International research unit formed at Georgia Tech Lorraine

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Georgia Tech and France’s Centre National de la Recherche Scientifique (CNRS) have partnered to create a joint international research unit (unité mixte internationale, or UMI) to focus on telecommunications and innovative materials research.

The UMI, which is the first of its kind in France, will be based at Georgia Tech Lorraine, the European campus located in Metz, France. Created in 1990, GT Lorraine excels in secure networks and innovative materials research.

Two large and select French engineering schools, Arts et Métiers and Supélec, and two universities, Franche Comté University and Paul Verlaine University in Metz, are associate members. With a budget close to $3 billion and a workforce of more than 26,000 people, the CNRS is an influential scientific organization that helps coordinate research in government, university, and corporate laboratories.

“The fact that the UMI was officially signed in Paris at the CNRS headquarters in the presence of Dr. Catherine Brechignac, president of UMI continued, page 3

Graphite-based circuitry may offer a foundation for nanoscale devices

John Toon
Research News and Publications

A study of how electrons behave in circuitry made from ultra-thin layers of graphene — known as graphene — suggests the material could provide the foundation for a new generation of nanometer-scale devices that manipulate electrons as waves — much like photonic systems control light waves.

In a paper published April 13 in Science Express, an online advance publication of the Journal Science, researchers at Georgia Tech and the Centre National de la Recherche Scientifique (CNRS) in France report measuring electron transport properties in graphene that are comparable to those seen in carbon nanotubes. Unlike carbon nanotubes, however, graphene circuitry can be produced using established microelectronics techniques, allowing researchers to envision a “road map” for future high-volume production.

“We have shown that we can make the graphene material, that we can pattern it, and that its transport properties are very good,” said Walt de Heer, a professor in the School of Physics. “The material has high electron mobility, which means electrons can move through it without much scattering or resistance. It is also coherent, which means electrons move through the graphene much like light travels through waveguides.”

The results should encourage further development of graphene-based electronics, though de Heer cautions that practical devices may be a decade away.

“At this point, it seems that a major step in a very long path,” he said. “We are at

Three undergraduates named Goldwater Scholars

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One’s a film director turned physicist, another is a second-generation engineer and another is a mathematician who studied the relationships between members of the U.S. House of Representatives. Sophomores Jonathan Diaz, Andrew Marin and A.J. Friend are Tech’s latest recipients of the prestigious Barry M. Goldwater Scholarship, a national award designed to foster and encourage select students to pursue careers in the fields of mathematics, the natural sciences and engineering.

Jonathan Diaz is proof that good high school teachers can change students’ lives, or at least their minds. He had planned to go to film school to become a director, but after taking a high school astronomy class he decided that his future lay in cosmology.

“I was always good in science,” said Diaz, a physics major from Alpharetta, “but the thought that I would spend my life devoted to it didn’t occur to me until I took an astronomy course. I realized that there is something more than what I see in front of my eyes.”

At Tech, Diaz is working in the PicoForce lab under Assistant Professor Elisa Reido, studying the atomic origins of friction and other phenomena on the nanoscale. But just because he’s an aspiring physicist, doesn’t mean he’s turned his back on filmmaking. He recently

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Research group gets $3 million boost

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Last week, Georgia Tech’s Center for Organic Photonics and Electronics (COPE) announced a new partnership that will provide $3 million for research funding.

Solvay, an international chemical and pharmaceutical group headquartered in Brussels, Belgium, signed a three-year commitment with Georgia Tech to fund research in organic light-emitting diodes (OLEDs).

“Solvay’s partnership represents a substantial investment in Georgia Tech and signifies the company’s confidence in Tech’s ability to provide end-to-end resources encompassing modeling, synthesis, fabrication and testing,” said Seth Harder, director of COPE.

Solvay’s commitment to Tech will help fund research in OLEDs, thin-films of organic materials that give off light when electricity is applied. OLEDs could be used in everything

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the-proof-of-principle stage, comparable to where transistors were in the late 1940s. We have a lot to do, but I believe this technology will advance rapidly.”

The research, begun by de Heer’s team in 2001, is supported by the U.S. National Science Foundation and the Intel Corporation.

‘A promising material’

In their paper, the researchers report seeing evidence of quantum confinement effects in their graphene circuitry, meaning electrons can move through it as waves. “The graphene ribbons we create are really like waveguides for electrons,” de Heer said.

Because carbon nanotubes conduct electricity with virtually no resistance, they have attracted strong interest for use in transistors and other devices. However, the discrete nature of nanotubes — and variability in their properties — pose significant obstacles to their use in practical devices. By contrast, continuous graphene circuitry can be produced using standard microelectronics processing techniques.

“Nanotubes are simply graphene that has been rolled into a cylindrical shape,” de Heer explained. “Using narrow ribbons of graphene, we can get all the properties of nanotubes because those properties are due to the graphene and the confinement of the electrons, not the nanotube structures.”

de Heer envisions using the graphene electronics for specialized applications, potentially within conventional silicon-based systems. “We have shown that we can interconnect graphene, put current into it, and take current out,” he said. “We have a very promising electronic material. We see graphene as a platform, a canvas on which we can work.”

Established techniques

de Heer and collaborators Claire Berger, Zhimin Song, Xuebin Li, Xiaosong Wu, state Brown, Tianbo Li, Joanna Hans, Alexei Marchenkov, Edward Conrad and Phillip First of Georgia Tech and Didier Mayou and Cecile Paud at CNMS start with a wafer of silicon carbide, a material made up of silicon and carbon atoms. By heating the wafer in a high vacuum, they drive silicon atoms from the surface, leaving a thin continuous layer of graphene.

Next, they spin-coat onto the surface a photo-resist material of the kind used in established microelectronics techniques. Using electron-beam lithography, they produce patterns on the surface, then use conventional etching processes to remove unwanted graphene.

“We are doing lithography, which is completely familiar to those who work in microelectronics,” said de Heer. “It’s exactly what is done in microelectronics, but with a different material. That is the appeal of this process.”

Using electron-beam lithography in Georgia Tech’s Microelectronics Research Center, they’ve created feature sizes as small as 80 nanometers. The graphene circuitry demonstrates high electron mobility — up to 25,000 square centimeters per volt-second, showing that electrons move with little scattering.

Beyond coherence and high electron mobility, the researchers note that the speed of electrons through the graphene is independent of energy — just like light waves. The electrons also possess the properties of Dirac particles, which allow them to travel significant distances without scattering.

Among the challenges ahead is improving the techniques for patterning the graphene, since electron transport is affected by the smoothness of edges in the circuitry. Researchers will also have to understand the material’s fundamental properties, which could still contain “show-stoppers” that might make the material impractical.

de Heer has seen hints that graphene may offer some surprises. “We already have indications of some new and surprising electronic properties of this material,” he said. “It is doing things that we have never seen in two-dimensional materials before.”
from television and computer monitors to house-
hold lighting to handheld computing devices. COPE has already developed a unique material platform for OLEDs that may be deposited over large areas by inkjet printing and patterned using standard photolithography. Tech researchers have found that exposing the material to ultraviolet light leads to hardened materials that are insoluble and maintain stability under high tempera-
tures, allowing researchers to build a multi-lay-
ered, high-efficiency device from liquid materials.

The partnership further strengthens the company’s solid presence in Georgia, with offices of Solvay Advanced Polymers in Alpharetta and Solvay Pharmaceuticals in Marietta. For Tech, the partnership enhances its already strong interna-
tional presence and reputation and adds an outlet for successful technology transfer and commer-
cialization of research.

COPE, through the research group of Jean-Luc Bredas, already conducts research activities with the University of Mons-Hainaut in Belgium. "Because Georgia Tech is an institution that is continuing to grow its reputation as a global player, this partnership helps that effort by strengthening the name recognition in the capital of Europe," said Bredas, a professor in the School of Chemistry and Biochemistry.

The UMI’s research will also focus on innova-
tive materials related to optics, electronics and mechanical engineering, with an emphasis on nanotechnology and intelligent materials. The research will target industrial applications for aeronautics, automobiles, biomedical engineering and energy.

Abdallah Ouazazraden, a GT Lorraine professor of electrical and computer engineering, will direct the program.

The Alumni Association is also sponsoring bus trips to the Clemson game on Oct. 21 and the Georgia game on Nov. 25.

For more information...
Center for Organic Photonics and Electronics
www.cope.gatech.edu