## PROCEEDINGS OF SPIE

## Advanced Etch Technology for Nanopatterning VII

Sebastian U. Engelmann Richard S. Wise Editors

26–28 February 2018 San Jose, California, United States

Sponsored by SPIE

Cosponsored by LAM Research Corporation (United States)

Published by SPIE

**Volume 10589** 

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 Advanced Etch Technology for Nanopatterning VII, edited by Sebastian U. Engelmann, Richard S. Wise, Proceedings of SPIE Vol. 10589 (SPIE, Bellingham, WA, 2018) Seven-digit Article CID Number.

ISSN: 0277-786X

ISSN: 1996-756X (electronic)

ISBN: 9781510616707

ISBN: 9781510616714 (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

SPIF orc

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 5 gpc WJUHY gr + DWz i bXYf "JW bgY Zfca 'GD-9.

Publication of record for individual papers is online in the SPIE Digital Library.



**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

V	Authors		
vii	Conference Committee		
ix	Introduction		
-	ADVANCED PLASMA PATTERNING TECHNIQUES		
10589 04	3D memory: etch is the new litho (Invited Paper) [10589-4]		
	MATERIALS AND ETCH INTEGRATION: JOINT SESSION WITH CONFERENCES 10586 AND 10589		
10589 07	Evolution of roughness during the pattern transfer of high-chi, 10nm half-pitch, silicon-containing block copolymer structures [10589-6]		
10589 08	Selective dry etching of silicon containing anti-reflective coating [10589-7]		
10589 09	New frontiers of atomic layer etching [10589-8]		
	INNOVATIONS IN PLASMA AND PATTERNING MATERIALS		
	INTO VALIGNO IN LEASING AND LATERAING MALERIALS		
10589 0C	Graphoepitaxy integration and pattern transfer of lamellar silicon-containing high- $\chi$ block copolymers [10589-11]		
10589 0C	Graphoepitaxy integration and pattern transfer of lamellar silicon-containing high- $\chi$ block		
10589 0C 10589 0D	Graphoepitaxy integration and pattern transfer of lamellar silicon-containing high- $\chi$ block copolymers [10589-11]		
	Graphoepitaxy integration and pattern transfer of lamellar silicon-containing high-χ block copolymers [10589-11]  PATTERNING PROCESS CONTROL		
10589 0D	Graphoepitaxy integration and pattern transfer of lamellar silicon-containing high- $\chi$ block copolymers [10589-11]  PATTERNING PROCESS CONTROL  Wafer edge overlay control solution for N7 and beyond (Invited Paper) [10589-12]  Exploration of BEOL line-space patterning options at 12 nm half-pitch and below (Invited		
10589 0D 10589 0E	Graphoepitaxy integration and pattern transfer of lamellar silicon-containing high- $\chi$ block copolymers [10589-11]  PATTERNING PROCESS CONTROL  Wafer edge overlay control solution for N7 and beyond (Invited Paper) [10589-12]  Exploration of BEOL line-space patterning options at 12 nm half-pitch and below (Invited Paper) [10589-13]  Advanced process and defect characterization methodology to support process		

	10589 OI	Isotropic atomic level etching of tungsten using formation and desorption of tungsten fluoride [10589-17]
	10589 OJ	Minimum reaction network necessary to describe Ar/CF4 plasma etch [10589-18]
-		PATTERNING SOLUTIONS FOR EMERGING PRODUCT APPLICATIONS
	10589 OP	Ion-beam nanopatterning: experimental results with chemically-assisted beam (Invited Paper) [10589-23]
-		POSTER SESSION
	10589 OR	Cost modeling 22nm pitch patterning approaches [10589-25]
	10589 0S	Optimized plasma etch window of block copolymers and neutral brush layers for enhanced direct self-assembly pattern transfer into a hardmask layer [10589-26]
	10589 OU	Modeling of block copolymer dry etching for directed self-assembly lithography [10589-28]
	10589 0Y	Computational nanometrology of line-edge roughness: noise effects, cross-line correlations and the role of etch transfer [10589-33]