

Study sheds light on environmental graphene interactions

May 24 2016

The interactions between graphene and its environment have a significant influence on the use of this promising material by the semiconductor industry. Thanks to the comprehensive findings of an international research project, these interactions are now better understood and can be controlled as a result.

Graphene is an atom-thin layer of carbon. Thanks to its unique structural and electronic characteristics, the material has enormous potential and is the focus of high expectations – however, concrete uses and applications have yet to materialise. As is so often the case when it comes to viable application, the devil is in the details. A project funded by the Austrian Science Fund FWF has managed to come to grips with some of these details.

Targeting semiconductors

"Individual components based on graphene already present outstanding characteristics," explains project leader Thomas Pichler from the Electronic Properties of Materials Department at the University of Vienna. "However, the major breakthrough in its application as an integrated electronic component has not yet emerged. It has simply not been possible to use this material for established semiconductor technology in a way that can be reliably replicated." One of the biggest obstacles is the lack of control of graphene interactions with its environment at [atomic level](#). As a result, it has been almost impossible to

deploy the material in a predictable and targeted way. Even the interaction between graphene and the substrate, to which it must be applied due to its extreme thinness, was only understood in part. Pichler and his research team have now determined the nature of this interaction.

Strain with charge

The team was also immediately successful in gaining some surprising new insights. "We were able to demonstrate a correlation between charge transfer – the shifting of electrons – and mechanical strain in graphene for the first time," says Pichler. "This observation could be of major practical significance, as it means that the entirely contactless measurement of internal strain in graphene-based components may be possible in the future."

The team also achieved significant successes in the targeted control of the environment of graphene. Within the framework of the project, it was possible to control the interface between graphene and traditional semiconductors like germanium on the atomic level for the first time. Many view this as an important step towards making graphene-based nanoelectronic components usable for [semiconductor technology](#).

Success with method

Crucial to the success of the cooperative project was its optimal combination and implementation of two processes. Pichler and his team used the very latest spectroscopy measurement techniques and complemented them with so-called ab-initio calculations, which were carried out by a team headed by Ludger Wirtz from the Institute for Electronics, Microelectronics and Nanotechnology at the University of Lille.

Extensive samples

The project succeeded in producing extensive samples of electronically insulated graphene. This provided an optimal starting material for the experimental work. "We then deliberately manipulated the electronic structure of the graphene," says Pichler, explaining the approach adopted by the project. "To do this, for example, we replaced certain atoms in the graphene substrate with hydrogen or nitrogen atoms and measured the impact of this substitution on the graphene." Another approach adopted by Pichler and his team involved a method known as intercalation. With this method, wafer-thin layers of potassium, lithium or barium are inserted between the graphene and the substrate and the resulting impact on the graphene is characterised.

These steps paved the way for many other advances arising from the FWF project, which are still needed to enable the comprehensive use of the miracle material graphene. Many challenges remain to be overcome before a "miracle-worker" like [graphene](#) can be put to practical use. Basic research will play a key role in overcoming these challenges.

More information: N. I. Verbitskiy et al. Atomically precise semiconductor—graphene and hBN interfaces by Ge intercalation, *Scientific Reports* (2015). [DOI: 10.1038/srep17700](https://doi.org/10.1038/srep17700)

Xianjie Liu et al. Tunable Interface Properties between Pentacene and Graphene on the SiC Substrate, *The Journal of Physical Chemistry C* (2013). [DOI: 10.1021/jp3103518](https://doi.org/10.1021/jp3103518)

Julio C. Chacón-Torres et al. Manifestation of Charged and Strained Graphene Layers in the Raman Response of Graphite Intercalation Compounds, *ACS Nano* (2013). [DOI: 10.1021/nl403885k](https://doi.org/10.1021/nl403885k)

Provided by University of Vienna

Citation: Study sheds light on environmental graphene interactions (2016, May 24) retrieved 9 April 2024 from <https://phys.org/news/2016-05-environmental-graphene-interactions.html>

This document is subject to copyright. Apart from any fair dealing for the purpose of private study or research, no part may be reproduced without the written permission. The content is provided for information purposes only.