

Functional Metal Oxide Nanostructures

**MATERIALS RESEARCH SOCIETY
SYMPOSIUM PROCEEDINGS VOLUME 1406**

Functional Metal Oxide Nanostructures

Symposium held November 28–December 2, 2011, Boston, Massachusetts, U.S.A.

EDITORS

Alberto Vomiero

CNR IDASC Sensor Lab
Brescia, Italy

Sanjay Mathur

University of Cologne
Cologne, Germany

Zhong Lin Wang

Georgia Institute of Technology
Atlanta, Georgia, U.S.A.

Eric Wei-Guang Diau

National Chiao Tung University
Hsinchu, Taiwan



Materials Research Society
Warrendale, Pennsylvania



CAMBRIDGE
UNIVERSITY PRESS

CAMBRIDGE UNIVERSITY PRESS
Cambridge, New York, Melbourne, Madrid, Cape Town,
Singapore, São Paulo, Delhi, Mexico City

Cambridge University Press
32 Avenue of the Americas, New York, NY 10013-2473, USA

www.cambridge.org
Information on this title: www.cambridge.org/9781605113838

Materials Research Society
506 Keystone Drive, Warrendale, PA 15086, USA
<http://www.mrs.org>

© Materials Research Society 2012

This publication is in copyright. Subject to statutory exception and to the provisions of relevant collective licensing agreements, no reproduction of any part may take place without the written permission of Cambridge University Press.

This book has been registered with Copyright Clearance Center, Inc. For further information please contact the Copyright Clearance Center, Salem, Massachusetts.

First published 2012

CODEN: MRSPDH

ISBN: 978-1-60511-383-8 Hardback

Cambridge University Press has no responsibility for the persistence or accuracy of URLs for external or third-party Internet Web sites referred to in this publication and does not guarantee that any content on such Web sites is, or will remain, accurate or appropriate.

CONTENTS

Preface ix

Materials Research Society Symposium Proceedings xi

SYNTHESIS OF NANOSTRUCTURED OXIDES

* **Zinc Oxide and Copper Oxide Nanostructures: Fundamentals and Applications.**3
Magnus Willander, Omer Nur, Gul Amin,
A. Zainelabdin, and S. Zaman

Characterization of Un-stabilized Orthorhombic Zirconia Synthesized at Ambient Temperature and Pressure11
Miriam P. Trubelja, Donald Potter, Claudia Rawn,
Karren More, and Joseph J. Helble

Surface Physical Property of the CrO₂ Thin Films Prepared using a Closed Chemical Vapor Deposition Method17
Y. Muraoka, S. Yoshida, T. Wakita,
M. Hirai, and T. Yokoya

Direct Synthesis of Pure Radiative VO₂ (M) Plate Like Structures Via Hydrothermolysis at Low Temperature.23
A. Simo, L.C. Edomwonyi-Otu, R. Madjoe,
and M. Maaza

Microstructure Dependence of Hydrogen Sensing Properties of Palladium Functionalized Tungsten Oxide Films.29
Meng Zhao, Jian-Xing Huang, and Chung-Wo Ong

Synthesis of ZnO Nanowires by Hydrothermal Technique for Integration into Chalcopyrite Thin Films.35
H. Karaagac, M. Parlak, and M. Saif Islam

Reusable Hybride CoFe₂O₄-ZnO Hollow Nanosphere Photocatalysts.41
A. Wilson, S.R. Mishra, B.K. Rai,
R.K. Gupta, and K. Ghosh

*Invited Paper

Rapid Synthesis of Nanocrystalline ZnGa₂O₄ Phosphor at Low Temperature.	49
Suresh D. Kulkarni and S.A. Shivashankar	

PHOTOELECTROCHEMICAL, ELECTRICAL AND MAGNETIC PROPERTIES OF NANOSTRUCTURED OXIDES

Metal- Metal Oxide Electrode: A Promising Energy Storage Candidate for Supercapacitor Application.	57
Anirudha Jena, N. Munichandraiah, and S.A. Shivashankar	

Resistance Change Caused by Electrochemically Induced Carrier Injection in NiO Films.	63
T. Yoda, K. Kinoshita, T. Fukuhara, S. Kishida, N. Sawai, and K. Honda	

Synthesis and Characterization of CeO₂ Nanoparticles by Low Temperature Hydrothermal and Solvent Thermal Process.	69
Eric Y.H. Teo, Ming Lin, Ziyuan Fu, Seng C. Ng, Siliang Song, and Jun C. Tan	

Photo-induced Changes in the Langmuir Adsorption Constants of Metal Oxide Layers in Self-cleaning Cation Sensors.	77
Philip S. Foran and Colin Boxall	

Hydrothermally Grown Nanostructured Tungsten Trioxide (hydrate) Films and their Photocatalytic Properties	83
Z.H. Jiao and X.W. Sun	

Intercluster Interaction and Magnetic Interaction between Iron Core and Iron Oxide Shell in Core-Shell Nanoclusters	89
Maninder Kaur, Qi Yao, and You Qiang	

High Mobile Electron Gas at LaAlO₃/SrTiO₃ Heterointerface	95
Shanshan Su and Jeong Ho You	

The Characterization of Electronic State from Surface to Several Nanometer Region on MgO:Si Thin Film	101
Mikihiko Nishitani, Mutsumu Fukada, Yukihiko Morita, Masaharu Terauchi, Tessei Kurashiki, Hiroki Tsuchiura, and Yasushi Yamauchi	

Gaussian Distribution of Schottky Barrier Heights on SnO₂ Nanowires	107
Cleber A. Amorim, Olivia M. Berengue, Luana Araújo, Edson R. Leite, and Adenilson J. Chiquito	
Correlation Between Filament Distribution and Resistive Switching Property in Binary-Transition-Metal-Oxide Based Resistive Random Access Memory	113
H. Tanaka, K. Kinoshita, M. Yoshihara, and S. Kishida	
Electrical Properties of Magnesium Carbon Co-sputtered Thin Films Applied Post Hydroxylation Treatment	119
Masafumi Chiba, Daisuke Endo, Mikihiko Maizono, Mikiteru Higashi, and Hideo Kiyota	
Insight into Distribution and Switching of ReRAM Filaments Based on Variation Analysis of Memory Characteristics	125
Kentaro Kinoshita, Hayato Tanaka, Masataka Yoshihara, and Satoru Kishida	
Effects of Size and Load on Transport Properties of Nanoscale Metal-Oxide Interfaces	131
Ramsey Kraya	
Author Index	137
Subject Index	139

PREFACE

Symposium Z, “Functional Metal Oxide Nanostructures” was held November 27–December 2 during the 2011 MRS Fall Meeting in Boston, Massachusetts.

Metal oxides represent an assorted and appealing class of materials whose properties cover the entire range from metals to semiconductors to insulators and almost all aspects of material science and physics in areas including superconductivity and magnetism. In the past few years, a great deal of progress has been made in the field of metal oxide nanostructures particularly with regard to innovative synthetic pathways as well as the structural, physical and chemical characterization, modification and assembly of nanostructured oxides to exploit their nanoscopic properties and their size-dependent modulation.

Specifically, the field of metal oxide nanostructured morphologies (e.g., nanowires, nanobelts, nanorods, nanotetrapods) has become one of the most active research areas within the nano-science community.

New fundamental research together with original and inspired potential applications is being continuously proposed, including nanowire electronics, nanowire photonics, nanowires as electron sources, and nanowires and their heterostructures for energy conversion and storage.

These proceedings captures some of the most recent developments in the field of synthesis, structural and functional characterization of self-assembled metal oxides nanostructures and heterostructures thereof to illustrate their application potential as functional materials, with particular consideration given to the capability to tailor and control material properties via surface and structural modifications and possible device integration.

Alberto Vomiero
Sanjay Mathur
Zhong Lin Wang
Eric Wei-Guang Diau

April 2012

MATERIALS RESEARCH SOCIETY SYMPOSIUM PROCEEDINGS

- Volume 1371 — Nanostructured Materials and Nanotechnology, C. Gutiérrez-Wing, J.L. Rodríguez-López, O.A. Graeve, J.J. Boeckl, P. Soukiassian, 2012, ISBN 978-1-60511-348-7
- Volume 1372 — Structural and Chemical Characterization of Metals, Alloys, and Compounds – 2011, R. Pérez Campos, A. Contreras Cuevas, R.A. Esparza Munoz, 2012, ISBN 978-1-60511-349-4
- Volume 1373 — Advanced Structural Materials – 2011, H.A. Calderon, A. Salinas Rodriguez, H. Balmori Ramirez, 2012, ISBN 978-1-60511-350-0
- Volume 1374 — Cultural Heritage and Archaeological Issues in Materials Science, J.L. Ruvalcaba Sil, J. Reyes Trujeque, A. Velazquez Castro, M. Espinosa Pesqueira, 2012, ISBN 978-1-60511-351-7
- Volume 1376E — Biomaterials for Medical Applications, S. Rodil, A. Almaguer, K. Anselme, 2012, ISBN 978-1-60511-353-1
- Volume 1380E — Materials Research for Mining and Mineral Processing, F.R.C. Pedroza, 2012, ISBN 978-1-60511-357-9
- Volume 1381E — Materials Welding and Joining Technologies, F.A.R. Valdes, 2012, ISBN 978-1-60511-358-6
- Volume 1383 — Material Challenges in Current and Future Nuclear Technologies, K.R. Whittle, M. Bertolus, B. Ueberuaga, R.W. Grimes, 2011, ISBN 978-1-60511-360-9
- Volume 1384E — Advanced Materials for Fuel Cells, J. Hertz, M.L. DiVona, P. Knauth, H.L. Tuller, 2011, ISBN 978-1-60511-361-6
- Volume 1385E — *In-Situ* Studies of Solid-Oxide Fuel-Cell Materials, R. Maher, 2011, ISBN 978-1-60511-362-3
- Volume 1386E — Sustainable Synthesis of Nanomaterials, H. Fan, M. Knez, S.S. Wong, W. Lee, 2011, ISBN 978-1-60511-363-0
- Volume 1387E — Advanced Materials for Solar-Fuel Generation, C. Hill, 2011, ISBN 978-1-60511-364-7
- Volume 1388E — Mobile Energy, S. Mhaisalkar, K. Shenai, G. Amaratunga, A. Nathan, 2011, ISBN 978-1-60511-365-4
- Volume 1389E — Applications of Hierarchical 3D Structures, J.H. Moon, S. Jeon, S. Yang, R.A. Vaia, 2011, ISBN 978-1-60511-366-1
- Volume 1390 — Organic Photovoltaics-Materials to Devices, V. BommiSETTY, G. Li, C. Deibel, T-Q. Nguyen, D.C. Olson, M. Riede, M. Leclerc, V. Dyakonov, G. Rumbles, N.S. Sariciftci, 2011, ISBN 978-1-60511-367-8
- Volume 1391E — Photonic and Plasmonic Materials for Enhanced Photovoltaic Performance, R. Biswas, 2011, ISBN 978-1-60511-368-5
- Volume 1392E — Materials for High-Performance Photonics, T.M. Cooper, S.R. Flom, M. Bockstaller, C. Lopes, 2011, ISBN 978-1-60511-369-2
- Volume 1393E — Topological Insulator Materials, C. Felser, Y. Cui, H. Peng, S. Murakami, 2011, ISBN 978-1-60511-370-8
- Volume 1394E — Oxide Semiconductors—Defects, Growth and Device Fabrication, T. Veal, S. Durbin, J. Phillips, M. Grundmann, 2011, ISBN 978-1-60511-371-5
- Volume 1395 — Diamond Electronics and Biotechnology—Fundamentals to Applications V, O.A. Williams, R.B. Jackman, P. Bergonzo, G.M. Swain, K.P. Loh, 2011, ISBN 978-1-60511-372-2
- Volume 1396 — Compound Semiconductors for Generating, Emitting and Manipulating Energy, T. Li, M. Mastro, A. Dadgar, H. Jiang, J. Kim, 2011, ISBN 978-1-60511-373-9
- Volume 1397E — Ferroelectric and Multiferroic Materials, M. Bibes, C.J. Fennie, L.W. Martin, B. Noheda, T. Kimura, 2011, ISBN 978-1-60511-374-6
- Volume 1398E — Magnetoelectric Composites, P. Finkel, 2011, ISBN 978-1-60511-375-3
- Volume 1399E — Compliant Electronics and Photonics, D. Tyler, 2011, ISBN 978-1-60511-376-0
- Volume 1400E — Solution Processing of Inorganic and Hybrid Materials for Electronics and Photonics, P.J. Smith, M.F.A.M. van Hest, D.B. Mitzi, A. Morrin, 2011, ISBN 978-1-60511-377-7
- Volume 1401E — Large-Area Processing and Patterning for Active Optical and Electronic Devices III, I. Kymissis, T. Anthopoulos, C. Madigan, M. Shtein, 2011, ISBN 978-1-60511-378-4
- Volume 1402E — Charge Generation/Transport in Organic Semiconductor Materials, J. Anthony, 2011, ISBN 978-1-60511-379-1
- Volume 1403 — Multifunctional Polymer-Based Materials, A. Lendlein, Y. Feng, T. Xie, Z. Guan, 2011, ISBN 978-1-60511-380-7
- Volume 1404E — Phonons in Nanomaterials—Theory, Experiments and Applications, S.L. Shinde, D.H. Hurley, G.P. Srivastava, M. Yamaguchi, 2011, ISBN 978-1-60511-381-4

MATERIALS RESEARCH SOCIETY SYMPOSIUM PROCEEDINGS

- Volume 1405E — Advances in Energetic Materials Research, M.R. Manaa, C-S. Yoo, E.J. Reed, M.S. Strano, 2011, ISBN 978-1-60511-382-1
- Volume 1406 — Functional Metal-Oxide Nanostructures, A. Vomiero, S. Mathur, Z.L. Wang, E. W-G. Diau, 2011, ISBN 978-1-60511-383-8
- Volume 1407 — Carbon Nanotubes, Graphene and Related Nanostructures, Y.K. Yap, 2011, ISBN 978-1-60511-384-5
- Volume 1408 — Functional Nanowires and Nanotubes, K. Nielsch, A.F. i Morral, H. Linke, H. Shin, L. Shi, 2011, ISBN 978-1-60511-385-2
- Volume 1409E — Functional Semiconductor Nanocrystals and Metal-Hybrid Structures, K.S Leschkie, P. Nagpal, M.A. Pelton, H. Mattoussi, P. Kambhampati, 2011, ISBN 978-1-60511-386-9
- Volume 1410E — Transport Properties in Polymer Nanocomposites II, S. Nazarenko, J. Grunlan, J. Bahr, E. Espuche, 2011, ISBN 978-1-60511-387-6
- Volume 1411E — Self Organization and Nanoscale Pattern Formation, S. Persheyev, 2011, ISBN 978-1-60511-388-3
- Volume 1412E — Mechanical Nanofabrication, Nanopatterning and Nanoassembly, G. Cross, A. Schirmeisen, A. Knoll, M. Rolandi, 2011, ISBN 978-1-60511-389-0
- Volume 1413E — Safety and Toxicity Control of Nanomaterials, W.W. Yu, V.L. Colvin, Q. Dai, P.C. Howard, 2011, ISBN 978-1-60511-390-6
- Volume 1415 — MEMS, BioMEMS and Bioelectronics—Materials and Devices, T. Albrecht, M.P. de Boer, F.W. DelRio, M.R. Dokmeci, C. Eberl, J. Fukuda, H. Kaji, C. Keimel, A. Khademhosseini, 2011, ISBN 978-1-60511-392-0
- Volume 1416E — Nanofunctional Materials, Nanostructures and Nanodevices for Cancer Applications, S. Svenson, P. Grodzinski, S. Manalis, X J. Liang, W. Lin, 2011, ISBN 978-1-60511-393-7
- Volume 1417E — Biomaterials for Tissue Regeneration, C.C. Sorrell, 2011, ISBN 978-1-60511-394-4
- Volume 1418 — Gels and Biomedical Materials, F. Horkay, R. Narayan, V. Dave, S. Jin, N. Langrana, J.D. Londono, W. Oppermann, S. Ramakrishna, D. Shi, R.G. Weiss, 2011, ISBN 978-1-60511-395-1
- Volume 1419E — Nucleation and Growth of Biological and Biomimetic Materials, P.M. Rodger, J. Harding, L.B. Gower, P. Vekilov, 2011, ISBN 978-1-60511-396-8
- Volume 1420E — Multiscale Mechanics of Hierarchical Materials, F. Barthelat, 2011, ISBN 978-1-60511-397-5
- Volume 1421E — Three-Dimensional Tomography of Materials, S. Pennycook, 2011, ISBN 978-1-60511-398-2
- Volume 1422E — Functional Imaging of Materials—Advances in Multifrequency and Multispectral Scanning Probe Microscopy and Analysis, A. Baddorf, 2011, ISBN 978-1-60511-399-9
- Volume 1423E — Dynamics in Confined Systems and Functional Interfaces, M.H. Müser, D.L. Irving, S.B. Sinnott, I. Szlufarska, 2011, ISBN 978-1-60511-400-2
- Volume 1424 — Properties and Processes at the Nanoscale—Nanomechanics of Material Behavior, D. Bahr, P. Anderson, N. Moody, R. Spolenak, 2011, ISBN 978-1-60511-401-9
- Volume 1425E — Combinatorial and High-Throughput Methods in Materials Science, J.B. Miller, J. Genzer, Y. Matsumoto, R.A. Potyrailo, 2011, ISBN 978-1-60511-402-6

Prior Materials Research Society Symposium Proceedings available by contacting Materials Research Society