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Nanopatterned epitaxial graphene for nanoelectronics

Claire Berger[a,b], Xiaosong Wu[a], Xuebin Li[a], Mike Sprinkle[a], Zhimin Song[a], W.A. de Heer[a]
[a] School of Physics, Georgia Institute of Technology, Atlanta, GA 30332, USA
[b] CNRS-Institut Néel, Grenoble, France

The development of a new electronic material for the post-CMOS era is one of the most important technological challenges facing the electronics industry. We will present results on epitaxial graphene, which is a new low dimensional electronic material recognized by the electronics industry as a prospective candidate material for high-speed low-power electronics.

Graphene is a one atom-thick layer of graphite, consisting of carbon atoms arranged in a honeycomb structure. We can grow large area of epitaxial graphene layers on electronics-grade single-crystal silicon carbide by thermal decomposition of the SiC surface. The samples are characterized using a wide array of techniques: local microscopy (AFM, STM), Auger spectroscopy, diffraction (LEED and X-ray), as well as Raman and IR spectroscopy. The system is composed of several graphene layers (one to a dozen graphene layers), of which the first layer is electron doped due to the built-in electric field and the other layers are essentially undoped.

The films show remarkable 2d electron gas properties. These include high mobility (a few 10^4 cm^2/Vs), shape-dependent electronic properties, exceptionally long coherence lengths and ballistic conduction; properties that may persist above cryogenic temperatures. These properties are related to the graphene nature of the films. Unlike graphite, the charge carriers show Dirac particle properties (i.e. an anomalous Berry's phase, weak anti-localization and square root field dependence of the Landau level energies). Some of these properties are shared with carbon nanotubes, but in contrast to carbon nanotubes, epitaxial graphene devices can be seamlessly interconnected to produce all-graphene electronic structures. Novel physical properties are also expected such as light-like transport and chiral charge carriers.

Epitaxial graphene can be patterned using standard lithography methods to define micrometer size down to tens of nanometer size devices. The process is designed to be scalable for many devices integration on large surface areas. The material can be chemically modified to produce electronically active structures. We recently have produced the first room-temperature top-gated epitaxial graphene transistor. These favorable features indicate that interconnected room temperature ballistic devices may be feasible for low-dissipation high-speed nanoelectronics.

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