SES11-2011-000115

Abstract for an Invited Paper
for the SES11 Meeting of
the American Physical Society

Graphene: it's all about the surface

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Every atom of graphene, a monolayer of graphite, belongs to the surface. Therefore, the environment of graphene – the substrate onto which graphene is deposited and the coating on top of graphene – intimately affects the properties of graphene. In this talk, we demonstrate that both mechanical and electrical properties of graphene can be greatly tuned by varying its environment. First, we discuss ultraclean graphene devices suspended in vacuum. We achieve a carrier mobility in excess of 200,000 cm^2/Vs in these devices and demonstrate previously inaccessible transport regimes, including ballistic transport and the fractional quantum Hall effect. Second, we explore the electrical properties of graphene surrounded by liquid dielectrics. We find that the ions in liquids can cause strong scattering in graphene and demonstrate very large values for room temperature mobility (>60,000 cm^2/Vs) in ion-free liquids with high dielectric permittivity. Finally, we demonstrate that the environment of graphene affects its mechanical properties. We develop a novel technique to study the mechanical properties of graphene films attached to substrates by measuring the temperature-dependent deflection of a "bimetallic" cantilever composed of graphene and silicon nitride or gold layers. We demonstrate that the built-in strain, the substrate adhesion force and even the thermal expansion coefficient of graphene depend on the substrate under it.