MAR09-2008-004673

Abstract for an Invited Paper
for the MAR09 Meeting of
the American Physical Society

Electronic properties of graphene and its operation at GHz frequencies

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Graphene, a two-dimensional carbon crystal, possesses great potential for applications in nanoelectronics because of its high intrinsic carrier mobility and the possibility of being processed using the well-established planar top-down technology in semiconductor industries. The former makes graphene an ideal candidate for electronic devices operating at high frequencies, while the latter allows us to tailor the transport properties of graphene devices by controlling their channel geometry. For example, it is, in principle, possible to create metallic and/or semiconducting graphene nanostructures if a precise edge termination can be achieved. In this talk, I will present our recent experimental studies on transport properties of graphene nanoribbons and high-frequency characteristics of graphene transistors operated at GHz frequencies. High-quality graphene nanoribbons with widths down to 30 nm are fabricated by e-beam lithography. In these graphene nanoribbon devices, clear plateau features are observed in the measured conductance as a function of gate voltage at T ¡ 80K, indicating the formation of subbands due to quantum confinement in nanoribbons. This conductance quantization behavior is observed in both metallic and semiconducting nanoribbons, and provides the direct experimental evidence of quantum size confinement effects and the formation of subbands for 1D graphene nanostructures. To explore the high-frequency transport in graphene, top-gated graphene field-effect transistors are fabricated and S- parameter measurements are performed to obtain their transport properties at microwave frequencies. In these graphene transistors, we found that the measured intrinsic current gain shows the ideal 1/f frequency dependence, indicating an FET- like behavior in these devices. The cutoff frequency f_T at which the current gain becomes unity is proportional to the dc transconductance g_m of the device, and is consistent with the relation $f_T = g_m/(2\pi C_G)$. The peak f_T was found to increase with a reducing gate length, and a cut-off frequency beyond 20GHz was measured in a graphene transistor with a gate length of 150 nm. This work is done in collaboration with Ph. Avouris, D. Farmer, K. Jenkins, A. Valdes-Garcia, V. Perebeinos, J. Small.