

APOS 2016

The 6th Asia Pacific Optical Sensors Conference

CONFERENCE PROGRAM

Oct. 11-14, 2016 / Shanghai, China



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Welcome Message

Asia-Pacific Optical Sensors Conference (APOS) has been held every 18 months tracing back to 2008, and continues a series of conferences that are intended to provide a central forum for an update and review of technical information covering a wide range of optical sensing fields from fundamental researches to systems and applications. The conference is open to researchers and professionals from not only Asia-Pacific Rim area but also all regions of the world.

The 6th APOS (APOS 2016) will be co-organized by Shanghai Jiao Tong University and Yangtze Optical Fibre and Cable Joint Stock Limited Company (YOFC). It is jointly sponsored by OSA, SPIE, IEEE Photonics Society, Chinese Optical Society (COS) and Chinese Society for Optical Engineering (CSOE). The APOS 2016 will be held in Shanghai, China, October 11-14, 2016.

On behalf of the organizing committee of the APOS 2016, it is our great honor and pleasure to cordially invite you to the conference, to share your most significant advances, and to take the chance of interacting in a mutually profitable relationship.

Welcome to APOS 2016, Shanghai!

General Chair: *General Co-Chairs:*



Prof. Zuyuan He



Prof. Wei Jin

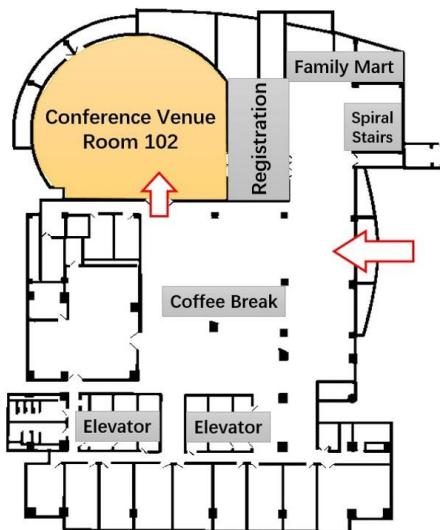


Prof. Yunjiang Rao



Dr. Weijun Tong

Floor Plan



1st Floor

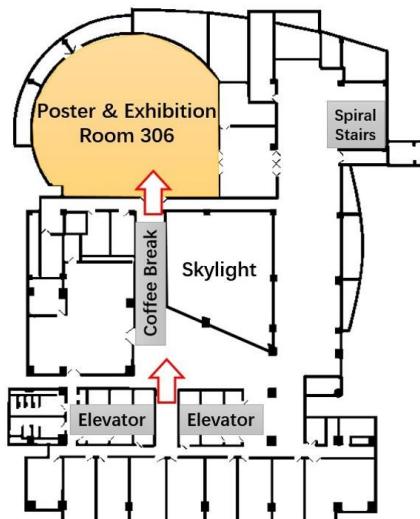
Haoran High-tech Mansion

- Registration
- Oral Session
- Coffee Break

3rd Floor

Haoran High-tech Mansion

- Poster
- Exhibition
- Coffee Break



General Information

Overview

Asia Pacific Optical Sensors Conference (APOS) is a leading Asia Pacific event on optical sensing spanning fiber, waveguide, bulk and nanophotonic sensor technologies.

- Title: The 6th Asia Pacific Optical Sensors Conference (APOS 2016)
- Date: October 11 (Tuesday) ~ 14 October (Friday), 2016
- Venue: Haoran High-tech Mansion, Shanghai, China
- Organized by:
 - Shanghai Jiao Tong University
 - Yangtze Optical Fibre and Cable Joint Stock Limited Company
- Conference Language: English
- Website: www.apos2016.org

Organization

General Chair:

Prof. Zuyuan He, Shanghai Jiao Tong Univ., China

General Co-Chairs:

Prof. Wei Jin, The Hong Kong Polytechnic Univ., China

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Dr. Weijun Tong, Yangtze Optical Fibre and Cable Joint Stock Limited Company (YOFCC), China

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Track 8: Distributed, Multiplexed and Networked Sensing

Chair:

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Dr. Zuying Xu, Yangtze Optical Fibre and Cable Joint Stock Limited Company, China

Registration

Registration fee for the conference includes admission to all Technical Sessions, Poster Sessions, Exhibition, Welcome Reception, Lunches, Refreshments, and Conference Banquet. APOS 2016 participants are supposed to wear their badges in the session room, which are given upon registration.

How to register

1. Pre-registration

Step 1. Submit on-line registration form and complete the payment in advance.

Step 2. Pick up conference materials and badge at the registration desk.

2. On-site registration

Step 1. Fill out the on-site registration form.

Step 2. Hand in the form to the staff and complete the payment.

Step 3. Registration materials and badge will be provided.

(The invoice for mainland Chinese attendees will be mailed after the conference)

3. Registration open time

- Pre-registration: Until September 23, 2016
- On-site registration: October 10~13, 2016

4. Registration desk

The registration desk will be located in 1F lobby at Haoran High-tech Mansion. All payments are made in Chinese Yuan (CNY), either by cash or by credit card. The registration hours are listed as follows:

Date	Oct. 10	Oct. 11	Oct. 12	Oct. 13
Time	14:00~17:30	08:00~17:30	08:00~17:30	08:00~17:30

Program Details

1. Oral Session

- **Date:** Oct. 11, 2016 (Tue.) ~ Oct. 14, 2016 (Fri.)
- **Place:** Room 102, Haoran High-tech Mansion

Oral Presentation is limited to 15 minutes (Plenary: 45 minutes, invited: 30 minutes) and includes:

- 12 minutes (Invited: 25 minutes) for presentation, and
- 3 minutes (Invited: 5 minutes) for Q&A

All presenters are supposed to report their attendance to the Session Chair at least 10 minutes prior to the commencement of the session. For presenters, please kindly bring your presentation saved in a USB memory stick and upload to the computer for presentation at least 15 minutes prior to the session.

2. Poster Session

- **Date:** Oct. 12, 2016 (Wed.) and Oct. 13, 2016 (Thu.)
- **Place:** Room 306, Haoran High-tech Mansion

Presenters should stick their materials on the poster board with their poster number at 8:00 am on the day of their presentation. During the poster session, at least one author is supposed to present at each poster to interact with the audience. Please ensure to fetch back your poster at the end of the session. The size of poster board Size is 2.3m (Height) X 1.0m (Width).

3. Post-deadline Paper Session

- **Date:** Oct. 14, 2016 (Fri.)
- **Place:** Room 102, Haoran High-tech Mansion

Post-deadline Paper Presentation is 15 minutes and this includes:

- 12 minutes for presentation, and
- 3 minutes for Q&A

All presenters are supposed to report their attendance to the Session Chair at least 10 minutes prior to the commencement of the session. For presenters, please kindly bring your presentation saved in a USB memory stick and upload to the computer for presentation 15 minutes prior to the session.

4. Best Student Paper Awards

To be eligible for the awards, a student must be the first author of the paper and declare his/her student candidature during online submission; and the student must give the presentation at the conference by himself/herself. The results will be announced at the closing ceremony on the last day of conference.

5. Exhibition

- **Date:** Oct. 11, 2016 (Tue.) ~Oct. 13, 2016 (Thu.)
- **Place:** Room 306, Haoran High-tech Mansion

Exhibition will be held in conjunction with the conference. All attendees are welcome to visit the exhibition and communicate with representatives from the participating companies and organizations.

6. Lunch

- **Date:** Oct. 11 (Tue.) ~ Oct. 14 (Fri.), noon
- **Place:** SJTU Faculty Club

All participants are invited. Faculty Club is an on-campus restaurant within walking distance from the conference venue. Typical Chinese dishes will be served.

7. Coffee Break

- **Place:** 1F & 3F Lobby, Haoran High-tech Mansion

All participants are invited. Please check Conference Program (back cover) for daily details.

8. Welcome Reception

- **Date:** Oct. 11, 2016 (Tue.)
- **Place:** TIKI CHINA & Patsy's

All participants are invited. Reception buffet will be served with snacks and refreshments. Please be gathered in Lobby (1F) after the session to follow a guided walking route to the restaurant.

9. Conference Dinner (Banquet)

- **Date:** Oct. 13, 2016 (Thu.)
- **Place:** Shanghai Grand Theatre Banquet Hall

All participants are invited. Delicate Shanghai cuisines and beverage will be served. Please be gathered in Lobby (1F) after the session to get on a shuttle bus.

10. Lab and Campus Tour

A tour to the State Key Laboratory of Advanced Optical Communication Systems and Networks at beautiful Minhang Campus of Shanghai Jiao Tong Univ. is scheduled after the conference on the afternoon of Oct. 14. Please make the reservation at the registration desk. The shuttle bus sets off at 1:30 pm.

Conference Program

Room 102

08:30 -- 09:30

Tu1A • Opening Ceremony and Plenary Talk

08:30 Opening Ceremony

08:45 Plenary Talk I

Presider: Prof. Yunjiang Rao, Univ. of Electronic Science and Technology of China, China

Tu1A.1 • 08:45 Plenary Talk

Liquid Crystal for Non-display Photonic Applications, Yanqing Lu¹;

¹*Nanjing Univ., China.* Inducing micro-patterns and structures inside a Liquid crystal (LC) cell is an effective way to improve the performance of LC display. However, in addition to display applications, LC also plays an important role in various tunable photonic devices with the advantages of low cost, no moving parts, low power consumption and high reliability. In this talk, I am going to review some of our work in merging LC and various artificial microstructures in different spans. The related photonic applications are discussed.

Room 102

10:00 -- 11:30

Tu2A • Plenary II

Presider: Prof. Wei Jin, The Hong Kong Polytechnic Univ., China

Tu2A.1 • 10:00 Plenary Talk

Ultra-precision Control of Optical Waves by Use of Fiber-based

Frequency Combs and its Application, Kaoru Minoshima¹; ¹*Univ. of Electro-Communications, Japan.* Optical frequency combs have opened up several new application fields not only in frequency metrology as “ultraprecise frequency ruler” but also in broad area by use of its capability for fully controlling the phase, time, and frequency information of light waves, i.e., “optical synthesizer”, with an extreme precision and wide dynamic range. In this talk, development of fiber-based frequency combs, which are the key for practical application is presented. Moreover, some of the applications of frequency combs, including

precision spectroscopy for gas sensing and material characterization, distance measurement, and imaging are presented.

Tu2A.2 • 10:45 Plenary Talk

Technology and Applications of Fiber Bragg Grating Sensors in Germany, Hartmut Bartelt¹; ¹*Fiber Optics, IPHT, Germany*. Fiber Bragg gratings have proven to be extremely versatile elements for manifold signal and sensing applications. They provide localized and fiber integrated sensing functionalities. Such attractive properties have resulted in several successful commercialization activities in Germany.

Room 102

13:00 -- 15:00

Tu3A • Physical Sensing

Presider: Prof. Luca Palmieri, Univ. of Padova, Italy

Prof. Dongning Wang, China Jiliang Univ., China

Tu3A.1 • 13:00 (Invited)

Brillouin Scattering in Plastic Optical Fibers and its Applications to High-speed Distributed Sensing, Yosuke Mizuno¹, Heeyoung Lee¹, Neisei Hayashi², Kentaro Nakamura¹; ¹*Tokyo Inst. of Technology, Japan*; ²*The Univ. of Tokyo, Japan*. We briefly review the unique properties of Brillouin scattering in plastic optical fibers (POFs). We then present our latest research results on POF-based distributed strain/temperature sensing with high spatial resolution and high sampling rate.

Tu3A.2 • 13:30

Semi-auxetic Optical Fibre Distributed Load Sensor, Luca Schenato², Alessandro Pasuto², Andrea Galtarossa¹, Luca Palmieri¹; ¹*Univ. of Padova, Italy*; ²*Research Inst. for Geo-Hydrological Protection, National Research Council, Italy*. A distributed optical fibre load sensor exploiting a semi-auxetic structure is presented. The fibre is interrogated by means of optical frequency domain reflectometry. The device is described and a prototype is assembled and characterized.

Tu3A.3 • 13:45

A High Sensitivity Three-Component Fiber Laser Seismic System, Zhihui Sun¹; ¹*Laser Inst. of Shandong Academy of S, China.* We are presenting experimental results for a new 3C fiber laser geophone and comparing its performance with regular exploration geophones. It has a better performance in terms of sensitivity and micro-seismic signal detection.

Tu3A.4 • 14:00

Ultra-Long Random Laser for Remote Real-time Interferometric Sensor Monitoring Using FFT Analysis, Veronica de Miguel¹, Aitor Lopez¹, Daniel Leandro¹, Manuel Lopez-Amo¹; ¹*Universidad Publica de Navarra, Spain.* A new sensing application of random distributed feedback fiber lasers that allows real-time remote monitoring of an interferometric sensor by means of FFT analysis is presented and demonstrated.

Tu3A.5 • 14:15

Multi-layer Graphene Diaphragm-based Fabry-Perot Interferometer for Acoustic Detection with Long Term Stability, Congzhe Zhang^{1,2}, Yuanhong Yang¹, Yanzhen Tan^{3,2}, Jun Ma³, Hoi Lut Ho^{3,2}, Wei Jin^{3,2}; ¹*Beihang Univ., China;* ²*Photonic Sensors Research Center, The Hong Kong Polytechnic Univ. Shenzhen Research Inst., China;* ³*Department of Electrical Engineering, The Hong Kong Polytechnic Univ., Hong Kong.* Graphene diaphragm-based Fabry-Perot interferometer acoustic sensor with a feedback control to achieve long term stable operation is reported. The long term stability test shows that the system can work over 12 hours without obvious reduction of detection sensitivity.

Tu3A.6 • 14:30

An Electro-optic Modulator Detection Method in All Optical Atomic Magnetometer, Yanhui Hu¹, Xuejing Liu¹, Yang Li¹, Ming Ding¹; ¹*Beihang Univ., China.* An EOM detection method is demonstrated to detect the optical atomic precession in the all optical atomic magnetometer, which achieved a sensitivity of $\sim 30 \text{ fT/Hz}^{1/2}$ @ 30Hz. It is feasible for the compactness and simplicity of atomic magnetometer.

Tu3A.7 • 14:45

High-resolution Fiber Laser Static Strain Sensor Using Beat

Frequency Interrogation Technique, Wentao Zhang¹, Wenzhu Huang¹, Shengwen Feng¹, Fang Li¹; ¹*Chinese Academy of Sciences, China.* A distributed feedback fiber laser is used for static strain sensing by beating with another fiber laser which is locked to a temperature compensation FBG resonator. A sub-0.5 nm resolution is achieved.

Room 102

15:30 -- 17:30

Tu4A • Grating and Component Technologies for Sensing

Presider: Dr. Koji Omichi, Fujikura Ltd., Japan

Prof. Yunqi Liu, Shanghai Univ., China

Tu4A.1 • 15:30 (Invited)

Introduction of FBG Sensors and their Application to Structural Health Monitoring, Yoshifumi Suzaki¹; ¹*Kagawa Univ., Japan.* Because fiber Bragg gratings (FBGs) have very sharp narrow-band reflection spectra, they are well suited for applications involving narrow-band optical signals, such as various types of fiber sensors. Some applications using FBGs will be introduced.

Tu4A.2 • 16:00

Periodically Patterned Long-period Grating on a D-shaped Photonic Crystal Fiber for Simultaneous Measurement of Temperature and Ambient Index, Jong Cheol Shin¹, Eun Ji Lim¹, Kwang Wook Yoo¹, Young-Geun Han¹; ¹*Hanyang Univ., Korea (the Republic of).* A periodically patterned long-period grating on a D-shaped photonic crystal fiber is investigated for simultaneous measurement of temperature and ambient index. The proposed LPG exhibits different temperature and ambient index sensitivities corresponding to two polarization states.

Tu4A.3 • 16:15

Orientation-dependent Accelerometer using Inner-Cladding-FBG, Weijia Bao¹, Qiangzhou Rong¹, Xueguang Qiao¹; ¹*Northwest Univ., China.* An orientation-dependent accelerometer based on inner-cladding-FBG inscribed on quadruple -cladding fiber is proposed and

demonstrated, experimentally. And the device shows a good sensitivity and orientation-dependence in the vector acceleration measurement.

Tu4A.4 • 16:30

A Gas Pressure Sensor Based on Long Period Fiber Grating

Inscribed in Air-core Photonic Bandgap Fiber, Jian Tang¹, Zhe

Zhang¹, Guolu Yin¹, Zhengyong Li¹, Shen Liu¹, Changrui Liao¹, Ying Wang¹, Yiping Wang¹; ¹*Shenzhen Univ., China*. We experimentally demonstrated a high-sensitivity gas pressure sensor based on long period fiber grating (LPFG) inscribed in an air-core photonic bandgap fiber (PBF), which exhibits a high gas pressure sensitivity of up to -1.30 nm/MPa.

Tu4A.5 • 16:45

Real-time Monitoring of the Dynamic Fiber Bragg Grating Sensor Interrogation, Jinwoo Park¹, Yong Seok Kwon¹, Min Yong Jeon¹;

¹*Chungnam National Univ., Korea (the Republic of)*. We report a real-time monitoring of the dynamic variation for the fiber Bragg grating (FBG) sensor interrogation using a 1550 nm band resonance Fourier domain mode-locked fiber laser. The resolution of the dynamic measurement could be achieved up to 2 Hz.

Tu4A.6 • 17:00

Strain Interrogation of FBG Sensor Based on Radio Frequency M-Z Interferometer with TDCMX, Jiaao Zhou^{2,1}, Li Xia^{2,1}, Ying Wu^{2,1}, Rui Cheng^{2,1}, Deming Liu¹; ¹*Huazhong Univ of Science & Technology, China*; ²*Wuhan National Laboratory for Optoelectronics, China*. The operation of a novel radio-frequency M-Z interferometer is demonstrated for strain interrogation on FBG sensor, which adopts a dispersion compensation module to change the phase difference and achieve strain sensing with high accuracy.

Tu4A.7 • 17:15

Short-time Energy Characterization of Low Velocity Impact

Localization Method on CFRP Using FBG Sensors, Junsong Yu¹, Jie Zeng¹; ¹*State Key Lab of Mechanics and Control of Mechanical Structures, Nanjing U.of Aero. and Astro., China*. An impact localization

method using four FBG sensors based on short-time energy characterization and SVM is proposed and verified on a CFRP plate with 300mm*300mm experiment area. By optimizing the free parameters of short-time energy characterization extraction method and SVM models, the experiment showed that most of the results are satisfying.

Room 102

08:00 -- 10:00

W1A • Biological / Biomedical Sensing and Imaging

Presider: Prof. Baiou Guan, Jinan Univ., China

Prof. Yuji Matsuura, Tohoku Univ., Japan

W1A.1 • 08:00 (Invited)

Real Time Optical Imaging for Biomedical Informatics, Tae Joong Eom¹; ¹Gwangju Inst of Science & Technology, Korea (the Republic of). The real time and high-resolution optical imaging were enhanced image processing quality and contribute for analyzing and diagnosis guidelines. A high speed OCT imaging system and an image processing modality was introduced for several ophthalmology applications to obtain quantified information.

W1A.2 • 08:30

Fiber Laser Ultrasound Detector With Enhanced Sensitivity for Photoacoustic Imaging Applications, Xue Bai¹, Long Jin¹, Yizhi Liang¹, Bai-Ou Guan¹; ¹Jinan Univ., China. A beat-frequency encoded fiber laser ultrasound probe has been demonstrated for photoacoustic imaging applications. Experimental result suggests the imaging contrast can be enhanced by shortening the laser cavity.

W1A.3 • 08:45

Measurement of Blood Glucose Level by using Mid-Infrared Hollow-Optical Fiber Probe with ATR Multi-Reflection Prism, Saiko Kino¹, Yuji Matsuura¹; ¹Tohoku Univ., Japan. Mid-infrared ATR spectroscopy system comprising hollow optical fibers and a multi-reflection prism are developed for blood-glucose measurement. Absorption spectra of lip mucosa revealed clear signatures of glucose and measurement errors less than 20% was obtained.

W1A.4 • 09:00

Lab on Fiber Biosensors Integrated with Microgels, Martino

Giaquinto¹, Anna Aliberti¹, Alberto Micco¹, Armando Ricciardi¹, Menotti Ruvo², Antonello Cutolo¹, Andrea Cusano¹; ¹*Univ. of Sannio, Italy;*

²*CNR-IBB, Italy.* We experimentally demonstrate a novel optical fiber label free biosensing platform resulting from the integration between Lab-on-Fiber Technology and Microgels Photonics. The novel platform allows to overcome the main issues associated to small molecule detection.

W1A.5 • 09:15

Whispering-gallery-type Sensor for Single Nanoparticle Detection

Using the Dissipative Interaction, Yanyan Zhi^{1,2}, Bo-Qiang Shen¹,
Xiao-Chong Yu¹, Li Wang^{1,2}, Donghyun Kim³, Qihuang Gong^{1,2}, Yun-Feng Xiao^{1,2}; ¹*State Key Laboratory for Mesoscopic Physics and School of Physics, Peking Univ., China;* ²*Collaborative Innovation Center of Quantum Matter, China;* ³*School of Electrical and Electronic*

Engineering, Yonsei Univ., Korea (the Republic of). Different from the conventional whispering-gallery-mode sensing using reactive interaction, the dissipative interaction is proposed and demonstrated to detect single nanoparticles which are lossy and with an ultra-small real part of the polarizability.

W1A.6 • 09:30

Rapid Estimation of Bacteria Counts using Acridine Orange, Rachel

Guo¹, Cushla M. McGoverin¹, Simon Swift², Frederique Vanholsbeeck¹;

¹*Dodd-Walls Centre for Photonic and Quantum Technologies,*

Department of Physics, Univ. of Auckland, New Zealand; ²*School of*

Medical Sciences, Univ. of Auckland, New Zealand. Determining

bacterial concentration by order of magnitude rapidly will be useful in several fields of microbiology. For this purpose we have analysed the fluorescence behavior of acridine orange bound to bacteria with independent components analysis.

W1A.7 • 09:45

Solving the Photon Maze for Sensing and Imaging inside Scattering

Media, Cheng Ma^{1,2}; ¹*Washington Univ. in St Louis, USA;* ²*Electronic*

Engineering, Tsinghua Univ., China. This paper summarizes some of our recent achievements in suppressing light scattering. These technologies may have profound impacts in biomedical applications since most biological tissues are opaque to visible or near-infrared photons due to scattering.

Room 102

10:30 -- 11:45

W2A • Integrated Technologies for Sensing

Presider: Prof. Kevin Chen, Univ. of Pittsburgh, USA

Prof. Feng Wang, Nanjing University, China

W2A.1 • 10:30 (Invited)

Direct Fabrications of Photonic Devices in Multi-Corre Fibers with Rectangular Cross-Sections, Ming-Jun Li¹, Kevin P. Chen²; ¹*Corning Incorporated, USA;* ²*Univ. of Pittsburgh, USA.* This paper reports ultrafast laser direct writing of optical components in multi-core rectangular shape fibers for sensing and fiber laser applications. We will discuss efforts to turn optical fibers from one-dimensional devices to three-dimensional devices.

W2A.2 • 11:00

Temperature Controlled Portable Smartphone Fluorimeter, Md. Arafat Hossain^{1,4}, Zhikang Yu², John Canning², Sandra Ast³, Joseph Wong², Peter Rutledge², Maxwell Crossley², Abbas Jamalipour¹; ¹*School of Electrical and Information Engineering, The Univ. of Sydney, Australia;* ²*School of Chemistry, The Univ. of Sydney, Australia;* ³*Australian Sensors and Identification Systems, Australia;* ⁴*Electrical and Electronic Engineering, Khulna Univ. of Engineering and Technology, Bangladesh.* A self-powered temperature-controlled smartphone fluorimeter is demonstrated. The device measures fluorescence for a temperature range of $T = 10$ to 40 °C with a precision of 0.1 °C. Results can be shared via wireless networking.

W2A.3 • 11:15

Simultaneous Measurement of Temperature and Humidity Based on Integrative Sensor of Fiber Bragg Grating and multilayer Fraby-

Perot interferometer, Jiankun -. Peng¹, Chongjie Qi¹, Weijia Wang¹, Minghong Yang¹; ¹Wuhan Univ. of Technology, China. Temperature and humidity measurement system based on Fabry-Perot interferometer and fiber Bragg grating is proposed. Experimentally results show the average humidity and temperature sensitivity of the integrative sensor are 0.57 nm/%RH and 10 pm/°C.

W2A.4 • 11:30

Refractive Index Sensing in an Optically Integrated Flat-fibeSubstrate, sumiyati ambran¹, Christopher Holmes², James Gates², Siti Rahmah Aid¹, Azura Hamzah¹, Minoru Yamada¹, Osamu Mikami¹, Peter Smith², Jayanta Sahu²; ¹Malaysia Japan International Inst. of Technology, Universiti Teknologi Malaysia, Malaysia; ²Optoelectronics Research Centre, Univ. of Southampton, UK. An optical flat-fiber substrate is presented for refractive index sensor. A series of Bragg grating is used as a sensing tool. A maximum sensitivity to approximately 95 nm per refractive index unit has been achieved.

Room 102

13:00 -- 15:00

W3A • Chemical and Gas Sensing

Presider: Prof. Yiping Wang, Shenzhen Univ., China
Prof. Ping Shum, Nanyang Technological Univ., Singapore

W3A.1 • 13:00 (Invited)

Microfluidics for Photochemical Harvesting of Solar Energy, Xuming Zhang¹; ¹Hong Kong Polytechnic Univ., Hong Kong. Abstract not available.

W3A.2 • 13:30

Dynamics of Photothermal Phase Modulation in a Gas-filled Hollow-core Photonic Bandgap Fiber, Yuechuan Lin¹, Wei Jin¹, Fan Yang¹, Yang Liu¹; ¹Hong Kong Polytechnic Univ., Hong Kong. The dynamics of photothermal phase modulation in a gas-filled hollow-core photonic bandgap fiber pumped by a pulsed laser is investigated. The magnitude of phase modulation for different parameters of the pump pulses is studied numerically and experimentally.

W3A.3 • 13:45

Near-infrared Enzyme-immobilized Dual-peak Long Period Fibre Grating (LPFG) as Sugar Concentration and Glucose Detection Biosensor, Abdulyezir Badmos¹, Qizhen Sun², Zhongyuan Sun¹, Zhijun Yan^{1,2}, Lin Zhang¹; ¹Aston Univ., UK; ²School of Optical and Electronic Information, Huazhong Univ. of Science and Technology, China. Dual-peak long period fibre grating UV-inscribed in boron-germanium (B/Ge) doped 80 μ m-cladding at near infra-red region is presented for sugar concentration and glucose detection. High sensitivities of ~4.6696 nm/% and 7.16nm/mg ml⁻¹ were obtained for sugar-concentration and glucose-detection respectively.

W3A.4 • 14:00

Sensitivity Improvement of Fiber-optic NH₃ Gas Sensor Using Pt Nanoparticle Doped Graphene Oxide, Caibin Yu¹, Yu Wu¹, Xiaolei Liu¹, Fei Fu¹, Yuan Gong¹, Yunjiang Rao¹, Yuanfu Chen¹; ¹Univ. of Electronic Science and Technology of China, China. By incorporating Pt nanoparticle with graphene oxide (GO), a nanocomposite-based microfiber sensor with high sensitivity for NH₃ sensing was fabricated and demonstrated, which indicates sensitivity improvement of 3 times over that without Pt doping.

W3A.5 • 14:15

Nitric Oxide Sensitive Optic Fiber Sensor Based on Immobilized Ruthenium(II) Complex, Peng Zhang^{1,2}, shuai ruan¹, Ruan Zhang³, Benjamin Pullen⁴, Xiaozhou Zhang¹, Malcolm S. Purdey¹, Heike E. Heidepriem¹, Andrew Abell¹, Liyun Ding⁵, ming tang², Yinlan Ruan¹; ¹IPAS, Univ. of Adelaide, Australia; ²Wuhan National Laboratory for Optoelectronics, Huazhong Univ. of Science and Technology, China; ³Macquarie Univ., Australia; ⁴South Australian Health & Medical Research Inst., Australia; ⁵National Engineering Laboratory for Fiber Optic Sensing Technology, Wuhan Univ. of Technology, China. A nitric oxide fiber dip sensor was developed by immobilizing ruthenium(II) complex on multimode fiber tip using silica sol-gel. The emitted fluorescence from fiber NO sensor showed linear dependence on NO concentration below 60mM.

W3A.6 • 14:30

A Raspberry Pi Based Tunable Diode Laser Spectroscopy System with an Android Back-end Application for Continuous Monitoring of Gas Parameters, Priti S. Chakraborty¹, Arup Lal Chakraborty¹, Abhishek Ranjan¹, Shashank Parea¹; ¹*Indian Inst. of Technology Gandhinagar, India.* A tunable diode laser spectroscopy system for absolute gas parameter measurements for urban pollution monitoring is described. The time-stamped data are stored on a server. An Android application remotely accesses the sensor data for analysis.

W3A.7 • 14:45

Localized Surface Plasmon Resonance Based Fiber Optic Ethanol and Methanol Sensor Using UV light based AgNO₃/ZnO Nanorods, shiva dixit¹, Praveen Sharma¹, Rajneesh K. Verma¹; ¹*Physics, Central Univ. of Rajasthan, India.* LSPR based sensor is proposed for Ethanol and Methanol by coating the fiber's unclad portion with UV light based AgNO₃ coating followed by a ZnO Nanorods and in both cases LSPR spectra finds red shift in wavelength for higher concentration.

Room 306

15:30 -- 17:30

W4A • Poster Session I

W4A.1 • 15:30

An Extension Apparatus for a Large Range of Optical Delay Line in Distributed Polarization Coupling Measurement, Yonggui Yuan^{2,1}, Dongchuan Lu², Guicang Ran², Feng Peng², Jun Yang², Libo Yuan²; ¹*College of Information and Communication Engineering, Harbin Engineering Univ., China;* ²*Key Lab of In-fiber Integrated Optics, Ministry Education of China, Harbin Engineering Univ., China.* We propose a new extension method of optical delay line for the demand of long-time delay in measurement. The method, combination of a scanning stage and switchable fixed delays, can provide an ultra-large range without increasing the insertion loss.

W4A.2 • 15:30

Fading-noise-free Distributed Fiber-optic Vibration Sensor Based on Time-gated Digital OFDR, Dian Chen¹, Qingwen Liu¹, Xinyu Fan¹, Zuyuan He¹; ¹*Shanghai Jiao Tong Univ., China.* A novel distributed fiber-optic vibration sensor based on phase detection method from TGD-OFDR is presented, where frequency shift method and weighted average method are utilized to eliminate phase demodulation errors caused by fading noise.

W4A.3 • 15:30

A FBG Senor for Tip-timing Measuring of Blades, Hongli Li¹, Huaping Mei¹, Hui Liu¹, Gang Xu^{1,2}, Min Wang³, Lei Liang²; ¹*Hubei Engineering Univ., China*; ²*Wuhan Univ. of Technology, China*; ³*Wuhan Textile Univ., China.* Based on tip-timing method, a FBG sensor adopting dual-FBG coupling and intensity demodulation is proposed, and experiments were carried out. The result shows that the sensor can be used in the blade condition monitoring.

W4A.4 • 15:30

Complex Conjugate-free Optical Coherence Tomography Imaging by using Vibration-induced Phase Shift, Seung Seok Lee¹, Joo Ha Kim¹, Woosub Song², Eun Seo Choi¹; ¹*Department of Physics, Chosun Univ., Korea (the Republic of)*; ²*Medical Photonics Research Center, Korea Photonics Technology Inst., Korea (the Republic of)*. We proposed complex conjugate-free optical coherence tomography imaging method and demonstrated its performance on mirror image suppression operating in fiber-based interferometer.

W4A.5 • 15:30

Sol-Gel Silica Waveguide for Biophotonic Sensors, Yasufumi Enami¹; ¹*Kochi Univ. of Technology, Japan.* We report a sol-gel silica waveguide for biophotonic sensors. The fist demonstration is simple and novel nano-imprint lithographic method to fabricate Bragg grating in a sol-gel silica optical waveguide with high resolution of 250 and 90 nm.

W4A.6 • 15:30

Conjugate Interferometer-Based Optical Detection System for Multi-component Gas Sensing, Xin Gui², Yuheng Tong¹, Haihu Yu²,

Zhengying Li¹; ¹*Key Laboratory of Fiber Optic Sensing Technology and Information Processing, Ministry of Education, Wuhan Univ. Of Technology, China*; ²*National Engineering Laboratory for Fiber Optic Sensing Technology, Wuhan Univ. of Technology, China*. An optical gas detection system for multi-component gas based on gas conjugate interferometer was proposed. The experimental results show that the system can simultaneously detect multi-component gases and has good sensing linearity.

W4A.7 • 15:30

Manipulating micro-silica particles using a tapered fiber, Yi Zhou¹, Yue Li¹, Qiangzhou Rong¹, Xueguang Qiao¹; ¹*Northwest Univ., China, China*. A tapered fiber technique as a facile strategy is proposed and demonstrated experimentally for manipulating the micro-silica particles, which make it as an optical tweezer for application in the biology.

W4A.8 • 15:30

Distributed acoustic sensing network with identical weak fiber Bragg gratings, Chen Wang¹, ying shang¹, Xiaohui Liu¹, Chang Wang¹, Gang-Ding Peng^{2,1}; ¹*Shandong Academy Sciences, China*; ²*Univ. of New South Wales, Australia*. We demonstrate a distributed sensing network with 600 identical weak fiber Bragg gratings using balanced Michelson OTDR-interferometer for acoustic measurement. Experimental results show that our system can demodulate distributed acoustic signal from 10Hz to 1280Hz.

W4A.9 • 15:30

Radio Frequency Interrogation of Large Scale Intensity-Modulated Ultra-short FBGs Sensing Network, Jalal Rohollahnejad¹, Li Xia¹, Rui Cheng¹, Jiaao Zhou¹; ¹*Huazhong Univ of Science & Technology, China*. A USFBGs sensing network interrogation based on its complex frequency response monitoring is reported. Experimentally high average strain sensitivity of ~0.038%/ $\mu\epsilon$ and dynamic range of ~2400 $\mu\epsilon$ obtained for three wavelength channels of cascaded USFBGs.

W4A.10 • 15:30

Path Imbalance Measurement of Fiber-Optic Interferometer Based On Phase-Compared Method, Changbo Hou^{1,2}, Jianguo Wang¹,

Dongchuan Lu¹, Yonggui Yuan¹, Feng Peng¹, Jun Yang¹, Libo Yuan¹;

¹*Key Lab of In-fiber Integrated Optics, Ministry Education of China,*

Harbin Engineering Univ., China; ²*College of Information and*

Communication Engineering, Harbin Engineering Univ., China. A

simple system for measuring path imbalance of two-arm fiber-optic interferometer based on phase-compared method is demonstrated. Its relative precision is beyond 10^{-4} in the range of tens centimeters to tens meters and the smallest absolute precision is 81 μm .

W4A.11 • 15:30

Single-prism method for ultrashort pulse compression in three-photon microscopy, Chang-Seok Kim¹, SooKyung Chun¹, seung won jun¹; ¹*Pusan National Univ., Korea (the Republic of)*. We demonstrated an optimized pulse compression method in the three-photon microscopy for 1200nm wavelength band by using a single-prism pulse compressor. A comparison of three-photon fluorescence intensity between non-compressed and compressed pulses of the same energy showed a 2-fold improvement.

W4A.12 • 15:30

Fiber Optical Methane Sensors Using Functional Metal Oxide

Nanomaterials, aidong yan¹, sheng huang¹, shuo li¹, paul ohodnicki², Kevin P. Chen¹; ¹*Univ. of Pittsburgh, USA;* ²*National Energy Technology Laboratory, USA.* This paper reports fiber optic sensors for methane measurements based on evanescent optical interactions. Porous Pd-SnO₂ thin film synthesized by block copolymer template scheme was coated on D-shaped fiber as functional sensing materials

W4A.13 • 15:30

Delayed differential pulse pair BOTDA sensor with three-tone probe,

Wenqiao Lin¹, Xiaobin Hong¹, Zhisheng Yang¹, Sheng Wang¹, Jian Wu¹;

¹*Beijing Univ. of Posts and Telecommunications, China.* A BOTDA

sensor based on delayed dual-frequency differential pulse pair is

proposed to realize extended range and sub-meter spatial resolution

simultaneously. Spatial resolution of 0.5 m is experimentally demonstrated with a 24.444 km sensing fiber.

W4A.14 • 15:30

A Single Optical Fiber Tweezers with High Trapping Efficiency Based on Bessel-like Beams, Yaxun Zhang¹, xiaoyun tang¹, Yu Zhang¹, Zhihai Liu¹; ¹*Key Laboratory of In-Fiber Integrated Optics, Ministry of Education, College of Science, Harbin Engineering Univ., Harbin 150001, P. R. China, China.* We propose and demonstrate a novel structure of single optical fiber tweezers with high trapping efficiency based on bessel-like beams, trapping of polystyrene with deep micrometer-scale and submicrometer-scale with larger force and high capture efficiency.

W4A.15 • 15:30

Polarization sensitive optical coherence domain reflectometry using mode-locked laser as optical source, Jin Chen¹, Xinyu Fan¹, Qingwen Liu¹, Zuyuan He¹; ¹*Shanghai Jiao Tong Univ., China.* A polarization-sensitive optical coherence domain reflectometry using mode-locked laser as optical source is proposed and demonstrated. Thanks to the high spatial resolution, polarization changes in polarization-maintaining fiber and fiber Bragg grating is successfully observed.

W4A.16 • 15:30

Beyond-Nominal-Resolution Distributed Strain Sensing by Slope-Assisted Brillouin Optical Correlation-Domain Reflectometry, Heeyoung Lee¹, Neisei Hayashi², Yosuke Mizuno¹, Kentaro Nakamura¹; ¹*Tokyo Inst. of Technology, Japan;* ²*The Univ. of Tokyo, Japan.* We investigate the system output of slope-assisted Brillouin optical correlation-domain reflectometry (BOCDR) and experimentally show that, unlike standard BOCDR, frequency-shift change along a section shorter than the nominal spatial resolution can be detected.

W4A.17 • 15:30

Novel interrogation of the multiple FBGs with same Bragg wavelength by using active mode locking cavity, Gyeong Hun Kim¹, Chang Hyun Park¹, Chang-Seok Kim¹, Hwi Don Lee², Youngjoo Chung³;

¹*Department of Cogno-Mechatronics Engineering, Pusan National Univ., Korea (the Republic of);* ²*Advanced Photonics Research Inst., Gwangju Inst. of Science and Technology, Korea (the Republic of);* ³*School of Electrical Engineering and Computer Science, Gwangju Inst. of Science and Technology, Korea (the Republic of).* We proposed a new type of FBG interrogator using active mode locking technique. Since the interrogation mechanism is based on the separated detection of mode-locked frequency of each series FBG, we can interrogate multiple same FBGs.

W4A.18 • 15:30

Bacterial cell enumeration using flow cytometry, Fang Ou¹, Cushla McGoverin¹, Simon Swift², Frederique Vanholsbeeck¹; ¹*The Dodd-Walls Centre for Photonic and Quantum Technologies, Department of Physics, The Univ. of Auckland, New Zealand;* ²*School of Medical Sciences, The Univ. of Auckland, New Zealand.* Traditional culture-based methods of bacterial detection are time consuming and have limited accuracy. We outline a reliable method for obtaining the absolute numbers of live, dead and total bacterial cells using flow cytometry.

W4A.19 • 15:30

Thin-core fiber modal interferometer for ammonia sensing, Xinyue Huang¹, xueming li¹, huifei chen¹, xin che¹, jianchun yang¹; ¹*Chongqing Univ., USA.* A ammonia sensor depositing with a polyelectrolyte thin film composed of poly(acrylic acid) (PAA) and poly(allyamine hydrochloride) (PAH) via the layer-by-layer (LbL) self-assembly technique, is demonstrated with a thin-core fiber modal interferometer (TCFMI).

W4A.20 • 15:30

Fiber Optic for Brain control in Optogenetics Studies, Mohammad I. Zibaii¹, Hamid Latifi¹, Leila Dargahi², Abdolaziz Ronaghi², Sareh Pandamoz², Saeid Salehi², Abbas Haghparast², Amir Hossein Baradaran Ghasemi¹; ¹*Shahid Beheshti Univ., Iran (the Islamic Republic of);* ²*Shahid Beheshti Univ. of Medical Sciences, Iran (the Islamic Republic of).* Neural activity can be controlled with visible light in optogenetics technique. Light-sensitive proteins are genetically targeted into specific

classes of neurons in living animal models and target neurons stimulated by a fiber optic optrode.

W4A.21 • 15:30

Glycoprotein Detection by Using the Surface Plasmon Resonance Technology, Xinlei Zhou¹, Ke Chen¹, Li Li¹, Zhenfeng Gong¹, Wei Peng¹, Qingxu Yu¹; ¹Dalian Univ. of Technology, China. Specific detection of glycoprotein is performed by using the surface plasmon resonance technology. Ribonuclease B solutions with different concentration are measured in the range of 0.01-1 mg/mL and a good linearity is obtained.

W4A.22 • 15:30

Fiber Microstructures based Distributed Sensor System for Dynamic Pressure Detection, Wei Zhang^{2,1}, Jingyi Wang^{2,1}, Qizhen Sun^{2,1}, Fan Ai^{2,1}, Yang Xiang^{2,1}, Chen Zhu², Chaotan Sima^{2,1}, Deming Liu^{2,1};

¹National Engineering Laboratory for Next Generation Internet Access System, Huazhong Univ. of Science and Technology, China; ²School of Optical and Electronic Information, Huazhong Univ. of Science and Technology, China. We report a distributed dynamic pressure sensor system based on fiber microstructure arrays packaged with high elastic polymer, achieving a spatial resolution of 1cm and high sensitivity of 1.665nm/Mpa.

W4A.23 • 15:30

Lossy Mode Resonances biosensor for the detection of C-reactive protein, Pablo Zubiate¹, Carlos R. Zamarreño¹, Pedro Sanchez¹, Ignacio R. Matias¹, Francisco J. Arregui¹; ¹Universidad Publica de Navarra, Spain. The fabrication and characterization of optical fiber biosensor based on Lossy Mode Resonances (LMR) to detect C-reactive protein (CRP) are presented. The optical fiber sensor presented shows a high selectivity and low limit detection.

W4A.24 • 15:30

Long-range BOTDA denoising with multi-threshold 2D discrete wavelet, Xianyang Qian¹, Zinan Wang¹, Wei Sun¹, Bin Zhang¹, Qiheng He¹, Li Zhang¹, Han Wu¹, Yunjiang Rao¹; ¹Univ. Electronic Sci. & Tech.

of China, China. Multi-threshold 2D discrete wavelet based on BayesShrink method is utilized to enhance the SNR of BOTDA. Then a 154.42 BOTDA is experimentally demonstrated with 40ns pump pulses, and the measurement uncertainty is reduced from $\pm 1.52\text{MHz}$ down to $\pm 1.03\text{MHz}$.

W4A.25 • 15:30

A Compact Fabry-Perot Photothermal Gas Sensor with Hollow-core Optical Fiber, Fan Yang¹, Wei Jin¹; ¹*Hong Kong Polytechnic Univ., China*. A compact and highly sensitive photothermal gas sensor with hollow-core fiber-based Fabry-Perot interferometer is reported. The noise equivalent concentration of 117 ppb acetylene is achieved with 2-cm-long hollow-core fiber.

W4A.26 • 15:30

Optical Fiber Liquid-Level Sensing Based on Self-Heated Optical Fiber and DPP-BOTDA, Hongying Zhang¹, Zhijun Yuan¹, Ziye Liu¹, Yifu Cheng¹, Yong Kang Dong²; ¹*Harbin U. Science and Technology, China*; ²*Harbin Inst. of Technology, China*. A liquid-level sensor with a large range of 20cm and a resolution of 1cm is demonstrated, where the principle is to measure the temperature abrupt position based on DPP-BOTDA with a self-heated high attenuation fiber.

W4A.27 • 15:30

Point-by-point inscription of microfiber Bragg gratings using femtosecond laser pulses, Changrui Liao¹, Tianhang Yang¹, Ying Wang¹, Yiping Wang¹; ¹*Shenzhen Univ., China*. Microfiber Bragg gratings have been successfully fabricated by femtosecond laser point-by-point inscription. Temporal thermal response of the induced microfiber gratings have been tested by means of periodic CO₂ laser irradiation to create a rapid temperature change for the fiber.

W4A.28 • 15:30

Optimization of Detection Schemes in BOTDA, Li Zhang^{2,1}, Marcelo A. Soto¹, Zinan Wang², Luc Thevenaz¹; ¹*Ecole Polytechnique Federale de Lausanne, Switzerland*; ²*Key Lab of Optical Fiber Sensing & Communication, Univ. of Electronic Science & Technology of China*,

China. The impact of different detection schemes on the performance of Brillouin optical time-domain analysis is investigated theoretically and experimentally. The study provides guidance for the optimization of BOTDA sensors depending on the targeted range.

W4A.29 • 15:30

A Non-contact Single Optical Fiber Multi-optical Tweezers Based on Bessel-like Beams, Zhihai Liu¹, xiaoyun tang¹, Yu Zhang¹, Yaxun Zhang¹; ¹*Key Laboratory of In-Fiber Integrated Optics, Ministry of Education, College of Science, Harbin Engineering Univ., Harbin 150001, P. R. China, China.* We propose and demonstrate a novel structure of non-contact single optical fiber multi-optical tweezers based on Bessel-like beams, simplified the structure of multi-optical tweezers, achieve the non-contact capture of particles at different axial positions.

W4A.30 • 15:30

A hybrid fiber-optic condition monitoring technique with arrayed waveguide grating, Daegil Kim¹, Hyunjin Kim¹, Umesh Sampath¹, Minho Song¹; ¹*Division of Electronics and Information Engineering, Chonbuk National Univ., Korea (the Republic of).* A fiber-optic sensor system for potential uses in multi-stress monitoring of large scale wind turbine is proposed. It consists of FBG sensors and Michelson interferometers in single fiber-optic circuit with an AWG for multiplexing the interferometers.

W4A.31 • 15:30

Study on fiber optic oxygen sensor and its application in coal mine, Wei Yubin¹, weisong zhao¹, Jie Hu², tingting zhang¹, Tongyu Liu², ¹*Shandong Academy of Sciences, China;* ²*shandong microsensor photonics limited, China.* Based on laser absorption spectroscopy and optical fibre sensing technology, this study proposed an optical fiber oxygen detection sensor. The system showed a good test results in the coal spontaneous combustion beam tube used .

W4A.32 • 15:30

Dual-Core Fiber Characterizations for Distributed Simultaneous Temperature and Strain Measurements Using Brillouin Optical Time

Domain Analysis, Kevin P. Chen¹, Mohamed Zaghloul¹, mohan wang¹, Ming-Jun Li²; ¹*Univ. of Pittsburgh, USA*; ²*Corning Inc., USA*. This paper reports characterizations of dual-core optical fiber designed for simultaneous temperature and strain measurements using Brillouin optical time domain analysis

W4A.33 • 15:30

Immobilization of cholesterol oxidase on SiO₂ nanoparticles and its application in Fiber optic cholesterol sensor, Mengshi Li¹, Jun Huang¹, Peipei Zhang¹, Pengfei Zhang¹, Liyun Ding¹; ¹*Wuhan Univ. of Technology, China*. Cholesterol oxidase was immobilized on SiO₂ nanoparticles, which was used to develop a fiber optic cholesterol sensor. The sensor has good repeatability, selectivity and can be used for the detection of practical samples.

W4A.34 • 15:30

Near-infrared photoacoustic imaging for detection of early-stage dental diseases, Teng Li^{1,2}; ¹*Beijing Jiaotong Univ., China*; ²*Biomedical Engineering, Washington Univ. in St. Louis, USA*. A compact near-infrared photoacoustic (PA) probe for detection of early-stage dental diseases was reported. An integrated probe with PVDF transducer and a fiber was designed. Visualization of dental caries in a human tooth phantom shows the potential of the probe for early-stage dental diseases diagnosis.

W4A.35 • 15:30

Modified technique for the fiber surface using Staphylococcal protein A, Bin-bin Luo¹, Shengxi Wu¹, Wengen Zou¹, Zhonghao Zhang¹, Mingfu Zhao¹, Xue Zou¹, Yong Liu²; ¹*Chongqing Univ. of Technology, China*; ²*School of Opto-electronic Information, Univ. of Electronic Science and Technology of China, China*. We presented a modified technique for the fiber surface using Staphylococcal protein A, and the effectiveness of the fiber surface modification was investigated by scanning electron microscope and fluorescence microscope.

W4A.36 • 15:30

A new method to fabricate phase-shifted Fiber Bragg gratings by femtosecond laser point-by-point inscription, Changrui Liao¹, Ying Wang¹, Yiping Wang¹, Feng Zhu¹; ¹*Shenzhen Univ., China*. Microfiber Bragg gratings have been successfully fabricated by femtosecond laser point-by-point inscription. Temporal thermal response of the induced microfiber gratings have been tested by means of periodic CO₂ laser irradiation to create a rapid temperature change for the fiber.

W4A.37 • 15:30

Feature Extraction with WD and WPD in Distributed Optical-fiber Vibration Sensing System for Oil Pipeline Safety Monitoring, Ya Qian¹, Huijuan Wu¹, Wei Zhang¹, Lidong Lu², Xiaoyan Sun², Yunjiang Rao¹; ¹*Univ of Electronic Sci & Tech of China, China*; ²*Information and Communication, Global Energy Interconnection Research Inst., State Grid Corporation of China, China*. Feature extraction methods in distributed optical-fiber vibration sensing system are comparatively studied. It proves the wavelet packet decomposition performs better in identifiable feature extraction for the field testing signals in oil pipeline safety monitoring.

W4A.38 • 15:30

High-robustness strain sensor based on in-fiber Fabry-Perot interferometer with an elliptical cavity, Shen Liu¹, Cailing Fu¹, Changrui Liao¹, Ying Wang¹, Yiping Wang¹; ¹*Shenzhen Univ., China*. An in-fiber Fabry-Perot interferometer based on an elliptical air-cavity was developed to a strain sensor with a high-robustness (up to 9800 $\mu\epsilon$), and the detailed fracture analysis of the high-robustness strain sensor was made.

W4A.39 • 15:30

Highly Sensitive Mach-Zehnder Gas Refractometer Using Slotted Photonic Crystal Fiber, Zhihua Shao¹, Xueguang Qiao¹, Qiangzhou Rong¹; ¹*Northwest Univ., China*. A compact gas refractometer based on Mach-Zehnder interference is proposed using a slotted photonic crystal fiber by femtosecond micromachining. An extremely high gas refractive index sensitivity of -827.94 dB/refractive index unit is obtained.

W4A.40 • 15:30

Optical fiber sensor for the detection of mercury based on immobilized fluorophore, Yinlan Ruan¹, shuai ruan¹, Heike E. Heidepriem¹; ¹*ARC Centre of Excellence for Nanoscale BioPhotonics, Inst. for Photonics and Advanced Sensing, The Univ. of Adelaide, Australia.* A mercury optical fiber dip sensor was developed by immobilizing Rhod-5N on a multimode fiber endface by silica sol-gel. The detection limit was 0.3 ppb with the dye in aqueous condition and 25 ppb when it was immobilized on fiber tips.

W4A.41 • 15:30

Analysis of the Influence of Offset on the Detection Accuracy of the Optical Fiber CO Detecting System, Tingting (. Zhang¹, Yubin Wei¹, Jie Hu², Yanfang Li¹, Tongyu Liu¹; ¹*Laser Inst. of Shandong Academy of S, China; ²Shandong Micro-sensor Photonics Limited, China.* The influence of offset on the detection accuracy of the CO detection system based on TDLAS has been researched and analyzed. It is concluded that the relative error of gas concentration is 0.16% when the offset difference is 1. It provides theoretical guidance and reference for the selection of components in gas detection system.

W4A.42 • 15:30

Distributed dynamic nano-strain sensing based on Φ -OTDR with coherent detection and IQ demodulation, Xi Chen¹, Erhu Liu¹, Cheng Fu¹, Hongying Zhang², Zhiwei Lu¹, Yong Kang Dong¹; ¹*National Key Laboratory of Science and Technology on Tunable Laser, Harbin Inst. of Technology, China; ²Inst. of Photonics and Optical Fiber Technology, Harbin Univ. of Science and Technology, China.* A sensing system is proposed for quantitative and large-range measurement of dynamic nano-strain based on phase-sensitive optical time domain reflectometer with a 1 nε strain resolution and a large sensing range of 10-1000 nε.

W4A.43 • 15:30

Ultrasensitive magnetic field sensor based on in-fiber Mach-Zehnder interferometer and magnetic fluid, Zhengyong Li¹, Changrui Liao¹, Jun Song¹, Ying Wang¹, Yiping Wang¹; ¹*Shenzhen Univ., China.* An

ultrasensitive magnetic field sensor based on in-fiber Mach-Zehnder interferometer created in twin-core fiber was proposed. The sensor exhibits an ultrahigh sensitivity of 20.8 nm/mT with a measurement range from 5 to 9.5 mT.

W4A.44 • 15:30

A Switch Resistance Monitoring Method Based on FBG, jianjun pan¹;

¹*Wuhan Univ. of Technology, China.* An FBG strain gauge with sensitizing method is used to monitor railway switch resistance. An on-line monitoring system was built at a Metro station. This method monitors health state of the switches in long-term service.

W4A.45 • 15:30

Hybrid Distributed Multi-Parameter Fiber Sensing System Based on Modulated Pulses Φ/B-OTDR, Jingdong Zhang¹, Tao Zhu¹, Leilei Shi¹, Huan Zhou¹, Min Liu¹; ¹*Key Laboratory of Optoelectronic Technology and Systems (Education Ministry of China), Chongqing Univ., China.* We demonstrate a hybrid distributed vibration, temperature and strain fiber sensing system using modulated pulses Φ/B-OTDR with the advantages of only one photo-detector and data acquisition channel for realizing 10km sensing range.

W4A.46 • 15:30

SNR enhancement with bilateral filtering algorithm for phase-sensitive optical time domain reflectometry, Haijun He¹, Li-Yang Shao¹, Hengchao Li¹; ¹*Southwest Jiaotong Univ., China.* A bilateral filtering algorithm has been proposed to process the phase-sensitive optical time domain reflectometry signal to enhance SNR. The maximum SNR enhancement of 8.3 dB has been achieved without spatial resolution loss.

W4A.47 • 15:30

Ultrafast and High Resolution Crack Detection Using Fully Distributed Chirped Fiber Bragg Grating Sensors, Dejun Feng^{1,2}, Eamonn J. Ahmad¹, Chao Wang¹; ¹*Univ. of Kent at Canterbury, UK*;
²*School of Information Science and Engineering, Shandong Univ., China.* We demonstrate for the first time that photonic time-stretch frequency

domain reflectometry (PTS-FDR) enables ultrafast and high spatial-resolution crack detection using fully distributed chirped fiber Bragg grating strain sensors.

W4A.48 • 15:30

1550 nm band Raman distributed temperature sensor using 35 km-long single-mode fiber, Sun Woo Kim¹, Jung Min Hwang², Min Seong Seo², Bong-Wan Lee², Min Yong Jeon¹; ¹*Chungnam National Univ., Korea (the Republic of)*; ²*FiberPro, Korea (the Republic of)*. We report a 1550 nm band Raman distributed temperature fiber-optic sensor based on 35 km-long single-mode fiber. We achieved the temperature resolution of 2.6°C with a measurement time of 600 s using a finite impulse response filter.

W4A.49 • 15:30

Hydrogel-Coated Long-Period Fiber Grating PH Sensor, Satyendra K. Mishra¹, Bing Zou¹, Kin S. Chiang¹; ¹*City Univ. of Hong Kong, Hong Kong*. We report a long-period fiber grating coated with a specially synthesized hydrogel for the measurement of pH changes in an aqueous solution. The coated grating operates sensitively for the pH ranges 2-5 and 8-12.

W4A.50 • 15:30

Improving Spatial Resolution of Time-gated Digital Optical Frequency Domain Reflectometry using Diode Laser Sources, Tianjiao Li¹, Qingwen Liu¹, Dian Chen¹, Xinyu Fan¹, Zuyuan He¹; ¹*Shanghai JiaoTong Univ., China*. To improve the spatial resolution of time-gated-digital OFDR, a distributed feedback (DFB) diode laser with current tuning is used to provide a large laser frequency tuning range. The driving current of DFB laser diode is pre-distorted to compensate the tuning nonlinearity of laser, and 10-cm spatial resolution over 74-km fiber link is realized.

W4A.51 • 15:30

Differential detection for coherent BOTDA sensor based on single sideband probe light, Yunpeng Zhang¹, Li-Yang Shao¹, Haijun He¹; ¹*Southwest Jiaotong Univ., China*. A differential detection method has

been used in a coherent BOTDA system for DC component cancellation. 10.8-dB SNR enhancement of the Brillouin gain signal and 2.7-MHz Brillouin frequency shift accuracy improvement have been achieved.

W4A.52 • 15:30

TDM-BOTDA with suppressed non-local effect and sweeping time reduction using frequency comb pairs, Xin-Hong Jia¹, Lei Ao¹, Han-Qing Chang¹, Cong Xu¹, ¹*Sichuan Normal Univ., China.* Simultaneous non-local effect suppression and sweeping time reduction was achieved experimentally over ~50km time-division-multiplexing (TDM) based Brillouin optical time domain analysis (BOTDA) sensors using pump-probe frequency comb pairs.

W4A.53 • 15:30

Temperature-Insensitive Strain Sensing with a Polarization-Maintaining Photonic Crystal Fiber Based on Brillouin Dynamic Grating, Hongying Zhang¹, Yong Kang Dong², Yafeng Bi¹, Xiaobo Hu¹, Guiyuan Cao¹; ¹*Harbin U. Science and Technology, China;* ²*Harbin Inst. of Technology, China.* We propose and demonstrate temperature-insensitive strain sensing by using a polarization-maintaining photonic crystal fiber based on Brillouin dynamic grating, where the results indicate a strain coefficient of -0.154MHz/ $\mu\epsilon$ while the temperature-insensitive range is of 5~80°C.

W4A.54 • 15:30

Massive data compression in long-distance distributed optical fiber sensing systems, Huijuan Wu¹, Wei Zhang¹, Jiwei Xu¹, David Atubga¹, Lidong Lu², Xiaoyan Sun², Yunjiang Rao¹; ¹*Univ of Electronic Sci & Tech of China, China;* ²*Information and Communication, Global Energy Interconnection Research Inst., State Grid Corporation of China, China.* In this paper, two compression algorithms of Huffman and Lempel-Ziv-Welch (LZW) are comparatively studied to effectively compress the huge amount of data of typical fully distributed optical fiber sensors (DOFSs), e.g. Φ -OTDR, P-OTDR, and BOTDA systems.

W4A.55 • 15:30

Temperature-compensated distributed hydrostatic pressure Brillouin sensor using a thin-diameter and high-birefringent photonics crystal fiber, Lei Teng¹, Yong Kang Dong¹, Deng w. Zhou¹, Taofei Jiang¹;

¹*Harbin Inst. of Technology, China.* A distributed hydrostatic pressure sensor based on Brillouin dynamic gratings is proposed and demonstrated, which features temperature-compensated and a distributed measurement with a 20-cm spatial resolution and a measurement accuracy of 0.025 MPa.

W4A.56 • 15:30

Nanorod engineering of Hydroxylated In₂O₃ for H₂ gas Sensing, Joel Yi Yang Loh¹; ¹*Univ. of Toronto, Canada.* Hydroxylated In₂O₃

nanoparticles is proposed for H₂ gas sensing. Dangling OH groups and surface oxygen vacancies enables capture of a H₂ gas molecule. The electrical conductivity of In₂O₃ nanoparticles increases by 3 times under H₂.

W4A.57 • 15:30

Photoacoustic microscopy equipped with a lensed fiber for pulsed diode laser scanning, Soongho Park¹, Jonghyun Eom¹, Byeongha Lee¹;

¹*GIST, Korea (the Republic of).* We present a photoacoustic microscopy using a self-built lensed fiber to guide the excitation laser. A pulsed laser diode was used to generate the acoustic signal, and the laser beam was focused on the sample.

W4A.58 • 15:30

Brillouin optical correlation domain analysis system for simultaneous interrogation of 150 sensing positions, Gukbeen G. Ryu^{1,2}, Kwang Yong Song³, Gyu-Tae Kim², Sang Bae Lee¹, Kwanil Lee¹; ¹*KIST, Korea (the Republic of);* ²*Korea Univ., Korea (the Republic of);* ³*Chung-Ang Univ., Korea (the Republic of).* Brillouin optical correlation domain system simultaneously interrogating 150 sensing position with time-domain data processing is proposed. Distributed strain sensing in 1,500 m-long fiber with 5 cm resolution is experimentally demonstrated.

W4A.59 • 15:30

A fiber optic cholesterol biosensor based on magnetic immobilized cholesterol oxidase, Peipei Zhang¹, Jun Huang¹, Mengshi Li¹, Pengfei Zhang¹, Liyun Ding¹; ¹Wuhan Univ. of Technology, China. A fiber optical cholesterol sensor based on magnetic immobilized cholesterol oxidase was developed, optimal detection conditions were obtained, detection range: 25-250 mg/dL, sensor has good repeatability, selectivity and stability.

W4A.60 • 15:30

Long-distance Brillouin optical time-domain analysis with 1st-order and 2nd-order distributed Brillouin amplification, Xin-Hong Jia¹, Han-Qing Chang¹, Lei Ao¹, Cong Xu¹; ¹Sichuan Normal Univ., China. We experimentally demonstrated the long-distance Brillouin optical time-domain analysis (BOTDA) sensing with high-efficiency 1st-order (~50km) and 2nd-order (~99km) distributed Brillouin amplification.

W4A.61 • 15:30

In-situ detection of electroactive biofilms using an electrochemical surface Plasmon resonance fiber-optic sensor, Wanjun Hu¹, Xuhui Qiu¹, Xuejun Zhang¹, Zhaochuan Zhang¹, Jiahuan Tang², Yong Yuan², Bai-Ou Guan¹, Tuan Guo¹; ¹Jinan Univ., China; ²Guangdong Inst. of Eco-Environmental and Soil Sciences, China. Electrochemical surface Plasmon resonance tilted fiber grating has been proposed for extracellular electron transfer mechanism of electroactive biofilms revealing. A close relationship between the redox state of the EABs and SPR signal has been achieved.

W4A.62 • 15:30

Ultra-long Distance Distributed Optical Fiber Vibration Sensing System, Lai M. Cheng^{1,3}, Qizhen Sun^{1,3}, Kuan Peng^{1,3}, Xiaolei Li^{1,3}, Xiang Li², Ying Qiu², Qi Yang², Deming Liu¹; ¹School of Optical and Electronic Information, Huazhong Univ. of Science and Techn, China; ²State Key Laboratory of Optical Comm, China; ³National Engineering Laboratory for Next Generation Internet Access System, Huazhong Univ. of Science and Technology, China. Based on bi-directional amplification

in the fiber sensing link, an ultra-long distance distributed optical fiber vibration sensing system is proposed and experimentally demonstrated.

W4A.63 • 15:30

A Satellite Communication Link Rain Attenuation Evaluating Scheme Based on Wide Range of Passive Optical Fiber Rainfall Monitoring System, Yuanshun Sun¹, Zhiguo Zhang¹, Luming Li²; ¹*BUPT, China;* ²*Information and Communications branch, Jiangxi Electric Power Company, Nanchang, China.* This paper proposes a satellite communication link rain attenuation evaluating scheme based on wide range of passive optical fiber rainfall monitoring system. Achieve wide range rain attenuation monitoring and the sensitivity is about 2dB.

Room 102

08:00 -- 10:15

Th1A • Industrial Structural Monitoring

Presider: Prof. Reinhardt Willsch, Leibniz Institute of Photonic Technology, Germany
Prof. Minghong Yang, Wuhan Univ. of Technology, China

Th1A.1 • 08:00 (Invited)

Advances of Fibre Optic Sensors for Mining Safety, Tongyu Liu¹; ¹*Shandong Micro-Sensor Photonics Ltd, China.* Abstract not available.

Th1A.2 • 08:30

Ring Circumferential Strain Measurement Based on a Model of Brillouin Gain Spectrum Shape, Hiroshi Naruse¹, Takeshi Ogawa¹, Takanori Nishino¹; ¹*Mie Univ., Japan.* We present a method based on a model of a Brillouin gain spectrum shape for measuring the strain formed at the circumference of ring structures. The effectiveness of this method is confirmed through our simulations.

Th1A.3 • 08:45

Application of Distributed Brillouin Optical Fiber Sensor Systems in Geo-technical Monitoring, Stephan Grosswig¹; ¹*GESO GmbH & Co. Projekt KG, Germany.* The potential of advanced commercial fiber optical Brillouin Distributed Strain and Temperature Sensor (DSTS)

systems for safety monitoring of geo-technical structures such as railroad embankments, tunnel construction, and landslides has been demonstrated.

Th1A.4 • 09:00

Optical Fiber Sensors for Asphalt Structures Monitoring, Mikel Bravo¹, Sergio Rota-Rodrigo¹, Daniel Leandro¹, Alayn Loayssa¹, Javier Urricelqui¹, Ana Bravo-Acha², Manuel Bravo-Navas³, Jose Ramon Mitxelena⁴, Jose Javier Martinez-Mazo⁴, Manuel Lopez-Amo¹;

¹*Universidad Publica de Navarra, Spain;* ²*Asfaltos y Construcciones del Baztán, Spain;* ³*Eurocontratas S.A., Spain;* ⁴*Obysur S.L., Spain.* A novel optical fiber installation method was explored for asphalt monitoring. Glass-fiber polymer encapsulated SMF was installed in the intermediate and surface layers in order to study the strain sensitivity with a distributed strain interrogator.

Th1A.5 • 09:15

2D Single-shot Profilometry for Scattered Media Using Supercontinuum Source Interferometry in Visible Region, Tuan Q. Banh^{1,2}, Tuan Truong Cong¹, Heui-Hyeon Kim¹, Tatsutoshi Shioda¹;

¹*Saitama Univ., Japan;* ²*Sevensix Inc., Japan.* Supercontinuum light and visible camera are employed for improving resolution of our 2D single-shot, long-range interferometry. A 3D plot of a profile surface of a scattered sample is effectively demonstrated.

Th1A.6 • 09:30

Long-range Single-shot 2-dimensional Profilometry Using Multi-order Comb Interferometry, Hikaru Ariya¹, Banh Q. Tuan¹, Tatsutoshi Shioda¹; ¹*SAITAMA UNIV., Japan.* Multiple interference orders of optical frequency comb interferometry expands a measurement range of profilometry and tomography. The order was identified by using two low-coherent combs with different teeth intervals generated from a supercontinuum light source.

Th1A.7 • 09:45

Optical Fiber Sensor-Fused Additive Manufacturing and Its Applications in Residual Stress Measurements in Titanium Parts, Kevin P. Chen¹, Ran Zou¹, Mohamed Zaghloul¹, aidong yan¹, rongzhang

chen¹, paul ohodnicki², michael buric², xuan liang¹, albert to¹; ¹*Univ. of Pittsburgh , USA;* ²*National Energy Technology Laboratory, USA.* This paper reports optical fiber embedding in titanium parts using additive manufacturing process. Residual stress incurred during laser processing on the sensor-embedded parts was measured using Rayleigh scattering distributed sensing scheme with 5-mm spatial resolutions.

Th1A.8 • 10:00

Application of Two Mixing Wave Interferometer on Laser Ultrasonic Detection of Thermal Barrier Coating, Yang Zhao¹, Jian Ma¹, Zhenzhen Zhang¹, Yinian Zhu², Sridhar Krishnaswamy²; ¹*Laser Inst. of Shandong Academy of Science, China;* ²*Northwestern Univ., American Samoa.* This paper describes an adaptive laser interferometer based on two wave mixing in InP:Fe photorefractive crystal. The interferometer is feasible for industrial applications due to its insensitivity of low frequency ambient vibrations and temperature change.

Room 102

10:45 -- 11:45

Th2A • Novel Materials for Sensing

Presider: Prof. Fei Xu, Nanjing Univ., China

Prof. Yu Wu, Univ. of Electronic Science and Technology of China, China

Th2A.1 • 10:45 (Invited)

Integration of Functional Nanomaterials with Fiber Devices for Sensing Applications, Hai Xiao¹; ¹*Clemson Univ., USA.* Abstract not available.

Th2A.2 • 11:15

Whispering-gallery-mode Tuning in a Magnetic-fluid-infiltrated Microbubble Resonator Based on Laser-induced Photo-thermal Effect, Yuetao Li¹, Hao Zhang¹, Bo Liu¹, Yuhan Li¹, Binbin Song¹; ¹*Nankai Univ. , China.* A magnetic-fluids-infiltrated microbubble resonator is proposed and experimentally demonstrated. WGM tuning property of this microresonator under different pump laser power

densities has been investigated, showing its potential applications in optically manipulated photonic devices.

Th2A.3 • 11:30

Highly Efficient Biosensing with All-Dielectric Nanoparticles, Nicolò Bontempi^{1,2}, Katie E. Chong¹, Henry Orton¹, Isabelle Staude³, Duk-Yong Choi⁴, Ivano Alessandri², Yuri S. Kivshar¹, Dragomir N. Neshev¹;

¹*Nonlinear Physics Centre, Australian National Univ., Australia;* ²*INSTM and Chemistry for Technologies Laboratory, Univ. of Brescia, Italy;*

³*Inst. of Applied Physics, Friedrich-Schiller-Univ. Jena, Germany;* ⁴*Laser Physics Centre, Australian National Univ., Australia.* We suggest a new platform for highly efficient biosensing using nontoxic, low loss silicon nanoresonators. We demonstrate a low-concentration detection limit of 10^{-10} M for streptavidin using biotin-coated silicon nanodisks with Mie-type magnetic dipole resonances.

Room 102

13:00 -- 15:00

Th3A • Distributed, Multiplexed and Networked Sensing

Presider: Prof. Mizuno, Tokyo Institute of Technology, Japan

Prof. Zinan Wang, Univ. of Electronic Science and Technology of China, China

Th3A.1 • 13:00 (Invited)

Pushing the Limits in Distributed Fibre Sensing, Luc Thevenaz¹;

¹*Ecole Polytechnique Federale de Lausanne, Switzerland.* Different techniques to improve the response of distributed fiber sensors are reviewed, which turn out to be far from simplistic as a result of cross-interactions between nonlinear effects.

Th3A.2 • 13:30

Single-Shot True Distributed Strain Variation Measurements

Over >10 km Using Phase-Sensitive OTDR with Chirped Pulses,

Andres Garcia-Ruiz¹, Hugo Martins², Juan Pastor-Graells¹, Sonia Martin-Lopez¹, Miguel Gonzalez-Herraez¹; ¹*Electronics Dept., Univ. of Alcalá, Spain;* ²*Research Dept, FOCUS S.L., Spain.* Single-shot, true strain dynamic measurements with few nm resolution over >10 km are achieved

with a Φ OTDR employing linearly chirped pulses. Strain variations at frequencies up to 4 kHz can be monitored over this distance.

Th3A.3 • 13:45

Long-range Millimeter-resolution OFDR Based on 100 GHz Linear Frequency-sweep of Optical Source by Injection-locking Technique and Cascaded FWM Process, Bin Wang¹, Xinyu Fan¹, Qingwen Liu¹, Jiangbing Du¹, Zuyuan He¹; ¹*Shanghai Jiao Tong Univ., China*. We demonstrate a high spatial resolution OFDR by utilizing injection-locking technique and cascaded FWM. A frequency sweeping span of ~100 GHz is obtained for realizing a 1.1 mm spatial resolution over 2 km measurement range.

Th3A.4 • 14:00

200 km Fiber-Loop Conventional Brillouin Distributed Sensor with 2m Spatial Resolution Using Image Denoising, Marcelo A. Soto¹, Jaime Ramírez¹, Luc Thevenaz¹; ¹*Ecole Polytechnique Federale de Lausanne, Switzerland*. Non-local means image denoising method is optimized to boost the performance of Brillouin distributed fiber sensors. Results demonstrate ultra-long sensing over a 200-km fiber-loop with 2m resolution using a sensing scheme without any hardware sophistication.

Th3A.5 • 14:15

Ultra-High-Resolution OTDR based on Linear Optical Sampling with Digital Dispersion Compensation, Wang Shuai¹, Xinyu Fan¹, Qingwen Liu¹, Zuyuan He¹; ¹*Shanghai Jiao Tong Univ., China*. We demonstrate an optical time domain reflectometry based on linear optical sampling (LOS). Taking advantage of its ultrahigh bandwidth and low timing jitter, we obtained a spatial resolution of 340 um at 10 km

Th3A.6 • 14:30

Overcoming High-resolution Limitations in Optimized Long-range BOTDA Sensors, Alejandro Dominguez-Lopez¹, Marcelo A. Soto², Sonia Martin-Lopez¹, Luc Thevenaz², Miguel Gonzalez-Herraez¹; ¹*Universidad de Alcala, Spain*; ²*Inst. of Electrical Engineering, SCI-STI-LT Station 11, Ecole Polytechnique Federale de Lausanne, Switzerland*. A fundamental limitation in high-resolution and long-range Brillouin

optical time-domain systems is overcome in this paper, enabling 500k resolved points over 25 km of SMF with 5 cm spatial resolution in a usual acquisition time.

Th3A.7 • 14:45

Enhanced and Spatially Equalized SNR in DAS via Digital Summation of Complex Rayleigh Speckles, Haniel Gabai¹, Avishay Eyal¹; ¹*Physical Electronics, Tel-Aviv Univ., Israel.* In distributed acoustic sensing the SNR of each sensor varies randomly along the fiber and is affected by propagation losses. We introduce a new method for enhancing and equalizing the SNR via digital means only.

Room 306

15:30 -- 17:30

Th4A • Poster Session II

Th4A.1 • 15:30

Multi-wavelength Fiber Bragg Grating Induced by Femtosecond Laser Point-by-Point Inscription, Changrui Liao¹, Yiping Wang¹;

¹*Shenzhen Univ., China.* Multi-wavelength fiber Bragg grating has been realized by the inscription of several fiber gratings with different pitches in the same part of the fiber core. The polarization dependent loss of this grating has also been experimentally investigated.

Th4A.2 • 15:30

Temperature-insensitive strain sensor using a microfiber Mach-Zehnder interferometer, Seungmin Lee¹, Eun Ji Lim¹, Ik Su Jo¹, Kwang Wook Yoo¹, Young-Geun Han¹; ¹*Physics, Hanyang Univ., Korea (the Republic of).* Temperature-insensitive strain sensor based on a microfiber Mach-Zehnder interferometer is proposed by controlling the waist diameter of the microfiber. The temperature sensitivity of the microfiber-MZI was dramatically reduced to be $1.94 \times 10^{-6} \text{ nm}^{-1} \times {}^\circ\text{C}^{-1}$.

Th4A.3 • 15:30

Integrated MFP/RSFBG Sensor with Micro-Channel for Simultaneous Measurement of Gas Pressure and Temperature, Haihong Bao¹, ZengLing Ran¹, Xuezhong Wu¹, Yunjiang Rao¹; ¹*Univ of*

Electronic Science & Tech China, China. An integrated sensor via overlapping a Fabry-Pérot (F-P) cavity with micro-channel on a regenerated fiber Bragg grating (RFBG) is constructed for dual-parameter sensing of temperature and gas pressure under high temperature.

Th4A.4 • 15:30

Real-time Transverse Force Sensing using Stokes Parameters through Fiber Bragg Grating and Performance Analysis, Yang SU¹, Hua Zhou¹, Yong Zhu¹, Baofu Zhang¹; ¹*PLA Univ. of Science and Technology, China.* Real-time force measurement is achieved through direct measurement of Stokes parameters through FBG at single wavelength. A proportional relationship and linear fit are found between Stokes parameters and applied force. The performance dependence on the state of polarization (SOP) of incident light is investigated experimentally.

Th4A.5 • 15:30

Chirped Bragg grating inscribed in microfiber, Peng Xiao¹, Fu-Rong Feng², Tong Liu¹, Yang Ran¹, Long Jin¹, Bai-Ou Guan¹; ¹*Inst. of Photonics Technology, China.* The chirped Bragg grating is inscribed in microfiber with a uniform phase mask. Characteristic of the spectrum in response to the ambient refractive index is studied.

Th4A.6 • 15:30

Application of phase shifted fiber Bragg grating to advanced ultrasonic structural health monitoring, Qi Wu¹, Yoji Okabe¹, Fengming Yu¹, Wensheng Kong¹; ¹*Univ. of Tokyo, Japan.* Several novel sensing systems based on phase-shifted fiber Bragg grating with high sensitivity and broad bandwidth were proposed and applied to acoustic emission detection and nonlinear ultrasonic detection, demonstrating their abilities in practical applications.

Th4A.7 • 15:30

LP₀₁-LP₂₁ intermodal interferometer based on long period grating in few mode fiber for dual parameter sensing, Ya Han¹, Yange Liu¹, wei huang¹, zhi wang¹, hongwei zhang¹; ¹*Inst. of Modern Optics, Nankai Univ, China.* A FMF-LPG converting LP₀₁ to LP₂₁ core mode is proposed

for the first time. The proposed interferometer is composed of the matching LPG and a slight core-offset spliced end. It can be used as dual parameter sensors

Th4A.8 • 15:30

Phase-shift Bragg gratings written in microfibers, Tong Liu¹, Fu-Rong Feng¹, Peng Xiao¹, Yang Ran¹, Long Jin¹, Bai-Ou Guan¹; ¹*Inst. of Photonics Technology, China*. The phase-shift Bragg gratings inscribed into microfibers are proposed. Depending on the narrow notch in the reflection spectrum, the grating can detect outer refractive index change with higher accuracy.

Th4A.9 • 15:30

Dual-Polarization Fiber Laser Ultrasound Hydrophone, Di Liu¹, Yizhi Liang¹, Long Jin¹, Bai-Ou Guan¹; ¹*Inst. of Photonics Technology, China*. A highly-sensitive fiber optic ultrasound hydrophone is fabricated by coating a dual-polarization fiber laser with epoxy resin. It presents broad working bandwidth and a detection limit of 31 Pa at 200 kHz. Its capability of ultrasound imaging is also demonstrated.

Th4A.10 • 15:30

Microwave photonics filtering technique for interrogating Fiber Bragg grating transverse load sensors, Yiping Wang¹; ¹*Nanjing Normal Univ., China*. A transverse load fiber Bragg grating (FBG) sensor exploiting microwave photonics filtering technique is presented and experimentally demonstrated. The proposed sensor has the advantages of higher resolution, remote sensing and adjustable sensitivity.

Th4A.11 • 15:30

Inscription and improvement of novel fiber Bragg gratings by 800 nm femtosecond laser through a phase mask, Jun He^{1,2}, Yiping Wang¹, Changrui Liao¹, Kaiming Yang¹, Shen Liu¹, Ying Wang¹, Gang-Ding Peng²; ¹*Shenzhen Univ., China*; ²*Univ. of New South Wales, Australia*. Novel FBGs were inscribed by 800 nm femtosecond laser through a phase mask. The improvement of the experimental setup and the inscription results of broadband FBGs, phase-shifted FBGs, and negative-index FBGs were exhibited.

Th4A.12 • 15:30**Magnetic field vector sensor based on directional scattering between polarized plasmon wave and arrayed nanoparticles, Zhaochuan**

Zhang¹, Xuejun Zhang¹, Jian Xu¹, Bai-Ou Guan¹, Tuan Guo¹; ¹Jinan Univ., China. A magnetic field vector sensor based on surface Plasmon resonance of a gold-coated tilted fiber Bragg grating and magnetic fluid is proposed. Both the orientation and the intensity of magnetic fields can be determined.

Th4A.13 • 15:30**Grating Inscription to Few-Mode Multi-Core Optical Fiber, Hiroki**

Ishihara¹, Hitoshi Uemura¹, Yusuke Sasaki¹, Koji Omichi¹, Takeshi Fujisawa², Kunimasa Saitoh²; ¹Fujikura Ltd., Japan; ²Hokkaido Univ., Japan. Preliminary fiber Bragg grating inscription to 2LP-mode 4-core fiber is demonstrated to confirm feasibility for optical fiber sensing application. Clear Bragg reflection spectra for LP₀₁ and LP₁₁ are obtained individually using all fiber-optic few-mode multi-core input/output module.

Th4A.14 • 15:30**Thermal response time measurement of photonic crystal fiber device based on anti-resonant reflecting guidance, Ying Wang¹, Zhengchun**

Peng¹, Changrui Liao¹, Yiping Wang¹; ¹Shenzhen Univ., China. The thermal response time of a photonic crystal fiber device based on anti-resonant reflecting guidance was measured to be ~267 ms with using a CO₂ laser as thermal excitation source.

Th4A.15 • 15:30**Secondary-type In grating and its laser applications, Feng Furong¹,**

Yang Ran¹, Bai-Ou Guan¹; ¹Inst. of Photonics Technology, China. An abnormal phenomenon of secondary dip existing in type In Bragg grating formation is discovered and the laser applications based on those secondary-type In gratings are researched.

Th4A.16 • 15:30**Remote point-sensing systems based on erbium-Raman random fiber laser, Wei Sun¹, Han Wu¹, Zinan Wang¹, Zedong Wei¹, Xianyang Qian¹,**

Qiheng He¹, Yunjiang Rao¹; ¹*Univ. Electronic Sci. & Tech. of China, China.* We demonstrate a long-distance point-sensing system based on the erbium-Raman random fiber laser. With the relatively low pump power, the sensing distance can reach 100km with the OSNR as high as 35dB.

Th4A.17 • 15:30

Fiber optic bending sensor based on resonance splitting of π -phase-shifted FBG, Jiageng Chen¹, Qingwen Liu¹, Xinyu Fan¹, Zuyuan He¹; ¹*State Key Laboratory of Advanced Optical Communication Systems and Networks, Shanghai Jiao Tong Univ., China.* We present a bending sensor using π -phase-shifted FBG (π -PSFBG).

Based on the bending-induced resonance splitting effect of the π -PSFBG, a curvature measurement within 25 m^{-1} or orientation-recognizable in $\pm 14\text{ m}^{-1}$ is realized.

Th4A.18 • 15:30

Particle trapping by a helical optical fiber, Hongchang Deng¹, Xianbin Wang¹, Yaxun Zhang¹, Xiaotong Zhang¹, Libo Yuan¹; ¹*Harbin Engineering Univ., USA.* We present a microparticle trapping technique using a helical optical fiber. The nearby polystyrene microparticles with $10\text{ }\mu\text{m}$ diameters will be trapped on the fiber surface by the evanescent wave induced by cladding modes interference.

Th4A.19 • 15:30

Investigation of relative humidity sensor using periodically micro-tapered long-period fiber gratings without sensing uncertainty, Jong Cheol Shin¹, Ik Su Jo¹, Ju Il Hwang¹, Young-Geun Han¹; ¹*Hanyang Univ., Korea (the Republic of).* We propose a humidity sensor using a periodically micro-tapered long-period fiber grating incorporating low index polymer and polyvinyl alcohol (PVA). We effectively suppress sensing uncertainty for measurement of the relative humidity.

Th4A.20 • 15:30

Torsion sensors based on Pre-twisted in-fiber Long period fiber gratings, Mi Deng¹, Shen Liu¹, Zhiyong Bai¹, Ying Wang¹, Yiping Wang¹; ¹*Shenzhen Univ., China.* We demonstrated a novel CO₂-laser

based long period fiber grating by periodically twisting the SMF to introduce a pre-twist strain for each point. The new structure exhibits very high torsion sensitivity of 17.9 nm/(rad/cm)

Th4A.21 • 15:30

Strain Sensor Based on Fiber Bragg Grating with a Carbon Fiber Coating, Rui Wang¹, Chunliu Zhao¹, Dongyou Yu²; ¹*China Jiliang Univ., China;* ²*Anshan Photonics Land Technology Co.Ltd, China.*

A strain sensor based on fiber Bragg grating with a carbon fiber coating is proposed and measurement. The range of measurement is from 2kg to 20kg and the strain sensor presents good characteristic of repeatability.

Th4A.22 • 15:30

A Compensation Method on Scale Factor of FOG for Space Application, Yuanhong Yang^{1,2}, Dandan Wang¹, Fuling Yang¹;

¹*National Key Laboratory on Inertial Technology, Beihang Univ., China;*

²*Key Laboratory on Precision Opto-Mechatronics Technology of*

Ministry of Education, Beihang Univ., China. The intrinsic parameter of multifunction integrated optic chip is extracted and found to be linear with wavelength and temperature experimentally. The scale factor stability of FOG is improved by about ten times with the established model.

Th4A.23 • 15:30

An Integrated All Fiber Whispering Gallery Mode Resonator,

Dongmei Huang¹, Tao Zhu¹, Leilei Shi¹, Min Liu¹, Ming Deng¹, Wei Huang¹; ¹*Key Laboratory of Optoelectronic Technology & Systems (Ministry of Education), Chongqing Univ., China.*

An integrated all fiber WGMR with the maximum quality factor 3.39×10^3 is demonstrated by positioning tapered fiber in the micro-groove fixed, which has potential applications in chemical solutions or current by tracing the resonant wavelength.

Th4A.24 • 15:30

Measurement of Distributed Polarization Crosstalk in LiNbO₃

Straight Through Waveguide Phase Modulator, Haoliang Zhang¹, Jun Yang¹, Zhangjun Yu¹, Chuang Li¹, Yonggui Yuan¹, Yongqing Cheng¹,

Zhe Yang¹, Feng Peng¹, Bing Wu¹, Hanyang Li¹, Libo Yuan¹; ¹*Harbin Engineering Univ., China.* A full analysis of distributed polarization crosstalk in straight through waveguide was proposed. The measuring error caused by dispersion was eliminated by using dispersion compensation. The results enable us to evaluate the performance of the waveguide accurately.

Th4A.25 • 15:30

A refractive-index sensor based on hollow-core silica tube, Yijian Huang¹, Ying Wang¹, Mi Deng¹, Shen Liu¹, Changrui Liao¹, Yiping Wang¹; ¹*Shenzhen Univ., China.* A novel design for a compact fiber-optic sensor based on a multimode interference self-imaging phenomenon is presented. Such a sensor exhibits an average sensitivity of 2548nm/RIU for the 1.42-1.442 refractive index range.

Th4A.26 • 15:30

Study on Vibration Isolation Packaging of Distributed Feedback Fiber Laser, Zhiqiang Song¹; ¹*Shandong Academy of Sciences, USA.* A vibration isolation packaging structure of distributed feedback fiber laser was designed. The experimental results show that laser line-width and wavelength are stable under acoustic and vibration disturbing.

Th4A.27 • 15:30

A VCSEL-Based Fast Precision FBG Interrogation System, Binxin Hu¹, Guangxian Jin¹, Tongyu Liu¹, Jinyu Wang¹; ¹*Shandong Academy of Sciences, China.* This paper presents a fast precision FBG interrogation system based on VCSEL. The system achieves 1.2 pm accuracy with 3 nm tuning range and 1 kHz tuning rate, applicable to both static and dynamic measurements.

Th4A.28 • 15:30

Discrete cavity length demodulation algorithm for optical fiber F-P sensor based on variable step size mountain climbing search algorithm, Huadong Yang¹, Xinglin Tong¹, Pan Hu¹, Qian Guo¹; ¹*Wuhan Univ. of Technology, China.* This paper present a novel variable step size mountain-climbing search algorithm to reduce the computation of the

discrete cavity length demodulation algorithm. Wavelet denoising is also used to realize fast high precision signal demodulation .

Th4A.29 • 15:30

All fiber-optic humidity sensor based on tungsten disulfide (WS₂), Heyuan Guan¹, Yunhan Luo¹, Chaoying Chen¹, Xia Kai¹, shuihua peng¹, Jieyuan Tang¹, Huihui Lu¹, JianHui Yu¹, Jun Zhang¹, Yi Xiao¹, Zhe Chen¹; ¹*Jinan Univ., China.* A novel all-fiber-optic humidity sensor comprised of a tungsten disulfide (WS₂) film and a side polished fiber (SPF) is demonstrated. This sensor will promote the employment of WS₂ in chemical sensing techniques.

Th4A.30 • 15:30

Magnetic Filed Tunability of All-solid Waveguide Array Fiber Integrated with Ferrofluid, Miao Yinping¹, CHAO LI¹, xixi ma¹; ¹*Tianjin Univ. of Technology, China.* All-solid waveguide array fiber integrated with ferrofluid was periodically modulated by both radial and axial microstructure. The propagation characteristics were studied through tuning the applied magnetic field intensity.

Th4A.31 • 15:30

Self-reference single-beam optical sensor for methane measurement in different background gases, Jun Chang¹; ¹*Shandong Univ., China.* Self-reference single-beam optical sensor is presented to detect methane concentration, whose advantage is measuring absorption line shape precisely. Consequently measurement accuracy could be improved by absorption line shape correction of methane in different background gases.

Th4A.32 • 15:30

All-fiber-optic Temperature Sensor Based on Cholesteric Liquid Crystal, Jieyuan Tang¹, Ruizhi Chen¹, Zhe Chen¹, Jianhui Yu¹, Heyuan Guang¹, Huihui Lu¹, Yunhan Luo¹, Jun Zhang¹; ¹*Dept of Optoelectronic Engin, Jinan Univ, China.* We propose a all-fiber-optic temperature sensor by coating cholesteric liquid crystal film on a side-polished fiber. This sensor has a sensitivity of 0.28 dB /°C from 30°C-70°C and possesses high potentiality in photonics applications.

Th4A.33 • 15:30

Fiber Optic Pressure and Temperature Sensor with Bourdon Tube for Downhole Application, Xiaohui Liu¹, an w. zhao¹, Qingchao Zhao¹, Yingying Wang¹, Long Ma¹, Chang Wang¹, Gang-Ding Peng^{2,1};

¹*Shandong Key Laboratory of Optical Fiber Sensing Technologies, Laser Inst. of Shandong Academy of Sciences, China;* ²*School of Electrical Engineering & Telecommunications, the Univ. of New South Wales, Australia.* A pressure and temperature sensor for downhole application is reported. Experiments show the sensor has sensitivity of $0.99\mu\text{m}/\text{MPa}$ and accuracy of 0.1%F.S. for pressure measurement. The sensor is successfully used for downhole 24-hours monitoring.

Th4A.34 • 15:30

A magnetic field sensor with optical resonant measurement, Qiang Huang¹; ¹*Harbin Engineering Univ., China.* This paper reports a magnetometer with optical resonant measurement. Experiments show the scalar signal with the resonant precession frequency of the coherent atoms and the vector signal with the Lock-in Amplifier phase shift on the field angle.

Th4A.35 • 15:30

A Miniaturized FBG Accelerometer based on a Lantern-Shape Metallic Shell, Jun Wang¹, Jing Zhu², Peng Gan¹, Zhengliang Hu¹, Yongming Hu¹; ¹*Academy of Ocean Science and Engineering, National Univ. of Defense Technology, China;* ²*College of Optoelectronic Science and Engineering, National Univ. of Defense Technology, China.* A miniaturized FBG accelerometer based on a lantern-shape metallic shell is demonstrated. The shell structures are analyzed and optimized using ANSYS. A Michelson interferometer system is applied to acquire signals. The accelerometer sensitivity is 43.6 pm/g, the resonant frequency is 1000 Hz, and the orthogonal crosstalk is -15.3 dB.

Th4A.36 • 15:30

Polarization Insensitive Electro-optic Probe, Dong-Joon Lee¹, Young-Pyo Hong¹, Seok Kim¹; ¹*Korea Research Inst of Standards & Sci, Korea (the Republic of).* A highly simple and polarization insensitive fiber-optic probe for electric field sensing is demonstrated. The polarization

instability problem – often occurs due to the birefringence drift in lengthy optical fibers – is overcome for fiber-coupled optical sensors.

Th4A.37 • 15:30

Fabrication of notched long-period fiber grating by inductively coupled plasma etching for temperature sensing, Chia-Chin Chiang¹;

¹*Dept. of Mechanical Engineering, KUAS, Taiwan.* This study proposes the notched long-period fiber grating (NLPFG) temperature sensor fabricated by inductive couple plasma (ICP) etching. The experimental results show that the largest sensitivity of the NLPFG sensor is 0.107 nm/°C. Therefore, the NLPFG temperature sensor possesses superior sensitivity.

Th4A.38 • 15:30

Theoretical Investigation on Whispering Gallery Modes of Microsphere with Anisotropic Deformation, xiaoxia wang¹, Honghui Zhang¹, Jia Wang¹; ¹*College of Optoelectronic Engineering, Chongqing Univ., China.* A sensing mechanism is proposed based-on microsphere with anisotropic deformation in whispering gallery modes. Ellipsoid index ϵ is introduced to describe the deformation, which happens on the microsphere under a unidirectional force.

Th4A.39 • 15:30

Load Identification Method Based on Fiber Bragg Grating Sensors, Song X. Gang¹; ¹*Nanjing Univ. of Aeronautics and Astronautics, State Key Laboratory of Mechanics and Control of Mechanical Structures, China.* Fiber Bragg Grating (FBG) sensing system is utilized to monitor load in this paper. The load identification theory is based on inverse FEM approach and least square method. Experiment results reveal that the novel algorithm can accurately estimates the values of load.

Th4A.40 • 15:30

Simultaneous Strain and Temperature Measurement Using Cascaded Chirp Long Period Fiber Grating, Mayumi Nagatsuka¹, Masayoshi Koizumi¹, Junki Saito¹, Than Ngo¹, Satoshi Tanaka¹, Atsushi Wada¹, Nobuaki Takahashi¹; ¹*National Defense Academy, Japan.* Simultaneous multi-parameter sensing using a cascaded chirp LPG is proposed, in

which two resonance peaks are utilized for discriminating between strain and temperature and applied strain and temperature changes are simultaneously determined within ± 23 micro-strain and ± 0.14 degree C, respectively.

Th4A.41 • 15:30

Broadband Vibration Sensors Using Fiber Bragg Gratings, Kenji Sato¹; ¹*National Inst. of Technology, Numazu College, Japan.* A vibration sensor using fiber Bragg gratings has been demonstrated for monitoring broadband vibrations. We proposed temperature-insensitive vibration sensing by monitoring and stabilizing the direct current from a photodiode.

Th4A.42 • 15:30

In-situ characterization of epoxy composites with polymer-coated fiber Bragg grating sensors, umesh sampath¹, Hyunjin Kim¹, Daegil Kim¹, Minho Song¹; ¹*Electronics and Information Engineering, Chonbuk National Univ., Korea (the Republic of)*. A pair of polymer-coated fiber Bragg gratings are proposed for simultaneous characterization of temperature and strain in curing composite structures. Temperature sensitivity was $81 \text{ pm}^{\circ}\text{C}$ which is 7 times larger than normal FBG sensors.

Th4A.43 • 15:30

Radio Frequency Detection Based on Photonic Time-Stretched Technique, Ying Yue¹, Zhongying Wu¹, Hui Ding¹; ¹*Xi'an jiaotong Univ., China.* Sample rate improvement via photonic time-stretched technique is proposed and experimentally demonstrated. This technique can be used to measure radio frequency with sampling rate of 220GSa/s and bandwidth of 27.5GHz.

Th4A.44 • 15:30

Specialty Optical Fibers for Fiber Optical Current Sensors, Yang Di¹, Xin Mao¹, Weijun Tong¹, Jinjin Tao¹, Tongqing Liu¹, Xiaoguang Liu¹, Huifeng Wei¹; ¹*Yangtze Optical Fibre and Cable Joint Stock Limited Company, China.* We design and manufacture specialty fibers for fiber optical current sensor (FOCS) head: PANDA, elliptical core fiber, and

spun highly birefringent fiber. The sensor head achieves good linearity in temperature range -40°C -70°C without compensation.

Th4A.45 • 15:30

Fiber Optic Gyro base on Photonic Crystal Fiber Sensing Coil,
KuiYan Song¹, Yuanhong Yang¹, Changxin Wu¹; ¹*Beihang Univ., China.*
We proposed a new type of fiber optic gyroscope with reduced thermal sensitivity and improved radiation resistant by introducing a polarization-maintaining photonic crystal fiber coil.

Th4A.46 • 15:30

Research on FBG Packaging Technique for Ultrahigh Resolution Strain Sensing, Jun Cao¹, Qingwen Liu¹, Xinyu Fan¹, Zuyuan He¹;

¹*Shanghai Jiao Tong Univ., China.* We reported a new FBG packaging method with both good long time stability and simple field assembly by fixing metallized fiber to metal board with V-shaped groove, for the purpose of ultrahigh strain sensing.

Th4A.47 • 15:30

Dual-parameter Measurement Based on Multiple Acoustic Modes in SBS Process, Xin Zhou¹, Zhen Guo¹, Changjian Ke^{1,2}, Ming Tang^{1,2}, Deming Liu^{1,2}; ¹*School of Optical and Electronic Information, Huazhong Univ. of Science and Technology, China;* ²*National Engineering Laboratory for Next Generation Internet Access System, Huazhong Univ. of Science and Technology, China.* A dual-parameter measurement method is proposed, utilizing the multi-peak BGS contributed by multiple acoustic modes in stimulated Brillouin scattering process. A fivefold enhancement in measurement sensitivity may be achieved for temperature and strain.

Th4A.48 • 15:30

A High Sensitive Magnetic Field Sensor Based on Photonic Crystal Fiber Modal Interferometer, Ying Li¹, Guofeng Yan¹, Sailing He¹;

¹*College of Optical Science and Engineering, Zhejiang Univ., China.* A high sensitive magnetic field sensor is newly designed and analyzed, which is consisted of two segments of thin core fiber and a sandwiched photonic crystal fiber. The average sensitivity we obtained is 481 pm/Oe.

Th4A.49 • 15:30

Photoluminescence spectral characteristics of Pb/Bi co-doped silica fiber, Jianxiang Wen¹, Haihong Zhan¹; ¹*Shanghai Univ., China.* A Pb/Bi co-doped silica fiber is fabricated by atomic layer deposition (ALD). The absorption bands are at 692 nm, ~800 nm and 1013 nm. There are broadband fluorescence spectra with 980 nm and 830 nm pumping.

Th4A.50 • 15:30

Metal enhanced fluorescence based on tapered fiber, Fenghong Chu¹, Jiayan Lu¹, Fengyu Cheng¹, Jie Sang¹, Chengxin Pang¹, Chunjuan Wei¹, Wei Jiang¹, Xiaojun Song¹; ¹*School of Electronic and Information Engineering, Shanghai Univ. of Electric Power, China.* Polymer tapered fiber was fabricated by photo-polymerization reaction method, gold nanoparticles and fluorophore were dipped coated on the tapered fiber, compared with fiber coated only with fluorophore this kind of structure can gather more fluorescence.

Th4A.51 • 15:30

A novel Mach-Zehnder interferometer based on hybrid liquid crystal-photonic crystal fiber, Xianping Luo¹, Kai Yu², Jialu Wang¹, Feiru Wang¹, Yongjun Liu¹, Weimin Sun¹; ¹*Key Lab of In-fiber Integrated Optics, Ministry Education of China, Harbin Engineering Univ., China;* ²*College of Information and Communications Engineering, Harbin Engineering Univ., China.* We propose a novel all fiber Mach-Zehnder interferometer based on photonic crystal fiber with liquid crystal-filled. We mainly studied the MZIs with different LC-filled structure. The temperature sensitivities can be enlarged to $-1.5666\text{nm}/^\circ\text{C}$.

Th4A.52 • 15:30

Exciting Surface Waves on Metal-Coated Multimode Optical Waveguides using Skew Rays, Han Chunyang^{2,1}, John Canning², Kevin Cook², Hui Ding¹; ¹*Xi'an Jiaotong Univ., China;* ²*The Univ. of Sydney, Australia.* Multi-point SPR excitation using skew ray within a multimode plastic optical waveguide is proposed and analysed. The approach entails a novel method of measuring the SPR angle which is in agreement with theoretically predicted values.

Th4A.53 • 15:30

An Intensity Modulation-Based FOVS Using Serpentine Spring with Proof Mass Structure, Ze Wei Zuo¹, Jae-Kyung Pan¹; ¹*Electrical Engineering, Chonbuk National Univ., Korea (the Republic of)*. An intensity modulation-based fiber optic vibration sensor (FOVS) using serpentine spring with proof mass structure is proposed and demonstrated via experiments. The structure, operating principle, and characteristics of the proposed sensor are given.

Th4A.54 • 15:30

Sensitivity improvement of fiber Bragg grating sensors based on optical attenuation-based weak value amplification, Kwang Wook Yoo¹, Young-Geun Han¹; ¹*Hanyang Univ., Korea (the Republic of)*. We investigate the sensitivity improvement of fiber Bragg grating (FBG) sensors based on the optical attenuation-based weak value amplification (WVA). We successfully enhance the strain sensitivity of the FBG sensor based on the proposed WVA.

Th4A.55 • 15:30

Near-infrared SPR Sensor based on D-shaped Photonic Crystal Fiber Coated with Indium Tin Oxide, Tianye Huang¹, Xiang Li², Ying Qiu²; ¹*China Univ. of Geosciences, China*; ²*Wuhan research Inst. of posts and telecommunications, China*. D-shaped photonic crystal fiber SPR sensor operating in near-infrared is proposed. The wavelength and phase sensitivity achieve 8800 nm/RIU and 5.4×10^5 Deg./RIU/cm, respectively. The sensor can be used for highly precise refractive index sensing.

Th4A.56 • 15:30

Improvement of Mechanical Strength of Polymer-Coated, Hollow-Optical Fiber for FT-IR Remote Spectroscopy, Katsumasa Iwai¹, Yuji Matsuura², Mitsunobu Miyagi¹, Hiroyuki Takaku¹, Takashi Katagiri², Yi-Wei Shi³; ¹*National Inst. of Tech., Sendai College, Japan*; ²*Tohoku Univ., Japan*; ³*Fudan Univ., China*. Rugged hollow fibers for FT-IR remote spectroscopy are fabricated by all-liquid phase technique. A buffer film coated on the inside of the silica-glass capillary protects the tube from acid solution and improves the mechanical strength.

Th4A.57 • 15:30

Single-End-Access Strain and Temperature Sensing Based on Multimodal Interference in Plastic Optical Fibers, Tomohito Kawa¹, Goki Numata¹, Neisei Hayashi², Yosuke Mizuno¹, Kentaro Nakamura¹;

¹*Inst. of Innovative Research, Tokyo Inst. of Technology, Japan;*

²*Research Center for Advanced Science and Technology, The Univ. of Tokyo, Japan.* We develop a single-end-access strain/temperature sensor configuration based on multimodal interference in a plastic optical fiber with an extremely high sensitivity. The light Fresnel-reflected at the distal open end of the plastic fiber is exploited.

Th4A.58 • 15:30

Optical Fiber Meta-Tips, Maria Principe¹, Marco Consales¹, Alberto Micco¹, Alessio Crescitelli², Giuseppe Castaldi¹, Emanuela Esposito², Vera La Ferrara³, Antonello Cutolo¹, Vincenzo Galdi¹, Andrea Cusano¹;

¹*Univ. of Sannio, Italy;* ²*Inst. for Microelectronics and Microsystems - CNR, Italy;*

³*ENEA research center, Italy.* We realize the first optical-fiber “meta-tips” implementing in the near-infrared the beam-steering with increasing angles, up to the limit case of surface-waves excitation.

We also explore their capability to work as local refractive index sensor.

Th4A.59 • 15:30

Refractive index insensitive Mach-Zehnder interferometer based on an air-clad thin-core fiber, Zi-Wei Feng¹, Chuang Wu¹, Zhengyong Liu², Bai-Ou Guan¹, Hwa Yaw Tam²; ¹*Inst. of Photonics Technology, Jinan Univ., China;* ²*Electrical Engineering, The Hong Kong Polytechnic Univ., Hong Kong.* We demonstrate an inline Mach-Zehnder interferometer (MZI) based on an air-clad thin-core fiber for strain and temperature sensing. The output spectrum of this MZI is insensitive to the variation of surrounding refractive index.

Th4A.60 • 15:30

Fabrication of Kagomé Hollow-core Photonic Crystal Fiber for Temperature Sensing, Haihu Yu^{1,2}, Xiong CHENG¹, Jian MA¹, Yu Zheng¹; ¹*National Engineering Laboratory for Fiber Optic Sensing Technology, Wuhan Univ. of Technology, China;* ²*Key Lab of Fiber Optic Sensing Technology and Information Processing, Ministry of Education,*

Wuhan Univ. of Technology, China. A kagomé-lattice photonic crystal fiber was fabricated using the “stack-and-draw” method and a temperature sensor based on the fiber was proposed. The calculation results show that the sensor has a high sensitivity of $4.09 \text{ nm}/^\circ\text{C}$.

Th4A.61 • 15:30

Microcavity Assisted Strain Sensor Using Wavelength and Intensity Based Interrogation, Rajan Jha¹, Jitendra N. Dash¹; ¹I.I.T.

Bhubaneswar, India. An axial strain sensor based on microcavity incorporated solid core photonic crystal fiber (SCPCF) modal interferometer is proposed. The probe has strain sensitivity of $2.4 \text{ pm}/\mu\epsilon$ and $0.005 \text{ dB}/\mu\epsilon$ in wavelength and intensity interrogation respectively.

Th4A.62 • 15:30

Fiber-coupled self-mixing displacement measurement with a waveguide phase modulator, YuFeng Tao¹, Ming Wang¹, Wei Xia¹;

¹*NanJing Normal Univ., China.* Fiber-pigtailed self-mixing sensor employs waveguide modulator in polarization maintaining fiber to introduce phase carrier. Quadrature phases are extracted from amplitudes of harmonics to recur displacement. High sensitivity is experimentally verified by comparison to laser LDV.

Th4A.63 • 15:30

Investigation of optimization of fiber Bragg grating writing based on single-pulse excimer laser, Cheng Cheng¹, Huiyong Guo¹, Yu Zheng¹, Haihu Yu¹; ¹*Wuhan Univ. of Technology, China.* The mechanism of the fiber Bragg grating based on 193/248 nm excimer laser by one pulse is compared. The results inspire the best way to write weak FBG on high/low germanium doped optical fibers.

Room 102

08:00 -- 10:00

F1A • Specialty Optical Fibers for Sensing

Presider: Prof. Yasufumi Enami, Kochi Univ. of Technology, Japan

Prof. Liyang Shao, Southwest Jiao Tong Univ., China

F1A.1 • 08:00 (Invited)

Specialty Optical Fibre Sensors and Their Applications, Hwa Yaw Tam¹; ¹*The Hong Kong Polytechnic Univ., Hong Kong.* Abstract not provided.

F1A.2 • 08:30

Step Index Optical Fibre Drawn From a 3D-printed Preform, Kevin Cook¹, Geoffrey Balle¹, John Canning^{1,2}, Md. Arafat Hossain¹, Chunyang Han¹, Jade-Edouard Comatt¹, Yanhua Luo², Gang-Ding Peng²; ¹*The Univ. of Sydney, Australia;* ²*Univ. of New South Wales, Australia.* The first successful fabrication of step index optical fibre drawn from a 3D-printed polymer preform is reported. This milestone in fibre fabrication has huge implications for optical fibre fabrication and fibre devices and sensors.

F1A.3 • 08:45

Resonant fiber optic gyro based on total internal reflection photonic crystal fiber ring resonator, Linglan Wang¹, Hanzhao Li¹, Huilian Ma¹, Zhonghe Jin¹; ¹*School of Aeronautics and Astronautics, Zhejiang Univ., China.* A new type resonant fiber optic gyro (RFOG) equipped with a fiber ring resonator fabricated by the total internal reflection photonic crystal fiber (TIR-PCF) is firstly demonstrated and achieves a bias stability of 4.63°/h.

F1A.4 • 09:00

Distributed Strain Monitoring in Tunnel Shotcrete (with and without yieldable concrete wedges) by fiber-based TW-COTDR technique, Isabelle Planes^{1,2}, Sylvain Girard², Aziz Boukenter², Emmanuel Marin², Sylvie Lesoille¹, Radwan Farhoud¹, Jad Zghondi³, Frank Fischli³, Youcef Ouerdane²; ¹*Andra, France;* ²*Laboratoire Hubert Curien, France;* ³*Marmota Engineering AG, Switzerland.* We studied the potential of a fiber-based sensor using the Tunable Wavelength Coherent Optical Time Domain Reflectometry (TW-COTDR) technique to monitor the distributed strain profile inside a tunnel shotcrete, with and without yieldable concrete wedges.

F1A.5 • 09:15

Raman Distributed Temperature Optical Fiber Sensor Based on Few Mode Fibers, Meng Wang², Tongqing Liu¹, Hao Wu², Yong Xiang¹, Huifang Wei^{1,2}, Weijun Tong¹, ming tang²; ¹*State Key Laboratory of Optical Fiber and Cable Manufacture Technology, Yangtze Optical Fiber and Cable Joint Stock Limited Company (YOFC), China;* ²*School of Optics and Electronic Information, Huazhong Univ. of Science and Technology, China.* We report a Raman based distributed temperature sensor over 20km few mode fibers. The spatial and temperature resolution are achieved with 6 meters and 3.3 degrees Celsius, respectively.

F1A.6 • 09:30

An Open-cavity Fabry-Perot Interferometer for Sensing Applications, Guofeng Yan¹, Shengnan Wu¹, Zhenggang Lian², Sailing He¹; ¹*Zhejiang Univ., China;* ²*Yangtze Optical Electronics Co.,Ltd. (YOEC), China.* An open-cavity Fabry-Perot Interferometer (FPI) is proposed and fabricated by using the chemical etching method based on a side-hole fiber. Its liquid RI, gas pressure and relative humidity sensing performance was experimentally tested as well.

F1A.7 • 09:45

Hybrid-Cavity Fabry-Perot Interferometer for Simultaneous Relative Humidity and Temperature Measurement, Chengliang Wang¹, Guofeng Yan¹, Sailing He¹; ¹*Centre for Optical and Electromagnetic Research, State Key Laboratory of Modern Optical Instrumentation, College of Optical Science and Engineering, Zhejiang Univ., China.* A novel hybrid-cavity Fabry-Perot interferometer based on four-hole suspended-core fiber and optical adhesive is theoretically and experimentally demonstrated for simultaneous RH and temperature measurement, by using the fast Fourier transform with the phase tracking method.

Room 102

10:30 -- 12:00

JF2A • Postdeadline Session

JF2A.1 • 10:30

An exploration on distributed wind speed measurement of transmission line based on optical fiber sensing, Haitao Wang¹, Tao Li¹; ¹*Wuhan Nari Limited Liability Company of State Grid Electric Power Research Institute, China.* A method of distributed wind speed measurement is proposed. The speed is calculated according to the Kaman vortex theory, by detecting the time-varying optical signal on the transmission line. Field test demonstrates its validity.

JF2A.2 • 10:45

Research on Current Sensor Based on POTDR, Xiao Zeng², Hongjun Yang³, Zhaofeng Wu³, Muping Song¹, Yan Lu¹, Cong Yin¹, Qiaolan Xia¹; ¹*Zhejiang University, China;* ²*Wuhan KangPuChangQing Software Technology Co., Ltd, Wuhan, China;* ³*Xiangyang State Grid Composite Insulator Co., Ltd, China.* A system of distributed current sensing based on Polarization Optical Time Domain Reflectometer (POTDR) is proposed to achieve the quantitative detection of current. Experimental results show that the system has high sensitivity.

JF2A.3 • 11:00

Reconfigurable optical microbubble-on-tip sensor for microfluidic applications, Chenlin Zhang¹, Yuan Gong¹, Wenliang Zou¹, Yunjiang Rao¹, Gang-Ding Peng²; ¹*Univ of Electronic Science & Tech China, China;* ²*University of New South Wales, Australia.* A novel reconfigurable optical microbubble-on-tip (MoT) structure is developed for microfluidic sensing applications. The generation and sensing mechanism of MoT is very different from traditional optical fiber sensors and the sensing performance is excellent.

JF2A.4 • 11:15

Theoretical Investigation on Whispering Gallery Modes of Microsphere with Anisotropic Deformation, xiaoxia wang^{1,2}, Honghui Zhang^{1,2}, Jia Wang^{1,2}; ¹*Key Lab. of Optoelectronic Technology and Systems of the Education Ministry of China, China;* ²*College of Optoelectronic Engineering, Chongqing University, China.* A sensing mechanism is proposed based-on microsphere with anisotropic deformation in whispering gallery modes. Ellipsoid index ϵ is introduced to describe the deformation, which happens on the microsphere under a unidirectional force.

JF2A.5 • 11:30

Asymmetric Spin Splitter Based on Total Reflection at Glass-air Interface, Wenguo Zhu¹, JianHui Yu¹, zhe chen¹; ¹*Jinan Univeristy, China.* We investigate the in-plane spin splitting of 1D Gaussian beam under total reflection. By tuning incident polarization, controllable asymmetric spin splitting can be achieved, and one spin component can undergo a displacement up to $\pm w_0/2$.

JF2A.6 • 11:45

Phase Noise Reduction of a Compact Brillouin/Erbium Fiber Laser, Chenyu Wang^{1,2}, Mo Chen², Zhou Meng²; ¹*College of Optoelectronic Science and Engineering, National University of Defense Technology, China;* ²*Academy of Ocean Science and Engineering, National University of Defense Technology, China.* A compact Brillouin/erbium fiber laser (BEFL) is investigated on its phase noise reduction characteristics. The phase noise of the Brillouin pump can be reduced by 40 dB/Hz^{1/2} through this BEFL.

Room 102

12:00 -- 12:15

Awards and Closing Ceremony

Key to All Authors

- Abell, Andrew - W3A.5
Ahmad, Eamonn J. - W4A.47
Ai, Fan - W4A.22
Aid, Siti Rahmah - W2A.4
Alessandri, Ivano - Th2A.3
Aliberti, Anna - W1A.4
Ambran, Sumiyati - W2A.4
Ao, Lei - W4A.52, - W4A.60
Ariya, Hikaru - Th1A.6
Arregui, Francisco J. - W4A.23
Ast, Sandra - W2A.2
Atubga, David - W4A.54
Badmos, Abdulyezir - W3A.3
Bai, Xue - W1A.2
Bai, Zhiyong - Th4A.20
Balle, Geoffrey - F1A.2
Banh, Tuan Q. - Th1A.5
Bao, Haihong - Th4A.3
Bao, Weijia - M4A.3
Baradaran Ghasemi, Amir Hossein - W4A.20
Bartelt, Hartmut - Tu2A.2
Bi, Yafeng - W4A.53
Bontempi, Nicolò - Th2A.3
Boukenter, Aziz - F1A.4
Bravo, Mikel - Th1A.4
Bravo-Acha, Ana - Th1A.4
Bravo-Navas, Manuel - Th1A.4
Buric, Michael - Th1A.7
Canning, John - F1A.2, Th4A.52, W2A.2
Cao, Guiyuan - W4A.53
Cao, Jun - Th4A.46
Castaldi, Giuseppe - Th4A.58
Chakraborty, Arup Lal - W3A.6
Chakraborty, Priti S. - W3A.6
Chang, Han-Qing - W4A.52, W4A.60
Chang, Jun - Th4A.31
Che, Xin - W4A.19
Chen, Chaoying - Th4A.29
Chen, Dian - W4A.2, - W4A.50
Chen, Huifei - W4A.19
Chen, Jiageng - Th4A.17
Chen, Jin - W4A.15
Chen, Ke - W4A.21
Chen, Kevin P. - Th1A.7, W2A.1, W4A.12, W4A.32
Chen, Rongzhang - Th1A.7
Chen, Ruizhi - Th4A.32
Chen, Xi - W4A.42
Chen, Yuanfu - W3A.4
Chen, Zhe - Th4A.29, Th4A.32
Cheng, Cheng - Th4A.63
Cheng, Fengyu - Th4A.50
Cheng, Lai M. - W4A.62
Cheng, Rui - M4A.6, W4A.9
Cheng, Xiong - Th4A.60
Cheng, Yifu - W4A.26
Cheng, Yongqing - Th4A.24
Chiang, Chia-Chin - Th4A.37
Chiang, Kin S. - W4A.49
Choi, Duk-Yong - Th2A.3
Choi, Eun Seo - W4A.4
Chong, Katie E. - Th2A.3
Chu, Fenghong - Th4A.50
Chun, SooKyung - W4A.11
Chung, Youngjoo - W4A.17
Chunyang, Han - Th4A.52
Comatti, Jade-Edouard - F1A.2
Consales, Marco - Th4A.58
Cook, Kevin - F1A.2, Th4A.52
Crescitelli, Alessio - Th4A.58
Crossley, Maxwell - W2A.2
Cusano, Andrea - Th4A.58, W1A.4
Cutolo, Antonello - Th4A.58,

- W1A.4
Dargahi, Leila - W4A.20
Dash, Jitendra N. - Th4A.61
de Miguel, Veronica - Tu3A.4
Deng, Hongchang - Th4A.18
Deng, Mi - Th4A.20, Th4A.25
Deng, Ming - Th4A.23
Di, Yang - Th4A.44
Ding, Hui - Th4A.43, Th4A.52
Ding, Liyun - W3A.5, W4A.33,
W4A.59
Ding, Ming - Tu3A.6
Dixit, Shiva - W3A.7
Dominguez-Lopez, Alejandro -
Th3A.6
Dong, Yong Kang - W4A.26,
W4A.42, W4A.53, W4A.55
Du, Jiangbing - Th3A.3
Enami, Yasufumi - W4A.5
Eom, Jonghyun - W4A.57
Eom, Tae Joong - W1A.1
Esposito, Emanuela - Th4A.58
Eyal, Avishay - Th3A.7
Fan, Xinyu - Th3A.3, Th3A.5,
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- Bo Xue Lou Hotel

Express Hotel

- Jinjiang Inn
- Hanting Express

Star-rated Hotel

- Crown Plaza Shanghai
- Tianping Hotel

长飞光纤，28年精耕的深度

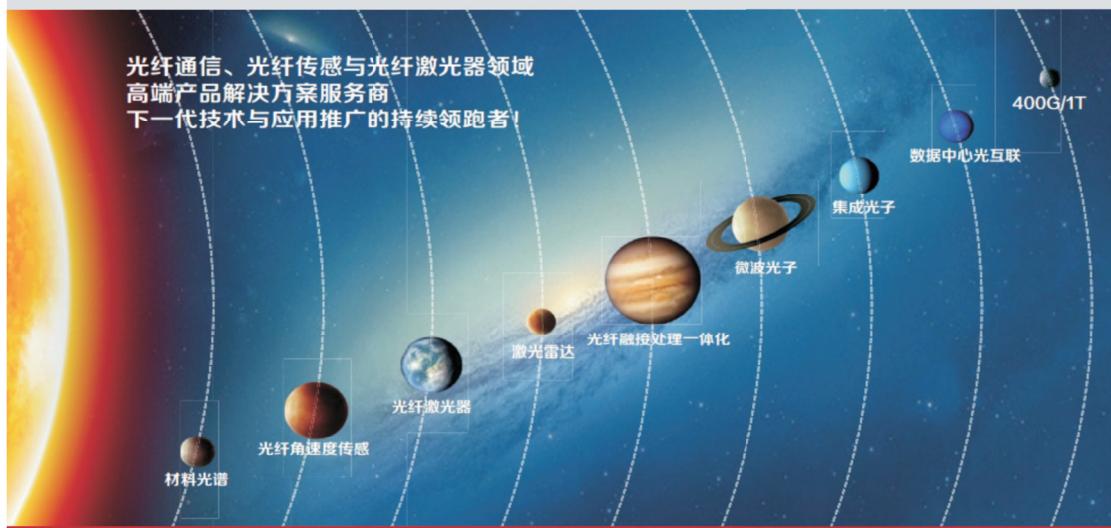


基于特种光纤的研发生产优势，长飞公司可提供基于特种光纤系列化传感解决方案：

- 光纤周界监测系统(FPMS)
- 分布式光纤测温系统(DTS)
- 光纤光栅传感系统(FBG)
- 全光纤电流互感器(FOCT)
- 传感用多芯及耦合模块、少模光纤(MCF/FMF)
- 光纤陀螺保偏光纤及光纤环(Gyro)
- 水听器/延时器等其它特种光纤传感(Hydrophone)

长飞光纤光缆股份有限公司
www.yofc.com
027-68789149
fuxin@yofc.com

YOFCL 长飞
Delivering Signals Smartly



凌云光技术集团

NKT Photonics 超连续谱光源

主要特点

- 波长范围覆盖260-2400nm
- 总功率范围覆盖0.1W-6W
- 功率稳定性 $\leq \pm 0.5\%$
- 光束质量M²<1.1
- 滤波器可最多同时输出16个单色激光
- 可用于生物光子学(荧光成像, 共聚焦, OCT, g-STED等), 表面等离子体, 微纳材料特性分析等。

NKT Photonics
the power of light



藤仓公司光纤熔接处理工作站LZM-100

主要特点

- 采用CO₂激光器, 清洁, 熔接抗拉强度高
- 具备熔接、拉锥、烧球等多种功能
- 多种对轴方式: 端面、PAS、IPA、手动
- 130mm超长拉锥距离, 实验结果最细可拉至3um
- 40-2300um超大范围光纤处理能力

Fujikura



HOT

LAZERMaster



Polatis 7000系列光开关

主要特点

- 矩阵规模: 4x4-384x384, 全球最大矩阵384x384, 2016年获得lightwave创新奖
- 性能优越: 超低损耗 (典型值1dB), 无光连接, 开关速度快, 一致性高
- 配置灵活: 可集成功率计、衰减器等功能, 满足客户各类需求。

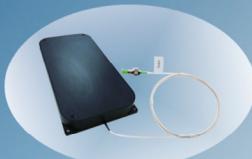
polatis
ADVANCING OPTICAL SWITCHING™

lightwave创新奖



诚信 沟通 创新 共赢

UniSilver
普銀光電



窄线宽激光器

Narrow Linewidth Laser

独特设计的超窄光纤滤波器保证了光纤激光器的单频运转，同时采用了独特的温度控技术和防振结构，消除了外界温度变化和振动对输出光波长的影响，从而实现了稳定的单纵模，超窄线宽的单频激光输出。

特点：

- <3KHz 线宽
- 20mW 功率
- 1550nm



光纤声光调制器

FCAOM

结构小巧紧凑，可靠性极高，适用于苛刻环境场合，具有上升时间快、调制带宽范围大、承受激光峰值功率高等特点。

特点：

- VIS/1064nm/1310nm/1550nm/2000nm 中心波长
- 承受 1W/5W 平均功率
- >6ns 上升沿时间
- >50dB 消光比



脉冲掺铒光纤放大器

Pulse EDFA

脉冲掺铒光纤放大器内置驱动电路与逻辑控制电路，对泵浦激光器温度、模块温度与信号增益等关键信息实时监测。

特点：

- 1550nm 波长
- 10ns 脉宽
- 100W 峰值功率输出
- 50KHz 重复频率



拉曼光纤放大器

Raman Fiber Amplifier

拉曼光纤放大器光电器件设计用于超长距离光传输系统与密集型波分复用(DWDM)光传输系统的光信号放大，增加传输距离。

特点：

- 1525nm-1563nm 工作波长
- 17dB 拉曼增益
- 800mW 泵浦功率输出

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光纤应变分布测试仪

AV6419光纤应变分布测试仪



分布式应变或温度测试

1m空间分辨率, $\pm 10\mu\epsilon$

单端无损测试, 80km测试范围

远程组网测试



◎ 布里渊散射分布测试功能

◎ 光纤应变分布测试功能

◎ 光纤损耗分布测试功能

◎ 布里渊散射谱测试功能

保偏光纤熔接机

AV6474保偏光纤熔接机

-40dB偏振串扰（熊猫型光纤）

0.1°旋转对轴精度

45秒保偏光纤快速熔接, 25秒高效热缩



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苏州至禅光纤传感技术有限公司由来自世界五百强企业两位博士和一位大学教授共同创立，为用户提供高品质的分布式光纤振动传感系统、光电模块产品、高速采集与处理电路板以及FPGA代码开发服务。至禅专注于基于OTDR(光时域反射)核心技术的光纤传感系统，产品广泛应用于石油天然气、高压电缆、边境等管线的安全监控。公司在常熟建有生产基地，并且在上海建立了产品研发中心。



产品 技术 PRODUCT TECHNOLOGY

- 专注于基于OTDR(光时域反射)核心技术的光纤传感系统；
- 独家提出的专利技术光纤供能摄像监控与分布式光纤振动传感技术的结合，提供高性能的分布式光纤管道与周界安防系统，真正解决误报漏报；
- 开发了核心的100M/250M/1G/2G的采集卡，应用于高分辨率的传感，可以在几十公里的长度上，分辨出10cm空间距离的温度与振动。

APOS 2016 PROGRAM AT A GLANCE					
	Monday 10 October	Tuesday 11 October	Wednesday 12 October	Thursday 13 October	Friday 14 October
08:00-17:30		Exhibition (13:00-17:00)	Registration		
08:00-10:00	Opening Ceremony & Plenary Talk (I) (08:30-09:30) Coffee Break (09:30-10:00)	Biological / Biomedical Sensing and Imaging (08:00-10:00)	Industrial Structural Monitoring (08:00-10:15)	Specialty Optical Fibers for Sensing (08:00-10:00)	Coffee Break (10:00-10:30)
10:00-10:30	Plenary Talk (II) (10:00-11:30)	Integrated Technologies for Sensing (10:30-11:45)	Coffee Break (10:00-10:30)	Novel Materials for Sensing (10:45-11:45)	Post-Deadline Paper Session (10:30-12:00)
10:30-12:00		Lunch (11:30-13:00)	Lunch (11:45-13:00)	Lunch (11:45-13:00)	Closing Ceremony (12:00-12:15)
12:00-13:00		Physical Sensing (13:00-15:00)	Chemical and Gas Sensing (13:00-15:00)	Distributed, Multiplexed and Networked Sensing (13:00-15:00)	Lunch (12:15-13:15)
13:00-15:00	Registration Opens (14:00-17:30)	Coffee Break (15:00-15:30)	Coffee Break (15:00-15:30)	Coffee Break (15:00-15:30)	Campus Tour (Reservation required)
15:00-15:30		Grafting and Component Technologies for Sensing (15:30-17:30)	Poster Session (I) (15:30-17:30)	Poster Session (II) (15:30-17:30)	
15:30-17:30				Bus Departures 17:45	
18:00-21:00		Welcome Reception		Conference Banquet	