Modeling of Metal-Insulator-Graphene-Metal diodes targeting RF applications

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Metal-insulator-graphene-metal (MIGM) diodes for radio-frequency applications have been recently demonstrated [1]-[2]. Its rectification capability relies on the bias dependent Schottky barrier height, which can be strongly modulated due to the work-function tunability of graphene. Excellent figures of merit (FoM) have been reported so far for this diode, including high on-current density, high asymmetry, strong maximum nonlinearity and large maximum responsivity outperforming several of such FoMs of metal-insulator-metal (MIM) diodes.

Here in this work a large-signal model of the vertical MIGM device (which scheme is shown in Fig. 1) has been developed, with the goal of simulating both static and dynamic regimes of complex circuits based on this technology. So, as a first step, we have implemented a compact model of the Schottky barrier height, which is based on the diode electrostatics (see Fig. 2a). Next, a model for the diode static current has been developed taking into account the carrier injection between a bulk (3D) metal and 2D graphene channel [3], [4] (Fig. 2b). Here a Dirac-Schottky or Dirac-thermionic emission has been assumed to take place, in which carriers are thermally excited over the tunnel barrier at the electrode/insulator interface. The dynamic response of the diode has been determined by adding an intrinsic capacitance, which is formed by the series combination of the geometric oxide capacitance and the quantum capacitance of graphene. The model has been implemented in Verilog-A, a language suited to circuit simulators.

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References

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Figures

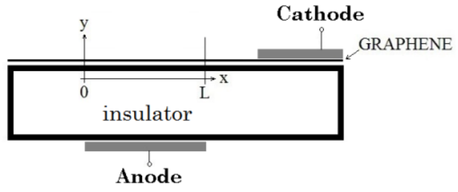

Figure 1: Cross-section of the vertical MIGM diode considered in this work.

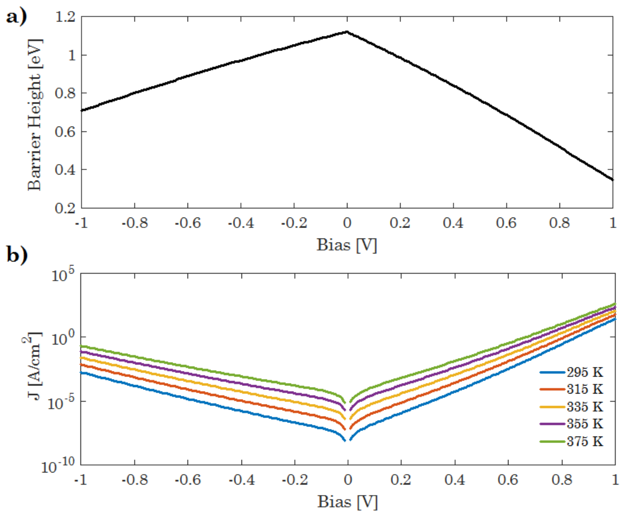

Figure 2: a) Schottky barrier height for electron transport and b) Current density –voltage (*J-V*) curve of a MIGM diode for different temperatures.