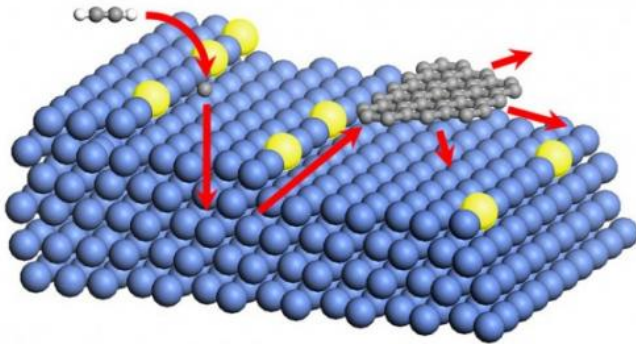


Golden touch makes low-temperature graphene production a reality

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Graphene growing on Au Ni. Credit: Robert Weatherup

(PhysOrg.com) -- A method which more than halves the temperature at which high-quality graphene can be produced has been pioneered by researchers.

The technique opens up new opportunities for the use of graphene, which is widely regarded as a potential "wonder substance" for the 21st century.

The researchers from the University of Cambridge's Department of Engineering added a very small amount of gold to the surface of a nickel film, on which the graphene was then grown. The resulting alloy meant that they were able to grow graphene at 450°C as opposed to the 1,000°C that is normally required.

The team, which was led by Robert Weatherup and Bernhard Bayer in the Department's Hofmann research group, was also able to find out more about how graphene forms during this process.

"Only once we'd developed a detailed picture of how the graphene was growing were we able to start tuning that growth and rationally engineering the catalyst - the nickel - to improve it," Weatherup

said. "Understanding this is interesting from a scientific point of view, but using this knowledge to improve the growth process has been the really useful outcome of our work."

Graphene is a microscopically thin substance - essentially existing in only two dimensions. It consists of a single, atom-thick sheet of carbon atoms, arranged in a hexagonal lattice.

What makes it exciting for scientists is its remarkable range of properties. Graphene is very strong, transparent and highly conductive. This means that it could be used for a whole range of applications, including flexible electronics that can be worn by the user, fast broadband, high-performance computing and lightweight components for planes and other machines.

For any of these possibilities to be realised, a reliable method for producing high-quality graphene is needed. The best option to date has involved scientists using chemical vapour deposition. In this process, a catalyst film - in some cases nickel, in others copper - is exposed to a carbon-containing gas at very high temperatures. Graphene then assembles on the surface of the film.

Until now, temperatures of about 1,000°C were needed for the graphene to form. This poses a problem, because the high-growth temperatures would severely damage many of the materials that are used in common manufacturing electronics, which means that the graphene cannot be directly integrated into the circuits that would then be used in electronic products.

Weatherup and Bayer's use of nickel films with a small amount of gold (less than 1%) opens up this possibility by reducing the growth temperature to 450°. The alloy also reduces the number of places where graphene grows on the film, because the gold blocks graphene growth.

This means that as each graphene flake emerges it grows larger and for longer before it joins with another flake. Because electrons travelling through the graphene are therefore not disturbed by joins between flakes as often, the conductivity of the graphene is improved. The result is graphene that can be produced at a drastically reduced temperature, but is still of the very high quality that would be needed for future applications.

Specialist techniques were also employed during the process to "sense" the atom-thick layer of graphene as it grew. The researchers were able to show definitively that graphene growth does not just occur when the substance cools down (as some academics had previously thought), and that its growth is not just affected by the surface of the catalyst film, but by a region of the film underneath.

Researchers widely predict that it is only a matter of time before graphene moves from the domain of scientific research and into industry. For now, however, commercial development is still some way off.

"We would ideally like to produce graphene directly on to an insulating substrate, as at present the alloy has to be removed after growth for graphene to be used in applications," Weatherup said. "The problem is that insulators tend to be less good at converting carbon-containing gases into high-quality graphene."

"Graphene growth is still a very young field, but it's moving incredibly fast. Using alloying of the catalyst, as we have here, is a brand new approach in improving the process and we expect further investigation of this will likely lead to improved [graphene](#) production, and perhaps at even lower temperatures."

The findings are reported in the new issue of the academic journal, *Nano Letters*.

Provided by University of Cambridge

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