

PROGRESS IN BIOMEDICAL OPTICS AND IMAGING

Vol. 20 No. 40

Label-free Biomedical Imaging and Sensing (LBIS) 2019

Natan T. Shaked

Oliver Hayden

Editors

2–5 February 2019

San Francisco, California, United States

Sponsored and Published by

SPIE

Volume 10890

Proceedings of SPIE, 1605-7422, V. 10890

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

Label-free Biomedical Imaging and Sensing (LBIS) 2019, edited by Natan T. Shaked,
Oliver Hayden, Proc. of SPIE Vol. 10890, 1089001 · © 2019 SPIE
CCC code: 1605-7422/19/\$18 · doi: 10.1117/12.2531129

Proc. of SPIE Vol. 10890 1089001-1

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 *Label-free Biomedical Imaging and Sensing (LBIS) 2019*, edited by Natan T. Shaked, Oliver Hayden, Proceedings of SPIE Vol. 10890 (SPIE, Bellingham, WA, 2019) Seven-digit Article CID Number.

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

ISBN: 9781510624221
ISBN: 9781510624238 (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>

COHERENT RAMAN IMAGING I

10890 03	Heterodyne dual-polarization epi-detected CARS microscopy for chemical and topographic imaging of interfaces (Invited Paper) [10890-2]
10890 04	Imaging lipids in living mammalian oocytes and early embryos by coherent Raman scattering microscopy [10890-3]
10890 05	Optimisation of multimodal coherent anti-Stokes Raman scattering microscopy for the detection of isotope-labelled molecules [10890-4]

SPONTANEOUS RAMAN I

10890 08	Raman spectroscopic imaging with frequency modulation based spatially encoded light [10890-7]
10890 09	Raman tomography with frequency-modulated excitation and spatially-coded detection [10890-8]

SPECTROSCOPY AND SCATTERING I

10890 0G	A 27-band snapshot hyperspectral imaging system for label-free tumor detection during image-guided surgery [10890-16]
10890 0H	Spectral image microscopy for label-free blood and cancer cell identification [10890-17]
10890 0J	Oxygen gas concentration measurements in the lungs of neonate chest phantom with realistic geometry and tissue optical properties using diode laser spectroscopy [10890-19]

SPECKLE IMAGING

10890 0L	Assessment of bacteria microencapsulation performance through bio-speckle dynamic analysis [10890-21]
----------	--

COHERENT RAMAN IMAGING II

- 10890 0N **Stimulated Raman scattering-spectroscopic optical coherence tomography (SRS-SOCT): theory, applications and new developments (Invited Paper)** [10890-23]
- 10890 0R **Simulation of the stimulated Raman scattering signal generation in scattering media excited by Bessel beams** [10890-27]

PHOTOACOUSTICS AND ACOUSTO-OPTICS

- 10890 0V **Hyperspectral phase imaging with a spatially matched acousto-optical tunable filter** [10890-31]
- 10890 0W **Towards accurate and label-free monitoring of bio-analytes using supercontinuum based multispectral photoacoustic spectroscopy in the extended near-infrared wavelength regime** [10890-32]

PLASMONICS AND BIOSENSORS

- 10890 11 **Multimodal signal amplification by collaborative plasmonic intensification and catalytic multiplication (c-PI/CM)** [10890-37]

POLARIZATION AND DARK-FIELD IMAGING

- 10890 1A **Multispectral Mueller matrix imaging dark-field microscope for biological sample observation** [10890-46]
- 10890 1B **Non-invasive spectral analysis of osteogenic and adipogenic differentiation in adipose derived stem cells using dark-field hyperspectral imaging technique** [10890-47]

AUTOFLUORESCENCE, NONLINEAR AND MULTIPHOTON IMAGING

- 10890 1D **Fluorescence lifetime imaging of unstained, fixed FaDu tumor slides (Invited Paper)** [10890-49]
- 10890 1F **Differentiation between normal and cancer cells with autofluorescence lifetime microscopy and nanosecond pulsed electric field effects** [10890-51]

SPECTROSCOPY AND SCATTERING II

- 10890 1L **Characterization of a multimodal endoscopically deployable veterinary spectroscopy and imaging probe to determine therapeutic response in a murine orthotopic tumor model** [10890-13]

SPONTANEOUS RAMAN II

- 10890 1R **Raman hyperspectral imaging of transferrin-bound iron in cancer cells** [10890-63]
- 10890 1S **Raman hyperspectral imaging of different salivary gland cell types for tissue engineering** [10890-64]
- 10890 1U **Time-lens based multi-color background-free coherent anti-Stokes Raman scattering microscopy** [10890-66]

PHASE IMAGING

- 10890 20 **Label-free imaging of cancer cells by in-flow tomography (Invited Paper)** [10890-71]

POSTER SESSION

- 10890 27 **Modeling the variation in speed of sound between couplant and tissue improves the spectral accuracy of multispectral optoacoustic tomography** [10890-78]
- 10890 29 **Extreme ultraviolet lensless imaging of biological specimen** [10890-80]
- 10890 2D **Swept-source OCT using pulsed mid-infrared light** [10890-84]
- 10890 2I **Line-field confocal optical coherence tomography operating simultaneously at 800 nm and 1300 nm center wavelengths** [10890-89]
- 10890 2J **Polarization characteristics of dark-field microscopic polarimetric images of human colon tissue** [10890-90]
- 10890 2K **High-speed imaging of scattering particles flowing through turbid media with confocally aligned, oblique plane illumination** [10890-91]
- 10890 2L **Label-free multispectral lifetime fluorescence to distinguish skin lesions** [10890-93]
- 10890 2M **Hyperspectral imaging fluorescence excitation scanning spectral characteristics of remodeled mouse arteries** [10890-94]
- 10890 2N **Multi-wavelength photoacoustic microscopy for detection of retinal vein occlusion during laser photocoagulation in rabbits** [10890-95]
- 10890 2Q **Plasmonic nanostructured chips for chemical and biological sensing in the UV-regime** [10890-98]

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.

Aaberg, Michael, 2N
Adamu, Abubakar I., 0W
Agrawal, Ajay Kumar, 2Q
Ahmed, Kaleem, 2Q
Alford, Anna, 2M
Andersson-Engels, Stefan, 0J
Awasthi, Kamlesh, 1F
Azimani, Hicham, 2I
Bang, Ole, 0W
Barroso, Margarida, 1R
Barton, Jennifer K., 1A, 2J
Berge, Elizabeth S., 1D
Bianco, V., 0L
Blair, Steven, 0G
Boorman, Dale, 05
Borri, Paola, 03, 04, 05
Bowen, Patrick, 0W
Bradley, Josephine, 04
Chakravarty, Monisha, 0J
Champagne, Justine, 0V
Chandra, Swati, 2J
Chen, Duofang, 08, 09
Chen, Xueli, 08, 09, 0R
Das, Abhijit, 2Q
Dasa, Manoj Kumar, 0W
David, Arthur, 2I
Deal, Joshua, 2M
Dempsey, Eugene, 0J
Desta, Habben, 1R
Devireddy, Ram, 1B
Dhawan, Anuj, 2Q
Dobrucki, Lawrence, 0G
Dominguez-Cooks, Joceline, 1A, 2J
Dubois, Arnaud, 2I
Durko, Heather L., 1A, 2J
Durr, Nicholas J., 2K
Favreau, Peter, 1D
Ferraro, P., 0L, 20
Fujii, Toru, 1A, 2J
Garcia, Missael, 0G
Gartia, Manas Ranjan, 1B
Gesley, Mark, 0H
Goldsby, Robert, 0H
Goldstein, Goldie L., 1A
Greening, Gage J., 1L
Grilli, S., 0L
Gruev, Viktor, 0G
Harlow, Dafydd Sion, 03
Heaster, Tiffany M., 1D
Helk, T., 29
Henry, Jessica, 2N
Hood, Steve, 05
Hsieh, Pei-Ying, 1F
Hsu, Hsin-Yun, 1F
Hutchens, Gabrielle V., 1A, 2J
Janting, Jakob, 0W
Jo, Javier A., 2L
Jones, Sydney, 2N
Jüstel, Dominik, 27
Kastelik, Jean-Claude, 0V
Khamladze, Alexander, 1R, 1S
Khoo, Ting Chean, 1R, 1S
Konopka, Christian, 0G
Kurachi, Cristina, 2L
Lane, Stephen, 0H
Langbein, Wolfgang, 03, 04, 05
Larsen, Melinda, 1S
Leavesley, Silas J., 2M
Levecq, Olivier, 2I
Li, Bo, 1U
Li, Haiyang, 0J
Li, Jingting, 1I
Li, Yanxiu, 2N
Liang, Jimin, 08, 09, 0R
Lin, Wai Ching, 2D
Lu, Feiyang, 08
Luo, Xixin, 09
Maffettone, P. L., 20
Mandrachchia, B., 0L
Markos, Christos, 0W
Martella, Pierluigi, 0J
Matcher, Stephen J., 2D
McFarland, Stuart J., 2M
McKay, Gregory N., 2K
Mehta, Nishir, 1B
Memmolo, P., 20
Merola, F., 20
Miccio, L., 20
Moichanov, Vladimir Y., 0V
Moskwa, Nicholas, 1S
Mugnano, M., 20
Muldoon, Timothy, 1L
Mundo, Ariel I., 1L
Narita, Ryo, 2J
Nazzaro, F., 0L
Nfonsam, Valentine N., 2J
Nguyen, Van Phuc, 2N
Nziachristos, Vasilis, 27

Ohta, Nobuhiro, 1F
Pacheco, Andrea, 0J
Paulus, Yannis M., 2N
Pham, Cat, 1R
Phillips, Alton H., 1A
Pope, Iestyn, 03, 04, 05
Prakash, Jaya, 27
Puri, Romin, 0H
Qin, Yifan, 1U
Qiu, Suyan, 11
Rega, R., 0L
Regan, David, 03
Rice, Photini F., 1A, 2J
Rich, Thomas C., 2M
Robinson, Anna, 2M
Robles, Francisco E., 0N
Romano, Renan A., 2L
Rosa, Ramon G. T., 2L
Rosen, Rachel, 2N
Sahu, Sushant, 1B
Saito, Naooki, 1A, 2J
Saito, Taku, 2J
Sato, Kenji, 1A
Sawada, Masayasu, 2J
Shah, Amy T., 1D
Shaik, Shahensha, 1B
Sharikova, Anna, 1R, 1S
Shih, Wei-Chuan, 11
Siret, David, 2I
Skala, Melissa C., 1D
Spielmann, C., 29
Subramanian, Senthil, 2Q
Swann, Karl, 04
Thurgood, Harrison T., 1A, 2J
Trick, Alexander Y., 2K
Tubbesing, Kate, 1R
Tuitje, F., 29
Villone, M., 20
Wang, Xinyu, 0R
Wang, Xueding, 2N
Watson, Peter, 05
Weber, David, 2M
Xia, Fei, 1U
Xia, Yuanqin, 1U
Xu, Chris, 1U
Yamasaki, Yasuko, 2J
Yan, Tianyu, 08
Yang, Hong, 27
Yushkov, Konstantin B., 0V
Zhan, Yonghua, 08, 09, 0R
Zhang, Wei, 2N
Zhao, Fusheng, 11
Zürch, M., 29

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

Natan T. Shaked, Tel Aviv University (Israel)

Oliver Hayden, Technische Universität München (Germany)

Conference Program Committee

Shi-Wei Chu, National Taiwan University (Taiwan)

Adam de la Zerda, Stanford University School of Medicine
(United States)

Pietro Ferraro, Istituto di Scienze applicata e Sistemi Intelligenti (Italy)

Jochen R. Guck, TU Dresden (Germany)

Ori Katz, The Hebrew University of Jerusalem (Israel)

Alexander T. Khmaladze, University at Albany (United States)

Aydogan Ozcan, University of California, Los Angeles (United States)

Jürgen Popp, Friedrich-Schiller-Universität Jena (Germany)

Francisco E. Robles, Georgia Institute of Technology & Emory
University School of Medicine (United States)

Melissa C. Skala, University of Wisconsin-Madison (United States)

Valery V. Tuchin, Saratov State University (Russian Federation) and
Tomsk State University (Russian Federation) and Institute of Precision
Mechanics and Control of the RAS (Russian Federation)

Yihui Wu, Changchun Institute of Optics, Fine Mechanics and Physics
(China)

Yizheng Zhu, Virginia Polytechnic Institute and State University
(United States)

Session Chairs

- 1 Coherent Raman Imaging I
Natan Tzvi Shaked, Tel Aviv University (Israel)
- 2 Spontaneous Raman I
Oliver Hayden, Technische Universität München (Germany)
- 3 Spectroscopy and Scattering I
Yizheng Zhu, Virginia Polytechnic Institute and State University
(United States)
Yihui Wu, Changchun Institute of Optics, Fine Mechanics and Physics
(China)
- 4 Speckle Imaging
Adam de la Zerda, Stanford University School of Medicine
(United States)
- 5 Coherent Raman Imaging II
Alexander T. Khmaladze, University at Albany (United States)
- 6 Photoacoustics and Acousto-Optics
Oliver Hayden, Technische Universität München (Germany)
- 7 Plasmonics and Biosensors
Shi-Wei Chu, National Taiwan University (Taiwan)
- 8 OCT and Interferometry
Natan Tzvi Shaked, Tel Aviv University (Israel)
- 9 Polarization and Dark-Field Imaging
Shi-Wei Chu, National Taiwan University (Taiwan)
- 10 Autofluorescence, Nonlinear and Multiphoton Imaging
Oliver Hayden, Technische Universität München (Germany)
- 11 Spectroscopy and Scattering II
Jochen R. Guck, TU Dresden (Germany)
- 12 Spontaneous Raman II
Francisco E. Robles, Georgia Institute of Technology & Emory
University School of Medicine (United States)

- 13 QPI-LBIS Joint Session: Joint Session with Conferences 10887 and 10890
YongKeun Park, KAIST (Korea, Republic of)
Oliver Hayden, Technische Universität München (Germany)
- 14 Phase Imaging
Natan Tzvi Shaked, Tel Aviv University (Israel)
Oliver Hayden, Technische Universität München (Germany)

