

PROCEEDINGS OF SPIE

Optical Microlithography XXIX

Andreas Erdmann
Jongwook Kye
Editors

23–25 February 2016
San Jose, California, United States

Sponsored by
SPIE

Cosponsored by
Cymer, an ASML company (United States)

Published by
SPIE

Volume 9780

Proceedings of SPIE 0277-786X, V. 9780

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 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 *Optical Microlithography XXIX*, edited by Andreas Erdmann, Jongwook Kye, Proceedings of SPIE Vol. 9780 (SPIE, Bellingham, WA, 2016) Six-digit Article CID Number.

ISSN: 0277-786X

ISSN: 1996-756X (electronic)

ISBN: 9781510600157

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 © 2016, 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/16/\$18.00.

Printed in the United States of America Vm7 i ffUb '5gg: WJUH g' bWzi bXYf`jW'bg' Zca 'GD-9.

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 six-digit CID article numbering system structured as follows:

- The first four 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 *Authors*
xi *Conference Committee*

SESSION 1 KEYNOTE SESSION

9780 02 **Patterning challenges in the sub-10 nm era (Keynote Paper)** [9780-1]

SESSION 2 PUSHING OPTICAL LIMIT

9780 04 **Expected innovations of optical lithography in the next 10 years (Invited Paper)** [9780-3]

9780 05 **Computational process modeling and correction in a multi-patterning era (Invited Paper)**
[9780-4]

9780 06 **Lithographic qualification of high-transmission mask blank for 10nm node and beyond**
[9780-5]

9780 07 **Ultimate intra-wafer critical dimension uniformity control by using lithography and etch tool
corrections** [9780-6]

SESSION 3 IMAGE AND PROCESS CONTROL

9780 08 **Lower BW and its impact on the patterning performance** [9780-7]

9780 09 **Intra-lot wafer by wafer overlay control using integrated and standalone metrology
combined sampling** [9780-8]

9780 0A **Reduction of wafer-edge overlay errors using advanced correction models, optimized for
minimal metrology requirements** [9780-9]

9780 0B **Overcoming low-alignment signal contrast induced alignment failure by alignment signal
enhancement** [9780-10]

9780 0C **Lithographic imaging-driven pattern edge placement errors at 10nm node** [9780-11]

SESSION 4 NEGATIVE TONE MATERIALS AND PROCESSES: JOINT SESSION WITH CONFERENCE 9779 AND 9780

9780 0D **Process window variation comparison between NTD and PTD for various contact type**
[9780-12]

9780 0E **Ultimate 2D resolution printing with negative tone development** [9780-13]

SESSION 5 COMPUTATIONAL LITHOGRAPHY

- 9780 OH **Machine learning (ML)-guided OPC using basis functions of polar Fourier transform** [9780-16]
- 9780 OI **Bayesian inference for OPC modeling** [9780-17]
- 9780 OJ **OPC recipe optimization using genetic algorithm** [9780-18]
- 9780 OK **Impact of bandwidth variation on OPC model accuracy** [9780-19]

SESSION 6 MATERIAL AND PROCESS DRIVEN RESOLUTION ENHANCEMENTS

- 9780 OM **An integrated source/mask/DSA optimization approach** [9780-21]
- 9780 ON **Multi-layer VEB model: capturing interlayer etch process effects for self-aligned via in multi-patterning process scheme** [9780-22]
- 9780 OO **Mask defect printability in the Self-Aligned Quadruple Patterning (SAQP) process** [9780-23]

SESSION 7 DESIGN AND LITHO OPTIMIZATION: JOINT SESSION WITH CONFERENCES 9780 AND 9781

- 9780 OP **Standard cell pin access and physical design in advanced lithography (Invited Paper)** [9780-24]
- 9780 OQ **Incorporating photomask shape uncertainty in computational lithography** [9780-25]

SESSION 8 NON-IC APPLICATIONS

- 9780 OR **Alternative high-resolution lithographic technologies for optical applications (Invited Paper)** [9780-26]
- 9780 OT **High dynamic grayscale lithography with an LED-based micro-image stepper** [9780-28]
- 9780 OU **Firefly: an optical lithographic system for the fabrication of holographic security labels** [9780-29]
- 9780 OV **Phase analysis of amplitude binary mask structures** [9780-30]

SESSION 9 OVERLAY OPTIMIZATION: JOINT SESSION WITH CONFERENCES 9778 AND 9780

- 9780 OW **Patterned wafer geometry (PWG) metrology for improving process-induced overlay and focus problems (Invited Paper)** [9780-31]
- 9780 OX **Improvement of unbalanced illumination induced telecentricity within the exposure slit** [9780-32]

SESSION 10 TOOLINGS

- 9780 0Y **High-order aberration control during exposure for leading-edge lithography projection optics** [9780-33]
- 9780 10 **The ArF laser for the next-generation multiple-patterning immersion lithography supporting green operations** [9780-35]
- 9780 11 **NXT:1980Di immersion scanner for 7nm and 5nm production nodes** [9780-36]
- 9780 12 **Next-generation immersion scanner optimizing on-product performance for 7nm node** [9780-37]
- 9780 13 **Investigation of systematic CD distribution error on intrafield** [9780-50]

INTERACTIVE POSTER SESSION

- 9780 14 **Periodic sub-100nm structures fabricated by proximity i-line mask-aligner lithography (and self-aligned double patterning)** [9780-38]
- 9780 15 **Innovative method to suppress local geometry distortions for fabrication of interdigitated electrode arrays with nano gaps** [9780-39]
- 9780 16 **Coherence management in lithography printing systems** [9780-40]
- 9780 17 **Fabricate large area and defect free periodic structures with advance achromatic laser interference lithography** [9780-41]
- 9780 18 **Optimizing the lithography model calibration algorithms for NTD process** [9780-42]
- 9780 19 **Source mask optimization using 3D mask and compact resist models** [9780-43]
- 9780 1A **Layer aware source mask target optimization** [9780-44]
- 9780 1C **A novel full chip process window OPC based on matrix retargeting** [9780-46]
- 9780 1E **Simple method for decreasing wafer topography effect for implant mask** [9780-48]
- 9780 1F **Native conflict aware layout decomposition in triple patterning lithography using bin-based library matching method** [9780-49]
- 9780 1G **Means to improve light source productivity: from proof of concept to field implementation** [9780-51]
- 9780 1H **Neon reduction program on Cymer ArF light sources** [9780-52]
- 9780 1I **The next-generation ArF excimer laser for multiple-patterning immersion lithography with helium free operation** [9780-54]

- 9780 1J **Rare resource supply crisis and solution technology for semiconductor manufacturing** [9780-55]
- 9780 1K **Progress on glass ceramic ZERODUR enabling nanometer precision** [9780-57]
- 9780 1L **Spatial conversion of excimer laser beam** [9780-56]
- 9780 1M **Optimal design of wide-view-angle waveplate used for polarimetric diagnosis of lithography system** [9780-58]
- 9780 1N **Confocal position alignment in high-precision wavefront error metrology using Shack-Hartmann wavefront sensor** [9780-59]
- 9780 1O **SEM signal emulation for 2D patterns** [9780-60]
- 9780 1P **Source mask optimization study based on latest Nikon immersion scanner** [9780-61]
- 9780 1Q **CDU budget breakdown as a diagnostic method for imaging sensitivity in HVM** [9780-62]
- 9780 1R **Inverse polarizer on immersion lithography mask** [9780-63]
- 9780 1S **Line edge roughness frequency analysis for SAQP process** [9780-64]
- 9780 1T **Fabrication of dual-wavelength diffractive beam splitters using maskless optical lithography based on a digital micromirror device** [9780-65]
- 9780 1U **OPC for curved designs in application to photonics on silicon** [9780-66]
- 9780 1V **Pixel-based mask optimization via particle swarm optimization algorithm for inverse lithography** [9780-67]