

PROCEEDINGS OF SPIE

Oxide-based Materials and Devices

Ferechteh Hosseini Teherani
David C. Look
Cole W. Litton
David J. Rogers
Editors

24–27 January 2010
San Francisco, California, United States

Sponsored and Published by
SPIE

Volume 7603

Proceedings of SPIE, 0277-786X, v. 7603

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 *Oxide-based Materials and Devices*, edited by Ferechteh Hosseini Teherani, David C. Look, Cole W. Litton, David J. Rogers, Proceedings of SPIE Vol. 7603 (SPIE, Bellingham, WA, 2010) Article CID Number.

ISSN 0277-786X
ISBN 9780819479990

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.

The logo for SPIE Digital Library features the word "SPIE" in a bold, sans-serif font above the words "Digital Library" in a smaller, lighter font. To the right of the text is a stylized graphic consisting of three vertical bars of increasing height, resembling a bar chart or a signal waveform.

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

- ix Conference Committee
xi *In Memoriam: Cole W. Litton (Sept. 29, 1930 – Jan. 26, 2010)*

SESSION 1 ZNO-BASED MATERIALS: ELECTRONIC STRUCTURE, TRANSPORT, EMISSION, ABSORPTION, AND POLARITY I

- 7603 03 **Theory of high field carrier transport and impact ionization in ZnO (Invited Paper)** [7603-02]
F. Bertazzi, M. Penna, Boston Univ. (United States) and Politecnico di Torino (Italy); M. Goano, Politecnico di Torino (Italy); E. Bellotti, Boston Univ. (United States)
- 7603 04 **Ultrafast carrier relaxation and diffusion dynamics in ZnO (Invited Paper)** [7603-03]
C. J. Cook, Univ. of Florida (United States); S. Khan, Univ. of Illinois (United States); G. D. Sanders, Univ. of Florida (United States); X. Wang, The Univ. of Texas at Austin (United States); D. H. Reitze, Univ. of Florida (United States); Y. D. Jho, Gwangju Institute of Science and Technology (Korea, Republic of); Y.-W. Heo, J.-M. Erie, D. P. Norton, C. J. Stanton, Univ. of Florida (United States)

SESSION 2 ZNO-BASED MATERIALS: ELECTRONIC STRUCTURE, TRANSPORT, EMISSION, ABSORPTION, AND POLARITY II

- 7603 06 **Properties of zinc oxynitride films deposited by reactive magnetron sputtering at room temperature (Invited Paper)** [7603-05]
J. L. Pau, M. J. Hernández, M. Cervera, E. Ruiz, J. Piqueras, Univ. Autónoma de Madrid (Spain)
- 7603 07 **Growth and properties of nonpolar and polar MgZnO/ZnO quantum structures (Invited Paper)** [7603-06]
H. Matsui, H. Tabata, The Univ. of Tokyo (Japan)

SESSION 3 USE OF ZNO AND TCO IN PHOTOVOLTAICS

- 7603 0B **ZnO transparent conductive oxide for thin film silicon solar cells (Invited Paper)** [7603-09]
T. Söderström, D. Dominé, A. Feltrin, M. Despeisse, F. Meillaud, G. Bugnon, M. Boccard, P. Cuony, F.-J. Haug, S. Fay, S. Nicolay, C. Ballif, École Polytechnique Fédérale de Lausanne (Switzerland)
- 7603 0C **Transparent conductive oxides for organic photovoltaics (Invited Paper)** [7603-10]
G. B. Murdoch, D. Gao, M. Greiner, L. Mordoukhovski, Univ. of Toronto (Canada); J. Zhang, Z. H. Lu, Yunnan Univ. (China) and Univ. of Toronto (Canada)
- 7603 0D **Growth and characterization of ZnO-based buffer layers for CIGS solar cells (Invited Paper)** [7603-12]
T. Törndahl, A. Hultqvist, C. Platzer-Björkman, M. Edoff, Uppsala Univ. (Sweden)

- 7603 OF **Band gap engineering of ZnO for high efficiency CIGS based solar cells (Invited Paper)** [7603-14]
C. Platzer-Björkman, A. Hultqvist, J. Pettersson, T. Törndahl, Uppsala Univ. (Sweden)
- 7603 OG **Self textured transparent conductive oxide film for efficiency improvement in solar cell (Invited Paper)** [7603-15]
D. Kim, Yonsei Univ. (Korea, Republic of); J. Yi, Sungkyunkwan Univ. (Korea, Republic of); H. Kim, Yonsei Univ. (Korea, Republic of)

SESSION 4 DOPING STUDIES OF ZNO

- 7603 OJ **Hydrogen in ZnO (Invited Paper)** [7603-18]
E. V. Lavrov, Technische Univ. Dresden (Germany)
- 7603 OK **Lattice location of the group V elements Sb, As, and P in ZnO (Invited Paper)** [7603-19]
U. Wahl, Instituto Tecnológico e Nuclear (Portugal) and Univ. de Lisboa (Portugal); J. G. Correia, Instituto Tecnológico e Nuclear (Portugal), Univ. de Lisboa (Portugal) and CERN-PH (Switzerland); T. Mendonça, Univ. do Porto (Portugal); S. Decoster, Katholieke Univ. Leuven (Belgium)

SESSION 5 PROGRESS IN SPIN-BASED MATERIALS AND DEVICES

- 7603 OO **Functionalization of multiferroic oxide structures for spintronic devices (Invited Paper)** [7603-23]
C.-L. Jia, J. Berakdar, Martin-Luther Univ. Halle-Wittenberg (Germany)

SESSION 6 GROWTH AND PROPERTIES OF MULTIFUNCTIONAL OXIDES I

- 7603 OR **Atomic layer epitaxy of ZnO and TiO₂ thin films on c-plane sapphire substrate for novel oxide soft x-ray mirrors** [7603-60]
M. Murata, Y. Tanaka, H. Kumagai, Osaka City Univ. (Japan); T. Shinagawa, Osaka Municipal Technical Research Institute (Japan); A. Kobayashi, Osaka City Univ. (Japan)

SESSION 7 GROWTH AND PROPERTIES OF MULTIFUNCTIONAL OXIDES II

- 7603 OU **Interface control in BaTiO₃ based supercapacitors (Invited Paper)** [7603-28]
M. Maglione, C. Elissalde, U.-C. Chung, ICMCB CNRS, Univ. Bordeaux 1 (France)
- 7603 OV **Molecular dynamics simulation of metal oxide growth on SrTiO₃ (Invited Paper)** [7603-29]
J. L. Wohlwend, Univ. of Florida (United States); C. N. Boswell-Koller, Univ. of California, Berkeley (United States); S. R. Phillpot, S. B. Sinnott, Univ. of Florida (United States)
- 7603 OW **Enhanced transport properties in La_xMnO_{3-δ} thin films grown on SrTiO₃ substrates (Invited Paper)** [7603-30]
P. Orgiani, A. Galdi, CNR-INFM Coherentia (Italy) and Univ. of Salerno (Italy); C. Aruta, CNR-INFM Coherentia (Italy) and Univ. of Napoli (Italy); R. Ciancio, CNR-INFM National Lab. TASC (Italy); U. Lüders, R. V. K. Mangalam, W. Prellier, Lab. CRISMAT, ENSICAEN, CNRS (France); L. Maritato, CNR-INFM Coherentia (Italy) and Univ. of Salerno (Italy)

- 7603 0X **Plasmonic effects on the laser-induced metal-insulator transition of vanadium dioxide (Invited Paper)** [7603-31]
D. W. Ferrara, E. R. MacQuarrie, J. Nag, R. F. Haglund, Jr., Vanderbilt Univ. (United States)

SESSION 8 OXIDE-BASED TRANSISTORS AND TRANSPARENT ELECTRONICS I

- 7603 10 **High performance transparent thin film transistor with atomic layer deposition ZnO based active channel layer (Invited Paper)** [7603-34]
H. Kim, S. J. Lim, J.-M. Kim, D. Y. Kim, Yonsei Univ. (Korea, Republic of)
- 7603 11 **Complementary use of organic and oxide semiconductors (Invited Paper)** [7603-35]
J. H. Na, M. Kitamura, Y. Arakawa, The Univ. of Tokyo (Japan)
- 7603 13 **Review on optical and electrical properties of oxide semiconductors (Invited Paper)** [7603-11]
D. L. Kim, H. J. Kim, Yonsei Univ. (Korea, Republic of)

SESSION 9 OXIDE-BASED TRANSISTORS AND TRANSPARENT ELECTRONICS II

- 7603 14 **Floating gate memory paper transistor** [7603-37]
R. Martins, L. Pereira, P. Barquinha, N. Correia, G. Gonçalves, I. Ferreira, C. Dias, E. Fortunato, CENIMAT, Univ. Nova de Lisboa (Portugal) and CEMOP-UNINOVA (Portugal)
- 7603 15 **Oxide thin film transistors on novel flexible substrates (Invited Paper)** [7603-38]
S. J. Pearton, W. Lim, E. Douglas, F. Ren, Univ. of Florida (United States); Y. W. Heo, Kyungpook National Univ. (Korea, Republic of); D. P. Norton, Univ. of Florida (United States)
- 7603 16 **Photosensor application of amorphous InZnO-based thin film transistor (Invited Paper)** [7603-39]
P.-T. Liu, Y.-T. Chou, L.-F. Teng, National Chiao Tung Univ. (Taiwan)
- 7603 18 **Thin film transistors with wurtzite ZnO channels grown on Si₃N₄/SiO₂/Si (111) substrates by pulsed laser deposition** [7603-41]
D. J. Rogers, Nanovation SARL (France); V. E. Sandana, Nanovation SARL (France) and Northwestern Univ. (United States); F. H. Teherani, Nanovation SARL (France); M. Razeghi, Northwestern Univ. (United States)

SESSION 10 USE OF ZNO FOR UV APPLICATIONS

- 7603 1A **Optical properties of metal-semiconductor-metal ZnO UV photodetectors** [7603-43]
L. Li, Univ. of Missouri, Columbia (United States); Y. Ryu, MOXtronic, Inc. (United States); H. W. White, Univ. of Missouri, Columbia (United States) and MOXtronic, Inc. (United States); P. Yu, Univ. of Missouri, Columbia (United States)
- 7603 1B **Cubic Zn_xMg_{1-x}O and Ni_xMg_{1-x}O thin films grown by molecular beam epitaxy for deep-UV optoelectronic applications (Invited Paper)** [7603-44]
J. W. Mares, C. R. Boutwell, A. Scheurer, M. Falanga, W. V. Schoenfeld, CREOL, The College of Optics and Photonics, Univ. of Central Florida (United States)

- 7603 1D **Epitaxial MOVPE growth of highly c-axis oriented InGaN/GaN films on ZnO-buffered Si (111) substrates (Invited Paper)** [7603-46]
A. Ougazzaden, Georgia Institute of Technology Lorraine (France); D. J. Rogers, F. H. Teherani, Nanovation SARL (France); G. Orsal, T. Moudakir, S. Gaufier, LMOPS, CNRS, Univ. de Metz et SUPELEC (France); V. E. Sandana, Nanovation SARL (France); F. Jomard, Univ. de Versailles-Saint-Quentin (France); M. Abid, Georgia Institute of Technology Lorraine (France); M. Molinari, M. Troyon, Univ. of Reims Champagne-Ardennes (France); P. L. Voss, Georgia Institute of Technology Lorraine (France); D. McGrouther, J. N. Chapman, Univ. of Glasgow (United Kingdom)

SESSION 11 NANOSTRUCTURED OXIDES AND THEIR APPLICATIONS I

- 7603 1H **Nanopatterned optical and magnetic $\text{La}_{0.7}\text{Sr}_{0.3}\text{MnO}_3$ arrays: synthesis, fabrication, and properties (Invited Paper)** [7603-50]
M.-C. Wu, National Taiwan Univ. (Taiwan); C.-M. Chuang, Institute of Nuclear Energy Research (Taiwan); Y.-C. Huang, Y.-J. Wu, National Taiwan Univ. (Taiwan); K.-C. Cheng, National Taipei Univ. of Technology (Taiwan); C.-F. Lin, Y.-F. Chen, W.-F. Su, National Taiwan Univ. (Taiwan)
- 7603 1I **Multi-layered water quality sensor based on RuO_2 nanostructures (Invited Paper)** [7603-51]
S. Zhuiykov, Commonwealth Scientific and Industrial Research Organisation (Australia)

SESSION 12 NANOSTRUCTURED OXIDES AND THEIR APPLICATIONS II

- 7603 1J **Nanolithography for oxide nanoarrays and their application in medical devices (Invited Paper)** [7603-52]
R. Luttge, Univ. of Twente (Netherlands)
- 7603 1L **Effect of surface modification on the optical properties of nanocrystalline zinc oxide materials** [7603-54]
J. W. Soares, D. M. Steeves, U.S. Army Natick Soldier Research, Development & Engineering Ctr. (United States); J. Singh, J. Im, J. E. Whitten, Univ. of Massachusetts, Lowell (United States)

POSTER SESSION

- 7603 1O **Characterization of ZnO UV photoconductors on the 6H-SiC substrate** [7603-58]
L. Li, Univ. of Missouri, Columbia (United States); Y. Ryu, MOXtronics, Inc. (United States); H. W. White, Univ. of Missouri, Columbia (United States) and MOXtronics, Inc. (United States); P. Yu, Univ. of Missouri, Columbia (United States)
- 7603 1P **Structural and electrical properties of rectifying p-ZnO/n⁺-InP heterojunction** [7603-59]
A. Mandal, S. Chakrabarti, Indian Institute of Technology (India)
- 7603 1R **Post-annealing of p-type ZnO:Sb thin film grown by pulsed laser deposition** [7603-62]
Y. Yata, T. Sakano, M. Obara, Keio Univ. (Japan)

- 7603 1U **Structural and optical properties of TiO₂ thin films annealed in O₂ and N₂ gases flow** [7603-65]
S. H. Kim, T. U. Kim, D. G. Kim, H. C. Ki, Korea Photonics Technology Institute (Korea, Republic of); G.-Y. Oh, Chung-Ang Univ. (Korea, Republic of); H. J. Kim, H. J. Ko, M.-S. Han, S. Hann, H. J. Kim, Korea Photonics Technology Institute (Korea, Republic of)
- 7603 1V **Physical properties of MgZnO film grown by RF magnetron sputtering using ZnO/MgO (80/20 wt%) target** [7603-66]
K.-P. Hsueh, Vanung Univ. (Taiwan); C.-J. Tun, National Synchrotron Radiation Research Ctr. (Taiwan); H.-C. Chiu, Chang Gung Univ. (Taiwan)

Author Index

Conference Committee

Symposium Chair

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

Symposium Cochairs

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

James G. Grote, Air Force Research Laboratory (United States)

Program Track Chair

James G. Grote, Air Force Research Laboratory (United States)

Conference Chairs

Ferechteh Hosseini Teherani, Nanovation SARL (France)

David C. Look, Wright State University (United States)

Cole W. Litton, Air Force Research Laboratory - retired (United States)

David J. Rogers, Nanovation SARL (France)

Program Committee

Rodrigo Ferrão de Paiva Martins, Uninova/CEMOP (Portugal)

Elvira M. C. Fortunato, Universidade Nova de Lisboa (Portugal)

Hiroshi Fujioka, The University of Tokyo (Japan)

Michael D. Gerhold, U.S. Army Research Office (United States)

Hanns-Ulrich Habermeier, Max-Planck-Institut für Festkörperforschung
(Germany)

Masashi Kawasaki, Tohoku University (Japan)

Tatsuo Okada, Kyushu University (Japan)

Stuart S. P. Parkin, IBM Almaden Research Center (United States)

Manijeh Razeghi, Northwestern University (United States)

Donald J. Silversmith, Air Force Office of Scientific Research (United
States)

Zhong Lin Wang, Georgia Institute of Technology (United States)

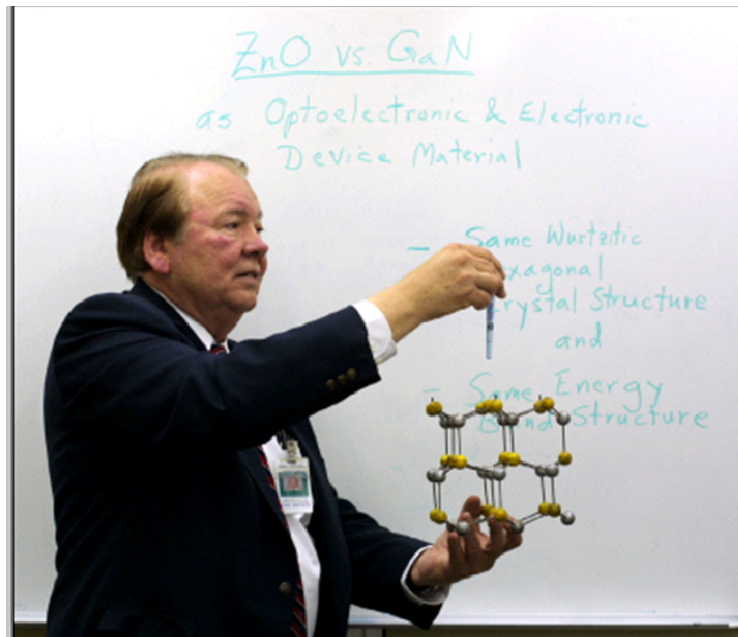
Session Chairs

- 1 ZnO-based Materials: Electronic Structure, Transport, Emission, Absorption, and Polarity I

David C. Look, Wright State University (United States)

- 2 ZnO-based Materials: Electronic Structure, Transport, Emission, Absorption, and Polarity II
David C. Look, Wright State University (United States)
- 3 Use of ZnO and TCO in Photovoltaics
David J. Rogers, Nanovation SARL (France)
Jose Luis Pau Vizcaino, Universidad Autónoma de Madrid (Spain)
- 4 Doping Studies of ZnO
Bruno Masenelli, Université Claude Bernard Lyon 1 (France)
- 5 Progress in Spin-based Materials and Devices
Chenglong Jia, Martin-Luther-Universität Halle-Wittenberg (Germany)
- 6 Growth and Properties of Multifunctional Oxides I
Hanns-Ulrich Habermeier, Max-Planck-Institut für Festkörperforschung (Germany)
Pasquale Orgiani, Università degli studi di Salerno (Italy)
- 7 Growth and Properties of Multifunctional Oxides II
Hanns-Ulrich Habermeier, Max-Planck-Institut für Festkörperforschung (Germany)
Pasquale Orgiani, Università degli studi di Salerno (Italy)
- 8 Oxide-based Transistors and Transparent Electronics I
Elvira M. C. Fortunato, Universidade Nova de Lisboa (Portugal)
Stephen J. Pearton, University of Florida (United States)
- 9 Oxide-based Transistors and Transparent Electronics II
Erica Douglas, University of Florida (United States)
Stephen J. Pearton, University of Florida (United States)
- 10 Use of ZnO for UV Applications
David J. Rogers, Nanovation SARL (France)
David C. Look, Wright State University (United States)
- 11 Nanostructured Oxides and their Applications I
Yicheng Lu, Rutgers, The State University of New Jersey (United States)
Diane M. Steeves, U.S. Army Soldier Systems Center (United States)
- 12 Nanostructured Oxides and their Applications II
Regina Luttge, Universiteit Twente (Netherlands)
Tatsuo Okada, Kyushu University (Japan)

In Memoriam



Cole W. Litton

Sept. 29, 1930 – Jan. 26, 2010

These proceedings are dedicated to the memory of Dr. Cole Litton, who passed away while attending the Photonics West 2010 symposium. The oxide semiconductor community will forever be indebted to Cole for his enthusiasm, kindness and tireless efforts to promote research into zinc oxide for optoelectronics applications.

