How does graphene polycrystallinity impact on the performance of graphene based transistors ?

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Abstract

The chemical vapor deposition (CVD) technique for growing wafer-scale graphene on metallic substrates[1-4] produces a polycrystalline pattern. This is because the growth of graphene is simultaneously initiated at different nucleation sites, leading to samples with randomly distributed grains of varying lattice orientations.[5] It has recently been predicted that the electronic properties of polycrystalline graphene differ from those of pristine graphene (PG), where the mobility scales linearly with the average grain size.[6] Based on these results, we report on how the electronic properties of polycrystalline graphene (Poly-G) impact the behavior of graphene-based devices. For such a purpose, we have developed a drift-diffusion transport model for the graphene field-effect transistor (GFET), based on a detailed description of electronic transport in polycrystalline graphene[7]. This model allows us to determine how a graphene sample's polycrystallinity alters the electronic transport in GFETs, enabling the prediction and optimization of various figures of merit for these devices. Specifically, we concentrate our study on the effect that Poly-G has on the gate electrostatics and *I-V* characteristics of GFETs. We find that the source-drain current and the transconductance are proportional to the average grain size, indicating that these quantities are hampered by the presence of grain boundaries (GBs) in the Poly-G. Besides, our simulations also show that current saturation is improved by the presence of GBs, and the intrinsic gain is insensitive to the grain size. We have found that the presence of GBs produces a severe degradation of both the maximum frequency and the cutoff frequency, while the intrinsic gain remains insensitive to the presence of GBs (Fig. 1). These results indicate that GBs play a complex role in the behavior of graphene-based electronics, and their importance depends on the application of the device. Overall, polycrystallinity is predicted to be an undesirable trait in GFETs targeting analog or RF applications.

We acknowledge support from SAMSUNG within the Global Innovation Program. The research leading to these results has received funding from Ministerio of Economía y Competitividad of Spain under the project TEC2012-31330 and MAT2012-33911, and from the European Union Seventh Framework Programme under grant agreement n°604391 Graphene Flagship.

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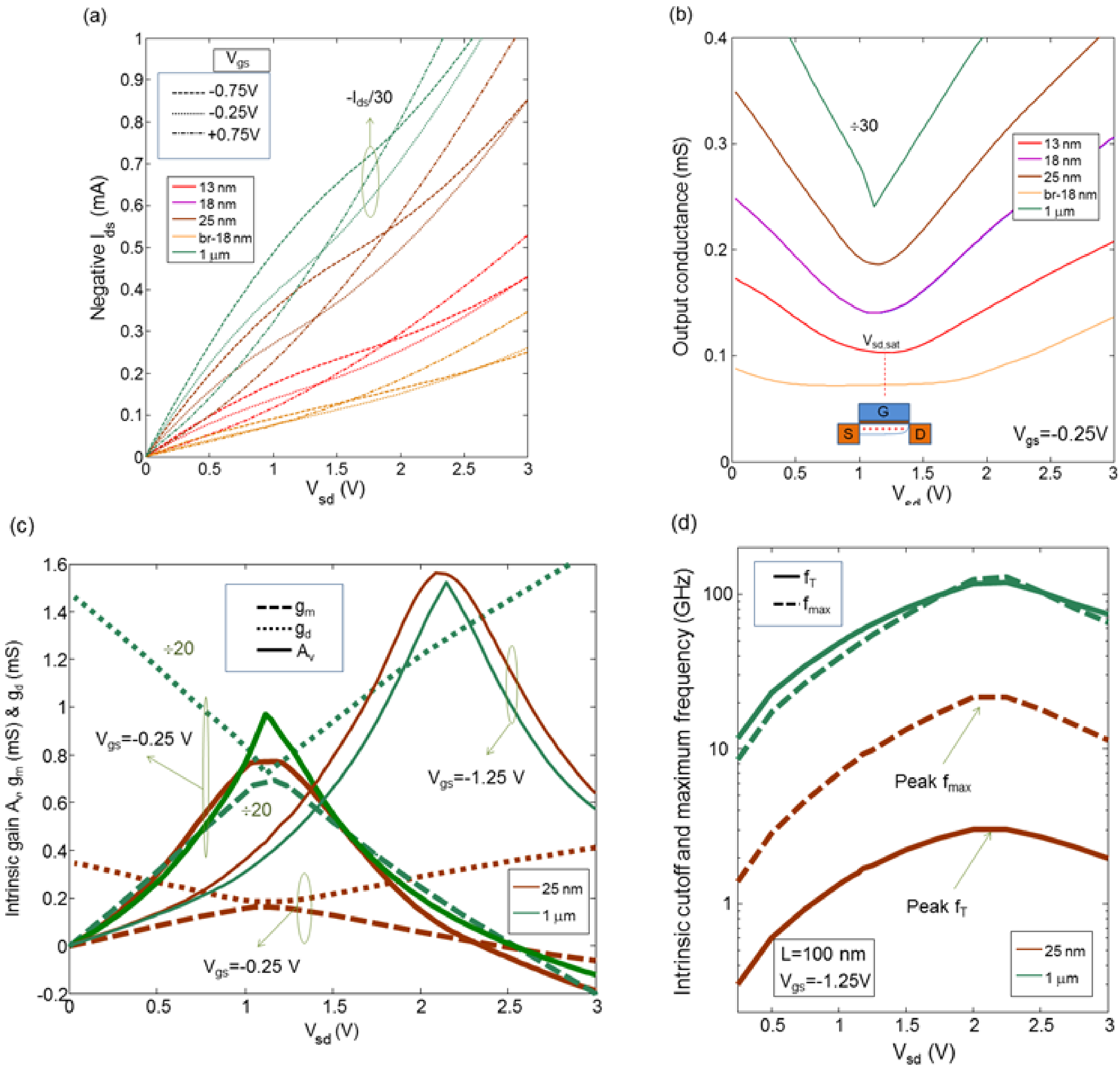

Fig. 1. Output characteristics (a) and output conductance (b) of a graphene field-effect transistor considering polycrystalline graphene with different GB average size. (c) Intrinsic gain as a function of the drain voltage. (d) Intrinsic maximum and cutoff frequency for the simulated transistor assuming a channel length of 100 nm.