

Performance assessment of graphene-based devices through a multi-scale approach

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Evaluating the potential performance of graphene-based devices is an issue suitable to be addressed by numerical simulations. In order to be predictive, such simulations have to deal with quantum effects involved at the atomistic level. Due to the reduced geometry, implemented physical models have to go beyond the effective mass approximation widely exploited in the past: the flexibility of atomistic approaches is indeed required to explore issues at this dimensional scale.

In this work, we will shed a light on the ultimate performance to be expected from devices at the end of the ITRS roadmap, in which graphene is exploited as channel material. To this purpose, we will present our method of choice for the simulation of graphene devices, i.e. a multi-scale approach, based on an atomistic investigation of the material properties through ab-initio simulations, which will feed tight-binding simulations, thus allowing to provide accurate results, but with reduced computational requirements with respect to Density Functional Theory simulations.

In order to get a clear understanding of the physical behaviour of realistic devices, transport equations have to be solved self-consistently with the Poisson equation. A versatile tool for this task is NanoTCAD ViDES [1], the first software package for the simulation of graphene devices released under an open-source license, capable to self-consistently solve the 2D and 3D Poisson equation together with the Schroedinger equation with open boundary conditions, within the Non-Equilibrium Green's Function (NEGF) formalism [2].

By exploiting the code we can investigate the performance on a wide set of devices, ranging from 1D dimensional transistors (based on nanotubes [3], graphene nanoribbons [4], one-dimensional heterojunctions [5]) to 2D dimensional transistors (based on monolayer and bilayer graphene [6-8], and on heterojunctions between graphene and other two-dimensional materials [9]).

In particular, attention will be focused on the evaluation of the main figures of merit for digital applications, such as the largest achievable current in the on state (I_{on}) as well as the smallest current when the device is switched off (I_{off}), and the ratio (I_{on}/I_{off}). For applications in analog electronics, we will focus on voltage gain and on cut-off frequency as a function of different device structures.

References

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Figures

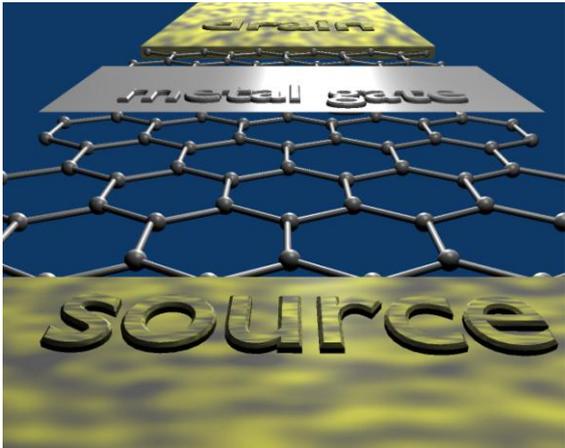


Fig.1: Graphene nanoribbon FET device

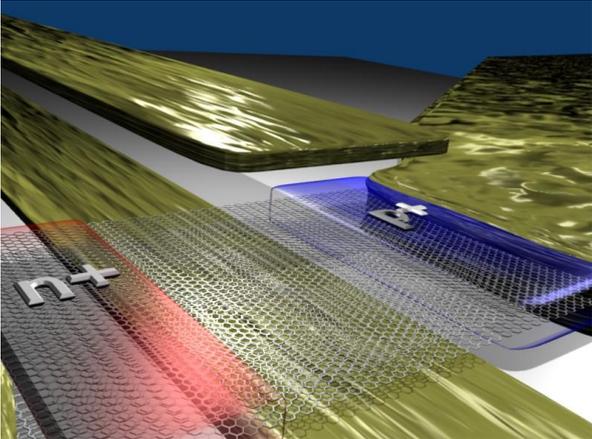


Fig.2: Tunnel FET bilayer graphene FET.