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2016

PHOTOMASK TECHNOLOGY.

TECHNICAL PROGRAM

San Jose Convention Center
San Jose, California, USA

Conferences:
12–14 September 2016

Exhibition:
12–13 September 2016

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Contents

Keynote Presentation 4
Special Events and Reception 5–7
Photomask Awards 8
Exhibition 9
Photomask Sponsors 10-11
Daily Event Schedule 12
Conference 13–28
Index of Authors, Chairs, and Committee Members 30-34
General Information 36-41
Proceedings of SPIE 42

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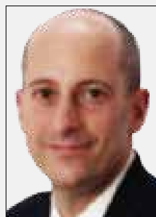
Larry S. Zurbrick, Keysight Technologies, Inc.

Keynote Presentation

Mon. 12 September 2016 8:30 am-9:10 am
Conv. Ctr. Room LL20B



Making Lithography Great[1]

Christopher Progler, Photronics Inc.,
cprogler@photronics.com

Multi-patterning masks stacked to the sky, wallet busting EUV infrastructure, inverse lithography and exploding mask content. The semiconductor industry confronts spiraling cost and complexity in delivering lithographic solutions for what some might argue is a gradually diminishing value provided by these solutions. From partial node shrinks with longer adoption cycles to certain non-lithographic value trends and device impediments, it is fair to reflect on the status quo approach to lithographic technology development. Moreover, promising applications such as internet of things and cloud computing might drive a different priority order for once dominant lithographic patterning in the future. Finally, many classes of semiconductor products no longer carry the profit margin to sustain the heavy R&D and infrastructure investments in a nominally maturing semiconductor industry. On the other hand, despite the enormous cost and technology hurdles, an ability to make smaller and denser features on a wafer with speed and efficiency through lithographic means should still provide a powerful capability and business advantage for certain classes of device and to those companies who enable them.

Taking a cue from the title of a best-selling, 1930's song written during the American great depression, Brother, Can You Spare a Dime?, we will consider ways in which an incremental investment – so called found money - might be deployed to address emerging trends in lithography. However, we bring the song title up to date by accounting for inflation and semiconductor investment multiples to yield a money conversion of 1 cent = 1 billion dollars. That is, Brother, Can You Spare 10 Billion?

We will take that hypothetical $10B and attempt to spread its impact to various corners of the lithosphere. The question posed is where? For example, shall we focus it on a specific vexing problem such as sub-nm edge placement in multi-patterning or perhaps seed an effort to pound down the remaining EUV implementation issues? Many IoT or 3D chips (e.g., NAND) do not require the same degree of lithographic scaling so we might instead target low cost and game changing productivity and ease of use in our lithographic spending spree. How about devoting dollars to the industry wide M&A trend for further consolidation in interest of efficiency, scale and product breadth? Then – there are the photomasks. Those 6" enablers that always seem to cost a little more yet do a little less than specified but we all apparently still cannot get by without them. How can we help you?

Yes, let us journey together[2] as we explore technical challenges in lithography while embracing this virtual spending opportunity to Make Lithography Great Again[1]!

1. Statement not meant to imply or encourage endorsement of any particular presidential candidate.

2. The author really does need your ideas. Please email or tweet to #MakeLithoGreatAgain

Monday 12 September.

Poster Viewing

Conv. Ctr. Room LL21B - Exhibition Hall

Monday 12 September . . . . 10 am to 4 pm, and 6 to 7:30 pm

Authors will be present during the Poster Reception 6:00 to 7:30 pm Monday to answer questions and provide in-depth discussion regarding their papers.

Tuesday 13 September . . . . .10 am to 3 pm

Poster/Exhibition Reception

Conv. Ctr. Room LL21 - Exhibition Hall

Monday 12 September . . . . .6:00 to 7:30 pm

Symposium attendees are invited to attend the Poster/Exhibition Reception. The reception provides an opportunity for attendees to meet with colleagues, network, view posters and interact with the authors, and visit the exhibition booths. Refreshments will be served.

Attendees are requested to wear their conference registration badges.

Beer & Wine Cosponsored by

SPECIAL EVENTS

Tuesday 13 September.

Photomask Dinner Show

Marriott San Jose Ballroom Salon

Tuesday 13 September . . . . .6:00 to 8:00 pm

Join your colleagues and friends at the annual Photomask Dinner Show. 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.

One ticket included in your paid Photomask registration. Extra guest tickets may be purchased at the Cashier's Desk.

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Wednesday 14 September.

PANEL DISCUSSION

Conv. Ctr. Room LL20B

The Impact of Full-scale Curvilinear ILT OPC on Photomask Manufacturing

OPC performed with Inverse Lithography Technology (ILT) is used today primarily as a local repair process for OPC hotspot regions. ILT OPC is generally considered to be too computationally expensive to use on full layouts. Due to write time limitations, the raw curvilinear OPC output is typically “Manhattanized” to make masks manufacturable, primarily since the VSB mask writers used today are optimized for Manhattan data and slow down considerably when writing non-orthogonal figures. However, the computational cost of full-layout ILT OPC relative to its perceived value is lowering. In addition there is concern that the Manhattanization process reduces OPC accuracy. The introduction of multi-beam raster mask writers is expected to reduce the write time cost of raw ILT mask data compared to VSB writers, possibly soon making full-layout ILT OPC a reality. It is expected that the new raster writers level the playing field – both reducing the write time for ILT, but also removing the write time advantage of simpler mask patterns. Is the mask industry ready for the complexity of full-layout raw ILT? What challenges exist to make this a reality?

PHOTOMASK

AWARDS

Don't miss the 2016 Photomask award presentations honoring the best in mask making for their significant achievements and contributions.

MONDAY 12 SEPTEMBER

STUDENT SESSION
4:20 to 6:00 pm

SECOND ANNUAL

Photronics Best BACUS/Photomask Student Paper Awards

The Finalists will be announced at the end of the session, and the overall Best Student Paper Award Winner will be announced during the Photomask Dinner Show on Tuesday.

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TUESDAY 13 SEPTEMBER

ZEISS Award

"In Memorium of Dr. Oliver Kienzle"

The ZEISS Award recognizes talents in the Photomask Industry (2016). Award Winner will be announced at the Photomask Dinner Show on Tuesday.

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EXHIBITION

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

Monday 12 September
10:00 am to 4:00 pm
6:00 to 7:30 pm

Tuesday 13 September
10:00 am to 4:00 pm

MEET KEY SUPPLIERS.

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

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

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DAILY EVENT SCHEDULE

MONDAY 12 September	TUESDAY 13 September	WEDNESDAY 14 September
MORNING SESSIONS		
SESSION 1: **Keynote and Invited Session** 8:30 to 10:10 am	**SESSION 6:** **Inspection and Metrology** 8:30 to 10:10 am	**SESSION 11:** **Cleaning and Repair** 8:40 to 10:00 am
COFFEE BREAK 10:10 to 10:40 am	**COFFEE BREAK** 10:10 to 10:40 am	**COFFEE BREAK** 10:00 to 10:30 am
SESSION 2: **Advanced Writers** 10:40 am to 12:10 pm	**SESSION 7:** **Mask Manufacturability** 10:40 am to 12:00 pm	**PANEL DISCUSSION** **The Impact of Full-scale Curvilinear ILT OPC on Photomask Manufacturing** 10:30 am to 12:30 pm
LUNCH BREAK 12:10 to 1:20 pm	**LUNCH BREAK** 12:00 to 1:30 pm	**LUNCH BREAK** 12:30 to 1:30 pm
AFTERNOON SESSIONS		
SESSION 3: **Advanced Materials** 1:20 to 3:10 pm	**SESSION 8:** **End User Analysis** 1:30 to 3:20 pm	**SESSION 12:** **Advanced EDA** 1:30 to 3:20 pm
COFFEE BREAK 3:10 to 3:40 pm	**COFFEE BREAK** 3:20 to 3:50 pm	**COFFEE BREAK** 3:20 to 3:50 pm
SESSION 4: **Best Paper: PMJ16** 3:40 to 4:20 pm	**SESSION 9:** **Best Paper: EMLC16** 3:50 to 4:10 pm	**SESSION 13:** **Alternative Lithography** 3:50 to 5:30 pm
SESSION 5: **Student Session** 4:20 to 6:00 pm	**SESSION 10:** **Process** 4:10 to 5:30 pm	
EXHIBITION · 10:00 am TO 4:00 pm		
POSTER/EXHIBITION RECEPTION 6:00 to 7:30 pm	**PHOTOMASK DINNER SHOW** 6:00 to 8:00 pm *One ticket included with your Photomask registration*	

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CONFERENCE 9985

LOCATION: CONV. CTR. ROOM LL20A

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12–14 September 2016
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Conference Chair: **Bryan S. Kasprowicz,** Photronics, Inc. (United States)

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MONDAY 12 SEPTEMBER

SESSION 1

Room: Conv. Ctr. Room LL20A . . . . . Mon 8:30 am to 10:10 am

Keynote and Invited Session

Session Chairs: **Bryan S. Kasprowicz,** Photronics, Inc. (United States); **Peter Buck,** Mentor Graphics Corp. (United States)

8:30 am: **Make Lithography Great Again** *(Keynote Presentation)*, Christopher J. Progler, Photronics, Inc. (United States) . . . . [9985-1]

9:10 am: **Data analytics and machine learning for ID design-process-yield optimization in EDA, mask making, and semiconductor manufacturing** *(Invited Paper)*, Luigi Capodieci, KnotPrime Inc. (United States) . . . . [9985-2]

9:40 am: **Challenges of 10nm and 7nm CMOS for high-performance and low-power applications** *(Invited Paper)*, Rama Divakaruni, IBM Thomas J. Watson Research Ctr. (United States) . . . . [9985-3]

Coffee Break . . . . Mon 10:10 am to 10:40 am

SESSION 2

Room: Conv. Ctr. Room LL20A . . . . Mon 10:40 am to 12:10 pm

Advanced Writers

Session Chairs: **Frank E. Abboud,** Intel Corp. (United States); **Steffen F. Schulze,** Mentor Graphics Corp. (United States)

10:40 am: **World's 1st high-throughput multi-beam mask writer** *(Invited Paper)*, Christof Klein, Elmar Platzgummer, IMS Nanofabrication AG (Austria) . . . . [9985-4]

11:10 am: **The technical consideration of multi-beam mask writer for production**, Sanghee Lee, Byung-Sup Ahn, Jin Choi, In-Kyun Shin, Shuichi Tamamushi, Chan-uk Jeon, SAMSUNG Electronics Co., Ltd. (Korea, Republic of) . . . . [9985-5]

11:30 am: **Improvement of electron-beam lithography modeling for overdose exposures by using dill transformation**, Mohamed Abaidi, LTM CNRS (France); Mohamed Saib, ASELTA Nanographics (France); Jean-Hervé Tortai, LTM CNRS (France); Patrick Schiavone, ASELTA Nanographics (France) . . . . [9985-6]

11:50 am: **Electron-beam mask writer EBM-9500 for logic 7nm node generation**, Hideki Matsui, Takashi Kamikubo, Satoshi Nakahashi, Haruyuki Nomura, Noriaki Nakayamada, Mizuna Suganuma, Yasuo Kato, Jun Yashima, Kenichi Saito, Ryoei Kobayashi, Nobuo Miyamoto, Munehiro Ogasawara, NuFlare Technology, Inc. (Japan) . . . . [9985-7]

Lunch/Exhibition Break . . . . Mon 12:10 pm to 1:20 pm

SESSION 3

Room: Conv. Ctr. Room LL20A . . . . . . Mon 1:20 pm to 3:10 pm

Advanced Materials

Session Chairs: **Takahiro Onoue,** HOYA Corp. (Japan); **Banqiu Wu,** Applied Materials, Inc. (United States)

1:20 pm: **Material requirements for EUV mask substrates** *(Invited Paper)*, Carlos A. Duran, Corning Incorporated (United States) . . . . [9985-8]

1:50 pm: **NXE pellicle development update**, Derk Brouns, Daniel A. Smith, Andrea Mancuso, ASML Netherlands B.V. (Netherlands); Jim N. Wiley, ASML US, Inc. (United States); Paul Colsters, Par Broman, Eric Casimiri, Raymond Lafarre, David Ockwell, David van de Weg, Matthias Kruizinga, ASML Netherlands B.V. (Netherlands) . . . . [9985-9]

2:10 pm: **Development of a novel closed EUV pellicle for EUVL manufacturing**, Yosuke Ono, Kazuo Kohmura, Atsushi Okubo, Daiki Taneichi, Hisako Ishikawa, Tsuneaki Biyajima, Mitsui Chemicals, Inc. (Japan). . . . . [9985-10]

2:30 pm: **Introducing the EUV CNT pellicle**, Jae Uk Lee, IMEC (Belgium) and KU Leuven (Belgium); Johannes Vanpaemel, Ivan Pollentier, Christoph Adelmann, Houman Zahedmanesh, Cedric Huyghebaert, IMEC (Belgium); Michael De Volder, Univ. of Cambridge (United Kingdom); Emily E. Gallagher, IMEC (Belgium) . . . . [9985-11]

2:50 pm: **Development of advanced multi-tone mask by using two different transmittance modulation materials**, Sei-Min Kim, Min-Ki Choi, Seong-Min Seo, Jong Hwa Lee, Cheol Shin, Kee-Soo Nam, S&S TECH (Korea, Republic of). . . . . [9985-12]

Coffee Break . . . . Mon 3:10 pm to 3:40 pm

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SESSION 4

Room: Conv. Ctr. Room LL20A . . . . . . Mon 3:40 pm to 4:20 pm

PMJ 2016

Session Chairs: **Peter Buck,** Mentor Graphics Corp. (United States); **Larry S. Zurbrick,** Keysight Technologies, Inc. (United States)

3:40 pm: **PMJ16 Best Paper: Multi-beam mask writer BMB-1000 and its application field**, Hiroshi Matsumoto, Hideo Inoue, Hiroshi Yamashita, Hirofumi Morita, Satoru Hirose, Munehiro Ogasawara, Hirokazu Yamada, Kiyoshi Hattori, NuFlare Technology, Inc. (Japan) . . . . [9985-13]

4:00 pm: **PMJ 2016 Panel Overview: EUV, MPT, NIL: What challenges lie ahead for masks?**, Naoya Hayashi, Dai Nippon Printing Co., Ltd. (Japan). . . . . [9985-87]

SESSION 5

Room: Conv. Ctr. Room LL20A . . . . . . Mon 4:20 pm to 6:00 pm

Student Session

Session Chairs: **Peter Buck,** Mentor Graphics Corp. (United States); **Larry S. Zurbrick,** Keysight Technologies, Inc. (United States)

4:20 pm: **Influence of non-uniform intensity distribution of locally deformed pellicle for N7 patterning**, In-Seon Kim, Guk-Jin Kim, Hanyang Univ. (Korea, Republic of); Michael Yeung, Fastlitho Inc. (United States); Eytan Barouch, Boston Univ. (United States); Hye-Keun Oh, Hanyang Univ. (Korea, Republic of). . . . . [9985-14]

4:40 pm: **Dependence of dissolution behavior of main-chain scission type resists on molecular weight**, Akihiro Konda, Hiroki Yamamoto, Takahiro Kozawa, Osaka Univ. (Japan); Shusuke Yoshitake, NuFlare Technology, Inc. (Japan) . . . . [9985-15]

5:00 pm: **Phase contrast pupil engineering for EUV actinic pattern inspection**, Yow-Gwo Wang, Andy R. Neureuther, Univ. of California, Berkeley (United States) and Lawrence Berkeley National Lab. (United States); Patrick P. Naulleau, Lawrence Berkeley National Lab. (United States) . . . . [9985-16]

5:20 pm: **Feature size dependence of mask topography induced phase effects measured with an aerial imaging tool**, Aamod Shanker, Univ. of California, Berkeley (United States); Martin Sczyrba, Falk Lange, Advanced Mask Technology Ctr. GmbH Co. KG (Germany); Brid Connolly, Toppan Photomasks, Inc. (Germany); Andy R. Neureuther, Laura Waller, Univ. of California, Berkeley (United States). . . . . [9985-17]

5:40 pm: **PMJ16 Best Student Poster: Observation results of actual phase defects using micro-coherent EUV scatterometry microscope**, Hiraku Hashimoto, Tetsuo Harada, Hiroo Kinoshita, Takeo Watanabe, Univ. of Hyogo (Japan) . . . . [9985-18]

POSTER/EXHIBITION SESSION

Room: Conv. Ctr. Room LL21A . . . . Mon 6:00 to 7:30 pm

Symposium attendees are invited to attend the **Poster/Exhibition Reception** on Monday evening. 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:
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Tuesday 13 September. . . . . 10 am to 3 pm

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Advanced Materials and Advanced Writers

Bottom layered attenuated phase-shift mask (PSM) blanks for flat panel display, Kagehiro Kageyama, Satoru Mochizuki, Yasunori Noguchi, Daisuke Nakamura, Shigeru Uchida, ULVAC Coating Corp. (Japan). . . . . [9985-50]

Prototyping 9-inch size PSM mask blanks for 450mm wafer process (2016), Noriyuki Harashima, ULVAC Coating Corp. (Japan). . . . . . [9985-51]

Evaluation of the properties of the permeability film material using cellulose nanofibers, Naoto Sugino, Takao Kameda, Sanko Gosei Ltd. (Japan); Satoshi Takei, Toyama Prefectural Univ. (Japan); Kigen Sugahara, Toyama Prefectual Univ. (Japan). . . . . [9985-52]

CONFERENCE 9985

7nm e-beam resist sensitivity characterization, Amy E. Zweber, GLOBALFOUNDRIES Inc. (United States); Yusuke Toda, Toppan Photomasks, Inc. (United States); Yoshifumi Sakamoto, Toppan Printing Co., Ltd. (Japan); Thomas B. Faure, Jed H. Rankin, Steven C. Nash, GLOBALFOUNDRIES Inc. (United States); Masayuki Kagawa, Toppan Photomasks, Inc. (United States); Michael Fahrenkopf, GLOBALFOUNDRIES Inc. (United States); Takeshi Isogawa, Toppan Photomasks, Inc. (United States); Richard E. Wistrom, GLOBALFOUNDRIES Inc. (United States) . . . . [9985-86]

Students

Mechanical stress induced by external forces in the extreme-ultraviolet pellicle, Hyun-Ju Lee, Hye-Keun Oh, Eun-Sang Park, In-Seon Kim, Hanyang Univ. (Korea, Republic of) . . . . [9985-55]

Investigation of fabrication process for sub-20nm dense pattern of non-chemically amplified electron-beam resist based on acrylic polymers, Shunsuke Ochiai, Tomohiro Takayama, Yukiko Kishimura, Hironori Asada, Yamaguchi Univ. (Japan); Manae Sonoda, Minako Iwakuma, National Institute of Technology, Miyakonojo College (Japan); Ryoichi Hoshino, Gluon Lab. LLC (Japan) . . . . [9985-56]

Inspection and Metrology

The CD control improvement by using CDSEM 2D measurement of complex OPC patterns, MingTe Lee, United Microelectronics Corp. (Taiwan); Colbert Lu, Photronics DNP Mask Corp. (Taiwan); William Chou, United Microelectronics Corp. (Taiwan) . . . . [9985-19]

The study of CD side to side error in line/space pattern caused by post-exposure bake effect, Jin Huang, Eric Guo, Haiming Ge, Yijun Wu, Mingjing Tian, Shichuan Yan, Ran Wang, Semiconductor Manufacturing International Corp. (China). . . . . [9985-36]

Reticle inspection equipment productivity increase using SEMI specification for reticle and pod management, Ron Taylor, Jack Downey, Jeffrey Wood, Yen-Hung Lin, GLOBALFOUNDRIES Inc. (United States); Bharathi Bugata, Dongsheng Fan, Carl E. Hess, KLA-Tencor Corp. (United States); Mark M. Wylie, KLA-Tencor Idaho (United States) . . . . . . [9985-57]

Deposition of super-micron particles for creating photomask calibration standards, William Dick, MSP Corp. (United States) . [9985-58]

Scanning coherent scattering methods for actinic EUV mask inspection, Yasin Ekinci, Istvan Mohacsi, Patrick Helfenstein, Rajeev Rajendran, Jens Gobrecht, Paul Scherrer Institut (Switzerland); Shusuke Yoshitake, NuFlare Technology, Inc. (Japan) . . . . [9985-60]

To repair or not to repair: with FAVOR(R) there is no question, Anthony D. Garetto, Kristian Schulz, Gilles Tabbone, Michael Himmelhaus, Thomas Scheruebl, Carl Zeiss SMT GmbH (Germany). . . . . [9985-61]

Actinic review of EUV masks: status of the AIMS™ EUV system, Sascha Perlitz, Dirk Hellweg, Renzo Capelli, Carl Zeiss SMT GmbH (Germany); Matt Malloy, SUNY Poly SEMATECH (United States). . . . . [9985-62]

Improvement of photomask CD uniformity using spatially resolvable optical emission spectrometry, Junhwa Jung, Youngkeun Kim, Il-Yong Jang, Byung-Gook Kim, Chan-uk Jeon, SAMSUNG Electronics Co., Ltd. (Korea, Republic of); Minwook Kang, Changmin Lee, Jae W. Hahn, Yonsei Univ. (Korea, Republic of) . . . . [9985-64]

Development of actual EUV mask observation method for micro-coherent EUV scatterometry microscope, Tetsuo Harada, Hiraku Hashimoto, Hiroo Kinoshita, Takeo Watanabe, Univ. of Hyogo (Japan). . . . . [9985-66]

Upgrading the SHARP EUV mask microscope for flux, cleanliness, and positioning accuracy, Markus P. Benk, Kenneth A. Goldberg, Antoine J. Wojdyla, Senajith B. Rekawa, Arnaud P. Allézy, Lawrence Berkeley National Lab. (United States). . . . . [9985-88]

Best practices for monitoring humidity in immersion scanner reticle environments to reduce reticle haze effect, Allyn Jackson, CyberOptics (United States). . . . . [9985-91]

Mask Manufacturability and End User

Correction of deflection under mask's own weight by bending mask, Takashi Kambayashi, Minako Azumi, Naoyasu Uehara, Nikon Corp. (Japan). . . . . [9985-29]

Defect inspection and printability study for 10nm node and beyond photomask, Kazunori Seki, Toppan Photomasks, Inc. (United States); Karen D. Badger, GLOBALFOUNDRIES Inc. (United States); Shinji Akima, Toppan Photomasks, Inc. (United States). [9985-68]

Reticle decision center: a novel application platform for enhanced reticle yield and productivity for 10nm technology and beyond, Sandhya Gopalakrishnan, KLA-Tencor California (United States); George Hwa, Raj Bugata, Kaiming Chiang, Suresh Lakkapragada, Vikram L. Tolani, KLA-Tencor Corp. (United States); Chun-Jen Chen, Taiwan Semiconductor Manufacturing Co. Ltd. (Taiwan) . . . . [9985-69]

EBL2: high-power EUV exposure facility, Edwin te Sligte, Norbert B. Koster, Freek T. Molkenboer, Peter van der Walle, Pim Muilwijk, Wouter F. W. Mulckhuyse, Bastiaan Oostdijck, Christiaan Hollemans, Bjorn Nijland, Peter Kerkhof, Michel van Putten, André M. Hoogstrate, Alex Deutz, TNO (Netherlands) . . . . [9985-70]

Wafer hot-spot identification through advanced photomask characterization techniques, Yohan Choi, Michael Green, Jeff A. McMurran, Young Mog Ham, Photronics, Inc. (United States); Howard Lin, Andy Lan, Richer Yang, Mike Lung, Inotera Memories Inc. (Taiwan) . . . . [9985-89]

Cleaning and Repair

Defect management on photomasks with dry treatment assistance, Irene Shi, Eric Guo, Max Lu, Semiconductor Manufacturing International Corp. (China) . . . . [9985-72]

Carbon dioxide gas purification and analytical measurement for leading-edge mask and wafer cleaning, Sarah Riddle Vogt, SAES Pure Gas, Inc. (United States); Cristian Landoni, SAES Getters S.p.A. (Italy); Charles H. Applegarth, Matt Browning, SAES Pure Gas, Inc. (United States); Marco Succi, Simona Pirola, Giorgio Macchi, SAES Getters S.p.A. (Italy) . . . . [9985-73]

Acoustic characterization of two megasonic devices for photomask cleaning, Claudio Zanelli, Xi Chen, Onda Corp. (United States); Manish Keswani, The Univ. of Arizona (United States); Nagaya Okada, Honda Electronics Co., Ltd. (Japan); Jyhwei Hsu, SUSS MicroTec (Taiwan) Co., Ltd. (Taiwan); Petrie H. Yam, Onda Corp. (United States) . . . . [9985-74]

Advanced EDA

Auto-score system to optimize OPC recipe parameters using genetic algorithm, Liang Cao, Abhishek Asthana, ChangAn Wang, Guo Xiang Ning, Jui-Hsuan Feng, Jie Zhang, William Wilkinson, GLOBALFOUNDRIES Inc. (United States). . . . . [9985-76]

Calibrating accurate MPC models on a reduced set of mask measurements, Ingo Bork, Mentor Graphics Corp. (United States); Anil Parchuri, Kushlendra Mishra, Mentor Graphics (India) Pvt. Ltd. (India); Peter D. Buck, Mentor Graphics Corp. (United States) . . . . [9985-77]

OPC model sampling evaluation and weak point in-situ improvement, Nan Fu, GLOBALFOUNDRIES Dresden Module One LLC & Co. KG (Germany); Shady Elshafie, GLOBALFOUNDRIES Inc. (Germany); Guo Xiang Ning, Stefan Roling, GLOBALFOUNDRIES Dresden Module Two, GmbH & Co. KG (Germany) . . . . [9985-78]

Suppressing rippling with minimized corner rounding for an asymmetric pixelated source through OPC fragmentation optimization, Jingyu Wang, GLOBALFOUNDRIES Inc. (United States); Alexander Wei, Mentor Graphics Corp. (United States); William Wilkinson, Norman Chen, GLOBALFOUNDRIES Inc. (United States) . . . . [9985-79]

Verification flow of model-based fracture output, John W. Lewellen, Synopsys, Inc. (United States) . . . . [9985-80]

Combining mask and OPC process verification for improved wafer patterning and yield, Ayman M. Hamouda, Hesham M. Abdelghany, GLOBALFOUNDRIES Inc. (United States) . . . . [9985-81]

Alternative Lithography

Fundamental study of green EUV lithography using natural polysaccharide for the use of pure water in developable process, Satoshi Takei, Toyama Prefectural Univ. (Japan) . . . . [9985-82]

Approach of UV nanoimprint lithography using template with gas-permeable and gaseous adsorption for reduction of air-trapping issue, Satoshi Takei, Toyama Prefectural Univ. (Japan); Naoto Sugino, Takao Kameda, Sanko Gosei Ltd. (Japan); Shinya Nakajima, Toyama Prefectural Univ (Japan); Makoto Hanabata, Toyama Prefectural Univ. (Japan)[9985-83]

Production and evaluation of measuring equipment for share viscosity of polymer melts included nanofiller with injection molding machine, Takao Kameda, Naoto Sugino, Sanko Gosei Ltd. (Japan); Satoshi Takei, Toyama Prefectural Univ. (Japan) . . . . [9985-84]

High-performance fabrication process for 2xnm hole-NIL template production, Keisuke Yagawa, Mana Tanabe, Takeharu Motokawa, Mitsuru Kondo, Kazuki Hagihara, Masato Saito, Shingo Kanamitsu, Masamitsu Itoh, Toshiba Corp. (Japan) . . . . [9985-85]

CONFERENCE 9985

TUESDAY 13 SEPTEMBER

SESSION 6

Room: Conv. Ctr. Room LL20A . . . . . Tue 8:30 am to 10:10 am

Inspection and Metrology

Session Chairs: **Paul C. Allen,** Toppan Photomasks, Inc. (United States); **Jim N. Wiley,** ASML US, Inc. (United States)

8:30 am: **Loading effect correction set up and verification using inspection based CD measurements**, Christian Buergel, Martin Sczyrba, Clemens S. Utzny, Elias Mohn, Advanced Mask Technology Ctr. GmbH Co. KG (Germany) . . . . [9985-63]

8:50 am: **YieldStar based reticle 3D metrology and applications**, Vidya Vaenkatesan, Jo Finders, Peter ten Berge, Reinder Plug, Anko Sijben, Twan Schellekens, Harm Dillen, Wojciech Pocobiej, Vasco G. Jorge, Jurgen van Dijck, ASML Netherlands B.V. (Netherlands) . . . . [9985-20]

9:10 am: **Evaluation of photomask flatness compensation for extreme ultraviolet lithography**, Katherine Ballman, Corning Incorporated (United States); Christopher A. Lee, John D. Zimmerman, Thomas J. Dunn, Alexander Bean, Corning Tropel Corp. (United States) . . . . [9985-21]

9:30 am: **Take a bite out of MEEF: VAMPIRE (vehicle for advanced mask pattern inspection readiness evaluations)**, Karen D. Badger, GLOBALFOUNDRIES Inc. (United States); Kazunori Seki, Toppan Photomasks, Inc. (United States); Jed H. Rankin, Daniel J. Dechene, Hesham M. Abdelghany, GLOBALFOUNDRIES Inc. (United States) . . . . [9985-22]

9:50 am: **Die to database reticle inspection: a new approach to data-prep optimization**, Patrick LoPresti, KLA-Tencor Corp. (United States) . . . . [9985-23]

Coffee Break . . . . .Tue 10:10 am to 10:40 am

SESSION 7

Room: Conv. Ctr. Room LL20A . . . . Tue 10:40 am to 12:00 pm

Mask Manufacturability

Session Chairs: **Thomas B. Faure,** GLOBALFOUNDRIES Inc. (United States); **Naoya Hayashi,** Dai Nippon Printing Co., Ltd. (Japan)

10:40 am: **Recent efforts in EUV mask fabrication toward high-volume manufacturing**, Guojing Zhang, Ted Liang, Srinath Satyanarayana, Sambit Misra, Kishore K. Chakravorty, Su Xu, Seh-Jin Park, John F. Magana, Yongbae Kim, Intel Corp. (United States) . . . . [9985-24]

11:00 am: **Mask manufacturing of advanced technology designs using multi-beam lithography, part II**, Michael Green, Photronics, Inc. (United States); Daniel Chalom, IMS Nanofabrication AG (Austria). . . . . [9985-25]

11:20 am: **Enabling defect-free masks for EUV high-volume manufacturing by e-beam repair**, Thorsten Hofmann, Hendrick Steigerwald, Tristan Bret, Klaus Edinger, Carl Zeiss SMT GmbH (Germany) . . . . [9985-26]

11:40 am: **The costs of masks: hiding or revealing the real solution**, Michael J. Lercel, ASML Fishkill (United States); Bryan S. Kasprowicz, Photronics, Inc. (United States). . . . . [9985-27]

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

SESSION 8

Room: Conv. Ctr. Room LL20A . . . . . . Tue 1:30 pm to 3:20 pm

End User Analysis

Session Chairs: **Thomas I. Wallow,** ASML Brion (United States); **Matthew E. Colburn,** IBM Corp. (United States)

1:30 pm: **Patterning in the era of sub-5nm technology node** *(Invited Paper)*, Nihar Mohanty, Jeffrey T. Smith, Anton de Villiers, David R. Hetzer, Richard A. Farrell, Lior Huli, Hoyoung Kang, Subhadeep Kal, Akiteru Ko, Peter Biolsi, TEL Technology Ctr., America, LLC (United States). . [9985-28]

2:00 pm: **Comparing raw versus Manhattan ILT shape efficacy on EPE and process window**, Dan Zhang, Peter D. Buck, Alexander Tritchkov, James Word, Mentor Graphics Corp. (United States). . . . . [9985-71]

2:20 pm: **Contrast enhancement and its interplay with mask 3D effects in EUVL**, Thorsten Last, Jo Finders, Laurens C. de Winter, Friso Wittebrood, Kateryna Lyakhova, Eleni Psara, Jan Lubkoll, ASML Netherlands B.V. (Netherlands) . . . . [9985-30]

2:40 pm: **Quantifying imaging performance bounds of extreme dipole illumination in high-NA optical lithography**, Myungjun Lee, Mark D. Smith, John Biafore, Trey Graves, Ady Levy, KLA-Tencor Corp. (United States) . . . . [9985-31]

3:00 pm: **UDOF enhancement and photoresist profile tuning by modulating mask absorber thickness**, En Chuan Lio, Tuan-Yen Yu, Po Tsang Chen, Chih-I Wei, Yi Ting Chen, United Microelectronics Corp. (Taiwan) . . . . [9985-32]

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

SESSION 10

Room: Conv. Ctr. Room LL20A . . . . . . Tue 3:50 pm to 5:10 pm

Process

Session Chairs: **Uwe Dietze,** SUSS MicroTec Inc. (United States); **Paul F. Morgan,** Micron Technology, Inc. (United States)

3:50 pm: **Effects of hard mask etch on final topography of advanced phase-shift masks**, Olga Hortenbach, Haiko Rolff, Alexander Lajn, Martin Baessler, Advanced Mask Technology Ctr. GmbH Co. KG (Germany) . . . . [9985-33]

4:10 pm: **Comparative study on PS material of EAPSM for flat panel display**, Jin Woong Jeong, Jin Han Song, Ho Jin Lee, Kyu Sik Kim, Woo-Gun Jeong, Sang Pil Yun, Young Jin Yoon, Samuel S. Jung, PKL Co., Ltd. (Korea, Republic of) . . . . [9985-54]

4:30 pm: **Improvement of CD error in local pattern area by optimizing develop loading condition**, JongHoon Lim, JaeSik Son, JaeYoung Jun, Yongdae Kim, Tae-Joong Ha, Hyun-Jo Yang, SK Hynix, Inc. (Korea, Republic of) . . . . [9985-35]

4:50 pm: **Registration performance on EUV masks using high-resolution registration metrology**, Steffen Steinert, Hans-Michael Solowan, Carl Zeiss SMT GmbH (Germany); Jinback Park, Hakseung Han, SAMSUNG Electronics Co., Ltd. (Korea, Democratic Peoples Republic of); Dirk Beyer, Thomas Scheruebl, Carl Zeiss SMT GmbH (Germany) [9985-67]

WEDNESDAY 14 SEPTEMBER

SESSION 11

Room: Conv. Ctr. Room LL20A . . . . . Wed 8:40 am to 10:00 am

Cleaning and Repair

Session Chairs: **Uwe F. W. Behringer,** UBC Microelectronics (Germany); **Brian J. Grenon,** RAVE LLC (United States)

8:40 am: **Quantitative simulation of MoSi migration in OMOG by ArF exposure and the effect of mask cleaning**, Taeki An, Jong Min Kim, Hyo-Jin Ahn, Ik-Boum Hur, Sang-Soo Choi, PKL Co., Ltd. (Korea, Republic of) . . . . [9985-37]

9:00 am: **Megasonic cleaning strategy for sub-10nm photomasks**, Jyhwei Hsu, SUSS MicroTec (Taiwan) Co., Ltd. (Taiwan); Martin Samayoa, Uwe Dietze, SUSS MicroTec Inc. (United States); Peter Dress, SUSS MicroTec Photomask Equipment GmbH & Co. KG (Germany); Ai-Jay Ma, Chia-Shih Lin, Rick Lai, Jong-Yuh Chang, Laurent C. Tuo, Taiwan Semiconductor Manufacturing Co. Ltd. (Taiwan) . . . . [9985-38]

9:20 am: **Identification of a new source or reticle contamination**, Brian J. Grenon, David Brinkley, RAVE, LLC (United States). . . . . [9985-39]

9:40 am: **Impact of EUV photomask multilayer defect repair on resolution enhancement techniques**, Shuo Zhao, Zhengqing John Qi, GLOBALFOUNDRIES Inc. (United States) . . . . [9985-40]

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

CONFERENCE 9985

PANEL SESSION

Room: Conv. Ctr. Room LL20 . . .Wed 10:30 am to 12:30 pm

Panel Discussion: The Impact of Full-scale Curvilinear ILT OPC on Photomask Manufacturing

OPC performed with Inverse Lithography Technology (ILT) is used today primarily as a local repair process for OPC hotspot regions. ILT OPC is generally considered to be too computationally expensive to use on full layouts. Due to write time limitations, the raw curvilinear OPC output is typically "Manhattanized" to make masks manufacturable, primarily since the VSB mask writers used today are optimized for Manhattan data and slow down considerably when writing non-orthogonal figures. However, the computational cost of full-layout ILT OPC relative to its perceived value is lowering. In addition there is concern that the Manhattanization process reduces OPC accuracy. The introduction of multi-beam raster mask writers is expected to reduce the write time cost of raw ILT mask data compared to VSB writers, possibly soon making full-layout ILT OPC a reality. It is expected that the new raster writers level the playing field – both reducing the write time for ILT, but also removing the write time advantage of simpler mask patterns. Is the mask industry ready for the complexity of full-layout raw ILT? What challenges exist to make this a reality?

Lunch Break . . . . Wed 12:30 pm to 1:30 pm

SESSION 12

Room: Conv. Ctr. Room LL20A . . . . . . Wed 1:30 pm to 3:20 pm

Advanced EDA

Session Chairs: **Bala Thumma,** Synopsys, Inc. (United States); **Shuichiro Ohara,** Nippon Control System Corp. (United States)

1:30 pm: **Computational Imaging: The Path Forward** *(Invited Paper)*, Vivek K. Singh, Intel Corp. (United States) . . . . [9985-41]

2:00 pm: **Software-based data path for raster-scanned multi-beam mask lithography**, Archana Rajagopalan, Ankita Agarwal, Mentor Graphics (India) Pvt. Ltd. (India); Peter D. Buck, Mentor Graphics Corp. (United States); Paul Geller, H. Christopher Hamaker, Applied Materials, Inc. (United States); Nagswara Rao, Mentor Graphics (India) Pvt. Ltd. (India). . [9985-42]

2:20 pm: **OPC care-area feedforwarding to MPC**, Brian Dillon, Masakazu Hamaji, Dai Tsunoda, Tomoyuki Muramatsu, Nippon Control System Corp. (Japan); Shuichiro Ohara, Nippon Control System Corp. (United States); Yi-Hsing Peng, Xiaolong Zhang, Stanislas Baron, Yi Zou, ASML US, Inc. (United States). . . . . [9985-43]

2:40 pm: **Improving corner acuity on photomasks using dose-based MPC**, Ingo Bork, Mentor Graphics Corp. (United States); Christian Bürgel, Advanced Mask Technology Ctr. GmbH Co. KG (Germany); Peter D. Buck, Mentor Graphics Corp. (United States). . . . . [9985-44]

3:00 pm: **The performance improvement of SRAF placement rules using GA optimization**, Yan Xu, Bidan Zhang, ChangAn Wang, William Wilkinson, John Bolton, GLOBALFOUNDRIES Inc. (United States). . . . . [9985-45]

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

CONFERENCE 9985

SESSION 13

Room: Conv. Ctr. Room LL20A . . . . . . Wed 3:50 pm to 5:30 pm

Alternative Lithography

Session Chairs: **Douglas J. Resnick,** Canon Nanotechnologies, Inc. (United States); **Ron R. Bozak,** RAVE, LLC (United States)

3:50 pm: **Writing next-generation display photomasks** *(Invited Paper)*, Mikael L. Wahlsten, Mycronic AB (Sweden); Youngjin Park, Mycronic Co., Ltd. (Korea, Republic of) . . . . [9985-46]

4:20 pm: **Advanced NIL mask technologies which hold the key to achieving the semiconductor production** *(Invited Paper)*, Tatsuhiko Higashiki, Toshiba Corp. (Japan) . . . . [9985-47]

4:50 pm: **Performance of nanoimprint templates for the next-generation lithography**, Koji Ichimura, Takaaki Hiraka, Masaaki Kurihara, Naoya Hayashi, Dai Nippon Printing Co., Ltd. (Japan). . . . . [9985-48]

5:10 pm: **Nanoimprint wafer and mask tool status for high-volume semiconductor manufacturing**, Yoichi Matsuoka, Junichi Seki, Kiyohito Yamamoto, Chiaki Sato, Fumio M. Sakai, Canon Inc. (Japan); Ali Aghili, Makoto Mizuno, Jin Choi, Chris E. Jones, Canon Nanotechnologies, Inc. (United States). . . . . [9985-49]

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INDEX OF AUTHORS, CHAIRS AND COMMITTEE MEMBERS

A

Abaidi, Mohamed [9985-6] S2
Abboud, Frank E. 9985 Program Committee, 9985 S2 Session Chair
Abdelghany, Hesham M. [9985-22] S6, [9985-81] SPS6
Ackmann, Paul W. 9985 Program Committee
Adelmann, Christoph [9985-11] S3
Agarwal, Ankita [9985-42] S12
Aghili, Ali [9985-49] S13
Ahn, Byung-Sup [9985-5] S2
Ahn, Hyo-Jin [9985-37] S11
Akima, Shinji [9985-68] SPS4
Allen, Paul C. 9985 S6 Session Chair
Allézy, Arnaud P. [9985-88] SPS3
An, Taeki [9985-37] S11
Applegarth, Charles H. [9985-73] SPS5
Asada, Hironori [9985-56] SPS2
Asthana, Abhishek [9985-76] SPS6
Azumi, Minako [9985-29] S8

B

Badger, Karen D. [9985-22] S6, [9985-68] SPS4
Baessler, Martin [9985-33] S10
Ballman, Katherine [9985-21] S6
Baron, Stanislas [9985-43] S12
Barouch, Eytan [9985-14] S5
Bean, Alexander [9985-21] S6
Behringer, Uwe F. W. 9985 S11 Session Chair
Bekka, Samy [9985-53] SPS1
Benk, Markus P. [9985-88] SPS3
Beyer, Dirk [9985-67] S10
Biafore, John J. [9985-31] S8
Biolsi, Peter [9985-28] S8
Biyajima, Tsuneaki [9985-10] S3
Bolton, John [9985-45] S12
Bork, Ingo [9985-44] S12, [9985-77] SPS6
Bouchard, Lucien 9985 Program Committee
Bozak, Ron R. 9985 Program Committee, 9985 S13 Session Chair
Bret, Tristan [9985-26] S7
Brinkley, David [9985-39] S11
Broman, Par [9985-9] S3
Brouns, Derk [9985-9] S3
Browning, Matt [9985-73] SPS5
Buck, Peter 9985 Conference CoChair, 9985 S1 Session Chair, 9985 S4 Session Chair, 9985 S5 Session Chair, [9985-42] S12, [9985-44] S12, [9985-71] SPS4, [9985-77] SPS6
Bugata, Bharathi [9985-57] SPS3
Bugata, Raj [9985-69] SPS4
Bürgel, Christian [9985-44] S12, [9985-63] SPS3

C

Cao, Liang [9985-76] SPS6
Capelli, Renzo [9985-62] SPS3
Capodieci, Luigi [9985-2] S1
Casimiri, Eric [9985-9] S3
Chakravorty, Kishore K. [9985-24] S7
Chalom, Daniel [9985-25] S7
Chang, Jong-Yuh [9985-38] S11
Chen, Charlie [9985-32] S8
Chen, Chung-Jen [9985-69] SPS4
Chen, Norman [9985-79] SPS6
Chen, Po Tsang [9985-32] S8
Chen, Xi [9985-74] SPS5
Chiang, Kaiming [9985-69] SPS4
Choi, Jin [9985-5] S2
Choi, Jin [9985-49] S13
Choi, Min Ki [9985-12] S3
Choi, Sang-Soo [9985-37] S11
Choi, Yohan [9985-89] SPS4
Chou, William [9985-19] S6
Cinque, Russell B. 9985 Program Committee
Colburn, Matthew E. 9985 Program Committee, 9985 S8 Session Chair
Colsters, Paul [9985-9] S3
Connolly, Brid [9985-17] S5

D

de Villiers, Anton [9985-28] S8
De Volder, Michael [9985-11] S3
de Winter, Laurens [9985-30] S8
Dechene, Daniel J. [9985-22] S6
Deutz, Alex [9985-70] SPS4
Dick, William [9985-58] SPS3
Dietze, Uwe 9985 Program Committee, 9985 S10 Session Chair, 9985 S9 Session Chair, [9985-38] S11
Dillen, Harm [9985-20] S6
Divakaruni, Rama [9985-3] S1
Downey, Jack [9985-57] SPS3
Dress, Peter [9985-38] S11
Dunn, Thomas J. [9985-21] S6
Duran, Carlos A. [9985-8] S3

E

Edinger, Klaus [9985-26] S7
Ekinci, Yasin [9985-60] SPS3
Elshafie, Shady [9985-78] SPS6

F

Fahrenkopf, Michael [9985-86] SPS1
Fan, Dongsheng [9985-57] SPS3
Farrell, Richard A. [9985-28] S8
Faure, Thomas B. 9985 S7 Session Chair, [9985-86] SPS1
Feng, Jui-Hsuan [9985-76] SPS6
Finders, Jo [9985-20] S6, [9985-30] S8, [9985-90] S9
Fu, Nan [9985-78] SPS6
Fujimura, Aki 9985 Program Committee

G

Gallagher, Emily E. 9985 Program Committee, [9985-11] S3
Garetto, Anthony D. [9985-61] SPS3
Ge, Haiming [9985-36] SPS3
Geller, Paul [9985-42] S12
Gobrecht, Jens [9985-60] SPS3
Goldberg, Kenneth A. [9985-88] SPS3
Gopalakrishnan, Sandhya [9985-69] SPS4
Graves, Trey [9985-31] S8
Green, Michael [9985-25] S7, [9985-89] SPS4
Grenon, Brian J. 9985 S11 Session Chair, [9985-39] S11
Guo, Eric [9985-36] SPS3, [9985-72] SPS5

H

Ha, Tae-Joong [9985-35] S10
Hagihara, Kazuki [9985-85] SPS7
Hahn, Jae W. [9985-64] SPS3
Ham, Young Mog [9985-89] SPS4
Hamaji, Masakazu [9985-43] S12
Hamaker, H. Christopher [9985-42] S12
Hamouda, Ayman M. [9985-81] SPS6
Han, Hakseung [9985-67] S10
Hanabata, Makoto [9985-83] SPS7
Harada, Tetsuo [9985-18] S5, [9985-66] SPS3
Harashima, Noriyuki [9985-51] SPS1
Hashimoto, Hiraku [9985-18] S5, [9985-66] SPS3
Hattori, Kiyoshi [9985-13] S4
Hayashi, Naoya 9985 Program Committee, 9985 S7 Session Chair, [9985-48] S13, [9985-87] S4
Helfenstein, Patrick [9985-60] SPS3
Hellweg, Dirk [9985-62] SPS3
Hess, Carl E. [9985-57] SPS3
Hetzer, David R. [9985-28] S8
Higashiki, Tatsuhiko [9985-47] S13
Himmelhaus, Michael [9985-61] SPS3
Hiraka, Takaaki [9985-48] S13
Hirose, Satoru [9985-13] S4
Hofmann, Thorsten [9985-26] S7
Hollemans, Christiaan [9985-70] SPS4
Hoogstrate, André M. [9985-70] SPS4
Hortenbach, Olga [9985-33] S10
Hoshino, Ryoichi [9985-56] SPS2
Hsu, Jyhwei [9985-38] S11, [9985-74] SPS5
Huang, Jin [9985-36] SPS3
Huli, Lior [9985-28] S8
Hur, Ik-Boum [9985-37] S11
Huyghebaert, Cedric [9985-11] S3
Hwa, George [9985-69] SPS4

I

Ichimura, Koji [9985-48] S13
Inoue, Hideo [9985-13] S4
Ishikawa, Hisako [9985-10] S3
Isogawa, Takeshi [9985-86] SPS1
Itoh, Masamitsu [9985-85] SPS7
Iwakuma, Minako [9985-56] SPS2

J

Jang, Il-Yong [9985-64] SPS3
Jeon, Chan-uk [9985-5] S2, [9985-64] SPS3
Jeong, Jin Woong [9985-54] S10
Jeong, Woo-Gun [9985-54] S10
Jones, Chris E. [9985-49] S13
Jorge, Vasco Guerreiro [9985-20] S6
Jun, JaeYoung [9985-35] S10
Jung, Junhwa [9985-64] SPS3
Jung, Samuel S. [9985-54] S10

K

Kagawa, Masayuki [9985-86] SPS1
Kageyama, Kagehiro [9985-50] SPS1
Kal, Subhadeep [9985-28] S8
Kambayashi, Takashi [9985-29] S8
Kameda, Takao [9985-52] SPS1, [9985-83] SPS7, [9985-84] SPS7

INDEX OF AUTHORS, CHAIRS AND COMMITTEE MEMBERS

Kamikubo, Takashi [9985-7] S2
Kanamitsu, Shingo [9985-85] SPS7
Kang, Hoyoung [9985-28] S8
Kang, Minwook [9985-64] SPS3
Kasprowicz, Bryan S. 9985 Conference Chair, 9985 S1 Session Chair, [9985-27] S7
Kato, Yasuo [9985-7] S2
Kerkhof, Peter [9985-70] SPS4
Keswani, Manish [9985-74] SPS5
Kiers, Ton [9985-90] S9
Kim, Byung-Gook 9985 Program Committee, [9985-64] SPS3
Kim, Guk-Jin [9985-14] S5
Kim, In-Seon [9985-14] S5, [9985-55] SPS2
Kim, Jong Min [9985-37] S11
Kim, Kyu Sik [9985-54] S10
Kim, Sei-Min [9985-12] S3
Kim, Yongbae [9985-24] S7
Kim, Yongdae [9985-35] S10
Kim, Youngkeun [9985-64] SPS3
Kinoshita, Hiroo [9985-18] S5, [9985-66] SPS3
Kishimura, Yukiko [9985-56] SPS2
Klein, Christof [9985-4] S2
Ko, Akiteru [9985-28] S8
Kobayashi, Ryoei [9985-7] S2
Kohmura, Kazuo [9985-10] S3
Konda, Akihiro [9985-15] S5
Kondo, Mitsuru [9985-85] SPS7
Koster, Norbert B. [9985-70] SPS4
Kozawa, Takahiro [9985-15] S5
Kruizinga, Matthias [9985-9] S3
Kurihara, Masaaki [9985-48] S13

L

Lafarre, Raymond [9985-9] S3
Lai, Rick [9985-38] S11
Lajn, Alexander [9985-33] S10
Lakcher, Amine [9985-90] S9
Lakkapragada, Suresh [9985-69] SPS4
Lan, Andy [9985-89] SPS4
Landoni, Cristian [9985-73] SPS5
Lange, Falk [9985-17] S5
Last, Thorsten [9985-30] S8
Lee, Changmin [9985-64] SPS3
Lee, Christopher A. [9985-21] S6
Lee, Ho Jin [9985-54] S10
Lee, Hyun-Ju [9985-55] SPS2
Lee, Jae Uk [9985-11] S3
Lee, Jong Hwa [9985-12] S3
Lee, MingTe [9985-19] S6
Lee, Myungjun [9985-31] S8
Lee, Sanghee [9985-5] S2
Le-Gratiet, Bertrand [9985-90] S9
Lercel, Michael J. [9985-27] S7
Levy, Ady [9985-31] S8
Lewellen, John W. [9985-80] SPS6
Liang, Ted [9985-24] S7
Lim, JongHoon [9985-35] S10
Lin, Chia-Shih [9985-38] S11
Lin, Howard [9985-89] SPS4
Lin, Yen-Hung [9985-57] SPS3
Lio, En Chuan [9985-32] S8
LoPresti, Patrick [9985-23] S6
Lu, Colbert [9985-19] S6
Lu, Max [9985-72] SPS5
Lubkoll, Jan [9985-30] S8
Lung, Mike [9985-89] SPS4
Lyakhova, Kateryna [9985-30] S8

M

Ma, Ai-Jay [9985-38] S11
Macchi, Giorgio [9985-73] SPS5
Magana, John F. [9985-24] S7
Malloy, Matt [9985-62] SPS3
Mancuso, Andrea [9985-9] S3
Matsui, Hideki [9985-7] S2
Matsumoto, Hiroshi [9985-13] S4
Matsuoka, Yoichi [9985-49] S13
McMurran, Jeff A. [9985-89] SPS4
Mishra, Kushlendra [9985-77] SPS6
Misra, Sambit [9985-24] S7
Miyamoto, Nobuo [9985-7] S2
Mizuno, Makoto [9985-49] S13
Mochizuki, Satoru [9985-50] SPS1
Mohacsi, Istvan [9985-60] SPS3
Mohanty, Nihar [9985-28] S8
Mohn, Elias [9985-63] SPS3
Molkenboer, Freek T. [9985-70] SPS4
Morgan, Paul F. 9985 Program Committee, 9985 S10 Session Chair, 9985 S9 Session Chair
Morita, Hirofumi [9985-13] S4
Motokawa, Takeharu [9985-85] SPS7
Muilwijk, Pim [9985-70] SPS4
Mulckhuyse, Wouter F.W. [9985-70] SPS4
Muramatsu, Tomoyuki [9985-43] S12

N

Nakahashi, Satoshi [9985-7] S2
Nakamura, Daisuke [9985-50] SPS1
Nakayamada, Noriaki [9985-7] S2

Nam, Kee-Soo [9985-12] S3
Nash, Steven C. [9985-86] SPS1
Naulleau, Patrick P. [9985-16] S5
Neureuther, Andrew R. [9985-16] S5, [9985-17] S5
Nijland, Bjorn [9985-70] SPS4
Ning, Guo Xiang [9985-76] SPS6, [9985-78] SPS6
Noguchi, Yasunori [9985-50] SPS1
Nomura, Haruyuki [9985-7] S2

O

Ochiai, Shunsuke [9985-56] SPS2
Ockwell, David [9985-9] S3
Ogasawara, Munehio [9985-7] S2
Ogasawara, Munehiro [9985-13] S4
Oh, Hye-Keun [9985-14] S5, [9985-55] SPS2
Ohara, Shuichiro 9985 S12 Session Chair, [9985-43] S12
Okada, Nagaya [9985-74] SPS5
Okubo, Atsushi [9985-10] S3
Ono, Yosuke [9985-10] S3
Onoue, Takahiro 9985 Program Committee, 9985 S3 Session Chair
Oostdijck, Bastiaan [9985-70] SPS4

P

Parchuri, Anil [9985-77] SPS6
Park, Eun-Sang [9985-55] SPS2
Park, Jinback [9985-67] S10
Park, Seh-Jin [9985-24] S7
Park, Youngjin [9985-46] S13
Peng, Yi-Hsing [9985-43] S12
Penley, Christopher [9985-53] SPS1
Perlitz, Sascha [9985-62] SPS3
Pirola, Simona [9985-73] SPS5
Platzgummer, Elmar [9985-4] S2
Plug, Reinder [9985-20] S6
Pocobiej, Wojciech [9985-20] S6
Pollentier, Ivan [9985-11] S3
Progler, Christopher J. [9985-1] S1
Psara, Eleni [9985-30] S8

Q

Qi, Zhengqing John [9985-40] S11

R

Rajagopalan, Archana [9985-42] S12
Rajendran, Rajeev [9985-60] SPS3
Rankin, Jed H. [9985-22] S6, [9985-86] SPS1
Rao, Nagswara [9985-42] S12
Rekawa, Senajith B. [9985-88] SPS3
Resnick, Douglas J. 9985 S13 Session Chair
Riddle Vogt, Sarah [9985-73] SPS5
Rolff, Haiko [9985-33] S10
Roling, Stefan [9985-78] SPS6

S

Saib, Mohamed [9985-6] S2
Saito, Kenichi [9985-7] S2
Saito, Masato [9985-85] SPS7
Sakai, Fumio M. [9985-49] S13
Sakamoto, Yoshifumi [9985-86] SPS1
Samayoa, Martin [9985-38] S11
Sato, Chiaki [9985-49] S13
Satyanarayana, Srinath [9985-24] S7
Schellekens, Twan [9985-20] S6
Scheruebl, Thomas 9985 Program Committee, [9985-61] SPS3, [9985-67] S10
Schiavone, Patrick [9985-6] S2
Schulz, Kristian [9985-61] SPS3
Schulze, Steffen F. 9985 S2 Session Chair
Sczyrba, Martin [9985-17] S5, [9985-63] SPS3
Seki, Junichi [9985-49] S13
Seki, Kazunori [9985-22] S6, [9985-68] SPS4
Seo, Seong-Min [9985-12] S3
Shanker, Aamod [9985-17] S5
Shi, Irene [9985-72] SPS5
Shin, Cheol [9985-12] S3
Shin, In-Kyun [9985-5] S2
Sijben, Anko [9985-20] S6
Singh, Vivek K. [9985-41] S12
Smith, Daniel A. [9985-9] S3
Smith, Jeffrey T. [9985-28] S8
Smith, Mark D. [9985-31] S8
Solowan, Hans-Michael [9985-67] S10
Son, JaeSik [9985-35] S10
Song, Jin Han [9985-54] S10
Sonoda, Manae [9985-56] SPS2
Steigerwald, Hendrik [9985-26] S7
Steinert, Steffen [9985-67] S10
Succi, Marco [9985-73] SPS5
Sugahara, Kigen [9985-52] SPS1
Suganuma, Mizuna [9985-7] S2
Sugino, Naoto [9985-52] SPS1, [9985-83] SPS7, [9985-84] SPS7

INDEX OF AUTHORS, CHAIRS AND COMMITTEE MEMBERS

T

Tabbone, Gilles [9985-61] SPS3
Takayama, Tomohiro [9985-56] SPS2
Takei, Satoshi [9985-52] SPS1, [9985-82] SPS7, [9985-83] SPS7, [9985-84] SPS7
Tamamushi, Shuichi [9985-5] S2
Tanabe, Mana [9985-85] SPS7
Taneichi, Daiki [9985-10] S3
Taylor, Ron [9985-57] SPS3
Tchikoulaeva, Anna 9985 Program Committee
te Sligte, Edwin [9985-70] SPS4
ten Berge, Peter [9985-20] S6
Thumma, Bala 9985 S12 Session Chair
Tian, Mingjing [9985-36] SPS3
Toda, Yusuke [9985-86] SPS1
Tolani, Vikram L. [9985-69] SPS4
Tortai, Jean-Hervé [9985-6] S2
Tritchkov, Alexander [9985-71] SPS4
Tuo, Laurent C. 9985 Program Committee, [9985-38] S11

U

Uchida, Shigeru [9985-50] SPS1
Uehara, Naoyasu [9985-29] S8
Utzny, Clemens S. [9985-63] SPS3

V

Vaenkatesan, Vidya [9985-20] S6
van de Weg, David [9985-9] S3
van der Walle, Peter [9985-70] SPS4
van Dijck, Jurgen [9985-20] S6
van Putten, Michel [9985-70] SPS4
Vanpaemel, Johannes [9985-11] S3

W

Wahlsten, Mikael Lars [9985-46] S13
Waller, Laura [9985-17] S5
Wallow, Thomas I. 9985 Program Committee, 9985 S8 Session Chair
Wang, ChangAn [9985-45] S12, [9985-76] SPS6
Wang, Jingyu [9985-79] SPS6
Wang, Ran [9985-36] SPS3
Wang, Yow-Gwo [9985-16] S5
Watanabe, Takeo [9985-18] S5, [9985-66] SPS3
Wei, Alexander [9985-79] SPS6
Wei, Chih-I [9985-32] S8
Wiley, Jim N. 9985 S6 Session Chair, [9985-9] S3
Wilkinson, William [9985-45] S12, [9985-76] SPS6, [9985-79] SPS6
Wistrom, Richard E. [9985-86] SPS1
Wittebrood, Friso [9985-30] S8
Wojdyla, Antoine [9985-88] SPS3
Wood, Jeffrey [9985-57] SPS3
Word, James [9985-71] SPS4
Wu, Banqiu 9985 Program Committee, 9985 S3 Session Chair
Wu, Yijun [9985-36] SPS3
Wylie, Mark M. [9985-23] S6, [9985-57] SPS3

X

Xu, Su [9985-24] S7
Xu, Yan [9985-45] S12

Y

Yagawa, Keisuke [9985-85] SPS7
Yam, Petrie H. [9985-74] SPS5
Yamada, Hirokazu [9985-13] S4
Yamamoto, Hiroki [9985-15] S5
Yamamoto, Kiyohito [9985-49] S13
Yamashita, Hiroshi [9985-13] S4
Yan, Shichuan [9985-36] SPS3
Yang, Hyun-Jo [9985-35] S10
Yang, Richer [9985-89] SPS4
Yashima, Jun [9985-7] S2
Yeung, Michael [9985-14] S5
Yoon, Young Jin [9985-54] S10
Yoshitake, Shusuke 9985 Program Committee, [9985-15] S5, [9985-60] SPS3
Yu, Dennis [9985-32] S8
Yun, Sang Pil [9985-54] S10

Z

Zahedmanesh, Houman [9985-11] S3
Zanelli, Claudio [9985-74] SPS5
Zhang, Bidan [9985-45] S12
zhang, Dan [9985-71] SPS4
Zhang, Guojing [9985-24] S7
Zhang, Jie [9985-76] SPS6
Zhang, Xiaolong [9985-43] S12
Zhao, Shuo [9985-40] S11
Zou, Yi [9985-43] S12
Zurbrick, Larry S. 9985 S4 Session Chair, 9985 S5 Session Chair
Zweber, Amy E. [9985-86] SPS1

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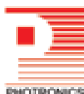

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