Modeling and simulation of graphene-based electronic devices through the Boltzmann transport equation

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Electron devices based on graphene have lately received a considerable interest; in fact, they could represent the ultimate miniaturization, since the active area is only one atom tick. However, the gapless dispersion relation of graphene at the Dirac points limits the possibility of using pristine graphene instead of traditional semiconductors in Field Effect Transistors (FET). For such a reason very accurate simulations are needed.

In [1] a graphene field effect transistor (GFET) has been proposed and simulated adopting a drift-diffusion model. Here, electron devices whose active area is made of monolayer graphene are simulated adopting as mathematical model the semiclassical Boltzmann transport equations (BTEs) in the bipolar case, coupled with the Poisson equation for the electric field [2]. The system is solved by means of a discontinuous Galerkin (DG) approach [3, 4] with linear elements in the spatial coordinate and constant approximation for the wave-vector space, discretized with a polar mesh. The correct physical range for the distribution function is preserved with the maximum-principle-satisfying scheme introduced in [5].

The adopted method reveals very robust and possesses a good degree of accuracy, making it particularly well suited for capturing the complex charge transport dynamics inherent to graphene-based devices. The results for suspended monolayer graphene and GFET constitute benchmark solutions for a rigorous assessment of the validity of macroscopic models, such as drift-diffusion and hydrodynamic ones.

References

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