What can happen when graphene meets a semiconductor

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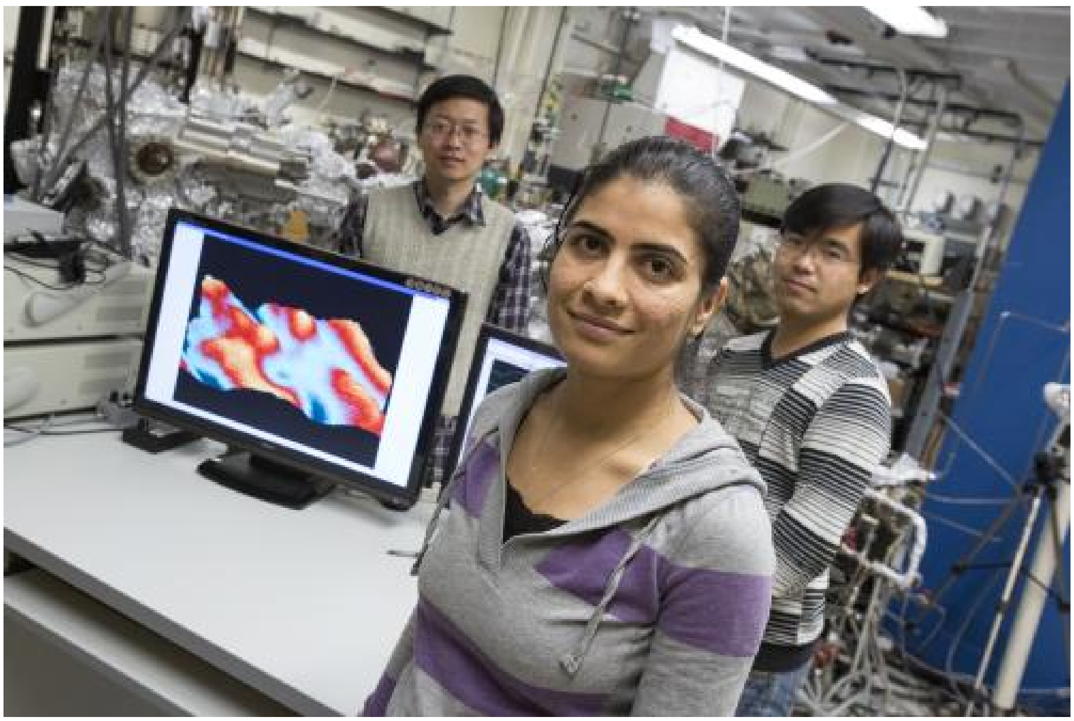

UWM doctoral student Shivani Rajput, first author on the paper, shows a reconstructed image of graphene with the ripples clearly visible. Two postdoctoral researchers also worked on the project: Yaoyi Li (left) and Mingxing Chen. Credit: Troye Fox

For all the promise of graphene as a material for next-generation electronics and quantum computing, scientists still don't know enough about this high-performance conductor to effectively control an electric current.

Graphene, a one-atom-thick layer of carbon, conducts electricity so efficiently that the electrons are difficult to control. And control will be necessary before this wonder material can be used to make nanoscale transistors or other devices.

A new study by a research group at the University of Wisconsin-Milwaukee (UWM) will help. The group has identified new characteristics of electron transport in a two-dimensional sheet of graphene layered on top of a semiconductor.

The researchers demonstrated that when electrons are rerouted at the interface of the graphene and its semiconducting substrate, they encounter what's known as a Schottky barrier. If it's deep enough, electrons don't pass, unless rectified by applying an electric field – a promising mechanism for turning a graphene-based device on and off.

The group also found, however, another feature of graphene that affects the height of the barrier. Intrinsic ripples form on graphene when it is placed on top of a semiconductor.

The research group, led by Lian Li and Michael Weinert, UWM professors of physics, and Li's graduate student Shivani Rajput, conducted their experiment with the semiconductor silicon carbide. The results were published in the Nov. 21 issue of *Nature Communications*.

The ripples are analogous to the waviness of a sheet of paper that has been wetted and then dried. Except in this case, notes Weinert, the thickness of the sheet is less than one nanometer (a billionth of a meter).

"Our study says that ripples affect the barrier height and even if there's a small variation in it, the results will be a large change in the electron transport," says Li.

The barrier needs to be the same height across the whole sheet in order to ensure that the current is either on or off, he adds.

"This is a cautionary tale," says Weinert, whose calculations provided the theoretical analysis. "If you're going to use graphene for electronics, you will encounter this phenomenon that you will have to engineer around."

With multiple conditions affecting the barrier, more work is necessary to determine which semiconductors would be best suited to use for engineering a transistor with graphene.

The work also presents opportunity. The ability to control the conditions impacting the barrier will allow conduction in three dimensions, rather than along a simple plane. This 3D conduction will be necessary for scientists to create more complicated nano-devices, says Weinert.

Provided by University of Wisconsin - Milwaukee

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