PROCEEDINGS OF SPIE

Photomask and Next-Generation Lithography Mask Technology XVIII

Toshio Konishi
Editor

13–15 April 2011
Yokohama, Japan

Sponsored by
PMJ Photomask Japan
BACUS
SPIE

Published by
SPIE

This conference was canceled due to the earthquake off the northeast coast of Japan in March 2011.
This volume includes some of the papers that were scheduled to be presented at the conference.

Volume 8081

Proceedings of SPIE, 0277-786X, v. 8081

Please use the following format to cite material from this book:
Author(s), "Title of Paper," in *Photomask and Next-Generation Lithography Mask Technology XVIII*, edited by Toshio Konishi, Proceedings of SPIE Vol. 8081 (SPIE, Bellingham, WA, 2011) Article CID Number.

ISSN 0277-786X
ISBN 9780819486738

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

vii *Conference Committees*

MATERIALS AND PROCESS I

8081 02 **Mask blank material optimization impact on leading-edge ArF lithography** [8081-44]
K. Mesuda, H. Watanabe, K. Hayano, E. Tsujimoto, H. Takamizawa, Dai Nippon Printing Co., Ltd. (Japan); T. Ohhashi, N. Sakasai, S. Kudo, T. Matsuyama, Nikon Corp. (Japan)

FPD PHOTOMASKS

8081 05 **Growth mechanism and inhibition technologies of a contamination on the surface of photomask for longtime LCD-TFT lithography process** [8081-20]
M. Murai, M. Tsuchiya, H. Shinchi, T. Hirano, Hoya Corp. (Japan); S. Kitajima, Y. Kaneko, T. Kimoto, S. Takayama, Asahi-Kasei E-materials Corp. (Japan)

8081 06 **Particle free pellicle mounting inside of the large size photomask inspection system** [8081-41]
M. Yonezawa, S. Matsumoto, D. Zhang, K. Hashimoto, Lasertec Corp. (Japan)

MATERIALS AND PROCESS II

8081 07 **Improvement of polymer type EB resist sensitivity and line edge roughness** [8081-22]
M. Otani, H. Asada, Yamaguchi Univ. (Japan); H. Tsunoda, M. Kunitake, Kumamoto Univ. (Japan); T. Ishizaki, EMF Japan Inc. (Japan); R. Miyagawa, LLC Gluon Lab. (Japan)

8081 08 **22nm node ArF lithography performance improvement by utilizing mask 3D topography: controlled sidewall angle** [8081-45]
H. Watanabe, K. Mesuda, K. Hayano, E. Tsujimoto, H. Takamizawa, Dai Nippon Printing Co., Ltd. (Japan); T. Ohhashi, N. Sakasai, S. Kudo, T. Matsuyama, Nikon Corp. (Japan)

PHOTOMASK WRITING TOOLS AND TECHNOLOGIES

8081 09 **Advancing the charging effect correction with time-dependent discharging model** [8081-40]
N. Nakayamada, T. Kamikubo, H. Anze, S. Tamamushi, NuFlare Technology, Inc. (Japan)

8081 0A **EB resolution capability with CP exposure** [8081-07]
M. Kurokawa, H. Isobe, K. Abe, Y. Oae, A. Yamada, Advantest Corp. (Japan); S. Narukawa, M. Ishikawa, H. Fujita, M. Hoga, N. Hayashi, Dai Nippon Printing Co., Ltd. (Japan)

INSPECTION TOOLS AND TECHNOLOGIES I

8081 0D **Practical mask inspection system with printability and pattern priority verification** [8081-30]
H. Tsuchiya, F. Ozaki, K. Takahara, T. Inoue, N. Kikuiri, NuFlare Technology, Inc. (Japan)

METROLOGY TOOLS AND TECHNOLOGIES I

8081 0G **New CD-SEM metrology method for the side wall angle measurement using multiple detectors** [8081-28]
H. Fukaya, T. Murakawa, S. Shida, M. Kuribara, T. Iwai, J. Matsumoto, T. Nakamura, Advantest Corp. (Japan); H. Hakii, I. Yonekura, M. Kawashita, Y. Nishiyama, K. Tanaka, Y. Kikuchi, Toppan Printing Co., Ltd. (Japan)

LITHOGRAPHY I

8081 0H **MRC optimization for EUV high NA imaging for the 32-nm HP technology node** [8081-05]
S.-E. Tseng, A. Chen, ASML Taiwan, Ltd. (Taiwan)

MDP, EDA, AND DFM

8081 0I **Mask data processing technique using GPU for reducing computer cost** [8081-31]
R. Tsujimura, K. Ogino, H. Hoshino, S. Satoh, Fujitsu Semiconductor Ltd. (Japan); K. Morishita, S. Yoshikawa, Fujitsu VLSI Ltd. (Japan); H. Futatsuya, T. Chijimatsu, S. Asai, S. Yamauchi, T. Okada, N. Ishiwata, M. Miyajima, Fujitsu Semiconductor Ltd. (Japan)

INSPECTION TOOLS AND TECHNOLOGIES II

8081 0K **The coherent EUV scatterometry microscope for actinic mask inspection and metrology** [8081-04]
T. Harada, M. Nakasuji, T. Kimura, Univ. of Hyogo (Japan) and RIKEN (Japan); Y. Nagata, Japan Science and Technology Agency (Japan) and RIKEN (Japan); T. Watanabe, H. Kinoshita, Univ. of Hyogo (Japan) and RIKEN (Japan)

METROLOGY TOOLS AND TECHNOLOGIES II

8081 0L **In-die job automation for PROVE** [8081-32]
R. J. Lesnick, Jr., S. Kim, Synopsys, Inc. (United States); M. Waechter, D. Seidel, A. Mueller, D. Beyer, Carl Zeiss SMS GmbH (Germany)

LITHOGRAPHY II

8081 0N **Collaborative research on emerging technologies and design** [8081-29]
A. R. Neureuther, J. Rubinstein, M. Miller, K. Yamazoe, E. Chin, C. Levy, L. Wang, N. Xu, C. Spanos, K. Qian, K. Poolla, J. Ghan, A. Subramanian, T.-J. King Liu, X. Sun, Univ. of California, Berkeley (United States); K. Jeong, Univ. of California, San Diego (United States); P. Gupta, A. Kaqalwalla, R. Ghaida, T.-B. Chan, Univ. of California, Los Angeles (United States)

8081 0O **Evaluation of process variations on OPC model predictions** [8081-18]
J. Oberschmidt, IBM Microelectronics (United States); S. Barai, IBM Microelectronics (India); T. Desouky, Mentor Graphics Egypt (Egypt); O. P. Jaiswal, IBM Microelectronics (India); A. Padmawar, Indian Institute of Technology Bombay (India); R. M. Pusuluri, IBM Microelectronics (India)

8081 0P **New yield-aware mask strategies** [8081-27]
K. Jeong, A. B. Kahng, Univ. of California, San Diego (United States); C. J. Progler, Photronics, Inc. (United States)

8081 0Q **Defect printability of advanced binary film photomask** [8081-34]
M. Naka, S. Yamaguchi, K. Morishita, S. Kanamitsu, R. Yoshikawa, H. Mashita, T. Hirano, Toshiba Corp. (Japan)

8081 0R **Role of ellipsometry in DPT process characterization and impact of performance for contact holes** [8081-36]
I. Kamohara, Nihon Synopsys G.K. (Japan); V. Domnenko, Synopsys, Inc. (Russian Federation); A. Philippou, Synopsys GmbH (Germany)

MDP

8081 0S **Elimination of lithographic hotspots which have been waived by means of pattern matching** [8081-17]
A. Chaudhary, IBM Corp. (India); P. Bouchard, K. Dave, IBM Corp. (United States); T. Desouky, Mentor Graphics Egypt (Egypt); K. Moamen, M. Simmons, Mentor Graphics Corp. (United States)

8081 0T **Efficient method for SRAF rule determination** [8081-35]
R. M. V. M. Pusuluri, P. Y. Bashaboina, IBM Microelectronics (India); J. M. Oberschmidt, IBM Microelectronics (United States)

8081 0U **Model-based mask data preparation (MB-MDP) for ArF and EUV mask process correction** [8081-23]
K. Hagiwara, D2S, KK (Japan); I. Bork, A. Fujimura, D2S, Inc. (United States)

MASK REPAIR

8081 0V **RegC: a new registration control process for photomasks after pattern generation** [8081-39]
E. Graitzer, G. Ben-Zvi, A. Cohen, D. Vladimir, D. Avizemer, Carl Zeiss SMS Ltd. (Israel)

MASK DEGRADATION

8081 0W **Binary 193nm photomasks aging phenomenon study** [8081-25]
F. Dufaye, STMicroelectronics Crolles (France); L. Sartelli, C. Pogliani, DNP Photomask Europe (Italy); S. Gough, F. Sundermann, STMicroelectronics Crolles (France); H. Miyashita, Y. Hidenori, DNP Photomask Europe (Italy); N. Charras, C. Brochard, N. Thivolle, STMicroelectronics Crolles (France)

8081 0X **193-nm radiation durability study of MoSi binary mask and resulting lithographic performance** [8081-26]
I. Servin, J. Belledent, L. Pain, CEA-LETI MINATEC (France); B. Connolly, Toppan Photomasks, Inc. (Germany); M. Sczyrba, Advanced Mask Technology Ctr. GmbH Co. KG (Germany); M. Lamantia, Toppan Photomasks Inc. (United States)

Author Index

Conference Committees

Symposium Chair

Toshiyuki Horiuchi, Tokyo Denki University (Japan)

Vice Chair

Masato Shibuya, Tokyo Polytechnic University (Japan)

Advisory Committee Chair

Yasuo Tarui, Tokyo University of Agriculture and Technology (Japan)

Members

Masanori Komuro, New Energy and Industrial Technology Development Organization (Japan)
Masatoshi Migitaka, Toyota Technological Institute (Japan)
Masao Otaki, Toppan Printing Company, Ltd. (Japan)
Norio Saito, Nippon Institute of Technology (Japan)
Yoshio Tanaka, Luminescent Technologies Inc. (Japan)

Organizing Committee Chair

Toshiyuki Horiuchi, Tokyo Denki University (Japan)

Vice Chair

Masato Shibuya, Tokyo Polytechnic University (Japan)

Members

Uwe Behringer, UBC Microelectronics (Germany)
Parkson Chen, Taiwan Mask Corporation (Taiwan)
Han-ku Cho, Samsung Electronics Company, Ltd. (Korea, Republic of)
Brian J. Grenon, Grenon Consulting, Inc. (United States)
Hideaki Hamada, HTL Company Japan Ltd. (Japan)
Naoya Hayashi, Dai Nippon Printing Company, Ltd. (Japan)
Morihisa Hoga, Dai Nippon Printing Company, Ltd. (Japan)
Eiichi Hoshino, Nikon Corporation (Japan)
Greg Hughes, International SEMATECH (United States)
Hiroichi Kawahira, Sony Corporation (Japan)
Toshio Konishi, Toppan Printing Company, Ltd. (Japan)
Yuichi Matsuzawa, Toppan Printing Company, Ltd. (Japan)
Warren Montgomery, SEMATECH (United States)
Ichiro Mori, Semiconductor Leading Edge Technologies, Inc. (Japan)

Osamu Nagarekawa, HOYA Corporation (Japan)
Kenichiro Okuda, SEMI Japan (Japan)
Yoshiki Suzuki, KLA-Tencor Japan Ltd. (Japan)
Tadahiro Takigawa, Brion Technologies K.K. (Japan)
Koichiro Tsujita, Canon Inc. (Japan)
Wataru Wakamiya, JEOL Ltd. (Japan)
Anto Yasaka, SII NanoTechnology Inc. (Japan)
Nobuyuki Yoshioka, Renesas Electronics Corporation (Japan)

Steering Committee Chair

Morihisa Hoga, Dai Nippon Printing Company, Ltd. (Japan)

Vice Chairs

Hiroaki Morimoto, Toppan Printing Company, Ltd. (Japan)
Tsuneo Terasawa, Semiconductor Leading Edge Technologies, Inc. (Japan)

Members

Takayuki Abe, NuFlare Technology Inc. (Japan)
Naoya Hayashi, Dai Nippon Printing Company, Ltd. (Japan)
Kunihiro Hosono, Renesas Electronics Corporation (Japan)
Naoyuki Ishiwata, Fujitsu Semiconductor Ltd. (Japan)
Ichiro Kagami, Sony Corporation (Japan)
Kokoro Kato, SII NanoTechnology Inc. (Japan)
Toshio Konishi, Toppan Printing Company, Ltd. (Japan)
Hiroshi Mohri, Dai Nippon Printing Company, Ltd. (Japan)
Takeshi Nakajima, KLA-Tencor Japan Ltd. (Japan)
Masatoshi Oda, NTT Advanced Technology (Japan)
Yasushi Ohkubo, HOYA Corporation (Japan)
Hiroyuki Shigemura, Semiconductor Leading Edge Technologies, Inc. (Japan)
Toshiyuki Takahashi, JEOL Ltd. (Japan)
Kiwamu Takehisa, Lasertec Corporation (Japan)
Hiroyoshi Tanabe, Intel K.K. (Japan)
Hidehiro Watanabe, Toshiba Corporation (Japan)

Program Committee Chair

Toshio Konishi, Toppan Printing Company, Ltd. (Japan)

Vice Chairs

Ichiro Kagami, Sony Corporation (Japan)
Kokoro Kato, SII NanoTechnology Inc. (Japan)
Hiroshi Mohri, Dai Nippon Printing Company, Ltd. (Japan)

Members

Shinji Akima, Toppan Printing Company, Ltd. (Japan)
Akihiko Ando, Renesas Electronics Corporation (Japan)
Jeff Farnsworth, Intel Corporation (United States)
Thomas B. Faure, IBM Corporation (United States)
Shigeru Hirukawa, Nikon Corporation (Japan)
Koji Hosono, Fujitsu Semiconductor Ltd. (Japan)
Gregg Inderhees, KLA-Tencor Corporation (United States)
Curt A. Jackson, Toppan Photomasks, Inc. (United States)
Byung-Gook Kim, Samsung Electronics Company, Ltd. (Korea, Republic of)
Koichi Kuhara, HOYA Corporation (Japan)
John Lin, Taiwan Semiconductor Manufacturing Company, Ltd. (Taiwan)
Mark Ma, Photronics, Inc. (United States)
Koji Murano, Toshiba Corporation (Japan)
Yoshikazu Nagamura, Renesas Electronics Corporation (Japan)
Yoshinori Nagaoka, KLA-Tencor Japan Ltd. (Japan)
Yasutoshi Nakagawa, JEOL Ltd. (Japan)
Noriaki Nakayamada, NuFlare Technology Inc. (Japan)
Nobuyuki Nishiguchi, Semiconductor Technology Academic Research Center (Japan)
Yuji Nonami, Panasonic Corporation (Japan)
Steffen Schulz, Mentor Graphics Corporation (United States)
Yasunari Sohda, Hitachi, Ltd. (Japan)
Osamu Suga, Semiconductor Leading Edge Technologies, Inc. (Japan)
Minoru Sugawara, Sony Corporation (Japan)
Koji Takagi, Applied Materials Japan, Inc. (Japan)
Kiwamu Takehisa, Lasertec Corporation (Japan)
Tatsuya Tomita, Dai Nippon Printing Company, Ltd. (Japan)
Yoichi Usui, HOYA Corporation (Japan)
Kenji Yamazoe, Canon Inc. (Japan)

Session Chairs

Invited Session
Toshio Konishi, Toppan Printing Company, Ltd.
Uwe Behringer, UBC Microelectronics (Germany)

Materials and Process
Thomas B. Faure, IBM Corporation (United States)
Koji Murano, Toshiba Corporation (Japan)

Special Session: FPD Photomasks
Ichiro Kagami, Sony Corporation (Japan)
Toshio Konishi, Toppan Printing Company, Ltd. (Japan)

Writing Technologies
Yasutoshi Nakagawa, JEOL Ltd. (Japan)
Curt A. Jackson, Toppan Photomasks, Inc. (United States)

EUV Masks
Minoru Sugawara, Sony Corporation (Japan)
Kurt Kimmel, SEMATECH (United States)

Inspection Tools and Technologies
Gregg Inderhees, KLA-Tencor Corporation (United States)
Wolf Staud, Applied Materials (United States)

Metrology Tools and Technologies
Yoshinori Nagaoka, KLA-Tencor Japan Ltd. (Japan)
Yasunari Sohda, Hitachi, Ltd. (Japan)

OPC and Mask-related Lithography
Kenji Yamazoe, Canon Inc. (Japan)
Steffen Schulze, Mentor Graphics Corporation (United States)

DFM, EDA, and MDP
Kokoro Kato, SII NanoTechnology Inc. (Japan)
Nobuyuki Nishiguchi, Semiconductor Technology Academic Research Center (Japan)

NIL
Hiroshi Mohri, Dai Nippon Printing Company, Ltd. (Japan)
Akihiko Ando, Renesas Electronics Corporation (Japan)
Byung-Gook Kim, Samsung Electronics Company, Ltd. (Korea, Republic of)

Mask Repair
Hiroshi Mohri, Dai Nippon Printing Company, Ltd. (Japan)
Akihiko Ando, Renesas Electronics Corporation (Japan)
Byung-Gook Kim, Samsung Electronics Company, Ltd. (Korea, Republic of)

Mask Degradation
Hiroshi Mohri, Dai Nippon Printing Company, Ltd. (Japan)
Akihiko Ando, Renesas Electronics Corporation (Japan)
Byung-Gook Kim, Samsung Electronics Company, Ltd. (Korea, Republic of)