Carbon Based Chips May One Day Replace Silicon Transistors

3 February 2010, by John Messina

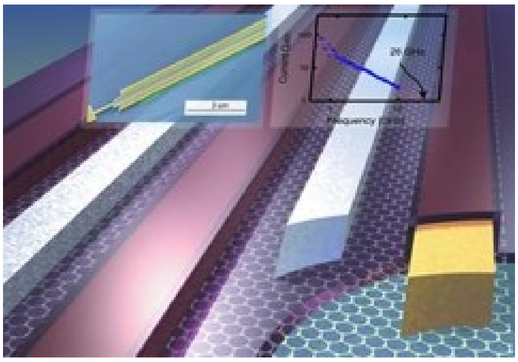
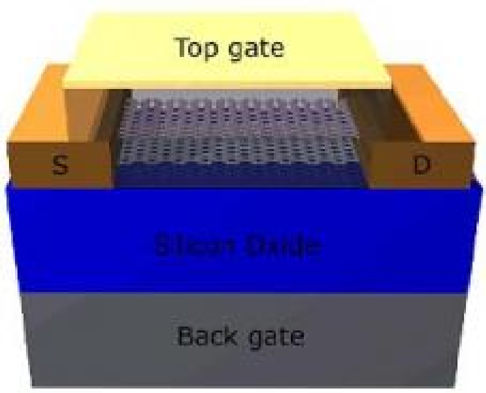


Image depicts carbon-based semiconductor chips with its dual-gate bi-layer graphene field-effect transistors.

(PhysOrg.com) -- IBM researchers are hopeful that, over the next decade, silicon-based transistors will be replaced by carbon-based transistors. IBM has already laid out the ground work for carbon-based transistors.

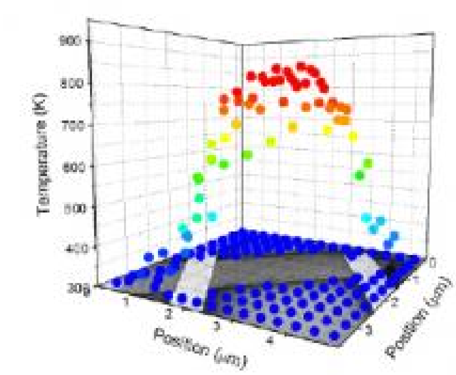
Graphene, one of the thinnest known materials, consists of a planar single sheet of carbon arranged in a honeycombed lattice. Graphene sheets also have higher carrier mobilities (the speed at which electrons travel at a given voltage) which translate to carrier mobilities that are hundreds of times larger than silicon chips used today. This makes graphene ideal for faster chip speeds.



However there are a few problems that need to be overcome before carbon-based transistors can be useful. Single layers of graphene sheets act more like a conductor than a semiconductor due to fact they have no band gap.

Semiconductors have a band gap between their conductive and insulating state, which allows them to be easily turned on and off. With a missing band gap, graphene FETs (field-effect transistors) have terrible on-to-off current ratios which is hundreds of times smaller than silicon.

Graphene also heats up considerably when operated at saturated currents. This becomes a big concern because high-performance graphene devices preferably need to operate at the saturation current limits.



Heat transfer from biased graphene into an underlying substrate can be much higher than that found in conventional silicon transistors.

The IBM research team has obtained heat flow results by determining the temperature distribution in active graphene transistors using optical microscopy combined with electrical transport measurements. They also used heat-flow modeling to calculate how heat travels along and across a graphene flake.

The research has shown that substrate interactions become much more important in graphene electronics than in traditional MOSFETs and heterostructures. This leaves engineers to focus on non-polar substrates and substrates that do not trap charges.

More information: Additional information: arxiv.org/PS_cache/arxiv/pdf/0910/0910.3614v2.pdf