Researchers Develop Techniques for Using Material Recognized in Nobel Prize

Georgia Institute of Technology

Georgia Institute of Technology researchers have pioneered the fabrication techniques expected to be used for manufacturing high-performance electronic devices from the material that has been recognized in this year's Nobel Prize in physics.

The 2010 physics prize was awarded for producing, isolating, identifying and characterizing graphene, a single atomic layer of carbon whose unique properties make the material attractive for electronic applications. Scientists at the University of Manchester were recognized for their work on graphene sheets peeled from blocks of graphite.

The work of the Georgia Tech group, headed by Professor Walt de Heer in the Georgia Tech School of Physics, was recognized by the Royal Swedish Academy of Sciences in its scientific background document on the physics prize. De Heer's group pioneered epitaxial techniques for growing large-scale graphene sheets by heating wafers of silicon carbide to drive off the silicon, leaving a thin layer of graphene.

The technique, which is now being used by research groups at companies such as IBM, has practical applications in large-scale production of electronic devices. On Oct. 3, the group published a paper in the journal *Nature Nanotechnology* describing a new technique used to produce an array of 10,000 graphene transistors.

"We believe that our technique, or one very much like it, will ultimately be used to manufacture future generations of graphene-based electronic devices," said de Heer. "Using techniques that are suitable for scaling up for mass production, we can grow graphene in the patterns that we need for electronic devices."

The Georgia Tech group holds a patent, filed in 2003, on fabricating electronic devices from these graphene layers.

Georgia Tech is home to a Materials Research Science and Engineering Center (MRSEC), funded by the National Science Foundation (NSF) and including collaborators from the University of California-Berkeley, University of California-Riverside and University of Michigan. The foundation focus of the center is research and development of epitaxial graphene.

"The unique properties of graphene portend considerable promise for future electronic and optical devices," said Dennis Hess, the center's director. "If graphene is to serve as a viable successor to silicon-based microelectronic devices and circuits, large scale production on a suitable substrate is required. Proof of concept of this approach has already been demonstrated by the fabrication of a 10,000 epitaxial graphene transistor array by Walt de Heer and his collaborators. This achievement is a significant advance toward realizing carbon-based electronics for the 21st century."

The Georgia Tech team also collaborates with researchers at the National Institute of Standards and Technology (NIST) on characterizing the unique properties of graphene. That work has led to several recent important papers, in journals such as *Science* and *Nature Physics*. The latter described for the first time how the orbits of electrons are distributed spatially by magnetic fields applied to layers of epitaxial graphene.

On Oct. 3 in the advance online publication of the journal *Nature Nanotechnology*, de Heer and collaborators described the development of a new "templated growth" technique for fabricating nanometer-scale graphene devices. The method addresses what had been a significant obstacle to the use of this promising material in future generations of high-performance electronic devices.

The technique involves etching patterns into the silicon carbide surfaces on which epitaxial graphene is grown. The patterns serve as templates directing the growth of graphene structures, allowing the formation of nanoribbons of specific widths without the use of e-beams or other destructive cutting techniques. Templated nanoribbon growth addresses the edge roughness that causes electron scattering.

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