Carrier control in bilayer graphene dual-gate field effect transistors by interlayer atomic arrangement

University of Tsukuba, Yanlin Gao, Susumu Okada
E-mail: ylgao@comas.frsc.tsukuba.ac.jp

Electronic structures of bilayer graphene are sensitive to interlayer atomic arrangement. In addition to the stacking arrangement, a perpendicular electric field further modulates the electronic properties of bilayer graphene. For instance, bilayer graphene with the AB interlayer stacking arrangement shows semiconducting electronic properties under the perpendicular electric field. However, comprehensive knowledge about the correlated effect of the stacking arrangement, external electric field, and carrier concentration on the carrier distribution in bilayer graphene is still absent. Therefore, in this work, we aim to elucidate the carrier distribution on the bilayer graphene under the perpendicular electric field in terms of the field strength, doping concentration, and interlayer stacking arrangement, using density functional theory combined with the effective screening medium method (Fig.1).

Our calculations show that the carrier distribution is sensitive to the stacking arrangement, external electric field, and carrier concentration. Under a strong electric field with low electron doping concentration, doped electrons are mainly accommodated in the lower layer situated at the positively charged electrode side of bilayer graphene with a twisted stacking arrangement, while those are in the opposite layer situated at the negatively charged electrode side of bilayer graphene with an AB stacking arrangement. In the bilayer graphene with an AA sacking arrangement, the injected electrons are almost equally accommodated in both layers. By injecting holes in the bilayer graphene, their distribution is symmetric to the case of electron doping. These characteristic asymmetric and symmetric carrier distributions depending on the stacking arrangements and doping concentration, respectively, is ascribed to the electronic structures of these bilayer graphene under an external electric field.

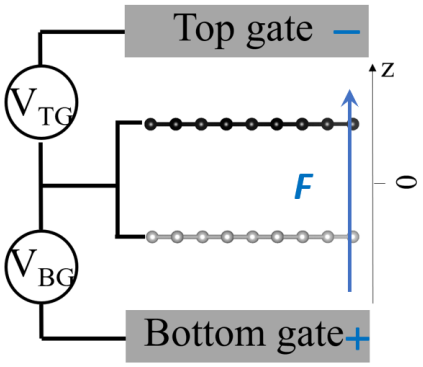

Fig. 1: Structural model of bilayer graphene dual-gate field effect transistor.