

PROCEEDINGS OF SPIE

Optical Metro Networks and Short-Haul Systems VI

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

**4–6 February 2014
San Francisco, California, United States**

Sponsored and Published by
SPIE

Volume 9008

Proceedings of SPIE 0277-786X, V. 9008

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

Optical Metro Networks and Short-Haul Systems VI, edited by Werner Weiershausen, Benjamin B. Dingel,
Achyut K. Dutta, Atul K. Srivastava, Proc. of SPIE Vol. 9008, 900801 · © 2014 SPIE
CCC code: 0277-786X/14/\$18 · doi: 10.1117/12.2057470

Proc. of SPIE Vol. 9008 900801-1

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 VI*, edited by Werner Weiershausen, Benjamin B. Dingel, Achyut K. Dutta, Atul K. Srivastava, Proceedings of SPIE Vol. 9008 (SPIE, Bellingham, WA, 2014) Article CID Number.

ISSN: 0277-786X

ISBN: 9780819499219

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 © 2014, 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/14/\$18.00.

Printed in the United States of America.

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



SPIDigitalLibrary.org

Paper Numbering: Proceedings of SPIE follow an e-First publication model, with papers published first online and then in print and on CD-ROM. Papers are published as they are submitted and meet publication criteria. A unique, consistent, permanent 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. Numbers in the index correspond to the last two digits of the six-digit CID Number.

Contents

vii *Conference Committee*

SESSION 1 OPTICAL COMMUNICATION PLENARY SESSION: JOINT SESSION WITH CONFERENCES 9007 AND 9010

9008 02 **Photonic networks that exploit digital coherent technologies (Invited Paper)** [9008-1]
Y. Mori, K. Sato, Nagoya Univ. (Japan)

SESSION 2 TOWARD 100G/400G FLEXIBLE SYSTEMS FOR ADVANCED ACCESS AND DATA CENTER NETWORKS: JOINT SESSION WITH CONFERENCES 9007, 9009, AND 9010

9008 03 **Universal transmitter for wireless and optical access converged networks (Invited Paper)** [9008-2]
Q. T. Le, F. Küppers, Technische Univ. Darmstadt (Germany)

9008 04 **Comparison of discrete multi-tone and pulse amplitude modulation for beyond 100 Gbps short-reach application** [9008-3]
M. Nishihara, Fujitsu Ltd. (Japan); Y. Kai, Fujitsu Labs., Ltd. (Japan); T. Tanaka, T. Takahara, Fujitsu Ltd. (Japan); L. Li, W. Yan, B. Liu, Z. Tao, Fujitsu Research and Development Ctr. Co., Ltd. (China); J. C. Rasmussen, Fujitsu Ltd. (Japan)

SESSION 3 NEXT-GENERATION INTEGRATED PHOTONICS DEVICES: JOINT SESSION WITH CONFERENCES 9007, 9009, AND 9010

9008 05 **Compact optical devices for high-speed digital coherent link (Invited Paper)** [9008-4]
S. Kamei, NTT Photonics Labs. (Japan)

SESSION 4 OPTICAL INTERCONNECTS AND DEVICES FOR SHORT-REACH NETWORKS: JOINT SESSION WITH CONFERENCE 9010

9008 06 **Analysis and characterization of semiconductor optical amplifiers for application in photonic switching networks** [9008-5]
F. Rudge Barbosa, D. Maia, E. Moschim, Univ. Estadual de Campinas (Brazil)

SESSION 5 ADVANCED COMPONENTS FOR SHORT-HAUL SYSTEMS: JOINT SESSION WITH CONFERENCE 9010

9008 07 **Tunable 1550nm VCSELs using high-contrast grating for next-generation networks (Invited Paper)** [9008-6]
C. Chase, Y. Rao, M. Huang, Bandwidth10 (United States); C. Chang-Hasnain, Bandwidth10 (United States) and Univ. of California, Berkeley (United States)

SESSION 6 PHOTONIC SWITCHING, ROUTING, AND WDM DEVICES: JOINT SESSION WITH CONFERENCE 9010

- 9008 08 **A hybrid optical switch architecture to integrate IP into optical networks to provide flexible and intelligent bandwidth on demand for cloud computing** [9008-7]
W. Yang, T. J. Hall, Univ. of Ottawa (Canada)
- 9008 09 **A design for an internet router with a digital optical data plane (Invited Paper)** [9008-8]
J. Touch, The Univ. of Southern California (United States); J. Bannister, The Aerospace Corp. (United States); S. Suryaputra, A. E. Willner, The Univ. of Southern California (United States)

SESSION 7 MODULATION FORMATS AND HIGH-EFFICIENCY TRANSMISSION I

- 9008 0A **High-performance transmission in analog photonic links (Invited Paper)** [9008-9]
Z. Chen, L. Yan, H. Jiang, J. Ye, W. Pan, B. Luo, X. Zou, Southwest Jiaotong Univ. (China)
- 9008 0B **Green photonics realized by optical complex systems** [9008-10]
H. Nanri, W. Sasaki, Doshisha Univ. (Japan)
- 9008 0C **Latency causes and reduction in optical metro networks (Invited Paper)** [9008-11]
V. Bobrovs, S. Spolitis, G. Ivanovs, Riga Technical Univ. (Latvia)
- 9008 0D **Optimization in spectrum-sliced optical networks (Invited Paper)** [9008-12]
K. Day Rosario Assis, A. Ferreira dos Santos, Univ. Federal da Bahia (Brazil); R. C. Almeida Jr., Univ. Federal de Pernambuco (Brazil)
- 9008 0E **Distributed optical multiplexing with precise frequency allocation using fiber frequency conversion (Invited Paper)** [9008-13]
T. Kato, R. Okabe, S. Watanabe, Fujitsu Labs., Ltd. (Japan)

SESSION 8 MODULATION FORMATS AND HIGH-EFFICIENCY TRANSMISSION II

- 9008 0F **Multidimensional SPC-based bit-interleaved coded-modulation for spectrally-efficient optical transmission systems (Invited Paper)** [9008-14]
H. G. Batshon, H. Zhang, TE SubCom (United States)
- 9008 0G **Digital signal processing for high spectral efficiency optical networks (Invited Paper)** [9008-15]
J. Zhang, Fudan Univ. (China) and ZTE USA (United States); J. Yu, ZTE USA (United States); N. Chi, Fudan Univ. (China)
- 9008 0H **Blocking analysis of dynamic routing, wavelength assignment, and spectrum allocation in flexible grid WDM networks** [9008-16]
A. N. Patel, P. N. Ji, NEC Labs. America, Inc. (United States); J. S. Patel, J. P. Jue, The Univ. of Texas at Dallas (United States); T. Wang, NEC Labs. America, Inc. (United States)

- 9008 0I **Toward ultra-broadband elastic optical networks: reconfigurable quasi-Nyquist transmitter for metro- and long-haul scenarios (Invited Paper)** [9008-17]
N. Guerrero Gonzalez, C. Franciscangelis, L. H. H. de Carvalho, E. P. da Silva, J. C. M. Diniz, J. C. R. F. de Oliveira, CPqD (Brazil)

SESSION 9 SHORT-REACH METRO AND ACCESS NETWORKS AND RELATED COMPONENTS I

- 9008 0K **Parametric spectro-temporal analyzer (PASTA) for ultrafast optical performance monitoring (Invited Paper)** [9008-19]
C. Zhang, K. K. Y. Wong, The Univ. of Hong Kong (China)
- 9008 0L **Flat amplification over C-band by quasi phase-matched fiber optical parametric amplifier using pump-phase shifters (Invited Paper)** [9008-20]
S. Takasaka, Furukawa Electric Co., Ltd. (Japan)
- 9008 0M **Optical beat interference noise reduction in OFDMA optical access link using self-homodyne balanced detection** [9008-21]
S.-M. Jung, Y.-Y. Won, S.-K. Han, Yonsei Univ. (Korea, Republic of)

SESSION 10 SHORT-REACH METRO AND ACCESS NETWORKS AND RELATED COMPONENTS II

- 9008 0O **Optical OFDM transmission for long-haul, metro/access, and data center applications (Invited Paper)** [9008-23]
A. Srivastava, Indian Institute of Technology Mandi (India)
- 9008 0P **Fibre-to-the-telescope: MeerKAT, the South African precursor to square kilometre telescope array (SKA) (Invited Paper)** [9008-24]
T. B. Gibbon, E. K. Rotich, H. Y. S. Kourouma, R. R. G. Gamatham, A. W. R. Leitch, Nelson Mandela Metropolitan Univ. (South Africa); R. Siebrits, R. Julie, S. Malan, W. Rust, F. Kapp, T. L. Venkatasubramani, B. Wallace, A. Peens-Hough, P. Herselman, Square Kilometre Array (South Africa)

Author Index

Conference Committee

Symposium Chairs

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

Symposium Cochairs

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

Program Track Chair

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

Conference Chairs

Werner Weiershausen, Deutsche Telekom AG (Germany)
Benjamin B. Dingel, Nasfne Photonics, Inc. (United States)
Achyut K. Dutta, Banpil Photonics, Inc. (United States)
Atul K. Srivastava, NEL America, Inc. (United States)

Conference Program Committee

Youichi Akasaka, Fujitsu Network Communications Inc. (United States)
Júlio César R. F. de Oliveira, Fundacao 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, DTU Fotonik (Denmark)
Toshiki Tanaka, Fujitsu Laboratories, Ltd. (Japan)
Jianjun Yu, ZTE USA (United States)

Session Chairs

- 1 Optical Communication Plenary Session: Joint Session with Conferences 9007 and 9010
Benjamin B. Dingel, Nasfne Photonics, Inc. (United States)
Atul K. Srivastava, NEL America, Inc. (United States)

- 2 Toward 100G/400G Flexible Systems for Advanced Access and Data Center Networks: Joint Session with Conferences 9007, 9009, and 9010
Guifang Li, CREOL, The College of Optics and Photonics, University of Central Florida (United States)
Werner Weiershausen, Deutsche Telekom AG (Germany)
- 3 Next-Generation Integrated Photonics Devices: Joint Session with Conferences 9007, 9009, and 9010
Atul K. Srivastava, NEL America, Inc. (United States)
Benjamin B. Dingel, Nasfina Photonics, Inc. (United States)
- 4 Optical Interconnects and Devices for Short-Reach Networks: Joint Session with Conference 9010
Hideki Isono, Fujitsu Ltd. (Japan)
Ivan Shubin, Oracle (United States)
- 5 Advanced Components for Short-Haul Systems: Joint Session with Conference 9010
Krishna Swaminathan, Intel Corporation (United States)
Achyut K. Dutta, Banpil Photonics, Inc. (United States)
- 6 Photonic Switching, Routing, and WDM Devices: Joint Session with Conference 9010
Kiyo Ishii, National Institute of Advanced Industrial Science and Technology (Japan)
Idelfonso Tafur Monroy, DTU Fotonik (Denmark)
- 7 Modulation Formats and High-Efficiency Transmission I
Toshiki Tanaka, Fujitsu Laboratories, Ltd. (Japan)
Ivan B. Djordjevic, The University of Arizona (United States)
- 8 Modulation Formats and High-Efficiency Transmission II
Youichi Akasaka, Fujitsu Network Communications Inc. (United States)
Jianjun Yu, ZTE USA (United States)
- 9 Short-Reach Metro and Access Networks and Related Components I
Takashi Saida, NTT Photonics Laboratories (Japan)
Júlio César R. F. de Oliveira, Fundacao CPqD (Brazil)
- 10 Short-Reach Metro and Access Networks and Related Components II
Atul K. Srivastava, NEL America, Inc. (United States)
Werner Weiershausen, Deutsche Telekom AG (Germany)