

# PROCEEDINGS OF SPIE

## ***Nanosensors and Microsensors for Bio-Systems 2008***

**Vijay K. Varadan**  
*Editor*

**11–13 March 2008**  
**San Diego, California, USA**

*Sponsored by*  
SPIE

*Cosponsored by*  
American Society of Mechanical Engineers (USA)

*Cooperating Organizations*  
Intelligent Materials Forum (Japan)  
Jet Propulsion Laboratory (USA)  
National Science Foundation (USA)

*Published by*  
SPIE

**Volume 6931**

Proceedings of SPIE, 0277-786X, v. 6931

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 *Nanosensors and Microsensors for Bio-Systems 2008*, edited by Vijay K. Varadan, Proceedings of SPIE Vol. 6931 (SPIE, Bellingham, WA, 2008) Article CID Number.

ISSN 0277-786X  
ISBN 9780819471178

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 © 2008, 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](http://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/08/\$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](http://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 *Symposium Committee*  
ix *Conference Committee*

---

## SESSION 1 KEYNOTE SESSION I

---

- 6931 02 **Innovative smart micro sensors for Army weaponry applications (Keynote Paper)** [6931-01]  
P. B. Ruffin, C. Brantley, E. Edwards, U.S. Army Research, Development, and Engineering Command (USA)

---

## SESSION 2 NANO AND MICRO DEVICES FOR BIOSENSING I

---

- 6931 04 **Development of an IrO<sub>x</sub> micro pH sensor array on flexible polymer substrate** [6931-03]  
W.-D. Huang, J. Wang, T. Ativanichayaphong, Univ. of Texas at Arlington (USA); M. Chiao, Univ. of British Columbia (Canada); J. C. Chiao, Univ. of Texas at Arlington (USA)
- 6931 05 **Fabrication of flexible and disposable carbon paste-based electrodes and their electrochemical sensing** [6931-04]  
L. Aryasomayajula, V. K. Varadan, Univ. of Arkansas (USA)

---

## SESSION 3 KEYNOTE SESSION II

---

- 6931 06 **Nanoscale materials for engineering and medicine (Keynote Paper)** [6931-05]  
G. Maheshwari, N. Mallik, J. Abot, A. Song, E. Head, M. Dadhania, V. Shanov, C. Jayasinghe, P. Salunke, L. Lee, D. Hurd, Y. Yun, Univ. of Cincinnati (USA); S. Yarmolenko, J. Sankar, North Carolina A&T State Univ. (USA); P. Phillips, R. A. Komoroski, W.-J. Chu, A. Bhattacharya, N. Watts, M. J. Schulz, Univ. of Cincinnati (USA)

---

## SESSION 4 NANOWIRE, NANOTUBES, AND NANOSTRUCTURES

---

- 6931 08 **Current transport modeling in carbon nanotube field effect transistors (CNT-FETs) and bio-sensing applications** [6931-08]  
J. M. Marulanda, A. Srivastava, Louisiana State Univ. (USA); A. K. Sharma, Air Force Research Lab. (USA)

---

## SESSION 5 MICRO/NANO DEVICES AND MEMS

---

- 6931 09 **Conductive nanoparticles in electro activated shape memory polymer sensor and actuator** [6931-09]  
J. Leng, H. Lu, Y. Liu, S. Du, Harbin Institute of Technology (China)
- 6931 0A **Schottky diode made on cellulose paper with PEDOT:PSS and pentacene** [6931-10]  
Y. Chen, K. J. Han, K. H. Yoo, K. S. Kang, J. Kim, Inha Univ. (South Korea)

- 6931 0B **Pre- and post-machining and release residual stresses in microelectromechanical systems (MEMS)** [6931-11]  
M. Vechery, Univ. of Maryland, College Park (USA) and Army Research Lab. (USA); A. Dick, B. Balachandran, Univ. of Maryland, College Park (USA); M. Dubey, Army Research Lab. (USA)
- 6931 0C **Micro-contact printing method for metal micro-patterning with PUA** [6931-12]  
K. J. Han, Y. Chen, K. H. Yoo, K. S. Kang, J. Kim, Inha Univ. (South Korea)
- 6931 0D **Study on shape recovery speed of SMP, SMP composite, and SMP foam** [6931-13]  
X. Wu, Y. Liu, J. Leng, Harbin Institute of Technology (China)

---

**SESSION 6 NANO AND MICRO DEVICES FOR BIOSENSING II**

---

- 6931 0F **Synthesis of vertically aligned carbon nanotubes, magnetic nanotubes, and magnetic CNTs for cellular growth and detection** [6931-15]  
K. Aatre, J. Xie, L. F. Chen, J. K. Abraham, HiDEC, Univ. of Arkansas (USA); V. K. Varadan, HiDEC, Univ. of Arkansas (USA) and Univ. of Arkansas for Medical Sciences (USA)

---

**SESSION 7 NANO BIOSENSORS**

---

- 6931 0G **Feasibility of e-paper made with cellulose (Invited Paper)** [6931-16]  
K. H. Yoo, K. J. Han, Y. Chen, K. S. Kang, J. Kim, Inha Univ. (South Korea)
- 6931 0H **Development of potassium ion sensors using polypyrrole electrodes on a polyimide substrate** [6931-17]  
V. Ramachandran, H. Yoon, V. K. Varadan, Univ. of Arkansas (USA)
- 6931 0I **Ion-sensitive field effect transistors for pH and potassium ion concentration sensing: towards detection of myocardial ischemia** [6931-18]  
P. Rai, S. Jung, T. Ji, V. K. Varadan, Univ. of Arkansas (USA)
- 6931 0J **Carbon nanotube strain sensors for wearable patient monitoring applications** [6931-19]  
J. K. Abraham, L. Aryasomayajula, A. Whitchurch, Univ. of Arkansas (USA); V. K. Varadan, Univ. of Arkansas (USA) and Univ. of Arkansas for Medical Sciences (USA)

---

**SESSION 8 SYSTEMS APPLICATION**

---

- 6931 0K **Development of a high performance peristaltic micropump** [6931-20]  
M. Pham, N. S. Goo, Konkuk Univ. (South Korea)
- 6931 0L **Study on microwave power via rectenna for airship applications** [6931-21]  
T. B. Stout, P. Basappa, F. Williams, K. D. Song, Norfolk State Univ. (USA); J. Kim, Inha Univ. (South Korea)
- 6931 0M **Millimeter wave identification: concept, applications, and demonstrations** [6931-23]  
T. Vähä-Heikkilä, P. Pursula, VTT-MilliLab. (Finland); A. Müller, D. Neculoiu, IMT-Bucharest (Romania); G. Konstantinidis, FORTH-IESL-MRG Heraklion (Greece); J. Tuovinen, VTT-MilliLab. (Finland)

- 6931 ON **MEMS-based liquid lens for capsule endoscope** [6931-27]  
S. W. Seo, BNP Science Co., Ltd. (South Korea) and Korea Univ. (South Korea); S. Han, Hoseo Univ. (South Korea); J. H. Seo, Y. M. Kim, M. S. Kang, N. G. Min, Korea Univ. (South Korea); W. B. Choi, BNP Science Co., Ltd. (South Korea); M. Y. Sung, Korea Univ. (South Korea)
- 6931 OO **2-D fiberoptic scanning microdisplay system** [6931-22]  
W.-C. Wang, C.-L. Tsui, F.-H. Lau, A. Perez, Univ. of Washington (USA); W.-C. Chuang, National Formosa Univ. (Taiwan)
- 6931 OP **Growth of CNT array for physiological monitoring applications** [6931-28]  
J. K. Radhakrishnan, H. Bhusan, P. S. Pandian, K. U. B. Rao, V. C. Padaki, Defence Research & Development Organisation (India); K. Aatre, J. Xie, J. K. Abraham, Univ. of Arkansas (USA); V. K. Varadan, Univ. of Arkansas (USA) and Univ. of Arkansas for Medical Sciences (USA)
- 6931 OQ **Low noise multi-channel biopotential wireless data acquisition system for dry electrodes** [6931-29]  
P. S. Pandian, Defence Research and Development Organisation (India); A. K. Whitchurch, J. K. Abraham, Univ. of Arkansas (USA); H. Bhusan Baskey, J. K. Radhakrishnan, Defence Research and Development Organisation (India); V. K. Varadan, Univ. of Arkansas (USA) and Univ. of Arkansas for Medical Sciences (USA); V. C. Padaki, K. U. Bhasker Rao, Defence Research and Development Organisation (India); R. E. Harbaugh, Penn State College of Medicine (USA)

---

#### POSTER SESSION

- 6931 OR **Microwave applications of carbon nanotubes: nano-antennas and nano-switches** [6931-07]  
A. Ziaei, M. Le Baillif, S. Demoustier, E. Minoux, Thales Research & Technology (France)
- 6931 OS **A low-frequency vibration-to-electrical energy harvester** [6931-24]  
M. Zhang, D. Brignac, P. Ajmera, K. Lian, Louisiana State Univ. (USA)

*Author Index*



# Symposium Committee

## *Symposium Chairs*

**Alison B. Flatau**, University of Maryland, College Park (USA)  
**George Y. Baaklini**, NASA Glenn Research Center (USA)  
**Donald J. Leo**, Virginia Polytechnic Institute and State University (USA)  
**Kara J. Peters**, North Carolina State University (USA)

## *Executive Committee*

**Alison B. Flatau**, University of Maryland, College Park (USA)  
**George Y. Baaklini**, NASA Glenn Research Center (USA)  
**Donald J. Leo**, Virginia Polytechnic Institute and State University (USA)  
**Kara J. Peters**, North Carolina State University (USA)  
**Mehdi Ahmadian**, Virginia Polytechnic Institute and State University (USA)  
**Yoseph Bar-Cohen**, Jet Propulsion Laboratory (USA)  
**Emilio P. Calius**, Industrial Research Ltd. (New Zealand)  
**Marcelo J. Dapino**, The Ohio State University (USA)  
**L. Porter Davis**, Honeywell, Inc. (USA)  
**Michael A. Demetriou**, Worcester Polytechnic Institute (USA)  
**Aaron A. Diaz**, Pacific Northwest National Laboratory (USA)  
**Wolfgang Ecke**, IPHT Jena (Germany)  
**Mehrdad N. Ghasemi-Nejhad**, University of Hawai'i at Manoa (USA)  
**Victor Giurgiutiu**, University of South Carolina (USA)  
**B. Kyle Henderson**, Air Force Research Laboratory (USA)  
**Kumar V. Jata**, Air Force Research Laboratory (USA)  
**Tribikram Kundu**, The University of Arizona (USA)  
**Douglas K. Lindner**, Virginia Polytechnic Institute and State University (USA)  
**Ajit K. Mal**, University of California, Los Angeles (USA)  
**M. Brett McMickell**, Honeywell, Inc. (USA)  
**Norbert G. Meyendorf**, Fraunhofer-Institut für Zerstörungsfreie Prüfverfahren (Germany) and University of Dayton (USA)  
**Zoubeida Ounaies**, Texas A&M University (USA)  
**Andrei M. Shkel**, University of California, Irvine (USA)  
**Peter J. Shull**, The Pennsylvania State University (USA)  
**Masayoshi Tomizuka**, University of California, Berkeley (USA)  
**Vijay K. Varadan**, University of Arkansas (USA)  
**Dietmar W. Vogel**, Fraunhofer-Institut für Zuverlässigkeit und Mikrointegration (Germany)  
**H. Felix Wu**, National Institute of Standards and Technology (USA)  
**Chung-Bang Yun**, Korea Advanced Institute of Science and Technology (South Korea)



# Conference Committee

## *Conference Chair*

**Vijay K. Varadan**, University of Arkansas (USA) and University of Arkansas for Medical Sciences

## *Conference Cochair*

**Andrei M. Shkel**, University of California, Irvine (USA)

## *Program Committee*

**Pratul K. Ajmera**, Louisiana State University (USA)  
**Steven W. Arms**, MicroStrain, Inc. (USA)  
**Joachim F. Baumann**, Siemens AG (Germany)  
**Bharat Bhushan**, The Ohio State University (USA)  
**James L. Blackshire**, Air Force Research Laboratory (USA)  
**D. L. Carroll**, Wake Forest University (USA)  
**Jung-Chih Chiao**, The University of Texas at Arlington (USA)  
**Sang H. Choi**, NASA Langley Research Center (USA)  
**Jürg Dual**, ETH Zürich (Switzerland)  
**Andras Der**, Biological Research Center (Hungary)  
**Lukas M. Eng**, Technische Universität Dresden (Germany)  
**Cläs-Göran Granqvist, Sr.**, Uppsala University (Sweden)  
**Peter Heszler, Sr.**, Uppsala University (Sweden)  
**Michael H. W. Hoffmann**, Universität Ulm (Germany)  
**Laszlo B. Kish**, Texas A&M University (USA)  
**Nikhil A. Koratkar**, Rensselaer Polytechnic Institute (USA)  
**Shriram Kumar**, University of Arkansas (USA)  
**Chih-Hao Lee**, National Tsing Hua University (Taiwan)  
**Eric Lifshin**, SUNY/University at Albany (USA)  
**Cheng Luo**, Louisiana Tech University (USA)  
**William H. Marlow**, Texas A&M University (USA)  
**Conrad Masterson**, Nanotechnology Foundation of Texas, Inc. (USA)  
**Kathryn M. McGrath**, University of Otago (New Zealand)  
**Norbert G. Meyendorf**, Fraunhofer-Institut für Zerstörungsfreie Prüfverfahren (Germany)  
**Bernd Michel**, Fraunhofer-Institut für Zuverlässigkeit und Mikrointegration (Germany)  
**Y. Eugene Pak**, Consultant (South Korea)  
**Yeonjoon Park**, NASA Langley Research Center (USA)  
**Yongrae Roh**, Kyungpook National University (South Korea)  
**Paul B. Ruffin**, U.S. Army Aviation and Missile Research, Development and Engineering Center (USA)

**Gabor Schmera**, Space and Naval Warfare Systems Center, San Diego (USA)  
**Ananth Selvarajan**, Indian Institute of Science (India)  
**Kyo D. Song**, Norfolk State University (USA)  
**Ashok Srivastava**, Louisiana State University (USA)  
**Maria Strømme**, Uppsala University (Sweden)  
**Joseph A. Turner**, University of Nebraska, Lincoln (USA)  
**Lode K. Vandamme**, Technische Universiteit Eindhoven (Netherlands)  
**Tian-Bing Xu**, National Institute of Aerospace (USA)  
**Kazushi Yamanaka**, Tohoku University (Japan)  
**Kaiming Ye**, University of Arkansas (USA)

### *Session Chairs*

- 1 Keynote Session I  
**Vijay K. Varadan**, University of Arkansas (USA) and University of Arkansas for Medical Sciences
- 2 Nano and Micro Devices for Biosensing I  
**Z. Ryan Tian**, University of Arkansas (USA)
- 3 Keynote Session II  
**Vijay K. Varadan**, University of Arkansas (USA) and University of Arkansas for Medical Sciences
- 4 Nanowire, Nanotubes, and Nanostructures  
**Ashok Srivastava**, Louisiana State University (USA)
- 5 Micro/Nano Devices and MEMS  
**Jae Hyung Kim**, Inje University (South Korea)  
**Hargsoon Yoon**, University of Arkansas (USA)
- 6 Nano and Micro Devices for Biosensing II  
**Vijay K. Varadan**, University of Arkansas (USA) and University of Arkansas for Medical Sciences
- 7 Nano Biosensors  
**Jose K. Abraham**, University of Arkansas (USA)  
**Bhanu L. Aryasomayajula**, University of Arkansas (USA)
- 8 Systems Application  
**Hargsoon Yoon**, University of Arkansas (USA)  
**Kyo D. Song**, Norfolk State University (USA)