

# PROCEEDINGS OF SPIE

## ***Interferometry XIX***

**Katherine Creath**  
**Jan Burke**  
**Michael B. North Morris**  
**Angela D. Davies**  
*Editors*

**21–23 August 2018**  
**San Diego, California, United States**

*Sponsored and Published by SPIE*

**Volume 10749**

Proceedings of SPIE 0277-786X, V. 10749

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 *Interferometry XIX*, edited by Katherine Creath, Jan Burke, Michael B. North Morris, Angela D. Davies, Proceedings of SPIE Vol. 10749 (SPIE, Bellingham, WA, 2018) Seven-digit Article CID Number.

ISSN: 0277-786X

ISSN: 1996-756X (electronic)

ISBN: 9781510620698

ISBN: 9781510620704 (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 © 2018, 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/18/\$18.00.

Printed in the United States of America

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

vii	<i>Authors</i>
ix	<i>Conference Committee</i>
xiii	<i>Introduction</i>

---

## SESSION 1    SPECKLE

---

10749 02	Three-dimensional shape measurement beyond the diffraction limit of lens using speckle interferometry [10749-1]
10749 03	Speckle contrast calculation based on pixels correlation: spatial analysis [10749-2]
10749 04	Contrast temporal analysis using correlation between frames [10749-4]

---

## SESSION 2    SHAPE AND THICKNESS MEASUREMENT

---

10749 05	The dimensional measurement of micro objects using the linear scanning confocal surface shape measurement system [10749-5]
10749 06	Features of surface contouring by digital holographic interferometry with tilt of the object illumination [10749-6]
10749 07	One part-per-million wafer thickness measurement repeatability using fast frequency space Moire effect tool [10749-7]
10749 08	Influence of measured surface materials on the accuracy of 3D measurement using fringe projection [10749-8]
10749 09	Single-shot RGB polarising interferometer [10749-54]

---

## SESSION 3    VIBRATION ANALYSIS

---

10749 0A	Laser-Doppler vibrometry with variable GHz heterodyne carrier via frequency-offset lock [10749-10]
10749 0B	Vibration amplitude determination through besselogram modulation analysis [10749-11]
10749 0C	A non-destructive evaluation system for additive manufacturing based on acoustic signature analysis with laser Doppler vibrometry [10749-12]

---

**SESSION 4      VIKRAM AWARD LECTURE I**

---

10749 OD      **From the speckle interferometer to digital holography (Invited Paper)** [10749-13]

---

**SESSION 5      SHAPE MEASUREMENT AND DEFLECTOMETRY: JOINT SESSION WITH CONFERENCES 10742 AND 10749**

---

10749 OE      **High-resolution 3D shape deformation, displacement, and strain measurement for robotic flapping wings (Invited Paper)** [10749-14]

10749 OF      **Grey-level coding for structured-light illumination systems** [10749-15]

10749 OG      **Characterization of the interpolation bias in the analysis of deflectometry measurement data** [10749-16]

---

**SESSION 6      BIO-RELATED TECHNIQUES**

---

10749 OH      **Moiré effect-based interference microscopy for biospecimen characterization (Invited Paper)** [10749-17]

10749 OI      **Multi-spectral digital holography with high-speed wavelength switching and high-speed camera** [10749-18]

10749 OJ      **Multi-beam spatially multiplexed interference microscopy for phase objects examination** [10749-19]

10749 OK      **A new morphological cell parameter based on optical phase for the evaluation of cell populations** [10749-20]

10749 OL      **Unlabeled flow cellular deformation measurement based on digital holographic microscopy** [10749-21]

---

**SESSION 7      ON THE FRINGE**

---

10749 OM      **Dual sensing-light-sheet OCT for microfluidic PTV (Invited Paper)** [10749-22]

10749 ON      **Amplitude checker grating-based multichannel lateral shear interferometry for extended aberration sensing** [10749-23]

10749 OO      **Multi-path interferometer structures with cleaved silica microspheres** [10749-24]

---

**SESSION 8**    **VIKRAM AWARD LECTURE II**

---

10749 0P    **A wonderful life of holography, interferometry, and optical testing (Invited Paper)** [10749-25]

---

**SESSION 9**    **CHARACTERIZATION**

---

10749 0Q    **Surface-height measurement noise in interference microscopy (Invited Paper)** [10749-26]

10749 0R    **Characterization and operation optimization of large aperture optical interferometers using binary pseudorandom array test standards** [10749-27]

10749 0S    **Specification and measurement of uncertainty in phase shifting Fizeau interferometry** [10749-28]

10749 0T    **Model based error separation of power spectral density artefacts in wavefront measurement** [10749-29]

---

**SESSION 10**    **TECHNIQUES I**

---

10749 0U    **Towards instantaneous spectrally controlled interferometry (Invited Paper)** [10749-30]

10749 0V    **Arbitrary phase shifting in diffraction common path interferometry** [10749-31]

10749 0W    **Minimizing the Abbe-offset in interferometric radius metrology** [10749-32]

10749 0X    **Dynamic interferometric measurements employing a pixelated polarization sensor and FFT spatial-temporal filtering techniques** [10749-33]

---

**SESSION 11**    **LOW COHERENCE**

---

10749 0Y    **Sampling the coherence function: a novel method for shape measurement** [10749-34]

10749 0Z    **Synchronized real-space and frequency-domain low-coherence interferometry for wafer thickness and metrology applications** [10749-35]

10749 10    **Short coherence dynamic Fizeau interferometer with internal path matching for radius of curvature measurement** [10749-36]

10749 11    **Inspection of hidden MEMS by an infrared low-coherence interferometric microscope** [10749-38]

10749 12    **Low-coherence interferometry in laser processing: a new sensor approach heading for industrial applications** [10749-52]

**SESSION 12    TECHNIQUES II**

---

- 10749 13    **Multi-wavelength phase unwrapping: a versatile tool for extending the measurement range, breaking the Nyquist limit, and encrypting optical communications [10749-39]**
- 10749 14    **Robust phase-shifting algorithms designed for high-dynamic range in fringe-projection profilometry [10749-40]**
- 10749 15    **Synthetic aperture phase-shifting interferometry for high numerical-aperture spherical surface measurement [10749-41]**
- 10749 16    **Further improvements of digital interferometer [10749-42]**

**POSTER SESSION**

---

- 10749 17    **Object scanning scheme in wide-field low-coherence interferometry [10749-37]**
- 10749 18    **Research on marine plankton imaging based on digital holographic technology [10749-45]**
- 10749 19    **Analysis of the local defects of a concave spherical surface using three measurement techniques [10749-46]**
- 10749 1A    **Stokes and Jones matrix polarimetry based on geometric phase measurements [10749-47]**
- 10749 1C    **Interferometric measurements of phase objects by using a simultaneous polarizing phase shifting Mach-Zehnder interferometer [10749-49]**
- 10749 1D    **High-accuracy three-dimensional tomographic observation of cell clusters [10749-50]**
- 10749 1E    **Improvement of topography measurement using denoising approach in Fourier digital holographic microscopy [10749-53]**