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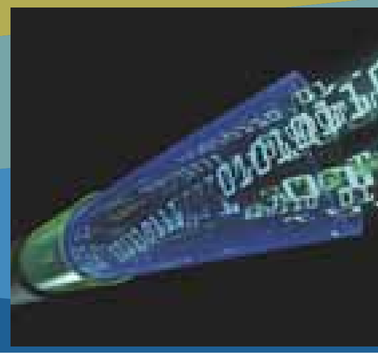
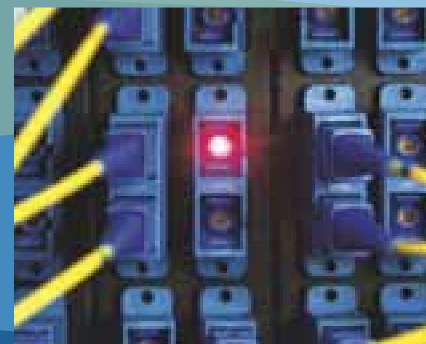
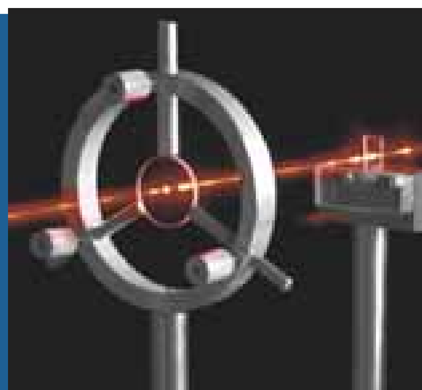
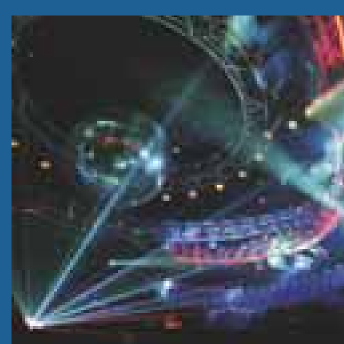



Celebrating **50 Years** of the Laser






AND **10 Years** for Duke's Fitzpatrick Institute for Photonics

2010 . VOLUME 5 . ISSUE 1

Professor Tuan Vo-Dinh

Welcome to this special issue of *BROADBAND*, the newsletter of the Fitzpatrick Institute for Photonics (FIP). As we celebrate the 10^{th} anniversary of the Institute in 2010, it is important to reflect on the achievements of the Institute for the last ten years and contemplate our leap into the next decade.

The FIP is the cornerstone of Duke's Photonics Initiative, and cross-disciplinary research is at the heart of its vision. We foster breakthroughs achieved by multidisciplinary research teams whose combined expertise extends beyond the traditional individual disciplines. It is gratifying to see a strong, shared vision of interdisciplinary spirit in our FIP faculty and across the Duke campus as the growing collaborations between disciplines and departments strengthen the vigor and relevancy of our efforts.

Who We Are

The FIP has experienced a remarkable growth and its faculty, staff, postdoctoral fellows, and students are the foundation of its development. The FIP faculty membership increased from 25 in 2006 to over 76 faculty members in 2010, with participation from 26 departments, centers and institutions ranging from Biomedical Engineering, Electrical and Computer Engineering, Mechanical Engineering & Material Science, Chemistry, Physics, Computer Science, and Mathematics to Anesthesiology, Cell Biology, Chemical Biology, Neurosurgery, Oncology, Orthopaedic Engineering, Ophthalmology, Pathology, Pediatrics, Radiology and Surgery. The research activities of the Institute are grouped in eight research programs, each led by a research director: biophotonics, nano & micro systems, quantum information, nanophotonics, photonics materials, advanced photonics systems, novel spectroscopies, and theory & systems modeling. The interdisciplinary members of the FIP faculty includes engineers, scientists, medical researchers and clinicians, all working together and dedicated to developing and applying the most advanced technology in photonics to address the challenges of the 21^{st} century in many areas ranging from information transfer technology to disease diagnostics and therapy.

Education

As education is an important component of the Institute's activities, the FIP Education Task Force has a strong commitment to expanding photonics as an area of emphasis for education and research. To best prepare undergraduate and graduate students for a career in photonics, we have developed the *Graduate Photonics Certificate (GPC) Program* and, more recently, the *Master of Engineering in Photonics and Optical Sciences*. Students are encouraged to develop interdisciplinary and transferable photonics skill sets in their course work and research activities. The Institute has established several Graduate Research Fellowships and Scholarships sponsored by the *John T. Chambers Fund* and the *Michael J. and Patricia W. Fitzpatrick Fellowship Fund* to encourage and assist graduate students and FIP faculty members from different departments and schools to establish long-term collaborations. We believe that this investment in seeding cross-disciplinary, cross-campus research activities will yield valuable future dividends for Duke and, ultimately, contribute to generation of interdisciplinary solutions addressing complex and global problems.

Need-Driven Research and Spinoffs

In addition to fostering fundamental research in its eight photonics programs, the Institute also encourages industry-funded research. The FIP Corporate Partnership Program has included companies, such as *Hamamatsu, Newport, Elcan, and CVI-Melles Griot*. Even during the economic downturn of the last few years the continuing support of our Corporate Partners has allowed our Institute to have important activities, such as the *FIP Breakfast Series* and the *FIP Seminar and Distinguished Lectures Series*. With the improving economy and the emergence of strong partners in photonics, the Institute hopes to strengthen its industrial relations programs in the coming years. We will also continue to actively promote transfer of technologies developed at FIP to the commercial sector. Spin-off companies initiated by FIP faculty research have included *Advanced Liquid Logic, Inc.*, *Applied Quantum Technologies, Inc.*, *Bioptigen, Inc.*, *Blue Angel Optics*, *Centice, Inc.*, *Endls Optics*, *Oncoscope, Inc.*, *Phase Bioscience, Inc.*, and *Signal Innovations Group*.

International Partnerships

To expand its global outreach the Institute has nurtured international partnerships with the *National Chiao Tung*

University (Taiwan) and the *University of Saint Andrews* (UK). Recently the FIP has further extended its international program by establishing partnerships with the *Institut d' Optique* (France) and the *Institute of Solar Fuels Research* (Germany). In addition, FIP faculty members have established numerous collaborations in photonics research with international investigators.

Our Vision

We are witnessing a very exciting period in the history of science because there is an epochal convergence of many revolutions of the 20th century, such as the quantum revolution, the technology revolution and the genomics revolution. Photonics has played a critical role by contributing key revolutionary and disruptive technologies. Light influences our lives today in new ways that we could never have imagined just a decade ago. As we move into a new decade, light will play an even more significant role, triggering a revolution in global photonic communications, creating nanoscale biosensors to unveil the inner world of the human cell, developing cost-effective medical cures for global health, inventing new energy sources, and galvanizing human exploration at the frontiers of the universe.

Photonics is a critical enabling technology at the heart of this scientific convergence that will define research progress in the 21st century. This is an exciting time for scientists and engineers, whose efforts are critically needed to address the challenges of our time. With the increasing awareness of our planet's limited resources, we are now entering a paradigm shift from a 'development-driven' society to a 'sustainability-driven' society. Scientists and engineers will have many opportunities to use their expertise in photonics, apply their innovativeness, and devote their energies to address these global challenges and contribute to a sustainable future.

We are confident that the highly interdisciplinary nature of the FIP faculty's resources and expertise prepares us for the challenges of the next decade. We have entered a phase where the knowledge of individual elements is no longer sufficient but should be combined and integrated in order to attain knowledge at the next level, i.e., the multi-scale systems level where the information on organization, activity and function requires a much higher level of complexity and sophistication. This transition from a knowledge base of individual elements to a systems level is one of the major paradigm shifts of the 21st century, which can be achieved only by integrating multiple disciplines and domains of knowledge. In a broader context, education and research in the next decade will evolve into a framework to fit the new reality of our world, i.e., a world that will be faced with cross disciplinary, systems level, and global challenges.

Photonics in the global era:
FIP faculty members have established numerous collaborations in photonics research with international investigators

We need to educate the next generation of innovators and leaders not only to solve scientific and technical problems but also to understand societal connections between various human activities, create bridges between elements spanning multiple disciplines, and ultimately build a better world.

Reaching beyond our current leadership in biophotonics, photonic materials and quantum optics, the FIP is pursuing new opportunities to focus the unique depth and breadth of its faculty's expertise and resources on critical areas of national and global importance such as energy and sustainability. As we aim to achieve international leadership through research, education and technology transfer, we will focus on developing translational research and integrated education aimed at service to a global society.

With this vision of hope I invite you to visit our website at *www.fitzpatrick.duke.edu* to learn more about our faculty, research programs, and activities.

Tuan Vo-Dinh, PhD
DIRECTOR, FITZPATRICK INSTITUTE OF PHOTONICS
R. EUGENE AND SUSIE E. GOODSON PROFESSOR OF BIOMEDICAL ENGINEERING
PROFESSOR OF CHEMISTRY

FIP is collaborating with the following countries:
Belgium
Brazil
Canada
China
Denmark
France
Germany
Greece
Israel
Korea
India
Italy
Spain
Taiwan
United Kingdom

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

Co-Sponsors • FIP Symposium

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

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

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

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

Corporate Sponsors • FIP Symposium

Platinum Partner – Hamamatsu Photonics | **Corporate Partner** – CVI Melles Griot

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

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

Since 1959, CVI Melles Griot is a global leader in the design and manufacture of products that enable the practical application of light. Headquartered in Albuquerque, New Mexico, CVI Melles Griot operates manufacturing facilities in New Mexico, California, New York, the British Isles, Japan, and South Korea with sales representatives and distributors located worldwide.

Femtosecond Spectroscopy

Lights, camera, action!

ATOMS AND CELLS IN THE MOVIES

It's hard to imagine much happening in a millionth of a billionth of a second. Apparently, though, a whole lot is going on. It's just that no one has been able to see it.

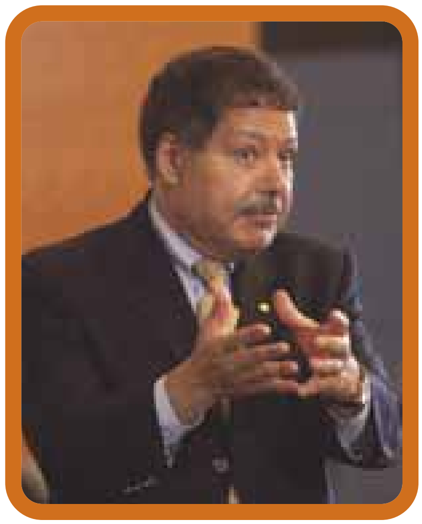
That is until a method was developed to capture images of events that happen that quickly. In this case the images are of events as small as the actions of individual atoms, the folding of proteins or layers of bacterial cell membranes.

It took scientists at the California Institute of Technology, led by Ahmed Zewail, to come up with an approach that added the all-important 4^{th} dimension to traditional imaging techniques: time. By combining traditional electron microscopy with ultrafast electron pulses to "light up" targets to produce what Zewail and his colleagues refer to as four-dimensional (4-D) electron microscopy.

Zewail, an Egyptian chemist, received the 1999 Nobel Prize in Chemistry for his contributions to developing this special type of "camera" to visualize events that occur on nanoscopic length scales and ultrafast timescales. Among his many other honors, Zewail was asked to present the keynote address at the Fitzpatrick Institute's 10^{th} annual symposium. He currently serves as the Linus Pauling Chair and Professor of chemistry, director of the Physical Biology Center for Ultrafast Science and Technology, and professor of physics at CalTech.

Zewail's technique operates on femtosecond time scales. The duration of a single femtosecond is just a millionth of a billionth of a second. To put this tiny duration in context, a femtosecond is to a single second what that second would be relative to 31 million years.

Fields as diverse as materials science, nanotechnology and medicine are expected to benefit from the insights allowed when able to examine miniscule structures and processes on heretofore inacessible time scales.



Professor Ahmed H. Zewail, Nobel Laureate in Chemistry (1999) delivered the keynote lecture at FIP 10 year celebration.

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"The most important development following the invention of the laser itself was achieving fine resolution and coherence, which allows us to achieve femtosecond abilities," Zewail told the audience in Schiciano Auditorium. "Until the 1960s, we could only achieve milli- and micro-seconds.

"To be able to measure the action of atoms, you need to be able to capture images at femtosecond speeds," he added.

In explaining the technique, he described early experiments designed to figure out how a falling cat rights itself and lands on its feet. The maneuver performed by the cat happens too fast for the eye to see, but scientists in the 1890s applied stop-action photography to the question. By flipping the individual images one after the other, they were able to see the cat's actions as it fell.

Zewail makes similar "movies" of individual atoms or cells using a "camera" that also captures individual images, but in femtosecond slices.

"Since the 1930s, electron microscopy images have been static, three-dimensional," Zewail said. "Our goal was add that fourth dimension – time. By integrating this fourth dimension, we are turning still pictures into the movies needed to watch matter's behavior — from atoms to cells — unfolding in real time."

Zewail received his early education in Egypt and completed a Ph. D. from the University of Pennsylvania and a postdoctoral (IBM) fellowship at the University of California, Berkeley, before joining the faculty at Caltech.

Last year, he was appointed to President Obama's Council of Advisors of the White House and named the first United States Science Envoy to the Middle East.

For his contributions to science and public life he has garnered other honors from around the globe: 40 honorary degrees in the sciences, arts, philosophy, law, medicine, and humane letters; Orders of State and Merit; commemorative postage stamps; and more than 100 international awards, including the Albert Einstein World Award, the Benjamin Franklin Medal, the Leonardo da Vinci Award, the King Faisal Prize, and the Priestley Medal.

Zewail was honored with the 2010 Pioneer in Photonics Award at the 10^{th} Annual Meeting of the Fitzpatrick Institute for Photonics at Duke University in October, 2010.

He is an elected member of academies and learned societies, including the American Philosophical Society, the National Academy of Sciences, the Royal Society of London, the French Academy, the Russian Academy, the Chinese Academy, and the Swedish Academy. ■

Lasers Inspire Three Duke Engineers

In their youth, engineers-to-be Joseph Izatt and Nan Marie Jokerst were fascinated by lasers and were inspired to build their own. Then, the early transformers that powered neon signs were large and bulky, sometimes weighing up to 40 pounds. Izatt and Jokerst both used transformers scavenged or lent from neon sign companies to power their early creations.

They were hooked from then on.

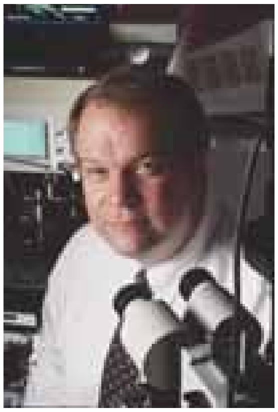
Izatt won a high school science fair competition in his hometown of Quebec City with his homemade laser, despite the sparks and smoke that shot out from the transformer. Now he uses lasers and other optics devices to non-invasively visualize individual layers of the eye's retina/cornea in exquisite detail.

Jokerst became fascinated with lasers after reading a story about them in Scientific American while in high school, and later, while an undergraduate at Creighton University, she built one of her own. Now, she not only fabricates minuscule lasers that fit on a chip, but she creates intricate connections between chips using laser light that could someday replace copper as the main conductor of information.

These are just a few of the examples of how engineers throughout the Pratt School of Engineering at Duke University are using lasers in their different areas of expertise. In fact, they and other Pratt engineers have said much of their work would not be possible without them.

As ubiquitous as lasers have become in laboratories across the world, they also appear in everyday household and office products.

"Lasers are everywhere," said Jungsang Kim, associate professor of electrical and computer engineering. "There are literally billions of them out there in everything from laptop computers to DVD and CD players. Optical communication would not be possible without lasers. If you think about it, every phone call, every connection, and every signal is generated by lasers."



Top to bottom: Professors Joseph Izatt, Nan Jokerst and Jungsang Kim representing FIP faculty.

Kim first became aware of lasers in the form of futuristic weapons in the hands of animated characters in Japan. Now, he uses them in trying to create the next generation of computers based on quantum physics.

Current computer designs are driven by the laws of classical physics. However, chips can only get so small before they become the size of an atom, at which time another type of physics, known as quantum physics, comes into play. This subatomic quantum world is often governed by its own rules, and its vast potential can only be realized when scientists figure out how to create and capture the fleeting atomic-scale events that are the core of the computer's power. When brought under control, these properties offer the possibility of unimaginable computing power, Kim said.

However, one of the keys to making quantum computing possible is building stable architectures so the many components can work reliably together. Kim and his colleagues at six other institutions were awarded $15 million earlier this year from the Intelligence Advanced Research Projects Activity (IARPA) to do just that.

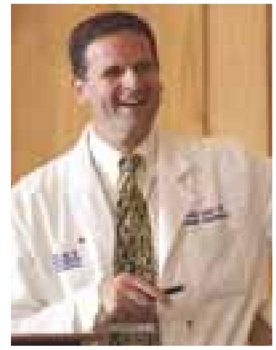
"In this five year research program, we propose a coherent and comprehensive research effort to construct an 80-qubit device," Kim said. "Using the resources provided by this hardware in an optimal way, we anticipate the realization of a versatile general-purpose quantum computer through which complex quantum algorithms can be executed. Our team consists of leading experimentalists in ion trap quantum computing, engineering talent with complex system integration expertise, and a group of outstanding theorists with strong history of working closely with experimental groups."

Not bad considering the laser was once called "a solution in search of a problem." ■

Lasers **and** Cancer

A Shining Light of Hope

By Ashley Yeager, Duke Office of News and Communications



Professor Gerald Grant
Surgery and Neurosurgery
Duke School of Medicine

Definitions don't always come easily to scientists. Consider Pluto's planethood, the question of what constitutes life, or determination of what is or is not a cancerous cell. Even the definition of a laser has recently been debated.

The acronym LASER stands for Light Amplification Stimulated Emission of Radiation. But fifty years of studying amplified light sources has moved the tools far beyond simple laser pointers, so much so that a large consortium of scientists could only agree that a laser is, "hard to define, but I know one when I see one," said Warren Warren, chair of Duke's chemistry department, during the 2010 Fitzpatrick Institute for Photonics, or FIP, symposium. Warren, part of the Technical Advisory Committee for LaserFest, a yearlong celebration of the 50th anniversary of the laser, said that dozens of scientists weighed in to develop a satisfactory definition of the device for the LaserFest Website, laserfest.org.

"Up to about three months ago, on no place on the site did it say what a laser was," Warren said.

LaserFest.org now describes the laser as a "device that strengthens light waves." Some have a well-directed, very bright beam with a very specific color; some have extremely short pulses, but the key is that the light amplification is well-defined and reproducible, unlike everyday light from the sun or a lamp. Warren added that a definition for Congress might also consider the laser is an economic engine. Ten billion dollars in research has enabled four trillion in technology, he said. Part of that growth is developing laser-based technologies to study cancer. Warren uses lasers to detect melanomas because current diagnostic methods using light and a magnifying glass—seventeenth century technologies—often yield inaccurate diagnoses. Even tissue bioposy, the removal and analysis of a piece of suspect tissue from a potential tumor, can lead to false positive diagnoses of cancer, unnecessary surgery and higher health care bills, he said.

Warren's group proposes using lasers to pump a small amount of energy, less than that of a laser pointer, into a suspicious mole or biopsied cell. Scientists watch the energy redistribute in the mole and in return obtain high-resolution images of how skin pigments are distributed in the cells. If the pigments appear organized, the cells are healthy. But if the pigmentation is disordered relative to putatively 'normal' tissue, the cells are likely diseased. It's the first time scientists have been able to look at where the different pigments are located in skin, opening up a whole new way of looking for melanomas.

Detecting diseased brain tissue isn't yet as straightforward. Duke neurosurgeon Gerald Grant demonstrated this when he stumped the symposium audience with the task of identifying the line between a cancerous tumor and healthy tissue in images of brain surgery patients. During surgery, neurosurgeons can become just as confused as that audience because doctors can't always tell the difference between normal and cancerous cells just by looking at them, Grant said. Identifying those tumor margins is critical: Patients have a higher rate of survival if more than 70% of a brain tumor is removed, but removal of too much tissue (as can occur when using current fluorescent imaging tools for tumor margin assessment) means that healthy brain matter has been cut away. Grant pleaded for new tools to locate tumor margins and proposed further collaborative investigations, possibly on the physiology of brain cells. One goal would be to determine whether biochemical differences exist between healthy and diseased tissue, then to develop a tool similar to Warren's which would allow real-time tumor margin assessment during surgery.

One possible solution to the challenges Grant raises is the SpectroPen, developed by Duke radiologist James Provenzale and colleagues at the University of Pennsylvania, Georgia Tech and Emory University. The tool looks like a laser pointer, and uses a combination of Raman scattering and near-infrared fluorescence to distinguish cancer cells from normal cells. When used in the operating room, the surgeon can use the integrated system to locate a tumor, excise the tumor, and confirm removal via image-guided surgery. The SpectroPen will soon be tested in clinical trials.

These and other laser-based technologies being developed at Duke may one day identify the presence or absence of cancer in real-time. Soon, that characterization may be even more straightforward than the definition of a laser itself. ■

chance encounters

Not Enough for Meaningful Collaborations

The scene is familiar. In a high school gym, with music blaring and streamers streaming, teenagers awkwardly shuffle their feet, building up the courage to ask someone to dance with them. When it finally happens for some, things often go well. But it’s that hesitancy to make contact at the beginning that stymies connections.

That’s how David Epstein, Duke’s chairman of ophthalmology, likened the process of how researchers from different corners of the university and from different specialties seem to approach collaborating with each other.

The Fitzpatrick Institute’s 10th anniversary symposium concluded with a panel discussion of how barriers separating different departments and disciplines can be broken down and how to foster a richer environment for collaboration.

Other panelists added their observations about how multidisciplinary collaborations come about.

“It’s said that collaborations often begin at the airport,” joked George Truskey, chair of the department of biomedical engineering. “We need to come up with better mechanisms for people to find what other people are doing.”

And as Danny Jacobs, Duke chairman of surgery put it: “We have to move from random collisions to planned collisions. Meetings such as this can help.”

“I’ve been in the department of radiology for five years, and I just got my first invitation to their faculty meeting,” said Warren Warren, professor of chemistry with a joint appointment in radiology. “In radiology, many of the basic scientists and clinicians do not know each other. That will change with our new chairman.”

Researchers and physicians, including Epstein, discussed their views on the issue and floated some suggestions. One of his ideas, which he has put in place, creates collaboration between people.

To help achieve this goal, Epstein established regular chairman’s lectures, where ophthalmology faculty members speak on a topic of clinical interest to faculty and students.

“What we’ve done is make each one of our presenting faculty members bring to the lecture a researcher from outside ophthalmology who is doing basic science on the topic,” Epstein said. “These collaborations typify the vast opportunities offered to Duke residents to work on groundbreaking research in conjunction with engineers, basic scientists, chemists, pharmacists and others.”

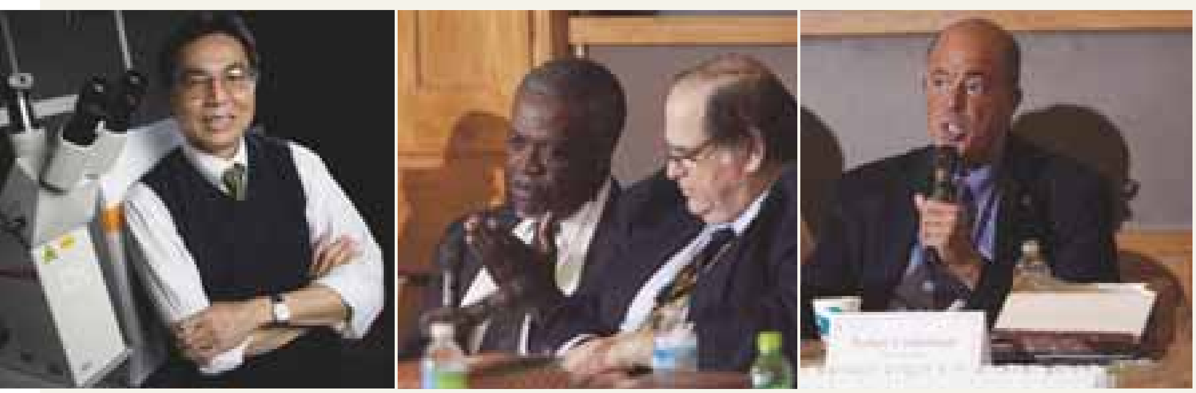
Tuan Vo-Dinh, R. Eugene and Susie E. Goodson Professor of Biomedical Engineering, the head of the Fitzpatrick Institute for Photonics, and the chair of the Institute's annual symposium, recounted his long experience at the national laboratories at Oak Ridge, Tennessee. The lab has a program where about three percent of research dollars are set aside annually for research ideas, with the caveat that at least three different investigators had to be part of the proposal. It started off slowly.

“But within five to ten years, the program took off and became quite successful in getting different kinds of scientists working together,” Vo-Dinh said. “

All panelists agreed that that there need to be more joint faculty appointments, as well as more common spaces where faculty can communicate with each other – whether it be a specific physical location or a website devoted to the issue.

Students, whether undergraduate, graduate or post-docs, can also be a mechanism for different labs to communicate and possibly collaborate.

“I believe that students can be very valuable in this regard,” said Joseph Izatt, professor of biomedical engineering. “Many of my students are over in the ophthalmology labs all the time, but not many medical students come over here to engineering.”



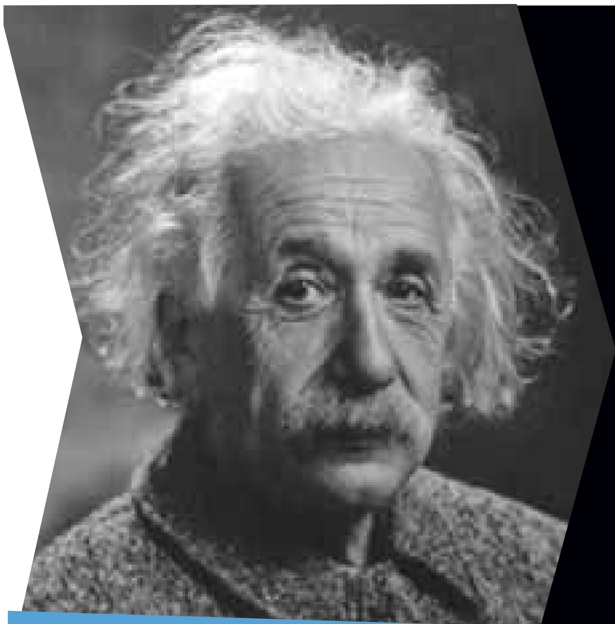
Left to right: *Professors Tuan Vo-Dinh, Danny Jacobs (next to Warren Grundfest from UCLA), David Epstein, participants of the Forum on Cross-disciplinary Research*

While he felt that Duke is not the best place for faculty from different departments to gather, Mark Dewhirst, professor of radiation oncology, said post-docs can help bridge the divide.

“They are a group that tends to be ignored but they can serve as great ambassadors between laboratories,” he said. “We should also try to establish more cross-disciplinary research programs.”

Vo-Dinh said that while Duke and other research institutions struggle to establish meaningful multidisciplinary collaborations, it appears to be happening on a smaller scale at the Fitzpatrick Institute.

“There are so many people from so many disciplines at Duke pushing the boundaries of science,” said Vo-Dinh. “At the Fitzpatrick Institute, people are coming together, typifying the environment we need to create across the campus. We try to make these collaborations happen.” ■



Albert Einstein
and
John Stewart Bell

Proving the Basis for **Quantum**Computing

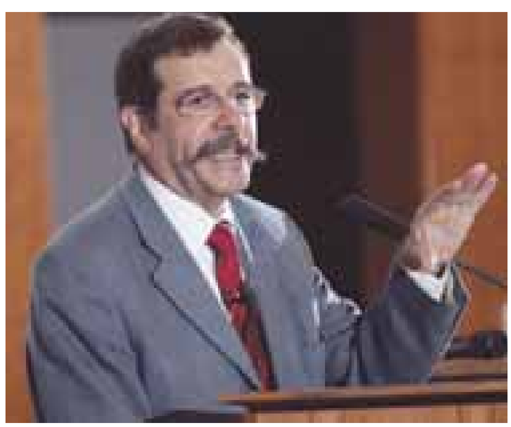
MORE THAN 75 YEARS AFTER it was postulated by Albert Einstein and colleagues, French physicist Alain Aspect helped prove experimentally a theory that could ultimately usher in the next generation of computing.

Einstein's theories of quantum physics explain the properties of particles at the atomic level, properties that are often counter-intuitive and seem to contradict the basics of classic physics. One particular theory of Einstein and his students, published in 1935, argued that there are certain quantum states that exhibit correlations which can occur almost instantaneously over great distances.

By taking advantage of these correlations, many scientists believe they can develop computers with almost unlimited quantum power. But this potential can only be realized when scientists figure out how to create and capture the fleeting events at the atomic scale. When brought under control, these properties offer the possibility of unimaginable computing power.

During his speech at the10th anniversary of the creation of the Fitzpatrick Institute of Photonics, Aspect described the scientific arguments that ensued after Einstein's theory was first published and the subsequent work of John Stuart Bell in 1965.

> "It was the most fascinating measurement I've made in my life."



Professor Alain Aspect, Wolf Prize (2010), CNRS Distinguished Scientist, Institut d'Optique (France)

Bell's argument, known as Bell's Inequality, stated that predictions of quantum mechanics cannot be explained by the assumption that distant events have no instantaneous effect on local ones. Or, in other worlds, one particle can have an immediate effect on another, no matter the distance between. This is known as quantum entanglement.

Aspect and his team played a key role in experimentally confirming Bell's Inequality theory by taking detailed measurements in his laboratory.

"It was the most fascinating measurement I've made in my life," Aspect, professor at the Ecole Polytechnique, told the audience.

"Wave / particle duality is all mystery but by 1985 the correlations aided in quantum computing, teleportation, cryptography, and computing new types of algorithms," he continued. "We're able to calculate exponentially faster than classical computers, and there may be an even larger parallelism."

Aspect is a member of the French Academy of Sciences and the French Academy of Technologies. In 2005 he was awarded the gold medal of the Centre National de la Recherche Scientifique, where he also is research director. The 2010 Wolf Prize in physics was awarded to Aspect, Anton Zeilinger and John Clauser. ■

STUDENT POSTER CONTEST

Forty-three students submitted abstracts for the poster contest at the 10th Annual Meeting of Duke's Fitzpatrick Institute for Photonics. Poster Prizes: 1st place $300, 2nd place $200, 3rd place $100. The winners were:

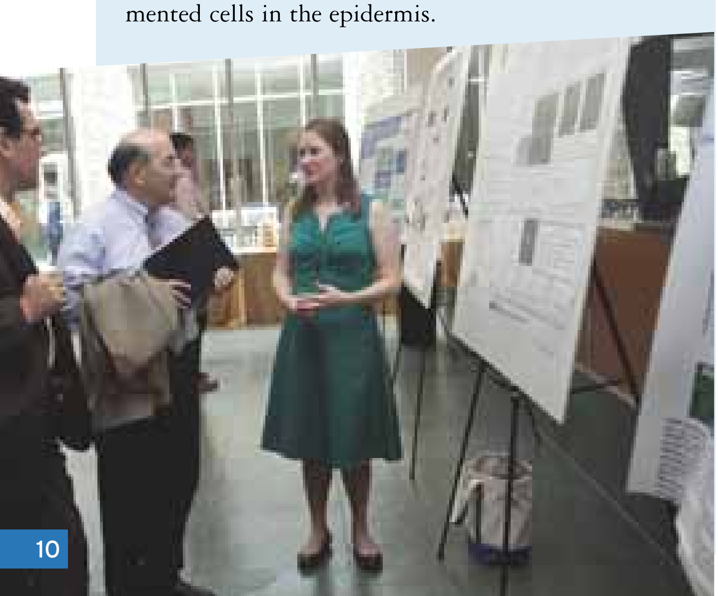
FIRST PLACE:

Mary Jane Simpson

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

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

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



SECOND PLACE: Neil Terry

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

Neil G. Terry, Yizheng Zhu, Matthew T. Rinehart, William J. Brown, Steven C. Gebhart, Stephanie Bright, Elizabeth Carretta, Courtney G. Ziefle, Masoud Panjehpour, Joseph Galanko, Ryan D. Madanick, Evan S. Dellon, Dimitri Trembath, Ana Bennett, John R. Goldblum, Bergein F. Overholt, John T. Woosley, Nicholas J. Shaheen and Adam Wax
Department of Biomedical Engineering, Duke University

Angle-resolved low coherence interferometry (a/LCI) is a light scattering technique that uses elastically scattered light to provide depth-resolved information about the morphology of nuclei and other cellular scatterers in vivo. a/LCI is able to identify dysplasia endoscopically by taking subsecond "optical biopsies" of target tissue and comparing the results to those predicted by Mie theory. We present the results of a pilot clinical study of 50 Barrett's esophagus patients to assess the efficacy of the a/LCI technique in identifying dysplasia in vivo in a clinical setting.who is using novel light-based technology to identify pre-cancerous cells of the esophagus. He is a Ph.D. student working in the laboratory of Adam Wax, associate professor of biomedical engineering.

THIRD PLACE: Stephanie Chiu

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

Stephanie J. Chiu[1] , Joshua Y. Choi[1], Francesco LaRocca[1], Anthony N. Kuo[1], Cynthia A. Toth[2,1], Joseph A. Izatt[1,2] Sina Farsiu[2,1]
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The accurate detection of anatomical and pathological structures in real-world ophthalmic Spectral Domain Optical Coherence Tomography (SDOCT) images is critical for the study and diagnosis of ocular diseases. Only recently have algorithms been developed to automate the segmentation process. These works, however, focus mainly on the segmentation of high quality images for only a particular anatomical or pathological feature. We extended a general segmentation framework based on graph theory and dynamic programming, which we introduced previously for segmenting retinal layers in normal eyes. We broadened the application of our framework by incorporating prior information about the morphology of the ocular structures. We applied this technique to segment images of varying quality from several different ophthalmic SDOCT applications, including normal retina, Level 3 aged-macular degeneration (AMD) retina with drusen, advanced AMD retina, pediatric retina (with and without edema), and cornea. The underlying algorithm for the segmentation of these various images was identical, with modifications made to the graph weights, search space, and segmentation order for each image category. Results show that our algorithm accurately segmented layers in retinal and corneal SDOCT images with varying degrees and types of pathology. Furthermore, our automatic segmentation matched an expert grader more closely than a second grader for all image targets. This is highly encouraging for not only reducing the time and manpower required to segment images in ophthalmic studies, but also for offering an extensible yet integrated algorithm for the segmentation of different ocular diseases.

Left: *Mary Jane Simpson (right) presenting the winning poster.*

2010-2011 Chambers Fellows

The Fitzpatrick Institute for Photonics is pleased to announce the five new recipients of the John T. Chambers Fellows for the 2010-2011 academic years. This program has been supporting FIP graduate students since 2001. Candidates for these fellowships are incoming graduate students to Duke University who have been nominated by a FIP professor. They are judged based on their prior research accomplishments, their research potential, their collaborative potential, and a range of their own personal qualities.

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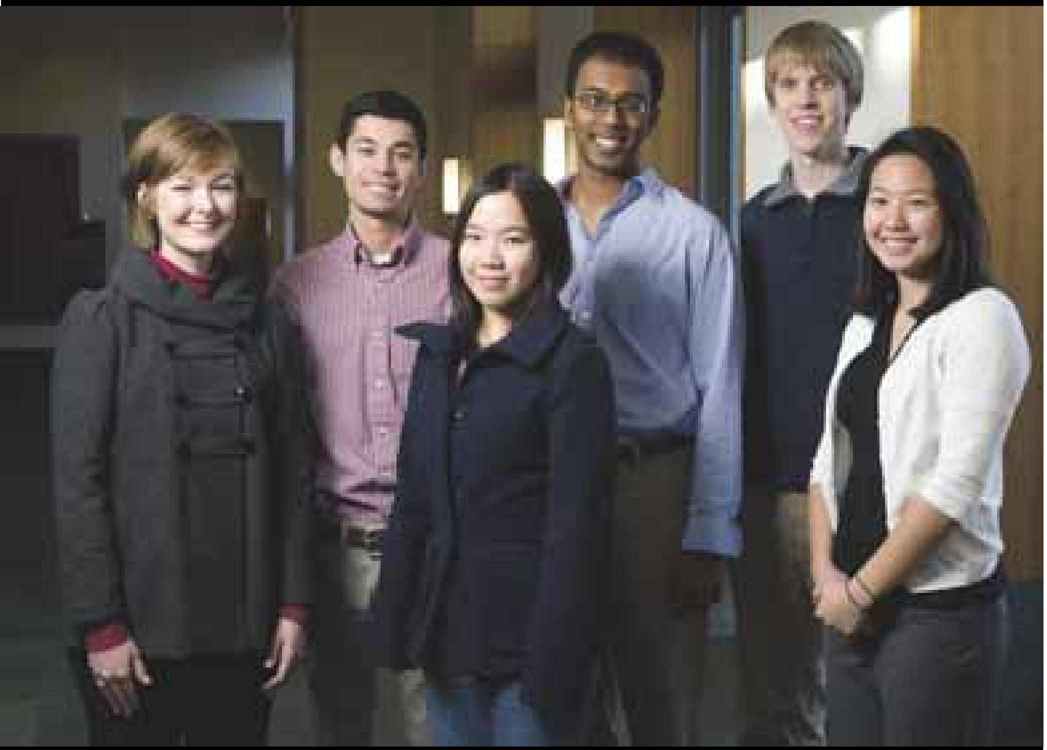

Left to Right: *Amy Frees, Andrew Fales, Meizhen Shi, Shwetadwip Chowdhury, Stephen Crain, Stephanie Chiu (Chambers Scholar)* Not pictured: *Ma Luo (Chambers Scholar)*

New Scholars Program

The Chambers Scholars is a new and distinctive award for the 2010-2012 academic years. The program provides existing Duke graduate student(s) within the FIP $40,000 each year towards their stipend and tuition for two years. The Chambers Scholars program is designed to reward the most outstanding individuals within FIP for their accomplishments and potential. Each candidate was nominated by a FIP professor, and was judged on criteria including demonstrated excellence both in the classroom and the laboratory, their two-year research plan, and projects involving inter-group or interdisciplinary research stimulating new collaborations within the FIP.

This year's recipients are:

Stephanie Chiu	Prof. Sina Farsiu	BME
Ma Luo	Prof. Qing Liu	ECE

NewDegree

Master of Engineering in Photonics and Optical Sciences

The Fitzpatrick Institute for Photonics is now offering a new master's degree designed to provide students with specialized classes in photonics and optical sciences paired with a core of business and management courses. Students are also required to complete an internship or project.

"The new Master of Engineering degree in Photonics and Optical Sciences is a natural extension for the Fitzpatrick Institute," said Adam Wax, Director of Graduate Studies for the Department of Biomedical Engineering, and the faculty adviser for the new degree program. "We are able to provide student training tailored to launch careers in industry—and that even provides job experience through internships."

The new degree program offers graduate courses in areas were Duke is leading photonics research, including biophotonics, nanophotonics, quantum information sciences, laser systems and optical imaging and spectroscopy.

For more information about the degree: http://meng.pratt.duke.edu/photonics-optical-curriculum

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DukeBroadband

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- **quantum information:** D. Gauthier, director
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- **advanced photonics systems:** M. Reichert, director
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- **metamaterials:** D. Smith, director
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