Key property of graphene sustained over wide ranges of density and energy

November 15 2012

(Phys.org)—A collaboration led by researchers from the NIST Center for Nanoscale Science and Technology has shown for the first time that charge carriers in graphene continue to behave as massless particles, like photons, over wider ranges of both density and energy than previously measured or modeled.

Graphene, a single layer of carbon atoms, is a material of great scientific and technological interest in part because it conducts electrons at high speed. However, in order for graphene to achieve its promise as a component of future electronic devices, it is important to understand at a fundamental level how charge carriers in the material interact with each other. The researchers used scanning tunneling spectroscopy measurements of the magnetic quantum energy levels of the graphene charge carriers to determine the changes in velocity of the charge carriers.

Using a CNST-developed technique called "gate mapping scanning tunneling spectroscopy," the researchers measured the energy levels as they changed the density of the carriers in the graphene by applying different potentials between a conducting gate and the two-dimensional graphene sheet. They established that the graphene carriers retain a proportional relationship between energy and momentum—a "linear dispersion" characteristic of massless particles—across an unexpectedly broad range of energies and densities, from electrons to holes. They were also able to show that when the density of carriers in graphene is lowered, the effect of each electron on other electrons increases, resulting in higher velocities than expected.

These surprising results are important both for understanding the physics of future graphene devices and because they will help guide the development of more accurate theoretical models of the interactions between electrons in two-dimensional systems.

More information: Chae, J. et al., Renormalization of the graphene dispersion velocity determined from scanning tunneling spectroscopy. *Physical Review Letters* 109, 116802 (2012).

Provided by National Institute of Standards and Technology