

PROCEEDINGS OF SPIE

# ***Optical Metro Networks and Short-Haul Systems VII***

**Atul K. Srivastava  
Benjamin B. Dingel  
Achyut K. Dutta**  
*Editors*

**10–12 February 2015  
San Francisco, California, United States**

*Sponsored and Published by*  
SPIE

**Volume 9388**

Proceedings of SPIE 0277-786X, V. 9388

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

Optical Metro Networks and Short-Haul Systems VII, edited by Atul K. Srivastava, Benjamin B. Dingel, Achyut K. Dutta,  
Proc. of SPIE Vol. 9388, 938801 · © 2015 SPIE · CCC code: 0277-786X/15/\$18 · doi: 10.1117/12.2185475

Proc. of SPIE Vol. 9388 938801-1

The papers included 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. The papers published in these proceedings 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 this book:

Author(s), "Title of Paper," in *Optical Metro Networks and Short-Haul Systems VII*, edited by Atul K. Srivastava, Benjamin B. Dingel, Achyut K. Dutta, Proceedings of SPIE Vol. 9388 (SPIE, Bellingham, WA, 2015) Article CID Number.

ISSN: 0277-786X

ISBN: 9781628414783

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 © 2015, 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/15/\$18.00.

Printed in the United States of America.

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, with papers published first online and then in print. Papers are published as they are submitted and meet publication criteria. A unique citation identifier (CID) number is assigned to each article at the time of the first 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, print, and electronic versions of the publication. SPIE uses a six-digit CID article numbering system in which:

- The first four 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. The complete citation is used on the first page, and an abbreviated version on subsequent pages.

# Contents

v	<i>Authors</i>
vii	<i>Conference Committee</i>

---

## MULTIDIMENSIONAL MULTIPLEXING TECHNOLOGIES FOR ADVANCED OPTICAL NETWORKS: JOINT SESSION WITH CONFERENCES 9388 AND 9389

---

- 9388 02 **MIMO signal processing in mode-division multiplexing systems (Invited Paper)** [9388-1]
- 9388 03 **Adaptive multidimensional modulation and multiplexing for next generation optical networks (Invited Paper)** [9388-2]

---

## NOVEL COMPONENTS FOR SHORT-REACH NETWORKS

---

- 9388 04 **Coherent receiver architectures for secure key distribution using faint optical multilevel signals (Invited Paper)** [9388-3]
- 9388 05 **Sliceable transponders for metro-access transmission links (Invited Paper)** [9388-4]
- 9388 06 **Comprehensive photonics-electronics convergent simulation and its application to high-speed electronic circuit integration on a Si/Ge photonic chip (Invited Paper)** [9388-5]
- 9388 07 **Wavelength-tunable filter utilizing non-cyclic arrayed waveguide grating to create colorless, directionless, contentionless ROADMs** [9388-6]

---

## ADVANCED SIGNAL PROCESSING TECHNIQUES

---

- 9388 08 **All-optical implementation of signal processing functions (Invited Paper)** [9388-7]
- 9388 09 **Laser characterization with advanced digital signal processing** [9388-8]
- 9388 0A **Digital signal processing approaches for semiconductor phase noise tolerant coherent transmission systems (Invited Paper)** [9388-9]

---

## ADVANCED AND EFFICIENT TRANSMISSION AND SIGNAL MONITORING TECHNIQUES

---

- 9388 0D **20-Gb/s QPSK transmission over 10-km-long holey fiber using a wavelength tunable quantum dot light source in O-band** [9388-12]
- 9388 0E **Optical performance monitoring for dynamic and flexible photonic networks (Invited Paper)** [9388-13]

- 9388 OF **Optimized signal constellations for ultra-high-speed optical transport (Invited Paper)**  
[9388-14]
- 9388 OG **Investigation of fiber dispersion impairment in 400GbE discrete multi-tone system for reach enhancement up to 40 km** [9388-15]
- 9388 OH **Realization of real-time 100G 16QAM OFDM signal detection (Invited Paper)** [9388-16]

---

#### SDN AND ENERGY EFFICIENT FUTURE SHORT REACH NETWORKS

---

- 9388 OI **Design of a stateless low-latency router architecture for green software-defined networking (Invited Paper)** [9388-17]
- 9388 OJ **Energy-efficient  $p^m$ -ary signaling for ultra-high-speed optical transport (Invited Paper)**  
[9388-18]

---

#### POSTER SESSION

---

- 9388 ON **Optical-electrical hybrid signal equalizer for ultra-high-speed transmission** [9388-22]
- 9388 OO **A novel optical path routing network that combines coarse granularity optical multicast with fine granularity add/drop and block** [9388-23]
- 9388 OP **FPGA implementation of high-performance QC-LDPC decoder for optical communications**  
[9388-24]
- 9388 OQ **High-performance broadband photodetector and its array for optical communication**  
[9388-25]
- 9388 OR **RFoG deployment into the next-generation networks** [9388-26]

## Authors

Numbers in the index correspond to the last two digits of the six-digit citation identifier (CID) article numbering system used in Proceedings of SPIE. The first four 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.

Akasaka, Youichi, 0E  
Aoki, Yasuhiko, 0E  
Arik, Sercan Ö., 02  
Askarov, Daulet, 02  
Bregman, Jeremy, 0Q  
Chen, Hao, 0G  
Chitgarha, M. R., 08  
Cvijetic, Milorad, 03  
Djordjevic, Ivan B., 0F, 0J, 0P  
Dutta, Achyut K., 0Q  
Ewald Eller, Ana C., 0I  
Fukuda, Hiroshi, 06  
Hajek, Lukas, 0R  
Hasegawa, Hiroshi, 07, 0O  
Herschel, Reinhold, 04  
Hiraki, Tatsuro, 06  
Hlavinka, Tomas, 0R  
Honda, Kentaro, 06  
Iglesias Olmedo, Miguel, 0A  
Jacobsen, Gunnar, 0A  
Kahn, Joseph M., 02  
Kai, Yutaka, 0G  
Kanno, Atsushi, 0D, 0N  
Kawanishi, Tetsuya, 0D, 0N  
Kleis, Sebastian, 04  
Kou, Rai, 06  
Koudelka, Petr, 0R  
Latal, Jan, 0R  
Li, Fan, 0H  
Liu, Tao, 0F, 0J  
Madsen, P., 05  
Manolova Fagertun, Anna, 0I  
Martinello, Magnos, 0I  
Maruyama, Shinya, 0N  
Mohajerin-Araei, A., 08  
Mori, Yojiro, 07, 0O  
Murano, Akihiro, 0D  
Nagi, Richie, 0Q  
Nishi, Hidetaka, 06  
Nishihara, Masato, 0G  
Niwa, Masaki, 07  
Nosaka, Hideyuki, 06  
Oda, Shoichiro, 0E  
Oduor, Patrick, 0Q  
Okabe, Ryo, 0G  
Okazaki, Kota, 06  
Olah, Robert, 0Q  
Pang, Xiaodan, 0A  
Piels, Molly, 09  
Poboril, Radek, 0R  
Popov, Sergei, 0A  
Ramos, Ramon M., 0I  
Rasmussen, Jens C., 0E, 0G  
Ribeiro, Moisés R. N., 0I  
Saldaña Cercós, Silvia, 0I  
Sato, Ken-ichi, 07, 0O  
Schaeffer, Christian G., 04  
Schatz, Richard, 0A  
Sekiya, Motoyoshi, 0E  
Siska, Petr, 0R  
Soares, Mauro M., 0O  
Sotobayashi, Hideyuki, 0D, 0N  
Spolitis, S., 05  
Tafur Monroy, Idelfonso, 05, 09, 0A, 0I  
Takahara, Tomoo, 0G  
Takashina, Shoichi, 07  
Takeda, Kotaro, 06  
Takeya, Tsutomu, 06  
Tanaka, Toshiki, 0G  
Tao, Zhenning, 0G  
Tomishige, Kazunari, 0N  
Tsuchizawa, Tai, 06  
Usui, Mitsuo, 06  
Vassilieva, Olga, 0E  
Vegas Olmos, J. J., 05  
Vitasek, Jan, 0R  
Wagner, C., 05  
Wang, Ting, 0F  
Watanabe, Toshio, 07  
Willner, Alan E., 08  
Xiao, Xin, 0H  
Yagi, Fumiya, 0D  
Yamada, Koji, 06  
Yamamoto, Naokatsu, 0D  
Yamamoto, Tsuyoshi, 06  
Yaman, Fatih, 0F  
Yamauchi, Tomohiro, 0E  
Yan, Weizhen, 0G  
Yang, Jeng-Yuan, 0E  
Yu, Jianjun, 0H  
Zhang, Shaoliang, 0F  
Zhang, Yequn, 0F  
Zibar, Darko, 09, 0A  
Ziyadi, M., 08  
Zou, Ding, 0P



# Conference Committee

## *Symposium Chairs*

**David L. Andrews**, University of East Anglia (United Kingdom)  
**Alexei L. Glebov**, OptiGrate Corporation (United States)

## *Symposium Co-chairs*

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

## *Program Track Chair*

**Benjamin B. Dingel**, Nasfina Photonics, Inc. (United States)

## *Conference Chairs*

**Atul K. Srivastava**, NEL America, Inc. (United States)  
**Benjamin B. Dingel**, Nasfina Photonics, Inc. (United States)  
**Achyut K. Dutta**, Banpil Photonics, Inc. (United States)

## *Conference Program Committee*

**Youichi Akasaka**, Fujitsu Network Communications Inc.  
(United States)  
**Júlio César R. F. de Oliveira**, CpqD (Brazil)  
**Ivan B. Djordjevic**, The University of Arizona (United States)  
**Ronald Freund**, Fraunhofer-Institut für Nachrichtentechnik  
Heinrich-Hertz-Institut (Germany)  
**Kiyo Ishii**, National Institute of Advanced Industrial Science and  
Technology (Japan)  
**Franko Küppers**, Technische Universität Darmstadt (Germany)  
**Bishnu P. Pal**, Indian Institute of Technology Delhi (India)  
**Takashi Saida**, NTT Photonics Laboratories (Japan)  
**Krishna Swaminathan**, Intel Corporation (United States)  
**Idelfonso Tafur Monroy**, Technical University of Denmark (Denmark)  
**Toshiki Tanaka**, Fujitsu Laboratories, Ltd. (Japan)  
**Jianjun Yu**, ZTE USA (United States)

### Session Chairs

- 1 Optical Communication Plenary Session: Joint Session with Conferences 9387, 9389, and 9390  
**Guifang Li**, CREOL, The College of Optics and Photonics, University of Central Florida (United States)  
**Benjamin B. Dingel**, Nasfine Photonics, Inc. (United States)
- 2 Multidimensional Multiplexing Technologies for Advanced Optical Networks: Joint Session with Conferences 9388 and 9389  
**Atul K. Srivastava**, NEL America, Inc. (United States)  
**Guifang Li**, CREOL, The College of Optics and Photonics, University of Central Florida (United States)
- 3 Workshop on High-Speed Transport in Datacenters  
**Akimasa Kaneko**, NEL America, Inc. (United States)  
**Atul K. Srivastava**, NEL America, Inc. (United States)
- 4 Optical Wireless and Advanced Fiber Technologies for Data Center and Access Network: Joint Session with Conferences 9387 and 9390  
**Benjamin B. Dingel**, Nasfine Photonics, Inc. (United States)  
**Atul K. Srivastava**, NEL America, Inc. (United States)
- 5 Novel Components for Short-Reach Networks  
**Youichi Akasaka**, Fujitsu Network Communications Inc. (United States)  
**Jianjun Yu**, ZTE USA (United States)
- 6 Advanced Signal Processing Techniques  
**Kiyo Ishii**, National Institute of Advanced Industrial Science and Technology (Japan)  
**Ivan B. Djordjevic**, The University of Arizona (United States)
- 7 Advanced and Efficient Transmission and Signal Monitoring Techniques  
**Idelfonso Tafur Monroy**, DTU Fotonik (Denmark)  
**Julio C. R. F. de Oliveira**, CpqD (Brazil)
- 8 SDN and Energy Efficient Future Short Reach Networks  
**Takashi Saida**, NTT Photonics Laboratories (Japan)  
**Krishna Swaminathan**, Intel Corporation (United States)