PROCEEDINGS OF SPIE

SPIDigitalLibrary.org/conference-proceedings-of-spie

Front Matter: 10963

, "Front Matter: 10963," Proc. SPIE 10963, Advanced Etch Technology for Nanopatterning VIII, 1096301 (14 June 2019); doi: 10.1117/12.2533873

SPIE.

Event: SPIE Advanced Lithography, 2019, San Jose, California, United States

PROCEEDINGS OF SPIE

Advanced Etch Technology for Nanopatterning VIII

**Richard S. Wise
Catherine B. Labelle**
Editors

**25–26 February 2019
San Jose, California, United States**

Sponsored by
SPIE

Cosponsored by
LAM Research Corporation (United States)

Published by
SPIE

Volume 10963

Proceedings of SPIE 0277-786X, V. 10963

SPIE is an international society advancing an interdisciplinary approach to the science and application of light.

Advanced Etch Technology for Nanopatterning VIII, edited by Richard S. Wise, Catherine B. Labelle, Proc. of SPIE Vol. 10963, 1096301 · © 2019 SPIE · CCC code: 0277-786X/19/\$18 · doi: 10.1117/12.2533873

Proc. of SPIE Vol. 10963 1096301-1

The papers 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. Additional papers and presentation recordings may be available online in the SPIE Digital Library at SPIDigitalLibrary.org.

The papers 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 these proceedings:

Author(s), "Title of Paper," in *Advanced Etch Technology for Nanopatterning VIII*, edited by Richard S. Wise, Catherine B. Labelle, Proceedings of SPIE Vol. 10963 (SPIE, Bellingham, WA, 2019) Seven-digit Article CID Number.

ISSN: 0277-786X
ISSN: 1996-756X (electronic)

ISBN: 9781510625730
ISBN: 9781510625747 (electronic)

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 © 2019, 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/19/\$18.00.

Printed in the United States of America by Curran Associates, Inc., under license from SPIE.

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. A unique citation identifier (CID) number is assigned to each article at the time of publication. Utilization of CIDs allows articles to be fully citable as soon as they are published online, and connects the same identifier to all online and print versions of the publication. SPIE uses a seven-digit CID article numbering system structured as follows:

- The first five 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.

Contents

v	<i>Authors</i>
vii	<i>Conference Committee</i>
ix	<i>Introduction</i>

KEYNOTE SESSION: PLASMA BASED PATTERNING INNOVATIONS

10963 04	Etch aware computational patterning in the era of atomic precision processing (Keynote Paper) [10963-3]
----------	--

MATERIALS AND ETCH INTEGRATION

10963 05	Fabrication challenges and opportunities for high-mobility materials: from CMOS applications to emerging derivative technologies (Invited Paper) [10963-4]
10963 06	Metal organic cluster photoresists: new metal oxide systems (Invited Paper) [10963-5]
10963 07	SPARC: a novel technology for depositing conformal dielectric thin films with compositional tuning for etch selectivity (Invited Paper) [10963-6]

PATTERNING PROCESS CONTROL AND COMPUTATIONAL PATTERNING

10963 08	Scanner and etch co-optimized corrections for better overlay and CD control [10963-7]
10963 09	Predicting and optimizing etch recipes for across the wafer uniformity [10963-8]
10963 0B	Integrated atomic scale CD control and local variability reduction techniques [10963-10]
10963 0C	Using machine learning technology to accelerate the development of plasma etching processes [10963-11]

ATOMIC LAYER ETCHING AND NOVEL PLASMA TECHNIQUES

10963 0E	Peculiarities of selective isotropic Si etch to SiGe for nanowire and GAA transistors [10963-13]
10963 0G	Across-wafer sub-1 nm critical dimension uniformity control by etch tool correction [10963-16]

EUV PATTERNING AND ETCH: JOINT SESSION WITH CONFERENCES 10957 AND 10963

- 10963 OH **EUV line-space pattern defect mitigation simulation using Coventor SEMulator3D to enable exposure dose reduction [10963-17]**

PATTERNING SOLUTIONS FOR EMERGING APPLICATIONS

- 10963 OM **Ultrahigh selective etching of Si₃N₄ over SiO₂ using plasma-less dry process for 3D-NAND device applications [10963-22]**

ADVANCED PATTERNING INTEGRATION

- 10963 OP **Plasma etch selectivity study and material screening for self-aligned gate contact (SAGC) [10963-25]**
- 10963 OQ **Virtual fabrication and advanced process control improve yield for SAQP process assessment with 16 nm half-pitch [10963-26]**

PATTERNING SOLUTIONS FOR EMERGING APPLICATIONS II

- 10963 OT **Simulation and optimization of etch on flexible substrates for roll-to-roll processing [10963-29]**

Authors

Numbers in the index correspond to the last two digits of the seven-digit citation identifier (CID) article numbering system used in Proceedings of SPIE. The first five digits reflect the volume number. Base 36 numbering is employed for the last two digits and indicates the order of articles within the volume. Numbers start with 00, 01, 02, 03, 04, 05, 06, 07, 08, 09, 0A, 0B...0Z, followed by 10-1Z, 20-2Z, etc.

Alian, A., 05	Lee, Changwoo, 0G
Altamirano Sánchez, Efrain, 0P	Lee, Jae Gyoo, 08
Baderot, J., 0C	Mannaert, G., 05
Ban, Yang, 09, 0T	Martinez, S., 0C
Bernard, G., 0C	Metz, Andrew, 0P
Biolsi, Peter, 0E	Milenin, A., 05
Bonnecaze, Roger T., 09, 0T	Musselman, Marcus, 08
Capogreco, E., 05	Ober, Christopher K., 06
Carbery, Marcus, 08	Oh, Nang-Lyeom, 08
Catano, Christopher, 0E	Pan, Wenyang, 06
Chang, Shihsheng, 0P	Pan, Yang, 0H
Chen, Owen, 08	Peralagu, U., 05
Chen, Ssuwei, 08	Peter, A., 05
Cho, Yong-Tae, 08	Radisic, Dunja, 0P
Chopra, Meghali, 09, 0T	Ranjan, Alok, 04, 0E
Collaert, N., 05	Sakai, Kazunori, 06
De Jaeger, B., 05	Schmidt, Lucian, 08
de Wit, Ruud, 08	Sebaai, Farid, 05, 0P
Deckers, David, 08	Shamma, Nader, 0H
Demand, Marc, 0P	Shen, Peng, 0M
Demuyne, Steven, 0P	Shinagawa, J., 04
Derville, A., 0C	Smith, Jeffrey, 0P
Devriendt, K., 05	Sobieski, Daniel, 0H
Ervin, J., 0Q	Sridhar, Shyam, 0E
Foucher, J., 0C	Stafford, Nathan, 0M
Fried, David, 0H	Sun, Junling, 0P
Gey, G., 0C	Talone, Christopher, 0E
Giannelis, Emmanuel P., 06	Teugels, Lieve, 05, 0P
Helpert, Sofia, 09, 0T	Vais, A., 05
Hisamatsu, Toru, 0B	van Dorp, D., 05
Honda, Masanobu, 0B	van Hemert, Tom, 08
Hopf, Toby, 05, 0P	Varadarajan, Bhadri, 07
Horiguchi, N., 05	Ventzek, P. L. G., 04
Hsu, Chih-Yu, 0M	Viatkina, Katja, 08
Jeong, Ik-Hyun, 08	Vincent, Benjamin, 0Q
Joy, Nicholas, 0E	Voronin, Sergey, 0E
Ju, Jae-Wuk, 08	Waldron, N., 05
Jung, Seok-Heon, 06	Walke, A., 05
Katsunuma, Takayuki, 0B	Wilson, C., 0Q
Kenis, K., 05	Wise, Rich, 0H
Kihara, Yoshihide, 0B	Witters, L., 05
Kim, Heung-Joo, 08	Wostyn, K., 05
Kim, Hyun-Sok, 08	Yu, H., 05
Kim, R. H., 0Q	Yu, Jengyi, 0H
Kim, Young-Sik, 08	
Koo, Seung-Woo, 08	
Kumar, Kaushik, 0P	
Kwon, Heidi, 08	
Lariviere, S., 0Q	

Conference Committee

Symposium Chair

Will Conley, Cymer, an ASML Company (United States)

Symposium Co-Chair

Kafai Lai, IBM Thomas J. Watson Research Center (United States)

Conference Chair

Richard S. Wise, Lam Research Corporation (United States)

Conference Co-Chair

Catherine B. Labelle, Intel Corporation (United States)

Conference Program Committee

Efrain Altamirano-Sánchez, IMEC (Belgium)

Keun Hee Bai, SAMSUNG Electronics Company, Ltd. (Korea, Republic of)

Julie Bannister, Tokyo Electron America, Inc. (United States)

Maxime Darnon, LN2 CNRS (Canada)

Sebastian U. Engelmann, IBM Thomas J. Watson Research Center
(United States)

Eric A. Hudson, Lam Research Corporation (United States)

Kaushik A. Kumar, Tokyo Electron Ltd. (Japan)

Qinghuang Lin, IBM Thomas J. Watson Research Center (United States)

Ru-Gun Liu, Taiwan Semiconductor Manufacturing Company Ltd.
(Taiwan)

Nihar Mohanty, Oculus VR, LLC (United States)

Jake O'Gorman, Hitachi High Technologies America, Inc. (United States)

Erwine Pargon, CNRS/LTM (France)

Nicolas Posseme, CEA-LETI (France)

Ricardo Ruiz, HGST (United States)

Yuyang Sun, Mentor Graphics Corporation (United States)

Ying Zhang, NAURA (United States)

Session Chairs

- 1 Keynote Session: Plasma Based Patterning Innovations
Efrain Altamirano-Sánchez, IMEC (Belgium)
Richard S. Wise, Lam Research Corporation (United States)

- 2 Materials and Etch Integration
Eric A. Hudson, Lam Research Corporation (United States)
Efrain Altamirano-Sánchez, IMEC (Belgium)
- 3 Patterning Process Control and Computational Patterning
Ricardo Ruiz, HGST, Inc. (United States)
Yuyang Sun, Mentor, a Siemens Business (United States)
- 4 Atomic Layer Etching and Novel Plasma Techniques
Jake O'Gorman, Hitachi High Technologies America, Inc. (United States)
Catherine Labelle, Intel Corporation (United States)
- 5 EUV Patterning and Etch: Joint session with conferences 10957 and 10963
Rich S. Wise, Lam Research Corporation (United States)
Nelson Felix, IBM Thomas J. Watson Research Center (United States)
- 6 Patterning Solutions for Emerging Applications
Nihar Mohanty, Oculus VR, LLC (United States)
Rich S. Wise, Lam Research Corporation (United States)
- 7 Advanced Patterning Integration
Julie Bannister, Tokyo Electron America, Inc. (United States)
Nicolas Possémé, CEA-LETI (France)
- 8 Patterning Solutions for Emerging Applications II
Jake O'Gorman, Hitachi High Technologies America, Inc. (United States)
Qinghuang Lin, ASML US, Inc. (United States)