Small graphene wires may be poor conductors

February 15 2008

Ohio University physicists researching electron properties in graphene ribbons have found that narrow wires made of this material may not be good conductors.

Graphene is considered to be the natural successor for silicon — the semiconductor material comprising the majority of all electronics today — with potential applications in the development of transistors and other circuitry devices that can revolutionize the future of electronics, said Nancy Sandler, an assistant professor of physics and astronomy at Ohio University.

Sandler, in collaboration with Ohio University postdoctoral fellow Mahdi Zarea, began researching electron phenomena in graphene — a single planar sheet of carbon-bonded atoms that forms graphite in its layered form — a year ago. The researchers were intrigued by the properties of the material when confined to small dimensions and focused on ribbon geometries as a first attempt to understand graphene wires.

"Under certain conditions carbon is a better conductor than silicon," said Sandler. "With graphene, only a minimum push — with a very small energy cost — is required to stimulate electrons to move. They can move faster and without deviations from their path even at room temperatures."

However, this behavior changes dramatically if the material is made into very thin wires, as the researchers found out in their latest work, which recently was published in the journal *Physical Review Letters* and in the *Virtual Journal of Nanoscale Science & Technology*.

The published work contains the first proposal of an explicit mechanism proved to dramatically alter the expected conduction properties of graphene ribbons.

“There are ‘minimum widths’ below which graphene ribbons are simply not good conductors at room temperatures. If we want to have smaller circuits, we need somehow to deal with the laws of repulsion that govern nature at such small scales,” Sandler said.

The effect is basically caused by the natural repulsion that alike charges feel when placed closer, when they are ‘confined,’ said Zarea. Surprisingly, and in contrast to predictions for graphene planes, intrinsic spin-orbit interactions originating from electrons moving around one another in which their spins can alter the motion — an effect due to relativistic corrections — don’t have the same consequences. It’s not the way electrons move, but their closeness that is fundamental in establishing the material's metallic behavior and viability as a conductor material, according to the researchers.

Sandler and Zarea are members of Ohio University’s Nanoscale and Quantum Phenomena Institute.

Source: Ohio University