Researchers achieves major step toward faster chips

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New research findings could lead to faster, smaller and more versatile computer chips. A team of scientists and engineers from Stanford, the University of Florida and Lawrence Livermore National Laboratory is the first to create one of two basic types of semiconductors using an exotic, new, one-atom-thick material called graphene.

The findings could help open the door to computer chips that are not only smaller and hold more memory—but are also more adept at uploading large files, downloading movies, and other data- and communication-intensive tasks.

A paper about the findings, co-authored by eight researchers, is set to be published Friday in the journal *Science*.

"There are still enormous challenges to really put it into products, but I think this really could play an important role," said Jing Guo, a UF assistant professor of electrical and computer engineering and one of two UF authors who contributed.

The team made, modeled and tested what is known in the industry as an "n-type" transistor out of graphene nanoribbon. Graphene is a form of carbon that has been called "atomic chicken wire," thanks to its honeycomb-like structure of interconnected hexagons. A graphene nanoribbon is a nanometer-wide strip cut from a graphene layer.

The team's feat is significant because basic transistors come in only two forms—"p-type" and "n-type"—referring to the presence of holes and electrons, respectively. "P-type" graphene semiconductors had already been achieved, so the manufacture of an "n-type" graphene semiconductor completes the fundamental building blocks.

"This work is essentially finding a new way to modify a graphene nanoribbon to make it able to conduct electrons," Guo said. "This addresses a very fundamental requirement for graphene to be useful in the production of electronics."

First isolated in 2004, graphene has spurred a great excitement in the chip research community because of its promising electrical properties and bare-minimum atomic size.

Scientists and engineers believe that after decades of development, silicon is fast reaching the upper limits of its physical performance. If the rapid evolution of ever-shrinking, ever-more-powerful, ever-cheaper semiconductors is to continue, they say, new materials must be found to complement or even replace silicon. Graphene is among the leading candidates for these nanoelectronics of the future.

Researchers at a number of institutions have reported using graphene to create a variety of simple transistor devices recently, with the Massachusetts Institute of Technology reporting in March the successful test of a graphene chip that can multiply electrical signals.

Guo said the team built and modeled the first-ever graphene nanoribbon n-type "field-effect transistor" using a new and novel method that involves affixing nitrogen atoms to the edge of the nanoribbon. The method also has the potential to make the edges of the nanometer-wide ribbon smoother, which is a key factor to make the transistor faster.

"This uses chemistry to really address the major challenges of electrical engineering when you get into such these small nanoscale dimensionalities," he said. "It is very unusual for electrical engineers, who are used to dealing with bulk structures of at least millions of atoms."

As exciting as the findings are, researchers must overcome many challenges before graphene semiconductors could be manufactured in bulk for use in consumer products, Guo said. For one thing, graphene is extremely expensive, so its cost would have to be reduced substantially. Also, to mimic or exceed silicon, engineers would have to figure out how to build not just one, but billions of transistors, on a tiny graphene fleck.

Five Stanford researchers led by Hongjie Dai, J.G. Jackson-C.J. Wood Professor of Chemistry, did the experimental work behind the findings. Guo and fellow author Youngki Yoon, who earned his doctoral degree from UF last December and is now at the University of California, Berkeley, did the computer modeling and simulation. The team also included Peter Webber of Lawrence Livermore National Laboratory.

Said Dai, "This work is just a beginning. It suggests that graphene chemistry and chemistry at the edges are rich areas to explore for both fundamental and practical reasons for this material."

Source: University of Florida (news : web)