

2018 EUVL Workshop

June 11-14, 2018

CXRO, LBL ▪ Berkeley, CA

Workshop Agenda



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Organized by



Vivek Bakshi (EUV Litho, Inc.), Chair

Patrick Naulleau (CXRO), Co-Chair

2018 EUVL Workshop

CXRO, LBL, Berkeley, CA, USA

June 11-14, 2018

Workshop Agenda Outline

Monday, June 11, 2018

EUVL Short Course: 8:30 AM to 5:00 PM

Building name: Building 66

Room Number: 66-316

Coffee served during AM and PM breaks. Walk from Building 66 to Café (Building 54) for lunch.

Tuesday, June 12, 2018

Lab Tour: 3 PM to 5:00 PM (Tentative tour of MET5 and SHARP)

Please meet at the CXRO -4th Floor lobby at 3 PM (Building 2, Across the street from Bay View Cafeteria or Building 54). 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 13, 2018

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: 8:00 AM – 8:30 AM

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

Continental Breakfast, morning registration and coffee during breaks will be served outside the auditorium. Seating also available next door in room # 316. Group can also walk together for Lunch to patio of Building 67.

Poster Session and Reception: 6:00 to 7:30 PM

Building name: Building 54 (Bay View Cafeteria - Name not shown on the building)

2018 EUVL Workshop

(Shuttle will be provided to take attendees from the auditorium to the poster session location.)

Thursday, June 14, 2018

Building name: Building 66 (317)

Continental Breakfast: 8:00 AM – 8:30 AM

Workshop Presentations: 8:30 AM – 5:00 PM

Steering Committee Meeting (Closed working lunch meeting) 12:20 to 1:20 PM

Building name: Building 66

Room Number: 66-316 (Located next door to the main auditorium #317)

Depart for Dinner: 5:00 PM

Dinner Cruise Location: Berkeley Mariana, Empress Hornblower Upper Deck

Shuttle will be available for pickup for off-site dinner and drop-off after dinner

Workshop Adjourned: 9:00 PM

**[Shuttle Bus Services and Parking Information to be available at the website
www.euvlitho.com](http://www.euvlitho.com)**

2018 EUVL Workshop

CXRO, LBL, Berkeley, CA, USA
June 11-14, 2018

Workshop Agenda

Monday, June 11, 2018

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 12, 2018

Facility Tour, Registration and Reception

3:00 PM- 5:00 PM

Lab Tour: 3 PM to 5:00 PM (MET5 and SHARP)

Please meet at the CXRO -4th Floor lobby at 3 PM (Building 2,
Across the street from Bay View Cafeteria or Building 54).
Tour Guide: Patrick Naulleau

5:00 PM- 6:30 PM

Registration, reception & Speaker Prep (Building 54, Bay View
Cafeteria)

Wednesday, June 13, 2018

8:30 AM Welcome and Introduction

Welcome to 2018 EUVL Workshop (Intro-1A)

Vivek Bakshi, *EUV Litho, Inc.*

Welcome to LBL

Horst Simon, *LBL*

Announcements (Intro-1B)

Patrick Naulleau, *LBL*

Introductions

All

Session 1: Keynote – 1

Session Chair: Tony Yen (ASML)

EUV Lithography at the Threshold of High Volume Manufacturing (P1)

(Keynote Presentation)

Harry J. Levinson

GLOBALFOUNDRIES, Santa Clara, CA

Current status, Challenges and Outlook of EUV lithography for High Volume Manufacturing (HVM) (P4) (Keynote Presentation)

Britt Turkot

Intel Corporation

10:40 AM Break (20 minutes)

Session 2: EUV Masks

Session Co-chairs: Jim Wiley (ASML) and Abbas Rastegar (AMAT)

Electron Multi-Beam Technology enabling EUV Mask Writing (P35) (Invited Presentation)

Hans Loeschner and Elmar Platzgummer

IMS Nanofabrication GmbH, Schreygasse 3, 1020 Vienna, Austria

Advances in High-volume Manufacturing of EUV Mask Blanks: Current Status and Roadmap (P37) (Invited Presentation)

Meng Lee, Sandeep Kohli, Katrina Rook, Boris Druz, Frank Cerio, Adrian Devasahayam

Veeco Instruments Inc (United States)

EUV mask substrate readiness for sub10 nm HP nodes (P34) (Invited Presentation)

Abbas Rastegar
Applied Materials

Advanced Deposition Techniques for Next Generation EUV Mask Blanks (P61)

Vibhu Jindal, Abbas Rastegar, Vik Banthia
Applied Materials

EUVL Mask Engineering in the Third Dimension: The Impact of Absorber Side-wall Angles on Imaging Behavior (P38) (Invited Presentation)

Tim Fühner^a, Lawrence S. Melvin III^a, Yudhishtir Kandel^a, Weimin Gao^b

^a *Synopsys, Inc. 2025 NW Cornelius Pass Road, Hillsboro, OR 97124, USA*

^b *Synopsys Inc., Technologielaan 11-0002B-3001 Leuven, Belgium*

Evaluating Thermal and Mechanical Properties of Composite Films for EUV Pellicle Applications (P33)

Seong Ju Wi¹, Yong Ju Jang², and Jinho Ahn^{1,2}

¹ *Division of Materials Science and Engineering*

² *Division of Nanoscale Semiconductor Engineering*

Hanyang University, 222 Wangsimni-ro, Seongdong-gu, Seoul 04763, Korea

Lunch 1:00 PM – 2:00 PM

Session 3: EUV Mask Metrology

Session Co-chairs: Frank Abboud (Intel) and Stefan Witte (ARCNL)

Coherent EUV Imaging and Metrology with High-harmonic Generation Sources

(P31) (Invited Presentation)

Stefan Witte

ARCNL and VU University Amsterdam

Full Field Imaging at 13.5nm in Reflection and Transmission Modes using Coherent High Harmonic Beams for EUVL and Materials Metrology (P32)

(Invited Presentation)

Henry Kapteyn^{1,2}, Margaret Murnane^{1,2} and Kevin Fahey²

¹*JILA, University of Colorado at Boulder* and ²*KMLabs Inc.*

Application of EUV Diffraction Optics for Actinic Mask Inspection and Metrology (P36)

Kenneth C. Johnson

KJ Innovation, 2502 Robertson Rd., Santa Clara, CA 95051

Mask 3D effects First Experimental Measurements with NA 0.55 Anamorphic Imaging (P62) (Invited Presentation)

Vincent Wiaux, Vicky Philipsen, Eric Hendrickx
IMEC, Belgium

A SHARP Look at Future Nodes of EUV Lithography (P64)

Markus Benk, Weilun Chao, Ryan Miyakawa, Kenneth Goldberg, Patrick Naulleau
CXRO, LBL

Break and Group Photograph 3:40 PM (30 Minutes)

Session 4: EUV Optics and Contamination

Session Chair: Sascha Migura (Zeiss) and Regina Soufli (LLNL)

Optics for EUV Lithography (P22) (Invited Presentation)

Sascha Migura
Carl Zeiss SMT GmbH, Germany

Mg-based multilayer coatings for sources > 25 nm (Tentative title) (P23)
(Invited Presentation)

Regina Soufli
LLNL

A Sustainable Approach to Next Generation EUV Manufacturing (P21) (Invited Presentation)

Supriya Jaiswal
Astrileux

Ion Fluxes Impacting Surfaces Exposed to EUV Induced Plasma (P25)

T.H.M. van de Ven¹, C.A. de Meijere², R.M. van der Horst², V.Y. Banine^{1,2}
and J. Beckers¹

¹ *University of Technology Eindhoven, 5600 MB Eindhoven, The Netherlands*

² *ASML, De Run 6501, 5504 DR Veldhoven, The Netherlands*

Session 5: Poster Session 6:00 - 7:30 PM

EUV Source Optics with 100% OOB Exclusion (P14)

Kenneth C. Johnson
KJ Innovation, 2502 Robertson Rd., Santa Clara, CA 95051

Compact Efficient CO₂ Amplifiers with Modular Design for Highly-efficient EUV Power Generations (P15)

Koji Yasui¹ and Naoya Kishida¹, Tatsuya Yamamoto² and Jun-ichi Nishimae², Masashi Naruse³, Sugihara Kazuo³, and Masato Matsubara³

¹*Mitsubishi Electric Corporation, Head quarter, Factory Automation Systems Group, Tokyo, Japan*

²*Mitsubishi Electric Corporation, Advanced technology R&D center, Hyogo, Japan*

³*Mitsubishi Electric Corporation, Nagoya works, Nagoya, Japan*

Xenon Plus Additives in the Energetiq EQ-10 (P16)

Stephen F. Horne, Don Smith, Matt Partlow, Debbie Gustafson, Paul Blackborow
Energetiq Technology, Inc.

High-brightness Tabletop Coherent EUV Source for Metrology with Sub-10-nm Resolution (P17)

G. Fan¹, T. Balčiūnas^{1,5}, E Kaksis^{1,2}, X. Xie¹, A Pugžlys¹, P Carpeggiani¹, K. Légaré², V. Cardin², G Andriukaitis¹, B. E. Schmidt³, J.P. Wolf⁴, F. Légaré², J. Lüning⁵, and A. Baltuška¹

¹*Institute of Photonics, TU Wien, Vienna, Austria*

²*Amplight Inc, Vienna, Austria*

³*Institut National de la Recherche Scientifique, Varennes, Quebec, Canada*

⁴*Few-cycle, Inc., Quebec, Canada*

⁵*GAP-Biophotonics, Université de Genève, Geneva, Switzerland*

⁶*Université Pierre et Marie Curie, Paris, France*

Storage Ring EUV Light Source Based on Steady State Microbunching Mechanism (P18)

Xiujie Deng

Tsinghua University, Beijing, China

(On behalf of the SSMB Collaboration)

Accelerator based Extreme- Ultraviolet (EUV) Sources for Lithography (P19)

J. Wu and A.W. Chao

SLAC

Fourier Space Spectral Analysis in EUV Reticle Imaging Using RESCAN: Facets & Advantages Offered by a Lensless Tool for Actinic Mask Inspection (P39)

Rajeev Rajendran, Sara Fernandez, Patrick Helfenstein, Iacopo Mochi and

Yasin Ekinici

Paul Scherrer Institut, 5232 Villigen, Switzerland

EUV Mask Characterization with Actinic Scatterometry (P64)

Stuart Sherwin¹, Andrew Neureuther¹, Patrick Naulleau²

¹*University of California Berkeley, Department of Electrical Engineering and Computer Science, Berkeley, USA*

²*Center for X-Ray Optics, Lawrence Berkeley National Laboratory, Berkeley, USA*

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Percolation Model of the Stochastic Effect of EUV Resists (P41)

Akira Sasaki, Masahiko Ishino, Masaharu Nishikino, and Yasunari Maekawa
Group of EUV ultra-precision technology, QST Advanced Study Laboratory

Stochastic Methods for Informing EUV Lithography (P43)

Aamod Shanker¹, Antoine Wojdyla², Gautam Gunjala¹, Markus Benk², Andy Neureuther¹,
Patrick naulleau², Laura Waller¹

¹*Dept of Electrical Engineering and Computer Sciences, University of California, Berkeley, CA*

²*Center for X-Ray Optics, Lawrence Berkeley National Lab, Berkeley, CA*

Inverse Problems in Turbulent Light (P44)

Aamod Shanker

Dept of Electrical Engineering and Computer Sciences, University of California, Berkeley, CA

The Impact of the Sub-Fab on the Availability of EUVL (P54)

Anthony Keen¹, Niall Walsh², Cansin Badan², Jos Donders

¹*Edwards Vacuum, Innovation Drive, Burgess Hill, RH15 9TW, UK*

²*Edwards Vacuum, De Run 6870, 5504 DW Veldhoven, Netherlands*

Advanced Modeling of Anisotropic Stochastics in EUV Resist (P55)

Luke Long¹, Andy Neureuther¹, and Patrick Naulleau²

¹ *University of California at Berkeley*

² *Center for X-ray Optics, Lawrence Berkeley National Laboratory*

Lateral-shearing Interferometry for High-NA EUV Wavefront Metrology (P56)

Wenhua Zhu, Ryan Miyakawa, and Patrick Naulleau

Center for X-ray Optics, Lawrence Berkeley National Laboratory

1 Cyclotron Road, Berkeley, CA 94720, USA

Additional Poster Papers to be Announced

End Day 1

Thursday, June 14, 2018

8:30 AM Announcements (Intro-2)

Patrick Naulleau, LBL

Session 6: Keynote-2

Session Chair: Harry Levinson (GlobalFoundries)

Continued Scaling in Semiconductor Manufacturing with Extreme-UV Lithography

(P3) (Keynote Presentation)

Anthony Yen

ASML

Compact, Bright, Plasma-based EUV Lasers for Metrology (P2)

(Keynote Presentation)

Jorge. J. Rocca

Colorado State University, Fort Collins, CO

Fundamentals of PSCAR and Overcoming the Stochastic Problems of EUV Lithography (P5) (Keynote Presentation)

Seichi Tagawa

Osaka University

10:40 AM Break (20 Minutes)

Session 7: Resist and Patterning - I

Session Co-Chairs: Yasin Ekinici (PSI) and Yoshi Hishiro (JSR)

Pushing the Resolution Limits of Photolithography (P42) (Invited Presentation)

Yasin Ekinici

Advanced Lithography and Metrology Group, Paul Scherrer Institute, 5232 Villigen PSI, Switzerland

EUV Resist: The Great Challenge of Small Things (P48) (Invited Presentation)

S. Castellanos

Advanced Research Center for Nanolithography (ARCNL), Science Park 110, 9810XG Amsterdam, The Netherlands

EUV Materials Solution (P52) (Invited Presentation)

Yoshi Hishiro

JSR

MTR Resist for Reduced LER in EUV Lithography (P51)

C. Popescu¹, A. McClelland², G. Dawson³, J. Roth⁴, W. Theis¹, A.P.G. Robinson³

¹ School of Physics and Astronomy, University of Birmingham, Edgbaston, B15 2TT, UK

² Irresistible Materials, Birmingham Research Park, Birmingham, UK

³ School of Chemical Engineering, University of Birmingham, Edgbaston, B15 2TT, UK

⁴ Nano-C, 33 Southwest Park, Westwood, MA, USA

Lunch 12:20 PM (60 Minutes)

Steering Committee working lunch meeting (Closed meeting)

Session 8: EUV Sources

Session Co-Chairs: Hakaru Mizoguchi (Gigaphoton) and Ladislav Pina (CTU and Rigaku)

High Power LPP-EUV Source with Long Collector Mirror Lifetime

for Semiconductor High Volume Manufacturing (P11) (Invited Presentation)

Hakaru Mizoguchi, Hiroaki Nakarai, Tamotsu Abe, Krzysztof M Nowak, Yasufumi Kawasuji, Hiroshi Tanaka, Yukio Watanabe, Tsukasa Hori, Takeshi Kodama, Yutaka Shiraishi, Tatsuya Yanagida, Georg Soumagne, Tsuyoshi Yamada, Taku Yamazaki and Takashi Saitou

Gigaphoton Inc. Hiratsuka facility: 3-25-1 Shinomiya Hiratsuka Kanagawa, 254-8567, JAPAN

Simulating EUV Emission from Laser-Produced Plasma (P12) (Invited Presentation)

Steven Langer, Howard Scott, and Hai Le

Lawrence Livermore National Laboratory, Livermore, CA, USA

Characterizations of a Nd:YAG Laser-driven Plasma (P13) (Invited Presentation)

O. O. Versolato, Dmitry Kurilovich

Advanced Research Center for Nanolithography (ARCNL), Science Park 110, 1098 XG Amsterdam, The Netherlands

Ar Plasma Discharge Sources for EUV/SXR Metrology and Imaging (P24) (Invited Presentation)

Ladislav Pina

Czech Technical University in Prague (Czech Republic)

Break 2:40 PM (20 Minutes)

Session 9: EUV Resist and Patterning - II

Session Co-chairs: Bill Hinsberg (Columbia Hill Technical) and Oleg Kostko (LBL)

Numeric Model for the Imaging Mechanism of Metal Oxide EUV Resists (P46)
(Invited Presentation)

W.D. Hinsberg¹ and S. Meyers²

¹*Columbia Hill Technical Consulting, Fremont CA*

²*Inpria Corporation, Corvallis OR*

LER tradeoffs for BEOL Patterning (P40) (Invited Presentation)

Puneet Gupta

UCLA

MET 5 Update (Tentative title) (P45)

Chris Anderson

LBL

Fundamental Understanding of Chemical Processes in EUV Lithography (P47)

Oleg Kostko,¹ Bo Xu,¹ Musahid Ahmed,¹ Daniel S. Slaughter,¹ D. Frank Ogletree,² Kristina D. Closser,² David G. Prendergast,² Patrick Naulleau,³ Deirdre L. Olynick,² Paul D. Ashby,² Yi Liu,² William D. Hinsberg,⁴ Gregory M. Wallraff⁵

¹*Chemical Sciences Division, Lawrence Berkeley National Laboratory, Berkeley, CA, USA*

²*Molecular Foundry, Lawrence Berkeley National Laboratory, Berkeley, CA USA*

³*Center for X-Ray Optics, Lawrence Berkeley National Laboratory, Berkeley, CA, USA*

⁴*Columbia Hill Technical Consulting, Fremont, CA USA*

⁵*IBM Research Center, Almaden, CA USA*

Using Resonant Soft X-ray Scattering to Image Patterns on Undeveloped Resists (P53)

Guillaume Freychet

LBL

Announcements

Vivek Bakshi

EUV Litho, Inc.

Depart for Dinner

6:00 -9:00 PM Dinner Cruise

