Spice-like Graphene Field Effect Transistor Model for Active THz Radiation and Detection

Jing Tian, and Yang Hao*
School of Electronic Engineering and Computer Science, Queen Mary University of London, London E1 4NS, UK

Over the past decade, graphene field effect transistors (GFETs) have shown great potential in active THz radiation and detection. The early drift-diffusion GFET model proposed by (Meric et al., 2008) successfully revealed the physical mechanisms behind the kink like feature in the saturation current of GFETs. This was followed by a list of publications focused on theoretical studies (Thiele, Schaefer, & Schwierz, 2010), (Thiele & Schwierz, 2011) as well as closed-form analytical solutions (Jiménez, 2011), (Parrish, Ramón, Banerjee, & Akinwande, 2012) of GFET models that are ready to be used for spice-like simulation. Recently, a comprehensive model based on hand-calculation was reported by (Rodriguez et al., 2014), allowing direct identification of the dominant physical parameters in the GFET design. In addition, a Verilog-A compactible model was also proposed by (Landauer & Jim, 2014), which not only achieved improved accuracy in the vicinity of the charge neutrality (Dirac) point but also provided a compact model that can be directly used in circuit simulators such as Cadence Spectre.

In this work we propose a GFET model based on the previous work, utilizing realistic graphene parameters in the calculation. Unlike those models using constant carrier mobility for electron and hole, our model takes into account the nature of carrier dependent mobility in grapheme (Zhu, Perebeinos, Freitag, & Avouris, 2009) and tends to derive closed-form analytical solutions for spice-like simulation. The model has been successfully implemented in Verilog-A language and simulated with Agilent ADS. Figure 1 (a) and (b) shows the simulation results of our model against measurement data from (Meric et al., 2010) and (Wang et al., 2011) respectively. Excellent agreement is achieved for various back gate (drain-to-source) voltages V_{bs} (V_{ds}) when sweeping the drain-to-source (top gate) voltage V_{ds} (V_{gs}). Compared to the previous schemes, our model is able to achieve good accuracy no matter the major carrier is electron or hole (i.e. on both sides of the Dirac point, see Figure 1 (b)). The proposed model can be used to model graphene based devices with integration of antennas for applications of simulation of radiation and detection. Further results will be presented at the conference.

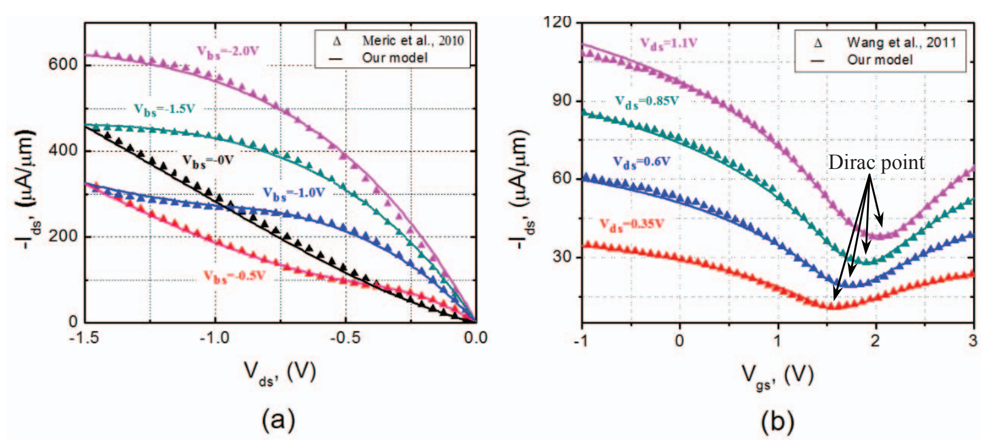

Figure 1. The modeling results vs. measurement data by (a) (Meric et al., 2010) and (b) (Wang et al., 2011).