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Graphene-based remote controlled molecular switches

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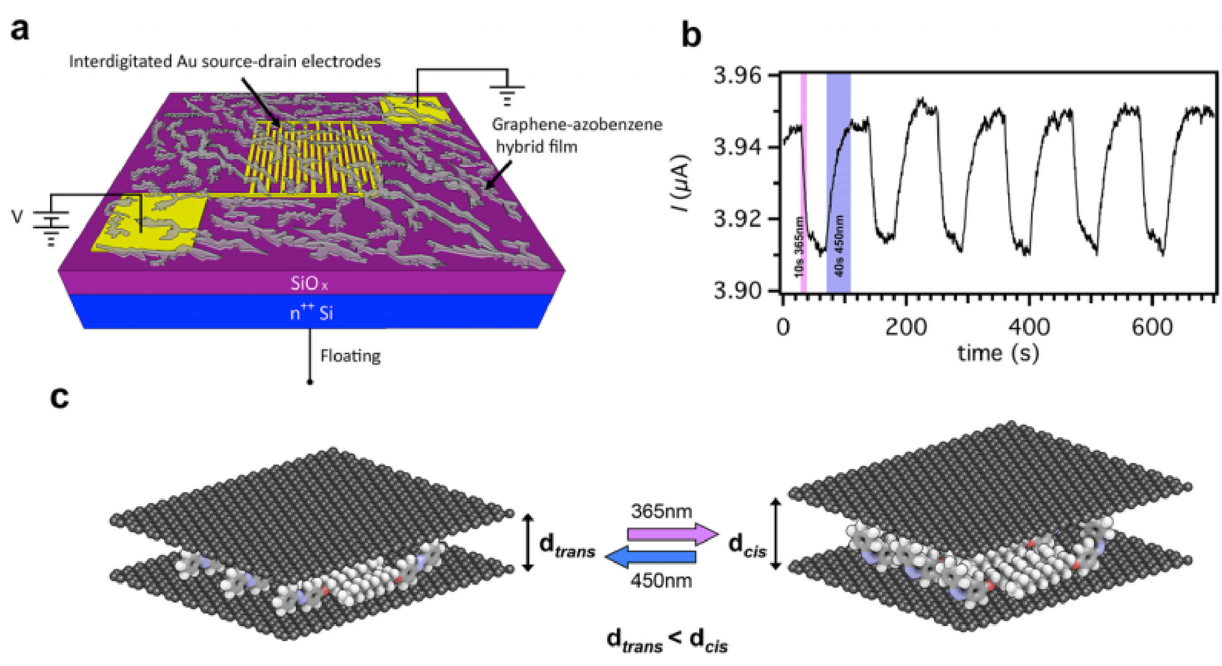

Electrical characteristics of graphene-azobenzene hybrid materials.(a) Scheme of the two-terminal device. (b) Reversible current modulation as a response to the device irradiation with different wavelengths (cycles of UV and visible light). (c) Scheme of the hybrid graphene–azobenzene structure when exposed to cycles of UV and visible light.

Imagine a world where you can tailor the properties of graphene to have the outcome you desire. By combining its unique properties with the precision of molecular chemistry, scientists from the Graphene Flagship have taken the first steps towards doing just that. In their paper published on 7th April in *Nature Communications* an international group of Flagship scientists show how it is possible to create light-responsive graphene-based devices, paving the way for many applications including photo sensors and even optically controllable memories.

The Graphene Flagship is a European initiative that promotes a collaborative approach to research with the aim to help translate graphene and related materials from the lab, through industry and into society. The multi-disciplinary nature of the work published in this paper, which was lead by Prof. Paolo Samorì from the Université de Strasbourg & CNRS in France, was facilitated by the Flagship and its collaborative approach, in particular with Prof. Andrea Ferrari from the Cambridge Graphene Centre. As Prof. Samorì explains "excelling in cross-disciplinary research requires a joint effort from a cohort of outstanding groups with complementary skills, and the EC Graphene Flagship project is the ideal platform to make this happen."

The work shows how, by combining molecules capable of changing their conformation as a result of light irradiation with graphite powder, one can produce concentrated graphene inks by liquid phase exfoliation. These graphene inks can then be used to make devices which, when exposed to UV and visible light, are capable of photo-switching current in a reversible fashion.

The paper demonstrates the exciting idea of combining graphene with a photochromic molecular switch. Here the researchers found that an ideal molecule is 4-(decyloxy)azobenzene. This commercially available alkoxy-substituted azobenzene has a high affinity for the basal plane of graphene, thereby hindering inter-flake stacking. When exposed to UV light this azobenzene molecule switches from the trans to the cis isomer (with the cis isomer being considerably more bulky than the trans form).

Importantly for the purpose of molecular switches this process is fully reversible by the simple exposure of the sample to white light.

By depositing the graphene–azobenzene hybrid ink onto a SiO2 substrate patterned with gold electrodes the authors made a light-modulated molecular switch. Because the trans to cis isomerisation is fully reversible by the simple application of white light, this molecular switch is also fully reversible which is a very important factor for creating optically controlled memories.

"This paper essentially gives an additional remote control to a graphene-based electrical device simply by the exposure to light at specific wavelengths." says Prof. Samorì "This is the first step towards the development of graphene-based multicomponent materials and their use for the fabrication of multifunctional devices - if you imagine a sandwich-like multi-layered structure with graphene sheets separated by multiple layers each one integrating a different functional molecular component. Each functional component therefore imparts a new stimuli-responsive character to the material which can respond to different independent inputs like light, magnetic field, electrochemical stimuli, etc, leading to a multi-responsive graphene based nanocomposite."

"The Graphene Flagship was always about the combination of graphene and other materials to form new hybrid structures," said Prof. Ferrari, who is also the Chair of the Flagship Management Panel. "This work is an interesting proof-of-principle of this concept and of the cross-disciplinary nature of the Flagship Research: Chemistry, Physics, Engineering, Fundamental Science and Optics, come together under the Flagship umbrella to develop new exciting device concepts."

More information: Markus Döbbelin et al. Light-enhanced liquid-phase exfoliation and current photoswitching in graphene–azobenzene composites, *Nature Communications* (2016). DOI:

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