THE HONG KONG POLYTECHNIC UNIVERSITY
香港理工大學

Organiser: PolyU Academy for Interdisciplinary Research 香港理工大學高等研究院

PAIR CONFERENCE 2023 理大高等研究院大會

PHOTONICS RESEARCH INSTITUTE 光子技術研究院

PAIR Conference 2023

Research Excellence For Societal Impacts

Photonics Research Institute (PRI)

Conference Program & Abstracts

11 MAY 2023

Venue: PolyU Campus
Oral Session - HJ304
Poster Session - HJ202

Rundown

(11 May 2023)

Time	Speakers	Topic	Session Chair	Venue
09:00 - 09:50	**Prof. Luc Thévenaz (Keynote)** Professor, Head of the EPFL Group for Fibre Optics, Member of the Swiss Academy of Science	Light amplification and sensing in hollow core fibres	**Prof. Wei JIN**	**HJ304**
09:50 - 10:10	**Prof. Changyuan YU** Professor, Department of Electronic and Information Engineering, PolyU	Non-wearable non-invasive smart health monitoring system based on optical fiber interferometer with machine learning		
10:10 - 10:40	Coffee Break			
10:40 - 11:30	**Prof. Tarik Bourouina (Keynote)** Professor in Physics, Université Gustave Eiffel, France	Radiative properties of Black Silicon revisited in the Mid-infrared and applications	**Prof. Daniel LAU Shu Ping**	
11:30 - 11:50	**Dr Puxiang LAI** Associate Professor, Department of Biomedical Engineering, PolyU	High-resolution optical focusing, imaging, stimulation, and encryption with scattered light		
11:50 - 13:30	Lunch			
13:30 - 14:00	**Prof. Changrui LIAO (Invited)** Distinguished Professor in College of Physics and Optoelectronic Engineering, Shenzhen University	3D nanoprinted optical fiber sensors	**Prof. Changyuan YU**	
14:00 - 14:30	**Prof. Tuan GUO (Invited)** Professor and Director of the Lab for Photonics Sensing for Energy & Biology, Jinan University	Operando battery monitoring using lab-on-fibre optical sensing technologies		
14:30 - 14:50	**Prof. Alan LAU Pak Tao** Professor, Department of Electrical Engineering, PolyU	Dynamic and self-aware Optical Communications and Networks		
14:50 - 15:50	Laboratory Visit (meet up point HJ202, tour start at 15:00) / Break		**Dr Dongmei HUANG**	
15:50 - 17:30	Poster Session		**Dr Puxiang LAI**	**HJ202**
17:30 - 18:30	Closing Ceremony		/	**V322**

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About the PAIR Conference

The PolyU Academy for Interdisciplinary Research (PAIR) is a central research platform at PolyU dedicated to providing world-leading interdisciplinary solutions to significant societal challenges. The PAIR Conference 2023, themed on "Research Excellence for Societal Impacts", is the Academy's debut flagship event.

The Conference is the first and the largest event in Hong Kong higher education dedicated to professional knowledge exchange on interdisciplinary research and development. It provides a platform to showcase the state-of-art research and technologies developed and led by PolyU as well as other universities, academic institutions, and research and technological development companies in Hong Kong and beyond; and to forge closer collaboration and professional exchange among stakeholders from various fields to build the capacities in science, technology, innovation and research for the positive growth of Hong Kong and beyond.

Keynote Presentation

Prof. Luc THÉVENAZ

- **Professor, Head of the EPFL Group for Fibre Optics**
- **Member of the Swiss Academy of Science**

Topic: "Light amplification and sensing in hollow core fibres"

Abstract

Hollow core fibres are foreseen to be a breaking progress in the transmission of an optical signal by massively reducing the interaction between light and matter and the associated limitations, such as loss, dispersion and nonlinearities. As a direct consequence this absence of interaction also limits the possibilities to process and to impact on a light wave. A solution is to use efficient light interactions in a fluid medium like gases or liquids and this may strikingly outperform interaction strength as observed in solids. Record optical amplification is obtained, paving the way to a novel class of devices, and original sensing concepts are devised and demonstrated.

Biography

Luc Thévenaz received the M.Sc. degree and the Ph.D. degree in physics from the University of Geneva, Switzerland. In 1988 he joined the Swiss Federal Institute of Technology of Lausanne (EPFL) where he currently leads a research group involved in photonics, namely fibre optics and optical sensing. Research topics include fibre sensors, slow & fast light, nonlinear fibre optics and laser spectroscopy in gases. His expertise covers all applications of stimulated Brillouin scattering in optical fibres and he is known for his innovative concepts related to distributed fibre sensing pushing beyond barriers.

During his career he joined Stanford University as a postdoctoral researcher, and later stayed at the Korea Advanced Institute of Science and Technology (KAIST), at Tel Aviv University, at the University of Sydney and at the Polytechnic University of Valencia. In 2000 he co-founded the company Omnisens that is developing and commercializing advanced photonic instrumentation based on distributed fibre sensing.

He is member of the Steering Committee of the International Conference on Optical Fibre Sensors and General Chairman of this conference in 2018. He has served in the Technical Committee of several conferences, such as ECOC, CLEO-Europe, APC, etc… and has been Associate Editor of Photonics Technology Letters and the Journal of Lightwave Technology. He is now co-Executive Editor-in-Chief of the journal Nature Light: Science & Applications and is Fellow of the IEEE and OPTICA (OSA), as well as Member of the Swiss Academy of Science.

Oral Presentation

Prof. Changyuan YU

- **Professor, Department of Electronic and Information Engineering, The Hong Kong Polytechnic University**
- **Optica Fellow**

Topic: "Non-wearable non-invasive smart health monitoring system based on optical fiber interferometer with machine learning"

Abstract

With the population ageing globally, "elderly health and care" becomes a critical issue in Hong Kong and worldwide. Vital signs (including breath and heartbeat) monitoring is a key tool in elderly healthcare. Current monitors need invasive electronic sensors attached to user's body, which is inconvenient and uncomfortable for elderly. We review our research on smart health monitoring system based on optical fiber interferometer with machine learning. Users simply lie/sleep on a sensor mat embedded with optical fiber interferometer. Breath and heartbeat will introduce slight strain changes on the mat and affect the light propagating within the fiber. Breathing and heartbeat waveforms can be achieved by analyzing the output light with machine learning. The system can collect user's signals continuously and remotely to provide big data for health analysis. It helps to provide good care of the users (especially elderly) in hospitals, nursing homes, and their own homes. Our technique is non-invasive, highly sensitive, and immune to electromagnetic interference.

Biography

Prof. Changyuan YU received his Ph.D. in Electrical Engineering from the Univ. of Southern California, USA in 2005. He was a visiting researcher at NEC Labs America in Princeton, USA in 2005.He then joined National Univ. of Singapore (NUS) in 12/2005, where he served as the founding leader of Photonic System Research Group in Dept. of Electrical and Computer Engineering till 12/2015. He was also a joint senior scientist with A*STAR Institute for Infocomm Research (I2R) in this period. And he was a visiting professor with Univ. of Melbourne, Australia in 2007. In 12/2015, he joined The Hong Kong Polytechnic Univ., where he is now a full professor in Dept. of Electronic and Information Engineering, while he also continues as an adjunct faculty member of NUS. His research focuses on photonic devices, optical fiber communication and sensor systems, and biomedical instruments. He has been the PI/co-PI/co-I of 50+ research projects with 10 million+ US dollars fund, and supervised 20+ postdocs and 40+ PhD students.He has authored/co-authored 6 book chapters and 600+ journal/conference papers (100+ keynote/invited, including OFC in USA). He served in organizing or technical program committees for 100+ international conferences, and Telecommunications Standards Advisory Committee for Singapore government.His group won 10 best paper awards in conferences and National Championship in China Innovation and Entrepreneurship Competition in 2014. He is an Optica/OSA fellow.

Keynote Presentation

Prof. Tarik Bourouina

- **Professor in Physics, Université Gustave Eiffel, France**

Topic: "Radiative properties of Black Silicon revisited in the Mid-infrared and applications"

Abstract

Black Silicon (B-Si) is among the most popular nanostructured surfaces. Its name is due to its appearance to the bare eye, and it is known to absorb light mainly in the visible wavelength range, up to nearly 1.1 μm, owing to band-gap absorption combined with its particular morphology.

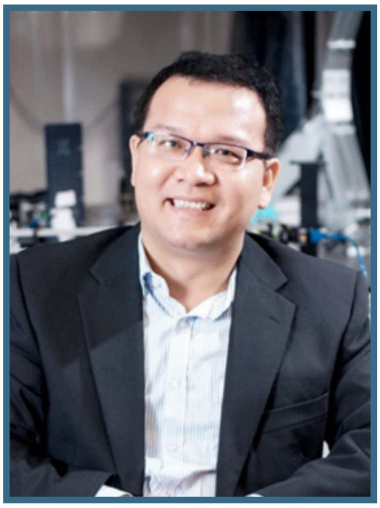
In this presentation, we revisit Black Silicon by investigating its properties in the wavelength range extending from 0.2 μm to 25 μm with a focus on the Mid-Infra-Red (MIR). We elucidate the synergetic effects of morphology and volume doping; and more specifically, how the high aspect-ratio of conical nanostructures plays a crucial role in extending and tailoring the spectral range over the mid-infrared. Unprecedented light absorptance levels are obtained with up to 99.5 % in the spectral range from 1 μm to 8 μm and above 90% until wavelength of 20 μm. The experimental findings are analyzed with supporting simulations.

Then, we explore applications dealing with the availability of fresh water resources taking advantage of the high absorptivity of Black Silicon, as well as its high emissivity, thanks to the Kirchhoff's law for thermal radiation. We will introduce opto-fluidic metasurfaces based on Black Silicon, specifically designed for harvesting water from air, thanks to a combination of their radiative cooling capabilities and tailored wetting properties. Another class of meta-surfaces based on Black Silicon are hierarchical 2D meta-foams, which were developed and specifically designed for optimal water desalination.

Biography

Prof. Tarik Bourouina has obtained his Ph.D. in 1991 and his Habilitation (HDR) in 2000 from Université Paris-Saclay. He has been Professor of Physics at ESIEE Paris, Université Gustave Eiffel since 2002. He is also affiliated to the French National Center for Scientific Research (CNRS), within the CINTRA laboratory IRL 3288 in Singapore jointly with Nanyang Technological University (NTU) and THALES, and within the ESYCOM laboratory UMR9007 in France. Before joining back ESIEE in 2002, Dr. Bourouina took several positions in France and in Japan; at Université Paris-Saclay (1995-1998) as Associate Professor in IEF Lab (CNRS UMR 8622), at the French National Center for Scientific Research (CNRS) and at The University of Tokyo (1998-2001) as Senior Researcher in LIMMS Lab (CNRS UMI 2820). He also used to serve as the Director of the ESIEE-NTU Singapore Dual-Degree Master of Engineering (2003-2006). In 2017, he was the recipient of the Chinese Academy of Sciences President's Fellowship. Prof. Bourouina has many contributions in the development of several companies launched by his former students and colleagues, which include Si-Ware Systems, Fluidion, Memscap, MEMS-Schlumberger and Izonics. Among his contributions to the international scientific community, Prof. Bourouina serves as an Editor in two journals of Nature Research: 'Light: Science and Applications' and 'Microsystems and Nanoengineering'. He also serves as Associate Editor in "Advanced Devices and Instrumentation" -a Science-Partner Journal. His current interest includes micro-scale photonic and fluidic devices and the related physics as well as their applications to sustainable development.

Oral Presentation



Dr. Puxiang LAI

- **Associate Professor, Department of Biomedical Engineering, The Hong Kong Polytechnic University**

Topic: "High-resolution optical focusing, imaging, stimulation, and encryption with scattered light"

Abstract

The usage of light has considerably reshaped the landscape of biomedicine in the past decades from imaging, sensing, treatment, stimulation, to control. The applications, however, are limited to superficial layers beneath sample surface or compromised resolution at depths due to the inherent nature of strong optical scattering in tissue. Many approaches have been proposed to tackle this challenge, such as switching to longer wavelengths to have lower tissue scattering coefficients, converting diffused light into not-so-scattered sound at the signal detection side, etc. In this talk, we will focus on wavefront shaping, a strategy of suppressing scattering by pre-compensating for the scattering-induced phase distortions. We will present the basics of working principle and our continuing endeavors in these directions, including the development of ultra-minimally invasive deep-brain neuron stimulation method and the exploiting of speckles arising from multiple scattering as a tool for information encryption that has an unprecedented digit key length. Challenges and roadmaps towards wide applications will also be briefed.

Biography

Dr. Puxiang Lai graduated with PhD from Boston University in 20211 and is currently an Associate Professor with Department of Biomedical Engineering and Photonics Research Institute, Hong Kong Polytechnic University. His research interests focus on deep-tissue optical focusing, imaging, stimulation, and treatment. Current research projects include, but are not limited to, wavefront shaping, photoacoustic imaging, computational optics, and artificial intelligence. His research has fueled more than 80 top journal publications, such as Nature Photonics, Nature Communications, Light: Science and Applications, PhotoniX, The Innovation, and Advanced Science. He has been invited to give more than 90 seminars or invited talks worldwide. Since 2015, his research has been continuously supported by National Natural Science Foundation of China (NSFC), Hong Kong Research Grant Council (RGC), Hong Kong Innovation and Technology Commission (ITC), Department of Science and Technology of Guangdong Province, and Shenzhen Science and Technology Innovation Commission (STIC). Dr. Lai was awarded the 2016-2017 Hong Kong RGC Early Career Award, the 2018 Hong Kong Polytechnic University Faculty of Engineering Research Grant Achievement Award, the 2019 PolyU K.C. Wong Belt and Road Visiting Fellowship Award, and the 2020 Hong Kong Polytechnic University Faculty of Engineering Faculty Research Award. As a recognition for his contribution to the field, currently Puxiang serves as Associate Editor or Editor for several premium journals like Advanced Photonics Nexus, The Innovation, Journal of Visual Computing for Industry, Biomedicine, and Art (VCIBA), Journal of Innovative Optics in Health and Science (JIOHS), and Medicine in Novel Technology and Devices (MEDNTD).

Invited Presentation

Prof. Changrui LIAO

- **Distinguished Professor in College of Physics and Optoelectronic Engineering, Shenzhen University**
- **Deputy Director of Guangdong and Hong Kong Joint Research Center for Optical Fiber Sensors**
- **Director of Shenzhen Key Laboratory of Ultrafast Laser Micro and Nano Manufacturing**

Topic: "3D nanoprinted optical fiber sensors"

Abstract

Material and structure of the optical fiber used for optical communication are relatively single and it cannot meet the increasing requirements of various optical fiber sensing applications. Optical fiber microstructured sensors combine the advantages of optical fiber and microstructure and it has become a hot research area in recent years. Femtosecond laser induced two-photon polymerization is a maskless and 3D nanoprinting method. In this presentation, I will introduce our recent research progress in 3D nanoprinted optical fiber sensors including MEMS and micro-optics. Femtosecond laser 3D nanoprinting method can significantly improve the performance of optical fiber sensors in both material and structure.

Biography

Changrui Liao is Distinguished professor in College of Physics and Optoelectronic Engineering at Shenzhen University and holds the position of Deputy Director of Guangdong and Hong Kong Joint Research Center for Optical Fiber Sensors and Director of Shenzhen Key Laboratory of Ultrafast Laser Micro and Nano Manufacturing. He received PhD degree from Hong Kong Polytechnic University in 2012 and then joined in Shenzhen University and successively served as lecturer, associate professor and distinguished professor. Prof. Liao's research interests lie in ultrafast laser 3D nanolithography and its application in optical fiber sensors, smart chip and new energy. He authored/co-authored 2 book chapters, >190 journal papers and >10 patents in the area of 3D nanolithography and optical fiber sensors. His works were cited >6000 times with an h-index of 44 (SCIE).

Invited Presentation

Prof. Tuan GUO

- **Professor and Director of the Lab for Photonics Sensing for Energy & Biology, Jinan University, China**

Topic: “Operando battery monitoring using lab-on-fibre optical sensing technologies”

Abstract

A crucial piece in renewable-energy power-management puzzle lies in the development of renewable energy storage devices such as lithium-ion batteries—poorly-understood degradation mechanisms that occur upon repeated cycling, and that increase the risk of catastrophic battery failure. To develop the next-generation of safe, high-capacity renewable-energy storage, it is therefore crucial to develop methods that monitor the battery’s physical and chemical state-of-health and operation in real-time. Right now, battery assessing methods are typically offline and simulation based. This talk will review the recent developments of in situ fibre-optic analytical technique that will enable us to monitor the state of health of batteries continuously during operation and to minimize their degradation. This method fills a very important gap in current battery monitoring methods, will guide the design of new materials, and will optimize existing and new electro-chemistries.

Biography

Tuan Guo is a full professor and director of the Lab for Photonics Sensing for Energy & Biology at Jinan University in China. He has authored more than 230 papers in reputational photonics and energy journals, including Nature Communications, Light: Science & Applications, Advances in Optics and Photonics, Energy & Environmental Science and 4 book chapters. He presented over 50 invited talks at international conferences and holds 26 patents in China and USA. He is the Chair of the IEEE I&M Technical Committee “Photonic Technology in Instrumentation and Measurement”, a Senior Member of IEEE and a Senior Member of OPTICA. He was awarded the “Distinguished Young Scientist Award” by the National Natural Science Foundation of China in 2018. Dr. Guo was a recipient of the “2018 Technical Award of the IEEE Instrumentation and Measurement Society” and “2022 Best Application Award of the IEEE Instrumentation and Measurement Society” for outstanding contributions to Energy and Health monitoring technologies.

Oral Presentation

Prof. Pak Tao LAU, Alan

- **Professor, Department of Electrical Engineering, The Hong Kong Polytechnic University**

Topic: "Dynamic and self-aware Optical Communications and Networks "

Abstract

Future optical communications and networks needs to be high speed, flexible, dynamic that can cater for applications ranging from 6G wireless, AI, metaverse just to name a few. We will review the technical challenges and key advances in recent years to enable such telecomm. Infrastructure of the future

Biography

Alan Pak Tao Lau received the B.A.Sc. degree in engineering science (electrical option) and the M.A.Sc. degree in electrical and computer engineering from the University of Toronto, Toronto, ON, Canada, in 2003 and 2004, respectively, and the Ph.D. degree in electrical engineering from Stanford University, Stanford, CA, USA, in 2008. He then joined The Hong Kong Polytechnic University as an Assistant Professor and he is currently a Professor. His current research interests include digital signal processing and machine learning techniques for various aspects of optical communication systems and networks, optical performance monitoring as well as optical fiber sensing. He collaborates extensively with Industry and serves as invited/tutorial speaker, organizing committee chair and associate editor for Optical Fiber Communication (OFC), Journal of Lightwave Technology(JLT) among others.

Ultrafast Spectroscopy: Unravelling Design Rules for Simple yet Highly-Efficient Organic Solar Cells

Top Archie Dela Peña,[1,3]* Mingjie Li,[1#] Gang Li,[2#] Jiaying Wu,[3#] Ruijie Ma,[2#] et al.

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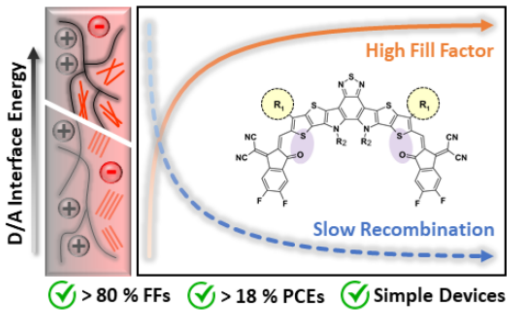
Abstract

Energy sustainability is of vital importance for continuous technological and economic developments, not only in China but also throughout the globe. Accordingly, organic solar cells (OSCs) have received significant research attention for solar energy harvesting applications. OSCs typically consist of polymer donors and small molecule acceptors, attributing several advantages such as solution-processability, low-cost, lightweight, and low carbon footprint.



To date, OSCs with power conversion efficiencies (*PCEs*) > 18% are already attainable on a lab scale. However, such state-of-the-art performances typically come with increasing fabrication complexities that undermine commercial scalability and manufacturing costs. In this work, acceptors with variable outer side chains and fs-transient absorption spectroscopy (fs-TAS) are used to understand the mechanisms and correlations between charge generation, charge recombination, and device performance. It was found that the presence of bulkier side groups increases the donor-acceptor interface disorder, elevating their transport energy levels that prompt stronger resistance to free-charge recombination which facilitates high fill factors (*FFs*). Meanwhile, the reduction of acceptor domain size is identified as necessary to preserve efficient charge generation. Through this framework, *PCEs* > 18% are revealed to remain accessible even with simple binary component devices. Hence, aside from tuning the intrinsic optical and electronic properties of organic precursors, their synthetic flexibility should also be taken advantage of to simultaneously regulate the donor-acceptor interface characteristics. These are believed to be pivotal guidelines fostering future optimizations toward more cost-effective strategies promoting OSCs marketplace realizations.

Photocatalytic Regeneration of Nicotinamide Cofactor in a Microfluidic Reactor

Fengjia Xie[1,2], Yujiao Zhu[1,2,3], Chi Chung Tsoi[1,2], Huaping Jia[1,2], and Xuming Zhang[1,2 *]

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[2]*Photonics Research Institute, The Hong Kong Polytechnic University, Hong Kong, China*
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Abstract
The provision of an adequate food supply is a matter of paramount importance to human society, yet the production of food continues to lag behind the escalating demand. Artificial photosynthesis is proposed as an alternative route to capture CO_2 to produce additional food. Learning from natural photosynthesis, we develop a microfluidic reactor for photocatalytic nicotinamide adenine dinucleotide (NADH) regeneration, an essential cofactor in the Calvin cycle of photosynthesis. The microfluidic reactor, coated with graphite carbon nitride using a facile immobilization method, offers several benefits, including fast diffusion, optimized photon utilization, low photocatalyst demand and enhanced reaction rate. The yield of the microfluidic reactor is measured to be 6.74 mmol h^{-1} g^{-1}, 13.48 times higher than that in the slurry reactor. These findings demonstrate the potential of microfluidic reactors in enhancing the efficiency of photosynthesis process. This technology can contribute to sustainable food production and the promotion of environmentally friendly practices. The results of this study highlight the importance of exploring novel methods for improving the efficiency of photosynthesis, in order to address the challenges posed by global food security.

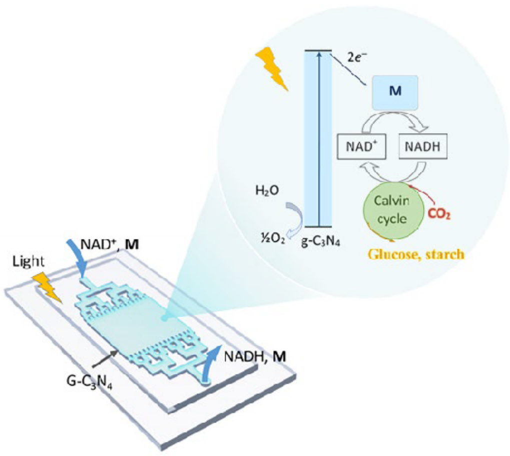

Figure 1. Schematic of photocatalytic NADH regeneration using a microfluidic reactor.

Acknowledgment:
This work was supported by the Research Grants Council (RGC) of Hong Kong (15221919, 15215620, N_PolyU511/20, and PDFS2021-2S02) and The Hong Kong Polytechnic University (1-CD4V, G-SB4J, 1-YY5V, and 1-CD6U). The Materials Research Centre (MRC), the University Research Facility in Material Characterization and Device Fabrication (UMF) and the University Research Facility in Life Sciences (ULS) of The Hong Kong Polytechnic University are acknowledged.

2-µm ultrafast fiber laser system with wavelength tunability, high pulse repetition rate, and high laser power

Jingcheng Shang[1,2], Dongmei Huang[1*], Tianli Feng[2*], and P. A. K. Wai[1,3]

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[2]*China Key Laboratory of Laser & Infrared System (Shandong University), Ministry of Education, Shandong University, Qingdao 266237, China*

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Abstract

In this study, we initially realize the nonlinear polarization rotation (NPR)-based mode-locking fiber oscillator, in which the gain management is performed by using the reabsorption effect of the Thulium (Tm)-doped gain fiber and the NPR-induced transmission modulation. The mode-locking wavelength can be tuned from 1949 nm to 2020 nm with the pulse duration about 460 fs (Fig. 1(A)). Besides that, enhancing the pump power enables the pulse repetition rate to increase from ~100 MHz to ~1 GHz. Then, the chirped pulse amplifier (CPA) is designed to further scale up the pulse energy of the seed pulsed laser (Fig. 1(B)). A homemade spatially wavelength filter is employed to optimize the CPA. After amplification, the average power of the 2-µm, ~100-MHz ultrafast laser pulse reaches to >7 W with the shortest pulse duration of ~200 fs. For further shortening the amplified 2-µm ultrafast laser pulse to few cycle optical oscillation, an all-fiber post nonlinear pulse compressor is firstly designed, in which the cascaded normal dispersion fibers are introduced (Fig. 1(C)). The 450-fs, 2.14-W driving laser pulse is finally compressed to 35.1 fs. The average power is large than 1 W, which breaks the record of the reported 2-µm, ~100-MHz fiber nonlinear pulse compressors. The designed the 2-µm ultrafast laser system with wavelength tunability, high repetition rate (>100 MHz), and high power can meet the demands of remote sensing, material processing, and laser communications *et. al* (Fig. 1(D)). Importantly, this 2-µm ultrafast laser system is being utilized to drive the ultrafast mid-IR optical parametric oscillator, which extends the ultrafast laser wavelength to 8-10 µm.

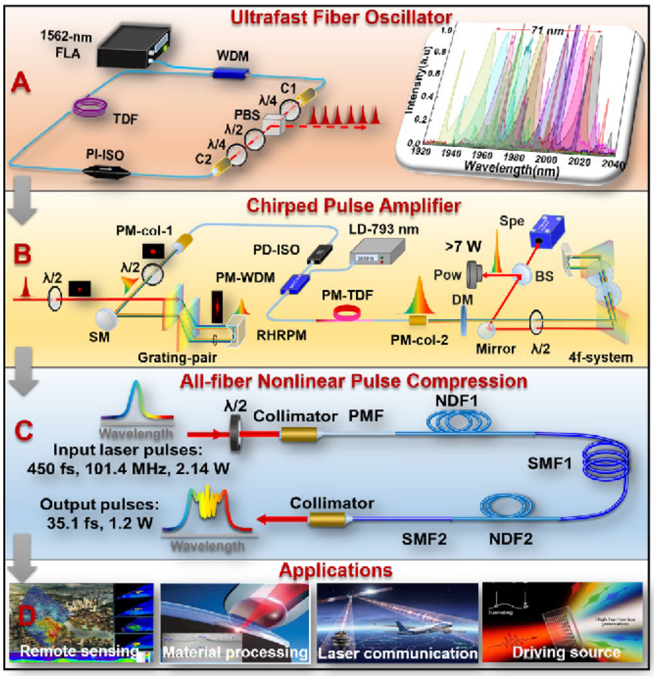

Figure 1. Experimental setup of the realized 2-µm ultrafast laser system with wavelength tunability, high pulse repetition rate, and high laser power.

Poster Presentation

Dual-comb generation in coupled nonlinear microcavities by tuning the coupling

Zihao Cheng[1,2], Dongmei Huang[2,3,*], and P. K. A. Wai[1,2,4]
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3 Photonics Research Centre, Department of Electrical Engineering, The Hong Kong Polytechnic University, Hong Kong
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Abstract

Dual-comb systems can be used in various fields like dual-comb spectroscopy and ultrafast optical ranging. Here, we propose a new dual-comb generation scheme based on coupled nonlinear microcavities with a single pump. Fig. 1(a) shows the schematic of the coupled microcavities structure under consideration. The main ring is pumped by a single frequency cw laser with an amplitude F through the lower straight waveguide. θ is the coupling coefficient between the microcavities and the waveguides, and θ_c is the coupling coefficient between the two microcavities. The bistability region is crucial for soliton comb generation and the bistability regions under different θ_c are shown in Fig. 1(b). In coupled nonlinear microcavities, the bistability regions are different from that in a single microcavity in two aspects. Firstly, the bistability region in the coupled microcavities can exist in the blue-detuned side, whereas the bistability region in a single microcavity only exists in the red-detuned side. Secondly, the location of the bistability region in the coupled nonlinear microcavities is red shifted when the coupling coefficient between the two microcavities increases. Thus, instead of tuning the pump laser, one can tune the coupling coefficient θ_c to move the bistability region to the frequency of the pump laser and generate soliton frequency combs in both the main cavity and the auxiliary cavity. We carried out numerical simulation to study the feasibility of this new comb generation scheme. The coupling coefficient θ_c is increased linearly from 0 to θ in the first 8000 roundtrips (around 35 ns) and fixed to θ in the next 8000 roundtrips. Fig. 1(c) shows the temporal profiles of the fields at the final (16,000-th) roundtrip in the two cavities. We note that the generated solitons locate at the same place relative to the time window and the soliton power in the auxiliary cavity is higher. Fig. 1(d) shows the corresponding spectral profiles. The spectrum of the soliton in the auxiliary cavity is a bit wider than that in the main cavity.

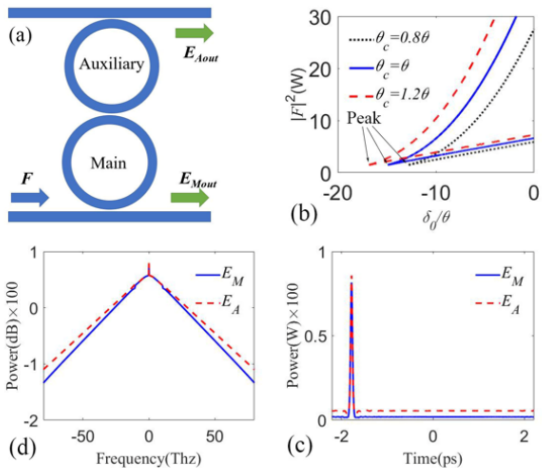

Figure 1. (a) Schematic of a coupled microcavities. (b) Bistability regions in coupled nonlinear microcavities with θc = 0.8θ, θ and 1.2θ, where θc is the coupling coefficient between the cavities, θ is the coupling coefficient between the cavities and the waveguides, δ0 is the detuning of the pump laser, and |F|2 is the pump power. (c) Temporal and (d) spectral profiles of the fields inside the main and auxiliary cavity at the 16000-th roundtrip.

Poster Presentation

E-band Fourier domain mode locked laser and its application in optical coherence tomography

Yihuan Shi[1,2], Dongmei Huang[1,2] and P. K. A. Wai[2,3,4]

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[4]Department of Physics, Hong Kong Baptist University, Hong Kong

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Abstract

The Fourier domain mode locked (FDML) laser finds applications in fiber Bragg grating (FBG) interrogation and optical coherence tomography (OCT) systems. The center wavelength of FDML laser is important in many applications. The C-band (1530–1565 nm) FDML laser is often used in FGB interrogation systems because of the availability of components at low cost. Swept sources with central wavelengths at 1300, 1060, or 800 nm are also used in OCT systems owing to the low water absorption loss at these wavelengths. FDML lasers at the E-band however have not yet been demonstrated. The E-band refers to the optical band between 1360 and 1460 nm. The E-band offers a superior near-infrared biological imaging window because it has a lower scattering coefficient optical fiber loss at the E-band is also low.

In this work, we demonstrate for the first time an E-band FDML laser and its application in a swept-source OCT system. The E-band FDML laser has a large sweep range by engineering the zero dispersion point of the long fiber delay to locate inside the E band, which is achieved by combining non-zero dispersion shifting fibers and single-mode fibers. Fig. 1(a) shows that the center wavelength of the FDML laser is 1440 nm and the sweep range is 90 nm. The sweep-rate is 50.748 kHz corresponding to a time period of 19.7 μs as shown in Fig.1(b). The E-band FDML laser is then used as the swept source of an OCT system. The swept source OCT system is then used to image human skin in vivo as shown in Fig. 1(c). Fig. 1(c) shows that the boundary between the stratum granulosum and the stratum corneum layer can be clearly distinguished and the thickness of the stratum corneum layer is about 200 μm.

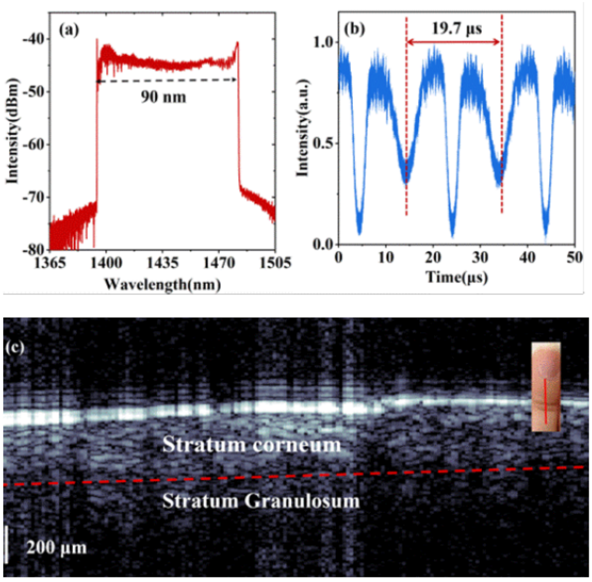

Figure 1. The (a) optical spectrum and (b) temporal waveform of the E-band FDML laser. (c) The OCT image of a human finger in vivo. Inset: a picture of the finger being imaged.

Edge-Orientation Dependent Nanoimaging of Mid-Infrared Waveguide Modes in High-Index $PtSe_2$

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Abstract

All-dielectric nanophotonics is a rapidly developing field that employs high-index low-loss dielectric materials to boost light–matter interactions at the nanoscale. This is owing to their potential in achieving low-loss optical responses and the coexistence of strong enhancement of electric and magnetic fields, which are absent in their plasmonic counterparts. Transition-metal dichalcogenides (TMDCs) have been utilized for high-index dielectric Mie nanoresonators in the visible to near-infrared spectral range due to their high in-plane and out-of-plane optical anisotropy, excitonic effect, and high-index properties. However, high-index materials for mid-infrared (MIR) nanophotonics are still highly sought after. Here, it is shown that PtSe2, a group-10 TMDC, could support dielectric waveguide modes in MIR despite its semimetallic nature. It is revealed that $PtSe_2$ optically acts as a dielectric material with a high refractive index of ≈ 5 and a low extinction coefficient in the MIR region. The value is among the highest in the low-loss TMDCs and mainstream dielectric materials. A comprehensive sample-edge-orientation dependent nanoimaging together with spectroscopic nanoimaging characterization of the $PtSe_2$ allows the extraction of the dispersion relations of the modes, from which the velocity parameters could be determined. This work paves the way for high-performance MIR devices via high-index $PtSe_2$-based nanostructures.

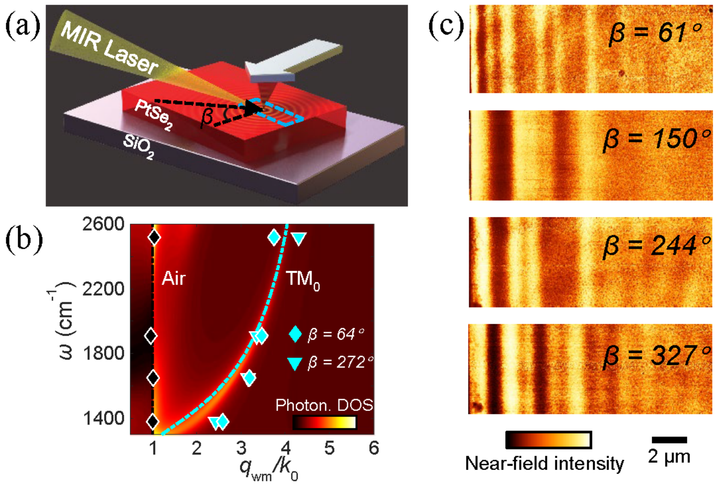

Figure 1. (a) Schematic diagrams of near-field imaging on a $PtSe_2$ sample. (b) Experimental dispersion data points and theoretical dispersion curves of the TE- and TM-polarized waveguide modes. (c) Sample-edge-orientation dependence of the waveguide-mode induced fringe patterns.

Enhancing Efficiency of Quasi-2D Perovskite Light-Emitting Diodes through Anti-Solvent Treatment-Induced Phases Modulation

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Abstract

Quasi-2D perovskite has drawn considerable attention for application in perovskite light-emitting diodes (PeLEDs) due to their higher exciton binding energy and moisture resistance. However, the inhomogeneous distribution of phases formed in spin-coated quasi-2D perovskite films inevitably leads to energy transfer loss. Here, the phases modulation behaviour is systematically investigated by introducing a series of anti-solvent with different polarity - namely, the toluene (TO), diethyl ether (DE), chlorobenzene (CB), anisole (AN), ethyl acetate (EA). The EA-treated perovskite films suppress significantly low-n phases due to strong hydrogen bonding between EA and organic spacer cations. As a result, an efficient energy cascade is ensured with a narrow distribution centred around the desired phases. Consequently, we achieve PeLEDs with improved external quantum efficiency (EQE) of 4.21%, 7.11%, and 8.77%, corresponding to ~490 nm, ~497 nm, and ~503 nm emissions, respectively. Furthermore, the anti-solvent treatment strategy provides a guide to regulate the phase distribution for efficient quasi-2D PeLEDs.

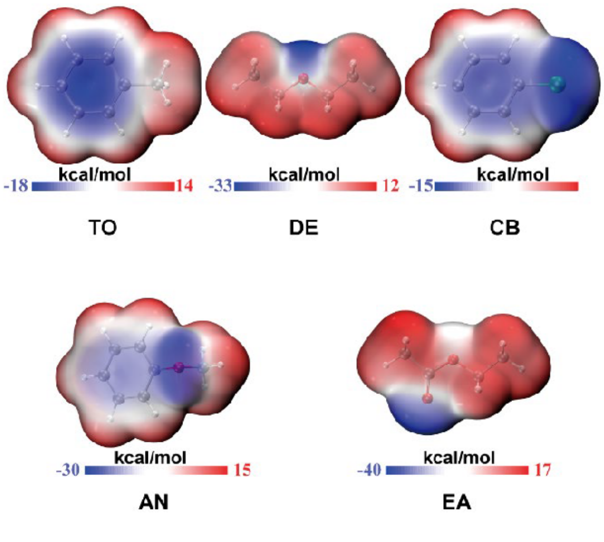

Figure 1. The electrostatic potential diagram of the different anti-solvents.

Poster Presentation

Optical fiber sensor-assisted cochlear implantation for hearing loss preservation

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Abstract

Hearing loss is a global health issue with a rapidly increasing prevalence rate. Cochlear implantation surgery is the only treatment available to restore hearing to patients suffering from severe hearing loss. Currently, cochlear implants (CIs) are considered the most widely used electronic neuromodulation implants with more than 800,000 recipients worldwide. However, the insertion process lacks visualization and force feedback of the intracochlear structure, necessitating the real-time assessment of the insertion force during surgical measurements.

Recently, the research interest of polymer optical fiber Bragg grating (POFBG) sensors in biomedical applications has increased significantly due to their advantages over silica fiber Bragg grating sensors, including low Young's modulus induced low stiffness levels, high flexibility, and high fracture toughness. The advent of POFBG sensors based on cycloolefin polymer, namely ZEONEX [1], is revolutionizing the biomedical sensing industry due to their low water affinity property, making them excellent candidates in aqueous surroundings such as cochlear implantation surgery.

The insertion force and localization characteristics of a ZEONEX-based POFBG sensor are investigated, with the integration of a CI which is suitable for surgical intervention [2]. Based on the force sensitivity characterization, the spectral responses of four POFBGs embedded in the CI during insertion are investigated. In addition, the insertion speed, as well as the approach of CI insertion, such as continuous and static methods are evaluated for the force assessment. Bent spectral analysis of POFBGs is performed through both simulations and experiments to determine the position of the CI at different insertion speeds. The analysis of force and location is crucial for surgical navigation and paves the way for atraumatic CI insertion.

[1] X. Cheng, D. S. Gunawardena, C. F. J. Pun, J. Bonefacino and H.-Y. Tam, Optics Express, 28, 33573 (2020).

[2] D. S. Gunawardena, J. Cui, X. Cheng, A. N Vadivelu, A. Mohammadi, G. Edbert, Z. Liu, B. Chen, D. Oetomo, S. O'Leary and H.-Y. Tam, Biosensors and Bioelectronics, 222, 114866 (2023).

Photocatalytic Ozonation for Seawater Decontamination

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Abstract

Seawater is used in Hong Kong and many other places to clear the road surface and flush toilets, causing massive amounts of polluted sea water. Sadly, the traditional biochemical treatment techniques, which are very effective for treating fresh effluent, are ineffective for cleaning up tainted seawater. This research aims to investigate photocatalytic ozonation for seawater purification. We use P25 TiO_2 as the photocatalyst to break down the model chemical methylene blue. In the setup (Figure 1), the ozone generator converts pure O_2 from a gas canister into O_3, which is then diluted by air and pushed into the reactor. Mechanism studies and experimental comparisons show that (1) the photocatalysis, the ozonation and the photocatalytic ozonation (PCO) all have lower efficiencies in seawater than that in fresh water; (2) the PCO is always more efficient than only the photocatalysis or only the ozonation; (3) the PCO has a reaction rate constant about 23 times higher than only the ozonation; (4) the seawater shows a positive synergistic effect of photocatalysis and ozonation and reaches the maximum when the pumping gas has an ozone concentration of 50 ppm in gas. It is found that the dissolved ozone can enhance and stabilize the photocurrent by rapidly scavenging the photoelectrons. This work may pave the way to practical applications of sea water decontamination with high efficiency and low cost.

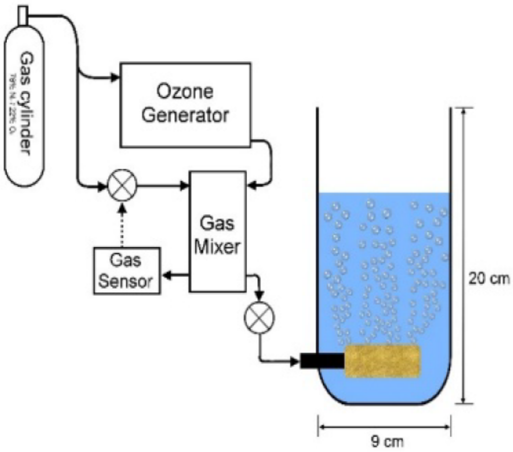

Figure 1. Schematic of experimental setup.

Acknowledgment:
This work was supported by the Research Grants Council (RGC) of Hong Kong (15221919, 15215620, N_PolyU511/20) and The Hong Kong Polytechnic University (1-CD4V, G-SB4J, 1-YY5V, and 1-CD6U). The Materials Research Centre (MRC), the University Research Facility in Material Characterization and Device Fabrication (UMF) and the University Research Facility in Life Sciences (ULS) of The Hong Kong Polytechnic University are acknowledged.

Poster Presentation

Learn from butterfly's eyes

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Abstract

Arthropods, including butterflies, have developed a unique natural compound eye imaging system that differs significantly from the monocular eyes of vertebrates. The anatomical structure of this kind of compound eye includes a series of corneal microlenses located in the outermost layer, which serve to focus incoming light onto inner light guide structures. Nevertheless, it still remains a significant challenge to create artificial microlens arrays with the same number of lenses as those found in a butterfly's compound eye, within a limited curved surface. Here, our objective is to (1)observe butterflies' compound eyes with advanced technique, and (2)replicate the microlens array pattern found in the compound eye of butterflies in order to achieve array imaging. In the near future, this artificial microlens array will be integrated with light guides to form a full-vision camera inspired by optical superposition and neural superposition.

keywords: Compound eyes; Biomimetics; Microlens arrays; Full-vision camera

Poster Presentation

Chiral Halide Perovskite/SWNT Heterojunction for Circular Polarization Sensing

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Abstract

Circularly polarized light (CPL) has become a promising candidate for advanced next-generation photonic technologies, including circularly polarized photonic memory, quantum computing, optical communication, and information encryption. To this end, the development of miniature devices capable of identifying the handedness of CPL is crucial. However, current state-of-the-art devices for CPL detection require the installation of external polarizers, which results in low detection efficiency. Here, we present a novel approach to detect CPL directly using a two-terminal device with a heterojunction structure comprising a helical one-dimensional structured halide perovskite (PVK) and single-wall carbon nanotubes (SWNTs).. The device can distinguish different circular polarization states and exhibits high-performance photoresponsivity to 310 and 390 nm CPL. Moreover, the optimized heterojunction has improved conductivity, constructing the foundation for CPL-modulated behaviors. In application, the device showcases superior learning, recognition, and cognition abilities, which are essential for neuromorphic computing, and demonstrates the feasibility of the SWNT/PVK heterojunction as an artificial retina synapse to enhance visual contrast for improved optical communication. To shed light on the underlying mechanism, a hot electron transfer process between PVK and SWNT is proposed and successfully demonstrated by the transient absorption technology. The constructed SWNT/PVK heterojunction-based device shows significant promise for CPL stimulated real-time and energy-efficient visual perception, opening up new avenues for the development of next-generation photonic technologies.

Mid-infrared optical frequency comb generation based on MgF_2 crystalline resonators

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Abstract

Microresonator-based optical frequency combs are broadband light sources consisting of equally spaced and coherent narrow lines, which are extremely promising for applications in molecular spectroscopy and sensing in the mid-infrared (MIR) spectral region. The unique combination of MgF_2 material properties includes an excellent mechanical stability, small thermo-refractive constant, and ultra-wide transparency window from the ultraviolet to the MIR. Here, we demonstrate the broadband MIR frequency comb, based on four-wave mixing effect in a MgF_2 microdisk resonator with optimized dispersion. The temporal and spectral evolution dynamics of dual soliton formation in the MgF_2 resonator are analyzed in detail. This work proceeds microresonator-based comb technology towards a miniaturization MIR spectroscopic device that provides potential opportunities in many fields such as fundamental physics and metrology.

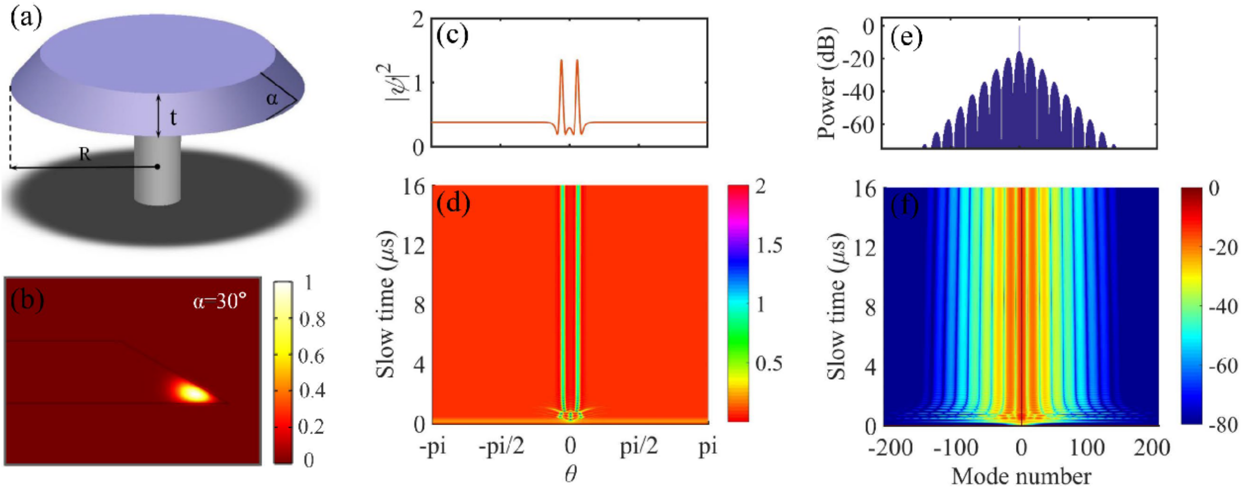

Figure 1. (a) Schematic of the MgF_2 crystalline microdisk resonator. (b) Electric filed magnitude profile for quasi TE mode with wedge angle of 30°. (c) Temporal waveform and (e) optical spectra corresponding to the dual-soliton states. (d) Temporal and (f) spectral envelope evolution plotted versus time.

Measurement of the attosecond-level timing jitter in the time stretched self-coherent detection system

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Abstract

Timing information between ultrafast pulses can be utilized to carry signals in applications such as optical ranging, optical-microwave networks, high precision 3-D morphological reconstruction. The speed and precision of such timing measurement are limited by the timing jitters and noise level of the laser pulses. High-speed attosecond-level timing jitter measurement in laser pulses is therefore required. The piezoelectric transducer (PZT) induces the timing jitter between two chirp pulses under test. The 2D evolution of the beating frequency signal (BFSs) driven by the sinusoid voltages with the Vpp values of 8 V, 6 V, and 2 V are shown in Figs. 1(a)-1(c), respectively, where the vibration amplitude of the pattern is decreased with the decrement of the voltage. The variation signal is obtained by calculating the phase change of the BFS. As shown in Figs. 1(d)-1(f), when the Vpp value decreases from 8 V to 2 V, the vibration amplitude of the timing jitter varies from 633.9 attoseconds to 159.3 attoseconds, indicating the approximately linear relationship between the amplitude of the vibrated timing jitter and the voltage. We input the experimentally retrieved vibration signal as the preset signal into the simulation. The obtained 2D evolution maps of the beating-frequency signal are almost the same as these experimental ones, and the retrieved vibrations in the simulation are also well matched with the experimental curves.

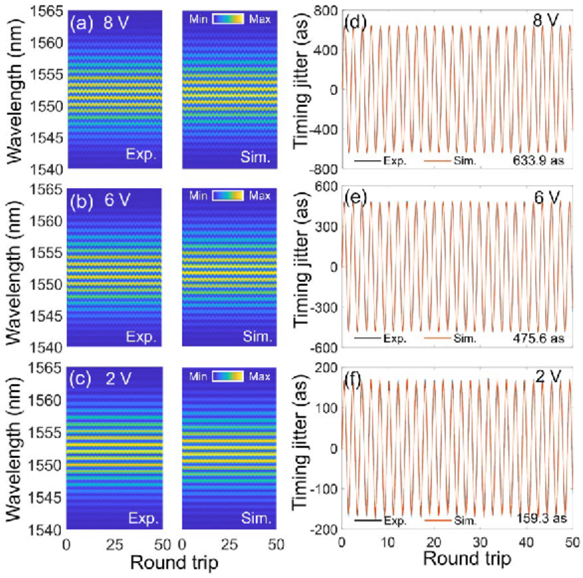

Figure 1. (a)-(c) Simulated and experimental 2D maps of the BFS evolution when the PZT is driven by the sinusoid voltages with peak-to-peak (Vpp) values of 8 V, 6 V, and 2 V; (d)-(f) timing jitter signals with different Vpp values on the PZT.

Poster Presentation

Tunable highly oscillatory optical resonances across visible light based on all-dielectric resonant metasurfaces

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Abstract

Metasurface provides an artificial platform for optical structure design in different application scenarios. According to Mie resonance theory, resonant metasurfaces based on dielectric optical antennas can greatly enhance the light-matter interaction strength, so as improve the quality factor (*Q*-factor) at the target wavelength. Here, we make a theoretical analysis of Mie resonance modulation covering the whole visible wavelength range with titanium dioxide (TiO_2) nanoantenna arrays. Symmetry-protected bound states in the continuum (BICs), which have infinite *Q*-factors at the Γ point, are discussed in detail. Benefiting from the nature of BIC, our symmetrical TiO_2-based nanoantenna array designs demonstrate >8000, >17000, and >25000 *Q*-factors for the blue, green, and red light, respectively. This work paves the way for the fundamental research of strong light-matter interaction mechanisms and provides a metasurface design strategy which has good application potential in light-emitting devices, like light-emitting diodes (LEDs) and lasers.

Poster Presentation

Fiber-optic Lead Ion Sensor using PCF based Modal Interferometer

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Abstract

Lead (Pb) ion is a well-known and dangerous heavy metal for its significant usage in industrial applications and consequences on human. A compact, reliable, and fast responsive PCF (photonic crystal fiber) based modal interferometric sensor for lead ion detection is proposed and experimentally demonstrated. The sensor has been fabricated by splicing a small section of PCF with SMF (single mode fiber) followed by collapsing of air holes of PCF at its tip. The interferometer is dip coated with chitosan-PVA (polyvinyl alcohol) and glutathione functionalized gold nanoparticles. The sensitivity response of the proposed sensor is recorded based on the shifting in the interference minima. Three probes have been fabricated, and the maximum sensitivity has been found to be 0.031 nm/ppb for lead ions whereas the detection range has been considered from 0 ppb to 50 ppb. The probe has been found to have a faster response time of ~10 s. Furthermore, the sensor has been found to be less responsive towards other heavy metal ions, thereby demonstrating its selectivity towards lead ions. Besides, a section of FBG (fiber Bragg grating) has been embedded into the interferometer and the temperature response of FBG peak along with interference spectra has been investigated for better accuracy.

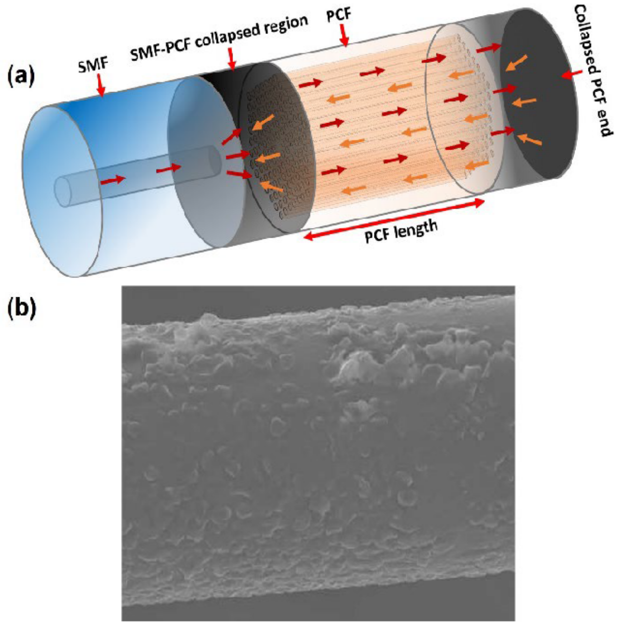

Figure 1. (a) Schematic of the fabricated SMF-PCF based interferometric sensor, (b) SEM images of the chitosan-PVA and GSH functionalized AuNPs coated probe.

Poster Presentation

Simultaneous Measurement of Axial Strain and Temperature Based on Twin-core Single-hole Fiber with Optical Vernier effect

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Abstract

An ultrasensitive optical fiber sensor based on the Vernier effect is proposed for simultaneous axial strain and temperature measurement. The sensor structure comprises two cascaded Mach-Zehnder interferometers (MZIs) with different free space ranges. The MZI is built up by fusion splicing a segment of ~3 mm Twin-core Single-hole fiber (TCSHF) between two pieces of ~5 mm None core fibers (NCF). The sensor can respond linearly to the axial strain change with a sensitivity of ~17 pm/με in the range of 0 to 2000 με and high-temperature sensitivity of ~1.16 nm/°C in the range from 30 to 70 °C. Moreover, the cascaded structure can simultaneously measure the axial strain and temperature change with acceptable error ranges. The proposed sensor has many other advantages, such as being easily fabricated, low cost, good robustness, etc. Thus, the designed sensor has great potential for many application fields. For example, extensive building health monitoring in engineering, vital sign detection in the medical field, etc.

2D Ternary Material as Saturable Absorber for NIR Mode-locked Laser

Sumaiya Umme Hani[12], Safayet Ahmed[12], Tawsif Ibne Alam[12], Ahmed Mortuza Saleque[12], Md. Nahian Al Subri Ivan[12], Ping Kwong Cheng[12] and Yuen Hong Tsang[12*]

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Abstract

With the commencement of Nano Age, seek for Low Dimension materials have taken great importance and that is where, 2D materials play imperative role in nanotechnology due to their fascinating properties. Intensive research works have been presented on various binary 2D material that has opened possible arena for ternary 2D materials which possess more firm and stable structure. Besides, ternary materials offer greater degrees of freedom as their bandgap can be tuned by altering the rate of two different atoms and thus various distinctive properties can be observed. GeSeTe is a chalcogenide glass with superior non-linear optical (NLO) response, therefore, it can be preferably used in many advanced photonics and optoelectronics devices such as ultrafast optical switching, Raman amplification, optical modulator, parametric amplifier to name some. Motivated by the potential growth of 2D ternary materials in the advanced photonics applications, for the very first time GeSeTe nanosheets are employed as Saturable absorber in this research work. Liquid phase exfoliation method was utilized for synthesizing GeSeTe nanosheets and followed by profound investigation was carried out to comprehend the morphology and chemical composition of the as prepared nanosheets. For instance, Figure 01 demonstrates the thickness of the prepared nanosheets which is less than 21nm; validating the ultra-thin feature of the prepared nanosheets. Afterwards, the GeSeTe nanosheets were incorporated into a side polished fiber and thereby, utilized as saturable absorber in Er-doped fiber laser cavity system. The obtained ultrashort pulse of 531fs with 7.83 MHz repetition rate and central wavelength at 1557.56 nm suggests commendable potential of GeSeTe in advanced photonics application.

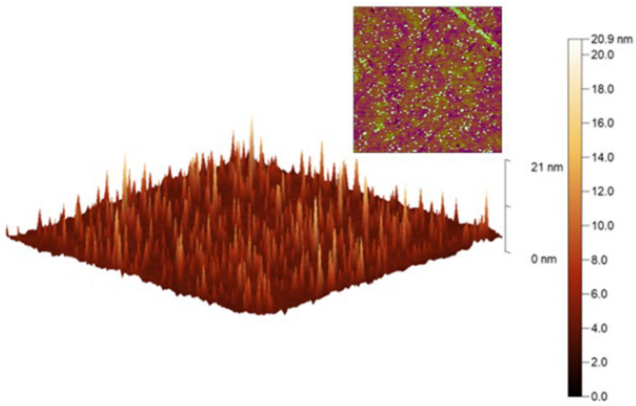

Figure 01: AFM image showing the height profile of the as prepared sample; inset is the lateral distribution of the sample.

Poster Presentation

Agricultural Waste Derived Self-Regenerating Solar Evaporator for Seawater Desalination

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Abstract
In recent years, interfacial solar steam generation (ISSG) technique is getting attention for seawater desalination due to its electricity independent nature. Instead of heating bulk water from the bottom of the reservoir, this technology utilizes a solar evaporator to concentrate solar energy at the site of evaporation (air-water interface) and hence have high water evaporation efficiency. However, one of the biggest challenges with this technology is the growth of salt on the top of solar absorbing surface during continuous seawater desalination. A solar evaporator has two main functions, i) absorbing sunlight and convert it to heat using the photothermal property of solar absorbing surface, ii) absorb water and transfer it to the top surface (where heat is localized) by its internal microchannels. The growth of salt crystals decreases solar absorption by reflecting light and blocks the internal microchannels of the solar evaporator that interrupts water transportation. Another challenge with ISSG technique is the cost of the solar evaporator. To solve these issues, a low cost, sustainable solar evaporator with self-regenerating capability is prepared by carbonising the top surface of alkali-treated Jute Stick (JS), an agricultural waste (produced nearly 4 million tonnes every year). The carbonised surface absorb sunlight and convert it to heat which facilitates water evaporation. JS has a natural hole of large diameter (ensure high water flux) surrounded by several microchannels with pits on the microchannels' walls. Therefore, water evaporation establishes a lateral salt gradient between the central hole and microchannels due to difference in water flux, that leads to lateral salt exchange through the pits of the microchannels walls and send the salt back to the bulk water using the central natural hole. Due to this salt diffusion mechanism, no salt was observed on the top of solar absorbing surface of the evaporator after 8.5 hours of seawater evaporation under 1sun with maximum evaporation rate and efficiency of 1.52 kg m^{-2} h^{-1} and 87.01%, respectively. The proposed evaporator also showed excellent wastewater purification capability and long-term stability.

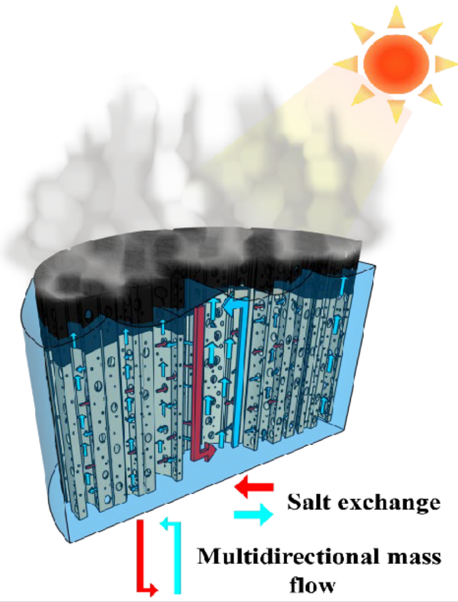

Figure 1. Interfacial solar steam generation and the mechanism of salt mitigation inside the proposed solar evaporator.

Plasmonic bound states in the continuum for unpolarized tightly focused light

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Abstract

Bound states in the continuum (BICs) are nonradiative states embedded in the spectra of the radiation continuum. The mechanism of BICs provides unprecedented opportunities to tailor light–matter interaction. On the other hand, focusing unpolarized light using an objective with a high numerical aperture (NA) is an important way to achieve optical field enhancement in the spatial domain. Therefore, using unpolarized tightly focused light to excite high quality-factor (Q-factor) quasi-BICs would be a promising approach to further enhance the light-matter interaction. However, excitation of high-Q quasi-BICs is often limited to collimated light at specific polarization and incident directions, rendering challenges for unpolarized focused light. The major hurdle is the lack of robustness against weak spatial coherence and poor polarization of incident light. To address these challenges, we designed a plasmonic metasurface having a deep subwavelength period. Arrays of silver–silicon–silver nano blocks on a silica spacer are employed to generate resonant modes that are insensitive to the wave-vector direction and polarization of incident light. Through simulations, the designed plasmonic metasurface is predicted to generate resonances with absorption amplitude greater than 90% and Q-factors up to 71 under the illumination of unpolarized light focused by an objective with the NA of 0.5 (elevation angle covers 0° to 30°). Our results open a new route to substantial electromagnetic field enhancement using unpolarized tightly focused light.

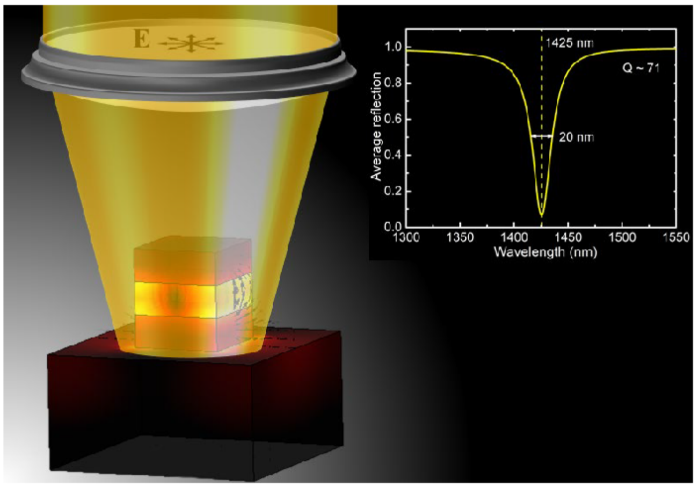

Figure 1. Schematic of the plasmonic metasurface illuminated by unpolarized focused light and the average reflection spectrum.

A Dual-wavelength Metasurface beam splitter

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Abstract

Metasurface, a manmade 2D material consisting of thousands of subwavelength nanostructures, has been well developed in the past decades. It shows excellent ability of manipulating the amplitude, phase and polarization of light, and is widely used in the applications of energy control, wavefront manipulation, and polarization detection. On the other hand, The technology breakthrough in erbium-doped fiber amplifiers (EDFAs) was the key component for SDM, which is widely studied among the scientific community to meet the growing demands for high-capacity communication systems, and an integrated, broadband and energy-efficient amplifier is highly desirable for the transmission system. There are several methods to couple pump light and signal light in an EDFA system, including wavelength division multiplexing coupler, free-space optical elements, cladding pump method and photonic lanterns. However, the complexity of these devices makes them difficult to fabricate. Here, we propose two 980/1550-nm metasurface-based beam splitters, which are fabrication-friendly and integrated. This metasurface could be applied to couple pump light and signal light in an EDFA.

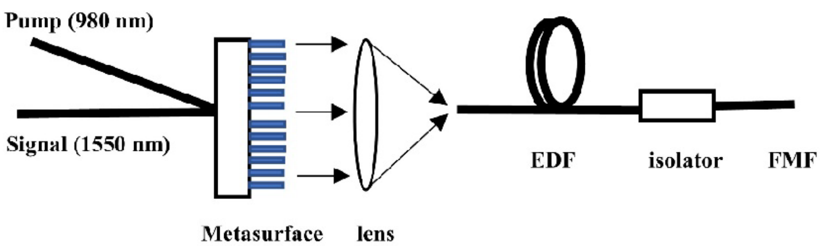

Figure 1 the schematic of an EDFA system combined with a metasurface

Near-Infrared Plasmonic Effect Induced Enhanced Water Splitting of MoS_2 Nanosheets

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Abstract

Photoelectrochemical (PEC) water splitting has been regarded as an effective approach for energy conversion by using two of the most abundant natural resources—sunlight and water on Earth, which offers an encouraging pathway for carbon neutrality. Among different two-dimensional (2D) materials, MoS_2 has attracted considerable research attention as a promising semiconductor photocatalyst because of its excellent catalytic activity, high chemical stability, eco-friendliness, and abundance in nature. Recently, the optical absorption of MoS_2 can be remarkably enhanced by employing plasmonic metal nanoparticles (NPs), and further enhanced PEC activity. However, conventional noble metals, such as Ag or Au, usually have strong resonance in the ultraviolet (UV) and visible light. Due to the large optical losses and high negative real-part permittivity, such metals are not optimal for plasmonic devices operating in the near-infrared (NIR) range. In recent research, the typical multilayer structure of ITO-Au-ITO (IAI) trilayer preserves the optical properties of the ITO, exhibits the obvious plasmonic effect in NIR region, and simultaneously possesses improved electrical properties by the insertion of the ultrathin metal layer. By combining with IAI trilayer, the optical absorption of the MoS_2/IAI over the entire solar spectrum has been greatly improved. This work provides a promising way for exploiting the full potential of MoS_2 for efficient PEC water splitting applications.

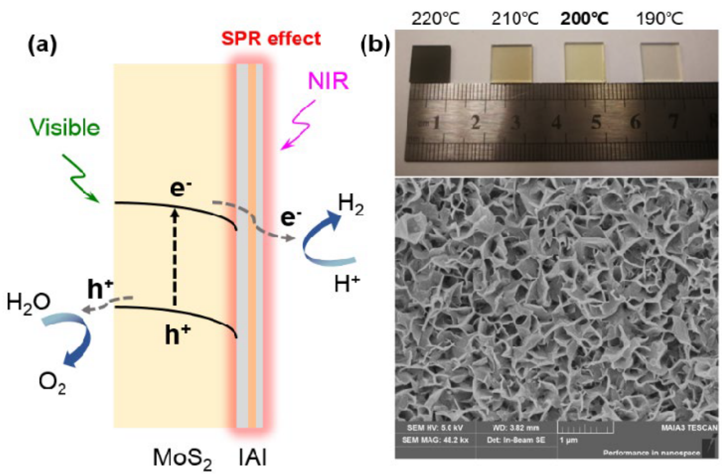

Figure 1. (a) The schematic diagram of MoS_2-IAI (ITO-Au-ITO) structure. (b) The image of MoS_2 samples on ITO substrate (upper), and the SEM image of MoS_2 film fabricated on 200℃ (lower).

Microstructured optical fiber-enhanced photothermal spectroscopy for trace gas detection

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Abstract

Detection of trace gases is critical for many practical applications, including environmental monitoring and medical diagnosis. Here, we report the use of microstructured optical fibers, namely hollow-core fiber (HCF) and microfiber (MF), for gas sensing via photothermal spectroscopy (PTS). HCF tightly confines both gas molecules and light in the central hollow-core over extended distances with low loss and provides a platform for efficient light-gas interaction. MF further enhances the light intensity and allows for enhanced heat accumulation around its air cladding. Both HCF and MF have achieved significantly higher photothermal efficiency compared to traditional free-space absorption cells. We report a novel technique named mode-phase-difference (MPD) PTS, which uses a pump-probe configuration and a two-mode HCF or MF to detect the differential photothermal phase modulation between the two guided modes. Simulation results show the MPD is sensitive to gas absorption but robust to external disturbances due to common-path noise cancelation, resulting in significantly enhanced signal-to-noise ratio and better stability. MPD-PTS gas sensors have demonstrated high sensitivity (parts-per-billion for MF and parts-per-trillion for HCF), good stability (< 2%), large dynamic range (>10^6) and rapid response (<50 s for HCF, <10 s for MF) in a lab environment, providing a solution to high quality gas detection.

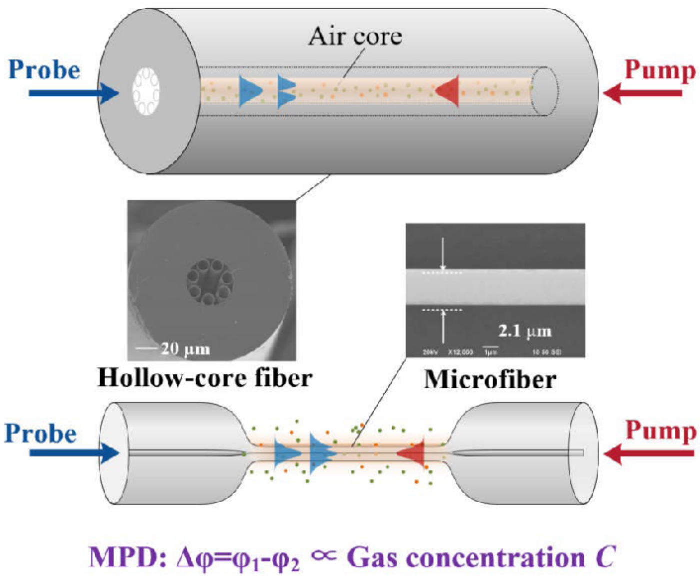

Figure 1. The basic principle of mode-phase-difference photothermal spectroscopy for gas detection.

Broadband hollow-core optical fiber phase modulators with low insertion loss and fast response

Linhao Guo[1,2*], Shoulin Jiang[2], Feifan Chen[1,2], Yan Zhao[1,2], Shuangxiang Zhao[1,2], Shoufei Gao[3], Yingying Wang[3], Hoi Lut Ho[1,2], Wei Jin[1,2]

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Abstract

Phase modulators (PMs) are key components in optical communication, sensing, and coherent beam combining. Here we report all-fiber optical PMs, which use a control beam to modulate the phase of a signal beam. Previously reported optical fiber PMs use two-dimensional (2D) materials deposited on the surface of micro-scale fibers, which have the disadvantages of complex and unreliable manufacturing process, high insertion loss (IL) and long response time. This study investigates a new type of all-fiber PM based on gas-filled hollow core fiber (HCF). As shown in the figure, absorptive gas inside the HCF absorbs the control beam to generate heat via photothermal (PT) effect, which modulates the temperature and refractive index (RI) distribution of the gas mixture and hence the accumulated phase (Δφ) of the signal beam propagating through the HCF. A PM was fabricated with anti-resonant HCF (AR-HCF) butt-coupled to thermally expanded core fibers at both ends, which has an average IL of 0.6 dB over a broad wavelength range from 1450 to 1650 nm, impressively lower than the previous PMs based on 2D materials. By optimising the concentration of absorptive gas, type of buffer gas, and the length of HCF, phase modulation of π-rad at 100 kHz is achieved with control light power of ~200 mW. By using a photonic bandgap HCF (PBG-HCF) with a smaller core diameter, we achieved -3dB modulation bandwidth of 1.1 MHz, the largest among all the reported fiber-based all-optical PMs to our knowledge. The measured rise and fall time of PBG-HCF modulator are 0.28 µs and 0.24 µs, respectively, three orders of magnitude faster than the reported PMs based on 2D materials.

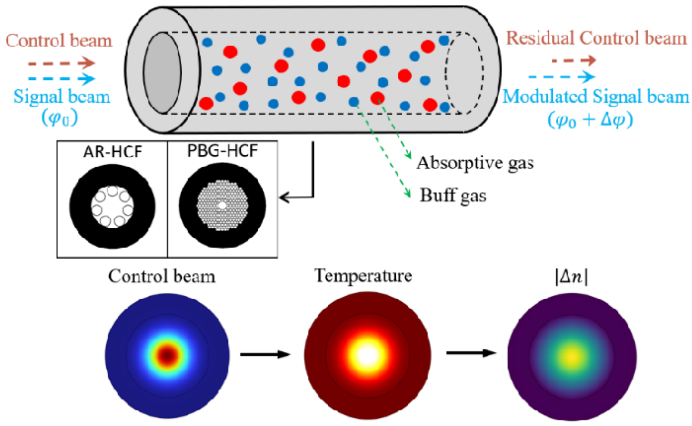

Figure 1. Principle of HCF-based PT phase modulator. φ_0 is the initial phase of the signal beam. $|\Delta n|$ is the absolute RI change.

Twelve-channel detection of spin and orbital angular momenta via dielectric metasurface

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Abstract

Spin angular momentum (SAM) and orbital angular momentum (OAM), which can provide different orthogonal states as independent information channels, have opened up new avenues in optical communications, imaging processing, and quantum optics. However, detection and analysis of these states concurrently require complicated optical setups, which greatly hinder system integration. Here, we propose a twelve-channel simultaneous detection of SAM and OAM through a single-layer metasurface based on the spin photonic Hall effect and an off-axis focusing scheme. Two types of phase modulation methods are adopted. The propagation phase modulation is based on the geometric parameters of nanoelements and the geometric phase stems from the rotation angle of the nanoelements. Eight silicon nanobricks are elaborately selected with their transmission over 90% and phase stepwise covering 0 to 2π in order to fulfill the propagation phase profile. The polarization conversion efficiency of the unit cells is also calculated at over 85% to ensure the manipulation of the geometric phase. When light beams containing multiple vortices are demultiplexed into several vortex beams with different topological charges, each one can be identified by its distinctive focused solid spot on a transverse plane with a distinct azimuthal coordinate. Simultaneous detection of OAM modes with topological charges ranging from 0 to 5 and SAM modes associated with left/right circular polarizations of light will be performed. The proposed scheme offers an effective method to simultaneously demultiplex the superposition of different OAM and SAM modes with a single layer metasurface. We believe this work will inspire the integration of ultracompact optical devices with high-efficiency optical communication systems.

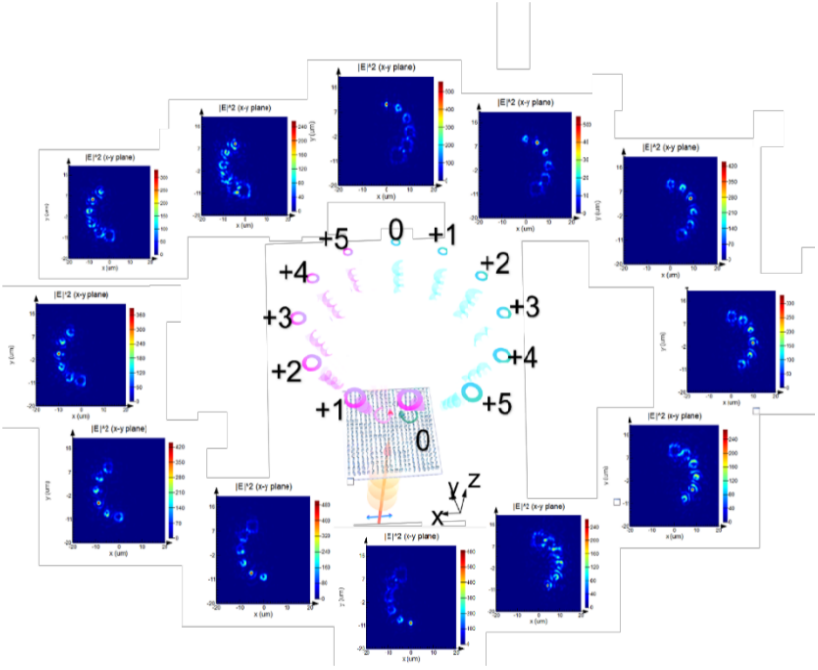

Figure 1. Working scheme for the twelve-channel detector.

Low temperature Corning Gorilla Glass direct bonding

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[1]*Department of Applied Physics, The Hong Kong Polytechnic University, Hong Kong, China*

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Abstract

Corning Gorilla Glass is well-known for its excellent optical, electrical, and mechanical properties. Recently this kind of strengthened alkali aluminosilicate glass is not only used as mobile devices' protective screens, but applications in optical imaging for mobile phones' cameras and optical substrates for Co-packaged Optics also get plenty of interest. In this case, bonding glass is necessary for light path design, glass substrate lamination, and device encapsulation.

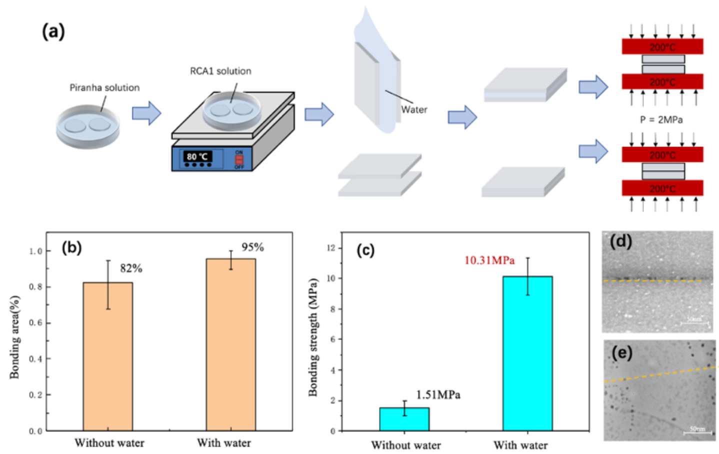

Figure 1. (a)Schematic of experimental setup, bonding (b)area and (c)strength with and without water, Cross-sectional TEM images (d)without and (e)with water

Conventional fusion glass bonding needs a temperature near the glass transition temperature to make a strength like the bulk, which will introduce structure distortion. In this paper, we develop a low-temperature glass direct bonding method. After normal industrial recipe (Piranha solution and RCA1 solution) cleaning, using water as intermedia and annealing at 200°C and 2MPa can bond two glass substrates together, whose strength and transmittance are the same as the bulk. The bonding mechanism is considered dehydration condensation. According to interface characterization, the water intermedia plays an important role in the bonding process by softening the surface, overcoming warpage, and reducing annealing temperature. This method also can be used to bond other kinds of glass for Electro-optical Circuit Board, lab-on-a-chip, and MEMS/NEMS applications.

Acknowledgment:

This work was supported by the National Natural Science Foundation of China (Grant No. 51505106) and Hong Kong Polytechnic University (G-SB4J).

Laboratory Visit

Meet up point
HJ202
Podium level

HJ805

FJ703a

DE502

EF405

Meet up details

11 May 2023 (Thursday)
at 15:00

HJ202, Podium level
(in front of Poster Session Venue)

Session Chair	Dr Dongmei HUANG (Electrical Engineering, PolyU)	
Laboratory	**Location**	**Person-in-charge**
Photonic Sensors Research Lab	HJ805	Dr Pengcheng ZHAO, Oliver (Electrical Engineering, PolyU)
Fs laser lab	FJ703a	Dr Mingjie LI (Applied Physics, PolyU)
PolyU-Huawei Joint Lab	DE502	Mr Weimin LYU (Electronic and Information Engineering, PolyU)
Femtosecond Laser Laboratory	EF405	Dr Jingxian CUI (Electrical Engineering, PolyU)

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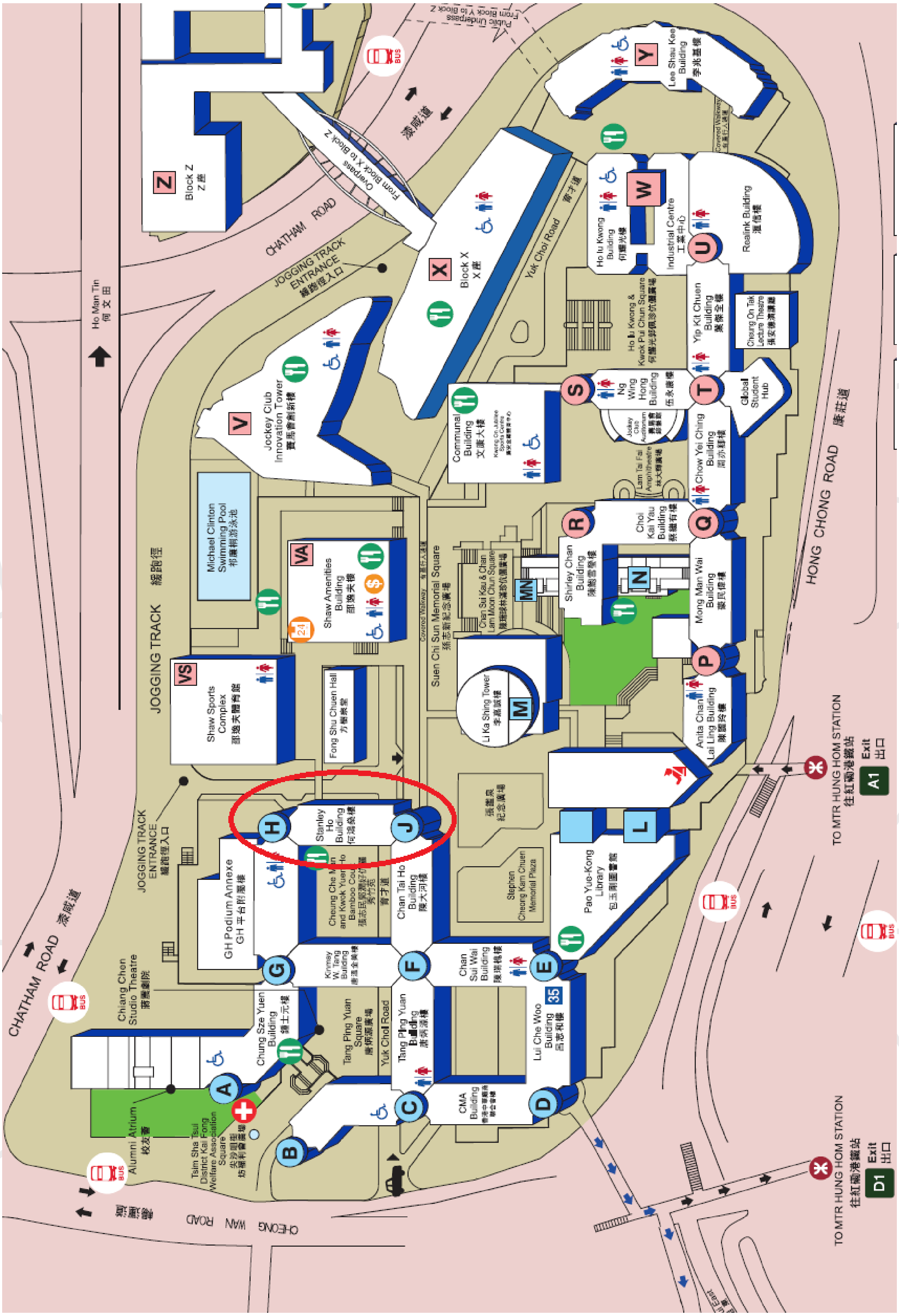
**list in alphabetical order of surnames*



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