

2014 International Workshop on EUV Lithography

June 23-27, 2014

Makena Beach & Golf Resort ▪ Maui, Hawaii

Workshop Proceedings



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Makena Beach & Golf Resort, Maui, Hawaii, USA

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Workshop Sponsors



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Wednesday, June 25, 2014

8:30 AM Welcome and Introduction

Introductions (Intro-1)

Vivek Bakshi
EUV Litho, Inc., Austin, TX, USA

Session 1: Keynote – 1

EUV: The Computational Landscape (P1)

Vivek Singh
Intel Corporation, MS: RA3-254, 2501 N.W. 229th Ave, Hillsboro, OR 97124

One hundred Watt Operation Demonstration of HVM LPP-EUV Source (P2)

Hakaru Mizoguchi, Hiroaki Nakarai, Tamotsu Abe, Takeshi Ohta, Krzysztof M Nowak, Yasufumi Kawasuji, Hiroshi Tanaka, Yukio Watanabe, Tsukasa Hori, Takeshi Kodama, Yutaka Shiraishi, Tatsuya Yanagida, Georg Soumagne, Tsuyoshi Yamada, Taku Yamazaki, Shinji Okazaki and Takashi Saitou
Gigaphoton Inc. Hiratsuka facility: 3-25-1 Shinomiya Hiratsuka Kanagawa, 254-8567, JAPAN

Break

Session 2: EUV Sources

Development of Scalable Laser Technology for EUVL applications (Invited Talk) (P21)

Tomas Mocek, Akira Endo, Taisuke Miura
HiLASE Project, Institute of Physics ASCR, Prague, Czech Republic

Gain Enhancements of CO₂ Laser Amplifiers by Using Transverse-gas-flow Configuration to Boost up Driving Powers for EUV Generation (Invited Talk) (P24)

Koji Yasui¹ and Jun-ichi Nishimae²
¹*Mitsubishi Electric Corporation, Head quarter, Tokyo, Japan*
²*Mitsubishi Electric Corporation, Advanced technology R&D center, Hyogo, Japan*

Colliding Laser-Produced Plasmas as Targets for Laser-Generated EUV Sources (P25)

T. Cummins¹, C. O'Gorman¹, P. Dunne¹, E. Sokell¹, G. O'Sullivan¹ and P. Hayden^{1,2}.
1)*School of Physics, University College Dublin, Belfield, Dublin 4, Ireland.*
2)*National Centre for Plasma Science and Technology, Dublin City University, Glasnevin, Dublin 9, Ireland*

In-Situ Cleaning of Sn EUV Sources (Invited Talk) (P42)

David N. Ruzic, Daniel Elg, Ivan Shchelkanov
Center for Plasma-Material Interactions; Department of Nuclear, Plasma and Radiological Engineering, University of Illinois at Urbana-Champaign, Illinois, USA

EUV Source: Progress & Challenges (Invited Talk) (P27)

Klaus Schuegraf and Nigel Farrar et al
Cymer, San Diego, CA, USA

12:00 PM – 1:00 PM

Lunch

Session 3: EUVL Regional Reviews

[Korea \(Jinho Ahn\) \(P31\)](#)

[Europe \(Tomas Mocek\) \(P32\)](#)

[Taiwan \(Kuen-Yu Tsai\) \(P33\)](#)

[Japan \(Hiroo Kinoshita\) \(P34\)](#)

[USA \(Greg Denbeaux\) \(P35\)](#)

[China \(Yanqui Li\) \(P36\)](#)

Break

Session 4: EUV Optics

[Progress of Optical Design for EUV Lithography tools in BIT \(Invited talk\) \(P56\)](#)

Yanqiu Li, Fei Liu, Qiuli Mei, Zhen Cao, Yan Liu
Key Laboratory of Photoelectron Imaging Technology and System (Ministry of Education of China), School of Optoelectronics, Beijing Institute of Technology, Beijing 10081, P.R. China

CNC Fabrication of High NA Aspheric Optics for EUVL Applications (P53)

Phil Baker, Richard Pultar, Dr. Riley Aumiller
HNu Photonics, LLC, 350Hoohana St, Kahului HI 96732

Error Compensation Phase Extraction Algorithm Used in Phase Shifting Point Diffraction Interferometer (P52)

Jie Yu, Haitao Zhang, Dongmei Ma, Chunshui Jin
State Key Laboratory of Applied Optics, Changchun Institute of Optics, Fine Mechanics & Physics, Chinese Academy of Sciences, No. 3888, Dongnanhu Road, Changchun, Jilin, People's Republic of China

[Large Reflectometer for EUV Optics \(P55\)](#)

Hiroo Kinoshita^{1,2}, Tetsuo Harada^{1,2}, Takeo Watanabe^{1,2}

¹⁾ *Center for EUV Lithography, University of Hyogo, Kamigori, Hyogo 678-1205, Japan*

²⁾ *JST, CREST, Kawaguchi, Saitama 331-0012, Japan*

Progress with EUV optics deposition at RIT (Invited Talk) (P57)

Yuriy Platonov, Michael Kriese, Vladimir Martynov, Raymond Crucet, Yang Li, Jim Rodriguez, Licai Jiang, Gary Fournier, Jerry Hummel
Rigaku Innovative Technologies, 1900 Taylor Rd., Auburn Hills, MI 48326, USA

Adjourn: Time off for Networking

End Day 1

Day 2: Thursday, June 26, 2014

[Welcome and Announcements \(Intro-2\)](#)

Vivek Bakshi
EUV Litho, Inc.

Session 5: Keynote-2

[Current status and expectation of EUV lithography \(P3\)](#)

Takayuki UCHIYAMA
Lithography Process Development Department, Center for Semiconductor Research and Development, TOSHIBA Corporation

Break

Session 6: EUV Masks

[A New EUV Mask Blank Defect Inspection Method with Coherent Diffraction Imaging \(Invited Talk\) \(P63\)](#)

Ding Qi^a, Kuen-Yu Tsai^a and Jia-han Li^b
^a *Department of Electrical Engineering, National Taiwan University, Taipei 106, Taiwan*
^b *Department of Engineering Science and Ocean Engineering, National Taiwan University, Taipei 106, Taiwan*

[Recent Results from the Measurement of Reflectivity of EUV Lithography Masks Blanks and Absorbers \(Invited Talk\) \(P64\)](#)

Rupert C. C. Perera
EUV Tech, 2840 Howe Road Suite A, Martinez, CA 94553, USA

[Improved Stochastic Imaging Properties in Contact Hole Pattern by Using Attenuated PSM for EUVL \(P65\)](#)

Jung Sik Kim¹, Seongchul Hong², Jae Uk Lee², Seung Min Lee², Jung Hwan Kim², Hyun Min Song¹, and Jinho Ahn^{1,2}
¹*Department of Nanoscale Semiconductor Engineering*
²*Department of Materials Science and Engineering*
Hanyang University, 222 Wangsimni-ro, Seongdong-gu, Seoul 133-791, Korea

[Advanced Mask Patterning: Inspection/Metrology and Cleans Requirements & Approaches \(P68\)](#)

Sushil Padiyar et al
AMAT

Overview of Actinic Mask Inspection System in NewSUBARU (Invited Talk) (P67)

Hiroo Kinoshita^{1,3}, Tetsuo Harada^{1,3}, Yutaka Nagata^{2,3}, Takeo Watanabe^{1,3} and Katsumi Midorikawa²

¹⁾ *Center for EUV Lithography, University of Hyogo, Kamigori, Hyogo 678-1205, Japan*

²⁾ *Riken ASI, Wako, Saitama 351-0198, Japan*

³⁾ *JST, CREST, Kawaguchi, Saitama 331-0012, Japan*

Lunch

Session 7: EUV Resists

Theoretical Study on Stochastic Effects in Chemically Amplified Resist Process for Extreme Ultraviolet Lithography (Invited Talk) (P71)

Takahiro Kozawa¹, Julius Joseph Santillan², and Toshiro Itani²

¹*The Institute of Scientific and Industrial Research, Osaka University, 8-1 Mihogaoka, Ibaraki, Osaka 567-0047, Japan*

²*EUVL Infrastructure Development Center, Inc. (EIDEC)*

Direct Visualization of the Impacts of EUV Mask Roughness (Invited Talk) (P72)

Patrick Naulleau

LBNL, Berkeley, CA, USA

Novel EUV Resist Materials and EUV Resist Defects (Invited Talk) (P74)

Yoshi Hishiro

JSR Micro INC, 1280 N. Mathilda Ave, Sunnyvale, CA 94089, USA

The Role of Secondary Electrons in EUV Resist (Invited Talk) (P75)

Greg Denbeaux et al

University of Albany, Albany, NY, USA

Optics Contamination from Resist Outgassing: Lessons Learned (Invited Talk) (P41)

C. Tarrio, S. B. Hill, R. F. Berg, S. Grantham, and T. B. Lucatorto

National Institute of Standards and Technology, Gaithersburg, MD, USA

Break

Session 8: Panel Discussion

Topic: Can EUVL deliver patterning solutions for 7nm node?

Moderator: Vivek Bakshi, EUV Litho, Inc.

[Questions for the Panel \(P10\)](#)

Vivek Bakshi
EUV Litho, Inc.

Panelists

[Gigaphoton Response \(P12\)](#)

Hakaru Mizoguchi
Gigaphoton

[Toshiba Response \(P13\)](#)

Takayuki UCHIYAMA
Toshiba

[AMAT Response \(P14\)](#)

Sushil Padiyar
AMAT

Cymer Response (P15)

Nigel Farrar
Cymer

[EUVL Workshop Summary \(2014 EUVL Workshop Summary\)](#)

Vivek Bakshi
EUV Litho, Inc.

Break

4:30- 5:30 PM Poster Session

Session 9: Poster Session

Modulation of the Langmuir Oscillation on the plasma radiation by Rabi oscillation (P22)

Xiangdong Li

State Key Laboratory of High Field Laser Physics, Shanghai Institute of Optics and Fine Mechanics, Shanghai (201800), People's Republic of China

EUV Radiation Characteristics of Xe Cluster Ensemble Irradiated by Nanosecond and Femtosecond Lasers (P23)

Cheng Wang, Zongxin Zhang, Guande Wang, Yuxin Leng, Quanzhong Zhao, Ruxin Li
State Key Laboratory of High Field Laser Physics, Shanghai Institute of Optics and Fine Mechanics, Chinese Academy of Sciences (CAS), Shanghai 201800, China

The Energetiq EQ-10 EUV Source for Metrology (P26)

Stephen F. Horne, Matthew J. Partlow, Deborah S. Gustafson, Matthew M. Besen, Donald K. Smith, Paul A. Blackborow
Energetiq Technology Inc., 7 Constitution Way, Woburn MA 01801 USA

A Novel Model for Coated System Analysis in Extreme Ultra-Violet Lithography (P51)

Wang Jun

State Key Laboratory of Applied Optics, Changchun Institute of Optics, Fine Mechanics and Physics, Chinese Academy of Sciences, 3888# Dong Nanhu Road, Changchun, Jilin, 130033, China

Comparison of High Precision Profilometry to Lateral Shearing Interferometry Collected from High NA Aspheric Surfaces with Materials from SIC, Aluminum, ULE and Zerodur (P54)

Richard Pultar, Phil Baker, Dr. Riley Aumiller
HNU Photonics, LLC, 350 Hoohana St, Kahului HI 96732, USA

Simplified Model for Spectrum Simulation of Multilayer with Buried Defect in EUV Lithography (P61)

Xiangzhao Wang, Sikun Li, Xiaolei Liu

Laboratory of Information Optics and Opt-Electronic Technology, Shanghai Institute of Optics and Fine Mechanics, Chinese Academy of Sciences, Shanghai 201800, China

EUV Ablation Experiments with Gas-puff and Capillary Discharge Sources (P28)

L. Pina², C. Liberatore^{1,2}, A. Bartnik³, K. Mann⁴, A. Endo¹, T. Mocek¹, L. Juha¹

¹Institute of Physics ASCR, Prague, Czech Republic

²Czech Technical University, Prague, Czech Republic

³Institute of Optics and Electronics, Warsaw, Poland

⁴Laser Laboratorium Göttingen (LLG), Göttingen, Germany

Measurement of Deflection of the Full scale Free Standing EUV Pellicle (P62)

Eun-Sang Park, Zahid Hussain Shamsi, Ji-Won Kim, Dai-Gyoung Kim, and
Hye-Keun Oh

Hanyang University, 222 Wangsimni-ro, Seongdong-gu, Seoul 133-791, Korea

