PROCEEDINGS OF SPIE

Optics and Photonics for Advanced Dimensional Metrology

Peter J. de Groot Richard K. Leach Pascal Picart Editors

6–10 April 2020 Online Only, France

Sponsored by SPIE

Cosponsored by City of Strasbourg (France) Eurometropole (France) CNRS (France) iCube (France) Université de Strasbourg (France)

Cooperating Organisations Photonics 21 (Germany) EOS—European Optical Society (Germany) Photonics Public Private Partnership (Belgium) Photonics France (France)

Published by SPIE

Volume 11352

Proceedings of SPIE 0277-786X, V. 11352

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

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 Optics and Photonics for Advanced Dimensional Metrology, edited by Peter J. de Groot, Richard K. Leach, Pascal Picart, Proceedings of SPIE Vol. 11352 (SPIE, Bellingham, WA, 2020) Seven-digit Article CID Number.

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

ISBN: 9781510634763 ISBN: 9781510634770 (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 © 2020, 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/20/\$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.



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

vii Authors

ix Conference Committee

MEASURING COMPLEX OPTICAL SYSTEMS AND COMPONENTS

- 11352 02 Reconfigurable dynamic optical system design, test, and data analysis (Invited Paper) [11352-1]
- 11352 03 Accurate 3D coordinate measurement using holographic multipoint technique [11352-3]
- 11352 04 Increasing the accuracy of imaging-based dimensional measurements [11352-4]
- 11352 05 UV absorption mapping as subsurface damage inspection in transparent optical materials [11352-5]

EXTENDING THE LIMITS OF WHAT CAN BE MEASURED

- 11352 07 Optical topography measurement of steeply-sloped surfaces beyond the specular numerical aperture limit [11352-7]
- 11352 09 Robot-assisted BRDF measurement and surface characterization of inhomogeneous freeform shapes [11352-10]

STATE-OF-THE-ART PHOTOGRAMMETRY AND STRUCTURED LIGHT

- 11352 0A Smart photogrammetry for three-dimensional shape measurement (Invited Paper) [11352-11]
- 11352 0B Concept of a control system based on 3D geometry measurement for open die forging of large-scale components [11352-12]
- 11352 0C **3D** registration of multiple surface measurements using projected random patterns [11352-13]
- 11352 OE Affine structured light sensor for measurements through inspection windows: basic concept and direct calibration approach [11352-15]
- 11352 OF High-speed fringe projection for robot 3D vision system [11352-16]

OPTICAL METROLOGY IN PRACTICE

- 11352 0G Adaptive merging of large datasets of a 3D measuring endoscope in an industrial environment [11352-18]
- 11352 0H Grazing incidence interferometry for testing rough aspherics: experimental results and data analysis [11352-19]
- 11352 01 Method of measurements of extended optical fibers with high precision [11352-20]
- 11352 0J Fast fringe analysis method using graphics processing unit acceleration for dynamic fault identification [11352-21]

ADVANCED MEASURING MICROSCOPES

- 11352 0K Surface scattering and the 3D transfer characteristics of optical profilometers (Invited Paper) [11352-22]
- 11352 OL Three-dimensional imaging confocal profiler without in-plane scanning [11352-23]
- 11352 0M Interferometric measurements of mold-plate assemblies designed for high-volume manufacturing of aspheric microlenses [11352-24]
- 11352 0N Demonstration of aberration-robust high-frequency modulated differential confocal microscopy with an oscillating pinhole [11352-25]

DEEP LEARNING, MACHINE LEARNING, AND MODEL-BASED METHODS

- 11352 OP Model-based dimensional optical metrology [11352-27]
- 11352 0Q Cascaded machine learning model for reconstruction of surface topography from light scattering [11352-28]
- 11352 ORDeep learning based speckle decorrelation denoising for wide-field optical metrology
[11352-29]
- 11352 0S Model-based calibration routine for a triangulation sensor for inner radius measurements of cylindrical components [11352-30]

RESOLUTION, ELLIPSOMETRY, AND HYPERSPECTRAL IMAGING

11352 OU	Measuring the spatial distribution of liquid crystal alignment and retardation using Stokes
	polarimetry [11352-32]

11352 0V Segmented wavefront metrology using multicolor PISTIL interferometry [11352-33]

11352 OW	Resolution and computational strategy in wideband multiphoton microscopy illustrated with muscle imaging [11352-34]
11352 OY	Detailed characterization of a hyperspectral snapshot imager for full-field chromatic confocal microscopy [11352-36]
	OPTICAL TOMOGRAPHY
11352 OZ	Optical coherence tomography in nondestructive testing (Invited Paper) [11352-37]
11352 11	Continuous measurement of wrist artery pulse vibration signals measurement using structured- light projection method [11352-39]
11352 12	One-shot roughness measurements based on dispersion-encoded low coherence interferometry [11352-40]
	QUANTITATIVE IMAGING: JOINT SESSION
11352 14	Scanning wavefront detection coherent Fourier scatterometry (SCFS) [11352-42]
	11352 ADDITIONAL PRESENTATIONS
11352 16	Accurate and low-cost ENEA solar compass for precision metrology of true azimuth: instrumental and smart versions [11352-8]
	POSTER SESSION
11352 18	The multichannel optical spectrometer for combustion processes control [11352-44]
11352 19	Precision inspection of micro components free form by Moiré interferometry [11352-45]
11352 1A	Design of a compact corneal topographer to characterize the shape of the cornea [11352-46]
11352 1B	White light interference microscopy system design [11352-48]
11352 1C	Modeling the conical corneal null-screen topographer with the Fermat principle [11352-50]
11352 1D	Comprehensive ranging disambiguation for amplitude-modulated continuous-wave laser scanner [11352-51]
11352 1E	3D images processing using acousto-optic Bragg diffraction [11352-52]

- 11352 1G Deep reinforcement learning for variability prediction in latent heat flux from low-cost meteorological parameters [11352-54]
- 11352 1H Analysis of the systematic and random errors in the conical corneal null-screen topographer [11352-56]
- 11352 11 Robustness improvement for the calibration of stereo deflectometry based on a search algorithm [11352-57]
- 11352 1J Optical sensor for drone coordinate measurements [11352-58]
- 11352 1K Development of a double-diffraction grating interferometer for measurements of displacement and angle [11352-59]
- 11352 1L Velocity estimation from fringe contrast using lensless Fourier transform digital holography [11352-60]
- 11352 1M Integration of an endoscopic fringe projection system into a milling machine for the regeneration of complex capital goods: a first prototype [11352-61]
- 11352 1N Phase calibration of a basic bright-field microscope for 3D metrology of transparent samples at the nanoscale [11352-62]