new hot papers - 2010

May 2010

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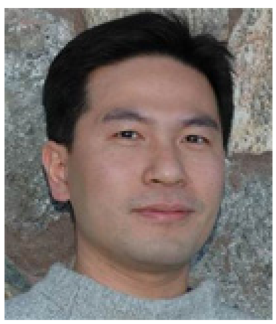
Yu-Ming Lin talks with *ScienceWatch.com* and answers a few questions about this month's New Hot Paper in the field of Chemistry. The author has also sent along images of his work.



Article Title: Operation of Graphene Transistors at Gigahertz Frequencies
Authors: **Lin, YM**;Jenkins, KA;Valdes-Garcia, A;Small, JP;Farmer, DB; Avouris, P
Journal: NANO LETT
Volume: 9
Issue: 1
Page: 422-426
Year: JAN 2009
* IBM Corp, Thomas J Watson Res Ctr, Yorktown Hts, NY 10598 USA.
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(addresses have been truncated.)

SW: Why do you think your paper is highly cited?

Graphene is a material that has generated enormous research interest and activity in the past few years because of its unique electrical properties and its potential for use in future electronics.

This paper is likely well-cited because it presents one of the first experimental demonstrations of gigahertz graphene transistors with the highest frequency reported thus far, and establishes the scaling behavior of device performance with respect to the device dimension. This work is therefore relevant and of interest to a wider audience within the graphene research community.

SW: Does it describe a new discovery, methodology, or synthesis of knowledge?

In this paper, we presented an approach to fabricate top-gated graphene transistors using exfoliated graphene extracted from a graphite crystal, and demonstrated the operation of the graphene transistors at a frequency as high as 26 gigahertz, or 26 billion cycles per second.

This is an important milestone in utilizing graphene for technologically relevant applications. We also investigated, for the first time, the scaling behavior of graphene devices as the device dimension shrinks, which exhibits a different trend from that of conventional semiconductors.

In our latest work,"100-GHz Transistors from Wafer-

Scale Epitaxial Graphene," Y.-M. Lin, *et al*., published in *Science* 327(5966): 662, 2010, we further demonstrated a large-scale epitaxial graphene synthesis on a SiC wafer and achieved graphene transistor operational frequencies of up to 100 gigahertz.

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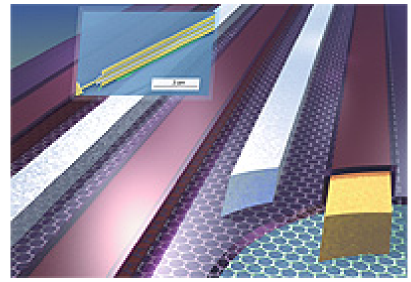

Top-gated graphene field-effect transistor. Inset: Scanning electron microscope image of a graphene device.

SW: Would you summarize the significance of your paper in layman's terms?

Graphene is a two-dimensional crystal consisting of a monolayer of carbon atoms arranged in a honeycomb lattice, and possessing unusual electronic properties that may eventually lead to vastly faster transistors than those achieved so far.

By placing a metal gate electrode on the graphene channel, we demonstrated a graphene transistor that is capable of amplifying electrical signals at very high frequencies. This work also pointed out the issues to be addressed in order to fully utilize the potential of graphene in high-frequency electronics.

SW: How did you become involved in this research, and were there any problems along the way?

This study was funded by the Defense Advanced Research Projects Agency (DARPA), the research arm of the US Department of Defense, to explore Carbon-based Electronics for Radio-frequency Applications (CERA).

I was already exploring electrical transport properties of graphene and its nano-ribbons, and became involved with the fabrication and characterization of graphene transistors when the CERA program was launched in May, 2008.

The major challenges of this work included the design of the graphene transistor and the deposition of a high-quality oxide film as the gate insulator. My colleagues Dr. Keith Jenkins and Dr. Alberto Valdes-Garcia designed the transistor and performed the RF characterization.

Another great challenge involved the deposition of a high-quality insulator on graphene without deteriorating its transport properties, and this issue was successfully addressed by a process developed by Dr. Damon Farmer. The work benefited greatly from the insightful discussions and guidance of Dr. Phaedon Avouris.

SW: Where do you see your research leading in the future?

Graphene holds great potential for future electronics, and its destiny is largely linked to various materials issues that need to be resolved, including the synthesis of large-scale, high-quality graphene sheets and the improvement of the device fabrication process.

I hope the impact of this research could lead to graphene-based integrated circuits for analog and, perhaps, digital applications.

SW: Do you foresee any social or political implications for your research?

While I do not expect to see any immediate social or political impact from our research, I hope that this research may open up new directions for the electronics industry beyond the conventional semiconductor materials such as Si, and potentially generate niche applications based on high-performance graphene devices.

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KEYWORDS: FIELD-EFFECT TRANSISTORS; MOBILITY; PHASE.

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2010 : May - New Hot Papers : Yu-Ming Lin on the Importance of Graphene in the Future