Modeling Electrical Conductivity and Transfer Characteristics of n- and p-Type Graphene/MoS2 Hetero-structures

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Abstract

Graphene being a gapless semimetal intrinsically has very high mobility but rather low on/off ratio. MoS2 is an indirect semiconductor with a band gap of _˜1.2 eV, and it becomes a direct semiconductor with a bigger band gap of _˜1.9 eV when being exfoliated as a monolayer two-dimensional material. MoS2 has much lower mobility but can reach rather higher on/off ratio than graphene. Therefore, they are expected to complement each other in theirhetero-structures with high mobility and high on/off ratio. Here we present a model calculation of electrical conductivity and transfer characteristics of n- and p-type graphene/MoS2 hetero-structures for different numbers of MoS2 monolayers and, accordingly, of different types and values of the band gap, at various temperatures under a large range of gate voltages. Our model takes account of electron-phonon interactions and many-body effects. Our calculated results for I-V characteristics and carrier densities as functions of gate voltages agree rather well with the available experimental data with the use of a few physical parameters (including the band offset, defect scattering rates, and fraction of the applied gate voltage in the active region), which all fall into a reasonable range. Therefore, our approach can also be applicable to graphene/transition metal dichalcogenides (TMDs) hetero-structures.

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