

PROGRESS IN BIOMEDICAL OPTICS AND IMAGING

Vol. 10, No. 17

# ***Photons Plus Ultrasound: Imaging and Sensing 2009***

**Alexander A. Oraevsky**

**Lihong V. Wang**

*Editors*

**25–28 January 2009**

**San Jose, California, United States**

*Sponsored by*  
SPIE

*Cosponsored by*  
Fairway Medical Technologies, Inc. (United States)

*Published by*  
SPIE

**Volume 7177**

Proceedings of SPIE, 1605-7422, v. 7177

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

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 *Photons Plus Ultrasound: Imaging and Sensing 2009*, edited by Alexander A. Oraevsky, Lihong V. Wang, Proceedings of SPIE Vol. 7177 (SPIE, Bellingham, WA, 2009) Article CID Number.

ISSN 1605-7422

ISBN 9780819474230

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 © 2009, 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](http://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 1605-7422/09/\$18.00.

Printed in the United States of America.

Publication of record for individual papers is online in the SPIE Digital Library.

The logo for SPIE Digital Library features the word "SPIE" in a bold, sans-serif font above the words "Digital Library" in a smaller, lighter font. To the right of the text is a stylized graphic consisting of three vertical bars of increasing height, resembling a bar chart or a signal waveform.

[SPIDigitalLibrary.org](http://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 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. Numbers in the index correspond to the last two digits of the six-digit CID number.

# Contents

- xiii Conference Committee  
xv Introduction to the 10th Proceedings of Photons Plus Ultrasound: Imaging and Sensing

---

## SESSION 1 CLINICAL APPLICATIONS

---

- 7177 02 **Quantitative analysis with the optoacoustic/ultrasound system OPUS** [7177-01]  
C. Haisch, K. Zell, Technische Univ. München (Germany); J. Sperl, M. W. Vogel, GE Global Research (Germany); R. Niessner, Technische Univ. München (Germany)
- 7177 03 **Development of laser optoacoustic and ultrasonic imaging system for breast cancer utilizing handheld array probes** [7177-02]  
S. A. Ermilov, Fairway Medical Technologies, Inc. (United States); M. P. Fronheiser, Seno Medical Instruments (United States); H.-P. Brecht, R. Su, A. Conjusteau, K. Mehta, Fairway Medical Technologies, Inc. (United States); P. Otto, Cancer Therapy and Research Ctr. (United States); A. A. Oraevsky, Fairway Medical Technologies, Inc. (United States) and Seno Medical Instruments (United States)
- 7177 04 **Real-time photoacoustic and ultrasound imaging of human vasculature** [7177-03]  
R. G. M. Kolkman, Univ. of Twente (Netherlands); P. J. Brands, Esaote Europe B.V. (Netherlands); W. Steenbergen, Univ. of Twente (Netherlands); T. G. van Leeuwen, Univ. of Twente (Netherlands) and Univ. of Amsterdam (Netherlands)
- 7177 05 **Clinical tests of highly portable 2-lb. laser diode-based noninvasive optoacoustic hemoglobin monitor** [7177-04]  
I. Y. Petrova, Y. Y. Petrov, D. S. Prough, R. O. Esenaliev, The Univ. of Texas Medical Branch at Galveston (United States)
- 7177 06 **Clinical tests of noninvasive optoacoustic cerebral venous oxygenation monitoring system** [7177-05]  
Y. Y. Petrov, I. Y. Petrova, R. O. Esenaliev, D. S. Prough, The Univ. of Texas Medical Branch at Galveston (United States)

---

## SESSION 2 TOWARD CLINICAL APPLICATIONS

---

- 7177 07 **Photoacoustic guidance of diffusive optical tomography with a hybrid reflection geometry probe** [7177-06]  
J. Gamelin, Y. Ardeshirpour, A. Aguirre, B. Takavoli, Q. Zhu, Univ. of Connecticut (United States)
- 7177 08 **Photoacoustic characterization of ovarian tissue** [7177-07]  
A. Aguirre, J. Gamelin, Univ. of Connecticut (United States); P. Guo, Electrocore LLC (United States); S. Yan, Siemens Molecular Imaging (United States); M. Sanders, M. Brewer, Q. Zhu, Univ. of Connecticut Health Ctr. (United States)

- 7177 09 **Reflection mode photoacoustic imaging through infant skull toward noninvasive imaging of neonatal brains** [7177-08]  
X. Wang, J. B. Fowlkes, D. L. Chamberland, Univ. of Michigan School of Medicine (United States); G. Xi, Univ. of Michigan (United States); P. L. Carson, Univ. of Michigan School of Medicine (United States)
- 7177 0A **Photoacoustic characterisation of vascular tissue at NIR wavelengths** [7177-09]  
T. J. Allen, P. C. Beard, Univ. College London (United Kingdom)

---

**SESSION 3 PRECLINICAL IMAGING IN SMALL ANIMALS**

---

- 7177 0B **A fast 512-element ring array photoacoustic imaging system for small animals** [7177-10]  
J. Gamelin, A. Maurudis, A. Aguirre, F. Huang, P. Guo, Univ. of Connecticut (United States); L. V. Wang, Washington Univ. in St. Louis (United States); Q. Zhu, Univ. of Connecticut (United States)
- 7177 0C **Photoacoustic microscopy of cerebral blood-oxygenation dynamics in mice** [7177-11]  
K. Maslov, E. W. Stein, L. V. Wang, Washington Univ. in St. Louis (United States)
- 7177 0D **Mesosopic imaging of fluorescent proteins using multi-spectral optoacoustic tomography (MSOT)** [7177-12]  
D. Razansky, Technical Univ. of Munich (Germany) and Helmholtz Ctr. Munich (Germany); C. Vinegoni, Massachusetts General Hospital (United States) and Harvard Medical School (United States); V. Ntziachristos, Technical Univ. of Munich (Germany) and Helmholtz Ctr. Munich (Germany)
- 7177 0E **Optoacoustic 3D whole-body tomography: experiments in nude mice (Best Paper Award)** [7177-13]  
H.-P. Brecht, R. Su, Fairway Medical Technologies, Inc. (United States); M. Fronheiser, Seno Medical Instruments, Inc. (United States); S. A. Ermilov, A. Conjusteau, Fairway Medical Technologies, Inc. (United States); A. Liopo, M. Motamedi, The Univ. of Texas Medical Branch at Galveston (United States); A. A. Oraevsky, Fairway Medical Technologies, Inc. (United States) and Seno Medical Instruments, Inc. (United States)
- 7177 0F **HYPR-spectral photoacoustic CT for preclinical imaging** [7177-14]  
R. Kruger, D. Reinecke, G. Kruger, OptoSonics, Inc. (United States); M. Thornton, P. Picot, T. Morgan, Endra, Inc. (United States); K. Stantz, Purdue Univ. (United States); C. Mistretta, Univ. of Wisconsin, Madison (United States)

---

**SESSION 4 HIGH-RESOLUTION IMAGING/MICROSCOPY**

---

- 7177 0G **Fast 3-D photoacoustic imaging in vivo with a high frequency ultrasound array toward clinical applications** [7177-15]  
L. Song, K. Maslov, Washington Univ. in St. Louis (United States); R. Bitton, K. K. Shung, Univ. of Southern California (United States); L. V. Wang, Washington Univ. in St. Louis (United States)
- 7177 0H **In vivo noninvasive monitoring of microhemodynamics using optical-resolution photoacoustic microscopy** [7177-16]  
S. Hu, K. I. Maslov, L. V. Wang, Washington Univ. in St. Louis (United States)

- 7177 0I **In vivo imaging of microcirculation using integrated photoacoustic and optical coherence microscopy** [7177-17]  
L. Li, K. I. Maslov, G. Ku, L. V. Wang, Washington Univ. in St. Louis (United States)
- 7177 0K **Three-dimensional photoacoustic tomography of small animal brain with a curved array transducer** [7177-19]  
X. Yang, L. V. Wang, Washington Univ. in St. Louis (United States); A. Maurudis, J. Gamelin, A. Aguirre, Q. Zhu, Univ. of Connecticut (United States)
- 7177 0L **Laser-scanning optical-resolution photoacoustic microscopy** [7177-20]  
H. F. Zhang, Z. Xie, Univ. of Wisconsin, Milwaukee (United States); S. Jiao, C. A. Puliafito, Univ. of Southern California (United States)

---

**SESSION 5 NEW OPTOACOUSTIC SYSTEMS**

---

- 7177 0M **Deep tissue optoacoustic imaging of polarized structures** [7177-22]  
D. Razansky, Technical Univ. of Munich (Germany) and Helmholtz Ctr. Munich (Germany); C. Vinegoni, Massachusetts General Hospital (United States) and Harvard Medical School (United States); V. Ntziachristos, Technical Univ. of Munich (Germany) and Helmholtz Ctr. Munich (Germany)
- 7177 0N **Endoscopic photoacoustic microscopy** [7177-23]  
J.-M. Yang, K. Maslov, Washington Univ. in St. Louis (United States); H.-C. Yang, Q. Zhou, Univ. of Southern California (United States); L. V. Wang, Washington Univ. in St. Louis (United States)
- 7177 0O **Novel optoacoustic array for noninvasive monitoring of blood parameters** [7177-24]  
V. G. Andreev, Lomonosov Moscow State Univ. (Russian Federation) and Univ. of Texas Medical Branch at Galveston (United States); Y. Y. Petrov, D. S. Prough, I. Y. Petrova, R. O. Esenaliev, Univ. of Texas Medical Branch at Galveston (United States)
- 7177 0Q **A photoacoustic method for optical scattering measurements in turbid media** [7177-26]  
R. J. Zemp, J. Ranasinghesagara, Y. Jiang, X. Chen, K. Mathewson, Univ. of Alberta (Canada)

---

**SESSION 6 NEW TRANSDUCERS AND ARRAYS**

---

- 7177 0R **High-NA-based virtual point detectors for photoacoustic imaging** [7177-27]  
C. Li, L. V. Wang, Washington Univ. in St. Louis (United States)
- 7177 0S **Photoacoustic imaging with limited diffraction beam transducers** [7177-28]  
G. Paltauf, S. Gratt, K. Passler, R. Nuster, Karl-Franzens-Univ. Graz (Austria); P. Burgholzer, Upper Austrian Research (Austria)
- 7177 0T **Comparison of optical and piezoelectric integrating line detectors** [7177-29]  
R. Nuster, S. Gratt, K. Passler, Karl-Franzens-Univ. Graz (Austria); H. Grün, Th. Berer, P. Burgholzer, Upper Austrian Research GmbH (Austria); G. Paltauf, Karl-Franzens-Univ. Graz (Austria)

- 7177 0U **Characterization of optoacoustic transducers through the analysis of angular-dependent frequency response** [7177-30]  
A. Conjusteau, S. A. Ermilov, R. Su, H.-P. Brecht, Fairway Medical Technologies, Inc. (United States); M. P. Fronheiser, Seno Medical Instruments (United States); A. A. Oraevsky, Fairway Medical Technologies, Inc. (United States)

---

**SESSION 7 IMPROVING AND TESTING SYSTEM PARAMETERS**

---

- 7177 0V **High sensitivity intravascular photoacoustic imaging of macrophages** [7177-31]  
B. Wang, E. Yantsen, The Univ. of Texas at Austin (United States); K. Sokolov, The Univ. of Texas at Austin (United States) and The Univ. of Texas M.D. Anderson Cancer Ctr. (United States); S. Emelianov, The Univ. of Texas at Austin (United States)
- 7177 0W **3D photoacoustic imaging of a moving target** [7177-32]  
P. Ephrat, M. Roumeliotis, F. S. Prato, J. J. L. Carson, Lawson Health Research Institute (Canada) and Univ. of Western Ontario (Canada)
- 7177 0X **Optoacoustic imaging: application to the detection of foreign bodies** [7177-33]  
L. Page, S. Maswadi, R. D. Glickman, The Univ. of Texas Health Science Ctr. at San Antonio (United States); N. Barsalou, Naval Health Research Ctr. Detachment (United States); R. Branstetter, S. Thompson, Seno Medical Instruments, Inc. (United States)
- 7177 0Y **Simultaneous recovery of chromophore concentrations and ultrasound velocity by spectrally resolved photoacoustic tomography** [7177-34]  
Z. Yuan, Q. Zhang, S. Grobmyer, H. Jiang, Univ. of Florida (United States)
- 7177 0Z **Reduction of background in optoacoustic image sequences obtained under tissue deformation** [7177-35]  
M. Jaeger, L. Siegenthaler, M. Kitz, M. Frenz, Univ. Bern (Switzerland)

---

**SESSION 8 COMBINED ULTRASOUND AND OPTOACOUSTICS**

---

- 7177 11 **Development of a fast-scanning combined ultrasound-photoacoustic biomicroscope** [7177-38]  
R. J. Zemp, H. Lu, K. Mathewson, J. Ranasinghesagara, Y. Jiang, A. Walsh, X. Chen, Univ. of Alberta (Canada)
- 7177 12 **Design, fabrication, and testing of a dual-band photoacoustic transducer** [7177-39]  
J.-H. Liu, C.-W. Wei, Y. Sheu, Y.-T. Tasi, Y.H. Wang, P.-C. Li, National Taiwan Univ. (Taiwan)

---

**SESSION 9 QUANTITATIVE OPTOACOUSTIC IMAGING AND MODELING**

---

- 7177 13 **The challenges for quantitative photoacoustic imaging (Invited Paper)** [7177-40]  
B. T. Cox, J. G. Laufer, P. C. Beard, Univ. College London (United Kingdom)
- 7177 15 **Quantitative measurement of tissue optical absorption spectrum in a scattering medium by photoacoustic technique** [7177-42]  
J. R. Rajian, P. L. Carson, X. Wang, Univ. of Michigan School of Medicine (United States)

- 7177 16 **Fast tissue-realistic models of photoacoustic wave propagation for homogeneous attenuating media** [7177-43]  
B. E. Treeby, B. T. Cox, Univ. College London (United Kingdom)
- 7177 17 **Monte Carlo simulation of light transport in dark-field confocal photoacoustic microscopy** [7177-44]  
Z. Xie, Univ. of Wisconsin, Milwaukee (United States); L. V. Wang, Washington Univ. in St. Louis (United States); H. F. Zhang, Univ. of Wisconsin, Milwaukee (United States)
- 7177 18 **Discriminating between absorption and scattering coefficients in optical characterisation measurements on gold nanoparticle based photoacoustic contrast agents** [7177-45]  
C. Ungureanu, Univ. Twente (Netherlands); A. Amelink, H. J. C. M. Sterenborg, Erasmus Medical Ctr. (Netherlands); S. Manohar, T. G. van Leeuwen, Univ. Twente (Netherlands)

---

**SESSION 10 SIGNAL PROCESSING AND IMAGE RECONSTRUCTION**

---

- 7177 1A **Image reconstruction in photoacoustic tomography with variable speed of sound using a higher order geometrical acoustics approximation** [7177-47]  
D. Modgil, The Univ. of Chicago (United States); M. A. Anastasio, K. Wang, Illinois Institute of Technology (United States); P. J. La Rivière, The Univ. of Chicago (United States)
- 7177 1B **Photoacoustic image reconstruction in an attenuating medium using singular value decomposition** [7177-48]  
D. Modgil, The Univ. of Chicago (United States); M. A. Anastasio, Illinois Institute of Technology (United States); P. J. La Riviere, The Univ. of Chicago (United States)
- 7177 1C **Improvements in time resolution of tomographic photoacoustic imaging using a priori information for multiplexed systems** [7177-49]  
J. Gamelin, A. Aguirre, A. Maurudis, Univ. of Connecticut (United States); L. V. Wang, Washington Univ. in St. Louis (United States); Q. Zhu, Univ. of Connecticut (United States)

---

**SESSION 11 ULTRASOUND MODULATED (ACOUSTO-OPTICAL) IMAGING I**

---

- 7177 1D **Ultrasound-modulated optical imaging using a photorefractive interferometer and a powerful long pulse laser** [7177-50]  
G. Rousseau, A. Blouin, J.-P. Monchalain, National Research Council Canada (Canada)
- 7177 1E **Ultrasound-modulated optical imaging using a confocal Fabry-Perot interferometer and a powerful long pulse laser** [7177-51]  
G. Rousseau, A. Blouin, J.-P. Monchalain, National Research Council Canada (Canada)
- 7177 1F **Ring-shaped light illumination ultrasound-modulated optical tomography and its application for sentinel lymph node mapping ex vivo** [7177-52]  
C. Kim, K. H. Song, K. Maslov, L. V. Wang, Washington Univ. in St. Louis (United States)
- 7177 1G **Sensing the optical properties of diffusive media by acousto-optic pressure contrast imaging** [7177-53]  
P. Lai, R. A. Roy, T. W. Murray, Boston Univ. (United States)

- 7177 1H **Three-dimensional acousto-optic mapping using planar scanning with ultrasound bursts** [7177-54]  
A. Bratchenia, R. Molenaar, R. P. H. Kooyman, Univ. of Twente (Netherlands)

---

**SESSION 12 ULTRASOUND MODULATED (ACOUSTO-OPTICAL) IMAGING II**

---

- 7177 1J **Ultrasound-modulated fluorescence based on a fluorophore-quencher labeled microbubble system** [7177-56]  
B. Yuan, The Catholic Univ. of America (United States)
- 7177 1L **Detection of ultrasound-modulated photons and enhancement with ultrasound microbubbles** [7177-58]  
D. J. Hall, M. J. Hsu, S. Esener, R. F. Mattrey, Univ. of California, San Diego (United States)

---

**SESSION 13 MOLECULAR IMAGING AND SENSING USING NANOPARTICLES**

---

- 7177 1M **Combined ultrasound and photoacoustic imaging of pancreatic cancer using nanocage contrast agents (Invited Paper)** [7177-59]  
K. Homan, J. Shah, S. Gomez, H. Gensler, A. Karpiouk, L. Brannon-Peppas, S. Emelianov, The Univ. of Texas at Austin (United States)
- 7177 1N **In vivo photoacoustic (PA) mapping of sentinel lymph nodes (SLNs) using carbon nanotubes (CNTs) as a contrast agent** [7177-60]  
M. Pramanik, K. H. Song, Washington Univ. in St. Louis (United States); M. Swierczewska, D. Green, B. Sitharaman, SUNY at Stony Brook Univ. (United States); L. V. Wang, Washington Univ. in St. Louis (United States)
- 7177 1P **Detection of gold-nanorod targeted pathogens using optical and piezoelectric optoacoustic sensors: comparative study** [7177-62]  
A. Conjusteau, Fairway Medical Technologies, Inc. (United States); S. Maswadi, The Univ. of Texas Health Science Ctr. at San Antonio (United States); S. Ermilov, H.-P. Brecht, Fairway Medical Technologies, Inc. (United States); N. Barsalou, Naval Health Research Ctr. Detachment (United States); R. D. Glickman, The Univ. of Texas Health Science Ctr. at San Antonio (United States); A. A. Oraevsky, Fairway Medical Technologies, Inc. (United States)
- 7177 1Q **Optoacoustic detection of viral antigens using targeted gold nanorods** [7177-63]  
S. Maswadi, L. Woodward, R. D. Glickman, The Univ. of Texas Health Science Ctr. at San Antonio (United States); N. Barsalou, Naval Health Research Ctr. Detachment (United States)
- 7177 1R **Tracking contrast agents using real-time 2D photoacoustic imaging system for cardiac applications** [7177-64]  
R. Olafsson, L. Montilla, P. Ingram, R. S. Witte, The Univ. of Arizona (United States)

---

**SESSION 14 MONITORING THERMAL LESIONS**

---

- 7177 1S **Photoacoustic temperature measurements for monitoring of thermal therapy** [7177-65]  
S.-H. Wang, National Taiwan Univ. (Taiwan) and National Taiwan Univ. Hospital (Taiwan); C.-W. Wei, National Taiwan Univ. (Taiwan); S.-H. Jee, National Taiwan Univ. Hospital (Taiwan); P.-C. Li, National Taiwan Univ. (Taiwan)

- 7177 1T **Phantoms for thermoacoustic tomography with RF heating** [7177-66]  
A. Eckhart, M. Schrauth, M. Rhodes, J. Becker, S. K. Patch, Univ. of Wisconsin, Milwaukee (United States)
- 7177 1U **RF testbed for thermoacoustic tomography** [7177-67]  
D. Fallon, Electronics Research Inc. (United States); L. Yan, Sichuan Univ. (China);  
G. W. Hanson, S. K. Patch, Univ. of Wisconsin, Milwaukee (United States)
- 7177 1V **Optoacoustic detection of thermal lesions** [7177-68]  
M. G. Arsenault, Univ. of Prince Edward Island (Canada); M. C. Kolios, Ryerson Univ. (Canada); W. M. Whelan, Univ. of Prince Edward Island (Canada) and Atlantic Veterinary College (Canada)

---

**SESSION 15 IMAGING WITH OPTICAL DETECTORS**

---

- 7177 1X **Assessment of opto-mechanical behavior of biological samples by interferometry** [7177-70]  
B. Soroushian, Ryerson Univ. (Canada); W. M. Whelan, Univ. of Prince Edward Island (Canada); M. C. Kolios, Ryerson Univ. (Canada)
- 7177 1Y **Photoacoustic detection of gold nanorods tagged prostate cancer cells in vitro** [7177-71]  
S. K. Gupta, K. Katti, J. A. Viator, Univ. of Missouri, Columbia (United States)
- 7177 1Z **Detection of melanoma cells suspended in mononuclear cells and blood plasma using photoacoustic generation** [7177-72]  
E. M. Spradling, J. A. Viator, Univ. of Missouri, Columbia (United States)

---

**SESSION 16 FREQUENCY DOMAIN AND TIME REVERSAL IMAGING**

---

- 7177 21 **Object orientation in RF field determines thermoacoustic contrast** [7177-74]  
S. K. Patch, L. Yan, Univ. of Wisconsin, Milwaukee (United States)
- 7177 23 **Information changes and time reversal for diffusion-related periodic fields** [7177-76]  
P. Burgholzer, F. Camacho-Gonzales, D. Sponseiler, Upper Austrian Research GmbH (Austria); G. Mayer, FHOOE Forschungs & Entwicklungs GmbH (Austria); G. Hendorfer, Upper Austria Univ. of Applied Sciences (Austria)

---

**POSTER SESSION**

---

- 7177 24 **Development of catheters for combined intravascular ultrasound and photoacoustic imaging** [7177-77]  
A. B. Karpiouk, B. Wang, S. Y. Emelianov, The Univ. of Texas at Austin (United States)
- 7177 25 **Photoacoustic molecular imaging using single walled carbon nanotubes in living mice** [7177-78]  
A. de la Zerda, C. Zavaleta, S. Keren, S. Vaithilingam, S. Bodapati, R. Teed, Z. Liu, J. Levi, B. R. Smith, T.-J. Ma, O. Oralkan, Z. Cheng, X. Chen, H. Dai, B. T. Khuri-Yakub, S. S. Gambhir, Stanford Univ. (United States)

- 7177 26 **Design and characterization of a photo-acoustic lens to generate tightly focused and high frequency ultrasound** [7177-79]  
H. Baac, T. Ling, S.-W. Huang, S. Ashkenazi, L. J. Guo, Univ. of Michigan (United States)
- 7177 27 **Spectroscopic intravascular photoacoustic imaging of neovasculature: phantom studies** [7177-80]  
J. L. Su, B. Wang, S. Y. Emelianov, The Univ. of Texas at Austin (United States)
- 7177 29 **Opto-photo-thermo-elastic displacement detection using coherent confocal microscope** [7177-82]  
I. Eliyahu, C. A. DiMarzio, Northeastern Univ. (United States)
- 7177 2A **Enhancement of multiphoton excitation-induced photoacoustic signals by using gold nanoparticles surrounded by fluorescent dyes** [7177-83]  
Y. Yamaoka, T. Takamatsu, Kyoto Prefectural Univ. of Medicine (Japan)
- 7177 2B **Wideband photoacoustic tomography using polymer microring resonators** [7177-84]  
S.-L. Chen, S.-W. Huang, T. Ling, S. Ashkenazi, L. J. Guo, Univ. of Michigan (United States)
- 7177 2C **In vivo photoacoustic monitoring of photosensitizer in skin: application to dosimetry for antibacterial photodynamic treatment** [7177-85]  
A. Hirao, Keio Univ. (Japan); S. Sato, D. Saitoh, N. Shinomiya, H. Ashida, National Defense Medical College (Japan); M. Obara, Keio Univ. (Japan)
- 7177 2D **Cell viability studies of PEG-thiol treated gold nanorods as optoacoustic contrast agents** [7177-86]  
S. Manohar, R. Rayavarapu, W. Petersen, Univ. of Twente (Netherlands); T. G. van Leeuwen, Univ. of Twente (Netherlands) and Univ. of Amsterdam (Netherlands)
- 7177 2E **A study on optical modulation signal and tissue displacement in ultrasound modulated optical tomography** [7177-87]  
R. Li, D. S. Elson, C. Dunsby, R. Eckersley, M.-X. Tang, Imperial College London (United Kingdom)
- 7177 2F **Development of an omni-directional photoacoustic source for the characterization of a hemispherical sparse detector array** [7177-88]  
M. Roumeliotis, P. Ephrat, J. J. L. Carson, Lawson Health Research Institute (Canada) and Univ. of Western Ontario (Canada)
- 7177 2G **Novel breast cancer detection system combining both thermoacoustic (TA) and photoacoustic (PA) tomography using carbon nanotubes (CNTs) as a dual contrast agent** [7177-89]  
M. Pramanik, G. Ku, C. Li, Washington Univ. in St. Louis (United States); M. Swierczewska, D. Green, B. Sitharaman, SUNY at Stony Brook (United States); L. V. Wang, Washington Univ. in St. Louis (United States)
- 7177 2H **Compact semiconductor laser sources for photoacoustic imaging** [7177-90]  
C.-S. Friedrich, M.-C. Wawreczko, M. P. Mienkina, N. C. Gerhardt, G. Schmitz, M. R. Hofmann, Ruhr-Univ. Bochum (Germany)

- 7177 2I **Monitoring the healing process of laser-induced microvascular lesions using optical-resolution photoacoustic microscopy (Best Poster Award)** [7177-91]  
S. Hu, K. I. Maslov, L. V. Wang, Washington Univ. in St. Louis (United States)
- 7177 2J **The speckle-free nature of photoacoustic imaging** [7177-92]  
Z. Guo, L. Li, L. V. Wang, Washington Univ. in St. Louis (United States)
- 7177 2K **Enhanced sensitivity carbon nanotubes as targeted photoacoustic molecular imaging agents (Best Poster Award)** [7177-93]  
A. de la Zerda, Z. Liu, C. Zavaleta, S. Bodapati, R. Teed, S. Vaithilingam, T.-J. Ma, O. Oralkan, X. Chen, B. T. Khuri-Yakub, H. Dai, S. S. Gambhir, Stanford Univ. (United States)
- 7177 2L **Noninvasive photoacoustic sentinel lymph node mapping using Au nanocages as a lymph node tracer in a rat model** [7177-94]  
K. H. Song, C. Kim, C. M. Cobley, Y. Xia, L. V. Wang, Washington Univ. in St. Louis (United States)
- 7177 2M **M-mode photoacoustic flow imaging** [7177-95]  
H. Fang, K. Maslov, L. V. Wang, Washington Univ. in St. Louis (United States)
- 7177 2N **Ultrasound-modulated optical microscopy for ex vivo imaging of scattering biological tissue** [7177-96]  
S.-R. Kothapalli, L. V. Wang, Washington Univ. in St. Louis (United States)

*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 Chairs*

- Steven L. Jacques**, Oregon Health & Science University (United States)  
**William P. Roach**, Air Force Research Laboratory (United States)

## *Conference Chairs*

- Alexander A. Oraevsky**, Fairway Medical Technologies, Inc. (United States)  
**Lihong V. Wang**, Washington University in St. Louis (United States)

## *Program Committee*

- Mark A. Anastasio**, Illinois Institute of Technology (United States)  
**Paul C. Beard**, University College London (United Kingdom)  
**Claude Boccara**, Centre National de la Recherche Scientifique (France)  
**Gerald J. Diebold**, Brown University (United States)  
**Charles A. DiMarzio**, Northeastern University (United States)  
**Stanislav Y. Emelianov**, The University of Texas at Austin (United States)  
**Rinat O. Esenaliev**, The University of Texas Medical Branch at Galveston (United States)  
**Martin Frenz**, Universität Bern (Switzerland)  
**Steven L. Jacques**, Oregon Health & Science University (United States)  
**Robert A. Kruger**, OptoSonics, Inc. (United States)  
**Pai-Chi Li**, National Taiwan University (Taiwan)  
**Andreas Mandelis**, University of Toronto (Canada)  
**Matthew O'Donnell**, University of Washington (United States)  
**Günther Paltauf**, Karl-Franzens-Universität Graz (Austria)  
**Wiendelt Steenbergen**, Universiteit Twente (Netherlands)  
**William M. Whelan**, University of Prince Edward Island (Canada)  
**Vladimir P. Zharov**, University of Arkansas for Medical Sciences (United States)  
**Quing Zhu**, University of Connecticut (United States)

### Session Chairs

- 1 Clinical Applications  
**Alexander A. Oraevsky**, Fairway Medical Technologies, Inc. (United States)
- 2 Toward Clinical Applications  
**Steven L. Jacques**, Oregon Health & Science University (United States)
- 3 Preclinical Imaging in Small Animals  
**Robert A. Kruger**, OptoSonics, Inc. (United States)
- 4 High-Resolution Imaging/Microscopy  
**Lihong V. Wang**, Washington University in St. Louis (United States)
- 5 New Optoacoustic Systems  
**Martin Frenz**, Universität Bern (Switzerland)
- 6 New Transducers and Arrays  
**Wiendelt Steenbergen**, Universiteit Twente (Netherlands)
- 7 Improving and Testing System Parameters  
**Rinat O. Esenaliev**, The University of Texas Medical Branch at Galveston (United States)
- 8 Combined Ultrasound and Optoacoustics  
**Stanislav Y. Emelianov**, The University of Texas at Austin (United States)
- 9 Quantitative Optoacoustic Imaging and Modeling  
**Benjamin Cox**, University College London (United Kingdom)
- 10 Signal Processing and Image Reconstruction  
**Mark A. Anastasio**, Illinois Institute of Technology (United States)
- 11 Ultrasound Modulated (Acousto-Optical) Imaging I  
**Claude Boccara**, Centre National de la Recherche Scientifique (France)
- 12 Ultrasound Modulated (Acousto-Optical) Imaging II  
**Charles A. DiMarzio**, Northeastern University (United States)
- 13 Molecular Imaging and Sensing Using Nanoparticles  
**Alexander A. Oraevsky**, Fairway Medical Technologies, Inc. (United States)
- 14 Monitoring Thermal Lesions  
**William M. Whelan**, University of Prince Edward Island (Canada)

- 15 Imaging with Optical Detectors  
**Günther Paltauf**, Karl-Franzens-Universität Graz (Austria)
- 16 Frequency Domain and Time Reversal Imaging  
**Xueding Wang**, University of Michigan (United States)
- Poster Session  
**Qing Zhu**, University of Connecticut (United States)



## Introduction to the 10th Proceedings of *Photons Plus Ultrasound: Imaging and Sensing*

This year marks the 10th anniversary of our conference. In these years we saw continuous and dynamic growth of our community and the corresponding number of inventions, peer-reviewed publications, and conference abstracts. It is significant that this year's conference was the biggest ever--with 98 papers submitted and 92 papers presented! The reports presented this year can be characterized as very mature, with deep theories and experiments performed in live subjects or equally complex phantoms.

The technologies developed by our community, optoacoustic (photoacoustic) imaging and sensing, attracts continuously growing interest from the medical imaging industry.

In order to recognize the leading researchers and attract young investigators to the field, in 2005 we established the Best Paper Award, sponsored by Fairway Medical Technologies of Houston, Texas. The following Best Papers have been presented:

- 2005** "Acoustically modulated x-ray phase contrast and vibration potential imaging" by **A.C. Beveridge**, C. J. Bailat, T. J. Hamilton, S. Wang, C. Rose-Petrucci, Brown Univ.; V. E. Gusev, Univ. du Maine (France); G. J. Diebold, Brown Univ.
- 2006:** "Technical considerations in quantitative blood oxygenation measurement using photoacoustic microscopy in vivo" by **K. I. Maslov**, M. Sivaramakrishnan, H. F. Zhang, G. Stoica, L. V. Wang, Texas A & M Univ.
- 2007:** "Detection and noninvasive diagnostics of breast cancer with two color laser optoacoustic imaging system" by **S. A. Ermilov**, A. Stein, A. Conjusteau, R. R. Gharieb, R. Lacewell, T. Miller, S. Thompson, P. Otto, B. McCorvey, T. Khamapirad, M. Leonard, and A. A. Oraevsky (Fairway Medical Technologies (Houston, Texas), Seno Medical Instruments (San Antonio, Texas), Univ. of Texas Cancer Therapy and Research Center, San Antonio, and Univ. of Texas Medical Branch at Galveston).
- 2008:** "3D photoacoustic imaging system for in vivo studies of small animal models" by **E. Z. Zhang**, J. Laufer, R. B. Pedley, P. Beard, Univ. College London (UK).

This year, our congratulations go to **H-P. Brecht** and the entire teams from Fairway Medical Technologies and Seno Medical Instruments, recipients of this year's Best Paper Award. Their paper entitled "Optoacoustic 3D whole-body tomography: experiments in nude mice" represents a leap in the systems for preclinical research, showing impressive images of the mouse body, organs and vasculature.

This year's competition was very close, which motivated 14 members of the organizing committee to also recognize the second-best paper entitled: "Combined ultrasound and photoacoustic imaging of pancreatic cancer using nanocage contrast agents" by **K. Homan**, J. Shah, S. Gomez, H. Gensler, A. B. Karpouk, L. Brannon-Peppas, and S. Y. Emelianov, The Univ. of Texas at Austin.

In addition to oral papers, 20 poster papers were presented this year as part of our conference. The poster session exceeded everybody's expectations in terms of the depth and excitement of discussions. We hope that very interesting poster sessions will no longer be of any surprise to the attendees. In order to motivate researchers to present their papers as posters, this year we established the Best Poster Award, which will be annual tradition. Due to a strong competition, two equally interesting posters received the 2009 award:

"Monitoring wound healing in mouse microvasculature using optical-resolution photoacoustic microscopy" by **S. Hu**, K. I. Maslov, L.V. Wang, Washington Univ. in St. Louis.

"Enhanced sensitivity targeted photoacoustic molecular imaging agents in living mice" by **A. de la Zerda**, Z. Liu, C. Zavaleta, Suni Bodapati, S. Vaithilingam, T-J. Ma, Ö. Oralkan, X. Chen, B. T. Khuri-Yakub, H. Dai, S. S. Gambhir, Stanford Univ.

Manuscripts included in this volume have been editor-reviewed by the two conference Chairs based on oral presentations and posters. Due to copyright conflicts, not all of these papers will appear in scientific journals. Therefore, this volume of SPIE Proceedings can serve as a comprehensive current status report for researchers and doctors working in the field of preclinical and clinical medical imaging employing photons and ultrasound.

**Alexander A. Oraevsky**  
**Lihong V. Wang**