The Strain Impact on Ferromagnetic/Graphene/Ferroelectric Nanostructures

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We proposed a phenomenological model for the nanostructure "high temperature ferromagnetic insulator/ graphene/ ferroelectric film" (see **Fig. 1**) taking into account the shift of the Dirac point due to the proximity of ferromagnetic insulator and using the Landauer formula for the conductance of the graphene channel. Spin-polarized conductance was calculated with a special attention to the control of electric polarization in a multiaxial ferroelectric film by a misfit strain [1].

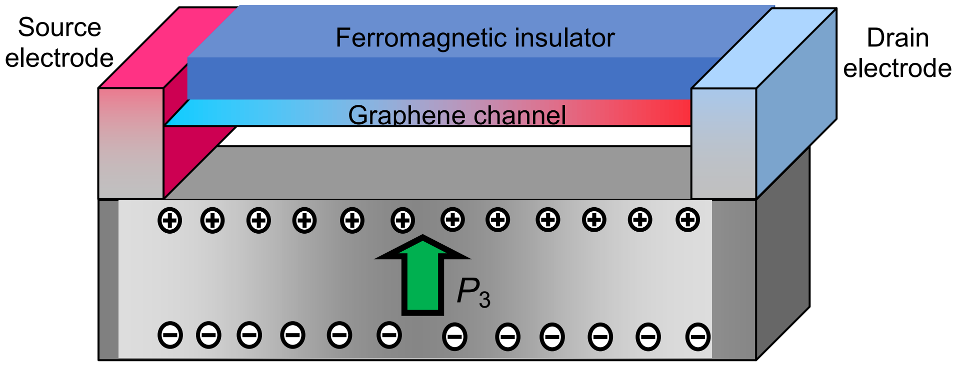

Fig. 1. Graphene single-layer placed between a single-domain ferromagnetic insulator and a polarized ferroelectric film. Adapted from Ref. [1].

The analytical expressions showing that the strain-dependent ferroelectric polarization governs the concentration of two-dimensional charge carriers and Fermi level in graphene in a self-consistent way was derived. It was shown that the graphene channel length should be shorter than an electron mean free path for spin polarization parallel with the one in the graphene channel modified by ferromagnetic insulator, and longer than an electron mean free path for spin polarization antiparallel with the one in graphene channel. However, because of long spin-flip length in a standard graphene-on-substrate, this restriction doesn't lead to ultra-short channels. Obtained results demonstrate the realistic opportunity to control the spin-polarized conductance of graphene by a misfit strain at room and higher temperatures in the nanostructures $CoFeO_4$/graphene/PZT and $Y_3Fe_5O_{12}$/graphene/PZT, and so open the possibilities for the applications of ferromagnetic/graphene/ferroelectric nanostructures as non-volatile spin filters and spin valves operating at room and higher temperatures.

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[1] Eugene A. Eliseev, Anna N. Morozovska, and Maksym V. Strikha. "Strain engineering of ferromagnetic-graphene-ferroelectric nanostructures." *Physical Review Applied* 14, 024081 (2020).