Improvement of the carrier scattering length 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 demonstrated that the graphene layers with the turbostratic stacking were grown on a graphene template under high process temperature (1300°C)[2]. The electrical transport properties of the carrier mobility and conductance in the multilayer graphene improve with increasing the number of layers. The improvement of the electrical transport properties was originated from the pseudo-linear dispersion and the screening effect of multi-stacking for the charge impurities on the substrate[3]. In this study, to understand these effects, we investigate the dependence of the layer numbers on the carrier transport properties of the multilayer graphene using a Hall-bar geometry.

【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. The carrier transport properties in the synthesized multilayer graphene were evaluated by Hall-bar device with a top gate structure using the Si_3N_4 thin film as an insulator layer.

【Results and discussion】 Table I shows the data summary of the electrical characteristics in the grown multilayer graphene device with different number of layers. The electrical transport properties of the carrier mobility and conductance improve as the number of layers increases. Moreover, the elastic scattering length extremely improves with increasing the layer numbers. In graphene composed of the single atomic layer, the charged impurities existing on a device substrate in addition to domain boundaries and lattice defects have a great effect on the electric scattering length. However, the crystalline size evaluated from the Raman spectra is almost the same value between them. Figure 1 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 anomalous improvement of the elastic scattering length is caused by the screening effect, resulting the enhancement of the carrier transport properties of the mobility and conductance.

TABLE I Electrical characteristics in the graphene devices measured at 1.7 K.

	Device A	Device B
Number of layers	3	7
Carrier mobility (cm^2/Vs)	506	817
Conductance (S)	3.2×10^{-4}	6.6×10^{-4}
Carrier concentration(cm^{-2})	4.1×10^{12}	5.0×10^{12}
Elastic scattering length (nm)	16.3	30.3
Crystalline size (nm)	38	40

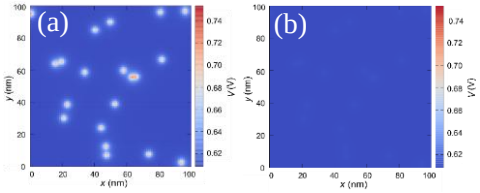

Fig. 1 Potential profiles at (a) the bottom layer and (b) the top layer in the multilayer graphene composed of 8 layers on the SiO_2 substrate when the density of charged impurity is 2×10^{11} cm^{-2}.

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