PROCEEDINGS OF SPIE

Dimensional Optical Metrology and Inspection for Practical Applications XII

Kevin G. Harding
Song Zhang
Jae-Sang Hyun
Editors

2–3 May 2023
Orlando, Florida, United States

Sponsored and Published by
SPIE

Volume 12524

Proceedings of SPIE 0277-786X, V. 12524

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

Dimensional Optical Metrology and Inspection for Practical Applications XII, edited by
Kevin G. Harding, Song Zhang, Jae-Sang Hyun, Proc. of SPIE Vol. 12524,
1252401 · © 2023 SPIE · 0277-786X · doi: 10.1117/12.2691044

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 XII*, edited by Kevin G. Harding, Song Zhang, Jae-Sang Hyun, Proc. of SPIE 12524, Seven-digit Article CID Number (DD/MM/YYYY); (DOI URL).

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

ISBN: 9781510661622
ISBN: 9781510661639 (electronic)

Published by
SPIE
P.O. Box 10, Bellingham, Washington 98227-0010 USA
Telephone +1 360 676 3290 (Pacific Time)
SPIE.org
Copyright © 2023 Society of Photo-Optical Instrumentation Engineers (SPIE).

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 fees. To obtain permission to use and share articles in this volume, visit Copyright Clearance Center 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.

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.

SPIEDigitalLibrary.org

Paper Numbering: A unique citation identifier (CID) number is assigned to each article in the Proceedings of SPIE 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 Conference Committee

SESSION 1 DIMENSIONAL OPTICAL METROLOGY AND INSPECTION I

12524 02 **Speckle interferometry single-shot applications with multiple carrier-fringe information (Invited Paper)** [12524-1]

12524 04 **Deep-learning enabled single-shot 3D feature detection in fringe projection profilometry** [12524-4]

SESSION 2 DIMENSIONAL OPTICAL METROLOGY AND INSPECTION II

12524 06 **Depth-of-field extension in structured-light 3D surface imaging by fast chromatic focus stacking (Invited Paper)** [12524-5]

12524 07 **High-accuracy digital fringe projection system for three-dimensional optical sensing using cell phone device** [12524-7]

12524 08 **Cylinder diameter measurement with iPhone embedded LiDAR and RGB sensors** [12524-8]

SESSION 3 DIMENSIONAL OPTICAL METROLOGY AND INSPECTION III

12524 09 **Opportunities for metrology in solar thermal heliostat applications (Keynote Paper)** [12524-9]

12524 0A **The critical parameters in high aspect ratio of structures such as deep trenches and deep holes comparison of theory and the experiment** [12524-10]

12524 0C **Measuring material thickness variations through tri-aperture DSPI** [12524-12]

SESSION 4 DIMENSIONAL OPTICAL METROLOGY AND INSPECTION IV

12524 0D **Surface texture effects and mitigation for optical triangulation gages (Invited Paper)** [12524-13]

12524 0F **Suitability of fringe projection profilometry to monitor the human respiration rate** [12524-16]

SESSION 5 DIMENSIONAL OPTICAL METROLOGY AND INSPECTION V

12524 0G **Challenges and opportunities in pixel-wise calibration methods for structured light systems** [12524-18]

SESSION 6 DIMENSIONAL OPTICAL METROLOGY AND INSPECTION VI

12524 0J **Quasi-calibration method for digital fringe projection system** [12524-21]

POSTER SESSION

12524 0K **Applications of projection fringes and structured light surface metrology for semiconductor packaging and their challenges** [12524-23]

DIGITAL POSTER SESSION

12524 0L **Defect detection and removal for depth map quality enhancement in manufacturing with deep learning** [12524-25]

12524 0M **Scanning trajectory optimization for industrial robot based on the scanned objects surface optical properties** [12524-26]

Conference Committee

Symposium Chairs

Tien Pham, The MITRE Corporation (United States)
Douglas R. Droege, L3Harris Technologies, Inc. (United States)

Symposium Co-chairs

Augustus W. Fountain III, University of South Carolina (United States)
Teresa L. Pace, L3Harris Technologies, Inc. (United States)

Program Track Chair

David W. Messinger, Rochester Institute of Technology (United States)

Conference Chairs

Kevin G. Harding, Optical Metrology Solutions (United States)
Song Zhang, Purdue University (United States)
Jae-Sang Hyun, Yonsei University (Korea, Republic of)

Conference Co-chair

Beiwen Li, Iowa State University of Science and Technology (United States)

Conference Program Committee

Nikola Dudukovic, Lawrence Livermore National Laboratory (United States)
Greg A. Finney, IERUS Technologies, Inc. (United States)
Jason C. Fox, National Institute of Standards and Technology (United States)
Motoharu Fujigaki, University of Fukui (Japan)
Steven E. Grantham, National Institute of Standards and Technology (United States)
Stefan Heist, Fraunhofer-Institut für Angewandte Optik und Feinmechanik IOF (Germany)
Aravinda Kar, CREOL, The College of Optics and Photonics, University of Central Florida (United States)
Damien P. Kelly, Technische Universität Ilmenau (Germany)
Chris Koontz, Raytheon Company (United States)
Peter Kühmstedt, Fraunhofer-Institut für Angewandte Optik und Feinmechanik (Germany)

Martin Landmann, Fraunhofer-Institut für Angewandte Optik und Feinmechanik IOF (Germany)
Rongguang Liang, College of Optical Sciences, The University of Arizona (United States)
Andrés Guillermo Marrugo Hernandez, Universidad Tecnológica de Bolívar (Colombia)
Georges T. Nehmetallah, The Catholic University of America (United States)
Gunther Notni, Technische Universität Ilmenau (Germany)
Kemao Qian, Nanyang Technological University (Singapore)
Prem Rachakonda, National Institute of Standards and Technology (United States)
Brian Simonds, National Institute of Standards and Technology (United States)
Lei Tian, Boston University (United States)
Yajun Wang, Wuhan University (China)
Zhaoyang Wang, The Catholic University of America (United States)
Jiangtao Xi, University of Wollongong (Australia)
Jing Xu, Tsinghua University (China)
Dongmin Yang, Apple Inc. (United States)
Xiangchao Zhang, Fudan University (China)
Zonghua Zhang, Hebei University of Technology (China)
Aurora A. Zinck, Lockheed Martin Corporation (United States)
Chao Zuo, Nanjing University of Science and Technology (China)