Supplementary Material

Photo-physical Dynamics in Semiconducting Graphene Quantum Dots Integrated with 2D MoS_2 for Optical Enhancement in the Near-UV

Misook Min[†], *Shambhavi Sakri*[†], *Gustavo A. Saenz*[‡], *and Anupama B. Kaul*[†,‡*]

[†]Department of Materials Science and Engineering, PACCAR Technology Institute, University of North Texas, Denton, Texas 76203, USA
[‡]Department of Electrical Engineering, University of North Texas, Denton, Texas 76203, USA
[*]Corresponding author. E-mail: anupama.kaul@unt.edu

Background for temperature-dependent mechanisms for current response at metal-semiconductor interface

By definition, a metal-semiconductor junction is either Schottky or Ohmic, depending on the Schottky barrier height, which is determined from the metal work function Φ and the semiconductor electron affinity difference based on the Schottky-Mott model. The I_{ds}–V_{ds} Characteristic (Figure 3(a) of manuscript), exhibits a nonlinear I–V curve, suggesting a Schottky barrier, where tunneling transport differs from the non-monotonic behavior in a tunnel diode. This I_{ds}–V_{ds} Characteristic is described by the thermionic emission model, where the I–V relation for a Schottky contact is given by

$$I = I_0\left(\exp\left(\frac{q(V - IR_S}{nkT}\right) - 1\right)$$

(1)

In Equation (1), n is the ideality factor, V is the applied bias voltage and the IRs term is the voltage drop across the series resistance Rs of the two terminal devices. Here, I_0 is the saturation current derived from the straight-line region of the forward bias current intercept at zero bias and is given by

$$I_0 = AA^*T^2 exp\left(-\frac{q\Phi_{B0}}{kT}\right)$$

(2)

where A is the contact area of the junction, A^* is the effective 2D Richardson constant, T is the absolute T in K, q is the electron charge, and Φ_{B0} is the zero-bias apparent Schottky barrier. In contrast to thermionic emission, transport via the tunneling mechanism has a weak T dependence for the saturation current. The tunneling current I_{tunnel} through the barrier is given by

$$I_{tunnel} = I_t\left\{\exp\left[\frac{q(V - IR_S}{E_0}\right] - 1\right\} \quad (3)$$

where I_t is the tunneling saturation current and E_0 is the tunneling parameter with E_0 defined as,

$$E_0 = E_{00}\coth\left(\frac{E_{00}}{kT}\right) \quad (4)$$

Here, E_{00} is the characteristic tunneling energy that is related to the tunnel effect transmission probability. It is evident from this relation that the mechanism of charge transport in the case of tunneling has a weak T dependence for I_0 (Ref. 48 of main manuscript) but in our studies, we see I_0 increases strongly with T.