Transport gap in vertical devices consisting of twisted graphene bilayers

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Abstract

Controlling the misorientation of graphene layers has been experimentally explored and used to achieve resonant tunneling in vertical devices based on graphene/hexagonal boron-nitride/graphene heterostructures [1]. The commensurate-incommensurate transition in graphene on top of hexagonal boron-nitride has been also reported in [2]. We have previously investigated theoretically devices made of commensurate vertical stack of misoriented (twisted) graphene layers [3]. Here, by means of atomistic tight-binding calculations, we additionally investigate the transport properties of vertical devices made of an incommensurate graphene bilayer stack, where the two layers partially overlap, as illustrated in Fig. 1. For a given transport direction (Ox-axis), we define two classes of rotated graphene lattice distinguished by differences in lattice symmetry and, hence, in Brillouin zone, i.e., the two Dirac cones are located either at the same k_y-point ($K'_y = K_y = 0$) or at different k_y-points ($K'_y = -K_y = 2\pi/3L_y$), where L_y is the periodic length along the Oy axis). As a consequence, in devices made of two layers of different lattice classes, the misalignment of Dirac cones between the layers opens a finite energy gap of conductance that can reach a few hundreds of meV [4]. We also show that strain engineering can be used to further enlarge the transport gap in this type of device, as shown in Fig. 2 for different structures and different strain orientations. These results suggest an alternative strategy to open an energy gap in graphene channels, without altering the graphene lattices, by controlling the misorientation of graphene layers.

References

[1] A. Mishchenko et al., Nat. Nanotechnol. **9** (2014) 808813.
[2] C. R. Woods et al., Nat. Phys. **10** (2014) 451456.
[3] V. Hung Nguyen, H. Viet Nguyen, J. Saint-Martin, and P Dollfus, Nanotechnol. **26** (2015) 115201.
[4] V. Hung Nguyen, P. Dollfus, J. Phys. D: Appl. Phys. **49** (2016) 045306.

Figures

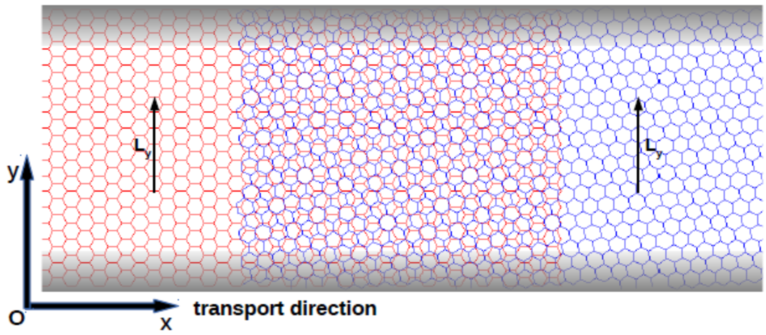

Figure 1. Example of a device made of a vertical stack of misoriented graphene bilayer. The left layer has an amrchair orientation along the transport direction.

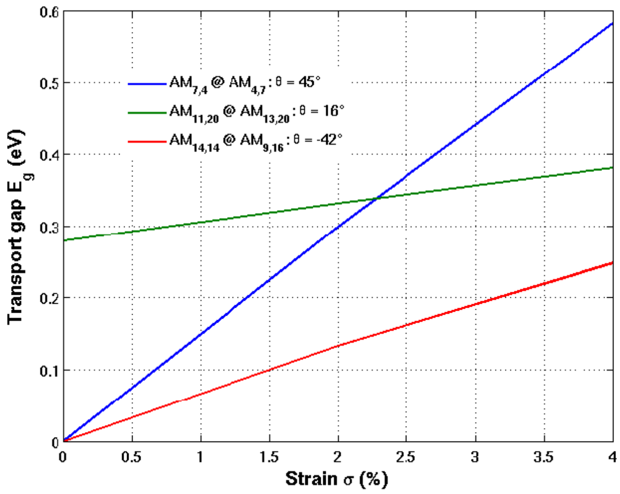

Figure 2. Strain effect on the transport gap in different devices. The angle θ is the strain of angle with respect to the transport direction Ox.