Effect of Dielectric Environment on Carrier Mobility in Graphene Double Layer

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One of recent progresses in nanoscience is the successful graphene device fabrication. Especially, graphene double layer structure (GDLS), where a structure of two graphene single layer embedded in three different relative dielectrics (ϵ_1, ϵ_2, and ϵ_3 in Fig. 1), has rich physics and possibility of real device application. In first experiment of GDLS, Al_2O_3 were used as inner dielectrics [1]. Another promising internal dielectric is h-BN [2], which has atomically smooth surface due to similar lattice constant of graphite, a large electronic band gap, and it can control internal layer number.

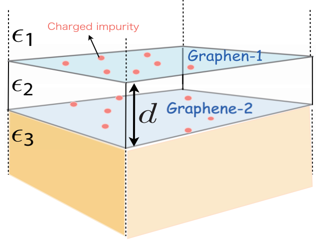

Figure 1: Schematic illustration of our target. A graphene double layer structure (separation distance d) in emerged in a three layered dielectric medium ϵ_1, ϵ_2, and ϵ_3. Red circles represents the random charged impurities.

This experimental progress demands to reveal the carrier transport properties on GDLS from theoretical calculation. Our main question is how the carrier mobility on GDLS depends on both the inner layer thickness d and background dielectrics, ϵ_1, ϵ_2, and ϵ_3. This question will be essential for next graphene based device application with including dielectric engineering [3, 4]. To answer this question, we have theoretically evaluated carrier mobility due to charged impurity on GDLS, by using Boltzmann transport theory and static screening effect on graphene [5]. Coulomb scattering potential due to charged impurity were introduced by mirror effect as first pointed out in Ref [6].

We will show the inner layer thickness d dependence of carrier mobility in several patterns of dielectric constants (e.g., h-BN, Al_2O_3, HfO_2), and discuss the condition that enhances carrier mobility as function of inner layer thickness. Our results offer a simple and practical design strategy to improve the impurity limited mobility in graphene double layer structures.

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