PROCEEDINGS OF SPIE

29th European Mask and Lithography Conference

Uwe F.W. Behringer
Wilhelm Maurer
Editors

25–27 June 2013
Dresden, Germany

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

Published by
SPIE

Volume 8886

Proceedings of SPIE 0277-786X, V. 8886

29th European Mask and Lithography Conference, edited by Uwe F.W. Behringer,
Wilhelm Maurer, Proc. of SPIE Vol. 8886, 888601 · © 2013 SPIE
CCC code: 0277-786X/13/$18 · doi: 10.1117/12.2048544

The papers included 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. The papers published in these proceedings 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 this book:
Author(s), "Title of Paper," in *29th European Mask and Lithography Conference*, edited by Uwe F.W. Behringer, Wilhelm Maurer, Proceedings of SPIE Vol. 8886 (SPIE, Bellingham, WA, 2013) Article CID Number.

ISSN: 0277-786X
ISBN: 9780819497550

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

Printed in the United States of America.

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

SPIE Digital Library
SPIEDigitalLibrary.org

Paper Numbering: Proceedings of SPIE follow an e-First publication model, with papers published first online and then in print and on CD-ROM. Papers are published as they are submitted and meet publication criteria. A unique, consistent, permanent citation identifier (CID) number is assigned to each article at the time of the first 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, print, and electronic versions of the publication. SPIE uses a six-digit CID article numbering system in which:

- The first four 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. The complete citation is used on the first page, and an abbreviated version on subsequent pages. Numbers in the index correspond to the last two digits of the six-digit CID Number.

Contents

MASK MATERIALS

E-BEAM LITHOGRAPHY

METROLOGY AND INSPECTION

Conference Committee

Conference Chair

Uwe F.W. Behringer, UBC Microelectronics (Germany)

Conference Cochairs

N. Hayashi, Dai Nippon Printing Company Ltd. (Japan)
B. Connolly, Toppan Photomasks GmbH (Germany)

Program Chair

W. Maurer, Infineon Technologies AG (Germany)

Program Cochairs

R. Seltmann, GLOBALFOUNDRIES (Germany)
J. Finders, ASML Netherlands B.V. (Netherlands)

Members

M. Arnz, Carl Zeiss SMT AG (Germany)
E. Baracchi, STMicroelectronics (Italy)
C. Blaesing, Carl Zeiss SMS GmbH (Germany)
P. Chen, Taiwan Mask Corporation (Taiwan)
R. Engelstad, University of Wisconsin, Madison (United States)
G. Hughes, SEMATECH Inc. (United States)
R. Jonckheere, IMEC (Belgium)
B. Lauche, Photronics MZD GmbH (Germany)
H. Löschner, IMS Nanofabrication AG (Austria)
C. Progler, Photronics Inc. (United States)
E. Rausa, Plasma-Therm LLC (United States)
D. J. Resnick, Molecular Imprints (United States)
K.-D. Roeth, KLA-Tencor MIE GmbH (Germany)
C. Romeo, Numonyx (Italy)
H. Scheer, Bergische Universität Wuppertal (Germany)
T. Scherübl, Carl Zeiss SMS GmbH (Germany)
R. Schnabel, VDE/VDI-GMM (Germany)
S. Schulze, Mentor Graphics Corporation (United States)
M. Staples, GLOBALFOUNDRIES (Germany)
I. Stolberg, Vistec Electron Beam GmbH Jena (Germany)
S. Tedesco, CEA-LETI (France)
M. Tissier, Toppan Photomasks S.A. (France)
J. Waelpoel, ASML Netherlands B.V. (Netherlands)
G. Wenz, Wenz Consulting (Germany)

J. Whittey, KLA-Tencor Corporation (United States)
H. Wolf, Photronics MZD GmbH (Germany)
S. Wurm, SEMATECH Inc. (United States)
L. Zurbrick, Agilent Technologies (United States)

Session Chairs

1 Plenary Session I
W. Maurer, Infineon Technologies AG (Germany)
R. Seltmann, GLOBALFOUNDRIES (Germany)

2 Plenary Session II
B. Connolly, Toppan Photomasks GmbH (Germany)
N. Hayashi, Dai Nippon Printing Company Ltd. (Japan)

3 EUV Tooling and Further Lithography Options
J. H. Peters, Carl Zeiss SMS GmbH (Germany)
H. Morimoto, Toppan Printing Company (Japan)

4 Optical Lithography and APC
U. F.W. Behringer, UBC Microelectronics (United States)

5 Mask Materials
D. Farrar, Hoya Corporation (United Kingdom)
M. Arnz, Carl Zeiss SMT AG (Germany)

6 E-beam Lithography
I. Stolberg, Vistec Electron Beam GmbH Jena (Germany)
N. Hayashi, Dai Nippon Printing Company Ltd. (Japan)

7 Panel Discussion
S. Wurm, SEMATECH Inc. (United States)

8 Metrology and Inspection
J. Finders, ASML Netherlands B.V. (Netherlands)
K.-D. Roeth, KLA-Tencor MIE GmbH (Germany)

9 Resolution Enhancement and DfM
W. Maurer, Infineon Technologies AG (Germany)
J. Finders, ASML Netherlands B.V. (Netherlands)

Foreword

On behalf of VDE/VDI-GMM, the sponsors, and the organizing committee, we welcome you to the proceedings volume from the 29th European Mask and Lithography Conference, EMLC2013, which was held at the Hilton Hotel in Dresden, Germany.

Each year this conference brings together scientists, researchers, engineers, and technologists from research institutes and companies from around the world to present innovations at the forefront of mask lithography and mask technology. The two and a half day conference was dedicated to the science, technology, engineering, and application of mask and lithography technologies and associated processes, giving an overview of the present status in mask and lithography technologies and the future strategy where mask producers and users have the opportunity of becoming acquainted with new developments and results. This year's sessions included: EUV Tooling & Further Lithography Options, Optical Lithography & APC, Mask Materials, E-beam Lithography, Metrology & Inspection, and Resolution Enhancement & DFM.

Dr. G. Teepe from GLOBALFOUNDRIES was the conference's welcome speaker. Ther first keynote speaker was Dr. H. Morimoto from Toppan Printing Company of Japan. His presentation was entitled "Photomask Technology Progress to meet with Electronics Product Requirements." Our second keynote speaker was Dr. H.J. Levinson from GLOBALFOUNDRIES. His presentation was entitled "The Lithographer's Dilemma: Shrinking without Breaking the Bank."

As a tradition we invited the Best Paper of PMJ 2013 and the Best Poster from Photomask Space 2012 to present their papers at the EMLC2013.

A Panel Session "EUVL – What else?" took place on Wednesday afternoon. The panelists were: H. Morimto from Toppan; H.J. Levinson from GLOBALFOUNDRIES; F. Goodwin from SEMATECH; N. Hayashi, from DNP; J. Finders from ASML; and J.H. Peters from Carl Zeiss SMS. S. Wurm from SEMATECH acted as Session Chair and Moderator.

Parallel to the Conference Presentations, the Technical Exhibition took place on Tuesday afternoon (1:00 PM), and continued all of Wednesday, and concluded Thursday afternoon (1:00 PM). Some of the exhibitor companies were: Vistec E-Beam; Photronics; Entegris; Nuflare; PI; Pozzetta; Carl Zeiss; JEOL; S3Alliance; Sistem; ibss Group. EQUIcon informed us on their products and support.

We hope that you enjoyed the Technical Sessions of the EMLC2013 as well as the Technical Exhibition, but also allow yourself to visit Dresden!

Uwe F.W. Behringer

Sponsors and Cooperating Partners

The 29th European Mask and Lithography Conference, EMLC would like to express its sincere appreciation to all the sponsors and cooperating partners mentioned below for their support.