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June 03-05, 2019

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Keynote Presentation

Spaceflight Laser and Photonics Technology

Michael A. Krainak

NASA Goddard Space Flight Center, MD

Abstract

NASA continues to develop space-based laser instruments and systems for science and exploration. We give a brief overview of laser technology on the Ice, Cloud & land Elevation Satellite-2 Advanced Topographic Laser Altimeter System (ICESat-2/ATLAS), the Laser Communication Relay Demonstration (LCRD) and the Global Ecosystem Dynamics Investigation (GEDI). We discuss laser technology for the upcoming Laser Interferometer Space Antenna (LISA) mission, a proposed Earth mesospheric temperature lidar, a robotic servicing laser imager, plans for space-based optical communications and more.

Biography

Michael Krainak received his BS in electrical engineering from Catholic University and MS and PhD in Electrical Engineering from Johns Hopkins University. He started his career at AT&T Western Electric. He worked for ten years at the National Security Agency. For the past twenty-five years he has worked at NASA Goddard Space Flight Center in the Lasers and Electro-Optics Branch. In 2001, he worked one year at the semiconductor laser start-up - Quantum Photonics Inc. He is the NASA representative to the American Institute of Manufacturing (AIM) Integrated Photonics Consortium. He is the Head of the Laser and Electro-Optics Branch at NASA-GSFC.

Giant, Ultrafast Nonlinear Refraction in Indium-Tin-Oxide at Epsilon-Near-Zero

David J. Hagan*, Sepehr Benis, Natalia Munera and Eric W. Van Stryland

CREOL, The College of Optics & Photonics, University of Central Florida, Orlando, FL

Abstract

We present beam deflection measurements to study the nondegenerate nonlinear refraction of highly doped semiconductors at epsilon-near-zero (ENZ) for several different pump and probe polarizations. Beam deflection is sensitive to induced optical path length as small as $1/20,000$ of a wavelength, which enables us to resolve NLR in the presence of large nonlinear absorption backgrounds. The optically induced index changes in these materials can be both very large (on the order of unity) and fast (on the order of 100 fs). Our results show that carrier redistribution effects dominate the nonlinear refraction, and by independently tuning the pump and probe wavelengths, we find that the strong wavelength dependence of nonlinearities around the ENZ point is quite different for pump and probe waves.

These nonlinear optical properties, where the ultrafast index change can be larger than the linear index, offer new paradigms for dynamically switchable diffractive elements that respond to structured light, allowing manipulation of optical beams in transmission and reflection not only along the two spatial dimensions but also in time. This is a revolutionary change in the field of nonlinear optics allowing a myriad of potential applications, ranging from rapid all-optical beam steering and switching, to spectral scanning, spatial mode conversion, as well as pulse shaping and suppression, all on sub-picosecond time scales.

Biography

David J. Hagan received his PhD degree in Physics at Heriot-Watt University, Edinburgh, Scotland in 1985. After a brief spell as research scientist at the University of North Texas, he moved to UCF in 1987 as a founding member of the CREOL faculty. He is currently Pegasus Professor of Optics and Physics and serves as Associate Dean for Academic Programs. He is currently executive Editor-in-Chief of Chinese Optics Letters and was the founding Editor-in-Chief of Optical Materials Express. His current research interests include nonlinear optical materials, especially semiconductors and organics, applications of extremely nondegenerate nonlinear optics, and techniques for nonlinear optical characterization and spectroscopy. He is a Fellow of OSA and SPIE.

THz Multi-Beam Source by a Phase Grating and a Quantum Cascade Laser for Space Applications

Jian-Rong Gao^{1,2}, B. Mirzaei², J. R. G. Silva^{1,2,3} and Y. Gan^{1,3}

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²*Delft University of Technology, The Netherlands*

³*Kapteyn Astronomical Institute, University of Groningen, The Netherlands*

Abstract

The sensitivity of terahertz (THz) heterodyne receivers approaches to the fundamental quantum noise limit, so there is limited room to improve the observation efficiency of the single pixel heterodyne instrument. A multi-pixel receiver increases the spatial observing efficiency considerably by speeding up the mapping process in comparison with a single pixel instrument. This technique makes the key advancement of NASA's science mission GUSTO (Galactic/X-galactic Ultra-duration-balloon Spectroscopic/Stratospheric Terahertz Observatory) over its pathfinder STO-2 (Stratospheric Terahertz Observatory-2). GUSTO will map three fine structure emission lines of N[II] (1.4 THz), C[II] (1.9 THz) and O[I] (4.7 THz) each using an 8-pixel array to uncover the life cycle of the interstellar medium. A multi-pixel receiver depends critically on the array local oscillator (LO), by which an array of mixing detectors should be pumped uniformly and simultaneously.

We have pioneered the multi-beam LO using a 4.7 THz quantum cascade laser (QCL) as the input single beam, but a Fourier phase grating to generate 8 uniform beams, which are demanded by GUSTO and future space missions. QCLs are the only supra-THz LO-qualified sources. A phase grating can generate multi-beams by phase manipulation of the incoming beam and multi-copying it to the far-field. We will share our knowledge/progress on the simulation, manufacture, and characterization of phase gratings, and the demonstration of the 8 beam using a QCL. We will also highlight GUSTO mission and the future space missions.

Biography

Jian-Rong Gao is a senior instrument scientist and a section manager at SRON. He is also a part time faculty member of Quantum Nanoscience at TUD and a theme leader on space sensing at TU Delft Space Institute. He is a Co-I for NASA GUSTO balloon observatory. He is a co-chair of the Millimeter, Submillimeter, and Far-Infrared Detectors and Instrumentation for Astronomy conference, SPIE Astronomical Telescopes and Instrumentation. He has more than 250 papers on phase gratings, superconducting hot electron bolometer mixers, THz quantum cascade lasers, TES for FIR and X-ray, space instrumentations, KIDs, SIS mixers, nano-physics.

Linear Frequency Conversion in Rapidly Time-variant Metasurfaces

Bumki Min

Mechanical Engineering, Korea Advanced Institute of Science and Technology (KAIST), Republic of Korea

Abstract

The energy of an electromagnetic wave is converted as the wave passes through a temporal boundary. Thus, effective temporal control of the medium is critical for frequency conversion. Here, we propose rapidly time variant metasurfaces as a frequency converting platform and experimentally demonstrate their efficacy at terahertz frequencies. The proposed metasurface is designed for the sudden merging of two distinct metallic meta-atoms into a single one upon ultrafast optical excitation. This sudden merging creates a spectrally designed temporal boundary on the metasurface, by which the frequency conversion can be achieved and engineered. Interestingly, the time delay between the abrupt temporal boundary and the input terahertz pulse is found to be strongly related to the phase of the converted wave as well as its amplitude. As the proposed scheme does not rely on the nonlinearity, it may be particularly advantageous for the frequency conversion of waves with weak intensities.

Biography

Bumki Min received the B.S. and M.S. degrees in Electrical Engineering from Seoul National University in 1999 and 2001, and the M.S. and Ph.D. degrees in Applied Physics from Caltech in 2003 and 2006, respectively. After graduation, he worked as a postdoctoral scholar at Caltech and UC Berkeley. He is currently an associate professor in the department of Mechanical Engineering at KAIST. His main research interests include metamaterials and micro/nanophotonics.

Femtosecond Laser 3D Micro and Nanofabrication

Koji Sugioka

Advanced Laser Processing Research Team, RIKEN Center for Advanced Photonics, Japan

Abstract

The extremely high peak intensity associated with ultrashort pulse width of femtosecond (fs) laser allows us to induce nonlinear multiphoton absorption with materials that are transparent to the laser wavelength. More importantly, focusing the fs laser beam inside the transparent materials confines the nonlinear interaction only within the focal volume, enabling three-dimensional (3D) micro- and nanofabrication. This 3D capability offers three different schemes, which involve undeformative, subtractive, and additive processing. The undeformative processing preforms internal refractive index modification to construct 3D optical microcomponents including optical waveguides inside transparent materials. Subtractive processing can realize the direct fabrication of 3D microfluidics, micromechanics, and photonic microcomponents in glass. Additive processing represented by two-photon polymerization (TPP) enables the fabrication of 3D micro- and nanostructures made of not only polymer but also protein for photonic, microfluidic, and biological applications. Furthermore hybrid approach of different schemes can create much more complex 3D structures and thereby promises to enhance functionality of micro- and nano-devices. This talk will present our recent achievements on fabrication of functional 3D micro- and nano-systems including microfluidics, optofluidics, microsensors, and 3D proteinaceous microstructures by femtosecond laser 3D processing

Nonlinear Photon Generation/Manipulation for Quantum Optics

Sunao Kurimura

National Institute for Materials Science, Japan

Abstract

Photon source / manipulator have been demonstrated for quantum optics by nonlinear optical (NLO) parametric conversion, where quasi-phase matching (QPM) by periodic structures allows artificial design. Superior performance in QPM devices realizes efficient operation even at low photon number in quantum-optics applications.

Frequency-entangled photon sources are presented by QPM NLO devices, with special designs for different pumping wavelength. Mg:SLT-based photon sources are to be pumped at short wavelength such as 400, and 532 nm, due to the low material's absorption in the UV-visible range [1, 2]. The emitters with broadband design produce octave-spanning bandwidth for two photon quantum interference. Polarization-entangled photon sources are also reported with specific design [3,4]. Waveguide-Mg:LN-based NLO devices operate at significantly low pump power because of the ultrahigh efficiency. Design flexibility in QPM NLO will be reviewed in the presentation.

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Biography

Sunao Kurimura received Ph. D in engineering at Waseda University, Japan. He was a visiting scholar at Stanford University (1997-99), and joined Institute for Molecular Science, Japan as a research associate in 1999. He has been a principal researcher of National Institute for Materials Science, Japan and had concurrent positions as a professor in Waseda University/Kyushu University, Japan. He has been the Editor of *Optical Materials Express (OSA)*, a committee member of *Advanced Solid State Laser 2017*, the Program Co-Chair of *Laser Display Conference 2017-19* and the Director of Photonics Division of Japan Society of Applied Physics.

Featured Presentations

Super-Contrast-Enhanced Darkfield Imaging Through the Delicate Control of Illumination Polarization

Seongkeun Cho¹, Janghwi Lee², Hyungu Kim², Seulgi Lee², Akinori Ohkubo², Jungchul Lee², Taehyun Kim², Sangwoo Bae² and Wondon Joo²

¹Semiconductor R&D Center, Samsung Electronics, Korea

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Abstract

We describe an innovative optical detection method of silicon nano defects as small as 20nm in size through a low magnification imaging system through null-ellipsometry principle. The scattered noises due to surface roughness and LER can be greatly reduced by applying delicate polarization condition known as null condition. Null conditions can easily be found by three or four measurements of different polarizations. This method can be applicable for detecting nano defects not only on bare wafers but also on patterned wafers. Rigorous numerical FDTD simulations support the feasibility of the proposed method. Experimental results show that Si defects of 20nm in size on bare wafer can be detected even with low magnification imaging optics (X20) through this novel technique. For Si 40nm Line and 40nm Space pattern (40nm in height), gap defects as small as 14.6nm and bridge defects as small as 21.9nm in size can also be identified in experiment. To the best of our knowledge, no method has been successful for identifying such small non-metal (silicon) nanoscale objects with such low magnification (×20) imaging optics.

Biography

Seongkeun Cho is Staff Engineer in Semiconductor Research and Development Center at Samsung Electronics in Korea. He received his Ph.D. from University of Rochester and performed post-doctoral research at Massachusetts Institute of Technology before joining Samsung Electronics.

His primary research interests are a simple but accurate theoretical modeling and experimental investigation of light propagation through arbitrary nano-structures in imaging, metrology and fabrication of state-of-the-art nano-patterned structures, including but not limited to a semiconductor and its related application.

2D Mono Detection Spatially Super-Resolved Microwave Imaging for Radar Applications

Isahar Gabay*, Amir Shemer and Zeev Zalevsky

Bar-Ilan University, Israel

Abstract

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

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

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

Biography

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

Novel Phenomena in Optical Manipulation Due to Magnetic-Field-Induced Resonant States

M. I. Marqués⁶, S. Edelstein¹, R. M. Abraham Ekeröth^{2,3}, P. A. Serena¹, J. J. Sáenz^{4,5} and A. García-Martín³

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²*Instituto de Física Arroyo Seco, Universidad Nacional del Centro de la Provincia de Buenos Aires, Argentina*

³*Instituto de Micro y Nanotecnología IMN-CNM, CSIC, CEI UAM+CSIC, Spain*

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⁵*IKERBASQUE, Basque Foundation for Science, Spain*

⁶*Departamento de Física de Materiales, Condensed Matter Physics Center (IFIMAC) and Instituto Nicolás Cabrera, Universidad Autónoma de Madrid, Spain*

Abstract

We study the effect of optical forces [1] and torques on a spherical isotropic magneto-optical (MO) nanoparticle [2]. The force on the direction of the applied external magnetic field has two contributions: A first conservative component coming from the “Zeeman” coupling between the light spin density and the external magnetic field through the imaginary part of the MO polarizability, and a second component coming from the direct transfer of the helicity of the electromagnetic field to the particle through the real part of the MO polarizability. The torque also has two contributions: The usual one coming from the spin of the light field and another one depending only on the modulus of the electromagnetic field.

We explicitly show examples where these new contributions lead to: (i) An optical torque on an isotropic, spherical particle using a linearly polarized plane wave, (ii) the formation of a conservative optical lattice with non-interfering incoming fields and (iii) radiation pressure using electromagnetic fields with zero average value of the Poynting vector.

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Biography

Manuel Marques obtained his B.A in physics at Universidad Complutense de Madrid in 1995 and was awarded with an extraordinary Ph.D. prize in physics at Universidad Autonoma de Madrid in 2000. Fullbright fellow at Boston University from 2001 to 2003. In 2003, he was awarded with a Ramón y Cajal appointment at the Universidad Autonoma de Madrid. He is now an Associate Professor in the Material Physics Department and member of the Institute of Condensed Matter Physics (IFIMAC). He has coauthored more than 90 scientific articles with more than 1100 citations.

A Compact Top-View Conformal Optical System Based on a Single Rotating Cylindrical Lens with Wide Field of Regard

Qun Wei¹, Linyao Yu², Jinggao Zheng², Mingda Ge² and Tianyi Zhang²

¹*Nanjing Hua Opt-tech Co., Ltd, China*

²*Changchun Institute of Optics, Fine Mechanics and Physics, Chinese Academy of Sciences, China*

Abstract

A new compact conformal dome optical system was established, and the aberration characteristics of the dome were investigated using Zernike aberration theory. The aberrations induced by the dome at different fields of regard (FORs) from 30° to 100° were effectively balanced by a rotating cylindrical lens. This kind of optical system can be widely used in top-view optical searching devices. A design method was introduced, and the optimization results analyzed in detail. The results showed that the Zernike aberrations produced by the conformal dome were decreased dramatically. Also, a complete conformal optical system was designed, to further illustrate the aberration correction effect of the rotating cylindrical lens. Using a cylindrical lens not only provided a large FOR, but also simplified enormously the structure of the conformal optical system.

Biography

Qun Wei got PhD degree of Mechanical Engineering in Graduate University of Chinese Academy of Science at Beijing in 2010. His research field is optical system design, optical instrument design, mechanical analysis, CFD simulation, and image processing. He has published more than 30 papers and one book. He was the director of New Technology Department at Changchun Institute of Optics, Fine Mechanics and Physics since 2015. He has been in laboratory as a visiting scholar in The Institute of Optics at the University of Rochester for one year. Now, he is the CEO of the Nanjing Hua Opt-tech Co., Ltd, China.

ECA (Electrical Conductive Adhesive) Induced Failure on Shingling Module

Wang Juan*, Guo Zhiqiu and Jin Hao

Zhejiang Jinko Solar Co., Ltd. China

Abstract

Shingling structured PV module can fully utilize the gap between cells in a module, which can significantly increase the power output of the module. Meanwhile it can reduce the influence of reverse current on the hot-spot effect. In this paper, we studied Shingling module reliability and found that ECA quality could induce module failure. This work focuses on the influence of the bubbles in the ECA on the reliability of module.

Experiment was conducted using shingling mono-PERC modules. First, full size cell was separated into small rectangular stripes by laser ablation. Second, ECA was applied onto the front busbar of each stripe. Third, the stripes were interconnected by overlapping the back of one stripe onto the front side connection of the next stripe in series, making into a single string. The strings were then encapsulated into module, and to be subjected to thermal cycle (TC) testing. TC failed module (power loss was 19.28%) was chosen to do root cause analysis, together with passed modules (power loss within 2%). From EL image, we can see that there are many dark areas as shown in A-3 while there is no such failure phenomenon in B3. Those selected two modules were disassembled, and then scanned ECA morphology via SEM. It can be obviously seen that there are many bubbles in the ECA as shown in A-1 and A-2. On the contrary, the morphology of ECA is homogeneous as shown in B-1 and B-2. Air constrained inside of bubbles will expand during thermal cycling, which may cause the separation between the stripe and the ECA, thus resulting in the failure of the module.

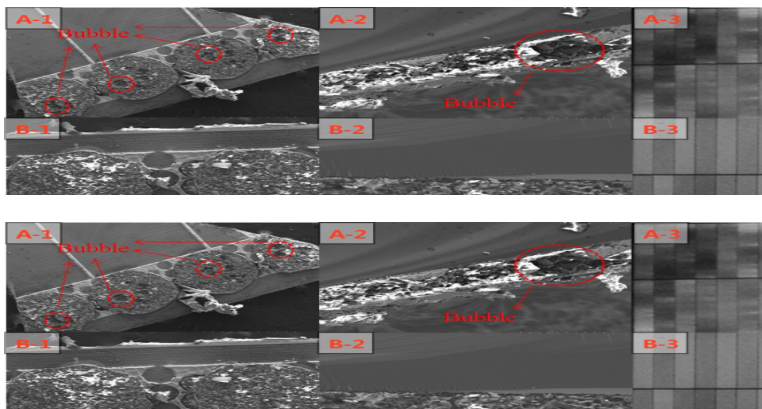


Fig. Failure caused by bubbles in ECA

Biography

Wang Juan received her Master's degree from Xi'an Jiaotong University (Atom and Molecular Physics) in 2008 and her second Master's degree from National University of Singapore (Management of Technology) in 2014. She has worked in Applied Materials, Solar Energy Research Institute of Singapore, REC Solar and JinkoSolar on 2008, 2010, 2015 and 2017. She has been engaged in Photovoltaic R&D for more than ten years. She is focused on Module design, System development and data analysis for outdoor test. Recently, she has been working on Shingled Module research and failure mode analysis for the new technology.

High Density Waveguide Integration for Optical Phased Array Lidars and Optical Interconnects

Wei Jiang

Nanjing University, Nanjing, China

Abstract

Silicon photonics can potentially transform the photonics technology owing to its low-cost fabrication and large-scale integration. 0.25 low-crosstalk waveguide integration at half-wavelength pitches have been demonstrated by introducing novel waveguide superlattice structures, which have broad applications in optical phased arrays, space-division multiplexing, wavelength-division multiplexing, and spectrometers. We will discuss the strategy of overcoming the key problem of crosstalk in achieving high-density waveguide integration and show that crosstalk below -20dB can be achieved with advanced waveguide superlattice design. Furthermore, we will show that half-wavelength pitch optical phased arrays can be developed based on such waveguide superlattices, which opens the door to a new generation of high-performance lidars with wide field of view.

Furthermore, we will present other related progress and potential applications of waveguide superlattices in high-density space-division multiplexing, flexible optical interconnects on chip, and spectrometers.

Biography

Wei Jiang is a Professor in the college of engineering and applied sciences at Nanjing University, China. Prior to joining NJU, he was an associate professor of electrical and computer engineering at Rutgers University, USA. His research is focused on silicon photonics with applications in optical interconnects, lidars, and optical computing. He demonstrated high-speed silicon photonic crystal modulators and high-density low-crosstalk waveguide integration at half-wavelength scale, which have been highlighted by *Laser Focus World*, *Nature Photonics*, *Phys.org* and *EE Times*. He received the 2012 DARPA Young Faculty Award and 2013 IEEE Region I Outstanding Teaching Award.

Enhanced Light-Harvesting Efficiency of Luminescent Solar Concentrators Based on Organosilane-Functionalized Carbon Nanodots

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¹Department of Electrophysics, National Chiao Tung University, Taiwan

²Department of Physics, Chung Yuan Christian University, Taiwan

Abstract

Luminescent solar concentrators (LSCs) are widely known for the efficient utilization of solar irradiation, conjointly able to harvest both incident and diffused sunlight without necessary complex tracking of the sunlight. In addition, LSCs provide benefits for building-integrated photovoltaics by simply integrating transparent LSCs as solar-harvesting devices in the form of PV windows. On the contrary, most of LSCs rely on toxic, heavy-metal colloidal quantum dots (CQDs) which pose grave threats to human health and environment. Moreover, the loading contents of CQDs in various matrices should be principally very low so as to preserve the intrinsic photoluminescent quantum yields in the solid-state free from concentration-induced quenching (CIQ) effect. However, the quantity of the absorbed light that can be further exploited are significantly decreased when the loading contents are lower. To address the aforementioned issues, in this study, we propose a cost-effective, earth-abundant, greener LSC based on cross-linked organosilane-functionalized carbon nanodots (Si-CNDs) as the luminophores. The newly developed Si-CNDs are well-thought-out as promising “greener” alternatives to vie or even replace those traditionally used heavy-metal-containing CQDs. The fabricated LSCs manifested high resistance against solid-state quenching, effectively suppressed scattering losses, leading to solidstate quantum yields up to $45 \pm 5\%$ upon calibration of the reabsorption losses. The fabricated LSCs exhibited an exceptional edge-emission efficiency of $\sim 68\%$ and excellent internal quantum efficiency of $\sim 22\%$. This study offers a profound discernment and knowledge into the photophysical properties of the innovative Si-CNDs, which is beneficial in advancing and further developing large-area, proficient LSCs based on environmental-friendly CNDs.

Biography

Maria Jessabel Aviles Talite is of Filipino descent born on 22 December 1992. She is currently residing in Taoyuan, Taiwan to pursue her Doctorate degree. She is enrolled in National Chiao Tung University and presently a 3rd year International Ph.D. student/candidate in the Department of Electrophysics. She is a recipient of an Outstanding Student Scholarship offered by the University for high achievers.

High-Speed Pure Frequency Modulation and Pulse Optimization Based on a Quantum Cascade Laser by All-Optical Modulation

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²Institute of Fluid Physics, China Academy of Engineering Physics, China

Abstract

Purified frequency modulation is demonstrated in a middle-infrared quantum cascade laser by illuminating its front facet with two optimized near infrared lasers. Pulse control and optimization are demonstrated in a standard middle-infrared quantum cascade laser via an all optical approach. It has the potential for application in free space optical communication and highspeed frequency modulation spectroscopy.

Keywords: quantum cascade laser, frequency modulation, infrared

1.Introduction: Quantum cascade lasers (QCLs) are compact optical sources operating at room temperature from $3 \mu\text{m}$

region to Terahertz band. High speed modulation of QCLs exhibits enormous potentials for gas sensing [1] and free space optical communication [2] (FSOC) applications. However, amplitude modulation (AM) inevitably existing with frequency modulation (FM) in most QCL-based high speed modulation system [3]. Utilization of purified FM without conventional AM is shown to be promising to improve the signal fidelity. Simultaneously, When the QCLs work in pulse model, the pulse shape and quality of QCLs are important for the applications in high-speed frequency modulation. They are necessary to optimized.

2.Experimental results: The system is schematically shown in Figure. 1. The QCL with a central wavelength of 4.6 μm . It was mounted on a liquid nitrogen cryostat and held at a temperature of 80 K. The QCL's middle-infrared (MIR) emission is collimate and then focused into an infrared photovoltaic detector. The near-infrared (NIR) beams are focused on the QCL front facet with an incident angle about 30 degrees to the QCL beam, and NIR focal spot diameter is less than 20 μm .

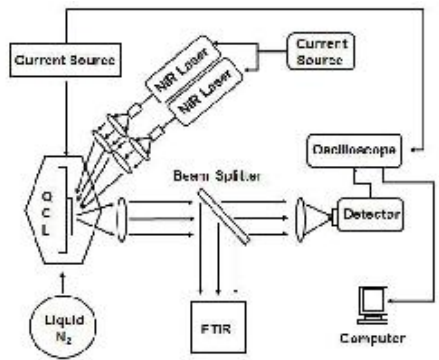


Fig. 1. Experimental setup of the purified frequency modulation based on the all-optical-modulation of a QCL.

When QCL is working above the threshold current, a 1550 nm NIR laser is used to irradiate its front end face. Using a 850 nm NIR laser is optimized to suppress amplitude modulation of QCL completely. We investigate the experimental results of purified frequency modulation and the change of the central wavelength of QCL by a Fourier transform infrared spectrometer (FTIR). As shown in Figure 2, both of the modulation of 850 nm and 1550 nm NIR laser reduces the wavelength of QCL.

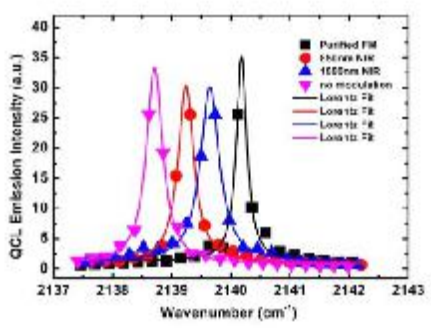


Fig.2.The QCL spectrum without modulation (violet) and only with 850 nm modulation (red), 1550 nm modulation (blue), purified frequency modulation (black).

We let the QCL work near the threshold current and ensure that there is no emission. As shown in figure 3(a), the rise time of a QCL pulse with a width of 200 ns, which is generated by the electric drive, is 29.6 ns, and that generated by the all-optical modulation is only 7.1 ns. As shown in figure 3(b), the fall time of a QCL pulse with a width of 200 ns, which is generated by the electric drive and all-optical approach, is 24.7 ns and 15.8 ns, respectively. The all-optical modulation approach can control the QCL pulse width, amplitude, and repetition frequency at the same time.

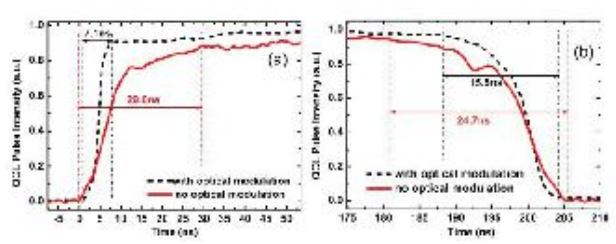


Fig.3. (a) QCL pulse generated in the rise time by an electric drive (solid) and with 1550 nm NIR modulation (dash), (b) QCL pulse generated in the fall time by an electric drive (solid) and with 850 nm NIR modulation (dash).

3. Summary: In conclusion, a purified FM of QCL with all optical approach has been presented for the first time, based on positive and negative AM of QCL with different NIR exciting wavelengths. Compared with the electric drive, the QCL pulse rise and fall times are shortened by 3/4 and 2/5, respectively. Simultaneously, we can precisely adjust the QCL pulse width, amplitude, and repetition rate. The optical approach can be used in MIR FSOC and high-speed frequency modulation spectroscopy application.

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Hybrid Perovskite Thin Films as Highly Efficient Luminescent Solar Concentrators

Katerina Nikolaidou* and Sayantani Ghosh

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Abstract

Hybrid organic-inorganic halide perovskite (PVSK) thin films have been the focus of considerable research efforts, with PVSK-based photovoltaic devices exceeding the power conversion efficiency of silicon solar cells. PVSK thin films possess various favorable characteristics, such as high refractive index, broad absorption spectrum, and high quantum yield, making them suitable candidates as active material in luminescent solar concentrators (LSCs). However, a continuous film could possibly suffer from high self-absorption, and along with the instability of PVSK, have prevented implementation of PVSK thin films in LSC applications. In this work, the potential of PVSK thin films in LSCs is examined using spectroscopic and photovoltaic measurements, and the impact of PVSK composition on optical stability and device performance is monitored. Although the devices exhibit high self-absorption losses, they reach optical efficiencies of 15% 29%, and are operational after 7 weeks of storage in ambient conditions. Their impressive performance is attributed to the high PVSK refractive index and quantum yield, which is supported by Monte Carlo simulations. Further, using simulations incorporating our experimental results, we have demonstrated the possibility of scaling these LSCs up to almost 100 cm, thereby providing a route toward optimizing thin film PVSK materials for these and other optoelectronic and photovoltaic applications. These results encourage the implementation of PVSK thin films in LSCs, but also demonstrate the possibility of tandem devices that could capture any energy escaping as radiative exciton recombination in solar cells.

Biography

Katerina Nikolaidou is a Ph.D. candidate in Physics at University of California, Merced. She is interested in material interfaces, and her work has focused on the interaction between plasmonic nanoparticles and magneto-optical materials for sensing purposes, as well as electron transfer between semiconductors for photovoltaic applications. She graduated from University of Bristol in 2012 with a degree in Physics, and earned a Master's degree in Sustainable Energy Futures from Imperial College London in 2013.

Hard X-Ray Lasing from Stimulated Emission Pumped by an X-Ray Free-Electron Laser

Thomas Kroll¹, Clemens Weninger¹, Roberto Alonso-Mori¹, Dimosthenis Sokaras¹, Diling Zhu¹, Laurent Mercadier², Vinay P. Majety, Agostino Marinelli¹, Alberto Lutman¹, Marc Guetg¹, Franz-Josef Decker¹, Sebastien Boutet¹, Andy Aquila¹, Jason Koglin¹, Jake Koralek¹, Daniel P. DePonte¹, Jan Kern^{1,3}, Franklin D. Fuller³, Ernest Pastor³, Thomas Fransson¹, Yu Zhang¹, Junko Yano³, Vittal K. Yachandra³, Nina Rohringer^{2,4,5}, and Uwe Bergmann¹

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³Lawrence Berkeley National Laboratory, CA

⁴DESY - Deutsches Elektronen Synchrotron, Germany

⁵University of Hamburg, Germany

Abstract

A highly focused X-ray beam tuned to above the Manganese ionization energy creates a population inversion along its beam path, which allows stimulated emission (lasing) that leads to massive intensities mainly in the forward direction from a single

X-ray shot. For this amplified spontaneous emission processes at the Manganese $K\alpha$ emission, we find spectra at amplification levels extending over four orders of magnitude until saturation, and observe bandwidths below the Manganese $1s$ core-hole lifetime broadening in the onset of the stimulated emission. In the exponential amplification regime, the measured spectral width is constant over three orders of magnitude, pointing to the build-up of transform-limited pulses of ~ 1 fs duration. Driving the amplification into saturation leads to broadening of the line. Using a second color as a seed, the amplified spontaneous emission process can be overcome, and weaker emission lines are amplified. $K\beta$ spectra are known for their high chemical sensitivity and dependence on the effective spin state of the transition metal ion. Stimulating the $K\beta$ emission lines (which are ~ 8 - 10 times weaker than $K\alpha$) is therefore an important and exciting step towards a broader applicability of stimulated emission spectroscopy. In this presentation, spontaneous and seed amplified stimulated emission experiments will be presented and discussed together with a comparison to conventional emission spectroscopy taken at a synchrotron.

Biography

Thomas Kroll is a Staff Scientist at SLAC National Accelerator Laboratory in Menlo Park, CA. His main research interests are in the determination of electronic structure properties of transition metal complexes and the development of new experimental and theoretical methods in X-ray spectroscopy. He received his PhD from the University of Dresden, Germany, in Solid State Physics and did a PostDoc at Stanford University in the field of Bio-Inorganic Chemistry. He worked as a Research Associate at the Linac Coherent LightSource (LCLS) and is now a Staff Scientist at the Stanford Synchrotron radiation Lightsource (SSRL) at SLAC.

Recent Advances on the J-KAREN-P High Intensity Laser Facility at QST

Hiromitsu Kiriya^{*}, Alexander S. Pirozhkov, Mamiko Nishiuchi, Yuji Fukuda, Koichi Ogura, Akito Sagisaka, Yasuhiro Miyasaka, Michiaki Mori, Hironao Sakaki, Nicholas P. Dover, Kotaro Kondo, Hazel F. Lowe, James K. Koga, Timur Zh. Esirkepov, Nobuhiko Nakanii, Kai Huang, Masaki Kando, Kiminori Kondo and Tetsuya Kawachi

Kansai Photon Science Institute (KPSI), National Institutes for Quantum and Radiological Science and Technology (QST), Japan

Abstract

The J-KAREN-P is a high contrast, high intensity, repetitive petawatt laser, which is the flagship system at the KPSI of the QST. Two of its booster amplifiers operating at a 0.1 Hz repetition rate have been optimally designed, fabricated, and tested. Broadband output energies of 63 J have been efficiently generated at 0.1 Hz. With precise OPCPA spectral shaping and compensation of spectral phase distortions by high dynamic range acousto-optic programmable dispersive filters (AOPDFs), a broad spectral bandwidth is obtained and the compressed pulses are less than 30 fs (FWHM). An adaptive optics system is used to correct the wavefront distortion. Reflective-type spherical mirror telescopes and the last grating adjustment in the compressor have compensated the chromatic aberration and angular chirp, respectively. High intensities of 1022 W/cm² on target by focusing a 0.3 PW laser in ~ 280 mm diameter with an $f/1.3$ off-axis parabolic mirror have been achieved. A high contrast front-end source based on a combination of a saturable absorber and low gain OPCPA configuration and the moderate gain operation of the Ti:sapphire amplifiers has achieved a high temporal contrast of 10¹² at 10 J output energies. Real prepulses originating from nonlinear coupling at the petawatt facility are also investigated by changing the output energies for a better understanding of the laser matter interaction process. Here, we also briefly introduce some experimental results. The J-KAREN-P laser, which provides high contrast and high intensity with repetitive operation, can support the study of high field science at unexplored laser intensity levels.

Biography

Hiromitsu Kiriya was born in Osaka, Japan, in 1970. He received a Ph.D. degree in electrical engineering from Osaka University, Osaka, Japan, in 1998. His doctoral thesis focused on high power laser-diode pumped solid-state lasers for inertial confinement fusion at the Institute of Laser Engineering, Osaka University, Osaka, Japan. In 1998, he joined the Advanced Photon Research Center, Japan Atomic Energy Research Institute (JAERI), Kyoto, Japan. He is currently a Group Leader with the Advanced Laser Group, Kansai Photon Science Institute, National Institutes for Quantum and Radiological Science and Technology (previously JAERI and the Japan Atomic Energy Agency).

Optical Monitoring of Arbitrary Distributed Substance: An Alternative Approach Against Image Processing

A. E. Martirosyan*, R. B. Kostanyan, P. H. Muzhikyan, and H. H. Azizbekyan

Institute for Physical Research, NAS of Armenia, Armenia

Abstract

The presented research is based on a new approach for optical monitoring of distributed substances by using a specially designed optical element: an apodizing filter with the quadratic light transmittance in the radial direction. The alternative technique is developed on the following principles: the radiant flux from the substance under observation is recorded in a single-step conversion of the light energy into an electrical signal; the uncertainty of measurements is minimal due to the usage of non-matrix detectors operating within the linear sensitivity range. The theoretical studies allowed us to obtain formulas for the parameters of distributed substances: distribution center, drift and drift speed of the center, radial standard deviation and its changing rate, diffusion. The apodizing filter with 60mm in diameter is made by printing technology. The green CW laser at a wavelength of 532 nm is used to measure the radial dependence of the light transmittance through the filter. The detection setup with apodizing filter is hanged from the ceiling to remotely observe in the green spectral region the mock-up scene on the floor with the dimensions of 1.4×1.4 m². The technique allows observing the process of reduction of artificial snow area on the mock-up surface covered with a soil. The process imitates the global warming consequences for northern territories on a timescale of years or decades. It is shown that new approach opens wide opportunities to carry out exact and direct measurements in the field of slow, as well as fast processes limited only by the feasibility of temporal response (up to 10÷100 GHz) detection.

Biography

Artur Martirosyan completed his PhD in the year 1985 at the age of 28 years from Institute for Physical Research. In 2012, he defended his doctoral dissertation and received the degree of Doctor of Phys.-Math. Sciences. He is the Senior Researcher at the Institute for Physical Research. He has published more than 50 papers in reputed journals and conferences proceedings. His research interests include optics, lasers, remote sensing, astronomy, acoustics, plasma physics, non-destructive testing.

A Compact and Portable Laser Radioactive Decontamination System Using a Fiber Laser and a Polygon Scanner

An-Chung Chiang*, Yu-Chieh Lin, Yu-Hsiang Huang and Yen-Yin Lin

National Tsing-Hua University, Taiwan

Abstract

We designed a compact and portable laser radioactive decontamination system using a fiber laser and a polygon scanner. The fiber laser produced 15-W average power at a 60-kHz repetition rate. The scanner system contained a 12-sided spinning polygon mirror driven by a DC motor. By varying the spinning speed of the polygon mirror, we achieved a processing speed exceeding 88500 mm/s. Radioactive contaminated samples of four different materials, including stainless steel, copper, iron, and aluminum, for laser decontamination experiments were artificially prepared by immersing them into radioactive mud collected from the bottom of the radioactive liquid waste storage tank of the reactor water cleanup system of Tsing-Hua Open-pool Reactor (THOR) in National Tsing-Hua University (NTHU). The primary radioactive nuclide in the radioactive mud was cobalt-60 (Co-60). This system was demonstrated to be very efficient for radioactive decontamination on surfaces of those materials. The percentage decontamination factor can be up to 99%. The compact design of the system makes it portable and can be remotely controlled. The fast processing speed also reduces the radiation exposure for people who are involved in the decontamination process. The secondary pollutants are also reduced. These advantages make the system very promising for radioactive decontamination.

Biography

An-Chung Chiang obtained his Ph.D. degree in Department of Electrical Engineering, National Tsing-Hua University (NTHU), Hsinchu, Taiwan. He majors in solid-state lasers, nonlinear optics, and beam physics. He was a postdoc research associate in Institute of Photonics Technologies, NTHU during 2003–2006. Since 2007, he joined to the NTHU Nuclear Science and Technology Development Center (NSTDC) as a nuclear technician, trying to develop combined technologies of lasers and radiations. He is currently working on decommission technologies of nuclear power plants. Laser radioactive decontamination is one of them.

Significant Suppression of Rayleigh Scattering Loss in Silica Glass Formed by the Compression of its Melted Phase

Madoka Ono^{1*}, Kenta Hara², Masanori Fujinami² and Setsuro Ito¹

¹AGC, Research Center, Japan

²Chiba University, Japan

Abstract

Silica glass had long and intensively been studied due to its technological interest in manufacturing higher-performance optical fibers and lasers. For these usages, suppression of Rayleigh scattering loss is highly desired. Here we propose a new method for suppressing the loss in silica glass. Previously, the major method to suppress the loss was to decrease the fictive temperature, T_f (temperature at which the glass network structure is “frozen”) of the glass. However, we have found that the Rayleigh scattering in silica glass can be explained in terms of the voids in the glass behaving as scattering particles. Here, the expression of “void” stands for sub-nanometer size structural empty space, not bubbles. When T_f decreased, the void size was observed to decrease, which caused suppression of the local density fluctuations which, in turn, led to less intense light scattering. Therefore, we tried further decrease of the void size, by conducting compressive stress onto silica glass under melting temperature, in order to realize further suppression of the Rayleigh scattering loss. By this method, scattering intensity was successfully suppressed together with the refractive index increase. This is very favorable for fiber-core media, where high transparency and strong confinement of light are desired. It is not possible to otherwise get such glass homogeneity (corresponding to such a low T_f) and reduce the Rayleigh loss simply by thermal engineering at standard atmospheric pressure.

Biography

Madoka Ono has obtained her PhD in the year 2004 from Tokyo University. Her PhD research was on the study of optically excited states in low-dimensional Mott insulators. She joined AGC Inc. in the year of 2004. Her research areas are optical properties of glass, and development of stronger glass. She is now working as a senior researcher and a project leader in AGC. She also works as a part-time lecturer of Yokohama National University. She is a board member of photonics division of Japanese Society of Applied Physics.

A Laser Brightness Amplifier for Detection of Dynamic Processes in the Laser Thermo-strengthening of the Material Surface in a Real-Time Scale

S.V. Zhirnova, E.L. Shamanskaya, G.A. Evstyunin, M.N. Gerke and S.M. Arakelian*

Stoletovs Vladimir State University, Vladimir, Russia

Abstract

1. The paper deals with experiments on laser thermal hardening with the registration of the dynamics of the material surface modification in a real time using a laser projection microscope (monitor) in the geometry of «pump-probe». Hardening of the metal materials by laser radiation, as well as dimensional processing compared to traditional methods, is much more environmentally friendly because it happens very quickly and almost without emissions of harmful substances. The possibility of observing the surface during direct time of the hardening process can improve the quality of processed products. By this technique it is possible to detect many details in dynamics: appearance of the transition region arising from the interaction of laser radiation with matter, to obtain its expansion, to register the appearance of the thermal front, the behavior of melting front and oxide front which are relevant in the heat treatment processes.

2. The basic physical principles of the technology, and the existing problems are discussed, including the use of computer simulation to find both the optimal optical circuits and the dynamics image recognition procedure through an optical fiber/optical bundle to control the process.

3. The analysis of obtained results for different materials is also carried out on the basis of computer modeling. These issues are important in the implementation of various thermal hardening regimes for different materials in experiments with single- and multi-beam radiation of a power laser affecting on the objects at the appropriate setting of the laser monitor in the probing channel.

Biography

Arakelian Sergei M. (A.S.M.) had his diploma project at the Dept. of Physics at the Lomonosov Moscow State University (MSU). In 1975, he got his PhD thesis and in 1988, he got his Senior Doctor of Science at the MSU as well. Having the status of a Post-Doctor, he stayed at Dept. of Physics at the University of California (UCB) in 1980-1981. He also worked at UCB as a Visiting Professor in 1985.

He is the author of more than 300 scientific papers, monographs and patents in the area of laser physics, quantum optics, coherent and non-linear optics.

Stress Measurement by Spectrum Analyses for Round Bar Subjected to Time-Varying Load

Tsutomu Yoshida*, Kyo Shinkou, Kunihiro Sakurada and Takeshi Watanabe

Takushoku University, Japan

Abstract

Feasibility study to measure a magnitude and a cycle of a time-varying axial stress in a specimen by a natural frequency was carried out. A tensile stress in a guitar string determines a tune of the string. An axial stress in a bar also determines the natural frequency of the bar. And if the stress varied, the natural frequency of the bar would vary. The variation of natural frequency tells us how the stress in the bar is changing with time. The experiment was conducted. We used a specimen of a round bar with 8 mm diameter and 290 mm span length which was fixed at both ends. A sinusoidal axial stress was applied to the bar, which is one-sided amplitude stress in tension. In the experiment, we can arbitrarily alter a magnitude of a mean stress and an amplitude stress of the sinusoidal applied load. We gave not only sinusoidal but also irregular time-varying stresses to the bar. A deflection of the bar in a free vibration was measured by a laser beam displacement device. We followed the variation of the 1st mode natural frequency of the deflection. To collect much information on the deflection, a device which hit the bar periodically was made up. Applying analyses to the experimental data, we tried to evaluate a magnitude and features of a time-varying load. We obtained relations among the time, the frequency and the spectrum of the deflection by analyses. We compared the stress evaluated by analyses with one measured by strain gauges attached to the specimen. For lower cycle than 10 Hz, the axial stress in the bar measured by strain gauges is determinable by time-frequency analyses for sinusoidal and irregular time-varying stresses. The short-time Fourier transform gives us the natural frequency with a tapered widening. For higher cycle than 20 Hz, outlines of time-varying stresses could be estimated, but definite values of their features were not obtained.

Biography

Tsutomu Yoshida is a mechanical engineer and his field of interest is mechanics of materials. He researched an optimal design employing a finite element method in computational mechanics. In recent years, his research field exists in experimental mechanics. He is interested in applying a natural frequency to various fields.

New Physical Properties in the Laser-Induced 4D-Topological Nanocluster Structures: Electrophysics and Optics of Thin Films

S.M. Arakelian*, I. Yu. Chestnov, A.V. Istratov and T.A. Khudaiberganov

Department of Physics and Applied Mathematics, Vladimir State University, Russia

Abstract

1. Laser-induced nanostructures and thin films with controllable topology are depended on the laser pulses duration and may be associated with the 4D-laser technology fabrication of new structures and materials. In fact, the interaction effects of solid targets with laser pulses of different durations for obtaining of various nanocluster structures can be viewed as the possibility of synthesizing the 4D-objects. The result depends not only on the stationary topological/geometric parameters of the system, but also on the dynamic interactions in the system leading to different final stable structures. This is due to the fact that for different durations of laser pulses the specific mechanisms of nanostructuring are activated. Therefore, time plays the role of a control parameter responsible for phase transitions, as well as the spatial parameters do when nanostructures of various dimensions arise – from quantum dots (0D) to 3D nanostructures.

2. Several topological structures for nanoobjects, obtained by computer simulation in arbitrary units, was modeled by us by different numbers of key parameters. The topology peculiarities of the granulated metallic film deposited on dielectric substrates are discussed in clustered metallic structures for both Volt-Ampere characteristics and the optical transmission spectra of deposited bimetallic films.

3. The problem of high temperature superconductivity, due to topological surface structures with correlated states, is under our consideration in frame of nonlinear dynamic modeling resulting in the electronic Cooper pairs appearance. Random temporal and spatial variations in selection topological parameters may result in large variations of such coupling.

Biography

Arakelian Sergei M. (A.S.M.) had his diploma project at the Dept. of Physics at the Lomonosov Moscow State University (MSU). In 1975, he got his PhD thesis and in 1988, he got his Senior Doctor of Science at the MSU as well. Having the status

of a Post-Doctor, he stayed at Dept. of Physics at the University of California (UCB) in 1980-1981. He also worked at UCB as a Visiting Professor in 1985.

He is the author of more than 300 scientific papers, monographs and patents in the area of laser physics, quantum optics, coherent and non-linear optics.

Topologically Insulating One-Dimensional Photonic Lattices Based on Gain and Loss

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¹NTT Nanophotonics Center and NTT Basic Research Laboratories, Japan

²Tokyo Institute of Technology, Japan

Abstract

The advent of parity-time-symmetric optics has opened up the access to various intriguing phenomena in judiciously designed photonic devices with distributed gain and loss. Such systems can form sharp spectral coalescence of two or more eigenmodes, called exceptional points (EPs), and the EPs induce various unconventional responses in their transmission/reflection and absorption/emission properties.

Topological features of non-Hermitian photonic systems have also been drawing attention. It was originally pointed that EPs could have topological charges in the quantum mechanical framework, and early reports clarified a topological transition and robust edge states in the photonic Su-Schrieffer-Heeger chains with gain and loss incorporated. Recently, topological phases peculiar to non-Hermitian systems have been being unveiled. Nonetheless, the possibility of controlling photonic topological insulating phases by pumping, namely gain and loss, has been unclear, because most of them have gapless spectra or rely on their Hermitian factors for their topological band gaps.

In this presentation, we show a scheme to control a non-Hermitian photonic topology and a band gap in uniformly coupled one-dimensional cavity arrays, *only* by arranging their optical gain and loss (on-site imaginary potential). This is based on the formation of dimers via non-Hermitian effective decoupling between a cavity with gain and that with loss. The topological transition can be achieved solely by tuning the pumping to each cavity, and the position and number of the midgap topological interface states can hence be controlled. We will also mention recent arguments about relevant non-Hermitian topological invariances and symmetry of the system.

Biography

Kenta Takata is a researcher of NTT Basic Research Laboratories. He received a Ph.D. from the University of Tokyo in 2015. His main research fields are non-Hermitian and topological nanophotonics. He is a member of the American Physical Society (APS) and the Japan Society of Applied Physics (JSAP).

Applications of Laser Induced Breakdown Spectroscopy in Elemental Analysis of Varied Materials

Jinesh Jain*, Dustin McIntyre, Daniel Hartzler and Chet Bhatt

USDOE National Energy Technology Laboratory, PA

Abstract

Laser induced breakdown spectroscopy (LIBS) is a versatile technique for elemental analysis and chemical mapping of materials. LIBS is a rapid analysis technique and offers simplicity and robustness of the instrumentation, permits real-time measurements, and the analysis can be performed in solid, liquid, and gases with minimal sample preparation. The flexibility of probe design and use of fiber optics makes it a suitable technique for real time measurements in harsh environment and at hard to reach places. We have applied LIBS for determination of carbon dioxide leak in carbon sequestration, rare earth elements (REE) source characterization, chemical mapping of gas producing shales, and analysis of slag samples. This presentation will summarize the results of work done in our laboratory and development of a LIBS sensor for field applications will be discussed.

Biography

Jinesh Jain is a R&D Scientist with AECOM and is currently working at the USDOE National Energy Technology Laboratory. He also held an adjunct associate professor position at the University of Pittsburgh. Previously he has taught at the University of Notre Dame for many years. He has published over 300 research papers, abstracts, and patents, and has made numerous invited presentations internationally. He is developing optical sensors for monitoring of CO₂ leak in carbon sequestration, for which he has won the URS President pyramid award and a recognition from the DOE Assistant Secretary of Fossil Energy.

Acoustic Emission Monitoring and Control During Laser Synthesis of Colloids

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¹Center for Nanointegration Duisburg-Essen (GENIDE), NanoEnergieTechnikZentrum (NETZ), Technical Chemistry I, University of Duisburg-Essen, Germany

²Institute for Coatings and Surface Chemistry (ILOC), Hochschule Niederrhein University of Applied Sciences, Germany

³Chair of Dynamics and Control (SRS), University of Duisburg-Essen, Germany

Abstract

Pulsed laser ablation in liquids (PLAL) is a recently established scalable method to synthesize surfactant-free nanoparticles in liquids [1]. To ensure continuous nanoparticle synthesis with high nanoparticle yield, it is mandatory to maintain a constant laser energy density, demanding a fixed distance between the focusing lens and target. With longer ablation time, the removal of material naturally leads to a shift of the working distance and therefore to a decreased laser energy density on the target surface. Thus, the target position needs to be adjusted accordingly. To that end, a field programmable gate array measurement and control system for automated adjustment of the working distance based on acoustic emission (AE) measurements was developed (Fig. 1A) [2]. From the measurement, bursttype AE signals can be observed at repetition rates smaller than the total lifetime of the cavitation bubble (Fig. 1B). The first collapse of the cavitation bubble can be estimated by the time delay between successive AE bursts [3]. Ablation characteristic acoustic frequencies were detected at base frequency correlating to the repetition rate as well as higher harmonics of the latter. Higher order signals vanish when the laser spot is shifted into the liquid due to attenuation in the liquid medium [3]. The amplitude intensities correlate well with the nanoparticle productivity, enabling automated optimization. Results of the automated optimization were discussed in terms of accuracy and how fast the optimal working distance is achieved after a manually introduced offset.

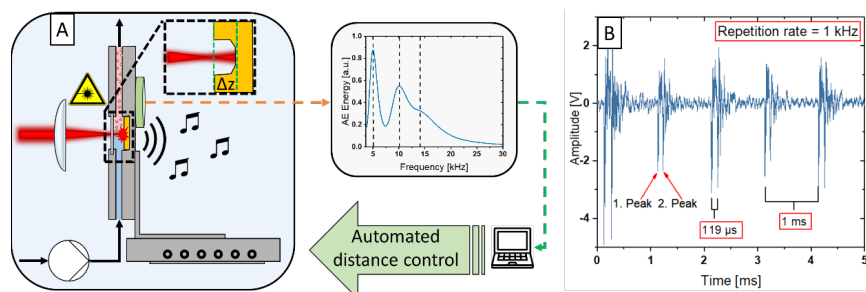


Figure 1 Sketch of the automated distance control (A) and time-resolved AE-data during PLAL (B)

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- [2] S.F. Wirtz et al., *Sensors* 18 (2018)
- [3] M. Labusch et al., *Applied Surface Science* 479 (2019)

Biography

Marc Labusch received his M.Eng. degree in Chemical Engineering in 2016 from the Hochschule Niederrhein, University of Applied Sciences (HSNR), Germany in cooperation with the LANXESS AG, Germany. He continued as a scientist and Ph. D. student at the University Duisburg-Essen in cooperation with the HSNR. His recent publications include “Development of a low-cost FPGA-based measurement system for real-time processing of acoustic emission data: proof of concept using control of pulsed laser ablation in liquids” *Sensors* 18 (2018) and “Acoustic emission control avoids fluence shifts caused by target runaway during laser synthesis of colloids” *Applied Surface Science* 479 (2019).

Keynote Presentation

Plasmon-Exciton-Polariton Condensation and Lasing

Jaime Gomez Rivas*, Mohammad Ramezani and Alexei Halpin

Department of Applied Physics, Eindhoven University of Technology, The Netherlands

Abstract

Metallic nanostructures supporting localized surface plasmon resonances provide a toolkit for the generation of coherent light below the diffraction limit. Plasmonic based lasing relies on the population inversion of emitters, such as organic fluorophores, with feedback provided by the plasmonic resonances. The radiative characteristics of the system in this regime (weak coupling regime) are described by the Purcell enhancement of the emission rate. Strong light-matter coupling between the excitons and the electromagnetic field generated by the plasmonic structures leads to the formation of hybrid quasi-particles known as plasmon-exciton-polaritons (PEPs). Due to the bosonic character of these quasi-particles, exciton-polaritons can condense in the ground state, leading to laser-like emission at lower threshold powers than conventional photon lasers. In this presentation, we will discuss organic PEP condensation and lasing in a lattice of metallic nanoparticles, which define a distributed feed-back optical cavity. These measurements represent the first demonstration of polariton condensation in a plasmonic system. Interestingly, the threshold power for lasing is reduced by increasing the degree of light-matter coupling despite the degradation of the quantum efficiency of the active organic material, highlighting the ultrafast dynamics responsible for the condensation. Direct measurements of this dynamics are performed with broadband transient absorption spectroscopy, revealing the role of molecular vibrations in the relaxation toward the ground state. These results demonstrate a unique room temperature platform for exploring the physics of exciton-polaritons in plasmonic open-cavities.

Biography

Gómez-Rivas received his PhD in 2002 from the University of Amsterdam for the investigation of light transport in disordered media. From 2002 until 2005, he worked as postdoctoral researcher at RWTH-Aachen, pioneering the field of THz plasmonics. He became group leader at the FOM Institute AMOLF in 2005. His group was partially located at Philips Research, introducing the concept of nanoantennas for solid state lighting. In 2010 Gomez-Rivas was appointed professor. Gómez-Rivas has received several prestigious grants and awards and is co-author of more than 140 articles. He also works as associate editor of the Journal of Applied Physics.

Schrodinger's Cat and Timeless Quantum Mechanics

Francis T. S. Yu

Emeritus Evan Pugh (University) Professor of Electrical Engineering, Penn State University, University Park, PA

Abstract

One of the most famous cats in science must be the Schrödinger's cat in quantum mechanics, in which the cat can be either alive or dead at the same time, unless we look into the Schrödinger's box. The life of Schrödinger's cat has been puzzling the quantum physicists for over eight decades as Schrödinger disclosed it in 1935. In this chapter, I will show that the paradox of the cat's life is primarily due to the underneath subspace in which the hypothetical subatomic model is submerged within a timeless empty subspace (i.e., $t = 0$). And this is the atomic model that all the particle physicists, quantum scientists and engineers had been using for over a century, since Niles Bohr's proposed in 1913. However, the universe (our home) is a temporal space (i.e., $t > 0$) and it does not allow any timeless subspace in it. I will show that by immersing the subatomic model into a temporal subspace, instead a timeless subspace, the situation is different. I will show that Schrödinger's cat can only either alive or dead, but not at the same time, regardless we look into or not look into the Schrödinger's box. Since the whole quantum space is timeless (i.e., $t = 0$), we will show that, the fundamental superposition principle fails to exist within our temporal space but only existed within a timeless virtual space. This is by no means of saying that timeless quantum space is a useless subspace. On the contrary it has produced numerous numbers of useful solutions for practical application, as long the temporal or causality condition (i.e., $t > 0$) is not the issue. In short, we have shown that Schrödinger's cat is not a scientific paradox and his quantum mechanics is a timeless which behaves like mathematics does.

Keywords: Schrodinger's Cat, Quantum Mechanics, Superposition Principle, Timeless Subspace, Temporal Space, Atomic Models.

Advanced Least-Squares Integration Method for Deflectometry

Xiangqiang Jiang* and Feng Gao

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Abstract

Deflectometry is used to measure the local slope of specularly reflecting surfaces using a CCD camera as the detector and a LCD screen as a light source. In order to obtain the 3D topography, an integration over the calculated slope data is needed. Least-squares integration (LSI) and radial basis function integration (RBF) methods are generally used to reconstruct the surface shape from gradient data. The traditional LSI method requires the gradient data to lie on a rectangular grid, while the RBF method is only in effect when handling small size measurement data set. Practically, the volume of the gradient data in a deflectometry measurement is quite large and the data points lie on quadrilateral grids. This talk is focused on an advanced LSI method to integrate the gradient data. The method is based on an approximation where the normal vector of one point is perpendicular to the vector connecting the points at either side. A small measurement data set integrated by the RBF method is employed as a supplementary constraint on the proposed method. Simulation and experimental results demonstrate that the proposed method is accurate and effective at handling deflectometry measurements.

Biography

Dame Jane Jiang is a RAEng/Renishaw Chair in Precision Metrology. She is the Director of the EPSRC National Hub for the Future Metrology. She obtained her PhD in measurement science in 1995, a DSc for precision engineering in 2007. Her research includes: development of mathematical models and algorithms for precision metrology; and development of optical techniques for embedded sensor and instrumentation. She has published more than 400 papers; 8 books on measurement technology. She is a Fellow of the Royal Academy of Engineering, a Fellow of CIRP. She was awarded a Royal Society Wolfson Research Merit Award in 2006 and received a Damehood in the 2017 Queen's Birthday Honours.

Diamond Brillouin Lasers

Richard P. Mildren*, Robert J. Williams, Zhenxu Bai, Ondrej Kitzler and David J. Spence

MQ Photonics Research Centre, Macquarie University, Australia

Abstract

Brillouin lasers rely upon light amplification by stimulating scattering from an induced hypersonic (GHz) beat wave in a photo elastic medium. Though many of their core principles are well established, and the phenomenon is often regarded a parasitic effect in fibre lasers, the exceptional properties of Brillouin gain (or loss) have triggered a recent increase in interest for applications as diverse as slow-light, high coherence lasers, quantum memories, frequency combs and microwave photonics. To date, however, Brillouin lasers have been demonstrated in only a handful of materials and in configurations that provide acoustic guidance.

Our recent studies show that diamond provides a novel free-space format for Brillouin lasers (ie., without relying on acoustic guidance) and extends the power and frequency range in accordance with diamond's extreme physical properties. In the first instance, we have characterized the basic Brillouin properties of diamond and demonstrate high power Brillouin lasing in a pure single Stokes mode. The results foreshadow development of lasers and nonlinear optical devices that leverage diamond capacities for extreme power densities and high frequency (50-300 GHz) microwave synthesis and manipulation. This paper will summarize our progress to date and highlight the potential for a new class of practical free-space Brillouin-based lasers and optical manipulators.

Biography

Rich Mildren graduated from the University of Adelaide for his BSc (Hons) and Macquarie University for his PhD in 1997. His research has centered on high power lasers and advanced optical materials, most recently that of diamond materials. He has 4 granted patents and 85 peer-reviewed journal publications. For 3 years (2005-2008) he led R&D for a University spin-off company in wavelength-switchable medical lasers. He was an Australian Research Council Future Fellow 2010-2014 and in 2017 a recipient of the Australian Museum Eureka Award for Outstanding Science for Safeguarding Australia. He is currently Professor in the Department of Physics and Astronomy at Macquarie University in Sydney.

Featured Presentations

Simulations and Experimental Demonstration of Large Aperture Harmonic Generation Energy Clamping due to Wavefront Distortion/Defocus in Glass Amplifier Systems for Nanosecond Pulses at 1 GW/Cm²

Waseem Shaikh*, Pedro Oliveira, Ian Musgrave, Marco Galimberti, Trevor Winstone and Cristina Hernandez-Gomez
Central Laser Facility, STFC Rutherford Appleton Laboratory, Chilton, Didcot, UK

Abstract

The efficient frequency doubling is needed in the next generation of long pulse OPCPA amplification schemes. We model and observe energy clamping in thick crystals due to wavefront distortion in the Nd:Glass amplifier systems. OCIS codes: (140.3530), (190.2620).

1. Introduction: There is growing interest in the development of optical parametric chirped pulse amplification (OPCPA) laser technologies for Multi-PW applications. These require the construction and development of suitable pump sources either based on Diode Pumped Solid State Lasers [1], or those that exist on large laser systems like Vulcan. We have previously described a temporally shaped 3 ns 30J pump laser based on a combination of rod Nd:Glass amplifiers seeded by a CW pumped regenerative amplifier and a fiber seed source[2]. We model the frequency conversion of this at 3.1 J/cm² and 1 GW/cm² in 22 mm KDP, 64 mm DKDP and LBO for super gaussian spatial and gaussian(G) and super gaussian(SG) temporal profiles using SNLO[3]. As is common in glass based laser systems, we observe far field profiles which are distorted at the 30J level. We incorporate this as wavefront curvature in our modelling and observe severe clamping of the doubled energy due to walk-off in the thicker crystals. The preferred option appears to be ~15 mm thick LBO which has a greater (>3) non-linear coefficient and a smaller (<3) walk-off angle.

2. Laser system and results: The 30J pump laser [2] is shown in Figure 1. It consists of a series of Nd:Glass Rod phosphate amplifiers, with various spatial filters for beam expansion before final amplification at a diameter of 35 mm in a double pass 45 mm diameter amplifier, which can be fired every 5 minutes. The final beam is spatially super gaussian of order 10.

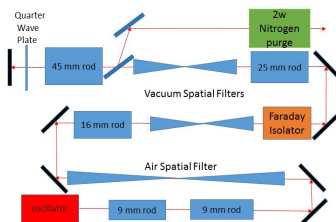


Fig 1. 30J pump laser used for frequency doubling studies.

The Type 1 doubling crystals are housed in a nitrogen purged enclosure. We also model in SNLO[3], the far field beam profiles in both the walk-off and non walk-off planes, both at low energy when the smaller rod amplifiers are operating as well as at full energy with the larger amplifiers. Importantly, this conversion efficiency is obtained at the ~57% level for the 22 mm thick KDP crystals (Figure 2) for flat wavefronts and wavefront curvatures (~200m) which are matched to those observed in our far field measurements where the beam can typically de-focus by > 7 times on full energy shots. Our second crystal is a 64 mm thick DKDP – computed conversion outputs are shown in Figure 3. Assuming a well collimated beam, the efficiency should approach 95% in these longer crystals. The graph shows output energies at the correct phase matching angle, again for both temporal gaussian(G) and super gaussian (SG) beams. Figure 4 demonstrates the anticipated output energies expected for LBO in XY plane.

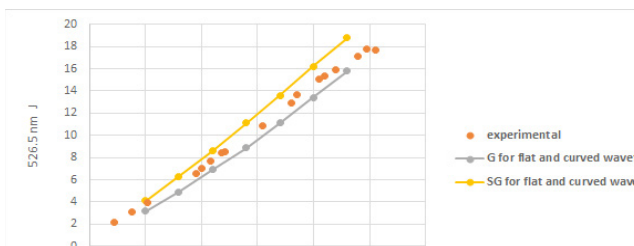


Fig 2. Experimental and calculated outputs for 22 mm KDP for flat and curved wavefronts - no change observed or expected.

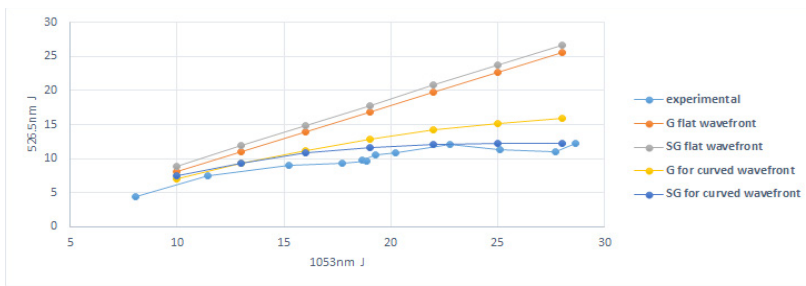


Fig 3. Experimental and calculated outputs for 64 mm thick DKDP

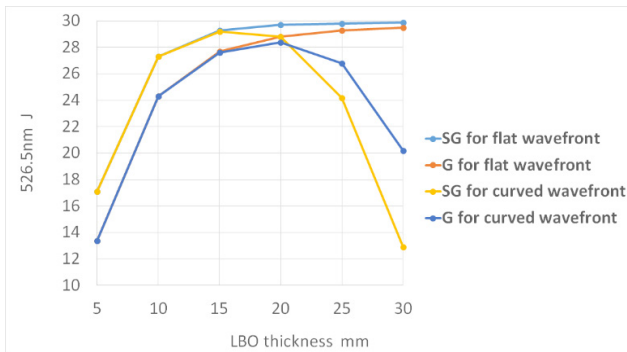


Fig 4. Calculated outputs expected for LBO for spatial super gaussian 30J 3 ns pulses at 3.1 J/cm²

3. Future plans: Higher energy and efficient (>90%) frequency doubled nanosecond pump sources are being built for long pulse OPCPA amplification using pump beams from glass amplifier systems. We plan to frequency double using ~15 mm thick LBO crystals or use a modified laser system which is wavefront corrected or utilise adaptive optics.

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VCSEL-Based Beam Scanner for 3D Sensing

Fumio Koyama

Institute of Innovative Research, Tokyo Institute of Technology, Japan

Abstract

Various applications of VCSELs have been seen including datacom, sensors, optical interconnects, spectroscopy, printers, LiDAR and high power sources. 3D sensing has been attracting much attention for a wide range of applications such as LiDAR for automatic driving cars, face ID in mobile phones, security camera, and motion sensors in virtual reality. 3D sensing has been based on two different schemes of time-of-flight technology and structure light principle. A big market is prospected for 3D depth camera, which was recently installed in iPhone X. An optical beam scanner is a key element for use in various applications such as laser displays, laser sensors and free-space optical communications. A mechanical beam scanner has been widely used, but nonmechanical solid-state scanner is attracting much attention for compact LiDAR applications in recent days. Phased array beam steering devices based on silicon photonics were reported, but there still remain critical issues to be solved. We proposed and demonstrated a beam steering device based on a VCSEL structure, showing the record high-resolution beam steering. But it is a passive device and it is a challenge to obtain high output power, which typically needs over 10W for LiDAR applications. In this paper, our recent activities of VCSEL photonics for 3D optical sensing will be reviewed. We demonstrate mm-long VCSEL amplifiers, which show a narrow divergence and a quasi-single mode operation under high power pulsed operations. The power scalability is discussed for use in 3D sensing. In addition, we present a VCSEL amplifier with a folded-path slow-light waveguide layout, which functions as a dot projector by scanning a dotted line beam.

Biography

Fumio Koyama is the director-general (dean), Institute of Innovative Research, Tokyo Institute of Technology. His research interest includes VCSEL photonics, photonic integrated devices, 3D optical sensing and LiDAR. He has authored or co-authored more than 1,000 journal and conference papers. He received various awards, including IEE Electronics Letters Premium in 1985 and 1988, the Ichimura Award in 2004, the MEXT Prize for Science and Technology in 2007, IEEE/LEOS William Streifer Scientific Achievement Award in 2008, Sakurai Memorial Award in 2017, Okawa Award in 2018, Nick Holonyak, Jr. Award and IEICE Achievement Award in 2019. He is Fellow of IEEE, IEICE and JSAP.

Energy Harvest Type Millimeter-Wave Integrated Photoreceiver for Photonic Wireless Communications

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¹National Institute of Information and Communications Technology (NICT), Japan

²Waseda University, Japan

³Hitachi Kokusai Ltd., Japan

Abstract

We present a newly developed energy harvest type millimeter-wave (W-band) hybrid integrated photoreceiver with a p-HEMT amplifier for radio and power over fiber transmission in advanced mobile front haul link beyond 5-G. It consists of a zero-bias operational high-speed photodetector (3dB bandwidth > 100 GHz), high gain 100 GHz enhancement type p-HEMT amplifier to enhance the O/E conversion gain and bias-T circuit. The zero-bias operational high-speed photodetector plays two roles. One of roles is high speed signal detection; another one is providing DC power supply to the 100 GHz amplifier for energy harvest. The design and characteristic of the new two key devices (photodetector and amplifier) will be reported with the performance of the integrated photoreceiver. Moreover, we report the demonstration on high data rate photonic wireless transmission using only photonic power supply without external electric power supply. The integrated photoreceiver with high optical to electrical conversion gain at 100 GHz can allow us high data rate photonic wireless communications. In the demonstration, an error-free, high-data-rate of 11 Gbps (OFDM, 16 QAM, IF = 92 GHz) was confirmed. The detail of the all photonic transmission system based on radio and power over fiber and its performance will be discussed.

Biography

Toshimasa Umezawa worked for the Yokogawa Electric Corporation; he was with the Central Research Laboratory from 1987 to 2011. In 1992, he was a visiting scholar in the Department of Applied Physics, Stanford University, and he received a Ph.D. degree in electronics from Tokyo University, in 1995, where he was engaged in research on superconductor devices, photonics devices, and their applications. In 2011, he joined the NICT, Tokyo, Japan. His current research interests are high speed E/O devices and photonic integrated circuits and millimeter-wave photonics.

Photogenerated Carrier Extraction from Low Dimensional Semiconductor Materials and its Application in Inter Band Transition Quantum Well Infrared Detector (IQWIP)

Lu Wang*, Ziguang Ma, Yang Jiang and Hong Chen

National Laboratory for Condensed Matter Physics, Institute of Physics, Chinese Academy of Sciences, Beijing, China

Abstract

For a long time, the interband transition of low dimensional semiconductor materials was considered not suitable to be used in light-to-electricity converting process due to the quantum confinement and infinite absorption thickness. Recently, it was found the photo-generated carriers can be extracted from the low dimensional semiconductor materials at a very high efficient and the absorption coefficient increased largely if they were placed in the depletion region of a PN junction. The phenomenon was checked in both quantum dots and quantum wells, and the effect was verified in GaN, GaAs, InP and GaSb material systems. The results show that such phenomenon is independent of dimension of quantum confinement and materials systems, so it should be a physical nature of PN junction. Although the mechanism behind such phenomenon was still unclear, prototype photodetectors based on interband transition of InGaAs/GaAs quantum wells and InAsSb/GaSb quantum wells were fabricated and tested. The results shows such phenomenon provide a powerful tool to fabricated low noise detectors and provide possibility to fabricate high performance multi-junction solar cells.

Biography

Lu Wang is an associate professor, who joined the Institute of Physics, Chinese Academy of Science in 2010. He is interested in Molecular Beam Epitaxy growth of III/V material for optoelectronics use.

Optically Extraordinary Behaviors of the Hbn Crystal With an Oblique Surface

Shufang Fu, Sheng Zhou and Xuan-Zhang Wang*

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School of Physics and Electronic Engineering, Harbin Normal University, China

Abstract

We theoretically investigated basically optical properties of the hexagonal boron nitride crystal (hBN) with an oblique surface, where the uniaxial axis of the hBN is arbitrarily orientated, as shown in Fig.1. The hBN has two hyperbolic frequency bands (HFBs) wherein the hBN is a hyperbolic material¹⁻³. When a transverse electric (TE) or transverse magnetic (TM) radiation is incident on the hBN surface, the reflective wave is composed of a transverse electric (TE) wave and a transverse magnetic (TM) wave with different amplitudes and phase angles. It means that the double-reflection phenomenon is predicted in this configuration. There naturally are two refractive waves in the hBN, or the o-wave and e-wave. In the upper HFB, there is a special point depending on the orientation of the uniaxial axis. For the TM incidence, the energy-flux density of the e-wave near the special point almost travels along the surface and is much stronger than that of the incident radiation, but that of the o-wave is much less. It is the most interesting that the energy flux of the e-wave is opposite in direction on the two sides of this point. It is obvious that this phenomenon is the switching effect of refractive radiation.

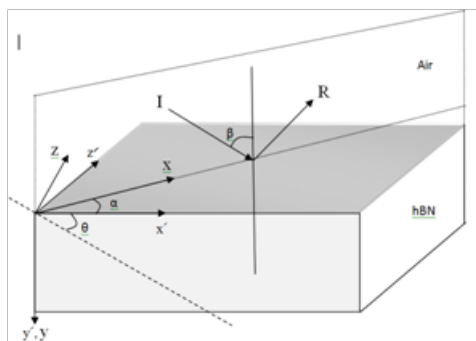


Fig.1 The configuration, where θ determines the orientation of the uniaxial axis indicated by the dashed line in the x-y plane, is the incident angle and the x-y plane is the incident plane. Atomic layers in the hBN are arranged along the dashed line.

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Biography

Xuan-Zhang Wang, born in 1957; Professor; received my doctor degree from the Graduate School, Chinese Academy of Science.

The Behavior of Hydrogen Atom Under Different Potential Well

Wei-Xing Xu

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Abstract

In this work, we consider the behavior of hydrogen atom under different potential well and found that with decreasing the distance between the electron and proton, the more multiple interaction terms start to take effect and the potential well becomes more and more sensitive to the distance between the electron and proton. Based on these results, the potential well for the neutron decaying is determined. Furthermore, the general topics, such as the origin of nuclear energy, the fundamental forces in the nature and the matter with negative mass also are discussed. At the end of this work, the duality model of our universe is put forth.

Broadband Two-Dimensional Electronic Spectroscopy in an Actively Phase Stabilized Pump-Probe Configuration

Weida Zhu^{*}, Rui Wang, Chunfeng Zhang and Min Xiao

School of Physics, Nanjing University, China

Abstract

We introduce a novel configuration for two-dimensional electronic spectroscopy (2DES) that combines the partially collinear pump-probe geometry with active phase locking. We demonstrate the method on a solution sample of CdSe/ZnS nanocrystals by employing two non-collinear optical parametric amplifiers as the pump and probe sources. The two collinear pump pulse replicas are created using a Mach-Zehnder interferometer phase stabilized by active feedback electronics. Taking the advantage of separated paths of the two pump pulses in the interferometer, we improve the signal-to-noise ratio with double modulation of the individual pump beams. In addition, a quartz wedge pair manipulates the phase difference between the two pump pulses, enabling the recovery of the rephasing and non-rephasing signals. Our setup integrates many advantages of available 2DES techniques with robust phase stabilization, ultrafast time resolution, two-color operation, long delay scan, individual polarization manipulation and the ease of implementation.

Biography

Weida Zhu graduated from Huazhong University of Science and Technology, China, with a B.S. in Applied Physics in 2015. Then, he attended Nanjing University for further study on ultrafast spectroscopy and now is a PhD student of School of Physics. His main research interests focus on the implementation of two-dimensional Fourier transform electronic spectroscopy (2DES) and the coherent dynamics in the ultrafast intramolecular singlet fission in covalently linked Tetracene-Pentacene dimers.

Replication of Large-Area Microstructures for Optics Using Induction Heated Belt Roller Embossing

Sen-Yeu Yang^{*} and Yi-Heng Chen

Department of Mechanical Engineering, National Taiwan University, Taiwan

Abstract

Roller hot embossing is an effective mass production technology for fabrication of polymeric components with microstructures for optical functions. However, the heating mechanism and mold fabrication need further improvements. In this paper, induction heating was used to heat the belt right before entering the roller. Roller was employed to apply uniform pressure along the contact line with the heated mold/substrate driven through under it. A simulation software was first used to simulate the heating rate and distribution of temperature of the heated thin steel belt upon the induction heating using coil. The analysis results show that the coil with frame shape is most suitable for the induction heating of the belt. Second, experiments of induction heating of the belt are setup to verify the heating rate and the temperature uniformity. Then a roller hot embossing facility, with induction heating and the belt roller mechanism, is designed, implemented and tested. Finally, two microstructures, microlens array and V-cut structure, are replicated onto the surface of PETG and PMMA substrates with dimension of $100 \times 100 \text{ mm}^2$. The transcription rate of 95% can be achieved. The illumination measurement has shown that, with the same light source, the brightness passing through the plates with V-cut has increases 52%, compared to the bare plates. This study demonstrates the feasibility, performance and potential of induction heated belt roller hot embossing for replication of microstructures onto polymeric substrates.

Biography

Sen-Yeu Yang is a Professor of Department of Mechanical Engineering, National Taiwan University, Taiwan, Republic of China. He has devoted himself to the research on fabrication of precision polymeric and glass optical components for more than 25 years. More than 120 papers on MEMS, injection molding, hot embossing of optical elements has been published in SCI Journals including Optics Express, Microsystem Technologies, and Journal of Micromechanics and Microengineering (JMM) etc. Paper has been selected for inclusion in IOP (Institute of Physics) Select and the Highlights of 2008. He was the general chair of the APCOM 2009 (Asia Pacific Conference on Optics Manufacture, 2009).

Enhancement Factors of Parity- and Time-Reversal-Violating Effects for Monofluorides

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²*Physical Research Laboratory, India*

³*Tokyo Institute of Technology, Japan*

Abstract

Charge-Parity (CP) violation predicted by the Standard Model (SM) of particle physics cannot explain the matter-antimatter asymmetry in the Universe. It is therefore necessary to consider CP violation beyond the SM. These additional sources of CP violation predict the electron electric dipole moment (eEDM) and the electron-nucleon scalar-pseudoscalar (S-PS) interaction, but they have not yet been observed. However, upper limits for these quantities have been obtained from YbF, HfF⁺, and ThO molecules.

Molecules with large enhancement factors of the eEDM and S-PS interactions are suitable for experiments, because the observable energy shift is proportional to these quantities. The enhancement factors of the eEDM and S-PS interactions are referred to as the effective electric field (E_{eff}) and the S-PS coefficient (W_s), respectively. Our objective is to analyze the enhancement mechanisms for E_{eff} and W_s, and the sensitivity of the eEDM and S-PS interactions.

In this work, we calculate E_{eff} and W_s of XF (X = Sr, Cd, Ba, Yb, Hg, Ra, and Cn) molecules using Dirac-Hartree-Fock (DHF) and relativistic coupled-cluster singles and doubles (RCCSD) methods. The magnitudes of E_{eff} and W_s at both DHF and CCSD levels increase with the atomic number of X, except for CdF and HgF, for which we obtain very large values. We attribute the reason for this to the weak screening effect of the outermost core d electrons. We also discuss the sensitivity of the eEDM and S-PS interaction by considering the ratio W_s/E_{eff}.

Development of Composite Lasers and Stacked Wavelength-Conversion Devices by Use of the Room-Temperature-Bonding Technique

Ichiro Shoji

Chuo University, Japan

Abstract

We are developing new solid-state lasers and wavelength-conversion devices using the room-temperature-bonding (RTB) technique. RTB, which is also called surface-activated bonding, realizes atomic bonding of two plates by three steps under vacuum condition at room temperature: setting of the two plates, irradiation of Ar atom beams to their surfaces, and those touching and pressing. A wide variety of materials even between different ones be bonded without degradation of crystal quality by use of the RTB.

First, we fabricated a Nd:YAG/diamond composite laser with the anti-reflection (AR)-coated layer at the bonded interface. We have confirmed that the slope efficiency of the composite is higher than that of the directly bonded composite without the AR layer and nearly the same with that of a non-composite Nd:YAG crystal because the Fresnel reflection at the bonded interface is minimized. Moreover, the power from the new composite with the AR layer is 1.2 and 1.5 times higher than from the previous composite without the AR layer and the non-composite, respectively.

Second, we developed two kinds of wavelength-conversion devices. One is a walk-off compensating β-BaB₂O₄ (BBO) device, which generates 1.8 times higher UV power than a conventional bulk BBO crystal. The other is multiple-plate-stacked GaAs quasi-phase-matching second-harmonic-generation devices. We have succeeded in fabricating low-loss device by improving the room-temperature-bonding process, and in generating the second-harmonic wave of a CO₂ laser.

Biography

Ichiro Shoji graduated from the Department of Applied Physics, the University of Tokyo, in 1992. He served as a research associate and got a PhD degree at the University of Tokyo in 1999. After working at the Laser Research Center in the Institute for Molecular Science, he obtained a position at Chuo University in 2004 and is a full professor from 2010.

He is currently engaged in characterization of linear and nonlinear-optical properties of laser and wavelength-conversion materials, and the research and development of high-performance compact solid-state lasers, using technology he has developed himself.

Compensation of Scanner Based Inertia for Laser Structuring Processes

Mario Pothen*, Kai Winands and Fritz Klocke

Fraunhofer Institute for Production Technology IPT, Germany

Abstract

Laser surface structuring is an innovative manufacturing technology as it offers high flexibility with regard to a range of materials. The technology itself is based on material ablation caused by the energy transfer of pulsed laser radiation into heat.

In order to deflect the pulsed laser beam on the workpiece surface, usually, a scanner system with two moveable mirrors is used. The mirrors are moved by high dynamic galvanometers. However, because of the inertia of the mirrors, the ablation is not evenly distributed along a marking path which is defined by a vector movement. The distribution density of the single laser pulses is higher in the areas of mirror acceleration as compared to the area of constant velocity. A new and innovative strategy has been developed at the Fraunhofer IPT to automatically analyze the behavior of the scanner system as well as to compensate the acceleration regions adapted to the used processing strategy and the machine system.

Biography

Dipl.-Ing. (FH) Mario Pothen, M.Sc. received his diploma in Technical Computer Science in 2007 at University of Applied Sciences Niederrhein (Krefeld, Germany). After that, he studied Computer Science at the Heinrich-Heine-University Düsseldorf (Germany), where he receives his master's degree. Since 2010 he has been working as a research associate at the Fraunhofer IPT (Aachen, Germany) in the field of laser structuring and CAx-systems. He also has been member of the winning team of the International Bionic Award 2016 related to his work in the field of biomimetic laser surface processing.

Laser Grown ZnO Nanowires for (SAW) Sensors Applications

Marcu^{*} and C. Viespe

National Institute for Laser Plasma and Radiation Physics, Romania

Abstract

Nanostructured materials are more and more used in various hi-tech applications and sensor area is just one of them. Among used nanostructures, nanowires present the big advantage of combining the high surface area with alignment capabilities while ensuring a good penetrability of the ambient medium into the sensor active area region. There are various fabrication techniques, but laser-based technique present the advantage of a perfectly "clean" method ensuring the best structure morphological and structural parameters. On the other hand, zinc oxide is known as a good sensing material for some gas detection, (including hydrogen detection) through its physical adsorption properties and represent a good option for sensor active area fabrication

In this work, we have used Vapor-Liquid-Solid (VLS) technique in a Pulsed Laser Deposition (PLD) system for growing ZnO nanowires with controlled morphology and surface patterning. Nanowires morphological parameters were performed through catalyst and plume parameters control. Fabricated surface-acoustic-wave (SAW) sensors using such structures have proven to have enhanced performances depending directly on the nanowire morphology, while nanostructure surface patterning was proved as another key parameter in enhancing sensor performances.

A summary of physical control (experimental) capabilities on nanowire grow in VLS/PLD systems and their direct influence on the SAW sensors performance is presented. Comparisons between different nanostructure patterns and structure morphologies with thin film surfaces are presented and exemplified on the hydrogen and deuterium detection.

Seeing is Believing

Valeriu Beiu^{*}, Roxana-Mariana Beiu, Marius M. Bălaș and Valentina E. Bălaș

"Aurel Vlaicu" University of Arad, Arad, Romania

Abstract

This is a review of the very latest developments in imaging biological samples. Visualizing cells/molecules/atoms is crucially important but excruciatingly difficult. Still, recent progress reveals many mature imaging techniques. We will recap the principles behind techniques allowing beyond diffraction limit imaging, highlighting historical and fresh advances for neuroscience. The first venture outside classical optics was represented by X-ray and electron microscopy (allows resolutions down to 40pm, but is unfriendly to biological samples). It has diverged into TEM, SEM, REM, and STEM, while lately merging with holography (scanning transmission electron holography, atomic-resolution holography, low-energy electron holography). The second departure from classical optics was represented by scanning probe techniques like AFM, STM, PFM, and RTM, which rely on a tip scanning a surface. The third attempt has come full circle, and is represented by super-resolution microscopy, which won the Nobel Prize in 2014. We shall start from basic principles, emphasizing the advantages and disadvantages of different bio-imaging techniques. The development of super-resolution microscopy (since the 1990's) has allowed imaging fluorescent molecules at unprecedentedly small scales and led to 'nanoscopy', a term coined in 2007. This distinguishes diffraction-unlimited techniques from conventional approaches, an incomplete (alphabetical) list include BALM, COLD, fBALM, FPALM, GSDIM, LSFM, PALM, SIM, STED, STORM, SMLM, SNOM, and TIRF (among others). Obviously, such improvements in resolving power opened unexplored avenues for studying synapses/axons/neurons, and a few of the latest experiments will highlight their unique capabilities, e.g., single-particle tracking inside cells (revealing the dynamics of receptor trafficking, and signaling/cargo transport).

Acknowledgment: Research supported by the EU through the European Research Development Fund (ERDF) under the Competitiveness Operational Program (BioCell-NanoART = Novel Bio-inspired Cellular Nano-Architectures, POC-A1-A1.1.4-E-2015 nr. 30/01.09.2016).

Biography

Valeriu Beiu received the MSc from the University “Politehnica” Bucharest (UPB), in 1980, and the PhD from the Katholieke Universiteit Leuven (KUL), in 1994. He was with the Research Institute for Computer Techniques, UPB, KUL, Kings College London, Los Alamos National Laboratory, Rose Research, Washington State University, United Arab Emirates University, being since 2015 with the “Aurel Vlaicu” University Arad. His research interests focus on brain-inspired nano-architectures for ultra-low power highly reliable VLSI designs. He was PI/co-PI on US\$ 51M research grants, authored over 240 articles (31 invited, 7 Best Paper Awards), gave over 200 invited talks, holding 11 patents.

Signal-to-Noise-Ratio Investigation of Silicon Photomultipliers for Functional Near Infrared Spectroscopy Applications

Valentina Giordano¹, Giovanni Maira¹, Sebania Libertino¹, Massimo Mazzillo², Vincenzo Vinciguerra², Giorgio Fallica² and Salvatore Lombardo

¹*CNR-IMM, Hq Catania, Italy*

²*STMicroelectronics, Catania, Italy*

Abstract

There is an increasing interest in using Silicon Photomultipliers (SiPMs) for portable applications, especially in the near infrared (NIR) range, whenever low light fluxes must be detected. Since this device is sensitive to the visible and NIR ranges, to maximize its performances and reduce the environmental light absorption we studied the use of passive filters glued on the detector's package. We made a careful characterization of SiPM n+-p type junctions coupled to commercial long pass (interferential and plastic) filters with cut-on wavelength in the range 500 nm–900 nm. Devices were fabricated in STMicroelectronics. Their performances were evaluated in terms of dark current variation, background light rejection, cross talk reduction at high overvoltage values, detection efficiency, spectral response and signal-to-noise-ratio (SNR). Samples underwent illumination of stray light, white lamps, and LEDs operating at 830nm. The NIR illumination wavelength was chosen for one of the possible applications of the detector, the functional Near Infrared Spectroscopy (fNIRS). This application would benefit from the use of highly sensitive detectors with optimized electro-optical characteristics in the Near Infrared. Our results show that long pass filters produce a consistent reduction of the dark current for high overvoltage (OV) values (up to 90%), a reduction of stray light absorption (up to 90% with a 900 nm cut-on wavelength long-pass filter) improving in this way the performance of the detectors in this operating range, with a benefit for the SNR.

Biography

Valentina Giordano got a PhD in nuclear and astroparticle physics on 2012 and worked as a post-doc fellowship at the INFN-Italian Institute for Nuclear Physics for the international collaborations of ANTARES and KM3NeT. Both collaborations aim to build a large volume underwater neutrino telescope and ANTARES is a first prototype. She worked in the simulation and data analysis group and in the technical staff of KM3NET, making photomultipliers characterizations and a test bench for optical modules. Currently, she works with a fellowship at the IMM-Institute for Microelectronics and Microsystems in the field of sensors.

Is It Possible to Measure Hemodynamic Changes Through the Frontal Sinus Using Continuous Wave DOT Systems?

Estefania Hernandez-Martin¹, Francisco Marcano, Cristian Modroño-Pascual, Oscar Casanova-Gonzalez, Julio Plata-Bello and José Luis Gonzalez-Mora

Department of Basic Medical Science (Physiology), Faculty of Health Sciences, Medicine Section, Universidad de La Laguna, Spain

Abstract

The frontal sinus (FS) is an anatomical structure which is not usually taken into account during light propagation modeling in the head. NIR light should cross the FS until the cerebral cortex, when performing functional studies which involve the prefrontal cortex. The bibliography just shows simulation studies of light propagation across the FS, but they are insufficient to prove whether NIR light can reach the prefrontal cortex. Therefore, knowing whether or not it is possible to reach the frontal cortex is a basic aspect of this research. On the one hand, the tracking of the cerebral blood inflow using contrast agents or dyes, as indocyanine green (ICG), provide information on the time signal changes. To study the reliability of NIR light reaching the

cerebral cortex target behind the FS, the changes in time during the tracking of ICG in the prefrontal cortex was monitored using continuous-wave techniques (CW-DOT).

On the other hand, to guarantee the cerebral activations in a controller manner, hemodynamic changes induced by low frequency of transcranial magnetic stimulation applied on the prefrontal cortex were recorded using CW-DOT. The results show how NIR light projected through the frontal sinus reaches the cerebral cortex target, providing enough information to have a reliable measurement of cortical hemodynamic changes using CW-DOT.

Biography

Hernandez Martin works in neuroimaging and electrophysiology fields. During some years has been working in the treatment of diffuse optical tomography (DOT) data, whose results have been always compared with the results given by a golden standard, functional magnetic resonance imaging (fMRI), in study complex regions as the frontal lobe.

Fabrication or Upgrade the Performance of Fiber Optic Sensors by Using Polymer Composite

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Abstract

Fiber optic sensors have shown several advantages compared to other sensors such as small size, low cost, lightweight, robustness, immunity to harsh environment and to electromagnetic interference. Due to their versatility, these devices have been used for measuring temperature, refractive index, pressure, relative humidity, etc. One feature that makes these sensors as good as electric sensors (in some cases better) is their sensitivity; recently, a lot of work has been done to increase this characteristic by means of modifying the sensing region. Different approaches have been proposed and experimentally demonstrated to fabricate or to improve the sensitivity, some techniques are based on thin metal layer deposition, chemical etching, tapering, and attaching of nanostructures and polymers. The last method offers an easy way to cover the sensing area to create new devices or to increase sensitivity, as well as the structure of the device becomes sturdier. In this talk, we will present three sensors based on tapered optical fiber, fiber Fabry-Perot cavity, and surface plasmon resonance optical fiber, respectively. Not only the implementation of some of them were feasible due to the polymer, but also their sensitivities were enhanced.

Biography

I. Hernández-Romano received the B.Sc. degree in physics from the Facultad de Ciencias Fisico Matematicas, BUAP, and the M.Sc. and Ph.D. degrees in optics from the Instituto Nacional de Astrofísica, Óptica y Electrónica, Puebla, México, in 2007 and 2011, respectively. He is currently a CONACYT Research Fellow with the Electronics Department, DICIS, University of Guanajuato, Salamanca, Mexico. His current research interests include optical fiber sensors and their applications.

Surface Plasmon Resonance Nanocounter and Nanosizer

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Abstract

Surface Plasmon Resonance (SPR) Spectroscopy in Kreschtmann configuration is a widespread optical technique commonly used for the label free detection of gases, analytes in solution, or the characterization of the optical properties of thin solid dielectric films. We demonstrate here that Au/SiO₂ plasmonic bilayers can be effectively used as sensing platforms not only for the detection and accurate counting of gold nanoparticles (AuNPs) but also, in the limit of low surface density (σ) approximation, for the accurate determination of the average size of the AuNPs. With numerical simulations based on the Finite Element Method (FEM), we evaluate the error performed in the determination of the surface density of nanoparticles σ when the Maxwell-Garnett effective medium theory is used for fast data processing of the SPR reflectivity curves upon nanoparticle detection. The deviation increases directly with the manifestations of non-negligible scattering cross-section of the single nanoparticle, dipole-dipole interactions between adjacent AuNPs and dipolar interactions with the metal substrate. Using citrate stabilized AuNPs with a nominal diameter of about 15 nm, we demonstrate experimentally that Dielectric Loaded Waveguides (DLWGs) can be used as accurate nanocounters in the range of surface density between 20 and 200 NP/mm². In the low surface density condition, when the AuNPs/water composite's optical density layer is negligible and the electron mean-free path limitation is taken into account

in the AuNPs' dielectric constants formulation, the surface density σ of the nanoparticle array and the statistical mean size $\langle r \rangle$ of the nanoparticles can be straightly determined by using two-color SPR spectroscopy in the context of Maxwell's Garnett theory. The presented results are important not only from the metrological point of view, but also for the development of the ultrasensitive Particle-Amplified Surface Plasmon Resonance (PA-SPR) spectroscopy.

Biography

Tommaso Del Rosso has a degree in Physics and PhD in Electronic and Telecommunication Engineering, obtained from the *Università degli Studi di Firenze* in 2002 and 2006, respectively. He is Professor of Physics at the *Pontificia Universidade Católica* of Rio de Janeiro, where he is the leader of the *NanoLaserLab*. His actual research is dedicated to the synthesis of new functional nanomaterials and metal-dielectric nanocomposites by Pulsed Laser Ablation in liquid, and the development of SPR based devices, applied to the characterization of nanomaterial and sensing of analytes of environmental interest.

RF Injection Locked 18 Ghz Regeneratively Mode-Locked Semiconductor Laser

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¹*Abdullah Gul University, Turkey*

²*Bahcesehir University, Turkey*

³*Tübitak Bilgem, Turkey*

Abstract

In this manuscript, a semiconductor-based fiber ring cavity mode-locked laser regeneratively driven at 18 GHz is presented. The optical spectrum of the laser is centered at 1578 nm. The laser is RF injection locked via an external source at 18 GHz. The phase noise of the mode-locked laser is measured, and the integrated timing jitter was found to be 10.8 fs (from 100 Hz to 20 MHz) and 13.3 fs (from 100 Hz to Nyquist frequency). The integrated amplitude fluctuation (from 100 Hz to 20 MHz) was less than 0.02%. The laser phase and amplitude noise responses to various injected RF power levels were also investigated. The injection RF power has significant effect on the phase noise and the best jitter value is around 40 dB lower than the cavity regenerated RF power.

Biography

Abdullah Oran was born in Nevsehir, Turkey, in 1990. He received B.S degree in Electrical and Electronics Engineering from the Dokuz Eylul University, Izmir, Turkey, and MSc. degree in Electrical and Computer Engineering from the Abdullah Gul University Kayseri, Turkey, in 2011 and 2016, respectively. In 2013, he joined the Department of Electrical and Electronics Engineering at Abdullah Gul University as a Research Assistant and currently, he is working toward a Ph.D. degree on mode-locked lasers, photonic lanterns and fiber optic transmitters.

Rare Earth Nanocrystal Doped Polymer Optical Fiber Via In Situ Polymerization for POF Laser Applications

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Abstract

In the past, integration of fluorescent dyes into polymers for active polymer optical fibers (POFs) is well studied, however, degradation of organic chromophores is still a problem for several optical applications. Luminescent nanoparticles represent an alternative due to their high chemical stability. Furthermore, they do not show photobleaching and photoblinking. Certainly, incubation of nanoparticles into a polymer matrix is challenging due to their high affinity for agglomeration. Rare earth nanoparticle (NP) doped polymers become accessible via in situ polymerization of a methyl methacrylate (MMA) and cyclohexyl methacrylate (CHMA) co-monomer solution with oleic acid functionalized nanoparticles. These nanoparticles were synthesized from rare earth salts via thermal decomposition method in high-boiling point solvent 1-octadecene and capping agent oleic acid. The particle size can be controlled during the synthesis and modification of ligands at the NP surface can be implemented in a following step. Behavior and optical properties of these different NPs was first analyzed in solution and polymer bulk samples. In a next step nanoparticle doped preforms were produced for fiber production in a fiber drawing tower to investigate effects within the fiber. Rare earth doping concentration and the nanoparticle medium (solvent and polymer matrix) can influence optical behavior of those nanoparticles.

Poster Presentations

Extracting Multiple Rescattering Events for Time-Resolved Emission of High-Order Harmonic Generation

Peng-Cheng Li^{1*} and Shih-I Chu²

¹*Department of Physics, College of Science, Shantou University, China*

²*Department of Chemistry, University of Kansas, KA*

Abstract

We investigate the dynamical origin of multiple rescattering processes in high-order harmonic generation (HHG) associated with the odd and even number of returning times of the electron to the parent ion. We perform fully ab initio quantum calculations and extend the empirical mode decomposition method to extract the individual multiple scattering contributions in HHG. We find that the tunneling ionization regime is responsible for the odd number times of rescattering and the corresponding short trajectories are dominant. On the other hand, the multiphoton ionization regime is responsible for the even number times of rescattering and the corresponding long trajectories are dominant. Moreover, we discover that the multiphoton- and tunneling-ionization regimes in multiple rescattering processes occur alternatively. Our results uncover the dynamical origin of multiple rescattering processes in HHG for the first time. It also provides new insight regarding the control of the multiple rescattering processes for the optimal generation of ultrabroad band supercontinuum spectra and the production of single ultrashort attosecond laser pulse.

Biography

Peng-Cheng Li Professor, Department of Physics, College of Science, Shantou University, Shantou, Guangdong 515063, China

Synthesis and Characterization of Gold Nanoclusters for Widely Tunable PL Emission

Hsiu-Ying Huang* and Chi-Tsu Yuan

Department of Physics, Chung Yuan Christian University, Taiwan

Abstract

Gold nanoclusters can be simply synthesized in aqueous solution without involving any toxic elements and hazardous organic solvent. However, unlike colloidal heavy-metal-containing quantum dots with tunable emission, the PL emission of AuNCs is restricted to a narrow spectral range. Here, we demonstrate a facile method to prepare glutathione-stabilized gold nanoclusters (GSH-AuNCs) with different PL emission. We found that by simply adjusting pH value of the solvent and the proportion of the precursors, the PL emission of GSH-AuNCs can be tuned from 400 to 680 nm. All GSH-AuNCs with different PL emission wavelength possess micro-second scale PL lifetimes and exhibit aggregation-enhanced emission which are supported by XPS and time-resolved PL spectroscopy. Motivated by such photophysical properties, we also demonstrate white-light generation based on all GSH-AuNC nano-phosphors under UV illumination.

Biography

Hsiu-Ying Huang received her Ph.D. (2013) in chemistry from the Chung Yuan Christian University. She is working as Postdoctoral Fellow department in physics at Chung Yuan Christian University. Her research mainly focuses on metal nanocluster and carbon dots materials.

Laser-Induced New Phase States in Carbon: Low Dimensional Controlled Structures Due to Nonlinear Dynamic Processes

K. Khorkov', D. Kochuev, R. Chkalov, V. Prokoshev and S. Arakelian*

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Abstract

Development of non-stationary technique for the laser-induced functional elements synthesis based on micro- and nanostructures in graphite samples is under study. Carbon nanostructures such as graphene, nanotubes and nanodiamonds have been obtained in our experiments. The formation mechanisms of nanostructures and microcrystals under femtosecond laser

radiation for graphite in liquid nitrogen are analyzed. Femtosecond laser pulses with high power allows to achieve the local transient conditions for the material processing resulting in ablation, sufficient modification of the structure and/or changing of the phase composition of the materials. Liquid nitrogen as a cryogenic and/or reaction liquid contributes to additional fast cooling and stabilization of the fabricated micro- and nanostructures.

In our experiments we used two femtosecond laser systems: Ytterbium laser system (wavelength $\lambda=1030$ nm, radiation pulse duration $\tau=280$ fs, pulse repetition rate $f=10$ kHz, pulse energy $E_{max}=150$ μ J) and Titanium-sapphire laser system (wavelength $\lambda=800$ nm, radiation pulse duration $\tau=50$ fs, pulse repetition rate $f=1$ kHz, pulse energy $E_{max}=1$ mJ). Surface processing of graphite was carried out in liquid nitrogen, which covered it with a layer thickness of 10 mm. The laser spot diameter was up to 100 μ m. As the samples we used target of highly oriented pyrolytic graphite HOPG-1,7-10x10x1-1 and glassy carbon GC-2000.

We discuss such formation of carbon nanostructures/microcrystals in respect of both fundamental study and possible application in topological photonics. Obtained controllable low size structures have a perspective for creation of different functional elements of possible applications.

Biography

Arakelian Sergei M. (A.S.M.) had his diploma project at the Dept. of Physics at the Lomonosov Moscow State University (MSU). In 1975, he got his PhD thesis and in 1988, he got his Senior Doctor of Science at the MSU as well. Having the status of a Post-Doctor, he stayed at Dept. of Physics at the University of California (UCB) in 1980-1981. He also worked at UCB as a Visiting Professor in 1985. He is the author of more than 300 scientific papers, monographs and patents in the area of laser physics, quantum optics, coherent and non-linear optics.

Characterization of a Laser Surface-Treated Martensitic Stainless Steel

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²Faculty of Engineering, Cairo University, Egypt

³Central Metallurgical Researches and Development Institute (CMRDI), Egypt

Abstract

Laser surface treatment was carried out on AISI 416 machinable martensitic stainless steel containing 0.225 wt.% sulfur. Nd:YAG laser with a 2.2-KW continuous wave was used. The aim was to compare the physical and chemical properties achieved by this type of selective surface treatment with those achieved by the conventional treatment. Laser power of different values (700 and 1000 W) with four corresponding different laser scanning speeds (0.5, 1, 2, and 3 m.min⁻¹) was adopted to reach the optimum conditions for impact toughness, wear, and corrosion resistance for laser heat treated (LHT) samples. The 0 °C impact energy of LHT samples indicated higher values compared to the conventionally heat treated (CHT) samples. This was accompanied by the formation of a hard surface layer and a soft interior base metal. Microhardness was studied to determine the variation of hardness values with respect to the depth under the treated surface. The wear resistance at the surface was enhanced considerably. Microstructure examination was characterized using optical and scanning electron microscopes. The corrosion behavior of the LHT samples was also studied and its correlation with the microstructures was determined. The corrosion data was obtained in 3.5% NaCl solution at room temperature by means of a potentiodynamic polarization technique.

Biography

Samar Reda is a lecturer in Engineering Applications of Lasers Department at National Institute of Laser Enhanced Sciences, Cairo University, Egypt. He graduated from Faculty of Engineering- Cairo University in June 2011. He completed his Diploma and his Masters of Science degree in Engineering Applications of Lasers in June 2015 then received his Ph.D degree in Engineering Applications of Lasers in August 2018. He has published two articles in Materials Journal in 2017, one article in Key Engineering Materials, Scientific.Net, 2018. He has participated in many conferences in Egypt and Italy and attended schools in Germany and Brazil.

Green White-Light Emitting Diode Based on Zn-Coordinated Gold Nano-Phosphors

Kun-Bin Cai^{*}, Hsiu-Ying Huang and Chi-Tsu Yuan

Department of Physics, Chung Yuan Christian University, Taiwan

Abstract

Most of W-LED was made from colloidal quantum dots (CQDs) which exhibit tunable light absorption, efficient PL emission and unique photophysical properties. Unfortunately, those CQDs involve toxic heavy metals. To address these issues,

gold nanoclusters (AuNCs) was prepared as nano-phosphors for W-LED. In our work, we have demonstrated a facile fabrication procedure of eco-friendly white-light emitting diode (W-LED) based on Zn-AuNCs nano-phosphors with large Stokes shift, high photoluminescence quantum yield (PL-QY, ~40%) and coordination-enhanced emission.

Biography

Kun-Bin Cai earned his Bachelor of Science (2016) and Master of Science degree (2018) in the department of Physics from Chung Yuan Christian University in Zhongli, Taoyuan, Taiwan. He is presently working on his Ph.D. in Physics Department, CYCU. His research interests include synthesis of biocompatible nanomaterials and fabrication of solid-state thin films designed specifically for luminescent solar concentrators application.

Aberration Analysis of Micro-Offset Free-Form Mirrors by Shack-Hartmann Wavefront Sensor

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¹Department of Power Mechanical Engineering, National Tsing Hua University, Taiwan

²Instrument Technology Research Center, National Applied Research Laboratories, Taiwan

Abstract

Free-form lenses have been widely used in optics in recent years, such as laser beam shaping, head-up displays, and progressive multifocal lenses. With the growing applications of free-form lenses, the manufacture and inspection technology in ultra-precision machining process have also developed rapidly. On the other hand, it is still necessary to circumvent technical problems in inspection since the metrology of freeform surface needs high accuracy during the coordinate transformation between the workpiece surface and metrology system. This paper is to establish a fast and accurate measurement method for micro-offset free-form mirrors, abbreviated as FM. Contrast to the non-symmetric freeform lenses, the FMs are usually made in rectangular. If the Shack-Hartmann wavefront sensor is employed for measurement of the entire lens, partial measurement method must be used. Hence, the measured results need to be post-processed, for example by sub-hole stitching method, in order to obtain the complete measurement results. In the post-process, many parameters would affect the measurement results especially in selection of the connection points combining each test frame. The bad selection of parameters will induce errors in image stitching. Therefore, this study bases on taking a sample mirror as a small circular shape served as a free-form target surface. The target is placed in the SH sensor measurement system to give measurement results for analysis and discussion in optical quality information. By preliminary optical simulation analysis, the Shack Hartmann wavefront sensor can be successfully used to establish an apparatus for measurement of micro-offset free-form mirrors. Given by the measured wavefront map, the mirror can be further analyzed for optical performance expressed in wavefront maps, Zernike polynomial coefficients, PSF and MTF.

Biography

Pei-Jen Wang is currently a professor at Department of Power Mechanical Engineering, National Tsing Hua University in Taiwan. His main research interests include intelligent manufacturing systems and optical instrument analysis and fabrication.

Light Extraction Efficiency Enhancement of Phosphor-In-Glass Plate Using Sapphire Powder for Laser Lighting Technology

Youyoung Kim^{1*}, Dong-Ho Lee², Sangki Park¹ and Sun-Kyu Lee¹

¹School of Mechanical Engineering, Gwangju Institute of Science and Technology, Korea

²Optical Instrumentation Research Center, Korea Basic Science Institute, Korea

Abstract

In recent years, laser lighting technology attracts high attention as a new light source for illumination such as automotive headlamps, backlight units, and medical equipment. Unlike low power-density white LEDs, the phosphor plate for LD-driven white lighting encounters a condensed high-power density of laser light, resulting in the drastic temperature rise of the phosphor, so that the luminous efficiency of white light decrease due to the thermal quenching. Durability and thermostability of the phosphor plate are very crucial factors to achieve desired performance.

In this study, the sapphire-phosphor-in-glass (SPIG) has been proposed to resolve the thermal issue of the conventional phosphor-in-glass (PIG) for laser lighting. Because the sapphire has high conductivity and visible light transmittance, it helps to improve the thermal stability of PIG in terms of phosphor conversion efficiency and light extraction efficiency, respectively. First, the light extraction efficiency between PIG and SPIG is compared by Monte Carlo ray tracing method based optical simulation; then, PIG and SPIG were fabricated and measured optical performances and thermal characteristics simultaneously. As a result, the temperature of SPIG was decreased by about 20% and the light intensity was increased by 37.3%. This improvement is attributed to that the thermal conductivity of SPIG increases and the light extraction efficiency also increases because of

sapphire particles. The light extraction efficiency of SPIG was about 19.9% higher than the PIG phosphor conversion efficiency by temperature decrease. This experimental result meets the simulation result.

Biography

Sun-Kyu Lee received the B.S. degree in mechanical engineering from Seoul National University, Korea, in 1980, and the M.S. and Ph.D. degrees in mechanical engineering for production from the Tokyo Institute of Technology, Japan, in 1991. He worked in Toyoda Machine Works Company, Japan, from 1991 to 1993. He is working in School of Mechanical engineering, Gwangju Institute of Science and Technology (GIST), Korea as a Professor from 1994. His current research interests include ultraprecision manufacturing systems, nano-positioning control, thermal management of electronic devices, thermal-opto-mechanical design of micro optic devices, micro-patterning.

Monitoring the Optical Power of LED by Combining Radiation Type Thermocouple

Youyoung Kim^{*}, Jongmin Kim, Sangki Park and Sun-Kyu Lee

School of Mechanical Engineering, Gwangju Institute of Science and Technology, Korea

Abstract

LED (Light-Emitting Diode) has many advantages such as luminescence, reliability, durability compared with conventional lighting. It has been widely applied for life, healthcare, smart farm, industry and lighting from indoor to automotive head lamp. However, it's vulnerable to damage due to the junction temperature especially in high power applications. Thus it is necessary to monitor the optical power and the junction temperature for securing reliability of lighting system.

In this study, the measurement of LED optical power is explored by combining a novel thermal sensor and IR camera. Radiation type thermal sensor consists of a photo-absorbent metal film and thermocouple. The sensor is irradiated by the photo-thermal heat as well as the radiative heat simultaneously from the LED lighting source at a distance. Therefore, the temperature measured by the radiation type thermal sensor involves not only the actual surface temperature but also the overestimated temperature due to the light absorbing at the metal film. They can be distinguished by comparing the actual surface temperature measured by IR camera and the photo-thermally overestimated temperature of thermal sensor at each different optical power. The differences between actual and overestimated temperature at each optical power level are used as a predetermined relationship which enables to estimate obtain the optical power. Eventually, the LED optical power can be evaluated simply based on predetermined relationship and difference between steady state temperature and its sudden drop immediately after switching OFF state in short time.

Biography

Sun-Kyu Lee received the B.S. degree in mechanical engineering from Seoul National University, Korea, in 1980, and the M.S. and Ph.D. degrees in mechanical engineering for production from Tokyo Institute of Technology, Japan, in 1991. He worked in Toyoda Machine Works Company, Japan, from 1991 to 1993. He is working in School of Mechanical engineering, Gwangju Institute of Science and Technology (GIST), Korea as a Professor from 1994. His current research interests include ultraprecision manufacturing systems, nano-positioning control, thermal management of electronic devices, thermal-opto-mechanical design of micro optic devices and micro-patterning.

Laser Impulse Transfer on Metallic Targets

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²Center for Advanced Laser Technologies (CETAL), National Institute for Laser, Plasma and Radiation Physics (INFLPR), Romania

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Abstract

Laser irradiation of various materials has plenty of technical and technological applications, from CD players and material processing (cutting drilling and so on) to medical applications. There are special cases when the laser beam needs to target a precisely determined zone or the target needs to be in a rather narrow laser focus zone and the beam alignment becomes a critical issue. However, the laser beam transfer some impulse and in some particular cases this could not be neglected and beside the laser-matter interaction processes a mechanical influence will have to be considered. Furthermore, in the case of space-application such impulse transfer could be even a main application of such a laser-matter interaction process.

Based on a 3D laser targeting system, this study presents some results on the impulse transfer from few different laser

systems to several materials of interest for space application (but not only). Computer modeling software based on a template matching algorithm together with a predictive algorithm for target motion based on Prony's Method using Python and open-sources libraries are briefly described. A comparison for different laser powers of the impulses transferred from short and long pulses is further presented. Interpretation of the laser efficiency impulse transfer is based on the physical models of the interaction and some conclusion for possible laser based propulsion systems are mentioned.

Matrix-Enhanced Carbon Nanodots for Sustainable Luminescent Solar Concentrator

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¹Department of Physics, Chung Yuan Christian University, Taiwan

²Department of Electrophysics, National Chiao Tung University, Taiwan

Abstract

Synthesis of photoluminescent carbon dots with longer emission wavelength and enlarged Stokes shift is one of the most focused topics in research due to its various applications in optoelectronic devices and biomedical imaging. In this work, we propose a one pot synthesis method in achieving highly efficient yellow emissive carbon dots (YCDs). The synthesized non-toxic, low cost, and eco-friendly YCDs were successfully prepared for the application in sustainable luminescent solar concentrator (LSC). Here, the homogeneous solution of the YCDs and matrix was drop-casted on a clean glass substrate to fabricate the LSC device wherein the YCDs serve as the luminophores and the clean glass substrate as the waveguide. The obtained material showed enlarged Stokes shift with photoluminescence emission centered at around 580 nm and high photoluminescence quantum yield. The fabricated luminescent solar concentrator possesses outstanding potential for forthcoming applications in building integrated photovoltaics.

Biography

Princess Genevieve Camilo Sena received her B.S. in Applied Physics from the University of Santo Tomas, Philippines. She is currently pursuing her M.S. in the Department of Physics at Chung Yuan Christian University, Taiwan. Her current research work involves the synthesis, characterization and optimization of luminescent carbon nanodots for several applications such as in the fabrication of luminescent solar concentrator devices.

Optomechanically Induced Transparency in the Presence of Non-Markovian Effect

Wei Jiang, Guojian Yang^{*} and Jun Xiong

Department of Physics, Beijing Normal University, China

Abstract

We investigate the non-Markovian dynamic response of a cavity-optomechanical system to the combination of a strong control and a weak probe fields, where the non-Markovian effect comes from the coupling between the mechanical oscillator and a bosonic bath characterized by Ohmic spectrum density. We employ the spectrum decomposition scheme to numerically fit the spectral density function, and then transform the original double-integral-differential equation for our system into a set of nonlinear ordinary differential equations. Based on this set of equations, we examine the dynamics of the output field at frequencies of the control and the probe fields. From the probe response of the system in the steady state, we find the widening and relocation of the bandwidth for optomechanically induced transparency due to the action of the structured bath. Our method can be applied to solving a non-Markovian problem in quantum optics where a bath with any frequency-dependent structure must be considered.

Biography

Jiang Wei is a Doctoral student of Physics Department, Beijing Normal University. He was graduated from Central South University and got his bachelor's degree of electronic information engineering. His research interest is about quantum optical properties of an optical system with non-Markovian effects.

Tunable Optical Nonlinearity in Synthetic Soft-Matter

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²*TEDA Applied Physics Institute & School of Physics, Nankai University, Tianjin 300457, China*

Abstract

In the past decade, the development of artificial materials exhibiting novel optical properties has become one of the major scientific endeavors. Of particular interest are soft-matter systems which play a central role in numerous fields ranging from life sciences to chemistry and physics. In this talk, we will present a brief overview of our recent work on a few types of soft-matter systems with tunable optical nonlinearities, including self-trapping of light in dielectric colloidal suspensions with negative polarizability and plasmonic resonant solitons. We will then discuss about controlled orientation of gold nanorods in colloidal suspensions and associated anisotropic optical properties. The ability to actively control the orientation of a large quantity of nanoscale objects and to produce desired synthetic properties is important for fundamental studies as well as technological applications.

Heterogeneously Integrated Low-Operating Energy Directly Modulated Lasers on Si

Shinji Matsuo^{*}, Takuro Fujii, Koji Takeda, Hidetaka Nishi and Takaaki Kakitsuka

NTT Device Technology Laboratories, NTT Corporation, Japan

Abstract

Reduction of operating energy is a key issue to use the lasers in datacom and computercom networks because internet traffic is still increasing. To do this, large optical confinement factor is important to improve modulation efficiency. Reduction of fabrication and assembly costs is also important and, therefore, the fabrication of large-scale photonic integrated circuits (PICs) employing Si photonics technology is desired. Thus, we have been developed membrane buried heterostructure (BH) lasers on SiO₂/Si substrate. Since BH is important to achieve efficient carrier confinement and thermal conductance, the fabrication of BH on Si substrate is an essential issue. We have employed epitaxial growth of InP layer on a directly bonded InP layer on SiO₂/Si substrate. To obtain high-quality epitaxial layers, total thickness of III-V layer must be less than critical thickness, which is determined by the difference in thermal expansion coefficients of Si, SiO₂ and InP. For datacom application, we have developed an 8-channel membrane Distributed Reflector (DR) laser array on SiO₂/Si substrate. Each DR laser was modulated with a 50-Gbit/s PAM-4 signal and an SiN arrayed waveguide grating (AWG) filter was integrated to multiplex output signals. We have also developed photonic crystal (PhC) laser for computercom application. The device exhibited a threshold current of 22 μA, and a 7.3-fJ/bit energy cost directly modulated with a 10-Gbit/s NRZ signal. These results indicate that the membrane BH lasers on SiO₂/Si substrate are highly suitable for use as a transmitter in datacom and computercom applications.

Biography

Shinji Matsuo is a Senior Distinguished Researcher in NTT Device Technology Laboratories. He received a B.E. and M.E. in electrical engineering from Hiroshima University in 1986 and 1988 and a Ph.D. in electronics and applied physics from Tokyo Institute of Technology in 2008. In 1988, he joined NTT, where he researched photonic functional devices using VCSELs. Since 2000, he has been researching tunable lasers and low-operating energy directly modulated lasers. He is a member of the JSAP, IEICE, and a Fellow of IEEE.

Nodal Aberration Theory in Non-Rotationally Asymmetric Freeform Optical System Design

Haodong Shi^{1*}, Xin Zhang², Huilin Jiang¹, Lingjie Wang² and Chao Wang¹

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²*Key Laboratory of Optical System Advanced Manufacturing Technology, Changchun Institute of Optics, Mechanics and Physics, Chinese Academy of Sciences, China*

Abstract

Freeform surfaces have advantages on balancing non-rotationally asymmetric aberrations of the unobscured mirror system. However, since the conventional paraxial aberration theory is no longer appropriate for the freeform system design, as a result of lacking insights on the imaging quality from the freeform aberration distribution for optical designers. Based on the framework

of nodal aberration theory (NAT), the wave aberration expressions of three kinds of off-axis optical system, such as field of view (FOV) decentered, pupil off-set and axis tilted, containing with Zernike polynomial freeform surfaces are derived, respectively. The relationship between the off-axis configuration and the Zernike freeform surface shape acting on the aberration node locations of the third-order spherical aberration, astigmatism, and coma are revealed, respectively. The nodal aberration properties of the off-axis freeform system are analyzed and validated by using full-field displays (FFDs). Those three kinds of off-axis freeform optical systems are designed according to the field aberration distribution properties. The design results show that some of the aberration node locations of the system are controlled in the real-FOV area by optimizing Zernike coefficients pointedly. Thus, the imaging quality, evaluated by modulation transfer function (MTF) or point spread function (PSF), is improved comparing with the initial configuration. By using this design method, the efficiency of designing non-rotationally asymmetric optical system with freeform surfaces can be increased. This research will support the next generation space telescope for increasing the survey sky FOV and improving the imaging quality in the future.

Biography

Haodong Shi was born in Changchun, China, in 1989. He received the B.E. degree in opt-electrical engineering from the Changchun University of Science and Technology (CUST), China, in 2012, and completed the Ph.D. degrees in optical engineering with the Academician of Chinese Academy of Engineering, Prof. Huilin Jiang at CUST in 2017. He joined Prof. Huilin Jiang's group at CUST as an assistant research fellow in November 2017. His current research is focused on the optical system design, freeform aberration theory, and polarization aberration.

Spectral Polarization Spreading in Stimulated Brillouin Scattering and its Influences on Brillouin Frequency Shift in Single Mode Fiber

Chunhua Wang¹, Jingjing Zhao¹, Li Li¹, Yali Zhang¹, Gang Liu¹ and Xiaoyi Bao²

¹Lab of Specialty Fiber and Broadband Access network, Shanghai University, China

²Fiber Optics Group, Department of Physics, University of Ottawa, Canada

Abstract

A vector theoretical model describing the polarization spectrum behavior of the stimulated Brillouin scattering (SBS) is proposed. It indicates a spectral polarization spreading behavior of SBS, i.e. the states of polarization (SOPs) of different frequency components of signal light experience distinct SBS pullings both in magnitude and in direction. In practical single mode fibers (SMFs), it is found that the SOP of signal light can be considered as firstly rotated by the fiber birefringence and then spread by SBS pulling, with heading direction towards the output SOP of signal light experiencing the maximum SBS gain. In addition, we investigate the deviation of Brillouin frequency shift (BFS) due to the influence of low fiber birefringence on the spectral polarization spreading in SMFs. SBS SOP spreading profile will be twisted by the birefringence in SMFs, resulting in BFS deviation. This polarization dependent deviation may cause measurement uncertainty in determination of BFS in practical sensing systems. In the paper, the regularities of the polarization dependent deviation of BFS are simulated and experimentally verified. A 1.38MHz and a 3.6MHz of BFS variations are observed with a 100m and a 25m SMFs, respectively.

Biography

Chunhua Wang obtained her PhD degree in major of Electronics Engineering in 2002. Her research areas include fiber optics, nonlinear polarization behaviors of fibers, polarization measurement, and broadband access network.

Study Nonlinear Effects of Dopants in Glass Matrices Using Z-Scan With Laguerre-Gauss Modes

Carlos Wiechers¹, Ma Alejandrina Martínez-Gómez², Miguel Ángel VallejoHernández¹, Mauricio Rodríguez-González¹, Xóchitl Sánchez-Lozano¹, Lorena Velazquez-Ibarra¹ and José Luis Lucio¹

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²Centro de Investigaciones en Óptica, Mexico

Abstract

We report analysis of the implications of the methodology we develop in [Wiechers C *et al*/JOSAB **36**(1), pp. 61-68 (2019)], in the Z-scan technique to describe complex systems through effective parameters in a general model. First, we describe the systems under the scope: the are glass matrices co-doped with rare earth ions and silver nanoparticles. Both kind dopants exhibit nonlinear behavior, since there are many processes involved which include energy transfer among ions, silver nanoparticles and the matrix, etc. They depend on which wavelength is used in the pump process, to choose with transitions are relevant. The silver nanoparticles produced to thermal decomposition in the samples shows a wide spectrum since there are a distribution in the particles size.

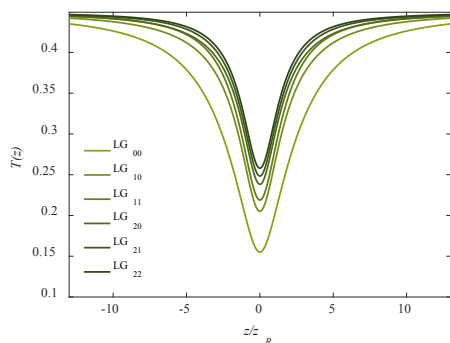


Fig.1. Theoretical curves of open aperture Z-scan technique for different Laguerre-Gauss modes.

In the modeling, we consider the following effective parameters intensity saturation, nonlinear absorption and refractive index, and using the approach of thin sample, we include a the numerical calculation to extend out analysis using the Laguerre-Gauss modes, showing that the mode preserves its topological shape, but the sensitive of the Z-scan technique changes depending of which mode is used as pump, see **Fig. 1**. Additionally, if the pump beam consist in a superposition two modes effective energy parameter is included.

Biography

Carlos Wiechers was born in León, Guanajuato, México. He got his bachelor and master's degrees (2004 and 2006) in the Physics Institute of University of Guanajuato. He got his PhD in Physics at the Division of Science and Technology in University of Guanajuato. During this master he did an stay in University of Texas at Dallas. Also during his PhD, he develop his research at the MPL in Erlangen, Germany and he did two stays: one in USP, Brazil and the second in the NTNU, Trondheim, Norway. He did a postdoctoral work in ICN UNAM, Mexico.

Surface Plasmon Aided Fluorescence for Quantitative Biomedical Assay with High Sensitivity and Good Reproducibility

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Abstract

Biomedical diagnosis that deals with biomarkers of very low concentration requires highly sensitive and reproducible detection technologies, in particular, in multiplexed assay. Fluorescence based assay platform can meet this demand, more effectively with an aid of near field coupling of fluorophore with surface plasmons. The experimental results presented in this work involve enhancement of fluorescence of SYBR green I and FAM for detecting very low concentration of molecules such as DNA. Using bimetallic surface plasmons excitable at dual spectral channels of excitation and emission of fluorophores, we enhance the fluorescence and demonstrate detection of double strand DNA (interferon-alpha promoter) as PCR template, of concentration of about 400 fg/L being the lowest ever reported to date in PCR DNA template assay. More importantly, we achieved the coefficient of variation in assay that represents the assay reproducibility, to be less than 1 %, which is very much unlike the assay that utilizes surface enhanced Raman scattering. We provide two different kinds of platforms for the plasmonic enhancement of fluorescence, being applicable to upright and inverted modes of microscopes. We offer detailed discussion on optimization of plasmonic coupling with fluorophores in addition to basic notion of surface plasmon induced increase in signal-to-noise ratio for fluorescence based biomedical assay.

Biography

Heongkyu Ju received his D.Phil degree from department of condensed matter physics, University of Oxford, UK, 2003, and moved to department of electrical engineering, Technical University of Eindhoven, Netherlands to work as a postdoctoral research fellow for two years. He also worked as a research associate at the photonic nanostructure research group, NTT Basic Research Laboratories, Japan in 2006. He joined department of physics, Gachon University as a faculty member, since 2007. He has published more than 60 peer-reviewed journal papers in biophotonics, 3D display optics, nonlinear/quantum optics, and ultrafast semiconductor optics.

Spontaneous Parametric Four Wave Mixing and Fluorescence Lifetime Manipulation in Diamond NV Center

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³Electrical Engineering Department, Sukkur IBA University, Pakistan

⁴Department of Physics, City University of Hong Kong, Hong Kong SAR

Abstract

We report the lifetime of spontaneous parametric four wave mixing (SP-FWM) and multi-order fluorescence in two, three and four level system of negatively charged nitrogen vacancy (NV⁻) in diamond. The lifetime of SP-FWM is enhanced at high power by induced dark state from coupling fields. The reduction and enhancement in fluorescence lifetime is attributed to destructive and constructive quantum interference, respectively. The quantum interference is induced by interaction among different decay pathways of spontaneous emission by closely spaced energy levels, which can be controlled by dipole-dipole interaction and the mutual orientations of dipole moments. The lifetime is observed to be longer in two level as compare to three level and four level systems. The different measured lifetimes suggests the sensitivity of these NV systems to quantum interference and dressing effect. These outcomes may provide new insights in development of all-optical communication devices and quantum storage on photonic chips.

Reference

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Biography

Irfan Ahmed is a final year PhD Student at department of Physics in City University of Hong Kong.

Solutions to Continuous-Wave Four-Wave-Mixing Equations in Silicon-On-Insulator Waveguides

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Abstract

Four-wave mixing (FWM) in silicon-on-insulator (SOI) waveguides enables a wide spectrum of key functionalities for all-optical communication systems such as optical amplification and frequency conversion. Today, modeling of FWM in SOI waveguides is mostly numeric because analytic solutions to the governing equations are difficult to find, as recent studies demonstrate in both pulsed and continuous-wave (CW) regimes. In this work, we provide novel analytic solutions to the pump-degenerate CW FWM equations including linear loss, two-photon absorption, and free-carrier absorption in SOI waveguides. The solutions are based on methods previously used to study time ordering effects in quantum optics. The analysis enables us to predict the wavelength conversion efficiencies from signal to idler in a pump-degenerate FWM process, and gain significant insight into the wavelength dependence of the process. Further we have confirmed the theoretical model with a numerical model of the process, which has been validated with experimental data.

Biography

Jacob Gade Koefoed obtained his MSc degree in Physics from DTU in 2016. After this he started a Ph.D. study in optical nonlinearities for quantum-resource generation at DTU Fotonik. His current research interests focus on using classical light fields to create and manipulate quantum-optical states. This includes using four-wave mixing in waveguides to create photon pairs with desired spectral properties and using optically induced acoustic fields to manipulate quantum-optical states through Brillouin scattering. He is currently visiting the group of Michael Steel at Macquarie university to work on Brillouin scattering in quantum optics.

Novel Ultrabroadband Binary Photoswitching in High-Performance G-C₃N₄/Si Hybrid Photodetector

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Abstract

Polymeric graphitic carbon-nitride (g-C₃N₄) is an emerging two-dimensional (2D) layered material which is structurally similar to graphene. It offers huge potential for semiconductor device applications due to a suitable direct band gap of $\approx 2.7\text{eV}$. In the nanosheets form, this material demonstrates enhanced light absorption below 450nm, large surface area, high electrical conductivity and efficient separation of electron-hole pairs. These nanosheets have already demonstrated their potential in photocatalysis, bio-imaging, novel photovoltaic applications, etc. Recently, a number of research groups have demonstrated photoswitching resembling "0" and "1" of a binary digital code, making them potentially suitable for weak signal detection and optical computing. However, the binary switching behavior of such devices reported till date is limited to UV and visible spectral range only at small forward biases. In the present paper, we demonstrate for the first time, binary photoswitching behavior over a wide region from 250 to 1350nm at a small forward biases.¹ Our device is based on ultrathin g-C₃N₄ nanosheets embedded into the silicon surface. It also works in self-powered (zero bias) mode showing high photosensitivity, responsivity, detectivity, and fast response speed at low-intensity light illuminations from 250 to 1650nm. The results suggests that g-C₃N₄ nanosheets might also be useful to enhance the performance of existing silicon solar cells using the proposed CN-Si integration technique. The presentation will involve discussion about 2D and 3D materials to realize a hybrid optoelectronic device.

References:

- [1] N. Prakash, G. Kumar, M. Singh, A. Barvat, P. Pal, S. P. Singh, H. K. Singh, S. P. Khanna, "Binary Multifunctional Ultrabroadband Self-Powered g-C₃N₄/Si Heterojunction High-Performance Photodetector" *Advanced Optical Materials* 2018, 6, 1800191.

Biography

Nisha Prakash was born in Delhi, India in 1982. She received her B.Tech. degree in Electronics & Communication Engineering in 2004 and M.Tech. degree in VLSI Design in 2008 from Guru Gobind Singh Indraprastha University, India. Presently, she is working towards the Ph.D. degree in engineering sciences from Academy of Scientific & Innovative Research, at CSIR-National Physical Laboratory, India. Her current research interests include application of two-dimensional materials for energy efficient optoelectronic devices.

Error Analysis in the Absolute Phase Maps Recovered by Fringe Patterns with Three Different Wavelengths

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Abstract

In our previous work, we have developed a technique to recover the absolute phase maps from the wrapped ones with three selected fringe wavelengths. The possible error in fringe order will significantly degrade the quality of recovered absolute phase maps, thus it is necessary to eliminate the error in fringe order. In this paper, we find that a major kind of error in fringe order is caused by an effect similar to optical heterodyne. Based on this fact, we propose a method to avoid this kind of error by adding more constraints in selecting the wavelengths of three fringe patterns. The theoretical conclusions in this paper are validated with experimental results, the effectiveness of the proposed method is also confirmed.

Biography

Jiangtao Xi is the full professor in SECTE, University of Wollongong, Australia. His research interests include signal processing in optical metrology and optoelectronics.

Making Short Reach Link Transmitter Figure of Merits Cognizant of Transmission Format

Douglas Gill

IBM T.J. Watson Research Center/Nanophotonics Department

Abstract

The traditional Mach-Zehnder modulator (MZM) figure of merit (FOM) has historically been defined as $(V\pi^2)/\nu^3dBe$, and works effectively for LiNbO₃ long haul modulators. However, this FOM is not appropriate for systems that use plasma dispersion based electro-optic modulators, or any modulator with an inherent relationship between bandwidth, required drive voltage, and optical insertion loss/gain. Furthermore, when modulators having a tradeoff between bandwidth, drive voltage, and optical loss are used in short reach links with no optical amplification this FOM is even less relevant for understanding relative system performance. I will present our recently proposed new modulator FOM (M-FOM) based on peak-to-peak drive voltage, modulator rise-fall time (or bandwidth), and relative optical modulation amplitude, which are device metrics that are essential for assessing unamplified short-reach link performance. By using this approach, and the appropriate scaling of its value with these performance metrics, the M-FOM can essentially be made 'transmission format aware'. Furthermore, a novel protocol using our M-FOM will be discussed that gives direct insight into how modulator performance impacts required optical power for unamplified data links as well as a discussion of how our new M-FOM allows, for the first time, a system-performance-based direct comparison between ring and Mach-Zehnder modulators.

Biography

Douglas Gill received his Ph.D. from the materials science program UW-Madison. He was a Northwestern University Research Associate, an Alcatel-Lucent Bell Labs MTS, and is currently a Research Staff Member at IBM Watson Research Center 2011-present. His research includes LiNbO₃, thin film, and nonlinear polymer modulators, CMOS compatible photonics, monolithic and hybrid transceivers, and advanced transmission formats for cost effective data transport. He is currently focusing on IBM quantum computing systems. He received the Newport research award, two IBM outstanding technical achievement awards, two Central Bell Labs teamwork awards, and holds over 45 patents and 80 refereed journal and conference articles.

Optical Electrostatic MEMS Microactuator on 4H-SiC

Feng Zhao* and Marcus Daniel Trimble

Micro/Nanoelectronics and Energy Laboratory, Department of Electrical Engineering, School of Engineering and Computer Science, Washington State University, WA

Abstract

This paper presents the design, fabrication and characterization of an optical MEMS device, more specifically, 4H-polytype silicon carbide (4H-SiC) electrostatic MEMS microactuator controlled by a low-power optical signal. The microactuator was monolithically integrated with an optically activated transistor switch on 4H-SiC substrate. The electrostatic force on the cantilever beam was modulated by the voltage change on the transistor due to optical activation, which bended down the cantilever beam and induced shift in the resonant frequency. For example, the transistor switched on when activated by UV illumination, and photogenerated current in the transistor reduced bias voltage on the microactuator, which relaxed the electrostatic force and consequently increased the resonant frequency. With a homoepitaxial structure, i.e., single crystal SiC film grown on single crystalline SiC substrate, 4H-SiC MEMS excels Si counterparts for operation in high temperature, high pressure, radiation and chemical environments. This is attributed to the superior material properties of 4H-SiC such as mechanical robustness, chemical and radiation hardness, electrical stability, etc. The optically activated transistor employs a bipolar structure with an internal current gain, which amplifies the photogenerated current and therefore has capability to reduce the optical-trigger power.

Biography

Feng Zhao received his Ph.D. degree in electrical engineering from University of Colorado, Boulder, in 2004. From 2004 to 2008, he was with Microsemi Corporation (now Microchip Technology, Inc.) as a Device Scientist. From 2008 to 2011, he was with University of South Carolina, Columbia, as an Assistant Professor of electrical engineering. Since 2011, he has been with Washington State University, Vancouver, where he is currently an Associate Professor of electrical engineering. His research interests include wide bandgap semiconductors devices and MEMS, organic electronics, and 2D materials and devices.

Metamaterial Nano-Cavities and MHA Coupled to Near and Mid- Infrared Intersubband Transitions in the GaN/Algan Based Quantum Cascade Detectors

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Department of Electrical Engineering, Technion-Israel Institute of Technology, Israel

Abstract

Intersubband (ISB) transitions constitute the backbone principle behind quantum cascade lasers (QCL) and quantum well infrared detectors (QWIP). A prominent difficulty in this family of detectors is that the ISB transition in the active QW is coupled only to the p polarization of the electric field, as dictated by the selection rules, not allowing normal incident illumination. Normal incidence operation of ISB detectors is usually achieved by patterning a top grating on the device surface. A different effective approach has emerged recently. It makes use of two dimensional metallic nano-holes arrays (MHAs) and generation of surface plasmon polaritons (SPPs). SPP is a TM mode and has the major electric field component normal to the surface. Metamaterials are artificial structures consisting of individual sub-wavelength resonators where the electric and magnetic resonances are defined by the geometry of its constituents. Metamaterials allow for strong electric field confinement and enhancement in their vicinity making them well suited to couple incoming light to a detector medium. The optical properties of dipole transitions in semiconductor heterostructures can be engineered to a similar extent as the optical resonances in metamaterials using advanced epitaxial growth techniques. In this work we demonstrate, that incorporation of MHA or metamaterial nano-antennas provides a substantial improvement to the responsivity of GaN/AlGaN based quantum cascade detector (QCD), in the Near and Mid IR wavelengths range, while allowing for normal incidence illumination. Additionally, we will show electrical strong light-matter coupling between ISBT and planar metamaterial Nano-cavity antennas.

Biography

Gad Bahir received the B.Sc. degree in physics and mathematics from Hebrew University, Jerusalem, Israel, and the M.Sc. and Ph.D. degrees in physics from the Technion-Israel Institute of Technology. He was a Visitor Professor at the University of California, Santa Barbara and a Visiting Scientist at Stanford University, CA, USA. In 1990 he joined the Department of Electrical Engineering, the Technion-Israel Institute of Technology, where he is now a Full Professor. He is currently engaged in research on advanced unipolar-based devices in III-Nitrides QWs and QDs. Other areas of interest include metamaterials light coupling to intersubband transitions.

Reliable Characterization of Hyperbolic Metamaterials using Total Internal Reflection Ellipsometry

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¹Physical Measurement Laboratory, National Institute of Standards and Technology, MD

²Maryland Nanocenter, University of Maryland, MD

Abstract

Hyperbolic metamaterials (HMMs) are highly anisotropic structures that exhibit metallic (i.e., $\text{Re}(\epsilon) < 0$) and dielectric (i.e., $\text{Re}(\epsilon) > 0$) response along orthogonal directions. They have been utilized to demonstrate various phenomena, including broadband light absorption, enhanced spontaneous emission, and engineered thermal radiation. The key to the array of rich phenomena enabled by HMMs is their highly anisotropic permittivity. Here, we demonstrate how both the in-plane and out-of-plane effective permittivities of an HMM operating at ultraviolet, visible, and near-infrared frequencies can be accurately extracted using a coupling-prism-enabled spectroscopic ellipsometry technique based on total internal reflection (TIR). This technique is compared to two other spectroscopic ellipsometry methods commonly used to date for HMM characterization, namely (1) interference enhancement (IE), in which reflection-mode ellipsometry exploits a substrate decorated with a silicon oxide layer to enhance light-HMM interaction, and (2) reflection plus transmission (R+T), which adds normal-incidence transmittance spectroscopy to standard reflection-mode ellipsometry. Although both IE and R+T techniques have been successfully used for characterizing isotropic thin absorbing films, we show here that neither method is able to robustly extract HMM out-of-plane effective permittivity. In contrast, the TIR method is demonstrated to provide robust permittivity extraction having well-converged fitting parameters. In particular, measurement sensitivity is improved compared to both the IE and R+T cases via prism-mediated enhancement of the out-of-plane electric field inside the HMM. The TIR technique requires neither modification of the HMM sample itself nor substantial re-configuration of a standard ellipsometer and can therefore serve as a reliable and easy-to-adopt technique for the characterization of both HMMs and a variety of other anisotropic metamaterials.

Biography

Cheng Zhang is a UMD Postdoctoral Researcher in the Photonics and Plasmonics Group of Physical Measurement Laboratory (PML), National Institute of Standards and Technology (NIST). He received Ph.D. in Electrical Engineering from University of Michigan-Ann Arbor in 2016. His research interest includes the study of new plasmonic materials, and design and characterization of metamaterials and metasurfaces in the visible and ultraviolet frequencies.

MOEMS-Based Imaging Probe with Integrated Mirau Micro-Interferometer and MEMS Microscanner for Swept-Source OCT Endomicroscopy

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²Silesian University of Technology, Poland

³University of Florida, FL

Abstract

In the rapid evolution of gastrointestinal endomicroscopy, Optical Coherence Tomography (OCT) has found many diverse applications. Until recently, MOEMS (micro-opto-electro-mechanical systems) technology has been playing a key role in shaping the miniaturization of these components. We report here a novel endoscopic microsystem. This is based on a spectrally tuned Mirau micro-interferometer integrated with a MEMS electro-thermal micromirror, operating in the regime of swept-source OCT (SS-OCT) imaging. This article validates our initial proof-of-concept toward development of such MOEMS probe and the presentation of experimental performances of the SS-OCT microsystem.

Biography

Christophe Gorecki is a Director of Research CNRS (DR1 CNRS) at FEMTO-ST. He received the Ph.D. in Optics at the University of Besançon in 1983 and joined Laboratoire d'Optique P.M. Duffieux (LOPMD) as a CNRS Scientist. He conducts researches in novel MOEMS architectures for on-chip optical microscopy, the atomic micro-clocks as well as development of metrology methods for characterization of MOEMS/MEMS. He has more than 180 technical papers to his credit and 3 book chapters. He served as national Secretary of the French Society of Optics (SFO). He is also a Fellow of the SPIE and member of the Board of Directors of SPIE. From 2007 to 2009, he was a member and expert of Disciplinary Committee of French ANR for programs Blanc and Jeunes Chercheurs. He received in 2012 the prize of European Optical Society. He is the President of the Collégium SMYLE which is a virtual French-Swiss research laboratory including FEMTO-ST and EPFL Lausanne.

Enhancement of Optical Sensitivity in a Grating Based Micromechanical Accelerometer by Reducing Non-Parallelism Error

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Key Laboratory on Inertial Science and Technology, Beihang University, Beijing, China

Abstract

Optical MEMS accelerometer detects the small displacement by optical system, providing a way to realize an ultrahigh sensitivity detection, which can be widely applied in the situations such as inertial navigation, land-based resource exploration and seismic monitoring. In this work, we report on the enhancement of optical sensitivity in a grating based micromechanical accelerometer by reducing the non-parallelism error. Figure 1 shows the schematic of acceleration measurement. Interference takes place between the two diffractive beams, and the intensity of different diffraction orders is monitored by separate photodiodes. Based on the multi-slit Fraunhofer diffraction theory, an equivalent optical model is proposed to discuss the non-parallelism induced error caused by the residual stress in material and fabrication. An integrated fabrication flow with optimized quartz-based and silicon-based procedure is then presented to improve the parallelism between the grating and mirror, and realize a hermetic package using silicon islands for the electrical interconnection. We experimentally characterize the behavior of accelerometer samples by an interferometric beam detecting setup, revealing the acceleration measurement with a scale factor improvement, noise floor decrease from 2.9 mg/ $\sqrt{\text{Hz}}$ to 0.9 mg/ $\sqrt{\text{Hz}}$, and thus a bias stability enhancement from 2 mg to 0.35 mg (20 seconds interval, 1 g = 9.8 m/s²).

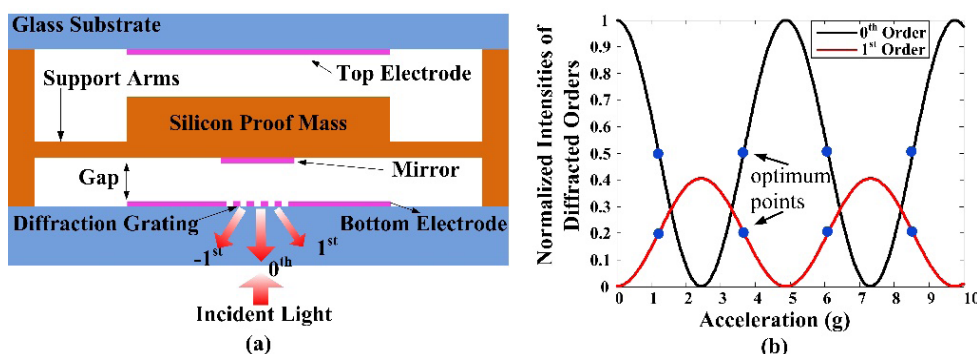


Fig. 1. (a) The architecture of optical interrogated micromechanical accelerometer, (b) the relationship between input acceleration and normalized light intensities.

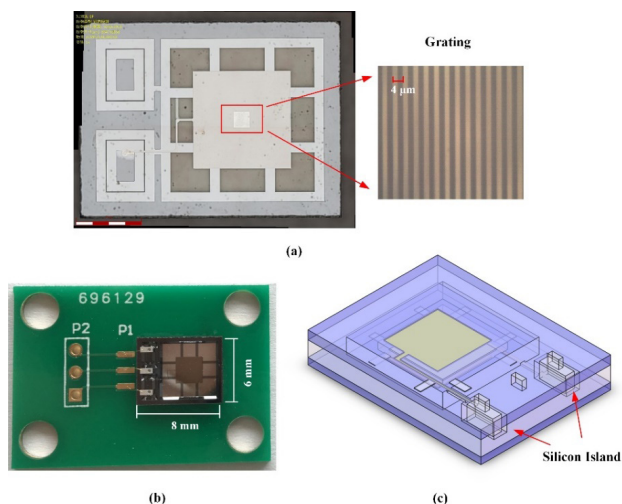


Fig. 2. (a) Optical microscope image of the grating, (b) Top view of the accelerometer, (c) The perspective view of the accelerometer.

Biography

Lishuang Feng is a member of a council of Chinese society of Micro-Nano Technology. She received her Ph.D. degrees from Saint Petersburg Institute of Fine Mechanics and Optics (1996). She has been a professor of Optical Engineering at Beihang University, Beijing, China since 2007, and she occupies the deputy director of Key Laboratory of Micro-nano Measurement-Manipulation and Physics (Ministry of Education) China. She has authored 3 books and over 180 papers, approximately half of which are in journals. Currently, she works on silicon photonics, integrated optic gyroscope and optical MEMS accelerometer.

Landau Damping in Isolated and Coupled Plasmonic Nanoparticles

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Abstract

The most remarkable feature of plasmonic structures in the optical range is their ability to concentrate the optical field into the surface plasmon polariton (SPP) modes with volumes that can be orders of magnitude less than the wavelength. Typical nanoantenna incorporates a dielectric gap between two metallic structures of various geometry and it is in this gap where the concentrated electric field gets enhanced. Naturally, reduction of the gap size causes decrease in the SPP volume which is expected to be accompanied by the commensurate increase in the energy density of the SPP field and Purcell factor. However, once the gap size decreases to a few nanometers and less, both the field enhancement and Purcell factor cease to increase while the linewidth of the resonance eventually broadens to the degree where the SPP resonances are no longer discernible. We will show the reason for the “saturation” and eventual decline of the enhancement in the gap is the result of the Landau damping in the vicinity of the Fermi level in the metal where direct transition between two electronic states around the Fermi level is allowed when the power spectrum of the SPP inside of metal contains wavevector components that provide the necessary momentum match. Such components increase significantly with the tightening of the field confinement as the dimer radius and gap shrink. We will demonstrate that Landau damping presents the most practically relevant limit to the achievable plasmonic enhancement inside the narrow gaps of plasmonic dimers and other similarly shaped plasmonic nanoantennas.

Biography

Greg Sun received his Ph.D. from Johns Hopkins University in 1993. He is currently a professor in Electrical Engineering and founding Chair of the Engineering Department at the University of Massachusetts Boston. His research interests are in optoelectronics, silicon photonics, and nanophotonics. He has published over 140 papers in refereed journals and book chapters, delivered over 150 invited and contributed conference talks, and given over 50 seminars and colloquia. He served on various conference and symposium committees and as a guest editor for Optics Express and ACS Photonics. He is now an associate editor for Journal of Lightwave Technology.

Heterogeneous Integration of 2D Materials on Si Photonic Platform

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Abstract

Photonic integrated circuits are a promising platform for optical communication and information processing for more-than-Moore devices [1]. However, Silicon's weak electro-optic properties and indirect bandgap severely limit device functionality. In contrast, hybrid materials and heterogeneous integration solutions offer an alternative, when combined with mature and low-cost CMOS fabrication technology such as Si/SiN photonics [2]. Here, 2-dimensional (2D) materials enable to greatly simplify the integration on photonic chip by the advent of sufficiently strong van der Waals (vdW) force, offering rich variety of electronic and optical properties that enable light generation, modulation, and detection for photonics applications alike. This presentation introduces several classes of integrated photonic components in a 2D materials-based heterogeneous architecture [3]. The first part will focus on efficient transfer of 2D materials on photonic platform by using our recently developed 2D material printer method. Secondly, we discuss our latest results on passive coupling tunability and index determination using a semi-empirical approach with heterogeneously integrating TMDs layer on Si micro-ring resonator for broadband on-chip modulators and photodetectors with high-speed and high responsivity [4]. Our results indicate that 2D materials could be an essential building block for a fully integrated photonic circuit.

References

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Biography

Rishi Maiti received his M.Sc. degree in Physics from IIT Kharagpur, India in 2012, and then received his Ph.D. degree in 2017 from same institute. His PhD research topic was studies on hybrid graphene nanostructures for optoelectronic devices. He joined the University of Brescia, Italy as a visiting scholar under Erasmus Mundus scholarship in 2016. Currently, he is a Post-Doctoral Fellow in the George Washington University. His research interests include the nanophotonic devices, Electro-optic modulator, optical interconnect, novel materials, plasmonics & metamaterials, Tunnel junction & Smart window, as well as their promising applications towards fully integrated photonic circuit.

Quantitative Phase Imaging of Fields Shaped by Plasmonic Metasurfaces

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Abstract

Plasmonic metasurfaces represent a new class of artificial materials that allow to manipulate the wavefront of passing light and thus provide unprecedented functionalities in optics and nanophotonics. Despite considerable effort, the widefield (non-scanning) phase imaging that would provide the quantitative phase imaging of the field formed by these metasurfaces still remains a challenge. In the first part we will report on phase imaging of fields formed by plasmonic metasurfaces using Coherence-controlled holographic microscopy (CCHM). CCHM is a real-time, wide-field, and quantitative light-microscopy technique enabling 3D imaging of electromagnetic fields, providing complete information about both their intensity and phase. We will demonstrate that CCHM is inherently suited to the task of characterization of optical fields formed by metasurfaces, including tunable ones [1]. In the second part we report on a new strategy in incoherent holographic imaging of metasurfaces, in which unprecedented spatial resolution and light sensitivity are achieved by taking full advantage of the polarization selective control of light through the geometric (Pancharatnam-Berry) phase. Thanks to superior light sensitivity of the method, we demonstrated, for the first time to our knowledge, the widefield measurement of the phase altered by a single nanoantenna, while maintaining the precision well below 0.15 rad [2].

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Biography

Tomas Sikola is a full Professor of Applied Physics, director of the Institute of Physical Engineering at Brno University of Technology (BUT), and leader of the “Fabrication and Characterization of Nanostructures” research group of the Central European Institute of Technology (CEITEC) in Brno. He also acts as a coordinator of the Advanced Nano and Microtechnology Research Programme of CEITEC. His present research interests are in surface science; thin film physics; nanoscale science and technology; fabrication of nanostructures and investigation of their functional properties for plasmonics, micromagnetism, and spintronics; and development of analytical and measurement methods and instruments.

Dielectric Metasurfaces Based on A-Si Nanodisk Arrays for Anti-Reflection and Color Filter Applications

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Abstract

Dielectric metasurfaces based on amorphous silicon (a-Si) nanodisks are interesting for nanophotonic applications due to the high refractive index and mature/low temperature fabrication of a-Si. The investigated metasurfaces consist of a-Si nanodisk arrays on top of a Si substrate (with and without an intervening SiO₂ layer) and those embedded in a flexible transparent film. The size-dependent optical properties of the nanodisk Mie resonators have been investigated by finite-difference time-domain (FDTD) simulations and spectrally-resolved reflectivity and transmission measurements. The a-Si nanodisk assemblies were fabricated by a combination of colloidal lithography and dry etching using a-Si/SiO₂ layers deposited on Si substrates. Selective etching of the underlying SiO₂ layer was performed to generate substrate free a-Si nanodisks which to a large extent retain their original spatial arrangement. The fabricated a-Si nanodisk arrays were characterized with regard to their broadband anti-reflection properties when placed on a crystalline silicon (c-Si) surface, reflectivity/transmission properties when embedded in a polydimethylsiloxane (PDMS) film and structural (reflected) colors when placed on SiO₂. Average surface reflections of ~7.5% were obtained in the visible-NIR wavelength region; where an additional dielectric coating can further reduce the surface reflections. We show that spectral filters in reflection and transmission modes with high (>75%) transmittance and reflectance can be obtained in the NIR region. Our results confirm broadband anti-reflection when placed on a Si substrate, while the optical characteristics of a-Si nanodisks embedded in PDMS or on a low-index layer are potentially useful for color/NIR filter applications as well as for coloring on the micro/nanoscale.

Biography

Dennis Visser received his B.Sc degree (2010) in Physics & Astronomy and his M.Sc degree (2013) in Physics from the VU University Amsterdam, The Netherlands. He currently works as a Ph.D. student in Physics at KTH Royal Institute of Technology in Stockholm (Sweden) and is at the finishing stage of his PhD studies. The topic of his research is based on ‘Photonic Semiconductor Nanostructures and Their Applications in Optoelectronic Devices’ and the work takes place at the Electrum Lab, Kista.



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