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Materials Issues and Modeling for Device Nanofabrication

Editors: Lhadi Merhari, Luc T. Wille, Kenneth E. Gonsalves, Mark F. Gyure,

Shinji Matsui and Lloyd J. Whitman

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Shinji Matsui and Lloyd J. Whitman
Frontmatter
[More information](#)

CONTENTS

Preface xi

Acknowledgments xiii

Materials Research Society Symposium Proceedings xiv

*ADVANCED TECHNIQUES FOR SUB-100 nm
RESOLUTION LITHOGRAPHY AND
MOLECULAR ELECTRONICS*

***Ion Projection Lithography for Nano-Patterning** 3
A. Heuberger and W. Bruenger

***Soft X-rays for Deep Sub-100 nm Lithography, With and
Without Masks** 11
Henry I. Smith, D.J.D. Carter, J. Ferrera, D. Gil, J. Goodberlet,
J.T. Hastings, M.H. Lim, M. Meinhold, R. Menon, E.E. Moon,
C.A. Ross, T. Savas, M. Walsh, and F. Zhang

***Lithographic Materials Technologies: 193 nm Imaging and Beyond** 23
Elsa Reichmanis, Omkaram Nalamasu, Francis M. Houlihan,
Allen H. Gabor, Mark O. Neisser, and Murrae J. Bowden

***Direct-Write Electron Beam Lithography: History and State of the Art** 33
Dustin W. Carr and Richard C. Tiberio

***Molecular Scale Electronics: Critical Nanolithography Issues of
Synthesis and Addressing** 45
S. Huang, E.T. Mickelson, A.M. Rawlett, C.L. Asplund, A.M. Cassell,
M. Kozaki, T.P. Burgin, L. Jones II, J.M. Tour, M.L. Myrick,
P.G. Van Patten, J. Chen, C-W. Zhou, C.J. Muller, M.R. Deshpande,
M.A. Reed, L.A. Bumm, M.T. Cygan, T.D. Dunbar, P.S. Weiss, and
D.L. Allara

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Shinji Matsui and Lloyd J. Whitman
Frontmatter
[More information](#)

EPITAXIAL GROWTH AND MORPHOLOGY

***Self-Organization of Steps and Domain Boundaries of 7x7
Reconstruction on Si(111) 59**
H. Hibino, Y. Homma, and T. Ogino

**Structural Evolution During the Initial Epitaxial Growth of Mo
on Sapphire 71**
P.A. Ryan and F. Tsui

Step Bunching During SiGe Growth on Vicinal Si(111) Surfaces 77
H. Hibino and T. Ogino

*NOVEL CONCEPTS OF RESISTS
FOR NANOLITHOGRAPHY*

***Resist Materials and Nanolithography 85**
Elizabeth A. Dobisz

**Anisotropic Organic/Inorganic Resists: A Novel Concept for
Electron Proximity Effect Reduction 97**
Lhadi Merhari, Henry H. Li, and Kenneth E. Gonsalves

***Fullerene-Incorporated Nanocomposite Resist System for
Nanolithography 103**
T. Ishii, H. Nozawa, E. Kuramochi, and T. Tamamura

Systematic Studies of Fullerene Derivative Electron Beam Resists 115
A.P.G. Robinson, R.E. Palmer, T. Tada, T. Kanayama, E.J. Shelley,
D. Philp, and J.A. Preece

**Polymer-Inorganic High Contrast and High Sensitivity Resists for
Nanolithography 121**
Hengpeng Wu, Jianzhao Wang, and Kenneth E. Gonsalves

New High Resolution Liquid Crystal Electron Beam Resists 129
A.P.G. Robinson, R.E. Palmer, T. Tada, T. Kanayama, M.T. Allen,
J.A. Preece, and K.D.M. Harris

***Resist Materials Providing Small Line-Edge Roughness 135**
Hideo Namatsu, Toru Yamaguchi, and Kenji Kurihara

*Invited Paper

Cambridge University Press
978-1-107-41417-4 - Materials Research Society Symposium Proceedings: Volume 584:
Materials Issues and Modeling for Device Nanofabrication
Editors: Lhadi Merhari, Luc T. Wille, Kenneth E. Gonsalves, Mark F. Gyure,
Shinji Matsui and Lloyd J. Whitman
Frontmatter
[More information](#)

A New High Performance CA Resist for E-Beam Lithography	147
Ranee Kwong, Wu-Song Huang, Wayne Moreau, Robert Lang, Christopher Robinson, David R. Medeiros, Ari Aviram, Richard C. Guarnieri, and Marie Angelopoulos	
Diffusion and Distribution of Photoacid Generators in Thin Polymer Films	155
Qinghuang Lin, Marie Angelopoulos, Katherina Babich, David Medeiros, Narayan Sundararajan, Gina Weibel, and Christopher Ober	
Photo and Scanning Probe Lithography Using Alkylsilane Self-Assembled Monolayers	163
H. Sugimura, T. Hanji, O. Takai, K. Fukuda, and H. Misawa	
Carbon Dioxide—Dilated Block Copolymer Templates for Nanostructured Materials	169
Garth D. Brown and James J. Watkins	

*ATOMIC SCALE CHARACTERIZATION
AND MEASUREMENT*

A New Purged UV Spectroscopic Ellipsometer to Characterize 157 nm Nanolithographic Materials	177
Pierre Boher, Jean Philippe Piel, Patrick Evrard, and Jean Louis Stehle	
Optical Characterization and Process Control of Top Surface Imaging	183
Ying-Ying Luo, Craig Stauffer, Carlos Ygartua, Dinh Chu, and Clive Hayzelden	
Improved Algorithm to Extract Force-Distance Curves From Scanning Force Microscope Data	189
Steven J. Eppell, Brian A. Todd, and Fredy R. Zypman	
Extending the Possibilities of Near-Field Scanning Optical Microscopy for Simultaneous Topographical and Chemical Force Imaging	195
N. Nagy and M.C. Goh	
Real-Time Observation of Pt-Si Micro-Droplet Migration by Photoelectron Emission Microscopy	201
W. Yang, H. Ade, and R.J. Nemanich	

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Materials Issues and Modeling for Device Nanofabrication
Editors: Lhadi Merhari, Luc T. Wille, Kenneth E. Gonsalves, Mark F. Gyure,
Shinji Matsui and Lloyd J. Whitman
Frontmatter
[More information](#)

**Second Derivative Ballistic Electron Emission Spectroscopy
in Au/(AlGa)As 207**
M. Kozhevnikov, V. Narayanamurti, D.L. Smith, and Yi-Jen Chiu

MODELING AND ATOMISTIC SIMULATIONS

***Modeling of Structural and Elastic Properties of In_xGa_{1-x}N Alloys 215**
Frank Grosse and Jörg Neugebauer

***Effects of Interface Roughness and Embedded Nanostructures on
Device Properties 223**
D.Z.-Y. Ting, T.C. McGill, N.Y. Chen, J.N. Wang, R.G. Li,
Y.Q. Wang, W.K. Ge, and J.N. Schulman

**Cluster Model Study of the Incorporation Process of Excess Arsenic
Into Interstitial Positions of the GaAs Lattice 233**
T. Marek, S. Kunsági-Máté, and H.P. Strunk

Computer Simulation of Nucleation on Patterned Surfaces 239
A. Kuronen, L. Nurminen, and K. Kaski

**Realization of Detailed Kinetic Models for the Growth of II-VI
Compounds Adopting DFT Calculations and Experimental Evidences 245**
Carlo Cavallotti, Valeria Bertani, Maurizio Masi, and Sergio Carrà

**Effect of Hydrogen Coverage on Silicon Thin Film Growth:
Molecular Dynamics Investigation 251**
Shinya Muramatsu, Masatoshi Shimada, and Masahiko Hirao

**A Kinetic Monte Carlo Model of Silicon CVD Growth From
a Mixed H₂/SiH₄ Gas Source 257**
M. Fearn, M. Sayed, J.H. Jefferson, and D.J. Robbins

**Molecular Dynamics Simulations of Solid Phase Epitaxy of Si:
Growth Mechanism and Defect Formation 263**
T. Motooka, S. Munetoh, K. Nisihira, K. Moriguchi, and
A. Shintani

**Multimillion-Atom Simulations of Atomic-Level Surface Stresses
and Pressure Distribution on InAs/GaAs Mesas 269**
Xiaotao Su, Rajiv K. Kalia, Anupam Madhukar, Aiichiro Nakano,
and Priya Vashishta

*Invited Paper

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Shinji Matsui and Lloyd J. Whitman
Frontmatter
[More information](#)

**Effects of the Electronic Structure on the Stability of Metallic
Superlattices: Semi-Empirical Calculations of the Total Energy 275**
A.M. Mazzone

NANODEVICES AND NANOSTRUCTURES

***Gate Technology Issues for Silicon MOS Nanotransistors 283**
D.M. Tennant, G.L. Timp, L.E. Ocola, M. Green, T. Sorsch,
A. Kornblit, F. Klemens, R. Kleiman, D.A. Muller, Y. Kim, and
W. Timp

***Nanostructure Fabrication Using Electron Beam 293**
Shinji Matsui

***Nanoscale Electron-Beam Processes and Its Application to
Nanodevices 305**
Masanori Komuro

**The Novel Technique of Nanometer-Size Fabrication by Using
Conventional Photolithography 313**
Shingi Hashioka and Hideki Matsumura

**SPM Based Lithography for Nanometer Scale Electrodes
Fabrication 319**
A. Notargiacomo, E. Giovine, E. Cianci, V. Foglietti, and
F. Evangelisti

**Fabrication of Isolated Nanoparticle Circuitry Via Lensless
Optical Tweezing (L.O.T.s) 325**
M.T. Dearing and G.C. Spalding

**Localized Charge Storage in CeO₂/Si(111) by Electrostatic Force
Microscopy 331**
J.T. Jones, P.M. Bridger, O.J. Marsh, and T.C. McGill

Author Index 337

Subject Index 339

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Frontmatter

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Frontmatter

[More information](#)

PREFACE

The exploding market of information technology requires ultra-high-speed integrated circuits, which imposes formidable challenges in terms of nanofabrication, advanced materials, atomic scale measurements and modeling. The enormous costs of next-generation lithographic machines to mass produce integrated circuits with sub-100 nm resolution justify alternative approaches where the use of advanced materials and techniques for nanofabrication including epitaxial growth, and their powerful modeling, can lead to more cost-effective strategies.

This volume contains most of the papers that were presented during Symposium J, "Advanced Materials and Techniques for Nanolithography," and Symposium N, "Atomic Scale Measurements and Atomistic Models of Epitaxial Growth and Lithography," at the 1999 MRS Fall Meeting in Boston, Massachusetts. Because of the complementary nature of the two subject matters, particularly in their applicability to device nanofabrication, it was felt that a combined proceedings volume offered the best way to present the findings in a unified and comprehensive manner. The editors trust that the reader will find here a nice overview of the state of the art, both theoretical and experimental, as well as an indication of the future trends and remaining challenges in this technologically important field.

Symposium J focused on the materials aspect of nanolithography by highlighting the advances in resist technology, which is now increasingly recognized as a bottleneck for sub-100 nm resolution. Indeed, whatever the degree of sophistication of a lithographic machine, a non-optimum resist can completely ruin the overall lithographic process. Major papers describing new concepts of resists based on various nanocomposites and particularly on ordered polymer/inorganic structures to decrease electron proximity effects are included in this volume.

Advances in lithographic techniques such as X-ray lithography and electron beam lithography are described, while a special emphasis is put on ion projection lithography. Indeed, ion projection lithography is a very promising and versatile technique which has benefitted from more research and development efforts in Europe than in the U.S.A. Generally regarded as the next revolution in electronics, molecular electronics has been covered bearing in mind that future lithographies should aim at taking up the challenge of "molecular"-scale interconnections. For the sake of completeness, contributions exemplifying the fabrication of real nanostructures and useful nanodevices such as nanotransistors are included.

The papers from Symposium N contained in this volume focus on recent advances made in both atomic scale measurements and models of epitaxial growth as well as lithography. They strike a nearly equal balance between theoretical and experimental approaches. Scanning probe microscopy is the dominant experimental theme, although other techniques are also represented. As described here, advances in plan view and cross

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Frontmatter

[More information](#)

sectional techniques make it clear that characterization of device materials has now reached the point where feedback from such measurements can be used to improve device growth. The theory papers are divided primarily between kinetic Monte Carlo (KMC) simulations of growth and ab initio calculations of basic surface properties. A few papers discuss how to combine ab initio data for transition energies with KMC simulations, and this appears to be a promising approach for the development of robust models for growth. Validation of such models by scanning probe microscopy is now at hand and promises to be an exciting area for the future, offering rich collaboration between theorists and experimentalists, ultimately leading to a faster design cycle, reduced costs, and more efficient devices.

Lhadi Merhari
Luc T. Wille
Kenneth E. Gonsalves
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[More information](#)

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Frontmatter

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