# PROCEEDINGS OF SPIE

# Nanosensors, Biosensors, and Info-Tech Sensors and Systems 2014

**Vijay K. Varadan** Editor

10–12 March 2014 San Diego, California, United States

Sponsored by SPIE

Cosponsored by American Society of Mechanical Engineers (United States)

Cooperating Organizations Intelligent Materials Forum (Japan) Jet Propulsion Laboratory (United States) National Science Foundation (United States)

Published by SPIE

Volume 9060

Proceedings of SPIE 0277-786X, V. 9060

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

Nanosensors, Biosensors, and Info-Tech Sensors and Systems 2014, edited by Vijay K. Varadan, Proc. of SPIE Vol. 9060, 906001 · © 2014 SPIE · CCC code: 0277-786X/14/\$18 · doi: 10.1117/12.2064704

Proc. of SPIE Vol. 9060 906001-1

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 Nanosensors, Biosensors, and Info-Tech Sensors and Systems 2014, edited by Vijay K. Varadan, Proceedings of SPIE Vol. 9060 (SPIE, Bellingham, WA, 2014) Article CID Number.

ISSN: 0277-786X ISBN: 9780819499868

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.



**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

#### **KEYNOTE SESSION I**

9060 02 Nonlinear plasmonics with Kerr-like media for sensing (Keynote Paper) [9060-1] S. H. Crutcher, P. B. Ruffin, E. Edwards, C. L. Brantley, U.S. Army Research, Development and Engineering Command (United States)

#### NANOSENSORS AND SYSTEMS I

- 9060 03 Metallic single-walled, carbon nanotube temperature sensor with self heating (Invited Paper) [9060-2]
   K. M. Mohsin, Y. M. Banadaki, A. Srivastava, Louisiana State Univ. (United States)
- 9060 04 Small-area decimators for delta-sigma video sensors [9060-3] E. Azabache Villar, O. Skorka, D. Joseph, Univ. of Alberta (Canada)
- 9060 05 **Oxygen sensing glucose biosensors based on alginate nano-micro systems** [9060-4] R. Chaudhari, A. Joshi, R. Srivastava, Indian Institute of Technology Bombay (India)

#### **KEYNOTE SESSION II**

9060 06 Boron nitride nanotube: synthesis and applications (Keynote Paper) [9060-5]
A. L. Tiano, C. Park, National Institute of Aerospace (United States); J. W. Lee, H. H. Luong, NASA Langley Research Ctr. (United States); L. J. Gibbons, S.-H. Chu, S. I. Applin, National Institute of Aerospace (United States); P. Gnoffo, S. Lowther, NASA Langley Research Ctr. (United States); H. J. Kim, National Institute of Aerospace (United States); P. M. Danehy, J. A. Inman, S. B. Jones, NASA Langley Research Ctr. (United States); S. A. Thibeault, NASA Langley Research Ctr. (United States); V. Yamakov, National Institute of Aerospace (United States); K. E. Wise, J. Su, C. C. Fay, NASA Langley Research Ctr. (United States)

#### NANOSENSORS AND SYSTEMS II

- 9060 07 A new low-cost, thick-film metallization transfer process onto PDMS using a sacrificial copper seed (Invited Paper) [9060-6]
   D. Hilbich, Simon Fraser Univ. (Canada); A. Khosla, Concordia Univ. (Canada); L. Shannon, B. L. Gray, Simon Fraser Univ. (Canada)
- 9060 08 Synthesis and characterization of graphene/cellulose nanocomposite [9060-7] A. Kafy, M. Yadav, K. Kumar, S. Mun, X. Gao, J. Kim, Inha Industrial Technology Complex (Korea, Republic of)

#### NANO- AND MICRO-SYSTEMS IN MEDICINE AND HEALTHCARE I

- 9060 0A Low-cost near-infrared measurement of subcutaneous fat for newborn malnutrition [9060-9] A. L. McEwan, The Univ. of Sydney (Australia); S. Bian, The Univ. of Sydney (Australia) and The Univ. of Oxford (United Kingdom); G. D. Gargiulo, Univ. of Western Sydney (Australia); R. Morhard, The Univ. of Sydney (Australia) and Swiss Federal Institute of Technology, Zürich (Switzerland); P. Jones, F. H. Mustafa, B. E. Bek, H. E. Jeffery, The Univ. of Sydney (Australia)
- 9060 0D Neural activity based biofeedback therapy for Autism spectrum disorder through wearable wireless textile EEG monitoring system [9060-12]
   A. Sahi, Sam Higginbottom Institute of Agriculture, Technology and Sciences (India) and Deemed Univ. (India); P. Rai, S. Oh, M. Ramasamy, Univ. of Arkansas (United States); R. E. Harbaugh, The Pennsylvania State Univ. (United States); V. K. Varadan, Univ. of Arkansas (United States), The Pennsylvania State Univ. (United States), and Global Institute of Nanotechnology in Engineering and Medicine Inc. (United States)
- 9060 OE Wireless sleep monitoring headband to identify sleep and track fatigue [9060-13] M. Ramasamy, S. Oh, Univ. of Arkansas (United States); V. K. Varadan, Univ. of Arkansas (United States), Pennsylvania State Univ. (United States), and Global Institute of Nanotechnology in Engineering and Medicine Inc. (United States)
- 9060 OF A graphene field effect transistor for high temperature sensing applications (Invited Paper) [9060-32]
   Y. M. Banadaki, K. M. Mohsin, A. Srivastava, Louisiana State Univ. (United States)

#### **KEYNOTE SESSION III**

- 9060 0G **CMOS digital pixel sensors: technology and applications (Keynote Paper)** [9060-15] O. Skorka, D. Joseph, Univ. of Alberta (Canada)
- 9060 OH Molecular dynamics study of phonon screening in graphene (Invited Paper) [9060-16] B. Javvaji, D. Roy Mahapatra, S. Raha, Indian Institute of Science (India)

#### NANO- AND MICRO-SYSTEMS IN MEDICINE AND HEALTHCARE II

- 9060 0J Antibacterial polyelectrolyte-coated Mg alloys for biomedical applications [9060-18] Md. S. Seraz, R. Asmatulu, Z. Chen, M. Ceylan, A. Mahapatro, S. Y. Yang, Wichita State Univ. (United States)
- 9060 0K **Efficient heart beat detection using embedded system electronics** [9060-19] M. Ramasamy, S. Oh, Univ. of Arkansas (United States); V. K. Varadan, Univ. of Arkansas (United States), Pennsylvania State Univ. (United States), and Global Institute of Nanotechnology in Engineering and Medicine Inc. (United States)
- 9060 OL Smart insole sensors for sports and rehabilitation [9060-20] T. Tamm, K. Pärlin, T. Tiimus, K. Leemets, T. Terasmaa, I. Must, Univ. of Tartu (Estonia)

9060 0M Non-destructive examination system of vitreous body [9060-21]
 T. Shibata, J. Gong, Y. Watanabe, M. H. Kabir, M. Makino, H. Furukawa, K. Nishitsuka, Yamagata Univ. (Japan)

#### **KEYNOTE SESSION IV**

 9060 0N Smart and functional polymer materials for smart and functional microfluidic instruments (Keynote Paper) [9060-22]
 B. L. Gray, Simon Fraser Univ. (Canada)

#### NANOCOMPOSITES I

- 9060 00 Flexible touchpads based on inductive sensors using embedded conductive composite polymer [9060-23]
   A. Rahbar, M. Rahbar, B. L. Gray, Simon Fraser Univ. (Canada)
- 9060 OP **FITC-tagged macromolecule-based alginate microspheres for urea sensoring** [9060-24] A. Joshi, R. Chaudhari, R. Srivastava, Indian Institute of Technology Bombay (India)
- 9060 0Q Strain sensor based on cellulose ZnO hybrid nanocomposite [9060-25] H.-U. Ko, G.-Y. Yun, J. H. Kim, J. Kim, Inha Univ. (Korea, Republic of)

#### NANOCOMPOSITES II

- 9060 0S Paper like cellulose-ZnO hybrid nanocomposite and its photoelectrical behavior [9060-27]
   S. Mun, H.-U. Ko, Inha Univ. (Korea, Republic of); B.-W. Kang, Samsung Electro-Mechanics (Korea, Republic of); J. Kim, Inha Univ. (Korea, Republic of)
- 9060 0U Screen printable flexible conductive nanocomposite polymer with applications to wearable sensors [9060-29]
   D. Chung, Simon Fraser Univ. (Canada); A. Khosla, Concordia Univ. (Canada); B. L. Gray, Simon Fraser Univ. (Canada)

#### **KEYNOTE SESSION V**

9060 0Y Printing nanotube/nanowire for flexible microsystems (Keynote Paper) [9060-31] R. P. Tortorich, J.-W. Choi, Louisiana State Univ. (United States)

#### NANOCOMPOSITES AND ACTUATORS

9060 16 **Cellulose based soft gel like actuator for reconfigurable lens array (Invited Paper)** [9060-39] K. K. Sadasivuni, M. Yadav, X. Gao, S. Mun, J. Kim, Inha Univ. (Korea, Republic of)

## 9060 17 Transparent and flexible haptic array actuator made with cellulose acetate for tactile sensation [9060-40]

M. Mohiuddin, H.–C. Kim, Inha Univ. (Korea, Republic of); S. Y. Kim, Korea Univ. of Technology and Education (Korea, Republic of); J. Kim, Inha Univ. (Korea, Republic of)

9060 18 PZT-actuated, 2D optical scanning image acquisition (Invited Paper) [9060-41]
 K. Gu, Univ. of Washington (United States); K.-R. Lin, National Cheng Kung Univ. (Taiwan);
 W.-C. Wang, Univ. of Washington (United States) and National Cheng-Kung Univ. (Taiwan)

#### MICROWAVE, RF, METAMATERIALS, AND OPTICAL APPLICATIONS

9060 19 **Development of electrical impedance tomography of microwave ablation (Invited Paper)** [9060-42] A. McEwan, The Univ. of Sydney (Australia) and Kyung Hee Univ. (Korea, Republic of);

A. McEwan, The Univ. of Syaney (Australia) and Kyung Hee Univ. (Korea, Republic of); H. Wi, Kyung Hee Univ. (Korea, Republic of); D. T. Nguyen, P. Jones, The Univ. of Sydney (Australia); V. Lam, The Univ. of Sydney (Australia) and Westmead Hospital (Australia); W. J. Hawthorne, M. A. Barry, Westmead Hospital (Australia); T. I. Oh, Kyung Hee Univ. (Korea, Republic of)

9060 1 A Parylene-C passivation and effects on rectennas' wireless power transfer performance [9060-43]

C. Cooper, K. Eldridge, M. H. Kim, H. Yoon, Norfolk State Univ. (United States); S. H. Choi, NASA Langley Research Ctr. (United States); K. D. Song, Norfolk State Univ. (United States)

- 9060 1B Efficient RF energy harvesting by using a fractal structured rectenna system [9060-44]
   S. Oh, M. Ramasamy, Univ. of Arkansas (United States); V. K. Varadan, Univ. of Arkansas (United States), Pennsylvania State Univ. (United States), and Global Institute of Nanotechnology in Engineering and Medicine Inc. (United States)
- 9060 1C 3D scanning of internal structure in gel engineering materials with visual scanning microscopic light scattering [9060-45]
   Y. Watanabe, J. Gong, M. Masato, M. H. Kabir, H. Furukawa, Yamagata Univ. (Japan)
- 9060 1D Yttrium oxide based three dimensional metamaterials for visible light cloaking [9060-46] P. Rai, P. S. Kumar, V. K. Varadan, Univ. of Arkansas (United States); P. Ruffin, C. Brantley, E. Edwards, U.S. Army Research, Development and Engineering Command (United States)

#### POSTER SESSION

- 9060 1F Lateral migration of particles in the Newtonian fluid [9060-48] M. Makino, Yamagata Univ. (Japan)
- 9060 1G Experimental and numerical study of cellulose-based electro-active paper energy harvester (Invited Paper) [9060-50]
   Z. Abas, H. S. Kim, Dongguk Univ. (Korea, Republic of); L. Zhai, J. Kim, Inha Univ. (Korea, Republic of)
- 9060 1 J Surface acoustic wave device for chemical and biological applications [9060-54] G.-H. Kim, Y.-J. Lee, D. Jung, J.-H. Kim, INHA Univ. (Korea, Republic of)

9060 1LPowering nanorobotic devices: challenges and future strategies [9060-58]K. M. Sankar, Accendere KMS (Knowledge Management Services) Labs. (India)

Author Index

### **Conference Committee**

Symposium Chairs

Victor Giurgiutiu, University of South Carolina (United States) Christopher S. Lynch, University of California, Los Angeles (United States)

#### Symposium Co-chairs

Jayanth N. Kudva, NextGen Aeronautics, Inc. (United States) Theodoros E. Matikas, University of Ioannina (Greece)

#### Conference Chair

Vijay K. Varadan, University of Arkansas (United States)

#### Conference Co-chairs

Jaehwan Kim, Inha University (Korea, Republic of) Kyo D. Song, Norfolk State University (United States) Sang H. Choi, NASA Langley Research Center (United States) Yeonjoon Park, National Institute of Aerospace (United States)

#### Conference Program Committee

Anja Boisen, Technical University of Denmark (Denmark) Christina L. Brantley, U.S. Army Research, Development and Engineering Command (United States) Natalie Clark, NASA Langley Research Center (United States) Dileepan Joseph, University of Alberta (Canada) Sam Kassegne, San Diego State University (United States) Kimiya Komurasaki, The University of Tokyo (Japan) Ajit Khosla, Simon Fraser University (Canada) Kunik Lee, Federal Highway Administration Turner Fairbank Highway Research Center (United States) Uhn Lee, Gachon University Gil Medical Center (Korea, Republic of) Xinxin Li, Shanghai Institute of Microsystem and Information Technology (China) Yanjian Liao, Chongging University (China) **Samuel C. Lee**, The University of Oklahoma (United States) **D. Roy Mahapatra**, Indian Institute of Science (India) Parag Ganapathi Patil, University of Michigan Health System (United States)

Ilkwon Oh, KAIST (Korea, Republic of)
Aswini K. Pradhan, Norfolk State University (United States)
Paul B. Ruffin, U.S. Army Research, Development and Engineering Command (United States)
Ashok Srivastava, Louisiana State University (United States)
Tauno Vaha-Heikkila, VTT Technical Research Center of Finland (Finland)
W-C. Wang, University of Washington (United States)
Richard K. Watt, Brigham Young University (United States)
Hargsoon Yoon, Norfolk State University (United States)
T. C. Yih, California State Univ., Long Beach (United States)
Ming Zhou, Suzhou Institute of Nano-tech and Nano-bionics (China)

#### Session Chairs

- Keynote Session I
   Prashanth S. Kumar, University of Arkansas (United States)
- 2 Nanosensors and Systems I **Prashanth S. Kumar**, University of Arkansas (United States)
- 3 Keynote Session II Sang H. Choi, NASA Langley Research Center (United States)
- 4 Nanosensors and Systems II Hargsoon Yoon, Norfolk State University (United States)
- 5 Nano- and Micro-Systems in Medicine and Healthcare I **Prashanth S. Kumar**, University of Arkansas (United States)
- Keynote Session III
   Daniel Hilbich, Simon Fraser University (Canada)
- 7 Nano- and Micro-Systems in Medicine and Healthcare II **Prashanth S. Kumar**, University of Arkansas (United States)
- 8 Keynote Session IV Ajit Khosla, Concordia University (Canada)
- 9 Nanocomposites I
   Prashanth S. Kumar, University of Arkansas (United States)
- 10 Nanocomposites II **Prashanth S. Kumar**, University of Arkansas (United States)
- 11 Keynote Session VMouli Ramasamy, University of Arkansas (United States)

- 12 Fabrication and Characterization Daniel Hilbich, Simon Fraser University (Canada)
- 13 Keynote Session VISang H. Choi, NASA Langley Research Center (United States)
- 14 Nanocomposites and Actuators **Prashanth S. Kumar**, University of Arkansas (United States)
- 15 Microwave, RF, Metamaterials, and Optical Applications **Prashanth S. Kumar**, University of Arkansas (United States)