

PROCEEDINGS OF SPIE

Metrology, Inspection, and Process Control for Microlithography XXXII

Vladimir A. Ukraintsev
Ofer Adan
Editors

26 February–1 March 2018
San Jose, California, United States

Sponsored by
SPIE

Cosponsored by
Nova Measuring Instruments Ltd. (Israel)

Published by
SPIE

Volume 10585

Proceedings of SPIE 0277-786X, V. 10585

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 *Metrology, Inspection, and Process Control for Microlithography XXXII*, edited by Vladimir A. Ukraintsev, Ofer Adan, Proceedings of SPIE Vol. 10585 (SPIE, Bellingham, WA, 2018) Seven-digit Article CID Number.

ISSN: 0277-786X

ISSN: 1996-756X (electronic)

ISBN: 9781510616622

ISBN: 9781510616639 (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 © 2018, 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/18/\$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 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 *Authors*
xv *Conference Committee*

OPTICAL METROLOGY

- 10585 07 **Study of μ DBO overlay target size reduction for application broadening** [10585-6]

INSPECTION

- 10585 08 **Defect inspection using a time-domain mode decomposition technique** [10585-7]
10585 0B **Contact inspection of Si nanowire with SEM voltage contrast** [10585-10]
10585 0C **Through-focus scanning optical microscopy (TSOM) with adaptive optics** [10585-11]

LWR

- 10585 0D **The need for LWR metrology standardization: the imec roughness protocol (Invited Paper)** [10585-12]
10585 0E **Line-width roughness of advanced semiconductor features by using FIB and Planar-TEM as reference metrology** [10585-13]
10585 0F **Programmed LWR metrology by multi-techniques approach** [10585-14]
10585 0H **Measurement of pattern roughness and local size variation using CD-SEM: current status** [10585-16]

CHALLENGES AND NEW METHODS

- 10585 0I **7/5nm logic manufacturing capabilities and requirements of metrology (Invited Paper)** [10585-17]

NEW METHODS: STUDENT SESSION

- 10585 0M **Complex EUV imaging reflectometry: spatially resolved 3D composition determination and dopant profiling with a tabletop 13nm source** [10585-21]
10585 0N **Characterization and imaging of nanostructured materials using tabletop extreme ultraviolet light sources (Best Student Paper)** [10585-22]
10585 0O **Image-based overlay measurement using subsurface ultrasonic resonance force microscopy** [10585-23]

- 10585 0P **EUV-angle resolved scatter (EUV-ARS): a new tool for the characterization of nanometre structures** [10585-24]
- 10585 0Q **X-ray EM simulation tool for ptychography dataset construction** [10585-25]

OVERLAY NEWS

- 10585 0R **Image-based overlay and alignment metrology through optically opaque media with sub-surface probe microscopy** [10585-26]
- 10585 0T **Holistic metrology qualification extension and its application to characterize overlay targets with asymmetric effects** [10585-28]
- 10585 0U **Overlay and stitching metrology for massively parallel electron-beam lithography** [10585-29]
- 10585 0V **Unique method for controlling device level overlay with high NA optical overlay technique using YieldStar in a DRAM HVM environment** [10585-30]

HYBRID METROLOGY AND MACHINE LEARNING

- 10585 0W **CD-SEM real time bias correction using reference metrology based modeling** [10585-31]
- 10585 0X **Implementation of machine learning for high volume manufacturing metrology challenges** [10585-32]

NEW METHODS AND MACHINE LEARNING

- 10585 12 **Critical-dimension grazing incidence small angle x-ray scattering** [10585-37]
- 10585 14 **Context-based virtual metrology** [10585-39]

SEM

- 10585 17 **Modeling of electron-specimen interaction in scanning electron microscope for e-beam metrology and inspection: challenges and perspectives (Invited Paper)** [10585-42]
- 10585 18 **Model improvements to simulate charging in SEM** [10585-43]
- 10585 19 **Advanced CD-SEM solution for edge placement error characterization of BEOL pitch 32nm metal layers** [10585-44]
- 10585 1A **Influence of e-beam aperture angle on CD-SEM measurements for high aspect ratio structure** [10585-45]

OVERLAY

- 10585 1B **Yield impact for wafer shape misregistration-based binning for overlay APC diagnostic enhancement** [10585-46]

- 10585 1C **Approaches of multilayer overlay process control for 28nm FD-SOI derivative applications** [10585-47]
- 10585 1D **In-cell overlay metrology by using optical metrology tool** [10585-48]
- 10585 1E **Matching between simulations and measurements as a key driver for reliable overlay target design** [10585-49]
- 10585 1F **Multi-wavelength approach towards on-product overlay accuracy and robustness** [10585-50]

DESIGN INTERACTIONS: JOINT SESSION WITH CONFERENCES 10585 AND 10588

- 10585 1H **Advanced combined overlay and CD uniformity measurement mark for double patterning** [10585-52]
- 10585 1I **Enabling optical metrology on small 5×5µm² in-cell targets to support flexible sampling and higher order overlay control for advanced logic devices** [10585-53]
- 10585 1J **Spectroscopic vector analysis for fast pattern quality monitoring** [10585-68]

PROCESS CONTROL NEWS

- 10585 1K **Setting up a proper power spectral density (PSD) and autocorrelation analysis for material and process characterization** [10585-54]
- 10585 1L **Holistic approach for overlay and edge placement error to meet the 5nm technology node requirements** [10585-55]
- 10585 1N **A novel patterning control strategy based on real-time fingerprint recognition and adaptive wafer level scanner optimization** [10585-57]
- 10585 1O **Scanner focus metrology and control system for advanced 10nm logic node** [10585-58]

PROCESS CONTROL

- 10585 1P **Computational metrology: enabling full-lot high-density fingerprint information without adding wafer metrology budget, and driving improved monitoring and process control** [10585-59]
- 10585 1Q **Correlation study of actual temperature profile and in-line metrology measurements for within-wafer uniformity improvement and wafer edge yield enhancement** [10585-60]
- 10585 1R **Higher order intra-field alignment for intra-wafer lens and reticle heating control** [10585-61]
- 10585 1T **Outlier detection in contamination control** [10585-63]

LATE BREAKING NEWS

- 10585 1U **Understanding overlay signatures using machine learning on non-lithography context information** [10585-64]

- 10585 1V **LMS IPRO: enabling local registration measurements for efficient e-beam writer correction** [10585-65]
- 10585 1W **Allowable SEM noise for unbiased LER measurement** [10585-114]

POSTER SESSION

- 10585 20 **Study on the dark-field illumination for near-field microscope using anamorphic optics to inspect defects on semiconductor wafers** [10585-69]
- 10585 21 **Advanced technique for ultra-thin residue inspection with sub-10nm thickness using high-energy back-scattered electrons** [10585-70]
- 10585 22 **Advanced CD-SEM imaging methodology for EPE measurements** [10585-71]
- 10585 24 **Unbiased roughness measurements: the key to better etch performance** [10585-73]
- 10585 25 **Assessment of variability and defectivity by high-throughput e-beam metrology for prediction of patterning defect probabilities** [10585-74]
- 10585 26 **How to measure a-few-nanometer-small LER occurring in EUV lithography processed feature** [10585-75]
- 10585 27 **Improved control of multi-layer overlay in advanced 8nm logic nodes** [10585-76]
- 10585 29 **Monte Carlo simulation of edge placement error** [10585-79]
- 10585 2A **Clean focus, dose and CD metrology for CD uniformity improvement** [10585-80]
- 10585 2B **Overlay of multiframe SEM images including nonlinear field distortions** [10585-82]
- 10585 2C **Geometry-based across wafer process control in a dual damascene scenario** [10585-83]
- 10585 2D **Advanced defect classification by smart sampling, based on sub-wavelength anisotropic scatterometry** [10585-84]
- 10585 2E **Developing a flexible model of electron scattering in solid for charging analysis** [10585-85]
- 10585 2I **Design optimization of highly asymmetrical layouts by 2D contour metrology** [10585-90]
- 10585 2J **I-line stepper based overlay evaluation method for wafer bonding applications** [10585-91]
- 10585 2L **Backscattered electron simulations to evaluate sensitivity against electron dosage of buried semiconductor features** [10585-116]
- 10585 2O **Prototype through-pellicle coherent imaging using a 30nm tabletop EUV source** [10585-117]
- 10585 2Q **Massive metrology using fast e-beam technology improves OPC model accuracy by >2x at faster turnaround time** [10585-94]

- 10585 2R **Cognitive learning: a machine learning approach for automatic process characterization from design** [10585-95]
- 10585 2S **A new way of measuring wiggling pattern in SADP for 3D NAND technology** [10585-96]
- 10585 2T **In-depth analysis and characterization of a dual damascene process with respect to different CD** [10585-97]
- 10585 2U **Automated AFM for small-scale and large-scale surface profiling in CMP applications** [10585-98]
- 10585 2W **Quantitative approach for optimizing e-beam condition of photoresist inspection and measurement** [10585-100]
- 10585 2X **Toward reliable and repeatable automated STEM-EDS metrology with high throughput** [10585-101]
- 10585 2Y **Tracking the defects of ultra-thin HfO₂ using a Cody-Lorentz multiple oscillator model** [10585-102]
- 10585 2Z **Feed-forward alignment correction for advanced overlay process control using a standalone alignment station "Litho Booster"** [10585-103]
- 10585 31 **Automated mask and wafer defect classification using a novel method for generalized CD variation measurements** [10585-107]
- 10585 32 **Accuracy optimization with wavelength tunability in overlay imaging technology** [10585-109]
- 10585 33 **Shot-noise limited throughput of soft x-ray ptychography for nanometrology applications** [10585-110]
- 10585 34 **Multifractal analysis of line-edge roughness** [10585-113]
- 10585 35 **Cutting edge multiple beam technology for EUV era: latest development progress and application** [10585-119]