Channel Length Scaling of Graphene Field-Effect Transistors targeting Radio Frequency Applications

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Abstract

Graphene Field-Effect Transistors (GFETs) are expected to play an important role in the radio frequency electronic applications due to the outstanding graphene carrier mobility and velocity saturation [1]. The best reported cut-off frequency f_T and maximum oscillation frequency f_{max} -figures of merit in radio frequency electronics- are, respectively, 427 GHz [2] and 45 GHz [3]. Although that record f_T is below state-of-the-art III-V transistors (e.g., InP or GaAs), this figure of merit has rapidly increased over the years [1]. By contrast, f_{max} has not followed a similar progression and there is still much room for improvement. The theoretical limit of both key frequencies is estimated to be over 1 THz for GFETs [4]. To make it happen, transistor channel lengths (L) must shrink dramatically to push forward the current figures of merit. But in doing so, short channel effects (SCE) can come into play, severely impacting on both f_T and f_{max}. To gain a deeper insight on the impact of SCE in GFETs figures of merit, we have developed a model under a drift-diffusion scheme that is based on the solution of the 2D Poisson equation in the GFET active region coupled with the current continuity equation. As an illustrative example, Fig. 1 shows the simulated output and transfer characteristics of a prototypical GFET with a channel length of 100 nm and a 40 nm thick HfO_2 dielectric [5]. From them we can infer the transconductance g_m, ($=dI_{ds}/dV_{gs}$) and the output conductance g_d ($=dI_{ds}/dV_{ds}$) which are key in determining both f_T and f_{max} [1].

In summary, our work allows the assessment of the SCE impact on the high frequency performance of the GFETs by solving the 2D Poisson equation coupled with a drift-diffusion model for the carrier transport. The proposed model has been benchmarked against reported experimental results [6].

Acknowledgements

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References

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Figures

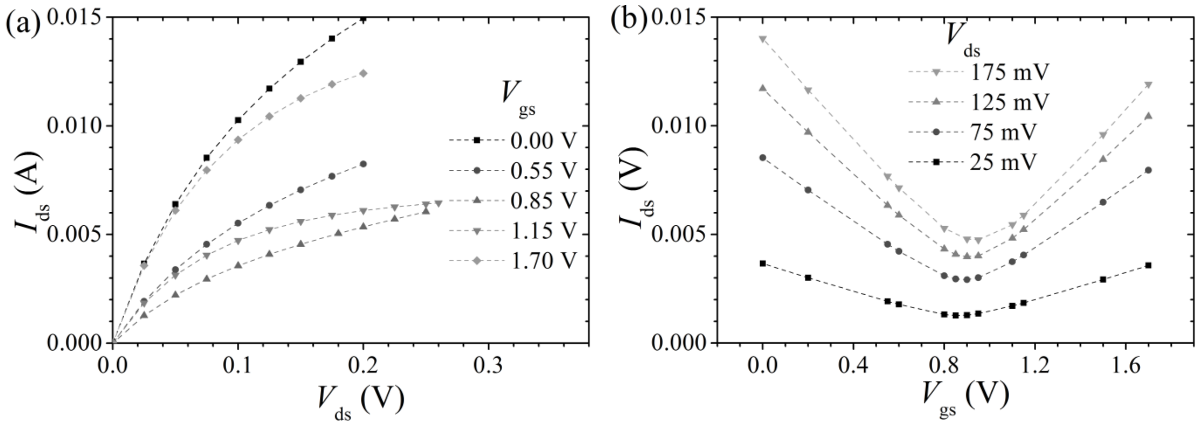

Figure 1. Output (a) and transfer (b) characteristics of the GFET under test including SCE.