Photomask Technology 2019

Jed H. Rankin
Moshe E. Preil
Editors

16–18 September 2018
Monterey, California, United States

Sponsored by

BACUS
The international technical group of SPIE dedicated
to the advancement of photomask technology

SPIE.

Published by
SPIE

Volume 11148
Contents

vii  Authors
ix  Conference Committee
xi  Introduction

PLENARY SESSION: JOINT SESSION WITH CONFERENCES 11147 AND 11148

11148 02  Chip to city: the future of mobility (Plenary Paper) [11148-301]

SURVEY

11148 03  2019 Mask makers' survey conducted by the eBeam Initiative (Invited Paper) [11148-1]

MATURE MASK SUPPORT

11148 06  Extending a multi-beam laser writer for optical and EUV masks [11148-4]

DEEP LEARNING MASK APPLICATIONS

11148 0A  Mask modeling using a deep learning approach [11148-8]

11148 0C  Loading effect correction set up by supplementing CD measurement analysis with machine learning [11148-10]

MASK WRITER AND MASK PROCESS CORRECTION (MPC)

11148 0F  Requirements of data technology for EUV photomask (Invited Paper) [11148-13]

11148 0G  Resist-slope aware modeling for mask process correction applications [11148-14]

11148 0H  MPC simplification for established model-based mask process correction solutions [11148-15]
### PROCESSING, PHOTORESIST AND NANOIMPRINT LITHOGRAPHY

<table>
<thead>
<tr>
<th>11148 OL</th>
<th>Improving chip performance by photomask tuning: ultimate intra-field CD control as a major part of an overall excursion prevention strategy [11148-19]</th>
</tr>
</thead>
<tbody>
<tr>
<td>11148 0M</td>
<td>Patterning, mask life, throughput and overlay improvements for high volume semiconductor manufacturing using nanoimprint lithography [11148-20]</td>
</tr>
<tr>
<td>11148 0N</td>
<td>Novel cleaning technology for nanoparticle removal [11148-21]</td>
</tr>
</tbody>
</table>

### MASK DATA PREP (MPD) AND CURVILINEAR DATA HANDLING

<table>
<thead>
<tr>
<th>11148 0Q</th>
<th>Machine learning guided curvilinear MPC (Invited Paper) [11148-24]</th>
</tr>
</thead>
<tbody>
<tr>
<td>11148 0T</td>
<td>Adopting curvilinear shapes for production ILT: challenges and opportunities [11148-27]</td>
</tr>
<tr>
<td>11148 0U</td>
<td>Study of mask and wafer co-design that utilizes a new extreme SIMD approach to computing in memory manufacturing: full-chip curvilinear ILT in a day [11148-28]</td>
</tr>
</tbody>
</table>

### EUV BLANK AND FILMS: JOINT SESSION WITH CONFERENCE 11147 AND 11148

| 11148 0V | Examination of flatness key performance indicators for reticles in next-generation, high-NA EUV scanners [11148-29] |

### EUV DEFECTS, INSPECTION AND CHARACTERIZATION: JOINT SESSION WITH CONFERENCES 11147 AND 11148

| 11148 0X | Capability of DUV inspection for the LWR improved EUV mask of sub-15 nm hp on wafer [11148-31] |

### EUV PELLICLE: JOINT SESSION WITH CONFERENCES 11147 AND 11148

| 11148 0Y | EUV reticle defectivity protection options (Invited Paper) [11148-32] |

### POSTER SESSION

<table>
<thead>
<tr>
<th>11148 10</th>
<th>Investigation of reducing mask writing time with shot count management solution [11148-35]</th>
</tr>
</thead>
<tbody>
<tr>
<td>11148 11</td>
<td>Wafer alignment mark placement accuracy impact on the layer-to-layer overlay performance [11148-37]</td>
</tr>
<tr>
<td>11148-12</td>
<td>Lithography printability review: an application on advanced photomask production for enhancing mask yield and cycle time [11148-38]</td>
</tr>
<tr>
<td>11148-13</td>
<td>A model based OPC method to add serifs for corner rounding design of CMOS image sensor [11148-39]</td>
</tr>
<tr>
<td>11148-14</td>
<td>Strategy for the breakthrough of RLS trade-off relationship in the development of novel resist materials and a developer [11148-40]</td>
</tr>
<tr>
<td>11148-16</td>
<td>High temperature baking process study in advanced mask cleaning [11148-42]</td>
</tr>
<tr>
<td>11148-17</td>
<td>Low reflection phase shift mask for high resolution flat panel displays [11148-43]</td>
</tr>
<tr>
<td>11148-18</td>
<td>A fast DFM-driven standard cell qualification approach for critical layers of 14nm technology node [11148-44]</td>
</tr>
<tr>
<td>11148-1A</td>
<td>Large dies stitching: a technical and cross-functional teams challenge [11148-46]</td>
</tr>
<tr>
<td>11148-1B</td>
<td>Exploring alternative EUV mask absorber for iN5 self-aligned block and contact layers [11148-47]</td>
</tr>
<tr>
<td>11148-1E</td>
<td>High throughput AFM inspection system with parallel active cantilevers [11148-50]</td>
</tr>
<tr>
<td>11148-1F</td>
<td>Atomic force microscope integrated into a scanning electron microscope for fabrication and metrology at the nanometer scale [11148-51]</td>
</tr>
<tr>
<td>11148-1G</td>
<td>193nm mask inspection challenges and approaches for 7nm/5nm technology and beyond [11148-52]</td>
</tr>
<tr>
<td>11148-1H</td>
<td>Practical lithography hotspot identification using mask process model [11148-53]</td>
</tr>
<tr>
<td>11148-1I</td>
<td>Characterization of quartz etched depth and optical density of opaque pattern for the wafer CD behavior on advanced mask [11148-54]</td>
</tr>
<tr>
<td>11148-1K</td>
<td>Evaluation of neighborhood pattern matching algorithm in MPC processing [11148-56]</td>
</tr>
<tr>
<td>11148-1L</td>
<td>A case study of benefits for the &quot;IOFF&quot; MDP automation project: development, integration, and optimization of the Integrated-Optimized-Fracture-Flow (IOFF) into production [11148-57]</td>
</tr>
<tr>
<td>11148-1N</td>
<td>Development of an EUV and OoB Reflectometer at NewSUBARU synchrotron light facility (Photomask Japan 2019 Best Poster Winner) [11148-59]</td>
</tr>
<tr>
<td>11148-1O</td>
<td>Demonstrating the value of integrated reticle automation solutions in high volume wafer fab manufacturing [11148-60]</td>
</tr>
<tr>
<td>11148-1P</td>
<td>Theory of transformation-invariant compact process modeling [11148-61]</td>
</tr>
</tbody>
</table>
Authors

Numbers in the index correspond to the last two digits of the seven-digit citation identifier (CID) article numbering system used in Proceedings of SPIE. The first five digits reflect the volume number. Base 36 numbering is employed for the last two digits and indicates the order of articles within the volume. Numbers start with 00, 01, 02, 03, 04, 05, 06, 07, 08, 09, 0A, 0B...0Z, followed by 10-1Z, 20-2Z, etc.
Conference Committee

Conference Chairs

Jed H. Rankin, GLOBALFOUNDRIES Inc. (United States)
Moshe E. Preil, KLA-Tencor Corporation (United States)

Conference Program Committee

Frank E. Abboud, Intel Corporation (United States)
Uwe F.W. Behringer, UBC Microelectronics (Germany)
Lucien Bouchard, Photronics, Inc. (United States)
Peter Buck, Mentor, a Siemens Business (United States)
Thomas B. Faure, GLOBALFOUNDRIES Inc. (United States)
Aki Fujimura, D2S, Inc. (United States)
Emily E. Gallagher, imec (Belgium)
Brian J. Grenon, RAVE LLC (United States)
Naoya Hayashi, Dai Nippon Printing Company, Ltd. (Japan)
Bryan S. Kasprowicz, Photronics, Inc. (United States)
Byung Gook Kim, ESOL, Inc. (Korea, Republic of)
Paul A. Morgan, Micron Technology, Inc. (United States)
Kent H. Nakagawa, Toppan Photomasks, Inc. (United States)
Takahiro Onoue, HOYA Corporation (Japan)
Jan Hendrik Peters, BMBG Consult (Germany)
Douglas J. Resnick, Canon Nanotechnologies, Inc. (United States)
Thomas Scherübl, Zeiss (Germany)
Shalini Sharma, JSR Micro, Inc. (United States)
Yuyang Sun, Mentor Graphics Corporation (United States)
Bala Thumma, Synopsys, Inc. (United States)
Banqiu Wu, Applied Materials, Inc. (United States)
Shusuke Yoshitake, NuFlare Technology, Inc. (Japan)
Larry S. Zurbrick, Keysight Technologies, Inc. (United States)

Session Chairs

Plenary Session: Joint session with conferences 11147 and 11148
Jed H. Rankin, GLOBALFOUNDRIES Inc. (United States)
Takahiro Kozawa, Osaka University (Japan)

Survey
Jed H. Rankin, GLOBALFOUNDRIES Inc. (United States)
Moshe E. Preil, KLA Corporation (United States)
Mature Mask Support

Jed H. Rankin, GLOBALFOUNDRIES Inc. (United States)
Moshe E. Preil, KLA Corporation (United States)

Deep Learning Mask Applications

Aki Fujimura, D2S, Inc. (United States)
Yuyang Sun, Mentor Graphics Corporation (United States)

Selected Poster Speed Talks: Joint Session with conference 11147 and 11148

Shalini Sharma, JSR Micro, Inc. (United States)
Julius Joseph S. Santillan, Osaka University (Japan)

EUV Mask and Lithography Integration: Joint Session with conferences 11147 and 11148

Frank E. Abboud, Intel Corporation (United States)
Rik Jonckheere, IMEC (Belgium)

Mask Writer and Mask Process Correction (MPC)

Uwe F.W. Behringer, UBC Microelectronics (Germany)
Jed H. Rankin, GLOBALFOUNDRIES Inc. (United States)

Processing, Photoresist and Nanoinprint Lithography

Thomas B. Faure, GLOBALFOUNDRIES Inc. (United States)
Shalini Sharma, JSR Micro, Inc. (United States)

Mask Data Prep (MPD) and Curvilinear Data Handling

Peter Buck, Mentor, a Siemens Business (United States)
Naoya Hayashi, Dai Nippon Printing Company, Ltd. (Japan)

EUV Blank and Films: Joint Session with conference 11147 and 11148

Onoue Takahiro, HOYA Corporation (Japan)
Ted Liang, Intel Corporation (United States)

EUV Defects, Inspection and Characterization: Joint Session with conferences 11147 and 11148

Thomas Scherübl, Carl Zeiss SMS Ltd. (Israel)
Vibhu Jindal, Applied Materials, Inc. (United States)

EUV Pellicle: Joint Session with conferences 11147 and 11148

Emily E. Gallagher, IMEC (Belgium)
Naoya Hayashi, Dai Nippon Printing Company, Ltd. (Japan)