PROCEEDINGS OF SPIE

Next-Generation Optical Communication: Components, Sub-Systems, and Systems VI

Guifang Li Xiang Zhou Editors

31 January–2 February 2017 San Francisco, California, United States

Sponsored by SPIE

Cosponsored by
Corning Incorporated (United States)
NTT Electronics Corporation (Japan)

Published by SPIE

Volume 10130

Proceedings of SPIE 0277-786X, V. 10130

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

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 SPIEDigitalLibrary.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 Next-Generation Optical Communication: Components, Sub-Systems, and Systems VI, edited by Guifang Li, Xiang Zhou, Proceedings of SPIE Vol. 10130 (SPIE, Bellingham, WA, 2017) Seven-digit Article CID Number.

ISSN: 0277-786X

ISSN: 1996-786X (electronic)

ISBN: 9781510607019

ISBN: 9781510607026 (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

Copyright © 2017, 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. 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/17/\$18.00.

Printed in the United States of America.

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



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

v vii	Authors Conference Committee
	SPECIAL WORKSHOP ON ADVANCED OPTICAL FIBERS AND AMPLIFIERS FOR SDM AND DATA CENTERS: JOINT SESSION WITH CONFERENCES 10129, 10130, AND 10131
10130 03	Coupled multicore fiber for space-division multiplexed transmission (Invited Paper) [10130-2]
10130 04	Recent progress in SDM amplifiers (Invited Paper) [10130-3]
10130 05	Integrated optical fiber amplifiers for space-division multiplexed systems (Invited Paper) [10130-4]
	SILICON PHOTONICS AND ALTERNATIVE TECHNOLOGIES FOR DATA CENTERS AND SHORT HAULS: JOINT SESSION WITH CONFERENCES 10128, 10129, 10130, AND 10131
10130 06	Novel paradigm for integrated photonics circuits: transient interconnection network [10130-5]
	SDM COMPONENTS, SYSTEMS, AND NETWORKS
10130 07	Multicore fiber transmission over transoceanic distances (Invited Paper) [10130-6]
10130 08	Mode-converter and multiplexer based on SOI technology for few-mode fiber at 1550 nm [10130-7]
10130 09	All-fiber mode selective couplers for mode-division-multiplexed optical transmission (Invited Paper) [10130-8]
10130 0A	Mode-division-multiplexing passive optical network with low-modal crosstalk (Invited Paper) [10130-9]
10130 OB	Strategies and resources of mode-division-multiplexed optical fibre transmission based on LP and orbital angular momentum modes (Invited Paper) [10130-10]
10130 OC	Overcoming the capacity crunch: ITU-T G.657.B3 compatible 7-core and 19-core hole-assisted fibers [10130-11]

ADVANCED MODULATION, DETECTION, AND DSP I

10130 0D	Scalable modulation technology and the tradeoff of reach, spectral efficiency, and complexity (Invited Paper) [10130-12]
10130 OE	Multidimensional modulation for next-generation transmission systems (Invited Paper) [10130-13]
10130 OF	Characterization of coherent receiver using polarization-multiplexed source generated from coherent transmitter [10130-14]
10130 0G	Stokes-vector direct detection for optical communications (Invited Paper) [10130-15]
10130 OH	Rigorous study of low-complexity adaptive space-time block-coded MIMO receivers in high-speed mode multiplexed fiber-optic transmission links using few-mode fibers (Best Student Paper Award) [10130-16]
	ADVANCED MODULATION, DETECTION, AND DSP II
10130 OK	Evaluation of correlated digital back propagation and extended Kalman filtering for non-linear mitigation in PM-16-QAM WDM systems (Best Student Paper Award) [10130-19]
10130 OL	Capacity-approaching transmission based on GMI-optimized modulation formats (Invited Paper) [10130-20]
10130 OM	Detection and compensation of power imbalances for DP-QAM transmitter using reconfigurable interference [10130-21]
	ADVANCED DEVICES AND OPTICAL SIGNAL PROCESSING
10130 ON	High-speed digital-to-analog converter concepts (Invited Paper) [10130-22]
10130 00	Toward a low-cost, low-power, low-complexity DAC-based multilevel (M-ary QAM) coherent transmitter using compact linear optical field modulator (Invited Paper) [10130-23]
10130 OP	A spectrally-efficient linear polarization coding scheme for fiber nonlinearity compensation in CO-OFDM systems [10130-24]
10130 0Q	Design of XOR/AND gate using 2D photonic crystal principle [10130-25]
	POSTER SESSION
10130 OT	High precision cross-correlated imaging in few-mode fibers [10130-28]

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.

Alam, Shaif-ul, 04
Alonzo, Massimo, 06
Amari, A., 0P
Anderson, Jon, 0F, 0M
Bastiani, Lorenzo, 06
Belardini, Alessandro, 06
Bienkowska, B., 0C
Bosco, Gabriella, 0D
Budnicki, D., 0C
Carena, Andrea, 0D
Chang, D., 0P
Chang, Sun Hyok, 09
Chauvet, Mathieu, 06
Che, Di, 0G

Chen, Haoshuo, 05 Corral, Juan L., 08 Dingel, Benjamin, 00 Dobre, O. A., 0P Essiambre, Ren-Jean, 05 Fazio, Eugenio, 06 Filipowicz, M., 0C Fontaine, Nicolas K., 05

Freund, Ronald, 0N

Garcia-Rodriguez, David, 08

Griol, Amadeu, 08 Guiomar, Fernando, 0D Hayashi, Tetsuya, 03 He, Xuan, 0H Holdynski, Z., OC Hu, Ziyang, OB Huang, Bin, 05 Jain, Saurabh, 04 Jin, Cang, 05 Jung, Yongmin, 04 Jungnickel, Volker, 0N Kang, Qiongyue, 04 Khodakarami, Hamid, 0G Kim, Kwanajoon, 09 Koike-Akino, Toshiaki, 0E Kojima, Keisuke, 0E Kolakowska, A., 0C Kottke, Christoph, 0N

Lægsgaard, Jesper, 0T LaRochelle, Sophie, 05 Lee, Joon Ki, 09

Kristensen, Torben, OT

Kumar, Santosh, 0Q

Li, An, 0G

Kunicki, D., 0C

Li, Juhao, 0A Liu, Jie, 0B

Llorente, Roberto, 08 Makara, M., 0C Mergo, P., 0C

Messaddeq, Youns, 05
Millar, David S., 0E
Muliar, Olena, 0T
Murawski, M., 0C
Napierala, M., 0C
Nasilowski, T., 0C
Omomukuyo, O., 0P
Ostrowski, L., 0C
Pakala, Lalitha, 0K
Pan, Zhongqi, 0H
Parsons, Kieran, 0E
Pilori, Dario, 0D
Poggiolini, Pierluigi, 0D
Poturaj, K., 0C

Pytel, A., OC Richardson, David J., 04 Rottwitt, Karsten, 0T Ryf, Roland, 05 Salsi, Massimiliano, 0F Schmauss, Bernhard, 0K Schmidt, Christian, 0N Sharma, Sandeep, 0Q Shieh, William, 0G Singh, Lokendra, 0Q Soci, Cesare, 06 Sunish Kumar, O. S., 0P Swarnakar, Sandip, 0Q

Szostkiewicz, L., 0C Szymanski, M., 0C

Tanggaard Alkeskjold, Thomas, 0T

Tenderenda, T., 0C Turukhin, Alexey, 07

Usuga Castaneda, Mario A., 0T

Venkatesan, R., 0P Vovan, Andre, 0F, 0M Wang, Junyi, 0H Wang, Qiang, 0F, 0M Wang, Xuyang, 0B Weng, Yi, 0H Wilson, S. K., 0P Wojcik, G., 0C Yu, Siyuan, 0B

Yuan, Feng, 0G Yue, Yang, 0F, 0M Zhang, Bo, OF, OM Zhang, Shaoliang, OL Zheludev, Nikolay I., 06 Zhu, Jiangbo, OB Ziolowicz, A., OC

Conference Committee

Symposium Chairs

Jean-Emmanuel Broquin, IMEP-LAHC (France) **Shibin Jiang**, AdValue Photonics, Inc. (United States)

Symposium Co-chairs

Connie J. Chang-Hasnain, University of California, Berkeley (United States)

Graham T. Reed, Optoelectronics Research Centre, University of Southampton (United Kingdom)

Program Track Chair

Benjamin B. Dingel, Nasfine Photonics, Inc. (United States)

Conference Chairs

Guifang Li, CREOL, The College of Optics and Photonics, University of Central Florida (United States)Xiang Zhou, Google (United States)

Conference Program Committee

Kazi S. Abedin, OFS Fitel LLC (United States)

Jin-Xing Cai, TE SubCom (United States)

Hwan Seok Chung, Electronics and Telecommunications Research Institute (Korea, Republic of)

Gabriella Cincotti, Università degli Studi di Roma Tre (Italy)

Benjamin B. Dingel, Nasfine Photonics, Inc. (United States)

John D. Downie, Corning Incorporated (United States)

Ronald Freund, Fraunhofer-Institut für Nachrichtentechnik Heinrich-Hertz-Institut (Germany)

Ezra Ip, NEC Laboratories America, Inc. (United States)

Inuk Kang, Alcatel-Lucent Bell Laboratories (United States)

Takahiro Kodama, Mitsubishi Electric Corporation (Japan)

Tsuyoshi Konishi, Osaka University (Japan)

Chao Lu, The Hong Kong Polytechnic University (Hong Kong, China)

Akihiro Maruta, Osaka University (Japan)

Zhongqi Pan, University of Louisiana at Lafayette (United States)

Jayanta K. Sahu, University of Southampton (United Kingdom)

Kunimasa Saitoh, Hokkaido University (Japan)

Junqiang Sun, Huazhong University of Science and Technology (China) and Wuhan National Laboratory for Optoelectronics (China)

Xinliang Zhang, Wuhan National Laboratory for Optoelectronics (China)

Yanjun Zhu, Huawei Technologies Company, Ltd. (United States)

Session Chairs

Optical Communications Plenary Session: Joint Session with Conferences 10128, 10129, 10130, and 10131

Benjamin B. Dingel, Nasfine Photonics, Inc. (United States)

Xiang Zhou, Google (United States)

Special Workshop on Optical Wireless and Integrated Photonics Technologies for Data Centers: Joint Session with Conferences 10128 and 10131

Atul K. Srivastava, NEL America, Inc. (United States)
Guifang Li, CREOL, The College of Optics and Photonics, University of Central Florida (United States)

Special Workshop on Advanced Optical Fibers and Amplifiers for SDM and Data Centers: Joint Session with Conferences 10129, 10130, and 10131

Guifang Li, CREOL, The College of Optics and Photonics, University of Central Florida (United States)

Atul K. Srivastava, NEL America, Inc. (United States)

4 Silicon Photonics and Alternative Technologies for Data Centers and Short Hauls: Joint Session with Conferences 10128, 10129, 10130, and 10131

Youichi Akasaka, Fujitsu Network Communications Inc. (United States)

Benjamin B. Dingel, Nasfine Photonics, Inc. (United States)

5 SDM Components, Systems, and Networks

Sun Hyok Chang, Electronics and Telecommunications Research Institute (Korea, Republic of)

Xiang Zhou, Google (United States)

6 Advanced Modulation, Detection, and DSP I

Osamu Ishida, Nippon Telegraph and Telephone Corporation (Japan)

Xiang Zhou, Google (United States)

- Advanced Modulation, Detection, and DSP II
 Guifang Li, CREOL, The College of Optics and Photonics, University of Central Florida (United States)
 David Millar, Mitsubishi Electric Research Laboratories (United States)
- 8 Advanced Devices and Optical Signal Processing Guifang Li, CREOL, The College of Optics and Photonics, University of Central Florida (United States) Juhao Li, Peking University (China)