Dominant factor of improving carrier transport properties in multilayer graphene with a turbostratic stacking

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【Introduction】 The multilayer graphene with a turbostratic stacking structure is one of the promising materials for the electrical device because of its excellent electrical transport properties that realize the both high carrier mobility and high electrical conductance due to the same band structure as a monolayer graphene [1]. In previous work, we analyzed the electrical transport properties of turbostratic stacking graphene [2], and demonstrated that elastic scattering length for multilayer graphene was significantly improved with increasing the number of layers based on the limited number of samples with 3 and 7 layers. The improvement of the electrical transport properties, especially the scattering length, should be originated from the pseudo-linear dispersion and the screening effect of multi-stacking for the charge impurities on the substrate [3]. In this study, we fabricated additional turbostratic graphene samples with 2 and 3 layers and analyze in detail the improvement by the effects of the layer thickness for the scattering length.

【Experimental】 Monolayer graphene used as a growth template was prepared by a chemical vapor deposition(CVD) growth using Cu foil. Graphene layers were grown on the monolayer graphene template by ethanol CVD method using the infrared radiation furnace under the process temperature of 1300°C.

【Results and discussion】 Figure 1 shows the elastic scattering and the phase relaxation length (l_e and l_p) with different number of graphene layers. The l_e and l_p are evaluated from the negative magnetoresistance observed in Hall-bar device using the fitting analysis on the basis of the random potential scattering theory [4], and are obtained at the Dirac point by tuning the top gate voltage. The l_e and l_p increase with increasing the number of layers up to 3 layers. When the number of layers is further increased, the l_e hardly changes, but the l_p decreases significantly. One of the dominant factor of the l_p is phonon scattering. Actually, the lattice defects tend to increases as the number of layers increase [3]. The l_e strongly depends on the remote coulomb scattering due to the charge impurities existed on the substrate. Figure 2 shows the self-consistent potential profiles at (a) the bottom layer and (b) the top layer in the multilayer graphene composed of 8 layers on the SiO_2 substrate. The potential profile is calculated within the Thomas-Fermi approximation. In the bottom layer attached on the substrate, the surface potential is strongly modulated by the charged impurities. On the other hand, the modulation of the surface potential due to the charged impurities dramatically reduces in the top layer because the charges on the substrate is screened in the interlayer of the multilayer graphene. Therefore, we conclude that the l_e is improved by the screening effect, but the l_p is degraded due to increasing the defects. The trade-off relationship between the l_e and l_p results in the enhancement of the mobility and conductance in multilayer graphene.

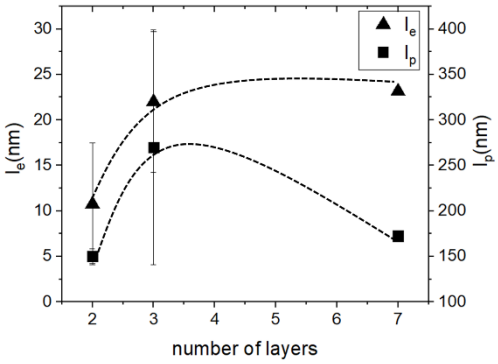

Fig. 1 The dependence of number of layers on the l_e and l_p. The curves are the trendlines.

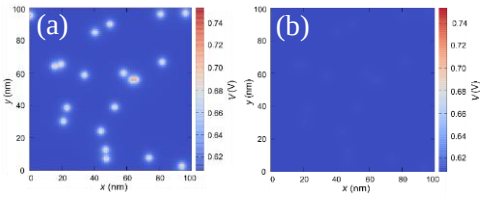

Fig. 2 Potential profiles at (a) the bottom layer and (b) the top layer in the multilayer graphene composed of 8 layers on the SiO_2 substrate when the density of charged impurity is 2×10^{11} cm^{-2}.

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