Breakthrough may lead to industrial production of graphene devices

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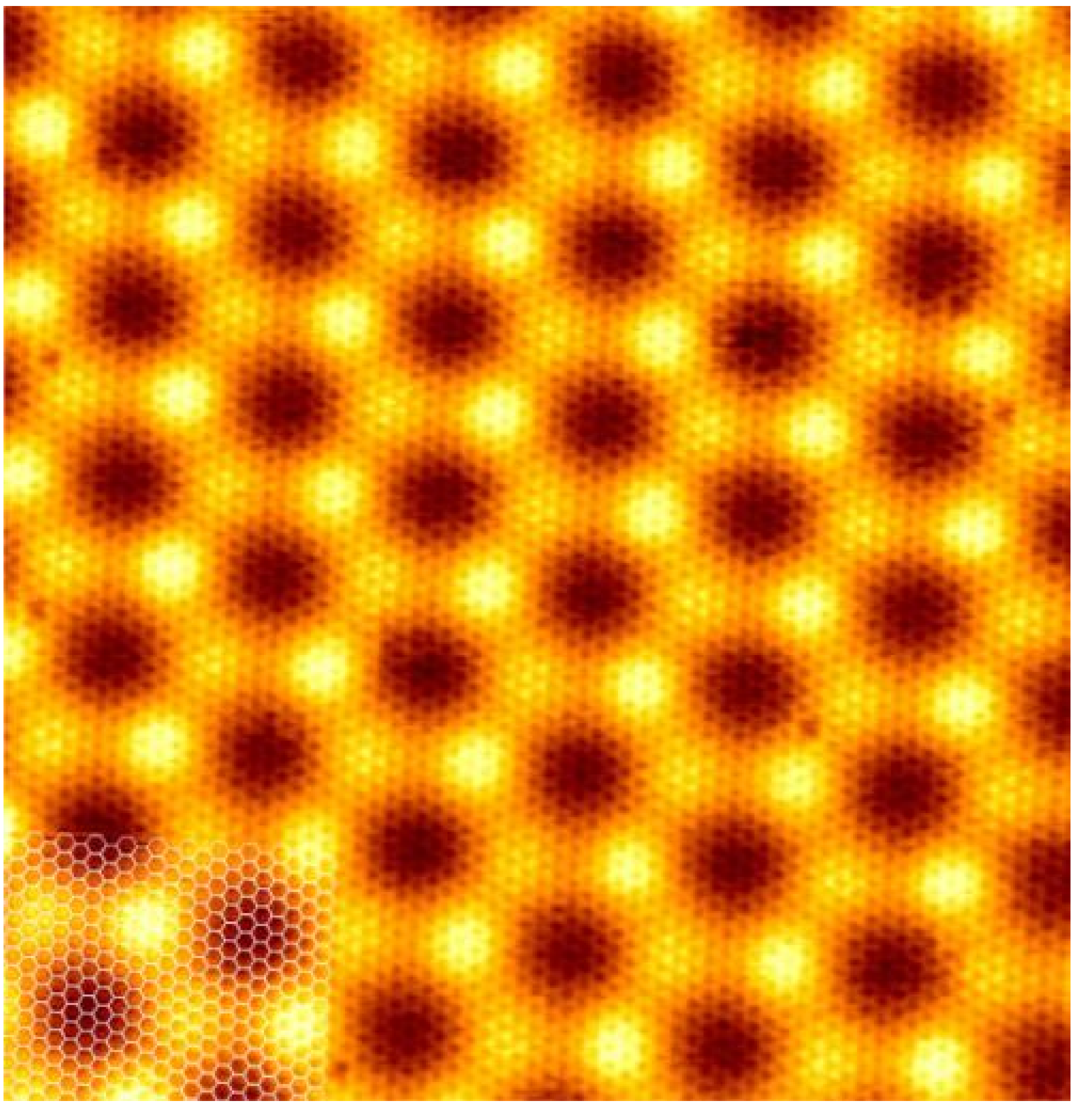

Scanning tunnelling microscopy (STM) image of graphene on Ir(111). The image size is 15 nm × 15 nm. Credit: ESRF

With properties that promise faster computers, better sensors and much more, graphene has been dubbed the 'miracle material'. But progress in producing it on an industrial scale without compromising its properties has proved elusive. University of Groningen scientists may now have made a breakthrough. Their results will be published in the journal *Nano Letters*.

Graphene is a special material with crystals that are just one atom thick. Electrons pass through it with hardly any resistance at all, and despite being very flexible, it is stronger than any metal. The discoverers of graphene, Andre Geim and Konstantin Novoselov, famously made it by peeling graphite with Scotch tape until they managed to isolate a single atomic layer: graphene. It won them the 2010 Nobel Prize in Physics.

'The challenge is to find a substrate that not only preserves the properties of graphene, but also enables scalable production.', says Stefano Gottardi, PhD student at the University of Groningen Zernike Institute for Advanced Materials. A good candidate is chemical vapour deposition . Here heat is used to vaporize a carbon precursor like methane, which then reacts with a catalytically active substrate to form graphene on its surface. A transition metal is normally used as the substrate. However, not only does the transition metal act as a support, but it also tends to interact with the graphene and modify - or even deteriorate - its outstanding properties.

Cumbersome

To restore these properties after growth on the metal, the graphene has to be transferred to a non-interacting substrate, but this transfer process is cumbersome and often introduces defects. Nevertheless, many scientists are trying to improve graphene growth on transition metals, mostly using copper foil as the substrate.

This is what the Surfaces and Thin Films group of Gottardi's supervisors Meike Stöhr and Petra Rudolf did too. 'When we analyzed a sample of graphene on copper, we made some strange observations', Stöhr recalls. The observations suggested that alongside the copper some copper oxide was also present. Indeed, a nice graphene film appeared to have formed on the copper oxide, and as oxidized metals might leave the properties of graphene unaltered, this was a potentially important observation.

The Groningen team began to study this possibility in more detail. That was three years ago. Since then, Gottardi and his colleagues have managed to successfully grow graphene on copper oxide. This achievement together with an in-depth characterization of graphene's properties will be published in Nano Letters. The team also reports the remarkable finding that graphene on copper oxide is decoupled from the substrate, which means that it preserves its peculiar electronic properties.

The results could be far-reaching. Stöhr: 'Other labs need to reproduce our findings, and quite a bit of work needs to be done to optimize growth conditions.' The best case scenario would be that large single-domain crystals of graphene could be grown on copper oxide. If this proves to be the case, it should then be possible to use lithographic techniques to make all sorts of electronic devices from graphene in a commercially viable manner. An unexpected observation three years ago may thus prove to be the start of a new era of graphene electronics.

More information: Comparing Graphene Growth on Cu(111) versus Oxidized Cu(111) *Nano Letters*, in press, DOI: 10.1021/nl5036463 .
pubs.acs.org/doi/full/10.1021/nl5036463

Provided by University of Groningen

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