PROCEEDINGS OF SPIE

Photomask Japan 2025: XXXI Symposium on Photomask and Next-Generation Lithography Mask Technology

Hiroshi Nakata
Editor

16–18 April 2025
Yokohama, Japan

Organized by
Photomask Japan and SPIE

Co-organized by
BACUS and EMLC

In cooperation with
SEMI Japan

Published by
SPIE

Volume 13655

Proceedings of SPIE 0277-786X, V. 13655

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 *Photomask Japan 2025: XXXI Symposium on Photomask and Next-Generation Lithography Mask Technology*, edited by Hiroshi Nakata, Proc. of SPIE 13655, Seven-digit Article CID Number (DD/MM/YYYY); (DOI URL).

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

ISBN: 9781510692251
ISBN: 9781510692268 (electronic)

Published by
SPIE
P.O. Box 10, Bellingham, Washington 98227-0010 USA
Telephone +1 360 676 3290 (Pacific Time)
SPIE.org
Copyright © 2025 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.

SPIE. DIGITAL LIBRARY
SPIEDigitalLibrary.org

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*

OPENING SESSION DAY 1: KEYNOTE AND MASK PATTERNING WITH MATERIAL

13655 02 **Dose reduction strategies for low-n PSM absorber using pupil and mask bias optimization at 0.33NA EUV lithography** [13655-33]

13655 03 **Fundamental characterization of mask with variable Ta thickness** [13655-34]

13655 04 **Mask absorber impact on local MEEF for pitch 32 nm hexagonal contact hole printing with low-n EUV masks** [13655-35]

MASK PATTERNING I

13655 05 **13th eBeam Initiative annual luminaries survey predicts photomask market and equipment growth (Invited Paper)** [13655-7]

13655 06 **Bright-field mask readiness: a key enabler for logic scaling roadmap in high-NA EUV lithography** [13655-38]

13655 07 **Stochastic-aware compact OPC model validation for reducing failure probability** [13655-26]

MASK REPAIR

13655 08 **Efficient defect repair methodology for N2 EUV masks by using a femto-pulse laser repair system** [13655-3]

13655 09 **Printability simulations of EUV photomask contamination clean and repair** [13655-19]

OPENING SESSION DAY 2: KEYNOTE AND MDP

13655 0A **A study that enhances the accuracy of multigon-based curvilinear mask rule check** [13655-5]

13655 0B **Curvilinear OPC and mask data prep for high-NA lithography** [13655-15]

13655 0C **Comparing curvilinear layouts for the verification of mask data preparation** [13655-16]

MASK METROLOGY

13655 0D **Curvilinear metrology in advance mask making process quality enhancement** [13655-8]

13655 0E **High-NA EUV mask CD-SEM metrology matching, and contour-based comparison of simulation result and wafer print** [13655-36]

13655 0F **Challenges in wafer metrology for advanced technology nodes** [13655-17]

MASK INSPECTION

13655 0G **Intel is paving the way to state-of-the-art anamorphic high-NA EUV mask manufacturing and lithography (Invited Paper)** [13655-41]

13655 0H **Actinic patterned mask inspection for high-NA EUV lithography** [13655-37]

13655 0I **EUV mask requalification study of new EUV blanks for advanced logic high volume production application** [13655-20]

13655 0J **Model-based layout rendering to improve mask database inspection** [13655-28]

OPENING SESSION DAY 2: DEFECT, HANDLING, ANALYSIS, AND PELLICLE

13655 0K **Development status and future prospects of CNT pellicle** [13655-31]

13655 0L **High durability beryllium-based membrane for EUV pellicles** [13655-29]

RESIST-RELATED TECHNOLOGIES

13655 0M **Introduction to TOK materials** [13655-24]

NIL

13655 0N **Enhanced nanoimprint lithography productivity using solvent-based resists** [13655-2]

MASK BLANKS

13655 0P **Reticle heating overlay impact of mask substrate thermal properties on high power EUV systems (Invited Paper)** [13655-40]

MASK PATTERNING II

13655 0Q **Time and cost-effective methodology for curvilinear masks process qualification** [13655-27]

13655 0R **Projection lithography on curved surfaces using paraboloid mirror optics and flat reticles** [13655-12]

LASER MASK WRITING TECHNOLOGY

13655 0S **Renewal of high throughput laser photomask writers** [13655-25]

EB MASK WRITING TECHNOLOGY

13655 0T **Application field expansion of the multi-beam mask writer: MBM-4000 for high-NA EUV and MBM-2000C for mature node** [13655-21]

13655 0U **Full reticle curvilinear inline linearity correction including variable bias with zero turnaround time** [13655-39]

13655 0V **Dose or bias? Which is the optimal GEC enabler from MPC model perspective?** [13655-22]

POSTER SESSION

13655 0W **Mask performance improvement by PLDC with n-CAR** [13655-32]

13655 0X **Evaluation of hydrogen plasma and ion injection to the EUV photomask using high power irradiation tool at NewSUBARU** [13655-30]

13655 0Y **Narrowing of EUV bandwidth by oblique laser incidence** [13655-18]

13655 0Z **Predicting sub-50-nm trench hotspots in ArFi lithography for DFM using machine learning** [13655-14]

13655 10 **Particle inspection capability for mature masks with MATRICS x783 inspection tool** [13655-10]

13655 11 **Multigon curvy mask manufacturability and advantage** [13655-11]