OPTICS FRONTIER

July 17-20,2017
Harbin, China

The 9th International Conference on Information Optics and Photonics

CONFERENCE PROGRAM/ABSTRACTS

Organizers

Hosts

International co-hosts

TIPS

1. CLP Service Center will help you in any way, including medicine and information. In case of any problem, please find the Blue T-shirt for help.

2. Please go to Registration Desk or CLP Service Center, if you need Wifi in emergency.

3. **Speaker Preparation**

   30 min presentation for an invited talk includes Q & A
   15 min presentation for an oral talk includes Q & A

4. **Poster Preparation**

   Authors are required to be standing by their poster for the duration of poster session. 10 posters will be awarded as Best Poster. We will call the authors who win the awards.

   Time: 15:30-17:30, 19th July **Location:** 1F, Main Building

5. **Meals**

   The meal tickets will be printed together with the badge. Please go to the canteen according to the time of ticket. No replacement of you lost.

6. **Shuttle Bus**

   Please pay attention to the notice board in the lobby of Sofitel (索菲特大酒店) and Splendent (斯堡莱登大酒店) Hotel for the information if shuttle buses.

7. **Contact**

   Daiming Ma: 13482300288
   Yizhu Peng: 18671773922
   Hannan Wang: 18801772276

ORGANIZERS

Hosts

Chinese Laser Press

Harbin Institute of Technology

Harbin Engineering University

Co-Hosts

- National Key Laboratory of Science and Technology on Tunable Laser
- Key Discipline Laboratory on Satellite Laser Communication Technology and Center for Freespace Optical Communication Technology
- Key Laboratory of In-Fiber Integrated Optics Harbin Engineering University, Ministry of Education

International Co-Hosts

The Optical Society

The Optical Society of Japan

The Optical Society of Korea

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Liancheng Zhao
Harbin Institute of Technology, China

Ian Walmsley
University of Oxford, UK

Wolfgang Osten
University of Stuttgart, Germany

Technical Chairs

Yidong Huang
Tsinghua University, China

Zhiping (James) Zhou
Peking University, China

Libo Yuan
Guilin University of Electronic Technology, China

Local Chair

Zhiwei Lü
Harbin Institute of Technology, China

Secretary-General

Lei Yang
Chinese Laser Press, China

Yongkang Dong
Harbin Institute of Technology, China

CIOP 2017
OPTICS FRONTIER
7. 17-20 Harbin - China

ACKNOWLEDGEMENT

The Conference Committee would like to thank the following teams for attending CIOP 2017

Team of Prof. Li Yu
Beijing University of Posts and Telecommunications

Team of Prof. Weitao Liu
National University of Defense Technology

Team of Prof. Feng Chen
Shandong University

Team of Prof. Mingjiang Zhang
Taiyuan University of Technology

Team of Prof. Fengtie Wu
Huaqiao University

Team of Prof. Min Xie
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EXHIBITION


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实验帮

National Key Laboratory of Science and Technology on Tunable Laser

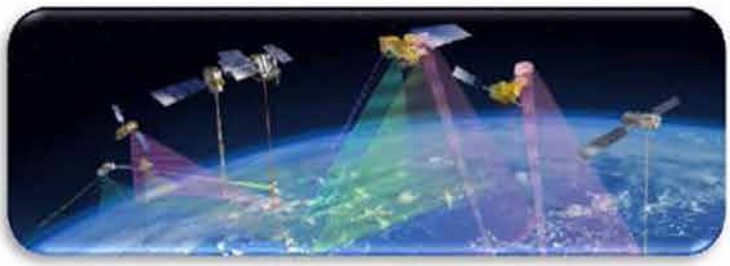
可调谐（气体）激光技术国家级重点实验室

Brief Introduction

National Key Laboratory of Science and Technology on Tunable Laser of Harbin Institute of Technology (HIT) was approved by COSTIND in 1997. The establishment of the laboratory indicates that our institute has built a advanced research platform in the field of tunable laser technology, laser space communication, nonlinear optical technology, which is of great significance to improve the capability of independent innovation of national electronic technology and narrow the gap with the international advanced level.

Major Research Fields

- Satellite Optical Communication
- High-power Laser and Nonlinear Optics
- Airborne LIDAR Scanning
- Medium-long Wave Infrared Solid-state Laser



Significant Achievement

- Over 50 research projects, including those funded by National 973 Projects, National Key S&T Special Projects, National Key Instrument Special Projects, 863 High-tech Key Projects, the National Natural Science Foundation of China, *etc.*
- A series of prominent science and technology studies supporting the significant progress of the National Defense Tech.
- More than 20 national and provincial awards, including First and Second Prizes in National Invention Award, Defense Science and Technology Progress Award and Natural science award of Heilongjiang province, *etc.*
- More than five hundred peer-reviewed papers, monographs and national patents during 2010~2015.
- Strict and pragmatic talent cultivation with 148 post-graduates and more than 30 Ph.D. graduations during 2010~2015.

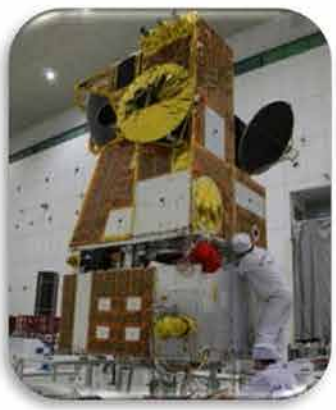
哈爾濱工業大學
HARBIN INSTITUTE OF TECHNOLOGY

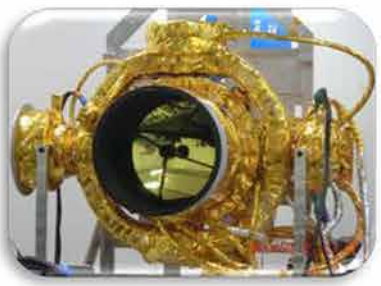
Key Discipline Laboratory on Satellite Laser Communication Technology and Center for Freespace Optical Communication Technology

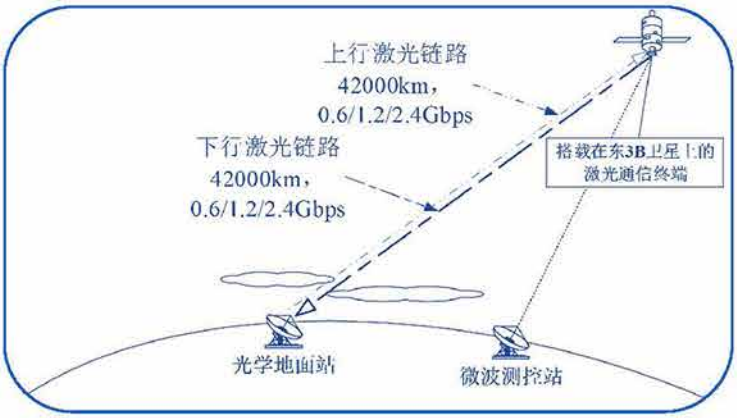
卫星光通信技术重点学科实验室
空间光通信技术研究中心

Brief Introduction

The Key Discipline Laboratory on Satellite Laser Communication Technology was founded in 2007 based on the Center for Freespace Optical Communication Technology at Harbin Institute of Technology. Its research focuses on the emerging multidisciplinary field of satellite laser communications, including fundamental theory of freespace optical communications, space and ground terminal designs, space radiation studies and mitigation techniques, laser communication networks, etc. The Laboratory hosts 11 faculties from various backgrounds including physics, optics, mathematics, system control. Its facilities include office and research area of over 2500 m^2 and advanced research equipment capable of carrying out a broad range of scientific research in this field. Over the past years, the Center/Laboratory has become one of the most advanced education and research base for space optical communication over the globe.







Significant Achievement

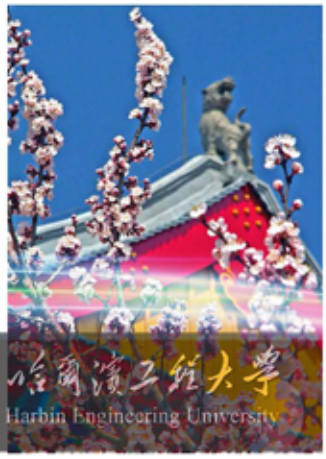
- Over 30 research projects, including those funded by the National Natural Science Foundation of China, Civil Aerospace Key Projects, 863 High-tech Key Projects, etc.
- More than 300 peer-reviewed papers and 8 books
- Over 60 national patents
- 11 national and provincial awards, including First and Second Prizes in National Invention Award

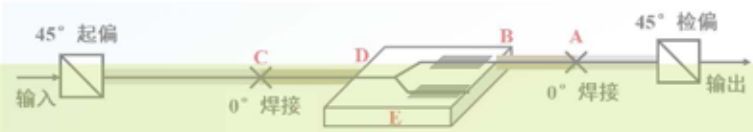
Featured Projects

- 2011 HY-2: China's first LEO-Ground laser communication demonstration
  - Record breaking downlink data rate of 504 Mbps
  - Maximum link distance 1050 km
  - Average acquisition time 4.5 s
- 2017 SJ-13: China's first GEO-Ground laser communication demonstration
  - Record breaking data rate of 5 Gbps
  - Two wavelength division multiplexing channels
  - Link distance 42,000 km

哈爾濱工業大學
HARBIN INSTITUTE OF TECHNOLOGY

纤维集成光学教育部重点实验室
Key Laboratory of In-Fiber Integrated Optics Harbin Engineering University,Ministry of Education





1. 学校简介：

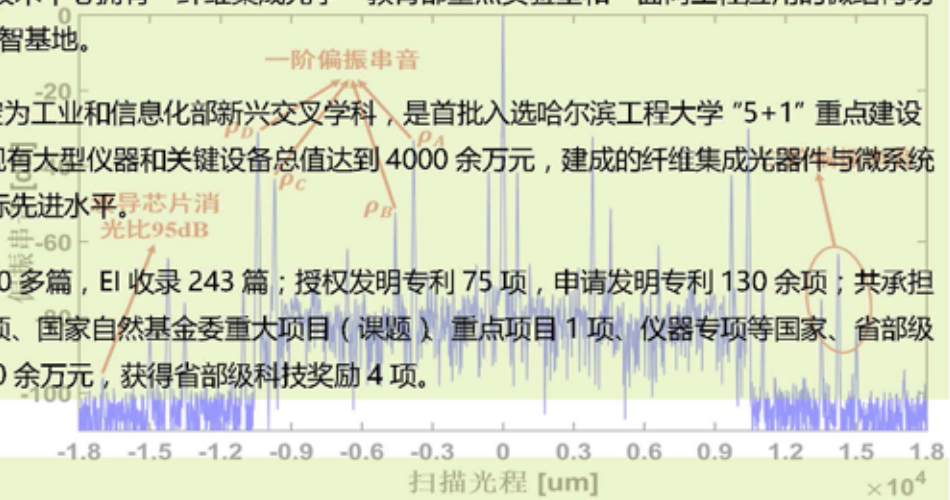
哈尔滨工程大学，“211 工程”、“985 创新平台”，中国“三海一核”领域重要的人才培养和科学研究基地。

2. 实验室简介：

哈尔滨工程大学光子科学与技术中心拥有“纤维集成光学”教育部重点实验室和“面向工程应用的微结构功能光纤”教育部 111 创新引智基地。

“集成光子信息技术”被认定为工业和信息化部新兴交叉学科，是首批入选哈尔滨工程大学“5+1”重点建设学科。面积 3800 平方米，现有大型仪器和关键设备总值达到 4000 余万元，建成的纤维集成光器件与微系统研究平台居于国内领先、国际先进水平。

近五年，共发表 SCI 收录 200 多篇，EI 收录 243 篇；授权发明专利 75 项，申请发明专利 130 余项；共承担科技部重大科学仪器开发专项、国家自然基金委重大项目（课题）、重点项目 1 项、仪器专项等国家、省部级项目 105 项，经费总额 9900 余万元，获得省部级科技奖励 4 项。



3. 项目简介：

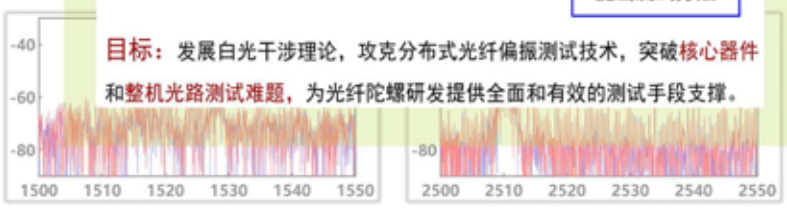
国家重大科学仪器开发专项（2013YQ040815）研制人员：苑立波 杨军 苑勇贵 彭峰

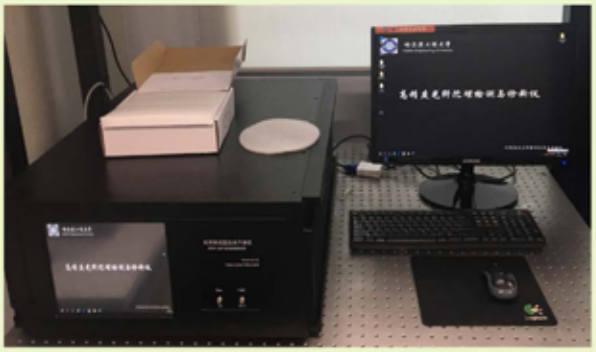
需求：解决光纤陀螺器件和整机光路的测试与诊断问题

近20年来研究工作

- （基础研究）白光干涉测量原理 → 成果1：干涉仪结构与噪声抑制
  - 发表SCI论文80余篇
  - 尽量无损传递
- （关键技术）光纤白光干涉测试技术 → 成果2：高精度分布式光纤白光干涉仪
  - 授权发明专利50多项
  - 测试与应用示范
- （典型应用）陀螺核心器件测试 → 成果3：构建测试平台 提出测试方法

目标：发展白光干涉理论，攻克分布式光纤偏振测试技术，突破核心器件和整机光路测试难题，为光纤陀螺研发提供全面和有效的测试手段支撑。





白光干涉仪仪器照片

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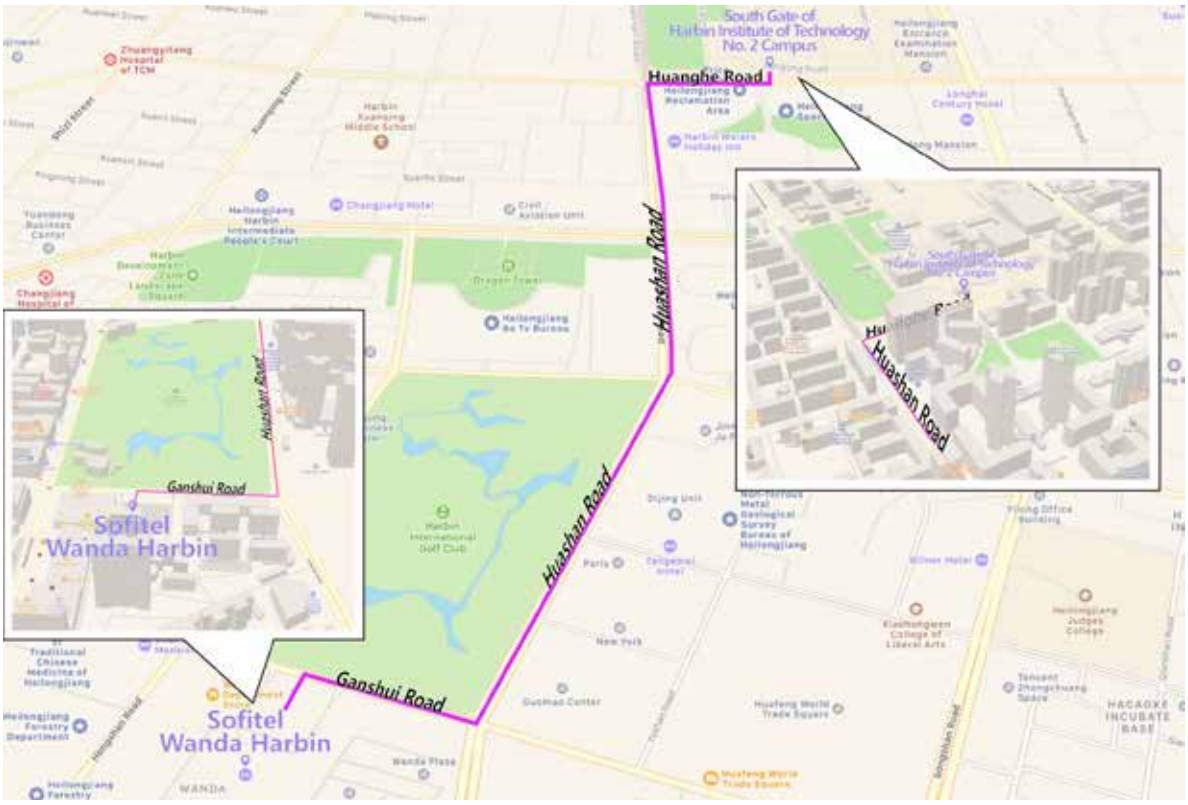
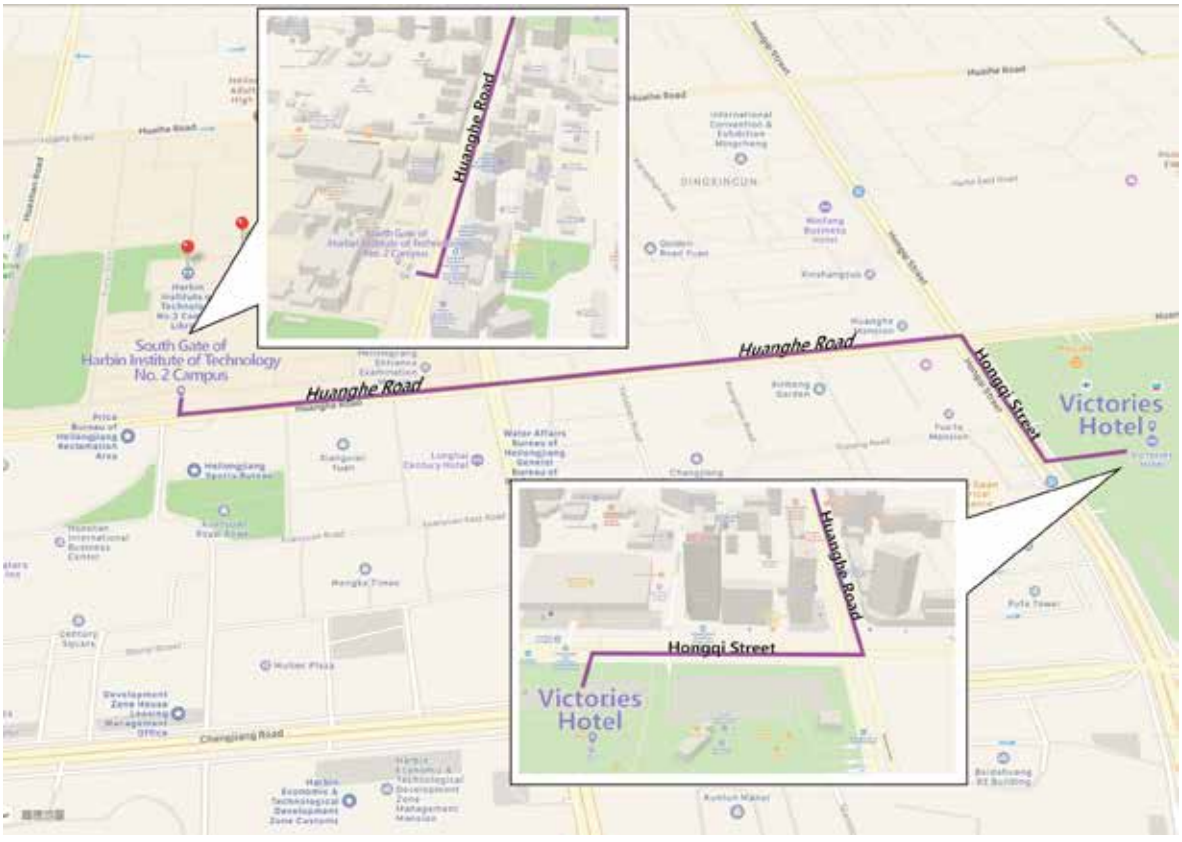
Maps — *Sofitel* to *Harbin Institute of Technology No.2 Campus*



Maps — *Victories Hotel* to *Harbin Institute of Technology No.2 Campus*



Map of Harbin Institute of Technology

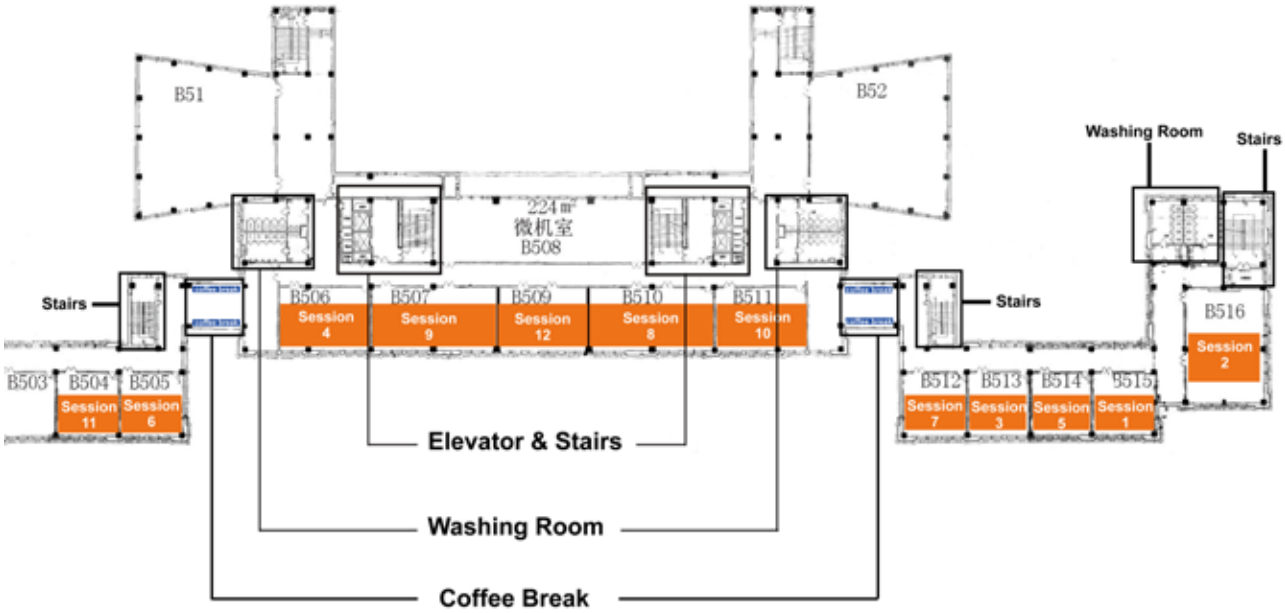
Conference General Program

Date	Conference Program	Location
July 17th	Registration	1F, Main Building
July 17th 13:30-17:00	Industry of Fiber Optic Gyroscope: Challenges and Solution	B507, 5F, Main Building
July 17th 19:00-21:00	CIOP Lecture: How to better present your research work with PowerPoint	B510, 5F, Main Building
July 18th a.m	Plenary Session	Culture & Sports Center
July 18th p.m	General Session	5F, Main Building
July 19th	The workshop on distributed fiber optics sensors	B516, 5F, Main Building
	General Session	5F, Main Building
	Poster Session	1F, Main Building
	Banquet	Sofitel Wanda Harbin
July 20th	General Session	5F, Main Building

Daily Conference Session Schedule

	Session	Location	18th	19th	20th
1	*Photonic Integration and Optical Interconnect*	**B515**	*14:00-17:30*	*09:00-11:45* *14:00-15:00*	
2	*Advanced Fiber Optics & Sensing Technology*	**B516**	*14:00-18:15*	*09:00-12:30* *14:00-15:30*	*09:00-12:30*
3	*Biomedical Photonics*	**B513**	*14:00-17:45*	*09:00-12:00* *14:00-15:30*	*09:00-12:00*
4	*Optical Design and Optical Precision Measurement*	**B506**	*14:00-18:00*	*09:00-12:00* *14:00-15:30*	
5	*Optical Communications and Networks*	**B514**	*14:00-18:15*	*09:00-12:30* *14:00-16:00*	
6	*Holography and Optical Information Processing*	**B505**	*14:00-18:00*	*09:00-12:15* *14:00-15:30*	*09:00-10:45*
7	*Optical Imaging and Display, Laser Radar*	**B512**	*14:00-18:00*	*09:00-12:00* *14:00-15:00*	*09:00-12:00*
8	*Micro-Nano Photonics and Metamaterials*	**B510**	*14:00-18:00*	*09:00-12:15* *14:00-16:30*	
9	*Lasers and Nonlinear Optics*	**B507**	*14:00-18:00*	*09:00-12:15* *14:00-17:30*	*09:00-12:15* *14:00-17:15*
10	*Quantum Optics and Quantum Information Technology*	**B511**	*14:00-18:00*	*09:00-12:15* *14:00-15:30*	
11	*Laser Micro-Nano Processing and Optical Precision Fabrication*	**B504**	*14:00-18:00*	*09:00-12:15* *14:00-15:30*	*09:00-11:15*
12	*Advanced Optical Functional Materials and Devices*	**B509**	*14:00-18:00*	*09:00-12:15* *14:00-15:30*	*09:00-11:45*

Map of 5F, Main Building



Opening Ceremony and Plenary Talks

Location: Culture & Sports Center No.2 Campus

18th July

Opening Ceremony		
Chair: **Zhiwei Lü**, Harbin Institute of Technology, China		
08:30-08:45	**Welcome Speech** **Zhiwei Lü**, Harbin Institute of Technology, China	
	Opening Speeches **Liancheng Zhao**, Harbin Institute of Technology, China **Duanfeng Han**, Harbin Engineering University, China	
Plenary Talks		
Chair: **Yidong Huang**, Tsinghua University, China		
09:00-10:00	**Exploiting the Whole Information Content of the Light Field: Limitations and Approache** Wolfgang Osten *University of Stuttgart, Germany*	- 2 -
10:00-10:15	**Coffee Break**	
Chair: **Libo Yuan**, Guilin University of Electronic Technology, China		
10:15-11:15	**Quantum Photonic Networks** Ian Walmsley *University of Oxford, UK*	- 3 -
11:15-12:15	**Amplification of High-Power and High-Energy ~200ps Laser Pulses for Shock-Ignition of ICF** Zhiwei Lü *Harbin Institute of Technology, China*	- 4 -
12:15-13:15	**Lunch Time**	

Wolfgang Osten
University of Stuttgart,
Germany

Note

Exploiting the Whole Information Content of the Light Field: Limitations and Approaches

ABSRTACT

In the context of measurement technology, optical methods have a number of unique features. To them belong in particular the non-contact and high speed interaction with the object under test, the largely free scalability of the dimension of the probing tool, the high resolution of the data, the diversity of information channels in the light field, and the flexible adaptability of the comparative standard. On the other hand, the user is also confronted with a bunch of challenges. Here one should mention especially the indirect nature of the measurement. This fact is the origin of a number of serious consequences which make it often difficult for the practitioner to decide for optical metrology. However, the numerous information channels recommend optical principles for the solution of various inspection and measurement problems. A broad variety of techniques is sensitive for the measurement of a particular quantity such as the intensity, the frequency, the phase, the angular spectrum, the polarization state, the angular momentum, the degree of coherence and the time of flight. By applying these methods a wide spectra of quantities can be evaluated. To them belong dimensional, structural, geometrical, colorimetrical, chemical, and mechanical properties of the object under test. More modern principles such as hyper-spectral technologies are designed to measure various modalities with one system. Known under the name of multimodal measurement techniques, these systems are capable of elegantly solving complex medical, structural-mechanical or biological problems. However, the high information density in optical signals is often not only an advantage but a challenge with respect to the correct interpretation of the measured data. This report starts with a brief summary of the advantages and disadvantages of optical metrology. Afterwards we discuss the various information channels and present examples for their exploitation. Special attention is directed to the correct interpretation of the data.

BIOGRAPHY

Wolfgang Osten received the MSc/Diploma in Physics from the Friedrich-Schiller-University Jena in 1979. From 1979 to 1984 he was a member of the Institute of Mechanics in Berlin working in the field of experimental stress analysis and optical metrology. In 1983 he received the PhD degree from the Martin-Luther-University Halle-Wittenberg for his thesis in the field of holographic interferometry. From 1984 to 1991 he was employed at the Central Institute of Cybernetics and Information Processes ZKI in Berlin making investigations in digital image processing and computer vision. Between 1988 and 1991 he was heading the Institute for Digital Image Processing at the ZKI. In 1991 he joined the Bremen Institute of Applied Beam Technology (BIAS) to establish and to direct the Department Optical 3D-Metrology till 2002. Since September 2002 he has been a full professor at the University of Stuttgart and director of the Institute for Applied Optics. From 2006 till 2010 he was the vice rector for research and technology transfer of the Stuttgart University where he is currently the vice chair of the university council. His research work is focused on new concepts for industrial inspection and metrology by combining modern principles of optical metrology, sensor technology and image processing. Special attention is directed to the development of resolution enhanced technologies for the investigation of micro and nano structures.

Quantum Photonic Networks

Ian Walmsley
University of Oxford, UK

ABSTRACT

Hybrid light-matter networks offer the promise for delivering robust quantum information processing technologies, from sensor arrays to quantum simulators and computer. New waveguide-based sources, integrated operations, detectors and memories are contributing to progress towards building a resilient, scalable photonic quantum network.

BIOGRAPHY

Ian Walmsley is the Hooke Professor of Experimental Physics at the University of Oxford, director of the Networked Quantum Technologies (NQIT) Hub and Pro-Vice-Chancellor (PVC) for Research and Innovation. As PVC he is responsible for oversight of the University's research and innovation strategy and policy. As NQIT director, he leads the primary UK effort to build the components of a quantum computer based on quantum networks. His current research focuses on both fundamental and applied quantum photonics for metrology, simulation and communications.

Note

Zhiwei Lü
Harbin Institute of Technology, China

Amplification of High-Power and High-Energy ~200 ps Laser Pulses for Shock-Ignition of ICF

ABSTRACT

Shock ignition has received considerable attention as an alternative path to ignition in inertial confinement fusion (ICF), e.g., for the National Ignition Facility (NIF), HiPER and the LMJ project. However, few experimental studies have been reported for ~200 ps shock pulses with high-power and high-energy challenging the current amplification of the short laser pulse. Theoretical analysis shows that the required ignition is 425 kJ, in which 275 kJ is the compression energy, 150 kJ is the shock energy. The shock pulse width is 170-230 ps according to simulation. Traditional progress to amplify nanosecond laser pulses mainly relies on MOPA (master mscillator mower-mmplifier). Amplification of femtosecond ultrashort pulses has relied on CPA (chirped pulse amplification) or OPCPA (optical parametric chirped pulse amplification). In ~200 ps laser pulse amplification, both methods are not appreciated. For MOPA method, on one hand, its energy extraction efficiency is low for 200 ps laser pulse amplification, on the other hand, the output intensity is limited by B integral. For CPA or OPCPA, these methods are limited by the Fourier spectral width in hundred picosecond laser pulse amplification.

By contrast, Brillouin amplification as a nonlinear optics method shows an attractive prospect of amplifying hundred picosecond lasers. Amplification of ~200 ps laser pulses with the method of initiative frequency matching stimulated Brillouin scattering is introduced. The theoretical and experimental results confirm the high efficiency of transferring the energy from the long pulse to ~200 ps. This method has been carried out on SG-III prototype system.

BIOGRAPHY

Prof. Zhiwei Lü received the Ph.D. degree in Physical Electronics and optoelectronics from Harbin Institute of Technology in 1993. He became a professor in 1995 and won the Chang Jiang Distinguished Professor in 2000.

He is dedicated to the research and the teaching work in the field of high-power solid-state laser, stimulated Brillouin scattering technology and laser spectroscopy application. He proposed the Brillouin amplification method and achieved the highest peak power of hundred-picosecond laser pulses on ICF drivers around the world. The research of laser beam combination technology based on SBS amplification is undergoing and aims at achieving hundred-joule, high peak power, 10Hz repetition rate laser output. Prof. Lü is also the deputy director of Laser Committee of China Optical Society, the deputy chief editor of *Chinese Journal of Lasers* and the director of Teaching Steering Committee of Electronics and Information in the Ministry of Education.

Note

Session 1: Photonic Integration and Optical Interconnect

Session Chairs: **Zhiping (James) Zhou**, Peking University, China
Yidong Huang, Tsinghua University, China
Siyuan Yu, Sun Yat-sen University, China

Location: B515, 5F, Main Building, Harbin Institute of Technology No.2 Campus

18th July

Chair: Daoxin Dai, Zhejiang University, China

14:00-14:45	**Photonic Integrated Devices with Nanostructures (Keynote)** Yidong Huang *Tsinghua University, China*	- 7 -
14:45-15:15	**Energy-Efficient Silicon Photonic Transmitters for Pulse-Amplitude Modulation (Invited)** Wei Shi *Center for optics, photonics, and lasers (COPL), Laval University, Canada*	- 8 -
15:15-15:45	**Engineering Wavefront for Tailoring Accelerating Beams Based on Integrated Photonic Approaches (Invited)** Yujie Chen *Sun Yat-sen University, China*	- 9 -
15:45-16:00	**Coffee Break**	

Chair: Yidong Huang, Tsinghua University, China

16:00-16:30	**Silicon Microring Resonators for Optical Filtering and Switching (Invited)** Daoxin Dai *Zhejiang University, China*	- 10 -
16:30-17:00	**Photonic Integrated Devices on Silicon Platform for Chip-Scale Optical Interconnects and Processing (Invited)** Jian Wang *Huazhong University of Science and Technology, China*	- 11 -
17:00-17:30	**Electro-Optic Modulation and Thermo-Optic Tuning Based on Silicon-Graphene Hybrid Structure (Invited)** Ciyuan Qiu *Shanghai Jiao Tong University, China*	- 12 -
18:00-19:00	**Dinner Time**	

19th July

Chair: Baile Zhang, Nanyang Technological University, Singapore

09:00-09:30	**Silicon Optical Modulators with Advanced Modulation Formats (Invited)** Lin Yang *State Key Laboratory on Integrated Optoelectronics, Institute of Semiconductors, CAS, Beijing, China*	- 13 -
09:30-10:00	**Monolithic Integration of III-V Quantum Dot Lasers on Silicon for Silicon Photonics (Invited)** Siming Chen *University College London, UK*	- 14 -
10:00-10:30	**Physics-Enabled Design and Innovation in Silicon Photonics: From Novel Devices to High-Density Waveguides Integration (Invited)** Wei Jiang *Nanjing University, China*	- 15 -
10:30-10:45	**Relative Intensity Noise of An InAs/GaAs Quantum Dot Laser Epitaxially Grown on Germanium (Oral)** Cheng Zhou[1], Yueguang Zhou[2], Chunfang Cao[3], Jiangbing Du[1], Qian Gong[3], Cheng Wang[2] [1] *Shanghai Jiao Tong University, China;* [2] *ShanghaiTech University, China;* [3] *Shanghai Institute of Microsystem and Information Technology, CAS, China*	- 19 -
10:45-11:00	**Coffee Break**	

Chair: Lin Yang, State Key Laboratory on Integrated Optoelectronics, Institute of Semiconductors, CAS, Beijing, China

11:00-11:30	**Surface-Wave Photonic Crystals (Invited)** Baile Zhang *Nanyang Technological University, Singapore*	- 16 -
11:30-11:45	**Measure and Correct the Orbital Angular Momentum Spectra of Light Beams (Oral)** Peng Zhao, Xue Feng, Yidong Huang *Tsinghua University, China*	- 19 -
12:15-14:00	**Lunch Time**	

19th July

Chair: Wei Jiang, Nanjing University, China

14:00-14:30	**Integrated Devices for Optical Vortices (Invited)** Xue Feng *Tsinghua University, China*	- 17 -
14:30-15:00	**China Silicon Photonics Platform in A Multi Project Wafer Service (Invited)** Junbo Feng *China Electronics Technology Group Corporation 38th Research Institute, China*	- 18 -
15:30-16:00	**Coffee Break**	
15:30-17:30	**Poster**	
18:00-20:00	**Banquet**	

Photonic Integrated Devices with Nanostructures

Yidong Huang
Tsinghua University, China

ABSTRACT

BIOGRAPHY

Yidong Huang was born in Beijing, China. She received the B.S. and Ph.D. degrees in optoelectronics from Tsinghua University, Beijing, China, in 1988 and 1994, respectively. From 1991 to 1993, she was with Arai Laboratories, Tokyo Institute of Technology, Japan, on leave from the Tsinghua University. Her Ph.D. dissertation was mainly concerned with strained semiconductor quantum well lasers and laser amplifiers. In 1994, she joined the Photonic and Wireless Devices Research Laboratories, NEC Corporation, where she was engaged in the research on semiconductor laser diodes for optical-fiber communication and became an assistant manager in 1998. She received “Merit Award” and “Contribution Award” from NEC Corporation in 1997 and 2003, respectively. She joined the Department of Electronics Engineering, Tsinghua University in 2003, as a professor, and be appointed by the Changjiang Project and the National Talents Engineering in 2005 and 2007, respectively. She was Vice Chairman of the Department from 2007-2012 and has been the Chairman of the Department from 2013. She is presently engaged in research on nano-structure optoelectronics. Professor Huang authored/co-authored more than 300 journal and conference papers. She is a senior member of the IEEE.

Note

Wei Shi
Center for Optics, Photonics, and Lasers (COPL), Laval University, Canada

Note

Energy-Efficient Silicon Photonic Transmitters for Pulse-Amplitude Modulation

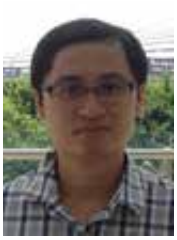
ABSTRACT

Energy-efficient data transmissions through optical interconnects are required for rapidly growing short and mid-reach markets such as data centers and ultra-high-speed computing. Further increase in optical transmission speed has been hindered by power consumption and limited bandwidth resources, for which integrated optical transceivers using advanced modulation formats, such as pulse-amplitude modulation (PAM), are a promising solution. In this talk, we review our recent progress in silicon photonics for PAM transmissions, such as femtojoule PAM modulators and DAC-less CMOS-SiP integrated transmitters.

BIOGRAPHY

Wei Shi is an Assistant Professor in the Department of Electrical and Computer Engineering, Université Laval, Québec, QC, Canada. He received the Ph.D. degree in electrical and computer engineering from the University of British Columbia, Vancouver, BC, Canada, in 2012, where he was awarded the BCIC Innovation Scholarship for a collaboration entrepreneurship initiative. Before joining Université Laval in 2013, he was a researcher at McGill University, Montreal, QC, Canada, where he held a Postdoctoral Fellowship from the Natural Sciences and Engineering Research Council of Canada (NSERC). His research focuses on integrated photonic devices and systems, involving silicon photonics, nanophotonics design and fabrication, CMOS-photonics co-design, high-speed optical transmission and detection, and integrated lasers. He currently directs a NSERC Strategic Partnership Grants (SPG) project on hybrid photonic integration and a NSERC Collaboration Research and Development Grants (CRD) project on high-speed silicon photonic transmitters for advanced modulation formats.

Engineering Wavefront for Tailoring Accelerating Beams Based on Integrated Photonic Approaches



Yujie Chen
Sun Yat-sen University, China

ABSTRACT

Light fields with appropriate wavefront design are capable of propagating along curved trajectories in free space, namely, accelerating beams, which can be useful for either energy or information delivery using light. Previous methods for the realization of accelerating beams are mainly based on bulky phase-only spatial light modulator. In this talk, I will discuss how we can engineer wavefront using integrated photonic approaches with the outcome of the generation of accelerating beams.

BIOGRAPHY

Yujie Chen received his Ph.D. degree in Physics (Photonics) from the Institute of Photonics, University of Strathclyde, Glasgow, UK, in 2012. He is currently an associate professor in School of Electronics and Information Technology at Sun Yat-sen University, Guangzhou, China. His research is mainly focused on the interaction of light with micro/nano-structures and their applications in integrated photonic devices. Up to date, he has authored/co-authored for about 48 peer-reviewed articles, 30 conference papers, 2 book chapters, as well as several patent applications.

Note

Daoxin Dai
Zhejiang University, China

Session 1

Note

Silicon Microring Resonators for Optical Filtering and Switching

ABSTRACT

Silicon-based optical micro-ring resonators (MRRs) are very attractive for many applications because of the ultra-compact footprint and easy fabrication. This paper gives a review of our recent work on novel silicon-based MRRs and the applications for optical filtering and switching. The following parts are included. (1) A “perfect” high-order MRR optical filter with a box-like filtering response is realized by introducing bent directional couplers; (2) A efficient thermally-tunable MRR optical filter with a graphene transparent nano-heater is realized by introducing transparent graphene nanoheaters; (3) Polarization-selective MRR optical filters are realized to work with resonances for only one of TE and TM polarizations for the first time. (4) A on-chip reconfigurable optical add-drop multiplexer for hybrid mode-/wavelength-division-multiplexing systems is realized for the first time by monolithically integrating a mode demultiplexer, four tunable MRR optical switches, and a mode multiplexer.

BIOGRAPHY

Prof. Daoxin Dai received the B. Eng. degree from Zhejiang University (ZJU) in 2000, and the Ph.D. degree from the Royal Institute of Technology (Sweden) in 2005. He joined ZJU as an assistant professor in 2005 and became an associate professor in 2007, a full professor in 2011. Dr. Dai worked at UCSB as a visiting scholar from the end of 2008 until 2011. His research interests are in silicon nanophotonics for optical interconnections and optical sensing. He has published >150 refered international journals papers (including 10 invited review papers). Dr. Dai is one of Most Cited Chinese Researchers in 2015 and 2016 (from Elsevier). His paper has >4560 citations and the H-index is 38 (Google Scholar). He has been invited to give more than 40 invited talks and served as the program committee member or session chair for many top international conferences (like OFC 2013-2015). Dr. Dai was the leading Guest Editor of the Integrated Photonics special issue of *Photonics Research*. He is serving as the Associate Editor of the Journals of "*IEEE Photonics Technology Letters*", "*Optical and Quantum Electronics*" and "*Photonics Research*".

Photonic Integrated Devices on Silicon Platform for Chip-Scale Optical Interconnects and Processing

Jian Wang
Huazhong University of Science and Technology, China

Note

ABSTRACT

Silicon photonics is a promising nanophotonic integration platform facilitating possible integration of complete optical communication systems on a monolithic chip. In this talk, we will report recent advances in photonic integrated devices on silicon platform for chip-scale optical interconnects and processing. Design, fabrication and applications of different kinds of silicon nanophotonic devices are discussed, such as strip waveguides, slot waveguides, hybrid plasmonic waveguides, microring resonators, comb filter and interleaver.

BIOGRAPHY

Jian Wang received the Ph.D. degree in physical electronics from the Wuhan National Laboratory for Optoelectronics, Huazhong University of Science and Technology, Wuhan, China, in 2008. He worked as a Postdoctoral Research Associate in the Optical Communications Laboratory in the Ming Hsieh Department of Electrical Engineering of the Viterbi School of Engineering, University of Southern California, Los Angeles, California, USA, from 2009 to 2011. He is currently a professor at the Wuhan National Laboratory for Optoelectronics, Huazhong University of Science and Technology, Wuhan, China. He gained supports from the New Century Excellent Talents in University in 2011, the National Science Foundation for Excellent Young Scholars in 2012, and the National Program for Support of Top-notch Young Professionals in 2015.

Jian Wang has devoted his research efforts to innovations in photonic integrated devices and frontiers of high-speed optical communications and optical signal processing. He has more than 300 publications, including 3 book chapters, 2 special issues, 3 review articles, 5 invited papers, 42 tutorial/keynote/invited talks (invited talk at OFC2014, tutorial talk at OFC2016), 8 postdeadline papers, and more than 100 journal papers published on *Science*, *Nature Photonics*, *Scientific Reports*, *Optics Express*, *Optics Letters*, etc.

Ciyuan Qiu
Shanghai Jiao Tong University, China

Session 1

Note

Electro-Optic Modulation and Thermo-Optic Tuning Based on Silicon-Graphene Hybrid Structure

ABSTRACT

Graphene is considered to be a promising material to build active optoelectronic device. In this talk, we firstly review recent research progress on the silicon-graphene optoelectronic devices. Then we present our works on the electro-optic modulators and the thermo-optic tunable filter based on silicon-graphene hybrid structure. By tuning the Fermi level of the graphene, we demonstrate a silicon-graphene micro-ring electro-optic (EO) modulator with modulation depth about 40%. We also propose a nanobeam EO modulator and a spatial light modulator with speed higher than 45 GHz. Thanks to the high thermo-optic coefficient of graphene, we demonstrate a tunable filter with heating efficiency about 1.5 nm/mW.

BIOGRAPHY

Ciyuan Qiu received the B.S. degree and M.S. degree from Tsinghua University, Beijing, China in 2005 and 2007 respectively, and the Ph.D. degree from Rice University, Houston, USA, in 2013. He then worked as post-doc in Rice University until June 2014. He joined Shanghai Jiao Tong University, Shanghai, China, in August 2014. Dr. Qiu has published 59 journal and conference papers. He has 1 first-author paper published in *Nano Letters* (IF=13.779) and 1 first-author paper published in *Scientific reports* (IF=5.578). The total SCI citation is 381 from other researchers.

Silicon Optical Modulators with Advanced Modulation Formats

Lin Yang
State Key Laboratory on Integrated Optoelectronics, Institute of Semiconductors, CAS, Beijing, China

Note

ABSTRACT

I will review our efforts in developing high-speed silicon Mach-Zehnder optical modulators with large optical bandwidth. Firstly, I will introduce how to optimize the modulation efficiency, optical loss, electro-optical bandwith of the silicon optical modulator. The fabricated silicon Mach-Zehnder optical modulator has an electro-optical bandwidth of 30 GHz. When the device is optically biased at the quadrature point, it has the dynamic extinction ratios of 6.5 dB, 5.9 dB and 5.2 dB at the speeds of 40 Gbps, 50 Gbps and 64 Gbps for OOK modulation. Secondly, I will introduce a silicon 16-QAM optical modulator, which is based on four Mach-Zehnder modulators driven by four binary electrical signals. With the simple electrical driving configuration, the device generates a 16-QAM optical signal at 20 Gbaud with an error vector magnitude of 13.7%. Finally, I will introduce two types of silicon PAM-4 optical modulator. One is driven by a PAM-4 electrical signal and the other is driven by two binary electrical signals with different peak-to-peak voltages. Both two devices can generate PAM-4 optical signals at the speed of over 30 Gbaud in the wavelength of 1525-1565 nm. The corresponding bit error rates could reach as low as ~10^{-6}, which is below the hard-decision forward error correction threshold of 3.8×10^{-3}.

BIOGRAPHY

Lin Yang received his Ph. D. degree in microelectronics and solid state electronics from Institute of Semiconductors, Chinese Academy of Sciences, Beijing, China, in 2003. From 2003 to 2007, he was a postdoctoral fellow of Research Center for Integrated Quantum Electronics, Hokkaido University, Sapporo, Japan. He is currently a professor of State Key Laboratory on Integrated Optoelectronics, Institute of Semiconductors, Chinese Academy of Sciences, Beijing, China. His current research interests include silicon-based photonic devices for optical interconnect, optical computing and optical communication. He is the author or co-author of 80 journal papers and 100 conference papers.

Siming Chen
University College
London, UK

Session 1

Monolithic Integration of III-V Quantum Dot Lasers on Silicon for Silicon Photonics

ABSTRACT

The availablility of silicon lasers is the key technology for the whole Si photonics industry. But the indirect bandgap of silicon is a severe limitation, and, despite recent advances, these devices will not, in the foreseeable future, outperform their III-V counterparts. Much effort has been directed toward hybrid integration of III-V lasers with Si photonics platforms. Although impressive results have been achieved, on a longer term, large-scale integration of photonics circuits will rely on monolithic integration of laser sources on silicon.

In this talk, I will review our recent progress made in the direct growth of III-V light sources on silicon. I firstly briefly address issues related to the III-V/Si substrates itself before moving to results on III-V quantum lasers monolithically integrated on Ge, Ge-on-Si, and Si substrates.

BIOGRAPHY

Siming Chen received his MSc and PhD degrees in Electrical Engineering from the University of Sheffield, U.K., in 2010 and 2014, respectively. In Sep 2013, he joined the Department of Electronic and Electrical Engineering at University College London, U.K., as a research associate. He is currently a Royal Academy of Engineering (RAEng) Research Fellow hosted by University College London. His major research interest concentrates on monolithic integration of III-V compound semiconductors and optoelectronic devices on silicon substrates.

Since 2011, Chen has published over 50 papers in international journals and conference proceedings, such as *Nature Photonics*, *ACS Photonics*, *MRS Bulletin*, *Applied Physics Letters*, *Optics Express* and *IEEE JSTQE*, etc. Chen's research achievements have been widely reported/highlighted by over 20 tech magazines, newspapers, and websites world-wide, including Daily Mail, OSA: optics & photonics, Technology.org, Photonics.com, Headlines & Global News, Science Daily, Nanotechnology Now, SPIE Newsroom, Semiconductor Today, IET, Phys.org and Space Daily, etc. Chen has also filed 5 international patents, with 1 granted already.

Note

Physics-Enabled Design and Innovation in Silicon Photonics: From Novel Devices to High-Density Waveguides Integration

Wei Jiang
Nanjing University, China

Note

ABSTRACT

Silicon photonics is making rapid advances in recent years. Currently, basic device building blocks have become widely available. In the future, innovation opportunities may continue to emerge in devices and integration. At the device level, novel structures (such as photonic crystals and resonators) show promise to reduce device size and power consumption, yet they may bring sophisticated physics that cannot be easily analyzed by common simulation tools such as FDTD. Advanced physics theory is needed to analyze performance of such novel devices. Furthermore, advanced device physics and design can also help to prevent device failure in fabrication. We will show an example how this helped to successfully fabricate Si photonic devices on a CMOS fab line that has not done photonics before. Lastly, for large-scale integration, physics-based theory can also help. High-density waveguide integration at half-wavelength waveguide pitch has been demonstrated with very low crosstalk, assisted by advanced physics theory. Potential applications of such high-density waveguides in optical phased arrays and space-division multiplexing will be discussed.

BIOGRAPHY

Wei Jiang received his B.S. degree in physics from Nanjing University, Nanjing, China, in 1996, and his M.A. degree in physics and his Ph.D. degree in electrical and computer engineering from the University of Texas, Austin, in 2000 and 2005, respectively.

He is currently a professor in the Department of Quantum Electronics and Optical Engineering, College of Engineering and Applied Sciences, Nanjing University, Nanjing, China. Prior to joining Nanjing University, he was an assistant professor and then an associate professor in the Department of Electrical and Computer Engineering of Rutgers, the State University of New Jersey, USA. His research interests include silicon photonics, photonic crystals, nanophotonics, and their applications in communications, computing, and sensing.

Dr. Jiang received DARPA Young Faculty Award in 2012 and IEEE Region I Outstanding Teaching Award in 2013, among other honors.

Surface-Wave Photonic Crystals

Baile Zhang
Nanyang Technological University, Singapore

Note

ABSTRACT

Photonic crystals, also known as photonic bandgap (PBG) materials, can forbid the propagation of electromagnetic (EM) waves in a certain frequency range in all directions, but they generally lack subwavelength features. In parallel, EM modes supported on periodically textured metal surfaces, which are commonly termed as spoof (or designer) surface plasmons, possess spatial scales typically much smaller than the wavelength, but they generally do not have PBG concepts. Here we show that it is possible to merge these two fields by creating surface-wave photonic crystals. Many device concepts in the context of photonic crystals can thus be transferred and applied directly to the manipulation of surface waves at the subwavelength scale.

BIOGRAPHY

Dr. Baile Zhang is an Associate Professor in the Division of Physics and Applied Physics, School of Physical and Mathematical Sciences, at Nanyang Technological University, Singapore. He received his Ph.D. in 2009 from MIT, following his B.S. degree in 2003 and M. S. degree in 2006 from Tsinghua University in Beijing, all majored in Electrical Engineering.

Integrated Devices for Optical Vortices

Xue Feng
Tsinghua University, China

Note

ABSTRACT

Introduced by Allen et al., it has been realized that light can carry orbital angular momentum (OAM) in addition to the spin angular momentum (SAM). Independent of the polarization state, light with an azimuthal phase dependence of exp(i$l\varphi$) has OAM $l\hbar$ per photon. The value of l (the topological charge), as a new dimensionality, can be valued with any integer. Having l spiral phase fronts and a transverse component of the Poynting vector perpendicular to the propagating direction, such kind of light is also known as optical vortex.

Aim to explore the benefit introduced by optical vortex, we have proposed and demonstrated several photonic integrated devices. In this article, some representative devices of our recent work would be briefly introduced. They are the integrated “Cobweb” emitter with a wide switching range of OAM modes, integrated “Cogwheel” emitter to generate optical superimposed vortex beam and plasmonic vortex devices.

BIOGRAPHY

Dr. Xue Feng received his BS, MS and PhD degrees in Electrical Engineering from Tsinghua University in 1999, 2002 and 2005, respectively. Since 2005, he has been working in Department of Electronic Engineering, Tsinghua University, Beijing, China. His major research interest is focused on micro/nano-structure optoelectronics, silicon photonics, and integrated optoelectronic devices. As author and co-author, he has published more than 100 journal or conference papers.

Junbo Feng
China Electronics Technology Group Corporation, China

Session 1

Note

China Silicon Photonics Platform in a Multi Project Wafer Service

ABSTRACT

Rapid progress has been made in recent years in the field of silicon photonics in China. Foundry processes now become an essential issue in the whole design and fabrication flow. Shared shuttle run services are ideal for rapid and relatively inexpensive prototyping. We present the silicon photonic platform in China that offers monolithically integrated active and passive silicon photonics devices through the MPW (multi-project wafer) service. A great number of devices have been demonstrated in this platform, which include low-loss waveguides, efficient grating couplers, passive optical devices, high-speed modulators and germanium waveguide photo-detectors.

BIOGRAPHY

Junbo Feng received the B.E. and Ph.D. degrees from Huazhong University of Science and Technology, China in 2004 and 2009, respectively. He is currently a senior engineer in the 38th Institute of China Electronics Technology Group Corporation. His research topics focus on silicon photonics and optical integration technologies. He studied in the Electronic Engineering Department of Georgia Tech. from January 2007 to June 2008. After that, he continued his research in Peking University and became a post doctor in Tsinghua University until 2011. He has authored more than 30 journal and conference publications and a book chapter, and owned more than 10 patents. He presided over 5 national and provincial projects in the past five years. He obtained Youth Talent Support Program and First Class Prizes of the State Scientific and Technological Progress Award of CETC38.

CIOP-2017-0773

Relative Intensity Noise of an InAs/GaAs Quantum Dot Laser Epitaxially Growing on Germanium

Cheng Zhou[1], Yueguang Zhou[2], Chunfang Cao[3], Jiangbing Du[1], Qian Gong[3], Cheng Wang[2]
[1] State Key Laboratory of Advanced Optical Communication Systems and Networks, Department of Electronic Engineering, Shanghai Jiao Tong University; [2] School of Information Science and Technology, ShanghaiTech University; [3] State Key Laboratory of Functional Materials for Informatics, Shanghai Institute of Microsystem and Information Technology, Chinese Academy of Sciences

Integration of photonic circuits on the CMOS-compatible silicon (Si) platform is increasingly demanded for cost-effective applications in data centers, access networks, and supercomputers. Nowadays, a large variety of Si-based optical modulators, detectors, and passive photonic devices have been successfully demonstrated. However, it remains challenging to monolithically integrate semiconductor lasers on Si. Fortunately, III-V quantum dot (Qdot) lasers are weakly sensitive to growth defects arising from the lattice mismatch between the III-V compounds and Si, and epitaxially-grown InAs/GaAs Qdot lasers on germanium (Ge), Ge-Si, and Si were reported in recent years. It was shown that the static performances including the lasing threshold and the output power were slightly degraded in comparison with their counterparts grown on the GaAs substrate, which was attributed to the high density of threading dislocation defects. However, there are few studies of the defect impacts on the dynamical characteristics. Among the laser dynamics, the relative intensity noise (RIN) increases the bit error rate during the data transmission and hence limits the maximum communication rate.

In this work, we report the RIN properties of an InAs/GaAs Qdot laser epitaxially grown on the Ge substrate. The laser was grown on a Ge [100] wafer with 6° miscut towards [111] plane, using the gas-source molecular beam epitaxy technique. A GaAs buffer layer grew on the Ge substrate, followed by the Qdot laser structure with an active region consisting of five-stacked InAs Qdot layers. Ridge-waveguide laser diodes were fabricated with cavity length of 4.4 mm and ridge width of 6.0 μm. Both cavity facets were as-cleaved. During the experiment, the laser temperature is kept constant at 20 ℃ using a thermo-electric cooler. The lasing threshold is 300 mA, and the optical spectrum peaks around 1045 nm. In the measurement of the laser's RIN, the background thermal noise and the photodiode shot noise are carefully removed.

Above threshold, the RIN of Ge-based Qdot laser is around -90.0 dB/Hz for frequencies less than 0.5 GHz, and it decreases to be lower than -115.0 dB/Hz for frequencies of 4.0–6.0 GHz. The high RIN at the low frequencies is due to excess noises arising from the current source, the thermal fluctuation and the multimode partitioning effect. The RIN exhibits a peak around 1.0 GHz owing to the relaxation oscillation resonance. In addition, the RIN shows another peak around 9.0 GHz, which is not common in the RIN spectrum of semiconductor lasers. This phenomenon can be attributed to the split of the longitudinal cavity modes resulting from the Qdot size fluctuations. Beyond 12.0 GHz, the RIN remains constant and lower than -115.0 dB/Hz. Increasing the bias current reduces the RIN down to a minimum level of about -120.0 dB/Hz. In contrast, an InAs Qdot laser growing on the GaAs substrate using the same layer structure and the same growth technique exhibits a minimum RIN of -135.0 dB/Hz. That is, the RIN performance of the Ge-based Qdot laser deteriorates by about 15 dB/Hz, which is mainly due to the growth dislocation defects.

Key words: silicon photonics; semiconductor lasers; quantum dots; fluctuations, relaxations, and noise

CIOP-2017-1792

Measure and Correct Orbital Angular Momentum Spectra of Light Beams

Peng Zhao, Xue Feng, Yidong Huang
Department of Electronic Engineering, National Laboratory for Information Science and Technology, Tsinghua University

In 1992, Allen et al. established the relation between light beam with an azimuthal phase distribution of exp(ilφ) and the orbital angular momentum (OAM), while the integer number of l names as the OAM order or the topological charge and the carried OAM is lħ per photon. OAM can be employed in plenty applications, such as optical communication, quantum information processing and optical imaging, since it provides an infinite and additional dimension of light. In such applications, measuring OAM spectrum of light is necessary, however, although many methods have been proposed, several issues are still not well addressed, such as sensitivity to the tilt of light and lack of relative phases between OAM spectrum coefficients. To obtain the whole information carried by the OAM light beam, the OAM spectrum has to be measured in terms of intensity and phase. Thus, it is necessary to measure the complex optical field distribution. In this work, an interference method is proposed and demonstrated to measure the complex optical field of a light beam. The scheme consists of a laser source operating at 1550 nm, a spacial light modulator (SLM) for generating objective light beams under test, an M-Z interferometer and a charge coupled device (CCD) camera for measuring the interference patterns. With the measured light field, the complex OAM spectrum of light can be obtained by mode matching. Furthermore, the small tilt angle of the objective light can be extracted from the field. Then with the obtained angle tilt, the dispersion of the OAM spectrum due to the tilt can be corrected.

Key words: orbital angular momentum; interference; optical field

Session 2: Advanced Fiber Optics & Sensing Technology

Session Chairs: **Libo Yuan**, Harbin Engineering University, China
Yongkang Dong, Harbin Institute of Technology, China
Elfed Lewis, University of Limerick, Ireland

Location: B516, 5F, Main Building, Harbin Institute of Technology No.2 Campus

18th July

Chair: Wei Jin, The Hong Kong Polytechnic University, China

14:00-14:45	**Optical Fibre Sensors for Measuring Physical Parameters in A Diverse Range of Applications (Keynote)** Elfed Lewis *University of Limerick, Ireland*	- 22 -
14:45-15:15	**All-Fiber Optoelectronic Devices Based on Low Dimensional Materials and Sensing Applications (Invited)** Fei Xu *Nanjing University, China*	- 23 -
15:15-15:30	**DPP-BOTDA Based-on Double-Peak BGS Technique for Sub-Spatial Resolution Events Detection in Long-Range Sensing (Oral)** Diakaridia Sanogo, Yue Pan, Pengbai Xu, Dengwang Zhou, Benzhang Wang, Yongkang Dong *Harbin Institute of Technology, China*	- 39 -
15:30-15:45	**Applications of NKT Ultra Low Noise Fiber Laser in Optical Fiber Sensing (Oral)** Jie Zhao *Luster*	- 39 -
15:45-16:00	**Coffee Break**	

Chair: Elfed Lewis, University of Limerick, Ireland

16:00-16:45	**Fiber-Enhanced Photothermal Interferometry for High Sensitivity Gas Sensing (Keynote)** Wei Jin *The Hong Kong Polytechnic University, China*	- 24 -
16:45-17:15	**Plasmonic Fiber-Optic Sensors (Invited)** Tuan Guo *Jinan University, China*	- 25 -
17:15-17:30	**Long Distance Raman Distributed Fiber Temperature Sensing Technology (Oral)** Jian Li, Mingjiang Zhang, Jianzhong Zhang, Yi Liu *Taiyuan University of Technology, China*	- 39 -
17:30-17:45	**Compact and Sensitive Er^{3+}/Yb^{3+} Co-doped YAG Single Crystal Optical Fiber Thermometry Based on Upconversion Luminescence (Oral)** Linhua Ye *Physics Dept. of Zhejiang University, China*	- 39 -
17:45-18:00	**Multi-Slope-Assisted Vector BOTDA Based on Frequency-Agile Technique (Oral)** Dengwang Zhou[1], Yongkang Dong[1], Benzhang Wang[1], Hongying Zhang[2], Zhiwei Lü[2] *[1] Harbin University of Science and Technology, China; [2] Harbin Institute of Technology, China*	- 40 -
17:45-18:00	**Distributed Fiber Sensor based on Chaotic Brillouin Optical Correlation Domain Analysis (Oral)** Wang Yahui, Zhang Mingjiang, Zhang Jianzhong, Liu Yi *Taiyuan University of Technology, China*	- 40 -
18:00-18:15	**Distributed Hydrostatic Pressure Sensor Based on Brillouin Dynamic Grating (Oral)** Lei Teng *Harbin Institude of Technology, China*	- 40 -
18:00-19:00	**Dinner Time**	

19th July

The workshop on distributed fiber optic sensors

Workshop Organizer: Yongkang Dong, Harbin Institute of Technology, China

Chair: Yosuke Mizuno, Tokyo Institute of Technology, Japan

09:00-09:30	**Distributed Fiber-Optic Sensing with Ultra-High Spatial Resolution by Using Linear Optical Sampling Technique (Invited)** Xinyu Fan *Shanghai Jiao Tong University, China*	- 26 -
09:30-10:00	**Distributed Temperature and Strain Sensing Based on Fibre Birefringence Measurements Using Coherent Rayleigh Scattering (Invited)** Marcelo A. Soto *EPFL Swiss Federal Institute of Technology, Institute of Electrical Engineering, Switzerland*	- 27 -
10:00-10:30	**Enabling Technologies for Ultra-Long-Distance Distributed Fiber-Optic Sensing (Invited)** Zinan Wang *University of Electronic Science and Technology of China, China*	- 28 -

19th July

10:45-11:00	**Coffee Break**	
Chair: Xinyu Fan, Shanghai Jiao Tong University, China		
11:00-11:30	**Distributed Brillouin Sensors Based on Direct Current Modulation of A Laser Diode (Invited)** Kwang Yong Song *Chung-Ang University, South Korea*	- 29 -
11:30-12:00	**Recent Advances in Distributed Fiber Sensors (Invited)** Liyang Shao *Southwest Jiaotong University, China*	- 30 -
12:00-12:30	**The Applications of Fiber Optic Sensors in Geophysics and Seismology (Invited)** Wentao Zhang *Institute of Semiconductors, CAS, China*	- 31 -
12:15-14:00	**Lunch Time**	
Chair: Marcelo A. Soto, EPFL Swiss Federal Institute of Technology, Institute of Electrical Engineering, Switzerland		
14:00-14:30	**Parameters-Tuning of Fiber Lasers (Invited)** Tao Zhu *Chongqing University, China*	- 32 -
14:30-15:00	**Recent Advances of Brillouin Sensing Technology Using Plastic Optical Fibers (Invited)** Yosuke Mizuno *Tokyo Institute of Technology, Japan*	- 33 -
15:00-15:30	**Recent Advances of Polarization Sensitive Optical Time Domain Reflectometry (Invited)** Feng Wang *Nanjing University, China*	- 34 -
15:30-15:45	**Coffee Break**	
15:30-17:30	**Poster**	
18:00-20:00	**Banquet**	

20th July

Chair: Xinghua Yang, Harbin Engineering University, China		
09:00-09:30	**Miniature Lab on/in Optical Fiber (Invited)** Dongning Wang *China Jiliang University, China*	- 35 -
09:30-10:00	**In-Fiber Air Bubbles and Applications (Invited)** Yiping Wang *Shenzhen University, China*	- 36 -
10:00-10:15	**Ultrahigh Sensitivity Temperature Sensor Based on Mach-Zehnder Interferometer Enhanced Vernier-Effect (Oral)** Chengcai Tian, Hao Zhang, Xia Xue, Jiaming Liu, Wenxiu Li, Xin Huang, Anping Huang, Zhisong Xiao *Beihang University, China*	- 41 -
10:15-10:30	**A Large-Scale Wavelength- and Frequency-Division Multiplexed Fiber Laser Sensor Array (Oral)** Xiujuan Yu *Heilongjiang Univeristy, China*	- 41-
10:30-10:45	**Fast Maximum Likelihood Estimation of Optical Path Difference From Low-Finesse Optical Interference Spectrum (Oral)** Yi Qi, Weimin Chen, Juxia Xie, Xiaohua Lei *Chongqing University, China*	- 42 -
10:45-11:00	**Coffee Break**	
Chair: Yiping Wang, Shenzhen University, China		
11:00-11:30	**Investigation of Microstructured Fiber Optic Surface Plasmon Resonance Sensor (Invited)** Wei Peng *College Physics and Optoelectronic Engineering, Dalian University of Technology, China*	- 37 -
11:30-12:00	**Microfluidic In-Fiber Optical Fiber Sensors Based on Hollow Optical Fibers (Invited)** Xinghua Yang *Harbin Engineering University, China*	- 38 -
12:00-12:15	**A Stable and Compact Scenario to Improve the Performance of A BOTDR (Oral)** Qing Bai, Yu Zhang, Baoquan Jin, Xin Liu, Dong Wang, Yu Wang, Yuncai Wang *Taiyuan University of Technology, China*	- 42 -
12:15-12:30	**Research on Distributed Vibration Sensor Based on Φ-OTDR for Real-time Pipeline Safety Monitoring (Oral)** Xin Liu, Yu Wang, Baoquan Jin, Qirui Ying, Dong Wang, Yuncai Wang *Taiyuan University of Technology, China*	- 41 -
12:15-14:00	**Lunch Time**	

Elfed Lewis
University of Limerick,
Ireland

Session 2

Note

Optical Fibre Sensors for Measuring Physical Parameters in a Diverse Range of Applications

ABSTRACT

Optical fibre sensors have become widely used in health care in recent years. Optical fibre sensors have several advantages over the conventional electrical sensors due to their potentially high sensitivity, immunity to electromagnetic radiation, small size, and potential high measurement resolution. Several miniature fibre optic sensors based on Fabry-Perot interferometer (FPI) have recently been fabricated at the Optical Fibre Sensors Research Centre (OFSRC) at University of Limerick which include proximally located Fibre Bragg Gratings (FBG) for the simultaneous measurement of pressure and temperature.

The Optical Fibre Pressure and Temperature Sensor (OFPTS) described here is fabricated entirely from glass, which makes it ideal for biomedical applications as well as many other industrial applications. Since there is no epoxy or adhesive used in the fabrication process, and all joints are made from fused silica glass, the sensors are extremely well sealed and stable over long periods of time. The fabrication of the EFPI/FBG array and the EFPI/CFBG is discussed along with results from test in a temperature controlled environment. Such sensors have been used in a wide range of medical applications where both distributed (or multi-point) temperature measurement and point pressure measurement provide valuable information. These include:

(i) Measurement of Bladder Pressure Upstream and Downstream of the bladder sphincter for assessment in Urology clinics. This has included patient based testing using two independent optical fibre sensors.

(ii) Measurement of Blood Pressure Upstream and Downstream of arterial blockages, i.e. Fractional Flow Recovery (FFR) in which two independent OFS pressure sensors measure the differential pressure upstream and downstream of a blockage.

(iii) Simultaneous measurement of pressure and temperature in radio frequency and/or laser thermal ablation of tumours.

BIOGRAPHY

Elfed Lewis graduated with BEng (Hons) in Electrical and Electronic Engineering from Liverpool University in 1978 and was awarded his Ph.D. from the same institution in 1987. He is Associate Professor and Director of the Optical Fibre Sensors Research Centre at University of Limerick, which he founded in 1996. He is Fellow of Institute of Physics, IET and Senior member IEEE. He has authored and co authored more than 70 journal papers and made in excess of 300 contributions to international conferences. He currently holds 7 patents on Optical Fibre Sensor Devices. In 2005 he was recipient of the University of Limerick Special Achievement in Research Award and was a Fulbright Scholar with CREOL (University of Central Florida) in 2008. He was Distinguished Lecturer for IEEE Sensors Council for the period July 2013-June 2015 and General Chair of the recent European Workshop on Optical Fibre Sensors (EWOFS2016) held at University of Limerick, Ireland.

All-Fiber Optoelectronic Devices Based on Low Dimensional Materials and Sensing Applications

Fei Xu
Nanjing University, China

Note

ABSTRACT

All-fiber optoelectronic devices have attracted great interest, however, most of those applications are severely limited because of the challenge of integrating optoelectronic materials (e.g., silicon and germanium) onto standard silica fibers. On the other hand, low-dimensional materials (LDMs) exhibit many extraordinary optoelectronic and optomechanical properties, are well suited for integration in not only planar photonic circuits but also optical fibers, especially microfibers. Here we will show several kinds of LDM-fiber-integrated devices and the optoelectronic and sensing applications (e.g., NEMS, modulator, and detector) will also be discussed.

BIOGRAPHY

Dr. Fei Xu received his Ph.D. in Optoelectronics in 2008 from the Optoelectronics Research Centre, University of Southampton, UK. He is currently a professor at the College of Engineering and Applied Sciences, Nanjing University, China. Dr. Xu's current research interests include developing novel fiber devices for ultra-small sensor and laser systems, and optomechanical effect in nano-scale waveguide systems. He received an award through the Program for New Century Excellent Talents in university run by the Ministry of Education of China, as well as the Program for Excellent Young Scientists run by the National Science Fund of China. To date, he has authored or coauthored 7 book chapters, granted >20 patents (China and US), and >100 peer reviewed articles in academic journals. His papers have been cited for more than 1,700 times (WOS).

Wei Jin
The Hong Kong Polytechnic University, China

Session 2

Note

Fiber-Enhanced Photothermal Interferometry for High Sensitivity Gas Sensing

ABSTACT

Recent progress in a novel gas sensing technique - fiber-enhanced photothermal interferometry is reported. The basics of photothermal phase modulation with contentiously wavelength/intensity modulated and pulsed pump laser sources are described, and various interferometric probe configurations for phase detection are discussed. The technique has ultra-high sensitivity and dynamic range, and the measurement is not affected by scattering and other non-absorbing losses. Sensors based on such a technique can be made compact in size with remote detection, multiplexing and networking capability. The all fiber configuration operated in the near infrared wave band enables practical and low cost systems, which could be useful for a range of high performance applications in environmental, medical and safety monitoring.

BIOGRAPHY

Wei Jin received a Ph.D. degree from University of Strathclyde, UK，in 1991. He worked as a Research Fellow at Strathclyde and joined The Hong Kong Polytechnic University (HK PolyU) in 1996. He is currently Chair Professor of Photonic Instrumentation. He has worked on various optical fiber components and sensor systems and is currently focused on micro- and nano-structured fiber devices for sensing applications. He edited two books, delivered over 70 invited/keynote/plenary talks, and published over 260 journal papers. He received HK PolyU President's Award for Outstanding Research Performance/Achievement, PolyU's Outstanding Professional Services and Innovation Award, as well as Chiang-Jiang Chair Professor and Distinguished Young Scholar Award (Category-B). He is a fellow of OSA.

Plasmonic Fiber-Optic Sensors

Tuan Guo
Jinan University, China

ABSTRACT

Surface plasmon resonance (SPR) optical fiber sensors can be used as a cost-effective and relatively simple-to-implement alternative to well established bulky prism configurations for in-situ high sensitivity biochemical and electrochemical measurements. The miniaturized size and remote operation ability offer them a multitude of opportunities for single-point sensing in hard-to-reach spaces, even possibly in vivo. In this talk, we briefly review our recent developments of plasmonic tilted fiber grating sensors, including the surface affinity studies of biomolecules for real life problems, electrochemical actives of electroactive biofilms for clean energy resources, the vector magnetic field measurement and the ultra-highly sensitive plasmonic sensing in gas.

BIOGRAPHY

Tuan Guo is a Professor in the Institute of Photonics Technology, Jinan University, Guangzhou, China. He received the Ph.D. in Optics from Nankai University in 2007. Thereafter he worked as a Postdoctoral Fellow with the Department of Electronics at Carleton University (Canada) and the Photonics Research Centre at The Hong Kong Polytechnic University. He joined the Jinan University as an Associate Professor in 2011 and promoted to a full Professor in 2014. He has authored and coauthored more than 120 papers in the peer-reviewed international journals (included 4 invited review papers) and presented over 20 invited talks at international and national conferences. He holds 15 patents and pending patents. His research activities include optical fiber sensors, fiber lasers, fiber gratings, plasmonics, biophotonics, optofluidics. He was an Associated Editor for *Journal of Sensors* from 2010 to 2014 and a Guest Editor for a Special Issue on “Recent Advances in Fiber Bragg Grating Sensing” in *MDPI Sensors* in 2016. He is a Senior Member of IEEE and Senior Member of OSA.

Note

Xinyu Fan
Shanghai Jiao Tong University, China

Session 2

Note

Distributed Fiber-Optic Sensing with Ultra-High Spatial Resolution by Using Linear Optical Sampling Technique

ABSTRACT

Pulse compression technique is a particularly competitive method that enables both high spatial resolution and dynamic range in coherent radar and distributed fiber sensing systems. In this talk, we propose an all-optic sub-THz-range linearly chirped optical source and a large-bandwidth detection system to characterize it. Taking advantage of the chromatic dispersion effect, ultrashort optical pulses are stretched to be ~10 ns linearly chirped pulses with sub-THz range, which yields a large time-bandwidth product of 4500, a high compression ratio of 4167 and a chirp rate of 45 GHz/ns. The generated waveform is characterized with high precision thanks to the large detection bandwidth of linear optical sampling technique. A spatial resolution of 120 microns and an extinction ratio of 20.4 dB is demonstrated by using this technique, which paves the way for ultra-high spatial resolution and long range sensing applications such as LIDAR and optical reflectometry.

BIOGRAPHY

Prof. Xinyu Fan received his B.Sc. in Applied Physics (2000), M.Sc. in Optical Engineering (2003), from Shanghai Jiao Tong University, China, and a Ph.D. degree in Electrical Engineering (2006) from the University of Tokyo, Japan. In 2006, he joined NTT Laboratories as a research scientist. In 2012, he joined Shanghai Jiao Tong University as a professor in the Department of Electronic Engineering.

His research interest focuses on optical fiber sensors, fiber applications, special optical fiber, fiber devices and systems, optical information processing. Prof. Fan has published over 100 journal articles and filed over 20 patents.

Marcelo A. Soto
EPFL Swiss Federal Institute of Technology
Lausanne, Switzerland

Note

Distributed Temperature and Strain Sensing Based on Fibre Birefringence Measurements Using Coherent Rayleigh Scattering

ABSTRACT

The strong dependence of coherent Rayleigh scattering on refractive index changes offers interesting possibilities to perform highly-sensitive distributed optical fibre sensing. Although this high sensitivity can lead to very low temperature and strain uncertainties, it also imposes serious constraints to real implementations. In this talk, a method to measure the distributed profile of the fibre birefringence will be presented based on coherent Rayleigh scattering. The method uses a polarisation-resolved coherent optical time-domain reflectometer (COTDR) and solves some of the limiting factors of the standard COTDR-based sensors. Experimental results demonstrate distributed temperature and strain sensing with resolutions in the order of tens of mK and hundreds of nε, respectively. Contrarily to conventional COTDR, the method allows for absolute temperature and strain measurements, as well as an extended measurand range. An approach for temperature-strain discrimination will also be discussed.

BIOGRAPHY

Marcelo A. Soto received his Ph.D. degree in Information and Communication Technologies from Scuola Superiore Sant'Anna, Pisa, Italy, in 2011. He is currently a Postdoctoral Researcher in the Group for Fibre Optics at EPFL Swiss Federal Institute of Technology Lausanne, Switzerland, where he has been working on high-performance Brillouin and Rayleigh distributed fibre sensing, nonlinear fibre optics, optical signal processing, and optical Nyquist pulse generation. Dr. Soto is author or co-author of about 140 scientific publications, 1 book chapter and 8 patents. He is member of the Review Board of major international journals in optical fibre sensing and photonics, and member of the Technical Program Committee of two major scientific conferences in optical fibre sensing.

Zinan Wang
University of Electronic Science and Technology of China, China

Session 2

Note

Enabling Technologies for Ultra-Long-Distance Distributed Fiber-Optic Sensing

ABSTRACT

Distributed fiber-optic sensing (DFOS) has drawn great attention in both academic research and industrial applications due to its unique advantages. Recent progress in ultra-long-distance DFOS, mainly on Brillouin optical time-domain analysis (BOTDA) and phase-sensitive optical time-domain reflectometry (Φ-OTDR), is discussed in this talk, including research progress and real-life applications.

BIOGRAPHY

Zinan Wang received the Ph.D. degree from Beijing University of Posts and Telecommunications, China, in 2009 (During 2007-2009, he was with Alcatel-Lucent Bell Labs as a visiting student). He was with Cornell University, as a postdoctoral research associate during 2009-2010. He joined University of Electronic Science and Technology in 2010, and became a full professor since 2015. His research interests include distributed fiber sensing and nonlinear fiber optics. He has published more than 100 papers in international journals and conference proceedings, and he is holding 10 Chinese patents and 1 US patent. He has given more than 10 invited talks at international conferences, and his research was highlighted in 'Optics in 2014' by OSA Optics and Photonics News. Zinan Wang is an Associate Editor for *IEEE Photonics Technology Letters*, and he is an IEEE Senior Member.

Distributed Brillouin Sensors Based on Direct Current Modulation of a Laser Diode

Kwang Yong Song
Chung-Ang University, China

Note

ABSTRACT

Distributed Brillouin sensors providing a long-distance real-time strain and temperature monitoring of large civil structures and materials have attracted considerable attention in photonics communities with the growth of the need for secure and safe societies. In this talk the progress in Brillouin optical time- and correlation domain analysis systems adopting direct current modulation of a laser diode will be reviewed, where the direct current modulation provides unique features such as uniform Brillouin gain along the fiber or replacement of microwave devices for realizing high performance and cost-effective sensor systems.

BIOGRAPHY

Kwang Yong Song received the Ph.D. degree in Physics from Korea Advanced Institute of Science and Technology (KAIST) in 2003. He worked as a post-doctoral researcher in KAIST and moved to Nanophotonics and Metrology Laboratory in Ecole Polytechnique Federale de Lausanne (EPFL), Switzerland where he researched distributed fiber sensors based on Brillouin scattering and started pioneering work on Brillouin slow light. In 2005, he joined the Dept. of Electronic Engineering, University of Tokyo as a research fellow. In 2007, he moved to Dept. of Physics, Chung-Ang University in South Korea where he currently works as a full professor. His research area includes distributed fiber sensors based on Brillouin scatterings, applications of Brillouin dynamic gratings and nonlinear optical phenomena in few-mode fibers. Prof. Song is an author or coauthor of more than 140 international journal and cofnerence papers.

Liyang Shao
Southwest Jiaotong University, China

Session 2

Note

Recent Advances in Distributed Fiber Sensors

ABSTRACT

Distributed fiber sensors have attracted wide attention because of the unique capability to achieve high-performance strain and temperature measurements over long distance. We focused on the Brillouin optical time domain analysis (BOTDA) sensors and phase-sensitive optical time domain reflectometry (f-OTDR). Coherent BOTDA system with phase modulation (PM), single sideband (SSB) intensity modulation, and differential detection has been developed to suppress the chromatic dispersion (CD) effect and phase jitter. For the dynamic sensing based on f-OTDR, self-mixing demodulation scheme avoids generating a local signal and eliminates the local oscillator frequency drift, which realizes a simplee and more cost-effective system. Moreover, multiple vibrations with high frequency have been determined by using a hybrid structure based on f-OTDR and Mach-Zehnder interferometer.

BIOGRAPHY

Professor. Liyang Shao received his Ph.D. degree in Optical Engineering in 2008 from Zhejiang University, China. From 2001 to 2003 he was with O-NET Communications Ltd. and Focused Photonics Ltd., as a research engineer. He was with The Hong Kong Polytechnic University, as a research assistant/associate working on fiber grating devices and sensors. Then, he has worked as a Post Doctoral Fellow with the Department of Electronics at Carleton University in Canada. In 2011, He returned to The Hong Kong Polytechnic University for another postdoctoral research project. In 2012, he was granted the Endeavor Research Fellowship from Australian government and worked with the Interdisciplinary Photonics Laboratory in the University of Sydney. In 2013, he joined the Center for Information Photonics and Communication in Southwest Jiaotong University as a full professor. In 2015, he was granted “the Thousand Talents Plan” (Young Professionals).

His research interests include fiber grating and sensors, distributed fiber optic sensing, microwave photonics for sensing, smart sensing systems for railway industry.

Applications of Fiber Optic Sensors in Geophysics and Seismology

Wentao Zhang
Institute of Semiconductors, Chinese Academy of Sciences, China

Note

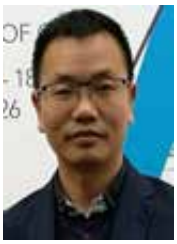
ABSTRACT

Fiber optic sensors have become promising instruments in geophysics and seismology research due to their high sensitivity, water resistance, feasibility in signal transmission and multiplexing, and low power. In this paper, we report the applications of optical fiber ocean bottom seismometer (OOBS), optical fiber seismometer and strainmeters. The field trials are performed. The test results show the fiber optic sensor based instruments have good performance and reliability.

BIOGRAPHY

Wentao Zhang received the Ph.D. degree in optics from the Institute of Semiconductors, Chinese Academy of Sciences, Beijing, China, in 2008. He is the winner of the Lujiaxi Young Scientist Prize and is the member of the Youth Innovation Promotion Association, CAS and Beijing Nova Program.

He is currently a Professor of Physics with the Institute of Semiconductors, Chinese Academy of Sciences. He has co-authored over 120 publications in journals and conference proceedings. His current research interests include optical fiber sensing technology and applications in the fields of geophysics, seismology, marine, and structural health monitoring.



Tao Zhu
Chongqing University, China

Session 2

Note

Parameters-Tuning of Fiber Lasers

ABSTRACT

Parameters-tuning of free-running fiber lasers in frequency or temporal domains has drawn considerable attention due to wide applications in fiber communications and sensing, micro-photonics, optical signal processing, and bio-chemistry etc. In the frequency domain, we utilize multiple weak feedback methods to achieve ultra-narrow linewidth lasers. Fiber laser with linewidth less than 100 Hz is obtained based on Rayleigh scattering originating from the interaction of photons with local material fluctuations. The proposed linewidth narrowing method can also be applied to semiconductor lasers, and distributed feedback laser with linewidth of 1 kHz is achieved. Meanwhile, in the temporal domain, we propose several schemes for high power mode-locked fiber lasers. We fabricate a new kind of saturable absorber with ultra-high thermal damage threshold, and femtosecond fiber laser with average power larger than 1 W is obtained. We also investigate the nonlinear response of graphene, and find that both incoherent and coherent optical modulation can be realized with different operating conditions. Through phase tuning of the graphene-hybrid structures, the wavelength, pulse width, and polarization of ultra-fast fiber lasers can be manipulated flexibly.

BIOGRAPHY

Zhu Tao received the Ph.D. degree in Optical Engineering from Chongqing University, Chongqing, China, in 2008. During 2010-2011, he was a Postdoctoral Research Fellow at the Department of Physics in University of Ottawa, Canada. Since April 2011, he has been a professor of Chongqing University, China. He has published over 200 papers in international journals and conference proceedings. His research focuses on fiber lasers, fiber devices, and optical fiber sensing technology.

Recent Advances of Brillouin Sensing Technology Using Plastic Optical Fibers

Yosuke Mizuno
Tokyo Institute of Technology, Japan

ABSTRACT

Plastic optical fibers (POFs) are expected to add a number of unique advantages to conventional Brillouin-based distributed sensing systems. In this presentation, we review the recent advancement of POF-based Brillouin sensing research. First, we briefly explain the sensing properties of Brillouin scattering in POFs, including a so-called “memory” function and a “frequency-shift-hopping” effect. Then, we present our latest demonstrations of POF-based distributed Brillouin sensing of strain and temperature, from high-spatial-resolution measurement to high-repetition-rate measurement. Finally, some on-going experiments (pressure and humidity sensing) are introduced, and the future prospects for practical applications are discussed.

BIOGRAPHY

Yosuke Mizuno received the B.E., M.E., and Dr.Eng. degrees in electronic engineering from the University of Tokyo in 2005, 2007, and 2010, respectively. From 2007 to 2010, he worked on Brillouin optical correlation-domain reflectometry (BOCDR) for his Dr.Eng. degree. From 2010 to 2012, as a JSPS Research Fellow (PD), he worked on polymer optics at Tokyo Institute of Technology as well as at BAM, Germany. Since 2012, he has been an Assistant Professor at Tokyo Institute of Technology, where he is active in fiber-optic sensing, polymer optics, and ultrasonics. He has authored more than 100 refereed journal papers and has given more than 20 invited talks at international conferences including OFS-23, APOS 2016, and OFS-25. In 2016, he achieved real-time one-end-access distributed Brillouin sensing using glass fibers (published in *Light: Science & Applications*), and he is currently attempting to add the numerous advantages of plastic optical fibers to this high-speed measurement system.

Note

Feng Wang
Nanjing University, China

Session 2

Note

Recent Advances of Polarization Sensitive Optical Time Domain Reflectometry

ABSTRACT

Polarization sensitive optical time domain reflectometry has advantages such as good sensitivity, low false alarm rate, low cost, and long sensing distance . Due to the correlation of the state of polarization (SOP) of optical lightwave in fiber, the signal induced by the first disturbance on fiber would emerge on all of the fiber behind the perturbation point, which makes it hard to detect the other disturbances. We have proposed an adopted wave-plate model which can simulate the signal of POTDR better, and has developed several techniques which can improve the performance of POTDR, including detecting multiple vibrations with the same frequency.

BIOGRAPHY

Dr. Feng Wang received the B.Sc. degree in Optics and Ph.D. degree in Microelectronics and Solid State Electronics from Nanjing University, Nanjing, China in 2003 and 2009 respectively. From 2007 to 2008, he has studied at University of Ottawa, Canada, and in 2014, he has been a visiting scholar at Aston University, UK, both granted by the CSC. He is currently an associate professor at the College of Engineering and Applied Sciences, Nanjing University, China, and the deputy director of Institute of Optical Communication Engineering, Nanjing University. He has coauthored the first book introducing the distributed optical fiber sensing techniques in China. His research interests include distributed optical fiber sensing and fiber grating based sensors. He has authored and co-authored more than 50 articles, and more than 20 inventions.

Dr. Wang has won the first class of the Technological Invention Award of the Ministry of Education of the People's Republic of China in 2012, and the first class of the Wu Wenjun Artificial Intelligence Science and Technology Progress Award in 2015.

Miniature Lab on/in Optical Fiber

Dongning Wang
China Jiliang University, China

ABSTRACT

Miniature lab on/in fiber is featured with ultra-compact size, high sensitivity, convenient operation and versatile sensing capability. This talk will present our work carried out in the design and construction of miniature lab on/in fiber, and its applications in photonic sensing.

BIOGRAPHY

Dongning Wang received the B.Sc. degree in telecommunications from the Beijing University of Posts and Telecommunications, China, in 1982, the MBA degree from the University of Ulster, UK, in 1989, and the Ph.D. degree from City University, London, UK in 1995. His main research interests include ultrafast optics, femtosecond laser micromachining, fiber lasers and optical fiber sensors. He has more than 170 international journal publications.

Note

Yiping Wang
Shenzhen University, China

Session 2

Note

In-Fiber Air Bubbles and Applications

ABSTRACT

The optical fiber devices based on different types of air bubbles in-fiber are discussed in terms of principle of operation, fabrication methods, sensing applications and tunable whispering gallery modes. Part I (gas pressure measurement): firstly, we demonstrate a fiber-tip air bubble with a sub-micron silica diaphragm based Fabry-Perot interferometer for pressure sensing applications. The all-silica spherical structure enhanced the mechanical strength of the micro-cavity sensor, making it suitable for high sensitivity pressure sensing in harsh environment. Secondly, we demonstrate an ultrahigh-sensitivity gas pressure sensor based on the Fabry-Perot interferometer employing a fiber-tip diaphragm-sealed cavity. The cavity is comprised of a silica capillary and ultrathin silica diaphragm with a thickness of 170 nm and a gas pressure sensitivity of 12.22 nm/kPa, which is more than two orders of magnitude greater than that of a similarly configured fiber-tip air bubble sensor. Part II (tensile strain measurement): firstly, a strain sensor, based on an in-fiber Fabry-Perot interferometer with an air bubble cavity, was created by splicing together two sections of standard single mode fibers. The sensitivity of this strain sensor was enhanced to 6.0 pm/με by improving the cavity length of the Fabry-Perot interferometer by means of repeating arc discharges for reshaping the air cavity. Secondly, a unique rectangular air bubble was fabricated, by means of splicing two sections of standard single mode fibers together and tapering the splicing joint. Such an air bubble can be used to develop a promising high-sensitivity strain sensor based on Fabry-Perot interference. The sensitivity of the strain sensor was measured to be up to 43.0 pm/με. Part III (tunable whispering gallery modes): we demonstrated the first optical microresonator based on an in-fiber rectangular air bubble created by means of splicing two sections of standard single mode fibers. Such an optical microresonator supports the whispering-gallery modes (WGMs) with a small mode volume and a high quality factor exceeding 10^6, and strain-based fully tuning of WGMs in this resonator is demonstrated.

BIOGRAPHY

Yiping Wang is a Distinguished Professor and a Pearl River Scholar in College of Optoelectronic Engineering, Shenzhen University, Shenzhen, China. He was born in Chongqing, China, in July 15, 1971. He received the Ph.D. degree in Optical Engineering from Chongqing University, China, in 2003, where he received the prestigious award of the National Excellent Doctoral Dissertations of China.

In 2005, he joined The Hong Kong Polytechnic University, Hong Kong, as a postdoctoral research fellow and a research fellow. In 2007, he joined the Institute of Photonic Technology, Jena, Germany as a Humboldt research fellow. In 2009, he joined the Optoelectronics Research Centre, University of Southampton, U.K. as a Marie Curie Fellow. His current research interests focus on optical fiber sensors, in-fiber gratings, photonic crystal fibers, and fluid-filling technologies. He has authored 11 patents, and more than 180 journal and conference papers with a SCI citation of more than 1800 times.

Investigation of Microstructured Fiber Optic Surface Plasmon Resonance Sensor

Wei Peng
College of Physics and Optoelectronic Engineering, Dalian University of Technology, China

Note

ABSTRACT

Fiber optic surface plasmon resonance (SPR) sensing technology has attracted great attention and interest in both SPR and optical fiber sensing fields, which has broad applications in many areas such as medicine and biomedicine, chemistry and environment etc. This talk will present some latest investigations in the theoretical modeling, sensor design, development and application of microstructured fiber optic SPR sensor systems. We will review the research status, major technical problems, and future development trend of this novel fiber optic sensing technology.

BIOGRAPHY

Wei Peng received a doctoral degree in optical engineering from Dalian University of Technology, Dalian, China in 1999. She worked in some typical research groups of optics and fiber optic sensor area in the United states after her graduation. In 2009, she took a professor faculty position in College of Physics and Optoelectronic Engineering at Dalian University of Technology, China. Wei Peng is an author or co-author of more than 100 journal and conference papers, her research interest includes fiber optic sensor, surface plasmon resonance, subwavelength optics, and optical measurement. She is a member of *IEEE*, *OSA* and *SPIE*.

Xinghua Yang
Harbin Engineering University, China

Session 2

Note

Microfluidic In-Fiber Optical Fiber Sensors Based on Hollow Optical Fibers

ABSTRACT

In this presentation, a serious optical fiber sensors based on special designed optical fiber such as twin-core fiber, circular-core fiber, suspended-core fiber will be introduced. We want to demonstrate some preliminary simple prototypes for in-fiber integrated optofluidic sensors based on these optical fibers. These sensors involve the fields of fluorescence, chemiluminiscence, capillary electrophoresis, vertical electrophoresis, magnetofluid, liquid crystal, refractive index detection and gas pressure detection. In fact, most of the sensing processes are realized in the holes of the optical fibers. Then, the integration degree of the microfluidic or on-line detection structure is greatly improved.

BIOGRAPHY

Dr. Xinghua Yang received his B.S. and M.S. degree from Department of Chemistry, Northeast Normal University, Changchun, China in 2002 and 2005 respectively. He received Ph.D. degree from State Key Laboratory of Transient Optics and Photonics, Xi'an Institute of Optics and Precision Mechanics, Chinese Academy of Sciences, Xi'an, China in 2008. Since 2008, he has been working in Key Laboratory of In-Fiber Integrated Optics Ministry of Education, Harbin Engineering University. During 2014-2015, he had been with the College of Optics & Photonics, University of Central Florida) as a visitor.

His research interests are mainly focused on optic fiber sensors, optical functional materials and nanomaterials. He has authored and co-authored over 40 articles mainly in the area of fiber optics and materials science.

CIOP-2017-0940

DPP-BOTDA Based on Double-Peak BGS Technique for Sub-Spatial Resolution Detection in Long-Range Sensing

Diakaridia Sanogo, Yue Pan, Pengbai Xu, Dengwang Zhou, Benzhang Wang, Yongkang Dong
Harbin Institute of Technology

A technique employing a 50-cm spatial resolution DPP-BOTDA sensor based on double-peak BGS technique to locate 50, 20, 10 and 5 cm perturbation sections respectively, at the remote end of 24 km of single mode fiber (SMF) has been investigated. Two types of SMF (main fiber and secondary fiber) with 116 MHz Brillouin frequency shift (BFS) difference have been used. Also, a 5-cm hotspot was resolved at 24016 m with a frequency resolution of 0.54 MHz for 0.5 °C temperature uncertainty while using a sampling rate of only 1GS/s which corresponds to 10 cm/point.
Key words: distributed fiber sensor; high spatial resolution; double-peak BGS, DPP-BOTDA

CIOP-2017-3009

Applications of NKT Ultra Low Noise Fiber Laser in Optical Fiber Sensing

Jie Zhao
Luster

The Koheras fiber lasers are ultra low noise sources with longitudinal single mode and single frequency operation. The lasers are based on a DFB design ensuring robust and reliable operation, and are delivered as fully integrated systems for the industry and scientific community. They offer an unprecedented low phase and intensity noise level, very high stability, and mode-hop free inherent single frequency output – both under stable and uneven environmental conditions. Furthermore, shot noise limited solutions are available for applications demanding a very low intensity noise level.

CIOP-2017-1064

Long Distance Raman Distributed Fiber Temperature Sensing Technology

Jian Li, Mingjiang Zhang, Jianzhong Zhang, Yi Liu
College of Physics and Optoelectronics, Institute of Optoelectronic Engineering, Taiyuan University of Technology

Distributed fiber sensors exploit specific optical effects activated along optical fibers, to obtain a spatially distributed profile of environmental quantities such as temperature, strain, pressure, and electromagnetic fields. This feature offers unique attributes and capabilities compared with conventional discrete sensing methods. With the development of science and technology, the long distance technology is more attractive in the optical sensing system. However, for Raman distributed fiber sensing technology, the sensing distance is limited by the signal-to-noise ratio (SNR) of the system. To increase the sensing distance in self-demodulation Raman distributed fiber sensor, dynamic noise difference algorithm and wavelet transform modulus maximum (WTMM) are proposed to de-noise Raman anti-Stokes signal. The noise doped in Raman anti-Stokes scattering signal is decreased by the wavelet transform modulus maximum, which can increase the sensing distance. Dynamic noise difference algorithm is used to suppress the ground noise of optical receiver, which utilizes the average value of dark current noise floor behind Fresnel reflection to calculate the dynamic ground noise, and then the actual intensity of Raman anti-Stokes can be obtained. By combining dynamic noise difference algorithm with WTMM method in self-demodulation RDTS, not only the influence of modal dispersion between two different light beams on temperature accuracy is eliminated, but also the sensing distance is improved in the experiment. In the experiment, a 29.1 km long sensing distance is achieved.
Key words: optical sensing and sensors; scattering; Raman; Wavelet transform modulus maximum

CIOP-2017-1213

Compact and Sensitive Er^{3+}/Yb^{3+} Co-Doped YAG Single Crystal Optical Fiber Thermometry Based on Upconversion Luminescence

Linhua Ye
Department of Physics, Zhejiang University

Compact and sensitive Er^{3+}/Yb^{3+} co-doped YAG single crystal optical fiber thermometry based on upconversion (UC) luminescence is presented. The thermal probe is a YAG single crystal fiber with end Er^{3+} /Yb^{3+} co-doped by laser heated pedestal growth method. Excited by a 976 nm diode laser, the UC fluorescence intensity ratio (FIR) of the Er^{3+} ions in two emission bands ($2H_{11/2}$,$4S_{3/2}$ →$4I_{15/2}$) was investigated at temperature ranging from 298 K to 723 K. The results illustrate that the maximum temperature sensitivity is approximately 0.00486 K^{-1} at 577 K. Thus, the Er^{3+}/Yb^{3+} co-doped YAG single crystal fiber has potential application in optical thermometry by FIR technique. Furthermore, the thermal probe has compact structure and high thermal stability, making it more convenient and efficient in the applications.
Key words: optical fiber temperature sensor; upconversion emissions; FIR; YAG single crystal fiber; Er^{3+}/Yb^{3+} co-doping

CIOP-2017-1754

Multi-Slope-Assisted Vector BOTDA Based on Frequency-Agile Technique

Dengwang Zhou[1], Yongkang Dong[1], Benzhang Wang[1], Hongying Zhang[2], Zhiwei Lü[2]
[1] Harbin Institute of Technology; [2] Harbin University of Science and Technology

Distributed Brillouin sensing has been widely studied in the diverse fields of structural health monitoring over the past several decades due to its ability to measure the distributed strain and temperature. Recently, the demand for dynamic measurement has dramatically increased in our society. We theoretically analyze and experimentally demonstrate a multi-slope-assisted vector BOTDA system using the frequency-agile technique for the wide-strain-range dynamic measurement. A vector BOTDA system is proposed by polynomial-fitting a dimensionless coefficient *K* spectrum, which is defined as the ratio of the Brillouin phase shift to gain and shows a 200 MHz-monotonous slope for a 30 ns pump pulse, to obtain the distributed Brillouin frequency shift. Then the multi-slope-assisted vector BOTDA system is implemented by frequency-modulating the pump pulses via frequency-agile technique to extend the strain variation range, resulting in a 160 MHz frequency interval which is twice of that of the gain-based BOTDA. In experiment, a dynamic measurement with the strain variation of 5372.9 με and the vibration frequency components of 5.58 Hz and 11.14 Hz is achieved by the multi-slope-assisted vector BOTDA.
Key words: fiber optics sensors; nonlinear optics, fibers; scattering, stimulated Brillouin

CIOP-2017-1065

Distributed Fiber Sensor Based on Chaotic Brillouin Optical Correlation Domain Analysis

Yahui Wang, Mingjiang Zhang, Jianzhong Zhang, Yi Liu
Institute of Optoelectronic Engineering, College of Physics and Optoelectronics, Taiyuan University of Technology

Distributed fiber sensor based on Brillouin scattering possesses the unique ability to measure the profile for long-range distributed strain and temperature by utilizing the ordinary single-mode fiber as sensing element. However, due to the difficulties in combining spatial resolution with large sensing range in current systems, the application of Brillouin scattering-based fiber sensors has been greatly limited. We propose and experimentally demonstrate a chaotic light based Brillouin optical correlation-domain analysis (BOCDA) system for distributed fiber sensor. The utilization of the chaotic laser with partially coherent state ensures high spatial resolution, which can reach a sub-centimeter magnitude. In this work, the chaotic BOCDA system is optimized to further extend the sensing distance based on the stimulated Brillouin scattering of chaos transmitting in sensing fiber. The Brillouin gain spectrum (BGS) of the temperature-dependence is directly obtained by applying a digital optical power meter instead of a real-time oscilloscope, which can increase the measurement range because of eliminating the electronic noise. Based on this configuration, we conducted an experimental study on the variation of the Brillouin frequency shift with temperature by BGS, and achieved the temperature coefficient of 1.24 MHz/℃ , and the distributed sensing along a 906-m fiber is experimentally verified with a spatial resolution of 3.92 cm.
Key words: distributed fiber sensor; Brillouin scattering; chaotic laser

CIOP-2017-1036

Distributed Hydrostatic Pressure Sensor Based on Brillouin Dynamic Grating

Lei Teng
Harbin Institude of Technology

Brillouin dynamic gratings (BDGs) have been, in recent years, addressed using a polarization-maintaining fiber with many prominent advantages and proved that the BDGs have a profound high sensitivity to fiber birefringence changes. When the two parallel polarized counter-propagating pump waves with a frequency offset of fiber Brillouin frequency shift, and the orthogonally polarized probe pulse wave satisfied the phase-matching condition, the BDGs would be excited through stimulated Brillouin scattering and read, while the optical frequency difference between the pump and probe waves is determined by the birefringence. The birefringence-induced frequency shift (BireFS) associated with the impact of external environment may be affected by local static pressure. Though the measurement of the BireFS changes along the fiber, one can realize a distributed fiber static pressure sensing. In our presentation, a temperature-insensitive distributed static pressure sensor based on BDGs is proposed and experimentally demonstrated for the first time, to the best of our knowledge. The measurement principle is to interrogate the static-pressure-induced fiber birefringence changes through generating and mapping the BDGs in the fiber under test (FUT). The experimental setup adopted two pump waves to excite a BDG and a short probe pulse to read the Brillouin grating spectrum associated with the birefringence with a spatial resolution of 20 cm. The sensing technique features a distributed measurement, temperature-insensitivity and high sensitivity to the static pressure. The distributed transverse load measurement experiment is conducted in an temperature-insensitive elliptical-core polarization-maintaining fiber with a measurement accuracy as high as 0.8 x 10^{-3} N/mm; and the distributed hydrostatic pressure measurement experiment is also performed in a thin-diameter pure silica polarization-maintaining photonic crystal fiber with a measurement accuracy as high as 0.025 MPa with a character of temperature compensation.
Key words: distributed measurement; hydrostatic pressure; Brillouin dynamic grating; fiber sensor

CIOP-2017-2405

Ultrahigh Sensitivity Temperature Sensor Based on Mach-Zehnder Interferometer Enhanced Vernier-Effect

Chengcai Tian, Hao Zhang, Xia Xue, Jiaming Liu, Wenxiu Li, Xin Huang, Anping Huang, Zhisong Xiao
Key Laboratory of Micro-Nano Measurement-Manipulation and Physics, Ministry of Education, School of Physics and Nuclear Energy Engineering, Beihang University

A temperature sensor using Mach-Zehnder interferometer (MZI) enhanced Vernier-effect was proposed and theoretically demonstrated with much larger sensitivity enhancement. This configuration, on a compact and standard silicon-on-insulator (SOI) chip, consists of the ring acting as the filter, and the MZI acting as the sensor, which works analogously to a Vernier-scale. The shift of center resonant wavelength of this sensor is larger than a single ring or MZI with approximate three orders of magnitude enhancement factor, which is related to the free space range difference between the filter and sensor interferometer. The proposed sensor has a linear response to the temperature change with an ultrahigh temperature sensitivity of 346 nm/℃ .
Key words: temperature sensor; Vernier-effect; Mach-Zehnder interferometer

CIOP-2017-2458

A Large-Scale Wavelength- and Frequency-Division Multiplexed Fiber Laser Sensor Array

Xiujuan Yu
Heilongjiang University

In this paper, we proposed a large-scale multilongitudinal mode fiber laser sensor array based on the combination of wavelength-division multiplexing and frequency-division multiplexing techniques. In the proposed multiplexing system, there are many different sensing units including many fiber laser sensors with approximately equal laser-operating wavelength but different cavity lengths. The fiber laser sensors in each sensing unit can be interrogated by frequency-division multiplexing technique due to different sensors with different beat frequency. The different sensing units can be demodulated by wavelength-division multiplexing technique because the fiber lasers have different operating wavelength. Thus the light of each sensing unit can be coupled to the designed channel of the dense wavelength-division multiplexers. To verify the proposed multiplexing system, a 4 × 4 fiber sensor laser array was set up and investigated experimentally. The strain or temperature sensing performance of the fiber sensor was successfully monitored. The proposed multiplexing system can dramaticly increase the number of multiplexed sensors and greatly reduce the cost of each fiber laser sensor. It shows great potential for large-scale monitoring applications.
Key words: fiber laser sensor; wavelength multiplexing; frequency multiplexing; sensor array; beat frequency demodulation

CIOP-2017-3002

Research on Distributed Vibration Sensor Based on Φ-OTDR for Real-time Pipeline Safety Monitoring

Xin Liu, Yu Wang, Baoquan Jin*, Qirui Ying, Dong Wang and Yuncai Wang
Key Laboratory of Advanced Transducers and Intelligent Control Systems (Ministry of Education and Shanxi Province), Taiyuan University of Technology, China

Oil/gas pipeline safety monitoring plays an important role in domestic production and life. Distributed vibration sensor based on phase-sensitive optical time domain reflectometer (Φ OTDR) technology is able to monitor vibration information over tens of kilometers, and has attracted wide research attention during the past few decades owing to its outstanding advantages of high sensitivity, accurate positioning, good spatial resolution, and simultaneous multi-point monitoring capability. Traditional Φ-OTDR technology realize vibration position monitoring by demodulation the Rayleigh back scattering curve. However, due to the long monitoring distance, the data amount is very large, and thus the real-time performance is poor.

Aiming at this problem, a high-speed data processing solution is designed, which includes both hardware and software design. The hardware is based on a high performance field programmable gate array (FPGA). Invalid parts between two adjacent Rayleigh back-scattering curves are removed to reduce the data amount and improve the work efficiency. Besides, the working mechanism of synchronous trigger, acquisition and transmission ensures that each back-scattering curve can be collected and transmitted to the host computer. Then, the software implemented in Microsoft Foundation Classes (MFC) receives the data, processes the data and finally displays the results on the host computer in real-time. The experimental platform of the proposed Φ-OTDR setup is built in laboratory. The results demonstrate that the system is able to detect vibration detection over a total fiber length of 12km, with a spatial resolution of 20m and a response time less then 1 s, which shows huge application potential in the field of real-time oil/gas pipeline safety monitoring.
Key words: pipeline safety monitoring; Φ OTDR; FPGA; real-time

CIOP-2017-2009

Fast Maximum Likelihood Estimation of Optical Path Difference from Low-Finesse Optical Interference Spectrum

Yi Qi, Weimin Chen, Juxia Xie, Xiaohua Lei
Chongqing University

To avoid transforming interference spectrum from wavelength domain to wavenumber domain, an evaluation of the optical path difference (OPD) directly from Low-finesse interference spectrum was established via maximum likelihood estimation. The Cramer-Rao bounds for the OPD estimator, which simulates the influence of wavelength sampling rate, wavelength range and signal-to-noise ratios (SNR), were given. A validation experiment was conducted with optical spectrum of extrinsic low-finesse fiber Fabry-Perot sensors. The result shows the validness of this algorithm with the average spectrum sampling rate below 0.4.
Key words: maximum likelihood estimation; low-finesse interference spectrum; average wavelength sampling rate; RMSE

CIOP-2017-3003

A Stable and Compact Scenario to Improve the Performance of a BOTDR

Qing Bai, Yu Zhang, Baoquan Jin*, Xin Liu, Dong Wang, Yu Wang, Yuncai Wang
Key Laboratory of Advanced Transducers and Intelligent Control Systems (Ministry of Education and Shanxi Province), College of Physics and Optoelectronics, Taiyuan University of Technology, China

An Electric Optic Modulator (EOM) is often used to modulate probe optical pulse in a Brillouin optical time domain reflectometer (BOTDR). However, the working point of EOM is easily affected by ambient temperature and thermoelectric effect, for the reason that the pulse light is susceptible to polarization and bias voltage, which always induces an unstable pulse extinction ratio and then affects the accuracy of the system. In view of the above issue, a stable and compact scenario to improve the detection stability is proposed.

In the proposed scheme, an integrated Semiconductor Optical Amplifier (SOA) module is utilized to produce the pulse probe light launched into the sensing optical fiber, instead of using an EOM. Meanwhile, a pulse generator is embedded in the module to drive the SOA as well as to output a synchronous trigger signal possessing the same frequency and phase as the pulse probe light. This configuration can ensure a high and stable pulse extinction ratio, and simultaneously economize an external pulse source and a bias voltage stabilizer along with an EOM. Then, the beat frequency signal is obtained through coherent detection and the Brillouin gain spectrum is figured out via the heterodyne sweeping-frequency approach. Ultimately, the curve of Brillouin frequency shift versus the sensing fiber length is plotted to realize the distributed strain measurement. The experiment results show that the strain measurement accuracy of ±56 με, the temperature measurement accuracy of ±1.5℃ and the spatial resolution of 1.15 m are achieved over a 10.8-kilometer sensing fiber. When the strain is measured repeatedly, the Brillouin frequency shift error is only ±0.5 MHz. Thus the scenario not only improves the detection stability but also compacts the hardware structure of a traditional BOTDR scheme.
Key words: BOTDR, measurement stability, semiconductor optical amplifier, pulse light generator, extinction ratio

Session 3: Biomedical Photonics

Session Chairs: **Qingming Luo**, Huazhong University of Science and Technology, China
Da Xing, South China Normal University, China
Junle Qu, Shenzhen University, China
Buhong Li, Fujian Normal University, China
Zhongping Chen, University of California, Irvine, USA

Location: B513, 5F, Main Building, Harbin Institute of Technology No.2 Campus

18th July

Chair: Zhen Yuan, The University of Macau, China

14:00-14:45	**Intravascular Photoacoustic Tomography—A New Clinical Technology for Detecting Vulnerable Plaque (Keynote)** Da Xing *South China Normal University, China*	- 45 -
14:45-15:15	**Super-Resolution Optical Imaging: 3D, Multiparticle Parallel Tracking and Time-Resolved Imaging (Invited)** Junle Qu *Shenzhen University, China*	- 46 -
15:15-15:45	**Theranostics with Radiation-Induced Ultrasound (Invited)** Liangzhong Xiang *University of Oklahoma, USA*	- 47 -
15:45-16:00	**Coffee Break**	

Chair: Da Xing, South China Normal University, China

16:00-16:30	**Multi-Contrast Photoacoustic Tomography (Invited)** Zhen Yuan *The University of Macau, China*	- 48 -
16:30-17:00	**Singlet Oxygen Detection *in vitro* and *in vivo* (Invited)** Steffen Hackbarth *Humboldt-Universität zu Berlin, Germany*	- 49 -
17:00-17:30	**(TBA) (Invited)** Ken-Tye Yong *Nanyang Technological University, Singapore*	- 50 -
17:30-17:45	**Easier Implement of SC Laser Based Super-Resolution STED Microscope (Oral)** Jinghe Yuan *Institute of Chemistry, CAS, China*	- 62 -
18:00-19:00	**Dinner Time**	

19th July

Chair: Junle Qu, Shenzhen University, China

09:00-09:45	**20 Years of Doppler OCT and OCT Angiography —Past, Present, and Future (Keynote)** Zhongping Chen *University of California, Irvine, USA*	- 51 -
09:45-10:15	**Noninvasive Monitoring of Nanoparticle Clearance and Aggregation in Blood Circulation by *in vivo* Flow Cytometry (Invited)** Xunbin Wei *Shanghai Jiao Tong University, China*	- 52 -
10:15-10:30	**Methods to Improve the Performances of the Swept Source at 1.0 μm Based on Polygon Scanner (Oral)** Junli Chang, Jing Cao, Pinghe Wang *University of Electronic Science and Technology of China, China*	- 62 -
10:30-10:45	**NKT Supercontinuum Product Introduction and Its Application (Oral)** Qi Wang *NKT Photonics*	- 62 -
10:45-11:00	**Coffee Break**	

Chair: Zhongping Chen, University of California, Irvine, USA

11:00-11:30	**Nonlinear Optical Interactions for Phototheranostics (Invited)** Tymish Y. Ohulchanskyy *Shenzhen University & University at Buffalo*	- 53 -
11:30-12:00	**Ultra High-Resolution Imaging of Whole Organisms Using Light-Sheet Fluorescent Microscopy (Invited)** Peng Fei *Huazhong University of Science and Technology, China*	- 54 -

19th July

12:15-14:00	**Lunch Time**	
Chair: Tymish Y. Ohulchanskyy, Shenzhen University & University at Buffalo		
14:00-14:30	**Skull Optical Clearing Techniques for Cortical Imaging in Mice (Invited)** Dan Zhu *Huazhong University of Science and Technology, China*	- 55 -
14:30-15:00	**Optical Techniques Monitoring Clinical Photodynamic Therapy Dosimetry (Invited)** Buhong Li *Fujian Normal University, China*	- 56 -
15:00-15:30	**Photoactivatable Nanotheranostics (Invited)** Peng Huang *Shenzhen University, China*	- 57 -
15:30-15:45	**Coffee Break**	
15:30-17:30	**Poster**	
18:00-20:00	**Banquet**	

20th July

Chair: Liang Song, Shenzhen Institutes of Advanced Technology, CAS, China

09:00-09:30	**Super-Resolution: Better, Deeper, and Richer Information (Invited)** Peng Xi *Peking University, China*	- 58 -
09:30-10:00	**All-Optical Photoacoustic Microscopy for Biomedical Applications (Invited)** Sihua Yang *South China Normal University, China*	- 59 -
10:00-10:30	**Improving Fluorescence Biosensor by Micro/Nano Photonic Structures (Invited)** Zhihui Chen *Taiyuan University of Technology, China*	- 60 -
10:30-10:45	**Local Field Enhancement Tuning of Horseshoe-Shaped Nanoparticles (Oral)** Zhiyuan Du, Bin Hu *Beijing Institute of Technology, China*	- 62 -
10:45-11:00	**Coffee Break**	
Chair: Peng Xi, Peking University, China		
11:00-11:30	**Photoacoustic Imaging: Technology Development towards Clinical Translations (Invited)** Liang Song *Shenzhen Institutes of Advanced Technology, CAS, China*	- 61 -
11:30-11:45	**Phase and Amplitude Correction in Polygon Tunable Laser-Based Optical Coherence Tomography (Oral)** Haiyang Luo, Pinghe Wang, Guohua Shi *University of Electronic Science and Technology of China, China*	- 63 -
11:45-12:00	**Solutions to Advanced Multiple Configuration Systems Resolution in Imaging Sensors (Oral)** Liu Hua, Quanxin Ding *Science and Technology on Electro-optic Control Laboratory, China*	- 63 -
12:15-14:00	**Lunch Time**	

Intravascular Photoacoustic Tomography—A New Clinical Technology for Detecting Vulnerable Plaque

Da Xing
South China Normal University, China

Note

ABSTRACT

Photoacoustic imaging, combining high optical contrast and high spatial resolution of ultrasound, is a very promising imaging modality for biomedical diagnostics, as the optical properties of tissue that are closely related to the physiological and pathological status of tissues can be reconstructed. In past years, the applications of photoacoustic imaging have covered a wide range of pathologies and organs, and are more and more often performed in vivo. This talk presented the new progress in photoacoustic imaging towards pre-clinical and clinical application. Photoacoustic microscopy was employed to study the microvasculature, catheter-based hybrid in-vivo intravascular photoacoustic imaging system was developed for characterization of spatial and quantitative features of lipid-rich plaques, and phase-resolved photoacoustic viscoelasticity imaging provides biomechanical properties of biological tissues, which has great potential for characterization of vulnerability atherosclerotic plaque.

BIOGRAPHY

Da Xing received the Doctor degree in Engineering from Harbin Institute of Technology, China, in 1989 and Ph. D degree in Physics from University of Electro-Communications, Japan, in 1991. He joined the faculty of UEC as an Assistant Professor in 1991 and an Associate Professor from 1993 with the Department of Electrical Engineering. Since 1995, he has gone back to China and became the Director and professor of Institute of Laser Life Science, South China Normal University. He got the Prime Minister's Fund for Distinguished Young Scholars in 1997, and the Natural Science Award of Guangdong Province in 2000, 2002, 2005, 2008 and 2009, the Natural Science Award of Ministry of Education, China in 2012. He has published more than 300 peer-reviewed journal papers, more than 150 book chapters and reviewed full proceedings, and more than 30 major invited talks of international conferences. His present research activities are Biophotonics, including Bio-Molecular Spectroscopy, Noninvasive Photoacoustic Imaging, Microfluidics, and Optical Imaging of Biometabolism.

Junle Qu
Shenzhen University, China

Super-Resolution Optical Imaging: 3D, Multiparticle Parallel Tracking and Time-Resolved Imaging

ABSTRACT

This talk will review the recent progress in super-resolution optical microscopy and present our recent work in this field. A 3D super-resolution optical microscope equipped with a real-time and high precision drift prevention device has been developed. The capability of this microscope to directly visualize a specific nonrepetitive DNA segment as short as 2.5 kb or even less within the human genome has been demonstrated, which allows in principle 3D super-resolution visualization of any functional cis-regulatory element, including promoter, enhancer, and CTCF-mediated loop, on open chromatin in single human cells. We achieved multiparticle parallel localization and tracking in transparent sample thicker than 10 μm using a distorted grating and a double-helix PSF device. Coherent adaptive optical technique (COAT) has been implemented in a stimulated emission depletion (STED) microscope to circumvent the scattering and aberration effect for thick sample imaging. In addition, by coming single molecule localization microscopy and acoustic optical deflector (AOD) based lifetime measurement, a dynamically moving single particle and its local microenvironment along its trajectory can be obtained.

BIOGRAPHY

Junle Qu received his Ph.D. degree in Physical Electronics from Xi'an Institute of Optics and Precision Mechanics, Chinese Academy of Sciences in 1998. He is currently a professor of Optical Engineering in Shenzhen University. He is the Dean of College of Optoelectronic Engineering of Shenzhen University and Director of Key Laboratory of Optoelectronic Devices and Systems of Ministry of Education and Guangdong Province. Prof. Junle Qu's research interests include nonlinear optical microscopy, fluorescence lifetime imaging, superresolution optical imaging and their applications in biomedicine. He has published over 90 scientific papers in peer-reviewed journals such as *Nature Photonics*, *Advanced Materials*, *Chemical Society Review*, *Journal of American Chemical Society*, *Theranostics*, *Optics Letters* etc., and holds 20 issued patents, including 2 US and 1 international patents. He is a senior member of SPIE and Chinese Optical Society. He is also the director of Biomedical Photonics Committee of Chinese Optical Society. Prof. Junle Qu serves on the editorial board of several journals including *Medical Photonics*, *Journal of Innovative Optical Health Sciences* and *Acta Laser Biology Sinica*. He has delivered more than 50 invited talks at various conferences and research institutions.

Note

Liangzhong Xiang
University of Oklahoma, USA

Theranostics with Radiation-Induced Ultrasound Emission (TRUE)

ABSTRACT

We look for novel ways to create new imaging modalities to push biomedical imaging forward. Especially, we look for other ways to generate ultrasound for imaging, in addition to laser-induced photoacoustic imaging. To break through the photoacoustic imaging depth limit, we use an X-ray excitation source as opposed to visible light, therefore developing a novel imaging modality, called X-ray-induced acoustic computed tomography (XACT). To break through the photoacoustic imaging resolution limit (~200 nm), we are developing a super-resolution photoacoustic tomography to push the imaging resolution down to 20 nanometers. We expect these new imaging techniques to find widespread applications in both fundamental and applied sciences including biomedical research.

BIOGRAPHY

Dr. Liangzhong Xiang is an Assistant Professor in the School of Electric and Computer Engineering, Biomedical Engineering Center, and Stephenson Cancer Center at University of Oklahoma. He was the PI of the U.S. Department of Defense (DoD) Postdoctoral Training Program grant at Stanford Medical School (2012-2015) before joining OU.

Dr. Xiang's research interest is the development of novel biomedical imaging techniques, including laser-induced photoacoustic tomography (PAT), X-ray-induced acoustic computed tomography (XACT), proton-induced acoustics and other radiation induced acoustic emission for cancer imaging and therapy monitoring.

Dr. Xiang has received many awards and honors for his work, including the SPIE Travel Scholarship Award (2016), RSNA Research Prize (2015), DoD Prostate Cancer Research Program Award (2013), and the Slvia Sorkin Greenfield Award for the best paper of the *Medical Physics* at AAPM 50th Annual Meeting (2008). He is a member of the OSA, SPIE, AACR, RSNA and AAPM, and has served as an associate editor of *Medical Physics* journal.

Note

Zhen Yuan
The University of Macau, China

Multi-Contrast Photoacoustic Tomography

ABSTRACT

Photoacoustic tomography (PAT) is a non-invasive, non-ionizing, and inexpensive monitoring and imaging technique that uses near-infrared light and acoustic measurements to probe tissue optical properties. Regional variations in oxy- and deoxy-hemoglobin concentration as well as blood flow can be imaged by monitoring spatial-temporal variations in the light absorption and acoustic pressure, giving PAT the special ability to directly measure the quantitative hemodynamic, metabolic, optical and mechanical parameters and neuronal responses to cells (neurons), tissues and organs activation with high spatial and temporal resolution as well as good penetration depth. These capabilities make PAT a unique stand-alone imaging tool and useful complement to fMRI, PET and EEG/MEG in studies of normal physiology and pathology. In this talk, Dr. Yuan will mainly talk about his research work on the development of novel quantitative photoacoustic tomography imaging techniques, which involve the optical absorption, scattering, physiology, mechanical and molecular contrasts.

BIOGRAPHY

Professor Yuan is the Director of Bioimaging Core with the Faculty of Health Sciences at the University of Macau. Before joining University of Macau, he had worked as a clinical assistant professor in the Arizona State University (08/2012-08/2013) and research assistant professor at University of Florida (09/2007-08/2012). He received his Ph.D. degree in Mechanical Engineering from University of Science and Technology of China in 2002. Between 2002 and 2007, he had received several postdoc trainings in different institutes including National University of Singapore (2002-2004), Clemson University (2005) and University of Florida (2005-2007). His academic investigation is focused on cutting-edge research and development in laser, ultrasound and EEG/fMRI-related biomedical technologies including fNIRS, OCT, photoacoustic tomography/microscopy, and diffuse optical tomography in biomedical optics field. He, as the principal or co-investigator for the above research activities, has achieved national and international recognition through more than 100 SCI publications in different international journals in his field. He is the senior member of SPIE and OSA.

Note

Singlet Oxygen Detection in vitro and in vivo

Steffen Hackbarth
Humboldt-Universität zu Berlin, Germany

Note

ABSTRACT

With growing knowledge about singlet oxygen and its interactions with biological material as well as the increasing number of clinical applications, the desire grew to directly observe the mediator of photosensitization and impact thereof. A large selection of methods has been developed worldwide, trying to reach a certain singlet oxygen activity imaging for a variety of samples, from suspensions to subcellular microscopy. However, such observations come along with a number of problems and obstacles, leaving the detection of the characteristic phosphorescence at around 1270 nm as the only realistic option to reach the intended goal. The presentation will give an overview on most recent results as well as an outlook on what might come next and discuss physical limits of detection.

BIOGRAPHY

Dr. Steffen Hackbarth got his diploma in physics in 1995 from Humboldt University Berlin, where he also finished his Ph.D. in 2000 in the Photobiophysics Group of Prof. Röder. Ever since then his work is focused on singlet oxygen and its detection. Finally, he becomes head of the Singlet Oxygen Lab. Since 2008 the Berlin lab is the worldwide reference when it comes to the detection of singlet oxygen phosphorescence. Together with his colleague Jan Schlothauer, he was awarded the Innovation Award 1st price individual researcher by SPIE Europe in 2012 for the development of a table-top detection system for singlet oxygen. They were the first to observe intracellular quencher consumption during a PDT treatment in cell suspensions and identify singlet oxygen diffusion effects in heterogeneous systems. A major focus of his work is on technical improvements for in vivo detection of singlet oxygen generation of systemically applied photosensitizers as well as the analysis of the detected kinetics thereof.

Ken-Tye Yong
Nanyang Technological University, Singapore

Note

20 Years of Doppler OCT and OCT Angiography — Past, Present, and Future

Zhongping Chen
Department of Biomedical Engineering, University of California, Irvine

Note

ABSTRACT

Optical coherence tomography (OCT) is one of the fastest growing areas of biomedical optics with many potential clinical applications. Many of the functional extensions of OCT technology that were developed in the last decade, such as Doppler OCT, have started to generate clinically important information in clinical studies.

Noninvasive techniques for imaging *in vivo* blood flow are of great value to biomedical research and clinical diagnostics where many diseases have a vascular etiology or component. In ophthalmology, many ophthalmic diseases may involve disturbances in ocular blood flow, including diabetic retinopathy, low tension glaucoma, anterior ischemic optic neuritis, and macular degeneration. For example, in diabetic retinopathy, retinal blood flow is reduced and the normal autoregulatory capacity is deficient. Ocular hemodynamics is altered in patients with glaucoma, and severe loss of visual function has been associated with reduced macular blood flow. Simultaneous imaging of tissue structure and blood flow could provide critical information for early diagnosis of ocular diseases.

In this presentation, I will review the advances in Doppler OCT over the last 20 years. The recent applications of Doppler OCT for quantifying the flow, imaging the vasculature, evaluating the vibration organ, and optical coherence elastography will be discussed.

BIOGRAPHY

Dr. Zhongping Chen is a professor of Biomedical Engineering and Director of the OCT Laboratory at the University of California, Irvine. He is a co-founder and chairman of OCT Medical Imaging Inc. Dr. Chen received his B.S. degree in Applied Physics from Shanghai Jiao Tong University in 1982, his M. S. degree in Electrical Engineering in 1987, and his Ph.D. degree in Applied Physics from Cornell University in 1993.

Dr. Chen's research interests encompass the areas of biomedical photonics, microfabrication, biomaterials and biosensors. His research group has pioneered the development of functional optical coherence tomography, which simultaneously provides high resolution 3D images of tissue structure, blood flow, and birefringence. These functional extensions of OCT offer contrast enhancements and provide mapping of many clinically important parameters. In addition, his group has developed a number of endoscopic and intravascular rotational and linear 2-D probes for OCT and MPM imaging and translated this technology to clinical applications through collaboration with clinicians. He has led numerous major research projects funded by NIH, NSF, DOD, and DARPA, including several interdisciplinary research projects such as the NIH Biomedical Research Partnership (BRP) grant and NSF Biophotonics Partnership Initiative grant. Currently, he is the principal investigator of three NIH R01 grants. He has published more than 190 peer-reviewed papers and review articles, and now he holds a number of patents in the fields of biomaterials, biosensors, and biomedical imaging.

Dr. Chen is a fellow of the American Institute of Medical and Biological Engineering (AIMBE), a fellow of SPIE, and a fellow of the Optical Society of America.

Xunbin Wei
Shanghai Jiao Tong University, China

Noninvasive Monitoring of Nanoparticle Clearance and Aggregation In Blood Circulation by In Vivo Flow Cytometry

ABSTRACT

Nanoparticles have been widely used in biomedical research as drug carriers or imaging agents for living animals. Blood circulation is crucial for the delivery of nanoparticles, which enter the bloodstream through injection, inhalation, or dermal exposure. However, the clearance kinetics of nanoparticles in blood circulation has been poorly studied, mainly because of the limitation of conventional detection methods. In this study, a novel detection method based on *in vivo* flow cytometry (IVFC) is applied to monitoring the clearance kinetics of nanoparticles in the bloodstream in real time noninvasively. Our results demonstrate that the rich information provided by IVFC can be employed to monitor nanoparticle concentrations and enumerate nanoparticle aggregates in blood circulation continuously. Our work shows that IVFC can be a powerful tool for pharmacokinetic studies of nanoparticles and other drug carriers, assessing cell-targeting efficiency, as well as potentially measuring cardiac output and hepatic function *in vivo*.

BIOGRAPHY

Dr. Wei received his BS in physics from University of Science and Technology of China in 1993. He received his PhD from Department of Physiology and Biophysics, University of California, Irvine, in 1999. Dr. Wei completed his post-doc training with Prof. David Clapham at Children's Hospital, Harvard Medical School. From 2006 to 2010, he is a professor in Fudan University, China. Currently he is a professor of School of Biomedical Engineering, Shanghai Jiao Tong University, China. Dr. Wei is a SPIE Fellow.

Note

Nonlinear Optical Interactions for Phototheranostics

Tymish Y. Ohulchanskyy
Shenzhen University
& University at Buffalo

Note

ABSTRACT

An ability of light to penetrate a tissue is a key to diagnostic (e.g., optical bioimaging) and therapeutic (e.g., light induced therapy) biophotonic applications. Photodynamic therapy (PDT) is an emerging type of phototherapy of cancer and other diseases, which is presently recognized for its minimal invasiveness, high selectivity and precision, absence of the systemic toxicity and good reproducibility. It can be combined with optical imaging, which can allow for characterization of the disease and treatment on different stages. The greatest barrier in a way of expanding current PDT methods towards large-scale clinical trials for various cancers is a limited penetration depth for the exciting laser light. Optical transmission windows for biological tissues have been identified in near-infrared (NIR) region, allowing researchers to benefit from the reduced tissue scattering and autofluorescence in this spectral range and achieve optical imaging guided PDT of deeper tissues. In this presentation, we will discuss PDT via nonlinear photon upconversion of the NIR light to visible one and demonstrate how these nonlinear optical interactions can transformatively advance PDT. The two approaches in the field will be presented: 1) PDT via *in situ* nonlinear photon conversion by endogenous biological molecules and tissues, and 2) PDT provided through use of the nanoparticles as exogenous nonlinear light transformers, specifically targeting malignant site and upconverting light *in situ*. The latest research results will be reported and a comparison between approaches will be given.

BIOGRAPHY

Tymish Y. Ohulchanskyy holds his B.S./M.S. (Physics) and Ph.D. (Physics; Optics and Laser Physics) degrees from Taras Shevchenko National University of Kyiv (Kyiv, Ukraine). After obtaining his Ph.D. in 2001, Dr. Ohulchanskyy joined the University at Buffalo (UB), Buffalo, NY, USA, where he advanced to a position of the Deputy Director at the UB Institute for Lasers, Photonics and Biophotonics (ILPB). Dr. Ohulchanskyy's current research interests include biophotonics field, with focus on nanoformulations for optical/multimodal bioimaging and light induced therapy; he also has an expertise in optics, photophysics and physical chemistry. He has published more than 110 articles in peer-reviewed journals (>9000 citations, h-index of 43, according to Google Scholar) and has a number of patents and patent applications. Dr. Ohulchanskyy has been a member of Material Research Society (MRS), The International Society for Optics and Photonics (SPIE) and American Chemical society (ACS), he also served on editorial boards of several journals. In 2016, Dr. Ohulchanskyy accepted position of Distinguished Professor in College of Optoelectronic Engineering of Shenzhen University, Shenzhen, Guangdong, China.

Peng Fei
Huazhong University of Science and Technology, China

Note

Ultra High-Resolution Imaging of Whole Organisms Using Light-Sheet Fluorescent Microscopy

ABSTRACT

Study of the brain is the hottest topic in neuron science. The complex functionalities of brain is highly from its complicated neuron structures (circuits). For better understanding how the brain works, it is crucial to map the neuron network at whole brain level, with high resolution. Among a variety of optical brain imaging techniques, such as serial two photon tomography (STP), micro-optical sectioning tomography (MOST), light-sheet fluorescent microscopy (LSFM) has recently emerged for its advantages of high-throughput and low photo-bleaching. However, compared to STP or MOST, its relatively low axial resolution at whole-brain scale limits its application for visualizing the neural connections in the brain, at subcellular level.

We hereby develop a Bessel brain-wide light-sheet fluorescence microscopy (2B-LSFM) for high-resolution, isotropic imaging of ultra-fine neural structures. Merely using continuous wave laser combined with large apex axicon, large aperture lenses, and tightly-synchronized confocal slit of camera, we final realize superior scanning Bessel light-sheet illumination on whole mouse brain, with 2 cm-long working distance, 2 mm-wide coverage and only 1 μm-sharp excitation at the vicinity of the focal plane. Using 2B-LSFM, we obtain the 3D connections of the giant pyramidal neurons in a whole mouse brain, including their tip dendrites and long axon projections, with an isotropic voxel resolution of 0.5 by 0.5 by 0.5 μm. Compared to the hyperbolic Gaussian laser-sheet which is the mainstream of LSFM, our 2B method improves the axial resolution of current LSFM-based whole brain imaging for 5 to 10 folds. By a relatively cost-effective means, with keeping the high-throughput, low photon burden advantages, 2B-LSFM method further achieves subcellular, isotropic resolution at whole-brain scale. Thus it shows great potentials for various applications of neuron/brain research.

BIOGRAPHY

Dr. Peng Fei received his B.S. from the Wuhan University in 2004 and his M.S. from the Peking University in 2008. He obtained his Ph.D. from the Peking University in 2012 and then joined the Prof. Chih-Ming Ho group at UCLA as a postdoctoral fellow. After obtaining the China 1000 Youth Talent Plan in 2015, he became a full professor in School of Optical and Electronic Information, Huazhong University of Science and Technology. Prof. Fei's group is currently interested in developing novel optical techniques/methods, such as functional optofludic chips and super resolution light-sheet microscopy. He has published over 20 high-index journal papers which have been cited for over 1000 times. His research has been highlighted by several news reports, such as *Nature Photonics*, MIT technique review, FOX news, etc. Prof. Fei has recently given lectures about light-sheet fluorescent microscopy in several international conferences. He is also the editorial board member of *Scientific Reports* and invited reviewer for a number of international journals.

Dan Zhu
Huazhong University of Science and Technology, China

Note

Skull Optical Clearing Techniques for Cortical Imaging In Mice

ABSTRACT

The development of various optical techniques provides a powerful tool to image neurons, glia, and microvasculature in the living brain. However, the strong scattering caused by the skull over the cortex hinders the observation of labeled neuronal processes and microvasculature. Some cranial window techniques were developed based surgical method, but there are some limitations. During the past years, we have been focusing on *in vivo* tissue optical clearing methods. Especially, we invented skull optical clearing methods without craniotomy, to meet requirement of imaging, from infatile stage, adult to old age. The safety of the techniques was evaluated, which demonstrates a switchable skull optical clearing window. The skull optical clearing window allows us to monitor the plasticity of dendritic protrusions in the critical period, to visualize the dynamics in dendrites and microglia upon laser injury, and tracing the cortical vascular dynamics about blood flow or oxygen saturation.

BIOGRAPHY

Dan Zhu is a distinguish professor of Huazhong University of Science and Technology (HUST), vice-director of Key laboratory of Biomedical Photonics (HUST), Ministry of Education, and Vice-Director of Division of Biomedical Photonics, Wuhan National Laboratory for Optoelectronics. She has authored more than 150 papers in the field of tissue optics imaging theory and techniques. During the past years, she has been focusing on optical clearing of tissue *in vivo* for cutaneous or cortical imaging. And she also pays attention to developing *in vitro* tissue optical methods for neuroimaging. She is also the secretary general and vice-president of Biomedical Photonics Committee of Chinese Optical Society.

Buhong Li
Fujian Normal University, China

Optical Techniques Monitoring Clinical Photodynamic Therapy Dosimetry

ABSTRACT

Photodynamic therapy (PDT) is based on the generation of highly reactive singlet oxygen through interactions of photosensitizer, light and molecular oxygen. PDT has become a clinically approved, minimally invasive therapeutic modality for a wide variety of malignant and nonmalignant diseases. The main dosimetric parameters for predicting the PDT efficacy include the delivered light dose, the quantification and photobleaching of the administrated photosensitizer, the tissue oxygen concentration, the amount of singlet oxygen generation and the resulting biological responses. In this talk, the emerging optical techniques in use or under development for monitoring clinical PDT dosimetry will be presented. In addition, the main challenges in developing real-time and noninvasive optical techniques for monitoring dosimetric parameters in PDT will be discussed.

BIOGRAPHY

Buhong Li is a professor of Biomedical Photonics and the Executive Vice-Dean of Graduate School, Fujian Normal University. He received his Ph.D. degree in Optical Engineering from Zhejiang University in 2003. He was a visiting scientist in the Ontario Cancer Institute and University of Toronto from September 2005 to September 2007. He then worked as a senior visiting fellow in Institute of Physics of Humboldt University of Berlin from April 2014 to August 2014. He was the New Century Excellent Talents in Ministry of Education of China. His research focuses on optical method and apparatus for monitoring photodynamic therapy dosimetry, in particular for the spatiotemporal detection of singlet oxygen luminescence. He has authored more than 80 publications. He is the Associate Editor of *Nano Biomedicine and Engineering*, and the editorial members of *Journal of Innovative Optical Health Sciences*, *Photonics & Laser in Medicine*, and *Acta Laser Biology*.

Note

Photoactivatable Nanotheranostics

Peng Huang
Shenzhen University, China

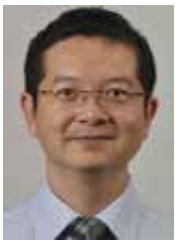
Note

ABSTRACT

Activatable theranostics is a novel clinical solution for early recognition, diagnosis, monitoring, and prognosis of diseases by enhancing contrast in various imaging modalities followed by tailored therapy. In the past few years, we have developed a series of photoactivatable nanotheranostics methods that have shown excellent imaging and high efficacy of cancer therapy in animal experiments. This talk will highlight our recent advances in using photoresponsive nanoplatforms for in vivo multimodality imaging and imaging-guided phototherapy. Some issues of theranostics in clinical translation will also be discussed.

BIOGRAPHY

Prof. Peng Huang received his Ph.D. in Biomedical Engineering from the Shanghai Jiao Tong University in 2012. Then he joined the Laboratory of Molecular Imaging and Nanomedicine (LOMIN) at the National Institute of Biomedical Imaging and Bioengineering (NIBIB), National Institutes of Health (NIH) as a postdoctoral fellow. In 2015, he moved to Shenzhen University as a Distinguished Professor. His group works on the following directions: activatable theranostics, activatable molecular imaging, cancer immunotheranostics, and 3D bioprinting in theranostics. Starting from 2008, Dr. Huang has authored over 100 peer-reviewed papers, which have received a total citation of > 4,900 times and given him an H-index of 38.



Peng Xi
Peking University, China

Super-Resolution: Better, Deeper, and Richer Information

ABSTRACT

I will introduce three technologies we developed recently for further application of super-resolution: (1) Better spatial resolution is always preferred especially at no additional cost; (2) Deeper imaging depth inside the scattering specimen; and (3) Richer biological information. Firstly, with mirror-enhanced super-resolution, we are able to convert a STED system to a STED-4Pi, with ~4x STED intensity and ~2-fold of resolution, with the same STED power (MEANS-STED). Secondly, benefitted from the rich choice of energy levels of upconversion nanoparticles, we have achieved 28 nm resolution with intermediate state STED, with only 30 mW CW laser power. Thirdly, we have also achieved a new super-resolution technique through the demodulation of fluorescent dipole orientation (SDOM). The dipole orientation describes the underlying structures it attaches to. A series of biological structures can be revealed by SDOM, but not conventional polarization microscopy.

BIOGRAPHY

Dr. Peng Xi is an associate professor in Peking University. His current research interests are focused on research and development of optical nanoscopy. Dr. Peng Xi has published over 50 scientific papers in peer-reviewed journals such as *Nature*, *Light. Sci. Appl.*, *ACS Nano*, etc., and holds 8 issued patents, including 2 US patents. He is a senior member of OSA, and the chair of OSA Imaging Technical Group. His research is sponsored by National Scientific Instrument Development Project and National Science Foundation of China. Dr. Peng Xi is on the editorial board of several SCI-indexed journals: *Scientific Reports*, *Microscopy Research and Techniques*, *Micron*, and *Chinese Optics Letters*. He has been invited to give several invited talks in international conferences hosted by OSA and SPIE.

Note

All-Optical Photoacoustic Microscopy for Biomedical Applications

Sihua Yang
South China Normal University, China

Note

ABSTRACT

The report focuses on the use of low coherence Michelson interferometer to obtain micro-vibration of the surface of the tissue surface for sensing the internal photoacoustic signal. Since the photoacoustic pressure is the first derivative of the change in tissue displacement caused by the photoacoustic pressure, the magnitude of the vibrational displacement of the biological tissue surface can be obtained to reflect the intensity of the photoacoustic signal. That is, the optical coherence intensity can be used to sense the micro-vibration of the tissue surface which is proportional to the intensity of the photoacoustic wave inside the tissue, so that the intensity of the photoacoustic signal can be detected by the optical method. All-optical sensing detection can realize the multi-modal imaging system of photoacoustic imaging, optical coherence tomography and fluorescence imaging, which can obtain the absorption and scattering information of photons in biological tissues simultaneously.

BIOGRAPHY

Sihua Yang received his doctoral degree in Optics in 2009 at South China Normal University. Now he is Professor, the Vice Dean of College of Biophotonics, Institute of Life Science, South China Normal University. He has published more than 60 peer-reviewed journal papers, including *Journal of the American College of Cardiology*, *Small*, *Biomaterials*, *Optics Letters*, *Optics Express*, *Applied Physics Letters* and so on. He got the" Sylvia Sorkin Greenfield Award" of American Association of Physicists in Medicine (AAPM) in 2008, and the Natural Science Award of Guangdong Province in 2008 and 2013. His main interests in research include photoacoustic microscopy imaging and clinical applications, multi-modality imaging of photoacoustics, ultrasound and fluorescence, and ultrashort microwave-induced thermoacoustic imaging.

Zhihui Chen
Taiyuan University of Technology, China

Improving Fluorescence Biosensor by Micro/Nano Photonic Structures

ABSTRACT

Enhancing the fluorescence emission of fluorescence nanoparticles (FNP) is crucial to reducing the detection limits of fluorescence biosensor. This talk will review the recent progress in enhancing the light absorption and emission of FNP by using micro/nano photonic structures and present our recent work in this field. We proposed many novel micro/nano photonic structures to enhance the excitation/emission of FNP. Due to scattering, constructive interference and coupling of optical modes in the micro/nano photonic structures, large-area/far-field range resonance modes can be created. Efficient resonance coupling between the optical mode and the excitation/emission of FNP can occur in the far-field range. The enhancement region is not only limited to the near-field range of the structure but also expanded to the far-field range of the structure.

BIOGRAPHY

Zhihui Chen received his PhD from Royal Institute of Technology (KTH), Stockholm, Sweden, in 2012, and performed postdoctoral research in SciLifeLab-KTH, Stockholm, Sweden, from 2013 to 2014. He is an associate professor in the College of Physics & Optoelectronics and Key Lab of Advanced Transducers & Intelligent Control System (Ministry of Education) in Taiyuan University of Technology, China. Zhihui Chen's research interests include light manipulation in novel micro/nano structures, light absorption/emission in photonic devices such as biomedical sensors. To date, he has successfully led 8 research projects (as Chief Investigator), published 2 scholar books (Sole Author) and 35 refereed journal articles in peer-reviewed journals, got 8 patents, presented 10 invited talks in international conferences, etc. Additionally, he has been invited as a TPC member for the 6th and 7th International Conference on Manipulation, Manufacturing and Measurement on the Nanoscale, and regular referee for 9 international SCI-indexed professional journals. He was awarded Eni award nomination of 2017 (Italia), 3M Creative Scholarship, Scholarships from Carl Tryggers Foundation and J. Gust. Richert Foundation in Sweden, Scholarship from China Scholarship Council and Top Young Academic Leaders of Shanxi (China), etc.

Note

Photoacoustic Imaging: Technology Development Towards Clinical Translations

Liang Song
Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences, China

Note

ABSTRACT

Photoacoustic imaging is a novel hybrid medical imaging technology that has experienced rapid growth during the past decade. It uniquely combines the advantages of optical absorption contrast (sensitive to molecular conformation and thus the early development of many diseases) with ultrasonic resolution for in vivo imaging as deep as 5 –7 centimeters. Here we will discuss some technology development pursued in our lab towards clinical translations, including: (1) intravascular photoacoustic endomicroscopy capable of imaging the thin-cap, composition, and other key features of atherosclerotic plaques for vulnerable plaque identification; (2) real-time handheld photoacoustic multimodality imaging technology capable of imaging tumor vasculature label-freely and sentinel lymph node noninvasively; (3) fully integrated in vivo photoacoustic/two-photon microscopy with a resolution as fine as 320 nm and multiple contrasts—absorption, second-harmonic, and fluorescence—for tumor microenvironment imaging and study.

BIOGRAPHY

Liang Song, Ph.D., is Professor at SIAT, CAS and founding director of the Shenzhen Key Lab for Molecular Imaging. Prior to joining SIAT, he studied at Washington University, St. Louis and received his Ph.D. in Biomedical Engineering. He has authored >40 peer-reviewed journal articles in *Advanced Functional Materials*, *Optics Letters*, *Biomaterials* etc., which have been cited by prestigious journals such as Science and *Nature Medicine* (Google scholar citations: 1085; h-index: 20). He serves on the editorial board of *Photoacoustics* (Elsevier CiteScore 2016: 5.7) and is a regular reviewer for >20 SCI-indexed journals such as *Biomaterials*, *IEEE Trans Med Imag* etc. He has invented and developed multiple novel photoacoustic imaging technologies and been awarded >10 US and Chinese invention patents, for example: (1) optical-resolution intravascular photoacoustic endomicroscopy aiming for the identification of vulnerable plaques; (2) fully integrated photoacoustic/two-photon microscopy that can potentially open up new avenues for multi-contrast sub-cellular biomedical imaging; (3) handheld, real-time photoacoustic imaging system for cancer theranostics. His research on photoacoustics has been supported by the NSFC (including the National Key Instrumentation R&D Grant and National Excellent Young Scholar Award), the MOST of China, the local governments, and the industry.

CIOP-2017-0264

Easier Implement of SC Laser Based Super-Resolution STED Microscope

Jinghe Yuan
Institute of Chemistry, Chinese Academy of Sciences

We have built a STED microscopic system based on the supercontinuum fiber laser. By using a simpler technique for wavelength selecting and the timing measurement, we achieved the super lateral resolution better than 40 nm. Super resolution images on some bio-samples have been collected as well. Meanwhile these improved techniques make the STED microscope easier to implement and more stable.
Key words: super resolution microscopy

CIOP-2017-1709

Methods to Improve Performance of Swept Source at 1.0 μm Based on Polygon Scanner

Junli Chang, Jing Cao, Pinghe Wang
University of Electronic Science and Technology of China

Swept sources have long been widely used in biomedical imaging especially for swept source optical coherence tomography. It is demonstrated that swept source OCT at 1050 nm wavelength is suitable for imaging in human retina and choroid layers. Meanwhile the parameters of swept source directly determine the performance of swept source optical coherence tomography. In this work, we investigate the methods to improve the performances of the swept source at 1.0 μm based on polygon scanner filter in Littrow arrangement, including in-cavity parameters and booster structures out of the cavity. The performances of the swept source have been improved by optimizing three in-cavity parameters, including cavity length, rotating speed of polygon scanner and energy in the cavity. With the decreasing cavity length, the spectrum bandwidth becomes wider and duty cycle becomes higher. With the increasing rotating speed of the polygon, the spectrum bandwidth becomes narrower, duty cycle becomes lower but the repetition rate becomes higher. With more energy in-cavity, the spectrum bandwidth becomes wider and duty cycle becomes higher. Then in order to further improve the performances of the laser, booster structures out of the cavity, including buffered structure, booster amplifier and dual-SOA structure, were used to double the sweep rate to 86 kHz, increase output power to 18 mW and improve spectrum bandwidth to 131 nm, respectively.
Key words: optical coherence tomography; swept source

CIOP-2017-3008

NKT Supercontinuum Product Introduction and Its Application

Qi Wang
NKT Photonics

The SuperK series is the industry leading range of turn-key supercontinuum lasers used by many of the most innovative companies within bio-imaging, semiconductor inspection and scientific instrumentation. The sources are extremely robust and reliable, build for intensive use and can replace multiple single line lasers, large dye and gas lasers as well as broadband sources like ASE soures and SLEDs. Select the EXTREME series if you need maximum wavelength coverage, high power and lots of functionality.

CIOP-2017-0855

Local Field Enhancement Tuning of Horseshoe-Shaped Nanoparticles

Zhiyuan Du, Bin Hu
Beijing Institute of Technology

A horseshoe-shaped nano-structure formed by etching a gap on a ring structure is proposed. Through numerical simulation, we find the local field of the structure is significantly enhanced compared with that of the traditional ring structure. Furthermore, an additional resonant peak appears corresponding to the electric field coupling in the gap, and the wavelength of the resonant peak is easy to tune significantly by the particle size, the gap size, as well as the gap position. Such properties make the structure promising in biomedical and sensing applications.
Key words: nanomaterials; sensors; surface plasmons

CIOP-2017-2235

Phase and Amplitude Correction in Polygon Tunable Laser-Based Optical Coherence Tomography

Haiyang Luo, Guohua Shi, Pinghe Wang
University of Electronic Science and Technology of China

Phase instability is a serious problem in swept-source optical coherence tomography (SS-OCT) with polygon tunable lasers; however, these devices have additional issues. Polygon tunable lasers also have fluctuations in output power and sweep range; the former creates artifacts that may impair the recognition of sample information, while the latter reduces the interference signal utilization during phase correction. We demonstrate a method that uses the calibration signal to quantify these problems and improve system stability and image quality. The proposed amplitude correction and phase correction methods are used to eliminate vertical artifacts and improve the resolution of OCT flow and intensity images while reducing the phase error.
Key words: optical coherence tomography; tunable laser; phase stability; biomedical imaging

CIOP-2017-2527

Solutions to Advanced Multiple Configuration Systems Resolution in Imaging Sensors

Quanxin Ding
Science and Technology on Electro-Optic Control Laboratory, Beijing, China

To break the optical diffraction limit and to achieve an improved resolution, based on single molecule microscopy in modern domain, a method of continuous zoom multiple configuration, with a micro lens array and core optics is proposed with novel principle on resonance energy transfer and high accuracy localization, by which the system resolution can be improved by a few nanometers. A comparative study on traditional vs modern methods can demonstrate that the dialectical relationship and their balance is important, among merit function, optimization algorithms and model parameterization. The effect of system evaluation criterion including MTF, REA, RMS etc. can support our arguments qualitatively. The results can develop new products.
Key words: system engineering; photonics; optical design

Session 4: Optical Design and Optical Precision Measurement

Session Chairs: **Jiubin Tan**, Harbin Institute of Technology, China
Jianqiang Zhu, Shanghai Institute of Optics and Fine Mechanics, CAS, China
Rihong Zhu, Nanjing University of Science and Technology, China
Yanqiu Li, Beijing Institute of Technology, China

Location: B506, 5F, Main Building, Harbin Institute of Technology No.2 Campus

18th July

13:40-13:55	**Introduction of Micro- and Nano-Positioning Stages of SYMC (Oral-Industry)** Keliang Liao, Sanying Motion Control Instruments Ltd	
Chair: Jian Liu, Harbin Institute of Technology, China		
14:00-14:45	**Advanced Distance Measurements Using Femtosecond Lasers (Keynote)** Seung-Woo Kim *Korea Advanced Institute of Science and Technology (KAIST), South Korea*	- 66 -
14:45-15:15	**Flexible Testing of Precision Optics – from Flexible Null Optics to Virtual Null Testing (Invited)** Christof Pruss *Institute of Applied Optics (ITO), University of Stuttgart, Germany*	- 67 -
15:15-15:30	**Self-Reliance and Independently Developed High Finesse Spherical UltraStable Optical Reference Cavity (Oral)** Guanjun Xu, Jun Liu, Tao Liu, Shougang Zhang *National Time Service Center, CAS, China*	- 73 -
15:30-15:45	**Optomechanical Magnetometry: Macroscale Resonator for Unltrasensitive Magnetic Field Detection (Oral)** Changqiu Yu[1], Yundong Zhang[2] *[1] Hangzhou Dianzi University, China; [2] Harbin Institute of Technology, China*	- 73 -
15:45-16:00	**Coffee Break**	
Chair: Christof Pruss, Institute of Applied Optics (ITO), University of Stuttgart, Germany		
16:00-16:30	**Terahertz Spectroscopy and Imaging Technology: From Source to System (Invited)** Yiming Zhu *University of Shanghai for Science and Technology, China*	- 68 -
16:30-17:00	**Elliptical Mirror Focusing and Its Application on Long Working Distance Objective Lens Design (Invited)** Jian Liu *Harbin Institute of Technology, China*	- 69 -
17:00-17:15	**Measurement of Mode Coupling in Few-Mode Fiber for Mode-Division Multiplexing System Based on Wavelet Packet De-Noising (Oral)** Feng Liu, Guijun Hu, Weicheng Chen, Cuiguang Chen *Jilin University, China*	- 73 -
17:15-17:30	**Polarization Orientation Manipulation in the Focal Volume (Oral)** Jiannong Chen, Zhigang Li, Linwei Zhu, Qinfeng Xu *Ludong University, China*	- 74 -
17:30-17:45	**Self-Absorbed Doublet Lines of Ca for Stand-off Quantitative Analysis of Calciferous Solid Samples by Laser Induced Breakdown Spectroscopy (Oral)** Menghan Wang, Ming Zhu, Junle Qu *Shenzhen University, China*	- 74 -
17:45-18:00	**A Single-Mode 1064 nm Laser for Dual-Wavelength Active Optical Clock (Oral)** Tiantian Shi, Duo An, Pengyuan Chang, Jingbiao Chen *Peking University, China*	- 74 -
18:00-19:00	**Dinner Time**	

19th July

Chair: Yiming Zhu, University of Shanghai for Science and Technology, China		
09:00-09:45	**Study on Dynamic Interferometry (Keynote)** Lei Chen *Nanjing University of Science and Technology, China*	- 70 -
09:45-10:15	**High Accurate Testing of Large Optical Flatness for High Power Laser System (Invited)** Sen Han *University of Shanghai for Science and Technology, China*	- 71 -

19th July

10:15-10:30	**Measuring Focal Ratio of Astronomical Fibers Bbased on Energy Method (Oral)** Yu Wu[1], Hang Jiang[1], Qiong Zhang[1], Zhenyu Ma[1], Liyuan Zhao[1], Qi Yan[1], Xudong Chen[1], Xiren Jin[1], Tao Geng[1], Weimin Sun[1], Zhongwen Hu[2], Yongtian Zhu[2], Xiangqun Cui[2], Liang Chang[3], Yue Zhong[3], Zhongquan Qu[3] *[1] Harbin Engineering University, China* *[2] National Astronomical Observatories, CAS, China* *[3] Yunnan Observatories, CAS, China*	- 75 -
10:30-10:45	**Femtosecond Z-Scan Measurements of the Nonlinear Refractive Index of Fused Silica (Oral)** Lin Zhang *China Academy of Engineering Physics, China*	- 75 -
10:45-11:00	**Coffee Break**	
Chair: Sen Han, University of Shanghai for Science and Technology, China		
11:00-11:30	**New Progress of Coherent Diffraction Imaging and Its Application in Wavefront Measurement (Invited)** Cheng Liu *Shanghai Institute of Optics and Fine Mechanics, CAS, China*	- 72 -
11:30-11:45	**Freeform Configuration to Advanced System Resolution (Oral)** Hua Liu, Quanxin Ding *Science and Technology on Electro-optic Control Laboratory, China*	- 76 -
11:45-12:00	**Gyro Coils Diagnosis Based on High Resolution White Light Interferometry (Oral)** Zhangjun Yu, Jun Yang, Yonggui Yuan, Feng Peng, Hanyang Li, Changbo Hou, Chengcheng Hou, Haoliang Zhang, Libo Yuan *Harbin Engineering University, China*	- 76 -
12:15-14:00	**Lunch Time**	
Chair: Lei Chen, Nanjing University of Science and Technology, China		
14:00-14:15	**Study on Mid-Frequency Wave-Front Error Measured by Interferometer (Oral)** Xuejie Zhang, Weixing Shen *Shanghai Institute of Optics and Fine Mechanics, CAS, China*	- 76 -
14:15-14:30	**Research on the Magnetic-Thermal Coupling in A Polarization Maintaining Fiber Optic Gyroscope (Oral)** Xuyou Li, Pan Liu, Xingxing Guang, Yanda Guo, Qingwen Meng, Guangchun Li *Harbin Engineering University, China*	- 77 -
14:30-14:45	**Design of Lens Coupler with Uniform Energy Distribution for LED and POF Bundle (Oral)** Xiaoting Zhang, Chujia Liu, Yu Qi, Zhihui Cai, Fengtie Wu, Qiren Zhuang *Huaqiao University, China*	- 77 -
14:45-15:00	**Experimental Study on the Effect of Atmospheric Turbulence on the Heterodyne Detection (Oral)** Bai Fang *Xidian University, China*	- 77 -
15:00-15:15	**High-sensitivity Temperature Sensor Based on Fano Resonance in Microcapillary Resonator (Oral)** Yu Lu, Mi Li, Yuejiang Song *Institute of Optical Communication Engineering, Nanjing University, China*	
15:15-15:30	**Determination of Residual Stress along Depth by In-Plane 3-directional Optical Interference Moire (Oral)** Keming Zhang *Shanghai Institute of Technical Physics of the Chinese Academy of Sciences, China*	
15:30-15:45	**Coffee Break**	
15:30-17:30	**Poster**	
18:00-20:00	**Banquet**	

Advanced Distance Measurements using Femtosecond Lasers

Seung-Woo Kim
Korea Advanced Institute of Science and Technology (KAIST), South Korea

Note

ABSTRACT

Emerging possibilities of using femtosecond pulse lasers as a new light source for advanced metrology are addressed in comparison to traditional continuous-wave lasers. Emphasis is put on explaining various principles of absolute distance interferometry which are practically feasible by exploiting the unique spatiotemporal nature of femtosecond lasers. Being a phase-locked combination of a large number of monochromatic laser lines evenly spaced over a wide range, a single source of femtosecond laser offers many new opportunities performing absolute distance measurements with sub-wavelength resolutions over extensive ranges. It is also discussed that the new light source allows one to improve the measurement uncertainty by frequency stabilization of a femtosecond laser to the radio-frequency atomic clock together with high finesse optical cavities.

BIOGRAPHY

Seung-Woo Kim has been working for KAIST from 1985 till now in the Department of Mechanical Engineering, leading a research group of graduate students working in the field of precision engineering and optical metrology. His professional interests are precision optical technology with specialty on optical-mechanics system synthesis for precision machines design, optical interferometry for 3D surface and thin-film metrology, and ultrafast photonics for nano-scale fabrication and ultra-precision measurements. During last three decades, he published ~150 technical papers in peer-reviewed journals, ~240 presentations in conferences, and ~50 patents. He has been working as principal investigator for numerous national and industrial research projects and currently involved in an important national creative research initiative project for the development of next generation precision engineering key technologies using femtosecond pulse lasers. He has also actively been involved in international academic societies for organizing on-time conferences for leading-edge precision engineering optical technologies. He was president of the Korea Society of Precision Engineering (KSPE) in 2011, and he is currently a member of OSA (Optical Society of America), SPIE (International Society of Optical Engineering), CIRP (International Academy for Production Engineering), and EUSPEN (European Society Precision Engineering).

Flexible Testing of Precision Optics – From Flexible Null Optics to Virtual Null Testing

Christof Pruss
Institute of Applied Optics (ITO), University of Stuttgart, Germany

Note

ABSTRACT

Different factors define the current path for new optical systems: The increasing demand from rapidly growing optics and photonics industry, progress in optics design combined with new fabrication technologies that allow precision fabrication of asphere and increasingly also freeform surfaces and last but not least the metrology capabilities that provide the vital feedback for any fabrication of precision surfaces. In this contribution, a review of recent developments in metrology is given with a focus on fast and flexible metrology approaches.

BIOGRAPHY

Christof Pruss has been a permanent scientist at the ITO, University of Stuttgart since 1999, has led the group “interferometry and diffractive optics” since 2002. The center of research activities is asphere and more recently also free-form surface testing. This includes the design and fabrication of diffractive optical elements such as null correctors but also polarizing elements for high power lasers, the development of absolute testing methods with computer generated holograms (CGH) as well as flexible methods such as Tilted Wave Interferometry, which was awarded the AMA Innovation award 2014.

Yiming Zhu
University of Shanghai for Science and Technolog, China

Note

Terahertz Spectroscopy and Imaging Technology: From Source to System

ABSTRACT

The vibration and rotation frequencies of some organic and bio molecules are located in terahertz region. Therefore, by using terahertz spectroscopy technology, the macro-organic materials can be detected and identified. Furthermore, because of the good transmission and low photon energy, terahertz wave is also considered as an option for homeland security check.

m-i-n diode based on intrinsic GaAs for terahertz emitter is fabricated by University of Shanghai for Science and Technology (USST), its operation frequency can reach to 4.2 THz. Furthermore, some terahertz functional devices are also developed, i.e., broadband high efficiency terahertz absorber, whose absorption can be more than 95% from 0.6 to 2.6 THz, and pump laser/terahertz wave isolator, which can prevents laser energy more than 10^{11} W/cm^2 together with terahertz transmission more than 90%.

Based on the above terahertz emitter and functional material, an fast scan and integral terahertz spectroscopy system is fabricated. The system can realize 0.1 s/spectrum scan for drug functional group identification and cancel cell detection.

Moreover, an active terahertz imaging system for homeland security check is also developed. The system is based on multi detectors and fast vibration scan mirror, which can realize a scan ~3 s/ person with the resolution about 1.5 cm.

BIOGRAPHY

YiMing Zhu PhD, graduated from University of Tokyo, is now a Young Yangtze professor in University of Shanghai for Science and Technology, the vice director of Shanghai Key Lab of Modern Optical System.

Up to now, he has published more than 100 papers, including more than 30 papers on Light Sci. & Appl., Sci. Rep., Appl. Phys. Lett., Opt. Lett., Opt. Exp., et al. He has also completed more than 20 projects at national and ministerial/provincial level, which include one project supported by National 863 Project, 3 projects supported by National Natural Science Foundation of China, 2 sub-projects supported by National 973 Project, 2 projects supported by Major National Development Project of Scientific Instrument and Equipment, etc.

In 2012, he also won the title of “New Century Talent” from the Ministry of Education. In 2013, he was recommended as the council member of China Instrument and Control Society. In 2014, he also won the title of “Excellent Academic Leaders of Shanghai”, and also was recommended as the council member of China Optical Engineering Society and the member of China Youth Scientist and Technician Association. In 2016, he was chosen as “Shanghai Leading Talent” and “Young Yangtze Scholar”.

Elliptical Mirror Focusing and Its Application on Long Working Distance Objective Lens Design

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Note

ABSTRACT

Elliptical mirror is discussed as a basic imaging component for high NA focusing. A number of original formulas reported for microscope design are potentially useful in field of bio-imaging, spectroscopy and industrial metrology. For fine stitching of multi-window wide-spectrum detectors, elliptical mirror is used to design a long working distance objective lens. An aspherical Schwarzschild objective with an effective working distance of 525 mm has been realized for chromatic aberration-free imaging in 400–900 nm wavelength range and with a numerical aperture of 0.13. A theoretical approach for analytical design of an initial configuration has been modeled using an on-axis Taylor series expansion, and the beam obscuration ratio (OR) has been controlled down to 4%. In comparison against the theoretical spherical-based Schwarzschild objective, 77.5% of the OR has been reduced for improved contrast.

BIOGRAPHY

Jian Liu has been engaged in optical microscopy, imaging and applied optics for over twelve years. His interests are the theory and implementation of scanning optical microscopes and optical system design. He is the member of ISO/TC213 (International Organization for Standardization) and China SAC/TC240, which are both served for geometrical products specifications. He is council member of China Optical Engineering Society and China Instrument and Control Society, and board member of Journal of Microscopy-Oxford, Optics Communication, and executive editorial board of IOP rising journal--Surface Topography: Metrology & Properties. He is professor and vice dean of School of Precise Instrumentation Science and Engineering of Harbin Institute of Technology, China.

Study on Dynamic Interferometry

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Note

ABSTRACT

Fizeau interferometers are frequently used for optical measurements because the common-path configuration prevents the measurement results from being susceptible to the aberrations of the optical system. The commonly used Fizeau interferometer is based on phase shifting interferometry, which is a versatile powerful tool that is used widely in a variety of precise optical measurement applications. However, phase shifting interferometry cannot be used effectively in the presence of unstable conditions such as vibration, air turbulence, or when the object under test is in motion. Nowadays, there is an urgent requirement for dynamic interferometry in optical manufacturing, especially for the measurements of a long cavity.

A novel dynamic Fizeau interferometer with the aperture of 600 mm is proposed based on simultaneous phase shifting with different incident angles through the lateral displacements of the point sources. Four point sources with identical intensity are generated using a phase grating and the corresponding interferograms with equal phase step are introduced by properly adjusting each point source to the optical axis of the interferometer. The interferograms are separated and clearly imaged at the CCD target in a single shot by putting a lens array in the imaging system, thereby realizing dynamic interferometry. The experimental results show the feasibility and high precision of the dynamic Fizeau interferometer.

In our opinion, the proposed dynamic interferometry is not only suitable for Fizeau interferometers, but also can be applied to interferometers such as Twyman-Green and Mach-Zehnder interferometers.

BIOGRAPHY

High Accurate Testing of Large Optical Flatness for High Power Laser System

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Note

ABSTRACT

High accurate processing and testing of large optics have been become very popular research projects in the field of high power laser system. The high accurate processing depends strongly on more accurate testing techniques. Optical coherent technique, such as Fizeau interferometer is most effective method. For small (below 100mm) or middle (150mm) aperture optics testing, a transmission flat with 1/20 wavelength PV is normally used. However, when an optical flat surface under test is better or much better than the transmission flat, a high accurate testing is needed. In this paper, a new method is developed and it is easily able to achieve the accuracy of 1/100 wavelength PV and repeatability of 1/1500 wavelength RMS. We have dedicated our efforts to do so. The theoretical analysis, computer simulations, and experimental validation are presented in the paper. In addition, other functions (homogeneity, right angle prism and corner cube) are extended.

BIOGRAPHY

Sen Han obtained his Ph.D.in Optical Engineering from University of Stuttgart, Germany. Dr. Han is a Professor of University of Shanghai for Science and Technology, China. He is both a SPIE Fellow and an Adjunct Professor of University of Arizona, USA. Dr. Han won R&D 100 Award twice in USA.

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Note

new progress of coherent diffraction imaging and its application in wavefront measurement

ABSTRACT

The high power laser system for inertial confinement fusion is a large Opto-Electronic engineering which has complex structure and amounts of large-scale optical components. It put forward high requirements for the precise diagnostic system in order to achieve high peak power and small size of focal-spot. An original wave-front coding imaging (WCI) technology which can fast measure the phase and amplitude of the laser field is presented. A single- shot intensity measurement is sufficient for wave-front reconstruction after the random phase plate has been accurately pre-characterized. The integrated device has advantages of compact size, fast convergence, high accuracy and spatial resolution. Meanwhile, the instrument is further expanded to multifunctional laser light field measurement technology for optical component measurement, MTF measurement of imaging system and so on. The WCI technology solves the bottleneck problem of online diagnostic tools for high power laser system and provides a new solution in the field of optical measurement.

BIOGRAPHY

Cheng Liu, professor of Shanghai Institute of Optics and Fine Mechanics (SIOM), China. He received his PhD from SIOM in 2003 and then his postdoctoral training abroad from2003 to 2011. His research interests are mainly focused on optical imaging and optical metrology including the interferometry, holography, optical nonlinear imaging, speckle interferometric metrology, coherent diffraction imaging etc. And currently his main research works are on the high power laser beam propagation and online diagnostics.

CIOP-2017-0258

Self-Reliance and Independently Developed High Finesse Spherical Ultra Stable Optical Reference Cavity

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Ultra-stable reference cavity with high finesse is the crucial component in the narrow-linewidth laser systems which are widely used in time and frequency metrology, test of Lorentz invariance, and measure of gravitational wave. In this paper, we report the recent progress of the self-made spherical reference cavity for future space application. The cavity's main function is the reference of ultra-stable laser, which is the local reference oscillation source of space optical clock.

The diameter of the spherical cavity spacer made of ultra-low expansion glass is 80 mm, the cavity length is 78 mm, and the radius of the concave mirror is 0.5 m. The support structure is designed as two 3.9 mm (radius) spherical groves located at the poles of the sphere along the diameter direction (defined as support axis), and the angle between the support axis and the optical axis is 53°. The mechanic vibration sensitivity of the cavity along and perpendicular to the optical axis is calculated by finite element analysis method to be below . Five-axis linkage CNC machining sphere forming technology is applied to φ80 mm spherical surface processing with spherical contour degree up to 0.02. After a three-stage surface polishing process, the fused silicamirror substrate surface roughness is measured to be less than 0.2 nm (RMS). Implementing double ion beam sputtering technique for mirrors coating, the coatings have a reflectivity of >99.999% and a loss of <4 ppm for 698 nm laser. The coating surface roughness is measured to be < 0.3nm (RMS). The cavity spacer and the mirrors are bonding by dried optical contact.In order to improve the thermal noise characteristics of the cavity, an ULE ring is contacted optically to the outer surface of the mirrors.

The cavity is characterized by ring-down spectroscopy and the finesse is around 195,000. With the help of a home-made 698 nm ultra narrow line-width laser, the cavity line-width is measured by sweeping cavity method to be 9.8 kHz. A 698 nm semiconductor laser is locked to this spherical cavity by PDH technology, and the cavity loss is measured to be <5 ppm.

Key words: ultra-stable cavity; ULE; finesse; optical clock

CIOP-2017-0946

Optomechanical Magnetometry: Macroscale Resonator for Unltrasensitive Magnetic Field Detection

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Magnetic field sensing is performed with a centimeter-scale whispering gallery mode resonator. Through utilizing the resonator's mechanical modes, ultrasensitive magnetic field detection can be realized and a peak magnetic field sensitivity of 131 pT/sqrt(Hz) at 126 kHz is achieved. Combining with microwatt optical power consumption and earth-field working condition, this ultrasensitive macroscale magnetic field sensor might find applications in the field of geophysical survey, medical imaging and national defence.

Key words: magnetic field sensing; whispering gallery mode; resonator

CIOP-2017-1305

Measurement of Mode Coupling in Few-Mode Fiber for Mode-Division Multiplexing System Based on Wavelet Packet Denoising

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When few-mode fibers (FMFs) are employed in mode-division multiplexing (MDM), mode coupling between the propagation modes severely deteriorates the transmission performance and thus limits the transmission distance. Therefore, the impairment measurement of mode coupling in FMF plays an important role in providing the reliable basis for impairment compensation of MDM system, and thus improves the transmission performance of MDM system. In this paper, we demonstrate the nondestructive measurement of distributed mode coupling along 9.8 km 3-mode fiber (3MF) using the experimental setup with the structure of photonic lantern and optical circulators based on wavelet packet denoising. Comparing the experimental results with the results obtained by traditional OTDR with average time/number denoising, we find that mode coupling between LP01 mode and higher order modes LP11a,b is successfully characterized with high-precision, and the dynamic ranges of mode-coupling measurement system are effectively improved.

Key words: optical communication; mode division multiplexing; few-mode fiber; mode coupling; wavelet packet denoising

CIOP-2017-1613

Polarization Orientation Manipulation in Focal Volume

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We propose an approach for tuning the three-dimensional polarization distribution of a focusing sub-wavelength spot by a high numerical aperture objective. The incident beams are composed of a radially polarized beam, an azimuthally polarized beam and a linearly polarized beam, with three different weighting factors, respectively. A specially designed adjustable amplitude angular selector is also inserted at the back aperture of the objective for tuning the polarization azimuthally. We calculated the overall polarization orientation in the focal volume. It is found that the polar angle of the overall polarization orientation can be arbitrarily tuned by the superposition of a radially polarized beam and a linearly polarized beam with different weighting factors and the azimuthal angle can be tuned by rotating the orientation of the linearly polarized beam azimuthally. It is demonstrated that the overall polarization with variable polar angle and adjustable azimuthal angle can be generated.
Key words: polarization; focal volume; manipulation

CIOP-2017-1961

Self-Absorbed Doublet lines of Ca for Stand-Off Quantitative Analysis of Calciferous Solid Samples by Laser Induced Breakdown Spectroscopy

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Laser induced breakdown spectroscopy (LIBS) is one of the promising techniques for stand-off detection of element composition. However, it is somewhat limited by quantitative shortage. Absolute line intensity may be influenced by acquisition conditions, environmental variation, and sample surface conditions. Relative intensity may also fluctuate greatly. This study shows that the intensity ratio between Ca II doublet emission lines (393.37 nm and 396.85 nm) is stable, and changes with Ca concentration (or Ca atoms count within the laser spot). This is due to differences in self-absorption between the two transitions. A theoretical calibration shows a linear section for low species density and quadratic section for high species density. Experimental results confirm the linear section after density correction of CaO pellets. However, an equipment factor should be considered for numerical calibration in different laboratories. For Ca containing samples, quantitative analysis could be based on the detected Ca spectrum. Ca is also shown to be suitable as an internal standard reference to determine other elemental concentration, such as Mg.
Key words: LIBS; quantitative; self-absorption; calcium doublet ionic lines

CIOP-2017-1980

A Single-Mode 1064 nm Laser for Dual-Wavelength Active Optical Clock

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Representing state of the art, the optical lattice clock based on neutral atoms has reached a perfect result, nevertheless, the limitation is still the Brownian thermal noise of high-fineness Fabry-Perot cavity for frequency stabilization of the oscillation laser. The active optical clock [1,2], which was firstly proposed by our group twelve years ago, can reduce the clock linewidth to millihertz level [3]. Since in the bad-cavity regime, the laser center frequency does not follow the cavity length variation exactly, but in a form of suppressed “cavity pulling” shift. It is worth mentioning that we have realized the 1469.9 nm stimulated emission of Cesium four-level active optical clock [4] whose output linewidth is measured to be 380 Hz [5]. However, without any vibration isolation, the stability is still limited by the residual cavity pulling effect. So we proposed the dual-wavelength good-bad cavity active optical frequency standard [6] to stabilize the main cavity length. Using an integrated structure, the Nd:YAG 1064 nm and Cs 1469.9 nm output lasers share a common cavity and work in good cavity regime and bad one, respectively. The output 1064 nm laser frequency, which is pumped by 808 nm laser with Nd:YAG as gain medium, will be locked to a super cavity at subhertz by PDH technique to stabilize the main cavity length . On the contrary, the 1469.9 nm output laser of bad cavity, is based on the stimulated emission radiation from Cs 72S1/2 to 62P2/3 level and realized by 459 nm laser pumping of Cs atoms in the cavity. With the above scheme, the main cavity length of the active optical clock is stabilized. Thus, the frequency stability of the 1469.9 nm output laser signal is expected to be improved by 2 orders of magnitude than that of the PDH stabilized signal, due to the effect of cavity pulling suppression mechanism in the bad cavity regime.

By selecting the ratio and size of the Nd:YAG crystal and adding to temperature control to it, calculating the optimal cavity length and mirror radius as well as reflectivity of the cavity, especially designing the light path and integrated cavity, we finally achieved the single longitudinal mode output 1064 nm laser of the good cavity. We also studied the wavelength trend with the temperature change of Nd:YAG crystal. By adjusting the temperature and 808 nm pumping laser power, we can control the wavelength and power of good cavity output laser. Moreover, the 1064 nm output linewidth is measured to be 25 kHz by beating with another identical setup. After a long-term experimental exploration, we finally realize the 1064 nm / 1469.9 nm dual-wavelength output of the active optical clock. In the next step, we will work on the PDH stabilization of the bad cavity signal.
Key words: dual-wavelength active optical clock; Single-mode 1064 nm laser; good-bad cavity

CIOP-2017-2176

Measuring focal ratio of astronomical fibers based on energy method

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The optical fibers are widely used in astronomy, for its convenience to transmit the spectrum of celestial body to the spectrometer. The optical fibers play crucial roles in telescopes' observations as a kind of important optical transmission medium. In a telescope system, the number of optical fibers could be up to hundreds or even thousands, so the transmission properties and various parameters of optical fibers are very significant. There are two most important factors to measure the transmission quality of optical fibers. One is the spectral transmittance of fibers, and the other one is the focal ratio degradation (FRD) of fibers. However, the traditional methods of measuring the FRD have many limitations, and they are inefficient. A method to quickly measure FRD of astronomical fibers based on energy is designed. This method has high flexibility and good stability.

Our device for measuring FRD based on energy for astronomical fibers is composed of two parts, including the incident system and the measurement system. The incident system can accurately control the input focal ratio coupling into the astronomical optical fibers. In order to compensate the fluctuation of light intensity, we insert a splitter into the output optical path of fibers so that we can get the reference beam and the testing beam. The intensity of the reference beam is used to correct the measuring errors of the total light intensity fluctuation of the testing beam. The Encircled Energy (EE) can be set and controlled by the control panel in LabVIEW.

The validity of feasibility and stability has been tested before its applications on other fibers and a Integral Field Unit (IFU). The experiments results show that the system is very stable with good performance of high efficiency. And the device proposed in this paper can be easily implemented to measure each fiber of the IFU. The homogeneity of FRD and transmission of whole IFU can be conducted.

Key words: large-core fiber; focal ratio degradation (FRD); encircled energy (EE); integral field unit (IFU)

CIOP-2017-2342

Femtosecond *Z*-Scan Measurements of Nonlinear Refractive Index of Fused Silica

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The self-focusing effect introduced by optical nonlinearities of optical materials plays an important role in the high power laser system, which will change the phase and amplitude distribution of the laser beam. As a result, the focused window on target plane will decrease and the risk of damage to the optical components will increase. Z-scan technology is a popular experimental technique for determining the nonlinear refractive index of the material. However, it encounters a great difficulty in measuring the weak nonlinearity material like fused silica which is about two orders of magnitude below the nonlinear refractive index of most of the materials usually studied with the *Z*-scan method. For this case, the phase distortion introduced by the nonlinear index of the material would be covered by the noise generated by accumulation of thermal effects. To solve this problem, we developed a metrology bench based on the femtosecond Z-scan technology. The intensity modulation component and the differential measurement system are applied to guaranteeing the accuracy of the measuring system. In this work, we perform femtosecond laser *Z*-scan technique on fused silica which has a size of 5 mm×5 mm×3 mm. Based on the femtosecond *Z*-scan theory, the nonlinear refractive index of fused silica is evaluated to be 9.2039×10^{-14} esu for 800 nm, 37 fs pulse duration at 50 GW/cm² with a good repeatability of 6.7‰. For a more reliable result, the femtosecond Z-scan measurement at different beam irradiance are studied. From the linear fitting, the nonlinear refractive index $n_2=8.6482\pm1.1923\times10^{-14}$esu was obtained. This result shows a good agreement with A.J Taylor's work at 804 nm using frequency-resolved optical gating technology ($n_2=8.5929\pm0.7969\times10^{-14}$esu). As a conclusion, we developed a very sensitive metrology setup based on the femtosecond *Z*-scan measurement that can measure nonlinear refractive index as small as fused silica and this is in femtosecond regime and close to the damage threshold of the sample. Moreover, this work also provides a potential application on the femtosecond time-resolved nonlinearities measurement to distinguish the mechanisms of nonlinear absorption and refraction in femtosecond regime.

Key words: nonlinear refractive index; fused silica; femtosecond laser; *Z*-scan technology; accumulation of thermal effects

CIOP-2017-2526

Freeform Configuration to Advanced System Resolution

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Freeform system theory and its influence on aberration and control, is the basis to develop such a system design, which has application value in engineering aspects. The principle approach, modeling, and error analysis are analyzed, and the system configuration based on freeform is advanced in algorithm analysis. To improve the resolution of the imaging system, and to achieve the theoretical limit, we introduced the technology principle of super resolution restructuring from the point of view on theory and engineering. Several methods to realize high resolution restructuring configurations are introduced based on theoretical analysis and engineering practice. Then, three kinds of restructuring technologies, prototype, micro scanning and sub pixel are described, and how to decrease their shortcomings is discussed in detail. Furthermore, to improve the band width by reconstruction without the spectral alias in super resolution technologies, a new coding technology combining optical encoding and sub pixel is proposed. With the global method, the bandwidth has been amplified by ten times as compared with that of traditional ones. Simulation results show that the system can meet the application requirements in MTF, REA, RMS and other related criteria. Compared with the conventional design, the system is reduced in volume and weight significantly. Therefore, the determining factors are the prototype selection and the system configuration combined optical, electronic and signal processing technologies.
Key words: system engineering; photonics; optical design

CIOP-2017-2023

Gyro Coils Diagnosis Based on High Resolution White Light Interferometry

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In this paper, we present an evaluation method to diagnose for fiber optic gyroscope (FOG) coils based on high resolution white light interferometry. Polarization mode coupling, i.e. polarization crosstalk (PC), between the two polarized modes of a FOG coil limits the phase accuracy of the FOG. It prompts distributed polarization crosstalk measurement to be a significant method for diagnosing FOG coil. Based on the nature of periodicity of distributed PC, we extract its low frequency component to characterize the PC of the fiber itself. On the other hand, we extract its high frequency component to characterize the PC of the perturbation point at different diameter of the coil. We tested two FOG coil with length of 2 km and 3 km, and evaluated them with this method. The comparison results demonstrated that this evaluation method could provide more information of the FOG coil than the distributed PC. The information could help to improve the coil winding technology, thus to suppress the PC.
Key words: fiber optic gyroscope; polarization crosstalk; white light interferometry

CIOP-2017-3012

Study on Mid-Frequency Wave-Front Error Measured by Interferometer

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For large scale optical components in high power laser driver, mid-frequency wave-front error in the spatial frequency range of 0.12-33 mm is the major cause of nonlinear small-scale self-focus effect and threats the safe operation of whole laser system seriously. Based on the Fourier analysis, the power spectral density (PSD) function is used to evaluate mid-frequency wave-front errors. However, due to low-pass filtering characteristics of interferometers, some mid-high frequency wave-front information is lost in the process of the reflection/transmission wave-fronts detection of optical components. How to effectively extract mid-frequency ripple information and further obtain relatively real PSD distribution of wave-front error is the main content of this report.

The calculation method and flow of 1-D/2-D PSD are introduced in detail. On this basis, the correction factor about Hanning window addition is derived, and the relationship between PSD and measured aperture is studied by experiment. 4D AccuFiz, ZYGO DynaFiz and ZYGO GPI interferometers are used to measure periodic ripple and scratch samples, and these obtained 1-D PSD curves are compared and analyzed. The results show that the responsivities to mid-high spatial frequency of different interferometers are different. The higher the interferometer resolution is, the higher the responsivity to mid-high spatial frequency is. The measured PSD distributions are corrected by instrument transfer function (ITF) and the more real PSD distributions are obtained. However, the ITF curve given by manufacturer may be different from practical responsivity in some frequency band, which cause reduced credibility of PSD correction.
Key words: mid-frequency wave-front error; power spectral density; instrument transfer function

CIOP-2017-1692

Research on the Magnetic-Thermal Coupling in a Polarization-Maintaining Fiber Optic Gyroscope

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Errors caused by the physical fields in fiber optic gyroscope (FOG) is important for high-grade inertial navigation systems. An investigation of magnetic-thermal coupling in the polarization maintaining fiber optic gyroscope (PM-FOG) with non-skeleton coil is presented. It is found that magnetic-thermal coupling can arise through the temperature dependence of birefringence and Verdet constant of polarization maintaining fiber (PMF). Jones matrix method is utilized to formulize the magnetic-thermal coupling in PM-FOG, and relevant experiments are performed to support the theoretical predictions. For the non-skeleton coil with length of 1 km, radius of 6 cm, linear birefringence of 2027 rad/m, and maximum twist rate of 0.382 rad/m, the change of the magnetic field error is 3.92 °/h and the degree of magnetic-thermal coupling is 4.12 %, which are caused by 1 mT radial magnetic field and the temperature range from -40 °C to 60 °C. This study has some theoretical significance for improving the environmental adaptation performance of PM-FOG.
Key words: fiber optic gyroscope; polarization maintaining fiber; magnetic-thermal coupling; magnetic field; Faraday effect

CIOP-2017-2551

Design of Lens Coupler with Uniform Energy Distribution for LED and POF Bundle

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The uniform side-emitting polymer optical fiber (POF) bundle requires that the light source coupling system be energy uniform and that the incident angle of light be not greater than the numerical aperture angle of the fiber. In this paper, the principle and design method of the uniform coupler of the high power LED as the light source are studied. Based on the energy compensation and coordinate iteration method, a free surface coupler is designed, and the coupler consists of four free surfaces of secondary refraction and secondary reflection. Refraction surfaces redistribute the energy of the light in the LED Lambertian beam with a divergence angle of less than 45 degrees, and the reflected surface will reallocate the light with a divergence angle greater than 45 degrees in the beam. Its layout is designed and optimized for energy uniformity and coupler efficiency of the end face of the fiber bundle through TracePro optical simulation software. The results of optical simulation show that when the 3535 LED is used as the light source, the designed coupler can make the energy of the 20 × 20 polymer fiber bundle with the diameter of 0.5mm reach more than 90% and the coupler efficiency above 70%.
Key words: LED-POF fiber bundle coupler; uniform energy coupler; coupler efficiency; optical simulation

CIOP-2017-2408

Experimental Study on the Effect of Atmospheric Turbulence on the Heterodyne Detection

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Heterodyne detection with its sensitivity several orders of magnitude higher than the direct detection and many other advantages, has been widely used in laser radar, laser communication, atmospheric monitoring, target detection and so on. With the deepening and expansion of the research, the lidar heterodyne detection technology is moving towards long distance target tracking detection. However, atmospheric turbulence seriously affects the performance of the long-range accurate tracking and detection, mainly because atmospheric turbulence caused by the wavefront distortion and the fluctuation of the arrival angle etc, seriously affects the system's signal to noise ratio (SNR) and thus limits the working performance of laser heterodyne detection system. Therefore, it is of great theoretical and practical significance to study the influence of atmospheric turbulence on laser heterodyne detection. Based on the existing instruments and equipments in the laboratory, a 1.55 μm laser heterodyne detection experiment system with optical fiber structure is constructed. The atmospheric turbulence simulator based on the hot air convection is used to simulate the atmospheric turbulence. Based on the system, series of experimental studies on the effect of atmospheric turbulence on the heterodyne detection system SNR are started. The heterodyne detection system uses a continuous fiber laser with a wavelength of 1.55 μm and a line width of 1 kHz. The signal light and the local oscillator have a fixed frequency shift of 165 MHz, and the method of balanced detection is used to eliminate the overpressure intensity noise. In order to simulate the actual atmospheric environment more effectively, this paper discusses the effect of atmospheric turbulence on heterodyne detection under different atmospheric coherence length.
Key words: single mode fiber; atmospheric turbulence; heterodyne detection; AOM.

CIOP-2017-2304

High-sensitivity Temperature Sensor based on Fano Resonance in Microcapillary Resonator

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This letter develops a high-sensitivity temperature sensor based on Fano Resonance(FR) in microcapillary resonator. High order FR modes can be excited by a thin fiber taper coupled to an optofluidic microcapillary resonator. The high order FR modes with Lorentzian peak is generated when high order whipering gallery modes(WGMs) interfere with the weak background scattering. We have successfully applied it to the refractive index sensing.

With thin fiber taper and ethanol-filled optofluidic microcapillary resonator, we successfully excite high order FR modes with over 4000 Q-factor. As WGMs are generated, their evanescent field penetrates inside the core liquid. Thus, the effective index of the WGMs becomes highly dependent on the index of the core liquid. If the refractive index of the liquid changes, a wavelength shift of WGMs can be observed. We change the temperature of the ethanol and record the transmission spectrum to compare the resonant wavelength of high order FR modes, then discover the linear relationship between wavelength shift and temperature. A blue-shift of the wavelength of FR modes is observed when increasing the temperature. The sensitivity observed is more than 0.2 nm/K at wavelength of 1550 nm, which is a large improvement compared to earlier work. The reason of high sensitivity is that high order WGMs modes have a much larger evanescent field inside the core liquid, which leads to a much larger sensitivity to refractive index's change than that of low order modes. Thus high order FR modes can be used in high-sensitivity sensing. Meanwhile, ethanol has a larger thermos-optic coefficient compared to glass, which makes its refractive index largely dependent of the temperature. This high-sensitivity temperature sensor has great potential in temperature measurement in microscale applications.
Key words: temperature sensor; fano resonance; whispering gallery modes

CIOP-2017-0629

Determination of Residual Stress along Depth by In-Plane 3-directional Optical Interference Moire

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A grating rosette moire interferometry and incremental hole drilling combined system is developed to determine the magnitude of the residual stress along depth in aluminum plate subjected to a uniform uniaxial tensile load. Performing in-plane 3-directional fringe analysis, the optical data contained in the moire interferograms are converted into values of strains in three directions corresponding to the grating rosette. The evaluation is carried out through the measurement of the in-plane displacement field in three directions generated by the introduction of the small incremental hole. The in-plane 3-directional displacement fields are determined from the calculation of the optical in-plane 3-directional phase distribution by means of a phase shifting method. The magnitude of the principal stresses is finally evaluated through a least-squares calculation and compared with the stress value applied to the specimen measured with strain gages.
Key words: residual stress; moire interferometry; in-plane displacement; grating rosette; hole drilling method

Session 5: Optical Communications and Networks

Session Chairs: **Jing Ma**, Harbin Institute of Technology, China
Zhaohui Li, Sun Yat-sen University, China

Location: B514, 5F, Main Building, Harbin Institute of Technology No.2 Campus

18th July

Chair: Songnian Fu, Huazhong University of Science and Technology, China

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15:00-15:15	**Performance of Misaligned Orbital Angular Momentum Communication System with MIMO Equalization (Oral)** Wenhao Zhang *Nangjing University of Posts and Telecommunications, China*	- 93 -
15:15-15:30	**Fast Acquiring and Pointing Characteristics of Modulating Retro-Reflecting Free Space Optical Communication (Oral)** Laixian Zhang, Huayan Sun, Yanzhong Zhao, Jianying Ren, Tianqi Zhang *Academy of Equipment, China*	- 93 -
15:30-15:45	**Gain Optimization of the Fiber Optical Parametric Amplifiers (Oral)** Hongna Zhu, Peipei Li, Chunrong Qiu, Xiaorong Gao *Southwest Jiaotong University, China*	- 93 -
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17:30-17:45	**Adaptive Kalman Filter Based on Covariances Matching in Coherent Optical Communication (Oral)** Qian Xiang, Yanfu Yang, Qun Zhang, Zhongqing Zhou, Qianwen He *Harbin Institute of Technology, China*	-94 -
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19th July

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Design, Properties, and Applications of Hybrid Graphene-on-Silicon Photonic Integrated Circuits

Zhenzhou Cheng
the University of Tokyo, Japan

Note

ABSTRACT

Graphene has attracted tremendous attention as a promising material to develop novel photonic and optoelectronic devices. However, the weak light-matter interaction in the atomic-thickness graphene seriously limits its applications. For example, the monolayer graphene can only absorb ~2.3% incident light under normal illumination. In our previous work, we developed several hybrid graphene-on-silicon photonic integrated circuits to overcome this bottleneck. In our methods, an in-plane evanescent-field coupling configuration is used to enhance light-matter interaction between top-layer graphene and propagating light in the waveguide. In this talk, I review design and properties of the developed hybrid graphene-on-silicon photonic integrated circuits, and their applications in photodetection, optical modulation, and sensing.

BIOGRAPHY

Dr. Zhenzhou Cheng is currently an assistant professor of physical chemistry in the Department of Chemistry at the University of Tokyo, Japan. He received his B.S. degree in physics and M.S. degree in optics from Nankai University, China, in 2006 and 2009, respectively. He received his Ph.D. degree in electronic engineering from The Chinese University of Hong Kong in 2013. He was awarded the Postgraduate Research Output Award and the Young Scholar Thesis Award from the Chinese University of Hong Kong, and the Young Scientist Award from Hong Kong Institute of Science in 2013. He joined the Goda lab in the Department of Chemistry at the University of Tokyo as an assistant professor in 2015. His research focuses on graphene and silicon photonics for sensing, spectroscopy and optical communications.

Shilong Pan
Nanjing University of Aeronautics and Astronautics, China

Ultrahigh Resolution Optical Fiber Length Measurement

ABSTRACT

Knowing the exact length of long optical fiber is of great importance to interferometry-based optical sensors, fiber-connected antenna arrays and other microwave photonic applications. This talk reviews recent efforts on long optical fiber length measurement with sub-millimeter resolution, including optical time domain reflectometers, optical frequency domain reflectometers, and optical backscatter reflectometers based on microwave frequency sweeping. Techniques to improve the measurement resolution and to reduce the measurement error are discussed.

Note

BIOGRAPHY

Shilong Pan received his B.S. and Ph.D. degrees in electronics engineering from Tsinghua University, Beijing, China, in 2004 and 2008, respectively. From 2008 to 2010, he was a “Vision 2010” postdoctoral Research Fellow in the Microwave Photonics Research Laboratory, University of Ottawa, Canada. He joined the College of Electronic and Information Engineering, Nanjing University of Aeronautics and Astronautics, China, in 2010, where he is currently a full professor and executive director of the Key Laboratory of Radar Imaging and Microwave Photonics (Nanjing Univ. Aeronaut. Astronaut.), Ministry of Education. His research focuses on microwave photonics, which includes optical generation and processing of microwave signals, photonic microwave measurement, and integrated microwave photonics. Prof. Pan has authored or co-authored over 280 research papers, including more than 140 papers in peer-reviewed journals and 140 papers in conference proceedings. Prof. Pan is a senior member of the IEEE Microwave Theory and Techniques Society, the IEEE Photonics Society and a member of the Optical Society of America. He was selected to receive an OSA outstanding reviewer award in 2015. Prof. Pan serves as a chair of Numerous International Conferences and Workshops, including the TPC chair of the International Conference on Optical Communications and Networks in 2015, TPC Co-chair of IEEE International Topical Meeting on Microwave Photonics in 2017, TPC chair of the Cigh-Speed and Broadband Wireless Technologies Subcommittee of the IEEE Radio Wireless Symposium in 2013, 2014 and 2016, TPC chair of the Optical Fiber Sensors and Microwave Photonics Subcommittee of the OptoElectronics and Communication Conference in 2015, and chair of the Microwave Photonics for Broadband Measurement Workshop of International Microwave Symposium in 2015.

Enabled Fiber Wireless Convergence Techniques Towards 5G Mobile Network

Songnian Fu
Huazhong University of Science and Technology, China

Note

ABSTRACT

We review enabled techniques of fiber wireless convergence towards 5G mobile network, with obvious advantages of transparence of modulation format and carrier frequency, and compatibility of multiple services and applications. Under the joint research efforts of spatial division multiplexing, microwave photonic, and distributed antenna, we are able to extend the capacity of wireless transmission. Meanwhile, we put forward adaptive channel equalization and compensation of phase noise and nonlinearity, in order to enable low-cost massive MIMO signal transmission over fronthaul link.

BIOGRAPHY

Songnian Fu received his B.Sc. and M.Sc. Degree from Xiamen University, Xiamen, China, in 1998 and 2001, respectively. He received his Ph.D. degree from Beijing Jiaotong University, Beijing, China, in 2005. From 2005 to 2011, he was with Network Technology Research Center (NTRC), Nanyang Technological University, Singapore, as a research fellow. Since Feb, 2011, he has been a professor in the school of Optical and Electronic Information, and Wuhan National Laboratory for Optoelectronics, Huazhong University of Science and Technology, Wuhan, China. His current research interests include fiber optical transmission and fiber wireless convergence.

Jian Chen
Nanjing University of Posts and Telecommunications, China

Note

Demand-Driven Indoor Visible Light Communications: A Technological Perspective

ABSTRACT

From the point of view of potential application scenario and main technical challenges, any technological advance on indoor visible light communication systems should be on a demand-driven basis. We report recent efforts on multi-user multiple-input multiple-output (MU-MIMO) with a novel concept of precoding. Modified orthogonal frequency division multiplexing (OFDM) applicable for such non-coherent circumstance should be further improved with a new method of time domain reshuffling (TDR) for both traditional DCO- and ACO-OFDM systems. Finally, futuristic design of both white LED and indoor lighting scheme with optimal support on maximizing indoor VLC performance is also investigated.

BIOGRAPHY

Jian Chen received his B.S., M.S., and Ph. D. degrees in electronic engineering from Southeast University, Nanjing, People's Republic of China (PRC), in 1988, 1990, and 1994, respectively. From 1999 to 2001, he was with the Department of Electrical Engineering of the Korea Advanced Institute of Science and Technology (KAIST), Daejeon, Korea. In 2002, he was with the Institute for Communication Research of National University of Singapore (NUS) as member of technical staff. In 2003, he joined the Communications & Devices Division of the Institute of Infocomm Research (I2R) as a research scientist, Singapore. In 2010, He is appointed as a full professor in NUPT. He has been engaged in research on optical fiber communication systems and optical access networks for almost 30 years, and in pioneering works in VLC research and development since 2005. His current interests are focusing on visible light communication (VLC) and digital signal processing in coherent optical communications.

Reconfigurable WDM-PON Empowered by a Low-Cost 8-Channel Directly-Modulated-Laser Module

Yu Liu
Institute of Semiconductors, Chinese Academy of Scicences, China

Note

ABSTRACT

In this study, we propose a reconfigurable WDM-PON based on a low-cost 8-channel DML module. Compared to the case that using discrete devices in conventional scheme, the proposed DML module provides a cost-effective solution with reduced complexity. Employing the module, a reconfigurable bidirectional transmission experiment with 10Gb/s modulation signal over 16 km single mode fiber is achieved. Due to the proper package design, the crosstalk between channels under condition of simultaneous operation is negligible. According to the experimental results, the clearly eye diagram and the BER of less than 2×10^{-7} with a sensitivity of -7 dBm are obtained.

BIOGRAPHY

Yu Liu was born in Hunan, China, in 1976. He received his B.S. degree in electronics and electrical engineering from the Beijing Institute of Technology, Beijing, China, in 1998, and the M.S. and Ph.D. degrees in microelectronics and solid-state electronics from the Institute of Semiconductors, Chinese Academy of Sciences, Beijing, in 2004 and 2008, respectively. He is an associate professor in the Institute of Semiconductors, Chinese Academy of Sciences. His research interests include high-frequency characteristics of microwave optoelectronic devices and design of high-speed optical transceiver modules.

Lilin Yi
Shanghai Jiao Tong University, China

High-Speed Chaotic Optical Communications With Enhanced Security

ABSTRACT

In this talk, I will review the research progress of chaotic optical communications in the past two decades and introduce our recent work on high-speed chaotic communications with enhanced security, specially focusing on how to improve the security level of chaotic optical communications meanwhile keep the compatibility with the current high-speed optical communication systems.

BIOGRAPHY

Lilin Yi received the BS (2002) and MS (2005) from Shanghai Jiao Tong University (SJTU), China. He achieved the PhD degree from Ecole Nationale Supérieure des Télécommunications (ENST, currently named as Telecom ParisTech), France and SJTU, China on Mar. and Jun. 2008 respectively as a joint-educated PhD student. In 2010, he joined the State Key Laboratory of Advanced Optical Communication Systems and Network, SJTU. Currently he is a full professor. His main research topics include optical signal processing, high-speed optical access networks and secure optical communications. Dr. Lilin Yi is the author or coauthor of more than 100 papers in peer-reviewed journals and conferences, including more than 20 invited papers/invited talks, which have been cited by more than 1200 times (Google Scholar). Dr. Yi has achieved the awards of “National Excellent PhD Thesis in China” and “National Science Fund for Excellent Young Scholars of China”. He serves as the TPC member of OFC2018/OFC2017/ACP2017/ACP2016/ICOCN2016 and TPC track and symposium co-chairs of OECC2015.

Note

Next Generation Optical Interconnection Network Architectures for Datacenters

Jiajia Chen
South China Normal University, China

Note

ABSTRACT

Due to the introduction of demanding and time-critical data services, growing importance of IT services and dramatically increasing traffic volume, interconnection networks within datacenters are facing serious problems. The following research challenges need to be addressed: 1) providing ultra-high capacity inside datacenters, particularly for large-scale site infrastructures hosting several hundred thousand servers, 2) improving cost- and energy-efficiency throughout all parts of the interconnection network with the datacenter, and 3) offering low latency to support emerging time-critical services, such as connected vehicles, tactile Internet. In this talk, we summarize our attempts to address the aforementioned challenges, targeting both data plane and control plane of next generation optical interconnection networks inside the datacenters. The data plane forwards the data traffic in the physical infrastructure, while the control plane is in charge to ensure the optimal network operation. For the optimal design of intra-datacenter networks, a cross-layer approach is instrumental, where the data plane constraints are taken into account by the control plane in order to efficiently schedule the traffic flows while satisfying end-to-end quality of service.

BIOGRAPHY

Jiajia Chen received her B.S. degree (2004) in information engineering of Zhejiang University, China, and Ph.D. degree (2009) in optical networking from KTH Royal Institute of Technology, Sweden. She is co-author of over 100 publications in international journals and conferences in the area of optical networking. Her main research interests are optical transport and interconnect technology supporting future 5G and cloud environment.

Bo Liu
Nanjing University of Information Science & Technology, China

Note

Software-Defined Flexible Access Network

ABSTRACT

With the enhancement of the transmission capacity of optical networks, the flexibility of access networks has become the focus of attention. In recent years, technologies such as OFDM-PON, WTDM-PON, and SDN have greatly improved the flexibility of optical access networks, but these technologies still face many challenges. Our team has done a number of research work on OFDM-PON, WTDM-PON, and software defined optical access. This report introduces frontier technologies and our research in flexible optical access. A novel software defined wavelength division multiplexing /time division multiplexing passive optical network (SD-WT-PON) is proposed to meet the requirements of high bandwidth, high performance and multiple services. A reasonable and effective uplink dynamic bandwidth allocation (DBA) algorithm is proposed. The simulation compares the proposed algorithm with the IPACT algorithm. The algorithm shows better performance in average delay, throughput and bandwidth utilization. The results show that the delay is reduced to 62%, and the throughput is improved up to 35%.

BIOGRAPHY

Bo Liu, professor, dean of Institute of Optoelectronics, Nanjing University of Information Science and Technology. He obtained his Ph.D. degree in BUPT, Beijing, China. He won the title of Top-Notch Young Talent in Beijing in 2016. He focused on the research areas including optical access network, nonlinear fiber optics, all-optical signal processing and high speed optical fiber communication.

Very High Throughput and Spectrally-Efficiency Coherent Ultra-Dense WDM-PON

Ze Dong
Huaqiao University, China

Note

ABSTRACT

A very high throughput coherent Ultra-Dense WDM-PON with its bandwidth efficiency enhanced by using Nyquist independent-sideband (N-ISB) modulation is proposed and experimentally demonstrated. The proposed optical line terminal (OLT) suggests 75 downlink optical subcarriers. For each optical subcarrier, there is as many as 16- 10-Gb/s N-ISB digital channels modulated on it, which can be efficiently generated using only one set of optical transmitter hardware. Experimental results show that the proposed UDWDM-PON is capable of accommodating 1,200 10G users, and achieving a total throughput of 12 Tb/s with a spectral efficiency of 5.628-bits/s/Hz. More importantly, the proposed system with spectral- and bandwidth-efficient N-ISB requires 16 times less downlink optical transmitters at the OLT, which can be translated into savings in cost, power consumption and footprint. In addition, key techniques such as N-ISB modulation in a PON system, frequency locked optical multi-carrier generation and digital pre-equalization are also studied.

BIOGRAPHY

Ze Dong is a professor of Department of Electronic Scienceand Technology, Huaqiao University. He received his Ph.D.. degree in electrical engineering from Hunan University, Changsha, China in 2011. His research is in the area of optics and photonics and telecommunication include optical coherent communications and broadband optical communication. He has authored and co-authored more than 140 prestigious journal papers and conference proceedings in the fields of coherent optical transmission, passive optical networks and broadband radio-over-fiber system.

Bin Zhang
San Yat-Sen University, China

Note

High-resolution Chalcogenide Fiber bundles for Thermal Image Delivery

ABSTRACT

Ordered fiber bundles (FBs) operating in the mid-infrared spectral region are desirable for the collection and delivery of thermal images in extreme (e.g. under nuclear irradiation) or unfavorable environments (e.g. stray electromagnetic fields, in restricted spaces, etc.). In this paper, high-resolution chalcogenide FBs suitable for transmitting images in the 1.5-6.5 μm and 3-12 μm spectral ranges are fabricated and characterized. A modified fabrication method, which combines an extrusion and a stack-and-draw techniques is demonstrated. The fabricated FBs show a resolution of >20 lp/mm, an active area of > 54%, and a crosstalk of < 3%. Fine thermal images of hot and room-temperature objects are delivered through the FBs, encouraging that it could be a promising candidate in fiber-optic thermal imaging in medical and industrial applications.

BIOGRAPHY

Bin Zhang received his Ph.D. degree in material physics and chemistry from Sun Yat-Sen university in 2011. He ever served as an associate professor at Jiangsu Normal University since 2012. He was a visiting scholar at the Australian National University (2014-2015) and a research fellow at the Hong Kong Polytechnic University (2015-2017). He joined the State Key Lab of Optoelectric Material & Technology at Sun Yat-Sen University as an associate professor in 2017. His major research interests include infrared materials, infrared fibers and waveguides, in-fiber nano-fabrication, and their applications in nonlinear optics, etc.

Parametric Mixer Based Passive Phase Correction for Stable Transfer of High-Frequency Reference

Xiaojie Guo
Jinan University, China

ABSTRACT

Phase-stable distribution of high-frequency signal is critical in radio astronomy and deep space networks. We propose to use a parametric mixer in passive phase correction scheme for stable distribution of high-frequency reference over fiber links. The parametric mixer is realized via ultrafast four-wave mixing processes thereby overcoming the bandwidth limit of conventional electronic devices. Distribution of high-stability 36 GHz millimeter wave over 20 km optical fiber was achieved.

Note

BIOGRAPHY

Xiaojie Guo received the B.S. degree (2008) from South China University of Technology, China, and the M.S. degree (2011) from Sun Yat-sen University, China. She received the Ph.D. degree in electronic engineering from the Chinese University of Hong Kong in 2014. She joined the Institute of Photonics Technology at Jinan University, China as a lecturer in 2015. Her research interests include optical signal processing, optical communications, nonlinear fiber optics, etc.

Fan Li
San Yat-Sen University, China

Generation and Reception of Faster-than-Nyquist Optical DFT-spread OFDM Signals

ABSTRACT

In this study, we successfully demonstrate the generation and reception of faster-than-Nyquist (FTN) optical orthogonal frequency-division multiplexing (OFDM) signals with coherent detection. In the FTN OFDM transmission system, frequency shaping is realized with a delay-and-add filter (DAF) in the transmitter to ensure the energy of signal concentrated at low frequencies, which will make the OFDM much more robust to strong filtering effect to some extent. Transmission of FTN optical OFDM signals with QPSK and 16QAM modulation formats are realized in the experimental setup.

BIOGRAPHY

Fan Li, Associate Professor, Sun Yat-Sen University. He obtained the Ph.D. degree in information and communication engineering from Hunan University, Changsha, China, in 2014. From 2012 to 2014, he worked as a visiting scholar in Georgia Institute of Technology under the supervision of Professor Gee-Kung Chang. After that, he worked as a research engineer in optical transmission labs in ZTE USA, New Jersey for two years. His research interests include High speed fiber –wireless integration, orthogonal frequency-division multiplexing (OFDM) radio-over-fiber systems, high-spectra efficiency direct-detection/coherent detection OFDM transmission systems, and signal processing on OFDM systems.

Note

CIOP-2017-1457

Performance of Misaligned Orbital Angular Momentum CommunicationSystem with MIMO Equalization

Wenhao Zhang
Nanjing University of Posts and Telecommunications, China

It is shown that the quality of communication system using orbital angular momentum multiplexing is inevitably degraded by the misalignment of orbital angular momentum modes between the transmitter and the receiver. In the paper, a scheme is proposed to mitigate the effect, where MIMO equalization is adopted to mitigate the crosstalk caused by misalignment. The numerical simulation results show that the crosstalk between OAM modes has been decreased, and the bit error rate performance of the system has been improved. In the case of small lateral displacement and angular deflection, the bit error rate performance has enhanced one or two orders of magnitude.
Key words: orbital angular momentum multiplexed communication; misalignment; MIMO equalization; bit error rate

CIOP-2017-1532

Fast Acquiring and Pointing Characteristics of Modulating Retro-Reflecting Free Space Optical Communication

Laixian Zhang, Huayan Sun, Yanzhong Zhao, Jianying Ren, Tianqi Zhang
Academy of Equipment

This study introduced the principle of modulating retro-reflecting free space optical communication, analyzed the classical modulating retro-reflecting free space communication link building process and mathematical model. The result shows that the retro-reflecting free space optical communication overleaps scanning process of a terminal compared with classical free space optical communication when building link, which reduces the link building time very much, and the greater the uncertain area, the greater the advantage. Using representative parameters, the link building time of retro-reflecting free space optical communication is 2 orders of magnitude shorter than the classical link. When the link range changes, receiving optical signal power of active terminal and the maximum link acquiring time remain unchanged by controlling transmitting angle of active terminal.
Key words: free space optical communication; retro-reflecting modulating; acquiring & pointing; communication link

CIOP-2017-1771

Gain Optimization of the Fiber Optical Parametric Amplifiers

Hongna Zhu, Peipei Li, Chunrong Qiu, Xiaorong Gao
School of Physical Science and Technology, Southwest Jiaotong University

During the last decade, the fiber optical parametric amplifier (FOPA) has attracted widespread interests due to the advantage of being able to operate in any of the telecom bands and offer uniform high gain over a relatively wide bandwidth, which has been used in many applications. The gain characteristics play a more important role for the FOPA systems, thus the FOPA with optimized gain is imperiously required. In our work, some new ways are adopted to optimize the gain of the FOPAs. Firstly, by inserting a phase-shifted fiber Bragg grating (PS-FBG) between two high nonlinear dispersion shift fibers (HNL-DSFs), where the PS-FBG is adopted to reduce the power and change the phase of the idler wave and lead to changes of the phase mismatch parameter and relative phase difference among the four involved waves in four wave mixing (FWM), it is shown that the gain of FOPA is enhanced significantly and also the conversion efficiency for pump-to-signal power is increased. Secondly, we experimentally introduce the standard single mode fiber (SMF) inserted between two same HNLFs to compensate the phase mismatching of the single-pump FOPA, the utilization of standard SMF can alter the situation from the de-amplification to the re-amplification process for the signal wave, hence the introduction of the SSMF provides a way to achieve the gain improvement of the FOPA. In addition, the genetic algorithm (GA) was used to determine the parameters the FOPA both considered the case of the four wave mixing and six wave mixing, where the numerical simulation showed that the genetic algorithm is an appropriate method to this multi-objective and multi-variate problem and we can obtain the flat and wide gain optimization. The methods of optimizing the gain characteristics of the FOPA are extremely useful for the optical communication system.
Key words: fiber optical parametric amplifiers; four wave mixing; gain optimization; genetic algorithm; six wave mixing

CIOP-2017-2096

Adaptive Kalman Filter Based on Covariances Matching in Coherent Optical Communication

Qian Xiang, Yanfu Yang, Qun Zhang, Zhongqing Zhou, Qianwen He
Shenzhen Graduate School, Harbin Institute of Technology

Driven by cloud computing and data center, polarization multiplexing, advanced modulation format and digital signal processing are the promising techniques to meet the increasing demand on communication capacity. Meanwhile, polarization demultiplexing and carrier phase recovery are two critical challenging modules in digital signal processing for coherent optical communication. To cope with this problem, many algorithms were proposed to estimate the inversely channel matrix and carrier phase noise. However, there are also some disadvantages in those algorithms. The conventional CMA (constant modulus algorithm) has the singularity problem and low convergence speed. The BPS (blind phase search) algorithm has high implementation complexity. EKF (extended Kalman filter) has attracted the attention of researcher in optical communication owing to its high accuracy of estimation quick convergence speed. However, its estimation accuracy and polarization tracking capacity are strongly dependent on its tuning parameter *Q*, which refer to the covariance of process noise. Considering that the dynamic noise levels in future optical network scenarios, it's desired to propose adaptive Kalman scheme which can set *Q* properly in dynamic scenarios.

To address this problem in conventional EKF efficiently, an AKF (adaptive EKF) based on covariances matching for jointly polarization de-multiplexing and carrier phase recovery is proposed in this study. The tuning parameter *Q* in AKF is estimated by forcing the difference between the actual measurement and its predicted value to zeros. Besides, the forget factor is adopted in AKF to emphasize the weight of previously tuning parameter *Q* and the estimated one, which make the tuning parameter *Q* adaptively in dynamic scenarios.

Compared with traditional EKF for polarization demultiplexing and carrier phase recovery, the performance of AKF are detailly investigated in QPSK and 16QAM at the scenarios of different tuning parameter *Q*. Simulation shows that the curve of BER Vs. OSNR in EKF is more sensitivity to the tuning parameter *Q* than its performance in AKF. What is more, the proposed AKF outperforms the conventional EKF at different initial tuning parameter *Q*. Meanwhile, the performance of polarization tracking ability in AKF is 100 times than EKF at the case of $Q=1e^{-5}$. The simulation also shows that AKF has excellent performance in the aspect of laser linewidth tolerance, which is similar with the performance of BPS and EKF.

The simulation results are consistent with the theoretical analysis ,which confirms the advantages of AKF. It is believed that AKF is a good candidate for jointly polarization demultiplexing and carrier phase recovery in flexible and elastic optical commutations.

Key words: AKF(adaptive Kalman filter); polarizationde-multiplexing;carrier phase rcovery; coherent optical communication

Session 5

CIOP-2017-2237

Mitigation of Crosstalk Based on CSO-ICA in Free Space Orbital Angular Momentum Multiplexing System

Jianfei Liu, Dengke Xing, Ziyao Yi, Xiangye Zeng, Jia Lu
Hebei University of Technology

Interference in free space OAM multiplexing system is mainly caused by atmospheric turbulence, which can cause the energy of the OAM beam to diffuse to adjacent beams to introduce crosstalk. We demonstrate the mitigation of crosstalk in a free space OAM multiplexing system based on CSO-ICA algorithm.

Key words:CSO-ICA; OAM multiplexing system; free space; modal crosstalk

CIOP-2017-1726

Multiplexing Scheme Both with Ring Radius and Topological Charge of Perfect Optical Vortex Beam Multiplexing System

Shengmei Zhao
Institute of Signal Processing and Transmission, Nanjing University of Posts and Telecommunication, China

With the growing demand of communication services, there is a corresponding increasing demand for higher bandwidth. It is crucial to be able to deliver more and more data within an available limited bandwidth in emerging wireless communications systems like 5G and beyond.

In this paper, we propose a multiplexing scheme with ring radius and topological charge of perfect optical vortex (POV) beam. A communication system using the proposed multiplexing scheme is also presented and OOK modulation is applied to demonstrate the bit error rate (BER) performance under atmospheric turbulence. The numerical results show that the BER performance of the proposed scheme is better when only orbital angular momentum (OAM) multiplexing scheme is used under the same conditions. At the same time, the capacity and the spectral efficiency of the system are improved since the ring radial degree is also used in the proposed multiplexing scheme.

Key words: orbital angular momentum; perfect optical vortex beam; OOK modulation; bit error rate

CIOP-2017-1999

Influence of Modulating Retro-Reflector Array on the BER of Atmospheric Laser Communication System

Tianqi Zhang, Guihua Fan, Laixian Zhang
Equipment Academy

The atmosphere laser communication technology based on modulating retro-reflector array not only solves the problem that the traditional laser communication can't works on small load platform but also effectively overcomes the influence of atmospheric turbulence. The atmosphere laser communication system based on modulating retro-reflector array is divided into two parts: forward link and reverse link. In the forward link, the modulating retro-reflector array is compared with a single modulating retro-reflector by the aperture averaging factor. The signal-to-noise ratio (SNR) of the beam transmitting through the atmosphere to the modulating retro-reflector array is derived. In the reverse link, based on the negative exponential distribution of the intensity probability density function, a channel model of modulating retro-reflector array reflection beams transmitting in the atmosphere is established. By the model, the intensity probability distribution when transmitting with different numbers of reflection beams and the bit error rate (BER) of the atmosphere laser communication system based on modulating retro-reflector array in different turbulent environment are analyzed. The analysis results show that under the condition of medium atmospheric turbulence, the BER of the modulating retro-reflector array consisting of three modulating retro-reflectors is reduced by 4dB compared with a single modulating retro-reflector when the transmission distance is 1 km.
Key words: atmosphere laser communication; modulating retro-reflector array; atmospheric turbulence; BER

CIOP-2017-2322

Constellation Design of 16QAM Modulation Formats in the Presence of Linear and Nonlinear Phase Noise for Coherent Optical Communication Systems

Qianwen He, Yanfu Yang, Qun Zhang, Qian Xiang, Yong Yao
Harbin Institute of Technology

With the increasing demand for communication capacity, higher order QAM modulation formats are becoming highly desired for obtaining high spectral efficiency. Constellation design has become an important task to improve the performance of transmission performance. Yang, L. proposed an optimized constellation design algorithm for circular 16QAM, its basic principle is to traverse the 16QAM modulation format under the condition of restricting the minimum Euclidean distance. However, in certain extreme circumstances, such as linear and nonlinear phase noise, the chosen modulation formats is costrained improvement due to the limitation of the fixed radii assumption. In this study, on the basis of the selected modulation formats using the above algorithm, the amplitude of the constellation shapes can be further optimized in a specific situation in order to improve the system performance as much as possible.

First of all, this study verify the improved design algorithm by simulation. According to the original designed constellation scheme, we traverse the common circular 16QAM and select two circular 16QAM modulation formats. These two modulation formats considered small phase noise and high phase noise, which are simulated by weak and strong fixed angle. After choosing the two circular 16QAM modulation format, the amplitude optimization of the circular 16QAM format is studied under different cases including strong Gauss white noise, strong phase noise, low phase noise and strong nonlinear effect. The simulation results show that the performance of the two circular 16QAM is significantly improved using blind phase search for phase noise recovery after amplitude optimization, and is obviously superior to the commonly used rectangular 16QAM modulation format.

Then, the improved algorithm is further verified by experiments. In the experiment, we consider strong Gaussian white noise and strong phase noise, respectively. The results show that after the amplitude optimization of the chosen modulation formats, the constellation design algorithm is better than the original constellation design algorithm.

The results show that the proposed constellation optimization design algorithm can optimize the constellation design in a specific channel situation in order to improve the performance of the system. Therefore, it also provides an effective constellation design method for improving transmission performance of future resilient dynamic optical communication networks.
Key words: signal design; 16QAM; linear; nonlinear; phase noise

CIOP-2017-2336

A Joint Frequency Offset and Phase Estimation Scheme Based on Cascaded EKF and LKF

Bingjie Hou, Yanfu Yang, Qian Xiang, Qun Zhang, Yong Yao
Harbin Institute of Technology (Shen Zhen)

In the future optical network, digital signal processing for signal recovery and parameter estimation will face many challenges considering elastic optical signals and dynamic optical path provisions. Among many DSP modules, the frequency offset and phase noise is expected to be estimated jointly for simple implementation. Furthermore, both wide estimation range and high accuracy is desired in the case of dynamic optical wavelength switching and burst mode detection. The traditional frequency offset and phase estimation algorithms, such as the Viterbi-Viterbi algorithm, is not applicable to high order modulation scheme, and the blind phase search algorithm has relatively high computational complexity. Recently, a linear Kalman filter with parallel processing architecture is proposed to estimate frequency offset and phase jointly with low computation complexity. However, the scheme suffers from low tolerance to frequency offset range.

In this study, an extended Kalman filter (EKF) and linear Kalman filter are employed together for achieving wide frequency offset tolerance and accurate estimation accuracy simultaneously. The former EKF are responsible for preliminary estimation of frequency offset. The latter LKF is responsible for tracking frequency offset and phase accurately. The linewidth tolerance, frequency offset estimation range and frequency offset tracking speed in our proposed scheme are analyzed in detail. The influence of the length of the block data and the tuning parameter *Q* on the estimation accuracy is investigated, and the practical application optimization strategy and parameter guidance are presented. The simulation and experimental results show that the scheme has fast convergence performance, and can achieve excellent estimation accurate for joint frequency offset and phase estimation. Compared with the traditional blind phase search method, the scheme has high frequency offset tolerance and low implementation complexity. Finally, the carrier recovery performance of quadrature phase-shift-keying (QPSK) and 16 quadrature amplitude modulation (16QAM) optical communication systems is studied. The performance of carrier frequency offset under different optical signal to noise ratio, block length and tuning parameters is studied.
Key words: optical communication; 16QAM; frequency offset and phase estimation; kalman filter

CIOP-2017-2348

A Novel Ultra Low Loss Few Mode Fibre for Weakly-Coupled MDM System

Lei Zhang, Ruichun Wang, Hongyan Zhou, Jun Wu, Lei Shen, Su Chen, Honghai Wang
State Key Laboratory of Optical Fiber and Cable Manufacture Technology, China

Few-mode fibre is the best choice for supporting MDM technology, and it can enlarge transmission capacity apparently.For future high speed large capacity long haul transmission, reduce fiber attenuation ia a key technology not only for single-mode fibre but also for few mode fibre.Here we designed and fabricated a step index few-mode fibre supporting four LP modes at C band for MDM system, and. We measured experimentally and calculated optical parameters of the designed step-index four LP- mode fibre by finite element method.A few mode fibre with a low loss is also a key direction for fibre manufacturer Fibre attenuation at 1550nm (0.16dB/km) is measured by over-filled launching condition and cutback method, and to our best knowledge it was for the first time a four-LP mode fibre reached the lowest loss.Differential group delay is measured by time of flight(ToF) method. Other optical parameters are also discussed.
Key words: ultra low loss; few mode fibre; DGD; Time of flight; MDM

CIOP-2017-0673

The Influence of Non-Kolmogorov Turbulence on Simulations of Vortex Beam transmission

Ming Chen, Taichang Gao, Shuai Hu, Qingwei Zeng, Lei Liu, Gang Li, Zhenhua Zhang
[1] *College of Meteorology and Oceanography, PLA University of Science and Technology;* [2] *Electronic Equipment-Test Center, 33th Base*

The transmissions of vortex beam in isotropic and anisotropic turbulence based on Kolmogorov theory and non-Kolmogorov theory is simulated. The distribution of power law in power spectrum along the transmission progress is described by normal distribution. Simulate the non-Kolmogorov turbulence phase screens based on equivalent structure constant by power spectrum inversion method and multiple-phase screens are used to simulate the transmission of vortex beam. And then observe the beam broadening and scintillation index to research the influence. The results reveal that when beam transmits through single phase screen, beam broadening increases first and then decreases with power law, finally tends to a relatively stable value such as 0.145; scintillation index increases with power law and tends to a stable value such as 0.5. When beam transmits through multiple phase screens, non-Kolmogorov turbulence has a great influence on simulations. Maximum relative error of beam broadening could reach 13% and scintillation index could reach 80%. But when the number of phase screens is large, the simulations in non-Kolmogorov turbulence is closer to the simulations in Kolmogorov turbulence. The researches can provide useful reference basis for simulations of vortex beam transmission in the atmosphere.
Key words: non-Kolmogorov turbulence; laguerre-Gaussian beam; beam broadening; scintillation index; power law

CIOP-2017-2422

Performance Evaluation and Intelligent Recovery of Distorted Optical Signals Assisted by Clustering Analysis Method

Zhongqing Zhou, Yanfu Yang, Qun Zhang, Qianwen He, Qian Xiang, Juntao Cao
Shenzhen Graduate School, Harbin Institute of Technology

Aiming at the high-order optical modulation dynamic optical network scene, an intelligent dynamic optical signal processing method based on cluster analysis is proposed. The method uses the clustering analysis which is applied for pretreating the dynamic signal data to intelligently identify the corresponding modulation format, and obtain the clustering center point position. This position can be used for intelligently setting radius-directed equalization (RDE), while providing the ideal constellation point for carrier phase recovery. The advantage of this method is that it can be applied to dynamic optical networks, which can effectively analyze the distortion damage and provide accurate signal quality evaluation results.

In order to verify the algorithm, the simulation of the proposed algorithm is carried out in the study. The standard and distorted signals of QPSK, 8QAM and 16QAM optical signals are simulated respectively, the signal distortion such as I-Q gain imbalance, I-Q phase error and I-Q amplitude uneven distribution are introduced into the simulation. The results show that the algorithm can realize the high accuracy of intelligent identification, which achieve a very obvious treatment to improve the effect for distorted signals compared with the traditional processing methods.

In experimental studies, we take the method of aligning the length of the signal light and LO light to ensure that the phase difference between them is the situation of slow fluctuations follow-up, which achieves a high tolerance for laser linewidths and greatly reduces phase noise damage in advanced modulation formats, more importantly, it provides enough number of symbols for cluster analysis. The results of the experimental data show that compared with the traditional equalization and phase recovery algorithm, the proposed scheme can achieve better signal constellation under signal impairments and obtain more accurate signal quality evaluation result.

In short, the results show that based on clustering analysis and EVM minimization, the proposed scheme can achieve the dynamic optical network modulation format recognition, and realize the good recovery effect on the distortion signal. The scheme has a wide application prospects in the dynamic network signal analysis and the optical transceiver module signal evaluation.

Key words: performance evaluation; cluster analysis; error vector magnitude(EVM); distorted signals

CIOP-2017-3004

Suppression of Mode Coupling In Few-Mode Large-Mode-Area Fiber Bragg Gratings

Songsong Xiong[1], Dapeng Yan[1], Weiping Liu[2],Jianming Wang[1], Bao Huang[1] and Cheng Li*[1]
1 Wuhan National Laboratory for Optoelectronics, Huazhong University of Science and Technology, China
2 Department of Electronic and Engineering, Jinan University, China

Fiber Bragg grating (FBG) fabricated in large mode area (LMA) fiber is a key device for high power all-fiber laser application. However, due to the larger core diameter, a few lower order modes are supported in the fiber and would take part in mode coupling in grating, leading to the degradation of laser beam quality. By theoretically analyzing the behaviors of few-mode coupling of LMA- FBGs, we proposed an effective way to eliminate the higher order coupling by means of providing a symmetrical exposing to the few mode LMA-fiber. Experiment results shows that the mutual mode coupling between liner polarization mode LP_{01} and LP_{11} can be significantly suppressed.

Key words: fiber laser; large mode area fiber; fiber Bragg grating; mutual mode suppression

Session 6: Holography and Optical Information Processing

Session Chairs: **Changhe Zhou**, Shanghai Institute of Optics and Fine Mechanics, CAS, China
Xiaodi Tan, Beijing Institute of Technology, China
Shutian Liu, Harbin Institute of Technology, China

Location: B505, 5F, Main Building, Harbin Institute of Technology No.2 Campus

18th July

Chair: Chau-Jern Cheng, National Taiwan Normal University

14:00-14:45	**Computational Phase Retrieval (Keynote)** George Barbastathis *Massachusetts Institute of Technology, USA*	- 100 -
14:45-15:15	**Spatial-Spectral Volume Holographic Imaging Systems (Invited)** Yuan Luo *National Taiwan University, Institute of Medical Device and Imaging*	- 101 -
15:15-15:45	**Computational Light Microscopy —— Optical Manipulation and Information Processing (Invited)** Chao Zuo *Nanjing University of Science and Technology, China*	- 102 -
15:45-16:00	**Coffee Break**	

Chair: Xinzhu Sang, Beijing University of Posts and Telecommunications, China

16:00-16:45	**Ongoing Developments in Spatio-Temporal Imaging and Metrology of Digital Holographic Microscopy (Keynote)** Chau-Jern Cheng *National Taiwan Normal University*	- 103 -
16:45-17:15	**Cyphertext-Only Attack to Double Random-Phase Encoding: Experimental Demonstration (Invited)** Guohai SiTu *Shanghai Institute of Optics and Fine Mechanics, China*	- 104 -
17:15-17:45	**Holographic 3D Display Application in Virtual Reality (Invited)** Hongyue Gao *Shanghai University, China*	- 105 -
17:45-18:00	**Three-Dimensional Super-Resolution Imaging by Adaptive STED Nanoscopy (Oral)** Tianlong Man, Yuhong Wan, Dayong Wang *Beijing University of Technology, China*	- 116 -
18:00-19:00	**Dinner Time**	

19th July

Chair: Yuan Luo, National Taiwan University, Institute of Medical Device and Imaging

09:00-09:30	**Optical Correlation-Based Image Retrieval System with A Deep Convolutional Neural Network (Invited)** Eriko Watanabe, Kanami Ikeda *University of Electro-Communications, Japan*	- 106 -
09:30-10:00	**Large-Size Three-Dimensional Light-Field Display (Invited)** Xinzhu Sang *Beijing University of Posts and Telecommunications, China*	- 107 -
10:00-10:15	**Grating Based Field of View Expansion in Digital Lens-Less Holography (Oral)** Wenhui Zhang, Song Zong, Liangcai Cao, Guofan Jin *Tsinghua University, China*	- 116 -
10:15-10:30	**Simultaneous 2D In-Plane Displacement Field Measurement Using Electronic Speckle Pattern Interferometry (ESPI) with Sinusoidal Phase Modulations (Oral)** Yunlong Zhu, Julien Vaillant, Guillaume Montay, Manuel François, Aurélien Bruyant *University of Technology of Troyes, France*	- 116 -
10:30-10:45	**3D Computer-Generated Holograms with Layer Based Processing (Oral)** Hao Zhang, Liangcai Cao, Guofan Jin *Tsinghua University, China*	- 117 -
10:45-11:00	**Coffee Break**	

Chair: Guohai SiTu, Shanghai Institute of Optics and Fine Mechanics, China

11:00-11:30	***In vivo* Imaging Flow Cytometry of Human Leukocytes (Invited)** Tzu-Ming Liu *University of Macau, China*	- 108 -
11:30-12:00	**Stimulated Emission Double Depletion (STEDD) nanoscopy (Invited)** Peng Gao *Karlsruhe Institute of Technology, Germany*	- 109 -

19th July

12:00-12:15	**High-Speed Real-Time 3D Measurements with the Fringe Projection (Oral)** Shijie Feng *Nanjing University of Science and Technology, China*	- 117 -
12:15-14:00	**Lunch Time**	
Chair: Peng Gao, Karlsruhe Institute of Technology, Germany		
14:00-14:30	**Optical Differentiation Wavefront Sensing Using Binary Pixelated Filters for Freeform Metrology and Phase Imaging (Invited)** Jie Qiao *Rochester Institute of Technology, USA*	- 110 -
14:30-15:00	**Simultaneous Multi-Plane Fluorescence Correlation Spectroscopy (Invited)** Shubin Li *Singapore-MIT alliance Technology and Research center, Singapore*	- 111 -
15:00-15:30	**Generation of Vortex Optical Field in Solid-state Laser (Invited)** Jianlang Li *Shanghai Institute of Optics and Fine Mechanics, Singapore*	- 112 -
15:30-15:45	**Coffee Break**	
15:30-17:30	**Poster**	
18:00-20:00	**Banquet**	

20th July

Chair: Shubin Li, Singapore-MIT alliance Technology and Research center, Singapore

09:00-09:30	**Amplification of DNA in A Oortable Buoyancy-Driven PCR System (Invited)** Dawei Zhang *University of Shanghai for Science and Technology, China*	- 113 -
09:30-10:00	**Phase Retrieval in Image and Measurement (Invited)** Zhengjun Liu *Harbin Institute of Technology, China*	- 114 -
10:00-10:30	**Research Development of Self-Interference Digital Holography for Three-Dimensional Imaging (Invited)** Yuhong Wan *Beijing University of Technology, China*	- 115 -
10:30-10:45	**Key Points in Design of Resolution-Enhanced Fourier Ptychographic Microscopy Systems (Oral)** Jiasong Sun, Chao Zuo, Qian Chen *Nanjing University of Science and Technology, China*	- 118 -
10:45-11:00	**Coffee Break**	
12:15-14:00	**Lunch Time**	

Computational Phase Retrieval

George Barbastathis
Massachusetts Institute of Technology, USA

ABSTRACT

Phase retrieval from intensity measurements is one of the oldest problems in optical imaging. In this talk, I will review several techniques old and new, and emphasize recent developments that utilize nonlinear transformations to mitigate the effects of noise and most efficiently incorporate object class priors.

BIOGRAPHY

Note

Spatial-Spectral Volume Holographic Imaging Systems

Yuan Luo
National Taiwan University, Institute of Medical Device and Imaging

Note

ABSTRACT

The biggest challenge on the path towards high-dimensional (HD) imaging is obtaining spatial and spectral information of a volumetric sample in real-time. Advances in this field are of vital importance for biology, material sciences, and medical applications. For example, cancer is one of the leading causes of death in the world, thus gaining a mechanistic understanding of cancer cell processes will significantly impact therapies targeting cancer metastasis pathways. Revealing the entire process with its surrounding environment will require real-time HD imaging systems, which will open the way for better understanding of cancer onset and tissue morphology. This talk will introduce real-time HD volume holographic imaging systems, which are based on multiplexed volume holographic (MVH) gratings acting as spatial-spectral filters used in conventional optical imaging systems. This allows the acquisition of spatial images with spectral selectivity but without scanning in both transverse and longitudinal directions. In addition, with proper multiplexed holographic pupil engineering, the MVH systems can provide multiple depth-resolved phase-contrast imaging in real-time and quantitative phase imaging in a single shot. Furthermore, the talk will address MVH techniques incorporating other state-of-the-art imaging methods to better manipulate light for label-free imaging as well as fluorescence imaging.

BIOGRAPHY

Yuan Luo received his MSc and PhD degrees in College of Optical Sciences in 2007 and 2008, respectively, from the University of Arizona. After post-doctoral work at Massachusetts Institute of Technology (MIT, 2009-2011), he joined the faculty at National Taiwan University (NTU) in 2011, where he is now associate professor of Institute of Medical Device and Imaging, and holds the associate professorship in NTU Molecular Imaging Center. He has worked or held visiting appointments at the Singapore-MIT Alliance for Research and Technology (SMART) Centre in Singapore. His research interests are three-dimensional (3D) and spectral imaging; shift-invariant optics theory and implementation with 3D active structured light. He is member of the Optical Society of America (OSA), and International Society for Optical Engineering (SPIE).

Chao Zuo
Nanjing University of Science and Technology, China

Note

Computational Light Microscopy —— Optical Manipulation and Information Processing

ABSTRACT

Computational light microscopy is an emerging technology which extends the capabilities of optical microscopy with the combination of optical coding and computational decoding. It provides us with novel imaging functionalities or improved imaging performance which are difficult or impossible to achieve by using conventional microscopic systems. Recent advances in LED lighting and digital display technology provide new opportunities for active digital illumination and imaging control for advancing microscopy. In this presentation, we report our most recent developments of computational light microscopy with programmable illumination and coded aperture. We describe several new approaches for achieving multi-modal computational light microscopy, including contrast-enhancement imaging, noninterferometic quantitative phase imaging, full-resolution light field imaging, giga-pixel high-resolution imaging, and lens-less tomographic imaging, with use of programmable LED array, tunable electronic tunable lens, or programmable LCD panel. Based on Transport-of-Intensity Equation (TIE) computational phase retrieval, we demonstrate for the first time that noninterferometic high-resolution quantitative phase microscopy with transverse resolution up to 208 nm (corresponding to an effective numerical aperture of 2.66) at temporal scales ranging from 1-second to several days, without resorting to interferometric measurement and explicit synthetic aperture manipulation. Besides, we also report wide-field high-resolution imaging at 300 nm transverse resolution (corresponding to an effective numerical aperture of 1.6) with only use of a 10x objective, achieving a space-bandwidth-product of 98.5 megapixels (more than 50 times higher than that of the conventional microscope with the same resolution) based on Fourier ptychography computational phase retrieval.

BIOGRAPHY

Dr. Chao Zuo is a professor in the department of Electronic and Optical Engineering, Nanjing University of Science and Technology (NUST). He received his Ph.D. and B.S. from Nanjing University of Science and Technology in 2014 and 2009, respectively. He was a research assistant at Centre for Optical and Laser Engineering (COLE), Nanyang Technological University (NTU), Singapore, from 2012 to 2013. In 2014 and 2016, he was exceptionally promoted to associate professor and professor of NUST, respectively. Now he is the principal investigator of the Smart Computational Imaging Laboratory (SCILab: www.scilaboratory.com) at NUST where his research interests focuse on computational bio-imaging, phase retrieval, optical information processing, and high-speed 3D optical sensing. He has published over 60 peer-reviewed journals and one book chapter in his research career with total citation over 1000 times according to Google Scholar. He is the member for several professional organizations, also reviewer for many prestigious peer-review journals (>30) in optical sciences related fields.

Ongoing Developments In Spatio-Temporal Imaging and Metrology of Digital Holographic Microscopy

Chau-Jern Cheng
National Taiwan Normal University

Note

ABSTRACT

Digital holographic microscopy (DHM) with full-field quantitative complex imaging (amplitude and phase) has been widely used in optical metrology for measuring optical micro-/nano- devices and biological living cells in high phase accuracy at different observation time. These push the spatio-temporal imaging and metrology of DHM becoming an attractive tool for scientific and industrial applications both in the spatial and temporal testing domains. This talk will describe state-of-the-art technology and recent progress of DHM in quantitative phase imaging and optical metrology. As an example, a novel tunable time-resolved spatio-temporal technique of DHM for ultrafast events will be introduced for studying the dynamic phenomena of laser and matter interaction from nanosecond to femtosecond time scales.

BIOGRAPHY

Professor Chau-Jern Cheng received his PhD degree in Electro-Optical Engineering from the National Chiao Tung University, Taiwan, in 1994. He was invited to be the faculty and served as chairman of the Department of Electronic Engineering, St. John's & St. Mary's Institute of Technology, Department of Electrical Engineering, Feng Chia University, and Department of Electro-Optical Engineering, National Taipei University of Technology, from 1994 to 2007, respectively. In 2007, he was invited to join the faculty of the Institute of Electro-Optical Science and Technology, National Taiwan Normal University, Taipei, Taiwan, and also elected as the Institute's Director. Prof. Cheng served as the supervisor at Large of Taiwan Photonics Society (TPS). He is the member of SPIE, OSA and TPS. He is currently the topical editor of *Chinese Optics Letters* and *Encyclopedia of Modern Optics* (2nd Edition, Elsevier). His research interests include information optics, optical metrology, digital holography, hybrid optical/electronic information systems, 3D imaging, and display.

Guohai Situ
Shanghai Institute of Optics and Fine Mechanics, China

Cyphertext-only Attack to Double Random-Phase Encoding: Experimental Demonstration

ABSTRACT

In this talk, we report our recent experimental study on the cryptanalysis of the double random-phase encoding (DRPE) technique. We find that one can reconstruct the magnitude of the plaintext image by using only one cyphertext image alone, without any knowledge of the random phase keys or other assumption. The result suggests that the DRPE technique can be vulnerable to cyphertext-only attack.

BIOGRAPHY

Guohai Situ is a professor of Shanghai Institute of Optics and Fine Mechanics, Chinese Academy of Sciences, holding a “1000 Plan Professorship for Young Experts”. Dr. Situ’s research interests span a wide field of “phase engineering”, ranging from developing novel techniques and algorithms for “passive” phase reconstruction, to “actively” engineering the phase for (computational) optical imaging and optical signal processing. He has published 40 papers in leading journals including *Nature Photonics*, and presented 10+ invited talks in conferences. His papers have been cited over 2000 times according to Google Scholar. Dr. Situ is in the editorial board of *Scientific Reports, Applied Optics*, and *Advanced Optical Technologies*.

Note

Holographic 3D Display Application in Virtual Reality

Hongyue Gao
Shanghai University, China

ABSRTACT

Holographic display is true 3D display technology. We realize RGB model color holographic 3D video display and use it in virtual reality (VR), which can overcome limitation of stereoscopic 3D virtual reality display. Viewing angle and imaging distance of holographic VR images are discussed based on spatial light modulators with different pixel sizes, which may be helpful for 3D VR technology. We have developed holographic 3D virtual reality glasses, which are suitable for observers with different pupillary distance without dizziness caused by some fake 3D display.

Note

BIOGRAPHY

Hongyue Gao, Research center Director, Associate Professor

In 2007, she received Ph.D. degree from Harbin Institute of Technology and obtained super-fast holographic video display in materials, China. During 2008-2010, she continued her research on holographic 3D display as a postdoctoral fellow at Fudan University, China. Then, she worked as a visiting scholar in Virginia Tech., USA. In 2012, she reported her achievements on holographic video display in materials, which is breakthrough of dynamic holographic display at Society for Information Display (SID) Display Week in USA, OSA Digital Holography and 3D Imaging in USA and International Symposium on Display Holography at MIT in the USA, her work was rated one of 11 SID Symposium 2012 Technical Highlights, and in 2013, she was invited by OSA to give an invited talk at Digital Holography and 3D Imaging in USA, and her real-time holography display was thought to be an important step to holographic video by experts. She has delivered ~ 20 invited talks in USA, Russia, Japan, Singapore, China. From 2013 to present, she works in Shanghai University, China, and is director of Ultra-Precision Optoelectronic Metrology and Information Display Technologies Research Center. Her current researchs focus on: (1) large size, high definition, color, real time holographic 3D display, (2) holographic 3D TV, (3) holographic disk, (4) 3D hologram print, (5) 3D volumetric display based on up-conversion materials, and (6) light field 3D.

Eriko Watanabe
University of Electro-Communications, Japan

Optical Correlation-Based Image Retrieval System with a Deep Convolutional Neural Network

Speaker: Kanami Ikeda

ABSTRACT

We have been developed a high-speed optical correlation system, which is based on the coaxial holography system. This system can correlate data with high-speed by using a holographic optical disc on which a huge amount of data can be stored. In this talk, we will introduce our optical correlation system, and high-speed optical correlation result will also be reported. A new application which is cross-domain image retrieval with a deep convolutional neural network using the optical correlation system will also be reported.

BIOGRAPHY

Eriko Watanabe has been an associate professor in the Graduate School of Informatics and Engineering at the University of Electro-Communications, since 2015. She graduated from the Japan Women's University with her BS and PhD degrees in Physics in 2000 and 2005, respectively. From 2004 to 2006, she was a research fellow of the JSPS. After her PhD, she became a PRESTO researcher at the Japan Science and Technology Agency, following which she worked at the MANA at the National Institute for Materials Science as an independent researcher. Her research interests include optical sensing devices, biomedical imaging devices, optical computing, and image processing.

Note

Large-Size Three-Dimensional Light-Field Display

Xinzhu Sang
Beijing University of Posts and Telecommunications, China

Note

ABSTRACT

A brief review of three-dimensional(3D) light filed displays in BUPT is presented. Back- and front-projection 3D light field displays with the holographic functional screen and the projector array are demonstrated, whose size is above 1.8 m ×1.2 m. The displayed depth is more than 1.2 m, and the view field angel is above 45°. With the holographic functional screen and the complex lens array, the full-parallax 3D light field display with 8100 viewpoints is demonstrated based on the 27 inch LCD panel. Floating 3D images with full parallax like real objects floated in the space can be perceived with the view angle above 40° along the horizontal and vertical directions. The functions of the holographic functional screen and the complex lens array are resolved and integrated in a thin optical devices, the full-parallax 3D light field display with the view angel above 60° is demonstrated.

BIOGRAPHY

Xinzhu Sang is a professor of the State Key Laboratory of Information Photonics and Optical Communications at Beijing University of Posts and Telecommunications. His current research interests include three-dimensional display, holography and novel photonic devices. He has published more than 160 pre-reviewed research papers in scientific journals. So far he holds 15 patents.

He received dual bachelor's degrees in instrument science and management engineering from Tianjin University in 1999, M.S. degree from Beijing Institute of Machinery in 2002, and Ph.D. degree at Beijing University of Posts and Telecommunications in 2005. From December 2003 to March 2005, he was with Optoelectronics Research Centre, Department of Electronic Engineering, City University of Hong Kong as a research assistant. From July 2007 to July 2008, he worked in University of California at Irvine as a postdoctoral research scholar. He has been a full professor in Beijing University of Posts and Telecommunications since September 2012.

He is the deputy director and the secretary-general of the committee of Holography and Optical information, Chinese Optical Society Processing, a senior member of Chinese Institute of Communication, and a senior member of Chinese Institute of Electronics. In 2011, he was selected for the Program for New Century Excellent Talents in University, and Beijing Nova Program of Science and Technology.

In Vivo Imaging Flow Cytometry of Human Leukocytes

Tzu-Ming Liu
University of Macau, China

ABSTRACT

Based on the third-harmonic-generation (THG) microscopy and its texture analysis, we developed a label-free imaging cytometry method to differentiate and determine the types of human leukocytes. With the help of the nonlinear structures of textures, the neutrophils, monocytes, and lymphocytes in peripheral blood samples from healthy volunteers were clustered into three differentiable groups. The THG imaging-based counting results agreed well with conventional blood count results. In the future, we believe that *in vivo* complete blood counts can be realized without a sampling of blood.

Note

BIOGRAPHY

Tzu-Ming Liu received his B.S. degree in Electrical Engineering from National Taiwan University in 1999 and the Ph.D. degree in Photonics & Optoelectronics from National Taiwan University in 2004. After the postdoctoral research in the same institute (2005-2009), he became an assistant professor at the Institute of Biomedical Engineering, National Taiwan University in 2009 and was promoted to associate professor in 2013. Since 2016, he was with the Faculty of Health Sciences, University of Macau. His research interests were primarily concerned with ultrafast optics, nanophotonics, tumor microenvironment, the pharmacokinetics of nanomedicines and medical spectroscopy. He developed a series of courses for medical device innovation and started to develop medical devices. He led a team of students to win the Outstanding Startup Award in 2014 and co-found a medical device company, FlatMedical Inc. in 2015.

Stimulated Emission Double Depletion (STEDD) Nanoscopy

Peng Gao
Karlsruhe Institute of Technology, Germany

Note

ABSTRACT

Far-field optical fluorescence microscopy plays a key role in the discovery of biomolecular structure and dynamics, because it is minimally invasive and selective to specific biomolecules of interest. This talk will focus on a super-resolution, background-free, 3D imaging technique, Stimulated Emission Double Depletion (STEDD) nanoscopy. The principle and experimental construction of the STEDD will be explained, as well as its application for biology. Preliminary work on aberration compensation and ultrafast imaging based on tunable acoustic gradient index of refraction lens (TAG lens) will also be explained to further improve the signal to noise ratio (SNR) and speed of the STEDD.

BIOGRAPHY

Peng Gao obtained his Ph.D. degree in physics from Xi'an Institute of Optics and Precision Mechanics, Chinese Academy of Sciences in 2012. He carried on his postdoctoral research in University Stuttgart from June 2012 to May 2014 under the support of Humboldt research fellowship. He joined in Karlsruhe Institute of Technology in May 2014. His research interests include phase imaging and super-resolution fluorescence imaging for biology. He has published over 50 papers in peer-reviewed journals such as *Nature Photonics*, *Scientific Reports*, *Optics Letters*, and so on.

Jie Qiao
Rochester Institute of Technology

Optical Differentiation Wavefront Sensing Using Binary Pixelated Filters for Freeform Metrology and Phase Imaging

ABSTRACT

Freeform optics, which have no symmetry of revolution, are becoming popular in optical engineering because they allow for building optical systems with higher performance, e.g., smaller aberrations and longer depth of field, with reduced cost and complexity in terms of number of components. The metrology of freeform optics is challenging because of their complex shapes: they typically have large apertures, large phase gradients, and no assumption on their surface profile can be made. I will review the concept, design and performance of an Optical Differentiation Wavefront Sensor (ODWS) relying on binary pixelated filters to synthesize the far-field amplitude filter via digital halftoning. The ODWS has demonstrated excellent accuracy and precision when characterizing wavefronts over small apertures.

BIOGRAPHY

Jie Qiao is currently an associate professor in the Carlson Center for Imaging Science at the Rochester Institute of Technology. She leads the Advanced Optical Fabrication, Instrumentation & Metrology Laboratory where her team works on ultrafast-lasers for advanced photonics / optics fabrication, optical metrology, and instrumentation. Prior to joining RIT, she was a laser system scientist at the Department-of-Energy-Funded Laboratory for Laser Energetics (University of Rochester) from 2005 to 2013. She was the PI and led the technical demonstration of the world's first 1.5-meter tiled-grating pulse compressor for the kilojoule, petawatt OMEGA EP short pulse lasers. Prior to that, she had worked on various innovative photonic devices, optical imaging and metrology systems, for two photonic startups and one optics company. She earned her Ph.D. in Electrical and Computer Engineering from the University of Texas at Austin and an M.B.A in entrepreneurship, strategy, finance and marketing from the Simon Graduate School of Business, University of Rochester. She has 65 scientific publications, and holds two patents. She founded WiSTEE Connect (Women in Science, Technology, Engineering and Entrepreneurship, www.wisteeconnect.org) in 2013, for which she is serving as the chair.

Note

Simultaneous Multi-Plane Fluorescence Correlation Spectroscopy

Shubin Li
Singapore-MIT alliance Technology and Research center

Note

ABSTRACT

Fluorescence correlation spectroscopy (FCS) enables studying aggregate dynamics of particles, which in turn reveals biochemical and biophysical information. While imaging FCS improved on traditional FCS by enabling simultaneous 2D capture, scanning is still required for volumetric data. We propose a multi-plane FCS technique using a multiplexed volume hologram (MVH)placed in the infinity section of a microscope to simultaneously capture images at multiple planes, each illuminated by its own light sheet. We will also give the cross correlation between different light sheets to see if any transport between light sheets, which can be used to study the dynamics process of biology.

BIOGRAPHY

Shubin Li received his PhD degree in 2016 from Shanghai Institute of Optics and Fine Mechanics (SIOM), Chinese Academy of Sciences (CAS). He is currently a postdoctoral researcher in Singapore-MIT alliance Technology and Research Center. His current research interests include diffraction optics, optics design, 3D optics image and fluorescence correlation spectroscopy.

Generation of Vortex Optical Field in Solid-state Laser

Jianlang Li
Shanghai Institute of Optics and Fine Mechanics, China

Note

ABSTRACT

High-order Laguerre-Gaussian (LG) modes are known as doughnut-like transverse field distributions and helical phase wavefronts. Owing to the existence of an azimuthally-dependent term in its amplitude expression, the photons in such mode carry the orbit angular momentum (OAM), and thus it is called as vortex beam. Currently, LG modes are valuable for many applications including particle trapping, optical communication, quantum computing, optical microscopy, gravitational-wave detection and etc.

In this presentation, I will show our results on the vortex-mode solid-state laser resonator based on annular pumping technique and intracavity mode-filtering technique.

BIOGRAPHY

Jianlang Li, professor at Shanghai Institute of Optics and Fine Mechanics (SIOM), Chinese Academy of Sciences (CAS), China

He obtained the Ph.D. degree in optical engineering from SIOM/CAS in 2000, and then was a Lecture with Shanghai Jiao Tong University. In 2002, he was a Research Fellow with the Max-Planck Institute for Extraterrestrial Physics, Germany. In 2004, he was a Research Fellow with the Institute of Laser Science (ILS), University of Electro-Communication (UEC) of Japan. Since 2008, he has been a professor at SIOM/CAS. He was also the guest professor at the ILS/UEC of Japan in 2010 and 2016.

Prof. Li's research focused on laser sciences, especially in the high-power vector and vortex laser. As a pioneer, he invented the radially polarized fiber laser, and then extended it to the high-power and pulsed operation. Prof. Li also developed highly efficient vector and vortex solid-state laser. Most recently, Prof. Li invented the maglev and optically-driven rotary disk laser.

Prof. Li has published more than 110 journal and conference papers, and now he is serving as a Topical Editor and also member of Editorial Board of Chinese Optics Letters journal. He is also members of Technical Committee of many international conferences including IBP 2015, CLEO-PR 2013 and etc.

Amplification of DNA in a Portable Buoyancy-Driven PCR System

Dawei Zhang
University of Shanghai for Science and Technology, China

Note

ABSTRACT

Polymerase chain reaction (PCR) is a powerful technology widely employed in genetic analysis, medical diagnostics, and forensic applications, because of its ability to amplify an initially dilute target DNA sample to a detectable concentration level. However, conventional PCR thermal cyclers need large microliter volume solution and do not allow for very fast changes in the vessel temperature, which leads to long cycling time, and thus rapid, low cost, and portable polymerase chain reaction system (PCR) can advance the diagnosis of infectious disease, especially for the third-world countries.

Herein, we developed a compact PCR system based on Rayleigh-Bénard convection (RB-PCR). The optimal geometry parameters of the RB-PCR cell was obtained by finite element analysis. The amplification efficiency was improved by adding polyvinyl pyrrolidone into the PCR reagent and evaluated by detection of PCR products in capillary electrophoresis. Results demonstrate that λ-DNA was successfully amplified within 15 min, and the PCR products was identified within 6.0 min. 0.1% PVP (10 mg/9 mL) in PCR solution offers the best amplification efficiency for RB-PCR. The device is easy to assemble, and it is well suited for point of care applications.

BIOGRAPHY

Dawei Zhang has received his PhD from Shanghai Institute of Optics and Fine Mechanics (SIOM), Chinese Academy of Sciences. He has been worked in School of Optical-Electrical and Computer Engineering, University of Shanghai for Science and Technology since 2005. He is a member of IEEE and has published more than 100 papers in refereed journals. His research interests include micro-nano optical devices and its application on biomedical. He received 3 times provincial awards in his research fields.

Zhengjun Liu
Harbin Institute of Technology, China

Phase Retrieval In Image and Measurement

ABSTRACT

Coherent diffraction imaging is a powerful lensless imaging technique, resulting from the lack of the optical devices for the X-ray regime or visible spectrum. It is proved that lens imaging is a general kind of diffraction, which can be depicted by the extended fractional Fourier transform mathematically. The multi-image phase retrieval is presented for obtaining more accurate reconstruction result of light field. Here more intensity patterns are introduced for amplitude and phase retrieval. The performance of this algorithm is enhanced by combining two existing retrieval methods with intensity patterns. Noise reduction is also considered for this algorithm in coherent diffraction imaging system. The measurement error analysis of these axial methods, such as axial position error and wavelength bias, is displayed for obtaining the high quality of result image. The impact of sampling condition on phase retrieval is also described here.

BIOGRAPHY

Zhengjun Liu received his BS degree in 2002 from Harbin Institute of Technology, Harbin, China. He received his PhD degree there in 2007 from the Department of Physics. He is currently a professor in the Department of Automatic Test and Control there. He was honored by the Program for New Century Excellent Talents in University (2012). He published 87 papers and 2 books. He is a senior member of OSA and a member of IEEE. His current research interests include optical information processing, information security, and optical physics.

Note

Research Development of Self-interference Digital Holography for Three-dimensional Imaging

Yuhong Wan
Beijing University of Technology, China

Note

ABSTRACT

Three-dimensional (3D) microscopic imaging techniques have been significant tools for discovering the mechanisms involved in biological cells and tissues. Self-interference digital holography (SIDH) has been proposed and developed for aiming scanning-free fluorescent microscopy and other 3D imaging with incoherent illumination. We have focused this topic research for several years. I prefer to review the main research development of SIDH as a 3D microscopic imaging technique in most recent years and present our research work about improvement of imaging speed by Parallel phase-shifting, reconstructive image quality by compressive sensing and 3D imaging resolution with structured illumination. And further researches about SIDH are still investigated towards high-resolution SIDH imaging towards 3D tracking of the fluorescent biological samples in a volume.

BIOGRAPHY

Yuhong Wan graduated from Beijing University of Technology in July 2005 and obtained her doctoral degree in optics. Since July 2005, she has been working in College of Applied Sciences, Beijing University of Technology, and focusing on the research of optical information processing, digital holographic microscopy, adaptive optics and applications in super-resolution microscopy. She has ever worked in Imperial College London for one year. She has awarded twice as one of excellent young scientists by Beijing Municipal Party Committee and Government. Currently, she is the principal of several research projects including National Natural Science Fund, Natural Science Fund Beijing Municipal Government etc. As a committee member of COS and Optical society of Beijing, she is active and enthusiastic on academic communications and affairs.

CIOP-2017-0463

Three-Dimensional Super-Resolution Imaging by Adaptive STED Nanoscopy

Tianlong Man, Yuhong Wan, Dayong Wang
Beijing University of Technology

Modern nanoscopic imaging methods are proving to be of increasing importance to obtain a more detailed and complete understanding of biophysical structures and complex biological systems. It has been demonstrated that by combing optical tweezers and one-dimensional stimulated emission depletion (STED) fluorescence microscopy is possible to visualization of individual DNA-binding proteins on densely covered DNA in the presence of high protein concentrations. However, for imaging of more complex and extended three-dimensional (3D) structures such as chromosomes and living cells, control of resolution enhancement in all three dimensions is required. Here we demonstrate 3D super-resolution imaging through STED nanoscopy based on adaptive optics. Sensorless adaptive optics is implemented by using a spatial light modulator as the wavefront controlling element. The optical aberrations in the depletion path are introduced by the optical system and the samples are detected and corrected. We demonstrate some methods to analyze and improve the quality of the engineered point spread function for 2D and 3D STED imaging. Multi-channel optical tweezers are also integrated into the system for accurate 3D manipulation of the samples. With the help of adaptive optics, ~100 nm lateral and ~200nm axial resolution is obtained for aberrated samples. We present nanoscopic imaging results of nano-diamonds attached on the optical tweezed beads. The proposed method is combined with optical trapping can provide superior means to uncover the biological structure and dynamics of healthy and diseased chromosomes.

Key words: STED microscopy; adaptive optics; fluorescence microscopy; confocal microscpy

CIOP-2017-1747

Grating Based Field of View Expansion in Digital Lens-Less Holography

Wenhui Zhang, Song Zong, Liangcai Cao, Guofan Jin
Tsinghua University

The field of view (FOV) in digital lens-less holographic imaging is limited by the spatial bandwidth product of the system. Due to the finite pixel number of the image sensor (IS), only a small part of the object can be reconstructed. We propose an FOV expansion method using a transmission grating in digital lens-less holography. Multiple diffraction orders in the object beam are generated and projected to the IS. Each order has its unique spatial carrier frequency according to the grating equation. A reference beam is used to interfere with the object beam and form a hologram, which helps to distinguish different orders during reconstruction. We first give the quantitative relationship among parameters in the grating system for FOV expansion. The requirements of system's stability are low because of the one-shot strategy. The grating is either placed in near contact with the object or imaged onto the object to avoid using the grating transmission formula (GTF) during reconstruction. Without using the GTF, the crosstalk between different orders can be significantly reduced. The experimental results of a transparent plate engraved with "THU" show the feasibility of this method.

Key words: digital holography; field of view; grating

CIOP-2017-1851

Simultaneous 2D In-Plane Displacement Field Measurement Using Electronic Speckle Pattern Interferometry (ESPI) with Sinusoidal Phase Modulations

Yunlong Zhu, JulienVaillant, GuillaumeMontay, ManuelFran?ois, AurélienBruyant
University of Technology of Troyes

Electronic speckle pattern interferometry (ESPI) is a well-established non-contact detection method, it has been widely used in the industry to carry out precise in-plane displacement field measurements. However, theoretically, a single in-plane ESPI system is only sensitive to the displacement along a specific direction determined by the optical arrangement, which means it is not possible to obtain the 2D in-plane displacement field at a time, while the simultaneous measurement of 2D in-plane displacement field or even the 3D displacement field are very important for many mechanical experiments.

Different solutions have been proposed to solve this problem. Some of them consist of changing the optical arrangement repeatedly (e.g. rotating the specimen, changing the incident angle, or using optical switches, etc.), which makes them unable to do the simultaneous measurement of two in-plane displacement components. Other solutions usually consist of overlapping two non-interfering laser illumination systems (e.g. using two lasers with different wavelengths, or using orthogonal polarizations, etc.), which, on the contrary, are able to carry out the simultaneous measurement. However, both of these two approaches will certainly increase the complexity and the cost of the whole measuring system.

In order to solve this problem, we propose a novel method: by continuously recording the interference pattern while two sinusoidal phase modulations with different frequencies are applied, a single video is recorded, and the whole 2D displacement field can then be extracted.

The data processing is based on the fact that when two sinusoidal phase modulations at different frequencies are used, the two corresponding interferometric signals can be discriminated in the frequency space by time Fourier transform. To obtain full information of the in-plane displacement components, the two phase modulations are applied on two different signal beams with different angles and a single reference beam.

Compared with previous reports, the proposed approach is much simpler with only one laser and one camera. Besides, with sinusoidal phase modulation, this system has the potential to be operated at a higher speed while providing more accurate results. Last but not least, by combining this system with an in-line digital holographic interferometry, the same approach could be used to carry out simultaneous measurement of the 3D displacement field without additional laser source or camera.

In this presentation, I will introduce the method (including the optical arrangement, the measurement process, and the data processing algorithms) as well as the results of measurements. At last, a comparison between this method and the classical ones will be made, and the perspective of this method will be discussed.

Key words: speckle interferometry; ESPI; displacement field measurement; parallel/simultaneous measurement

CIOP-2017-2011

3D Computer-Generated Holograms with Layer Based Processing

Hao Zhang, Liangcai Cao, Guofan Jin
Department of Precision Instrument, Tsinghua University

Holographic 3D display can reconstruct the whole optical wave field of the 3D scene, hence it has the potential to provide all the depth cues that human eyes can perceive. With the developments of spatial light modulators (SLMs) and computing technology, computer-generated holograms (CGHs) can be used to perform dynamic reconstruction of the 3D scene, which get rid of the complicated interference recording procedures of traditional holographic systems. CGHs can reconstruct both real and virtual scenes as long as the mathematical representation is provided. The CGH algorithm is used to encode the 3D data into the optical wavefront information, which is directly related to the depth cues that hologram can provide during optical reconstruction. Accommodation cue, motion parallax, and occlusion effect are the important depth cues in the depth perceptions of human eyes, and can affect the qualities of the reconstructed 3D scenes.

In this study, a layer based algorithm with single-viewpoint rendering geometry is proposed for calculating full-parallax 3D CGH with occlusion effect. Different to the conventional layer based algorithms, the 3D scene is sliced into multiple parallel layers with the slab based orthographic projection instead to the depth map. Orthographic projections are performed between the adjacent layers to generate the shading information, which can render the hidden primitives for occlusion processing. In order to deal with the occlusion problem, silhouette mask culling is implemented in each layers. Layer based angular spectrum is used to calculate the wave propagations from the layers to the CGH plane without paraxial approximation. The algorithm is robust for CGHs with different parameters and compatible with the computer graphics pipeline for photorealistic rendering of the 3D scenes. The CGH generated by the proposed algorithm can efficiently provide accurate depth information as well as occlusion effect of the 3D scene.

Key words: computer holography; holographic display

CIOP-2017-2020

High-Speed Real-Time 3D Measurements with the Fringe Projection

Shijie Feng
Nanjing University of Science and Technology

Fringe projection is an extensively applied technique for optical three-dimensional (3D) shape measurements. Although showing favorable performance for motionless objects, it tends to have some difficulties to retrieve surfaces globally or locally varying over time. The reason is that common methods developed for static scenes are prone to fail when measuring dynamic processes. Therefore, to facilitate the application of high-speed real-time measurements, we suggest considerations from four aspects to improve conventional fringe projection methods. The first two aspects are related to raising the measuring efficiency, which can be achieved by encoding the measured object robustly yet with less required patterns, and by increasing the rate of pattern projection which is a bottleneck restricting the measuring speed. The third consideration is to obtain accurate 3D reconstructions by removing unreliable points induced by system and random errors during dynamic measurements. The last one is to handle moving shiny objects as it is supposed to be a time-consuming process for traditional approaches. We believe that the mentioned considerations will help to ease the efforts to achieve desired results for fast real-time measurements.

Key words: high-speed real-time 3D measurements; fringe projection; phase measurement; Fourier transform

CIOP-2017-2329

Key Points in Design of Resolution-Enhanced Fourier Ptychographic Microscopy Systems

Jiasong Sun, Chao Zuo, Qian Chen
Nanjing University of Science and Technology

High-resolution (HR) and wide field-of-view (FOV) microscopic imaging plays a central role in diverse applications such as high-throughput screening and digital pathology. However, for bright-field microscopy system, high-resolution and wide field-of-view (FOV) always could not be achieved simultaneously, limiting its applications which require large space-bandwidth-product (SBP). In order to break the limitation warious super-resolution techniques were proposed, such as on-chip sub-pixel scanning methods, structured illumination microscopy, and Fourier ptychographic microscopy (FPM). Among these super-resolution techniques, FPM became increasingly popular recently because it can combine the numerical apertures (NAs) of the objective lens and the illumination light to form a larger synthetic system NA without sacrificing the FOV. Thus, the resolution-FOV tradeoff can be effectively decoupled in FPM. In addition, it is also very convenient to build an FPM system by simply replacing the illumination system of a bright-field microscope with a commercial programmable LED board. Lately, a lot of efforts have been made to improve the accuracy and efficiency of FPM, however, to date, the effective imaging NA achievable with a typical FPM system is still limited to the range of 0.4-0.7. Here, we build an FPM platform using an oil-immersion condenser to boost the resolution of a bright-field microscopy system and significantly increase its SBP. This FPM system involves a 10X 0.4NA objective lens and a 1.2NA oil-immersion condenser to synthesize a system NA of 1.6. We confirmed the accuracy of this technique by achieving a half-pitch resolution of 154 nm at a wavelength of 435 nm with a FOV of 2.34 mm^2, corresponding to an SBP of 98.5 megapixels (~ 50 times higher than that of the conventional incoherent microscope with the same resolution). We also demonstrated the effectiveness of this approach by imaging various biological samples, such as human blood smears. Our work indicates that FPM is an attractive method which could broadly benefit wide-field imaging applications that demand large SBP, and it still has a great potential to achieve much larger SBP of bright-field microscopes.

Key words: computational imaging; microscopy; phase retrieval; image reconstruction techniques; super-resolution

Session 7: Optical Imaging and Display, Laser Radar

Chairs: **Yongtian Wang**, Beijing Institute of Technology, China
Xiudong Sun, Harbin Institute of Technology, China
Qionghua Wang, Sichuan University, China
Ting-Chung Poon, Virginia Polytechnic Institute and State University, USA
Vasyl Molebny, Acad Technol Sci Ukraine, Ukraine

Location: B512, 5F, Main Building, Harbin Institute of Technology No.2 Campus

18th July

Chair: Sin-Doo-Lee, Seoul National University, Korea

14:00-14:45	**Optical Scanning Holography (OSH) for 3D Imaging and Remote Sensing (Keynote)** Ting-Chung Poon *Virginia Polytechnic Institute and State University, USA*	- 121 -
14:45-15:15	**Optical Imaging Using Low-Diffraction Airy Beams in Phase Space (Invited)** Ping Yu *University of Missouri, USA*	- 122 -
15:15-15:45	**Spatial-Temporal Psycho-Visual Modulation, A New Paradigm for Information Display (Invited)** Guangtao Zhai *Shanghai Jiao Tong University, China*	- 123 -
15:45-16:00	**Coffee Break**	

Chair: Kenji Yamamoto, National Institute of Information and Communications Technology, Japan

16:00-16:45	**Future Display Technologies Beyond LCDs and OLEDs (Keynote)** Sin-Doo Lee *Seoul National University, Korea*	- 124 -
16:45-17:15	**Electro-Holographic Retina Display for Augmented Reality (Invited)** Jun Xia *Southeast University, China*	- 125 -
17:15-17:45	**Carbon Electronics for Information Storage and Displays (Invited)** Juqing Liu *Nanjing Tech University, China*	- 126 -
17:45-18:00	**Visibility Enhancement Method for Hazy Image Based on Polarimetric Imaging (Oral)** Wenfei Zhang[1], Jian Liang[1], Liyong Ren[1], Haijuan Ju[1], Zhaofeng Bai[1], Zhaoxin Wu[2] [1] Xi'an Institute of Optics and Precision Mechanics, Chinese Academy of Sciences, China; [2] Xi'an Jiaotong University, China	- 134 -
18:00-19:00	**Dinner Time**	

19th July

Chair: Ting-Chung Poon, Virginia Polytechnic Institute and State University, USA

09:00-09:45	**Hologram Printing Technology (HOPTECH) – Applications from Static 3D Visualization to Projection-Type Dynamic Holographic 3D Display (Keynote)** Kenji Yamamoto *National Institute of Information and Communications Technology, Japan*	- 127 -
09:45-10:15	**Three Dimensional Display with An Expanded Space-Bandwidth Product (Invited)** Liangcai Cao *Tsinghua University, China*	- 128 -
10:15-10:30	**Error Analysis and Experimental Investigations for Spaceborne Laser Rangefinder (Oral)** Peng Huan *Beijing Institute of Space Mechanics & Electricity, China*	- 134 -
10:30-10:45	**A Novel Computational Ghost Imaging Using Periodical Pseudo-Thermal Light Generated by Rndomly Phased Fiber Array Beams (Oral)** Chunbo Liu *Xidian University, China*	- 134 -
10:45-11:00	**Coffee Break**	

Chair: Liangcai Cao, Tsinghua University, China

11:00-11:30	**Compact Zoom Imaging System Based on Liquid Lenses (Invited)** Lei Li *Sichuan University, China*	- 129 -
11:30-11:45	**Single-Shot Compressed Ultrafast Photography (Oral)** Chengshuai Yang, Dalong Qi, Fengyan Cao, Shian Zhang *East China Normal University, China*	- 135 -

19th July

11:45-12:00	**A New Automatic Exposure Algorithm for Spaceborne Camera Using the Solar Position (Oral)** Haoyang Li, Lijin Li, Weigang Wang, Pengmei Xu *Beijing Institute of Space Mechanics & Electricity, China*	- 135 -
12:15-14:00	**Lunch Time**	
Chair: Lei Li, Sichuan University, China		
14:00-14:15	**Depth Extraction with High Accuracy in Intrgral Imaging Based on Moving Array Lenslet Technique (Oral)** Yaoyao Wang[1], Xuewei Zhao[1,2], Bo Zhang[1,2], Xing Zhao[1,2] *[1] Nankai University, China; [2] Tianjin Key Laboratory of Optoelectronic Sensor and Sensing Network Technology, China*	- 135 -
14:15-14:30	**Edge Detection Based on Ghost Imaging using Improved Sobel Operator (Oral)** Hongdou Ren *Nanjing University Of Posts And Telecommunications, China*	- 136 -
14:30-14:45	**Study on Flat-topped Beams Obtained by the Butterfly LCD Module for Autostereoscopic Display (Oral)** Fangping Chen, Xiaoting Zhang, Qi-ren Zhuang, Chujia Liu, Yu Qi, Fengtie Wu *Huaqiao University, China*	- 136 -
14:45-15:00	**Analysis on Structured Light Reconstruction Method and Characteristics through Scattering Media (Oral)** Chen Jia *Tianjin University of Technology, China*	- 137 -
15:00-15:15	**Coffee Break**	
15:30-17:30	**Poster**	
18:00-20:00	**Banquet**	

20th July

Chair: Yuan Zhao, Harbin Institute of Technology, China		
09:00-09:45	**Is Laser Radar a Younger Brother of Microwave Radar? (Keynote)** Vasyl Molebny *Acad Technol Sci Ukraine, Ukraine*	- 130 -
09:45-10:15	**Statistics of Atmospheric Opacity Derived from CALIPSO Measurements for Developing Future Space-Based Lidar Applications (Invited)** Zhaoyan Liu *NASA Langley Research Center, USA*	- 131 -
10:15-10:45	**Imaging Over Scattering Media Based on Second-Order Correlation of Light Field (Invited)** Weitao Liu *National University of Defense Technology, China*	- 132 -
10:45-11:00	**Coffee Break**	
Chair: Zhaoyan Liu, NASA Langley Research Center, USA		
11:00-11:30	**Non-Line-of Sight Laser Imaging Systerm Based On Photon Counting (Invited)** Yuan Zhao *Harbin Institute of Technology, China*	- 133 -
11:30-11:45	**RF Up-Conversion Using a Fiber Frequency-Shifting Amplifier Loop (Oral)** Haiyang Zhang, Hongzhi Yang, Changming Zhao, Suhui Yang, Chen Li *Beijing Institute of Technology, China*	- 137 -
11:45-12:00	**Measurement of Extinction Coefficient of Near - surface Aerosol by CCD Lidar in the Daytime (Oral)** Peiyu Sun[1], Kee Yuan[2], Jie Yang[3] *[1] University of Chinese Academy of Sciences, China; [2] Anhui Institute of Optics and Fine Mechanics, China; [3] University of Science and Technology of China, China*	- 137 -
12:15-14:00	**Lunch Time**	

Optical Scanning Holography (OSH) for 3D Imaging and Remote Sensing

Ting-Chung Poon
Virginia Polytechnic Institute and State University, USA

Note

ABSTRACT

Optical scanning holography (OSH) is a single-pixel digital holographic technique where real-time holographic recordings of a three-dimensional (3D) object can be acquired by utilizing two-dimensional (2-D) active optical heterodyne scanning without the need of a low-resolution 2-D pixel array sensor as in conventional digital holography for passive 3D imaging. Indeed, applications of the technique include cryptography, fluorescence holographic microscopy, 3D pattern recognition, 3D holographic TV, and 3D optical remote sensing. In this presentation, I will first provide an overview of OSH. I will then describe how OSH can be used as a digital holographic technique for 3D optical remote sensing applications. Successful demonstration of infrared OSH could open doors for novel digital holographic remote sensing applications such as in automated driving.

BIOGRAPHY

Ting-Chung Poon is a professor of Electrical and Computer Engineering at Virginia Tech, Virginia, USA. His current research interests include 3D image processing and optical scanning holography (OSH). Dr. Poon is the author of the monograph *Optical Scanning Holography with MATLAB* (Springer, 2007), and is the co-author of, among other textbooks, *Introduction to Modern Digital Holography with MATLAB* (Cambridge University Press, 2014). He is also editor of the book *Digital Holography and Three-Dimensional Display* (Springer, 2006). Dr. Poon served as Topical Editor/Division Editor of Applied Optics from 2004 to 2014. He was also associate editor of the IEEE Transactions on Industrial Informatics. Currently Dr. Poon is associate editor-in-chief of *Chinese Optics Letters*. Dr. Poon is a fellow of the Institute of Electrical and Electronics Engineers (IEEE), the Institute of Physics (IOP), the Optical Society (OSA), and the International Society for Optics and Photonics (SPIE). He received the 2016 Dennis Gabor Award of the SPIE for “his pioneering contributions to optical scanning holography (OSH), which has contributed significantly to the development of novel digital holography and 3D imaging.”

Ping Yu
University of Missouri, USA

Optical Imaging Using Low-Diffraction Airy Beams in Phase Space

ABSTRACT

Phase-space method with Wigner distribution function (WDF) in optics can be used for both coherent light and partially coherent light in optical imaging. WDF represents the optical signal in the space domain and spatial frequency domain simultaneously. It has an advantage of handling optical scattering in biological samples for the tomography imaging. We study the WDF for both Gaussian and Airy beams using a simulation and experimental studies. To experimentally determine the WDF, we use a configuration of a scanning aperture in the Fourier plane while the images are acquired in the real space. By minimizing the difference between the measured WDF and simulation, the positions of an object can be reconstructed. Our results provide experimental data and methodology for optical imaging using the WDF of finite-energy Airy beams.

BIOGRAPHY

Dr. Ping Yu is a professor at the Department of Physics and Astronomy, University of Missouri. He received B.Sc. degree from Nankai University in 1984 and M.Sc. degree in 1987, and received his Ph.D. degree from Hong Kong University of Science and Technology in 1998. Dr. Ping Yu is a physicist whose researchs include nonlinear optics, optical imaging, material science and biomedical imaging. He has spent his career exploring basic physical processes in optics and materials, and applying acquired knowledge to the development of novel optical materials, optoelectronic devices, and imaging systems. The most well known of his research contributions are: (1) his pioneering work on room temperature stimulated emission, lasing and gain mechanism of zinc oxide epitaxial thin films and microstructures; (2) his contribution to understanding optical polarization and electronic states of vertically coupled semiconductor quantum dots; and (3) his innovation in holographic imaging, coherence domain imaging and fluorescence mediated tomographic imaging. His research has been supported by funds from NSF and NIH. He has more than 80 journal publications that received over 7000 citations.

Note

Guangtao Zhai
Shanghai Jiao Tong University, China

Note

Spatial-Temporal Psycho-Visual Modulation, A New Paradigm for Information Display

ABSTRACT

Information display technologies have played an indispensable role in the advancement of human civilization, from rock carving of prehistoric tribesmen to pervasive use of electronic displays in modern societies. The ever-presence, great variety and continuously increasing sophistication of optoelectronic displays profoundly shape the ways we learn, work, communicate, and how entertain and even how we socially behave. This article presents a new paradigm of information display, called Spatial-Temporal Psycho-Visual Modulation (STPVM), which is conceived as an ingenious interplay of signal processing, optoelectronics, and psychophysics. This talk reviews the basic working principle and several applications of STPVM display, including information security display, dual-view TV, 2D/3D compatible display and etc.

BIOGRAPHY

Guangtao Zhai received the B.E. and M.E. degrees from Shandong University, Jinan, China, in 2001 and 2004, respectively, and the Ph.D. degree from Shanghai Jiao Tong University, Shanghai, China, in 2009, where he is currently a Research Professor with the Institute of Image Communication and Network Engineering. He was a Student Intern with the Institute for Infocomm Research, Singapore, from 2006 to 2007, and a Visiting Student with the School of Computer Engineering, Nanyang Technological University, Singapore, from 2007 to 2008, and the Department of Electrical and Computer Engineering, McMaster University, Hamilton, ON, Canada, from 2008 to 2009, where he was a Post-Doctoral Fellow from 2010 to 2012. From 2012 to 2013, he was a Humboldt Research Fellow with the Institute of Multimedia Communication and Signal Processing, Friedrich Alexander University of Erlangen-Nuremberg, Erlangen, Germany. He was a recipient of the National Excellent Ph.D. Thesis Award from the Ministry of Education of China in 2012. His research interests include multimedia signal processing and perceptual signal processing. He has published about 200 papers in those areas.

Future Display Technologies Beyond LCDs and OLEDs

Sin-Doo Lee
Seoul National University, Korea

ABSTRACT

Since the early 90's, liquid crystal displays (LCDs) have been successfully commercialized for use in computers, mobile devices such as smart phones and pads, and HDTVs owing to their light-weight, thin panel thickness, and low power consumption. Currently, we come into the age of organic light-emitting diodes (OLEDs) that exhibit the superior performance in the viewing properties, the response speed, the luminance, and flexible applications. The rapid growth of a huge worldwide market size is forecasted for OLEDs in displays and lighting by several market analysts. I will give an overview of the current status of OLEDs and technical issues on advanced OLEDs that should be challenged for more sophisticated applications. I will also discuss two of future display technologies, that are organic light-emitting transistors (OLETs) and quantum.

BIOGRAPHY

Sin-Doo Lee is a professor of school of Electrical Engineering of Seoul National University, Korea. He received his BS and MS degrees in solid-state physics from Seoul National University, Korea in 1980 and 1982, respectively, and his Ph.D. degree in liquid crystal physics from Brandeis University, USA in 1988. Prof. Lee is one of the leading interdisciplinary scientists with worldwide high reputation in physics, optics, and device engineering of soft matters including liquid crystals, organic semiconductors, and polymers. He has authored about 300 scientific publications and delivered over 320 conference presentations. He is currently the fellow of three major display societies of SID, SPIE, and OSA. He has been served as a general chair/co-chair, an organizing committee chair, and a member of the program committee in many scientific and technical societies. His current research areas include organic solar cells, OLETs and QDs for future displays, and biomimetic devices such as e-skins and and an artificial iris.

Note

Electro-Holographic Retina Display for Augmented Reality

Jun Xia
Southeast University, China

Note

ABSTRACT

We use a single phase-only spatial light modulator and a double phase method to directly modulate the light at multiple planes inside the eye. The complex amplitude of hologram is transformed to pure phase value based on double-phase method. To suppress noises and higher order diffractions, we introduced a 4-*f* system with a filter at the frequency plane. A blazing grating is proposed to separate the complex amplitude on the frequency plane. Due to the complex modulation, the speckle noise is reduced. Both computer simulation and optical experiment have been conducted to verify the effectiveness of the method. The results indicate that this method can effectively reduce the speckle in the reconstruction in 3D holographic display. By changing the focal length of the eye, images at different depth planes are sharply projected onto the retina, which solve the accommodation and convergence conflict problem for augmented display.

BIOGRAPHY

Jun Xia, Professor at Southeastern University. Visiting professor of Technology University of Delft. Member of the national standardization Technical Committee, member of the Professional Committee of China Society of image and graphics stereo image technology, member of the Professional Committee of China optical society, holography and optical information. His research areas include three-dimensional display, holographic display and micro display technology. He has published more than 100 academic papers, and been authorized more than 30 national invention patent. He was honored the first technology progress prize by Jiangsu Province.

Juqing Liu
Nanjing Tech University, China

Carbon Electronics for Information Storage and Displays

ABSTRACT

Carbon electronics have attracted significant attention from the scientific community due to their unique structures and novel properties, making them potential applications in many next generation technologies, largely because traditional silicon electronics are approaching their fundamental limits in terms of miniaturization and capacity, et al. In this talk, the development and challenge of information technologies, such as information storage and displays, will be introduced briefly. Our objective is to advance our fundamental understanding of the properties of carbon-based electronic materials, now we are using them to create new emerging devices through solution process, with the merit of potential low cost, large area and simple fabrication process. The devices we study include carbon-based electrical memories for data storage and carbon-based light emitting devices for displays and lighting.

BIOGRAPHY

Dr. Juqing Liu is currently professor at Institute of Advanced Materials (IAM) at Nanjing Tech University. His mainly research interests are the design and fabrication of carbon electronics, organic/plastic electronics, flexible and stretchable electronics, the devices include electrical memories for information storage, light-emitting devices for information displays, and transistors for logical circuits. He has published over 30 papers in high-impact international scientific journals including *Adv. Mater.*, *Angew. Chem. Int. Ed.*, *J. Am. Chem. Soc.*, *ACS Nano*, *Small*, with a total citation of over 1700 and H-index of 21. He has been honored as Excellent Young Scholar of China by NSFC and the Jiangsu Specially-Appointed Professor.

Note

Hologram Printing Technology (HOPTECH) – Applications from Static 3D Visualization to Projection-Type Dynamic Holographic 3D Display

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

Note

ABSTRACT

Hologram Printing Technology mainly consists of computer generated hologram, wavefront printing and duplication. Many applications are expected by using this technology, such as 3D static visualization, the projection-type dynamic 3D display, large HOE, complex HOE, and so on. In this presentation, I will introduce the overview of the technology.

BIOGRAPHY

Kenji Yamamoto received his PhD from Nagoya University, Japan, in 2007. He is a chief senior researcher at Applied Electromagnetic Research Institute, NICT. His research interests include 3D and ultra-realistic visual system, especially electronic holography, wavefront printer, computer-generated hologram, integral photography, multi-camera system, multi-view video coding, depth estimation, and view synthesis.

Now, he serves the vice-president in holographic display artists and engineers club (HODIC) under OSJ, the executive director and the reader of ultra-realistic display working group in ultra-realistic communications forum (URCF), the program chair in 3D systems and applications (3DSA), the program chair of 3D/hyper-realistic display workshop in International Display Workshops (IDW), the chair of AR/VR subcommittee in SID Japan chapter, a member of program committee in OSA Frontiers in Optics (FiO) etc.

Liangcai Cao
Department of Precision Instruments, Tsinghua University

Note

Three Dimensional Display with an Expanded Space-Bandwidth Product

ABSTRACT

A volume holographic printing method for dynamic three-dimensional (3D) display with an expanded space-bandwidth product (SBP) using unconventional angular multiplexing techniques is investigated. By wavefront encoding of the 3D scene with computer generated holography, the object beam is loaded onto a 2-D phase spatial light modulator (SLM) with a limited SBP. The printing method then writes a single hologram through the interference of the object beam with a reference beam as a holographic element (hogel) in the volume holographic polymer. In addition, multiple 3D scenes can be recorded and dynamically reconstructed by angular multiplexing in the same hogel location. The SBP can be expanded compared to the conventional holographic printing method, showing the potential to realize a dynamic and high-resolution 3D display.

BIOGRAPHY

Liangcai Cao received his BS/MS and PhD degree from Harbin Institute of Technology and Tsinghua University, in 1999/2001 and 2005, respectively. Then he became an assistant professor at Department of Precision Instruments, Tsinghua University. He is now an associate professor and director of the Institute of Opto-Electronic Engineering at Tsinghua University. He was a visiting scholar at UC Santa Cruz and MIT in 2009 and 2014. His current research interests are holography and 3D storage, imaging and display. He has more than 100 peer-reviewed journal papers published and holds more than 15 patents. He serves as editor or guest editor of Journal of *Optical Memory & Neural Networks*, International Journal of *Precision Instruments and Manufacturing*, Journal of the *Optical Society of America B and Optics Communications*. He is a senior member of OSA.

Compact Zoom Imaging System Based on Liquid Lenses

Lei Li
Sichuan University, China

Note

ABSTRACT

Compact imaging systems are important features of next generations of imaging product. Among key specifications, maybe overall size and manufacturing cost are most important. Nowadays, many imaging systems are designed to be smaller and smaller by using liquid optical device. In this talk, we report several compact zoom imaging systems based on liquid lenses. The proposed zoom system can realize continuous zoom change and correct aberrations during the tuning range. Only voltages are used to control the system. Therefore, the proposed system is very compact without any mechanical movement part.

BIOGRAPHY

Dr. Lei Li is an associate professor of School of Electronics and Information Engineering, Sichuan University. He received his Ph.D. and B.S. from Sichuan University in 2013 and 2008, respectively. He was a research assistant at Institute of Optics and Electronics, Chinese Academy of Sciences, from 2013 to 2014. In 2015, he was exceptionally promoted to associate professor in Sichuan University. His research interests focus on liquid optical device, optical system design, and 3D display. He is the author or coauthor of more than 30 papers in peer-reviewed journals and conferences and one book chapter in his research career. He is the member for several professional organizations, also reviewer for many prestigious peer-review journals in optical sciences related fields.

Is Laser Radar a Younger Brother of Microwave Radar?

Vasyl Molebny
Academy of Technological Sciences of Ukraine, Ukraine

Note

ABSTRACT

Many of the colleagues when asked this question answer “yes”. The lecture discusses not only the age of both radars but their achievements and potentials in solving many problems in military and civilian fields. Historically both started with measuring the distance having fixed the word “ranging” in their names. Both did not restrict the solved problems only by “detection and ranging”: imaging, velocity measurement, etc. And here their ways split: microwaves are better in their fields, lasers – in theirs. Lecture will show very specific fields where microwaves are powerless – in the micro-scale region, where laser radar can provide, for example, reading the information from CD disks, tomographic imaging of eye bottom, measuring the aberrations of the human eye, imaging the blood vessels from inside, etc. New tendencies will be discussed of “penetrating through the walls”, “looking round the corner”, and multi-attribute tasks, requiring to marry the potentials of both radars.

BIOGRAPHY

MSc and PhD in radio-engineering from National Technical University of Ukraine, Kiev. DSc in Optics from Altair Institute, Moscow. Professor of Optics, National University of Kiev. Vice-president of Kvant Scientific Research Institute, Kiev, and designer-in-chief of active and passive EO systems, laser radars, high-precision laser designators, counter-measure and directed-energy laser systems. Academic exchange – universities of Bayreuth, Munich, and Heraklion. Member of organizing and scientific committees of numerous international meetings, OSA reviewer, NATO Fellowship. Inventor of the ray tracing wave front sensing. Interests: precision laser radar systems and information processing and display, wave front measurement and correction. Over 400 publications and presentations at international meetings, books and chapters at Springer, Taylor and Francis, CRC, Slack, Encyclopedia of Modern Optics (Elsevier). Over 100 patents. Member of the Academy of Technological Sciences of Ukraine, member of its Presidium, vice-president of the Optical Society of Ukraine. National prize of Russian Federation, Glushkov Academic award.

Statistics of Atmospheric Opacity Derived from CALIPSO Measurements for Developing Future Space-Based Lidar Applications

Zhaoyan Liu
NASA Langley Research Center, USA

Note

ABSTRACT

The World Meteorological Organization (WMO) and US National Research Council (NRC) have identified global wind and CO_2 measurements a high priority need. Teams at NASA's Langley Research Center (LaRC) have developed airborne coherent Doppler lidar for wind measurements and integrated path differential absorption (IPDA) lidar to measure column-averaged CO_2, targeting future NASA space missions. However, lidar measurements from space are often interfered by clouds and the laser beam cannot always transmit to the low atmosphere and surface to provide full column measurements. Opaque clouds will completely block the laser beam, making it impossible to acquire measurements beneath them. Knowledge of the atmospheric opacity is thus essential for designing future space lidars. We will present distributions of the horizontal extents of opaque clouds derived from the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO) measurement.

BIOGRAPHY

Dr. Zhaoyan Liu received a B.E. degree in Laser Physics in 1984 and a M.E. degree in Optics in 1987 from Harbin Institute of Technology (HIT) in China, and a D.E. degree in System Design Engineering in 1996 from Fukui University in Japan. He is currently a lidar scientist at NASA Langley Research Center (LaRC). Dr. Liu has 30+ year experience in the field of laser and lidar system development and lidar remote sensing. He was a team member of a Japanese space lidar project, the Experimental Lidar In Space Equipment (ELISE), and was in charge of the development of data processing algorithms. Dr. Liu is a key member of the Lidar Science Working Group of the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) mission, a NASA-CNES joint satellite project. He is also involved in the LaRC airborne coherent Doppler lidar for wind measurements and integrated path differential absorption (IPDA) lidar for atmospheric CO_2 measurements.

Imaging Over Scattering Media Based on Second-Order Correlation of Light Field

Weitao Liu
National University of Defense Technology, China

ABSTRACT

Ghost imaging allows to obtain an image of objects via signal from a single-pixel detector, based on second-order correlation of light fields, being more powerful against scattering media. Based on self-correlation of speckle patterns, the image of objects behind scattering media can also be retrieved, based on memory effect. We try to compare both imaging techniques and explain self-correlation imaging method using second-order correlation of light fields, similarly to that of ghost imaging. An approach taking advantages of both techniques is also discussed.

Note

BIOGRAPHY

Associate professor of Physics, College of Science, National University of Defense Technology, Changsha, China; Interdisciplinary Center of Quantum Information, National University of Defense Technology. 2014.09-2015.09, visiting scholar, Department of Physics and Astronomy, University of Rochester.

In 2012, PhD thesis titled “Photonic entanglement states and their applications” was nominated as a degree thesis of excellence of China.2015 The first prize in Natural Science Award of Hunan Province was granted, the second author.2013.11-2016.11 Supported by Program for New Century Excellent Talents in University.

Yuan Zhao
Harbin Institute of Technology, China

Note

Non-line-of sight Laser Imaging Systerm Based on Photon Counting

ABSTRACT

The traditional laser 3D imaging technology has the advantages of high resolution, small ranging error and fast imaging speed. For some non line of sight target hidden behind shelter, the existing imaging methods are difficult to get effective detection. With the development of device technology, especially the emergence of photon counting detector with high sensitivity and high time resolution, make it possible to detect and identify some targets in special conditions or special environment. Especially non line of sight laser imaging has attracted more and more researcher's attention. We first reviewed a variety of non line of sight laser imaging system in recent years, establishes the forward and reverse process simulation of non line of sight laser imaging based on ray tracing method, design and establish non line of sight laser imaging system based on photon counting. A new sphere projection method and an imaging system with two intermediary walls are proposed.

BIOGRAPHY

Zhao Yuan, born in 1963, professor and PhD supervisor, is the head of Department of Physics at Harbin Institute of Technology. He is a member of Photoelectronic Technology Professional Committee of Chinese Astronautics Society and editorial member of Infrared and Laser Engineering. He has more than 30 years of scientific research work on laser radar, laser imaging, quantum detection and microwave photonics integrated technology. With rich experience and foresight of development direction, he has contributed a lot to the key technical research and technical advancement in these fields.

CIOP-2017-0423

Visibility Enhancement Method for Hazy Image Based on Polarimetric Imaging

Wenfei Zhang[1], Jian Liang[1], Liyong Ren[1], Haijuan Ju[1], Zhaofeng Bai[1], Zhaoxin Wu[2]
[1] Xi'an Institute of Optics and Precision Mechanics, Chinese Academy of Sciences; [2] Xi'an Jiaotong University

Haze is a common atmospheric phenomenon, where there are plenty of atmospheric particles. The particles not only scatter and absorb the object light, but also scatter the atmospheric light to blend the object light. Thus, the images captured in haze usually show low contrast, poor visibility and color distortion, which is fatal for machines and vision systems in outdoor applications. Image dehazing technique is an important way to enhance the image quality captured in such scattering surroundings, and it has attracted many attentions in optics and computer vision fields due to its wide applications. In particular, the development of fast and real-time dehazing methods is significant for automatic systems.

Attributing to the wide demands, the dehazing methods have been widely developed based on different principles. Among them, the polarimetric dehazing method is a new kind of method developed in the past decade. The polarimetric dehazing method has advantages in detailed information restoration and color fidelity, and it is widely used in image dehazing, underwater image enhancement and medical inspection. The atmospheric light scattered by particles (called airlight) is partially linearly polarized according to the Mie theory. The polarimetric dehazing method can estimate the airlight intensity according to multiple hazy images with different polarization states and recover the object light according to the scene depth. For the color image, the current polarimetric dehazing methods always implement the dehazing process three times in Red, Green and Blue channels, respectively. This prevents the further improvement of their efficiency.

In order to advance the efficiency of the polarimetric dehazing method for color image dehazing, we propose a fast method based on the hue, saturation and intensity (HSI) color space and color correction. In HSI color space, the intensity channel is only dependent on RGB intensities. So we can dehaze the intensity channel using the polarimetric dehazing method once. The color distortion aroused by haze is corrected using white patch retinex method.

Experiment demonstrates the effectiveness of the proposed method in quality improvement. The contrast is obviously enhanced, and the detailed information is recovered well. Meanwhile, the proposed method performs high efficiency, which is beneficial for real-time video dehazing.

Key words: polarimetric imaging; Imaging through turbid media

CIOP-2017-1079

Error Analysis and Experimental Investigations for Spaceborne Laser Rangefinder

Peng Huan
Beijing Institute of Space Mechanics & Electricity

The error sources of spaceborne laser rangefinder consist of both system errors and random errors.System errors were constant errors which could be removed through laboratory or field experiments calibration.Random errors consist of both spaceborne laser rangefinder internal random errors and random errors caused by atmosphere, target characteristics and laser pointing jitter, et al. Random errors were main factors impacting ranging precision of spaceborne laser rangefinder and can not be eliminated. In this study, the main sources of internal random errors were analyzed by means of an example of spaceborne laser rangefinder. Demonstration of the spaceborne laser rangefinder showed its internal random error was 0.2939 m@3σ. Then system errors and internal random error calibration of the spaceborne laser rangefinder were done by means of fiber delay timer, and the experiment results showed that under particular conditions, the internal random errors were 0.2803 m~0.3033 m@3σ, which was in accord with analysis results. The testing results were significant for manufacturing, testing and post-data applications of spaceborne laser rangefinder.

Key words: space borne laser rangefinder; system error; random error; experiment

CIOP-2017-1602

A Novel Computational Ghost Imaging Using Periodical Pseudo-Thermal Light Generated by Randomly Phased Fiber Array Beams

Chunbo Liu
Xidian University

Ghost imaging has been attracting worldwide researchers' attention for its distinctive feature of nonlocal imaging with single-pixel detector that provides no spatial resolution since it was first reported by Pittman and Shih in 1995. In the original experimental setup, two-photon entangled source was used, but afterwards, the classical thermal light experimentally proved to be feasible. The mostly used pseudo-thermal light results from a coherent beam through a dynamic diffuser (such as rotating ground glass plate) and thus the coincidence or correlation measurement between the signal and the reference arm is necessary to obtain the image of object. In 2008, Shapiro proposed the computational ghost imaging scheme based on phase spatial-light-modulator (SLM), where a high-resolution sensor in the reference arm is not compulsory because the reference speckle field can be precomputed according to the model for the free-space wave propagation. Since then, computational ghost imaging becomes one of research focuses owing to the convenience of system configuration to practical applications. Much progresses have been made, those progresses involve the system

realization using liquid crystal SLM and digital micro-mirror device (DMD), the imaging algorithm using compressive sensing, a high quality imaging scheme using three-color multi-fluorescent screen, three-dimensional imaging technique, and the imaging in turbulent atmosphere, etc. Some applications, such as remote sensing, optical encryption, and digital holography have been investigated as well.

Imaging speed is an important factor of restricting the development and application of ghost imaging in some fields, such as moving target sensing. Restricted physically by the response speed, however, the pseudo-thermal light resulted from a phase SLM or DMD fluctuates in intensity at the frequency of no more than 40 kHz. The key to solving the problem is how to increase the modulation speed imposed on laser beam.

To obtain a high imaging speed, a novel computational ghost imaging system scheme is proposed based on a particular pseudo-thermal light source generated by randomly phased fiber array beams. In the scheme, fiber array beams are randomly modulated using high-speed electro-optic phase modulators to generate a fast time-variant, spatially periodical pseudo-thermal light field, which can be precomputed according to the array geometry and the known phases. The signal light is collected and detected by a low-pixel avalanche photodiode (APD) array, which can avoid the image ambiguity and simultaneously decrease the requirement on sample quantity. The schematic system is presented and the imaging process through space-time correlation and compressive sensing algorithm is then formulated, respectively. Furthermore, the imaging performance of the proposed scheme is discussed by numerical simulations. The results show that the imaging speed of the proposed scheme can be significantly improved owing to both the fast time-variant field and the decreased requirement on sample quantity.

Key words: computational imaging; ghost imaging; correlated imaging; pseudo-thermal light; optical phased array

CIOP-2017-1609

Single-Shot Compressed Ultrafast Photography

Shian Zhang, Chengshuai Yang, Dalong Qi, Fengyan Cao
State Key Laboratory of Precision Spectroscopy, East China Normal University

Capturing the transient scenes at high imaging speed is a long-term dream of scientists. Especially, the introduction of electronic imaging sensors based on charge-coupled device (CCD) or complementary metal-oxide-semiconductor (CMOS) technology can make the imaging speed up to 107 frames per second, but the frame rate of this technique is limited by the on-chip storage and electronic readout speed, and therefore further increasing frame rate is impossible. In this talk, we would like to demonstrate a two-dimensional dynamic imaging technique, compressed ultrafast photography (CUP), which can capture non-repetitive transient events at up to 2´1012 frames per second. Compared with existing ultrafast imaging technique, CUP has the prominent advantage of measuring transient scene with a single camera snapshot, and so it can observe the transient events with the temporal resolution in the range of picosecond. Considering CUP's ability, it would have widespread applications in both fundamental science and applied science fileds.

Key words: streak carema; compressed sensing; ultra-high speed photography

CIOP-2017-1805

A New Automatic Exposure Algorithm for Spaceborne Camera Using Solar Position

Haoyang Li, Lijin Li, Weigang Wang, Pengmei Xu
Beijing Institute of Space Mechanics & Electricity

It is complicated of illumination conditions on the dawn-dusk orbit, ranging from full sunlight in day-time to quarter moon in night-time, which means that spaceborne cameras need large dynamic range. In order to improve the dynamic range and the image quality of the camera, automatic exposure algorithm is enhanced according to the real time scenery and illumination condition. As the reference of algorithm designing, the regular pattern of spaceborne camera radiance in pupil was researched. A new automatic exposure algorithm based on solar position was proposed. Following with the changing of solar azimuth and zenith, imaging parameters such as exposure time and electron multiplication gain were adjusted to adapt the different ground targets with different dynamic ranges. The algorithm was embedded into the imaging circuit of one spaceborne camera prototype. At last, the experimental results show the correctness, stability and reliability of the algorithm for real time automatic exposure control.

Key words: automatic exposure; solar position; dawn-dusk orbit

CIOP-2017-2519

Depth Extraction with High Accuracy in Intergral Imaging Based on Moving Srray Lenslet Technique

Yaoyao Wang, Xuewei Zhao, Bo Zhang, Xing Zhao
Institute of Modern Optics, Key Laboratory of Optical Information Science and Technology Nankai University, Ministry of Education of China

In this talk we proposed a method to improve depth extraction accuracy by using moving array lenslet technology (MALT) in pickup stage to decrease the depth interval caused by pixelation. Firstly, we analyzed the feasibility of decreasing the pixelation effect by MALT. In conventional pickup process, owing to the limited size of the pixel of the recording device, the pixels containing the corresponding image points in each EI will overlap in the image space and lead to a depth interval during reconstruction. The pixilation effect results in that the energy distribution is

indistinguishable in these depth intervals. By using MALT, a serious of EIs can be obtained and the limitation of the pixel size will be overcome, so the depth interval is decreased. Therefore a depth extraction method by MALT in capture stage was proposed.

In our proposed method, the lenslet array was moved along the horizontal and vertical direction simultaneously *N* times in a pitch to get *N* sets of elemental images. Computational integral imaging reconstruction method for MALT was taken to obtain the slice images of the 3D scene, and the SMD blur metric is taken on these slice images to achieve the depth information of the 3D scene. To verify the proposed method, using a resolution target as the object, the simulation experiment was implemented. The curve of the SMD value varying with the reconstructed depth *z* is drawn. It can be seen in the curve that the SMD value for MALT has a sharp peak and dramatic changes with the depth. However, the values for the conventional pickup method oscillate, which make it is difficult to extract the exact depth information.

The optical experiment is also conducted. The 3D scene was a cube with question mark and the other is a warning board. We use all of these elemental images to get the slice images of 3D scene. In order to extract the depth of the warning board, SMD evaluation is carried out. From the curve of SMD value varying with the depth *z*, the depth value of the board can be clearly confirmed. As a parison, the conventional recording method is hard to extract the depth.

In conclusion, we proposed a depth extraction method with high accuracy by using moving array lenslet technique. Optical and simulation experiments were conducted to verify the feasibility of this method.

Key words: depth extraction; integral imaging; moving array lenslet technique

CIOP-2017-1710

Edge Detection Based on Ghost Imaging Using Improved Sobel Operator

Hongdou Ren[1], Shengmei Zhao[1,2]
[1] Institute of Signal and Transmission, Nanjing University of Posts and Telecommunications;
[2] Key Lab of Broadband Wireless Communication and Sensor Network Technology (NanjingUniversity of Posts and Telecommunications)

As a new type of imaging technology, ghost imaging can make up for the shortcomings of conventional imaging technology which makes it become one of the frontiers and hotspots of quantum optics in recent years. In addition, edge detection can get the edge information of the object, and has great application prospect in the fields of machine vision and pattern recognition. The traditional method of edge detection using ghost imaging to obtain the edge information of an object needs to get the object image before the use of classic edge detection technology. In the opposite, edge detection based on ghost imaging doesn't require an image of the object, which can directly achieved the edge of an unknown object. In this paper, the improved Sobel operator whose template size is N*N and the number of pixels in it is large which results in a more accurate edge image. Besides, the template coefficient is composed of the form of the same Sobel operator whose size is determined by the distance between the neighborhood pixel and the current pixel with the minimum value of 1 and the maximum of (N-1)/ , and the multiple between two of coefficients is $\sqrt{2}$. The simulation and experimental results show that the proposed improved Sobel operator can get more accurate edge information, and the edge of the image line is continuous without false edge, so it is more suitable for edge detection based on ghost imaging.

Key words: ghost imaging; edge detection; Improved Sobel operator

CIOP-2017-2330

Study on Flat-Topped Beams Obtained by the Butterfly LCD Module for Autostereoscopic Display

Fangping Chen, Xiaoting Zhang, Qiren Zhuang, Chujia Liu, Yu Qi, Fengtie Wu
Key Laboratory of Light Propagation and Transformation of Fujian Province; College of Information Science and Engineering, Huaqiao University

The crosstalk of the left and right parallax images can be greatly reduced by using the directional backlight autostereoscopic display of the transverse flat-topped beams. In this talk, we studied a principle and method of cylindrical mirror directional backlight flat topped beam by using the butterfly-shaped liquid crystal unit. Based on the generalized Huygens Fresnel diffraction integral, we can get the expression of the diffraction field distribution of beams passing through cylindrical lens with the butterfly-shaped liquid crystal switch unit as the light source. The butterfly-shaped liquid crystal switch unit was placed on the cube focal plane of the cylindrical lens, we simulate the different focal length lens under the transverse optical field energy distribution curve by MATLAB programming, and we analyse the influence of the ratio of center width to side length of the butterfly-shaped liquid crystal switch unit (Butterfly parameter β) to the transverse optical field distribution. The simulation results show that the uniformity of transverse diffraction field energy firstly increases and then decreases with the reduction of β ,thus there exists a β value that maximizes the uniformity of energy.

Key words: flat-topped light beam; butterfly LCD module; cylindrical lens; autostereoscopic 3d display; diffraction theory

CIOP-2017-1133

Analysis on Structured Light Reconstruction Method and Characteristics through Scattering Media

Chen Jia
Tianjin University of Technology, China

The structured light experiences multiple scattering when passing through biological tissue, dust and other strong scattering medium. The original phase and direction of propagation are changed, and coherence is destroyed, too. Finally, speckle is formed. In this paper, the characteristics and applicability of the reconstruction of structured light are analyzed. Stripe structured light is used to pass through scattering medium as the incident light. Direct inverse method, phase conjugation method and TVAL3 method are adopted to restructure the incident light. The reconstruction results of three methods are analyzed under different measurement noise levels. Simulation results show that: the reconstruction result of direct inverse method is superior to the others when the measurement noise level is 0. And the reconstruction result of TVAL3 method is more perfect when measurement noise exists and under level 0.025 I. However, the reconstruction result of phase conjugation method is poor all through. Meanwhile, the reconstruction of single point and three points light source are realized by the three methods in this paper.

Key words: scattering medium; structured light reconstruction; TVAL3; measurement noise

CIOP-2017-2239

RF Up-Conversion Using a Fiber Frequency-Shifting Amplifier Loop

Haiyang Zhang, Hongzhi Yang, Changming Zhao, Suhui Yang, Chen Li
Beijing Institute of Technology

Lidar-radar is a powerful technique for applications involving remote sensing. The method is based on the use of an optically carried RF signal in order to benefit from both the directivity of the optical beam (lidar), and the accuracy of RF signal processing (radar) . Compared with single-optical-frequency lidars, coherent RF-modulated lidar-radars are insensitive to atmospheric turbulence and can overcome the speckle noise induced by target's roughness. Here we aim at extending the technique developed previously with a free-space pulsed laser to an efficient fully fibered ring interferometer seeded by a single-frequency laser.This paper presents experimental and simulated studies on the fiber frequency shifted feedback laser. By selecting the magnification parameter of the amplifier, we obtained highest modulation frequency from 2.4 GHz to 4.2 GHz (by steps of 200 MHz). Experiments are conducted with 1 μm fiber-optic components. Using a 200 MHz acousto-optic frequency-shifter, we find a 19-fold up-conversion up to 3.8 GHz with a typical gain of about 3. The changes of waveform were observed by changing the loop length. A good agreement between experimental and theoretical results is obtained.

Key words: lidar-radar; single-frequency laser; radio frequency modulation; fiber amplifier; FSF laser

CIOP-2017-2056

Measurement of Extinction Coefficient of Near - surface Aerosol by CCD Lidar in the Daytime

Peiyu Sun[1], Kee Yuan[2], Jie Yang[3]
[1] *University of Chinese Academy of Sciences, China;*
[2] *Anhui Institute of Optics and Fine Mechanics, China;*
[3] *University of Science and Technology of China, China*

The aerosols near the ground are closely related to human health and climate change, the study on which has important significance. Atmospheric aerosol extinction coefficient vertical profiles of near-surface in Hefei western suburb were measured by a CCD lidar system in the day and night, which could fill the gap of the traditional Mie-scattering lidar system especially in the blind area and overlapped region. By comparison of the aerosol extinction coefficient retrieved by Mie-scattering aerosol lidar and CCD lidar at night, the reliability of the CCD lidar system was verified, and the daytime detection of the CCD lidar system was feasible. Profiles of atmospheric aerosol extinction coefficient for 10-180m altitude were obtained with high spatial resolution, of which the highest resolution was up to 1cm. Two cases of aerosol extinction coefficient profiles showed that the aerosol extinction coefficient was not monotone decreasing in vertical direction, at the same time, changed violently in the day. The spatio-temporal evolution of aerosol extinction coefficient retrieved by CCD lidar showed that the overall aerosol had a tendency to reduce as the day getting dark. The daytime detection of aerosol extinction coefficient profile by using CCD lidar is credible and fulfilled.

Key words: atmospheric optics; CCD lidar; aerosol extinction coefficient vertical profile; near surface; in the daytime

Session 8: Micro-Nano Photonics and Metamaterials

Chairs: **Limin Tong,** Zhejiang University, China
Tiejun Cui, Southeast University, China
Ya Cheng, East China Normal University, China & Shanghai Institute of Optics and Fine Mechanics, CAS, China

Location: B510, 5F, Main Building, Harbin Institute of Technology No.2 Campus

18th July

13:40-13:55	**Progress and Application of Angle Resolved Spectroscopy (ARS) in Nano-Photonics (Oral-Industry)** Hyway Yin *Shanghai Ideaoptics Corp., Ltd.*	
Chair: Ya Cheng, East China Normal University, China & Shanghai Institute of Optics and Fine Mechanics, CAS, China		
14:00-14:30	**Two Challenges in Semiconductor Nanolasers (Invited)** Cunzheng Ning *Tsinghua University, China & Arizona State University, USA*	- 140 -
14:30-15:00	**Fano Resonance Rabi Splitting of Surface Plasmons in 3D Metallic Microstructures (Invited)** Zhiyuan Li *South China University of Technology, China*	- 141 -
15:00-15:30	**Organic Printed Microlaser Arrays (Invited)** Yongsheng Zhao *Institute of Chemistry, CAS, China*	- 142 -
15:30-15:45	**3D Active Metamaterial Perfect Absorber Based on Phase-Change Material (Oral)** Ximin Tian[1], Zhiyuan Li[2] *[1] Institute of Physics, CAS, China; [2] South China University of Technology, China*	- 155 -
15:45-16:00	**Coffee Break**	
Chair: Cunzheng Ning, Tsinghua University, China & Arizona State University, USA		
16:00-16:30	**Lithium Niobate Thin Film Nanophotonics Integration (Invited)** Ya Cheng *East China Normal University, China & Shanghai Institute of Optics and Fine Mechanics, CAS, China*	- 143 -
16:30-17:00	**Manipulation of Optical Fields by Plasmonic Metasurfaces (Invited)** Shuqi Chen *Nankai University, China*	- 144 -
17:00-17:30	**Optical Super Resolution Imaging and SERS Detection of Exosomes (Invited)** Shenfei Zong, Yiping Cui *Southeast University, China*	- 145 -
17:30-17:45	**Ultrafast Dynamics of Femtosecond Laser Interaction with Noble Metal Films and Nanostructures (Oral)** Guangqing Du, Feng Chen, Qing Yang *Xi'an Jiaotong University, China*	- 155 -
17:45-18:00	**Manipulating Polarization and Light Propagation Based on Metamaterials (Oral)** Jinhui Shi *Harbin Engineering University , China*	- 156 -
18:00-19:00	**Dinner Time**	

19th July

Chair: Limin Tong, Zhejiang University, China		
09:00-09:30	**Plasmonic Metasurface for Photonics Applications in Demand (Invited)** Din Ping Tsai *Research Center for Applied Sciences, Academia Sinica*	- 146 -
09:30-10:00	**High-Capacity Metasurfaces: Hologram, Security Print, and Beyond (Invited)** Chengwei Qiu *National University of Singapore, Singapore*	- 147 -
10:00-10:30	**Digital Convolutions on Coding Metasurfaces to Rreach Extreme Controls to Electromagnetic Waves (Invited)** Tiejun Cui *Southeast University, China*	- 148 -
10:30-10:45	**The Optical Leaky-Wave Antenna with Two-Dimensional Symmetric Tapered Ellipsoidal Holes Array (Oral)** Dongzhou Zhong, Chengpeng Liu *Wuyi university, China*	- 156 -

19th July

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11:30-12:00	**New Progress in Metasurfaces: Tunability and Efficiency (Invited)** Lei Zhou *Fudan University, China*	- 150 -
12:00-12:15	**Enhanced Electric Tuning of Raman Scattering in Monolayer Graphene by Gold Nanorods (Oral)** Weiguang Liu, Bin Hu, Juan Liu, Yongtian Wang *Beijing Institute of Technology, China*	- 156 -
12:15-14:00	**Lunch Time**	
Chair: Lei Zhou, Fudan University, China		
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14:30-15:00	**Plasmonic Subwavelength Systems Toward Terahertz Photonic Devices (Invited)** Weili Zhang *Tianjin University, China*	- 152 -
15:00-15:30	**Plasmonic Spin-Hall Effects and Topological Interface States (Invited)** Hui Liu *Nanjing University, China*	- 153 -
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Cunzheng Ning
Tsinghua University, China and Arizona State University, USA

Two Challenges in Semiconductor Nanolasers

ABSTRACT

In this talk, I will discuss two important challenges related to semiconductor lasers and nanolasers. The first one is related to the applications of semiconductor lasers in optical interconnects for future computer chips and the second is related to the multi-color lasers for possible applications in displays, illumination and lighting. My talk will highlight the application background, challenging issues to be resolved, what nanophotonics can offer in terms of possible solutions, and the progress made over the last 10 years. The specific topics will include metal-cavity or plasmonic nanolasers and semiconductor alloy nanowire lasers with multi-color and white output.

BIOGRAPHY

Cun-Zheng Ning received his PhD in physics from the University of Stuttgart, Germany. He has published over 180 papers on laser physics, nanophotonics and nanolasers. He has also given over 180 invited, plenary, or colloquium talks worldwide. He was a senior scientist, nanophotonics group leader, and nanotechnology task manager at NASA Ames Research Centre (1997-2007), ISSP Visiting Professor at University of Tokyo in 2006, Visiting Professor at Technical University of Berlin and Tsinghua University in 2013. Since 2006, he has been professor of electrical engineering and affiliate professor in physics and materials science and engineering at Arizona State University. He is a “Thousand Talen Program” Professor at Tsinghua University since 2014. He was a winner of several awards including NASA and NASA Contractor Awards, NASA Space Act Patent Awards, CSC Technical Excellence Award, and IEEE/Photonics Society Distinguished Lecturer Award (2007-2009). Dr. Ning is a Fellow of the Optical Society (OSA), IEEE, and the Electromagnetic Academy. His many achievements have been widely reported in new media and tech magazines such as Science and Nature Photonics. The first white laser demonstration by his group has won “The Best of Tech in 2015” as the “Top 10 Engineering Achievements” by Popular Science magazine.

Note

Fano Resonance Rabi Splitting of Surface Plasmons in 3D Metallic Microstructures

Zhiyuan Li
South China University of Technology, China

Note

ABSTRACT

Rabi splitting and Fano resonance are well-known physical phenomena in conventional quantum systems as atoms and quantum dots, arising from strong interaction between two quantum states. In recent years similar features have been observed in various nanophotonic and nanoplasmonic systems. Yet, realization of strong interaction between two or more Fano resonance states has not been accomplished either in quantum or in optical systems. Here we report the observation of Rabi splitting of two strongly coupled surface plasmon Fano resonance states in a three-dimensional (3D) plasmonic nanostructure consisting of vertical asymmetric split-ring resonators (aSRRs). The plasmonic system stably supports triple Fano resonance states and double Rabi splittings can occur between lower and upper pairs of the Fano resonance states. The experimental discovery agrees excellently with rigorous numerical simulations, and is well explained by an analytical three-oscillator model. The discovery of Fano resonance Rabi splitting could provide a stimulating insight to explore new fundamental physics in analogous atomic systems and could be used to significantly enhance light-matter interaction for optical sensing and detecting applications.

BIOGRAPHY

Zhiyuan Li is a professor in College of Physics and Optoelectronics, South China University of Technology. Before this he worked in Institute of Physics, CAS as a principal investigator. Prof. Li's research interests include theory, experiment, and application of photonic crystals, nonlinear and ultrafast optics, plasmonics, optical tweezers, quantum optics, and quantum physics. He is the author or coauthor of more than 380 peer-reviewed papers in physics, optics, chemistry, and materials science journals. These papers have been cited by about 17,000 times. He serves as a Co-Editor of *EPL* and the editorial board member of *Acta Optica Sinica*, and *Advanced Optical Materials*. He has presented over 100 invited talks in international and domestic conferences.

Organic Printed Microlaser Arrays

Yongsheng Zhao
Institute of Chemistry, Chinese Academy of Sciences, China

ABSTRACT

Exploring a universal technique for the manufacture of reproducible organic material geometries in large quantities, just as photo-lithography is to the traditional silicon-based electronics and photonics, is essential for the upcoming flexible integrated photonics. We developed a solution of printing strategy for the function-directed controllable and rapid fabrication of high-quality organic microlaser arrays, which was subsequently applied as the building blocks of the panels of organic laser displays and as the elements in photonic integrated circuits. The printed soft photonic systems showed competitive performances with their nowadays silicon based counterparts. Moreover, they even have the advantages of mild processing, flexible doping, active/responsive characteristics, etc.

BIOGRAPHY

Yong Sheng Zhao received his Ph.D. degree in 2006 from Institute of Chemistry, Chinese Academy of Sciences (ICCAS). After that, he joined the University of California at Los Angeles (UCLA) and Northwestern University as a postdoctoral fellow. In 2009, he returned to ICCAS as a Professor of Chemistry. His research interest is focused on organic nanophotonic materials and devices, including the controllable fabrication of low-dimensional organic materials, organic nano- and micro-scale lasers, as well as the construction of photonic integrated devices.

Note

Lithium Niobate Thin Film Nanophotonics Integration

Ya Cheng
East China Normal University, China&Shanghai Institute of Optics and Fine Mechanics, CAS, China

Note

ABSTRACT

The recent advances in fabricating a variety of high quality nanophotonic structures on lithium niobate thin films open an avenue for applications ranging from high-efficiency nonlinear optics to tunable classical/quantum photonic circuits. We review the current status of the field and report on the results achieved by us in the past several years.

BIOGRAPHY

Ya Cheng is a researcher of Shanghai Institute of Optics and Fine Mechanics and a professor of School of Physics and Materials Science, East China Normal University. His current research focuses on ultrafast nonlinear optics and femtosecond laser materials processing.

Shuqi Chen
Nankai University, China

Manipulation of Optical Fields by Plasmonic Metasurfaces

ABSTRACT

With bulky size and high thermal dissipation, traditional optical materials and devices no longer meet the needs of the burgeoning development of information optics and nanophotonics. To achieve tailorable functional micro−optical devices, the most challenging procedure is to manipulate light with multi−degree−of−freedom in sub−wavelength scale. With elaborate design of artificial nanostructures, we realized full control of light both in near and far field. Consequently, amplitude, phase and polarization of light have been effectively manipulated. To improve the efficiency of the nanostructures, we took advantage of near field coupling and interference of nanostructure, and proposed few−layer artificial nanostructures to enhance the interaction between light and matters. This designing methodology provides a wide platform for further development and applications with artificial nanostructures in modern optics.

BIOGRAPHY

Dr. Shuqi Chen was selected as the new century excellent talents in University in 2013 and the hundred youth academic leader at Nankai University in 2014, respectively. His research interests are in the fields of multidimensional tuning optical field by artificial microstructure and their applications, and the nonlinear optical characteristics. Dr. Chen has published over 60 research papers in the famous international journals including *Light: Sci. & Appl.*, *Adv. Mater.*, *Adv. Funct. Mater.*, *Phys. Rev. Appl.*, *Sci. Rep.*, *Adv. Opt. Mater.*, *Appl. Phys. Lett.*, and *Opt. Lett*. He has also published a chapter for the book of Metamaterials-Devices and Advanced Applications. He is currently carrying on several funds, such as the National Key Research and Development Program of China, the National Basic Research Program (973 Program) of China, the Chinese National Key Basic Research Special Fund, and the Natural Science Foundation of China.

Note

Yiping Cui
Southeast University, China

Note

Optical Super Resolution Imaging and SERS Detection of Exosomes

Speaker: Shengfei Zong

ABSTRACT

Exosome is one kind of the extracellular vesicles secreted by cells. It also plays a vital role in intercellular communication and substance exchange. For tumor cell derived exosomes, they are deeply involved in modulation of tumor microenvironment and metastatic niche formation. This makes tumor derived exosomes an important cancer biomarker. Thus analyzing of tumor derived exosomes can give important insight into the pathological stages of cancerous diseases.

In this talk, we will present our most recent work on imaging and detection of exosomes and exosomal microRNAs using optical super resolution imaging and SERS techniques. The relatively small size of exosomes makes them hard to visualize with common optical microscopies. Hence, we utilized single molecule localization microscopy (SMLM) to image them. Besides, sensitive and multiplex detection of exosomes was also realized using SERS

BIOGRAPHY

Yiping Cui received his B.S., M.S. and Ph. D. degree from Department of Electronic Engineering, Southeast University, China in 1982, 1984 and 1994 respectively. Since 1993, he has been a professor in Department of Electronics (Now School of Electronic Science and Engineering), Southeast University, China. From 1995-1996, he was a visiting professor in the State University of New York at Buffalo. He established the Advanced Photonics Center in Southeast University and has been engaged in research on Polymeric Nonlinear Optics, Nanophotonic materials, and Biophotonics. He has published over 500 papers on key journals and co-authored two book chapters in monographs: “Optics of intense light and its applications” and “Physics of Nonlinear Optics” (English Version) and a graduate student textbook “Laser Physics”.

For his pioneering contributions to the understanding of nonlinear and luminescent properties of polymeric, organic and nanophotonic materials, Dr. Cui was elected as a Fellow of the Optical Society of America. He is Vice President of 27th CIE (Commission International de L’Eclairage, International Commission on Illumination). He is also a Cheung Kong Professor and the winner of China National Funds for Distinguished Young Scientist in China.

Din Ping Tsai
Research Center for Applied Sciences, Academia Sinica

Note

Plasmonic Metasurface for Photonics Applications in Demand

ABSTRACT

The functionalities of traditional optical component are mainly based on the phase accumulation through the propagation length, leading to a bulky optical component like lens and waveplate. Plasmonic metasurfaces composed of two-dimensional (2D) artificial structures have attracted a huge number of interests due to their ability on controlling the optical properties including electromagnetic phase as well as amplitude at a subwavelength scale. They therefore pave a promising way for the development of flat optical devices and integrated optoelectronic systems. In this talk, several research topics for photonic applications based on metasurfaces will be presented and discussed: high efficiency anomalous beam deflection, highly dimensional holographic imaging, versatile polarization generation and analysis, multi-functional and tunable metadevices and engineering non-radiating anapole mode for the generation of toroidal dipole moment in free space.

BIOGRAPHY

Din Ping Tsai received his Ph.D from University of Cincinnati, USA in 1990. He is a Fellow of AAAS, APS, IEEE, OSA, SPIE, Electro Magnetics Academy (EMA) and The Physical Society of Taiwan. He is also Academician of Asia Pacific Academy of Materials (APAM), and Corresponding Member of International Academy of Engineering (IAE). He currently serves as Editor of *Progress in Quantum Electronics*, Associate Editor of *Journal of Lightwave Technology*, Member of Editorial boards of *ACS photonics*, *Physical Review Applied*, *Optics Communications*, *Plasmonics and Optoelectronics Letters*, respectively. He is now the President of Taiwan Information Storage Association (TISA), Member of IEEE I&M Fellow Committee. He was the Director of the Board of SPIE; Member of OSA Fellows & Honorary Committee; SPIE Fellow Committee; IEEE Joseph F. Keithley Award Committee; OSA and IS&T Edwin H. Land Medal Committee; respectively. He was President of Taiwan Photonics Society (TPS); Chairman of IEEE Instrument and Measurement Society Taipei Chapter; and Chairman of the SPIE Taiwan chapter.

High-Capacity Metasurfaces: Hologram, Security Print, and Beyond

Chengwei Qiu
National University of Singapore, Singapore

Note

ABSTRACT

I will report some of the most recent developments in my group as well as in the field of the interfacial engineering of manipulation of light-matter interactions, via the artificially constructed structures of ultrathin thickness compared to the wavelength. In particular, the low-dimension and high-frequency scaling may promise more interesting applications, while the challenges in designing principle and fabrication capability will become critical limits. Nano-patterned surfaces to modulate and structure novel light behavior have been studied and the following advanced functionalities will be discussed: 3D meta-hologram, high-pixelated nanopriting, dynamic OAM generation, and more interestingly, the 2D-material meta-lens of <1nm thickness, etc. Our work paves a roadmap to design sophisticated and advanced optical devices, with low dimension, miniaturization, randomness, and scaled-up capability.

BIOGRAPHY

Prof. Cheng-Wei Qiu received his B.Eng. and Ph. D. degree in 2003 and 2007, respectively. He was a Postdoctoral Fellow at Physics Department in MIT till the end of 2009. Since December 2009, he joined NUS as an Assistant Professor and was promoted to Associate Professor with tenure in Jan 2017. He was the recipient of the SUMMA Graduate Fellowship in Advanced Electromagnetics in 2005, IEEE AP-S Graduate Research Award in 2006, URSI Young Scientist Award in 2008, NUS Young Investigator Award in 2011, MIT TR35@Singapore Award in 2012, Young Scientist Award by Singapore National Academy of Science in 2013, and Faculty Young Research Award in NUS 2013. He has managed over 10 million grants as Lead PI, and 6 million grant as co-PI. His research interests are in the areas of electromagnetic wave theory of metasurface, light-matter interaction, and nanophotonics. He has published over 160 peer-reviewed journal papers, including 1 *Nature Photonics*, 8 *Nature Communications*, 10 *Advanced Materials*, 4 *PRL*, 3 *LSA*, 4 *Nano Lett./ACS Nano*, etc. He has given quite a few keynotes in international conferences. He has been serving in Associate Editor for various journals such as *EPJ*, *Scientific Reports*, and Topical Editor for *JOSA B*, Guest Editor for *ACS Photonics*, and General Chairs and TPC Chairs in various conferences.

Tiejun Cui
Southeast University, China

Digital Convolutions on Coding Metasurfaces to Reach Extreme Controls to Electromagnetic Waves

ABSTRACT

I will introduce the convolution theorem to digital coding metasurfaces and propose a principle of scattering-pattern shift, which realizes arbitrary rotations of scattering patterns with little distortion. By performing the digital convolution operation, the single-beam scattering is able to scan in the entire upper-half space with high resolution. The proposed method also helps form the multiple ring-shaped radiation patterns and generate helicity-controlled multi-beams, including vortex beams carrying orbital angular momentum. More interestingly, I will present a controllable random surface by simply adding a random coding sequence to gradient coding sequences, which can control the probability of "scattering cloud" appearing in the desired range of angles. All the concepts and designs are numerically demonstrated and experimentally verified with fabricated samples, indicating the excellent performance of coding metasurfaces for controlling electromagnetic waves.

BIOGRAPHY

Tie Jun Cui received the Ph.D. degree in Xidian University, Xi'an, China, in 1993. He is now a full professor with the Department of Radio Engineering, Southeast University, Nanjing, China. Dr. Cui is the first author of the books Metamaterials – Theory, Design, and Applications (Springer, Nov. 2009) and Metamaterials: Beyond Crystals, Noncrystals, and Quasicrystals (CRC Press, Mar. 2016). He has published over 400 peer-review journal papers in *Science*, *PNAS*, *Nature Journals*, *Physical Review Letters*, *Advanced Materials*, *IEEE Transactions*, etc., which have been cited by more than 15200 times. Based on ELSEVIER, he is one of the Most Cited Chinese Researchers. Dr. Cui received the First Prize of Natural Science from Ministry of Education, China, in 2011, and the Second Prize of National Natural Science, China, in 2014. His researches have been selected as one of the "10 Breakthroughs of China Science in 2010", "Best of 2010" in New Journal of Physics, and "Optics in 2016", and has been reported by Nature News, Science, MIT Technology Review, Scientific American, New Scientists, etc. Dr. Cui is an IEEE Fellow.

Note

Electrically Tunable Metasurfaces

Houtong Chen
Los Alamos National Laboratory, USA

ABSTRACT

Metasurfaces have enabled unprecedented control of electromagnetic waves in propagation, amplitude, phase, and polarization states. Integration of functional materials to accomplish active functionalities will greatly expand the application scope of metasurfaces. Here we show the electrically tunable terahertz metasurfaces by integrating semiconductor Schottky junctions and mid-infrared metasurface absorbers by integrating graphene. The resonance response in these metasurfaces can be actively tuned simply through varying the applied voltage bias.

Note

BIOGRAPHY

Hou-Tong Chen received his BS and MS degrees from University of Science and Technology of China in 1997 and 2000, and a Ph.D. degree from Rensselaer Polytechnic Institute in 2004, all in physics. He is currently a Technical Staff Member in the Center for Integrated Nanotechnologies, Los Alamos National Laboratory. His research interests include metamaterials and metasurfaces, terahertz science and technology, ultrafast nanophotonics, and near-field microscopy. He has published over 70 journal papers, which together received citations over 7700 times. He has delivered nearly one hundred invited technical presentations in conferences and accredited research institutions. He was elected a Fellow of American Physical Society (2015), won LANL Fellows' Prize for outstanding research (2015), is a Topical Editor of *Optics Letters* (since 2017), and the conference chair of the 8th Optical Terahertz Science and Technology (OTST) to be held at Santa Fe, USA (2019).

Lei Zhou
Fudan University, China

New Progress In Metasurfaces: Tunability and Efficiency

ABSTRACT

Metasurfaces, ultrathin metamaterials composed by array of planar "meta-atoms" with pre-designed electromagnetic (EM) properties, have attracted extensive attention recently. However, so far most realized metasurfaces are passive and their working efficiencies are not high. In this talk, I will summarize our recent efforts in this field, emphasizing mainly on the tunability and efficiency issues of them. In particular, I will show how to make tunable metasurfaces to actively control EM waves, in both THz and GHz frequency domains, and how to make ultrathin pancharatnam-berry metasurfaces with nearly 100% efficiencies, in both reflection and transmission geometries.

BIOGRAPHY

Zhou, Lei received his PhD in Physics from Fudan University, Shanghai, China, in 1997. He then went to Institute for Material Research in Tohoku University (Sendai, Japan) for postdoctoral research. During 2000 - 2004, he was a visiting scholar in Physics Department of the Hong Kong University of Science and Technology. He joined Physics Department of Fudan University in 2004 as a professor, and became a "Xi-De" Chair Professor since 2013. Starting from 1993, Professor Lei Zhou has been working in the fields of magnetism, meta-materials, photonic crystals and plasmonics, and he has published over 140 papers in scientific journals including *Nature Materials*, *Phys. Rev. X*, *Phys. Rev. Lett.*, *Nano Lett*, *Light: Science & Applications*. He is the co-author of a monograph (Springer) and 3 book chapters. He successfully held several international conferences as general chair, severed as program committee members or session chairs in many top international conferences, and was invited to give invited/keynote talks in many top international conferences. Professor Lei Zhou got many awards, including the NSFC "Grant for Outstanding Young Scientist" (2007), the "Chang Jiang Scholars Program" Chair Professorship (2009), the "OSA Young Scientist Award" (2016) and the "APS Outstanding Referee" (2017).

Note

On-Chip Integrated Nanofiber and Nanowire Photonic Devices

Limin Tong
Zhejiang University, China

Note

ABSTRACT

Free-standing optical nanowires or nanofibers surpass nanowaveguides fabricated by almost all other means in terms of sidewall smoothness and diameter uniformity, conveying their low waveguiding losses.With high index contrast between the core and the surrounding, a nanowire can guide light with tight optical confinement, high fractional evanescent waves and small effective mode area simultaneously, which enable highly localized and efficient near-field interaction between the guided fields and the surrounding media.

In this talk, we show the possibility of on-chip integration of free-standing optical nanofibers and nanowires for functional photonic devices. Firstly, by embedding nanofibers with microfluidic chips, we show ultrasensitive optical sensors for physical and bio-chemical detection. Secondly, by near-field coupling of free-standing nanowires/nanofibers with silicon-on-insulator (SOI) waveguides, we show hybrid photonic circuits for optical modulation and light generation on silicon chips.

BIOGRAPHY

Limin Tong is a professor with College of Optical Science and Engineering, Zhejiang University, China. His research interests are in nanophotonics and fiber optics.

Weili Zhang
Tianjin University, China

Plasmonic Subwavelength Systems Toward Terahertz Photonic Devices

ABSTRACT

At terahertz frequencies, the lack of functional devices has been a bottle neck and constrains the fast development of terahertz technology and applications. Recent breakthroughs in subwavelength plasmonics and metamaterials enabled the launch of a fascinating new field, subwavelength photonics. Composite materials comprised of subwavelength-sized metallic resonators arranged in a periodic array may be designed to interact with the electric or magnetic field, or both, of a propagating or surface wave in ways not observed in natural materials. Numerous exciting phenomena including anomolous light transmission, negative index of refraction, invisibility cloaking, and giant optical activities have been observed, paving the way towards developing integrated functionable devices, components, and systems. Using the state-of-the-art terahertz spectroscopy and semiconductor fabrication technology, we studied plasmonic geometries resonating at terahertz frequencies with an ultimate goal of developing next-generation integrated terahertz photonic devices.

BIOGRAPHY

Weili Zhang received the B.S. degree in laser science, and the M.S. and Ph.D. degrees in optical engineering from Tianjin University (TJU), China, in 1987, 1990, and 1993, respectively. In 1993, he joined the Department of Physics, the Hong Kong University of Science and Technology as a Postdoctoral Research Associate. Since 1995, Dr. Zhang has been on the faculty of TJU and/or Oklahoma State University (OSU). Currently, he is professor of Electrical Engineering at OSU and Changjiang distinguished professor of Optoelectronics, Director of the Center for Optics, and Director of the Center for Terahertz Waves at TJU. His research interests include terahertz optoelectronics, nano- and micro-structured materials optics, and ultrafast phenomena. Dr. Zhang has published over 270 invited or contributed articles in peer-reviewed journals and presented over 140 plenary, keynote, invited, and contributed talks at international conferences and institutional colloquia. He is currently the Primary Guest Editor of *IEEE Journal of Selected Topics in Quantum Electronics* featured issue on terahertz photonics, Editorial Board member of *Scientific Reports*, and Associate Editor or Topical Editor for a number of other journals. Dr. Zhang is a Fellow of The Optical Society (OSA).

Note

Plasmonic Spin-Hall Effects and Topological Interface States

Hui Liu
Nanjing University, China

Note

ABSTRACT

In this talk, we demonstrate coherent and independent control of SPP orbitals for the two opposite spins using multiple rings of nano-slots with properly designed orientations on a metasurface. This scheme provides us to achieve arbitrary optical spin-Hall effect. This is a form of spin-enabled coherent control and provides a unique way in achieving tunable orbital motions in plasmonics. On the other hand, we report that the existence of these interface states is protected by the topological properties of the Weyl points and the trajectories of these states in the parameter space resembles those of Weyl semimetal “Fermi arcs surface states” in momentum space. Tracing the origin of interface states to the topological character of the parameter space paves the way for a rational design of strongly localized states with enhanced local field.

BIOGRAPHY

Hui Liu, Professor at Nanjing University, Associate director of National Key Laboratory of Solid State Microstructures. National Science Fundation for Outstanding Young Talents of China, 2014. Hui Liu received his Ph.D. in 2003 from Department of Physics, Nanjing University in China. In 2004-2005 he did postdoctoral research at University of California at Berkeley. His research interests cover plasmonics, metamaterials, and photonic crystals. His achievements include photonic black hole, plasmonic stereo-metamaterial, magnetic plasmon waveguide and coherent plasmonic spin hall effect. He has published over 60 SCI papers, including *Nature Photonics*, *Nature Communications*, and *Phys. Rev. Letts*. He has taken charge of several national projects, including “863” key projects and NSFC projects. He also worked as the referee for *Optic Express*, *JOSAB*.

Yu Luo
Nanyang Technological University, Singapore

Note

High Harmonic Generation In Nonlinear Chiral Metamaterials

ABSTRACT

Backward harmonic generation, in which the coherent harmonic wave propagates along a direction opposite to that of the incoming fundamental wave, promises important applications in optical communication and quantum information processing. Generally speaking, backward nonlinear propagation requires negative index materials as the host, and hence, previous experimental demonstrations of this phenomenon are normally limited to linear polarizations and the high harmonic generation cannot be actively switched from forward to backward direction. In this talk, I shall discuss how judiciously designed nonlinear chiral metamaterials can simultaneously fulfill the forward and backward phase matching conditions for circular polarizations. Our experimental measurements show that, by simply changing the polarization state of the fundamental wave, the propagation of harmonic signals can be switched from forward to backward direction, or even to forward and backward directions, simultaneously. Our study not only provides a feasible way to actively control the high-harmonic generation, but also benefits the understanding of nonlinear interaction in chiral materials.

BIOGRAPHY

Yu Luo received the B.E. degree in Electronic & Information Engineering from Zhejiang University, China, in 2006, and Ph.D. in physics from Imperial College London, UK, in 2012. He then remained in Imperial College London as a research associate after graduation. In 2015, he joined the School of Electrical and Electronic Engineering, Nanyang Technological University, as an assistant professor. Luo's research interests focus on metamaterials and plasmonics ranging from the design of invisibility cloaks and plasmonic light- harvesting devices to the study of nonlocal and quantum phenomena in mesoscopic plasmonic systems. He has published more than 60 international refereed journal papers which have received over 2,000 citations.

CIOP-2017-1930

3D Active Metamaterial Perfect Absorber Based on Phase-Change Material

Ximin Tian[1], Zhiyuan Li[2]
1 Institute of Physics, Chinese Academy of Sciences;
2 School of Physics and Optoelectronics, South China University of Technology

Plasmonic absorbers have attracted tremendous interest in recent years due to their capacity of confining energy within nanoscale volume and strongly enhance light–matter interaction. Yet, multiband or broadband plasmonic absorbers inevitably become increasingly complex in fabrication. Moreover, once the geometry, material, and substrate of a plasmonic absorber are chosen, its resonance response is determined, and this is unsuitable for building active devices. Phase-change materials (PCMs), such as $Ge_2Sb_2Te_5$ with large real and imaginary parts of refractive index or VO_2 with large contrast of refractive index between different states, can support unique opportunities for ultra-broadband perfect absorber or reversible tunable/switchable surface plasmons by incorporating with metallic nanostructures. Furthermore, PCMs exhibit reversible phase transitions at relatively low critical temperatures, low pump powers and ultrafast rates. Here we firstly report a novel ultra-broadband polarization-independent metamaterial perfect absorber in the visible and near-infrared region involving the phase-change material $Ge_2Sb_2Te_5$ (Figure 1). The novel perfect absorber scheme consists of an array of strong-absorbance $Ge_2Sb_2Te_5$ square resonators separated from a continuous Au substrate by a low-index lossless dielectric layer (silica) and a high-index $Ge_2Sb_2Te_5$ planar cavity. Three absorption peaks with the maximal absorbance up to 99.94% are achieved, owing to the excitation of plasmon-like dipolar or quadrupole resonances and cavity resonances. Besides that, we proposed another heterostructure incorporating the plasmonic resonance of Au nanoantennas with VO_2 to achieve all-optical manipulation of switchable absorption effect (Figure 2). The proposed device shows a large switching contrast (from ~99.9% to ~10% in absorption efficiency) at the mid-infrared wavelength of 3609 nm. Interestingly, the resonance of the proposed device can be continuously tuned by varying the side length of the antennas or governing the metallization level of VO_2 layer. Heat transfer models show that the resonant-mediated local heating effects of the two proposed designs occur on sub-nanosecond time scale at quite low incident intensity. Therefore, the hybrid strategies of plasmonic absorbers based on PCMs provide conceptual frameworks of ultra-broadband metamaterial perfect absorbers and active plasmonics.

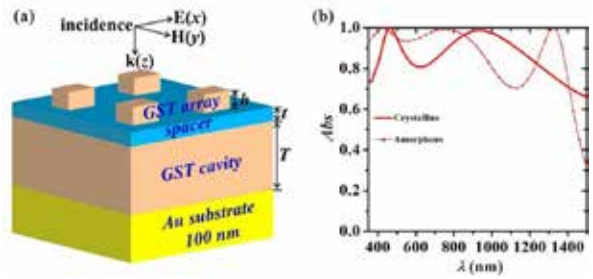

Fig. 1 3D schematic diagram of the proposed metamaterial perfect absorber and its absorption spectra with amorphous and crystalline states of $Ge_2Sb_2Te_5$.

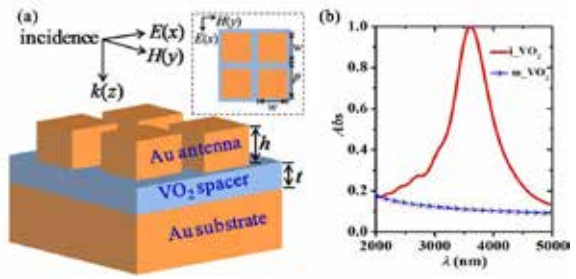

Fig. 2 Schematic of the switchable hybrid absorber device and its absorption spectra with insulator (i_VO_2) and metallic (m_VO_2) states of VO_2.

Key words: metamaterial; phase-change materials; active plasmonics

CIOP-2017-0539

Ultrafast Dynamics of Femtosecond Laser Interaction with Noble Metal Films and Nanostructures

Guangqing Du, Feng Chen, Qing Yang
Xi'an Jiaotong University

Noble metal films and nanostructures with well-defined electronic and magnetic properties have potential applications in a wide range of fields such as electronic devices, near-field optics and magnetic elements. Generally, the electronic properties of noble metals can be modified by external excitations of electron and light beams, resulting in novel optical and thermal properties for potential applications. In this study, we theoretically investigated the ultrafast dynamics of femtosecond laser excitations of noble metal Au films and nanostructures. It is revealed that the temperature field distributions in Au film can be well controlled via temporally shaping femtosecond laser pulses. More interestingly, we find that the localized electric-field produced within the designed nanostructured Au geometry can be well controlled via modifying the Au geometry parameters and femtoseocnd laser fluence. The results exhibit great benefits for both understanding of the basic excitation dynamics of noble metals and promoting practical applications of infrared thermal sensor, high-precision optothermal surgery and near-field optical trapping.

Key words: ultrafast dynamics; femtosecond laser; noble metal; nanostructures

CIOP-2017-0632

Manipulating Polarization and Light Propagation Based on Metamaterials

Jinhui Shi
Harbin Engineering University

The field of metamaterials develop rapidly in recent years. Metamaterials with subwavelength elements can control properties of electromagnetic wave to realize desirable amplitude, phase-shift or polarization conversion in unconventional way that can be unachievable using traditional materials. For instance, chiral metamaterials and metasurfaces, as promising candidates, hold great advantages and flexibilities to manipulate the polarization state. Substantial efforts have been devoted to the exploration of gradient metasurfaces, leading to the demonstration of wave-front shaping, photonic spin Hall effect, optical vortex plate, broadband optical retardation, propagating-to-surface-wave conversion, flat lenses and mirrors, super-oscillatory focusing and optical holograms. I will present experimental results of manipulating polarization properties using chiral metamaterials. We demonstrated that in slabs of linear material of sub-wavelength thickness optical manifestations of birefringence and optical activity can be controlled in the coherent technique. In addition, reflection and refraction effects on phase gradient metasurfaces can be coherently controlled. Such control can be exerted at arbitrarily low intensities, thus arguably allowing for fast handling of electromagnetic signals without facing thermal management and energy challenges.
Key words: metamaterial; metasurface; polarization manipulation

CIOP-2017-0256

The Optical Leaky-Wave Antenna with Two-Dimensional Symmetric Tapered Ellipsoidal Holes Array

Dongzhou Zhong, Chengpeng Liu
Wuyi university, China

Based on the plasma waveguide with four layers structure such as silicon- metal - silicon – silica, we design an optical leaky-wave antenna with two-dimensional symmetric tapered ellipsoidal holes array in metal layer. Also, we explore its physical properties, including the return loss, the insertion loss, the radiation pattern, the half power beam width (HPBW), the directivity and the bandwidth. When the operating wavelength is fixed at 1550 nm, the ultra wideband of more than 80 THz which covers most bands of the optical communication(S+→ L+). With the antenna ports filled in the air and the silicon nitride, respectively, the antenna shows different physical properties. Especially, there are great differences in the return loss, the insertion loss, radiation pattern, HPBW and directivity.
Key words: surface plasmons; leaky-wave antenna; micro-optical devices.

CIOP-2017-1813

Enhanced Electric Tuning of Raman Scattering in Monolayer Graphene by Gold Nanorods

Weiguang Liu[1], Bin Hu[1], Juan Liu[2], Yongtian Wang[2]
[1] School of Optoelectronics, Beijing Institute of Technology; [2] Beijing Institute of Technology

Graphene shows extraordinary properties that can be combined with some metallic micro-nanostructures. We experimentally investigate the electric tuning of Raman scattering in both a monolayer graphene and a graphene with gold nanorods (AuNRs) structure. It is found that when the gate voltage is applied from -30V to 30V, the G and 2D peaks of the graphene structures can be tuned. It is also found that the tuning can be significantly enhanced when AuNRs are deposited on the graphene, including the change of the peak position, width and intensity. In order to study the influence of AuNRs on the electric tuning of Raman scattering in monolayer graphene, we design two structures to measure their Raman scattering spectrum. One is Glass/ITO/SiO_2/Graphene structure, and another is Glass/ITO/SiO2/Graphene/AuNRs structure. We used Renishaw RM2000 laser confocal micro raman spectrometer system to measure the monolayer graphene and the graphene – AuNRs hybrid structure at room temperature, while the gate voltage changed from –30V to 30V through Keithley 4200 semiconductor characterization system. We test Raman scattering spectra and analyze the parameters of G peak and 2D peak by Origin lab. We experimentally demonstrate that Raman scattering peaks can be tuned by electrical field easily in monolayer graphene and graphene - AuNRs hybrid structure. By applying a gate voltage from -30V to 30V on both the Glass/ITO/ SiO_2/Graphene and Glass/ITO/ SiO_2/ Graphene / AuNRs structures, we found that the electric tuning can be enhanced by the AuNRs on graphene. For both the G and 2D peaks, the changes of peak position, peak FWHM, as well as the peak intensity are larger when there are AuNRs. In these structures, SiO_2 is dielectric layer, so its thickness can be more thin for adding gate voltage easily. But if the quality of the dielectric layer is not very good, the small gate voltage can damage to the device. SiO_2 layer also can be replaced by other dielectric material. The simulation also demonstrate that the AuNRs play an enhanced role. Our findings may provide a new way for enhanced tunable Raman scattering of graphene structures.
Key words: raman scattering; graphene; AuNRs

Session 9: Lasers and Nonlinear Optics

Chairs: **Liejia Qian**, Shanghai Jiao Tong University, China
Dingyuan Tang, Nanyang Technological University, Singapore

Location: B507, 5F, Main Building, Harbin Institute of Technology No.2 Campus

18th July

Chair: Dingyuan Tang, Nanyang Technological University, Singapore

14:00-14:45	**Coherent Beam Combination Using SBS-PCM for High Power Laser System (Keynote)** Hong Jin Kong *Korea Advanced Institute of Science and Technology, Korea*	- 160 -
14:45-15:15	**Coherent Polarization Beam Combining of High Power Fiber Lasers (Invited)** Pu Zhou *National University of Defense Technology, China*	- 161 -
15:15-15:30	**High Power Kerr-Lens Mode-Locked Yb-Bulk Oscillators (Oral)** Wenlong Tian[1], Jiangfeng Zhu[1], Yingnan Peng[1], Zhaohua Wang[2], Zhiyi Wei[2] *[1] Xidian University, China; [2] Institute of Physics, CAS, China*	- 176 -
15:30-15:45	**Diode-Pumped Cesium-vapor Laser and Blue-Violet Laser by Frequency Doubling (Oral)** Chen Fei *Changchun Institute of Optics, Fine Mechanics and Physics, China*	- 176 -
15:45-16:00	**Coffee Break**	

Chair: Pu Zhou, National University of Defense Technology, China

16:00-16:30	**Ultrafast Fiber Soliton Lasers (Invited)** Xueming Liu *Zhejiang University, China*	- 162 -
16:30-17:00	**Frequency Noise Characteristics in Single-Frequency Fiber Laser (Invited)** Shanhui Xu *South China University of Technology, China*	- 163 -
17:00-17:30	**Generation and Propagation of Partially Coherent Beams (Invited)** Yangjian Cai *Soochow University, China*	- 164 -
17:30-17:45	**Calculation of Laser Transverse Modes in Stable Cavities using Mode Coupling Matrix (Oral)** Jian Lei, Peifeng Chen, Ying Wang *Huazhong University of Science and Technology, China*	- 176 -
17:45-18:00	**Reconfigurable Dynamic All-Optical Chaotic Logic Operations in an Optically Injected VCSEL (Oral)** Zhongdong Zhou, Xuge Liang, Wei Luo, Xiaozhen Zhen *Wuyi University, China*	- 177 -
18:00-19:00	**Dinner Time**	

19th July

Chair: Xueming Liu, Zhejiang University, China

09:00-09:45	**Dissipative Soliton Lasers and Beyond (Keynote)** Dingyuan Tang *Nanyang Technological University, Singapore*	- 165 -
09:45-10:15	**Binary Pixelated Beam Shapers for Laser Engineering and Wavefront Metrology (Invited)** Christophe Dorrer *Aktiwave LLC, USA*	- 166 -
10:15-10:30	**Process-Oriented Adaptive Optics Control Method in the Multi-pass Amplifiers (Oral)** Qiao Xue *Research Center of Laser Fusion, China*	- 177 -
10:30-10:45	**Cr^{2+}: CdSe Passively Q-Switched Ho: YAG Laser (Oral)** EncaiJi, Qiang Liu, Mingming Nie *Tsinghua University, China*	- 177 -
10:45-11:00	**Coffee Break**	

Chair: Yangjian Cai, Soochow University, China

11:00-11:30	**Ultraclean Femtosecond Vortices Generation from a High-Order Transverse-Mode Femtosecond Mode-Locked Laser (Invited)** Guoqiang Xie *Shanghai Jiao Tong University, China*	- 167 -

19th July

11:30-11:45	**Laser Beam Conditioning Using Spatial Shaping, Temporal and Polarization Smoothing (Oral)** Rui Zhang *Laser Fusion Research Center, China Academy of Engineering Physics, China*	- 177 -
11:45-12:00	**Multi-Target Ranging by Using Chaotic Laser Radar Based on the Complete Chaotic Synchronizations of the Polarization Components in the Drive-Response VCSELs (Oral)** Wei Luo, Zhongdong Zhou *Wuyi university, China*	- 178 -
12:00-12:15	**An Identification Technology for Crude Oil and Lubricant on Simulated Sea Surface (Oral)** Xiaobing Zhang, Changqing Cao *Xidian University, China*	- 178 -
12:15-14:00	**Lunch Time**	
Chair: Hong Jin Kong, Korea Advanced Institute of Science and Technology, Korea		
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14:45-15:15	**Langasite Crystals: From Crystal Growth to Nonlinear Optical Applications (Invited)** Haohai Yu *Shandong University, China*	- 169 -
15:15-15:30	**Output Characteristics of Actively Q-Switched Ho:CYA Laser (Oral)** Huiting Xia[1], Fan Wu[2], Yongguang Zhao[1], Deyuan Shen[1] *[1] Jiangsu Normal University, China; [2] Fudan University, China*	- 178 -
15:30-16:00	**Coffee Break**	
Chair: Xiaoyan Liang, Shanghai Institute of Optics and Fine Mechanics, CAS, China		
15:30-16:00	**Recent Progress on High Power, Mid-IR, Ultra-fast Fiber Lasers (Invited)** Pu Wang *Beijing University of Technology, China*	- 170 -
16:00-16:15	**Graphene Binary/Ternary-Nanocomposites: Synthesis, Characterization and Their Application to Ultrafast Soliton Lasers (Oral)** Bo Guo *Harbin Engineering University, China*	- 178 -
16:15-16:30	**Novel Tm: $CaYAlO_4$ Mode-Locked Laser at 2 μm Water Absorption Band (Oral)** Wei Zhou, Xiaodong Xu, Rui Xu, Xuliang Fan, Yongguang Zhao, Deyuan Shen, Dingyuan Tang *Jiangsu Normal University, China*	- 179 -
16:30-16:45	**Characterization of Chaotic Brillouin Dynamic Grating (Oral)** Zhuping Li, Jianzhong Zhang, Mingjiang Zhang, Yi Liu *Taiyuan University of Technology, China*	- 179 -
16:45-17:00	**Dynamic Characteristics of Packaged Chaotic Semiconductor Laser (Oral)** Yanan Niu, Mingjiang Zhang, Tong Zhao, Jianzhong Zhang, Yi Liu, Anbang Wang, Yuncai Wang *Taiyuan University of Technology, China*	- 179 -
17:00-17:15	**A Short-Cavity integrated Chaotic Semiconductor Laser Packaged by a Butterfly Package (Oral)** Yuhang Xu, Mingjiang Zhang, Tong Zhao, Jianzhong Zhang , Yi Liu , Yuncai Wang , Anbang Wang *Taiyuan University of Technology, China*	- 180 -
17:15-17:30	**Continuous-Wave Brightness Enhancement in an External Cavity Diamond Raman Laser (Oral)** Zhenxu Bai, Robert J.Williams, HadiyaJasbeer, SoumyaSarang, OndrejKitzler, AaronMckay, Richard P.Mildren *Macquarie University, Australia*	- 180 -
15:30-17:30	**Poster**	
18:00-20:00	**Banquet**	

20th July

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09:00-09:30	**Temporal Dual-Pulse Pumped Ti: Sapphire Amplifier for 10 PW SULF Laser (Invited)** Xiaoyan Liang *Shanghai Institute of Optics and Fine Mechanics, CAS, China*	- 171 -
09:30-10:00	**Temporal Contrast Enhancement for LFEX Petawatt Laser (Invited)** Zhaoyang Li *Osaka University, Japan*	- 172 -
10:00-10:15	**Modelling End-Pumped Electro-Optic Q-Switching Lasers with the Influences of Thermal Effects and Spatial Mode Matching (Oral)** Hongli Wang, Yulei Wang, Zhiwei Lü *Harbin Institute of Technology, China*	- 180 -

20th July

10:15-10:30	**An External-Cavity Faraday Laser at Rb 1529 nm Transition (Oral)** Pengyuan Chang, Tiantian Shi, Jingbiao Chen, Shengnan Zhang, HaosenShang, Duo Pan *Peking University, China*	- 181 -
10:30-10:45	**Mode-Locking of Tm:Lu_2O_3 Laser at 1943 nm with GaSb-based SESAM (Oral)** Xinyang Liu, KejianYang, Shengzhi Zhao, Tao Li, Christian Kränkel *Shandong University, China*	- 181 -
10:45-11:00	**Coffee Break**	
Chair: Zhaoyang Li, Osaka University, Japan		
11:00-11:30	**Generation of Ultrashort Dissipative Soliton Pulses in Solid-State Lasers (Invited)** Jie Ma *Nanyang Technological University, Singapore*	- 173 -
11:30-11:45	**RFA-Based 589 nm Guide Star Laser Pulsed at Larmor Frequency (Oral)** Xuezong Yang, Lei Zhang, Yan Feng *Shanghai Institute of Optics and Fine Mechanics, CAS, China*	- 181 -
11:45-12:00	**Generation of Cylindrical Vector Beams in Mode-Locked Fiber Laser Using Mode Selective Coupler (Oral)** Yu Cai, Jie Wang, Jiaojiao Zhang, Hongdan Wan, Zuxing Zhang *Nanjing University of Posts and Telecommunications, China*	- 182 -
12:00-12:15	**Direct Generation of OAM-Tunable Vortex Laser (Oral)** Qiyao Liu[1], Yongguang Zhao[2], Manman Ding[2], Deyuan She[1] *[1] Fudan University, China; [2] Jiangsu Normal University, China*	- 182 -
12:15-14:00	**Lunch Time**	
Chair: Jingui Ma, Shanghai Jiao Tong University, China		
14:00-14:30	**Laser Beam Combination Based on Brillouin Serial Amplification (Invited)** Yulei Wang *Harbin Institute of Technology, China*	- 174 -
14:30-14:45	**The Time Resolved SBS and SRS Research in Heavy Water and Its Application in CARS (Oral)** Baodong Gai[1], Hong Yuan[1], Jinbo Liu[1], Jianfeng Sun[2], Xin Zhou[2], Di Liu[2], Pengyuan Wang[1], Shu Hu[1], Ying Chen[1], Jingwei Guo[1], Yuqi Jin[1], Fengting Sang[1] *[1] Dalian Institute of Chemical Physics, Chinese Academy of Sciences, China;* *[2] National Key Institute of Tunable Laser Technology, Harbin Institute of Technology, China*	- 182 -
14:45-15:00	**A Tunable Long-Cavity Passive Mode-Locked Fiber Laser Based on Nonlinear Amplifier Loop Mirror (Oral)** Junli Chang, Pinghe Wang *University of Electronic Science and Technology of China, China*	- 182 -
15:00-15:15	**A 13.8-W, High-Efficiency, A-Cut Tm, Ho:YAP Laser Pumped by Two Laser Diodes (Oral)** Linjun Li, Xining Yang, Guangchao Ye, Long Zhou, Yunfeng Bai *Heilongjiang Institute of Technology, China*	- 183 -
15:15-15:30	**Efficient Yb:LuYAG Mixed Crystal Microchip Laser (Oral)** Dimeng Chen, Jun Dong *Xiamen University, China*	- 183 -
15:30-15:45	**Coffee Break**	
Chair: Yulei Wang, Harbin Institute of Technology, China		
15:45-16:15	**Temperature-Insensitive Parametric Amplification and Pulse-contrast Characterization for Ultrafast Intense Lasers (Invited)** Jingui Ma *Shanghai Jiao Tong University, China*	- 175 -
16:15-16:30	**Bundle Multi-FM Beam Smoothing by Spectral Dispersion Technology (Oral)** Tianran Zheng, Ying Zhang *Research Center of Laser Fusion, China Academy of Engineering Physics, China*	- 183 -
16:30-16:45	**Reflection and Transmission of Vector Bessel Vortex Beam from Uniaxial Anisotropic Slab (Oral)** LiuJia Wei, LiHai Ying, WuZhen Sen, BaiLu, LiZheng Jun *Xidian University, China*	- 184 -
16:45-17:00	**Generation of Polarization Locked Vector Solitons in Mode-Locked Thulium-Doped Fiber Laser (Oral)** Xuliang Fan[1], Wei Zhou[2], Deyuan Shen[1] *[1] Fudan University, China; [2] Jiangsu Normal University, China*	- 184 -
17:00-17:15	**Influence of Deposition Parameter on Structures and Nonlinear Optical Properties of IB Group Elements Doped ZnO Nanostructures (Oral)** Kexin Zhang, Xing Wen *Harbin Normal University, China*	- 185 -

Hong Jin Kong
KAIST (Korea Advanced Institute of Science and Technology), Korea

Coherent Beam Vombination Using SBS-PCM for High Power Laser System

ABSTRACT

Coherent beam combination is one of the most promising technology for the next generation high power laser system. SBS-PCM is one of the most simple and scalable component to achieve this goal.

The general aspects and experimental results using SBS-PCM for the coherent beam combination will be given in this talk.

He got Master of Physics from KAIST in 1978 and Ph.D. from KAIST in 1981. He joined Physics department of Inha University in 1981 as an assistant professor, and moved to the department of physics of KAIST in 1984 as an assistant professor.

Note

BIOGRAPHY

He became a full professor in 1989, and the director of Laser Science Research Laboratory in 1990.

He was a visiting professor of LLE of Rochester University from 1988 to 1989. He was a 6-months invited professor of ILE, Osaka University in 1997. He was a invited professor of Guangzhou Normal University from 2001.

He became an invited editor of Laser and Particle Beams from 2007. He became a topical editor of High Power Laser Science and Engineering from 2014.

He became a Fellow of SPIE from 2010. He became a Senior Scientist of OSA from 2012.

He is a laser scientist. He has a lot of experiences on designing hyper spectral cameras, 2 photon absorption polymerization, 3Dimensional imaging LIDAR system, high power solid state laser, dye laser, and coherent beam combination using stimulated Brillouin scattering phase conjugate mirrors.

He got awards Korean Physical Society young scientist award in 1988, Korean Presidental award in 1991, KAIST Research award in 2014, Hanbit Great Award in 2015.

Coherent Polarization Beam Combining of High Power Fiber Lasers

Pu Zhou
National University of Defense Technology, China

Note

ABSTRACT

We will report the recent advances in coherent beam combining of fiber lasers in our group. Power scaling of all-fiber linear-polarized fiber amplifier is studied with efficient suppression of SBS and modal instability, and a record power of 2.5 kW is achieved for this kind of fiber laser. Based on active phase control method, four channels of kilo-watt level narrow-linewidth linear-polarized fiber amplifiers are coherently polarization combined with an efficiency of 92%. The combined beam has an output power of 3.2 kW, and the beam quality M^2 factor of the combined beam is ~1.3 @ 3 kW.

BIOGRAPHY

Pu Zhou (1984-) received his Ph.D degree in Optical Engineering from National University of Defense Technology (NUDT) in 2009. He is the author of National Excellent Doctoral Dissertations of China, and now he is a Professor and supervisor for Ph.D student in NUDT. His recent research interests include fundamental investigation on high power fiber laser and beam combining, where novel research results on nonlinear optical effect manipulation, lasing at extreme wavelength and its application in tandem pumping, precise phase control of multi-channel laser beams, propagation of beam array and its performance evaluation have been achieved. As the first author or corresponding author, he has published more than 90 papers in *Applied Physics Letters*、*IEEE Journal of Selected Topics on Quantum Electronics*、*Optics Letters*、*Optics Express*、*Scientific Reports* and so on.

Ultrafast Fiber Soliton Lasers

Xueming Liu
Zhejiang University,
China

ABSTRACT

We report a compact all-fiber laser system mode-locked by Nano-materials such as nanotube and graphene. The proposed laser can deliver the multiple wavelengths and the central wavelengths are tunable. Nanomaterial-based mode-locked fiber laser emits the dissipative solitons with higher pulse energy. These results may provide helpful theoretical and experimental fundamentals for the in-depth study of new high-energy pulses, and bring the new understandings about nonlinear phenomenon of ultra-short high-energy pulses under extreme conditions.

Note

BIOGRAPHY

Prof. Liu received the PhD degree in 2000. Successfully, He had engaged in the post-doctoral research in Tsinghua University and Seoul National University from 2000 to 2004. From May 2004 to Oct. 2005, He was a Scientist in Agency for Science, Technology and Research, Singapore. From Apr. 2007 to Jun. 2007 and from Nov. 2007 to Oct. 2008, He was a visiting scholar and research professor in the Chinese University of Hong Kong and Gwangju Institute of Science and Technology (GIST), respectively. From Mar. 2012 to Sep. 2012, He was a senior visiting scholar in the University of Cambridge. He has authored or coauthored papers more than 150. He was honored to the National Science Fund for Distinguished Young Scholars.

Frequency Noise Characteristics in Single-Frequency Fiber Laser

Shanhui Xu
South China University of Technology, China

Note

ABSTRACT

The frequency noise characteristics of single-frequency highly Er^{3+}/Yb^{3+} co-doped phosphate fiber laser is investigated experimentally. The frequency noise and the relative intensity noise (RIN) of the single-frequency fiber laser with various lengths of the phosphate fiber and different pumping powers. These results show that optimizing the length of phosphate fiber can reduce the frequency noise of this fiber laser. And the adjustment of the pumping power can also promote the frequency noise performance. These investigations are conducive to optimizing laser property and promote the wide application of this single-frequency fiber laser.

BIOGRAPHY

Shanhui Xu received the M.Sc. degree from the South China University of Technology (SCUT), Guangzhou, China, in 2001, and the Ph.D. degree from South China Normal University, Guangzhou, China, in 2009. From 2001 to 2003, he was a Research Engineer in Huawei Technologies Co., Ltd. He is currently a Professor in the State Key Laboratory of Luminescent Materials and Devices and Institute of Optical Communication Materials, South China University of Technology.

Yangjian Cai
Soochow University, China

Generation and Propagation of Partially Coherent Beams

ABSTRACT

Coherence is an important property of laser beam. Laser beam with low spatial coherence named partially coherent beam exhibits many interesting propagation properties and is preferred in many applications. In this talk, we will introduce recent development on generation and propagation of partially coherent beams.

BIOGRAPHY

Prof. Yangjian Cai was born in Zhejiang, China, in 1977. He received Ph.D. degree in Physics from Zhejiang University, China, in 2005, and Ph.D. degree in electromagnetic theory from Royal Institute of Technology, Sweden, in 2006. From Dec. 2016 to Jan. 2009, he worked as a Postdoctoral Researcher and as a Humboldt Research Fellow in Max Planck Research Group, Institute of Optics, Information, and Photonics, University of Erlangen, Germany. In 2007, he won National 100 Excellent Ph. D. Theses Award of Ministry of Education of China. Since 2009, he works as a full professor in School of Physical Science and Technology, Soochow University, China. His research fields include optical coherence and polarization, laser physics, optical imaging and atmospheric optics. He has published more than 250 SCI-indexed papers in refereed international journals (over 100 papers in OSA journals), and the number of SCI citations (without self-citations) is over 3300. In 2015, he obtained the National Science Fund for Distinguished Young Scholars. In 2016, he was selected as a distinguished professor of Jiangsu Province.

Note

Dissipative Soliton Lasers and Beyond

Dingyuan Tang
Nanyang Technological University, Singapore

Note

ABSTRACT

Ultrashort pulse generation in mode locked lasers is one of the hot topics of laser physics and engineering and has been extensively studied. Based on the textbook laser mode locking theory, when the phases of all oscillating longitudinal modes are synchronized, either by the active or passive mode locking techniques, a laser will emit a train of optical pulses whose minimum pulse width is ultimately limited by the laser gain bandwidth. However, the conventional laser mode locking theory didn't consider the effects of nonlinear light propagation in the laser cavity. For many mode locked lasers this is also justified. Recent advance of the laser technology has demonstrated more and more mode locked laser operations where the nonlinear light propagation in the cavity is no longer ignorable. In this talk we show both theoretically and experimentally that many novel new features, such as the dissipative soliton formation, soliton period-doubling and route to chaos, twin-pulse emission etc., could appear in these mode locked lasers. The goal of laser mode locking is to generate optical pulses with possibly large energy and narrow pulse width. Experimentally we found that by operating a mode locked laser in the nonlinear regime, not only ultra-stable mode locked pulse train can be obtained, under suitable operation conditions, ultrashort pulses whose spectral bandwidth is far larger than the gain bandwidth can be formed. It could be an effective technique to generate ultra-stable and ultra-narrow optical pulses directly from a laser oscillator.

BIOGRAPHY

Prof. D. Y. Tang received his B.Sc. degree in physics from Wuhan University, China in 1983, M.Sc. degree in laser physics from Shanghai Institute of Optics and Fine Mechanics, Chinese Academy of Science in 1986 and Ph.D. degree in physics from Hannover University, Germany in 1993. From 1993 to 1994, he worked as a scientific employee at the Physikalisch-Technische Budesanstalt (PTB), Braunschweig, Germany. From 1994 to 1997 he was a university Postdoctoral Research Fellow, and from 1997 to 1999 an Australian Research Council (ARC) Postdoctoral Research Fellow at the University of Queensland, Australia. From 1999 to 2000 he was a Research Fellow in the Optical Fiber Technology Center (OFTC), University of Sydney, Australia. Since July 2000 he has been an Associate Professor in the School of Electrical and Electronic Engineering, Nanyang Technological University, Singapore. Prof. Tang's research interests are in the areas of laser physics and techniques, nonlinear optics, ultrafast optics, and ceramic laser materials. He has published over 300 international journal papers with an H-index of 47. He is an associate editor for the international journals of *Optical Engineering* and *Optics Express*.

Christophe Dorrer
Aktiwave LLC, USA

Binary Pixelated Beam Shapers for Laser Engineering and Wavefront Metrology

ABSTRACT

Binary pixelated beam shapers relying on distributions of small transparent or opaque pixels designed by spatial dithering algorithms allow for quasi-arbitrary continuous spatially varying transmission control. I will review the principle and application of metal-on-glass devices and variants based on binary phase modulation and binary polarization modulation to precise apodization and beam shaping in laser systems. Examples of applications to laser wavefront metrology will also be presented.

Note

BIOGRAPHY

Christophe Dorrer received his PhD in Optics from the Ecole Polytechnique (France) in 1999. He was a post-doctoral fellow at the Institute of Optics (Rochester, NY, USA) from 1999 to 2001 and a member of technical staff at Bell Laboratories (Holmdel, NJ, USA) from 2001 to 2005. Since 2005, he is a scientist at the Laboratory for Laser Energetics (Rochester, NY, USA), where he works on the development of fiber front ends for laser systems, optical parametric chirped pulse amplification, temporal pulse characterization, techniques for temporal contrast characterization and improvement, wavefront sensing, and beam shaping. Since 2008, he is the chief technology officer at Aktiwave LLC, a company that specializes in metrology and beam shaping. He is a fellow of the Optical Society (OSA) and an associate editor for Optica.

Guoqiang Xie
Shanghai Jiao Tong University, China

Note

Ultraclean Femtosecond Vortices Generation From A High-Order Transverse-Mode Femtosecond Mode-Locked Laser

ABSTRACT

Since the birth in the 1970s, the first generation of femtosecond laser, characterized by emitting Gaussian beam, has shown a wide range of applications from industry to scientific research. The second generation of femtosecond laser, characterized by structured beams with special spatial phase and intensity profiles, represented by femtosecond vortex beams, is reforming traditional ultrafast technology and has shown tremendous potential in a wide range of applications, including sub-wavelength nonlinear microscopy, femtosecond micro-nano manipulation, femtosecond special-structure micro-processing, filament optics, and vortex-based strong-field physics, etc.

However, the generation of high-quality clean femtosecond optical vortex is a challenge. The traditional vortex generation techniques based on phase or diffraction elements (spiral phase plate, hologram grating, etc.) work well for CW and picosecond lasers with a narrow spectral bandwidth, where the effect of dispersion can be ignored. However, femtosecond vortex has a wide spectral bandwidth. Therefore, the traditional vortex generation techniques based on phase or diffraction elements are intrinsically limited by dispersion, which will result in unclean or distorted femtosecond vortices generation.

Here, we report on ultraclean femtosecond vortex generation by a femtosecond mode-locked laser operating in a single high-order transverse mode. By controlling the oscillation thresholds of various-order transverse modes in a laser, a pure and mode-order-tunable femtosecond Hermite-Gaussian (HG) beam is generated from the mode-locked laser and subsequently is converted into the femtosecond vortex by a cylindrical lens converter. The obtained femtosecond vortex has an unprecedented ring-to-center intensity contrast of 36 dB measured with a near wavelength-spatial-resolution detecting device, which approaches to the theoretical limit of an ideal vortex beam. This work may open up a wide range of application prospects for femtosecond vortices and motivate novel femtosecond structured beam generation directly from mode-locked lasers.

BIOGRAPHY

Guoqiang Xie is currently a research professor at the School of Physics and Astronomy of Shanghai Jiao Tong University. He received the Ph.D. degree from Fudan University in 2008. From 2006 to 2009, he worked at Nanyang Technological University in Singapore as a Project Officer and then Research Fellow. In 2009, he joined in Shanghai Jiao Tong University as a Research Professor. He has published over 70 papers in international journals and conferences, and has a citation of more than 1300 times. He is the editorial board member (EBM) of *Scientific Reports*, guest editor of *International Journal of Optics*, Deputy Director of Youth Committee of Shanghai Laser Association, etc. His research interests include ultrafast laser, novel laser materials, and quadratic nonlinear optics, etc.

Rich Mildren
Macquarie University,
Australia

The Nonlinear and Laser Optics of Diamond

ABSTRACT

Many of diamond's optical and thermal properties have been coveted in laser applications for many years, however, until recently these have not been exploited in applications due to its poor proclivity for hosting for fluorescent dopants. Our research has focused on the laser properties of diamond in its pure state by using Raman gain. Since our first demonstration of Raman laser using synthetic diamond in 2008, there has been rapid progress in using diamond to enhance the efficiency, wavelength range and output power of Raman lasers in temporal regimes spanning the ultrafast to cw. In this talk, I'll review progress to date and highlight the directions in laser and nonlinear optics where it is well placed to make a substantial impact. Amongst a range of interesting advantages, its capacity for very high average power (>>kW) and high spectral brightness at traditionally difficult regions of the spectrum are areas that will be especially highlighted.

BIOGRAPHY

Rich Mildren (Australian Research Council Future Fellow in 2010-2014) is an Associate Professor in the Department of Physics and Astronomy. His research is in the development of novel and versatile photonic sources, instrumentation and applications. His PhD and early postdoctoral research was in the plasma kinetics of high power metal vapour lasers. He has studied ultrafast lasers at the National Research Council in Pisa, Italy. For 3 years (2005-2008) he led R&D for a University spin-off company in wavelength-switchable medical lasers, during which time he brought several medical laser products through to the stage of medical device regulatory approval. His most recent focus, conducted in the MQ Photonics Research Centre, is in the nonlinear optical properties of Group IV materials, particularly diamond.

Note

Langasite Crystals: From Crystal Growth to Nonlinear Optical Applications

Haohai Yu
Shandong University, China

Note

ABSTRACT

Langasite crystal is a multifunctional crystal material, and has important applications in the field of electro-optical, piezoelectric and nonlinear optics, etc. Compared with each other, we found that $La_3Ga_{5.5}Nb_{0.5}O_{14}$ (LGN) crystal satisfies the requirements of the mid-infrared lasers in transmission spectra, nonlinear coefficient and optical damage threshold. We studied the quadratic nonlinear optical properties of LGN crystal in mid-infrared range and realized the OPG generation. After particular calculations of the gain bandwidth of LGN, it is found that this crystal could be a qualified candidate in the field of mid-infrared amplification, especially in the aspects of mid-infrared CPA and/or OPCPA aiming to obtain high-peak-power few-cycle mid-IR pulses.

BIOGRAPHY

Haohai Yu was born in Jinan, China, on October 16, 1981. He received the Ph.D. degree from Shandong University, Jinan, in 2008. He is currently a scientist at the State Key Laboratory of Crystal Materials and Institute of Crystal Materials, Shandong University. His current research interests include crystal growth, diode-pumped solid-state lasers, and nonlinear optics based on the new crystals.

Pu Wang
Beijing University of Technology, China

Recent Progress on High Power, Mid-IR, Ultra-Fast Fiber Lasers

ABSTRACT

The research on mid-infrared laser sources has attracted worldwide attentions because of their attractive applications in atmospheric gas detection, laser medicine, laser lidar, mid-infrared imaging and electro-optical countermeasure system. Due to its characteristics of high power, excellent beam quality and high temporal stability, 2 μm high average power, high peak power, and short pulsed thulium-doped fiber laser is considered to be a good candidate for implementing of 2~5 μm high power mid-infrared laser. Developing the 2 μm high power all-fiber thulium-doped fiber laser has become imperative to promote a new generation of mid-infrared laser system. Here, I will review our recent progress in developing 2 μm short pulsed thulium-doped fiber oscillator, 2 μm high power thulium-doped fiber amplifier and 2~5 μm supercontinuum generation. The recent progress on high power chirped pulse amplification Tm-doped femtosecond fiber lasers, and the high power tunable Raman solitons of 1.5 ~ 2.4 μm will also be presented.

BIOGRAPHY

Pu WANG received the Bachelor degree in Physics from Shandong University, Jinan, Shandong, P.R.China, in 1986 and the Ph.D. degree in Laser Physics from Macquarie University, Sydney, Australia, in 1999, respectively. He is now a professor in Institute of Laser Engineering, Beijing University of Technology. His current research interests include high power rare-earth-doped fiber lasers and amplifiers, ultrafast fiber lasers and amplifiers, nonlinear frequency conversion in fiber optics, etc. So far, he has published over 50 scientific papers.

Note

Temporal Dual-Pulse Pumped Ti: Sapphire Amplifier for 10PW SULF Laser

Xiaoyan Liang
Shanghai Institute of Optics and Fine Mechanics, CAS, China

Note

ABSTRACT

The laser project of Shanghai Ultra-intense and Ultra-fast Laser Facility (SULF) is aimed to develop a laser with peak power of 10 PW which will be used for three intense physical experimental platform. The laser facility is based on the technology of chirped pulse amplification (CPA) and Ti:sapphire crystal. To suppress the parasitic lasing in large aperture Ti:sapphire amplifier for high energy output, we proposed a new method of temporal dual-pulse pumping. For a energy amplifier containing a 150mm diameter Ti:sapphire, energy of 202.8 J was obtained with pump of 320 J corresponding the conversion efficiency of 49.3%. The compressed pulse duration of 24.0 fs was measured with a throughput efficiency of 64%, leading to a peak power of 5.4 PW. For the next step, we will improve the amplified energy with a 200 mm Ti:sapphire amplifier to support the peak power of 10 PW.

BIOGRAPHY

Xiaoyan Liang is currently a professor in Shanghai Institute of Optics and Fine Mechanics (SIOM), China. She received the B.S. degree in physics from Shanxi University in China in 1988, and the Ph.D. in Laser Optics in 2001 from Institute of Physics, Chinese Academy of Science. From 2001 to 2003 she was a postdoctoral fellow in department of physics, University of Kaiserslautern in Germany, where her research was on solid state lasers and widely tunable optical parametric oscillator. She joined SIOM in 2003, and her current research interests involve exploring of ultra-intense and ultra-fast petawatt lasers. Her work mainly focuses on petawatt (PW) femtosecond laser based on chirped pulse amplification (CPA) and optical parametric chirped pulse amplification (OPCPA). At the moment, she is engaged in build of the SULF 10 PW laser.

Zhaoyang Li
Osaka University, Japan

Temporal Contrast Enhancement for LFEX Petawatt Laser

ABSTRACT

LFEX is the recent strongest petawatt (PW, 10^{15} W) laser which could support a 3 kJ, 1.5 ps, and accordingly 2 PW output. The temporal contrast, defined as the intensity ratio between the signal and the pre-noise, is a key parameter for a PW laser which directly determines the applications of such lasers. The temporal contrast of LFEX in the picosecond range is 10^{8}, and then peak power of the noise would reach to around 10^{7} W, which is powerful enough to generate low-density plasma and destroy the experimental target before the real signal arriving. In this talk, we investigated the influence factors and proposed corresponding methods for temporal contrast enhancement. The proposed theory models and theoretical predictions were verified by experimental demonstrations. We believe this work is expected to further optimize PW-class lasers with high temporal contrasts.

BIOGRAPHY

Zhaoyang Li received his B.S. degree from Beijing Institute of Technology in 2005, M.S. degree from China Academy of Engineering Physics in 2008, and Ph.D. degree from Nanjing University of Science and Technology in 2015. From 2006 to 2014 he worked as a research associate for Chinese first PW laser (ShenGuang-II petawatt faciltiy), from 2014 to 2016 he worked as a research associate for Chinese first 10-PW laser (Shanghai Super-intense Ultra-fast Laser Facility, SULF), and from 2016 he worked as an assistant professor for the recent strongest PW laser (LFEX at Institute of Laser Engineering, Osaka University, Japan). His recent research interests include ultrahigh ultrafast lasers, high average power lasers, fiber lasers, and nonlinear optics.

Note

Generation of Ultrashort Dissipative Soliton Pulses in Solid-State Lasers

Jie Ma
Nanyang Technological University, Singapore

Note

ABSTRACT

The generation of ultrashort optical pulses has been one of the hottest research topics in the laser physics and engineering due to their widespread applications in modern science and technology. In this talk, we will present our recent progress on generation of ultrashort sub-100 fs even sub-50 fs dissipative soliton pulses, whose dynamics are governed by the complex Ginzburg-Landau Equation, in different Yb-doped and Nd-doped mode-locked solid-state lasers. Ultrashort soliton pulses of 30 fs and 79 fs were obtained from Yb:$CaYAlO_4$ and Nd:$Ca_3La_2(BO_3)_4$ lasers, respectively, which is the shortest pulse for Yb-doped and Nd-doped solid-state oscillators up to now. The experimental results demonstrated ultrashort soliton pulses shorter than that allowed by the net gain bandwidth could be achieved if the various pulse-shaping mechanisms, including cavity dispersion, nonlinear phase modulation, laser gain and losses, and the gain bandwidth, could be appropriately balanced.

BIOGRAPHY

Jie Ma received his B.S. degree from Shandong University, China, in 2007, and Ph.D. degree in physics from Shanghai Jiao Tong University, China, in 2013. After that, he worked as a postdoctoral research fellow in National University of Singapore during 2014 to 2015. In 2015, he joined in School of Electrical and Electronic Engineering, Nanyang Technological University in Singapore as a research fellow. His research interests include ultrafast laser, novel optical materials, and nonlinear optics.

Yulei Wang
Harbin Institute of Technology, China

Laser Beam Combination Based on Brillouin Serial Amplification

ABSTRACT

Laser beam combination is an effective method to generate high power laser and avoid the thermal damage and the limitation of energy capacity of a single laser beam. The serial laser beam combination based on stimulated Brillouin scattering (SBS), compared to other laser beam combination technology, is close to one completely coherent laser beam. Its advantages have been confirmed that the phase controlling is unnecessary, and the high-quality laser beam is coherent with high stability and significant scalability. Two pivotal difficulties have been discussed. One is the amplification of the strong Stokes seed, and the other is phase matching for non-collinear Brillouin amplification.

BIOGRAPHY

Yulei Wang is Professor of physical electronics at Harbin Institute of Technology. He received the B.S. degree and Ph.D. degree from Harbin Institute of Technology, Harbin, China, in 2001 and 2007 respectively. He worked at Imperial College London as a visiting scholar from 2011 to 2012. His research interests are high power solid-state lasers, stimulated Brillouin scattering (SBS) and its applications in high-power lasers. He worked as a leadership to build the high power hundred-Joule laser facility with the extremely excellent quality. He holds 15 patents, has authored and co-authored 76 papers in peer-reviewed journals, including *APL*, *OL*, *OE*, etc. He gained the National Science Foundation for Excellent Young Scholars in 2016.

Note

Temperature-Insensitive Parametric Amplification and Pulse-Contrast Characterization for Ultrafast Intense Lasers

Jingui Ma
Shanghai Jiao Tong University, China

Note

ABSTRACT

Noncollinearity provides an effective design freedom for the nonlinear three-wave interactions. Two applications of the noncollinear configuration in ultrafast intense lasers will be presented. The first example is the noncollinear achromatic phase matching scheme, in which the noncollinearity is employed to eliminate the first derivative of phase-mismatch with respect to temperature. By combining an angularly dispersed seed, this scheme can support simultaneous temperature- and wavelength-insensitive amplification for high-average-power ultrafast lasers. The second example is the noncollinear cross-correlator, in which the noncollinearity is employed to realize time-to-space encoding for enabling the single-shot characterization of pulse contrast of intense lasers. Recent pulse-contrast measurement results for several petawatt-class laser facilities in China will be reported.

BIOGRAPHY

Dr. Ma, born in 1986, received his B.S. in Optics at Shandong University in 2009 and his Ph.D. in Optics at Fudan University in 2014. He worked in Shanghai Jiao Tong University for his postdoc research from 2014-2016. He is now a lecturer in School of Physics and Astronomy, SJTU. Research interests include nonlinear optics, ultrafast lasers and intense lasers. He has published over 20 papers, including 1 in Nature Communications, 1 in Optica and 7 in Optics Letters/Express. He has obtained 8 licenses of invention patents, including 4 United States Patents.

CIOP-2017-1375

High Power Kerr-Lens Mode-Locked Yb-Bulk Oscillators

Wenlong Tian, Jiangfeng Zhu, Yingnan Peng, Zhaohua Wang, Zhiyi Wei
Xidian University, Institute of Physics, Chinese Academy of Sciences

Yb doped gain media have attracted numerous interests in high-power ultrashort pulse generation due to their excellent spectroscopic and thermal conductivity for decades. In particular, sub-50 fs pulses can be obtained from some specific Yb-doped materials by using Kerr-lens mode-locking technique. However, most of them suffered from limited output average power of less than 100 mW due to the limited power of single mode laser diodes (LDs) which are essential for pure Kerr-lens mode-locking operation. To increase the average power of the ultrafast Kerr-lens mode-locked Yb: lasers, either using high-power single-mode fiber laser as the pump source or utilizing multi-mode LD to implement Kerr-lens mode-locking operation with hard aperture is needed. With the previous method, we demonstrated a bright fiber laser pumped Kerr-lens mode-locked Yb:GSO oscillator, which delivered 4-W, 249-fs pulses at the repetition rate of 92 MHz. The corresponding optical-to-optical efficiency with respect to the absorbed pump power was as high as 54%. This is, to the best of our knowledge, the highest optical-to-optical efficiency ever achieved from a Kerr-lens mode-locked solid-state oscillator. In addition, we also demonstrated a high power Kerr-lens mode-locked Yb:YSO laser with as high as 2 W average power and 95 fs pulse duration for the first time. By employing the second methods, an additional Kerr medium is introduced to enhance the Kerr effect as well as a small pinhole acts as the hard aperture. As a result, a LD pumped Kerr-lens mode-locking Yb:CYA laser is demonstrated for the first time. Output power up to 1.5 W is obtained at a repetition rate of 50 MHz. The corresponding signal pulse energy is as high as 30 nJ, which is the highest single pulse energy ever achieved from the Yb:CYA lasers. With optimized intra-cavity dispersion compensation, the pulse duration of the KLM pulses is 68 fs, corresponding to the peak power of 0.44 MW. By better thermal management and cavity dispersion compensation, multi-watt, sub-100 fs pulses could be produced from the solid-state Yb-based oscillators by these simple architectures and will have wide applications in many fields.
Key words: Kerr-lens mode-locking; all-solid-state laser; diode-pumping; femtosecond; high power

CIOP-2017-2453

Diode-pumped cesium-vapor laser and blue-violet laser by frequency doubling

Fei Chen
Changchun Institute of Optics, Fine Mechanics and Physics, CAS

The diode-pumped alkali-vapor lasers (DPALs) have the preferred properties of solid-state lasers and gas lasers, such as high quantum efficiency, large stimulation emission cross-section, easy heat elimination and good optical characteristics. The DPALs are expected to obtain near-infrared laser output with high power, high efficiency and high beam quality, which has potential applications in military and civilian. Therefore, it has attracted more and more attention in recent years. In addition, it is a new way to achieve blue-violet laser by frequency doubling of DPALs, which has important applications in scientific research, medical treatment, laser displays and underwater communication. In this paper, the experimental investigations on a diode-pumped cesium-vapor laser (Cs-DPAL) and its frequency doubling to obtain blue-violet laser are carried out. First of all, a Cs-DPAL is constructed. By optimizing the parameters, the CW Cs laser with fundamental transverse mode is obtained, and the center wavelength and the line width are 894.57 nm and 0.032 nm, respectively. When the operating temperature of the Cs vapor cell is 107.6℃ , the maximum stable CW power of Cs-DPAL is 1.74 W and the optical-optical efficiency is 17.3%. Under the condition of pulsed operation, the maximum stable power of Cs-DPAL is about 3 W and the efficiency is 14.6%. And then the researches on blue-violet laser by extra-cavity and intra-cavity frequency doubling are presented by using the type I phase matching method with LBO crystal. By extra-cavity frequency doubling, the highest power of the 447.3 nm pulsed blue-violet laser reaches to 0.01 mW. With intra-cavity frequency doubling, the CW and pulsed powers of blue-violet laser are 0.22 mW and 0.36 mW, respectively.
Key words: diode-pumped alkali-vapor laser; cesium-vapor laser; frequency doubling

CIOP-2017-0188

Calculation of Laser Transverse Modes in Stable Cavities Using Mode Coupling Matrix

Jian Lei, Peifeng Chen, Ying Wang
School of Optical and Electronic Information, Huazhong University of Science and Technology

We propose a method to calculate laser transverse modes in stable cavities using mode coupling matrix. Asymmetrical optical elements can lead to the couplings of orthogonal eigenmodes. The couplings are measured by the overlap integrals of eigenmodes after the optical elements. Using the overlap integrals as matrix elements, we construct a transverse mode coupling matrix. Fields on the transverse planes in laser cavities can be expressed as the linear superposition of eigenmodes and thus are written as vectors whose elements are the superposition coefficients. The field-propagation in stable laser cavities is simulated by the multiplication of the vector with the coupling matrixes. We can know the eigenmodes in an oscillation mode from the simulation. A stable end-pumped solid-state laser model is constructed to study our method. The calculation results have an overlap of over 99% with the desired modes. This indicates asymmetrical optical elements can lead to the couplings of orthogonal eigenmodes.
Key words: laser coupling; stable cavbity; solid-state

CIOP-2017-0375

Reconfigurable Dynamic All-Optical Chaotic Logic Operations in an Optically Injected VCSEL

ZhongDong Zhou, XuGe Liang, LuoWei, XiaoZhen Zhen
The Department of Information Engineering, Wuyi University

By using the polarization bistability characteristics and the threshold mechanism, we propose a novel implementation scheme for reconfigurable dynamic all-optical chaotic logic operations in a chaotic system of vertical cavity surface emitting laser (VCSEL) with external optical-injection. Here, two logic inputs are encoded by the optically injected amplitude. One of logic outputs is decoded from the difference between the mean square error (MSE) of the *x*-polarization component emitted by VCSEL and its threshold, the other is decoded from the difference between the MSE of *y*-polarization component and its threshold. We explore the dynamic polarization bistability evolutions of VCSEL caused by the external injection amplitude under the conditions of different key parameters, such as the bias current, the injection strength and frequency detuning between the tunable distributed feedback laser and the VCSEL. Based on the evolution laws, here we consider the frequency detuning as the control logic signal, and the conversion among different logic functions such as AND, NAND, OR, NOR, XOR, XNOR can be realized in different time periods in the case that the frequency detuning logic meets corresponding logic operation with the two logic inputs.
Key words: verticalcavity surface emitting laser (VCSEL); semiconductor logic devices; polarization switching; chaos; logic design

CIOP-2017-0577

Process-Oriented Adaptive Optics Control Method in the Multi-Pass Amplifiers

Qiao Xue
Research Center of Laser Fusion, Mianyang, China

In this talk, we propose and demonstrate the process-oriented adaptive optics (AO) wavefront control method, for optimizing the beam quality in the multi-pass amplifiers. Different from the conventional target-oriented wavefront control approach, the novel method divides the aberration correction process into several steps, to optimize the wavefront quality in time during the courses of the beam's transport and amplification. The experimental results show that the proposed method can effectively prevent the beam quality from worsening and ensure the successful reality of multi-pass amplification, so it has obvious advantages both in efficiency and accuracy over the traditional target-oriented method.
Key words: adaptive optics; aberration compensation; laser amplifiers

CIOP-2017-0688

Cr^{2+}: CdSe Passively *Q*-switched Ho: YAG Laser

Qiang Liu, Encai Ji, Mingming Nie
State Key Laboratory of Precision Measurement Technology and Instruments, Department of Precision Instrument, Tsinghua University

We firstly demonstrate the laser performance of a Cr^{2+}:CdSe passively Q-switched (PQS) 2.09 μm Ho: YAG laser resonantly pumped by a thulium-doped fiber laser. Maximum output pulse energy of 1.766 mJ, corresponding to a repetition frequency of 685 Hz, was obtained with a pulse duration of 15.4 ns. The pulse peak power was 114.7 kW, while the PQS efficiency was about 21.45% against the continuous-wave output. The laser wavelength in PQS operation was precisely measured to be 2090.2 nm.
Key words: infrared and far-infrared lasers; lasers, Q-switched; lasers, solid-state

CIOP-2017-0689

Laser Beam Conditioning Using Spatial Shaping, Temporal and Polarization Smoothing

Rui Zhang
Laser Fusion Research Center, China Academy of Engineering Physics

In the research of inertial confinement fusion, laser plasma interaction (LPI) is becoming a key problem that affects ignition. In this paper, continuous phase plate (CPP), smoothing by spectral dispersion (SSD) using multi-frequency modulation and polarization smoothing (PS) were simulated and experimentally studied on the SG-III laser facility. After using these technologies, the focal spots of SG- Ⅲ laser facility can be adjusted, controlled and repeated accurately. The output spectra of the cascade phase modulators used for Multi-FM SSD were stable and the FM-to-AM effect was controlled to less than 5%. Experiments on SG-III laser facility indicated that when the number of color cycles adopted 1, imposing SSD with 3-TDL angular spectral dispersion did not lead to pinhole closure in the spatial filters of the preamplifier and the main amplifier with 30-TDL pinhole size. Polarization smoothing using flat birefringent plate in the convergent beam of final optics assembly (FOA) was studied. Nonuniformity of the focal spots using CPP, Multi-FM SSD and PS drops to 0.18, comparing to 0.26 with CPP and SSD, and 0.84 with CPP and wedged lens.
Key words: continuous phase plate; smoothing by spectral dispersion; polarization smoothing; inertial confinement fusion

CIOP-2017-0776

Multi-Target Ranging by Using Chaotic Laser Radar Based on the Complete Chaotic Synchronizations of the Polarization Components in the Drive-Response VCSELs

Wei Luo, Zhongdong Zhou
Wuyi University

According to the principle of complete chaos synchronization and the theory of Hilbert phase transformation, we propose a novel real-time multi-target ranging scheme by using chaotic radar in the drive-response vertical-cavity surface-emitting lasers (VCSELs). In the scheme, to ensure each polarization component (PC) of the master VCSEL (M-VCSEL) to be synchronized steadily with that of the slaver VCSEL, the output x-PC and y-PC from the M-VCSEL in the drive system and those in the response system are modulated by linear electro-optic effect simultaneously. Under this condition, by simulating the influence of the bias current, the applied electric field and the propagating delay time on the synchronization quality, related operating parameters can be optimized. The x-PC and the y-PC, as two chaotic radar sources, are used to be implemented the real-time ranging for two targets. It is found that the measured distances of the two targets at arbitrary position exhibit a slight jitter. Their resolutions are up to millimeters, and their relative errors are very small, less than 2.7%.
Key words: chaotic laser radar; real-time ranging; complete chaotic synchronization; the drive-response VCSELs

CIOP-2017-0950

An Identification Technology for Crude Oil and Lubricant on Simulated Sea Surface

Xiaobing Zhang, Changqing Cao
Xidian University

A recognition technology for crude oil and lubricant is described by use of back-scattering fluorescence. It is shown that when the fluorescence intensity reaches the maximum peak, its attenuation ratio has no obvious dependence on laser power, incident angle and thickness of oil film during a fixed wavelength interval. An algorithm is presented to reflect the fluorescence intensity decay rate and considering the distinction and stability, two relatively constant wavelength regions for the algorithm are selected. Then the two coefficients are fused in a two-dimensional spectrum. Then two areas which represent the two kinds of oil are identified in the two-dimensional spectrum, and the oil type can be determined according to which area the measurement data lies in. The experimental results show that the correct identification probabilities for crude oil and lubricant can reach 96% and 98%, respectively. It is expected that this can be a useful method for oil type recognition.
Key words: laser-induced fluorescence; spectroscopy; crude oil; lubricant; oil type recognition

CIOP-2017-1027

Output Characteristics of Actively Q-switched Ho:CYA Laser

Huiting Xia[1], Fan Wu[2], Yongguang Zhao[1], Deyuan Shen[1]
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[2] *Department of Optical Science and Engineering, Fudan University*

High power solid-state lasers emitting in the 2.1 μm wavelength region are of great interest for eye-safe applications, such as medical surgery, light detection and ranging (LIDAR), and interferometric sensing. In particular, high energy 2.1 μm *Q*-switched lasers are effective pump sources for frequency conversion in the 3-12 μm range. Since the holmium has a large emission cross section in the 2.1 μm region and a long upper-state fluorescence lifetime among various earth ions , Ho^{3+}-doped laser materials are important candidates to produce high energy *Q*-switched laser around 2.1 μm. Here, in this paper, we report on an actively *Q*-switched Ho:CYA laser in band pumped (5I8→5I7) by a homemade Tm:fiber laser at the wavelength of 1922 nm. With the incident pump power of 40.1 W, a maximum average output power of 8.1 W was achieved at the pulse repetition frequency (PRF) of 50 kHz. Shortest pulse duration of 20.5 ns with peak power of 60.6 kW has been obtained at 2 kHz PRF under 19.7 W of incident pump power. Our experimental results indicated that Q-switched Ho:CYA laser, which has high peak power and short pulse duration, will provide an excellent pump source for mid-IR optical parametric oscillators.
Key words: lasers, q-switched; lasers, solid-state; rare earth and transition metal solid-state lasers

CIOP-2017-1090

Graphene Binary/Ternary-Nanocomposites: Synthesis, Characterization and Their Application to Ultrafast Soliton Lasers

Bo Guo
Key Laboratory of In-Fiber Integrated Optics of Ministry of Education, Harbin Engineering University

Since firstly reported in 2009, the research on graphene and its derivatives as a saturable absorber in the field of ultrafast photonics is booming. Here, we experimentally demonstrate a switchable single-, and dual-wavelength soliton fiber laser based on graphene binary/ternary-nanocomposite, that is, graphene/polyaniline (G/PANI) and graphene/tin oxide/polyaniline (G/SnO_2/PANI), respectively. In experiment, we firstly synthesized the G/PANI and G/SnO_2/PANI nanocomposites by using the liquid-phase ultrasonic method and studied their nonlinear optical properties by using the *z*-scan technology.

Then, they are transferred into the laser cavity by the polymer-film method. The experimental results show that the as-prepared graphene device not only can act as an excellent saturable absorber for mode-locking, but also induces a highly third-order nonlinear optical effect to form a filter for dual-wavelength pulse generation in the laser. By exploiting the dual-function of this device, the switchable dual-wavelength soliton operation of the fiber laser is stably initiated with a minimum pulse width of 1.25 ps, a fundamental repetition rate of 2.13 MHz, pulse energy of 1.51 nJ and peak power of 1.2 kW.

Key words: graphene composite; fiber laser; soliton laser; mode-locking; multiwavelength

CIOP-2017-1162

Novel Tm: $CaYAlO_4$ Mode-Locked Laser at 2 μm Water Absorption Band

Wei Zhou, Xiaodong Xu, Rui Xu, Xuliang Fan, Yongguang Zhao, Deyuan Shen, Dingyuan Tang
Key Laboratory of Advanced Laser Materials and Devices, School of Physics and Electronic Engineering, Jiangsu Normal University

We report on stable passively harmonic mode-locking dissipative pulses with high repetition rate and narrow bandwidth in 2 μm Tm: $CaYAlO_4$ laser. At the large intracavity intensity, the laser generated 1st-order to 5th-order passively harmonic solitons with fundamental repetition rate of about 198 MHz and 5th-order repetition rate up to 0.98 GHz, which was mainly caused by the peak power clamp effect. Employed a simple quartz plate, the fundamental mode-locked solitons demonstrated a wide tunable wavelength from 1874 nm to 1973 nm, a narrow optical spectrum bandwidth of 60 pm and the maximum output average power up to 1.2 W. To our knowledge, this is the first observation of passively harmonic mode locking in 2 μm solid laser system, and also the first Watt-level wavelength tunable mode-locked laser in this laser system.

Key words: Tm: CaYAlO4; mode-locking; 2 μm ; water absorption band

CIOP-2017-1188

Characterization of Chaotic Brillouin Dynamic Grating

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Institute of Optoelectronic Engineering, College of Physics and Optoelectronics, Taiyuan University of Technology

The Brillouin dynamic grating (BDG) based on chaotic laser has particular advantages over the conventional BDG, for example, the creation of single and permanent BDG. To gain insight into the chaotic BDG, we theoretically investigate the reflection and gain spectra characteristics of the chaotic BDG generated in the polarization maintaining fiber. We find that the reflection spectral width of the chaotic BDG is inversely proportional to the effective grating length and the variation in the gain spectral width is negligible with respect to the effective grating length. The widths of the reflection and gain spectra are not affected by the power of the chaotic pump wave. Besides, in the generation process of the chaotic BDG, the occurrence of the weak BDGs resulted from the time-delay signature of the chaotic laser is further analyzed, which leads to the side-lobe of the reflected pulse. In order to improve the reflection characterization of the chaotic BDG, the chaotic laser subject to filtered optical feedback is utilized to generate the chaotic BDG. The results indicate that the weak BDGs can be effectively suppressed under the proper filter parameters. When the spectral width of the filter is 4 GHz and its detuning from the laser frequency is 5.02 GHz, the side-lobes of the reflected plus can be almost completely suppressed.

Key words: Brillouin dynamic grating; chaotic laser; reflection spectrum; gain spectrum; filtered optical feedback; reflection characterization

CIOP-2017-1192

Dynamic Characteristics of Packaged Chaotic Semiconductor Laser

Yanan Niu, Mingjiang Zhang, Tong Zhao, Jianzhong Zhang, Yi Liu, Anbang Wang, Yuncai Wang
Institute of Optoelectronic Engineering, College of Physics and Optoelectronics, Taiyuan University of Technology

Chaotic signal has attracted considerable research interest owing to its many potential applications, including high-speed random bit generation, secure communication, chaotic radar, and distributed optical sensor. However, most of the chaotic lasers are fabricated by the discrete optical components in lab, the stability and size are common issues for the practical application. In order to solve these problems, many research groups have put forward the integrated chaotic semiconductor lasers.

In this paper, an integrated chaotic semiconductor laser with short-cavity optical feedback is proposed. The middle part between the semi-reflective mirror and the front face of the chaotic semiconductor laser chip (CSLC) works as an external feedback cavity. In particular, the strong optical feedback makes it possible to generate chaos. The dynamic characteristics of this integrated chaotic semiconductor laser are investigated by a rate equation model. The simulating results shown period-doubling route to chaos when fext/fr > 5.2 and the system shows chaotic state when the Kap > 0.12. In order to make the simulating results more accurate, the internal parameters of the CSLC are extracted by experiment. This research will provide a theoretical foundation for the further production of this integrated chaotic semiconductor laser.

Key words: Integrated chaotic semiconductor laser; short-cavity optical feedback; chaotic dynamic characteristics; extract the internal parameters extraction

CIOP-2017-1196

A Short-Cavity Integrated Chaotic Semiconductor Laser Packaged by a Butterfly Package

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Chaotic light is of great interest owing to its important roles in both basic science and applied technology. Research on generation of chaotic light usually uses semiconductor laser with various separate external optical components. It is huge, environmental sensitive and instable. Therefore researchers have done lots of effort to develop a small, stable and low-cost photonic integrated chaotic semiconductor laser. However, we have noticed that the most relevant investigations only focus on solitary monolithically integrated semiconductor laser and pay little attention to component integration.

In this letter, a short-cavity integrated chaotic semiconductor laser packaged by a butterfly package is designed and fabricated for chaos generation. A distributed feedback laser chip, a collimator lens, a transflective mirror, a focus lens and an optical fiber are coupled, so chaotic laser can be generated. It should be point out that a short external straight feedback cavity is formed by the transflective mirror. All these sections above together with chip submount, heat sink and thermoelectric cooler are packaged by a commercial 14-pin butterfly package. After several trial productions, the perfect reflectivity of the transflective mirror is 5%, and the perfect external cavity length which is the distance between the transflective mirror and the distributed feedback laser chip is 2 mm. The bandwidths of power spectra of the chaotic signal generated by the chaotic semiconductor laser are wider than 4.5 GHz under multiple currents when the temperature is maintained at 18.5℃ .

Key words: chaos; short-cavity; integration; laser; butterfly package

CIOP-2017-1693

Continuous-Wave Brightness Enhancement in an External Cavity Diamond Raman Laser

Zhenxu Bai, Robert J. Williams, Hadiya Jasbeer, Soumya Sarang, Ondrej Kitzler, Aaron Mckay, Richard P. Mildren
MQ Photonics Research Centre, Department of Physics and Astronomy, Macquarie University

Demonstrations of high power continuous-wave (CW) lasers with high brightness have been key solutions to remote sensing and defense. A significant amount of effort has been devoted to improve the laser brightness, however, the extreme thermal load in the active medium has been a primary challenge for currently available high power lasers due to the intrinsic thermal properties of suitable laser materials. At present, diamond possesses record-high thermal conductivity, which makes diamond a promising crystal to withstand extremely high power operation. The high Raman gain coefficient and broad transparency make diamond Raman laser (DRL) a method for extending the wavelength coverage of mature high-power laser sources with high efficiency. Moreover, Raman lasers are capable of beam cleanup that lead to output Stokes beam near-diffraction-limited with a Gaussian shape and enhance beam brightness. Here, we report frequency conversion in an external cavity DRL using highly multi-spatial mode pumping in the continuous wave regime. Brightness enhancement was investigated as a function of input beam quality in the range M_2 of 2.3-3.3 for pumping durations of 0.25 ms, sufficient for steady-state thermal gradients. Up to 389 W pump-limited 1240 nm output is generated with a brightness enhancement factor of 2.7 and M_2 of 1.25. Much higher brightness enhancement factors are predicted for lower beam quality pumps which foreshadows a scalable approach to high brightness continuous wave lasers of Raman-shifted frequency.

Key words: Raman laser; diamond; brightness enhancement; continuous-wave

CIOP-2017-1758

Modelling End-Pumped Electro-Optic Q-Switching Lasers with the Influences of Thermal Effects and Spatial Mode Matching

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Spatial mode matching between the pump and lasing modes and the thermal effects within the laser crystal have important effects on output parameters of diode-end-pumped laser oscillator. A theoretical model for the electric-optic *Q*-switched operation which includes spatial mode matching under thermal effects like thermal lensing effect and thermally induced diffraction loss is developed to directly determine the critical parameters such as pulse energy, peak power and pulse width. A computational approach has been employed by introducing the dimensionless parameters for practical design and analyses of diode-end-pumped lasers. An actively *Q*-switched system with asymmetrical flat-flat dynamically stable resonators which can acquire fairly stable *Q*-switched pulse is exploited to manifest the proposed theoretical model. The experimental results agree well with the theoretical predictions showing that the high accuracy of the proposed model for designing actively *Q*-switched lasers in consideration of both the spatial mode matching and thermal effects.

Key words: lasers; *Q*-switched; spatial mode matching; thermal effects

CIOP-2017-1859

An External-Cavity Faraday Laser at Rb 1529 nm Transition

Pengyuan Chang, Tiantian Shi, Jingbiao Chen, Shengnan Zhang, Haosen Shang, Duo Pan
State Key Laboratory of Advanced Optical Communication Systems and Networks, and Institute of Quantum Electronics, School of Electronics Engineering and Computer Science, Peking University

External-cavity diode lasers are increasingly popular in fundamental research and practical applications due to their compactness and reliability. For various laser spectroscopic measurements and metrological applications, frequency-stabilized lasers are essential and frequency stabilization with long-term stability is very important. In particular, much effort is presently devoted toward the realization of practical laser frequency standards in the telecommunication region (1528 -1563 nm) for the field of multi-wavelength optical communications. However, in conventional 1529 nm optical wavelength standards, the method of utilizing an optically pumped rubidium vapor cell which exhibits resonances at 1529 nm made the whole system costly, bulky and complex. It is highly desirable to devise an approach where excited-state frequency standard do not depend on a frequency-stabilized laser. One promising solution to this problem is by using a Rb electrodeless discharge lamp (EDL)-based excited-state Faraday anomalous dispersion optical filter (LESFADOF), which has many advantages such as high transmission, ultranarrow bandwidth, and high noise rejection. In this work, we experimentally demonstrated a Faraday laser at 1529 nm by using a performance-improved LESFADOF. A cavity mirror provides optical feedback with free spectrum range of 300 MHz, and the LESFADOF successfully limits the laser frequency to the excited-state $5P_{3/2}$-$4D_{5/2}$ of Rb 1529 nm transition. The peak transmission assigned to the transition in the LESFADOF is 46% with a filter bandwidth of 600 MHz. The Allan deviation of the Faraday laser is around 3×10^{-9} at 100s. Laser frequency is always kept in the center of the transmitted peak assigned to $5P_{3/2}$-$4D_{5/2}$ of Rb 1529 nm transition. The external-cavity Faraday laser is highly appreciated for its frequency corresponding to Rb atom excited-state 1529 nm transition while utilizing a EDL instead of a frequency-stabilized laser as a prerequisite to preparing Rb atom from 5S to 5P excited state. Hence the light emitted by the Faraday laser can be used for further research on metrology, microwave photonics and optical communication systems. In addition, this method does not employ any electrical locking schemes, thus, it is small in size and greatly low in complexity. Furthermore, due to the extraordinarily rich spectra of the EDL, this scheme provides a highly novel approach for laser frequency stabilization.

Key words: Faraday filters; external-cavity diode lasers; Faraday laser

CIOP-2017-1943

Mode-Locking of Tm:Lu_2O_3 Laser at 1943 nm with GaSb-Based SESAM

Xinyang Liu, Kejian Yang, Shengzhi Zhao, Tao Li, Christian Kränkel
School of Information Science and Engineering, and Shandong Provincial Key Laboratory of Laser Technology and Application, Shandong University

Using GaSb-based semiconductor saturable absorber mirror (SESAM), a diode-pumped self-starting continuous-wave mode-locked crystalline Tm:Lu_2O_3 laser was realized. Ultra-short pulses with a minimum duration of 14.3 ps, a repetition rate of 90 MHz and a maximum average output power of 115 mW were obtained. The central wavelength of the output laser was 1943 nm.

Key words: mode-locked lasers; ultrafast lasers; infrared and far-infrared lasers

CIOP-2017-1949

RFA-Based 589 nm Guide Star Laser Pulsed at Larmor Frequency

Yan Feng, Lei Zhang, Xuezong Yang
Shanghai Institute of Optics and Fine Mechanics, Chinese Academy of Sciences

Obtaining high resolution images of astronomical objects with ground-based large aperture telescopes is limited by image distortion induced by atmospheric turbulence. Adaptive optics (AO) system can sense and correct atmospheric aberrations in real time. Sodium guide star, generated at ~90 km altitude by 589 nm laser irradiation, is considered as the best choice of AO beacons. It has been widely used in astronomical telescopes. Many works had been done to develop robust 589 nm guide star laser to excite the sodium layer and generate guide star efficiently. The presence of geomagnetic field reduces the brightness of sodium guide star, because the sodium atoms precess along the magnetic field. Guide star laser pulsed at the Larmor frequency was proposed to improve the brightness, because it allows the laser light to interact with the atoms at a fixed point in the precession cycle. But sodium guide star lasers pulsed at this frequency range with enough output power are technically challenging to develop and have not been reported yet. Here we report our recent advancement in developing fiber based guide star laser pulsed at Larmor frequency. A continuous wave 1064 nm and 1120 nm double wavelength laser is modulated at 350 kHz repetition rate with an AOM, and seeds an Yb-Raman integrated fiber amplifier to generate high power pulsed linearly polarized 1120 nm laser. By pulse shaping of the seed laser, the amplifier emits close-to-rectangular pulses at 1120 nm. The high power pulsed 1120 nm fiber laser pumps an 1178 nm narrow linewidth Raman fiber amplifier at backward direction. The generated high power 1178 nm laser is then coupled into a frequency doubling resonator locked with the PDH method. A pulsed 589 nm laser with 17 W average power is demonstrated at a duty cycle of 20 % and a repetition rate of 350 kHz, which is suitable for a geomagnetic field of 0.5 G. The demonstrated laser is an important new development in guide star lasers. Detailed laser design and system performance will be presented at the conference.

Key words: fiber lasers; Raman laser; frequency conversion

CIOP-2017-2016

Generation of Cylindrical Vector Beams in Mode-Locked Fiber Laser Using Mode Selective Coupler

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Advanced Photonic Technology Laboratory, Nanjing University of Posts and Telecommunications

We experimentally obtained cylindrical vector beams in a passively mode-locked fiber laser based on nonlinear polarization rotation. A mode selective coupler composed of both single-mode fiber (SMF) and two-mode fiber (TMF) is incorporated into the cavity to act as a mode converter from LP01 mode to LP11 mode with broad spectral bandwidth. Cylindrical vector beams in different mode-locked states including single-pule, multipulse and bound pulse states have been obtained.
Key words: cylindrical vector beams; mode-locked fiber laser; mode selective coupler; different mode-locked states

CIOP-2017-2030

Direct generation of OAM-Tunable Vortex Laser

Qiyao Liu[1], Yongguang Zhao[2], Manman Ding[2], Deyuan Shen[1]
[1] Department of Optical Science and Engineering, Fudan University; [2] Jiangsu Collaborative Innovation centre of Advanced Laser Technology and Emerging Industry, Jiangsu Normal University

Direct generation of vortex laser with tunable OAM state was researched in an Er:YAG solid-state laser. Based on mode-matching principle, the targeted Laguerre-Gaussian (LG) beams was designed having the largest overlapping efficiency with pump beam through adjusting the cavity parameters. Then effective methods of handedness control for vortex were further explored due to the degeneration always happening between opposite-handed modes. We successfully obtained laser beams with five OAM states, i.e. 0, ±ħ, and ±2ħ, which was expected to offer a new degree of freedom for light source in optical communication systems. Additionally, a reflective volume Bragg grating (VBG) was used as one folding mirror in this Er:YAG laser, and it was found that VBG could be an effective wavelength selector for vortex beams without deteriorating the OAM integrity. Such property opens the possibility of multiplexing information channels simultaneously with OAM and the conventionally used wavelength domains in packaged and robust resonant cavity.
Key words: vortex; OAM; solid-state laser; optical communication

CIOP-2017-2128

The Time Resolved SBS and SRS Research in Heavy Water and Its Application in CARS

Baodong Gai[1], Hong Yuan[1], Jinbo Liu[1], Jianfeng Sun[2], Xin Zhou[2], Di Liu[2], Shu Hu[1], Ying Chen[1], Jingwei Guo[1], Yuqi Jin[1], Fengting Sang[1], Pengyuan Wang[1]
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[2] National Key Institute of Tunable Laser Technology, Harbin Institute of Technology

We present the time resolved character of stimulated Brillouin scattering (SBS) and backward stimulated Raman scattering (BSRS) in heavy water and its application as a robust laser source in Coherent Anti-Stokes Raman Scattering (CARS) technique. A nanosecond laser pulse from a frequency-doubled Nd: YAG laser was introduced into a cell filled with heavy water that with SRS and SBS activity, to generate SBS and BSRS beams. The SBS and BSRS beams are excellent collinear, and their time resolved property are studied by streak tube, experimental results show that the stimulated scattering beams generated by this method is ideally compact, low-cost and robust source for the CARS system, possible method to improve the system is also discussed .
Key words: stimulated Brillouin scattering; stimulated Raman scattering; coherent anti-stokes Raman scattering

CIOP-2017-2150

A Tunable Long-Cavity Passive Mode-Locked Fiber Laser Based on Nonlinear Amplifier Loop Mirror

Junli Chang, Pinghe Wang
University of Electronic Science and Technology of China

In this paper, we demonstrate long-cavity passive mode-locked fiber laser. The mode locker is a nonlinear amplifying loop mirror (NALM). The cavity frequency of the laser is 465 kHz because that 404 m SMF is inserted in the cavity. A tunable bandpass filter with ~1 nm 3 dB bandwidth is inserted into the cavity to realize tunable mode locking. The passive mode-locked laser at a fixed wavelength is investigated in detail. The experimental results indicate that the laser operates in dissipative soliton resonance (DSR) region. When the pump power is 400 mW, the laser generates the rectangular pulses with 10.58 ns pulse duration, 70.28 nJ single-pulse energy. When the pump power is 400 mW, the laser keeps stable mode locking status in the range from 1523.4 nm to 1575 nm. During the whole tuning range, the SNR ,the pulse duration, the output power and single pulse energy have a little fluctuation because that the gain of the EDF changes with the wavelength.
Key words: mode-locked laser; tunable filter; dissipative soliton resonance

CIOP-2017-2222

A 13.8-W, High-Efficiency, Horizontal-cut Tm, Ho:YAP Laser Pumped by Two Laser Diodes

Linjun Li, Xining Yang, Guangchao Ye, Long Zhou, Yunfeng Bai
Heilongjiang Institute of Technology

We report a high-power, high-efficiency Tm,Ho:$YAlO_3$ (Tm,Ho:YAP) laser pumped by two laser diodes. The Tm (fraction, 5%) and Ho (0.3%):YAP crystal is cut along the horizontal axis, and the size of the resulting crystals is 4 mm x 4 mm x 8 mm. The laser crystal is double end-pumped by two 18.0- W fiber-coupled laser diodes at 793.6 nm, and the output power of the Tm,Ho:YAP laser is 13.8 W in continuous wave (CW) mode operation. An optical-optical conversion efficiency of 38.3% is acquired, corresponding to a slope efficiency of 40.6%.
Key words: high efficiency; CW; Tm,Ho: YAP crystal; laser diode

CIOP-2017-2254

Efficient Yb:LuYAG Mixed Crystal Microchip Laser

Dimeng Chen, Jun Dong
Laboratory of Laser and Applied Photonics (LLAP), Department of Electronics Engineering, Xiamen University

Ytterbium-doped crystals have been intensely investigated for generating short pulses and high peak power in solid-state laser around 1 μm. Yb:YAG and Yb:LuAG crystals are two dominant laser gain medias used for solid-state lasers owing to the excellent optical, thermal, chemical, and mechanical properties. Mixing Lu^{3+} and Y^{3+} compositions to form Yb:$(Lu_xY_{1-x})_3Al_5O_{12}$ (Yb:LuYAG) mixed crystal is extremely attractive to be gain medium. The disordered crystal structure resulting from the mixing of the two compositions could induce a spectral broadening of the absorption band, providing a broader range well suited for laser diode pumping; the melting point of the LuYAG is lower than LuAG by several tens of K, resulting in an easier crystal growth; the preparation of LuYAG in comparison with LuAG requires a smaller amount of high purity Lu_2O_3 powder, which is very expensive. On the other hand, LuYAG has a high thermal conductivity, similar to LuAG, which should be almost unaffected by Yb^{3+} doping, providing an advantage over YAG at high doping levels. In this work, optical properties and laser performance of Yb:LuYAG mixed crystal were investigated and compared to Yb:YAG single crystal. There are four absorption peaks centered at 916 nm, 938.7 nm, 968 nm and 1030 nm, respectively. The absorption band-width of Yb:LuYAG mixed crystal centered at 938.7 nm was measured to be 22.6 nm, which is about 2.9 nm wider than that of Yb:YAG crystal. The absorption cross-section at 938.7 nm was measured to be 0.72×10^{-20} cm^2 and the emission cross-section was measured to be 2×10^{-20} cm^2 at 1030 nm, which is comparable to that of Yb:YAG single crystal (2.2×10^{-20} cm^2). The excellent optical properties of the Yb:LuYAG mixed crystal show that the Yb:LuYAG mixed crystal is very suitable for laser diode pumping and huge-pulses laser generation in passively Q-switched lasers. Continuous-wave laser operation of the Yb:LuYAG mixed crystal pumped by high -brightness single emitter laser diode has been demonstrated at room temperature for the first time. A 0.7-mm-thick Yb:LuYAG crystal plate doped with 10% Yb^{3+}-ions was used as the gain medium, four plane-parallel 2 mm-thick BK7 with different reflectivity (ROC) of 80%, 85%, 90%, 95% at 1030 nm were used as output couplers to compare the laser performance. The optimal reflectivity of the output coupler has been found to be 90% for achieving highly efficient laser performance. The output power increases linearly with the absorbed pump power and the slope efficiency was 73.7%. The maximum output power of 1.12 W was measured at the absorbed pump power of 1.65 W. The corresponding optical-to-optical efficiency was as high as 67.6%, which is the highest efficiency achieved in microchip laser with rare-earth ions doped LuYAG materials as gain medium to our best knowledge. The Yb:LuYAG laser oscillates in multi-longitudinal modes owing to the broad emission spectrum of Yb:LuYAG mixed crystal. Excellent laser performance of Yb:LuYAG mixed crystal indicates that Yb:LuYAG mixed crystal could be a potential candidate for high power and high energy solid state lasers.
Key words: Yb:LuYAG; mixed crystal; microchip laser; optical properties

CIOP-2017-2255

Bundle Multi-FM Beam Smoothing by Spectral Dispersion Technology

Tianran Zheng[1], Ying Zhang[2]
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[2] Research Center of Laser Fusion, China Academy of Engineering Physics

In research of inertial confinement fusion, laser plasma interaction (LPI) problem is a key issue that affects ignition. Many beam smoothing technologies were proposed and adopted to suppress laser plasma instabilities. Smoothing by spectral dispersion (SSD) combined with continuous phase plate (CPP) and polarization smoothing (PS) is the mainstream beam smoothing technology at present. Single-beam smoothing technologies were widely studied both theoretically and experimentally. However，actual laser drivers may adopt a bundle of beams focusing on one point. Additionally, adding more laser beams into a bundle is a development trend of high power laser drivers. Besides, LPI is still one of the most important problems in the ignition process, eager for new beam smoothing technology. To obtain a smoother focal spot, bundle Multi-FM SSD were proposed and studied. Traditional Multi-FM SSD adopts multi-frequency

modulation in one single beam. Bundle Multi-FM SSD adopts one modulation frequency in one single beam, and then a bundle of beams with different modulation frequencies focuses on one point. By using this novel technology, the number of frequency modulators can be decreased especially when more beams are adopted in one bundle. Simulation results indicate that the contrast caused by interference between single beams can be decreased and the uniformity of far field intensity distribution can be improved by using this novel beam smoothing technology. Compared with traditional Multi-FM SSD, a more uniform focal spot can be achieved when the number of color cycles is close to practical situation.
Key words: inertial confinement fusion; smoothing by spectral dispersion; bundle of beams; multi-frequency modulation; illumination uniformity

CIOP-2017-2480

Reflection and Transmission of Vector Bessel Vortex Beam from Uniaxial Anisotropic Slab

Liujia Wei, Lihai Ying, Wuzhen Sen, Bai Lu, Lizheng Jun
School of Physics and Optoelectronic Engineering, Xidian University

Shaped vortex beams with orbit angular momentum (OAM) have vast potential applications in the fields of optical manipulation, quantum and optical information, optical detection. Since the Laguerre-Gaussian (LG) beam was demonstrated to possess OAM, the generation methods, propagation characteristics and application of light beams with OAM have been attracting great attention of many scholars. The interaction of light beams with different media is an important topic that has been extensively studied in the past several decades. As a typical vortex beam, characteristics of the high-order Bessel beam have been developed widely. With the increasing applications of anisotropic media in optical signal processing, optical fiber designing, radar cross section controlling, interactions between anisotropic media and beams have been intensively investigated, Understanding the effects of various media on vortex beam propagation is an important premise to study their potential applications. The reflection and transmission of vector Bessel vortex beams from a uniaxial anisotropic slab are investigated in this work. Based on the cylindrical vector wave function expansion and Fourier transform method, the reflection and transmission characteristics of vector Bessel vortex beam incident on a homogeneous uniaxial anisotropic slab are studied. Firstly, making use of the relationship between spherical vector wave functions and cylindrical vector wave functions, the beam coefficients of arbitrary polarized vector Bessel vortex beams are deduced, and their applicable conditions are checked. Secondly, the electromagnetic fields of the incident vector Bessel vortex beam, the reflected beam and the transmitted beam are expressed by cylindrical vector wave functions directly. With the help of Fourier transform method, the electromagnetic fields of the internal beam in the uniaxial anisotropic media are also expressed in detail. Then, according to the boundary conditions of electromagnetic fields on the dielectric interfaces, equations of all the unknown coefficients of the reflected beam, the transmitted beam and the internal beam are given. The unknown coefficients are obtained by solving these equations. Finally, the complete expressions of fields for all spaces can be obtained. Numerical results of the intensity magnitude distributions of the reflected beam, the transmitted beam and the internal beam are simulated. The effects of beam's half-cone angle, the incident angle, the topological charge, the thickness of the slab, and the dielectric tensor of the uniaxial anisotropic media are discussed. The methods we provide here can be applied to the propagation of vector Bessel vortex beam in other kinds of anisotropic media conveniently. The results presented in this work are important for the propagation of vector Bessel vortex beams in uniaxial anisotropic media and provide the opportunity for a wide application of the Bessel vortex beams in areas such as optical information, optical detection, and vortex wave communication.
Key words: uniaxial anisotropic slab; vector Bessel vortex beam; reflection and transmission

CIOP-2017-2547

Generation of Polarization Locked Vector Solitons in Mode-Locked Thulium-Doped Fiber Laser

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[2] Jiangsu Key Laboratory of Advanced Laser Materials and Devices, School of Physics and Electronic Engineering, Jiangsu Normal University

As an attractive platform for investigating solitary wave dynamics, ultrafast fiber lasers have drawn numerous interests. The potential applications of vector solitons in nanophotonics, high precision spectroscopy, and expanding the optical communication capacity based on polarization division multiplexing (PDM) and polarization switch are stirring up more and more explorations. We report on polarization locked vector solitons generation in a linear thulium-doped fiber laser. The fiber laser was made of all-anomalous-dispersion fibers and passively mode locked with a semiconductor saturable absorber mirror. Extra "peak-dip" spectral sidebands were clearly visible on the polarization resolved optical spectra, indicating coherent energy exchange between the two polarization components of vector solitons.
Key words: polarization-locked; vector solitons; four-wave-mixing; birefringence.

CIOP-2017-1862

Influence of Deposition Parameter on Structures and Nonlinear Optical Properties of IB Group Elements Doped ZnO Nanostructures

Kexin Zhang, Xing Wen
Harbin Normal University

IB group elements doped ZnO nanostructures with different deposition parameter were grown using magnetron sputtering technique. The detailed study has been carried out for the effect on the ?lm properties comes from the component, substrate temperature, annealed temperatures, and annealed atmosphere. The structural and morphological of samples are systematically investigated by X-ray diffraction (XRD) and scanning electronic microscopy (SEM), respectively. The results show that the Ag- doped ZnO (AZO) and Cu- doped ZnO (CZO) films can maintain a wurtzite structure. Moreover, the optical transmittance spectra of AZO and CZO films show a transmittance of 70%~80% within the visible wavelength region. The Ag and Cu atoms exert a significant impact on emission by creating the localized energy levels inside the ZnO band gap. Furthermore, the open-aperture Z-scan measurements of the ?lm were realized by nanosecond laser pulse. These samples show two-photon absorption behavior, and the two-photon absorption coefficient of AZO and CZO films is higher than that of pure ZnO film. Our results show that AZO and CZO ?lms are promising candidates in further opto-electronic device applications.

Key words: nano-films materials; semiconductor materials; nonlinear optical properties

Session 10: Quantum Optics and Quantum Information Technology

Chairs: **Qiang Zhang**, University of Science & Technology of China, China
Chaoyang Lu, University of Science & Technology of China, China
Fuguo Deng, Beijing Normal University, China
Sven Hoefling, University of Wuerzburg, Germany

Location: B511, 5F, Main Building, Harbin Institute of Technology No.2 Campus

18th July

13:40-13:55	**Point Piezo Stage Presentation (Oral-Industry)** Hongyu Chen, Natsu Electromechanical	
Chair: Chaoyang Lu, University of Science and Technology of China, China		
14:00-14:45	**Long Distance Quantum Communication Network in China (Keynote)** Yu-Ao Chen *University of Science and Technology of China, China*	- 188 -
14:45-15:15	**(TBA) (Invited)** Xianmin Jin *Shanghai Jiao Tong University, China*	- 190 -
15:15-15:45	**Programmable Quantum Emitter Arrays and Spin-Orbit Coupled Superlattices of Moirè Excitons (Invited)** Hongyi Yu *The University of Hong Kong, China*	- 191 -
15:45-16:00	**Coffee Break**	
Chair: Yu-Ao Chen, University of Science and Technology of China, China		
16:00-16:30	**Multi-Photon Quantum Boson-Sampling Machines (Invited)** Chaoyang Lu *University of Science and Technology of China, China*	- 192 -
16:30-17:00	**OAM Sorting, Imaging and Sensing with Twisted Photons (Invited)** Lixiang Chen *Xiamen University, China*	- 193 -
17:00-17:30	**SNSPDs and Its Applications for Quantum Information in SIMIT (Invited)** Weijun Zhang *Shanghai Institute of Microsystem and Information Technology, CAS, China*	- 194 -
17:30-18:00	**Photonic Quantum Information Processing with Orbital Angular Momentum (Invited)** Xilin Wang *University of Science and Technology of China, China*	- 195 -
18:00-19:00	**Dinner Time**	

19th July

Chair: Xinlun Cai, Sun Yat-sen University, China		
09:00-09:30	**Quantum Communication and Imaging with Photons (Invited)** Feihu Xu *Massachusetts Institute of Technology, USA*	- 196 -
09:30-10:00	**Space-Based Quantum Communication Towards Global Quantum Network (Invited)** Juan Yin *University of Science and Technology of China, China*	- 197 -
10:00-10:30	**Strong Light-matter Interactions Based on Graphene Plasmon (Invited)** Qing Dai *National Center for Nanoscience and Technology, China*	- 198 -
10:30-10:45	**Generating Quantum States of light from Monolithic Chips (Oral)** Dongpeng Kang *Harbin Institute of Technology, China*	- 204 -
10:45-11:00	**Coffee Break**	
Chair: Feihu Xu, Massachusetts Institute of Technology, USA		
11:00-11:30	**Integrated Cavity-Optomechanical Circuits Towards a Photonic-Phononic Quantum Interface (Invited)** Kejie Fang *California Institute of Technology, USA*	- 199 -

19th July

11:30-12:00	**Photonic Integrated Devices for Quantum Key Distributions (Invited)** Xinlun Cai *Sun Yat-sen University, China*	- 200 -
12:00-12:15	**GHz InGaAs/InP Single-Photon Detection with Ultrashort Gates (Oral)** Zinan Huang[1], Min Yu[1], Heping Zeng[2], Yan Liang[1] *[1] Shanghai University of Science and Technology, China; [2] East China Normal University, China*	- 204 -
12:15-14:00	**Lunch Time**	
13:40-13:55	**Quantum Optics Laser Solutions (Oral-Industry)** Ming Lu, PulsePower Technology Ltd	
Chair: Qing Dai, National Center for Nanoscience and Technology, China		
14:00-14:30	**2-Dimensional Spin-Orbit Coupling of Ultracold Bose Gas in Optical Lattices (Invited)** Shuai Chen *University of Science and Technology of China, China*	- 201 -
14:30-15:00	**A Deterministic Quantum Dot Micropillar Single Photon Source for Quantum Photonics (Invited)** Ying Yu *Sun Yat-sen University, China*	- 202 -
15:00-15:30	**From Photonics Integration to Quantum Integration (Invited)** Wenfu Zhang *Xi'an Institute of Optics and Precision Mechanics, CAS, China*	- 203 -
15:30-15:45	**Coffee Break**	
15:30-16:00	**Poster**	
18:00-20:00	**Banquet**	

Yu-Ao Chen
University of Science and Technology of China, China

Note

Long Distance Quantum Communication Network in China

ABSTRACT

Driven by the initial curiosity in Bell's inequality, the last few decades have witnessed tremendous progress in the coherent control of individual quantum systems, which has subsequently led to a gradual transition from the fundamental physics to potential practical technologies. Today, there have been already some quantum communication networks constructed that allow practical applications in the metropolitan area. Based on linear optics, a number of progresses have been made along quantum computing, quantum simulation and quantum metrology. However, scalable quantum information processing still faces major challenges. In particular, the distance of fiber-based quantum communications is limited due to intrinsic fiber loss and decreasing of entanglement quality. Moreover, probabilistic single-photon source and entanglement source demand exponentially increased overheads for scalable quantum information processing. While quantum repeaters are practically still challenging, based on truthful relays, we have built world's biggest quantum secure communication backbone, from Beijing to Shanghai, with a distance exceeding 2000 km. Another line is satellite-based global quantum communication, taking advantage of the negligible photon loss and decoherence in the atmosphere. We realized teleportation and entanglement distribution over 100 km, and later on a rapidly moving platform. Based on the developed technologies, the first quantum science satellite 'Micius' has been launched on 16th Aug, 2016. 'Micius' will establish the first secure QKD from the satellite to the ground with kHz rate over a distance up to 1200 km, which is about 20 orders of magnitudes more efficient than using telecommunication optical fibers as quantum channel, will test the contradiction between Einstein's local realism and quantum mechanics for the first time at space-scale, and more ambitiously will teleport an unknown quantum state from the ground station to the satellite. The Quantum Science Satellite is expected to enable intercontinental secure communications and provide a platform for more fundamental tests in the future.

BIOGRAPHY

Under the mentorship of Prof. Jian-Wei Pan, Yu-Ao Chen received his master's degree from the University of Science and Technology of China (USTC) in 2004 and his Ph.D. degree from the University of Heidelberg in 2008. He then joined the QUANTUM group led by Prof. Immanuel Bloch in the University of Mainz as a postdoctoral researcher. He subsequently moved with the group to Max-Planck Institute for Quantum Optics and the Ludwig-Maximilians University, where he became the project leader for the experiment of ultracold bosonic quantum gases in optical super-lattices. In 2011, Yu-Ao was selected as a "Thousand Youth Talents Plan" scholar by the "Recruitment Program of Global Experts" and then appointed as a professor at USTC. In recognition of "outstanding achievements in the

fields of multi-photon entanglement, quantum communication, quantum computation and quantum simulation based on manipulation of photons and atoms", the European Physical Society recently awarded Yu-Ao the 2013 Fresnel Prize for fundamental aspects. And later Yu-Ao received the "Qiu Shi Outstanding Youth Scholar", one of the most prestigious awards for young scientist in China, from Qiushi Science & Technologies Foundation. His current research focuses on quantum manipulation of photons and atoms including the further development of multi-photon entanglement research, fundamental research on long-distance free-space quantum communication, exploration of atomic-ensemble based quantum memory and the study of ultra-cold atoms in optical lattices based quantum many body physics. Meanwhile, since 2013, he was appointed as the Chief Engineer for Quantum Communication Beijing-Shanghai Backbone project, which aiming a quantum secure communication network from Beijing to Shanghai over more than 2000 kilometers.

Note

Xianmin Jin
Shanghai Jiao Tong University, China

Note

Programmable Quantum Emitter Arrays and Spin-Orbit Coupled Superlattices of Moiré Excitons

Hongyi Yu
The University of Hong Kong, China

Note

ABSTRACT

Highly uniform and ordered nanodot arrays are crucial for high performance quantum optoelectronics including new semiconductor lasers and single photon emitters, and for synthesizing artificial lattices of interacting quasiparticles towards quantum information processing and simulation of many-body physics. Van der Waals heterostructures of 2D semiconductors are naturally endowed with a strictly ordered nanoscale landscape, i.e. the moiré pattern that laterally modulates electronic and topographic structures. Here we find these moiré effects realize superstructures of nanodot confinements for long-lived interlayer excitons, which can be either electrically or strain tuned from perfect arrays of quantum emitters to excitonic superlattices with giant spin-orbit coupling (SOC). Besides the wide range tuning of emission wavelength, the electric field can also invert the spin optical selection rule of the emitter arrays. This unprecedented control arises from the gauge structure imprinted on exciton wavefunctions by the moiré, which underlies the SOC when hopping couples nanodots into superlattices. We show that the moiré hosts complex-hopping honeycomb superlattices, where exciton bands feature a Dirac node and two Weyl nodes, connected by spin-momentum locked topological edge modes. With the observed long lifetime and spin dependent interaction, these moiré excitons provide an exciting Bose-Hubbard system with versatile controllability for exploring exotic quantum phases.

BIOGRAPHY

2000 - 2004, Bachelor of Physics
Department of Physics, Peking University
2004 - 2010, PhD in Physics
Institute of Physics, Chinese Academy of Sciences
2010 - 2015, Postdoctor
The University of Hong Kong
2016 - now, Research Assistant Professor
The University of Hong Kong

Current research interest: Valley and spin physics of excitons in 2D layered semiconductors.

Chaoyang Lu
University of Science and Technology of China, China

Note

Multi-Photon Quantum Boson-Sampling Machines

ABSTRACT

Boson sampling is considered as a strong candidate to demonstrate the "quantum supremacy" over classical computers. However, previous proof-of-principle experiments suffered from small photon number and low sampling rates owing to the inefficiencies of the single-photon sources and multi-port optical interferometers. In this talk, I will report two routes towards building Boson Sampling machines with many photons.

In the first path, we developed SPDC two-photon source with simultaneously a collection efficiency of ~70% and an indistinguishability of ~91% between independent photons. With this, we demonstrate genuine entanglement of ten photons. Such a platform will provide enabling technologies for teleportation of multiple properties of photons and efficient scattershot Boson Sampling.

In the second path, using a QD-micropillar, we produced single photons with high purity (>99%), near-unity indistinguishability for >1000 photons, and high extraction efficiency—all combined in a single device compatibly and simultaneously. We build 3-, 4-, and 5-bosonsampling machines which runs >24,000 times faster than all the previous experiments, and for the first time reaches a complexity about 100 times faster than the first electronic computer (ENIAC) and transistorized computer (TRADIC) in the human history [5,6]. Our architecture is feasible to be scaled up, and might provide experimental evidence against the Extended Church-Turing Thesis.

BIOGRAPHY

Chao-Yang Lu received his PhD from University of Cambridge and is a Professor of Physics at the University of Science and Technology of China. Lu has published 36 articles in Rev. Mod. Phys., Nature, Nature research journals, PNAS and PRL. His work on teleportation was selected "Physics World Breakthrough of the Year 2015". He has been awarded Fellowship from Churchill College, National Thousand Talent, Hong Kong Qiushi Outstanding Young Scholars, USTC Young Faculty Career Award. He is the PI of 8 research grants with a total value >2.5 M €.

OAM Sorting, Imaging and Sensing with Twisted Photons

Lixiang Chen
Xiamen University, China

Note

ABSTRACT

Twisted photons carry quantized orbital angular momentum states that can be utilized to construct a high-dimensional Hilbert space. Here, I will talk about the research progress achieved with twisted photons in our labs over the past few years, which includes: (1) A high-efficiency method to sort the orbital angular momentum of single photons based on photonic spin-orbit coupling effect; (2) The quantum version of digital spiral imaging that can be exploited to probe pure phase objects. (3) 120 m free-space remote sensing of spinning objects with turbulence based on the rotational Doppler effect.

BIOGRAPHY

Lixiang Chen is currently a professor of Optics in the department of Physics at Xiamen University. His research interest mainly focuses on nonlinear optics, optical communication, and quantum information with structured light, particularly, with photon orbital angular momentum. He has published nearly 50 papers in physical/optical journals including Physical *Review Letters*, *Light: Science & Applications*, *Laser & Photonics Reviews,* etc. Some of these papers were published as a Cover story, Editors Suggestion, or highlighted by Nature China, Word Scientific, or selected for “2014 China’s Optics Important Achievement”. He has won the 2nd class “Rao Yutai award for fundamental optics”, and the program for New Century Excellent Talents in University of China.

Weijun Zhang
Shanghai Institute of Microsystem and Information Technology, Chinese Academy of Sciences (SIMIT, CAS), China

Note

SNSPDs and Its Applications for Quantum Information in SIMIT

ABSTRACT

In this talk, I will introduce our work on SNSPD and its applications for quantum information in SIMIT, CAS.

1. High detection efficiency SNSPDs for the wavelengths from the visible to near infrared;

2. How to reduce the dark count rate of SNSPD by the on-chip film narrow-bandpass filter, and by an on-fiber bandpass filter;

3. Applications of SNSPD in quantum information and others.

BIOGRAPHY

Weijun Zhang received his Ph.D. degree in condensed matter physics from Institute of Physics, Chinese Academy of Sciences (CAS), Beijing, China, in 2012. He is currently an Associate Researcher of the SNSPD Group in Shanghai Institute of Microsystem and Information Technology, Chinese Academy of Sciences. His current research interests include superconducting nanowire single-photon detectors, superconducting devices and physics, and electrical and magnetic properties of nanostructures.

Photonic Quantum Information Processing with Orbital Angular Momentum

Xilin Wang
University of Science and Technology of China, China

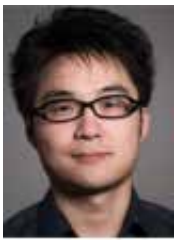
Note

ABSTRACT

Orbital angular momentum (OAM) arising from the helical phase structure of a photon could be used to encode a qubit or a qudit. It plays an important role for the photonic quantum information processing since it could result in some unique functions such as entanglement with high momentum, and alignment-free communication. In this talk, I will start with a brief introduction to OAM and a short review of the recent advances in OAM application in quantum information processing. Then, I will in particular talk about our work using OAM and spin angular momentum (SAM) to implement the first quantum teleportation of multiple degrees of freed om (DoFs) of a single photon [Nature 518, 516-519 (2015)]. Now, together with the production technology of new entanglement photon source developed in our recent work of ten-photon entanglement [Phys. Rev. Lett. 117, 210502 (2016)], we are striving hard to generate the six-photon eighteen-qubit entanglement with three degrees of freedom of a photon including SAM, OAM and path.

BIOGRAPHY

Xi-Lin Wang now is a research professor at the University of Science and Technology of China. His research interest focuses on photonic quantum information processing with multi photons in multiple degrees of freedom including polarization, orbital angular momentum and path. As first author, he published the work on quantum teleportation with multiple degrees of freedom in 2015 [Nature 518, 516-519 (2015)], which was elected as “Breakthrough of the Year 2015” by IOP Physics World. In 2016, he generated ten-photon entanglement as first author [Phys. Rev. Lett. 117, 210502 (2016)], which set a new world record. In addition, based on orbital angular momentum, he had made systematic contributions in the field of classical optics by manipulation of optical vector fields including generation and application of different optical vector fields, and published 18 articles (5 as first author) in peer-reviewed journals.



Feihu Xu
Massachusetts Institute of Technology, USA

Note

Quantum Communication and Imaging with Photons

ABSTRACT

Quantum technology is believed to the second revolution of information processing. In this talk, I will present two important advances in quantum information processing: quantum communication and quantum imaging. 1) Quantum communication can provide unconditional security for data transmission. This is the technology at the basis of the famous quantum satellite “Mozi”. In the first part, I will present our recent developments in quantum cryptography, including practical security, Si photonic-chip based quantum key distribution (QKD) and measurement-device-independent (MDI) QKD. 2) Quantum imaging involves the detection and timing of single photons to beat classical limits. In the second part, I will address how to perform accurate 3D imaging with a single-photon camera at a light level of one photon per pixel. Our novel photon-efficient imaging systems can allow us to achieve long-range dynamic sensing, see around corners and push the limits of imaging technology in widespread applications.

BIOGRAPHY

Feihu Xu is the recipient of Thousand Young Talents Program (2017) and will join the University of Science and Technology of China (USTC) as a Professor in Sep. 2017. He is currently a Postdoctoral Associate at the Research Laboratory of Electronics, Massachusetts Institute of Technology (MIT). He works on quantum information processing and single-photon imaging, and has published several Journal papers in *Nature Photonics*, *Nature Communications*, *Physical Review Letters*, etc. His research has been featured in major media outlets including The Economist, Nature News and Physics World. He is the recipient of Canadian NSERC Postdoc Fellowship (ranking No. 1 in Electrical Engineering), Best Student Paper Award in QCrypt2014, and OCPA Outstanding Dissertation Award. He received an M.Sc and Ph.D in Electrical and Computer Engineering from the University of Toronto in 2011 and 2015, and a B.Sc from USTC in 2009.

Space-Based Quantum Communication Towards Global Quantum Network

Juan Yin
University of Science and Technology of China, China

Note

ABSTRACT

Quantum communication is proven to be the only unconditionally secure method for information exchange, which could well be the first commercial application of quantum information science. Compared with fiber-based demonstrations, free-space links could provide a more promising approach because photon loss and decoherence are almost negligible in the atmosphere. Furthermore, by using satellites, ultra-long-distance quantum communication and tests of quantum foundations could be achieved on a global scale. Here we report a serial of experimental progresses on free-space quantum communication over long distance. In the meantime, besides the experimental efforts on the ground, Chinese Quantum Science Satellite has been launched on August 16th 2016. And we will introduce the latest achievements in satellite-based quantum communication and large-scale tests of quantum foundations obtained through Micius.

BIOGRAPHY

Juan Yin is an associate researcher for experimental physics at University of Science and Technology of China (USTC). Her research interest mainly focuses on entanglement based quantum communication and fundamental tests of quantum mechanics with linear optics. In 2012, she was appointed as chief designer of the first space-borne entangled source payload in Micius and the corresponding ground experimental stations. The quantum science satellite was launched on August 16th, 2016, which will realize a space-earth wide-area quantum communication for the first time in the world.

Qing Dai
national Center for Nanoscience and Technology, China

Note

Strong Light-Matter Interactions Based on Graphene Plasmon

ABSTRACT

Graphene plasmon provides a platform for strong light-matter interactions due to its ultrahigh confinement and low intrinsic damping, which opens up possibilities to explore room-temperature quantum devices. We experimentally studied the properties of graphene plasmon. Strong coupling between graphene plasmon and optical phonons in monolayer h-BN has been demonstrated. The graphene plasmon mode is split into distinct optical modes that display anticrossing behavior near the h-BN phonons at 820 and 1370 cm-1. This hybridization can be dynamically tuned via electrostatic gating. Based on this strong light-matter interaction, we realized molecular sensor with ultra high sensitivity. The mid-infrared fingerprint spectra of 8 nm thick PEO film have been enhanced more than 20-fold and can be directly detected. In addition, undisturbed and highly confined graphene plasmon offers simultaneous detection of in-plane and out-of-plane vibrational modes with ultrahigh detection sensitivity down to the sub-monolayer level. Our results pave the way for study of cavity quantum electrodynamics and single-plasmon devices based on graphene plasmon.

BIOGRAPHY

Qing Dai received the BEng and MEng from Imperial College, London, before coming to the University of Cambridge to pursue a PhD in Nanophotonics at the Department of Engineering. After completing his PhD in 2011, he continued as a Research Associate at Centre of molecular materials for photonics and electronics. Since 2012, he was recruited by the thousand talents program of China and then joined National Center for Nanoscience and Technology where he is a professor in Nanophotonics.

Integrated Cavity-Optomechanical Circuits Towards a Photonic-Phononic Quantum Interface

Kejie Fang
California Institute of Technology, USA

Note

ABSTRACT

Hybrid quantum architecture, harnessing the distinctive advantages of the constituent physical systems, is anticipated to benefit universal quantum information processing and quantum computating. Photons and phonons, residing on disparate energy scales yet both being able to interact with a plethora of physical systems, can play a critical role for interconnections in such hybrid quantum architecture. In this regard, understanding and engineering the interaction between phonons and photons in micro- and nano-scale structures is of great importance. In this talk, I will present the work on developing integrated cavity-optomechanical circuits towards a photonic-phononic quantum interface. I will first introduce a novel chip-scale device platform that interfaces light and sound: optomechanical crystals, which allows for simultaneous engineering of artificial optical and mechanical properties in scalable thin-film structures with unprecedented photon-phonon interaction strength. Based on this platform, I will show a traveling wave photon-phonon translator integrated on silicon microchips to realize radiation-pressure controlled microwave phonon routing and waveguide-mediated distant phonon coupling. Using the techniques of synthetic magnetism and reservoir engineering, I will also show an optomechanical circuit that works as a directional optical amplifier with >35 dB distinction ratio and >12 dB amplification, and is projected added noise close to standard quantum limit.

BIOGRAPHY

Kejie Fang is a Senior Research Scientist in Applied Physics at California Institute of Technology. He received B.S. in physics from Peking University, and M.S. in electrical engineering, Ph.D. in physics, both from Stanford University. His research interests include optomechanics, nanophotonics, and quantum optics, with a theme to develop novel chip-scale devices and systems for applications in quantum information processing and quantum metrology. He has published multiple papers in Nature Physics, Nature Photonics, and Phys. Rev. Lett. In 2018, he will start as assistant professor in the ECE department of University of Illinois at Urbana-Champaign.

Xinlun Cai
Sun Yat-sen University, China

Photonic Integrated Devices for Quantum Key Distributions

ABSTRACT

The rules of quantum mechanics enable applications in information technologies that are inherently more powerful than their classical counterparts. Quantum key distribution now makes it possible to transmit information with unconditional security. The next generation of quantum key distribution requires sophisticated photonic integrated devices. This talk will review the recent efforts in developing the devices in Sun Yat-sen University.

BIOGRAPHY

Since 2014, Professor, Sun Yat-sen University, Guagnzhou, China

2012-2014, Research Assistant, School of Physics, University of Bristol, UK

2012, Doctoral degree in Electrical and Electronics，University of Bristol, UK

2004, Bachelor of Optoelectronics, Huazhong University of Science and Technology, Hubei, China

Note

2-Dimensional Spin-Orbit Coupling of Ultracold Bose Gas in Optical Lattices

Shuai Chen
University of Science and Technology of China, China

ABSTRACT

Cold atoms with laser-induced spin-orbit (SO) interactions provide a platform to explore quantum physics beyond natural conditions of solids. Here we propose and experimentally realize two-dimensional (2D) SO coupling and topological bands for a rubidium-87 degenerate gas through an optical Raman lattice, without phase-locking or fine-tuning of optical potentials. A controllable crossover between 2D and 1D SO couplings is studied, and the SO effects and nontrivial band topology are observed by measuring the atomic cloud distribution and spin texture in momentum space. Our realization of 2D SO coupling with advantages of small heating and topological stability opens a broad avenue in cold atoms to study exotic quantum phases, including topological superfluids.

BIOGRAPHY

Note

Ying Yu
Sun Yat-sen University, China

Note

A Deterministic Quantum Dot Micropillar Single Photon Source for Quantum Photonics

ABSTRACT

Bright and indistinguishable single photons are one of key elements in photonic quantum technologies, such as quantum teleportation, optical quantum networks, and Boson sampling devices for intermediate quantum computing tasks. In recent years, bright and indistinguishable single photons are mostly achieved in quantum dot-micropillar systems due to the large Purcell effect and the excellent suppression for the resonant laser. In this talk, we will discuss how can we determine the position of single quantum dots (QDs) in planar distributed Bragg reflector (DBR) cavities using the photoluminescence imaging technique. We will also demonstrate some results on QD single-photon sources in micropillar cavities and integrated orbital angular momentum modes (OAM) quantum light sources.

BIOGRAPHY

Ying Yu received her PhD degree in Condensed Matter Physics from the Institute of Semiconductors, Chinese Academy of Sciences, China, in 2014. She is currently a lecturer in School of Electronics and Information Technology at Sun Yat-sen University, Guangzhou, China. Her research mainly focuses on the self-assembled Ⅲ - Ⅴ quantum dots, nanocavities (nanowire, micropillar) and their applications in quantum light sources.

From Photonics Integration to Quantum Integration

Wenfu Zhang
Xi'an Institute of Optics and Precision Mechanics of CAS, China

Note

ABSTRACT

Nonclassical light sources are the backbone for future applications in quantum optics area including quantum communications and computations. Yet they have been severely limited to the large size, weight, and power of a complex system with emission of just a few photons. Thanks to the availability of CMOS fabrication technology and the property of high index contrast, the functional waveguide devices &circuits benefiting from the unprecedented small chip size and strong energy confinement, had not only play crucial roles in the success of silicon photonics but also would in the future quantum optics. Recent progresses such as the realization of complex entangled photon states by means of integratable microresonators, implies that the exploitation of quantum integration with its ability to generate customizable and complex quantum states, can provide a scalable and practical compact platform for quantum technologies.

BIOGRAPHY

Dr. Wenfu Zhang is working as a professor in State Key Laboratory of Transient Optics and Photonics, Xi' an Institute of Optics and Precision Mechanics (XIOPM) of CAS. He is also the Executive Vice Director of China-UK joint research center of micro/nano photonics of XIOPM. His current research interests include integrated photonics, nonlinear optics and quantum optics.

CIOP-2017-3011

Generating Quantum States of light from Monolithic Chips

Dongpeng Kang
Harbin Institute of Technology, China

Generating nonclassical states of light in a chip form-factor is a major milestone towards real-life applications of optical quantum information processing including quantum key distribution and quantum computing. In this presentation, I will review our theoretical and experimental research on on-chip generation of quantum states of photons via the nonlinear process of spontaneous parametric down-conversion (SPDC), including polarization entangled photons, hyperentangled photons and heralded pure single photons. A majority of the study was based on III-V semiconductor AlGaAs, which could lead to monolithic integration of pump lasers and enable electrically pumped sources operating at room temperature.

CIOP-2017-1666

GHz InGaAs/InP Single-Photon Detection with Ultrashort Gates

Zinan Huang[1], Min Yu[1], Yan Liang[1], Heping Zeng[2]
[1] *Shanghai Key Laboratory of Modern Optical System, Engineering Research Center of Optical Instrument and System, Ministry of Education, School of Optical-Electrical and Computer Engineering, University of Shanghai for Science and Technology;*
[2] *State Key Laboratory of Precision Spectroscopy, East China Normal University*

Several important advances were reported in high-speed single-photon detection(SPD) at telecom wavelength of 1550 nm in recent years. Here, a low-noise single-photon detector was demonstrated with InGaAs/InP avalanche photodiode(APD) operated in 1 GHz gated Geiger mode. The capacitance-balancing technique was combined with low-pass filtering to eliminate the spike noise and achieve the valid extraction of the avalanche signal. With this combining technique, the suppression ratio of the spike noise could exceed 30 dB, and the repetition frequency of this detector could be continuously tuned on a relatively large scale without any change of the device components, making it more generally applicable. Moreover, ultrashort gates were employed to fast switch the bias voltage of the APD between over-voltage and under-voltage, reducing the gate-on time and further improving the performance of the detector. Detection efficiency of 11.0% was finally attained with dark count rate of 7.0×10^{-7}/gate and afterpulse probability of 4.7%. Besides that, the timing jitter of this GHz single-photon detector was measured to be ~94 ps, making it quite suitable for a number of high-speed applications, such as quantum key distribution and laser ranging systems.

Key words: single-photon detector; high-speed detection; avalanche photodiode; quantum optics

Session 11: Laser Micro-Nano Processing and Optical Precision Fabrication

Chairs: **Hongbo Sun**, Jilin University, China
Feng Chen, Shandong University, China

Location: B504, 5F, Main Building, Harbin Institute of Technology No.2 Campus

18th July

13:40-13:55	**Ultrafast Laser Micromachining and Fabrication of Fiber Bragg Gratings (Oral-Industry)** Dongchao Hou, Newport	
Chair: Feng Chen, Shandong University, China		
14:00-14:45	**Material Processing/Printing Using Ultra-Short Laser Pulses (Keynote)** Saulius Juodkazis *Swinburne University of Technology, Australia*	- 207 -
14:45-15:15	**Fabrication & Applications of Complex Microstructures Based on Femtosecond Laser Micromachining (Invited)** Feng Chen *Xi'an Jiaotong University, China*	- 208 -
15:15-15:45	**Femtosecond Laser 3D Microfabrication for Functional Devices (Invited)** Dong Wu *University of Science and Technology of China, China*	- 209 -
15:45-16:00	**Coffee Break**	
Chair: Xiangping Li, Jinan University, China		
16:00-16:30	**Ultrashort Pulsed Laser Induced Luminescence in Transparent Solids (Invited)** Quanzhong Zhao *Shanghai Institute of Optics and Fine Mechanics, CAS, China*	- 210 -
16:30-17:00	**Laser Induced Growth, Assembly and 3D Structuring of Carbon Nanomaterials (Invited)** Wei Xiong *Huazhong University of Science and Technology, China*	- 211 -
17:00-17:30	**Optical Two-Beam Direct Laser Writing Towards 3D Photonic Nanofabrication (Invited)** Yaoyu Cao *Jinan University, China*	- 212 -
17:00-18:00	**Interaction of Femtosecond Laser with Crystals: From THz Photonics to Hyperdoping Crystals (Invited)** Qiang Wu *Nankai University, China*	- 213 -
18:00-19:00	**Dinner Time**	

19th July

Chair: Saulius Juodkazis, Swinburne University of Technology, Australia		
09:00-09:45	**Advances of Ultrafast Laser Written Waveguides in Crystalline Materials(Keynote)** Feng Chen *Shandong University, China*	- 214 -
09:45-10:15	**Nanofabrication of Intracellular Plasmonics and Probing Cellular Features by Laser Light (Invited)** Nicholas Isaac Smith *Osaka University, Japan*	- 215 -
10:15-10:45	**Harnessing Photothermal Reshaping Effects of Plasmonic Materials for Multiplexed Information Technologies (Invited)** Xiangping Li *Jinan University, China*	- 216 -
10:45-11:00	**Coffee Break**	
Chair: Feng Chen, Xi'an Jiaotong University, China		
11:00-11:30	**Predicting Optimal Femtosecond Laser Processing of Silicon via Integration of the Thermal and Two-Temperature Models (Invited)** Jie Qiao *Rochester Institute of Technology, USA*	- 217 -

19th July

11:30-12:00	**Nano-Crystal in Photo-Thermal Refractive Glass Preparing with fs Laser and Thermal Development (Invited)** Guanghua Cheng *Xi'An Institute of Optics and Precision Mechanics, CAS, China*	- 218 -
12:00-12:15	**Plasma Propulsion of a Glass Microsphere with Nanosecond Laser Pulse (Oral)** Hanyang Li, Haichao Yu, Lugui Cui, Jun Yang *Harbin Engineering University, China*	- 225 -
12:15-14:00	**Lunch Time**	
Chair: Qiang Wu, Nankai University, China		
14:00-14:30	**High Throughput Micro/Nano Manufacturing by Femtosecond Laser Temporal Pulse Shaping (Invited)** Jie Hu *Beijing Institute of Technology, China*	- 219 -
14:30-15:00	**Femtosecond Laser-Induced Subwavelength Periodic Ripples Studied by Pump-Probe Imaging (Invited)** Tianqing Jia *East China Normal University, China*	- 220 -
15:00-15:30	**Fabrication of Micro-Optoelectronics Devices by Femtosecond Laser (Invited)** Qidai Chen *Jilin University, China*	- 221 -
15:30-16:00	**Coffee Break**	
15:30-17:30	**Poster**	
18:00-20:00	**Banquet**	

20th July

Chair: Dong Wu, University of Science and Technology of China, China		
9:00-9:30	**Laser Processing of Graphene Oxides for Multiform Applications (Invited)** Yonglai Zhang *Jilin University, China*	- 222 -
9:30-10:00	**Recent Progress in Integrated Optical Circuits for Quantum Key Distribution (Invited)** Wei Chen *University of Science and Technology of China, China*	- 223 -
10:00-10:30	**Fabrication of Square-Shaped Depressed Cladding Waveguides in Transparent Materials with Slit-shaped Femtosecond Laser Beams (Invited)** Yang Liao *Shanghai Institute of Optics and Fine Mechanics, CAS, China*	- 224 -
10:30-10:45	**Double-Sided Microlens Arrays with Compound Imaging Patterns (Oral)** Yang Wei, Qing Yang, Hao Bian, Feng Chen, Minjing Li, Xun Hou *Xi'an Jiaotong University, China*	- 225 -
10:45-11:00	**Coffee Break**	
Chair: Yang Liao, Shanghai Institute of Optics and Fine Mechanics, CAS, China		
10:45-11:00	**An Embedded 3D Driving Unit Fabricated in Fused Silica for Microfluidics Systems (Oral)** Hong Zhang, Feng Chen, Qing Yang, Chao Shan, Qichao Li, Shuhao Zheng, Xun Hou *Xi'an Jiaotong University, China*	- 225 -
11:00-11:15	**High Efficiency Fabrication for Microtube Based Femtosecond Structured Light (Oral)** Jiawen Li, Yanlei Hu, Dong Wu *University of Science and Technology of China, China*	- 225 -
12:15-14:00	**Lunch Time**	

Material Processing/Printing Using Ultra-short Laser Pulses

Saulius Juodkazis
Swinburne University of Technology, Australia

Note

ABSTRACT

Material processing with ultra-short sub-picosecond laser pulses have evolved over the last two decades into unique 3D fabrication/printing technology with emerging industrial applications. A broad overview of the field with examples of applications will be presented. Constantly evolving new materials for laser structuring, new high pulse energy and repetition rate lasers together with modern laser beam delivery and sample scanning are responsible for the achieved progress. Unique capability of nanoscale structuring of materials using tightly focused ultra-short laser pulses will be highlighted.

BIOGRAPHY

Saulius Juodkazis is Professor of nanophotonics and Director of the nanotechnology facility at Swinburne's Centre for Micro-Photonics. He has contributed to the development of a three-dimensional laser printing with nano-/micro-scale precision using femtosecond laser for applications in opto-fluidic, micro-optics, optical memory, and photonic crystals. He has shown experimentally the creation of high-pressure density phases of materials using tightly focused ultra-short laser pulses.

S. Juodkazis received his doctorate in experimental physics and material science jointly from Vilnius University (Lithuania) and Lyon-I University (France). He is Fellow of OSA, SPIE and ChangJiang scholar.

Feng Chen
Xi'an Jiaotong University, China

Note

Fabrication & Applications of Complex Microstructures Based on Femtosecond Laser Micromachining

ABSTRACT

Complex fine structures with micro / nanostructures have been widely used in many fields such as aerospace, aviation, ocean, information, energy, and biomedicine. Compared with the traditional processing methods, laser micro machining technology presents the advantages of the high peak energy, easy operation, high flexibility, high efficiency, high quality, energy saving and environmental protection and so on. Especially the ultrafast laser micromachining, due to its minimal thermal and mechanical damage, and high processing precision, it can be widely used to process various types of micro machining and surface treatment in metal, semiconductor, dielectric and polymer materials, etc. The Ultrafast laser micromachining has become a hotspot of the international micro processing technology in recent years. In this report, we will present the research progress in the ultrafast laser processing of the complex fine structures especially those with special features and discuss the application and possible future development direction.

BIOGRAPHY

Feng Chen is a full professor of Electronic Engineering at Xi'an Jiaotong University, where he directs the Femtosecond Laser Laboratory and has severed as vice director of the International Joint Research Center for Micro/Nano Manufacturing and Measurement Technologies. In 2002, Dr. Chen joined the Xi'an Jiaotong University, where he became a group leader. He has been a full Professor of Electronics Engineering at Xian Jiaotong University since 2002. His current research interests are femtosecond laser microfabrication and Bionic Microfabrication. Dr. Chen took charge in over 20 research projects including the national NSF key projects, the Special-funded programme on national key scientific instruments and equipment development of China，863 key projects, as well as series of national and provincial key projects, etc, and has published more than 200 peer-reviewed papers including *Adv. Funct. Mater.*, *Adv. Mater. Interface.*, *J.Mater.Chem.A*, *ACS AM&I*, *Soft Matter*, *Langmuir*, *JPCC*, *Appl. Phys. Lett.*, *Opt. Lett.*.

Femtosecond Laser 3D Microfabrication for Functional Devices

Dong Wu
University of Science and Technology of China, China

Note

ABSTRACT

Micro/nanofabrication technologies are very crucial for the fabrication of functional microstructures and devices, which is the key for various optical, electric, chemical and biological applications. So, to develop advanced microfabrication technologies is always highly desirable. Here, based on the basic principle of femtosecond laser and mater interaction, we systemically investigate direct laser writing and realize high-quality micro-optical devices, movable micromechanical machines, large-area bio-inspired hydrophobic surfaces and true three dimensional microfluidic devices, which is an important step towards their broad applications.

BIOGRAPHY

Dong Wu is a professor of engineering science at University of Science and Technology of China. He obtained the fifth "Thousand Youth Talents Plan". His current research interests are femtosecond laser 3D microfabrication for microoptical devices, microfluidic chips, micromachines, and biomimetic microstructures. Prof. Wu has published 50 papers in the international journals of *Light: Sci & Appl.*, *PNAS*, *Laser Photon. Rev.*, *Adv. Mater.*, *Adv. Funct. Mater.*, *Small*, *Lab Chip*, *Appl. Phys. Lett.*, *Opt. Lett.* and so on.

Quanzhong Zhao
Shanghai Institute
of Optics and Fine
Mechanics, CAS, China

Note

Ultrashort Pulsed Laser Induced Luminescence in Transparent Solids

ABSTRACT

Ultrashort laser pulses can induce not only upconversion luminescence but also long persistent luminescence (LPL) in transition metal or rear earth metal doped transparent solids. A structureless broad continuum emission can also be initiated in transparent materials by a single ultrashort laser pulse, which is proved to be black-body radiation in nature.

Firstly, this talk will review the ultrashort laser pulses induced luminescence phenomena. Then, we will present several progresses of ultrashort laser pulses induced luminescence in our group. Finally, the potential applications of ultrashort laser pulses induced luminescence will be demonstrated.

BIOGRAPHY

Dr. Quanzhong Zhao received his B.S. & M.S. degrees from Northwestern Polytechnical University, China in 1997 and 2000, respectively. He obtained his Ph.D. in Optical Engineering from Chinese Academy of Sciences, China in 2003. He worked as a postdoctoral researcher in Max-Planck Institute for the Science of Light, Germany, from 2005 to 2009, and he became a full professor in Shanghai Institute of Optics and Fine Mechanics, CAS in 2009. His research interest includes laser-based micro-/nanoprocessing, structuring of versatile materials, functional photonic materials and devices, physics of ultrashort pulsed laser interaction with matter, and fundamental research with potential commercialization. He has authored and co-authored two book chapters and more than 80 journal papers and 20 conference papers.

Laser Induced Growth, Assembly and 3D Structuring of Carbon Nanomaterials

Wei Xiong
Wuhan National Laboratory For Optoelectronics , China

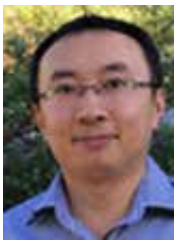
Note

ABSTRACT

The growth, assembly and structuring of nanomaterials are three major aspects of modern nanotechnology, which are requisite in developing nanoscale devices or systems with a broad range of applications and significant impacts to our society. Although extensive research efforts have been invested and significant progress has been made, the above three aspects of nanotechnology are still facing tremendous challenges. For example, the synthesis of high-quality graphene generally requires stringent growth conditions such as high temperature and special catalytic substrates which are not economically viable and incompatible for typical semiconductor processing; precise assembly of carbon nanotubes and other nanowires to form arbitrary patterns or three-dimensional (3D) structures on demand is still a challenging task. In this talk, potential solutions using laser techniques will be introduced. Due to the unique merits of lasers including ultra-short pulse duration, ultra-strong light intensity, etc., non-equilibrium extreme conditions can be easily achieved by advanced laser techniques which are beneficial to nanofabrication. Research efforts on development of the laser-induced material processing in multi-dimensional nanofabrication will be systematically discussed, including laser-based and rapid thermal processing (RTP) techniques for the growth and fabrication of one-dimensional (1D), two-dimensional (2D) and three-dimensional (3D) carbon nanomaterials or micro/nanostructures. Our results show that ultrafast laser is a promising tool in growth, assembly and structuring of nanomaterials.

BIOGRAPHY

Dr. Wei Xiong is currently a professor at Wuhan National Laboratory for Optoelectronics in Huazhong University of Science & Technology, scholar of "Thousand Youth Talents Plan". He got his Ph.D. in 2013 from University of Nebraska-Lincoln, and he obtained his B.Sc. and M.Sc. degrees from Huazhong University of Science and Technology and Fudan University, respectively. His current research interest is laser-based 3D micro/nano-fabrication.



Yaoyu Cao
Jinan University, China

Optical Two-Beam Direct Laser Writing Towards 3D Photonic Nanofabrication

ABSTRACT

Nanofabrication has continuously promoted cutting-edge researches with widely spreading scope from nanophotonics to nano-biology. In compared with conventional Electron beam lithography, direct laser writing (DLW), regarded as a powerful fabrication tool to realize three-dimensional micro/nanostructures, has demonstrated its exceptional superiority in non-contact, mask-free, cost effective, flexibility and versatility over extended materials. However, the DLW employing single laser beam suffers from relatively low accuracy and resolution owing to the diffraction nature of light, while light is focused with a microscopy-based approach. This fundamental limit, also named as Ernst Abbe's law, prevents super-fine resolution from the nano-scale.

In this presentation, an emerging direct laser writing technique inspired by optical super-resolution nanoscopy is demonstrated for realizing three dimensional nanostructures. A super-resolved feature in deep sub-wavelength scale can be achieved by employing an optical two-beam method for developing 3D nanostructures and exploiting their functionalities.

BIOGRAPHY

Yaoyu Cao is professor of the Institute of Photonics Technology at Jinan University, where he has joined since 2016. He received a B. S. from the University of Science and Technology of China in 2004. From 2007 to 2008, he studied as a visiting Ph. D. candidate in Nanophotonics Lab at RIKEN in Japan. He received his Ph. D. from the Technical Institute of Physics and Chemistry, Chinese Academy of Sciences in 2009. From 2009 to 2016, he worked in Centre for Micro-Photonics at Swinburne University of Technology in Australia. He was the session chair of Optical Data Storage 2014 at SPIE. In 2016, he was awarded the "Thousand Youth Talents Plan" program.

As one of the research pioneers in 3D laser nanofabrication of functional materials, Yaoyu Cao has published over 17 internationally referred journal publications including *Nature Communications*, *Small*, *OPTICA* and Light: Science & Applications. He has demonstrated the world's record nanofeatures with the size of 9 nm based on dual-beam optical super-resolution fabrication technique.

Note

Interaction of Femtosecond Laser with Crystals: From THz Photonics to Hyperdoping Crystals

Qiang Wu
Nankai University, China

Note

ABSTRACT

The invention of femtosecond laser has greatly promoted the development of physics, chemistry, biology and other disciplines. Because of the characteristics of femtosecond laser, ultrashort pulse duration and ultrahigh peak power, the interaction of femtosecond laser with matter cannot be described by the usual textbook formulas. Therefore, some new theories are brought out, based on which some new applications are emerging. Our work in ultrafast photonics are focused in two aspects: (I) THz phonon polariton in ferroelectric crystals; (II) femtosecond laser hyperdoping crystals and devices. In this presentation, I will give a brief introduction of these two projects.

BIOGRAPHY

Qiang Wu is a professor of School of Physics & TEDA Institute of Applied Physics, Nankai University (P. R. China). He received BSc in 2000 and PhD in 2005 from Nankai University and was a postdoc at Tufts University and MIT in 2007 and 2008, respectively. He was appointed full professor and became a Member of Editorial Board of *Scientific Reports*, in 2013. His main research interest has been focused in ultrafast photonics from 2005. Especially in the research area of THz phonon polariton, hyperdoped materials and devices, he has a series of research results. His research work has resulted in more than 60 peer-reviewed journal publications and more than ten patents, including 2 foreign patents.

Feng Chen
Shandong University, China

Advances of Ultrafast Laser Written Waveguides in Crystalline Materials

ABSTRACT

The ultrafast laser writing has been realized as a powerful technique to fabricate photonic devices in versatile optical materials. In dielectric crystals, diverse configurations of optical waveguide structures have been therefore designed and implemented by utilizing laser beams of various parameters. Recent advances related to crystalline materials on the new prototypes of waveguiding geometries and new applications in photonics will be summarized in this work.

Note

BIOGRAPHY

Feng Chen is currently a Professor and the Dean of School of Physics, Shandong University, China. He received the degrees of BSc and PhD from Shandong Normal University in 1997 and Shandong University in 2002, respectively. He spent 2 years in Germany, from 2003 to 2005, as an Alexander von Humboldt Research Fellow. He became an Associate Professor and Professor at Shandong University in 2004 and 2006, respectively. His research interests include laser materials processing, optical waveguides, lasers, ion beam modification of materials etc. He has more than 200 papers published in peer-reviewed journals and holds 5 patents. He is a Fellow of Institute of Physics (IOP), UK, a Senior Member of OSA, and a Director Board Member of Chinese Physical Society. In 2014, he was elected to be the President of Physical Society of Shandong Province. He also serves an Associate Editor of Optical Engineering, an Editorial Board Member of Scientific Reports, and a subcommittee member of CLEO: Light-Matter Interactions and Materials Processing.

Nanofabrication of intracellular plasmonics and probing cellular features by laser light

Nicholas Isaac Smith
Osaka University (Immunology Frontier Research Center), Japan

Note

ABSTRACT

Most use of light for biological applications has been for the purpose of observing cellular features. Modes such as fluorescence imaging have driven widespread advances in knowledge. This presentation will discuss the use of light to do more than simply observe a sample, but to interact with it. One application of interest in our group is using light to fabricate plasmonic structures inside a cell. These can then be used to enhance Raman scattering signals from intracellular features. The nanofabrication of intracellular particles has not been widely explored, but shows promise as a new technique to evaluate areas inside biological cells that are difficult to reach with most methods that have molecular specificity. Indeed, the plasmonic enhancement from fabricated particles shows evidence of highly sensitive, possibly single molecule-level detection.

BIOGRAPHY

1999-2002 Osaka University, Graduate School Engineering (Ph.D.)

2003-2007 Assistant Prof., Dept. Frontier Biosciences, Osaka University.

2007-2009 Lecturer, Photonics Center, Osaka University.

2010-2015 Specially Appointed Assoc. Prof., Principal Investigator, Biophotonics Lab, Immunology Frontier Research Center (IFReC), Osaka University.

Aug 2015-present Associate Professor and Principal Investigator, Biophotonics Lab, Immunology Frontier Research Center (IFReC), Osaka University.

As one of the research pioneers in 3D laser nanofabrication of functional materials, Yaoyu Cao has published over 17 internationally referred journal publications including Nature Communications, Small, OPTICA and light science & applications. He has demonstrated the world's record nanofeatures with the size of 9 nm based on dual-beam optical super-resolution fabrication technique.

Xiangping Li
Jinan University, China

Harnessing Photothermal Reshaping Effects of Plasmonic Materials for Multiplexed Information Technologies

ABSTRACT

The advance in nanotechnology has allowed the metallic materials to be structured on the nanometer scale, which in turn has enabled the electrons to respond collectively by oscillating in resonance with light's intrinsic properties known as surface plasmons. The photothermal effect is one of the most pronounced properties of plasmonic materials illuminated by intense pulsed laser beams, which can quickly raise the temperature of the plasmonic structure. In this paper, we report on the harnessing of photothermal effects of plasmonic materials for multiplexed information technologies including high density optical data storage and vivid color printing. Once the temperature effect is above certain thresholds, the photothermal reshaping effect starts, which leads to the reshape of the structured plasmonic materials and drastically changed dispersion properties. Harnessing this intriguing feature introduced by tightly focused femtosecond pulses, multiplexed information technologies are demonstrated.

BIOGRAPHY

Dr. Xiangping Li completed his PhD at Swinburne University of Technology in 2009. His research is focused on nanophotonic techniques for high capacity optical information technologies including optical multiplexing, plasmonics and superresolution microscopy. Dr. Li has published over 60 internationally referred journal publications including Science, Nature Photonics, and Nature Communications. Dr. Li is a recipient of a number of prestigious awards including the Australian Postdoctoral Fellow funded by Australian Research Council in 2011, Swinburne's Vice Chancellor Award for early career researcher in 2012, Victoria Fellowship in 2013, Discovery Early Career Researcher Award by Australian Research Council in 2014, "Thousand Youth Talents Plan" scholar in 2015 and Distinguished Young Scholars from National Natural Science Foundation of China in 2015. He joined the Institute of Photonics Technology at Jinan University as a full professor and research leader in nanophotonic devices group in 2015.

Note

Predicting Optimal Femtosecond Laser Processing of Silicon via Integration of the Thermal and Two-Temperature Models

Jie Qiao
Rochester Institute of Technology, UAS

Note

ABSTRACT

Femtosecond lasers for photonics fabrication require the determination of optimal parameters to effectively control thermal effects and ablation efficiency during welding, polishing and texturing. Non-optimal laser parameters induce oxidation and melting during ablation. The heat accumulation was simulated to optimize interaction parameters for mitigating the resulting thermal effects. A thermal and a two-temperature model describing femtosecond laser-material interactions are compared and linked. Both models accurately describe the thermal response of silicon to multi-pulse irradiations, while the two-temperature model distinguishes between the thermal and non-thermal regimes.

BIOGRAPHY

Jie Qiao is currently an Associate Professor in the Carlson Center for Imaging Science at the Rochester Institute of Technology. She leads the Advanced Optical Fabrication, Instrumentation & Metrology Laboratory where her team works on ultrafast-lasers for advanced photonics / optics fabrication, optical metrology, and instrumentation. Prior to joining RIT, she was a laser system scientist at the Department-of-Energy-Funded Laboratory for Laser Energetics (University of Rochester) from 2005 to 2013. She was the PI and led the technical demonstration of the world's first 1.5-meter tiled-grating pulse compressor for the kilojoule, petawatt OMEGA EP short pulse lasers. Prior to that, she had worked on various innovative photonic devices, optical imaging and metrology systems, for two photonic startups and one optics company. She earned her Ph.D. in Electrical and Computer Engineering from the University of Texas at Austin and an M.B.A in entrepreneurship, strategy, finance and marketing from the Simon Graduate School of Business, University of Rochester. She has 65 scientific publications, and holds two patents. She founded WiSTEE Connect (Women in Science, Technology, Engineering and Entrepreneurship, www.wisteeconnect.org) in 2013, for which she is serving as the Chair.

Guanghua Cheng
State Key Laboratory of Transient Optics and Photonics, Xi'an Institute of Optics and Precision Mechanics, Chinese Academy of Sciences, China

Note

Nano-Crystal in Photo-Thermal Refractive Glass Preparing With Femtosecond Laser and Thermal Development

ABSTRACT

The photo-thermal refractive (PTR) glass changes its refractive index after an exposure to the near UV radiation and thermal development due to the formation of nanocrystal. Here we report nano-sized crystals in PTR glass with femtosecond laser exposure. It reveals that The concentration of nano-crystals depended on the writing power, but the size of the nano-crystals was found to be quasi power-independent. Transmission volume phase holographic gratings were fabricated in bulk PTR glass using zero-order femtosecond laser Bessel beams and subsequent thermal treatment. Effects of the gratings thickness, writing laser power and thermal treatment on the diffraction efficiency were investigated. A maximum diffraction efficiency of 94.73% was achieved (at 532 nm testing wavelength) with 1 mm grating thickness. Also the double line and tubular depressed cladding waveguide structures were fabricated in PTR glasses using femtosecond laser, respectively. The results show that the tubular waveguide possesses lower loss and larger normalized frequency after heat development than that without heat development. And the normalized frequency of the waveguide can be tuned by heat treatment duration since the refractive index of femtosecond exposure zone depends on annealing time. The quality of waveguide can be improved by eliminating uneven stress distribution by thermal development.

BIOGRAPHY

Summary of qualifications and professional experience:

- 2009-2017, invited Professor at Laboratoire Hubert Curien, France
- 2011- now, professor at XIOPM, CAS, China
- 2008~2009, Post-Doc at Université Jean Monnet, France
- 2004-2010, association professor at XIOPM, CAS, China

Field of expertise:

- Ultrafast laser machining and process
- High power solid laser technique
- Interaction between ultrafast laser and mater, nonlinear optics

Selected appointments and activities:

- *Reviewer: Sci. rep., Optics Express, Optics Materials Express, Applied Surface Science, Applied Physics A, Applied Physics B, Chinese Physics Letters, Chinese Optics Letters, Journal of Quantum Electronics,*
- *The Project Manager of Chinese Post-doctoral foundation, Chinese National Natural Science Foundation, and Canada Natural Science and engineering Foundation*
- *The Project Manager of Entrepreneurship Program and National Natural Science*

High Throughput Micro/Nano Manufacturing by Femtosecond Laser Temporal Pulse Shaping

Jie Hu
Beijing Institute of Technology, China

Note

ABSTRACT

In recent years, femtosecond laser micro/nano manufacturing has attracted increasing interest. With ultrahigh power intensities and ultrashort irradiation periods, femtosecond laser presents unique advantages over conventional laser. In this talk, we improved the manufacturing throughput by modulating the plasma density based on the femtosecond laser temporal pulse shaping. Temporal distributions of free electron density and the localized transient properties of dielectrics can be adjusted by shaping the femtosecond laser pulses. We designed femtosecond laser pulse trains so that the resonant absorption between plasma and laser can be achieved when the oscillation frequency of the plasma is equal to the frequency of the incident laser, which will effectively improve the manufacturing throughput. It was shown that the removal rate of micro channels can be increased by 5-56 times using our proposed manufacturing method.

BIOGRAPHY

Jie Hu, Professor of Mechanical Engineering at Beijing Institute of Technology. She received the National Excellent Young-Scientist Award (National Natural Science Foundation of China) in 2013 and the New Century Excellent Talent Award (Ministry of Education) in 2011. She is the core member in the Key Laboratory of Nontraditional Micro/Nano Manufacturing (Ministry of Industry and Information Technology) and the Nontraditional Micro/Nano Manufacturing Innovation Group (Ministry of Education). She has published an article in Science as the first author and the total citations of her articles are more than 230 times.

Tianqing Jia
East China Normal University, China

Femtosecond Laser-Induced Subwavelength Periodic Ripples Studied by Pump-Probe Imaging

ABSTRACT

The formation mechanism of periodic surface structures by femtosecond laser is an interesting problem in the last two decades. More experiments are urgent and necessary to figure out the roles of Surface plasmon polaritons (SPPs) and thermal effects on the formation of surface ripples on gold. We study the influences of surface plasmons and thermal effects on the formation of subwavelength periodic ripples on semiconductors and metal films irradiated by 800 nm femtosecond laser pulses by a collinear pump-probe imaging. Spatial resolution of the experiment is 300 nm, and temporal resolution is 1 ps. SPPs cause a modulated energy deposition and the formation of transient ripples. The residual heat influences the ripples after the molten surface is solidified.

BIOGRAPHY

Jia Tianqing's research focuses on the femtosecond laser micro/nanofabrication. He reports more than 100 papers on the ultrafast dynamics of dielectrics and semiconductors ablated by femtosecond laser pulses, femtosecond laser-induced periodeic nanostructures. Recently, he begins studying the processing of cooling holes of engine leaf of air plane by using ns laser and fs laser. He obtained his doctoral degree in Tongji University in September, 2000. In 2000-2005, He made his research in Shanghai Institute of Optics and Fine Mechanisms, Chinese Academic Sciences. In 2005-2007, he studied in the Tokyo University as a JSPS fellow. He works as a professor at East China Normal University since September, 2007.

Note

Fabrication of Micro-Optoelectronics Devices by Femtosecond Laser

Qidai Chen
Jilin University, China

Note

ABSTRACT

Femtosecond laser micro-nano fabrication has been established as a nano-enabler to solve problems that are otherwise not possible in scientific and industrial fields, because of its unique three-dimensional processing capability, arbitrary-shape designability, and high fabricating accuracy up to tens of nanometers, far beyond the optical diffraction limit. As a newly-born fine processing approach, the femtosecond laser micro-nanofabrication technology is still at its infant stage, and many problems ranging from the fundamental fabrication principle to enabling technologies, as well as how to apply it on frontier scientific fields, need solving. In this presentation, some detail points of our achievements about micro-optoelectronics fabrication are introduced as follows.

BIOGRAPHY

Qidai Chen received the Ph.D. degree in Plasma Physics from Institute of Physics, CAS, Beijing, China, in 2004. He worked as a JST postdoctoral researcher in Department of Physics, the Osaka City University, Japan, from 2005 to 2006, and then as an associate professor in College of electronic science and engineering, Jilin University, China. In 2011, he was promoted as a full professor. His research interests have been in laser nanofabrication technology for micro-optics, semiconductor laser beam shaping and sub-wavelength anti-reflective microstructure. So far, he has published over 130 scientific papers in the above fields, which have been cited for over 2600 times according to ISI search report.

Yonglai Zhang
Jilin university, China

Note

Laser Processing of Graphene Oxides for Multiform Applications

ABSTRACT

We reported here the laser processing of graphene oxides (GO) film by controllable photoreduction treatment. Typical photoreduction processes, including femtosecond laser direct writing (FsLDW), laser holographic lithography and controllable UV irradiation have been employed to make conductive reduced GO (RGO) mirco-circuits, hierarchical RGO micronanostructures with both superhydrophobicity and structural color, as well as moisture responsive GO/RGO bilayer structures, respectively. As compared with other reduction protocols, for instance, chemical reduction and thermal annealing, the photoreduction strategy shows distinct advantages such as mask-free patterning, chemical-free modification, controllable reduction degree and environment-friendly processing. These works indicates that the surface and interface engineering of GO through laser processing holds great promise for the development of various graphene-based micro-devices.

BIOGRAPHY

Dr. Yonglai Zhang received his Ph.D. (2009) from Jilin University, China. Then he joined the faculty in the State Key Laboratory on Integrated Optoelectronics, College of Electronic Science and Engineering, Jilin University. In 2011, he worked as a research professor in Yonsei University, Korea. After that, he was awarded a “Hong Kong Scholar” postdoctoral fellow and worked at Center of Super Diamond and Advanced Films (COSDAF), City University of Hong Kong. His research interests include laser micronanofabrication of functional micronanostructures, biomimetic materials and devices as well as Bio-MEMS. He has authored more than 90 SCI papers, including *NanoToday*, *Adv. Mater.*, *Adv. Funct. Mater.*, and *LabChip*, which have been cited for more than 2500 times.

Recent Progress in Integrated Optical Circuits for Quantum Key Distribution

Wei Chen
University of Science and Technology of China, China

Note

ABSTRACT

Quantum key distribution (QKD) is one of the best-known quantum information technology, which can generate secret key bits between two legitimate parties by employing the quantum laws of physics. Any eavesdropping will change the quantum states transmitted in the channel and be perceived. By combing QKD and the one-time pad encryption, the information-theoretical security (ITS) communication can be achieved.

For the last few years, many significant advances of QKD have been achieved and new technologies are kept utilizing in this field. Integrated optical circuit is an extremely promising approach for both classical and quantum communications, while it is just unfolding for the latter.

In this talk, the concept of QKD will be briefly introduced and the recent progress in integrated optical QKD chips will be summarized. Then special requirements for integrated optical circuits from the perspective of QKD will be investigated.

BIOGRAPHY

Wei Chen has received his Ph.D. degree from the University of Science and Technology of China (USTC) in 2008. He is currently an associate professor of the Dept. of Optics and Optical Engineering, School of Physical Sciences, USTC, where he is involved in the research on quantum key distribution (QKD) and quantum information. Dr. Chen has made much effort to promote the real-life researches and applications of QKD. He has published more than 60 papers in this field, including the papers in *Nat. Photon.*, *Phys. Rev. Letts*, *Phys. Rev. A*, *Opt. Letts.*, *J. Lightwave Technol.*, et al. Meanwhile, he has developed several types of practical QKD terminal and network routing equipment, as well as applied them in the field test QKD networks. Up to now, the QKD networks he built have more than 50 nodes over more than 400 km fiber channels, including a wide area QKD network between two cities which are nearly 200 km apart.

Yang Liao
Shanghai Institute of Optics and Fine Mechanics, CAS, China

Note

Fabrication of Square-Shaped Depressed Cladding Waveguides in Transparent Materials With Slit-Shaped Femtosecond Laser Beams

ABSTRACT

Due to the potential of enabling low-loss propagation and the capability of preserving the nonlinear optical properties of the bulk materials, the depressed cladding waveguides are now under intensive investigations. To form the depressed cladding waveguides, one can produce a cladding region of reduced refractive index through the irradiation of femtosecond laser pulses. In the transverse writing scheme, the claddings can be formed by parallelly overlapping a large number of tracks written by the focused femtosecond laser pulses along the boundaries of the waveguiding areas. This requires a considerable number of scan times to form the claddings, and the large thicknesses of the formed claddings may cause considerable difficulty in using such waveguides for constructing evanescent-coupling-based three-dimensional (3D) photonic circuits. Here, we demonstrate fabrication of square-shaped depressed cladding waveguides (SSDCWs) by forming the four sides of the cladding with slit-shaped femtosecond laser beams, and the polarization-independent single mode propagation of SSDCW has been achieved in a lithium niobate (LN) crystal. Moreover, we show that with the correction of the spherical aberration, the SSDCWs can be inscribed in a LN crystal at depths up to 1400 μm.

BIOGRAPHY

Dr. Yang Liao received his PhD from the Shanghai Institute of Optics and Fine Mechanics (SIOM), Chinese Academy of Sciences in 2010. Then he joined the faculty in the State Key Laboratory of High Field Laser Physics, SIOM, and now he is an associate researcher of SIOM. Since 2015, he worked as a visiting researcher in RIKEN, Japan. His research interests include femtosecond laser micro/nano-fabrication of integrated optical devices, microfluidic and optofuidic devices. He is a member of Youth Innovation Promotion Association, CAS. He has authored more than 50 SCI papers, which have been cited for more than 1000 times.

CIOP-2017-1953

Plasma Propulsion of a Glass Microsphere with Nanosecond Laser Pulse

Hanyang Li, Haichao Yu, Lugui Cui, Jun Yang
Harbin Engineering University

Nanosecond laser pulse was coupled into optical fiber, and about 60 μm diameter microsphere was propelled by the outputting laser pulse. Change of the laser pulse energy from 2.58 to 21.67 μJ, the initial velocity of the microsphere varied from 0.063 to 0.58 m/s. Meanwhile, the propulsion efficiency was also calculated. We found Cm reaches minimum at the point of E = 13.74 μJ, and we infer it was attribute to the laser plasma shielding. Furthermore, transmission beam through spectrograph show that plasma generation during microsphere surface was irradiated by laser pulse in our experiment.

Key words: laser pulse propulsion; plasma; momentum coupling coefficient; specific impulse

CIOP-2017-2125

Double-Sided Microlens Arrays with Compound Imaging Patternsc

Yang Wei[1], Qing Yang[1], Hao Bian[1], Feng Chen[2], Minjing Li[1], Xun Hou[2]
[1] *School of Mechanical Engineering, Xi'an Jiaotong University;*
[2] *Key Laboratory of Photonics Technology for Information, School of Electronics & Information Engineering, School of Mechanical Engineering, Xi'an Jiaotong University*

The double-sided microlens arrays (MLAs) which can be considered as the integrated fly-eye, is one promising optical element for efficient homogeneous illumination. In this paper, we have introduced facilely designed double-sided microlens arrays on glass chips, which would be used as beam shapers to produce novel compound imaging patterns, such as coaxial nested rectangular-shaped, coaxial nested hexagonal-shaped, non-coaxial nested hexagonal-shaped imaging patterns. These beam shapers possess nearly 5000 close-packed coaxial microlenses on double-sided of substrate, which were created by femtosecond laser wet etch process within 2 hours. This method shows the advantages of controllability, quality and efficiency in forming the microlens array. Furthermore, compound imaging patterns can be simply realized by controlling the shape, the size of the microlens and the arrangement of the microlens arrays on the double-sided glass chips. These beam shapers which can produce the compound imaging patterns have the potential applications for laser beam shaping, light emission, photolithography, projection and micro-optical processing.

Key words: laser beam shaping; microstructure fabrication; femtosecond laser wet etch; ultrafast lasers; micro-optical devices.

CIOP-2017-2159

An Embedded 3D Driving Unit Fabricated in fused silica for microfluidics systems

Hong Zhang[1], Feng Chen[2], Qing Yang[1], Chao Shan[2], Qichao Li[1], Shuhao Zheng[1], Xun Hou[2]
[1] *School of Mechanical Engineering, Xi'an Jiaotong University;*
[2] *Key Laboratory of Photonics Technology for Information, School of Electronics & Information Engineering, Xi'an Jiaotong University*

3D driving units inside the hard material play a pivotal role in the microfludics systems, such as the micropump. Miniaturization also has great significance for device integration and expansion of its application scope, particularly for "lab-on-a-chip" systems. In this letter, we demonstrate a novel method of fabricating a 3D driving unit inside the fused silica with a three-step process, combining the femtosecond laser wet etching (FLWE) process and a metal microsolidification process, in which a metal alloy with a high melting point was used. Inside fused silica, we fabricated a simple microvalve with a spherical structure controlling the current's flow, whose diameter is nearly 70 μm. In addition, a metal aloy Rogowski coil was made as the source of driving force when electricity is applicated. The novel 3D driving unit can be integrated easily and has a wide application in the microfluidics systems.

Key words: femtosecond laser; microstructure fabrication; laser processing

CIOP-2017-2240

High Efficiency Fabrication for Microtube Based Femtosecond Structured Light

Yanlei Hu, Dong Wu, Jiawen Li
University of Science and Technology of China

Structured light can be used as the processing element in femtosecond laser holographic processing for high efficiency. We will present our recent results on high efficiency fabrication for microtube based femtosecond structured light. Firstly, we will introduce to modulate and construct structured lights using sptial light modulator (SLM). Then, we will show some 3D structures fabricated by holographic femtosecond laser processing. Lastly, we will discuss the application in some fields. The holographic femtosecond laser processing method based on structural light can greatly improve processing efficiency compared to the tradtional focus-by-focus scanning fabrication and will promote the wide application of two-photon polymerization in many fields.

Key words: structured light; femtosecond laser; microtube; high fabrication efficiency

Session 12: Advanced Optical Functional Materials and Devices

Chairs: **Xutang Tao**, Shandong University, China
Qingdong Zheng, Fujian Institute of Research on the Structure of Matter, CAS, China
Kiyoshi Shimamura, National Institute for Materials Science (NIMS), Japan

Location: B509, 5F, Main Building, Harbin Institute of Technology No.2 Campus

18th July

Chair: Xutang Tao, Shandong University, China

14:00-14:45	**Efficient Fiber-Shaped Energy and Electronic Devices (Keynote)** Dechun Zou *Peking University, China*	- 228 -
14:45-15:15	**Coinage Metal Nanohole Films as Light-Trapping Electrodes for Organic Photovoltaics (Invited)** Ross Hatton *University of Warwick, UK*	- 229 -
15:15-15:45	**Printable Silicon Quantum Dots (Invited)** Xiaodong Pi *Zhejiang University, China*	- 230 -
15:45-16:00	**Coffee Break**	

Chair: Decun Zou, Peking University, China

16:00-16:30	**New Nonlinear Optical Materials (Invited)** Shilie Pan *Xinjiang Technical Institute of Physics & Chemistry, CAS, China*	- 231 -
16:30-17:00	**Synthesis, Characterization and Application of Novel Twistacenes and Heteroacenes (Invited)** Qicun Zhang *Nanyang Technological University, Singapore*	- 232 -
17:00-17:30	**Design and Properties of High Efficient Acousto-Optic Q-Switch Based on a Biaxial Crystal: α-$BaTeMo_2O_9$ (Invited)** Zeliang Gao *Shandong University, China*	- 233 -
17:30-18:00	**Two Dimensional Black Phosphorus Based Ultrafast Optical Modulation and Bio-Photonics (Invited)** Han Zhang *Shenzhen University, China*	- 234 -
18:00-19:00	**Dinner Time**	

19th July

Chair: Han Zhang, Shenzhen University, China

09:00-09:30	**Ca*Ln*AlO_4 (*Ln* = Y, Gd) Host Crystals for Ultrafast Laser Pulses (Invited)** Jun Xu *Tongji University, China*	- 235 -
09:30-10:00	**Growth and Properties of Mid-infrared Nonlinear Optical Crystals (Invited)** Shanpeng Wang *Shandong University, China*	- 236 -
10:00-10:30	**Growth and Performances of Crystals for Mid-Far Infrared Nonlinear Optical Applications (Invited)** Chunhui Yang *Harbin Institute of Technology, China*	- 237 -
10:30-10:45	**Study of GaN Photocathode with Variable Aluminum Fraction $Al_xGa_{1-x}N$ in Emission Layer (Oral)** Xiaoqian Fu, Yang Li, Junju Zhang *University of Jinan, China*	- 246 -
10:45-11:00	**Coffee Break**	

Chair: Jun Xu, Tongji University, China

11:00-11:30	**Promising Re^{3+}: CALGO Crystals for Ultrafast Laser Application (Invited)** Zhitai Jia *Shandong University, China*	- 238 -

19th July

11:30-12:00	**Structural Regulation of Hybrid Perovskite Crystals via Mixed Halide Resources and the Induced SHG Effects (Invited)** Yang Liu *Shandong University, China*	- 239 -
12:00-12:15	**Growth and Optical Properties of Lithium Tantalate Single Crystals Doped with Indium and Neodymium (Oral)** Chongjun He, Weili Li, Jiming Wang, Xiaorong Gu, Tong Wu, Youwen Liu *Nanjing University of Aeronautics and Astronautics, China*	- 246 -
12:15-14:00	**Lunch Time**	
Chair: Chunhui Yang, Harbin Institute of Technology, China		
14:00-14:30	**Semiconducting Materials for High-Performance Polymer Solar Cells (Invited)** Qingdong Zheng *Fujian Institute of Research on the Structure of Matter, CAS, China*	- 240 -
14:30-15:00	**Compositional Engineering of Lead Halide Perovskite for High Performance Solar Cells (Invited)** Peng Gao *Xiamen Institute of Rare-earth Materials, CAS, China*	- 241 -
15:00-15:30	**Materials for Organic Solar Cells (Invited)** Jian Zhang *Guilin University Of Electronic Technology, China*	- 242 -
15:30-16:00	**Coffee Break**	
15:30-17:30	**Poster**	
18:00-20:00	**Banquet**	

20th July

Chair: Qingdong Zheng, Fujian Institute of Research on the Structure of Matter, CAS, China		
9:00-9:45	**Single Crystal Phosphors for High-Brightness White Lighting Applications(Keynote)** Kiyoshi Shimamura *National Institute for Materials Science (NIMS), Japan*	- 243 -
9:45-10:15	**High Performance Ternary Organic Optoelectronic Devices (Invited)** Fujun Zhang *Beijing Jiaotong University, China*	- 244 -
10:15-10:45	**Light Manipulation in Organic Optoelectronic Devices (Invited)** Jianxin Tang *Soochow University, China*	- 245 -
10:45-11:00	**Coffee Break**	
Chair: Fujun Zhang, Beijing Jiaotong University, China		
11:00-11:15	**Synthesis and Photoluminescence Properties of Ho^{3+}/Yb^{3+} Co-Doped Fluorotellurite Glass (Oral)** Xin Huang, Jiaming Liu, Hao Zhang, Wenxiu Li, Xia Xue, Chengcai Tian, Anping Huang, Zhisong Xiao *Beihang University, China*	- 246 -
11:15-11:30	**Broadband Nonlinear Optical Enhancement Induced by Synergistic Effect between Graphene and CdS Nanocrystals(Oral)** Baohua Zhu, Yuzong Gu *Henan University, China*	- 247 -
11:30-11:45	**Growth and Characterization of Nd-Doped Niobate Laser Crystals (Oral)** Shoujun Ding[1], Qingli Zhang[2], Wenpeng Liu[2] *[1] University of Science and Technology of China, China; [2] Anhui Institute of Optics and Fine Mechanics, China*	- 247 -
12:15-14:00	**Lunch Time**	

Dechun Zou
Peking University, China

Session 12

Efficient Fiber-Shaped Energy and Electronic Devices

ABSTRACT

Fiber-shaped electronics have been attracting increasing attention due to their potential applications as functional units in smart textiles and portable/wearable devices. Traditional solar cells based on planar sandwiched structures are restricted by heavy electrode materials, cost-consuming technologies and application flexibility. To overcome these issues, fiber-shaped dye-sensitized (FDSC) and perovskite solar cells (FPSC) for potable/wearable energy harvesting were developed, and conversion efficiencies of 8.07% (FDSC) and 5.35% (FPSC) have been achieved. Compared with typical solar cells, these fiber solar cells are TCO-free, cost-efficient and flexible, exhibiting outstanding light harvesting property, which are feasible for utilizing low-cost electrode materials and various optical designs. Memristors are devices that can store and process information based on their switchable internal resistance. Based on organometal trihalides and electrochemical active metals, fiber-shaped memristors showed a clear bipolar resistance-switching feature with small switching voltages and good retention stability.

BIOGRAPHY

Prof. Dechun Zou received his doctoral degree from Kyushu University, Japan, in 1990 (his supervisor was Prof. Shyogo Saito). He joined Mitsubishi Petrochemicals, Japan as a research scientist from 1990 to 1993, and Tokyo University of Agriculture and Technology as a visit researcher from 1994 to 1995, Casio Computer Co., Ltd., as a research contractor in 1996, a research contractor in CREST, JST, Japan (Tsutsui Project) in 1997. He was an associate professor in Kyushu University from 1998 to 2001. Since 2001, he has been a full professor in College of Chemistry and Molecular Engineering, Peking University, China. In recent ten years, he has been involved in more than 6 NSFC projects on organic light-emitting diodes (OLEDs) and solar cells. His research interests include OLED materials, photovoltaics, flexible energy storage devices and related device physics, as well as new process technologies for optoelectronic device fabrication. He was one of the recipients of the National Science Fund for Distinguished Young Scholars. He is also an advisory board member of *Advanced Materials Technologies*, Chairman of Solar Materials Branch, Chinese Materials Research Society(C-MRS). He was the chief scientist of National Key Basic Scientific Research Program (973) on fiber-shaped solar cells in China(20011-2015).

Note

Ross Hatton
University of Warwick, UK

Note

Coinage Metal Nanohole Films as Light-Trapping Electrodes for Organic Photovoltaics

ABSTRACT

Organic photovoltaics offer the possibility of very short energy payback times and low cost fabrication. However, the low charge carrier mobilities in organic semiconductors invariably constrain the thickness of the light harvesting layer to less than that needed to absorb all of the potentially useful photons incident on the device, which limits device efficiency. This talk will describe recent progress in the development of a scalable approach to addressing this constraint, that is based on trapping the incident light as plasmonic excitations at the surface of copper and silver electrodes with a random array of sub-optical wavelength apertures. Due to the very large absorption coefficient in many organic semiconductors, it is possible for this trapped light to directly excite electrons from the highest occupied molecular orbital to the lowest unoccupied molecular orbital in a nearby organic semiconductor, before the plasmonic excitations dissipate their energy as heat due to ohmic losses in the metal.

BIOGRAPHY

Dr Ross Hatton is an Associate Professor of Physical Chemistry at the University of Warwick in the United Kingdom (UK). He is currently the holder of a £1.15M Engineering and Physical Science Research Council Fellowship focused on the development of new concepts in window electrode design for emerging thin film photovoltaics. He was awarded his PhD in 2003 from the University of Nottingham (UK), and a prestigious five-year Royal Academy of Engineering Research Fellowship in 2007. He has published 50 papers in peer reviewed international journals, including *Nature Energy*, *Advanced Materials* and *Advanced Energy Materials*.

Xiaodong Pi
Zhejiang University,
China

Printable Silicon Quantum Dots

ABSTRACT

Among all kinds of semiconductor quantum dots (QDs), silicon (Si) QDs hold an advantageous position given the abundance and nontoxicity of Si and their compatibility with conventional Si technologies. We have prepared freestanding Si QDs that may be facilely dispersed in common solvents to form Si-QD inks. The use of Si QDs in device structures is realized by printing Si-QD inks. Si QDs are firstly incorporated into the classical bulk-heterojunction organic solar cells based on poly (3-hexylthiophene) (P3HT) and [6,6]-phenyl-C61-butyric acid methyl ester (PCBM). It is found that the solar cell efficiency may increase by ~ 40% when ~ 5% of PCBM in the original P3HT:PCBM blend is replaced with Si QDs. The efficiency enhancement is enabled by the improved short-wavelength absorption, optimized film structure and cascade energy-level alignment. By coating graphene that is on the top of bulk Si with Si QDs we have fabricated Si-QD/graphene/bulk-Si Schottky-junction photodetectors. The porous Si-QD films with anti-reflection effect increases the light absorption of the photodetectors. Charge transfer between Si QDs and graphene raises the Schottky–barrier height. Therefore, the Si-QD/graphene/bulk-Si photodetectors show excellent responsivity and detectivity in the wide spectral range of 300 - 1000 nm. In addition, ultra-broadband photodetection from ultraviolet to mid-infrared has been realized by coupling plasmonic boron-doped Si QDs and graphene in phototransistors. We have found that Si-QD light-emitting diodes (LEDs) can work much more efficiently after the use of MoO_3 interlayers between ITO and PEDOT:PSS to enhance the hole transport of the devices. MoO_3 increases the work function of ITO, leading to better hole injection. The resulting mitigated charge unbalance causes both the external quantum efficiency (EQE) and stability of Si-QD LEDs to significantly increase (up to ~ 170% for EQE and ~ 240% for device half lifetime).

BIOGRAPHY

Dr. Xiaodong Pi is a full professor in the State Key Laboratory of Silicon Materials and School of Materials Science and Engineering at Zhejiang University. He obtained his PhD degree in the department of physics at the University of Bath, UK with the Derek Chesterman medal for original research in 2004. He then carried out research in the department of engineering physics at McMaster University, Canada and in the department of mechanical engineering at the University of Minnesota, USA. Dr. Pi was a research assistant professor at the University of Minnesota before he joined Zhejiang University as an associated professor near the end of 2008. Dr. Pi was promoted to be a full professor in 2012. Dr. Pi's research has been supported by National Natural Science Foundation for Excellent Young Researchers. Dr. Pi has recently published papers in peer-reviewed journals such as *Physical Review Letters*, *Physical Review B*, *Advanced Materials*, *Advanced Optical Materials*, *ACS Nano* and *ACS Photonics*.

Note

New Nonlinear Optical Materials

Shilie Pan
Xinjiang Technical Institute of Physics & Chemistry
Chinese Academy of Sciences , China

Note

ABSTRACT

Relying on the process of second-harmonic generation (SHG), nonlinear optical (NLO) materials are considered to be the best way for solid-state lasers to produce coherent light. However, the efficient frequency conversion requires the NLO crystals possessing the suitable SHG coefficients, wide transparent region, moderate birefringence and high laser damage thresholds (LDTs). By rational design, we have obtained more than 70 NLO-active compounds. Representative results are as follows: (1) Four new UV NLO crystals - KBOC/BBOF/CZBO/CBSO with short UV cut-off edges (< 200 nm) and large SHG effects (> 3 × KDP). (2) Server Mid- IR NLO crystals. As a representative, the POC crystals can be obtained in open air system, exhibiting large SHG, wide transparent range, and high LDTs. (3) Fundament research on the mechanism of SHG effect. Using the first-principles method and new theoretical models, we have investigated the SHG enhancement mechanism of serveral NLO crystals.

BIOGRAPHY

Prof. Pan has been Professor of XJIPC, CAS since 2007 as the “One-hundred talent” scholar. He received his Ph.D. degree from the University of Science & Technology of China in 2002. Before 2007, he worked as a postdoctor in Technical Institute of Physics & Chemistry, CAS, and later at Northwestern University in USA. Prof. Pan is now the director of New Opto-electronic Functional Materials Laboratory. His current research interests focus on synthesis, crystal growth, properties characterization, structure-property relationships and devices in new optical-electronic functional materials. As the first author or the corresponding author, Prof. Pan has published more than 260 papers in peer-reviewed international journals such as *J. Am. Chem. Soc.*, *Angew. Chem. Int. Edit*, etc. And he has 5 authorized US patents, 55 authorized Chinese patents. He was also awarded National Ten Thousand Talents Project, National Science Fund for Distinguished Young Scholars, National Youth Science and Technology Innovation Leading Talent, China Youth Science and Technology Award, New Century National Hundred, Thousand and Ten Thousand Talent Project.

Qicun Zhang
Nanyang Technological University, Singapore

Session 12

Synthesis, Characterization and Application of Novel Twistacenes and Heteroacenes

ABSTRACT

We report the synthesis, optical and electrochemical properties, as well as fabrication of light-emitting devices for a series of twistacenes and heteroacenes (Scheme 1). Their structures, determined by X-ray crystallography, confirmed that these materials have twisted topology with torsion angles as high as 23.0°. These materials can emit blue, green and orange light. Organic light emitting devices using these materials as emitters have been fabricated. The results revealed that these materials are promising materials for high efficiency OLEDs. In addition, we also made a lot of N-substituted oligoacenes and their properties will be discussed in this talk.

BIOGRAPHY

Qichun Zhang obtained his BS at Nanjing University in China in 1992, MS in physical organic chemistry (organic solid lab) at Institute of Chemistry, Chinese Academy of Sciences (Prof. Peiji Wu/Daoben Zhu's group,Beijing) in 1998, MS in organic chemistry (Prof. Fred Wudl's group) at University of California, Los Angeles (USA), and completed his PhD in inorganic chemistry at University of California Riverside (Prof. Pingyun Feng's group, USA) in 2007. Then, he joined Prof. Kanatzidis' group at Northwestern University as a Postdoctoral Fellow (Oct. 2007 –Dec. 2008). Since Jan. 2009, he joined School of Materials Science and Engineering at Nanyang Technological University (NTU, Singapore) as an Assistant Professor. On Mar 1st, 2014, he has promoted to Associate Professor with tenure and on Dec 1st, 2014, he became an adjunct Associate Professor at Division of Chemistry and Biological Chemistry, School of Physical and Mathematical Sciences, Nanyang Technological University. Besides, he also has three-year working experience in research institute of Nanjing Chemical Industry Co. (Aug. 1992 – Aug. 1995) and two-year's research experience in ICCAS (Aug. 1998 – Jun 2000). Currently, he is an associate editor of *J. Solid State Chemistry*, the Advisory board member of *Materials Chemistry Frontiers*, and the Advisory board member of *Inorganic Chemistry Frontiers*. Currently, He is a fellow of the Royal Society of Chemistry. He has published more than 240 papers and 4 patents (H-index: 50).

Note

Design and properties of high efficient acousto-optic Q-switch based on a biaxial crystal: α-$BaTeMo_2O_9$

Zeliang Gao
Shandong University, China

Note

ABSTRACT

Usually, the acoustic-optic devices are design in uniaxial crystals. As a biaxial crystal, α-$BaTeMo_2O_9$ exhibits excellent optical-electric properties which can be comparable to that of TeO_2. Here the acousto-optic Q-switch made of α-$BaTeMo_2O_9$ has been design and demonstrated for the first time. At the radio-frequency signal of 100 MHz, the diffraction angle and efficiency of α-$BaTeMo_2O_9$ Q-switch were determined to be 1.432° and 82%, respectively, which were larger than that of TeO_2 acoustic-optic modulator. This Q-switch was applied in laser modulations which were operated by Nd:YVO_4 and YAG at 1064 nm. The minimum pulse width can reach to be 8 ns at the repetition frequency of 15 kHz . This work can not only provide a high efficient acoustic-optic modulator for pulse lasers, but also lead to search novel acousto-optic materials in biaxial crystals.

BIOGRAPHY

Acousto-optic interaction has long been exploited in various acousto-optic devices based on solid materials, while acoustic-optic medium are usually using uniaxial crystals. There has never been any report about the application of biaxial crystals as acousto-optic materials. In this work, the theoretical analysis was illustrated for the availability of the biaxial crystals as acousto-optic medium. And an acousto-optic Q-switch made of biaxial α-$BaTeMo_2O_9$ crystal has been designed and demonstrated for the first time. At the radio-frequency signal of 100 MHz, the diffraction angle and efficiency of α-$BaTeMo_2O_9$ Q-switch were determined to be 1.432° and 82%, respectively, which were larger than those of TeO_2 acoustic-optic modulator. This work not only provides a high efficient acoustic-optic modulator for lasers, but also acts as a leading role in searching for novel acousto-optic materials in biaxial crystals, confirming the availability of the biaxial crystals as acousto-optic materials.

Zeliang Gao received his doctor degree from State Key Laboratory of Crystal Materials, Shandong University, China. He is an associate professor with Shandong University, China. His Current research interests include crystal physics and optical devices.

Han Zhang
Shenzhen University, China

Session 12

Note

Two dimensional Black phosphorus Based Ultrafast Optical Modulation and Bio-Photonics

ABSTRACT

Black phosphorous (BP), the most thermodynamically stable allotrope of phosphorus, is a high-mobility layered semiconductor with direct band-gap determined by the number of layers from 0.3 eV (bulk) to 2.0 eV (single layer). Therefore, BP is considered as a natural candidate for broadband optical applications, particularly in the infrared (IR) and mid-IR part of the spectrum. The strong light-matter interaction, narrow direct band-gap, and wide range of tunable optical response make BP as a promising nonlinear optical material, particularly with great potentials for infrared and mid-infrared opto-electronics. We demonstrate all-optical-thresholding, optical modulation and four wave-mixing for optical communications by using phosphorene-decorated microfiber. Our findings, as the first prototypic device of all-optical-thresholding, optical modulation and all-optical signal processing might facilitate the development of phosphorene-based optical communication technologies. Furthermore, BP has higher surface area to volume ratio as compare to MoS_2 and graphene since it has a puckered lattice formation, which can enhance the drug loading capacity. In addition to its fascinating electronic structure, BP nanosheet has been found to be highly efficient photosensitizer, and can ben employed as an agent of photodynamic treatment to produce radical oxygen. Moreover, BP nanoparticles and BP quantum dots display broad absorptions in the whole visible light region. This phenomenon shows that both BP nanoparticles and BP quantum dots have NIR photothermal properties which is use for photothermal treatment, these exceptional properties of BP make it as a new potential nanomaterial for photothermal treatment and drug delivery system of multimodal therapy for cancer. The potential applications of Black phosphorus based ultrafast optical modulation and Bio-photonics applications will be discussed in this talk.

BIOGRAPHY

Professor and Director of Shenzhen Engineering Laboratory of Phosphorene and Optoelectronics, Shenzhen University, China. He was born in Hubei, China at 1984. He received the B.S. degree from Wuhan University and received the Ph.D. from Nanyang Technological University. He is the winner of National “Thousand Talents Program” for Distinguished Young Scholars, a government endowed professorship, and National Science Fund for Excellent Young Scholars as well as the New Century Excellent Talent Award, MOE, China. His current research is on the ultrafast and nonlinear photonics of two dimensional materials. He is also an Associate Editor of OSA Photonics Research, Editorial Board Member of Scientific Reports, Lead Guest Editor of Photonics Research, Optical Engineering, Optics Communication, Chinese Laser, Chinese Optics Letters special issues. He has published more than 160 papers with total citations higher than 10000 times and H-index of 48 (according to google scholar).

$CaLnAlO_4$ (Ln = Y, Gd) Host Crystals for Ultrafast Laser Pulses

Jun Xu
Tongji University, China

Note

ABSTRACT

Tetragonal rare-earth calcium aluminates, $CaLnAlO_4$ where Ln = Y or Gd, are attractive laser host crystals because they combine disordered structure leading to broadening of the absorption/emission bands for the rare-earth dopants. $CaLnAlO_4$ crystals have a negative dn/dT, which is important for the design high-power mode-locked laser oscillators. Re^{3+} (Yb^{3+}, Nd^{3+}, Tm^{3+}, Ho^{3+}) doped $CaLnAlO_4$ crystals were grown using traditional Czochralski method. The spectra parameters were obtained at room temperature. The laser operations have been demonstrated. The results show that $CaLnAlO_4$ crystals are good host materials for ultrafast.

BIOGRAPHY

Jun Xu is a professor in School of Physics Science and Engineering, Tongji University, China. He received the B.S. degree in physics from Nanjing University, Nanjing, China, in 1986, and the Ph.D. degrees in material science from Shanghai Institute of Optics and Fine Mechanics of Chinese Academy of Sciences, Shanghai, China, in 1996. He has been granted 100 patents and has published over 500 papers in scientific journals, and edited five books. His recent research interests include laser crystals, wide bandgap semiconductor crystals and crystal growth technology.

Shanpeng Wang
Shandong University, China

Note

Growth and Properties of Mid-infrared Nonlinear Optical Crystals

ABSTRACT

Mid-infrared laser sources in the range of 3-20 μm have become research focus of infrared (IR) laser technology. Frequency conversion by infrared nonlinear optical (NLO) crystals is an effective way of producing coherent mid-infrared lasers. Lithium containing chalcogenide (such as $LiInS_2$, $LiInSe_2$ LiGa3Te5) are promising candidates for mid-IR optical frequency conversion. $LiInS_2$ has wide transparency range (0.35~12.5 μm), high nonlinear coefficient and is phase matchable over a large wavelength range. $LiInS_2$ crystal displays a nearly isotropic thermal expansion behaviour and a 5-times-larger thermal conductivity. Owing to its wider band gap and lower absorptions in the range of near infrared, $LiInS_2$ crystals can be pumped by Nd: YAG laser. Compared with LIS, LISe has a larger nonlinearity and a wider transparency window. LiGa3Te5 is transparent from 3.5 to 18 μm at the level of 40%, and the cut-off edges at long wavelength is 25 μm. It can be a promising candidate in the mid- and far-infrared or THz technology.

In this paper, we report the growth and properties of large-sized lithium containing chalcogenide crystals. After a suitable heat treatment process, the high quality crystals are obtained for fabricating nonlinear optical devices. Pumped by 1064 nm laser, the 3.47μm mid-infrared laser was also realized by difference frequency generation with the output energy of ~100 μJ. A 3.6-4.8 and 7-12 μm widely tunable picosecond (ps) MIR optical parametric amplifier (OPA) based on LISe crystal was demonstrated.

BIOGRAPHY

Shanpeng Wang is a professor in state key laboratory of crystal materials in Shandong University. He received his doctor degree in 2007. From 2013 to 2014, he carried out research on nonlinear optical and THz time domain spectrocopy in University of Konstanz, Germany. The current research interests are focus on: (1) crystal growth and characterization of novel mid-infrared nonlinear optical crystals ($LiInS_2$, $LiInSe_2$, $LiGa_3Te_5$, $ZnGeP_2$, $CdSiP_2$, etc.), (2) synthesis and characterization of novel optoelectrical functional materials, (3) Terahertz time domain spectroscopy characterization of optoelectronic functional materials.

Chunhui Yang
Harbin Institute of Technology, China

Note

Growth and Performances of Crystals for Mid-Far Infrared Nonlinear Optical Applications

ABSTRACT

This contribution is devoted to success in growth of very promising mid-far infrared nonlinear optical compounds: ZnGeP2, CdGeAs2, LiInSe2, and GaSe.

Mid-far infrared lasers, operating in the atmospheric transmission window are of great importance for many applications, such as infrared countermeasure, spectra, chemical monitoring, medical apparatus, and remote sensing. The possibility of wider applications of these crystals as nonlinear medium depends on the crystals growth with perfect structures and optical qualities. However, the synthesis and growth of crystals were proved to be difficult due to the high vapor pressure produced mainly by volatile components, and there must be deviation from stoichiometry of composition. In addition, there are some problems in the large single crystals growth process, such as stress-induced cracking and high absorption coefficient in as grown crystal caused by native defects.

In our laboratory, more than 500 g of the high-purity polycrystalline material was obtained in a run by Two Temperature Zone technique. Crack-free single crystals with 30-50 mm in diameter were grown by Vertical Bridgman technique, which have lower absorption and good performances in mid-far infrared wavelength.

BIOGRAPHY

Chunhui Yang is Professor at School of Chemistry and Chemical Engineering, Harbin Institute of Technology. Her research interests mainly focus on: nonlinear optical single crystals growth, defects structures, performances and devices. She has published more than 100 peer-reviewed scientific papers, and co-edited two books.

Zhitai Jia
State Key Laboratory of Crystal Materials, Shandong University, China

Note

Promising Re^{3+}: CALGO Crystals for Ultrafast Laser Application

ABSTRACT

$CaGdAlO_4$ (CALGO) crystal is a promising laser host crystal since it has a disordered structure and should be a good candidate for the ultra-fast laser. Structural disorder can lead to differing crystal-field potentials at spatially differing active ion sites. As a result, the absorption and emission spectra can be inhomogeneously broadened, which provides great convenience for laser diode pumping and mode locking in the generation of ultrafast laser. In this work, the brown coloration issue and its effect of CALGO crystal have been discussed in detail, and then the Re^{3+}:CALGO crystals have been grown in optimized conditions for different lasing wavelengths, especially for promising ultrafast ultraviolet and visible laser applications.

BIOGRAPHY

Zhitai Jia received the B. Sc. degree from Department of Chemistry, and the Ph.D. degree from State Key Laboratory of Crystal Materials, Shandong University, China. He is an associate professor of Shandong University, China. His current research interests include growth and characterization of band gap semiconductor, laser, and scintillation crystals by Cz, μ-PD, EFG, and LHPG techniques.

Structural Regulation of Hybrid Perovskite Crystals via Mixed Halide Resources and the Induced SHG Effects

Yang Liu
Shandong University, China

Note

ABSTRACT

Mixed halide coordination has been widely used to finely tune the properties of inorganic and inorganic-organic hybrid compounds, especially for emerging perovskites materials. Despite the increasing number of reports on preparation methods and the affected functionalities, the peculiar and precise role of the doping halogens in structural regulation of the crystals and the resulting variations on the basic properties remain to be addressed. Here, to shed light into the “blind box”, a new series of $[NH_2(CH_2CH_3)_2]_3Bi(Cl_{1-x}Br_x)_6$ (x=0, 0.135, 0.255, 0.385, 0.847, and 1) single crystals were grown from the mixed halide solvents by temperature lowering method. The correlation between the inclusion amounts of Br in the final crystals with the halide concentrations in the precursors is discussed from different perspectives. The two kinds of halogens share the same position in the mixed halide system, with every crystallographically independent halide site possessing different halogen occupancies. The mixed halide coordination exhibits a regulated effect on the distortion of the anion octahedra. Optical absorption, TGA, DSC, and the SHG measurements have confirmed that with increased Br inclusion, $[NH_2(CH_2CH_3)_2]_3Bi(Cl_{1-x}Br_x)_6$ crystals exhibit a regulated effect on their bandgaps, thermal stabilities, and SHG capacities.

BIOGRAPHY

Dr. Liu Yang’s core contribution area includes growth of organic functional crystalline materials, crystallization methodology and mechanism, and the preparation of the related optoelectronic devices. He has published about 50 SCI papers in journals such as J. Am. Chem. Soc., Angew. Chem. Int. Ed., Adv. Mater., etc, applied for two U.S. patents. His publications have been cited about 2000 times, with an H-factor of 21 for him. Several of his research achievements have been reported and highlighted specially by American Chemical Society Noteworthy Chemistry, Cutting-Edge Chemistry, Nature-Asia Materials, American Chemical Society C&EN, JACS SPOTLIGHTs, and Hong Kong Economic Journal, etc. A study of “The Applications of Crystallography in the Studies of Organic Optoelectronic Materials” was rewarded as the second class prize of natural science of the ministry of education.

Qingdong Zheng
Fujian Institude of Research opn The Structure, China

Note

Semiconducting Materials for High-Performance Polymer Solar Cells

ABSTRACT

As key components in the active layer of multi-junction, ternary blend, or non-fullerene polymer solar cells (PSCs), wide bandgap semiconducting polymers have the characteristic of exhibiting strong absorption bands in the short-wavelength region. In the multi-junction, ternary blend, or non-fullerene PSCs, the wide bandgap polymers can provide complementary absorption profiles with the low bandgap counterparts, thereby further increase the power conversion efficiencies. In this talk, we report on the design and synthesis of a series of wide bandgap conjugated polymers or small molecule non-fullerene acceptors based on ladder-type acenes with the inclusion of fluorene, carbazole or thiophene units. The band gaps and carrier transporting properties of the materials can be easily tuned by introducing different heteroatoms (sulfur, nitrogen) in the ladder-type fused-ring system. Solar cells based on these conjugated polymers exhibit power conversion efficiencies (PCEs) as large as 9.14%. A best performance tandem solar cell using a wide-bandgap copolymer-based device and a PTB7-Th-based device as the bottom and top cell components, respectively, exhibits a PCE of 11.15% with a large VOC of 1.70 V. Polymer solar cells based on one of the best non-fullerene acceptors delivered a highest PCE of 9.03% with a high FF of 72.84%. At the same time, the effect of cathode buffer layer on the device performance of PSCs is also discussed.

BIOGRAPHY

Qingdong Zheng obtained his B.S. (1998), and M.S. (2001) degrees from East China University of Science and Technology, and his Ph.D. degree from the State University of New York at Buffalo in 2005. After carrying out his postdoctoral research at the Johns Hopkins University, he joined the Fujian Institute of Research on the Structure of Matter, Chinese Academy of Sciences (CAS), and became a full professor in 2010. Selected honors and awards include the “100 Talents Programme” of CAS in 2010, and distinguished Young Scholars of National Science Foundation of China (NSFC) in 2013. His main interests include the design, synthesis and application of optoelectronic materials, particularly for energy related applications. He has published over 80 papers in peer-reviewed journals such as *Nature Photonics*, *J. Am. Chem. Soc.*, *Energy Environ. Sci.*, *Adv. Energy Mater*. He is serving as Associate Editor of *RSC Advances*.

Compositional Engineering of Lead Halide Perovskite for High Performance Solar Cells

Peng Gao
Xiamen Institute of Rare-earth Materials, Chinese Academy of Sciences, China

Note

ABSTRACT

As one of the third generation PV technologies, hybrid perovskite solar cells (PSCs) emerged since Miyasaka et al incorporated MAPbX3 (X=I, Br) perovskite as sensitizers into dye-sensitized solar cells (DSSCs), achieving a power conversion efficiency (PCE) of 3.8% in 2009. After near eight-year development, especially numerous research endeavors in recent years, the power conversion efficiency (PCE) of PSCs has been rapidly improved to 22.1%. This presentation will give systemic introduction of the efforts in optimizing the perovskite active layers and increasing the devices performance in our lab. We doped methods like passivation, surface modification, gradient doping, and finally we could realize solar cell devices with PCE above 21%.

BIOGRAPHY

Dr. Gao Peng, since 2006, he studied at the Max-Planck Institute for Polymer Research (Mainz, Germany) in the group of Professor Klaus Müllen in Organic Chemistry. Since 2010, he joined the École Polytechnique Fédérale de Lausanne the lab of Professor Micheal Grätzel as a postdoctoral researcher specializing in synthesis of near-infrared absorption dyes and hybrid perovskite materials. From 2015 he followed Professor Md. K. Nazeeruddin to participate in EPFL Valais Wallis project, and worked in the newly established EPFL Sion Energy Center. In the past six years, Gao Peng applied for four patents, one authorized, published 21 papers as first author and corresponding author, co-authored 60 papers in the peer reviewed journals, including 1 featured article, 4 cover articles, And 2 book chapters. Up to now, according to google scholar statistics, his SCI H-index is 34, total citation of the publications is 11906 times. He is currently a reviewer of *Science*, *Adv. Mater.*, *Adv. Funct. Mater.*, *Adv. Energy Mater.*, *NanoEnergy* and other major international academic journals. At present, he is working in the Xiamen Institute of Rare-earth Materials, Chinese Academy of Sciences and he is the fellow of “Thousand Youth Talent Plan”. He started Lab of Advanced Functional Materials and will focus on rare earth elements application in organic optoelectronic functional materials and efficient photovoltaic materials.

Jian Zhang
Guilin University of Electronic Technology, China

Note

Materials for Organic Solar Cells

ABSTRACT

Organic solar cells (OSCs) have attracted large attention in photovoltaic community due to potential low cost and flexibility. In OSCs, interface engineering at the electrode/semiconductor interface by introducing proper interface materials is crucial for higher performance. A wide temperature tolerance, water-free and solution-processed MoO_x was synthesized and used as anode interface layers in OSCs. The MoO_x thin films possess the suitable morphology and electronic properties for application in OSCs, and show wide temperature tolerance from room temperature to 250°C. The OSCs with the solution processed MoOx thin films show high PCE of 7.40% and good environment stability. The application of nanomaterials in PSCs as interface materials in our lab will be introduced in the presentation.

BIOGRAPHY

Jian Zhang is a professor in the college of material science and technology in Guilin University of Electronic Technology. He obtained his doctor degree from Changchun Instituted of Applied Chemistry, CAS. After finish his researches in Humboldt University Berlin as a Humboldt fellow, he joined the State Key Laboratory of Catalysis in Dalian Institute of Chemical Physics with finical support of “100 Talent programme”. Since 2014, He has worked in Guilin University of Electronic Technology. He has published more than 70 publications on organic semiconductors and their applications in organic thin-film transistors and organic solar cells.

Single Crystal Phosphors for High-Brightness White Lighting Applications

Kiyoshi Shimamura
National Institute for Materials Science (NIMS), Japan

Note

ABSTRACT

Conventional white lighting packages consist of blue-LEDs and the yellow Ce^{3+}:$Y_3Al_5O_{12}$ (Ce:YAG) ceramic powder phosphors (CPPs). However, in applications that require high-brightness (HB), a conventional packaging possesses several drawbacks. That is why, a new concept of HB white LEDs based on yellow Ce:YAG single crystal phosphors (SCPs), which can overcome the conventional temperature- and photo-degradation problems of CPPs, is proposed. SCPs demonstrated high internal quantum efficiency (QEint) (over 95%), outstanding thermal stability of QE_{int} in the temperature range of 25-300°C, and quite low temperature increase under high blue irradiation, which contrast with the performance of CPPs. Ce^{3+}:$Lu_3Al_5O_{12}$ (Ce:LuAG) SCP is also proposed as an efficient and clear green source. SCP powders obtained by crashing SCPs have shown the same performances as SCPs. These natures also favor the binder free HB packaging based on LD.

BIOGRAPHY

1990, BEG, Waseda University, Japan,
1995, Ph.D., Tohoku University, Japan,
1995, Research Associate, Tohoku University, Japan,
2002, Associate Professor, Waseda University, Japan,
2007-present Group Leader, NIMS, Japan,
2009-present Visiting Professor, Waseda University.
2016, Academician, World Academy of Ceramics, 2016 : The President Prize for Achievement in Applied Research (NIMS),
2015, Global Star Award (American Ceramic Society),
2012, The Richard M. Fulrath Award (American Ceramic Society), etc
Main research interest is bulk single crystal growth and exploration of new crystal materials for opto-electric applications.

Fujun Zhang
Beijing Jiaotong University, China

Session 12

Note

High Performance Ternary Organic Optoelectronic Devices

ABSTRACT

The PCE of small molecule solar cells was improved over 10% based on ternary strategy, the certified PCE is about 9.36% for the cells staying 5 hours in air without any encapsulation. For the inverted PSCs, the champion PCE is about 12.01% based on a novel system in my group.

The PM type OPDs were successfully prepared with P3HT:acceptor (100:1, wt/wt) as the active layer. The narrowband response can be achieved by adjusting the photogenerated electron distribution in the active layer, especially in acceptor near Al electrode. The FWHM of EQE spectra can be adjusted from less 30 nm to more than 400 nm. Meanwhile, EQE values of our OPDs arrive to more than 50,000% for narrowband and broadband response devices, respectively.

BIOGRAPHY

Fujun Zhang completed his undergraduate study from Minzu University of China in 1999. He started his research in organic electronics under the supervision of Prof. Xurong Xu in 2002. In 2006, he joined in the group of Prof. Norbert Koch as Guest researcher, Humboldt University, Germany. In 2007, he obtained his Ph.D. degree in Optics from Beijing Jiaotong University. In 2013, he was exceptionally promoted as professor due to his excellent research. His research field focuses mainly on device physical problems on OLEDs, OPVs and organic photodetectors. He published more than 100 research papers and 4 papers cited by ESI.

Selected papers:

1. Qiaoshi An, Fujun Zhang*, Energy & Enviromental Science 9 (2016) 281
2. Wenbin Wang, Fujun Zhang*, Nano Letters 17 (2017) 1995
3. Qiaoshi An, Fujun Zhang*, Nano Energy 30 (2016) 276
4. Miao Zhang, Fujun Zhang*, Nano Energy 22 (2016) 241
5. Qiaoshi An, Fujun Zhang*, Nano Energy 26 (2016) 180
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Light Manipulation in Organic Optoelectronic Devices

Jianxin Tang
Soochow University, China

Note

ABSTRACT

Organic optoelectronic devices, including organic light-emitting devices (OLEDs) and organic solar cells (OSCs) have been attracting considerable interest as next-generation lighting source and renewable energy applications. Significant progress on the device performance of OLEDs and OSCs with nearly 100% internal quantum efficiency has been made in recent years via the incorporation of new materials, morphology control, interface engineering, and device fabrication processes. However, further improvement in efficiency remains a daunting challenge due to limited light extraction or absorption in conventional device architectures. Here we report a universal method of optical manipulation of light by integrating a dual-side bio-inspired moth's eye nanostructure (MEN) with broadband anti-reflective and quasi-omnidirectional properties for use in the performance improvement of organic optoelectronic devices of various material systems. Light out-coupling efficiency of white OLEDs is over 2 times that of a conventional device, resulting in drastic increase in external quantum efficiency and power efficiency exceeding 70% and 160 lm/W without introducing spectral distortion and directionality. Besides a substantial increase in efficiency, this device structure offers an extremely small roll-off in efficiency at high brightness and superior angular color stability over the visible range. Similarly, the light in-coupling efficiency of OSCs is increased by 20%, yielding a certificated power conversion efficiency over 12%. Note also that the method developed here brings about an invaluable advantage, which enables the processing compatibility with the high-throughput large-area roll-to-flat and roll-to-roll manufacturing techniques in future mass production of low-cost organic optoelectronic devices.

BIOGRAPHY

Jianxin Tang received his B.Sc. degree in physics from Zhejiang University, and Ph.D. degree in Physics and Materials Science from City University of Hong Kong. In 2008, he was appointed professor at the Institute of Nano Functional & Soft Materials (FUNSOM), Soochow University. His research areas/interests span device physics and surface science on organic light-emitting diodes and photovoltaic cells, including localized electronic state and charge barrier formation at organic interfaces, and novel device architectures to improve device performance with interface modification for carrier transport and light manipulation.

CIOP-2017-2058

Study of GaN Photocathode with Variable Aluminum Fraction $Al_xGa_{1-x}N$ in Emission Layer

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[1] *School of information science and engineering, University of Jinan;*
[2] *Institute of Electronic Engineering and Optoelectronic Technology, Nanjing University of Science and Technology*

To introduce the built-in electric field in photoelectron emission layer, the GaN photocathode with variable aluminum fraction $Al_xGa_{1-x}N$ was grown. After treated with surface cleaning and Cs/O activation, this sample indicated different properties from other GaN photocathodes. The vacuum degree in the ultra-high vacuum chamber with heating temperature indicated that there were no much carbon and oxide residua on GaN surface after chemical cleaning. After co-deposited with oxygen, the photocurrent obtained a comparatively high increase, which can partly verify the Ga-O-Cs dipole model proposed before. High quantum efficiencies (QEs) were achieved with the wavelength from 240 nm to 275 nm, and the lower QEs at shorter wavelengths can be explained with the small optical absorption coefficient of $Al_xGa_{1-x}N$ material.
Key words: GaN; $Al_xGa_{1-x}N$; photocathode; quantum efficiency

CIOP-2017-2238

Growth and Optical Properties of Lithium Tantalate Single Crystals Doped with Indium and Neodymium

Weili Li, Jiming Wang, Xiaorong Gu, Tong Wu, Youwen Liu
College of Science, Naning University of Aeronautics and Astronautics

Rare earth doped $LiTaO_3$ single crystals not only have outstanding electro-optic property, but also can realize optical frequency conversion. They are widely used in integrated optics. However, the low optical damage resistance restricts their applications in high power devices. Optical damage resistance ability can be enhanced by the doping technique. In this paper, $LiTaO_3$ single crystals double-doped with mole fraction of 1.0% Nd^{3+} and various In^{3+} ions (In:Nd:$LiTaO_3$) concentration were grown by the Czochralski method from a congruent melt (molar ration of Li and Ta element is 0.946). Ultraviolet-visible absorption spectra were measured and discussed in terms of the defect structure. Threshold concentration of In^{3+} ion in In:Nd:$LiTaO_3$ crystals is 3.0%. Optical damage resistance of In:Nd:$LiTaO_3$ crystals significantly increases when the concentration of In^{3+} ion exceeds its threshold concentration. In^{3+} ion replaces the anti-site $TaLi^{4+}$, thus enhanced photo-conductivity reduces the photorefractive effect. Absorption band of In:Nd:$LiTaO_3$ crystal at 0.808 μm has a 15 nm FWHM, absorption cross-section σab is equal to 5.26×10^{-21} cm^2. Pumped by the 0.808 μm diode-laser, strong luminescent band of Nd^{3+} ion at around 1.06 μm has been observed. These results indicate that In:Nd:$LiTaO_3$ crystal could be applied in high power photonic or integrated optoelectronic devices as multi-functional crystals.
Key words: optical material; $LiTaO_3$ crystal; defect structure; optical damage; photoluminescence

CIOP-2017-2343

Synthesis and Photoluminescence Properties of Ho^{3+}/Yb^{3+} Co-doped Fluorotellurite Glass

Xin Huang, Jiaming Liu, Hao Zhang, Wenxiu Li, Xia Xue, Anping Huang, Zhisong Xiao, Chengcai Tian
Key Laboratory of Micro-nano Measurement, Manipulation and Physics (Ministry of Education), School of Physics and Nuclear Energy Engineering, Beihang University

Using high temperature melting method, a series of Ho^{3+} ,Yb^{3+} co-doped TeO_2-BaF_2-NaF (TBN) fluorotellurite glasses with different doping concentrations were prepared. The molar percentages of the components in the samples were (69-*x*) TeO-20BaF_2-10NaF-1$Ho_2O_{3-x}YbF_3$ (x=1.0, 1.5, 2, 2.5, 3) respectively. Raman spectrum revealed that the fluorides disrupted the Te-O-Te chains in the glass network, resulting in the decrease of the maximum phonon energy of the glass matrix. The spectroscopic parameters of Ho^{3+}, Yb^{3+} in TBN glass ($\Omega_2=8.12\times10^{-20}$ cm^2, $\Omega_4=5.19\times10^{-20}$ cm^2, $\Omega6=1.93\times10^{-20}$ cm^2) are calculated by Judd-Ofelt theory. When samples were excited by 980 nm wavelength laser, intense frequency up-conversion emissions peaking at 547 nm and 660 nm in Ho^{3+} /Yb^{3+} co-doped TBN glass were observed. By changing the pump power of 980 nm laser, the up-conversion luminescence spectra with the different power are tested. It is proved that the series of samples' visible light up-conversion is a two-photon absorption in the excitation process. Fluorescence emission of samples is also observed in the near infrared region at 1.2 μm and 2.0 μm. It is shown that Ho^{3+} and Yb^{3+} co-doped TBN glasses have good application prospects in up-conversion light emitting devices and near infrared light emitting devices.
Key words: Ho^{3+}/Yb^{3+}; fluorotellurite glass; photoluminescence

CIOP-2017-2463

Broadband Nonlinear Optical Enhancement Induced by Synergistic Effect Between Graphene and CdS Nanocrystals

Baohua Zhu, Yuzong Gu
Henan University

Due to the strong light-matter interactions and unique nonlinear optical properties, graphene, a layer of 2D carbon atoms, are attractive for photonics applications. To further enhance the optical nonlinearity, it is necessary to combine graphene with semiconductor nanocrystals to form new graphene-based functionalization. Here, CdS nanocrystals are successfully attached on graphene nanosheets and their broadband nonlinear optical properties are investigated by picosecond Z-scan technique at 532 nm and 1064 nm. We found that synergistic effect between the graphene and CdS makes a major enhancement on the nonlinear optical absorption of graphene/CdS nanohybrid in comparison with cooperative effect. The improvement limited within one order of magnitude is mainly attributed to nonradiative defects in G/CdS NHs. Furthermore, we find that the synergistic susceptibility rapidly rises at the intensity range from 4.3 GW·cm^{-2} to 8.1 GW·cm^{-2} while changes slowly as the intensity is outside this range. It is very important for improving the total susceptibility of graphene-based nanohybrid that the inclusion material and the host perform low nonradiative defects and opposite sign with the incoming intensity at a suitable range where the charge transfer is more effective.
Key words: optical nonliearity; synergistic effect; G/CdS nanohybrids; broadband response

CIOP-2017-0595

Growth and characterization of Nd-Doped Niobate Laser Crystals

Shoujun Ding[1], Qingli Zhang[2], Wenpeng Liu[2]
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Currently, diode pumped solid-state lasers (DPSSLs) based on Nd-doped crystals have attracted a great deal of attention because of the high efficiency, compactness and high stability, which have been widely applied in the fields of medical treatment, industry processing, military and optical communication. In this case, a series of Nd-doped niobate laser crystals have been grown successfully by our group, including Nd:$YNbO_4$, Nd:$GdNbO_4$, Nd:$GdLaNbO_4$, and Nd:$GdYNbO_4$. The characterizations (including structure, mechanical and optical properties) of these crystals have been investigated. Laser experiment of these niobate crystals were performed and the slope efficiency of Nd:$YNbO_4$, Nd:$GdNbO_4$, Nd:$GdLaNbO_4$, and Nd:$GdYNbO_4$ crystal were obtained to be 24%, 35.3%, 34.2% and 30.4%, respectively. All the results indicated that these crystals have application prospects in low and even moderate lasers.
Key words: niobate; crystal growth; spectral properties; CW lasers

Session 1: Photonic Integration and Optical Interconnect

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CIOP-2017-1589	**Observability Analysis for Fixed Position Alignment of Strapdown Inertial Navigation System** **Qi Wang** *National University of Defense Technology*
CIOP-2017-2111	**The Impact of Soliton Spectral Tunneling on Supercontinuum Manipulation in Cascaded Photonic Crystal Fibers** **Hua Yang, Min Liu, Gangyan Xiao, Saili Zhao, Xue Tian** *Hunan University*
CIOP-2017-2214	**A New Scrambling Fiber Transmission System for Astronomical Exploration** **Yaokun Xu, Shihai Sun, Weitao Liu** *National University of Defense Technology*
CIOP-2017-2220	***Research on Multiple Electromagnetically Induced Transparency (EIT)-like Resonance Effect in Cascaded Self-Coupled Ring Resonators*** **Xuenan Zhang, Yao Wang, Xiaoli Wang, Zhenyan Li** *Schoolof Information Science and Engineering, Northeastern University*

Session 2: Advanced Fiber Optics & Sensing Technology

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CIOP-2017-0464	**Influence of Preform Structure on Tensile Strength of Reduced Diameter PANDA PMF** **Feng Tu, Qi Qian, Zhongmin Yang, Xia Zhao, Dan Xu, Xiaofei Lei, Shucheng Liu** *State Key Laboratory of Luminescent Materials and Devices and Institute of Optical Communication Materials, South China University of Technology*
CIOP-2017-0499	**A Micro S-Shaped Optical Fiber Temperature Sensor Based on Dislocation Fiber Splice** **Haitao Yan** *[1] Henan University of Science & Technology, the College of Physics Engineering; [2] The Puyang Photoelectric Industry Technology Institute*
CIOP-2017-0666	**Study on Vibration Performance and Damaging Detection of Composite Materials Based on FBG** **Fangdong Zhu** *NingBo LiangHe Road & Bridge Technology CO.,ltd.*
CIOP-2017-0879	**A Study on Packaging and Characteristics of Tapered Fiber for the Refractive Index of Liquid** **Xingliu Hu** *Jinling Institute of Technology*
CIOP-2017-1012	**Influence of Laser Source Wavelength Stability on Measurement Error of Electro-optic Integrated Electric Field Sensor** **Wanqing Jing, Bo He, Cheng Chen, Mingxi Zhao, Shuming Liu** *State Key Laboratory of Electrical Insulation and Power Equipment, School of Electrical Engineering, Xi'an Jiaotong University*
CIOP-2017-1203	**High OSNR and Simple Configuration Dual-Wavelength Fiber Laser with Wide Tunability in S+C+L Band** **Ting Feng, Mingming Wang, Dongliang Ding, X SteveYao** *Hebei University*
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CIOP-2017-1579	**High-Sensitivity Temperature Sensor Based on Liquid-Core Photonic Crystal Fiber Coated with Nanoscale Gold Film** **Qiang Liu, Shuguang Li, Jianshe Li** *Yanshan University, College of Science*
CIOP-2017-1643	**Accuracy Improvement in Temperature Detection Using Brillouin Optical Time-Domain Reflectometry with Segmentation-Based Wavelet Transform** **Zhangjun Yu, Jun Yang, Yonggui Yuan, Feng Peng, Hanyang Li, Changbo Hou, Chengcheng Hou, Haoliang Zhang, Libo Yuan** *Key Lab of In-fiber Integrated Optics, Ministry Education of China, Harbin Engineering University*
CIOP-2017-1921	**Research on Starting Stability of a Missile Borne Fiber Optical Gyroscope** **Jiang Junbiao, Wang Xiaozhang, Zhang Hui, Li Rui, Long Pengyi, Tang Feng, Li Xiao**
CIOP-2017-1937	**High Stable Dual-Wavelength Switching Through Hybrid Frequency Bistable Control** **Liu Chunyu, Zhang Xudong, Hou Liangtao, Liu Jiping, Bu yinGaridi, Wang Peng, Yang Jiuru** *Heilongjiang University*
CIOP-2017-1974	**Channel Capacity of Brillouin Optical Time Domain Reflectometry and Brillouin Optical Time Domain Analysis Based on Wavelength Division Multiplexing** **Zelin Zhang,Yunqin Zhao,Yuangang Lu** *Department of Applied Physics, Nanjing University of Aeronautics and Astronautics*
CIOP-2017-2215	**Short Cavity DFB Fiber Laser Based Cector Hydrophone for Low Frequency Signal Detection** **Xiaolei Zhang, Faxiang Zhang** *Laser Instiute, Shandong Academy of Science*
CIOP-2017-2311	**Self-Calibration of Different Sensing Optical Fibers in Distributed Raman Optical Fiber Sensing System** **Fuchang Chen, Chaoqun Yu, Hualin Zhang, Jinrong Zhou, Zhimin He** *Minnan Normal University*
CIOP-2017-2417	**Development of High Temperature Acoustic Emission Sensing System Using Fiber Bragg Grating** **Dandan Pang** *Shandong Jianzhu University*
CIOP-2017-2551	**Design of Lens Coupler with Uniform Energy Distribution for LED and POF Bundle** **Zhang Xiaoting[1,2], Liu Chujia[1,2], Qi Yu[1,2], Cai Zhihui[1], Wu Fengtie[1], Zhuang Qiren[1,2]** *[1] Huaqiao University,College of Information Science and Engineering; [2] Fujian Provincial Key Laboratory of Light Propagation and Transformation*

Session 3: Biomedical Photonics

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CIOP-2017-0315	**Higher Order Micro-Fiber Modes for Escherichia Coli Manipulation Using a Tapered Seven-Core Fiber** **Yi Zhou, Xunli Yin, Lei Liang, Jiaxian Xing, Xueguang Qiao, Qiangzhou Zhou** *Department of Physics, Northwest University; China, School of Science, Xi'an Shiyou University, China; Department of Physics, Northwest University, Shaanxi, China.*
CIOP-2017-0929	**A Novel Probe to Enhance OCT Imaging in Cerebral Blood Vessel *in vivo* In Mouse** **Shaozhuang Yang[1], Liwei Liu[1], Siyi Hu[2], Jingrui Xiu[2], Bingling Chen[1], Junle Qu[1]** *[1] Key Laboratory of Optoelectronic Devices and Systems of Ministry of Education and Guangdong Province, Shenzhen University; [2] International Joint Research Center for Nanophotonics and Biophotonics, School of Science, Changchun University of Science and Technology*
CIOP-2017-1386	**Study of Speckle Property in Optical Coherence Tomography for Tissue Classification** **Yanfeng Wu, Yong Huang, Kailin Zhang, Shizhao Peng, Ailing Yang, Xiaodi Tan** *School of Optoelectronics, Beijing Institute of Technology*
CIOP-2017-1494	**The Photobleahcing Properties of a Second-Generation Photosensitizer-Hematoporphyrin Monomethyl ether** **Huimin Zhao, Lixin Zang, Bingjie Ma, Qinyu Liu, Meng Kou, Jinhua Lü, Xuemei Liu, Chengshan Guo** *Shandong Normal University,Harbin Institute of Technology*
CIOP-2017-1510	**Vertical Placement of Oblique-Incidence Reflectivity Difference for High-Throughout Label-Free Measurement** **Junwei Hu, Hao Chen** *Jiangsu Normal University*

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CIOP-2017-1536	**A Penalty Method for Multispectral Bioluminescence Tomography** **Jingjing Yu, Qiyue Li, Wenbin Xiang** *Shanxi Normal University*
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CIOP-2017-1720	**Terahertz Spectral Characteristics of Oligosaccharides** **Li Ge, Liu Wei** *Dept. of physics, Capital Normal Univ.*
CIOP-2017-1729	**Terahertz Time-Domain Spectroscopy of Melatonin** **Yang Xi, Liu Wei** *Department of physics, Capital Normal University*
CIOP-2017-1731	**Two-Photon Excited Fluorescence Imaging of Blood Flow in Live Mouse Dorsal Skin Window Chamber Model** **Shaozhuang Yang, Xiao Peng, Qi Wang, Wei Yan, Bin Yu, Jian Gao, Liwei Liu, Bingling Chen, Junle Qu** *Key Laboratory of Optoelectronic Devices and Systems of Ministry of Education and Guangdong Province, College of Optoelectronic Engineering, Shenzhen University, Shenzhen, Guangdong Province, China*
CIOP-2017-1817	**Generation and Propagation Characteristics of Generalized Airy Beams with Tunable Trajectories**
CIOP-2017-1823	**Generation and Propagation Characteristics of Generalized Airy Beams with Tunable Trajectories** **Yixian Qian** *Zhejiang Normal University*
CIOP-2017-1946	**Application of Optical Feedback Cavity Enhanced Absorption Spectroscopy to The Breath Diagnostics** **Luo Zhifu,Liu Siqi,Tan Zhongqi** *National University of Defense Technology*
CIOP-2017-1956	**Dynamic Analysis of Laser-Induced Collapse Micro-Jet Acting on Bone Tissue** **Mingxin Hua, Jing Wang, Zhenlin Zhan, Nenrong Liu, Xianzeng Zhang** *Institute of Laser and Optoelectronics Technology Fujian Provincial Key Laboratory for Photonics Technology, Key Laboratories of Optoelectronics Science and Technology for Medicine of Ministry of Education*
CIOP-2017-2160	**Rapid Measurement of Transversal Flow Velocity Vector with High Spatial Resolution Using Speckle Decorrelation Optical Coherence Tomography** **Lei Fu, Ya Su, Wenping Li, X. Steve Yao** *Hebei University*
CIOP-2017-2478	**Image Reconstruction Based on Single-molecule Localization Algorithm for Photoactivated Localization Microscopy** **Lixin Liu, Mengzhu Li, Xinzhu Xue,Qian Wang, Danni Chen, Junle Qu** *School of Physics and Optoelectronic Engineering, Xidian University, College of Optoelectronic Engineering, Shenzhen University, Key Laboratory of Optoelectronic Devices and Systems of Ministry of Education and Guangdong Province*

Session 4：Optical Design and Optical Precision Measurement

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CIOP-2017-0242	**Amelioration of Field Curvature in Magnetic -Focusing Image Converter Tube** **Yubo Liao, Houzhi Cai, Yanli Bai, Jinyuan Liu, Wenyong Fu, Jiayu Chen, Quanliang Guo** *Shenzhen University*
CIOP-2017-0438	**基于摄影测量的星箭分离相对位姿测量方法** **Jie Wang, Xiaohu Zhang, Shaowen Ding** *National University of Defense Technology*
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CIOP-2017-0559	**Generating Long-Distance Nondiffracting Bessel Beams with Liquid-immersion Composite-Axicon** **Liang Liu, Xiujun Huang, Hongyan Xu, Zhenjiang Song, Shanshan Wang** *Yantai Industry and Trade Technician College*

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CIOP-2017-0569	**Large Range Measurement Method Research Based on Multi-View Reconstruction** **Shaowen Ding, Xiaohu Zhang, Jie Wang** *National University of Defense Technology*
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CIOP-2017-0727	**Investigation on the Properties of Laser Induced Ni Plasma** **Guiyin Zhang, Huan Song, Yang Liu, Zhi Ren, Zhanlong Zhao** *North China Electric Power University*
CIOP-2017-0728	**Intelligent Extraction and Characteristic Parameter Analysis of Electron Beam Moiré Fringe** **Quanliang Guo, Jinhua Long, Yanli Bai, Yubo Liao, Jiayu Chen, Wenyong Fu, Jinyuan Liu** *Shenzhen University*
CIOP-2017-0766	**The Analysis and Performance Test of the High Temporal-Spatial Framing Technology** **Yanli Bai** *Guilin University of Electronic Technology*
CIOP-2017-0808	**Design of A High-speed Atomic Force Microscope with An Independent Fast-Axis Scanner** **Lu Liu** *Tianjin university*
CIOP-2017-0923	**The Nonlinearity Measurement of Array CCD Spectrometer for Color Test Using Color LEDs** **Weiqiang Zhao, Hui Liu, Jian Liu** *The National Institute of Metrology*
CIOP-2017-1284	**A Compact High-Resolution Spectrometer by Using Two Plane Gratings with Triple Diffraction** **Yajun Pang[1], Yinxin Zhang[1], Zhanhua Huang[1], Huaidong Yang[2], Guofan Jin[2]** *[1] Tianjin University; [2] Tsinghua University*
CIOP-2017-1293	**Research on Image Acquisition and Preprocessing Method for Visual Measurement of Pipeline Inner Surface Corrosion** **Zhonghu Li, Lin Zhang, Junhong Yan, Jinming Wang, Kang Li** *Inner Mongolia University of Science and Technology*
CIOP-2017-1316	**Experimental Research on Polarization Mode Dispersion Measurement Based on Empirical Mode Decomposition** **Pan Pan, Lixia Xi, Xiaoguang Zhang, Xianfeng Tang, Dong Wan** *Beijing University of Posts and Telecommunications*
CIOP-2017-1487	**Research on the Aberration Properties of Pupil Off-Axis Freeform Optical System** **Haodong Shi** *Changchun University of Science and Technology*
CIOP-2017-1592	**Plasma Screening Laser Induced Breakdown Spectroscopy** **Ming Zhu, Menghan Wang, Xiao Peng, Junle Qu** *Shenzhen University*
CIOP-2017-1631	**A Multi-Channel Semiconductor Laser Temperature Control System** **Qixin He, Huifang Liu, Bin Li, Chuantao Zheng, Yiding Wang** *Jilin University*
CIOP-2017-1651	**Effect on Diffraction Efficiency of Multi-layer Diffractive Optics with Surface Roughness** **Lidong Zhao, Yuanming Zhao, Shan Mao** *Changchun University of Science and Technology*
CIOP-2017-1670	**New Method of Measuring Polarizer's Extinction Ratio Based on Heterodyne Interference Amplified** **Zhendong Shi** *Chinese Academy of Engineering Physics*

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CIOP-2017-1688	**Three-Dimensional Elemental Imaging of Jadeite Via Micro Laser Induced Breakdown Spectroscopy** **Kaiting Lin, Menghan Wang, Xiao Peng, Ming Zhu, Junle Qu** *Shenzhen University*
CIOP-2017-1860	**Filterless Photonic Microwave Generation with Frequency Sextupling without Accurate Phase Controlling** **Yichao Teng, Yiwang Chen, Baofu Zhang, Pin Zhang** *PLA University of Science and Technology*
CIOP-2017-1886	**Optimal Design of A High Accuracy Photoelectric Auto-collimator based on Position Sensitive Detector** **Peipei Yan, Yongqing Yang, Wenji She, Ka iLiu ,Kai Jiang, Jing Duan, Qiusha Shan** *Xi'an Institute of Optics and Precision Mechanics, CAS*
CIOP-2017-1902	**Three-Dimensional Shape Profiling Based on Fourier Analysis** **Xintian Bian[1], Feng Lei[1], Masahideitoh[2]** *[1] Huaiyin Normal University; [2] University of Tsukuba*
CIOP-2017-1907	**Analysis and Optical Design of Near Infrared Spectrometer for Soil Content Measurement** **Zhenye Wang, Keyan Dong, Yan An** *Changchun University of Science and Technology*
CIOP-2017-1909	**Analysis and Simulation Effect of Mass Fraction in the Air-Holes Photonic Crystal on Band Gap Width** **Abudu, Abdu** *Xinjiang University*
CIOP-2017-1987	**The Measurement of Liquid Diffusion Coefficient by Using A Double Liquid-Core Cylindrical Lens: Equivalent Altitude Method** **Yan Xia, Weidong Meng, Yan Chen, Fangxi Song, Xiaoyun Pu** *Yunnan University*
CIOP-2017-1992	**Measuring Diffusion Coefficient of Sucrose?solution by Using A Double Liquid-Core Cylindrical Lens** **Fangxi Song, Weidong Meng, Yan Xia, Xiaoyun Pu** *Yunnan University*
CIOP-2017-2084	**Distortion Analysis and Testing of Short Magnetic Focused Image Tube** **Jiayu Chen, Jinyuan Liu, Houzhi Cai, Yubo Liao, Wenyong Fu, Quanliang Guo, Yanli Bai** *College of Optoelecronic Engineering in Shenzhen University*
CIOP-2017-2109	**Highly Sensitivity Detection of Hg2+ Using Surface Plasma Resonance Sensor Based Liquid Crystal Molecular** **Shaopeng Wang, Hongyan Zhang, Huaixiang Huang** *The Technical Institute of Physics and Chemistry, CAS*
CIOP-2017-2113	**The Optical Design and Simulation of the Solar Simulator** **Jun Zhang** *Soochow University*
CIOP-2017-2114	**Design of Measurement System of 3D Surface Profile Based on Chromatic Confocal Technology** **Ansu Wang** *Soochow University*
CIOP-2017-2115	**Design of Laser Afocal Zoom Expander System** **Jiang Lian** *Soochow university*
CIOP-2017-2164	**The Technique of Installation Error Angle Calibration in the Experiment of Accuracy Evaluation in INS** **Xinyue Gao, Yanhong Lü** *Beihang University*
CIOP-2017-2184	**High- Efficiency Bending Couplers Using Impedance-Tunable Coordinate Transformation** **Jun Cao** *Nanjing Xiaozhuang University*
CIOP-2017-2400	**Measuring Uniaxial Axis Direction of Electro-Optic Crystal by Conoscopic Polarized Interference** **Yong Liu, Dong Li, Xu Liu, Hongzhen Jiang, Fanglan Zheng** *Research Center of Laser Fusion, China Academy of Engineering Physics*
CIOP-2017-2412	**Optical System Design of Star Sensor with Long-Life** **Hu Wang** *Xi'an Institute of Optics and Precision Mechanics, CAS*

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CIOP-2017-2497	**A Flat and Low Dispersion Microstructured Optical Fiber for Supporting 22 Orbital Angular Momentum Modes** **Yong You** *Tianjin university of technology*
CIOP-2017-2498	**Research on Underwater Target Depth Detection Technology** **Yingchao Li, Qiang Fu, Xiao Yin, Zhuang Liu, Chao Wang, Yan An, Huilin Jiang** *Changchun University of Science and Technology*
CIOP-2017-2552	**Fabrication of Side-Glowing Fiber with Acreen Printing Method** **Chujia Liu, Yu Qi, Fangping Chen, Xiaoting Zhang, Qiren Zhuang** *Huaqiao University*

Session 5: Optical Communications and Networks

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CIOP-2017-0209	**The Study And Implement of Recognizable Optical Add-Drop Multiplexer Based on Space-Division-Multiplexing (Sdm)** **Kang Yang[1], Guoyu Li[1], Yan Li[1], Mu Zhang[2], Sumei Jia[1]** *[1] Nankai University; [2] China Unicom of Handan branch*
CIOP-2017-0397	**Modeling of Laser Beam Propogation From Air Into Seawater** **Mengmeng Tao, Feng Zhu, Li Yu, Yanlong Shen** *State Key Laboratory of Laser Interaction with Matter*
CIOP-2017-0474	**Effects of Moderate-To-Strong Marine-Atmospheric Turbulence on Spiral Spectrum of Hankel-Bessel Beams In The Slant Link** **Yixin Zhang** *Jiangnan University*
CIOP-2017-0752	**Adaptive Phase-Diversity Technique In A Dpsk Homodyne Receiver** **Changqing Cao** *Xidian University*
CIOP-2017-0765	**Studies on Low-Loss Coupling Based on Injecting Tapered Solid-Core Fibers Into The Core-Area of Anti-Resonant Hollow-Core Fibers** **Naiqian Zhang, Zefeng Wang** *College of Optoelectronic Science and Engineering, National University of Defense Technology*
CIOP-2017-0793	**Performance Analysis of Different Modulation Formats Based on Rof System** **Li Li** *Anyang Institute of Technology*
CIOP-2017-0811	**Joint Channel/Frequency offset Estimation And Correction For Coherent optical Fbmc/oqam System** **Qifei Zhao, Shoupeng Wang, Daobin Wang, Yumeng Xu** *Lanzhou University of Technology*
CIOP-2017-0919	**Research on Average Power Requirement of Multiple Subcarrier Modulation In Wireless Optical Communication** **Yu Lei** *Xian University of Technology*
CIOP-2017-0928	**Edge-Dip Air Core Fiber For Improvement of The Transmission of Higher-order oam Modes** **Xibo Sun,Yuanchao Geng,Qihua Zhu,Xi Feng,Wanqing Huang,Ying Zhang,Lanqin Liu** *Research Center of Laser Fusion, China Academy of Engineering Physics*
CIOP-2017-1058	**Mdns Based Automatic Discovery Method In Optical Nms** **Yangan Zhang,Jie He,Xueguang Yuan** *Beijing University of Posts and Telecommunications*
CIOP-2017-1204	**Research on Deeply Converged Communication Based on Photonic-Rf Wave Via High Frequency-Doubled** **li Guang** *Guangdong Polytechnic of Science and Technology*
CIOP-2017-1457	**Performance of Misaligned orbital Angular Momentum Communication System With Mimo Equalization** **Wenhao Zhang** *Nanjing University of Posts and Telecommunications*

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CIOP-2017-1699	**The Characteristics of Wavelength Conversion Based on The Fopa** **Peipei Li, Hongna Zhu, Chunrong Qiu, Jianqiang Guo, Xiaorong Gao** *Southwest Jiaotong University, Chengdu*
CIOP-2017-1947	**Study of The Characteristics of Laser Transmission In Atmosphere-Seawater Channel Under Complicate Sea Conditions** **Xiangzhen Li[1], Xicai Miao[2], Xiao Qi[2], Xiang'E Han[2]** *[1] Jiangsu Automation Research Institute; [2] Xidian University*
CIOP-2017-2204	**Bit Error Rate Performance For Modulating Retro-Reflector Free Space optical Communication System Based on Adaptive Threshold** **Xiaoyan Li, Peng Zhang, Peng Zhang, Shoufeng Tong** *Changchun University*
CIOP-2017-2261	**The Influence of Different Fiber-End Fixing Methods on The Focal Ratio Degradation of Astronomical Fibers** **Huaizhi Zhang[1], Liyuan Zhao[1], Qi Yan[1], Qiong Zhang[1], Hang Jiang[1], Zhenyu Ma[1], Ying Wang[1], Xiren Jin[1], Xudong Chen[1], Chunlian Lu[1], Tao Geng[1], Weimin Sun[1], Zhongwen Hu[2], Yongtian Zhu[2], Xiangqun Cui[2], Yue Zhong[1], Liang Chang[1], Zhongquan Qu[1]** *[1] Harbin Engineering University; [2] the Nanjing Institute of Astronomical Optics & Technology*
CIOP-2017-2292	**Flatness Bandwidth Modulation And Controllable Based on Reconfigurable Dual-Ring Coupled Resonator** **Zhang Jing, Yi Hong, Zhenghua Li, Lijiao Guo** *Dalian Minzu University*
CIOP-2017-2300	**Carrier Phase Estimation Algorithm Based on Blind Phase Search By Linear Approximation** **Qi Zhang, Muguang Wang, Qi Ding, Jing Zhang, Su Zhang, Hongqian Mu, Tangjun Li** *Beijing Jiaotong University*
CIOP-2017-2347	**Dynamic Bandwidth Allocation Algorithm Based on Neural Network Prediction Under The Software-Defined Time-Division Multiplexing Passive optical Network** **Ming Liu[1], Bo Liu[2], Lijia Zhang[1], Xiangjun Xin[1], Qi Zhang[1], Yongjun Wang[1], Qinghua Tian[1]** *[1] Beijing University of Posts and Telecommunications (BUPT); [2] Nanjing University of Information Science & Technology (NUIST)*
CIOP-2017-2358	**Rate-Compatible Punctured Rs-Ldpc-Cc Product-Code** **Zhibo Wang[1], Bo Liu[2], Lijia Zhang[1], Xiangjun Xin[1]** *[1] School of ELectronic Engineering, Beijing University of Posts and Telecommunication(BUPT); [2] Institute of Optoelectronics, Nanjing University of Information Science & Technology(NUIST)*
CIOP-2017-2370	**Adaptive Interpolation Phase Splitting Timing Recovery Loop For Coherent optical Communication System** **Xuan Liu[1], Bo Liu[2], Lijia Zhang[1], Xiangjun Xin[1], Qi Zhang[1], Yongjun Wang[1]** *[1] Beijing University of Posts and Telecommunications (BUPT); [2] Nanjing University of Information Science & Technology (NUIST), Beijing University of Posts and Telecommunications (BUPT)*
CIOP-2017-2372	**Two-Dimensional Dynamic Wavelength And Bandwidth Allocation Model For Qos In Wdm/Tdm Pon Networks** **Yixin Sun[1], Bo Liu[2], Lijia Zhang[1], Xiangjun Xin[1]** *[1] Beijing University of Posts and Telecommunications (BUPT); [2] Nanjing University of Information Science & Technology (NUIST)*
CIOP-2017-2374	**The Research of Adaptive Modulation Technology In ofdm-Rof System** **Chongxin Liu[1], Bo Liu[2], Lijia Zhang[1], Xiangjun Xin[1]** *[1] Beijing University of Posts and Telecommunications (BUPT);[2] Nanjing University of Information Science & Technology(NUIST)*
CIOP-2017-2421	**Optimal Design of Step-Index Ring Fibers Supporting Stable oam Modes** **Zhang Xia** *Liaocheng University*
CIOP-2017-2461	**Study on The Propagation Characteristics of Lg Beam With oam Multiplexing In Atmospheric Turbulence** **Yongping Zheng[1], Qinghua Tian[1], Qi Zhang[1], Lei Zhu[1], Yongjun Wang[1], Bo Liu[2], Xiangjun Xin[1]** *[1] Beijing University of Posts and Telecommunications (BUPT); [2] Nanjing University of Information Science & Technology (NUIST)*
CIOP-2017-2491	**Research on Space objectives optical Detection And Communication Integration Technology** **Qiang Fu,Yingchao Li,Haodong Shi,Zhuang Liu,Zhang Tao,Xiao Yin,Huilin Jiang** *Changchun University of Science and Technology*
CIOP-2017-2536	**A Kind of Multi-Mode Mimo Equalization Method Based on Mode Coupling Coefficient** **Yuan Bi[1], Bo Liu[2], Lijia Zhang[1], Xiangjun Xin[1]** *[1] Beijing University of Posts and Telecommunications (BUPT); [2] Nanjing University of Information Science & Technology (NUIST)*

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CIOP-2017-2545	**The Influence of Rain Weather on The Receiving Power of Ultraviolet Communication** **Hang Dong, Xiaoyi Li** *Chongqing communicationinstitute of PLA*
CIOP-2017-3001	**A Dual-Laser Single-Modulation Microwave Photonic Link with High Gain and Low Noise Figure** **ZhenghuaZhou, HuijunXu, Yu Zhang** *School of Mechanical and Electrical Engineering, Nanchang Institute of Technology*

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CIOP-2017-0831	**Compensation of The Phase Aberrations In Digital Holographic Microscopy Based on Reference Lens Method** **Yanan Zeng[1], Hai Lei[2], Yuan Liu[1], Rui Zhu[3], Xiaodong Hu[2], KangYan Su[1]** *[1] Tianjin Agricultural University; [2] Tianjin University; [3] Tianjin Jinhang institute of computing technology*
CIOP-2017-0862	**Particle Tracking In Three Dimensional By Digital Holographic Microscopy Concerned on The Variation of optical Path Length** **Yanan Zeng[1], Xiaodong Hu[2], Junsheng Lu[2], Rui Zhu[3], Kangyan Su[1], Yuan Liu[1]** *[1] Tianjin Agricultural University; [2] Tianjin University; [3] Tianjin Jinhang institute of computing technology*
CIOP-2017-0906	**一种基于双 QR 码双随机相位加密系统的多重水印方法** **Weimin Wu[1], Jiazhen Chen[2]** *[1] Fujian Chuanzheng Communications College; [2] Fujian Normal University*
CIOP-2017-0908	**一种基于层析法和非插值可控重建的虚拟光学多图像加密方法** **Jiazhen Chen[1], Zihua Zheng[1], Feng Ye[1], Guiren Lian[1], Weimin Wu[2], Li Xu[1]** *[1] Fujian Normal University; [2] Fujian Chuanzheng Communications College*
CIOP-2017-1366	**Design And Fabrication of Antireflection Grating** **Wenlong Zou, Jianhong Wu** *Optoelectronics and Energy of Soochow University*
CIOP-2017-2039	**Design And Control of Multifocal Spots Array By Phase-only Analytical Formulas Under Tight Focusing Conditions** **Linwei Zhu, Meiyu Sun, Jiannong Chen, Rui Yang** *Ludong University*
CIOP-2017-2092	**All-optical Ultrafast Coaxial Framing Photography Based on Parallel Coherence Shutters** **Guanghua Chen** *Institute of Fluid Physics, CAEP*
CIOP-2017-2117	**An Algorithm of Phase Unwrapping Based on Interpolation Method For Digital Holography** **Xumeng Li, Zhao Wang, Junhui Huang, Yang Zhang, Jianmin Gao** *Xi'an Jiaotong University*
CIOP-2017-2414	**Aberration Correction In Fresnel Incoherent Digital Holography Using Phase Diversity** **Hongqiang Zhou, Wan Yuhong Wan, Tianlong Man** *Beijing University of Technology*
CIOP-2017-3015	**Mountain Agricultural Machinery Intelligence Research Institute Challenge for Knowledge Creation and Innovative Technology** **Zhao Zhixiong**

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CIOP-2017-0884	**Fluorescent Spectral Imaging Technology In Active Components of Pilose Antler Decoction Slices** **Fucui Li, Jia Dong, Siqi Zhu, Furong Huang** *Opto-electronic Department of Jinan University*

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CIOP-2017-0926	**Infrared Dim-Small Target Tracking Based on Guided Image Filter And Kernelized Correlation Filter** **Dong Zhao, Huixin Zhou, Kun Qian, Shenghui Rong** *Xidian University*
CIOP-2017-0968	**Application of High-Accuracy Laser Doppler Velocimeter In Self-Contained Land Navigation System** **Zhihui Ying, Chunfeng Gao, Qi Wang** *National University of Defense Technology*
CIOP-2017-1133	**Analysis on Structured Light Reconstruction Method and Characteristics Through Scattering Media** **Chen Jia** *Tianjin University of Technology*
CIOP-2017-1141	**The Study of The Human Lung Cancer Tissue By The Aotf Based Fast Hyperspectral Imaging** **Jiangwei Yuan, Chunguang Zhang, Hao Wang, Lei Shi** *Fujian Normal University*
CIOP-2017-1149	**A Numerical Calculation Method For Laser Radar Cross Section of Rotating Convex Body** **Yunhua Cao, Yongzhi Du** *Xidian University*
CIOP-2017-1152	**Hyperspectral Microimaging System Base on Double-Filtering Technology and Image Analysis** **Lei Shi, Hao Wang, Chunguang Zhang, Jiangwei Yuan** *Fujian Normal University*
CIOP-2017-1264	**Correction of Rotation And Magnification Errors In Distributed Aperture Synthesis Imaging System** **Bo Chen** *North China University of Science and Technology*
CIOP-2017-1303	**Implementation of Biological Tissue Mueller Matrix For Polarization-Sensitive optical Coherence Tomography Based on Labview** **Yongping Lin** *Fujian Normal University*
CIOP-2017-1488	**Waveform Lidar Signal Denoising Based on Connected Domain** **Liyu Sun, Deying Chen, Ruihuan Zhang, Rongwei Fan, Zhiwei Dong** *Harbin Institute of Technology*
CIOP-2017-1710	**改进 Sobel 算子在基于鬼成像的边缘检测中的研究** **Hongdou Ren** *Nanjing University of Posts and Telecommunications*
CIOP-2017-1787	**Study on the Characteristic of Internal Solitary Waves at Wenchang Area Based on Optical Remote Sensing Images** **Xiaoyi Pan, Jing Wang, Yuan Mei** *Department of Physics, College of Information Science and Engineering, Ocean University of China*
CIOP-2017-1918	**Study on Propagation Characteristics of Internal Solitary Waves in the Strait of Gibraltar Based on Optical Remote Sensing Images** **Lu Shi, Jing Wang, Yuan Mei** *Department of Physics, College of Information Science and Engineering, Ocean University of China*
CIOP-2017-2012	**Viewing Angle Enlargement Method of Holographic Augmented Reality Using An off-Axis Holographic Lens** **Yanfeng Su, Zhijian Cai, Lingyan Shi, Peiliang Guo, Yifan Lu, Jianhong Wu, Wenlong Zou** *Soochow University*
CIOP-2017-2056	**Measurement of Extinction Coefficient of Near - Surface Aerosol By Ccd Lidar In The Daytime** **Peiyu Sun[1], Kee Yuan[2], Jie Yang[3]** *[1] Graduate University of Chinese Academy of Sciences; [2] Anhui Institute of Optics and Fine Mechanics; [3] University of Science and Technology of China*
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CIOP-2017-2367	**Uncertainty Analysis of Luminance Measurement For Laser Display** **Guoquan Wang, Quanshe Sun, Facai Zhao, Shaoshui Wang, Xiangliang Zheng, Zhong Han** *The 41'st institute of CETC*
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CIOP-2017-2397	**Multiframe Blind Deconvolution Using object Phase obtained By Speckle Imaging** **Chengang Ren** *Xichang Satellite Launch Center*
CIOP-2017-2398	**Improvement of Underwater Visibility With Polarization Technique** **Yi Wei, Pingli Han, Fei Liu** *Xidian University*
CIOP-2017-2496	**Research on Target Polarization Imaging Detection Technology In Smog Environment** **Qiang Fu, Duan Jin, Yingchao Li, Juntong Zhan, Yang Liu, Zonghui Tao, Zheng Li, Huilin Jiang** *Changchun University of Science and Technology*
CIOP-2017-2538	**Adaptive optics Images Restoration By Gaussian Total Variation Constraint Richardson-Lucy Iterative Blind Deconvolution** **Wei Niu[1], Jianhua Zou[1], Jianglin Shi[1], Shiping Guo[2]** *[1] Xi'an Jiaotong University; [2] Northwestern Polytechnical University*

Session 8: Micro-Nano Photonics and Metamaterials

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CIOP-2017-0980	**Influence of Welding Parameters on Weld Shape and Microstructure of Fiber Laser Beams Welded T-Joint of Aluminium Lithium Alloy** **Enguang He, Li Chen, Kun Luo** *Research Institute*
CIOP-2017-1013	**Tunable Electromagnetic Induced Transparency in Metamaterial** **Yu Wang, Guohua Dong, Tingting Lv, Yuxiang Li, Zheng Zhu, Jinhui Shi** *Harbin Engineering University*
CIOP-2017-1030	**Linear Polarization Conversion in Optical Metamaterial** **Guohua Dong, Yu Wang, Ping Li, Yuxiang Li, Zheng Zhu, Jinhui Shi** *Harbin Engineering University*
CIOP-2017-1044	**Tunable Circular Dichroism in Achiral Metamaterials** **Shaoen Zhou, Wenjin Lv, Yuxiang Li, Zheng Zhu, Jinhui Shi** *Harbin Engineering University*
CIOP-2017-1248	**Slow Light in A Slot Photonic Crystal Waveguide with Asymmetric Dielectric Rods** **Jing Shu** *Nanjing University of Science and Technology*
CIOP-2017-1250	**Self-Accelerating Beams Generated by Metasurface** **Lixiang Liu** *Shanxi Datong University*
CIOP-2017-1266	**A Low Lasing Threshold and Widely Tunable Spaser Based on Two Dark Surface Plasmons** **Tianqing Jia** *East China Normal University*

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CIOP-2017-1289	**Fabrication of Two Dimensional Micro-Nano Photonic Structures by Symmetry-Breaking Coherent Beams** **Hao Lü, Kai You, Xia Wang, Yanyan Lan, Qiuling Zhao** *Qingdao University of Science and Technology*
CIOP-2017-1444	**Wide-Band Achromatic Lens for Visible Light Based on Sub-Wavelength Grating Array** **Shaowu Wang, Jianjun Lai** *Wuhan National Laboratory for Optoelectronics*
CIOP-2017-1673	**Tunable Dualband Absorption Enhancement and Light Trapping in A Coupled Graphene Grating-Sheet System at Mid-Infrared Wavelengths** **Pei Ding** *Zhengzhou University of Aeronautics*
CIOP-2017-1875	**Bidirectional and Tunable Multi-Channel Quantum Router by Single Photons** **BinChen Gui** *Huaiyin Normal University*
CIOP-2017-1890	**A Simple and Tunable Switch between Slow- and Fast-Light in Two Signal Modes with Anoptomechanical System** **Binchen Gui** *Huaiyin Normal University*
CIOP-2017-1991	**Ultra-Broadband Polarization-Independent Metamaterial Perfect Absorber at Visible-Near Infrared Frequencies** **Peixiang Wang, Jianjun Lai** *Huazhong University of Science and Technology*
CIOP-2017-2116	**Demonstration of WGM Lasing Threshold with Rhodamine B Gain in Mixed Solution** **Dongyang Li, Xiaoyun Pu, Yuanxian Zhang** *Yunnan University*
CIOP-2017-2218	**Narrow-Band Filter Using Gires-Tournois Cavity in Metal-Insulator-Metal Waveguide** **Yang Gao,Yachen Gao, Lingling Ran, Jiuru Yang** *HeilongjiangUniversity*
CIOP-2017-2219	**W-Band Metamaterial-Based Compressive Imaging System** **Ying Chen[1,2], Yuan Zhou[1], Lulu Wang[1]** *[1] Changsha University; [2] Hunan Univesristy*
CIOP-2017-3007	**A Universal Plasmonic Polarization State Analyzer** **Qi Zhang, Shuyun Teng*** *Shandong Normal University*
CIOP-2017-3020	**Highly Efficient Dielectric Waveguide for Quantum Well Infrared Photodetectors** **Guangxu Su, Long Liu, Hai Su, Peng Zhan, Zhenlin Wang**

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CIOP-2017-0493	**The Analytical Solution of Temperature Distribution in Side-Cooled Rod and disk Lasers** **Liang Liu** *Shandong Institute of Aerospace Electronics Technology*
CIOP-2017-0558	**Self-Correction of Thermal-Induced Wavefront-Distortion in Slab Laser** **Liang Liu[1], Xiaojun Xu[2], Shanshan Wang[3], Dele Shi[1]** *[1] Shandong Institute of Aerospace Electronics Technology; [2] National University of Defense Technology; [3] Yantai Industry and Trade Technical College*
CIOP-2017-0580	**Yellow and Green Light Selectable in Q-switched Nd:YVO_4/LBO Raman Laser** **Simeng Chen, Ye Yu, Liaoqing Liao, Yaqing Mao, Haiyong Zhu, Yanmin Duan** *Wenzhou University*
CIOP-2017-0651	**Complex-Enhanced Chaotic Signals with Time Delay Signature Suppression Based on Vertical-Cavity Surface-Emitting Lasers Subject to Chaotic Optical Injection** **Yan Li[1], Linfu Li[2], JianjunChen[3]** *[1]Bingtuan Radio &TV University; [2] Guizhou Minzu University; [3] Xinjiang Medical University*

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CIOP-2017-0659	**Pumping Efficiency and Overlap Efficiency of Solar-Pumped Cr/Nd:YAG Ceramic Laser by Fresnel Lens: Influnce of Laser Medium Size** **Yu Lu** *Tianjin University of Technology and Education*
CIOP-2017-0664	**Nd:YAG Ultra-short Pulse Regenerative Amplifier Pumped by Laser Diode Array** **Minqiang Kang** *Research Center of Laser Fusion, CAEP*
CIOP-2017-0810	**Matrix Calculation Based on Coupling Effect of Inhomogeneous Mediums in Cavities** **Peifeng Chen, Ying Wang** *Huazhong University of Science and Technology*
CIOP-2017-0826	**Femtosecond Fiber Laser System and Pulse Trains Selection Based on High Repetition Rate KTP Pockels Cell** **Feng Li, Zhiguo lv, Zhi Yang, Yang Yang, Wenqi Zhu, Baoning Jiang, Qianglong Li, Xiaojun Yang, Yishan Wang, WeiZhao** *Xi'an Institute of Optics and Precision Mechanics of CAS*
CIOP-2017-0995	**The Study of the Effect of Complementary Dual M-Z Modulator Structure on the Performance of PTS-ADC System** **Junda Wang, Ying Chen, Xiangning Chen** *Academy of Equipment*
CIOP-2017-1051	**Temperature Measurement by Single-Laser-Shot Chirped-Probe-Pulse Femtosecond Coherent Anti-Stokes Raman Scattering** **Guozhong Hou, Yuan Zhang, Yuanqin Xia, Zeming Zhang, Sheng Zhang, Hongyang Yu** *Harbin Institute of Technology*
CIOP-2017-1193	**Thermal Dependence of Spectral Overlap between High Power LD Pump and Laser Madium in Double Face Pumped Laser** **Yanzhong Chen, Ye Lang, Guangyan Guo, Zhongwei Fan, Lifen Liao** *Academy of Opto-Electronics, CAS*
CIOP-2017-1307	**Q-Factor Improvement of Degenerate Four-Wave-Mixing Regenerators For ASE Degraded Signals** **Hang Lu, Baojian Wu, Yong Geng, Xingyu Zhou, Fan Sun** *University of Electronic Science and Technology of China*
CIOP-2017-1502	**Influence of Deuterium Homogeneity of Large-Scale DKDP Crystals on the Third Harmonic Generation** **Xiangxu Chai[1], Fang Wang[1], Bin Feng[1], Fuquan Li[1], Wei Han[1], Xi Feng[1,2], Yong Xiang[1], Liquan Wang[1], Yukun Jing[1]** *[1] Research Center of Laser Fusion, China Academy of Engineering Physics; [2] Shandong University*
CIOP-2017-1505	**Going Beyond the Femtosecod Filament by A Gaussian Beam: Use of A Superposed Gaussian Beam** **Zhenming Song** *Tianjin Polytechnic University*
CIOP-2017-1515	**Efficient Tunable Wavelength Conversion Based on Four-Wave Mixing Effect in Photonic Crystal Fiber** **Jianshe Li, Shuguang Li, Qiang Liu, Weihong Bi** *Yanshan University*
CIOP-2017-1572	**Technical and Theoretical Development of Second Harmonic Generation in Poled Fused Silica** **Xi Feng[1], Fuquan Li[1], Aoxiang Lin[1], Xiangxu Chai[1], Fang Wang[1], Zhengping Wang[2], Sen Zhang[1], Xibo Sun[1], Qihua Zhu[1], Xun Sun[2]** *[1] Research Center of Laser Fusion, China Academy of Engineering Physics; [2] Shandong University*
CIOP-2017-1773	**Characterization of the Terahertz Frequency Optical Constants of Tourmaline** **Weichong Tang, Zhiyuan Zheng, Zili Zhang, Ke Xiao** *China University of Geosciences*
CIOP-2017-1799	**Application of Energetic Liquid Polymer in Laser Plasma Propulsion** **Jing Qi, Zhiyuan Zheng** *China Univercity of Geoscience*
CIOP-2017-1842	**Research of Suppressing Small-Scale Self-Focusing Based on the Pre-Compensation with Negative B-Integral in High-Power Laser System** **Xiangjun Xiang, Ying Deng** *Laser Fusion Research Center, China Academy of Engineering Physics*
CIOP-2017-1874	**Propagation of Collimated Gaussian Beam in Turbulent Atmosphere with A Random Spectrum Distribution** **Yujie Li, Wenyue Zhu** *Anhui Institude of Optics and Fine Mechanics*

Number	***Title*** ***Author*** Organization
CIOP-2017-1888	**Theoretical Modeling and Optimization of Mid-Infrared Fluoride Raman Fiber Laser at 3.54 μm** **Tianfu Yao, Yuan Tian, Pu Zhou, Bing Lei, Jinyong Leng, Jinbao Chen** *National University of Defense Technology*
CIOP-2017-1896	**Experimental Investigation on the SBS-PCM for High Repetition Rate Laser** **Zhijun Kang[1], Ye Lang[2], Jianguo He[1], Zhenao Bai[1], Hongbo Zhang[1], Zhongwei Fan[1]** *[1] Academy of Opto-Electronics, Chinese Academy of Sciences; [2] Beijing Institute of Technology*
CIOP-2017-1898	**A Numerical Solution of III-V-on-Silicon DBR Lasers Based on Digital Filter Approach and Traveling-Wave Model** **Mo Qu, Yu Li, Weiping Huang, Lianlu Liu** *Shandong University*
CIOP-2017-1995	**Noise-Like Pulse Generation from A Ho-Doped Fiber Laser Based on Nonlinear Polarization Rotation** **Guangchen Liu, Ke Yin, Bin Zhang, Jing Hou** *National University of Defense Technology*
CIOP-2017-2005	**Single Low-Index Trench Fiber with Effective Single-Mode Operation for High-Power Application** **Liangjin Huang[1], Tianfu Yao[2], Binhua Yang[1], Shaoyi Gu[1], Jinyong Leng[1], Pu Zhou[2], Xiang'ai Cheng[1]** *[1] National University of Defense Technology; [2] The 23th Research Institute of China Electronics Technology Group Corporation*
CIOP-2017-2019	**Research of Uniform Irradiation on A Direct Drive Target Based on Multi-Fiber Coherent Combining** **Hongxun Li, Rui Zhang** *China Academy of Engineering Physics*
CIOP-2017-2077	**A Method of Real-Time Temperature Measurement in Fiber Lasers** **Junjie Sun, Zefeng Wang, Meng Wang, Kai Han, Jinbao Chen** *National University of Defense Technology*
CIOP-2017-2078	**716 nm Deep-red Passively Q-Switched Pr^{3+}-Doped Fluoride All-Fiber Laser Using A Carbon Nanotube Saturable Absorber** **Wensong Li, Huiying Xu, Zhiping Cai** *Xiamen university*
CIOP-2017-2190	**Generation of Controllable High Order Transverse Modes in Passively Q-Switched Microchip Laser Under Decentered Gaussian Pumping** **Mingming Zhang, Yue Pan, Jun Dong** *Xiamen University*
CIOP-2017-2197	**Cr^{4+}:YAG Stabilized Nd:YAG/Cr^{4+}:YAG Composite Crystal Passively Q-Switched Microchip Laser with Quasi-CW Laser Diode Pumping** **Yue Pan, Chaoyu Li, Mingming Zhang, Jun Dong** *Xiamen University*
CIOP-2017-2200	**Passively Q-switched Nd:$GdVO_4$/Cr^{4+}:YAG/YVO_4 Raman Microchip Laser Operating at Dual-Wavelength of 1164.4 nm and 1174.5 nm** **Xiaojie Wang, Xiaolei Wang, Zhifen Zheng, Jun Dong** *Xiamen University*
CIOP-2017-2207	**Experimental Research on Raman Spectrum in 1.7μm Wavelength Region Pumped by Multimode Laser** **Quanli Du, Peng Zhang, Di Wu, Qingsong Jia** *Changchun university of Science and Technology*
CIOP-2017-2264	**Three-Photon Excitation of An Upconversion Laser in Organic-Inorganic Halide Perovskite Thin Films** **Jiao Tian** *East China Normal University*
CIOP-2017-2267	**Optical Super-Resolution Effect Enabled with Nonlinear Charateristics of GO Film** **Yongchuang Zhao[1], Zhongquan Nie[1], Aiping Zhai[1], Yanting Tian[1], Chao Liu[1], Changkun Shi[1], Baohua Jia[2]** *[1] Taiyuan University of Technology; [2] Swinburne University of Technology*
CIOP-2017-2268	**A Stochastic Parallel Gradient Descent Method for the Wavefront Control of Spatial Conditioning Beam** **De'en Wang** *China Academy of Engineering Physics*
CIOP-2017-2289	**Realization of the Carrier-Envelope Offset Frequency Stabilization of A 137 fs, 814 nm Ti: Sapphire Mode-Locked Laser** **Xiao Xiang** *National Time Service Center, CAS*

Number	***Title*** ***Author*** Organization
CIOP-2017-2308	**Theory and Experiment Researches on the Third-Order Nonlinear Optical Properties of the N-6-Hydroxy-Hexyl-4-Azophenyl-Carbazol** **Quanjie Zhong** *China Academy of Engineering Physics*
CIOP-2017-2315	**Characterization of Optical Filamentation Generated by Femtosecond Laser with Different Repetition Rate** **Xiaolong Liu, Yin Zhu, Gaoxiang Ouyang** *Academy of Opto-Electronics, CAS*
CIOP-2017-2350	**Multi-photon Excitation of An Upconversion Incoherent Random Laser in ZnO Powders** **Guoen Weng** *East China Normal University*
CIOP-2017-2430	**A Heterodyne Grating Interferometer with Periodic Nonlinearity Smaller than ±50 pm** **Weinan Ye, Ming Zhang** *Tsinghua University*
CIOP-2017-2504	**Fabrication and Application of High Nonlinear Silica Photonic Crystal Fibers** **Yinyao Liu, Dakun Wu, Lili Hu, Meisong Liao** *Shanghai Institute of Optics and Fine Mechanics*
CIOP-2017-2532	**Repetitively Q-Switched Operation of Er-Doped Sesquioxide Ceramic Lasers at ~2.7 μm** **Xiaojing Ren[1], Jian Zhang[2], Dingyuan Tang[2], Deyuan Shen[1]** *[1] Fudan University; [2] Jiangsu Normal University*
CIOP-2017-2546	**Laser Detection Target Identification Based on Wavelet Analysis** **Xinzhu Wang, Xuliang Lv, Xiaodong Sun** *PLA university of Science and Technology*

Session 10: Quantum Optics and Quantum Information Technology

Number	***Title*** ***Author*** Organization
CIOP-2017-0221	**Polarization Gradient Cooling in A Non-Degenerated 2D Optical Lattice** **Chunhua Wei, carloskuhn** *Australia National University*
CIOP-2017-0511	**Average Polarizability of Quantization Bessel-Gaussian Schell-Model Beams in Anisotropic Non-Kolmogorov Turbulence** **Ye Li** *Jiangnan University*
CIOP-2017-0716	**Theoretical and Experimental Investigations on Lengthening the Transverse Relaxation Time of Cesium Atoms** **Yangying Fu** *National University of Defense Technology*
CIOP-2017-0723	**Development of An Electronic System for Mid-Infrared Quantum Cascade Laser Gas Detection Device** **Baiyang Lin, Jinmin Dang, Chuantao Zheng, Yu Zhang, Yiding Wan** *Jilin University*
CIOP-2017-1373	**Generation of Long-Living Entanglement between Two Distant Three-Level Atoms in Non-Markovian Environments** **Chuang Li** *Harbin Institute of Technology*
CIOP-2017-1750	**Toward Cesium Magnetometer Based on Squeezed Vacuum** **Jianfeng Tian, Chen Yang, GuanHua Zuo, Chenxi Wang, Yuchi Zhang, Gang Li, Pengfei Zhang, Tiancai Zhang** *Shanxi University*
CIOP-2017-1831	**Phase Measurement Via HOM Interference** **Yaokun Xu, Shihai Sun, Weitao Liu** *National University of Defense Technology*
CIOP-2017-1882	**Abbe-Porter Imaging with Thermal Light** **Ke Xiao, Lu Gao, Zhiyuan Zheng, Weichong Tang** *China University of Geosciences*
CIOP-2017-1906	**Entanglement Properties of Quantum Rabi Model with Two Arbitrary Qubits** **Yuhu Xu, Xuezao Ren, Xueying Liu** *Southwest University of Science and Technology*

Number	***Title*** ***Author*** Organization
CIOP-2017-1941	**Polaron Effects on the Second-Harmonic Generation in Asymmetrical Semiexponential Quantum Wells** **Kangxian Guo** *Guangzhou University*
CIOP-2017-2121	**A Deterministic Quantum Dot Micropillar Single Photon Source for Quantum Photonics** **Shunfa Liu[1], Ying Yu[1], Yuming Wei[1], Yujia Wei[1], Ben Ma[2], Zhichuan Niu[2], Lin Liu[1], Lidan Zhou[1], Siyuan Yu[1]** *[1] Sun Yat-sen University; [2] Institute of Semiconductors, CAS*
CIOP-2017-2244	**Estimate Quality of Ghost Imaging Directly Using Covariance Matrix of Illumination Patterns** **Shufeng Jia, Huizu Lin, Quan Li, Weitao Liu, Long Li** *National University of Defence Technology*

Poster

Session 11: Laser Micro-Nano Processing and Optical Precision Fabrication

Number	***Title*** ***Author*** Organization
CIOP-2017-0610	**Femtosecond Laser Inscription Waveguides and Waveguide Laser in Nd: YAG Crystals** **Shiling Li** *Qufu Normal University*
CIOP-2017-0740	**Femtosecond Laser Inscribed Waveguide Structures in Ti:Sapphire for Beam Splitting** **Yingying Ren[1], Limu Zhang[1], JavierVázquez de Aldana[2], Feng Chen[3]** *[1] Shandong Normal University; [2] University of Salamanca,School of Physics; [3] Shandong University,*
CIOP-2017-0771	**Channeled Waveguide Structure in Nd:YAG Crystal Fabricated by Femtosecond Laser Writing and Ion Irradiation for Q-Switched Waveguide Lasing** **Linan Ma, Yang Tan** *Shandong University*
CIOP-2017-0994	**Ultrafast Laser-Induced Periodic Surface Ripple on HgCdTe Single Crystal** **Dai Ye** *Shanghai University*
CIOP-2017-1015	**Design of Computer-Generated Hologram and Its Application on Holographic Laser Processing with a High-Power Laser** **Hwihyeong Lee, Sangwoo Park, Seongwoo Cha, Hong Jin Kong** *KAIST*
CIOP-2017-1075	**Femtosecond Laser Writing of Polytype Waveguide in $LiNbO_3$ Crystal** **Jinman Lü** *Shandong University*
CIOP-2017-1112	**Second Harmonic Generation from 3D Optical-Lattice-Like Cladding Waveguide Splitters in KTP Crystal by Femtosecond Laser Writing** **Weijie Nie[1], Feng Chen[1], Javier R.Vázquez de Aldana[2]** *[1] Shandong University; [2] Universidad de Salamanca*
CIOP-2017-1169	**Thermal Damage on Graphene Induced by Femtosecond Laser** **Chen Cheng, Feng Chen** *Shandong University*
CIOP-2017-1172	**Optical Waveguiding structure in β-BBO Crystal Fabricated by Femtosecond-Laser Micromachining** **Ziqi Li** *Shandong University*
CIOP-2017-1181	**All-Laser-Micromachining of Ridge Waveguides in $LiNbO_3$ Crystal for Mid-Infrared Band Applications** **lingqi Li** *Shandong University*
CIOP-2017-1861	**Study on Etch Process of GaSb-based VCSEL** **Xin Zhang, Yang Li, Xia Wang, Yang Li,Guangli Yue, Zhiwei Wang, Jianlai Xie, Yongqin Hao** *Changchun University of Science and Technology*
CIOP-2017-1951	**Research Status of Laterally Coupled DFB - LD** **Guangli Yue, Jiabin Zhang, Zhiwei Wang, Xin Zhang, Yang Li, Jianlai Xie, Xia Wang, Yongqin Hao** *Changchun University of Science and Technology*

Number	***Title*** ***Author*** Organization
CIOP-2017-1952	**Development of High Power Distributed Feedback Semiconductor Laser and Its Applications** **Yang Li, Yuan Feng, Xin Zhang, Guangli Yue, Zhiwei Wang, Jianlai Xie, Xia Wang, Yongqin Hao** *Changchun University of Science and Technology*
CIOP-2017-2036	**Downstream Light Intensification Induced by Gaussian Mitigation Pits Using Micro-Milling on KDP Rear Surface** **Hao Yang[1], Jian Cheng[1], Kehui Hu[2], Qi Liu[1], Mingjun Chen[1], Zhichao Liu[3], Chenhui An[3], JianWang[3]** *[1] Harbin Institute of Technology; [2] Tsinghua University; [3] China Academy of Engineering Physics*
CIOP-2017-2118	**Super-Resolution Longiudinally Polarized Light Needle Achieved by Tightly Foucsing Radially Polarized Beams** **Changkun Shi, Zhongquan Nie, Yanting Tian, Liu Chao, Yongchuang Zhao, Baohua Jia** *Taiyuan University of Technology*
CIOP-2017-2333	**Influence of Heat Effect on Material Removal of Optical Element During Annular Polishing** **Yiren Wang** *Harbin Institute of Technology*
CIOP-2017-2509	**Fabrication of Side-Glowing Polymer Optical Fiber by Laser Marking Method** **Qi Yu** *Huaqiao University*

Session 12：Advanced Optical Functional Materials and Devices

Number	***Title*** ***Author*** Organization
CIOP-2017-0206	**Tunable Terahertz Optical Properties of Monolayer Graphene in Dc Electric Fields** **H.M.Dong, Fei Huang, Jinlong Liu** *China University of Ming and Technology*
CIOP-2017-0505	**An Organic–Inorganic Broadband Photodetector Based on A Single Polyaniline Nanowire Doped with Quantum Dots** **Xianguang Yang** *Jinan University*
CIOP-2017-0642	**Studies On The Structures And Optical Properties Of 9,10-DIphenylanthracene Crystals Preparated By Two Methods** **Lin Jin, Lan Dong, Dongxu Li** *China Academy of Engineering Physics*
CIOP-2017-1377	**Characteristics of Electronically Controllable Sagnac Optical Switch Based on Cascaded Magneto-Optical Microrings** **Shuang Ni, Baojian Eu, Gang Yu** *University of Electronic Science and Technology of China*
CIOP-2017-1694	**Effect of Maleic Anhydride on Trap Levels of Alumina/Low-Density Polyethylene By Photo-Stimulated Discharge** **Lijuan He, Huiqin Niu, Dawei Li, Lei Zhao, Chuntian Chen** *Harbin University of Science and Technology*
CIOP-2017-1764	**Photon Tunneling and Transmittance Through Composite Layers of Negative- and Positive-Index Media with Sinusoidal Interface** **Xiaobao Zhang, Hui Luo, Zhongqi Tan, Zhifu Luo, Siqi Liu** *Xiaobao Zhang, Hui Luo, Zhongqi Tan, Zhifu Luo, Siqi Liu*
CIOP-2017-2175	**Design of Temperature Control System for DPL Laser** **Ping Li** *Changchun University of Science and Technology School of Optielectronic Engineering*
CIOP-2017-2332	**Synthesis and Luminescence of Novel CH_4N_2O Assisted $NaLa(MoO_4)_2:Eu^{3+}$ Phosphors** **Weiping Gao, Lin Ma, Xuejie Duan, Ninghua Zhang** *Xidian University*
CIOP-2017-3006	**Refractive indices expressions of liquid crystal E7** **Mingjian Ma, Hailiang Chen, Shuguang Li, Xili Jing** *College of Science, Yanshan University*

Workshops

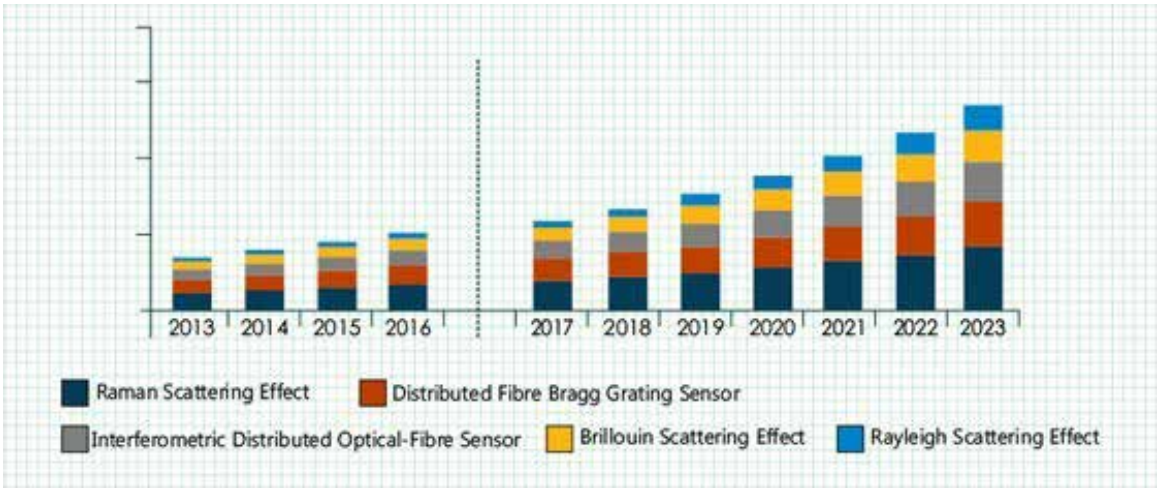
1. The workshop on distributed fiber optic sensors

Distributed fiber optic sensors refer to the integration of distributed sensing technology along the entire length of fiber cable to achieve continuous and real-time measurements. Distributed fiber optic sensors overcome the built-in constraints of traditional technologies such as thermocouples and strain gauges. The distributed fiber optic sensors offer several advantages including immunity to electromagnetic interference, high sensitivity, broad bandwidth, lightweight, small size, and ease of implementation.

Presently, most of the research groups have moved their focus towards distributed sensors, capable of detecting various dynamic parameters including dynamic strains, electromagnetic fields and sound waves. Due to the rapid adoption of distributed fiber optic sensors in various industry verticals for several applications, commercialization of distributed optical fiber sensors has found some success. New ideas to enhance the application areas of distributed fiber optic sensors are uninterruptedly being developed and helping traditional measurements along with new applications.

The global distributed fiber optic sensor market is expected to witness a CAGR of 15.0% during the forecast period, to reach $1,970.1 million by 2023. Distributed fiber optic sensors are widely being adopted in oil and gas vertical. In oil and gas applications, these sensors are being used for specific monitoring of well-temperature and for obtaining an authentic picture of physical parameters of wellbore. However, the market is expected to register fastest growth in civil engineering vertical, during the forecast period. Distributed fiber optic sensors are widely being adopted in civil engineering to enhance the inspection accuracy and efficiency. The application of structured health monitoring (SHM) systems to civil engineering is the major factor escalating the adoption of distributed optic fiber sensors in this vertical. Engineers trained in visual inspection used to execute several civil engineering infrastructures including assessment of buildings, bridges, dams and tunnels, which includes the probability to be inaccurate because of the deviations in their background for safety condition assessments. These sensors help civil engineering vertical with their features of durability, small size, security and insensitivity to external electromagnetic perturbations.

GLOBAL DISTRIBUTED FIBER OPTIC SENSOR MARKET $M (2013–2023)



Workshop organizer

Yongkang Dong, Harbin Institute of Technology, aldendong@163.com

This workshop includes 9 invited talks on distributed fiber optic sensors.

Location: ***B516, 5F, Main Building, Harbin Institute of Technology No.2 Campus***

Distributed temperature and strain sensing based on fibre birefringence measurements using coherent Rayleigh scattering
Marcelo A. Soto
EPFL Swiss Federal Institute of Technology

Recent advances of Brillouin sensing technology using plastic optical fibers
Yosuke Mizuno
Tokyo Institute of Technology

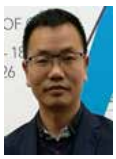
Distributed Brillouin sensors based on direct current modulation of a laser diode
Kwang Yong Song
Chung-Ang University

Enabling Technologies for Ultra-Long-Distance Distributed Fiber-Optic Sensing
Zinan Wang
University of Electronic Science and Technology of China

The applications of fiber optic sensors in geophysics and seismology
Wentao Zhang
Institute of Semiconductors, Chinese Academy of Sciences

Recent advances in distributed fiber sensors
Liyang Shao
Southwest Jiaotong University

Recent advances of polarization sensitive optical time domain reflectometry
Feng Wang
Nanjing University



Parameters-tuning of fiber lasers
Tao Zhu
Chongqing University

Distributed fiber-optic sensing with ultra-high spatial resolution by using linear optical sampling technique
Xinyu Fan
Shanghai Jiao Tong University

2. Industry of Fiber Optic Gyroscope: Challenges and Solution

Location: ***B507, 5F, Main Building, Harbin Institute of Technology No.2 Campus***
Time: ***17th, July***

Time	Title	Speaker	Organization
13:30-13:50	Estimation of Bias Drift Due to Distributed Polarization Crosstalk in Optical Fiber Coil of Fiber Optical Gyroscope application	杨远洪	北京航空航天大学
13:50-14:10	超高精度光纤偏振器件测试在光纤陀螺核心器件检测中的应用	杨 军	哈尔滨工程大学
14:10-14:30	用于光纤环检测的分布式布里渊光纤多参量测量技术	董永康	哈尔滨工业大学
14:30-14:50	光纤陀螺温度特性分析及补偿技术研究	李绪有	哈尔滨工程大学
14:50-15:10	光子晶体光纤可靠性研究	李晶	北京航天时代光电科技有限公司
15:10-15:30	茶歇		
15:30-15:50	机载光纤陀螺发展面临的挑战与对策	谢良平	中航工业西安飞行自动控制研究所
15:50-16:10	光纤陀螺领域对特种光纤的需求和应用	彭志强	航天科工湖北红峰控制有限公司
16:10-16:30	超高可靠性光纤熔接技术及应用	陈德玺	北京凌云光技术集团
16:30-16:50	光纤陀螺用光纤器件的应用和发展趋势	金新刚	嘉兴旭锐电子科技有限公司
	茶歇		

Concurrent events

Badminton & Table tennis Game

- **Playing Time:** 18:00-21:00, 17th-18th July
- **Awarding ceremony:** Banquet, 19th July

Lecture —— 如何用 PPT 完美展现你的科研工作

- **Time:** 19:00, 17th July
- **Location:** B510, 5F, Main Building, Harbin Institute of Technology No.2 Campus

Part 1 — 做好科研，也要做好科研报告

周常河 研究员： 中科院上海光学精密机械研究所 博导
国家杰出青年基金获得者 美国光学学会 *(OSA) fellow*
曾任 *Optics Express Associate Editor*
现任 *Chinese Optics Letters* 执行主编 （期刊 *2016 IF: 1.859*）

Part 2 — 简约至上的 PPT——不能说的秘密

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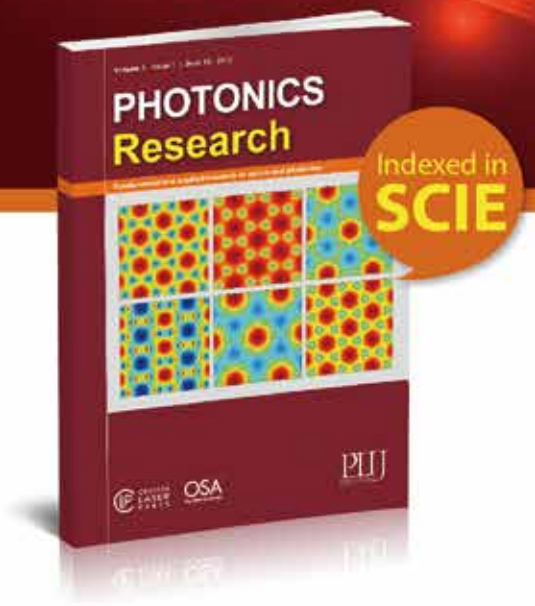

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Track 1: Optical Fibers and Fiber-based Devices
Track 2: Optical Transmission Systems and Networks
Track 3: Photonic Devices, Components, and Photonic Integration
Track 4: Microwave Photonics
Track 5: Micro-, Nano-, and Ultrafast Photonics: Science and Applications
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赵维谦 教授	北京理工大学	沈卫星 高　工	中科院上海光机所

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本届新增VR课程（主讲：程德文教授）

时间：2017年10月22日—27日（22日报到）

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