PROCEEDINGS OF SPIE

Advances in Patterning Materials and Processes XL

Douglas Guerrero Gilles R. Amblard *Editors*

27 February – 1 March 2023 San Jose, California, United States

Sponsored by SPIE

Cosponsored by IBM Corporation (United States) Tokyo Electron Ltd. (Japan)

Published by SPIE

Volume 12498

Proceedings of SPIE 0277-786X, V. 12498

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

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 Advances in Patterning Materials and Processes XL, edited by Douglas Guerrero, Gilles R. Amblard, Proc. of SPIE 12498, Seven-digit Article CID Number (DD/MM/YYYY); (DOI URL).

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

ISBN: 9781510661035 ISBN: 9781510661042 (electronic)

Published by **SPIE** P.O. Box 10, Bellingham, Washington 98227-0010 USA Telephone +1 360 676 3290 (Pacific Time) SPIE.org Copyright © 2023 Society of Photo-Optical Instrumentation Engineers (SPIE).

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 fees. To obtain permission to use and share articles in this volume, visit Copyright Clearance Center 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.

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.



Paper Numbering: A unique citation identifier (CID) number is assigned to each article in the Proceedings of SPIE 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 Conference Committee

MATERIALS FOR HIGH NA EUV LITHOGRAPHY

- 12498 06 Advanced development methods for high-NA EUV lithography [12498-4]
- 12498 07 Development on main chain scission resists for high-NA EUV lithography [12498-5]

PROCESS IMPROVEMENTS

- 12498 0A Continued optimization of point-of-use filtration for metal oxide photoresists to reduce defect density [12498-8]
- 12498 OB Development of a novel cleaner for contaminant removal in equipment used in semiconductor manufacturing which reduces time and solvent waste [12498-9]
- 12498 0C Modification of organic underlayers by plasma during dry etching and its effect on the film properties [12498-10]

EUVL STOCHASTICS: JOINT SESSION WITH 12494 AND 12498

- 12498 0D A novel formulated developer for negative-tone imaging with EUV exposure to improve chemical stochastic [12498-11]
- 12498 0E Towards molecular-scale kinetic Monte Carlo simulation of pattern formation in photoresist materials for EUV nanolithography [12498-12]
- 12498 OF Photoresists with precisely controlled molecular weight, composition, and sequence [12498-13]

RESISTS FUNDAMENTALS I

Effects of photoacid generator decomposition on dissolution kinetics of poly(4-hydroxystyrene) in tetraalkylammonium hydroxide aqueous solutions [12498-16]
Mean free path of electrons in EUV photoresist in the energy range 20 to 450 eV [12498-17]
Role of counter-anion chemistry, free volume, and reaction byproducts in chemically amplified resists [12498-20]

UNDERLAYERS AND TOP COATS

- 12498 0N Novel assist layers to enhance EUV lithography performance of photoresists on different substrates [12498-21]
- 12498 00 New functional surface treatment process and primers for high-NA EUV lithography [12498-22]
- 12498 0Q Chemical trimming overcoat: an advanced spin-on process for photoresist enhancement in EUV lithography [12498-24]
- 12498 OR Scaled-down deposited underlayers for EUV lithography [12498-73]

RESISTS FUNDAMENTALS II

- 12498 OS Dissociative photoionization of EUV lithography photoresist models [12498-26]
- 12498 0T EUV-induced activation mechanism of photoacid generators: key factors affecting EUV sensitivity [12498-27]
- 12498 0U Fundamental studies of interactions between polymer substrate and precursor in sequential infiltration synthesis [12498-28]
- 12498 0W A scientific framework for establishing ultrafast molecular dynamic research in imec's AttoLab [12498-30]

NON CHEMICALLY AMPLIFIED RESISTS FOR EUV LITHOGRAPHY I

- 12498 0X Enhancing the sensitivity of a high resolution negative-tone metal organic photoresist for extreme ultra violet lithography [12498-31]
- 12498 0Z Influence of the anion in tin-based EUV photoresists properties [12498-33]
- 12498 11 Indium nitrate hydrate films as EUV resists by evaluating with 92-eV electron beam [12498-35]

NON CHEMICALLY AMPLIFIED RESISTS FOR EUV LITHOGRAPHY II

- 12498 12 EUV lithography patterning using multi-trigger resist [12498-36]
- 12498 13 Negative-tone resists for EUV lithography [12498-37]
- 12498 14 Single-component silicon-based patterning materials for EUV lithography [12498-38]

12498 15 Potential of biomass EUV non-CAR type resist for high-NA EUV lithography [12498-39]

12498 16 Fluoroalkylated tin-oxo nano clusters as resist candidates for extreme UV lithography [12498-40]

NOVEL PATTERNING MATERIALS

12498 1C	The novel materials for pattern growing on EUV resists [12498-46]
12498 1B	Molecular layer deposition of an Al-based hybrid resist for electron-beam and EUV lithography [12498-45]
12498 19	Micro-nanostructuring by optical lithography and nitridation of photo-patternable TiO ₂ sol-gel to obtain micro-nanostructured TiN [$12498-43$]
12498 18	Chitosan as a water-based photoresist for DUV lithography [12498-42]
12498 17	Sequence-defined polypeptoid CARs for electron-beam and EUV lithography [12498-41]

POSTER SESSION

12498 1D	Metal purifier for TMAH developer solution [12498-47]
12498 1E	Fundamentals of EUV stack for improving patterning performance [12498-49]
12498 1F	Establishment of new process technology for EUV lithography [12498-50]
12498 1G	Recent advances in EUV patterning in preparation towards high-NA EUV [12498-51]
12498 1H	Novel UPE filtration technology for advanced photolithography materials [12498-53]
12498 1J	Profile control in conductor metal wet etch with advanced photoresists [12498-55]
12498 1K	Positive tone i-line photoresist with controlled undercut profile for advanced packaging [12498-56]
12498 1L	Metallic contamination reduction in polymer solution using membrane purification technology [12498-57]
12498 1M	Thin underlayer materials for metal oxide resist patterning [12498-58]
12498 1N	Use of highly EUV absorbing element in chemically amplified resist [12498-59]

- 12498 10 Design concept of a positive tone organometal chemically amplified resist to enhance the sensitivity and etching durability for high resolution EUV single patterning [12498-60]
- 12498 1R Novel polymer design for ultra-low stress material for advanced packaging applications [12498-63]
- 12498 1S Electron beam and optical patterning of polymerizable ionic liquid-based resists [12498-65]
- 12498 17 Ultra-high carbon fullerene-based spin-on-carbon hardmasks [12498-66]
- 12498 10 Predicting the critical features of the chemically-amplified resist profile based on machine learning [12498-67]
- 12498 1V Considerations in the design of photoacid generators [12498-68]
- 12498 1W Spin speed impact on photoresist thin film properties and EUV lithographic performance [12498-69]
- 12498 1Y Defectivity reduction in EUV resists through novel high-performance Point-Of-Use (POU) filters [12498-74]
- 12498 21 Coater/developer-based techniques to achieve tight pitches towards high-NA EUV [12498-80]
- 12498 22 Optimization of spin-on metal oxide resist performance via new development techniques on sub-30nm pitch patterning [12498-81]
- 12498 25 Chemical information extraction from scanning electron microscopy images on the basis of image recognition [12498-97]
- 12498 26 Reaction mechanisms and EB patterning evaluation of Sn-complex-side-chain polymer used for EUV lithography [12498-99]
- 12498 27 Study on irradiation effects by femtosecond-pulsed extreme ultraviolet in resist materials [12498-100]
- 12498 29 Dependence of swelling and dissolution kinetics of poly(4-hydroxystyrene) in alkaline aqueous solution on alkyl chain length of tetraalkylammonium hydroxide [12498-104]