Graphene with triangular perforations

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Abstract

Spin-polarization along zigzag edges in graphene systems has been predicted by many theoretical works.[1] Recent experimental progress in fabricating and processing precise edged structures, and in measuring signatures of their edge magnetism,[2] suggest that spintronic devices incorporating zigzag edge magnetism are approaching reality. Nanopatterning of graphene with perforations, or antidots, has meanwhile been suggested as a route to opening an electronic band gap,[3] and suggested to introduce magnetic properties.[4] In this work, we investigate the electronic and transport properties of zigzag-edged triangular antidots using a tight-binding and mean-field Hubbard approach. Fig. (1) displays one such triangle considered and the associated electronic spin density polarization.

Before spin-polarization is included, we demonstrate that lattices of such antidots display more robust band gap formation than their armchair edged counterparts. Furthermore, unlike traditional antidot systems in graphene, this behavior is independent of superlattice geometry and is more robust against geometric disorders. Fig. (2) shows the density of states of the zigzag edged triangle; notably an armchair edged triangle with a similar superlattice is metallic. Including spin polarization the system becomes half-metallic, where the gap is filled with dispersive spin dependent states. Fig. (3) shows the spin dependent density of states. This opens a whole new range of interesting spin-related applications. Robust spin-filtering and –splitting devices are theoretically realized using arrays of triangular antidots. For example, Fig. (4) shows the spin-polarization of an electric current passing through a nanostructured graphene cross device. The currents flowing to the top and bottom leads are strongly spin-polarized, resulting in a similar spin splitting to that expected for a quantum spin Hall setup. These findings suggest robust paths to realize nanostructured graphene with a large bandgap or magnetic graphene with half-metallic properties.

References

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Figures

(1) The electronic spin density polarization (moments, *m*) around a triangular antidot embedded into graphene. (2) The density of states of the unpolarized triangle shown in (1). (3) The spin-polarized density of states. (4) Transmission current-polarization (*PJ*) through a nanostructured graphene cross when injecting from the left. (5) A cross section of the electronic currents (*J*) in (4) along the dashed line between the two first antidot columns.