DIGITAL OPTICAL TECHNOLOGIES
A conference focused on the components, systems design, and applications of emerging digital optical technologies

24–27 June 2019
Internationales Congress Center
Munich, Germany

ADVANCE TECHNICAL PROGRAMME
PROGRAMME CURRENT AS OF 7 MARCH 2019

Co-located with
SPIE OPTICAL METROLOGY

spie.org/dot19programme

- Novel optics for Augmented, Mixed and Virtual Reality Systems
- Computational optics
- Digital optics for image formation
- Switchable, tunable and digitally reconfigurable optics
- Digital optics for sensing
- Integrated digital photonics
JOIN US IN MUNICH!

Take this opportunity to share your research at SPIE Digital Optical Technologies, a conference dedicated to emerging digital trends and perspectives in optics. Come to Munich to meet with users and researchers to discuss the latest developments in the field of digital optics. The symposium will highlight all digital aspects from design, fabrication, to integration in systems and final functionality, such as:

- **Design**: numerical algorithms to help design novel optics from macroscopic (freeform optics) to nanoscopic scales (metamaterials, plasmonics,...).
- **Fabrication**: novel digital lithography and freeform mold diamond turning techniques and technologies.
- **Functionality**: computational techniques to enhance functionality in imaging and display. Digital switching, tuning, and reconfiguring to alter optics functionality dynamically.

Collocated with Laser 2019 in Munich, Germany, this symposium aims at combining all three aspects of digital optics around the following topics:

- **Novel optics for Augmented, Mixed and Virtual Reality systems**
- **Digital optics for image formation**
- **Computational optics for display and imaging**
- **Switchable, tunable, and digitally reconfigurable optics**
- **Digital optics for sensing**

These are emerging today as very hot topics in academia, research institutions, and industry, as well as in the venture capital community. Researchers, engineers, managers, industry leaders, as well as market analysts are welcome to share their knowledge and experience, and be part of the ongoing digital optics revolution.

Come and experience first-hand hot new consumer products demoed throughout the Symposium, such as Mixed Reality (Microsoft Hololens) and Virtual Reality (Oculus and HTC Vive) headsets.

Learn about recent advances in using digital technologies to enhance the performance of optical imaging and display. Find out about new approaches that push digital principles at the macro-, micro- and nanoscales to the forefront of optics. Exchange new ideas, address your shared concerns, and get access to information not yet published in the mentioned topical areas. Share your research with other engineers, scientists, researchers, and managers.

Presentations will be permanently archived in the SPIE Digital Library, and made available to others in the international scientific community who seek to learn, make discoveries, and innovate.

We invite you to join your colleagues and share the most recent developments and applications at SPIE Digital Optical Technologies.

**Symposium Chairs**

**Bernard C. Kress,**
Microsoft Corp. (USA)

**Peter Schelkens,**
Vrije Univ. Brussel (Belgium)
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Registration Rates Increase
After 3 June 2019

REGISTER TODAY
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Robert E. Stevens, Adlens Ltd. (United Kingdom)
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Adrian Travis, Microsoft Research (USA)
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Your paper becomes globally available to the research community.
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**PLENARY EVENTS**

**WORLD OF PHOTONICS CONGRESS-WIDE PLENARY SESSION**

**Monday 24 June 2019 · 10:00 - 11:00**

**Listening to the universe with gravitational waves**

**Prof. Danzmann**
Max Planck Institute for Gravitational Physics and Leibniz Univ. Hannover (Germany)

*Biography: Prof. Karsten Danzmann is director at Max Planck Institute for Gravitational Physics (Albert Einstein Institute) and head of the division Laser Interferometry and Gravitational Wave Astronomy. He is Director of the Institute of Gravitation Physics at Leibniz Universität Hannover.*

Prof. Danzmann is one of the most important scientists in the study of gravitational waves: His groundbreaking work has enabled the direct detection of gravitational waves, thus ushering in a new era of astrophysical research. For his merits he was honoured with the Edison Volta Prize of the European Physical Society and the Stern-Gerlach Medal of the German Physical Society (DPG) in 2018.

Karsten Danzmann has already been presented with the Fritz Behrens Foundation Science Prize 2016, the Lower Saxony Science Award 2016, the Körber European Science Prize 2017, and the Otto Hahn Prize 2017. As a member of the LIGO Scientific Collaboration he was awarded the Special Breakthrough Prize in Fundamental Physics, the Gruber Cosmology Prize, and the Princess of Asturias Award.

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**DIGITAL OPTICAL TECHNOLOGIES PLENARY SESSION**

**Monday 24 June 2019 · 13:00 - 14:00**

*Co-located Event with Optical Metrology*

**13:00 to 13:15**

**Welcome and Introduction**

Bernard C. Kress, Microsoft Corp. (USA)
Peter Schelkens, Vrije Univ. Brussel (Belgium)

**13:15 to 14:00**

**Light field image processing: overview and research problems**

**Christine Guillemot**
INRIA, France

*Biography: Christine Guillemot is currently Director of Research at INRIA (Institut National de Recherche en Informatique et Automatique) in France. She holds a PhD degree from ENST (Ecole Nationale Supérieure des Télécommunications) Paris (1992). From 1985 to 1997, she has been with France Telecom working in the areas of image and video compression for multimedia and digital television. From 1990 to mid 1991, she has worked as visiting scientist at Bellcore Bell Communication research) in the USA. Her research interests are signal and image processing, and in particular 2D and 3D image and video processing for various problems (compression, super-resolution, inpainting, classification). She has co-authored 25 patents, has published 80 journal publications and 190 publications in peer reviewed international conferences. She received an ERC advanced grant for a project on computational imaging (2016-2021). She has served in both the IEEE MMSP technical committee (2005-2008), and the IEEE IVMSP technical committee (2013-2016). She has been Associate Editor for IEEE Trans. on Image Processing (from 2000 to 2003 and from 2014 to 2016), for IEEE Trans. on Circuits and Systems for Video Technology (2004-2006), IEEE Trans. on Signal Processing (2007-2009), for the Eurasp journal on image communication (2010-2016), and member of the IEEE journal on selected topics in signal processing (2013-2016). She is currently senior area editor for IEEE Trans. on Image Processing and senior member of the steering committee of IEEE Trans. on Multimedia. She is IEEE fellow since January 2013.*

Light field imaging is becoming increasingly popular thanks to recent advances in acquisition devices. By capturing light rays emitted along different directions, light fields yield a rich description of the scene, enabling post-capture processing capabilities that can be appealing for a variety of applications. However, the huge volume of high-dimensional light field data is an obvious issue for storage, transmission but also for fast processing. In addition, acquisition devices designed so far to capture light fields come with some technological limitations that translate into trade-offs between angular and spatial resolution. This talk will review fundamentals in light field imaging, the main capturing devices and will present fundamental problems in light field image processing.
PLENARY EVENTS

WORLD OF PHOTONICS CONGRESS-WIDE NOBEL PLENARY SESSION
Monday 24 June 2019 · 18:00 - 19:00

Passion for Extreme Light
Gerard Mourou
Ecole Polytechnique (France); 2018 Physics Nobel Prize Laureate

Extreme-light laser is a universal source providing a vast range of high energy radiations and particles along with the highest field, highest pressure, temperature and acceleration. It offers the possibility to shed light on some of the remaining unanswered questions in fundamental physics like the genesis of cosmic rays with energies in excess of 1020 eV or the loss of information in black-holes. Using wake-field acceleration some of these fundamental questions could be studied in the laboratory. In addition extreme-light makes possible the study of the structure of vacuum and particle production in “empty” space which is one of the field’s ultimate goals, reaching into the fundamental QED and possibly QCD regimes.

Looking beyond today’s intensity horizon, we will introduce a new concept that could make possible the generation of attosecond-zep- tosecond high energy coherent pulse, de facto in x-ray domain, opening at the Schwinger level, the zettawatt, and PeV regime; the next chapter of laser-matter interaction.

CO-LOCATED: OPTICAL METROLOGY PLENARY SESSION

Wednesday 26 June 2019 · 10:30 - 11:25

10:30 to 10:40
Welcome and Introduction
Marc P. Georges, Univ. de Liège (Belgium)
Jörg Seewig, Technische Univ. Kaiserslautern (Germany)
2019 Symposium Chairs

10:40 to 11:25
Towards a complete framework for calibration of optical surface and coordinate measuring instruments
Richard Leach
University of Nottingham, United Kingdom

The optics and semiconductor manufacturing industries have well-established calibration infrastructures for optical measurements of surface geometry. These infrastructures are less developed for many precision manufacturing industries that rely on machining of complex surface geometries.

Highly complex freedom geometries and textures, as found for example in the automotive, aerospace and medical parts industries, mean that many of the established calibration techniques for optical surface measurements may not be directly relevant. In addition, with the industrial uptake of additive manufacturing techniques, the complexity of the resulting surfaces is leading to new measurement challenges.

It is commonplace in many manufacturing industries to hear users expressing alarm about the incompatibility of optical instruments with contact methods of measuring surface texture and geometry, and these concerns are often borne out in formal comparisons. In many cases, the difference between the results from optical and contact instruments can be explained after critical assessment of the measurement conditions and sample geometries, but the damage has already been done: take up of optical instruments in many manufacturing industries has been slowed.

Why the disconnect, why the lack of trust? One of the primary reasons for this disconnect with complex surfaces is the lack of a calibration framework for optical instruments, where calibration is the process of comparing a measurement result to a reference result in order to establish traceability. It is relatively simple to understand and model the physical interaction of a contact probe tip with a surface, but it is not so simple to model the equivalent optical interaction – it is a more complex physics problem.

To try to address this issue in the surface texture measurement community, a framework is being developed that attempts to simplify the problem by introducing a number of common or instrument-independent metrological characteristics – instrument parameters that can be determined with a suitable material measure and procedure, and the resulting parameter values can then be propagated through a measurement model to give an estimate of measurement uncertainty. The framework only applies if certain well-defined assumptions about the measurement scenario are adhered to, but it is a solid start and will significantly enhance the kudos of optical instruments in manufacturing industries.

In the world of optical coordinate measurement, for example with laser triangulation or fringe projection systems, there is work in the standards committees to bring optical instruments into the performance verification framework that has been developed for contact coordinate measuring systems. However, with the exception again of the optics industry, there seems to be little research into how to apply the same equivalence to calibration of such instruments – calibration of optical coordinate measuring systems is not currently being addressed in the standardisation committees but is clearly needed in manufacturing industry. In the contact coordinate measuring system world, substitution can be applied in simple cases and virtual instruments can be used in more complex measurement scenarios, but such virtual instrument models are not widely available for optical instruments nor is it completely obvious how to develop them. The presentation will discuss the philosophy and positive advances that have been made in the development of a metrological characteristics framework for surface texture measuring instruments, research work to plug the gaps in situations when the usual assumptions do not apply and will take a forward look at how the framework might be applied to optical coordinate measuring systems.

As Professor Wolfgang Osten once said: “...the transfer of technologies from the laboratory to the industrial environment is often an adventure” – I hope I can present a new chapter in this adventure and give some useful hints about the content of the chapters to come.

Biography: Professor Richard Leach currently holds the Chair in Metrology in the Faculty of Engineering at the University of Nottingham where he has established The Manufacturing Metrology Team to investigate information-rich metrology of surfaces, to support next-generation manufacturing technologies. Drawing on concepts such as machine learning and sensor fusion, his research is changing the approach to quality control in manufacturing.

Prior to his current position, he spent 25 years at the National Physical Laboratory and led a team in surface and nanometrology. He is an internationally recognised researcher in the field of surface topography measurement, particularly in the area of traceability for areal surface metrology, including optical instruments. Richard has developed a range of instruments over his 30 years of metrology research, including both theory and practical developments. Some instruments developed include Fizeau, Michelson, Twyman-Green, homodyne and low coherence interferometers; fringe projection, photogrammetry, and contact stylus systems; and co-ordinate measuring machine probes.

He has over 400 publications, including five textbooks. He is the European Editor-in-Chief for Precision Engineering journal. He is a Fellow of the Institute of Physics, the Institution of Engineering & Technology, the Institute of Measurement & Control, the International Society of Nanomanufacturing, a Sustained Member of the American Society of Precision Engineering and a Council Member of the European Society of Precision Engineering & Nanotechnology. Richard is a visiting professor at Loughborough University and the Harbin Institute of Technology.
Bier & Brezel Reception  
Monday 24 June 2019 · 19:00 - 21:00  
SPIE invites all attendees to a Bier & Brezel reception. All registered congress attendees are welcome; please remember to wear your conference registration badges. Dress is casual.

Digital Optical Technologies and Optical Metrology Welcome Reception  
Wednesday 26 June 2019 · 19:00 - 21:30  
All attendees are invited to relax, socialise, and enjoy light refreshments. Please remember to wear your conference registration badges. Dress is casual.

Digital Optical Technologies and Optical Metrology Joint Poster Sessions  
Tuesday - Thursday 25 - 27 June 2019 · 12:00 - 12:40  
All symposium attendees are invited to attend Digital Optical Technologies and Optical Metrology Joint Poster Sessions provided as an opportunity to enjoy networking while reviewing poster papers. Please note that the Digital Optical Technologies Conference Poster Session (Conf. 10335) has been scheduled as part of the Wednesday Poster Session 2, and will run from 13:00 to 14:00 hrs.

TUESDAY POSTER SESSION 1: Conf. 11056, 11058, 11060 (Optical Metrology)  
WEDNESDAY POSTER SESSION 2: Conf. 11057, 11059 (Optical Metrology), 11062 (Digital Optical Technologies)  
THURSDAY POSTER SESSION 3: Conf. 11061 (Optical Metrology)

Attendees are encouraged to review the high-quality papers and interact with the poster authors. Poster authors must be present at their posters at the Poster Session times designated for their conference to answer questions and interact with the poster session audience. Attendees are requested to wear their conference registration badges to the poster sessions.

Please see below for specific conference poster session timing.

Tuesday 25 June · Poster Session 1  
Optical Metrology, Conf. 11056 (Opt. Measurement Systems-Industrial Inspection): 13:00 to 14:20  
Optical Metrology, Conf. 11058 (Optics for Arts, Architecture, and Archaeology): 12:30 to 13:10  

Wednesday 26 June · Poster Session 2  
Digital Optical Technologies, Conf. 11062: 13:00 to 14:00  
Optical Metrology, Conf. 11057 (Modeling Aspects in OM): 11:30 to 12:40  
Optical Metrology, Conf. 11059 (Multimodal Sensing and Artificial Intelligence: Technologies and Applications): 11:30 to 12:40

Thursday 27 June · Poster Session 3  

Poster Authors, please note the following:

Set up and removal times for each of the Poster Session days.  
Your poster may be displayed any time after setup time and must be removed by the break-down time noted below.

Tuesday 27 June - Conf. 11056, 11058, 11060  
Setup—Monday, 13:00 hrs; Break-down—Tuesday, 17:00 hrs

Wednesday 28 June - Conf. 11057, 11059, 11062  
Setup—Wednesday, 10:00 hrs; Break-down—Wednesday, 17:00 hrs

Thursday 29 June - Conf. 10334  
Setup—Thursday, 9:30 hrs; Break-down—Thursday, 16:30 hrs

Poster presenters may post their poster papers starting at the announced times for each conference, and present them during their respective conference Poster Session. Any papers left on the boards following the poster removal time will be considered unwanted and will be discarded. SPIE assumes no responsibility for posters left up after the end of the Poster Session. Poster authors should be at their papers during their assigned times to answer questions from attendees.

AR VR MR Headset Demos  
Try out the latest virtual reality hardware while at the conference.  
Monday 24 June 2019 · 10:00 - 17:00  
Tuesday 25 June 2019 · 9:00 - 17:00  
Wednesday 26 June 2019 · 9:00 - 17:00  
Learn more online under Special Events!
COURSES

Get focused, effective training that you can apply directly to your work.

TO REGISTER FOR COURSES
Registration for these Courses is being done through SPIE Digital Optical Technologies, also taking place at World of Photonics Congress. To register for these courses, please visit the website and separate from your Optical Metrology registration, please register for the “course only” option through SPIE Digital Optical Technologies.

COURSE INSTRUCTOR SPOTLIGHT
Bernard Kress
Over the past two decades Bernard Kress has made significant scientific contributions as an engineer, researcher, associate professor, consultant, instructor, and author. He has been instrumental in developing numerous optical sub-systems for consumer electronics and industrial products, generating IP, teaching and transferring technological solutions to industry.

What attendees have said about his courses:
- The instructor is very knowledgeable in AR/VR and presented an extremely interesting course.
- Excellent course. Bernard has a lot of energy and enthusiasm!!
- Excellent presentation. Very thorough and generous at answering questions.

Optical Technologies and Architectures for Virtual Reality (VR), Augmented Reality (AR) and Mixed Reality (MR) Head-Mounted Displays (HMDs)

SC1218
Course Level: Intermediate
CEU: 0.4  €280 Members | €165 Student Members | €330 Non-Members
Sunday 8:30 to 12:30

The course provides an extensive overview of the current product offerings as well as the various optical architectures, as in:
- Smart Glasses and Digital Eyewear
- Augmented Reality (AR) and Mixed Reality (MR) headsets
- Virtual Reality (VR) and Merged Reality headsets

The course describes the optical backbone of existing systems, as well as the various optical building blocks, as in:
- Display engines including microdisplay panel architectures, scanner based light engines and phase panels
- Optical combiners integrated either in free space or waveguide platforms
- Depth mapping sensors either though structured illumination or time of flight
- Head tracking, gaze tracking and gesture sensors

Emphasis is set on the design and fabrication techniques to provide the best display immersion and comfort:
- Wearable comfort (size/ weight, CG)
- Visual comfort (eye box size and IPD coverage, angular resolution, FOV, distortion, dynamic range, contrast,...)
- Passive and active foveated rendering and peripheral displays
- VAC (Vergence Accommodation Conflict) mitigation through varifocal, multifocal, spatial and temporal light fields and per pixel depth holographic displays.

The features and limitations of current optical technologies addressing such specifications are reviewed.

MONEY-BACK GUARANTEE
We are confident that once you experience an SPIE course for yourself you will look to us for your future education needs. However, if for any reason you are dissatisfied, we will gladly refund your money. We just ask that you tell us what you did not like; suggestions for improvement are always welcome.

CONTINUING EDUCATION UNITS
SPIE is accredited by the International Association for Continuing Education and Training (IACET) and is authorized to issue the IACET CEU.

SPIE reserves the right to cancel a course due to insufficient advance registration.
In order to design next generation head worn systems, one needs to fully understand the specifics and limitations of the human visual system, and design the optics and the optical architecture around such. Challenges for next generation systems are reviewed, where immersion and comfort need to be addressed along with consumer level costs requirements.

Finally, the course reviews market analysts’ expectations, projected over the next 5 to 10 years, and lists the main actors (major product design companies, start-ups and optical building block vendors, and current investment rounds in such). Demonstration of some of the state of the art AR, MR and VR headsets will be offered to attendees at the end of the course.

LEARNING OUTCOMES
This course will enable you to:

• Identify the various consumer and enterprise head worn systems available in industry today, defined as smart glasses, digital eyewear, AR, MR and VR HMDs, and understand their fundamental differences and specifics.
• Explain the current optical technologies and sub-systems, understand their advantages and limitations.
• Describe the relations and implications between FOV, resolution, MTF, eyebbox size, effective IPD coverage, screen door effects, pupil swing, vergence/accommodation disparity, foveated rendering, peripheral displays,
• Identify the limitations of current optical architectures and how some can be overcome by designing the optics around the human visual system.
• Describe the feature and functionality requirement for next generation systems, and review the key enabling technologies.
• Examine the current AR/VR market status as well as the upcoming market expectations for each field (smart glasses, AR and VR)

INTENDED AUDIENCE
Optical, mechanical and electrical engineers involved in the design and development of Enterprise and Consumer HMDs in all their descinations. Product and project managers involved in defining current and next generation HMD products, technology product roadmaps and next generation optical sub-systems.

INSTRUCTOR
Bernard Kress Over the past two decades, Bernard Kress has made significant scientific contributions as an engineer, researcher, associate professor, consultant, instructor, and author. He has been instrumental in developing numerous optical sub-systems for consumer and industrial products, generating IP, teaching and transferring technological solutions to industry. Application sectors include laser materials processing, optical anti-counterfeiting, biotech sensors, optical telecom devices, optical data storage, optical computing, optical motion sensors, digital displays systems, and eventually HUD and HMD displays (smart glasses, AR/MR/VR). Bernard has been specifically involved in the field of micro-optics, wafer scale optics, holography and nano-photonics. He has published half a dozen books and has more than 35 patents granted. He is a short course instructor for the SPIE and has been chair of various SPIE conferences. He is an SPIE fellow since 2013 and has been elected to the board of Directors of SPIE (2017-19). Bernard has joined Google [XR] Labs, in 2011 as the Principal Optical Architect on the Google Glass project, and is since 2015 the Partner Optical Architect at Microsoft Corp. on the Hololens project.

Design, modeling and fabrication techniques for micro-optics: applications to display, imaging, sensing and metrology

SC1217
Course Level: Intermediate
CEU: 0.4  €280 Members | €165 Student Members | €330 Non-Members
Sunday 13:30 to 17:30

This course provides an overview of the various design and fabrication techniques available to the optical engineer for micro / nano optics, diffractive optics and holographic optics. Emphasis is put on DFM (Design For Manufacturing) for wafer scale fabrication, Diamond Turning Machining (DTM) and holographic exposure. The course shows how design techniques can be tailored to address specific fabrication techniques’ requirements and production equipment constraints. The course will also address various current application fields such as display, imaging, sensing and metrology.

The course is built around 4 points: (1) design, (2) modeling, (3) fabrication/mass production and (4) application fields.

We will also review in details the basic micro-optics building blocks and the overall architecture of the iPhone X IR human face sensor.

1) The course will review various design techniques used in standard optical CAD tools such as Zemax and CodeV to design Diffractive Optical Elements (DOEs), Micro-Lens Arrays (MLAs), hybrid optics and refractive micro-optics, Holographic Optical Element (HOE), as well as the various numerical design techniques for Computer Generated Holograms (CGHs).

2) Modeling single micro optics or complex micro-optical systems including MLAs, DOEs, HOEs, CGHs, and other hybrid elements can be a difficult or nearly impossible task when using classical ray tracing algorithms. We will review techniques using physical optics propagation to model not only multiple refraction effects and their interferences, but also systematic and random fabrication errors, multi-order propagation and other effects which cannot be modeled accurately through ray tracing.

3) Following the design (1) and modeling tasks (2), the optical engineer usually needs to perform a DFM process so that his/her design can be fabricated by the target manufacturing partner/vendor on specific equipment. We will review such DFM for wafer fab via optical lithography (tape-out process), single point diamond turning (SPDT), or holographic optics recording specification. The course also reviews fracturing techniques to produce GDSII layout files for specific lithographic fabrication techniques and manufacturing equipment.

4) In order to point out the potential of such micro-optics for consumer products, this section reviews current application fields for which such elements are providing an especially good match, impossible to implement with traditional optics, such as depth mapping sensing (structured illumination based sensor) and augmented reality display (waveguide grating combiner optics). We will also review applications in high resolution incremental/absolute optical encoders. Design and modeling techniques will be described for such applications fields, and optical hardware sub-system implementations and micro-optics elements will be shown and detailed.

INTENDED AUDIENCE

• Examine the current AR/VR market status as well as the upcoming market expectations for each field (smart glasses, AR and VR)

INTENDED AUDIENCE

• Examine the human visual system, its specifics and limitations.
• Identify the limitations of current optical architectures and how some can be overcome by designing the optics around the human visual system.
• Describe the feature and functionality requirement for next generation systems, and review the key enabling technologies.
• Examine the current AR/VR market status as well as the upcoming market expectations for each field (smart glasses, AR and VR)

INTENDED AUDIENCE

Optical, mechanical and electrical engineers involved in the design and development of Enterprise and Consumer HMDs in all their descinations. Product and project managers involved in defining current and next generation HMD products, technology product roadmaps and next generation optical sub-systems.

INSTRUCTOR

Bernard Kress Over the past two decades, Bernard Kress has made significant scientific contributions as an engineer, researcher, associate professor, consultant, instructor, and author. He has been instrumental in developing numerous optical sub-systems for consumer and industrial products, generating IP, teaching and transferring technological solutions to industry. Application sectors include laser materials processing, optical anti-counterfeiting, biotech sensors, optical telecom devices, optical data storage, optical computing, optical motion sensors, digital displays systems, and eventually HUD and HMD displays (smart glasses, AR/MR/VR). Bernard has been specifically involved in the field of micro-optics, wafer scale optics, holography and nano-photonics. He has published half a dozen books and has more than 35 patents granted. He is a short course instructor for the SPIE and has been chair of various SPIE conferences. He is an SPIE fellow since 2013 and has been elected to the board of Directors of SPIE (2017-19). Bernard has joined Google [XR] Labs, in 2011 as the Principal Optical Architect on the Google Glass project, and is since 2015 the Partner Optical Architect at Microsoft Corp. on the Hololens project.

Design, modeling and fabrication techniques for micro-optics: applications to display, imaging, sensing and metrology

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Course Level: Intermediate
CEU: 0.4  €280 Members | €165 Student Members | €330 Non-Members
Sunday 13:30 to 17:30

This course provides an overview of the various design and fabrication techniques available to the optical engineer for micro / nano optics, diffractive optics and holographic optics. Emphasis is put on DFM (Design For Manufacturing) for wafer scale fabrication, Diamond Turning Machining (DTM) and holographic exposure. The course shows how design techniques can be tailored to address specific fabrication techniques’ requirements and production equipment constraints. The course will also address various current application fields such as display, imaging, sensing and metrology.

The course is built around 4 points: (1) design, (2) modeling, (3) fabrication/mass production and (4) application fields.

We will also review in details the basic micro-optics building blocks and the overall architecture of the iPhone X IR human face sensor.

1) The course will review various design techniques used in standard optical CAD tools such as Zemax and CodeV to design Diffractive Optical Elements (DOEs), Micro-Lens Arrays (MLAs), hybrid optics and refractive micro-optics, Holographic Optical Element (HOE), as well as the various numerical design techniques for Computer Generated Holograms (CGHs).

2) Modeling single micro optics or complex micro-optical systems including MLAs, DOEs, HOEs, CGHs, and other hybrid elements can be a difficult or nearly impossible task when using classical ray tracing algorithms. We will review techniques using physical optics propagation to model not only multiple refraction effects and their interferences, but also systematic and random fabrication errors, multi-order propagation and other effects which cannot be modeled accurately through ray tracing.

3) Following the design (1) and modeling tasks (2), the optical engineer usually needs to perform a DFM process so that his/her design can be fabricated by the target manufacturing partner/vendor on specific equipment. We will review such DFM for wafer fab via optical lithography (tape-out process), single point diamond turning (SPDT), or holographic optics recording specification. The course also reviews fracturing techniques to produce GDSII layout files for specific lithographic fabrication techniques and manufacturing equipment.

4) In order to point out the potential of such micro-optics for consumer products, this section reviews current application fields for which such elements are providing an especially good match, impossible to implement with traditional optics, such as depth mapping sensing (structured illumination based sensor) and augmented reality display (waveguide grating combiner optics). We will also review applications in high resolution incremental/absolute optical encoders. Design and modeling techniques will be described for such applications fields, and optical hardware sub-system implementations and micro-optics elements will be shown and detailed.
LEARNING OUTCOMES
This course will enable you to:
• review the various micro-optics / diffractive optics design techniques used today in popular optical design software such as Zemax and CodeV
• decide which design software would be best suited for a particular micro-optics design task
• evaluate the various constraints linked to either ray tracing or physical optics propagation techniques, and develop custom numerical propagation algorithms
• model systematic and random fabrication errors, especially for lithographic fabrication
• compare the various constraints linked to mask layout generation for lithographic fabrication (GDSII)
• review the different GDSII fabrication layout file architectures, and how to adapt them to various lithographic fabrication techniques such as the ones described in SC454
• discuss current application fields and products using such optics, as in Augmented and Mixed Reality headsets, and high resolution hybrid incremental/absolute diffractive optical encoders.

INTENDED AUDIENCE
Scientists, engineers, technicians, or managers who wish to learn more about how to design, model, fabricate and test micro-optics, diffractive optics and hybrid micro-optics, and how such optics can be integrated effectively in consumer products. Basic knowledge in optics is assumed.

INSTRUCTOR
Bernard Kress  Over the past two decades, Bernard Kress has made significant scientific contributions as an engineer, researcher, associate professor, consultant, instructor, and author. He has been instrumental in developing numerous optical sub-systems for consumer and industrial products, generating IP, teaching and transferring technological solutions to industry. Application sectors include laser materials processing, optical anti-counterfeiting, biotech sensors, optical telecom devices, optical data storage, optical computing, optical motion sensors, digital displays systems, and eventually HUD and HMD displays (smart glasses, AR/MR/VR). Bernard has been specifically involved in the field of micro-optics, wafer scale optics, holography and nano-photonics. He has published half a dozen books and has more than 35 patents granted. He is a short course instructor for the SPIE and has been chair of various SPIE conferences. He is an SPIE fellow since 2013 and has been elected to the board of Directors of SPIE (2017-19). Bernard has joined Google [X] Labs. in 2011 as the Principal Optical Architect on the Google Glass project, and is since 2015 the Partner Optical Architect at Microsoft Corp. on the Hololens project.

An Introduction to Deep Learning
New

SC1275
Course Level: Introductory
CEU: 0.4  €280 Members | €165 Student Members | €330 Non-Members
Sunday 13:30 to 17:30

This course explains basic principles and applications of deep learning. In the first half the principles and history of deep learning and neural networks are explained, followed by many examples of applications of deep neural networks from image classification to deep fakes. In the second half of the course we will build our own basic networks using Google Collaboratory notebooks and will examine some more advanced options such as data augmentation and transfer learning. Anyone who wants to learn more about what deep learning is and how it can be used will benefit from this course.

LEARNING OUTCOMES
This course will enable you to:
• list the basic types of deep learning networks
• list the basic uses that deep networks are currently used for
• list the advantages and disadvantages of using neural networks
• construct a simple neural network using python
• use data augmentation to decrease the amount of data needed for training a neural network
• use transfer learning to make use of pre-trained models to train on less data

INTENDED AUDIENCE
Scientists, engineers, technicians, or managers who wish to learn about deep learning and its applications. Undergraduate training in engineering or science is assumed. To join in the second half of the course a laptop with Chrome browser, a Google account, and some rudimentary python knowledge is needed.

INSTRUCTOR
Maarten Kruithof  has worked at TNO in the computer vision group since 2008 and primarily in neural networks and deep learning since 2015. He currently leads a group that applies deep neural network technology to real world problems such as transport and mobility, health care, and industrial and infrastructure inspection. Together with his colleagues, he developed an introductory course on deep learning to teach the basic principles of deep neural networks to new employees, and teaches this course in and outside of TNO. Attendees will need their laptop with Chrome browser and a Google account.
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Nobu Koshiba

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CONFERENCE 11062

Monday - Wednesday 24–26 June 2019 • Proceedings of SPIE Vol. 11062

Digital Optical Technologies II

Conference Chairs: Bernard C. Kress, Microsoft Corp. (USA); Peter Schelkens, Vrije Univ. Brussel (Belgium)

Programme Committee: Tibor Balogh, Holografika Kft. (Hungary); Partha P. Banerjee, Univ. of Dayton (USA); Christian Bossard, Ctr. Suisse d’Electronique et de Microtechnique SA (Switzerland); Arie den Boef, ASML Netherlands B.V. (Netherlands); Federico Capasso, Harvard School of Engineering and Applied Sciences (USA); Olivier Cassart, Northwestern Univ. (USA); Andreas Hermerschmidt, HOLOLEYE Photonics AG (Germany); Yoshio Hayasaki, Tsukumoiya Univ. (Japan); Hans Peter Herzig, Ecole Polytechnique Fédérale de Lausanne (Switzerland); Hong Hua, College of Optical Sciences, The Univ. of Arizona (USA); Pu-Chung Huang, NVIDIA Corp. (USA); Bahram Javidi, Univ. of Connecticut (USA); Sabina Jeschke, RWTH Aachen Univ. (Germany); Norbert Kerwien, Carl Zeiss AG (Germany); Joel S. Kollin, Microsoft Corp. (USA); ByoungHo Lee, Seoul Nat. Univ. (Korea, Republic of); Scott McEldowney, Facebook/Oculus VR, LLC (USA); Juan C. Minano, Limbak 4PI S.L. (Spain); Ilmars Osmanis, Lightspace Technologies, SIA (Latvia); Silvania F. Pereira, Technische Univ. Delft (Netherlands); Christophe Perez, Magic Leap, Inc. (USA); Pascal Picart, Univ. du Maine (France); Ting-Chung Poon, Virginia Polytechnic Institute and State Univ. (USA); Dometri Psaltis, École Polytechnique Fédérale de Lausanne (Switzerland); Monika Ritsch-Marte, Medizinische Univ. Innsbruck (Austria); Robert E. Stevens, Adiens Ltd. (United Kingdom); Hagen Stolle, SeeReal Technologies GmbH (Germany); Adrian Travis, Microsoft Research (France); Reinhard Voelkel, SUSS MicroOptics SA (Switzerland); Angus Wu, Huawei Technologies Co., Ltd. (USA); Frank Wykowski, LightTrans International UG (Germany)

MONDAY 24 JUNE

PLENARY SESSION ................... MON 10:00 TO 11:00

World of Photonics Congress-wide Plenary Session
Listening to the universe with gravitational waves
Karsten Danzmann, Max Planck Institute for Gravitational Physics and Leibniz Univ. Hannover (Germany)

See details page 4.

Lunch Break ................................. Mon 11:15 to 13:00

PLENARY SESSION ................... MON 13:00 TO 14:00

SPIE Digital Optical Technologies Plenary Session
13:00 to 13:15: Welcome and Introduction
Bernard C. Kress, Microsoft Corp. (USA)
Peter Schelkens, Vrije Univ. Brussel (Belgium)

13:15 to 14:00: Light field image processing: overview and research problems
Christine Guillemot, INRIA, France

See details page 4.

SESSION 1 ............................ MON 14:00 TO 15:40

3D Display Technologies and Displays
Design and fabrication of flexible naked-eye 3D display thin film device based on micro nanostructure, Axiu Cao, Institute of Optics and Electronics (China); Lihong Shui, Hui Peng, Qilin Deng, Song Hu, Institute of Optics and Electronics (China) 

Large-scale full-color computer-generated display holograms created by stacking transferred volume holograms, Orie Kunieda, Kyoji Matsushima, Kansai Univ. (Japan)

Exact mask-based occlusion processing in large-scale computer holography for 3D display, Kenta Nakamoto, Kyoi Matsushima, Kansai Univ. (Japan)

Eippolar-like image analysis for projection-based light field displays, Oleskii Doronin, Attila Barsi, Holografika Kft. (Hungary)

Design of freeform surface backlight unit for 3D display, Nikolai I. Petrov, Scientific and Technological Ctr. for Unique Instrumentation (Russian Federation)

SESSION 2 ............................ MON 16:10 TO 17:50

Switchable, Tunable and Reconfigurable Optics
Tunable filter using birefringent plasmonic structures and liquid crystals, Benjamin Gallinet, Ctr. Suisse d’Electronique et de Microtechnique SA (Switzerland); Dimitrios Kazazis, Yasin Ekinci, Paul Scherrer Institut (Switzerland); François Federspiel, Richard Frantz, Rolic Technologies Ltd. (Switzerland); Rolando Ferrini, Fulvia Nakamoto, Kyoi Matsushima, Ctr. Suisse d’Electronique et de Microtechnique SA (Switzerland)

Optically computational 3D structural measuring approaches and integration architecture with digitally reconfigurable digital optics array platform, Cheng-Feng Yue, Jasper Display Corp. (Taiwan)

Broadband visible reflective metasurfaces for the visualisation of 3D effects, Diane J. Roth, Alexander E. Minovich, King’s College London (United Kingdom); Guixin Li, Southern Univ. of Science and Technology of China (China); Anatoly V. Zayats, King’s College London (United Kingdom)

14x VLC wavelength demultiplexer based on multisolat waveguide structures, Drrr Malik, Holon Institute of Technology (Israel)

Design of a tunable automotive light system with high collimated light engine for adaptive headlight system application, Lun-Ying Chen, Industrial Technology Research Institute (Taiwan); Jui-Wei Pan, National Chiao Tung Univ. (Taiwan); Kao-Der Chang, National Central Univ. (Taiwan)

TUESDAY 25 JUNE

SESSION 3 ............................ TUE 8:00 TO 10:00

Novel Optics for Augmented, Mixed and Virtual Reality Systems (AR, MR, VR)
Crystal: an optical train for upsacle VR (Invited Paper), Philippe Benitez, Dejan Grabovikic, Marina Buljan, Milos Nikolic, Julio Cesar Pinto Chaves, Juan C. Miñano, Pablo Zamora, Rubén Mohedano, Limbak 4PI S.L. (Spain)

NewSight Reality Inc. (NSR) novel transparent optical module for augmented reality glasses (Invited Paper), Amitava Gupta, Foresightvision Inc. (USA); Roland Blum, Svetlana Samoiko, NewSight Reality (USA); Igor Landau, OpticsWorks Inc. (USA)

A novel approach to freeform optimization: designing an augmented reality system using grid-based sag optimization, Zachary Derocher, Shawn Gay, Ken Moore, Zemax, LLC (USA)

A compact red-green-blue superluminescent diode module: a novel light source for AR microdisplays, Nikolay Primerov, Jean Dadaiah, Stefan Gloor, Tim von Niederhäusern, Nicolai Matuschek, Antonio Castiglione, Marco Malinverni, Christian Mounir, Marco Rossetti, Marcus Dueck, Christian Vélez, EXALOS AG (Switzerland)

Innovative systematic design approach for lightguide devices for XR applications, Christian Helmmann, Wyowski Photonics UG (Germany); Stefan Steiner, Roberto Knott, Site Zhang, LightTrans International UG (Germany); Frank Wykowski, Friedrich-Schiller-Univ. Jena (Germany)
SESSION 4 ............................ TUE 10:30 TO 12:30
Waveguide Optics for AR/MR Systems
Optical design of a thin curved lightguide and manufacturing using ophthalmic approaches (Invited Paper), Ozan Cakmakci, Oscar Martinez, Jerry Carollo, Google (USA) ................................................ [11062-15]

Physical-optics analysis of lightguides for augmented and mixed reality glasses, Christian Hellmann, Wyrobski Photonics UG (Germany); Stefan Steiner, Roberto Knott, Site Zhang, LightTrans International UG (Germany); Frank Wyrobski, Friedrich-Schiller-Univ. Jena (Germany) ........ [11062-16]

Features and limitations of waveguide combiner architectures for augmented reality headsets, Bernard C. Kress, Microsoft Corp. (USA) .......................................................... [11062-17]

Physical-optical analysis of lightguide coupling setup and systematic design strategy, Roberto Knott, Stefan Steiner, Site Zhang, LightTrans International UG (Germany); Christian Hellmann, Wyrobski Photonics UG (Germany); Frank Wyrobski, Friedrich-Schiller-Univ. Jena (Germany) [11062-18]

Waveguide grating combiner for small form factor smart glasses (Invited Paper), Anrit Sunnar, Dispex Oy (Finland). ........................................ [11062-19]

Lunch Break

SESSION 5 ............................ TUE 13:30 TO 15:30
Digital Optics for Image Formation
3D imaging systems based on projectors and mobile phones, Nikolay I. Petrov, Maxim K. Khromov, Vladislav G. Nikitin, Scientific and Technological Ctr. for Unique Instrumentation (Russian Federation); Yurii M. Sokolov, RUJD Univ. (Russian Federation). .......................................................... [11062-20]

PixMap: automatic license plate recognition with convolutional neural network based on saliency map, Asen Sanogo, Arcadi Llanza, Abul Hasnat, Nadiya Shvai, Antoine Meicler, Marouan Khata, Alic Hemeny, cyclope.ai (France); Amir Nakib, Univ. Paris-Est Créteil (France). ........................................ [11062-21]

Holistic optimization of optical systems, Kumar Rishav, Carsten Reichert, Alois Herkommer, Institut für Technische Optik (Germany) ................................................ [11062-22]

Influences of atmospheric turbulence on long-distance Fourier pachrometric imaging, Mingyang Yang, Xian Institute of Optics and Precision Mechanics (China) and Univ. of Chinese Academy of Sciences (China); Xuewu Fan, Hui Zhao, Chuang Li, Xian Institute of Optics and Precision Mechanics (China); Meng Xiang, Xian Institute of Optics and Precision Mechanics (China) and Univ. of Chinese Academy of Sciences (China) ........................................ [11062-23]

Optimization of guide star catalogue for three-FOV daytime star sensors, Feng Wu, Xifang Zhu, Ruxi Xiang, Qingquan Xu, Changzhou Institute of Optics and Electronics Technology (China). ................................................ [11062-24]

Investigation the effect of shapes, size and orientation of dielectric rods on the photonic band gap for various lattices in 2D anisotropic photonic crystals, Mahsa Hadadi Moghadam, Behrouz Rezaei, Ali Soltani Vala, Manoochehr Kalafi, Univ. of Tabriz (Iran, Islamic Republic of) ................ [11062-25]

SESSION 6 ............................ TUE 16:00 TO 17:40
Increasing Visual Comfort in 3D Displays
A device and clinical evaluation of vergence-accommodation conflict, Robert E. Stevens, Adiens Ltd. (United Kingdom) ................................................ [11062-26]

Accommodation corrected displays using spatial volume image demultiplexer, Kriss Osmanis, Robert Zabels, Ilmars Osmanis, Martins Narels, Ugis Gertners, Lightspace Technologies, SIA (Latvia) ................ [11062-27]

Advanced screen-space ambient occlusion on HoloVizio 3D display, Oleksii Doronin, Attila Barsi, Holografika Kft. (Hungary) ................ [11062-28]

Evaluation of AR displays performances based on human visual perception, Sebastien de Cunsel, WaveOptics Ltd. (United Kingdom) ................................................ [11062-29]

Analysis of the visual perception conflicts in the mixed reality systems with the real-world illumination parameters restoration, Igor S. Potemin, Dmitry Zhdanov, Andrey Zhdanov, Nikolay Bogdanov, Yan Wang, ITMO Univ. (Russian Federation) ................................................ [11062-30]

WEDNESDAY 26 JUNE
SESSION 7 ............................ WED 08:40 TO 10:00
Digital Optics for Sensing
Enhanced field-of-view structured illumination projector using stacked microlens arrays, Rohan Kundu, Friedrich-Schiller-Univ. Jena (Germany); Peter Schreiber, Peter Dannberg, Stephanie Fischer, Chen Li, Uwe D. Zeltner, Andreas Tünnemann, Fraunhofer-Institut für Angewandte Optik und Feinmechanik IOF (Germany) ................................................ [11062-31]

Inspection of surface imperfections via height contrast imaging based on angle selective illumination, Thomas Milde, Carl Zeiss AG (Germany) ................................................ [11062-32]

Ultraprecision angle measurement sensors with optimized size, weight and power, Edward R. Dowks Jr., Ascentia Imaging, Inc. (USA) ................................................ [11062-33]

Point patterns generation using thin sinusoidal phase grating under Gaussian beam illumination, Maryam Youssufi, Toralf Scharf, Ecole Polytechnique Fédérale de Lausanne (Switzerland); Markus Rossi, are AG (Switzerland) ................................................ [11062-34]

SESSION 8 ............................ WED 10:30 TO 11:50
Computation Display and Imaging I
Single exposure lensesub pixel phase imaging, Péter Kocsics, Igor Shevkunov, Vladimir Katskovnik, Karen Egiazarian, Tampere Univ. (Finland) ................................................ [11062-35]

Increasing the accessible resolution range for computational ghost imaging based on Hadamard matrices, Robert Aare, Andreas Valdman, Univ. of Tartu (Estonia) ................................................ [11062-36]

Optical quality metrics for image restoration, Patrick Müller, Matthias Lehmam, Alexander Braun, Hochschule Düsseldorf (Germany) ................................................ [11062-37]

Computational imaging technology based on birefringent materials, Lifang Shi, Aixu Cao, Institute of Optics and Electronics (China); Hui Pang, Institute of Optics and Electronics (China); Qing Ling, Dang, Institute of Optics and Electronics (China) ................................................ [11062-38]

Lunch Break

POSTERS-WEDNESDAY ........................ WED 12:50 TO 13:50
Conference attendees are invited to attend the Digital Optical Technologies Poster Session on Wednesday. Come view the posters and network with colleagues in your field. Authors of poster papers will be present to answer questions concerning their papers. Attendees are required to wear their conference registration badges to the poster sessions. Posters will be available for viewing starting at 12:50 through 13:50 hrs on Wednesday. Poster authors, view poster presentation guidelines and set-up instructions on page 6, and at http://spie.org/e6513.xml, (Follow the Special Events link)

Design and research of lenses with a remote pupil and a telecentric beam path, Vasilisa Ezhova, Alexey Ikonnikov, Galina E. Romanova, Lev Andreev, ITMO Univ. (Russian Federation) ................................................ [11062-49]

Determination of sample surface microrelief by optical vortices superposition, Bogdan V. Sokolonen, Dmitrii Petolav, Natalya Shostka, V.I. Vernadsky Crimean Federal Univ. (Ukraine) ................................................ [11062-50]

Arbitrary power splitting ratio on logic operation of NL-MMI, Mehdi Tajaldini, Graduate Univ. of Advanced Technology (Iran, Islamic Republic of); Mohammad Zuber Mat Jafri, Univ. Sains Malaysia (Malaysia) ................................................ [11062-51]

Automated fine focusing in digital microscopy, Pet'r Pokorny, Filip Smejkal, Pavel Novak, Jiri Novak, Antonin Mile, Czech Technical Univ. in Prague, Czech Republic) ................................................ [11062-52]

A method of increasing the depth-of-field of images of flat discrete transparencies, reconstructed using synthesized holograms, Marina Frolova, ITMO Univ. (Russian Federation) ................................................ [11062-53]

Computational ghost imaging using the native aspect ratio of a digital light projector, Joonas Ariva, Andreas Valdman, Jan Bogdanov, Univ. of Tartu (Estonia) ................................................ [11062-54]

Design of real-time compression and storage system for CoaXPress high-speed camera based on MSPsoc FPGA, Gringkai Hou, Qiong Yao, Fuyin Wang, Hu Chen, Shuidong Xiong, Chunyan Cao, Weihua Zhang, Changxiang Linghu, National Univ. of Defense Technology (China) ................................................ [11062-55]

Formation and identification of atmospheric structure data by digital holography methods, Ekaterina Seledkina, Anton Ekiemienko, ITMO Univ. (Russian Federation) ................................................ [11062-56]

Segmentation of illuminated areas of light using fully-convolutional neural networks, Igor S. Potemin, Maxim Sorokin, Dmitry Zhdanov, Andrey Zhdanov, Nikolay Bogdanov, ITMO Univ. (Russian Federation) ................................................ [11062-57]

Digital methods of impact on the image, Anton Chukhlamov, Ksenia Ezhova, ITMO Univ. (Russian Federation) ................................................ [11062-58]

Simultaneous quantification of biomarkers using wax-patterned paper-paper-based computational imaging, Yulian Tashchyan, Dami Kim, Sejin Kim, Sanghyo Kim, Gachon Univ. (Korea, Republic of) ................................................ [11062-59]

Colorimetric detection of pesticide using paper hybrid centrifugal fluidic on disc platform, Dami Kim, Sejin Kim, Sanghyo Kim, Gachon Univ. (Korea, Republic of) ................................................ [11062-60]

Graphene nonlinear optic all-optical switch based on multimode interference coupler, Mohand Zuber Mat Jafri, Adnin Abd. Hassim, Univ. Sains Malaysia (Malaysia) ................................................ [11062-61]
SESSION 9 .......................... WED 13:50 TO 17:40
Computation Display and Imaging II
Comparing synthetic and real images of image quality targets to assess a physically based PSF model, Matthias Lehmann, Patrick Müller, Alexander Braun, Hochschule Düsseldorf (Germany) .............................. [11062-39]
Adaptation of tone mapping algorithms for light field displays, Oleksii Doronin, Attila Barsi, Holografika Kft. (Hungary) ................................. [11062-40]
A plug-n-play framework and acquisition methodology for remote exploration systems with single pixel cameras, Protim Bhattacharjee, Anko Bömer, Deutsches Zentrum für Luft- und Raumfahrt e.V. (Germany) ........................ [11062-41]
Design of a spectral zoom imaging system, Xiaohu Guo, Chenxiao Zhao, Ping Zhou, Jingjing Zhu, Weiwei Zhu, Zuming Kang, China North Vehicle Research Institute (China) .............................................. [11062-42]
Study of peak to background-noise ratio for digital optical phase conjugator, Yeh-Wei Yu, Ching-Cherng Sun, National Central Univ. (Taiwan) ........................ [11062-43]

SESSION 10 .............................. WED 16:00 TO 17:40
Computation Display and Imaging III
Automated, AI-driven reconfigurable phase contrast microscope for the diagnostic of fibers in air samples, David A. Mendeds, xRapid-Group (France) ............................ [11062-44]
Improved vector extrapolation-based Richardson-Lucy algorithm used for wavefront coded imaging and experimental demonstration, Hui Zhao, Xi’an Institute of Optics and Precision Mechanics (China); Jingxuan Wei, Xidian Univ. (China); Jingxiao Xie, Mingyang Yang, Xuewu Fan, Xi’an Institute of Optics and Precision Mechanics (China) .................................................. [11062-45]
Visibility enhancement for haze removal based on adaptive double opponency, Ruli Xiang, Changzhou Institute of Technology (China) ................ [11062-46]
Spatially varying blur kernel measurement based on discrete cosine transform single-pixel imaging, Hongzhi Jiang, Yu Wang, Huijie Zhao, Xudong Li, Yang Xu, Xue Li, Yunfan Wang, Beihang Univ. (China) ................ [11062-47]
Digital correction of chromatic aberrations using tailored point spread function for refractive telescope, Jingzhang Wang, Univ. of Chinese Academy of Sciences (China) and Chinese Academy of Sciences (China); Yunfeng Nie, Vrije Univ. Brussel (Belgium); Qiang Fu, King Abdullah Univ. of Science and Technology (Saudi Arabia); Yifan Peng, The Univ. of British Columbia (Canada); Shuzhen Wang, Xidian Univ. (China); Bin Xiangli, Chinese Academy of Sciences (China) ................................................................. [11062-48]

The International Day of Light is a global initiative highlighting the citizens of the world the importance of light and light-based technologies in their lives, for their futures, and for the development of Society. SPIE supports the International Day of Light and its annual celebration on 16 May.

SPIE IDL GRANTS
SPIE will provide seed funding up to US$3,000 to organizations creating Day of Light activities.

IDL RESOURCES
SPIE encourages communities to plan their own annual celebration on 16 May and provides various resources to help create an event.

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GENERAL INFORMATION

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Onsite Registration and Badge Pick-up Hours
ICM Foyer West
Sunday 23 June · 7:30 to 17:30 hrs.
Monday 24 June · 7:30 to 17:00 hrs.
Tuesday 25 June · 8:00 to 17:00 hrs.
Wednesday 26 June · 8:30 to 17:00 hrs.
Thursday 27 June · 8:30 to 16:00 hrs.

Conference Registration
Includes admission to all conference sessions, plenaries, panels, and poster sessions, admission to the AR/VR headset demonstrations, admission to the Laser World of Photonics Exhibition, Welcome Reception, coffee breaks, and a choice of online proceedings.

Early Registration Pricing and Dates
Conference registration prices increase by €90 after 3 June 2019. The online form will automatically display the increased prices.

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SPIE seeks to cultivate a culture of openness and inclusivity. Help us eradicate bias and make the world of optics and photonics a shining example of all minds coming together to innovate regardless of gender, race, nationality, culture, educational background, politics, sexuality, body-type and age, for the betterment of life.

Educate yourself on the issues faced by a diverse workforce, challenge your own assumptions, and tap into the rich pool of talent, perspectives, and ideas offered by people different from you.
SPEAKERS ARE NOT ABLE TO PRESENT USING THEIR OWN LAPTOP OR OTHER DEVICE

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2. Preview your presentation onsite
All presenters are strongly encouraged to visit Speaker Check-In at least 2 hours prior to their presentation to preview their files through the SPIE presentation system, or the day before if presenting in first morning session).
GENERAL INFORMATION

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ICM Foyers, and Hall A1
Complimentary coffee will be served twice daily at the times indicated in the programme. Check individual conference listings for exact times and locations.

Food and Refreshments for Purchase
The ICM has three permanent food-service operations in the foyer area – the ICM Bistro, ICM Bar, and ICM Café where guests can purchase food. There is also the “Am See” Restaurant located on the 1st floor above the registration in Entrance West. In good weather, a beer garden is operated in the courtyard between Halls A and C. There are also a number of bars and restaurants located in the surrounding hotels as well as the “Riem Arkaden” shopping centre on the other side of the underground station “Messestadt West”.

Hotels
SPIE recommends using the hotel services provided by Laser World of Photonics. To book a room please visit their site: https://world-of-photonics.com/about/travel-stay/accommodation/index.html.

Travel to Munich

About Munich
Munich, “the city with a heart,” is the capital of Bavaria, and has established itself as Germany’s high-tech hub (Silicon Bavaria) and is one of the most important industrial and economic centers in the European community. It boasts of such high-tech corporations as BMW and Daimler-Chrysler Aerospace. In addition to being the country’s leading university center and hub for insurance, banking, electronic, and mechanical engineering, Munich offers its visitors shopping, music, art, gourmet restaurants, beer gardens, outdoor cafes, ethnic restaurants, popular night-spots, grand cathedrals, and opulent palaces. For more information on Munich and the surrounding area, please refer to the official website for the city of Munich. https://www.muenchen.de/int/en.html

Airport Information
At Munich Airport, you’ll enjoy excellent national, inter-European and international flights. With approximately 46 million passengers a year, the airport is ranked number two in Germany. Its 106 airlines, 73 direct flights and 244 destinations make Munich an attractive destination. Find all current flight routes along with detailed information about the Munich Airport at their website. https://www.munich-airport.com/

Transportation from the Airport
The Franz Josef Strauss Airport (MUC) is located 17 miles (27 km) northeast of the center of Munich.

Shuttles
For large events such as the Laser World of Photonics, Messe München offer their own airport shuttle to and from Munich Airport. Tickets at the time of printing are EU 9 one way or EU 15 return. For further information or to book tickets, please visit https://www.airport-messe-shuttle.com/en.

Public Transportation
The S1 and S8 S-Bahn lines connect the airport with the center of Munich, with departures every 10 minutes. A recommended ticket is the Airport-Day-Ticket which costs EU 13 one way and covers travellers all the way to their final destination, and includes changes of transport and lines. For further information, please visit: https://www.mvv-muenchen.de/en/tickets-and-fares/tickets-daytickets/airport-city-day-ticket/index.html

How to reach the Internationales Congress Center Munich by car or public transport
Please visit the information provided by Messe München https://world-of-photonics.com/about/travel-stay/getting-there/.

Digital Optical Technologies

Attendee Discount
15% OFF
Qualifying Affordable Rates
PC#137480

Important Rental Information
1. The SPIE discount is available at participating locations in Munich, Germany.
2. The 15% Discount applies to rentals on Affordable Rates from June 15 - July 7, 2019.
3. Reservations must be made at least 24 hours prior to vehicle pickup, using the PC# on the coupon. No CDP discounts apply.
4. Minimum rental period is 3 days.
5. Offer includes Compact and above both manuals and automatic (including basic/standard cars - not vans, premium, luxury, collections, etc.).
6. Discount does not apply to taxes, intercity drop charges, insurance or optional services.
7. Certificate has no cash value and may not be combined with any other offer, discount or promotion. Certificate must be presented and surrendered at time of rental.
8. Normal intercity rules and rate restrictions apply.
9. Minimum rental age is 25 (exceptions apply). Hertz standard driver and credit qualifications for the rental location apply. Blackout periods may apply.

Car Rental
1. Call the Hertz International Reservation Center at 1-800-654-3001 in the USA or your local Hertz Reservations Center to receive a special discount for SPIE. Reservations may also be placed on-line at www.hertz.com. You will receive 15% off qualifying affordable rates at participating locations in Munich, Germany.
2. Be sure to identify yourself as a SPIE attendee. The PC# below must be on your advance reservation to receive this special offer. You must present this coupon at the time of rental in order to receive this discount.
3. This special offer is available for rentals from June 15- July 7, 2019.

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Food and Refreshments for Purchase
The ICM has three permanent food-service operations in the foyer area – the ICM Bistro, ICM Bar, and ICM Café where guests can purchase food. There is also the “Am See” Restaurant located on the 1st floor above the registration in Entrance West. In good weather, a beer garden is operated in the courtyard between Halls A and C. There are also a number of bars and restaurants located in the surrounding hotels as well as the “Riem Arkaden” shopping centre on the other side of the underground station “Messestadt West”.

Hotels
SPIE recommends using the hotel services provided by Laser World of Photonics. To book a room please visit their site: https://world-of-photonics.com/about/travel-stay/accommodation/index.html.

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Proceedings

SPIE. DIGITAL OPTICAL TECHNOLOGIES

Paid conference registration includes online Proceedings of SPIE. In the tables below you will find product order numbers to use on the registration form.

Available as part of registration:

- **Online Proceedings Volume**—access to a single conference proceedings volume via the SPIE Digital Library. Available as papers are published.

Conference Attendees may purchase additional online proceedings volumes for $60 each; add during registration or contact SPIE you may purchase print Proceedings of SPIE volumes for this conference from www.Proceedings.com.

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- Go to My Account at the top of the page, to find your available conference proceedings volumes.

You can also access this content via your organization’s SPIE Digital Library account.

For assistance, contact SPIE:

Email: SPIEDLsupport@spie.org
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SPIE Event Policies

Acceptance of Policies and Registration Conditions

The following Policies and Conditions apply to all SPIE Events. As a condition of registration, you will be required to acknowledge and accept the SPIE Registration Policies and Conditions contained herein.

Attendee Registration and Admission Policy
SPIE, or their officially designated event management, in their sole discretion, reserves the right to accept or decline an individual's registration for an event. Further, SPIE, or event management, reserves the right to prohibit entry or to remove any individual whether registered or not, be they attendees, exhibitors, representatives, or vendors, whose conduct is not in keeping with the character and purpose of the event. Without limiting the foregoing, SPIE and event management reserve the right to remove or refuse entry to anyone who has registered or gained access under false pretenses, provided false information, or for any other reason whatsoever that they deem is cause under the circumstances.

Payment Policy
Registrations must be fully paid before access to the conference is allowed. SPIE accepts VISA, MasterCard, American Express, Discover, Diner's Club, checks and wire transfers. Onsite registrations can also be paid with cash.

SPIE Safe Meeting Policy | Code of Conduct
SPIE is committed to providing a harassment- and discrimination-free experience for everyone at our events, an experience that embraces the richness of diversity where participants may exchange ideas, learn, network, and socialize in the company of colleagues in an environment of mutual respect.

SPIE does not tolerate harassment of event participants, attendees, exhibitors, speakers, volunteers, contractors, service providers, venue staff, or SPIE staff. This Code of Conduct applies to all SPIE meeting-related events, including those sponsored by other organizations but held in conjunction with SPIE events, in public or private facilities.

The SPIE Anti-Harassment Policy may be found at http://spie.org/policy (PDF)
The SPIE Code of Conduct may be found at http://spie.org/conduct (PDF)
In addition, SPIE Members and authors of SPIE publications must adhere to the SPIE Code of Ethics, found at http://spie.org/ethics (PDF)

Recording Policy
Conferences, courses, and poster sessions: For copyright reasons, recordings of any kind are prohibited without prior written consent of the presenter or instructor. Attendees may not capture or use materials presented in any meeting/course room or in course notes on display without written permission. Consent forms are available at Speaker Check-In or SPIE Registration. Individuals not complying with this policy will be asked to leave a given session and/or asked to surrender their recording media. Refusal to comply with such requests is grounds for expulsion from the event.

Exhibition Hall Access / Access for Children Younger than 18
Everyone who attends the exhibition must be registered and have a badge. Badges for children are free and available onsite at the registration desk. Children under 14 years of age must be accompanied by an adult at all times, and guardians are asked to help maintain a professional, disturbance-free conference environment.

Unauthorized Solicitation Policy
Unauthorized solicitation in the Exhibition Hall is prohibited. Any nonexhibiting manufacturer or supplier observed to be distributing information or soliciting business in the aisles, or in another company's booth, will be asked to leave immediately.

Unification Requirement Policy
To verify registered participants and provide a measure of security, SPIE will ask attendees to present a government-issued photo identification at registration to collect registration materials.

Individuals are not allowed to pick up badges for other attendees. Further, attendees may not have some other person participate in their place at any conference-related activity. Such other individuals will be required to register on their own behalf to participate.

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Laser Pointer Safety Information/Policy

SPIE supplies tested and safety-approved laser pointers for all conference meeting rooms. For safety reasons, SPIE requests that presenters use provided laser pointers. Use of a personal laser pointer represents the user’s acceptance of liability for use of a non-SPIE-supplied laser pointer. If you choose to use your own laser pointer, it must be tested to ensure <5 mW power output. Laser pointers in Class II and IIIa (<5 mW) are eye safe if power output is correct, but output must be verified because manufacturer labeling may not match actual output. You are required to sign a waiver releasing SPIE of any liability for use of potentially non-safe, personal laser pointers. Waivers are available at Speaker Check-In.

Unsecured Items Policy

Personal belongings should not be left unattended in meeting rooms or public areas. Unattended items are subject to removal by security. SPIE is not responsible for items left unattended.

Wireless Internet Service Policy

At most events, SPIE provides wireless access for attendees. Properly secure your computer before accessing the public wireless network. SPIE is not responsible for computer viruses or other computer damage.

No-Smoking Policy

Smoking, including e-cigarettes, is not permitted at any SPIE event.

Agreement to Hold Harmless

Attendee agrees to release and hold harmless SPIE from any and all claims, demands, and causes of action arising out of or relating to your participation in the event you are registering to participate in and use of any associated facilities or hotels.

Event Cancellation Policy

If for some unforeseen reason SPIE should have to cancel an event, processed registration fees will be refunded to registrants. Registrants will be responsible for cancellation of travel arrangements or housing reservations and the applicable fees.
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