2018 EUVL Workshop

June 11-14, 2018

CXRO, LBL ▪ Berkeley, CA

Workshop Proceedings

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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
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Workshop Proceedings

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], Yudhishthir 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 Wi[1], Yong Ju Jang[2], 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)
Christina Porter, Henry Kapteyn[1,2], Margaret Murnane[1,2] and Kevin Fahey[2]
[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

Corrosion-resitant Mg-based multilayer coatings for sources > 25 nm (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 Ven[1], C.A. de Meijere[2], R.M. van der Horst[2], V.Y. Banine[1,2] and J. Beckers[1]
[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 CO_2 Amplifiers with Modular Design for Highly-efficient EUV Power Generations (P15)
Koji Yasui[1] and Naoya Kishida[1], Tatsuya Yamamoto[2] and Jun-ichi Nishimae[2], Masashi Naruse[3], Sugihara Kazuo[3], and Masato Matsubara[3]
[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) **(Withdrawn)**
G. Fan[1], T. Balčiūnas[1,5] ,E Kaksis[1,2], X. Xie[1], A Pugžlys[1], P Carpeggiani[1], K. Légaré[2], V. Cardin[2], G Andriukaitis[1], B. E. Schmidt[3], J.P. Wolf[4], F. Légaré[2], J. Lüning[5], and A. Baltuška[1]
[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

First Place: Best Poster Awards
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 Ekinci
Paul Scherrer Institut, 5232 Villigen, Switzerland

Second Place: Best Poster Awards

EUV Mask Characterization with Actinic Scatterometry (P63)

Stuart Sherwin[1], Andrew Neureuther[1], Patrick Naulleau[2]
[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*

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 Shanker[1], Antoine Wojdyla[2], Gautam Gunjala[1], Markus Benk[2], Andy Neureuther[1], Patrick naulleau[2], Laura Waller[1]
[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 Keen[1], Niall Walsh[2], Cansin Badan[2], 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 Long[1], Andy Neureuther[1], and Patrick Naulleau[2]
[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

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 Ekinci (PSI) and Yoshi Hishiro (JSR)

Pushing the Resolution Limits of Photolithography (P42) (Invited Presentation)
Yasin Ekinci
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. Popescu[1], A. McClelland[2], G. Dawson[3], J. Roth[4], W. Theis[1], A.P.G. Robinson[3]
[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] *eNano-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. Hinsberg[1] and S. Meyers[2]
[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 (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. Wallraff[5]
[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

2018 EUVL Workshop Summary
Vivek Bakshi
EUV Litho, Inc.

Announcements
Vivek Bakshi
EUV Litho, Inc.

6:00 -9:00 PM Dinner Cruise

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