

Optical Techniques in Neurosurgery, Neurophotonics, and Optogenetics

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

**1–4 February 2014
San Francisco, California, United States**

Sponsored and Published by
SPIE

Volume 8928

Proceedings of SPIE, 1605-7422, V. 8928

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

Optical Techniques in Neurosurgery, Neurophotonics, and Optogenetics, edited by Henry Hirschberg, et al.,
Proc. of SPIE Vol. 8928, 892801 · © 2014 SPIE · CCC code: 1605-7422/14/\$18 · doi: 10.1117/12.2053579

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*, edited by Henry Hirschberg, et al., Proceedings of SPIE Vol. 8928 (SPIE, Bellingham, WA, 2014) Article CID Number.

ISSN: 1605-7422

ISBN: 9780819498410

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 © 2014, 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 1605-7422/14/\$18.00.

Printed in the United States of America.

Publication of record for individual papers is online in the 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 and on CD-ROM. Papers are published as they are submitted and meet publication criteria. A unique, consistent, permanent 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.

Contents

ix *Conference Committee*

New small quantum dots for neuroscience (Hot Topics Presentation, Presentation Video) [8928-301]

P. Selvin, Univ. of Illinois at Urbana-Champaign (United States)

View the presentation on the SPIE Digital Library: <http://dx.doi.org/10.1117/12.2064194>

Journey into the brain: from single synapse to whole brain anatomy by correlative microscopy (Hot Topics Presentation, Presentation Video) [8928-501]

F. Pavone, European Lab. for Non-linear Spectroscopy (Italy)

View the presentation on the SPIE Digital Library: <http://dx.doi.org/10.1117/12.2064487>

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

MICROSCOPY AND OCT I

8928 04 **Optical coherence microscopy of mouse cortical vasculature surrounding implanted electrodes** [8928-3]

D. X. Hammer, A. Lozzi, E. Abliz, N. Greenbaum, K. P. Turner, T. J. Pfefer, A. Agrawal, V. Krauthamer, C. G. Welle, U.S. Food and Drug Administration (United States)

MICROSCOPY AND OCT II

8928 06 **Interpreting CARS images of tissue within the C-H-stretching region** [8928-5]

B. Dietzek, Institut für Photonische Technologien e.V. (Germany) and Friedrich-Schiller-Univ. Jena (Germany); T. Meyer, Friedrich-Schiller-Univ. Jena (Germany); A. Medyukhina, N. Bergner, C. Krafft, Institut für Photonische Technologien e.V. (Germany); B. F. M. Romeike, R. Reichart, R. Kalf, M. Schmitt, Friedrich-Schiller-Univ. Jena (Germany); J. Popp, Institut für Photonische Technologien e.V. (Germany) and Friedrich-Schiller-Univ. Jena (Germany)

8928 08 **Raman spectroscopy of gliomas: an exploratory study** [8928-7]

M. Shenoy, A. R. Hole, E. Shridhar, A. V. Moiyadi, C. M. Krishna, ACTREC, Tata Memorial Ctr. (India)

OPERATIVE AND POST-OP THERAPY I

- 8928 09 **Quantitative spectrally resolved intraoperative fluorescence imaging for neurosurgical guidance in brain tumor surgery: pre-clinical and clinical results** [8928-8]
P. A. Valdés, Dartmouth College (United States) and Dartmouth Hitchcock Medical Ctr. (United States); V. L. Jacobs, F. Leblond, Dartmouth College (United States); B. C. Wilson, Univ. of Toronto (Canada); K. D. Paulsen, D. W. Roberts, Dartmouth College (United States) and Dartmouth Hitchcock Medical Ctr. (United States)
- 8928 0B **Photochemical internalization (PCI) enhanced nonviral transfection of tumor suppressor and pro-drug activating genes: a potential treatment modality for gliomas** [8928-10]
F. Wang, G. Zamora, C.-H. Sun, A. Trinidad, Beckman Laser Institute and Medical Clinic (United States); K. Berg, Oslo Univ. Hospital (Norway); S. J. Madsen, Univ. of Nevada, Las Vegas (United States); Y. J. Kwon, Univ. of California, Irvine (United States); H. Hirschberg, Beckman Laser Institute and Medical Clinic (United States) and Univ. of Nevada, Las Vegas (United States)
- 8928 0D **Mid-IR laser system for advanced neurosurgery** [8928-12]
M. Klosner, C. Wu, D. F. Heller, Light Age, Inc. (United States)

OPERATIVE AND POST-OP THERAPY II

- 8928 0E **5-ALA based photodynamic management of glioblastoma** [8928-13]
A. Rühm, H. Stepp, W. Beyer, G. Hennig, T. Pongratz, R. Sroka, O. Schnell, J.-C. Tonn, F.-W. Kreth, Klinikum der Univ. München (Germany)
- 8928 0F **Ultra low fluence rate photodynamic therapy: simulation of light emitted by the Cerenkov effect** [8928-14]
J. Gonzales, F. Wang, G. Zamora, A. Trinidad, Beckman Laser Institute and Medical Clinic (United States); L. Marcu, S. Cherry, Univ. of California, Davis (United States); H. Hirschberg, Beckman Laser Institute and Medical Clinic (United States)

OPTICAL SPECTROSCOPY AND TOMOGRAPHY: PRE-CLINICAL

- 8928 0I **Combining ICA and Granger causality: a novel tool for investigation of brain dynamics and brain oscillations using fNIRS measurements** [8928-17]
Z. Yuan, Univ. of Macau (Macao, China)
- 8928 0J **Monitoring closed head injury induced changes in brain physiology with orthogonal diffuse near-infrared reflectance spectroscopy** [8928-18]
D. Abookasis, A. Shochat, Ariel Univ. (Israel); M. S. Mathews, Univ. of California Irvine Medical Ctr. (United States)
- 8928 0K **Near-infrared diffuse reflectance imaging of infarct core and peri-infarct depolarization in a rat middle cerebral artery occlusion model** [8928-19]
S. Kawauchi, National Defense Medical College (Japan); I. Nishidate, Tokyo Univ. of Agriculture and Technology (Japan); H. Nawashiro, Tokorozawa Central Hospital (Japan); S. Sato, National Defense Medical College (Japan)

- 8928 OL **Implantable CMOS imaging device with absorption filters for green fluorescence imaging** [8928-20]
Y. Sunaga, M. Haruta, H. Takehara, Y. Ohta, M. Motoyama, T. Noda, K. Sasagawa, T. Tokuda, J. Ohta, Nara Institute of Science and Technology (Japan)
- 8928 ON **In vivo imaging of scattering and absorption properties of exposed brain using a digital red-green-blue camera** [8928-22]
I. Nishidate, K. Yoshida, Tokyo Univ. of Agriculture and Technology (Japan); S. Kawauchi, S. Sato, National Defense Medical College Research Institute (Japan); M. Sato, Yamagata Univ. (Japan)

OPTICAL SPECTROSCOPY AND TOMOGRAPHY: CLINICAL

- 8928 OO **Hemodynamic measurements in deep brain tissues of humans by near-infrared time-resolved spectroscopy** [8928-23]
H. Suzuki, M. Oda, E. Yamaki, T. Suzuki, D. Yamashita, K. Yoshimoto, S. Homma, Y. Yamashita, Hamamatsu Photonics K.K. (Japan)
- 8928 OQ **Noninvasive optical evaluation of low frequency oscillations in prefrontal cortex hemodynamics during verbal working memory** [8928-26]
T. Li, Y. Zhao, K. Li, Y. Sun, Univ. of Electronic Science and Technology of China (China)

POSTER SESSION

- 8928 OR **Development of a fiber-less fNIRS system and its application to hair-covered head** [8928-27]
T. Yamada, National Institute of Advanced Industrial Science and Technology (Japan); M. Ohashi, Spectratech, Inc. (Japan); S. Umeyama, National Institute of Advanced Industrial Science and Technology (Japan)
- 8928 OS **Precise spatial co-registration in simultaneous fNIRS and fMRI measurements using markers coaxially fixable to the optodes** [8928-28]
T. Yamada, K. Matsuda, T. Iwano, S. Umeyama, National Institute of Advanced Industrial Science and Technology (Japan)
- 8928 OT **Technical considerations on confocal based fluorescence micro-optical sectioning tomography for visualizing brain circuits** [8928-29]
X. Qi, X. Lv, H. Xiong, C. Yan, J. Chen, H. Gong, Q. Luo, S. Zeng, Huazhong Univ. of Science and Technology (China)
- 8928 OU **Photothermal therapy of human glioma spheroids with gold-silica nanoshells and gold nanorods: a comparative study** [8928-30]
S. Chhetri, Univ. of Nevada, Las Vegas (United States); H. Hirschberg, Beckman Laser Institute and Medical Clinic (United States); S. J. Madsen, Univ. of Nevada, Las Vegas (United States)
- 8928 OV **Activity-dependent signal changes in neurons by fiber-coupled microscopy** [8928-31]
T. Sakurai, K. Koida, Toyohashi Univ. of Technology (Japan)

Part B Neurophotronics

NOVEL PHOTONIC/OPTOELECTRONIC METHODS AND APPLICATIONS II

- 8928 14 **Studying hemispheric lateralization during a Stroop task by near-infrared spectroscopy (Invited Paper)** [8928-40]
L. Zhang, J. Sun, B. Sun, Q. Luo, H. Gong, Huazhong Univ. of Science and Technology (China)
- 8928 15 **Quantitative assessment of brain tissue oxygenation in porcine models of cardiac arrest and cardiopulmonary resuscitation using hyperspectral near-infrared spectroscopy (Invited Paper)** [8928-41]
S. S. Loffabadi, Ryerson Univ. (Canada) and Centennial College (Canada); V. Toronov, Ryerson Univ. (Canada); A. Ramadeen, X. Hu, St. Michael's Hospital (Canada); S. Kim, Ryerson Univ. (Canada); P. Dorian, G. M. Hare, St. Michael's Hospital (Canada) and Univ. of Toronto (Canada)
- 8928 16 **Optical stimulation of the hearing and deaf cochlea under thermal and stress confinement condition** [8928-42]
M. Schultz, Laser Zentrum Hannover e.V. (Germany) and Cluster of Excellence "Hearing4all" (Germany); P. Baumhoff, Medizinische Hochschule Hannover (Germany); N. Kallweit, Laser Zentrum Hannover e.V. (Germany) and Cluster of Excellence "Hearing4all" (Germany); M. Sato, Medizinische Hochschule Hannover (Germany) and Cluster of Excellence "Hearing4all" (Germany); A. Krüger, T. Ripken, Laser Zentrum Hannover e.V. (Germany) and Cluster of Excellence "Hearing4all" (Germany); T. Lenarz, Medizinische Hochschule Hannover (Germany) and Cluster of Excellence "Hearing4all" (Germany); A. Kral, Medizinische Hochschule Hannover (Germany) and Cluster of Excellence "Hearing4all" (Germany)
- 8928 18 **Infrared neural stimulation (INS) inhibits electrically evoked neural responses in the deaf white cat** [8928-103]
C.-P. Richter, Northwestern Univ. (United States); S. M. Rajguru, Univ. of Miami (United States); A. Robinson, H. K. Young, Northwestern Univ. (United States)
- 8928 19 **Target structures in the cochlea for infrared neural stimulation (INS)** [8928-104]
H. Young, X. Tan, C.-P. Richter, Northwestern Univ. (United States)

OPTICAL NEUROIMAGING I

- 8928 1B **Development of optical neuroimaging to detect drug-induced brain functional changes *in vivo* (Invited Paper)** [8928-45]
C. Du, Y. Pan, Stony Brook Univ. (United States)
- 8928 1D **Imaging of rat brain using short graded-index multimode fiber** [8928-47]
M. Sato, T. Kanno, S. Ishihara, H. Suto, T. Takahashi, R. Kurotani, H. Abe, Yamagata Univ. (Japan); I. Nishidate, Tokyo Univ. of Agriculture and Technology (Japan)

VISIBLE BRAINWIDE NETWORKS II

- 8928 1N ***In vivo* imaging of neural reactive plasticity after laser axotomy in cerebellar cortex (Invited Paper)** [8928-57]
A. L. Allegra Mascaro, European Lab. for Non-Linear Spectroscopy, Univ. of Florence (Italy); L. Sacconi, European Lab. for Non-Linear Spectroscopy, Univ. of Florence (Italy) and INO-CNR (Italy); B. Maco, G. W. Knott, Ecole Polytechnique Fédérale de Lausanne (Switzerland); F. S. Pavone, European Lab. for Non-Linear Spectroscopy, Univ. of Florence (Italy), INO-CNR (Italy), and ICON Foundation (Italy)

OPTICAL NEUROIMAGING IV

- 8928 1W **Astrocytic adaptation during cerebral angiogenesis follows the new vessel formation induced through chronic hypoxia in adult mouse cortex (Invited Paper)** [8928-67]
K. Masamoto, Univ. of Electro-Communications (Japan) and National Institute of Radiological Sciences (Japan); I. Kanno, National Institute of Radiological Sciences (Japan)

POSTER SESSION

- 8928 1Z **Cerebral hemodynamics in patients with obstructive sleep apnea syndrome monitored with near-infrared spectroscopy (NIRS) during positive airways pressure (CPAP) therapy: a pilot study** [8928-69]
Z. Zhang, M. Schneider, Clinic Barmelweid (Switzerland) and Univ. Hospital Zurich (Switzerland); M. Laures, U. Fritschi, I. Lehner, M. Qi, Clinic Barmelweid (Switzerland); R. Khatami, Clinic Barmelweid (Switzerland) and Univ. Hospital Zurich (Switzerland)
- 8928 20 **A pilot study to compare the cerebral hemodynamics between patients with obstructive sleep apnea syndrome (OSA) and periodic limb movement syndrome (PLMS) during nocturnal sleep with near-infrared spectroscopy (NIRS)** [8928-70]
Z. Zhang, Clinic Barmelweid (Switzerland) and Univ. Hospital Zurich (Switzerland); M. Schneider, M. Laures, U. Fritschi, G. Hügli, I. Lehner, M. Qi, Univ. Hospital Zurich (Switzerland); R. Khatami, Clinic Barmelweid (Switzerland) and Univ. Hospital Zurich (Switzerland)
- 8928 22 **The effect of RGB monochromatic and polychromatic LED lighting on growth performance, behavior, and development of broilers** [8928-72]
W. B. B. Morrill, J. M. C. Barnabé, T. P. N. da Silva, H. Pandorfi, A. S. Gouveia-Neto, W. S. Souza, Univ. Federal Rural de Pernambuco (Brazil)
- 8928 29 **Optical monitoring of shock wave-induced spreading depolarization and concomitant hypoxemia in rat brain** [8928-79]
W. Okuda, Tokyo Univ. of Agriculture and Technology (Japan); S. Kawachi, H. Ashida, S. Sato, National Defense Medical College Research Institute (Japan); I. Nishidate, Tokyo Univ. of Agriculture and Technology (Japan)

Part C Optogenetics and Optical Control of Cells

OPTOGENETICS II

- 8928 2F **Non-invasive activation of optogenetic actuators** [8928-85]
E. Birkner, K. Berglund, M. E. Klein, Duke Univ. (United States); G. J. Augustine, Nanyang Technological Univ. (Singapore), Institute of Molecular and Cell Biology (Singapore), and Korea Institute of Science and Technology (Korea, Republic of); U. Hochgeschwender, Duke Univ. (United States)

OPTICAL CONTROL OF CELLS II

- 8928 2N **Fiber optic fluorescence microscopy for functional brain imaging in awake mobile mice** [8928-92]
J. Cha, Johns Hopkins Univ. (United States); M. Paukert, Johns Hopkins School of Medicine (United States) and The Univ. of Texas Health Science Ctr. at San Antonio (United States); D. E. Bergles, Johns Hopkins School of Medicine (United States); J. U. Kang, Johns Hopkins Univ. (United States)

OPTOGENETICS III

- 8928 2S **Recombinant Adeno-associated virus (rAAV)-mediated transduction and optogenetic manipulation of cortical neurons in vitro** [8928-96]
W. Lange, L. Jin, V. Maybeck, A. Meisenberg, A. Baumann, A. Offenhäusser, Forschungszentrum Jülich GmbH (Germany);

HOT TOPICS SESSION

- 8928 2X **New small quantum dots for neuroscience (Presentation Video)** [8928-301]
P. Selvin, Univ. of Illinois at Urbana-Champaign (United States)
- 8928 2Y **Journey into the brain: from single synapse to whole brain anatomy by correlative microscopy (Presentation Video)** [8928-501]
F. Pavone, European Lab. for Non-linear Spectroscopy (Italy)

Author Index

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)

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

Session Chairs

1 Microscopy and OCT I
Steen J. Madsen, University of Nevada, Las Vegas (United States)

2 Microscopy and OCT 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
Henry Hirschberg, Beckman Laser Institute and Medical Clinic
(United States)
- 5 Optical Spectroscopy and Tomography: Pre-Clinical
David Abookasis, Ariel University (Israel)
- 6 Optical Spectroscopy and Tomography: Clinical
Frederic Leblond, Ecole Polytechnique de Montréal (Canada)

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

Yu Chen, University of Maryland, College Park (United States)
Hongwei Dong, University of California, Los Angeles (United States)
Congwu Du, Stony Brook University (United States)
Z. Josh Huang, Cold Spring Harbor Laboratory (United States)
Matthew D. Keller, Lockheed Martin Aculight (United States)
Beop-Min Kim, Korea University (Korea, Republic of)
Vesa Kiviniemi, University of Oulu (Finland)
Pengcheng Li, Britton Chance Center for Biomedical Photonics,
Huazhong University of Science and Technology (China)
Anita Mahadevan-Jansen, Vanderbilt University (United States)
Timothy H. Murphy, The University of British Columbia (Canada)
Francesco Saverio Pavone, European Lab. for Non-linear
Spectroscopy (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,
Huazhong University of Science and Technology (China)

Session Chairs

- 7 Novel Photonic/Optoelectronic Methods and Applications I
Yu Chen, University of Maryland, College Park (United States)
Ling Fu, Huazhong University of Science and Technology (China)
- 8 Novel Photonic/Optoelectronic Methods and Applications II
Vladislav Toronov, Ryerson University (Canada)
Ling Fu, Huazhong University of Science and Technology (China)
- 9 Optical Neuroimaging I
Shy Shoham, Technion-Israel Institute of Technology (Israel)
Congwu Du, Stony Brook University (United States)
- 10 Optical Neuroimaging II
Wei Zhou, Huazhong University of Science and Technology (China)
- 11 Visible Brainwide Networks I
Qingming Luo, Huazhong University of Science and Technology (China)
Francesco Saverio Pavone, European Lab. for Non-linear Spectroscopy (Italy)
- 12 Visible Brainwide Networks II
Timothy H. Murphy, The University of British Columbia (Canada)
- 13 Optical Neuroimaging III
Jun Ding, Stanford School of Medicine (United States)
Beop-Min Kim, Korea University College of Health Sciences (Korea, Republic of)
- 14 Optical Neuroimaging IV
E. Duco Jansen, Vanderbilt University (United States)
Shaoqun Zeng, Britton Chance Center for Biomedical Photonics, Huazhong University of Science and Technology (China)

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

Anna W. Roe, Vanderbilt University (United States)
Elizabeth M. Hillman, Columbia University (United States)
Isaac P. Clements, Plexon Inc. (United States)
John P. Welsh, University of Washington (United States)
Rafael Yuste M.D., Columbia University (United States)
Xue Han, Boston University (United States)
George J. Augustine, Duke-NUS Graduate Medical School
(Singapore)
Richard Kramer, University of California, Berkeley (United States)
Klaus B. Gerwert, Ruhr-Universität Bochum (Germany)
Alfred L. Nuttall, Oregon Health and Science University (United States)
Antoine Adamantidis, McGill University (Canada)

Session Chairs

- 15 Optogenetics I
Samarendra K. Mohanty, The University of Texas at Arlington
(United States)
- 16 Optogenetics II
Wei-Chuan Shih, The University of Houston (United States)
- 17 Optical Control of Cells I
Darcy Peterka, Columbia University (United States)
- 18 Optical Control of Cells II
Francesco Saverio Pavone, European Lab. for Non-linear
Spectroscopy (Italy)
- 19 Optogenetics III
John Lin, University of California at San Diego (United States)
- 20 Optogenetics IV
Fow-Sen Choa, The University of Maryland, Baltimore County
(United States)