

PROCEEDINGS OF SPIE

Silicon Photonics VI

Joel A. Kubby
Graham T. Reed
Editors

23–26 January 2011
San Francisco, California, United States

Sponsored and Published by
SPIE

Volume 7943

Proceedings of SPIE, 0277-786X, v. 7943

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

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 *Silicon Photonics VI*, edited by Joel A. Kubby, Graham T. Reed, Proceedings of SPIE Vol. 7943 (SPIE, Bellingham, WA, 2011) Article CID Number.

ISSN 0277-786X

ISBN 9780819484802

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 © 2011, 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/11/\$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

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

ix *Conference Committee*

SESSION 1 LAB-ON-A-CHIP

- 7943 04 **Nanoplasmonic resonance integrated with optofluidics for biochemical sensing and identification (Invited Paper) [7943-03]**
L. Pang, H. M. Chen, J. N. Ptasinski, P.-C. Sun, Y. Fainman, Univ. of California, San Diego (United States)

SESSION 2 MATERIALS

- 7943 05 **Molecular beam epitaxial growth of GaAs/AlGaAs multiquantum well on germanium substrate [7943-04]**
S. Banerjee, N. Halder, S. Chakrabarti, Indian Institute of Technology, Bombay (India)
- 7943 06 **Phase change characteristics of Ge₂Sb₂Te₅ thin film for a self-holding optical gate switch [7943-05]**
T. Toyosaki, D. Tanaka, Keio Univ. (Japan); Y. Shoji, M. Kuwahara, X. Wang, K. Kintaka, H. Kawashima, National Institute of Advanced Industrial Science and Technology (Japan); Y. Ikuma, H. Tsuda, Keio Univ. (Japan)

SESSION 3 RING RESONATORS

- 7943 07 **Highly sensitive optical sensor based on two cascaded micro-ring resonators with an LED light source [7943-06]**
L. Jin, M. Li, J.-J. He, Zhejiang Univ. (China)
- 7943 08 **Defect mediated detection of wavelengths around 1550 nm in a ring resonant structure [7943-07]**
A. P. Knights, J. K. Doylend, D. F. Logan, J. J. Ackert, McMaster Univ. (Canada); P. E. Jessop, Wilfrid Laurier Univ. (Canada); P. Velha, M. Sorel, R. M. De La Rue, Univ. of Glasgow (United Kingdom)
- 7943 09 **Liquid core integrated ring resonator [7943-08]**
G. Testa, Consiglio Nazionale delle Ricerche (Italy); Y. Huang, Technische Univ. Delft (Netherlands); L. Zeni, Seconda Univ. degli Studi di Napoli (Italy); P. M. Sarro, Technische Univ. Delft (Netherlands); R. Bernini, Consiglio Nazionale delle Ricerche (Italy)

SESSION 4 PHOTONIC CRYSTALS

- 7943 0C **Low-loss off-axis photonic crystal waveguides with bends [7943-11]**
R. C. Gauthier, S. Newman, K. E. Medri, Carleton Univ. (Canada)

- 7943 0D **Reconfigurable bi-directional optical routing in photonic crystals enabled by silicon nanomembrane modules** [7943-12]
M. J. Zablocki, Univ. of Delaware (United States); A. S. Sharkawy, Lumilant, Inc. (United States); D. W. Prather, Univ. of Delaware (United States)
- 7943 0E **Transformation of one-dimensional silicon photonic crystal into Fabry-Pérot resonator** [7943-13]
V. A. Tolmachev, Ioffe Physico-Technical Institute (Russian Federation) and Trinity College Dublin (Ireland); T. S. Perova, A. V. Baldycheva, Trinity College Dublin (Ireland)
- 7943 0F **Design, fabrication, and optical characterization of multicomponent photonic crystals for integrated silicon microphotronics** [7943-14]
A. Baldycheva, Trinity College Dublin (Ireland); V. A. Tolmachev, Ioffe Physico-Technical Institute (Russian Federation); T. S. Perova, Trinity College Dublin (Ireland); K. Berwick, Dublin Institute of Technology (Ireland); Y. A. Zharova, E. V. Astrova, Ioffe Physico-Technical Institute (Russian Federation)

SESSION 5 PHOTONIC WIRES

- 7943 0G **Engineering light at the sub-wavelength scale using silicon photonics (Invited Paper)** [7943-15]
S. Janz, P. Cheben, J. H. Schmid, P. Bock, National Research Council Canada (Canada); R. Halir, Univ. de Málaga (Spain); D.-X. Xu, A. Densmore, R. Ma, National Research Council Canada (Canada); I. Molina-Fernandez, Univ. de Málaga (Spain); A. Delâge, M. Vachon, J. Lapointe, W. Sinclair, E. Post, B. Lamontagne, National Research Council Canada (Canada)
- 7943 0H **Rigorous characterization of silicon nanowires and nanophotonic devices** [7943-16]
B. M. A. Rahman, D. M. H. Leung, K. Namassivayane, T. Koshy, Z. J. Jiang A. Law, H. Ahmed, K. T. V. Grattan, The City Univ. (United Kingdom)
- 7943 0I **Reflection and transmission characteristics of silicon photonic wire Bragg gratings** [7943-17]
P. Muellner, R. Bruck, R. Hainberger, Austrian Institute of Technology (Austria); M. Karl, M. Baus, T. Wahlbrink, AMO GmbH (Germany)

SESSION 6 WAVEGUIDES I

- 7943 0J **Backscattering in silicon photonic waveguides and circuits (Invited Paper)** [7943-18]
F. Morichetti, Fondazione Politecnico di Milano (Italy) and Politecnico di Milano (Italy)
A. Canciamilla, C. Ferrari, M. Martinelli, A. Melloni, Politecnico di Milano (Italy)
- 7943 0K **Development of a 0.75 micron wavelength, all-silicon, CMOS-based optical communication system** [7943-19]
L. W. Snyman, K. A. Ogudo, Tshwane Univ. of Technology (South Africa); D. Foty, Gilgamesh Associates, LLC (United States)
- 7943 0L **Patterned overlays: thin silicon layer applied to glass waveguides** [7943-20]
K. E. Medri, R. C. Gauthier, Carleton Univ. (Canada)

SESSION 7 WAVEGUIDES II

- 7943 ON **Far-field approximation in two-dimensional slab-waveguides** [7943-22]
A. Hosseini, R. T. Chen, The Univ. of Texas at Austin (United States)
- 7943 OP **Pluggable compact optical connector for Si-photonics chip using MT-ferrule** [7943-24]
D.-W Kim, J.-Y. Lee, J.-H. Kim, G. Kim, Electronics and Telecommunications Research Institute (Korea, Republic of)

SESSION 8 WAVEGUIDES III

- 7943 OQ **Mid-infrared silicon photonic devices (Invited Paper)** [7943-25]
G. Z. Mashanovich, M. M. Milosevic, M. Nedeljkovic, N. Owens, W. R. Headley, Univ. of Surrey (United Kingdom); E. J. Teo, B. Xiong, A*STAR Institute of Materials Research and Engineering (Singapore); P. Yang, Y. Hu, Univ. of Surrey (United Kingdom)
- 7943 OR **Light confinement and propagation characteristics in plasmonic gap waveguides on silicon** [7943-26]
R. Salas-Montiel, S. Blaize, A. Bruyant, A. Apuzzo, G. Léron del, Univ. de Technologie Troyes (France); C. Delacour, P. Grosse, J.-M. Fedeli, A. Tchelnokov, CEA LETI (France)
- 7943 OS **Optical near field in silicon photonics** [7943-27]
R. Salas-Montiel, A. Apuzzo, A. Bruyant, P. Royer, G. Léron del, S. Blaize, Univ. de Technologie Troyes (France)
- 7943 OT **Micro-cavities based on width modulated SOI waveguides** [7943-28]
S. Meister, A. Al-Saadi, B. A. Franke, S. Mahdi, M. Szczambura, B. Kuhl ow, U. Woggon, Technische Univ. Berlin (Germany); L. Zimmermann, H. H. Richter, D. Stolarek, IHP GmbH (Germany); S. K. Schrader, Technische Fachhochschule Wildau (Germany); H. J. Eichler, Technische Univ. Berlin (Germany)

SESSION 9 INTEGRATION

- 7943 OU **Integrated recirculating optical hybrid silicon buffers (Invited Paper)** [7943-29]
G. Kurczveil, M. J. R. Heck, J. M. Garcia, H. N. Poulsen, H. Park, D. J. Blumenthal, J. E. Bowers, Univ. of California, Santa Barbara (United States)
- 7943 OV **Fast 100-channel wavelength selectors integrated on silicon** [7943-30]
T. Aalto, M. Harjanne, M. Kapulainen, S. Yl inen, VTT Technical Research Ctr. of Finland (Finland); L. Mörl, Fraunhofer Institute for Telecommunications (Germany)

SESSION 10 FILTERS

- 7943 OX **Design of SOI wavelength filter based on multiple MMIs structures** [7943-32]
Y. Hu, F. Y. Gardes, R. M. Jenkins, E. D. Finlayson, G. Z. Mashanovich, G. T. Reed, Univ. of Surrey (United Kingdom)

- 7943 0Y **Integrated optical phased array based large angle beam steering system fabricated on silicon-on-insulator** [7943-33]
D. N. Kwong, Y. Zhang, A. Hosseini, R. T. Chen, The Univ. of Texas at Austin (United States)

SESSION 11 GRATINGS

- 7943 10 **Low-energy silicon-on-insulator ion implanted gratings for optical wafer scale testing** [7943-35]
R. Loiacono, G. T. Reed, G. Z. Mashanovich, R. M. Gwilliam, Univ. of Surrey (United Kingdom); G. Lulli, Istituto per la Microelettronica ed i Microsistemi (Italy); R. Feldesh, Numonyx Memory Solutions (Israel); R. Jones, Intel Corp. (United States)
- 7943 11 **SOI ring resonators with controllable MMI coupler sections** [7943-54]
Y. Hu, F. Y. Gardes, G. Z. Mashanovich, G. T. Reed, Univ. of Surrey (United Kingdom)

SESSION 12 EMITTERS

- 7943 12 **Integrated photonic quantum technologies with fiber-integrated single photon emitters (Invited Paper)** [7943-37]
T. Schröder, A. W. Schell, G. Kewes, M. Barth, T. Aichele, O. Benson, Humboldt-Univ. zu Berlin (Germany)
- 7943 13 **Spintronics using Si (Invited Paper)** [7943-38]
H. Dery, P. Li, Univ. of Rochester (United States)
- 7943 14 **Polarized electroluminescence from edge-emission organic light emitting devices** [7943-39]
G. Z. Ran, D. F. Jiang, Peking Univ. (China)
- 7943 15 **Spontaneous and stimulated Raman scattering in planar silicon waveguides** [7943-40]
S. Wang, S. Meister, S. Mahdi, B. A. Franke, A. Al-Saadi, Technische Univ. Berlin (Germany); L. Zimmermann, H. H. Richter, D. Stolarek, IHP GmbH (Germany); V. Lisinetskii, V. Ksianzou, S. K. Schrader, Technische Fachhochschule Wildau (Germany); H. J. Eichler, Technische Univ. Berlin (Germany)

SESSION 13 MODULATORS

- 7943 16 **Silicon-based optical modulation within the HELIOS project (Invited Paper)** [7943-41]
D. J. Thomson, F. Y. Gardes, Y. Hu, A. Ahmed, G. T. Reed, Univ. of Surrey (United Kingdom); G. Rasigade, M. Ziebell, D. Marris-Morini, L. Vivien, Univ. Paris Sud (France); A. Brimont, P. Sanchis, Univ. Politécnica de Valencia (Spain); J. Fédéli, F. Milesi, CEA LETI (France); C. Min, P. E. Composites Ltd. (United Kingdom)
- 7943 17 **A CMOS-based light modulator for contactless data transfer: theory and concept** [7943-42]
A. Serb, K. Nikolic, T. G. Constandinou, Imperial College London (United Kingdom)

- 7943 18 **A compact depletion mode silicon modulator based on a photonic hybrid-lattice mode-gap resonator** [7943-43]
M. Xin, National Univ. of Singapore (Singapore) and A*STAR Institute of High Performance Computing (Singapore); C. E. Png, A*STAR Institute of High Performance Computing (Singapore); A. J. Danner, National Univ. of Singapore (Singapore) and A*STAR Institute of High Performance Computing (Singapore)
- 7943 19 **40 Gb/s high-speed silicon modulator for TE and TM polarisation** [7943-44]
F. Y. Gardes, D. J. Thomson, G. T. Reed, Univ. of Surrey (United Kingdom)
- 7943 1A **SiGe metallized stub and plasmonic gap mode electro-absorption modulators** [7943-45]
R. Thomas, Z. Ikonić, R. W. Kelsall, Univ. of Leeds (United Kingdom)

SESSION 14 SILICON PHOTONICS: JOINT SESSION WITH CONFERENCE 7953

- 7943 1B **Hybrid silicon ring lasers (Invited Paper)** [7943-46]
D. Liang, M. Fiorentino, Hewlett-Packard Labs. (United States); J. E. Bowers, Univ. of California, Santa Barbara (United States); R. G. Beausoleil, Hewlett-Packard Labs. (United States)
- 7943 1C **Self-organized InAs quantum dot tube lasers and integrated optoelectronics on Si (Invited Paper)** [7943-47]
Z. Mi, P. Bianucci, F. Li, Z. Tian, V. Veerasubramanian, A. G. Kirk, D. V. Plant, McGill Univ. (Canada); P. J. Poole, National Research Council Canada (Canada)

POSTER SESSION

- 7943 1F **Variation of optical properties by the crystalline phase transition of polycrystalline silicon** [7943-50]
H. Iwata, T. Kita, H. Yamada, Tohoku Univ. (Japan)
- 7943 1G **Wavelength tunable laser diodes with Si-wire waveguide ring resonator wavelength filters** [7943-51]
K. Suzuki, T. Kita, H. Yamada, Tohoku Univ. (Japan)
- 7943 1I **Optical spectra of two-dimensional photonic crystal bars based on macroporous Si** [7943-53]
S. A. Dyakov, Trinity College Dublin (Ireland) and Lomonosov Moscow State Univ. (Russian Federation); E. V. Astrova, Ioffe Physico-Technical Institute (Russian Federation); T. S. Perova, Trinity College Dublin (Ireland); V. A. Tolmachev, G. V. Fedulova, Ioffe Physico-Technical Institute (Russian Federation); A. Baldycheva, Trinity College Dublin (Ireland); V. Yu. Timoshenko, Lomonosov Moscow State Univ. (Russian Federation); S. G. Tikhodeev, N. A. Gippius, A. M. Prokhorov General Physics Institute (Russian Federation)
- 7943 1J **Distributed actuator deformable mirror** [7943-55]
S. Bonora, Lab. for Ultraviolet and X-ray Optical Research, CNR-IFN (Italy) and Adaptica S.r.l. (Italy); J. Lafranceschina, Lab. for Ultraviolet and X-ray Optical Research, CNR-IFN (Italy); T. Occhipinti, Adaptica S.r.l. (Italy)

Author Index

Conference Committee

Symposium Chair

Liang-Chy Chien, Kent State University (United States)

Symposium Cochairs

Klaus P. Streubel, OSRAM GmbH (Germany)

E. Fred Schubert, Rensselaer Polytechnic Institute (United States)

Program Track Chair

Yakov Sidorin, Quarles Brady LLP (United States)

Conference Chairs

Joel A. Kubby, University of California, Santa Cruz (United States)

Graham T. Reed, University of Surrey (United Kingdom)

Program Committee

Laurence W. Cahill, La Trobe University (Australia)

Philippe M. Fauchet, University of Rochester (United States)

L. Cary Gunn, Genalyte, Inc. (United States)

Siegfried Janz, National Research Council Canada (Canada)

Andrew P. Knights, McMaster University (Canada)

Laura M. Lechuga, Centro d'Investigacions en Nanociència i Nanotecnologia (Spain)

Sebania Libertino, Istituto per la Microelettronica e Microsistemi (Italy)

Goran Z. Mashanovich, University of Surrey (United Kingdom)

Mario J. Paniccia, Intel Corporation (United States)

Andrew W. Poon, Hong Kong University of Science and Technology (Hong Kong, China)

Holger Schmidt, University of California, Santa Cruz (United States)

Dan-Xia Xu, National Research Council Canada (Canada)

Zhiping Zhou, Peking University (China)

Session Chairs

1 Lab-on-a-Chip

Holger Schmidt, University of California, Santa Cruz (United States)

- 2 Materials
 Andrew P. Knights, McMaster University (Canada)
- 3 Ring Resonators
 Graham T. Reed, University of Surrey (United Kingdom)
- 4 Photonic Crystals
 Andrew P. Knights, McMaster University (Canada)
- 5 Photonic Wires
 Graham T. Reed, University of Surrey (United Kingdom)
- 6 Waveguides I
 Graham T. Reed, University of Surrey (United Kingdom)
- 7 Waveguides II
 Siegfried Janz, National Research Council Canada (Canada)
- 8 Waveguides III
 Siegfried Janz, National Research Council Canada (Canada)
- 9 Integration
 Andrew W. Poon, Hong Kong University of Science and Technology
 (Hong Kong, China)
- 10 Filters
 Zhiping Zhou, Peking University (China)
- 11 Gratings
 Zhiping Zhou, Peking University (China)
- 12 Emitters
 Philippe M. Fauchet, University of Rochester (United States)
- 13 Modulators
 Philippe M. Fauchet, University of Rochester (United States)
- 14 Silicon Photonics: Joint Session with Conference 7953
 Mario J. Paniccia, Intel Corporation (United States)