

PROCEEDINGS OF SPIE

DTCO and Computational Patterning V

Harsha Grunes

Kevin Lucas

Editors

24–26 February 2026

San Jose, California, United States

Sponsored and Published by
SPIE

Volume 13980

Proceedings of SPIE 0277-786X, V. 13980

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 *DTCO and Computational Patterning V*, edited by Harsha Grunes, Kevin Lucas, Proc. of SPIE 13980, Seven-digit Article CID Number (DD/MM/YYYY); (DOI URL).

ISSN: 0277-786X

ISSN: 1996-756X (electronic)

ISBN: 9781510699069

ISBN: 9781510699076 (electronic)

Published by

SPIE

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

Telephone +1 360 676 3290 (Pacific Time)

SPIE.org

Copyright © 2026 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*

DESIGN FOR MANUFACTURABILITY AND DESIGN FOR YIELD I

- 13980 07 **Methodologies for advanced BEOL test structure design and synthetic layout pattern generation for sub-2nm nodes (Invited Paper)** [13980-1]
- 13980 08 **Fuzzy pattern grouping for machine learning-based OPC optimization** [13980-2]
- 13980 09 **Full-chip high sigma probabilistic modeling, defect detection and repair in advanced EUV nodes** [13980-3]
- 13980 0A **Machine learning framework for real-time focus and dose drift detection in advanced lithography** [13980-4]
- 13980 0B **Demonstration of an efficient, high-performance repair flow for any-angle post-OPC layouts** [13980-5]

HIGH-NA AND COMPUTATIONAL PATTERNING

- 13980 0C **Machine learning enhanced optical proximity correction modeling for high-NA EUV lithography (Invited Paper)** [13980-6]
- 13980 0D **Analysis of mask-3D-induced imaging degradation mechanisms in high- and hyper-NA EUV lithography** [13980-7]
- 13980 0E **Production high-NA EUV stitch coloring and physical verification for physical design and mask synthesis** [13980-8]
- 13980 0F **Advanced OPC modeling and impact on OPC for dry resist by using low-n mask** [13980-9]
- 13980 0G **Co-optimized double-exposure stitching with ILT to maximize high-NA EUV process window** [13980-10]

JOINT SESSION WITH 13979 AND 13980

- 13980 0I **Rigorous modeling and repair of EUV multilayer defects** [13980-109]

DTCO AND SCTO I

- 13980 OK **Yield enhancement through design optimization using deep learning-based layout risk feature analysis (Invited Paper)** [13980-14]
- 13980 OL **The curvy road to silicon photonics manufacturing** [13980-15]
- 13980 OM **Pattern matching for inverse silicon photonic devices** [13980-16]
- 13980 ON **Design layout optimization for advanced-node custom design flows** [13980-17]
- 13980 OO **Guided dataset enrichment for robust process modeling: from random exploration to intelligent feature-aware pattern generation** [13980-18]

COMPUTATIONAL PATTERNING I

- 13980 OP **Inverse lithography in polar coordinates (Invited Paper)** [13980-19]
- 13980 OQ **Overcoming BEOL patterning challenges for the ArF immersion extension** [13980-73]
- 13980 OR **Determining lithographic parameters of amorphous zeolitic imidazolate resists using machine learning** [13980-21]
- 13980 OS **Optical proximity correction based on the direct use of rigorous electromagnetic simulation** [13980-22]

INTEGRATION

- 13980 OT **A hybrid machine learning framework for systematic optimization of overlay key positions** [13980-23]
- 13980 OU **Open collaborative AI platform to support process optimization for semiconductor industry with digital twin** [13980-24]
- 13980 OV **Efficient mathematical modeling for stress analysis in overlapping material interfaces of CMOS circuits** [13980-25]
- 13980 OW **0.33 NA EUV linear fading response prediction and measurement through dose** [13980-71]

COMPUTATIONAL PATTERNING II

- 13980 OY **Convolutional neural network-based machine learning tool for detecting printed sub resolution assist features (SRAFs)** [13980-27]

- 13980 0Z **Toward accurate optical model calibration with a near-perfect resist model** [13980-28]
- 13980 10 **GPU accelerated Bezier mask rule check for high volume production** [13980-29]
- 13980 11 **Flexible and expandable automatic OPC hotspot repairing flow** [13980-30]

CURVILINEAR DATA FOR COMPUTATIONAL PATTERNING

- 13980 13 **Vector-based site-anchor decoupling for curvilinear optical proximity correction (Invited Paper)** [13980-32]
- 13980 14 **Etch proximity correction for curvilinear layout: curve sampling with ML etch bias model** [13980-33]
- 13980 15 **Curvilinear data formats and the impact on mask-to-wafer fidelity** [13980-34]
- 13980 16 **Beyond Manhattan OPC: improving contact array fidelity using curvilinear OPC** [13980-35]

DTCO AND SCTO II

- 13980 17 **Design for manufacturability analysis in dual damascene 28nm-pitch single exposure EUV metal logic designs using voltage contrast** [13980-153]
- 13980 18 **Near-optimal sampling of physical design layout regions based on rigorous pattern coverage (Invited Paper)** [13980-36]
- 13980 19 **Accelerating DRC closure using AI-powered framework (Invited Paper)** [13980-37]
- 13980 1A **Building systematic defect library with GenAI** [13980-38]
- 13980 1B **IGNITE: sparking optimal OPC strategies through ML-guided site selection** [13980-39]

DEEP LEARNING, MACHINE LEARNING AND AI

- 13980 1C **Proactive yield maximization in photolithography via human-in-the-loop AI on an on-premise big data platform (Invited Paper)** [13980-41]
- 13980 1E **Mask space optimization (MSO) for ILT and SMO: reinforcement learning-driven recipe tuning** [13980-43]
- 13980 1F **Fast and scalable computational lithography using neural operators** [13980-45]

POSTER SESSION

- 13980 1G **Accelerating yield ramp-up on advanced nodes via design-inspection co-optimization** [13980-49]
- 13980 1H **End-to-end auto tape-out: from cell build-up to mask data** [13980-50]
- 13980 1I **Machine learning-enhanced framework for hotspot detection and path-based analysis in advanced semiconductor nodes** [13980-51]
- 13980 1J **EUV M3D parameter prediction of curvilinear mask patterns by convolutional neural networks** [13980-52]
- 13980 1L **Thermal diffusion modeling, simulation, and optimization of non-uniform laser beam shaping for precise semiconductor patterning** [13980-54]
- 13980 1N **Enhancing lithography process model accuracy using deep learning techniques** [13980-56]
- 13980 1O **OPC model optimization by combining scalable trust-region Bayesian optimization and various clustering techniques** [13980-202]

DIGITAL POSTER SESSION

- 13980 1Q **D2CNet: towards end-to-end design to wafer contour prediction for AI computational lithography** [13980-44]