PROCEEDINGS OF SPIE

SPIDigitalLibrary.org/conference-proceedings-of-spie

Front Matter: Volume 7591

, "Front Matter: Volume 7591," Proc. SPIE 7591, Advanced Fabrication Technologies for Micro/Nano Optics and Photonics III, 759101 (24 March 2010); doi: 10.1117/12.861996

SPIE.

Event: SPIE MOEMS-MEMS, 2010, San Francisco, California, United States

PROCEEDINGS OF SPIE

Advanced Fabrication Technologies for Micro/Nano Optics and Photonics III

Winston V. Schoenfeld

Jian Jim Wang

Marko Loncar

Thomas J. Suleski

Editors

25–27 January 2010

San Francisco, California, United States

Sponsored and Published by

SPIE

Volume 7591

Proceedings of SPIE, 0277-786X, v. 7591

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 *Advanced Fabrication Technologies for Micro/Nano Optics and Photonics III*, edited by Winston V. Schoenfeld, Jian Jim Wang, Marko Loncar, Thomas J. Suleski, Proceedings of SPIE Vol. 7591 (SPIE, Bellingham, WA, 2010) Article CID Number.

ISSN 0277-786X

ISBN 9780819479877

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 © 2010, 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/10/\$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 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*

- ix *Emerging research in micro and nano systems: opportunities and challenges for societal impact (Plenary Paper) [7593-201]*
Y. B. Gianchandani, Univ. of Michigan (United States)

- xvii *MEMS technologies for artificial retinas (Plenary Paper) [7594-202]*
W. Mokwa, RWTH Aachen Univ. (Germany)

- xxxi *Shaping light: MOEMS deformable mirrors for microscopes and telescopes (Plenary Paper) [7595-203]*
T. Bifano, Boston Univ. Photonics Ctr. (United States)

SESSION 1 NON-DIFFRACTION LIMITED 3D LASER LITHOGRAPHY

- 7591 02 **Two-color photo-initiation/inhibition lithography (Invited Paper) [7591-01]**
R. R. McLeod, B. A. Kowalski, Univ. of Colorado at Boulder (United States); M. C. Cole, InPhase Technologies (United States)

- 7591 05 **3D biomedical implants fabricated using direct laser writing (Invited Paper) [7591-04]**
C. Schizas, Univ. of Piraeus (Greece); V. Melissinaki, Foundation for Research and Technology-Hellas (Greece) and Univ. of Crete (Greece); A. Gaidukeviciute, Foundation for Research and Technology-Hellas (Greece); C. Reinhardt, Foundation for Research and Technology-Hellas (Greece) and Laser Zentrum Hannover e.V. (Germany); C. Ohrt, Laser Zentrum Hannover e.V. (Germany); V. Dedoussis, Univ. of Piraeus (Greece); B. N. Chichkov, Foundation for Research and Technology-Hellas (Greece) and Laser Zentrum Hannover e.V. (Germany); C. Fotakis, Foundation for Research and Technology-Hellas (Greece) and Univ. of Crete (Greece); D. Karalekas, Univ. of Piraeus (Greece); M. Farsari, Foundation for Research and Technology-Hellas (Greece)

SESSION 2 NANOFABRICATION I: PHOTONIC NANOSTRUCTURES

- 7591 06 **Fabrication of vertical silicon nanowire photodetector arrays using nanoimprint lithography [7591-05]**
H. Kim, A. Zhang, Y.-H. Lo, Univ. of California, San Diego (United States)

- 7591 07 **Critical nanofabrication parameters for the e-beam assisted design of a subwavelength aluminum mesh [7591-06]**
C. Mazuir, W. V. Schoenfeld, CREOL, The College of Optics and Photonics, Univ. of Central Florida (United States)

- 7591 08 **Low-cost optical microstructures fabricated by imprinting porous silicon [7591-07]**
J. D. Ryckman, Vanderbilt Univ. (United States); M. Liscidini, Univ. degli Studi di Pavia (Italy); J. E. Sipe, Univ. of Toronto (Canada); S. M. Weiss, Vanderbilt Univ. (United States)

- 7591 09 **Hollow ARROW waveguides on self-aligned pedestals for high-sensitivity optical sensing** [7591-08]
E. J. Lunt, B. S. Phillips, J. M. Keeley, A. R. Hawkins, Brigham Young Univ. (United States);
P. Measor, B. Wu, H. Schmidt, Univ. of California, Santa Cruz (United States)
- 7591 0A **Inkjet printing techniques for the fabrication of polymer optical waveguides** [7591-09]
N. A. Vacirca, T. P. Kurzweg, Drexel Univ. (United States)

SESSION 3 ADVANCED LITHOGRAPHY

- 7591 0C **Design, fabrication, and control of scanning plasmonic probe for near-field photolithographic applications** [7591-11]
Y.-Y. Huang, Y. Wang, K. Hoshino, D. Giese, Y. Shrestha, X. Zhang, The Univ. of Texas at Austin (United States)
- 7591 0D **Fabrication techniques of high aspect ratio vertical lightpipes using a dielectric photomask** [7591-12]
W. N. Ye, Harvard Univ. (United States) and Zena Technologies Inc. (United States); P. Duane, M. Wober, Zena Technologies Inc. (United States); K. B. Crozier, Harvard Univ. (United States)

SESSION 4 NEW MATERIALS

- 7591 0G **Micro-patternable hybrid nanocomposites with tailorable mechanical and thermomechanical properties** [7591-15]
C. Becker-Willinger, P. Kalmes, P. Herbeck-Engel, M. Veith, Leibniz Institute for New Materials (Germany)

SESSION 5 LASER-BASED FABRICATION

- 7591 0J **Fabrication of micro- and nanostructures in thin metallic films by femtosecond laser ablation** [7591-18]
V. Mizeikis, Shizuoka Univ. (Japan); S. Juodkazis, Swinburne Univ. of Technology (Australia); K. Sun, H. Misawa, Hokkaido Univ. (Japan)
- 7591 0K **Femtosecond laser photopolymerization of photonic and free-movable microstructures in sol-gel hybrid resist** [7591-19]
Q. Sun, Hokkaido Univ. (Japan); S. Juodkazis, Hokkaido Univ. (Japan) and Swinburne Univ. of Technology (Australia); N. Murazawa, Hokkaido Univ. (Japan); V. Mizeikis, Shizuoka Univ. (Japan); H. Misawa, Hokkaido Univ. (Japan)
- 7591 0M **Laser direct writing of submicron lines using micro- and nanofiber pens** [7591-21]
F. Tian, G. Yang, J. Bai, J. Xu, Q. Zhou, Zhejiang Univ. (China)

SESSION 6 NANOFABRICATION II: ACTIVE AND PASSIVE DEVICES

- 7591 0N **Challenges and opportunities of manufacturing the next generation of integrated photonics (Invited Paper)** [7591-22]
R. Singh, N. Gupta, J. A. Sadie, K. F. Poole, J. Ballato, S. J. Hwu, Clemson Univ. (United States)

- 7591 0O **Multiwavelength rolled-up InGaAs/GaAs quantum dot microtube lasers** [7591-23]
F. Li, Z. Mi, McGill Univ. (Canada)
- 7591 0P **Demonstration of thermal emission control** [7591-24]
A. A. Cruz-Cabrera, S. A. Kemme, M. J. Cich, A. R. Ellis, J. R. Wendt, A. M. Rowen, Sandia National Labs. (United States); S. Samora, LMATA Government Services, LLC (United States); M. J. Martinez, D. A. Scrymgeour, D. W. Peters, Sandia National Labs. (United States)
- 7591 0R **Dry etching of TiO₂/SiO₂ DBR mirrors for tunable optical sensor arrays** [7591-26]
O. Setyawati, Univ. Kassel (Germany) and Opsolution Nanophotonics GmbH (Germany); M. Engenhorst, S. Wittzack, F. Köhler, C. Woidt, Univ. Kassel (Germany); T. Woit, Univ. Kassel (Germany) and Opsolution Nanophotonics GmbH (Germany); V. Daneker, M. Bartels, H. Hillmer, Univ. Kassel (Germany)

SESSION 7 NANOFABRICATION III: GROWTH AND DEPOSITION

- 7591 0S **Atomic layer deposition (ALD) for optical nanofabrication (Invited Paper)** [7591-27]
J. Maula, Beneq Oy (Finland)
- 7591 0T **Modification of conformal-evaporated-film-by-rotation technique to improve uniformity of replicas of nonplanar biotemplates** [7591-28]
D. P. Pulister, A. Lakhtakia, The Pennsylvania State Univ. (United States); R. J. Martín-Palma, Univ. Autónoma de Madrid (Spain)

SESSION 8 MICRO- AND NANO-OPTICS

- 7591 0W **Tolerancing and analysis of a diffractive beam shaper** [7591-31]
A. Fedor, M. Himel, Tessera, Inc. (United States)
- 7591 0X **Precision glass molding: an integrative approach for the production of high precision micro-optics** [7591-32]
M. Hüntel, F. Klocke, O. Dambon, Fraunhofer Institute for Production Technology (Germany)
- 7591 0Y **Ion beam figuring (IBF) for high precision optics** [7591-33]
M. Demmler, M. Zeuner, F. Allenstein, T. Dunger, M. Nestler, Roth & Rau MicroSystems GmbH (Germany); S. Kiontke, asphericon GmbH (Germany)
- 7591 0Z **Multi-phase-level diffractive elements realized by binary effective medium patterns** [7591-34]
W. Freese, T. Kämpfe, E.-B. Kley, A. Tünnermann, Friedrich-Schiller-Univ. Jena (Germany)

POSTER SESSION

- 7591 10 **Fabrication of corrugated long-period fiber gratings by wet bulk micromachining** [7591-36]
C.-C. Chiang, L. Tsai, H.-J. Chang, National Kaohsiung Univ. of Applied Sciences (Taiwan); C.-L. Lin, Central Taiwan Univ. of Science and Technology (Taiwan); J.-S. Kuo, National Kaohsiung Univ. of Applied Sciences (Taiwan)

- 7591 11 **Dynamics of percolation phenomena in colloidal printing inks** [7591-37]
M. A.-A. Daniele, A. L. Foguth, P. Rungta, I. Bandera, V. Tsyalkovskyy, S. H. Foulger, Clemson Univ. (United States)
- 7591 12 **Antireflection on plastic substrates using ion etching with discontinuous metallic film** [7591-38]
Y.-W. Yeh, S.-H. Chen, C.-C. Lee, National Central Univ. (Taiwan); S.-L. Ku, National Central Univ. (Taiwan) and Chung-Shan Institute of Science and Technology (Taiwan); C.-C. Huang, Chung-Shan Institute of Science and Technology (Taiwan)
- 7591 13 **Quantum dots (QDs) immobilization on metal nanowire end-facets for single photon source application** [7591-39]
J. Kim, Korea Univ. (Korea, Republic of) and Korea Institute of Science and Technology (Korea, Republic of); B. C. Lee, Korea Institute of Science and Technology (Korea, Republic of); C. Kang, Korea Univ. (Korea, Republic of) and Korea Institute of Science and Technology (Korea, Republic of); S. Y. Lee, Korea Institute of Science and Technology (Korea, Republic of); J. H. Park, Korea Univ. (Korea, Republic of); H. J. Shin, Korea Institute of Science and Technology (Korea, Republic of)
- 7591 14 **Multi-photon polymerization of inorganic-organic hybrid polymers using visible or IR ultrafast laser pulses for optical or optoelectronic devices** [7591-40]
S. Steenhusen, T. Stichel, Fraunhofer-Institut für Silicatforschung (Germany) and Julius-Maximilians-Univ. Würzburg (Germany); R. Houbertz, Fraunhofer-Institut für Silicatforschung (Germany); G. Sextl, Fraunhofer-Institut für Silicatforschung (Germany) and Julius-Maximilians-Univ. Würzburg (Germany)
- 7591 15 **Device integration of Ti-catalyzed Si nanowires grown using APCVD** [7591-41]
M. A. U. Usman, B. Smith, Univ. of Utah (United States)

Author Index

Conference Committee

Symposium Chair

Thomas J. Suleski, The University of North Carolina at Charlotte
(United States)

Symposium Cochair

Harald Schenk, Fraunhofer Institute for Photonic Microsystems
(Germany)

Conference Chairs

Winston V. Schoenfeld, CREOL, The College of Optics and Photonics,
University of Central Florida (United States)
Jian Jim Wang, OmniPV Inc. (United States)
Marko Loncar, Harvard University (United States)
Thomas J. Suleski, The University of North Carolina at Charlotte
(United States)

Program Committee

John M. Ballato, Clemson University (United States)
Gregg T. Borek, MEMS Optical, Inc. (United States)
Stefano Cabrini, Lawrence Berkeley National Laboratory
(United States)
Matthew A. Davies, The University of North Carolina at Charlotte
(United States)
Erez Hasman, Technion-Israel Institute of Technology (Israel)
Aaron R. Hawkins, Brigham Young University (United States)
Tsinghua Her, The University of North Carolina at Charlotte
(United States)
Saulius Juodkazis, Hokkaido University (Japan)
Shanalyn A. Kemme, Sandia National Laboratories (United States)
Ernst-Bernhard Kley, Friedrich-Schiller-Universität Jena (Germany)
Stephen M. Kuebler, CREOL, The College of Optics and Photonics,
University of Central Florida (United States)
Dwayne L. LaBrake, Molecular Imprints, Inc. (United States)
Akhlesh Lakhtakia, The Pennsylvania State University (United States)
Ki-Dong Lee, LG Electronics Inc. (Korea, Republic of)
Uriel Levy, The Hebrew University of Jerusalem (Israel)
Patrick P. Naulleau, Lawrence Berkeley National Laboratory
(United States)

Dennis W. Prather, University of Delaware (United States)
John A. Rogers, University of Illinois at Urbana-Champaign (United States)
Markus Rossi, Heptagon Oy (Switzerland)
Raymond C. Rumpf, Prime Research, LC (United States)
Georg von Freymann, Forschungszentrum Karlsruhe GmbH (Germany)
Michael P. Watts, Impattern Solutions (United States)
Wei Wu, Hewlett-Packard Laboratories (United States)

Session Chairs

- 1 Non-Diffraction Limited 3D Laser Lithography
Georg von Freymann, Forschungszentrum Karlsruhe GmbH (Germany)
- 2 Nanofabrication I: Photonic Nanostructures
Winston V. Schoenfeld, CREOL, The College of Optics and Photonics, University of Central Florida (United States)
- 3 Advanced Lithography
Winston V. Schoenfeld, CREOL, The College of Optics and Photonics, University of Central Florida (United States)
- 4 New Materials
Winston V. Schoenfeld, CREOL, The College of Optics and Photonics, University of Central Florida (United States)
- 5 Laser-Based Fabrication
Vyngantas Mizeikis, Shizuoka University (Japan)
- 6 Nanofabrication II: Active and Passive Devices
Akhlesh Lakhtakia, The Pennsylvania State University (United States)
- 7 Nanofabrication III: Growth and Deposition
Pradeep Srinivasan, The University of North Carolina at Charlotte (United States)
- 8 Micro- and Nano-Optics
Aaron R. Hawkins, Brigham Young University (United States)