# PROCEEDINGS OF SPIE

# EUV and X-ray Optics: Synergy between Laboratory and Space VI

René Hudec Ladislav Pina Editors

3–4 April 2019 Prague, Czech Republic

Sponsored by SPIE

Cooperating Organisations
ELI Beamlines (Czech Republic)
Laserlab Europe
European Optical Society
HiLASE (Czech Republic)

Published by SPIE

**Volume 11032** 

Proceedings of SPIE 0277-786X, V. 11032

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

EUV and X-ray Optics: Synergy between Laboratory and Space VI, edited by René Hudec, Ladislav Pina, Proc. of SPIE Vol. 11032, 1103201 · © 2019 SPIE CCC code: 0277-786X/19/\$18 · doi: 10.1117/12.2535646

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 SPIEDigital Library.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 EUV and X-ray Optics: Synergy between Laboratory and Space VI, edited by René Hudec, Ladislav Pina, Proceedings of SPIE Vol. 11032 (SPIE, Bellingham, WA, 2019) Seven-digit Article CID Number.

ISSN: 0277-786X

ISSN: 1996-756X (electronic)

ISBN: 9781510627307

ISBN: 9781510627314 (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 \$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/19/\$18.00.

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.



**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**

**Authors** vii Conference Committee REFRACTIVE, ACTIVE, AND MULTILAYER X-RAY OPTICS 11032 08 **2D** lens array for multi-contrast x-ray imaging [11032-7] 11032 09 Study of Nb-based material combination multilayer for x-ray applications [11032-8] INTEGRATED DEVICES/SURFACE CHARACTERIZATION 11032 OB Optical performances of new materials in the EUV spectral range: metrology, methods and results (Invited Paper) [11032-10] 11032 0D Reactive ion beam etching-based planarization of optical aluminium surfaces [11032-12] 11032 OE Study of surface quality and subsurface damage of germanium optics produced by single point diamond nanomachining [11032-13] 11032 OF Examination of EUV CCDs and their applications for space research of solar flares [11032-14] 11032 0G Superior photodetector based on solution-synthesized perovskite film [11032-15] **COHERENT RADIATION/LASERS** 11032 OH Tomography with compact laser plasma double-stream gas-puff target source of the EUV and **SXR radiation** [11032-16] EUV-induced plasmas created using intense ionizing radiation pulses from laser-produced 11032 OI plasma sources [11032-17] 11032 OJ Absolute interferometric testing of an ultra-precise flat substrate with a liquid mirror [11032-18] 11032 OK Time of flight in electrostatic ion analyser for laser produced plasma ion resolving [11032-19] 11032 OL Cluster and aerosol targets produced using a gas puff approach for laser-matter interaction **experiments** [11032-20]

11032 OM	Pulsed radiography and tomography of transient and low-density objects using laser plasma sources of extreme ultraviolet (EUV) [11032-21]
11032 ON	Tomographic imaging with the use of a compact soft x-ray microscope based on a laser plasma light source $[11032-22]$
	FREE-SPACE OPTICS
11032 00	Structure system design of super-resolution space camera [11032-23]
	POSTER SESSION
11032 OP	Global optimization of two-multilayer mirror objective for focusing soft x-ray high harmonics [11032-26]
11032 0Q	Multilayer polarizers at the energy range 50-1000eV [11032-27]
11032 OR	Fabrication of a two-dimensional graded periodic Mo/Si multilayer mirror using magnetron sputtering technology [11032-28]
11032 0U	A comparison of customized Hartmann and newly introduced inverted Hartmann masks for single-shot phase-contrast x-ray imaging [11032-31]
11032 OV	EUV reflective ellipsometry in laboratory: determination of the optical constants and phase retarder properties of SiO <sub>2</sub> at hydrogen Lyman–alpha [Best Student Paper Award] [11032-32]
11032 OW	Silicon carbide detectors for diagnostics of laser-produced plasmas [11032-33]
11032 0X	A newly developed ultra-sensitive Faraday optical rotation device [11032-34]
11032 0Y	Use of opportunities of contact microscopy: optical design [11032-35]
11032 10	Amplitude spiral zone plates for generation of optical vortices [11032-37]
11032 11	Analysis of focusing properties of amplitude zone plates [11032-38]
11032 12	Photonic jets for mid-IR focal plane arrays based on triangular dielectric prism [11032-39]
11032 13	Interferometric precision measurement of highly reflective thin film using wavelength tuning Fizeau interferometry [11032-40]
11032 15	Analysis of transfer function dependence on configuration of acousto-optic interaction in uniaxial crystals [11032-46]

### **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.

AbdElazem, Sohaib, 0X Ahmed, Nadeem, 0B, 0V Al-Basheer, Watheq, 0X Alnaimi, Radhwan, 0K Arikkatt, A. J., 0H Arnold, Thomas, 0D

Bartnik, Andrzej, OH, OI, OL, OM, ON

Batshev, Vladislav I., 15 Bauer, Jens, 0D Baumbach, T., 0U Bogachev, Sergey A., 0F Boritko, Sergey V., 15

Chen, J., 0P

Chen, Jinwen, 09, 0Q, 0R Cui, Mingqi, 09, 0Q, 0R Engelhardt, Sabine, 0U

Fang, Yu, 0O

Fiedorowicz, Henryk, OH, OI, OL, OM, ON, OW

Fok, Tomasz, OI, OL, OM Fomchenkov, Sergey A., 11 Frolov, Alexey D., OY Frolov, Dmitry N., OY Frost, Frank, OD

Guan, Zanyang, 0G

Gaballah, Ahmed E. H., OB, OV

Halahovets, Yuriy, 0E Hibino, Kenichi, 13 Hou, Xi, 0J Hu, Xiaochuan, 0J Janulewicz, K., 0L Jarocki, Roman, 0M Jergel, Matej, 0E Ji, Bin, 09, 0Q, 0R Jimenez, Kety, 0B, 0V Kečkéš, Jozef, 0E Kim, Yangjin, 13 Korytár, Dušan, 0E Kostecki, J., 0N Kotlyar, Victor V., 10, 11

Korlyar, Victor V., 10, 11 Kozlova, Elena S., 10, 11 Krauze, W., 0N Kunka, Danays, 08, 0U

Kuzin, Sergey V., 0F Li, Miao, 09, 0Q, 0R Li, Weiyan, 0O Li, Yulong, 0G Liu, Xiangming, 0G Liu, Yangyang, 0O Lv, Qunbo, 0O Machikhin, Alexander S., 15

Maisano, M., 0N Majková, Eva, 0E Maťko, Igor, 0E

Mikhaylov, Andrey A., 08, 0U

Mikulík, Petr, 0E
Mitsuishi, Mamoru, 13
Nicolosi, Piergiorgio, 0B, 0V
Peng, Xiaoshi, 0G
Pertsov, Andrei A., 0F
Plech, Anton, 08
Pozhar, Vitold E., 15
Quan, Haiyang, 0J
Reich, Stefan, 08, 0U
Šiffalovič, Peter, 0E
Stafeev, Sergey S., 12
Torrisi, A., 0N, 0W
Torrisi, L., 0W

Toyoda, M., 0P Tran Thi, Thu Nhi, 0E Ulitschka, Melanie, 0D Vinogradova, Olga A., 0Y Vishnyakov, Eugene A., 0F Vlnieska, Vitor, 08, 0U

Wachulak, Przemysław, OH, OI, OL, OM, ON, OW

Wang, Feng, 0G Wang, Ming, 0G

Węgrzyński, Łukasz, OH, OI, OL, OM

Wei, Huiyue, OG Wen, Liyun, OY Wu, Gaofeng, OJ Xu, Tao, OG

Yablokova, Anastasiya A., 15

Yamashita, S., 0P Zaitsev, Vladislav D., 12 Zakharova, Margarita, 08, 0U Zang, Zhigang, 0G

Zápražný, Zdenko, 0E Zhang, Dandan, 0O Zhang, Jiayi, 09, 0Q, 0R Zhao, Na, 0O

Zhu, Jie, 09, 0Q, 0R Zhu, Jingtao, 09, 0Q, 0R Zhu, Shengming, 09, 0Q, 0R

Zuber, Marcus, OU Zuppella, Paola, OB, OV

# **Conference Committee**

### Symposium Chairs

**Bedřich Rus**, ELI Beamlines, Institute of Physics of the CAS, v.v.i. (Czech Republic)

**Chris Edwards**, STFC Rutherford Appleton Laboratory (United Kingdom)

Saša Bajt, Deutsches Elektronen-Synchrotron (Germany)

Ivo Rendina, Istituto per la Microelettronica e Microsistemi (Italy)

Mike Dunne, SLAC National Accelerator Laboratory (United States)

### Honorary Symposium Chair

**Erich Spitz**, French Academy of Sciences, National Academy of Technologies (France) Advisor to Thales (France)

### Conference Chairs

René Hudec, Astronomical Institute of the ASCR, v.v.i. (Czech Republic) and Czech Technical University in Prague (Czech Republic)

Ladislav Pina, Czech Technical University in Prague (Czech Republic)

### Conference Program Committee

Webster Cash, University of Colorado at Boulder (United States)
Henryk Fiedorowicz, Military University of Technology (Poland)
René Hudec, Czech Technical University in Prague (Czech Republic)
Ali M. Khounsary, X-ray Optics, Inc. (United States)
Randall L. McEntaffer, The University of Iowa (United States)
Stephen L. O'Dell, NASA Marshall Space Flight Center (United States)
Giovanni Pareschi, INAF - Osservatorio Astronomico di Brera (Italy)
Ladislav Pina, Czech Technical University in Prague (Czech Republic)
Yuriy Ya Platonov, Rigaku Innovative Technologies, Inc.
(United States)

**Paul B. Reid**, Harvard-Smithsonian Center for Astrophysics (United States)

**Bedřich Rus**, ELI Beamlines (Czech Republic) and Institute of Physics of the ASCR, v.v.i. (Czech Republic)

Anatoly Snigirev, ESRF - The European Synchrotron (France)
Melville P. Ulmer, Northwestern University (United States)
David L. Windt, Reflective X-Ray Optics LLC (United States)

William W. Zhang, NASA Goddard Space Flight Center (United States)

### Session Chairs

- 1 Astronomical and Laboratory X-ray Optics Paola Zuppella, CNR-Istituto di Fotonica e Nanotecnologie (Italy)
- 2 Refractive, Active, and Multilayer X-ray Optics Frank Siewert, Helmholtz-Zentrum Berlin für Materialien und Energie GmbH (Germany)
- 3 Integrated Devices/Surface Characterization Henryk Fiedorowicz, Wojskowa Akademia Techniczna im. Jaroslawa Dabrowskiego (Poland)
- 4 Coherent Radiation/Lasers

  Melanie Ulitschka, Leibniz-Institut für Oberflächenmodifizierung e.V.

  (Germany)
- 5 Free-Space Optics Melanie Ulitschka, Leibniz-Institut für Oberflächenmodifizierung e.V. (Germany)