

PROCEEDINGS OF SPIE

***Instrumentation, Metrology, and
Standards for Nanomanufacturing***

**Michael T. Postek
John A. Allgair**
Editors

**29–30 August 2007
San Diego, California, USA**

Sponsored and Published by
SPIE

Volume 6648

Proceedings of SPIE, 0277-786X, v. 6648

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 *Instrumentation, Metrology, and Standards for Nanomanufacturing*, edited by Michael T. Postek, John A. Allgair, Proceedings of SPIE Vol. 6648 (SPIE, Bellingham, WA, 2007) Article CID Number.

ISSN 0277-786X
ISBN 9780819467966

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 © 2007, 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/07/\$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

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 *Conference Committee*
- ix *Introduction*

SESSION 1 INSTRUMENTATION METROLOGY AND STANDARDS I

- 6648 02 **Instrumentation, metrology, and standards: key elements for the future of nanomanufacturing** [6648-01]
M. T. Postek, K. Lyons, National Institute of Standards and Technology (USA)
- 6648 03 **Infrared reflectivity spectroscopy of optical phonons in short-period AlGaIn/GaN superlattices** [6648-03]
J. B. Herzog, A. M. Mintairov, K. Sun, Y. Cao, D. Jena, J. L. Merz, Univ. of Notre Dame (USA)
- 6648 04 **Near-field birefringence response in thickness direction of liquid crystal thin film** [6648-04]
J. Qin, N. Umeda, Tokyo Univ. of Agriculture and Technology (Japan)

SESSION 2 INSTRUMENTATION AND METROLOGY II

- 6648 06 **The helium ion microscope: a new tool for nanomanufacturing** [6648-06]
M. T. Postek, A. E. Vladár, J. Kramar, National Institute of Standards and Technology (USA); L. A. Stern, J. Notte, S. McVey, ALIS/Zeiss Corp. (USA)
- 6648 07 **Length calibration standards for nano-manufacturing** [6648-07]
D. C. Joy, Univ. of Tennessee (USA) and Oak Ridge National Lab. (USA); S. Deo, Univ. of Tennessee (USA); B. J. Griffin, Oak Ridge National Lab. (USA) and Univ. of Western Australia (Australia)
- 6648 08 **Microstructure of 100 nm damascene copper overburden and lines** [6648-08]
R. H. Geiss, D. T. Read, National Institute of Standards and Technology (USA)
- 6648 09 **Nanomanufacturing via fast laser-induced self-organization in thin metal films** [6648-09]
C. Favazza, H. Krishna, R. Sureshkumar, R. Kalyanaraman, Washington Univ. in St. Louis (USA)

SESSION 3 INTEGRATION, INTEROPERABILITY, AND INFORMATION MANAGEMENT I

- 6648 0D **Integration, interoperability, and information management: What are the key issues for nanomanufacturing?** [6648-13]
K. W. Lyons, National Institute of Standards and Technology (USA)
- 6648 0F **Modelling of angle-resolved x-ray photoelectron spectroscopy (ARXPS) intensity ratios for nanocharacterisation of closely packed shell-core nanofibres** [6648-15]
J. Wang, P. J. Cumpson, National Physical Lab. (United Kingdom)

- 6648 OG **Optimal architecture of a neural network for a high precision in ellipsometric scatterometry** [6648-16]
I. Gereige, S. Robert, Univ. Jean Monnet-St. Etienne (France); G. Granet, Lab. des Sciences et Matériaux pour l'Electronique et d'Automatique, CNRS (France)
- 6648 OH **Nano-precision dynamic motion control** [6648-17]
C.-Y. Lin, T.-C. Tsao, Univ. of California, Los Angeles (USA)
- 6648 OI **Combining coordinate measurement and nanometrology for large-range nanoscale metrology** [6648-18]
M. Gruhlke, H. Rothe, Helmut-Schmidt Univ. (Germany)

SESSION 4 INTEGRATION, INTEROPERABILITY, AND INFORMATION MANAGEMENT II

- 6648 OK **Computational modeling of laser-induced self-organization in nanoscopic metal films for predictive nanomanufacturing** [6648-14]
J. Trice, R. Kalyanaraman, R. Sureshkumar, Washington Univ. in St. Louis (USA)
- 6648 OL **In silico design of metal-dielectric nanocomposites for solar energy applications** [6648-21]
J. Trice, Washington Univ. in St. Louis (USA); H. Garcia, Southern Illinois Univ. (USA); R. Sureshkumar, R. Kalyanaraman, Washington Univ. in St. Louis (USA)
- 6648 ON **A CAD integration framework for designing devices with atomic scale resolution** [6648-23]
Y.-C. Chang, Stanford Univ. (USA); K. Ramaswami, Indian Institute of Science (India); M. Pinilla, Navis, LLC (USA); S. Walch, F. Prinz, Stanford Univ. (USA)

POSTER SESSION

- 6648 OP **A novel low-cost high-throughput probe card scanner analyzer for characterization of magnetic tunnel junctions** [6648-25]
P. W. T. Pong, M. Schmoueli, E. Marcus, W. F. Egelhoff, Jr., National Institute of Standards and Technology (USA)
- 6648 OR **Silicon test object of the linewidth of the nanometer range for SEM and AFM** [6648-27]
Yu. A. Novikov, A.M. Prokhorov General Physics Institute (Russia); V. P. Gavrilenko, Ctr. for Surface and Vacuum Research (Russia); Yu. V. Ozerin, Mikron Corp. (Russia); A. V. Rakov, A.M. Prokhorov General Physics Institute (Russia); P. A. Todua, Ctr. for Surface and Vacuum Research (Russia)
- 6648 OS **Measurements of linear sizes of relief elements in the nanometer range using an atomic force microscope** [6648-28]
P. A. Todua, Ctr. for Surface and Vacuum Research (Russia); M. N. Filippov, N.S. Kurnakov Institute of General and Inorganic Chemistry (Russia); V. P. Gavrilenko, Ctr. for Surface and Vacuum Research (Russia); Yu. A. Novikov, A. V. Rakov, A.M. Prokhorov General Physics Institute (Russia)

- 6648 OT **Measurements of linear sizes of relief elements in the nanometer range using a scanning electron microscope** [6648-29]
V. P. Gavrilenko, Ctr. for Surface and Vacuum Research (Russia); M. N. Filippov, N.S. Kurnakov Institute of General and Inorganic Chemistry (Russia); Yu. A. Novikov, A. V. Rakov, A.M. Prokhorov General Physics Institute (Russia); P. A. Todua, Ctr. for Surface and Vacuum Research (Russia)
- 6648 OV **Spatial redistribution of nano-particles using electrokinetic micro-focuser** [6648-31]
D. E. Garcia, Univ. of California, Los Angeles (USA); A. Silva, Instituto Tecnológico y de Estudios Superiores de Monterrey (Mexico); C.-M. Ho, Univ. of California, Los Angeles (USA)

Author Index

Conference Committee

Symposium Chairs

David L. Andrews, University of East Anglia Norwich (United Kingdom)

James G. Grote, Air Force Research Laboratory (USA)

Kevin J. Liddane, Oerlikon Optics USA, Inc. (USA)

Conference Chair

Michael T. Postek, National Institute of Standards and Technology
(USA)

Conference Cochair

John A. Allgair, SEMATECH, Inc. (USA) and Freescale Semiconductors,
Inc. (USA)

Program Committee

Haris Doumanidis, National Science Foundation (USA)

Daniel J. C. Herr, Semiconductor Research Corporation (USA)

Mark D. Hoover, The National Institute for Occupational Safety and
Health (USA)

David C. Joy, The University of Tennessee (USA) and Oak Ridge
National Laboratory (USA)

Kevin W. Lyons, National Institute of Standards and Technology (USA)

Ron L. Remke, SEMATECH, Inc. (USA)

Richard M. Silver, National Institute of Standards and Technology
(USA)

Stephan J. Stranick, National Institute of Standards and Technology
(USA)

Session Chairs

- 1 Instrumentation Metrology and Standards I
David C. Joy, The University of Tennessee (USA)
George Orji, National Institute of Standards and Technology (USA) and
SEMATECH (USA)
- 2 Instrumentation and Metrology II
Richard M. Silver, National Institute of Standards and Technology
(USA)
John Small, National Institute of Standards and Technology (USA)

- 3 Integration, Interoperability, and Information Management I
Kevin W. Lyons, National Institute of Standards and Technology (USA)
Haris Doumanidis, Consultant (USA)
- 4 Integration, Interoperability, and Information Management II
Daniel J. C. Herr, Semiconductor Research Corporation (USA)
Kevin W. Lyons, National Institute of Standards and Technology (USA)

Introduction

Nanomanufacturing is the essential bridge between the discoveries of nanoscience and real world nanotech products. Nanomanufacturing is the vehicle by which the nation and the world will realize the promise of major technological innovation across a spectrum of products that will affect virtually every industrial sector.

For nanomanufactured products to achieve the broad impacts envisioned, they must be manufactured in market-appropriate quantities in a reliable, repeatable, economical, and commercially viable manner. In addition, they must be manufactured so that environmental and human health concerns are met, worker safety issues are appropriately assessed and handled, and liability issues are addressed.

Critical to this realization of robust nanomanufacturing is the development of the necessary instrumentation, metrology, and standards. Integration of the instruments, their interoperability, and appropriate information management are also critical elements that must be considered for viable nanomanufacturing. Advanced instrumentation, metrology, and standards will allow the physical dimensions, properties, functionality, and purity of the materials, processes, tools, systems, products, and emissions that will constitute nanomanufacturing to be measured and characterized.

This will in turn enable production to be scaleable, controllable, predictable, and repeatable to meet market needs. If a nano-product cannot be measured it cannot be manufactured; additionally if that product cannot be made safely it should not be manufactured. This proceedings introduces the Instrumentation, Metrology, and Standards for Nanomanufacturing Conference at the 2007 SPIE Optics and Photonics meeting. The goal is for this Conference to become the leading forum for the exchange of foundational information and discussion of instrumentation, metrology, and standards which are key elements for the success of nanomanufacturing.

Michael T. Postek
John A. Allgair

