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量子伝導計算による GNRFET でのゲート静電制御の解析

Quantum transport simulation of gate electrostatic control in GNRFET

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Quantum capacitance of graphene is receiving much attention as it is the key to the gate control of electrostatic potential barrier in the transistor channel. The channel capacitance of a graphene transistor can be small enough to have a significant effect because of the small effective mass of the Dirac fermion. It is in contrast to the case of a conventional MOSFET where its channel capacitance is well in excess of its gate one so that the gate voltage has a small effect on the channel potential. Thus it is doubtful if conventional design principle can fully derive potential advantage from graphene transistors.

A first-principle quantum transport simulation, however, still requires an expensive computational cost for redesigning a realistically sized gate structure including a graphene channel ($> 10^4$ atoms). This motivated us to utilize ESQC (elastic scattering quantum chemistry) technique used for designing molecular devices and to develop a coarse-grained version.

Fig. 1 shows our simulation result of gate electrostatic control of a GNRFET (graphene nanoribbon field effect transistor) with armchair edges. Electrostatic potential is plotted in fig. 1(a) where z axis is perpendicular to the graphene ribbon and x axis is in the direction of channel length. The local density of states is shown in fig. 1(b). In the middle of the transistor channel, top gate voltage shifts up the band gap region into the Fermi level so that the transistor current is switched off. Note that the potential at the top of electrostatic barrier is well controlled by the gate voltage, as opposed to the case of MOS limit.

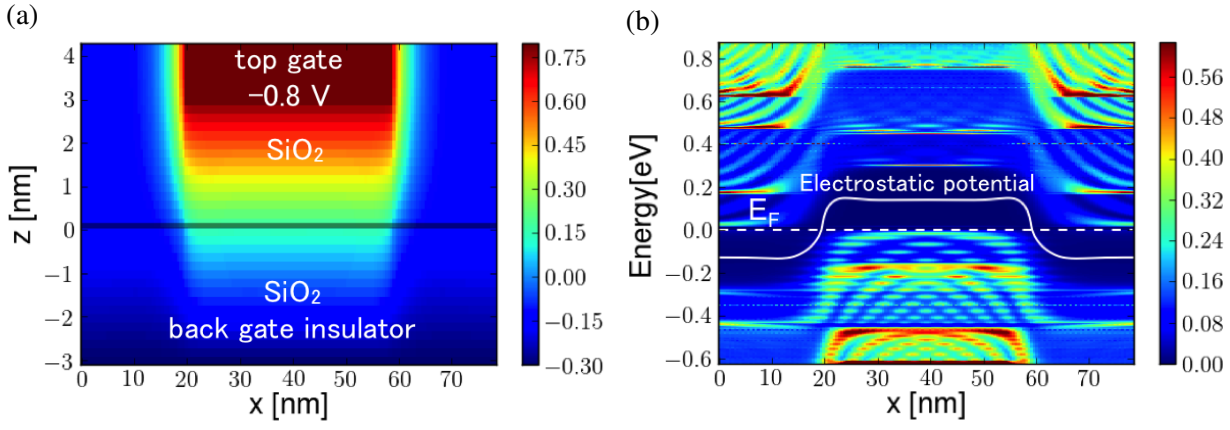

Figure 1 (a) electrostatic potential distribution in a GNRFET (b) local denisty of states

We are now applying our coarsed-grained quantum transport simulation method to a new gate structure.