# International Workshop on EUV and Soft X-Ray Sources (2016 Source Workshop)

November 7-9, 2016

Amsterdam ▪ The Netherlands

# Workshop Proceedings

EUV LITHO, INC.

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# 2016 International Workshop on EUV and Soft X-ray Sources
## (2016 Source Workshop)




## Workshop Co-Organizers


## Source Technical Working Group (TWG)

Reza Abhari (ETH Zurich)
Jinho Ahn (Hanyang University)
Peter Anastasi (Silson)
Sasa Bajt (DESY)
Vadim Banine (ASML)
Klaus Bergmann (ILT-Fraunhofer)
Davide Bleiner (University of Bern)
Vladimir Borisov (Trinity)
John Costello (DCU)
Padraig Dunne (UCD)
Samir Ellwi (ALSphotonics)
Akira Endo (HiLase)
Henryk Fiedorowicz (Military University of Technology, Poland)
Torsten Feigl (OptiXfab)
Francesco Flora (ENEA)
Debbie Gustafson (Energetiq)
Ahmed Hassanein (Purdue)
Takeshi Higashiguchi (Utsunomia University)
Larissa Juschkin (Aachen University)
Hiroo Kinoshita (Hyogo University)
Chiew-seng Koay (IBM)
Konstantin Koshelev (ISAN)
Rainer Lebert (Bruker)
Peter Loosen (ILT-Fraunhofer)
Eric Louis (University of Twente)
James Lunney (Trinity College, Dublin)
John Madey (University of Hawaii)
Shunko Magoshi (EIDEC)
Hakaru Mizoguchi (Gigaphoton)
Udo Dinger (Carl Zeiss)
Katsuhiko Murakami (Nikon)
Patrick Naulleau (LBNL)
Fergal O'Reilly (UCD)
Gerry  O'Sullivan (UCD)
Luca Ottaviano (University of L'Aquila)
Yuriy Platonov (RIT)
Martin Richardson (UCF)
Valentino Rigato (INFN-LNL)
Jorge Rocca (University of Colorado)
David Ruzic (University of Illinois)
Akira Sasaki (JAEA)
Leonid Shmaenok (PhysTex)
Emma Sokell (UCD)
Seichi Tagawa (Osaka University)
Hironari Yamada (PPL)
Mikhail Yurkov (DESY)
Sergey Zakharov (NAEXTSTREAM)
Vivek Bakshi (EUV Litho, Inc.) - Organizing Chair
Oscar Versolato (ARCNL) – Co-Chair

# Workshop Proceedings

# WORKSHOP PROCEEDINGS

# 2016 International Workshop on EUV and Soft X-Ray Sources

## November 7-9, 2016, Amsterdam, The Netherlands

## Monday, November 7, 2016 (Hotel Casa 400)

6:00 - 8:00 PM Reception and Speaker Prep at Hotel Casa 400

## Tuesday, November 8, 2016 (Amsterdam Science Park Congress Centre)

### 8:40 AM Announcements and Introductions

**Welcome, Announcements and Introductions** (Intro-1)

Vivek Bakshi
*EUV Litho, Inc., USA*

### 9:00 AM Session 1: Keynote Session -1

**Session Chair:** Joost Frenken (ARCNL)

**EUVL Exposure Tools for HVM: It's Under (and About) Control (S1)**
Wim J. van der Zande
*ASML Netherlands B.V., De Run 6501, 5504 DR Veldhoven, The Netherlands*

**X-ray Microscopy with Laboratory Sources (S2)**
Hans M Hertz
*Biomedical and X-Ray Physics, Dept. of Applied Physics, KTH/Albanova, Stockholm, Sweden*

### Break 10:20 AM (15 Minutes)

## 10:35 AM Session 2: HVM EUV Sources - 1

**Session Chairs:** Igor Fomenkov (ASML) and Akira Endo (HiLase)

**Development of 250 W LPP EUV Light Source for HVM Lithography (S11) (Invited)**
T. Yanagida, S. Nagai, G. Soumagne, K. M Nowak, Y. Kawasuji, H. Tanaka, H. Hayashi, Y. Watanabe, T. Hori, Y. Shiraishi, T. Yamada, T. Abe, T. Okamoto, T. Kodama, H. Nakarai, T. Yamazaki, T. Saitou and H. Mizoguchi
*Gigaphoton Inc., 3-25-1 Shinomiya, Hiratsuka-shi, Kanagawa 254-8555, Japan*

**Correlation of Fundamental Plasma Parameters with EUV Emission Profiles of Laser-produced Sn Plasmas for EUV Lithography Light Sources (S12) (Invited)**
Kentaro Tomita[1], Yuta Sato[1], Syoichi Tsukiyama[1], Toshiaki Eguchi[1], Kiichiro Uchino[1], Kouichiro Kouge[2], Tatsuya Yanagida[2], Hiroaki Tomuro[2], Yasunori Wada[2], Masahito Kunishima[2], Takeshi Kodama[2], Hakaru Mizoguchi[2]
*[1] Interdisciplinary Graduate School of Engineering and Sciences, Kyushu University, 6-1, Kasugakoen, Kasuga, Fukuoka 816-8580, JAPAN*
*[2] Gigaphoton Inc., 400 Yokokurashinden Oyama, Tochigi, 323-8558, JAPAN*

**Power Scaling of Pico-second Thin Disc Laser for LPP and FEL EUV Sources (S13) (Invited)**
Akira Endo
*HiLASE Centre, Dolni Brezany, Czech Republic*

**Dynamics of a Metallic Micro-droplet upon Interaction with Nanosecond Laser Pulse (S14) (Invited)**
D. Kurilovich[1,2], A. Klein[3], F. Torretti[1,2], M. Noordam[1], J. Scheers[1,2], W. Ubachs[1,2], R.A. Hoekstra[1,4], H. Gelderblom[3], O.O. Versolato[1]
*[1]Advanced Research Center for Nanolithography (ARCNL), Science Park 110, 1098 XG Amsterdam, The Netherlands*
*[2]Department of Physics and Astronomy, and LaserLaB, Vrije Universiteit, De Boelelaan 1081, 1081 HV Amsterdam, The Netherlands*
*[3]Physics of Fluids Group, Faculty of Science and Technology, MESA+Institute, University of Twente, P.O. Box 217, 7500 AE Enschede, The Netherlands*
*[4]Zernike Institute for Advanced Materials, University of Groningen, Nijenborgh 4, 9747 AG Groningen, The Netherlands*

## Lunch 11:55 AM (60 Minutes)

## 12:55 PM Session 3: HVM EUV Sources – 2

**Session Chairs:** Reza Abhari (ETH) and Klaus Bergmann(Fraunhofer)

**High-radiance LDP Source: Clean, Reliable and Stable EUV Source for Mask Inspection (S15) (Invited)**
Yusuke Teramoto, Bárbara Santos, Guido Mertens, Ralf Kops, Margarete Kops, Hironobu Yabuta, Akihisa Nagano, Noritaka Ashizawa, Yuta Taniguchi, Daiki Yamatani, Takahiro Shirai, Kunihiko Kasama, Alexander von Wezyk[1] and Klaus Bergmann[1]
*Ushio Inc.*
*[1]Fraunhofer ILT*

**Droplet-based High Brightness LPP Light Sources for High Volume Metrology and Inspection Applications (S16) (Invited)**
Reza S. Abhari, Markus Brandstaetter, Duane Hudgins, Alexander Sanders, Marco Weber, Daniel Boehringer[1]
*Laboratory for Energy Conversion, Swiss Federal Institute of Technology Zurich (ETHZ), Switzerland*
*[1]Adlyte AG, Zug, Switzerland*

**Scaling of Discharge based XUV Sources for Metrology Applications (S17) (Invited)**
Klaus Bergmann, Alexander von Wezyk, Jochen Vieker
*Fraunhofer Institute for Laser Technology – ILT, Steinbachstr. 15, 52074 Aachen, Germany*

**A High-Brightness LPP EUV Source based on Liquid Lithium Jet for Actinic Mask Inspection (S18) (Invited)**
Konstantin Koshelev, Alexander Vinokhodov, Mikhail Krivokoritov, Oleg Yakushev, Denis Glushkov, Pavel Seroglazov, Samir Ellwi
*RnD-Isan, Moscow, Russia*
*ISTEQ B.V., Eindhoven, the Netherlands*

**Progress Towards Actinic Patterned Mask Inspection (S19) (Invited)**
Oleg Khodykin
*RAPID, KLA-Tencor Inc.*

## 14:35 PM Break (15 Minutes)

## 14:50 PM Session 4: Plasma Dynamics

**Session Chairs:** Rainer Lebert (RI) and Gerry O'Sullivan (UCD)

**Conversion Efficiency of Laser-produced Plasmas at 13.5 nm and Colliding Plasmas as EUV Sources (S21) (Invited)**
Gerry O'Sullivan, Thomas Cummins, Colm O'Gorman, Tony Donnelly, Padraig Dunne, Paddy Hayden, Domagoj Kos, Oisín Maguire, Fergal O'Reilly and Emma Sokell
*School of Physics, University College Dublin, Belfield, Dublin 4, Ireland*

**Physics of Laser Ablation and the Quest for Maximum CE (S22) (Invited)**
M. M. Basko
*Keldysh Institute of Applied Mathematics (KIAM), Moscow, Russia*
*RnD-ISAN/EUV Labs, Moscow, Troitsk, Russia*

**Cross-sections for Electron-impact Ionization of Tin ions from a Crossed-beams Experiment (S23) (Invited)**
Stefan Schippers
Atom und Molekülphysik, I. Physikalisches Institut, Justus-Liebig-Universität Gießen
Leihgesterner Weg 217, 35392 Gießen, Germany

**Charge-state Resolving Analysis of EUV Spectra using Electron-beam Ion Traps (S24) (Invited)**
José R. Crespo López-Urrutia
*Max-Planck-Institut für Kernphysik, D-69117 Heidelberg, Germany*

**Electron and Ion Dynamics in EUV-induced Plasmas (S25) (Invited)**
J. Beckers[1], R.M. van der Horst[2], T.H.M. van de Ven[1], C.A. de Meijere[2], G.M.W. Kroesen[1] and V.Y. Banine[1,2]
*[1] Eindhoven University of Technology, Den Dolech 2, 5612 AZ Eindhoven, The Netherlands*
*[2] ASML, De Run 6501, 5504 DR Veldhoven, The Netherlands*

## 16:30 PM Break (15 Minutes)

## 16:45 PM Session 5: Poster Session

**Session Chair:** Oscar Versolato (ARCNL)

**Transmission Grating Spectrometer for Broadband Characterization of EUV Sources (S81)**
Muharrem Bayraktar[1], Bert Bastiaens[2], Caspar Bruineman[3], Boris Vratzov[4] and Fred Bijkerk[1]
*[1] Industrial Focus Group XUV Optics, MESA + Institute for Nanotechnology, University of Twente, The Netherlands*
*[2] Laser Physics and Nonlinear Optics, MESA + Institute for Nanotechnology, University of Twente, The Netherlands*
*[3] Scientec Engineering, The Netherlands*
*[4] NT&D – Nanotechnology and Devices, Germany*

**Femtosecond Laser Ablation of a Solid Tin Target (S82)**
M.J. Deuzeman*, †, E. Leerssen*, A. Stodolna*, N. Spook*, ‡, S. Witte*, §, P.C.M. Planken*, ‡, K.S.E. Eikema*, §, W. Ubachs*, §, R. Hoekstra*, †, O.O. Versolato*
** Advanced Research Center for Nanolithography (ARCNL), Science Park 110, 1098 XG Amsterdam, The Netherlands*
*† Zernike Institute for Advanced Materials, University of Groningen, Nijenborgh 4, 9747 AG Groningen, The Netherlands*
§ *Department of Physics and Astronomy, Vrije Universiteit, De Boelelaan 1081, 1081 HV Amsterdam, The Netherlands*
*‡ Van der Waals-Zeeman Institut, University of Amsterdam, Science Park 904, 1098 XH, Amsterdam, The Netherlands*

**Compact Discharge based EUV Source with High-power and Long Maintenance Interval (S83)**
Jochen Vieker and Klaus Bergmann
*Fraunhofer Institute for Laser Technology – ILT, Steinbachstr. 15, 52074 Aachen, Germany*

**Development of a Collective Thomson Scattering System for High-Z Plasmas for Soft X-ray Sources (S84)**
Yuta Sato, Kentaro Tomita, Toshiaki Euchar, Syoichi Tsukuyomi, Kiichiro Uchino
*Interdisciplinary Graduate School of Engineering and Sciences, Kyushu University, 6-1, Kasugakoen, Kasuga, Fukuoka 816-8580, JAPAN*

**Optimization of Extreme Ultraviolet Emission and the Time of Flight Spectra with Dual-pulse Laser Irradiating Tin-droplet Target (S85)**
Lan Hui [1], Wang Xinbing [2], Zuo Duluo [2], Zheng Guang[1]
*[1] School of Physics and information engineering, Jianghan University, Wuhan 430056, China*
*[2] Wuhan National Laboratory for Optoelectronics, Huazhong University of Science and Technology, Wuhan 430074, China*

**Advanced Laser Development for Plasma-based EUV Generation (S86)**
Tiago Pinto, Randy Meijer, Aneta Stodolna, Stefan Witte, Kjeld Eikema
*Advanced Research Center for Nanolithography*

## Winner: 2nd Place: Poster Session Award

**In-line EUV beam Monitoring using Microwaves (S87)**

F.M.J.H. van de Wetering[1], O.J. Luiten[1], G.J.H. Brussaard[2], V.Y. Banine[1,2] & J. Beckers[1]
*[1] Eindhoven University of Technology, Department of Applied Physics, P.O. Box 513, 5600 MB Eindhoven, The Netherlands*
*[2] ASML The Netherlands B.V., PO Box 324, 5500 AH Veldhoven, The Netherlands*

**Spectroscopic, Microscopic and Ultrafast Studies of Nanoscale Sn islands Formed by Thermal Evaporation (S88)**

Nick Spook[1,2], Harmen Sielcken [1,3], Paul Planken, [1,2]
*[1] Advanced Research Center for Nanolithography*
*[2]UvA*
*[3]UU*

**Enhancement of X-ray Emission by Double-pulse Target Ablation in a Laser-produced Plasma (S26)**

Pranitha Sankar, Reji Philip
*Ultrafast and Nonlinear Optics Lab, Light and Matter Physics Group*
*Raman Research Institute, Bangalore 560080, India*

**Analysis of the Fine Structure of the EUV Emitting Ions $Sn^{7+...14+}$ (S27)**

F. Torretti[1,2], A. Windberger[1,3], A. Borschevsky[4], A. Ryabtsev[5,6], S. Dobrodey[3], H. Bekker[3], W. Ubachs[1,2], R. Hoekstra[1,7], J. R. Crespo López-Urrutia[3] and O. O. Versolato[1]
*[1] Advanced Research Center for Nanolithography, Science Park 110, 1098 XG Amsterdam, The Netherlands*
*[2] Department of Physics and Astronomy, Vrije Universiteit, de Boelelaan 1081, 1081 HV Amsterdam, The Netherlands*
*[3] Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, Heidelberg, Germany*
*[4] The Van Swinderen Institute for Particle Physics and Gravity, University of Groningen, Nijenborgh 4, 9747 AG Groningen, The Netherlands*
*[5] Institute of Spectroscopy, Russian Academy of Sciences, Troitsk, Moscow, Russia*
*[6] EUV Labs, Ltd., Troitsk, Moscow, 108840 Russia*
*[7] Zernike Institute for Advanced Materials, University of Groningen, Nijenborgh 4, 9747 AG Groningen, The Netherlands*

**EBL2: Versatile EUV Exposure and Analysis facility (S54)**

E. (Edwin) te Sligte, N. B. Koster, F. T. (Freek) Molkenboer, P. (Peter) van der Walle, P. M. (Pim) Muilwijk, W. F. W. (Wouter) Mulckhuyse, B.W. (Bastiaan) Oostdijck, C.L. (Christiaan) Hollemans, J. (Jeroen) Westerhout, B. A. H. (Bjorn) Nijland, P.J. (Peter) Kerkhof, M. (Michel) van Putten, A. M. (André) Hoogstrate, A. F. (Alex) Deutz,
*TNO; Stieltjesweg 1,2628 CK Delft -The Netherlands*

**Concept Studies for Actinic Pellicle Characterization (S55a)**
**Progress with EUV-Reflectometer Tooling with Upgraded V4 Platform (S55b)**

Rainer Lebert, Christoph Phiesel, Thomas Missalla, Christian Piel
*RI Research Instruments GmbH, D-51429 Bergisch Gladbach, Germany*

## Winner: 1st Place: Poster Session Award

**Study of Plasma Dynamics and Spectral Tunability in Hollow -cathode Triggered Gas-discharge Sources (S45)**

Florian Melsheimer [1,2,4], Malte Ranis [1,2,4], Daniel Wilson [1,2,3], Sophia Schröder [1, 2, 4] and Larissa Juschkin [1,2,4]

*[1] Forschungszentrum Jülich, Peter Grünberg Institut (PGI-9), Germany*
*[2] RWTH Aachen University, Experimental Physics of EUV, Aachen, Germany*
*[3] Forschungszentrum Jülich, Peter Grünberg Institut (PGI-6), Germany*
*[4] Jülich-Aachen Research Alliance (JARA), Fundamentals of Future Information Technology, Germany*

**Alternative Emitters for LPP sources around 6.x nm (S47)**

Alexander von Wezyk, Klaus Bergmann
Fraunhofer Institute for Laser Technology, Steinbachstr. 15, 52074 Aachen, Germany

**Picosecond Laser Krypton Plasma Emission in Water-Window Spectral Range (S48)**

P. Vrba[1], M. Vrbova[2]
*[1]Institute of Plasma Physics, Czech Academy of Sciences, 182 00 Prague 8, CR*
*[2]Czech Technical University, Faculty of Biomedical Engineering, 272 01 Kladno, CR*

**High-Radiance LPP Source for Microscopy (S49)**

Padraig Dunne et al
*University College Dublin, Dublin, Ireland*

## 18:15 PM Leave for Off-site Dinner

## 19:00 PM Dinner (2 Hours)

# Wednesday, November 9, 2016 (Amsterdam Science Park Congress Centre)

## 8:40 AM Announcements and Introductions

**Welcome, Announcements and Introduction** (Intro-1)

Vivek Bakshi, *EUV Litho, Inc., USA*

## 8:50 AM Session 6: Keynote Session - 6

**Session Chair:** Oscar Versolato (ARCNL)

***Interferometry, Spectroscopy and Lensless Imaging with Extreme-ultraviolet Radiation (S3)***
Stefan Witte
*ARCNL and VU University Amsterdam*

## 9:30 AM Session 7: XUV Applications

**Session Chairs:** Larissa Juschkin (Aachen University) and Padraig Dunne (UCD)

**Coherent Diffraction Imaging with Partially-coherent Discharge Plasma based EUV Sources (S71) (Invited)**
Larissa Juschkin[1,2], Jan Bußmann[1,2], Michal Odstrcil[1,3], Raoul Bresenitz[1], Yusuke Teramoto[4], Marco Perske[5], Torsten Feigl[5], William S. Brocklesby[3]
*[1] Chair for Experimental Physics of EUV, JARA-FIT, RWTH Aachen University, Steinbachstrasse 15, 52074 Aachen, Germany*
*[2] Peter Grünberg Institute 9, JARA-FIT, Forschungszentrum Jülich GmbH, 52425 Jülich, Germany*
*[3] Optoelectronics Research Center, University of Southampton, SO17 1BJ, United Kingdom*
*[4] BLV Licht- und Vakuumtechnik GmbH, Steinbachstraße 15, Aachen, Germany*
*[5] OptiXfab. GmbH, Hans-Knoell-Str. 6, 07745 Jena, Germany*

**Transient XUV and X-ray lasers pumped by Free-Electron Laser Sources (S72) (Invited)**
N. Rohringer
*Max Planck Institute for the Structure and Dynamics of Matter Hamburg, 22761, GERMANY*

**Optimization of Laser-produced Plasma towards the Generation of High-order Harmonics (S74)**
N. Smijesh*, Kavya H. Rao, D. Chetty, R. T. Sang and I. Litvinyuk
*Australian Attosecond Science Facility, Centre for Quantum Dynamics, Griffith University Nathan Campus, QLD-4111, Australia.*

## 10:50 Break (15 Minutes)

## 11:05 PM Session 8: XUV Sources (Including HHG)

**Session Chairs:** Takeshi Higashiguchi (Utsunomiya University) and Klaus Mann (LLG)

**Fiber Laser - driven High Harmonic Generation as Powerful Source for Applications (S41) (Invited)**
Steffen Hädrich[1], Jan Rothhardt[2,3], Jens Limpert[2,3,4]
*[1]Active Fiber Systems GmbH, Wildenbruchstraße 15,07745 Jena, Germany*
*[2]Institute of Applied Physics, Abbe Center of Photonics, Friedrich-Schiller-Universität Jena, Albert-Einstein-Straße 15, 07745 Jena, Germany*
*[3]Helmholtz Institute Jena, Fröbelstieg 3, 07743 Jena, Germany*
*[4]Fraunhofer Institute for Applied Optics and Precision Engineering, Albert-Einstein-Straße 7, 07745 Jena, Germany*

**Enhancement of Extreme-Ultraviolet Fluorescence and Localized High Harmonic Generation using Structured Solids (S42) (Invited)**
Murat Sivis
*4th Physical Institute - Solis and Nanostructures, Georg-August University, Göttingen, Germany*

**Applications of a Table-top Laser Driven EUV/Soft X-ray Source and Wavefront Optimization at Short Wavelengths (S43) (Invited)**
K. Mann, J.O. Dette, M. Lübbecke, T. Mey, M. Müller, B. Schäfer
*Laser-Laboratorium Göttingen e.V., D-37077 Göttingen, Germany*

**Unresolved Transition Array (UTA) Emission from Highly -charged Ions in Heavy-element Plasmas by a Dual-laser Pulse Irradiation (S44) (Invited)**
Takeshi Higashiguchi
*Department of Electrical and Electronic Engineering, Faculty of Engineering and CORE, Utsunomiya University, Yoto 7-1-2, Utsunomiya, Tochigi 321-8585, Japan*

**Laser-produced Highly-ionized Aluminum Plasma for High Harmonic Generation (S46)**
N. Smijesh[1], Kavya H. Rao[1], N. Klemke[1], R. Philip[2], I. Litvinyuk [1] and R. T. Sang [1]
*[1]Australian Attosecond Science Facility, Centre for Quantum Dynamics, Griffith University Nathan, QLD-4111, Australia*
*[2] Ultrafast and Nonlinear Optics Lab, Light and Matter Physics Group, Raman Research Institute, Bangalore 560080, India*

## 12:45 Lunch and Break (90 Minutes)
## (Tour of ARCNL from 1:15 PM to 2:15 PM)

## 2:15 PM Session 9: Optics for EUV and BEUV

**Session Chairs:** Eric Louis (Univ. of Twente) and Ladislav Pina (CTU)

**Multilayer and Thin Film Coatings for EUVL and Beyond (S51) (Invited)**
I.A. Makhotkin, D.S. Kuznetsov, R.A.J.M. van den Bos, R. Coloma Ribera, S.P. Hendrikx, A. Zameshin, J. M. Sturm, C.J. Lee, R.W.E. van de Kruijs, A. Yakshin, E. Louis and F. Bijkerk
*MESA+ Institute for Nanotechnology, University of Twente, Netherlands*

**Leading Edge EUV /XUV Optics – Recent Highlights (S52) (Invited)**
Torsten Feigal
*optiXfab, Germany*

**A Study of EUV/SXR Grazing Incidence Collectors for Metrology Sources (S53) (Invited)**
Ladislav Pina[1] and Andrzej Bartnik[2]
*[1]Czech Technical University, Prague*
*[2]Institute of Optoelectronics, Military University of Technology, Warsaw*

## 3:15 PM Session 10: FEL based Sources for EUV

**Session Chairs:** M. V. Yurkov (DESY) and Hiroshi Kawata (KEK)

**Recent Activities at FLASH and European XFEL (S61) (Invited)**
M. V. Yurkov
*DESY, Hamburg*

**Strategy to Realize the EUV-FEL High-power Light Source: Present Status on the EUV-FEL R&D Activities (S62) (Invited)**
Hiroshi Kawata
*High Energy Accelerator Research Organization (KEK), Tsukuba, Ibaraki 305-0801, Japan*

**Linear and Non-linear Interaction of X-ray Free Electron Laser Radiation with Materials (S63) (Invited)**
Hermann A. Dürr
*SLAC National Accelerator Laboratory, Menlo Park CA 94025, USA and Van der Waals – Zeeman Institute, University of Amsterdam, Science Park 904 C4 23, 1098XH Amsterdam, The Netherlands*

## 4:15 PM Break (15 Minutes)

## 4:30 PM Session 11: Modeling

**Session Chairs:** Michael Purvis (ASML) and Howard Scott (LLNL)

**Multiphysics Model of Plasma Interaction with Gas flow in EUV Source chamber (S31) (Invited)**
D. Astakhov[1], V. Konovalov[1,2], I. Vichev[1,2], M. Kraposhin[3], Yu. Mankelevich[1,4], V. Ivanov[1,5], I. Popov[6], A. Ziganshin[1], D. Labetsky[7], V. Medvedev[1,2], A. Yakunin[7], K. Feenstra[7]
[1] *RnD-ISAN, Moscow, Troitsk, Russia*
[2] *KIAM RAS, Moscow, Russia*
[3] *Institute for System Programming RAS, Moscow, Russia*
[4] *SINP MSU, Moscow, Russia*
[5] *Institute for Spectroscopy RAS, Moscow, Troitsk, Russia*
[6] *ISTEQ, Eindhoven, The Netherlands*
[7] *ASML Netherlands B.V., De Run 6501, 5504 DR Veldhoven, The Netherlands*

**How a Laser Impact Propels, Deforms and Fragments a Liquid Drop: The Liquid Dynamics of the Pre-pulse (S32) (Invited)**

Hanneke Gelderblom[1], Alexander L. Klein[1], Henri Lhuissier[2], Emmanuel Villermaux[3], Dmitry Kurilovich[4], Oscar Versolato[4], Jacco H. Snoeijer[1,5] and Detlef Lohse[1]
*[1] Physics of Fluids, Faculty of Science & Technology, University of Twente, The Netherlands,*
*[2]IUSTI - Aix-Marseille Universitie, France,*
*[3]IRPHE - Aix-Marseille Universitie, France,*
*[4]Advanced Research Centre for Nanolithography, The Netherlands,*
*[5] Mesoscopic Transport Phenomena, Department of Applied Physics,*
*Eindhoven University of Technology, The Netherlands*

**Simulating EUV Generation in Laser-Produced Plasma (S33) (Invited)**

Howard Scott[1] and Frank McQuillan[2]
*[1]Lawrence Livermore National Laboratory, Livermore, CA, USA*
*[2]School of Physics, University College Dublin, Belfield, Dublin, Ireland*

**Application of Plasma Formation Modeling for LPP EUV Sources (S34) (Invited)**

Michael Purvis[a], Alexander Schafgans[a], Daniel Brown[a] , Igor Fomenkov[a], Rob Rafac[a], Josh Brown[a], David Brandt[a], Harry Kreuwel[b], Andrei Yakunin[b], Aaron Fisher[c], Howard Scott[c], , Dave Eder[c], Scott Wilks[c], Anthony Link[c], Jave Kane[c], Fred Hartemann[c], Alice Koniges[d], Kevin Gott[d], Steve Langer[c]
*[a]Cymer LLC, 17075 Thormint Ct, San Diego, USA*
*[b]ASML Netherlands B.V., De Run 6501, 5504 DR Veldhoven, The Netherlands*
*[c] Lawrence Livermore National Laboratory, P.O. Box 808, Livermore, CA 94550, USA*
*[d] Lawrence Berkeley National Laboratory, 1 Cyclotron Rd., Berkeley, CA 94720, USA*

## 5:50 PM Workshop Summary and Announcements

**2016 Source Workshop Summary**

Vivek Bakshi
*EUV Litho, Inc.*

## Workshop Adjourned


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