2009 International Workshop On EUV Lithography

July 13-17, 2009

Sheraton Waikiki Beach ▪ Honolulu, Hawaii

Workshop Proceedings

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EUV LITHO, INC.

2009 International Workshop on EUV Lithography
Sheraton Waikiki Beach, Honolulu, Hawaii, USA
July 13-17, 2009

Workshop Agenda

(A) Lithography Education Series (July 13-14, 2009)

EUV Lithography
Kona Room, 8:00 AM -5:00 PM, Monday, July 13, 2009

Resist Materials for High Resolution Patterning
Kona Room, 6:00 PM-10:00 PM, Monday, July 13, 2009

EUV Physics
Kona Room, 8:00 AM – 12:00 PM, Tuesday, July 14, 2009

Introduction to Lithography
Kona Room, 1:00 PM – 5:00PM, Tuesday, July 14, 2009

(B) EUVL Workshop (July 14-17, 2009)

Tuesday, July 14, 2009

5:00 PM- 7:00 PM	Reception (Helumoa Playground)
4:00 PM- 6:00 PM	Registration & Speaker Prep (Lanai Room)

Wednesday, July 15, 2009

7:00 AM	–	8:00 AM	Continental Breakfast (Lanai Foyer)
8:00 AM	–	12:00 PM	Oral Presentations (Lanai Room)
12:00 PM	–	1:00 PM	Lunch (Honolulu Suite)
1:00 PM	–	4:30 PM	Oral Presentations (Lanai Room)
5:00 PM	–	6:30 PM	Poster Session and Reception (Honolulu Suite)
7:00 PM			Dinner (Rum Fire)

Thursday, July 16, 2009

7:00 AM	–	8:00 AM	Continental Breakfast (Lanai Foyer)
8:00 AM	–	12:00 PM	Oral Presentations and Panel Discussions (Maui Room)
12:00 PM	–	1:00 PM	Lunch (Honolulu Suite)
1:00 PM	–	4:00 PM	Oral Presentations (Maui Room)
4:00 PM			Adjourn

Friday, July 17, 2009

8:30 AM	– 10:30 AM	Breakfast and Steering Committee Meeting (Honolulu Suite)

WORKSHOP PROCEEDINGS

2009 International Workshop on EUV Lithography

Sheraton Waikiki Beach, Honolulu, Hawaii, USA
July 13-17, 2009

Wednesday, July 15, 2009

8:00 AM Welcome and Introduction

Vivek Bakshi
EUV Litho, Inc.

8:10 AM Session 1: Keynote Presentations

Session Chair: David Attwood (LBNL/ UC Berkeley)

R&D Status and Key Technical and Implementation Challenges for EUV HVM (KEY-1)
Sam Sivakumar
Intel Corporation

Readiness and Challenges in EUV Mask Technology for 32nm-HP Node and Beyond (KEY-2)
Han-Ku Cho and Seong-Sue Kim
Semiconductor R&D Center, Samsung Electronics Co., LTD.

9:10 AM Award Ceremony

9:10 AM Session 2: EUV Source Technology

Session Co-Chairs: Ndaona Chokani (ETHZ) and Padraig Dunne (UCD)

High Brightness Next Generation EUV Lithography Light Source (Source-1, Invited)

Peter CHOI [1,2], Sergey V. ZAKHAROV [2+], Raul ALIAGA-ROSSEL [1], Aldrice BAKOUBOULA [1], Otman BENALI [1,2], Philippe BOVE [1], Michèle CAU [1], Grainne DUFFY [1], Sebastian FANT [2], Blair LEBERT [2], Ouassima SARROUKH [2], Edmund WYNDHAM [3], Clement ZAEPFFEL [2], Vasily S. ZAKHAROV [2*]

[1] *NANO-UV sas, 16-18 av du Québec, SILIC 705, Villebon/Yvette 91140, France*

[2] *EPPRA sas, 16 av du Québec, SILIC 706, Villebon/Yvette 91140, France*

[3] *Pontificia Universidad Catolica de Chile, Santiago, Chile*

[+] *RRC Kurchatov Institute, Moscow, Russia*

[*] *KIAM RAS, Moscow, Russia*

Determination of Charge State, Energy and Angular Distribution of tin Ions Emitted from LPP EUV Sources (Source-2)

Oran Morris, Aodh O'Connor, Emma Sokell and Padraig Dunne

School of Physics, University College Dublin, Belfield, Dublin 4, Ireland

Molecular Dynamics Investigation on Tin (Source-7)

M. Masnavi, M. Nakajima and K. Horioka

Department of Energy Sciences, Tokyo Institute of Technology, Nagatsuta, Midori-ku, Yokohama 226-8502, Japan

Fiber Lasers for EUV Lithography (Source-6, Invited)

Almantas Galvanauskas, Kai-Chung Hou*, Cheng Zhu, P. Amaya+,

University of Michigan, Ann Arbor, MI, USA,

** Currently with Cymer, Inc.,*

+Arbor Photonics, Inc.

LPP EUV Source Development at ETHZ (Source-4)

B. Rollinger, A. Giovannini, D. Bleiner, N. Chokani, and R. S. Abhari

Laboratory for Energy Conversion, ETH Zurich, Sonneggstrasse 3, 8092 Zurich, Switzerland

High Power EUV Sources: Technology Status (Source-5)

Vivek Bakshi

EUVL Litho, Inc., Austin, TX 78748, USA

10:50 AM Break (15 minutes)

11:05 AM Session 3: EUV Optics

Session Chair: Patrick Naulleau (LBNL)

Multilayer Optics for Next-generation EUVL Systems (OP-1, Invited)
Regina Soufli
Lawrence Livermore National Laboratory, Livermore, CA 94550, USA

Use of Free Form Optical Surfaces for EUVL Projection *(OP-2, Invited)*
R. Hudyma and Mike Thomas
Hyperion Development LLC, 358 South Overlook Dr., San Ramon, CA 94582, USA

Technology Readiness for HVM Source Collector (OP-3)
Roland Geyl, Renaud Mercier Ythier
Sagem, Avenue de la Tour Maury, 911280 Saint Pierre du Perray FRANCE

12:00 PM Lunch (Honolulu Suite)

1:00 PM Session 4: METROLOGY

Session Co-Chairs: Regina Soufli (LLNL) and Charles Tario (NIST)

High Accuracy EUV Reflectometry and Scattering at the Advanced Light Source (MET-8, Invited)
Eric M. Gullikson
Center for X-Ray Optics, Lawrence Berkeley National Laboratory, One Cyclotron Road, Berkeley, CA 94720

At-wavelength EUV metrology at NIST (MET-4)
C. Tarrio, S. Grantham, R. E. Vest, P-S. Shaw T. B. Lucatorto
National Institute of Standards and Technology, *100 Bureau Drive, Gaithersburg, MD*

EUV Reflectometry for Determining the Optical Properties of Photoresists and Underlayer Materials upon Irradiation at 13.5 nm (MET-7)
Grace H. Ho,[1] Fu-H. Kang,[1] Yu-H. Shih,[1] Hok-S. Fung,[2] Hwang-W. Fu,[2] Rikimaru Sakamoto,[3] Takafumi Endo,[3] Bang-C. Ho,[3] Yang-T. Huang,[4] and Bor-Y. Shew[2]
[1]*Department of Applied Chemistry, National University of Kaohsiung, Nanzih, Kaohsiung 811, Taiwan*
[2]*National Synchrotron Radiation Research Center, Hsinchu 311, Taiwan.*
[3]*Electronic Materials Research Laboratories, Nissan Chemical Industries, Ltd., Tayama 937-2792, Japan*
[4]*Department of Electronics Engineering, National Chiao Tung University, Hsinchu300, Taiwan*

Hydrothermal method grown ZnO crystal as a fast EUV scintillator and EUV laser imaging device (MET-1, Invited)
T. Shimizu[a,d], K. Yamamoi[a], E. Estacio[a], T. Nakazato[a,d], N. Sarukura[a,d],Y. Kagamitani[b], D. Ehrentraut[b], T. Fukuda[b,c],
[a] *Institute of Laser Engineering, Osaka Univ., 2-6 Yamadaoka, Suita, Osaka 565-0871, Japan*
[b] *Institute of Multidisciplinary Research for Advanced Materials, Tohoku Univ.*
[c] *WPI Advanced Institute for Materials Research Tohoku University*

Development of X-ray Tool for Critical-Dimension Metrology (MET-2)
Boris Yokhin[1 *], Alexander Krokhmal[1], Alexander Dikopoltsev[1], David Berman[1], Isaac Mazor[1], Byoung-Ho Lee[2], Dong-Chul Ihm[2] and Kwang Hoon Kim[2]
[1]*Jordan Valley Semiconductors Ltd., Ramat Gabriel Ind. Zone, Migdal Haemek, Israel, 23100*
[2]*Samsung Electronics, San#16 Banwol-dong, Hwasung-City, Gyeonggi-Do, Korea 445-701*

Development of ultra-fine structure metrology system using coherent EUV source (MET-5)
Hiroo Kinoshita[1,3], Nagata Yutaka[2,3], Tetsuo Harada[1,3], and Takeo Watanabe[1,3]
[1]*LASTI, University of Hyogo, 3-1-2, Koto, Kamigori, Ako, Hyogo, Japan 678-1205*
[2]*RIKEN Wakou*
[3] *JST CREST*

2:40 PM Break (20 Minutes)

3:00 PM Session 4: Contamination

Session Co-chairs: David Ruzic (UIUC) and Grace Ho (NUK)

An Investigation of Debris Production by Various EUV Sources (CONT-1, Invited)
D.N. Ruzic, J. Sporre, V. Surla, M.J. Neumann
Center for Plasma Material Interactions, Department of Nuclear Plasma and Radiological Engineering, University of Illinois at Urbana-Champaign, IL, USA

Modification of Ru Surfaces during Simultaneous Irradiation of Thermalized and Energetic Sn particles at Grazing Incidence (CONT-2, Invited)
V. Rigato
INFN Laboratori Nazionali di Legnaro, Italy

Predicting optics carbonization from a knowledge of resist outgas composition (CONT-3)
C. Tarrio,[1] S. B. Hill,[1] N. Faradzhev,[2] R. E. Vest,[1] R. Garg,[3] T. B. Lucatorto[1]
[1]*National Institute of Standards and Technology*
[2]*Rutgers University*
[3]*University at Albany*

Absolute Total Ion Yield and the Relative Extent of Ionic Outgassing of Photoresists and Underlayer Materials upon Irradiation at 13.5 nm (CONT-4)
Grace H. Ho, Yu-H. Shih, and Fu-H. Kang
Department of Applied Chemistry, National University of Kaohsiung, Nanzih, Kaohsiung 811, Taiwan

EUV Mask and Optics Contamination (CONT-5)
G. Denbeaux, Leonid Yankulin,Yu-Jen Fan, R. Garg, Chimaobi Mbanaso, Petros Thomas, Alin Antohe
College of Nanoscale Science and Engineering, University at Albany, NY, USA

4:30 PM BREAK (30 Minutes)

5:00 PM – 6:30 PM Poster Session and Reception

5:00 PM Session 5: Poster Session

Session Chair: Ken Goldberg (LBNL)

1-D Plasma Modeling with Radiation Transport (Source-3)
J. White, A. Cummings, P. Dunne, and G. O'Sullivan,
School of Physics, University College Dublin, Ireland

Tabletop Synchrotron for Actinic Defect Inspection of EUVL Mask (Source-9)
H. Yamada, Y. Shimura, D. Minkov, S. Narita and K. Igarashi
Ritsumeikan University, Kusatsu, Shiga Prefecture, Japan

Resist Transmission Measurement using EUV Light (MET-3)
Takeo Watanabe, Yasuyuki Fukushima, Tetsuo Harada, and Hiroo Kinoshita
Laboratory of advanced Science and Technology for Industry, University of Hyogo, Hyogo 678-1205, Japan

A Compact and Ultrahigh-vacuum Reflectometer for EUV Applications (MET-6)
Hwang-W. Fu,[1] Grace H. Ho,[2] Liang-J. Huang,[1] Chia-F. Chang,[1] Shang-W. Lin,[1] Shiang-W. Luo,[1] Fu-H. Kang,[2] Yuh-H. Shih,[2] Hok-S. Fung,[1] and Bor-Y. Shew[1]
[1]National Synchrotron Radiation Research Center, Hsinchu 311, Taiwan.
[2]Department of Applied Chemistry, National University of Kaohsiung, Nanzih, Kaohsiung 811, Taiwan

An Investigation of the Impact of Mask Shadowing Effect on Flare in Extreme Ultraviolet Lithography (MASK-1)
Jun-Hwan Lee, O-Hyun Kim
Department of Electronic and Electrical Engineering,
Pohang University of Science and Technology, South Korea

Development of Mask Contamination / Inspection System for EUV Lithography (MASK-2)
Sangsul Lee[1 2], Chang Young Jeong[1], Dong Geun Lee[3], Seong-Sue Kim[3], Han-Ku Cho[3], Seung-yu Rah[4], Ohyun Kim[5], Moonsuk Yi[6] and Jinho Ahn[1]
[1] Department of Materials Science and Engineering, Hanyang University
[2]Information Display Research Institute, Hanyang University
[3] Photomask Team, Memory Division, Semiconductor Business, Samsung Electronics Co., LTD
[4] Pohang Accelerator Laboratory
[5] Department of Electrical Engineering, Pohang University of Science and Technology
[6] School of Electrical and Computer Engineering, Pusan National University

Optimizing Structure of Attenuated Phase Shift Mask for Minimizing Shadowing Effect (MASK-7)

Hyun-Duck Shin[1], Chang Young Jeong[2], Sangsul Lee[2], Tae Geun Kim[2], and Jinho Ahn[2]

[1]*Department of Nanoscale Semiconductor Engineering, Hanyang University, Korea*

[2]*Department of Material Science and Engineering, Hanyang University, Korea*

Line Width Roughness Investigation through Resist Molecular Structure in Extreme Ultra-violet Lithography (Resist-3)

Hyunsu Kim[1], In Wook Cho[2], Hakjin Jang[3], Mihwa Kang[3], Seong Wook Kim[3] and Hye-Keun Oh[2]

[1.] *Department of Bio-Nanotechnology, HanyangUniversity, Ansan, 426-791, Korea*

[2.] *Department of Applied Physics, HanyangUniversity, Ansan, 426-791, Korea*

[3.] *Department of Applied Mathematics, HanyangUniversity, Ansan, 426-791, Korea*

Dependence of Acid Yield on Polymer Structure in EUV Chemically Amplified Resist (RESIST-5)

Hiroki Yamamoto[1], Takahiro Kozawa[1], Seiichi Tagawa[1],Takeshi Iwai[2], and Junichi Onodera[2]

[1]*The Institute of Scientific and Industrial Research, Osaka University (ISIR), Japan*

[2]*Tokyo Ohka Kogyo Co., Ltd. (TOK), Japan*

7:00 PM **Dinner (Rum Fire)**

Thursday, July 16, 2009

8:00 AM Welcome Day-2 Agenda
Vivek Bakshi
EUV Litho, Inc.

8:05 AM Poster Session Awards, Ken Goldberg, LBNL

8:10 AM Session 7: Panel Discussion
Panel Discussion Moderator: David Attwood (LBNL)

Topic: EUVL R&D Status

Panelists:

US EUVL R&D Status (R&D-1)
Greg Denbeaux – USA
University of Albany, NY

EUVL Development Projects in Japan (R&D-2)
Hiroo Kinoshita –Japan
Hyogo University, Japan

The European Perspective: EUVL R&D Status (R&D-3)
Padraig Dunne – Europe
University College, Dublin, Ireland

An Overview of EUVL Related R&D in Taiwan (R&D-4)
Grace Ho – Taiwan
National University of Kaohsiung, Taiwan

EUVL R&D Status of Korea (R&D-5)
Jinho Ahn – Korea
Hanyang University, Korea

9:00 AM Session 8: EUV Mask

Session Co-Chairs: Hiroo Kinoshita (Hyogo University) and Jinho Ahn (Hanyang University)

Optimizing the Mask Structure for Extreme Ultraviolet Lithography (MASK-6, Invited)
Chang Young Jeong, Sangsul Lee, Hyun-Duck Shin, Tae Geun Kim, and Jinho Ahn
Department of Materials Science and Engineering, Hanyang University, 17 Haengdang-Dong, Seoul, 133-791, Korea

Wavelength-Specific Reflections: A Decade of EUV Mask Inspection Research (MASK-4, Invited)
Kenneth A. Goldberg[1], Iacopo Mochi[1], Sungmin Huh[2]
[1]*Lawrence Berkeley National Laboratory*
[2]*SEMATECH*

Study of Critical Dimensions of Printable Phase Defects Using an Extreme Ultraviolet microscope (MASK-3, Invited)
Hiroo Kinoshita[1, 3] Yoshito Kamaji[1, 3], Kei Takase[1, 3], Takashi Sugiyama[2], Toshiyuki Uno[2] Tetsuo Harada[1] and Takeo Watanabe[1, 3]
[1]*Laboratory of Advanced Science and Technology for Industry, University of Hyogokamigori, Ako-gun, Hyogo 678-1205, Japan*
[2]*Asahi Glass Co., Ltd., R&D Center, Yokohama 221-8755, Japan*
[3]*JST, CREST, Yonban, Chiyoda, Tokyo 102-0081, Japan*

Zoneplate lenses for EUV microscopy (MASK-5)
Iacopo Mochi[1], Kenneth A. Goldberg[1], Erik H. Anderson[1], Sungmin Huh[2]
[1] *Lawrence Berkeley National Laboratory*
[2] *SEMATECH*

10: 15 AM Break (15 Minutes)

10:30 AM Session 9: Panel Discussion

Panel Discussion Moderator: Vivek Bakshi (EUV Litho, Inc.)

Topic: Actinic Defect Inspection Technology for EUVL Masks

Introduction: Actinic Mask Defect Inspection: Are EUV Sources Available? (Mask Panel-1)
Vivek Bakshi
EUV Litho, Inc.

Panelists:

Requirements of EUV Light Source for Actinic Mask Inspection (Mask Panel-2)
Takeo Watanabe and Hiroo Kinoshita
Hyogo University

EQ-10 EUV Source for Actinic Inspection (Mask Panel-3)
Debbie Gustafson
Energetiq

High Brightness EUV Light Source for Metrology (Mask Panel-4)
Sergey Zakharov
Nano UV

Compact Optical Undulator Technology for a High Brightness EUV Lithography Source (Mask Panel-5)
John M. J. Madey, Eric B. Szarmes,Mike Hadmack, Bryce Jacobson, and Shidong Kan
Department of Physics and Astronomy, University of Hawai'i at Manoa

Tabletop Synchrotron for Actinic Defect Inspection of EUVL Mask (Mask Panel-6)
H. Yamada, Y. Shimura, D. Minkov, S. Narita and K. Igarashi
Ritsumeikan University, Kusatsu, Shiga Prefecture, Japan
&
Photon Production Lab. Ltd.

Actinic Mask Defect Inspection: EUV Source Technology Status (Mask Panel-7)
Vivek Bakshi
EUV Litho, Inc.

12:00 PM – 1:00 PM Lunch

1:00 PM Session 10: EUV Resist

Session Co-Chairs: Takahiro Kozawa (Osaka University) and Chris Mack (Lithoguru.com)

Development Status and Future Prospect of Extreme Ultraviolet Resists (Resist -9, Invited)
Takahiro Kozawa
The Institute of Scientific and Industrial Research, Osaka University (ISIR), Japan

Improvement of EUV Resist Materials (Resist-1, Invited)
Jeongsik KIM, Jungyoul LEE, Jae-Woo LEE, Deog- Bae KIM, Jaehyun KIM
Dongjin Semichem CO., Ltd, 625-3 Yodang-Ri, Yanggam-Myun, Hwasung-Si, Gyeonggi-Do, 445-931 KOREA

Molecular Resist Materials for Next Generation Lithography: A Rich Diversity of Possibilities (Resist-11, Invited)
Clifford L. Henderson[1], Richard A. Lawson[1], Laren M. Tolbert[2]
[1] *School of Chemical & Biomolecular Engineering, Georgia Institute of Technology, Atlanta, GA 30332-0100, USA*
[2] *School of Chemistry and Biochemistry, Georgia Institute of Technology, Atlanta, GA 30332, USA*

EUV Interference Lithography (Resist-10, Invited)
Harun H. Solak[1,2], V. Auzelyte[1], A. Langner[1], S. S. Sarkar[1], A. Weber[1], H. Pruchova[1], M. Kropf[1], C. David[1], J. Gobrecht[1]
[1] *Paul Scherrer Institut, Lab for Micro and Nanotechnology, Villigen 5232, Switzerland*
[2] *EULITHA AG, 5232 Villigen PSI, Switzerland*

EUV Interference Lithography in New SUBARU (Resist-6)
Takeo Watanabe[1], Tae Geun Kim[1, 2], Tetsuo Harada[1], Yasuyuki Fukushima[1], and Hiroo Kinoshita[1]
[1] Laboratory of advanced Science and Technology for Industry, University of Hyogo, Hyogo 678-1205, Japan
[2] Division of Advanced Materials Science and Engineering, Hanyang University, Seoul 133-791, Korea

Monte Carlo Simulation of Chemical Intermediates in CARs (Resist-4)
A. Saeki, T. Kozawa, and S. Tagawa
The Institute of Scientific and Industrial Research, Osaka University, 8-1 Mihogaoka, Ibaraki, Osaka 567-0047, Japan

2:50 PM Break (15 minutes)

3:05 PM Session 11: LER

Session Chair: Cliff Henderson (Georgia Tech)

Stochastic Approach to Modeling Line Edge Roughness in Photolithography (Resist-8, Invited)
Chris Mack
Lithoguru.com, 1605 Watchhill Rd., Austin, TX 78703

How Will Wafer Plane Line-edge Roughness Requirements Impact Mask Specifications? (Resist-7, Invited)
Patrick P. Naulleau and Simi A. George
Center for X-Ray Optics, Lawrence Berkeley National Laboratory, Berkeley, CA 94720

Sub-22 nm Line and Space patterning using Resist Reflow Process for Extreme Ultra-Violet Lithography (Resist-2)
In Wook Cho, Hyunsu Kim, Jee-Hye You, Hye-Keun Oh
Lithography Laboratory, Department of Applied Physics, Hanyang University, Ansan, 426-791, S. Korea

4:00 PM WORKSHOP SUMMARY
Vivek Bakshi
EUV Litho Inc.

4:10 PM Adjourn