PROCEEDINGS OF SPIE

Optical Fabrication, Testing, and Metrology IV

Angela Duparré
Roland Geyl
Editors

7–8 September 2011
Marseille, France

Sponsored by
SPIE

Coorganised by
POPsud - Optitec (France)

Cosponsored by
Communauté Urbaine Marseille Provence Métropole (France)
Ville de Marseille (France)

Cooperating Organisation
Schott AG (Germany)

Published by
SPIE

Volume 8169

Proceedings of SPIE, 0277-786X, v. 8169

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

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:
Author(s), "Title of Paper," in *Optical Fabrication, Testing, and Metrology IV*, edited by Angela Duparré, Roland Geyl, Proceedings of SPIE Vol. 8169 (SPIE, Bellingham, WA, 2011) Article CID Number.

ISSN 0277-786X
ISBN 9780819487957

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 © 2011, 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/11/$18.00.

Printed in the United States of America.

Publication of record for individual papers is online in the 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 and on CD-ROM. Papers are published as they are submitted and meet publication criteria. A unique, consistent, permanent 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. Numbers in the index correspond to the last two digits of the six-digit CID number.

Contents

vii *Conference Committee*

SESSION 1 CONVENTIONAL OPTICS: MANUFACTURING AND TESTING I

8169 02 **MRF with adjustable pH (Invited Paper)** [8169-01]
S. D. Jacobs, Univ. of Rochester (United States)

8169 03 **Stress polishing of E-ELT segment at LAM: full-scale demonstrator status** [8169-02]
M. Laslandes, N. Rousselet, M. Ferrari, E. Hugot, J. Floriot, S. Vivès, G. Lemaitre, Lab. d'Astrophysique de Marseille (France); J. F. Carré, SESO (France); M. Cayrel, European Southern Observatory (Germany)

8169 04 **Manufacturing and testing of the large lenses for Dark Energy Survey (DES) at SESO** [8169-03]
D. Fappani, J. Fourez, SESO (France); P. Doel, D. Brooks, Univ. College London (United Kingdom); B. Flaugher, Fermilab Chicago (United States)

8169 05 **TMA optics for HISUI HSS and MSS imagers** [8169-04]
R. Geyl, H. Leplan, J. Rodolfo, Sagem SA (France)

8169 06 **Fused silica long-term stability: case studies** [8169-05]
M. Vannoni, A. Sordini, G. Molesini, Istituto Nazionale di Ottica, CNR (Italy)

SESSION 2 CONVENTIONAL OPTICS: MANUFACTURING AND TESTING II

8169 07 **Metrology for an imaging Fourier transform spectrometer working in the far-UV (IFTSUV)** [8169-06]
C. Ruiz de Galarreta Fanjul, A. Philippon, J.-C. Vial, Institut d'Astrophysique Spatiale (France); J.-P. Maillard, Institut d'Astrophysique de Paris (France); T. Appourchaux, Institut d'Astrophysique Spatiale (France)

8169 09 **Experimental determination of aberration in lithographic lens by aerial image** [8169-09]
L. Duan, Shanghai Institute of Optics and Fine Mechanics (China), Graduate School of the Chinese Academy of Sciences (China), and Shanghai Micro Electronics Equipment Co., Ltd. (China); X. Wang, G. Yan, Shanghai Institute of Optics and Fine Mechanics (China); A. Bourov, Shanghai Micro Electronics Equipment Co., Ltd. (China)

SESSION 3 CONVENTIONAL OPTICS: MANUFACTURING AND TESTING III

8169 0A **Wavefront reconstruction and piston measurement using Ronchi test** [8169-10]
D. H. Penalver, F. Granados-Agustin, D. L. Romero-Antequera, Instituto Nacional de Astrofísica, Óptica y Electrónica (Mexico)

SESSION 4 MICROOPTICS AND MICROSTRUCTURES I

8169 0C **Wafer-level micro-optics: trends in manufacturing, testing, and packaging (Invited Paper)** [8169-12]
R. Voelkel, K. J. Weible, M. Eisner, SUSS MicroOptics SA (Switzerland)

8169 0D **Fabrication and testing of highly efficient resonance domain diffractive optical elements (Invited Paper)** [8169-13]
O. Barlev, M. A. Golub, Tel Aviv Univ. (Israel); A. A. Friesem, D. Mahalu, Weizmann Institute of Science (Israel); M. Nathan, Tel Aviv Univ. (Israel)

SESSION 5 MICROOPTICS AND MICROSTRUCTURES II

8169 0E **Method for the characterization of Fresnel lens flux transfer performance** [8169-14]
J. C. Martinez Antón, D. Vázquez Moliní, J. Muñoz de Luna, J. A. Gómez Pedrero, A. Á. Fernández-Balbuena, Univ. Complutense de Madrid (Spain)

8169 0G **Manufacturing, testing, and metrology of axi-symmetric circular phase masks for stellar coronagraphy** [8169-17]
M. N'Diaye, K. Dohlen, Lab. d'Astrophysique de Marseille, CNRS, Univ. de Provence (France); S. Tisserand, S. Gautier, Silios Technologies (France); K. El Hadi, G. Moreaux, Lab. d'Astrophysique de Marseille, CNRS, Univ. de Provence (France); R. Soummer, Space Telescope Science Institute (United States); S. Cuevas, C. Sánchez-Pérez, Univ. Nacional Autónoma de México (Mexico)

8169 0H **Fabrication of bilayer wire grid polarizer using replicated polymer nano grating** [8169-18]
Y. Han, J. Kim, E. Byeon, S.-M. Kim, Chung-Ang Univ. (Korea, Republic of); Y. Lee, C. K. Hwangbo, Inha Univ. (Korea, Republic of)

SESSION 6 SCATTERING AND PHOTOMETRY I

8169 0K **Multimodal scattering facilities and modelization tools for a comprehensive investigation of optical coatings (Invited Paper)** [8169-21]
M. Zerrad, M. Lequime, C. Amra, Institut Fresnel, CNRS (France)

8169 0N **Spectrophotometric bench dedicated to the characterization of micro-patterned optical coatings** [8169-24]
S. Sorce, L. Abel-Tiberini, M. Lequime, Institut Fresnel, CNRS (France)

SESSION 7 SCATTERING AND PHOTOMETRY II

8169 0O **SCPEM-based polarization modulation ellipsometry in the NIR** [8169-25]
F. Bammer, Vienna Univ. of Technology (Austria); R. Petkovsek, Univ. of Ljubljana (Slovenia)

8169 0P **Roughness characterization of large EUV mirror optics by laser light scattering** [8169-26]
M. Trost, Fraunhofer Institute for Applied Optics and Precision Engineering (Germany) and Friedrich-Schiller-Univ. Jena (Germany); S. Schröder, T. Feigl, A. Duparré, Fraunhofer Institute for Applied Optics and Precision Engineering (Germany); A. Tünnermann, Fraunhofer Institute for Applied Optics and Precision Engineering (Germany) and Friedrich-Schiller-Univ. Jena (Germany)

8169 0Q **3D features measurement using YieldStar: an angle resolved polarized scatterometer** [8169-27]
A.-L. Charley, P. Leray, K. D'havé, S. Cheng, IMEC (Belgium); P. Hinnen, F. Li, P. Vanoppen, M. Dusa, ASML Netherlands B.V. (Netherlands)

8169 0R **Impact of surface roughness on the scatter losses and the scattering distribution of surfaces and thin film coatings** [8169-28]
S. Schröder, T. Herffurth, A. Duparré, Fraunhofer Institute for Applied Optics and Precision Engineering (Germany); J. E. Harvey, CREOL, The College of Optics and Photonics, Univ. of Central Florida (United States)

SESSION 8 SURFACE PROFILE MEASUREMENT I

8169 0T **Isara 400 ultra-precision CMM (Invited Paper)** [8169-30]
H. A. M. Spaan, I. Widdershoven, IBS Precision Engineering bv (Netherlands)

8169 0V **Non-contact measurement of aspherical and freeform optics with a new confocal tracking profiler** [8169-32]
A. Pintó, Sensofar-Tech, S.L. (Spain); F. Laguarta, R. Artigas, C. Cadevall, Technical Univ. of Catalonia (Spain)

8169 0W **Phase-shifting fringe projection system using freeform optics** [8169-33]
S. Zwick, P. Kühmstedt, G. Notni, Fraunhofer Institute for Applied Optics and Precision Engineering (Germany)

SESSION 9 SURFACE PROFILE MEASUREMENT II

8169 0X **Data handling and representation of freeform surfaces** [8169-34]
R. Steinkopf, Fraunhofer Institute for Applied Optics and Precision Engineering (Germany); L. Dick, JENOPTIK Polymer Systems GmbH (Germany); T. Kopf, A. Gebhardt, S. Risse, R. Eberhardt, Fraunhofer Institute for Applied Optics and Precision Engineering (Germany)

8169 0Y **Adaptive two-beam interferometer for testing optical surfaces** [8169-35]
A. Miks, J. Novak, P. Novak, Czech Technical Univ. in Prague (Czech Republic)

8169 0Z **Adaptive null test system using a ferrofluid deformable mirror** [8169-36]
D. B. Landry, D. Brousseau, S. Thibault, E. F. Borra, Univ. Laval (Canada)

8169 10 **Optical method for the surface topographic characterization of Fresnel lenses** [8169-37]
J. C. Martínez Antón, J. A. Gómez Pedrero, J. Alonso Fernández, J. A. Quiroga, Univ. Complutense de Madrid (Spain)

POSTER SESSION

8169 12 **Extremely aspheric surfaces: toward a manufacturing process based on active optics** [8169-38]
Z. Challita, E. Hugot, M. Ferrari, D. Le Mignant, S. Vivès, J.-G. Cuby, Lab. d'Astrophysique de Marseille (France)

8169 13 **Two-dimensional thickness measurement of a dielectric thin layer on a metal by use of surface-plasmon-resonance-based ellipsometry** [8169-40]
T. Iwata, Y. Wada, K. Nishigaki, Y. Mizutani, Univ. of Tokushima (Japan)

8169 14 **Wavefront instabilities in thin glass mirrors** [8169-41]
S. Bouillet, T. Lanternier, E. Lavastre, C. Chappuis, F. Macias, CEA, CESTA (France)

8169 15 **Absolute calibration of three reference flats based on an iterative algorithm: study and implementation** [8169-42]
C. Morin, S. Bouillet, CEA, CESTA (France)

Author Index

Conference Committee

Symposium Chair

Michel Lequime, Institut FRESNEL and Ecole Centrale Marseille (France)

Symposium Cochairs

Andreas Tünnermann, Fraunhofer-Institut für Angewandte Optik und Feinmechanik (Germany)
David M. Williamson, West Malvern (United Kingdom) and Nikon Research Corporation of America (United States)

Conference Chairs

Angela Duparré, Fraunhofer-Institut für Angewandte Optik und Feinmechanik (Germany)
Roland Geyl, Sagem SA (France)

Program Committee

Genevieve M. Chabassier, Commissariat à l'Énergie Atomique (France)
Svetlana Dligatch, Commonwealth Scientific and Industrial Research Organisation (Australia)
Sead Doric, Doric Lenses Inc. (Canada)
James E. Harvey, CREOL, The College of Optics and Photonics, University of Central Florida (United States)
Raymond F. Mercier, Institut d'Optique Graduate School (France)
Manfred Prantl, Alicona Imaging GmbH (Germany)
Alon Regev, Rafael Advanced Defense Systems Ltd. (Israel)
Joanna Schmit, Bruker Corporation (United States)
Theo Tschudi, Technische Universität Darmstadt (Germany)
Reinhard Völkel, SUSS MicroOptics SA (Switzerland)
Lingli Wang, Jos. Schneider Optische Werke GmbH (Germany)

Session Chairs

1 Conventional Optics: Manufacturing and Testing I
Genevieve M. Chabassier, Commissariat à l'Énergie Atomique (France)

2 Conventional Optics: Manufacturing and Testing II
Roland Geyl, Sagem SA (France)

3 Conventional Optics: Manufacturing and Testing III
Genevieve M. Chabassier, Commissariat à l'Énergie Atomique (France)

4 Microoptics and Microstructures I
Angela Duparré, Fraunhofer-Institut für Angewandte Optik und Feinmechanik (Germany)

5 Microoptics and Microstructures II
Reinhard Völkel, SUSS MicroOptics SA (Switzerland)

6 Scattering and Photometry I
Angela Duparré, Fraunhofer-Institut für Angewandte Optik und Feinmechanik (Germany)

7 Scattering and Photometry II
Myriam Zerrad, Institut FRESNEL (France)

8 Surface Profile Measurement I
Stephen D. Jacobs, University of Rochester (United States)

9 Surface Profile Measurement II
Roland Geyl, Sagem SA (France)