SPIE. PHOTOMASK TECHNOLOGY

2015

PHOTOMASK TECHNOLOGY TECHNICAL PROGRAM.

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CO-LOCATED WITH SPIE SCANNING MICROSCOPIES 2015.

Conferences: 29 September–1 October 2015
Exhibition: 29–30 September 2015
Monterey Conference Center and Monterey Marriott
Monterey, California, USA

SPIE. | BACUS

CO-LOCATED WITH 2015 SCANNING MICROSCOPIES

SPIE. PHOTOMASK TECHNOLOGY

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Monterey Conference Center and Monterey Marriott
Monterey, California, USA

Contents

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Dai Nippon Printing Co., Ltd.

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Bryan S. Kasprowicz
Photronics, Inc.

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Jim N. Wiley, ASML US, Inc.

Larry S. Zurbrick, Keysight Technologies, Inc.

Keynote Presentation

Tuesday 29 September 2015 · 8:20 to 9:00 am
Location: Steinbeck Forum

Lithography and Mask Challenges at the Leading Edge

Harry J. Levinson
Senior Director, GLOBALFOUNDRIES Inc.

Continued scaling using multiple patterning is resulting in large increases in mask counts. Mask defect inspection times are increasing much faster than write times. Pushing optical lithography to its limits necessitates exceedingly tight mask-making process control. The use of EUV lithography introduces many new technical challenges associated with a mask architecture very different from optical masks. Because of higher resolution, smaller defects and LER at higher spatial frequencies print with EUV lithography than with optical lithography.

Dr. Levinson spent most of his career working in the field of lithography, starting at AMD. He then spent some time at Sierra Semiconductor and IBM before returning to AMD – now GLOBALFOUNDRIES – in 1994. During the course of his career, Dr. Levinson has applied lithography to many different technologies, including bipolar memories, 64Mb and 256Mb DRAM development, the manufacturing of applications-specific integrated circuits, thin film heads for magnetic recording, flash memories and advanced logic. He was one of the first users of 5× steppers in Silicon Valley and was an early participant in 248 nm and 193 nm lithography.

Tuesday 29 September.

Tuesday Lunch

12:30 to 2:00 pm · Location: Marriott, San Carlos Ballroom

Buffet style lunches are served Tuesday, Wednesday, and Thursday. Admission is included with your paid Photomask Registration. Extra guest tickets may be purchased at the SPIE Registration Desk.

Poster Viewing

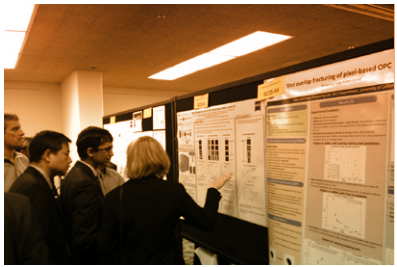
10:00 am to 4:00 pm and 6:00 to 7:30 pm
Location: Exhibition Hall, Serra Grand Ballroom

Poster authors may set up their poster papers between 10:00 am and 4:00 pm on Tuesday and will leave them up until Wednesday afternoon. Authors will be present during the Poster Reception 6:00 to 7:30 pm Tuesday to answer questions and provide in-depth discussion regarding their papers.

Poster/Exhibition Reception

6:00 to 7:30 pm · Location: Exhibition Hall, Serra Grand Ballroom

Symposium attendees are invited to attend the Poster/Exhibition Reception on Tuesday evening in the Serra Grand Ballroom. The reception provides an opportunity for attendees to meet with colleagues, network, view poster papers and interact with the authors, and visit the exhibition. Refreshments will be served.



Attendees are requested to wear their conference registration badges.

SPECIAL EVENTS

Wednesday 30 September.

Poster Viewing

10:00 am to 3:00 pm
Location: Exhibition Hall, Serra Grand Ballroom

Poster authors may set up their poster papers between 10:00 am and 4:00 pm on Tuesday and will leave them up until Wednesday afternoon. Authors will be present during the Poster Reception 6:00 to 7:30 pm Tuesday to answer questions and provide in-depth discussion regarding their papers.

Wednesday Lunch

12:00 to 1:30 pm · Location: Marriott, San Carlos Ballroom

Buffet style lunches are served Tuesday, Wednesday, and Thursday. Admission is included with your paid Photomask Registration. Extra guest tickets may be purchased at the SPIE Registration Desk.

Photomask Reception

Don't Miss the Photomask Reception

6:00 to 8:00 pm · Marriott, San Carlos Ballroom

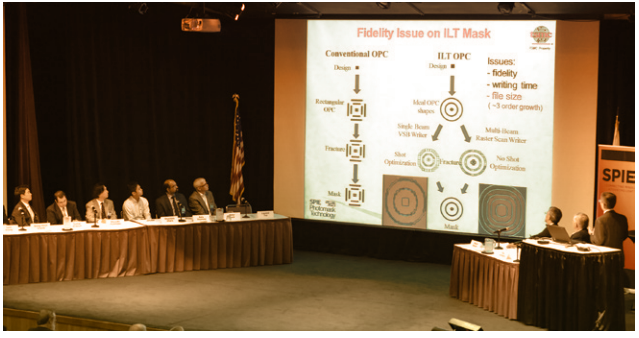
Make plans to join your colleagues and friends at the annual Photomask Reception. This year's event focuses on good food, beverages, and plenty of time to socialize or talk business with fellow conference attendees. Awards, entertainment, and other presentations will be included in the evening.

Admission is included with your paid Photomask registration. Extra guest tickets may be purchased at the SPIE Registration Desk onsite.

BEER/WINE SPONSOR

HOYA

Thursday
1 October.



PANEL DISCUSSION

10:30 am to 12:30 pm · Location: Steinbeck Forum

EUV Mask Readiness: Where Are We?

Moderators: **Bryan S. Kasprowicz,** Photronics, Inc. and **Naoya Hayashi,** Dai Nippon Printing Co., Ltd.

Panelists: **Laurent Tuo,** Taiwan Semiconductor Manufacturing Co. Ltd.; **Jeff Farnsworth,** Intel Corp.; **Peter D. Buck,** Mentor Graphics Corp.; **Emily E. Gallagher,** IMEC; **Jan Hendrik Peters,** Carl Zeiss SMT GmbH; **Yalin Xiong,** KLA-Tencor Corp.; **Takahiro Onoue,** HOYA Corp.

What mask challenges currently exist to introduce EUV into manufacturing? Which are show-stoppers? What are the work arounds while solutions are being developed?

Thursday Lunch

12:30 to 2:00 pm · Location: Marriott, San Carlos Ballroom

Buffet style lunches are served Tuesday, Wednesday, and Thursday. Admission is included with your paid Photomask Registration. Extra guest tickets may be purchased at the SPIE Registration Desk.

PHOTOMASK AWARDS.

Location: Steinbeck Forum

Don't miss the 2015 Photomask award presentations honoring the best in optics and photonics for their significant achievements and contributions.

TUESDAY 29 SEPTEMBER

8:15 to 8:20 am

PRESENTATION OF THE

2015 BACUS Scholarship

AWARDED TO

You-Owe (Henry) Wang

Univ. of California at Berkeley

Photomask Japan Best Paper Award

Winner will be awarded $1500 toward travel support.

SPONSORED BY ASML

4:00 to 5:40 pm

NEW STUDENT SESSION

Photronics Best BACUS Student Paper Finalists Awards

$500 will be awarded to 4 student papers. The top paper will receive $1000.

SPONSORED BY PHOTRONICS

WEDNESDAY 30 SEPTEMBER

6:00 to 8:00 pm

ANNOUNCED AT THE PHOTOMASK RECEPTION

BACUS Lifetime Achievement Award

This award recognizes an individual who has, through inventions or other activities over the course of their career, made a significant impact on the technology of mask making.

ZEISS Award

"In Memorium of Dr. Oliver Kienzle"

The ZEISS Award recognizes talents in the Photomask Industry (2015). Winner will be awarded $1500.

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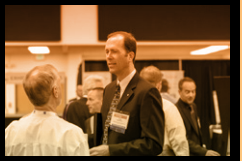
E.
EXHIBITION



The SPIE Photomask Technology Exhibition, the mask-making industry's premier event.

Tuesday 29 September
10:00 am to 4:00 pm

Wednesday 30 September
10:00 am to 4:00 pm

WALK THE FLOOR TO MEET KEY SUPPLIERS.

STAY UP TO DATE ON INDUSTRY TRENDS. SEE THE LATEST IN:

- Mask Making
- Mask Application
- Emerging Mask Technologies
- Mask Business

SPIE. PHOTOMASK TECHNOLOGY

THANKS TO THIS YEAR'S CONTRIBUTING SPONSORS

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PHOTOMASK DAILY EVENT SCHEDULE

TUESDAY 29 September	WEDNESDAY 30 September	THURSDAY 1 October
MORNING SESSIONS		
Opening Remarks and Award Presentation, Session Chairs: Naoya Hayashi, Bryan S. Kasprowicz, Michael T. Postek, 8:15 to 8:20 am		
SESSION 1: Keynote Session 8:20 to 9:00 am **KEYNOTE PRESENTATION Lithography and Mask Challenges at the Leading Edge, Harry J. Levinson**	**SESSION 6: Scanning Beam Technologies and Applications: Joint Session with Photomask and Scanning Microscopies** 8:30 to 10:10 am, (Session Chairs: Michael T. Postek, Jan Hendrik Peters)	**SESSION 10: Invited and Best Papers,** 8:30 to 9:40 am (Session Chairs: Uwe F. W. Behringer, Brian J. Grenon)
SESSION 2: Invited Session: Joint Session with Photomask and Scanning Microscopies, 9:00 to 10:30 am		
COFFEE BREAK, 10:30 to 11:00 am	**COFFEE BREAK,** 10:10 to 10:40 am	**COFFEE BREAK,** 10:00 to 10:30 am
SESSION 3: Edge Placement Error Issue and Solutionfor Multi-Patterning, 11:00 am to 12:30 pm (Session Chairs: Peter D. Buck, Aki Fujimura)	**SESSION 7: EUV Simulation,** 10:40 am to 12:00 pm (Session Chairs: Paul C. Allen, Banqiu Wu)	**PANEL DISCUSSION: EUV Mask Readiness: Where are we?** 10:30 am to 12:30 pm, Moderators: Bryan S. Kasprowicz, Naoya Hayashi

= Co-located Sessions with SPIE Scanning Microscopies 2015.

TUESDAY 29 September	WEDNESDAY 30 September	THURSDAY 1 October
LUNCH · Buffet lunches are served Tuesday and Thursday - 12:30 to 2:00 pm, Wednesday - 12:00 to 1:30 pm. Admission is included with your paid Photomask registration. Extra guest tickets may be purchased at the SPIE registration desk onsite.		
AFTERNOON SESSIONS		
SESSION 4: EUV Mask Infrastructure Readiness, 2:00 to 3:30 pm (Session Chairs: Emily E. Gallagher, Thomas B. Faure)	**SESSION 8: Photomask Technology for Alternative Lithography: NIL,** 1:30 to 3:20 pm (Session Chairs: Douglas J. Resnick, Uwe Dietze)	**SESSION 11: Metrology and Inspection,** 2:00 to 3:20 pm (Session Chairs: Mark M. Wylie, Mark T. Jee)
COFFEE BREAK, 3:30 to 4:00 pm	**COFFEE BREAK,** 3:20 to 3:50 pm	**COFFEE BREAK,** 3:20 to 3:50 pm
SESSION 5: Student Session, 4:00 to 6:00 pm (Session Chairs: Bryan S. Kasprowicz, Jim N. Wiley)	**SESSION 9: Mask Data Preparation and Mask Process Correction,** 3:50 to 5:10 pm (Session Chairs: Bala Thumma, Linyong Pang)	**SESSION 12: Patterning and Process,** 3:50 to 5:30 pm (Session Chairs: Kenichi Saito, Russell B. Cinque)
EXHIBITION · 10:00 am TO 4:00 pm		
POSTER/EXHIBITION RECEPTION 6:00 to 7:30 pm	**PHOTOMASK RECEPTION** 6:00 to 8:00 pm *One ticket included with your Photomask registration*	

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CONFERENCE 9635

Tuesday–Thursday 29 September–1 October 2015
Proceedings of SPIE Vol. 9635

Photomask Technology 2015

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Conference Co-Chair: **Bryan S. Kasprowicz,** Photronics, Inc. (USA)

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TUESDAY 29 SEPTEMBER

OPENING REMARKS AND AWARD PRESENTATION

Location: Steinbeck Forum . . . . . 8:15 am to 8:20 am

Session Chairs: **Naoya Hayashi,** Dai Nippon Printing Co., Ltd. (Japan); **Bryan S. Kasprowicz,** Photronics, Inc. (USA)

2015 BACUS Scholarship Award

Presented to

Yow-Gwo (Henry) Wang
Univ. of California at Berkeley

KEYNOTE SESSION 1

Location: Steinbeck Forum . . . . . Tue 8:20 am to 9:00 am

Session Chairs: **Naoya Hayashi,** Dai Nippon Printing Co., Ltd. (Japan); **Bryan S. Kasprowicz,** Photronics, Inc. (USA)

Lithography and Mask Challenges at the Leading Edge

Harry J. Levinson, Senior Director
GLOBALFOUNDRIES Inc.

SESSION 2

Location: Steinbeck Forum . . . . . Tue 9:00 am to 10:30 am

Invited Session

Joint with Photomask and Scanning Microscopies

Session Chairs: **Naoya Hayashi,** Dai Nippon Printing Co., Ltd. (Japan); **Bryan S. Kasprowicz,** Photronics, Inc. (USA); **Michael T. Postek,** National Institute of Standards and Technology (USA)

9:00 am: **EUV lithography scanner and mask optimization for sub-8nm resolution** *(Invited Paper)*, Jan van Schoot, Koen van Ingen Schenau, Kars Troost, ASML Netherlands B.V. (Netherlands); John D. Zimmerman, ASML (USA); Sascha Migura, Jens Timo Neumann, Bernhard Kneer, Winfried Kaiser, Carl Zeiss SMT GmbH (Germany). . . . . [9635-2]

9:30 am: **Advances in FIB ex situ lift out specimen preparation** *(Invited Paper)*, Lucille A. Giannuzzi, EXpressLO LLC (USA). . . . . [9636-2]

10:00 am: **How to make EUV work!** *(Invited Paper)*, Hermann Gerlinger, Carl Zeiss SMT GmbH (Germany). . . . . [9635-3]

Coffee Break . . . . . .Tue 10:30 am to 11:00 am

SESSION 3

Location: Steinbeck Forum . . . . . Tue 11:00 am to 12:30 pm

Edge Placement Error Issue and Solution for Multi-Patterning

Session Chairs: **Peter D. Buck,** Mentor Graphics Corp. (USA); **Aki Fujimura,** D2S, Inc. (USA)

11:00 am: **Expanded view of characterization and mitigation of edge placement errors in full-chip computational lithography** *(Invited Paper)*, John L. Sturtevant, Rachit Gupta, Shumay Shang, Vladislav Liubich, James Word, Ahmed Seoud, Mentor Graphics Corp. (USA) . . . . . [9635-4]

11:30 am: **Accurate mask registration on tilted lines for 6F2 DRAM manufacturing**, K.D. Roeth, KLA Tencor MIE GmbH (Germany); Youngmo Lee, Sangpyo Kim, Donggyu Yim, Wonseok Choi, SK Hynix, Inc. (Korea, Republic of); Frank Laske, Michael Ferber, KLA Tencor MIE GmbH (Germany); Mehdi Daneshpanah, KLA Tencor Inc (USA); Eric Kwon, KLA Tencor Korea (Korea, Republic of) . . . . . [9635-5]

11:50 am: **Higher order feed-forward control of reticle writing error fingerprints**, Richard J. F. van Haren, ASML Netherlands B.V. (Netherlands) . . . . . [9635-6]

12:10 pm: **Exploring the origin of pattern positioning errors induced by the charging effect in mask making using e-beam writers**, Chien-Cheng Chen, Tzu-Ling Liu, Shao-Wen Chang, Chia-Jen Chen, Chih-Cheng Lin, Hsin-Chang Lee, Anthony Yen, Taiwan Semiconductor Manufacturing Co. Ltd. (Taiwan) . . . . . [9635-7]

Lunch/Exhibition Break . . . . . Tue 12:30 pm to 2:00 pm

SESSION 4

Location: Steinbeck Forum . . . . . Tue 2:00 pm to 3:30 pm

EUV Mask Infrastructure Readiness

Session Chairs: **Emily E. Gallagher,** IMEC (Belgium); **Thomas B. Faure,** GLOBALFOUNDRIES Inc. (USA)

2:00 pm: **EUV mask infrastructure readiness and gaps for TD and HVM** *(Invited Paper)*, Ted Liang, Brittany McClinton, John Magana, Guojing Zhang, Kishore Chakravorty, Eric Panning, Rajesh Nagpal, Intel Corp. (USA) . . . . . [9635-8]

2:30 pm: **Fabrication of a full-size EUV pellicle based on silicon nitride**, Dario L. Goldfarb, IBM Thomas J. Watson Research Ctr. (USA) . . . [9635-9]

2:50 pm: **Detection capability enhancement with a learning system for PEM mask inspection tool**, Ryoichi Hirano, EUVL Infrastructure Development Ctr., Inc. (Japan); Masahiro Hatakeyama, Kenji Terao, EBARA Corp. (Japan); Hidehiro Watanabe, EUVL Infrastructure Development Ctr., Inc. (Japan) . . . . . [9635-10]

3:10 pm: **Film loss-free cleaning chemicals for EUV mask lifetime elongation developed through combinatorial chemical screening**, Jaehyuck Choi, SAMSUNG Electronics Co., Ltd. (Korea, Republic of) . . . . . [9635-11]

Coffee Break . . . . . Tue 3:30 pm to 4:00 pm

SESSION 5

Location: Steinbeck Forum . . . . . Tue 4:00 pm to 5:40 pm

Student Session

Session Chairs: **Bryan S. Kasprowicz,** Photronics, Inc. (USA);
Jim N. Wiley, ASML US, Inc. (USA);
Thomas Scheruebl, Carl Zeiss SMT GmbH (Germany)

The Best Student Paper finalists will be announced.

SPONSORED BY: PHOTRONICS

4:00 pm: **The study of mask shadowing induced phase on absorber defect to improve EUV actinic pattern inspection**, Yow-Gwo Wang, Univ. of California, Berkeley (USA) and Lawrence Berkeley National Lab. (USA); Andrew R. Neureuther, Univ. of California, Berkeley (USA); Patrick P. Naulleau, Lawrence Berkeley National Lab. (USA) . . . . . [9635-12]

4:20 pm: **ILP-based co-optimization of cut-mask layout, dummy fill, and timing for sub-14nm BEOL technology**, Kwangsoo Han, Andrew B. Kahng, Hyein Lee, Lutong Wang, Univ. of California, San Diego (USA) . . . . . [9635-13]

4:40 pm: **Phase retrieval algorithms for patterned mask metrology in EUV**, Rene A. Claus, Yow-Gwo Wang, Univ. of California, Berkeley (USA); Antoine J. Wojdyla, Markus P. Benk, Kenneth A. Goldberg, Lawrence Berkeley National Lab. (USA); Andrew R. Neureuther, Univ. of California, Berkeley (USA); Patrick P. Naulleau, Lawrence Berkeley National Lab. (USA); Laura Waller, Univ. of California, Berkeley (USA). . . . . [9635-14]

5:00 pm: **Absorption dependence of phase edge effects in OMOG masks**, Aamod Shanker, Univ. of California, Berkeley (USA); Martin Sczyrba, Falk Lange, Advanced Mask Technology Ctr. GmbH Co. KG (Germany); Brid Connolly, Toppan Photomasks, Inc. (Germany); Laura Waller, Andrew R. Neureuther, Univ. of California, Berkeley (USA) . . . . . [9635-15]

5:20 pm: **PMJ Best Student Paper: Extreme ultraviolet mask observations using a coherent extreme ultraviolet scatterometry microscope with a high-harmonic-generation source**, Takahiro Fujino, Yusuke Tanaka, Tetsuo Harada, Univ. of Hyogo (Japan); Yutaka Nagata, RIKEN (Japan); Takeo Watanabe, Hiroo Kinoshita, Univ. of Hyogo (Japan). . . . . [9635-16]

Poster/Exhibition Reception

Location: Serra Grand Ballroom . . . . . Tue 6:00 pm to 7:30 pm

Symposium attendees are invited to attend the **Poster/Exhibition Reception** on Tuesday evening in the Serra Grand Ballroom. The reception provides an opportunity for attendees to meet with colleagues, network, view poster papers and interact with the authors, and visit the exhibition booths. Refreshments will be served.

Additional Poster Viewing:

Tuesday 29 September . . . . . 10:00 am to 4:00 pm

Wednesday 30 September . . . . . 10:00 am to 3:00 pm

All attendees and authors are requested to wear their conference registration badges.

EUV Masks

Automatic defect review for EUV photomask reticles by atomic force microscope, Ardavan Zandiatashbar, Byong Kim, Young-kook Yoo, Keibock Lee, Park Systems Inc. (USA); Ahjin Jo, Ju Suk Lee, Sang-Joon Cho, Sang-il Park, Park Systems Corp. (Korea, Republic of) . . . . . [9635-46]

Ruthenium capping layer preservation for 100X clean through pH driven effects, Davide Dattilo, SUSS MicroTec Photomask Equipment GmbH & Co. KG (Germany); Jyh-Wei Hsu, SUSS MicroTec (Taiwan) Co., Ltd. (Taiwan); Uwe Dietze, SUSS MicroTec Inc. (USA) . . . . . [9635-47]

Process capability of etched multilayer EUV mask, Kosuke Takai, Takashi Kamo, Noriko Iida, Toshiba Corp. (Japan); Yasutaka Morikawa, Naoya Hayashi, Dai Nippon Printing Co., Ltd. (Japan) . . . . . [9635-48]

Actinic review of EUV masks: status and recent results of the AIMS™ EUV System, Sascha Perlitz, Markus R. Weiss, Dirk Hellweg, Renzo Capelli, Krister Magnusson, Jan Hendrik Peters, Carl Zeiss SMT GmbH (Germany); Vibhu Jindal, SUNY Poly SEMATECH (USA) . . . . . [9635-75]

Phase imaging results of phase defect using the lensless EUV microscope, Tetsuo Harada, Hiraku Hashimoto, Yusuke Tanaka, Univ. of Hyogo (Japan); Tsuyoshi Amano, EUVL Infrastructure Development Ctr., Inc. (Japan); Takeo Watanabe, Hiroo Kinoshita, Univ. of Hyogo (Japan) . . . . . [9635-76]

CONFERENCE 9635

Mask Data Preparation

Material and Process

Photomask repair using low-energetic electrons, Klaus Edinger, Karsten Wolff, Petra Spies, Timo Luchs, Horst Schneider, Nicole Auth, Carl Zeiss SMT GmbH (Germany); Ch. Felix Hermanns, ZEISS (Germany) and Carl Zeiss SMT GmbH (Germany); Markus Waiblinger, Carl Zeiss SMT GmbH (Germany) . . . . . [9635-77]

Metrology

Accurate defect die placement and nuisance defect reduction for reticle die-to-die inspections, Liang Rong Huang, Taiwan Semiconductor Manufacturing Co. Ltd. (Taiwan); David Wu, KLA-Tencor Taiwan (Taiwan) . . . . . [9635-38]

A study of in die mask overlay control for 14nm double-patterning lithography, Chin-kuei Chang, William Chou, J. K. Wu, Chain Ting Huang, Ming Jui Chen, Simon C. C. Hsu, Y. C. Pai, United Microelectronics Corp. (Taiwan) . . . . . [9635-60]

Reduction of in-lot overlay variation with integrated metrology, and a holistic control strategy, Hong-Goo Lee, Sang-Jun Han, Won Kwang Ma, Young-Sik Kim, Noh-Jung Kwak, SK Hynix, Inc. (Korea, Republic of); Paul Böcker, David Deckers, Kevin Ryan, Elliott McNamara, ASML Netherlands B.V. (Netherlands); Gyu-Hyun Shin, Kyu-Tae Sun, ASML Korea Co., Ltd. (Korea, Republic of); Young-Wan Lim, ASML Netherlands B.V. (Korea, Republic of); Jin-Moo Byun, Jung-Joon Suh, ASML Korea Co., Ltd. (Korea, Republic of) . . . . . [9635-61]

Novel CD control of HTPSM by advanced process for sub-20nm tech, Sang Jin Jo, Chunseon Choi, Sunghyun Oh, Tae-Joong Ha, Youngmo Lee, Sangpyo Kim, Donggyu Yim, SK Hynix, Inc. (Korea, Republic of) . [9635-62]

A study of reticle CD behavior for inter-area pattern loading difference, Sungjin Kim, Kweonjae Lee, Jongsuk Yim, Hyunjoong Kim, Sukwhan Kim, Sukho Shin, Woosun Choi, Jinhee Jung, Kyungwha Chun, Inja Lee, Jooyoung Lee, Hyeongsun Hong, Gyoyoung Jin, SAMSUNG Electronics Co., Ltd. (Korea, Republic of) . . . . . [9635-63]

Wafer weak point detection based on aerial images or WLCD, Guo Xiang Ning, GLOBALFOUNDRIES Inc. (USA); Peter Philipp, Advanced Mask Technology Ctr. GmbH Co. KG (Germany); Lloyd C. Litt, Paul W. Ackmann, GLOBALFOUNDRIES Inc. (USA); Crell Christian, Advanced Mask Technology Ctr. GmbH Co. KG (Germany); Norman Chen, GLOBALFOUNDRIES Inc. (USA). . . . . [9635-64]

Automatic classification and defect verification based on inspection technology with lithography simulation, Masaya Kato, Hideki Inuzuka, Takeshi Kosuge, Shingo Yoshikawa, Kayoko Kanno, Hidemichi Imai, Hiroyuki Miyashita, Dai Nippon Printing Co., Ltd. (Japan); Anthony D. Vacca, Peter J. Fiekowsky, Daniel I. Fiekowsky, AVI-Photomask (USA) . . [9635-66]

CONFERENCE 9635

Patterning

WEDNESDAY 30 SEPTEMBER

SESSION 6

Location: Steinbeck Forum . . . . . Wed 8:30 am to 10:10 am

Scanning Beam Technologies and Applications

Joint Session with Photomask and Scanning Microscopies

Session Chairs: **Michael T. Postek,** National Institute of Standards and Technology (USA); **Jan Hendrik Peters,** Carl Zeiss SMS GmbH (Germany)

8:30 am: **Very-high energy (300-400 keV) SEM imaging of Cu interconnects** *(Invited Paper)*, Lynne Gignac, Christopher M. Breslin, Jemima Gonsalves, Franco Stellari, Chung-Ching Lin, IBM Thomas J. Watson Research Ctr. (USA) . . . . . [9636-12]

9:00 am: **Quantitative analysis of CD error induced by the fogging effect in e-beam lithography**, Shao-Wen Chang, Tzu-Yi Wang, Ta Cheng Lien, Chia-Jen Chen, Chih-Cheng Lin, Shin-Chang Lee, Anthony Yen, Taiwan Semiconductor Manufacturing Co. Ltd. (Taiwan) . . . . . [9635-72]

9:30 am: **Application of gas field ion source to photomask repairs** *(Invited Paper)*, Fumio Aramaki, Tomokazu Kozakai, Osamu Matsuda, Hiroshi Oba, Yasuhiko Sugiyama, Kazuo Aita, Anto Yasaka, Hitachi High-Tech Science Corp. (Japan) . . . . . [9636-13]

9:50 am: **The reparability of various pattern and material for 10nm lithography mask and beyond**, Shingo Yoshikawa, Takeshi Kosuge, Takao Nishiguchi, Koichi Kanno, Hidemichi Imai, Masaaki Kurihara, Hiroyuki Miyashita, Naoya Hayashi, Dai Nippon Printing Co., Ltd. (Japan) . [9635-19]

Coffee . . . . . Wed 10:10 am to 10:40 am

SESSION 7

Location: Steinbeck Forum . . . . . Wed 10:40 am to 12:00 pm

EUV Simulation

Session Chairs: **Paul C. Allen,** Toppan Photomasks, Inc. (USA); **Banqiu Wu,** Applied Materials, Inc. (USA)

10:40 am: **Imaging enhancement by reduction of mask topography induced phase aberrations for horizontal 1D spaces under D90Y illumination**, Thorsten Last, Laurens C. de Winter, Jo Finders, ASML Netherlands B.V. (Netherlands) . . . . . [9635-20]

11:00 am: **EUV photomask defects: What prints, what doesn't, and what is required for HVM**, Jed H. Rankin, Zhengqing John Qi, Mark Lawliss, GLOBALFOUNDRIES Inc. (USA); Eisuke Narita, Kazunori Seki, Toppan Photomasks, Inc. (USA); Karen D. Badger, GLOBALFOUNDRIES Inc. (USA); Ravi K. Bonam, Scott D. Halle, IBM Corp. (USA); Christina Turley, GLOBALFOUNDRIES, Inc. (USA) . . . . . [9635-21]

11:20 am: **New method of detection and classification of yield-impacting EUV mask defects**, Ioana C. Graur, Dmitry A. Vengertsev, Ananthan Raghunathan, Ian Stobert, Jed H. Rankin, GLOBALFOUNDRIES Inc. (USA). . . . . [9635-22]

11:40 am: **Viability of pattern shift for defect-free EUV photomasks at the 7nm node**, Zhengqing John Qi, Jed H. Rankin, GLOBALFOUNDRIES Inc. (USA); Eisuke Narita, Masayuki Kagawa, Toppan Photomasks, Inc. (USA) . . . . . [9635-23]

Lunch/Exhibition Break . . . . . .Wed 12:00 pm to 1:30 pm

SESSION 8

Location: Steinbeck Forum . . . . . .Wed 1:30 pm to 3:20 pm

Photomask Technology for Alternative Lithography: NIL

Session Chairs: **Douglas J. Resnick,** Canon Nanotechnologies, Inc. (USA); **Uwe Dietze,** SUSS MicroTec Inc. (USA)

1:30 pm: **Device fabrication using nanoimprint lithography and challenges for template process technologies** *(Invited Paper)*, Tatsuhiko Higashiki, Toshiba Corp. (Japan) . . . . . [9635-24]

2:00 pm: **Nanoimprint system development and status for high-volume semiconductor manufacturing**, Kazunori Iwamoto, Takehiko Iwanaga, Canon Inc. (Japan); S. V. Sreenivasan, Canon Nanotechnologies, Inc. (USA) . . . . . [9635-25]

2:20 pm: **Nanoimprint lithography template readiness for HVM**, Naoya Hayashi, Koji Ichimura, Masaaki Kurihara, Dai Nippon Printing Co., Ltd. (Japan) . . . . . [9635-26]

2:40 pm: **DUV inspection tool application for beyond optical resolution limit pattern**, Nobutaka Kikuiri, Hiromu Inoue, Hideo Tsuchiya, Ikunao Isomura, Riki Ogawa, NuFlare Technology, Inc. (Japan); Takashi Hirano, Ryoji Yoshikawa, Toshiba Corp. (Japan) . . . . . [9635-27]

3:00 pm: **Optical simulations for fractional fluorine terminated coatings on nanoimprint lithography masks**, Thomas E. Seidel, Seitek50 (USA); Alex Goldberg, Mathew D. Halls, Schrödinger, LLC (USA) . . . . . [9635-28]

Coffee Break . . . . . .Wed 3:20 pm to 3:50 pm

SESSION 9

Location: Steinbeck Forum . . . . . .Wed 3:50 pm to 5:10 pm

Mask Data Preparation and Mask Process Correction

Session Chairs: **Bala Thumma,** Synopsys, Inc. (USA); **Linyong Pang,** D2S, Inc. (USA)

3:50 pm: **Mask process matching using a model-based data preparation solution**, Brian Dillon, Christopher J. Progler, Photronics, Inc. (USA); Thiago Figueiro, Mohamed Saib, Paolo Petroni, Patrick Schiavone, Aselta Nanographics (France) . . . . . [9635-29]

4:10 pm: **A fully model-based MPC solution including VSB shot dose assignment and shape correction**, Ingo Bork, Peter D. Buck, Mentor Graphics Corp. (USA); Murali M. Reddy, Mentor Graphics (India) Pvt. Ltd. (India) . . . . . [9635-30]

4:30 pm: **MPC model validation using reverse analysis method**, Sukho Lee, So-Eun Shin, Jungwook Shon, Jisoong Park, Inkyun Shin, Chan-Uk Jeon, SAMSUNG Electronics Co., Ltd. (Korea, Republic of) . . . . . [9635-32]

4:50 pm: **Accurate mask model implementation in OPC model for 14nm node and beyond**, Nacer Zine El Abidine, STMicroelectronics (France) and IMEP-LAHC (France); Frank Sundermann, Emek Yesilada, STMicroelectronics (France); Frederic Huguennet, Mentor Graphics Corp. (France); Ingo Bork, Mentor Graphics Corp. (USA); Michael Chomat, Mentor Graphics Corp. (France); Peter D. Buck, Mentor Graphics Corp. (USA); Isabelle Schanan, IMEP-LAHC (France) . . . . . [9635-33]

THURSDAY 1 OCTOBER

SESSION 10

Location: Steinbeck Forum . . . . . Thu 8:30 am to 10:00 am

Invited and Best Papers

Session Chairs: **Uwe F. W. Behringer,** UBC Microelectronics (Germany); **Brian J. Grenon,** Grenon Consulting, Inc. (USA)

8:30 am: **Properties and performance of EUVL pellicle membranes** *(Invited Paper)*, Emily E. Gallagher, Johannes Vanpaemel, Ivan Pollentier, Houman Zahedmanesh, Cedric Huyghebaert, Christoph Adelmann, Rik Jonckheere, IMEC (Belgium). . . . . [9635-34]

9:00 am: **PMJ Best Paper: Pattern inspection of etched multilayer EUV masks**, Susumu Iida, EUVL Infrastructure Development Ctr., Inc. (Japan). . . . . [9635-35]

9:20 am: **Experimental validation of novel mask technology to reduce mask 3D effects**, Lieve Van Look, Vicky Philipsen, Eric Hendrickx, IMEC (Belgium); Natalia V. Davydova, Friso Wittebrood, Robert C. de Kruif, Anton B. van Oosten, ASML Netherlands B.V. (Netherlands); Junji Miyazaki, ASML Japan Co., Ltd. (Japan); Timon F. Fliervoet, Jan van Schoot, ASML Netherlands B.V. (Netherlands); Jens Timo Neumann, Carl Zeiss SMT GmbH (Germany). . . . . [9635-36]

9:40 am: **PMJ 2015 Panel Discussion Overview: EUV or 193i: Who wins the center stage for 7nm-node HVM in 2018?**, Yoshinori Nagaoka, KLA-Tencor Japan (Japan) . . . . . [9635-78]

Coffee Break . . . . . .Thu 10:00 am to 10:30 am

PANEL DISCUSSION

Location: Steinbeck Forum . . . . . 10:30 am to 12:30 pm

EUV Mask Readiness: Do We Finally Kick the Ball?

Moderators:
Bryan S. Kasprowicz, Photronics, Inc.;
Naoya Hayashi, Dai Nippon Printing Co., Ltd.

Panelists:
Peter Chang, Taiwan Semiconductor Manufacturing Co. Ltd.;
Jeff Farnsworth, Intel Corp., **Peter D. Buck,** Mentor Graphics Corp.;
Emily E. Gallagher, IMEC; **Jan Hendrik Peters,** Carl Zeiss SMT GmbH;
Yalin Xiong, KLA-Tencor Corp.; **Takahiro Onoue,** HOYA Corp.

For years, Charlie Brown lined up time and time again to try and kick the football that was being held by the devilish Lucy. He would run as fast as he could to put a good wallop on it, yet much to his dismay, during each attempt she would pull that ball away at just the last second causing him to look foolish as he landed on his backside.

For years, designers, lithographers and mask makers have played the role of Charlie Brown, getting ready to introduce EUV as a manufacturing option, only to have that ball pulled away for various technical reasons. Today we are closer than we have ever been and may even have a chance to finally get a kick away. Recent progress in source power, resist performance and blank defectivity have given confidence that equipment orders are now being placed.

As we look to prepare for a new paradigm, new challenges and old will inevitably present themselves. This esteemed panel will help us understand how ready the mask industry is to support manufacturing of EUV masks, where what mask challenges exist and might be expected as we look to “finally” introduce EUV into the lithography flow.

Lunch Break . . . . . Thu 12:30 pm to 2:00 pm

SESSION 11

Location: Steinbeck Forum . . . . . Thu 2:00 pm to 3:20 pm

Metrology and Inspection

Session Chairs: **Mark M. Wylie,** KLA-Tencor Idaho (USA);
Mark T. Jee, HOYA Corp. USA (USA)

2:00 pm: **From nightmares to sweet dreams: inspection of aggressive OPC on 14nm reticles (and beyond) using a novel high-NA and low-NA dual method**, Karen D. Badger, Michael S. Hibbs, GLOBALFOUNDRIES Inc. (USA); Kazunori Seki, Toppan Photomasks, Inc. (USA); William H. Broadbent Jr., Vincent A. Redding, Trent Hutchinson, KLA-Tencor Corp. (USA) . . . . . [9635-37]

2:20 pm: **Study of various pattern impact for registration and overlay**, Shingo Yoshikawa, Nobuaki Fujii, Takashi Yamada, Issei Sakai, Katsuya Hayano, Hidemichi Imai, Hiroyuki Miyashita, Dai Nippon Printing Co., Ltd. (Japan); Takashi Sayano, Carl Zeiss Co., Ltd. (Japan); Sven Heisig, Dirk Beyer, Carl Zeiss SMT GmbH (Germany) . . . . . [9635-65]

2:40 pm: **Variations in programmed phase defect size and its impact on defect detection signal intensity using at-wavelength inspection system**, Tsuyoshi Amano, Noriaki Takagi, EUVL Infrastructure Development Ctr., Inc. (Japan); Tsukasa Abe, Dai Nippon Printing Co., Ltd. (Japan). . . . . [9635-39]

3:00 pm: **EUV actinic brightfield mask microscopy for predicting defect aerial images**, Kenneth A. Goldberg, Markus P. Benk, Antoine J. Wojdyla, Lawrence Berkeley National Lab. (USA); Erik A. Verduijn, IMEC (Belgium); Obert R. Wood II, Pawitter J. Mangat, GLOBALFOUNDRIES Inc. (USA) . . . . . [9635-40]

Coffee Break . . . . . Thu 3:20 pm to 3:50 pm

SESSION 12

Location: Steinbeck Forum . . . . . Thu 3:50 pm to 5:30 pm

Patterning and Process

Session Chairs: **Kenichi Saito,** NuFlare Technology, Inc. (Japan); **Russell B. Cinque,** JEOL USA Inc. (USA)

3:50 pm: **Sensitivity analysis for the high-accuracy proximity effect correction**, Kang-Hoon Choi, Fraunhofer-Institut für Photonische Mikrosysteme (Germany); Clyde H. Browning, Thiago Figueiro, Aselta Nanographics (France); Christoph K. Hohle, Fraunhofer-Institut für Photonische Mikrosysteme (Germany) and Fraunhofer-Ctr. Nanoelektronische Technologien (Germany); Mohamed Saib, Patrick Schiavone, Aselta Nanographics (France); Xaver Thrun, Fraunhofer-Ctr. Nanoelektronische Technologien (Germany) and Fraunhofer-Institut für Photonische Mikrosysteme (Germany) . . . . . [9635-41]

4:10 pm: **Photomask etch process for 10nm technology node and beyond**, Madhavi R. Chandrachood, Michael Grimbergen, Keven Yu, Toi-Yue B. Leung, Jeffrey X. Tran, Jeff Chen, Darin D. Bivens, Rao Yalamanchili, Applied Materials, Inc. (USA); Richard E. Wistrom, Thomas B. Faure, Peter Bartlau, Shawn Crawford, GLOBALFOUNDRIES, Inc. (USA); Yoshifumi Sakamoto, Toppan Printing Co., Ltd. (USA) . . . . . [9635-42]

4:30 pm: **High-durability phase-shift film with variable transmittance**, Osamu Nozawa, HOYA Corp. (Japan) . . . . . [9635-43]

4:50 pm: **Evaluation of multilayer defect repair viability and protection techniques for EUV masks**, Takeshi Isogawa, Kazunori Seki, Toppan Photomasks, Inc. (USA); Mark Lawliss, Zhengqing John Qi, Jed H. Rankin, GLOBALFOUNDRIES Inc. (USA); Shinji Akima, Toppan Photomasks, Inc. (USA) . . . . . [9635-44]

5:10 pm: **Relationship between mask surface wettability and cleaning effectiveness**, Chen-Yang Lin, Taiwan Semiconductor Manufacturing Co. Ltd. (Taiwan) . . . . . [9635-45]

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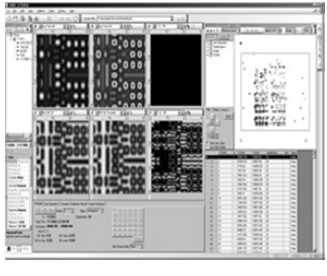

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Wednesday 30 September . . . . . 7:30 am to 4:00 pm
Thursday 1 October . . . . . 8:00 am to 10:30 am

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Tuesday 29 September. . . . . 6:00 to 7:30 pm

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Exhibition Hall

Tuesday 29 September. . . . . ..10:00 am to 4:00 pm, and 6:00 to 7:30 pm

Wednesday 30 September . . . . . .10:00 am to 3:00 pm

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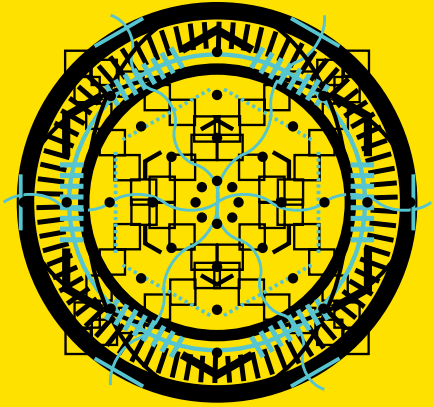

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