

PROCEEDINGS OF SPIE

***Dimensional Optical Metrology
and Inspection for Practical
Applications VIII***

Kevin G. Harding
Song Zhang
Editors

16–17 April 2019
Baltimore, Maryland, United States

Sponsored and Published by
SPIE

Volume 10991

Proceedings of SPIE 0277-786X, V. 10991

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 *Dimensional Optical Metrology and Inspection for Practical Applications VIII*, edited by Kevin G. Harding, Song Zhang, Proceedings of SPIE Vol. 10991 (SPIE, Bellingham, WA, 2019) Seven-digit Article CID Number.

ISSN: 0277-786X

ISSN: 1996-756X (electronic)

ISBN: 9781510626478

ISBN: 9781510626485 (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.

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	<i>Authors</i>
vii	<i>Conference Committee</i>

3D METROLOGY APPLICATIONS

10991 02	Wide-field 3D imaging with an LED pattern projector for accurate skin feature measurements via Fourier transform profilometry (Rising Researcher Paper) [10991-1]
10991 04	Toward an automatic 3D measurement of skin wheals from skin prick tests (Invited Paper) [10991-3]
10991 05	In-situ measurement of aspherics with sub-aperture deflectometry for precision optical manufacturing (Invited Paper) [10991-4]

METROLOGY ANALYSIS I

10991 06	Sources of errors in structured light 3D scanners (Invited Paper) [10991-5]
10991 08	Motion-induced error reduction for phase shifting profilometry using double-shot-in-single-illumination technique [10991-7]
10991 09	Efficient correspondence search algorithm for GOBO projection-based real-time 3D measurement [10991-8]

METROLOGY ANALYSIS II

10991 0A	Three-dimensional shape measurement of specular object with discontinuous surfaces by direct phase measuring deflectometry (Invited Paper) [10991-9]
10991 0D	Bi-frequency temporal phase unwrapping using deep learning [10991-12]
10991 0F	Fitting contrast by least square method for phase-shifting interferometry of unknown and arbitrary phase-steps under high non-uniform illumination [10991-14]

3D METHODS I

- 10991 0H Single-shot 3D shape reconstruction using multi-wavelength pattern projection [10991-15]
- 10991 0I Real-time high dynamic range 3D scanning with RGB camera [10991-16]
- 10991 0J Pattern projection in the short-wave infrared (SWIR): accurate, eye-safe 3D shape measurement (Rising Researcher Paper) [10991-17]
- 10991 0K Large-volume NIR pattern projection sensor for continuous low-latency 3D measurements [10991-18]
- 10991 0L Methods for addressing multiple reflections in a structured light profiler [10991-19]

3D METHODS II

- 10991 0M High dynamic range 3D shape measurement based on multispectral imaging (Invited Paper) [10991-20]
- 10991 0N Multi-axis heterodyne interferometric for simultaneous observation of 5 degrees of freedom using a single beam [10991-21]
- 10991 0O Simultaneous high-speed measurement of 3D surface shape and temperature [10991-22]

METROLOGY FOR ADDITIVE MANUFACTURING I

- 10991 0R X-ray computed tomography instrument performance evaluation: Detecting geometry errors using a calibrated artifact [10991-25]
- 10991 0S 3D on machine metrology for conformal printing of conductors and dielectrics onto complex 3D surfaces [10991-26]

METROLOGY FOR ADDITIVE MANUFACTURING: CRITICAL TECHNOLOGY REVIEW

- 10991 0U Evaluation of technologies for autonomous visual inspection of additive manufacturing (AM) (Invited Paper) [10991-28]
- 10991 0X Process monitoring strategy for metal additive using off-the-shelf metrology (Invited Paper) [10991-31]