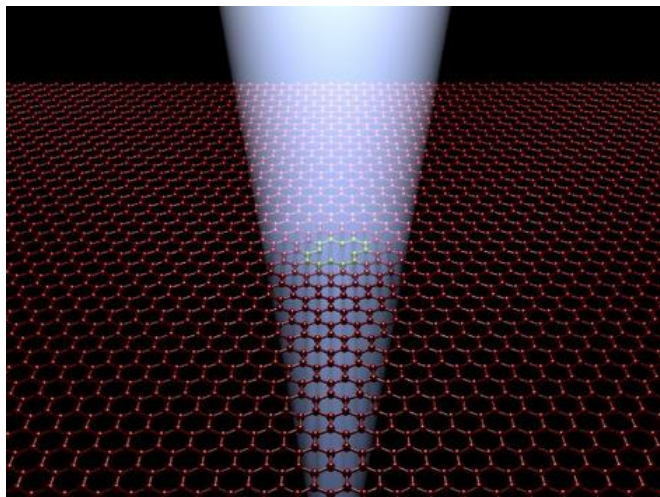


Electron 'sniper' targets graphene

25 October 2012, by Pete Wilton



'Both methods lack any form of control in terms of spatial precision and also the defect type, but to date are the only reported methods known for defect creation.'

The new method replaces the 'shotgun' with something more like a sniper rifle: a minutely-controlled beam of electrons fired from an [electron microscope](#).

'The shotgun approach is restricted to micron scale precision, which is roughly an area of 10,000,000 square nanometres, we demonstrated a precision to within 100 square nanometres, which is about four orders of magnitude better,' explains Alex Robertson of Oxford University's Department of Materials, another member of the team.

Yet it isn't just about the accuracy of a single 'shot'; the researchers also show that by controlling the length of time graphene is exposed to their focused beam of [electrons](#) they can control the size and type of defect created.

'Our study reveals for the first time that only a few types of defects are actually stable in graphene, with several defects being quenched by surface atoms or relaxing back to pristine by bond rotations,' Jamie tells me.

The ability to create just the right kind of stable defects in graphene's crystal structure is going to be vital if its properties are to be harnessed for applications such as mobile phones and flexible displays.

'Defect sites in graphene are much more chemically reactive, so we can use defects as a site for chemical functionalisation of the graphene. So we can attach certain molecules, such as biomolecules, to the graphene to act as a sensor,' Alex tells me.

'Defects in graphene can also give rise to localized electron spin, an attribute that has important future use in quantum nanotechnology and quantum

Because of its intriguing properties graphene could be the ideal material for building new kinds of electronic devices such as sensors, screens, or even quantum computers.

One of the keys to exploiting graphene's potential is being able to create atomic-scale defects – where [carbon atoms](#) in its flat, honeycomb-like structure are rearranged or 'knocked out' – as these influence its electrical, chemical, magnetic, and [mechanical properties](#).

A team led by Oxford University scientists report in *Nature Communications* a new approach to a new approach to engineering graphene's [atomic structure](#) with unprecedented precision.

'Current approaches for producing defects in graphene are either like a 'shotgun' where the entire sample is sprayed with high energy ions or electrons to cause widespread defects, or a chemistry approach where many regions of the graphene are chemically reacted,' said Jamie Warner from Oxford University's Department of Materials, a member of the team.

computers.'

At the moment scaling up the team's technique into a manufacturing process to create graphene-based technologies is still a way off. Currently electron microscopes are the only systems that can achieve the necessary exquisite control of an electron beam.

But, Alex says, it is always possible that a scalable electron beam lithography type technique may be developed in the future that could allow for defect patterning in graphene.

And it's worth remembering that it wasn't so long ago that the technology needed to etch millions of transistors onto a tiny slice of silicon seemed like an impossible dream.

More information:

[www.nature.com/ncomms/journal/ ...
full/ncomms2141.html](http://www.nature.com/ncomms/journal/full/ncomms2141.html)

Provided by Oxford University

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