GSELOP2022
2nd Global Summit and Expo on Lasers, Optics and Photonics

August 22-24, 2022
Edinburgh, Scotland

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FOREWORD

After successful organization of GSELOP2021 which featured cutting edge presentations by Prof. Shuji Nakamura, Nobel Laureate-2014 and other world renowned researchers in the field, we are pleased to announce the 2nd Global Summit and Expo on Lasers, Optics and Photonics (GSELOP2022) will be held during August 22-24, 2022 in Edinburgh, Scotland will address diverse topics related to recent trends and progress made in the field of lasers, optics and photonics.

The GSELOP2022 will present the most recent advances in technology developments and business opportunities in lasers, optics and photonics commercialization. Highly cited researchers from renowned universities across the globe and industry leaders will share their research and vision, while selected talks from industrial exhibitors will present commercial showcases in all current market fields of optics and photonics.

This conference offers an excellent forum for the state of art presentations by invited speakers, leading specialists in the field of lasers, optics and photonics. Most recent developments, progress and achievements realized in the fields covered by the conference will be presented in plenary, keynote presentations and short oral contributions as well as in poster sessions.

As you enjoy the intellectual interaction with peers and leaders in the field, we encourage you to immerse yourselves in the Edinburgh, experience with her rich cultural diversity. We are confident that your stay with us will be enriching and fascinating.

Welcome to Edinburgh and we wish you a pleasant, fruitful and unforgettable experience!

Sincerely,
Prof. Dieter Bimberg
Conference Chair
GSELOP2022
"Bimberg Chinese-German Center for Green Photonics" at CIOMP of CAS, Changchun.
Founding Director "Center of NanoPhotonics", TU Berlin, Germany.
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Green data communication: Intelligent physics and engineering will contribute to a sustainable society

Abstract
Since 2014 novel consumer applications like Netflix, Block Chain, LIDAR... not known at that time have led to a huge increase of internet traffic of 60%/year, much more than then originally predicted by companies like Cisco. This increased use of the internet is increasing its electrical power consumption due to increased data traffic mostly inside data centers. New data centers have crossed the 500 MW level. 5G with its big jump in data speed will be another enabler for new services, like LIDAR and more we cannot think about yet, and will increase the energy consumption to an extent not further tolerable. More research has to be done on the energy-efficiency of data traffic on all hierarchy levels. Inside data centers advanced design of active optical cables, their electronic driver and receiver circuits and the active photonic devices are suddenly in the focus, but now with the goal to minimize their combined power consumption. Vertical-cavity surface-emitting lasers (VCSELs) for 200+ Gbit/s single fiber data transmission across OM5 multimode fiber with a record heat to bit rate ratio (HBR) of only 240 fJ/bit x wavelength @ 50Gbit/s developed in our labs are presented. Photon lifetime management is a new key to adopt the overall energy consumption to the bit rate of the data traffic (e.g. 25 Gb/s, 50 Gb/s,..).

A completely novel design approach for VCSELs will be presented based on etching multiple holes, oxidizing one or several apertures from these holes and refilling them with metal, in order to increase heat conduction and cut-off frequency and reduce parasitic effects. Thermal roll-over is expected to appear at much larger currents compared to the present standard designs, allowing larger single mode output power and possibly dense wavelength multiplexing across distances of several hundred m to 1 km in data centers. Finally work on high speed novel drivers based on advanced CMOS design is reported, leading to dramatically reduced energy consumption of VCSEL modules below 500 fJ/bit.
Photonic Technologies for Sustainable Development

Abstract
Photonics has a key role to play in enabling the UN sustainability goals. For example, silicon photovoltaic solar cells provide a route affordable and clean energy, optical communications support quality education and optical sensing technologies underpin the development of sustainable cities and communities. In this presentation we will describe work done under the Canada India network center of excellence, IC-IMPACTS aimed at developing sustainable communities. The presentation will outline two examples of how photonic technologies have enabled new, portable systems for the detection, monitoring and screening of infectious diseases and how new light delivery systems are being developed to support the growth of algal biofilms for carbon capture and clean energy.
Dr. Waguih S. Ishak
Division VP & Chief Technologist, Silicon Valley
Corning Research & Development Corporation
Sunnyvale, CA

The Connected World – A vision

Abstract
We are living a highly creative era in which digital consumer electronics will drive much of high-technology research and products for the betterment of people, society, and the environment. High speed communications, artificial intelligence, autonomous cars, AR/VR, quantum computing are just examples of what PHOTONICS and OPTICAL technologies can make a big impact.

The talk will describe recent advances in optical materials and technologies which will improve our lives. Mega trends, problems that matter, the role of R&D are examples of topics in the talk.
Ultrafast Resonant and Non-Resonant Nonequilibrium, Nonlinear Optical Interactions in Semiconductors

Ultrafast dynamics in strong field resonantly and off-resonantly driven semiconductors is dominated by competing ultrafast carrier-carrier (electron-electron, electron-hole, electron-phonon) many-body interactions that strongly influence the resonant behavior of mode-locked lasers and non-resonant THz driven high harmonic generation (HHG). These are examples of nonlinear systems driven far from equilibrium where ultrashort resonant pulses burn kinetic holes in initial quasi-equilibrium Fermi distributions and carriers are driven across the entire Brillouin zone. A rigorous bottoms-up approach based on these first principles theories avoids ad hoc parameterization and has provided a powerful predictive laser design tool now being incorporated by industry in the development of broad classes of novel continuous wave and pulsed semiconductor lasers.

I will present an overview of the key physics principles and illustrate with applications to mode-locking of high power vertical external cavity semiconductor lasers (VECSELS) with experimental applications to offset-free GHz mid-IR frequency combs. VECSELS have been demonstrated to achieve record CW multimode and single frequency output power spanning UV through near-IR wavelengths while being promising sources for laser guidestars and tunable room temperature THz sources. Moreover, ultrafast intense THz driven excitations generate HHG in detuned passive semiconductors and induce an intrinsic symmetry breaking via quantum interferences.

Transition Metal Dichalgonides (TMDC) are quasi-2D semiconducting material exhibiting unique optical properties due to the strong difference between in-plane Coulomb and much weaker out of plane Van der Waals forces. The latter have been shown to exhibit optical gain and their extreme sensitivity to external perturbations making them ideal candidates for sensing and electronic applications.

Figure 1 Sampled kinetic holes burned in initial Fermi distribution as mode-locked pulse hits the gain chip. Blue curve – initial Fermi distribution.
Foundry Based Approach of Realizing Tunable Laser Arrays for Optical Sensing and Networking

Abstract
Tunable lasers are indispensable light sources for applications in next-generation all-photonic networks, medical diagnostics, and optical sensing to provide agility and reconfigurability. Most applications require tunable lasers to have wide tuning range and compact footprint. Though there exist various approaches to make photonic integrated widely tunable lasers, we aim to develop tunable lasers fabricated with foundry services to cope with the large-volume demands for being used as wavelength programmable light sources. This approach allows to use the mature DFB laser structure and simplify the testing and packaging procedures. We designed a laser array including multiple DFB lasers of different Bragg wavelengths to cover a wide wavelength range \[1,2\]. For reducing the number of parallel output ports to decrease the coupling loss, the laser array is arranged to form a matrix with cascaded two lasers in each row [3].

This talk will cover the evolution of tunable lasers and address the design and fabrication considerations for tunable lasers formed of cascaded DFB lasers. The laser arrays are tape-out for foundry services, and the laser arrays can output>30-nm uniform spectrum with simple tuning by adjusting bias current and device temperature. The array yield will also be reported.

Keywords
Laser Array, Tunable Laser, Photonic Integration, Optical Sensing

References

Biography
San-Liang Lee received the Ph.D. degree from the University of California, Santa Barbara (UCSB), in 1995. He joined the faculty of the Department of Electronic and Computer Engineering (ECE), National Taiwan University of Science and Technology (NTUST) in 1988 and became a Full Professor in 2002 and a Chair Professor in 2019. He was the Vice President of the university from 2011 to 2014. He is currently the Director of Photonics Division of the Ministry of Science and
Technology (MoST), Taiwan, and also the Director of the MoST-sponsored research program on Silicon Photonics and Integrated Circuits. Since 2013, he serves as the Associate Editor of IEEE ACCESS Journal. He received the Outstanding Research Award of 2018 from MoST. His research interests include semiconductor optoelectronic components, photonic integrated circuits, and optical networking technologies. He has published more than 300 referred papers in international journals and conferences and holds >30 patents.
Invited Forum
Day-1
Plasmonic Inverted-Pyramid Arrays For Harvesting Infrared Sunlight

Abstract
In any solar cell, the exploitable spectral range of sunlight is limited by the band gap of the active photovoltaic material, which in the case of silicon is 1.1 eV (roughly 1100 nm). Thus, nearly half of the solar spectrum remains unabsorbed, namely, the near infrared (NIR) part. To alleviate this situation, an alternative to photoelectric conversion relies on the mechanism of plasmon-enhanced internal photoemission of hot electrons at metal/semiconductor heterostructures. NIR photons with energies below the gap of the semiconductor are absorbed by the metal, launching surface plasmons, which, upon relaxation, produce a photocurrent of hot carriers into the semiconductor.

The focus of this talk is set on the purposely design of interfaces between a nanostructured metal and a semiconductor to efficiently absorb NIR solar light, also including the fabrication, characterization and optimization of the photonic/plasmonic nanostructured NIR absorbers. Both the far and near-field optical properties are tailored with the final goal of attaining sizeable photocurrents. The proposed strategy for harvesting NIR sunlight is based on the fabrication of silicon inverted-pyramid arrays, fully or partially covered with thin Au films [1]. The textured structures are obtained either by scalable soft nanoimprint lithography (submicron size pyramids) or conventional photolithography (few micron-size pyramids), subsequent wet KOH etching and thermal Au deposition. The obtained nanostructures show high light absorption in the NIR region (in excess of 80%) that can be tuned by modifying their geometric parameters. The spectral features are in excellent agreement with computational calculations. Photocurrents are still low but already ten times higher than the state of the art.

Reference
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Advances in the Photovoltaic Field through Light Manipulation

Abstract
Solar energy is the most abundant and cost-free renewable energy source. However, in comparison to the potential, the use of solar energy is still negligible and unsatisfactory. In 2019, renewable technologies accounted for only 11% of global primary energy, with solar technologies accounting for around 1%. The fact is that having such a powerful source of energy as the sun requires people to be able to use it more effectively than they do now. The project addresses how to overcome this issue and use free energy more effectively.

Manipulating sunlight spectra and intensity through innovative design to increase the efficiency of solar devices is one way to expand our knowledge and effects of light and make significant progress toward better solar energy utilization. By the term “manipulation”, we primarily allude to light phenomena for which we do not yet have an explanation, such as the higher efficiency of solar devices then expected at higher as well as lower light intensities, and non-uniform or non-linear basic current and voltage characteristics of the solar cells, which, at least in part, depend on the light spectra. Only with a better understanding of the light effects will we make progress in harnessing the sun’s energy. The development of novel and low-cost solar materials and devices, a part of their reliability and durability, is an important step towards further progress because we need more cost-effective, reliable, and durable products as a backup for developed Si-solar cells. So far, the cost-effective replacements have a problem with instability, toxicity, or with an insufficiently cheap product. Efficiency is not the only limiting parameter. In reality, the efficiency/cost ratio is the deciding parameter towards implementation. This means that the competitive product has to be significantly cheaper, the price has to be far below that of the already well-developed Si-solar cells, with still good efficiency.

For photovoltaics to become a more mainstream and pragmatic energy source, the efficiency of solar panels will need to improve drastically. This idea is in line with the Goal 7 of the Sustainable Development Goals of the United Nations. The most efficient crystalline Si-solar cells have almost reached their theoretical maximum efficiency, so it is not clear how efficiency could be increased with today’s knowledge. However, with the manipulation of light, we can far exceed the theoretical efficiencies of solar devices by expanding our knowledge concerning light effects.

Keywords
Solar Energy; Light Manipulation; Light Effects; Optics
Biography
Dr. Ivana Validžić is a Research Professor at the Vinča Institute of Nuclear Sciences, the National Institute of the Republic of Serbia, and the University of Belgrade. After graduating from the Faculty of Physical Chemistry at the University of Belgrade, she obtained her Ph.D. in 2004 at Utrecht University’s Van Hoff Laboratory in the Netherlands. She is the author of more than forty peer-reviewed publications, the author of the book “Advances in photovoltaics by light manipulation”, Cambridge Scholars Publishing, accepted for publication in 2021, and a book reviewer for “New materials and nanotechnology,” 2012, University of Banja Luka, ISBN 978-9993854-42-5. Research interests and work in the last decade have been connected to the synthesis of the V-VI group of semiconductors for photovoltaic applications, the development of new solar cells based on undoped and doped semiconductor Sb2S3, and the development of optics to improve the photovoltaic response of designed and commercial solar cells, as well as towards establishing low light intensity standard conditions.
Optical Waveguide Structures for Plasmonic Sensor Implementation

Abstract
Sensing based on surface plasmon is already a well-established platform suitable for detecting molecular changes as well as presence of certain types of molecules for biosensing. However, the main drawback of this technology lies in its inability to be integrated on a small scale. Even if the substrates are relatively small, today mostly the external or standalone measurement device as Raman's spectrometer or ellipsometer has to be used, which prevents these devices from being integrated into more complex optical networks or lab-on-chips.

We present a possible solution for integration by designing a plasmonic waveguiding sensor using the eigenmode expansion simulation method. It combines the sensitivity of sensors based on surface plasmon with the ease of fabrication and integrability of conventional inorganic waveguides. We designed the sensor to be used in the visible light spectrum to take advantage of the transparency of the SiON material with refractive index specifically tuned to the needs of water solution-based sensors. We also present the optimization of technological processes used to realize the waveguide sensor as well as grating patterns used to couple light in and out of the waveguide. The processes presented include PECVD deposition of SiON layer, RIE etching of the device, and measurements of topological as well as spectral characteristics of the device.

This work was supported by projects 1/0733/20 of VEGA grant agency and APVV 20 0437 from Slovak research and development agency, all of Ministry of Education, Science, Research and Sport of the Slovak Republic.

Keywords
Plasmonic, SiON, Sensor, Waveguide, Lab-on-Chip
The reciprocity principle and loss asymmetry between counterpropagating modes in whistle-geometry ring lasers

Abstract:
A key feature of the whistle-geometry ring lasers (WRLs) is the asymmetry between the two counterpropagating modes, with the device structure strongly favoring unidirectional operation. The asymmetry between the modal losses results in different lifetimes for the two counterpropagating modes, which might be misconstrued as a violation of the Helmholtz reciprocity principle and the time-reversal symmetry of Maxwell’s equations. According to the Helmholtz reciprocity principle, a ray of light and its reverse ray encounter matched optical events, such as reflections, refractions, and absorption in a passive medium, or at an interface. While this principle does not apply to moving, non-linear, or magnetic media, it is expected to apply to the WRL structure when properly interpreted. The important realization is that the reciprocity principle applies to the complete solution of the Maxwell’s equations when a mode conversion takes place, but not to each mode separately. In the WRL structure, the mode conversion occurs due to bending losses (which are symmetric and apply equally to both counterpropagating modes), scattering at the junction with the straight waveguide (which may or may not affect both modes equally), and the outcoupling into the straight waveguide (which affects only one of the counterpropagating modes and is the primary reason for the asymmetry between the modes). Thus, the losses experienced by the counterpropagating modes (and therefore their lifetimes) can be different without violating the reciprocity principle.

Biography
Marek Osiński is a Distinguished Professor of Electrical and Computer Engineering, Physics and Astronomy, Computer Science, and Nuclear Engineering at UNM. His main current research interests include semiconductor ring lasers, monolithically integrated optoelectronic circuits, quantum photonic integrated circuits, superconducting-nanostripe single-photon detectors, ultrafast optoelectronic devices, comprehensive simulation of optoelectronic devices, memristors, neuromorphic computing, colloidal nanocrystals for biomedical applications, nanoscintillators, and hybrid nanocrystals for solar hydrogen production. He is a Life Fellow of IEEE and a Fellow of the Optical Society of America and the International Society for Optical Engineering (SPIE). He has authored or co-authored over 550 technical papers, 7 book chapters, 23 awarded, and 6 pending patents. He also co-edited 28 books of SPIE conference proceedings on physics and simulation of optoelectronic devices and 23 other SPIE volumes in the fields of advanced high-power lasers, optoelectronics, nano-biophotonics, and colloidal nanoparticles for biomedical applications.
Ping Zhao

P. Zhao*, V. Torres-Company, M. Karlsson and P. A. Andrekson

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Low-Noise Phase-Sensitive Amplifiers based on Integrated Nanophotonic Silicon Nitride Waveguides

Abstract
Due to the advantages of low noise figure beyond the conventional 3 dB quantum limit, broad bandwidth and high flexibility in operation wavelength, phase-sensitive amplifiers (PSAs) have been widely applied in various photonic areas [1–3] we demonstrate a quantum technique to extract the second- and third-order chromatic dispersion of a short single-mode fiber using a fiber-based quantum nonlinear interferometer. The interferometer consists of two cascaded fiber-based biphoton sources, with each source acting as a nonlinear beam splitter. A fiber under test is placed between these two sources and introduces a frequency-dependent phase that is imprinted on the biphoton spectrum (interferogram). With the trend of being more compact and robust, PSAs based on integrated nonlinear photonic waveguides have been attracting vast interest in recent years. However, continuous-wave (CW) pumped PSAs are challenging as a result of the high requirements on the losses, power handling ability, dispersion engineering and fabrication of integrated nonlinear waveguides. Nanophotonic silicon nitride waveguides, which are advantageous in high nonlinearity, low loss, excellent power handling ability, ease in fabrication and good compatibility with CMOS technologies, pay ways for low-noise CW pumped PSAs [4] which hold great prospects in optical communications [5], signal processing [6,7], spectroscopy and quantum optics.

Keywords
Phase-Sensitive Amplification, Integrated Waveguides, Four-Wave Mixing, Optical Communication, Optical Signal Processing

Reference
Z. Ye, P. Zhao, K. Twayana, M. Karlsson, Torres-Company Victor, and Andrekson Peter A.

Biography
Dr. Ping Zhao received the B.Sc. and Ph.D. degrees from Huazhong University of Science and Technology (HUST), China, in 2009 and 2014, respectively. Presently, he is a researcher with the Department of Microtechnology and Nanoscience in Chalmers University of Technology, Sweden. His research topics cover low-noise parametric amplification and micro-nano photonic waveguide devices for optical communication, microwave photonics and signal processing.
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High Performance Fiber Optical Amplifiers and Single Frequency Fiber Lasers in the 2000 nm Band

Abstract
Recent rapid progress in the development of high performance Tm- and Ho-doped fiber optical amplifiers and single frequency fiber lasers operating in the 1760 nm—2130 nm spectral region is surveyed. Output powers of > 25 W have been obtained in the CW mode of operation for both standard and polarization maintaining 2000 nm band fiber amplifiers. The design and performance of single frequency narrow linewidth PM DFB-FBG fiber sources in the 2000 nm band are also discussed. Measured linewidths of < 10 kHz have been obtained with CW output powers of > 325 mW from a polarization-maintaining fiber laser source at 2039 nm. Operation of the 2000 nm fiber lasers and amplifiers in the pulsed mode with nS pulses is described. Real world applications and products incorporating these fiber amplifiers and single frequency fiber lasers are presented.
Emission Enhancement for Red-Emitting InGaN by Nanocrystalline Effects and Surface Plasmon Coupling

Abstract
The realization of a micro-LED display, which is a next-generation self-emitting display, is expected. However, the emission efficiencies of red LEDs are quite low in addition to the high manufacturing cost. One method to solve these problems is the monolithic integration of micro-LEDs using columnar nanocrystals called nanocolumns (NCs). GaN NCs were discovered at Sophia University in 1997 and were initially fabricated by a self-assembly method. After that, Ti-mask selective growth method has been developed to control the position and size [1]. NCs exhibit effects unique to nanocrystals (nanocrystalline effects) such as dislocation filtering and strain relaxation, resulting in more efficient luminescence than planar quantum wells.

In this presentation, the nanocrystalline effects will be outlined, followed by the demonstration of a micro-LED display panel using the emission color change technique in NC arrays [2]. On the other hand, the internal quantum efficiency in the red region is approximately 20%, which is lower than those of other emission colors due to the increase of point defects, even if the NC structures are introduced. Therefore, the nanocrystalline effects alone are not enough to increase the red emission efficiency. As a technology to enhance red emission, we have developed NC plasmonic crystals (NC-PlCs), which can be introduced by post-process. Furthermore, the NC-PlC has the advantage that the surface plasmon polariton (SPP) resonance wavelength can be controlled by changing the diameter and period and can be shifted to the red region [3, 4]. The design method and properties for red emission enhancement will be presented.

Keywords
InGaN, Nanocolumn, Nanocrystalline effects Surface plasmon, Plasmonic crystal

References

Biography
Dr. T. Oto is an assistant professor at the Dept. of Informatics and Electronics in Yamagata University. After receiving a PhD degree at Kyoto University in 2014, I joined Prof. K. Kishino’s group in Sophia University as a postdoctoral researcher. In 2017, I took up his current position. I have studied the
optical characterization of InGaN based nanostructures and developed the emission enhancement from InGaN-based light emitters by SPP coupling.
Creating Customized Polarization Structures with Ultrathin Optical Devices

Abstract
Polarization is a fundamental property of light, which has been used to record and store information. To meet the requirement of device miniaturization and system integration, there is huge interest in developing ultrathin and compact optical devices with functionalities that cannot be obtained with traditional optical elements. Optical metal surfaces, the two-dimensional (2D) counterparts of meta materials, have revolutionized design concepts in photonics, providing a new platform to develop unusual ultrathin optical devices for polarization manipulation that is very challenging or impossible to realize with traditional optical elements. In this talk, I am going to report our recent progress on ultrathin meta surface devices for polarization generation and manipulation, including 2D polarization structures (e.g., arbitrarily shaped focal curves with a predefined polarization distribution), 3D polarization structures (e.g., 3D knots), and their potential applications in the future.

Keywords
Metalens, Polarization Structures, Multiple Functions, Image Concealment, Security.

References

Biography
Xianzhong Chen is an Associate Professor at the Institute of Photonics and Quantum Sciences at Heriot-Watt University (HWU), UK. He is leading the Experimental Nanophotonics Group at HWU, which is dedicated to the fundamental physics of metasurface and its application in ultrathin optical devices for imaging, defence, display and information processing. His current main research interests include metalenses, holograms, optical vortex beams and polarization detection. The ultrathin nature and unusual functionalities have enabled the discovery of new phenomena and the development of novel prototype devices for future technologies. To explore the commercial applications of novel nanodevices and integrated optical systems, he has built connection with industry, including STMicroelectronics, Renishaw and Holoxica. He has published 80 papers, including Nature Communications, Nano Letters, Advanced Materials, and Light: Science & Applications.
Invited Forum
Day-2
Heterostructure Scintillators based on Nitride Semiconductors

Abstract

Scintillators are materials which have luminescence response to ionizing radiation. We meet them for instance anytime when x-ray has to be detected for in x-ray imaging, in computer tomography, when our luggage is checked on airports, but also in electron microscopy for detection of electrons. Scintillators are traditionally dominated by crystals with very wide band gaps e.g. different garnets or perovskites or other types of wide band gap oxides, which contain also heavy atoms enhancing absorption of ionizing radiation. Scintillation of these materials is based on deep luminescent centers in their band gaps.

Recently, also wide band gap semiconductors, such as GaN or ZnO started to be used for several scintillator applications. Their main advantage is that they have much faster luminescence response, since they use fast “band to band” or excitonic transition instead of slow luminescence of deep centers. On the other hand, to have strong excitonic transition high quality semiconductor is required with low density of dislocations and other defects. Such quality can be obtained only in quite thin epitaxial layers with thickness in the range of micrometers. Small thickness of scintillating layers is significant disadvantage for the detection of highly penetrating gamma or x-ray radiation. On the other hand, for detection of particle radiation, e.g. electrons, positrons, alfa particles or protons, specially designed semiconductor heterostructures seems to be extremely promising. The presentation will be devoted to design, problems and properties of scintillator structures containing high InGaN/GaN QW number. Although InGaN/GaN QWs is well developed for LED applications, scintillators have significantly different requirements for heterostructure design and material quality[1]. Influence of piezoelectric field, doping, QW number, QW thickness and buffer layer morphology on scintillating properties will be discussed. Cathodoluminescence of InGaN/GaN scintillator will be compared with traditional bulk ones.

Keywords

InGaN/GaN MQW, scintillator, cathodoluminescence

References

Biography
Ing. Alice Hospodková, Ph.D. is head of MOVPE (Metal Organic Vapor Phase Epitaxy) laboratory, preparing and characterizing strained quantum wells and quantum dots nanostructures in semiconductor material system AIIIBV, particularly InGaN/GaN, In(Ga)As/GaAs, GaSb/GaAs or In(Ga)Sb/GaSb and their characterization. Since 2015 she concentrates on design of nitride polar heterostructures for scintillators and HEMT.
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**Few-Cycle Nonlinear Photonics: From Nanoscale Devices to Large-Scale Circuits**

Evident from more than 50 years of table-top nonlinear optics, utilizing strong quadratic nonlinearities in integrated photonics can significantly expand the potentials of photonics for applications ranging from sensing to computing. In the past few years, nanophotonic lithium niobate (LN) has emerged as one of the most promising integrated photonic platforms with strong quadratic nonlinearity. In this talk we present some of our recent experimental results on realization and utilizing of dispersion-engineered and quasi-phase-matched devices in nanophotonic LN for intense optical parametric amplification [1], ultrafast ultra-low-energy all-optical switching [2], and few-cycle vacuum squeezing [3]. We also present some recent experimental and numerical results on how resonators with only strong quadratic nonlinearities exhibit phase transitions in the spectral domain [4], and pulse compression [5]. We show a path for realization of large-scale ultrafast nanophotonic circuits in the classical and quantum regimes and discuss how networks of such resonators can lead to topological [6] and non-Hermitian dynamics [7], and all-optical quantum information processors.

**References**

Machining of Semiconductor Materials with Ultra-Short Laser Pulses

Abstract
(100) oriented silicon and germanium wafers, machined with ultra-short (ps and fs) pulses in the NIR (1064 nm and 1030 nm), clearly show two ablation regimes when the peak fluence is raised from the threshold to several J/cm². In the first regime the roughness increases with the fluence due to strong cavity formation whereas the second regime is dominated by the formation of a melt film leading to smooth and flat surfaces. The separation into two regimes and the formation of a liquid layer cannot be observed in case of 10 ps pulses for (110) and (111) oriented wafers, neither for silicon nor for germanium. The surface roughness continuously increases with raising peak fluence due to progressing cavity formation leading to larger bumps. In case of 400 fs pulses again a drop in the surface roughness is observed also for (110) and (100) oriented wafers, but this drop is small and the corresponding surface is only partially covered by a melt film.

The appearance of the full melt layer for the (100) oriented wafers might be caused by the higher surface energy [1] compared to the other two orientations which could lead to a higher wettability. However, this hypothesis has to be fostered by additional experiments e.g. with other orientations, different semiconductor materials or with pulse bursts.

Keywords
Laser micro-processing, ultra-short pulses, brittle materials, semiconductors,

References

Biography
Beat Neuenschwander studied physics at the University of Bern and realized 1996 his PhD in the field of diode pumped solid state lasers. From 1997 to 2002 he joined the company Numerical Modelling and since 2000 he is also at the Bern University of Applied Sciences BUAS where he lectures physics and applied laser technology. There he built up the laboratory for laser micro machining and laser surface engineering, became full professor in 2005 and is actually heading the institute for applied laser, photonics and surface technologies ALPS. His main research topic, where he published more than 70 papers, is laser micromachining with ultra-short pulses and its industrial application. He was chair of the LASE Symposium 2018-2021 and is founder member of the national thematic network NTN swissphotonics, which he headed from 2008 – 2011 as managing director.
Actually, he is also serving as expert for the Swiss funding agency innosuisse.
ROTSCHILD$^{1,2,*}$
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Generalization of Kirchhoff’s Law: The inherent relations between quantum efficiency and emissivity

Abstract
Planck’s law of thermal radiation depends on the temperature, $T$, and the emissivity, $\varepsilon$, which is the coupling of heat to radiation depending on both phonon-electron nonradiative- interactions and electron-photon radiative-interactions. In contrast, absorptivity, $\alpha$, only depends on the electron-photon radiative-interactions. At thermodynamic equilibrium, nonradiative- interactions are balanced, resulting in Kirchhoff’s law of thermal radiation, $\varepsilon = \alpha$. At non- equilibrium, Quantum efficiency (QE) describes the statistics of photon emission, which like emissivity depends on both radiative and nonradiative interactions. Past generalized Planck’s equation extends Kirchhoff’s law out of equilibrium by scaling the emissivity with the pump- dependent chemical-potential $\mu$, obscuring the relations between the body properties. Here we theoretically and experimentally demonstrate a prime equation relating these properties in the form of $\varepsilon = (1 - QE)$. At equilibrium, these relations are reduced to Kirchhoff’s law. Our work lays out the evolution of non-thermal emission with temperature, which is critical for the development of lighting and energy devices.
C. T. Liu

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High Performance III-V Quantum Well Laser Hybrid Integration with Silicon Photonics

Abstract
Our work on high performance III-V quantum well (QW) laser hybrid integration with silicon photonics will be presented [1,2]. III-V QW semiconductor optical amplifiers (SOAs) are used to realize light amplification, while silicon photonic circuits are chosen to act as the wavelength selective elements, and at the same time, to retain the compact footprint of the device. With the edge coupling method, we developed the hybrid III-V/silicon external cavity tunable laser with narrow linewidth and high tuning range, with the silicon double-ring vernier filter acts as the wavelength selective component. In addition, we also realized a mode-locked laser integrated with silicon photonic chips with controllable feedback loop. With this scheme, significant phase noise reduction was realized for GaSb-based passively mode-locked semiconductor lasers.

Keywords
Quantum Well Lasers, Silicon Photonics, Mode-Locked Laser, Hybrid Integration

References

Biography
Chongyang Liu received the Ph.D. degree in semiconductor photonics in 2004 from Nanyang Technological University (NTU), Singapore. From October 2009 to January 2012, he was awarded a Humboldt Fellowship (for experienced researcher) from Alexander von Humboldt Foundation for doing research in the Technische Universität Berlin, Germany in Prof. Dieter Bimberg’s group. He is currently a Principal Investigator with Temasek Laboratories, NTU, Singapore. His research interests include design, fabrication, and characterization of high power quantum well lasers, ultrafast quantum dot lasers, microwave photonics as well as their integration with Si photonics. He has authored and co-authored more than 120 technical articles in these fields so far.
Coherent Supercontinuum from Picosecond Pulses under Anomalous Dispersion

Abstract
Pumping with femtosecond (fs) pulses is widely considered to be a prerequisite to generate coherent super continuum (CSC) spectra [1]. From a fundamental point of view, under anomalous group-velocity dispersion (GVD), $\beta_2 < 0$, pulses experience self-phase modulation (SPM) and modulation instability (MI), and depending on the mechanism that dominates the propagation, their spectral broadening is either coherent or incoherent. In particular, MI tends to govern the evolution of picosecond (ps) or longer pulses resulting in incoherent regimes, hence the limitation to fs pulses to produce a CSC [1].

As noise amplifies owing to MI, this process should not exist to ensure a coherent pulse spectral broadening, which would not be possible according to the nonlinear Schrödinger equation (NLSE) [2]. In spite of this fact, if self-steepening, here referred to as first-order nonlinear-coefficient dispersion (FOND), $\gamma_1$, is taken into account, MI vanishes at very high powers [3]. Moreover, MI can also be cancelled using relatively low powers at wavelengths close to the 2-photon absorption (2PA) threshold, where the Kerr nonlinear index, $n_2$, shows a resonance [4], provided the stability condition $\gamma_1^2 > |\beta_2| \gamma_0^2 / (2\alpha)$ is satisfied [5], where $\gamma_0$ is the nonlinear coefficient at the pumping wavelength, and $\alpha$ denotes the propagation losses.

Using silicon’s $n_2$ measurements carried out in Ref. [4], a 340 nm height $\times$ 1600 nm width silicon waveguide surrounded by silica, which is foundry compatible, is designed so that its nonlinear
coefficient and GVD curves, plotted in Fig. (a), fulfill the stability condition at 2.3 μm with α = 50 m−1 (~2 dB cm−1). On the one hand, solving numerically the generalized NLSE [2], 5-ps-long pulses with 50 W of peak power are shown to preserve their coherence after a 2-cm propagation, see Fig. (b). Furthermore, Fig. (c) indicates that their coherence largely degradates when the n2 dispersion is neglected, which supports the crucial role of the FOND enhancement in Fig. (b). On the other hand, if the simulations corresponding to Fig. (b) are repeated using 1-ps-long pulses, then a CSC is generated, as can be observed in Fig. (d) [5].

Keywords
Supercontinuum, self-phase modulation, modulation instability, picosecond pulses, Kerr-index dispersion, silicon waveguides

References

Acknowledgements
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Biography
David Castelló-Lurbe is a Research Foundation-Flanders (FWO) senior postdoc fellow at the Faculty of Engineering of Vrije Universiteit Brussel (Belgium). He received his PhD degree in physics from Universitat de València in 2014 and joined Brussels Photonics group in 2015. His research focuses on nonlinear optics in guiding media, with a particular interest in the physics of supercontinuum generation. His contributions to this field include a theory describing nonlinear pulse dynamics in on-chip waveguides covered by graphene, a general measurement technique of the soliton number, a formalism to study the generalized nonlinear Schrödinger equation analytically, and the prediction of coherent supercontinuum from long pulses pumped in the anomalous dispersion regime. Some of these achievements have been published in Nature Communications, Laser & Photonics Reviews, and highlighted as Editors’ Pick in Optics Letters.
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Direct Hyperspectral Dual-Comb Imaging

Abstract

Direct dual-comb hyperspectral imaging is a very recently proposed technique intended for ultra-high precision spectroscopic imaging. The method provides a virtually unmatched combination of superfine spectral and high temporal resolution, and can be implemented in different wavelength ranges. Direct dual-comb hyperspectral imaging is based on the direct reading by a camera of a train of dual-comb interferograms. In this way, it is possible to recover a dual-comb spectrum from every single pixel of the camera sensor. Even though this idea is quite simple in principle, in practice the main technological challenge to address is the generation of two optical frequency combs with a mutual coherence that has to be high enough to generate interferograms with frequency components that are sufficiently low to be digitized by the camera sensor (regularly limited to a few tens or hundreds of images, or samples, per second). In the first demonstrations of the method, the mutual coherence issue was overcome by the use of electro-optic dual-comb generators. These particular dual-comb sources are mainly characterized by its simplicity, as combs are generated by the non-linear modulation, using electro-optic modulators from the telecommunications industry, of a monochromatic signal. In the same way, it is worthwhile mentioning that the method can operate with independence of the wavelength range; as a matter of fact, experimental validations in the near and mid infrared regions and the terahertz range have been demonstrated. In particular, in these latter demonstrations, non-linear processes were employed to shift the frequency range of the dual-comb signal from the 1550 nm range, in which many optical fiber telecommunication components are designed to operate, to the mid-infrared and the THz region.
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Master Equations for Laser Modelocking: Atomic Coherence, Dynamic Gain Saturation, and Boundary Conditions

Abstract
Modelocking is the fundamental method for producing optical frequency combs and laser pulses of very short duration, from tens of picoseconds to tens of femtoseconds, and with repetition rates in the MHz to GHz range. Their relevance in science and technology is enormous, so good modeling is crucial to design and tailor the desired properties, avoiding instabilities and other possible detrimental features. Generally, the master equation (ME) approach introduced by Haus in 1975 [1] is the default modeling tool. Haus ME owes its popularity to its simplicity, ease of use, and ability to incorporate different physical effects. However, using a ME is problematic when quantum coherence effects are involved, as in cascade lasers, or when material dynamics on the pulse time scale play a role, as in passive modelocking with slow saturable absorbers.

Recently, a novel approach to the modeling of active modelocking –the coherent ME– has been presented that incorporates both atomic coherence and fast gain dynamics, and can account for experimental observations that standard MEs cannot [2]. Also, two ME alternatives for passive modelocking in slow-gain media, such as solid-state, fiber, and semiconductors, have been communicated in the past two years [3, 4].

Here we present our results on what we believe to be the definitive ME for passive modelocking, based on the framework developed in [2], closing a half-century-old puzzle. The novel ME correctly incorporates gain and absorber dynamics at any relevant temporal scale, successfully accounting for the instabilities that affect modelocked pulses. A crucial part of the success comes from the exact periodic boundary conditions with which the novel ME is endowed. Periodic boundary conditions remove the challenge of describing modelocked states whose repetition rate is not fixed externally, but depends on the system dynamic state [3].

Keywords
Laser Mode Locking, Master Equation, Atomic Coherence, Fast Gain Dynamics

References
Biography
Germán J. de Valcárcel is a professor of Optics at the University of Valencia, where he teaches Quantum Optics, Nonlinear Optics, and Laser Physics. His main research interests include the theory of laser modelocking, the nonlinear dynamics of optical cavities, and its relevance to the generation of quantum states of light.
Isaac Sackey

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Selected Recent Advances of Optical Signal Processing Novel Concepts for Future Ultra-fast Optical Networks

Abstract

The quest for data-hungry immersive applications such as holographic communications, high-definition streaming telemetry, and ultra-fast high-data management services, for future optical networks is driving network operators to search for technologies that will revolutionize the existing network infrastructure. In this context, optical signal processing approaches have made significant advances towards the realization of the above goals including spectrum optimization [1], multiband transmission, and spectrally efficient fiber nonlinearity mitigation. Furthermore, the use of brain-inspired machine-learning assisted concepts (e.g. neuromorphic computing) in conjunction with small-scale planar waveguides, for optical signals, have no doubt led to novel use-cases including optical modulation format identification [2] and optical signal equalization [3]. Such applications scenarios are some of the key performance indicators for future autonomous networks. These novel advances coupled with the inherent benefits of optical signal processing such as high-speed, parallelism using multiple wavelengths, low-power and low latency, will pave way for efficient and ultra-fast optical systems. This talk will review and discuss some of the promising novel optical signal processing approaches that can be game-changing technologies for 5G and beyond optical communication networks.

Keywords

Multiband transmission, nonlinearity mitigation, neuromorphic computing, autonomous networks, optical signal processing, optical communication systems.

References

Biography
Dr.-Ing. Isaac Sackey received his PhD in Electrical/Computer Engineering in 2016 from the Technical University of Berlin. Since 2011, he has been working on R&D in optical signal processing, coherent transceivers, silicon photonics and neuromorphic computing, at the Fraunhofer Heinrich Hertz Institute, Berlin, Germany. Currently, he is a project manager and his primary focus is on physical layer optical networks.
Funded by the German Research Foundation (DFG) under grant FR 851/3-1, and the German Ministry of Education and Research (BMBF) under 6G-RIC Project with grants, 16KIS1281, 16KISK020K, and 16KISK030.
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Dental, Powder, Laser: Where Analytics Helps Best Treatment Option

Abstract
Today a new and modern professional prophylaxis method exists in dentistry to keep teeth clean and healthy: Guided Biofilm Therapy (GBT). This treatment protocol strongly refers to the use of a powder jet system (AIRFLOW) with specific powders to clean the teeth quickly, efficiently, and being minimally invasive. Nevertheless, mastering the powder flow of this system is a challenge to reach the perfect treatment comfort. To help the development of perfect powder jet system, the usage of green laser sheets together with the light scattering properties of airborne particles becomes a precious auxiliary to set up precise powder measurement methods in an industrial environment. Different tips and tricks to combine light measurement and dusty powder will be reviewed. This specific usage of accurate light measurement becomes the basis for happy users and satisfied patients with clean teeth [1].

Keywords
Powder, Light scattering, Dental, Prophylaxis, Airborne

References

Biography
Dr. Marcel Donnet is a Powder & Fluid Research Expert at EMS Electro Medical Systems SA (Switzerland). He is a chemical engineer with a PhD in Powder Technology. He has been carrying out academic as well as applied research for more than 20 years in interdisciplinary domains, including powders, fluids, chemical, medical and dental technologies. Over the 18 last years, his research passion was mainly directed to dental technologies to offer best clinical option for both user and patient. He is instrumental in all powder related device development at EMS. It is within the frame of this research that he developed his interest into laser field to enhance powder technology development.
Engineering Light’s Degrees-of-Freedom

Abstract
Arguably, one of the most, if not the most, important goal(s) of optical sciences is the ability to generate a desired optical field suitable for a given application. Stated otherwise, given light’s various Degrees-of-Freedom (DoF), the goal is to have the ability to engineer and control these DoF, which include light’s intensity value, intensity pattern, orbital angular momentum, state-of-polarization, wavelength, and so on.

In this talk, I will present two independent approaches aimed at achieving the aforementioned goal. I will begin with discussing an approach, which relies on the superposition of Bessel Beams to engineer light’s DoF in the paraxial regime. I will develop the theoretical foundation of the approach and show experimental results demonstrating our ability to engineer the light’s intensity values, pattern, polarization, orbital angular momentum, and wavelength along the beam’s axis of propagation.

Using a different approach based on the calculus of variations, I will then devise a boundary value problem the solution of which can be used to generate any complex values (phase and amplitude) optical field in three-dimensions. To be precise, given a desired complex-valued scalar or vectorial field, the theory guarantees to provide the required boundary conditions (for example, in the form of computer-generated hologram) that can be used to generate a scalar or vectorial optical field, that either:

a) is an exact duplicate of , or b) if , due to some fundamental physical laws is strictly forbidden, then is the closest approximate of , in L2 norm sense.

I will demonstrate the versatility of the approach via experimentally generating various desired optical fields in different media.
Laser-mediated production of ad hoc Ag/TiO nanoalloys for improving microfiltration membranes used for water reclamation from oily polluted sources

Abstract
The following talk will deal with the controlled synthesis of titanium-silver nanoalloys by Reactive Laser Ablation in Liquids; the methodology, which benefits from the possibility of performing an environmentally friendly one-step synthesis of the Ti-Ag-based nanoparticles.

Besides, this work aimed to find the optimal composition of the mentioned nanostructures for their subsequent use for the surface modification of PVDF microfiltration membranes, which were subsequently used for the purification of oil-polluted water. The nanoalloys prepared from the non-equilibrium conditions of the RLAL method exhibited an ultrasmall size of about \((7 \pm 2)\) nm and a specific structure that allowed providing superhydrophilicity of the PVDF membranes and oil rejection up to 97.9 %. Thus, a twofold improvement in oil separation performance and a much lower membrane fouling during the separation cycles could be observed compared to the decorated membrane.

However, since oils are not usually found alone in polluted water, the developed nanoalloys were additionally tested for their ability to fully degrade a persistent organic pollutant (4-nitrophenol), whose degradation leads to the formation of a drugs precursor known as 4-aminophenol. Since the prepared nanoalloys successfully solved both types of pollution, it is believed that the present study can serve as a solid basis for the design of future nanomaterials for the separation and treatment of oily polluted waters.

Acknowledgments
The Ministry of Education Youth and Sports in the Czech Republic supported the research presented in this contribution through the program Research Infrastructures NanoEnviCz (Project No. LM2018124).
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Overtone Sub-Doppler Spectroscopy of HD

Abstract
Molecular hydrogen is the quantum molecular system to benchmark for challenging the fundamental physics, i.e., the Quantum ElectroDynamics (QED), and the molecular Hamiltonians. Actually, soon or later, the accurate determination of the vibrational sequences of the molecular hydrogen isotopologues will open new perspectives for challenging the proton-to-electron mass ratio, the proton radius size, and even for testing the new Physics, i.e., the extra dimensions of the space and the constant variation over cosmological time, in the laboratory.

We will report on the recent experimental developments involving optical cavities, key environments to challenge weak transitions and/or the low pressure regime. The finesse of the cavity allows ‘amplifying’ the intensity of the electromagnetic field at level high enough to induce coupling between energy levels.

We will illustrate the sub-Doppler spectroscopy of weak dipole transitions (forbidden in the Born-Oppenheimer approximation) of the $v:2 \leftarrow 0$ overtone mode of HD at $\lambda \sim 1.38 \mu m$ by using the Noise-Immune Cavity-Enhanced Optical Heterodyne Molecular Spectroscopy (NICE-OHMS) technique locked against a Cs-clock referenced Optical Frequency Comb (OFC).

The experimental sensitivity ($\sim 10^{-12}/cm^{-1}/Hz^{1/2}$) allowed us to determine the frequency centre of a few transitions with an accuracy of the order of 20 kHz. However, the shape of the observed NICE-OHMS resonances suffers from controverted abnormal asymmetry (similar to Fano profiles) which may be attributed to several origins like the hyperfine level structure. This will be discussed. In this perspective, we have developed an effective Hamiltonian taking into account the hyperfine structure of the rotational levels (derived from ab-initio quantum chemistry calculations) which also provides Zeeman transition intensities. An analytical new saturation model (nonlinear spectroscopy) based on the interference of 2 counter-propagating electromagnetic fields (EMF) have been developed (in the electric dipole plane-wave approximation) associated with 3-level systems, by solving the Liouville/von Neumann equation. The V- and Λ-configurations, encompassing the Lamp-dips, the crossover resonances, as well as the recoil effects, between the Zeeman sub-levels have been considered to deal with the EMF polarizations (i.e., linear and circular). If the signal asymmetry cannot be explained by the sole interference, additional other possible origins will be discussed, as those due to collisions. Furthermore, the finite transit-time interaction requires for considering EMF beyond the monochromatic EMF, i.e., exhibiting Gaussian profile. This is specially required when considering the low pressure ranges.

References
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The Microlens Revolution in Automotive Lighting

Abstract
Refractive and diffractive micro-optical components are a very exciting novel approach for illumination in automotive lighting. The first application was a microlens-array-based projectors for a welcome light carpet (BMW) invented by the Fraunhofer IOF in 2014. Today, microlens arrays (MLA) are used for illumination and projection within head lights, interior and exterior lighting, rear lights and LiDAR. The preferred manufacturing technology is SUSS microlens imprint lithography (SMILE) using a mask aligner to imprint microlens arrays (MLA) or diffractive optical components (DOE) onto one or two sides of a glass wafer. Wafers with microlens arrays, aperture arrays, structured absorbers or other structures are the stacked in a mask aligner. We will present an overview of state-of-the-art of manufacturing technology and applications in cars.

Keywords
Microlens Array, Micro-Optics, Wafer-Level Optics, Automotive Lighting, Headlamp, Light Carpet

Biography
Reinhard Voelkel, CEO SUSS MicroOptics SA, is an executive with profound background in technology and innovation. He holds a Diploma and an PhD in Physics from the University of Erlangen-Nuernberg, Germany. He is expert for Innosuisse (Swiss Innovation Agency), member of EOS, Swissmem, EPIC, Sand Hill Angels, senior member of OPTICA (OSA) and fellow of SPIE. He has won the Swiss Manufacturing Award 2021 (HSG: Uni St. Gallen) and the CEO Award 2022 from EPIC, the European Photonics Industry Consortium.
Limits on Optical Device Performance

Abstract
As the use and need of computationally driven methodologies continues to grow throughout applied science, longstanding questions concerning optimality in device design continue to gain practical importance. Intuitively, limits exist on device performance in any moderately realistic description of physical phenomena. However, barring a small collection of celebrated results (the blackbody bound, the inherent uncertainty in complementary measurements, etc.), the extent to which physical limits impact attainable component performance is seldom clear.

In this presentation we will illustrate how the heuristic of Lagrange duality can be productively applied to the design of optical devices—revealing implicit bounds on what can be achieved by any device of a specified size and material composition. Discussed examples will include the maximization of radiative emission from a dipolar current source and toy optical “math-kernels”.
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Laser Processing of Silicon Carbide

Abstract
Nowadays, minimizing the conduction losses in discrete power devices is a fundamental requirement to reduce the overall energy consumption of modern circuits and power modules. In this context, owing to its physical properties, silicon carbide (4H-SiC) is a key material to fabricate low ON-resistance (RON) devices and to improve the energy efficiency in the next generation of power electronics systems. Clearly, in a 4H-SiC power device (e.g., a Schottky diode) besides the drift layer there are several contributions to the total RON. As an example, in a 650V SiC Schottky diode fabricated onto a 350 µm thick substrate, about 70% of the total RON is represented by the SiC substrate contribution[1]. On the other hand, by thinning the substrate to 110 µm allows to reduce this resistive contribution down to 44% of the total RON. This latter explains why for medium voltage applications (600-1200V), the wafer grinding step has become mandatory in SiC technology to reduce the substrate thickness and, hence, to minimize the total device RON. Therefore, it is also important to appropriately modify the standard devices fabrication flow to minimize the risk of breaking the thinned wafers during device fabrication, by keeping small and gentle (also in terms of thermal budgets) the processes carried out after grinding[2]. In this sense, laser annealing represents an alternative solution for achieving the back side ohmic contact formation with a limited heat transfer.

Keywords
Laser Annealing, 4H-SiC, ohmic contact

References

Biography
Simone Rascunà received the M.Sc. degree in Physic from the University of Catania in 2001. Since 2002 he works in the Research & Development organization inside STMicroelectronics for High Power Devices. From 2002 to 2010 he has been involved in the development of Silicon SuperjunctionMosfets technologies. From 2010 his main research is focused on compound semiconductor for High Power Applications. As Advanced Research Manager, he heads the design and development group for Silicon Carbide Diodes.

He is inventor of many patents in the field of SiC devices and coinventor of the patent for the realization of the fifth generation of the MDmeshSuperjunction technology. He is involved on several EU research projects, author of papers published on ISI journals and serves as referee for international scientific journals.
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Emission enhancement for red-emitting InGaN by nanocrystalline effects and surface plasmon coupling

Abstract
The realization of a micro-LED display, which is a next-generation self-emitting display, is expected. However, the emission efficiencies of red LEDs are quite low in addition to the high manufacturing cost. One method to solve these problems is the monolithic integration of micro-LEDs using columnar nanocrystals called nanocolumns (NCs). GaN NCs were discovered at Sophia University in 1997 and were initially fabricated by a self-assembly method. After that, Ti-mask selective growth method has been developed to control the position and size [1]. NCs exhibit effects unique to nanocrystals (nanocrystalline effects) such as dislocation filtering and strain relaxation, resulting in more efficient luminescence than planar quantum wells.

In this presentation, the nanocrystalline effects will be outlined, followed by the demonstration of a micro-LED display panel using the emission color change technique in NC arrays [2]. On the other hand, the internal quantum efficiency in the red region is approximately 20%, which is lower than those of other emission colors due to the increase of point defects, even if the NC structures are introduced. Therefore, the nanocrystalline effects alone are not enough to increase the red emission efficiency. As a technology to enhance red emission, we have developed NC plasmonic crystals (NC-PlCs), which can be introduced by post-process. Furthermore, the NC-PlC has the advantage that the surface plasmon polariton (SPP) resonance wavelength can be controlled by changing the diameter and period and can be shifted to the red region [3, 4]. The design method and properties for red emission enhancement will be presented.

Keywords
InGaN, Nanocolumn, Nanocrystalline effects Surface plasmon, Plasmonic crystal

References

Biography
Dr. T. Oto is an assistant professor at the Dept. of Informatics and Electronics in Yamagata University. After receiving a PhD degree at Kyoto University in 2014, I joined Prof. K. Kishino’s group in Sophia University as a postdoctoral researcher. In 2017, I took up his current position. I have studied the
optical characterization of InGaN based nanostructures and developed the emission enhancement from InGaN-based light emitters by SPP coupling.
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Design, Implementation and Applications of Laser Curve Beams

Abstract
Optical manipulation of micro-/nano-objects plays an important role in fundamental and applied physics, chemistry and biology [1]. Programmable optical transport of single and multiple particles along a desired trajectory is one of challenging problems in this field. The optical trajectories in 2D and 3D have to be robust, flexible in order to overcome obstacles and enable to transport particles en masse. Moreover, the programmable control of particle speed is also required. There are different mechanisms for optical particle movement, however, a structured beam approach is more versatile and less sensitive to particle type. The high intensity gradients of such beam exert forces to confine particles along a trajectory while especially designed phase gradients forces propel them along a desired route.

We have proposed a direct method for generation of laser beam, referred as polymorphic beam [2], which provides important degrees of freedom for the generation of laser curves of almost arbitrary 2D and 3D shape with independent control of its intensity, phase and polarization distributions. In particular, the phase design along the curve allows controlling the particle speed [3]. Such free-style laser trap is created by using computer generated holograms addressed into spatial light modulator which can be easily modified on demand paying a way to robotic-like particle transport. Its application for transport of dielectric and metal micro and nanoparticles have been experimentally demonstrated for different trajectory configurations [2-4]. The repulsor and tractor laser beams providing downstream and upstream particle motion along various open and closed curves have been achieved.

Free-style optical traps is also a useful tool for light-matter interaction study. The multiple particles can electrodynamically interact (e.g., plasmonic coupling or optical binding) with each other in an optical trap, via their mutually scattered light. Such interaction producing dimers and trimers have been observed during rotation of argent particles (radius 60 nm) in all-optical 3D trap [3].

The illumination of a metal nanoparticle with a wavelength close to the plasmon resonance transforms it into an efficient local heat source due to the enhanced light absorption. We have demonstrated the formation of a quasi-stable group of hot gold particles (radius 200 nm) whose motion around the laser trap and size was controlled by optical propulsion forces [4]. It has been observed that this moving heat source creates an optothermal convective fluid flow dragging tracers towards the particle assembly.
Keywords
Laser tweezers, micro-/nano- particle optical manipulation, optical matter.

References

Biography
Tatiana Alieva is a full professor of Optics at the Faculty of Physics of Complutense University of Madrid. Her current research focuses on design, generation and characterization of optical coherent and partially coherent beams, their application for optical particle manipulation and quantitative microscopy including phase retrieval and refractive index tomography. She has published more than 90 peer-reviewed papers, 18 book chapters, more than 130 contributions in congress proceedings, and 4 text books for undergraduate and master students. She was a chair and program committee member of several OSA and SPIE organized meetings. She served for six years as an associate editor of Optics Express and actually is a topical editor of Optics Letters.
Orthogonal Sampling for the Processing of High-Bandwidth Signals with Low-Bandwidth Integrated Photonic Devices

Abstract

New applications and services like 6G and beyond, the internet of things, autonomous driving and so on require increasing data rates in data centers, access networks and the communication backbone. To keep pace with the requirements, spectral efficient modulation and coding, advanced error correction and a parallelization of the transmission channels are used. All these approaches, however, rely on a massive electronic signal processing. For increasing data rates, the bandwidth of the processing has to increase, leading to a much higher power consumption of the networks. Additionally, to reduce the costs per transmitted bit, an integration of the data processing in low-cost platforms like silicon on insulator (SOI) is needed. But, the processing of high bandwidth signals in SOI is increasingly challenging.

For future networks new approaches, which allow the processing of high data rates with low-bandwidth integrated equipment are necessary. Here we review a method which is based on a sampling of the incoming signals with an optical bandwidth $B$ with sinc pulse sequences into $N$ sub-signals. These sub-signals can be detected and processed in parallel with photonics and electronics with a bandwidth of $B/(2N)$. Due to their inherent orthogonality, sinc-pulse sequences can enable an ideal sampling. Since the signal to noise and distortion ratio increases quadratically with a reduction of the bandwidth, lower bandwidth signals can be detected with an improved effective number of bit, further relaxing the requirements of the following electronic signal processing. No high-bandwidth devices, special photonics or electronics are required, thus, the method can be straightforwardly integrated into any low-cost platform and might enable a solution for the increasing bandwidth requirements of tomorrow's networks.

Keywords
Orthogonal Sampling, Optical Communications, Integrated Photonics

Biography

Thomas Schneider is the head of the THz-photonics group at the Technische Universität Braunschweig, Germany. He received the diploma degree in electrical engineering from the Humboldt Universität zu Berlin, Germany, in 1995, and the Ph.D. degree in physics from the Brandenburgische Technische Universität Cottbus, Germany in 2000. From 2000 to 2014 he was with the Hochschule für Telekommunikation (HFT) in Leipzig, Germany. From 2006 to 2014 he has been the head of the Institut für Hochfrequenztechnik at the HFT.
Dr. Schneider was a guest professor at the Swiss Federal Institute of Technology (EPFL), Lausanne, Switzerland, a guest scientist at the Deutsche Telekom Innovation Laboratories and the Fraunhofer Heinrich Hertz Institute Berlin.
Andrea Tognazzi
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Controlling Quantum dot Directivity by Mie Resonances In AlGaAs Nanostructures

Abstract
Controlling the scattering properties of sub wavelength particles is of paramount importance for application in the fields of optical science and technology, ranging from sensing to optical communications, and laser development [1]. In this research field, one of the most attractive topics is the possibility to shape in a flexible way the light emission pattern as it plays a crucial role for the development of nanoantennas, photovoltaic devices, and so on [2]. In recent years, dielectric nanoresonators proved to be valuable candidates to mold the radiation pattern of visible light.

In this work, we demonstrate that in truncated cone nanoresonators made of AlGaAs, since the directivity of the scattered electromagnetic field quantum dots embedded in the nanostructure depends on the emitter vertical position, it is possible to design the resonator in such a way that only forward or backward emission is supported.

The emission of the embedded quantum dot sources centered at 800 nm excite the nanoresonator electric and magnetic dipole modes, whose interference (optimized through geometrical consideration) results in the desired forward or backward emission, respectively. We employ full wave numerical simulations and multipolar decomposition to find the optimal quantum dot position for achieving the so called Kerker condition, which correspond to constructive or destructive interference of the magnetic and electric dipole components of the electromagnetic field [3]. The angle of the cone sidewalls determines if, by changing the quantum dot position, it is possible to achieve both forward and backward emission. Lastly, the truncated cone geometry is also compatible with wet etching nanofabrication technique, which is cheaper than dry etching.

Altogether the reported results pave the way to new strategies to efficiently control and exploit quantum dot emission at the nanoscale.
Keywords
Quantum dots, Nanoantennas, Dielectrics

References

Biography
Andrea Tognazzi got his Ph.D. at the University of Brescia in 2020 and then became a Post-Doc for 1 year at the same institution. He has been a Post-Doc at the University of Padova and he is currently a researcher at the University of Palermo. His main research interests include metasurfaces, nonlinear optics and tunability of nanostructures.
Yijie Shen
Yijie Shen, University of Southampton, UK

Geometry, Topology, and Space-Time “Entanglement” of Light

Abstract
Topologically structured light, using methods of topology to manipulate light patterns in higher dimensions, has recently attracted great interest for fundamental science and advanced applications. Meeting the increasing demand for information bandwidth in modern communication, more complex and tunable topological structures of light in quantum-classical regime provide the solution to encode large-capacity, high-speed, and secret information transfer. Especially, recent advance of structured light promised its ability to arbitrarily tailor multiple degrees of freedom (DoFs) of light, from conventional 2D transverse patterns to exotic forms of 3D, 4D, and even higher-dimensional modes of light, which break fundamental paradigms and open new and exciting applications connecting classical and quantum scenarios. The description of diverse DoFs of light can be based on different interpretations and exploiting of geometric transformation hidden symmetry in space-time, angular momentum, vector singularity, ray-wave trajectory, toroidal vortex, etc. Facing these important challenges, this talk reports new theories and techniques for generation, detection and application of spatiotemporally structured light, manipulating tunable DoFs and creating new classically entangled states in structured light towards multiple DoFs and higher dimensions.
Ultralow Noise Quantum-Dot/Dash Mode-Locked Semiconductor Lasers for High-Capacity Optical Networks

Abstract
We report semiconductor quantum-dot (Qdot) and quantum-dash (Qdash) passively mode-locked lasers (PMLL) developed in National Research Council Canada. The lasers are comprised of 350-355 nm thick InGaAsP (1.15Q) core embedding 5-layers of InAs Qdot or Qdash in the center surrounded with InP cladding layers. 2.0-2.3 µm ridge waveguides are formed by etching through the InP cladding. A Fabry-Perot cavity is formed by cleaving the cavity length corresponding to the laser mode spacing. No facet coatings are applied. The performance of optical spectrum, RIN, phase noise, RF beating note, and timing jitter with both dot and dash structures will be presented with discussion. For an InAs/InP Qdot-PMLL with 56 individual channels at a mode spacing of 28.4 GHz, the average of integrated RIN values for all filtered individual channels is from −134 dB/Hz to −127 dB/Hz and the optical linewidth (phase noise) is in the range 0.2-1.5 MHz. The 3-dB mode beating RF linewidth for all lines simultaneously is 650 Hz, and such an extremely low noise leads to excellent pulse-to-pulse timing jitter value of 2.1 fs. Applications of these PMLLL lasers for high capacity optical communication networks with high order PAM and QAM modulated data formats and 5G fiber-wireless integrated mobile front-haul are presented. These achievements may be a significant step towards low-cost, high wavelength channel count light sources for large-scale high-capacity optical networking systems.

Keywords

Biography
Youxin Mao received her Ph.D. in Opto-Electronics from Lancaster University, UK, in 1995. Since 2006, she has been a Senior Research Officer with National Research Council Canada and is the author of over 200 peer reviewed articles. Her research interests include ultra-low timing jitter quantum-dot mode-locked semiconductor lasers, PAM and QAM data format digital optical and wireless networks, high speed and high power wavelength swept laser, semiconductor laser package, ultra-small optical fiber probe, and optical coherence tomography.
Zonghua Liu

Zonghua Liu1,2*, Tomoko Takahashi3, Sarah Giering2, Blair Thornton1,4, Thangavel Thevar5; John Watson5

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Applications of Digital Holography in Marine Science: In-situ Measurement of Marine Particles and Data Processing

Abstract
The importance of microscale particles in oceans has been recognised by the Global Ocean Observing System [1]. They play a crucial role in the oceanic and global nutrient cycles, such as the oxygen and carbon cycles. More and more human-made micro-particles, such as micro-plastics appear in oceans and have caused serious pollution. Therefore, measuring their quantity and distribution at the spatial and temporal scales is very important for understanding oceans.

There have been many optical imaging techniques which can be used to measure these particles, such as microscopy, shadowgraphy and dark-field illumination. Digital holography is one technique, which, due to some outstanding advantages, has been commonly used to image and analyse marine micro-particles.

This presentation will show several digital holographic cameras I and my colleagues used or developed in my previous and current research, including eHoloCam, RamaCam, LISST-Holo and weeHoloCam. Some images recorded by them will be shown, and some data analysis based on the collected images will also be shown.

I will also talk about some limitations of the underwater holographic imaging systems. At the end, I will briefly introduce some popular research topics related to applications of digital holography in oceans.

Keywords
Marine Microparticles; Digital Holography; Holographic Data Analysis

References
Biography
Dr Zonghua Liu studied as a Ph.D. student at the School of Engineering in the University of Aberdeen, UK between October 2014 and June 2018. His study areas were holographic image processing, and pattern identification and classification in holograms. After graduating from the University of Aberdeen, he worked as a software developer in a company. Afterwards, he became a project researcher at the IIS in the University of Tokyo in April 2019. His main work was to develop a novel underwater imaging system combining the techniques of digital holography and Raman Spectroscopy. He will start a new job as an Ocean Computer Vision Scientist at the National Oceanography Centre (Southampton, UK) in June 2022.
Poster Presentation
A new diffractive multifocal intraocular lens with kinoform-fractal profile

Abstract
Presbyopia is a natural physiological process, associated with the aging of the eye, that results in progressively worsening ability to focus clearly on close objects. Consequently, defocus is the main source of image degradation due to insufficiency of accommodation caused by an increased hardness and decreased elasticity of the crystalline lens. Many often, presbyopic eyes develop cataracts (a cloudy area in the lens). In these cases, cataract surgery, i.e.; the removal of the crystalline lens and its replacement with an artificial multifocal intraocular lens (IOL), is the best solution for presbyopia.

In this presentation we evaluate the optical performance of a new trifocal intraocular diffractive lens which was designed using the fractal devil’s staircase function [1]. An optical design program (Zemax Optic Studio) was employed for the numerical simulation of the performance of the new IOL design in a realistic model eye (Liou-Brennan [2]) in which the crystalline lens, was replaced by the IOL under test, simulating the condition that occurs in cataract surgery. The new IOL design was tested for different pupil eye diameters. The point spread function (PSF) and the through the focus area under the MTF (MTFa) were used as merit functions.

Experimental results were also obtained with the new IOL design by means of an adaptive optics based visual simulator, (VAO, Voptica SL, Murcia, Spain) and the images of a test object at different distances provided by the IOL were registered with a high-resolution camera. An excellent agreement between the numerical and experimental results was obtained.

Keywords
Presbyopia, Multifocal Intraocular Lens, Fractal lenses.

References

Biography
Walter D. Furlan received his MS and Ph.D. degrees in physics from the University of La Plata, Argentina, in 1984 and 1988, respectively. He joined the Optics Department of the University of Valencia, Spain in 1990, where he is currently is full Professor of Optics. In the last years, he focused on the study of the properties of non-conventional diffractive optical elements. He co-authored more than 100 papers and 4 patents. Currently, co-director of the Diffractive Optics Group (DiOG).
a member of the European Optical Society.
Abstract
Plasmonic resonance in metallic nanoparticles has created exhaustive research efforts in nanoscale optics, photonics, and sensors in the last two decades. The resonance frequency of these metal nanoparticles strongly depends on geometry, size, and separation between nanoparticles. According to recent research, sample annealing results in the change in size and separation distance of the nanoparticles and subsequently it leads to a shift in their resonance wavelength. In this work, gold nanoparticles are prepared using a physical vapor deposition technique with different thicknesses on a SiO2 substrate. The samples are annealed at different temperatures and times, and their resonance wavelengths are compared. Moreover, SEM pictures determine the shape of the nanoparticles before and after annealing and their size and separation distances are measured using post processes software. In other hand, dependency of the gold nanoparticles resonance wavelength to their size and separation distances are simulated and compared with the experimental results.

This work was supported by projects 1/0733/20 of VEGA grant agency and APVV 20 0437 from Slovak research and development agency, all of Ministry of Education, Science, Research and Sport of the Slovak Republic.

Keywords
Plasmonic, SERS, Raman Spectroscopy, Nanoparticles, Gold
The GINGER Project

Abstract
GINGER (Gyrosopes IN General Relativity) is a proposal aiming at measuring the Lense-Thirring effect with an experiment based on Earth. It is an array of ring lasers, which are the most sensitive inertial sensors to measure the rotation rate of the Earth. Rotation and angular measurements are of great importance for various fields of science: General Relativity predicts rotation terms originated from the kinetic term, Earth Science studies the Earth’s angular velocity and all its variations, the tides and related perturbations, the normal modes of the Earth, the angular perturbations associated to the movement of the plates, the deformations of hydrological nature, without neglecting the rotational signals produced by the earthquakes. A ring laser integral to the Earth’s surface is sensitive not only to the angular rotation of the planet, but also to all the global and local rotational signals to which it is subjected. For this reason GINGER is relevant for geophysics.
The importance of the measurements feasible with GINGER depends on the effective sensitivity limit of ring lasers. Based on the data of our prototypes the effective sensitivity will be discussed.
Anna Chiara De Luca*

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SERS-bases Biosensors: Design and Biomedical Applications

Abstract
Surface-enhanced Raman spectroscopy (SERS) has received increasing research interest due to its excellent resolution, high sensitivity and rapid detection of low concentration analytes, particularly in biomedicine. Herein, I will provide an overview of recent developments and applications of SERS-based nanosensors and nanoreporters developed in our laboratory for use in biochemical monitoring, medical diagnostics, and therapy[1]. In particular design and fabrication of diatom-based plasmonic-active substrates will be discussed. Diatom microalgae are characterized by nanostructured silica shells, whose optical properties can be exploited in biophotonics and biomedical applications. Metallization of diatom biosilica, both in the shape of intact frustules or diatomite particles (DNPs), can trigger plasmonic effects that in turn can find application in high-sensitive SERS detection platforms, allowing to obtain effective nanosensors at low cost and on a large scale. Diatom-based plasmonic devices are developed for SERS imaging of cell membrane components with several exciting prospects including sub-diffraction resolution and single molecule sensitivity which would aid studies of trans-membrane transport dynamics[2]. A hybrid nanoplatform of DNPs decorated by gold nanoparticles and capped by a layer of gelatin was developed for monitoring the drug release in colorectal cancer cells at a femtogram scale by SERS[3]. The combination of the drug-loading capacity of DNPs with the strong Raman enhancement enabled combining therapeutic purposes with label-free intracellular drug monitoring.

Keywords
SERS, Biosensors, Diatomite Nanoparticles, cancer.

References

Biography
Anna Chiara obtained a master’s degree in Physics (2004), followed by a PhD thesis in the field of Biophotonics at Department of Physics, University of Naples “Federico II” (2008). In 2009, she joined K. Dholakia group at University of St Andrews as post-doctoral research fellow. Since February 2012, she joined CNR and the same year she has been appointed a tenured Research Fellow by the CNR. She is currently senior researcher director at IEOS, CNR and her research activity is focused on the development of new tools enabling enhanced Raman Spectroscopy for cancer cell
identification and imaging. She has published more than 80 papers in reputed journals. She has been recognized with numerous prestigious research grants, including the Grant from AIRC, Italian “future in Science” grant (FIRB), PON from Italian Ministry of Research and University, POR from Campania Region, Grant from Ministry of Health and @CNR grant.
Displacement and Vibration Measurement based on Self-Imaging Effect of Optical Gratings

Abstract
Recent interest in high-precision machining for mechanical devices and semiconductor chips has created a compelling need for the miniaturization of displacement and vibration measuring devices with high performance [1]. In past decades, optical gratings have been demonstrated as an effective platform for displacement and vibration sensors based on either phase or amplitude detecting mechanism, among which amplitude-detecting-based approaches have attracted continuous interests for compact structure and high stability [2]. In the cases, detecting is typically performed through moiré interference fringe image processing using high-performance CCDs and optimization algorithm [3]. Using gratings with relatively large period (over 10 μm typically), the method generally suffers from a limited resolution. Here, we report a new method for optical displacement and vibration detection based on the self-imaging effect of micrograting. We propose a double-layer micrograting structure, in which optical transmission of the structure is in sinusoidal relationship to relative displacement between the two gratings. Using a four-quadrant detector, a four-way signal output with a phase difference of 90° is successfully realized. And a subdivision circuit is used to achieve displacement and vibration detection with a high resolution up to nm level. Benefitting from a simple optical path, compact structure and high stability, the propose shows great potential in integrated displacement and micro-vibration detecting.

Keywords
Self-imaging effect, optical micrograting, displacement measurement, vibration measurement

References

Biography
Dr. Chenguang Xin is associate professor in School of Instrument and Electronics, North University of China. Dr. Chenguang Xin earned his doctorate in optical engineering at Zhejiang University in 2018. His research interests include nanophotonics and nonlinear optics, such as nonlinear optical
devices based on nanowires and micro-displacement sensors based on nano/micrograting.
Chet Raj Bhatt

Chet Raj Bhatt\textsuperscript{1,2*}, Daniel Hartzler\textsuperscript{1,2}, and Dustin McIntyre\textsuperscript{1}

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Underwater Laser-Induced Breakdown Spectroscopy (LIBS) in High Pressure Liquid Environments

Abstract

Underwater laser-induced breakdown spectroscopy (LIBS) is a promising technique for in-situ measurements in high pressure liquid environments. Many traditional analytical techniques such as ICP-MS require test samples to be collected and brought to a laboratory for analysis, resulting in significant delays in obtaining results and possible chemical changes to the sample during collection. LIBS, however, can be employed in situ to obtain results in minutes and avoid temperature and pressure changes that can occur during collection and result in changes to sample chemistry. In this presentation, underwater LIBS and its application for elemental analysis of liquid samples at both ambient and elevated pressure conditions will be discussed. Recently, the National Energy Technology Laboratory (NETL) has developed a field-deployable, prototype LIBS probe for subsurface measurements to detect groundwater contamination resulting from leakage at geological carbon storage sites. The working principle of this LIBS probe and an overview on the recent updates on the LIBS field measurements for continuous monitoring of ground and surface water will be presented.

Keywords

Underwater LIBS, LIBS, LIBS-Probe, High Pressure LIBS

Biography

Dr. CR Bhatt is currently a research scientist at US Department of Energy’s National Energy Technology Laboratory through LEIDOS. Dr. Bhatt completed his PhD and MS in applied physics from Mississippi State University USA and master’s in physics from Tribhuvan University Nepal. During his PhD, he received Oak Ridge Institute for Science and Education (ORISE) fellowship and later post-doctoral fellowship to work at National Laboratory. Dr. Bhatt worked as a R & D Scientist for AECOM for some time and then he was appointed as a research scientist at National Energy Technology Laboratory through LEIDOS in 2018. Primary research area of Dr. Bhatt is Laser spectroscopy and laser-based sensor development. Dr. Bhatt’s research group was awarded R&D 100 award in 2019. Up to 150 words
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Strain-Engineered Group-IV and Graphene Light Sources for Photonic-Integrated Circuits

Abstract
Strain engineering is widely used in the semiconductor industry to improve fundamental material properties such as mobility. However, the limited level of strain achievable in mechanically weak bulk-scale materials has allowed only incremental improvements in such material properties. At the nanoscale, these same materials can withstand extraordinarily large strains, thereby unlocking unconventional physical properties that are otherwise out of reach.

In this talk, I will discuss two interesting possibilities of strain-engineered nanostructures: direct bandgap Ge and GeSn for laser applications and Landau-quantized graphene under giant pseudo-magnetic fields. In the first part of this talk, I will introduce our recent progress on Ge and GeSn lasers integrated on Si [1-5]. I will discuss the potential applications of our on-chip lasers for quantum photonics applications. In the second part of this talk, I will present a variety of our innovative strain engineering platforms that can tailor strain distribution in graphene to allow creating pseudo-Landau levels [6-8]. I will end my talk by discussing the potential of our strain-engineered graphene for light sources by presenting our simulation results that show an optical net gain in Landau-quantized graphene.

Keywords
Strain engineering, silicon photonics, graphene photonics

References
Biography
Dr. Donguk Nam received his Ph.D. (2014) and M.S. (2012) degrees both in the Department of Electrical Engineering from Stanford University, and obtained a B.Eng. degree from Korea University (2009). After working as a postdoctoral scholar at Stanford University for one year, he joined Inha University, South Korea, as an Assistant Professor. In Aug 2017, he joined NTU as an Assistant Professor. His research works focus on developing quantum photonic devices and systems for integrated optical and quantum computing technologies. His research group has constantly published research outputs in high-impact journals including Nature Communications, which have been highlighted by a number of media and magazines including Channel NewsAsia (CNA) and Optics and Photonics News (OPN). Dr. Nam has served and is currently serving as a committee chair and member for several top international conferences such as CLEO, IEEE SUM, ECS Meetings, etc. He has also delivered 10+ invited talks at several top conferences including SPIE Photonics West and CLEO. He is currently serving as a Guest Editor for a special feature on 2D photonics at Optical Materials Express and also as an Overseas Editor at Journal of the Korean Physical Society (JKPS). His current research group has 10+ postdocs/staff/PhD students, who are supported by government funding from NRF, MOE, and ASTAR.
Ehab Awad  
Electrical Engineering Department, King Saud University, Saudi Arabia  

Recent Progress in Optical Nanoplasmonic Antennas

Abstract

Infrared optical detection devices like solar cells, photodetectors, microbolometers, and cameras are becoming tiny in size with an active area in the micro/nanometers range. That results in a smaller device aperture area and thus poor collection of infrared energy. Therefore, infrared plasmonic optical antennas are becoming essential to efficiently collect optical energy from freespace and concentrate it down to tiny devices’ areas. However, it is required to develop plasmonic antennas with a broad bandwidth, polarization insensitivity, wide field-of-view, and reasonable plasmonic losses. That can ensure the collection of most infrared and enhanced power absorption efficiency. In this talk, some types of plasmonic antennas are explored with an emphasis on an innovative type of optical antenna called Bundt optical antenna (Optenna). This Optenna has a novel shape that looks like a Bundt baking pan and it is made of gold. This Optenna utilizes surface plasmons to squeeze both electric and magnetic fields of infrared radiation down to a 50 nm wide area. Thus, it can enhance infrared absorption efficiency within a thin-film absorbing layer or guided graphene metamaterial. The Optenna demonstrates polarization insensitivity and ultra-broad bandwidth with a possibility for operation within the near, short-wave, or mid-wave infrared band. The Optenna can have a remarkable enhanced power absorption efficiency and a wide field of view. It is promising for applications in energy harvesting, imaging, sensors, free-space optical communications, and biomedical technology.
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High-Brightness and High-Speed VCSEL Array for Communication and Sensing

Abstract
High brightness and high-speed VCSEL array plays important role in the fields of sensing and communications. The high brightness beam with narrow divergence angle can minimize the diffraction loss in the receiver-ends. There are three major ways to increase the brightness of beam output from VCSEL array. First is to reduce the mirror reflectivity for a higher output power, however, this approach results in the increase of RIN and seriously degrades the quality of eye-patterns under large signal modulation [1]. The second is to narrow down the divergence angle of far-field patterns (FFPs) of VCSEL outputs. However, the reported solutions for FF patterns narrowing usually lead to spatial hole burning effect and un-desired low-frequency roll-off in the E-O response [2]. The third issue is to reduce the size of light-emission active area, which can be realized by minimizing the spacing between neighboring unit VCSEL in the array. In this work, we demonstrated a novel VCSEL array structure, which can have a compact device active area, FFPs with narrow divergence angles, and high-quality eye patterns under large signal modulation. Figure 1 (a) and (b) shows the top-view of our demonstrated array structure (Device A: dual pads) and reference one (Device B: single pad). Here, the pitch size between different light-emission apertures in both devices is the same and as small as 20 mm. As can be seen, compared with the traditional VCSEL array (B), the unique point of our one is that we have dual pads for DC and DC+RF current injections, respectively. Figure 1 (c) and (d) shows the measured L-I curves of such two devices. We can clearly see that device A can have a higher output power (44 vs. 40 mW) than that of device B under the same total bias current (240 mA). Figure 2 (a) and (b) show the measured near- and far-field 1-D and 2-D patterns for device A and B. We can clearly see that both devices exhibit Gaussian FFPs with the same value of narrow divergence angle. Figure 2 (c) show the measured E-O responses and their insets show the corresponding eye-patterns at 13 Gbit/sec. As can be seen, device A can have a more flatten E-O responses and much better quality of eye patterns than those of device B. Overall, the demonstrated device structure opens new possibilities for VCSEL array with higher brightness output with better eye-openings at higher modulation speed.

Keywords
VCSEL, VCSEL Array, Optical Wireless Communication
M. Csete
B. Bánhelyi¹,2, A. Szenes¹,2, D. Vass¹,2, E. Tóth¹,2, O. Fekete¹,2 and M. Csete¹,2*
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Optimized Active Plasmonic Resonators

Abstract
Configuration of active plasmonic nanoresonators was optimized to design near-field amplifier, spaser and nanolaser, as well as efficient out-coupler. The geometry of individual nanoresonators with metal-gain and dielectric/gain-metal-gain core-shell composition, periodic and complex patterns was tuned to plasmonically enhance stimulated dye emission. The field-enhancement, optical cross-sections and responses were monitored to find pump and concentration regions with potential to enter into different operation regions. Finally, the concentration was optimized to improve lasing characteristics. (a) Individual nanoresonators coated by gain material can be tuned on demand to maximize near-field and to improve out-coupling. Spaser transition occurring above composition dependent thresholds is accompanied by strongly coupled localized modes that result in more uniform far-field emission. (b) Coupled long-range plasmonic modes in optimal azimuthal orientation and tilting of 1D periodic structures enhance stimulated emission location selectively and maximize out-coupling direction specifically. (c) Spectrally split enhancement of emission is achieved and boosted in the gap of coupled localized–propagating modes on 2D complex patterns.

Keywords
plasmonic nanoresonator, coupled modes, optimal configuration, dye concentration

References

Biography
Dr. Mária Csete is a senior research fellow at the University of Szeged, Hungary, where she has received PhD in physics in 1999. She was a predoctoral fellow at the University of Ulm (1998-2000), and a visiting postdoctor at the Research Laboratory of Electronics, MIT (2008-2010). Present research topics in the Group for Nanoplasmonics involve plasmonic resonator configuration optimization to enhance light-matter interaction phenomena: spontaneous and stimulated light emission, nanolasing and superradiance, infrared photodetection, biosensing, lithography. Fields of her expertise are design and optimization of plasmonic architectures via theoretical methods (FEM, FDTD). She has accomplished several experimental projects on spectroscopy (SPR), microscopy (AFM) and application of laser-systems.
Flat Far-Field and Reusable Delay-Lines Arrayed Waveguide Gratings (RDL-AWG’s) for Astronomy and Quantum Information

Abstract

We present our work on arrayed waveguide gratings performed on the SiN/SiO2 platform for applications in astronomy and quantum information. One of the major objectives of the emerging field of astrophotonics is the miniaturization of next-generation astronomical instrumentation by leveraging the integrated photonics platform. On this SiN/SiO2 platform, we typically observe a loss of 0.02 dB/cm. In particular, we discuss flat far field arrayed waveguide gratings (AWG’s) based on three-point astigmatically compensated AWG. Such a flat field AWG allows for the use of detector arrays butt coupled to the AWG. Here we design a flat-focal-field AWG with 21 output channels and 51 array waveguides on a 100 nm Si3N4 platform. We demonstrate AWGs with resolving power of 3000 and 5000 and we observe no-reduction of the resolving power for the edge channels. The spectrum simulation of the designed flat-focal-field AWG is realized by using Synopsys RSoft and Matlab software. This design provides a solution for a flat-focal-field spectrometer. In separate work, we demonstrate a completely new approach to realizing an AWG which dramatically decreases the size of the AWG and increases their uniformity. In traditional AWG’s, a constant path difference is introduced between adjacent waveguides. The longest waveguide in the arrayed waveguides is at least, where is the operating wavelength and R is the resolving power. This implies that to achieve a high resolving power on-chip AWG spectrometer requires an increase in the optical path length of the arrayed waveguides. Not only does this result in an increase of the footprint of the device, but also, more importantly, it leads to optical phase errors that are generated by fabrication imperfections which can become a significant issue. For this reason, active correction of waveguide phase errors based on integrating electro-optic or thermo-optic phase shifters in high-R AWGs are typically used, which increases the complexity for fabrication and testing. To break the ultimate limitation in achieving high-R, we present the AWG with reusable delay lines. Unlike the traditional AWGs, where the phase distribution is introduced by an array of waveguides with different lengths between two free propagation regions (FPRs), one single waveguide is used to provide the phase distribution by an array of embedded directional couplers (DCs). The footprint of the spectrometer is significantly reduced. It eliminates the need for making large AWGs and the associated step of actively compensating the phase error. The purpose of the DC array is to generate the power and phase distribution that feed into the FPR. We have designed, fabricated, and characterized two AWGs with reusable delay lines. Both of them are fabricated on an ultra-low loss Si3N4/SiO2 on a silicon platform. The targeted R value are 10,000 and 29,600. The measured R at 1550 nm is 8,812 and 27,780, respectively, which is in good agreement with the simulated results. The footprint of the fabricated devices are reduced by factors of 22 and 71, respectively, as compared to the traditional AWGs.
Keywords
Arrayed waveguide grating, integrated spectrometer

Biography
Mario Dagenais is received the Ph.D. degree in Physics from the University of Rochester in 1978 working in Quantum Optics under the direction of Professor Mandel. He made the first observation of photon antibunching. He was a Research Fellow at Harvard University from 1978 to 1980, where he worked in nonlinear optics with Professor Nicolaas Bloembergen. From 1980 to 1987, he worked at GTE Laboratories. He joined the University of Maryland in 1987 where he has been Professor of Electrical and Computer Engineering since 1991. He has more than 300 archival and conference publications. He has co-chaired several national and international meetings. He was associate editor for Optics Letters, Applied Optics and IEEE Photonics Journal. Professor Dagenais was VP membership for the Americas for the IEEE Photonics Society. Professor Dagenais is a Fellow of the Optical Society of America, a Fellow of IEEE, and a Fellow of the Electromagnetic Society.
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Nonlinear Photonics Based on Thin-Film Lithium Niobate

Abstract
Lithium niobate (LN) is an excellent nonlinear photonic material due to its large electro-optic (EO) coefficient, second order and Kerr (\(\chi^2\)) nonlinearity, along with a wide optical transparency window. Thanks to the recent advances in nanofabrication technology, monolithic LN waveguides with high optical confinement and ultralow linear loss has been achieved, which was critical to the success of the silicon-based platform in the past decade. Highly efficient and controllable light-matter interactions can be achieved using optical, electrical, or mechanical waves at extremely compact footprints. In this talk, I will review our recent developments of thin-film LN nonlinear devices for frequency-based parametric frequency conversion, high power EO frequency combs, femtosecond pulse synthesis and spectral-shaping of single photons. Combination of multiple nonlinearities of LN unlocks an ultrabroadband electromagnetic spectrum from microwave to mid-infrared. Lastly, I will discuss the potential of LN photonic platform for scaling up and accelerating classical and quantum technologies in sensing, photonic computing, and communication networks.
Multisoliton Pulse Breakup: Approximations and Instabilities

Abstract
In nonlinear media with positive Kerr nonlinearity, which is described by the Nonlinear Schrödinger Equation (NLS), the pulses break into solitons and radiation. Emerging soliton parameters are determined by eigenvalues of the Zakharov-Shabat scattering problem (ZS), which usually has intrinsic instability issues for multisoliton pulses. Mathematically, this is due to the non self-adjoint character of ZS operator. Because of this character, little is known about general properties of the spectrum for a given initial pulse with phase variation (for real one-hump pulses the spectrum is purely imaginary). We discuss the application of WKB approximation method to the ZS problem. It works well for smooth multisoliton pulses with big amplitude, with or without phase modulation. Typical for WKB, for the fixed pulse shape, the error scales as inverse pulse amplitude. Different from standard quantum mechanical applications, the complex form of WKB has to be used, which includes complex roots and integration over closed line in a complex plane. For the case of one-hump pulses with big amplitude and limited phase variation, the approximate ZS eigenvalues lie on a single line in the complex plane. For this case, the integration can be performed along the real axis interval, and analytic expressions are available for some phase-modulated pulses [1]. This approximation proved to be helpful in finding a new exactly solvable potential for ZS problem [2]. Another case, which admits simplification, is moderate amplitude and big phase variation, for which the solitons are formed in the directions of interference fringes [3]. If both amplitude and phase variation are big, bifurcations are possible; there are two typical scenarios for symmetric pulses, the first one involves three roots, and produces Y-shaped spectrum, the second includes four root interaction, and can produce a spectrum with a loop. Integration over line between two roots with big imaginary part means, that small harmonic perturbations of initial shape grow exponentially with analytic continuation, which produces big changes in soliton parameters for pulses which have both high amplitude and strong phase variation [1,3].

Keywords
Kerr nonlinearity, Zakharov-Shabat scattering problem, Solitons, WKB method, Instability

References
Biography
Dr. Nikolai Korneev graduated from St.Petersburg (Leningrad) State University, Russia, in 1985. In 1994 he received Ph.D. in solid state physics from A.F.Ioffe Physical-Technical Institute, St. Petersburg. Since 1994 he works as a researcher at the National Institute of Astrophysics, Optics and Electronics (INAOE), Puebla, Mexico. His scientific interests are theoretical and experimental studies of nonlinear propagation in fibers, photorefractives and atomic gases, interferometry, chaos theory and photoconductivity.
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Magnetooptical Properties of the Plasmonic Nanostructures with Spatial Symmetry Breaking

Abstract

Magnetooptical effects find their applications in many systems. Optical properties are managed by external magnetic field and otherwise the magnetic response of the medium is governed by the optical pulse coming through. Here we address how the magnetooptical effects can be controlled by the symmetry of the magnetoplasmonic nanostructure. The spatial symmetry breaking provides ample opportunities for the engineering of their magnetooptical properties. Nonsymmetric plasmonic patterning violates the reciprocity of the spatial direction along the optical mode propagation. As a result, the excitation of the SPPs and related magnetooptical effects turns to depend on the asymmetry of the plasmonic grating. Recently in [1,2] it was shown the novel transverse magnetophotonic effect in transmission (or TMPTE) that reveals itself as a modulation of the magnetooptical response of the nonsymmetric magnetic nanostructures even in case of the normal incidence of light. In [2] it was demonstrated that the plasmonic patterning can be optimized to achieve the most intensive effect. Apart from the plasmonic patterning, the ferrimagnetic layer can provide the spatial symmetry breaking by the spatial modulation of its magnetization. Magnetic domains, spin waves, etc. lead to the nonsymmetric distribution of the magnetic properties of the layer inside one plasmonic period. The TMPTE can be supported also by symmetric plasmonic grating combined with nonsymmetry of the ferrimagnetic layer [3]. Moreover, the Faraday effect can be enhanced in the magnetic nanostructure composed of symmetric plasmonic grating and nonsymmetrically magnetized layer. Vice versa, the mentioned effects can serve for the detection of the magnetization modulation in the material. For instance, the reported effects facilitate the spectrally selective detection of the spin waves. The work was supported by Russian Science Foundation (project no. 20-72-10159).

Keywords

magnetooptics, spatial symmetry breaking, plasmonics, surface plasmon polaritons.

References

Biography
Dr. Olga Borovkova is a specialist in areas of photonics, magnetooptics, and plasmonics. She obtained her PhD degree in the Institute of Photonic Sciences (ICFO) in Barcelona. Her PhD thesis was devoted to the nonlinear effects in the engineered materials and reported the novel properties of solitons. Then, her area of interest shifted from the structures engineered in micron scales to the nanostructuring. She investigated the magnetooptical effects in various magnetoplasmonic settings, like ultrathin magnetic films, ferrimagnetic layers with gain, magnetic quantum wells, magnetoplasmonic nanostructures with broken spatial symmetry. Dr. Olga Borovkova has been published about 50 papers in peer-reviewed journals.
Femtosecond-Laser Texturing as a Powerful Tool to Tailor Surfaces’ Optical Properties in Wide Spectral Ranges

Abstract
The use of high power pulsed lasers is an effective tool for microstructuring material surfaces. It appears particularly useful when the material has some characteristics making difficult using other procedures (e.g. a high hardness). The present work reports on the femtosecond-laser treatment on tantalum diboride ultra-high temperature ceramics with different starting porosity fractions. The interaction with the laser beam creates a pattern with a complex multi-scale structure on the ceramic surface, whose characteristics depend on accumulated laser fluence and pristine porosity. Optical properties are significantly changed, allowing to separately optimize the interaction of the material with electromagnetic radiation spectrally located in different regions. As a case study, we apply the proposed strategy considering high-temperature solar thermal absorber applications, where the independent management of UV-Visible-Near IR radiation (sunlight) and Mid-IR (thermal radiation at the operating temperatures) are required. The correlation between the typical sizes of the realized multi-scale structures and the optical parameters (solar absorptance and thermal emittance in our example application) is discussed using an original predictive approach. The method here shown can be extended to every situation where materials are required to simultaneously interact with electromagnetic radiation in various spectral ranges.

Keywords
surface texturing; multi-scale structures; multi-range optimization; high-temperature solar receiver; CSP; borides

References
Biography
Elisa Sani, PhD. (ORCID ID: 0000-0001-9854-2892), is Researcher at INO-CNR, Italy. Her research activity is focused on optical properties of materials, in particular solids for high-temperature solar thermodynamic exploitation, colloidal suspensions for mid-temperature solar thermal, optical property tailoring of surfaces, fundamental optical constants of liquids, as well as nonlinear optical phenomena in liquids and colloids and solar-enabled hybrid power generation in different materials and by different effects. Co-author of 112 papers in peer-reviewed international journals, 2 book chapters, 3 patents. Editorial Board member of the journals: Scientific Reports, Energies, Applied Sciences, Energy Storage & Saving.
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Nanowire LEDs and Lasers for Microdisplays and UVC Emitters

Abstract
Submicron-scale, high-efficiency, multicolor light sources monolithically integrated on a single chip are required by the display technologies of tomorrow. GaN-based LEDs are bright, stable, and efficient but are produced in one color across an entire wafer. And achieving efficient green and red LEDs using GaN-based technology has proven stubbornly difficult. But InGaN nanowire structure studies have shown promise to solve such critical challenges. Nanostructured LEDs exhibit low dislocation densities and improved light extraction efficiency. Multicolored emission can be demonstrated from InGaN nanowire arrays integrated on a single chip. Thus, display technologies based on nano-LED pixel arrays integrated on a single chip could become the ultimate emissive light sources for three-dimensional (3D) projection displays, flexible displays, virtual retinal display (VRD) technologies, and disinfection with ultraviolet light in the UVC wavelength range. The emission cone and direction can be tailored by the one-dimensional columnar design of each nanostructure, essential to realizing ultrahigh definition displays. In addition, arrays of nanowires can operate at extremely high current densities, which has been utilized to make record-low threshold green surface-emitting lasers. Critical to these emerging technology areas is the realization of full-color, tunable emitters, including LEDs and lasers, on a single chip. This requires fine tuning of alloy composition in different nanostructured regions, and that these compositional variations are made in a single process step. Dr. Coe-Sullivan will describe how monolithic integration of single nanowire, multicolor LEDs on a single substrate can be achieved by incorporating multiple InGaN/GaN quantum discs in GaN nanowires of various diameters grown in selective area epitaxy in a single MBE process step. Red, orange, green, and blue InGaN/GaN nanowire LEDs are formed simultaneously on the same chip, with representative current-voltage curves and strong visible light emission. This offers a new avenue for achieving multiprimary optoelectronic devices at the nanometer level on a single chip for many applications, including imaging, micro-LEDs, microdisplays, sensing, spectroscopy, communications, and UVC disinfection.

Keywords
LEDs, microdisplays, nanostructures, nanowires, nano-LEDs

References
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Shaping Free-space Emission with Monolithically Integrated Metasurfaces on Silicon Photonic Waveguides

Abstract
We develop a platform to integrate metasurfaces on top of silicon photonic waveguides. This platform addresses the need for versatile shaping of free-space emission, while maintaining the CMOS compatibility and monolithic integration of silicon photonics. The metasurfaces are composed of amorphous silicon nanopillars evanescently coupled to the guided mode of the waveguide, as shown in Fig. 1(a). By changing the radius of the meta-atom, we can control the emission phase. We demonstrate diffraction-limited beam focusing with a Strehl ratio of 0.82 (Fig. 1(b)) and versatile holographic projection (Fig. 1(c)). Our platform enables precise delivery of free-space emission to detect or manipulate external objects. Applications include LiDARs, free-space optical communications, optogenetics, and quantum photonics.

Figure 1. (a) Device schematic. Measured focusing profiles (b) and holographic projection (c).

Keywords
silicon photonics, metasurfaces, holography
References

Biography
Prof. You-Chia Chang received his Ph.D. in Applied Physics from University of Michigan in 2016. From 2016 to 2018, he worked as a postdoctoral research scientist at Columbia University. He joined the faculty of Department of Photonics, National Yang Ming Chiao Tung University in 2018. His research interests include silicon photonics, metamaterials, and 2-D materials. In 2018, he was a recipient of the Jade Mountain (Yushan) Young Scholar Award.
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Photonic Nanojet Mediated Backaction on Biological Cells

Abstract

Light photons carry momentum and exert forward radiation force on the microparticle [1]. The optical pulling is quite challenging, and attracts great interests in the past decade. Dielectric microparticle concentrates light into sub-wavelength photonic nanojet (PNJ) [2, 3]. We observed the PNJ-mediated backaction on the dielectric particle owing to the light absorption inside PNJ [4, 5]. The backaction force is the consequence of light absorption and thermal conductivity of the surrounding medium [4]. We also observed the hysteresis on the backaction force owing to the distinguishable temperature response between the global and local medium [6]. Despite the force direction is reversed in contrast to the traditional scattering force, the magnitude of force is greatly augmented due to the light focusing by microparticle. Consequently, the PNJ-mediated force takes place with even collimated beam, and one direct advantage is that the collimated beam can produce large-scale manipulation of microparticles. In combination with multiple beams, the magnitude and direction of velocity can all be readily controlled [7]. Such tool can be applied for biological cell manipulation and high-throughput classification. In contrast to the ultrashort pulse induced breakdown [8] or plasmonic mediated heating [9,10], the PNJ-mediated backaction force works at moderate light power density, which alleviates the photodamage on the microparticle. Our observation is significantly useful for manipulation and inspection of massive biological cells.

Keywords

Photonic nanojet, pulling force, optical manipulation, cell classification

References

Biography
Dr. Ren graduated in the University of Science and Technology of China in 2012. He then worked in the Institute of Biochemistry and Cell Biology as an assistant researcher. He did Post-Doc research in San Francisco State University and the University of Hong Kong before he took the current position as associate research Professor at Fudan University in 2021. He had a broad interest in fluorescence microscopy, optical trapping and manipulation, and nonlinear optics. He has published over 50 scientific papers with a google scholar citation over 1200.
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