

3rd International Conference and Exhibition on Materials Science & Engineering

October 06-08, 2014 Hilton San Antonio Airport, USA

High-quality graphene devices on SiC for resistance metrology and wafer-scale electronics

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Graphene is a highly promising material for both quantum resistance metrology and wafer-scale electronics. Great progress has been achieved in producing monolayer epitaxial graphene on silicon carbide substrates. However, the resulting material is typically found to be heavily n-doped, and this causes the Fermi energy to be shifted far away from the Dirac point. The carrier densities reported for epitaxial graphene are usually in the range of 10^{11} - 10^{13} cm⁻², due to the charge exchange between the graphene and the non-conducting buffer layer beneath it that is covalently bonded to the SiC substrate. Various gating methods have been developed to reduce the carrier density, but require organic chemical lithography processes that increase the probability of contamination that degrades the performance of the devices.

Recently, we fabricated high-quality quantum Hall devices based on epitaxial graphene on diced semi-insulating SiC wafers, obtaining carrier densities in the range of 10^{10} - 10^{11} cm⁻² and mobility above 10^4 cm²V⁻¹s⁻¹ without gating. Our graphene is grown on the Si face of 7.6 mm x 7.6 mm large SiC substrates by a controlled sublimation method at NIST. The epitaxial graphene is characterized by AFM and Raman microscopy, which show that they are homogeneous across 95% of the center area of the samples. Well-developed quantum Hall effect plateaus with the filling factor $\nu=2$, the fingerprint for monolayer graphene, are measured at low magnetic field below 2 T at liquid helium temperature. I will discuss our recent progress in quantum resistance metrology, as well as other quantum phenomena observed in these clean, high quality graphene devices.

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