PROCEEDINGS OF SPIE

SPIDigitalLibrary.org/conference-proceedings-of-spie

Front Matter: Volume 11326

, "Front Matter: Volume 11326," Proc. SPIE 11326, Advances in Patterning Materials and Processes XXXVII, 1132601 (14 May 2020); doi: 10.1117/12.2571086

Event: SPIE Advanced Lithography, 2020, San Jose, California, United States

PROCEEDINGS OF SPIE

Advances in Patterning Materials and Processes XXXVII

**Roel Gronheid
Daniel P. Sanders**
Editors

**24–26 February 2020
San Jose, California, United States**

Sponsored and Published by
SPIE

Volume 11326

Proceedings of SPIE 0277-786X, V. 11326

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

Advances in Patterning Materials and Processes XXXVII, edited by Roel Gronheid, Daniel P. Sanders, Proc. of
SPIE Vol. 11326, 1132601 · © 2020 SPIE · CCC code: 0277-786X/20/\$21 · doi: 10.1117/12.2571086

Proc. of SPIE Vol. 11326 1132601-1

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 *Advances in Patterning Materials and Processes XXXVII*, edited by Roel Gronheid, Daniel P. Sanders, Proceedings of SPIE Vol. 11326 (SPIE, Bellingham, WA, 2020) Seven-digit Article CID Number.

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

ISBN: 9781510634190
ISBN: 9781510634206 (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 © 2020, 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 \$21.00 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/20/\$21.00.

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

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

INORGANIC RESISTS: JOINT SESSION WITH CONFERENCES 11323 AND 11326

11326 04	All-new nickel-based Metal Core Organic Cluster (MCOC) resist for N7+ node patterning [11326-3]
----------	---

STOCHASTICS: JOINT SESSIONS WITH CONFERENCES 11323 AND 11326

11326 07	Algebraic model for extremely unlikely resist dissolution events [11326-6]
11326 09	EUV chemically amplified resist component distribution and efficiency for stochastic defect control [11326-8]

NOVEL RESISTS

11326 0A	EUV resist chemical gradient enhancement by UV flood exposure for improvement in EUV resist resolution, process control, roughness, sensitivity, and stochastic defectivity [11326-9]
11326 0B	Molecular resists equipped with fluorinated aromatic units for electron-beam and extreme UV lithography [11326-10]
11326 0C	High sensitivity non-CAR resists for EUV and EB lithography [11326-11]
11326 0D	Sensitivity enhancement of chemically amplified EUV resist by adding diphenyl sulfone derivatives [11326-12]
11326 0E	Explorations of missing hole defect in EUV patterning [11326-13]

FUNDAMENTALS AND MODELING

11326 0G	Mechanism of resist heating effect in chemically amplified resist [11326-15]
11326 0I	A physics-driven complex valued neural network (CVNN) model for lithographic analysis [11326-17]
11326 0J	Infiltration synthesis of hybrid nanocomposite resists for advanced nanolithography [11326-18]

INTEGRATION

- 11326 OK **Defectivity modulation in EUV resists through advanced filtration technologies** [11326-102]
- 11326 OM **How to improve overlay of highly deformed 3D NAND wafers** [11326-20]
- 11326 ON **Challenges and opportunities of KrF photoresist development for 3D NAND application**
[11326-21]
- 11326 OO **A DOE study of plasma etched microlens shape for CMOS image sensors** [11326-22]
- 11326 OP **Unique freeze cleaning technology** [11326-23]

DEPOSITION-BASED PATTERNING

- 11326 OS **Sacrificial hardmask ALD with hydrogen peroxide: comparative study of low temperature growth and film characteristics for TiO₂ and Al₂O₃** [11326-27]

NOVEL PATTERNING

- 11326 OX **Roughness study on line and space patterning with chemo-epitaxy directed self-assembly**
[11326-31]
- 11326 OY **Defect mitigation of chemo-epitaxy DSA patterns** [11326-32]
- 11326 OZ **Establishing a sidewall image transfer chemo-epitaxial DSA process using 193 nm immersion lithography** [11326-33]

SUPPLIER

- 11326 11 **Performance enhancements with high opacity multi-trigger resist** [11326-35]
- 11326 12 **Stochastic effects on EUV CAR systems: investigation of materials impact** [11326-36]
- 11326 13 **Addressing metallic contaminants in the photochemical supply chain** [11326-37]

UNDERLAYERS

- 11326 14 **Improvement of EUV Si hardmask performance through wet chemistry functionalization**
[11326-38]

- 11326 15 **Underlayer optimization method for EUV lithography** [11326-39]
- 11326 16 **Are surfaces of silicon hardmasks adaptive?** [11326-40]
- 11326 17 **Planarized spin-on carbon hardmask** [11326-41]
- 11326 18 **Highly substituted fullerene-based spin-on organic hardmasks** [11326-42]

POSTER SESSION: EUV

- 11326 19 **Consideration of missing defect suppression technique in EUV hole patterning** [11326-47]
- 11326 1C **Focusing on nanoparticles-based photomultiplier in n-CARs** [11326-65]

POSTER SESSION: DIRECTED SELF-ASSEMBLY

- 11326 1E **Block copolymers with a fluoro-block for 5 nm DSA patterning application** [11326-43]
- 11326 1I **Block copolymer line roughness measurement via PSD: application to fingerprint samples**
[11326-66]
- 11326 1J **Expanding DSA process window with atmospheric control** [11326-103]
- 11326 1K **Understanding and mitigating bridge defects in block copolymer directed self-assembly
through computational materials design and optimization** [11326-104]

POSTER SESSION: UNDERLAYERS

- 11326 1M **New poly-maleimide resin for SOC hardmask with high thermal stability** [11326-52]
- 11326 1N **Design considerations for high etch resistance spin-on carbon underlayers** [11326-57]
- 11326 1O **Development of planarizing spin-on carbon materials for high-temperature processes**
[11326-61]
- 11326 1P **Super planarizing material for trench and via arrays** [11326-64]
- 11326 1Q **Defect mitigation and characterization in silicon hardmask materials** [11326-68]
- 11326 1R **Development of ion exchange purification for advanced materials contain siloxane polymer**
[11326-71]

POSTER SESSION: FUNDAMENTALS

- 11326 1S **Study of lithographic characteristics due to differences in novolac resin structure** [11326-44]
- 11326 1U **Local condensation of TMAH developer at photoresist/glass interface analyzed by using confocal laser scanning microscope (CLSM)** [11326-56]
- 11326 1V **Adhesion improvement of photoresist: destruction mode analysis** [11326-60]
- 11326 1W **Fundamental study on lithographic characteristics of metal oxo clusters for KrF, ArF, and electron beam lithography** [11326-105]

POSTER SESSION: INTEGRATION

- 11326 1X **A novel filter screening methodology for Si hardmask materials in EUV lithography** [11326-49]
- 11326 1Z **Improving EUV underlayer coating defectivity using point-of-use filtration** [11326-58]
- 11326 20 **CD uniformity improvement for sub 20 nm DRAM process with negative tone development** [11326-63]
- 11326 22 **Marangoni effect-based under-layer for a dual Damascene via-first approach: a scalable solution to the unwanted photoresist swing effect** [11326-70]

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.

Ahn, Kyusu, 0I	Foubert, Philippe, 0A, 0K, 1Z
Alexander, Vineet, 1Q	Frolet, Nathalie, 1J
Alvarez, Daniel, Jr., 0S	Gharbi, A., 0Z
Andachi, Keisuke, 0S	Ghosh, Subrata, 04, 1C
Aqad, Emad, 0N	Giammaria, T. J., 0Z
Argoud, Maxime, 0Z, 1I, 1J	Gildehaus, Levi, 1Q
Arisawa, You, 0C, 1J	Goldfarb, Dario L., 09
Asai, Masaya, 0C, 1J	Gonsalves, Kenneth E., 04, 1C
Ayothi, Ramakrishnan, 12	Grannemann, Stephen M., 14
Baranowski, Paul, 0N	Guerrero, Douglas J., 14, 15, 1Q, 1Z
Bavarian, Mona, 1Q	Gusmao Cacho, M. G., 0Z
Bayana, Hareem, 1Z	Hamzik, James, 13
Beckers, Johan, 0M	Hanabata, Makoto, 1S
Beera, Rajan, 0K	Hara, Arisa, 0E, 19
Benotmane, K., 0Z	Harumoto, Masahiko, 0C, 1J
Bouet, Charlotte, 0Z, 1I, 1J	Hasegawa, K., 1V
Brakensiek, Nick, 1Q	Hashimoto, Yusaku, 20
Brewster, Justin, 13	Hattori, Atsushi, 0K
Briggs, Virgil, 1Q	Hattori, Kei, 0P
Brown, Alan G., 18	He, Huan, 0N
Cameron, Jim, 17, 1N	Henderson, Clifford L., 1K
Cantù, P., 22	Hess, Alexander E., 09
Cao, Hui, 1E	Hong, Minjong, 0I
Chacko, Andrea M., 14, 15, 1Z	Hontake, Koichi, 20
Chauhan, Manvendra, 04	Horiuchi, Junya, 1M
Chavez, Anton, 1N	Hou, Xisen, 0N
Chevalier, X., 0Z	Huang, Runhui, 1O, 1P
Coley, Suzanne, 17, 1N	Huguenin, Jean-Luc, 0O
Corneo, N., 22	Ido, Yasuyuki, 0Y
Cui, Li, 17, 1N	Ikari, Y., 0G
Dado, Glenn, 1Q	Jaber, Jad A., 13
Dai, Le, 1E	Jarnias, Romain, 1I
Dall'Asta, V., 22	Jeauneau, J., 22
Daugherty, Richard, 16	Jimbo, Sadayuki, 0P
Dawson, Guy, 18	Jin, Jing, 0M
Dei, Satoshi, 12	Jullian, Karine, 1J
Delony, Jakin B., 1K	Kaneko, Tetsurou, 12
Demura, Kensuke, 0P	Kang, Min, 0I
Deng, Hai, 1E	Kasahara, Kazuki, 12
De Silva, Anuja, 09	Kawai, A., 1U, 1V
De Simone, Danilo, 0A, 15	Kawai, Shunpei, 0D
Dinh, Cong Que, 0A	Ke, lou-Sheng (Ike), 17, 1N
Drent, Waut, 0K	Kim, Jiyoung, 0J
Dudash, Viktor, 0X	Kim, Kanghyun, 0B
D'Urzo, Lucia, 0K, 1Q	Kim, Yongjo, 0I
Echigo, Masatoshi, 1M	Kisslinger, Kim, 0J
Fan, Zhiqiang, 16	Kitano, Takahiro, 0Y
Filipancic, Nicholas, 13	Kohyama, T., 1X
Foltz, Benjamin, 1N	Kommu, Srikanth, 16

Konda, A., 0G
 Kondo, Yoshihiro, 0A
 Koza, Jakub, 1O, 1P, 22
 Kozawa, Takahiro, 0D, 0G
 Kubis, Michael, 0M
 Kumar, Rudra, 04
 LaBeaume, Paul, 1N
 Lada, Tom, 11, 18
 Lamb, James, 16
 Lawson, Margaret C., 09
 Lee, Heehwan, 0I
 Lee, Jin-Kyun, 0B
 Lee, Sangsul, 0B
 Lee, Yongwoo, 0I
 Le Pennec, Aurélie, 0Z, 11
 Leverd, François, 0O
 Li, Mingqi, 0N
 Li, Xuemiao, 1E
 Li, Zhilong, 1E
 Liang, Yichen, 14, 15
 Limmer, Tim, 16, 1Q
 Lin, Y. C., 20
 Litterio, E., 22
 Liu, Cong, 0N
 Liu, Huiying, 0N
 Liu, Sheng, 17
 Long, Luke, 07
 Lorusso, Gian, 0X
 Lowes, Joyce, 16
 Lowrey, Ethan, 14
 Lu, Ming, 0J
 Ludovice, Peter J., 1K
 Luo, Ming, 14
 Mack, Chris, 0X
 Maeda, N., 0G
 Maekawa, Yasunari, 1W
 Makinoshima, Takashi, 1M
 Marshall, William, 1N
 Maruyama, Ken, 12
 Matsuda, Yusuke, 0N
 Matsumoto, Yoko, 1S
 Matsushima, Daisuke, 0P
 McClelland, Alexandra, 11, 18
 Meliorisz, Balint, 0A
 Mesawich, Mike, 1Q
 Minami, Hiroko, 1S
 Miura, Kozue, 1X
 Mizuno, Takehito, 0K
 Moinuddin, Mohamad G., 04, 1C
 Montgomery, Warren, 18
 Mori, Chisayo, 0C, 1J
 Morita, Kazuyo, 0C
 Mortini, Etienne, 0O
 Motonoto, Tomohiro, 0C, 1J
 Muramatsu, Makoto, 0Y
 Nafus, Kathleen, 0A
 Nagahara, Seiji, 0A
 Nagao, Shinichi, 1M
 Nam, Chang-Yong, 0J
 Naulleau, Patrick, 07
 Navarro, Christophe, 0Z, 1I
 Nealey, P., 0Z
 Neureuther, Andrew R., 07
 Nicolet, Célia, 0Z, 1I
 Nishi, Takanori, 0Y
 Nishikori, Katsuaki, 12
 O'Callaghan, Greg, 11, 18
 Oelklaus, Samantha, 14
 Oh, Hyun-Taek, 0B
 Ohtaguro, Hiroki, 20
 Okada, Soichiro, 0E
 Okamoto, Kazumasa, 0D, 0G
 Omatsu, Tadashi, 1M
 Oya, Takumi, 1R
 Paquet, A., 0Z
 Park, Byeon-Gyu, 0B
 Park, Hyun Sung, 0I
 Park, Jong, 0N
 Paudel, Shyam, 1Q
 Peter, Jerome, 04
 Petersen, John S., 0A
 Pham, H., 0Z
 Polgrean, Heather, 09
 Popescu, Carmen, 11, 18
 Pourteau, M.-L., 0Z
 Pradeep, Chullikkattil P., 04
 Quéméré, Patrick, 1I
 Rademaker, Guido, 0Z, 1I
 Rêche, Jérôme, 1I
 Ristoiu, Delia, 0O
 Robinson, Alex P. G., 11, 18
 Roth, J., 1I
 Sahani, Manoj, 1C
 Sakavuyi, K., 0Z
 Sakurai, Tomohiko, 12
 Sassa, Suguru, 1R
 Schofield, Bryan, 18
 Sedlacek, Ivan R., 14
 Sekiguchi, Atsushi, 1S
 Shaikh, Fayaz, 0M
 Sharma, Satinder K., 04, 1C
 Sharma, Shivani, 1C
 Shimoaoki, Takeshi, 20
 Shimura, Satoru, 0E, 19
 Shiozawa, Takahiro, 19
 Shiraishi, Gosuke, 0A
 Simmons, Sean, 1O, 1P
 Singh, Amarnauth, 0K
 Smith, Stephen, 1P
 Song, Yang, 0N
 Spiegelman, Jeff, 0S
 Steen, Steven, 0M
 Stein, Aaron, 0J
 Stock, Hans-Jürgen, 0A
 Stokes, Harold, 0C, 1J
 Subramanian, Ashwanth, 0J
 Suh, Hyo Seon, 0X
 Sun, Baijun, 20
 Suzuki, Katsumasa, 0S
 Takemi, H., 1U

Tamura, T., 0G
 Tanaka, Hatsuyuki, 1S
 Tanaka, Yuji, 0C, 1J
 Thomas, Conor R., 09
 Tiron, Raluca, 0Z, 1I, 1J
 Tiwale, Nikhil, 0J
 Tsuchibuchi, Gaku, 0S
 Umeda, Toru, 0K
 Vandenberghe, Geert, 0A, 15
 Vandenbroeck, Nadia, 15
 Vandereyken, Jelle, 0K
 Van Driessche, Veerle, 14, 15
 Vanelderen, Pieter, 15
 van Schravendijk, Bart, 0M
 Varanasi, Rao, 0K, 1Q
 Wang, Le, 20
 Wang, Olivia, 09
 Wu, Aiwen, 1Z
 Wu, Janet, 0N
 Wu, Mifong, 20
 Xia, Annie, 13
 Xu, Cheng Bai, 0N
 Xu, Gu, 1O
 Yaegashi, Hidetami, 0E, 19
 Yamada, Shintaro, 17, 1N
 Yamamoto, Hiroaki, 1M
 Yamamoto, Hiroki, 1W
 Yamamoto, Kimiko, 0C
 Ye, Xianggui (Shawn), 16
 Yogesh, Midathala, 1C
 Yoshida, Keisuke, 0A
 Yoshihara, Kosuke, 0A
 Zhang, Boyu, 1O, 1P
 Zhang, Keren, 17, 1N
 Zhang, Lei, 1N
 Zhong, Xing-Fu, 1O, 1P
 Zhu, Zhimin, 16

Conference Committee

Symposium Chairs

Will Conley, Cymer, an ASML Company (United States)
Kafai Lai, IBM Thomas J. Watson Research Center (United States)

Conference Chair

Roel Gronheid, KLA-Tencor/ ICOS Belgium (Belgium)

Conference Co-chair

Daniel P. Sanders, IBM Research - Almaden (United States)

Conference Program Committee

Robert Allen, IBM Research - Almaden (United States)
Gilles R. Amblard, SAMSUNG Austin Semiconductor LLC
(United States)
Ramakrishnan Ayothi, JSR Micro, Inc. (United States)
Ryan Callahan, FUJIFILM Electronic Materials U.S.A., Inc.
(United States)
James F. Cameron, DuPont Electronics & Imaging (United States)
Joy Y. Cheng, Taiwan Semiconductor Manufacturing Company Ltd.
(Taiwan)
Ralph R. Dammel, EMD Performance Materials Corporation
(United States)
Anuja De Silva, IBM Corporation (United States)
Danilo De Simone, IMEC (Belgium)
Douglas Guerrero, Brewer Science, Inc. (United States)
Clifford L. Henderson, University of South Florida (United States)
Craig D. Higgins, KLA (United States)
Christoph K. Hohle, Fraunhofer-Institut für Photonische Mikrosysteme
(Germany)
Scott W. Jessen, Texas Instruments Inc. (United States)
Yoshio Kawai, Shin-Etsu Chemical Company, Ltd. (Japan)
Qinghuang Lin, ASML US, Inc. (United States)
Nobuyuki N. Matsuzawa, Panasonic Corporation (Japan)
Steve S. Putna, Intel Corporation (United States)
Mark H. Somervell, Tokyo Electron America, Inc. (United States)
Jason K. Stowers, Inpria (United States)
Raluca Tiron, CEA-LETI (France)
Rick Uchida, Tokyo Ohka Kogyo America, Inc. (United States)
Thomas I. Wallow, ASML Brion Technologies (United States)

Session Chairs

- 1 Keynote Session
Daniel P. Sanders, IBM Research - Almaden (United States)
Roel Gronheid, ICOS VISION SYSTEMS NV (Belgium)
- 2 Inorganic Resists: Joint Session with conferences 11323 and 11326
Anuja De Silva, IBM Research - Almaden (United States)
Robert L. Brainard, SUNY CNSE/SUNYIT (United States)
- 3 Stochastics: Joint Sessions with Conferences 11323 and 11326
Gilles R. Amblard, SAMSUNG Austin Semiconductor LLC (United States)
Marie E. Krysak, Intel Corporation (United States)
- 4 Novel Resists
Ramakrishnan Ayothi, JSR Micro, Inc. (United States)
Jason K. Stowers, Inpria Corporation (United States)
- 5 Fundamentals and Modeling
Craig D. Higgins, KLA (United States)
Ramakrishnan Ayothi, JSR Micro, Inc. (United States)
- 6 Integration
Clifford L. Henderson, University of South Florida (United States)
Ryusuke Uchida, Tokyo Ohka Kogyo America, Inc. (United States)
- 7 Deposition-based Patterning
Thomas I. Wallow, ASML Brion Technologies (United States)
Mark H. Somervell, Tokyo Electron America, Inc. (United States)
- 8 Novel Patterning
Qinghuang Lin, ASML US, Inc. (United States)
Ralph R. Dammel, EMD Performance Materials Corporation (United States)
- 9 Supplier
Christoph K. Hohle, Fraunhofer-Institut für Photonische Mikrosysteme IPMS (Germany)
Nobuyuki N. Matsuzawa, Panasonic Corporation (Japan)
- 10 Underlayers
Scott W. Jessen, Texas Instruments Inc. (United States)
James F. Cameron, DuPont Electronics & Imaging (United States)