PROGRESS IN BIOMEDICAL OPTICS AND IMAGING
Vol. 17 No. 30

Quantitative Phase Imaging II

Gabriel Popescu
YongKeun Park
Editors

14–17 February 2016
San Francisco, California, United States

Sponsored and Published by
SPIE

Volume 9718

Proceedings of SPIE, 1605-7422, V. 9718

Quantitative Phase Imaging II, edited by Gabriel Popescu, YongKeun Park, Proc. of SPIE Vol. 9718, 971801

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 *Quantitative Phase Imaging II*, edited by Gabriel Popescu, YongKeun Park, Proceedings of SPIE Vol. 9718 (SPIE, Bellingham, WA, 2016) Six-digit Article CID Number.

ISSN: 1605-7422
ISSN: 2410-9045 (electronic)
ISBN: 9781628419528

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

Printed in the United States of America.

Publication of record for individual papers is online in the 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 six-digit CID article numbering system structured as follows:

- The first four 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

Authors

Numbers in the index correspond to the last two digits of the six-digit citation identifier (CID) article numbering system used in Proceedings of SPIE. The first four 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.

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 School of Medicine (United States)

Program Track Chairs

Ammasi Periasamy, University of Virginia (United States)
Daniel L. Farkas, University of Southern California (United States) and Spectral Molecular Imaging, Inc. (United States)

Conference Chairs

Gabriel Popescu, University of Illinois at Urbana-Champaign (United States)
YongKeun Park, Korea Advanced Institute of Science and Technology (Korea, Republic of)

Conference Program Committee

George Barbastathis, Massachusetts Institute of Technology (United States)
Audrey K. Ellerbee, Stanford University (United States)
Pietro Ferraro, Istituto di Scienze Applicate e Sistemi Intelligenti (Italy)
Björn Kemper, Westfälische Wilhelms-Universität Münster (Germany)
Myung K. Kim, University of South Florida (United States)
Theo Lasser, École Polytechnique Fédérale de Lausanne (Switzerland)
Jerome Mertz, Boston University (United States)
Aydogan Ozcan, University of California, Los Angeles (United States)
Demetri Psaltis, École Polytechnique Fédérale de Lausanne (Switzerland)
Colin James Richard Sheppard, Istituto Italiano di Tecnologia (Italy)
Peter T. C. So, Massachusetts Institute of Technology (United States)
Laura Waller, University of California, Berkeley (United States)
Changhuei Yang, California Institute of Technology (United States)

Session Chairs

1 QPI Methodologies I
Gabriel Popescu, University of Illinois at Urbana-Champaign (United States)
YongKeun Park, Korea Advanced Institute of Science and Technology (Korea, Republic of)

2 QPI Algorithms and Image Processing
George Barbastathis, Massachusetts Institute of Technology (United States)
Colin James Richard Sheppard, Istituto Italiano di Tecnologia (Italy)

3 QPI of Cells and Tissues I
Björn Kemper, Westfälische Wilhelms-Universität Münster (Germany)
Peter T. C. So, Massachusetts Institute of Technology (United States)

4 QPI Clinical Applications
Aydogan Ozcan, University of California, Los Angeles (United States)

5 QPI from Lab to Market
Gabriel Popescu, University of Illinois at Urbana-Champaign (United States)

6 QPI Methodologies II
Jerome Mertz, Boston University (United States)
Demetri Psaltis, École Polytechnique Fédérale de Lausanne (Switzerland)

7 QPI of Cells and Tissues II
Gabriel Popescu, University of Illinois at Urbana-Champaign (United States)

8 QPI Methodologies III
YongKeun Park, Korea Advanced Institute of Science and Technology (Korea, Republic of)
David C. Clark, University of South Florida (United States)

9 QPI Methodologies IV
Audrey K. Ellerbee, Stanford University (United States)
Pietro Ferraro, Istituto di Scienze Applicate e Sistemi Intelligenti (Italy)

10 QPI Material Applications
Pietro Ferraro, Istituto di Scienze Applicate e Sistemi Intelligenti (Italy)

Introduction

After the launch of the first conference in 2015, the second conference on Quantitative Phase Imaging (QPI II) at Photonics West BiOS has continued its success. For four full days, 14–17 February, the QPI conference hosted a dense program of oral presentations, covering both novel methodologies and applications in diverse fields. The conference was kicked-off with the keynote presentation by James C. Wyant from University of Arizona (United States), highlighting the evolution of interferometry from metrology to biomedical applications and commenting on the exciting future of QPI. Each presentation throughout the conference was followed by insightful comments and questions, truly engaging discussions about the state of the art and future directions of the field. This year QPI II received 107 abstract submissions, making it one of the largest conferences at Photonics West. Recognizing the importance of transferring the QPI technology to the hands of the biomedical users, this year we inaugurated a special session on entrepreneurship, "From lab to market," inviting start-up companies operating in the QPI market to tell their stories. The keynote of this special session was given by Jim Sharp, President of Carl Zeiss Microscopy, LLC (United States) and President and CEO of Carl Zeiss, Inc. (Germany).

Together, this growing event gives a strong message that the QPI field has become one of the most active fields in biophotonics.

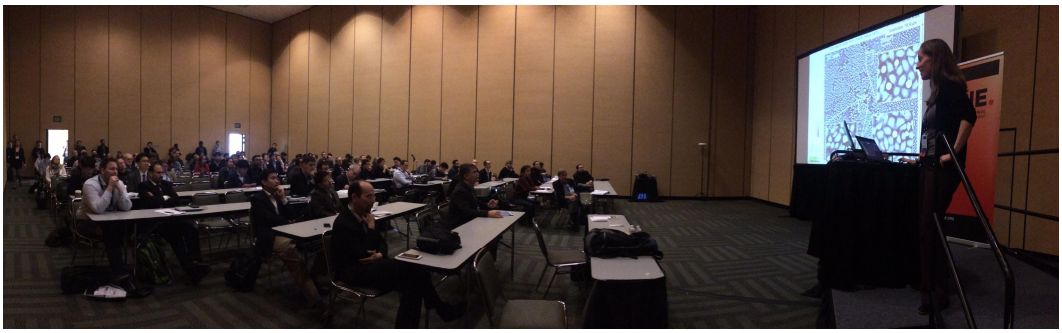

Figure 1. A morning session during the QPI Conference at Photonics West, BIOS (San Francisco, 7-10 Feb. 2015)

The papers published in this issue, proceedings volume on Quantitative Phase Imaging II, cover the latest developments and applications. The objective of this volume is to highlight recent progress and trends in novel optical technology developments as well as their biological, clinical, and industrial applications. The papers published here can be categorized into the following major topics:

1. QPI Methodologies
2. QPI Algorithms and Image Processing
3. QPI of Cells and Tissues
4. QPI Clinical Applications
5. QPI Material Applications

These topics are discussed in the contributed papers, covering original results and recent developments. Many of the papers published in this special issue represent an in-depth elaboration of topics presented at the Quantitative Phase Imaging II, Photonics West, BiOS, 2016. As chairs of the QPI II Conference, we are grateful to the contributors to this Volume and all the conference participants who have helped shape this exciting field of quantitative phase imaging.

Gabriel Popescu
YongKeun Park