The Fitzpatrick Institute for Photonics

Frontiers in Photonics Science and Technology

Tenth (10^{th}) Annual Meeting

Wednesday, October 27, 2010
Fitzpatrick Building
8:30 am - 9:00 am Registration
9:00 am - 5:10 pm Meeting
5:10 pm Poster Session-Reception

Thursday, October 28, 2010
Searle Center
8:30 am - 9:00 am Registration
9:00 am - 12:00 pm Meeting

Fitzpatrick Building
Duke Engineering Campus
(Day 1 – Fitzpatrick Building, Schiciano Auditorium)

Searle Center
Duke University Medical Center
(Day 2 - Seeley G. Mudd Building, Searle Center Lecture Hall)

Symposium Chair – Tuan Vo-Dinh, Director, Fitzpatrick Institute for Photonics

Scientific Program Committee – David Beratan, Daniel Gauthier, Joseph Izatt, Nan Jokerst, Jungsang Kim, Kam Leong, Barry Myers, William Reichert, David Smith, Warren Warren, Adam Wax, Weitao Yang

Symposium Administrative Manager – August Burns

Assistant Coordinator – Yan Zhang

Registration and Contact Information – august.burns@duke.edu ⅄ 919-660-5598

Tenth Annual Meeting -The Fitzpatrick Institute for Photonics
Frontiers in Photonics Science and Technology

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2010 Fitzpatrick Institute for Photonics (FIP) Annual Meeting
Frontiers in Photonics Science and Technology
50th Year Anniversary of the Laser Celebration / 10 Year Anniversary of FIP
October 27-28, 2010

Program Agenda

Wednesday, October 27 (Fitzpatrick Center)

8:30-9:00 **Registration**

9:00-9:10 **Welcome Address**
Peter Lange, Provost, Duke University

9:10-9:30 **Opening Remarks**
Tom Katsouleas, Dean, Pratt School of Engineering, Duke University
Tuan Vo-Dinh, FIP Director, R. Eugene and Susie E. Goodson Professor of Biomedical Engineering and Professor of Chemistry, Duke University

9:30-10:20 **Symposium Keynote: Ahmed H. Zewail**, Nobel Laureate in Chemistry (1999), Linus Pauling Chair Professor of Chemistry and Professor of Physics Director of the Center for Physical Biology, California Institute of Technology
"Lasers after 50 years – From Atoms to Cells"

10:20-10:35 **FIP Award Presentation – *2010 Pioneer in Photonics Award***

10:35-11:05 **Plenary Lecture: Alain Aspect**, 2010 Wolf Prize, CNRS Scientist and Professor, Institut d'Optique; Professor, Ecole Polytechnique, Paris (France)
"From Einstein's intuition to quantum bits: a new quantum age?"

11:05-11:20 **Coffee Break**

11:20-12:00 **Session 1 – Advanced Photonics**
Chair: April Brown, Sr. Associate Dean for Research, Pratt School of Engineering, Duke University

11:20-11:40 David Smith, Director, Center for Metamaterials and Integrated Plasmonics (CMIP) and William Bevan Distinguished Professor of Electrical and Computer Engineering, Duke University
"Transformation Optics and Imaging: New Approaches for Optical Design"

11:40-12:00 Nan Jokerst, Executive Director of Shared Materials Instrumentation Facility (SMIF) and J.A. Jones Distinguished Professor of Electrical and Computer Engineering, Duke University
"Integrated Multi-Material Photonic Systems for Imaging, Sensing and Interfaces"

12:00-1:30 **Lunch Break (Lunch Boxes Provided)**

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POSTER SESSION

Posters are exhibited in the Atrium area of the Fitzpatrick Center

12:30-1:30 pm

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Wednesday, October 27 (Fitzpatrick Center) – Afternoon Session

1:30-2:00 **Invited Lecture: Warren Grundfest**, Professor of Bioengineering and Electrical Engineering, University of California Los Angeles
"*Terahertz, fluorescence lifetime contrast, and Raman imaging for diagnostic applications*"

2:00-3:20 **Session 2 – Special Topic on LASERS IN BIOLOGY AND MEDICINE**
(Co-organized by the Pratt School of Engineering and Duke School of Medicine)
Chairs: Sally Kornbluth, Vice Dean for Research, Duke School of Medicine
William Reichert, Associate Dean for Diversity and PhD Education, Pratt School of Engineering, Duke University

2:00-2:20 Warren Warren, James B. Duke Professor and Chair of Chemistry, Professor in Radiology, Duke University; Chair Division of Laser Science, American Physical Society
"Laserfest: A 50th Year Anniversary of the Laser Discovery"
"Detecting Melanoma and Imaging Neuronal Activity with Controlled, Low-Power Femtosecond Lasers"

2:20-2:40 Thomas D' Amico, Professor of Surgery and Chief, Section of General Thoracic Surgery, Duke School of Medicine
"Lasers in Lung Cancer & Esophagus Cancer"

2:40-3:00 Joseph Izatt, Professor of Biomedical Engineering and Ophthalmology and Director of the Laboratory for Biophotonics at FIP, Duke University
"Optical Coherence-Based Imaging and Sensing in Biomedicine and Biotechnology"

3:00-3:20 Cynthia Toth, Professor of Ophthalmology and Biomedical Engineering, Duke School of Medicine and Duke University
"From Ophthalmic Lasers to Novel Imaging: Translation of Biomedical Tools to Ophthalmology"

3:20-3:40 **Coffee Break and Poster Session**

3:40-4:10 **Plenary Lecture: Erich P. Ippen**, Elihu Thompson Professor of Electrical Engineering, Massachusetts Institute of Technology
"*Femtosecond Optics – More Than Just Really Fast*"

4:10-5:10: **Session 3 – 2010 Forum on Science and Engineering*: New Horizons for Technology Development in the Global Era***

John M. Baldoni. Senior Vice President, GlaxoSmithKline
Ken Kaufmann, Vice President of Marketing, Hamamatsu
Marc Mackowiak, CEO of BioMérieux Inc
Ed Paradise, Vice President, Cisco Systems, Inc.
Diether Recktenwald, Vice President of Advanced Technologies, BD Biosciences
James Siedow, Vice Provost for Research, Duke University
Brent Park, Associate Laboratory Director of the Global Security Directorate, Oak Ridge National Laboratory

Panel Moderators
Tuan Vo-Dinh, FIP Director, R. Eugene and Susie E. Goodson Professor of Biomedical Engineering and Professor of Chemistry, Duke University
Robert Lieberman, President and CTO, Intelligent Systems, Inc.

5:10-6:30 **Poster Session**
Chairs: Martin Fischer, Assistant Research Professor of Chemistry, Duke University; Qing Liu, Professor of Electrical and Computer Engineering, Duke University; Victoria Seewaldt, Professor of Medicine, Associate Professor of Pharmacology & Cancer Biology, Duke School of Medicine

Theme Lab Visits (see Registration Desk for participation)

5:30-7:30 **Cocktail Reception**
(Heavy hors d'oeuvres will be served)

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SPECIAL EDUCATION PROGRAM FOR UNDERGRADUATES (for Students Only)

Introduction to the Master of Engineering Program in Photonics

Chair: Adam Wax
Wednesday, October 27th 5:30-6:00 pm
(Schiciano Auditorium, Fitzpatrick Center)
Reception to Follow

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Thursday, October 28 (Searle Center, Duke School of Medicine)

Note: The technical sessions of the second day will be at the Searle Center, Duke University School of Medicine

8:30-9:00 **Registration**

9:00-10:10 **Session 4 – Advanced Photonics**
Chair: Jungsang Kim, Associate Professor, Department of Electrical and Computer Engineering, Duke University

9:00-9:30 **Invited Lecture: Joachim Lewerenz**, Professor of Physics, Technical University, Berlin, Institute for Solar Fuels and Energy Storage Materials, Hemholtz Center Berlin for Materials and Energy, Berlin (Germany)
"*Photoelectrocatalysis: Processes, Materials and Architectures*"

9:30-9:50 Ying Wu, Associate Professor of Physics, Duke University
"From Free-Electron Laser to High Intensity Gamma-ray Source"

9:50-10:10 Benjamin Wiley, Assistant Professor of Chemistry, Duke University
"Guiding Surface Plasmons with Single-Crystalline Metallic Nanowires"

10:10-10:30 **Coffee Break**

10:30-10:50 **Invited Lecture: Michael Canva**, Directeur de Recherche au CNRS, Université Paris Sud (France)
"*Surface Plasmon Resonance Imaging Sensors – Application to Biochip Systems*"

10:50-11:50 **Session 5: Special Topic on LASERS IN BIOLOGY AND MEDICINE II**
(Co-organized by the Pratt School of Engineering and School of Medicine)
Chair: Danny O. Jacobs, Chair, Dept of Surgery, Duke School of Medicine
Kam Leong, James B. Duke Professor of Biomedical Engineering and Surgery, Duke University and Duke School of Medicine

10:50-11:10 Adam Wax, Associate Professor of Biomedical Engineering, Duke University
"Optical spectroscopy and low-coherence interferometry for cancer detection and analysis"

11:10-11:30	Gerald Grant, Associate Professor of Surgery, Duke School of Medicine *"Fluorescence Technique for In Vivo Detection of Brain Tumor in Mouse Studies"*
11:30-11:50	James Provenzale, Professor of Radiology, Duke School of Medicine presented jointly with Aaron Mohs, PhD, Duke School of Medicine and Michael Mancini, BS, Georgia Tech/Emory *"Laser-guided widefield imaging and spectroscopy for guidance during surgical resection of tumors"*

11:50-12:00 **Poster Awards**

12:00 **Symposium Adjourn**

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THURSDAY, OCTOBER 28
12:15-2:00 pm
(*Searle Center*)
12:15-1:30 – Lunch Provided

WORKSHOP ON COLLABORATIVE RESESEARCH

Empowering Cross-disciplinary Research in Science, Engineering and Medicine
(Co-organized by the Pratt School of Engineering and Duke School of Medicine)

Panel Members
Robert Calderbank, Dean of Natural Sciences and Professor of Electrical and Computer Engineering, Duke University
David L. Epstein, Chair, Department of Ophthalmology, Duke University School of Medicine
Daniel Gauthier, Chair, Department of Physics, Duke University
Warren Grundfest, Professor of Bioengineering and Electrical and Computer Engineering, UCLA
Danny O. Jacobs, Department of Surgery, Duke University School of Medicine
George Truskey, Chair, Department of Biomedical Engineering, Duke University
Warren Warren, Chair, Department of Chemistry, Duke University

Panel Participants
Invited Faculty members of Duke University and Duke School of Medicine

Moderators
Tuan Vo-Dinh, Departments of Biomedical Engineering and Chemistry, Duke University
Mark Dewhirst, Department of Radiation Oncology, Duke University School of Medicine
Barry Myers, Professor and Director of Emerging Programs, Duke Translational Research Institute
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Frontiers in Photonics: Science and Technology

Welcome

 **Dr. Peter Lange** Provost, Duke University	**Opening Address** **Peter Lange, Ph.D.** Peter Lange joined the Department of Political Science at Duke University in 1981 after a previous teaching position at Harvard University. Since arriving at Duke, he has been Associate Professor (1982-1989), Full Professor (since 1989), and Chair of the Department of Political Science (1996 to 1999). He assumed his position as the Provost of Duke University in July of 1999.
 **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.

Speaker Abstracts & Biographical Sketches

Professor Ahmed H. Zewail,
Nobel Laureate in Chemistry (1999), Linus Pauling Chair Professor of Chemistry and Professor of Physics, Director of the Center for Physical Biology, California Institute of Technology
Pasadena, California

Symposium Keynote

~ Wednesday, October 27, 2010~ 9:30-10:20am

Ahmed H. Zewail, Ph.D.

"*Lasers after 50 years – From Atoms to Cells*"

In over half a century of laser developments revolutionary advances have been accomplished, both in fundamental science and in technology. In this lecture, we will overview these developments and the lead to four-dimensional (4D) imaging of nanomaterials, photonics, and biological structures. A perspective on future directions of explorations will be presented in the concluding remarks.

Some recent references:
[1] Four-Dimensional Electron Microscopy. A. H. Zewail, Science 328, 187-193 (2010).
[2] Filming the Invisible in 4D. A. H. Zewail, Sci. Am. 303, 74-89 (2010).
[3] 4D Electron Microscopy: Imaging in Space and Time. A. H. Zewail and J. M. Thomas, Imperial College Press (2009).

Ahmed Zewail is the Linus Pauling Chair professor of chemistry and professor of physics at the California Institute of Technology (Caltech), and is currently the Director of the Moore Foundation's Center for Physical Biology at Caltech. He received his early education in Egypt and in the U.S. completed a Ph. D. from the University of Pennsylvania and a postdoctoral (IBM) fellowship at the University of California, Berkeley, before joining the faculty at Caltech. On April 27, 2009, President Barack Obama appointed him to the President's Council of Advisors of the White House, and in November of the same year, he was named the first United States Science Envoy to the Middle East.

Dr. Zewail was the sole recipient of the 1999 Nobel Prize for his pioneering developments in femtoscience, making possible observations of atomic motions during molecular transformations in femtoseconds, a millionth of a billionth of a second. More recently, he and his group have developed the field of 4D electron microscopy for the direct visualization of matter's behavior, from atoms to biological cells, in the four dimensions of space and time. A significant effort is also devoted to giving public lectures on science and on the promotion of education and partnership for world peace, and he continues to serve on national and international boards for academic, cultural, and world affairs.

For his contributions to science and public life he has garnered other honors from around the globe: Forty Honorary Degrees in the sciences, arts, philosophy, law, medicine, and humane letters; Orders of State and Merit; commemorative postage stamps; and more than 100 international awards, including the Albert Einstein World Award, Benjamin Franklin Medal, the Leonardo da Vinci Award, the King Faisal Prize, and the Priestley Medal. In his name, international prizes have been established, and the AZ foundation provides support for the dissemination of knowledge and for merit awards in arts and sciences. He is an elected member of academies and learned societies, including the American Philosophical Society, National Academy of Sciences, Royal Society of London, French Academy, Russian Academy, Chinese Academy, and the Swedish Academy.

Professor Alain Aspect, 2010 Wolf Prize, CRNS Distinguished Scientist and Professor, Institut d'Optique; Professor, Ecole Polytechnique
Palaiseau, Paris, France

Symposium Plenary Lecture 1

~ Wednesday, October 27, 2010~ 10:35-11:05am

Alain Aspect, Ph.D.

"*From Einstein's intuition to quantum bits: a new quantum age?*"

In 1935, with co-authors Podolsky and Rosen, Einstein discovered an amazing quantum situation, where particles in a pair are so strongly correlated that Schrödinger called them "entangled". By analyzing that situation, Einstein concluded that the quantum formalism was incomplete. Niels Bohr immediately opposed that conclusion, and the debate lasted until the death of these two giants of physics, in the 1950's.

In 1964, John Bell produced his famous inequalities, which would allow experimentalists to settle the debate, and to show that the revolutionary concept of entanglement is indeed a reality.

Based on that concept, a new field of research has emerged, quantum information, where one uses quantum bits, the so-called "qubits". In contrast to classical bits which are either in state 0 or state 1, qubits can be simultaneously in state 0 and state 1, as a Schrödinger cat could be simultaneously dead and alive. Entanglement between qubits enables conceptually new methods for processing and transmitting information. Large scale practical implementation of such concepts might revolutionize our society, as did the laser, the transistor and integrated circuits, some of the most striking fruits of the first quantum revolution, which began with the 20th century.
Alain Aspect, born in 1947, studied physics at ENS de Cachan and Université d'Orsay. In 1974 he started at Institut d'Optique on a

series of experiments on the foundations of quantum mechanics, known as "Experimental Tests of Bell's Inequalities with Entangled Photons", resulting in his PhD in 1982. Then, with his student Philippe Grangier, he developed and characterized the first source of heralded single photons, and performed an experiment on wave particle duality. From 1985 to 1992 he worked at ENS Paris with Claude Cohen-Tannoudji on atom cooling. Since 1992, he has been the head of the Atom Optics Group at the Institut d'Optique, with main activity on Bose Einstein Condensates, Atom Lasers, and Quantum Atom Optics. Alain Aspect is a CNRS senior scientist at Institut d'Optique, and a Professor at Ecole Polytechnique, Palaiseau. He is a member of the Académie des Sciences and of the Académie des Technologies (France), and a foreign associate of the National Academy of Sciences (USA). He is a fellow of the OSA, EOS, and APS, and has received several international awards. In 2005, he received the CNRS gold medal.

Professor April Brown
Sr. Associate Dean for Research, Professor of Electrical & Computer Engineering, Duke University

Session 1: Advanced Photonics

~ Wednesday, October 27, 2010~ 11:20 – 12:00pm

Session Chair

April Brown completed her BSEE at North Carolina State University and her MS and PhD degrees from Cornell University. She has held numerous positions in industry, academia and the government, including Senior Scientist at Hughes Research Labs, the Pettit Professor of Microelectronics at the Georgia Institute of Technology and the John Cocke Professor of Electrical Engineering in the Pratt School of Engineering. She is a Fellow of the IEEE and has published and presented over 200 papers.

Professor David Smith, Director of Center for Metamaterials and Integrated Plasmonics (CMIP) and William Bevan Distinguished Professor of Electrical and Computer Engineering, Duke University

Session 1: Advanced Photonics

~ Wednesday, October 27, 2010~ 11:20 – 11:40am

David Smith, Ph.D.

"Transformation Optics and Imaging: New Approaches for Optical Design"

Over the past decade, metamaterials have emerged as a means of obtaining controlled electromagnetic response that can often lie outside of what is possible or at least convenient to obtain using conventional materials. The nearly point-by-point control of material properties throughout a volume, made possible by metamaterials, has led to the relevance of coordinate transformation methods as a new optical design approach. Now embodied within the field of Transformation Optics, the collection of coordinate transformation techniques has brought us both new and exotic device concepts—such as invisibility cloaks or optical black holes—as well as methods to modify and improve traditional optical devices. The degrees of freedom available in transformation optical media are so large, we have probably only begun to explore the nearly infinite possibilities. We will discuss the manner in which Transformation Optics might impact an entire class of gradient index optical devices, including Luneburg and Maxwell lenses, improving their utility for implementation in practical systems.

David R. Smith is currently the William Bevan Professor of Electrical and Computer Engineering Department at Duke University and serves as Director for the Center for Metamaterial and Integrated Plasmonics. He holds a secondary faculty appointment in the Physics Department at Duke University and a Visiting Professor of Physics at Imperial College, London. Dr. Smith received his Ph.D. in 1994 in Physics from the University of California, San Diego (UCSD). Dr. Smith's research interests include the theory, simulation and characterization of unique electromagnetic structures, including photonic crystals, metamaterials and plasmonic nanostructures. Smith and his colleagues (then at UCSD) demonstrated the first left-handed (or negative index) metamaterial at microwave frequencies in 2000, and has continued to study the fundamentals and potential applications of negative index media since. In 2006, Smith, along with Sir John Pendry (Imperial College) and Prof. David Schurig (NC State University) introduced the technique of transformation optics as a new design approach for electromagnetic media. Later that year, Smith's group at Duke University reported the experimental demonstration of a transformation optical designed "invisibility cloak." Currently, Dr. Smith is the lead on a Multiple University Research Initiative involving four universities investigating transformation optical media, sponsored by the Army Research Office.

Dr. Smith's research on electromagnetic media includes the study of surface plasmons at visible and near infrared wavelengths. Surface plasmons are excitations that couple electromagnetic waves with electronic oscillations. Dr. Smith's group studies all aspects of plasmonic structures, including plasmon nanoparticles as a platform for biological and biomedical diagnostics, as well as integrated plasmonic components as chip-scale nanophotonic devices for information processing. Recent work has focused on the demonstration of a variety of optical components based on *long-range* plasmons, including couplers, bends, multimode couplers and interferometers.

In 2002, Dr. Smith was elected a member of The Electromagnetics Academy. In 2005, Dr. Smith was part of a five member team that received the Descartes Research Prize, awarded by the European Union, for their contributions to metamaterials and other novel electromagnetic materials. In 2006, Dr. Smith was selected as one of the "Scientific American 50," a group recognized by the editors of Scientific American for achievements in science, technology and policy. In 2008, Dr. Smith was presented with a numbered coin from DARPA for his contributions, particularly in the field of metamaterials. Dr. Smith's work has twice appeared on the cover of Physics Today, and twice been selected as one of the "Top Ten Breakthroughs" of the year by Science Magazine. In 2009, Dr. Smith was named a "Citation Laureate" by Thomson-Reuters ISI Web of Knowledge, for having the most number of highly cited papers in the field of Physics over the past decade

Professor Nan Jokerst,
Executive Director of Shared Materials and Instrumentation Facility (SMIF) and J.A. Jones Distinguished Professor of Electrical and Computer Engineering, Duke University

Session 1: Advanced Photonics

~ Wednesday, October 27, 2010~ 11:40 – 12:00pm

Nan Jokerst, Ph.D.

"Integrated Multi-Material Photonic Systems for Imaging, Sensing, and Interfaces"

Techniques such as wafer bonding and the heterogeneous integration of thin film optoelectronic devices, such as photodetectors and lasers, will be presented, highlighting integrated photonic system applications in imaging, sensing, and optoelectronic interfaces.

Nan Marie Jokerst is the J. A. Jones Professor of Electrical and Computer Engineering at Duke University and the Executive Director of Duke University's Shared Materials Infrastructure Facility (SMIF), which houses Duke's cleanroom and materials characterization facilities. She received her PhD in Electrical Engineering from the University of Southern California in 1989. She was named a Fellow of the IEEE in 2003, a Fellow of the Optical Society of America in 2000, received an IEEE Third Millenium Medal in 2000, was a National Science Foundation Presidential Young Investigator in 1990, a DuPont Young Professor in 1989, a Newport Research Award winner in 1986, and a Hewlett Packard Fellow in 1983. She received the University of Southern California Alumni in Academia award from the Viterbi School of Engineering in their 100^{th} anniversary year, 2006. She joined the Duke faculty in 2003 after 14 years on the faculty at Georgia Tech. She has also been recognized for her teaching accomplishments, which include the Harriet B. Rigas IEEE Education Society/Hewlett Packard Award in 2002. She is currently serving on the National Academies Board on Global Science and Technology. Her research work focuses on the fabrication, integration, and application of thin film semiconductor optoelectronic and high speed electronic devices for integrated nano and micro systems, optical interconnections, planar lightwave integrated circuits, chip scale integrated sensors and sensing systems, metamaterials, and plasmonics. She has 6 patents, and over 250 journal and conference publications.

Professor Warren Grundfest,
Professor of Bioengineering and Electrical and Computer Engineering, University of California Los Angeles
Los Angeles, California

Symposium Invited Lecturer

~ Wednesday, October 27, 2010~ 1:30-2:00pm

Warren Grundfest, Ph.D.

"Terahertz, fluorescence lifetime contrast, and Raman imaging and diagnostic applications"

In 1935, with co-authors Podolsky and Rosen, Einstein discovered an amazing quantum situation, where particles in a pair are so strongly correlated that Schrödinger called them "entangled". By analyzing that situation, Einstein concluded that the quantum formalism was incomplete. Niels Bohr immediately opposed that conclusion, and the debate lasted until the death of these two giants of physics, in the 1950's.

In 1964, John Bell produced his famous inequalities which would allow experimentalists to settle the debate, and to show that the revolutionary concept of entanglement is indeed a reality.

Based on that concept, a new field of research has emerged, quantum information, where one uses quantum bits, the so-called "qubits". In contrast to classical bits which are either in state 0 or state 1, qubits can be simultaneously in state 0 and state 1, as a Schrödinger cat could be simultaneously dead and alive. Entanglement between qubits enables conceptually new methods for processing and transmitting information. Large scale practical implementation of such concepts might revolutionize our society, as did the laser, the transistor and integrated circuits, some of the most striking fruits of the first quantum revolution, which began with the 20th century.

Dr. Warren S. Grundfest is the former Chair of Bioengineering at UCLA where he holds appointments as Professor of Bioengineering, Electrical Engineering and Surgery. He serves as the Senior West Coast Clinical Advisor and Portfolio Manager for Nanomedicine and Biomaterials for TATRC (the Telemedicine and Advanced Technology Research Center of the U.S. Army). He is one of the nation's foremost experts on image-guided therapies and medical device design and development, with research interests in minimally invasive surgery, optical diagnostics, medical robotics, and advanced medical imaging technologies. He is a Fellow of the American College of Surgeons, AIMBE, ASLMS, and SPIE, and currently serves as Chair of the AIMBE Council of Societies. He holds 15 patents, has 5 more pending, and has authored 225+ papers and 46 book chapters. He has been involved with multiple corporate and venture technology development programs. Dr. Grundfest is also on the Executive Board of and Principal Investigator in UCLA's CASIT Center (Center for Advanced Surgical and Interventional Technologies).

Professor Sally Kornbluth
James B. Duke Professor of Pharmacology and Cancer Biology, Vice Dean for Research, Duke University Medical Center

Session 2: Special Topic on LASERS IN BIOLOGY AND MEDICINE (Co-organized by the Pratt School of Engineering and Duke School of Medicine)

~ Wednesday, October 27, 2010~ 2:00 – 3:20pm

Session Co-Chair

Sally Kornbluth was appointed Vice Dean for Research at Duke University School of Medicine on August 1, 2009. From 2006 to 2009, she served as Vice Dean, Basic Science. Dr. Kornbluth received a B.A. in Political Science from Williams College in 1982 and a B.S. in Genetics from Cambridge University, England in 1984 where she was a Herchel Smith Scholar at Emmanuel College. She received her Ph.D. from The Rockefeller University in 1989 in Molecular Oncology and went on to postdoctoral training at the University of California, San Diego. She joined the Duke faculty in 1994 and is currently a Professor in the Department of Pharmacology and Cancer Biology.

Dr. Kornbluth's research interests include the study of cell proliferation and programmed cell death, areas of central importance for understanding both carcinogenesis and degenerative disorders. She has published extensively in these areas, studying these problems in a variety of model organisms.

Dr. Kornbluth serves as a liaison between the Dean's office and the Department Chairs and faculty. Her duties include oversight of the biomedical graduate programs in the School of Medicine, implementation of programs to support the research mission of the faculty, and oversight of new and existing core laboratories. She also has broad oversight of IRB, CRSO, IBC, Research Integrity and Conflict of Interest activities.

Professor Monty Reichert
Professor of Biomedical Engineering, Associate Dean for Diversity and PhD Education for Pratt School of Engineering, Duke University

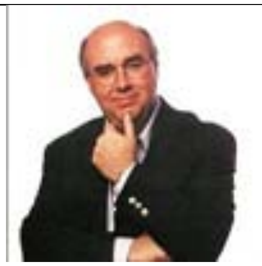
Session 2: Special Topic on LASERS IN BIOLOGY AND MEDICINE (Co-organized by the Pratt School of Engineering and Duke School of Medicine)

~ Wednesday, October 27, 2010~ 2:00 – 3:20pm

Session Co-Chair

Monty Reichert has been appointed to the newly created position of Associate Dean for Diversity and PhD Education for Pratt. Reichert's leadership and expertise in promoting diversity are nationally recognized through published work on the techniques he developed in his role as DGS. His work on diversity has led to receiving the Dean's Award for Excellence in Mentoring from the Duke Graduate School, the Pioneer Award from the Samuel DuBois Cook Society, and the Catalyst for Institutional Change Award from the Quality Education for Minorities Network. This year he was recognized by the Society for Biomaterials with the Clemson Award for Basic Research in Biomaterials.

Dr. Reichert's research interests include biosensors, protein mediated cell adhesion, and wound healing. In general, my research concerns the behavior of proteins and cells at surfaces. These phenomena are central to many aspects of biology and medicine, for example thrombus formation, inflammation, complement activation, immune recognition, wound healing, cell-cell recognition, and cell adhesion to artificial and natural substrates. Proteins and cells at surfaces are also important in many technological applications, such as separation and purification systems, biorecognition-based diagnostics, indwelling sensors, tissue engineering, and soon-to-be realized biologically integrated devices. More specifically, I have focused on protein adsorption, protein-ligand binding, and protein-mediated cellular adhesion at artificial surfaces from the perspective of developing new diagnostics and improving biomaterials



Professor Warren Warren
James B. Duke Professor and Chair of Chemistry, Professor in Radiology, Duke University; Chair Division of Laser Science, American Physical Society

Session 2: Special Topic on LASERS IN BIOLOGY AND MEDICINE (Co-organized by the Pratt School of Engineering and Duke School of Medicine)

~ Wednesday, October 27, 2010~ 2:00 – 2:20pm

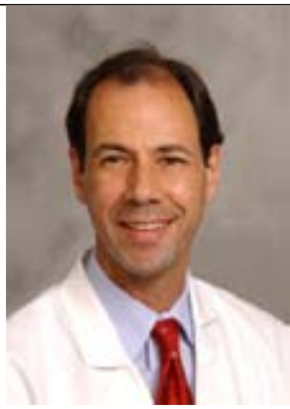
Warren Warren, Ph.D.

"*Detecting Melanoma and Imaging Neuronal Activity with Controlled Low-Power Femtosecond Lasers*"

Light can non-invasively probe cells and tissue with high resolution, but conventional optical microscopies are limited by the strong scattering in biological tissue. The effect of scattering can be reduced by the localized nature of nonlinear optical interactions. The nonlinear interactions that are in common use generate light at wavelengths well separated from the illumination light. However, very few *intrinsic* biological markers yield such convenient contrast with sufficient strength and resolution in tissue, and the use of *exogenous* (expressed or injected) contrast agents is often not an option.

Our lab has developed advanced femtosecond pulse shaping and detection technologies to access *intrinsic* nonlinear signatures that were not previously observable in tissue. We have developed two such measurement techniques: a *spectral reshaping* technique that can measure nonlinear dispersive or absorptive processes; and a *pulse train shaping* technique (essentially a modulated pump-probe spectroscopic technique) that is more sensitive, but restricted to absorptive contrast. Applications to imaging hemoglobins and melanins in tissue by nonlinear absorption (in particular, our demonstration that we can image skin in vivo or pathology slides, and improve diagnostic abilities), and to imaging neuronal firing by self-phase modulation, will be highlighted.

Dr. Warren received his bachelor's degree in chemistry and physics summa cum laude from Harvard in 1977, and his PhD from Berkeley in chemistry in 1980. After post-doctoral work at Caltech with Ahmed Zewail, he moved to Princeton in 1982, and then to Duke in 2005, where he is the James B. Duke Professor and Chair of Chemistry. He is also professor of radiology and biomedical engineering and director of the Center for Molecular and Biomolecular Imaging at Duke, and chair of the Division of Laser Science, American Physical Society. His research interests focus on the use of enhanced control over radiation fields to enhance molecular spectroscopy and imaging, primarily in magnetic resonance and optics. He is a fellow of APS, AAAS, and ISMAR. He is also the author of an award-winning honors chemistry textbook, The Physical Basis of Chemistry.



Professor Thomas D'Amico
Professor of Surgery and Chief, Section of General Thoracic Surgery, Duke School of Medicine

Session 2: Special Topic on LASERS IN BIOLOGY AND MEDICINE (Co-organized by the Pratt School of Engineering and Duke School of Medicine)

~ Wednesday, October 27, 2010~ 2:20 – 2:40pm

Thomas D'Amico, Ph.D.

"*Lasers in Lung Cancer & Esophagus Cancer*"

The incidence of esophageal adenocarcinoma has been increasing during the past two decades, and approximately 13,500 new cases were diagnosed in the United States in 2009. The new developments in the management of Barrett's esophagus result in refinements of decision making. New techniques including magnification endoscopy have been used for real-time recognition of intestinal metaplasia but are not yet validated. The finding of Barrett's esophagus in patients lacking reflux symptoms highlights the problems of developing screening criteria for the general population

The natural history of Barrett's esophagus is not well known, but the annual incidence of invasive adenocarcinoma is estimated to be 0.5% (reported range, 0.2%-2.0%). This represents an increased risk for esophageal cancer of 30 to 60 times higher than normal subjects. Malignant degeneration is Barrett's esophagus is thought to occur through a continuum of histologic stages: metaplasia, dysplasia and neoplasia. Barrett's high-grade dysplasia (formerly referred to as carcinoma in situ) is the histologic stage of disease that immediately precedes the development of invasive carcinoma.

Patients with HGD were routinely referred for esophageal resection surgery based upon the assumption of inevitable progression to cancer, the high rate of undiagnosed synchronous cancers, and few treatment alternatives. Important developments in Barrett's high-grade dysplasia include recent publications regarding the natural history of Barrett's high-grade dysplasia and the regulatory approval for endoscopic ablation therapy using porfimer sodium photodynamic therapy (Photofrin PDT).

Three basic elements are essential to the photodynamic reaction and the basis of PDT: a chemical photosensitizing agent, light, and oxygen. After the photosensitizer is administered, 48 to 72 hours are allowed to pass before the patient is exposed to the light source, so that the drug is eliminated by normal tissues while still relatively retained in abnormal cells. PDT requires endoscopic delivery of light to the target lesion(s). Since each photosensitizing compound has a unique absorption spectra, light of a specific wavelength is administered to activate the photosensitizer, resulting in the formation of toxic oxygen metabolites, most likely singlet oxygen that allows a large area of epithelium to be treated with a low risk of perforation.

The overall survival from esophageal cancer is 5% to 10%, and fewer than 50% of patients will be eligible for potentially curative resection at time of presentation. Most often patients present with dysphagia and weight loss; thus, the majority of patients may be candidates for palliative interventions to improve their swallowing, allow adequate oral intake, and reduce the risk of aspiration pneumonia.

Current modalities of palliating malignant dysphagia and improving esophageal obstruction include external beam radiation therapy, surgical resection, and endoscopic interventions including self-expandable metal stents, pneumatic dilation, Neodymium:yttrium-aluminum garnet (Nd:YAG) laser, brachytherapy, and PDT.

Dr. Thomas D'Amico is a graduate of Harvard University (BA) and the College of Physicians & Surgeons of Columbia University (MD). He received training in General Thoracic Surgery at Duke University Medical Center. After completing a Fellowship in Thoracic Surgical Oncology at the Memorial Sloan-Kettering Cancer Center, Dr. D'Amico joined the faculty at Duke University Medical Center. He is currently Professor of Surgery, Chief of the Section of General Thoracic Surgery, and the Director of the Residency Training Program in Thoracic Surgery. He is also Co-Director of Thoracic Oncology Research Laboratory, investigating the molecular biology of lung cancer and esophageal cancer.

As Medical Director of Clinical Oncology of the Duke Comprehensive Cancer Center, Dr. D'Amico supervises the clinical programs in Oncology for the Duke Health System. He is also involved in improving safety and quality in cancer care, as a member of the Medical Center and Cancer Center Safety and Quality Committees.

Dr. D'Amico is active in the leadership of the American Association for Thoracic Surgery, the Society of Thoracic Surgeons, Thoracic

	Surgery Foundation for Research and Education, and he is the Chair of the National Comprehensive Cancer Network.
 **Professor Joseph Izatt** Professor of Biomedical Engineering and Ophthalmology, Director of the Laboratory for Biophotonics at FIP, Duke University	**Session 2: Special Topic on LASERS IN BIOLOGY AND MEDICINE (Co-organized by the Pratt School of Engineering and Duke School of Medicine)** **~ Wednesday, October 27, 2010~ 2:40 – 3:00pm** **Joseph Izatt, Ph.D.** **"*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 undergoing clinical trials 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. Functional extensions of OCT for Doppler blood flow imaging, polarization-based tissue birefringence mapping, and molecular imaging using intrinsic and nanoparticle-based contrast media are undergoing rapid development. Recent technology advances have also enabled the design of OCT-based highly phase-stable interference microscopes capable of resolving nanometer-scale structures and motions in living cells in the optical far field 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. The lecture will review the operating principles of these technologies and provide an overview of selected applications. **Joseph A. Izatt** received the B.S. degree in physics, and the M.S. and Ph.D. degrees in Nuclear Engineering from the Massachusetts Institute of Technology, Cambridge, Massachusetts in 1986, 1988, and 1991, respectively. He pursued postdoctoral studies in the department of Electrical Engineering and Computer Science at MIT. He was Assistant Professor of Biomedical Engineering at Case Western Reserve University and Director of the Endoscopy Research Laboratory at University Hospitals of Cleveland in Cleveland, Ohio from 1994-2001. Dr. Izatt is currently Professor of Biomedical Engineering and Ophthalmology at Duke University and Director of the Laboratory for Biophotonics at the Fitzpatrick Institute for Photonics at Duke University. He is also Chairman and CTO of

Bioptigen, Inc., a manufacturer of research-grade biophotonic instrumentation located in Research Triangle Park, North Carolina. Dr. Izatt's research interests include biomedical optics and spectroscopy, coherence-based optical imaging in scattering media, and novel instrumentation for minimally invasive medical diagnostics. Dr. Izatt is a Fellow of the American Institute for Medical and Biological Engineering (AIMBE), Society of Photo-Instrumentation Engineers (SPIE), and Optical Society of America (OSA). He is the founding Editor-in-Chief of OSA's newest peer-reviewed, rapid publication, open-access journal, *Biomedical Optics Express*.

Professor Cynthia Toth
Professor of Ophthalmology,
Duke School of Medicine

Session 2: Special Topic on LASERS IN BIOLOGY AND MEDICINE (Co-organized by the Pratt School of Engineering and Duke School of Medicine)

~ Wednesday, October 27, 2010~ 3:00 – 3:20pm

Cynthia Toth, Ph.D.

"From Ophthalmic Lasers to Novel Imaging: Translation of Biomedical Tools to Ophthalmology"

Dr. Toth received her M.D. from the Medical College of Pennsylvania in 1983. After Ophthalmology Residency at Geisinger Medical Center, she served in as a general ophthalmologist in the US Air Force from 1987-89. After Fellowship in Vitreoretinal Diseases and Surgery at UC Davis in 1991, she became Chief of the Retina Service at the USAF Medical Center in San Antonio, Texas. Dr. Toth joined the Duke faculty in 1993 and directed the Eye Center Biophysics Laboratory, which she evolved into the Duke Advanced Research in SDOCT Imaging (DARSI) Lab. As Director of Grading for OCT for the Duke Reading Center, Dr. Toth ensures standardized OCT review for multicenter clinical trials. Her research interests for over 18 years include ophthalmic diagnostics such as optical coherence tomography, microsurgical instrumentation and techniques, and quality-of-life outcomes. Her translational research centers on improving the diagnosis, treatment and outcome for adults and children with vitreoretinal disease.

Professor Erich P. Ippen
Elihu Thompson Professor of Electrical Engineering, Massachusetts Institute for Technology, Research Laboratory of Electronics
Cambridge, MA

Symposium Plenary Lecture 2

~ Wednesday, October 27, 2010~ 3:40-4:10pm

Erich P. Ippen, Ph.D.

"*Femtosecond Optics – More Than Just Really Fast*"

Advances in ultrafast optics have created dramatic new capabilities for a wide range of applications such as optical clocks, medical imaging, micro-machining, and precision signal processing as well as for a wide range of science. Many of these applications do not themselves rely on ultrafast time resolution but benefit from the ultra wide bandwidths, low temporal coherence, low noise or high peak powers of ultra short light pulses. This talk will describe briefly the femtosecond laser state-of-the-art that makes these things possible and will illustrate how it enables such a wide range of uses.

Erich P. Ippen received his B.S. degree from MIT in 1962 and his M.S. and Ph.D. from the University of California in 1965 and 1968 respectively. He worked at Bell Laboratories in Holmdel, NJ from 1968 to 1980 before joining the faculty of MIT where he is now Elihu Thomson Professor of Electrical Engineering and Professor of Physics. Prof. Ippen has received Major awards for his work from IEEE, the OSA, the APS and the SPIE; and he is a member of the National Academy of Sciences, the National Academy of Engineering and the American Academy of Arts and Sciences. His current research interests include femtosecond optical clock and arbitrary waveform technologies, ultrafast studies of materials and devices, microphotonics, and ultrashort-pulse fiber devices.

Dr. John M. Baldoni
Senior Vice President
GlaxoSmithKline

Session 3: 2010 Forum on Science and Engineering: *New Horizons for Technology Development in the Global Era*

~ Wednesday, October 27, 2010~ 4:10 – 5:10pm

Panel Members

John Baldoni, Ph.D., is Senior Vice President, Platform Technology and Science, GlaxoSmithKline. Platform Technology and Science (PTS) is a multidisciplinary organization that contributes to the selection and development of compounds from target identification and pre-candidate selection through commercial launch and lifecycle management. Their major activities fall into two broad categories: 1) Preclinical Development, which supports the chemistry, formulation and manufacture of the physical product and assesses the biological risks associated with candidates using preclinical models; and 2) Molecular Discovery Research, which provides materials and knowledge required to test the possibility of addressing a biological target with a drug-like molecule. The major scientific and technical disciplines in PTS include synthetic, process, formulation, computational and analytical chemistry, mechanical and chemical

	engineering, solid state science, veterinary pathology, toxicology, clinical veterinary science, drug metabolism, and biochemistry, cell biology, structural biology, and automation. PTS's interactions in the pharmaceutical development process are diverse, ranging from discovery biology to commercial manufacturing. John joined GSK in 1989 and has worked in the pharmaceutical industry for 31 years. His work experience spans new chemical entity product design, development and commercialization, and biopharmaceutical development. In progressing to his current role, John has held various positions at GSK: Sr. VP, Platform Technology and Science; Sr. VP, Pharmaceutical Development; VP, Product Development; Director, Product Development; Assistant Director of Biopharmaceutical Formulation Development, among others. He has also led several key cross functional problem solving and strategic initiatives. John has a BS in biochemistry (1974), and MS and Ph.D. degrees in chemistry (1980) from Penn State University.
 **Dr. Ken Kaufmann** Vice President of Marketing, Hamamatsu Corporation	**Session 3: 2010 Forum on Science and Engineering:** ***New Horizons for Technology Development in the Global Era*** **~ Wednesday, October 27, 2010~ 4:10 – 5:10pm** **Panel Members** **Dr. Ken Kaufmann** received his BS in Chemistry at the City College of New York, and his PhD in physical chemistry from the Massachusetts Institute of Technology. He performed post-doctoral work at the California Institute of Technology and Bell Laboratories. He then joined Hamamatsu Corporation, where he has worked in various marketing positions for the last 22 years. Dr. Kaufmann is currently Vice President of marketing.
 **Marc Mackowiak** Chief Executive Officer bioMérieux, Inc.	**Session 3: 2010 Forum on Science and Engineering:** ***New Horizons for Technology Development in the Global Era*** **~ Wednesday, October 27, 2010~ 4:10 – 5:10pm** **Panel Members** **Marc Mackowiak** is the Chief Executive Officer, bioMérieux, Inc. From 2006 to the present, Marc Mackowiak has also been serving as the Corporate Vice President of Product Development and Support for R&D. Previously, from 2000 to 2006, he directed the development and support of Human Diagnosis worldwide for bioMérieux, and the management of a multifunctional R&D team of 600 people, as Executive Vice President, R&D Development & Support. Before joining bioMérieux, Marc spent most of his career working in France and abroad with IFFA-Mérieux / Rhône-Mérieux /

Mérial in Vaccine development, manufacturing and testing, notably serving 9 years in the USA at Rhône-Mérieux, Inc./Mérial as the Vice President of Biodevelopment, Quality Control, Vaccinovigilance and Regulatory Affairs. Marc Mackowiak obtained his doctorate degree from the National Veterinary School, Lyon, France in 1975, and a Diploma of Public Health, which he received in 1976 from the Veterinary Inspection of Infectious Diseases and Hygiene of Food, Paris, France. He received a postgraduate degree in 1979 in Immunology from the Faculty of Medicine, Lyon, France.

Ed Paradise
Vice President of Development for Cisco's Global Government Solutions Group,
Cisco Systems, Inc.

Session 3: 2010 Forum on Science and Engineering:
New Horizons for Technology Development in the Global Era

~ Wednesday, October 27, 2010~ 4:10 – 5:10pm

Panel Members

Ed Paradise is Vice President of Development for Cisco's Global Government Solutions Group. He is also Executive Sponsor for Cisco's North American Connected Sites.

As Vice President of Development for the Global Government Solutions Group (GGSG), Mr. Paradise leads the engineering and product marketing teams that focus on enhancing existing Cisco products and developing new technologies when necessary to meet the unique requirements of governments. This includes work with industry partners; international agencies; national, state and local governments; developing capabilities, products, technology solutions and best practices in defense, transportation, public safety, intelligence, critical infrastructure protection, and communication security.

As Cisco's North American Connected Sites Executive, Mr. Paradise works across major Cisco locations to ensure Cisco is the local employer of choice and a key corporate partner in quality of life issues in the local community.

Mr. Paradise joined Cisco in April 1993 and has held several key roles in RTP over the last 17 years.

Mr. Paradise is a founding member of the National Knowledge & Intellectual Property Management. He also serves on the Board of Directors for the North Carolina Technology Association and the for National Institute Urban Search & Rescue. He is on the Orange County Advisory Board for Habitat of Humanity, the steering committee of the American Heart Association's Triangle Heart Walk, a Board Member of North Carolina FIRST and a Member of the Duke University Masters of Engineering Management Industrial Advisory Board. He was also honored with a Triangle Business Leader of the Year Award in March 2008.

Mr. Paradise holds a Master's of Science degree in Electrical Engineering from Syracuse University and a Bachelor's of Science degree in Electrical Engineering from the University of Hartford.

Dr. Diether Recktenwald
Vice President of Advanced Technologies
BD Biosciences

Session 3: 2010 Forum on Science and Engineering: *New Horizons for Technology Development in the Global Era*

~ Wednesday, October 27, 2010~ 4:10 – 5:10pm

Panel Members

Dr. Recktenwald specializes in fluorescence techniques for the detection of biological analytes and in methods for the selective enrichment of those analytes. Starting in 1981, his group at BD developed the technology for multi-color fluorescence reagent-, instrument- and software-systems for cell analysis. Fluorescence detection with single molecule sensitivity was demonstrated by his group using CCD based fluorescence microscopy. As VP R&D of AmCell Corporation from 1994 to 1998, in collaboration with Amgen he was responsible for the development and documentation of the CliniMACSTM system for stem cell purification for cell therapy. The system is based on immunomagnetic cell selection. It was introduced into the European oncology market in 1997. Dr. Recktenwald and his AmCell team also investigated several applications of immunomagnetic cell enrichment to increase the sensitivity for the detection of rare cells. As Director of Industrial and Environmental Bioscience at BD from 1999 to 2001, Dr. Recktenwald was responsible for assessing and developing novel detection methods for microorganisms. As VP R&D for BD Biosciences Immunocytometry Systems from 2002 to 2004, he led the development effort to release several new flow cytometry systems (i.e FACSAria, FACSArray, LSR-II, FACSCanto) and accessories (i.e SPA, LWA) to the market. In 2004 he was appointed VP Advanced Technology for BD Biosciences to identify relevant technologies and to integrate them to grow the Biosciences business. Dr. Recktenwald is a BD fellow.

Dr. James N. Siedow

Session 3: 2010 Forum on Science and Engineering: *New Horizons for Technology Development in the Global Era*

~ Wednesday, October 27, 2010~ 4:10 – 5:10pm

Panel Members

Jim Siedow received his BA from the University of Texas at Austin in 1969 and completed his Ph.D. in plant biochemistry from Indiana University in 1972. He did postdoctoral research at the University of Michigan and Rice University before joining the Duke faculty as an Assistant Professor of Botany in 1976. He became a Full Professor of Botany in 1987 and a Professor of Biology in 2000. He was a recipient of the Trinity College Distinguished Teaching Award in

Vice Provost for Research and Professor of Biology, Duke University	1984. Past service at Duke includes election to the Executive Committee of the Academic Council (1992-93) and election as Chair of the Academic Council (1994-96). He also served as the Dean of Faculty Development in Arts and Sciences from 1997-99. He became Vice Provost for Research in January, 2001. Professionally, Dr. Siedow has held numerous positions in the American Society of Plant Biologists, including President, Chair of the Board of Trustees, Secretary, and Chair of the Public Affairs Committee. He also currently serves as the Chair of the Board of Trustees of the Southeastern Universities Research Association and is a member of the Board of Governors of the Oak Ridge National Laboratory and the Research Triangle Institute, among others. He is an elected Fellow of the American Association for the Advancement of Science (2002) and the American Society of Plant Biologists (2007). He currently serves as an Associate Editor for the *Journal of Biological Chemistry* and the journal *Plant Molecular Biology*. In other national service, Dr. Siedow spent a year as a Program Director of the Cellular Biochemistry Program at the National Science Foundation in 1998-99 and he currently serves as a member of the Advisory Committee for the Biology Directorate of the National Science Foundation. He also served as a member of the U.S. Department of Commerce Deemed Export Advisory Committee (09/06-11/07) and the NIH Blue Ribbon Panel on Intramural Conflict of Interest Policy (Spring, 2004). Internationally, Dr. Siedow currently holds a Distinguished Honorary Professorship in the School of Biology at Capital Normal University in Beijing, China (2008-2010). Dr. Siedow's research is represented by over 120 publications and has primarily involved the study of oxidative reactions in higher plants with an emphasis on processes related to plant respiration. A primary project in his laboratory has involved characterizing the structural and regulatory features of the unusual cyanide-resistant (alternative) oxidase found in all plant mitochondria. In addition, a long-term collaboration with a group at North Carolina State University led to elucidating the molecular mode of action of the toxin associated with the fungus responsible for Southern Corn Leaf Blight.

Dr. Brent K. Park
Associate Laboratory Director of the Global Security Directorate (GSD), Oak Ridge National Laboratory

Session 3: 2010 Forum on Science and Engineering: *New Horizons for Technology Development in the Global Era*

~ Wednesday, October 27, 2010~ 4:10 – 5:10pm

Panel Members

Dr. Brent Park is the Associate Laboratory Director of the Global Security Directorate (GSD) at the Oak Ridge National Laboratory (ORNL). He is responsible for national security programs at ORNL.

Dr. Park began his career at Los Alamos National Laboratory (LANL) in 1989 when he performed his Ph.D. thesis experiment at the Los Alamos Meson Physics Facility (now the Los Alamos Neutron Science Center), using the spallation neutron source. After joining the LANL research staff, he held progressively higher level management positions supporting DOE's Basic Energy Science Program, Stockpile Stewardship Program, and nuclear nonproliferation missions. Dr. Park served as Deputy Division Leader of the LANL Nuclear Nonproliferation Division and then joined the NTS. Dr. Park served as the Director of DOE/NNSA Remote Sensing Laboratory, an integral part of the NTS contract, before joining ORNL.

Dr. Robert A. Lieberman
President and CTO
Intelligent Optical Systems (IOS)

Session 3: 2010 Forum on Science and Engineering: *New Horizons for Technology Development in the Global Era*

~ Wednesday, October 27, 2010~ 4:10 – 5:10pm

Panel Moderator

Dr. Robert A. Lieberman, President & CTO, received his B.S. and M.S. degrees in Physics at Rensselaer Polytechnic Institute, and a Ph.D. in Physics with an emphasis on solid-state physics and biophysics from the University of Michigan. After receiving his doctorate in 1981, Dr. Lieberman joined AT&T Bell Laboratories where he was a Member of the Technical Staff for ten years, earning three Bell Labs Exceptional Contribution Awards. In the Development Area of Bell Labs, he was involved in the development and testing of electronic devices for two commercial solid state device products. He then transferred to the Research Area of Bell Labs, becoming the Principal Investigator for research on fiber-optic sensors.

Dr. Lieberman moved to Physical Optics Corporation (POC) in 1991, becoming the Director of POC's Advanced Fiber Optics Laboratory, was promoted to Vice President in 1994, and to General Manager of R&D in 1996. In 1998 he founded Intelligent Optical Systems, Inc. (IOS), where he now serves as President. During his tenure at IOS, Dr. Lieberman also co-founded and served as the first Chairman and CTO of Optinetrics LLC, a $23M startup company devoted to the manufacture of integrated optic telecommunications components. He is also the President of OpTech Ventures, LLC, a company founded to commercialize IOS technologies.

Dr. Lieberman has been the Principal Investigator on more than 40 federally and privately funded projects aimed at developing novel fiber optic devices and sensors, for applications ranging from biowarfare agent detection and medical diagnosis to industrial process control and structural health monitoring. He has invented and developed noninvasive and minimally invasive fiber optic physiological sensors for medical applications, novel fiber-optic sensors for a variety of industrial chemicals, fiber-tip pressure sensors, fiber optic electromagnetic field sensors, and distributed fiber optic sensors for both temperature and chemical concentration. Dr. Lieberman has also overseen research on spectral analysis, signal processing, medical image processing, novel laser structures, integrated optic sensors, and plasmonic devices. Over 50 publications bear his name; he holds 31 U.S. patents. Dr. Lieberman has chaired more than 30 national and international sensor conferences and symposia, and has presented more than 40 invited talks around the world on optical biological and chemical sensors. He is Chairman of ASTM standards Subcommittee E13.09 on Fiber Optics, Waveguides, and Optical Sensors. Dr. Lieberman is a Fellow of SPIE, a Senior Member of IEEE, and received the SPIE President's Award in 2008. He has served on the editorial boards of Optical Engineering and the Journal of Measurement Science and Technology, and serves on the Boards of Directors of SPIE, IOS, OpTech Ventures, and Optical Security Sensing LLC.

Dr. Tuan Vo-Dinh
Director, Fitzpatrick Institute for Photonics, R. Eugene and Susie E. Goodson Professor of Biomedical Engineering, Professor of Chemistry, Duke University

Session 3: 2010 Forum on Science and Engineering: *New Horizons for Technology Development in the Global Era*

~ Wednesday, October 27, 2010~ 4:10 – 5:10pm

Panel Moderator

Dr. Tuan Vo-Dinh is Director of the Fitzpatrick Institute for Photonics and *R. Eugene and Susie E. Goodson* Distinguished Professor of Biomedical Engineering and Professor of Chemistry at Duke University. Before joining Duke University in 2006, Dr. Vo-Dinh was Director of the Center for Advanced Biomedical Photonics, Group Leader of Advanced Biomedical Science and Technology Group, and a Corporate Fellow, one of the highest honors for distinguished scientists at Oak Ridge National Laboratory (ORNL). He received a Ph.D. in biophysical chemistry in 1975 from ETH (Swiss Federal Institute of Technology) in Zurich, Switzerland. His research has focused on the development of advanced technologies for the protection of the environment and the improvement of human health. His research activities involve laser spectroscopy, molecular imaging, medical diagnostics, cancer detection, chemical sensors, biosensors, nanosensors, and biochips.

Dr. Vo-Dinh has received seven *R&D 100 Awards* for Most Technologically Significant Advance in Research and Development for his pioneering research and inventions of innovative technologies. received the *Gold Medal Award,* Society for Applied Spectroscopy (1988); the *Languedoc-Roussillon Award* (France) (1989); the *Scientist of the Year Award*, ORNL (1992); the *Thomas Jefferson Award*, Martin Marietta Corporation (1992); two *Awards for Excellence in Technology Transfer*, Federal Laboratory Consortium (1995, 1986); the *Inventor of the Year Award*, Tennessee Inventors Association (1996); and the Lockheed Martin *Technology Commercialization Award* (1998), The *Distinguished Inventors Award,* UT-Battelle (2003), and the *Distinguished Scientist of the Year Award*, ORNL (2003). In 1997, Dr. Vo-Dinh was presented the *Exceptional Services Award* for distinguished contribution to a Healthy Citizenry from the U.S. Department of Energy.

Professor Joachim Lewerenz, Professor of Physics, Technical University, Berlin, Institute for Solar Fuels and Energy Storage Materials, Hemholtz Center Berlin for Materials and Energy, Berlin, Germany

Symposium Invited Lecturer

~ Thursday, October 28, 2010~ 9:00-9:30pm

Joachim Lewerenz, Ph.D.

"Photoelectrocatalysis: Processes, Materials and Architectures"

The energetic conditions for single- and multiple-photon induced water splitting in monolithically integrated structures are reviewed as an introduction to the topic. The processes that will be addressed relate to excitation energy transfer in the classical sense via charge carriers but also to carrier-less transfer over a distance (Förster process) from the site of photon absorption to the catalytic center. Often, metallic nanoparticles (NPs) are used as co-catalysts on already otherwise photoactive (and sometimes simultaneously catalytic) material. The transfer of the excitation energy to the catalyst and at the catalyst-solution interface for oxidation or reduction reactions involves analysis of illuminated local Schottky-type junctions at the metal NP-semiconductor contact and of exchange currents for the catalytic reactions. In addition, recent results on improving photocurrent response by adsorption of Au NPs onto Si, which show localized surface plasmon resonances, will be presented.

A short overview on selection criteria of materials for photo(electro)catalysis with regard to their application in single- or multiple photon conversion structures will be given with emphasis on stability and energy band structure related to the thermodynamic and kinetic values for water splitting. The realization of water splitting devices demands concepts on architectures and an efficient half cell for light-induced hydrogen generation with an InP thin film absorber structure will be presented. The optimization of half cell systems is an important step in the realization of complete tandem structures that harvest the excess energy of photons.

Joachim Lewerenz received his Ph.D. from Physics TUB and Fritz-Haber-Institut der Max-Planck-Gesellschaft (FHI) in 1978. Since 2000, Lewerenz has been Head of Interface Engineering Group, Hahn-Meitner Institute (HMI). In 2008, he also became Deputy Director, Institute Solar Fuels and Energy Storage, Helmholtz Zentrum Berlin (HZB).

Professor Jungsang Kim
Associate Professor, Electrical & Computer Engineering
Duke University

Session 4: Advanced Photonics

~ Thursday, October 28, 2010~ 9:30 – 10:10am

Session Chair

Jungsang Kim received his Ph.D. in physics from Stanford University in 1999. Kim was a Technical Manager at Bell Laboratories in Murray Hill, New Jersey, before joining Duke University in 2004. His research interests include quantum information processing, optical MEMS and advanced optical sensors and imaging systems.

Professor Ying K. Wu
Associate Professor of Physics,
Duke University

Session 4: Advanced Photonics

~ Thursday, October 28, 2010~ 9:30 – 9:50am

Ying K. Wu, Ph.D.

"From Free-Electron Laser to High Intensity Gamma-ray Source"

As accelerator based coherent photon sources, free-electron lasers (FELs) have been developed to produce laser beams in a wide range of wavelengths from mm-wave, to infrared, to ultraviolet, and more recently to hard x-ray. At Duke FEL lab, storage ring based FELs have been developed to operate in a wavelength range from infrared (1060nm) to vacuum-ultraviolet (194 nm). The high-power FEL beam is now used as a photon driver to power world's most powerful Compton gamma-ray source, High Intensity Gamma-ray Source (HIGS). Operated in the 1 to 100 MeV region, HIGS can produce a highly-polarized, nearly monochromatic gamma-ray beam with a total flux up to few 1E10 gamma/second (around 10 MeV). With these outstanding capabilities, the HIGS facility is a premier high-energy photon source for frontier scientific research and industrial applications.

Ying K. Wu received his Ph.D. in Physics from Duke University in 1995. From 1994 to 1999, he worked at Duke FEL laboratory as a research scientist and a postdoc fellow. From 1999 to 2001, he spent two years at the Berkeley National Laboratory as a staff scientist, working at the Advanced Light Source. In 2001, he joined the Duke Physics Department as a faculty. Since 2003, he has led the accelerator physics program and High Intensity Gamma-ray Source (HIGS) development and upgrade projects as an Associate Director at Duke FEL Laboratory (DFELL). Joining Triangle Universities Nuclear Laboratory (TUNL) in 2008, he became the TUNL's Associate Director for Accelerator Physics and Light Source Operation at DFELL. Currently, he is an Associate Professor in the Department of Physics, Duke University. His research focuses on beam dynamics in accelerators, free-electron laser physics, and Compton gamma-ray source development.

Professor Benjamin Wiley
Assistant Professor of Chemistry, Duke University

Session 4: Advanced Photonics

~ Thursday, October 28, 2010~ 9:50 – 10:10am

Benjamin Wiley, Ph.D.

"Guiding Surface Plasmons with Single-Crystalline Metallic Nanowires"

Surface plasmons enable the guiding and manipulation of light at length scales an order of magnitude smaller than the wavelength of light in vacuum. Plasmonic waveguides thus represent a possible solution to the scaling problems faced by photonic interconnects in integrated circuits. In this talk, I will discuss the fabrication of atomically-smooth, single-crystalline nanostructures consisting of silver and gold, and illustrate three ways to couple light into these nanostructures. Tuning the plasmon resonance frequency of a nanostructure at the end of a nanowire can control the frequency of light that couples into the plasmonic waveguide, and thus enable wavelength-division multiplexing at the nanoscale.

Benjamin J. Wiley has a B.S. in chemical engineering from the University of Minnesota, and a Ph.D. in chemical engineering from the University of Washington, where he studied with Younan Xia. From 2007-2009, he was a postdoctoral researcher in the lab of George M. Whitesides at Harvard University. He joined the department of chemistry at Duke Univeristy as an Assistant Professor in July 2009.

Symposium Invited Lecturer

~ Thursday, October 28, 2010~ 10:30-10:50pm

Michael Canva, Ph.D.

"*Multidimensional Surface Plasmon Resonance Imaging Sensors – Applications to Biochip Systems"*

Surface plasmon resonance biosensors are being increasingly used in laboratories as sensitive biochemical transducers of biomolecular

Professor Michael Canva,
Laboratoire Charles Fabry
de l'Institut d'Optique,
Institut d'Optique Graduate
School, Université Paris-Sud,
CNRS
Paris, France

interactions; model case often chosen being DNA:DNA interactions and application to genetic diagnosis, proteomics or environmental applications are other examples. Indeed, surface plasmon waves, which localize the light matter interactions in the vicinity of an interface, are sensitive to the refractive index variations of their propagating medium, and minute changes in either refractive index or deposited thickness of material such as biomolecules can be quantitatively monitored by means of reflectivity measurements.

We have developed multiparametric systems devoted to exploring the 6 dimension parameter space (voxel: space x,y, time t, angle θ, wavelength λ and polarization p) of surface plasmon resonance beyond the classical SPR imaging biosensors. Some new possible application examples follow. By changing the angular and spectral coupling conditions, a complete reflectivity surface R(Θ, λ) can be obtained from the SPR images. The 2D reflectivity dip is affected by both the real and imaginary part of the optical index of the dielectric surrounding medium as well as its spectral dispersion. With such experimental data set, it is possible to back calculate the dispersion of the complex refractive index of the dielectric layer. Determining the average orientation or order parameter of a layer of biomolecules bound to a surface can also be of importance for fluidic studies or for discriminating between different conformations. We developed a dual SPRI system, based on a classical, single-wavelength approach, capable of resolving the average anisotropy of a biomolecular surface-bound nanometric thin-film.

Biomolecular interaction characterization will be presented, including model case of DNA:DNA interactions with demonstration of parallel genotyping of Single Nucleotide Polymorphism (SNP) on PCR amplified patient material, using the plasmonic biochip reader configuration..

Michael Canva, born in 1963 in France, studied at the Ecole Normale Superieure de Cachan and the University of Orsay Paris Sud. He conducted his PhD research with Dr. Alain Brun on the "optical properties of organically doped sol-gel materials and their applications to optical components", defended in 1992. He is full time researcher for CNRS since 1993, conducting research activities at the Laboratoire Charles Fabry de l'Institut d'Optique, then in Orsay and now in Palaiseau. He started getting involved in plasmonics and applications to biosensing in the early 2000. As Research Director, he currently heads the "Materials, Components and Systems for Biophotonics". He was visiting research scientist at CREOL, University of Central Florida in Orlando for two years (1996-1998) working with Dr. Georges Stegeman. He was also visiting researcher at Duke University for one year, working with Dr. Tuan Vo-Dinh (2009-2010). He has co-authored about 100 publications and about 200 international conferences. His main current interests are focused on nano-plasmonics structures and properties, plasmonic imaging systems and biochip applications.

Danny O. Jacobs, MD, MPH
Chair, Department of Surgery,
Duke School of Medicine

Session 5: Special Topic on LASERS IN BIOLOGY AND MEDICINE II (Co-organized by the Pratt School of Engineering and Duke School of Medicine)

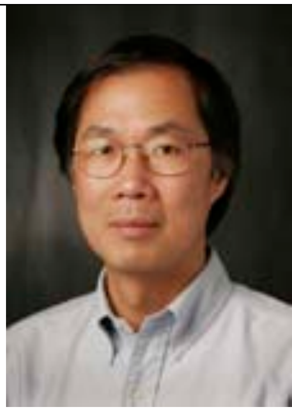
~ Thursday, October 28, 2010~ 10:50 – 11:50am

Session Co-Chair

Danny Jacobs joined Duke University Medical Center as professor and chair of the Department of Surgery in February 2003. A specialist in gastrointestinal surgery, Jacobs is a highly regarded teacher and researcher.

Jacobs received his undergraduate degree from Harvard University and earned his MD degree from Washington University in St. Louis School of Medicine in 1979. After completing a residency and fellowship in surgery at the University of Pennsylvania School of Medicine, Jacobs returned to Harvard as a research fellow in surgery in 1986. He stayed there for 14 years, rising to assistant professor of surgery and then associate professor. He also earned a MPH degree from Harvard's School of Public Health and served as associate program director of the Brigham and Women's Hospital's (BWH) Clinical Research Center, chief of BWH's Metabolic service, and director of the Laboratory for Surgical Metabolism and Nutrition. Jacobs left Harvard in 2000 to join the faculty at Creighton University School of Medicine in Omaha, Nebraska, where he served as the Arnold W. Lempka Distinguished Professor of Surgery and chairman of the surgery department. He stayed at Creighton until coming to Duke.

Jacobs's research focuses on the effects of critical illness and malnutrition on cellular bioenergetics and organ function and metabolism. His clinical interest is treating patients with nutritional or metabolic diseases that are amenable to surgical treatment including patients with intestinal fistulas and morbid obesity.
A prolific writer, Jacobs serves on the editorial boards of the prestigious *New England Journal of Medicine*, *Surgery*, and *Archives of Surgery*. He also is a member of numerous honorific and academic societies including the American College of Surgeons, Society of University Surgeons, the American Surgical Association, the Society for Surgery of the Alimentary Tract, the American Physiological Society, American Surgical Association, the Society of Surgical Chairs, Society of Black Academic Surgeons, Western Surgical Association, Alpha Omega Alpha Honor Medical Society, the Society of Laparoendoscopic Surgeons, Society of Critical Care Medicine, and the Institute of Medicine of the National Academy of Sciences.



Professor Kam Leong
James B. Duke Professor of Biomedical Engineering,
Professor of Surgery,
Duke University

Session 5: Special Topic on LASERS IN BIOLOGY AND MEDICINE II (Co-organized by the Pratt School of Engineering and Duke School of Medicine)

~ Thursday, October 28, 2010~ 10:50 – 11:50am

Session Co-Chair

Kam W. Leong holds the James B. Duke Professorship in Biomedical Engineering at the Pratt School of Engineering at Duke University, with a joint appointment in the Division of Experimental Surgery in the School of Medicine. He was a faculty member in The Johns Hopkins University School of Medicine from 1986 to 2005, and directed the Therapeutics and Tissue Engineering Laboratory at the Division of Johns Hopkins in Singapore from 1998-2005. As the Director of Bioengineering Initiative at Duke University, he is leading a research initiative on applying nanotechnology to drug, gene and cell therapy. He also directs a lab on stem cell bioengineering in the Duke-NUS Graduate Medical School in Singapore. He received his PhD from the University of Pennsylvania and his postdoctoral training at MIT. The research focus of his laboratory is on understanding and exploiting the interactions of cells with nanostructures for therapeutic applications. Discreet nanostructures in the form of multi-functional nanoparticles are applied to deliver drug, antigen, protein, siRNA, and DNA to cells for drug, gene and immunotherapy.

He has published more than 180 peer-reviewed manuscripts and more than 30 patents. He is the recipient of the Young Investigator Research Achievement Award of the Controlled Release Society in 1994 and a Fellow of the American Institute for Medical and Biological Engineering. He serves on the editorial board of Journal of Controlled Release, Biomaterials, Molecular Therapy, Acta Biomaterialia, Genetic Vaccines and Therapy, International Journal of Nanomedicine and Nanomedicine.

Professor Adam Wax
Associate Professor of

Session 5: Special Topic on LASERS IN BIOLOGY AND MEDICINE II (Co-organized by the Pratt School of Engineering and Duke School of Medicine)

~ Thursday, October 28, 2010~ 10:50 – 11:10am

Adam Wax, Ph.D.

"Optical spectroscopy and low-coherence interferometry for cancer detection and analysis"

The study of intact, living cells using non-invasive optical spectroscopic methods offers the opportunity to assess cellular structure and organization in a way that is not possible with traditional methods. We have developed a novel spectroscopic

<table>
<tr>
<td>Biomedical Engineering,
Duke University</td>
<td>technique for diagnosing disease at the cellular level based on using low-coherence interferometry (LCI) to detect the angular distribution of scattered light. Angle-resolved LCI (a/LCI) combines the ability of LCI to isolate scattering from sub-surface tissue layers with the ability of light scattering spectroscopy to obtain structural information on sub-wavelength scales. In application to examining cellular structure, a/LCI enables quantitative measurements of changes in the size and texture of cell nuclei which are characteristic of different pathological states. The capabilities of a/LCI were demonstrated initially by detecting pre-cancerous changes in epithelial cells within intact animal tissue samples without the need for exogenous fixation or staining agents. We have developed a new a/LCI system with fast acquisition times and a fiber optic probe that can be applied in endoscopic surveillance of esophageal tissue. Clinical results which use this new system will be presented, demonstrating high sensitivity and specificity for detecting dysplastic tissues in vivo. Experiments with in vitro cell samples will also show the utility of a/LCI in observing structural changes due to environmental stimuli as well as detecting apoptosis due to chemotherapeutic agents.

Adam Wax received dual B.S. degrees in 1993, one in electrical engineering from Rensselaer Polytechnic Institute, Troy, NY and one in physics from the State University of New York at Albany, and the Ph.D. degree in physics from Duke University, Durham, NC in 1999. He joined the George R. Harrison Spectroscopy Laboratory at the Massachusetts Institute of Technology, as a postdoctoral fellow of the National Institutes of Health immediately after his doctorate. Dr. Wax joined the faculty of the Department of Biomedical Engineering at Duke University in the fall of 2002. In 2006, Dr. Wax founded Oncoscope, Inc. to commercialize early cancer detection technology developed in his laboratory. In 2010, he was named as Fellow of the Optical Society of America and SPIE. He is currently associate professor of biomedical engineering at Duke University and Chairman of Oncoscope, Inc. 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.</td>
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<td>
Gerald Grant, M.D.
Associate Professor of Surgery,
Duke School of Medicine</td>
<td>Session 5: Special Topic on LASERS IN BIOLOGY AND MEDICINE II (Co-organized by the Pratt School of Engineering and Duke School of Medicine)
~ Thursday, October 28, 2010~ 10:50 – 11:10am

Gerald Grant, M.D.

“In vivo detection of brain tumor interface using point detection fluorescence spectroscopy: A preclinical study”

Gerald Grant received his BS from the Duke University Medical</td>
</tr>
</table>

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.

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.

James Provenzale, M.D.
Professor of Radiology, Duke School of Medicine

Jointly presented with
Aaron Mohs, Ph.D.
Duke School of Medicine
And Michael Mancini, BS
Georgia Tech/Emory

Session 5: Special Topic on LASERS IN BIOLOGY AND MEDICINE II (Co-organized by the Pratt School of Engineering and Duke School of Medicine)

~ Thursday, October 28, 2010~ 10:50 – 11:10am

James Provenzale, M.D.

"*Laser-guided widefield imaging and spectroscopy for guidance during surgical resection of tumors*"

Surgery is an effective and widely used procedure for treating human cancers. However, a remaining challenge is that the surgeon often fails to remove the entire tumor, leaving behind tumor-positive margins, metastatic lymph nodes, and/or satellite tumor nodules. To improve intraoperative detection of malignant tumors we have developed a handheld fiber-optic probe, termed SpectroPen, for Raman scattering and near-infrared (NIR) fluorescence spectroscopic measurements. The SpectroPen utilizes a near-infrared diode laser, emitting at 785 nm that is fiber-coupled to a compact head unit for light excitation and collection. Its performance has been evaluated by using an FDA-approved fluorescent contrast agent (indocyanine green, or ICG) as well as a surface-enhanced Raman scattering (SERS) nanoparticle (pegylated colloidal gold). Under *in vitro* conditions, the detection limits are approximately 2-5 x 10^{-11} M for ICG dye and 0.5-1 x 10^{-13} M for the SERS contrast agent. We have further integrated the SpectroPen with a wide-field multichannel imaging system so that an operator can monitor the entire surgical field and see light emission from introduced contrast agents. The wide-field imaging system simultaneously records three distinct optical channels corresponding to a NIR fluorescence channel, a laser channel, and a visible light channel. These signals are processed by a computer and are co-displayed to the system operator in real-time. Using the laser from the SpectroPen as a directed excitation source for the contrast agent, the surgeon can use the integrated system to locate a tumor, excise the tumor, and confirm removal. *In vivo* studies using mice bearing breast tumor xenografts that were systemically administered ICG demonstrate that the tumor borders can be precisely detected intraoperatively (**Fig. 1**). After surgery, the SpectroPen device permits further evaluation of both positive and negative tumor margins around the surgical cavity, raising new possibilities for real-time tumor detection and image-guided surgery. Future work will establish the relationship between detected fluorescence signal by the imaging system and margin status.

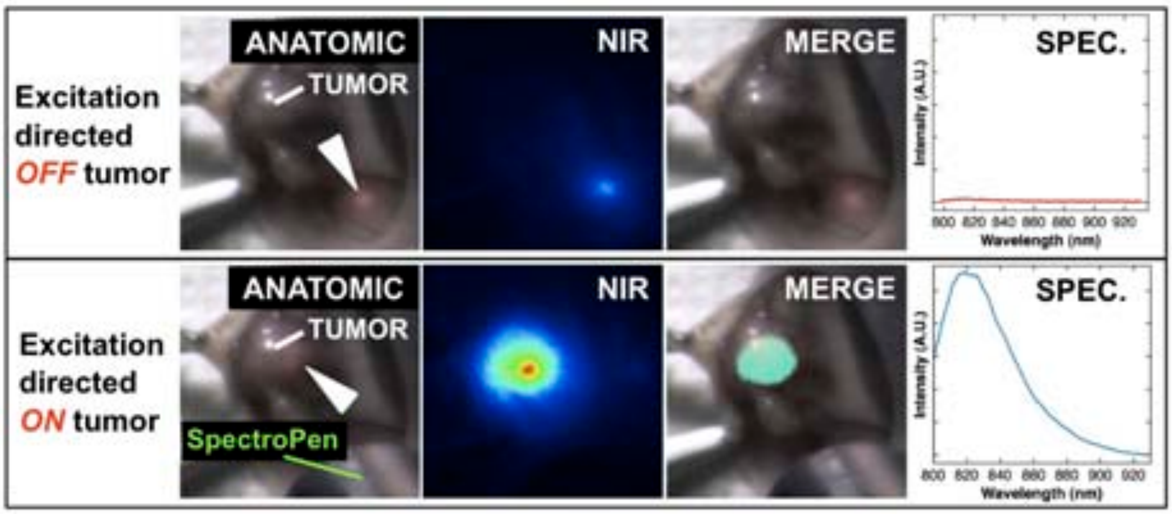


Figure 1. Mouse studies showing multi-channel wide-field imaging using directed excitation by the SpectroPen. These images depict the views seen on the wide-field system during surgery. Each panel consists (from left to right) of an image showing the surgeon's view (labeled "Anatomic"), a near-infrared image (labeled "NIR"), a processed image showing the NIR signal location (from ICG) relative to the anatomic image (labeled "Merge"), and the fluorescence spectrograph taken at the laser position (labeled "Spec."). In the *upper panel*, the SpectroPen is directed on normal tissue (white arrowhead showing laser position) away from the tumor and shows little NIR fluorescence, which is due to intrinsic tissue background (NIR image on top row). In the *lower panel*, the SpectroPen is directed on the tumor (white arrowhead in the Anatomic image), producing high NIR fluorescence signal (NIR image on bottom row), which is confirmed to be ICG as proven by wavelength-resolved measurements by the SpectroPen (Spec. on lower panel).

Frontiers in Photonics: Science and Technology

⅄ Themed Lab Tours ⅄

Wednesday, October 27, 2010
~5:10-6:30pm~

Tours by:
Sean Burrows
Torre Bydlon
Stephanie Kennedy
Benoit Lauly
Ryan McNabb

FCIEMAS
Fitzpatrick Center for Interdisciplinary Engineering, Medicine and Applied Science
Duke University, North Carolina USA

FIP LAB TOURS

5:30 – 5:50pm

Tuan Vo-Dinh, Director

The Fitzpatrick Institute for Photonics (FIP) is located in FCIEMAS, which is designed to position the Pratt School and its partners to make major advancements in the fields of bioengineering, photonics, communications, and materials science and materials engineering.
http://www.pratt.duke.edu/about/fitzpatrick_center.php
http://www.fitzpatrick.duke.edu/

5:30-5:50: Room 3547 FCIEMAS – **Yan Zhang**

http://www.vodinh.pratt.duke.edu/

CENTER FOR METAMATERIALS & INTEGRATED PLASMONICS (CMIP)

5:30 – 5:50pm

David Smith, Director

The mission of the Center for Metamaterials and Integrated Plasmonics is to continue to advance the basic understanding of electromagnetic metamaterials, exploring their capabilities and limitations across the electromagnetic spectrum. We want to develop fabrication techniques for metamaterials that may operate in various environments, with a particular emphasis on structures designed for terahertz, telecommunications and optical wavelengths.

5:30-5:50: Room 2520 FCIEMAS – **Jack Mock**

http://metamaterials.duke.edu/about-cmip

⅄ Lab Tours ⅄
continued

~Wednesday, October 27 ▪ 5:10-6:30pm ~

Duke University

HIGH INTENSITY GAMMA-RAY SOURCE (HIGS) FACILITY AT FEL LAB

5:30 –6:00pm

Ying Wu, Associate Director at DFELL

The newest accelerator facility operated by Triangle Universities Nuclear Laboratory (TUNL) is the High Intensity Gamma-ray Source (HIGS) at the Duke Free Electron Laser Laboratory (DFELL). The DFELL houses an accelerator based photon source in a 52,000 square-foot facility. There are two types of primary photon beams available at the DFELL: the HIGS with energies from 1 to 100 MeV and an optical beam with continuous tunable wavelength from IR to VUV. Both photon beam types are produced by an electron storage ring free electron laser (FEL) and its undulators.

5:30-6:00: Room 210 FEL Bldg – **Ying Wu**

http://www.tunl.duke.edu/higs/

CENTER FOR MOLECULAR & BIOMOLECULAR IMAGING

6:10-6:30pm

Warren Warren, Chair

The Center for Molecular and Biomolecular Imaging (CMBI) is a multidisciplinary Program that integrates activities in engineering, the life sciences and medicine. Participating faculty are based in Departments across the University, including basic science departments (such as Chemistry, Physics, and Biology), engineering departments (such as Biomedical Engineering and Electrical and Computer Engineering) and medical school departments (such as Biochemistry and Radiology); this list is meant to be representative, not exclusive. The Program emphasizes research, education and interactions with industry. The focus of the Program is upon imaging technologies, from the subcellular level to preclinical (animal) and clinical (human) studies in biological systems. Such work spans the most basic research to direct research applications and implementations in medicine and health care. It may also incorporate significant thrusts in non-biological imaging.

6:10-6:30: Room 2220, French Family Science Center – **Martin Fischer**

http://www.cmbi.duke.edu/

CENTER FOR IN VIVO MICROSCOPY

6:10-6:30pm

G. Allan Johnson, Director

The Center for In Vivo Microscopy has a wide array of imaging systems, special animal facilities, visualization tools, and a computer network that all contribute to our world-class facility. Because small animal imaging is so specialized, our integrated team has the skills to design and in some cases, manufacture the equipment needed.

6:10-6:30: Room 141, Bryan Research Building – **Dr. Cristian Badea and Ergys Subashi**

http://www.civm.duhs.duke.edu/

Frontiers in Photonics: Science and Technology

Poster Session

Meet the Judges

Martin Fischer
Assistant Research Professor of Chemistry
Duke University

Qing Liu
Professor of Electrical and Computer Engineering
Duke University

Victoria Seewaldt
Professor of Medicine, Associate Professor of Pharmacology and Cancer Biology, Duke School of Medicine

Poster Session

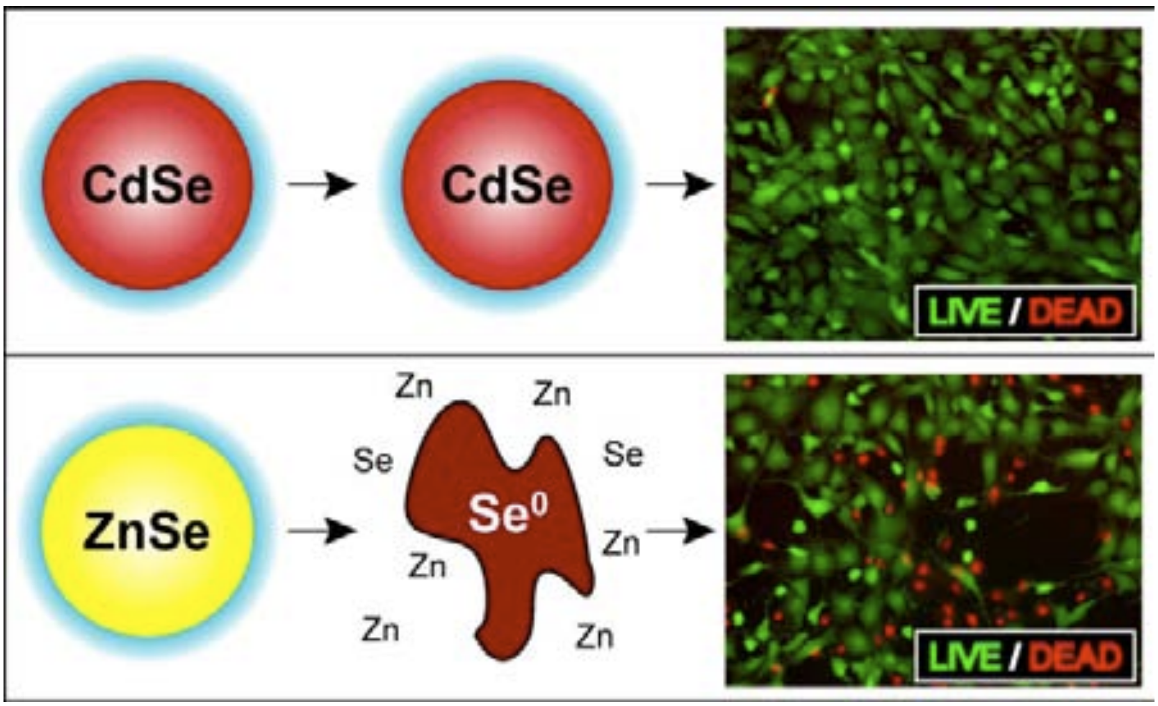
⅄ Poster # 1

The Unusual Chemistry and Cellular Toxicity of Cadmium-Free Quantum Dots

Aaron M. Mohs[1], Andrew M. Smith[1], Michael C. Mancini[1], James M. Provenzale[1,2,3] and Shuming Nie[1]
[1]*Wallace H. Coulter Department of Biomedical Engineering at Emory University and Georgia Institute of Technology, Atlanta, Georgia;* [2]*Departments of Radiology and Oncology, Emory University, Atlanta, Georgia;* [3]*Department of Radiology, Duke University Medical Center, Durham, North Carolina*

Semiconductor quantum dots (QDs) are light-emitting nanoparticles that have great promise for an extensive range of biomedical applications. Despite their vast potential, *in vivo* development of QDs is limited since they generally are composed of highly toxic elements. Thus, recent efforts have focused on reducing the amount of toxic metals in QDs, especially cadmium. For example, ZnSe is used for doped QDs and as a compressive shell material for type II QDs. The use of ZnSe is highly touted because it is "Cd-free". Interestingly, ZnSe displays unusual chemistry that is not observed with CdSe. We have consistently observed that ZnSe-based QDs produce a brick-red precipitate almost immediately after phase transfer into aqueous solvent (**Fig. 1**). This precipitate is amorphous elemental selenium (a-Se) as determined by x-ray photoelectron spectroscopy. The production of a-Se from ZnSe is greatly accelerated by peroxide, photooxidative conditions, and low pH. CdSe is either stable or completely dissolves under similar conditions. Because ZnSe and CdSe degrade differently and the only difference is the cation, the presence of Zn2+ likely accounts for the production of a-Se at the nano-scale. *In vitro* cellular assays suggest that the production of a-Se induces signifi cant cytotoxicity. In fact, cellular proliferation and live/dead assays suggests that Cd-free ZnSe QDs are even more toxic than CdSe QDs (**Fig. 1**). ZnSe completely inhibited the growth of HUVEC cells and partially inhibited the growth of HepG2 cells. Analyses of ZnSe on NIH3T3 fibroblasts shows that not only do ZnSe QDs inhibit proliferation, but they also cause necrosis. In addition, (CdTe)ZnSe (core)shell strain-tunable QDs were more toxic than (CdTe)CdSe QDs, which have 20-times more Cd2+ than (CdTe)ZnSe QDs. a-Se likely undergoes further oxidation to water-soluble Se species, such as selenite, Se4+, and selenate, Se6+, which also contribute to the cytotoxicity. To that end, we tested model oxidative species we expected to be present from the degradation of the QDs. Selenite, Se4+, was as toxic as Cd2+ as determined by a metabolic assay. This work suggests that minimizing Cd2+ content in QDs does not necessarily decrease the cellular toxicity. Future investigations are actively underway and are focused on determining the exact mechanism of a-Se production and elucidating the mechanism by which a-Se or Se 4+ induces cellular toxicity. In broad terms, we are interested the whether the unique oxidative pathways of ZnSe at the nano-scale that facilitate the production of a-Se can be applied to a larger range of nanoparticles and if this poses a potential environmental hazard.

Figure 1. (*Upper*) CdSe QDs are stable over time and cause very little cell cytotoxicity as very few dead (red) cells are present; shown by the epifluorescent image on the right. (*Lower*) Cd-free ZnSe QDs rapidly degrade and produce a red precipitate, amorphous selenium. Amorphous selenium and other selenium oxidation states cause significant cellular toxicity as depicted by red cells due to uptake of propidium iodide.



⅄ Poster # 2

Novel melanin imaging technique provides intrinsic chemical contrast and melanoma diagnostic capability

Thomas E. Matthews[1], Mary Jane Simpson[1], M. Angelica Selim[2], Ivan R. Piletic[1], Warren S. Warren[1]
[1]*Department of Chemistry, Duke University*
[2]*Department of Pathology, Duke University Medical Center*

Melanoma diagnosis is clinically challenging; the accuracy of visual inspection by dermatologists is highly variable and heavily weighted towards false positives, and even the current gold standard of biopsy gives discordance amongst pathologists. We have developed a multiphoton imaging technique which for the first time allows direct imaging of the microscopic distribution of eumelanin and pheomelanin in tissue. By performing transient absorption spectroscopy in the near infrared using a modulation transfer technique, eumelanin was found to have an excited state absorption while pheomelanin exhibited ground state bleaching. Imaging based on this contrast shows a marked shift in the chemical variety of melanin from non-malignant nevi to melanoma as well as a number of substantial architectural differences, creating the basis for a both highly sensitive and specific diagnostic method. Examining slices from 27 pigmented lesions, it was found that melanomas had a significantly increased eumelanin content compared to non-malignant nevi. The ratio of eumelanin to pheomelanin as a diagnostic criterion for melanoma had 100% sensitivity and greater than 85% specificity in this limited sample set. Specificity was further increased when architectural and cytological features revealed by multiphoton imaging were taken into consideration, including the maturation of melanocytes, presence of pigmented melanocytes in the dermis, number and location of melanocytic nests and confluency of pigmented cells in the epidermis.

⅄ Poster # 3

Photonics Research at NC State University

Primary Contact: Dr. Leda Lunardi, Email: leda_lunardi@ncsu.edu
Alternate Contact: Dr. Michael Escuti, Email mjescuti@ncsu.edu
www.ece.ncsu.edu

The interdisciplinary research involves six departments in the College of Engineering and the College of Physics and Mathematical Sciences (PAMS) with the Electrical and Computer Engineering (ECE) Department as the main contributor. Technical strengths include photonics devices and semiconductors materials in experiment and theory; optoelectronics, optical networks, remote optical sensors, and nanophotonics. The ECE Monteith Research Center (MRC) houses the NC State Nanofabrication Facility (NNF) with a broad range of processing capabilities including a state-of-the-art ASML laser scanner (193 nm), and serving a community of researchers from academia, government labs and industry. In addition, the College of Management specifically guides commercialization through the technology Entrepreneurship and Commercialization (TEC) program.

⅄ Poster # 4

Size and Shape Determination of Spheroidal Scatterers using Two-Dimensional Angle Resolved Low Coherence Interferometry

Michael Giacomelli, John Lee, Yizheng Zhu, and Adam Wax
Department of Biomedical Engineering, Duke University
Fitzpatrick Institute for Photonics, Duke University

We demonstrate accurate determination of the size and shape of spheroidal scatters through inverse analysis of two-dimensional solid angle resolved backscattered light intensities with subwavelength accuracy.

⅄ Poster # 5

Clinical detection of dysplasia in Barrett's esophagus with angle-resolved low coherence interferometry

Neil G. Terry, Yizheng Zhu, Matthew T. Rinehart, William J. Brown, Steven C. Gebhart, Stephanie Bright, Elizabeth Carretta, Courtney G. Ziefle, Masoud Panjehpour, Joseph Galanko,

Ryan D. Madanick, Evan S. Dellon, Dimitri Trembath, Ana Bennett, John R. Goldblum, Bergein F. Overholt, John T. Woosley, Nicholas J. Shaheen and Adam Wax
Department of Biomedical Engineering, Duke University

Angle-resolved low coherence interferometry (a/LCI) is a light scattering technique that uses elastically scattered light to provide depth-resolved information about the morphology of nuclei and other cellular scatterers in vivo. a/LCI is able to identify dysplasia endoscopically by taking subsecond "optical biopsies" of target tissue and comparing the results to those predicted by Mie theory. We present the results of a pilot clinical study of 50 Barrett's esophagus patients to assess the efficacy of the a/LCI technique in identifying dysplasia *in vivo* in a clinical setting.

⅄ Poster # 6

Trace level detection of PAHs through the enhancement of fluorescence emission of CdSe/ZnS QD-entrapped membranes

Hong Dinh Duong, Jong Il Rhee*
School of Applied Chemical Engineering, Research Center for Biophotonics, Chonnam National University, Yong-Bong dong 300, 500-757 Gwangju, Republic of Korea

In this work, CdSe/ZnS core/shell QDs with emission wavelengths of 535, 545, 555, and 575 nm were synthesized and exchanged ligands on their surface by mecaptopropionic acid (MPA) to be water-soluble QDs. Hydrophilic QDs were incorporated in a sol-gel matrix of 3-aminopropyl trimethoxysilane (APTMS) and 3-glycidoxypropyl trimethoxysilane (GPTMS) for fabricating the QD-entrapped membranes. Fluorescence intensity of the QDs entrapped in the sol-gel membranes was increased after being activated by energy transfer from polycyclic aromatic hydrocarbon compounds (PAHs). The signal increase of QDs was proportional to the increase of PAHs' concentration. Herein, trace levels of pyrene (PYR), anthracene (ANT) and phenanthrene (PHE) were detected through the increase of the fluorescence intensity of the QD-entrapped membranes. Linear detection ranges were of 0.01-0.05 μM for PYR and 0.01-0.1 μM for ANT and PHE.

⅄ Poster # 7

Enhancing Coherent anti-Stokes Raman Scattering Background Suppression with Phase Cycled Structured Femtosecond Laser Pulses

Baolei Li[1], Martin C. Fischer[2], and Warren S. Warren[1,2,3]
[1] *Department of Physics, Duke University;* [2] *Department of Chemistry, Duke University;*
[3] *Department of Radiology, Duke School of Medicine*

We demonstrate a homodyne coherent anti-Stokes Raman scattering (CARS) technique based on femtosecond laser pulse shaping. This technique utilizes fast phase cycling to extract nonlinear Raman signatures with a self-generated reference signal acting as a local oscillator. The local oscillator is generated at the focus and is intrinsically stable relative to the Raman signal even in highly scattering samples. We can therefore retrieve phase information from the Raman signal and can suppress the ubiquitous non-resonant background.

⅄ Poster # 8

X-ray luminescence of doped Y_2O_3 nanocrystals

Yan Zhang, C V Gopal Reddy, and Tuan Vo-Dinh
Fitzpatrick Institute for Photonics, Department of Biomedical Engineering, Duke University

Metal-ion doped yttria nanocrystals were prepared by combustion method and annealed at various temperatures to obtain luminescent nanocrystals. The structure and morphology of doped yttria nanoparticles were characterized by x-ray diffraction, transmission electron microscopy and light scattering. The size of the nanoparticles was in the range of 10-100 nm, and showed a narrow size distribution and high crystallinity. The particle size and luminescence intensity increase as the sintering temperature rises. This work allows us to understand the phosphors' microstructure on luminescent properties under x-ray excitation.

⅄ Poster # 9

Self-phase modulation measurements in scattering media

Prathyush Samineni, [1] Kevin Claytor, [2] Zachary Perret, [1] Warren S. Warren,[3] and Martin C. Fischer[1]
[1]Department of Chemistry, Duke University, Durham, NC 27708, USA; [2]Department of Physics, Duke University, Durham, NC27708, USA; [3]Departments of Chemistry, Radiology, and Biomedical Engineering, Duke University, Durham, NC 27708, USA

We have recently developed a spectral re-shaping technique based on acousto-optic femtosecond pulse-shaping to sensitively extract intrinsic nonlinearities in scattering media. In the traditional Z-scan technique, the nonlinear signal is encoded as phase shifts in the spatial domain, whereas our technique encodes the information as new frequency components in the spectral domain. Here we compare nonlinear spectral re-shaping and Z-scan measurements of refractive samples in a highly scattering environment to show that frequency encoding is much more robust with respect to scattering. We demonstrate that the spectral re-shaping technique can accurately extract nonlinearities even in highly scattering media that preclude the use of a conventional Z-scan approach.

⅄ Poster # 10

Optical Interface Bloch Modes Based on 3D Photonic Crystals

Shu-Yu Su and Tomoyuki Yoshie
Department of Electrical and Computer Engineering, Duke University

We designed two types of optical interface Bloch modes induced by a single heterojunction of three-dimensional woodpile photonic crystals. For the (100) interface modes, mode length as small as 0.26(lambda/2n) was obtained with quality factor of 2.8×10^10 by the finite-difference time-domain method. Compared to familiar surface-plasmon modes at a metal/dielectric interface, optical interface Bloch modes at a two-dissimilar-PC interface maintain the advantage of strong light confinement at the interface while the materials involved are metal-absorption-

free. Therefore, they have great potential for realization light localization in subwavelength scales simultaneously with low energy dissipation.

⅄ Poster # 11

Supercontinuum at Your Fingertips

Tana E Villafana[1], Mary Jane Simpson[1], Baolei Li[2], Warren S Warren[1] and Martin C Fischer[1]
[1]Department of Chemistry, Duke University; [2]Department of Physics, Duke University

Laser spectroscopy and imaging has long been used to study important chemical, physical and biological processes. In particular, multiple wavelength (for example, pump-probe) experiments can provide a wealth of information on the internal structure and dynamics of molecules. . However many laser systems have little flexibility in the combined wavelength – pulse duration parameter space and while tunable lasers do exist, they come at a great cost. Photonic crystal fibers use a cascade of nonlinear optical processes to produce a supercontinuum of light spanning the UV to the infrared. We work on methods to extract multiple colors from the supercontinuum, giving ultimate flexibility at a relatively low cost. We plan to use photonic crystal fibers in a variety of two color experiments, such as two-color transient absorption or CARS microscopy, but the versatility of the fiber opens up the possibility of other multi-color experiments. Development of an entirely fiber based supercontinuum system, would make multiple color experimentation easier, cheaper, and more widely available.

⅄ Poster # 12

Three-dimensional woodpile photonic crystal of various crystal orientations

Lingling Tang, Shu-Yu Su and Tomoyuki Yoshie
Department of Electrical and Computer Engineering, Fitzpatrick Institute for Photonics, Duke University

Three-dimensional photonic crystal is a unique platform that molds light in a 3D space via the complete photonic bandgap. Woodpile photonic crystals built by the layer-by-layer methods have (001) photonic crystal surface plane only. The development of 3D photonic crystals with diverse crystal orientations would benefit 3D integrated optics and surface Bloch mode research. We fabricate woodpile photonic crystals with a variety of crystal orientations and surfaces, including (110), (001), (100) and (010) planes, by multi-directional etching methods. The technique studied can be modified to produce woodpiles with an arbitrary (mn0) surface plane.

⅄ Poster # 13

Development of optical immunosensors with CdSe/ZnS QDs and their application to the analysis of human bone morphogenetic protein-7 (BMP-7)

Chun-Kwang Kim, Jong Il Rhee*, Ok-Jae Sohn
School of Applied Chemical Engineering, Research Center for Biophotonics, Center for Functional Nano Fine Chemicals, Chonnam National University, 500-757 Yong-Bong dong 300, GwangJu, Republic of Korea

Bone morphogenetic protein-7 (BMP-7) induces bone formation and renders it to a protein of pharmaceutical importance. Optical immunosensors have been developed and applied to determine the concentrations of BMP-7. Hydrophilic CdSe/ZnS quantum dots (QDs) were synthesized and conjugated to the antibody of BMP-7. A 96-well microtiter plate and an optical fiber of 2 mm diameter have been used to immobilize the QD-conjugated antibody. The fluorescence intensity was measured with a multifunctional microplate reader and a fluorescence detector (M-FOS) at excitation and emission wavelengths of 480 nm and 600 nm. Limit of detection was 0.0-1.0 ng/mL with a 96-well microtiter plate and 0.0-10.0 ng/mL (R^2=0.979) with an optic fiber immunosensor. The immunosensor based on optical fiber has been also applied to a sequential injection analysis for the automatic determination of BMP-7.

⅄ Poster # 14

Experimental demonstration of individual addressing of multiple neutral atom qubits with a MEMS based optical system

Caleb Knoernschild[1], XianLi Zhang[2], Larry Isenhower[2], Alex T. Gill[2], Felix P. Lu[1,3], Mark Saffman[2], Jungsang Kim[1,3]
[1]*Fitzpatrick Institute for Photonics, Electrical and Computer Engineering, Duke University;*
[2]*University of Wisconsin;* [3] *Applied Quantum Technologies*

We demonstrate a scalable approach to individually addressing multiple neutral atom qubits for quantum information processing. Five Rb atoms, serving as qubits, are linearly confined in a far-off-resonant trap and manipulated with a single laser that is directed to one of the chosen qubits with a microelectromechanical beam steering system. Single qubit gates are shown on multiple sites with negligible crosstalk to neighboring locations. Measurements of the beam steering system switching time between qubits is also shown to be between 6 to 14 us.

⅄ Poster # 15

Optical Invisibility – Advances in Theory and Design

Yaroslav Urzhumov, Nathan Kundtz, John Hunt and David Smith
Center for Metamaterials and Integrated Plasmonics; Fitzpatrick Institute for Photonics, Electrical and Computer Engineering, Duke University

We review several approaches to optical invisibility designed using Transformation Optics (TO) and Optical Conformal Mapping (CM) techniques. TO is a general framework for solving inverse scattering problems based on mimicking spatial coordinate transformations with distributions of material properties. There are two essential steps in the design of TO media: first, a coordinate transformation that achieves some desired functionality, resulting in a continuous spatial distribution of constitutive parameters that are generally anisotropic; and, second, the reduction of the derived continuous constitutive parameters to a metamaterial that serves as a stepwise approximation. We focus here on the first step, discussing the merits of various TO strategies proposed for the long-sought ``invisibility cloak" - a structure that renders opaque objects invisible. We also evaluate the cloaking capabilities of structures designed by the related CM approach, which makes use of conformal mapping to achieve index-only material distributions. The performance of the various cloaks is evaluated and compared using a universal measure - the total (all-angle) scattering cross-section. Finally, we introduce a new class of optical media based on adiabatically modulated, dielectric-only, and potentially extremely low-loss, photonic crystals (PC). The media we describe represent a generalization of the eikonal limit of transformation optics. The basis of the concept is the possibility to fit some equal frequency surfaces (EFS) of certain PCs with elliptic surfaces, allowing them to mimic the dispersion relation of light in anisotropic effective media. PC cloaks and other TO devices operating at visible wavelengths can be constructed from optically transparent substances like glasses, whose attenuation coefficient can be as small as 10 dB/km, suggesting the TO design methodology can be applied to the development of optical devices not limited by the losses inherent to metal-based, passive metamaterials.

⅄ Poster # 16

Fabrication of 2D Nano-scale Optical Components Utilitzing Transformational Optics

Sulochana Dhar, Talmage Tyler, John Hunt, Yu-Ju Tsai, David R. Smith, Nan M. Jokerst
Center for Metamaterials and Integrated Plasmonics; Fitzpatrick Institute for Photonics, Electrical and Computer Engineering, Duke University

Metamaterial cloaks, perfect lenses, and integrated optical devices using transformational optics have garnered much attention in recent years. Transformational optics devices utilize a spatial distribution of the dielectric constant to shift or focus light beams in a medium that would otherwise support straight propagation of light. The structures used to design transformational optic devices are non-resonant. Therefore, these lenses and cloaks can, in principle, support wide-bandwidth operation. This poster reports on the development of a two dimensional beam shifter fabricated on a 250 nm thick silicon-on-insulator substrate. The beam shifter is composed of nano-scale (120 nm diameter) holes that provide spatial distribution of the dielectric constant. This 2D beam shifter allows for the characterization of the effective index realized by patterning holes in silicon using e-beam lithography and reactive-ion etching and its deviation from the designed effective index for the transformational optic device. Once the value of the experimentally realized effective index is known, more complex optical components such as lenses and cloaks will be designed and fabricated.

⅄ Poster # 17

Simultaneous confocal fluorescence microscopy and optical coherence tomography for *in vivo* drug distribution and tissue integrity assessment

Matthew Rinehart, Jeffrey LaCroix, Marcus Henderson, David Katz and Adam Wax
Department of Biomedical Engineering, Duke University

We have developed a system combining confocal fluorescence microscopy with Fourier domain optical coherence tomography to measure local concentrations and diffusion coefficients of active pharmaceutical ingredients (APIs) during transport from microbicidal gels into tissue, while simultaneously assessing tissue integrity. Each imaging modality uses separate optical scanning systems to independently optimize imaging properties and scan rates prior to combination in a mutual imaging objective. Time-resolved API concentration measurements were obtained at fixed depths of *ex vivo* epithelial tissue coated with experimental microbicidal gels. Future studies will evaluate microbicide performance *in vivo*.

⅄ Poster # 18

Calibration schemes of a field-compatible optical spectroscopic system to quantify optical contrast in the dysplastic cervix

Vivide Tuan-Chyan Chang, MS[1], Delson Merisier, MD[2], Bing Yu, PhD[1], David Walmer, MD[3], Nirmala Ramanujam, PhD[1]
[1]Duke University Biomedical Engineering Durham, NC, USA; [2]Family Health Ministries Leogane, Haiti; [3]Duke University Medical Center Ob&Gyn, Durham, NC, USA

A significant challenge in detecting cervical pre-cancer in low-resource settings is the lack of effective screening techniques and trained personnel to detect the disease before it is advanced. Light based technologies have the potential to provide an effective, low cost and portable solution for cervical pre-cancer screening in these communities. The goal of this study is to construct and field-test a field-compatible optical spectroscopic system in Haiti to aid in the diagnosis of high-grade cervical intraepithelial neoplasia (CIN), or severe dysplastic lesion that is most likely to progress into cervical cancer. Previously we have shown that stromal total hemoglobin is significantly increased in high-grade CIN (CIN 2+), compared to normal and low-grade CIN (CIN 1), reflecting neovascularization in highly dysplastic cervix. We have developed and characterized a portable USB-powered optical spectroscopic system to quantify total hemoglobin (Hb) content, Hb saturation, and reduced scattering. The system consists of a high-power LED, a bifurcated fiber optic assembly, and 2 spectrometers for sample and calibration spectra acquisitions. The system was subsequently tested in Leogane, Haiti, where diffuse reflectance spectra from 20 colposcopically normal sites and 12 colposcopically abnormal sites in 21 patients were acquired. Extracted scattering was significantly associated with applied contact probe pressure using diffuse reflectance spectra acquired from the colposcopically normal sites. The effect on optical property extraction using two different reflectance standards, i.e., a Spectralon® puck and a built-in self-calibration channel was also elucidated. Our results suggest that a self-calibration channel led to a more accurate extraction of scattering contrast through simultaneous correction of intensity drifts in the system. Hence, future contact spectroscopy or imaging systems should incorporate a self-calibration channel and acquire spectra at a consistent tissue-probe contact pressure to reliably extract scattering contrast.

⅄ Poster # 19

Separating the scattering and absorption coefficients using the real and imaginary parts of the refractive index with low-coherence interferometry

Francisco Robles and Adam Wax
Department of Biomedical Engineering and Medical Physics Program, Duke University, Durham, North Carolina 27708, USA

We present an analytical method that yields the real and imaginary parts of the refractive index (RI) from low- coherence interferometry measurements, leading to the separation of the scattering and absorption coefficients of turbid samples. The imaginary RI is measured using

time-frequency analysis, with the real part obtained by analyzing the nonlinear phase induced by a sample. A derivation relating the real part of the RI to the nonlinear phase term of the signal is presented, along with measurements from scattering and nonscattering samples that exhibit absorption due to hemoglobin.

⅄ Poster # 20

Optical Breast Cancer Margin Assessment: An Observational Study of the Effects of Tissue Heterogeneity on Optical Contrast

Stephanie Kennedy, Joseph Geradts, Torre Bydlon, J. Quincy Brown, Jennifer Gallagher, Marlee Junker, William Barry, Lee Wilke, and Nimmi Ramanujam
Duke University and Duke University Medical Center, Durham, North Carolina

The American Cancer Society estimated over 250,000 women were diagnosed with breast cancer in 2009 [1]. The preferred treatment for early stage cancer is breast conserving surgery (BCS). Residual cancer following BCS has an increased risk of local recurrence and mortality, thus motivating the need for intra-operative margin assessment. For every four women who develop a local recurrence after BCS there is one potential mortality [2, 3]. Breast tissue is markedly heterogeneous and a function of menopausal status, which makes distinguishing foci of cancer within normal tissue challenging. Current intra-operative margin assessment techniques include frozen section analysis and touch-prep cytology which require a trained pathologist and perform poorly for close and fatty margins. Optical spectroscopy has the potential to provide surgeons with intra-operative diagnostic tools. Here we evaluate the optical properties of ex-vivo breast tissue, and determine which sources of optical contrast have the potential to detect malignancy on margins in women of differing breast composition.

⅄ Poster # 21

Effect of patient characteristics on the optical properties of breast tumor margins

Bydlon TM, Kennedy SA, Brown JQ, Gallagher JE, Junker MS, Barry WT, Geradts J, Ramanujam N, Wilke LG,
Duke University and Duke University Medical Center, Durham, North Carolina

Background: Twenty to 60% of patients receiving breast conservation therapy (BCT) for breast cancer undergo multiple surgeries for complete tumor resection. To address this clinical need, our group is developing an optical device, based on diffuse reflectance spectroscopy, to intraoperatively evaluate tumor margins. The device senses malignant biochemical and morphological changes to a depth of 2.2mm. Patient characteristics affect breast tissue composition and can impact the optical contrast observed between negative and close/positive margins. Here we report on the effect of 5 of these characteristics. Methods: Spectral images were measured and converted into compositional maps that reflect the total hemoglobin and fat (β-carotene) content, and cellular density (scattering) of the tissue. Patient characteristics included: menopausal status, radiographic breast density, race, parity, and breast feeding status. The mean of each map was calculated and Wilcoxon rank-sum tests were used to determine statistical significance. Results: The 92 imaged margins consisted of 46 negative margins and 46 close/positive margins. The first analysis of the data looked at the effect of the patient characteristics on the optical data of negative margins. Mean total hemoglobin was found to be significantly higher in high density patients compared to low density patients ($p=0.05$). Mean β-carotene was significantly higher in high density patients compared to low density patients ($p=0.0002$) and higher in women who had breast fed than not ($p=0.016$). No significant differences were found in mean scattering when comparing the negative margins of different patients. The second analysis of the data looked at the impact of patient characteristics on the contrast between negative and close/positive margins. Mean total hemoglobin was significantly lower in the close/positive margins of parous women ($p=0.028$) and women who had breast fed ($p=0.022$). Mean β-carotene was significantly lower in close/positive margins in high density ($p=0.001$), pre-menopausal ($p=0.013$), African American ($p=0.037$), and parous women ($p=0.016$); as well as women who had breast fed ($p<0.0001$). Mean scattering was significantly higher in the close/positive margins of post-menopausal ($p=0.005$) and nulliparous women ($p=0.027$). Discussion: Optical technology for breast margin assessment is influenced by the heterogeneous patient population undergoing surgery. Total hemoglobin, scattering and (-carotene are all influenced by patient characteristics thus affecting the ability to differentiate benign from malignant changes. Future studies will evaluate additional parameters for tumor discrimination intraoperatively and account for this heterogeneity.

⅄ Poster # 22

Generating Non-Classical Light from Waveguide QED

Huaixiu Zheng, Daniel J. Gauthier and Harold U. Baranger
Department of Physics & Center for Theoretical and Mathematical Sciences, Duke University, Durham, NC

We show that strong coupling between a two-level system and bosonic modes in a waveguide produces dramatic quantum optics effects. We consider a one-dimensional continuum of bosons coupled to a single localized two-level system, a system which may be realized in a variety of plasmonic or photonic contexts. Multi-photon bound states appear in the scattering of two or more photons due to the strong coupling between photons and the two-level system. Such bound states are shown to substantially affect the scattering of coherent states [1]: single-photon probability is suppressed, while multi-photon probabilities are strongly enhanced. Therefore, the statistics is non-classical. The second-order correlation function shows that strong bunching or antibunching correlations may arise among the photons, which are very sensitive to the coupling strength. We call this novel arena for quantum electrodynamics “Waveguide QED”.

⅄ Poster # 23

SERS Detection and Tracking of Nanoprobes: Enhanced Uptake and Nuclear Targeting in Single Cells

Molly K. Gregas, Jonathan P. Scaffidi, Benoit Lauly, Stephanie Dudzinski, and Tuan Vo-Dinh
Department of Biomedical Engineering, Fitzpatrick Institute for Photonics, Duke University, Durham, NC

We describe the development and application of a co-functionalized nanoprobe and biodelivery platform combining a nuclear targeting peptide (NTP) for improved cellular uptake and intracellular targeting with p-mercaptobenzoic acid (pMBA) as a surface-enhanced Raman scattering (SERS) reporter for tracking and imaging. The nuclear targeting peptide, an HIV-1 protein-derived TAT sequence, has been previously shown to aid entry of cargo through the cell membrane via normal cellular processes, and furthermore, to localize small cargo to the nucleus of the cell. In this work, two-dimensional SERS mapping was used to track the spatial and temporal progress of nanoparticle uptake in PC-3 human prostate cells and to characterize localization at various time points, demonstrating the potential for an intracellularly-targeted multiplexed nanobiosensing system with excellent sensitivity and specificity. Silver nanoparticles co-functionalized with the TAT peptide showed greatly enhanced cellular uptake over the control nanoparticles lacking the targeting moiety and preferential localization in the cell nucleus, as verified by confocal fluorescence co-localization studies. The ability to detect and monitor nanoprobe trafficking using SERS spectroscopy offers an improved alternative over previous tracking and detection methods such as light microscopy and fluorescence methods. The development of multifunctional nanoconstructs for intracellular delivery has potential clinical applications in early detection and selective treatment of disease in affected cells. Other applications include use in basic research aimed at understanding the inner workings of living cells and how they respond to chemical and biological stimuli.

⅄ Poster # 24

Raman Antenna Formed from a Nanoparticle Coupled to a Surface

Shiuan-Yeh Chen,[1,2,6] Jack J. Mock,[1,2,6] Ryan T. Hill,[3,6] Ashutosh Chilkoti,[3,4,6] David R. Smith[1,2,6] and Anne A. Lazarides[2,3,5,6*]
[1]Department of Electrical and Computer Engineering, Duke University, Durham, North Carolina 27708, USA; [2] Center for Metamaterials and Integrated Plasmonics, Duke University, Durham, North Carolina 27708, USA; [3]Center for Biologically Inspired Materials and Material Systems, Duke University, Durham, North Carolina 27708, USA; [4]Department of Biomedical Engineering, Duke University, Durham, North Carolina 27708, USA; [5]Department of Mechanical Engineering and Materials Science, Duke University, Durham, North Carolina 27708, USA; [6] Fitzpatrick Institute for Photonics, Duke University, Durham, North Carolina 27708, USA

A nanoparticle-surface coupled system provides promising performance for surface-enhanced Raman scattering (SERS). In this study, first we use three substrates with different polarizability coupled to gold nanoparticles to experimentally and semianalytically show distinct plasmonic responses. Raman images and spectra are collected from the nanoparticles coupled to polarized film. These Raman images have spatial distributions similar to the Rayleigh scattering images. This indicates that emission of Raman molecules is controlled by the nano-antenna formed by the nanoparticle-surface coupled substrate. This system provides high SERS enhancement and may enable single molecule detection.

⅄ *Poster # 25*

Effects of Matrix-Assisted Pulsed Laser Evaporation on the Molecular Weight and Morphology of Polymer Thin Films

Ryan McCormick[1], Adrienne Stiff-Roberts[1], Jeremy Lenhardt[2]
[1]Department of Electrical and Computer Engineering, Duke University; [2]Department of Chemistry, Duke University

There has been much work done on the processing of conjugated polymers for optoelectronic devices. However, a major challenge resulting from solution-based fabrication techniques, such as spin and drop casting, is that device properties are generally uncontrollable and unrepeatable due to solvent-based conformational defects. Matrix-assisted pulsed laser evaporation (MAPLE), an extension of pulsed laser deposition (PLD), has the potential to address this challenge by controlling substrate exposure to solvents in a repeatable manner [1]. The goal of this work is to demonstrate the potential and novel capabilities of MAPLE as a fabrication technique for organic-based optoelectronic devices. In contrast to other ablation-based techniques (e.g. PLD), the unique approach of this work is to avoid significant polymer degradation by using an infrared laser with energy resonant with hydroxyl bonds. By preparing a target of a polymer emulsion, the absorption of the infrared laser energy occurs only in the target matrix, leaving the polymer intact for deposition onto a substrate. With this technique, MAPLE has been used to demonstrate high-quality thin film deposition of MEH-PPV with an rms surface roughness less than 1 nm [2]. In addition, Fourier transform infrared (FTIR) absorbance spectra have shown that polymer bond stretches of MAPLE depositions resemble those of the native polymer [2]. However, an important question remains regarding the impact of MAPLE deposition on the molecular weight of the polymer. In this work, gel permeation chromatography (GPC) is used to determine the molecular weight of MAPLE-deposited polymers (PMMA and MEH-PPV). The measured results will be compared with published results of other laser-ablation deposition techniques that tend to show degradation of the native polymer. Preliminary results indicate that MAPLE deposition yields molecular weights that most closely resemble that of the native polymers, and may even exhibit polymerization such that the deposited polymer attains a molecular weight larger than the native polymer. In addition, MAPLE has the potential to selectively deposit polymers in a preferred morphological orientation. This capability will be demonstrated using X-ray diffraction analysis to determine the morphological orientation of polymer films made of P3HT via measurement of the d-spacing between different polymer planes.

⅄ Poster # 26

Automatic Segmentation of Real-World Ophthalmic SDOCT Images with Better Accuracy than Expert Manual Segmentation

Stephanie J. Chiu[1], Joshua Y. Choi[1], Francesco LaRocca[1], Anthony N. Kuo[1], Cynthia A. Toth[2,1], Joseph A. Izatt[1,2] Sina Farsiu[2,1]
[1]Department of Biomedical Engineering, Duke University, Durham, NC, 27708, USA
[2]Department of Ophthalmology, Duke University Medical Center, Durham, NC, 27710, USA

The accurate detection of anatomical and pathological structures in real-world ophthalmic Spectral Domain Optical Coherence Tomography (SDOCT) images is critical for the study and diagnosis of ocular diseases. Only recently have algorithms been developed to automate the segmentation process. These works, however, focus mainly on the segmentation of high quality images for only a particular anatomical or pathological feature. We extended a general segmentation framework based on graph theory and dynamic programming, which we introduced previously for segmenting retinal layers in normal eyes. We broadened the application of our framework by incorporating prior information about the morphology of the ocular structures. We applied this technique to segment images of varying quality from several different ophthalmic SDOCT applications, including normal retina, Level 3 aged-macular degeneration (AMD) retina with drusen, advanced AMD retina, pediatric retina (with and without edema), and cornea. The underlying algorithm for the segmentation of these various images was identical, with modifications made to the graph weights, search space, and segmentation order for each image category. Results show that our algorithm accurately segmented layers in retinal and corneal SDOCT images with varying degrees and types of pathology. Furthermore, our automatic segmentation matched an expert grader more closely than a second grader for all image targets. This is highly encouraging for not only reducing the time and manpower required to segment images in ophthalmic studies, but also for offering an extensible yet integrated algorithm for the segmentation of different ocular diseases.

⅄ Poster # 27

Doppler Velocity Detection Limitations in Spectrometer and Swept-Source Fourier-Domain Optical Coherence Tomography

Hansford C. Hendargo, Ryan P. McNabb, Al-Hafeez Dhalla, and Joseph A. Izatt
Department of Biomedical Engineering, Fitzpatrick Institute for Photonics, Duke University

Doppler optical coherence tomography has demonstrated important potential uses in medical imaging and diagnostics, particularly in the field of ophthalmology. Recent advances in Doppler and variance techniques have enabled high sensitivity for imaging regions of biological flow to measure blood flow velocities and vascular perfusion. In recent years, the sensitivity and imaging speed benefits of Fourier domain OCT have become apparent. Spectrometer-based and wavelength-swept implementations have both undergone rapid development, and a wide variety of Doppler acquisition protocols and signal processing approaches have emerged. Comparative analysis of the potential benefits and limitations for the various configurations would be useful for matching technology capabilities to specific clinical problems. Here we take a first step in such a comparative analysis by presenting theoretical predictions and experimental results characterizing the lower and upper observable velocity limits in high speed spectrometer-based versus swept-source Doppler OCT.

⅄ Poster # 28

Axial Motion Correction for Keratometric SDOCT Using a Conventional Galvonometer-Based Scanner

Ryan P. McNabb[1], Francesco LaRocca[1], Sina Farisu Ph.D. [1,2], Anthony N. Kuo M.D. [2], and Joseph A. Izatt Ph.D. [1,2]
[1] *Department of Biomedical Engineering and The Fitzpatrick Institute for Photonics; Duke University; Durham, NC 27708;* [2]*Department of Ophthalmology, Duke University Eye Center, Durham, NC 27710*

Corneal keratometry and topography are currently the primary methods for clinically assessing corneal shape. These placido ring-based methods accurately measure the curvature of the anterior surface of the cornea while calculating the total power of the cornea by assuming a constant ratio between the anterior and posterior surfaces of the cornea. This power calculation fails however when the ratio between surfaces can no longer be considered constant, notably in subjects who have undergone laser refractive surgery. Spectral domain optical coherence tomography (SDOCT) could potentially overcome this limitation by offering the capability to acquire full tomographic information of both anterior and posterior surfaces. A major limitation, however, is the corruption of data by low spatial frequency subject motion during the multiple seconds required to obtain a volumetric image. We have developed a novel scanning approach based on the spatial distribution of individual A-scans across the cornea during a volume acquisition, thus encoding subject motion into high spatial frequencies which are then removed by spatial filtering. We report on a preliminary patient study comparing the corneal power acquired using distributed scanning keratometric SDOCT (K-SDOCT) to corneal topography, Scheimpflug photography, and standard scanning K-SDOCT. The RMS error for axial motion corrected K-SDOCT was superior to standard linear scanning and comparable to that of both topography and Scheimpflug photography.

⅄ Poster # 29

Optical microcavities clad by transparent conductive oxides

Ozlem Senlik, Lingling Tang, Pantana Tor-ngern, and Tomoyuki Yoshie
Department of Electrical and Computer Engineering, Fitzpatrick Institute for Photonics, Duke University

Transparent conductive oxide (TCO) films are proposed as electrode materials for direct current injection optical microcavity devices. Four types of planar indium-tin-oxide (ITO) clad optical microcavities –microdisk, 1-D photonic crystal nanobeam, 2-D photonic crystal slab and 3-D photonic crystal are designed and analyzed both by perturbation theory and 3D finite difference time domain (FDTD) analysis. The quality (Q) factors of cavities obtained by perturbation theory in which imaginary part of the dielectric constant of ITO is introduced as a perturbation and FDTD method agree well. Microcavities analyzed in this work still preserve high Q-factor in the presence of metal clad and would provide an excellent heat sink and efficient carrier injection for electrically-driven continuous-wave, room-temperature microlasers.

⅄ Poster # 30

A Method to Standardize the Characterization of Supercapacitor Electrodes and its Demonstration on Carbon Nanotubes

Akshay S. Raut, Charles B. Parker, and Jeffrey T. Glass
Department of Electrical and Computer Engineering, Duke University, Durham NC 27708

Electrochemical double layer capacitors, also referred to as supercapacitors, are a promising technology in the field of energy storage. Carbon nanotube (CNT)-based supercapacitors are particularly interesting because of CNTs' high surface area and conductivity. CNT supercapacitors can potentially be used in hybrid electric vehicles due to their higher power density[1]. Comparing energy storage systems that store energy in different ways; such as batteries, fuel cells, supercapacitors, and flywheels; requires that an appropriate set of performance data be collected. A Ragone plot is a log-log plot of a device's energy density versus power density, giving insight into its operational range. A method to obtain Ragone plots for CNT-based supercapacitors in a three-terminal electrochemical cell was adapted from a technique to test commercial capacitors for electric vehicles.

Energy and power densities are frequently given for a packaged device, rather than an electrode or a half-cell (electrode, solvent, and electrolyte.) However, materials research on new electrodes requires the ability to isolate the performance of individual components, such as the electrode or electrolyte, to understand the effects of changes to these components while avoiding the cost of developing a packaged device. The technique reported here provides a way to assess and compare the performance of components of a super capacitor as a part of conventional three-terminal electrochemical cells. The present work focuses on comparing the energy and power performance of different electrode materials and modifications thereof, such as surface engineering and geometric modifications[2]. Such materials development will be critical to the realization of supercapacitors that can challenge the energy density of lithium-based batteries. A curve on a Ragone plot for a given device represents the range of energy and power densities over which the device can be operated. This facilitates the selection of an optimal working region for a given energy storage system. Every point on a Ragone curve is associated with a characteristic discharge time given by the intersection of a unique positive unity slope line with the given point on the curve. Ragone plots can be used for all types of energy storage systems and are not dependent on the way in which is energy is stored, e.g., electrochemically for batteries and mechanically for flywheels.

Our procedure was adopted from a similar procedure developed for the Department of Energy to standardize performance evaluation of packaged, commercial capacitors for use in electric drivelines and for battery load leveling[3]. This method was adapted for the research environment, where a typical system uses a three terminal electrochemical cell to characterize a single electrode (the working electrode in a half cell) without the similar opposing electrode found in a packaged supercapacitor. This procedure uses a potentiostat operated in both galvanostatic and potentiostatic modes to obtain key electrochemical parameters of the half-cell to generate a Ragone plot.

Energy and power densities for CNT electrodes in saline, acid and non-aqueous electrolyte were obtained and the data was used to construct a Ragone plot. These results will be presented along with the procedural details of this new method to obtain electrode-specific energy and power densities. As the electrode weight is required to calculate the energy and power density, a theoretical weight calculation using physical parameters for a carbon nanotube film (e.g., length, number of walls, and nucleation density) was derived and validated with a direct weight measurement. Surface engineering and geometric modification of the electrode is an important way to improve the performance of the supercapacitor. Recent results from functionalization of the CNTs will be discussed.

⅄ Poster # 31

Electrochemical characterization of vertically aligned carbon nanotubes for use as a neural stimulation electrode

Billyde Brown[1], Charles B. Parker[1], Brian R. Stoner[1,2], Warren M. Grill[3], and Jeffrey T. Glass[1]
[1] Department of Electrical and Computer Engineering, Duke University; [2]RTI International, Center for Materials & Electronic Technologies, RTP, NC 27709, USA, [3]Department of Biomedical Engineering, Duke University, Durham, NC 27708, USA

Carbon nanotubes (CNTs) are an excellent candidate for neural stimulation electrodes given their unique properties, including high mechanical strength, flexibility, corrosion resistance, high conductivity, neuronal affinity1, and large specific surface area. The last is of key importance, especially if ionic accessibility within the pores can be achieved at high rates. This would allow low interface impedance and high capacitive charge injection within a non-damaging range of potentials during the short duration, high frequency pulses applied for neural stimulation. The electrode can then be miniaturized to increase the selectivity of stimulation, while preserving capability for non-damaging stimulation. Or in the absence of a nominal size reduction, the battery life of device stimulators can be prolonged2. This would reduce the prevalence of costly and risky battery replacement surgeries.

In this study, vertically aligned, bamboo-like multi-walled CNTs were grown via a 5 nm thick iron catalyst on highly conductive (0.1 Ω-cm) Si substrates using microwave plasma-enhanced chemical vapor deposition. CNT-film electrodes were characterized in-vitro via cyclic voltammetry (CV), impedance spectroscopy (EIS), and potential transient measurements (PTMs) in a physiologic solution based on an interstitial fluid model3. The electrodes were activated using 10 CV sweeps (100 mV/s) across the potential window just within the limits of water electrolysis. Electrochemical properties; including specific capacitance, impedance, and charge injection; were measured in low and high frequency regimes and compared to a Pt electrode. Although the Pt electrode had a greater cathodal charge storage capacity than CNT films of lengths < 20 μm (as calculated from slow-sweep CV curves), the charge injection capacity during PTMs of the as-deposited CNT-film electrodes was much greater.

The average lengths of the as-deposited CNTs were varied between 2 – 25 μm. The films were characterized to gain a better understanding of electrolyte penetration within the porous volume as evaluated by the measured electrolytic capacitance. After electrode activation there was a significant enhancement in the magnitude and linear dependence of the specific capacitance as a function of average CNT length given a constant exposed nominal area (0.06 cm2). This indicated the effectiveness of the simple activation procedure to reduce the hydrophobicity of the as-deposited CNTs and showed that the interior volume of the CNT film was accessed since the electrochemically active area is proportional to the interfacial capacitance.

CNT films of equal length (12 μm) were functionalized with oxygen functional groups via thermal treatments in oxygen for 20 min at varying temperatures. It was previously reported that a thermal treatment in air at 400 °C for 1 hr could significantly improve the charge injection capacity of CNT-based microelectrodes (from 20 μC/cm2 to ~ 1.6 mC/cm2)4. The present study also revealed a significant increase in charge storage and capacitance following most treatments. Raman spectroscopy indicated that at ≤ 400 °C (region I), there is a steady decrease in amorphous carbon impurities5 as a function of temperature. At ≥ 475 °C (region III) Raman data indicated a significant increase in noticeable film defects. Catalyst particle exposure and a concomitant decrease in the average CNT length and film density as revealed by scanning electron microscopy indicated bulk etching of the CNT film. This was accompanied by an increase in Faradaic behavior of the electrode and a decrease in charge injection during PTMs. Between 400 and 475 °C a transition region exists (region II) in which significantly higher levels of charge injection or “fast capacitance” can be obtained during PTMs due to asymmetric voltage transients. This behavior is appealing, but not well understood and requires further study.

Vertically aligned CNTs show great potential as a neural stimulation electrode especially since their properties can be tailored by appropriate pretreatments or functionalization chemistry.

⅄ Poster # 32

Characterization of nonlinear metamaterials via transfer matrix-based retrieval

Alec Rose, Stéphane Larouche, Ekaterina Poutrina, Da Huang, David R. Smith
Department of Electrical and Computer Engineering, Duke University

Metamaterials are structured materials whose electromagnetic responses can be described by homogenized constitutive parameters. Through purposeful engineering and design, this class of artificial materials can display properties that are limited or entirely absent in natural materials, such as enhanced nonlinear susceptibilities and negative indices of refraction. In this poster, we present our work on the design, fabrication, and characterization of nonlinear metamaterials. In particular, we have developed a method for the retrieval of effective nonlinear susceptibilities from both metamaterial simulations and experiments, using a modified transfer matrix approach. Subsequently, we fabricated a slab of varactor-loaded split ring resonators, a canonical example of a nonlinear metamaterial, and performed second harmonic generation and 3-wave mixing experiments on the sample. From this data, we were able to characterize the nonlinear susceptibilities of the metamaterial, yielding quantitative agreement with the independent predictions of an analytical model.

⅄ Poster # 33

Synthesis and Characterization of Tm^{3+} doped YbF_3 for NIR to UV Energy Conversion

Jong K. Park[1], Jennifer A. Ayres[1], Martin C. Fischer[1], Warren S. Warren[2], Michael J. Therien[1]
[1] *Department of Chemistry, Duke University, Durham, NC 27708*
[2] *Department of Chemistry, Radiology, and Biomedical engineering, Duke University, Durham, NC 27708*

Photon upconversion is an intriguing process in which multiple low energy (NIR) photons are absorbed to emit higher energy light in the ultraviolet (UV), visible or a higher energy NIR spectral region. The excited states in lanthanide ions enable multiple transitions or energy transfers between neighboring ions using near infrared (NIR) excitation. Upconverting nanoparticles have tremendous potential in biological imaging applications due to the high penetration depth of the 980 nm radiation used for particle excitation. In addition, light-scattering and autofluorescence are significantly reduced in this wavelength region compared to the visible. We have recently synthesized water-soluble YbF_3:Tm^{3+} particles where the ratio of emission intensity between UV and NIR regions varies with concentration of Tm^{3+}. In order to maximize quantum efficiency in the desired wavelength region, it is necessary to understand the energy pathways within these crystals. Energy pathway and multiexcitation process will be studied with ns-transient absorption (TA) technique with a modified Z-scan method.

⅄ Poster # 34

Observation of Elliptical Rings in Degenerate, Type I, Spontaneous Parametric Down-Conversion

Hannah Guilbert, Ken (Yu-Po) Wong, Daniel J. Gauthier
Physics Department and Fitzpatrick Institute of Photonics, Duke University

Spontaneous parametric down-conversion is a nonlinear optical process used to create entangled photon pairs. In general the photons can be entangled in many degrees of freedom including time, space, angular momentum, transverse momentum, energy and polarization. In order to be optimally useful for applications to quantum communication, the entangled photons must be completely indistinguishable. While the literature predicts the down-converted photons will be emitted along a cylindrically symmetric ring, we instead find that they are emitted along an ellipse. In this poster we investigate the spatial distribution of a pair of polarization entangled down-converted photons produced by a BiBO crystal phase-matched for degenerate, Type I, non- collinear parametric down-conversion and discuss its impact on future quantum communication schemes.

⅄ Poster # 35

Analytical and Experimental Analysis of Nonlinear Metamaterials

Da Huang, Ekaterina Poutrina, and David R. Smith
Department of Electrical and Computer Engineering, Center for Integrated Metamaterials and Plasmonics, Fitzpatrick Institute for Photonics, Duke University

Various nonlinear phenomena such as harmonic generation, parametric down-conversion, or tunability have been demonstrated experimentally in metamaterials incorporating nonlinear elements. A diverse spectrum of nonlinear phenomena in negative index materials (NIM) has been also analyzed theoretically, assuming a homogeneous NIM layer with presumed values of linear and nonlinear response. In this way a variety of novel effects has been predicted arising from the specific electromagnetic properties that negative-index media possess. For further practical applications, the design and optimization of nonlinear metamaterial-based devices requires a more quantitative approach, one that relates the particular metamaterial geometry incorporating nonlinear elements to the nonlinear properties of the resulting effective medium.

We analyze here the properties of a nonlinear metamaterial formed by integrating nonlinear components or materials into the capacitive regions of metamaterial elements. We develop an analytical approach based on the nonlinear oscillator model providing the general expressions for the nonlinear susceptibilities of the composite metamaterial medium. The expressions are convenient, as they enable an inhomogeneous system of scattering elements to be described as a continuous medium using the standard notation of nonlinear optics. We illustrate the validity and accuracy of our theoretical framework by performing measurements on a fabricated metamaterial medium composed of split ring resonators with packaged varactors embedded in the capacitive gaps. Within the range of applicability the approach allows the development of the model of a homogeneous analog nonlinear medium that aligns with the same concept in nonlinear optics.

⅄ Poster # 36

Polymer Microresonator Biosensors

Matthew Royal[1], Lin Luan[1], Prof. Nan Jokerst[1], Prof. Thomas LaBean[2,3] , Prof. Richard Fair[1], Dr. Debra Schwinn[4]
[1]*Department of Electrical and Computer Engineering, Duke University*
[2]*Department of Computer Science, Duke University*
[3]*Department of Chemistry, Duke University*
[4]*Department of Anesthesiology, University of Washington, Seattle, WA*

Biosensors have the potential to enable rapid, sensitive, and specific diagnosis of infectious pathogens. Most notably, detection of specific DNA sequences could help to determine subtype and drug resistance of infectious diseases, such as malaria, from DNA extracted from pathogens present in a patients' blood. A simple, inexpensive, high sensitivity and high specificity biosensor device could improve the accuracy of disease diagnosis by utilizing multiple disease markers and, additionally, has the best chance of being adopted for use in resource poor areas. Polymer based vertically-coupled microring resonator sensors are promising as inexpensive biosensors, because they are fabricated with inexpensive processes and materials and are easy to functionalize with a variety of different biomolecules. Biosensing is accomplished by utilizing surface-bound molecular 'probes', which bind only to their complementary 'targets' in solution. With a microresonator sensor, the change in the surface refractive index due to the additional surface bound material is detected by observing the resulting change in the optical resonance spectrum of the microresonator. Detection of biotin-streptavidin binding with a polymer microresonator sensor has been demonstrated and DNA hybridization on the sensor material in less than 5 minutes has been observed. The long term goal of this work 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 # 37

Full-field optical coherence tomography at two wavelengths

Delphine Sacchet, Julien Moreau, Patrick Georges, Michael Canva, Arnaud Dubois
Laboratoire Charles Fabry de l'Institut d'Optique, Université Paris- Sud, CNRS UMR 8501 Campus Polytechnique, RD 128, 91127 Palaiseau Cedex, France
E-mail: arnaud.dubois@institutoptique.fr

Full-field optical coherence tomography (FF-OCT) was introduced a few years ago as an alternative method to conventional OCT using an interference microscope and a camera as an array detector combined with a low coherence illumination source for parallel acquisition of *en-face* tomographic images. To take advantage of the spectroscopic response of the sample being imaged, conventional OCT has been developed recently at two distinct wavelengths using supercontinuum generation in non-linear crystal fibers and two single detectors at 800 nm and 1300 nm. We present an ultrahigh-resolution FF-OCT system operating in the 800 nm and 1200 nm wavelength regions simultaneously using two different cameras: a Silicon-based (Si) CCD camera and an Indium Gallium Arsenide (InGaAs) camera. A quartz tungsten halogen lamp is employed as illumination source. The FF-OCT setup is optimized to support the two broad spectral bands in parallel, achieving a detection sensitivity of ~ 90 dB and a spatial resolution of

1-2 µm in the three directions. Images of *ex vivo* biological tissues are presented with an increase in penetration depth at 1200 nm. A color image representation is applied to enhance spectroscopic property visualization.

⅄ Poster # 38

Surface Plasmon Resonance Imaging BioSensors and Nano-Micro Structuration

Julien Moreau[1,*], Anuj Dhawan[2,*], Aurélien Duval[1,*], Mohamed Nakkach[1], Alain Bellemain[1], Michael Canva[1,ǂ], and Tuan Vo-Dinh[2,ǂ]
[1]*Laboratoire Charles Fabry de l'Institut d'Optique, Université Paris-Sud CNRS UMR 8501, Campus Polytechnique, RD 128, 91127 Palaiseau Cedex, France*
[2]*Fitzpatrick Institute for Photonics, Department of Biomedical Engineering, Pratt School of Engineering, Duke University, Durham, NC, USA*
[*]These authors contributed equally to this work
ǂCorresponding Authors: michael.canva@institutoptique.fr, tuan.vodinh@duke.edu

Surface Plasmon Resonance Imaging, SPRI, offers many advantages to study surface modification thanks to its great sensitivity to any changes in the optical index in the vicinity of the metal-dielectric interface where the plasmon wave is localized. In parallel, the sensing surface can be structured into a biochip characterized by many different localized biofunctionalities, a classical example involving single stranded DNA sequences for genotyping of mutations. Some of our systems, although exhibiting some of the best S/N ratio published to date are getting very close to theoretical limitations as pointed out in a recent publication. Micro- and nano- structuration of the surface can lead to enhanced sensitivity, as demonstrated in recent publications.

Surface Plasmon Resonance Imaging, SPRI, is a fast developing field in which one of the roads that leads to further developments lies in the design and realization of new micro- and nano-structured surfaces on millimetric areas. We are currently investigating plasmonics in view of better understanding and bridging the gap between propagating plasmons, PPs, and localized plasmons, LPs, including quasi propagating plasmons, QPPs, and coupled localized plasmons, CLPs, and in particular their properties and usefulness for sensing applications.

We are investigating the intermediate regime between propagating plasmons on homogeneous surface and localized plasmon on nanoparticles. Simulations were run using RCWA based software, and samples were prepared using E-beam or deep UV lithography. The plasmonic properties are investigated using a angulo-spectral SPRI system. An example concerning nanometric gratings will be provided.

⅄ Poster # 39

Study of the protein synthesis at the single molecule level

Contributors:
Le Gall, K. Perronet, D. Dulin, P. Bouyer and N. Westbrook (Institut d'Optique, Palaiseau)
biologists : N. Soler, D. Fourmy and S. Yoshizawa (ICSN - CGM Gif/Yvette)

collab. : K. Visscher (University of Tucson Arizona)
collab : G. Clavier and R. Méallet (PPSM, ENS Cachan)
E-mail: karen.perronet@institutoptique.fr

At the Optics Institute, we have developed optical tools in order to study biomolecular motors at the single molecule level. Together with biologists, specialist of the ribosome, we focused on the protein synthesis and especially the dynamics of the process.

We built a total internal reflexion fluorescence microscopy set-up in order to follow different factors (ribosome, amino-acids, mRNA...) in real time during translation. We already measured the distribution of translation rate for the translation of a complete protein. We are also developing optical tweezers to measure the forces involved in the translation process. We proposed a direct way to calibrate the trap, and we are now studying specific secondary structures of mRNA involved in protein translation.

⅄ Poster # 40

Safe Detector System for Hydrogen Leaks

Robert. A. Lieberman. Manal H. Beshay
Intelligent Optical Systems, Inc.

Hydrogen safety is an important key to commercializing hydrogen energy technologies, and to facilitate the use of hydrogen as a green energy source. We have developed hydrogen-sensitive chemical indicators and incorporated them into three different optical formats: point optrodes, multichannel integrated optic chips, and fully-distributed fiber optic cables. This poster focuses on the development and performance of a complete hydrogen safety sensor that uses two optrodes in a format suitable for handheld hydrogen concentration measurements or for use as a wall-mounted leak alarm.

⅄ Poster # 41

Field-usable Multiplexed TBI Biomarker Diagnostic Device

Srivatsa Venkatasubbarao[1], Manal Beshay[1], Jessica O'Connor[1], Madhusoodana P. Nambiar[2], Hong Q. Yan[3], Youming Li[3], Xiecheng Ma[3], Ava M. Puccio[3], David O. Okonkwo[3], Edward C. Dixon[3]
[1]Intelligent Optical Systems, 2520 West 237th Street, Torrance CA 90505; [2]Department of Closed Head Injury, Division of Brain Dysfunction and Blast Injury, Walter Reed Army Institute of Research, 503 Grant
Avenue, Silver Spring, MD 20910; [3]University of Pittsburgh, Department of Neurological Surgery, 200 Lothrop Street, Pittsburgh, PA 15213

Traumatic brain injury (TBI) is the leading cause of death and injury-related disability among soldiers. TBI can lead to disturbances in cognitive, behavioral, emotional, and physical functioning. There is an immediate need to develop field-usable TBI diagnostic devices to determine if the reported symptoms are as a result of TBI. It is widely accepted that the sensitivity and specificity of diagnosis can be improved by the judicious selection and measurement of multiple biomarkers in body fluids. We report the measurement of multiple biomarkers for highly sensitive TBI diagnosis from serum samples. Under an IRB-approved protocol, data was collected prospectively in 20 severe adult TBI patients, with a Glasgow Coma Scale (GCS) score ≤ 8, age 21-74 years, admitted to the University of Pittsburgh Brain Trauma Research Center from 2008-2009. Serum samples were collected from these patients every 12 hours starting from 10 hours after TBI until 136 hours after TBI insult. Serum samples from 20 healthy adults served as normal controls. Quantum dot-based lateral flow test strips were designed and fabricated to measure TBI biomarkers from serum samples. A cassette to apply samples onto the test strips, and a reader to quantify the concentrations of the biomarkers, were developed. Serum biomarker levels for TBI were compared to the controls. The protein concentrations were normalized and the concentrations of the biomarkers were correlated to the Glasgow Coma Scale and Glasgow Outcome Scale. The results showed elevated levels of biomarkers (S100 β, NSE, and GFAP) in patients with TBI. The peak concentration of the biomarkers was observed by 40 hours after injury; these levels gradually decreased over time. The use of a multiplexed biomarker approach will improve the specificity and sensitivity of TBI diagnosis. The lateral flow test strip technology can be reliable for quantitative measurement of TBI biomarkers. The results obtained thus far use samples from patients with GCS scores ≤ 8. Further studies are ongoing to evaluate the utility of these biomarkers for patients with mild to moderate TBI.

⅄ Poster # 42

Universal Quantum Viscosity in a Unitary Fermi Gas

C. Cao[1], E. Elliott[1], J. Joseph[1], H. Wu[1], J. Petricka[2], T. Schafer[3], and J. E. Thomas[1]
[1]Physics Department, Duke University, Durham, North Carolina 27708
[2]Physics Department, Gustavus Adolphus College, Saint Peter, Minnesota 56082
[3]Physics Department, North Carolina State University, Raleigh, North Carolina 27695

A Fermi gas of atoms with resonant interactions is predicted to obey universal hydrodynamics, where the shear viscosity and other transport coefficients are universal functions of the density and temperature. At low temperatures, the viscosity has a universal quantum scale hbar*n where n is the density, while at high temperatures the natural scale is pT^3/hbar^2 where pT is the thermal momentum. We employ breathing mode damping to measure the shear viscosity at low temperature. At high temperature T, we employ anisotropic expansion of the cloud to find the viscosity, which exhibits precise T^(3/2) scaling. In both experiments, universal hydrodynamic equations including friction and heating are used to extract the viscosity. We estimate the ratio of the shear viscosity to the entropy density and compare to that of a perfect fluid.

⅄ Poster # 43

Near-Eye-Safe Trace Molecular Detection via SERS and SERRS at a Stand-Off Distance of 15 Meters

Jonathan Scaffidi[1], Molly Gregas[1], Benoit Lauly[1], J. Chance Carter[2], S. Michael Angel[3], Tuan Vo-Dinh[1,4]
[1]Duke University, Department of Biomedical Engineering and Fitzpatrick Institute for Photonics; [2]Lawrence Livermore National Laboratory, M Division; [3]University of South

Carolina, Department of Chemistry and Biochemistry; [4]Duke University, Department of Chemistry

We report the first demonstration of surface-enhanced Raman spectroscopy (SERS) detection of para-mercapto benzoic acid (pMBA) and surface-enhanced resonance Raman spectroscopy (SERRS) detection of brilliant cresyl blue (BCB) and cresyl violet perchlorate (CVP) with continuous-wave excitation from a stand-off distance of 15 meters. We further report the first stand-off SERRS detection of BCB and CVP at that same distance in the presence of ambient fluorescent and incandescent / blackbody background light. These preliminary results suggest that it is possible to detect sub-nanomole amounts of material at reasonable distances with eye-safe laser powers using stand-off SERRS, and serve as proof-of-concept highlighting the potential extension of stand-off Raman spectroscopy to include SERS and SERRS for remote, eye-safe chemical detection, analysis and imaging in the presence of ambient background light.

NOTES: ____

⅄ Co-Sponsors of FIP Symposium ⅄

The Fitzpatrick Institute for Photonics would like to thank our Co-Sponsors and Corporate Partners for contributing to the organization of the 2010 FIP Symposium "Frontiers in Photonics: Science and Technology".

Laserfest is a yearlong celebration of the 50th anniversary of the laser, which was first demonstrated in 1960, and is a collaboration between the American Physical Society, the Optical Society, SPIE and IEEE Photonics Society. From DVD players to eye surgery, the laser is one of the greatest inventions of the 20th century—one that has revolutionized the way we live.

The Eastern North Carolina Section (ENCS) IEEE Photonics Society (IPS) Chapter was established in March 2007. The broad technical field of interest of the IPS includes lasers, optoelectronics, and photonics. The IPS is also concerned with the research, development, design, manufacture, and application of materials, devices, and systems in the field of quantum electronics.

The Duke University OSA/SPIE Student Chapter (DOSC) is a student organization officially affiliated with the Optical Society of America (OSA) and SPIE. The chapter consists of graduate and undergraduate students interested in research in optics, photonics, biophotonics and related fields. DOSC engages in many activities related to the exploration and promotion of optical sciences such as hosting invited speakers, fostering industry connections and conducting K-12 optics outreach.

SPIE is the international society for optics and photonics founded in 1955 to advance light-based technologies. Serving more than 180,000 constituents from 168 countries, the Society advances emerging technologies through interdisciplinary information exchange, continuing education, publications, patent precedent, and career and professional growth.

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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.

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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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.

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- Chemistry
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- Computer Science
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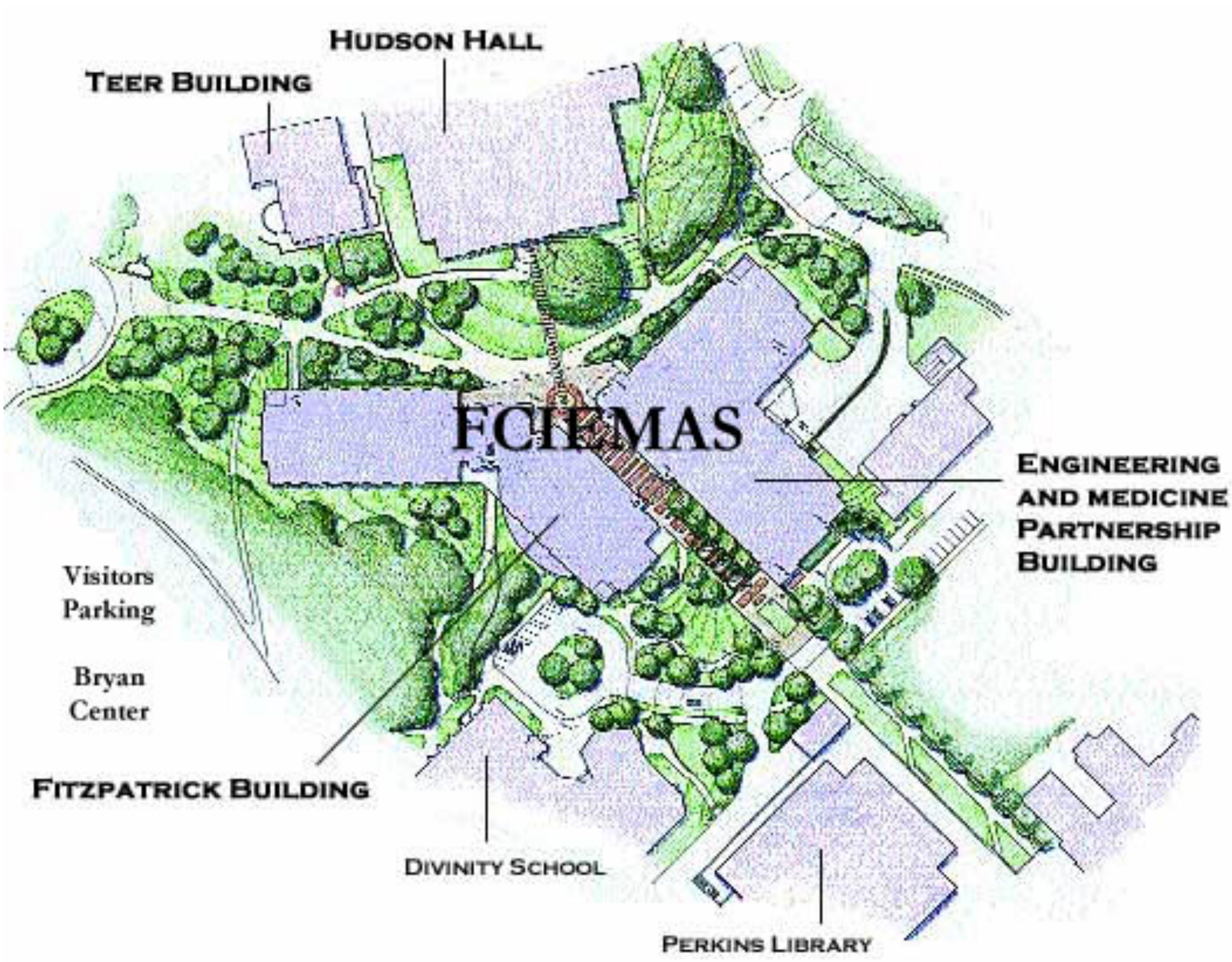

The Fitzpatrick Institute for Photonics and Schiciano Auditorium are located in the Fitzpatrick Building of FCIEMAS.

For Further Information:

Dept. Business Manager, Fitzpatrick Institute for Photonics .... August Burns
305 Teer Building, Box 90271
Durham, NC 27708-0271
august.burns@duke.edu

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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: the FIP meeting has regular breaks and meals during the conference.)

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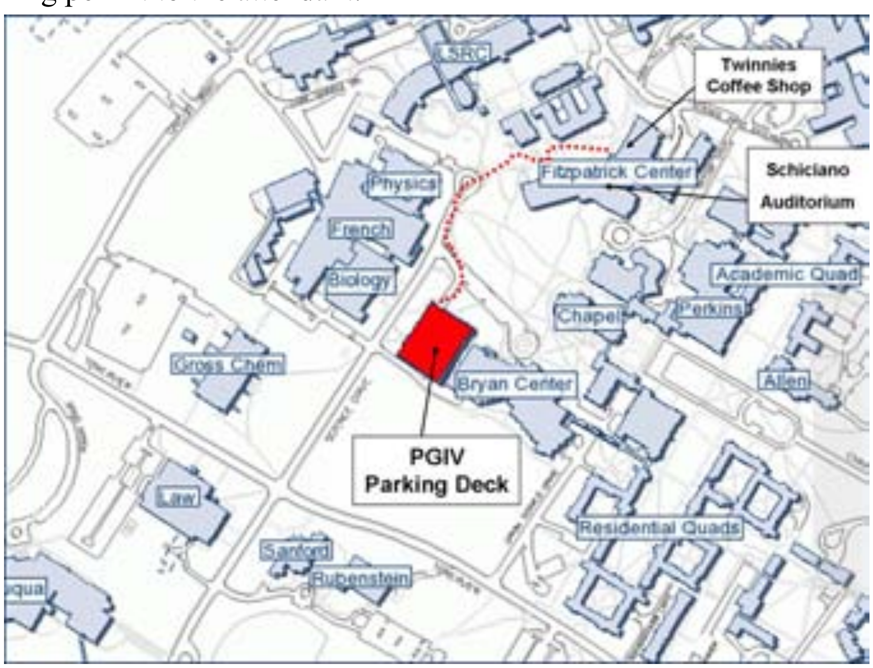

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