

PROCEEDINGS OF SPIE

Metrology, Inspection, and Process Control XXXVI

John C. Robinson
Matthew J. Sendelbach
Editors

24–28 April 2022
San Jose, California, United States

23–27 May 2022
ONLINE

Sponsored by
SPIE

Cosponsored by
Hitachi High Technologies, America, Inc. (United States)
KLA Corporation (United States)
AUROS Technology (Korea, Republic of)

Published by
SPIE

Volume 12053

Proceedings of SPIE 0277-786X, V. 12053

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 *Metrology, Inspection, and Process Control XXXVI*, edited by John C. Robinson, Matthew J. Sendelbach, Proc. of SPIE 12053, Seven-digit Article CID Number (DD/MM/YYYY); (DOI URL).

ISSN: 0277-786X

ISSN: 1996-756X (electronic)

ISBN: 9781510649811

ISBN: 9781510649828 (electronic)

Published by

SPIE

P.O. Box 10, Bellingham, Washington 98227-0010 USA

Telephone +1 360 676 3290 (Pacific Time)

SPIE.org

Copyright © 2022 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

ix *Conference Committee*

NOVEL METHODS I

- 12053 02 **A study on the detection and monitoring of weak areas in wafer using massive 2D and 3D measurement data** [12053-8]
- 12053 03 **New metrology technique for measuring patterned wafer geometry on a full 300mm wafer** [12053-9]
- 12053 04 **GHz half wavelength contact acoustic microscopy (HaWaCAM): a feasibility study** [12053-10]
- 12053 05 **Enhancement of acoustic-wave induced reflection changes through surface plasmon polaritons** [12053-11]

SEM I

- 12053 06 **Throughput vs. yield: reviewing the metrology needs for stochastics-aware process window analysis (SA-PWA) (Invited Paper)** [12053-13]
- 12053 07 **Probabilistic process window: a new approach to focus-exposure analysis** [12053-14]
- 12053 08 **Highlighting stochastic manifestations in 193 nm immersion lithography with contour-based metrology metrics (Karel Urbanek Best Student Paper Award)** [12053-17]
- 12053 09 **Low dosage SEM image processing for metrology applications** [12053-18]
- 12053 0A **Simulating process subtleties in SEM imaging** [12053-19]

EPE/OVERLAY I

- 12053 0B **Fast and robust overlay metrology from visible to infrared wavelengths using dark-field digital holographic microscopy** [12053-25]
- 12053 0C **Enabling on-device and target-free overlay measurement from CD-SEM contours** [12053-26]
- 12053 0D **Overlay challenges in 3D heterogeneous integration** [12053-27]

12053 OE **Overlay stability control in IBO measurement using rAIM target** [12053-29]

INSPECTION CHALLENGES

12053 OF **Identification of sub-20 nm EUV defects with nano-IR PiFM** [12053-30]

12053 OG **High-speed wafer magnetic field inspection for semiconductor manufacturing** [12053-31]

12053 OH **EUV mask defect material characterization through actinic lensless imaging** [12053-33]

12053 OI **Defect detection and classification on imec iN5 node BEoL test vehicle with MultiSEM** [12053-34]

12053 OJ **Ultra-high throughput e-beam inspection for DRAM high aspect ratio storage node defect detection** [12053-35]

12053 OK **Unbiased roughness measurements from low signal-to-noise ratio SEM images** [12053-64]

GAA AND NANOSHEET

12053 OL **Recess metrology challenges for 3D device architectures in advanced technology nodes** [12053-36]

12053 OM **Inferred measurement of subsurface nanosheet structures using scanning probe microscopy, solving the inverse problem** [12053-37]

EUV CHALLENGES

12053 ON **Optical overlay metrology trends in advanced nodes** [12053-101]

12053 OO **Metrology of thin resist for high NA EUVL** [12053-2]

12053 OP **Low-voltage aberration-corrected SEM metrology of thin resist for high-NA EUVL** [12053-3]

12053 OQ **Outlier analysis for understanding process variations and probable defects** [12053-4]

OPTICAL CD

12053 OS **Vertical travelling scatterometry for metrology on fully integrated devices** [12053-40]

- 12053 OT **Novel inline on-device measurement of silicon nitride lateral recess post channel hole ACI with IRCD metrology** [12053-42]
- 12053 OU **A novel methodology for wafer-level scanner focus spot capture and back-tracing mechanism** [12053-153]

MACHINE LEARNING

- 12053 OV **Regularized autoencoder for the analysis of multivariate metrology data** [12053-44]
- 12053 OW **Multi-branch neural network for hybrid metrology improvement** [12053-46]

KEYNOTE SESSION II AND KAREL URBÁNEK BEST STUDENT PAPER AWARD ANNOUNCEMENT

- 12053 OX **Diversifying the role of MI in semiconductor manufacturing through new technologies and innovations (Keynote Paper)** [12053-49]

EPE/OVERLAY II

- 12053 OY **Model-less analysis method for characterizing overlay in EUV lithography** [12053-51]
- 12053 OZ **E-beam metrology-based EUVL aberration monitoring** [12053-52]
- 12053 10 **Subsurface scanning probe metrology for overlay through opaque layers** [12053-54]

NOVEL METHODS II

- 12053 11 **Sensitivity and repeatability performance on overlay and CD measurement by incorporating hologram based ellipsometry** [12053-55]
- 12053 12 **Inline metrology of high aspect ratio hole tilt using small-angle x-ray scattering** [12053-58]
- 12053 13 **Imaging of buried overlay and alignment markers using picosecond acoustic microscopy** [12053-59]
- 12053 14 **Advanced CD uniformity correction using radial basis function (RBF) models** [12053-60]

LATE BREAKING NEWS

- 12053 15 **Absolute overlay measurement based on voltage contrast defect inspection with programmed misalignments for DRAM devices** [12053-149]
- 12053 16 **Improved multi-lot overlay performance via phase-based ADI overlay measurements** [12053-154]

POSTER SESSION

- 12053 17 **Efficient cross-sectional evaluation method of three-dimensional NAND flash memory by cooperation of coherence scanning interferometry and scanning electron microscopy** [12053-57]
- 12053 18 **Overcome machine to machine overlay for better scanner mix-run control** [12053-61]
- 12053 19 **A comprehensive study of scanner alignment mark quantity and layout-dependent effect for overlay performance optimization** [12053-62]
- 12053 1A **New DRAM application space for optical AEI metrology enabled by ASML self reference (ASR) targets** [12053-65]
- 12053 1B **Virtual cross metrology: leveraging process sequence for improved process characterization** [12053-68]
- 12053 1C **Metrology test artifact availability improvement** [12053-70]
- 12053 1D **High-performance denoiser based on deep learning trained by precisely reproduced SEM noise** [12053-71]
- 12053 1E **Prediction and optimization of small scatterometry based overlay targets** [12053-72]
- 12053 1G **Model-based contour extraction: an enabler for very low-frame SEM images metrology** [12053-75]
- 12053 1H **OPO reduction in scatterometry metrology by rotated quadrupole illumination** [12053-77]
- 12053 1I **Adopting combined feed forward solution in HVM fab to improve on product overlay** [12053-78]
- 12053 1J **Spatial frequency analysis of LER and LWR to tune SADP process** [12053-79]
- 12053 1K **Image-based alignment sensor unaffected by aberration** [12053-86]
- 12053 1L **Exposure process optimization using machine learning overlay prediction** [12053-87]

- 12053 1M **Computational metrology introduction into high volume manufacturing fab through 1x nm uDBO measurement and monitor** [12053-88]
- 12053 1N **An automated system for detecting systematic defect in memory cell array** [12053-91]
- 12053 1O **Reduction in on-product overlay random error using machine learning algorithm** [12053-92]
- 12053 1P **In device overlay control with multiple overlay metrology in 3D-NAND process** [12053-93]
- 12053 1Q **Machine learning modeling using process context and exposure data for overlay prediction** [12053-94]
- 12053 1R **Application of machine learning-based metrology for writer main pole CD measurement by CDSEM** [12053-95]
- 12053 1S **Improved fab-out EDS prediction of memory device using effective accuracy equation** [12053-98]
- 12053 1T **Using pattern analysis to improve wafer inspection flow** [12053-99]
- 12053 1U **In-line monitoring of overlay and process window using design-assisted voltage contrast inspection for 14nm FINFET technology** [12053-102]
- 12053 1V **An in-depth look at comprehensive and efficient methodology for CD uniformity budget breakdown** [12053-103]
- 12053 1W **Predicting overlay mark performance based on process emulation and optical simulation** [12053-105]
- 12053 1X **A novel target optimization methodology for 3D NAND overlay measurement improvement** [12053-106]
- 12053 1Y **Fast generation of SEM images including charging effect by neural network** [12053-107]
- 12053 1Z **Spectral analysis overlay measurement approach for improvement of overlay accuracy in advanced integrated circuits** [12053-108]
- 12053 20 **Trilayer hardmask lithography and etch for BEOL manufacturing** [12053-110]
- 12053 21 **Real-time monitoring of acetic acid and PGMEA in a photolithographic multifunction chemical filter using a laser-based multi-species VOC analyzer** [12053-111]
- 12053 22 **Process optimization by virtual target design in overlay metrology** [12053-112]
- 12053 23 **Real-time monitoring of critical AMC compounds in the photolithography cell using a novel laser-based, multi-species detection system** [12053-113]
- 12053 24 **Depth measurement using high-voltage SEM that changes the inclination of the incident beam** [12053-117]

- 12053 25 **Efficient metrology for edge placement error (EPE) characterization using design for inspection methodology [12053-119]**
- 12053 26 **Chemical metrology: a novel approach to measuring critical airborne molecular contamination in photolithography and track tools in real-time [12053-120]**
- 12053 27 **Automated extraction of critical dimension from SEM with Weave [12053-121]**
- 12053 28 **Conducting a metrology measurement using M-FOUP system in fab environment [12053-124]**
- 12053 29 **A new development algorithm to optimize scanner alignment sampling for cross-chuck overlay performance optimization [12053-152]**
- 12053 2A **Advanced dose control using random logic device patterns and massive metrology in a foundry high-volume manufacturing environment [12053-155]**