2016 International Workshop on EUV Lithography

June 13-16, 2016

CXRO, LBNL ▪ Berkeley, CA

Workshop Agenda

2016 International Workshop on EUV Lithography
(EUVL Workshop)

June 13-16, 2016, The Center for X-Ray Optics (CXRO),
Lawrence Berkeley National Laboratory, Berkeley, CA

2016 International Workshop on EUV Lithography

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Organized by

EUREKA

Vivek Bakshi (EUV Litho, Inc.), Chair

Patrick Naulleau (CXRO), Co-Chair

2016 International Workshop on EUV Lithography

CXRO, LBNL, Berkeley, CA, USA

June 13-16, 2016

Workshop Agenda Outline

Monday, June 13, 2016

EUVL Short Course: 8:30 AM to 5 PM
Building name: Building 66
Room Number: 66-316
Coffee served during AM and PM breaks. Shuttle from Building 66 to Café for lunch.

Tuesday, June 14, 2016

CXRO Tour: 3 PM to 5:00 PM
Building name: CXRO (4th Floor lobby)
Meet in the lobby at 3 PM (Tour Guide: Patrick Naulleau)

Registration, Speaker prep and Reception: 5:00 PM - 6:30 PM
Building name: Building 54 (Also known as Bay View Cafeteria – name not shown on the building)
Room Number: Main Hall

Wednesday, June 15, 2016

Building name: Building 66
Room Number: Auditorium (317). Building entrance is from the second floor. Stairs are directly to the left after entering the building.

Continental Breakfast and Registration: 7:30 AM – 8:30 AM
Workshop Presentations: 8:30 AM – 4:30 PM

Continental Breakfast, morning registration and coffee during breaks will be served outside the auditorium. Seating also available next door in room # 316.

Group will walk together for Lunch to patio of Building 67. We also have inside room (67-3111, Chemla room) reserved for those who will prefer to eat inside.

4:30 PM: Adjourn for the day for Networking
(Option of a shuttle for area tour will be provided. Details to be announced.)

Thursday, June 16, 2016

Building name: Building 66 (317)

Continental Breakfast: 7:30 AM – 8:30 AM

Workshop Presentations: 8:30 AM – 5:10 PM

Lunch: 12:00 PM – 1:30 PM

EUVL Workshop Steering Committee Meeting (Closed working lunch meeting) 11:20 AM to 12:50 PM
Building name: Building 66
Room Number: 66-316 (Located next door to the main auditorium #317)

Poster Session and Reception: 5:50 PM to 7:00 PM
Building name: Building 54
(Bay View Cafeteria. *Shuttle will be provided to take attendees from the auditorium to the poster session location.)*

Depart for Dinner: 7:15 PM (from Poster Session Location)
Dinner Location: Hotel Claremont (off-site, Berkeley, CA)
Shuttle will be available for pickup and drop-off for off-site dinner

Workshop Adjourned: 9:30 PM

Shuttle Bus Services and Parking Information

Updated information is available on the website www.euvlitho.com

2016 International Workshop on EUV Lithography

CXRO, LBNL, Berkeley, CA, USA
June 13-16, 2016

Workshop Agenda

Monday, June 13, 2016

Short Courses

EUV Lithography
by Vivek Bakshi (EUV Litho, Inc.), Patrick Naulleau (LBNL) and Jinho Ahn (Hanyang University)

8:30 AM -5:00 PM (Building 66 – Room 316)

Tuesday, June 14, 2016

Registration and Reception

3:30 PM- 5:00 PM	CXRO Tour (Building # 2, Fourth floor)
5:00 PM- 6:30 PM	Registration, reception & Speaker Prep (Building 54, Bay View Cafeteria)

Wednesday, June 15, 2016

8:30 AM Welcome and Introduction

Welcome to LBL
Mike Witherell, Director, LBL

Introduction to Agenda (Intro-1)
Vivek Bakshi
EUV Litho, Inc., Austin, TX, USA

Session 1: Keynote – 1

Session Chair: Patrick Naulleau (CXRO)

EUV Lithography's Present and Future (P1)
Harry J. Levinson
GLOBALFOUNDRIES

EUVL Readiness for High Volume Manufacturing (P3)
Britt Turkot
Intel Corporation

Break (20 minutes)

Session 2: EUV Sources

Session Co-chairs: H. Mizoguchi (Gigaphoton) and Padraig Dunne (UCD)

Development of 250 W EUV Light Source For HVM Lithography (P34) (Invited)
H. Mizoguchi*, H. Nakarai, T. Abe, K. M Nowak, Y. Kawasuji, H. Tanaka, Y. Watanabe, T. Hori, T. Kodama, Y. Shiraishi, T. Yanagida, G. Soumagne, T. Yamada, T. Yamazaki , S. Okazaki and T. Saitou
Gigaphoton Inc. Hiratsuka facility, JAPAN

CO_2 Amplifiers to Generate > 20 kW Laser Power for Stable > 250 W Extreme Ultraviolet (EUV) Power (P33) (Invited)
Koji Yasui[1], Naoyuki Nakamura[2], Jun-ichi Nishimae[2], Masashi Naruse[3], and Masato Matsubara[3]
[1]Mitsubishi Electric Corporation, Head quarter, Tokyo, Japan
[2]Mitsubishi Electric Corporation, Advanced technology R&D center, Hyogo, Japan
[3]Mitsubishi Electric Corporation, Nagoya works, Nagoya, Japan

New Concepts for a High Brightness LPP EUV Source (P35)
Konstantin Koshelev, Alexander Vinokhodov, Mikhail Krivokoritov, Oleg Yakushev, Samir Ellwi, Denis Glushkov, Pavel Seroglazov
RnD-Isan, Moscow, Russia and ISTEQ B.V., Eindhoven, the Netherlands

Laboratory Soft X-ray Tomography with a Simple Robust Laser Plasma Light Source (P32) (Invited)

F. O'Reilly[1,2], G. Wielgoszewski[2], J. Howard[2], F. McGrath[2], R. Byrne[2], A. Mahon[2], O. Hammad[2], T. McEnroe[2], T. McCormack[1], G. O'Sullivan[1], E. Sokell[1], P. Dunne[1], N. Kennedy[1], K. Fahy[2], P. Sheridan[2]
1 University College Dublin, School of Physics, Dublin, Ireland
2 SiriusXT Ltd, Science Centre North, Belfield, Ireland

Lunch 11:50 AM – 1:00 PM

Session 3: FEL based EUV Sources

Session Chairs: Alex Murokh (Radiabeam) and Erik R. Hosler (GLOBALFOUNDRIES)

Free-electron Lasers: Beyond EUV Lithography Insertion (P41) (Invited)

Erik R. Hosler, Obert R. Wood II
GLOBALFOUNDRIES, 400 Stone Break Road Extension, Malta, NY 12020

High Efficiency Free Electron Lasers (P44) (Invited)

Alex Murokh
Radiabeam

Design and Development of a 10-kW Class EUV-FEL Project in Japan (P43) (Invited)

Ryukou Kato
High Energy Accelerator Research Organization (KEK), Tsukuba, Ibaraki, 305-0801 Japan

Break and Group Photograph 2:00 PM (30 Minutes)

Session 4: EUV Optics

Session Chair: Regina Soufli (LLNL) and Ladislav Pina (Rigaku)

EUV Lithography High-NA Scanner for Sub 8 nm Resolution (P61) (Invited)

Jan van Schoot[1], Eelco van Setten[1], Gerardo Bottiglieri[1], Kars Troost[1], Sascha Migura[2], Jens-Timo Neumann[2], Bernhard Kneer[2], Winfried Kaiser[2]
[1]ASML, De Run 6501, 5504 DR Veldhoven, Netherlands
[2]Carl Zeiss SMT GmbH, Rudolf-Eber-Straße 2, 73447 Oberkochen, Germany

Multilayer coatings for the first Micro-Exposure Tools with NA=0.5 (P64) (Invited)

Regina Soufli[1], Jeff Robinson[1], Eberhard Spiller[2], Monica Fernández-Perea[1], Eric Gullikson[3], Luc Girard[4], Lou Marchetti[4], John Kincade[4]
[1]Lawrence Livermore National Laboratory, Livermore, CA 94550
[2]Spiller X-ray Optics, Livermore, CA 94550
[3]Lawrence Berkeley National Laboratory, Berkeley, CA 94720

[4]*Zygo Corporation, Extreme Precision Optics, Richmond, CA 94806*

Atomic-scale investigations of formation and aging processes of EUV optics (P66) (Invited)

Joost W.M. Frenken
Advanced Research Center for Nanolithography (ARCNL)
Science Park 110, 1098 XG, Amsterdam, The Netherlands

Diffractive Optics for EUV Applications (P67)

Ryan Miyakawa, Henry Wang, Weilun Chao, and Patrick Naulleau
Center for X-ray Optics, Lawrence Berkeley National Lab, 1 Cyclotron Rd, Berkeley, CA 94720

Fabrication of EUVL Micro-field Exposure Tools with 0.5 NA (P68)

Luc Girard[1], Lou Marchetti[1], Jim Kennon[2], Bob Kestner[2], Regina Soufli[3], Eric Gullickson[4]
[1]*Zygo Corporation, Extreme Precision Optics (EPO), Richmond, CA 94806, USA*
[2]*Akumen Engineering, LLC. (former employees of Zygo EPO)*
[3]*Lawrence Livermore National Laboratory, 7000 East Avenue, Livermore, CA 94550*
[4]*Lawrence Berkeley National Laboratory, 1 Cyclotron Road, Berkeley, CA 94720*

Multilayer EUV Optics with Integrated IR Suppression Gratings (P69)

Torsten Feigl[1], Marco Perske[1], Hagen Pauer[1], Tobias Fiedler[1], Uwe Zeitner[2], Robert Leitel[2], Hans-Christoph Eckstein[2], Philipp Schleicher[2], Sven Schröder[2], Marcus Trost[2], Stefan Risse[2], Christian Laubis[3], Frank Scholze[3]
[1] *optiX fab GmbH, Hans-Knöll-Str. 6, 07745 Jena, Germany*
[2] *Fraunhofer IOF, Albert-Einstein-Str. 7, 07745 Jena, Germany*
[3] *PTB Berlin, Abbestr. 2-12, 10587 Berlin, Germany*

Adjourn: Time off for Networking

End Day 1

Thursday, June 16, 2016

Welcome and Announcements (Intro-2)
Vivek Bakshi
EUV Litho, Inc.

Session 5: Keynote-2

Session Chair: Patrick Naulleau (CXRO)

EUVL Exposure Tools for HVM: Status and Outlook (P2)
Igor Fomenkov
Cymer LLC, An ASML Company, San Diego, CA 92127, USA

Session 6: Mask-1

Session Co-Chairs: Ted Liang (Intel)

Eigenmode Analysis of Electromagnetic Fields in Binary EUV Masks (P51)
Michael Yeung[1], Eytan Barouch[2] and Hye-Keun Oh[3]
[1]Fastlitho, 123 E. San Carlos Street, #251, San Jose, CA 95112
[2]Boston University, 15 St. Mary's Street, Boston, MA 02215
[3]Hanyang University, Ansan, Gyeonggi 426-791, Republic of Korea

Challenges for Predictive EUV Mask Modeling (P82) (Invited)
P. Evanschitzky, A. Erdmann
Fraunhofer IISB, Schottkystrasse 10, 91058 Erlangen, Germany

Break 10:00 AM (20 Minutes)

Session 7: Mask -2

Session Chair: Ken Goldberg (LBNL)

Actinic Mask Inspection System Using Coherent Scattreometry Microscope (P84) (Invited)
H. Kinoshita, T. Harada, Y. Nagata, T. Watanabe and K. Midorikawa
University of Hyogo, Japan

Near Wavelength Limited, 15nm Spatial Resolution, Ptychographic Imaging using a 13.5nm Tabletop High Harmonic Light Source (P59) (Invited)
Henry Kapteyn
KMLabs Inc., 1855 S. 57th Court, Boulder, CO 80301 USA

Improvement of Coherent Scattering Microscopy by applying Ptychographical Iterative Engine (P55)
Dong Gon Woo[1], Seongchul Hong[1], Hoon Jo[2], Whoi-Yul Kim[2], and Jinho Ahn[1]
[1]Department of Materials Science and Engineering
[2]Department of Electronics and Computer Engineering
Hanyang University, 222 Wangsimni-ro, Seongdong-gu, Seoul 133-791, Korea

Lunch 11:20 PM (90 Minutes)

Steering Committee working lunch meeting (Closed meeting)

12:50 PM Session 8: Mask -3

Session Chair: Jim Wiley (ASML)

Extreme Ultraviolet Mask Manufacturing: Challenges and Opportunities (P52) (Invited)
Bryan Kasprowicz[1], Henry Kamberian[2]
[1]Photronics Inc., Allen, Texas, USA
[2]Photronics Boise nanoFab, Boise, Idaho, USA

Progress and Opportunities in EUV Mask Development (P53) (Invited)
Ted Liang
Intel Mask Operations, 3065 Bowers Avenue, Santa Clara, CA USA

Title TBA (P67) (Invited)
Patrick Naulleau
CXRO

Extending CO_2 Cryogenic Aerosol Cleaning for EUV Mask Cleaning (P57) (Invited)
Ivin Varghese and Charles W. Bowers
Eco-Snow Systems, RAVE N.P. Inc., 4935A Southfront Rd., Livermore, CA, USA 94551

Break 2:10 PM (20 Minutes)

Session 9: Resist -1

Session Co-Chairs: Stephen Meyers (Inpria) and Yoshi Hishiro (JSR)

EUV Radiation Chemistry Fundamentals: Novel Probing Techniques (P72)
Oleg Kostko, B. Xu, D. S. Slaughter, K. D. Closser, S. Bhattarai, B. Hinsberg, G. M. Wallraff, D. L . Olynick, D. G. Prendergast, P. D. Ashby, D. F. Ogletree, Y. Liu, P. Naulleau, M. Ahmed
Chemical Sciences Division, Lawrence Berkeley National Laboratory, 1 Cyclotron Rd, Berkley, CA 94720, USA

Mechanisms of Exposure of Resists to EUV Light: Photons, Electrons and Holes (P76) (Invited)
Amrit Narasimhan, Steven Grzeskowiak, Greg Denbeaux, Robert Brainard
SUNY Polytechnic Institute, Albany NY 12203

Fundamentals of X-Ray Excitation and Relaxation in EUV Resists (P78) (Invited)
D. Frank Ogletree
Molecular Foundry, Materials Sciences Division, Lawrence Berkeley National Laboratory, 1 Cyclotron Road, Berkeley CA 94720 USA

Session 10: Resist -2

Session Co-Chairs: Robert Brainard (SUNY) and Frank Ogletree (LBNL)

Fundamental Aspect of Photosensitized Chemically Amplified Resist: How to overcome RLS trade-off (P73) (Invited)
Seiichi Tagawa[1,2] and PSCAR Collaboration Members
[1]Graduate School of Engineering, Osaka University, Ibaraki, Osaka 567-0047, Japan,
[2]Institute of Scientific and Industrial Research, Osaka University, Ibaraki, Osaka 567-0047, Japan

Molecular Resist Materials for Extreme Ultraviolet Lithography (P74) (Invited)
Hiroki Yamamoto[1], Hiroto Kudo[2], and Takahiro Kozawa[1]
[1]The Institute of Scientific and Industrial Research, Osaka University, 8-1 Mihogaoka, Ibaraki, Osaka 567-0047, Japan (Osaka Univ.)
[2]Department of Chemistry and Materials Engineering, Faculty of Chemistry, Materials and Bioengineering, Kansai University, 3-3-35, Yamate-cho, Suita-shi, Osaka 564-8680, Japan

Metal Oxide EUV Photoresist for N7 Relevant Patterns (P79) (Invited)
Stephen T. Meyers, Andrew Grenville
Inpria Corporation, 2001 NW Monroe Avenue, Corvallis, OR, USA 97330

Title TBA (P91) (Invited)
Yoshi Hishiro
JSR

EUVL Workshop Summary (P90)
Vivek Bakshi
EUV Litho, Inc.

5:50- 7:00 PM Poster Session

7:30 -9:30 PM Dinner

Session 11: Poster Session (5:50 PM - 7:00 PM)

Session Chairs: Vivek Bakshi (EUV Litho Inc.) and Patrick Naulleau (CXRO)

1. Inspection Efficiency Comparison between Phase Contrast and Dark Field Microscopy for EUV Actinic Blank Inspection (P86)

Yow-Gwo Wang*[a,b], Andy Neureuther[a,b], Patrick Naulleau[b]
[a]Department of Electrical Engineering and Computer Sciences, University of California, Berkeley, CA USA 94720; [b]Center for X-ray Optics, Lawrence Berkeley National Laboratory, Berkeley, CA USA 94720

2. Off-axis Aberration Estimation in an EUV Microscope using Natural Speckle (P54)

Aamod Shanker[1], AntoineWojdyla[2], Gautam Gunjala[1], Jonathan Dong[3], Markus Benk[2], Andy Neureuther[1], Kenneth Goldberg[2], Laura Waller[1]
[1]Dept of Electrical Engineering and Computer Sciences, UC Berkeley, CA
[2]Center for X-Ray Optics, Lawrence Berkeley National Lab, Berkeley, CA
[3] D´epartement de Physique, Ecole Normale Sup´erieure, Paris 75005, France

3. Improving SRAF margin and imaging performance by using PSM in EUVL (P56)

Yong Ju Jang[1], Jung Sik Kim[1], Seongchul Hong[2], 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 04763, Korea

4. CSM with Ptychography

Dong Gon Woo[1], Seongchul Hong[1], Hoon Jo[2], Whoi-Yul Kim[2], and Jinho Ahn[1]
[1]Department of Materials Science and Engineering
[2]Department of Electronics and Computer Engineering
Hanyang University, 222 Wangsimni-ro, Seongdong-gu, Seoul 133-791, Korea

5. Multilayer Development for EUV Lithography in CIOMP (P62)

Bo Yu[1], Chunshui Jin[1],Chun Li[1], Shun Yao[1]
[1]Changchun Institute of Optical, Fine Mechanics and Physics, Chinese Academy of Sciences, 3888 Dong Nanhu Road, Changchun, China, 130033

6. Realization of EBL2, an EUV exposure facility for EUV induced contamination research (P65)

Norbert Koster, Edwin te Sligte, Freek Molkenboer, Alex Deutz, Peter van der Walle, Pim Muilwijk, Wouter Mulckhuyse, Bastiaan Oostdijck, Christiaan Hollemans, Björn Nijland, Peter Kerkhof, Michel van Putten
TNO, Stieltjesweg 1, 2628 CK Delft, The Netherlands

7. Modeling the Interaction of EUV radiation with Photoresist Materials (P71)

[1]Kristina D. Closser, [1]David Prendergast, [2]Musa Ahmed, [1]Paul D. Ashby, [2]Oleg Kostko, [1]D. Frank Ogletree, [1]Deirdre L . Olynick, [2]D. Slaughter, [2]Bo Xu, [3]Patrick Naulleau
[1]Molecular Foundry, Lawrence Berkeley National Laboratory
[2]Chemical Sciences Division, Lawrence Berkeley National Laboratory
[3]Center for X-ray Optics (CXRO), Lawrence Berkeley National Laboratory

8. Tin Cage Photoresists for EUV Lithography (P75)
Jarich Haitjema
Nano photochemistry Group, Advanced Research Center for Nanolithography (ARCNL), The Netherlands

9. Study of Energy Delivery and Mean Free Path of Low Energy Electrons in EUV Resists (P92)
Suchit Bhattarai[a], Andrew R. Neureuther[a], Patrick P. Naulleau[b]
[a]*Department of EECS, Univ. of California, Berkeley, CA, USA 94720*
[b]Center for X-Ray Optics, Lawrence Berkeley National Laboratory, Berkeley, CA, USA 94720

10. Advances in EUV Resists 2010-2016
Robert Brainard,[a] Gregg Gallatin,[b] and Mark Neisser[c]
[a]SUNY Polytechnic Institute
[b]Applied Math Solutions, LLC
[c]Whitehouse Station, NJ

11. Influence of Pulse Duration on CO_2 Laser Produced tin Plasma by 1D Plasma Modeling (P31)
Wang Xinbing, Yao Liwei and Zuo Duluo
Wuhan National Laboratory for Optoelectronics, Huazhong University of Science Technol Technology, Wuhan, 430074, China

12. Stable Droplet Generator for High brightness LPP EUV Source (P36)
Konstantin Koshelev[1,2], Alexander Vinokhodov[1], Mikhail Krivokorytov[1], Yuri Sidelnikov[2], Oleg Yakushev[1], Denis Glushkov[3], Pavel Seroglazov[3], Samir Ellwi[3]
[1]*RnD-ISAN/EUV Labs, Troitsk, 142190 Russia*
[2]*Institute for Spectroscopy RAS, Troitsk, 142090 Russia*
[3]*ISTEQ, 5656 AG Eindhoven*

13. Laboratory Cryo Soft X-ray Tomography: Progress in the Development of a Commercial Microscope (P37)
Kenneth Fahy[1], Fergal O'Reilly[1,2], Tony McEnroe[1], Felicity McGrath[1], Jason Howard[1], Aoife Mahon[1], Ronan Byrne[1], Osama Hammad[1], and Paul Sheridan[1]
[1]*SiriusXT Ltd., Science Centre North, UCD, Belfield, Dublin 4, Ireland*
[2]*School of Physics, UCD, Belfield, Dublin 4, Ireland*

14. Light Source Development at Energetiq (P38)
Stephen F. Horne, Donald K Smith, Matthew M Besen, Paul A Blackborow, Deborah S Gustafson, Matthew J. Partlow, Huiling Zhu
Energetiq Technology, Inc.

15. Commercial Poster – Sponsor Product Description
Arnd Baurichter
Research-Instruments, Germany

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