# Fitzpatrick Institute for Photonics Symposium

*Frontiers in Photonics Science and Technology*

Duke University
March 11-12, 2013

# Welcome to the Fitzpatrick Institute for Photonics

2013 Fitzpatrick Institute for Photonics (FIP) Annual Meeting
March 11-12, 2013, Duke University

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

**Symposium Co-Chair** – David Beratan, RJ Reynolds Professor of Chemistry

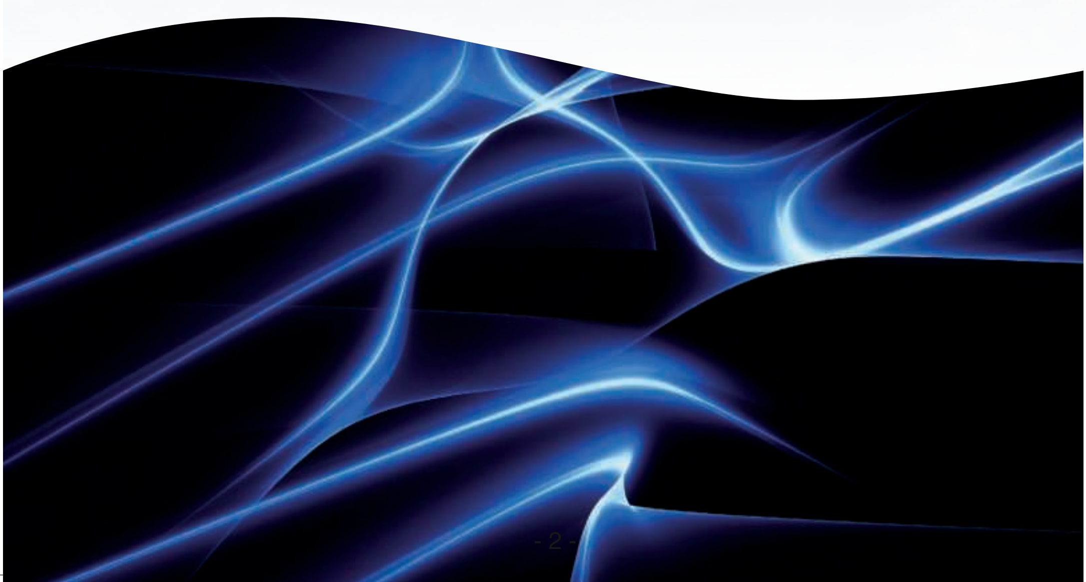
**Scientific Program Committee** – Daniel Gauthier, Joseph Izatt, Nan Jokerst, Jungsang Kim, Kam Leong, Barry Myers, William Reichert, David Smith, Warren Warren, Adam Wax, Weitao Yang

**Symposium Administrative Manager** – August Burns, Department Business Manager, Fitzpatrick Institute for Photonics

**Assistant Coordinator** – Janna Register, Lab Manager, Fitzpatrick Institute for Photonics

**Monday, March 11, 2013**
**Fitzpatrick Building**
8:00 am - 9:00 am Registration
9:00 am - 5:30 pm Meeting
5:30 pm Poster Session-Reception

**Tuesday, March 12, 2013**
**Fitzpatrick Building**
8:30 am - 9:00 am Registration
9:00 am - 12:00 pm Meeting



# Frontiers in Photonics Science and Technology

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# Frontiers in Photonics Science and Technology

The Fitzpatrick Institute for Photonics is an extensively interdisciplinary Duke effort to advance photonics and optical sciences. The institute leverages Duke's faculty from the Pratt School of Engineering, Trinity Arts and Sciences, and the Duke Medical School to explore problems at the boundary nexus of nano-bio-info-opto convergence.

The Fitzpatrick Institute for Photonics (FIP) has 87 Faculty Members from 30 Participating Departments, Centers & Institutions at Duke University

Departments:

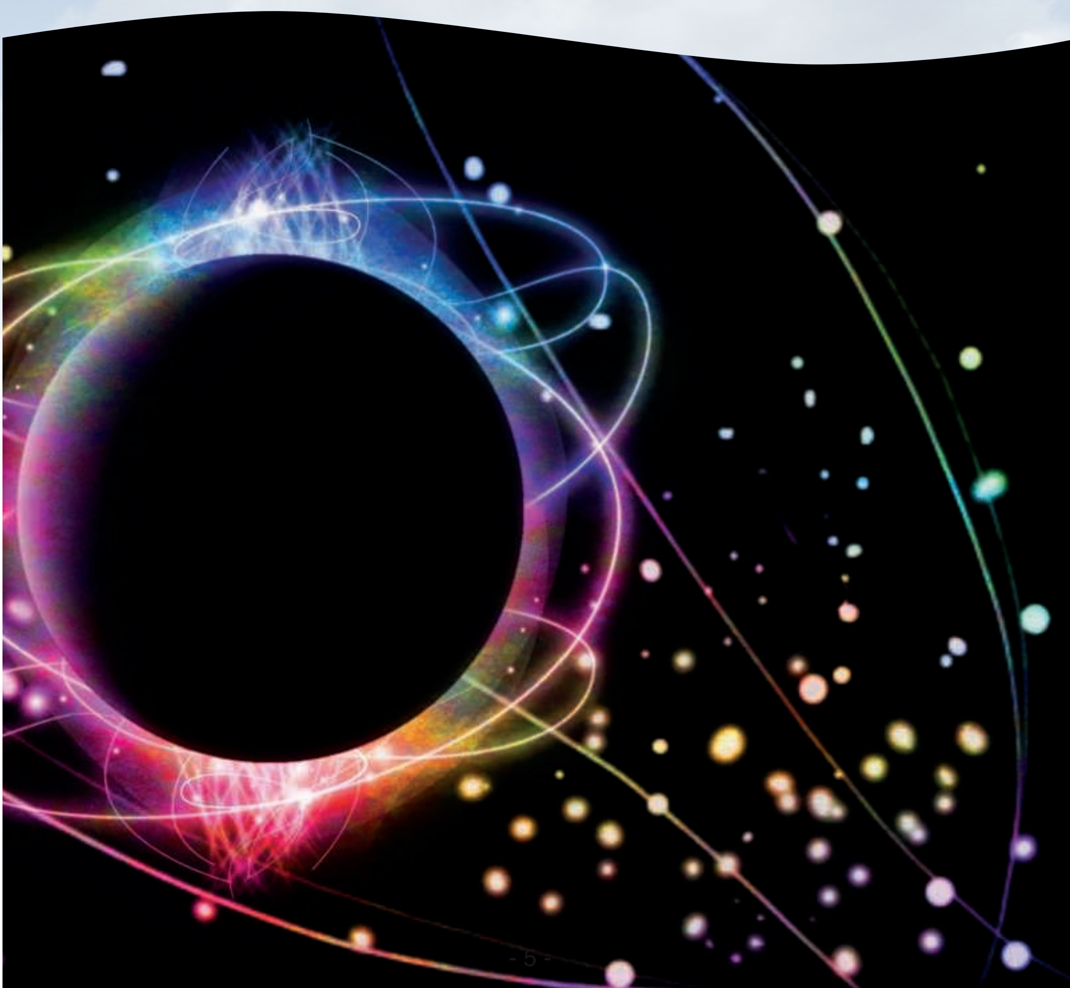
- Anesthesiology
- Biology
- Biomedical Engineering (BME)
- Cell Biology
- Chemical Biology
- Chemistry
- Civil & Environmental Engineering (CEE)
- Computer Science
- Dermatology
- Electrical and Computer Engineering (ECE)
- Gastroenterology
- Mathematics
- Mechanical Engineering and Materials Science (MEMS)
- Neurosurgery
- Oncology
- Ophthalmology
- Orthopaedic Engineering
- Pathology
- Pediatrics
- Philosophy
- Physics
- Radiation Oncology
- Radiology
- Surgery

Center for Metamaterials & Integrated Plasmonics
Division of Infectious Diseases & International Health
Duke Comprehensive Cancer Center
Duke Human Vaccine Institute
Institute for Genome Science and Policy
Nicholas School of the Environment

# Frontiers in Photonics Science and Technology

## FIP Research Programs and Program Directors

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



# Frontiers in Photonics Science and Technology
# Program

## Monday, March 11, 2013 (Fitzpatrick Center) – Morning Session

| | |
|---|---|
| 8:00-9:00 am | **Registration**<br>*Photonics Theme Lab Tours*<br>*Smart Home Tours*<br>*SMIF Lab Tours*<br>(signup at Registration Desk for Participation and times) |
| 9:00-9:10 | **Introduction**<br>**Tuan Vo-Dinh**, FIP Director, R. Eugene and Susie E. Goodson Professor of Biomedical Engineering and Professor of Chemistry, Duke University |
| | **Welcome Address**<br>**Keith Whitfield**, Vice Provost for Academic Affairs, Duke University |
| 9:10-9:30 | **Opening Remarks**<br>**Laurie Patton**, Dean of Arts and Sciences, Duke University |
| | **George Truskey**, Senior Associate Dean, Pratt School of Engineering, R. Eugene and Susie E. Goodson Professor of Biomedical Engineering, Duke University<br>*The Energy Initiative at the Pratt School of Engineering* |
| 9:30-10:10 | **Symposium Keynote**<br>**William D. Phillips**, Nobel Laureate in Physics (1997), National Institute of Standards and Technology, and University of Maryland<br>*"Quantum Information: A Scientific and Technological Revolution for the 21st Century"* |
| 10:10-10:25 | **FIP Award Presentation** – *2013 Pioneer in Photonics Award* |
| 10:25-10:40 | **COFFEE BREAK** |
| 10:40-11:10 | **Plenary Lecture**<br>**Peidong Yang**, S.K and Angela Chan Distinguished Chair in Energy University of California at Berkeley *"Semiconductor Nanowires for Solar Fuel Generation"* |

11:10-12:15 **Session 1:** **Special Topic on Photonics for Energy I**
**Chair: Jeffrey Glass**, Hogg Family Professor of Electrical and Computer Engineering, Duke University

11:10-11:35 **Invited Lecture: Henry Schriemer**, Associate Professor, Electrical Engineering, SUNLAB, University of Ottawa *"Third Generation Strategies in High-Efficiency Solar Cell and System Design"*

11:35-11:55 **Adrienne Stiff-Roberts**, Associate Professor of Electrical and Computer Engineering, Duke University *"Enhancement of Vertical Charge Transport in Organic Photovoltaic Devices Deposited by Resonant Infrared Matrix-Assisted Pulsed Laser Evaporation (RIR-MAPLE)"*

11:55-12:15 **David Beratan**, RJ Reynolds Professor of Chemistry, Professor of Biochemistry and Physics, Duke University *"The Elementary Events of Solar Fuel Production: Some Theoretical Challenges"*

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12:15-1:15 pm **LUNCH BREAK** (Lunch provided)

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**Poster Session & Industry Booths**
Posters and Industry Booths are exhibited in the Atrium area of the Fitzpatrick Center

## Monday, March 11 - Afternoon Session

1:15-1:55 **Investiture Presentation** – Fitzpatrick Family University Professor of Engineering

1:15-1:30 **George Truskey**, Senior Associate Dean, Pratt School of Engineering, R. Eugene and Susie E. Goodson Professor of Biomedical Engineering, Duke University - *honoring* ***Michael J. Fitzpatrick****, T'70 and* ***Dr. Jennifer West*** *as the inaugural holder of the Fitzpatrick Family University Professorship in Engineering*

| | | |
|---|---|---|
| | 1:30-1:55 | **Jennifer West**, Fitzpatrick Family University Professor of Engineering, Professor of Biomedical Engineering, Professor of Mechanical Engineering and Materials Science, Cell Biology and Chemistry, Duke University<br>*"Therapeutic and Diagnostic Applications of Gold Nanoshells"* |
| 1:55-2:35 | **Session 2:** | **Advances in Photonics I**<br>**Chair: Joseph Izatt**, Professor of Biomedical Engineering, Duke University |
| | 1:55-2:15 | **Invited Lecture: Kristin Weidemaier**, Technology Manager, BD Technologies *"SERS Nanotechnology for the Development of Medical Diagnostics"* |
| | 2:15- 2:35 | **Invited Lecture: Robert Lieberman**, President and CEO, Intelligent Optical Systems *"Fiber Optic Sensors for Energy Applications"* |
| 2:35- 2:50 | **COFFEE BREAK** | |
| 2:50- 3:55 | **Session 3:** | ***PANEL FORUM SESSION***<br>***Energy Challenges and Choices: From Personal to Global*** |

**Panel Members:**

- **Rudy Baum**, Editor-at-Large, Chemical & Engineering News (Moderator)
- **Richard Newell**, Director of Duke Energy Initiative and Gendell Associate Professor of Energy and Environmental Economics, Duke University
- **Vikram Rao**, Executive Director, Research Triangle Energy Consortium
- **James Roberto**, Deputy Director, Oak Ridge National Laboratory
- **Eric Toone**, Anne T. and Robert M. Bass Professor of Chemistry, Duke University

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|---|---|---|
| 3:55-4:25pm | **Plenary Lecture on Energy Photonics** | |
| | **Joseph Hupp**, Morrison Professor of Chemistry, Northwestern University and Argonne National Laboratory *"Toward Solar Fuels: Water Splitting with Sunlight and Rust"* | |
| | *Plenary Lecture on Energy Photonics co-sponsored by The UNC Energy Frontier Research Center, An Energy Frontier Research Center, University of North Carolina, Chapel Hill* | |
| 4:25-5:30 | **Session 4:** | **Special Topic on Photonics for Energy II** **Chair: David Brady,** Michael J. Fitzpatrick Professor, Electrical and Computer Engineering, Duke University |
| | 4:25-4:50 | **Invited Lecture: Victor Klimov**, Fellow of Los Alamos National Laboratory and Director of the Center for Advanced Solar Photophysics of the U.S. Department of Energy *"Making the Most of the Absorbed Photon: New Insights into Carrier Multiplication in Semiconductor Nanostructures"* |
| | 4:50-5:10 | **Jie Liu**, George Barth Geller Professor, Department of Chemistry, Duke University *"Chemically Doped ZnO as white light Phosphors"* |
| | 5:10-5:30 | **Invited Lecture: KC Tran**, Chief Executive, and Co-founder, Carbon Recycling International, Iceland *"Renewable Methanol from Emissions and Renewable Energy: Conversions to Green Mega Joules by Electro-thermo-chemical-synthesis and Photo-synthesis"* |
| 5:30-6:00 | **POSTER SESSION & INDUSTRY BOOTHS** Posters and Industry Booths are exhibited in the Atrium area of the Fitzpatrick Center | |

**Thank You for Industry Support**

(Industry Booths*)

- **FIP Corporate Partners:** BD Technologies, Cisco, and Hamamatsu*
- **Elite Conference Sponsors:** Block*, Coherent*, Edmund Optics*, Newport*, Optosigma* and Zenalux*
- **Duke Conference Sponsors:** Office of Licensing and Ventures* and Duke Optical Student Chapter*

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5:30-7:30pm **COCKTAIL RECEPTION**
(Heavy hors d'oeuvres will be served)

## SPECIAL EDUCATION PROGRAM FOR HIGH-SCHOOL STUDENTS

Tuesday, March 12th 8:00-9:00 am
Fitzpatrick Center

Dr. William D. Phillips, Nobel Laureate in Physics
Special Education Program for High School Students

## Breakfast with a Nobel Laureate

Arranged by
**Allan Shang**, Director of Outreach Program, Fitzpatrick Institute for Photonics,
**Martha Absher**, Associate Dean, Education & Research Programs, Pratt School of Engineering

## Tuesday, March 12, (Fitzpatrick Center) – Morning Session

| | | |
|---|---|---|
| 8:30-9:00 am | Registration | |
| 9:00-10:10 | **Session 5:** | **Special Topic on Photonics for Energy III**<br>**Chair: Gleb Finkelstein**, Associate Professor of Physics, Duke University |
| | 9:00-9:20 | **Nico Hotz**, Assistant Professor, Department of Mechanical Engineering and Materials Science, Duke University<br>*"Solar-Powered Hydrogen Production"* |

| | | |
|---|---|---|
| | 9:20-9:45 | **Invited Lecture: Wei You**, Associate Professor of Chemistry, University of North Carolina *"Conjugated Polymers for Harvesting Solar Energy: The Impact of Side Chains and Fluorine"* |
| | 9:45- 10:10 | **Invited Lecture: Jonathan Lindsey**, Glaxo Distinguished University Professor of Chemistry, Organic, Bio-Organic, and Materials Chemistry, North Carolina State University *"Capturing Near-Infrared Light with Synthetic Chlorophylls for Solar Photoconversion"* |
| 10:10-10:40 | **COFFEE BREAK** | |
| 10:40-12:00 | **Session 6:** | **Advances in Photonics II**<br>**Chair: Benjamin Wiley**, Assistant Professor of Chemistry, Duke University |
| | 10:40-11:00 | **Invited Lecture: Frederick Haibach**, Ph.D Block Engineering, LLC<br>*"Creating New Frontiers of Infrared Spectroscopy"* |
| | 11:00-11:20 | **Maiken H. Mikkelson**, Assistant Professor of Electrical and Computer Engineering, Assistant Professor of Physics, Duke University<br>*"Enhanced Light-Matter Interactions of a Single Emitter Coupled to a Slot Waveguide"* |
| | 11:20-11:40 | **Xuanhe Zhao**, Assistant Professor of Mechanical Engineering and Materials Science, Duke University *"Multifunctionality and Control of the Crumpling and Unfolding of Large-area Graphene"* |
| 11:40-12:00 | **Poster Awards Announced** | |
| 12:00 pm | **SYMPOSIUM ADJOURNS** | |

**Post-Symposium Workshop I**
(Invitation Only & Lunch provided)
12:15-2:00pm - 1441 FCIEMAS - Working Lunch

**WOMEN IN SCIENCE AND ENGINEERING**
Arranged by
**Allan Shang,** Director of Outreach Program, Fitzpatrick Institute for Photonics
**Sharon Schulze**, Associate Dean, Research Advancement, Pratt School of Engineering

**Post-Symposium Workshop II**
(Invitation Only and Lunch provided)
12:15-1:15pm - Mumma Commons (3121 FCIEMAS) - Lunch
1:15 - 4:00pm - Mumma Commons (3121 FCIEMAS) - Workshop
Breakout Sessions: 3399 FCIEMAS and 3427 FCIEMAS

**BUILDING BRIDGES**
**BETWEEN ACADEMIA AND THE FEDERAL LABORATORY:**
**The Future of Research and Education**

Arranged by
**Ian Anderson**, Associate Director, Oak Ridge National Laboratory
**Robert Calderbank**, Dean of Natural Sciences, Duke University
**Tuan Vo-Dinh**, Director of Fitzpatrick Institute for Photonics, Duke University

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# Welcome and Opening Remarks

2013 Fitzpatrick Institute for Photonics (FIP) Annual Meeting
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**Tuan Vo-Dinh, Ph.D.**
Director of the Fitzpatrick Institute for Photonics
R. Eugene and Susie E. Goodson Professor of Biomedical Engineering
Professor of Chemistry
Duke University

**Keith Whitfield, Ph.D.**
Vice Provost for Academic Affairs
Professor of Psychology and Neuroscience
Research Professor of Medicine
Co-Director, Center on Biobehavioral Research on Health Disparities
Duke University

**Laurie Patton, Ph.D.**
Dean of the Faculty of Trinity College of Arts and Sciences
and Professor of Religion
Duke University

**George Truskey, Ph.D.**
Senior Associate Dean, Pratt School of Engineering
R. Eugene and Susie E. Goodson Professor of Biomedical Engineering
Duke University

# Keynote Speaker & 2013 FIP Pioneer Award Recipient

**William D. Phillips, Ph.D.**
*Nobel Laureate in Physics (1997)*
*National Institute of Standards and Technology (NIST)*
*University of Maryland*

*"Quantum Information: a scientific and technological revolution for the 21st century"*

Two of the great scientific and technical revolutions of the 20th century were the discovery of the quantum nature of the submicroscopic world, and the advent of information science and engineering. Both of these have had a profound effect not only on our daily lives but on our worldview. Now, at the beginning of the 21st century, we see a marriage of quantum mechanics and information science in a new revolution: quantum information. Quantum computation and quantum communication are two aspects of this revolution. The first is highly speculative: a new paradigm more different from today's digital computers than those computers are from the ancient abacus. The second is already a reality, providing information transmission whose security is guaranteed by the laws of physics. This talk will discuss the basics of quantum information and the crucial role of optics and photonics in realizing this revolution.

William D. Phillips was born in 1948, in Wilkes-Barre PA, in the USA. He received a bachelor of science in Physics from Juniata College in 1970 and a Ph.D. from MIT in 1976. After two years as a Chaim Weizmann postdoctoral fellow at MIT, he joined the staff of the National Institute of Standards and Technology (then the National Bureau of Standards) in 1978. He is currently the leader of the Laser Cooling and Trapping Group of NIST's Physical Measurement Laboratory, and a Distinguished University Professor at the University of Maryland. He is a Fellow of the Joint Quantum Institute, a cooperative research venture of NIST and the University of Maryland that is devoted to the study of quantum coherent phenomena. At the JQI he is the co-director of an NSF-funded Physics Frontier Center focusing on quantum phenomena that span different subfields of physics.

The research group led by Dr. Phillips has been responsible for developing some of the main techniques now used for laser-cooling and cold-atom experiments in laboratories around the world. Today, the group pursues research in laser cooling and trapping; Bose-Einstein condensation; atom optics; collisions of cold atoms; cold atoms in optical lattices; quantum information processing; quantum simulation of the behavior of complex systems; and the study of cold-atom analogs to condensed matter.

Dr. Phillips is a fellow of the American Physical Society and the American Academy of Arts and Sciences. He is a Fellow and honorary member of the Optical Society of America, and a member of the U.S. National Academy of Sciences. In 1997, Dr. Phillips shared the Nobel Prize in Physics "for development of methods to cool and trap atoms with laser light."

# Plenary Speaker

Plenary Lecture on Energy Photonics co-sponsored by the The UNC Energy Frontier Research Center, An Energy Frontier Research Center, University of North Carolina at Chapel Hill

**Joseph Hupp, Ph.D.**
*Morrison Professor of Chemistry*
*Northwestern University and*
*Argonne National Laboratory*

SOLAR FUELS UNC EFRC

*"Toward Solar Fuels: Water Splitting with Sunlight and Rust"*

The ultimate clean, carbon-neutral fuel would be molecular hydrogen obtained by splitting water using solar energy. In a "frictionless" world, with perfect catalysts, photons throughout the visible spectrum and significantly into the near-infrared would be capable of accomplishing water splitting. An intriguing photo-catalytic material for this purpose is a-$Fe_2O_3$ – essentially rust in dehydrated form.* This material is inexpensive, highly photo-oxidizing, and capable of absorbing light to wavelengths as long as 600 nm. As shown by several research teams, hematite is indeed capable of photo-catalytically generating O2 from water, but with less than terrific efficiency. This presentation will focus on very recent experimental efforts to identify and understand reaction bottlenecks, and on new materials-synthesis-driven approaches for circumventing them.
*For a recent critical review, see: M. J. Katz, et al. Coord. Chem. Rev. 2012, 21-22, 2521-2529, DOI:

Joseph Hupp is a native of rural western New York state. He was introduced to chemical research as an undergraduate student at Houghton College in New York, evaluating candidate electrode materials for heart pacers. He completed a B.S. degree in 1979. Subsequently he was a student of the late Mike Weaver at Michigan State University and Purdue University, completing a Ph.D. degree in 1983. He was a postdoc with T. J. Meyer at the University of North Carolina. He moved to Northwestern University in 1986 where he is currently a Morrison Professor of Chemistry. He also holds an appointment as a Senior Science Fellow at Argonne National Laboratory in the Division of Materials Science and in the Division of Chemical Sciences & Engineering. Additionally he serves as an Associate Editor for the Journal of the American Chemical Society.

His research centers on energy-relevant materials chemistry, including materials for light-to-electrical energy conversion, catalytic water oxidation, chemical separations, chemical catalysis, and high-capacity storage and release of molecular hydrogen. His research accomplishments have been recognized with awards from the Sloan Foundation, the Dreyfus Foundation, the American Chemical Society, the Electrochemical Society, the Defense Threat Reduction Agency, the Inter-American Photochemical Society, and others. He has mentored 48 students to Ph.D. completion. Roughly two dozen of his former graduate and postdoctoral advisees hold faculty positions at research universities. His research findings (and those of his students) are described in about 370 peer-reviewed articles and in a dozen patents, provisional patents, and active invention disclosures. His work has attracted roughly 18,000 citations. More detailed research descriptions can be found at:
http://chemgroups.northwestern.edu/hupp/

# Plenary Speaker

2013 Fitzpatrick Institute for Photonics (FIP) Annual Meeting
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**Peidong Yang, Ph.D.**
*S. K. and Angela Chan Distinguished Chair in Energy*
*University of California at Berkeley*

*"Semiconductor Nanowires for solar fuel generation"*

Nanowires, with their unique capability to bridge the nanoscopic and macroscopic worlds, have already been demonstrated as important materials for different energy conversion. One emerging and exciting direction is their application for solar to fuel conversion. The generation of fuels by the direct conversion of solar energy in a fully integrated system is an attractive goal, but no such system has been demonstrated that shows the required efficiency, is sufficiently durable, or can be manufactured at reasonable cost. One of the most critical issues in solar water splitting is the development of a suitable photoanode with high efficiency and long-term durability in an aqueous environment. Semiconductor nanowires represent an important class of nanostructure building block for direct solar-to-fuel application because of their high surface area, tunable bandgap and efficient charge transport and collection. Nanowires can be readily designed and synthesized to deterministically incorporate heterojunctions with improved light absorption, charge separation and vectorial transport. Meanwhile, it is also possible to selectively decorate different oxidation or reduction catalysts onto specific segments of the nanowires to mimic the compartmentalized reactions in natural photosynthesis. In this talk, I will highlight several recent examples in this lab using semiconductor nanowires and their heterostructures for the purpose of direct solar water splitting.

1Peidong Yang received a B.S. in chemistry from University of Science and Technology of China in 1993 and a Ph.D. in chemistry from Harvard University in 1997. He did postdoctoral research at University of California, Santa Barbara before joining the faculty in the department of Chemistry at the University of California, Berkeley in 1999. He is currently professor in the Department of Chemistry, Materials Science and Engineering; and a senior faculty scientist at the Lawrence Berkeley National Laboratory. He is S. K. and Angela Chan Distinguished Chair Professor in Energy. He was recently elected as MRS Fellow, and the member of American Academy of Arts and Sciences.

He is the deputy director for the Center of Integrated Nanomechanical Systems. He is one of the founding members for DOE Energy Innovation Hub: Joint Center for Artificial Photosysnthesis (JCAP) and served as its north director for the first two years. Yang is an associate editor for Journal of the American Chemical Society and also serves on editorial advisory board for number of journals including Acct. Chem. Res. and Nano. Lett. He was the founder of the Nanoscience subdivision within American Chemical Society. He has co-founded two startups Nanosys Inc. and Alphabet Energy Inc. He is the recipient of MRS Medal, Baekeland Medal, Alfred P. Sloan research fellowship, the Arnold and Mabel Beckman Young Investigator Award, National Science Foundation Young Investigator Award, MRS Young Investigator Award, Julius Springer Prize for Applied Physics, ACS Pure Chemistry Award, and Alan T. Waterman Award. According to ISI (Thomas Reuters), Yang is ranked as No. 1 in materials science and No. 10 in chemistry for the past 10 years based on average citation per paper. His main research interest is in the area of one dimensional semiconductor nanostructures and their applications in nanophotonics and energy conversion.

# Invited Speakers

2013 Fitzpatrick Institute for Photonics (FIP) Annual Meeting
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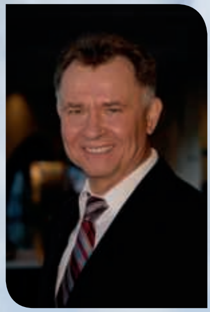
**Frederick Haibach, Ph.D.**
*Block Engineering*

*"Creating new frontiers of infrared spectroscopy"*

Modern practice of infrared spectroscopy is almost synonymous with the use of "FTIR." Instruments that serve as tunable light sources or tunable detectors have fallen by the wayside as the performance of interferometers complements incandescent sources. Many of the published advantages of interferometers rely on the limitations of the incandescent source. Recent advances in interferometers seek to recapture of the applications where dispersive instruments proved to have superior performance. Step-scan was the most prominent of these advances. The dominance is now so complete, that many modern practitioners of infrared spectroscopy have experience with other spectroscopic instrument designs only peripherally through terahertz, near-infrared or UV-vis.

Quantum cascade lasers (QCLs) make it possible to take advantage of both laser properties and widely tunable infrared. The four advantages that QCLs provide over incandescent sources are: (1) orders of magnitude higher spectral radiance, (2) nearly diffraction-limited source size, (3) collimated light and (4) inherently greater than 100:1 polarization. Pulsed mode operation makes it possible to obtain operation across hundreds of wavenumbers in a single unit. Other properties, such as scan rates in milliseconds, miniaturization, low power consumption and ultrahigh resolution spectroscopy depend on the laser packaging. These advantages enable spectroscopy that is difficult or impossible to do well with incandescent sources. Standoff absorbance measurements, efficient fiber and ATR coupling, microscopy and measurements on high absorbance materials have now become possible without compromising effectiveness. Direct measurements are now possible that were not previously achievable, or required extensive work around. Examples and performance of these types of spectroscopy will be discussed.

Dr. Fred Haibach's primary function at Block Engineering is to lead the applications engineering team and provide feedback on instrument designs and improvements as well as project management for new algorithms in spectroscopy. A large portion of the role is developing technical solutions both for spectroscopy and algorithms for the QCL laser products. Understanding material composition, structure and optical properties are essential tools for developing robust methods. Dr. Haibach's background is in vibrational spectroscopy, mid-infrared, near-infrared and Raman, as well as other analytical techniques in Chemistry.



**Victor I. Klimov, Ph.D.**
*Laboratory Fellow*
*Director, Center for Advanced Solar Photophysics*
*Los Alamos National Laboratory*

*"Making most of the absorbed photon: New insights into carrier multiplication in semiconductor nanostructures"*

Carrier multiplication (CM) or multiexciton generation (MEG) is a process whereby absorption of a single photon produces multiple electron-hole pairs (excitons). CM could benefit a number of solar-energy conversion technologies, most notably photocatalysis and photovoltaics. This presentation overviews recent progress in understanding of the CM process in semiconductor nanocrystals, motivated by an outstanding challenge in this field - the lack of capability to quickly discern between candidate nanomaterials for enhanced CM performance. We present a possible solution to this problem by showing that using measured biexciton Auger lifetimes and intraband relaxation rates as surrogates for, respectively, CM time constants and non-CM energy-loss rates we can rationalize relative changes in CM yields as a function of composition. Indeed, by studying PbS, PbSe, and PbTe NCs for a variety of sizes we determine that the significant difference in CM yields for these compounds comes from the dissimilarities in their non-CM relaxation channels, i.e., the processes that compete with CM. We further explore the role of nanostructure shape in the CM process. We observe that via a moderate elongation (aspect ratio of 6–7) of PbSe NCs we can obtain up to an approximately two-fold increase in the multiexciton yield compared to spherical nanoparticles. Beyond this appreciable improvement in CM, increased Auger lifetimes and improved charge transport properties (generally associated with elongated nanostructures) suggest that lead chalcogenide nanorods are a promising system for testing CM concepts in practical photovoltaics. Finally, we discuss how this newly developed understanding can help in the development of tailored nanostructures with CM performance approaching that at the energy-conservation defined limit.

Victor I. Klimov is a Fellow of Los Alamos National Laboratory and the Director of the Center for Advanced Solar Photophysics of the U.S. Department of Energy. He received his M.S. (1978), Ph.D. (1981), and D.Sc. (1993) degrees from Moscow State University. He is a Fellow of the American Physical Society, a Fellow of the Optical Society of America, and a former Fellow of the Alexander von Humboldt Foundation. His research interests include optical spectroscopy of semiconductor and metal nanostructures, carrier relaxation processes, strongly confined multiexcitons, energy and charge transfer, and fundamental aspects of photovoltaics.

**Dr. Robert A. Lieberman, President & CTO**
*Intelligence Optical Systems (IOS)*

*"Fiber Optic Sensors for Energy Applications"*

Dr. Robert A. Lieberman, President, Intelligent Optical Systems (IOS), received his Ph.D. in Physics with an emphasis on solid-state physics and biophysics from the University of Michigan in 1981. Dr. Lieberman then joined AT&T Bell Laboratories where he was a Member of the Technical Staff for ten years. Before founding IOS, he served as Vice President and General manager for Research and Development at Physical Optics Corporation. He holds 34 U.S. patents and has chaired more than 25 conferences and symposia on fiber optic sensors and optical biosensors. He is Chairman of ASTM Subcommittee E13.09 on standards for Fiber Optic Waveguides and Optical Sensors. Dr. Lieberman is a Fellow of SPIE, a Senior Member of IEEE, has served on the editorial boards of Optical Engineering and the Journal of Measurement Science and Technology, and on the boards of directors of SPIE, IOS, OpTech Ventures, Optinetrics, Sensorware Systems, Optical Security Sensing LLC, and the South Bay Science Center. He is the 2008 winner of the SPIE President's Award, three NASA Tech Briefs awards, and three Bell Labs Exceptional Contribution Awards.

**Jonathan Lindsey, Ph.D.**
*Glaxo Distinguished University Professor of Chemistry*
*North Carolina State University*

*"Capturing Near-Infrared Light with Synthetic Chlorophylls for Solar Photoconversion"*

The near-infrared spectral region (NIR, 700–1000 nm) is relatively unexplored in photochemical studies yet nearly half of the usable photons from the sun reside in this spectral window. Nature employs bacteriochlorophylls in photosynthetic bacteria to capture NIR photons, yet synthetically malleable analogues of bacteriochlorophylls (i.e., bacteriochlorins) have until recently remained inaccessible. The challenge of light-harvesting also entails organization of a large number of such pigments in a 3-dimensional architecture such that excited-state energy is funneled with minimal quenching to a designated site. We recently have developed rational synthetic methods for the construction and tailoring of stable bacteriochlorins, giving rise to a palette of bacteriochlorins with strong absorption in the 700–900 nm region. The bacteriochlorins have been tailored for use as molecular building blocks with tunable spectral, photophysical, redox, and solubility properties. To address the daunting organizational issue, we have conjugated the bacteriochlorins to analogues of natural light-harvesting peptides. The ensuing self-assembly affords a macrocyclic architecture that incorporates as many as 36 pigments, which together function to capture visible and NIR light. Such biohybrid systems, which draw on principles from biology and make ample use of modern chemical synthesis, open the door to diverse studies in artificial photosynthesis.

Jonathan Lindsey received his B.S. Degree (with Distinction and Honors) in Chemistry from Indiana University in 1978 and Ph.D. from The Rockefeller University in 1983. His doctoral and postdoctoral work with Dr. David C. Mauzerall concerned the synthesis and photochemical characterization of a model for the reaction center of photosynthetic bacteria. After 12 years on the faculty at Carnegie Mellon University, he joined NC State University in 1996 as Glaxo Distinguished University Professor. His research concerns fundamental studies of the synthetic chemistry and photochemistry of compounds that constitute the "pigments of life" (heme, chlorophylls, bacteriochlorophylls, vitamin B12, etc.) and their use in artificial photosynthesis and the life sciences. He has developed versatile de novo methods for the synthesis of porphyrins, chlorins, and bacteriochlorins. A longstanding interest in light-harvesting has led to the design, synthesis, and characterization of chromophore building blocks and their incorporation in multi-chromophore architectures, including bio-inspired, self-assembling systems that absorb across the visible and near-infrared regions. An extension of his synthetic work has led to discovery of a plausible prebiotic route to porphyrins, which could form the basis for the emergence of proto-photosynthesis and drive the origin of life.

**Henry Schriemer, Ph.D.**
*Associate Professor, Electrical Engineering*
*SUNLAB*
*University of Ottawa*

*"Third Generation Strategies in High-Efficiency Solar Cell and System Design"*

In order for photovoltaics to reach grid parity, i.e. be cost competitive with conventional sources of energy, such as coal and nuclear power, in areas other than highly sunny locations, there must be a simultaneous increase in solar cell efficiencies and an overall decrease in their manufacturing cost [1]. Flat silicon panels have been leading the way forward with costs as low as $0.70/watt, and typical efficiencies in the range of 15-20%. Although silicon panel technology sets the current standard for solar power, further advancements will come at a slow pace as the technology has nearly reached maturity. In contrast, dramatic increases in efficiency have been achieved with multi-junction solar cells composed of III-V semiconductors, albeit using relatively high-cost manufacturing processes. Manufacturing efficiencies >40% have been achieved by triple junction solar cells composed of GaInP/InGaAs/Ge. Variations on this design, including the use of metamorphic layers and dilute nitride subcells, now hold the world record for solar cell efficiency of 44%. These third generation photovoltaic technologies are expected to reach the 50% efficiency benchmark within the next decade, assuming that current PV device efficiencies continue to increase by ~1%/year. Here we present numerical and experimental research from the University of Ottawa SUNLAB that explores the potential avenues for achieving a >50% efficiency solar cell and cost reduction strategies. This research includes: four junction solar cell designs utilizing dilute nitrides [2-3] and quantum confinement structures [4]; cost reduction of epitaxial growth via the growth of III-V semiconductors on porous Si substrates [5]; and light guided high concentration photovoltaics systems that have dimensions similar to a flat silicon panel.

[1] S. D'Souza, J. Haysom, H. Anis, and K. Hinzer, "The Down-to-Earth Future of Si Substrate Multi-junction Concentrator Photovoltaics,", IEEE Electricity and Power Engineering Conference (EPEC), Oct. 3-5, 2011. pp. 57-61. Winnipeg, Canada. ieeexplore.ieee.org.

[2] G. Arbez, A. Walker, M. Wilkins, J. F. Wheeldon, K. Hinzer, and H. Schriemer, "4 Junction Dilute Nitride Solar Cell Optimization: Comparing Current Matching Approaches in Detailed Balance Algorithms," 2013 IEEE 39th Photovoltaic Specialists Conference, Tampa, USA, June 16-21 2013. Submitted.

[3] M. Wilkins, A. Walker, J. F. Wheeldon, G. Arbez, H. Schriemer, and K. Hinzer, "Design Constraints of p-i-n GaAs/InGaAsN Dilute Nitride Sub-Cells for 3- and 4-Junction Solar Cell Applications under Concentrated Illumination," 2013 IEEE 39th Photovoltaic Specialists Conference, Tampa, USA, June 16-21 2013. Submitted.

[4] A. Walker, O. Thériault, J. F. Wheeldon, and K. Hinzer, "The Effects of Absorption and Recombination on Quantum Dot Multi-Junction Solar Cell Efficiency," IEEE J. Photovoltaics. Accepted January 2013.

[5] M. Wilkins, A. Boucherif, R. Beal, J. E. Haysom, J. F. Wheeldon, V. Aimez, R. Arès, T. J. Hall, and K. Hinzer, "Multijunction Solar Cells using Bottom Subcell and Porous Silicon Compliant Membrane," IEEE J. Photovoltaics. Accepted January 2013.

**Henry Schriemer** received the B.Sc. degree in mathematics, and the Ph.D. degree in physics from the University of Manitoba, Canada, in 1987 and 1997, respectively. He is currently an Associate Professor in Electrical Engineering at the University of Ottawa. where he previously held an NCIT Research Fellowship in Photonics from 2003 to 2005. His research interests generally lie within engineered complex systems, with a focus on photonic technologies for energy efficiency. His current activities range from the modeling of multijunction concentrator solar cells and systems, the design and test of thermal-photovoltaic receivers, the development of spectral models that incorporate local weather conditions, and impact of variable generation on the electrical distribution system. Prior to this, he spent several years in the photonics industry, where he is recognized as one of the innovators of strain engineered planar lightwave circuits. His previous research accomplishments have ranged from the description of optical singularities in photonic crystals, to fundamental advances in the design and realization of laterally-coupled distributed feedback lasers. He has held a Postdoctoral Fellowship in laser physics and nanophotonics at the van der Waals-Zeeman Institute, The Netherlands, where he made the first measurements of significant spontaneous emission inhibition in active photonic crystals. He has authored over 60 refereed publications.

**K-C Tran, CEO and Co-founder**
*Carbon Recycling International, Ehf*

*"Renewable Methanol from Emissions and Renewable Energy: Conversion to Green Mega Joules by Electro-thermo-chemical-synthesis and photo-synthesis"*

This presentation describes the advancement of Carbon Recycling International in carbon recycling science and technology, the electro-thermo-chemical synthesis of renewable methanol from carbon dioxide and renewable energy, and the regulatory and infrastructure challenges in the market place. It includes the company long term research in making renewable methanol by photosynthesis of water and carbon dioxide in collaboration with the Nordic industry and university partners.

Mr. Tran graduated from MIT in Management and Rensselaer Polytechnic Institute in Nuclear Engineering. He did advanced studies in management at Stanford and in Engineering at Dartmouth College.

He co-founded Carbon Recycling International, Ehf in 2006, where he currently serves as its Chief Executive and a Director of the Board since inception in Iceland. Prior to founding Carbon Recycling International, he was an executive and engineer at Thermo Electron and Westinghouse Electric Corporation in the US.

He is the Chairman of Cleantech Association of the Federation of Industries Iceland and was the recipient of the Icelandic Fulbright Commission for the US Icelandic Partnership Award.
Mr. Tran is a citizen of the US. He resides with his family in Gardarbaer, Iceland.

**Wei You, Ph.D.**
*Associate Professor of Chemistry*
*University of North Carolina*

*"Conjugated Polymers for Harvesting Solar Energy: The Impact of Side Chains and Fluorine"*

In the past two decades, the bulk heterojunction (BHJ) organic photovoltaic cells, arguably one of the hottest research fields, has attracted tremendous amount of research efforts. Impressive progress has been made through synergistic efforts of chemists, physicists, and engineers. For example, the efficiency has reached 8 – 10% recently, largely through the engineering the conjugated backbone of these polymers to reach ideal energy levels and band gaps.

However, side chains and fluorine substituents on conjugated polymers have shown significant impacts on the photovoltaic properties these polymers based devices. We comprehensively investigate a series of conjugated polymers with an identical backbone but different combinations of side chains and F substituents, aiming to elucidate the fundamental mechanisms that govern the impacts of the side chains and F substitutions.

Wei You obtained his BS from University of Science and Technology of China in 1999. He graduated with his PhD from the University of Chicago in 2004 with Professor Luping Yu, and finished his postdoctoral training at Stanford University in 2006 with Professor Zhenan Bao. In July 2006, Dr. You joined the University of North Carolina at Chapel Hill as an Assistant Professor in Chemistry, and was promoted to the rank of Associate Professor in 2012. He has published over 30 papers in leading journals such as JACS, Angew. Chem., Int. Ed., Macromolecules, Advanced Materials, among others. He has been awarded a DuPont Young Professor Award (2008), a NSF CAREER Award (2010), a Camille Dreyfus Teacher-Scholar Award (2011), a Tanner Award for Excellence in Undergraduate Teaching (2011), and a CAPA Distinguished Junior Faculty Award (2012). His group is currently investigating organic solar cells, molecular spintronics/electronics and devices, new methods for nanofabrication (microfabrication), and new materials for dental applications.

**Kristin Weidemaier, Ph.D., Technology Manager**
*BD Technologies*
*Senior Manager*

*"SERS Nanotechnology for the Development of Medical Diagnostics"*

Surface Enhanced Raman Scattering (SERS) is of growing interest in medical diagnostics because of its potential for sensitive, multiplexed detection of conditions ranging from cancer to infectious diseases. SERS combines a unique set of attributes including bright signals, near-infrared excitation, and spectral fingerprints that can be easily multiplexed and clearly distinguished from background fluorescence common in biological samples. In this talk, the development of SERS-based diagnostics for Point-of-Care and Developing World applications will be described. The technology uses a glass-encapsulated gold nanoparticle in a homogeneous no wash assay format that permits the detection of proteins, cells, and nucleic acids directly in complex biological samples without the need for wash steps. Commercialization considerations around manufacturing, cost, and performance will also be discussed.

Dr. Kristin Weidemaier is a Senior Manager in Becton Dickinson's Biosensors department, where she has spent the past 10 years designing biosensors and in vitro diagnostics. Kristin's group works on new technology development, with an emphasis on taking technology from a feasibility stage through to product development. She currently leads BD's nanotechnology R&D program which is focused on nanotechnology-based diagnostics for Point-of-Care applications.

Kristin has a Ph.D. in physical chemistry from Stanford University and an undergraduate degree from Duke University. She has a background in optics and spectroscopy, combined with fifteen years of industrial experience in assay and instrumentation development.

# Duke Speakers

**David Beratan, Ph.D.**
*RJ Reynolds Professor of Chemistry*
*Professor of Biochemistry and Physics*
*Duke University*

*"The elementary events of solar fuel production: some theoretical challenges"*

The elementary events of solar photochemistry are light absorption, exciton transport, and free carrier generation. We have been carrying out studies of these processes in organic materials, hybrid organic-inorganic structures, proteins, and nucleic acids. I will summarize our very recent progress, focusing on three vexing puzzles: (1) Why don't organic chromophores deliver the full oscillator strength promised by the Thomas-Kuhn sum rule of quantum mechanics? (2) What is the molecular mechanism for exchange-mediated (or through-bond) Dexter excitation-energy transfer? (3) Under what circumstances may charge transfer through organic bridges be enhanced by transient or flickering resonance among electronic states? These projects are under study in my research group at Duke, in collaboration with Jiaxing Lin, Chaoren Liu, Nicholas Polizzi, Aaron Virshup, Gary Zhang, and Peng Zhang, with support from NSF, DOE, NIH, and ONR.

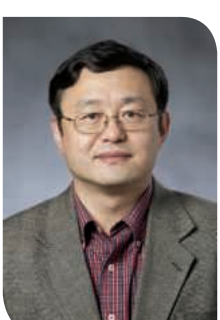
David Beratan studied Chemistry at Duke (BS, 1980) and at Caltech (PhD, 1985). Following National Research Council and technical staff appointments at NASA's Jet Propulsion Laboratory, he moved to the University of Pittsburgh as Associate Professor in 1992 and was later Professor of Chemistry. At JPL and Pittsburgh, David established the first atomic-resolution theories for electron tunneling in proteins and nucleic acids, including the popular tunneling pathway model for biological electron transfer. He also established new theoretical approaches for assigning the absolute stereochemistry of complex natural products through the computation of optical rotation angles. In 2001, David returned to Duke, where he has focused on dynamical issues in charge transfer (with applications to molecular biophysics, DNA nanoelectronics, and solar energy conversion), inverse design of optimal materials, molecular diversity and library design, and molecular chirality. He serves on the leadership teams of the Duke University Energy Initiative, the UNC-Chapel Hill Energy Frontier Research Center, and the RTI Solar Fuels Institute. Honors include a J.S. Guggenheim Foundation fellowship, fellowship election to AAAS and APS, and named visiting professorships at the Universities of Pennsylvania, Chicago, and Oxford. David is on the editorial advisory boards of two journals and serves as an NIH study section member. His research program is supported by NSF, DOE, NIH, ONR and NASA.

**Nico Hotz, Ph.D.**
*Assistant Professor of Mechanical Engineering and Materials Science*
*Duke University*

*"Solar-power hydrogen production"*

In this talk, two concepts of hydrogen production under sunlight will be discussed:
On the one hand side, we have investigated the idea of converting (ideally biomass-derived) hydrocarbon and alcoholic fuels to a hydrogen-rich gas mixture using steam reforming. Since steam reforming is an endothermic reaction and the reactants have to preheated and evaporated, the required thermal energy is significant to perform the reaction. A solar collector has been developed using highly selective, nano-scale absorber coatings and advanced thermal designs to achieve collector temperature up to 250-C under non-concentrated sunlight. Methanol, as an example, has been converted to hydrogen in such collectors with the help of highly active catalyst nanoparticles, and the hydrogen is subsequently reacted in a low-temperature fuel cell to generate electricity. By taking advantage of sunlight as a cost-effective energy source to upgrade the initial fuel, drastically higher energy efficiencies and power densities can be achieved.  On the other hand, ideas have been developed to directly use photonic energy to generate hydrogen via water splitting or fuel reforming, without a separate step of light absorption and heat transfer to a catalyst. By generating nano-scale structures with the ability to harvest sunlight and use the solar energy to initiate catalytic reaction at the same location or in very close vicinity, the need for heat transfer over longer distances with its attributed energy losses will be avoided.

Dr. Nico Hotz received his Ph.D. in 2008 from ETH Zurich, Switzerland, and worked at UC Berkeley as a postdoctoral researcher in 2009/2010. In 2010, he joined the Department of Mechanical Engineering and Materials Science at Duke University, where he heads the Thermodynamics and Sustainable Energy Lab. He received the Georg A. Fischer Award 2009 for his Ph.D. thesis, the Best Paper Award of the ASME Energy Sustainability Conference 2010, and the 2012 Ralph. E. Power Junior Faculty Enhancement Award by the Oak Ridge Associated Universities.



**Jie Liu, Ph.D.**
*George B. Geller Professor of Chemistry*
*Duke University*

*"Chemically Doped ZnO as white light Phosphors"*

Improving the efficiency of general lighting is one of the approaches our society needs to take for a more sustainable energy future. There is a strong need to find better materials and techniques for efficient white light generation. Current single color LEDs can reach an efficiency of about 50%, two times better than fluorescent lamps, and ten times more efficient than incandescent lamps. However, current white LEDs, which use ultraviolet LEDs to excite white light phosphors, demonstrate lower efficiency with rather poor color quality using phosphors that contains rare-earth elements, are costly, toxic, and degrade in performance with increasing temperature. Indeed, the DOE "Basic Research Needs for Solid-State Lighting" report identifies the need for new photon conversion materials (i.e. phosphors) as a major research objective to pave the way for next generation solid-state lighting (SSL) devices. More recently, the need to eliminate the dependence of an industry on rare-earth elements also makes the discovery of new phosphors, that are highly efficient and rare-earth element free, a priority in white lighting field. Recently, we and others have shown the potential of zinc oxide (ZnO) nanostructures as a compelling candidate for solid state lighting (SSL) phosphors.1-2  ZnO is an inexpensive, easily manufactured, stable, environmentally friendly, non-toxic material widely used in sun block, diaper rash medicine, galvanization, and vulcanization. There are many advantages in using ZnO as a white light phosphor compare to other existing phosphors. We have pursued an intensive investigation of the energy transfer dynamics of doped ZnO nanostructures using ultrafast spectroscopic techniques in close collaboration with researchers in the Army AMRDEC WS. (Dr. Henry Everitt and Dr. John Foreman) and obtained many insights that will make ZnO an important material in white light LED applications.

References: 1. Burgess, D. S., ZnO nanowire LEDs emit white light. Photonics Spectra 2005, 39 (3), 116-116.
2. Foreman, J. V.; Li, J. Y.; Peng, H. Y.; Choi, S. J.; Everitt, H. O.; Liu, J., Time-resolved investigation of bright visible wavelength luminescence from sulfur-doped ZnO nanowires and micropowders. Nano Letters 2006, 6 (6), 1126-1130.

Jie Liu is currently the George B Geller Professor of Chemistry at Duke University. He earned a B.S. in Chemistry from Shandong University in 1987 and a Ph.D. in Chemistry from Harvard University in 1996.  His research interests include synthesis and chemical functionalization of nanomaterials, light emission from doped metal oxide nanostructures, nanoelectronic devices, scanning probe microscopy and carbon nanomaterials. As a faculty member, Professor Liu has received the DuPont Young Professor Award, Outstanding Oversea Young Investigator Award from NSF-China, Ralph E. Powe Junior Faculty Enhancement Award from Oak Ridge Associated Universities, Bass Professorship from Duke University for excellence in teaching and research and elected as AAAs fellow in 2013.

**Maiken H. Mikkelsen, Ph.D.**
*Assistant Professor, Electrical and Computer Engineering*
*Assistant Professor, Physics*
*Duke University*

*"Enhanced light-matter interactions of a single emitter coupled to a slot waveguide"*

Strong and controllable light-matter interactions at the single emitter-photon level are of fundamental importance for many quantum information applications. While narrow cavity resonances are traditionally used for strong optical interactions, sub-wavelength plasmonic nano-structures have recently been introduced to improve emission directivity and coupling to tightly confined electromagnetic modes. However, these approaches suffer from metal-intrinsic absorption and emission quenching. Here, we demonstrate strong optical interactions at the single photon and emitter level using an all-dielectric nanoscale waveguide that allows a deep sub-wavelength field confinement. A slot-waveguide architecture is employed squeezing light in a low index gap region between a high index dielectric nanowire and slab. The large discontinuity in the indices of refraction concentrates the field in a nanometer scale gap region below the nanowire, constituting a squeezed one-dimensional waveguide mode. Using the tip of an Atomic Force Microscope (AFM), individual colloidal quantum dots are controllably coupled to this waveguide mode. Strongly enhanced spontaneous emission rates are observed along with significant blinking suppression and efficient coupling. The small footprint and broadband nature of this dielectric system suggests a broader use for efficient on-chip optical components and networks both at the classical and quantum level.

Maiken H. Mikkelsen is an Assistant Professor of Electrical and Computer Engineering and Physics at Duke University. She received her B.S. in Physics from the University of Copenhagen, Denmark in 2004 and her M.A. and Ph.D. degrees in Physics from the University of California, Santa Barbara in 2007 and 2009, respectively. She did her PhD in the group of Prof. David Awschalom on experimental studies of single electron spins in semiconductor quantum dots. Before joining Duke, she was a postdoctoral fellow in the group of Prof. Xiang Zhang at the University of California, Berkeley doing research in the area of nanophotonics. In 2011 she received the European Physical Society's Ph.D. Thesis prize from the Quantum Electronics and Optics Division. Her research interests include experimental studies of spin dynamics in solid state systems, light-matter interactions in nanostructures, nanophotonics, metamaterials, and quantum information science.

**Adrienne Stiff-Roberts, Ph.D.**
*Associate Professor*
*Electrical and Computer Engineering*
*Duke University*

*"Colloidal Quantum Dot-Conducting Polymer Nanocomposites for Multi-spectral Photodetection"*

Multi-spectral photodetection can increase the spectral resolution of IR imaging focal plane arrays and improve the power conversion efficiency of solar cells. Colloidal quantum dots (CQDs) could provide an important advantage as the active region material in such devices because multi-spectral photon detection across a wide spectral range can be integrated at the device level by changing the nanoparticle material, size, and/or shape. In addition, there are no inherent restrictions, such as strain or contamination, to limit the different types of nanoparticle materials that can be combined in a single heterostructure. However, two long-standing, fundamental challenges to the use of CQD-conducting polymer nanocomposites for photodetection are controlling the nanoscale morphology and achieving efficient charge transfer through insulating ligand layers surrounding the quantum dots. Therefore, in this talk, I will review progress in addressing these fundamental challenges.

Adrienne D. Stiff-Roberts is an Associate Professor in the Department of Electrical and Computer Engineering at Duke University. Dr. Stiff-Roberts received both the B.S. degree in physics from Spelman College and the B.E.E. degree in electrical engineering from the Georgia Institute of Technology in 1999. She received an M.S.E. in electrical engineering and a Ph.D. in applied physics in 2001 and 2004, respectively, from the University of Michigan, Ann Arbor. Her current research interests include materials growth of polymer, nanoparticle, and organic/inorganic hybrid nanocomposite thin films by matrix-assisted pulsed laser evaporation (MAPLE); epitaxial materials growth of thin-films and nanostructures; structural, optical, and electrical materials characterization of organic and inorganic materials; and the design, fabrication, and characterization of organic and inorganic optoelectronic devices, especially multi-spectral photodetectors. Dr. Stiff-Roberts is a recipient of the National Science Foundation CAREER Award (2006), the Office of Naval Research Young Investigator Award (2007), the IEEE Early Career Award in Nanotechnology of the Nanotechnology Council (2009), and the Presidential Early Career Award in Science and Engineering (2009).

**Jennifer West, Ph.D.**
*Fitzpatrick Family University Professor of Engineering, Professor of Biomedical Engineering, Mechanical Engineering and Materials Science, Cell Biology and Chemistry*
*Duke University*

*"Therapeutic and Diagnostic Applications of Gold Nanoshells"*

The increasing capability to manipulate matter at the nanoscale is generating new materials with unique properties that promise to address unmet medical needs for future generations. As an example, metal nanoshells are a relatively new class of nanoparticles with highly tunable optical properties. Metal nanoshells consist of a dielectric core nanoparticle such as silica surrounded by an ultrathin metal shell, usually composed of gold for biomedical applications. Depending on the size and composition of each layer of the nanoshell, particles can be designed to either absorb or scatter light over much of the visible and infrared regions of the electromagnetic spectrum, including the near infrared region where penetration of light through tissue is maximal.

For photothermal cancer therapy, nanoshells can be fabricated to achieve strong near infrared absorption, injected intravenously to accumulate at tumor sites due to the enhanced permeability and retention (EPR) effect and/or molecular targeting, then generate heat upon illumination with near infrared light, leading to destruction of the tumor. This has shown very promising results in several animal models. For example, in a mouse colon carcinoma model, we demonstrated 100% survival of nanoshell treated mice at 1 year. These materials are now in three phase I human clinical trials.

For use in diagnostics and imaging, nanoshells can be designed to strongly scatter near infrared light. Molecularly targeted nanoshells have been used as optical contrast agents for cancer imaging with sub-cellular resolution. For example, anti-HER2 conjugated nanoshells allow near infrared imaging of HER2+ breast carcinoma cells. Furthermore, integrated imaging and therapy applications have been accomplished with nanoshells designed to provide both absorption and scattering, potentially enabling "see-and-treat" approaches to cancer therapy. Gold nanoshells also provide x-ray contrast due to the electron density of gold and can be conjugated to MR contrast agents such as gadolinium to provide highly mulit-modal imaging capabilities in addition to therapy as well.

**Jennifer West** recently joined the faculty at Duke, after having been the department chair and Cameron Professor of Bioengineering Rice University. Professor West was one of the founding members of Rice's Department of Bioengineering, building it to a top ten program over the past sixteen years.

Professor West's research focuses on the development of novel biofunctional materials. Part of her program has developed nanoparticle-based approaches to biophotonics therapeutics and diagnostics. An example of this work is the application of near-infrared absorbing nanoparticles for photothermal tumor ablation. In animal studies, this therapeutic strategy has demonstrated very high efficacy with minimal side effects or damage to surrounding normal tissues. In 2000, Professor West founded Nanospectra Biosciences, Inc. to commercialize the nanoparticle-assisted photothermal ablation technology, now called AuroLase. Nanospectra Biosciences, Inc., located in Houston, TX, is the recipient of a NIST ATP Award and a grant from the Texas Emerging Technology Fund. Professor West is a director of the company. The company has built GMP manufacturing facilities, and AuroLase cancer therapy is now in three human clinical trials.

Professor West has received numerous accolades for her work. In 2010 she was named Texas Inventor of the Year and also Admiral of the Texas Navy (highest honor the governor of Texas can bestow on a civilian). In 2008, The Academy of Medicine, Engineering and Science of Texas honored her with the O'Donnell Prize in Engineering as the top engineer in the state. In 2006, she was named one of 20 Howard Hughes Medical Institute Professors, recognizing integration of world class research and teaching. She has been listed by MIT Technology Review as one of the 100 most innovative young scientists and engineers world wide. Other recognitions include the Christopher Columbus Foundation Frank Annunzio Award for scientific innovation, Nanotechnology Now's Best Discovery of 2003, Small Times Magazine's Researchers of the Year in 2004, and the Society for Biomaterials Outstanding Young Investigator Award.

Professor West has authored more than 140 research articles. She also holds 14 patents that have been licensed to eight different companies. She has lectured at numerous institutions, including Harvard, Harvard Medical School, MIT, FDA, and NCI. She was an invited speaker at the 2006 Nobel Symposium.

Professor West has served as a member of the Bioengineering, Technology, and Surgical Sciences study section at NIH, and has served on numerous other review boards for NIH and NSF. She has also been a member of the Defense Sciences Study Group, a member of the NRC panel on management of university intellectual property, and a member of the AAMC panel on research. Her laboratory receives funding from NIH, NSF, Howard Hughes Medical Institute, and DOD.

**Xuanhe Zhao, Ph.D.**
*Assistant Professor*
*Mechanical Engineering and Materials Science*
*Duke University*

*"Multifunctionality and control of the crumpling and unfolding of large-area graphene"*

Crumpled graphene films of atomic thickness are used in diverse applications including electronics, energy storage, composites, and biomedicine. While it is known that the degree of crumpling strongly affects the properties of graphene and the performance of graphene-based devices and materials, in existing technology it is not possible to fold and unfold crumpled graphene films in a controlled manner. Here we present a new approach, investigated by joint experiment, atomistic simulation and theory, to control reversible crumpling and unfolding of large-area graphene, achieved by harnessing mechanical instabilities of graphene adhered on highly pre-strained polymer substrate. By relaxing the pre-strain in the substrate in a particular order, we crumple graphene films into tailored self-organized hierarchical structures that mimic super-hydrophobic leaves. The degree of crumpling in graphene is controlled by stretching/relaxing the substrate. The reversible crumpling and unfolding of graphene films enables us to fabricate large-area conductive coatings and electrodes capable of giant stretchability, high transparency, super-hydrophobicity, and tunable wettability. We further demonstrate the use of novel graphene-polymer laminates as artificial muscles.
Reference: Zang et al, Nature Materials, doi:10.1038/nmat3542 (2013).

Xuanhe Zhao received his PhD in Mechanical Engineering from Harvard University in 2009, MS in Materials Engineering from University of British Columbia in 2006, and BE in Electrical Engineering from Tianjin University in 2003. Upon finishing a postdoctoral training in Biomedical Engineering at Harvard, in 2010, Zhao joint the faculty of Duke University and founded the Soft Active Materials Laboratory. Dr. Zhao is the winner of Faculty Early Career Development (CAREER) Award from National Science Foundation and Early Career Researchers Award from AVS Biomaterial Interfaces Division.

# Panel Members

**Rudy Baum, Ph.D. (Moderator)**
*Editor-at-Large*
*Chemical & Engineering News*

After a 32-year career at Chemical & Engineering News, the weekly news magazine published by the American Chemical Society, Rudy M. Baum is now reviewing books and obtaining and editing outside-written book reviews for the magazine as C&EN's first editor-at-large.

Baum earned a B.A. in chemistry from Duke University in 1975 and spent one year studying at Georgetown Medical School before joining the staff of the Education Division of the American Chemical Society in Washington, D.C., in 1976. He joined the staff of C&EN in 1980 as a production editor and moved to the San Francisco Bay Area in 1981 to become the magazine's West Coast Bureau Head, a position he held for 14 years. His coverage included all areas of basic chemical research, especially physical chemistry, atmospheric chemistry, and the discovery of C60, carbon nanotubes, and nanotechnology. He also covered environmental issues, the emerging HIV/AIDS epidemic, the evolution/creationism debate, and global climate change.

In 1994, Baum returned to Washington to become C&EN's Assistant Managing Editor for science/technology/education coverage. He was promoted to Managing Editor in 1995 and, working closely with Editor-in-chief Madeleine Jacobs, reinvented C&EN as the premier news magazine in the world covering chemistry and related scientific disciplines, the environment and energy issues, STEM education, and the chemical, pharmaceutical, and biotechnology industries. Baum was promoted to C&EN Editor-in-chief in 2004. During his tenure, he wrote more than 300 editorials on topics ranging from climate change and sustainability to an appreciation of Kurt Vonnegut after the writer's death in 2007.

Baum, who is 59 years old, has been married to his wife, Jan (a retired third-grade school teacher), for 31 years. They have two sons, Rudy Jr. (25) and Greg (23). Rudy and Jan enjoy traveling and are avid about outdoor activities, including hiking, bicycling, and scuba diving.

**Richard Newell, Ph.D.**
*Director of Duke Energy Initiative*
*Gendell Associate Professor of Energy and Environmental Economics*
*Duke University*

Dr. Richard G. Newell is the Gendell Professor of Energy and Environmental Economics at the Nicholas School of the Environment, Duke University and Director of Duke's university-wide Energy Initiative. He is the former head of the U.S. Energy Information

Administration (EIA) and has also served as the Senior Economist for energy and environment on the President's Council of Economic Advisers. He is on the Board of Directors of Resources for the Future, where he was previously a Senior Fellow. He is a Research Associate of the National Bureau of Economic Research, has served on numerous boards and National Academy of Science expert committees related to energy, environment, and innovation, and has participated in National Petroleum Council studies on the Future of Transportation Fuels, the North American Resource Base, and Global Oil and Gas. He holds a Ph.D. from Harvard University and an M.P.A. from Princeton's Woodrow Wilson School.

**Vikram Rao, Ph.D.**
*Executive Director*
*Research Triangle Energy Consortium*

Vikram Rao is Executive Director, Research Triangle Energy Consortium www.rtec-rtp.org , a non-profit in energy founded by Duke University, North Carolina State University, RTI International and University of North Carolina at Chapel Hill. Its mission is to illuminate national energy priorities, and those of the world by extension, and to catalyze research to address these priorities.

Dr. Rao serves on the board of Intelligent Well Controls Ltd. and also advises venture capitalist Energy Ventures AS, and firms BioLargo Inc., Global Energy Talent Ltd. and Integro Earth Fuels Inc. He retired as Senior Vice President and Chief Technology Officer of Halliburton Company in 2008 and followed his wife to Chapel Hill, NC, where she is on the faculty. Later that year he took his current position. He also serves on North Carolina Mining and Energy Commission and chairs the Water and Waste Management Committee. Dr. Rao's book Shale Gas: the Promise and the Peril was recently released by RTI Press and can be found at www.rti.org/shalegasbook . It is written for general audiences and is intended to inform on the heated debate on fracturing for shale gas.

**James B. Roberto, Ph.D.**
*Deputy Director*
*Oak Ridge National Laboratory*

James B. Roberto is Interim Deputy for Science and Technology and Associate Laboratory Director for Science and Technology Partnerships at Oak Ridge National Laboratory (ORNL). As Interim Deputy, he has overall responsibility for ORNL's science and technology portfolio, strategic directions and investments, and key relationships with sponsors and stakeholders. As Associate Laboratory Director, he is responsible for technology transfer and industry and university partnerships. He previously served as ORNL's Deputy for Science and Technology, Associate

Laboratory Director for Physical Sciences, and Director of the Solid State Division. His research interests include condensed matter and materials physics, materials for fusion reactors, ion-surface interactions, and most recently the synthesis and properties of super-heavy nuclei, where he participated in the recent discovery of element 117. A former president of the Materials Research Society, he has served on numerous National Research Council committees and testified before Congress on nanotechnology and energy-related issues. He is a fellow of the American Association for the Advancement of Science, and a recipient of the 2004 National Materials Advancement Award from the Federation of Materials Societies and the 2010 Gordon Battelle Prize for Scientific Discovery from the Battelle Memorial Institute.

**Eric Toone, Ph.D.**
*Anne T. and Robert M. Bass Professor of Chemistry*
*Duke University*

Dr. Eric Toone was born and raised in northeastern Ontario. He studied chemistry as an undergraduate at the University of Guelph, graduating in 1983. That same year he moved to the University of Toronto to begin graduate studies in applied enzymology under the supervision of Professor J. Bryan Jones. Toone graduated from the University of Toronto in 1988 and moved to Harvard University to continue his studies with Professor George Whitesides. He began his independent career at Duke in 1990, and is currently Professor of Chemistry and Professor of Biochemistry. Professor Toone is currently Director of Duke University Innovation and Entrepreneurship Initiative, an initiative designed to foster entrepreneurship across the entire university community.

From 2009 to 2012 Professor Toone was detailed to the US Department of Energy where he was a founding member of the Advanced Research Projects Agency – Energy (ARPA-E). During that time, he served both as Program Director and Deputy Director for Technology before leading the Agency in 2012. As a Program Director, Professor Toone devised and implemented ARPA-E's Electrofuels program, which explores the use of non-photosynthetic autotrophic organisms for the production of energy-dense, infrastructure-compatible liquid fuels.

# Session Chairs

2013 Fitzpatrick Institute for Photonics (FIP) Annual Meeting
March 11-12, 2013, Duke University

**David J. Brady, Ph.D.**
*Michael J. Fitzpatrick Professor*
*Electrical and Computer Engineering*
*Duke University*

*"Session 4: Special Topic on Photonics for Energy II"*
*March 11 4:25-5:30pm*

David Brady leads the Duke Imaging and Spectroscopy Program (DISP), which builds computational imaging systems. Current DISP projects focus on snapshot gigapixel photography using multiscale optics, x-ray scatter tomography, millimeter wave diffraction tomography, focal tomography and compressive spectral imaging.

**Gleb Finkelstein, Ph.D.**
*Associate Professor, Physics*
*Duke University*

*"Session 5: Special Topic on Photonics for Energy III"*
*March 12 9:00-10:10am*

Gleb Finkelstein obtained his PhD in Physics from the Weizmann Institute of Science, Israel in 1999. Following postdoctoral work at MIT, he moved to Duke University, where he is now an Associate Professor. His group works on a range of subjects in condensed matter physics and nanoscience.

**Jeffrey T. Glass, Ph.D.**
*Hogg Family Professor, Mechanical Engineering and Materials Science*
*Director, Mechanical Engineering and Management Program*
*Duke University*

*"Session 1: Special Topic on Photonics for Energy I"*
*March 11 11:10-12:15pm*

Jeffrey T. Glass is a Professor in the Department of Electrical and Computer Engineering and is the Director of the Pratt School's Master of Engineering Management Program at Duke University. He also holds the Hogg Family endowed chair in Engineering Management and Entrepreneurship. Formerly, he was the Co-Director of The Institute for the Integration of Management and Engineering at Case Western Reserve University (CWRU) and held the Joseph F. Toot, Jr. endowed chair in the Case School of Engineering. Jeff received his Bachelors and Masters degrees from Johns Hopkins University, and a Ph.D. in Materials Science and Engineering from the University of Virginia. He also received an MBA from Duke University's Global Executive (GEMBA) program.

**Joseph Izatt, Ph.D.**
*Professor*
*Biomedical Engineering and Ophthalmology*
*Duke University*

*"Session 2: Advances in Photonics I"*
*March 11 1:55-2:35pm*

Professor Joseph Izatt's research interests are in the area of biophotonics and include coherence-based biomedical imaging and microscopy, novel technologies for ophthalmic imaging, and nanoscale studies of cellular morphology and dynamics.

**Benjamin J Wiley, Ph.D.**
*Assistant Professor Chemistry*
*Duke University*

*"Session 6: Advances in Photonics II"*
*March 12 10:40-12:00pm*

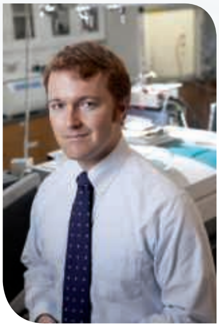
Benjamin Wiley makes new nanomaterials by controlling the assembly of atoms in solution, and exploring applications for nanomaterials in medicine, catalysis, plasmonics, and electronics. My team's goal is to precisely control the size, shape, and composition of materials on the nanometer scale to explore how these parameters affect the fundamental properties of a material, and produce such nanomaterials economically so they can be applied to solve real-world problems.

# Poster Session Judges

2013 Fitzpatrick Institute for Photonics (FIP) Annual Meeting
March 11-12, 2013, Duke University

**Nico Hotz**
*Assistant Professor*
*Mechanical Engineering and Materials Science*
*Duke University*

**Adam Wax**
*Associate Professor of Biomedical Engineering*
*Duke University*



**Benjamin J Wiley, Ph.D.**
*Assistant Professor of Chemistry*
*Duke University*

# Poster Session Exhibit

Poster # 1 **Ion Trap Fabrication in a High Finesse Optical Cavity**

*Daniel Gaultney, Andre Van Rynbach, Rachel Noek, Taehyun Kim, Seongphill Moon, Stephen Crain, Peter Maunz, and Jungsang Kim*
*Department of Electrical and Computer Engineering, Duke University, Durham, North Carolina 27708, USA*

Poster # 2 **ML2VR: Providing MATLAB Users and Easy Transition to Virtual Reality and Immersive Interactivity**

*David J. Zielinski, Duke University; Ryan P. McMahan, University of Texas at Dallas; Wenjie Lu, Duke University and Silvia Ferrari, Duke University*

Poster # 3 **Towards Image-Guided Photothermal Therapy with Near-Infrared Resonant Gadolinium-Nanoshell Conjugates**

*Andrew J. Coughlin, Jeyarama S. Ananta, Nanfu Deng, Irina V. Larina, Paolo Decuzzi, and Jennifer L. West, Duke University*

Poster # 4 **Exploiting Collective Electron Resonances in Photocatalysis for Energy Productions**

*Tuan Vo-Dinh, Fitzpatrick Institute for Photonics, Duke University, Durham, North Carolina, USA*
*Hans-Joachim Lewerenz, Joint Center for Artificial Photosynthesis, California Institute for Technology, Pasadena, California, USA and Institute of Solar Cells, Hemholtz Center, Berlin, Germany*

Poster # 5 **Super-resolution structured illumination microscopy of non-fluorescent, coherently scattering samples**

*Shwetadwip Chowdhury, Al-Hafeez Dhalla, Joseph Izatt, Fitzpatrick Institute for Photonics, Biomedical Engineering, Duke University*

Poster # 6 **Solution-Processed, Antimony-Doped Tin Oxide Colloid Films Enable High-Performance TiO2 Photoanodes for Water Splitting**

*Qing Peng[1], Berç Kalanyan[2], Paul G. Hoertz[3], Andrew Miller[3], Do Han Kim[2], Kenneth Hanson[4], Leila Alibabaei[4], Jie Liu[5], Thomas J. Meyer[5], Gregory N. Parsons[2,3], Jeffrey T. Glassa*

1. *Electrical and Computer Engineering Department, Duke University, Durham, NC 27708 USA;*
2. *Department of Chemical and Biomolecular Engineering, North Carolina State University, 911 Partners Way, Raleigh, NC 27695 USA;*
3. *RTI International, Research Triangle Park, NC 27709 USA;*
4. *Chemistry Department, UNC-Chapel Hill, NC 27599 USA;*
5. *Chemistry Department, Duke University, Durham, NC 27708*

Poster # 7 **Pharmacokinetics and Tumor Accumulation of Near-Infrared Emissive Polymersomes Composed of Poly(ethylene glycol) and Random Poly(caprolactone-co-trimethylene carbonate)**

*Christina L. Hofmann, Wei Qi, Chelsea D. Landon, Michael Therien, Mark W. Dewhirst, Gregory Palmer, Fitzpatrick Institute for Photonics, Duke University*

Poster # 8 **Optical Pattern Formation in Cold Atoms: The Role of Sisyphus Cooling**

*Bonnie L. Schmittberger and Daniel J. Gauthier, Physics Department, Fitzpatrick Institute for Photonics, Duke University*

Poster #9 **High Performance Yb+ Quantum Bits in Microfabricated Surface Traps**

*Emily Mount, So-Young Baek, Stephen Crain, Rachel Noek, Daniel Gaultney, Peter Maunz, Jungsang Kim, Electrical and Computer Engineering, Fitzpatrick Institute for Photonics, Duke University*

Poster # 10 **Towards Waveguide-QED-based Quantum Networks**

*Huaixiu Zheng, Daniel J. Gauthier, and Harold U. Baranger, Physics Department, Fitzpatrick Institute for Photonics, Duke University*

Poster # 11 **Raman-Labeled Gold Nanostars as Photodynamic Therapy Drug Carriers for Theranostics**

*Andrew Fales[1,2], Hsiangkuo Yuan[1,2], and Tuan Vo-Dinh [1,2,3]*
*Fitzpatrick Institute for Photonics[1], Department of Biomedical Engineering[2], Department of Chemistry[3], Duke University*

1. Fitzpatrick Institute for Photonics
2. Department of Biomedical Engineering
3. Department of Chemistry, Duke University

Poster # 12 **MEMS-Based Beam Steering for Individual Addressing of Trapped Ions**

*Stephen Crain, Emily Mount, Caleb Knoernschild*, Seongphill Moon, Andre Van Rynbach, Soyoung Baek, Peter Maunz**, Jungsang Kim, Fitzpatrick Institute for Photonics, Department of Electrical and Computer Engineering, Duke University*
** Raytheon, Goleta, CA 93117*
*** Sandia National Laboratories, Albuquerque, NM 87185*

Poster # 13 **Study on the Fault-Tolerant Code Conversion of Several Quantum Error-Correction Codes**

*Byung-Soo Choi and Jungsang Kim*
*Fitzpatrick Institute for Photonics, Department of Electrical and Computer Engineering, Duke University*

Poster # 14 **Examining melanin degradation with pump-probe microscopy**
*Mary Jane Simpson[1], Keely Glass[1], Jesse Wilson[1], John Simon[2], Warren Warren[1],*
*[1]Department of Chemistry, Duke University and [2]Department of Chemistry, University of Virginia*

Poster # 15 **Infrared Metamaterials for Diffractive Optics**
*Yu-Ju Tsai, Talmage Tyler, Stéphane Larouche, Antonio Llopis, Matthew Royal, Nan M. Jokerst, David R. Smith*
*Center for Metamaterials and Integrated Plasmonics, Department of Electrical and Computer Engineering, Duke University*

Poster # 16 **Imaging Hemoglobin Deep in Scattering Samples with Spectroscopic Multiple Scattering Low Coherence Interferometry**
*Thomas E. Matthews, Michael G. Giacomelli, Adam Wax*
*Fitzpatrick Institute for Photonics, Department of Biomedical Engineering, Duke University*

Poster # 17 **Optimization of a widefield structured illumination microscope for non-destructive assessment and quantification of nuclear features in tumor margins of a primary mouse model of sarcoma**
*Henry L. Fu[1], Jenna L. Muller[1], Melodi Javid [2], David G. Kirsch[2,3], Ph.D., Nimmi Ramanujam[1], Ph.D., J. Quincy Brown[4], Ph.D.*

1. *Department of Biomedical Engineering, Duke University, Durham, North Carolina, USA.*
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3. *Department of Radiation Oncology, Duke University School of Medicine, Durham, North Carolina, USA.*
4. *Department of Biomedical Engineering, Tulane University, New Orleans, Louisiana, USA.*

Poster # 18 **Securing time bins in a high dimensional QKD system**
*Hannah Guilbert, Yunhui Zhu, and Daniel J. Gauthier*
*Fitzpatrick Institute for Photonics, Department of Physics, Duke University*

Poster # 19 **Unwrapping Layers: Virtual Cross Sections with Pump-Probe Microscopy**
*Tana E. Villafana[1], William Brown[2], John K. Delaney[3], Michael Palmer[3], Jennifer Mass[4], Warren S. Warren[1], and Martin C. Fischer[1]*

1. *Department of Chemistry, Duke University, Durham, NC 27708, USA*
2. *North Carolina Museum of Art, Raleigh, NC 27607, USA*
3. *Scientific Research Department, National Gallery of Art, Washington, DC, USA*
4. *Henry Francis DuPont Winterthur Museum, Winterthur, DE 19735, USA*

Poster # 20 **Spectroscopy of Psoralen Drug Systems for PUVA Treatment: A Comparative Experimental and Theoretical Study**

*Yang Liu, Hsiangkuo Yuan and Tuan Vo-Dinh*
*Fitzpatrick Institute for Photonics, Department of Biomedical Engineering, Department of Chemistry, Duke University*

Poster # 21 **Pump-probe nonlinear phase dispersion spectroscopy**

*Francisco E. Robles, Prathyush Samineni, Jesse W. Wilson, and Warren S. Warren*
*Fitzpatrick Institute for Photonics, Department of Chemistry, Duke University*

Poster # 22 **Single-Photon Avalanche Diodes and Active Quenching Circuits for High-Speed Quantum Key Distribution Systems**

*Meizhen Shi, Mario Stipcevic, Hannah Guilbert, Daniel Gauthier*
*Fitzpatrick Institute for Photonics, Department of Physics, Duke University*

Poster # 23 **Detecting multi-walled carbon nanotubes with pump-probe microscopy**

*Christopher Dall, Mary Jane Simpson, Jesse W. Wilson, Jie Liu and Warren S. Warren*
*Department of Chemistry, Duke University*

Poster # 24 **Film-coupled nanoparticles: from nonlocal plasmonics to large area absorbers**

*Cristian Ciracì*, Antoine Moreau**, Jack J. Mock*, Yaroslav Urzhumov* and David R. Smith**
** Center for Metamaterials and Integrated Plasmonics, and Department of Electrical and Computer Engineering, Duke University, Durham North Carolina 27708, USA.*
***Clermont Université, Université Blaise Pascal, Institut Pascal, BP 10448, F-63000 Clermont-Ferrand, France.*

Poster # 25 **Cell-penetrating peptide-enhanced theranostic plasmonic nanoplatform for mesenchymal stem cells tracking and photothermal therapy**

*Hsiangkuo Yuan[1], Andrew M. Fales[1], Jennifer S. Chien[1], Jose A. Gomez[2], Maria Mirotsou[2], Victor J. Dzau[2], Tuan Vo-Dinh[1,3]*

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2. *Duke Cardiovascular Research Center, Duke University Medical Center, Durham, NC*
3. *Department of Chemistry, Duke University, Durham, NC*

Poster # 26 **A quantitative method to analyze fluorescence microscopy images of heterogeneous tissue: application to the detection of residual disease in sarcoma tumor margins**

*Jenna L. Mueller[1], B.S., Zachary T. Harmany[2], Ph.D., Jeffrey K. Mito[3], Ph.D., Stephanie A. Kennedy[1], Ph.D., Yongbaek Kim[4], D.V.M., Ph.D., Leslie Dodd[5], M.D., Joseph Geradts[6], Ph.D., David G. Kirsch[3,7], M.D. Ph.D., Rebecca M. Willett[2], Ph.D., J. Quincy Brown[8], Ph.D and Nimmi Ramanujam[1], Ph.D.*

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7. *Department of Radiation Oncology, Duke University School of Medicine, Durham, North Carolina, USA.*
8. *Department of Biomedical Engineering, Tulane University, New Orleans, Louisiana, USA.*

Poster # 27 **Molecular imaging via coherent x-ray scatter**

*Joel A. Greenberg, Kalyani Krishnamurthy, Mehadi Hassan, Ehsan Samei, David Brady*
*Fitzpatrick Institute of Photonics, Electrical and Computer Engineering, Duke University, Durham, NC*

Poster # 28 **Evaluation of microbicide film dissolution dynamics by real-time quantitative imaging refractometry**

*Matthew Rinehart[1], Lisa Rohan[2], David Katz[1] and Adam Wax[1]*
1. *Biomedical Engineering, Duke University*
2. *University of Pittsburgh*

Poster # 29 **Er:YAG laser ablation of a Roman Urn, with SERS analysis of surface encrustation.**

*Science in the Service of Art.*

*Adele DeCruz[1,2,3] and Tuan Vo-Dinh[1,3,4]*
1. *Fitzpatrick Institute for Photonics, Duke University*
2. *Department of Biology, Duke University*
3. *Department of Chemistry, Duke University*
4. *Department of Biomedical Engineering, Duke University*

Poster # 30 **Software Automated Genomic Engineering (SAGE) Enabled by Digital Microfluidics**

*Andrew Madison, Matthew Royal, and Richard Fair*
*Fitzpatrick Institute for Photonics, Electrical and Computer Engineering, Duke University*

Poster # 31 **Externally triggered picosecond optical pulse generation with 10 GHz-bandwidth-system**

*Yunhui Zhu and Daniel Gauthier*
*Fitzpatrick Institute for Photonics, Physics Department, Duke University*

Poster # 32 **Feasibility of Brain Tumor Delineation using Immunolabeled Gold Nanorods**

*Kevin Seekell [1], Spencer Lewis [1], Christy Wilson [2], Shuqin Li [2], Gerald Grant [2], and Adam Wax [1]*
1. *Department of Biomedical Engineering, Duke University, Durham, NC 27708*
2. *Department of Neurosurgery, Pediatric Division, Duke University Medical Center, Durham, NC. 27708*

Poster # 33 **Detection of retinal degeneration using angle-resolved low coherence interferometry**

*Michael Giacomelli* Sanghoon Kim, and Adam Wax*
*Fitzpatrick Institute for Photonics, Department of Biomedical Engineering, Duke University, Durham, NC 27708*

Poster # 34 **Characterization and Modeling of OPVs with RIR-MAPLE as Enabling Technique**

*Ayomide Atewologun[1], Wangyao Ge[1], Xin Xu[2] and Adrienne Stiff-Roberts[1]*
1. *Department of Electrical and Computer Engineering, Duke University*
2. *University of Texas, Austin.*

Poster # 35 **Long-term tissue integration of porous biopolymers as a material platform for metabolic biosensors**

*Thies Schroeder, Eugenia Cho, Alina Boico, Nga Le Brown, Natalie Wisniewski, Kristen Helton, and Bruce Klitzman*
*Radiation Oncology, Plastic Surgery, Duke University Medical Center and Biomedical Engineering Duke University and PROFUSA Corp, San Francisco, CA*

Poster # 36 **A Calibration Standard for Two-Dimensional Angle-Resolved Low-Coherence Interferometry**

*Steven K. Yarmoska[1], Sanghoon Kim[1], Michael G. Giacomelli[2], and Adam Wax[1]*
1. *Department of Biomedical Engineering, Duke University, Durham NC 27708, USA*
2. *Department of Electrical Engineering and Computer Science, Massachusetts Institute of Technology, Cambridge MA 02139, USA*

Poster # 37 **SERS-like Plasmonic Enhancement of Raman Spectroscopy in DNA Origami-based Complex Metallic Nanostructures**

*M. Pilo-Pais[†], A. Watson[†], T. H. LaBean[§], and G. Finkelstein[†]*
† *Department of Physics, Duke University, Durham NC,*
§ *Department of Materials Science and Engineering, North Carolina State University Raleigh, NC*

Poster # 38 **Pump-Probe Imaging of Melanoma in the BRAFV600E/PTENnull a Mouse Model**

*Christina Gainey, Jesse Wilson, Simone Degan, Warren Warren*
*Fitzpatrick Institute for Photonics, Department of Chemistry, Duke University, Durham NC,*

Poster # 39 **Organic Thin Films for Anti-Reflection Applications**

*Ryan D. McCormick[1], Eric D. Cline[2], Arvinder S. Chadha[3], Weidong Zhou[3], and Adrienne D. Stiff-Roberts[1]*

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2. *Previously, ZT Solar, Inc., Dallas, TX 75235; currently, Hydrotex, Farmers Branch, TX 75234*
3. *Department of Electrical Engineering, University of Texas, Arlington, TX 76019*

Poster # 40 **Using diffuse reflectance spectroscopy for optical detection of cartilage degeneration arthroscopically**

*Marlee Junker[1,2], Nickolas Trutiak[4], J.Quincy Brown[3], Jesko von Windheim[1,2], Nimmi Ramanujam[1,2], Mark B. Hurtig[4]*

1. *Department of Biomedical Engineering, Duke University, Durham NC*
2. *Zenalux, Durham, NC*
3. *Tulane University, New Orleans, LA*
4. *University of Guelph, Guelph, Canada*

Poster # 41 **Remote entanglement of an atomic ensemble and a single ion**

*Margaret E. Shea, Physics Department, Duke University*
*Jungsang Kim, Electrical and Computer Engineering, Duke University*
*Daniel J. Gauthier, Physics Department, Duke University*

Poster # 42 **Probing In Vivo Trafficking of Drug Nanocarrier Labeled With Near-Infrared-Emitting Quantum Dots**

*Chai-Hoon Quek[1], Hon-Fai Chan[2], Kristina Riebe[3], Gregory Sempowski[3], Kam W. Leong[1,2]*

1. *Department of Mechanical Engineering and Materials Science, Duke University*
2. *Department of Biomedical Engineering, Duke University*
3. *Duke Human Vaccine Institute, Duke University*

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| 6. Lawrence Carin | William H. Younger Professor | ECE |
| 7. Krishnendu Chakrabarty | Professor | ECE |
| 8. Ashutosh (Tosh) Chilkoti | Theo Pilkington Professor | BME |
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| 60. Neil L. Spector | Faculty | Oncology |
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| 65. Nathan Thielman | Associate Professor | Duke Human Vaccine Institute |
| 66. Jingdong Tian | Assistant Professor | BME |
| 67. Eric Toone | Professor | Chemistry |
| 68. Cynthia A. Toth | Professor | Ophthalmology |
| 69. George Truskey | R. Eugene and Susie E. Goodson Professor & Sr. Associate Dean of Research | BME |
| 70. Stephanos Venakides | Professor | Mathematics |

| | | |
|---|---|---|
| 71. Tuan Vo-Dinh | R. Eugene and Susie E. Goodson Professor & Director of FIP | BME & Chemistry |
| 72. Judith Voynow | Professor | Pediatrics |
| 73. Warren Warren | James B. Duke Professor | Chemistry, Radiology, BME |
| 74. Adam Wax | Theodore Kennedy Associate Professor | BME |
| 75. Jennifer West | Fitzpatrick Family University Professor of Engineering | BME, MEMS |
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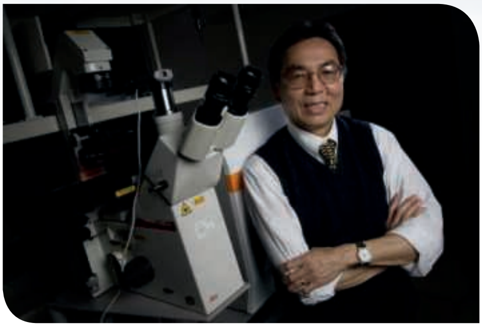
| 78. Ying Wu | Associate Professor | Physics |
| 79. Weitao Yang | Philip J. Handler Professor | Chemistry |
| 80. Benjamin B. Yellen | Assistant Professor | MEMS |
| 81. Tomoyukie Yoshie | Assistant Professor | ECE |
| 82. Terry Yoshizumi | Assoc. Professor, Director of Radiation Safety. | Radiation |
| 83. Lingchong You | Associate Professor | BME, Inst. For Genome Science & Policy |
| 84. Fan Yuan | Professor | BME |
| 85. Aimee Zaas | Assistant Professor | Div. of Infectious Diseases & Int'l Health; IGSP |
| 86. Xuanhe Zhao | Assistant Professor | MEMS |
| 87. Pei Zhong | Associate Professor | MEMS |

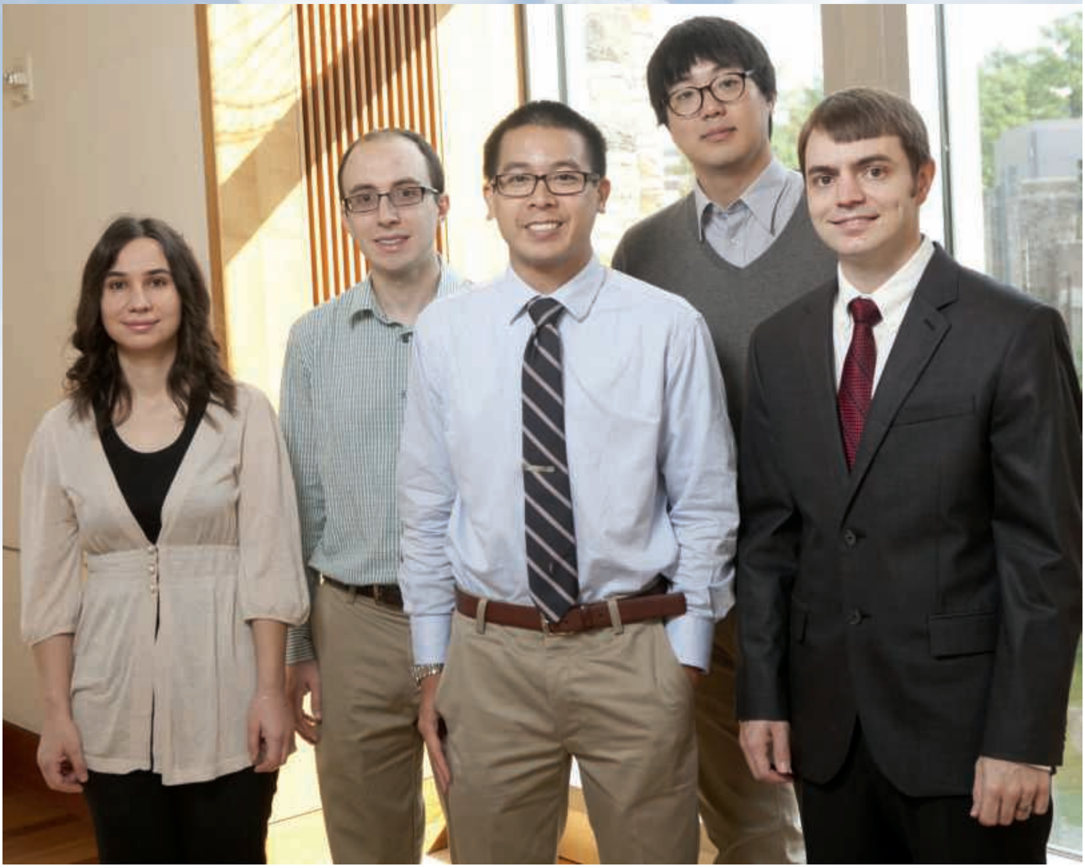


Director, Fitzpatrick Institute for Photonics
*Tuan Vo-Dinh*

Department Business Manager
Fitzpatrick Institute for Photonics
*August Burns*

# 2012 FIP Fellow & Scholar Winners
# John Chambers Fellows
# John Chambers Scholar
# Fitzpatrick Foundation Scholar

The Fitzpatrick Institute for Photonics (FIP) was able to award several graduate student fellowships through the continued support and generosity of the Fitzpatrick Foundation and John Chambers. Each candidate was nominated by a FIP Professor and judged on the criteria of research accomplishments, research potential, personal qualities and collaborative potential.



*From Left to Right: Ozlem Senlik (Chambers Scholar), Kevin Seekell (Chambers Scholar), Christopher Lam (Chambers Fellow), Sanghoon Kim (Chambers Fellow) and Derek Nankivil (Fitzpatrick Scholar)*



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Stoplights will talk to cars will talk to road sensors about increasing traffic efficiency.
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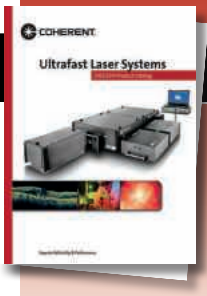


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USGBC Excellence in Green Building Recognition Award

International Green Industry Hall of Fame

Pilot project for the Sustainable SITES Initiative

## About the Program

The Smart Home is located on Duke's Central Campus in Durham, North Carolina. The Smart Home program encourages students to form interdisciplinary teams and experiment with new technologies in order to create a more sustainable world. Building the Smart Home was a Duke student idea that became a reality in 2007 and now other students have the opportunity to live and work in this unique laboratory full of sustainable technologies, such as solar power, solar hot water, passive solar design, rainwater harvesting, high efficiency appliances, recycled materials, green roof, and programmable lights. The Smart Home promotes smarter living through innovation, sustainability, and education.

**Read about student research in:**

- Optical sensing devices
- RFID tracking technology
- Wireless power transmission
- Solar powered vehicles
- Voice recognition
- Alternative and backup energy

**online at www.smarthome.duke.edu**

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The **D**uke **O**SA/**S**PIE Student **C**hapter (**DOSC**) is a Duke student organization interested in research in optics and photonics. Our affiliation with OSA, SPIE, and the Fitzpatrick Institute for Photonics provides us with funding and resources that allow us to engage in many activities related to the exploration and promotion of Optical Sciences. Here are some of the things that we do:

- Professional networking events on campus and at conferences
- Outreach programs to local schools
- Support optics-related extracurricular projects
- Interact with visiting professors in small groups
- Assist with FIP breakfast poster sessions

To get involved with **DOSC**, email our president, Jenna (jenna.mueller@duke.edu) and check us out on the web!

## Duke University

## dosc.pratt.duke.edu

# Notes:

# Notes:

# www.fitzpatrick.duke.edu

The Fitzpatrick Institute for Photonics business office has achieved the Duke Green Workplace Certification.

Duke Green Workplace Certification is a program created by Sustainable Duke to help staff reduce the environmental footprint of their workplace. The program helps to train and foster staff sustainability leaders within a department and provides resources to guide the process of greening your workplace.

The Fitzpatrick Institute for Photonics supports and promotes Duke Sustainability. This program was printed on recyclable paper working with the Forest Steward Council.