

PROCEEDINGS OF SPIE

***Nanoengineering: Fabrication,
Properties, Optics, and Devices IV***

Elizabeth A. Dobisz

Louay A. Eldada

Editors

27–30 August 2007

San Diego, California, USA

Sponsored and Published by
SPIE

Volume 6645

Proceedings of SPIE, 0277-786X, v. 6645

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 *Nanoengineering: Fabrication, Properties, Optics, and Devices IV*, edited by Elizabeth A. Dobisz, Louay A. Eldada, Proceedings of SPIE Vol. 6645 (SPIE, Bellingham, WA, 2007) Article CID Number.

ISSN 0277-786X
ISBN 9780819467935

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 © 2007, 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/07/\$18.00.

Printed in the United States of America.

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


SPIEDigitalLibrary.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

ix	<i>Conference Committee</i>
xi	<i>Introduction</i>

SESSION 1 PHOTONIC CRYSTALS

- 6645 03 **SiN photonic crystal cavities: promising tools for the manipulation of light in the visible** [6645-02]
M. Barth, Humboldt-Univ. Berlin (Germany); J. Kouba, BESSY GmbH (Germany); J. Stingl, Humboldt-Univ. Berlin (Germany); B. Löchel, BESSY GmbH (Germany); O. Benson, Humboldt-Univ. Berlin (Germany)
- 6645 05 **Fabrication and optical characterization of Si₃N₄ 2D-photonic crystals for applications in visible range** [6645-04]
J. Kouba, S. Kiss, BESSY GmbH (Germany); M. Barth, Humboldt Univ. of Berlin (Germany); W. Eberhardt, B. Loechel, BESSY GmbH (Germany)

SESSION 2 NANO-BIOTECHNOLOGY

- 6645 06 **Parallel optical tweezers with combining a diffractive optical element and a spatial light modulator for photonic DNA memory (Invited Paper)** [6645-05]
M. Zheng, N. Tate, Y. Ogura, J. Tanida, Osaka Univ. (Japan)
- 6645 09 **Nano-scale patterning of phospholipid thin films by interferometric UV lithography** [6645-08]
A. Kassu, J.-M. Taguenang, A. Sharma, Alabama A&M Univ. (USA)
- 6645 0A **Biological fabrication of nanostructured silicon-germanium photonic crystals possessing unique photoluminescent and electroluminescent properties** [6645-09]
G. L. Rorrer, C. Jeffryes, C. Chang, D.-H. Lee, Oregon State Univ. (USA); T. Gutu, J. Jiao, R. Solanki, Portland State Univ. (USA)
- 6645 0B **Development of ultra-low magnetic field sensors with magnetic tunneling junctions** [6645-10]
P. W. T. Pong, J. E. Bonevich, W. F. Egelhoff, Jr., National Institute of Standards and Technology (USA)

SESSION 3 OPTICAL INTERCONNECTS

- 6645 0D **Flexible optical wire-bonding for planar lightwave circuits packaging** [6645-12]
R. R. Panepucci, A. J. Zakariya, T. Liu, Florida International Univ. (USA)
- 6645 0E **Nanotaper coupler for the horizontal slot-waveguide** [6645-13]
A. M. P. Fièvre, T. Liu, R. R. Panepucci, Florida International Univ. (USA)

- 6645 OG **Enhancement of light extraction efficiency of light-emitting diode with hexagonal photonic crystal layer** [6645-15]
D. H. Long, H.-A. Do, J. Park, I.-K. Hwang, S.-W. Ryu, J.-K. Lee, Chonnam National Univ. (South Korea)

SESSION 4 NANOFABRICATED OPTICAL DEVICES

- 6645 OH **Short polymer waveguide resonator with Bragg reflectors** [6645-17]
T. Liu, M. Nawrocka, R. Panepucci, Florida International Univ. (USA)
- 6645 OI **Wavelength reconfigurable photonic switching using thermally tuned micro-ring resonators fabricated on silicon substrate** [6645-18]
M. R. Wang, H.-Y. Ng, Univ. of Miami (USA); D. Li, New Span Opto-Technology, Inc. (USA); X. Wang, J. Martinez, R. R. Panepucci, Florida International Univ. (USA); K. Pathak, U.S. Army Space and Missile Defense Command (USA)
- 6645 OK **Variable diffraction gratings using nanoporous electrodes and electrophoresis of dye ions** [6645-20]
P. C. P. Hrudehy, M. A. Martinuk, M. A. Mossman, Univ. of British Columbia (Canada); A. C. van Popta, M. J. Brett, Univ. of Alberta (Canada); J. S. Huizinga, 3M Co. (USA); L. A. Whitehead, Univ. of British Columbia (Canada)

SESSION 5 QUANTUM DOTS AND WIRES

- 6645 OP **Design, fabrication, and testing of enhanced EO materials for mmW modulators** [6645-25]
B. Redding, N. Faleev, X. Long, T. Creazzo, S. Shi, D. Prather, Univ. of Delaware (USA)

SESSION 6 NANOSTRUCTURE ENGINEERING

- 6645 OR **Ultrafast pulsed laser ablation for synthesis of nanocrystals (Invited Paper)** [6645-26]
B. Liu, Z. Hu, IMRA America, Inc. (USA); Y. Chen, K. Sun, X. Pan, Univ. of Michigan (USA); Y. Che, IMRA America, Inc. (USA)
- 6645 OS **Fabrication of spintronic devices: etching endpoint detection by resistance measurement for magnetic tunnel junctions** [6645-27]
P. W. T. Pong, M. Schmoueli, W. F. Egelhoff, Jr., National Institute of Standards and Technology (USA)
- 6645 OT **Preliminary design and noise considerations for an ultrasensitive magnetic field sensor** [6645-29]
P. W. T. Pong, R. McMichael, National Institute of Standards and Technology (USA); A. S. Edelstein, Army Research Lab. (USA); E. R. Nowak, Univ. of Delaware (USA); W. F. Egelhoff, Jr., National Institute of Standards and Technology (USA)
- 6645 OV **In situ Raman scattering in nanomaterial flame synthesis: a case on TiO₂ nanoparticles** [6645-31]
X. Liu, Rutgers, The State Univ. of New Jersey (USA)

SESSION 7 THIN FILM NANOSTRUCTURE OPTICS

- 6645 0W **Optics of thin-film silicon solar cells with efficient periodic light trapping textures** [6645-32]
C. Haase, Forschungszentrum Jülich (Germany); D. Knipp, Jacobs Univ. Bremen (Germany);
H. Stiebig, Forschungszentrum Jülich (Germany)
- 6645 0X **Tailored circular Bragg phenomena in TiO₂ sculptured thin films through post-deposition processing** [6645-33]
S. M. Pursel, M. W. Horn, A. Lakhtakia, Pennsylvania State Univ. (USA)
- 6645 0Z **Fabrication and characterization of silicon/silicon dioxide super lattices for silicon based light emitting devices** [6645-35]
T. Creazzo, E. Marchena, B. Redding, T. Hodson, D. Prather, Univ. of Delaware (USA)
- 6645 10 **Function of bubble pit in super-RENS storage** [6645-36]
Q. Liu, C. Guo, S. Cao, Z. Zhang, National Ctr. for Nanoscience and Technology (China);
T. Fukaya, National Institute of Advanced Industrial Science and Technology (Japan)
- 6645 11 **Narrowband linear-polarization rejection filter based on columnar thin film superlattice**
[6645-37]
F. Chiadini, Univ. of Salerno (Italy); V. Fiumara, Univ. of Basilicata (Italy); A. Scaglione, Univ.
of Salerno (Italy); A. Lakhtakia, Pennsylvania State Univ. (USA)

SESSION 8 ORGANIC NANOSTRUCTURES

- 6645 13 **Fabrication of sub-diffraction-limit molecular structures by scanning near-field photolithography** [6645-39]
R. E. Ducker, M. T. Montague, S. Sun, G. J. Leggett, Univ. of Sheffield (United Kingdom)
- 6645 14 **Elasticity of two-photon-fabricated nano-wires** [6645-40]
S. Nakanishi, Osaka Univ. (Japan); H.-B. Sun, Jinlin Univ. (China); S. Kawata, Osaka Univ.
(Japan)

SESSION 9 NANOTUBES

- 6645 16 **Optical polarizer made of mechanically aligned carbon nanotubes** [6645-42]
S. Shoji, Osaka Univ. (Japan) and CREST, Japan Corp. of Science and Technology (Japan);
H. Suzuki, Osaka Univ. (Japan); R. P. Zaccaria, Osaka Univ. (Japan) and CREST, Japan Corp.
of Science and Technology (Japan); Z. Sekkat, Osaka Univ. (Japan), Al Akhawayn Univ. in
Ifrane (Morocco), and Academy Hassan II of Science and Technology (Morocco);
S. Kawata, Osaka Univ. (Japan), RIKEN (Japan), and CREST, Japan Corp. of Science and
Technology (Japan)
- 6645 1A **Nano materials for efficiently lowering the freezing point of heat transfer nanofluids**
[6645-46]
H. Hong, South Dakota School of Mines and Technology (USA); W. Roy, Army Research Lab.
(USA)

- 6645 1B **Light source with carbon nanotubes field emission cathode and rare-earth doped nanocrystalline phosphors** [6645-47]
P. Psuja, W. Strek, Institute of Low Temperature and Structure Research (Poland)

SESSION 10 NANOWIRES, NANOFIBERS, AND NANORODS

- 6645 1D **Self-sensing of CNF and Ni nanowire/PVDF and cellulose composites using electro-micromechanical test** [6645-50]
J.-M. Park, Gyeongsang National Univ. (South Korea) and The Univ. of Utah (USA); P.-G. Kim, J.-H. Jang, S.-J. Kim, Gyeongsang National Univ. (South Korea); D.-J. Yoon, Korea Research Institute of Standards and Science (South Korea); G. Hansen, Metal Matrix Composites, Inc. (USA); K. L. DeVries, The Univ. of Utah (USA)

SESSION 11 OPTOFLUIDICS

- 6645 1E **Diffusive and convective dye replenishment in optofluidic light sources** [6645-51]
M. Gersborg-Hansen, N. A. Mortensen, A. Kristensen, Technical Univ. of Denmark (Denmark)
- 6645 1G **Holographic fabrication of photonic nanostructures for optofluidic integration** [6645-53]
S.-K. Lee, S.-G. Park, J.-H. Kang, Korea Advanced Institute of Science and Technology (South Korea); J. H. Moon, Samsung Advanced Institute of Technology (South Korea); S.-M. Yang, Korea Advanced Institute of Science and Technology (South Korea)
- 6645 1H **Photonic crystal biosensor microplates with integrated fluid networks for high throughput applications in drug discovery** [6645-54]
C. J. Choi, L. L. Chan, M. F. Pineda, B. T. Cunningham, Univ. of Illinois at Urbana-Champaign (USA)
- 6645 1I **Capillary driven tunable optofluidic DFB dye lasers** [6645-55]
M. Gersborg-Hansen, A. Kristensen, Technical Univ. of Denmark (Denmark)
- 6645 1J **Nanoscale optofluidic sensor arrays for Dengue virus detection** [6645-56]
S. Mandal, R. Akhmechet, L. Chen, S. Nugen, A. Bæumner, D. Erickson, Cornell Univ. (USA)
- 6645 1K **Microfluidic channel with built-in photonic crystal nanolaser** [6645-57]
S.-H. Kim, S.-K. Lee, Y.-H. Lee, S.-M. Yang, Korea Advanced Institute of Science and Technology (South Korea)
- 6645 1L **Liquid-infiltrated photonic crystals for lab-on-a-chip applications** [6645-58]
S. Xiao, J. Pedersen, N. A. Mortensen, Technical Univ. of Denmark (Denmark)
- 6645 1M **Electroactive nanowells for spectrographic fluidic memory** [6645-59]
B. Cordovez, Cornell Univ. (USA); D. Psaltis, Ecole Polytechnique Fédérale de Lausanne (Switzerland); D. Erickson, Cornell Univ. (USA)

SESSION 12 NANOPROCESSING TECHNOLOGIES AND NANOSYSTEMS FOR MEDICAL APPLICATIONS

- 6645 1P **Electron microscopy characterization of iron oxide nanopowders (prepared by laser pyrolysis) for magnetic fluid applications** [6645-63]
V. Ciupina, G. Prodan, Ovidius Univ. of Constanta (Romania); I. Morjan, F. Dumitrache, R. Alexandrescu, National Institute for Laser, Plasma and Radiation Physics (Romania); E. Vasile, Metav-CD SRL (Romania); L. Vegas, D. Bica, National Institute for Research and Development in Microtechnology (Romania)
- 6645 1Q **Cytotoxicity of the photoluminescent silicon nanocrystals** [6645-64]
J. Choi, Univ. of Maryland, College Park (USA), National Institute of Standards and Technology (USA), and U.S. Food and Drug Administration (USA); Q. Zhang, V. M. Hitchins, U.S. Food and Drug Administration (USA); N. S. Wang, Univ. of Maryland, College Park (USA); V. Reipa, National Institute of Standards and Technology (USA)
- 6645 1U **Near-infrared laser photothermal therapy and photodynamic inactivation of cells by using gold nanoparticles and dyes** [6645-68]
G. G. Akchurin, G. G. Akchurin, Saratov State Univ. (Russia); V. A. Bogatyrev, Institute of Biochemistry and Physiology of Plants and Microorganisms (Russia); I. L. Maksimova, Saratov State Univ. (Russia); G. A. Seliverstov, Saratov State Medical Univ. (Russia); G. S. Terentyuk, First Veterinary Clinic (Russia); B. N. Khlebtsov, N. G. Khlebtsov, Institute of Biochemistry and Physiology of Plants and Microorganisms (Russia); V. V. Tuchin, Saratov State Univ. (Russia)

POSTER SESSION

- 6645 1V **Fabrication strategies for magnetic tunnel junctions with magnetoelectronic applications** [6645-69]
P. W. T. Pong, W. F. Egelhoff, Jr., National Institute of Standards and Technology (USA)
- 6645 1W **Flexible Bragg reflection waveguide devices fabricated on a plastic substrate** [6645-72]
K.-J. Kim, J.-A. Yi, M.-C. Oh, Pusan National Univ. (South Korea); Y.-O. Noh, H.-J. Lee, ChemOptics (South Korea)
- 6645 1X **Characterization of AlF_3 thin films in the ultraviolet by magnetron sputtering of aluminum target** [6645-73]
B.-H. Liao, M.-C. Liu, C.-C. Lee, National Central Univ. (Taiwan)
- 6645 1Y **The research of oblique deposition of lanthanum fluoride thin films at 193nm** [6645-74]
M.-C. Liu, B.-H. Liao, W.-H. Cho, C.-C. Lee, National Central Univ. (Taiwan); C.-C. Jaing, Minghsin Univ. of Science and Technology (Taiwan)
- 6645 1Z **Dynamic force microscopy and x-ray photoemission spectroscopy studies of conducting polymer thin film on nanoscale structured Al surface** [6645-75]
H. Kato, S. Takemura, A. Ishii, Y. Takarai, Y. Watanabe, T. Sugiyama, T. Hiramatsu, N. Nanba, Kanto Gakuin Univ. (Japan); O. Nishikawa, M. Taniguchi, Kanazawa Institute of Technology (Japan)

- 6645 20 **Photopolymerization of hybrid organic/inorganic materials based on nanostructured units for photonic applications** [6645-77]
I. Fortunati, T. Dainese, R. Signorini, R. Bozio, Univ. of Padova (Italy); V. Tagliazucca, S. Dirè, Univ. of Trento (Italy); G. Lemerrier, J.-C. Mulatier, C. Andraud, Lab. de Chimie, CNRS, ENS-Lyon (France); P. Schiavuta, CIVEN, Nanofabrication Facility (Italy); Y. Bottazzo, G. Della Giustina, G. Brusatin, M. Guglielmi, Univ. of Padova (Italy)
- 6645 21 **Theory and numerical design of coupled-resonator optical waveguide sections with bends** [6645-78]
S. V. Pishko, S. V. Boriskina, V. Karazin Kharkov National Univ. (Ukraine)
- 6645 23 **Covalent attachment of photoluminescent silicon nanoparticles to streptavidin** [6645-80]
J. Choi, Univ. of Maryland, College Park (USA) and National Institute of Standards and Technology (USA); P. Niarhos, N. S. Wang, Univ. of Maryland, College Park (USA); V. Reipa, National Institute of Standards and Technology (USA)
- 6645 25 **Micro-opto-electro-mechanical system (MOEMS) for microstructure manipulation and optical characterization** [6645-82]
J. A. Martinez, T. Liu, R. R. Panepucci, Florida International Univ. (USA)
- 6645 28 **The role of electro-osmosis and dielectrophoresis in collection of micro/nano size particles in low frequency AC electric field** [6645-85]
C. Wei, C.-W. Hsu, C.-C. Wang, Tatung Univ. (Taiwan)
- 6645 29 **A sub-wavelength level polarizer with high contrast and high tolerance of incident ray's angle in the range of visible wavelength** [6645-86]
Y.-C. Lo, K.-Y. Cheng, T.-C. Teng, C.-C. Sun, National Central Univ. (Taiwan)
- 6645 2A **Dielectric constant trends in silicate spin-on glasses** [6645-87]
N. Iwamoto, T. Li, Honeywell Specialty Materials (USA); J. Sepa, A. Krishnamoorthy, Honeywell Electronic Materials (USA)

Author Index

Conference Committee

Symposium Chairs

David L. Andrews, University of East Anglia Norwich (United Kingdom)
James G. Grote, Air Force Research Laboratory (USA)
Kevin J. Liddane, Oerlikon Optics USA, Inc. (USA)

Conference Chairs

Elizabeth A. Dobisz, Hitachi Global Storage Technologies (USA)
Louay A. Eldada, DuPont Photonics Technologies (USA)

Program Committee

Luisa D. Bozano, IBM Almaden Research Center (USA)
Gregory J. Exarhos, Pacific Northwest National Laboratory (USA)
Cynthia Hanson, Space and Naval Warfare Systems Command (USA)
Daniel J. C. Herr, Semiconductor Research Corporation (USA)
Ghassan E. Jabbour, Arizona State University (USA)
Miguel Levy, Michigan Technological University (USA)
Robert Magnusson, University of Connecticut (USA)
Juan R. Maldonado, Stanford University (USA)
Jun Tanida, Osaka University (Japan)
Chee Wei Wong, Columbia University (USA)

Session Chairs

- 1 Photonic Crystals
Louay A. Eldada, DuPont Photonics Technologies (USA)
- 2 Nano-Biotechnology
Elizabeth A. Dobisz, Hitachi Global Storage Technologies (USA)
- 3 Optical Interconnects
El-Hang Lee, Inha University (South Korea)
- 4 Nanofabricated Optical Devices
Louay A. Eldada, DuPont Photonics Technologies (USA)
- 5 Quantum Dots and Wires
Elizabeth A. Dobisz, Hitachi Global Storage Technologies (USA)

- 6 Nanostructure Engineering
Yusuke Ogura, Osaka University (Japan)
- 7 Thin Film Nanostructure Optics
Gregory J. Exarhos, Pacific Northwest National Laboratory (USA)
- 8 Organic Nanostructures
Louay A. Eldada, DuPont Photonics Technologies (USA)
- 9 Nanotubes
Elizabeth A. Dobisz, Hitachi Global Storage Technologies (USA)
- 10 Nanowires, Nanofibers, and Nanorods
André-Jean Attias, Université Pierre et Marie Curie (France)
- 11 Optofluidics
Demetri Psaltis, École Polytechnique Fédérale de Lausanne
(Switzerland)
Yehaiahu Fainman, University of California, San Diego (USA)
- 12 Nanoprocessing Technologies and Nanosystems for Medical
Applications
Frederic Zenhausern, Arizona State University (USA)

Introduction

This volume features contributions from scientists and engineers in the general area of nanoengineering. Over the past couple of years, mature technologies such as logic, memory, and data storage have been rapidly thrust into the sub-100nm regime. Existing processes of record have been extended well beyond the ranges deemed feasible or reliable. New technologies such as biotechnology, medical nanosystems, 3D sensors, 3D displays, systems on a chip, optofluidics, nanophotonics, and molecular electronics and optics are emerging. The upcoming synthesized nanomaterials, nanotubes, and nanowires, offer extremely attractive physical features and great opportunities. Continuing improvements in the design and fabrication of micro/nano/quantum-scale optical elements have driven the development of passive and active miniature optical components with applications in ever more diverse areas of photonics. These areas include optical communication, neural systems, optical information processing, optical computing, optical storage, optical scanning, smart pixel arrays, information display, imaging, printing, medical diagnosis, and chemical and biological sensing. Emerging nanotechnologies present new opportunities and challenges in materials processing, device design, and integration. Drivers for commercial deployment include function, performance, reliability, space, and cost.

Papers in these proceedings include discussions of materials nanoengineering, properties of nanostructures, innovative patterning and processing techniques, micro/nano/quantum optics, and fabrication and packaging of miniature devices. Some papers describe the refinement of existing schemes and processes, while others introduce novel concepts and new designs. Papers from academic and research institutions push the state of the art in miniaturization, level of integration, and performance figures of merit, and papers from the industry emphasize design criteria and manufacturing methods that result in practical components and systems that can be deployed commercially.

Although this volume cannot include all the recent important work in the vast field of nanoengineering, it does cover a significant cross-section of the advances happening globally in areas where nanoengineering is making an impact. We hope these papers by world-renown experts serve the purpose of bringing the readers up to date on the state of the art in this fast-growing and exciting field.

Elizabeth A. Dobisz
Louay A. Eldada

