Investigating ballistic transport via 1D graphene/FM spin injectors

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Despite its great promise for spintronics, experimental values for spin transport parameters extracted from graphene are currently significantly below theoretical predictions. Our group recently reported encouraging results from a state-of-the-art device architecture, constituting a fully encapsulated single layer graphene channel with one-dimensional (1D) ferromagnetic (FM) contacts, in which we observed record high charge mobility for a spintronic device, and long-range spin transport [1]. Full encapsulation of the channel in hexagonal boron nitride preserves the quality of the graphene, giving rise to the high charge mobilities we observed, while 1D contacts mitigate the high levels of doping associated with tunnel contacts [2, 3]. Here, we explore how the nanoscale geometry and potential profile of the graphene/FM interface places transport across it in the ballistic regime (Fig. 1a). This allows for achieving sizeable contact resistance without the need for tunnel barriers, as well as for realising quantum transport phenomena such as quantized conductance across the 1D graphene/FM junction, previously unexplored in such a device. We have focussed on ballistic transport through these junctions, at low temperature. Bias spectroscopy measurements demonstrate quantized conductance through the junction, displaying 1D-subbands at fractions of the conductance quantum, G0 - indicating a transmission factor T ≈ 0.25 (Fig. 1b). Furthermore, application of an out-of-plane magnetic field leads to better defined quantization, due to a transition into the quantum Hall regime [4]. Finally, we investigate the effect of quantized conductance at our contacts, on spin transport through the channel of our devices. Quantized conductance arising from nanoscale 1D FM contacts, in the absence of a fabricated graphene nanoconstriction, is a previously unreported result and demonstrates a path for the development of ballistic spintronics.

References

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[3] Xu, J., et al. (2018). Nature Communications, 9(1), 2869.
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Figures

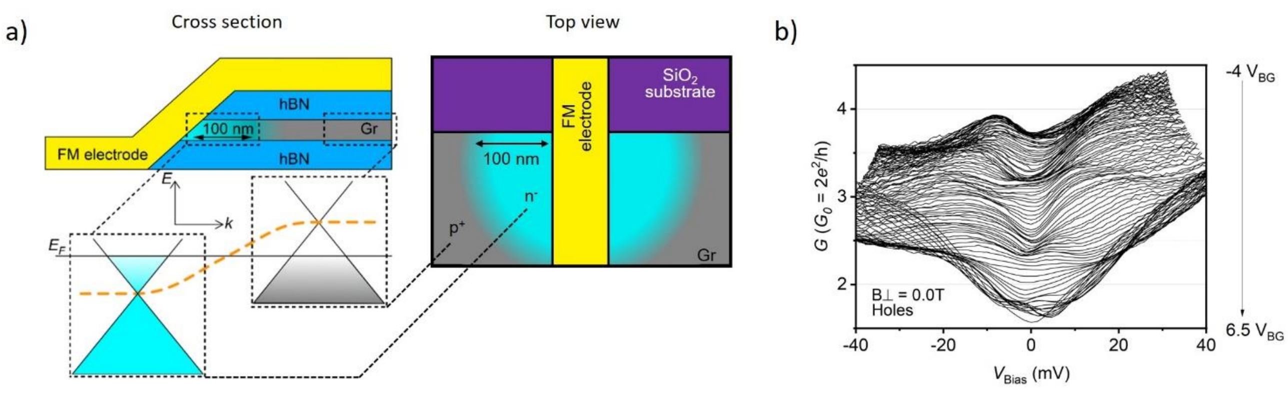

Figure 1: (a) 2D cross section and top view of the 1D contact architecture. Figure adapted from [1]. (b) Bias spectroscopy conductance measurement of a 1D contact, for hole transport ($V_{BG} > V_D$) without an applied magnetic field