PROCEEDINGS OF SPIE

SPIDigitalLibrary.org/conference-proceedings-of-spie

Front Matter: Volume 10584

, "Front Matter: Volume 10584," Proc. SPIE 10584, Novel Patterning Technologies 2018, 1058401 (10 July 2018); doi: 10.1117/12.2325244

SPIE.

Event: SPIE Advanced Lithography, 2018, San Jose, California, United States

PROCEEDINGS OF SPIE

Novel Patterning Technologies 2018

**Eric M. Panning
Martha I. Sanchez**
Editors

**26 February–1 March 2018
San Jose, California, United States**

Sponsored and Published by
SPIE

Volume 10584

Proceedings of SPIE 0277-786X, V. 10584

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

Novel Patterning Technologies 2018, edited by Eric M. Panning, Martha I. Sanchez,
Proc. of SPIE Vol. 10584, 1058401 · © 2018 SPIE · CCC code:
0277-786X/18/\$18 · doi: 10.1117/12.2325244

Proc. of SPIE Vol. 10584 1058401-1

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 SPIEDigitalLibrary.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 *Novel Patterning Technologies 2018*, edited by Eric M. Panning, Martha I. Sanchez, Proceedings of SPIE Vol. 10584 (SPIE, Bellingham, WA, 2018) Seven-digit Article CID Number.

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

ISBN: 9781510616608
ISBN: 9781510616615 (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 © 2018, 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/18/\$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**
SPIEDigitalLibrary.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

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

INVITED SESSION: SCANNING PROBE PATTERNING

10584 04	High-throughput scanning probe instruments for nanopatterning, alignment, and overlay metrology (Invited Paper) [10584-3]
10584 05	Thermal scanning probe lithography: from spintronics to biomedical applications (Invited Paper) [10584-4]
10584 06	Field-emission scanning probe lithography with self-actuating and self-sensing cantilevers for devices with single digit nanometer dimensions (Invited Paper) [10584-5]

NOVEL LITHOGRAPHY AND ALTERNATIVE PATTERNING I

10584 07	The state of the art in multicolor visible photolithography (Invited Paper) [10584-6]
10584 08	Multi-color approach on self-aligned multiple patterning for single line cut application [10584-7]
10584 09	Helium ion active hybrid non-chemically amplified resist (n-CAR) for sub-10 nm patterning applications [10584-8]

SELF-ASSEMBLY

10584 0C	Precise control of template affinity achieved by UV-assisted graphoepitaxy approach on silicon nanowires applications [10584-11]
----------	---

E-BEAM LITHOGRAPHY

10584 0F	e-beam direct write: why it's always left standing at the altar of new nodes (Invited Paper) [10584-14]
10584 0G	Performance validation of Mapper's FLX-1200 (Invited Paper) [10584-15]

10584 OH **Multi-beam mask writer MBM-1000** [10584-16]

DSA MATERIALS AND CHARACTERIZATION: JOINT SESSION WITH CONFERENCES 10586 AND 10584

10584 OK **Studying the effects of chemistry and geometry on DSA hole-shrink process in three dimensions**
[10584-19]

DSA MATERIALS AND INTEGRATION: JOINT SESSION WITH CONFERENCES 10586 AND 10584

10584 OL **The integration of 193i and DSA for BEOL metal cuts/blocks targeting sub-20nm tip-to-tip CD**
[10584-20]

10584 OM **Defect and roughness reduction of chemo-epitaxy DSA pattern** [10584-21]

10584 ON **Evaluation of line-edge/line-width roughness of directed self-assembled PS-b-PMMA patterns using coarse-grained molecular dynamics simulation** [10584-22]

NANOIMPRINT LITHOGRAPHY MASKS AND SYSTEMS

10584 OQ **Performance of a nanoimprint mask replication system** [10584-25]

10584 OR **Design for nanoimprint lithography: hot spot modification through total NIL process simulation**
[10584-26]

10584 OS **A novel resist system for enhanced resist spreading in nanoimprint lithography** [10584-27]

NANOIMPRINT LITHOGRAPHY FOR HIGH VOLUME MANUFACTURING

10584 OT **Updates of nanoimprint lithography for production and applications for next generation memory devices (Invited Paper)** [10584-28]

10584 OU **Overlay improvements using a novel high-order distortion correction system for NIL high-volume manufacturing (Invited Paper)** [10584-29]

10584 OV **Improvement of nano-imprint lithography performance for device fabrication** [10584-30]

NOVEL LITHOGRAPHY AND ALTERNATIVE PATTERNING II AND 3D PATTERNING METHODS

10584 OX **3D micro-mirror lithography for mass production (Invited Paper)** [10584-32]

- 10584 0Y **Electrochemical nanoimprinting of silicon: a direct patterning approach** [10584-33]
- 10584 0Z **AutoSCIL 200mm tooling in production, x-ray optics, and cell growth templates** [10584-34]

NOVEL LITHOGRAPHY AND ALTERNATIVE PATTERNING III

- 10584 1I **Process development of a maskless N40 via level for security application with multi-beam lithography** [10584-36]
- 10584 1J **Single-nanometer accurate 3D nanoimprint lithography with master templates fabricated by NanoFrazor lithography** [10584-37]

POSTER SESSION

- 10584 1K **Contact/proximity stepper using UVA, UVB, and UVC light sources** [10584-38]
- 10584 1L **Green ethanol-developable electron beam lithography processes using positive tone biomass resist material** [10584-39]
- 10584 1M **Nanoimprint lithography using gas permeable template II** [10584-40]
- 10584 1N **Gas permeable template derived from cellulose in ultraviolet nanoimprint** [10584-41]
- 10584 1O **Benchmarking 3-color photoresists for multiphoton absorption lithography** [10584-42]
- 10584 1P **Thin films for high-resolution, 3-color lithography** [10584-43]
- 10584 1Q ***In situ* polymerization threshold detection of 3-color systems and a study of the time dependence** [10584-44]
- 10584 1R **Substrate damageless tri-layer process for advanced ArFi lithography** [10584-46]
- 10584 1S **Model-based proximity effect correction for helium ion beam lithography** [10584-47]
- 10584 1T **Process control technology for nanoimprint lithography** [10584-49]
- 10584 1U **Mask lithographic performance investigation with computational Monte-Carlo method on advanced mask patterning** [10584-50]
- 10584 1V **Material development for high-throughput nanoimprint lithography** [10584-48]
- 10584 1W **Fabrication of optical nanodevices through field-emission scanning probe lithography and cryogenic etching** [10584-51]

10584 1H **Effect of homopolymer concentration on LER and LWR in block copolymer/homopolymer blends** [10584-52]

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.

Aghili, Ali, 0Q	Farrell, Richard, 08, 0L
Ahmad, Ahmad, 06	Felix, Nelson, 0L
Alaca, B. Erdem, 06, 1G	Fourkas, John T., 07, 17, 18, 19
Albisetti, E., 05	Fregin, Trevor, 0X
Allouti, N., 0C	Fröhlich, Thomas, 06
Argoud, M., 0C	Fuessl, Roland, 06
Ates, Onur, 1G	Fukuhara, Kazuya, 0V
Aydogan, Cemal, 06, 1G	Germain, Allan, 11
Azeredo, Bruno, 0Y	Ghosh, Subrata, 09
Baskaran, Durairaj, 0N	Glinser, T., 12
Bernadac, Arthur, 11	Glodde, Martin, 0L
Bertacco, R., 05	Gonsalves, Kenneth E., 09
Bezik, Cody, 0K	Gronheid, Roel, 0K
Bicer, Mahmut, 06, 1G	Guliyev, Elshad, 06
Biolsi, Peter, 08	Guo, Jing, 0L
Blancquaert, Yoann, 0G, 11	Gutierrez Razo, Sandra A., 07, 17, 18, 19
Brandt, Pieter, 0G	Hanabata, Makoto, 15, 16
Breaux, Caleb L., 1H	Hatano, Masayuki, 0V, 1F
Brun, Philippe, 11	Haugabrook, Lynelle, 0X
Budden, Matthias, 06	Hayashi, Tatsuya, 0U
Bullerjahn, F., 12	Henderson, Clifford L., 1H
Calo, Annalisa, 05	Herfst, Rodolf, 04
Cayrefourcq, I., 0C	Hetzer, David, 0L
Chalupa, Z., 0C	Higashiki, Tatsuhiko, 0T
Chamiot-Maitral, G., 0C	Hiura, Mitsuru, 0Q, 0U
Chang, Chia-Hua, 1E	Hofmann, Martin, 06, 1G
Chang, Shih-Ming, 1E	Holz, Mathias, 06
Chen, Alex, 1E	Holzner, F., 12
Chen, Chien-Cheng, 1E	Hsieh, Chia-Yun, 08
Chi, Cheng, 0L	Huber, Rebecca P., 0Z
Chien, Sheng-Wei, 1C	Hutcheson, G. Dan, 0F
Choi, Eun Hyuk, 0V, 1F	Ido, Yasuyuki, 0L, 0M
Choi, Jin, 0Q	Im, Ji-Young, 0R
Chou, Shuo-Yen, 1E	Imoto, Kohei, 0Q
Claveau, G., 0C	Inada, Hiroshi, 0Q
Cohen, Samuel R., 07, 18	Inoue, Hideo, 0H
Comboroure, C., 0C	Ishikawa, Masayoshi, 1B
Corliss, Daniel, 0L	Ivanov, Tzvetan, 06
Dansberg, Michel, 0G	Iwanaga, Takehiko, 0Q
Dazai, Takahiro, 0K	Jager, Remco, 0G
de Boer, Guido, 0G	Jones, Chris, 0Q
de Pablo, Juan, 0K	Jones, Mervyn, 06
Delly, Evan, 0X	Joo, Yong Lak, 0N
Delony, Jakin B., 1H	Jung, Wooyung, 0V, 1D, 1F
Doise, Jan, 0K	Kaestner, Marcus, 06
Durrani, Zahid, 06	Kato, Hirokazu, 0V, 1F
Ehara, Kengo, 1B	Khusnatdinov, Niyaz, 0S
Essomba, Philippe, 11	Kimura, Atsushi, 0Q, 0U
Falvey, Daniel E., 07, 18	Kitano, Takahiro, 0M

Ko, Akiteru, 08
 Kobayashi, Kei, 0V, 1F
 Kobayashi, Sachiko, 0R
 Komori, Motofumi, 0R, 1D
 Kono, Takuya, 0R, 0V, 1D, 1F
 Kuehnelt, Michael, 06
 Kulmala, T. S., 12
 Kurosawa, Tsuyoshi, 0K
 Lai, Kafai, 0L
 Landis, Stéfan, 0G, 11
 Lee, Chien-Lin, 1C
 Lenk, Claudia, 06, 1G
 Lenk, Steve, 06
 Liaros, Nikolaos, 07, 17, 18, 19
 Liu, Chi-Chun, 0L
 Liu, Chun-Hung, 1E
 Liu, Eric, 08
 Liu, Ru-Gun, 1E
 Liu, Weijun, 0S
 Liverman, Nicholas, 0X
 Lo, Wen, 1E
 Ludovice, Peter J., 1H
 Manske, E., 06
 Matsumoto, Hiroshi, 0H
 Matsumoto, Yoko, 15
 Matsumura, Yuushi, 1B
 Maturova, Klara, 04
 McCoy, Jake, 0Z
 Metz, Andrew, 0L
 Mignot, Yann, 0L
 Miura, Ichihiko, 1B
 Mizui, Kento, 16
 Mizuno, Makoto, 0Q
 Mohtashami, Abbas, 04
 Moinuddin, Mohamad Ghulam, 09
 Moore, N. Collin, 0X
 Mullin, Amy S., 07, 18, 19
 Muramatsu, Makoto, 0L, 0M
 Nakagawa, Hiroki, 1B
 Nakajima, Shinya, 15, 16
 Nakamura, Takayuki, 1F
 Nakasugi, Tetsuro, 0R, 0V, 1D, 1F
 Navarro, C., 0C
 Navarro, Violeta, 04
 Nealey, Paul F., 0K
 Niazorau, Stanislaw, 0Y
 Nicolet, C., 0C
 Nishi, Takanori, 0M
 Oehrlin, Gottlieb S., 07, 18
 Ogden, Hannah M., 07, 18, 19
 Ohtoshi, Kenji, 0H
 O'Meara, David, 08
 Paans, Manuel, 0Z
 Pain, Laurent, 0C, 0G
 Peijster, Jerry, 0G
 Petersen, John S., 07, 17, 18, 19
 Petti, D., 05
 Pimenta-Barros, Patricia, 0C, 11
 Pinge, Shubham, 0N
 Piras, Daniele, 04
 Posseme, N., 0C
 Pradeep, Chulikkattil P., 09
 Pradelles, Jonathan, 0G, 11
 Pranda, Adam, 07, 18
 Rademaker, Guido, 0G
 Rangelow, Ivo W., 06, 1G
 Rawlings, C. D., 12
 Reddy, Pulikanti Guruprasad, 09
 Ren, Jiaxing, 0K
 Reum, Alexander, 06
 Reuter, Christoph, 06
 Riedo, E., 05
 Rincon-Delgadillo, Paulina, 0K
 Sadeghian, Hamed, 04
 Sakai, Tatsuya, 1B
 Sato, Chiaki, 0Q
 Schleunitz, A., 12
 Segal-Peretz, Tamar, 0K
 Sekiguchi, Atsushi, 15
 Servin, Isabelle, 0G, 11
 Sha, Jing, 0L
 Sharma, Satinder K., 09
 Sharstniou, Aliaksandr, 0Y
 Shy, Shyi-Long, 13
 Slot, Erwin, 0G
 Spieser, M., 12
 Stachowiak, Tim, 0S
 Steenbrink, Stijn, 0G
 Sugino, Naoto, 15
 Suzuki, Yoshio, 0U
 Suzuki, Masato, 0V
 Takanashi, Kazunori, 1B
 Takei, Satoshi, 14, 15, 16
 Tamura, Takao, 0H
 ten Berge, Gerard, 11
 Thum, Matthew, 07
 Tiron, R., 0C
 Tokue, Hiroshi, 0V, 1F
 Tomova, Zuleykhan, 07, 17
 Torun, Hamdi, 1G
 Tsai, Kuen-Yu, 1C
 Tsuda, Hirotaka, 0R, 1D
 van Brakel, Remco, 0Z
 van Es, Maarten, 04
 Verschuuren, Marc A., 0Z
 Volland, Burkhard, 1G
 Voorkamp, Rob, 0Z
 Washida, Kazuhiro, 0R, 1D
 Wieland, Marco, 0G, 11
 Wolf, Steven M., 07, 18
 Wu, Hsin-Wei, 1E
 Yalcinkaya, Arda D., 1G
 Yamamoto, Kiyohito, 0Q
 Yamashita, Hiroshi, 0H
 Yamashita, Kyoji, 0R
 Yamazaki, Akiyoshi, 0K
 You, Gen, 0M
 Zheng, Xiaorui, 05
 Zhou, Chun, 0K
 Zöllner, Jens-Peter, 06

Conference Committee

Symposium Chair

Bruce W. Smith, Rochester Institute of Technology (United States)

Symposium Co-chair

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

Conference Chair

Eric M. Panning, Intel Corporation (United States)

Conference Co-chair

Martha I. Sanchez, IBM Research - Almaden (United States)

Conference Program Committee

Chris Bencher, Applied Materials, Inc. (United States)

Alan D. Brodie, KLA-Tencor Corporation (United States)

Kenneth R. Carter, University of Massachusetts Amherst (United States)

Juan J. de Pablo, The University of Chicago (United States)

Richard A. Farrell, TEL Technology Ctr., America, LLC (United States)

Naoya Hayashi, Dai Nippon Printing Co., Ltd. (Japan)

Daniel J. C. Herr, The University of North Carolina at Greensboro
(United States)

Tatsuhiko Higashiki, Toshiba Corporation (Japan)

Erik R. Hosler, GLOBALFOUNDRIES Inc. (United States)

J. Alexander Liddle, National Institute of Standards and Technology
(United States)

Shy-Jay Lin, Taiwan Semiconductor Manufacturing Company Ltd.
(Taiwan)

Chi-Chun Liu, IBM Corporation (United States)

Hans Loeschner, IMS Nanofabrication GmbH (Austria)

John G. Maltabes, Applied Materials GmbH & Company KG
(United States)

Laurent Pain, CEA-LETI (France)

Ivo W. Rangelow, Technische University Ilmenau (Germany)

Douglas J. Resnick, Canon Nanotechnologies, Inc. (United States)

Ricardo Ruiz, HGST (United States)

Chandrasekhar Sarma, Intel Corporation (United States)

Frank M. Schellenberg, Consultant (United States)

Helmut Schiff, Paul Scherrer Institut (Switzerland)
Ines A. Stolberg, Vistec Electron Beam GmbH (Germany)
Hsinyu Tsai, IBM Thomas J. Watson Research Center (United States)
Kevin T. Turner, University of Pennsylvania (United States)
Marco J. Wieland, MAPPER Lithography (Netherlands)
Wei Wu, The University of Southern California (United States)

Session Chairs

- 1 Keynote Session
Eric M. Panning, Intel Corporation (United States)
Martha I. Sanchez, IBM Research - Almaden (United States)
- 2 Invited Session: Scanning Probe Patterning
Chandrasekhar Sarma, Intel Corporation (United States)
Richard A. Farrell, TEL Technology Ctr., America, LLC (United States)
- 3 Novel Lithography and Alternative Patterning I
Ivo W. Rangelow, Technische University Ilmenau (Germany)
Marco Wieland, MAPPER Lithography (Netherlands)
- 4 Self-Assembly
Ricardo Ruiz, Western Digital (United States)
Laurent Pain, CEA-LETI (France)
- 5 E-beam Lithography
Ines A. Stolberg, Vistec Electron Beam GmbH (Germany)
Hans Loeschner, IMS Nanofabrication GmbH (Austria)
- 6 DSA Materials and Characterization: Joint Session with Conferences 10586 and 10584
Ralph R. Dammel, EMD Performance Materials Corporation (United States)
Chi-Chun Liu, IBM Corporation (United States)
- 7 DSA Materials and Integration: Joint Session with Conferences 10586 and 10584
Daniel Sanders, IBM Research - Almaden (United States)
J. Alexander Liddle, National Institute of Standards and Technology (United States)
- 8 Nanoimprint Lithography Masks and Systems
Tatsuhiko Higashiki, Toshiba Memory Corporation (Japan)
John G. Maltabes, Applied Materials GmbH & Company KG (United States)

- 9 Nanoimprint Lithography for High Volume Manufacturing
Douglas J. Resnick, Canon Nanotechnologies, Inc. (United States)
Naoya Hayashi, Dai Nippon Printing Co., Ltd. (Japan)
- 10 Novel Lithography and Alternative Patterning II and 3D Patterning Methods
Eric M. Panning, Intel Corporation (United States)
Martha I. Sanchez, IBM Research - Almaden (United States)
- 11 Novel Lithography and Alternative Patterning III
Eric R. Hosler, Global Foundries (United States)
Martha I. Sanchez, IBM Research - Almaden (United States)