Flexural phonon scattering induced by electrostatic gating in graphene

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Two-dimensional materials are promising candidates for future electronic devices with properties that can be tuned by the electrostatic and dielectric environment. One of the advantages of two-dimensionality is that it allows very precise control of the carrier density by a gate which enables tuning of the electron-phonon interaction[1]. We have recently theoretically described a new flexural phonon scattering mechanism induced by the electrostatic gating of a graphene device[2]. Graphene's extremely high carrier mobility originates partly from the planar mirror symmetry, inhibiting scattering by the highly occupied acoustic flexural phonons. However, gating graphene can break the planar mirror symmetry activating one-phonon scattering from flexural phonons that has detrimental impact on the performance of a graphene device.

We examine the effect of the gate-induced scattering on the mobility for several gate geometries and dielectrics using first-principles calculations and the Boltzmann equation[3,4]. The mobility degradation is illustrated in Fig. 1.

Our findings may explain the high deformation potential for in-plane acoustic phonons extracted from experiments at room temperature and furthermore suggest a direct relation between device symmetry and resulting mobility. The modified temperature and density scaling of the mobility, allows for its experimental verification. Paradoxically, better sample quality may show worse performance due to a lower cutoff of the long-wavelength scattering. Protecting the planar mirror symmetry is therefore of utmost importance to fully exploit the unique transport properties of graphene.

References

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[4] Atomistix ToolKit, version 2016, QuantumWise A/S.

Figures

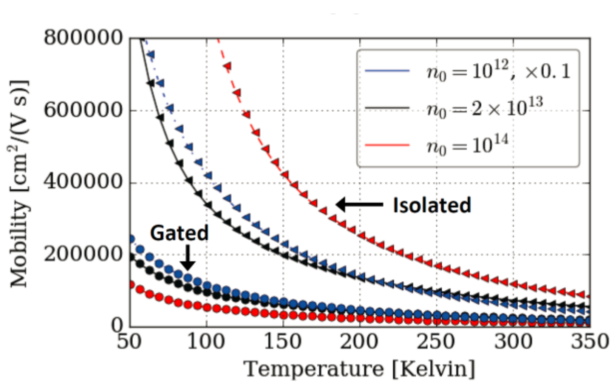

Figure 1: Mobility vs temperature at different carrier densities (in cm^{-2}) for a gated graphene device (circles: o) and isolated graphene with preserved planar mirror symmetry (triangles: ◁); i.e., respectively, with and without field-induced flexural phonon scattering.