19th Fraunhofer IISB Lithography Simulation Workshop

Lithography Simulation

June 6 – 8, 2024, Behringersmühle, Germany

Program

(status as of May 16, 2024)

Thursday, June 6

6:00 pm: Welcome reception

- 8:00 8:15 pm: Welcome and introduction, Andreas Erdmann (Fraunhofer IISB)
- 8:15 9:00 pm: How computing, GPU, and deep Learning are reshaping lithography, Leo Pang (D2S)

Friday, June 7

- 9:00 9:25 am: **EUV lithography: past, present and future**, Mark van de Kerkhoff (ASML, Univ. of Eindhoven)
- 9:25 9:50 am: **Tip-to-tip printability at High NA EUVL: rigorous simulations and AIMS results,** Guillaume Libeert, Rik Jonckheere, Joern-Holger Franke, Nick Pellens, Peter De Bisschop, Vicky Philipsen (imec)
- 9:50 10:15 am: Modeling of multi-trigger resists, Thiago Jose dos Santos¹, Zelalem Belete¹, Andreas Erdmann¹, Alex P.G. Robinson², Carmen Popescu², A. McClelland² (¹Fraunhofer IISB, ²Irresistible Materials Ltd.)

10:15 – 10:45 am: Coffee break

- 10:45 11:10 am: Fast EUV lithography simulation by CNN including M3D effects, Hiroyoshi Tanabe (Tokyo Institute of Technology)
- 11:10 11:35 am: PINN-based EMF solver for modeling of light diffraction from EUV masks and optical metasurfaces, Vlad Medvedev, Andreas Erdmann, Andreas Rosskopf, Philipp Brendel (Fraunhofer IISB)
- 11:35 am– 12:00 pm: Metalens design: from single component to optical system, Sébastien Héron, Enzo Isnard, Laure Lee, Brigitte Loiseaux (THALES Research & Technology)

12:00 – 1:30 pm: Lunch

- 1:30 1:55 pm: Manufacturing of microlens by grayscale lithography for CMOS image sensors, Marie-Line Pourteau, <u>Aurélien Fay</u>, Sébastien Bérard-Bergery, Florian Tomaso, Elénore Letty, Rémi Coquand, Ujwol Palanchoke, Charlotte Beylier, Guillaume Claveau, Samir Guerroudj (Leti)
- 1:55 2:20 pm: Neural lithography: real2Sim redefines the pipeline of computational lithography, Cheng Zheng¹, Guangyuan Zhao², Peter T.C. So¹ (¹MIT, ²The Chinese University of Hong Kong)
- 2:20 2:45 pm: Training and application of physics-inspired neural networks for two-photon lithography, Valeriia Sedova¹, Andreas Erdmann¹, Joël Rovera², Florie Ogor², Kevin Heggarty² (¹Fraunhofer IISB, ²IMTA)
- 2:45 3:10 pm: Modeling a massively parallelized TPP process for 3D micro/nanostructures fabrication, Joël Rovera¹, Kevin Heggarty¹, Valeriia Sedova², Andreas Erdmann², Thomas Le Deun¹ (¹IMTA, ²Fraunhofer IISB)

3:30 pm: Special event and dinner

Saturday, June 8

- 9:00 9:25 am: A fast method for predicting resist top loss from aerial image, with a reconstructed 3D resist profile using deep neural network, Dereje S. Woldeamanual, Joe Tang, Wolfgang Hoppe, Hans-Juergen Stock, Mariya Braylovska (Synopsys)
- 9:25 9:50 am: A generative approach for SEM images towards advanced node defect inspection in semiconductor manufacturing, Bappaditya Dey, Vic De Ridder, Victor Blanco, Bartel Vanwaeyenberge, Philippe Leray (imec)
- 9:50 10:15 am: EUV imaging enhancement via phase injection: from theory to application, Hidde Keizers, Eelco van Setten, Steven Beekmans, Jungtae Lee (ASML)

10:15 – 10:45 am: Coffee break

- 10:45 11:10 am: Extending EUV beyond 8 nm half-pitch: imaging aspects of increasing NA, Gerardo Bottiglieri, John Mcnamara, Reinier van der Meer, S. Blok, Jim Overkamp (ASML)
- 11:10 11:35 am: Mask repair optimization by aerial image simulation, Fan Tu, Christian Felix Hermanns, Micheal Budach, Hubertus Marbach (Zeiss SMT)
- 11:35 am 12:00 pm: OPC and modeling solution to support High-NA EUV stitching, Dongbo Xu¹, Qinglin Zeng¹, Werner Gillijns², Xuefeng Zeng¹, Vincent Wiaux², Vicky Philipsen², Edita Tejnil¹, Yuyang Sun¹, Germain Fenger¹ (¹Siemens EDA, ²imec)
- 12:00 12:10 pm: Final discussion and concluding remarks

12:30 pm: Lunch

18th Fraunhofer IISB Lithography Simulation Workshop

May 25 – 27, 2023, Behringersmühle, Germany



Program

Thursday, May 25

6:00 pm: Welcome reception

- 8:00 8:15 pm: Welcome and introduction, Andreas Erdmann (Fraunhofer IISB)
- 8:15 9:00 pm: Lithography and the Semiconductor Device Roadmap, Antony Yen (ASML)

Friday, May 26

- 9:00 9:25 am: EUV optics at ZEISS, status and outlook, Martin Kaumanns (Zeiss)
- 9:25 9:50 am: **Imaging objective for higher energy region,** Mitsunori Toyoda, Shota Yamashita, Jun Chen (Tokyo Polytechnic University)
- 9:50 10:15 am: Investigation of the resolution limit for Talbot lithography with compact EUV sources, Bernhard Lüttgenau^{1,2}, Sascha Brose^{1,2}, Serhiy Danylyuk³, Jochen Stollenwerk^{1,2,3}, Carlo Holly^{1,2,3} (¹RWTH Aachen, ²JARA, ³Fraunhofer ILT)
- 10:15 10:40 am: Extreme ultraviolet metalens by vacuum guiding, Marcus Ossiander¹, Maryna Leonidivna Meretska¹, Hana Kristin Hampel², Soon Wei Daniel Lim¹, Nico Knefz², Thomas Jauk², Federico Capasso¹, Martin Schultze² (¹Harvard University, ²Graz University of Technology)

10:40 – 11:10 am: Coffee break

- 11:10 11:35 am: Modeling and simulation of grayscale photolithographic patterning for optical microstructures, Robert Leitel¹, Jiayi Lu¹, Valeriia Sedova², Andreas Erdmann² (¹Fraunhofer IOF, ²Fraunhofer IISB)
- 11:35 am 12:00 pm: Modeling the massively parallel fabrication of 2.5D and 3D profiles into triplet-triplet annihilation up-conversion process photoresists, Valeriia Sedova¹, Florie Ogor², Kevin Heggarty², Andreas Erdmann¹ (¹Fraunhofer IISB, ²IMTA)
- 12:00 12:25 pm: Grayscale lithography: using machine learning to explore the next step in mask development, Jean-Baptiste Henry, Sébastien Bérard-Bergery, Sébastien Balle, Bao-Luu Tran, Loic Perraud (Leti)

12:25 – 2:00 pm: Lunch

- 2:00 2:25 pm: **IMEC mask roadmap and strategy towards high NA EUV era**, Kenichi Miyaguchi, Darko Trivkovic, Jane Wang, Werner Gillijns, Youssef Drissi, Ryan Ryoung han Kim (imec)
- 2:25 2:50 pm: **Towards an OPC rulebook: two practical examples**, Sander Blok, Sofia Leitao, Launora Bilalaj (ASML)
- 2:50 3:15 pm: Exposure optimization used in Multi-Beam Mask Writer (MBMW) for leadingedge mask patterning, Peter Hudek (IMS Nanofabrication GmbH)
- 3:15 3:40 pm: AI supported defect detection on lithography masks, Peter Evanschitzky (Fraunhofer IISB)

4:00 pm: Special event and dinner

Saturday, May 27

- 9:00 9:25 am: Levelling of photoresist over topography, Thomas Mulders, Hans-Juergen Stock (Synopsys)
- 9:25 9:50 am: LWR offset: identifying imaging contrast and resist impact contributions to pattern variability, Bernardo Oyarzun, Joost van Bree, Luc van Kessel, Ruben Maas (ASML)
- 9:50 10:15 am: Multiple spectral harmonics and spatial modes EUV ptychography with automatic-differentiation, Yifeng Shao, Sven Weerdenburg, Jacob Seifert, Paul H. Urbach, Allard Mosk, Wim Coene (TU Delft, LINX Team)

10:15 – 10:45 am: Coffee break

- 10:45 11:10 am: **Stitching simulation methodology for 0.55 NA EUV**, Daniel Wilson, Bram Slachter, Airat Galiullin, Tenzin Kunsel, Laura Huddleston, Friso Wittebrood, Eelco van Setten, Natalia Davydova (ASML)
- 11:10 11:35 am: **High NA EUV imaging trade-offs in the mask absorber material space**, Nick Pellens, Peter De Bisschop, Vicky Philipsen (imec)
- 11:35 am 12:00 pm: Modeling of multilayer degradation and impact on lithographic imaging metrics, Hazem Mesilhy, Peter Evanschitzky, Andreas Erdmann (Fraunhofer IISB)
- 12:00 12:10 pm: Final discussion and concluding remarks

12:30 pm: Lunch



AGENDA

The workshop brings together experts from various fields of lithography simulation.

It provides an excellent opportunity to exchange ideas and discuss results and developments in:

- Computational EUV lithography: 3D mask, high NA and stochastic effects, resolution enhancement techniques, novel resist materials and phenomena
- Computational metrology and imaging for lithography: Deep learning and related techniques, mask characterization, hybrid optical models, SEM modeling, big data and novel methods for process characterization
- Modeling challenges and solutions for lithography applications beyond CMOS: 3D lithography and gray tone techniques for micro- and nanooptics, Si-photonics, bio-sensing, MEMS, ...

scatterometry mask defect inspection interference lithography high-NA EUV new mask stacks direct laser writing lithography gray-tone lithography 3-D lithography_{GSAX} non-IC applications EUV pellicle EUV DSA phase retrieval ptychography stochastic effects STED-inspired lithography metrology for DSA

DIRECTIONS AND CONTACT

ADDRESS

Behringers Freizeit- und Tagungshotel Behringersmühle 23, 91327 Gößweinstein, Germany

phone +49 9242 740030 www.tagungshotel-behringers.de

If you arrive by car:

- Coming from Frankfurt follow highway A3, take the exit Höchstadt-Ost, follow the B470
- Coming from Berlin follow highway A9, take the exit Pegnitz, follow the B470
- Coming from Munich follow highway A9, take the exit Pegnitz, follow the B470

If you arrive by airplane or by train, or if you require further information, please contact:

Dr. Andreas Erdmann Fraunhofer Institute for Integrated Systems and Device Technology IISB Schottkystrasse 10, 91058 Erlangen, Germany

phone: +49 9131 / 761 258 lithography@iisb.fraunhofer.de www.drlitho.com

REGISTRATION

www.litho-workshop.com



FRAUNHOFER INSTITUTE FOR INTEGRATED SYSTEMS AND DEVICE TECHNOLOGY

17th FRAUNHOFER IISB LITHOGRAPHY SIMULATION WORKSHOP

September 26 – 28, 2019, Behringersmühle, Germany









Thursday, September 26

20:15 –	A Rising Tide Lifts All Boats: Machine
20:00 – 20:15	Welcome and introduction, A. Erdmann (Fraunhofer IISB)
18:00	Welcome reception

21:00 in the Context of Photomask Production, C. Utzny (AMTC)

Learning

Friday, September 27

- 09:00 Developing Methods for Studying Ultrafast EUV
 09:25 Resist Kinetics for Improved Resist Modeling, R. Fallica¹, I. Pollentier¹, P. Vanelderen¹, B. Peterson², P. van der Heide¹, J. Petersen¹ (¹imec, ²KMLabs)
- 09:25 Pattern Formation Mechanisms of Metal
- 09:50 Oxide Nanocluster EUV Resists, T. Kozawa (Osaka University)
- 09:50 -Calibration Strategy of Physical Stochastic EUV10:15Resist Models, D. Ponomarenco, T. Mülders,
- U. Welling, J. Tang, H.-J. Stock (Synopsis)
- 10:15 10:45 Coffee break
- 10:45 High NA EUV Lithography Simulation Using
- 11:10 New Calibrated Mo/Si Multilayer Model, M. Wu, I. Makhotkin, V, Philipsen (imec)
- 11:10 Pathfinding the Perfect EUV Mask: The Role
- 11:35 of the Multilayer, H. Mesilhy¹, P. Evanschitzky¹,
 G. Bottiglieri², E. van Setten², T. Fliervoet²,
 A. Erdmann¹ (¹Fraunhofer IISB, ²ASML)

- 11:35 Extreme-Ultraviolet Refractive Optics,
- 12:00 O. Kornilov, L. Drescher, T. Witting, M. Vrakking, B. Schütte (Max-Born-Institut Berlin)

12:00 – 13:30 Lunch

13:30 - Computational Metrology: Challenges and

 13:55 Opportunities, A. Fay¹, A. Forier¹, A. Girodon¹, J.-B. Henry¹, L. Perraud¹, P. Quéméré¹, S. Bérard-Bergery¹, C. Valade² (¹Leti, ²STMicroelectonics)

13:55 – EUVPtycho – Ptychography Reconstruction Us-

14:20 **ing Distributed GPUs,** U. Locans, A. Dejkameh, Y. Ekinci, I. Mochi, R. Nebling (PSI)

14:20 – 14:50 Coffee break

- 14:50 **Deep Learning with Broad Applications in**
- 15:15 Lithography, M. Pisarenco, S. Middlebrooks, M. Kooiman, C. Batistakis, T. Huisman (ASML)

15:15 – Mask Defect Assessment from SEM Images 15:40 Aided by Deep Learning Methods, P. Evanschitzky (Fraunhofer IISB)

16:00 Special event and dinner

Saturday, September 28

- 09:00 First Principle Based Physical Modeling of 09:25 Photoresists, G. Khaira, Y. Granik, A. Druts
 - Photoresists, G. Khaira, Y. Granik, A. Drutsa, G. Fenger, A. Kostas (Mentor Graphics)

09:25 – Simulation Study for Organometallic 09:50 Resists for EUV Lithography, Z. Belete^{1, 2}, A. Erdmann^{1, 2}, P. De Bisschop³, U. Welling⁴ (¹Fraunhofer IISB, ²FAU Erlangen-Nürnberg, ³imec, ⁴Synopsys)

09:50 – Mask Simulation Impact on Wafer Pattern

10:15 **Stochastic Patterning Predictions,** D. Dunn¹, S. Sieg¹, L. Melvin², K. Hooker², M. Ramadan³, M. Green³ (¹IBM, ²Synopsys, ³Photronics)

10:15 – 10:45 Coffee break

10:45 – 11:10	Investigating the Lithographic Effects of Particles on High NA EUV Mask Pellicle, L. Devaraj ¹ , G. Bottiglieri ¹ , A. Erdmann ² , F. Wählisch ¹ , M. Kupers ¹ , E. van Setten ¹ , T. Fliervoet ¹ (¹ ASML, ² Fraunhofer IISB)
11:10 – 11:35	Critical Pattern Behavior at Nanometer Scale Vicinity of Etched Black Border, T. Kovalevich ¹ , J. Bekaert ¹ , V. Wiaux ¹ , MC. Tien ² , N. Davydova ³ (¹ imec, ² Brion, ³ ASML)
11:35 – 12:00	Introducing Etch Kernels for Efficient Pattern Sampling and Etch Bias Prediction, F. Weisbuch, A. Lutich, J. Schatz (Globalfoundries)
12:10 – 12:20	Final discussion and concluding remarks

12:30 Lunch



AGENDA

The workshop brings together experts from various fields of lithography simulation.

It provides an excellent opportunity to exchange ideas and discuss results and developments in:

- Computational EUV lithography: 3D mask, high NA and stochastic effects, resolution enhancement techniques, mask metrology
- Emerging computational techniques for lithography and imaging: Machine learning, deep learning, multi-objective optimization
- Modeling challenges and solutions for lithography applications beyond CMOS: Si-photonics, flat-panel displays, bio-sensing, MEMS, ...

scatterometry mask defect inspection interference lithography high-NA EUV new mask stacks direct laser writing lithography gray-tone lithography 3-D lithography GSAX non-IC applications EUV pellicle EUV DSA phase retrieval ptychography stochastic effects STED-inspired lithography metrology for DSA

DIRECTIONS AND CONTACT

ADDRESS

HOTEL SCHLOSSBERG Haidhof 5, 91322 Gräfenberg, Germany

phone +49 9197 62 84 0 www.hotel-schlossberg.com

Arrival by car:

• Ask your navigation system

Public transport:

You have the following choices,

- take the train line R21 from Nuremberg station Nordost to Gräfenberg; hourly connection,
- take train or bus to Forchheim (Oberfranken) and Bus 223 to Gräfenberg; connection every 90 minutes.

Inform us about your approximate arrival time in Gräfenberg. We will organize shuttle service from the hotel.

If you require further information, please contact:

Dr. Andreas Erdmann Fraunhofer Institute for Integrated Systems and Device Technology IISB Schottkystrasse 10, 91058 Erlangen, Germany

phone: +49 9131 / 761 258 | fax: +49 9131 / 761 212 lithography@iisb.fraunhofer.de www.drlitho.com

REGISTRATION

www.litho-workshop.com



FRAUNHOFER INSTITUTE FOR INTEGRATED SYSTEMS AND DEVICE TECHNOLOGY

16th FRAUNHOFER IISB LITHOGRAPHY SIMULATION WORKSHOP

September 13 – 15, 2018, Gräfenberg, Germany











Thursday, September 13

- 12:30 Welcome, lunch
- 14:00 Welcome and introduction,
- 14:15 A. Erdmann (Fraunhofer IISB)
- 14:15 Logic technology scaling paradigm change its
- 15:00 **impact on patterning and computational lithography,** R.H. Kim et al. (imec)
- 15:00 15:30 Coffee break
- 15:30 High NA EUV lithography: The next step in
- 15:55 EUV imaging, E. van Setten¹, J. McNamara¹, J. van Schoot¹, G. Bottiglieri¹, K. Troost¹, T. Fliervoet¹, S. Hsu², J. Zimmermann³, J.T. Neumann³, M. Roesch³, P. Graeupner³ (¹ASML Netherlands B.V., ²ASML Brion, ³Carl Zeiss SMT)
- 15:55 EUV optics with flexible illumination for
- 16:20 enhanced resolution, J. Liddle et al. (Carl Zeiss SMT)
- 16:20 3D mask effects in high NA EUV imaging,
- 16:45 A. Erdmann¹, P. Evanschitzky¹, G. Bottiglieri², E. van Setten², T. Fliervoet² (Fraunhofer IISB, ASML)
- 16:45 17:15 Coffee break
- 17:15 Lithography simulation and OPC for photonic
- 17:40 **IC,** N. Uenal¹, U. Hofmann¹, J. Bolk² (¹GenISys, ²TU Eindhoven)
- 17:40 -**3D shapes patterning with single optical**
- 18:05 lithography step: Application to the imagers case, S. Bérard-Bergery¹, J. Hazart¹, P. Quéméré¹, P. Chevalier² et al. (¹CEA LETI, ²STMicroelectronics)

18:05 – Projection, ablation and printing through
 18:30 multimode fibres, E. Kakkava, B. Rahmani,
 G. Konstantinou, D. Psaltis, C. Moser (EPFL Lausanne)

19:00 Conference reception

Friday, September 14

09:00 – 09:25	Is the future of semiconductor metrology with short wavelengths?, S. Danylyuk, L. Bahrenberg, P. Loosen (RWTH Aachen)
09:25 – 09:50	Image recovery in lenless imaging of EUV reticles with broad band illumination employing state mixtures, S. Fernandez, R. Rajeev P. Helfenstein, I. Mochi, D. Kazazis, and Y. Ekinci (PSI)
9:50 – 10:15	Spectrally resolved lensless imaging with table- top extreme-ultraviolet sources; M. Jansen, A. de Beurs, X. Liu, K. Eikema, S. Witte (ARCNL)

10:15 – 10:45 Coffee break

10:45 - Simulating scattering of lamellar optical

 11:10 gratings with irregularities, M. Heusinger¹, M. Banasch², D. Michaelis³, T. Flügel-Paul³, Uwe D. Zeitner^{1,3} (¹FSU Jena, IAP; ²Vistec Electron Beam GmbH, ³Fraunhofer IOF)

11:10 – Study of simulated EUV mask absorber

- 11:35 **thickness and sidewall variation impact on wafer pattern fidelity,** L.S. Melvin III¹, E. Gallagher², A. Frommhold², Y. Shusuke³ et al. (¹Synopsys, ²imec, ³NuFlare)
- 11:35 Stochasticity in EUV lithography, T. Kozawa¹,
 12:00 J.J. Santillan², T. Itani² (¹Osaka Univ., ²EIDEC)

12:00 – 13:30 Lunch

13:30 -A generalized framework for reconstructing 13:55 low-resolution lithography images using Fourier ptychography and U-net convolutional network, P. Govalkar¹, C. Syben¹, A. Erdmann^{1,2}, A. Maier¹ (¹FAU Erlangen-Nuremberg, ²Fraunhofer IISB) 13:55 – Ptychography with multiple wavelength illumination, X. Wei, H.P. Urbach (TU Delft) 14:20 14:20 -Analysis of resist deformation and 14:45 shrinkage during lithographic processing, S. D'Silva¹, T. Mülders², H.J. Stock², A. Erdmann¹ (¹Fraunhofer IISB, ²Synopsys) 14:45 – 15:15 Coffee break New EUV mask absorbers, V. Luong, V. Philipsen, 15:15 -E. Hendrickx (imec) 15:40 15:40 -**Rigorous EUV SRAF optimization,** F. Lenahan¹, P. Evanschitzky¹, V. Philipsen², A. Erdmann¹ 16:05 (¹Fraunhofer IISB, ²imec) 16:05 -Patterning analysis for 5nm and beyond employing virtual fabrication, B. Vincent et al. 16:30 (Coventor – A Lam Research Company) 17:00 Special event and dinner

.

Saturday, September 15

09:00 – 14:00 Litho hike ~ 10 km: Participation optional; risk, food and drink are on your own. Don't forget walking shoes!



AGENDA

The workshop brings together experts from various fields of lithography simulation.

It provides an excellent opportunity to exchange ideas and discuss results and developments in:

- Latest research activities and future developments in lithography and lithography simulation
- Limitations of present simulation models and required model extensions
- Sharing experience and ideas from various fields of expertise (modeling, tool & material suppliers, and semiconductor manufacturing)

This year's workshop will focus on:

scatterometry mask defect inspection interference lithography high-NA EUV new mask stacks direct laser writing lithography gray-tone lithography 3-D lithography GSAX non-IC applications EUV pellicle EUV DSA phase retrieval ptychography stochastic effects STED-inspired lithography metrology for DSA

DIRECTIONS AND CONTACT

Address:

Behringers Freizeit- und Tagungshotel Behringersmühle 23, 91327 Gößweinstein, Germany

phone +49 9242 740030 www.tagungshotel-behringers.de

If you arrive by car:

- Coming from Frankfurt follow highway A3, take the exit Höchstadt-Ost, follow the B470
- Coming from Berlin follow highway A9, take the exit Pegnitz, follow the B470
- Coming from Munich follow highway A9, take the exit Pegnitz, follow the B470

If you arrive by airplane or by train, or if you require further information, please contact:

Dr. Andreas Erdmann Fraunhofer Institute for Integrated Systems and Device Technology IISB Schottkystrasse 10, 91058 Erlangen, Germany

phone: +49 9131 / 761 258 | fax: +49 9131 / 761 212 lithography@iisb.fraunhofer.de www.drlitho.com

Registration:

www.litho-workshop.com



FRAUNHOFER INSTITUTE FOR INTEGRATED SYSTEMS AND DEVICE TECHNOLOGY

15th FRAUNHOFER IISB LITHOGRAPHY SIMULATION WORKSHOP

September 21 – 23, 2017, Behringersmühle, Germany









Thursday, September 21

06:00 p.m. Welcome reception

- 08:00 Welcome and introduction,
- 08:15 p.m. A. Erdmann (Fraunhofer IISB)
- 08:15 Computational microscopes for gigapixel 3D
- 09:00 p.m. **imaging and inspection,** R. Horstmeyer (Charite, Humboldt University Berlin)

Friday, September 22

- 09:00 Latest developments in EUV optics, 09:25 a.m. J. Liddle, J. Zimmermann, J.T. Neumann, M. Roesch,
- R. Gehrke, P. Gräupner (Zeiss SMT)
- 09:25 -Exploration of nearfield scattering in an EUV09:50 a.m.lithography mask stack with a high numerical
aperture systems,

Y. Kandel, L. S. Melvin III (Synopsys)

- 09:50 -
- 10:15 a.m. Attenuated PSM for EUV: Will they fly?,
 A. Erdmann¹, P. Evanschitzky¹, T. Fühner¹,
 V. Philipsen², E. Hendricx², M. Bauer³ (¹Fraunhofer IISB, ²imec, ³Zeiss SMS)
- 10:15 10:45 a.m. Coffee break
- 10:45 -SLM-based three-dimensional micro-printing,11:10 a.m.F. E.H. Waller, J. Hering, C. Jörg, G. von Freymann
- (TU Kaiserslautern)

11:10 - **3D direct laser writing of camera lenses on**

11:35 a.m. **CMOS substrates,** S. Ristok, S. Thiele, T. Gissibl, A. Herkommer, H. Gießen (University of Stuttgart)

- 11:35 Exploring 3D resist effects in e-beam and
- 12:00 a.m. **laser direct writing,** FC. Kaspar¹, T. Onanuga² (¹IMS Chips, ²Fraunhofer IISB)

12:00 – 01:30 p.m. Lunch

- 01:30 -Impact of NXE3400 source on process window01:55 p.m.for 7 nm node,
Jae Uk Lee and Ryan Ryoung han Kim (imec)
- 01:55 Application of SRAFs and source optimization
- 02:20 p.m. for mitigation of mask3D effects in high-NA EUV lithography, J. Lubkoll, E. van Setten, J. Finders, L. de Winter (ASML)

02:20 – 02:50 p.m. Coffee break

02:50 - Simulation of metal resist used for extreme

03:15 p.m. **ultraviolet lithography,** T. Kozawa¹, J.J. Santillan², T. Itani² (¹The Institute of Scientific and Industrial Research, Osaka University, ²Evolving Nano-process Infrastructure Development Center, Inc. - EIDEC)

03:15 - Comparison of modeling options for NTD resist

03:40 p.m. **shrinkage,** S. D'Silva¹, T. Mulders², H.J. Stock², A. Erdmann¹ (¹Fraunhofer IISB, ²Synopsys)

04:00 p.m. Special event and dinner

Saturday, September 23

09:00 – A heuristic derivation of fundamental laws of 09:25 a.m. optical lithography, D. Peng (TSMC)

09:25 – 09:50 a.m.	Application of hyperbolic meta-material for waveguide engineering, Ying Tang (TU Delft)	
09:50 – 10:15 a.m.	Characterization of Talbot lithography based on self-imaging, T. Sato, A. Yamada, T. Suto, R. Inanami, K. Matsuki, S. Ito (Toshiba)	
10:15 – 10:	10:15 – 10:45 a.m. Coffee break	
10:45 – 11:10 a.m.	Single exposure EUV block downscaling for metal pitches below 32nm, J.H. Franke ¹ , P. Colsters ² , J. Bekaert ¹ , E. Hendrickx ¹ , F. Wittebrood ² , A. Pathak ¹ , G. Schiffelers ² (¹ imec, ² ASML)	
11:10 – 11:35 a.m.	Actinic mask inspection with RESCAN - recent progress, P. Helfenstein ¹ , I. Mochi ¹ , R. Rajeev ¹ , Y. Ekinci ¹ , S. Yoshitake ² (¹ PSI, ² NuFlare)	
11:35 – 12:10 a.m.	High NA anamorphic EUV lithography: Scan- ner design and imaging performance from a different angle, E. van Setten ¹ , G. Bottiglieri ¹ , L. de Winter ¹ , J. McNamara ¹ , P. Rusu ¹ , J. Lubkoll ¹ , G. Rispens ¹ , J. van Schoot ¹ , J.T. Neumann ² , M. Roesch ² , B. Kneer ² (¹ ASML, ² Zeiss SMT)	
12:10 – 12:30 p.m.	Final discussion and concluding remarks	

12:30 p.m. Lunch





AGENDA

The workshop brings together experts from various fields of lithography simulation.

It provides an excellent opportunity to exchange ideas and discuss results and developments in:

- Latest research activities and future developments in lithography and lithography simulation
- Limitations of present simulation models and required model extensions
- Sharing experience and ideas from various fields of expertise (modeling, tool & material suppliers, and semiconductor manufacturing)

This year's workshop will focus on:

- Computational resolution enhancements for lithography, microscopy and other imaging applications
- Modeling of material-driven resolution enhancements: directed self-assembly (DSA), multi-color lithography
- Computational challenges of EUV lithography: high NA, new mask stacks, stochastic effects
- Lithography applications beyond CMOS: Silicon-photonics, MEMS, flat panel displays, bio-sensing, ...

DIRECTIONS AND CONTACT

Address:

Hotel Lindenhof Hubmersberg 2, 91224 Pommelsbrunn, Germany

phone +49 9154 / 270 | fax +49 9154 / 273 70 www.tagungsoase.de

If you arrive by car:

Follow highway A9 (Munich–Nuremberg–Berlin), take the exit to Hersbruck / Sulzbach-Rosenberg, pass Hersbruck, follow the B14 and take the exit Neuhaus-Hohenstadt. After 500 m, turn right to Hubmersberg.

If you arrive by airplane or by train, or if you require further information, please contact:

Dr. Andreas Erdmann Fraunhofer Institute for Integrated Systems and Device Technology IISB Schottkystrasse 10, 91058 Erlangen, Germany

phone: +49 9131 / 761 258 | fax: +49 9131 / 761 212 lithography@iisb.fraunhofer.de www.drlitho.com

Registration:

www.litho-workshop.com



FRAUNHOFER INSTITUTE FOR INTEGRATED SYSTEMS AND DEVICE TECHNOLOGY

14th FRAUNHOFER IISB LITHOGRAPHY SIMULATION WORKSHOP

September 22 – 24, 2016, Hersbruck, Germany





Lithography Simulation





Thursday, September 22

06:00 p.m. Welcome reception

- 00:80	Welcome and introduction,
08:30 p.m.	A. Erdmann (Fraunhofer IISB)

08:30 – **Imaging at the 5 nm node,** 09:00 p.m. J. Finders (ASML)

Friday, September 23

09:00 – 09:25 a.m.	EUV mask modeling and material improvements for reducing M3D effects, V. Philipsen ¹ , V. Long ¹ , E. Hendrickx ¹ , A. Erdmann ² , P. Evanschitzky ² , D. Xu ² , C. Laubis ³ , F. Scholze ³ (¹ imec, ² Fraunhofer IISB, ³ PTB)
09:25 – 09:50 a.m.	Lensless imaging of EUV waveguides: Mode profiles and polarization dependence,

- S. Zayko, M. Sivis, T. Salditt, S. Schäfer, C. Ropers (University of Göttingen)
- 09:50 Challenges in EUV modeling for OPC simulations
- 10:15 a.m. **due to exposure field dependent effects,** K. Adam, M. Lam, G. Fenger (Mentor Graphics)
- 10:15 10:45 a.m. Coffee break
- 10:45 -Challenges in sub-10 nm fabrication using EUV11:10 a.m.lithography,

T. Kozawa¹, J.J. Santillan², T. Itani² (¹Osaka Univ., ²EIDEC)

11:10 – 11:35 a.m.	 Bright field vs. dark field imaging in EUV at N7 pitches and beyond, JH. Franke¹, J. Bekaert¹, E. Gallagher¹, E. Hendrickx¹, P. Colsters², F. Wittebrood², G. Schiffelers², M. Dusa², J. van Dijk² (¹imec, ²ASML)
11:35 – 12:00 a.m.	Optical systems with freeform surfaces – challenges in simulation and realization, H. Gross, A. Brömel, J. Stock (FSU Jena)
12:00 – 01:.	30 p.m. Lunch
01:30 – 01:55 p.m.	Scanning coherent diffraction microscopy for EUV photomask metrology, P. Helfenstein, I. Mohacsi, Y. Ekinici (Paul Scherrer Institute)
01:55 – 02:20 p.m.	Variations of ptychographic phase retrieval algorithms, S. Konijnenberg ¹ , W. Coene ^{1,2} , S. Pereira ¹ , P. Urbach ¹ (¹ TU Delft, ² ASML)
02:20 – 02:50 p.m. Coffee break	
02:50 – 03:15 p.m.	Comparison of the Cahn-Hillard equation and direct minimization of the free energy functional for the simulation of directed self-assembly, B. Meliorisz, T. Mülders, HJ. Stock, W. Gao (Synopsys)
03:15 –	Automated source/mask/directed self-assembly

03:40 p.m. **optimization using a self-adaptive hierarchical modeling approach,** T. Fühner (Fraunhofer IISB)

Saturday, September 24

09:00 – 09:25 a.m.	Shaping wavefronts with spatial light modulators, A. Jesacher (Innsbruck Medical University, SAOT)	
09:25 – 09:50 a.m.	Flexible pattern generation with laser illumination for mask aligner lithography, T. Weichelt ¹ , U.D. Zeitner ^{1,2} , Yannick Bourgin ¹ (¹ FSU Jena, ² Fraunhofer IOF)	
09:50 – 10:15 a.m.	A physical model for laser direct write lithography, T. Onanuga (Fraunhofer IISB, SAOT)	
10:15 – 10:45 a.m. Coffee break		
10:45 – 11:10 a.m.	Topology optimization projection methods for micro/nano lithography, B. Lazarov, M. Zhou, O. Sigmund (Technical University of Denmark)	
11:10 – 11:35 a.m.	A semi-analytical method for fast electromagnetic modeling in the EUV range, M. Pisarenco, R. Quintanilha, M.G. M. M. van Kraaij, W.M. J. Coene (ASML)	

11:35 – **Efficient simulation of EUV pellicles,** 12:00 a.m. P. Evanschitzky (Fraunhofer IISB)

12:00 – **Final discussion and concluding remarks** 12:20 p.m.

12:30 p.m. Lunch



AGENDA

The workshop brings together experts from various fields of lithography simulation.

It provides an excellent opportunity to exchange ideas and discuss results and developments in:

- Latest research activities and future developments in lithography and lithography simulation
- Limitations of present simulation models and required model extensions
- Sharing experience and ideas from various fields of expertise (modeling, tool & material suppliers and semiconductor manufacturing)

This year's workshop will focus on:

- Computational chemistry for material-driven resolution enhancements: directed self-assembly, multiple patterning and novel imaging materials
- Computational challenges of EUV lithography
- Computational optics for the creation and detection of micro- and nanopatterns: similarities and differences between resolution enhancements in lithography and microscopy

DIRECTIONS AND CONTACT

Address:

Behringers Freizeit- und Tagungshotel Behringersmühle 23, 91327 Gößweinstein, Germany

phone +49 9242 740030 www.tagungshotel-behringers.de

If you arrive by car:

- Coming from Frankfurt follow highway A3, take the exit Höchstadt-Ost, follow the B470
- Coming from Berlin follow highway A9, take the exit Pegnitz, follow the B470
- Coming from Munich follow highway A9, take the exit Pegnitz, follow the B470

If you arrive by airplane or by train, or if you require further information, please contact:

Dr. Andreas Erdmann Fraunhofer Institute for Integrated Systems and Device Technology IISB Schottkystrasse 10, 91058 Erlangen, Germany

phone: +49 9131 / 761 258 | fax: +49 9131 / 761 212 lithography@iisb.fraunhofer.de www.drlitho.com

Registration:

www.litho-workshop.com



FRAUNHOFER INSTITUTE FOR INTEGRATED SYSTEMS AND DEVICE TECHNOLOGY

13th FRAUNHOFER IISB LITHOGRAPHY SIMULATION WORKSHOP

September 10 – 12, 2015, Behringersmühle, Germany





SAOT graduate school in advanced optical technologies



Thursday, September 10

- 06:00 p.m. Welcome reception
- 08:00 Welcome and introduction,
- 08:30 p.m. A. Erdmann (Fraunhofer IISB)
- 08:30 Predictive modeling of equilibrium and non-
- 09:00 p.m. equilibrium block polymer directed assembly for sub-lithographic patterning, J. de Pablo¹, P. Nealey¹, M. Müller² (¹University of Chicago, ²University of Göttingen)

Friday, September 11

- 09:00 High-NA EUV lithography optics: The key to 09:25 a.m. shrinking beyond 8 nm, M. Rösch, J.T. Neumann, B. Kneer, P. Gräupner (Zeiss SMT)
- 09:25 Mask topography-induced phase aberrations
- 09:50 a.m. in EUVL: Impact, fundamental understanding, mitigation, T. Last, L. de Winter, J. Finders (ASML)
- 09:50 **EUV challenges in N7 printability: Experiment vs.** 10:15 a.m. **simulation,** V. Philipsen¹, V. Luong¹, I. Mochi¹, L. Van
- Look¹, E. Hendrickx¹, F. Wittebrood², G. Schiffelers², M. Dusa², T. Fliervoet² (¹imec, ²ASML)
- 10:15 10:45 a.m. Coffee break
- 10:45 Actinic characterization of EUV photomasks by
- 11:10 a.m. **EUV scatterometry,** F. Scholze¹, V. Soltwisch¹, A. Ullrich², V. Philipsen³, S. Burger⁴ (¹PTB, ²AMTC, ³imec, ⁴JCMwave)

- 11:10 Understanding and modeling illumination
 11:35 a.m. systems in projection lithography, D. Smith, D. Flagello, J. Sakamoto (Nikon Research Corporation of America)
- 11:35 Using SEM contours to calibrate OPC models:
- 12:00 a.m. **Advantages and challenges,** F. Weisbuch, K. Jantzen (Globalfoundries)
- 12:00 01:30 p.m. Lunch
- 01:30 **193i lithography for contact doubling with** 01:55 p.m. **grapho-epitaxy DSA: A simulation study,** A. Fouquet¹, L. Perraud¹, S. Bérard-Bergery¹, A. Gharbi¹, P. Pimenta-Barros¹, R. Tiron¹, J. Hazart¹, V. Farys² (¹CEA-LETI, ²ST Microelectronics)

01:55 – A Hamiltonian model application for full chip

- 02:20 p.m. **directed self-assembly (DSA) simulation,** G. Fenger, A. Torres, Y. Ma, Y. Granik, P. Krasnova, J. Mitra (Mentor Graphics)
- 02:20 02:50 p.m. Coffee break

02:50 – Reduced models for DSA simulations, U. Welling¹,

- 03:15 p.m. W. Li¹, J.C. Orozco¹, P. Michalak², T. Fühner², A. Erdmann², M. Müller¹ (¹University of Göttingen, ²FhG IISB)
- 03:15 Toward an integrated lithography/DSA mode-
- 03:40 p.m. **ling platform,** T. Fühner¹, P. Michalak¹, U. Welling², W. Li², J.C. Orozco², M. Müller², A. Erdmann¹ (¹FhG IISB, ²University of Göttingen)

04:00 p.m. Special event and dinner

Saturday, September 12

09:00 -09:25 a.m.
Shot noise effects in extreme ultraviolet lithography, T. Kozawa¹, J.J. Santillan², T. Itani² (¹Osaka University, ²EIDEC)
09:25 -09:50 a.m.
Radially polarized light for detection and nanolocalization of dielectric particles on a planar substrate, S. Roy, K. Ushakova, Q. van den Berg, S.F. Pereira, H.P. Urbach (TU Delft)
09:50 -10:15 a.m.
Detection of sub-lambda asymmetries using phase only structured illumination, S. Peterhänsel, M.L. Gödecke, K. Frenner, W. Osten (University of Stuttgart)
10:15 - 10:45 a.m. Coffee break

- 10:45 Angular dependent scattering of extreme ultraviolet phase and amplitude multilayer defects in an actinic defect inspection,
 L. Bahrenberg¹, S. Herbert¹, S. Danylyuk¹, J. Tempeler¹,
 A. Maryasov¹, R. Lebert², P. Loosen¹, L. Juschkin¹ (¹RWTH Aachen, ²RI Research Instruments GmbH)
- 11:10 **EUV multilayer defect parameter retrieval**
- 11:35 a.m. for patterned masks, D. Xu (FhG IISB)
- 11:35 Methods to determine the optimal shift
- 12:00 a.m. of pattern shifting for mitigation of mask defects in EUV lithography, S. Li, X. Wang, X. Liu, H. Zhang, F. Dai, C. Yang (SIOM)
- 12:00 **Final discussion and concluding remarks** 12:20 p.m.





AGENDA

The workshop brings together experts from various fields of lithography simulation.

It provides an excellent opportunity to exchange ideas and discuss results and developments in:

- Latest research activities and future developments in lithography and lithography simulation
- Limitations of present simulation models and required model extensions
- Sharing experience and ideas from various fields of expertise (modeling, tool & material suppliers, and semiconductor manufacturing)

This year's workshop will focus on:

- Material-driven versus wavelength-driven scaling: latest results from double patterning, directed self-assembly and EUV
- Combination of simulation and metrology: methods to retrieve modeling parameters from metrology, simulation-aided metrology
- Lithography applications beyond CMOS: 3-D nanoprinting, fabrication of photonic components, MEMS and more

DIRECTIONS AND CONTACT

Address:

Hotel Lindenhof Hubmersberg 2, 91224 Pommelsbrunn, Germany

phone +49 9154 / 270 | fax +49 9154 / 273 70 www.tagungsoase.de

If you arrive by car:

Follow highway A9 (Munich–Nuremberg–Berlin), take the exit to Hersbruck / Sulzbach-Rosenberg, pass Hersbruck, follow the B14 and take the exit Neuhaus-Hohenstadt. After 500 m, turn right to Hubmersberg.

If you arrive by airplane or by train, or if you require further information, please contact:

Dr. Andreas Erdmann Fraunhofer Institute for Integrated Systems and Device Technology IISB Schottkystrasse 10, 91058 Erlangen, Germany

phone: +49 9131 / 761 258 | fax: +49 9131 / 761 212 lithography@iisb.fraunhofer.de www.drlitho.com

Registration:

www.litho-workshop.com



FRAUNHOFER INSTITUTE FOR INTEGRATED SYSTEMS AND DEVICE TECHNOLOGY

12th FRAUNHOFER IISB LITHOGRAPHY SIMULATION WORKSHOP

September 11–13, 2014, Hersbruck, Germany





SAOT graduate school in advanced optical technologies



Thursday, September 11

06:00 p.m. Welcome reception

- 08:00 Welcome and introduction, 08:30 p.m. A. Erdmann (Fraunhofer IISB)
- 08:30 High NA the extension path of EUV 09:00 p.m. lithography, J.T. Neumann (Zeiss SMT)

Friday, September 12

- 09:00 **Evaluation of EUV shadowing models across slit** 09:25 a.m. **position,** M. Lam, C. Clifford, G. Fenger (Mentor Graphics)
- 09:25 Capabilities of next generation EUV illumination 09:50 a.m. system 3400, A. Keckeisen (Zeiss SMT)
- 09:50 **Mask-induced phase effects in EUV and DUV,** 10:15 a.m. A. Erdmann¹, P. Evanschitzky¹, J.T. Neumann²,
- P. Gräupner² (¹Fraunhofer IISB, ²Zeiss SMT)
- 10:15 10:45 a.m. Coffee break
- 10:45 Periodic phase masks for high resolution proxi11:10 a.m. mity lithography, L. Stürzebecher, F. Fuchs,
 T. Harzendorf, U. D. Zeitner (Fraunhofer IOF)
- 11:10 Process window optimization for mask aligner
- 11:35 a.m. proximity lithography, U. Vogler¹, A. Bramati¹, R. Völkel¹, D. Nguyen¹, J. Brugger¹, A. Voigt², G. Grützner², A. Erdmann³, N. Ünal⁴, U. Hofmann⁴ (¹Süss Microoptics, ²Microresist Technology, ³Fraunhofer IISB, ⁴GenISys GmbH)

11:35 – **Displacement Talbot lithography using phase**-12:00 a.m. **shift masks,** H. Solak, F. Clube, C. Dais, L. Wang (Eulitha)

12:00 – 01:30 p.m. Lunch

- 01:30 OPW limiting mechanisms of M1 printability
- 01:55 p.m. performance for random-logic applications with 193i, J. Mailfert, P. De Bisschop, K. De Meyer (IMEC)

01:55 – Application of basis functions to robust and

- 02:20 p.m. efficient lithography optimization, X. Wu¹, S. Liu², W. Lv¹, E. Y. Lam¹ (¹Hongkong University, ²Huazhong University)
- 02:20 02:50 p.m. Coffee break

02:50 – Theoretical study on stochastic effects in

03:15 p.m. **chemically amplified resist process for extreme ultraviolet lithography,** T. Takahiro Kozawa¹, J.J. Santillan², T. Itani² (¹Osaka University, ²EIDEC)

03:15 - Stochastic modeling via SEM emulator and PSD

03:40 p.m. **analysis,** A. Vaglio Pret, C. Fang, M.D. Smith, J.J. Biafore, S. Robertson (KLA-Tencor)

04:00 p.m. Special event and dinner

Saturday, September 13

09:00 - Defocus based phase imaging for quantifying

09:25 a.m. **electromagnetic edge effects in photomasks,** A. Shanker¹, M. Sczyrba², B. Connolly³, A. Neureuther¹, L. Waller¹ (¹UC Berkeley, ²AMTC, ³Toppan)

- 09:25 Mask defect parameter retrieval based on 09:50 a.m. high-NA optical projection images, D. Xu (Fraunhofer IISB)
- 09:50 **Method to retrieve aberration of an optics** 10:15 a.m. **from measured vectorial aerial images,** Y. Li, L. Dong, K. Liu, X. Guo (Beijing Institute of Technology)
- 10:15 **Demonstration of aberration retrieval by**
- 10:40 a.m. **using extended Nijboer-Zernike theory,** Y. Shao, A. Polo, S.F. Pereira, H.P. Urbach (TU Delft)

10:40 – 11:10 a.m. Coffee break

1

1:10 –	Defect removal of block-copolymers on pat-
1:35 a.m.	terned surfaces, W. Li ¹ , U. Welling ¹ ,
	J. Orozco ¹ , M. Müller ¹ , P. Michalak ² , T. Fühner ² ,
	A. Erdmann ² (¹ Univ. of Göttingen, ² Fraunhofer IISB)

11:35 – Validation of reduced models for DSA by 12:00 a.m. coarse grained simulations,

> P. Michalak¹, T. Fühner¹, A. Erdmann¹, W. Li², J. Orozco², U. Welling², M. Müller² (¹Fraunhofer IISB, ²Univ. of Göttingen)

12:00 - Multi-color lithography asessment by simula-

12:25 p.m. **tion,** J.S. Petersen¹, J.T. Fourkas², C.A. Mack³, D.A. Markle¹ (¹Periodic Structures, ²Univ. of Maryland, ³lithoguro.com)

12:25 – **Final discussion and concluding remarks** 12:45 p.m.

12:45 – 01:45 p.m. Lunch





Fraunhofer

FRAUNHOFER INSTITUTE FOR INTEGRATED SYSTEMS AND DEVICE TECHNOLOGY

AGENDA

The workshop brings together experts from various fields of lithography simulation. It provides an excellent opportunity to exchange ideas and discuss results and developments in:

- Latest research activities and future developments in lithography and lithography simulation
- Limitations of present simulation models and required model extensions
- Sharing experience and ideas from various fields of expertise (modeling, tool & material suppliers, and semiconductor manufacturing)

This year's workshop will focus on:

- Mask modeling and optimization for EUV and optical lithography: accuracy versus performance, integration into OPC, exploration of new mask concepts.
- Lithography materials and processes: Will they kill or save us? From line edge roughness and pattern collapse to multiple patterning and directed self-assembly.
- Computational lithography for inverse problems: new developments in source mask optimization, defect and aberration retrieval, resist model parameter calibration.

DIRECTIONS AND CONTACT

Address:

Hotel Lindenhof Hubmersberg 2, 91224 Pommelsbrunn, Germany

phone +49 9154 / 270 | fax +49 9154 / 273 70 www.tagungsoase.de

If you arrive by car:

Follow highway A9 (Munich-Nuremberg-Berlin), take the exit to Hersbruck / Sulzbach-Rosenberg, pass Hersbruck, follow the B14 and take the exit Neuhaus-Hohenstadt. After 500 m, turn right to Hubmersberg.

If you arrive by airplane or by train, or if you require further information, please contact:

Dr. Andreas Erdmann

Fraunhofer Institute for Integrated Systems and Device Technology IISB Schottkystrasse 10, 91058 Erlangen, Germany

phone: +49 9131 / 761 258 | fax: +49 9131 / 761 212 lithography@iisb.fraunhofer.de www.drlitho.com

Registration:

www.litho-workshop.com

11[™] FRAUNHOFER IISB LITHOGRAPHY SIMULATION WORKSHOP

September 26–28, 2013, Hersbruck, Germany



Lithography Simulation





Thursday, September 26

06:00 p.m. Welcome reception

08:00 – Welcome and introduction, A. Erdmann 08:30 p.m. (Fraunhofer IISB)

08:30 – Evolution of modeling in OPC: Modeling complex
 09:15 p.m. physical phenomena at large scale and keeping up with ever tighter accuracy requirements,
 K. Adam, Y. Granik, M. Lam, N. Cobb (Mentor Graphics)

Friday, September 27

09:00 – High NA Chapter II – The Journey into EUV Land, 09:25 a.m. D. Flagello (Nikon)

09:25 – Modeling and optimization of EUV-masks for 09:50 a.m. future technology generations,

A. Erdmann¹, T. Fühner¹, K. Motzek¹, J.T. Neumann², P. Gräupner² (¹Fraunhofer IISB, ²Zeiss SMT)

09:00 - Assessing native defect printability and repair

09:25 a.m. **on EUV lithographic masks**, U. Okoroanyanwu¹, P. Mangat¹, P. Nesladek², X. Zhu¹, T. Bret³, T. Wallow¹, O. Wood¹, L. Sun¹, K. Goldberg⁴, R. Ghaskadev⁵ (¹Globalfoundries, ²AMTC, ³Zeiss SMS, ⁴Lawrence Berkeley Nat. Lab., ⁵KLA Tencor)

10:15 – 10:45 a.m. Coffee break

- 10:45 Stochastic effects in chemically amplified resists,
- 11:10 a.m. T. Kozawa (Osaka University)

11:10 – Topographic and other Effects on DUV/EUV

11:35 a.m. pattern fidelity, C. Sarma (Sematech)

11:35 – Measurement and modeling of light scattering 12:00 a.m. from optical components for lithographic systems,

S. Schröder, M. Trost, A. Duparré (Fraunhofer IOF)

12:00 – 01:30 p.m. Lunch

01:30 - Simulation of EUV proximity printing and

01:55 p.m. interference lithography with plasma–based laboratory EUV sources, S. Danylyuk¹, P. Loosen¹, K. Bergmann², H. Kim¹, L. Juschkin¹ (¹RWTH Aachen, ²Fraunhofer ILT)

01:55 - Design and Source Shaping for micron-size

02:20 p.m. **lithography,** U. Hofmann¹, N. Ünal¹, M. Hennemeyer², R. Voelkel³ (¹GenlSys GmbH, ²SUSS MicroTec, ³SUSS MicroOptics)

02:20 – 02:50 p.m. Coffee break

02:50 – Physical DSA model based on Cahn–Hilliard

03:15 p.m. **equation for grapho-epitaxy applications,** S. Moulis¹, R. Orobtchou², A. Gharbi³, M. Argoud³, X. Chevalier⁴, R. Tiron³, J. Belledent³, V. Farys¹ (¹STMicroelectronics, ²INL, ³LETI, ⁴Arkema)

03:15 - Modeling the directed assembly of copolymer

03:40 p.m. materials: a coarse-grained approach, M. Müller, U. Welling (Uni Göttingen)

04:00 p.m. Special event and dinner

Saturday, September 28

- 09:00 Adaptive optics by phase retrieval algorithm
- 09:25 a.m. with minimum number of defocused intensity measurements, A. Polo, S.F. Pereira, H.P. Urbach (TU Delft)
- 09:25 Source representation for SMO using genetic
- 09:50 a.m. algorithm, X. Wang, S. Li, C. Yang, G. Yan (SIOM)
- 09:50 Efficient source and mask optimization with
- 10:15 a.m. **augmented Lagrangian methods in optical lithography**, J. Li, S. Liu, E.Y. Lam (Hongkong University)

10:15 – 10:45 a.m. Coffee break

10:45 – 11:10 a.m.	20nm logic node computational lithography: From calibration to verification at Litho & Etch, J. Mailfert, J. Van De Kerkhove, W. Gillijns, K. De Meyer, P. De Bisschop (IMEC)
11:10 – 11:35 a.m.	Overlay metrology for low-k1: Simulation challenges and solutions, J.T. Neumann, P. Gräupner, B. Geh (Zeiss SMT)
11:35 – 12:00 a.m.	Double patterning-specific process variations and electrical performance of a 6T SRAM cell, P. Evanschitzky (Fraunhofer IISB)
12:00 – 12:30 p.m.	Final discussions and concluding remarks

12:30 p.m. Lunch





AGENDA

The workshop brings together experts from various fields of lithography simulation. It provides an excellent opportunity to exchange ideas and discuss results and developments in:

- Latest research activities and future developments in lithography and lithography simulation
- Limitations of present simulation models and required model extensions
- Sharing experience and ideas from various fields of expertise (modeling, tool & material suppliers, and semiconductor manufacturing)

This year's workshop will focus on:

- Modeling, characterization, and optimization of masks for optical and EUV lithography
- Requirements and use cases for future lithography simulation infrastructure
- Lithographic patterning for micro and nano optics
- Lithographic techniques for the fabrication of micro and nanooptical components

DIRECTIONS AND CONTACT

Address:

Hotel Lindenhof Hubmersberg 2, 91224 Pommelsbrunn, Germany

phone +49 9154 / 270 | fax +49 9154 / 273 70 www.tagungsoase.de

If you arrive by car:

Follow highway A9 (Munich-Nuremberg-Berlin), take the exit to Hersbruck / Sulzbach-Rosenberg, pass Hersbruck, follow the B14 and take the exit Neuhaus-Hohenstadt. After 500 m, turn right to Hubmersberg.

If you arrive by airplane or by train, or if you require further information, please contact:

Dr. Andreas Erdmann

Fraunhofer Institute for Integrated Systems and Device Technology IISB Schottkystrasse 10, 91058 Erlangen, Germany

phone: +49 9131 / 761 258 | fax: +49 9131 / 761 212 lithography@iisb.fraunhofer.de www.drlitho.com

Registration:

www.litho-workshop.com



FRAUNHOFER INSTITUTE FOR INTEGRATED SYSTEMS AND DEVICE TECHNOLOGY

10[™] FRAUNHOFER IISB LITHOGRAPHY SIMULATION WORKSHOP

September 20–22, 2012, Hersbruck, Germany



Lithography Simulation





Thursday, September 20

06:00 p.m. Welcome reception

- 08:00 **Welcome and introduction,** A. Erdmann 08:30 p.m. (Fraunhofer IISB)
- 08:30 Computational lithography for EverMoore,
- 09:15 p.m. V. Singh (Director Computational Lithography, Intel Corporation, USA)

Friday, September 21

- 09:00 How to model imaging in EUV lithography,
- 09:25 a.m. P. Gräupner (Carl Zeiss SMT)
- 09:25 -Efficient simulation of EUV multilayer defects09:50 a.m.with a rigorous data base approach,
P. Evanschitzky (Fraunhofer IISB)
- 09:50 Resist properties required for 6.67 nm extreme
- 10:15 a.m. **ultraviolet lithography,** T. Kozawa¹, A. Erdmann² (¹Osaka University, Japan; ²Fraunhofer IISB)
- 10:15 10:45 a.m. Coffee break
- 10:45 **New design methods for high-quality optical** 11:10 a.m. **systems,** F. Bociort (TU Delft, Netherlands)
- 11:10 Feature type dependent contrast limits of Focus
 11:35 a.m. Drilling for DoF enhancement in HR lithography, C. Kohler, J. van Schaik (ASML, Netherlands)

11:35 – SMARTER microscopy: sparsity mediated algo-

12:00 a.m. rithmic reconstruction technique for enhanced resolution, A. Szameit¹, Y. Shechtman¹, E. Oshero-vich², E. Bullkich¹, P. Sidorenko¹, H. Dana², S. Steiner¹, E.-B. Kley¹, S. Gazit¹, S. Shoham², M. Zibulevsky², I. Yavneh², Y. C. Eldar², O. Cohen², M. Segev¹ (¹University of Jena; ²Technion Haifa, Israel)

12:00 – 01:30 p.m. Lunch

01:30 - Challenges for e-Beam direct write proximity

01:55 p.m. effect correction at the 28nm node, C. Hohle, K.H. Choi, M. Freitag, M. Gutsch, K. Steidel, X. Thrun (Fraunhofer CNT)

01:55 - Enhanced model calibration for e-beam litho-

02:20 p.m. graphy: from pattern selection to parameter optimization, P. Schiavone¹, T. Figueiro¹, M. Saib¹, J.H. Tortai², K. H. Choi³, C. Hohle³ (¹Aselta Nanographics, France; ²CNRS LTM France; ³Fraunhofer CNT)

02:20 – 02:50 p.m. Coffee break

02:50 - Computer simulation of directed self assembly,

03:15 p.m. **equilibrium and kinetics,** U. Welling, C. Daoulas, M. Müller (University of Göttingen)

03:15 - Kinetics of volume hologram formation in

03:40 p.m. epoxy based photopolymers, T. Sabel (TU Berlin)

04:00 p.m. Special event and dinner

Saturday, September 22

09.00 -Numerical calculation of LER scatter 09:25 a.m. signatures in the presence of side-wall angle and roundings, K. Frenner, B. Bilski, W. Osten (TU Stuttgart) 09:25 -Research on in-situ aberration measurement 09:50 a.m. of lithographic projection lenses, X. Wang, S. Li, L. Duan, J. Yang, and G. Yan (SIOM, China) 09.50 -White light Fourier scatterometry for 10:15 a.m. sub-wavelength metrology, V. Ferreras Paz, S. Peterhänsel, K. Frenner, W. Osten (TU Stuttgart) 10:15 – 10:45 a.m. Coffee break Recent progress in fast rigorous electromag-10.45 -11:10 a.m. netic modeling by the Generalized Source Method and perspectives for optical lithography, A. Tishchenko (CNRS UMR, France) Application of an artificial neural network 11:10 -11:35 a.m. to a compact mask model optimization, V. Agudelo-Moreno (Fraunhofer IISB) 11.35 -Rigorous real-time simulation of topo-12:00 a.m. graphic masks effects, J. Pomplun¹, J. Tyminski², L. Zschiedrich¹, S. Burger¹, F. Schmidt¹ (¹JCMwave GmbH; ²Nikon Research Corporation of America, USA) 12:00 -Final discussions and concluding remarks 12:30 p.m





DIRECTIONS AND CONTACT

If you arrive by car:

Follow highway A9 (Munich-Nuremberg-Berlin), take the exit to Hersbruck / Sulzbach-Rosenberg, pass Hersbruck, follow the B14 to the exit Neuhaus-Hohenstadt. After 500 m turn right into Hubmersberg.

Address:

Hotel Lindenhof, Hubmersberg 2 91224 Pommelsbrunn, Germany phone +49 9154 / 270 | fax +49 9154 / 273 70 www.tagungsoase.de

If you arrive by airplane or by train, or if you require further information, please contact:

Andreas Erdmann phone: +49 9131 / 761 258 | fax: +49 9131 / 761 212

Fraunhofer Institute for Integrated Systems and Device Technology Schottkystrasse 10 91058 Erlangen, Germany lithography@iisb.fraunhofer.de www.drlitho.com

Registration: www.litho-workshop.com

Fraunhofer

FRAUNHOFER INSTITUTE FOR INTEGRATED SYSTEMS AND DEVICE TECHNOLOGY

9TH FRAUNHOFER IISB LITHOGRAPHY SIMULATION WORKSHOP

September 15 – 17, 2011, Hersbruck, Germany



Lithography Simulation



AGENDA

The workshop brings together experts from various fields of lithography simulation. It provides an excellent opportunity to exchange ideas and discuss results and developments in:

- Latest research activities and future developments in lithography and lithography simulation
- Limitations of present simulation models and required model extensions
- Sharing experience and ideas from various fields of expertise (modeling, tool & material suppliers, and semiconductor manufacturing)

This year's workshop will focus on:

- Modeling challenges of EUV lithography
- Photoresist modeling from sub-20-nm to 10-µm structures
- Lithographic patterning for micro- and nano-optics
- Modeling approaches to complement standard lithography simulation

Sponsored by:





Thursday, September 15

- 06:00 p.m. Welcome reception
- 08:00 Welcome and introduction, A. Erdmann 08:30 p.m. (Fraunhofer IISB)
- 08:30 **3D direct laser writing: Optical lithography** 09:15 p.m. **without limits?,** M. Wegener (Karlsruhe Institute of Technology)

Friday, September 16

09:00 – Extension of the domain decomposition method 09:25 a.m. for modeling through-slit variations of mask shadowing, K. Adam, M.C. Lam, M. Oliver, J. Word (Mentor Graphics, USA)

09:25 – Analytical model for EUV mask diffraction

- 09:50 a.m. **field calculation,** Y. Cao¹, X. Wang, P. Bu¹, Y. Bu¹, A. Erdmann² (¹SIOM, China; ²IISB)
- 09:50 -Exploration and understanding EUV multilayer10:15 a.m.defects by simulation, A. Erdmann¹,
 - P. Evanschitzky¹, T. Bret², R. Jonkheere³ (¹IISB; ²Zeiss SMS; ³IMEC, Belgium)
- 10:15 10:45 a.m. Coffee break
- 10:45 Theoretical study of 11-nm-fabrication using
- 11:10 a.m. **6.67-nm EUV lithography,** T. Kozawa¹, A. Erdmann² (¹Osaka University, Japan; ²IISB)

11:10 - Modeling photoresist development and optimiz-

- 11:35 a.m. ing resist profiles for mask aligner lithography,
 - K. Motzek¹, S. Partel² (¹IISB; ²FH Vorarlberg, Austria)

 11:35 – Design and verification of a fast physical photoresist imaging and development model from an optical engineering perspective, D. Flagello (Nikon Research Corporation of America, USA)

12:00 – 01:30 p.m. Lunch

01:30 - Alternative methods to determine the e-beam

01:55 p.m. **process proximity function,** R. Galler¹, D. Melzer¹, M. Krüger¹, M. Sülzle¹, U. Weidenmüller², L.E. Ramos² (¹EQUIcon; ²Vistec)

01:55 - Complementary e-beam lithography (CEBL) -

02:20 p.m. **The "dark zebra" in the sub-20 nm lithography race**, M.C. Smayling¹, D.K. Lam², David Liu² (¹Tela Innovations, Inc., USA; ²Multibeam Corporation, USA)

02:20 – 02:50 p.m. Coffee break

02:50 – Photonics on the move: Tunable micro-optics 03:15 p.m. and micro-optical systems, H. Zappe (IMTEK)

03:15 - Nano-optical devices generated by double

03:40 p.m. **patterning,** D. Lehr¹, T. Weber¹, K. Dietrich¹, T. Käsebier¹, S. Babin², E.B. Kley¹, A. Tünnermann¹ (¹FSU Jena; ²Abeam Technologies, USA)

04:00 p.m. Special event and dinner

Saturday, September 17

09:00 - Real-time inverse scatterometry with the re-

09:25 a.m. **duced basis method,** J. Pomplun¹, B.H. Kleemann², J. Kurz³, J. Hetzler², S. Burger^{1,4}, L. Zschiedrich¹, F. Schmidt^{1,4} (¹JCMWave; ²Zeiss; ³KIT; ⁴Zuse-Institut) 09:25 – Mask model optimization in spatial and fre-09:50 a.m. duency domains: Enhancement of the scalar model to retrieve EMF effects, V. Agudelo (IISB)

 Simulations in nano-optics: Better description of nanostructures permittivities and optimization of resonant properties of metallic nanoparticles, A. Vial, D. Macias (CNRS, Troyes, France)

10:15 – 10:45 a.m. Coffee break

10:45 –	How to make radially polarized light for
11:10 a.m.	higher resolution lithography, P. Urbach (TU Delft Netherlands)

- 11:10 Modeling and analysis of diffraction effects at
 11:35 a.m.
 lens surface errors with high spatial frequencies in lithographic inspection systems, H. Schweitzer¹, F. Wyrowski² (¹LightTrans; ²FSU Jena)
- 11:35 Alternative application of predictive image
 12:00 a.m. simulation: Speckle techniques for surface characterization, P. Evanschitzky (IISB)

12:00 – **Final discussion and concluding remarks** 12:30 p.m

12:30 p.m. Lunch





DIRECTIONS AND CONTACT

If you arrive by car:

Follow highway A9 (Munich-Nuremberg-Berlin), take the exit to Hersbruck / Sulzbach-Rosenberg, pass Hersbruck, follow the B14 to the exit Neuhaus-Hohenstadt. After 500 m turn right into Hubmersberg.

Address:

Hotel Lindenhof, Hubmersberg 2 91224 Pommelsbrunn, Germany phone +49 91 54 / 270 | fax +49 91 54 / 2 73 70 www.tagungsoase.de

If you arrive by airplane or by train, or if you require further information, please contact: Andreas Erdmann

phone: +49 91 31 / 76 12 58 | fax: +49 91 31 / 76 12 12

Fraunhofer Institute for Integrated Systems and Device Technology Schottkystrasse 10 91058 Erlangen, Germany lithography@iisb.fraunhofer.de www.drlitho.com

Registration: www.litho-workshop.com

Fraunhofer

FRAUNHOFER INSTITUTE FOR INTEGRATED SYSTEMS AND DEVICE TECHNOLOGY

8TH FRAUNHOFER IISB LITHOGRAPHY SIMULATION WORKSHOP

September 23 – 25, 2010, Hersbruck, Germany







AGENDA

The workshop brings together experts from various fields of lithography simulation. It provides an excellent opportunity to exchange ideas and discuss results and developments in:

- Latest research activities and future developments in lithography and lithography simulation
- Limitations of present simulation models and required model extensions
- Sharing experience and ideas from various fields of expertise (modeling, tool & material suppliers, and semiconductor manufacturing)

This year's workshop will focus on:

- Modeling challenges of EUV lithography
- Advanced mask and image models for projection lithography
- Modeling and metrology for mask aligner lithography
- Pattern generation beyond standard thin film technology





Thursday, September 23

06:00 p.m. Welcome reception

- 08:00 **Welcome and introduction**, A. Erdmann 08:30 p.m. (Fraunhofer IISB, Germany)
- 08:30 Simulating for food and the evolution of litho-09:15 p.m. graphic simulation, D. Flagello (Nikon Research Corporation of America, USA)

Friday, September 24

- 09:00 Resist parameter extraction from line and
- 09:25 a.m. **space patterns of chemically amplified resist for extreme ultraviolet lithography,** T. Kozawa¹, H. Oizumi², T. Itani², S. Tagawa¹ (¹Osaka University, Japan, ²Selete, Japan)
- 09:25 Impact of mask topography and multilayer stack
- 09:50 a.m. **on high NA imaging of EUV masks,** J. Ruoff, R. Stützle (Carl Zeiss SMT, Germany)
- 09:50 Prediction of the printing behavior of EUV
- 10:15 a.m. **multilayer defects using different simulation methods,** F. Shao, P. Evanschitzky, K. Motzek, A. Erdmann (Fraunhofer IISB, Germany)
- 10:15 10:45 a.m. Coffee break
- 10:45 Adaptive optics and polarization in lithography,11:10 a.m. P. Urbach (TU Delft, The Netherlands)

11:10 - Kernel convolution for fast aerial image

11:35 a.m **estimation,** M. Miller, K. Yamazoe, A. Neureuther (University of California Berkeley, USA)

- 11:35 -
12:00 a.m.Compensation of mask-induced aberration focus
shifts by projector wavefront control,
P. Evanschitzky, F. Shao, T. Fühner, A. Erdmann
 - (Fraunhofer IISB, Germany)

12:00 - 01:30 p.m. Lunch

01:30 - Innovation in mask aligner lithography – MO ex-

01:55 p.m. **posure optics,** R. Voelkel¹, U. Vogler¹, M. Hornung² (¹SUSS Microoptics, Switzerland, ²SUSS Microtec, Germany)

01:55 - Sub-micrometer pattern generation by diffrac-

02:20 p.m. **tive proximity lithography,** U.D. Zeitner, L. Stürzebecher, T. Harzendorf (Fraunhofer IOF, Germany)

02:20 - Optical proximity correction and source mask

- 02:45 p.m. **optimization for mask aligner lithography,** K. Motzek, A. Erdmann (Fraunhofer IISB, Germany)
- 02:45 03:15 p.m. Coffee break

03:15 - New extraction technique of the Dill parameters

03:40 p.m. **for thick resist,** S. Liu, G. Roeder, P. Evanschitzky, A. Erdmann (Fraunhofer IISB, Germany)

03:40 - A new flexible development rate monitor,

04:05 p.m. M. Mayer, S. Partel, R. Schneider, P. Hudek (FH Vorarlberg, Austria)

04:30 p.m. Special event and dinner

Saturday, September 25

- 09:00 Structure origination by complex interference
- 09:25 a.m. **lithography processes,** M. Nitsche, M. Peters, O. Höhn, B. Bläsi (Fraunhofer ISE, Germany)
- 09:25 Measuring amplitude and phase of light
- 09:50 a.m. **emerging from microstructures with the high resolution interference microscope,** T. Scharf, M. Kim, H.P. Herzig (EPFL Neuchatel, Switzerland)

09:50 - First steps towards traceability in scattero-

10:15 a.m. **metry**, H. Groß, B. Bodermann, F. Scholze (PTB, Germany)

10:15 - 10:45 a.m. Coffee break

10:45 - Modal method based on spline expansion for

11:10 a.m. **electromagnetic modeling,** A.M. Armeanu^{1,2}, K. Edee², G. Granet², P. Schiavone¹ (¹LTM/CNRS, France, ²LASMEA Clermont-Ferrand, France)

11:10 - Mask models for the imaging of contact holes

11:35 a.m. **in optical projection lithography**, V. Agudelo, F. Shao, P. Evanschitzky, A. Erdmann (Fraunhofer IISB, Germany)

11:35 - From 2D lithography to 3D patterning,

- 12:00 a.m. H.W. van Zeijl, J. Wei, C. Shen, T.M. Verhaar, P.M. Sarro (TU Delft, The Netherlands)
- 12:00 **Final discussion and concluding remarks** 12:30 p.m
- 12:30 p.m. Lunch



The workshop brings together experts from various fields of

exchange ideas and discuss results and developments in:

lithography and lithography simulation

semiconductor manufacturing)

modeling approaches for EUV

model extensions

This year's workshop will focus on:

and nanosystems

lithography simulation. It provides an excellent opportunity to

Latest research activities and future developments in

Limitations of present simulation models and required

Sharing experience and ideas from various fields of

expertise (modeling, tool & material suppliers, and

Lithography below the Rayleigh limit: double

Lithography at shorter wavelengths: physical effects and

Modeling of lithographic fabrication methods for micro-

Modeling approaches for advanced imaging materials

exposure/patterning and other tricks



DIRECTIONS AND CONTACT

If you arrive by car:

Follow highway A9 (Munich-Nuremberg-Berlin), take exit to Hersbruck/Sulzbach-Rosenberg, pass Hersbruck, follow the B14 to exit Neuhaus-Hohenstadt. After 500 m turn right to Hubmersberg.

Address:

Hotel Lindenhof, Hubmersberg 2 91224 Pommelsbrunn, Germany phone +49 9154/270 | fax +49 9154/27370 www.tagungsoase.de

If you arrive by airplane or by train, or if you require further information, please contact: Andreas Erdmann phone +49 9131/761258 | fax +49 9131/761212

Fraunhofer Institute for Integrated Systems and Device Technology, Schottkystrasse 10 91058 Erlangen, Germany lithography@iisb.fraunhofer.de www.drlitho.com

Registration www.litho-workshop.com



FRAUNHOFER INSTITUTE FOR INTEGRATED SYSTEMS AND DEVICE TECHNOLOGY

7TH FRAUNHOFER IISB LITHOGRAPHY SIMULATION WORKSHOP

September 25–27, 2009, Hersbruck, Germany







Sponsored by:

AGENDA

٠

.

٠

٠





Friday, September 25

06:00 p.m. Welcome reception

- 00:80	Welcome and introduction, A. Erdmann
08:30 p.m.	(Fraunhofer IISB, Germany)

- 08:30 Optical imaging using metamaterials,
- 09:15 p.m. E. Shamonina (University Erlangen-Nuremberg, Germany)

Saturday, September 26

- 09:00 Wafer topography and multiple exposure 09:25 a.m. effects in dual resist double patterning processes, A. Erdmann, F. Shao, P. Evanschitzky, T. Fühner (Fraunhofer IISB, Germany)
- 09:25 Modeling and simulation of post exposure
- 09:50 a.m. **bake processes in double patterning**, J. Fuhrmann¹, A. Fiebach¹, A. Erdmann² (¹WIAS, Germany; ²Fraunhofer IISB, Germany)

09:50 - **Optimization of the field in focus for**

10:15 a.m. **applications in imaging on polarizationsensitive media**, S.F. Pereira, H.P. Urbach (TU Delft, The Netherlands)

10:15 - 10:45 a.m. Coffee break

1(0:	45	5 -	Τv	/0	photon	ро	lym	eriza	tion –	a	versatile
										-		-

- 11:10 a.m. **tool for nanotechnology**, G. von Freymann (Forschungszentrum Karlsruhe, Germany)
- 11:10 -Near-field lithography with noble metal11:35 a.m.nanostructures and photosensitive silanes,

M. Alvarez, A. Best, K. Koynov, J.M. Alonso, G. Rodriguez, A. del Campo, M. Kreiter (MPI for Polymer Research, Germany

- 11:35 Near-field optical and interferometric
- 12:00 a.m. **methods for the fabrication of molecular nanostructures**, G. Leggett (University Sheffield, UK)

12:00 - 01:30 p.m Lunch

01:30 - 01:55 p.m.	EUV interference lithography at the limits of patterning with photons , H. Solak, V. Auzelyte A. Langner, Y. Ekinci, C. David, J. Gobrecht (Paul Scherrer Institute, Switzerland)
01:55 - 02:20 p.m.	Diffraction effects in an EUV interferometer , M. Saib, M. Besacier, P. Michallon, C. Constancias (LTM/CNRS, France)
02:20 - 02:45 p.m.	Efficient analysis of threedimensional EUV mask-induced imaging artifacts using the waveguide decomposition method, F. Shao, P. Evanschitzky, A. Erdmann (Fraunhofer IISB, Germany)
02:45 - 03:1	5 p.m. Coffee break
03:15 - 03:40 p.m.	Modeling and simulation of chemically amplified resists for EUV lithography, T. Kozawa, S. Tagawa (Osaka University, Japan)
03:40 - 04:05 p.m.	Investigation of the E-beam resist FEP171 by modeling and experiments , S. Ratzsch (University Jena, Germany)
04:30 p.m.	Special event and dinner

Sunday, September 27

09:00 - Examination of Maxwell solver selection

09:25 a.m. **in deep sub-wavelength**, R.T. Greenway, J.S. Petersen (DFMSim, USA)

09:25 - 09:50 a.m.	Finite-Integration method for simulating optical waves in lithography masks , Z. Rahimi ¹ , C. Pflaum ² , A. Erdmann ¹ (¹ Fraunhofer IISB; ² University Erlangen-Nuremberg, Germany)
09:50 - 10:15 a.m.	Diffraction of EUV radiation at EUV masks – experimental results and first interpretation , F. Scholz (PTB, Germany)
10:15 - 10:40 a.m.	Simulation based sensitivity analysis and LER effects for future scaterrometry applications , V. Ferreras-Paz, H. Gilbergs, T. Schuster, K. Frenner, W. Osten (University Stuttgart, Germany)
10:40 - 11:1	0 a.m. Coffee break
11:10 - 11:35 a.m.	Design and fabrication of structured thin films and multilayer gratings , J. Shao (Shanghai Institute of Optics and Fine Mechanics, China)
11:35 – 12:00 a.m.	3D topography effects in mask aligner lithography , B. Meliorisz ¹ , H. Lerch ² , D. Ritter ¹ (¹ GenISys GmbH, Germany; ² AMO GmbH, Germany)
12:00 - 12:25 p.m.	Optimizing illumination pupil and mask layout in mask aligner lithography , K. Motzek, A. Erdmann (Fraunhofer IISB, Germany)
12:25 - 01:00 p.m.	Final discussion and concluding remarks
01.00	

01:00 p.m. Lunch

Organizational Information

Address of the institute:

Fraunhofer Institute of Integrated Systems and Device Technology Schottkystrasse 10 91058 Erlangen, Germany

Contact:

Andreas Erdmann phone +49 9131 / 761-258 fax +49 9131 / 761-212 lithography@iisb.fraunhofer.de www.drlitho.com

Registration:

https://www.triaenatours.gr/mne.php

See also:

www.litho-workshop.com

Venue:

Hilton Hotel Athens Room Thalia 3 46 Vassilissis Sofias Avenue 11528 Athens, Greece phone +30 210 728-1000 fax +30 210 728-1111 www.hilton.com

Directions:

By car:

From the Athens International Airport take Attiki Odos Avenue, which leads to Messogion Avenue. At the end turn left into Vassilissis Sofias Avenue. Follow the road for 1 km (0.6 miles). The Hilton Athens Hotel is located on the left-hand side.

By public transport:

You can use the metro (Line 3, get off at station Evangelismos). The ride is about 25 minutes from the Airport.







Lithography Simulation

6th Fraunhofer IISB Lithography Simulation Workshop September 18 – 20, 2008 at MNE in Athens, Greece



Fraunhofer Institut

Integrierte Systeme und Bauelementetechnologie



6th Fraunhofer IISB Lithography Simulation Workshop

Agenda

The workshop brings together experts from various fields of lithography simulation.

It provides an excellent opportunity to exchange ideas and discuss results and developments in the areas of:

- Latest research activities and future developments in lithography and lithography simulation
- Limitations of present simulation models and required model extensions
- Sharing experience and ideas from various fields of expertise (modeling, tool & material suppliers, and semiconductor manufacturing)

The 2008 workshop will focus on:

- Lithography simulation for 32 nm and below: Double patterning or EUV?
- Lithography simulation and OPC: Which effects have to be covered?
- Lithography simulation for alternative applications: From MEMS to photonic crystals
- Computational lithography

Program

Thursday, September 18

6:00 p.m. Welcome reception

Friday, September 19

9:15 – 9:50 a.m.	Welcome and introduction, A. Erdmann (Fraunhofer IISB, Germany)
9:50 – 10:15 a.m.	The future for EUV and its impact on lithography simulations, A. Göhnermeier, W. Kaiser, M. Lowisch, and M. Bienert (Carl Zeiss SMT, Germany)
10:15 – 10:45 a.m.	Coffee break
10:45 – 11:10 a.m.	Fast simulation methods for EUV masks with buried defects, C.H. Clifford and A.R. Neu- reuther (Univ. of California Berkeley, USA)
11:10 – 11:35 a.m.	Heuristic optimization of EUV lithography process conditions, T. Fühner, A. Erdmann, and P. Evanschitzky (Fraunhofer IISB, Germany)
11:35 a.m. – 12:00 p.m.	Mask aligner lithography simulation for layout verification and optimization using OPC methdology, H. Lerch ¹ , B. Meliorisz ^{2,3} , D. Ritter ² (¹ AMO GmbH, Germany; ² GenlSys GmbH, Germany; ³ Fraunhofer IISB, Germany)
12:00 – 1:30 p.m.	Lunch
1:30 – 1:55 p.m.	An alternative method for advanced litho- graphic imaging: the Extended Nijboer- Zernike formalism, S. van Haver, O.T.A. Janssen, J.J.M. Braat, and S.F. Pereira (TU Delft, Nether- lands)
1:55 – 2:20 p.m.	Design, implementation, and application of a novel Extended Abbe approach, P. Evan- schitzky and T. Fühner (Fraunhofer IISB, Germany)
2:20 – 2:45 p.m.	
	PEB simulation: Benchmarking of numerical solvers for 2D and 3D geometries, A. Fiebach ¹ , T. Schnattinger ² , A. Erdmann ² , J. Fuhrmann ¹ , M. Uhle ¹ (¹ WIAS, Germany; ² Fraunhofer IISB, Germany)
2:45 – 3:10 p.m.	PEB simulation: Benchmarking of numerical solvers for 2D and 3D geometries, A. Fiebach ¹ , T. Schnattinger ² , A. Erdmann ² , J. Fuhrmann ¹ , M. Uhle ¹ (¹ WIAS, Germany; ² Fraunhofer IISB, Germany) Coffee break
2:45 – 3:10 p.m. 3:10 – 3:35 p.m.	PEB simulation: Benchmarking of numerical solvers for 2D and 3D geometries, A. Fiebach ¹ , T. Schnattinger ² , A. Erdmann ² , J. Fuhrmann ¹ , M. Uhle ¹ (¹ WIAS, Germany; ² Fraunhofer IISB, Germany) Coffee break Determination of proximity effect correction parameters for fabrication of nanoimprint templates using variable shaped beam lithography, H. Sailer, J. Butschke, M. Irmscher, and M. Pritschow (IMS Chips, Germany)

F. Schrempel, T. Gischkat, H. Hartung, E.B. Kley, A. Tünnermann, and W. Wesch (Univ. Jena, Germany) Coffee break 4:00 - 4:30 p.m. Design, fabrication, and application of 4:30 – 4:55 p.m. leaky-mode resonant waveguide gratings, R. Magnusson (Univ. Connecticut, USA) 4:55 – 5:20 p.m. Investigating the effect of topography on stitching strategies for pitch splitting double patterning using rigorous physical simulation, S. Robertson, J. Biafore, T. Graves, and M. Smith (KLA-Tencor, USA) 5:20 - 5:45 p.m. Investigation of wafer topography effects in double patterning using rigorous diffraction simulations, F. Shao, P. Evanschitzky, A. Erdmann (Fraunhofer IISB, Germany) Saturday, September 20 9:00 - 9:25 a.m. Stochastic lithography simulation. Updated material models, G. Patsis (IMEL, Greece) 9·25 – 9·50 a m Kinetic Monte Carlo simulation of molecular resists, R.A. Lawson and C.L. Henderson (Georgia Institute of Technology, USA) 9:50 – 10:15 a.m. LWR measurements and its effects on transistor performance, V. Constandoudis (IMEL, Greece) 10:15 – 10:45 a.m. Coffee break 10:45 – 11:10 a.m. Fieldstitching method comprising Kirchhoff's approximation for description of small perturbations of perfectly periodic structures, T. Schuster, S. Rafler, V.F. Paz, K. Frenner, and W. Osten (TU Stuttgart, Germany) 11:10 – 11:35 a.m. Evolution of the domain decomposition method – present and future research to enable 3D mask modeling of mask features smaller than the wavelength (DUV-193nm) or many wavelengths tall (EUV-13nm), K. Adam (Mentor Graphics, USA) 11:35 a.m. -Benchmarking of rigorous methods for electromagnetic field simulations, P. Evan-12:00 p.m. schitzky¹, S. Burger², S. Zschiederich², F. Schmidt², Z. Rahimi¹, A. Erdmann¹ (¹Fraunhofer IISB, Germany; ²JCMWave, Germany) 12:00 – 12:45 p.m. Final discussion and concluding remarks

by means of ion beam enhanced etching.

Organizational Information

Address of the institute:

Fraunhofer Institute of Integrated Systems and Device Technology Schottkystrasse 10 91058 Erlangen, Germany

Contact:

Andreas Erdmann phone +49 (0) 9131 / 761-258 fax +49 (0) 9131 / 761-212 lithography@iisb.fraunhofer.de

Hotel:

Hotel Lindenhof Ringhotel Hersbruck Hubmersberg 2 91224 Pommelsbrunn

To register and for more information, visit: www.litho-workshop.com

Directions – arrival by car:

- follow highway A9 (Munich Nuremberg Berlin), take exit Lauf/Hersbruck,
- pass Hersbruck, follow the B14 to exit Neuhaus-Hohenstadt
- after 3 km take the second road on the right



Please contact us if you arrive by air or by train. We will send you further information.





Lithography Simulation

5th Fraunhofer IISB Lithography Simulation Workshop September 28 – 30, 2007 in Hersbruck, Germany



Fraunhofer Institut

Integrierte Systeme und Bauelementetechnologie





5th Fraunhofer IISB Lithography Simulation Workshop

Agenda

The workshop brings together experts from various fields of lithography simulation. It provides an excellent opportunity to exchange ideas and discuss results and developments in the areas of:

- Latest research activities and future developments in lithography and lithography simulation
- Limitations of present simulation models and required model extensions
- Various fields of expertise (modeling, tool & material suppliers, and semiconductor manufacturing)

The 2007 workshop will focus on :

- Electromagnetic field modeling
- Photoresists
- Process, tool, and wafer fab perspective
- Model development and software integration

Accommodation during the workshop:

The workshop is being held in Hersbruck at the Conference Hotel Lindenhof, located in a typical Franconian landscape.

Program

	Friday, September 28
6:00 pm	Dinner
7:00 pm	Welcome and introduction A. Erdmann (IISB)
7:45 pm	Recent progress in resist materials design for sub-45 nm node lithography applications: Analysis of the limits and possibilities for future resists C.L. Henderson, R. Lawson, C.T. Lee, L.M. Tolbert, R. Whetsell (Georgia Institute of Technology), K. Gonsalves, M. Wang (University of North Carolina Charlotte), W. Yueh, and J. Roberts (Intel Corporation)
8:30 pm	Welcome reception

Saturday, September 29

	····· , ·· , ·· , ··· , ·· ,
8:00 am	Breakfast
9:00 am	Discrete and continuous simulation of photoresist processing T. Schnattinger (IISB)
9:25 am	Mechanistic simulation of line-edge roughness J. Biafore, M. Smith, S. Robertson, and T. Graves (KLA-Tencor)
9:50 am	Polymeric and molecular glass resist models for stochastic lithography simulation D. Drygiannakis, G. P. Patsis, I. Raptis, and E. Gogolides (IMEL Demokritos)
10:15 am	Discussion on resist modeling
10:30 am	Coffee break
11:00 am	The diffraction of dielectric transmission gratings in Littrow mounting – a physical investigation T. Clausnitzer and E.B. Kley (University of Jena)
11:25 am	Coupled eigenmode theory for EMF modeling of grating reticles G. Allen and P. Davids (Intel Corporation)
12:15 pm	Extraordinary high transmission effects – can we exploit them to make better masks? D. Reibold, A. Erdmann (IISB), K. Bubke, and C. Pierrat (AMTC)
12:40 pm	Lunch
2:00 pm	Comparison of convergence behaviour of RCWA and Differential Method S. Rafler (University of Stuttgart)
2:25 pm	Simulation of larger mask areas using the Waveguide Method with a fast decomposition technique F. Shao and P. Evanschitzky (IISB)
2:50 pm	Coffee break
3:20 pm	On the validity of 3-D mask simulations V. Philipsen, P. De Bisschop (IMEC), A. Erdmann, G. Citarella, and P. Evanschitzky (IISB)
3:45 pm	Real time scatterometry for process control S. Soulan, M. Besacier, and P. Schiavone (Laboratoire des Technologies de la Microélectronique CNRS)
4:10 pm	Discussion on rigorous EMF modeling

5:00 pm Special event and dinner

Sunday, September 30

8:00 am	Breakfast
9:00 am	The portability of full physical resist models across illumination conditions and between exposure tools S. Robertson, J. Biafore, and M. Smith (KLA-Tencor)
9:25 am	Modeling three-dimensional EMF mask effects during full-chip OPC M. Lam and K. Adam (Mentor Graphics)
9:50 am	32 nm half pitch node OPC process model development for three dimensional mask effects using rigorous simulation L.S. Melvin III, T. Schmöller, and J. Li (Synopsys)
10:15 am	Coffee break
10:45 am	Root causes of pattern position shift and asymmetry of printed image by non-telecentric optics in EUV lithography M. Sugawara (SONY Electronics Inc.)
11:10 am	Impact of mask pellicle effects on OPC quality H. Koop, T. Schmöller (Synopsys), and W. Cheng (Intel Corporation)
11:35 am	Interference lithography for components in compact integrated spectral sensors and beam shaping optics M. Burkhardt, R. Steiner, K. Rudolf, HJ. Dobschal, M. Helgert, and R. Brunner (Carl Zeiss AG)
12:00	Discussion and closing remarks
1:00 pm	Lunch
2:00 pm	Departure

Fax registration

to Fraunhofer Institute of Integrated Systems and Device Technology

fax + 49(0) 9131/761 - 212

I will participate I will arrive by train in Hersbruck at _____

September 8, 2006

registrationParticipation475,- €feeThe fee covers board, lodging and the evening
program. You will receive a confirmation of
registration. We will invoice you for the fee.

Cancellation In case of cancellations after the expiration of the deadline you will be charged 75% of the fee. Standing in for a registered participant is possible.

Sender

Deadline for

Title, First-Name, Name
Company / Institution
Street
City
Phone, Fax
E-mail

Date, Signature

Use one form per person please.

Organizational information

Address of the

Ş.

Fraunhofer Institute of Integrated

institute	Systems and Device Technology Schottkystrasse 10 91058 Erlangen, Germany
Organization of the workshop	Andreas Erdmann phone +49 (0) 9131/761-258 fax +49 (0) 9131/761-212 lithography@iisb.fraunhofer.de
Hotel	Hotel Lindenhof Ringhotel Hersbruck Hubmersberg 2 91224 Pommelsbrunn
Directions – arrival by	y car
 follow highway Hersbruck/Sulzb 	A9 (Munich – Nuremberg – Berlin), take exit <i>pach-Rosenberg</i> ,
 pass Hersbruck, 	follow the B14 to exit <i>Neuhaus-Hohenstadt</i>
 after 3 km take 	the second road on the right
Schmann Robert Schmann Exit Hersbruck/ Sulzbach-Ro	acti Kirchensittenbach Vorra Hipselbach Kirchensittenbach Hotel Lindenhof Hubmersberg Hersbruck B14 B14 Happarg Exit Neuhaus/ Hohenstadt

Please contact us if you arrive by air or train. We will send you further information.



4th IISB Lithography Simulation Workshop





September 29 – October 1, 2006

in Hersbruck, Germany



Fraunhofer Institut Integrierte Systeme und Bauelementetechnologie

Lithography simulation workshop

Content

The workshop will provide an excellent opportunity to discuss

- the results of the latest research activities and future developments in lithography and lithography simulation
- strong and weak points of present simulation models and necessary model extensions
- various topics from different points of view, as the participants have different backgrounds (modeling, tool & material suppliers, and semiconductor manufacturing)

Focal topics of the 2006 workshop are:

• Alternative lithographies

Simulation of lithographic processes besides from standard projection printing (proximity and near field lithography, nanoimprint, direct e-beam or laser writing, ...)

- Optimization and its application Optimization methods and their applications in lithography simulation
- Extensions of electromagnetic field simulation (EMF) Extensions of 3D electromagnetic field simulations of light diffraction from lithographic masks (material properties, impact of evanescent waves, surface plasmons, ...)

In order to have a fruitful exchange of ideas, the number of participants is limited to 35.

Workshop accomodations

The workshop takes place in Hersbruck at the Conference Hotel Lindenhof, which is located in a typical Franconian landscape.

This workshop is organized by Fraunhofer IISB

Program

Friday, September 29, 2006

6:00 pm Dinner

- 7:00 pm Welcome and introduction A. Erdmann (IISB)
- 7:45 pm **Breaking the diffraction limit using plasmonics** O. Martin (EPFL, Lausanne)
- 8:30 pm Welcome reception

Saturday, September 30, 2006

8:00 am Breakfast

- 9:00 am Theory and practice of polarized optical lithography: Implications for image simulation M. Totzek, D. Krämer, O.Dittmann, A. Göhnermeier (Carl Zeiss)
 9:30 am Fast optical and EUV mask near field simulation using
- the waveguide method P. Evanschitzky (IISB)

10:00 am Coffee break

10:30 am Convergence improvement for RCWA considering crossed gratings using normal vector fields T. Schuster, N. Kerwien, S. Rafler, W. Osten (University of Stuttgart), J. Ruoff (Carl Zeiss)

11:00 am Sensitivity of lithography to scanner and reticle imperfections P. De Bischop, V. Philipsen (IMEC), G. Citarella, A.

Erdmann (IISB)

11:30 pm Discussion on EMF simulation

12:00 pm Lunch

- 1:30 pm Heuristic search methods: Optimization for real-world applications G. Kokai (University of Erlangen / Nuremberg)
- 2:00 pm Optimization of lithographic process conditions by means of artificial evolution T. Fühner (IISB)

2:30 pm	Coffee break
3:00 pm	Simulation and optimization of optical nanostructures Ch. Hafner (ETH Zurich)
3:30 pm	Inverse lithographic imaging of two dimensional gratings R. Köhle, B. Küchler, C. Nölscher (Qimonda)
4:00 pm	ARC and swing optimization for high-NA photolithography J. Bauer, U. Haak (IHP Frankfurt)
4:30 pm	Discussion on optimization
5:00 pm	Special event and dinner
Sunday, C	October 1, 2006
8:00 am	Breakfast
9:00 am	Numerical simulations of electrostatic discharge effects on photomasks S. Boschert (Siemens)
9:30 am	Writing and exposure optimization in maskless direct e-beam lithography P. Hudek (FH Vorarlberg)
10:00 am	Combining flexibility, user-friendliness and a utomation for process simulation, optimization and verification tools

U. Hofmann, N. Ünal (GenISys)

10:30 am Coffee break

11:00 am Mask proximity printing B. Meliorisz (IISB)

- 11:30 am Wafer-scale simulation of nanoimprint V. V. Sirotkin, A. A. Svintsov, S. I. Zaitsev (IMT RAS)
- 12:00 pm Discussion and summary

1:00 pm Lunch

2:00 pm Departure

Fax registration

to Fraunhofer Institute of Integrated Systems and Device Technology

fax + 49(0) 9131/761 - 212

□ I will participate

Deadline for registration	August 31, 2005
Participation fee	475,- € The fee covers board, lodging and the evening program. You will receive a confirmation of registration. We will invoice you for the fee.
Cancellation	In case of cancellations after the expiration of the deadline you will be charged 75% of the fee. Standing in for a registered participant is possible.

Sender

Title, First-Name, Name		
Company, Institution		
Street		
City		
Phone, Fax		
E mail		
E-IIIdii		

Date, Signature

Use one form per person please.

Organizational information

Address of the institute	 Fraunhofer Institute of Integrated Systems and Device Technology Schottkystrasse 10 91058 Erlangen, Germany
Organization of the workshop	of Andreas Erdmann phone +49 (0) 9131 / 761-258 fax +49 (0) 9131 / 761-212 lithography@iisb.fraunhofer.de
Contact	Bernd Tollkühn phone +49 (0) 9131 / 761-216 fax +49 (0) 9131 / 761-212 lithography@iisb.fraunhofer.de
Hotel and wor shop location	 k- Schlosshotel Pommersfelden Schloss 1 96178 Pommersfelden Phone: +49 (0) 9548 / 680
Directions – ar	rival by car
 follow hig <i>Pommersi</i> 	hway A3 (Nuremberg – Würzburg), take exit <i>felden/Bamberg</i> ,
 follow the 	B505 to exit Pommersfelden
	Bamberg
Pomme	rsfelden B 505
Würzburg	exit
	🖌 🖌 🖌 Pommersfelden

Please contact us if you arrive by air or train. We will send you further information.

Erlangen

Nuremberg

A3



3rd IISB Lithography Simulation Workshop





September 16 – 18, 2005

in Pommersfelden, Germany



Fraunhofer Institut Integrierte Systeme und Bauelementetechnologie

Lithography workshop

Content

The workshop will provide an excellent opportunity to discuss

- the results of the latest research activities and future developments in lithography and lithography simulation
- strong and weak points of present simulation models and necessary model extensions
- various topics from different points of view as the participants have different backgrounds (modeling, tool & material suppliers, and semiconductor manufacturing)

Focal topics of the 2005 workshop are:

- **Rigorous electromagnetic field modeling** Methods to compute light diffraction from advanced lithographic masks; mask and wafer topography effects in hyper NA lithography; applications
- Predictivity of resists models

Coupled diffusion in kinetic systems and molecular effects; Line edge roughness and other factors restricting resolution; materials for immersion lithography and simulation issues

• Further simulation issues

Which effects need to be considered in future? Are appropriate models available?

In order to have a fruitful exchange of ideas we will limit the number of participants to 35.

Workshop Accomodations

The workshop takes place at Pommersfelden in the Schlosshotel Pommersfelden which is located in a typical Franconian landscape.

This workshop is organized by Fraunhofer IISB

Program

Friday, September 16, 2005

6:00 pm Dinner

- 7:00 pm Welcome and introduction A. Erdmann (IISB)
- 8:00 pm Lithographic image simulation for the 21st century with 19th century tools R. Gordon (ORA), A. Rosenbluth (IBM)
- 8:30 pm Welcome reception

Saturday, September 17, 2005

8:00 am Breakfast

- 9:00 am Mask topography effects: historical perspective and future trends

 C. Pierrat, K. Bubke, M. Sczyrba, S. Teuber (AMTC)

 9:30 am 3D rigorous electromagnetic simulation using modal methods: applications to EUV masks and scatterometry

 P. Schiavone (CEA-Léti)
- 9:50 am Finite difference time domain and waveguide method beyond the Hopkins approach J. Schermer, P. Evanschitzky (IISB)

10:10 am Coffee break

- 10:30 am Electromagnetic diffraction methods: a comparison from the user perspective J. Ruoff, B. Kleemann (Carl Zeiss)
- 11:00 am Finite elements for the rigorous simulation of timeharmonic waves A. Rathsfeld (WIAS)
- 11:20 am **Mask diffraction at conical off-axis illumination** R. Köhle (Infineon)
- 11:40 pm Discussion on EMF modeling

12:45 pm Lunch

- 2:00 pm Summary of discussion on EMF modeling
 2:30 pm Modeling photoresist in immersion lithography processes

 S. Robertson (Rohm&Haas)
 3:00 pm Numerical simulations of PEB processes
 J. Fuhrmann (WIAS), B. Tollkühn (IISB)

 3:20 pm Coffee break
- 3:40 pm Challenges in applying molecular level models for resist processing simulation T. Schnattinger (IISB)
 4:00 pm Spin coating over topography T. Mülders (Infineon)
 4:20 pm Discussion on resist modeling
- 5:30 pm Sightseeing of the castle and dinner

Sunday, September 18, 2005

8:00 am Breakfast

9:00 pm 9:30 am	Summary of discussion on resist modeling Simulation of photomasks as electromagnetic objects F. Schellenberg, K. Adam (Mentor Graphics), J. Matteo, L. Hesselink (Stanford University)
10:00 am	Simulation study of source polarization on imaging for attenuated PSM masks P. De Bisschop (IMEC)
10:20 am	Polarization effects of a partially coherent light field: applications in optical metrology N. Kerwien, W. Osten (Stuttgart University, ITO), M. Totzek (Carl Zeiss)
10:50 am	Prospects of scatterometry for shape and dimensional metrology on structured surfaces B. Bodermann, M. Wurm (PTB)
11:10 am	Discussion and summary
12:15 pm	Lunch

1:00 pm Departure

Fax registration

to Fraunhofer Institute of Integrated Systems and Device Technology

fax+49(0)9131/761-212

I will participate
 I will arrive by train in Hersbruck at _____

possible.

Deadline for registrations	August 31, 2004
Participation fee	425,- € The fee covers board, lodging and the evening program. You will receive a confirmation of registration. We will invoice you for the fee.
Cancellation	In case of cancellations after the expiration of the deadline you will be charged 75% of the

fee. Standing in for a registered participant is

Sender

-

Date, Signature

Use one form per person please.

Organizational information

Address of the institute	Fraunhofer Institute of Integrated Systems and Device Technology Schottkystrasse 10 91058 Erlangen, Germany
Organization of the workshop	Andreas Erdmann phone +49 (0) 9131/761-258 fax +49 (0) 9131/761-212 lithography@iisb.fraunhofer.de
Contact	Bernd Tollkühn phone +49 (0) 9131/761-216 fax +49 (0) 9131/761-212 lithography@iisb.fraunhofer.de
Hotel	Hotel Lindenhof Ringhotel Hersbruck Hubmersberg 2 91224 Pommelsbrunn
Directions – arrival by	y car
 follow highway Hersbruck/Sulzb 	A9 (Munich – Nuremberg – Berlin), take exit <i>pach-Rosenberg</i> ,
 pass Hersbruck, 	follow the B14 to exit <i>Neuhaus-Hohenstadt</i>
 after 3 km take 	the second road on the right
Hand Schnäin	ach Kirchensittenbach Vorra Hinschback

Henfenfeld

Engelthal

Please contact us if you arrive by air or train. We will send you

omnelshrun

Ausfahrt: Neuhaus /

Hokenstadi

Sulzbach-Rosenberg

further information.



2nd IISB Lithography Simulation Workshop





September 17 – 19, 2004

in Hersbruck, Germany



Fraunhofer Institut Integrierte Systeme und Bauelementetechnologie

Lithography workshop

Content

The workshop will provide an excellent opportunity to discuss

- the results of the latest research activities and future developments in lithography and lithography simulation
- the pros and cons of present simulation models and prospective model extensions

Participants from industry and public research with different

background (modeling, tool & material suppliers, and semiconductor manufacturing) will discuss several topics from different points of view

The special topics for the 2004 workshop are:

- Immersed in Polarization Effects? Modeling of high NA, hyper NA projection lithography and other immersion issues
- Metrology and simulation where are the error bars? Mask and wafer CD measurement, aberrations, flare, stack analysis
- Further simulation issues what do we need for the future? e-beam and EUV lithography, correlation of process parameters

In order to have a fruitful exchange of ideas we will limit the number of participants to 30.

Workshop Accomodations

The workshop takes place at Hersbruck in the Conference Hotel Lindenhof which is located in a typical Franconian landscape.

This workshop is organized by Fraunhofer IISB

Program

Friday, September 17, 2004

6:00 pm Dinner

- 7:00 pm Welcome and introduction A. Erdmann (IISB)
- 7:30 pm Aberration retrieval for a lithographic lens in the presence of focus variation and spatial diffusion P. Dirksen, J. Braat, A. Janssen, D. van Steenwinckel, A. Leeuwestein (Philips)

8:00 pm Meeting

Saturday, September 18, 2004

8:00 am Breakfast

- 9:00 am New simulation challenges associated with upcoming high-NA exposure tools: a user perspective P. De Bisschop, V. Philipsen, M. Opdebeeck (IMEC) A. Erdmann (IISB)
- High NA and polarization effects from the viewpoint 9:30 am of a DRAM manufacturer R. Ziebold (Infineon)
- 10:00 am Polarization issues of high-NA lithography imaging D. Krähmer, O. Dittmann, V. Kamerov, M. Totzeck (Zeiss)

10:30 am Coffee break

- 10:45 am Extended Nijboer-Zernike aberration analysis applied to high-NA image projection systems J. Braat (Delft University of Technology), P. Dirksen, A.
 - Janssen (Philips Research Laboratories)
- 11:15 am High NA and mask induced polarization effects P. Evanschitzky, A. Erdmann (IISB)
- 11:45 pm Discussion: Modeling high-NA lithography

12:30 pm Lunch

- 2:00 pm Getting it together model based optical, SEM and AFM CD metrology at PTB B. Bodermann, H. Bosse, S. Czerkas, C. G. Frase, W. Haessler-Grohne, W. Mirandé (PTB)
- 2:30 pm Flare metrology used for PSD reconstruction; theory, basic principles and most practicable PSD models M. Arnz (Zeiss)
- 3:00 pm Coffee break
- 3:15 pm Determination of optical constants using swing curves J. Bauer, G. Drescher, U. Haak (IHP) 3:30 pm **Optical scatterometry of 3D patterns** J. Bischoff (Timbre Technologies) 3:45 pm Line Edge Roughness: Measurement and Simulation T. Mülders, T. Marschner (Infineon) 4:15 pm Discussion: Metrology and simulation
- 5:30 pm Short tour to a Franconian landmark and dinner

Sunday, September 19, 2004

8:00 am Breakfast

- 9:00 am Exposure optimization in EBL Peter Hudek, Dirk Beyer (Leica)
- 9:30 am Modal method by wavelet expansion, application to EUV lithography P. Schiavone (CNRS)
- 9:45 am Correlation analysis a new method for lithography simulation and process optimization B. Tollkühn, A. Heubner (IISB)
- 10:30 am Discussion: Future tasks for lithography simulation

12:00 pm Lunch

1:00 pm Departure

fax registration

Fraunhofer Institute of Integrated Systems and Device Technology

fax +49 (0) 9131 / 761- 212

□ I'm registering! (binding) □ I will arrive by train in Hersbruck at deadline for August 29, 2003 registrations participation 370.-€ The fee covers board and lodging and the fee evening program. You will receive a confirmation of registration. We will invoice vou for the fee. cancellations In case of cancellations after the expiration of the deadline you will be charged 75% of the fee. Standing in for a registered participant is possible.

sender

first name, last name			
company, institution			
street, house number, F	'O box		
Zip code, city			
phone, fax			
e-mail			

date, signature

Use only one form per person please.

organizational information

address of the institute	Fraunhofer Institute of Integrated Systems and Device Technology Schottkystrasse 10 91058 Erlangen, Germany
organization of the workshop	Andreas Erdmann phone +49 (0) 9131 / 761-258 fax +49 (0) 9131 / 761-212 e-mail: erdmann@iisb.fraunhofer.de
contact	Bernd Tollkühn phone +49 (0) 9131 / 761-216 fax +49 (0) 9131 / 761-212 e-mail: tollkuehn@iisb.fraunhofer.de
hotel	Hotel Lindenhof Ringhotel Hersbruck Hubmersberg 2 91224 Pommelsbrunn
directions – arrival b	y car
 follow highway Hersbruck/Sulzb 	A9 (Munich – Nuremberg – Berlin) take exit bach-Rosenberg,

- pass Hersbruck, follow the B14 to exit *Neuhaus-Hohenstadt*
- take the second road, then turn right (after about 3 km)



Please contact us, if you arrive by air or train. We will send you further information.



1st IISB Lithography Simulation Workshop





September 19 – 21, 2003





Fraunhofer Institut Integrierte Systeme und Bauelementetechnologie

lithography workshop

Content

The workshop's emphasis will be on:

- results of the latest research activities and future developments in lithography and lithography simulation
- discussion on strengths and weaknesses of current simulation models
- discussion on essential model extensions
- opportunity to discuss the topics from different aspects and points of view

The topics of the workshop are:

- What kind of models do we need for modern resists? (effects that are not described by existing models, full resist models of diffused aerial images)
- How to calibrate our model parameters? (optical systems and resist parameters, experimental data for process characterization, target functions, optimization methods, standardization)
- What type of model extensions do we need for EUVlithography? (light scattering from defective masks, flare, polarization effects, resist models)
- What are the future tasks for lithography simulation? (alternative techniques: immersion lithography, nanoimprint, coupling of simulation and experiment, application of lithography simulation in design)

In order to have a fruitful exchange of ideas we have limited the number of participants to 30 persons.

Workshop Accomodations

The workshop takes place at Hersbruck in the Conference Hotel Lindenhof, which is located in a typical Franconian landscape.

This workshop is organized by Fraunhofer IISB

program

Friday, September 19, 2003

6:00 pm Dinner

- 7:00 pm Welcome A. Erdmann
- 7:15 pm Lithography simulation at Fraunhofer IISB A. Erdmann
- 8:00 pm Presentations of the members of the lithography simulation group at Fraunhofer IISB

Saturday, September 20, 2003

8:00 am Breakfast

- 9:00 am Is there a recompense for resist calibration efforts? A. Semmler (Infineon)
- 9:30 am Diffused aerial image model, an accurate simplified resist model?

D. Fuard, P. Schiavone, J.H. Tortai (CNRS LETI)

10:00 am Resist models and calibration methods – what leads to predictive results?
 B. Tollkühn, D. Matiut (IISB)

10:30 am Coffee break

10:45 am Resist models: A practical guide to timely parameter determination and a review of model deficiencies
 S. Robertson (Shipley)
 11:45 am Discussion: Resist topics

12:30 pm Lunch

2:00 pm Image modeling for defect-free and defective EUVmasks P. Evanschitzky, A. Erdmann (IISB) 2:30 pm **EUV lithography modeling using a modal method** P. Schiavone, M. Besacier, V. Farys (CNRS), G. Granet (Université Blaise Pascal)

3:00 pm	Coffee break
3:15 pm	Apodization effects of a multilayer coated mask HJ. Mann, M. Lowisch (Zeiss), U. Mickan (ASML)
3:45 pm 4:15 pm	Challenges for future EUV modeling S. Hirscher (Infineon) Discussion: EUV topics
5:30 pm	Hike and Barbecue

Sunday, September 21, 2003

8:00 am Breakfast

- 9:00 am Towards automatic mask and source optimization for optical lithography A. Erdmann, T. Fühner (IISB)
- 9:45 am Hot topics in algorithms and models for lithography simulation C. Noelscher, R. Koehle (Infineon)

10:15 am Discussion: Future tasks for lithography simulation

12:00 pm Lunch

1:00 pm Departure