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**RIGHT:** Researchers Simeon Harbert, left, Blair Macintyre, center, and Parth Bhawalkar have developed two augmented reality systems to improve communication between an automated poultry inspection system and the workers who trim birds on a processing line.

## Missing Link

*Augmented reality technology may bridge communication gap in poultry processing plants.*

Technology that transfers computer-generated information onto the physical world is being tested for use in poultry plants to improve communication between computers and workers.

Using augmented reality (AR) technology, researchers have designed two systems that project graphical instructions from an automated inspection system onto birds on a processing line. These symbols tell workers how to trim or whether to discard defective products.

Right now, inspection is done visually by human screeners, who communicate instructions to trimmers using gestures. But an automated inspection system developed and field tested by the Georgia Tech Research Institute (GTRI) is being commercialized, and poultry plant officials are likely to implement the technology in the near term, says J. Craig Wyvill, head of the GTRI Food Processing Technology Division.

"When that happens, the industry will need an efficient way to link communication

from the imaging system to the trimmers," Wyvill notes.

So in a project funded by GTRI's state-supported Agricultural Technology Research Program, GTRI researchers are collaborating with experts in the Georgia Tech College of Computing to use AR technology in poultry plants. AR applications have been successfully demonstrated in industrial assembly and inspection, as well as the medical field.

"It's easy to see this technology working in a poultry plant," says Blair Macintyre, an assistant professor in the Georgia Tech College of Computing and augmented reality (AR) expert. "The question is, 'What is the best implementation of the technology to satisfy the environmental constraints?'"

Researchers have had to consider that poultry processing plants are typically wet and slippery and have to be thoroughly washed down with high-pressure water streams daily. Also, trimmers need simple, graphical instructions and must have their hands free of any object except a knife for cutting defective bird parts.

Two AR solutions developed by Macintyre and colleagues Parth Bhawalkar, a College of Computing graduate student, and Simeon Harbert, a GTRI research engineer, address these requirements.

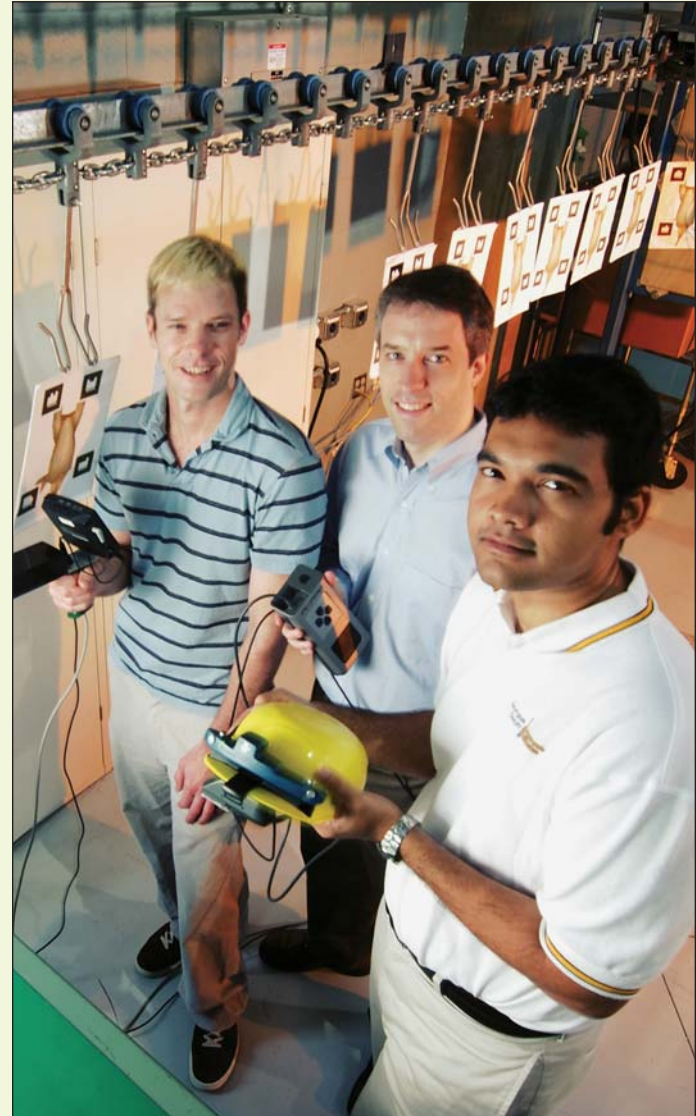
The first approach uses a location-tracked, see-through, head-mounted display worn by a trimmer. It directly overlays graphical instructions on a trimmer's view of the birds.

A second solution uses a laser scanner, mounted in a fixed location near the processing line, to project graphical instructions directly onto each bird that requires some action, such as trimming. In this approach, the product, but not the user, must be tracked for the instructions to appear on the product.



*ABOVE: One augmented reality system developed at Georgia Tech uses a location-tracked, see-through, head-mounted display (foreground) worn by poultry workers. It directly overlays graphical instructions on a trimmer's view of the birds.*

PHOTOS BY GARY MEEK



“Each solution appears to have advantages and disadvantages,” Macintyre says. One of the greatest benefits that both solutions provide is the potential for advance warning to trimmers of the workload coming down the line, he adds. Current practices don’t provide this advantage.

“But our suspicion is that the laser-based system is the more practical in the near term and potentially in the long term,” Macintyre says. “The real disadvantage of the head-mounted system is its cost.”

Researchers are conducting laboratory experiments with the two proof-of-concept prototypes they have designed. Experiments are expected to uncover the potential benefits or drawbacks of each AR application.

Researchers will likely choose one of the two solutions to develop further based on economics and logistics, Macintyre says. But it may be several years before the technology is commercially available, Wyvill notes.

— Jane M. Sanders

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PHOTO BY GARY MEEK



## Bridges of Water

**K**ee cool to reduce friction might be the advice given to designers of nanoscale machinery by researchers who have just completed a study of factors influencing the formation of “water bridges” — capillary connections that can glue surfaces together, giving rise to friction forces.

When surfaces touch in a humid environment, moisture forms water bridges, or capillaries, between them. On familiar size scales, this process — known as nucleation — helps hold sand castles and wet concrete together, and is critical to the formation of clouds. But sometimes these structures

can be less helpful, causing friction sufficient to slow or even stop nanoscale machinery — or in food processing, creating large clusters of sugar, salt, baby cereals or coffee.

By studying the frictional forces acting on an atomic force microscope (AFM) tip drawn across a glass surface, researchers at the Georgia Institute of Technology have demonstrated for the first time that the formation of these capillaries is thermally activated. Their study suggests that it may be possible to reduce the adhesion between surfaces by reducing temperatures and putting nanoscale surfaces into motion before the water bridges have time to form.

“When you move very slowly, there is time for a capillary to form at each tiny bump or asperity in the surface,” explains Elisa Riedo, an assistant professor in Georgia Tech’s School of Physics. “But when you move faster, you have fewer capillaries. If you go fast enough, the capillaries do not have time to form.”

Understanding the relationship between nucleation time and temperature could be crucial to the designers of very small devices that must operate in the presence of moisture, as well as to the food processing industry.

“Since formation of the capillaries affects friction and adhesion between particles, if we understand this relationship, we can understand how small particles and nano-surfaces glue together,” she notes.

A report on the research, which was sponsored by the National Science Foundation and the Petroleum Foundation, was published in the journal *Physical Review Letters* on Sept. 23.

Beyond applications to atmospheric science, the food industry and nanoscale sliding machinery, the researchers’ findings suggest another way to control ink flow in dip-pen nanolithography.

— John Toon

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**LEFT:** Researchers Elisa Riedo and Robert Szoszkiewicz demonstrate how they used an atomic force microscope (AFM) to study how “water bridges” form at the nanoscale.



# NOTES

## Anytime, Anywhere Learning

In U.S. cities and suburbs, high-speed wireless Internet connections are becoming more commonplace, making “anytime, anywhere learning” for students a more viable concept. But that kind of access — and the opportunities it provides — is not yet available in most rural areas.

However, a solution is in sight, and two recent demonstrations at educational technology conferences in Missoula, Mont., whet the appetite of educators and

PHOTO COURTESY OF JEFF EVANS



ABOVE: GTRI researcher Jay Sexton, left, sets up wireless equipment atop a remote mountaintop near Missoula, Montana.

(an acronym for Worldwide Interoperability for Microwave Access).

“WiMax is important because it's potentially the most cost-effective approach for broadband data service in rural areas,” says Jeff Evans, a GTRI senior research engineer who led the demo team. “With WiMax, an Internet service provider that wants to provide service to a small community up to 30 miles away can set up wireless long-haul and local links for thousands of dollars rather than the hundreds of thousands it costs to lay fiber for wired broadband.”

Around the nation, wireless technology companies and researchers have been demonstrating the capabilities of the new standards. Mike Hall, the Georgia Department of Education's deputy superintendent of information technology, involved GTRI researchers in the Montana demo through GTRI's Foundations for the Future (F3) technology assistance

program for K-12 Georgia schools.

Hall hailed the success of the demo in overcoming the speed, performance, distance and security issues that hamper current wireless technology. Though WiMax won't necessarily be a solution inside the walls of Georgia schools — many of which are already hard-wired for broadband Internet access — the technology could make it possible for students to learn via the Internet from home and other locations in their communities. He hopes GDOE, in partnership with GTRI, can lead the nation in implementing this goal.

— Jane M. Sanders

RIGHT: GTRI researcher Jay Sexton participates in a conference call to Georgia Tech from a remote mountaintop near Missoula, Montana. Other participants in the background participate in the wireless network access demo.



information specialists who want to use it to level the playing field for students. Atop a remote mountain near Missoula, engineers at the Georgia Tech Research Institute (GTRI) awed conference attendees with the video streaming, Web surfing and email capabilities of new wireless technology standards called 802.16 or WiMax

WiMax is a set of standards for delivering point-to-point, as well as point-to-multi-point wireless broadband connectivity. Point-to-point transmission is a direct transmission from a tower to a central-office-type location up to 30 miles away. At the central office location, point-to-multi-point connectivity extends up to five miles from the central office.

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# Switchable Solvents

*New class of solvents could provide more environmentally friendly processing of specialty chemicals.*

A new class of solvents whose key properties can be rapidly “switched” by the introduction of a common gas could provide a more environmentally friendly way of producing specialty chemicals for the pharmaceutical and other industries.

A research team from Queen's University in Canada and the Georgia Institute of Technology in the United States reported on the development of the “switchable solvents” in the Aug. 24 issue of the journal *Nature*. The first example of what could become a family of such solvents can be changed from a non-ionic liquid to an ionic liquid — and back again — with the alternate addition of nitrogen or carbon dioxide.

The ability to rapidly change the key properties of a solvent could allow multiple steps of a chemical reaction to be carried out without the need for removing and replacing solvents. That could potentially reduce pollution, cut cost and speed chemical processing.

“This process could provide a potential tool for benign and economical processing in the manufacture of high-value specialty chemicals,” says Charles Liotta, Georgia Tech's vice provost for research and dean of graduate

studies, Regents professor of chemistry and a member of the team reporting in the journal. “One possible use for these solvents would be for such applications as the manufacture of pharmaceuticals and pharmaceutical precursors, especially for asymmetric or chiral compounds.”

Chemical processing often requires multiple reaction and separation steps, and the type of solvent required for each step may be different. The solvent is therefore usually removed and replaced after each step, contributing to total processing costs, says Charles Eckert, a professor in Georgia Tech's School of Chemical and Biomolecular Engineering and director of the Specialty Separations Center.

“When you have to add and remove solvents, it's both expensive and polluting,” he notes. “With this new class of solvents, we would be able to do what are called ‘one-pot syntheses’ — that is, to carry out several steps in the same container with the same materials without having to do separations in between.”

The switchable solvent system provides a means of reducing the environmental impact from producing pharmaceuticals and other products that are essential to society today, notes Philip Jessop, the paper's lead author and Canada Research Chair in Green Chemistry at Queen's University. The

solvent tested by Queen's and Georgia Tech researchers is a “proof of concept,” though practical applications aren't yet known. The work being done by the research team — which also includes David Heldebrant and Xiowang Li, both from Queen's University — is an example of how chemical design principles are facilitating the application of green chemistry.

“We are designing molecules for a specific function,” Eckert explains. “We decide what functions we want, then put atoms together in such a way that we can achieve that function. The collaboration of chemists and chemical engineers at different institutions is what makes it possible to look at both the molecular aspects and the applications.”

Solvents known as ionic liquids are salts that are liquid at room temperature or near-room temperature.

“They tend to have a lot of organic character, and have been widely hailed as environmentally benign because they have no vapor pressure,” Eckert notes. “They have applications where they are beneficial, and they have some unusual properties that we hope to use.”

— John Toon

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*BELOW: Professor Charles Eckert, left, and Vice Provost Charles Liotta were part of a team of researchers that recently reported the development of “switchable solvents” whose properties can be rapidly changed.*



PHOTO BY NICOLE CAPPELLO



# SCIENTIST

**RIGHT:** Here, human breast cancer cells are tagged with quantum dots — tiny semiconductor particles that have unique electronic and optical properties. Quantum-dot-based probes can act as markers for specific proteins and cells and can be used to study protein-protein interactions in live cells or to detect diseased cells.

**LOWER RIGHT:** Shuming Nie is the director of the new Emory-Georgia Tech Nanotechnology Center for Personalized and Predictive Oncology.

## Discovery Accelerator

*New national research center will use nanotechnology to develop cancer detection and treatment technologies.*

A new national research center at the Georgia Institute of Technology and Emory University will serve as a “discovery accelerator” to integrate nanotechnology into personalized cancer treatments and early detection.

The National Cancer Institute (NCI) of the National Institutes of Health selected Georgia Tech and Emory this fall as one of seven National Centers of Cancer Nanotechnology Excellence (CCNE). The new center — the Emory-Georgia Tech Nanotechnology Center for Personalized and Predictive Oncology — will be housed on both campuses. The awarded amount is \$3.66 million for the first year, and is expected to reach \$19-20 million over a five-year period.

With the CCNE designation, Emory and Georgia Tech now possess one of the largest federally funded programs in the United States for biomedical nanotechnology, biomolecular and cellular engineering, cancer bioinformatics and biocomputing, translational cancer research, education and training, intellectual property creation, and nanomedicine commercialization and economic development.

Nanotechnology is research and technology at the atomic, molecular or macromolecular levels, where particles are measured with a nanometer equivalent to one-billionth of a meter, or 100,000 times smaller than a

strand of human hair. Coupled with the new genomic understanding of human cancers, nanotechnology offers promise for much earlier cancer detection, personalized diagnostics for targeted treatment and the creation of new nanoscale drugs for metastatic cancers.

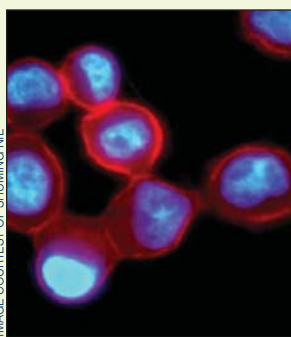


IMAGE COURTESY OF SHUMING NIE

Scientists involved in this grant will accelerate the development of “bioconjugated nanoparticles” for cancer molecular imaging, molecular profiling and personalized therapy. Emory and Georgia Tech scientists already have productive research collaborations to develop several kinds of nanoparticle probes, including “quantum dot” nanoparticles — tiny semiconductor particles that have unique electronic and optical properties because of their size and their highly compact structure. Quantum-dot-based probes can act as markers for specific proteins and cells and can be used to study protein-protein interactions in live cells or to detect diseased cells.

“Nanotechnology will eventually apply to all cancers; however, this grant is focusing on breast and prostate cancers because they represent a number of compelling challenges and opportunities in cancer research,” says Bill Todd, president and CEO of the Georgia Cancer Coalition and an important supporter of the grant. “These cancers are among the most common cancers and have high mortality rates, yet there is evidence that with targeted therapies for these types of cancer we can improve survival in Georgia and in the nation.”

The CCNE's director and principal investigator is Shuming Nie, the Wallace H. Coulter Distinguished Chair and a professor in the Wallace H. Coulter Department of Biomedical Engineering (BME) at Georgia Tech and Emory. He is also the associate director for nanotechnology bioengineering at Emory's Winship Cancer Institute, and a Georgia Cancer Coalition Scholar. The co-principal investigator is physician Jonathan Simons, director of the Winship Cancer Institute and a professor

of materials science and engineering at Georgia Tech.

“Nanotechnology enables us to bring together scientists in many disciplines, including basic biomedical and clinical sciences, engineering and computer science,” Nie says. “The joint Department of Biomedical Engineering at Georgia Tech and Emory University provides a truly collaborative environment for multidisciplinary research in 'Bio+Nano+Info', and for translating bio-engineering technologies and basic discoveries into clinical medicine. This Center will benefit cancer patients not only in the Winship clinics, but also in Georgia and the world, by providing new technologies for early detection, more accurate molecular-level diagnosis and targeted nanoparticle drugs for individualized cancer therapy.”

— Megan McRainey

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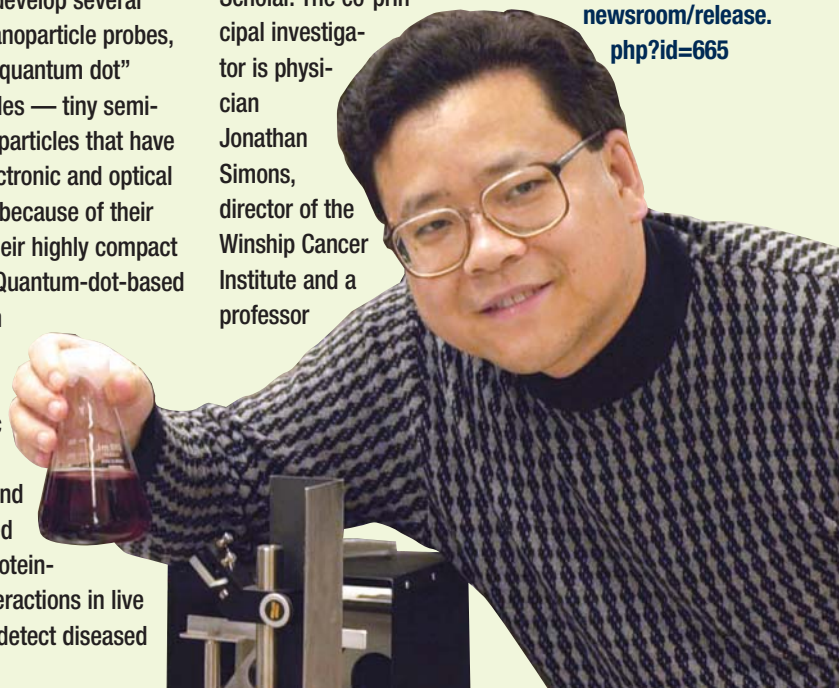


PHOTO COURTESY OF SHUMING NIE

## Endangered Schools

**B**ecause of its size and location in metro Atlanta, the DeKalb County School System is vulnerable to natural and human-caused disasters. Recognizing the potential for crisis, the district has sought the help of the Georgia Tech Research Institute (GTRI) in improving its emergency preparedness.

GTRI research associate Dara O'Neil and her colleagues are providing technology and policy assistance, and emergency preparedness evaluation to DeKalb through the system's Schools United Responding to Emergencies (SURE) initiative. The U.S. Department of Education is funding the effort.

"The DeKalb County School System has become one of the more innovative school systems in implementing new technologies to help prepare for a crisis situation," O'Neil says.

In May 2005, O'Neil helped organize a tabletop emergency exercise involving a simulated petroleum tank farm explosion near DeKalb's Oakcliff Elementary School. About 20 school employees and top state and local emergency response officials participated in the event sponsored by the Office of Homeland Security-Georgia Emergency Management Agency (OHS-GEMA).

PHOTO BY STANLEY LEARY



*GTRI helped organize a tabletop emergency exercise involving a simulated petroleum tank farm explosion near a DeKalb County school in metro Atlanta. School employees and top state and local emergency response officials participated in the event.*

"The tabletop drill is a very effective way to review plans, get feedback and make improvements — all without the trauma of a real emergency," says DeKalb administrative coordinator Terry Segovis, the former principal at Oakcliff. "As we moved through the exercise, I was able to test our plans, hear from the responders about the quality of those plans and make some important connections along the way."

In the exercise, officials planned an evacuation of Oakcliff, but the scenario was complicated by an estranged parent holding his child hostage. To help officials respond, GTRI researchers demonstrated the Geographic Tool for Visualization and Collaboration (GTVC), a high-tech collaborative mapping tool developed by GTRI for OHS-GEMA. It allowed participants to see the distance between the tank farm and the school and the best route to take for the evacua-

tion. Also, GTVC was linked to panoramic images of every entrance, classroom, hallway and closet of the school — a video database that GTRI is helping the school system build.

The exercise concluded with everyone safely evacuated to a nearby middle school and apprehension of the parent. Participants agreed that DeKalb responded satisfactorily during the exercise, but they made recommendations for improvement, O'Neil says.

"This exercise was a good opportunity to get first responders and school personnel to know each other face-to-face under fairly normal circumstances," she adds. "That kind of contact helps them later when there's a crisis."

— Jane M. Sanders

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## Controlling Nanoparticle Size

**B**ecause the properties of nanoparticles depend so closely on their size, size distribution and morphology, techniques for controlling the growth of these tiny structures is of great interest to materials researchers today.

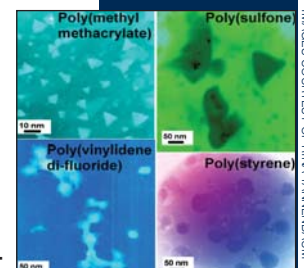
A research team from the Georgia Institute of Technology and Drexel University has discovered a surprising new mechanism by which polymer materials used in nanocomposites control the growth of particles.

Reported in August at the 230th national meeting of the American Chemical Society, the findings could provide a new tool for controlling the formation of nanoparticles.

Growing particles within the confinement of polymer-based structures is one technique commonly used for controlling nanoparticle growth. After formation of the particles, the polymer matrix can be removed — or the resulting nanocomposite used for a variety of applications.

In a series of experiments, the research team found a strong relationship between the chemical reactivity of the polymer and the size and shape of resulting nanoparticles.

"We have concentrated on the reactivity of the polymeric matrix and how that influences the growth of particles," explains Rina



IMAGES COURTESY OF RINA YANINBENBAUM

**ABOVE:** These images show how the size and shape of iron oxide nanoclusters are controlled by interfacial interactions with polymers having various functional groups.

*continued on page 38*



# STATUS

**ABOVE RIGHT:** *Pirelli and Georgia Tech have formed a partnership to develop new optical components and broadband access technologies for future high-speed telecommunications networks. Shown making the announcement are, from left to right, Giorgio Grasso, CEO of Pirelli Labs Optical Innovation, Georgia Tech President Wayne Clough, and Georgia Governor Sonny Perdue.*

Tannenbaum, an associate professor in Georgia Tech's School of Materials Science and Engineering. "We found that in the melt the key parameter influencing particle size is the type of interaction with the polymer. The molecular weight of the polymer and the synthesis temperature are almost insignificant."

In a series of experiments, Tannenbaum and her collaborators created iron oxide nanoparticles within polymer films of different types, including polystyrene, poly(methyl methacrylate), bisphenol polycarbonate, poly(vinylidene di-fluoride) and polysulfone. The polymeric matrix was then decomposed using heat, leaving the particles to be characterized using transmission electron microscopy.

"These polymers spanned a variety of functional groups that differed in the strength and nature of their interactions with the iron oxide particles and in their position along the polymer chain," Tannenbaum says. "We found the characteristic nanoparticle size decreased with the increasing affinity — the strength of the interaction — between the polymer and iron oxide particles."

The researchers also found that the length of the polymer chain was only weakly related to the particle growth. "This means that for the same result, we can work in the melt with lower molecular-weight materials and have lower glass transitions," Tannenbaum explains.

Based on the experimental results, Tannenbaum and Associate Professor Nily Dan

of Drexel's Department of Chemical Engineering charted the relationship between average particle size and the reactivity of the polymer interface. That information should help other scientists as they attempt to regulate the growth of nanoparticles using polymer reactivity.

The research was sponsored by the National Science Foundation, Petroleum Research Fund of the American Chemical Society, U.S. Air Force Research Labs and Defense Advanced Research Projects Agency.

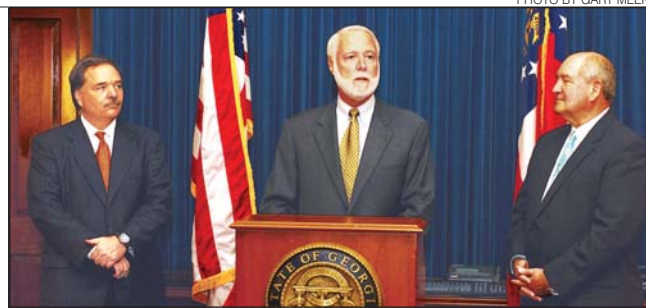
— John Toon

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Read more at: [gtresearchnews.gatech.edu/newsrelease/polymer-sizing.htm](http://gtresearchnews.gatech.edu/newsrelease/polymer-sizing.htm)

## Telecom Technologies

Pirelli and the Georgia Institute of Technology have formed a partnership to develop new optical components and systems and broadband access technologies for high-speed telecommunications networks. They signed a five-year strategic R&D agreement in September.

Pirelli and scientists from the Georgia Electronic Design Center (GEDC) at Georgia Tech are studying a new generation of integrated optical systems based on nanotechnologies and solutions for advanced home networking. Atlanta has also become the North American operational branch of Pirelli Labs, the advanced research center of the group based in Milan, Italy. Pirelli



has consolidated all of its North American corporate staff activities in the new Atlanta center, including the headquarters of Pirelli Broadband Solutions, a new company that engineers and markets the innovations conceived in Pirelli Labs. This alliance positions Georgia to become a world-class center of research excellence in photonics and broadband technologies, state officials say.

Under the agreement, visiting scientists from both organizations are working in Georgia Tech laboratories and in the clean rooms of Pirelli Labs near Milan. In Atlanta, Pirelli has laboratory space at the GEDC in the Technology Square Research Building at Georgia Tech, as well as additional headquarters office space next door in the Centergy One building.

"By combining the respective know-how, Pirelli Labs and Georgia Tech will be able to develop new cutting-edge broadband access and optical technologies for the North American market. We view our partnership with GEDC as a major strategic asset in our future broadband activities," says Giorgio Grasso, CEO of Pirelli Labs Optical Innovation.

Pirelli's decision demonstrates the effect that Georgia Tech can have on the state's economy, notes Georgia Tech President Wayne Clough. The

partnership "reflects the power of linking Georgia Tech's research and educational assets with those of the state of Georgia to help build the state technology sector in a time when competition for such jobs comes not only from other states, but other nations as well," he says.

In a related development in August, Samsung Electro-Mechanics Company opened a North American radio frequency integrated circuit (RFIC) design center in the Technology Square Research Building, which also houses the GEDC. The center will develop technology for next-generation communication systems, expanding to system-on-chip devices for modem, digital and RF equipment. Over the next five years, the new center could employ more than 100 design scientists and engineers.

Earlier this year, the company cited Georgia Tech's strengths in radio-frequency and mixed-signal research as major reasons for choosing the Atlanta location. Center researchers are expected to collaborate with Georgia Tech faculty and staff on a broad range of issues, including contributions to the IEEE standard for cognitive radio (IEEE 802.22).

— Rick Robinson

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