Team reports scalable fabrication of self-aligned graphene transistors, circuits

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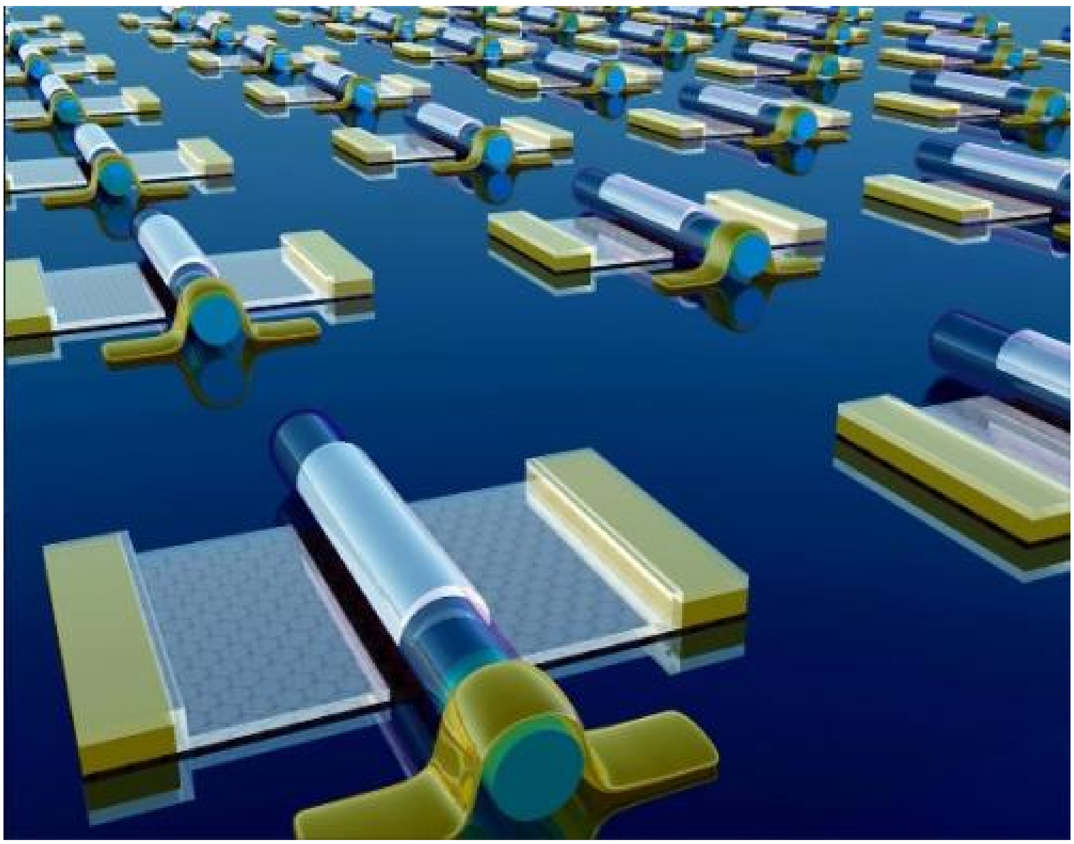

Self-aligned graphene transistor array

(PhysOrg.com) -- Graphene, a one-atom-thick layer of graphitic carbon, has the potential to make consumer electronic devices faster and smaller. But its unique properties, and the shrinking scale of electronics, also make graphene difficult to fabricate and to produce on a large scale.

In September 2010, a UCLA research team reported that they had overcome some of these difficulties and were able to fabricate graphene transistors with unparalleled speed. These transistors used a nanowire as the self-aligned gate — the element that switches the transistor between various states. But the scalability of this approach remained an open question.

Now the researchers, using equipment from the Nanoelectronics Research Facility and the Center for High Frequency Electronics at UCLA, report that they have developed a scalable approach to fabricating these high-speed graphene transistors.

The team used a dielectrophoresis assembly approach to precisely place nanowire gate arrays on large-area chemical vapor deposition–growth graphene — as opposed to mechanically peeled graphene flakes — to enable the rational fabrication of high-speed transistor arrays. They were able to do this on a glass substrate, minimizing parasitic delay and enabling graphene transistors with extrinsic cut-off frequencies exceeding 50 GHz. Typical high-speed graphene transistors are fabricated on silicon or semi-insulating silicon carbide substrates that tend to bleed off electric charge, leading to extrinsic cut-off frequencies of around 10 GHz or less.

Taking an additional step, the UCLA team was able to use these graphene transistors to construct radio-frequency circuits functioning up to 10 GHz, a substantial improvement from previous reports of 20 MHz.

The research opens a rational pathway to scalable fabrication of high-speed, self-aligned graphene transistors and functional circuits and it demonstrates for the first time a graphene transistor with a practical (extrinsic) cutoff frequency beyond 50 GHz.

This represents a significant advance toward graphene-based, radio-frequency circuits that could be used in a variety of devices, including radios, computers and mobile phones. The technology might also be used in wireless communication, imaging and radar technologies.

The research was recently published in the peer-reviewed journal *Nano Letters*.

The UCLA research team included Xiangfeng Duan, professor of chemistry and biochemistry; Yu Huang, assistant professor of materials science and engineering at the Henry Samueli School of Engineering and Applied Science; Lei Liao; Jingwei Bai; Rui Cheng; Hailong Zhou; Lixin Liu; and Yuan Liu. Duan and Huang are also researchers at the California NanoSystems Institute at UCLA.

More information: Scalable Fabrication of Self-Aligned Graphene Transistors and Circuits on Glass, *Nano Lett.*, Article ASAP, DOI: 10.1021/nl201922c

Abstract
Graphene transistors are of considerable interest for radio frequency (rf) applications. High-frequency graphene transistors with the intrinsic cutoff frequency up to 300 GHz have been demonstrated. However, the graphene transistors reported to date only exhibit a limited extrinsic cutoff frequency up to about 10 GHz, and functional graphene circuits demonstrated so far can merely operate in the tens of megahertz regime, far from the potential the graphene transistors could offer. Here we report a scalable approach to fabricate self-aligned graphene transistors with the extrinsic cutoff frequency exceeding 50 GHz and graphene circuits that can operate in the 1–10 GHz regime. The devices are fabricated on a glass substrate through a self-aligned process by using chemical vapor deposition (CVD) grown graphene and a dielectrophoretic assembled nanowire gate array. The self-aligned process allows the achievement of unprecedented performance in CVD

graphene transistors with a highest transconductance of 0.36 mS/μm. The use of an insulating substrate minimizes the parasitic capacitance and has therefore enabled graphene transistors with a record-high extrinsic cutoff frequency (> 50 GHz) achieved to date. The excellent extrinsic cutoff frequency readily allows configuring the graphene transistors into frequency doubling or mixing circuits functioning in the 1–10 GHz regime, a significant advancement over previous reports (20 MHz). The studies open a pathway to scalable fabrication of high-speed graphene transistors and functional circuits and represent a significant step forward to graphene based radio frequency devices.

Provided by University of California Los Angeles

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