale wind turbine blade has been monitored.Starting from a high precision strain transducer, a strain patch has been designed and installed on the structure surface.

JW4A.26
Multi-QCLs based Open-path Sensor for Atmospheric NO, NO_2 and NH_3 Detections, Chenguang Yang[1], Mai Hu[1], Xiang Chen[1], Zhenyu Xu[1], Xueli Fan[1], Jianguo Liu[1], Ruifeng Kan[1]; [1]*AIOFM, CAS, China.* For monitoring NO, NO_2 and NH_3 in atmosphere, three QCLs multiplexing sensor with open-path multi-pass cell was developed. The three pollutions' minimum-detection-limits of this sensor are less than 0.5ppb within 2 minute integral time.

JW4A.27
Measurement of Methane Emission on Biogas Plants using Tunable Diode Laser Absorption Spectroscopy, Tina Clauss[1]; [1]*DBFZ (German Biomass Research Centre), Germany.* Open path tunable diode laser absorption spectroscopy was used to determine the methane emission of not gas tight digestate storage tanks of four different agricultural biogas plants at different seasons to estimate the total annual emission.

JW4A.28
Observation of the Boundary Layer Structure and Aerosol Properties over Yangtze River Zone using Mobile Shipboard Lidar, Yunsheng Dong[1], Cheng Liu[1,2], Tianshu Zhang[1], Zhouqing Xie[2], Lihui Lv[1], Shidong Fan[2], Guangqiang Fan[1], Zhenyi Chen[1], Yuchen Shi[1], Yan Xiang[1]; [1]*Key Lab of Environmental Optics & Technology, Anhui Inst. of Optics and Fine Mechanics, Hefei Inst.s of Physical Science, Chinese Academy of Sciences, China;* [2]*School of Earth and Space Sciences, Univ. of Science and Technology of China, China.* From 21 November 2015 to 3 December 2015, particulate matter (PM) observed with mobile shipboard lidar was carried out in the Yangtze River, China, as a part of Yangtze River Campaign (YRC).

JW4A.29
Development of a Discontinuous Galerkin Time Domain Solver on a Staggered Grid for Pan-spectral Single Scattering Analysis, Patrick G. Stegmann[1], Ping Yang[1]; [1]*Texas A&M Univ., USA.* The present work discusses the progress made in the development of a Discontinuous Galerkin (DG) solver in the time domain on a staggered grid specifically tailored towards the scattering of electromagnetic radiation by nonspherical particles.

JW4A.30
Simulation of the Infrared Signature of Transient Luminous Events in the Middle Atmosphere for a Limb Line of Sight, Frédéric Romand[1,2], Laurence Croizé[1], Sébastien Payan[2], Nathalie Huret[3]; [1]*ONERA, France;* [2]*LATMOS, France;* [3]*LPC2E, France.* We study the effects of Sprites on the atmospheric chemistry and radiances. We use the code SAMM2 to model the excitation of the ambient atmosphere. Then we explain how we will include a sprite model.

JW4A.31
Withdrawn.

JW4A.32
Cloud Remote Sensing Using the Hyperspectral Cloud and Sky Imager specMACS, Tobias Zinner[1], Florian Ewald[2], Tobias Kölling[1], Ulrich Schwarz[1], Bernhard Mayer[1], Manfred Wendisch[3]; [1]*Ludwig-Maximilians-Universität, Germany;* [2]*Deutsches Zentrum fuer Luft- und Raumfahrt, Germany;* [3]*Universität Leipzig, Germany.* specMACS is the new spectral cloud and sky imager of LMU. Examples of its first deployment during ACRIDICON-CHUVA campaign 2014 are presented: radiance, vegetation, shadow mask, cloud phase detection, effective radius, cloud distance derivation.

JW4A.33
Analysis of S-HIS Dual-Regression Retrievals during the HS3 Field Campaign, Dan DeSlover[1], Joe Taylor[1], William L. Smith[1], Elizabeth Weisz[1], Robert O. Knuteson[1], Henry E. Revercomb[1]; [1]*UW-Madison / SSEC, USA.* We analyze retrieved atmospheric state profiles from S-HIS measured upwelling radiances during the NASA HS3 field campaign (2012-2014 hurricane seasons). The retrieved profiles were compared to nearly 1500 AVAPS dropsondes during the mission.

JW4A.34
Image Formation Model of a Light Field Imaging Spectrometer, Lijuan Su[1], Qiangqiang Yan[1], Yan Yuan[1], Jun Cao[1]; [1]*Beihang University, China.* A light field imaging spectrometer can obtain spatial-spectral datacube in one snapshot. We present an image formation model of the spectrometer based on wave optics to demonstrate the spectral imaging process of the system.

JW4A.35
Angle-resolved Reflectivity Analysis of Textured Substrates for Liquid-Phase Crystallized Silicon Thin-Film Solar Cells, David Eisenhauer[1], Grit Köppel[1], Bernd Rech[1], Christiane Becker[1]; [1]*Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Germany.* Angular dependency of the reflectivity of two distinct nano-textured and planar reference liquid-phase crystallized silicon solar cells are investigated. We show that nano-textured layers outperform planar devices for all incident angles.

JW4A.36
Withdrawn.

JW4A.37
Synthesis of Non-toxic Sn-based Perovskites with the Ability to Absorb NIR Radiation, Effat Hanifeh[1], Ali A. Sabbagh Alvani[1], Hassan Sameie[1], Reza Salimi[1], Ali Amiri Zarandi[1], Shima Moosakhani[1], Farinaz Koochak[1]; [1]*Amirkabir Univ. of Technology, Iran.* $CH_3NH_3SnI_xCl_{3-x}$ were synthesized at various synthesis temperatures. UV-Vis absorption portrays maximum absorption for the sample prepared at 120 ˚C whose band gap (1.25 eV) is lower than Pb-based ones (1.55 eV).

JW4A.38
The Effect of pH on Facile Synthesis of Rutile Nanorod Titanium Dioxide Photoanode for Solar Cells, Ali Baqaei[2], Ali A. Sabbagh Alvani[1], Hassan Sameie[1], Reza Salimi[1], Shima Moosakhani[2]; [1]*Color and Polymer Research Center (CPRC), Amirkabir Univ. of Technology, Iran;* [2]*Faculty of Polymer and Color Engineering, Amirkabir Univ. of Technology, Iran.* one-dimensional TiO_2 nanorods were synthesized via hydrothermal method at different pH for solid state perovskite sensitized solar cells and various structural and optical characteristics were analysed by XRD, SEM and UV-visible spectroscopy.

JW4A.39
Fabrication of Nanostructures Using Plasmonic Nanolithography Depends on Spacing Layer, Hee Sang Ahn[1], Hyerin Song[1], Taeyeon Kim[1], Kyujung Kim[1]; [1]*Pusan National Univ., Korea.* We investigated plasmonic lithography using nanohole array mask which allows generation of subwavelength exposure by different gap distance. The fabricated pattern through nanohole mask was investigated as gap distance changes.

JW4A.40
Measurements of Enhanced Plasmonic Signal with Gold Nanoparticles on the Stochastic Nanostructure Substrates, Hyerin Song[1], Hee Sang Ahn[1], Seonhee Hwang[1], Seunghun Lee[1], Yeji Lee[1], Kyujung Kim[1]; [1]*Pusan National Univ., Korea.* The enhancements of surface-enhanced Raman signal constructed on the silver nanoislands were investigated through a simulation and experiments. The intensity of Raman signal were improved up to ~20-fold compared to that of the control signal.

JW4A.41
Optical Trapping and Measurement of a Single Cell using Capacitive Sensors, Seonhee Hwang[1], Tae Young Kang[1], Hee Sang Ahn[1], Dong-Myeong Shin[1], Kyujung Kim[1]; [1]*Pusan National Univ., Korea.* We designed capacitance sensors for analyzing capacitance of a single cell. A capacitance change of single cell could be measured using optical trapping in real-time. It can help to detect a little of biomarker's expression.

JW4A.42
Detecting High-refractive-index (n>1.5) Media using Surface Plasmon Sensor with One-dimensional Au Diffraction Grating on Glass Substrate, Atsushi Motogaito[1,2], Shinya Mito[1], Hideto Miyake[3,2], Kazumasa Hiramatsu[1,2]; [1]*Graduate School of Engineering, Mie Univ., Japan;* [2]*The Center of Ultimate Technology on nano-eElectronics, Mie Univ., Japan;* [3]*Graduate School of Regional Innovation Studies, Mie Univ., Japan.* We experimentally detect high-refractive-index media using surface plasmon resonance sensors with Au grating. A medium (n~1.700) was successfully detected. The extraordinary transmission is occurred at the interface between Au and a medium.

JW4A.43
Influence of Gas Partial Pressure on the Optoelectronic and Structural Properties of Si, SiC and SiGe Films by PECVD, William W. Hernández Montero[1], Carlos Zúñiga Islas[1]; [1]*Inst Nat Astrofisica Optica Electronica, Mexico.* We address the link between partial pressure and solid phase properties of silicon films and their alloys synthesized by PECVD. Partial pressure is better than flows in order to predict their structural and optoelectronic properties.

JW4A.44
Broadband and Low Angle-sensitive Solar Absorber, Xu Han[1], Zhaoyu Zhang[2]; [1]*School of Electronic and Computer Engineering, Peking Univ., China;* [2]*School of Science and Engineering, Chinese Univ. of Hong Kong, Shenzhen, China.* A broadband polarization-insensitive simple structure solar absorber based on metamaterials was proposed. Several peaks from 0.5μm to 1.8μm enable a wide plateau exceeding 90% absorptance. Results show wide working window up to 60°oblique incidence.

JW4A.45
Nanostructures for Light Management in Thin-film GaAs Quantum Dot Solar Cells, Antonio Musu[2], Federica Cappelluti[2], Timo Aho[1], Ville Polojärvi[1], Tapio K. Niemi[1], Mircea Guina[1]; [1]*Tampereen Teknillinen Yliopisto, Finland;* [2]*Department of Electronics and Telecommunications,, Politecnico di Torino, Italy.* We have investigated structures for thin-film GaAs quantum dot solar cells. Light trapping at quantum dot bands is realized by a triangular grating reflector whose aspect ratio is identified as the main design parameter.

Optical Nanostructures and Advanced Materials for Photovoltaics (PV)

Solid-State Lighting (SSL)

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

17:30–18:30
PW5A • Light Management in Solar Modules and New Approaches

Presider: Carsten Rockstuhl; Karlsruhe Inst. of Technology, Germany

PW5A.1 • 17:30
Nanostructured Surfaces for Enhancing Light Harvesting in Photovoltaic Devices, Ning Dai[1], Xin Chen[1], Tianning Zhang[1]; [1]*Shanghai Inst. of Technical Physics, China.* Nanostructured surfaces have been used for suppressing light reflection. These nanostructures and surfaces were prepared based on self-assembly process and were used in Si solar cells and novel photovoltaics.

PW5A.2 • 17:45
Coloured Module Glass for BIPV Inspired by Morpho Butterfly, Benedikt Bläsi[1], Thomas Kroyer[1], Oliver Hoehn[1], Claudio Ferrara[1], Tilmann E. Kuhn[1]; [1]*Fraunhofer ISE, Germany.* Colored photovoltaic modules with high angle tolerance can be achieved using the photonic Morpho butterfly effect. Mimicking this effect, we achieved various saturated colors and demonstrated the technology on large area module glass.

PW5A.3 • 18:00
Increasing the Efficiency of Solar Modules by Femtosecond Laser Written Blazed Phase Gratings in the Volume of Soda Lime Glass, Markus Muchow[1,2], Alexander N. Sprafke[3], Gerhard Seifert[2,4], Marko Turek[5], Stefan Eiternick[5]; [1]*Anhalt Univ. of Applied Science , Germany;* [2]*Centre of Innovation Competence SiLi-nano, Germany;* [3]*Inst. of Physics, Martin Luther Univ. Halle-Wittenberg, Germany;* [4]*Fraunhofer-Inst. for Silicate Research ISC, Germany;* [5]*Fraunhofer-Center for Silicon-Photovoltaics CSP, Germany.* We inscribed phase gratings into the cover glass of a solar module using femtosecond laser pulses to guide light around the front side metallization. Photocurrent and efficiency of the module increased by 1 % (relative).

PW5A.4 • 18:15
Artificial Photosynthetic Complexes for Solar Energy Harvesting, Tianning Zhang[2], Xin Chen[2], Chunhong Yang[1], Ning Dai[2]; [1]*Inst. of Botany, Chinese Academy of Sciences, China;* [2]*Shanghai Inst. of Technical Physics, Chinese Academy of Sciences, China.* The concept of natural photosynthesis is extended to fabricate photosynthetic solar cells. Construction of bio-photovoltaics with photosynthetic complexes shed light on energy transfer processes in natural photosynthesis.

17:30–18:30
SSW5B • OLED Device Physics

Presider: Chung-Chih Wu; National Taiwan Univ., Taiwan

SSW5B.1 • 17:30 Invited
Unified Analysis of Transient and Steady-state Electrophosphorescence in Organic Light-Emitting Devices (OLEDs), Russell Holmes[1]; [1]*Chemical Engineering and Materials Science, Univ. of Minnesota, USA.* The OLED efficiency roll-off can be modeled with bimolecular quenching. Transient luminescence is not well-modeled with this approach. Here, both regimes are reproduced with a dynamic polaron density that also rigorously connects to charge balance.

SSW5B.2 • 18:00
Recombination Current in Organic Light-emitting Diodes, Axel Fischer[1], Koen Vandewal[1], Simone Lenk[1], Sebastian Reineke[1]; [1]*IAPP, Technische Universität Dresden, Germany.* We analyze the voltage and temperature dependent recombination current of organic light-emitting diodes (OLED) by the exponential current-voltage characteristic. Its correct description is of great importance for understanding the prospects of OLEDs.

SSW5B.3 • 18:15
Fluctuating Emission Dipole Moments of Aligned Phosphors in Organic Light-Emitting Diodes, Rossa Mac Ciarnain[1,2], Dirk Michaelis[1], Thomas Wehlus[4], Andreas F. Rausch[4], Sebastian Wehrmeister[3], Tobias D. Schmidt[3], Wolfgang Brütting[3], Norbert Danz[1], Andreas Bräuer[1], Andreas Tünnermann[1,2]; [1]*Fraunhofer IOF, Germany;* [2]*Applied Physics, Friedrich-Schiller Univ. , Germany;* [3]*Physics, Univ. of Augsburg, Germany;* [4]*OSRAM OLED GmbH, Germany.* Aligned emitters increase OLED outcoupling but their orientation averaging has not yet been studied. This averaging is measured after the introduction of plasmonic losses in the emitter's near field causing orientation dependent lifetime changes.

NOTES

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

17:30–18:30
FW5C • FTS Instruments for Astrophysics
Presider: David Naylor; Univ. of Lethbridge, Canada

FW5C.1 • 17:30 Invited

The SITELLE Optical Imaging Fourier Transform Spectrometer at the Canada-France-Hawaii Telescope, Frederic Grandmont[1], Laurent Drissen[2], Marc Baril[3]; [1]*ABB Group, Canada;* [2]*Université Laval, Canada;* [3]*CFHT, USA.* With its 2k CCDs, SITELLE is the world's largest Imaging FTS ranked on simultaneous number of spectra acquired (>4M). It was deployed at CFHT in mid-2015 and has since performed a number of striking astronomical observation.

FW5C.2 • 18:00

Challenges for the Extended Source Calibration of the Herschel-SPIRE Fourier-transform Spectrometer, Ivan A. Valtchanov[1]; [1]*European Space Agency, Spain.* We discuss some challenges for the SPIRE-FTS extended source calibration scheme and introduce a correction method using cross-calibration with the SPIRE photometer.

FW5C.3 • 18:15

Correcting the Herschel SPIRE/FTS Double Bump, Nichola Marchili[2], David A. Naylor[1], Ivan Valtchanov[4], Trevor R. Fulton[5,1], Edward Polehampton[6,1], Rosalind Hopwood[3], Locke D. Spencer[1]; [1]*Univ. of Lethbridge, Canada;* [2]*IAPS-INAF, Italy;* [3]*Physics, Imperial College, UK;* [4]*Herschel Science Centre, European Space Astronomy Centre, European Space Agency, Spain;* [5]*Blue Sky Spectroscopy, Canada;* [6]*RAL Space, Rutherford Appleton Laboratory, UK.* The Herschel/SPIRE FTS used two standard resolution modes: high- and low-res (HR/LR). In a hybrid H+LR mode, a clear systematic discrepancy in the continuum is seen. An empirical correction which removes this noise has been developed.

17:30–18:30
HW5D • Atmospheric Measurements with Infrared Hyperspectral Sensing
Presider: Ulrich Platt; Ruprecht Karls Universitat Heidelberg, Germany

HW5D.1 • 17:30 Invited

On the Information Content of Hyperspectral Infrared Observations with Respect to Mineral Dust, Lars Klüser[1]; [1]*German Remote Sensing Datacenter (DFD), German Aerospace Center, Germany.* Silicate absorption bands carry information on dust properties. The IMARS retrieval scheme typically provides 2.5 – 4.0 independent signals for desert dust. Several examples will be shown, what properties beyond AOD can be retrieved with this method.

HW5D.2 • 18:00 Invited

Towards High Resolution Infrared Limb Sounding of the Upper Troposphere / Lower Stratosphere (UTLS), Martin Riese[1], Jorn Ungermann[1], Felix Plöger[1], Johannes Orphal[2]; [1]*Forschungszentrum Julich GmbH, Germany;* [2]*Karlsruhe Inst. of Technology, Germany.* We give an overview on the role of the upper troposphere and stratosphere in the climate system and the important scientific questions that can the investigated based on previous and newly developed infrared limb-sounding technique.

NOTES

08:00–12:00, 13:30–16:00 Registration, *South Foyer*

Weißer Saal

Joint

08:30–10:00
JTh1A • Keynote Session III

JTh1A.1 • 08:30 Keynote
Solid State Lighting: Opportunities and Challenges, Klaus P. Streubel[1]; [1]*Osram Licht AG, Germany.* LEDs have become the dominating light source in many applications such as mobile devices, displays or laptop computers. They also play a significant role in the area of general lighting. In this presentation we will discuss the success stories of LEDs in lighting, the challenges and the opportunities in future solid state lighting systems.

JTh1A.2 • 09:15 Keynote
Optical Properties of Industrially Mass-produced Crystalline Silicon Solar Cells and Prospects for Improvements, Pietro Altermatt[1], Yifeng Chen[1], Yang Yang[1], Adnan Ali[2], Pierre J. Verlinden[1]; [1]*Trina Solar Limited, China;* [2]*Department of Physics, GC Univ. Faisalabad, Pakistan.* The optical properties of mass-produced crystalline Si solar cells are reviewed and the requirements and constraints for their improvements by modern optical methods are outlined from the perspective of one of the largest manufacturers.

10:00–10:30 Networking and Coffee Break, *Großer Saal*

Telemann-Saal

Optical Nanostructures and Advanced Materials for Photovoltaics (PV)

10:30–12:30
PTh2A • Ordered and Disordered Structures for Light Management
Presider: Ning Dai; Chinese Academy of Sciences, China

PTh2A.1 • 10:30 Invited
Total Absorption in Structured Ultrathin Semiconductor Layers, C. Martijn de Sterke[1], Bjorn C. Sturmberg[1], Teck K. Chong[2], Duk-Yong Choi[2], Thomas P. White[2], Lindsay C. Botten[2], Kokou B. Dossou[3], Christopher G. Poulton[3], Kylie R. Catchpole[2], Ross C. McPhedran[1]; [1]*Univ. of Sydney, Australia;* [2]*Australian National Univ., Australia;* [3]*Univ. of Technology Sydney, Australia.* We show that essentially total absorption can be achieved in ultrathin layers of a modestly absorbing semiconductor using a grating geometry. Fabrication requires standard techniques and structured metal elements are not required.

PTh2A.2 • 11:00
A Green's Function Based Inverse Method to Perceive Gratings that Critically Couple Light into Solar Cells, Aimi Abass[1], Stefan Nanz[1], Carsten Rockstuhl[1]; [1]*Karlsruher Institut für Technologie, Germany.* An analytical method for inverse modelling an optimum grating structure that critically couples light into guided modes is developed. This paves the way for inverse modelling optimum surface textures for solar cell absorption enhancement.

PTh2A.3 • 11:15
Absorption Enhancement Using Surface Textures Defined by a Monolayer of Tailored Nanospheres, Stefan Nanz[1], Aimi Abass[1], Peter Piechulla[2], Alexander N. Sprafke[2], Ralf Wehrspohn[3,2], Carsten Rockstuhl[1]; [1]*Karlsruhe Inst. of Technology, Germany;* [2]*Martin Luther Univ. Halle-Wittenberg, Germany;* [3]*Fraunhofer Inst. for Mechanics of Materials, Germany.* We numerically explore a bottom-up approach using a monolayer of nanospheres to define an optimum surface texture for light trapping. The impact of nanosphere size distributions on the defined surface's scattering response is studied.

Schiller-Saal

Solid-State Lighting (SSL)

10:30–12:15
SSTh2B • Flexible OLEDs
Presider: Jang-Joo Kim; Seoul National Univ., Korea

SSTh2B.1 • 10:30 Invited
Improving the Efficiency of Flexible Organic Light-emitting Diodes via Alternating High- and Low-index Layers, Seunghyup Yoo[1], Jaeho Lee[1], Tae-Hee Han[2], Dae Yool Jung[1], Jeongmin Seo[1], Hong-Kyu Seo[2], Hyunsu Cho[3], Eunhye Kim[1], Jin Chung[1], Min-Ho Park[2], Sung-Yool Choi[1], Taek-Soo Kim[1], Tae-Woo Lee[2]; [1]*Korea Advanced Inst of Science & Tech, Korea;* [2]*Pohanh Univ. of Science and Technology (POSTECH), Korea;* [3]*Electronics and Telecommunications Research Inst. (ETRI), Korea.* We present strategies to increase the efficiency of flexible organic light-emitting diodes using planar high-index and low-index layers sandwiching an ultra-thin transparent electrode such as graphene or metallic film.

SSTh2B.2 • 11:00
ITO-free Flexible Organic Light Emitting Diodes with Enhanced Light Outcoupling, Kyung Min Lee[1], Romain Fardel[1], Tae-Wook Koh[1], Joshua Spechler[1], Jake Herb[1], Craig Arnold[1], Barry P. Rand[1]; [1]*Princeton Univ., USA.* We introduce flexible organic light-emitting diodes on silver nanowire substrates with enhanced light outcoupling through the use of porous polyimide (p-PI) films. The p-PI extracts substrate and waveguide losses without electrical alteration.

SSTh2B.3 • 11:15
Flexible Organic Light-emitting Diodes with Novel Transparent Electrodes, Jianxin Tang[1]; [1]*Soochow Univ., China.* We present highly power-efficient flexible organic light-emitting diodes by combining nanostructured metallic transparent conductor on plastic substrates, leading to a power efficiency over 160 lm/W with angular color stability.

Händel-Saal

Fourier Transform Spectroscopy (FTS)

10:30–12:30
FTh2C • Interferometer Design (Including Miniaturized Spectrometers)
Presider: Jérôme Genest; Universite Laval, Canada

FTh2C.1 • 10:30 Invited
Broadband Stationary Fourier Transform Spectrometer Integrated on a Silicon Nitride Photonics Platform, Xiaomin Nie[1,2], Eva Ryckeboer[1,2], Gunther Roelkens[1,2], Roel G. F. Baets[1,2]; [1]*INTEC, Ghent Univ.-IMEC, Belgium;* [2]*Ghent Univ., Center for Nano- and Biophotonics (NB-photonics), Belgium.* We experimentally demonstrate a novel type of Fourier transform spectrometer that is integrated on a Si_3N_4 waveguide platform. It features an extremely small size (0.1 mm^2) with high resolution (6 nm) and large bandwidth (>100 nm).

FTh2C.2 • 11:00
Major Advances in Developments and Algorithms of the Stationary-wave Integrated Fourier-transform Technology, Fabrice Thomas[1], Bruno Martin[1], Céline Duchemin[1], Renaud Puget[1], Eric Morino[1], Christophe Bonneville[1], Thierry Gonthiez[1], Pierre Benech[2], Etienne LE Coarer[3]; [1]*RESOLUTION Spectra Systems, France;* [2]*IMEP-LAHC, France;* [3]*IPAG, France.* SWIFTS is a breakthrough innovation in Fourier Transform spectrometry, particularly valuable for lasers characterization and structural health monitoring. This integrated technology requires precise calibration and advanced processing algorithms.

FTh2C.3 • 11:15
Withdrawn.

Telemann-Saal

Optical Nanostructures and Advanced Materials for Photovoltaics (PV)

PTh2A • Ordered and Disordered Structures for Light Management—Continued

PTh2A.4 • 11:30
Photonic Crystal Backside Structures for PV Applications, Alexander N. Sprafke[1]; *[1]Martin-Luther Univ. Halle, Germany. Photonic crystals provide new concepts for light management. Here, we fabricate 3DPCs via spray coating, which is a fast, cheap, and scalable technique, and apply them as backside structures in solar cells and solar modules.*

PTh2A.5 • 11:45
Broadening of Light Coupling to Waveguide Modes in Solar Cells by Disordered Grating Textures, Karsten Bittkau[1], André Hoffmann[1], Ulrich W. Paetzold[1,2], Reinhard Carius[1]; *[1]IEK5 - Photovoltaik, Forschungszentrum Jülich GmbH, Germany; [2]Inst. for Microstructure Technology, Karlsruhe Inst. of Technology, Germany.* Light coupling to waveguide modes in thin-film solar cells by disordered grating textures is investigated by means of optical simulations. The focus is the study of the broadening of wave vector transfer and waveguide mode.

PTh2A.6 • 12:00
Light Management in Thin Film Solar Cells using Internal Scattering Layers made by Polymer Blend Lithography, Yidenekachew J. Donie[1,2], Michael Smeets[3], Vladimir Smirnov[3], Jan B. Preinfalk[1,2], Amos Egel[1,2], Uli Lemmer[1,2], Karsten Bittkau[3], Guillaume Gomard[1,2]; *[1]Nanophotonics, Light Technology Inst., Germany; [2]Inst. for Microstructure Technology, Germany; [3]IEK5 – Photovoltaik, Forschungszentrum Jülich GmbH, Germany.* We report on disordered nano-structured scattering layers fabricated by lateral phase separation of two immiscible polymers, and demonstrate a short-circuit current density enhancement of +13.5%$_{rel}$ in hydrogenated amorphous silicon solar cells.

PTh2A.7 • 12:15
Analysis of RCWA Validity for Optical Simulations of Si Solar Cells with Various Textures, Ziga Lokar[1], Janez Krc[1], Marko Topic[1]; *[1]Univ. of Ljubljana, FEE, Slovenia. RCWA method was analyzed for optical simulations of Si solar cells with various textures. Good convergence and accuracy is obtained for rounded nanotextures while for large scale textures different methods have to be combined.*

Schiller-Saal

Solid-State Lighting (SSL)

SSTh2B • Flexible OLEDs—Continued

SSTh2B.4 • 11:30
Replacing ITO - Ultrathin Metal Electrodes for Flexible OLEDs, Simone Lenk[1], Sebastian Reineke[1]; *[1]Inst. of Applied Physics, Technische Universität Dresden, Germany.* We demonstrate that ultrathin metal electrodes with < 10 nm thickness are a suitable replacement for indium tin oxide for flexible optoelectronic devices and can be applied to various organic light-emitting diode architectures.

SSTh2B.5 • 11:45 Invited
Fabrication Technologies for Flexible OLED Lighting Modules, Christian May[1]; *[1]Fraunhofer FEP, Germany.* Flexible OLED allows new kinds of curved and transparent lighting systems. Specific topics of flexible OLED fabrication by sheet-to-sheet and roll-to-roll processing of polymer webs, metal foils and flexible ultra-thin glass the will be discussed.

Händel-Saal

Fourier Transform Spectroscopy (FTS)

FTh2C • Interferometer Design (Including Miniaturized Spectrometers)—Continued

FTh2C.4 • 11:30
Withdrawn.

FTh2C.5 • 11:45
Spectral Bandwidth Limitations of Static Common-path and Single-mirror Fourier Transform Infrared Spectrometers, Michael Schardt[1], Anton J. Tremmel[1], Markus S. Rauscher[1], Patrik J. Murr[1], Alexander W. Koch[1]; *[1]Inst. for Measurement Systems and Sensor Technology, Technical Univ. of Munich, Germany.* Microbolometer arrays allow spectral analysis of infrared light using static Fourier transform spectrometers (sFTS). Here we evaluate limitations of common-path and single-mirror sFTS regarding their spectral bandwidth.

FTh2C.6 • 12:00
A Sagnac Fourier Spectrometer, Matthias Lenzner[1], Jean-Claude Diels[2]; *[1]Lenzner Research LLC, USA; [2]Univ. of New Mexico, USA.* A transmission grating is placed in a Sagnac interferometer. Two diffracted orders propagate in opposite directions; the interference pattern at the output contains spectral information heterodyned around the design wavelength.

FTh2C.7 • 12:15
Demonstration of Spectral/Spatial Interferometry with a Far-infrared Double Fourier Laboratory Testbed Instrument, Locke D. Spencer[1], David A. Naylor[1], Jeremy Scott[1], Vince F. Weiler[1], Roderick K. MacCrimmon[1], Geoffrey Sitwell[1]; *[1]Univ. of Lethbridge, Canada.* Spectral/spatial characterization results are presented for a lab double Fourier spatial/spectral interferometer. This is a testbed for developing imaging techniques, processing algorithms, and component characterization for astronomy.

12:30–14:00 Lunch *(on your own)*

Telemann-Saal

Optical Nanostructures and Advanced Materials for Photovoltaics (PV)

14:00–15:45
PTh3A • Crystalline PV II
Presider: Karsten Bittkau; Forschungszentrum Julich, Germany

PTh3A.1 • 14:00 Invited
Wafer-level Integrated Micro-concentrating Photovoltaics, Tian Gu[1], Duanhui Li[1], Lan Li[1], Bradley Jared[2], Gordon Keeler[2], Bill Miller[2], William Sweatt[2], Scott Paap[2], Michael Saavedra[2], Ujjwal Das[3], Steve Hegedus[3], Robert Birkmire[3], Anna Tauke-Pedretti[2], Juejun Hu[1]; [1]*Massachusetts Inst. of Technology, USA;* [2]*Sandia National Laboratories, USA;* [3]*Inst. of Energy Conversion, Univ. of Delaware, USA.* Development of novel micro-scale photovoltaics is presented. A new micro-CPV approach seamlessly integrates micro-scale multijunction cells with a multi-functional Si platform that provides micro-concentration, hybrid photovoltaic and micro-assembly.

PTh3A.2 • 14:30 Invited
Degradation Mechanism and Enhancement Solutions for Field-effect Passivation in Nanostructured Si Solar Cells, Dae Woong Kim[1], Jae-Won Song[1], Jung-Ho Lee[1], Tae Joo Park[1]; [1]*Hanyang Univ., Korea.* Surface passivation of nanostructured Si solarcell plays crucial role in collecting photogenerated carriers by mitigating recombination at surface. Degradation mechanism of field-effect passivation is revealed and enhancement solutions are proposed.

PTh3A.3 • 15:00
Promising Plasma Textured Black Silicon at Etch Temperatures > 0 °C for PV Applications, Maria Gaudig[1,2], Jens Hirsch[1,3], Johannes Ziegler[2], Dominik Lausch[3], Alexander N. Sprafke[2], Norbert Bernhard[1], Ralf Wehrspohn[2,4]; [1]*Department of Electrical, Mechanical and Industrial Engineering, Anhalt Univ. of Applied Sciences, Germany;* [2]*Inst. of Physics, Martin Luther Univ. Halle-Wittenberg, Germany;* [3]*Fraunhofer Center for Silicon Photovoltaics CSP, Germany;* [4]*Fraunhofer Inst. for Microstructure of Materials and Systems IMWS, Germany.* Maskless plasma texturing, as an outstanding method to fabricate highly antireflective silicon surfaces, is optimized at etch temperatures above 0 °C. We achieve excellent optoelectronic properties suitable for silicon solar cell applications.

PTh3A.4 • 15:15
Inverted Silicon Nanocones for a Next Generation of Silicon-based Optoelectronics, Sebastian W. Schmitt[1,2], George Sarau[1,2], Manuela Göbelt[2], Silke Christiansen[1,2]; [1]*HZB Berlin, Germany;* [2]*Max Planck Inst. for the Science of Light, Germany.* The study introduces a novel type of photonic structure, the inverted silicon nanocone (SiNC). It exhibits a unique photonic mode formation, and permits the design of novel Si-based optoelectronic devices such as solar cells LEDs or optical sensors.

PTh3A.5 • 15:30
Nanophotonic Light Management for Silicon Heterojunction Solar Cells with Planar Passivation Layers – Implementation and Material Perspective, Michael Smeets[1], Markus Ermes[1], Manuel Pomaska[1], Kaining Ding[1], Ulrich W. Paetzold[2], Karsten Bittkau[1]; [1]*Forschungszentrum Jülich GmbH - IEK 5, Germany;* [2]*Inst. of Microstructure Technology, Karlsruhe Inst. of Technology, Germany.* The successful implementation of light management concepts processed after the planar passivation of SHJ solar cells is demonstrated. We present prototype solar cells, improved performance and discuss promising approaches for future development.

Händel-Saal

Fourier Transform Spectroscopy (FTS)

14:00–16:00
FTh3B • Frequency Combs II
Presider: Piotr Maslowski; Instytut Fizyki UMK, Poland

FTh3B.1 • 14:00 Invited
Dual-comb Spectroscopy in the THz Region, Takeshi, Yasui[1]; [1]*Tokushima Univ., Japan.* We combine dual-comb spectroscopy with spectrally interleaving in terahertz (THz) region, enabling us to achieve the spectral sampling equal to linewidth of the comb tooth in the low-pressure gas spectroscopy in THz region.

FTh3B.2 • 14:30
Precision Doppler-broadened and Sub-Doppler Absorption Spectroscopy using Optical Frequency Comb Generators, Adam J. Fleisher[1], David Long[1], David Plusquellic[1], Joseph Hodges[1]; [1]*National Inst of Standards & Technology, USA.* We report progress towards precision spectroscopy with optical frequency comb generators, including the first demonstration of multiplexed saturated absorption spectroscopy. Hyperfine transitions of ^{39}K were observed with sub-Doppler resolution.

FTh3B.3 • 14:45
Non-uniform Operation of Cascaded Mach-zehnder Modulator Based Flat Comb Generators for Higher Spectral Bandwidth and Resolution, Takahide Sakamoto[1], Isao Morohashi[1], Naokatsu Yamamoto[1]; [1]*National Inst of Information & Comm Tech, Japan.* We demonstrate optical comb generation by cascaded Mach-Zehnder modulator based flat comb generators. Two modulators were non-uniformly operated for satisfying with both "higher-bandwidth" and "finer frequency-spacing" optical comb generation.

FTh3B.4 • 15:00
Mid-infrared and Near-infrared Dual-comb Spectroscopy with Electro-optic Modulators, Ming Yan[1], Pei-Ling Luo[1], Kana Iwakuni[1], Guy Millot[2], Theodor Hänsch[1], Nathalie Picque[1]; [1]*Max Planck Inst. of Quantum Optics, Germany;* [2]*Laboratoire Interdisciplinaire Carnot de Bourgogne, France.* Dual-comb spectroscopy with electro-optic modulators records broadband spectra with high signal-to-noise ratio and resolved comb-lines within milliseconds. The spectrometer is tunable from 185.0 to 195.9 THz and from 85.6 to 96.7 THz.

FTh3B.5 • 15:15
Mid-infrared Gas Sensing with Optical Parametric Oscillator Based Dual-comb Spectrometer, Julien Mandon[1], Simona M. Cristescu[1], Frans J. M. Harren[1]; [1]*Radboud Universiteit Nijmegen, Netherlands.* A dual-comb spectrometer based on an optical parametric oscillator is used for gas sensing in the 3-5 µm spectral region. The design of light source combined with a simple stabilization scheme allow Doppler-limited spectral resolution.

FTh3B.6 • 15:30
Feed-forward Coherent Dual-comb Spectroscopy, Zaijun Chen[1,2], Ming Yan[1,2], Gwenaëlle Mélen[1], Theodor Hänsch[1,2], Nathalie Picque[1,2]; [1]*Max-Planck Inst. of quantum optics, Germany;* [2]*physics, Ludwig-Maximilians-Universität München, Germany.* We demonstrate a feed-forward technique to establish the mutual coherence between two mode-locked-laser-based frequency combs for dual-comb spectroscopy. Coherent averaging is achieved without adaptive sampling or post-signal processing.

FTh3B.7 • 15:45
Direct Comb Spectroscopy by Heterodyne Detection with a Continuous-wave Laser for High Spectral Resolution, Taro Hasegawa[1], Hiroyuki Sasada[1]; [1]*Keio Univ., Japan.* A scheme to resolve individual comb modes by heterodyne detection with a continuous-wave laser for direct comb spectroscopy is proposed and demonstrated. This is simple and suitable for application to high-resolution spectroscopy.

16:00–16:30 Networking and Coffee Break, *Großer Saal*

Telemann-Saal

Optical Nanostructures and Advanced Materials for Photovoltaics (PV)

16:30–18:30
PTh4A • Novel Fabrication Methods and Applications
Presider: Alexander Sprafke; Martin Luther Univ. Halle, Germany

PTh4A.1 • 16:30 Invited
Electrochemical Synthesis of Nanostructured Materials for Solar Energy Conversion, Sanghwa Yoon[2], Jiwon Kim[1], Bongyoung Yoo[2], Jaehong Lim[1]; [1]*Korea Inst. of Materials Science, Korea;* [2]*Hanyang Univ., Korea*. Surface manipulation can affect both the efficiency and reliability of metal oxide photoelectrodes through the adjustment of the properties of the interface between the electrodes and the electrolyte.

PTh4A.2 • 17:00 Invited
Withdrawn.

PTh4A.3 • 17:30
Determining the Optimal Laser Wavelength for Laser Power Conversion Depending on Operation Temperature, Oliver Hoehn[1], Alexandre W. Walker[1], Andreas Bett[1], Henning Helmers[1]; [1]*Fraunhofer ISE, Germany.* Optical power transmission efficiency is maximized by optimal match of laser wavelength and bandgap of PV laser power converters. Here, we present an experimentally verified model for GaAs taking into account the influence of temperature.

PTh4A.4 • 17:45
Thermal Emitter Design Based on Gap and Spacer Plasmon Mode Coupling, Bingnan Wang[1], Jianjian Wang[1], Chungwei Lin[1], Koon Hoo Teo[1]; [1]*Mitsubishi Electric Research Labs, USA.* We propose tungsten based thermal emitters. With a simple three-layer metal-dielectric-metal design we obtain over 0.9 emittance between 0.5 and 2.2 um, which is achieved by strong coupling between gap and spacer plasmon resonances.

PTh4A.5 • 18:00
Bragg Stacks Enhancing Upconversion for Photovoltaics: A Theoretical And Experimental Analysis, Clarissa L. Hofmann[1,2], Stefan Fischer[3], Christian Reitz[4], Andrew Mondon[1], Dmitry Busko[2], Ian Howard[2], Bryce S. Richards[2,5], Jan C. Goldschmidt[1]; [1]*Fraunhofer ISE, Germany;* [2]*Inst. of Microstructure Technology (IMT), Karlsruhe Inst. of Technology, Germany;* [3]*Department of Chemistry, Univ. of California Berkeley, USA;* [4]*Inst. of Nanotechnology (INT), Karlsruhe Inst. of Technology, Germany;* [5]*Light Technology Inst. (LTI), Karlsruhe Inst. of Technology, Germany.* To enhance upconversion, we optimize Bragg stacks considering changes of local field, density of states and dynamics of β-$NaYF_4$:Er^{3+}. We experimentally characterize the impact on upconversion luminescence, spectrally resolved and power-dependent.

PTh4A.6 • 18:15
Plasmonically Enhanced Upconversion of 1500 nm Light in Er^{+3} Doped TiO_2, Harish Lakhotiya[1], Adnan Nazir[1], Søren Peder Madsen[1], Jeppe Christiansen[1], Emil Eriksen[1], Joakim Vester-Petersen[1], Sabrina R. Johannsen[1], Bjarke Rolighed Jeppesen[1], Peter Balling[1], Arne Nylandsted Larsen[1], Brian Julsgaard[1]; [1]*Aarhus Univ., Denmark.* Upconversion enhancement of 1500 nm light has been achieved using geometrically optimized Au nano-discs placed in close vicinity of Er^{+3} ions in a TiO_2 matrix. A finite element modeling is compared to the experimental findings.

Händel-Saal

Fourier Transform Spectroscopy (FTS)

16:30–18:30
FTh4B • Spaceborne Instruments and Measurements of the Earth and Earth's Atmosphere
Presider: Anne Kleinert; Karlsruhe Inst. of Technology, Germany

FTh4B.1 • 16:30 Invited
IRS, the European Hyperspectral Infrared Sounder Mission from the Geostationary Orbit, Stefano Gigli[1], Stephen Tjemkes[1], Rolf Stuhlmann[1], Gary Fowler[1], Daniel Lamarre[2]; [1]*EUMETSAT, Germany;* [2]*ESTEC, Netherlands.* This paper gives an overview of the Infrared Sounder mission, exploiting a hyperspectral sounder that will fly on-board the Meteosat Third Generation (MTG), the next series of European geostationary satellites for meteorological observations

FTh4B.2 • 17:00
As-built Specifications of MIGHTI – The Thermospheric Wind and Temperature Instrument for the NASA ICON, Christoph R. Englert[1], Charles M. Brown[1], Kenneth Marr[1], John Mark Harlander[7], Ian J. Miller[8], Jed Hancock[2], Jay Kumler[3], William Morrow[4], Thomas Mooney[5], Thomas Immel[6], Mende B. Stephen[6], Stewart Harris[6]; [1]*US Naval Research Laboratory, USA;* [2]*Space Dynamics Laboratory, USA;* [3]*Jenoptic Optical Systems LLC, USA;* [4]*Resonance Ltd., Canada;* [5]*Materion, USA;* [6]*Space Sciences Laboratory, University of California, USA;* [7]*St Cloud State University, USA;* [8]*LightMachinery Inc., Canada*. The Michelson Interferometer for Global High-resolution Thermospheric Imaging (MIGHTI), was delivered for integration into the Ionospheric Connection (ICON) Explorer payload in 2016. We present as-built specifications and laboratory data.

FTh4B.3 • 17:15 Invited
The As-Built Performance of the MIGHTI Interferometers, John Mark Harlander[1], Christoph R. Englert[2], Charles M. Brown[2], Kenneth Marr[2], Ian J. Miller[3], Vaz Zastera[3], Bernhard W. Bach[5], Mende B. Stephen[4]; [1]*St Cloud State University, USA;* [2]*US Naval Research Laboratory, USA;* [3]*LightMachinery Inc., Canada;* [4]*University of California-Berkeley, USA;* [5]*Bach Research, USA.* We describe as-built performance of the Michelson Interferometer for Global High-resolution Thermospheric Imaging (MIGHTI), designed to measure thermospheric wind and temperature for the NASA-sponsored Ionospheric Connection (ICON) Explorer mission.

FTh4B.4 • 17:45
An Overview of the Design and Test of the Interferometer for the GOSAT-2 FTS, Louis Moreau[1], Yan Montembeault[1], Michel Roux[1]; [1]*ABB Inc, Canada.* We present the design and the test results of the interferometer for the GOSAT-2 sensor, a successor of the Greenhouse gases Observing SATellite launched in 2009 by Japan. Comparison to GOSAT-1 will be made.

FTh4B.5 • 18:00
The Atmospheric Chemistry Experiment Fourier Transform Spectrometer (ACE-FTS): Mission and Validation Status, Kaley A. Walker[1,2], Patrick E Sheese[1], Jiansheng Zou[1], Chris D Boone[2], Peter Bernath[3]; [1]*University of Toronto, Canada;* [2]*University of Waterloo, Canada;* [3]*Old Dominion Univeristy, USA.* This paper will describe the mission status and the current validation results for the Atmospheric Chemistry Experiment Fourier Transform Spectrometer (ACE-FTS) with a focus on new developments for this instrument.

FTh4B.6 • 18:15
Nonlinearity Issues and Their Corrections During 7 Years Operation of TANSO-FTS Onboard GOSAT, Akihiko Kuze[1], Hiroshi Suto[1], Kei Shiomi[1], Jun Yoshida[2], Yoshifumi Yamamoto[3], Fumie Kataoka[4], Robert O. Knuteson[5], Henry Buijs[6], Thomas E. Taylor[7]; [1]*Japan Aerospace Exploration Agency, Japan;* [2]*NEC Cooperation, Japan;* [3]*NEC Informatec Systems, Japan;* [4]*Remote Sensing Technology Center of Japan, Japan;* [5]*University of Wisconsin, USA;* [6]*ABB Inc., Canada;* [7]*Colorado State University, USA.* TANSO-FTS onboard GOSAT measures GHG with wide spectral-range by solving two non-linearity issues: analogue circuit for weak solar-scattered light at O_2A band shorter than the sampling laser and a PC-MCT detector for atmospheric thermal radiation.

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