Proceedings of

Global Congress on

ADVANCEMENTS OF LASER, OPTICS & PHOTONICS

March 25-27, 2019 | Valencia, Spain

HOSTING ORGANISATION

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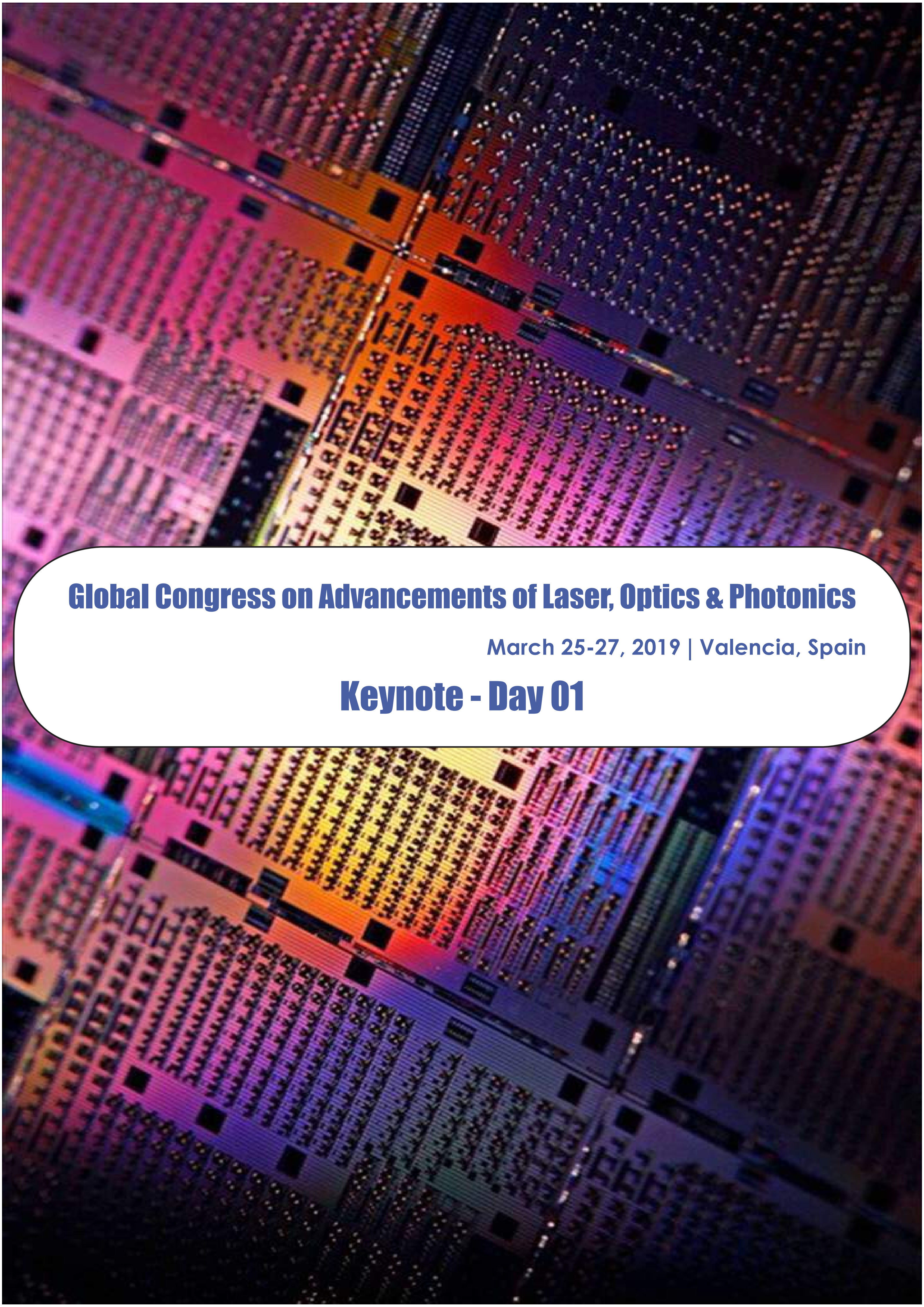

Global Congress on Advancements of Laser, Optics & Photonics

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Keynote - Day 01

State of the art of lidar imaging for autonomous vehicles

Santiago Royo
Universitat Politècnica de Catalunya, Spain

All types of autonomous vehicles have been proposed in the late times, for almost any type of transportation modality. The increase in safety and the push forward of novel models of mobility are turning vehicles into robotic (automobiles, railway, boats…). Such a trend implies additional sensing capabilities on board, which brings on constraints regarding size, cost and performance of the sensors. Lidar imagers are on the spot, as far as there is now a general agreement on the need of a 3D sensor with depth perception to complement cameras and radars in a data fusion environment. In this lecture we will overview the main aspects to be considered in a lidar imager, starting from the typical specifications of sensing in an autonomous vehicle, the different components and measurement strategies involved, and an overlook at which are the key components being used. It will be explained how the limitation and why combining all specifications with the needs of the application ends up being so complex. Some of the approaches known will be discussed, and examples of performance of lidar imagers will be also presented.

Biography

Santiago Royo, PhD, is currently professor at UPC and VP of Business Development of Beamagine S.L (2016, Barcelona), a company devoted to the development and commercialization of novel 3D electrooptic vision systems based on lidar imaging. He is co-founder of two more photonics-based spin-off companies: SnellOptics (2002, Terrassa, Spain), devoted to marketing quality plastic optical components; and ObsTechSpA (2012, Santiago, Chile) commercializing systems for internet-controlled telescopes. He holds 17 patents, 11of them licensed to four different companies, and over 50 refereed publications. He has been Director of the Center for Sensor, Instruments and System Development (CD6), a research and innovation center in Optical Engineeringin Greater Barcelona for the last 10 years, and has participated and led research projects involving different optical metrology techniques for the last 20 years. He is also member of the Board of Stakeholders of Photonics21, and co-secretary of the Spanish Platform for Photonics Fotónica21.

Notes:

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Biomedical optoacoustic imaging: Exponential growth from the first ideas to clinical trials

Alexander Oraevsky

CEO, TomoWave Laboratories, USA

Optoacoustic imaging established its place in the main stream medicine due to its capability to provide physician not only with anatomical, but also functional and molecular information. This lecture will discuss development of the field of optoacoustic imaging from pioneering works that set the basic principles of the technology to the first in vivo images, to the most recent validation of clinically viable systems, and finally our vision of the future medical imaging modalities and their applications in the main stream medicine and surgery. Since clinically viable applications require visualization of tissues at the depth of at least 1 cm, we are most interested in the optoacoustic technologies that enable high resolution imaging in the depth of tissue.

Discoveries that made optoacoustic imaging the most rapidly developing biomedical imaging technology in the 21st century are that (1) laser pulses may be effectively used to produce ultrawide-band acoustic pressure (ultrasonic waves) in biological tissues, which carry its main energy in the lower frequency range and, thus, propagate in tissues with minimal attenuation, (3) 2D and 3D images of the absorbed optical energy can be reconstructed with high resolution under the illumination condition of pressure confinement in the course of the optical energy deposition in a voxel to be resolved.

2D and 3D system designs will be discussed along with their advantages and limitations for specific biomedical applications. The most important results obtained by our group in the past 25 years will be presented, including in vivo preclinical and clinical functional-anatomical maps of vasculature and tumors. Diagnostic imaging of breast cancer motivated development of the first optoacoustic imaging systems in the early years, and today it has become the first commercially available clinical application. Many more clinical applications of the optoacoustic imaging will be commercialized in the near future. The technological developments that will transform optoacoustic imaging systems into compact and robust clinical modalities are the high power diode lasers and the supersensitive ultrawide-band ultrasonic detectors.

Biography

Alexander obtained a doctorate in laser spectroscopy and laser biophysics from the USSR Academy of Sciences in 1986. In 1992, as Whitaker Fellow, he joined the faculty at Rice University, where he invented and performed pioneering research in optoacoustic imaging. Prior to his leadership position at TomoWave Laboratories, he was a Chief Scientific Officer at Seno Medical Instruments, Vice President of R&D at Fairway Medical Technologies, Director of the Optoacoustic Imaging and Spectroscopy Laboratory at the University of Texas Medical Branch in Galveston and an Assistant Professor at the Department of Ophthalmology and Visual Sciences. Presently he holds a Santander Chair of Excellence in Physics at the University Carlos III of Madrid, Distinguished Professor of Medical Imaging at Guangzhou Medical University, an adjunct Professor of Biomedical Engineering at the University of Houston. Alexander is the holder of 21 patents, has published ten book chapters and over 200 scientific papers dealing with novel laser technologies applicable in biology and medicine. Dr. Oraevsky is the recipient of multiple research awards advancing biomedical applications of the optoacoustic imaging sensing and monitoring. Dr. Oraevsky is the founder and Chair of the largest conference in the field of laser optoacoustic ultrasonic imaging under the auspices of SPIE.

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Fiber optical sensors for medicine, robotics and smart factories

Wolfgang Schade

Fraunhofer HHI, Germany and Clausthal University of Technology, Germany

The future concept for smart factories is directly correlated to the development of smart sensor concepts. Here photonic sensors can lead to considerably higher flexibility, user-friendliness and efficiency in automation, robotics, optimizing individual machine processes or human machine interaction. Integration of communication with sensors and actuators on the lowest field level provides a complete and consistent flow of information within the entire automation pyramid. Fiber optics enable guiding information and in combination with fiber embedded sensors (Lab-in-a-fiber) a simple sensor network can be established that fulfills the above mentioned requirements. Such concept allows completely new possibilities for gesture control in combination with smart glasses (virtual and augmented reality) to provide safe working places in harsh industrial environment but also supports workers at production lines with respect to ageing society. Different photonic sensor concepts will be described and discussed for various industrial and medical applications.

Biography:

Wolfgang Schade is a full Professor of physics at Clausthal University of Technology in Germany and also head of the department Fiber Optical Sensor Systems at Fraunhofer Heinrich Hertz Insititute (HHI) in Goslar/Germany. He is author or co-author of more than 150 papers in journals and books and holds more than 30 patents. His research interests are femtosecond laser materials processing, development of photonic sensor devices and application of fiber optical sensors to industrial process control, robotics, battery safety and medical. Very recently he developed with his team a fiber optical 3D shape and tracking system on the basis of fiber Bragg gratings processed in a single mode optical fiber by point to point femtosecond laser direct writing that finds applications in human-machine interaction as well as medicine in combination with virtual and augmented reality techniques.

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Nanostructures for flying q-bits and green photonics

Dieter Bimberg [1,2]

[1]Institute of Solid State Physics, Center of Nanophotonics, Technical University Berlin, Germany,
[2]Bimberg Chinese-German Center for Green Photonics of the Chinese Academy of Sciences at CIOMP, Changchun, China

Universal self-organization and self-ordering effects at surfaces of semiconductors lead to the formation of coherent zero-dimensional clusters, quantum dots (QDs). The electronic and optical properties of QDs, being smaller than the de-Broglie-wavelength in all three directions of space are close to those of atoms in a dielectric cage than of solids. Their delta-function-like energy eigenstates are only twofold (spin) degenerate. All few particle excitonic states are strongly Coulomb correlated due to the strong carrier localisation. Their energies depend on shape and size of the dots, such that positive, zero or negative biexciton binding energies and fine-structure splitting (caused by exchange interaction) appear.

Consequently, single QDs present the most practical possible basis of emitters of single polarized photons (Q-bit emitters) on demand or entangled photons via the biexciton-exciton cascade for future quantum cryptography, repeaters and communication systems. Embedding them in electrically pumped resonant cavity structures, they can emit single photons at rates beyond 1 Gbit/s. Using GaN-based structures room temperature operation is possible.

Multiple QD layers, as active materials for nano-optoelectronic devices like edge and surface emitting lasers, or semiconductor optical amplifiers, are extremely promising. Their properties, in particular their energy efficiency, are outperforming those of photonic devices based on higher dimensional systems.

Semiconductor nanotechnologies transform presently to enabling technologies for new economies. The commercialization of nano-devices and systems has started. High bit rate and secure quantum cryptographic systems, nano-flash memories, ultra-high speed nano-photonic devices for metropolitan area networks, the 400 Gbit/s Ethernet,… present some of the first fields of applications of nano-devices.

Biography

Dieter H. Bimberg received the Diploma in physics and the Ph.D degree from Goethe University, Frankfurt, in 1968 and 1971, respectively. From 1972 to 1979 he held a Principal Scientist position at the Max Planck-Institute for Solid State Research in Grenoble/France and Stuttgart. In 1979 he was appointed as Professor of Electrical Engineering, Technical University of Aachen.

Since 1981 he holds the Chair of Applied Solid State Physics at Technical University of Berlin. He was elected in 1990 Excecutive Director of the Solid State Physics Institute at TU Berlin, a position he hold until 2011. In 2004 he founded the Center of Nanophotonics at TU Berlin, which he directed until 2015. From 2006-2011 he was the chairman of the board of the German Federal Government Centers of Excellence in Nanotechnologies.

His honors include the Russian State Prize in Science and Technology 2001, his election to the German Academy of Sciences Leopoldina in 2004, to the Russian Academy of Sciences in 2011, to the American Academy of Engineering in 2014, to the American Academy of Inventors 2016, as Fellow of the American Physical Society and IEEE in 2004 and 2010, respectively, the Max-Born-Award and Medal 2006, awarded jointly by IoP and DPG, the William Streifer Award of the Photonics Society of IEEE in 2010, the UNESCO Nanoscience Award and Medal 2012 and the Heinrich-Welker-Award 2015. In 2015 he was bestowed the D.Sc.h.c. of the University of Lancaster, UK and in 2018 the Dr.h.c. from the Research University St.Petersburg of the Russian Academy of Sciences. 2018 he received the Holonyak Award of the Optical Society of America. 2017-18 he served as Einstein Professor at CIOMP of the Chinese Academy of Sciences. Since 2018 he is the director of the Bimberg Chinese-German Center for Green Photonics of the Chinese Academy of Sciences at CIOMP

He has authored more than 1500 papers, 36 patents, and 7 books resulting in more than 56,000 citations worldwide and a Hirsch factor of 106 (@ google scholar).

His research interests include the growth and physics of nanostructures and nanophotonic devices, ultrahigh speed and energy efficient photonic devices for information systems, single/entangled photon emitters for quantum cryptography and ultimate nanoflash memories based on quantum dots.

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Special Session- Day 01

Infrared optical fibers for passive and active applications: The challenges to bring the technology to the market

Mohammed Saad

Thorlabs Inc., USA

Optical fibers are being increasingly used in many real applications, such as telecommunication, medicine, spectroscopy and sensing, astronomy, aerospace, military and industry…There are many optical materials than can be drawn into optical fibers, but there is no single material that can fulfill all application needs. Scientists and engineers have to select the right material for the right applications. The ideal candidate has to combine, mature drawing technology, good mechanical strength and transparency at the wavelength of interest high solubility of active ions, rare-earth elements, in addition to the ability to be cleaved and spliced along with the ability to write Brag gratings in the fibers. Silica fiber technology has been pulled up to the market, thanks to the huge telecommunication market. The technology is very mature and well established in many industrial and high technology applications. However, silica fibers are opaque above 2 microns. To extend the application range, other glass materials have been investigated, such as heavy metal glasses (mainly fluoride), chalcogenide, Tellurite, phosphate….Unfortunately, as these materials did not have a huge established marked, the investment was limited. To create this market one has to demonstrate that the technology is mature enough for application needs, and for that you need huge investment. To get the huge investment you need to prove that the technology is mature…. Furthermore, all components have to be developed such as sources, detectors, couplers, splitters…. Fluoride glasses are among exotic materials that have intensively investigated. This is of course due to their unique optical properties. With theoretical loss two orders of magnitudes lower that silica fibers one, they attracted many interest especially in telecommunication field. Unfortunately, after 25 years of intensive development this goal was not reached. However, this development has made the technology quite mature to address short and medium length applications. These markets have to be developed. The presentation will report the latest development of fluoride fibers technology and their applications. It will show examples of some products development. Furthermore, it will also highlight the challenges these emerging technologies are facing during their development cycles to get into the market place.

Biography

Mohammed Saad is one of the world experts in fluoride glass and fluoride fiber technologies and their derivatives. He has more than 30 years of experience in both university and industrial research fields. He has over 70 publications and 25 invited talks in international conferences. In 1986 he obtained his PhD in fluoride glasses and fibers, from Rennes University in France. In 2003 he founded Irphotonics in Montreal (Canada), a leader in fluoride glass fibers technology. In 2013, Irphotonics has been acquired by Thorlabs. And since then Dr. Saad is a senior scientist at Thorlabs, Inc. in NJ, USA. He is a senior member of SPIE and OSA. He is member of technical committee of many international conferences.

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Super pulsed regimes of diode and fiber lasers for surgical and therapeutic medical applications

Ilya Yaroslavsky
IPG Medical, USA

Recent advances in laser technology expended applications of lasers in many medical fields. Ability to deliver sufficiently high energy in a short pulse while maintaining required average power ("super pulse") is advantageous for a number of surgical and therapeutic procedures. Super Pulse (SP) regimes in Laser Diodes (LD) and Fiber Lasers (FL) offer numerous benefits over existing techniques. In this work, we have conducted thorough evaluation of two super-pulse LD and FL systems, respectively designed for treatment of soft tissues (in surgical and therapeutic modes) and stones of urinary tract (lithotripsy).

SYSTEMS EVALIATED:

1. Super pulse LD system providing up to 30 W average and up to 150 W peak power at 980 nm wavelength. The laser was operated in various modes of control including those with thermal feedback. The following characteristics of the system performance were evaluated: 1) Speed and depth of cutting; 2) Degree of charring and dimensions of coagulative margin; 3) Effective treatment depth in therapeutic mode.
2. Super pulse Thulium (Tm) FL system for lithotripsy capable of operation with up to 50 W average and 500 W peak power at 1940 nm wavelength. The in vitro experimental setup included a specially designed cuvette allowing quantitative assessment of size distribution of stone fragments and evaluation of the ablation rate. Magnitude of the retropulsion effect was measured as well.

RESULTS:

1. The SP laser diode system was compared with industry-leading conventional diode and CO_2 devices. The results indicated that the super-pulse diode laser system yielded increase in speed of controlled cutting by a factor of 2-3 in comparison with the conventional diode laser and approaching that of CO_2 device;
2. In therapeutic mode, the SP regime of the laser diode system provided substantial increase in the effective treatment depth compared with CW regime at equal average power;
3. The SP Tm fiber laser system was compared with leading Ho:YAG system on the market. The two systems were matched in terms of average power and/or pulse energy. Ablation rate measurements revealed that, depending on stone composition and laser settings, the Tm laser provided between 1.2 and 4.3 times faster ablation than the Ho system. The average retropulsion distance after a single pulse was substantially shorter with the Tm laser

CONCLUSION:

Super-pulse technology implemented in laser diodes and fiber lasers may have significant potential for creating a new standard of care in surgical and therapeutic medical applications.

Biography:

Ilya V Yaroslavsky received MSc degree summa cum laude in Physics in 1990 and PhD degree in Laser Physics in 1994, both from Saratov State University (Saratov, Russia). From 1994 to 2000, he did his postdoctoral training in Heinrich Heine University (Düsseldorf, Germany), working on laser interstitial thermotherapy of brain tumors, and in Louisiana State University (Shreveport, LA), developing optical diffusion techniques for stroke diagnostics. He started his industrial carrier at Palomar Medical Technologies, Inc. (Burlington, MA) in 2000 and in 2012 assumed position of the Vice President of Advanced Research of the company. In 2015, he joined IPG Medical Corporation (Marlborough, MA) as Manager for Advanced Product Development. His scientific interests include light-tissue interactions and use of lasers for biomedical applications. He has authored and co-authored more than 50 scientific papers and inventions.

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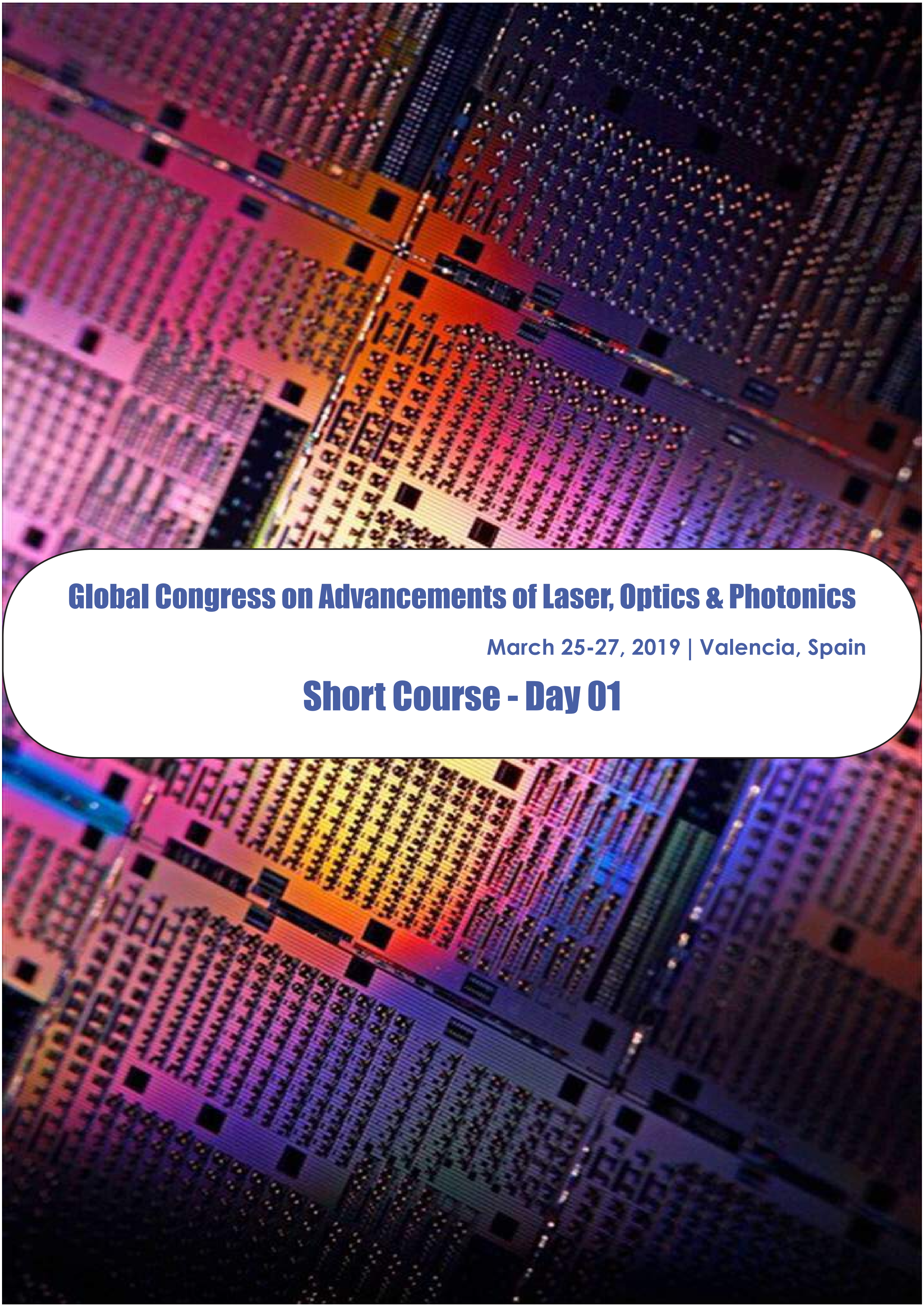

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Short Course - Day 01

High-speed optical transceiver technology for data centers

Ricardo Saad

Lumentum & University of Texas

High-speed optical transceivers are one of the key technologies in the development of modern optical communications systems. The demand for more bandwidth due to the high growth on internet traffic has generated the need for optical transceivers that work at very high speeds. Optical transceivers operating at 400 Gbs and 1 Tbs will be deployed in the near future. Microwaves and high-speed optoelectronics are key technical areas for the development of the next generation optical transceivers. This short course introduces fundamental concepts of high-speed optical transceivers. Topics are presented in a step-by-step approach starting from fundamental electrical engineering concepts. Optical communication concepts are introduced at the beginning of the course to highlight the different applications and requirements for optical transceivers. The operation of key components such as high-speed photodiodes, lasers, electro-absorption and Mach Zehnder modulators, transimpedance amplifiers, and drivers are introduced from a practical viewpoint. Different optical transceiver architectures and their corresponding implementations are presented. Design and characterization techniques of optical transceivers are reviewed. Impairments on optical transceivers are highlighted. The course concludes presenting different state-of-the art optical transceivers for multiple applications including optical transceiver for data centers.

Course Syllabus:

Fundamental of Optical Communications

- Multimode and single mode fibers.
- Multimode and Chromatic dispersion effects.
- Dispersion compensation using optical fibers.
- Attenuation on optical fibers.
- Different bands in optical fibers: O-band, S-band, C-band, L-band.
- Standard optical frequencies in optical communications.
- Non-linearities in optical fibers.
- Brief description of optical amplifiers.
- Basic optical communication system configurations.

Optical Transceiver Architecture

- General Architecture of Optical Transceivers.
- Multisource Agreement Form Factors.

Photodetectors

- Photodetection Process.
- Responsivity, quantum efficiency, dark current definitions.
- PIN Phododetector: operation, electrical model
- Avalanche photodetectors (APD), operation, electrical model.
- PIN and APD photodetectors specifications.
- Characterization of photodetectors.
- Examples of commercially available photodetectors.

Modeling of Optical Receivers

- Noise in electronic circuits.
- Noise in linear circuits.
- Noise theory applied to optical receivers.
- PIN noise model.
- APD noise model.
- Basic architecture of optical receives.
- Bit error rate, Q-factor definition.
- Relationship between sensitivity and extinction ratio, noise, and bit error rate.
- Effect of threshold adjustment on the performance of optical receivers.
- Effect of finite rise time in optical receiver sensitivity. Optical dispersion effect.
- Basic configuration of optical receivers
- Main specification of optical receivers
- Receiver Optical Sub-Assembly (ROSA) examples.

Transimpedance Amplifier-Post Amplifiers

- Transimpedance amplifiers (TIA) specifications
- Linear transimpedance amplifier-Automatic Gain Control (AGC)
- Limiting transimpedance amplifiers (LA)
- Architectures of transimpedance amplifiers
- FETs and BJT front-ends for transimpedance amplifier.
- Post-amplifier specifications
- Examples of commercially available TIAs, LA and AGC amplifiers.

Lasers

- Absorption, spontaneous emission, andstimulated emission
- Fabry-Perot cavity.
- Principle of operation of lasers.
- Fabry-Perot laser operation
- DFB and DBR laser operation
- VCSEL operations
- Tunable laser operation
- Examples of commercially available lasers.

Optical Transmitters

- Architecture of optical transmitters
- Transmitter specifications
- Direct modulated transmitters
- External modulated transmitters: Electro-absorption and Mach-Zehnder modulators.
- RF & microwave drivers for optical transmitters
- Transmitter utilizing thermo-electric coolers/heaters.

Optical Transceiver architectures for different Form factors

- Multisource Agreements (MSA) for 10 Gbs transceivers
- Architecture and operation of10 Gbs optical transceivers
- Examples of 10 Gbs optical transceivers.
- MSAs for 100 Gbs transceivers

- Architecture and operation of 100 Gbs optical transceivers.
- Effect of dispersion on bit error rate performance.
- Transceivers under low optical signal to noise ratio: effect on the BER performance.
- Optical transceivers with clock data recovery (CDR)
- Optical transceivers with forward error correction (FEC)

Test Methodologies for Optical Transceivers

- Optical characterization
- Electrical characterization

Impairments in Optical Transceivers

- Optical impairments
- Electrical impairments

Application for Optical Transceivers

- Telecommunications
- Datacom and data centers
- Passive Optical Networks.
- Examples of optical transceiver for different applications.

Importance of this short course:

High-speed optical transceivers are presently working at microwave frequencies. In the next few years, 400 Gbs and 1 Tbs optical transceiver will be developed due to the demand of more bandwidth for internet applications. As such high-speed electronic (RF & Microwaves) components will be developed. The development of those components required RF & Microwave knowledge as well as a detail understanding of high-speed optoelectronics. Presently, some major Microwave-core companies are designing microwave components for high-speed optical transceivers.

In general, there is not a full understanding within microwave companies on what to develop for the next generation optical transceivers. Also, optoelectronics components do not have a clear understanding on the capabilities of microwave technology. This is because standard electrical engineering curriculum does not integrate both areas of electrical engineering.

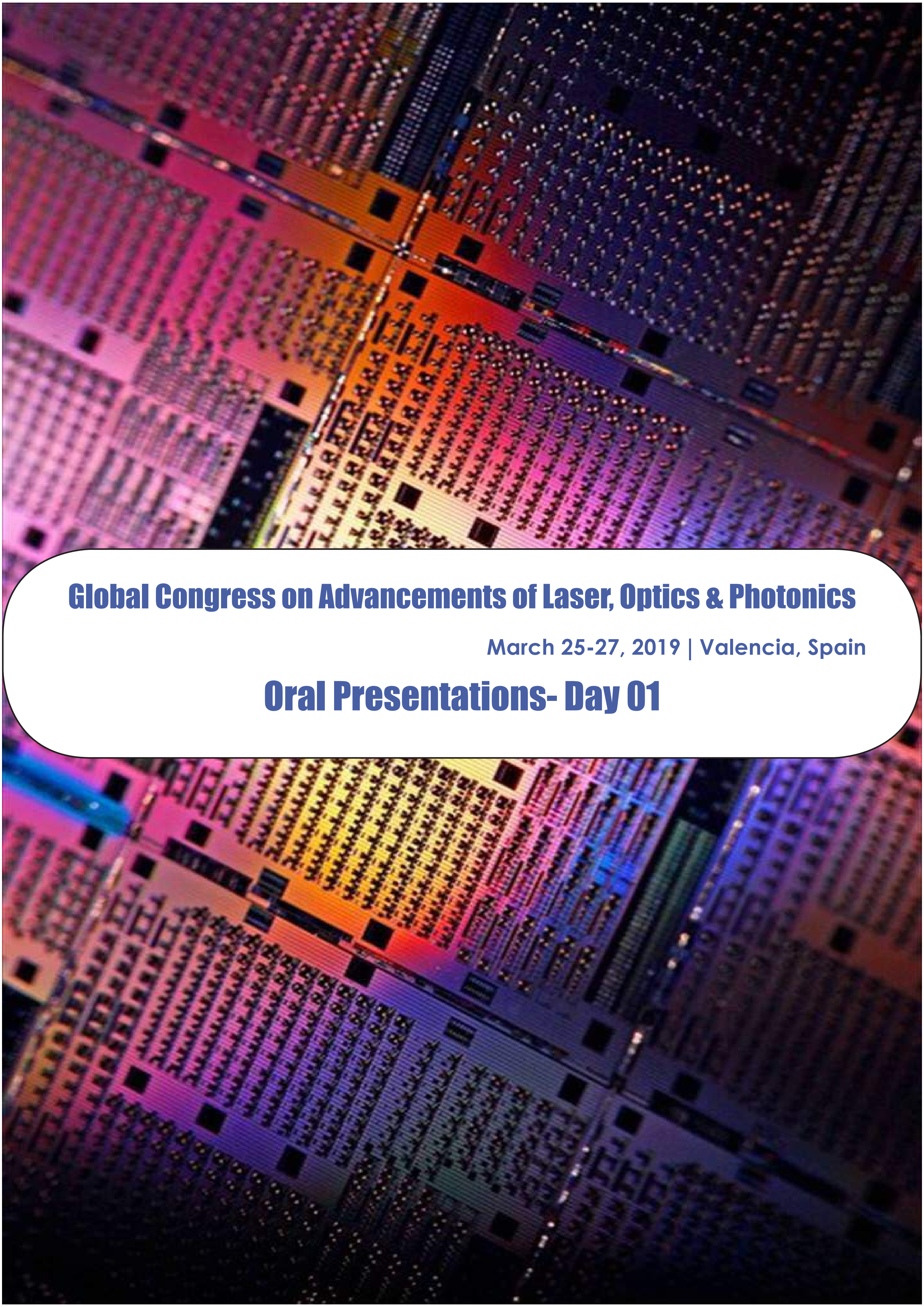
The main objective of this course is to introduce to the attendees the fundamentals topics related to optoelectronics and high-speed optical transceiver.

Previous Experience teaching short courses:

He taught short courses (1-week long each) on high-speed optical receivers and high-speed optical transmitters (as separate topics) and on optical communications for Finisar corporation engineers in Ipoh, Malaysia, between 2006 and 2009. He had also given some lecturers on optical transceivers at JDSU (now Lumentum) in an effort to train engineering resources of the company. He also created and lectured once a year a graduate course on high speed optical transceivers (EEOP6338 High-Speed Optical Transmitters and Receivers) since 2013 in the Department of Electrical Engineers. The objective of the course is to prepare engineers that are capable to understand high-speed optical transceiver technology which requires a deep understanding in communications, optoelectronics, and RF & Microwaves. A similar course to the one that he is proposing was taught at IEEE International Symposium in Microwaves, May 2016 in San Francisco. This was an invited short course by the Short Course Committee.

Short Course Learning Objectives and Outcomes:

- Ability to understand optical communications concepts related to optical transceiver design.
- Ability to understand high-speed optical receivers circuits and architectures
- Ability to apply noise theory to optical receivers and its relationship with sensitivity.
- Ability to understand different photodetectors and its application in optical transceivers
- Ability to understand transimpedance, limiting and AGC amplifiers.
- Ability to understand high-speed optical transmitter circuits and architectures.
- Ability to understand different laser types and their operations and applications.
- Ability to understand internal and external modulation in optical transmitters (i.e. electro-absorption and Mach-Zehnder Modulators).
- Ability to understand impairments in optical transceivers.
- Ability to understand latest technologies in the design of high-speed optical transceivers.



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Oral Presentations- Day 01

Second harmonic generation in spatially randomized crystals: Application to ultrashort pulse characterization

Crina Cojocaru and Jose Trull
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The precise characterization of ultrashortlaser pulses is a challenging task and a hot topic of research, since this kind of lasers are now a days implemented in different applications. In Westudy and discuss the spatial distributed second harmonic generation obtained in a disordered nonlinear crystal, having a random size and distribution of nonlinear domains with homogeneous refractive index. The particular distribution of the nonlinear domains generate a transverse second harmonic signal emitted in all directions of the plane perpendicular to the propagation direction, with a similar efficiency over a very broad wavelength range, without the need of the phase matching condition. On the other hand, the crystal itself serves as a highly dispersive and ultra-broadband nonlinear medium, acting on the pulse propagating trough it.

We implement these particular nonlinear properties of such crystal to different configurations of a novel single shot auto- or cross-correlation technique, capable of measuring the most important parameters of an ultrashort laser pulse: pulse duration, chirp parameter, wave front tilt and, in a particular configuration, also the spectral phase. This method does not require phase matching condition nor sensitive alignment of thin nonlinear crystals and the same set-up can be used for the measurements of pulses with duration between 30 fs and 1 ps and wavelength in the range of 800 and 2000 nm.

We show that the same effect can be implemented to an indirect, non-destructive optical method for domain statistic characterization in random nonlinear crystals. We apply this technique to the characterization of different random media, with drastically different statistical distributions of ferroelectric domains.

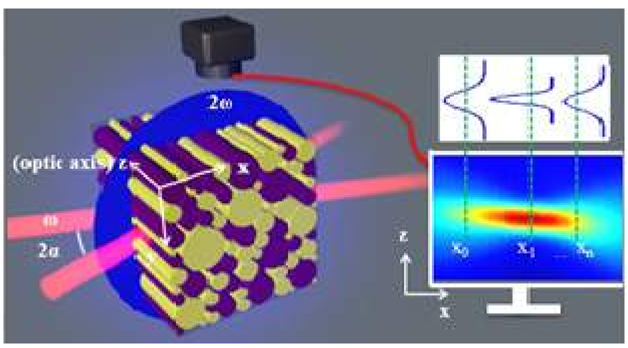

Figure 1: Schematic representation of the transverse auto-correlation trace in a media with spatially randomize quadratic nonlinearity

Biography:

Crina Cojocaru received her BSc and MSc in Physics from the University "Al. I. Cuza", Romania, in 1996 and the PhD degree in Physics from the Polytechnic University of Catalunya, Barcelona in 2002. After two years as a Marie Curie post-doc researcher at LPN - CNRS in Paris, she joined the Physics Department at Polytechnic University of Catalunya, Barcelona, first as post-doc researcher in 2004, later as a lecturer in 2006 and since 2008 she is an associate professor.

Her research covers different aspects of Photonics, focuses but is not limited to linear and nonlinear optics in a variety of materials, such as photonic crystals, metamaterials and random structures, ultrashort laser pulse characterization, laser beam shaping and control at micrometric scale using photonic crystals. These fields are reflected in more than sixty-five articles in peer reviewed journals, eighty international conferences with more than twenty-five invited talks. She is co-inventor in one European patent, and has authored two book chapters.

She has participated in a large number of research projects (six of them as PI) and has supervised 5 PhD thesis and more than 15 Master and Bachelor degree thesis. She is an active member of several steering committees of international scientific conferences and member of the Optical Society of America, European Physical Society, Royal Spanish Society of Physics and Catalan Society of Physics.

At academic level, she teaches different courses on nonlinear optics, photonics and experimental physics for BSc and Master program students. She is currently the director of the Inter-University Master in Photonics "PhotonicsBCN" and of the Joint Master Erasmus Mundus "Europhotonics-POESII" (Spain, France and Germany).

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Embedding the photon with its relativistic mass as a particle into the electromagnetic wave explains the Gouy phase shift as an energetic effect

Konrad Altmann

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In the paper "Embedding the photon with its relativistic mass as a particle into the electromagnetic wave" [K. Altmann, Opt. Express 26(2), 1375-1389 (2018)] a new aspect concerning the relationship between photon and electromagnetic wave has been developed by considering the question why the energy and the mass density of an electromagnetic wave are propagating in the same direction. For instance, in optical resonators the energy density usually propagates along curved lines. However, according to Newton's first law the mass density should propagate along a straight line, if no force is exerted it. In order to solve this problem, which represents a contra-diction between fundamental physical laws, the assumption has been made that a transverse force is exerted on the mass density and in consequence on the mass of the photons which forces them to follow the propagating energy density. This force has been computed by considering the infinitesimal change of the normalized Poynting vector with respect to an infinitesimal propagation step. Integration of the negative value of this force along the curvature of the phase front shows that the photon is moving within a transverse potential. This potential allows to describe the transverse quantum mechanical motion of the photon by the use of a Schrödinger equation which is identical with the Schrödinger equation describing the motion of the electron, except that the mass of the electron is replaced by the relativistic mass of the photon. In this way, it could for the first time be shown that the Schrödinger equation is also describing the motion of a particle which has no rest mass. The eigensolutions $\chi nm(x,y,z)$ of this Schrödinger equation allow to compute the probability density $|\chi nm(x,y,z)|^2$ of the photons propagating with an electromagnetic wave. This seems to show, how the photon can be assumed to be embedded with its relativistic mass as a particle into the electromagnetic wave. The obtained results have been verified for the case of the plane, the spherical, and the Gaussian wave. In case of a Gaussian wave it could be shown that the probability density $|\chi nm(x,y,z)|^2\ )|^2$ of the photon computed in this way is in full agreement with the normalized local intensity provided by paraxial wave optics for a Gaussian mode of order n,m. In addition, also the Guoy phase shift could be computed by the use of this particle picture in full agreement with the result obtained by the use of wave optics. This demonstrates that the Gouy effect can be equivalently understood as a wave optics as well as a quantum mechanical effect. In the paper "Explaining the Gouy phase shift as an energetic effect" [K. Altmann, accepted for publication by OSA in Continuum] it could furthermore be shown that the Guoy phase shift represents an energetic to effect. For this purpose, the above described results are used to show that in case of a Gaussian wave the effective axial propagation constant can be expressed as $kz(z)=[Eph-Enm(z)]/(\hbar c)$ where Eph is the total energy of the photon, and the Enm(z) are the energy eigenvalues of the transverse quantum mechanical motion of the photon. Since according to this result $\hbar ckz(z)$ represents a real energy, it has been concluded that also the effective axial propagation constant represents a real propagation constant. This leads to the conclusion that $\lambda nm=2\pi/\ kz(z)=hc/[Eph-Enm(z)]$ represents the real local wave length of the photon at the position z. According to this conclusion, $\lambda nm(z)$ increases inversely proportional to the energy difference Eph-Enm(z), which decreases with decreasing z, and therefore, describes the Gouy phase shift in agreement with wave optics. This shows that the deeper physical reason for Gouy phase shift consists in the fact that the energy of the photon is increasingly converted into its transverse quantum mechanical motion when the photon approaches the focus. This explains the Gouy phase shift as an energetic effect.

Biography:

Konrad Altmann has completed his PhD in Physics from the Ludwig-Maximilian University of Munich, Germany, at 1975. The issue of his thesis was the quantum mechanical description of molecular spectra. For this work, he obtained the marking "with excellence". From 1976 to 1991 he was with the industrial company Messerschmitt-Bolkow-Blohm and developed a computer program for the description of a gas dynamic CO_2 laser. From 1991 to 1993 he was with the German Aerospace and developed computer programs and published papers concerning laser beam propagation in the atmosphere. In 1993 he founded the company LAS-CAD GmbH with the purpose to integrate different simulation tools, necessary for the analysis of the multi-physics interaction in solid-state lasers, into the commercial program LASCAD. This program provides the laser engineer with the ability of a quantitative understanding of the complicated effects in laser systems. He has over 25 years of progressively responsible experience in computational physics especially in the field of optics. He wrote more than 40 scientific publications in molecular physics, propagation engineering and laser technology and applied for 38 patents of which 15 have been granted. He also wrote programs for the simulation of laser beam propagation in the atmosphere. In 2014 he was becoming Adjunct Professor of the National Engineering Center for DPSSL of the Chinese Academy of Science.

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Notes:

Optical interconnection networks and enabling technologies

Qimin Yang
Harvey Mudd College, USA

Large scale communication systems such as data centres have driven the development of optical interconnection networks (OIN) in the past decade. Initial architectures of OINs that are developed for high performance computing use cost and performance metrics that are significantly different from that in data centre communication systems. This talk will review OIN networks and the enabling technologies more readily deployed in data centre systems. We will review technologies both in the level of photonic devices as well as in the areas of architectural and system developments. We will also address the scaling issues and limitation in different technologies involved. A balance of electrical and optical technology is also an important aspect and potential cost and feasibility incorporating different devices and technologies. Some building blocks or functionalities of OIN may still request newer technology and different strategy than existing methods, and we will cover some questions for future development in this research area.

Biography:

Qimin Yang is professor in Engineering Department in Harvey Mudd College in Claremont, California USA. Harvey Mudd College is an undergraduate institution focused on science and engineering. Since 2002, Qimin Yang has been teaching in various courses in signals and systems, system controls, analog circuits and fibre optic communication systems. She is also the associate Clinic director in Engineering, where Clinic is a project-based capstone program critical for HMC engineering program.

Qimin Yang received her bachelor's degree in Electrical Engineering in Zhejiang University in China in 1994, and Master's degree from Beijing University of Posts and Telecommunications in 1997. She completed her Ph.D. from Princeton University in 2002, focusing on researches in optical communication and network areas. Her research interests include high capacity network architecture development for parallel computing and large scale communication systems.

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Notes:

Medical applications of ultraviolet LEDs

Paul Michael Petersen

Technical University of Denmark, Denmark

Solid state lighting based on LEDs is being implemented everywhere in our society and this technology is well known for its energy saving potential. There is now a rapid growth in lighting based on UV LEDs. This new UV technology will in the future lead to many new medical applications. The talk reviews how UV LEDs in the future may be used in biomedical applications such as cancer diagnostics, disinfection of specific bacteria, and improved health by using light-induced enhancement of vitamin D.

Ultraviolet emitters based on UVA and UVB LEDs are new LED light sources that may be used for disinfection without the need for a photosensitizer. Recently, we have worked on the development of UV-LEDs that are optimized for disinfection of specific bacteria. These results offer new possibilities for applications within dental applications related to treatments of periodontitis and infections in the dental root canal.

Furthermore, the UV B wavelength that is found effective for killing bacteria in biofilm, is part of the wavelength that exists in daylight. This gives new possibilities for applications within oral disinfections.

In the talk we will discuss the latest results of the efficiencies of killing bacteria using UV-LEDs and how these light sources potentially may be used to kill bacteria in the tooth root canal and also for the treatment of periodontitis.

UV LEDs light goes far beyond traditional solid state lighting and may be used for many new biomedical application including treatment and prevention of bacterial infections. Recently, we have introduced a new concept *light assisted antibiotics* where UVB light in a narrow range around 300 nm is used in combinations with antibiotics to eradicate with the same efficiency as 10 times higher concentrations of antibiotics. These findings together with the ability of the same UVB wavelengths to induce enhancement of vitamin D in humans and animals are very encouraging for novel medical applications based on ultraviolet LEDs.

Biography:

Paul Michael Petersen is Full Professor in New Light Sources at the Technical University of Denmark. From 2002 until 2012 he was appointed adjunct professor in Optics at the Niels Bohr Institute, Copenhagen University. His research focuses on lasers, LEDs and biomedical photonics. P. M. Petersen has authored more than 180 international scientific publications and holds 18 patents. P. M. Petersen is chairman of DOLL – a *Photonics Green lab* that develops new lighting technologies based on LED and diode laser technologies.

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Notes:

The prospect of a green laserbased on AlGaN/AlN structures heavily doped with silicon

Konstantin Zhuravlev, PA Bokhan, NV Fateev, TV Malin, DmE Zakrevsky

Rzhanov Institute of Semiconductor Physics of the Siberian Branch of the RAS, Russia

The $Al_xGa_{1-x}N$ alloys with a bandgap in the range of 3.4–6.2 eV has emerged as perspective semiconductor materials with applications to laser sources. Luminescent properties of the $Al_xGa_{1-x}N$ films with Si dopant concentration more than 10^{20} cm^{-3} grown by molecular beam epitaxy on sapphire substrates with AlN buffer film were investigate. Time-resolved photoluminescence spectroscopy was employed to study the donor-acceptor pair transitions in the $Al_xGa_{1-x}N/AlN/Al_2O_3$ structures with Al mole fraction x from 0.56 to 1 under action of Nd:YAG laser radiation with $\lambda = 266$ nm (4.66 eV).

The radiation inside planar waveguide consists of spontaneous emission and amplified spontaneous emission. The spontaneous emission spectra demonstrated inhomogeneous broadening with FWHM of 0.51 eV covers full visible range and propagate randomly in all directions. The measured values of quantum yield of spontaneous luminescence are ~ 0.8, 0.5, 0.14 for $Al_{0.74}Ga_{0.26}N$, $Al_{0.65}Ga_{0.35}N$ and $Al_{0.5}Ga_{0.5}N$ films, respectively.

The amplified spontaneous emission propagates at near the critical angle of incidence along zigzag path under total internal reflection conditions at the interfaces of the waveguide. Its spectrum consists of several TE_m and TM_m modes, which have mutually orthogonal polarizations. The optical measured gains are equals to $g \approx 58$ cm^{-1} for $Al_{0.65}Ga_{0.35}N$ at 510 nm and $g \approx 20$ cm^{-1} for $Al_{0.74}Ga_{0.26}N$ films at $\lambda = 528$ nm, applying the stripe excitation method under optical pumping. The decay curves of the amplified spontaneous emission from the films after action of pumping radiation is described by the sum of two exponential dependences with characteristic time as τ_f(the fast decay time) and τ_s (the slow decay time). Experimental results shows that the τ_f decreases as a function of the pump power density. When the pump power density is reduced to zero, then τ_f approaches the spontaneous decay time τ_s, which are differ for the various structures. Decay times τ_s for $Al_{0.74}Ga_{0.26}N$ and $Al_{0.65}Ga_{0.35}N$ films are equals to 90 ns and 40 ns respectively. The estimated emission cross-sections σ are 1.5×10^{-18} and 3.1×10^{-18} cm^2 for the $Al_{0.74}Ga_{0.26}N$ and $Al_{0.65}Ga_{0.35}N$ structures respectively. Using the values for the optical gain values, we find the population inversion $\Delta N \approx 1.3\times10^{19}$ cm^{-3} for $Al_{0.74}Ga_{0.26}N$ and $\Delta N \approx 1.9\times10^{19}$ cm^{-3} for $Al_{0.65}Ga_{0.35}N$ films.

To obtain amplifying medium for light waves, the possible four level scheme for creating population inverse in AlGaN films was considered.

Biography:

Zhuravlev Konstantin Sergeevich is the Head of Laboratory of MBE growth of III-V semiconductor, Rzhanov Institute of Semiconductor Physics Russian Siberian Brach of Academy of Sciences (ISP SB RAS). He received his M.S. from Novosibirsk Institute of Electrical Engineering, 1979, Ph.D. from Institute of Semiconductor Physics SB RAS, 1992, and DSc from Institute of Semiconductor Physics SB RAS, 2006 respectively. From 1982 to 1992, he was engaged in the research of the Laboratory of Nonequilibrium Processes in Semiconductor. In 1993 he joined to Laboratory of MBE growth of III-V semiconductor where has investigated photoluminescence of gallium arsenide films and gallium arsenide-based low-dimensional structures as well as luminescence properties of Si nanocrystals and II-VI nanocrystals. Currently, his research interests include the study of the MBE growth and photoluminescence of III-V semiconductor materials and nanostructures, the design and manufacture of a new type heterostructures for optical and electronic devices.

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Quantum sustainability phenomenon in opticalsystems and its applications

Konstantin G. Zloshchastiev

Durban University of Technology, South Africa

We use the quantum-statistical density operator approach to illustrate that sustainability is a universal quantum phenomenon, which emerges during propagation of electromagnetic waves inside different media, such as waveguides, metamaterials or biological tissues. For illustrative purposes, we show two examples, of both natural and human-controlled systems, where this phenomenon occurs. First is the environment-assisted excitonic energy transfer in photobiological complexes, such as photosynthetic reaction centers or centers of melanogenesis inside living organisms or organelles. As a second example, we demonstrate how this phenomenon of sustainability can manifest itself in a large class of human-controlled EMW systems, such as optical couplers and amplifiers. An introductory reading: K. G. Zloshchastiev, Phys. Rev. B 94, 115136 (2016); Ann. Phys. (Berlin) 529, 1600185 (2017).

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Notes:

5 J, 200 Hz Nd: YAG laser system with high beam quality

Jie Li[1,2] , Zhong-Wei Fan[1,2], Ji-Si Qiu[1,2,3], Zhi-Jun Kang[1,2,3], Yan-Zhong Chen[1,2,3], Wen-Qi Ge[1,2,3], Xiong-Xin Tang[1,2,3]

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[2]National Engineering Research Center for DPSSL, China

[3]Sino-HG Applied Laser Technology Institute Company Ltd., China

An all-solid-state Nd:YAG laser system with high beam quality and excellent energy stability has been developed for Thomson scattering diagnosis. A 1.7 times diffraction limited output beam with a pulse energy of 5 J at 1064 nm is achieved for the first time with a pulse duration of 6.6 ns (FWHM) at 200 Hz repetition rate. The output energy fluctuation is only 0.71 % RMS over 6000 shots.

Biography:

Jie Li joins Academy of Opto-Electronics as an associate researcher in Chinese Academy of Sciences (CAS). He received his BS from University of Science and Technology in China and his PhD from the College of Optics & Photonics at the University of Central Florida in USA. Jie's primary research interests are in the field of Ultrafast Laser and Attosecond Science. He and his colleagues had developed a CEP-stabled, 3 mJ, 1.7 micron OPCPA laser system for driving isolated attosecond pulse in the soft X-ray spectrum range and demonstrated isolated 53 attosecond pulse with 300 eV photon energy.

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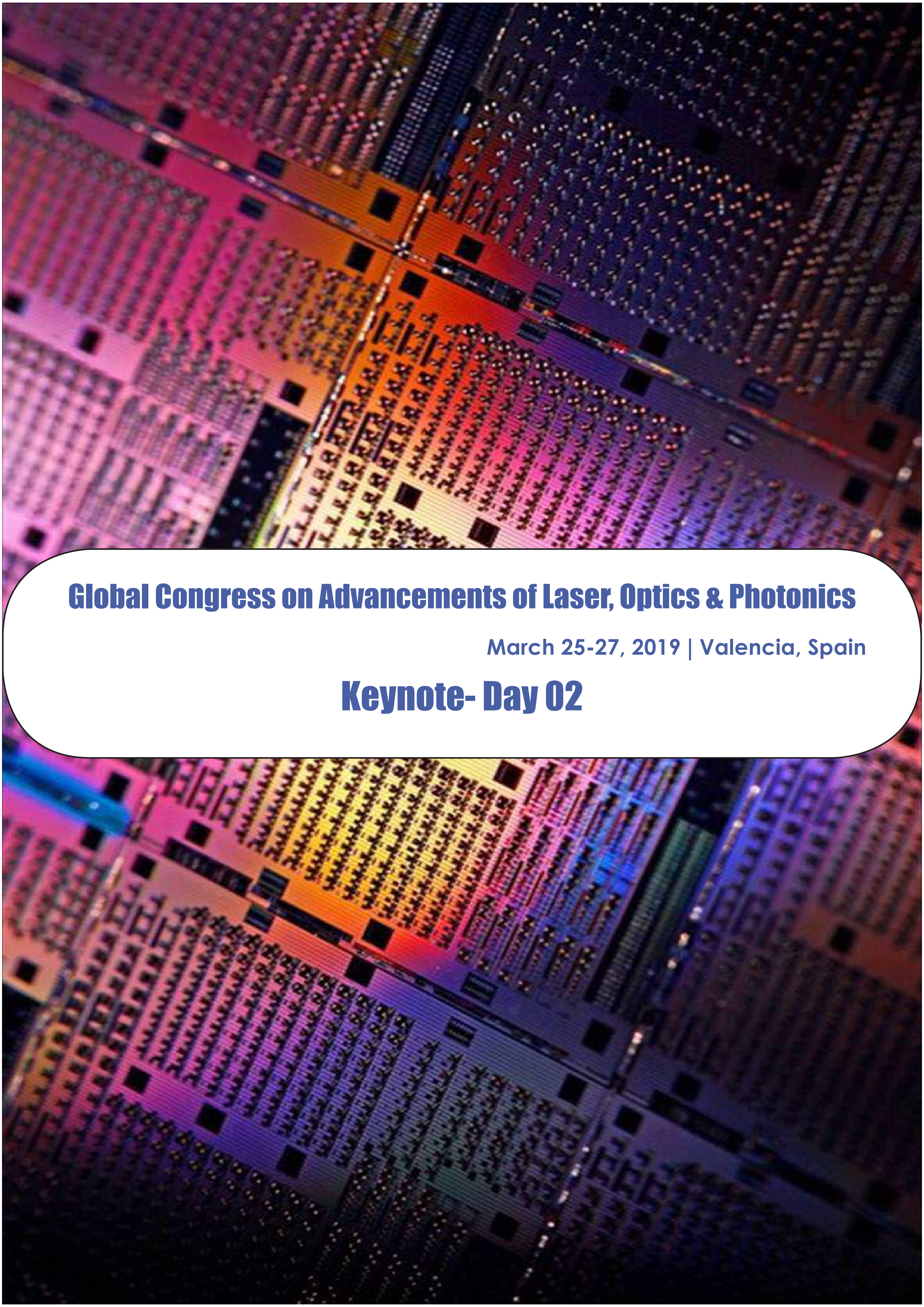

Global Congress on Advancements of Laser, Optics & Photonics

March 25-27, 2019 | Valencia, Spain

Keynote- Day 02

Healing with light: The potential of photodynamic therapy

Jose Miguel López-Higuera

Photonic Engineering Group of Universidad de Cantabria[1], CIBER-BBN[2] and IDIVAL[3], Spain

Light Science and Technologies (Photonics) now touches almost every area of our lives including the healing and health care one. To provide the health and care services required in this period of our lives, new breakthroughs and new cost-effective methods for improved diagnosis, and therapy are very welcome.

In this talk, we will explore the potential of healing of a treatment activate by light to overcome cancer, pre-cancer and chronic diseases: the Photodynamic Therapy (PDT). PDT, offers a localized treatment against cancer and infectious lesions, by using specialized compounds or photosensitizers (PS) activated by Light to produce disease killing Reactive Oxygen Species (ROS). These, can directly damage cells and/or vasculature, with little damage to surrounding tissue, and also could produce the indirect effect of alarming the immune system against the specific cancer.

In this invited keynote, after the clarification of what can be understood as Photodynamic Therapy how it does work and devices required, several significant cases will be presented and discussed. Then, the potential of PDT to be used alone or "harmonically" combined with the already commonly used "standard" therapies to reach a higher or better level of healing, will be mentioned in the presentation. After that, the attendees will be aware of the of power of healing with this light based therapy and its significant impact on the modern medicine of XXI century.

Biography

López-Higuera is the founder and head of the Photonics Engineering Group of the University of Cantabria, CIBER-BBN of the Instituto de Salud Carlos III and IDIVAL of Hospital Universitario Marqués de Valdecilla, Spain. He is a Member of a wide set of international Committees of Conferences, R&D Institutions, and Companies in the area of photonic sensing. His work is focused on optical sensor systems and instrumentations for any sector application. He has worked in a wide range of R&D&i projects, acting in more than 90 of them as manager. He has contributed with more than 700 research publications including 20 patents closely related to optical and fiber techniques for sensors and instrumentations. He has worked as an editor and co-author of four R&D international books, as a co-editor of several conference proceedings and Journals and he has been the director of 18 PhD theses. He is co-founder of three technology-based companies. Prof. López-Higuera is a Fellow of OSA, Fellow of SPIE, Senior of IEEE and a Member of the Royal Academy of Medicine of Cantabria, Spain.

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Lab-on-a-chip Spectroscopy: Learning the structural complexity

Maxim S. Pshenichnikov
University of Groningen, The Netherlands

The natural light-harvesting antennae of plants and photosynthetic bacteria are one of the most fascinating functional molecular nanoassemblies. Their unprecedented quantum efficiency relies on the strong coupling between thousands of densely packed chromophores giving rise to highly delocalized excitons which travels over long distances. However, the structural complexity of these systems leads to spectral congestion thereby blurring individual exciton transfer pathways that are vital to unravel for potential applications. Artificial model systems allow for better understanding of the structure-property relationship through reducing the complexity of natural light-harvesting complexes and disclosing the working principles to the basic elements.

Here we demonstrate a novel spectroscopic/microfluidics approach to deconvolute the supramolecular hierarchy of the model system, multilayered nanotubes. The outer shell is selectively unwrapped in a microfluidic cuvette thereby providing a sufficient time window for ultrafast spectroscopy, before the original structure is re-established. We will also discuss the intermediate dynamical states of self-assembly by combining microfluidics, ultrafast two-dimensional spectroscopy, and extensive computer simulations.

Biography

Maxim S. Pshenchnikov obtained his PhD from Moscow State University in 1987. In 1992, he moved to the University of Groningen, the Netherlands, as a postdoctoral fellow, to join the staff in 1996, first at the department of chemistry, and since 2006 at the department of physics. In the early 90s, he began to design experiments and theoretical description of femtosecond spectroscopy on liquid state dynamics. He with co-workers was the first to report time-gated and heterodyne-detected photon echoes from solutions. The technical aspects of this work culminated in 1998 with the Guinness Book of World Records certificate awarded for "The shortest flashes of light produced and measured, lasted for 4.5 femtosecond". Later, his research was focused on hydrogen-bond dynamics in liquids and at (bio)interfaces. He published 150+ papers in international journals and 6 chapters in books, which altogether received more than 4800 citations (h-index 37). He organized and co-chaired a number of international meetings in the fields of spectroscopy, organic electronics and excitonics. Since 2016, he is also a visiting professor at Nanyang Technological University, Singapore.His current research interests cover a wide range of ultrafast phenomena in organic materials at nanoscopic lengths and ultrafast time scales, with the focus on exciton and charge dynamics in energy-related and bio-inspired materials.

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Notes:

Long-range optical interactions

Gershon Kurizki
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Nonlinear optical phenomena are typically local. We have predicted the possibility of highly nonlocal optical nonlinearities mediated by long-range interactions of photons propagating in atomic media [Shahmoon et al.]. Part of our predictions has concerned the possibility of entangling photons in waveguides that has recently been experimentally confirmed by M.Lukin's group. It has grown out of our work on the enhancement of long-range interactions by virtual quanta exchanged via the bath in confined geometries [Friedler et al.]. It is at present the only mechanism capable of deterministically entangling distant photons. This mechanism is one of our predictions of bath-induced entanglement [Rao et al.]. Its essence is that the mediation of virtual quanta by the modes of a waveguide can cause their enhancement by many orders of magnitude and drastically extend their range [Shahmoon et al.].

For atoms trapped near a nano-waveguide, where long-range interactions between the atoms can be tailored in an electromagnetically-induced transparency configuration, the atomic interactions may be translated to long-range interactions between photons and thus to highly nonlocal optical nonlinearities. We find a roton-like excitation spectrum for light [O'Dell et al.] and the emergence of order in its output intensity.

For atoms coupled to a waveguide with a bandgap spectrum illuminated by an off-resonant laser, the resulting dynamics of the atoms is predominantly affected by an extremely long-range conservative force that can enhance their interaction.

Even more dramatic, giant, enhancement of the interaction is achievable via the control of the geometry, for dipolar forces induced by the electromagnetic vacuum, namely, the Casimir and van der Waals (vdW) forces. The idea is to consider atoms coupled to an electric transmission line (TL), such as a coaxial cable or coplanar waveguide, which support the propagation of quasi-1d transverse electromagnetic (TEM) modes. Virtual excitations (photons) of these extended modes can mediate much stronger and longer-range Casimir and vdW forces than in free-space [Shahmoon et al.].

These predictions open the door to studies of unexplored wave dynamics and many-body physics with highly-nonlocal interactions of optical fields in one dimension.

Biography

Gershon Kurizki was born in 1952. He completed his M.Sc. in physics in 1979. He did his PhD from University of New Mexico in 1983. He later joined the Weizmann Institute of Science (WIS) in 1985. He is a tenured Professor at WIS since 1991. His Fields of expertise include Open Quantum-System Control (particularly control of decay and decoherence) Quantum Optics, Quantum Theory of Light-Matter Interactions. Kurizki's research on the control of open quantum systems, their bath-induced interactions and thermodynamic aspects (along with other pioneering contributions) has yielded a number of groundbreaking results, supported by experiment, that have impacted diverse fields and deepened our understanding of quantum system-bath interactions. One intriguing insight is that "the bath is more a friend than a foe" it can induce and not only destroy quantumness.

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Wavelet packet transform (WPT) applications in high spectral efficiency (SE) optical communication systems

Yosef Ben Ezra[1,2]

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There exist two approaches to the signal processing in the optical communication systems: the electric domain signal processing and the optical signal processing. In the latter case, the fast nonlinear optical phenomena such as self-phase modulation (SPM), cross-phase modulation (XPM), four-wave mixing (FWM) are used for the digital, analogue and quantum information processing. The passive photonic components such as Mach-Zehnder interferometers (MZIs) and ring resonators can also be used as basic elements for the all-optical signal processing. The optical signal processing increases the processing speed and reduces the energy consumption and latency of the optical communication systems. Such operations as all-optical wavelength conversion (WC), radio and microwave frequency pulse generation and beam forming, orthogonal frequency-division multiplexing (OFDM), switching, regeneration, can be realized. Coherent optical OFDM (CO-OFDM) systems combine the advantages of coherent detection and OFDM modulation. However, the performance of CO-OFDM systems strongly deteriorates due to the inter-symbol-interference (ISI) and inter-carrier-interference caused by the channel chromatic dispersion and polarization dispersion (PMD). The different types of the wavelet packet transform analysis such as a wavelet packet transform (WPT), multi-wavelet and complex wavelet analysis for the CO-OFDM systems had been proposed instead of discrete Fourier Transform (DFT) and inverse DFT (IDFT) . In such a case, the signal is expanded in an orthogonal set of wavelet packets (WPs) as the basis functions, where each channel occupies a separate WP. We investigated numerically the advanced modulation formats QAM 16, QAM 4 for the 1Tb/s transmission in the long-haul WPT-OFDM systems. The comparison of these system performance with the conventional OFDM systems shows that the WPT-OFDM systems have some advantages.

Biography

Yosef Ben Ezra, Dean of Engineering faculty at Holon institute of Technology and CTO at Mer Group, received his Ph.D. from the Tel-Aviv University. During 2003-2005 Prof. Ben-Ezra was the principleresearcher in joint industry-academy project TRANSMOR focused on automatic detection and classification ofpower transients in WDM optical communication networks. Between 2007-2009 Prof. Yosef Ben-Ezra was the principle researcher in a joint industry-academy project, DIAMOND, thatdeveloped high-spectral-efficient modulation techniques formodern optical communications. In the framework of MAGNET project Tera-Santa Prof. Ben-Ezra develop the novel method of OFDM based on Multiwavelets. He is currently working on the silicon photonic implementation of the Multiwavelet OFDM in Peta-Cloud consortium. He has co-authoredover 85 papers in international journals and conferences in fields of semiconductorphysics and nonlinear effects, and optical communication. He is the author 15 chapters in scientific books and of 12 patents.

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Lab-on-a-chip photonic biosensors for point-of-care applications

Aurel Ymeti
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In recent years, there have been several examples of serious virus outbreaks raising significant fears that such outbreaks can rapidly spread worldwide to become pandemics with devastating effects on populations and their social and economic development. Therefore fast, on-site, and sensitive detection of viruses is essential in detecting the onset of viral epidemics and preventing their spread. Currently available methods such as PCR (Polymerase Chain Reaction) and ELISA (Enzyme-Linked Immuno Sorbent Assay), used for detection of viruses and other analytes, are time-consuming, expensive and require labor-intensive sample preparation and trained personnel for their operation. This has been the motivation behind the increased interest for the development of alternative virus/analyte detection methods.

In this invited keynote, I will talk about research, development and commercialization of Lab-on-a-Chip photonic biosensors and their application for sensitive, rapid and multiplex detection of various analytes such as micro-organisms (viruses and bacteria) and biomarkers (proteins and DNA/RNA molecules). These sensors can be applied in various application areas such as health care, e.g. for early diagnosis of cancer and heart diseases, food industry, e.g. for sensitive and fast detection of bacteria infections, national security, environmental monitoring, process technology, etc. The high sensitivity that photonic sensors can achieve could result to less sample pre-concentration handling, which contributes to faster analysis and savings on operational costs. Moreover, these sensors are simple, easy-to-use and compact, offering the possibility for development of portable/handheld devices. As such, photonic sensors are excellent candidates for fast, point-of-care analyte detection.

Biography

Aurel Ymeti is co-Founder and CEO of Nanoalmyona BV, a hightech Dutch company specialized in research and technology development, project management and new business development in Hightech Systems and Materials, including integrated photonics, Lab-on-a-Chip biosensing, optoelectronics, microscopy and nanomedicine.

He received a MSc in Theoretical Physics from the University of Tirana, Albania, in 1996, and a PhD in Applied Physics/ Nanotechnology from the University of Twente, Netherlands, in 2004, working on the development of ultrasensitive multichannel integrated photonic (bio-)sensing platforms. Subsequently, he worked as a postdoctoral research fellow at the same University on development of portable devices for staging of HIV infection in point-of-care settings, later commercialized by Immunicon/ Veridex (J&J).

In 2008 Aurel co-founded Ostendum, a spin-off company of the MESA+ Institute for Nanotechnology of the University of Twente, focusing on the commercialization of extremely sensitive and label-free optical analysis methods for rapid detection of micro-organisms and biomarkers based on the Lab-on-a-Chip Nanotechnology, initially invented and developed by Aurel during his PhD project. As CTO at Ostendum, he was responsible for the research and technology development, product management and new business development. In 2017 Aurel was appointed as Associate Professor at the Department of Engineering Physics, Polytechnic University of Tirana, Albania, working on application of High Tech Systems and Materials in innovative product development.

Aurel has (co)authored about 40 publications in refereed journals, peer-reviewed conference proceedings and books, is inventor of several patents and has presented more than 30 keynote/invited lectures in (inter)national conferences. He was/is involved as a member of the International Society for Optics and Photonics (SPIE), Optical Society of America (OSA), International AIDS Society (IAS), International Society for Analytical Cytology (ISAC) and Advisory Board Member of the Lifeboat Foundation. Aurel has served as Program Committee Member of several international conferences, including SPIE conference series of Defense, Security and Sensing (2010 – 2015).

His work on photonic biosensors has been featured in many well-known international media publications, incl. MIT's Technology Review, Nature,Le Monde and BBC Focus Magazine and in 2007 the highly reputablebusiness magazine FORBES has highlighted his work as one of the "13 Amazing New Nanotechnologies". Aurel has received several awards including the prestigious European Lab-on-a-Chip Nanodevices Technology Innovation Leadership Award from FROST & SULLIVAN in 2013.

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Notes:

Energy efficient, large bit-rate VCSELs for Wavelength Division Multiplexing

Gunter Larisch
Bimberg Chinese-German Center for Green Photonics" of the Chinese Academy of Sciences (CAS) at People's Republic of China

The energy required to transmit information as encoded optical and electrical data bits within and between electronic and photonic integrated circuits, within and between computer servers, within and between data centers, and ultimately across the earth from one point to another one clearly must be minimized. This energy spans from typically tens of picojoules-per-bit to well over tens of millijoules-per-bit for the intercontinental distances. So, with a large number and high density of data links, large data centers already form part of the dominant energy consumers in the world-wide power grid. VCSEL based optical interconnects are the key for an enormous reduction of energy consumption in concert with an increase of the data rate per fiber in those data centers. A reduction of power consumption of VCSELs based on photon lifetime tuning combined with wavelength division multiplexing is presented here leading to VCSELs for +200 Gbit/s single multimode data transmission.

Biography

Gunter Larisch is Associate Professor at the "Bimberg Chinese-German Center for Green Photonics" at Chinese Academy of Sciences and head of its High Frequency Lab at Changchun Institute of Optics Fine Mechanics and Physics, as well as guest scientist at Technische Universität Berlin, Germany. He received the Diploma (M.Ss. equivalent) degree in applied physics, and a Ph.D. in science from the Technische Universität Berlin, Germany. He continued working as Postdoctoral Researcher at Technische Universität Berlin, Germany until June 2018.

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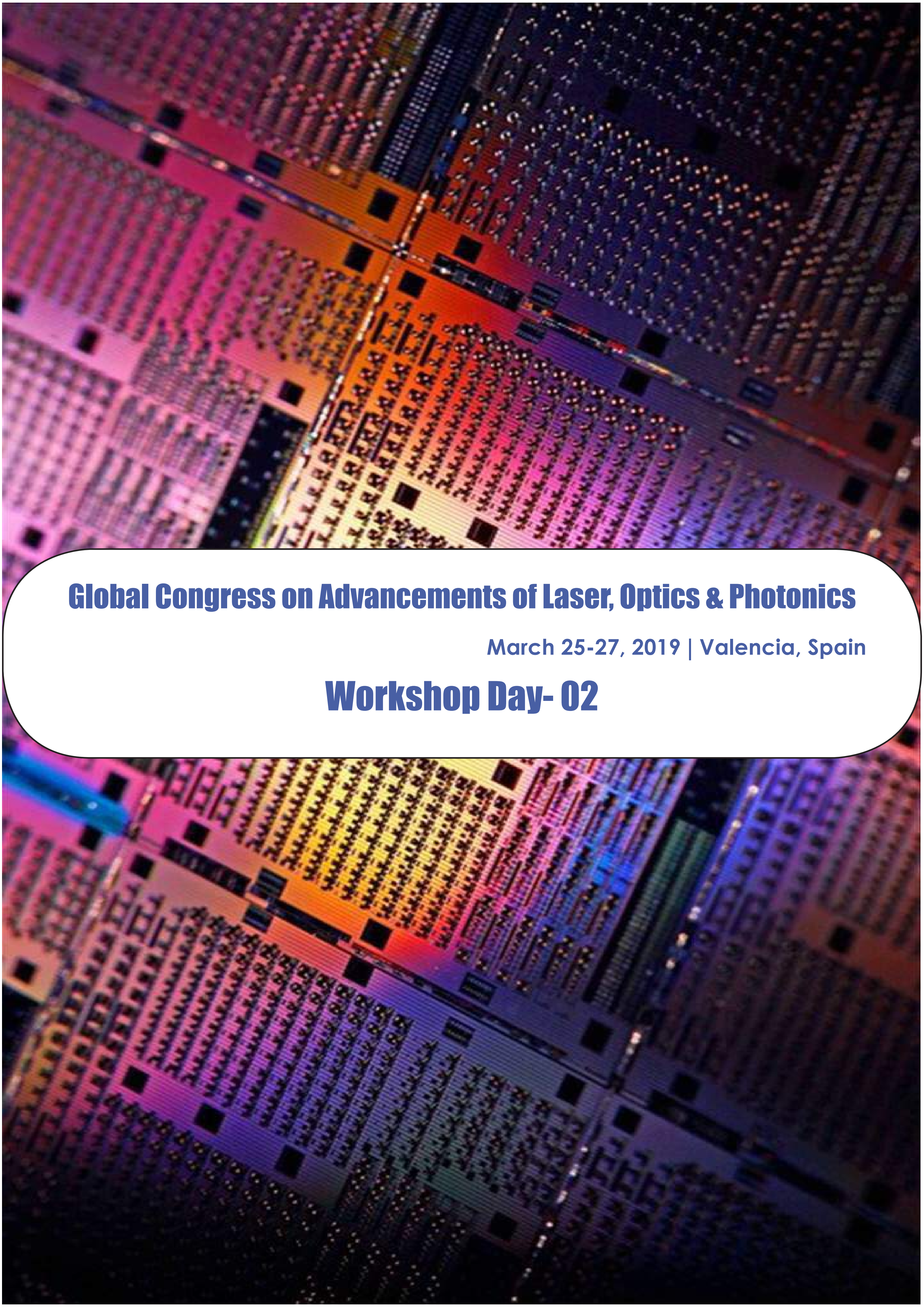


Global Congress on Advancements of Laser, Optics & Photonics

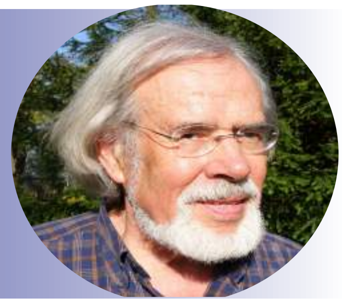
March 25-27, 2019 | Valencia, Spain

Workshop Day- 02

The unique combination of simulation tools for LASer Cavity Analysis and Design

Konard Altmann

LAS-CAD GmbH, Germany



During the last 15 years **LASCAD™** has become industry-leading so ware for LASer Cavity Analysis and Design. The feedback from a large community of users has helped us gather experience for improving laser resonator design.

To optimize laser resonator design, **LASCAD™** provides a unique combination of simulation tools:

- **Thermal and Structural Finite Element Analysis (FEA)**
of thermal effects in laser crystals

- **ABCD Gaussian Beam Propagation Code**
taking into account thermal lensing, gain guiding, etc.

- **Dynamic Analysis of Multimode and Q-switched operation (DMA)**
analyzing the dynamic, 3D behavior of laser beams

- **3D Physical Optics Beam Propagation Code (BPM)**
including diff raction, gain dynamics, etc.

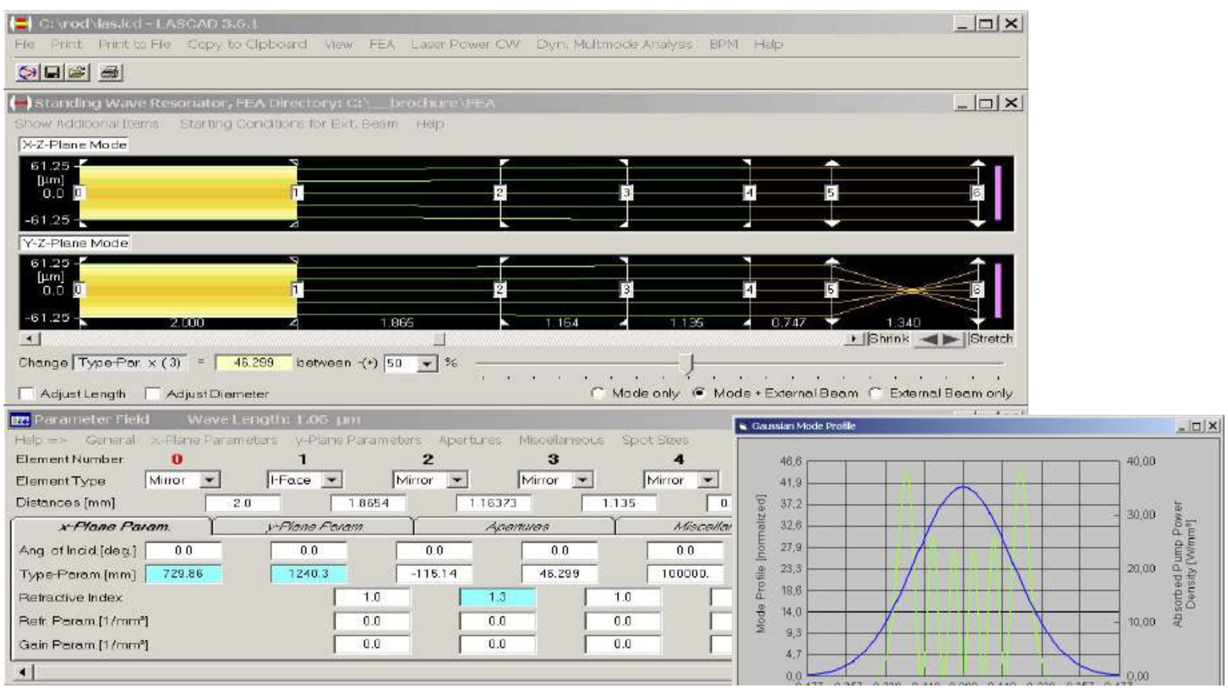


Fig. 1. Graphical User Interface of **LASCAD™**

LASCAD™
The Optical Workbench on the PC

LASCAD™ provides complex engineering tools developed for ease of operation. The user interface of the program, shown in Fig. 1, can be used like an optical workbench on the PC, allowing intuitive design of laser resonators. In this way **LASCAD™** helps users process experimental results without wasting valuable time studying complicated manuals.

- Optical elements, such as mirrors, lenses, or crystals can be added, combined, adjusted, or removed by mouse clicks.
- Astigmatism in the resonator and crystal is automatically taken into account.
- The program menu makes available thermal fi nite element analysis, Gaussian ABCD matrix code, physical optics code, analysis of Q-switched operation, computation of laser stability and power output.

LASCAD™
The Laser Engineering Tool

To develop a powerful resonator design, the laser engineer is confronted with many interacting technical and physical problems. Thermal lensing is of growing importance, due to the tendency to miniaturize laser systems, while simultaneously increasing power output. The eff ect strongly depends on system characteristics, such as: material parameters, resonator geometry, pump beam distribution, and cooling layout. It interferes with gain dynamics, mode competition, Q-switching, and other eff ects, which control beam quality and laser effi ciency in a complicated manner. Based on numerical simulation of these eff ects, **LASCAD™** provides the laser engineer with a quantitative understanding of the characteristics of a cavity design.

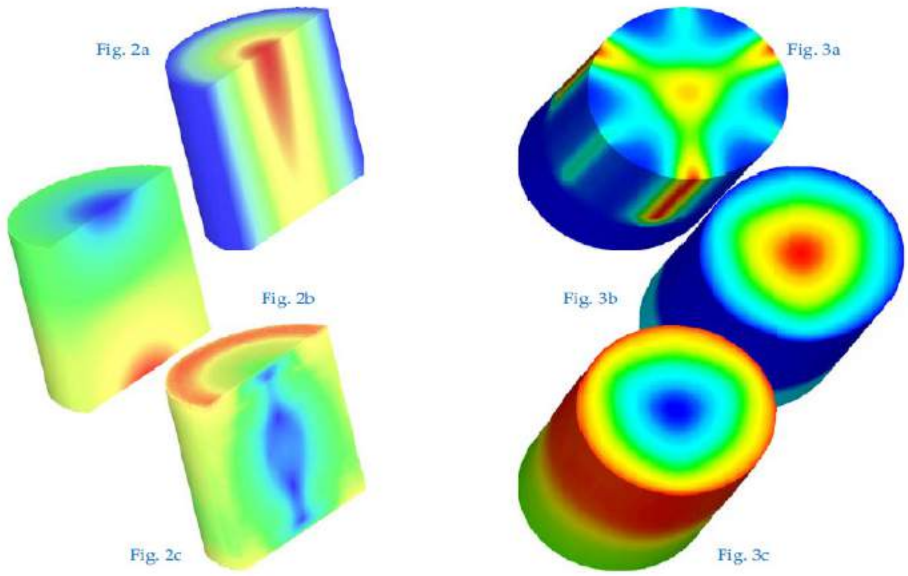
Finite Element Analysis (FEA) of Thermal Effects

FEA is used to compute temperature distribution, deformation, stress and fracture mechanics in laser crystals. This takes into account material parameters, pump confi guration and cooling geometry. FEA is a well known numerical method for solving partial diff erential equations of technical physics, such as the equation of heat conduction. Though indispensable and applied with great success in other engineering disciplines, the benefi ts of FEA have not been available so far in commercial laser design software.

To enable the straightforward use of FEA for laser cavity design, **LASCAD™** off ers pre-designed FEA models for important confi gurations, such as: end and side pumped rods, slabs, and thin disk lasers. Models are also available for crystals composed of various materials, or of doped and undoped regions, such as undoped end caps. The user can customize dimensions, FEA mesh, boundary conditions, and other parameters within the models. Temperature dependence of material parameters can be taken into account by the use of analytical expressions provided by the user.

Analytical approximations, based on super-Gaussian functions, are used to model the absorbed pump power density. To enable numerical modeling of the absorbed pump light distribution, **LASCAD™** has interfaces to **ZEMAX** and **TracePro** raytracing programs. These programs generate 3D data sets of the absorbed pump power density that can be used as input for **LASCAD™**. Numerical modeling of the absorbed pump light with **ZEMAX** or **TracePro** is particularly useful for flash lamp pumped lasers or unusual pump confi gurations.

Figures 2a, 2b, and 2c show plots of temperature distribution, deformation, and stress intensity, respectively, in an end pumped cylindrical rod. Figures 3a, 3b, and 3c show absorbed pump power, temperature, and the zz-component of the stress tensor, respectively, in a side pumped rod.



Gaussian ABCD Matrix Approach

When using the FEA results with the ABCD matrix code, the temperature distribution, multiplied by the temperature dependence of the refractive index, is fitted parabolically at right angles to the optical axis, as shown in Fig. 4. For this fit, the finite element mesh subdivisions along and perpendicular to the crystal axis are used. In the same way, a fit of the deformed end faces of the crystal is accomplished. For many configurations end pumped rods for example this approximation delivers reliable results for the laser mode.

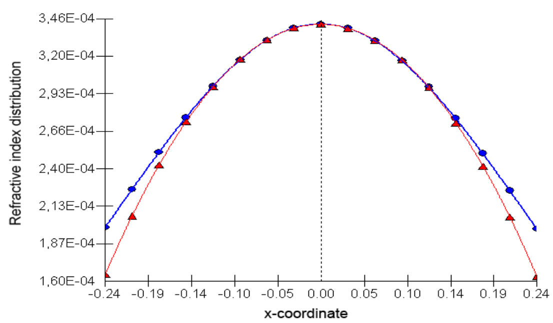


Fig. 4. FEA Result Parabolic Fit

To visualize the results of the ABCD matrix approach, fundamental mode spot size, as well as higher order Hermite-Gaussian polynomials, are displayed along the resonator axis. Inside the crystal overlap between pump beam and transverse laser modes can be visualized, as shown in Fig. 1. To account for astigmatism, the computations are carried through simultaneously in two planes perpendicular to the resonator axis.

In case of standing wave resonators, a stability diagram, based on generalized g-parameters, can be computed, as shown in Fig. 5.

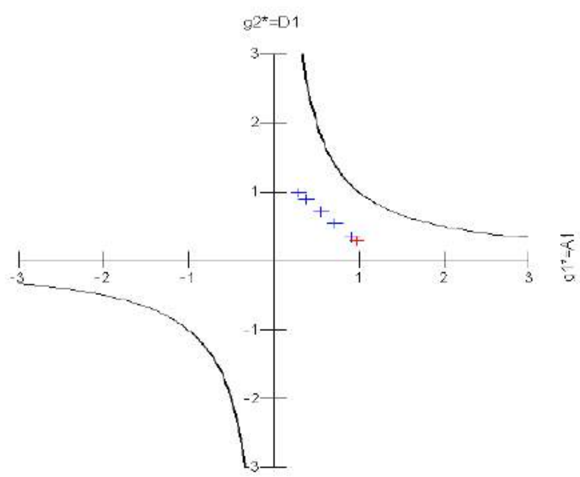


Fig. 5. Stability Diagram

The obtained Gaussian modes and the distribution of the absorbed pump power density are used to analyze CW, as well as transient laser behavior.

CW Laser Behavior

A straightforward tool is provided for CW operation. It computes the power output for fundamental mode and approximately also for multimode operation. Solution of the time independent 3D laser rate equations is obtained by iterative integration over the crystal volume. Fig. 6 shows an example with results for an end pumped Nd:YAG rod. The circles represent simulation results; the green triangles are measurements. See paragraph *Verification of Results.*

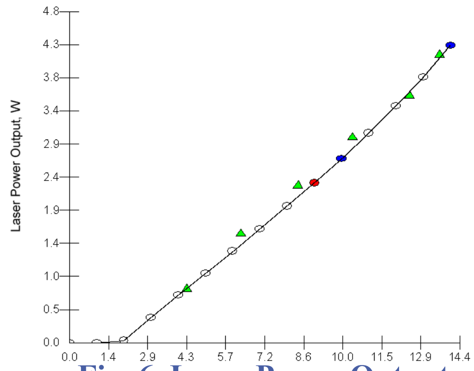


Fig. 6. Laser Power Output

Transient Laser Behavior

To analyze the transient laser behavior, **LASCAD™** provides a tool for the dynamic analysis of multimode and Q-switched operation (DMA). For this purpose, time dependent rate equations, describing the individual numbers of photons in a predefined set of Gaussian transverse eigenmodes, are solved by the use of a finite element solver. This approach provides a detailed description of mode competition, power output, beam quality, and pulse shape. Results turned out to be in good agreement with experimental measurements; see paragraph *Verification of Results*.

The **Dynamic Multimode Analysis (DMA)** offers important features:

- Computation of pulse shape and time-dependent power output for Q-switched lasers with high repetition rates, as well as for single pulse operation
- Computation of individual power output of transverse modes for CW and Q-switched operation
- Computation of beam quality M^2 for CW and Q-switched operation
- Effect of hard-edged and Gaussian apertures on beam quality
- Output mirrors with Gaussian and super-Gaussian reflectivity profile

Fig.7 shows an example of the power output over time, as obtained by **DMA**. Since the computation starts with population inversion density, $N(x,y,z,t=0) = 0$, a spiking behavior can be seen at the beginning, that is attenuating with increasing time and finally approaching a constant value. Fig. 8 shows a typical **DMA** pulse shape result.

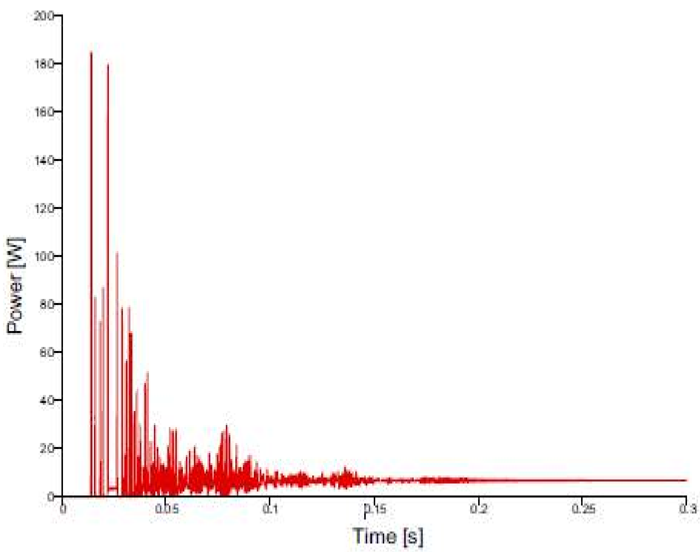


Fig. 7. DMA Power Output over Time

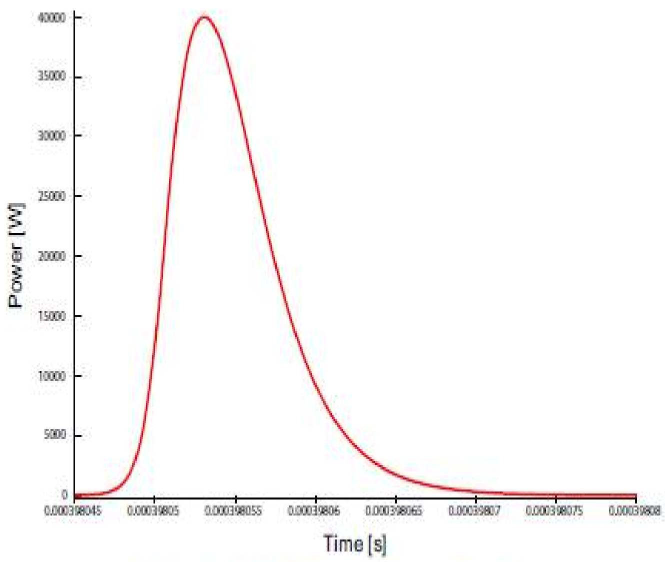


Fig. 8. DMA Pulse Shape Result

Physical Optics Approach

In cases where parabolic approximation and ABC matrix code are not suffi cient, FEA results can be used as input for a physical optics code. This code provides full 3D simulation of the interaction of a wavefront propagating through the crystal **without using parabolic approximation**. For this purpose, the code uses a split-step **Beam Propagation Method (BPM)** to propagate the wavefront in small steps through the hot, thermally deformed crystal. It takes into account the distribution of the local refractive index, as well as the deformed end faces of the crystal, as obtained by FEA. Based on the principle of Fox and Li, a series of round-trips through the resonator is computed, which fi nally converges to the fundamental mode or to a superposition of higher order transverse modes.

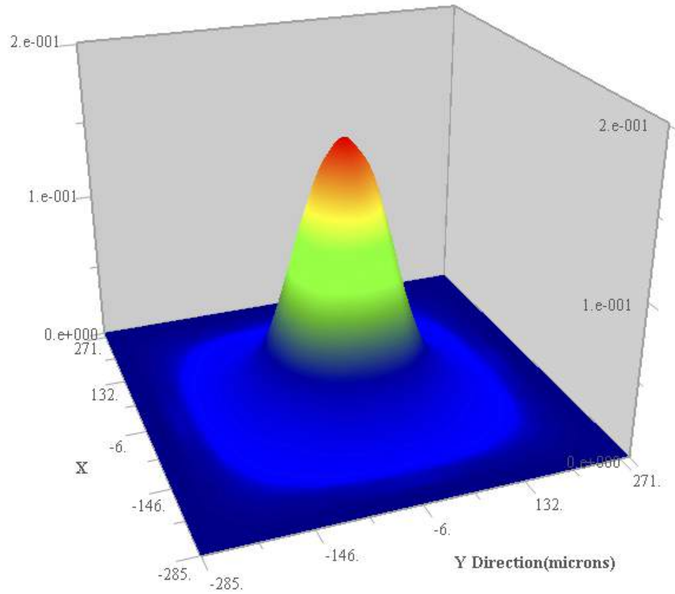


Fig. 9. BPM Beam Profile

Two graphic windows are opened while this computation is running. One of them shows the intensity profile at the output mirror, as it develops with increasing number of iterations. An example is shown in Fig. 9. The other window displays the convergence of the spot size with cavity iteration and the simultaneously computed power output, as shown in Fig. 10. Additionally, a third window showing the beam quality can be opened.

The BPM tool is also capable of numerically computing the spectrum of resonator eigenvalues and the shape of the transverse eigenmodes.

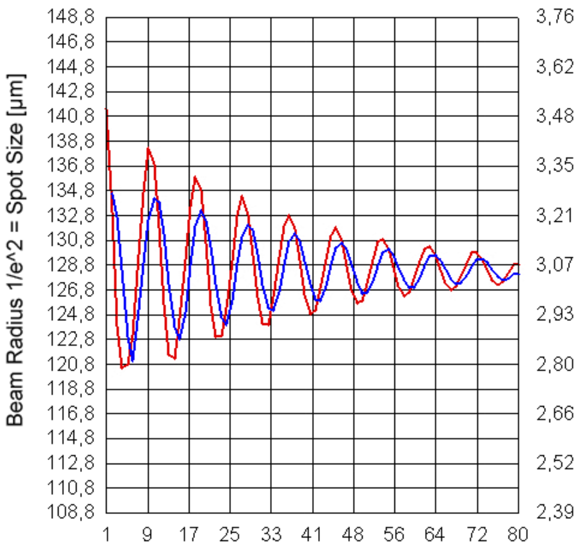


Fig. 10. / Beam Radius / Power Output over Cavity Iteration

The BPM tool takes into account gain dynamics and diffraction effects, due to the finite extension of apertures and mirrors, more physically than the **DMA** code. Another important feature of the BPM physical optics code is the simulation of misalignment effects.

LASCAD™
The Educational Tool

Though primarily designed for laser engineering, the easy-to-use GUI makes **LASCAD™** ideally suited for educational purposes for students, as well as for practicing scientists and engineers. The principles of Gaussian beam optics can be studied interactively, and the behavior of complicated heterogeneous resonator configurations, including thermal lensing effects, apertures and Q-switches can be clearly demonstrated.

Verification of Results and Outlook

The laser group of Prof. R. Wallenstein at the University of Kaiserslautern, Germany has been using the program for several years for analysis and optimization of the behavior of composite crystals in diode-pumped, high-power lasers. A series of detailed measurements have verified the results of simulation to a high degree; see Fig. 6.

Currently, LAS-CAD GmbH is partner in the government supported research project *Simulation and Optimization of Innovative Laser Systems*. In this project LAS-CAD GmbH is cooperating with seven German laser manufacturers, the University Erlangen, and the Laser Laboratory Göttingen Germany, to develop new tools for the numerical simulation of laser cavities. An important result of this cooperation is the new tool, **DMA**, as described above. Numerical results obtained with **DMA** have been verified experimentally in cooperation with InnoLas GmbH Germany, as described in the paper *Dynamic multimode analysis of Q-switched solid state laser cavities* in Optics Express, Vol. 17, 17303-17316 (2009). Another objective of the research project is the development of an FEA approach to provide a dynamic 3D solution of the electromagnetic field equations in a laser cavity. First results were presented at Photonics West 2009; see *Finite element simulation of solid state laser resonators* in Proceedings of SPIE Vol. 7194-16 (2009).

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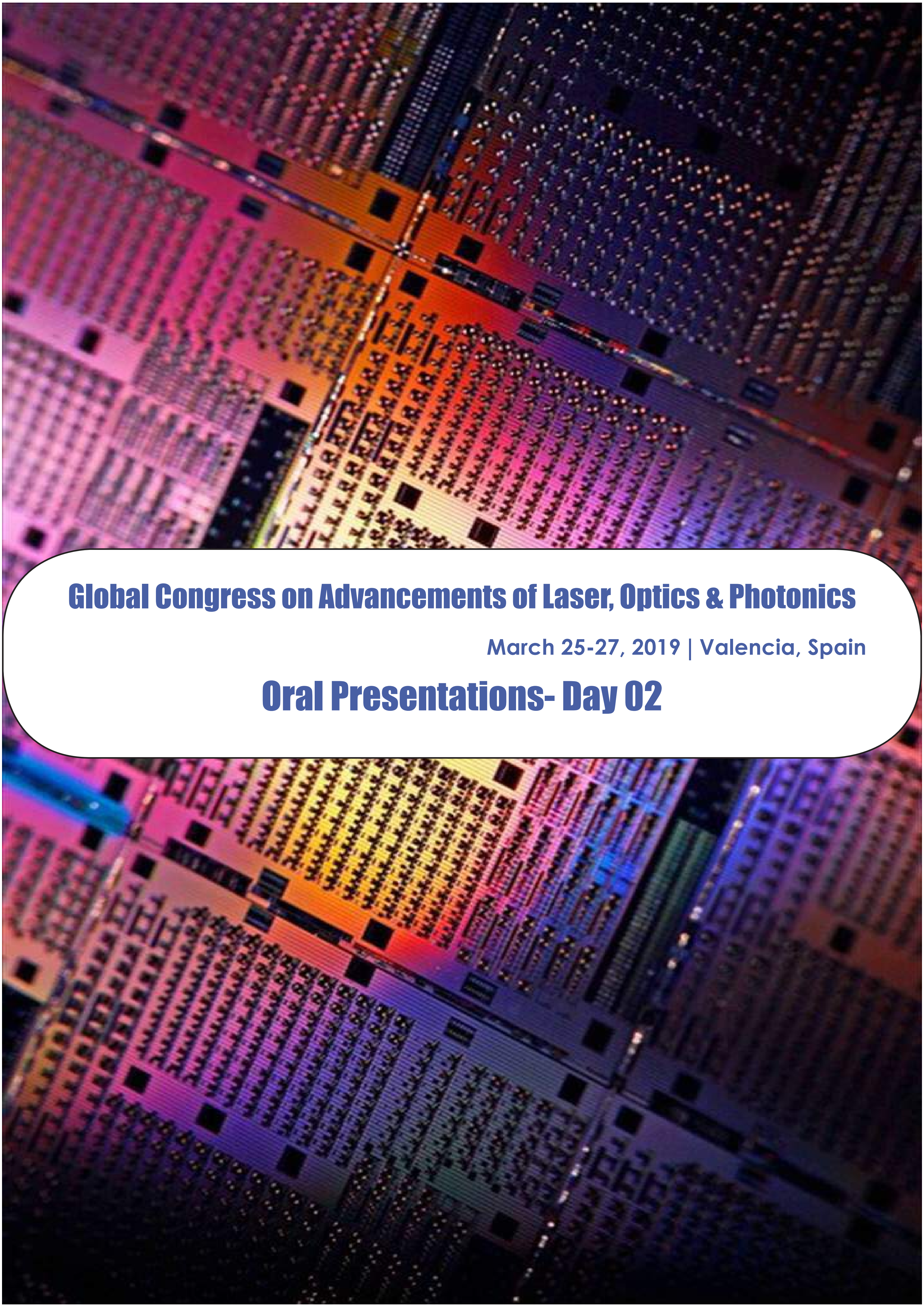
Notes:



Global Congress on Advancements of Laser, Optics & Photonics

March 25-27, 2019 | Valencia, Spain

Oral Presentations- Day 02

Real-time up conversion to the visible of 2D infrared images

Juan Capmany
Universidad Miguel Hernández, Spain

Real time video of infrared images lacks presently some attractive features as compared to their VIS/NIR counterpart based on silicon CCD and CMOS Focal Plane Array (FPA) imaging sensors, with a typical response cutoff wavelength around 1 µm. Presently, although FPA image sensors based on InGaAs or InSb cover most of the infrared spectral range, they suffer from operational characteristics limitations in terms of uncooled operation, speed, noise, and resolution.

A way to circumvent these limitations in IR imaging, is through real-time nonlinear optical frequency upconversion of infrared images to the spectral detection range of silicon-based FPA imaging sensors. The 2D Fourier components of the infrared image are mixed with a pump laser wave in a nonlinear crystal to shift their spectrum by sum-frequency mixing (heterodyning) their optical frequency with the frequency of a pump laser. This techniqueallows for visualization with standard silicon CCD video cameras of images at virtually any infrared region extending even up to the THz range and multispectral IR imaging.

In this talk, the present status and foreseen trends of nonlinear image upconversion will be reviewed, including the work presently being realized in our lab, that pursues miniaturization down to quasi-monolithic diode-pumped image upconversion systems.To boost upconversion efficiency, we use nonlinear crystals based on poled ferroelectric crystals placed inside the cavity of a diode pumped solid-state laser, where the intense intracavity laser beam acts as the pump wave for the up conversion.

Biography:

Juan Capmany (PhD in Physics) was born in Madrid, Spain. Presently, he is a Professor at the Communications Engineering Department (Universidad Miguel Hernández, Elche, Spain), where he founded and leads the Photonic Systems Group. He worked for ten years in the Spanish Naval Research Center (CIDA) andthe Spanish National Research Council (CSIC) in the development of image intensifier tubes for night vision, and in Laser Spectroscopy of Solid-State laser materials, Solid-State lasers, Crystal Growth, and Nonlinear Optics at Universidad Autónoma de Madrid. His main research activity has focused for the last decades on intracavitynonlinear frequency conversion in solid-state lasers and range-gated systems. He has authored or coauthored more than 150 research publications in peer-reviewed journals and conference papers and has lead over 15 research projects. He is a Senior Member of OSA and IEEE.

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Notes:

Ultraportable nanostructured sensors for point-of-use biochemical applications

Carlos Escobedo
Queen's University, Canada

Metallic nanostructures support surface plasmon polaritons (SPP) that can be exploited as signal for the recognition of biochemical events. Nanostructured gratings produced by laser interference are particularly suited for point-of-use biosensing applications and are extremely cost-effective, and can be easily fabricated on practically any flat surface. Here, we present a new generation of metallic nanostructures fabricated using holographic laser-inscription that are capable of producing accurate photonic signals that can be employed as label-free (bio)sensors for the rapid, in situ detection and identification of biomarkers of diseases, illegal drugs and terrorism agents. These (bio)sensor consist of a network of three-dimensional 60-nm-thick metallic nanostructures, and can be employed for different sensing strategies, including surface plasmon resonance (SPR) and surface-enhanced Raman scattering (SERS). The platform utilize smartphone-analogous, off-the-shelf inexpensive optical components for the generation and detection of the photonic signal. We demonstrate sensing of solutions with different refractive indices and real-time detection of biologically relevant analytes including proteins and pathogenic bacteria. The (bio)sensing platform has a production cost of less that US$1 per unit and has a sensitivity of ~103 PIU/RIU, representing a 3-fold improvement compared to current nanostructure-based sensors. This work presents a great promise towards the development of fully-integrated, handheld portable (bio)sensing platform for point-of-use applications requiring (bio)detection in real-time.

Biography:

Carlos Escobedo joins Queen's University in 2013 as an Assistant Professor of Chemical Engineering. He received a B.Sc. from the National University of Mexico, MSc from University of Toronto, and PhD from University of Victoria, and was an NSERC postdoctoral fellow in the Bioengineering Laboratory at ETH Zürich, Switzerland. Carlos has published papers in different scientific journals related to micro- and nanotechnology, including Lab-on-a-Chip, Analytical Chemistry, Nature Communications, Small and Nano Letters, some of them featured in Optics and Photonics News, Nanowerk and Nature Photonics. He received the prestigious Early Researcher Award and the TD Most Influential Hispanic Canadian Award in 2018, and serves as Technical Chair for MEMS and Nanotechnology in the Canadian Society for Mechanical Engineering. His research program involves the development of microfluidic systems, and micro- and nanostructures for analytical applications in biology, medicine and chemistry.

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Integrated optical imaging and spectroscopy approach for biological tissue characterization in the spatial frequency domain

David Abookasis and Daniel Baruch
Ariel University, Israel

We present, a noncontact optical setup integrating spectrometer and camera arrays to quantify optical properties of both tissue-phantoms and biological tissue by spatial light modulation. In this setup, sinusoidal light patterns are serially projected onto the sample at both low and high spatial frequencies to isolate the target's absorption (linked to tissue metabolism) and scattering (related to tissue structure) properties. The diffuse reflected light is simultaneously acquired by single spectrometer and passes through two cameras. In addition to the extraction of the tissue's optical properties, we calculated hemoglobin oxygen saturation levels from the hands of healthy human volunteers. An additional validation methodology based on the theoretical model-based diffusion equation in the spatial frequency domain was demonstrated. A major advantage of this parallel optical configuration lies in the ability of each component to complement the other, enabling high spectral and spatial resolution. Overall, this work demonstrates the potential of the integrated setup for diagnostic and research applications which we believe will be beneficial to the Biophotonics' community. Index Terms: Integrated optical system; Tissue characterization; Spatial frequency domain; Reflectance spectroscopy; Oxygen saturation level.

Biography:

Abookasis is a faculty member in the Department of Electrical Engineering at Ariel University, Israel where he also serves as the head of the medical engineering program. His main research focuses on optical diagnosis and therapy in neurological diseases and brain trauma. He possesses a multi-disciplinary background combining engineering, optics, biomedical optics, medical instrumentations, and neurology.

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Development of 100J-level kW cryogenic gas cooled DPSSL for high energy density experiments at the European-XFEL facility

Saumyabrata Banerjee[1], Paul Mason[1], Klaus Ertel[1], Jonathan Phillips[1], Mariastefania De. Vido[1], Jodie Smith[1], Thomas Butcher[1], Stephanie Tomlinson[1], Jorge Suarez-Merchan[1], Toma Toncian[2], Hauke Höppner[2], Dominik Möller[2], Ulf Zastrau[3], Erik Brambrink[3], Andrew Lintern[1], Billy Costello[1], Ian Hollingham[1], Andrew Norton[1], Mike Tyldesley[1], Cristina Hernandez-Gomez[1], Chris Edwards[1], and John Collier[1].

[1]Central Laser Facility, UK
[2]Helmholtz-Zentrum Dresden-Rossendorf, Germany
[3]European X-Ray Free-Electron Laser-Facility GmbH, Germany

High energy, high repetition rate laser systems are pivotal to the development of scientific and commercial application. Direct applications of such systems include materials processing, such as laser shock peening, and compression of matter to extreme densities. Alternatively, these lasers can be used as pump sources for Ti:sapphire or OPCPA amplifier chains, for the realisation of the next generation of PW-class lasers. The DiPOLE amplifier concept, developed at the STFC Central Laser Facility rely on cryogenic gas cooled, multi-slab ceramic Yb:YAG DPSSL system and allows a scalable, high-energy, high-repetition rate laser. Recently, 100J-level performance was demonstrated based on the DiPOLE concept and was commissioned at the HiLASE facility. The successful operation and satisfactory performance of the kW-class 100 J nanosecond pulsed laser has led to the development of another system to be made available to users of the high energy density (HED) instrument at the European XFEL in collaboration with HiBEF / HZDR. This system, DiPOLE-100X, with frequency up-conversion (SHG) will be used for compression of materials which will be probed by bright X-ray pulses for fundamental research into their structure at high density. In this paper, we report on the operational and commissioning results of the DiPOLE- 100X laser currently being developed at the Central laser facility (CLF). Additionally, results from frequency up-conversion experiments for second harmonic (SHG) and third harmonic generation (THG) on a scaled down prototype will also be presented.

Biography:

M.Sc in Electronics from Nagpur University, India (1999), M.Tech in Laser Science and applications from DAVV, Indore, India (2001), P.hD in Nonlinear optics from CIST, Japan (2007), "Noncritical phase-matched parametric frequency conversion in mid-IR". Research staff at Bharat Electronics Ltd (2001-2004), Postdoctoral position at Brunel University London, UK (2008-09) and Staff Scientist at Central laser Facility (2009 to present).

Saumyabrata Banerjee holds a permanent position at the Central Laser facility (CLF) and is responsible for the development of high energy, high repetition rate, cryogenically gas cooled multi-slab diode pumped solid state laser systems. He has being exploring novel transparent composite ceramic materials for broadband amplification, frequency conversion in nonlinear optical materials, and frontend development including multi-pass and regenerative amplifier design.

Saumyabrata has co-authored over 60 publications and has 1 international patent application.

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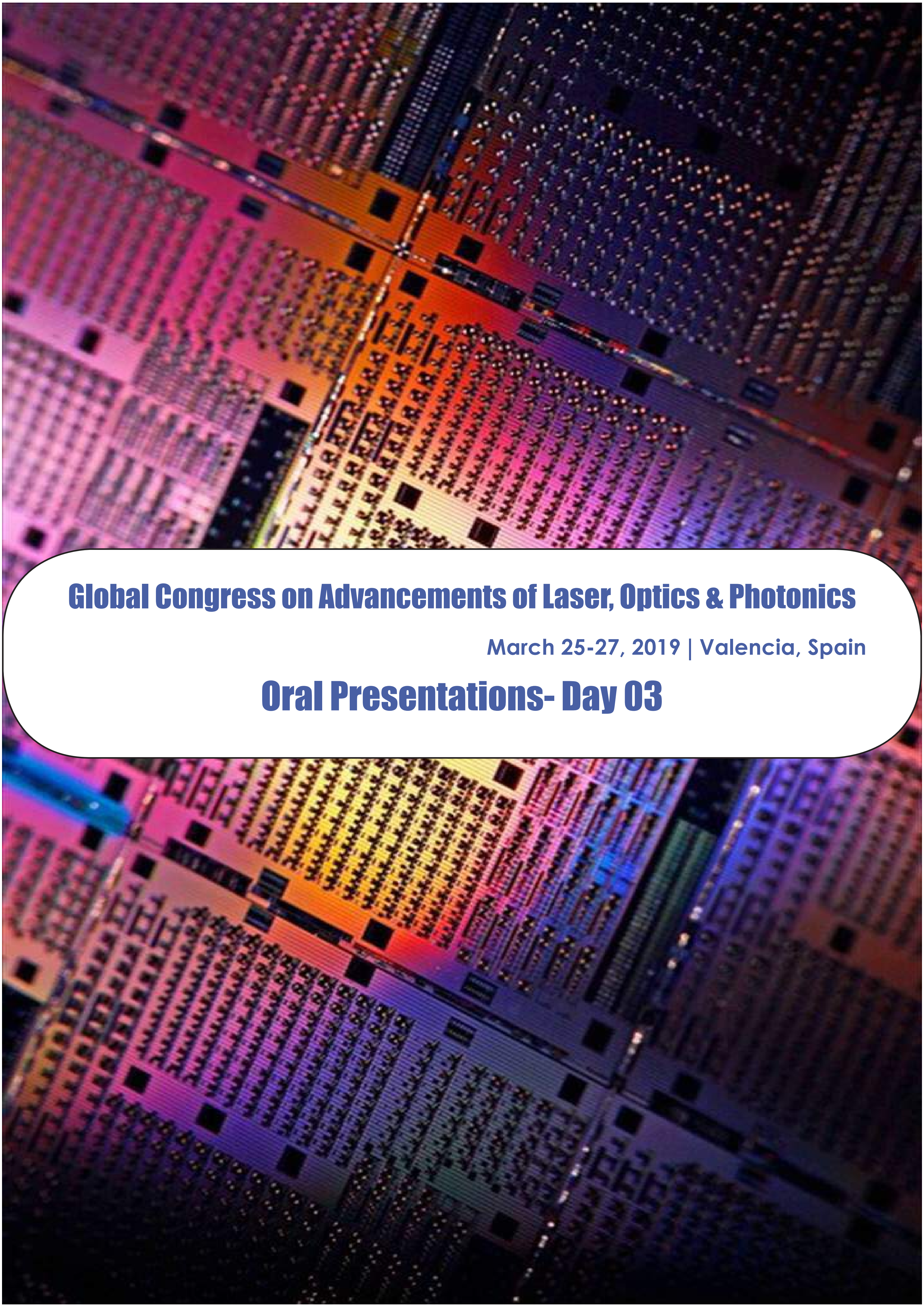

Global Congress on Advancements of Laser, Optics & Photonics

March 25-27, 2019 | Valencia, Spain

Oral Presentations- Day 03

Active alignment tolerance of space off-axis TMA telescope based on secondary mirror

Hongcai Ma*, Guohao Ju, and Xiaoquan Bai
University of Chinese Academy of Sciences, China

Due to on-orbit gravity off-loading and temperature transitions from room environment to the space operating environment, the perturbations of rigid-body motion (misalignments) and surface deformation of space telescope unavoidably occur, which degrade the optical performance. Based on the on-orbit wave front-measurement and the corrections of the misalignments and surface deformation of the reflective mirror, space active optics technology can effectively guarantee the telescope well working. In this paper, the active alignment tolerances of secondary mirror for off-axis TMA (Three Mirror Anastigmatic) telescope are introduced. For satisfying the required active alignment tolerances of optical system, the number, location arrangement and error of wave front-measurement field points are optimized. Based on the sensitivity matrix table, the corrections of the secondary mirror are calculated and the off-axis TMA are improved in only one correction loop. As a result, an efficient strategy of active alignment for space off-axis TMA is presented firstly.

Biography:

Hongcai Ma is an associate professor at the Changchun Institute of Optics, Fine Mechanics and Physics, Chinese Academy of Sciences (CIOMP) now. He received his BS degree in physics from Jilin University in 2008 and his PhD degree in optical engineering from the CIOMP in 2013.His current research interests focus on space active optics, optical design of low misalignment sensitivity system and nodal aberration theory (NAT).

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Notes:

Nonlocal Limit of Cherenkov radiation in Hyperbolic metamaterials

Hao Hu[1], Xiao Lin[1], Dongjue Liu[1], Patrice Genevet[2], Baile Zhang[1], and Yu Luo[1]

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[2]Universite Cote d'Azur, France

A charged particle travelling faster than the phase velocity of light in a substance can emit Cherenkov radiation (CR). This phenomenon was experimentally discovered by Cherenkov in 1934 and theoretically explained by Framk and Tamm's work in 1937. However, CR in conventional isotropic crystals requires the particle velocity beyond a threshold so called Cherenkov threshold (i.e. *c/n*). Due to finite refractive index nof the nature material, the Cherenkov threshold is high up to hundreds of keV, limiting the applications of Cherenkov devices (e.g. Cherenkov detectors or Cherenkov emitters).

A recent work revealed that CR in the hyperbolic metamaterials (HMMs) may offer the possibility to 'remove' the Cherenkov threshold, suggested by effective medium theory (EMT). While this theory is ubiquitous in the deep subwavelength range, it leads us to specious conclusions in some special situations. Especially, when optical modes involve much larger wavevectors compared with those in bulk media, metamaterials exhibit strong spatial dispersion. This regime, also called non-local regime, gives a more accurate description of the material dielectric response. How the nonlocal effects modify behaviors of CR such as the Cherenkov threshold still remains elusive.

In this work, we explored the nonlocal effects on the CR in the HMM, shown as Fig. 1(a). We prove the existence of Cherenkov threshold in realistic multilayer structure, as suggested in Fig. 1(b) and (c). On the one hand, the finite thicknesses introduces a cut-off on the maximum achievable wavevectork_y^{cf}(seeing Fig. 1(d)-(f)), inducing none-zero Cherenkov threshold. On the other hand, as geometric features approach to the Thomas-Fermi screening length λF, the charge screening effect inside the metal sets an ultimate bound on the minimum Cherenkov threshold as $v_{th}=\beta=\sqrt{(3/5)}\ v_F$, where v_F is Fermi-velocity (seeing Fig. 1(g)).

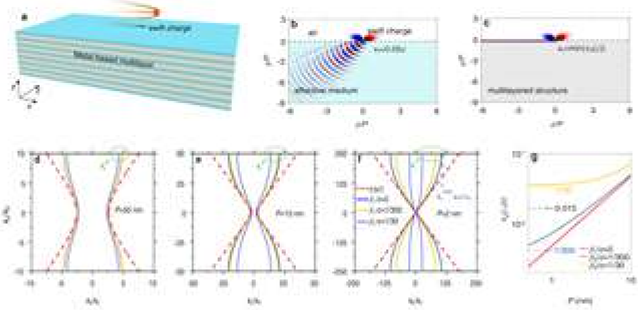

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Fig. 1. (a) Structural schematic. A swift electron moves with a velocity of $\bar{v}=\hat{z}v_0$ and its trajectory parallel to the interfaces of a multilayer periodic structure. The unit cell of the periodic structure is composed by anAg slab and a SiO_2 slab, with the thickness of $d_1$and d_2 respectively; the pitch of unit cell is $P=d_1+d_2$ ($P\leq50$ nm), which is much smaller than the interested wavelength λ in free space ($\lambda \in [0.1\ 10]$ μm). For all cases, we set $d_1/P=0.4$. (**b-c**) Field distribution of Cherenkov radiation in the time domain. The realistic multilayer structure in (a) is adopted for (c), while it is replaced by an effective homogeneous hyperbolic material for (b).Here P=25 nm, and $v_0=0.05c$.**(d)-(f)** is the dispersion relation of the hyperbolic metamaterial in effective medium approximation, and realistic structure with different level of nonlocal charge screening effect. Here the period is varied from 50 nm to 2 nm. (g) The determined Cherenkov threshold at the wavelength $\lambda_0=1\ \mu m$, in realistic structure with different level of nonlocal charge screening effect.

Acknowledgement

This work was supported by Singapore Ministry of Education Academic Research Fund TIER 2 under Grant No. MOE2015-T2-1-145.

Biography

Hu Hao received his Bachelor of Engineering in Zhejiang University, China, in 2016. He is currently a PhD student at the Photonics Centre of Excellence OPTIMUS, Nanyang Technological University, Singapore. Hao does research in Electrical and Electronic Engineering. His research interests are quantum and nonlocal plasmonics, Cherenkov radiation and metamaterials.

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Notes:

Fibre taper coated with zinc and bismuth chalcogenides thin film heterostructure

Konstantin M Golant
Kotel'nikov Institute of Radioengineering and Electronics of Russian Academy of Sciences, Russian Federation

Optical fibre tapers coated with nanometre thick dielectric films having significantly higher refractive index as compared to the glass of the fibre core can function as highly sensitive fibre sensors in Bioengineering and Medicine. Their operating principle is based on the lossy mode resonance (LMR), whichspectral position strongly depends on surrounding medium refractive index value.This happens due to a strong optical, electromagnetic field localizing in the coating film under the LMR conditions. In the case of tapers coated with bismuth or antimony chalcogenides another significant feature of field localizing in the coating film is associated with absorption saturation. The latter is an important property for the design of fibre lasers operating in the passively mode-locked regime. The aims of this study are to screen recent advances in the fabrication and investigation of thin film coated fibre tapers using metalorganic chemical vapour deposition. Zinc and bismuth chalcogenides thin film heterostructure is deposited along the lateral surface of tapered fibres with in situ recording of changes in fibre transmission spectra in the 1 -1.6 µm wavelength range. Dependences of the LMR on taper diameter and thickness of the coating film are addressed.

Biography:

Konstantin M. Golant, Doctor of Physics and Mathematics, Russian Federation State Prise laureate (2001) is a Principal Investigator at Kotel'nikov IRE RAS. Prior attending Kotel'nikov IRE RAS, he was a Head of Laboratory at the Fiber Optics Research Centre of Russian Academy of Sciences. He graduated from Moscow Institute for Physics and Technology, received his PhD from Lebedev Physical Institute of USSR Academy of Sciencesand DSc from the General Physics Institute of RAS. He is an author and co-author of more than 200 articles in peer reviewed journals. His primary research interests are in the field of Material Science and Technology. Specifically, he is interested in plasma chemical glass synthesis, optical fibre technology, semiconductor physics, fiber lasers and sensors.

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Dynamic rotative ferroelectricity of trojan electrons on multiple parallel interacting regular 2 -dimensional lattices

Matt Kalinski
Utah State University, USA

We have recently discovered that several types or regular two dimensional lattices like square, Honeycomb or face centered Honeycomb lattice are capable to support stable ferroelectric or antiferroelectric ordering of rotating dipole moments by a strong short-range dipole interactions collectively generating local Circularly Polarized electromagnetic fields self -consistently supporting Trojan or anti -Trojan Wave Packets. Several parallel layers of such 2D lattices are considered here where we show that it is possible to obtain the native ferroelectric order of all atoms coherently carrying circulating persistent currents in the Trojan Wave Packet state where the inter -layer distance is sufficiently close and the interactions are sufficiently strong. We solve the system of the time -dependent Hartree equations within the nearest-neighbors Bethe-Peierls-Weiss approximation. We obtain the following effective Grss-Piaevskii-like equation for any lattice node.

$$
(-\frac{\nabla^2}{2} - \frac{1}{|r|} - \sum_{i=1}^{NN} \frac{1}{|r - W_i|} + \int \frac{\left|\varnothing(r' - W_i, t)\right|^2}{|r - r'|} dr') \varnothing = i\varnothing
$$

Where the summation is made over wi both the nearest neighbors position within a single lattice as well as nearest neighbors between the parallel lattices surrounding a given Trojan atom. In case of all 2D lattices in which we have previously found various ferroelectric orders with anti -Trojan Wave Packets and anti-ferroelectric orders with Trojan Wave Packets we find the native ferroelectric order when all hydrogen atoms are in the same Trojan Wave Packet state only if the inter -layer distance between the lattices is sufficiently close.

Biography:

Matt Kalinski (born 1968) is US theoretical physicist who discovered Trojan wave packets, sqeezed, coherent and intrinsically coordinate-entangled states of electrons in true atoms solving the long standing problem of interstellar rocket propulsion by extending the positron or positronium lifetime and control the arbitrary slowdown of the recombination process of antimatter in positronic rocket engine. Kalinski earned his PhD in Physics from the University of Rochester. The broad applications of his discovery of coherent non-dispersing electrons and electron pairs in atoms, polar molecules and heterodyne two-electron Rydberg atoms are important and not limited to photonic superconductivity, laser centrifugal isotope separation of Deuterium, theory of cold nuclear fusion in Palladium, detection of ultra-weak magnetic fields with Aharonov-Bohm effect, direct observation of Berry phase in single atoms, arbitrary quantum state preparation with the technique of chirped quantum painting, observation of Unruh-Davies effect as well as for the detection of possible gravitoelectromagnetic force and twisted corrections to Einstein equations and precise engineering of complex quantum dot systems. While studying Trojan states he also discovered full exact quantum revival and stroboscopic eternal existence of Trojan wave packets and any quantum state of Hydrogen without any fields implying total revival of arbitrary quantum system after sufficiently long time (sometimes billions of years and even ages of universe) if only the fundamental spectral frequency exists. Kalinski's research interests focus in theoretical atomic molecular and optical physics and theoretical condensed matter physics. His early 90-ties PhD theoretical predictions of positron confinement in antiproton and rotating electromagnetic field using Hartree method applied to space coordinate of non-separable system was just recently confirmed in experiments in University of Virginia, Rice University and Vienna University of Technology and till now only with normal matter because of high costs of antimatter production. His original PhD work induced hundreds of publications of other authors in the topic of electron confinement and Trojans wave packet.

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Global Congress on Advancements of Laser, Optics & Photonics

March 25-27, 2019 | Valencia, Spain

Workshop- Day 03

2D Mono detection spatially super resolved microwave imaging for Radar applications

Gabay Isahar

Bar Ilan University, Israel

Detection and identification of objects by using radio frequency signals is one of the most important tasks of microwave systems. Some systems are an active, which are transmitting a known signal and receiving the reflected signals from metallic objects. Some other systems are passive, which are operating in receiving mode only and relies on direct or indirect signals from external sources. The resolution of the system is very important because of the ability not only to detect signals, but to identify and classify objects which caused the reflected waves. This work presents two novel researches which dealing with.

- 2D mono detection spatially super resolved imaging for Radar applications
- Radio frequency echo mapping based on cellular signals

The solution based on phased array technique. The results are strongly reconstructed the object's form and location.

Biography:

Isahar Gabay was born in Marrakesh, Morocco in 1955. He received the B.Sc. and M.Sc. degrees in electrical and computers engineering from Ben-Gurion University of Negev in Beer-Sheba, Israel, in 1981 and 2003 respectively and Ph.D. degree in electro-optics engineering at Bar-Ilan University, Ramat-Gan, Israel in 2017. From 1981 to 1984, he was an electronic engineer officer in the Israeli Air Force. Since 1984, he has been a microwave system designer, Antenna developing and ESM & ECM systems engineer at Israel Aerospace Industries (IAI) ELTA Systems in Ashdod, Israel.

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Notes:

All-fiber terahertz time domain spectroscopy system

Chunchao Qi and Xinhui Tan

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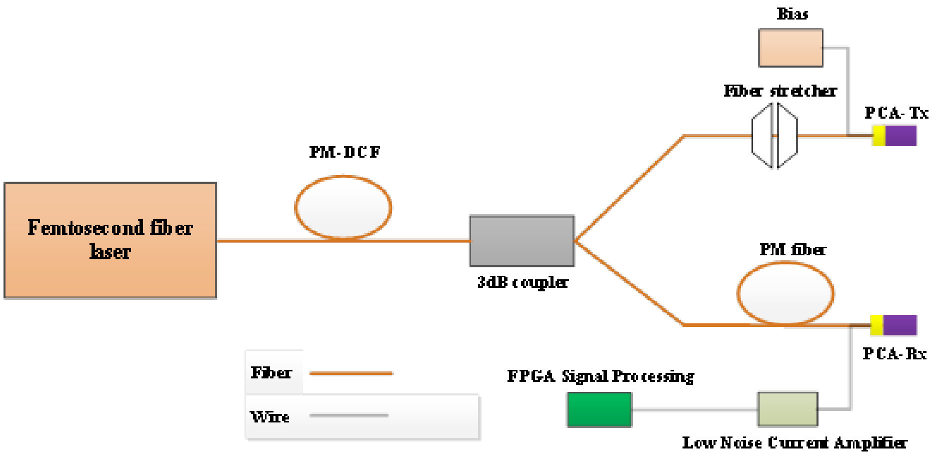
Terahertz time domain spectroscopy (THz-TDS) has been proved particularly valuable in the field of semiconductors characterization, molecular spectroscopy, and biomedical applications. THz-TDS system is becoming more flexible, more stable and low-cost. In this work, we present an all-fiber THz-TDS system which mainly consists of a 1560nm fiber femtosecond laser, a highly accurate PZT fiber stretcher, and fiber-coupled InGaAs/InAlAs photoconductive antennas (PCAs). Using polarization maintaining dispersion compensation fiber (PMDCF), the pulse widths of the laser at the ends of PCAs were compressed to less than 100fs with 3dB bandwidth about 50nm after 46-meter polarization maintaining (PM) fiber propagation. Time delay accuracy was enhanced owing to the stretching length calibration of the fiber stretcher. Thus, our system can achieve 80ps scan range, 40dB peak dynamic range (for a scan). This all-fiber THz-TDS system is portable, compact, and suitable forindustrial environment and field applications.



Biography:

Chunchao Qi joined China Communication Technology Co., Ltd (CCT) in 2015 and was promoted to vice president in 2018. Prior attending CCT, he was a senior engineer at the Southern University of Science and Technology (SUSTech). He received his PhD from the Huazhong University of Science and Technology. He is a senior member of OSA and was selected for the National Science and Technology Programmes Expert Database of China. His primary research interests lie in the field of terahertz sources, quasi-optical devices and semiconductor carrier lifetime measurement. Recently, Dr. Qi focuses on millimetre/terahertz wavespectrum and imaging. He has published 14 papers indexed by Science Citation Index (SCI) and held 46 patents (licensed).

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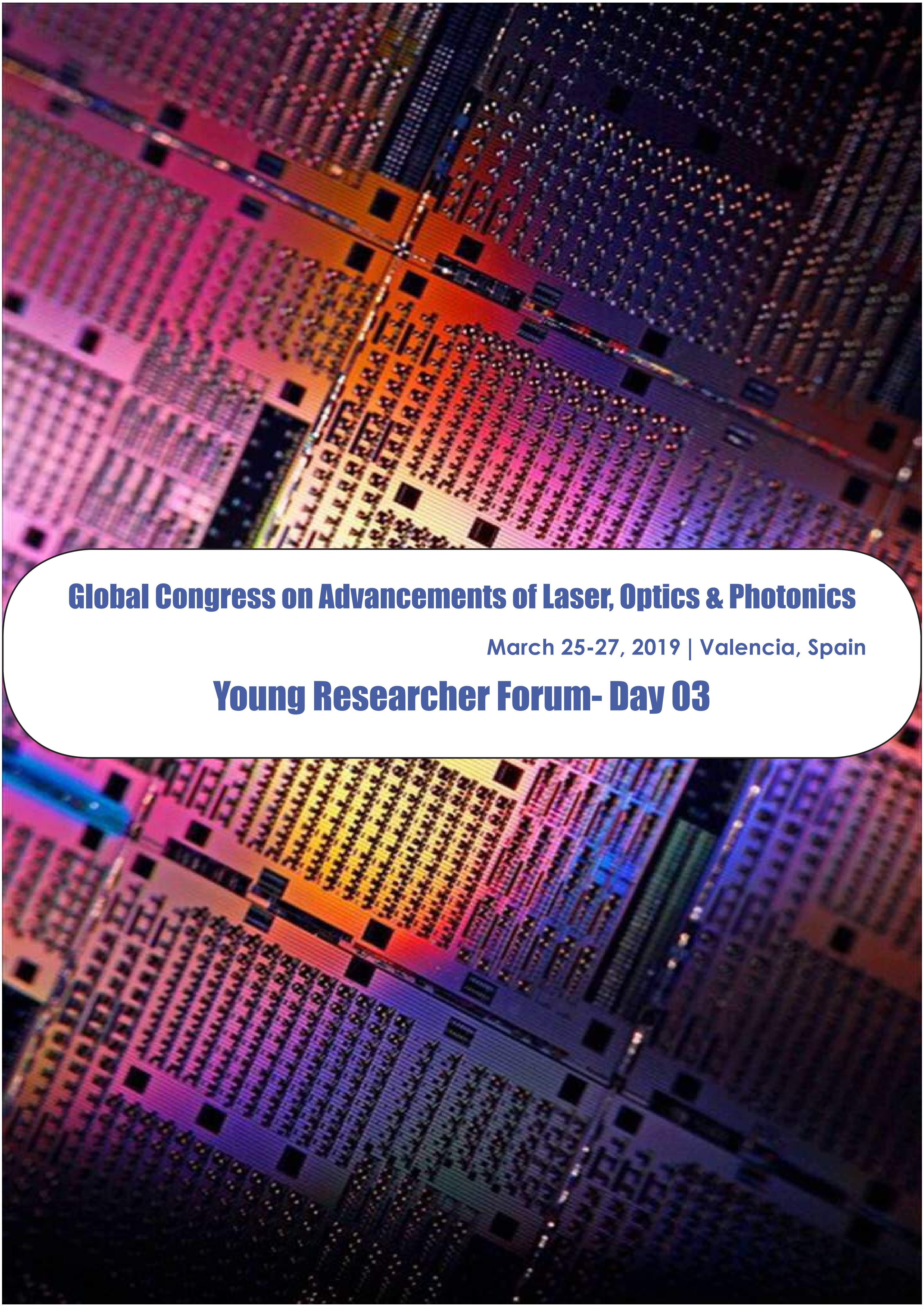

Global Congress on Advancements of Laser, Optics & Photonics

March 25-27, 2019 | Valencia, Spain

Young Researcher Forum- Day 03

Active control of terahertz wave based on metasurface

Jie Ji

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A structure of metasurface based on two-dimensional molybdenum disulfide ultrathin film was investigated. We characterized the transmission properties of the structure by terahertz spectroscopy when applying an external optical pumped field. Electrically induced transparency like phenomenon was observed in the transmission spectra, resulting from near-field coupling of two bright modes. According to simulated results, the phenomenon was based on the length of cut wire structure and distance between DSSRs. Furthermore, when the sample was applied with an optical field supported by a 1064 nm laser, the transmission of the sample could be tuned by optical power. The resonances of the EIT-like structure was disappeared when the optical field was further increased, as the excited carriers in molybdenum disulfide ultrathin film blocked the terahertz wave. In addition, we found the interface between molybdenum disulfide ultrathin film and Si substrate help the structure more sensitive to the optical field. Owing to its excellent optical property, the molybdenum disulfide ultrathin film was found to be a potential candidate for applications in the THz range, such as THz modulators and detectors. The results of the present experiment provide a reference for further development of tunable structures controlled by an external optical field.

Biography:

Jie Ji, a doctoral student in optical engineering from Huazhong University of Science and Technology in China. Her primary research interests are in fields of ultrafast optics, and terahertz technology. She did some research work in optoelectric devices based on ferroelectric thin film and metasurface. In her free time, she likes running and visiting kinds of historical museums to enjoy different culture in.

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Notes:

Differential equations for electromagnetic turbulence

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The differential equations underlying the non-linear dynamics of turbulent fluid flow are extended to the transport of electromagnetic energy and electromagnetic phase in coherent lasers in a new theoretical framework. Since light acts like a pure, incompressible, inviscid fluid, the momentum and mass transport of the Navier-Stokes equations translate directly to the intensity and phase transport equations in scalar diffraction theory, respectively. The non-linear term in the phase transport equation describes the emergence of turbulent dynamics near cusps and singularities in the electromagnetic field, enabling insights into the topology and dynamics of turbulent optical speckle in 6D phase space. A better understanding of the mathematical forms of turbulent wave dynamics allows for reformulating the inverse computational problem for many perennial and current problems in the physics and engineering - imaging through turbulent media, understanding stochastic effects in sub 20nm extreme ultraviolet lithography for extending Moore's law, holographic reconstruction of chaotic diffusion in image processing - but in context of latest computational and sensing capabilities. Turbulence in visible laser light is simply measured with inexpensive table-top laser sources, scientific cameras, and simple imaging optics, enabling volumetric energy measurements of visible/X-Ray light. These are compared with simulations of fluid turbulence to formulate Navier-Stokes like transport equations for electromagnetic phase.

Light is an electromagnetic super fluid, with no rest mass, as well as no viscosity characteristic of shear stresses in fluid mechanics. Hence, the wave mechanics of light propagation encompasses only the inviscid aspect of fluid dynamics, allowing for a simplification of the laws of fluid mechanics in their differential form to describe the laws of optical/electromagnetic propagation. The spatio temporally localized description of optical dynamics using partial differential equations (PDEs) are shown to parallel the Navier-Stokes equations, where the optical intensity plays the role of fluid mass, and the optical phase is the fluid momentum, guiding the propagation of mass. Additionally since there is no viscosity, the laws of optical propagation are isomorphic to the Euler equation, the inviscid form of the Navier-Stokes equation for fluid flow.

Due to its low viscosity, or potentially infinite Reynolds number (R), coherent light enters regimes of turbulent flow even due to slight perturbations, causing laser beams to eventually develop granular stochastics called 'speckle' (Fig. 1). The properties and limitations of the differential equations underlying optical/ fluid transport are compared and validated using measurements of coherent optical speckle and computational fluid dynamical simulations (Fig 2). The Transport of phase is shown to predict spatio-temporally localized energy – momentum dynamics in laser speckle, similar to the role of the Navier stokes for inviscid fluids.

Once the phase recovery for turbulent optical flow is posed as coupled differential equations a process equivalent to unfolding manifolds in phase-space, many of the numerical and analytical tools used in the turbulence theories of modern physics (e.eKolmogrov's turbulence models) are applicable. With new understanding gained from free space experiments with light, complemented with current computational modeling and learning approaches. The applications are wide ranging 0 such as imaging through turbulent media (brain, retina, atmosphere), cosmological and relativistic fluid mechanics, magnetohydrodynamics of the earth, among others.

The differential equation analogy between optical and fluid transport

I is the optical intensity, analogous to the mass density of a fluid $\rho;\vec{\nabla}\Phi$ is analogous to the fluid velocity vector $\vec{v}$;. The differential equations of fluid flow consist of mass mand momentum $\rho\vec{v}_i$. transport ; energy flows in the direction of momentum, or equivalently of phase gradients (Huygen's principle).

	Optical Dynamics	Fluid Dynamics
Mass Transport	Transport of Intensity $k\dfrac{\delta I}{\delta z} = \vec{\nabla}_{xy}\cdot I\vec{\nabla}_{xy}\varphi$	Continuity Equation $\dfrac{\delta\rho}{\delta t} = \vec{\nabla}.\rho\vec{v}$
Momentum Transport	Transport of Phase (proposed in this paper) $\dfrac{\delta\varphi}{\delta z} = -\dfrac{\vec{\nabla}_{xy}\varphi\cdot\vec{\nabla}_{xy}\varphi}{2} - \dfrac{\nabla^2_{xy}\sqrt{I}}{\sqrt{I}}$	Navier Stokes $\dfrac{\delta\vec{v}}{\delta t} = -(\vec{v}.\vec{\nabla})\vec{v} - \dfrac{\vec{\nabla}p}{\rho}$ forirrotational flows $\Downarrow$ $\vec{v} = \vec{\nabla}\varphi$ Euler's equation $\dfrac{\delta\varphi}{\delta t} = -\dfrac{\vec{\nabla}\varphi\cdot\vec{\nabla}\varphi}{2} - \dfrac{p}{\rho}$

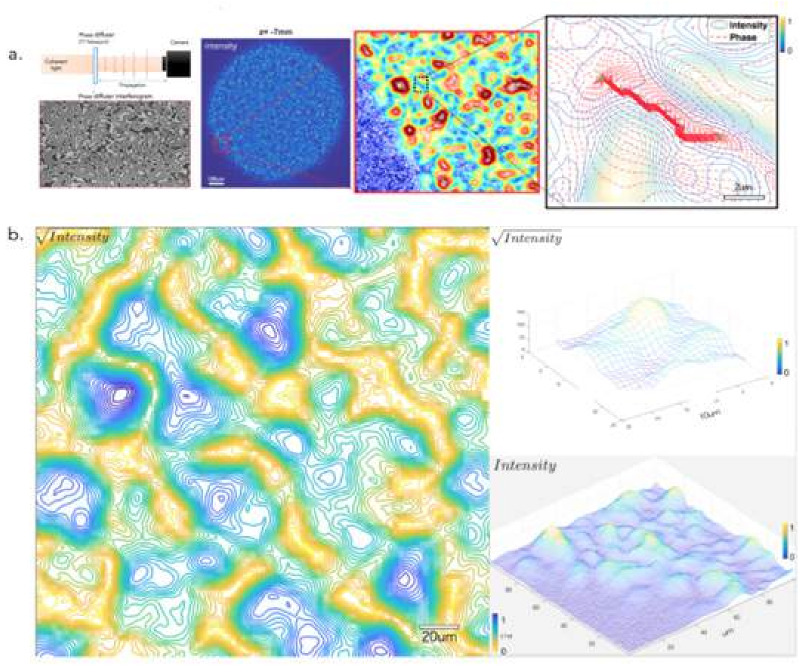
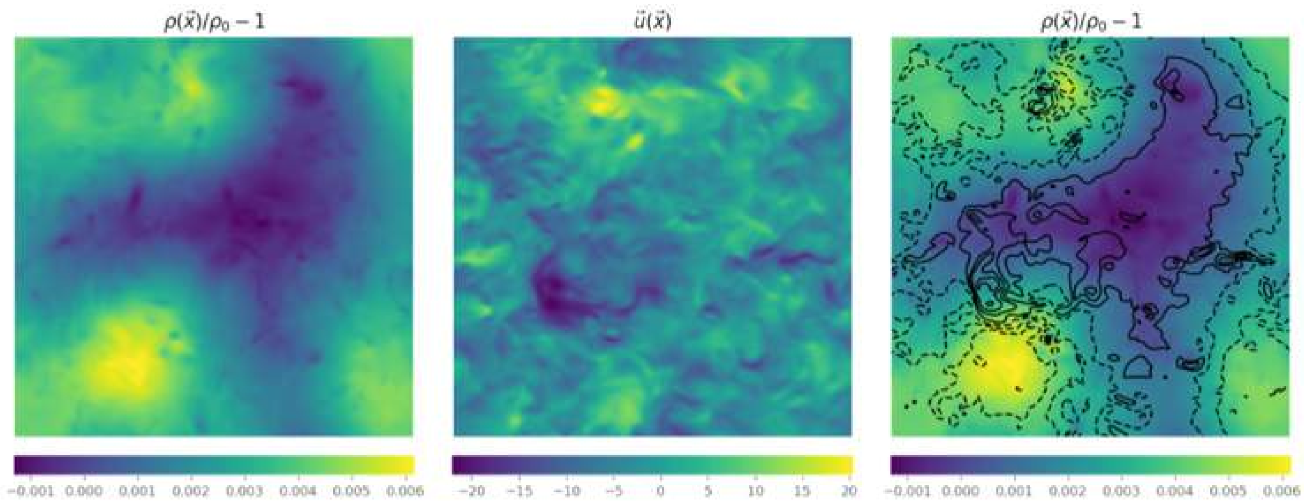


Fig. 1. a. Coherent speckle intensity experimentally measured as a function of propagation, the camera measuring a 3D volume by stepping through defocus or with propagation; turbulence is seen to appear as two dimensional singularity manifolds in the measured 3D speckle intensity. In the in- set, $\vec{\nabla} I \perp \vec{\nabla}\varphi$ this equates to dark rivers (blue) permeating the bright intensity hills (orange). In the in-inset, indicate point singularities, with each line singularity terminating at point singularities with opposite topological charge at either end. b. In negative contrast, the singularities pop (yellow) against intensity valleys (blue), a network of 1D lines in the 2D intensity terrain, the positions of singularity cusps indicating divergence or convergence of phase gradients or fluid momentum; measured intensity on the camera sensor is smooth, since cusps are swallowed when amplitude is squared.



(a) Density field (b) Velocity field (c) Density field with Energy contours

Fig. 2. The simulated density ρ, velocity u and energy $e = \langle u \cdot u \rangle /2 - P/\rho$ obtained for a homogeneous isotropic turbulent flow field with $Re_0 = 650$. The density field is the measured intensity for light, and the velocity velocity field $\vec{u} = \vec{\nabla}\phi$ is analogous to $\sqrt{intensity}$ for light, revealing singularities in the flow field.

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Tunable and reconfigurable integrated filter based on long-period waveguide grating

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A tunable and reconfigurable integrated filter based on long-period waveguide grating is proposed and studied in this paper. It consists of a long-period waveguide grating fabricated on Lithium Niobate substrate and multiple electrode pairs deposited on both sides of gratings. The performances of the filter are analyzed theoretically and measured experimentally. The spectrum of the filter is tuned by adding same voltage on all electrode pairs and the spectrum function is reconfigured by applying different voltage on different electrode pairs due to the electro-optic effect in Lithium Niobate.

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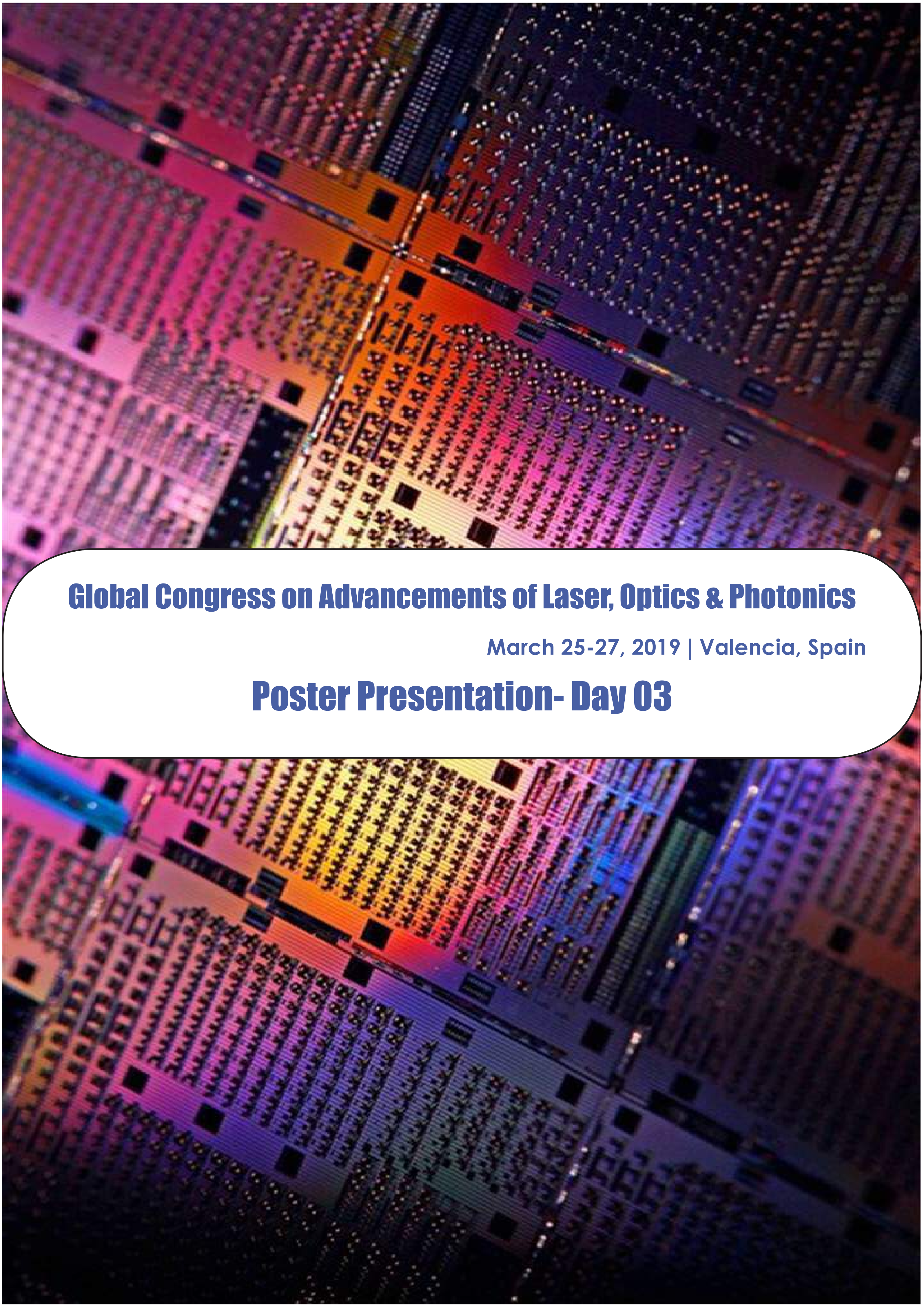

Global Congress on Advancements of Laser, Optics & Photonics

March 25-27, 2019 | Valencia, Spain

Poster Presentation- Day 03

The improvement of the polarization extinction technique by using polarization beam splitter for measuring amplifier spontaneous emission in optical amplifier

Bian Ji, Wang Chao
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We use polarization characteristics of the polarization beam splitter (PBS) to improve the optical path of the polarization extinction technique for measuring the amplifier spontaneous emission (ASE). Thus we can obtain a more efficient optical path for measuring the ASE in the erbium-doped fiber amplifier. Based on experimental data, we discussed the convenience and efficiency of this improvement.

Polarization extinction method is used to measure the ASE in the EDFA. By measuring the ASE, the Gain (G) and Noise Figure (NF) of the EDFA can be calculated. These two parameters are important reference values for the EDFA performance standard.

The conventional test method needs to adjust the polarization controller to separate signal light and ASE noise. The value of the ASE noise can be measured after the ASE is separated, but the adjustment of the polarization controller requires a certain amount of time, and the accuracy needs to be increased. Therefore, we propose to use PBS instead of polarization controller to measure ASE.This is a more accurate and efficient test method.

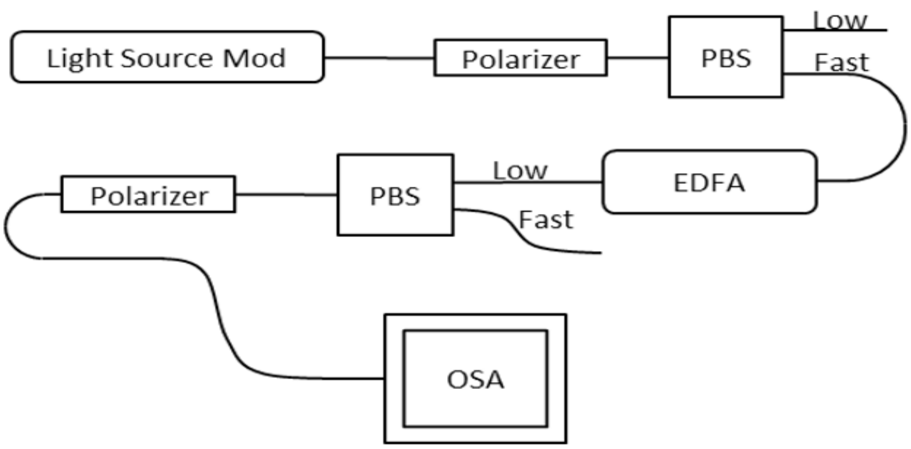

Fig 1The new measurement of using PBS

The light passing through the fast axis of PBS and entering the EDFA and is amplified in the EDFA. The polarized light amplified by the EDFA will have a specific polarization state, while the ASE generated during the EDFA amplification process is a fully polarized state light. The amplified optical signal can again distinguish the spontaneous emission ASE noise in the EDFA through another arm in the PBS and measure the rest half of the ASE. Test optical path is shown in Figure 1.

Biography

Bian Ji is a PhD student of Fudan Fiber Research Center at the Department of Material Science of Fudan University. He received his BS degrees in Computer and Science from Harbin Engineering University in 2014. His current research interests in fiber optical sensing technology and optoelectronic system.

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Optically controlled terahertz modulator by Formamidinium Lead Iodide ($FAPbI_3$)

Weijun Wang[1] Wen Xiong[1], Jie Ji[1], Siyan Zhou[1], Furi Ling[1,*] and Jianquan Yao[2]

[1]Huazhong University of Science and Technology, China

[2]Tianjin University, China

Solution-processed organic-inorganic hybrid halide perovskite has emerged as an excellent material for harnessing solar energy. Perovskites has strong photoresponsive properties that are used in solar cells, light-emitting diodes, infrared lasers and ultrafast photodetectors. Therefore, the perovskite terahertz modulators are received increasing attention. Formamidinium Lead Iodide ($FAPbI_3$) has larger organic cations that can replace metal ions to form a more symmetrical crystal structure. In the meantime, $FAPbI_3$ has a higher decomposition temperature and potential for improved stability. In this article, we experimentally demonstrate that the silicon- based perovskite terahertz modulator has excellent modulation capability and good stability. So the $FAPbI_3$ terahertz modulator is an excellent new illumination-controlled terahertz modulator. As the external optical pump increases, the transmission gradually decreases, and significant light saturation occurs. In the case of high optical pump power, the terahertz transmission is less than 10%, showing excellent modulation.

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Notes:

Optical modulation of PZT/LNO thin films with different periodic structures in the terahertz range

Ying Zeng[1], Jie Ji[1], Weijun Wang[1], Furi Ling[1*], and Jianquan Yao[1,2]

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The optical modulation of PZT/LNO films with different periodic structures with optical pump was investigated by terahertz spectroscopy at room temperature. Three samples had the same thickness. Best performance on the dielectric permittivity and the refractive index modulation was observed in the PZT/LNO films with three periodic structures, due to the soft mode hardening. The largest loss was also found in the same sample. This phenomenon was interpreted by an interfacial dead-layer model with low permittivity interface layer in the film.

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Notes:

Laser radiation power sensor with adjustable dynamic range based on the copper-coated silica optical fiber

Ivan Khramov
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In present work we propose a novel method for fiber laser radiation power measurement using a metal coated fiber as a sensor. High intensity laser radiation transmitting through this fiber is partially scattered and therefore absorbed by outer layers of the fiber. This leads to fiber heating and, consequently, to a change in the electrical resistance of the metal coating which is measured by an ohmmeter.

Linear dependence of fiber coating temperature on transmitted laser radiation power was experimentally observed. Sensibility of the sensor was increased by more than two orders of magnitude by applying fiber bending due to bend losses of higher-order modes. The numerical modeling of fiber heating was performed and radiation scattering coefficients were calculated. The described method can be used for real-time high power laser radiation measurements due to low power losses and beam quality maintenance.

Biography

Ivan is currently a student in Moscow Institute of Physics and Technology, Moscow, Russia. He has received a bachelor degree in photonics in 2017. Field of interest: fiber optics, fiber sensors.

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Notes:

High-power laser beam profile measurements based on the matrix array of the copper-coated passive optical fibers

Nikolay Vanyushkin[1], R.I. Shaidullin[1,2], O.A. Ryabushkin[1,2], A.V. Kozhevnikov[3]

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Nowadays, the optical power of industrial CW fiber lasers exceeds 10 kW level. In many practical laser applications it is necessary to know its beam quality and, therefore, transverse optical intensity profile. In this paper, we introduce a novel approach for the measurement of the intensity profile of high-power laser radiation, which does not require any preliminary attenuation. It is based on the application of the array made of multimode passive optical fibers coated with external copper layer. The investigated laser radiation was directed into the polished end faces of the matrix fiber elements. Laser radiation, scattered in each fiber, was completely absorbed inside its' copper coating leading to its heating and, therefore, to its proportional electrical resistance change. The intensity profile of the incident beam was evaluated by measuring the copper coatings resistance change of each fiber. Intensity profiles of the single-mode and multimode fiber laser beams were successfully measured using proposed fiber array sensor. The introduced technique can be applied for the determination of the beam quality factors (M^2).

Biography

Nikolay Vanyushkin received his BS degree in applied physics and mathematics from Moscow Institute of Physics and Technology, Russia, in 2018. His research interests include fiber optics, optical switching, and applied optics.

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Notes:

Measurement of optical absorption coefficients of nonlinear-optical materials using piezoelectric crystal oscillator circuits

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Nonlinear conversion of laser radiation frequency in nonlinear-optical crystals is an efficient way to obtain laser generation at new wavelengths. It is essential that conversion efficiency is governed by phase matching conditions between interacting electromagnetic waves. Crystals applied in nonlinear optics usually have low optical absorption coefficients in operating range. However, in the case of high power radiation even low absorption can lead to significant non uniform heating of crystals and violation of phase matching conditions. Determination of optical absorption coefficients of nonlinear-optical crystals as well as measurement and control of its temperature during laser irradiation is an important task. For this purpose we propose to exploit temperature sensitive piezoelectric resonances of crystals, which can be excited noncontactly using probe radio frequency electric field. Piezoelectric resonance frequency is measured using the crystal as a frequency selective filter in a feedback loop of the generator (e.g. Pierce electronic oscillator). Therefore, when the crystal is heated by laser radiation its temperature kinetics can be directly obtained by measuring the oscilation frequency change. Optical absorption coefficient is determined by finding the correspondence between the solution of the nonstationary heat conduction equation and measured temperature kinetics.

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Notes:

Piezoelectric resonance laser calorimetry of LBO crystals in vacuum

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Quality of nonlinear-optical materials is characterized by the level of its residual absorption. Modern nonlinear-optical crystals can have absorption below 0.1 m^{-1} in the operating wavelength range. However, in the case of conversion of laser radiation frequency even low optical absorption of pump and generated radiation along with multiphoton absorption can lead to the considerable heating of crystals. A nonuniform heating of nonlinear-optical crystals results in decrease of the conversion efficiency due to the violation of phase-matching conditions and also leads to the deterioration of the output beam quality.

Piezoelectric resonance laser calorimetry (PRLC) was recently introduced for precise measurements of low optical absorption of nonlinear-optical crystals. It is based on measurements of equivalent temperature kinetics of the sample heated by laser radiation. Equivalent temperature of the sample is determined directly by measuring the induced frequency shift of its piezoelectric resonances, preliminary calibrated on temperature in uniform heating conditions.

We have used PRLC technique for the measurement of optical absorption and heat transfer coefficients of nonlinear-optical lithium triborate (LBO) crystals interacting with laser radiation at one micron wavelength at different air pressures from 10^{-1} Pa to 10^{5} Pa. Obvious interrelated benefits of performing measurements in vacuum conditions are the possibilities of the application of much lower optical power for reaching the same overheating level of the tested sample and measurement of much lower values of optical absorption coefficients.

Biography

Ilya Savichev received his BS degree in Optics from Moscow Institute of Physics and Technology, Russia, in 2018. His research interests include optoelectronics and applied optics.

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Notes:

The study on optofluidic fluorescence resonance energy transfer lasing in a pdms microfluidic channel

Xiao-YunPu, Wei-Dong Meng,Yuan-Xian Zhang
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A bare quartz fiber with single refractive index is implanted in a poly dimethylsiloxane (PDMS) microfluidic channel, the circular cross section of the fiber forms a ring resonator and has high quality (Q) whispering gallery modes (WGMs). The lasing gain media consists of fluorescence resonance energy transfer (FRET) donor-acceptor dye pair, which is Rhodamine B (RhB)-LDS821 mixture solution with a lower refractive index than that of the optical fiber, the solution acts as the cladding liquid material and flows in the PDMS microfluidic channel. Pumping along the optical fiber axis, the FRET characteristic parameters have been studied firstly by using a continuous wave laser as a pump light with a wavelength of 532 nm. Then the excited states are created in the donor (RhB) by usinga pulse laser and transferred to the adjacent acceptor (LDS821) through FRET, whose emission is coupled into the WGMs. Due to high energy transfer efficiency of the donor-acceptor dye pair used, and high Q-factor WGMs of the ring resonator, the built laser in the microfluidic channel shows a lasing threshold as low as 1.26μJ/mm^2.

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Notes:

Investigation of temperature dependent optical spectral properties of polysiloxane polymers used in high-power fiber optics

Renata Ismagilova, Khramov IO, Shaidullin RI, Ryabushkin OA
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Thermal degradation of polysiloxane polymers used in fiber optics under conditions of high-power laser generation is one of the main limiting factors of fiber lasers power scaling. In this work, spectral properties, such as absorption coefficient and optical scattering, of several polymers used as active fiber coating and industrial fiber unit fillers are investigated. Temperature dependences of optical absorption coefficient of polymers at the wavelengths of laser and pumping radiation were measured by means of laser calorimetry technique. Heating of fiber laser unit under lasing conditions was experimentally measured. The fraction of optical pumping power, transforming into heat due to absorption in polymer, was estimated.

Biography

Renata Ismagilova is a first year postgraduate student of the Institute of Radio-engineering and Electronics of RAS. She has graduated from the Moscow Institute of Physics and Technology in 2018 with a master’s degree in applied physics and mathematics. Her primary research interests are in the field of fiber laser optics, magneto-optics and optical materials. She has authored and co-authored more than 10 scientific papers.

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Notes:

Piezoelectric resonator for temperature measurement of metal-dielectric heterostructures interacting with laser radiation

D.M. Mukhankov[2], I.A. Savichev[1], K.V. Zotov[1], A.V. Konyashkin[1,2], I.V. Shebarshina[1], O.A. Ryabushkin[1,2]

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An investigation of the interaction with laser radiation of thin metal films deposited onto the dielectric substrates is of great interest in the fields of nanophotonics and plasmonics. We propose to use the temperature dependence of the eigen mode frequencies of the substrate for measuring the overheating of various metal-dielectric hetero structures under laser irradiation. In the case the substrate is made of a piezoelectric material its eigenmode scan be excited using probe radio frequency electric field. Two electrodes should be employed in order to form a capacitor with piezoelectric substrate in between. A piezoelectric resonance occurs when the frequency of the external electric field corresponds to any eigen mode frequencies of the substrate. During laser irradiation the heating of the metal film can be determined by measuring the induced shifts of piezoelectric resonance frequencies.

The temperature calibration of the resonance frequencies is preliminary performed in uniform heating conditions. In the first approximation, resonance frequencies linearly depend on temperature:, here is the piezoelectric resonance thermal coefficient of the i-theigenmode.

During the interaction with laser radiation of the average power P the induced frequency shift corresponds to the change of the equivalent temperature of the heterostructure. Consequently, the temperature of the metal film can be restored.

The introduced approach was corroborated experimentally using the lithium niobate crystal substrate coated with gold and different UV and visible laser sources.

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