Electric control of electron transport in twisted graphene nanoribbons

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Graphene is one of the most flexible and stretchable materials. Numerical simulations show that the shape of a narrow free-standing graphene nanoribbon (GNR) is fully random at 700 K, while carbon nanotubes would remain almost straight at that temperature [1]. As temperature is lowered, the energy minimization leads to two possibles shapes: saddle-shapes or twists. Mechanical deformations, and specifically twists, not only are spontaneous but also can be controllable.

In this work, we analyze the electron transmission through twisted GNRs with armchair or zigzag edges connected to leads and subject to an external electric field. The combination of both electric field and helical conformation of the GNR induces a periodic potential for electrons flowing from the source to the drain. The periodic potential results in allowed bands and gaps (see Fig. 1) that lead to negative differential resistance in the current-voltage characteristics of zig-zag GNRs. In addition, the electric field can efficiently control the current passing through the GNR (see Fig. 2). This opens the possibility to use the proposed device as a field-effect transistor.

References

[1] K. V. Bets and B. I. Yakobson, Nano Res. **2**, 161 (2009).

Figures

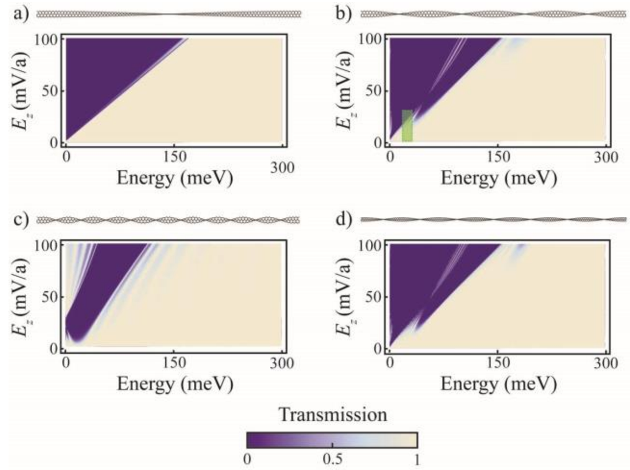

Figure 1: Transmission map as a function of the energy and the applied electric field in the z-direction for several GNRs. The first three panels correspond to 3-zGNR with L ≈ 20 nm and (a) n = 1, (b) n = 4, and (c) n = 10. n stands for the number of twists. Panel (d) corresponds to a 3-zGNR with L ≈ 35 nm and n = 7. GNRs in panels (b) and (d) the twist length is 5 nm. The electric field E_z is measured in units of mV/a, where a = 0.142 nm is the carbon-carbon distance.

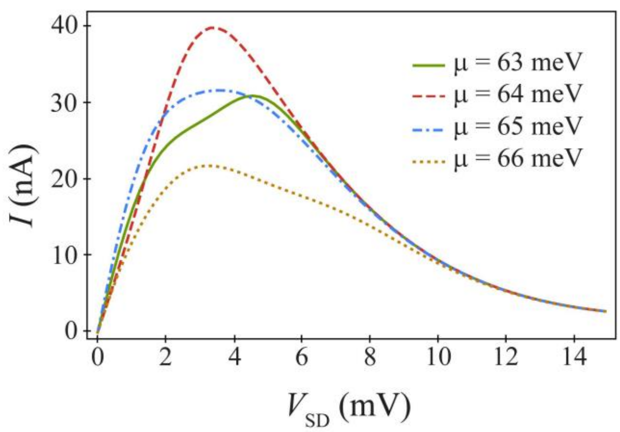

Figure 2: Electric current as function of the source-drain bias for different fixed values of the Fermi energy. Results correspond to the sample shown in Figure 1(b).