

Quantitative Phase Imaging V

Gabriel Popescu
YongKeun Park
Editors

2–5 February 2019
San Francisco, California, United States

Sponsored by
SPIE

Cosponsored by
Tomocube, Inc. (Korea, Republic of)
Phi Optics, Inc. (United States)

Published by
SPIE

Volume 10887

Proceedings of SPIE, 1605-7422, V. 10887

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

Quantitative Phase Imaging V, edited by Gabriel Popescu, YongKeun Park, Proc. of SPIE Vol. 10887, 1088701
© 2019 SPIE · CCC code: 1605-7422/19/\$18 · doi: 10.1117/12.2531643

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 SPIDigitalLibrary.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 *Quantitative Phase Imaging V*, edited by Gabriel Popescu, YongKeun Park, Proceedings of SPIE Vol. 10887 (SPIE, Bellingham, WA, 2019) Seven-digit Article CID Number.

ISSN: 1605-7422
ISSN: 2410-9045 (electronic)

ISBN: 9781510624160
ISBN: 9781510624177 (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 1605-7422/19/\$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**

SPIDigitalLibrary.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>

QPI METHODOLOGIES I

10887 04	Surface profilometry by employing synthetic partially spatially coherent holograms [10887-3]
----------	---

QPI METHODOLOGIES II

10887 08	Comparative study of laboratory and commercial limited-angle holographic tomography setups [10887-7]
----------	---

QPI METHODOLOGIES IV

10887 0F	High-accuracy identification of micro-plastics by holographic microscopy enabled support vector machine [10887-14]
10887 0G	Terahertz pulse time-domain holography method for phase imaging of breast tissue [10887-15]
10887 0H	Real time polarization phase imaging based on off-axis digital holographic scheme [10887-16]

QPI METHODOLOGIES V

10887 0J	Spatial resolution and signal-to-noise ratio in x-ray imaging (Invited Paper) [10887-18]
10887 0M	Ultraviolet multi-spectral microscopy using iterative phase-recovery from chromatic aberrations [10887-21]

QPI METHODOLOGIES VI

10887 0O	Three-dimensional tomographic microscopy technique with multi-frequency combination with partially coherent illuminations [10887-23]
----------	---

QPI ALGORITHMS AND IMAGE PROCESSING I

- 10887 0S **The importance of physical pre-processors for quantitative phase retrieval under extremely low photon counts** [10887-27]
- 10887 0T **Analysis of Phase-Extraction Neural Network (PhENN) performance for lensless quantitative phase imaging** [10887-28]
- 10887 0V **A comparison of ptychographic phase retrieval algorithms** [10887-30]

QPI ALGORITHMS AND IMAGE PROCESSING II

- 10887 0Z **Simulation analysis of the enhancement of asymmetric illumination-based differential phase contrast microscope** [10887-34]

QPI OF CELLS AND TISSUES I

- 10887 10 **Quantitative phase microscopy for label-free evaluation of intestinal inflammation (Invited Paper)** [10887-35]
- 10887 13 **Refractive index tomography of myelinating glial cells** [10887-38]

QPI OF CELLS AND TISSUES II

- 10887 14 **High-throughput analysis at single-cell level through multimodal label-free microscopy (Invited Paper)** [10887-39]
- 10887 17 **Mechanical characterization of erythrocyte-derived optical microparticles by quantitative phase imaging and optical tweezers** [10887-42]

QPI OF CELLS AND TISSUES III

- 10887 19 **Measuring sub-nanometre thickness changes during phase transitions of supported lipid bilayers with quantitative differential interference contrast microscopy** [10887-44]
- 10887 1A **Label-free holographic microscopy for in vitro cadmium cytotoxicity testing** [10887-45]

QPI OF CELLS AND TISSUES IV

- 10887 1E **Application of quantitative phase imaging mass accumulation measurements to research and clinical problems in cancer (Invited Paper)** [10887-49]

- 10887 1F **Nanocapsule induced morphology and migration changes in single cell layers quantified with digital holographic microscopy** [10887-50]
- 10887 1H **The significance of cell water content in cell biology** [10887-52]

QPI-LBIS JOINT SESSION: JOINT SESSION WITH CONFERENCES 10887 AND 10890

- 10887 1M **Quantitative phase imaging-based concepts for the analysis of global morphology changes in confluent cell layers** [10887-57]

POSTER SESSION

- 10887 1O **Polarization effect of quantitative phase imaging using digital holography method** [10887-59]
- 10887 1U **Low refractive index microfluidic device fabrication for quantitative phase imaging** [10887-65]
- 10887 1W **Anaemias diagnosis by label-free quantitative phase imaging** [10887-67]
- 10887 1Y **Applications of higher-order phase shifting algorithms for multiple-wavelength metrology** [10887-69]
- 10887 21 **Drug resistance detection of endometrial cancer cell lines using digital holographic microscopy** [10887-72]
- 10887 22 **Cancer cells metastatic potential measurement by quantitative phase microscopy** [10887-73]
- 10887 24 **Evaluation of metastatic potential of circulating tumor cells using quantitative phase imaging (QPI)** [10887-75]
- 10887 25 **Phase contrast imaging in acoustophoresis platforms for biological applications** [10887-76]
- 10887 28 **Polarization wavefront shaping for quantitative phase contrast imaging by axially-offset differential interference contrast (ADIC) microscopy** [10887-79]
- 10887 29 **Refractive index determination of buffer solutions from visible to near-infrared spectral range for multispectral quantitative phase imaging using a calibrated Abbe refractometer** [10887-80]
- 10887 2C **Linear space-variant optical cryptosystem via Fourier ptychography** [10887-83]

- 10887 2E **Multiple wavelength fringe analysis for surface profile measurements** [10887-85]
- 10887 2F **Biological phase sample study using variational Hilbert imaging technique** [10887-86]
- 10887 2G **Improving qualitative phase imaging using error eliminating assist of two-steps phase shifting method in digital holography system** [10887-87]

Authors

Numbers in the index correspond to the last two digits of the seven-digit citation identifier (CID) article numbering system used in Proceedings of SPIE. The first five digits reflect the volume number. Base 36 numbering is employed for the last two digits and indicates the order of articles within the volume. Numbers start with 00, 01, 02, 03, 04, 05, 06, 07, 08, 09, 0A, 0B...0Z, followed by 10-1Z, 20-2Z, etc.

Alzubi, Mohammad, 1E
Andolfo, Immacolata, 1W
Anvari, B., 17
Arthur, Kwabena, 0S
Baczewska, Maria, 08
Balbekin, Nikolay S., 0G
Balkanov, Andrey, 24
Barbastathis, George, 0S, 0T
Barroso, Álvaro, 29
Bettenworth, Dominik, 10
Bianco, Vittorio, 0F, 1W
Bokemeyer, Arne, 10
Boonsri, Chantira, 2G
Borri, Paola, 19
Bramanti, Alessia, 1A
Buranasiri, Prathan, 1O, 2G
Cacace, T., 25
Calabuig, Alejandro, 1A
Cao, Runyu, 21
Carcagni, P., 0F
Cassar, Quentin, 0G
Chen, Qian, 0O
Cywińska, Maria, 2F
de Corato, M., 25
Dembele, Vamara, 0H
Deng, Fengyuan, 28
Ding, Changqin, 28
Distante, C., 0F
Döpker, Eva, 1M
Ferraro, Pietro, 0F, 1A, 1W, 25
Gambale, Antonella, 1W
Gasosoth, T., 1O
Gewirtz, David A., 1E
Gorzalanny, Christian, 1F
Götte, Martin, 1F
Goy, Alexandre, 0S, 0T
Goycoolea, Francisco M., 1F
Griffin, Justin J., 1U
Grilli, Simonetta, 1A
Guillet, Jean-Paul, 0G
Gureyev, T. E., 0J
Harrell, J. Chuck, 1E
Ho, Cheng-Wei, 0Z
Hobro, Alison J., 14
Iolascon, Achille, 1W
Jongjinakool, K., 1O
Kaiser, Mathias, 1F, 1M
Kardasheva, Ziver, 24
Kastl, Lena, 1F, 22
Kemper, Björn, 10, 1F, 1M, 22, 29
Kerman, Bilal Ersen, 13
Ketelhut, Steffi, 10, 1F, 1M, 29
Kim, Daesuk, 0H
Kozacki, Tomasz, 04
Kozlov, A., 0J
Krauze, Wojciech, 08
Kujawińska, Małgorzata, 08
Kulya, Maksim S., 0G
Kuś, Arkadiusz, 08
Langbein, Wolfgang, 19
Lenz, Philipp, 10
Li, Chen, 28
Li, Jiaji, 0O
Li, Shuai, 0S, 0T
Li, Xiaoping, 21
Lifenko, Roman, 24
Lu, Thompson, 17
Mac, Jenny T., 17
MacGrogan, Gaetan, 0G
Maffettone, P., 25
Maiden, Andrew M., 0V
Martinez-Carranza, Juan, 04
Masia, Francesco, 19
Mazzon, Emanuela, 1A
Memmolo, Pasquale, 0F, 1A, 1W, 25
Merola, Francesco, 0F, 1A, 1W
Metelin, Vladislav, 24
Miccio, Lisa, 1A, 1W
Mikula, Marta, 04
Model, Michael, 1H
Mounaix, Patrick, 0G
Mugnano, Martina, 1A, 1W
Murray, Graeme F., 1E
Ojaghi, Ashkan, 0M
Paganin, D. M., 0J
Pan, An, 2C
Pan, Feng, 21
Patorski, Krzysztof, 2F
Paturzo, M., 25
Pavillon, Nicolas, 14
Petrov, Nikolay V., 0G
Pohl, Luisa, 1F, 1M
Polanco, Edward R., 1U
Pramanik, Manojit, 1Y, 2E
Quiney, H. M., 0J
Radhakrishnan, Rohan, 29
Reed, Jason, 1E
Regan, David, 19

Robles, Francisco E., 0M
Russo, Roberta, 1W
Saleh, Tareq, 1E
Schnekenburger, Jürgen, 1F, 1M, 22, 29
Seesan, Thitiya, 2G
Simpson, Garth J., 28
Smith, Nicholas I., 14
Smolyanskaya, Olga A., 0G
Sun, Jiasong, 0O
Toor, Amir, 1E
Toy, Muhammed Fatih, 13
Tran, Kimmy, 17
Trusiak, Maciej, 2F
Tseng, Snow H., 0Z
Tuchin, Valery V., 0G
Turner, Tia H., 1E
Tweini, Ramzi, 17
Upputuri, Paul Kumar, 1Y, 2E
Vankayala, Raviraj, 17
Vasilenko, Irina, 24
Vatandaslar, Burcu Kurt, 13
Villone, M., 25
Wen, Kai, 2C
Western, Nicholas, 1U
Williams, Joseph, 19
Winnik, Julianna, 04
Xiao, Wen, 21
Yao, Baoli, 2C
Yao, Tian, 21
Yi, Xiaosu, 21
Zangle, Thomas A., 1U
Zhang, Jialin, 0O
Zhang, Zhuoqun, 0V
Ziemczonok, Michal, 08
Zuo, Chao, 0O

Conference Committee

Symposium Chairs

James G. Fujimoto, Massachusetts Institute of Technology
(United States)
R. Rox Anderson, Wellman Center for Photomedicine, Massachusetts
General Hospital (United States) and Harvard Medical School
(United States)

Symposium Co-chairs

Jennifer K. Barton, The University of Arizona (United States)
Wolfgang Drexler, Medical University of Vienna (Austria)

Program Track Chairs

Ammasi Periasamy, University of Virginia (United States)
Daniel L. Farkas, University of Southern California (United States) and
SMI (United States)

Conference Chairs

Gabriel Popescu, University of Illinois (United States)
YongKeun Park, KAIST (Korea, Republic of)

Conference Program Committee

Tatiana Alieva, Universidad Complutense de Madrid (Spain)
George Barbastathis, Massachusetts Institute of Technology
(United States)
Pietro Ferraro, Istituto di Scienze applicata e Sistemi Intelligenti (Italy)
Elena Holden, Executive Strategic Advisory, Biotech and IVD
(United States)
Björn Kemper, Westfälische Wilhelms-Universität Münster (Germany)
Myung K. Kim, University of South Florida (United States)
Yang Liu, University of Pittsburgh (United States)
Jerome Mertz, Boston University (United States)
Aydogan Ozcan, University of California, Los Angeles (United States)
Demetri Psaltis, Ecole Polytechnique Fédérale de Lausanne
(Switzerland)
Monika Ritsch-Marte, Medizinische Universität Innsbruck (Austria)
Peter T. C. So, Massachusetts Institute of Technology (United States)
Laura Waller, University of California, Berkeley (United States)
Renjie Zhou, The Chinese University of Hong Kong (Hong Kong, China)

Session Chairs

- 1 QPI Methodologies I
Gabriel Popescu, University of Illinois (United States)
- 2 QPI Methodologies II
YongKeun Park, KAIST (Korea, Republic of)
- 3 QPI Methodologies III
Gabriel Popescu, University of Illinois (United States)
- 4 QPI Methodologies IV
Renjie Zhou, The Chinese University of Hong Kong (Hong Kong, China)
- 5 QPI Methodologies V
YongKeun Park, KAIST (Korea, Republic of)
- 6 QPI Methodologies VI
Pietro Ferraro, Istituto di Scienze Applicate e Sistemi Intelligenti (Italy)
- 7 QPI Algorithms and Image Processing I
Alexandre Goy, Massachusetts Institute of Technology (United States)
- 8 QPI Algorithms and Image Processing II
Aydogan Ozcan, University of California, Los Angeles (United States)
- 9 QPI of Cells and Tissues I
Gabriel Popescu, University of Illinois (United States)
- 10 QPI of Cells and Tissues II
Yang Liu, University of Pittsburgh (United States)
- 11 QPI of Cells and Tissues III
Björn Kemper, Westfälische Wilhelms-Universität Münster (Germany)
- 12 QPI of Cells and Tissues IV
YongKeun Park, KAIST (Korea, Republic of)
- 13 QPI-LBIS Joint Session: Joint Session with Conferences 10887 and 10890
YongKeun Park, KAIST (Korea, Republic of)
Oliver Hayden, Klinikum rechts der Isar der Technischen Universität München (Germany)