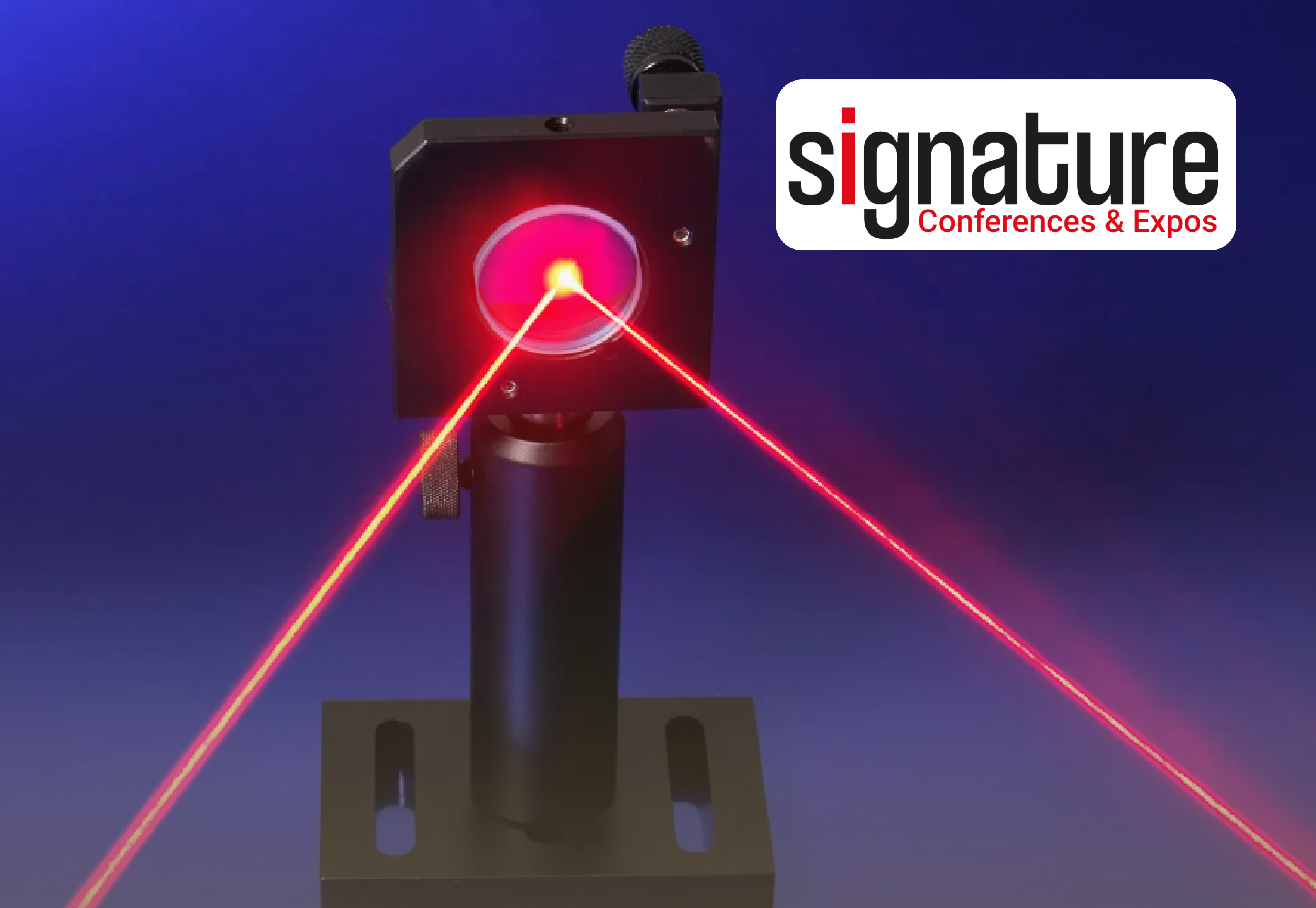

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We warmly welcome the prospective authors who are interested in the sessions to submit abstract to EUROPL2024 to join in the conference.

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Conference Chair

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Executive Director "Bimberg Chinese-German Center for Green Photonics", CIOMP, CAS, China and "Founding Director "Center of NanoPhotonics", TU Berlin, Germany.

From Quantum Dots to Green Quantum Technologies

Dieter Bimberg

"Bimberg Chinese-German Center for Green Photonics" Changchun Institute of Optics, Fine Mechanics and Physics, Chinese Academy of Sciences and Center of NanoPhotonics, TU Berlin
bimberg@physik.tu-berlin.de and bimberg@ciomp.ac.cn

Abstract

Universal self-organization at surfaces of semiconductors grown preferentially by MOCVD leads to the formation of self-similar quantum dots (QDs). Their electronic and optical properties are close to those of atoms in a dielectric cage. All their energy levels are however only twofold degenerate [1]. The few particle states like excitons are strongly Coulomb-correlated due to the carrier localization. Their energies depend on shape and size of the dots, such that positive, zero or negative biexciton binding energies and fine-structure splitting appear [2].

Applications of single, few and millions of QDs for novel Quantum Technologies will be elucidated.

a. Single QDs can be emitters of Q-bits on demand or entangled photons for future quantum cryptography systems. In electrically pumped RCLED structures, emission of q-bits at rates beyond 1 Gbit/s were shown [3, 4].

b. Hybridization of Flash and DRAMs, bringing together the advantages of both types of memories, is the "Holy Grail" of memories and ensures future memory development after the end of Moore's law. The goal of non-volatility (i.e. storage time > 10 years) can be achieved for the storage of holes in type II (InGa)Sb QDs embedded in a (AlGa)P matrix [5].

c. The demand for higher data rates in optical networks, requires novel ultra-high bit rate, energy efficient sources. QD Lasers based on GaAs emit up to the O-band at 1.3 μm, showing record low jth and complete temperature stability up to 80°C. Passive mode-locking generates pulses in the sub-ps range at repetition rates up to 90 GHz. The hat spectrum of one single laser of several tens of closely spaced narrow lines is thus a potential pulse source for bit rates up to ≈6 TBit/s using higher order modulation formats like DQPSK [6]

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Metaoptics and nanoantenna spatial light modulators

Arseniy Kuznetsov[1]

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Abstract

Metasurfaces has recently emerged as a new platform to control properties of light at subwavelength dimensions. Flat optical elements based on metasurfaces, so called "metaoptics", can produce optical function similar or superior to conventional optics with much smaller device footprint. In this talk, I will first show our progress on developing passive/ static metalenses, which can achieve various unique functionalities such as extremely high (~0.99 in air) numerical aperture or extra-large field of view (~180°). I will also show how by combining multiple lenses and controlling their dispersion we can enable white-light imaging in the visible spectrum and hyperspectral imaging in the mid-wave IR. Finally, I will focus on tunable metasurfaces, particularly demonstrating single pixel tunability in both 1D and 2D pixel arrays, providing the first demonstration of nanoantenna spatial light modulators with ~1 micron pixel size.

Silicon Photonics, today and tomorrow

Prof. Roel Baets
Ghent University, Belgium

Abstract
Silicon photonics has become a mainstream technology for high-speed transceivers. Tier-1 CMOS-foundries such as Global Foundries, Tower and TSMC are offering mature process flows. New markets are appearing on the horizon but some of them require functionalities and performance levels not offered by conventional silicon photonics. Heterogeneous integration is one of the answers to these new needs. Technologies are being developed to mix and match photonic integration approaches that used to be isolated relative to each other. InP is prominently present in this evolution.

Frontiers of 3D photoelectron momentum microscopy (PMM) and Soft X-ray resonant inelastic scattering (SX-RIXS) down to sub micrometer scale

S.Suga
SANKEN, Osaka University
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Abstract

After the optical studies of exciton polaritons and excitonic molecules in 1968-1973,
I started opto-electronic studies of solids by photoelectron spectroscopy (PES) of conductive materials by photons from a few eV up to hard X-rays from 1975. Angle resolved ARPES for the photoelectron kinetic energy Ek from few eV up to several hundreds eV were extensively performed so far. In addition to the necessity of discrimination of the surface, subsurface and bulk electronic states by changing the photon energy hn, the spin polarization must be measured in the PES & ARPES to understand the details of electronic states of functional materials. Though the single channel spin detection has mainly be performed by Au-Mott, W-LEED, FeO-VLEED spin detectors so far with Figure of Merit (FoM) being less than 10-2 , multichannel FoM larger than 10□ became feasible by using the newly developed Photoelectron Momentum Microscope with 2D spin filter (2D-SP-PMM). Then the efficiency of the SP-ARPES became around million times higher than the single channel SP-ARPES[1]. By using PEEM type objective lens, measurement is feasible down to sub mm fixed region and high reliability is guaranteed by the unnecessary sample rotation. Sample surface radiation damage is not induced within million times shorter measuring time than those measurements so far done by 1 channel spin detection.

To investigate the electronic states of non-conductive materials, however, ARPES cannot be applied because the surface charge up takes place. Still the change of bulk electronic states of them with phase transition under external perturbation should be reliably confirmed through the collaboration with top theoreticians. For such purposes, soft X-ray resonant scattering can be a powerful approach with external perturbations such as magnetic field, electric field as well as uniaxial strain. These experiments can be done in conductive materials as well. Radiation induced changes of surface spin-electronic states must be excluded in these experiments from now on by using frontier spectroscopy. Reliable analyses must be done by collaboration between experimentalists and theoreticians. New era of synchrotron radiation spectroscopy just started. So we ask brilliant theoreticians to prepare more advanced analyses methods in few months.

I acknowledge the collaboration with Prof.Matsui of UVSOR, Prof.Umetsu of Tohoku University, and Dr.Tusche in Forschungszentrum Jülich.

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Optoelectronic Devices for AI Chips

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Rhines Endowed Professor in Semiconductor Photonics
Fellow: IEEE, OSA/Optica, SPIE, IAAM, German National Academic Foundation
PECASE Awardee

Theme Lead: SRC/DARPA JUMP2.0 CHIMES Center
Theme Lead: AFRL ExPlor Center
Co-Lead: SCALES Consortium

Editor: Optica, Applied Physics Review, Nanophotonics, eLight, Chips, Frontiers in Photonics

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Abstract
Next generation AI and machine learning hardware requires new paradigms to perform specialty compute and data communication. In this talk I will show how emerging optoelectronic components along with chip integration setup roadmap possibly allowing for 1000x higher compute efficiency. I will review our work on efficient photodetectors and compact electro-optic modulators offering record-low VpL. Then, I show how these building blocks can be used in photonic tensor core accelerators and for convolutional neural network accelerators featuring a lower scaling complexity based on on-chip energy-free Fourier transformation. Finally, I will offer a technology roadmap view for the next decade for optoelectronics and AI hardware technology.

Integrated Quantum Light Sources in Silicon Photonic Platforms

Andrew W. Poon[1,*]
[1]Photonic Device Laboratory, Department of Electronic and Computer Engineering, The Hong Kong University of Science and Technology, Clear Water Bay, Kowloon, Hong Kong, China.
**eeawpoon@ust.hk*

Abstract
Integrated nonlinear photonics platforms enable the realization of integrated quantum light sources and quantum photonic circuits operating at the ambient condition without the requirements of a vacuum or of a cryogenic temperature. Spontaneous four-wave mixing (SFWM) and spontaneous parametric down-conversion (SPDC) are two nonlinear optic processes to realize photon pair sources. We exploit the third-order nonlinearity in the silicon nitride (Si3N4) platform and the second-order nonlinearity in the non-centrosymmetric 3C-silicon carbide (3C-SiC) platform for generating photon pairs through SFWM and SPDC, respectively. Aiming to obtain efficient spontaneous processes in a compact footprint for large-scale integration, we adopted the waveguide-coupled microring resonators to enhance the spontaneous processes.

In this keynote talk, I will discuss our recent work demonstrating an integrated polarized-entangled photon pair source using two microring resonators coupled to a common input-/output-waveguide on the Si3N4 platform [1, 2]. We align the orthogonal linearly polarized resonances from the two microring resonators using integrated thermo-optic tuners. We demonstrated generating a non-maximumly entangled state in the optical communications C-band upon an on-chip pump power of ~5 mW with a fidelity exceeding 75%.

I will also discuss our recent work demonstrating an integrated photon pair source using an elliptical microring resonator coupled to a waveguide on the 3C-SiC-on-insulator platform [3]. We adopted the waveguide modal phase matching while the elliptical microring resonator effectively exploits the nonlinear susceptibility tensor element . We demonstrated a photon-pair generation rate of 4.8 MHz in the optical communications L-band upon an on-chip pump power of 5.8 mW. We demonstrated time-bin entanglement in an off-chip interferometer using this source with a two-photon interference visibility of .

Keywords
integrated quantum light sources, optical nonlinearity, silicon photonics, microresonators

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Biography
Prof. Andrew W. Poon received his B.A. (Hons.) degree from The University of Chicago in 1995, and his M. Phil and Ph. D. degrees from Yale University in 1998 and 2001, all in Physics. In 2001, he joined the Department of Electronic and Computer Engineering, The Hong Kong University of Science and Technology. He is now Professor and Head of the Department. He is a Senior Editor of the IEEE Photonics Technology Letters. In 2022, Prof. Poon was elected a Fellow of Optica.

Broadband Integrated Optical Phased Arrays for Optical Wireless Communication

Prof. Caiming Sun, RIM,
The Chinese University of Hong Kong (CUHK), China

Abstract

Broadband operation on integrated optical phased arrays (OPA) will be discussed in this talk. We will demonstrate the widest beam steering angle of 66° on a silicon nitride phased array so far, by wavelength tuning from 520 nm to 980 nm. Then, a two-dimensional (2D) beam steering on SiN_x nanophotonic phased arrays from visible to near-infrared (NIR) wavelengths is reported. In order to implement the parallel beam steering along transverse direction, multiple wavelengths from visible to NIR range are used to excite the phased array based on one-dimensional (1D) waveguide surface grating. Moreover, these parallel emitted beams are steered along longitudinal direction, with multiple wavelengths simultaneously tuned by phase shifts from $-\pi$ to over $+\pi$.

Based on this 1D grating array, we developed a demultiplexer for wavelength separation in blue-green band. With polarization-sensitive OPA, the channel spacing of 1.2nm is reported for blue-green wavelength division multiplexing (WDM). Furthermore, underwater wireless optical communication (UWOC) is demonstrated using dense blue-green WDM with channel spacing of 2nm.

Liquidcrystalsandnanostructures–Recent examplesofaliaisonwithmut ualbenefits

Patrick Meier,[1] Gaby Nordendorf,[1]Roman Rennerich,[1]Bingru Zhang,[1]René Geromel,[1]ThomasZentgraf,1MaltePlidschun,[2]Markus Schmidt,[2]andHeinz-S.Kitzerow[1]

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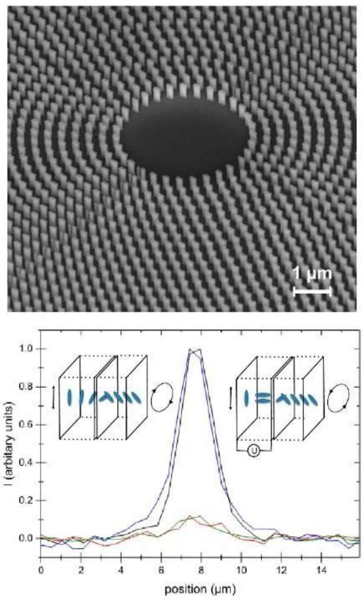
Liquid crystals (LCs, i. e. ordered fluids) and solid nanostructures are emerging fields, whichare progressively combined in order to extend their potential properties and applications. Forexample,tuneable,compactintegratedopticaldevicesbecomefeasiblebycombiningphotonicmeta-surfaces with electrically addressable LCs (Fig. 1). On the other hand, nanostructurescanhelptoextendoneoftheessentialpreconditionsofLCapplications–namely,averywell-defined LC alignment – to complex three-dimensional geometries (Fig. 2). The addition ofnanoparticles to LCs may help to enhance LC switching performance, while – on the otherhand – an anisotropic LC matrix may be used to align anisometric nanoparticles. Some kindsof liquid crystals show beneficial semiconducting properties; yet, their application in organicelectronics requires thin layers (thicknesses of about 10 nm and smaller). Again, modernmethods of nanotechnology and the unusual anisotropic properties of LCs may complementeach other for achieving advanced performance. The present lecture summarizes somespecificquestions,on whichwe have beenworking, recently[1-4].



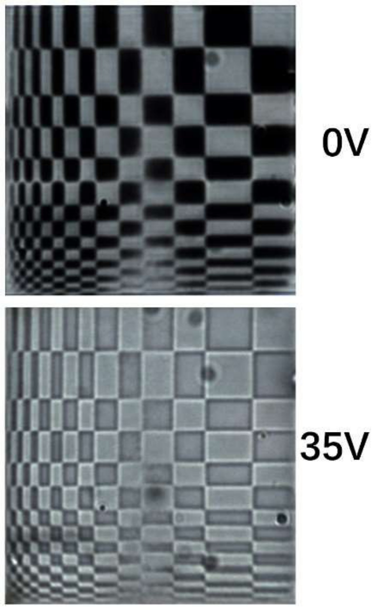


Fig. 1. Electrically addressable meta-lensthatcanbeusedinmicrofluidicsforopticaltrapping of mi-cro-particles[1].

Fig. 2. Nematic LC exhibiting a complexalignment pattern on a nano-sculpturedsurfacemade bydirectlaser writing [2].

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A Materials Approach to the Thermal Management of Fiber Amplifiers and Lasers

J. Ballato,[1] B. Meehan,[1] T. W. Hawkins,[1] P. D. Dragic,[2] and M. J. F. Digonnet[3]

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Abstract

Heat generation in advanced fiber amplifiers and lasers lead to a myriad of practical issues ranging from excess frequency and intensity noise to transverse mode instability (TMI). Conventional routes to thermal management, such as liquid cooling, add to the system's size, weight, and power-consumption, but are so far the only realistic option. This Keynote will broadly review and discuss internal methods of thermal management while delving deeper into the enabling materials science. Specifically, topics will include reduced quantum defect fiber core compositions, anti-Stokes fluorescence cooling, and the numerous considerations that must be considered during the processing and fabrication of the preforms and fibers to permit the realization of these phenomena. Overlapping benefits of internal cooling and intrinsically low optical nonlinearities will also be discussed.

Bound states in the continuum: From photoluminescence to second harmonic enhancement

Kezhou Fan[1], Haohan Chen[2], Aleksandr A. Sergeev[1], Lijun Wu[2] and Kam Sing Wong[1*].

1. *Department of Physics, The Hong Kong University of Science and Technology, Hong Kong S.A.R., P. R. China.*
2. *School of Information and Optoelectronic Science and Engineering, South China Normal University, Guangzhou, P. R. China.*

**phkswong@ust.hk*

Abstract

We demonstrated efficient tuning and 12-fold enhancement of photoluminescence in HgTe quantum dots coupled to plasmonic metasurface that supports bound states in the continuum (BIC) which is fabricated by a single step laser printing technique. Using low loss dielectric material, strong second harmonic generation (SHG) supported by arbitrarily polarized excitation is also realized in GaN metasurface via BIC. The polarization insensitivity remarkably enhances the SHG output by 66.2% under unpolarized illumination condition. This tuning and enhancement of linear and nonlinear optical properties using metasurfaces via BICs open up new opportunities for photonic devices in the visible and near infrared regions.

This work is supported in part by Research Grants Council of Hong Kong (grant No. 16304772).

Fused-ring pyrrole organic semiconductors for organic field effect transistors

Dr. Mihaela C. Stefan

Eugene McDermott Professor, FRSC University of Texas at Dallas

Abstract

The smallest S, N-heteroacene, thieno[3,2-b]pyrrole is a good building block for organic semiconductors due to the high electron density, asymmetry, and easily modifiable NH group. Our group have shown that organic semiconductors from thieno[3,2-b]pyrrole display "nearly-ideal" OFET characteristics without compromising charge carrier mobilities or threshold voltages. We have varied the structure and topology to investigate the relatively under-explored banana shape thieno[3,2-b]pyrrole ole semiconductors and the influence of the heteroatom.

Banana shaped donor-acceptor molecules with benzothiadiazole, fluorinated benzothiadiazole acceptors and thieno[3,2-b]pyrrole donor (TP-BT2T-BT and TP-FBT2T-TP) have been reported by our group and the OFET parameters were evaluated in a bottom-gate/bottom-contact (BGBC) OFET architecture. Hole mobility of 0.08 cm2 V-1 s-1 was measured for the molecule (TP-BT2T-BT) with benzothiadiazole as the acceptor. The molecule containing fluorinated benzothiadiazole (TP-FBT2T-BT) showed hole mobility of 1.57×10-3 cm2 V-1 s-1.

Lengthening conjugation by synthesizing conjugated polymers was employed to facilitate the hole transport and to obtain comparatively stable semiconductors. Our group reported the donor-acceptor polymer containing thienopyrrole donor and diketopyrrolopyroole acceptor, P(DPP-TP) and the OFET parameters were evaluated with bottom-gate/top-contact (BGTC) OFET architecture. An increase in hole mobility to 0.12 cm2 V-1 s-1 was observed for the polymer (P(DPP-TP)) as compared to the conjugated small molecules.

Fourier-ptychographic microscopy: achievements and applications

Prof. Muhammad Nadeem Akram
University of South-eastern Norway, Norway

Abstract

Fourier ptychography Microscopy (FPM) [1, 2] is a computational imaging technique based on a standard microscope where the traditional sample illumination has been replaced by an array of colored LEDs. By taking one image of the sample for each LED sequentially, one gets a set of images that can be used to reconstruct both the amplitude (absorption profile) and the phase (depth profile) of the imaged object, with a resolution far beyond the Rayleigh resolution limit imposed by the optics and the digital CCD camera Nyquist limit. In other words, one single high-resolution wide field-of-view (gigapixel) image is obtained after the numerical manipulations.

In this talk, I will explain the theoretical background, and major achievements by the community in this imaging modality. Such FPM systems can be used for Lab-on-Chip platform and cell identification with low cost hardware.

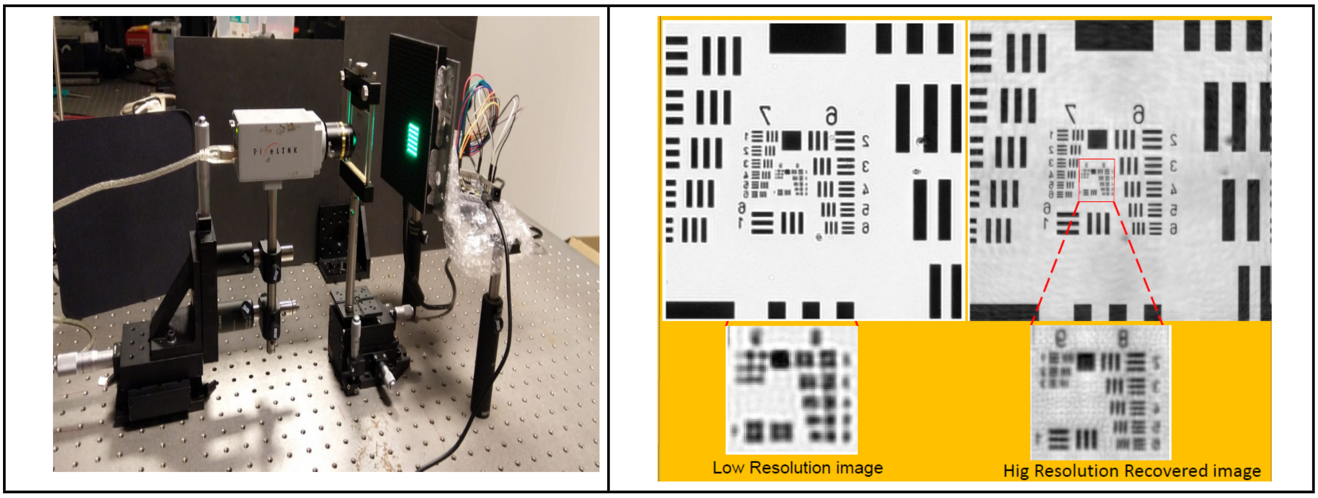

Figure. Fourier Ptychography Setup with LED array, CMOS camera and optics (Left). Low-resolution image acquired using the camera and reconstructed high resolution image (Right).

1- G. Zheng, R. Horstmeyer, and C. Yang, "Wide-field, high-resolution Fourier ptychographic microscopy", Nat. Photonics 7, 739–745 (2013).
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Chip-scale Nanophotonic Technologies and Applications

Yeshaiahu (Shaya) Fainman

Department of Electrical and Computer Engineering, University of California Dan Diego

La Jolla California 92093, USA

Abstract

This paper explores the role of CMOS compatible nanotechnology with special focus on novel nanophotonic materials to create novel functionalities for various applications including optical communications, optical signal processing, imaging and sensing.

Biography

Yeshaiahu (Shaya) Fainman is Cymer Chair and Distinguished Professor in Electrical and Computer Engineering (ECE) at the University of California, San Diego (UCSD). He received the Ph. D. from Technion-Israel Institute of Technology in 1983. He is directing research of the Ultrafast and Nanoscale Optics group at UCSD and made significant contributions to near field optical phenomena, inhomogeneous and meta-materials, nanophotonics and plasmonics, and non-conventional imaging. His current research interests are in near field optical science and technology with applications targeting information technologies and biomedical sensing. He contributed over 320 manuscripts in peer review journals and over 540 conference presentations and conference proceedings. He is a Fellow of the OSA, IEEE, SPIE, and a recipient of the Miriam and Aharon Gutvirt Prize, Lady Davis Fellowship, Brown Award, SPIE Gabor Award, OSA Emmett N. Leith Medal, OSA Joseph Fraunhofer Award/Robert M. Burley Prize and OPTICA (former OSA) Nick Holonyak Jr Award.

Machine Learning Assisted Selective Emitter Design for Solar Thermophotovoltaic System

Odebowale, Ambali. Alade[1*], Andargachew Mekonnen Berhe[1], Haroldo T. Hattori[1] and Andrey. E. Miroshnichenko [1]

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Abstract

This study showcases the application of machine learning techniques for designing and optimizing a selective emitter within a solar thermophotovoltaic (STPV) system. Specifically, we utilize random forest (RF) and genetic algorithm (GA) approaches to refine the emitter's structure, aiming to achieve high emissivity in the solar spectrum while minimizing emissivity in the thermal spectrum. Additionally, we analyze the impact of emitter design on the current-voltage and power-voltage characteristics of the STPV system, illustrating the direct influence of emitter configuration on system performance. This research underscores the effectiveness of machine learning in enhancing the performance of solar thermophotovoltaic system energy conversion technologies.

Keywords

emissivity, genetic algorithm, random forest, selective emitter, thermophotovoltaic

Results

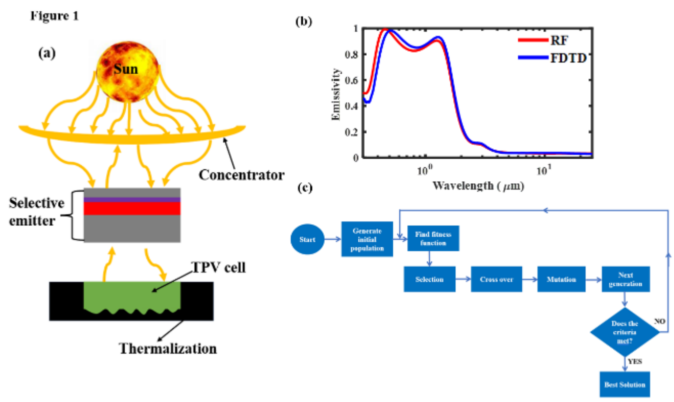

Figure 1: (a) Schematic of an STPV system. (b) Comparison of the predicted spectrum (RF) and the ground truth (FDTD (c) A Flowchart showing implementation of Genetic algorithm (GA)

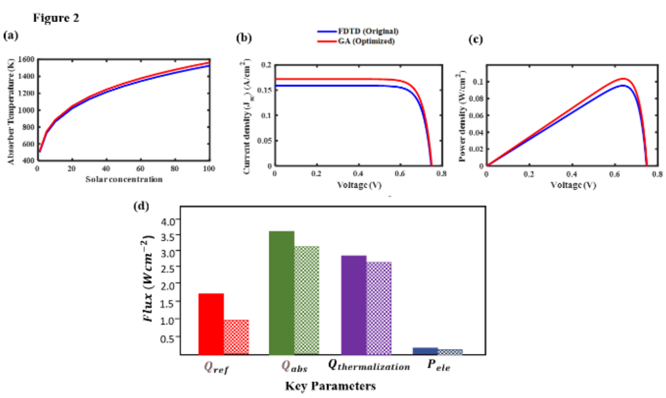

Figure 2: (a) Comparison of the absorber temperature for optimized structure using GA and original structure (b) Comparison of the J – V characteristics of optimized STPV system and original system (c) Comparison of the P – V characteristics of the optimized STPV system and the original system (d) Comparison of various key parameters.

Biography

A. A Odebowale is a PhD student at The University of New South Wales, ADFA, Canberra, Australia; (Corresponding author, Ambali Odebowale, email: a.odebowale@unsw.edu.au).

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Haroldo T. Hattori (PhD) is a senior lecturer at The University of New South Wales, ADFA, Canberra, Australia; (e-mail: h.hattori@unsw.edu.au)

Andrey E. Miroshnichenko (Prof) is the deputy head (Administration) School of Engineering and Technology, The University of New South Wales, ADFA, Canberra, Australia; (e-mail: andrey.miroshnichenko@unsw.edu.au)

High-Q Fano Resonances in All-Dielectric Metasurfaces

V. Bonino, G. Leonetti, N. De Leo, F. Ferrarese Lupi, A. Angelini.

Abstract
In recent years, metasurfaces have demonstrated their capability to drive the evolution of photonic technologies by replacing bulky optical components with ultrathin, integrable, and high performance devices ready for mass scale production [1]. Metasurfaces consist of a large number of nanoresonators, also known as meta-atoms, whose arrangement influences light scattering, resulting in local modulation of amplitude and phase of the emerging field.

In this work, we report on the full suppression of forward scattering achieved by a nanostructured Silicon Nitride surface on a glass substrate that satisfies the Kerker conditions [2]. The numerical model reveals that a simple geometrical pattern such as a square lattice of nanopillars sustains Fano-like resonances with Q-factor as high as 3.5 · 105 that can be excited by plane waves impinging normally on the surface.[3]

We show that the geometrical parameters of the individual nanopillars affect both the resonant frequency and the line shape and we investigate the role of intrinsic losses on the optical response. Our findings show that a simple array of pillars-based meta-surfaces are a valuable nanophotonic platform to control light scattering at the nanoscale, which is crucial to foster both linear and nonlinear effects.

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Optimal Form of Uncertainty Principle and Their Applications

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Abstract
The Heisenberg's uncertainty principle is one of the three important quantum mechanics principles, however, we thought that the form of the traditional uncertainty principle is not optimal yet. We first proposed that the optimal forms of the uncertainty principle should be a pair of equations instead of one inequality. When dealing with entangled states, our formulas can be several orders of magnitude more accurate than the traditional uncertainty principle. Furthermore, we thought our formulas can show the wave-particle duality more clearly. The well known journal Science listed 125 Questions: EXPLORATION AND DISCOVERY, where one of these 125 questions is "Are there any deeper principles behind quantum uncertainty and non-locality?" . We first proposed a quantitative formula to measure the non-locality, and first found that the relative net energy uncertainty is equal to the relative net non-locality.

In this invited talk, we shall review the studies of optimal forms of the uncertainty principle and their applications in quantum communication, quantum computing, and quantum measurement.

Biography
Professor Anhui Liang is a national high level talent of China. He held several positions, e.g. Chief Scientist, FiberHome Technologies Group; Chief Scientist, WTD; Deputy Director of University Academic Committee, Nanjing University of Posts and Telecommunications, second level professor, Shandong University of Science & Technology and Tyco Submarine Systems Ltd. in USA etc. He has published more than 100 papers and patents. He has made significant contributions in the fields of optical fiber communications, vision, biological optical AI, quantum mechanics and Chinese meridian, chromosome optical fibers and biological fibers. He is China Overseas Chinese Contribution Award recipient (2014); Yearly Person of "Scientific Chinese"(2015). He has made significant contributions in 9 questions which were among 125 questions: exploration and discovery listed by the famous journal Science . His contributions have been well reported in famous national media. Their interview by Baidu Scholar received 180 millions of internet exposures in the first month of the video release in 2021. There are over 700 thousands of audiences in his 8 super-large online scientific lectures.

Concrete as image texture target for movement measurement with subpixel precision

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Abstract

The measurement of the movement of certain parts of a civil structure serves as a crucial indicator of their durability. Often, the most movable zones are situated in inaccessible areas, necessitating non-contact measurement methods. In addition, it is often the case that the most mobile parts are located in the most inaccessible areas, so non-contact measurement methods have become essential. Among them, image-based methods stand out as they can be adapted to various budgets.

Concrete structures constitute a significant portion of civil structures worldwide. Hence, studying the surface characteristics of concrete and how they are represented in images is essential for developing new methods to measure movements in concrete structures using imaging techniques. To conduct this study, we created a series of laboratory samples replicating a wide range of real concrete textures. These samples were subjected to recordings where linear movement was induced at a predetermined speed, and camera parameters were adjusted to ensure that the displacement between consecutive images remained less than one pixel.

The image processing techniques tested on these textures yielded valuable insights into the surface textures of concrete and the optimal environmental conditions for minimizing errors when employing image processing for measuring movements on concrete surfaces.

High-Speed Silicon Photonic DWDM Transceivers

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Abstract

The computing capability of high-performance computing (HPC) systems depends on computing unit performance and interconnection bandwidth. However, current artificial intelligence (AI) architectures underutilize GPU computational power due to memory and communication bottlenecks. Inter-chip optical interconnect technology offers high bandwidth, low latency, and low power consumption, consolidating computing, storage, and communication resources to accelerate AI potential. Silicon photonics, with high integration and CMOS compatibility, is optimal for optical interconnects. Microring based dense wavelength division multiplexing (DWDM) surpasses traditional optical interconnects in power efficiency and bandwidth density. Demonstrations show microring based DWDM transceivers achieving a shoreline bandwidth density of higher than 400Gbps/mm for optical input/output (OIO). Integrating optical interconnects into AI systems addresses HPC speed-up challenges, enhancing electronic-photonic hybrid computing. High-speed silicon photonic DWDM transceivers leverage these advancements, promising enhanced OIO capabilities and efficiency in computing systems. This talk highlights the potential of silicon photonic DWDM transceivers in revolutionizing OIO capabilities, paving the way for enhanced performance and efficiency in next-generation computing systems.

Biography

Binhao Wang received the B.S. degree in electrical engineering and the M.S. degree in optical engineering from Zhejiang University, Hangzhou, China, in 2008 and 2011, respectively, and the Ph.D. degree in electrical engineering from Texas A&M University, College Station, TX, USA, in 2016. From 2016 to 2020, he was a Research Scientist with Hewlett Packard Laboratories, Hewlett Packard Enterprise, Palo Alto, CA, USA. In 2020, he joined the State Key Laboratory of Transient Optics and Photonics, Xi'an Institute of Optics and Precision Mechanics, Chinese Academy of Sciences, Xi'an, China, where he is currently a Professor. He has authored or coauthored over 70 peer-reviewed journal and conference papers, and has been granted over 10 patents in China and the USA. His research interests include VCSEL photonics and silicon photonics.

Diode pumped alkali lasers (DPALs): High power gas lasers using hybrid technology

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Chemical Gas Lasers

Abstract

Since 2001, when Krupke proposed and introduced the Diode Pumped Alkali Laser (DPAL) concept, these lasers have been intensively studied due to their great potential as high-power lasers. DPAL uses a hybrid technology in which gas lasers are optically pumped by laser diodes. They combine the positive characteristics of gas/chemical lasers and solid-state lasers without suffering the negative properties. The interest in DPALs is due to their high wall-plug efficiency, good beam quality and scalability to high power. Noticeable results were reported for Cesium, Potassium and Rubidium flowing-gas lasers, where multikilowatt output powers were achieved. We will present the current state and prospects of DPALs as well as the results of experimental and theoretical studies of these lasers carried out at Ben-Gurion University of the Negev. Experimental study of continuous wave flowing-gas Cs DPAL cesium laser with gas circulation, operating at CW mode for several hours was performed. Maximum CW output power of 24 W with a slope efficiency of 48% was obtained for pump power of 65 W. Optical quality of the DPAL output beam was studied experimentally and theoretically. In particular, it was predicted that large radial gradients of the refractive index induced by the pump beam in the heated gain medium could lead to improved DPAL beam quality. This counterintuitive finding by careful measurements of the beam quality factor M2 in static Cs DPALs with different compositions of the buffer gases. Modeling of static and flowing gas K and Rb DPALs and Rb amplifier applying a 3D CFD, K and Rb kinetics models and wave optics model for the laser beam propagation was performed. The standard kinetics schemes were supplemented by the analysis of the electron temperature and K ions ambipolar diffusion. The calculated results are in satisfactory agreement with the experimental ones.

Engineering Coercive Fields via Ion-Exchange forPeriodic PolingofRKTP

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The ferroelectric crystal, rubidium-doped potassium titanyl phosphate (RKTP) is widely used for quasi-phase-matching (QPM) applications due to its low ionic conductivity, wide transparency window and high damagethreshold. Furthermore, its highly anisotropic ferroelectric domain growth enabled straight-forward fabricationof periodically-poled RKTP (PPRKTP) for typical frequency conversion processes such as second harmonicgenerations and optical parametric oscillations. However, for interesting nonlinear optical interactions such asmirrorless optical parametric oscillators [1], which involves the generation of counter-propagating photons, itdemandsQPMperiodsin thesub-micrometerrangetoco mpensatethelargephoton-momentum mismatch.

Moreover, for optical parametric interactions to scale with high-energy outputs, it would require such QPMdevices to have large apertures. The conventional periodic poling method, based on patterned metal electrodes,faces limitations in fabricating PPRKTP with large apertures and narrow domains. These limitations stem fromthe fringing fields that extend beyond the metal electrode boundaries, resulting in domain broadening andmerging. The most viable approach to achieve PPRKTP with such high aspect ratio is through coercive fieldengineering [2], which bypasses the need of metal electrodes. This method is based on ion-exchange (IE) ofRKTP in a molten salt rich in rubidium ions. In this work, we will present the effect of IE of rubidium ions onRKTP that enables the tuning of coercive fields which aids the fabrication of high aspect ratio PPRKTP withhighfidelity.

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Fully-Integrated FMCW THz Spectrometers For Non-Destructive Thickness Measurements

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Abstract

Photonics-enabled FMCW THz spectrometers offer comparable functionality to traditional time-domain spectrometers but with reduced complexity, size, and cost. This presentation provides a comprehensive performance analysis of an FMCW THz spectrometer designed for single-layer thickness measurement in reflection geometry. Furthermore, we introduce the cutting-edge photonic integration platform developed within the European-funded project, POLYNICES. This initiative is set to advance the field by introducing a disruptive set of integration and packaging technologies, paving the way for fully integrated FMCW THz spectrometers.

Optical Imaging of drug-induced brain dysfunction

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Abstract

Neuroimaging tools have expanded our capabilities for investigating the brain and the effects of drugs such as cocaine on brain function. Here we report different optical imaging techniques1-4 developed in our laboratories to investigate the effects of cocaine on neuro-vascular network from the brains of living animals that result in brain dysfunction. These multimodality optical approaches allow for high-resolution angiographic images of cerebral vessels, quantitative measures of cerebral blood flow, and the assessment of changes in hemoglobin oxygenation and deoxygenation (a marker of tissue metabolism) and intracellular calcium (a measure of cellular such as neuronal activity) at high spatiotemporal resolutions with a relatively large field of view. Also, it can assess their dynamic changes in response to drug challenge such as cocaine. These optical imaging techniques have been applying for studying the cocaine's effects on blood flow and metabolism in the brain as well its effects on neuro-glial-vascular network within preclinical animal models. Our results provide new insights into neurobiological effects of cocaine on the brain, which could help to develop therapeutic intervention aimed at neuronal repair and minimizing the brain ischemia resulting from drug abuse and addiction. With a broad impact, these novel in vivo optical imaging modalities will complement other neuroimaging tools such as PET and MRI to measure cellular and vascular aspects of brain function changes induced by drug abuse and addiction as well other brain disorders (e.g., Alzheimer's disease etc).

Keywords

Optical coherence tomography, in vivo fluorescence imaging, blood flow image, brain imaging, light source

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Biography

Dr. Congwu Du received her PhD in Biomedical Engineering (BME) from the University of Luebeck, Germany in 1996. She is currently a professor at the Department of BME, State University of New York at Stony Brook. Her research interest focuses on development of advanced optical techniques for translational research, specifically for neuroimaging with the goal of addressing challenges related to the brain functional changes induced by drug addiction. She has over 100 scientific publications, also has been serving as a principle investigator on many bioimaging-based research grants, including the cutting-Edge Basic Research Award (CEBRA) and the Awards of the American Recovery and Reinvestment Act (ARRA) and Brain Initiatives from National Institute of Health (NIH) and received the Outstanding Mentor Award from Department of Energy (DOE). She is a fellow of AIMBE, also she serves on the editorial board of several journals in the areas of Neuropharmacology, Neuroimaging and Biomedical Optics and Instrumentation.

Cr:ZnS mid-infrared mode-locked laser with carbon nanotube films

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Abstract

The mid-infrared region is traditionally called the molecular fingerprint region. Numerous vibrational spectroscopic techniques are employed in medical and environmental applications, as well as in fundamental physical/chemical research. Recently, Cr2+ or Fe2+ ion-doped chalcogenides, such as Cr:ZnS and Fe:ZnSe, have garnered considerable attention due to their outstanding properties as broadband laser gain media in the mid-infrared [1].

In our research, we developed a mid-infrared ultrafast pulsed laser oscillator [2], utilizing Cr:ZnS as the gain material and incorporating large-diameter single-walled carbon nanotubes (SWCNTs) due to their outstanding saturable absorption properties in the mid-infrared [3]. Combining SWCNTs with Cr:ZnS successfully generates a mid-infrared femtosecond laser pulse directly, and it shows the self-starting of the mode-locked operation. These pulses achieved a Fourier-limited pulse duration of 21 fs at a central wavelength of 2350 nm. Our Two-Dimensional Spectral-Interferometry measurements verified the pulse duration to be approximately 30 fs [4], marking it as one of the shortest electric field cycles observed in a mode-locked laser utilizing nanocarbon materials. Moreover, the robustness of our mode-locking technique enables the interaction of light with gaseous molecules inside optical cavities, achieving intense multiple spectral peak shaping within the broadband spectra of our laser [5].

Keywords
Laser, femtosecond, mode-locked, mid-infrared

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Stretchable Optical Memristor Design, Fabrication, and Characterization

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Abstract

Wearable electronics/photonics are developing rapidly in the era of artificial intelligence (AI) and the Internet of Things (IoT). However, wearable computing devices developed so far are mainly limited to "electronic hardware" implementations, which are incompatible with wearable photonic components. A highly attractive vision is to develop wearable photonic computing devices that can be attachable to the human skin for direct interface with wearable photonic components, such as optical sensors. In this work, we present a novel material combination for a buried waveguide-type, hydrogel-based stretchable optical memristor that can be used for next-generation wearable photonic computing.

To fabricate a stretchable optical memristor, we first fabricate a PDMS substrate with a straight waveguide channel. Then we synthesize polyoxometalates (POMs) doped polyacrylamide (PAAm) hydrogel with a refractive index of 1.43, which is higher than that of PDMS (1.41) at visible light wavelengths thus allowing total internal reflection in the hydrogel, inside the waveguide channel. The POMs within the hydrogel can be switched between a reduced, colored state and an oxidized, uncolored state under UV and oxygen environments, respectively, thereby modulating the transmittance across the visible light spectrum. We use UV light for programming the waveguide transmittance and a 650 nm light for optical readout due to its large photochromic response. By controlling the UV and oxygen environments, we achieve a maximum attenuation of 12 dB, 16 levels of memory, retention over 10000 s, and reversibility under an oxygen environment. Moreover, the stretchable optical memristor exhibits intrinsic stretchability owing to the hydrogel matrix, enabling it to withstand up to 50% strain while maintaining performance after repeated stretching. The combination of POM-doped hydrogel and PDMS substrate enables a buried-type waveguide that functions as an effective optical memristor with inherent stretchability. Such a stretchable optical memristor holds promise for applications in wearable photonic computing, serving as a key component of photonic skin for smart wearable devices, personal healthcare devices, and human-machine interaction interfaces.

Potential and opportunities of software defined optics in optical inspection and metrology

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Abstract

Software-Defined Optics, also known as Digital Optics, represents a revolutionary technological advancement that allows for precise control and manipulation of light through software. The main advantage of this technology lies in its ability to quickly realize optical path designs that are difficult or impossible to achieve with traditional optics, greatly enhancing design flexibility and innovation. Additionally, Software-Defined Optics can make optical systems lighter and add more functionalities, thus improving the overall efficiency and application scope of the systems.

In this talk, the potential and opportunities of software-defined optics, especialy in fields such as semiconductors, biomedicine, and material science, will be introduced. It not only has the potential to improve the precision of inspections and measurements but also to open up new possibilities for applications, thereby driving development and innovation in these areas. With the fine control of light behavior through software, we can anticipate witnessing many breakthrough technological achievements in the future.

From Stokes to Mode Vector Modulation: Multidimensional Constellations andPolarimetricDetectionforEnergyEfficiency

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Abstract

Recently,therehasbeenagrowinginterestinad- vanced modulation formats and direct-detection receiver architectures for Tb/s Ethernet optical interconnects[1].
Among other prominent direct-detection re- ceiver designs studied over the past few years, such as the Kramers–Kronig receiver[2]and the phase retrieval receiver[3],[4], Stokes Vector (SV) receivers[5],[6]havegarneredsignificantattention . The latter are digital versions of the original fast analog direct-detection polarimeters intended for thereceptionofP olarizationshiftkeying(PolSK)[7], whicharecurrentlyequippedwithelectronicpolar- izationtrackingusingsimplifiedmultiple-inputand multiple-output (MIMO) digital signal processing algorithms[5],[6].
StokesVector(SV)receiverscanbeusedtode- tecteitherdigitalpolarizationmodulationschemes, like the ones proposed in the nineties[7]–[9], as well as in the more recent literature[5],[10],[11], or various coherent modulation formats using self- homodyning[6],[12],[13].In the following, we will refer to all the above design paradigms collec- tivelyasStokesVectorModulation/direct-detection (SVM/DD) optical communications systems.
Alongside this progress in short-haul transmis- sion,thereisalotofexcitementregardingthepo- tential use of N−modal few-mode and multicore fibersorNorthogonalpropagationmodesoffree- space to increase the capacity of optical links[14]. Typically, space division multiplexing (SDM) is used to transmit independent data streams over individualspaceandpolari zationdegreesoffree- dom in multimode links.However, it is possibleto consider spatial modulation schemes that use alla vailablespatialandpolarizationmodesjointly ratherthanindependentlytotransmitasingledata stream with increased energy efficiency[15].
This venue has been studied theoretically by our team, where we focused on the multimode analog of SVM[16], a type of spatial modulation thatwasneverconsideredbefore[15]. Wecallthis newmodulationformatbythenameModeVector Modulation(MVM)[16]. MVMcanbedemodulated using a digital polarimetric direct-detection (DD) receiverthatisanexten sionoftheoriginalsingle- mode Stokes vector receiver to multimode links.

In this invited talk, we will review the MVM transceiver architecture, the optimized geomet- ric shaping of the MVM constellation and the re- latedbit-to-symbolmapping,andtheback-to-back performance of optically-preamplified DD MVM receivers.We will show that MVM DD outper- formsconventionalsingle-mode,direct-detection- compliant, digital modulation formats by several dB's in terms of receiver sensitivity and the SNR gainincreaseswiththenumberofspatial degrees offreedom(SDOFs)N. Attheendofthetalk,we willconsiderthepotentialapplicationofMVMasa substitutefor M-ary pulse amplitude modulation (M-PAM)orM-SVMinshort-haulopticallinksand evaluate its benefits and drawbacks.

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Computational Spectroscopy and Molecular Aggregation in Aqueous Solutions

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Abstract

Consideration of solvent effect in vibrational spectrum of a given mode is crucial for the calculation of the vibrational absorption, Raman and 2D vibrational spectra in the solution state. Recently, a theoretical way was developed to describe the solvent effect on a vibrational spectrum such as inhomogeneous broadening and to calculate the IR spectra of peptide, CO stretch mode of myoglobin and O-H stretch mode in water and HDO systems.1-2 Furthermore, it was also applied to the numerical simulations of vibrational CD (VCD) and Raman optical activity (ROA) spectra of given chiral molecules. The time-varying solvatochromic frequency shift was obtained using molecular dynamics simulation and various spectra of the polypeptides were calculated and compared with the experimental results of the amide I IR, Raman, VCD and ROA.2 On the other hand, using MD simulation and graph theory, the molecular aggregation was examined in various aqueous solutions, and the relationship with phase behaviour in binary liquid mixtures was proposed.3-4

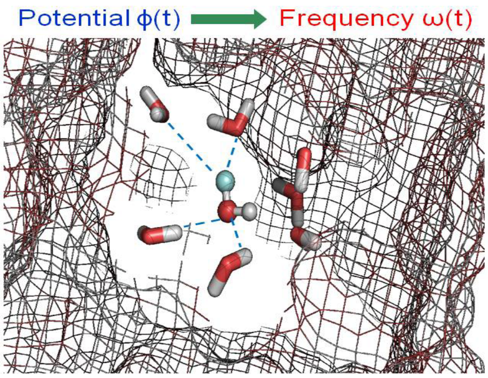

Figure 1. Solvent-induced frequency shift

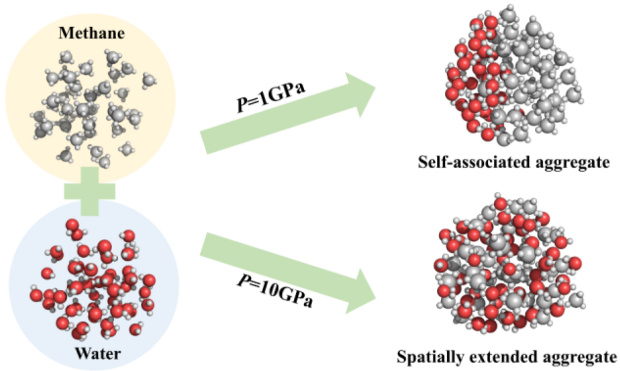

Figure 2. Bifurcating molecular aggregation pathway

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Spectrally efficient THz-wave communication using optical-domain or direct THz-domain reception signal processing

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Abstract

The terahertz (THz)-wave communication is suitable for implementing high-speed wireless communication of more than 10 Gbit/s by utilizing its wide bandwidth. One of its application areas is to build out a high-speed wireless link at a location where it is difficult to lay a fiber-optic cable [1]. Considering the future increase in a data rate, we are investing spectrally efficient multi-carrier communication in the THz-band, which employs frequency division multiplexing (FDM) with densely allocated channels [2], and orthogonal FDM (OFDM) and Nyquist wavelength division multiplexing (WDM) with the spectral efficiency of 1 symbol/s/Hz [3], [4]. Demultiplexing of the multi-carrier channels in the electrical domain has problems including the processing speed limit due to the bandwidth limit of used components and large power consumption. Therefore, we proposed two kinds of demultiplexing methods that utilized photonics [5] and direct demultiplexing in the THz-domain [2]. Although the demultiplexing using photonics needs the configuration that employs THz-radio frequency-optical conversion, it can embrace highly developed photonic devices including optical filters. In addition, it provides an insight into the connection technology between the THz-wave and fiber-optic links. The direct demultiplexing has merits including the possibility of high-speed processing, low power consumption, and the simplified configuration.

In this talk, I report our FDM, OFDM, and Nyquist WDM communications in the 300 GHz-band using optical-domain or direct THz-domain reception signal processing. I explain the underlying operating principles of the signal processing methods and experimental results of these communications. In addition, I present our adaptive THz-wave communication using these multiplexing schemes [2], [6]. The adaptive communication, which employs the requisite minimum bandwidth depending on the traffic and communication distance, is achieved by varying the channel number, symbol rate per channel, and/or modulation formats [7]. This type of communication might be needed in the intending THz-wave communication to conserve the communication resources and power consumption.

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Advances in Materials Integration for Photonic Structures

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Abstract

Fusion bonding and layer transfer techniques have been key components in advancing optical components such as high power laser structures and integrated photonics. Here, we describe strategies from semiconductor-based hetero-integration to reduce fusion temperatures for both single crystalline and polycrystalline YAG-based structures using chemical mechanical polishing (CMP). These practices are extended to the CMP of lithium niobate thin film structures using exfoliation techniques to produce thin films of lithium niobate on various substrates for both integrated photonics and for acoustic resonator structures.

Millimeter Wave Spectroscopy of Materials for the 6G Telecom Spectrum

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Abstract

With 5G wireless technology commercially rolled out, the leading edge of telecommunications research is on enabling 6G wireless technology. The United States Federal Communications Commission has authorized use of the frequency range from 95 to 300 GHz ("upper millimeter-wave") to explore new technologies for 6G. The upper millimeter-wave approaches the "THz technology gap" that is too high for microwave electronics and too low for photonics while also confronting a rise in atmospheric attenuation. Therefore, a 6G system must overcome much more stringent signal-to-noise requirements compared to 5G. The upper millimeter-wave is high enough that electromagnetic properties of many commonly used materials have not been accurately measured and cannot be assumed to be close to their microwave or optical values, limiting the ability to do reliable electromagnetic modeling.

Modern semiconductor technology uses a variety of dielectric materials to package high-performance semiconductor chips. Packaging protects the chip from the environment, provides support against mechanical stresses, acts as a thermal heat sink, and serves as the interface between chip and signal. For 6G telecom chips, packaging may also form a platform for integration of passive components such as waveguides and antennas. It is highly desirable that the packaging material minimally interfere with or degrade high-frequency performance of the completed circuit.

To model, design, and understand a packaged circuit's electromagnetic performance, it is critical that the packaging material's basic dielectric properties, namely its permittivity (or dielectric constant), Dk, and its dissipation factor (or loss tangent), Df, be reliably known across the frequency band. Depending on specific design and application, there is use for materials having both relatively low ($1 < Dk \leq 3$) and relatively high ($Dk > 3$) values of Dk. It is usually desirable that Dk be nearly constant or non-dispersive across the frequency range of interest, although there are applications that can exploit a known dispersion. Minimizing loss is critical to the performance of upper mm-wave circuits, so in all cases a smaller value of Df is preferred.

In this talk I will show broadband measurements of Dk and Df on a variety of cutting edge dielectric packaging materials across the 6G band from 90 to 325 GHz. Materials include liquid crystal polymers (LCP), epoxy-oxide composites (EOC), and ceramic and fiberglass laminates. Measurements were made using a quasi-optical, phase-sensitive spectrometer capable of obtaining real and imaginary transmittance and reflectance with a material held at 23 °C or 150 °C. The Dk values encountered ranged from 1.1 to 4.5, with two materials showing significant dispersion, and mostly showed little or no significant difference between the two temperatures. The Df values encountered ranged from 0.01 to 0.04 at 23 °C, depending on material, and in most cases were a factor of 2× to 3× higher at 150 °C compared to 23 °C. Implications for packaging of 6G electronics will be discussed.

Terahertz photonics of carbon-based nanostructures

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Abstract

One of the recent trends in bridging the terahertz (THz) gap in electromagnetic spectrum is to use carbon-based nanostructures [1]. Following our earlier work on narrow-gap carbon nanotubes and graphene nanoribbons [2], as well as graphene bipolar waveguides [3] and double quantum wells [4], we consider THz transitions in two other types of quasi-one-dimensional nanocarbons – carbynes and cyclocarbons.

The technology for synthesizing carbynes, also known as linear acetylenic or polyynic carbons, has experienced significant advancements over the past few years [5]. Stable long aligned chains of carbynes are now being successfully deposited on substrates [6]. One notable characteristic of long polyyne chains, which feature two alternating non-equal bonds, is the presence of mid-gap edge states that are topologically protected. In a finite-length chain, these two edge states form an even and odd combination, with the energy gap proportional to the overlap of the edge states due to tunneling. These split states of different parity support strong dipole transitions. Our research [7] has demonstrated that, for carbyne chains that are long enough (over 18 atoms), the energy separation between the HOMO and LUMO molecular orbitals formed by the edge states corresponds to the THz frequency range. This HOMO-LUMO energy gap can be tuned by external electric field [8]. Additionally, there are several other allowed optical transitions in this system that can be used to maintain the inversion of population required for THz lasing.

Another recent achievement in nanocarbon technology is a demonstration of controlled synthesis of cyclocarbons, in particular cyclo[18]carbon allotrope [9]. The properties of cyclocarbons in an external electric field differ drastically depending on the parity of the number of dimers in a polyyne ring. This is a direct consequence of breaking the inversion symmetry in a ring consisting of an odd number of dimers, including the famous C18. Our estimates [10] show that adding just one extra carbon dimer to C16 is equivalent to placing this molecule in an external magnetic field of 104 T. For an odd-dimer cyclocarbon, as a result of the inversion symmetry absence, an experimentally attainable electric field should open a tunable gap between otherwise degenerate states leading to two states with allowed dipole transitions between them in the THz range. A population inversion can be achieved again using optical pumping.

This work was supported by the EU H2020-MSCA-RISE projects TERASSE (H2020-823878) and CHARTIST (H2020-101007896), by the UK EPSRC grant EP/Y021339/1 and by the NATO Science for Peace and Security project NATO. SPS.MYP.G5860.

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InvestigationoftheElectronicStructureofMaterialsusingPhotoelectron Momentum Microscopy

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Photoelectron momentum microscopy (MM) is a modern research method for determining the electronic structure of solids using photoelectron energy, momentum and optional spin analysis. In the language of electron microscopy, this information can be retrieved from the ‘reciprocal image’, constituting an alternative route to angle-resolved photoelectron spectroscopy(ARPES)[1].Therearеseveraldesignsofmicroscopestoobtainthisinformation: using a single or double hemisphere as dispersive analyzer or time-of-flight (ToF) recording. The latter allows us to sort the energy states in an interval of several eV width by their time- of-flight. A time-resolving image detector, here a delay-line detector (DLD), is used for momentum-space and real-space imaging as well as for spatio-temporal beam diagnostics.

Photoelectron diffraction, primarily studied in the X-ray range (XPD), presents a powerful technique that acquires structural information of solids and their surfaces. We use the MM methodforXPD, which yieldshighly-resolved (angularresolution0.03°) diffractionpatterns, rich in details.

Circular dichroism depicts the difference in response of matter when exposed to two orthogonalcircularpolarizations tatesofanincomingphotonbeam.Inangular-ormomentum- resolved observation, this phenomenon was termed circular dichroism in the angular distribution (CDAD). CDAD [1] appears in core level and valence band photoemission.

A total of □50 publications in the last three years show that ToF-MM is becoming a well- established method. However, there are several remaining challenges related to the data acquisition, especially in femtosecond time-resolved MM studying ultrafast electronic processes. Further development targets the control of the extractor field close to the sample surface [2] and the suppression of background using bandpass filters [3].

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Generation and tailoring of graphitic microelectrodes fabricated in diamond by pulsed Bessel beams

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Graphitic electrodes in diamond have been extensively used in various lab-on-a-chip circuits due to the fact that they can act as a conductive pathway for various sensing applications such as biosensing and radiation detection. Here we report the fabrication of highly conductive graphitic micro wires in 500 mm thick diamond perpendicular to the sample surface, using pulsed Bessel beams, and making use of the best combination of beam parameters, crystallographic orientation of the sample and writing mode of the laser.

The microfabrication studies have been carried out using femtosecond and picosecond laser pulses from two different sources, namely a Ti:Sapphire amplified laser system from Amplitude at 800 nm wavelength and 20 Hz for single pulse mode operation, and and a Pharos-SP from Light Conversion Ltd at a repetition rate that can be tuned between 1 kHz and 1 MHz for burst writing mode. The electrical characterisation of the fabricated electrodes is carried out using a current-voltage-temperature (I-V-T) chamber.

It has been observed that a higher pulse duration of the laser favours better conductivity. In addition, the electrodes fabricated with 200 fs in a (100) cut sample, often show the presence of a potential barrier in their I-V curves and higher resistivity [1]. In order to eliminate such barriers, the electrodes are fabricated in a (110) cut sample at 200 fs pulse duration for a comparative study with the (100) cut sample. The electrodes showed a huge improvement both in morphology and conductivity with no potential barrier compared to that generated in the (100) cut sample [2]. Figure 1 depicts the morphology of electrodes fabricated in (110) and (100) cut samples. In the (110) oriented diamond, resistivities lower than 0.015 Ω cm have been obtained.

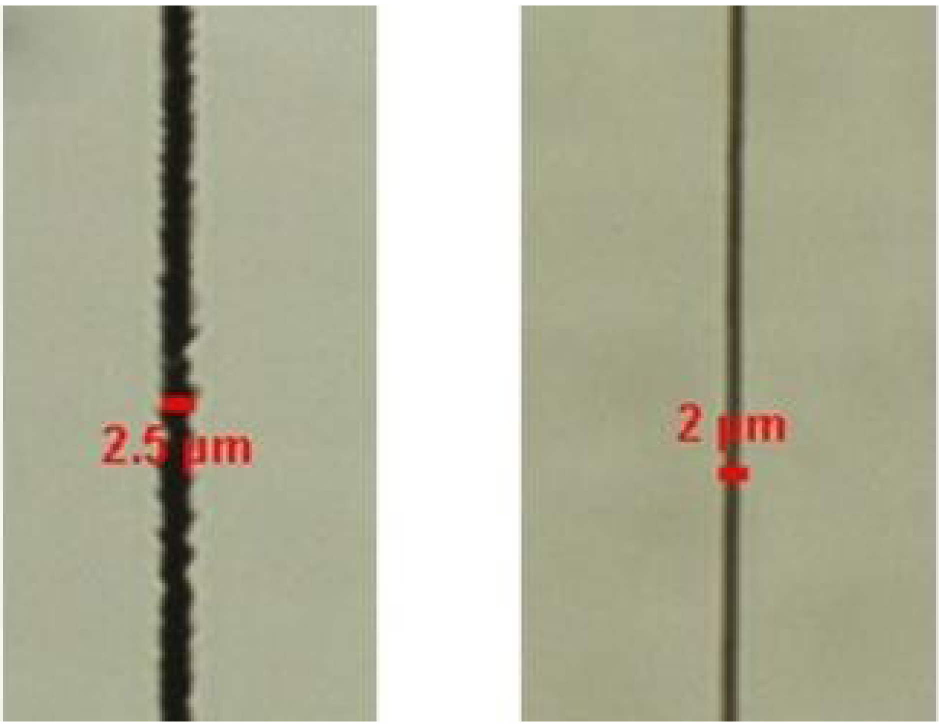
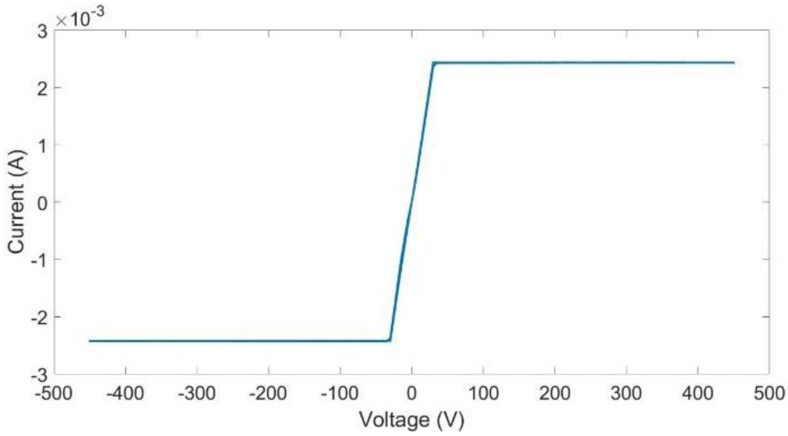


Fig.1 Morphology of electrodes fabricated at 5 μJ pulse energy and 200 fs pulse duration in (100) cut sample (left) and (110) cut sample (right)



To achieve similar low values of resistivities in a (100) oriented sample, burst mode writing has been implemented. It has been observed that the electrodes fabricated with femtosecond sub-pulses, in burst configurations consisting of longer bursts with higher number of sub-pulses, and lower time delay between them, yields lower resistivity values compared to other configurations. Indeed, using the best Bessel beam burst writing mode and beam parameters, we could fabricate low resistivity electrodes with laser bursts of 10 μJ energy, featured by a duration of 46.7 ps, 32 sub-pulses (with 200 fs duration) within the burst and a time delay of 1.5 ps between them. After 900° temperature annealing the IV characterization led to a resistivity of ρ ~ 0.01 Ω cm. The corresponding I-V curve is presented in figure 2.

Fig.2 I-V curve of the electrode with lowest resistivity value.

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The Quantum Internet: A Photonic Approach

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Abstract

This presentation explores the evolution of the Quantum Internet, emphasizing the critical role of photonics in realizing quantum communication. Photonics is a crucial technology due to its compatibility with existing telecommunications infrastructure and ability to facilitate high-speed, long-distance quantum information transfer. However, the practical application of photonics in quantum networks is hampered by challenges such as photon loss and decoherence, which significantly degrade the quality of quantum information over distance. Addressing these challenges, quantum error correction emerges as an essential tool within photonic systems to preserve the integrity and reliability of quantum information, ensuring the feasibility of a scalable and robust Quantum Internet.

The paper reviews the current quantum error correction protocols designed for photons, focusing on their ability to maintain information integrity during transmission. These protocols are key to ensuring reliable quantum communication. The paper also introduces our work on W-state protocols in photonic systems. This novel approach to quantum error correction tailored for photonic qubits enhances the fidelity of quantum information transmission, and it shows how error correction can be applied in practice, improving the reliability of quantum networks.

Keywords

Quantum internet, photonics, quantum communication, quantum error correction, photonic qubits, W-state protocol

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Biography

Dr Rohit Ramakrishnan is a Postdoctoral Researcher at the Centre for High Energy Physics, Indian Institute of Science, Bangalore, specializing in Quantum Technology, Machine Learning, and Nanophotonics. Holding a PhD in Photonic Quantum Technology from the Electrical Communication Engineering Department at the Indian Institute of Science, Dr Ramakrishnan’s expertise spans theory, experiment, and design in the interdisciplinary fields of Quantum Technology and Nanophotonics. With a rich and diverse research background, he previously served as a Research Assistant at the Centre for Quantum Technologies, National University of Singapore, contributing to the Quantum Satellite project. Before that, Dr Ramakrishnan was a Postgraduate Researcher in the Quantum Optics research group at the Australian Defence Force Academy. He is also the co-author of the book “The Quantum Internet – The Second Quantum Revolution,” published by Cambridge University Press. Dr Ramakrishnan focuses on advancing Quantum Machine Learning, leveraging his expertise in Quantum Technology and Nanophotonics to push the boundaries of interdisciplinary research.

**High energy Tm based/
KGW SWIR Raman laser**

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Abstract

This study describes a novel material based heterostructure photodetector designed for deep and near ultraviolet (UV) applications. The photodetector is constructed with a composite of Zirconium Boride (79.3% ZrB2) and Chromium (20.7% Cr) alloy, deposited onto a 6H nitrogen-doped silicon carbide substrate. The determination of the optimal alloy thickness is achieved through Finite-Difference Time-Domain (FDTD) simulation, and the synthesis of the alloy is accomplished using radio frequency (RF) sputtering. Remarkably, the resulting photodetector exhibits an exceptional responsivity of 3.5 A/W under an applied voltage of -2 V, at wavelengths of 405 nm and 280 nm. This heterostructure not only exemplifies high performance but also provides a versatile platform for the development of near UV photodetectors capable of operating effectively in challenging conditions, such as environments characterized by high power and elevated temperatures.

Keywords

Responsivity, silicon carbide, ultraviolet photodetector, zirconium boride.

Results

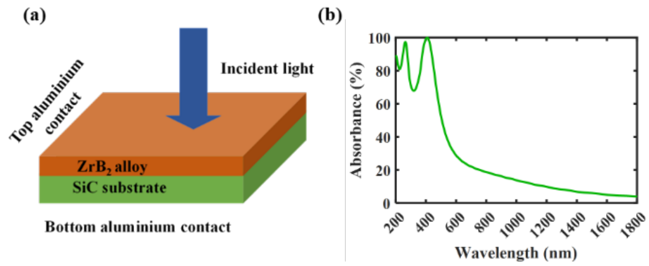

Figure 1: (a) Schematic diagram of the fabricated photodetector. (b) Wavelength versus absorbance curve for alloy material.

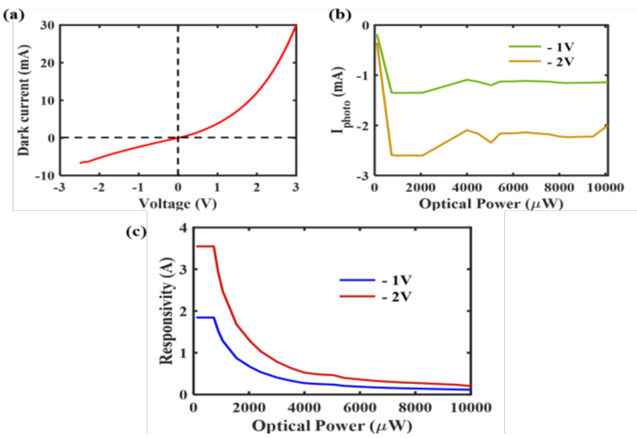

Figure 2: (a) Dark current versus voltage for the 79.3% ZrB2/20.7% Cr alloy. (b) Photocurrent for -1V and -2V applied voltages and incident optical power levels (c) Responsivity as a function of applied optical power for an applied voltage of − 1 V and − 2 V.

Biography

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Automatic Differentiation Accelerated Feature Mapping Methods forPhotonicInverseDesign

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Shape optimization approaches to inverse design offer low-dimensional, physically intuitiveparameterizationsofstructure sbyrepresentingthemascombinationsofelementaryprimitives.However, on fixed rectilinear grids, computing the gradient of a user objective via the adjointvariables method requires a reduction of the field solutions with the Jacobian of the structuralmaterial distribution. Shape parameters often perturb global parts of the simulation gridresultinginmanynon-zeroJacobianentries.Thesearetypicallycomputedbyfinite-differencein practice, and hence can be non-trivial for large variable count. In this work we propose toacceleratethegradientcalculationbyinvokingautomaticdifferentiation(AD) ininstantiationsof structural material distributions. In doing so, we develop differentiable global featuremappingsfrom parameterstoprimitivesanddifferentiableeffectivelogicoperations.Wegoonto show that the same feature maps can be used to accelerate FD-based shape optimization byefficient boundary selection. We demonstrate AD-enhanced shape optimization using threeintegrated photonic examples: a blazed grating coupler, a fast waveguide transition taper, andapolarization-splittinggratingcoupler.WefindaccelerationsofthegradientcalculationbyADrelativetostate-of-the-artFDw ithboundaryselectionexceed10x,resultingintotaloptimization wall time accelerations of 1.4x–3.8x on the same hardware with no compromisetodevicefigure-of-merit.

FastBroadbandOpticalEnergyLaserMeters:State oftheArt

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Abstract

A new generation of Optical Energy Laser Meters showing Laser Induced TransverseVoltage (LITV) is rapidly bridging the gap withSemiconductor-based Detectors, in terms ofresponse speed, minimum detectable energy, and is capable to operate metrologically from UV toLWIRandbeyondinmulti-Wattsdirectirradiation

Summary: Is well known the capability of Semiconductor-based Detectors to show high speed and very highDetectivity (D*), allowing the sensing of extremely low light levels. Particularly in the IR regions there is plethoraof Detectors based, among the others, on these material systems: Si, Ge, III–V ternary alloys, InSb, Hg1–xCdxTe.Drawbacks of these sensors when used for Laser Energy measurement are related, e.g. to the D*, that stronglydecreases at room temperature (RT, where the Laser Energy Meters are preferentially used), low Laser peak powersaturationlevel,smalla ctiveareas,strongresponsivity dependenceon Laserwavelength,narrowspectralrange.

Fast broadband optical Energy Laser Meters, subject of this work, belong to the category of Thermal Detectors. Dueto fundamental different types of noise, Thermal Detectors as compared to photon detectors these have differentdependencies of detectivities on wavelength and temperature. E.g. at RT, the D* of thermal detectors is in principlemuch better than LWIR photon detectors. The detectors showing LITV effect (that is due to anisotropic componentsofthe Seebecktensor) transduce an axial thermal gradientintoanelectricsignal.

Asfar asweknow,thereareonly twoDetectortypesofthiskindavailableto themarket,oneofwhichismanufactured bythe comp anytheAuthorisaffiliatedwith.

Currently the advantage of sensors using the LITV effect over Semiconductor-based Detectors (or other ThermalDetectors like Pyroelectric) for Laser radiation measurement is the combination of an overall fast response time(sub-ns signal rise time), capability to measure Lasers with pulse duration from Femtosecond to CW with repetitionfrequencies > 3.5 MHz, high saturation threshold to direct laser irradiation and broadband spectral acceptance (fromUV to LWIR and beyond). Minimum demonstrated detectable Energy/pulse in Fast and Ultrafast Lasers as low as100 nJ/pulse.

In this work we focus on LITV sensors capability to measure metrologically Laser types from frequency quadrupledYAG, to pulsed Ho, Tm, ns pulsed CO2, and on two key laser characteristics, i.e. Turn-on Transient effects andMissing Pulsesdetectionof mediumpowerFastandUltrafastLasers[1],[2]

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Suppression of Scattering Clutters in an Underwater Lidar System

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Abstract

Underwater target detection lidar has the characteristics of high spatial resolution, large point cloud density, flexible platform, and high detection efficiency. It has a wide range of applications in the fields of near-shore seabed topographic mapping, underwater target detection, and underwater infrastructure maintenance. However, the scattering of the detection beam by the water body will cause problems such as the decrease of spatial resolution and the limitation of detection distance. Scattered clutter seriously restricts the application of lidar for underwater target detection. In view of the differences in frequency, statistical distribution and coherence between scattered clutter and target echo, anti-scattering methods such as wavelet time-frequency decomposition filtering, blind source separation based on one-time measurement and vortex light field spatial filtering are proposed. Both theoretical and experimental results show that the above methods can effectively improve the ranging accuracy of the underwater lidar system in turbid water.

NonlinearOpticalandTime-ResolvedPropertiesofNovel OrganicMaterials

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Abstract

Organicconjugatedmoleculesforopticalandelectronicapplicationshavereceivedgreatattentionduetotheirversatilityandrelatively lowmanufacturingcosts.Whiletherehasbeengreatimprovement of light conversion efficiency in certain organic photovoltaic materials, there stillremainquestionsconcerningthestructuralandinhomogeneityoftheelectronandenergytransportprocesses.Inthisregard,understandingthefastprocesses(fs)atalocallevel(nm)inthesesystemsiscrucialinthedesigncriteriaforbetterperformanceinopticalandelectronicapplications.Inthispresentation, the results of photo-physical dynamics of organic materials useful for nonlinearoptical and light harvesting applications will be described. These materials have been analyzedusingtime-resolvedabsorptionandfluorescencespectroscopyandmicroscopyaswellasnonlinearand quantum optical methods. Ultra-fast interferometric microscopic measurements were carriedout to investigate the role of coherent energy transport in these organic photovoltaic materials.Theuseofthesemethodsprovideinsightsintothedynamicsanddegreeofheterogeneityinnovelorganicmaterials foroptical and electronicapplications.

Dirac-Volkov Propagator: When Matter Perturbs Light and Relativistic Perturbation Theory is Not Enough

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Abstract
In the talk, we will discuss the Dirac-Volkov propagator, which is a key ingredient in laser-assisted bremsstrahlung, laser-assisted Bethe-Heitler pair production, and other high-energy signatures of intense laser-matter interactions, in a regime where laser fields are so intense that matter perturbs light, not the other way around. A few example calculations will be presented, and an overview of the difficulties encountered in the theoretical treatment will be given. Numerical methods will be discussed, an an outlook of further developments will be given. High-energy processes in laser fields of extreme intensity are a hot topic of research. The treatment of highly intense fields is, notably, more complicated than that of weak fields, because no expansion in the number of absorbed laser photons is possible: Both relativistic effects as well as the laser-matter interaction must be treated perturbatively. An overview of the technical issues and numerical methods involved in the Dirac-Volkov picture calculations will be given.

Spin-to-orbit conversion mechanism in optical vortices creating miniature atom traps

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Abstract

We propose a novel type of dark atom traps in the form of a finite set of sub-wavelength bottle traps. This trapping configuration is formed by two strongly focused counter-propagating vortex beams with the same winding number ℓ = ±1 and the same circular polarization (□ = □1) respectively. Such stronlgy focussed beams are characterized by the existence of a longitudinal field component due to spin-to-orbital conversion. This component gives rise to an on-axis standing wave which results to an axial confinement of far blue-detuned atoms. There is a pi/2-phase difference between this on-axis standing wave and the off-axis stading wave due to the transverse components of the counter-propagating optical vortice. In far blue-detune atoms, the donut rings in the off-axis standing wave provides the radial confiment in the axial region, leading to the generation of an overall three-dimensional bottle-like trapping.

Generationofbroadbandterahertzradiationinlaser-createdairplasmaandi tsapplications

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Generation of terahertz (THz) radiation in gases by focused bichromatic laser pulses is an efficientand well-established technique [1]. However, the yield, divergence and spectral characteristics ofgenerated THz radiation strongly depend on various experimental parameters. Since thesedependencies are not yet fully understood, in this report we present the results of experimentaland theoretical analysis of terahertz radiation generation in air by focused fundamental andsecond harmonic pulses of femtosecond and subpicosecond Ti:Sapphire and Yb:KGW lasers,respectively.During the experiments, by selecting the optimal laser pulse polarizations, focusingconditions and other parameters we have obtained a broadband THz radiationwith the energyconversion efficiency exceeding 10-4. THz spectra were registered and analysed using a home-madeMichelsoninterferometeralongwith thedetector sensitiveinTHz spectralrange.

The generated broadband (0.1-50 THz) terahertz beam has been applied for the setup capable toperform a direct time-resolved characterization of the plasma created by other laser beam. Thissetup allowed us to obtain plasma collision rates, electron temperatures and other plasmaparameterswithintheplasma density range from1016to1020cm−3[2].

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Development of Photonic Interposer for HPC

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Abstract
We pave the way towards an efficient 3D photonic computing engine by designing and fabricating a 3D vertically-coupled photonic interposer formed via fusion bonding. Simulations reveal that the waveguide design is highly efficient, with a coupling transmission efficiency of 98% with oxide layer 500nm. Experimentally, the extent of bonding at different oxide thicknesses is revealed via IR and CSAM images. These results are further complemented by relevant physical parameters for successful bonding such as surface roughness, oxide thicknesses, and warpage. Compared with previous literatures [1][2], our fusion bonded photonic interposer enables photonic devices to be designed on different chips before being integrated onto the same wafer. This enhanced modularity enables parallel processing of different device components before the final bonding, significantly reducing the total cycle time and difficulty of handling. As a result, the total risk involved in the manufacturing process is also decreased.

Keywords
Photonic Interposer, CSAM, Fusion Bonding, Coupling Efficiency

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[2] Yichi Zhang, Kuanping Shang, Yu Zhang, Siwei Li, Yi-Chun Lin, and S. J. Ben Yoo; Optics Express Vol. 32, Issue 1, pp. 40-51 (2024); Low-loss and broadband wafer-scale optical interposers for large-scale heterogeneous integration

Biography
Wen Lee received the Ph.D. degree from NTU in 1997. He held a Senior Principal Scientist position at the IME (Institute of Microelectronics) of A*STAR (Agency for Science Technology and Research). His research topics are BSI (Backside Image Sensor), PIC (Photonic IC), HPC (High Performacne Computing), 2.5D Interposer packaging, Fan Out WLP (Wafer Level Packaging), FB (Fusion Bonding), and HB (Hybrid Bonding).

Evanescent field engineering enabled silicon photonicdevices

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Abstract

Thehighindexcontrastofthesilicon-on-insulator(SOI)platformisattherootofthehigh-density integrated silicon photonic circuits. However, in the meantime, it not only makeswaveguide devices susceptible to fabrication errors, but also makes the precise tailoring of theopticalpropertiesagreatchallenge.Tocircumventthisdilemma,weproposetousesubwavelengthstructurestoengineertheevanescentfieldinsteadofthecoreofthewaveguide.which can significantly weaken the perturbation to the guided mode. In this talk, we willintroduce our recent progress in evanescent field engineered silicon photonic devices. Ultra-long waveguide grating antennas are the essential building block for large aperture opticalphasedarrays.Byperiodicallyperturbingtheevanescentfieldofatypicalstripwaveguidewithsubwavelengthsiliconblocks,waveguidegratingantennasofanydesiredlengthcanberealizedwith critical dimensions compatible with commercialized silicon photonics foundries. Thediffractionpropertiesoftheseantennascanbefurtherengineeredbyincorporatingboundstatesinthecontinuumeffect.Withsimilarstructures,ultra-highextinctionratioandnarrowlinewidth filters can be realized with coherency-broken cascaded bimodal gratings, which arealsoformedbyperiodicallyperturbingthecladdingwithsubwavelengthstructures.Arejectionlevel > 74 dB is experimentally demonstrated. In addition to Hermitian devices, we alsodemonstrate that evanescent field engineering also provides a convenient tuning knob for non-Hermitian photonic components.We are able to tune an on-chip integrated silicon microringresonator to exceptional point by manipulating the evolutions of backscatterings with twonanocylinders of disparate diameters. These demonstrations show that perturbing evanescentfield with subwavelength structures is a powerful tool which can potentially open a new venuefor silicon photonicdevices.

Utilization of multi-dimensional quantum entanglement in sensing and imaging

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Abstract

The generation, and detection, of correlated photon pairs has been at the heart of fundamental tests and applications of quantum mechanics. The landscape of photon correlation is complex and multidimensional with unbounded degrees of freedom (DOF) such as time, frequency, position, momentum and angular momentum. However, conventional single photon detectors can often only measure one such DOF. Single pixel detectors offer 1D timing measurement, while multi pixel cameras can provide a 2D image but lack the necessary temporal resolution. With the advent of a new generation of detectors, more than one such DOF can be simultaneously measured. Here, with the use of such a detector, I will demonstrate utilization of more than one such continuous DOF in realizing quantum sensing and imaging applications previously difficult to accomplish. This includes quantum lidar with enhanced noise resistance, quantum light-field microscopy with extreme depth of field, quantum snap-shot hyperspectral imaging that does not require a trade-off between imaging and spectral resolution and non-interferometric, single-shot quantum phase microscopy.

Doubleaerialimage-assistedejectiondevice

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Abstract

In this work, I have fabricated a novel arm-equipped material ejection device with functionalityasopticalaerialimagingsights.Todate,thetechniqueforaerialimagingusingaretroreflector(RR)plate has been reported in various studies [1].However, limited literature is available on theinterlocking between the obtained aerial images and the motion mechanism device. If such a devicefunctionisestablished,aninnovativemodelinthefieldofhuman-machineinterface(HMI)[2]canbefinalized. Here, I tried to create an ultimate system combining an aerial imaging device with ashooting device [3], as part of HMI research.By recommending aerial images (A1, A2) as sights, Ifabricatedanewtypeofarm-equippedmaterialejection(EJM) devicewithaninterestingfunctionthatcan change the sight shapes during triggering as seen in Fig. 1.The fabricated device would beappliedforthe air-gun,water-gun,andbow-gunin thefieldoftoyindustry.

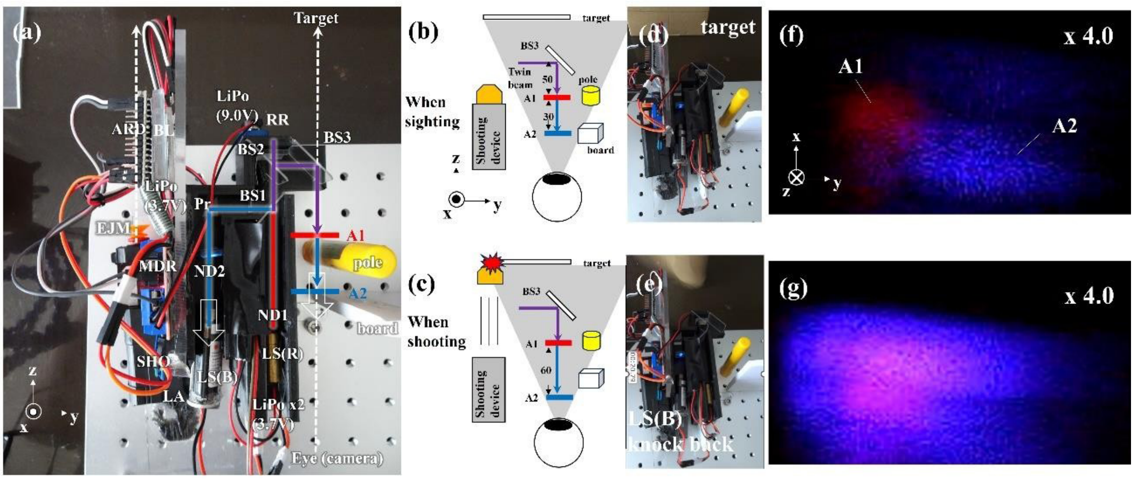

Fig. 1Double aerial images assisted-arm equipped material ejection device: (a) A photo for the opticalconfigurationf ortheaerialsights(A1, A2)-equippeddevice.(b),(c);thechangeintheopticalconfiguration during sighting and shooting.The positions of the ejection material (EJM) and the opticalsight (A2) change during shooting.(d), (e); the change in the ejection function during sighting andshooting. As can be seen from these figures, the target is blown off during shooting and the position ofthe blue colored-laser light source (LS-B) is slightly retarded due to knock-back resulting from the pull ofthetrigger.(f), (g); thechange ofsightimageswhen sightingandshooting.

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Innovative Optical and Wireless Network (IOWN) for the next generation communication and computing infrastructure

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Emerging technologies such as artificial intelligence or autonomous driving require ultra-high performimance and ultra-low latency for both communication and computing infrastructure. On the other hand, power consumption by those technologies has increased exponentially and has become one of the important social problems. Datacenters are getting bigger and require huge amount of electricity, comparable to the size of a medium-sized city. Innovative Optical and Wireless Network (IOWN) is a next generation communication and computing infrastructure that enables both high-performance and low power consumption.

All Photonics Network (APN) provides cost-effective end-to-end wavelength direct paths with disaggregated network equipments. It enables ultra-low latency and network deployment agility. APN can develop distributed datacenters that connect client's on-premises sites to datacenters located in suburban area with ultra-low latency similar to datacenters in metropolitan area. Datacenters in suburban area can use more sustainable energy than in metrolitan area. It can reduce carbon foot print.

Photonics Disaggregated Computing is a next generation computing architecture shifting from CPU centric to data centric architecture with optical interfaces to all compuring components. Is is also called data-centric infrastructure (DCI). In the generation of artificial intelligence and cloud computing, applications tend to use more GPUs, accelerators, and memories than traditional CPU centric applications. This architecture can optimize power consumption dramatically. Those targets of IOWN are extremely challenging. To develop IOWN technologies and IOWN use cases, IOWN Global Forum was established in 2020 for cross industry collaboration. With 140 members, IOWN Global Forum has developed a series of documents on architecture of APN and DCI, future looking use cases, and reference implementation models. For clarifying business value of IOWN use cases and technologies, members of IOWN Global Forum start to make a series of PoCs. IOWN Global Forum also collaborates with several external organizations such as ITU-T, OUT-R, The Linux Foundation, and OpenROADM.

FabricationControlandChallengesinSurfacePlasmonPolariton(SPP)Lasers

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SurfacePlasmonPolaritons(SPPs)aresurfacewavesthatpropagatealongtheinterfaceof a dielectric and a metal, effectively confining electric fields within extremely smallregions. This capability enables the creation of subwavelength-scale photonic devices.This phenomenon holds significant scientific importance as it opens up numerouspotential applications. For instance, the principles of SPPs can be employed in thefabrication of miniaturized laser devices. By placing semiconductor nanowires on alayer of dielectric deposited on metal (SIM structure), the volume of coherent lightsource devices can be reduced below the optical diffraction limit. This reductionenablestheintegrationofcoherent activelight-emittingdeviceswithothermicro/nanodevices, which is crucial for the advancement of integrated photonics. Furthermore, SPP lasers can be applied in fields such as cell imaging, explosivedetection, and microdisplays, offering new possibilities in these areas [1-3]. However,currentresearchfacesseveralobstacles.Intermsoffabricationprocesses ,itisnecessary to have high-quality fabrication processes to achieve low surface roughness,high-quality metal films, and accurate control of SPP structures to operate SPP lasersat room temperature. In our study, we utilized the finite element method (FEM) toinvestigate the influence of the thickness of dielectric and metal layers on opticalconfinement. Additionally, we explored the relationship between the side length ofsemiconductornanowiresandsurfaceplasmonmod es.Tovalidateoursimulations,weutilized an electron beam evaporator and atomic layer deposition (ALD) to depositmetal and dielectric layers, adjusting their thickness to match the theoretical volumesderived from our simulations. Ultimately, we successfully operated SPP lasers attemperatures higher than room temperature, with semiconductor nanowire side walls,dielectriclayer,andmetallayerthicknessesof70nm,4nm,and10nm,respectively.

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High-Speed Lithium Niobate Modulators for Optical Fiber and Radio-Over-Fiber Links

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Abstract

Recent research on high-speed lithium niobate modulator for optical fiber communications and radio over fiber applications is reviewed. For the fiber communications, half-wave voltage (Vp) and 3dB bandwidth are key parameters to achieve high baud-rate data transmissions. For the analog radio over fiber applications, optical loss of the modulator is also significant factor to obtain a high signal-to-noise ratio for high-capacity transmission. We introduce two types of modulators. One is a high bandwidth modulator for the baseband modulation for optical fiber links [1, 2], and the other is a high slope-efficiency modulator for band-limited modulation for radio over fiber links [3].

Keywords

optical modulator, optical fiber communications, radio over fiber

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Acknowledgement

This work was supported in part by JSPS KAKENHI under Grants 22K04116 and 23K13340, JST CREST under Grant JPMJCR2103, and JST Moonshot R&D Program under Grant JPMJMS226C.

Biography

Yuya Yamaguchi received the B.E., M.E., and Ph.D. degrees in applied physics from Waseda University, Tokyo, Japan, in 2012, 2014, and 2017, respectively.

From 2015 to 2016, he was a research associate in Waseda University. Since 2016, he has been with the National Institute of Information and Communications Technology (NICT), Tokyo, Japan. His research interests include optical modulators and functional optoelectronic devices.

Dr. Yamaguchi is a member of the Institute of Electronics, Information, and Communication Engineers of Japan, and the Japan Society of Applied Physics.

Teaching Generalized Refraction With Kadidak Startup

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Abstract
I am presenting a blended teaching approach (using both in-classroom and online resources) for STEM disciplines at undergraduate college level, exploiting open-source online technologies, based on my experience in teaching from 1995, in very diverse cultural environments, including the United States, Italy and Mauritius. The approach leverages on an interdisciplinary style, inspired by the Italian curriculum, and includes fully scalable automatic assessment procedures, with random input data, not limited to multiple choice questions, and which require student input from keyboard. I have tested this method since 2020 in my 1st year physics class at the University of Trento, in which approximately 170 students are enrolled each academic year. The teaching is handled by the startup “Kadidak”, which I founded in Italy in 2021. As an example, I will use this approach in my presentation, targeting an audience of 15-year-old students: I will explain a paper of mine (N. Yu et al., “Light Propagation with Phase Discontinuities: Generalized Laws of Reflection and Refraction”, Science 334, 2011).

The spectral reshaping of XUV pulse in macroscopic systems

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Abstract

The study of ultrafast physics has revolutionized people's understanding of light-matter interaction, and greatly promoted the development of related technologies. However, as the research object is expanded to more complex and dense media systems, the propagation effects cannot be ignored, which results in complex structures in macroscopic absorption spectra. We investigate the evolution of the XUV spectral reshaping induced by NIR-laser-imposed modulation during pulse propagation. A general approach was proposed to manipulate and substantially enhance the absorption property of a macroscopic medium. The key idea is to introduce manipulations to the polarization decay of the system, thus confining its free evolution and the natural reshaping of the driving pulse. Analytical solutions were given to interpret the propagation-induced pulse reshaping effect. The present study will help us establish a "optical-optical modulation scenario" for the pulse shaping of light with photon frequency beyond visible.

Biography

Liu Zuoye, got a Ph. D. from Lanzhou University in 2015, now works as a professor at School of Nuclear Science and Technology in Lanzhou University. From 2012 to 2015, he worked as Joint Ph. D. student in Max-Planck institute for nuclear physics. At present, he is mainly engaged in the research of ultrafast physics and nuclear testing technology basing on pulsed laser. In recent years, he has published more than 40 SCI academic papers in Phys. Rev. Lett., Phys. Rev. A, Optics Express and other journals, and won Young "Feitian" Scholar at 2022.

Flexible SERS Substrate based on Ag Nanopyramids and Organosilicon Compound

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Abstract

Surface-enhanced Raman scattering (SERS) substrates have proven to be a promising platform in optical sensing of chemicals and biomolecules due to their high sensitivity [1]. Currently, most of the research is devoted to the creation of rigid SERS substrates which are limited in real-world detection. Comparable to rigid substrates, flexible SERS substrates offer unrivaled advantages in portable, rapid, and personalized detection in the field of point-of-care test [2].

In this work, we proposed a simple and reproducible method to prepare Ag nanopyramids (AgNPs) on organosilicon compound as flexible SERS substrate. Firstly, an Ag island film was formed on a single-crystal Si (c-Si) substrate using chemical solution (AgNO3 + HF) (Figure 1, point 1). Secondly, the resulting sample was annealed in an atmosphere of H2O vapor at a temperature of 1000 ºC, after which the layer of SiO2 formed due to the oxidation of c-Si was removed (Figure 1, point 2). As a result, "endotaxial" inverted AgNPs in a c-Si matrix were obtained [3]. Thirdly, the resulting sample was covered with a layer of organosilicon compound, and then annealed at a temperature of 150 ºC for its complete polymerization (Figure 1, point 3). Finally, organosilicon compound with AgNPs were lift-off from c-Si substrate. The average sizes of the AgNPs bases are 223 ± 106 nm and aspect ratio of size to height are 1.76 ± 0.34 nm according to scanning electron microscopy. Simulation results in COMSOL Multiphysics software showed that "hot spots" were detected at the corners of the base and at the top of the AgNPs. The dependence of the localized surface plasmon resonance spectral positions on the geometry of the structure was numerically determined using Ansys Lumerical software, which are consistent with the experimental data. SERS showed reliable detection of triphenylmethane dyes at concentration of 10−10 M (crystal violet, brilliant green, bromothymol blue) with the enhanced factor □ 106 and the relative standard deviation of signal □ 10 %.

This work was supported by the Russian Science Foundation (Project 24-22-00334).

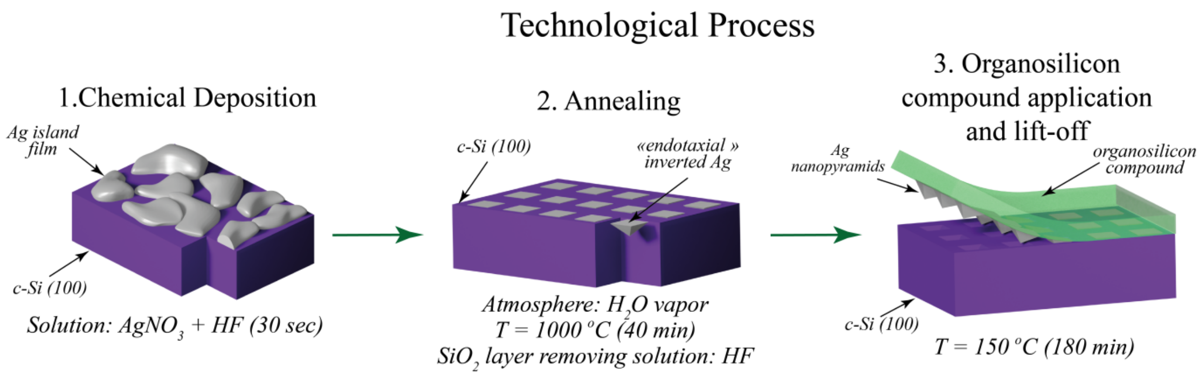

Figure 1. Schematic representation of the experimental process

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Experimental limits for subpixel movement detection

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Abstract

In recent years, various methods have emerged for detecting movements or deformations in objects using digital cameras and image processing to achieve subpixel precision. In the literature, we find theoretical studies suggesting that the increase in resolution with these techniques is virtually infinite, while in practice, we find few applications that go beyond the hundredth of a pixel. Therefore, it is worth asking whether there are practical limits to subpixel resolution and if it is possible to exceed such limits.

In a digital camera, movement will only be detected when the transfer of energy from one pixel to an adjacent one exceeds a minimum threshold determined by the camera's dynamic range. By proposing models of Gaussian and rectangular impulse responses, we have found that the maximum achievable resolution is on the order of 1/NL, where NL is the number of gray levels of the camera. Thus, for an 8-bit camera, the experimental subpixel detection limit will be 0.004 pixels.

To prove this limitation both numerical simulations and an experimental implementation at different dynamic ranges. Results agree with our hypothesis, showing that the standard deviation of the location error of a moving target is of the order of 1/NL.

Quadruplets of photonic resonances in non-Hermitian dielectric objects

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Abstract
In our world, most phenomena are described by non-Hermitian physics, which gave us bound states in continuum (BICs) with a giant quality factor [1], paired exceptional points (EPs) [2] and bulk Fermi arcs (FAs) connecting them [2,3]. The main result of this work is the discovery of a new effect: the detection of two EPs connected by FA in a single dielectric resonator.
We previously established that when the geometric parameters of a ring resonator with a rectangular cross-section change, the radial and axial modes have different spectral shifts, forming anti-crossing regions in which a single BIC was observed [4].
In this work, we report the discovery of EPs in single dielectric ring arising from interaction of radial and azimuthal modes, which depend differently on the height of the ring. Continuing the study of scattering spectra for a very narrow ring, we moved on to the space of three parameters, such as height (h), internal (Rin) and external (Rout) radii. Riemann surfaces were calculated for the eigenvalues and eigenfunctions of the two interacting modes TE012 and TE020 (Fig. 1). Three-dimensional representation made it possible to detect two EPs in which both eigenvalues and eigenfunctions coincide. The calculation showed that EPs are connected by bulk FA (a continuous set of parameters and) along which the frequencies of the two modes coincide, while the half-widths vary. Note that bulk FAs should be distinguished from surface FAs, which connects Weyl points [2].
As a result of analytical and numerical calculations, it was found that each EPs is adjacent to BICs, and the corresponding contours in the scattering spectra overlap. Thus, we report a new stable "cluster" of singular points in non-Hermitian systems, such as the 2EPs + 2BICs quadruplet. We discovered two quadruplet in narrow dielectric rings, and the calculations were carried out by three independent methods (COMSOL + QNM, TCMT, RSE), which guarantees the validity of our results and conclusions.
This work was supported by the Russian Science Foundation (Project 23-12-00114).

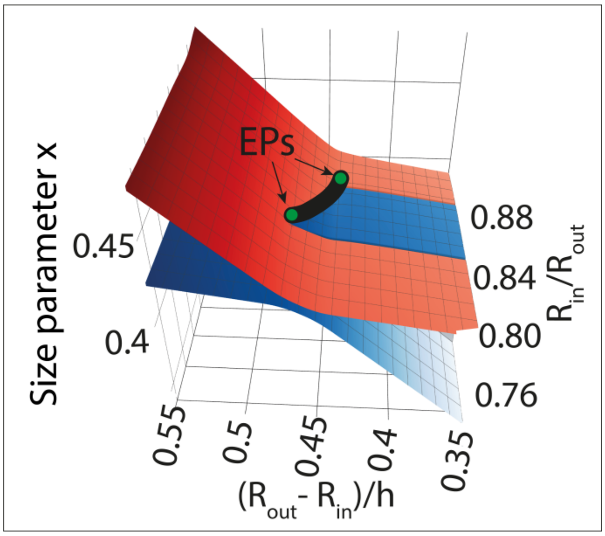

Figure 1. Three-dimensional representation of the eigenvalues of the TE_{012} and TE_{020} modes with a singularity in two *EPs* (green dots) in parameter space $(R_{out} - R_{in})/h$ and R_{in}/R_{out}. Two *EPs* are connected by a *FA* (black line). Dimensional parameter: $x = k(R_{out} - R_{in})$.

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