Fabrication of Double-layer Graphene

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Unlike fermions, which obey the Pauli exclusion principle, bosons in any number may occupy the same quantum state. At sufficiently low temperatures, it has been predicted that all the bosons in a system inhabit the same low energy state, forming a Bose-Einstein Condensate (BEC). In this state, a large number of particles are described by a single wavefunction with phase coherence larger than the separation between particles. Composite bosons, formed when an even number of fermions pair up, may form condensates: examples include Cooper pairs (electron-electron) and excitons (electron-hole). Excitons can be found in semiconductors, where the electron is in the conduction band and the hole (empty electron state) inhabits the valence band. Exciton condensation is expected to be found in bilayer 2D-electron systems. Double-layer graphene is a promising candidate for high-temperature bilayer exciton condensate because graphene is a gap-less semiconductor, and its massless Dirac band structure suggests excellent particle-hole symmetry. Min, Bistritzer, Su, and MacDonald have predicted the transition temperature in this system to be near room temperature, much larger than high-T_c superconductors.

In this project, we attempt to produce double-layer graphene with an insulating layer. Graphene folding can be achieved by gently flushing water or other solvents across a substrate: we plan to optimize this procedure to control the orientation of the fold and eventually deposit an oxide layer over a selected region of the graphene flake.

Fig. 1: Graphene flake, beneath a layer of PMMA. A square region exposed during e-beam lithography is visible (50x)

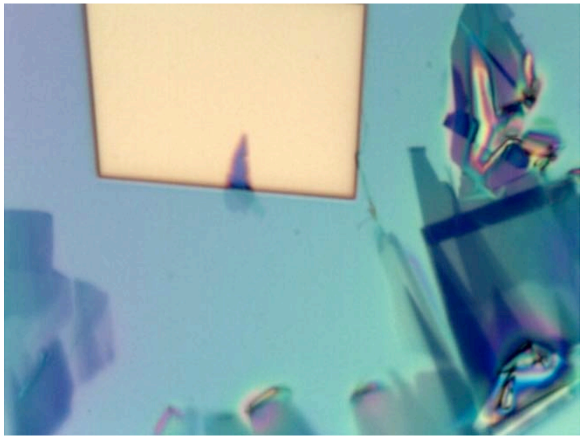

Fig. 2: Folded graphene, after developing, etching, and flushing (100x)

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