A Smarter Way to Grow Graphene

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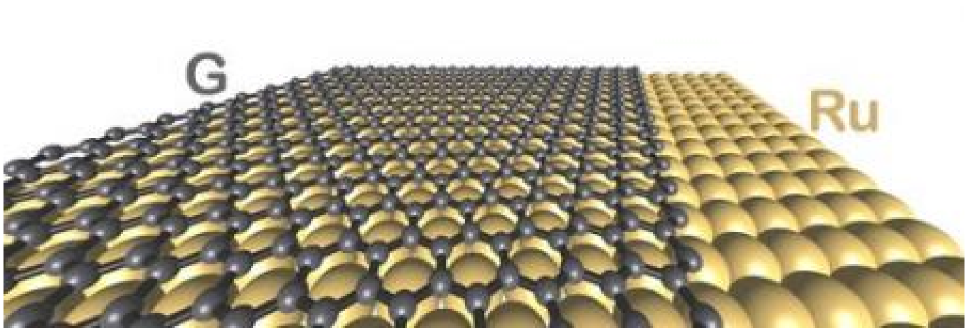

A schematic rendering of the first graphene layer (G) grown on the ruthenium substrate (Ru). Image courtesy Peter Sutter, Brookhaven National Laboratory

Graphene, a sheet of carbon just one atom thick, has many potential uses in the electronics industry, but producing these ideal two-dimensional carbon sheets is very difficult and, as a result, their use has been stifled so far. But scientists from Brookhaven National Laboratory may have finally found a way around the issue, devising a method to yield high-quality graphene sheets.

The current methods of isolating graphene each have problems. The most common, known as micromechanical cleavage, in which sheets are sheared off of a larger crystal, doesn't reliably produce graphene samples that are large enough for applications.

Another method, in which the atomic structure of a substrate is used to seed the growth of the graphene, known as epitaxial growth, doesn't yield a sample with a uniform thickness of graphene layers, and bonding between the bottom graphene layer and the substrate may affect the properties of the carbon layers.

The Brookhaven group based their technique on this second method, except that they were able to grow the graphene in a controlled, layer-by-layer manner. The substrate they chose is the rare metal ruthenium, and while the bottom graphene layer does interact strongly with it, the next layer up is almost completely detached, only weakly electrically coupled to it, and behaves much like free-standing graphene.

“This second layer retains the inherent electronic structure of graphene,” Brookhaven physicist Peter Sutter, who led the work, told *PhysOrg.com*. “Thus, our findings may represent a long-sought route toward rational graphene synthesis and the creation of high-quality graphene for applications in electronic devices and sensors.”

Graphene has several properties that make it desirable for electronics, including its very high carrier mobility—that is, electrons in graphene can roam rather freely. Graphene can respond to a single gas molecule, making it very attractive as a detector material for sensors.

The Brookaven group's growth process takes place at high temperatures. To start, the researchers caused carbon atoms to become absorbed within the ruthenium by heating the entire sample to 1150 degrees Celsius (ºC). The sample was then cooled to about 850 ºC, which caused large amounts of the absorbed carbon to rise to the surface of the ruthenium. The carbon formed single-layer lens-shaped islands about 100 micrometers (millionths of a meter) in width, dotting the entire substrate surface.

Eventually, the islands grew into a complete first graphene layer. And at about 80 percent coverage, the growth of the second layer began.

Sutter and his group observed the growth and studied the graphene's properties using various instruments, including a scanning electron microscope and a low-energy electron microscope.

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