

PROCEEDINGS OF SPIE

# ***Optical Communication and Optical Fiber Sensors and Optical Memories for Big Data Storage***

**Yanbiao Liao**  
**Xiaodi Tan**  
*Editors*

**9–11 May 2016**  
**Beijing, China**

*Organized by*

Chinese Society for Optical Engineering (CSOE) (China)  
Photoelectronic Technology Committee, Chinese Society of Astronautics (China)  
Photoelectronic Industrialization Committee, CHIA (China)  
Department of Cooperation and Coordination for Industry, Academe and Research, CHIA  
(China)

*Sponsored by*

Chinese Society for Optical Engineering (CSOE) (China)  
China High-tech Industrialization Association (CHIA) (China)

*Technical Co-Sponsor and Publisher*  
SPIE

**Volume 10158**

Proceedings of SPIE 0277-786X, V. 10158

SPIE is an international society advancing an interdisciplinary approach to the science and application of light.

Optical Communication, Optical Fiber Sensors, and Optical Memories for Big Data Storage,  
edited by Yanbiao Liao and Xiaodi Tan, Proc. of SPIE Vol. 10158, 1015801 © 2016 SPIE  
CCC code: 0277-786X/16/\$18 · doi: 10.1117/12.2264743

Proc. of SPIE Vol. 10158 1015801-1

The papers in this volume were part of the technical conference cited on the cover and title page. Papers were selected and subject to review by the editors and conference program committee. Some conference presentations may not be available for publication. Additional papers and presentation recordings may be available online in the SPIE Digital Library at [SPIDigitalLibrary.org](http://SPIDigitalLibrary.org).

The papers reflect the work and thoughts of the authors and are published herein as submitted. The publisher is not responsible for the validity of the information or for any outcomes resulting from reliance thereon.

Please use the following format to cite material from these proceedings:

Author(s), "Title of Paper," in *Optical Communication, Optical Fiber Sensors, and Optical Memories for Big Data Storage*, edited by Yanbiao Liao, Xiaodi Tan, Proceedings of SPIE Vol. 10158 (SPIE, Bellingham, WA, 2016) Seven-digit Article CID Number.

ISSN: 0277-786X  
ISSN: 1996-756X (electronic)

ISBN: 9781510607743  
ISBN: 9781510607750 (electronic)

Published by

**SPIE**

P.O. Box 10, Bellingham, Washington 98227-0010 USA  
Telephone +1 360 676 3290 (Pacific Time) · Fax +1 360 647 1445  
[SPIE.org](http://SPIE.org)

Copyright © 2016, Society of Photo-Optical Instrumentation Engineers.

Copying of material in this book for internal or personal use, or for the internal or personal use of specific clients, beyond the fair use provisions granted by the U.S. Copyright Law is authorized by SPIE subject to payment of copying fees. The Transactional Reporting Service base fee for this volume is \$18.00 per article (or portion thereof), which should be paid directly to the Copyright Clearance Center (CCC), 222 Rosewood Drive, Danvers, MA 01923. Payment may also be made electronically through CCC Online at [copyright.com](http://copyright.com). Other copying for republication, resale, advertising or promotion, or any form of systematic or multiple reproduction of any material in this book is prohibited except with permission in writing from the publisher. The CCC fee code is 0277-786X/16/\$18.00.

Printed in China.

Publication of record for individual papers is online in the SPIE Digital Library.

**SPIE. DIGITAL  
LIBRARY**

[SPIDigitalLibrary.org](http://SPIDigitalLibrary.org)

---

**Paper Numbering:** *Proceedings of SPIE* follow an e-First publication model. A unique citation identifier (CID) number is assigned to each article at the time of publication. Utilization of CIDs allows articles to be fully citable as soon as they are published online, and connects the same identifier to all online and print versions of the publication. SPIE uses a seven-digit CID article numbering system structured as follows:

- The first five digits correspond to the SPIE volume number.
- The last two digits indicate publication order within the volume using a Base 36 numbering system employing both numerals and letters. These two-number sets start with 00, 01, 02, 03, 04, 05, 06, 07, 08, 09, 0A, 0B ... 0Z, followed by 10-1Z, 20-2Z, etc. The CID Number appears on each page of the manuscript.

# Contents

|      |                             |
|------|-----------------------------|
| vii  | <i>Authors</i>              |
| xi   | <i>Conference Committee</i> |
| xiii | <i>Introduction</i>         |

## OPTICAL COMMUNICATION, OPTICAL FIBER SENSORS, AND OPTICAL MEMORIES FOR BIG DATA STORAGE

---

|          |  |
|----------|--|
| 10158 02 | <b>Design galvanometer position detection unit based on single detector compound axis tracking system [10158-1]</b>                                    |
| 10158 03 | <b>Slow-light effects in microfiber coil resonator [10158-2]</b>   |
| 10158 04 | <b>Laser interference effect evaluation method based on character of laser-spot and image feature [10158-5]</b>  |
| 10158 05 | <b>Continuous-variable quantum key distribution with random intensity fluctuation of the local oscillator [10158-6]</b>                                |
| 10158 06 | <b>An auto-bias control scheme for IQ-modulator with various modulation formats [10158-7]</b>  |
| 10158 07 | <b>Numerical study of CSRZ, RZ-DPSK, and ODB formats in 32 × 40 Gb/s DWDM transmission [10158-8]</b>   |
| 10158 08 | <b>Label switching and transmission of FSK-PPM signal in optical label switching [10158-10]</b>  |
| 10158 09 | <b>Ultra-broadband near perfect absorption of visible light based on one-dimensional metal-dielectric-metal grating for TM polarization [10158-11]</b> |
| 10158 0A | <b>Theoretical investigation on the effect of ASE noise for amplified fiber loop ring-down gas sensing [10158-12]</b>                                  |
| 10158 0B | <b>Design of adaptive filter amplifier in UV communication based on DSP [10158-13]</b>   |
| 10158 0C | <b>Channel cooperation for anti-occlusion visible light communication systems [10158-14]</b>   |
| 10158 0D | <b>Grapefruit photonic crystal fiber long period gratings sensor for DNT sensing application [10158-17]</b>  |
| 10158 0E | <b>Review of ultra-high density optical storage technologies for big data center [10158-20]</b>  |
| 10158 0F | <b>Propagation of elegant vortex Hermite-Gaussian beams in turbulent atmosphere [10158-21]</b>   |
| 10158 0G | <b>Low-bending loss and single-mode operation in few-mode optical fiber [10158-22]</b>   |

- 10158 OH **Design and optimization of mode converter based on long period fiber grating** [10158-23]
- 10158 OI **WiFi-based person identification** [10158-24]
- 10158 OJ **SDN-based path hopping communication against eavesdropping attack** [10158-25]
- 10158 OK **Superresolution far-field diffraction spot in the free-space laser communication system due to radially polarized beam** [10158-26]
- 10158 OL **All-optical relative intensity noise suppression method for the high precision fiber optic gyroscope** [10158-27]
- 10158 OM **Routing and spectrum assignment based on ant colony optimization of minimum consecutiveness loss in elastic optical networks** [10158-28]
- 10158 ON **Optical fiber current sensor with small size for the high voltage watt-hour meter** [10158-29]
- 10158 OO **A training-aided MIMO equalization based on matrix transformation in the space division multiplexed fiber-optic transmission system** [10158-31]
- 10158 OP **123 km  $\Phi$ -OTDR system based on bidirectional erbium-doped fiber amplifier** [10158-32]
- 10158 OQ **A fiber Bragg grating sensor system for estimating the large deflection of a lightweight flexible beam** [10158-33]
- 10158 OR **Squeezed triangular photonic crystal fiber with high birefringence and low dispersion** [10158-34]
- 10158 OS **Modeling and simulation on temperature performance in fiber optic gyroscope fiber coil of shipborne strapdown inertial navigation system** [10158-35]
- 10158 OT **Terahertz phase modulator with graphene based metasurface** [10158-36]
- 10158 OU **Pressure sensor for Weight-In-Motion measurement based on fiber loop ring-down spectroscopy** [10158-37]
- 10158 OV **Measuring outer scale in atmospheric optical turbulence from the point view of spatial correlation function** [10158-38]
- 10158 OW **A method of the synthesis of fiber bragg grating array without any damage** [10158-39]
- 10158 OX **Protocol independent transmission method in software defined optical network** [10158-40]
- 10158 OY **Theoretical and experimental on the Shupe-like bias caused by thermal stress of fiber optic gyros** [10158-41]
- 10158 OZ **Distributed vibration fiber sensing system based on Polarization Diversity Receiver** [10158-43]
- 10158 IO **Adverse effect of the Brillouin optical time-domain analysis system caused by self-phase modulation** [10158-44]

- 10158 11 **Optimum design of Cassegrain antenna for space laser communication** [10158-45]
- 10158 12 **High dynamic range microwave photonic down-conversion based on dual-parallel Mach-Zehnder modulator** [10158-46]
- 10158 13 **The rotation modulation inertial navigation system for blackout area during hypersonic reentry** [10158-47]
- 10158 14 **Multiconfiguration to improve resolution on sensor systems** [10158-48]
- 10158 15 **Adaptively optimized threshold of strong atmospheric turbulence channel in free space optical communication** [10158-49]
- 10158 16 **Research on key technology of space laser communication network** [10158-50]
- 10158 17 **Flat broadband slow light with low dispersion in one-dimensional treble photonic crystals** [10158-51]
- 10158 18 **Dispersion engineering of slow light in hexagonal ring hole photonic crystal waveguide** [10158-54]
- 10158 19 **Effect of complex optical field on the modulation instability of 100 km unrepeated fiber transmission system with DFRA** [10158-55]
- 10158 1A **Quantitative analysis and demonstration of modified triple-branch signal detection scheme for SAC-OCDMA systems** [10158-56]
- 10158 1B **Effect on FOG caused by non-uniform distribute magnetic field** [10158-57]
- 10158 1C **A refractive index insensitive PbS fiber temperature sensor based on Sagnac interferometer** [10158-59]
- 10158 1D **A few mode fiber curvature sensor based on two spherical-shape structures modal interferometer** [10158-60]
- 10158 1E **A long-term target detection approach in infrared image sequence** [10158-61]
- 10158 1F **The tension sensor of Photonic Crystal Fiber based on core-offset splicing and waist-enlarged fiber taper** [10158-62]
- 10158 1G **A novel communication mechanism based on node potential multi-path routing** [10158-63]
- 10158 1H **The architecture of blind equalizer for MIMO free space optical communication system** [10158-66]
- 10158 1I **Nanoparticle detection using fano-resonance photonic crystal on optical fiber-tip** [10158-68]
- 10158 1J **Flutter signal extracting technique based on FOG and self-adaptive sparse representation algorithm** [10158-72]

- 10158 1K **Study on embedding fiber Bragg grating sensor into the 3D printing structure for health monitoring** [10158-74]
- 10158 1L **Software defined multi-OLT passive optical network for flexible traffic allocation** [10158-75]
- 10158 1M **Toward of a highly integrated probe for improving wireless network quality** [10158-76]
- 10158 1N **Optical voltage sensors: principle, problem and research proposal** [10158-78]

## Authors

Numbers in the index correspond to the last two digits of the seven-digit citation identifier (CID) article numbering system used in Proceedings of SPIE. The first five digits reflect the volume number. Base 36 numbering is employed for the last two digits and indicates the order of articles within the volume. Numbers start with 00, 01, 02, 03, 04, 05, 06, 07, 08, 09, 0A, 0B...0Z, followed by 10-1Z, 20-2Z, etc.

Bi, Weihong, 1C, 1D, 1F  
Bu, Youjun, 0J, 1G  
Cai, Zhi-Min, 0G  
Chang, Chengwu, 16  
Chang, Li-Jun, 0H  
Chang, Shuai, 02  
Chen, Fujun, 1A  
Chen, Linsen, 09  
Chen, Ming-Yang, 0G, 0H  
Chen, Shikai, 0W  
Chen, Wei, 10  
Chen, Yiyang, 1K  
Chen, Yudan, 1B  
Cheng, Chunfu, 0A  
Cheng, Liyu, 16  
Cui, Hongliang, 0T  
Dang, Rui, 0P  
Ding, Fei, 1M  
Ding, Q. X., 14  
Du, Chunlei, 0T  
Fang, Liang, 1K  
Feng, Gang, 1A  
Fu, Guangwei, 1C, 1D, 1F  
Fu, Hai-Wei, 03  
Fu, Xinghu, 1C, 1D, 1F  
Gao, Hongyu, 0S  
Gao, Shenghua, 16  
Gao, Yinan, 02  
Gu, Rentao, 1L  
Guan, Xiaoning, 0O  
Gui, Ming, 05  
Hao, Ruan, 0E  
Hou, Xingzhe, 0N  
Hou, Yanfang, 0X  
Hu, Chao, 1E  
Hu, Yongming, 0Z, 19  
Hu, Yuan, 0K, 11  
Hu, Zhengliang, 0Z, 19  
Huang, Huiming, 16  
Huang, Ming-Qiu, 05  
Huang, Yong, 0N  
Huang, Yongmei, 1H  
Huang, Zhitong, 0C  
Ji, Yuefeng, 0C, 0X, 11, 1L  
Jia, Yupeng, 12  
Jiang, Lun, 0K, 11  
Jiang, Peng, 0Z  
Jiang, Tao, 07  
Jiang, YiMing, 1G  
Ke, Xizheng, 15  
Lei, Jian, 1J  
Lei, Sichen, 15  
Li, Changhong, 17, 18  
Li, Changsheng, 1N  
Li, Dengao, 0O  
Li, Fan, 13  
Li, Hang, 1E  
Li, Hongli, 12  
Li, Hongwei, 1H  
Li, Hui, 0X, 1L  
Li, Jin, 13  
Li, Jingke, 0D  
Li, Jingnan, 12  
Li, Junyu, 0B  
Li, Lijing, 0L  
Li, Liucun, 18  
Li, Lu-Ming, 0G  
Li, Qifeng, 1D, 1F  
Li, Ruiya, 1K  
Li, Wei, 0C  
Li, Yanjun, 1D, 1F  
Li, Ying-chao, 0K, 11  
Li, Yunpu, 1F  
Liang, Lin-Mei, 05  
Liu, Bo, 0M, 0O  
Liu, H., 14  
Liu, Hongyang, 16  
Liu, Jie, 0E  
Liu, Lu, 0P  
Liu, Qin, 1D  
Liu, Yang, 02  
Liu, Ying-Gang, 03  
Liu, Yingjun, 0M  
Liu, Yuxin, 0C  
Liu, Yuze, 0X  
Liu, Zhuang, 0K  
Lu, Jun, 1B  
Luo, Biao, 0M  
Luo, Bin, 0F  
Luo, Fengguang, 08  
Luo, Minghui, 09  
Luo, Xiaolin, 04  
Lv, Hui, 0A  
Lv, Qinghua, 0A  
Lv, Zhaoshun, 0B  
Ma, Cheng-Ju, 03  
Ma, Lin, 0S, 0Y  
Ma, Lina, 0Q, 0W  
Mao, Shaojuan, 1B  
Mei, Hai-Ping, 0V

Meng, Xiangtao, 1J  
 Meng, Zhou, 10  
 Nie, Changbin, 0T  
 Ou, Yiwen, 0A  
 Pan, Zhiwen, 1M  
 Peng, Nai, 0N  
 Peng, Te, 0Q  
 Qian, Xian-Mei, 0V  
 Qiao, Liwei, 0Y  
 Qiu, Yajun, 0X  
 Rao, Lan, 0M  
 Rao, Rui-Zhong, 0V  
 Rong, Lu, 12  
 Ruan, Chi, 0U  
 Sha, Xiaoqiang, 13  
 Shen, Su, 09  
 Song, Aiguo, 1M  
 Song, Lailiang, 0L  
 Song, Peng, 0R  
 Song, Yansong, 02  
 Tan, Dongjie, 0P  
 Tan, Yuegang, 1K  
 Tang, Bao, 0M  
 Tang, Jianfeng, 04  
 Tang, Lihua, 17  
 Tao, Chuanyi, 0D  
 Tian, Feng, 0M, 0O  
 Tian, Qinghua, 0M, 0O  
 Tian, Xiaozhong, 0P  
 Tong, Shoufeng, 02  
 Wang, Chao, 0K, 11  
 Wang, Dayong, 12  
 Wang, Fu, 0M  
 Wang, Haiming, 0P  
 Wang, Hua, 0G  
 Wang, Le, 0K  
 Wang, Qian, 0V  
 Wang, Renfan, 0O  
 Wang, Sijiang, 0T  
 Wang, Siwen, 1C, 1D  
 Wang, Xin, 1E  
 Wang, Yueze, 0S, 0Y  
 Wang, Yumeng, 18  
 Wang, Yuntao, 0U  
 Wang, Yunxin, 12  
 Wei, Dongshan, 0T  
 Wei, Jin, 0G  
 Wu, Guohua, 0F  
 Wu, Hanping, 0B  
 Wu, Limin, 0R  
 Wu, Lingxia, 04  
 Wu, Min, 18  
 Wu, Shangliang, 09  
 Wu, Wei, 0Y  
 Wu, Zhenyang, 1M  
 Xia, Liangping, 0T  
 Xiang, Qian, 0H  
 Xiang, Zheng, 1J  
 Xie, Haiyang, 1D  
 Xin, Xiangjun, 0M, 0O  
 Xu, Pan, 19  
 Yang, Daquan, 11  
 Yang, Dengcai, 12  
 Yang, Feili, 0N  
 Yang, Huayong, 0Q, 0W  
 Yang, Jiandong, 1F  
 Yang, Ji-Hai, 0G  
 Yang, Liu, 08  
 Yang, Songlin, 0U  
 Yang, Yangyang, 0Q, 19  
 Ye, Yan, 09  
 Yi, Mengjie, 17  
 Yin, Jianling, 1B  
 Yin, Ping, 0G  
 You, Xiaohu, 1M  
 Yu, Hao, 0S  
 Yu, Pingping, 17  
 Yuan, Jing, 0I  
 Yuan, Wei, 1I  
 Yuan, Xueguang, 06  
 Yuan, Yujie, 0S  
 Zeng, Yan, 0A  
 Zhang, Chuanhao, 0J, 1G  
 Zhang, Chunxi, 0L  
 Zhang, Jiangpeng, 1C  
 Zhang, Jiawei, 1L  
 Zhang, Jinye, 0A  
 Zhang, Junan, 0Z  
 Zhang, Kefei, 07  
 Zhang, Lijia, 0M, 0O  
 Zhang, Qi, 0M, 0O, 1E  
 Zhang, Qiwen, 15  
 Zhang, Shizong, 1L  
 Zhang, Shunyang, 1D  
 Zhang, Siwei, 1A  
 Zhang, Wenjie, 0W  
 Zhang, Wenqi, 06  
 Zhang, Xin, 0T  
 Zhang, Yang'an, 06  
 Zhang, Yuhui, 0L  
 Zhang, Zhen, 1G  
 Zhao, Jianhui, 13  
 Zhao, Jingjing, 0Y  
 Zhao, Jumin, 0O  
 Zhao, Kewei, 02  
 Zhao, Zheng, 0J  
 Zheng, Yue, 0L  
 Zhong, Xin, 12  
 Zhou, L. W., 14  
 Zhou, Tao, 12  
 Zhou, Yun, 09  
 Zhou, Yuqing, 10  
 Zhou, Zude, 1K  
 Zhu, Jinrong, 0A  
 Zhu, Tenglong, 0D  
 Zhu, Xuanxuan, 0F  
 Zhu, Yuan-Feng, 0G



# Conference Committee

## *Conference Chairs*

**Yanbiao Liao**, Tsinghua University (China)  
**Xiaodi Tan**, Beijing Institute of Technology (China)

## *Conference Co-Chairs*

**Desheng Jiang**, Wuhan University of Technology (China)  
**Weixu Zhang**, BeiHang University (China)  
**Wei Wang**, Beijing Institute of Aerospace Control Device (China)  
**Min Gu**, Royal Melbourne Institute of Technology (Australia)  
**Xiangping Li**, Jinan University (China)

## *Conference Committee*

**Zhiqian Bao**, State Grid Xuji Group Corporation (China)  
**Wei Jin**, The Hong Kong Polytechnic University (Hong Kong, China)  
**Libo Yuan**, Harbin Engineering University (China)  
**Zuyuan He**, Shanghai Jiao Tong University (China)  
**Changsheng Xie**, Huazhong University (China)  
**Din Ping Tsai**, National Taiwan University (Taiwan)  
**Hao Ruan**, Shanghai Institute of Optics and Fine Mechanics (China)  
**Kazuo Kuroda**, Center for Optical Research and Education,  
Utsunomiya University (Japan)  
**Liangcai Cao**, Tsinghua University (China)  
**Min Zhu**, Netzon (China)

## *Program Committee*

**Yuanhong Yang**, BeiHang University (China)  
**Tongyu Liu**, Shandong Laser Institute (China)  
**Hao Zhao**, Shanghai Bohui Technologies Inc. (China)  
**Yulin Li**, Wuhan Jing Yu Light Sensing System Research Institute  
Company, Ltd. (China)  
**Songhe Yin**, Hualu Company (China)  
**Ryushi Fujimura**, Utsunomiya University (Japan)  
**Tsutomu Shimura**, The University of Tokyo (Japan)  
**Yoshimasa Kawata**, Shizuoka University (Japan)  
**Yuzuru Takashima**, The University of Arizona (United States)



## Introduction

We had the great honor of organizing the International Symposium on Optical Communication and Optical Fiber Sensors and the International Symposium on Optical Memories for Big Data Storage. It was truly a great pleasure for us to greet more than 1,000 participants from many different countries attending the symposia. We firmly believe the symposia will become important international event in the field of optical technology.

The International Symposium on Optical Communication and Optical Fiber Sensors and the International Symposium on Optical Memories for Big Data Storage were sponsored by Chinese Society for Optical Engineering and China High-tech Industrialization Association (CHIA); organized by the Chinese Society for Optical Engineering (CSOE), the Photo-electronic Technology Committee, the Chinese Society of Astronautics, the Photo-electronic Industrialization Committee, CHIA, and the Department of Cooperation and Coordination for Industry, Academia and Research, CHIA.

The purpose of the symposia was to provide a forum for the participants to report and review the innovative ideas and up-to-date progress and developments, discuss novel approaches to application in the optical field. It was sincerely hoped that the research and development in optical field would get promoted, and the international cooperation sharing the common interest would get enhanced.

On behalf of the other co-chairmen and the Organizing Committee of the conference, we would like to heartily thank for our sponsors and cooperating organizers for all they have done for the symposia. Thanks also to all the authors for their contributions to the Proceedings, to all of the participants and friends for their interest and efforts in helping us to make the symposia possible, to the Program Committee for their effective work and valuable advice— especially the Secretariat— and the editors at SPIE for their tireless effort and outstanding services in preparing the symposia and publishing the Proceedings.

**Yanbiao Liao**  
**Xiaodi Tan**

