PROCEEDINGS OF SPIE

SPIDigitalLibrary.org/conference-proceedings-of-spie

Front Matter: Volume 10858

, "Front Matter: Volume 10858," Proc. SPIE 10858, Ophthalmic Technologies XXIX, 1085801 (23 May 2019); doi: 10.1117/12.2531204

SPIE.

Event: SPIE BiOS, 2019, San Francisco, California, United States

PROGRESS IN BIOMEDICAL OPTICS AND IMAGING

Vol. 20 No. 8

Ophthalmic Technologies XXIX

Fabrice Manns
Per G. Söderberg
Arthur Ho
Editors

2–3 February 2019
San Francisco, California, United States

Sponsored and Published by
SPIE

Volume 10858

Proceedings of SPIE, 1605-7422, V. 10858

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

Ophthalmic Technologies XXIX, edited by Fabrice Manns, Per G. Söderberg, Arthur Ho, Proc. of SPIE
Vol. 10858, 1085801 · © 2019 SPIE · CCC code: 1605-7422/19/\$18 · doi: 10.1117/12.2531204

Proc. of SPIE Vol. 10858 1085801-1

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 *Ophthalmic Technologies XXIX*, edited by Fabrice Manns, Per G. Söderberg, Arthur Ho, Proceedings of SPIE Vol. 10858 (SPIE, Bellingham, WA, 2019) Seven-digit Article CID Number.

ISSN: 1605-7422

ISSN: 2410-9045 (electronic)

ISBN: 9781510623583

ISBN: 9781510623590 (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>
xiii	<i>Introduction</i>

ANGIOGRAPHY AND BLOOD FLOW I

10858 02	Quantitative artery-vein analysis in optical coherence tomography angiography of diabetic retinopathy [10858-1]
----------	--

PASCAL ROL LECTURE

10858 0B	Need for technologies in advanced corneal research, diagnosis, and transplantation (Keynote Paper) [10858-82]
----------	--

OCULAR OPTICS AND MECHANICS

10858 0H	Varying femtosecond laser induced crosslink density in corneal stroma to control degree of refractive error correction [10858-15]
10858 0J	Quantifying changes in lenticular stiffness with optical coherence elastography [10858-17]

OPHTHALMIC ADAPTIVE OPTICS

10858 0K	Classifying cone photoreceptors in the living human eye using their unique phase response to light (Pascal Rol Award) [10858-18]
10858 0L	Method to track and measure loss of inner retinal neurons in the living human eye [10858-19]
10858 0O	Photoreceptor identification and quantitative analysis for the detection of retinal disease using AO-OCT imaging [10858-22]
10858 0P	Visualizing and enhancing axial resolution in nonconfocal adaptive optics ophthalmoscopy [10858-52]

OPHTHALMIC IMAGING: TECHNOLOGY

10858 13 **Device for silent substitution excitation of melanopsin for human eye** [10858-36]

OPHTHALMIC IMAGING: CLINICAL

10858 1C **Optic nerve head morphometry for glaucoma diagnosis, optimization of clinical measurement strategy** [10858-45]

POSTER SESSION

10858 1H **Lacrimal canaliculus imaging by dynamic OCT using extrinsic contrast agent** [10858-50]

10858 1I **Wide field of view retinal imaging by handheld fundus camera** [10858-51]

10858 1K **Multiscale Hessian filtering for enhancement of OCT angiography images** [10858-54]

10858 1L **Optical coherence tomography guided artery-vein classification in the retinal OCT angiography of macular region** [10858-55]

10858 1N **Longitudinal optical coherence tomography angiography of hyaloid vessels in the developing mouse eye** [10858-57]

10858 1V **Second harmonic generation imaging of chick corneal development** [10858-65]

10858 1X **Non-invasive and label-free follow-up of accelerated-crosslinking using multiphoton tomography** [10858-67]

10858 1Z **Performance analysis of a hyperspectral system for human iris imaging** [10858-69]

10858 21 **Nano sensitive study and fractal analysis of segmented retinal layers in Fourier domain OCT: promises for early disease detection** [10858-71]

10858 23 **Fully automated corneal nerve segmentation algorithm for corneal nerves analysis in-vivo UHR-OCT images** [10858-73]

10858 24 **An original low-power opto-fluidic engine for presbyopia-correcting adaptive eyeglasses** [10858-74]

10858 26 **Modeling the load resistance in laser-assisted cornea transplantation** [10858-76]

10858 28 **Macular pigment reflectometry: development and evaluation of a novel clinical device for rapid objective assessment of the macular carotenoids** [10858-78]

10858 29 **Impact of retinal image quality: software aid for a low-cost device and effects on disease detection** [10858-79]

10858 2D **Refractive index measurement system for contact lens in a natural hydrated state** [10858-84]

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.

Aglyamov, Salavat, 0J	Lagali, Neil, 0B
Agrici, Sergiu, 13	Larin, Kirill, 0J
Alam, Minhaj Nur, 02, 1L	Lassoued, Ayoub, 0K, 0L
Alexandrov, Sergey, 21	Lavigne, Quentin, 24
Baig, Sarfaraz, 1I	Leahy, Martin, 21
Balachandran, Chirojean, 13	Lee, Sheng-Lin, 1V
Barriga, Simon, 29	Lim, Jennifer I., 02
Batista, Ana, 1X	Liu, Changgeng, 1L
Benson, Jeremy, 29	Malandrini, Alex, 26
Berge, Bruno, 24	Manna, Suman K., 1K
Bizheva, Kostadinka, 23	Maynard, John, 29
Breunig, Hans Georg, 1X	Mecê, Pedro, 0P
Canovetti, Annalisa, 26	Meimon, Serge, 0P
Cassaing, Frédéric, 0P	Meleppat, Ratheesh K., 1K
Cebulla, Colleen M., 0O	Menabuoni, Luca, 26
Chen, Yang-Fang, 1V	Miller, Donald T., 0K, 0L
Chhablani, Jay, 21	Miller, Eric B., 1K
Choi, Dong-hak, 1H	Molliex, Norbert, 24
Choi, Stacey S., 0O	Nemeth, Sheila, 29
Cross, Jeneatte, 28	Ngo, Angeline, 28
Crowell, James A., 0K, 0L	O'Gorman, Sean, 21
Das, Nandan, 21	Ohbayashi, Kohji, 1H
Davey, Pinakin G., 28	Ohr, Matthew, 0O
Dey, Rajib, 21	Palacios, Diego, 1I
di Cecilia, Luca, 1Z	Paques, Michel, 0P
Doble, Nathan, 0O	Petit, Cyril, 0P
Dong, Chen-Yuan, 1V	Pini, Roberto, 26
Fan, Jiashuai, 0H	Pugh, Edward N., 1K
Ferrara, Paolo, 26	Rossi, Francesca, 26
Fomovsky, Mikhail, 0H	Rossi, Michele, 26
Fujimoto, Masahiro, 1H	Rovati, Luigi, 1Z
Geiser, Martial, 13	Sahel, José, 0P
Ghosh, Nirmalya, 21	Sandberg Melin, Camilla, 1C
Gibson, Donald, 2D	Seitz, Berthold, 1X
Gierhart, Dennis L., 28	Shen, Kai, 1I
Gofas-Salas, Elena, 0P	Singh, Manmohan, 0J
Grieve, Kate, 0P	Söderberg, Per G., 1C
Hager, Tobias, 1X	Soliz, Peter, 29
Han, Le, 23	Son, Taeyoon, 02, 1L, 1N
Hiwatashi, Fumiko, 1H	Sorbara, Luigina, 23
Hosseinaee, Zohreh, 23	Szarlan, Todd, 2D
Ignatovich, Filipp, 2D	Tan, Bingyao, 23
Jarosz, Jessica, 24	Toslak, Devrim, 02, 1L
Kawasaki, Aki, 13	Truffer, Frederic, 13
Kim, Tae-Hoon, 1N	Uji, Akihito, 1H
King, Travis, 2D	Vukelic, Sinisa, 0H
König, Karsten, 1X	Wang, Chao, 0H
Kralj, Olivera, 23	Wang, James H., 1I
Kurokawa, Kazuhiro, 0K, 0L	Wang, Michael R., 1I

Wells-Gray, Elaine M., 00
Wigdahl, Jeffrey, 29
Wong, Alexander, 23
Wu, Chen, 0J
Yao, Xincheng, 02, 1L, 1N
Yoshimura, Reiko, 1H
Yu, Zhaohua, 1C
Zamora, Gilberto, 29
Zawadzki, Robert J., 1K
Zhang, Furu, 0K, 0L
Zhang, Hongqiu, 0J
Zhang, Pengfei, 1K

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

Brian Jet-Fei Wong, Beckman Laser Institute and Medical Clinic,
University of California, Irvine (United States)
Eva Sevick, The University of Texas Health Science Center at Houston,
(United States)

Conference Chairs

Fabrice Manns, University of Miami (United States)
Per G. Söderberg, Uppsala University (Sweden)
Arthur Ho, Brien Holden Vision Institute (Australia)

Conference Program Committee

Rafat R. Ansari, NASA Glenn Research Center (United States)
Michael Belkin, Tel Aviv University (Israel)
Kostadinka Bizheva, University of Waterloo (Canada)
David Borja, Alcon Laboratories, Inc. (United States)
Ralf Brinkmann, Universität zu Lübeck (Germany)
Wolfgang Drexler, Medizinische Universität Wien (Austria)
Sina Farsiu, Duke University (United States)
Daniel X. Hammer, U.S. Food and Drug Administration (United States)
Karen M. Joos, Vanderbilt University (United States)
Kirill V. Larin, University of Houston (United States)
Ezra Maguen, American Eye Institute (United States)
Donald T. Miller, Indiana University (United States)
Derek Nankivil, Johnson & Johnson Vision Care, Inc. (United States)
Daniel V. Palanker, Stanford University (United States)

Jean-Marie Parel, Bascom Palmer Eye Institute (United States)
Roberto Pini, Istituto di Fisica Applicata Nello Carrara (Italy)
Ygal Rotenstreich, The Chaim Sheba Medical Center, Tel Hashomer (Israel)
Luigi Rovati, Università degli Studi di Modena e Reggio Emilia (Italy)
Marco Ruggeri, Bascom Palmer Eye Institute (United States)
Georg Schuele, OptiMedica Corporation (United States)
Jerry Sebag, VMR Institute (United States)
Peter Soliz, VisionQuest Biomedical, LLC (United States)
Yuankai K. Tao, Vanderbilt University (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)
Robert J. Zawadzki, University of California, Davis (United States)

Session Chairs

- 1 Angiography and Blood Flow I
Robert J. Zawadzki, University of California, Davis (United States)
Kostadinka Bizheva, University of Waterloo (Canada)
- 2 Small Animal Imaging
Marco Ruggeri, Bascom Palmer Eye Institute (United States)
Yuankai Kenny K. Tao, Vanderbilt University (United States)
- 3 Pascal Rol Lecture
Per Söderberg, Uppsala University (Sweden)
- 4 OCT Technology
Daniel X. Hammer, U.S. Food and Drug Administration (United States)
Derek Nankivil, Johnson & Johnson Vision Care, Inc. (United States)
- 5 Ocular Optics and Mechanics
Arthur Ho, Brien Holden Vision Institute (Australia)
Georg Schuele, Johnson & Johnson Vision (United States)
- 6 Ophthalmic Adaptive Optics
Wolfgang Drexler, Medical University of Vienna (Austria)
Sina Farsiu, Duke University (United States)
- 7 Angiography and Blood Flow II
Daniel V. Palanker, Stanford University (United States)
Per Söderberg, Uppsala University (Sweden)
- 8 Ophthalmic Therapy and Vision Restoration
Ezra Maguen, American Eye Institute (United States)

Ygal Rotenstreich, The Chaim Sheba Medical Center, Tel Hashomer
(Israel)

9 Spectral Imaging

Donald T. Miller, Indiana University (United States)

Luigi Rovati, University degli Studi di Modena e Reggio Emilia (Italy)

10 Ophthalmic Imaging: Technology

Arthur Ho, Brien Holden Vision Institute (Australia)

Marco Ruggeri, Bascom Palmer Eye Institute (United States)

11 Ophthalmic Imaging: Clinical

Karen M. Joos, Vanderbilt University Medical Center (United States)

Roberto Pini, Istituto di Fisica Applicata "Nello Carrara" (Italy)

Introduction

The papers contained in this volume were presented at the twenty-ninth conference on Ophthalmic Technologies, held from 2 to 3 February 2019, at the Moscone Center in San Francisco, California (United States) as a part of the SPIE Photonics West BIOS Symposium.

A total of 48 oral presentations and 34 posters were presented by scientists, clinicians, and engineers from academia and industry representing 22 countries spanning 4 continents. The conference covered a broad range of topics, including novel approaches to increase the resolution of photovoltaic retinal implants, the use of high speed retinal imaging for imaging neuronal activity, laser-induced ocular gene therapy and fundus imaging using transmitted light.

The conference hosted its thirteenth presentation on the topic of the unmet needs and impact of technology in the clinical area. Dr. Neil Lagali, from the Department of Clinical and Experimental Medicine at Linköping University (Sweden), presented current needs and recent advances in the field of corneal research, diagnostics and surgery.

The nineteenth Pascal Rol Award was presented to Dr. Furu Zhang and his colleagues from Indiana University (United States) for their outstanding paper on "*Classifying cone photoreceptors in the living human eye using their unique phase response to light*" [10858-18]. Established in memory of Dr. Pascal O. Rol, former chair and co-founder of the Ophthalmic Technologies conference, the award is in recognition of the best manuscript and presentation. Special congratulations to Dr. Zhang, who also won the award just two years ago, in 2017! The 2019 finalists of the award, selected by the entire program committee among 78 abstract submissions, included Kazuhiro Kurokawa [10858-19], and Tingwei Zhang [10858-35].

We are very grateful to Johnson and Johnson Vision for sponsoring the 2019 Pascal Rol award and keynote lecture through the Pascal Rol Foundation.

We thank the Program Committee members, session chairs, speakers and participants, as well as the SPIE staff, for their support and dedication in making this conference a success.

We extend an invitation for the Ophthalmic Technologies XXX conference, which is scheduled for Saturday 1 February 2020 and Sunday 2 February 2020 in San Francisco, California (United States).

Fabrice Manns
Per G. Söderberg
Arthur Ho

Nineteenth Pascal Rol Award for Excellence in Ophthalmic Technologies
Sponsored by Johnson and Johnson Vision through the Pascal Rol
Foundation

Presented on Sunday February 3, 2019 to

Dr. Furu Zhang

for his excellent paper on

***"Classifying cone photoreceptors in the living
human eye using their unique phase response to
light "***

Prof. Roberto Pini (left) presents the 2019 Pascal Rol Award to Furu Zhang (right).

Past awardees

2018	Kazuhiro Kurokawa	<i>Method to investigate temporal dynamics of ganglion and other retinal cells in the living human eye</i>
2017	Furu Zhang	<i>Tracking dynamics of photoreceptor disc shedding with adaptive optics-optical coherence tomography</i>
2016	Zhuolin Liu	<i>Imaging human retinal pigment epithelium cells using adaptive optics optical coherence tomography</i>
2015	Francesco de la Rocca	<i>Ultra-compact switchable SLO/OCT handheld probe design</i>
2014	Marco Ruggeri	<i>Biometry of the ciliary muscle during dynamic accommodation assessed with OCT</i>
2013	Yossi Mandel	<i>In-vivo performance of photovoltaic subretinal prosthesis</i>
2012	Clemens Alt	<i>In vivo quantification of microglia dynamics with an SLO in a mouse model of focal laser injury</i>
2011	James Loudin	<i>Photovoltaic retinal prosthesis</i>
2010	Daniel Hammer	<i>Multimodal adaptive optics for depth enhanced high-resolution ophthalmic imaging</i>
2009	Kazuhiro Kurokawa	<i>1μm wavelength adaptive optics scanning laser ophthalmoscope</i>
2008	Boris Povazay	<i>Minimum distance mapping using volumetric OCT: A novel indicator for early glaucoma diagnosis</i>
2007	Yoshiaki Yasuno	<i>Clinical examinations of anterior eye segments by three-dimensional swept-source optical coherence tomography</i>
2006	Enrique Fernandez	<i>Adaptive optics using a liquid crystal spatial light modulator for ultrahigh-resolution optical coherence tomography</i>
2005	Karsten König	<i>Cornea surgery with nanojoule femtosecond laser pulses</i>
2004	Daniel Palanker	<i>Attracting retinal cells to electrodes for high-resolution stimulation</i>
2003	Igor Ermakov	<i>Non-invasive optical techniques for the measurement of macular pigments</i>
2002	Georg Schuele	<i>Non-invasive temperature measurements during laser irradiation of the retina with optoacoustic techniques</i>
2001	Matthew Smith	<i>Minimizing the influence of fundus pigmentation on retinal vessel oximetry measurements</i>

The 2019 Pascal Rol Lecture on Ophthalmic Technologies

Saturday February 2, 2019

Professor Neil Lagali, Linköping University (Sweden)

Need for technologies in advanced corneal research, diagnosis, and transplantation

The Pascal Rol Lecture on Ophthalmic Technologies is presented by a leading researcher in ophthalmology with a strong interest and pioneering research contributions to the field of ophthalmic technologies. This invited lecture is intended to trigger further development of ophthalmic technologies by stimulating discussions between basic scientists, engineers, and clinicians.

The 2019 lecture was supported by
Johnson and Johnson Vision
through the Pascal Rol Foundation
(www.pascalrolfoundation.org)

Johnson & Johnson VISION