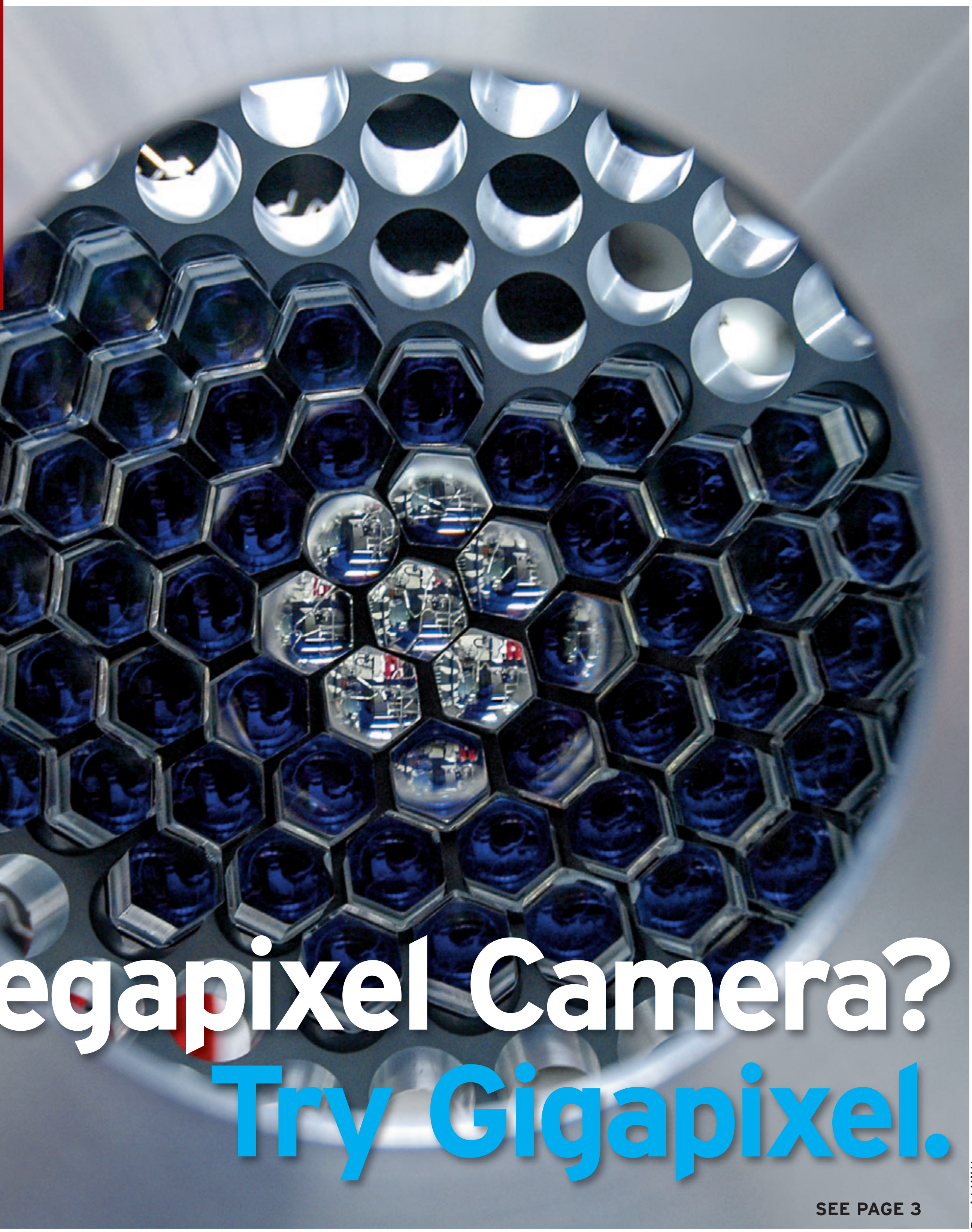
DukeBroadband

FITZPATRICK INSTITUTE FOR PHOTONICS • DUKE UNIVERSITY

FIP FACULTY HIGHLIGHT
V. Seewaldt

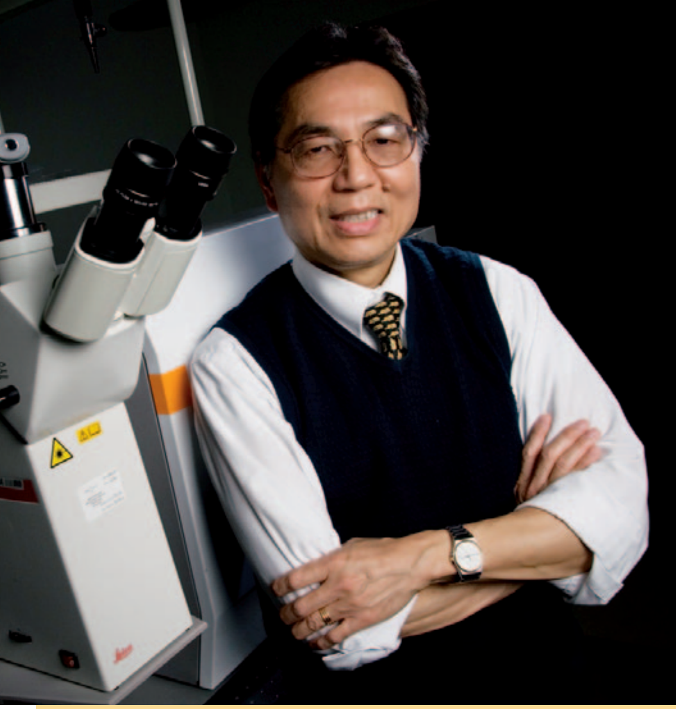


Megapixel Camera? Try Gigapixel.

SEE PAGE 3

David Kittle

2012 VOLUME 6 . ISSUE 1



Professor Tuan Vo-Dinh

Welcome to the Fall 2012 issue of BROADBAND, the Newsletter of the Fitzpatrick Institute for Photonics (FIP). Due to the dedication and contribution of its faculty, students and staff, the FIP has continued to grow in research, education, industrial activities and membership. The membership of the Institute has increased to 86 faculty members belonging to 28 departments and institutions from the Pratt School of Engineering, the Trinity School of Arts & Sciences, and the Duke School of Medicine.

As education is an important element of our Institute's activities, we continue to promote the curriculum of the Graduate Certificate Program in Photonics and have recently initiated the program for the Master of Engineering degree with a focus in Photonics and Optical Sciences. In addition, we are expanding our outreach programs by having graduate students help to reach younger generations from undergraduates to high school students. As a part of our outreach activities to get pre-college students more familiarized with and excited by photonics science and technologies at Duke, we have invited and hosted students from several high schools, locally such as Franklin Academy, Riverside High School, North Carolina School of Science and Math and nationally Rockdale Magnet School for Science and Technology in Georgia, to visit the FIP at Duke. To generate excitement in science and engineering in young minds, we organized the '*Breakfast with the Nobel*' session during the 2011 Annual Meeting where top high schools students in the area were invited for breakfast and informal discussion with our Keynote speaker, Dr. Martin Chalfie, 2008 Nobel Laureate in Chemistry.

Promoting cross-disciplinary collaborative research at Duke is a major goal of the FIP, and one of its criteria for success. This issue of BROADBAND highlights the research activities and achievements of some of our faculty members that have worked with other FIP colleagues within and outside of the Pratt School of Engineering, underlining their cross-disciplinary collaborations. This issue features Professor Victoria Seewaldt from the Duke School of Medicine and Professor Gleb Finkelstein from the Physics Department, who have closely collaborated with other FIP members. This issue also includes articles about the important and exciting achievements of Professor David Smith and coworkers in plasmonics research and of Professor David Brady and coworkers in the gigapixel camera development.

We are most delighted to announce the *Ralph Eno Hamamatsu Scholarship* for undergraduates. Hamamatsu Corporation has made a gift to Pratt for sponsoring this undergraduate fellowship in honor of Ralph Eno, one of the founders' of Hamamatsu Corporation (HC), USA. We welcome our newest FIP Corporate Partner, BD (Becton, Dickinson and Company), a leading global medical technology company that is dedicated to improving people's health throughout the world by advancing research, discovery and production of new medical instruments, drugs and vaccines. We continue to work with corporate partners to develop collaborative activities and outreach programs and we give special thanks to each of them for their support.

I invite you to visit our website at www.fitzpatrick.duke.edu to learn more about our faculty, research programs, and activities.

I hope you have a successful and enjoyable year.

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

ANNUAL MEETING: The Fitzpatrick Institute for Photonics (FIP) has moved the FIP Annual symposium to spring to have less conflict with other national photonic meetings. **The next symposium is scheduled for March 12-13, 2013.**

Keynote Speaker: William D. Phillips
Dr. Phillilps was awarded the Nobel Prize in Physics 1997 "for development of methods to cool and trap atoms with laser light".
Special Topic: Photonics for Energy Technologies
Special Panel Session: "Energy Technologies: Research & Education in the Incoming Global Strategic Shift"

Megapixel Camera? Try Gigapixel.

BY RICHARD MERRITT • GRAPHICS BY HUI SON
PHOTOGRAPHY BY DAVID KITTLE

By synchronizing 98 tiny cameras in a single device, electrical engineers from Duke University and the University of Arizona have developed a prototype camera that can create images with unprecedented detail.

The camera's resolution is five times better than 20/20 human vision over a 120 degree horizontal field.

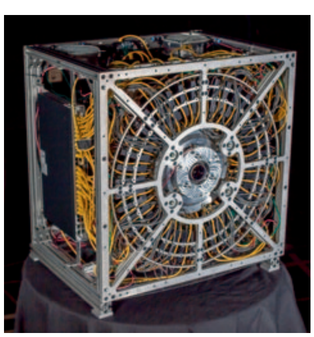
The new camera has the potential to capture up to 50 gigapixels of data, which is 50,000 megapixels. By comparison, most consumer cameras are capable of taking photographs with sizes ranging from 8 to 40 megapixels. Pixels are individual "dots" of data – the higher the number of pixels, the better resolution of the image.

THE CAMERA

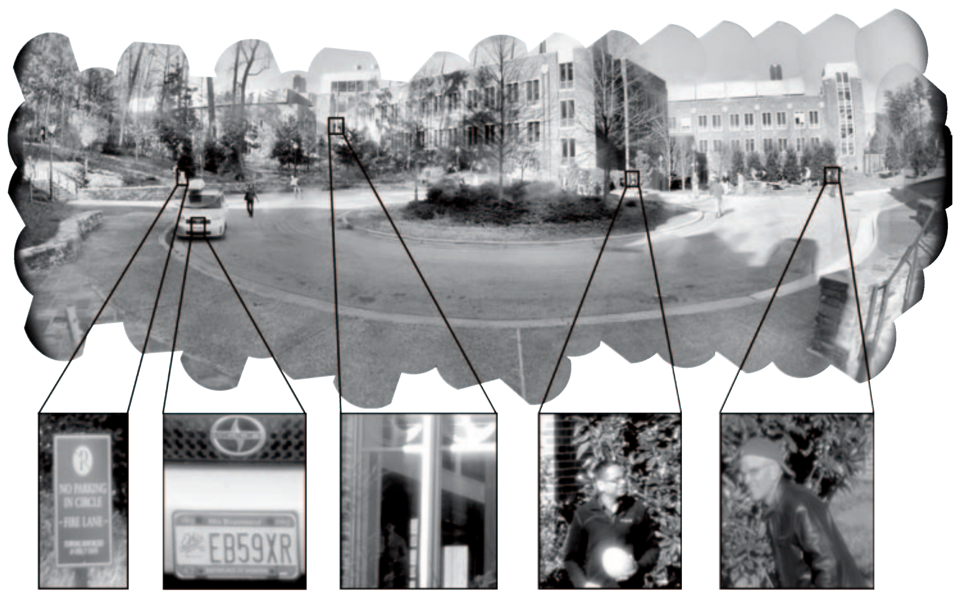
The researchers believe that within five years, as the electronic components of the cameras become miniaturized and more efficient, the next generation of gigapixel cameras should be available to the general public.

Details of the new camera were published online in the journal Nature. The team's research was supported by the Defense Advanced Research Projects Agency (DARPA).

The camera was developed by a team led by David Brady, Michael J. Fitzpatrick Professor of Electric Engineering at Duke's Pratt School of Engineering, along with scientists from the University of Arizona, the University of California – San Diego, and Distant Focus Corp.



"Each one of the microcameras captures information from a specific area of the field of view," Brady said. "A computer processor essentially stitches all this information into a single highly detailed image. In many instances, the camera can capture images of things that photographers cannot see themselves but can then detect when the image is viewed later."



"The development of high-performance and low-cost microcamera optics and components has been the main challenge in our efforts to develop gigapixel cameras," Brady said. "While novel multiscale lens designs are essential, the primary barrier to ubiquitous high-pixel imaging turns out to be lower power and more compact integrated circuits, not the optics."

The software that combines the input from the microcameras was developed by an Arizona team led by Michael Gehm, assistant professor of electrical and computer engineering at the University of Arizona.

"Traditionally, one way of making better optics has been to add more glass elements, which increases complexity," Gehm said. "This isn't a problem just for imaging experts. Supercomputers face the same problem, with their ever more complicated processors, but at some point the complexity just saturates, and becomes cost-prohibitive."

DAVID BRADY

"Our current approach, instead of making increasingly complex optics, is to come up with a massively parallel array of electronic elements," Gehm said. "A shared objective lens gathers light and routes it to the microcameras that surround it, just like a network computer hands out pieces to the individual work stations. Each gets a different view and works on their little piece of the problem. We arrange for some overlap, so we don't miss anything."

The prototype camera itself is two-and-half feet square and 20 inches deep. Interestingly, only about three percent of the camera is made of the optical elements, while the rest is made of the electronics and processors needed to assemble all the information gathered. Obviously, the researchers said, this is the area where additional work to miniaturize the electronics and increase their processing ability will make the camera more practical for everyday photographers.

"The camera is so large now because of the electronic control boards and the need to add components to keep it from overheating," Brady said, "As more efficient and compact electronics are developed, the age of hand-held gigapixel photography should follow."

Co-authors of the Nature report with Brady and Gehm include Steve Feller, Daniel Marks, and David Kittle from Duke; Dathon Golish and Esteban Vera from Arizona; and Ron Stack from Distance Focus. ■

READ ONLINE:
http://online.wsj.com/article/SB10001424052702304441404577478182111367056.html?mod=googlenews_wsj

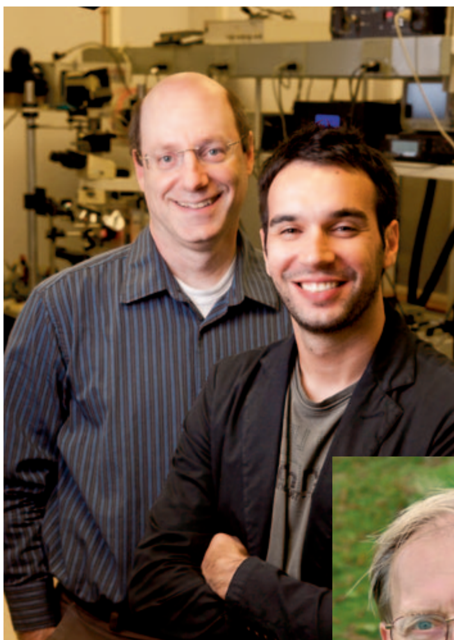
Photonic Interactions at the **Atomic Level**

BY RICHARD MERRITT

By measuring the unique properties of light on the scale of a single atom, researchers from Duke University and Imperial College, London, believe that they have characterized the limits of the ability of metals to be used in devices that rely on the enhancement of light.

This field is known as plasmonics because scientists are trying to take advantage of plasmons, electrons that have been "excited" by light in a phenomenon that produces electromagnetic field enhancement. The enhancement achieved by means of metals at the nanoscale is significantly higher than that achievable with any other material.

Until now, researchers have been unable to quantify plasmonic interactions at very small sizes, and thus have been unable to quantify the practical limitations of light enhancement. This new knowledge should help in the development of devices, such as medical sensors and integrated photonic communications components, since scientists will have a roadmap for precisely controlling the scattering of light.



L-R: David Smith, Christian Ciraci, and Sir John Pendry

Typically, plasmonic devices involve the interactions of electrons between two metal particles separated by a very short distance. For the past 40 years, scientists have been trying to figure out what happens when these particles are brought closer and closer, at sub-nanometer distances, according to the Duke electrical engineers.

Cristian Ciraci

"We were able to demonstrate the accuracy of our model by studying the optical scattering from gold nanoparticles interacting with a gold film," said Cristian Ciracì, postdoctoral fellow at Duke's Pratt School of Engineering. "Our results provide a strong experimental support in setting an upper limit to the maximum field enhancement achievable with plasmonic systems."

The results of Ciracì and co-workers' experiments, which were conducted in the laboratory of senior researcher David R. Smith, William Bevan Professor of electrical and computer engineering at Duke, were published in the journal Science as the cover article.

In their experiments, Ciracì and his team started with a thin gold film coated with an ultra-thin monolayer of organic molecules, studded with precisely controllable carbon chains. Nanometric gold spheres were dispersed on top of the monolayer. Essential to the experiment was that the distance between the spheres and the film could be adjusted with a precision of a single atom. In this fashion, the researchers were able to overcome the limitations of traditional approaches and obtain a photonic signature with atom-level resolution.

David Smith

"Once you know maximum field enhancement, you can then figure out the efficiencies of any plasmonic system," Smith said. "It also allows us to 'tune' the plasmonic system to get exact predictable enhancements, now that we know what is happening at the atomic level. Control over this phenomenon has deep ramifications for nonlinear and quantum optics."

The Duke team worked with colleagues at Imperial College, specifically Sir John Pendry, who has long collaborated with Smith.

Sir John Pendry

"This paper takes experiment beyond nano and explores the science of light on a scale of a few tenths of a nanometer, the diameter of a typical atom," said Pendry, physicist and co-director of the Centre for Plasmonics and Metamaterials at Imperial College. "We hope to exploit this advance to enable photons, normally a few hundred nanometers in size, to interact intensely with atoms which are a thousand times smaller".

The research was supported by the Air Force Office of Scientific Research and by the Army Research Office's Multi-disciplinary University Research Initiative (MURI).

The other members of the team were Duke's Ryan Hill, Jack Mock, Yaroslav Urzhumov and Ashutosh Chilkoti; and from Imperial College, Antonio Fernández-Domínguez and Stefan Maier. ■

FACULTY SPOTLIGHT

DNA Self-array

BY WHITNEY L.J. HOWELL

At every turn, nanotechnology has become the buzzword in research. DNA self-assembly is no different, and the widespread use of nanostructures has fundamentally changed how these investigations are conducted.

Through self-assembly, super molecular structures with designed properties build themselves. Researchers are no longer tasked with building each object individually. Early on, electronic measurements produced the best results when using DNA self-assembly to make metallic structures. But shrinking these bodies to a nano-level makes electronic tactics cumbersome.

"We figured out that using optical and photonic methods is more suitable than the electronic measurements we had initially planned," said **Gleb Finkelstein**, Ph.D., associate physics professor. "For electronic measurements you need to address individual structures, and there are significant challenges in providing electrical leads to structures 100 nanometers in size. Optics can give you access to lots of structures in parallel."

The underlying idea behind optics and photonics, he said, is that ability to observe average signals emitted by many structures simply by shining light on several simultaneously. As a result, Finkelstein said, he anticipates the results of this work will support the fabrication of a wide range of components for nano-electronic and plasmonic applications.

"It's clear from an electronics end that people can develop chips for processors and carve various structures into semi-conductors. That is a very well developed strategy, but it's a dead end," he said. "You can't progress much below 20 nanometer structures. Molecular work on a sub-nano scale – that's the way to go."

At this point, however, according to Finkelstein's graduate research assistant Mauricio Pilo-Pais, the work is at the proof-of-concept phase. But there is a concrete benefit. The DNA building the nanostructures is programmed to automatically space all particles at the same, specific distance from each other. That level of precision isn't achievable through other methods.

"Molecular work on a sub-nano scale – that's the way to go."

Gleb Finkelstein, Ph.D.

Based on this uniform spacing, Finkelstein and Pilo-Pais are able to determine where and in what ways these nanostructures will be most useful, such as biosensors, surface-enhanced Raman spectroscopy, fluorescence enhancement, non-linear plasmonics, plasmonic metamaterials, and many other applications.

"As we need faster computers and more processing power, we need to access smaller regimes," Pilo-Pais said. "Having plasmons to serve for that purpose will come into place. DNA could bridge some sort of synergy between electronics, plasmonics, and photonics."

To determine where each nanostructure will work best, the researchers rely on the colors they emit on the plasmon resonance spectrum. Colors are determined by several physical characteristics, including size, shape, and composition (either silver or gold), and dielectric properties of the surrounding medium.

To identify emitted colors and get a much closer look at the DNA structures, Pilo-Pais works with Jack Mock, a research associate working with **David Smith**, the William Bevan Professor of electrical and computer engineering best known for his work with the invisibility cloak. Together, they measure the plasmon resonance spectrum of single DNA/plasmonic nanoparticle structures.

Taking these measurements requires a customized dark field optical microscope, Mock said.

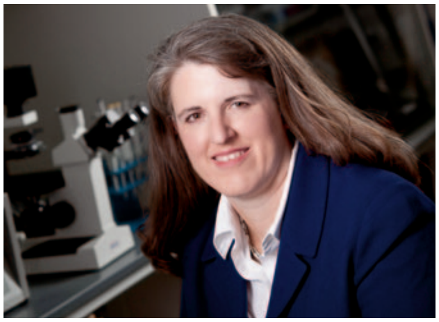
"I help Pilo-Pais load the samples on the scope, locate the structures of interest, take color microscope images of the structures, and acquire spectra of the structures," Mock said. "Then, we discuss the results and how to improve the experiment for the next round of characterizations."

Access to the dark field optical microscope is critical, he said, because it enables Finklestein and Pilo-Pais to complete single-structure spectral characterization. They use this knowledge to predict the plasmon resonant behavior and selectively tune future iterations of the DNA template process.

In addition to Mock and Smith, Finkelstein also works with collaborators from the chemistry and computer science departments. ■

WELCOME OUR NEWEST FIP FACULTY

Harold Erickson, Professor, Cell Biology
Gleb Finkelstein, Associate Professor, Physics
Russell P. Hall, III, Professor, Dermatology
Daniel Kiehart, Professor, Biology
Anthony Kuo, Assistant Professor, Ophthamology
▼ **Jennifer West**, Biomedical Engineering



Breast Cancer

BY WHITNEY L.J. HOWELL

Hearing the words "breast cancer" in the doctor's office is a frightening experience for a woman of any age. These diagnoses often come to women over age 50, but those under 40 face the most dangerous, aggressive forms of the disease. It's unclear why this is so, and that's the exact question Duke oncologist **Victoria Seewaldt, M.D.**, intends to answer.

Victoria Seewaldt, M.D.

While women under 40 account for only 7 percent of the nearly 227,000 new breast cancer cases each year, according to the American Cancer Society, they are far more likely to die from the disease. Together with colleagues from the Duke University Fitzpatrick Institute for Photonics (FIP), Seewaldt uses nanotechnology strategies and extremely small breast cancer cell samples to pinpoint the genesis of these deadly cancers.

According to **Tuan Vo-Dinh**, Ph.D., FIP director, the institute is an enthusiastic partner in this multi-pronged investigation.

"The Fitzpatrick Institute is the cornerstone of Duke's Photonics Initiative and cross-disciplinary research is at the heart of its vision," he said. "We're glad to see a strong, shared vision of interdisciplinary spirit in our faculty and across the Duke campus as the growing collaborations between disciplines and departments allow us to address the major research and translational challenges of our time."

The goal of this particular partnership, Seewaldt said, is to profile and analyze proteins suspected of playing a role in cancer and, hopefully, identify their pathways. To date, determining how these proteins act has been wishful thinking, making the tools and methods available through FIP vital to this research.

"Cancer is a network of proteins, and if you look at only one protein, you can't really appreciate the complexity of the network," she said. "Microarray, which we do with the help of our Fitzpatrick colleagues, allows us to work with a small amount of cells aspirated from the breasts and see how one protein leads to another."

> "the nanocage sits in the fluid, sucks up the things you want and leaves everything else. **It's like an open shark cage with meat in it."**

One of these tools is the nanocage, a hollow, porous 10 nm to more than 150 nm gold nanoparticle that has been used in other cancer research efforts. According to Jon Scaffidi, Ph.D., a former postdoctoral fellow in Vo-Dinh' s group and current Miami University chemistry and biochemistry assistant professor, nanocages can help researchers study a widely discussed breast cancer hypothesis.

Currently, researchers theorize that obese women are at higher risk for the disease because they produce more inflammatory cytokines, cell-signaling protein molecules that could prompt healthy cells to turn malignant. Analyzing cytokines is usually a tricky, messy process, but nanocages make it easier, he said.

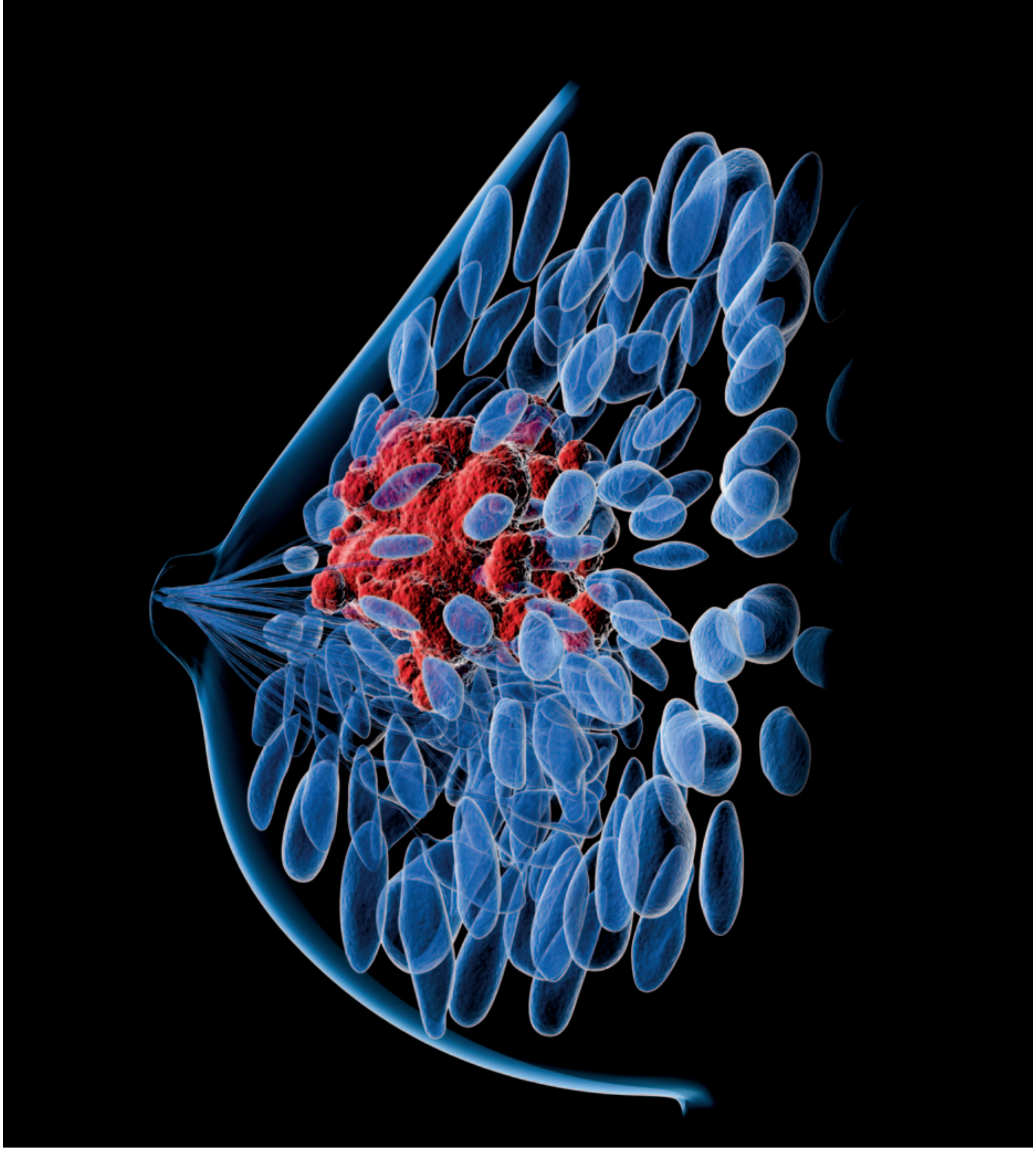
"When you first remove cytokines from the breast, the fluid is junky and really dilute. Doing any analysis is tough because of the crud, yuck, and blood, and you can never be confident of the results," Scaffidi said. "But the nanocage sits in the fluid, sucks up the things you want and leaves everything else. It's like an open shark cage with meat in it."

This filtering process also paves the way for more targeted and accurate cytokine signaling analysis. In addition, Fei Yan, Ph.D., Yan Zhang, Ph.D., Hsiang-kuo Yuan, M.D., and Molly K. Gregas, Ph.D., have worked with Vo-Dinh to determine how well nanocages can deliver cancer drugs. Initial study results have revealed this is a successful tactic.

In addition, this partnership is also shedding light on the role glucose uptake plays in identifying the most insidious breast cancers. In cases of highly aggressive, triple negative breast cancers, even precancerous cells have a high glucose uptake, Seewaldt said, and her team is investigating whether it is possible to detect rapidly spreading phenotypes in these premalignant cells.

"Is this why a whole breast can seem to go bad at once? Are there cells that cause everything to explode?" she said. "This problem happens so quickly and diffusely that perhaps there is a signaling path activated before cells even get to the cancer stage. Again, this is why technology from Fitzpatrick is so important."

There is potential through bioanalysis, she said, to identify precancerous cells that could become "unkillable" and remove them before they become malignant. The team is using fiber-optic nanoprobes to monitor



Side view of a female breast with a tumor. Features body silhouette, lobules, lactiferous ducts and tumor.

changes at a single-cell level and zero-in on any suspicious cells, solidifying knowledge of these pathways.

In addition, FIP's Hsin-Neng Wang, Ph.D., is using nanoprobes to detect certain DNA sequences associated with breast cancer biomarkers in solution. So far, his work has revealed these nanoprobes can be useful tools for medical diagnostics and high-throughput assays.

But researchers aren't only concerned with changes that happen within cells. They are also investigating whether the presence of vimentin – a protein often found in the inner lining of blood vessels – in the ducts of the breast is an early indicator of breast cancer. It is thought, Seewaldt said, that migrating vimentin indicates cancer cells can move throughout the blood stream to new locations. To answer this question, the team is using molecular nanoprobes to study microRNA in situ. The hope is to examine the protein and microRNA expression to discover why and how vimentin is present in unexplained places.

Although fluorescent signals can also illuminate signal expression, nanostars are more powerful and efficient when excited with two-photon light that can reach in deep-tissue tumors, according to a study conducted by Duke's Hsiangkuo Yuan, M.D., Christopher G. Khoury, M.S., Hanjun Hwang, M.S., Christy M. Wilson, Ph.D., and **Gerald A. Grant**, M.D. This tool makes signals tunable and more easily focused, and it can rapidly analyze many signals sequentially. In addition, nanostars can also be used as contrast agents in biomedical imaging and diagnostic applications to identify abnormalities on cell slides.

As the partnership between Seewaldt's team and FIP faculty continues to grow, so will the opportunities to employ nanotechnology solutions. No matter the tool, however, it's clear FIP's involvement has been integral to the research.

"Work and partnerships like this are extremely important for the younger women who face the deadlier forms of breast cancer," Seewaldt said. "We're doing this research for the 32-year-old woman with three kids who comes in and could be dead within a year. And, thanks to the Fitzpatrick Institute, we're making progress." ■

Lasers ID ancient artists' intent

A new laser system aids art conservation and restoration.

BY ASHLEY YEAGER • PHOTOGRAPHY BY SIMONE DEGAN

Shooting a laser at a priceless 14th century painting may seem problematic. But, precisely tuned and timed, the laser system may be the only non-destructive way to get into the mind of long-dead artists like Puccio Capanna and determine his materials, techniques and intent for painting the Crucifixion around 1330 A.D.

Duke chemist **Warren Warren** originally designed the laser system, which uses less power than a laser pointer, to detect changes in the chemicals that give skin cells their color. But one day, while walking through the National Gallery in England, Warren wondered whether his laser system would be able to identify pigments in art the same way it does for chemicals in human skin. He says the new laser system is a tool that can identify both the three-dimensional structure of layers in the art piece as well as the chemical signatures of the pigments in it.

In art, the pigment is the material, a powder of salt or stone, which makes up the color of paint. Warren and his team tested the laser system with small samples of the aquamarine pigment lapis lazuli, the red pigment vermillion and several other synthetic and naturally made pigments. The scientists discovered that the laser system, which uses infrared light, could identify distinct chemical fingerprints for each of the pigments and that it could even distinguish between the man-made and natural versions. The tests showed it also could penetrate through discolored or deteriorated surfaces.

William Brown, a conservator at the North Carolina Museum of Art, says the results are promising. He was so impressed by the first set of experiments that he now feels confident enough to volunteer Capanna's the Crucifixion as the first full piece of art for scientists to analyze. The laser system could identify the precise pigments and layering techniques the artist used and possibly where Capanna's pigments came from geographically. It might also verify whether this piece came from the same altarpiece as a panel on display at the Vatican, Brown says.

Warren's group is not the only one at Duke to work on scientific methods for imaging art. Chemist **Tuan Vo-Dinh** is developing a system based on nanoparticles, biochemical engineer **Joe Izatt** is using optical coherence tomography and computer scientist Robert Calderbank is using a form of mathematical analysis, called wavelets, to study brush strokes. The collaboration with the NC Museum of Art is not a first either. Brown has spent many years working with fine arts conservator Adele De Cruz, an adjunct associate professor of chemistry at the university.

About 15 years ago, De Cruz designed a laser technique to remove waxes, dirt and other incrustations from the surfaces of ancient paintings, sculptures and other works of art. She says Warren's laser system offers conservators a "new way to analyze works of art and use the information to organize our approach to cleaning it." The new laser system by itself cannot be used for cleaning an artwork, but it can provide "valuable information" about the raw materials an artist used and possibly who painted the piece, if the artist's identity is unknown, she says.

Conservators currently use x-ray and ultraviolet wavelengths of light to study paintings and also look at how light scatters off of the materials. Each technique, however, has limitations. Some can't probe through layers of pigments. Others can't determine the chemical characteristics of the materials that make up a pigment.

The laser system is based on pump-probe spectroscopy. It is an imaging technique that shoots two laser pulses through a series of lenses and mirrors and into a custom-built microscope. A tiny sample of a painting, or in the case of The Crucifixion, the entire piece, sits on the stage of the microscope. The pulses are timed so that the pump pulse excites the molecules at the focal point of the microscope's lens. Then, after a billionth of a millisecond delay, the probe pulse hits the same pigment. The intensity of the probe pulse will change depending on its interaction with the excited pigment molecules. The change in intensity over time of the probe pulse gives each pigment a unique pump-probe signature, says Tana Villafaña, a Duke graduate student who works on the project. She says one of the clearest signatures the team has identified is from the aquamarine pigment lapis lazuli. Artists originally made this pigment from a relatively rare, semi-precious stone. The stone is ground, then the lapis pigment extracted through a process of mashing the coarse grind under water in a ball of wax and resin. The purified pigment is then tempered with egg yolk and water to the right right consistency and gloss for brushing it onto a canvas.

Originally the stone for lapis lazuli was found only in Afghanistan. When explorers discovered the new world, they found a similar stone in Chile to make the pigment. Now, paint companies manufacture it synthetically. Villafaña and Prathyush Samineni, who received his doctoral degree partially based on this work in July 2012, studied natural and synthetic samples of the pigment using the pump-probe laser system. To their surprise, each type – the synthetic, Chilean and Afghani version, each had a different chemical signature. The laser system can also recognize the chemical signatures of these pigments, even if they are layered beneath other colors.

"We're really excited about this tool, especially the 3-D and chemical analysis and that it's right down the road," Brown says. He's hoping that if the results from the analysis of lapis and vermillion on the Crucifixion come back with enough detail, perhaps the team could get Vatican conservators to send their Capanna piece to Durham. Studied together, the pieces might reveal more about Capanna, how he structured the altarpiece that encapsulated the works and possibly what story he was trying to tell.

The team is still testing and standardizing the laser system. If the research and development continues, Warren says it is possible that the laser system could be turned into a portable device, making this type of analysis easier for conservation scientists and art conservators around the world. ■

Fitzpatrick Institute for Photonics Fellowships

The Fitzpatrick Institute for Photonics (FIP) is able to offer several graduate student fellowships through the continued support and generosity of the Fitzpatrick Foundation and John T. Chambers.

The Scholars program provides existing Duke graduate students within the FIP approximately $44,000 each year towards their stipend, tuition remission, grad school fees and health insurance for two years. This program is designed to reward the most outstanding individuals within FIP for their accomplishments and potential. Each candidate, nominated by a FIP Professor was judged on the criteria of demonstrated excellence in their academic studies, research and projects that involved inter-group or interdisciplinary research stimulating new collaborations among FIP faculty.

Eligibility:
Current FIP/engineering graduate students

Deadline for faculty to submit nominations: June 10

Length of Award: 2 years

The Fellows program used as a recruiting tool for the top candidates, provides incoming graduate students a one-year fellowship program, which awards a $10,000 top-up on their stipend and $1,000 towards educational travel. Each candidate is nominated by a FIP Professor and judged on the criteria of research accomplishments, research potential, personal qualities and collaborative potential.

Eligibility:
Incoming FIP graduate students

Deadline for faculty to submit nominations: March 11

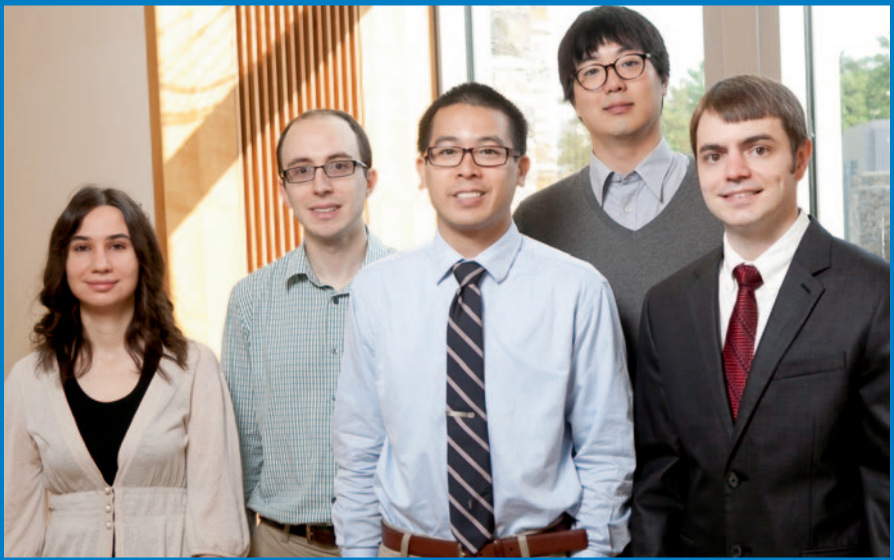
Length of Award: 1 year

The Fitzpatrick Institute for Photonics (FIP) is pleased to announce and introduce the recipients of the Fitzpatrick Foundation Scholars, John T. Chambers Scholars and the John T. Chambers Fellows for the 2012 academic year!

2012-2014 ~ Fitzpatrick Foundation Scholars
Derek Nankivil (BME – Professor Izatt)

2012-2014 ~ John T. Chambers Scholars
Kevin Seekell (BME – Professor Wax)
Ozlem Senlik (ECE – Professor Jokerst)

2012-2013 ~ John T. Chambers Fellows
Christopher Lam (BME – Professor Ramanujam)
Sanghoon Kim (BME – Professor Wax)



L-R: Ozlem Senlik, Kevin Seekell, Christopher Lam, Sanghoon Kim and Derek Nankivil.

Breakfast with Nobel Laureate, Dr. Chalfie

DOSC poster session.

Outreach at Fitzpatrick Institute for Photonics

The Fitzpatrick Institute for Photonics incorporated a new addition to our program last year to include an outreach to high school students. Local high school students from Riverside High School and Franklin Academy School attended an informal "Breakfast with a Nobel Laureate" to meet with our keynote speaker, **Dr. Martin Chalfie**, Nobel Laureate in Chemistry (2008). Dr. Chalfie, a discoverer of the green fluorescent protein (GFP) chatted with students about personal challenges and about his scientific discoveries while answering the students inquiries. Laughter was an important part of Dr. Chalfie's conversations at breakfast. Dr. Chalfie did leave them with an important statement, "It's been my experience that many discoveries, like Shimomura's [shared Nobel Prize with Chalfie], turn out to be accidental. As many of you probably already know, grad students and post-docs are the real innovators in the laboratory. And just as importantly, basic science and research is the essential driver of innovation." The DOSC (see below) also joined with FIP to host a poster session for local high school students after spending the summer of 2012 working on research together. ■

Culture at FIP

FIP moves to Social Media and you can access directly from the home page of our website.
www.fitzpatrick.duke.edu

Facebook for the latest at FIP
http://www.facebook.com/pages/The-Fitzpatrick-Institute-for-Photonics/196155823816521

Twitter for the latest photonic news in research
https://twitter.com/fipduke

LinkedIn for the latest job postings and connecting with FIP peers.
http://www.linkedin.com/groups/Fitzpatrick-Institute-Photonics-FIP-Duke-4264574?trk =myg_ugrp_ovr

The Fitzpatrick Institute qualifies for the Duke Green Certified Workplace.
http://today.duke.edu/2011/11/greenworkplace

2012-13 DOSC Officers

The Duke OSA/SPIE Student Chapters (DOSC) is a Duke Student organization interested in research in optics and photonics. They are officially affiliated as a student chapter with SPIE and The Optical Society of America, two professional societies dedicated to optics and photonics. Their affiliation with these societies along with the Fitzpatrick Institute for Photonics at Duke provides them with funding and resources that allows them to engage in many activities related to the exploration and promotion of optical sciences. Here are some of the things that they 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 the DOSC, check out their website: **dosc.pratt.duke.edu**

L-R: Faculty Advisor: Prof. Adam Wax; 2012-13 DOSC officers: Jenna Mueller, Chris Lam, Oscar Zevallos, Shwetadwip Chowdhury and Amy Frees.

Which Photonics program is right for you?

www.fitzpatrick.duke.edu/education

MEng

Master of Engineering Photonics and Optical Sciences

Curriculum: Core industry prep courses in business fundamentals and management with technical courses focused within a chosen engineering discipline. Also includes an industry internship, project or equivalent experience.

Ideal candidates: Recommended for students in the earliest stages of their careers who are interested in a practicing engineering position with a focus on product design and innovation.

Duration: 18-24 months

Certificate In Photonics for MS and PhD students

Curriculum: Photonics courses focused on technical areas of interest, a research presentation, and attendance at at least four FIP seminars.

Ideal candidates: Doctoral students in any technical field who wish to gain greater depth of skill and exposure to photonics and optical sciences.

Duration: Flexible. Courses can be taken at any time during the student's tenure at Duke while working towards a primary degree.

RALPH ENO HAMAMATSU SCHOLARSHIP

Hamamatsu Corporation, has made a gift to Pratt for sponsoring the Ralph Eno Hamamatsu Scholarship, an undergraduate fellowship in honor of Ralph Eno.

Julius Ralph Eno

Julius Ralph Eno, was one of the founders of Hamamatsu Corporation (HC), USA. As the US based subsidiary of the Japanese company Hamamatsu Photonics KK, HC has been instrumental in the development of the Photonics industry in the USA. It was largely through the vision of Ralph Eno, that many innovative products and services in support of the scientific, industrial, and medical instrument markets were pioneered by Hamamatsu.

Ralph Eno was born in 1929 in Long Beach California. His family was impoverished and he struggled to overcome his humble roots as a young man. After a stint in the Navy during the Korean War, Ralph attended Whittier College. After working many years as an instrument design engineer, he met Mr. Teruo Hiruma. At that time Mr. Hiruma was a key person in what was known as Hamamatsu Television Corporation. While vidicon tubes were one of this company's main products, it also had an active program of developing advanced photomultiplier tubes, and other light sensitive devices.

In 1969 Ralph Eno joined with Mr. Hiruma to establish Hamamatsu Corporation (USA). First headquartered in Garden City, New York, the company was established to distribute products made by Hamamatsu Television in Japan. Eventually, the company was relocated to New Jersey, and production facilities were completed for production of Photomultipliers in the USA. Mr. Eno was eventually promoted to President of the US operation.

Ralph Eno continues to serve as an inspiration to the company he helped establish. Upon his retirement in October of 2006, the Board of Directors of Hamamatsu Corporation, announced the establishment at Duke University of the Hamamatsu / Julius Ralph Eno scholarship in the Pratt School of Engineering. The scholarship honors his dedication to the field of higher education and the training of the next generation of engineers.

The Ralph Eno Hamamatsu Scholarship was awarded both this year and last year to Cheryl Lee. Lee is majoring in Civil and Environmental Engineering and expected to graduate in May 2013. Lee is also the current president of the Society of Women Engineers. ■

THANK YOU TO OUR PLATINUM CORPORATE PARTNERS

HAMAMATSU Photonics

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NEW PLATINUM CORPORATE PARTNER

BD

BD is a leading global medical technology company that develops, manufactures and sells medical devices, instrument systems and reagents. The Company is dedicated to improving people's health throughout the world. BD is focused on improving drug delivery, enhancing the quality and speed of diagnosing infectious diseases and cancers, and advancing research, discovery and production of new drugs and vaccines. BD's capabilities are instrumental in combating many of the world's most pressing diseases. Founded in 1897 and headquartered in Franklin Lakes, New Jersey, BD employs approximately 29,000 associates in more than 50 countries throughout the world. The Company serves healthcare institutions, life science researchers, clinical laboratories, the pharmaceutical industry and the general public. For more information, please visit **www.bd.com**.

Former FIP students and John T. Chambers Fellows are now engineers at BD Biosciences: Matt Crow, Christopher Khoury, David Sebba, and Neil Terry.

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Durham, NC
Permit #60

DukeBroadband

DukeBroadband is published by the Fitzpatrick Institute for Photonics, Pratt School of Engineering, Duke University. Edited by: Adam Wax, Tuan Vo-Dinh, and August Burns. Design: Lacey Chylack, phase5creative, inc. Direct comments to august.burns@duke.edu.

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- Anesthesiology
- Biology
- Biomedical Engineering (BME)
- Center for Metamaterials & Integrated Plasmonics
- Cell Biology
- Chemical Biology
- Chemistry
- Civil & Environmental Engineering (CEE)
- Computer Science (CS)
- Dermatology
- Division of Infectious Diseases & International Health
- Duke Comprehensive Cancer Center
- Duke Human Vaccine Institute
- Electrical and Computer Engineering (ECE)
- Gastroenterology
- Institute for Genome Science and Policy
- Mathematics
- Mechanical Engineering and Material Science (MEMS)
- Neurosurgery
- Oncology
- Ophthalmology
- Orthopaedic Bioengineering
- Pathology
- Pediatrics
- Physics
- Radiation Oncology
- Radiology
- Surgery

CORE RESEARCH THEMES

- **biophotonics:** J. Izatt, director
- **nano & micro systems:** N. Jokerst, director
- **quantum information:** D. Gauthier, director
- **systems modeling:** W. Yang, director
- **advanced photonics systems:** M. Reichert, director
- **nanophotonics:** K. Leong, director
- **metamaterials:** D. Smith, director
- **novel spectroscopes:** W. Warren, director