PROCEEDINGS OF SPIE

Advances in Metrology for X-Ray and EUV Optics VIII

Lahsen Assoufid
Haruhiko Ohashi
Anand Asundi
Editors

11–12 August 2019
San Diego, California, United States

Sponsored and Published by
SPIE

Volume 11109

Proceedings of SPIE 0277-786X, V. 11109

SPIE is an international society advancing an interdisciplinary approach to the science and application of light.

Advances in Metrology for X-Ray and EUV Optics VIII, edited by Lahsen Assoufid,
Haruhiko Ohashi, Anand Asundi, Proc. of SPIE Vol. 11109, 1110901 · ©
2019 SPIE · CCC code: 0277-786X/19/$21 · doi: 10.1117/12.2551651

The papers 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. Additional papers and presentation recordings may be available online in the SPIE Digital Library at SPIEDigitalLibrary.org.

The papers 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 these proceedings:
Author(s), "Title of Paper," in *Advances in Metrology for X-Ray and EUV Optics VIII*, edited by Lahsen Assoufid, Haruhiko Ohashi, Anand Asundi, Proceedings of SPIE Vol. 11109 (SPIE, Bellingham, WA, 2019) Seven-digit Article CID Number.

ISSN: 0277-786X
ISSN: 1996-756X (electronic)

ISBN: 9781510629110
ISBN: 9781510629127 (electronic)

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 © 2019, 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 $21.00 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/19/$21.00.

Printed in the United States of America by Curran Associates, Inc., under license from SPIE.

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. A unique citation identifier (CID) number is assigned to each article at the time of 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 and print versions of the publication. SPIE uses a seven-digit CID article numbering system structured as follows:

- The first five 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.

Contents

v *Authors*
vii *Conference Committee*

CALIBRATION TOOLS AND METHODS

11109 02 **A precise aperture centring device (ACenD) for autocollimator-based surface measuring profilers (Invited Paper)** [11109-1]

11109 03 **High-accuracy autocollimator calibration by interferometric 2D angle generator** [11109-2]

11109 04 **Stress releasing procedure approach for an x-ray mirror holder for round-robin measurements** [11109-3]

FACILITIES

11109 06 **The Optical Metrology Laboratory at Diamond: pushing the limits of nano-metrology** [11109-5]

OPTICS FABRICATION AND TESTING

11109 09 **One-dimensional ion-beam figuring solution from Brookhaven National Laboratory** [11109-8]

11109 0A **Ion beam figuring and optical metrology system for synchrotron x-ray optics** [11109-9]

11109 0B **Metrology of MID offset mirrors before and after coating** [11109-10]

OPTICAL SYSTEMS AND THEIR METROLOGY

11109 0C **Collaborative development of diffraction-limited beamline optical systems at US DOE light sources (Invited Paper)** [11109-11]

11109 0E **Controlling an active bimorph deformable mirror with sub-nanometre resolution** [11109-13]

11109 0F **First commissioning results of the KB mirrors at the SCS instrument of the European XFEL** [11109-14]

11109 0G **EUV Stokes reflection polarimeter using gold coated mirrors for use up to 150 eV photon energy** [11109-15]

AT-WAVELENGTH METROLOGY

11109 0I **Three-dimensional shape measurement of an ellipsoidal mirror by industrial x-ray computed tomography** [11109-16]

11109 0K **High-speed characterization of refractive lenses with single-grating interferometry** [11109-18]

PROFILOMETRY AND APPLICATION

11109 0M **Investigation on lateral resolution of surface slope profilers** [11109-28]

11109 0N **On the characterization of ultra-precise XUV-focusing mirrors by means of slope- measuring deflectometry** [11109-21]

11109 0O **New surface slope profiler with sub-millimeter spatial resolution** [11109-22]

11109 0P **Transparent element surface measurement using binary pattern in phase-measuring deflectometry** [11109-23]

11109 0Q **The in-situ LTP window glass optomechanical analysis** [11109-24]

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.

Akgoz, S. Asli, 02
Alcock, Simon G., 06, 0A, 0E, 0F
Arnold, Thomas, 0M
Assoufid, Lahsen, 0C, 0K
Badami, Vivek, 0E
Bazan da Silva, Murilo, 06
Black, Gillian, 0G
Bouet, Nathalie, 09
Broers, C., 0F
Bryant, Diane, 0C
Buchheim, Jana, 0N
Burian, T., 0F
Byman, V., 03
Cai, Quan, 0O
Carley, R., 0F
Cascella, M., 0F
Chalupský, J., 0F
Chao, Weilun, 0C
Chen, Bo-Yi, 0Q
Cocco, Daniele, 0C
Cui, Xiaoyu, 0G
Delitz, J. T., 0F
Eisebitt, S., 0F
Fung, Hok-Sum, 0Q
Geckeler, Ralf D., 02, 03
Gerasimova, N., 0F
Goldberg, Kenneth A., 0C
Gorovikov, Sergey, 0G
Grizolli, Walan, 0C, 0K
Grubert, Bernd, 02
Gwalt, Grzegorz, 0N
Hájková, V., 0F
Hand, Matthew, 0A
Hardin, Corey, 0C
He, Feizhu, 0G
Heikkinen, V., 03
Henneberg, Grant, 0G
Hillman, Michael, 0A
Hsu, Ming-Ying, 0Q
Huang, Lei, 09, 0C
Huang, Yu-Shan, 0Q
Idir, Mourad, 09, 0C
Islam, Zahirul, 0K
Juha, L., 0F
Just, Andreas, 02, 03
Kearney, Steve P., 0C
Krause, Michael, 02, 03
Kreitschik, David, 02
Kuhne, Dennis, 09
La Civita, D., 04, 0F
Lacey, Ian, 0M
Lassila, A., 03
Le Guyarder, L., 0F
Lee, Chien-yu, 0Q
Lee, Lance, 0C
Li, Dahai, 0P
Li, Ming, 0O
Lin, Shang-Wei, 0Q
Littlewood, Richard, 0A
Liu, Peng, 0O
MacDonald, Michael A., 0G
Madsen, A., 0B
Martin, I. Frejio, 04, 0B
Mercadier, L., 0F
Mercurio, G., 0F
Mimura, Hidekazu, 0I
Moriconi, Simone, 0A
Morton, Daniel, 0C
Nagai, Yukie, 0I
Ng, May Ling, 0C
Nistea, Ioana-Theodora, 06, 0E, 0F
Ohtake, Yutaka, 0I
Paetzelt, Hendrik, 0M
Pfau, B., 0F
Rebuffi, Luca, 0K
Reich, A., 0F
Rochester, Simon, 0M
Sawhney, Kawal, 06, 0A, 0E
Scherz, A., 0F
Schlappa, J., 0F
Schmidtchen, S., 04, 0B
Schnabel, Olaf, 02
Schneider, M., 0F
Schumann, Matthias, 02, 03
Setoodehnia, K., 0F
Sheng, Weifan, 0O
Shi, Xianbo, 0C, 0K
Shimizu, Satsuki, 0I
Shpak, M., 03
Shu, Deming, 0C, 0K
Shvyd'ko, Yuri, 0C
Siewert, Frank, 02, 0M, 0N
Signorato, Riccardo, 0E
Sinn, H., 04, 0F
Störmer, M., 0B
Takacs, Peter Z., 0M
Takeo, Yoko, 0I
Tayabaly, Kashmira, 09

Teichmann, M., 0F
Vannoni, M., 04, 0B, 0F
Vescovi, Matthew, 09
Viefhaus, Jens, 0N
Vozda, V., 0F
Vyšín, L., 0F
Wang, Duan-Jen, 0Q
Wang, Hongchang, 0A
Wang, Ruiyang, 0P
Wang, Tianyi, 09
Wojcik, Michael, 0C
Wojdyla, Antoine, 0C
Yamaguchi, Gota, 0I
Yandayan, Tanfer, 02
Yang, Fugui, 0O
Yaroslavtsev, A., 0F
Yashchuk, Valeriy V., 0M
Yates, Brian, 0G
Yin, Gung-Chian, 0Q
Zhang, Xiaowei, 0O
Zozulya, A., 0B
Zuin, Lucia, 0G

Conference Committee

Program Track Chairs

Ali M. Khounsary, Illinois Institute of Technology (United States)
Ralph B. James, Savannah River National Laboratory (United States)

Conference Chairs

Lahsen Assoufid, Argonne National Laboratory (United States)
Haruhiko Ohashi, RIKEN SPring-8 Center (Japan)
Anand Krishna Asundi, Nanyang Technological University (Singapore)

Conference Program Committee

Simon G. Alcock, Diamond Light Source Ltd. (United Kingdom)
Raymond Barrett, ESRF - The European Synchrotron (France)
Daniele Cocco, Lawrence Berkeley National Laboratory (United States)
Uwe Flechsig, Paul Scherrer Institut (Switzerland)
Ralf D. Geckeler, Physikalisch-Technische Bundesanstalt (Germany)
Kenneth A. Goldberg, Lawrence Berkeley National Laboratory (United States)
Mikhail V. Gubarev, NASA Marshall Space Flight Center (United States)
Christian F. Guertin, Vermont Photonics Technologies Corporation (United States)
Yu-Shan Huang, National Synchrotron Radiation Research Center (Taiwan)
Mourad Idir, Brookhaven National Laboratory (United States)
Weiguo Liu, Xi'an Technological University (China)
Jonathan Manton, Inprentus, Inc. (United States)
Hidekazu Mimura, The University of Tokyo (Japan)
Josep Nicolas, ALBA Synchrotron (Spain)
Lorenzo Raimondi, Elettra-Sincrotrone Trieste S.C.p.A. (Italy)
Rajdeep Singh Rawat, National Institute of Education (Singapore)
Kawal J. S. Sawhney, Diamond Light Source Ltd. (United Kingdom)
Frank Siewert, Helmholtz-Zentrum Berlin für Materialien und Energie GmbH (Germany)
Regina Soufli, Lawrence Livermore National Laboratory (United States)
Peter Z. Takacs, Brookhaven National Laboratory (United States)
Muriel Thomasset, Synchrotron SOLEIL (France)
Maurizio Vannoni, European XFEL GmbH (Germany)
Amparo Vivo, ESRF - The European Synchrotron (France)

Zhanshan Wang, Tongji University (China)
Kazuto Yamauchi, Osaka University (Japan)
Tanfer Yandayan, TUBITAK UME (Turkey)
Valeriy V. Yashchuk, Lawrence Berkeley National Laboratory (United States)
Brian W. Yates, Canadian Light Source Inc. (Canada)

Session Chairs

1 Calibration Tools and Methods
Lahsen Assoufid, Argonne National Laboratory (United States)

2 Facilities
Frank Siewert, Helmholtz-Zentrum Berlin für Materialien und Energie GmbH (Germany)

3 Optics Fabrication and Testing
Haruhiko Ohashi, RIKEN SPring-8 Center (Japan)

4 Optical Systems and Their Metrology
Lahsen Assoufid, Argonne National Laboratory (United States)

5 At-Wavelength Metrology
Haruhiko Ohashi, RIKEN SPring-8 Center (Japan)

6 Profilometry and Application
Anand Asundi, Nanyang Technological University (Singapore)

7 Subaperture Stitching
Kazuto Yamauchi, Osaka University (Japan)