PROCEEDINGS OF SPIE

SPIDigitalLibrary.org/conference-proceedings-of-spie

Front Matter: Volume 9305

, "Front Matter: Volume 9305," Proc. SPIE 9305, Optical Techniques in
Neurosurgery, Neurophotonics, and Optogenetics II, 930501 (9 April 2015);
doi: 10.1117/12.2183897

SPIE.

Event: SPIE BiOS, 2015, San Francisco, California, United States

PROGRESS IN BIOMEDICAL OPTICS AND IMAGING

Vol. 16 No. 3

Optical Techniques in Neurosurgery, Neurophotonics, and Optogenetics II

**Henry Hirschberg
Steen J. Madsen
E. Duco Jansen
Qingming Luo
Samarendra K. Mohanty
Nitish V. Thakor**
Editors

**7–10 February 2015
San Francisco, California, United States**

Sponsored and Published by
SPIE

Volume 9305

Proceedings of SPIE, 1605-7422, V. 9305

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

Optical Techniques in Neurosurgery, Neurophotonics, and Optogenetics II, edited by Henry Hirschberg, Steen J. Madsen, E. Duco Jansen, Qingming Luo, Samarendra K. Mohanty, Nitish V. Thakor, Proc. of SPIE Vol. 9305, 930501 · © 2015 SPIE · CCC code: 1605-7422/15/\$18 · doi: 10.1117/12.2183897

Proc. of SPIE Vol. 9305 930501-1

The papers included 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. The papers published in these proceedings 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 this book:

Author(s), "Title of Paper," in *Optical Techniques in Neurosurgery, Neurophotonics, and Optogenetics II*, edited by Henry Hirschberg, Steen J. Madsen, E. Duco Jansen, Qingming Luo, Samarendra K. Mohanty, Nitish V. Thakor, Proceedings of SPIE Vol. 9305 (SPIE, Bellingham, WA, 2015) Article CID Number.

ISSN: 1605-7422

ISBN: 9781628413953

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 © 2015, 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 1605-7422/15/\$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

SPIDigitalLibrary.org

Paper Numbering: Proceedings of SPIE follow an e-First publication model, with papers published first online and then in print. Papers are published as they are submitted and meet publication criteria. A unique citation identifier (CID) number is assigned to each article at the time of the first 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, print, and electronic versions of the publication. SPIE uses a six-digit CID article numbering system in which:

- 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. The complete citation is used on the first page, and an abbreviated version on subsequent pages.

Contents

vii	<i>Authors</i>
ix	<i>Conference Committee</i>
xiii	<i>Introduction to Optogenetics and Optical Control of Cells</i>

Part A Optical Techniques in Neurosurgery, Brain Imaging, and Neurobiology

OCT AND MICROSCOPY I

9305 04	Quantitative biochemical investigation of various neuropathologies using high-resolution spectral CARS microscopy [9305-102]
9305 05	Coaxial cavity injected OCT and fiber laser ablation system for real-time monitoring of ablative processes [9305-103]

OCT AND MICROSCOPY II

9305 07	Cadaveric in-situ testing of optical coherence tomography system-based skull base surgery guidance [9305-105]
9305 0A	Spinal cord deformation due to nozzle gas flow effects using optical coherence tomography [9305-108]

OPERATIVE AND POST-OP THERAPY I

9305 0C	Macrophage mediated PCI enhanced gene-directed enzyme prodrug therapy [9305-110]
9305 0D	Interstitial photodynamic therapy and glioblastoma: light fractionation study on a preclinical model: preliminary results [9305-111]
9305 0E	Efficacy of combined photothermal therapy and chemotherapeutic drugs [9305-112]

OPERATIVE AND POST-OP THERAPY II

9305 0J	Real-time quantitative fluorescence imaging using a single snapshot optical properties technique for neurosurgical guidance [9305-119]
---------	---

OPTICAL SPECTROSCOPY AND TOMOGRAPHY

- 9305 0L **Hemodynamic and morphologic responses in mouse brain during acute head injury imaged by multispectral structured illumination** [9305-121]
- 9305 0M ***In vivo* estimation of light scattering and absorption properties of rat brain using single reflectance fiber probe during anoxic depolarization** [9305-122]
- 9305 0N **FNIRS-based evaluation of cortical plasticity in children with cerebral palsy undergoing constraint-induced movement therapy** [9305-123]

OCT AND MICROSCOPY III

- 9305 0Q **Evaluation of hemodynamics changes during interventional stent placement using Doppler optical coherence tomography** [9305-126]

OPERATIVE AND POST-OP THERAPY III

- 9305 0U **Accuracy of image-guided surgical navigation using near infrared (NIR) optical tracking** [9305-117]

Part B **Neurophotonics**

NOVEL PHOTONIC OR OPTOELECTRONIC METHODS

- 9305 0Y **Visualization and neuronal cell targeting during electrophysiological recordings facilitated by quantum dots** [9305-202]
- 9305 0Z **Abnormal hemodynamic response to forepaw stimulation in rat brain after cocaine injection** [9305-203]

NEUROPHOTONIC APPLICATIONS I

- 9305 14 **A new versatile clearing method for brain imaging** [9305-208]

NEUROPHOTONIC APPLICATIONS II

- 9305 17 **Hemodynamic low-frequency oscillation reflects resting-state neuronal activity in rodent brain** [9305-211]

DIFFUSIVE OPTICAL TOMOGRAPHY AND FUNCTIONAL NEAR-INFRARED IMAGING

- 9305 1A **Enhancing motor performance improvement by personalizing non-invasive cortical stimulation with concurrent functional near-infrared spectroscopy and multi-modal motor measurements (Invited Paper)** [9305-215]
- 9305 1B **A portable fNIRS system with eight channels** [9305-216]

HIGH RESOLUTION AND MULTIMODAL IMAGING

- 9305 1D **Changes in the cerebral blood flow in newborn rats assessed by LSCI and DOCT before and after the hemorrhagic stroke (Invited Paper)** [9305-219]
- 9305 1G **Simultaneous measurement of cerebral and muscle tissue parameters during cardiac arrest and cardiopulmonary resuscitation** [9305-222]

NOVEL OPTICAL METHODS FOR STUDYING CORTICAL FUNCTION

- 9305 1J **Nanoparticle-assisted-multiphoton microscopy for *in vivo* brain imaging of mice** [9305-259]

VISIBLE BRAIN-WIDE NETWORKS

- 9305 1O **Whole brain optical imaging (Invited Paper)** [9305-226]

POSTER SESSION

- 9305 1S **Experimental studies with selected light sources for NIRS of brain tissue: quantifying tissue chromophore concentration** [9305-230]
- 9305 1X **Improvement of the background optical property reconstruction of the two-layered slab sample based on a region-stepwise-reconstruction method** [9305-235]
- 9305 1Y **Cell-based optical assay for amyloid β -induced neuronal cell dysfunction using femtosecond-pulsed laser** [9305-236]
- 9305 23 **Photoacoustic imaging for transvascular drug delivery to the rat brain** [9305-242]
- 9305 26 **Multichannel fiber-based diffuse reflectance spectroscopy for the rat brain exposed to a laser-induced shock wave: comparison between ipsi- and contralateral hemispheres** [9305-245]
- 9305 27 **Optimized optical clearing method for imaging central nervous system** [9305-246]
- 9305 2H **Miniature device for chronic, label-free multi-modal optical imaging of cortical hemodynamics in rats** [9305-256]

- 9305 2I **Near-infrared spectroscopy assessment of divided visual attention task-invoked cerebral hemodynamics during prolonged true driving** [9305-258]

Part C Optogenetics and Optical Control of Cells

OPTOGENETICS I

- 9305 2K **Demonstration of a setup for chronic optogenetic stimulation and recording across cortical areas in non-human primates** [9305-301]
- 9305 2L **Visible array waveguide gratings for applications of optical neural probes** [9305-302]
- 9305 2N **Laser-induced perturbation into molecular dynamics localized in neuronal cell** [9305-304]
- 9305 2O **Fabrication of multipoint light emitting optical fibers for optogenetics** [9305-305]

OPTOGENETICS II

- 9305 2R **Near-infrared (NIR) optogenetics using up-conversion system** [9305-309]
- 9305 2T **Bringing the light to high throughput screening: use of optogenetic tools for the development of recombinant cellular assays** [9305-311]

OPTOGENETICS III

- 9305 2Y **Spatio-angular light control in microscopes using micro mirror arrays** [9305-316]

OPTOGENETICS IV

- 9305 34 **Experimental systems for optogenetic control of protein activity with photodissociable fluorescent proteins** [9305-322]

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.

Abdurashitov, A. S., 1D	Hososhima, Shoko, 2R
Abookasis, David, 0L	Hu, Xudong, 1G
Agus, Viviana, 2T	Huang, Yize, 05, 0A
Alarcon, Joseph, 0U	Huber, Daniel, 0Y
Alexandrakis, George, 0N, 1A	Huston, Alan L., 0Y
Allegra Mascaro, Anna Letizia, 14, 1O	Ishizuka, Toru, 2R
Andrásfalvy, Bertalan K., 0Y	Jakubovic, Raphael, 0U
Angelo, Joseph, 0J	Jia, Mengyu, 1X
Barbic, Mladen, 0Y	Jiang, Tianzi, 1B
Bellow, S., 2Y	Jivraj, Jamil, 05, 07, 0A, 0Q
Berg, Kristian, 0C	Kajbeleva, E. I., 1D
Berndt, D., 2Y	Kassim, M., 1D
Brideau, Craig, 04	Kawasoe, Jean H., 04
Cao, Jianwei, 0N	Kawauchi, Satoko, 0M, 23, 26
Chen, Min, 2I	Khan, Bilal, 0N, 1A
Chen, Wei, 0Z, 17	Khan, Osaama H., 07
Choi, Chulhee, 1Y	Kim, Siwook, 1G
Choi, Jeonghun, 0Z	Kiviniemi, Vesa, 1S
Christie, Catherine E., 0C	Klauser, Antoine M., 04
Clegg, Nancy J., 0N	Klaver, Roel, 04
Costantini, Irene, 14, 1O	Koletar, Margaret, 2H
De Vittorio, Massimo, 2O	Kondraske, George, 1A
Delehanty, James B., 0Y	Korhonen, Vesa, 1S
Delgado, Mauricio R., 0N	Kudoh, Suguru N., 2N
Di Giovanna, Antonino Paolo, 14	Kwon, Young J., 0C
Di Silvio, Alberto, 2T	Ledochowitsch, Peter, 2K
Diaz-Botia, Camilo, 2K	Lee, Seunghee, 1Y
Dorian, Paul, 1G	Lejeune, Jean-Paul, 0D
Du, Congwu, 0Z, 17	Leroy, Henri-Arthur, 0D
Faraon, Andrei, 2L	Levi, Ofer, 2H
Farooq, Hamza, 0Q, 0U	Li, James, 17
Field, Lauren D., 0Y	Li, Ting, 2I
Fowler, Trevor, 2L	Lin, Michael Z., 34
Gad, Raanan, 2H	Liu, Hanli, 0N
Galiñanes, Gregorio L., 0Y	Liu, Ming, 1X
Gao, Feng, 1X	Liu, Peng, 17
Gao, Yuan, 2I	Lohmer, Stefan, 2T
Genis, Helen, 0Q	Lu, Yi, 05
Geurts, Jeroen J., 04	Luo, Qingming, 27
Gioux, Sylvain, 0J	Lychagov, V. V., 1D
Gong, Hui, 27	MacFarlane, Duncan, 0N
Gu, Xijia, 05	Macklin, John J., 0Y
Hanson, Tim, 2K	Madsen, Steen J., 0C, 0E
Heber, J., 2Y	Maharabiz, Michel M., 2K
Hervey, Nathan, 0N, 1A	Makara, Judit K., 0Y
Hefian, Yiyi, 2I	Mathews, Marlon S., 0L
Hirschberg, Henry, 0C, 0E	Medintz, Igor L., 0Y
Hodics, Timea, 1A	Miyaki, Mai, 26
Hosokawa, Chie, 2N	Mondini, Anna, 2T

Montag, Katharina, 2T
 Mordon, Serge, 0D
 Müllenbroich, Marie Caroline, 14
 Myllylä, Teemu, 1S
 Nawashiro, Hiroshi, 26
 Nishidate, Izumi, 0M, 26
 Nosrati, Reyhaneh, 1G
 Okuda, Wataru, 26
 Pan, Yingtian, 0Z, 17
 Park, Kicheon, 0Z
 Pavlov, A. N., 1D
 Pavone, Francesco S., 14, 1O
 Pisanello, Ferruccio, 2O
 Pisanello, Marco, 2O
 Poon, Kelvin W., 04
 Qi, Yisong, 27
 Qian, Jun, 1J
 Qin, Zhuanping, 1X
 Ramadeen, Andrew, 1G
 Ramjst, Joel, 05, 0A, 0Q
 Redaelli, Loredana, 2T
 Reid, Dahlia, 0N
 Reyns, Nicolas, 0D
 Ringuette, Dene, 2H
 Roberts, Heather, 0N
 Rolland, Jean Francois, 2T
 Roukes, Michael L., 2L
 Rückerl, F., 2Y
 Sabes, Philip N., 2K
 Sacconi, Leonardo, 14, 1O
 Sato, Manabu, 0M
 Sato, Shunichi, 0M, 23, 26
 Scarabottolo, Lia, 2T
 Schenk, Geert J., 04
 Segev, Eran, 2L
 Semyachkina-Glushkovskaya, O. V., 1D
 Shagman, Laura, 0N
 Shierk, Angela, 0N
 Shih, En-Chung, 0E
 Shorte, S., 2Y
 Si, Juanning, 1B
 Siegler, Peter, 07
 Sigal, Iliya, 2H
 Sileo, Leonardo, 2O
 Silvestri, Ludovico, 14, 1O
 Sindeev, S. S., 1D
 Sindeeva, O. V., 1D
 Smith, Linsley, 0N
 Stefanovic, Bojana, 2H
 Stowe, Ann, 1A
 Stys, Peter K., 04
 Su, Yu, 2I
 Sun, Cuiru, 07, 0A, 0Q
 Sun, Yunlong, 2I
 Susumu, Kimihiro, 0Y
 Taguchi, Takahisa, 2N
 Takeda, Naoko, 2N
 Takemura, Toshiya, 23, 26
 Terakawa, Mitsuhiro, 23
 Tétard, Marie-Charlotte, 0D
 Tian, Fenghua, 0N
 Tinevez, J-Y., 2Y
 Toronov, Vladislav, 1G
 Tremolada, Sara, 2T
 Tsunoi, Yasuyuki, 23
 Tuchin, Valery, 1D, 1S
 Tulchin-Francis, Kirsten, 0N
 Valdes, Pablo A., 0J
 Vermandel, Maximilien, 0D
 Volkov, Boris, 0L
 Vuong, Barry, 05, 0A, 0Q
 Wagner, M., 2Y
 Watanabe, Ryota, 23
 Woldemichael, Ermias, 1G
 Wong, Ronnie J., 05, 07, 0A, 0Q
 Yang, Victor X. D., 05, 07, 0A, 0Q, 0U
 Yawo, Hiromu, 2R
 Yazdan-Shahmorad, Azadeh, 2K
 Yoon, Jonghee, 1Y
 Yoshida, Keiichiro, 0M
 Yu, Tingting, 27
 Yuasa, Hideya, 2R
 Zamora, Genesis, 0C
 Zhang, Xin, 1B
 Zhang, Yujin, 1B
 Zhao, Huijuan, 1X
 Zhao, Ruirui, 1B
 Zhao, Yue, 2I
 Zhou, Xin X., 34
 Zhu, Dan, 27
 Zinchenko, E. M., 1D
 Zuo, Nianming, 1B

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 Chair

Brian Jet-Fei Wong, Beckman Laser Institute and Medical Clinic
(United States)

Part A Optical Techniques in Neurosurgery, Brain Imaging, and Neurobiology

Conference Chairs

Henry Hirschberg, Beckman Laser Institute and Medical Clinic
(United States)

Steen J. Madsen, University of Nevada, Las Vegas (United States)

Conference Program Committee

David Abookasis, Ariel University of Samaria (Israel)

Frederic Leblond, Ecole Polytechnique de Montréal (Canada)

Herbert Stepp, Ludwig-Maximilians-Universität München (Germany)

Pablo A. Valdes, Dartmouth College (United States)

Victor X. D. Yang, Ryerson University (Canada)

Session Chairs

- 1 OCT and Microscopy I
 Victor X. D. Yang, Ryerson University (Canada)
- 2 OCT and Microscopy II
 Steen J. Madsen, University of Nevada, Las Vegas (United States)
- 3 Operative and Post-op Therapy I
 Henry Hirschberg, Beckman Laser Institute and Medical Clinic
 (United States)

- 4 Operative and Post-Op Therapy II
Frédéric Leblond, Ecole Polytechnique de Montréal (Canada)
- 5 Optical Spectroscopy and Tomography
David Abookasis, Ariel University (Israel)
- 6 OCT and Microscopy III
Pablo A. Valdes, Dartmouth College (United States)
- 7 Operative and Post-Op Therapy III
Pablo A. Valdes, Dartmouth College (United States)

Part B Neurophotonics

Conference Chairs

E. Duco Jansen, Vanderbilt University (United States)
Qingming Luo, Huazhong University of Science and Technology
(China)

Conference Co-chairs

Jun Ding, Stanford School of Medicine (United States)
Anna W. Roe, Vanderbilt University (United States)

Conference Program Committee

David A. Boas, Massachusetts General Hospital (United States)
Yu Chen, University of Maryland, College Park (United States)
Javier DeFelipe, University Politécnica de Madrid (Spain)
Hongwei Dong, University of California, Los Angeles (United States)
Congwu Du, Stony Brook University (United States)
Beop-Min Kim, Korea University College of Health Sciences
(Korea, Republic of)
Vesa Kiviniemi, University of Oulu (Finland)
Pengcheng Li, Britton Chance Center for Biomedical Photonics
(China)
Anita Mahadevan-Jansen, Vanderbilt University (United States)
Francesco Saverio Pavone, Laboratorio Europeo per la Spettroscopia
Non-lineare (Italy)
Kambiz Pourrezaei, Drexel University (United States)
Claus-Peter Richter, Northwestern University (United States)
Shy Shoham, Technion-Israel Institute of Technology (Israel)
Vladislav Toronov, Ryerson University (Canada)
Shaoqun Zeng, Britton Chance Center for Biomedical Photonics
(China)

Session Chairs

- 1 Novel Photonic or Optoelectronic Methods
E. Duco Jansen, Vanderbilt University (United States)
- 2 Neurophotonic Applications I
Francesco Saverio Pavone, Laboratorio Europeo per la Spettroscopia Non-lineare (Italy)
- 3 Neurophotonic Applications II
Beop-Min Kim, Korea University College of Health Sciences (Korea, Republic of)
- 4 Diffusive Optical Tomography and Functional Near-Infrared Imaging
Hope T. Beier, Air Force Research Laboratory (United States)
- 5 High Resolution and Multimodal Imaging
Shy Shoham, Technion-Israel Institute of Technology (Israel)
- 6 Novel Optical Methods for Studying Cortical Function
Anna Wang Roe, Vanderbilt University (United States)
- 7 Neurophotonics Plenary Speaker
Qingming Luo, Britton Chance Center for Biomedical Photonics (China)
- 8 Visible Brain-Wide Networks
Yu Chen, University of Maryland, College Park (United States)

Part C Optogenetics and Optical Control of Cells

Conference Chairs

Samarendra K. Mohanty, The University of Texas at Arlington (United States)
Nitish V. Thakor, Johns Hopkins University (United States)

Conference Program Committee

Antoine Adamantidis, McGill University (Canada)
George J. Augustine, Duke-NUS Graduate Medical School (Singapore)
Klaus B. Gerwert, Ruhr-Universität Bochum (Germany)
Xue Han, Boston University (United States)
Elizabeth M. Hillman, Columbia University (United States)
Richard Kramer, University of California, Berkeley (United States)

Alfred L. Nuttall, Oregon Health & Science University (United States)
Anna W. Roe, Vanderbilt University (United States)
Ulrich T. Schwarz, Fraunhofer IAF (Germany) and IMTEK, Albert-Ludwigs-Universität Freiburg (Germany)
John P. Welsh, University of Washington (United States)
Rafael Yuste M.D., Columbia University (United States)

Session Chairs

- 1 Optogenetics I
Nitish V. Thakor, Johns Hopkins University (United States)
Samarendra K. Mohanty, The University of Texas at Arlington (United States)
- 2 Optogenetics II
Nitish V. Thakor, Johns Hopkins University (United States)
Samarendra K. Mohanty, The University of Texas at Arlington (United States)
- 3 Optogenetics III
George J. Augustine, Lee Kong Chian Medical School (Singapore)
- 4 Optogenetics IV
George J. Augustine, Lee Kong Chian Medical School (Singapore)

Introduction

While light has been used for several decades for non-contact stimulation and manipulation of cells, optogenetics adds to the innovative optical toolkit for optical control of cells. Optogenetics refers to the use of optics and genetics together for controlling activity of proteins and cellular function. Optogenetics present cell-specific optical control of the functioning of genetically-targeted/modified cells. The use of optogenetics has exploded in last few years and has given rise to great advances in basic and applied research. The cellular functions that can be controlled with optogenetics include stimulation/inhibition of cells, gene activation, intracellular signaling, and migration. Many different cells including neurons, cardiac cells, stem cells and cancer cells can be controlled by optogenetic modulation. Optogenetics technologies could eventually form the basis for vision restoration, psychiatric treatment and pain-control. Photonic technologies are playing crucial role in both delivering light for cellular control, and, in some cases, for imaging the consequences of this control. The conference was divided into four major sessions spread over two days.

Innovative schemes for delivery and control of light irradiation, including miniaturized light sources, fiber optics, waveguides and special beams can potentially transform optogenetic approaches. Prof. John Rogers (UIUC) described the advancement on implantable, wireless optoelectronic systems for optogenetics, as part of the opening keynote lecture. Results of chronic optogenetic stimulation and recording across cortical areas in non-human primates using high-density micro-electrocorticography were presented in this session. Further, ultra-compact multi-channel implantable optical neural probes for deep brain optogenetic stimulation using visible array waveguide gratings or multipoint light emitting optical fibers were described in several talks. Prof. Patrick Ruther (Univ. of Freiburg) presented an invited talk on "Highly compact MEMS-based optrodes with integrated light sources" in which he reviewed the state-of-the-art technologies for optrodes enabling simultaneous illumination and electrical recording from brain. Together, these talks depicted the role of nanophotonics and electronics in successful implementation of optogenetic technologies.

Prof. Edward S. Boyden (MIT) gave the second Keynote lecture on "Optical tools for mapping and engineering the brain". His talk described his recent work on high-resolution imaging of brain using expansion microscopy. Further, he presented advancement in the development of new opsins in his lab providing red-shifted activation. With development of near-infrared light controllable proteins, cellular systems can be modulated in a minimally-invasive manner. Yawo group presented use of up-conversion of near-infrared light by lanthanide nanoparticles to activate channelrhodopsins for manipulating neural activities. Researchers from Mohanty Laboratory presented development of multi-opsin

and use of broad-band light for ambient white-light based restoration of vision in photodegenerative retinal diseases. While molecular biology researchers will continue to engineer more efficient opsins having unique temporal, functional, and spectral characteristics, there is also a need to develop new molecular probes and imaging method for mapping cellular activation. Label-free optical polarimetric detection of cellular activation by optogenetic excitation was presented in this conference. A representative from industry (AXXAM, Italy) presented the use of different light-gated actuators and sensors in the generation of novel cellular recombinant assays, in order to prove their robustness and adaptability for drug discovery assays.

Several studies on *in-vivo* optical stimulation and optical/electrical read-out from neural circuits in non-human primates and rodents were presented. In a keynote lecture titled "Playing the piano with neural circuits: simultaneous 3D all-optical imaging and activation of neurons *in vivo*", Prof. Yuste (Columbia University) reviewed the efforts of his group in developing optical methods to perform two-photon imaging and photostimulation of neuronal populations using spatial light modulators, PSF engineering and a variety of optical, optogenetic and optochemical sensors. He also delivered a talk on "Simultaneous Imaging of Neural Activity in 3D" as part of BiOS hot topics. Detection and modulation of spatiotemporal patterns of neuronal activity in primary visual cortex from awake behaving mice was presented. Dr. Nassi (Salk Institute) presented measurement on the causal effects of locally-generated excitation and inhibition on spontaneous and visually-evoked responses in visual cortex of alert, fixating macaque monkeys. Prof. Augustine (KIST and Duke) presented an invited talk on optogenetics to map the spatial organization of local circuits.

Innovations in optical techniques hold significant promise for advancing optogenetic technologies. The introduction of non-linear optics has allowed precise and in-depth spatial control of optogenetic stimulation with (sub)cellular resolution. *In vivo* all-optical interrogation of neurons in mice using two-photon optogenetic stimulation and calcium imaging with two-photon fluorescence microscopy was presented by researchers from Canada. Prof. Shoham (Israel Institute of Technology) presented an invited talk on "Distributed optogenetic interfacing with retinas, optonets and brains: photonics and potential applications". Researchers from UIUC described the use of a photonic crystal fiber pumped by Ytterbium laser as a broadband femtosecond source for two-photon optogenetics and imaging. Researchers from Europe presented Spatio-angular light control in microscopes using micro mirror arrays for precise, localized activation of optogenetic probes or the activation and deactivation of signaling cascades using photo-activated ion-channels. An automated laser tracking and photothermal/optogenetic manipulation system for studying social behaviors in multiple freely moving fruit flies was described in an invited talk by Dr. Lin (National Tsing Hua Univ). Researchers from Mohanty Laboratory described use of ultrafast NIR laser microbeam for delivery of opsin-encoding genes and

impermeable actin-staining molecules into spatially-targeted neurons enabling visualization of neuronal network and their activation.

Besides control of light-activatable ion-channels, optogenetics encompasses controlling activity of other proteins and cellular functions. The varieties of cellular functions that can be controlled with optogenetics include stimulation/inhibition of cells, gene activation, intracellular signaling, and migration. Prof. Hahn (UNC at Chapel Hill) presented a keynote lecture on "Engineering proteins for visualization and control of signaling networks in vivo". He described new tools to visualize and manipulate signaling in cells, using Rho family GTPase networks and cell motility as test beds. Further, methods to direct activated kinases to specific targets and control sequestration of proteins at intracellular membranes with light was described. Prof. Lin (Stanford) described optogenetic control of protein activity with photodissociable fluorescent proteins. Such fluorescent light-inducible proteins enabled optical control over guanine nucleotide exchange factor and protease domains, and can be generalized in future to other protein families including kinase and DNA nuclease. Studies on optomechanical and photothermal manipulation of cells were also presented by various researchers. Scientists from Japan presented work on "Laser-induced perturbation into molecular dynamics localized in neuronal cell" using optical trapping dynamics of synaptic vesicles or neural cell adhesion molecules. Further, dielectrophoretic trapping using metal coated chemically etched fiber was proposed for cell manipulation and isolation. At the end of the conference, Prof. Mohanty presented all-optical approach for construction (by optical tweezers, and axonal guidance), and manipulation (laser nanosurgery and optoporation) as well as modulation (optical or optogenetic) and detection (calcium and quantitative phase imaging) of neural activities.

While looking forward, we believe applications of optogenetic and other optical modulation of cells will have wide-variety of basic research and biomedical applications. Though representatives from industry also participated in the conference, more active role of the photonics industry in developing novel source and imaging platforms for optical activation and detection of cellular activities will be crucial for the successful development of this area. We hope that reading the talks presented in the annual Optogenetics and Optical control of cells conference and abstracts/articles provided in this volume will convey the knowledge and excitement of this exciting field. We look forward to your participation as authors and presenters in this conference next year. In addition to the travel support provided by SPIE to selected students, we were able to partially support selected speakers. We believe that we will be able to support more participants next year with support from the sponsors.

Acknowledgements

We would like to thank BiOS symposium chairs Prof. Rox Anderson (Harvard) and Prof. Jim Fujimoto (MIT) for continuous encouragement to organize the conference on Optogenetics and Optical control of cells as part of the BiOS

symposium during Photonics West 2015. We would also like to thank Prof. George Augustine (KIST and Duke University), Prof. Rafael Yuste (Columbia University), Prof. Ulrich T. Schwarz (Univ. of Freiburg), Prof. Anna Roe (Vanderbilt University), Prof. John Welsh (University of Washington-Seattle), Prof. Richard Kramer (UC Berkeley), Prof. Xue Han (Boston University), Prof. Klaus Gerwert (Ruhr-Univ. Bochum), Prof. Elizabeth Hillman (Columbia University), Prof. Alfred L. Nuttall (Oregon Health & Science Univ), Prof. Antoine Adamantidis (McGill University) for their valuable input as members of the Program Committee. We would like to thank all keynote and invited speakers, session chairs, and participants for their important contributions. We would like to thank our sponsors, SPIE and Plexon Inc. (Mr. Harvey Wiggins) for their support.

Samarendra K. Mohanty
Nitish V. Thakor