The international technical group of SPIE dedicated to the advancement of photomask technology

2013 Photomask Technology

10–12 September 2013

Technical Program

www.spie.org/pm

Conference
10–12 September 2013

Exhibition
10–11 September 2013

Location
Monterey Marriott &
Monterey Conference Center
Monterey, California, USA

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2013 Photomask Technology

Welcome!

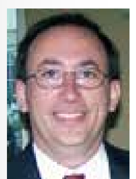
On behalf of SPIE, BACUS, and the Organizing Committee, we welcome you to the 33rd Annual SPIE/BACUS Photomask Symposium in Monterey, California. This annual meeting continues to be the premier worldwide technical meeting for the photomask industry.

The conference will give all attendees a condensed and up-to-date overview of the photomask industry. The various sessions will include presentations and poster papers that span a number of critical topics in the photomask industry. These include current technical issues, emerging technologies, and future trends. It will also give the authors an opportunity to present their exciting research findings that relate to the emerging technical challenges facing the photomask industry to a large international audience of their peers. We have received over 100 presentations this year, covering all aspects of mask making, mask application, and related technologies.

The official opening session will be on Tuesday morning, 10 September, with a Keynote Presentation that you will not want to miss titled "Delivering Complexity at the Frontier of Electronics," given by Michael C. Mayberry, Intel Corp. The conference will follow a single track, three-day event, which means all presentations will be in one room, avoiding the need to hop between rooms to catch your favorite paper. The first two days of the conference will feature larger sessions focused on single topics such as OPC/Simulation and Mask Contamination/Long Term Durability. In addition, we will have a session that will be focused exclusively on one-beam direct write. EUV masks are now part of the mainstream of mask technology. To affirm this statement, all individual mask-related tasks of EUV will be part of their regular topic. We will begin day 3 with Paul Ackmann leading the panel discussion on the topic of "Big Glass: Will It Return?" This subject is sure to provide lively discussion and debate amongst industry experts.

Welcome to beautiful Monterey. Not only will you have a great experience attending the sessions, you will also have fun on the California coast in the middle of its best season.

2013 Symposium Chair



Thomas B. Faure
IBM Corp.

2013 Symposium Co-Chair

Paul W. Ackmann
GLOBALFOUNDRIES Inc.

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SPIE Green Initiative

As host to events that bring together scientists and engineers from around the globe, SPIE is committed to making our symposia as environmentally friendly as possible.

Ongoing efforts of SPIE include using non-disposable materials such as glass plates and metal flatware as often as possible, and encouraging facilities to donate surplus meals to soup kitchens. Many partnering facilities have robust recycling programs for paper, plastic, and aluminum products. SPIE continues to collaborate with venues, hotels, suppliers and the local Chambers of Commerce to assess and ease the conference's environmental impact. SPIE is currently working to implement solutions from the Green Meetings Industry Council guidelines with a goal to take our environmental efficiency to a whole new level.

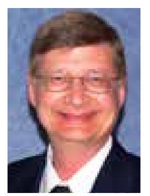
When at this event, SPIE encourages you to take advantage of recycling bins, to reuse towels at your hotel, and to carpool whenever transportation is required during your stay in Monterey.

Keynote Presentation

Steinbeck Forum

Tuesday 10 September, 8:10 to 8:50 am

Delivering Complexity at the Frontier of Electronics



Michael C. Mayberry, Corporate VP of the Technology and Mfg. Group, Director of Components Research, Intel Corp.

The current era of semiconductor research is heavily dependent on the incorporation of new materials into structures measured in nanometers. We require complexity at not only the functional level but complexity in how these functions work together to make better products. The mask set is the critical element in managing that complexity in a cost effective manner but mask making today is challenged to keep up with demands. For the next decade, these trends are expected to continue and will suffice to improve the traditional metrics of performance-power and costs. There are many choices to be made but a rich future lies ahead of us.

Michael C. Mayberry is corporate vice president of the Technology and Manufacturing Group and director of Components Research at Intel Corporation. He is responsible for ongoing research to enable future process options for Intel's technology development organizations. This scope includes internal research, external university research, and other external collaborations.

Since joining Intel in 1984 as a process integration engineer, Mayberry has held a variety of positions. As part of the California Technology Development team, he developed EPROM, flash and logic wafer fabrication processes. In 1994 he moved to Sort Test Technology Development, most recently as director, responsible for roadmaps and development of test processes for Intel microprocessors. In 2005, he moved to Components Research.

Mayberry received his Ph.D. in physical chemistry from the University of California, Berkeley in 1983 and his bachelor's degree in chemistry and mathematics from Midland College in 1978.

Exhibition/Poster Session

Serra Grand Ballroom

Tuesday 6:00 to 7:30 pm

Symposium attendees are invited to attend an Exhibition/Poster 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. Attendees are requested to wear their conference registration badges.

Poster Viewing

Serra Grand Ballroom

Tuesday 10 September, 10 am to 4 pm, and 6 to 7:30 pm
Wednesday 11 September, 10 am to 3 pm

Poster authors may set up their poster papers between 10 am and 4 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.

Don't Miss the Photomask Reception

Beer/Wine Sponsor

HOYA

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

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 registration. Guest tickets may be purchased at the Registration Desk. *Space is limited.*

Special Session Panel Discussion: Big Glass: Will It Return?

Again We Look at Bigger Glass: The Glass is on Trial

Steinbeck Forum • Thursday 8:20 to 10:20 am

Moderator: **Paul W. Ackmann,** GLOBALFOUNDRIES Inc.

Is there a need to move to larger glass to enable changes in the wafer landscape?

What is the cost of not doing bigger glass for 450mm wafers?

What are the issues with changes in the glass size?

Does high-NA EUV really need this or will another technique support technology?

How would we propose to cover the costs?

Panelists:

Donis G. Flagello, Nikon Research Corp. of America

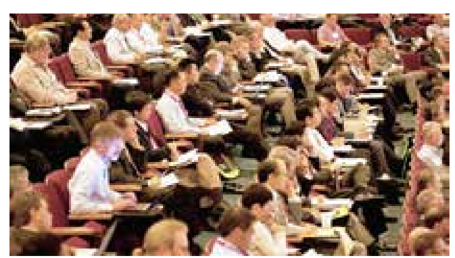
Janice M. Golda, Intel Corp.

Brian J. Grenon, RAVE LLC

Franklin D. Kalk, Toppan Photomasks, Inc.

Harry J. Levinson, GLOBALFOUNDRIES Inc.

Daniel C. Wack, KLA-Tencor Corp.



MAKE TIME FOR THE FREE EXHIBITION

Monterey Conference Center · Serra Ballroom
Exhibition: **10 – 11 September 2013**

Tuesday-Wednesday · 10:00 am to 4:00 pm
Tuesday Poster Reception · 6:00 to 7:30 pm

Company Name	Booth #
Carl Zeiss SMS GmbH.	302
Fortrend Engineering	409
Gudeng	405
Ibss Group, Inc.	210
Inko Industrial Corp.	506
Micro Lithography, Inc.	203
Mitsui Chemicals America, Inc.	407
Nippon Control System Corporation	512
Plasma-Therma LLC	401
Pozzetta	206
RAVE LLC	402
Shin-Etsu MicroSi, Inc.	400
Solid State Technology	108
Synopsys, Inc.	303
XYALIS	510
Zeeko Ltd.	301

Exhibition Floor Plan - Serra Grand Ballroom

Exit Only

Poster Area

508 510 512

504 506

Exit Only

210

208

Coffee and Dessert Area

409

407

206

405

203 302

*
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201

303 402

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Featured Product: 20 years of AIMS™, Aerial Image Measurement

Carl Zeiss SMS is a leading global supplier of both metrology and manufacturing equipment. Core expertise in light and electron optics, complemented by a revolutionary femtosecond laser technology form the foundation of a product portfolio comprising in-die metrology, actinic qualification, repair and tuning of photomasks. The strategic business unit is headquartered in Jena/Germany and has three further sites in Rossdorf/Germany, Oberkochen/Germany and Karmiel/Israel. Contact: Nadine Schuetze, Marketing Manager, nadine.schuetze@zeiss.com; James Polcyn, Sales Manager, jim.polcyn@zeiss.com

Fortrend Engineering #409

3080 Oakmead Village Dr., Santa Clara, CA, CA, 95051 United States
+1 408 734 9311; fax +1 408 734 4299
sales@fortrend.com; www.fortrend.com

Featured Product: EUVL Mask Transfer systems and OEM load port solutions

Fortrend has launched a series of ISO Class 1 Mask handling tools for the emerging EUVL market. The SMIF pod openers meets the SEMI 152 EUVL SMIF pods opening requirements: The PIS 200EUV DUAL; Opens both the inner and outer pods. The PLS 200 EUV; A table top opener for opening the EUVL SMIF pod. The PLM 200 EUV; Lifts the Outer Pod lid. The PLUS 500 G4 SMIF arm ISO Class 1 system enables a Mask to be picked up from a SMIF pod rotated 360° and/or tilted up to 270°. Contact: Richard Morgan, VP of Operations, rmorgan@fortrend.com

Gudeng #405

SPIE Corporate Member

9F, No. 2 Sec. 4 Zhongyang Rd, Tucheng Dist., New Taipei, 23678 Taiwan
+886 2 2268 9141; fax +886 2 2269 1943
scottchen@gudeng.com; www.gudeng.com.tw

ibss Group, Inc. #210

SPIE Corporate Member

1559B Sloat Blvd #270, San Francisco, CA, 94132 United States
+1 415 566 5774; fax +1 415 566 9779
admin@ibssgroup.com; www.ibssgroup.com

Featured Product: The GV10x Downstream Asher is the new paradigm in situ cleaner for vacuum chambers.

Founded in 2002, ibss Group, Inc. was developing field-free ion beam (IBS) deposition systems for EM specimen preparation. In 2003 ibss Group agreed to market a tool to minimize hydrocarbon contamination in SEMs by remote or downstream oxidation. In 2007 ibss Group began cooperating with an inventor of a unique, patented plasma source. ibss Group developed and produced the GV10x, a new paradigm in situ downstream plasma asher. Contact: Vince Carlino, President, vince.carlino@ibssgroup.com; Gabe Morgan, Technical Director, cgm@ibssgroup.com

Inko Industrial Corp. #506

695 Vaqueros Ave, Sunnyvale, CA, 95051 United States
+1 408 830 1041; fax +1 408 830 1058
sales@pellicle-inko.com; www.pellicle-inko.com

Featured Product: pellicle for 193nm lithography with minimized outgas

INKO, a U.S. based company, manufactures complete line of pellicles for photomask protections, ranging from ASIC production to high volume memory production, from 193nm to 248nm, to I/G line lithography. We have the right pellicles for your photomask protection. Contact: Joe Mac, customer service manager, joemac@pellicle-inko.com; Feng Ye, technical support, ye@pellicle-inko.com Contact: Feng ye, QA manager, ye@pellicle-inko.com; Joe Mac, customer support manager, joemac@pellicle-inko.com

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1257 Elko Drive, Sunnyvale, CA, 94089 United States
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Featured Product: Pellicles and Mounting Tool

MLI is featuring pellicles formulated to yield high rates of transmission and long lifetimes for UV exposure. Our complete line of pellicle films ranges from broadband, g-/i-line to DUV (KrF-248nm and ArF-193nm). MLI's DUV pellicles have the lowest outgassing materials available in the market today. Contact: Kevin Duong, Customer Service Manager, kevin.duong@mliusa.com; Diana Tjin, Sales Administrative Manager, diana.tjin@mliusa.com

Mitsui Chemicals America, Inc. #407

2099 Gateway Place, Ste 300, San Jose, CA, 95110 United States
+1 408 487 2891; fax +1 408 453 0684
www.mitsuichemicals.com

Since 1986, Mitsui has been the industry leader in providing pellicles to the semiconductor industry. Mitsui's ISO 9001 certified full automated plant produces Mitsui Pellicle, which transmits more than 99% of exposed light with excellent uniformity and longevity. Mitsui Pellicle, manufactured by rigorous selection of all materials and with 20 years accumulated expertise of non-dust structure, contributes to maximum production yields by eliminating pellicle related particle generations.

Nippon Control System Corporation #512

3333 Bowers Ave Ste 280, Santa Clara, CA, 95054 United States
+1 408 737 0338; fax +1 408 737 0329
ncs-patacon@nippon-control-system.co.jp; www.nippon-control-system.co.jp/en/index.html

Featured Product: NDE-MS offers total solutions to mask manufacture. It covers from post-opc through pre-mask writing.

Nippon Control System Corp has been providing fracturing tool to the industry over 20 years. As a successor of the famous PATACON, we have offered NDE Mask Manufacturable Suite (NDE-MS) which includes all applications required by mask manufactures from post-opc through pre-mask writing. The applications are NDE-Fracture, MRC, Select, PEC, MPC, and View. Now NDE-MS also offers a shot count reduction feature which is one of the hottest topics in the mask industry. Contact: Shu Ohara, General Manager, oohara@nippon-control-system.co.jp

Plasma-Therm LLC #401

SPIE Corporate Member

10050 16th St N, Saint Petersburg, FL, 33716-4219 United States
+1 727 577 4999
information@plasmatherm.com; www.plasmatherm.com

Pozzetta #206

3121 S Platte River Dr, Englewood, CO, 80110 United States
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customerservice@pozzetta.com; www.pozzetta.com

Featured Product: Photomask Compacts and Pods, Custom Wafer Carriers

Companies around the world trust Pozzetta to create secure environments for the handling, storage, and transport of photomasks, reticles, and wafers. Pozzetta will protect your valuable products from particles, ESD damage, outgassed components, and high costs. Contact: Scott Reese, Account Executive, scott.reese@pozzetta.com; Artemis Vasiliades, Account Executive, artemis@pozzetta.com

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RAVE LLC #402

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Featured Product: Merlin® 20nm Nanomachining Mask Repair; fp650 Femto-pulse Laser Mask Repair; Rhazer® Haze Removal System

RAVE is a technology driven company with a long history of unique technical contributions to the Photomask Industry. RAVE's exceptionally talented team is well known for the development and on-time delivery of innovative, cost-saving process solutions. RAVE is now delivering the new Gen 5 - Merlin® 20nm mask repair nanomachine and the revolutionary Rhazer® haze removal system. RAVE's fp650™ femto-pulse laser tool continues to be the fastest, most efficient 45nm production mask repair system. Contact: Dave Lee, VP Sales & Marketing, Dave.Lee@ravenano.com; Michael Archuletta, Director of Marketing, Michael.Archuletta@ravenano.com

Shin-Etsu MicroSi, Inc. #400

10028 S 51st St, Phoenix, AZ, 85044-5203 United States
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Shin-Etsu, the world's No. 1 supplier of semiconductor silicon wafers and a leading supplier of essential electronic materials. Shin-Etsu's product portfolio includes, photomask blanks, EB resists, pellicles, synthetic quartz, semiconductor advanced resists along with numerous specialized thermal interface materials. Contact: Ed Nichols, Marketing Manager, enichols@microsi.com; info@microsi.com

Solid State Technology #108

98 Spit Brook Road, Nashua, NH, 03062 United States
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Featured Product: Solid State Technology

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XYALIS #510

SPIE Corporate Member

World Trade Center Grenoble - BP 1510, Grenoble - Cedex 01, 38025 France
+33 476 70 64 75
info@xyalis.com; www.xyalis.com

Featured Product: GTframe, automatic frame generator, now includes a visual debugger to solve placement conflicts

XYALIS offers advanced solutions for Mask Data Preparation (MDP) and Design For Manufacturing (DFM) that shorten time to manufacturing, increase yield, and remove errors during mask and wafer production. A proven integrated MDP solution automates frame generation, MPW design, maskset creation, and Mask Order Form management. A dummy fill engine for the most advanced processes combines power and accuracy of model-based approaches with simplicity and performance of rule-based tools. Contact: Sylvie Hurat, US Area Manager, sylvie@xyalis.com

Zeeko Ltd. #301

4 Vulcan Court, Vulcan Way, Coalville Leicester, LE67 3FW United Kingdom
+44 1530 815 832; fax +44 1530 839 631
info@zeeko.co.uk; www.zeeko.co.uk

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Tuesday - Thursday 10–12 September 2013 • Proceedings of SPIE Vol. 8880

SPIE Photomask Technology

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Tuesday 10 September

WELCOME AND INTRODUCTION

Room: Steinbeck Forum . . . . 8:00 am to 8:10 am

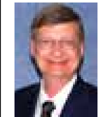
Session Chairs: **Thomas B. Faure,** IBM Corp. (United States); **Paul W. Ackmann,** GLOBALFOUNDRIES Inc. (United States)

SESSION 1

Room: Steinbeck Forum . . . . Tue 8:10 am to 8:50 am

Keynote Session

Session Chairs: **Thomas B. Faure,** IBM Corp. (United States); **Paul W. Ackmann,** GLOBALFOUNDRIES Inc. (United States)



8:10 am: **Delivering Complexity at the Frontier of Electronics** *(Keynote Presentation)*, Michael C. Mayberry, Intel Corp. (United States) . . . . [8880-1]

SESSION 2

Room: Steinbeck Forum . . . . Tue 8:50 am to 10:10 am

Materials and Process I

Session Chairs: **Mark T. Jee,** HOYA Corp. USA (United States); **Uwe Dietze,** SUSS MicroTec Inc. (United States)

8:50 am: **Effect of chemical composition of Ru capping layer and wet chemical processing EUV mask**, Yun Yue Lin, Taiwan Semiconductor Manufacturing Co. Ltd. (Taiwan) . . . . [8880-2]

9:10 am: **Photomask linewidth roughness and its control**, Banqiu Wu, Ajay Kumar, Applied Materials, Inc. (United States) . . . . [8880-3]

9:30 am: **Ultra-low roughness magneto-rheological finishing for EUV mask substrates**, Paul Dumas, Chuck McFee, QED Technologies, Inc. (United States); Arun J. Kadaksham, Ranganath Teki, SEMATECH North (United States) . [8880-4]

9:50 am: **Study of outgassing of electron-beam resists for photomask applications**, Gregory M. Wallraff, IBM Almaden Research Ctr. (United States); Steven C. Nash, IBM Corp. (United States); Linda K. Sundberg, IBM Almaden Research Ctr. (United States); William D. Hinsberg, Columbia Hill Technical Consulting (United States); Amy E. Zweber, Ray W. Jeffer, IBM Corp. (United States); Tasuku Senna, Toppan Photomasks, Inc. (United States); Gregory Denbeaux, College of Nanoscale Science & Engineering (United States); Alexander M. Friz, IBM Corp. (United States); Campbell Scott, Luisa D. Bozano, IBM Almaden Research Ctr. (United States) . . . . [8880-5]

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

SESSION 3

Room: Steinbeck Forum . . . . Tue 10:40 am to 11:10 am

Best Paper JPM13

Session Chairs: **Wilhelm Maurer,** Infineon Technologies AG (Germany); **Linyong Pang,** Luminescent Technologies (United States)

10:40 am: **2013 JPM Best Paper: A study of phase defect measurement on EUV mask by multiple detectors CD-SEM** *(Invited Paper)*, Isao Yonekura, Hidemitsu Hakii, Shinya Morisaki, Toppan Printing Co., Ltd. (Japan); Tsutomu Murakawa, Soichi Shida, Masayuki Kuribara, Toshimichi Iwai, Jun Matsumoto, Takayuki Nakamura, Advantest Corp. (Japan) . . . . [8880-6]

SESSION 4

Room: Steinbeck Forum . . . . Tue 11:10 am to 12:20 pm

Simulation, OPC, and Mask Data Preparation I

Session Chairs: **Wilhelm Maurer,** Infineon Technologies AG (Germany); **Linyong Pang,** Luminescent Technologies (United States)

11:10 am: **Entering mask process correction era for EUV mask manufacturing** *(Invited Paper)*, Christian Buergel, Martin Sczyrba, Advanced Mask Technology Ctr. GmbH Co. KG (Germany); Keith P. Standiford, GLOBALFOUNDRIES Inc. (United States); Gek Soon Chua, GLOBALFOUNDRIES Singapore (Singapore). . . . . [8880-7]

11:40 am: **Simulation study of multi-beamlet fogging effect on hard mask**, Hyuncheong Ha, Sanghee Lee, Inkyun Shin, Shuichi Tamamushi, Chan-Uk Jeon, SAMSUNG Electronics Co., Ltd. (Korea, Republic of) . . . . [8880-8]

12:00 pm: **Automated defect classification and progression monitoring (DPM) in wafer fab reticle requal**, Vikram L. Tolani, Luminescent Technologies (United States); T. H. Yen, Rick Lai, Laurent Tuo, Taiwan Semiconductor Manufacturing Co. Ltd. (Taiwan); Dongxue Chen, Peter Hu, Jiao Yu, Y. C. Wei, George Hwa, Suresh Lakkapragada, Kechang Wang, Danping Peng, Luminescent Technologies (United States); Bill Wang, Kaiming Chiang, Luminescent Technologies, Inc. (Taiwan) . . . . [8880-9]

Lunch/Exhibition Break . . . . .Tue 12:20 pm to 1:50 pm

SESSION 5

Room: Steinbeck Forum . . . . Tue 1:50 pm to 3:10 pm

Mask Inspection I

Session Chairs: **William H. Broadbent Jr.,** KLA-Tencor Corp. (United States); **Anna Tchikoulaeva,** Lasertec U.S.A., Inc. Zweigniederlassung Deutschland (Germany)

1:50 pm: **Performance of an automatic algorithm for quantifying critical dimensions in actinic aerial images**, Douglas Uzzel, Mark Ma, Shad E. Hedges, Photronics, Inc. (United States); Saghir Munir, Reticle Labs. (United States) . . . . [8880-10]

2:10 pm: **Improve mask inspection capacity with automatic defect classification (ADC)**, Eric G. Guo, Blade Gao, Crystal Wang, Steven Ho, Semiconductor Manufacturing International Corp. (China); Kechang Wang, Luminescent Technologies (China); Suresh Lakkapragada, Jiao Yu, Peter Hu, Vikram L. Tolani, Linyong Pang, Luminescent Technologies (United States) . . . . [8880-11]

2:30 pm: **Increasing reticle inspection efficiency and reducing wafer print-checks via automated defect classification and simulation**, Sung Jae Ryu, Sung Taek Lim, SAMSUNG Electronics Co., Ltd. (Korea, Republic of); Anthony D. Vacca, Peter J. Fiekowsky, Dan Fiekowsky, AVI-Automated Visual Inspection (United States). . . . . [8880-12]

2:50 pm: **Your worst nightmare: inspection of aggressive OPC on 14nm masks with emphasis on defect sensitivity and wafer defect print predictability**, Karen D. Badger, IBM Corp. (United States); Kazunori Seki, Toppan Photomasks, Inc. (United States); Ian Stobert, Daniel J. Dechene, Donald J. Samuels, IBM Corp. (United States); Vincent A. Redding, William H. Broadbent Jr., KLA-Tencor Corp. (United States) . . . . [8880-13]

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

SESSION 6

Room: Steinbeck Forum . . . . Tue 3:40 pm to 4:40 pm

Simulation, OPC, and Mask Data Preparation II

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

3:40 pm: **The impact of 14nm photomask variability and uncertainty on computational lithography solutions** *(Invited Paper)*, John L. Sturtevant, Edita Tejnil, Steffen F. Schulze, Peter D. Buck, Mentor Graphics Corp. (United States); Franklin D. Kalk, Kent H. Nakagawa, Toppan Photomasks, Inc. (United States); Paul W. Ackmann, GLOBALFOUNDRIES Inc. (United States); Christian Buergel, Fritz Gans, Advanced Mask Technology Ctr. GmbH Co. KG (Germany) . [8880-14]

4:00 pm: **An accurate ILT-enabling mask 3D full chip modeling for all-angle patterns**, Hongbo Zhang, Qiliang Yan, Ebo H. Croffie, Lin Zhang, Yongfa Fan, Synopsys, Inc. (United States) . . . . [8880-15]

4:20 pm: **Simulation study of CD variation caused by field-edge effects and out-of-band radiation in EUVL**, Weimin Gao, Synopsys, Inc. (Belgium); Ardavan Niroomand, Micron Technology, Inc. (United States); Gian F. Lorusso, IMEC (Belgium); Robert Boone, Kevin Lucas, Synopsys, Inc. (United States); Wolfgang Demmerle, Synopsys GmbH (Germany) . . . . [8880-16]

SESSION 7

Room: Steinbeck Forum . . . . Tue 4:40 pm to 5:20 pm

Patterning and Double-Patterning Technology

Session Chairs: **Douglas J. Resnick,** Molecular Imprints, Inc. (United States); **Frank Goodwin,** SEMATECH Inc. (United States)

4:40 pm: **Color balancing for triple-pattern lithography with complex designs**, Haitong Tian, Univ. of Illinois at Urbana-Champaign (United States); Hongbo Zhang, Synopsys, Inc. (United States); Zigang Xiao, Martin D. F. Wong, Univ. of Illinois at Urbana-Champaign (United States) . . . . [8880-17]

5:00 pm: **450mm wafer patterning with jet and flash imprint lithography**, Ecron Thompson, Paul Hellebrekers, Paul Hofemann, Dwayne L. LaBrake, Douglas J. Resnick, S. V. Sreenivasan, Molecular Imprints, Inc. (United States) . . . . [8880-19]

SESSION 7A

Room: Steinbeck Forum . . . . Tue 5:20 pm to 5:45 pm

Mask Industry Survey

5:20 am: **2013 Mask Industry Survey** *(Invited Paper)*, Matt Malloy, Long He, SEMATECH Inc. (United States) . . . . [8880-100]

EXHIBITION/POSTER RECEPTION

Room: Serra Grand Ballroom . . . . 6:00 pm to 7:30 pm

Symposium attendees are invited to attend an Exhibition/Poster 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. Attendees are requested to wear their conference registration badges.

POSTER VIEWING

Tuesday 10 September, 10 am to 4 pm, and 6 to 7:30 pm
Wednesday 11 September, 10 am to 3 pm

Poster authors may set up their poster papers between 10 am and 4 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.

High-fidelity dummy fill printing with repair OPC, Louis Lin, Wei-Long Wang, Sarah N. McGowan, GLOBALFOUNDRIES Inc. (United States). . . . . [8880-56]

Phase preservation study on ArF mask for haze-free mask resist strip and cleaning, Irene Shi, Eric G. Guo, Eric Mingjing Tian, Tracy Gu, Forrest Jiang, Sandy Qian, Semiconductor Manufacturing International Corp. (China); Daisuke Matsushima, Shibaura Mechatronics Corp. (Japan) . . . . [8880-57]

A new mask linearity specification for EUV masks based on time-dependent dielectric breakdown requirements, Keith P. Standiford, GLOBALFOUNDRIES Inc. (United States); Christian Buergel, Advanced Mask Technology Ctr. GmbH Co. KG (Germany) . . . . [8880-58]

A study on the chromium surface damage in the structure of a silicon oxynitride hardmask on the chromium surface of PSM blank, Songbae Moon, Heebom Kim, Inkyun Shin, Chan-Uk Jeon, SAMSUNG Electronics Co., Ltd. (Korea, Republic of). . . . . [8880-59]

In-die mask registration measurement on 28nm-node and beyond, Shen-Hung Chen, Yung-Feng Cheng, Ming-Jui Chen, United Microelectronics Corp. (Taiwan) . . . . [8880-60]

2X metal and implant layers proximity matching for different reticle blanks, GuoXiang Ning, Selvi Gopalakrishnan, Thomas Thamm, Remi Rivière, Nikolay Oleynik, Stephanie Maelzer, GLOBALFOUNDRIES Dresden Module Two, GmbH & Co. KG (Germany); Yee Mei Foong, GLOBALFOUNDRIES Singapore (Singapore); Paul W. Ackmann, GLOBALFOUNDRIES Inc. (United States) . . . . [8880-61]

OPC modeling with CD-AFM measurement, Kyoil Koo, Gyengseop Kim, SAMSUNG Electronics Co., Ltd. (Korea, Republic of) . . . . [8880-62]

Increased depth of focus through wave-front coding: using an off-axis zone plate lens with cubic phase modulation in an EUV microscope, Markus P. Benk, Kenneth A. Goldberg, Iacopo Mochi, Erik H. Anderson, Weilun Chao, Lawrence Berkeley National Lab. (United States). . . . . [8880-63]

A study of the defect detection technology using the optic simulation for the semiconductor device, Yusin Yang, Yongdeok Jeong, SAMSUNG Electronics Co., Ltd. (Korea, Republic of); Mitsunori Numata, Samsung Yokohama Research Institute Co., Ltd. (Japan); Mira Park, ChungSam Jun, SangKil Lee, SAMSUNG Electronics Co., Ltd. (Korea, Republic of) . . . . [8880-64]

Mask contamination study in electron and ion-beam repair system, Hyo-Jin Ahn, Jong-Min Kim, Dong-Seok Lee, Dong-Heok Lee, Sang-Soo Choi, PKL Co., Ltd. (Korea, Republic of) . . . . [8880-67]

Model-driven design target movement to resolve design hot spots through image quality enhancement, Sung-Woo Lee, Synopsys Korea Inc. (Korea, Republic of); Thomas Cecil, Guangming Xiao, Mindy Lee, Synopsys, Inc. (United States); Jung-Hoe Choi, Seung-Hee Baek, Synopsys Korea Inc. (Korea, Republic of); Jin-Hyuck Jeon, Chan-Ha Park, SK Hynix, Inc. (Korea, Republic of); Dave H. Kim, Kevin Lucas, Synopsys, Inc. (United States) . . . . [8880-68]

Sensitivity analysis for OMOG and EUV masks characterized by UV-NIR spectroscopic ellipsometry, Anett Heinrich, Ingo Dirnstorfer, NaMLab gGmbH (Germany); Jörg Bischoff, OSIRES Optical Engineering and Software (Germany); Uwe Richter, SENTECH Instruments GmbH (Germany); Thomas Mikolajick, NaMLab gGmbH (Germany) and Technisch Univ. Dresden (Germany) . . [8880-70]

Fleet matching performance for multiple registration measurement tools, Dirk Seidel, Dirk Beyer, Carola Bläsing, Klaus Böhm, Sven Heisig, Carl Zeiss SMS GmbH (Germany). . . . . [8880-71]

The recovering method of etch chamber condition by using the optical emission spectroscopy monitoring system, Choonghan Ryu, Jun Jae Young, Ho Yong Jung, Sang Pyo Kim, Yim Dong Gyu, Hynix Semiconductor Inc. (Korea, Republic of) . . . . [8880-72]

Analysis of EUV mask durability under various absorber etch conditions, Dong Wook Lee, Sang Jin Jo, Tae Joong Ha, Sang Pyo Kim, Dong Gyu Yim, SK Hynix, Inc. (Korea, Republic of). . . . . [8880-73]

Finite-element based EMF simulation methods for computational lithography and computational metrology in the DUV and EUV regimes, Sven Burger, JCMwave GmbH (Germany) and Konrad-Zuse-Zentrum für Informationstechnik Berlin (Germany); Lin Zschiedrich, Jan Pomplun, JCMwave GmbH (Germany); Frank Schmidt, JCMwave GmbH (Germany) and Konrad-Zuse-Zentrum für Informationstechnik Berlin (Germany) . . . . [8880-74]

Metrology variability and its impact in process modeling, Thiago R. Figueiro, Aselta Nanographics (France) and CNRS/UJF-Grenoble1/CEA LTM (France); Mohamed Saib, Aselta Nanographics (France); Kang-Hoon Choi, Christoph K. Hohle, Fraunhofer-Ctr. Nanoelektronische Technologien (Germany); Martin J. Thornton, Cyril Vannufel, CEA-LETI-Minatec (France); Patrick Schiavone, Aselta Nanographics (France) . . . . [8880-75]

Mask topography effect characterization by rigorous model and its implementation for full-chip simulation, Hongbo Zhang, Qiliang Yan, Ebo H. Croffie, Lin Zhang, Yongfa Fan, Jing Xue, Synopsys, Inc. (United States) . . . . [8880-76]

Pupil shaping and coherence control in an EUV mask-imaging microscope, Iacopo Mochi, Kenneth A. Goldberg, Markus P. Benk, Patrick P. Naulleau, Lawrence Berkeley National Lab. (United States). . . . . [8880-77]

An efficient and accurate full-chip mask 3D model for off-axis illumination with effective mask rigorous library, Hongbo Zhang, Qiliang Yan, Lin Zhang, Ebo H. Croffie, Peter D. Brooker, Qian Ren, Yongfa Fan, Synopsys, Inc. (United States) . . . . [8880-78]

In-die mask registration for multipatterning, Klaus-Dieter Roeth, Frank Laske, KLA-Tencor MIE GmbH (Germany); Shinji Kunitani, Akira Fuse, Tatsuhiko Kamibayashi, Mitsuharu Yamana, Toppan Printing Co., Ltd. (Japan); Hisaya Sakaguchi, KLA-Tencor Japan (Japan); Mark P. Wagner, Michael Ferber, KLA-Tencor MIE GmbH (Germany); Mehdi Daneshpanah, KLA-Tencor Corp. (United States) . . . . [8880-79]

Improving wafer level CD uniformity for logic applications utilizing mask level metrology and process, Avi Cohen, Carl Zeiss SMS Ltd. (Israel); Ute Buttgereit, Carl Zeiss SMS GmbH (Germany); Erez Graitzer, Carl Zeiss SMS Ltd. (Israel); Thomas Trautzsch, Carl Zeiss SMS GmbH (Germany); Ori Hanuka, Carl Zeiss SMS Ltd. (Israel) . . . . [8880-81]

A fast convolution method using basis expansion for highly-efficient intensity calculation in mask optimization, Yaping Sun, Yehua Zuo, Jinyu Zhang, Yan Wang, Zhiping Yu, Tsinghua Univ. (China) . . . . [8880-82]

Impact of an etched EUV mask black border on imaging and overlay, part II, Natalia V. Davydova, Robert C. de Kruif, ASML Netherlands B.V. (Netherlands); Hiroaki Morimoto, Yo Sakata, Toppan Printing Co., Ltd. (Japan); Jun Kotani, Toppan Photomasks, Inc. (United States); Norihito Fukugami, Shinpei Kondo, Tomohiro Imoto, Toppan Printing Co., Ltd. (Japan); Brid Connolly, Toppan Photomasks, Inc. (Germany); Dorothe Oorschot, ASML Netherlands B.V. (Netherlands); John D. Zimmerman, Noreen Harned, ASML (United States) . . . . [8880-83]

Development of inspection system for EUV mask with novel projection electron microscopy (PEM), Masahiro Hatakeyama, Takeshi Murakami, Terao Kenji, Shoji Yoshikawa, Kenji Watanabe, EBARA Corp. (Japan); Tsuyoshi Amano, Ryoichi Hirano, Susumu Iida, Tsuneo Terasawa, Hidehiro Watanabe, EUVL Infrastructure Development Ctr., Inc. (Japan) . . . . [8880-84]

A novel method for utilizing AIMS to evaluate mask repair and quantify over-repair or under-repair condition, Douglas Uzzel, Jon Morgan, Mark Ma, Photronics, Inc. (United States); Vahagn Sargsyan, Kevin R. Olson, Carl Zeiss SMS (United States); Thomas Scherübl, Anthony D. Garetto, Gilles Tabbone, Carl Zeiss SMS GmbH (Germany) . . . . [8880-85]

Analysis of edge effects in attenuating phase-shift masks using quantitative phase imaging, Aamod Shanker, Univ. of California, Berkeley (United States); Martin Sczyrba, Advanced Mask Technology Ctr. GmbH Co. KG (Germany); Brid Connolly, Toppan Photomasks, Inc. (Germany); Franklin D. Kalk, Toppan Photomasks, Inc. (United States); Andrew R. Neureuther, Laura Waller, Univ. of California, Berkeley (United States). . . . . [8880-86]

Recovering effective amplitude and phase roughness of EUV masks using an EUV microscope, Rene A. Claus, Univ. of California, Berkeley (United States); Markus P. Benk, Kenneth A. Goldberg, Iacopo Mochi, Lawrence Berkeley National Lab. (United States); Andrew R. Neureuther, Univ. of California, Berkeley (United States); Patrick P. Naulleau, Lawrence Berkeley National Lab. (United States) . . . . [8880-87]

EUV mask scatterometry metrology challenges, Oleg Kritsun, GLOBALFOUNDRIES Inc. (United States); Jeffrey W. Roberts, Rahim Forouhi, n&k Technology, Inc. (United States) . . . . [8880-88]

AF printability check with a full-chip 3D resist profile model, Cheng-En R. Wu, Synopsys Taiwan Ltd. (Taiwan); Hua Song, Synopsys, Inc. (United States) . . . . [8880-89]

HSQ process development for a superior resolution and a reasonable sensitivity for an EB master-mold fabrication for nanoimprint lithography, Hideo Kobayashi, Hiromasa Iyama, Takeshi Kagatsume, Takashi Sato, Shuji Kishimoto, Tsuyoshi Watanabe, HOYA Corp. (Japan) . . . . [8880-90]

EUV lithography tool focus monitoring using a 90-degree phase-shift mask, Sudharshanan Raghunathan, Lei Sun, Obert R. Wood II, GLOBALFOUNDRIES Inc. (United States); Timothy A. Brunner, IBM Corp. (United States); Sang-in Han, ASML US, Inc. (United States); Haiko Rolff, Thorsten Schedel, Markus Bender, Advanced Mask Technology Ctr. GmbH Co. KG (Germany); Pawitter J. Mangat, GLOBALFOUNDRIES Inc. (United States) . . . . [8880-91]

Underlayer effects in block levels: are they under control?, Dongbing Shao, Bidan Zhang, Alan J. Leslie, Anuja De Silva, IBM Corp. (United States) . [8880-92]

Evaluation results of a newly designed slim column for wide-range application of e-beam lithography, Masahiro Takizawa, Hitoshi Tanaka, Tomohiko Abe, Youichi Shimizu, Masaki Kurokawa, Shin-ichi Hamaguchi, Akio Yamada, Kiichi Sakamoto, Takayuki Nakamura, Advantest Corp. (Japan). . . . . [8880-93]

Novel fracturing algorithm to reduce shot count for curvy shape, Masakazu Hamaji, Takuya Tao, Nobuyasu Takahashi, Nippon Control System Corp. (Japan). . . . . [8880-94]

Extreme-ultraviolet mask defect observation using an extreme-ultraviolet microscope, Tsuyoshi Amano, Tsuneo Terasawa, Hidehiro Watanabe, EUVL Infrastructure Development Ctr., Inc. (Japan); Mitsunori Toyoda, Tohoku Univ. (Japan); Tetsuo Harada, Takeo Watanabe, Hiroo Kinoshita, Univ. of Hyogo (Japan). . . . . [8880-95]

E-beam GIDC resolution enhancement technology in practical applications, Stephan Martens, Jörg Butschke, Holger Sailer, Institut für Mikroelektronik Stuttgart (Germany); Reinhard R. Galler, Michael Krüger, Martin Suelzle, EQUIcon Software GmbH Jena (Germany) . . . . [8880-96]

Advancement of fast EUV lithography modeling/simulations and applications on evaluating different repair options for EUV mask multilayer defect, Danping Peng, Masaki Satake, Ying Li, Peter Hu, Luminescent Technologies (United States); Qing Huo Liu, Duke Univ. (United States); Linyong Pang, Luminescent Technologies (United States). . . . . [8880-97]

The optical SLM: a superior photomask, Tor Sandstrom, Micronic Mydata AB (Sweden) . . . . [8880-98]

Potential of mask production process for finer pattern fabrication, Keisuke Yagawa, Kunihiro Ugajin, Machiko Suenaga, Yoshihito Kobayashi, Takeharu Motokawa, Kazuki Hagihara, Masato Saito, Masamitsu Itoh, Toshiba Corp. (Japan). . . . . [8880-101]

Patterning of EUVL binary etched multilayer mask, Kosuke Takai, Takeharu Motokawa, Koji Murano, Takashi Kamo, Toshiba Corp. (Japan); Naoya Hayashi, Dai Nippon Printing Co., Ltd. (Japan) . . . . [8880-102]

Modeling and correction of reactive-ion-etch contributions to mask CD nonlinearities, Youhei Ookawa, Katsuya Hayano, Yasutaka Morikawa, Dai Nippon Printing Co., Ltd. (Japan); Christoph Sambale, Ulrich Hofmann, Nezih Unal, GenISys GmbH (Germany). . . . . [8880-103]

Wednesday 11 September

SESSION 8

Room: Steinbeck Forum . . . . Wed 8:00 am to 9:00 am

Mask Contamination, Cleaning, and Long-Term Durability I

Session Chairs: **Brian J. Grenon,** RAVE LLC (United States); **Lucien Bouchard,** Photronics, Inc. (United States)

8:00 am: **Computational mask defect review for contamination and haze inspections**, Paul Morgan, Daniel L. Rost, Daniel Price, MP Mask Technology Ctr., LLC (United States); Noel Corcoran, Masaki Satake, Peter Hu, Danping Peng, Dean Yonenaga, Vikram L. Tolani, Luminescent Technologies (United States) . . . . [8880-20]

8:20 am: **Evaluation of dry technology for removal of pellicle glue on advanced exposed optical photomasks**, Shazad Paracha, Benjamin G. Eynon Jr., SAMSUNG Austin Semiconductor LLC (United States) . . . . [8880-21]

8:40 am: **Inline detection of chrome degradation on binary 193nm photomasks**, Félix Dufaye, STMicroelectronics (France); Astrid Sippel, KLA-Tencor France (France); Mark M. Wylie, Charles W. Crawford, Carl E. Hess, KLA-Tencor Corp. (United States); Carlo Pogliani, Luca Sartelli, Hiroyuki Miyashita, DNP Photomask Europe S.p.A. (Italy); Stuart Gough, Frank Sundermann, Christophe Brochard, STMicroelectronics (France) . . . . [8880-22]

SESSION 9

Room: Steinbeck Forum . . . . Wed 9:00 am to 10:00 am

Mask Metrology I

Session Chairs: **Jacek K. Tyminski,** Nikon Research Corp. of America (United States); **Thomas Scherübl,** Carl Zeiss SMS GmbH (Germany)

9:00 am: **Comparison of CD measurements by EUV scatterometry and CD-AFM of an EUV photomask**, Frank Scholze, Victor Soltwisch, Gaoliang Dai, Mark-Alexander Henn, Hermann A. Gross, Physikalisch-Technische Bundesanstalt (Germany) . . . . [8880-23]

9:20 am: **Two-dimensional mask effects at the 14nm logic node**, Amy E. Zweber, Anne E. McGuire, Chester Huang, Katherine Ballman, Mike S. Hibbs, Steven C. Nash, IBM Corp. (United States); Takeshi Isogawa, Yoshiyuki Negishi, Tasuku Senna, Toppan Photomasks, Inc. (United States); Tom B. Faure, Emily E. Gallagher, Jed H. Rankin, Daniel J. Dechene, Lin Hu, Mohamed Talbi, IBM Corp. (United States); Samit Barai, IBM India Private Ltd. (India); Yongan Xu, IBM Corp. (United States). . . . . [8880-24]

9:40 am: **Measurement of EUV absorber and resist CD using spectroscopic ellipsometer**, Kyung M. Lee, Malahat A. Tavassoli, Pei-Yang Yan, Intel Corp. (United States). . . . . [8880-25]

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

SESSION 10

Room: Steinbeck Forum . . . . Wed 10:50 am to 11:10 am

Best Paper EMCL 2013

Session Chairs: **Emily E. Gallagher,** IBM Corp. (United States); **Pawitter J. Mangat,** GLOBALFOUNDRIES Inc. (United States)

10:50 am: **2013 EMLC Best Paper: Experimental approach to EUV imaging enhancement by mask absorber height optimization** *(Invited Paper)*, Natalia V. Davydova, Robert C. de Kruif, ASML Netherlands B.V. (Netherlands); Haiko Rolff, Advanced Mask Technology Ctr. GmbH Co. KG (Germany); Brid Connolly, Eelco van Setten, Ad Lammers, Dorothe Oorschot, ASML Netherlands B.V. (Netherlands); Norihito Fukugami, Yutaka Kodera, Toppan Printing Co., Ltd. (Japan). . . . . [8880-26]

SESSION 11

Room: Steinbeck Forum . . . . Wed 11:10 am to 12:10 pm

Mask Inspection II

Session Chairs: **Emily E. Gallagher,** IBM Corp. (United States); **Pawitter J. Mangat,** GLOBALFOUNDRIES Inc. (United States)

11:10 am: **Reflecting on inspectability and wafer printability of multiple EUV mask absorbers**, Kazunori Seki, Toppan Photomasks, Inc. (United States); Karen D. Badger, Emily E. Gallagher, Gregory R. McIntyre, IBM Corp. (United States); Toshio Konishi, Toppan Photomasks, Inc. (United States); Yutaka Kodera, Satoshi Takahashi, Toppan Printing Co., Ltd. (Japan); Vincent A. Redding, KLA-Tencor Corp. (United States). . . . . [8880-27]

11:30 am: **The SEMATECH high-NA actinic reticle review project (SHARP) EUV mask-imaging microscope**, Kenneth A. Goldberg, Iacopo Mochi, Markus P. Benk, Arnaud P. Allezy, Michael R. Dickinson, Carl W. Cork, James B. Macdougall, Patrick P. Naulleau, Senajith B. Rekawa, Lawrence Berkeley National Lab. (United States). . . . . [8880-28]

11:50 am: **EUV patterned mask inspection system using projection electron microscope technique**, Hidehiro Watanabe, Ryoichi Hirano, Susumu Iida, Tsuyoshi Amano, Tsuneo Terasawa, EUVL Infrastructure Development Ctr., Inc. (Japan); Masahiro Hatakeyama, Takeshi Murakami, Shoji Yoshikawa, Kenji Terao, EBARA Corp. (Japan) . . . . [8880-30]

Lunch/Exhibition Break . . . . Wed 12:10 pm to 1:40 pm

SESSION 12

Room: Steinbeck Forum . . . . Wed 1:40 pm to 3:10 pm

Mask Materials and Process II

Session Chairs: **M. Warren Montgomery,** College of Nanoscale Science & Engineering (United States); **Glenn R. Dickey,** Shin-Etsu MicroSi, Inc. (United States)

1:40 pm: **Defects on high-resolution negative-tone resist: the revenge of the blobs** *(Invited Paper)*, Martha I. Sanchez, Linda K. Sundberg, Luisa D. Bozano, Ratnam Sooriyakumaran, Daniel P. Sanders, IBM Almaden Research Ctr. (United States); Tasuku Senna, Toppan Photomasks, Inc. (United States); Masahito Tanabe, Toru Komizo, Itaru Yoshida, Toppan Printing Co., Ltd. (Japan); Amy E. Zweber, IBM Corp. (United States) . . . . [8880-31]

2:10 pm: **Controlling the sidewall angle of advanced attenuated phase-shift photomasks for 14nm and 10nm lithography**, Richard E. Wistrom, IBM Corp. (United States); Yoshifumi Sakamoto, Toppan Photomasks, Inc. (United States); Thomas B. Faure, Jeffery Panton, IBM Corp. (United States); Takeshi Isogawa, Toppan Photomasks, Inc. (United States); Anne E. McGuire, IBM Corp. (United States) . . . . [8880-32]

2:30 pm: **Model-based etch profile simulation of advanced PSM films**, Michael Grimbergen, Madhavi R. Chandrachood, Jeffrey X. Tran, Toi-Yue B. Leung, Keven Yu, Amitabh Sabharwal, Ajay Kumar, Applied Materials, Inc. (United States) . . . . [8880-33]

2:50 pm: **Implementable and systematic mitigation of EUV phase defects**, Wen Chang Hsueh, Taiwan Semiconductor Manufacturing Co. Ltd. (Taiwan) . . . . [8880-34]

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

SESSION 13

Room: Steinbeck Forum . . . . Wed 3:40 pm to 4:40 pm

Mask Contamination, Cleaning, and Long-Term Durability II

Session Chairs: **Byung Gook Kim,** SAMSUNG Electronics Co., Ltd. (Korea, Republic of); **Banqiu Wu,** Applied Materials, Inc. (United States)

3:40 pm: **Studying the effects of modified surface chemistry on chrome migration in binary photomasks**, Christopher Kossow, Peter S. Kirlin, Michael J. Green, Photronics, Inc. (United States). . . . . [8880-35]

4:00 pm: **Investigation of EUVL reticle capping layer peeling under wet cleaning**, SherJang Singh, Uwe Dietze, SUSS MicroTec Inc. (United States); Arun J. Kadaksham, Mason Jang, Frank Goodwin, SEMATECH Inc. (United States) . . . . [8880-36]

4:20 pm: **Causes and mitigation of large killer defects in ultralow defect extreme UV mask blanks**, Adrian Devasahayam, Alan Hayes, Boris Druz, Viktor Kanarov, Timothy L. Pratt, Alfred Weaver, Veeco Ion Beam Equipment Inc. (United States); Patrick A. Kearney, SEMATECH Inc. (United States); Alin O. Antohe, SEMATECH Inc. (United States) and Veeco Ion Beam Equipment Inc. (United States); Frank Goodwin, SEMATECH Inc. (United States) . . . . [8880-37]

SESSION 14

Room: Steinbeck Forum . . . . Wed 4:40 pm to 5:40 pm

Direct-Write

Session Chairs: **Frank E. Abboud,** Intel Corp. (United States); **Thomas H. Newman,** Micronic Laser Systems Inc. (United States)

4:40 pm: **1D design style implications for mask making and CEBL**, Michael C. Smayling, Tela Innovations, Inc. (United States). [8880-38]

5:00 pm: **Charting CEBL's role in mainstream semiconductor lithography**, David K. Lam, Multibeam Corp. (United States) . . . . [8880-39]

5:20 pm: **Impact of proximity model inaccuracy on patterning in electron-beam lithography**, Shy-Jay Lin, Taiwan Semiconductor Manufacturing Co. Ltd. (Taiwan) . . . . [8880-40]

Thursday 12 September

SESSION 15

Room: Steinbeck Forum . . . . Thu 8:00 am to 8:20 am

2013 JPM Panel Overview

Session Chair: **Paul W. Ackmann,** GLOBALFOUNDRIES Inc. (United States)

8:00 am: **2013 Photomask Japan Panel Discussion Summary: Future mask patterning technologies in the next decade: searching for the best mix solution** *(Invited Paper)*, Noriaki Nakayamada, NuFlare Technology, Inc. (Japan); Ichiro Kagami, Sony Semiconductor Kyushu Co., Ltd. (Japan) . . . . [8880-41]

PANEL DISCUSSION

Room: Steinbeck Forum . . . . 8:20 am to 10:20 am

Special Session Panel Discussion: Big Glass: Will It Return?

Again We Look at Bigger Glass: The Glass is on Trial

Moderator: **Paul W. Ackmann,** GLOBALFOUNDRIES Inc.

Is there a need to move to larger glass to enable changes in the wafer landscape? What is the cost of not doing bigger glass for 450mm wafers? What are the issues with changes in the glass size? Does high-NA EUV really need this or will another technique support technology? How would we propose to cover the costs?

Panelists: **Donis G. Flagello**, Nikon Research Corp. of America; **Janice M. Golda,** Intel Corp.; **Brian J. Grenon,** RAVE LLC; **Franklin D. Kalk,** Toppan Photomasks, Inc; **Harry J. Levinson,** GLOBALFOUNDRIES Inc.; **Daniel C. Wack,** KLA-Tencor Corp.

SESSION 16

Room: Steinbeck Forum . . . . Thu 10:50 am to 12:10 pm

Mask Manufacturing, and Yield and Mask Business

Session Chairs: **Bryan S. Kasprowicz,** Photronics, Inc. (United States); **Wolfgang Staud,** Consultant (United States)

10:50 am: **Mask automation: need a revolution in mask makers and equipment industry**, Seong-yong Moon, Sangyong Yu, Young-Hwa Noh, Hyung-Joo Lee, Han-Ku Cho, SAMSUNG Electronics Co., Ltd. (Korea, Republic of) . . . . [8880-42]

11:10 am: **Simulation and correction of resist charging due to fogging in electron-beam lithography**, Sergey V. Babin, Sergey S. Borisov, Vladimir O. Militsin, Elena Payjukova, abeam Technologies, Inc. (United States). . . . [8880-99]

11:30 am: **DSA template mask determination and cut redistribution for advanced 1D gridded design**, Zigang Xiao, Yuelin Du, Martin D. F. Wong, Univ. of Illinois at Urbana-Champaign (United States); Hongbo Zhang, Synopsys, Inc. (United States). . . . . [8880-44]

11:50 am: **Finishing of EUV photomask substrates by CNC precessed Bonnet polisher**, Anthony T. Beaucamp, Chubu Univ. (Japan); Phillip Charlton, Zeeko K.K. (Japan); Richard R. Freeman, Zeeko Ltd. (United Kingdom); Yoshiharu Namba, Chubu Univ. (Japan) . . . . [8880-45]

Lunch Break . . . . Thu 12:10 pm to 1:40 pm

SESSION 17

Room: Steinbeck Forum . . . . Thu 1:40 pm to 3:00 pm

Mask Metrology II

Session Chairs: **Naoya Hayashi,** Dai Nippon Printing Co., Ltd. (Japan); **Emmanuel Rausa,** Plasma-Therm LLC (United States)

1:40 pm: **A novel design-based global CDU metrology for 1X nm-node logic devices**, Young-Keun Yoon, Paul D. H. Chung, Min-Ho Kim, Jung-Uk Seo, Byung-Gook Kim, Chan-Uk Jeon, SAMSUNG Electronics Co., Ltd. (Korea, Republic of); Jiuk Hur, KLA-Tencor Korea (Korea, Republic of); Wonil Cho, Tetsuya Yamamoto, KLA-Tencor Corp. (United States) . . . . [8880-46]

2:00 pm: **EUV scatterometry-based measurement method for the determination of phase roughness**, Rikon Chao, Univ. of California, Berkeley (United States); Eric M. Gullikson, Lawrence Berkeley National Lab. (United States); Michael Goldstein, Frank Goodwin, Ranganath Teki, SEMATECH Inc. (United States); Andrew R. Neureuther, Univ. of California, Berkeley (United States); Patrick P. Naulleau, Lawrence Berkeley National Lab. (United States) . . . . [8880-47]

2:20 pm: **SEM image quality enhancement technology for bright field mask**, Naoki Fukuda, Yuta Chihara, Soichi Shida, Advantest Corp. (Japan) . . . [8880-48]

2:40 pm: **Direct phase-shift measurement of an EUV mask with gradient absorber thickness**, Hiroyoshi Tanabe, Tetsunori Murachi, Intel Kabushiki Kaisha (Japan); Seh-Jin Park, Intel Corp. (United States); Eric M. Gullikson, Lawrence Berkeley National Lab. (United States); Tsukasa Abe, Naoya Hayashi, Dai Nippon Printing Co., Ltd. (Japan). . . . . [8880-49]

Coffee Break . . . . Thu 3:00 pm to 3:30 pm

SESSION 18

Room: Steinbeck Forum . . . . Thu 3:30 pm to 4:40 pm

Mask Pattern Generators

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

3:30 pm: **eMET POC: performance of the proof-of-concept electron multibeam mask writer** *(Invited Paper)*, Christof Klein, Hans Loeschner, Elmar Platzgummer, IMS Nanofabrication AG (Austria) . . . . [8880-50]

4:00 pm: **Shot count reduction for non-Manhattan Geometries: concurrent optimization of data fracture and mask writer design**, Russell B. Cinque, JEOL USA Inc. (United States); Tadashi Komagata, Taiichi Kiuchi, JEOL Ltd. (Japan); Paolo Petroni, Thomas Quaglio, Luc Martin, Aselta Nanographics (France) . . . . [8880-51]

4:20 pm: **Turret-type electron gun for EBM-8000**, Nobuo Miyamoto, NuFlare Technology, Inc. (Japan); Rodney A. Kendall, NuFlare Technology, Inc. (United States); Kenichi Saito, NuFlare Technology, Inc. (Japan) . . . . [8880-52]

SESSION 19

Room: Steinbeck Forum . . . . Thu 4:40 pm to 5:40 pm

Simulation, OPC, and Mask Data Preparation III

Session Chairs: **Steffen F. Schulze,** Mentor Graphics Corp. (United States); **Shy-Jay Lin,** Taiwan Semiconductor Manufacturing Co. Ltd. (Taiwan)

4:40 pm: **EUV multilayer defect compensation (MDC): latest progress on model and compensation methods**, Linyong Pang, Masaki Satake, Danping Peng, Ying Li, Peter Hu, Dongxue Chen, Vikram L. Tolani, Luminescent Technologies (United States) . . . . [8880-53]

5:00 pm: **Full-chip implant correction with wafer topography OPC modeling in 2xnm FDSOI technologies**, Jean-Christophe Michel, Jean-Christophe Le Denmat, Elodie Sungauer, Frederic Robert, Emek Yesilada, STMicroelectronics (France); Ana Maria Armeanu, Jorge Entradas, Mentor Graphics (Ireland) Ltd. (France); John L. Sturtevant, Thuy Do, Yuri Granik, Mentor Graphics Corp. (United States) . . . . [8880-80]

5:20 pm: **Using segmented models for initial mask perturbation and OPC speedup**, Ayman M. Yehia Hamouda, GLOBALFOUNDRIES Inc. (United States); Mohab Anis, The American Univ. in Cairo (Egypt); Karim S. Karim, Univ. of Waterloo (Canada). . . . . [8880-55]

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General Information

Registration

Onsite Registration and Badge Pickup Hours

Portola Lobby

Monday 9 September . . . . .12:00 pm to 5:00 pm
Tuesday 10 September . . . . .7:15 am to 4:00 pm
Wednesday 11 September .7:30 am to 4:00 pm
Thursday 12 September . . . . 8:00 am to 10:30 am

Conference Registration

Includes Admission to all conference sessions, Keynote, Panel Discussion, Poster Reception, Photomask Reception, Admission to the Exhibition, Buffet-style Lunches on Tuesday, Wednesday, Thursday, Morning Breakfast Breads, Coffee Breaks, Afternoon Dessert Snacks, Conference Proceedings on CD + Access via SPIE Digital Library for 90 Days.

Exhibition Registration

Exhibition-Only visitor registration is complimentary.

SPIE Member, SPIE Student Member, and Student Pricing

- SPIE Members receive conference registration discounts. Discounts are applied at the time of registration.
- SPIE Student Members receive a 50% discount on all courses.
- Student registration rates are available only to undergraduate and graduate students who are enrolled full time and have not yet received their Ph.D. Post-docs may not register as students. A student ID number or proof of student status is required with your registration.

Press Registration

For credentialed press and media representatives only. Please email contact information, title, and organization to media@spie.org

SPIE Cashier

Registration Area

Open during registration hours

Registration Payments

If you are paying by cash or check as part of your onsite registration, wish to add a course, workshop, or special event requiring payment, or have questions regarding your registration, visit the SPIE Cashier.

- **Receipts and Certificate of Attendance**
  Preregistered attendees who did not receive a receipt or attendees who need a Certificate of Attendance may obtain those from the SPIE Cashier.
- **Badge Corrections**
  Badge corrections can be made by the SPIE Cashier. Please have your badge removed from the badge holder and marked with your changes before approaching the counter.
- **Refund Information**
  There is a US$40 service charge for processing refunds. Requests for refunds must be received by 15 August 2013; all registration fees will be forfeited after this date. Membership dues, reception tickets, and SPIE Digital Library subscriptions are not refundable.

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Author / Presenter Information

Presentation Preview

Steinbeck Lobby

Open during Registration Hours

The computers at the Internet Pavilion are available to preview speakers' presentations. They are identical to the computer in the conference room. Speakers may use their own computer to present and may test their presentation in the conference room before, after or during breaks in the conference schedule. If experiencing any difficulties with a presentation please visit the SPIE Registration Desk.

Poster Setup Instructions

Exhibition/Poster Reception

Contributing Sponsors TAIWAN MASK CORP. HOYA

Tuesday 10 September . . . . .6:00 to 7:30 pm

Symposium attendees are invited to attend an Exhibition/Poster 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. Attendees are requested to wear their conference registration badges.

Poster Viewing

Exhibition Hall

Tuesday 10 September . . . . 10 am to 4 pm, and 6 to 7:30 pm
Wednesday 11 September . . . . .10 am to 3 pm

Poster authors may set up their poster papers between 10 am and 4 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.

Food and Beverage Services

Breakfast Breads

Steinbeck Lobby

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Complimentary coffee and breakfast bread will be served Tuesday through Thursday 7:30 to 8:30am.

Coffee Breaks

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APPLIED MATERIALS

Complimentary coffee will be served Tuesday through Thursday in the following locations.

Tuesday 10 September . . . . 10:00 am and 3:00 pm
Serra Grand Ballroom – Exhibition Hall

Wednesday 11 September . . . . 10:00 am and 3:00 pm
Serra Grand Ballroom – Exhibition Hall

Thursday 12 September . . . . 10:00 am and 3:00 pm
Steinbeck Lobby

SPIE-Hosted Lunches

San Carlos Ballroom - Marriott

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Hosted lunches will be served at the lunch break Tuesday – Thursday in the San Carlos ballroom at the Monterey Marriott.

Complimentary lunch tickets will be included for full conference registrants. Exhibitors and students may purchase tickets in the SPIE registration area in Portola Lobby.

Desserts

Complimentary tickets for dessert snacks are included in course and conference attendee and exhibitor registration packets.

Car Rental

Hertz

Hertz Car Rental has been selected as the official car rental agency for SPIE Photomask Technology. To reserve a car, identify yourself as a conference attendee using the Hertz Meeting Code CV#029B0018. When booking from international Hertz locations, the CV# must be entered with the letter CV before the number, i.e. CV029B0018.

- In the United States call 1-800-654-2240
- In Canada call 1-800-263-0600, or 1-416-620-9620 in Toronto.
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Onsite Services

Internet Access

Steinbeck Lobby – Internet Pavilion

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WiFi

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ShinEtsu

Monterey Conference Center – WiFi available in the entire center

Complimentary wired Internet access is available; attendees can hook up their laptops or use provided workstations. Complimentary wireless access is also available; instructions will be posted onsite.

SPIE Book Display

Steinbeck Lobby –display

View the latest SPIE Press books. Please go to SPIE Cashier with available order form for onsite purchases.

Business Center

Monterey Marriott

Attendees may use their hotel room key at the Monterey Marriot to access the on-site Business Center which offers use of the free on-line computers. Copy and fax machines are available at the front desk. Copies are free for the first 20 copies, 10 cents per page after. The fax machine is $1 per page for domestic usage and $3 per page for international usage.

Off-site

FedEx Kinkos is located at 799 Lighthouse Ave., Suite A, Monterey, Calif., 93940, Phone: 831.373.2298. It is located 1.3 miles from the Monterey Marriott. Go north on Calle Principal, left onto Del Monte Avenue, right onto Pacific St., right onto ramp to merge onto Lighthouse Avenue.

Child Care Services

The Monterey Marriott suggests the following childcare service companies:

- Parents Time Out. Phone: 831.375.9269
- VIP Babysitting Solutions Inc. (in-room hotel babysitting services). Phone: 800.838.2787

SPIE does not imply endorsement or recommendation for these services. Information provided as “information only” for your further analysis and decision. Other services may be available.

Urgent Message Line

An urgent message line is available during registration hours: 831.646.5312

Lost and Found

SPIE Cashier

Registration Hours

Found items will be kept at SPIE Cashier until the close of Registration each day and then turned over to Inact Protective Services, 831.763.2594. At the end of the meeting, all found items will be turned over to Monterey Conference Center, 831.646.3770.

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SPIE, or their officially designated event management, in their sole discretion, reserves the right to accept or decline an individual's registration for an event. Further, SPIE, or event management, reserves the right to prohibit entry or remove any individual whether registered or not, be they attendees, exhibitors, representatives, or vendors, who in their sole opinion are not, or whose conduct is not, in keeping with the character and purpose of the event. Without limiting the foregoing, SPIE and event management reserve the right to remove or refuse entry to any attendee, exhibitor, representative, or vendor who has registered or gained access under false pretenses, provided false information, or for any other reason whatsoever that they deem is cause under the circumstances.

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SPIE is a professional, not-for-profit society committed to providing valuable conference and exhibition experiences. SPIE is dedicated to equal opportunity and treatment for all its members and meeting attendees. Attendees are expected to be respectful to other attendees, SPIE staff, and contractors. Harassment and other misconduct will not be tolerated; violators will be asked to leave the event.

Identification

To verify registered participants and provide a measure of security, SPIE will ask attendees to present a government-issued Photo ID at registration to collect registration materials.

Individuals are not allowed to pick up badges for attendees other than themselves. Further, attendees may not have some other person participate in their place at any conference-related activity. Such other individuals will be required to register on their own behalf to participate.

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Payment Method

Registrants for paid elements of the event, who do not provide a method of payment, will not be able to complete their registration. Individuals with incomplete registrations will not be able to attend the conference until payment has been made. SPIE accepts VISA, MasterCard, American Express, Discover, Diner's Club, checks and wire transfers. Onsite registrations can also pay with Cash.

Authors/Coauthors

By submitting an abstract, you agree to the following conditions:

- An author or coauthor (including keynote, invited, and solicited speakers) will register at the author registration rate, attend the meeting, and make the presentation as scheduled.
- A full-length manuscript (6-page minimum) for any accepted oral or poster presentation will be submitted for publication in the SPIE Digital Library, printed conference Proceedings, and CD. (Some SPIE events have other requirements that the author is made aware of at the time of submission.)
- Only papers presented at the conference and received according to publication guidelines and timelines will be published in the conference Proceedings and SPIE Digital Library (or via the requirements of that event).

Audio, Video, Digital Recording Policy

Conferences, courses, and poster sessions: For copyright reasons, recordings of any kind are prohibited without prior written consent of the presenter. Attendees may not capture nor use the materials presented in any meeting room without written permission. Consent forms are available at Speaker Check-In. Individuals not complying with this policy will be asked to leave a given session and asked to surrender their recording media.

Exhibition Hall: For security and courtesy reasons, recordings of any kind are prohibited unless one has explicit permission from on-site company representatives. Individuals not complying with this policy will be asked to surrender their recording media and to leave the exhibition hall.

Your registration signifies your agreement to be photographed or videotaped by SPIE in the course of normal business. Such photos and video may be used in SPIE marketing materials or other SPIE promotional items.

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Access to Technical and Networking Events

Persons under the age of 18 including babies, carried or in strollers, and toddlers are not allowed in technical or networking events. Anyone 18 or older must register as an attendee. All technical and networking events require a valid conference badge for admission.

Underage Persons on Exhibition Floor Policy

For safety and insurance reasons:

- No persons under the age of 18 will be allowed in the exhibition area during move-in and move-out.
- Children 14 and older, accompanied by an adult, will be allowed in the exhibition area during open exhibition hours only
- All children younger than 14, including babies in strollers and toddlers, are not allowed in the exhibition area at any time.

Underage Persons on Exhibition Floor Policy

For safety and insurance reasons, no one under the age of 16 will be allowed in the exhibition area during move-in and move-out. During open exhibition hours, only children over the age of 12 accompanied by an adult will be allowed in the exhibition area.

Unauthorized Solicitation Policy

Unauthorized solicitation in the Exhibition Hall is prohibited. Any nonexhibiting manufacturer or supplier observed to be distributing information or soliciting business in the aisles, or in another company's booth, will be asked to leave immediately.

Unsecured Items Policy

Personal belongings should not be left unattended in meeting rooms or public areas. Unattended items are subject to removal by security. SPIE is not responsible for items left unattended.

Wireless Internet Service Policy

At SPIE events where wireless is included with your registration, SPIE provides wireless access for attendees during the conference and exhibition but cannot guarantee full coverage in all locations, all of the time. Please be respectful of your time and usage so that all attendees are able to access the internet.

Excessive usage (e.g., streaming video, gaming, multiple devices) reduces bandwidth and increases cost for all attendees. No routers may be attached to the network. Properly secure your computer before accessing the public wireless network. Failure to do so may allow unauthorized access to your laptop as well as potentially introduce viruses to your computer and/or presentation. SPIE is not responsible for computer viruses or other computer damage.

Mobile Phones and Related Devices Policy

Mobile phones, tablets, laptops, pagers, and any similar electronic devices should be silenced during conference sessions. Please exit the conference room before answering or beginning a phone conversation.

Smoking

For the health and consideration of all attendees, smoking is not permitted at any event elements, such as but not limited to: plenaries, conferences, workshops, courses, poster sessions, hosted meal functions, receptions, and in the exhibit hall. Most facilities also prohibit smoking in all or specific areas. Attendees should obey any signs preventing or authorizing smoking in specified locations.

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Attendee agrees to release and hold harmless SPIE from any and all claims, demands, and causes of action arising out of or relating to your participation in the event you are registering to participate in and use of any associated facilities or hotels.

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If for some unforeseen reason SPIE should have to cancel the event, registration fees processed will be refunded to registrants. Registrants will be responsible for cancellation of travel arrangements or housing reservations and the applicable fees.

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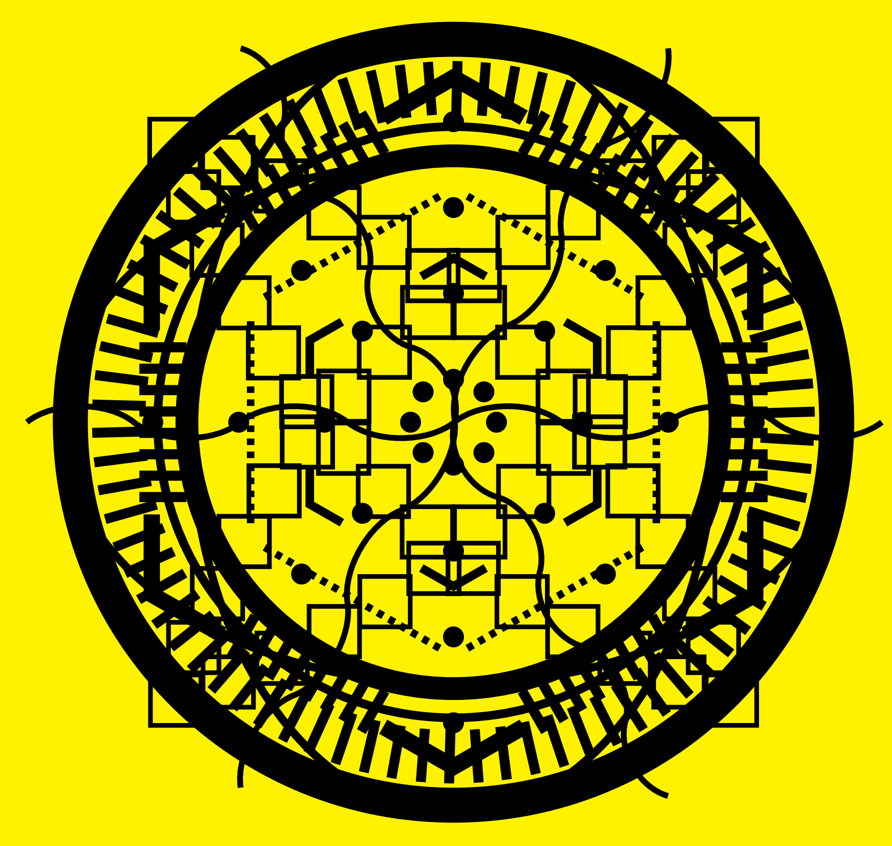

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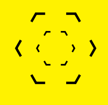

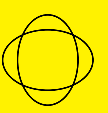
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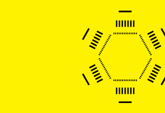
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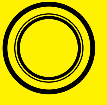
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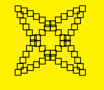
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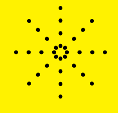
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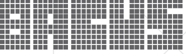

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