26th European Mask and Lithography Conference

Uwe F.W. Behringer
Wilhelm Maurer
Editors

18–20 January 2010
Grenoble, France

Organised by
VDE/VDI GMM—The Society for Microelectronics
Micro- and Precision Engineering (Germany)

Sponsored by
CEA-LETI Grenoble, AEPI Grenoble Isere, Ville de Grenoble (France)
UBC Microelectronics (Germany)

Cooperating Organisations
BACUS
Photomask Japan (Japan)
SEMI
SPIE
UBC Microelectronics (Germany)

Published by
SPIE

Volume 7545
# Contents

<table>
<thead>
<tr>
<th>Conference Committees</th>
<th>ix</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foreword</td>
<td>xi</td>
</tr>
<tr>
<td>Cooperating Partners of EMLC 2010</td>
<td>xiii</td>
</tr>
<tr>
<td>Best Paper from PMJ 2009</td>
<td>xxi</td>
</tr>
<tr>
<td>Actinic EUVL mask blank inspection and phase defect characterization</td>
<td>[7379-16]</td>
</tr>
<tr>
<td>T. Yamane, T. Iwasaki, T. Tanaka, T. Terasawa, O. Suga, Semiconductor Leading Edge Technologies, Inc. (Japan); T. Tomie, National Institute of Advanced Industrial Science and Technology (Japan)</td>
<td></td>
</tr>
<tr>
<td>Best Poster from BACUS 2009</td>
<td>xxxi</td>
</tr>
<tr>
<td>Aerial plane inspection for advanced photomask defect detection</td>
<td>[7488-101]</td>
</tr>
<tr>
<td>W. S. Kim, J. H. Park, D. H. Chung, C. U. Jeon, H. K. Cho, SAMSUNG Electronics, Co. Ltd. (Korea, Republic of); T. Hutchinson, KLA-Tencor Corp. (United States); O. Lee, KLA-Tencor Corp. (Korea, Republic of); W. Huang, A. Dayal, KLA-Tencor Corp. (United States)</td>
<td></td>
</tr>
</tbody>
</table>

## PLENARY SESSION I

**7545 02**

Mask industry assessment trend analysis: 2010 (Invited Paper) | [7545-26]
---
G. Hughes, H. Yun, SEMATECH (United States)

## EUV I

**7545 03**

Impact of mask absorber on EUV imaging performance | [7545-22]
---
E. van Setten, C. W. Man, R. Murillo, S. Lok, K. van Ingen Schenau, K. Feenstra, C. Wagner, ASML Netherlands B.V. (Netherlands)

**7545 04**

Overview of IP error compensation techniques for EUVL | [7545-12]
---
P. Vukkadala, D. Patil, R. L. Engelstad, Univ. of Wisconsin-Madison (United States)

**7545 05**

Contributions to EUV mask metrology infrastructure | [7545-28]
---
A. Farahzadi, R. Lebert, Bruker Advanced Supercon GmbH (Germany); M. Benk, Fraunhofer Institute TOS (Germany); L. Juschkin, S. Herbert, A. Maryasov, RWTH Aachen Univ. (Germany)

## MASKLESS LITHOGRAPHY I

**7545 06**

Multi-shaped beam data preparation | [7545-21]
---
U. Weidenmueller, H.-J. Doering, R. Jaritz, Vistec Electron Beam GmbH (Germany); D. Melzer, EQUIcon Software GmbH (Germany); A. Sloeckel, Vistec Electron Beam GmbH (Germany)
Metrology

- Checkerboard pattern for PSF parameter determination in electron beam lithography [7545-23]

Data Preparation, Simulation, and RET

- Update on next generation metrology tool for DPL reticles [7545-01]
  K.-D. Roeth, J. Bender, F. Laske, D. Adam, K.-H. Schmidt, KLA-Tencor MIE GmbH (Germany)

- CD forecasting in resist by means of scatterometry [7545-25]
  J. Richter, Advanced Mask Technology Ctr. GmbH & Co. KG (Germany)

- A 193nm microscope for CD metrology for the 32nm node and beyond [7545-15]
  B. Bodermann, Z. Li, F. Pilarski, D. Bergmann, Physikalisch-Technische Bundesanstalt (Germany)

Data Preparation, Simulation, and RET I

- Deployment of OASIS in the semiconductor industry: status, dependencies, and outlook [7545-20]
  J. C. Davis, S. Schulze, S. Fu, Y. Tong, Mentor Graphics Corp. (United States)

- Rigorous EMF simulation of absorber shape variations and their impact on lithographic processes [7545-14]
  Z. Rahimi, A. Erdmann, Fraunhofer Institute for Integrated Systems and Device Technology (Germany) and Erlangen Graduate School in Advanced Optical Technologies (Germany); P. Evanschitzky, Fraunhofer Institute for Integrated Systems and Device Technology (Germany); C. Pflaum, Friedrich-Alexander-Univ. Erlangen-Nürnberg (Germany) and Erlangen Graduate School in Advanced Optical Technologies (Germany)

Data Preparation, Simulation, and RET II

- Efficient simulation of three-dimensional EUV masks for rigorous source mask optimization and mask induced imaging artifact analysis [7545-02]
  P. Evanschitzky, T. Fühner, F. Shao, A. Erdmann, Fraunhofer Institute for Integrated Systems and Device Technology (Germany)

- Proximity effect correction sensitivity analysis [7545-16]
  A. Zepka, Synopsys, Inc. (United States); R. Zimmermann, W. Hoppe, M. Schulz, Synopsys GmbH (Germany)

- Modified dose correction strategy for better pattern contrast [7545-09]
  R. Galler, D. Melzer, EQUIcon Software GmbH (Germany); M. Boettcher, Vistec Electron Beam GmbH (Germany); M. Krueger, M. Suelzle, C. Wagner, EQUIcon Software GmbH (Germany)
RESIST, REPAIR, AND CLEANING

7545 0G 193nm resist deprotection study from outgassing measurements by TD-GCMS/FID [7545-06] R. Tiron, S. Derrough, H. Fontaine, S. Cetre, CEA, LETI (France); D. Perret, Dow Electronic Materials (France); J. W. Thackeray, Dow Electronic Materials (United States); P. Paniez, CNRS-LTM (France)

7545 0H Increasing mask yield through repair yield enhancement utilizing the MeRiT [7545-18] A. Garetto, Carl Zeiss SMT Inc. (United States); J. Oster, Carl Zeiss SMS NaWoTec GmbH (Germany); M. Waiblinger, Carl Zeiss SMS GmbH (Germany); K. Edinger, Carl Zeiss SMS NaWoTec GmbH (Germany)

7545 0I Study of the molecular contaminants deposition on Cr, MoSi and SiO2 surfaces representative of photomasks layers [7545-19] H. Fontaine, S. Cetre, G. Demenet, F. Piallat, CEA, LETI, MINATEC (France)

7545 0J Mask cleaning process evaluation and modeling [7545-24] P. Nesladek, Advanced Mask Technology Ctr. (Germany); S. Osborne, Sigmameltec Ltd. (Japan)

APPLICATION

7545 0K Mask lithography for display manufacturing [7545-29] T. Sandstrom, P. Ekberg, Micronic Laser Systems (Sweden)

7545 0L Deep-UV KrF lithography for the fabrication of Bragg gratings on SOI rib waveguides [7545-10] J. Bauer, D. Stolarek, L. Zimmermann, IHP GmbH (Germany); I. Giuntoni, Technische Univ. Berlin (Germany); U. Haak, H. Richter, S. Marschmeyer, A. Gajda, IHP GmbH (Germany); J. Bruns, K. Petermann, Technische Univ. Berlin (Germany); B. Tillack, IHP GmbH (Germany) and Technische Univ. Berlin (Germany)

7545 0M Mask phase and transmission variation effects on wafer critical dimensions for nodes 65nm and 45nm [7545-05] F. Dufaye, S. Gough, F. Sundermann, V. Farys, STMicroelectronics (France); H. Miyashita, L. Sartelli, F. Perissinotti, Dai Nippon Photomasks Europe (Italy); U. Buttgereit, S. Perlitz, R. Birkner, Carl Zeiss SMS GmbH (Germany)

EUV II

7545 0N Study of real defects on EUV blanks and a strategy for EUV mask inspection [7545-13] S. Huh, A. Rastegar, S. Wurm, SEMATECH (United States); K. Goldberg, I. Mochi, Lawrence Berkeley National Lab. (United States); T. Nakajima, M. Kishimoto, M. Komakine, AGC Electronics America (United States)

7545 0O Defect inspection with an EUV microscope [7545-17] S. Herbert, A. Maryasov, L. Juschkin, RWTH Aachen Univ. (Germany); R. Lebert, Bruker Advanced Supercon GmbH (Germany); K. Bergmann, Fraunhofer Institute for Laser Technology (Germany)
e-beam induced EUV photomask repair: a perfect match (Best Paper of EMLC 2010) [7545-11]
M. Waiblinger, Carl Zeiss SMS GmbH (Germany); K. Kornilov, T. Hofmann, K. Edinger, Carl Zeiss SMS NaWoTec GmbH (Germany)

MASKLESS LITHOGRAPHY II

Projection mask-less lithography and nanopatterning with electron and ion multi-beams [7545-03]
C. Klein, E. Platzgummer, H. Loeschner, IMS Nanofabrication AG (Austria)

Low voltage resist processes developed for MAPPER tool first exposures [7545-04]
D. Rio, C. Constancias, CEA-LETI MINATEC (France); J. van Nieuwstadt, J. Vijverberg, MAPPER Lithography B.V. (Netherlands); S. Derrrough, B. Icard, L. Pain, CEA-LETI MINATEC (France)

NANOIMPRINT LITHOGRAPHY

Template masters for substrate conformal imprint lithography generated by charged particle nanopatterning techniques [7545-07]
F. van Delft, R. van de Laar, M. Verschuuren, Philips Research (MiPlaza) (Netherlands); E. Platzgummer, H. Loeschner, IMS Nanofabrication AG (Austria)

Positive or negative tone resist for a T-NIL/UVL hybrid process [7545-08]
S. Möllenbeck, N. Bogdanski, A. Mayer, H.-C. Scheer, Univ. of Wuppertal (Germany)

Antisticking layers on antireflective chromium for hybrid (CNP) nanoimprint molds [7545-27]
R. Kirchner, Technische Univ. Dresden (Germany) and Fraunhofer-Institute for Photonic Microsystems (Germany); B. Adolphi, Technische Univ. Dresden (Germany); R. Landgraf, Technische Univ. Dresden (Germany) and Fraunhofer-Institute for Photonic Microsystems (Germany); W.-J. Fischer, Technische Univ. Dresden (Germany) and Fraunhofer-Institute for Photonic Microsystems (Germany)

Author Index
Conference Committee

Members of the International Steering Committee, the International Program Committee* and the Local Committee of the EMLC 2010

Conference Chair

U. F.W. Behringer*, UBC Microelectronics (Germany)

Conference Cochairs

B. Grenon*, Grenon Consulting (United States)
N. Hayashi*, DNP (Japan)

Program Chairs

W. Maurer*, Infineon Technologies AG (Germany)
J. Waelpoel*, ASML (Netherlands)

Program Cochair

W. Montgomery*, SEMATECH (United States)

Members

M. Arnz*, Carl Zeiss SMT AG (Germany)
C. Blaesing, Carl Zeiss SMS GmbH (Germany)
P. Chen*, Taiwan Mask Corporation (Taiwan)
C. Constantine*, Oerlikon USA Inc. (United States)
R. Engelstad*, University of Wisconsin-Madison (United States)
B. G. Eynon*, Molecular Imprints, Inc. (United States)
C. Gale*, Applied Materials (Germany)
B. Grenon*, Grenon Consulting, Inc. (United States)
N. Hayashi*, Dai Nippon Printing Company Ltd. (Japan)
R. Jonckheere*, IMEC (Belgium)
B. Lauche, Photronics MZD GmbH (Germany)
H. Loeschner*, IMS Nanofabrication AG (Austria)
W. Montgomery, SEMATECH, (United States)
V. Pequignat, AEPI (France)
Ch. Pierrat*, Cadence Design Systems Inc. (United States)
E. Rausa*, Oerlikon USA Inc. (United States)
C. Reita, CEA-LETI, Grenoble (France)
D. J. Resnick*, Molecular Imprints, Inc. (United States)  
F. Reuther, micro resist technology GmbH (Germany)  
C. Romeo*, Numonyx (Italy)  
K. Ronse, IMEC (Belgium)  
H.-C. Scheer*, University of Wuppertal (Germany)  
R. Schnabel*, VDE/VDI-GMM (Germany)  
M. Staples, GOLBALFOUNDRIES, Inc. (Germany)  
I. Stolberg*, Vistec Electron Beam GmbH (Germany)  
S. Tedesco*, CEA-LETI, Grenoble (France)  
M. Tissier*, Toppan Photomasks S.A. (France)  
J. T. Weed, Synopsys, Inc. (United States)  
J. Whittey*, KLA-Tencor Corporation (United States)  
H. Wolf*, Photronics MZD GmbH (Germany)  
S. Wurm*, SEMATECH (United States)  
L. Zurbrick*, Agilent Technologies (United States)
Foreword

Welcome to the proceedings volume of the 26th European Mask and Lithography conference, EMLC2010 held 18-20 January 2010, at the MINATEC Conference Center in Grenoble, France. The conference has annually brought together scientists, researchers, engineers and technologists from research institutes and companies from around the world to present papers at the forefront of mask lithography and mask technology.

The three-day conference is dedicated to the science, technology, engineering and application of mask and lithography technologies and associated processes, and gives an overview of the present status in mask and lithography technologies and the future strategy where mask producers and users have the opportunity to become acquainted with new developments and results. This year’s sessions include: EUV, Metrology, Data Preparation, Simulation & RET, Resist, Repair & Cleaning, Application, ML2, as well as NIL.

Each year we plan to focus on one lithography and mask technology. This year we have selected two: EUV and ML2. For the second time in its 26-year history the EMLC will take place in Grenoble, France. The VDE/GMM and the EMLC Organizing Committee were again invited to come to Grenoble, France.

We are pleased to report that Geneviève Fioraso, the deputy mayor in charge of economic development of Grenoble, France, provided opening comments.

Our first keynote speaker was Dr. Gérard Matheron, Site Director of STMicroelectronics Advanced Manufacturing Centre in Crolles, France. His presentation was titled, “Silicon ecosystems in Europe: the key to competitiveness.”

Our second keynote speaker was Dr. Udo Nothelfer, Vice President and General Manager Fab 1 GLOBALFOUNDRIES, Dresden, Germany. His presentation was titled, “The semiconductor foundry transition and its impact on the mask industry.”

Parallel to the full day of conference presentations on Tuesday and Wednesday, a technical exhibition took place where companies (mask suppliers, material suppliers, and equipment suppliers) exhibited their companies and products.
Some background information on Grenoble, France

Grenoble (its historical name was Cularo), was founded in the 3rd century by the Romans. Today it is one of the strongest high tech areas in France and in Europe. Since the year 2000, €4 billion has been invested with €3 billion more to be invested by the end of 2007 for the nano-technology sector in the Grenoble-Isère area. Many high tech companies are located in the region such as: Alliance-Crolles2, CEA-LETI MINATEC, Nanotec 300, Minalogic, Nanosmart Centre (Soitec), etc., STMicroelectronics, NXP Semiconductors (ex-Philips), Freescale Semiconductor, Soitec, Tronic’s Microsystems, e2v Semiconductors (ex-Atmel), Synopsys, HP, Mentor Graphics, Maxim, Applied Materials, ASML, KLA-Tencor, Entegris, Air Liquide Electronics Systems, Schneider Electric, MGE UPS Systems, Radiall, Thales, etc. With more than 38,000 jobs in Grenoble-Isère, the information and communication technology (ICT) sector is one of the largest in the area, having enjoyed spectacular growth over the last 15 years. Grenoble-Isère is France’s second largest center for research, after the Paris area. It has forged an international reputation in micro- and nano-technology, drawing on powerful, complementary skills in information technology and software. As a result Grenoble-Isère is a key European center for innovation.

Some facts of the High Tech companies in the Grenoble area:

**MINATEC:** A top European center for micro- and nano-technology innovation bringing together training, research and industry. It accounts for 4,000 jobs, 10,000 square meters of clean room space (including CEA-LETI).

**Alliance-Crolles2:** It has a state-of-the-art facility for leading-edge CMOS processes to provide 90nm to 32nm chip technologies on 300 mm wafers. There is strong collaboration between STMicroelectronics, NXP Semiconductors (founded by Philips) and Freescale Semiconductor for the development of high-performance technologies such as System-on-Chip (SoC). Investments of approximately €2.8 billion have been allocated over a five year period.

**Nanosmart Centre - Soitec:** A world-class center of excellence dedicated to advanced materials research in partnership with CEA-LETI, bringing together approximately 100 researchers, and €170 million over a period of five years.

**MINALOGIC:** A world-class competitive center with more than 60 partners that combines semiconductors and software to develop smart miniaturized solutions, and to capitalize on technological progress in industrial sectors to achieve competitive advantages. Over €870 million has been spent or allocated for 16 research projects over a one year period.

Uwe F.W. Behringer
COOPERATING PARTNERS OF THE EMLC 2010