Metrology, Inspection, and Process Control for Microlithography XXXI

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Proc. of SPIE Vol. 10145 1014501-2
## Contents

ix  Authors

xv  Conference Committee

xix  Introduction

### HYBRID METROLOGY

| 10145 05 | Patterning control strategies for minimum edge placement error in logic devices [10145-4] |
| 10145 06 | Hybrid scatterometry measurement for BEOL process control [10145-5] |
| 10145 08 | A hybrid solution using computational prediction and measured data to accurately determine process corrections with reduced overlay sampling [10145-7] |

### OVERLAY

| 10145 09 | Impact of stochastic process variations on overlay mark fidelity towards the 5nm node (Invited Paper) [10145-8] |
| 10145 0A | A complete methodology towards accuracy and lot-to-lot robustness in on-product overlay metrology using flexible wavelength selection [10145-9] |
| 10145 0B | Reaching for the true overlay in advanced nodes [10145-10] |
| 10145 0C | Image based overlay measurement improvements of 28nm FD-SOI CMOS front-end critical steps [10145-11] |
| 10145 0D | High-volume manufacturing device overlay process control [10145-13] |
| 10145 0E | In-depth analysis of indirect overlay method and applying in production environment [10145-14] |

### FUTURE

| 10145 0G | Metrology capabilities and needs for 7nm and 5nm logic nodes (Invited Paper) [10145-15] |
| 10145 0H | Variability study with CD-SEM metrology for STT-MRAM: correlation analysis between physical dimensions and electrical property of the memory element [10145-16] |
| 10145 0I | Designed tools for analysis of lithography patterns and nanostructures [10145-17] |
Required metrology and inspection for nanoimprint lithography [10145-18]

High throughput electrical characterization for robust overlay lithography control [10145-85]

Sub-wavelength transmission and reflection mode tabletop imaging with 13nm illumination via ptychography CDI (Best Student Paper Award) [10145-113]

EUV MASK INSPECTION AND IMAGING: JOINT SESSION WITH CONFERENCES 10143 AND 10145

Application of actinic mask review system for the preparation of HVM EUV lithography with defect free mask [10145-21]

Towards a stand-alone high-throughput EUV actinic photomask inspection tool: RESCAN [10145-22]

WAFER-SHAPE INDUCED OVERLAY

Patterned wafer geometry grouping for improved overlay control [10145-23]

Wafer-shape metrics based foundry lithography [10145-24]

Topography based wafer clustering for wafer level overlay correction [10145-26]

PROCESS CONTROL

In-line E-beam metrology and defect inspection: industry reflections, hybrid E-beam opportunities, recommendations and predictions (Invited Paper) [10145-27]

Smart sampling for process control [10145-28]

A new method for wafer quality monitoring using semiconductor process big data [10145-29]

Combined process window monitoring for critical features [10145-30]

Computational overlay metrology with adaptive data analytics [10145-31]

Advanced in-production hotspot prediction and monitoring with micro-topography [10145-33]

LINE EDGE ROUGHNESS (LER)

Global minimization line-edge roughness analysis of top down SEM images (Invited Paper) [10145-34]
<table>
<thead>
<tr>
<th>Page</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>0Z</td>
<td>Level crossing methodology applied to line-edge roughness characterization (Invited Paper) [10145-35]</td>
</tr>
<tr>
<td>10</td>
<td>Multitaper and multisegment spectral estimation of line-edge roughness [10145-36]</td>
</tr>
<tr>
<td>11</td>
<td>An OCD perspective of line edge and line width roughness [10145-37]</td>
</tr>
<tr>
<td></td>
<td><strong>SEM I</strong></td>
</tr>
<tr>
<td>12</td>
<td>Enabling CD SEM metrology for 5nm technology node and beyond (Invited Paper) [10145-38]</td>
</tr>
<tr>
<td>13</td>
<td>Framework for SEM contour analysis [10145-39]</td>
</tr>
<tr>
<td>14</td>
<td>Robust 2D patterns process variability assessment using CD-SEM contour extraction offline metrology [10145-40]</td>
</tr>
<tr>
<td>15</td>
<td>CD-SEM distortion quantification for EPE metrology and contour analysis [10145-41]</td>
</tr>
<tr>
<td></td>
<td><strong>Part Two</strong></td>
</tr>
<tr>
<td></td>
<td><strong>INSPECTION AND REFERENCE METROLOGY</strong></td>
</tr>
<tr>
<td>16</td>
<td>Assessing the wavelength extensibility of optical patterned defect inspection [10145-42]</td>
</tr>
<tr>
<td>17</td>
<td>Anamorphic approach for developing hi-efficiency illumination system to inspect defects on semiconductor wafers [10145-43]</td>
</tr>
<tr>
<td>18</td>
<td>1.5nm fabrication of test patterns for characterization of metrological systems [10145-45]</td>
</tr>
<tr>
<td>19</td>
<td>Fabrication of metrology test structures with helium ion beam direct write [10145-46]</td>
</tr>
<tr>
<td></td>
<td><strong>OPTICAL METROLOGY</strong></td>
</tr>
<tr>
<td>1B</td>
<td>High-NA optical CD metrology on small in-cell targets enabling improved higher order dose control and process control for logic [10145-47]</td>
</tr>
<tr>
<td>1C</td>
<td>Complex metrology on 3D structures using multi-channel OCD [10145-48]</td>
</tr>
<tr>
<td>1D</td>
<td>Optical metrology strategies for inline 7nm CMOS logic product control [10145-49]</td>
</tr>
<tr>
<td>1E</td>
<td>Evaluating the effects of modeling errors for isolated finite 3D targets [10145-50]</td>
</tr>
<tr>
<td>1F</td>
<td>Scatterometry control for multiple electron beam lithography [10145-51]</td>
</tr>
<tr>
<td>1G</td>
<td>Advanced optical modeling of TiN metal hard mask for scatterometric critical dimension metrology [10145-52]</td>
</tr>
</tbody>
</table>
Advanced applications of scatterometry based optical metrology [10145-53]

3D SEM AND 3D APPLICATIONS

SEM image prediction based on modeling of electron-solid interaction [10145-54]
SEM-based overlay measurement between via patterns and buried M1 patterns using high-voltage SEM [10145-56]
High-precision CD measurement using energy-filtering SEM techniques [10145-57]
SEM imaging capability for advanced nano-structures and its application to metrology [10145-58]

DESIGN INTERACTIONS WITH METROLOGY: JOINT SESSION WITH CONFERENCES 10148 AND 10145

Pattern centric design based sensitive patterns and process monitor in manufacturing [10145-60]
The use of computational inspection to identify process window limiting hotspots and predict sub-15nm defects with high capture rate [10145-61]

SEM II

Using the analytical linescan model for SEM metrology [10145-63]
High-throughput multi-beam SEM: quantitative analysis of imaging capabilities at IMEC-N10 logic node [10145-64]

LATE BREAKING NEWS

Materials characterization for process integration of multi-channel gate all around (GAA) devices [10145-66]
Molecular dynamics and dynamic Monte-Carlo simulation of irradiation damage with focused ion beams [10145-68]
Application of advanced hybrid metrology method to nanoimprint lithography [10145-108]
Connected component analysis of review-SEM images for sub-10nm node process verification [10145-112]
<table>
<thead>
<tr>
<th>Session</th>
<th>Title</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>10145 1Z</td>
<td>Overlay degradation induced by film stress [10145-71]</td>
<td></td>
</tr>
<tr>
<td>10145 23</td>
<td>Scanning electron microscope automatic defect classification of process induced defects [10145-75]</td>
<td></td>
</tr>
<tr>
<td>10145 24</td>
<td>Process resilient overlay target designs for advanced memory manufacture [10145-76]</td>
<td></td>
</tr>
<tr>
<td>10145 25</td>
<td>Asymmetry overlay correction for lithography processes [10145-77]</td>
<td></td>
</tr>
<tr>
<td>10145 26</td>
<td>Hybrid methodology for on-product focus control using CD and diffraction-based focus marks [10145-78]</td>
<td></td>
</tr>
<tr>
<td>10145 27</td>
<td>Monitoring of 450mm copper seeding and plating process via dark field inspection haze [10145-79]</td>
<td></td>
</tr>
<tr>
<td>10145 28</td>
<td>Application of advanced diffraction based optical metrology overlay capabilities for high volume manufacturing [10145-80]</td>
<td></td>
</tr>
<tr>
<td>10145 29</td>
<td>EPE analysis of sub-N10 BEoL flow with and without fully self-aligned via using Coventor SEMulator3D [10145-81]</td>
<td></td>
</tr>
<tr>
<td>10145 2B</td>
<td>Enhanced 28nm FD-SOI diffraction based overlay metrology based on holistic metrology qualification [10145-83]</td>
<td></td>
</tr>
<tr>
<td>10145 2C</td>
<td>New alignment mark design structures for higher diffraction order wafer quality enhancement [10145-84]</td>
<td></td>
</tr>
<tr>
<td>10145 2D</td>
<td>High throughput and dense sampling metrology for process control [10145-86]</td>
<td></td>
</tr>
<tr>
<td>10145 2E</td>
<td>Efficient hybrid metrology for focus, CD, and overlay [10145-87]</td>
<td></td>
</tr>
<tr>
<td>10145 2G</td>
<td>Reducing the overlay metrology sensitivity to perturbations of the measurement stack [10145-89]</td>
<td></td>
</tr>
<tr>
<td>10145 2I</td>
<td>Lab- and field-test results of MFIG, the first real-time vacuum-contamination sensor [10145-93]</td>
<td></td>
</tr>
<tr>
<td>10145 2J</td>
<td>CD uniformity control for thick resist process [10145-94]</td>
<td></td>
</tr>
<tr>
<td>10145 2K</td>
<td>Enhanced methodology of focus control and monitoring on scanner tool [10145-96]</td>
<td></td>
</tr>
<tr>
<td>10145 2L</td>
<td>Wafer-shape based in-plane distortion predictions using superfast 4G metrology [10145-97]</td>
<td></td>
</tr>
<tr>
<td>10145 2M</td>
<td>Monitoring of multi-patterning processes in production environment [10145-98]</td>
<td></td>
</tr>
<tr>
<td>10145 2O</td>
<td>Improved multi-beam laser interference lithography system by vibration analysis model [10145-100]</td>
<td></td>
</tr>
<tr>
<td>10145 2Q</td>
<td>A pattern-based method to automate mask inspection files [10145-102]</td>
<td></td>
</tr>
</tbody>
</table>
SAQP pitch walk metrology using single target metrology [10145-104]

Projection lens testing with Moiré effect [10145-105]

Precise design-based defect characterization and root cause analysis [10145-110]
Authors

Numbers in the index correspond to the last two digits of the seven-digit citation identifier (CID) article numbering system used in Proceedings of SPIE. The first five 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.

Abe, Hideaki, 0J
Adam, Omer, 0A
Adams, Daniel A., 0L
Adel, Michael E., 09, 24
Aharon, Sharon, 09
Ahmad Ibrahim, Muhammad Asraf Bin, 2Q
Ahmad Noorhani, Ahmad Nurul Ihsan Bin, 2Q
Anberg, Doug, 2L
Anis, Fatima, 0O
Anunciado, R., 2E
Appeltans, Raf, 12
Asakawa, Yuji, 2D
Asano, Masafumi, 0J, 1X
Babin, Sergey, 1B
Baderot, Julien, 01
Bae, Sung Yong, 2G
Barnes, Bryan M., 16, 1E
Baudemopez, Bart, 09
Belletti, Filippo, 1B
Bellmann, Enrico, 0Q
Bello, A. F., 0G
Bernard, Guilhem, 01
Besacier, Maxime, 14
Bevis, Charles S., 0L
Bhattacharyya, Kaustuve, 0A, 0V
Bizen, Daisuke, 1K
Blancquaert, Yoann, 1F
Boerboom, Patrique, 2I
Bömmels, Jürgen, 12
Bonom, Ravi, 11
Borosov, Sergey, 11
Bouche, Eric, 0P
Bouet, N., 18
Bouyssou, Régis, 0C, 2B
Breton, Mary, 11
Briggs, Basone, 12
Brinster, Irina, 0D
Brown, Justin, 27
Brunner, Timothy A., 0Z
Buengener, Ralf, 0R
Buhl, Stefan, 0E, 0Q, 0U, 2M
Bunday, Benjamin D., 0G, 0R, 1R
Cabrini, S., 18
Calafiore, G., 18
Camp, Janay, 1D, 2R
Cantone, Jason, 0R
Cepler, Aron J., 1C, 1U
Chang, C.-H., 25
Chang, Ken, 0A
Chao, Robin, 1U
Charley, Anne-Laure, 12
Chen, Charlie, 25
Chen, K. C., 12, 2J
Chen, Kai-Hsiung, 0A, 28
Chen, Ming-Jui, 25
Chen, Owen, 08
Chen, Sheng-Yung, 19
Chen, Xuemei, 0Z
Chen, Yen-Jen, 2K
Chen, Zhijin, 2W
Cheng, Guojie, 1O
Cheng, Kevin, 0A
Cheng, Marjorie, 06
Chien, Sheng-Wei, 19
Choi, DongSub, 0D, 0O, 24
Choi, Eunhyuk, 0J
Choo, Jae, 0K
Chu, Seungyong, 17
Chuang, S. M., 28
Chuang, T. K., 28
Clark, William, 29
Collaert, Nadine, 12
Conley, R., 18
Couraudon, Vincent, 0A
Cramer, Hugo, 1B
Cross, Andrew, 1Y
Crotti, Davide, 12
Cumurcu Gysen, Aysegul, 28
Dai, Xintuo, 0G, 0R, 2D
d'Alfonso, Maxime, 28
de Graaf, Frank, 2I
dekkers, Harold, 2L
de la Fuente, Isabel, 1B
de la Peña, Abraham A., 1U
Delhougne, Romain, 12
den Boef, Arie, 0A
Depre, Jerome, 28
Depre, L., 0X
de Ruiter, Chris, 0V, 2G
ervillé, Alexandre, 0I
De Simone, Danilo, 12
Dettoni, Florent, 0C, 2B
Devender, Devender, 0K
dezauzier, Christophe, 0C, 2B
Di, Ming, 1D
Dillen, Harm, 15
Di Piazza, Luca, 12
Dixit, Dhairya, 1H
Tachibana, Ichiro, 1L
Takada, Satoshi, 1I
Takeda, Kuniaki, 2D
Tallon, Milo, 27
Tamam, Lilach, 1C
Tan, Chi Lim, 12
Tang, Teck Jung, 0K
Tanksalvala, Michael, 0L
Tel, Vim T., 05, 0V, 2E
Teng, L. G., 0A
Thomas, Joel, 0V
Thul, Klaus, 0V
Tian, Ye, 2K
Tian, Zhengguo, 2C
Tien, Ming-Chun, 1P
Timoney, Padraig, 06
Timoshkov, Vadim, 05
Todi, Vinit, 1H
Tottevitz, Steven, 0Q
Tsai, Damon, 0P
Tsai, Kuen-Yu, 19
Tu, Ward, 1B
Tzeng, Wilson, 0A
Ullah, Zakir, 0V
Urbanowicz, Adam M., 1G
Vaid, Alok, 06, 0G, 0R, 1C, 1D, 1H, 2R
Van den Bosch, Geert, 12
Vandenheuvel, Dieter, 09
van der Heijden, Marco J. A., 26
van der Laarhoven, Rik, 26
van der Laan, Hans, 2G
van Dijk, Leon, 2L
Van Elshocht, Sven, 2L
van Haren, Richard, 2L
van Laarhoven, Rik, 1B
van Loon, Francois, 26
van Putten, Michel, 2l
van Roey, Frieda, 15
Velez, Anaabel, 12
Venkatadri, Panneerselvam, 2W
Venkataramanan, Karthik, 1D
Ventzek, Peter, 0Y
Visser, Bart, 2G
Vladar, A., 18
Vukkadala, Pradeep, 0O
Wuong, Tam, 2G
Wakamoto, Koichi, 1X
Wallow, Thomas L., 15
Wang, Cathy, 0A
Wang, Weihung, 2J
Wang, Wenhu, 2D
Wang, Y. C., 0A
Warnock, Scott, 0S
Wei, Ming Sheng, 0P
Wei, Yaoi, 2C
Weintraub, Jeffrey, 0S
Weng, Tang Chun, 25
Weng, Weihao, 0R
Wilson, Christopher J., 12
Wolfe, Scott, 23
Wolfling, Shay, 1F, 1U
Wong, P., 2E
Woo, Jaesung, 0D, 0O, 2M
Womington, Matthew, 1U
Wu, Jen, 28
Wu, Keiching, 1O
Wu, Kevin, 0R
Xie, Qian, 2W
Yamaguchi, Atsuko, 0H, 12
Yamashita, Tenko, 1U
Yan, Philip, 1P
Yang, Elvis, 1Z, 2J
Yang, Mars, 1Z, 2J
Yang, Sunseok, 17
Yang, T. H., 1Z, 2J
Yang, Yin-Kuang, 2O
Yang, Yusin, 0T
Yashchuk, V. V., 18
Yasin, Fauziah, 0H, 12
Yathapu, Nithin, 27
Ye, Tianchun, 2C
Yellai, Naren, 06, 1C
Ye, Sun-Young, 1P
Yokosuka, Toshiyuki, 1I
Yoon, Nam Hee, 1D
Yoshikawa, Ryoji, 0J
Yoshikawa, Shushuke, 0N
Yu, Chia Hsiang, 25
Yu, Chun-Chi, 25
Yueh, Jenny, 28
Zach, Franz, 2R
Zafar, Khurram, 2W
Zeidler, D., 1S
Zhang, Lihua, 2C
Zhang, Liming, 0V
Zhang, Xiaoshi, 0L
Zhang, Ye, 2E
Zhou, Daisy, 12
Zhou, Hui, 16, 1E
Zhou, Philip, 12
Zhou, Yue, 2G
Zimmermann, Yann, 0I
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1 Keynote Session
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Vladimir A. Ukraintsev, Qorvo, Inc. (United States)

2 Hybrid Metrology
Masafumi Asano, Toshiba Corporation (Japan)
Narender Rana, Western Digital Corporation (United States)

3 Overlay
Alexander Starikov, I&I Consulting (United States)
Hugo Cramer, ASML Netherlands B.V. (Netherlands)

4 Future
Richard M. Silver, National Institute of Standards and Technology (United States)
Masafumi Asano, Toshiba Corporation (Japan)

5 EUV Mask Inspection and Imaging: Joint Session with Conferences 10143 and 10145
Anna Tchikoulaeva, Lasertec U.S.A., Inc. Zweigniederlassung Deutschland (Germany)
Ofer Adan, Applied Materials, Ltd. (Israel)

6 Wafer-Shape Induced Overlay
Shunsuke Koshihara, Hitachi High-Technologies Corporation (Japan)
Christopher J. Raymond, Nanometrics Inc. (United States)

7 Process Control
Timothy F. Crimmins, Intel Corporation (United States)
Matthew J. Sendelbach, Nova Measuring Instruments Inc. (United States)

8 Line Edge Roughness (LER)
John A. Allgair, International Consortium for Advanced Manufacturing Research (ICAMR) (United States)
Benjamin D. Bunday, CNSE/SEMATECH (United States)

9 SEM I
Benjamin D. Bunday, CNSE/SEMATECH (United States)
Shunsuke Koshihara, Hitachi High-Technologies Corporation (Japan)

10 Inspection and Reference Metrology
Narender Rana, Western Digital Corporation (United States)
Matthew J. Sendelbach, Nova Measuring Instruments Inc. (United States)
11 Optical Metrology
John C. Robinson, KLA-Tencor Corporation (United States)
Christopher J. Raymond, Nanometrics Inc. (United States)

12 3D SEM and 3D Applications
John A. Allgair, International Consortium for Advanced Manufacturing Research (ICAMR) (United States)
Masafumi Asano, Toshiba Corporation (Japan)

13 Design Interactions with Metrology: Joint Session with Conferences 10148 and 10145
Jason P. Cain, Advanced Micro Devices, Inc. (United States)
John C. Robinson, KLA-Tencor Corporation (United States)

14 SEM II
Timothy F. Crimmins, Intel Corporation (United States)
Martha I. Sanchez, IBM Research - Almaden (United States)

15 Late Breaking News
Martha I. Sanchez, IBM Research - Almaden (United States)
Vladimir A. Ukraintsev, Qorvo, Inc. (United States)
Introduction

The 31st conference on Metrology, Inspection, and Process Control for Microlithography began with two outstanding keynote presentations. Richard M. Silver from National Institute of Standards and Technology began the Keynote Session with “Advancing measurement science at NIST to enable atom-scale technology,” starting with non-destructive techniques to techniques with atomic-scale resolution including 3D CD metrology and tomography. This was followed by Philippe Leray from IMEC with, “Metrology challenges for in-line process control,” describing energy and angular filtered SEM, metrology of HAR (high aspect ratio) structures, use of SEM to improve accuracy of overlay (OVL), including complicated OVL models, tunable wavelength OCD (scatterometry) and OVL to minimize overlay and CD errors and enable nm-scale uncertainty.

Strong student presentations for the Best Student Paper Award this year compelled us to recognize the runner-up paper. The presentations were professional and presented with the confidence of understanding their topics fully. There was an overwhelming number of overlay metrology papers underpinning the importance, improvement in accuracy, and paving the way to nm uncertainty. There has been good progress with SEM modeling and parameters to allow better imaging of high aspect ratio and buried features. Joint sessions continued to be an excellent way to merge and interact with other conferences. This year we had two joint sessions.

SESSION 5: EUV Mask Inspection and Imaging: Joint Session with Conferences 10143 and 10145. The joint session with the EUV Lithography conference, 10143, chaired by Ofer Adan and Anna Tchikoulaeva, was extremely well attended:

- “Application of actinic mask review system for the preparation of HVM EUV lithography with defect free mask,” Ji Hoon Na, et al., SAMSUNG Electronics Co., Ltd.
- “Printability and actinic AIMS review of programmed mask blank defects,” Erik Verduijn, et al., GLOBALFOUNDRIES Inc. [10143-16]

SESSION 13: Design Interactions with Metrology: Joint Session with Conferences 10148 and 10145. The second joint session was with the Design-Process-Technology Co-optimization for Manufacturability conference, 10148, chaired by Jason P. Cain and John C. Robinson:

- “Pattern centric design based sensitive patterns and process monitor in manufacturing,” Chingyun Hsiang, et al., Anchor Semiconductor, Inc. [10145-60]
- “The use of computational inspection to identify process window limiting hotspots and predict sub-15nm defects with high capture rate,” Boo-Hyun Ham, et al., SAMSUNG Electronics Co., Ltd. [10145-61]
Following are the winners of the 2016 Diana Nysssonen Memorial Award for Best Paper and the 2017 Karel Urbánek Best Student Paper Award.

Martha I. Sanchez
Vladimir A. Ukrainsev
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 2016, as well as those who have won in previous years:

2016

2015

2014

2013

2012

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2005

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2003

2002

2001
The Karel Urbánek Best Student Paper Award

Karel Urbánek studied electronics and high-vacuum physics at the Charles University in Prague, the valedictorian of his class. To earn his way through college, and to learn about the life in the West, he worked as a tour guide. That is how he met two key people in his life and career: Lida Náprstek, then a student at Radcliffe College leading a group of American school kids, and Sonny (Melville) Marx, an investment banker from San Francisco. After graduation he used this learning and cash to escape the soviet system by flying to a “vacation” in Cuba. He slipped away during a stopover in Halifax, Nova Scotia. His first call was to Lida; the second was to Sonny. He requested asylum. The local American consul arranged for his entry into the United States.

Karel soon found a job with Lincoln Labs in Cambridge, Massachusetts, then moved to the San Francisco Bay Area. He joined Varian Associates working for Bill Wheeler on vacuum equipment for semiconductor manufacturing.

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

By 1973, with Randex business in rapid growth, its founders agreed to an acquisition by Perkin-Elmer. Karel became the research director for the Ultek division of Perkin-Elmer in Palo Alto, California.

Sputtering projects often led to the need to accurately measure the thickness of the deposited film. Recognizing another opportunity, some of the original Randex team (Urbánek, Schwabacher, Kren, Hart, and Kerswill) formed Tencor in 1976. Bill Wheeler and Jerry Gabe later joined Tencor. Sonny Marx, their venture capitalist in the Randex start up, insisted that they re-invest their gains in this new venture, a move to leverage their past success and to control their new business, ultimately making most of them wealthy.

Tencor’s first product was the Alpha-Step profilometer in 1977. It used a simple but very robust method for measuring displacement. Urbánek even insisted on literally kicking a packing case containing an Alpha-Step across a room, then opening it up to set up and, within minutes, measure film thickness and step height. Simple to use, stable and repeatable to sub-1nm the tool was an instant success. The Tencor team then bet the company on their next big product, Surfscan wafer inspection tool. They nearly bankrupted the company developing reliable detection of small defects and automation. That pioneering technology, as in the Alpha-Step, also quickly became ubiquitous and it is still in use today.
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 Lida Urbánek were passionate supporters of education, particularly in science and engineering. This support lives on through the Karel Urbánek Fellowship at Stanford University, the Karel Urbánek Laboratories at the Charles University in Prague, and the Urbánek /Levy Education Fund for the children of KLA-Tencor employees.

The Karel Urbánek Best Student Paper Award sponsored by KLA-Tencor Corp. 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:

2017
Michael Tanksalvala, JILA, University of Colorado at Boulder (United States); Christina L. Porter, Dennis F. Gardner, Michael Gerrity, Giulia F. Mancini, Xiaoshi Zhang, Galen P. Miley, Elisabeth R. Shanblatt, Benjamin R. Galloway, Charles S. Bevis, Robert Karl Jr., Daniel A. Adams, Henry C. Kapteyn, Margaret M. Murnane, “Sub-wavelength transmission and reflection mode tabletop imaging with 13nm illumination via ptychography CDI,” [10145-113]

2016
Maria Laura Gödecke, Univ. Stuttgart (Germany); Sandy Peterhänsel, Karsten Frenner, and Wolfgang Osten, “Measurement of asymmetric side wall angles by coherent scanning Fourier scatterometry,” [9778-16]

2015
Kathleen M. Hoogeboom-Pot, Univ. of Colorado at Boulder (USA); 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