Metrology, Inspection, and Process Control for Microlithography XXIX

Jason P. Cain
Martha I. Sanchez
Editors

23–26 February 2015
San Jose, California, United States

Sponsored by
SPIE

Cosponsored by
NOVA Ltd. (United States)

Published by
SPIE

Volume 9424
The papers included in this volume were part of the technical conference cited on the cover and title page. Papers were selected and subject to review by the editors and conference program committee. Some conference presentations may not be available for publication. The papers published in these proceedings reflect the work and thoughts of the authors and are published herein as submitted. The publisher is not responsible for the validity of the information or for any outcomes resulting from reliance thereon.

Please use the following format to cite material from this book:


ISSN: 0277-786X
ISBN: 9781628415261

Published by
SPIE
P.O. Box 10, Bellingham, Washington 98227-0010 USA
Telephone +1 360 676 3290 (Pacific Time) · Fax +1 360 647 1445
SPIE.org

Copyright © 2015, Society of Photo-Optical Instrumentation Engineers.

Copying of material in this book for internal or personal use, or for the internal or personal use of specific clients, beyond the fair use provisions granted by the U.S. Copyright Law is authorized by SPIE subject to payment of copying fees. The Transactional Reporting Service base fee for this volume is $18.00 per article (or portion thereof), which should be paid directly to the Copyright Clearance Center (CCC), 222 Rosewood Drive, Danvers, MA 01923. Payment may also be made electronically through CCC Online at copyright.com. Other copying for republication, resale, advertising or promotion, or any form of systematic or multiple reproduction of any material in this book is prohibited except with permission in writing from the publisher. The CCC fee code is 0277-786X/15/$18.00.

Printed in the United States of America.

Publication of record for individual papers is online in the SPIE Digital Library.

SPIE Digital Library
SPIEDigitalLibrary.org

Paper Numbering: Proceedings of SPIE follow an e-First publication model, with papers published first online and then in print. Papers are published as they are submitted and meet publication criteria. A unique citation identifier (CID) number is assigned to each article at the time of the first publication. Utilization of CIDs allows articles to be fully citable as soon as they are published online, and connects the same identifier to all online, print, and electronic versions of the publication. SPIE uses a six-digit CID article numbering system in which:

- The first four digits correspond to the SPIE volume number.
- The last two digits indicate publication order within the volume using a Base 36 numbering system employing both numerals and letters. These two-number sets start with 00, 01, 02, 03, 04, 05, 06, 07, 08, 09, 0A, 0B … 0Z, followed by 10-1Z, 20-2Z, etc.

The CID Number appears on each page of the manuscript. The complete citation is used on the first page, and an abbreviated version on subsequent pages.
## Contents

### Part One

<table>
<thead>
<tr>
<th></th>
<th>ix Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>xv Conference Committee</td>
</tr>
<tr>
<td></td>
<td>xix Introduction</td>
</tr>
</tbody>
</table>

### CHARACTERIZATION OF FEATURE PROFILE AND LER

| 9424 03 | More systematic errors in the measurement of power spectral density [9424-3] |
| 9424 04 | Application of frequency domain line edge roughness characterization methodology in lithography [9424-4] |
| 9424 05 | The effect of sidewall roughness on line edge roughness in top-down scanning electron microscopy images [9424-5] |
| 9424 06 | Line profile measurement of advanced-FinFET features by reference metrology [9424-6] |
| 9424 07 | Induced e-beam charge impact on spatial orientation of gate-all-around silicon wires device fabricated on boron nitride substrate [9424-7] |

### OVERLAY METROLOGY

| 9424 08 | Hybrid overlay metrology with CDSEM in a BEOL patterning scheme [9424-8] |
| 9424 09 | Scatterometry or imaging overlay: a comparative study [9424-9] |
| 9424 0A | 64nm pitch metal1 double patterning metrology: CD and OVL control by SEMCD, image based overlay and diffraction based overlay [9424-10] |
| 9424 0B | Influence of the process-induced asymmetry on the accuracy of overlay measurements [9424-11] |
| 9424 0C | Overlay accuracy investigation for advanced memory device [9424-12] |
| 9424 0D | Stack and topography verification as an enabler for computational metrology target design [9424-13] |
| 9424 0E | Overlay metrology solutions in a triple patterning scheme [9424-14] |
## SEM Metrology and Modeling

<table>
<thead>
<tr>
<th>Paper ID</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>9424 0F</td>
<td>Analytical linescan model for SEM metrology [9424-15]</td>
</tr>
<tr>
<td>9424 0G</td>
<td>Solving next generation (1x node) metrology challenges using advanced CDSEM capabilities: tilt, high energy and backscatter imaging [9424-16]</td>
</tr>
<tr>
<td>9424 0H</td>
<td>Methodology for determining CD-SEM measurement condition of sub-20nm resist patterns for 0.33NA EUV lithography [9424-17]</td>
</tr>
<tr>
<td>9424 0I</td>
<td>Fast analytical modeling of SEM images at a high level of accuracy [9424-18]</td>
</tr>
<tr>
<td>9424 0J</td>
<td>Simulating massively parallel electron beam inspection for sub-20 nm defects [9424-19]</td>
</tr>
<tr>
<td>9424 0K</td>
<td>Investigating SEM metrology effects using a detailed SEM simulation and stochastic resist model [9424-20]</td>
</tr>
</tbody>
</table>

## Wafer Geometry and Topography Effects on Process Control

<table>
<thead>
<tr>
<th>Paper ID</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>9424 0L</td>
<td>Effect of wafer geometry on lithography chucking processes [9424-21]</td>
</tr>
<tr>
<td>9424 0M</td>
<td>Improvement of process control using wafer geometry for enhanced manufacturability of advanced semiconductor devices [9424-22]</td>
</tr>
<tr>
<td>9424 0N</td>
<td>Lithography overlay control improvement using patterned wafer geometry for sub-22nm technology nodes [9424-23]</td>
</tr>
</tbody>
</table>

## AFM

<table>
<thead>
<tr>
<th>Paper ID</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>9424 0O</td>
<td>Demonstration of parallel scanning probe microscope for high throughput metrology and inspection [9424-24]</td>
</tr>
<tr>
<td>9424 0P</td>
<td>Self-actuated, self-sensing cantilever for fast CD measurement [9424-25]</td>
</tr>
<tr>
<td>9424 0Q</td>
<td>High-speed AFM for 1x node metrology and inspection: Does it damage the features? [9424-26]</td>
</tr>
<tr>
<td>9424 0R</td>
<td>Multiple height calibration reference for nano-metrology [9424-27]</td>
</tr>
<tr>
<td>9424 0S</td>
<td>Development of a comprehensive metrology platform dedicated to dimensional measurements of CD atomic force microscopy tips [9424-28]</td>
</tr>
</tbody>
</table>

## Metrology and Inspection for Directed Self-Assembly: Joint Session with Conferences 9423 and 9424

<table>
<thead>
<tr>
<th>Paper ID</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>9424 0T</td>
<td>Optical CD metrology for directed self-assembly assisted contact hole shrink process [9424-29]</td>
</tr>
<tr>
<td>9424 0U</td>
<td>Metrology of DSA process using TEM tomography [9424-30]</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td><strong>SCATTEROMETRY</strong></td>
<td></td>
</tr>
<tr>
<td>9424 0X</td>
<td>Improved scatterometry time-to-solution using virtual reference [9424-33]</td>
</tr>
<tr>
<td>9424 0Y</td>
<td>Data refinement for robust solution to the inverse problem in optical scatterometry [9424-34]</td>
</tr>
<tr>
<td>9424 0Z</td>
<td>Hp-finite element method for simulating light scattering from complex 3D structures [9424-35]</td>
</tr>
<tr>
<td>9424 10</td>
<td>Scatterometry-based metrology for the 14nm node double patterning lithography [9424-36]</td>
</tr>
<tr>
<td>9424 11</td>
<td>Scatterometric analysis of a plasmonic test structure [9424-37]</td>
</tr>
<tr>
<td><strong>DEVICE OVERLAY</strong></td>
<td></td>
</tr>
<tr>
<td>9424 12</td>
<td>Target design optimization for overlay scatterometry to improve on-product overlay [9424-38]</td>
</tr>
<tr>
<td>9424 13</td>
<td>Overlay improvement by exposure map based mask registration optimization [9424-39]</td>
</tr>
<tr>
<td>9424 14</td>
<td>Improving full-wafer on-product overlay using computationally designed process-robust and device-like metrology targets [9424-40]</td>
</tr>
<tr>
<td>9424 15</td>
<td>Advanced overlay analysis through design based metrology [9424-41]</td>
</tr>
<tr>
<td><strong>INSPECTION</strong></td>
<td></td>
</tr>
<tr>
<td>9424 16</td>
<td>9nm node wafer defect inspection using three-dimensional scanning, a 405nm diode laser, and a broadband source [9424-42]</td>
</tr>
<tr>
<td>9424 17</td>
<td>Mechanical and thermal properties of nanomaterials at sub-50nm dimensions characterized using coherent EUV beams (Karel Urbánek Best Student Paper Award) [9424-43]</td>
</tr>
<tr>
<td>9424 18</td>
<td>Spectral emission properties of a LPP light source in the sub-200nm range for wafer inspection applications [9424-44]</td>
</tr>
<tr>
<td>9424 19</td>
<td>Scatterometry-based defect detection for DSA in-line process control [9424-45]</td>
</tr>
<tr>
<td>9424 1A</td>
<td>Simulation of AIMS measurements using rigorous mask 3D modeling [9424-46]</td>
</tr>
</tbody>
</table>
Part Two

**DESIGN INTERACTION WITH METROLOGY: JOINT SESSION WITH CONFERENCES 9424 AND 9427**

9424 1B  A new paradigm for in-line detection and control of patterning defects [9424-47]

9424 1C  Predictability and impact of product layout induced topology on across-field focus control [9424-48]

9424 1D  The analysis method of the DRAM cell pattern hotspot [9424-49]

**HYBRID METROLOGY AND PROCESS CONTROL**

9424 1E  Holistic approach using accuracy of diffraction-based integrated metrology to improve on-product performance, reduce cycle time, and cost at litho [9424-83]

9424 1F  Intra-field patterning control using high-speed and small-target optical metrology of CD and focus [9424-51]

9424 1G  Comprehensive BEOL control using scatterometry and APC [9424-52]

9424 1H  Hybrid metrology implementation: server approach [9424-53]

9424 1I  Machine learning and predictive data analytics enabling metrology and process control in IC fabrication [9424-54]

9424 1J  Optimizing hybrid metrology: rigorous implementation of Bayesian and combined regression [9424-55]

**OVERLAY OPTIMIZATION: JOINT SESSION WITH CONFERENCES 9424 AND 9426**

9424 1K  Intra-field on-product overlay improvement by application of RegC and TWINSCAN corrections [9424-56]

9424 1L  Pattern recognition and data mining techniques to identify factors in wafer processing and control determining overlay error [9424-57]

**X-RAY AND NOVEL OPTICAL METHODS**

9424 1M  Hybridization of XRF/XPS and scatterometry for Cu CMP process control [9424-58]

9424 1N  Grazing-incidence small angle x-ray scattering studies of nanoscale polymer gratings [9424-59]

9424 1P  Signal response metrology (SRM): a new approach for lithography metrology [9424-61]
LATE BREAKING NEWS

9424 1R The development and advantages of helium ion microscopy for the study of block copolymer nanopatterns [9424-63]

9424 1S Potential application of tip-enhanced Raman spectroscopy (TERS) in semiconductor manufacturing [9424-64]

9424 1T Virtual overlay metrology for fault detection supported with integrated metrology and machine learning [9424-75]

9424 1U Further advancing the throughput of a multi-beam SEM [9424-101]

9424 1V HVM capabilities of CPE run-to-run overlay control [9424-102]

POSTER SESSION

9424 1W Metrology of 50nm HP wire-grid polarizer: a SEM-scatterometry comparison [9424-65]

9424 1X High-throughput automatic defect review for 300mm blank wafers with atomic force microscope [9424-66]

9424 1Y High order overlay modeling and APC simulation with Zernike-Legendre polynomials [9424-67]

9424 20 Overlay improvement using Legendre-Zernike model-based overlay corrections and monitoring with interpolated metric [9424-69]

9424 21 3D isolation mounts scatterometry with RCWA and PML [9424-70]

9424 24 Overlay target selection for 20nm process on A500 LCM [9424-73]

9424 25 Qmerit-calibrated overlay to improve overlay accuracy and device performance [9424-74]

9424 26 A diffractometer for quality control in nano fabrication processing based on subwavelength diffraction [9424-76]

9424 27 High-sensitivity tracking of CD-SEM performance: QSEM [9424-77]

9424 28 Improvement of depth of focus control using wafer geometry [9424-79]

9424 29 Through pitch monitoring by optical scatterometry [9424-80]

9424 2A Understanding the impact of CD-SEM artifacts on metrology via experiments and simulations [9424-81]

9424 2B Overlay measurement accuracy enhancement by design and algorithm [9424-82]
9424 2C Lithography process controllers and photoresist monitoring by signal response metrology (SRM) [9424-84]
9424 2D Lithography develop process electrostatic discharge effect mechanism study [9424-85]
9424 2E Scanner focus metrology for advanced node scanner monitoring and control [9424-86]
9424 2F The use of eDR-71xx for DSA defect review and automated classification [9424-87]
9424 2G Real time decision based multiple mode SEM review imaging solution [9424-88]
9424 2H Accelerated technology development by the use of critical point imaging SEM [9424-89]
9424 2I Study on ADI CD bias correlating ABC function [9424-90]
9424 2J CD uniformity improvement of dense contact array in negative tone development process [9424-91]
9424 2M Study on immersion lithography defectivity improvement in memory device manufacturing [9424-94]
9424 2N Carbon dioxide gas purification and analytical measurement for leading edge 193nm lithography [9424-96]
9424 2O EUV tools: hydrogen gas purification and recovery strategies [9424-98]
9424 2P Silicon fin line edge roughness determination and sensitivity analysis by Mueller matrix spectroscopic ellipsometry based scatterometry [9424-99]
9424 2Q Transient tip-sample interactions in high-speed AFM imaging of 3D nano structures [9424-100]
9424 2R Quantitative nanomechanical measurement of electron beam surface modification [9424-103]
Authors

Numbers in the index correspond to the last two digits of the six-digit citation identifier (CID) article numbering system used in Proceedings of SPIE. The first four digits reflect the volume number. Base 36 numbering is employed for the last two digits and indicates the order of articles within the volume. Numbers start with 00, 01, 02, 03, 04, 05, 06, 07, 08, 09, 0A, 0B...0Z, followed by 10-1Z, 20-2Z, etc.

Abhari, Reza, 1E
Abreu, F., 18
Adam, Ormer, 1E
Adan, Ofer, 07, 0G
Adel, Michael E., 0D
Ahmad, Ahmad, 0P
Amir, Nuriel, 09, 0E, 2B
Amit, Eran, 25
Anderson, Erik, 17
Ang, Jesline, 25
Angelov, Tihomir, 0P
Applegarth, Chuck, 2N, 2O
Atanasov, Ivaylo, 0P
Awasthi, Amartya, 0M, 2B
Babin, S., 0I, 27
Bailey, Todd C., 0H, 19, 1I
Banerjee, Sarbajit, 1S
Bangsaruntip, Sarunya, 07
Bar Or, Ron, 0Q
Baral, Sudhir, 1G
Barnes, Bryan M., 1J
Bar-Zvi, Maayan, 0G
Baudemprez, Bart, 0E
Bayana, Hareen, 2F
Beique, Genevieve, 04
Bekaert, Joost, 2A
Bell, Alan P., 1R
Bellmann, Enrico, 20
Bellman, Jan, 12, 1L
Besacier, M., 10
Bhattacharyya, Kaustuva, 1E
Biafore, John J., 2A
Biswas, Mahua, 0U
Blancquaert, Yoann, 12
Borisov, S. S., 0I
Bos, Sandra, 0S
Bouckou, Loemba, 2F, 2H
Boudreau, A., 1R
Bojssou, Régis, 0A, 10
Bozdag, Cornel, 0X, 19, 1H
Bringoltz, Barak, 0B
Brown, Jim, 2F
Browning, Matt, 2N
Brucke, S. R. J., 1W
Brynarski, Casey A., 16
Buhl, Stefan, 20
Bunday, Benjamin D., 0F, 0J, 2R
Burger, Sven, 0Z
Byeon, Jungho, 0M, 2B
Byun, Jin-Moo, 14
Cangiano, Agostino, 0B
Carau, Damien, 0A, 10
Cekli, Hakkı Ergun, 1K
Cepler, Aron, 19
Chang, Jinman, 1D
Chao, Robin, 19, 1M
Chao, Weilun, 17
Chaudhari, Atul, 1R
Chen, Charlie, 09
Chen, Chien-Hao, 2C
Chen, Frank, 1B
Chen, Garry, 2G
Chen, K. C., 2J
Chen, Ming, 13
Chen, Wei, 1N
Chen, XiuGuo, 0Y
Cheng, Chao-Yu, 2C
Chirko, Konstantin, 07
Cho, Chanseob, 24
Cho, Sang-Joon, 1X
Choi, Bumjin, 1D
Choi, Byoung-il, 2E
Choi, DongSub, 0C, 0M, 1Y, 25, 2B, 2E
Chou, Chih-Shiang, 1A
Christophersen, M., 0R
Chu, Fu-Sheng, 1A
Chu, Wei-Yuan, 2C
Chu, Yuan-Chih, 1A
Chuen, Lieu Chia, 20, 25
Chun, Jun Sung, 0T
Chung, Woong Jae, 1V
Cohen, Guy M., 07
Cohen, Oded, 19
Cooper, Moshe, 2E
Cordes, Aaron, 2R
Cotte, Eric, 0B
Couraudon, Vincent, 1E
Cramer, Hugo, 1F
Dasari, Prasad, 1G
David, Tien, 2E
Dechter, Rimma, 1S
Deckers, David, 1L
Dekker, Bert, 0O
Dellmann, Gregor, 1U
Demirer, Onur, 1V
den Boef, Arie, 1E, 1F
Deng, Guogui, 2I
Montgomery, Cecilia, 2R
Montgomery, Warren, 0T
Moreau, Olivier, 2H
Morris, Mick A., 1R
Motoyama, Koichi, 1M
Mueller, Dieter, 28
Mukhtar, Maseeh, 0J
Mulens, Jan, 1K
Munoz, Alexander, 1W
Munoz, Gangadhara Raja, 2P
Nardi, Damiano, 17
Nealey, Paul F., 0U, 1N
Neumayer, Deborah, 0T
Nulkes, Nicole, 0O
Ocola, Leonidas E., 0U
Oh, Nang-Lyeom, 14
Okagawa, Yutaka, 08
Okai, Nobuhiro, 0H
O'Loughlin, Thomas E., 1S
O'Mullane, Samuel, 11, 2P
Osborne, Jason, 2R
O'Sullivan, Michael, 0T
Pai, White, 2G
Pai, Yuan Chi, 09
Paris, Paola, 2F, 2H
Park, Byungjun, 15
Park, Chanha, 15
Park, Chris, 14
Park, Minwoo, 15
Park, Sang-il, 1X
Park, Sean, 14
Park, Sung-Ki, 0C, 0M, 1T, 28, 2B
Park, Youngsik, 2E
Pasqualini, F., 1C
Pathangi, Hari, 2F
Perets, Yuval, 1K
Peterson, Joel, 0N
Petra, Stefan, 1F
Phlips, B. F., 0R
Piers, Bill, 1V, 1Y
Pirola, Simona, 2N
Pomplun, Jan, 02
Popescu, Gabriel, 16
Prell, Moše, 0T, 2P
Prentice, C., 1C
Quoi, Kathy, 0J
Race, Joseph, 0T, 11, 2P
Ramanathan, Vidya, 1P, 1V, 24
Ramirez-Hernandez, Abelardo, 1N
Rana, Narender, 11
Rangelow, Ivo W., 0P
Ren, Jiaxing, 0U
Reum, Alexander, 0P
Riddle Vogt, Sarah, 2N, 2O
Riggs, Brent, 1V
Rijnbeek, Ramon, 0O
Roncon Delgadillo, Paulina A., 1N
Robertson, Stewart A., 2A
Robinson, John C., 1V, 1Y
Rollinger, Bob, 18
Ruhm, Matthias, 0B
Rusk, Gary, 0N
Ryan, Kevin, 14, 1T
Sadeghian, Harmed, 0O, 0Q, 2Q
Sanayoa, Martin, 1S
Sanchez, Dominique, 2H
Sanko, Dimitry, 1P
Sass, B., 29
Schade, Sebastian, OS
Schmidt, Frank, 0Z
Schmidt, Sebastian W., 0S
Schmitt-Weaver, Emil, 1T
Schuh, Andreas, 0P
Schul, Bernd, 0B
Schwarzband, Tshai, 0G
Segal-Peretz, Tamar, 0U
Seger, Bart, 1F
Sellmann, Rolf, 0B
Sendelbach, Matthew, 0X, 19
Senthamaraikannan, Ramsankar, 1R
Shahjedry, Mir, 14
Shapoval, Tetyana, 0B
Sharoni, Ofir, 1K
Shaw, Justin, 17
Shaw, Matt T., 1R
Shen, Manhua, 2I
Shen, Z., 29
Sherwin, Stuart, 1Y
Shi, Irene, 13
Shi, Leathen, 07
Shi, Xuelong, 2I
Shirasaki, Hiroki, 21
Shoval, Ori, 0G
Silver, Richard M., 1J
Sim, Stella, 25
Simiz, J.-G., 1C
Singham, Shrawan, 1W
Sinha, Harsh, 2G
Sinha, Jaydeep K., 0L, 0M, 0N, 28
Siedzinska, Marianna, 26
Slotboom, Daan, 1T
Smilde, Henk-Jan H., 12, 1F
Smith, Mark D., 1Y, 2A
Snow, Patrick W., 0G, 24
Solecky, Eric, 0G
Sotomayor Torres, Clivia M., 26
Sparka, Christian, 1V
Spence, Chris, 1B
Sreenivasan, S. V., 1W
Staal, Frank, 1C, 1F
Staecker, Jens, 1T
Standaert, Theodorus, 1M
Strazalka, Joseph, 1N
Su, Eason, 1E
Subramony, Lokesh, 1P, 1V, 24
Succi, Marco, 2N, 2O
Suh, Hyo Seon, 1N
Sun, Kyu-Tae, 14, 1T
Conference Committee

Symposium Chair

Mircea V. Dusa, ASML US, Inc. (United States)

Symposium Co-chair

Bruce W. Smith, Rochester Institute of Technology (United States)

Conference Chair

Jason P. Cain, Advanced Micro Devices, Inc. (United States)

Conference Co-chair

Martha I. Sanchez, IBM Research - Almaden (United States)

Conference Program Committee

Ofer Adan, Applied Materials Ltd. (Israel)
John A. Allgair, Nanometrics Inc. (United States)
Masafumi Asano, Toshiba Corporation (Japan)
Benjamin D. Bunday, SEMATECH Inc. (United States)
Alek C. Chen, ASML Taiwan Ltd. (Taiwan)
Timothy F. Crimmins, Intel Corporation (United States)
Daniel J. C. Herr, The University of North Carolina at Greensboro (United States)
Chih-Ming Ke, Taiwan Semiconductor Manufacturing Company Ltd. (Taiwan)
Shunsuke Koshihara, Hitachi High-Technologies Corporation (Japan)
Yi-Sha Ku, Industrial Technology Research Institute (Taiwan)
Byoung-Ho Lee, Ultratech (United States)
Christopher J. Raymond, Nanometrics Inc. (United States)
John C. Robinson, KLA-Tencor Corporation (United States)
Matthew J. Sendelbach, Nova Measuring Instruments Inc. (United States)
Richard Silver, National Institute of Standards and Technology (United States)
Eric Solecky, GLOBALFOUNDRIES Inc. (United States)
Costas J. Spanos, University of California, Berkeley (United States)
Alexander Starikov, I&I Consulting (United States)
Vladimir A. Ukarintsev, Nanometrology International, Inc. (United States)
Alok Vaid, GLOBALFOUNDRIES Inc. (United States)
Session Chairs

1  Keynote Session
   Jason P. Cain, Advanced Micro Devices, Inc. (United States)
   Martha I. Sanchez, IBM Research - Almaden (United States)

2  Characterization of Feature Profile and LER
   Benjamin D. Bunday, SEMATECH Inc. (United States)
   Ofer Adan, Applied Materials Ltd. (Israel)

3  Overlay Metrology
   Alexander Starikov, I&I Consulting (United States)
   Matthew J. Sendelbach, Nova Measuring Instruments Inc. (United States)

4  SEM Metrology and Modeling
   Eric Solecky, IBM Corporation (United States)
   Shunsuke Koshihara, Hitachi High-Technologies Corporation (Japan)

5  Wafer Geometry and Topography Effects on Process Control
   Timothy F. Crimmins, Intel Corporation (United States)
   John A. Allgair, Nanometrics Inc. (United States)

6  AFM
   Benjamin D. Bunday, SEMATECH Inc. (United States)
   Christopher J. Raymond, Nanometrics Inc. (United States)

7  Metrology and Inspection for Directed Self-Assembly: Joint Session with Conferences 9423 and 9424
   Martha I. Sanchez, IBM Research - Almaden (United States)
   Alexander Liddle, National Institute of Standards and Technology (United States)

8  Scatterometry
   Alok Vaid, GLOBALFOUNDRIES Inc. (United States)
   Matthew J. Sendelbach, Nova Measuring Instruments Inc. (United States)

9  Device Overlay
   Richard M. Silver, National Institute of Standards and Technology (United States)
   Masafumi Asano, Toshiba Corporation (Japan)
10 Inspection
Timothy F. Crimmins, Intel Corporation (United States)
Byoung-Ho Lee, Ultratech (United States)

11 Design Interaction with Metrology: Joint Session with Conferences 9424 and 9427
Alexander Starikov, I&I Consulting (United States)
Jason P. Cain, Advanced Micro Devices, Inc. (United States)

12 Hybrid Metrology and Process Control
Masafumi Asano, Toshiba Corporation (Japan)
Eric Solecky, IBM Corporation (United States)

13 Overlay Optimization: Joint Session with Conferences 9424 and 9426
John C. Robinson, KLA-Tencor Corporation (United States)
Mark Phillips, Intel Corporation (United States)

14 X-ray and Novel Optical Methods
Martha I. Sanchez, IBM Research - Almaden (United States)
Christopher J. Raymond, Nanometrics Inc. (United States)

15 Late Breaking News
Jason P. Cain, Advanced Micro Devices, Inc. (United States)
Vladimir A. Ukraintsev, Nanometrology International, Inc. (United States)
Introduction

The 29th conference on Metrology, Inspection, and Process Control for Microlithography was a successful forum for discussion of challenges, opportunities, and new ideas with many of the top professionals in the field in attendance. This exchange reached across other conferences at the Advanced Lithography Symposium as well, as evidenced by the success of three joint sessions.

The first joint session, with the conference on Alternative Lithographic Technologies, continued a popular series of similar joint sessions in the past few years at the symposium related to metrology challenges in directed self-assembly:

SESSION 7: Metrology and Inspection for Directed Self-Assembly: Joint Session with Conferences 9423 and 9424, chaired by Martha Sanchez and J. Alexander Liddle.


The second joint session was with the conference on Design-Process-Technology Co-optimization for Manufacturability. This was the first time such a joint session has appeared at the symposium:

SESSION 11: Design Interaction with Metrology: Joint Session with Conferences 9424 and 9427, chaired by Jason Cain and Alexander Starikov.

- “Full chip two-layer CD and overlay process window analysis,” Rachit Gupta, Shumay D. Shang, John L. Sturtevant [9427-16]

“Predictability and impact of product layout induced topology on across-field focus control,” Jean-Gabriel Simiz, Tanbir Hasan, Frank Staals, Bertrand Le-Gratiet, Pascal Gilgenkrantz, Alexandre Villaret, François Pasqualini, Wim Tel, Christopher Hugh Angus Prentice, Alexandre Tishchenko [9424-48]

“The analysis method of the DRAM cell pattern hotspot,” Kyusun Lee, KweonJae Lee, Jinman Chang, Tae Heon Kim, DaeHan Han, Ae-Ran Hong, Yonghyeon Kim, Jinyoung Kang, Bumjin Choi, Joo-Sung Lee, Jooyoung Lee, Hyeongsun Hong, Kyupil Lee, Gyoyoung Jin [9424-49]

The third joint session was held with the conference on Optical Microlithography. It covered issues related to overlay metrology, a very popular topic at this year’s conference:

SESSION 13: Overlay Optimization: Joint Session with Conferences 9424 and 9426, chaired by John Robinson and Mark Phillip.

“Overlay improvement methods with diffraction based overlay and integrated metrology,” YoungSun Nam, Jang-Sun Kim, Ju Hee Shin, Young-Sin Choi, Sang Ho Yun, Young-Hoon Kim, Si Woo Shin, Jeong-Heung Kong, Young Seog Kang, Hunhwan Ha [9426-38]

“Intra-field overlay correction for illumination based distortion,” Michael B. Pike, Timothy A. Brunner, Bradley Morgenfeld, Nick Jing, Timothy J. Wiltshire [9426-39]

“Wafer to wafer overlay control algorithm implementation based on statistics,” ByeongSoo Lee, Young Seog Kang, Jeong-Heung Kong, Hyunwoo Hwang, Myeong Gyu Song [9426-40]

“Intra-field on-product overlay improvement by application of RegC® and TWINSCAN™ corrections,” Ofir Sharoni, Vladimir Dmitriev, Kujan Gorhad, Hakki Ergun Cekli, Jan Mulken [9424-56]

“Pattern recognition and data mining techniques to identify factors in wafer processing and control determining overlay error,” Auguste Lam, Alexander Ypma, Maxime Gatefait, David Deckers, Arne Koopman, Richard J. F. van Haren, Jan Beltman [9424-57]

Jason P. Cain
Martha I. Sanchez
Diana Nyyssonen was a pioneer in the field of dimensional metrology. Her early interests in optics were formed under the tutelage of Professor Edward L. O'Neill at Boston University. In 1965 she went to work for Brian J. Thompson and George B. Parrent, Jr. at Technical Operations, Inc., Burlington, Massachusetts. Diana’s knowledge of physical optics and related modeling grew rapidly as she worked on the teams developing the theory of partially coherent imaging, physical models, equipment and applications for the US government, astronomy, and industry. Her professional circle at that time included George O. Reynolds, John B. DeVelis, Adriaan Walther, Philip S. Considine, Richard J. Becherer, and Richard E. Swing.

In 1969 Diana Nyyssonen joined the Image Optics and Photography Section of the Metrology Division at the National Bureau of Standards (NBS), initially working for Calvin S. McCamy on microdensitometry, then on linewidth measurements for integrated circuit manufacturing applications. Sponsored by NBS, Diana also attended the Institute of Optics, University of Rochester at Rochester, New York where Professor B. J. Thompson, Director of the Institute, was her advisor. She completed her PhD in 1975 with her Thesis “High resolution microdensitometry of photographic emulsions” reflecting the scientific foundations and the outlook of the things to come. Dr. Nyyssonen’s modeling of thin films observed by an optical microscope demonstrated that line (space) width smaller than Rayleigh resolution limit can be measured. She produced linewidth measurements in photomasks with calibration based on physical modeling and first principles, establishing the first critical dimension standards for the microelectronics industry and the foundation of today’s dimensional metrology.
Dr. Nyyssonen left NBS in 1985 to form her own metrology company then joined IBM at East Fishkill, New York in 1988. Continuing the development of accurate optical modeling of imaging of thick films with Christopher P. Kirk, NBS and other teams, she started projects on metrology with scatterometry and interference microscopy, modeled imaging in low voltage CD-SEM, and spearheaded the establishment of CD-AFM.

Diana Nyyssonen’s personal contributions to the field of dimensional metrology, as well as her collaborations and mentorships in the industry, consortia, and academia, accelerated and influenced the development of basic technology and metrology applications with optical microscopy and scatterometry, SEM, and AFM.

Metrology, Inspection, and Process Control for Microlithography is the leading international forum for the discussion and presentation of technical advances in the broader field of semiconductor metrology. The Diana Nyyssonen Memorial Award for the Best Paper at this Conference recognizes the most significant current contributions.

Due to the Conference’s long history, significant attendance and high paper counts, to win this Award requires a very significant new contribution to the field. The selection of the best paper is initiated during the Conference by nomination, followed by extensive review by the Program Committee. It is based on both the technical merit and persuasiveness of the oral presentation and the overall quality of the published paper. Past award winners include leading international researchers in the area of semiconductor metrology and process control whose contributions have fundamentally improved the way semiconductors are manufactured.

We are pleased to honor the winners of the Diana Nyyssonen Memorial Award for the Best Paper of 2014, as well as those who have won in previous years:

2014

2013

2012

2011
2010

2009

2008

2007

2006

2005

2004

2003

2002

2001
The Karel Urbánek Best Student Paper Award

Karel Urbánek studied mathematics and physics at the Charles University in Prague where he was the valedictorian of his class in 1963. After graduation he immigrated to the United States where he soon found employment with Lincoln Labs in Cambridge, Massachusetts. Karel stayed there for a short time before moving to the San Francisco Bay Area and joined Varian Associates, where he worked for Bill Wheeler in the Vacuum Division on semiconductor manufacturing equipment.

Recognizing an opportunity in the new field of sputtering for thin film deposition, Karel joined fellow Varian employees John Schwabacher, Ed Kerswill, Al Lang, and Barry Hart to found Randex in 1970.

By 1973 the company was on a very rapid growth trajectory and the founders agreed to an acquisition by Perkin-Elmer in order to provide resources for continued growth. Karel became the research director for the Ultek division in Palo Alto, California.

Sputtering research projects at Perkin-Elmer led to the need to accurately measure the thickness of the deposited film. The primary instruments of the day were known for being difficult to operate and required highly-skilled operators. Seeing an opportunity, some of the original Randex team (Urbánek, Schwabacher, Kren, Hart, and Kerswill) formed a new startup company called Tencor in 1976. Bill Wheeler and Jerry Gabe also joined the Tencor team.

Tencor’s first product was the Alpha-Step profilometer in 1977. The Alpha-Step was a simple, low-cost method for measuring film thickness, step height, and surface morphology and the basic design is still in wide use today. It entered a market where the dominant tool
had a reputation for being difficult to use and maintain and for poor repeatability. In contrast, the Alpha-Step was simple to use, robust to environmental changes, highly repeatable, and was capable of being automated. Urbánek even insisted on literally kicking a packing case containing an Alpha-Step across a room and then opening it up to demonstrate that the tool would still work correctly. Setup time was designed to be in the 5-10 minute range where other comparable equipment could take hours.

Karel Urbánek served as CEO and Chairman of the Board of Tencor for fifteen years until his death in 1991. He was also active in the SEMI International Standards Program and was honored in 1992 with the creation of the Karel Urbánek Award, the most prestigious honor for participants in the SEMI International Standards Program.

Karel and his wife Lida were also passionate about supporting education for young people, particularly in science and engineering. Among their contributions are the Karel Urbánek Postdoctoral Fellowship at Stanford University, the Karel Urbánek Teaching Laboratories at Charles University, and the Urbánek /Levy Education Fund, a scholarship fund for children of KLA-Tencor employees.

The Karel Urbánek Best Student Paper Award was created in 2014 to recognize the best paper authored by a current student at the conference. In order to be eligible, the student must be the primary author and must present the work at the conference. It is our great pleasure to recognize this year’s winner along with previous recipients:

2015
Kathleen M. Hoogeboom-Pot, Jorge N. Hernandez-Charpak, Travis Frazer, Xiaokun Gu, Emrah Turgut, Erik H. Anderson, Weilun L. Chao, Justin M. Shaw, Ronggui Yang, Margaret M. Murnane, Henry C. Kapteyn, Damiano Nardi, “Mechanical and thermal properties of nanomaterials at sub-50nm dimensions characterized using coherent EUV beams,” [9424-43]

2014

The first Best Student Paper Award at the conference was given in 2013 to: