

MRS SYMPOSIUM PROCEEDINGS

Volume 1547 • 2013 MRS Spring Meeting



Solution Synthesis of Inorganic Functional Materials—Films, Nanoparticles, and Nanocomposites

EDITORS

Menka Jain

Quanxi Jia

Teresa Puig

Hiromitsu Kozuka

CAMBRIDGE

A publication of the

MRS MATERIALS RESEARCH SOCIETY
Advancing materials. Improving the quality of life.

**MATERIALS RESEARCH SOCIETY
SYMPOSIUM PROCEEDINGS VOLUME 1547**

Solution Synthesis of Inorganic Functional Materials — Films, Nanoparticles, and Nanocomposites

Symposium held April 1–5, 2013, San Francisco, California U.S.A.

EDITORS

Menka Jain

University of Connecticut
Storrs, Connecticut, U.S.A.

Quanxi Jia

Los Alamos National Laboratory
Los Alamos, New Mexico, U.S.A.

Teresa Puig

Institut de Ciència de Materials de Barcelona, CSIC
Bellaterra, Spain

Hiromitsu Kobzuka

Kanai University
Suita, Osaka, Japan



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/9781605115245

Materials Research Society

506 Keystone Drive, Warrendale, PA 15086

<http://www.mrs.org>

© Materials Research Society 2013

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 2013

CODEN: MRSPDH

ISBN: 978-1-60511-524-5 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.

**Solution Synthesis of Inorganic Functional
Materials — Films, Nanoparticles,
and Nanocomposites**

PREFACE

Symposium M, "Solution Synthesis of Inorganic Functional Materials — Films, Nanoparticles, and Nanocomposites" was held April 1–5th, 2013 at the 2013 MRS Spring Meeting in San Francisco, California.

The symposium was focused on solution synthesis approaches for the growth of a wide range of advanced functional inorganic materials. Recent results were presented on the growth of: (i) highly crystalline functional oxide films; (ii) nanoparticles and nanocrystals; and (iii) nanostructures or nanocomposites by various chemical solution methods. An increased interest in the low-cost and high throughput synthesis of functional and multifunctional inorganic materials indicates the importance of these studies. Gas sensing, photovoltaic, plasmonics, memory devices, spintronics, bio-medical, superconducting, and magnetic-field sensing applications were extensively discussed. The symposium promoted information exchange between worldwide researchers from universities, national labs, and industries.

At this symposium, 225 abstracts were presented and more than 100 attendees attended the sessions. Both oral presentations and poster sessions were held.

The articles in this symposium proceeding volume cover the development of different chemical solution approaches to synthesize inorganic functional materials for enhanced and/or novel functionalities for a variety of applications. The papers in the volume have been divided into four sections: (1) thin film preparation methods, (2) ferroelectrics and multiferroics, (3) materials for energy and electronic devices, and (4) nanomaterials and nanocomposites. These papers convey the breadth of exciting advancements happening in the area of functional materials grown by various solution methods.

Menka Jain
Quanxi Jia
Teresa Puig
Hiromitsu Kozuka

September 2013

ACKNOWLEDGMENTS

The papers published in this volume result from the MRS Spring 2013 Symposium M. We sincerely thank all of the oral and poster presenters who contributed to this proceeding volume. We also thank the reviewers who provided valuable feedback to the editors and authors. We greatly appreciate the MRS publication staff for their constant help and for guiding us smoothly through the submission/review/decision process.

MATERIALS RESEARCH SOCIETY SYMPOSIUM PROCEEDINGS

- Volume 1536 — Film Silicon Science and Technology, 2013, P. Stradins, A. Boukai, F. Finger, T. Matsui, N. Wyrsh, ISBN 978-1-60511-513-9
- Volume 1537E — Organic and Hybrid Photovoltaic Materials and Devices, 2013, S.W. Tsang, ISBN 978-1-60511-514-6
- Volume 1538 — Compound Semiconductors: Thin-Film Photovoltaics, LEDs, and Smart Energy Controls, 2013, M. Al-Jassim, C. Heske, T. Li, M. Mastro, C. Nan, S. Niki, W. Shafarman, S. Siebentritt, Q. Wang, ISBN 978-1-60511-515-3
- Volume 1539E — From Molecules to Materials—Pathways to Artificial Photosynthesis, 2013, J.-H. Guo, ISBN 978-1-60511-516-0
- Volume 1540E — Materials and Integration Challenges for Energy Generation and Storage in Mobile Electronic Devices, 2013, M. Chhowalla, S. Mhaisalkar, A. Nathan, G. Amaratunga, ISBN 978-1-60511-517-7
- Volume 1541E — Materials for Vehicular and Grid Energy Storage, 2013, J. Kim, ISBN 978-1-60511-518-4
- Volume 1542E — Electrochemical Interfaces for Energy Storage and Conversion—Fundamental Insights from Experiments to Computations, 2013, J. Cabana, ISBN 978-1-60511-519-1
- Volume 1543 — Nanoscale Thermoelectric Materials, Thermal and Electrical Transport, and Applications to Solid-State Cooling and Power Generation, 2013, S.P. Beckman, H. Böttner, Y. Chalopin, C. Dames, P.A. Greaney, P. Hopkins, B. Li, T. Mori, T. Nishimatsu, K. Pipe, R. Venkatasubramanian, ISBN 978-1-60511-520-7
- Volume 1544E — *In-Situ* Characterization Methods in Energy Materials Research, 2014, J.D. Baniecki, P.C. McIntyre, G. Eres, A.A. Talin, A. Klein, ISBN 978-1-60511-521-4
- Volume 1545E — Materials for Sustainable Development, 2013, R. Pellenq, ISBN 978-1-60511-522-1
- Volume 1546E — Nanoparticle Manufacturing, Functionalization, Assembly and Integration, 2013, H. Fan, T. Hyeon, Z. Tang, Y. Yin, ISBN 978-1-60511-523-8
- Volume 1547 — Solution Synthesis of Inorganic Functional Materials—Films, Nanoparticles and Nanocomposites, 2013, M. Jain, Q.X. Jia, T. Puig, H. Kozuka, ISBN 978-1-60511-524-5
- Volume 1548E — Nanomaterials in the Subnanometer-Size Range, 2013, J.S. Martinez, ISBN 978-1-60511-525-2
- Volume 1549 — Carbon Functional Nanomaterials, Graphene and Related 2D-Layered Systems, 2013, P.M. Ajayan, J.A. Garrido, K. Haenen, S. Kar, A. Kaul, C.J. Lee, J.A. Robinson, J.T. Robinson, I.D. Sharp, S. Talapatra, R. Tenne, M. Terrones, A.L. Elias, M. Paranjape, N. Kharche, ISBN 978-1-60511-526-9
- Volume 1550E — Surfaces of Nanoscale Semiconductors, 2013, M.A. Filler, W.A. Tisdale, E.A. Weiss, R. Rurali, ISBN 978-1-60511-527-6
- Volume 1551 — Nanostructured Semiconductors and Nanotechnology, 2013, I. Berbezier, J.-N. Aqua, J. Floro, A. Kuznetsov, ISBN 978-1-60511-528-3
- Volume 1552 — Nanostructured Metal Oxides for Advanced Applications, 2013, A. Vomiero, F. Rosei, X.W. Sun, J.R. Morante, ISBN 978-1-60511-529-0
- Volume 1553E — Electrical Contacts to Nanomaterials and Nanodevices, 2013, F. Léonard, C. Lavoie, Y. Huang, K. Kavanagh, ISBN 978-1-60511-530-6
- Volume 1554E — Measurements of Atomic Arrangements and Local Vibrations in Nanostructured Materials, 2013, A. Borisevich, ISBN 978-1-60511-531-3
- Volume 1556E — Piezoelectric Nanogenerators and Piezotronics, 2013, X. Wang, C. Falconi, S.-W. Kim, H.A. Sodano, ISBN 978-1-60511-533-7
- Volume 1557E — Advances in Scanning Probe Microscopy for Imaging Functionality on the Nanoscale, 2013, S. Jesse, H.K. Wickramasinghe, F.J. Giessibl, R. Garcia, ISBN 978-1-60511-534-4
- Volume 1558E — Nanotechnology and Sustainability, 2013, L. Vayssieres, S. Mathur, N.T.K. Thanh, Y. Tachibana, ISBN 978-1-60511-535-1
- Volume 1559E — Advanced Interconnects for Micro- and Nanoelectronics—Materials, Processes and Reliability, 2013, E. Kondoh, M.R. Baklanov, J.D. Bielefeld, V. Jousseume, S. Ogawa, ISBN 978-1-60511-536-8
- Volume 1560E — Evolutions in Planarization—Equipment, Materials, Techniques and Applications, 2013, C. Borst, D. Canaperi, T. Doi, J. Sorooshian, ISBN 978-1-60511-537-5
- Volume 1561E — Gate Stack Technology for End-of-Roadmap Devices in Logic, Power and Memory, 2013, S. Banerjee, ISBN 978-1-60511-538-2

MATERIALS RESEARCH SOCIETY SYMPOSIUM PROCEEDINGS

- Volume 1562E — Emerging Materials and Devices for Future Nonvolatile Memories, 2013, Y. Fujisaki, P. Dimitrakis, D. Chu, D. Worledge, ISBN 978-1-60511-539-9
- Volume 1563E — Phase-Change Materials for Memory, Reconfigurable Electronics, and Cognitive Applications, 2013, R. Calarco, P. Fons, B.J. Kooi, M. Salina, ISBN 978-1-60511-540-5
- Volume 1564E — Single-Dopant Semiconductor Optoelectronics, 2014, M.E. Flatté, D.D. Awschalom, P.M. Koenraad, ISBN 978-1-60511-541-2
- Volume 1565E — Materials for High-Performance Photonics II, 2013, T.M. Cooper, S.R. Flom, M. Bockstaller, C. Lopes, ISBN 978-1-60511-542-9
- Volume 1566E — Resonant Optics in Metallic and Dielectric Structures—Fundamentals and Applications, 2013, L. Cao, N. Engheta, J. Munday, S. Zhang, ISBN 978-1-60511-543-6
- Volume 1567E — Fundamental Processes in Organic Electronics, 2013, A.J. Moule, ISBN 978-1-60511-544-3
- Volume 1568E — Charge and Spin Transport in Organic Semiconductor Materials, 2013, H. Sirringhaus, J. Takeya, A. Facchetti, M. Wohlgenannt, ISBN 978-1-60511-545-0
- Volume 1569 — Advanced Materials for Biological and Biomedical Applications, 2013, M. Oyen, A. Lendlein, W.T. Pennington, L. Stanciu, S. Svenson, ISBN 978-1-60511-546-7
- Volume 1570E — Adaptive Soft Matter through Molecular Networks, 2013, R. Ulijn, N. Gianneschi, R. Naik, J. van Esch, ISBN 978-1-60511-547-4
- Volume 1571E — Lanthanide Nanomaterials for Imaging, Sensing and Optoelectronics, 2013, H. He, Z.-N. Chen, N. Robertson, ISBN 978-1-60511-548-1
- Volume 1572E — Bioelectronics—Materials, Interfaces and Applications, 2013, A. Noy, N. Ashkenasy, C.F. Blanford, A. Takshi, ISBN 978-1-60511-549-8
- Volume 1574E — Plasma and Low-Energy Ion-Beam-Assisted Processing and Synthesis of Energy-Related Materials, 2013, G. Abrasonis, ISBN 978-1-60511-551-1
- Volume 1575E — Materials Applications of Ionic Liquids, 2013, D. Jiang, ISBN 978-1-60511-552-8
- Volume 1576E — Nuclear Radiation Detection Materials, 2014, A. Burger, M. Fiederle, L. Franks, D.L. Perry, ISBN 978-1-60511-553-5
- Volume 1577E — Oxide Thin Films and Heterostructures for Advanced Information and Energy Technologies, 2013, G. Herranz, H.-N. Lee, J. Kreisel, H. Ohta, ISBN 978-1-60511-554-2
- Volume 1578E — Titanium Dioxide—Fundamentals and Applications, 2013, A. Selloni, ISBN 978-1-60511-555-9
- Volume 1579E — Superconducting Materials—From Basic Science to Deployment, 2013, Q. Li, K. Sato, L. Cooley, B. Holzapfel, ISBN 978-1-60511-556-6
- Volume 1580E — Size-Dependent and Coupled Properties of Materials, 2013, B.G. Clark, D. Kiener, G.M. Pharr, A.S. Schneider, ISBN 978-1-60511-557-3
- Volume 1581E — Novel Functionality by Reversible Phase Transformation, 2013, R.D. James, S. Fähler, A. Planes, I. Takeuchi, ISBN 978-1-60511-558-0
- Volume 1582E — Extreme Environments—A Route to Novel Materials, 2013, A. Goncharov, ISBN 978-1-60511-559-7
- Volume 1583E — Materials Education—Toward a Lab-to-Classroom Initiative, 2013, E.M. Campo, C.C. Broadbridge, K. Hollar, C. Constantin, ISBN 978-1-60511-560-3

Prior Materials Research Symposium Proceedings available by contacting Materials Research Society

CONTENTS

Preface	ix
Acknowledgments	xi
Materials Research Society Symposium Proceedings	xiii

THIN FILM PREPARATION METHODS

* Thin $\text{YBa}_2\text{Cu}_3\text{O}_{7-\delta}$ Patterns by Chemical Solution Processing using Ink-jet Printing Jonas Feys, Bram Ghekiere, Petra Lommens, Simon C. Hopkins, Pieter Vermeir, Michael Baecker, Bartek A. Glowacki, and Isabel Van Driessche	3
<i>In-situ</i> Preparation of Metal Oxide Thin Films by Inkjet Printing Acetates Solutions Mei Fang, Wolfgang Voit, Yan Wu, Lyubov Belova, and K.V. Rao	13
* Growth and Physical Properties of Vanadium Oxide Thin Films with Controllable Phases Yanda Ji, Yin Zhang, Min Gao, Zhen Yuan, Changqing Jin, and Yuan Lin	21
Effect of Adding Zn in $\text{Cd}_{1-x}\text{Zn}_x\text{S}$ Thin Films Prepared by an Ammonia-free Chemical Bath Deposition Process Iyali Carreón-Moncada, Luis A. González, Martin I. Pech-Canul, and Rafael Ramírez-Bon	29
Fabrication of Flexible and Conductive Graphene-silver Films by Polymer Dispersion and Coating Method Jiang-Jen (JJ) Lin, Sheng-Yen Shen, Po-Ta Shih, and Rui-Xuan Dong	35

*Invited Paper

FERROELECTRICS AND MULTIFERROICS

Hydrothermal Epitaxy of Lead Free (Na,K)NbO₃-based Piezoelectric Films	45
Albertus D. Handoko and Gregory K.L. Goh	
Field Dependent Carrier Transport Mechanisms in Metal-insulator-metal Devices with Ba_{0.8}Sr_{0.2}TiO₃/ZrO₂ Heterostructured Thin Films as the Dielectric.....	53
Santosh K. Sahoo, H. Bakhru, Sumit Kumar, D. Misra, Colin A. Wolden, Y.N. Mohapatra, and D.C. Agrawal	
Fabrication of 0.6(Bi_{0.85}La_{0.15})FeO₃-0.4PbTiO₃ Multiferroic Ceramics by Tape Casting Method	61
Guoxi Jin, Jianguo Chen, Shundong Bu, Dalei Wang, Rui Dai, and Jinrong Cheng	

MATERIALS FOR ENERGY AND ELECTRONIC DEVICES

Solution Processed TiO₂ Nanotubular Core with Polypyrrole Conducting Polymer Shell Structures for Supercapacitor Energy Storage Devices	69
Navjot K. Sidhu, Ratheesh R. Thankalekshmi, and A.C. Rastogi	
Dual Function Polyvinyl Alcohol Based Oxide Precursors for Nanoimprinting and Electron Beam Lithography	75
J. Malowney, N. Mestres, X. Borriase, A. Calleja, R. Guzman, J. Llobet, J. Arbiol, T. Puig, X. Obradors, and J. Bausells	
Melting Gel Films for Low Temperature Seals	81
Mihaela Jitianu, Andrei Jitianu, Michael Stamper, Doreen Aboagye, and Lisa C. Klein	
Low Temperature Syntheses of Transition Metal Bronzes with an Open Structure for High Rate Energy Storage.....	87
X. Pétrissans, V. Augustyn, D. Giaume, P. Barboux, and B. Dunn	

Field Dependent Electrical Conduction in Metal-insulator-metal Devices using Alumina-silicone Nanolaminate Dielectrics	95
Santosh K. Sahoo, Rakhi P. Patel, and Colin A. Wolden	
Growth of Silicon Nanowires-based Heterostructures and Their Plasmonic Modeling	103
Yuan Li, Wenwu Shi, John C. Dykes, and Nitin Chopra	
Luminescence Enhancement of Colloidal Quantum Dots by Strain Compensation	109
Y. Lu, Y.Q. Zhang, and X.A. Cao	
Enhanced Visible-light Absorption of Mesoporous TiO₂ by Co-doping with Transition-metal/nitrogen Ions	115
J.E. Mathis, Z. Bi, C.A. Bridges, M.K. Kidder, and M.P. Paranthaman	

NANOMATERIALS AND NANOCOMPOSITES

Effects of Amines on Chemical and Physical Behaviors of Viscous Precursor Sols to Indium Gallium Zinc Oxide.	123
Nobuko Fukuda, Shintaro Ogura, Ken-ichi Nomura, and Hirobumi Ushijima	
Structural and Functional Properties of Iron (II, III)-doped ZnO Monodisperse Nanoparticles Synthesized by Polyol Method	129
Yesusa Collantes and Oscar Perales-Perez	
Size-controlled Synthesis of MgO Nanoparticles and the Assessment of Their Bactericidal Capacity	135
Yarilyn Cedeño-Mattei, Myrna Reyes, Oscar Perales-Pérez, and Félix R. Román	
Synthesis of Urethane Base Composite Materials with Metallic Nanoparticles	141
Anayansi Estrada Monje and J. Roberto Herrera Reséndiz	
Innovative Gold Nanoparticle Patterning and Selective Metallization	149
E.S. Kooij, M.A. Raza, and H.J.W. Zandvliet	

A Thermal Decomposition Approach for the Synthesis of Iron Oxide Microspheres	.155
Geetu Sharma and Jeevanandam Pethaiyan	
Multifunctional Silicone Nanocomposites for Advanced LED Encapsulation.	.161
Ying Li, Peng Tao, Richard W. Siegel, and Linda S. Schadler	
Study on the Production of Silver/Modified Clay Nanocomposites	.167
Natália F.N. Pessanha and Gerson L.V. Coelho	
DFT Investigation of the Mechanism and Chemical Kinetics for the Gelation of Colloidal Silica.	.173
Steven S. Burnett and James W. Mitchell	
Author Index	.183
Subject Index	.185

Thin Film Preparation Methods

