CURRICULUM VITAE

PART I:

Date Prepared: 09/5/06

Name:	David A. Boas
Address:	188 Highland Avenue Winchester, MA 01890 email: dboas@nmr.mgh.harvard.edu
Place of Birth:	Cleveland, Ohio

Education:

1991 B.S.	Rensselaer Polytechnic Institute, Troy, NY (Physics)
1996 Ph.D.	University of Pennsylvania, Philadelphia, PA (Physics)

Academic Appointments:

1996-2000	Research Assistant Professor in Electrical Engineering and Computer Science, Tufts University, Medford, MA
1998-2003	Assistant Professor in Radiology, Harvard Medical School
2003-	Associate Professor in Radiology, Harvard Medical School

Hospital Appointments:

1998-	Assistant Physicist, Massachusetts General Hospital, Boston, MA
2003-	Associate Physicist, Massachusetts General Hospital, Boston, MA

Other Professional Positions and Major Visiting Appointments:

1996-1998	Assistant Professor in Ophthalmology, Tufts University, Boston, MA
2000 June	Visiting Scientist at Laboratoire d'Optique Physique, Ecole Supérieure de Physique et Chimie Industrielles, in Paris

Awards and Honors:

1991	Sigma Phi Sigma, National Physics Honorary Society
1992	Distinction in Ph.D. qualifying exam in the Department of Physics, University of Pennsylvania
1994,1996	New Focus Travel Grant
1996	Burstein prize in condensed matter physics

Editorial Boards and Scientific Reviewer:

1997-2002	Associate Editor, Optics Express
1998-2000	Guest Editor, Medical Physics
2002	Co-Editor, Journal of Electronic Imaging (SPIE); special edition
2002	Topical Editor, special issue on Biomedical Optics, Applied Optics
2004	Guest Editor, Journal of Biomedical Optics
1995-	Reviewer, Applied Optics
1995-	Reviewer, Journal of the Optical Society of America A
1995-	Reviewer, Optics Letters
1996,1999,2000	Reviewer, Physical Review E
1996-	Reviewer, Journal of Biomedical Optics
1997,1999,2000	Reviewer, Photo-Chemistry and Photo-Biology
1997	Reviewer, Analytical Biochemistry
1997-	Reviewer, Optics Express
1998	Reviewer, IEEE Image Processing
1999	Reviewer, Review of Scientific Instruments
1999-	Reviewer, NeuroImage
1999	Reviewer, Medical Physics
2000-	Reviewer, Physics in Medicine and Biology
2000-2001	Reviewer, Physical Review Letters
2000-2001	Reviewer, Optics Communications
1999,2001	Reviewer, National Science Foundation
1999	Reviewer, Canadian Cancer Institute
2000-	Reviewer, National Institutes of Health
2000-	Reviewer, Engineering Research Council, London

Memberships, Offices and Committee Assignments in Professional Societies:

1992-1996	Member, American Physical Society
1993-1996	Member, Biophysical Society
1995-	Member, Optical Society of America
1995-	Member, Society of Photonics in Industry and Engineering
1996-2002	Member, OSA Bio-Optics Ad Hoc Committee
1997	Vice-chair, Optical Society of America Biomedical Optical Spectroscopy Council
1997-1998	Ad hoc member, OSA OpticsNet Committee
1998	Member, OSA Advances in Photon Migration Topical Meeting Program Committee
1998	Member, OSA Annual Meeting Program Committee
1998	Member, Saratov Fall Meeting on Biomedical Optics Program Committee
1998-2000	Chair, Optical Society of America Biomedical Optical Spectroscopy Council. Organized meeting on the State

	of Diffuse Optical Tomography at the OSA Annual Meeting 1998.
1998-2000	Member, Optical Society of America New Focus Student Award Selection Committee
1999	Member, OSA Advances in Photon Migration Munich Meeting Program Committee
1999	Member, OSA Conference on Lasers and Electro-Optics Program Committee
2002	Chair, OSA Advances in Photon Migration Topical Meeting on Optical Techniques in NeuroScience
2003	Chair, OSA Advances in Photon Migration Munich Meeting on Photon Migration Imaging
2004	General Chair, Organizer, OSA Topical Meeting in Biomedical Optics
2004	Organizer, Gordon Conference on Lasers in Medicine, Session on Optics in Neuroscience
2005	General Chair, OSA European Conference on Biomedical Optics in Munich
2006	Chair, Multi-Modal Functional Neuroimaging in Cortona, Italy

PART II

A. Report of Research (Prepared in 2002, please see attached current research plan prepared in 2006)

1. Major Research Interests:

   a. Photon migration in highly scattering media with emphasis on Diffuse Optical Tomography
   b. Clinical applications of Diffuse Optical Tomography in brain and breast radiology
   c. Fundamental studies of brain function and stroke using diffuse optical tomography and optical microscopy

2. My research plans for the next 5 to 10 years will focus on the development of photon migration methods to address specific physiological / scientific and clinical questions related to brain function and breast cancer.

These first 4 years at Massachusetts General Hospital, I have built a laboratory focused on the development of photon migration technologies for the basic study of cerebral and tumor physiology and for associated clinical application. While 4 years ago the lab consisted of myself and a few graduate students, today it consists of almost 20 students, fellows, staff, and other faculty. Progress is being made on tomographic optical breast imaging and small animal molecular optical imaging, but to-date the most significant published progress has been in the study of cerebral physiology and the development of new neuroimaging methodology. My progress in this area is covered in the following 9 publications:

Microscopy of Cerebral Physiology

1) Dunn A.K., Bolay H., Moskowitz M.A. and Boas D.A.. "Dynamic imaging of cerebral blood flow using laser speckle." Journal of Cerebral Blood Flow and Metabolism 21:195-201 (2001).
2) Bolay H., Reuter U., Dunn A.K., Huang Z., Boas D.A., Moskowitz M.A. "Intrinsic brain activity triggers trigeminal meningeal afferents in a migraine model." Nat Med. 8(2):136-42. (2002).
3) Dunn, A.K., Devor, A., Bolay, H., Andermann, M.L., Moskowitz, M.A., Dale, A.M. and Boas, D.A. "Simultaneous imaging of total cerebral hemoglobin concentration, oxygenation, and blood flow during functional activation." Optics Letters 28(1): 28-30. 2003.

Functional Diffuse Optical Tomography of the Brain

4) Franceschini M.A., Boas D.A., Zourabian A., Diamond S.G., Nadgir S., Lin D.W., Moore J.B., and Fantini S. Near-infrared spiroximetry: Non-invasive measurements of venous saturation in piglets and human subjects. J Appl Physiol. 92, 372-384 (2002).
5) Boas D.A., Gaudette T.J., Strangman G., Cheng X., Marota J.J.A. and Mandeville J.B.. "The accuracy of near infrared spectroscopy and imaging during focal changes in cerebral hemodynamics." NeuroImage 13:76-90 (2001).
6) Strangman, G., Franceschini, M.A. and Boas, D.A. "Factors affecting the accuracy of near-infrared spectroscopy concentration calculations for focal changes in oxygenation parameters." NeuroImage 18: 865-879. 2003.
7) Strangman, G, Culver, J.P., Thompson, J.H., Boas, D.A. "A Quantitative Comparison of Simultaneous BOLD fMRI and NIRS Recordings during Functional Brain Activation." NeuroImage 17: 719-731. 2002.

Brain Development

8) Hintz S.R., Benaron D.A., Siegel A.M., Zourabian A., Stevenson D.K. and Boas D.A.. "Bedside functional imaging of the premature infant brain during passive motor activation." J Perinat Med 29: 335-343 (2001).
9) Baird, A.A., Kagen, J., Gaudette, T., Walz, K.A., Hershlag, N., and Boas, D.A. "Frontal Lobe Activation during Object Permanence: Data from Near-Infrared Spectroscopy." NeuroImage 16: 1120-1126. 2002.

Microscopy of Cerebral Physiology

Over the last 10 years several advances have been made in the development of novel optical methods for the study of tissue. Surprisingly, few of these advances have found their way into the neurosciences (except for, e.g. confocal and two photon microscopy), principally because these new methods are not commercially available and thus require a close collaboration between a bio-optics specialist and neuroscientists. I have been successful in developing such a close inter-disciplinary collaboration to guide focused technology development to address specific neuroscience questions. With Dr. Michael Moskowitz, my group has developed a new method that provides 2D images of cortical blood flow with temporal resolution of up to 10 ms [1]. This method has been validated against laser Doppler flowmetry and applied to the study of cortical spread depression and neuronal activation. It was central to helping Dr. Moskowitz confirm a long held hypothesis on the triggering mechanisms in migraine [2]. Combining flow imaging with 2D spectroscopic imaging (another first for our group), we are now obtaining the first 2D optical images of the cerebral metabolic rate of oxygen (CMRO2) [3]. My group is now

working on developing optical methodology for directly measuring neuronal activity. The combination of these methods will provide high spatial-temporal resolution maps of neuronal, metabolic, and hemodynamic processes within the normal and diseased brain. Through collaborations with Dr. Moskowitz and other MGH neuro-specialists, I will bring these new tools to bear on important questions in neuro-vascular coupling, and the pathophysiology of stroke and Alzheimer's disease.

While these methods will have limited direct clinical impact because of the requirement to remove the scalp and thin the skull, other efforts in the lab are focusing on extending and developing methodology for more routine human use.

Functional Diffuse Optical Imaging of the Brain

Non-invasive diffuse optical measurements of the brain through the intact scalp and skull provides an important complement to other neuroimaging methods as it provides direct measures of the concentrations of oxy- and deoxy-hemoglobin from which we can determine cerebral blood volume (through the total hemoglobin concentration) and hemoglobin oxygen saturation. With flow information provided by some assumptions or another imaging modality, we can then determine CMRO2 (manuscript in preparation). Additionally, we are finding that it is possible to measure neuronal activity directly with diffuse optical imaging (manuscript in preparation). No other non-invasive imaging modality offers this diversity of neuronal, metabolic, and hemodynamic information. The combination of this work with our microscopy work will accelerate the translation of new scientific findings of cerebral pathophysiology to a clinical setting. Furthermore, this work is finding widespread use in functional brain imaging studies. Our efforts so far have focused on the development and validation of the technology.

Diffuse optical imaging (DOI) has its origins with pulse oximetry. As pulse oximetry derives arterial oxygen saturation (SaO2) from the pulsations of the heart, we have shown that venous oxygen saturation (SvO2) can be determined in a similar fashion since venous blood volume is modulated by respiration [4]. A measure of SvO2 will provide an earlier indicator of perfusion deficit than that of SaO2, as well as providing another approach to quantifying oxygen consumption. DOI is unique in its potential to provide quantitative images of the hemoglobin concentrations. It is therefore essential to establish the accuracy of the methodology through identifying systematic errors, testing solutions, and validating against other available methods. The partial tissue volume sampling effect poses a challenging problem for quantitative accuracy that was not given proper attention until our publication in NeuroImage showed that it could lead to significant cross-talk in the determined hemoglobin concentrations [5]. Our follow up work has established through experimental and computer simulation studies a procedure to minimize this cross-talk [6]. We are beginning to make progress in validating the accuracy of DOI through simultaneous comparison with fMRI [7]. While the preliminary findings are encouraging, further study is required including comparisons with PET, MEG, and EEG. I envision the routine combination of DOI and MRI such that DOI accuracy will be improved by MRI structural guidance and in turn MRI features will be quantitatively characterized by DOI, providing new metrics for the neuro-radiologist and cognitive-neuro scientist.

Brain Development

An important application for diffuse optical imaging is the study of brain development. Few longitudinal studies of human brain development have been performed because of

physical restrictions imposed by the imaging method (as is the case for MRI) or because of ethical concerns (as is the case for PET). Because DOI is portable and poses no risk to the subject, it is possible to perform imaging studies on immobilized patients and during active behavioral studies. Our work has shown that it is possible to image brain activation in premature babies in the neonatal intensive care unit [8], which opens the door for studying the developing normal and diseased brain in the first weeks of life. In addition, in a classic longitudinal behavioral study of object performance we have shown that changes in brain activation patterns correlate with the well known behavioral changes [9]. While such neuro-physical changes are accepted fact, they have rarely been measured longitudinally within individual subjects. It is likely that DOI will have a profound impact during the next 20 years on our understanding of the developing human brain.

B. Research Funding Information:

Current:

NIH SBIR "Use of Diffuse Optical Tomography for Stroke Management" PI Franceschini Dates 10/1/04-9/30/06

AFOSR "Advanced Technology for Ultrahigh Resolution Structural and Functional Imaging using Optical Coherence Tomography" PI Fujimoto and Boas Dates 12/1/03-11/3/06

NIH R01 "Optical Monitoring of Cerebral Oxygenation in Infants" PI Franceschini Dates: 7/1/02-4/30/06

NIH R01 CA97305-01 "3D Optical Imaging and Digital X-Ray of Breast Lesions" PI David A. Boas, Ph.D. Dates 8/1/02-7/31/07

NIH R01 EB00790-01 "Spatiotemporal Brain Imaging: Microscopic and Systems Level" PI Dale Dates 9/5/02-8/31/07

NIH R01 EB002482-01 "Exploring Cerebral Metabolic-Vascular Coupling with DOT/fMRI" PI: David A. Boas Dates 9/1/03-8/31/08

NIH P01 NSD10828-28 "Interdepartmental Stroke Program" PI Moskowitz Dates 8/1/04-7/31/09

NIH P41 RR14075-06 PI: Bruce Rosen (Boas PI of project 4), Ph.D. "Brain Functional Imaging Regional Resource" Dates 9/1/04-8/31/09

NIH R01 EB1954-04 "Non-invasive Optical Imaging of the Human Brain" PI Franceschini Dates 12/1/04-11/30/09

NIH P01 NS55104 "Physiologic and pathologic coupling in the neurovascular unit", PI Eng Lo (Boas PI of optical imaging core). Dates 1/1/07-12/31/11

Past:

CIMIT "Development of a continuous-wave diffuse optical tomography system" PI: David A. Boas, Ph.D. and Walter Koroshetz, M.D. Dates 9/97-8/98

NIH SBIR 1R43CA78036-01 Phase I sub-contract to Tufts University "A novel hemodynamic monitor" PI: David A. Boas, Ph.D. Dates 4/98-10/98

NIH SBIR 1R43HL61057-01 Phase I sub-contract to Tufts University "Spectroscopy and imaging of Hb in fetal brain in-utero" PI: David A. Boas, Ph.D. Dates 8/98-2/99

NSF DBI-9728937 "Optical microscopy tools to study biomineralization interfaces" PI: David Kaplan, Ph.D. and David A. Boas, Ph.D. Dates 2/98-1/00

NIH 1 R29 NS038842-01 "Imaging of intracranial hematomas with diffuse optical tomography" PI: David A. Boas, Ph.D. Dates 9/98-8/03

Advanced Research Technologies PI: David A. Boas, Ph.D. "Continuous-Wave and Frequency-Domain Optical Mammography" Dates 8/1/99-7/30/03

NIH RR P41-RR 14075-04 PI: Bruce Rosen (David Boas) "Brain Functional Imaging Regional Resource" Dates 9/28/99-8/31/04

NIH SBIR 1R43HL61057-01 Phase II sub-contract to Tufts University "Spectroscopy and imaging of Hb in fetal brain in-utero" PI: David A. Boas, Ph.D. Dates 9/00-8/02

CIMIT "Monitoring and Imaging of Stroke with Diffuse Optical Tomography" PI: David A. Boas, Ph.D. Dates 10/98 – 9/02

NSF "Engineering Research Center Subsurface Sensing and Imaging Systems" PI Silevich Dates 9/1/00-8/31/05

C. Report of Teaching:

1. a. Local Contributions
   Medical/Dental School Courses (for Medical/Dental/Graduate Students)

   b. Graduate Medical Courses/Seminars/Invited Teaching Presentations

   Irving Bigio, Boston University
   "Diffuse optical tomography and health-science applications"
   October 2002
   Audience - Graduate students from biomedical engineering,
   approximately 20 students attended

   Brett Bouma, HST, MIT
   "Diffuse optical tomography and health-science applications"
   November 2002

Audience - Graduate students from HST, MIT
approximately 8 students attended

c. Continuing Medical Education Courses
Greg Sorensen's fMRI Course
September 1999, September 2000, September 2001, September 2004, September 2006
Audience – Visiting scientists from around the world
Approximately 60-80 attended each year

d. Advisory and Supervisory Responsibilities in Clinical or Laboratory Setting

M.S. Students

Chris Nunes, M.S., EE, Tufts, 1997-1998
Telecom Industry, White Plains, NY

Lai Wang, EE, Tufts, 1998-2000
Telecom Industry, Palo Alto, CA

Anna Zourabian, EE, Tufts, 1998-2001
Clinical Trial Research Coordinator, Boston, MA

Frances Clark, ECE & BME, Boston University, 2001-2002
Biomedical industry, Albuquerque, New Mexico

Jian Yu, EECS, MIT, 2002-
Sonamed, Waltham, MA

Ph.D. Students

Xuefeng Cheng, EE, Tufts 1997-2000
Chief Technology Officer, Photonify, Palo Alto, CA

Kostadinka Bizheva, Physics, Tufts, 1997-2001
Assistant Professor, University of Waterloo, Waterloo, Ontario, Canada

Tom Bruckilacchio, EE, Tufts, 1997-2003
President of Innovations in Optics, Waltham, MA

Andy Siegel, EE, Tufts, 1997-2004
Lincoln Labs, Lexington, MA

Abigail Baird, Psychology, Harvard University, 2000-2001
Assistant Professor, Department of Cognitive Science,
Dartmouth College

Ang Li, Physics, Tufts, 2000-2004
Post-doctoral fellow, University of California, Irvine

Solomon Diamond, ME, Harvard University, 2000-2003
Post-doctoral fellow, Harvard Medical School

Mark Anderman, Harvard University, 2000-2005

Shuai Yuan, EE, Tufts University, 2002-

Greg Boverman, EE, Northeastern University, 2000-2006
Post-doctoral fellow, RPI, Troy NY 2006-

Anna Custo, EECS, MIT, 2002-

Theodore Huppert, Harvard University, Biophysics Department, 2003-

Fellows

Andy Dunn, MGH/HMS Radiology Fellow 1999-2000,
Instructor 2001-2005
Assistant Professor, Biomedical Engineering, University of Texas, Austin
2005-

Gary Strangman, MGH/HMS Radiology Fellow 1999-2001,
Instructor of Psychiatry, Harvard Medical School, 2001-

Quan Zhang, MGH/HMS Radiology Fellow 1999-2004,
Instructor of Psychiatry, Harvard Medical School, 2004-

Joe Culver, MGH/HMS Radiology Fellow 2001, Instructor 2002-2003
Assistant Professor, Radiology, Washington University St Louis, 2003-

Alex Barnett, MGH/HMS Radiology Fellow 2002
Instructor, Assistant Professor, Courant Institute of Mathematical
Sciences, 2002-2005
Assistant Professor, Dartmouth College,2005-

Elizabeth Hillman, MGH/HMS Radiology Fellow 2003-2004,
Instructor 2005-2006
Assistant Professor, Department of Biomedical Engineering, Columbia
University 2006-

Solomon Diamond, ME, Harvard University, 2000-2003
Post-doctoral fellow, Harvard Medical School, 2003-

Qianqian Fang, Dartmouth College, 2000-2005
Post-doctoral fellow, MGH/HMS, 2005-

Stefan Carp, U.C. Irvine - Chemical Engineering M.S., 2000-2002
U.C. Irvine - Chemical Engineering Ph.D., 2002-2005
Post-doctoral fellow, MGH/HMS, 2005-

Mark Shalinsky, Dartmouth College,
Post-doctoral fellow, MGH/HMS, 2006-

2. Regional, National or International Contributions

a. Invited presentations (Selected Presentation List)

Boas DA. Images of motions in highly scattering media with diffusing temporal correlation, Engineering Foundation Conference, Snowbird, Utah, July 16, 1997

Boas DA. Light scattering: the transition from single scattering to light diffusion, Gordon Conference on Lasers in Biology and Medicine, New Hampshire, June 1998

Boas DA, Siegel AM, Cheng X, Chance B. An effective continuous-wave diffuse optical tomography system for anatomical and functional tissue imaging, SPIE Photonics China, Beijing, China, Sept.16-19, 1998

Boas D. A. Optical Imaging in Tissue (Mammography), OSA Annual Meeting, Workshop on Emerging Technologies in Biomedical Optics, Baltimore, MD, Oct. 7, 1998

Boas D A., "Optical Imaging: Seeing into the future," Harvard Medical School Department of Continuing Education course on Clinical Functional MRI, Boston, MA, Oct. 13-15, 1998.

Boas DA, Bizheva K, Imaging in the single scattering, few scattering, and light diffusion regimes with low-coherent light, SPIE/BioS West, San Jose, CA, Jan. 1999

Boas DA, "Diffuse Optical Tomography: The Basics," Human Brain Mapping Meeting, Dusseldorf, Germany, June 1999

Boas DA, "Optical Mammography," Engineering Foundation Conference, Kona, Hawaii, August 1999

Boas DA, Bizheva, K, "Imaging in the Single Scattering, Few Scattering, and Light Diffusion Regimes," French Summer School on Biomedical and Quantum Optics, Corsica, France, September 1999

Boas DA, "Non-invasive Diffuse Optical Imaging of the Brain," Gordon Conference on Lasers in Medicine and Biology, Connecticut, June 2000

Boas DA, "Non-invasive Diffuse Optical Imaging," Human Brain Mapping Satellite Meeting on Functional Brain Optics, Albuquerque, New Mexico, June 2000

Boas DA, “Diffuse Optical Tomography of the Brain,” Radiological Society of North America, Chicago, Illinois, December 2000

Boas DA, “NIRS of Brain Activation: Is it quantitatively Accurate,” Human Brain Mapping Meeting, Brighton, England, June 2001

Boas, DA, “Near Infrared Spectroscopy of $CMRO_2$”, OSA Advances in Optical Imaging and Photon Migration, Miami, Florida, April 2002

Boas, DA, “Diffuse Optical Imaging of Brain Function: Validation and Combination with MRI”, NIH Workshop on Biomedical Optics, September 2002

Boas, DA, “Diffuse Optical Imaging of the Developing Brain”, Athens, Greece, Brainstorm 2002

Boas, DA, “Diffuse Optical Imaging: Past, Present, and Future,” Engineering Research council Workshop on Multi-Modality Imaging, London, England, November 2002

Boas, DA, “Principles of Diffuse Optical Tomography and its Potential Application to Brain and Breast Imaging,” New England Chapter of the American Association of Physicists in Medicine, Annual Summer Meeting, Plymouth, MA, June 2003

Boas, DA, “Tomographic Optical Breast Imaging combined with Tomosynthesis Mammography,” Engineering Foundation Conference, Banff Canada, August 2003

Boas, DA, “Multi-Modality Diffuse Optical Tomography of Breast” Cranfield, England, SPIE, Biomedical Optics, September 2003.

Boas, DA, “Diffuse Optical Imaging of Brain Function” Cranfield, England, SPIE, Biomedical Optics, Plenary Talk, September 2003.

Boas, DA, “Multi-Modality Diffuse Optical Imaging of Brain Function”, Santa Fe, New Mexico, Institute for Complex Adaptive Matter, Physics of Neural Tissue, November 2003.

Boas, DA, “Multi-Modality Funtional Brain Imaging with NIRS, MRI, and MEG”, Cambridge, MA, Workshop on NIRS for Brain Development, February 2004.

Boas, DA, “Multi-Modality Functional Brain Imaging with NIRS, MRI, and MEG”, Hamamatsu City, Japan, Tenth Conference of Peace through Mind/Brain Science, February 2004.

Boas, DA, “Diffuse Optical Imaging of Brain Activation,” Los Angeles, CA, Institute for Pure and Applied Mathematics Graduate Summer School for Mathematics in Brain Imaging, July 2004.

Boas, DA, “Functional Diffuse Optical Imaging of the Infant Brain”. London Ontario, Non-Invasive Assessment of Brain Development and Injury, March 2004.

Boas, DA, “Photon Migration: Functional Imaging of Human Brain Function,” SPIE, Bios Photonics West, Hot Topics Talk, January 24, 2004.

Boas, DA, “Optical Imaging of the neuro-vascular relationship during brain activation,” Miami, Florida, Biomedical Engineering Department, Florida International University, March 2005.

Boas, DA “Recent Advances in Optical Breast Imaging,” Massachusetts General Hospital, Breast Rounds, June 7, 2005.

Boas, DA “Optical Imaging: From Animal to Man”, Amsterdam, The Netherlands, Brain'05 & BrainPET'05, June 8, 2005.

Boas, DA “Diffuse Optical Imaging of the Neuro-Metabolic-Vascular Relationship during Brain Activation”, McMaster University, Canadian College of Physicists in Medicine Symposium, July 7, 2005.

Boas, DA “Optical Imaging of the Neuro-Vascular Relationship During Brain Activation”, University of Pennsylvania, Center for Functional NeuroImaging, October 25, 2005.

Boas, DA “Diffuse Optical Imaging of the Neuro-Metabolic-Vascular Relationship during Brain Activation”, NY, NY, The Mount Sinai School of Medicine, Advanced Imaging Program Seminar Series, December 16, 2005.

Boas, DA “The Role of Optics in Multi-Modality Functional Neuro-Imaging”, Fort Lauderdale, Fl, Biomedical Optics Topical Meeting, Optical Society of America, March 20, 2006.

Boas, DA “Estimating the Cerebral Metabolic Rate of Oxygen with Multi-Modal Optical Imaging and fMRI”, Massachusetts Institute of Technology, Brainmap Seminar, HST Athinoula A. Martinos Center for Biomedical Imaging at MGH, April 26, 2006.

Boas, DA “Diffuse Optical Imaging of Brain Activation: Approaches to Optimizing Image Sensitivity, Resolution and Accuracy”, Montreal, Canada, The Centre de Recherches Mathematiques (CRM), May 11, 2006.

Boas, DA “Optical Imaging Bridging MEG/EEG and MRI”, Multi-Modal Functional Neuroimaging, Cortona, Italy, June 9, 2006.

Boas, DA “Optical Imaging of brain hemodynamic function”, 2006 Brain Energy Metabolism and Blood Flow Gordon Research Conference, Magdalen College, Oxford, UK, August 23, 2006.

Boas, DA “Assessing Brain Function, Development, and Disease with Optical Imaging”, Santa Fe Institute Seminar, Santa Fe, New Mexico, September 6, 2006.

Boas, DA “Optical Breast Imaging Combined with X-Ray Tomosynthesis”, Sunnybrook Health Sciences Centre, Toronto, Canada, October 24, 2006.

Part III: Bibliography

Original Reports:

1. O'Leary MA, Boas DA, Chance B, Yodh AG. Refraction of diffusion photon density waves. Phys Rev Lett. 1992; 69:2658-2661.
2. Boas DA, O'Leary MA, Chance B, Yodh AG. Scattering and wavelength transduction of diffuse photon density waves. Phys Rev E. 1993; 47:R2999-R3002.
3. O'Leary MA, Boas DA, Chance B, Yodh AG. Reradiation and imaging of diffuse photon density waves using fluorescent inhomogeneities. Journal of Luminescence 1994; 60:281-286.
4. Boas DA, O'Leary MA, Chance B, Yodh AG. Scattering of diffuse photon density waves by spherical inhomogeneities within turbid media. Proc Natl Acad Sci USA 1994; 91:4887-4891.
5. Boas DA, Campbell LE, Yodh AG. Scattering and imaging with diffusing temporal field correlation. Phys Rev Lett. 1995; 75:1855-1858.
6. Liu H, Boas DA, Zhang Y, Yodh AG, Chance B. Determination of optical properties and blood oxygenation using continuous NIR light. Phys Med Biol. 1995; 40:1983-1993.
7. O'Leary MA, Boas DA, Chance B, Yodh AG. Experimental images of heterogeneous turbid media by frequency-domain diffusing-photon tomography. Optics Letters 1995; 20:426-428.
8. O'Leary MA, Boas DA, Li X, Chance B, Yodh AG. Fluorescence lifetime imaging in turbid media. Optics Letters 1996; 21:158-160.
9. Li X, O'Leary MA, Boas DA, Chance B, Yodh AG. Fluorescent diffuse photon density waves in homogeneous and heterogeneous media: Analytic solutions and sensitivity analysis. Applied Optics 1996; 31:3746-3758.
10. Boas DA. A fundamental limitation of linearized algorithms for diffuse optical tomography. Optics Express 1997; 1:404-413.
11. Durduran T, Chance B, Yodh AG, Boas DA. Does the photon diffusion coefficient depend on absorption?. J Opt Soc Am A 1997; 14:3358-3365.
12. Boas DA, Yodh AG. Spatially Varying Dynamical Properties of Turbid Media Probed with Diffusing Temporal Light Correlation. J Opt Soc Am A 1997; 14:192-215.
13. Boas DA, O'Leary MA, Chance B, Yodh AG. Detecting and characterizing optical inhomogeneities with diffuse photon density waves: A signal-to-noise analysis. Applied Optics 1997; 36:75-92.
14. Cheng X, Boas DA. Diffuse Optical Reflection Tomography with Continuous Illumination. Optics Express 1998; 3:118-123.
15. Bizheva KK, Siegel AM, Boas DA. Pathlength resolved dynamic light scattering in highly scattering random media: the transition to diffusing wave spectroscopy. Phys Rev E 1998; 58:7664-7667.
16. Boas DA, Bizheva KK, Siegel AM. Using Low Coherence Domain Reflectometry to Image Brownian Motion within Highly Scattering Media. Optics Letters 1998; 23:319-321.
17. Walker SA, Boas DA, Gratton E. Photon density waves scattered from cylindrical inhomogeneities: Theory and Experiments. Applied Optics 1998; 37:1935-1944.
18. Siegel AM, Marota JJA, Boas DA. Design and evaluation of a continuous-wave diffuse optical tomography system. Optics Express 1999; 4:287-298.

19. Cheng X, Boas DA. Systematic diffuse optical image errors resulting from uncertainty in the background optical properties. Optics Express 1999: 4:299-307.
20. Dunn A, Boas D. Transport-based image reconstruction in turbid media with small source-detector separations. Optics Letters 2000; 25:1777-1779.
21. Gaudette RJ, Brooks DH, Dimarzio CA, Kilmer ME, Miller EL, Gaudette T, Boas DA. A comparison study of linear reconstruction techniques for diffuse optical tomographic imaging of absorption coefficient. Phys. Me.d Biol. 2000;45:1051-1070.
22. Benaron DA, Hintz SR, Villringer A, Boas D, Kleinschmidt A, Frahm J, Hirth C, Obrig H, van Houten JC, Kermit EL, Cheong WF, Stevenson DK. Noninvasive functional imaging of the human brain using light. J Cerebral Blood Flow and Metabolism. 2000; 20:469-477.
23. Zourabian A, Siegel A, Chance B, Ramanujan N, Rhoade M, Boas DA. Trans-abdominal monitoring of fetal arterial blood oxygenation using pulse oximetry. Journal of Biomedical Optics 2000; 5(4):391-405.
24. Boas DA, Gaudette T, Strangman G, Cheng X. Marota JJA, Mandeville JB. The accuracy of near infrared spectroscopy and imaging during focal changes in cerebral hemodynamics. NeuroImage 2001; 13:76-90.
25. Kilmer M, Miller E, Boas D, Brooks D. A shape-based reconstruction technique for DPDW data. Optics Express 2001; 7:481-491.
26. Dunn AK, Bolay H, Moskowitz MA, Boas DA. Dynamic imaging of cerebral blood flow using laser speckle. J Cerebral Blood Flow and Metabolism. 2001;21:195-201.
27. Hintz SR, Benaron DA, Siegel AM, Zourabian A, Stevenson DK, Boas DA. Functional imaging of the premature infant brain during passive motor activation. Journal of Perinatal Medicine. 2001;29:335-343.
28. Boas DA, Gaudette TJ, Arridge SA. Simultaneous imaging and optode calibration with diffuse optical tomography. Opt Express 2001;8:263-270.
29. Boas DA, Brooks DH, Miller EL, DiMarzio CA, Kilmer M, Gaudette RJ, Zhang G. Imaging the body with diffuse optical tomography. IEEE Signal Processing Magazine 2001;18(6):57-75.
30. Boas DA, Culver JP, Stott JJ, Dunn AK. Three dimensional Monte Carlo code for photon migration through complex heterogeneous media including the adult human head. Opt Express 2002;10:159-170.
31. Bolay H, Reuter U, Dunn AK, Huang Z, Boas DA, Moskowitz MA. Intrinsic brain activity triggers trigeminal meningeal afferents in a migraine model. Nat Med 2002;8(2):136-432
32. Franceschini MA, Boas DA, Zourabian A, Diamond SG, Nadgir S, Lin DW, Moore JB, Fantini S. Near-infrared spiroximetry: non-invasive measurements of venous saturation in piglets and human subjects. J Appl Physiol 2002;92:372-384.
33. Baird AA, Kagen J, Gaudette T, Walz KA, Hershlag N, Boas DA. Frontal lobe activation during object permanence: Data from near-infrared spectroscopy. NeuroImage 2002;16:1120-1126.
34. Strangman G, Culver JP, Thompson JH, Boas DA. A quantitative comparison of simultaneous BOLD fMRI and NIRS recordings during functional brain activation. NeuoImage 2002;17:719-731.
35. Strangman G, Boas DA, Sutton JP. Non-invasive neuroimaging using near-infrared light. Biol Psychiatry 2002;52:679-693.
36. Dunn AK, Devor A, Bolay H, Andermann ML, Moskowitz MA, Dale AM, Boas DA. "Simultaneous imaging of total cerebral hemoglobin concentration, oxygenation, and blood flow during functional activation," Optics Letters 2003;28(1):28-30.

37. Strangman G, Franceschini MA, Boas DA. “Factors affecting the accuracy of near-infrared spectroscopy concentration calculations for focal changes in oxygenation parameters,” NeuroImage 2003;18:865-879.
38. Prince S, Kolehmainen V, Kaipio JP, Franceschini MA, Boas DA, Arridge SR. “Time-series estimation of biological factors in optical diffusion tomography,” Physics in Medicine and Biology 2003;48:1491-1504.
39. Siegel AM, Culver JP, Mandeville JB, Boas DA. “Temporal comparison of functional brain imaging with diffuse optical tomography and fMRI during rat forepaw stimulation,” Physics in Medicine and Biology 2003;48:1391-1403.
40. Stott JJ, Culver JP, Arridge SR, Boas DA. “Optode Positional Calibration in Diffuse Optical Tomography,” Applied Optics 2003;42(16):3154-3162.
41. Kilmer, M.E., Miller, E.L., Barbaro, A. and Boas, D.A. "Three-Dimensional Shape-Based Imaging of Absorption Perturbation for Diffuse Optical Tomography." Applied Optics 2003;42(16): 3129-3144.
42. Barnett AH, Culver JP, Sorensen AG, Dale AM, Boas, DA. “Robust Inference of Baseline Optical Properties of the Human Head with Three-Dimensional Segmentation from Magnetic Resonance Imaging,” Applied Optics 2003;42(16): 3095-3108.
43. Milstein AB, Oh S, Webb KJ, Bouman CA, Zhang Q, Boas DA, Millane RP. “Fluorescence Optical Diffusion Tomography,” Applied Optics 2003;42(16): 3081-3094.
44. Hebden JC, Boas DA, George JS, Durkin AJ. “Topics in Biomedical Optics: Introduction” Applied Optics 2003;42(16): 2869-2870.
45. Franceschini MA, Fantini S, Thompson JH, Culver JP, Boas DA. “Hemodynamic evoked response of the sensorimotor cortex measued non-invasively with near-infrared optical imaging,” Psychophysiology 2003;40: 548-560.
46. Devor A, Dunn AK, Andermann ML, Ulbert I, Boas DA, Dale AM. “Coupling of Total Hemoglobin Concentration, Oxygenation, and Neural Activity in Rat Somatosensory Cortex." Neuron 2003;39: 353-359.
47. Boas, DA, Strangman, G, Culver, JP, Hoge, RD, Jasdzewski, G, Poldrack, RA, Rosen, BR, and Mandeville, JB. “Can the cerebral metabolic rate of oxygen be estimated with near-infrared spectroscopy?” Physics in Medicine and Biology 2003; 48: 2405-2418.
48. Culver, JP, Siegel, AM, Stott, JJ and Boas, DA. “Volumetric diffuse optical tomography of brain activity,” Optics Letters 2003; 28(21): 2061-2063.
49. Jasdzewski, G, Strangman, G, Wagner, J, Kwong, KK, Poldrack, RA and Boas, DA. “Differences in the hemodynamic response to event-related motor and visual paradigms as measured by near-infrared spectroscopy,” NeuroImage 2003; 20: 479-488.
50. Li, A, Miller, EL, Kilmer, ME, Brukilacchio, TJ, Chaves, T, Stott J, Zhang, Q, Wu, T, Chorlton, M, Moore, RH, Kopans, DB and Boas, DA. “Tomographic optical breast imaging guided by three-dimensional mammography,” Applied Optics 2003; 42(25): 5181-5190.
51. Yodh, AF and Boas, DA. “Functional Imaging with Diffusing Light,” Biomedical Photonics. Ed. Vo-Dinh, T. Boca Raton: CRC Press, 2003; 21-1 – 21-45. (Part 1, Part 2, Part 3, Part 4).
52. Ayata C, Dunn AK, Gursoy-Ozdemir Y, Huang Z, Boas DA and Moskowitz MA. “Laser Speckle Flowmetry for the Study of Cerebrovascular Physiology in Normal and Ischemic Mouse Cortex.” Journal of Cerebral Blood Flow and Metabolism 2004; 24:744-755.
53. Boas DA, Chen K, Grebert D and Franceschini MA. “Improving the diffuse optical imaging spatial resolution of the cerebral hemodynamic response to brain activation in humans.” Optics Letters 2004; 29(13):1506-1508.

54. Franceschini, MA and Boas, DA. “Noninvasive measurement of neuronal activity with near-infrared optical imaging.” NeuroImage 2004; 21(1): 372-386.
55. Hillman, EMC, Boas DA, Dale AM, and Dunn AK, “Laminar optical tomography: demonstration of millimeter-scale depth-resolved imaging in turbid media.” Optics Letters 2004; 29(14): 1650-1652.
56. Li, A, Zhang, Q, Culver, JP, Miller, EL and Boas, DA. “Reconstructing chromosphere concentration images directly by continuous-wave diffuse optical tomography.” Optics Letters 2004; 29(3): 256-258.
57. Milstein AB, Stott JJ, Seungseok O, Boas DA, Millane RP, Bouman CA and Webb KJ. “Fluorescence optical diffusion tomography using multi-frequency data.” J Opt Soc of Am A 2004; 21(6): 1035-1049.
58. Boas DA, Dale AM and Franceschini MA. “Diffuse optical imaging of brain activation: approaches to optimizing image sensitivity, resolution and accuracy.” NeuroImage 23. 2004; S275-S288.
59. Ayata C, Shin HK, Salamone S, Ozdemir-Gursoy Y, Boas DA, Dunn AK and Moskowitz MA. "Pronounced Hypoperfusing During Spreading Depression in Mouse Cortex." Journal of Cerebral Blood Flow and Metabolism 24: 1172-1182. 2004.
60. Boas and Dale AM. Simulation study of magnetic resonance imaging-guided cortically constrained diffuse optical tomography of human brain function. Applied Optics 44(10): 1957-1968. 2005.
61. Boas DA and Frostig RD. Optics in Neuroscience (Special Guest Editorial). Journal Biomed Optics 10(1): 011001. 2005.
62. Devor, A. Ulbert I, Dunn AK, Narayanan SN, Jones SR, Andermann ML, Boas DA and Dale A. Coupling of the cortical hemodynamic response to cortical and thalamic neuronal activity. PNAS 102(10): 3822-3827. 2005. (Supporting Information)
63. Hoge RD, Franceschini MA, Covolan RJM, Huppert T, Mandeville JB and Boas DA. Simultaneous recording of task-induced changes in blood oxygenation, volume, and flow using diffuse optical imaging and arterial spin-labeling MRI. NeuroImage 25: 701-707. 2005.
64. Li A, Boverman G, Zhang Y, Brooks D, Miller EL, Kilmer ME, Zhang Q, Hillman EMC and Boas DA. Optimal linear inverse solution with multiple priors in diffuse optical tomography. Applied Optics 44(10): 1948-1956. 2005.
65. Nioka S, Izzetoglu M, Mawn T, Nijland MJ, Boas DA and Chance B. Fetal transabdominal pulse oximeter stuides using a hypoxic sheep model. The Journal of Maternal-Fetal and Neonatal Medicine 17(6): 393-399. 2005.
66. Selb J, Stott JJ, Franceschini MA, Sorenson AG andBoas DA. Improved sensitivity to cerebral dynamics during brain activation with a time-gated optical system: analytical model and experimental validation. Journal Biomed Optics 10(1): 011013. 2005.
67. Wilcox T, Bortfeld H, Woods R, Wruck E and Boas DA. Using near-infrared spectroscopy to assess neural activation during object processing in infants. Journal Biomed Optics 10(1): 011010. 2005.
68. Yuan, S, Devor A, Boas DA and Dunn AK. Determination of optimal exposure time for imaging of blood flow changes with laser speckle contrast imaging. Applied Optics 44(10): 1823-1830. 2005.
69. Zhang Y, Brooks DH, Franceschini MA and Boas DA. Eigenvector-based spatial filtering for reduction of physiological interference in diffuse optical imaging. Journal Biomed Optics 10(1): 011014. 2005.

70. Zhang Q, Brukilacchio TJ, Li A, Stott J, Chaves T, Hillman E, Wu T, Chorlton M, Rafferty E, Moore RH, Kopans DB and Boas DA. Coregistered tomographic x-ray and optical breast imaging: initial results. Journal Biomed Optics 10(2): 024033. 2005.
71. Devor A. Ulbert I, Dunn AK, Narayanan SN, Jones SR, Andermann ML, Boas DA and Dale A. Coupling of the cortical hemodynamic response to cortical and thalamic neuronal activity. PNAS 102(10): 3822-3827. 2005. (Supporting Information)
72. Diamond, S.G., Huppert, T.J., Kolehmainen, V., Franceschini, M.A., Kaipio, J.P., Arridge, S.R. & Boas, D.A. Physiological system identification with the Kalman filter in diffuse optical tomography. Med Image Comput Comput Assist Interv Int Conf Med Image Comput Comput Assist Interv, 8(Pt 2), 649-656. 2005.
73. Dunn AK, Devor A, Dale AM and Boas DA. Spatial extent of oxygen metabolism and hemodynamic changes during functional activation of the rat somatosensory cortex. NeuroImage 27: 279-290. 2005.
74. Hoge RD, Franceschini MA, Covolan RJM, Huppert T, Mandeville JB and Boas DA. Simultaneous recording of task-induced changes in blood oxygenation, volume, and flow using diffuse optical imaging and arterial spin-labeling MRI. NeuroImage 25: 701-707. 2005.
75. Kumar ATN, Skoch J, Bacskai BJ, Boas DA and Dunn AK. Fluorescence-lifetime-based tomography for turbid media. Optics Letters 30(24): 3347-3349. (also selected for the January 1, 2006 issue of the Virtual Journal of Biological Physics Research) 2005.
76. Li A, Boverman G, Zhang Y, Brooks D, Miller EL, Kilmer ME, Zhang Q, Hillman EMC and Boas DA. Optimal linear inverse solution with multiple priors in diffuse optical tomography. Applied Optics 44(10): 1948-1956. 2005.
77. Nioka S, Izzetoglu M, Mawn T, Nijland MJ, Boas DA and Chance B. Fetal transabdominal pulse oximeter stuides using a hypoxic sheep model. The Journal of Maternal-Fetal and Neonatal Medicine 17(6): 393-399. 2005.
78. Selb J, Stott JJ, Franceschini MA, Sorenson AG and Boas DA. Improved sensitivity to cerebral dynamics during brain activation with a time-gated optical system: analytical model and experimental validation. Journal Biomed Optics 10(1): 011013. 2005.
79. Boas DA and Dale AM. Simulation study of magnetic resonance imaging-guided cortically constrained diffuse optical tomography of human brain function. Applied Optics 44(10): 1957-1968. 2005.
80. Boas DA and Frostig RD. Optics in Neuroscience (Special Guest Editorial). Journal Biomed Optics 10(1): 011001. 2005.
81. Boverman G, Miller EL, Li A, Zhang Q, Chaves T, Brooks DH and Boas DA. Quantitative spectroscopic diffuse optical tomography of the breast guided by imperfect a priori structural information. Phys. Med. Biol. 50: 3941–3956. 2005.
82. Culver JP, Siegel AM, Franceschini MA, Mandeville JB and Boas DA. Evidence that cerebral blood volume can provide brain activation maps with better spatial resolution than deoxyhemoglobin. NeuroImage 27: 947-959. 2005.
83. Custo, A., Wells III, W.M., Barnett, A.H., Hillman, E.M. & Boas, D.A. Effective scattering coefficient of the cerebral spinal fluid in adult head models for diffuse optical imaging. Appl Opt, 45(19), 4747-4755. 2006.
84. Diamond, S.G., Huppert, T.J., Kolehmainen, V., Franceschini, M.A., Kaipio, J.P., Arridge, S.R. & Boas, D.A. Dynamic physiological modeling for functional diffuse optical tomography. Neuroimage, 30(1), 88-101. 2006.
85. Huppert, T.J., Hoge, R.D., Diamond, S.G., Franceschini, M.A. & Boas, D.A. A temporal comparison of BOLD, ASL, and NIRS hemodynamic responses to motor stimuli in adult humans. Neuroimage, 29(2), 368-382. 2006.

86. Shin, H.K., Dunn, A.K., Jones, P.B., Boas, D.A., Moskowitz, M.A. & Ayata, C. Vasoconstrictive neurovascular coupling during focal ischemic depolarizations. J Cereb Blood Flow Metab, 26(8), 1018-1030. 2006.

Reviews and Book Chapters:

1. Boas DA, Meglinsky IV, Zemany L, Campbell LE, Chance B, Yodh AG. Diffusion of temporal field correlation with selected applications. In: Tuchin V, ed. SPIE Coherence-Domain Methods in Biomedical Optics. SPIE, Bellingham, 2732:34-46, 1996.
2. Ramanujam N, Boas DA, Li Y. Laser Spectroscopy and Imaging for Characterization of Human Tissue. In: Dahotre NB, ed. Lasers in Surface Engineering. American Society for Materials, Ohio, 1998.
3. Boas DA, Franceschini MA, Dunn AK, Strangman G. Noninvasive imaging of cerebral activation with diffuse optical tomography. In: InVivo Optical Imaging of Brain Function. CRC Press, Boca Raton 193-221, 2002.
4. Yodh AG, Boas DA. Functional Imaging with Diffusing Light. In: Biomedical Photonics. ed. Vo-Dinh T. CRC Press, Boca Raton 21-45, 2003.