Eighth Annual Meeting -The Fitzparick Institute for Photonics
Frontiers in Photonics Science and Technology

Program Agenda

~ Monday, October 13, 2008 ~

Duke University, FCIEMAS, Fitzpatrick Building, Schiciano Auditorium

8:00 – 9:00am	**Registration and Continental Breakfast**
9:00 – 9:10am	**Opening Address** **John Simon**, Vice Provost for Academic Affairs and George B. Geller Professor in Chemistry, Duke University
9:10 – 9:30am	**Introductory Remarks** **Thomas Katsouleas**, Dean, Pratt School of Engineering and Professor of Electrical & Computer Engineering, Duke University **Tuan Vo-Dinh**, Director, Fitzpatrick Institute for Photonics (FIP), R. Eugene & Susie E. Goodson Professor of Biomedical Engineering and Professor of Chemistry, Duke University
9:30 – 10:20am	**Symposium Keynote Lecture** **John L. Hall**, Nobel Laureate in Physics (2005), Professor, University of Colorado at Boulder National Institute of Standards and Technology (NIST) *"The Optical Frequency Comb – a remarkable tool for Metrology, Science and Medical Diagnostics"*
10:20 – 11:00am	**Plenary Lecture** **Ian Walmsley**, Hooke Professor of Experimental Physics University of Oxford, United Kingdom *"Beyond the fringe: classical coherence and quantum correlation"*
11:00 – 11:20am	**Coffee Break/Poster Sessions**
11:20 – 12:00pm	**Session 1 Advanced Photonics** Chair**, Anne Lazarides**, Mechanical Electrical & Materials Science Duke University

~ Monday, October 13, 2008 ~
(continued)

11:20 – 12:00pm (continued)

Session 1 Advanced Photonics (continued)

Joseph Izatt, Professor of Biomedical Engineering,
Duke University
"Optical Coherence-Based Imaging and Sensing in Biomedicine and Biotechnology"

Adam Wax, Associate Professor, Biomedical Engineering,
Duke University
"Spatial and temporal coherence in low coherence interferometry and imaging"

12:00 – 1:30pm

Lunch Break/Poster Sessions

1:30 – 2:50pm

Session 2 Special Topic on *Coherence Techniques I*
Chair**, Dan Gauthier,** Chair and Professor of Physics,
Duke University

Robert Boyd, (*Invited Lecture*)
M. Parker Givens Professor of Optics and Optical Physics,
The Institute of Optics, University of Rochester
"Quantum Imaging: Enhanced Image Foundation Using Quantum States of Light"

John Schotland (*Invited Lecture*)
Professor of Bioengineering and Electrical Engineering
University of Pennsylvania
"Optical Tomography: Bigger is Better"

Jungsang Kim, Nortel Networks Assistant Professor of
Electrical & Computer Engineering, Duke University
"Direct sampling of optical coherence using quantum interference"

2:50 – 4:00pm

Session 3: Special Topic on *Coherence Techniques II*
Chair**, Joseph Izatt,** Professor of Biomedical Engineering,
Duke University

Aristide Dogariu, (*Invited Lecture*)
Professor of Optics
Florida Photonics Center of Excellence Professor of Optics
University of Central Florida
"Variable Coherence Sensing"

~ Monday, October 13, 2008 ~
(continued)

2:50 – 4:00pm (continued)	**Session 3: Special Topic on *Coherence Techniques II* (continued)** **David Brady,** Professor of Electrical & Computer Engineering, Duke University *"Generalized Sampling and Signal Estimation in Imaging, Inferometry and Spectroscopy"* **Tomoyuki Yoshie**, Assistant Professor of Electrical & Computer Engineering, Duke University *"Suppressing Decoherence in a Microcavity QED System"*
4:00 – 4:20pm	**Coffee Break/Poster Sessions**
4:20 – 5:00pm	**Session 4 Advanced Photonics** Chair**, Nan-Marie Jokerst,** J. A. Jones Professor of Electrical and Computer Engineering, SMIF Executive Director, Duke University **Bruce Klitzman**, Duke University Medical Center *"Intravital Microscopy: A 'Window' to the Future of Biocompatibility Testing"* **Adrienne Stiff-Roberts**, Assistant Professor of Electrical and Computer Engineering, Duke University *"Photonic Nanomaterials for Infrared Photodetection"*
5:00 – 6:00pm	**Poster Sessions (see Posters Sessions for Abstract details)** Co-Chairs: **Adam Wax**, Associate Professor of Biomedical Engineering, Duke University **Anne Lazarides**, Assistant Professor of Mechanical Engineering & Material Sciences, Duke University **Hisham Masoud,** Professor of Electrical & Computer Engineering, Duke University
5:00 – 6:00pm	**Themed Lab Tours (see Lab Tours for more details)** FIP – Fitzpatrick Institute for Photonics Labs SMIF – Shared Materials Instrumentation Facility DiVE – Duke Immersive Virtual Environment

~ Monday, October 13, 2008 ~
(continued)

6:00 – 8:30pm

Dinner and Reception

Duke University, FCIEMAS, Fitzpatrick Building, Atrium

2008 FIP Photonics Pioneer Award Ceremony

Dinner Featuring Live Entertainment from John Brown Jazz Band

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~ Tuesday, October 14, 2008 ~
DAY 2

Duke University, FCIEMAS, Fitzpatrick Building, Schiciano Auditorium

8:30 – 9:00am **Registration and Continental Breakfast**

9:00 - 9:40am **Plenary Lecture**
John Thomas, Fritz London Professor, Duke University
"Searching for perfect fluidity in an Atomic Fermi Gas"

9:40 – 11:00am **Session 5** ***Special Panel Session***
"What Physicians Request from Biophotonics Engineers"

Co-Chairs:
James Provenzale, Professor of Radiology and Neuroradiology, Duke University Medical Center
Kim Lyerly, George Barth Geller Professor for Research in Cancer, Associate Professor of Pathology, Assistant Professor in Immunology, Duke University School of Medicine, Director of Duke Comprehensive Cancer Center

Gerald Grant, Professor of Surgery and Neurosurgery, Duke University Medical Center, Duke Comprehensive Cancer Center
"Needs for assessing therapy in brain tumors"

James Provenzale, Professor of Radiology and Neuroradiology, Duke University Medical Center
"The Meeting Ground between Medicine and Biophotonics: Translating Biophotonics Advances into Improvements in Health Care"

~ Monday, October 14, 2008 ~
Day 2
(continued)

9:40 – 11:00am (continued)	**Session 5** ***Special Panel Session*** ***"What Physicians Request from Biophotonics Engineers"*** **(continued)**
	Daniel C. Sullivan, Professor of Radiology, Duke University Medical Center, Duke Comprehensive Cancer Center *"What Oncology Needs from Bioengineering"*
11:00 – 11:20am	**Coffee Break/Poster Sessions**
11:20 – 12:00pm	**Session 6 Session 1 Advanced Photonics** Chair**, Martin Brooke,** Associate Professor of Electrical and Computer Engineering, Duke University
	Jie Liu, Associate Professor of Chemistry, Duke University *"Lighting Up All Carbon Nanotubes Using Surface Enhanced Raman Spectra"*
	Steve Cummer, Jeffrey N. Vinik Associate Professor of Electrical and Computer Engineering, Duke University *"Design and Measurements of Powered Active Metamaterials"*
12:00 – 12:10pm	**Closing Comments**

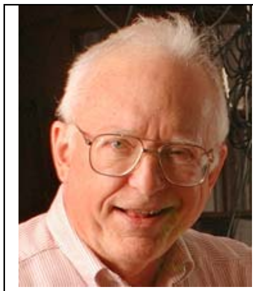
Frontiers in Photonics: Science and Technology

Welcome

 **Dr. John Simon** George B Geller Professor Vice Provost for Acad. Affairs Faculty	**Opening Remarks** **John Simon, Ph.D.** Dr. Simon is the Vice Provost for Academic Affairs and the George B. Geller Professor of the Department of Chemistry. He is a biophysical chemist studying the structure and functions of melanins.
 **Dr. Tom Katsouleas** Dean of Pratt School of Engineering, Professor of Electrical & Computer Engineering, Duke University	**Introduction** **Tom Katsouleas, Ph.D.** Tom Katsouleas is a specialist in the use of plasmas as novel particle accelerators and light sources. His work has been featured on the covers of Physical Review Letters, Scientific American, the CERN Courier and Nature. He has authored or co-authored over 200 publications and given more than 50 major invited talks
 **Dr. Tuan Vo-Dinh** Director, Fitzpatrick Institute for Photonics, R. Eugene and Susie E. Goodson Professor of Biomedical Engineering, Professor of Chemistry, Duke University	**Introduction** **Tuan Vo-Dinh, Ph.D.** Dr. Tuan Vo-Dinh's research activities and interests involve biophotonics, laser-excited luminescence spectroscopy, room temperature phosphorimetry, synchronous luminescence spectroscopy, surface-enhanced Raman spectroscopy, field environmental instrumentation, fiberoptics sensors, nanosensors, biosensors and biochips for the protection of the environment and the improvement of human health.

Frontiers in Photonics: Science and Technology

Speaker Abstracts & Biographical Sketches



Professor John L. Hall, Nobel Laureate in Physics (2005), JILA, University of Colorado and National Institute of Standards and Technology, Boulder, Colorado 80309 USA

Symposium Keynote Lecture

~ Monday, October 13, 2008~ 9:30-10:20am

John L. Hall, Ph.D.
Email address:: jhall@jila.colorado.edu

"The Optical Frequency Comb – a remarkable tool for Metrology, Science and Medical Diagnostics"

The Optical Frequency Comb concept and technology exploded in 1999-2000 from the synthesis of advances in independent fields of Laser Stabilization, UltraFast Lasers, and NonLinear Optical Fibers. The Comb was developed first as a method for optical frequency measurement, enabling a thousand-fold advance in optical frequency measurement, and searches (in the 17th digit) for time-variation of physical "constants". The Comb methods also empower enhanced time-domain control, with broad applications in spectroscopy, metrology, and the extension of nonlinear optics into the XUV range and beyond. A comb-excited Cavity Ringdown measurement allows massively multiplex spectroscopy, sensitively to detect disease-marker molecules within human breath. In Comb-based length metrology, the incredible resolution is accessible ALONG WITH intrinsic resolution of the integer fringe question: two great applications will be control/calibration of next-generation interferometric planet-finder missions, and cold-start dimensional metrology for accurate photolithography of large semiconductor wafers.

John L. Hall was born in 1934 in Denver, Colorado, and earned his PhD.(1961) degree from Carnegie Tech (now Carnegie Mellon University). He had 44 good years of research at the National Institute of Standards and Technology (NIST), working in laser technology, opto-electronic development and precision measurement. He is now NIST Senior Fellow Emeritus, Adjoint Professor of the University of Colorado, and an Adjoint Fellow of JILA (formerly the Joint Institute for Laboratory Astrophysics), a cooperative institute of NIST and the University of Colorado-Boulder. Known as a preeminent laser experimentalist and innovator, Dr. Hall has contributed significantly to the evolution of the laser from a laboratory curiosity into one of the fundamental tools of modern science. He is known also for his training and mentoring of new generations of inspired physicists, several now being star researchers themselves.

Hall's work has concentrated on improving the precision and accuracy with which lasers can produce a specific frequency, and the stability with which they can hold that frequency. He has helped to develop a broad range of laser advances in fields such as precision spectroscopy for physical and chemical analysis, new tests of fundamental physical "laws", measurement and redefinition of the speed of light, and other refinements in time and length metrology. These advances are represented by more than 240 publications and 11 US patents, and have been recognized by more than 20 Awards and Prizes from professional societies, and his employer. He has received a number of Honorary degrees, and became a member of the French Légion d'Honneur in 2004.

Dr. Hall was awarded the 2005 Nobel Prize in Physics, sharing this honor with Theodor W. Hänsch of the Max-Planck-Institute (Garching) and Roy J. Glauber of Harvard University. This recognition was awarded "for their contributions to the development of laser-based precision spectroscopy, particularly the optical frequency comb technique." The optical frequency comb can rapidly measure the frequency of another laser with extraordinarily high precision, and has many broader applications in Science, Metrology and, most recently, in Diagnostic Medicine.

Professor Ian Walmsley
Hooke Professor of Experimental Physics
University of Oxford,
United Kingdom

Plenary Lecture

~ Monday, October 13, 2008~ 10:20-11:00am

Ian Walmsley, Ph.D.
Email address:: walmsley@physics.ox.ac.uk

"Beyond the fringe: classical coherence and quantum correlation"

The coherence of an electromagnetic field is a fingerprint that enables important properties such as its classical or quantum character to be specified precisely. Further, recent developments in ultrafast technology have provided a remarkable ability to manipulate both quantum and classical light fields on ultrashort timescales. This provides new challenges for the measurement of coherence, as well as its application in novel technologies from precision measurement to secure communications. I will discuss some aspects of coherence in the context of these technologies, focusing on the measurement of both quantum and classical coherence in the femtosecond domain.

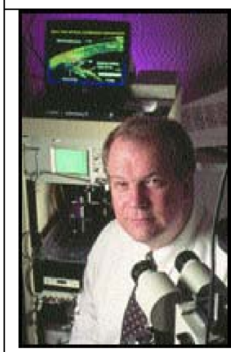
Ian Walmsley is the Hooke Professor of Experimental Physics at the University of Oxford. He read physics at Imperial College, London, and did a Ph.D. at the Institute of Optics, University of Rochester. His research interests are in ultrafast, nonlinear and quantum optics.

Dr. Anne Lazarides
Assistant Professor, Mechanical Electrical & Materials Science
Duke University

Session 1: Advanced Photonics
~ Monday, October 13, 2008~ 11:20 – 12:00pm

Session Chair

Anne Lazarides is Assistant Professor in Mechanical Electrical & Materials Science, Duke University.



Dr. Joseph Izatt
Professor, Biomedical Engineering
Duke University

Session 1: Advanced Photonics
~ Monday, October 13, 2008~ 11:20 – 11:40am

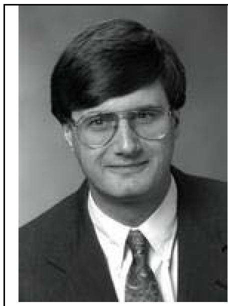
Joseph Izatt, Ph.D.
Email address:: jizatt@duke.edu

"Optical Coherence-Based Imaging and Sensing in Biomedicine and Biotechnology"

Optical coherence-based imaging techniques including optical coherence tomography (OCT), optical coherence microscopy (OCM), and spectral domain phase microscopy (SDPM) use low-coherence spectral interferometry to obtain nanometer to micron-scale measurements of structure, motion, and molecular composition in living cells, tissues, and organisms. OCT has become a standard diagnostic tool in clinical ophthalmology, and is under investigation for other human diagnostic applications including cancer detection and evaluation of cardiovascular disease. Within the past few years, dramatic technology advances have increased the performance of OCT and OCM systems manyfold, and are now capable of micron-scale two and three-dimensional functional and molecular imaging noninvasively in living systems. Applications of these new technologies for noninvasive, quantitative characterization of ophthalmic disease progression, and for high-throughput phenotyping of small animal models of disease and genetic manipulation are particularly compelling. Related technology advances have enabled the design of highly phase-stable interference microscopes capable of resolving nanometer-scale structures and motions in living cells with ms temporal resolution. These new capabilities are being used to probe cellular internal and external surfaces and their responses to chemical and mechanical stimuli. I will review our ongoing work at Duke in these areas.

Joseph A. Izatt is Professor of Biomedical Engineering and Ophthalmology, and Program Director for Biophotonics at the Fitzpatrick

	Institute for Photonics at Duke University in Durham, North Carolina. He is also Chairman and Chief Technology Officer at Bioptigen, Inc., a North Carolina startup company commercializing optical coherence tomography technology for clinical and biomedical research applications.
 **Dr. Adam Wax** Associate Professor Biomedical Engineering Duke University	**Session 1: Advanced Photonics** **~ Monday, October 13, 2008~ 11:40 – 12:00pm** **Adam Wax, Ph.D.** **Email address:: a.wax@duke.edu** ***"Spatial and Temporal Coherence in Low Coherence Interferometry and Imaging"*** Understanding the role of coherence is essential for optimizing the acquisition and analysis of low coherence interferometry signals. We have developed new methods of coherence gating imaging by employing rigorous models of coherence for analysis. For example, traditional analysis of spectroscopic optical coherence tomography (SOCT) signals is limited by an uncertainty relationship between time (depth) and frequency (wavelength). We have developed a method to avoid this tradeoff through the use of a bilinear time–frequency distribution which employs two Gaussian windows to simultaneously obtain high spectral and temporal resolution. In another imaging modality, we have examined the role of spatial coherence to better understand how OCT signals originating from multiple depths combine in different manners depending on the detection method. In this presentation, we will present our models for analyzing coherence in OCT imaging, illustrate their properties through numerical simulations and demonstrate new imaging modalities that they enable. **Adam Wax** received the Ph.D. degree in physics from Duke University, Durham, NC in 1999 and was a postdoctoral fellow of the National Institutes of Health at the Massachusetts Institute of Technology. Dr. Wax joined the faculty of the Department of Biomedical Engineering at Duke University in the fall of 2002 and currently is appointed as an associate professor. His research interests are in the use of light scattering and interferometry to probe the biophysical properties of cells for both diagnosis of disease and fundamental cell biology studies.



Dr. Daniel Gauthier
Physics Chair, Anne T. and Robert M. Bass Professor of Physics, Professor of Biomedical Engineering, Duke University

Session 2: Coherence Techniques I
~ Monday, October 13, 2008~ 1:30 – 2:50pm

Session Chair

Daniel Gauthier is a professor of physics and biomedical engineering at Duke and has been associated with the Fitzpatrick Institute of Photonics since its inception. He is the chair of the physics department and has interests in photonics, nonlinear dynamical systems, and dynamics of the heart.

Dr. Robert W. Boyd
M. Parker Givens Professor of Optics and Optical Physics
The Institute of Optics
University of Rochester
Rochester, NY 14627 USA

Session 2: Coherence Techniques I
~ Monday, October 13, 2008~ 1:30 – 2:00pm

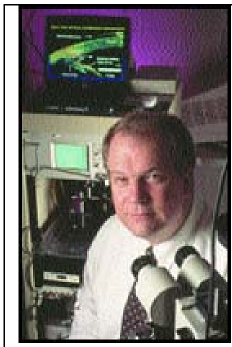
Robert W. Boyd, Ph.D.
Email address:: boyd@optics.rochester.edu

"Quantum Imaging: Enhanced Image Foundation Using Quantum States of Light"

Image formation making use of quantum states of light allow dramatic new possibilities in the field of image science. In this contribution, we review some of the conceptual possibilities afforded by quantum imaging and describe some recent work that displays some of these features. Examples include the possibility of imaging with resolution surpassing the classical Rayleigh limit and the ability to perform "interaction-free" imaging. In addition, we present some new experimental results on the role of coherence and indistinguishability in determining the properties of two-photon interference.

Robert Boyd received the B.S. degree in physics from the Massachusetts Institute of Technology and the Ph.D. degree in physics in 1977 from the University of California at Berkeley. His Ph.D. thesis was supervised by Professor Charles H. Townes and involves the use of nonlinear optical techniques in infrared detection for astronomy. Professor Boyd joined the faculty of the Institute of Optics of the University of Rochester in 1977 and since 1987 has held the position of Professor of Optics. Since July 2001 he has also held the position of the M. Parker Givens Professor of Optics, and since July 2002 has also held the position of Professor of Physics. His research interests include studies of "slow" and "fast" light propagation, quantum imaging techniques, nonlinear optical interactions, studies of the nonlinear optical properties of materials, the development of photonic devices including photonic biosensors, and studies of the quantum statistical properties of nonlinear optical interactions. Professor Boyd has written two

	books, co-edited two anthologies, published over 275 research papers, and been awarded five patents. He is a fellow of the American Physical Society and the Optical Society of America and is a past chair of the Division of Laser Science of the American Physical Society.
 **Professor John C. Schotland** Professor of Bioengineering And Electrical Engineering University of Pennsylvania Philadelphia, PA 19104 USA	**Session 1 – Advanced Photonics** **~ Monday, October 13, 2008~ 2:00 – 2:30pm** **John C. Schotland, M.D., Ph.D.** **Email address:: schotland@seas.upenn.edu** ***"Optical Tomography: Bigger is Better"*** Dr. Schotland's research is focused on theoretical optical physics with applications to biomedical imaging and nano-optics. Areas of current interest include optical tomography, optical imaging of nanoscale systems, and the use of quantum states of light for optical imaging. Inverse problems, particularly inverse scattering problems, are a unifying theme which connects these areas.
 **Professor Jungsang Kim** Nortel Networks Assistant Professor of Electrical Computer Engineering Duke University Durham, NC 27708 USA	**Session 1 – Advanced Photonics** **~ Monday, October 13, 2008~ 2:30 – 2:50pm** **Jungsang Kim., Ph.D.** **Email address:: jungsang@ee.duke.edu** ***"Direct sampling of optical coherence using quantum interference"*** Professor Jungsang Kim, in collaboration with Professor David Brady ~ We describe the concept of a quantum coherence detector where the mutual coherence of two optical fields can be measured directly using quantum interference. Our approach utilizes an atomic Raman transition where the state evolution is driven by the mutual coherence of the fields interacting with the atoms. Feedback control is used to tune the system evolution to balance the mutual coherence of the fields being characterized. We show that the sensitivity of the coherence measurement can be enhanced significantly above that of conventional interferometric methods.



Dr. Joseph Izatt
Professor, Biomedical Engineering
Duke University

Session 3: Coherence Techniques II

~ Monday, October 13, 2008~ 2:50 – 4:00pm

Session Chair

Joseph A. Izatt is Professor of Biomedical Engineering and Ophthalmology, and Program Director for Biophotonics at the Fitzpatrick Institute for Photonics at Duke University in Durham, North Carolina. He is also Chairman and Chief Technology Officer at Bioptigen, Inc., a North Carolina startup company commercializing optical coherence tomography technology for clinical and biomedical research applications.

Professor Aristide Dogariu
Professor of Optics
Florida Photonics Center of Excellence
University of Central Florida
Orlando, FL 32816 USA

Session 3: Coherence Techniques II

~ Monday, October 13, 2008~ 2:50 – 3:20pm

Aristide Dogariu, Ph.D.
Email address:: adogariu@creol.ucf.edu

"Variable Coherence Sensing"

Properties of light such as wavelength, polarization, wavefront curvature, etc., have been commonly exploited in a variety of sensing procedures. Remarkably, manipulating the spatial coherence of optical fields permits high resolution probing of structural properties over extended volumes while relying on simple detection systems. The idea of using the spatial coherence properties of radiation in tomographic procedures applies to any type of electromagnetic radiation. Operating on principles of statistical optics, such sensing techniques can become alternatives for various cutting-edge microscopies that rely on isolating small volumes of analyte or that require high-resolution scanning over minute dimensions of a sample.

Aristide Dogariu received his PhD from Hokkaido University and is the Florida Photonics Center of Excellence Professor of Optics. His research interests include optical physics, waves propagation and scattering, electromagnetism, and random media characterization. Within the College of Optics and Photonics at the University of Central Florida he leads the *Laboratory for Photonics Diagnostics of Random Media* (http://random.creol.ucf.edu/). Professor Dogariu is a Fellow of the Optical Society of America, the Physical Society of America, and currently serves as the editor of *Applied Optics - Optical Technology*.

Dr. David J. Brady
Professor, Electrical and Computer Engineering
Duke University

Session 3: Coherence Techniques II

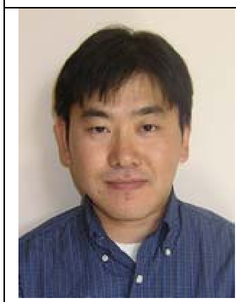
~ Monday, October 13, 2008~ 3:20 – 3:40pm

David J. Brady, Ph.D.
Email address:: dbrady@duke.edu

"Generalized sampling and signal estimation in imaging, interferometry and spectroscopy"

Generalized sampling enables compressive and feature specific measurement in optical imaging and spectroscopy. This talk describes a methodology for comparative analysis of generalized sampling strategies and discusses examples in coded aperture, multiple aperture and adaptive optical designs.

David Brady is a Professor of Electrical Computer & Engineering and leads the Duke Imaging and Spectroscopy Program (DISP), which builds computational optical sensor systems. DISP projects include hyperspectral microscopy, Raman spectroscopy for tissue chemometrics, optical coherence sensors and infrared spectral filters.



Dr. Tomoyuki Yoshie
Assistant Professor, Electrical and Computer Engineering
Duke University

Session 3: Coherence Techniques II

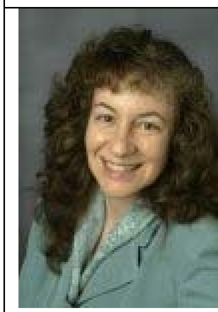
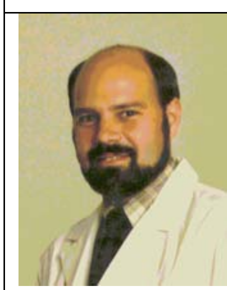
~ Monday, October 13, 2008~ 3:40 – 4:00pm

Tomoyuki Yoshie, Ph.D.
Email address:: yoshie@duke.edu

"Suppressing Decoherence in a Microcavity QED System"

Cavity-QED experiments are used as a test bet for investigating quantum nature of light, including coherence in quantum mechanics. The system consists of a single atomic emitter and single mode field. We use a single quantum dot as a quasi-atomic emitter and a photonic crystal mode as a single mode field. In an open cavity-QED system including our dot-nanocavity system, the coherence is degraded due to energy dissipation from a cavity-QED system to a reservoir. The light confinement is so imperfect that stored energy in the system dissipates away through a cavity mirror. In order to suppress the photon decay from the cavity, we use an ultra-high-Q (UHQ) nano-resonator based on 3D photonic crystal. In this talk, we show our efforts in developing an UHQ 3D photonic crystal nanocavity for suppressing decoherence in a microcavity QED system.

Tomoyuki Yoshe is an Assistant Professor of Electrical and Computer Engineering at Duke University. He received his B.Eng. and M.Eng. degrees in Electrical Engineering from Kyoto University in 1990 and 1992, respectively, and then worked as a research engineer and later a chief

	research engineer at Sanyo Electric, Japan, for developing green-blue-UV semiconductor laser diodes. He received his M.S. and Ph.D. degrees in Electrical Engineering from Caltech in 2000 and 2004, respectively. His achievements include quantum dot photonic crystal nanolasers, 130 GHz photonic crystal nanolasers and strong coupling with a single quantum dot in a photonic crystal nanocavity.
 **Dr. Nan Marie Jokerst** J.A. Jones Professor, Electrical and Computer Engineering Duke University	**Session 4: Advanced Photonics** **~ Monday, October 13, 2008~ 4:20 – 5:00pm** **Session Chair** **Nan Jokerst** is the J. A. Jones Distinguished Professor of Electrical and Computer Engineering at Duke University, and the Executive Director of the Duke Shared Materials Instrumentation Facility, a Duke shared cleanroom and characterization facility. She received her BS in Physics from Creighton University in 1982, and her MS and PhD in Electrical Engineering from the University of Southern California in 1984 and 1989, respectively. She is a Fellow of the IEEE, and has served as an elected member of the IEEE LEOS Board of Governors, and as the VP for Conferences and as the VP Technical Affairs. She is a Fellow of the Optical Society of America, and has served as Chair of the OSA Engineering Council. Her awards include an NSF Presidential Young Investigator Award, an IEEE Third Millenium Medal, the IEEE/HP Harriet B. Rigas Medal, and the Alumni in Academia Award for the University of Southern California Viterbi School of Engineering. She has published over 200 refereed journal and conference publications, and has 6 patents.
 **Dr. Bruce Klitzman** Associate Professor, Departments of Surgery, Cell Biology and Biomedical Engineering Senior Director, Kenan Plastic Surgery Research Laboratories Duke University Medical Center	**Session 4: Advanced Photonics** **~ Monday, October 13, 2008~ 4:20 – 4:40pm** **Bruce Klitzman, Ph.D.** **Email address:: klitz@duke.edu** ***"Intravital Microscopy: A 'Window' to the Future of Biocompatibility Testing"*** Research interests are in the area of tissue engineering and physiological mechanisms of controlling transport from blood to tissue. This broad topic covers basic and clinical studies on a whole animal, whole organ, microvascular, cellular, ultrastructural, and molecular level. The current projects include: 1) control of total blood flow and flow distribution in the microcirculation in normal and in pathological states such as wounds, tumors, and traumatized tissue; 2) angiogenesis stimulation and inhibition; 3) improving the biocompatibility and performance of synthetic and biosynthetic blood vessels; 4) controlling the development of tumor microcirculation and its

effect on oxygenation;
5) measurement of tissue blood flow and oxygenation as a predictor of tissue damage or ability to heal; and
6) sampling of extracellular fluid using microdialysis to measure metabolites and drug delivery.

Dr. Adrienne Stiff-Roberts
Assistant Professor, Electrical Computer Engineering
Duke University

Session 4: Advanced Photonics

~ Monday, October 13, 2008~ 4:40 – 5:00pm

Adrienne Stiff-Roberts, Ph.D.
Email address:: astiff@ee.duke.edu

"Photonic Nanomaterials for Infrared Photodetection"

Infrared (IR) photodetectors are used in a range of imaging applications, including military signature analysis, environmental monitoring, medical diagnosis, and industrial equipment diagnosis. A significant reduction in the cost of IR camera systems is possible if traditional cooling systems, such as liquid-nitrogen dewars or Stirling coolers, are replaced by thermo-electric coolers. Such a design change requires the development of an IR photodetector that operates at elevated temperatures (≥150 K). Photonic nanomaterials, i.e. quantum dots, have great potential to provide the required performance at high temperatures due to three-dimensional quantum confinement of the detector active region. In this talk, recent progress related to two classes of quantum dots (QDs) will be presented: epitaxial InAs/GaAs QDs grown by the Stranski-Krastanow (S-K) growth mode and colloidal CdSe QDs embedded in conducting polymers. I will discuss: 1) efforts to understand dopant incorporation in InAs/GaAs QDs grown by molecular beam epitaxy, and 2) progress in using matrix-assisted pulsed laser evaporation to demonstrate controlled nanoscale morphology in hybrid organic/inorganic nanocomposites.

Dr. Stiff-Roberts is an Assistant Professor in the Department of Electrical and Computer Engineering at Duke University. Dr. Stiff-Roberts received both the B.S. degree in physics from Spelman College and the B.E.E. degree in electrical engineering from the Georgia Institute of Technology in 1999. She received an M.S.E. in electrical engineering and a Ph.D. in applied physics in 2001 and 2004, respectively, from the University of Michigan, Ann Arbor, where she investigated high-temperature quantum dot infrared photodetectors. Dr. Stiff-Roberts received the David and Lucile Packard Foundation Graduate Scholars Fellowship and the AT&T Labs Fellowship Program Grant from 1999-2004. She is a member of Phi Beta Kappa, Sigma Pi Sigma, IEEE, and MRS. She is also a recipient of the National Science Foundation CAREER Award in 2006 and the Office of Naval Research Young Investigator Award in 2007.

Professor John E. Thomas
Fritz London Professor
Duke University

Plenary Lecture

~ Tuesday, October 14, 2008~ 9:00-9:40am

John E. Thomas, Ph.D.
Email address:: jet@phy.duke.edu

"Searching for perfect fluidity in an Atomic Fermi Gas"

An optically-trapped mixture of spin ½-up and spin ½-down ^{6}Li atoms provides a new paradigm for exploring strongly interacting Fermi systems in nature. This ultracold atomic gas offers unprecedented opportunities to test theoretical techniques that cross interdisciplinary boundaries. A bias magnetic field is used to tune the gas near a Feshbach resonance, where the s-wave scattering length diverges and the interparticle spacing sets the only length scale. Even though it is dilute, an atomic Fermi gas near a Feshbach resonance is the most strongly interacting nonrelativistic system known, enabling tests of recent theories in disciplines from high temperature superconductors to nuclear matter. Strongly interacting Fermi gases also exhibit extremely low viscosity hydrodynamics, of great interest in the quark-gluon plasma and string theory communities, where it has been conjectured that the ratio of the shear viscosity to the entropy density has a universal lower bound, which defines a perfect fluid.

I will describe our all-optical cooling methods and our studies of the thermodynamic and hydrodynamic properties of the ^{6}Li cloud. Our measurements of the entropy reveal a high temperature superfluid transition, which occurs at a large fraction of the Fermi temperature. Our most recent estimates of the shear viscosity are obtained from observations of the hydrodynamic expansion of a rotating cloud. Together, these results suggest that a strongly interacting Fermi gas may be the most perfect quantum fluid ever studied.

John E. Thomas is the Fritz London Professor of Physics at Duke University. His group explores the physics of an optically-trapped ultracold atomic Fermi gas. The Duke group pioneered the development of ultrastable all-optical traps for neutral atoms in 1999, achieving trap lifetimes of more than 400 seconds, comparable to the best magnetic traps. The team has developed methods for direct evaporative cooling of neutral atoms in optical traps, enabling the first all-optical production of a degenerate Fermi gas in 2001. In 2002, the Duke group was the first to produce and study a strongly interacting degenerate Fermi gas, which is now a paradigm for strong interactions in nature. The team provided the first evidence for high temperature superfluid hydrodynamics in that system in 2004 and developed model-independent methods for measuring the energy and entropy in 2007.

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Dr. James Provenzale
Professor of Radiology - Neuroradiology
Duke University Medical Center
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Session 5: Special Panel Session
"What Physicians Request from Biophotonics Engineers"
~ Tuesday, October 14, 2008~ 9:40 – 11:00am

Session Co-Chair

James Provenzale, MD is board-certified in both Neurology and Radiology. He is Chief of Neuroradiology at Duke University Medical Center. His major area of research interest is applications of nanotechnology to cancer diagnosis and therapy.
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Dr. H. Kim Lyerly
George Barth Geller Professor for Research in Cancer, Associate Professor of Pathology, Assistant Professor in Immunology
Duke University School of Medicine
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Session 5: Special Panel Session
"What Physicians Request from Biophotonics Engineers"
~ Tuesday, October 14, 2008~ 9:40 – 11:00am

Session Co-Chair

H. Kim Lyerly, Md is the Director of the Duke Comprehensive Cancer Center and has recently been appointed to the National Cancer Advisory Board by President George W. Bush.
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Dr. Gerald Grant
Professor of Surgery, Neurosurgery, Duke University Medical Center
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Session 5: Special Panel Session
"What Physicians Request from Biophotonics Engineers"
~ Tuesday, October 14, 2008~ 9:40 – 11:00am

Gerald Grant, M.D.
Email address:: gerald.grant@duke.edu

"Needs for assessing therapy in brain tumors"

Dr. Gerald Grant received his BS from the Duke University Medical Center in 1989, and his MD from the Stanford University Medical Center in 1994. Since then, Dr. Grant has interned at the University of Washington, been a fellow at Atkinson Morley's Hospital in London and the Children's Hospital and Regional Medical Center in Seattle, and been an active member of the USAF medical corps. Currently, Dr. Grant is an Assistant Professor of Pediatric Neurosurgery at the Duke University Medical Center.
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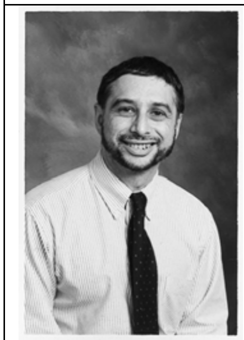
Dr. Grant's work has yielded numerous awards including the Air Force Physician's Most Outstanding Research Award, as well as recognition from the American College of Surgeons, the American Academy of Neurological Surgery, and the American Heart Association. In addition, Dr. Grant has been recognized by the National Institutes of Health and Duke University's SPORE career development program. Dr. Grant currently serves on the Advisory Board for the Fitzpatrick Institute for Photonics.



Dr. James Provenzale
Professor of Radiology - Neuroradiology
Duke University Medical Center

Session 5: Special Panel Session

"What Physicians Request from Biophotonics Engineers"

~ Tuesday, October 14, 2008~ 9:40 – 11:00am

James Provenzale, M.D.
Email address:: james.provenzale@duke.edu

"The Meeting Ground between Medicine and Biophotonics: Translating Biophotonics Advances into Improvements in Health Care"

This presentation will define some of the challenges in Medicine in which Biophotonics may play an important role in diagnostics and therapeutics. Specifically, the need for biosensing capabilities to understand physiological processes as well as to better determine response to therapy in real-time will be discussed.

Dr. Daniel C. Sullivan
Professor of Radiology, Duke University Medical Center, Duke Comprehensive Cancer Center

Session 5: Special Panel Session

"What Physicians Request from Biophotonics Engineers"

~ Tuesday, October 14, 2008~ 9:40 – 11:00am

Daniel C. Sullivan, M.D.
Email address:: daniel.sullivan@duke.edu

"What Oncology Needs from Bioengineering"

Detectors for: Biochemistry, Physiology
Markers or Monitors for: Risk, Therapy, Drugs
Methods to increase Quantification (reduce qualitative or subjective interpretations)
Error-reduction tools or systems (e.g., simulators)
Data integration/Decision-support tools
Minimally-invasive or robotics devices
Low-cost solutions

Daniel C. Sullivan, M.D. is Professor of Radiology at Duke University Medical Center, coordinator of the imaging activities for the Duke Comprehensive Cancer Center (DCCC), and Director fo the Imaging Core of the Duke CTSA program. He is also Science Adviser to the Radiological Society of North America (RSNA). He completed radiology residency and nuclear medicine fellowship in 1977 at Yale-New Haven Hospital, and was in academic radiology for 20 years before joining the National Cancer Institute at NIH in 1997. From 1977 to 1997 Dr. Sullivan held faculty appointments at Yale University Medical Center, Duke University Medical Center, and University of Pennsylvania Medical Center. His areas of clinical and research expertise are in nuclear medicine and oncologic imaging.

From 1997 to 2007 Dr. Sullivan was Associate Director in the Division of Cancer Treatment and Diagnosis of the National Cancer Institute (NCI), and Head of the Cancer Imaging Program (CIP) at NCI. CIP initiated several collaborative groups including the In Vivo Cellular and Molecular Imaging Centers, the Small Animal Imaging Resource Programs, the Lung Imaging Database Consortium, the Network for Translational Research in Optical Imaging, the American College of Radiology Imaging Network, and the Imaging Workspace within NCI's caBIG program. Dr. Sullivan was Chari of the NIH Bioengineering Consortium (BECON) from 2004 to 2006, and is a Fellow of AIMBE.

Dr. Sullivan's current responsibilities at Duke include improving the use of imaging in DCCC clinical trials and facilitating translational research involving new imaging methods. He also serves part-time as Special Assistant to the Senior Vice Chancellor for Academic Affairs, advising on strategic planning for imaging research. In his role with the RSNA Dr. Sullivan coordinates integration of a wide range of national and international activities related to evaluating and validating imaging methods as biomarkers in clinical research.

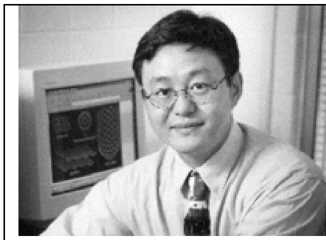
Dr. Martin A. Brooke
Associate Professor, Electrical and Computer Engineering
Duke University

Session 6: Advanced Photonics

~ Tuesday, October 14, 2008~ 11:20am – 12:00pm

Session Chair

Martin A. Brooke received the B.E. (Elect.) Degree (1st. Class Hons.) from Auckland University in New Zealand in 1981. He received the M.S. and Ph. D. in Electrical Engineering from The University of Southern California in 1984, and 1988, respectively. He is currently an Associate Professor of Electrical Engineering at Duke University. Professor Brooke was an Analog Devices Career development award recipient from 1988-1993, won a National Science Foundation Research Initiation Award in 1990, the 1992 IEEE Midwest Symposium on Circuits and Systems, Myril B. Reed Best Paper Award, and the Georgia Tech Outstanding Thesis Advisor Award in 2003. He has graduated twenty three PhD students from his research group and has six U.S. patents awarded. He has published more than 120 articles in technical Journals and Proceedings, and articles on his work have appeared in several trade publications. Dr. Brooke is a senior member of the IEEE.



Dr. Jie Liu
Associate Professor, Chemistry
Duke University

Session 6: Advanced Photonics

~ Tuesday, October 14, 2008~ 11:20 – 11:40am

Jie Liu, Ph.D.
Email address:: j.liu@duke.edu

"Lighting up All Carbon Nanotubes Using Surface Enhanced Raman Spectra"

Raman spectroscopy is an important and widely used metrology technique to characterize carbon nanotubes (CNTs). The standard Raman spectroscopy generally used for probing single-walled carbon nanotubes (SWNTs) is resonance Raman spectroscopy (RRS), which is based on the selective resonance of excitation photons coinciding with an electronic transition between the van Hove singularities of the valence band and the conduction band of SWNTs. Due to its enhanced identification, RRS can provide the detailed electronic and phonon properties of SWNTs at the single nanotube level. However, this method has its limitation that only SWNTs in resonance with excitation photons are enhanced in Raman intensity. The radial breathing mode (RBM) peaks of SWNTs in the nonresonance regions are difficult to observe by RRS because of the narrow resonance windows of RBM. Thus, only a very small portion of SWNTs can be characterized using a certain excitation wavelength. This limitation has been preventing Raman spectroscopy from exhibiting the full-scale information of the SWNTs in a sample, especially for the surface-grown SWNTs, which show extremely low Raman intensity due to the strong interaction between SWNTs and the substrates. Tunable laser or multi-wavelength laser system is necessary in order to obtain a comprehensive picture of any given SWNT sample. Based on metal nanostructures/SWNTs hybrids, Surface enhanced Raman spectra (SERS) might present a competitive approach to avoid this limitation but using only one laser wavelength. IN this talk, we discuss an method that not only greatly enhances the Raman intensity of SWNTs by up to six orders of magnitude, but also enables the observation of RBM peaks originally undetectable with RRS, after decorating highly SERS-active Au nanoparticles (NPs) on surface-grown SWNTs.

Dr. Liu's research interests are focusing on the chemistry and material science of nanoscale materials. Specific topics in his current research program include: Self-assembly of nanostructures; Preparation and chemical functionalization of single walled carbon nanotubes; Developing carbon nanotube based chemical and biological sensors; SPM based fabrication and modification of functional nanostructures.

Dr. Steve Cummer
Jeffrey N. Vinik Associate Professor, Electrical & Computer Engineering,
Duke University

Session 6: Advanced Photonics

~ Tuesday, October 14, 2008~ 11:40am – 12:00pm

Steve Cummer, Ph.D.
Email address:: cummer@ee.duke.edu

"Design and Measurements of Powered Active Metamaterials"

Metamaterials can be engineered to have a much broader range of electromagnetic properties than conventional materials. As presently realized through self-resonant inclusions, electromagnetic metamaterials are inherently lossy, and their bandwidth is fixed and typically narrow. These constraints limit their performance in many applications, especially at IR and optical frequencies. It has long been recognized that metamaterials containing externally powered active elements can in principle be used to reduce or control loss and dispersion in engineered materials. However, little experimental work in this area has been reported. We describe the theoretical design and experimental validation of one approach to create externally powered active metamaterial particles. This active particle combines elements that sense and generate local fields with an embedded amplifier to control the phase and magnitude of the particle response. We demonstrate experimentally the characteristics of these active elements by directly measuring the effective permeability and permittivity from reflection and transmission measurements in a waveguide loaded with these active structures. The measurements confirm that properties such as zero loss and minimal dispersion can be obtained for near zero or even negative permeability and permittivity. We also show examples of electromagnetic properties not easily obtainable with other approaches, such as nonreciprocity.

Dr. Cummer is currently the Jeffrey N. Vinik Associate Professor of Electrical and Computer Engineering at Duke University. He received his Ph.D. in Electrical Engineering from Stanford University in 1997 and spent two years at NASA Goddard Space Flight Center as an NRC postdoctoral research associate before joining Duke. He has written or coauthored more than 85 papers in refereed journals and has been an author on more than 160 national and international conference presentations. He received a National Science Foundation CAREER award and a Presidential Early Career Award for Scientists and Engineers (PECASE) in 2001. His current work is in a variety of theoretical and experimental wave propagation problems in engineered materials and geophysical remote sensing

Frontiers in Photonics: Science and Technology

Poster Session

Meet the Judges

AdamWax
Associate Professor, Biomedical Engineering Duke University

Hisham Massoud
Professor, Electrical Computer & Engineering
Duke University

Anne Lazarides
Assistant Professor, Mechanical Electrical & Materials Science
Duke University

Student Poster Session

⅄ Poster # 1

Noncontact Fluorescence Diffuse Optical Tomography for In Vivo Molecular Imaging in Small Animals

Xiaofeng "Steve" Zhang, Cristian Badea, G. Allan Johnson
Center for In Vivo Microscopy, Radiology, Duke University

Fluorescence imaging is an important tool for tracking molecular-targeting probes in preclinical studies. It offers high sensitivity but nonetheless low spatial resolution compared to other leading imaging methods such CT and MRI. We demonstrate our methodological development in noncontact small animal in vivo imaging using fluorescence diffuse optical tomography (FDOT). We have implemented a noncontact fluid-free FDOT system that uses a raster-scanned continuous-wave diode laser as the light source and an ICCD camera as the detector to acquire fluorescence signal. The specimen was positioned on a motorized rotation stage. Laser scanning, data acquisition, and stage rotation were controlled via LabVIEW applications. The forward problem in the heterogeneous medium was based on the normalized Born method, and the sensitivity function was determined using a Monte Carlo method. The inverse problem (image reconstruction) was performed using a regularized iterative algorithm, in which the cost function was defined as a weighted sum of the L-2 norms of the solution image, the residual error, and the image gradient. The relative weights were adjusted by two independent regularization parameters. Our initial tests used a phantom that consists of a translucent plastic cylinder filled with tissue-simulating liquid and two thin-wall glass tubes containing indocyanine green (ICG). The newly developed system and phantom are currently used to explore the impact of the number of sources, number of detectors, and number of measurement angles on the achievable spatial resolution in FDOT imaging using over-sampled measurements. The optimal sampling configurations will be applied to in vivo animal studies.

⅄ Poster # 2

Understanding and Predicting the Frequency-Dependent First Hyperpolarizabilities based on Linear Absorption Spectra and Generalized Sum Rules

Xiangqian Hu†, Dequan Xiao†, Shahar Keinan†, Weitao Yang†, Michael J. Therien†, Koen Clays§ and David N. Beratan†,‡
† *Department of Chemistry and ‡Department of Biochemistry, Duke University*
§*Department of Chemistry, University of Leuven, Celestijnenlaan 200D,B-3001 Leuven, Belgium*

We employ the generalized Thomas-Kuhn sum (TKS) rules to compute the transition dipoles between excited states, allowing us to predict the frequency dispersion of first hyperpolarizabilities using the experimental linear absorption spectra. We calibrate the frequency dependent first hyperpolarizabilities using two parameters: a shifting factor for transition energies and an absorption band half-width parameter. The predicted dispersions show quantitative agreements with several experimental datasets. The predicted dispersions include β-contributions from both “two-level” transitions and “three-level” transitions, enabling us to quantitatively explain the unusual oscillatory frequency dependence of in metal-mediated porphyrin derivatives. We show that structurally related porphyrin derivatives with

similar linear absorption spectra can have dramatically different dynamic hyperpolarizabilities because of strongly coupled charge transfer (CT) transitions as suggested in earlier experimental studies. Our approach provides a quantitative strategy to link measured linear optical absorption spectrum to the prediction of nonlinear optical properties.

Poster # 3 ********HONORABLE MENTION*********

Velocity-Resolved Single-Pass Volumetric Bidirectional Blood Flow Imaging Using Spectral Domain Optical Coherence Tomography

Yuankai K. Tao, Anjul M. Davis, Kristen M. Kennedy,Joseph A. Izatt
Fitzpatrick Institute for Photonics, Duke University

Spectral domain optical coherence tomography (SDOCT) has demonstrated strong clinical potential for *in vivo* high-resolution and high-speed imaging of biological structure. Advances in Doppler SDOCT have demonstrated several image acquisition schemes that enabled real-time, high-resolution, volumetric display of blood flow maps. Current generation Doppler SDOCT systems use phase differences between sequential A-scans acquired at a single spatial position to calculated the velocity of moving scatterers. These techniques, while able to provide 3D flow maps and velocimetry data, have reduced imaging speeds and are more susceptible to sample motion as compared to conventional SDOCT since they are inherently temporally oversampled. Recently, several methods for optical angiography have been developed which resolve moving scatterers by imposing a spatial frequency modulation across a lateral scan dimension. The carrier frequency is generated by adding a reference phase delay using a moving reference arm or an off-pivot scanning beam. The resulting data is spatial frequency windowed such that all moving scatterers (flow) modulating the carrier frequency can be separated from non-moving scatterers (structure). However, spatial frequency modulation requires precise synchronization of reference arm delay with B-scan acquisition and multiple B-scans are required to image bidirectional flow into and out-of the A-scan axis. Here we demonstrate single-pass volumetric bidirectional blood flow imaging (SPFI) SDOCT using a modified Hilbert transform without the use of spatial frequency modulation. By windowing low-spatial frequency scatterers across a B-scan, bidirectionally moving scatterers centered at Doppler frequencies outside of the frequency window are resolved. Furthermore, 3D velocimetry maps can be resolved by setting the spatial frequency window to a corresponding velocity range and shifting it across all spatial frequencies to image scatterers moving in a particular velocity range. SPFI SDOCT allows for 3D imaging of *in vivo* microvasculature down to 15um, thus providing information about vessel morphology and dynamics.

Poster # 4

Multiplexed Low-Coherence Interferometry Instrument for Measuring Microbicide Gel Thickness Distribution

Tyler K Drake, Francisco Robles, Marcus H Henderson, David F Katz, and Adam Wax
Fitzpatrick Institute for Photonics, Duke University

Microbicidal gels have shown great promise in combating sexually transmitted infections, including HIV/AIDS. Distribution dynamics in the applied region greatly affect the microbicidal gel¹s efficacy. Recent studies indicate that coating layers with thicknesses in excess of 100 µm may be sufficient to

neutralize semen-borne HIV before it can contact epithelium tissue and initiate infection. The ability to measure the thickness of the gel coating accurately is paramount in the evaluation of candidate microbicidal products and in the design improved gels. We propose a multiplexed low coherence interferometry (LCI) instrument to be used as a new label-free, high-resolution method for intravaginal measurement of microbicidal gel thickness distributions. The multiplexed system will utilize six (6) parallel channels to obtain broad area scanning of epithelial coating thickness.

Currently, fluoroscopic methods are often employed to measure microbicidal gel thickness. Fluoroscopy, however, suffers from limitations of the contrast agents used to achieve a signal. The agents experience diffusion losses to the surrounding tissue and photobleaching,, which both limit the length of time and the number of measurements that can be made accurately. LCI has previously been shown to be an effective method of measuring gel thickness, with precision and accuracy exceeding flourometery techniques. LCI exploits the low coherence of broadband light to achieve depth resolved thickness measurements with micrometer resolution. In addition to being label-free, it is also a time independent method of acquiring depth information, which makes it very desirable for applications where non-invasiveness and high accuracy are needed over a period of time. Consequently, LCI is more suited to extended time studies, which are necessary in monitoring the natural diffusion of microbicidal gels in the lower female reproductive tract in vivo.

⅄ Poster # 5

Diffuse Reflectance Spectroscopy with a Self-Calibrating Fiber Optic Probe

Bing Yu, Henry Fu, Torre Bydlon, Janelle E. Bender, and Nirmala Ramanujam
Department of Biomedical Engineering & Fitzpatrick Institute for Photonics, Duke University

Calibration of diffuse reflectance spectrum for instrument response and time-dependent fluctuation as well as inter-device variations is complicated, time-consuming and potentially inaccurate. This letter describes a novel fiber optic probe with real-time, self-calibration capability that can be used for tissue optical spectroscopy. The probe was tested in a number of synthetic liquid phantoms over a relevant range of tissue optical properties. Absorption and scattering coefficients are extracted with 6.9+/-7.2% and 3.5+/-1.5% errors, respectively, with an inverse scalable Monte Carlo model.

⅄ Poster # 6

Photothermal Optical Coherence Tomography of Epidermal Growth Factor Receptor in Live Cells Using Immunotargeted Gold Nanospheres

Melissa Skala, Matthew Crow, Adam Wax and Joseph Izatt
Biomedical Engineering & Fitzpatrick Institute for Photonics, Duke University

Molecular imaging is a powerful tool for investigating disease processes and potential therapies in both *in vivo* and *in vitro* systems. However, high resolution molecular imaging has been limited to relatively shallow penetration depths that can be accessed with microscopy. Optical coherence tomography (OCT) is an optical analogue to ultrasound with relatively good penetration depth (1-2 mm) and resolution (~1-10 μm). We have developed and characterized photothermal OCT as a molecular contrast mechanism that allows for high resolution molecular imaging at deeper penetration depths than microscopy. Our photothermal system consists of an amplitude-modulated heating beam that spatially overlaps with the focused spot of the sample arm of a spectral-domain OCT microscope. Validation experiments in tissue-like phantoms containing gold nanospheres that absorb at 532 nm revealed a sensitivity of 14 parts per million nanospheres (weight/weight) in a tissue-like environment. The nanospheres were then conjugated to anti-EGFR, and molecular targeting was confirmed in cells that over-express EGFR (MDA-MB-468) and cells that express low levels of EGFR (MDA-MB-435). Molecular imaging in three-dimensional tissue constructs was confirmed with a significantly lower photothermal signal ($p<0.0001$) from the constructs composed of cells that express low levels of EGFR compared to the over-expressing cell constructs (300% signal increase). This technique could potentially augment confocal and multiphoton microscopy as a method for deep-tissue, depth-resolved molecular imaging with relatively high resolution and target sensitivity, without photobleaching or cytotoxicity.

⅄ Poster # 7 ********3RD PLACE WINNER*********

Three-dimensional Photonic Crystal Nano-resonators

Lingling Tang, Tomoyuki Yoshie
Department of Electrical and Computer Engineering, Duke University

We designed monopole, dipole and quadrupole modes in woodpile three-dimensional photonic crystal nano-resonators by the modulation of unit cell size along a low-loss optical waveguide. Light is three-dimensionally confined by a complete photonic band gap so that, in the analyzed range, the quality factor exponentially increases as the increase in the number of unit cells used for confinement of light. The designed nano-resonators were fabricated by a two angled etching technique based on high-resolution electron beam lithography and high aspect ratio deep dry etching.

⅄ Poster # 8

High Performance MEMS-based Multi-color, Multi-beam Steering System for 2D Addressing of Atomic Qubits

Caleb Knoernschild, Changsoon Kim, Felix Lu, and Jungsang Kim
Duke University & Applied Quantum Technology

While quantum computation utilizing trapped ions or neutral atoms has seen significant advances in recent years, the necessary scalability of such implementations is limited in part by the distribution of laser resources. The capability to address multiple qubit locations with a single laser is an essential element in moving these experiments beyond individual quantum gate demonstrations. An optical system utilizing micro-electromechanical system (MEMS) technology can provide a scalable solution to address a qubit array with multiple independent beams concurrently. Broadband coatings can accommodate a large range of wavelengths, while fabrication techniques allow expansion to multiple parallel laser beams over a large number of trap locations. We demonstrate a two-spot beam steering system using MEMS mirrors that can simultaneously and independently illuminate any of 25 different locations within a 5x5 array with 2 laser beams of different wavelengths. Mirrors with settling times of <5 us have been fabricated allowing fast access times between qubits. Such systems can be used to implement two-qubit gates in a 1D or 2D array of qubits.

⅄ Poster # 9

Plasmonics-active biosensing at the single cell level: uptake, tracking, and delivery of functionalized nanoparticles in mammalian and human cell lines

Molly K. Gregas, Fei Yan, Jon Scaffidi, Hsin-Neng Wang, Amanda Hascoe, and Tuan Vo-Dinh
Duke University Fitzpatrick Institute for Photonics

Plasmonically-active nanoprobes (PENs) based on surface-enhanced Raman spectroscopy (SERS) combine high sensitivity with chemical and biomolecular specificity, making them ideal for molecularly-specific analysis within the intracellular environment. Through proper choice of molecular targets, our PENs sensing platform will allow single-cell examination of biological processes such as fertilization, mitosis and meiosis, DNA replication/damage/mutation, cell development/maturation/division, and apoptosis.

We present proof-of-concept results illustrating critical milestones on the path to applying our PEN sensors for in vivo single-cell analysis, including (1) use of molecularly-specific, SERS-based PENs for in vitro biochemical sensing, (2) use of SERS-based PENs for intracellular sensing, and (3) determination of spatial and temporal characteristics of nanobiosensor uptake in mammalian and human cell lines through normal cellular processes.

⅄ Poster # 10

Single-mode Waveguide Optical Isolator Based on Direction-Dependent Cutoff Frequencies

Samuel Drezdzon, Lingling Tang, and Tomoyuki Yoshie
Duke University Department of Electrical and Computer Engineering

A single-mode-waveguide optical isolator based on propagation direction dependent cutoff frequency is proposed. The isolation bandwidth is the difference between the cutoff frequencies of the lowest forward and backward propagating modes. Perturbation theory is used for analyzing the correlation between the material distribution and the bandwidth. The mode profile determines an appropriate distribution of nonreciprocal materials.

⅄ Poster # 11

Response of human Mesenchymal Stem Cells to Nanotopography

Karina Kulangara, Kevin Chalut, Yong Yang and Kam W. Leong
Duke University Department of Biomedical Engineering

Tissue and organ formation results from a complex coordination of cell-substrate adhesion, proliferation, migration, cell-cell adhesion, differentiation, and cell death. Interaction of cells with extracellular matrix via cell adhesion molecules is at the center of these events. The fact that *in vivo* the extracellular matrix or substratum with which cells interact often includes topography at the nanoscale brings up the need to investigate cell-substrate interactions at the sub-micron scale. One of the challenges in tissue engineering is to understand and control cell behavior in an unnatural environment, so the isolated cells can recapitulate their *in vivo* function. Here we study the culture of human mesenchymal stem cells (hMSCs) on polydimethylsiloxane (PDMS) as flat substrate or with nanogratings (350 nm width, 350 nm height and 700 nm periodicity). In addition to the cell body aligning with the 350 nm gratings, the actin cytoskeleton and the intermediate filament vimentin also lay parallel to the gratings. Similarly, the extracellular matrix protein fibronectin is deposited in an organized manner along the gratings, and so is the localization of integrin β1 and the focal adhesion protein vinculin on the nanotopography. Understanding the role played by nanotopographical features in dictating the behavior of stem cells will help design the optimal microenvironment to manipulate these cells for regenerative medicine applications.

⅄ Poster # 12

A Reconfigurable Frequency Selective Surface Using Adressable Metamaterials

Thomas H. Hand and Steven A. Cummer
Duke University Department of Electrical and Computer Engineering

We present measurements of a tunable metamaterial surface composed of digitally addressable complementary electric resonators (CELCs). The CELC unit cell consists of a complementary ELC screen backed by a 5 mm layer of FR4 substrate on top of a copper ground plane. The CELCs are loaded with Skyworks SMV 1405-079 hyperabrupt junction varactor diodes, which are reversed biased using a network of digital potentiometers configured as voltage dividers. Each digital potentiometer can be addressed independently on a single bus wire, allowing for precise control of the bias across each diode. By changing the bias across the diodes to tune each CELC self-resonant frequency, the potentiometer states can be programmed to create an arbitrary spatial gradient in the reflection coefficient phase angle. This gradient can be configured to control the scattering of an incident plane wave. Measurements of reflection angle from a sample fabricated for operation from 2–3 GHz show that the angle of peak reflected radiation can be steered more than 45 degrees away from the specular direction. Such a reconfigurable surface could be useful in antenna applications where precise control of reflected waves is needed, and in principle the concept can be extended to significantly higher frequencies.

⅄ Poster # 13

Intracellular Bioanalysis of Single Living Cells Using a SERS-based Fiber-Optic Nanoprobe

Jonathan P. Scaffidi,[1,2] Molly K. Gregas,[1,2] Victoria Seewaldt[2,3] and Tuan Vo-Dinh[1,2,4,*]
[1]*Department of Biomedical Engineering, Duke University,* [2]*Fitzpatrick Institute for Photonics, Duke University, Division of Medical Oncology, Duke School of Medicine,* [4]*Department of Chemistry, Duke University*

Sub-micron surface-enhanced Raman scattering (SERS)-based fiber-optic nanoprobes developed for intracellular measurements in single living cells have the potential to yield unprecedented insight regarding cellular biochemistry. In this poster, we discuss the development and application of one such nanoprobe for intracellular pH measurements in single living HMEC-15/hTERT immortalized “normal” human mammary epithelial cells, PC-3 human prostate cancer cells and MCF-7 human breast cancer cells. Nanoprobe pH measurements for MCF-7 human breast cancer cells compare well with literature values, demonstrating the utility of the SERS nanoprobe for single-cell analysis. In addition, the results for the HMEC-15/hTERT and PC-3 cell lines indicate that nanoprobe insertion and laser interrogation do not induce an aggressive cellular response, demonstrating the potential utility of the SERS nanoprobe technique for single-cell analysis in a systems biology framework.

⅄ Poster # 14

Increase SBS Slow Light Effect Via Suppressing Modulation Instability

Yunhui Zhu, Daniel J.Gauthier,
Department of Physics, Duke University

Slow light has been widely investigated for its potential application in all-optical buffer devices. Stimulated Brillouin Scattering is a promising nonlinear effect that can produce slow light in tunable wavelength. In our path to increase the delay of light pulses using SBS in optical fiber, it is found that except for the saturation of SBS effect that can limits maximum delay, competitions between different nonlinear effect such as modulation instability also tends to attenuate slowness of the light.

⅄ Poster # 15

Single Particle QD-FRET: Evaluation of the Stability and Composition of Nanocomplexes for Gene Delivery

Yi-Ping Ho 1, Hunter H. Chen 2 , Kam W. Leong 1, Tza-Huei Wang 3
1 Dept. of Biomedical Engineering and Surgery, Duke University
2 Dept. of Biomedical Engineering, Johns Hopkins School of Medicine, Baltimore, MD
3 Dept. of Mechanical Engineering, Johns Hopkins University, Baltimore, MD

The need to develop a safe and effective nonviral gene vector has increased with the growing promise of genetic medicine. Rational design of more efficient gene carriers will be possible only with sufficient insight into the physicochemical properties and stability of the DNA nanocomplexes, and their intracellular trafficking in the gene transfer process. To that end, we have adopted a sensitive single particle QD-FRET approach to investigate the DNA nanocomplexes through a combination of quantum dots (QD)-mediated fluorescence resonance energy transfer (FRET) and confocal fluorescence spectroscopy. Cationic polymer and plasmid DNA were labeled with a fluorescent organic dye and CdSe-ZnS quantum dots, respectively, generating a FRET pair within a nanocomplex. As an efficient FRET donor yielding a high signal-to-noise ratio, QDs serve as a sensitive probe for conformational changes in the nanocomplex state at the single-particle level and under different microenvironments. Characterization of batches of single nanocomplex provides valuable insight to the heterogeneity of nanocomplexes, a parameter difficult to study with other techniques and may be the source of many experimental discrepancies. Meanwhile, intracellular trafficking of the FRET-mediated signals would shed light on the unpacking behavior of the DNA nanocomplexes across cellular compartments. Integration of extracellular characterization and intracellular monitoring of QD-FRET nanocomplexes enable the correlation between structural properties of nanocomplexes and their intracellular kinetics, helping to unravel the mechanisms of nanocomplex unpacking and release of DNA in the delivery route. We have demonstrated in this study that single particle QD-FRET provides a sensitive and quantitative measure to evaluate the stability and composition of DNA nanocomplexes at different microenvironments, and is expected to facilitate the optimum design of gene carriers.

⅄ Poster # 16 ********2ND PLACE WINNER*********

Distance-Dependent Plasmon Resonant Coupling between a Gold Nanoparticle and Gold Film

Ryan T. Hill *Center for Biologically Inspired Materials and Material Systems (CBIMMS), Department of Biomedical Engineering, Duke University*
Jack J. Mock *Center for Metamaterials and Integrated Plasmonics (CMIP), Department of Electrical and Computer Engineering, Duke University*
Aloyse Degiron *Center for Metamaterials and Integrated Plasmonics (CMIP), Department of Electrical and Computer Engineering, Duke University*
Stefan Zauscher *Center for Biologically Inspired Materials and Material Systems (CBIMMS), Department of Mechanical Engineering and Materials Science, Duke University*
David R. Smith *Center for Metamaterials and Integrated Plasmonics (CMIP), Department of Electrical and Computer Engineering, Duke University*
Ashutosh Chilkoti *Center for Biologically Inspired Materials and Material Systems (CBIMMS), Department of Biomedical Engineering, Duke University*

We present an experimental analysis of the plasmonic scattering properties of gold nanoparticles controllably placed nanometers away from a gold metal film. We show that the spectral response of this system results from the interplay between the localized plasmon resonance of the nanoparticle and the surface plasmon polaritons of the gold film, as previously predicted by theoretical studies. In addition, we report that the metal film induces a polarization to the single nanoparticle light scattering resulting in a doughnut-shaped point spread function when imaged in the far-field. Both the spectral response and the polarization effects are highly sensitive to the nanoparticle-film separation distance. Such a system shows promise in potential bio-metrology and diagnostic devices.

⅄ Poster # 17

Multiplex Detection of Breast Cancer Biomarkers Using Plasmonic Molecular Sentinel Nanoprobes

Hsin-Neng Wang and Tuan Vo-Dinh
Dept. of Biomedical Engineering and Chemistry, Fitzpatrick Institute for Photonics, Duke University

We have demonstrated for the first time the feasibility of multiplex detection using the surface-enhanced Raman scattering (SERS)-based molecular sentinel (MS) technology in a homogenous solution. Two MS nanoprobes tagged with different Raman labels were used to detect the presence of the *erbB-2* and *ki-67* breast cancer biomarkers. The multiplexing capability of the MS technique was demonstrated by mixing the two MS nanoprobes and tested in the presence of single or multiple DNA targets.release of DNA in the delivery route. We have demonstrated in this study that single particle QD-FRET provides a sensitive and quantitative measure to evaluate the stability and composition of DNA nanocomplexes at different microenvironments, and is expected to facilitate the optimum design of gene carriers.

⅄ Poster # 18

DeteVideo rate spectral imaging using a coded aperture snapshot spectral imager

Ashwin Wagadarikar and David Brady
Department of Electrical and Computer Engineering, Fitzpatrick Institute for Photonics, Duke University

Spectral imaging is a method to capture a three dimensional datacube of information where the two dimensional spatial image obtained from a regular camera is complemented with spectral information at every pixel. With this additional information, one can better identify and classify objects in a scene, allowing the use of this technique in areas such as environmental remote sensing, astrophysics and biological imaging.

Unlike conventional spectral imagers that require temporal scanning to capture a datacube, our novel coded aperture snapshot spectral imagers (CASSI) are able to recover a spectral image from just one snapshot, two dimensional, coded projection of the three dimensional datacube. The snapshot ability of these instruments relies on the use of (i) coding of an aperture within the instrument and (ii) compressed sensing theory. This theory suggests that direct sampling of every element of the datacube is unnecessary, as it ignores correlations between the spatial and spectral elements within the datacube. As a result, we can recover a faithful representation of the three dimensional datacube from just a two dimensional set of multiplexed measurements of elements of the datacube.

We present the design and reconstruction algorithm for a single disperser-CASSI prototype, before demonstrating its application to video rate spectral imaging of a fast changing scene.

⅄ Poster # 19

Biodistribution of Quantum-dot labeled DNA Nanoparticles in Intestinal Constructs

Yihua Loo 1,2, Yvonne J Yamanaka 2, Kam W. Leong 2
1 Biomedical Engineering, Johns Hopkins University;
2 Biomedical Engineering, Duke University

We The gastrointestinal tract (GIT) is a harsh environment for orally administered pharmaceutics. While it has been demonstrated that polymer-DNA nanoparticles induce transgene expression in mouse models of haemophilia factor VIII, the fate of these particles after oral administration is by and large a mystery. The rodent closed intestinal loop model is thus utilized to study the biodistribution of nanoparticles in different segments of the GIT and confirm that they were sequestered by the liver or spleen after uptake. From ex vivo imaging studies using AlexaFluor680-labeled chitosan and 800nm quantum-dot labeled DNA as shown below, the duodenum and ileum demonstrated the highest uptake, while co-localization of AlexaFluor680 and quantum dot signals reflect the presence of intact nanoparticle in the liver and spleen. These observations were further confirmed quantitatively using inductively coupled plasma mass spectrometry. By identifying the GI regions of highest uptake, macroformulations can be designed to release the nanoparticles in the segments of interest.

In order to elucidate the mechanism of transport of nanoparticles from the lumen of the GI into the hepatic circulation, *in vitro* co-culture systems of Caco2, Caco2-Raji and Caco2-HT29MTX cells were used to study the transcytosis of various polymer-DNA nanoparticles from the apical surface to HepG2 cells on the basolateral surface. RT-PCR results of the underlying HepG2 cells show that the plasmids delivered retain their bioactivity following transcytosis. The various co-culture systems were then used to systematically screen various gene carriers with different biophysical characteristics such as colloidal stability and degree of PEGylation. Such pre-screening would facilitate the identification of ideal polymer candidates for oral gene therapy or DNA vaccination prior to costly animal studies.

⅄ Poster # 20

Top-Bottom Stripe Thin Film InGaAs/GaAsP laser integrated on Silicon

Sabarni Palit, Gene Tsvid*, Jeremy Kirch*, Juno Yu-Ting Huang*, Talmage Tyler, Sang-Yeon Cho#, Nan Jokerst, Luke Mawst*, Thomas Kuech+
ECE Dept., Duke University, Durham, NC, 27708;
**ECE Dept., Univ. of Wisconsin- Madison, WI;*
#ECE Dept, New Mexico State University, Las Cruces, NM;
+CBE Dept. Univ. of Wisconsin, Madison, WI

Thin film InGaAs/GaAsP edge emitting lasers emitting at 980 nm, have been fabricated and bonded to silicon. Both top and bottom sides of the thin film edge emitting laser have been lithographically patterned with metal stripes (while under substrate support) for better current confinement, and the bottom stripe contact is connected to a broad area metal contact for broad area bonding to the silicon for improved heat-sinking and mechanical strength. This improves on previous thin film laser designs for silicon integration, where typically, current distribution is compromised by single-side contacts or heat dissipation is compromised by dielectric interfaces.

⅄ Poster # 21

Single Source Dual-Wavelength Phase Unwrapping for Spectral Domain-Optical Coherence Tomography

Hansford C. Hendargo, Mingtao Zhao, Neal Shepherd, and Joseph A. Izatt
Fitzpatrick Institute for Photonics, Duke University

Phase-sensitive implementations of spectral domain optical coherence tomography (SDOCT) allow for quantitative depth-resolved measurements of sample structure and dynamics. However, the phase information in all of these techniques suffers from a 2π ambiguity that limits resolvable optical pathlength differences to less than half the source center wavelength. This is problematic for situations where it may be necessary to monitor sample profiles, displacements, phase differences, or refractive index variations which vary rapidly in space or time. A technique previously introduced in phase shifting interferometry uses phase information from multiple wavelengths to overcome this limitation. We show that by appropriate spectral windowing of the broadband light source already used in OCT about two different center wavelengths, the resulting phase variation may be cast in terms of a much longer synthetic wavelength chosen to span the phase variation of interest. We demonstrate this technique in spectral domain OCT by correctly reconstructing the phase profile from a phantom sample containing multiple 2π wrapping artifacts at the center wavelength and compare our result with atomic force microscopy. We also image human epithelial cheek cells and demonstrate the ability to measure surface profiles and thickness in single and clustered cells.

⅄ Poster # 22

Monocyte Spreading and Activation by Topographical Cues

Sulin Chen*#, Ami Saheba* and Kam W. Leong*
** Duke University, Biomedical Engineering, Durham, NC*
 # Johns Hopkins University, Biomedical Engineering, Baltimore, MD

Monocyte differentiation into activated macrophage is a pre-requisite for the foreign body reaction to biomaterial implants. Macrophages with a spread morphology of large surface area indicate an activated phenotype that would fuse into foreign body giant cells (FBGCs). This contributes to inflammatory cytokine secretion and biomaterial degradation. While surface modification and biochemical stimuli have been used to modulate monocyte/macrophage response to implants, the effect of topographical cues has scarcely been examined. Observing the significant effect of topography on morphology of other cell types, we hypothesize that topographical cues may influence macrophage spreading and subsequent activation. In this study, we investigated the behavior of human monocytes cultured on micro- and nanometer-scale poly(dimethyl siloxane) (PDMS) topography. We fabricated patterns with parallel gratings of 1 µm, 500 nm and 300 nm widths for comparison with planar PDMS. Attached monocytes differentiated into macrophage-like cells and acquired a highly spread morphology over 3 to 7 days. Cell spreading was significantly reduced on 1 µm gratings, decreased in size by 38% compared to planar PDMS. Less spread cells on 1 µm surfaces exerted contractile forces that distorted the underlying PDMS gratings. The profiles of secreted cytokines and contractile protein expression were different on the patterned PDMS compared to planar controls. These results suggest the potential of incorporating topographical cues into biomaterial design that could reduce macrophage activation and FBGC formation.

⅄ Poster # 23

Magneto-Optical Trapping of 87Rb with Distributed Feedback Lasers

Crystal Senko, Joel Greenberg, and Daniel Gauthier,
Duke University, Fitzpatrick Institute for Photonics,

We have constructed a magneto-optical trap for 87Rb, and use this apparatus to investigate whether distributed feedback diode lasers can be used for cooling and trapping work. The trap was designed with an emphasis on simplicity and robustness, so that it can be incorporated into an undergraduate Advanced Laboratory course.

⅄ Poster # 24

Momentum-State Engineering via Recoil-Induced Resonances

Joel A. Greenberg, Daniel J. Gauthier
Duke University Department of Physics and the Fitzpatrick Institute for Photonics

Few-photon nonlinear optical (NLO) elements are critical for quantum information applications. Because most materials have a small nonlinear atom-photon coupling, large intensities (i.e. large photon numbers)

are typically required. The nonlinear coupling can be enhanced in a dilute sample of cold atoms through careful control of the internal and external states of the atoms, thus leading to new experimental paths toward single-photon NLO. In particular, a two-photon process between atomic momentum states known as recoil-induced resonance (RIR) allows for large nonlinear couplings at low light levels, as well as enabling one to carefully tailor the population of atomic momentum states. In this poster, I describe the basics of our anisotropic magneto-optical trap (MOT) which is used for creating an optically thick sample of cold Rb atoms, as well as the physical mechanism of RIRs. Finally, I describe our preliminary results regarding coherent control of the atomic momentum distribution for application to single photon information storage.

⅄ Poster # 25 ********HONORABLE MENTION*********

Development of a clinical Fourier-domain angle-resolved low coherence interferometry system for in vivo measurements

Neil Terry *Department of Biomedical Engineering, Duke University*
Yizheng Zhu *Department of Biomedical Engineering, Duke University*
William Brown *Department of Biomedical Engineering, Duke University*
Adam Wax *Department of Biomedical Engineering, Duke University*

Fourier-domain angle resolved low coherence interferometry (a/LCI) is a novel light scattering spectroscopy technique that provides quantitative depth-resolved morphological measurements of the size and optical denisty of examined cell nuclei. These measurements have been shown to be biomarkers of dysplasia. The clinical viability of the a/LCI system has been demonstrated by analysis of ex vivo human esophageal tissue from Barrett's esophagus patients using a portable a/LCI system. Design and implementation of a endoscope-compatible system for in vivo measurements and preliminary clinical results are presented.

⅄ Poster # 26

Chip-scale Integration of Optical Microresonator Sensors with Digital Microfludics Systems

L. Luan, R.D. Evans, D. Schwinn*, R.B. Fair, and N.M. Jokerst
Department of Electrical and Computer Engineering, Duke University,
**Department of Anesthesiology, University of Washington, Seattle*

Chip scale integration of optical microresonator sensors with digital microfluidics systems were demonstrated. Glucose solution of different concentrations were dispensed, actuated, and sensed on this lab-on-chip platform.

⅄ Poster # 27

A Strategy for Quantitative Spectral Imaginn of Tissue Absorption and Scattering Using LEDs and Photdiodes

Justin Y. Lo [1], Bing Yu [1], Henry Fu [1], Janelle E. Bender [1], Gregory M. Palmer [2], Thomas F. Kuech [3], Nimmi Ramanujam [1]
[1] Dept. of Biomedical Engineering, *Duke University*
[2] Dept. of Radiation Oncology, *Duke University*

[3] Dept. of Chemical & Biological Engineering, *University of Wisconsin*

A diffuse reflectance spectroscopy system has been modified as a step towards miniaturization and spectral imaging of tissue absorption and scattering. The modified system uses a tunable light source and an optical fiber for illumination and a photodiode in contact with tissue for detection. It is smaller, less costly, and has comparable performance in extracting optical properties in tissue phantoms. Additional wavelength reduction simulations show the feasibility of further reducing the size and cost by implementing five different LEDs as the light source in the next generation of system design. Simulated crosstalk analysis indicates that this evolving system has the potential to be multiplexed and used for spectral imaging in the future.

⅄ Poster # 28 ********HONORABLE MENTION*********

Surface-enhanced Ramand Scattering from Controlled Nanoparticle System

ShiuanYeh Chen [1], David S. Sebba [2], Anne A. Lazarides [2]
[1] *Department of Electrical and Computer Engineering, Duke University, Durham, NC*
[2] *Department of Mechanical and Material Science, Duke University, Durham, NC*

We present a theoretical and experimental study of surface-enhanced Raman scattering from core-satellite nanoparticle assemblies of known structure in the solution phase. The detectability of the Raman signal is attributed to enhanced electromagnetic fields localized between plasmonically coupled core and satellite metal nanoparticles. Compared to isolated particles, this controlled assembly supports intense fields that amplify Raman scattering from molecules positioned in between core and satellite particles. The design of the structures was accomplished using near field calculations based upon Generalized Mie theory, a theory that accurately accounts for multipolar coupling within clusters of spherical particles. Assembly structures were identified on the basis of their potential to support hot spots that occur when plasmon resonance frequencies overlap with Raman excitation spectra and available laser lines. Core-satellite structures are assembled using DNA linkers of controlled length and characterized by transmission electron microscopy (TEM). The control of field strength and plasmon frequency provided by the coupled particle system is expected to provide insight into SERS signaling of use in application of SERS to biomolecule sensing.

⅄ Poster # 29

Cooperative Molecular Recognition ata DNA Nanostructure-Metal Interface

Elizabeth Irish-Nelson[†], Dr. Thom LaBean[‡], and Dr. Anne Lazarides[†],
[†]*Department of Mechanical Engineering and Materials Science at Duke University*
[‡]*Department of Chemistry at Duke University*

Recent work in assembly of complex DNA nanostructures has demonstrated the effectiveness with which the non-covalent forces of DNA hybridization can drive formation of a topologically rich set of engineered DNA nanostructures. These novel addressable nanostructures can be used as structural components within a variety of complex nanosystems, including integrated systems for molecular detection. However, there is a need for new techniques for controlling deposition of the nanostructures on surfaces. The objective of this research is to investigate thermodynamic and kinetic mechanisms by which interactions between DNA nanostructures and oligonucleotide functionalized surfaces can be controlled. In this research, surface plasmon resonance (SPR) and a Quartz Crystal Microbalance (QCM) are used for real-time monitoring of the hybridization of DNA structures on oligonucleotide

functionalized metal surfaces. Kinetic and thermodynamic parameters derived from the SPR and QCM data are used to evaluate the role of multivalence on the strength and temperature dependence of the interaction. Kinetic measurements, such as the association and dissociation rates, are determined through monitoring of the SPR response to hybridization as a function of concentration. Ultimately, new understanding of the kinetic and thermodynamic parameters that characterize multivalent interactions between DNA nanostructures and functionalized surfaces will enable user designed control of assembly at soft/hard matter interfaces. Additionally, cooperative molecular recognition between the soft matter and a functionalized metal template could be tailored to provide a thermodynamic mechanism for mitigating misalignment on a patterned surface. It is anticipated that the new tools for integrating soft matter on patterned templates will prove useful in future applications of DNA nanostructures that require organization of the soft matter.

⅄ Poster # 30

Polymer Microresonator Based DNA Sensors

Matthew Royal,[1] Jessica Zinck[2], Lin Luan[1], Prof. Nan Jokerst[1], Prof. Richard Fair[1], Dr. Debra Schwinn[3]

[1]*Department of Electrical and Computer Engineering, Duke University*
[2]*Department of Biomedical Engineering, Duke University*
[3]*Department of Anesthesiology, University of Washington, Seattle, WA*

DNA based diagnostics enable rapid, sensitive, and specific diagnosis of infectious microbes, including subtypes and drug-resistant strains. Most notably, they could help to determine subtype and drug resistance of infectious diseases, such as malaria, from microbes present in a patients' blood. A simple, inexpensive, highly sensitive, and specific DNA sensor device could improve healthcare by enabling clinics in remote and poor areas of these regions to provide more specific and effective treatment tailored for a given strain of disease and more judicious use of antibiotics to mitigate the development of drug resistance. Polymer based vertically-coupled microring resonator sensors are promising as inexpensive sensors for sensitive and specific detection of pathogens by DNA identification, because they are inexpensive and easy to functionalize with DNA probes. Microring resonator sensors sense DNA by detecting a change in refractive index on the surface due to the binding of probe DNA to the complementary identifying DNA molecules in solution. Attachment of probe oligonucleotides to the sensor material and hybridization in under 5 minutes has been demonstrated. The long term goal is to integrate the sensor into a total diagnostic system, consisting of a compact digital microfluidic device that will carry out sample preparation, actuation to the sensors, and analysis of the sensor data.

⅄ Poster # 31 ********1ST PLACE WINNER*********

Nano-engineering of metallic nanoparticles for surface-enhanced plasmonic sensing

Christopher Khoury and Tuan Vo-Dinh
Fitzpatrick Institute for Photonics, Duke University

Synthetic methods to generate gold and silver nanoparticles with arbitrarily chosen shapes and sizes are investigated for the fundamental study of the effects of geometry and physico-chemical composition on plasmonic behavior. Determining the extent of these effects is of significant importance when contemplating the use of such nanoparticles for the detection of disease biomarkers via surface-enhanced plasmonic sensing techniques such as Surface Enhanced Raman Scattering (SERS).

⅄ Poster # 32

Supramolecular Protein Cages for Drug Delivery and Nanoparticle Synthesis

Yan Zhang, Fei Yan, Kyu Seo Kim, Hsiang-kuo Yuan, Molly K. Gregas, and Tuan Vo-Dinh*
Fitzpatrick Institute for Photonics, Departments of Biomedical Engineering and Chemistry, Duke University, Durham, NC 27708, USA. E-mail: tuan.vodinh@duke.edu; Fax: 1-919-613-9145; Tel: 1-919-660-8520

Apoferritin, a cage-shaped supramolecular protein, has potential as novel nanocarriers for the targeted delivery of therapeutic compounds as employed in photodynamic treatment of cancer cells, as well as confined reaction environments for the controlled synthesis of silver nanoparticles. Here, we present the synthesis and characterization of an apoferritin-based nanocarrier, which is designed to be internalized by tumor cells and deliver singlet oxygen ($^1O_2$) intracellularly for photodynamic therapy (PDT). As a model, we demonstrate the successful loading of a photodynamic anticancer agent Methylene Blue (MB), and also demonstrate its positive effect on the singlet oxygen production. Our preliminary *in vitro* PDT study using the MB-loaded apoferritin nanoparticles was conducted on MCF-7 tumor cells with positive photodynamic results. The delivery of photosensitizers through targeted nanocarriers that could be internalized by cells provides an effective route of delivery for photodynamic drugs into cells. In addition, we also present the preparation of apoferritin-encapsulated silver nanoparticles. The protein shell prevents bulk aggregation of the silver particles, which renders them water soluble and stable over a long period of time.

⅄ Poster # 33

Synthesis and plasmonic properties of Ag/Au-coated Y_2O_3 nanoparticles by photoreduction

Benoit Lauly, John Scaffidi, Tuan Vo-Dinh
Biomedical Engineering Department, Duke University

Much effort in the photonic community is directed towards the improvement and understanding of plasmon-derived optical effect from nanoshells. Yttrium oxides (Y_2O_3) materials doped with rare earths ions such as Eu^{3+} and Ce^{3+} show promising photoluminescence properties as one- and two-photons fluorescing emitters and can be applied for cellular imaging as they are non-toxic. The control of particle composition leads to control of the spectral position of the absorption band and/or plasmonic band. Several chemical approaches have been developed for the synthesis of nanostructures with a specific size and material. This work focuses on the direct UV-photoreduction of silver and gold shells on Y_2O_3 nanoparticles of around 30 nm. Core/shells material of sub 100nm were obtained and can potentially improve cellular uptake and strong surface plasmon resonance. Aggregation of Y_2O_3 in different solvents is often a limit when coating individual nanoparticles and surface photoreduction provided promising results. The coated particles are characterized by transmission electron microscopy (TEM), UV-visible spectroscopy and Raman spectroscopy.

⅄ Poster # 34

Quantitative phase microscopy with fast multi-wavelength unwrapping for observing cellular dynamics

Matthew Rinehart, Michael Giacomelli, Kevin Chalut, and Adam Wax
Fitpatrick Institute for Photonics, Duke University

Quantitative phase microscopy has recently proven to be an effective method for characterizing cellular dynamics. Classic optical microscopy lacks contrast at cell and organelle boundaries, and fluorescent contrast agents photobleach and can be cytotoxic. Alternatively interferometric phase measurements at imaged points allows the detection of sub-wavelength optical path length changes on a biologically relevant time scale. Asynchronous digital holography (ADH) has been used to obtain quantitative phase images on millisecond time scales. We now present the use of multi-wavelength unwrapping with ADH to remove 2-pi ambiguities arising from samples with path length differences larger than the wavelength of incident light. This processing is significantly faster than standard techniques of phase unwrapping and has been shown to reduce artifacts commonly introduced by these methods. We demonstrate the potential for multi-wavelength ADH to produce real-time quantitative phase images, thus allowing future characterization of dynamics in biological systems.

NOTES: ____

⅄ Themed Lab Tours ⅄

~Monday, October 13th, 2008 ▪ 5:00-6:00pm ~
Duke University, FCIEMAS, Fitzpatrick Building

<table>
<tr><td>Fitzpatrick Center for Interdisciplinary Engineering, Medicine & Applied Sciences (FCIEMAS)</td><td></td></tr>
<tr><td>SHARED MATERIALS INSTRUMENTATION FACILITY (SMIF)

5:00 – 5:20pm

with Mark Walters</td><td>The Shared Materials Instrumentation Facility (SMIF) at Duke University operates as an interdisciplinary shared use facility. It was established in 2002 as part of the University's Materials Initiative with funding from the Provost's office. SMIF Provide researchers with high quality and cost-effective access to advanced materials characterization and fabrication capabilities.
http://smif.lab.duke.edu/about.htm
</td></tr>
<tr><td>VISUALIZATION TECHNOLOGY GROUP

5:20 – 5:40pm

with Rachel Brady</td><td>The Duke Immersive Virtual Environment (DiVE), which is located in the Fitzpatrick Center for Interdisciplinary Engineering, Medicine and Applied Science (FCIEMAS), will demonstrate the application of Virtual Reality technology towards understanding complex three-dimensional time-varying data.
http://vis.duke.edu/Facilities/visroom/visualization_room.html
</td></tr>
</table>

⅄ Corporate Partners ⅄

Platinum Partner – Hamamatsu Photonics
Silver Partner - Newport
Corporate Partner – New Focus

A main goal of the FIP Corporate Partnership Program is to strengthen its industrial relations programs in the coming years in order to encourage need-driven research and further develop technology transfer programs. In this activity the FIP works closely with the Office of Corporate Industrial Relations at the Pratt School of Engineering at Duke.

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www.hamamatsu.com

Hamamatsu an internationally recognized leader in photonics products. The principal lines of the company's business is the development, manufacturing and marketing of optical sensors, such as high-speed, high-sensitivity photomultiplier tubes, as well as various kinds of light sources, photodiodes, photo ICs, image sensors and other opto-semiconductor elements, and high-power semiconductor lasers. The principal line of business in the Systems division is upgrading systems of devices that are optimum for applications involving fields such as biotechnology, semiconductors and medical care.

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www.newport.com

In 2004, Newport acquired Spectra-Physics, which has long been recognized as the laser technology leader - serving customers in over 70 countries around the world. Founded in 1961, Spectra-Physics designs, develops, manufactures and distributes premier lasers and laser systems for a variety of commercial and industrial markets such as Life & Health Science, Aerospace and Defense, Computers, Telecommunications, Research and Development, Original Equipment Manufacturers (OEM) and Microelectronics.

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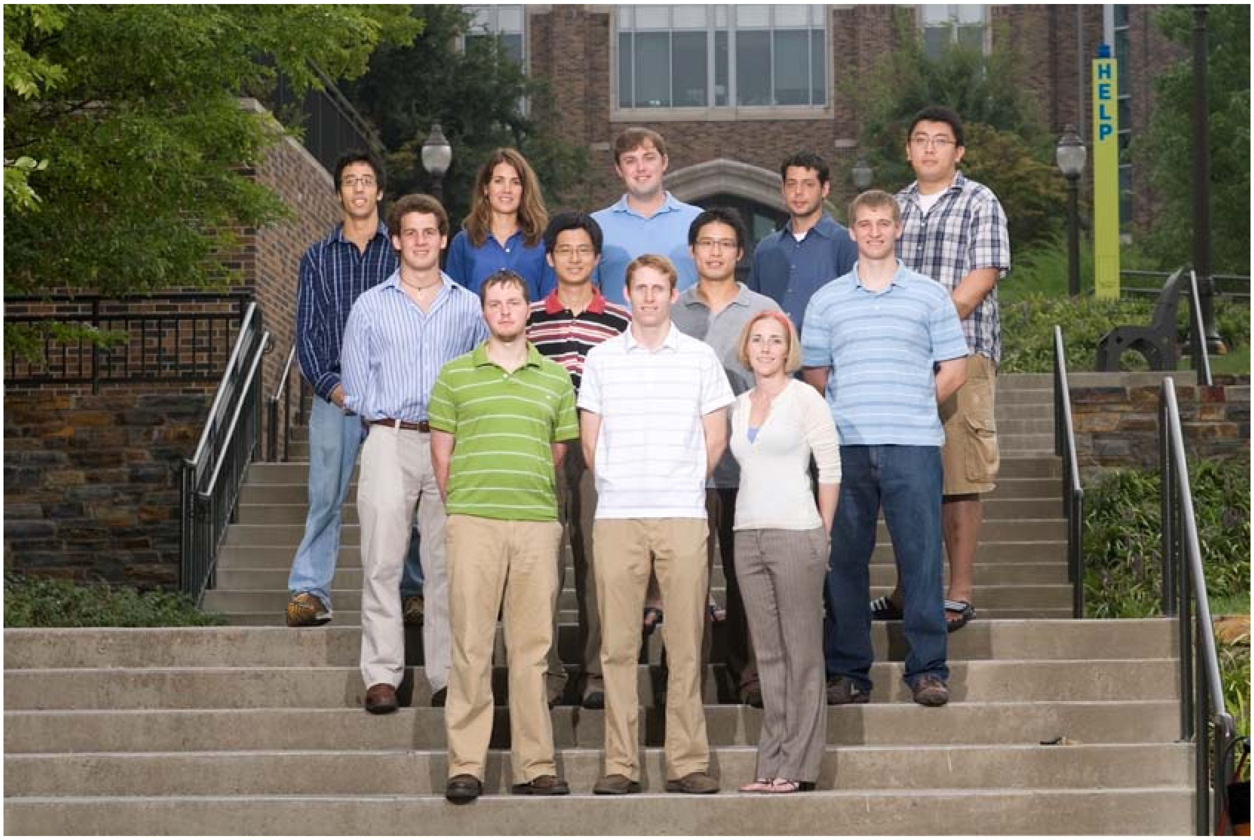
www.newfocus.com

New Focus, a division of Bookham, is a leader in developing, manufacturing and delivering innovative, high-performance and high-quality photonics products for industrial and research applications worldwide.

Founded in 1990, New Focus has developed high-performance products that includes tunable lasers, opto-electronics, high-resolution actuators, stable optomechanics, vacuum and ultraclean solutions, and OEM engineered solutions. The company products are used in many applications around the world including semiconductor equipment, biomedical, industrial, test and measurement and advanced research.

~2008-2009~
John T. Chambers Fellows

The Fitzpatrick Institute for Photonics (FIP) is pleased to announce the recipients of the John T. Chambers Fellows for the 2008-2009 academic years. We are delighted to say that with continued support and generosity of John Chambers we are able to provide thirteen (13) graduate students a one-year fellowship program.



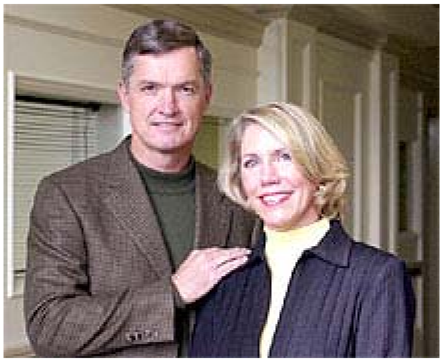
Top row (left to right): C. Khoury, M. Gregas, N. Terry, J. Joseph, K. Tao,
M. Rinehart, S. Chen, V. Change, C. Knoernschild,
K. McKay, M. Royal, E. Irish-Nelson
(not pictured: L. Lang)

~2008-2009~
John T. Chambers Fellows
(continued)

Each candidate was nominated by a FIP Professor and judged on the criteria of research accomplishments, research potential, personal qualities and collaborative potential and the following thirteen (13) students were chosen:

Student Fellow Awardee	Advisor	Department
Vivide Chang	Prof. Nimmi Ramanujam	BME
Shiuan-Yeh Chen	Prof. Anne Lazarides	MEMS
Molly Gregas	Prof. Tuan Vo-Dinh	BME
James Joseph	Prof. John Thomas	Physics
Chris Khoury	Prof. Tuan Vo-Dinh	BME
Caleb Knoernschild	Prof. Jungsang Kim	ECE
Kyle McKay	Prof. Jungsang Kim	ECE
Elizabeth Irish Nelson	Prof. Anne Lazarides	MEMS
Matthew Rinehart	Prof. Adam Wax	BME
Matthew Royal	Prof. Nan Marie Jokerst	ECE
Lingling Tang	Prof. Tomoyukie Yoshie	ECE
Yuankai (Kenny) Tao	Prof. Joseph Izatt	BME
Neil Terry	Prof. Adam Wax	BME

Patricia and Michael Fitzpatrick



Duke Alumni, Patricia (Patty) and Michael Fitzpatrick's substantial donation toward photonics education is a natural outgrowth of Michael's first hand knowledge of the significant shortage of highly trained photonics engineers and of Patty's long term commitment to education. "Our foundation and our gift to photonics at Duke both express, in different ways, our desire to support the potential of education to make a positive impact on people's lives," says Patty.

The impact of the Fitzpatrick's gift will ultimately expand far beyond Duke. "The Center's real value will stem from the quality of its students and their research," Michael says. "Research is the pulse of technology, and we are confident that Duke will be at the heart of it."

Michael Fitzpatrick began his career in technology as a mainframe computer programmer. By his early 30's he had risen rapidly through management ranks and already accomplished the sale and public offerings of several companies. After serving as CEO of Network Systems and Pacific Telesis Enterprises, Michael foresaw wireless and photonics as pivotal new technologies. Returning to his entrepreneurial roots, he joined a tiny optical company, E-Tek Dynamics. In just over three years, Michael grew the company's run rate from $50 million to $1 billion and guided its sale to JDS Uniphase - resulting in the second largest merger in the history of the telecommunications industry.

Patty enjoyed a successful career as a corporate training and developing executive at Abraham and Strauss and Mt. Sinai Hospital, both in New York City. She founded the Design Source, a California interior design firm, and now heads the Fitzpatrick Foundation, dedicated to improving educational opportunities for disadvantaged youth in northern California.

Faculty at FIP

64 Faculty
22 Participating Departments & Institutions at Duke University

- Dept. of Anesthesiology
- Dept. of Biomedical Engineering (BME)
- Dept. of Cell Biology
- Dept. of Chemical Biology
- Dept. of Chemistry
- Dept. of Computer Science
- Dept. of Electrical and Computer Engineering (ECE)
- Institute for Genome Science and Policy
- Dept. of Mechanical Engineering and Material Science (MEMS)
- Dept. of Mathematics
- Dept. of Neurosurgery
- Dept. of Oncology
- Dept. of Ophthalmology
- Dept. of Orthopaedic Engineering
- Dept. of Pathology
- Dept. of Pediatrics
- Dept. of Physics
- Dept. of Radiation Oncology
- Dept. of Radiology
- Dept. of Surgery
- Duke Comprehensive Cancer Center
- Duke Human Vaccine Institute

FIP Research Programs and Program Directors

- Biophotonics – Joseph Izatt
- Nano/Micro Systems – Nan Jokerst
- Quantum Optics and Information Photonics –Daniel Gauthier
- Photonic Materials – David Smith
- Advanced Photonic Systems – William “Monty” Reichert
- Nanophotonics – Kam Leong
- Systems Modeling, Theory & Data Treatment – Weitao Yang
- Novel Spectroscopies – Warren Warren

Faculty at FIP				
1	Harold	Baranger	Professor	Physics
2	David	Beratan	RJ Reynolds Professor	Chemistry
3	David	Brady	Professor	ECE
4	Rachael	Brady	Research Scientist	ECE
5	Martin	Brooke	Associate Professor	ECE
6	April	Brown	John Cocke Professor and Senior Associate Dean for Research	ECE
7	Krishnendu	Chakrabarty	Professor	ECE
8	Ashutosh (Tosh)	Chilkoti	Theo Pilkington Professor	BME
9	Leslie	Collins	Professor & Chair	ECE
10	Steve	Cummer	Jeffrey N. Vinik Associate Professor	ECE
11	Gayathri	Devi	Assistant Professor	Surgery and Pathology
12	Mark	Dewhirst	Professor	Radiation Oncology
13	Chris	Dwyer	Assistant Professor	ECE
14	Glenn	Edwards	Professor	Physics
15	Richard	Fair	Professor	ECE
16	Martin	Fischer	Asst. Research Professor	Chemistry

18	Daniel	Gauthier	Professor & Chair	BME, Physics
19	Geoffrey	Ginsburg	Professor & Director	Institute for Genome Science & Policy
20	Jeff	Glass	Sr. Associate Dean and Hogg Family Director of Engineering Management and Entrepreneurship Professor	ECE
21	Gerald	Grant	Assistant Professor	Neurosurgery
22	Bob	Guenther	Research Senior Scientist	Physics
23	Farshid	Guilak	Assistant Professor	Orthopaedic Engineering & BME
24	Joseph	Izatt	Professor	BME & Ophthalmology
25	G. Allan	Johnson	Charles E. Putman Professor	Radiology, BME & Physics
26	Nan	Jokerst	J.A. Jones Professor	ECE
27	Jungsang	Kim	Nortel Networks Assistant Professor	ECE
28	Jeffrey	Krolik	Professor	ECE
29	Thomas	LaBean	Associate Professor	CS
30	Anne	Lazarides	Assistant Professor	MEMS
31	Kam	Leong	James B. Duke Professor	BME & Surgery
32	Jie	Liu	Associate Professor	Chemistry
33	Qing	Liu	Professor	ECE

34	Hisham	Massoud	Professor	ECE & BME
35	Barry	Myers	Anderson-Rupp Professor, Sr. Associate Dean for Industrial Partnerships	BME
36	Richard A.	Palmer	Professor	Chemistry
37	Nikos	Pitsianis	Associate Research Professor	ECE & CS
38	James	Provenzale	Professor	Radiology, Neuroradiology
39	Nimmi	Ramanujam	Associate Professor	BME
40	William (Monty)	Reichert	Professor & Director	BME, Chemistry, Biomolecular & Tissue Eng.
41	John	Reif	A. Hollis Edens Professor	CS
42	Victoria	Seewaldt	Associate Professor	Oncology
43	Allan	Shang	Assistant Professor	Anesthesiology
44	John	Simon	George B. Geller Professor & Vice Provost for Academic Affairs	Chemistry
45	David R.	Smith	William Bevan Professor and Director of Center for Metamaterials & Integrated Plasmonics (CMIP)	ECE
46	Neil L.	Spector	Faculty	Oncology
47	Adrienne	Stiff-Roberts	Assistant Professor	ECE
48	Xiaobai	Sun	Associate Professor	CS

49	Michael J.	Therien	Professor	Chemistry
50	Nathan	Thielman	Associate Professor	Duke Human Vaccine Inst.
51	John	Thomas	Fritz London Professor	Physics
52	Jingdong	Tian	Assistant Professor	BME
53	Eric J.	Toone	Professor	Chemistry
54	George	Truskey	Professor & Chair	BME
55	Stephanos	Venakides	Professor	Mathematics
56	Tuan	Vo-Dinh	R. Eugene and Susie E. Goodson Professor, Director of FIP	BME & Chemistry
57	Judith	Voynow	Associate Professor	Pediatrics
58	Warren	Warren	James B. Duke Professor	Chemistry
59	Adam	Wax	Associate Professor	BME
60	Jo Rae	Wright	Professor & Vice Dean for Basic Sciences	Cell Biology
61	Weitao	Yang	Philip J. Handler Professor	Chemistry
62	Tomoyukie	Yoshie	Assistant Professor	ECE
63	Terry T.	Yoshizumi	Associate Professor, Director of Radation Safety Division & Duke RSO	Radiology, Radiation Oncology
64	Fan	Yuan	Associate Professor	BME

Logistics

Restrooms: As you exit the Schiciano Auditorium, women's restoom is on the right and men's restroom is on the left.

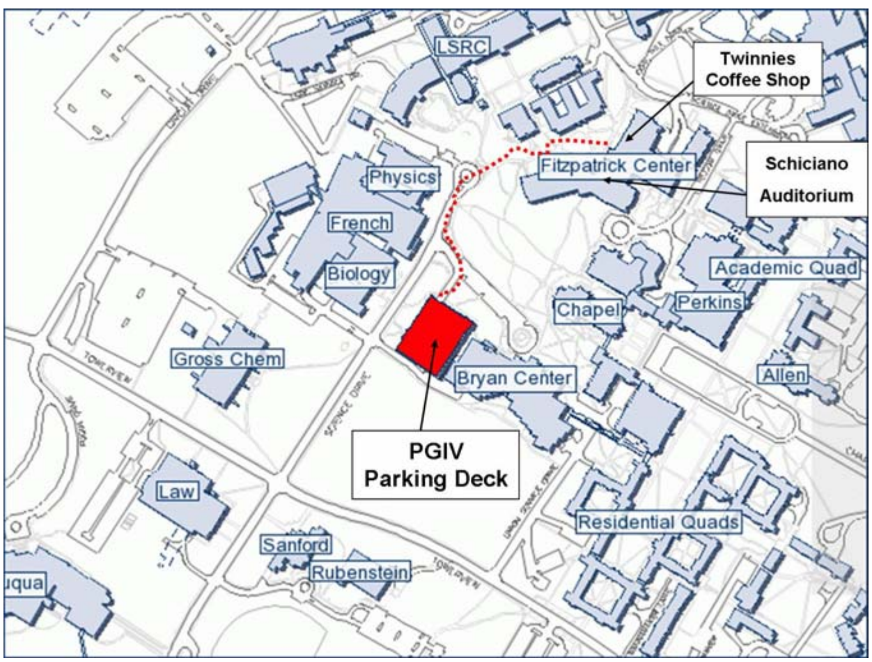
Water Fountain: As you exit the Schiciano Auditorium, the water fountain is located on your left next to the men's restroom.

Twinnie's Café: Located across from the Schiciano Auditorium, has coffee, snacks and sandwiches. (Please note: FIP has regular breaks and meals during the conference.)

Wireless Internet Access: Duke requires that all computers and laptops be registered before having internet access. To register, goto netreg.duke.edu and do a simple registration.
Net ID: dukeguest Password of the week: _____________
If you have any problems connecting, you may call our OIT helpdesk (919)684-2200 and tell them that you are visiting guest for our FIP annual meeting and ask for assistance as a guest.

Name Badges: Please return your name badges to the registration table upon leaving so that we may recycle. Thanks.

Parking for Visitors: If you are parked in the Bryan Center Parking Garage/Deck (PGIV) and have received a ticket stub, you may request a free parking permit at the registration table. When you leave the parking garage, give the ticket stub and parking permit to the attendant.



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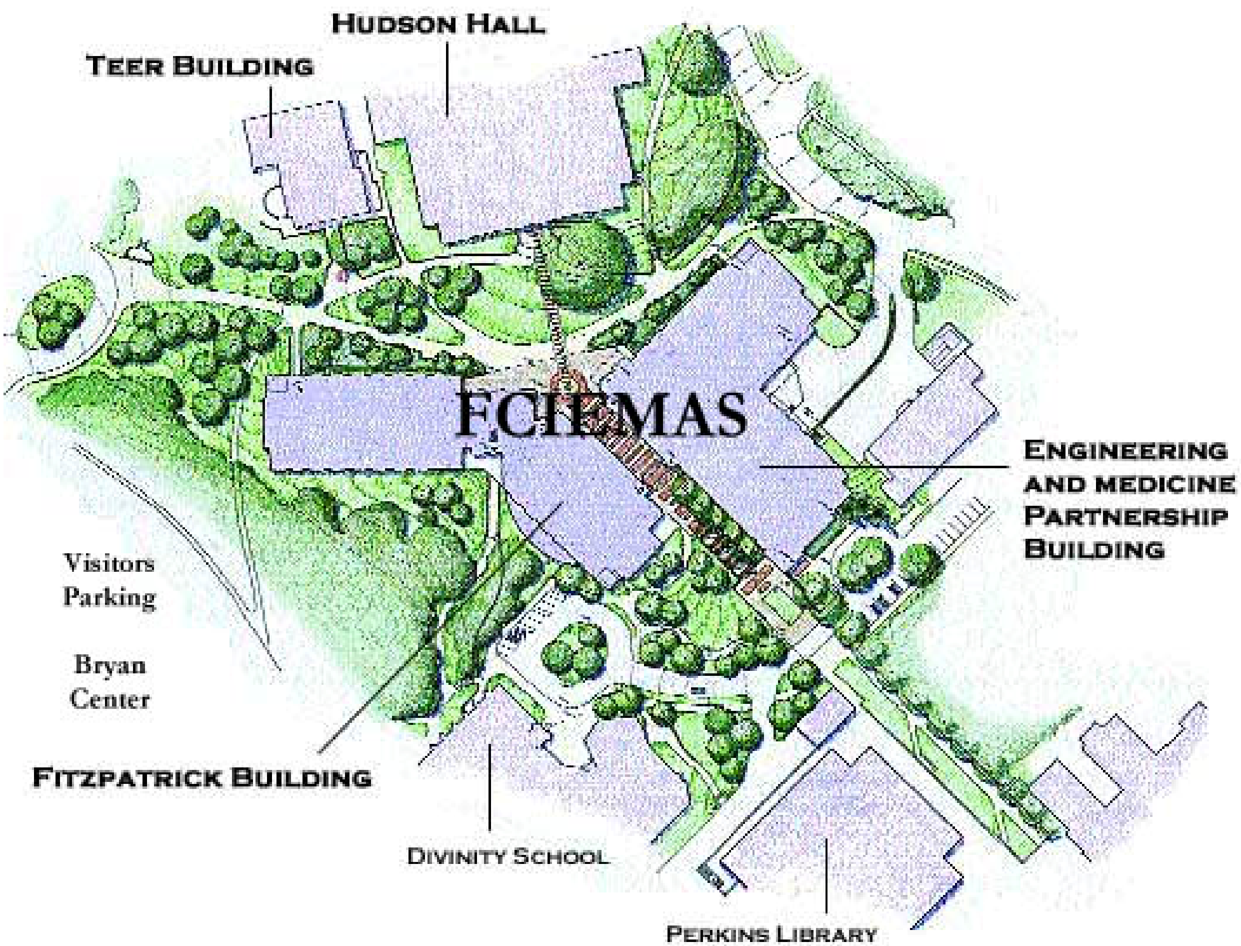

The Fitzpatrick Institute for Photonics and Schiciano Auditorium are located in the Fitzpatrick Building of FCIEMAS.

For Further Information:

Dept. Business Manager, Fitzpatrick Institute for Photonics .... August Burns
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Durham, NC 27708-0271