GrapheneforUS

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Electron emission theory via tunneling in forward biased Graphene/n-GaAs Schottky Junctions

We propose new first-principles modeling for direct electron tunneling current in graphene/n-Semiconductor Schottky Barrier (SB) junction. Specifically, we consider a forward biased (FB) G/n-GaAs and develop a model of electronic tunneling and escape from graphene to the semiconductor. We model the tunneling process using a triangular barrier representing the FB junction. The junction barrier of height q represents the Schottky junction between graphene and semimetal where the quasi-Fermi levels split by an amount equal to the applied voltage. Typically, excited carriers in the graphene side may escape thermionically over the junction barrier or may tunnel through the junction barrier quantum mechanically. There are therefore two channels of carrier transport through the Schottky junction (a) thermionic escape (TE) to the other side and (b) thermionic field emission (TFE) through the barrier. In this communication we develop a detailed TFE tunneling diode model for net electron transport through the junction in both conduction directions (from the graphene to the semimetal side and vice versa). The graphene/n-GaAs system operates as a Schottky tunneling diode with current J_{TU} that includes several parameters of fundamental importance such as (a) new Richardson's constant A* (b) WKB based transmission tunneling coefficient $T(E_z)$ (c) applied forward voltage and (d) a numerical factor dependent on diode parameters (n-type doping of the GaAs layer, effective electronic mass, built-in potential. The finalized current is an analytical result as: $J_{TU} = A^* I(T(E_z))\, T^2\, I(\lambda) \exp(-(q\Phi_B - E_{FL})/kT) \exp([\exp(V_a/V_t)-1]$ or expressed as a typical tunnel diode current density: $J_{TU} = J_{oo}T^2 \exp(-(q\Phi_B - E_{FL})/kT) \exp[(\exp(V_a/V_t)-1]$. We predict tunneling currents of 16.703 mA/cm^2 at 300^{o}K, graphene/GaAs barrier height at 550meV, A* = 8.026A/cm^2 ^{o}K^2, V_a in a range from 0.2V to 1.2 V.

References

[1] Seung Ming, et al, Nano Lett. 2012 Aug 8;12(8): 3887-92
[2] Yanbin Luo et al, Nanoscale, 2018, 10, 9212-9217
[3] D Tomer et al, Applied Physics Letters, 106, 173510 (2015)