Magnetic proximity effects in graphene/chromia heterostructures

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1. Introduction

Heterostructures formed with graphene and magnetic insulators have attracted enormous attention recently, due to their promise of application in future 2D spin-logic and memory devices. By means of the magnetic proximity effect, in which magnetism is induced in graphene via exchange coupling with adjacent magnetic insulators, spin polarized currents can be generated when applying a source drain voltage across graphene. Previous research has successfully demonstrated the magnetic proximity effect in graphene/magnetic-insulator systems, such as those formed on EuS [1], EuO [2], $CrBr_3$ [3] and yttrium iron garnet [4]. In these systems, the spin transport arises by means of the magnetic proximity effect. This behavior is typically restricted to low temperatures, below 50 K, however, due to the low Curie temperature in these systems. Moreover, magnetization reversal in these insulating materials typically requires the application of an external magnetic field. Therefore, the development of fully functional devices based upon these heterostructures remains a significant challenge.

In this study, we have investigated the signatures of spin transport in heterostructures formed from CVD-graphene and chromia (Cr_2O_3). Chromia is an insulating magneto-electric, exhibiting antiferromagnetic character in bulk up to an elevated Neel temperature of 307 K. Recently, however, it has been demonstrated that the (0001) surface of this material exhibits the phenomenon of boundary magnetism [5]. The magneto-electric nature of the chromia allows the direction of the net magnetism at this surface to be reversed electrically, by application of an appropriate voltage in the simultaneous presence of magnetic field and with low power dissipation. As a substrate, chromia offers room-temperature control of magnetic proximity effects in graphene, in marked contrast to previously reported ferromagnetic insulators.

2. Experiment

In order to investigate the existence of magnetic proximity effects in graphene/chromia heterostructures, we investigated the nonlocal spin Hall effect in this system at various temperatures (275 – 350 K), under both magnetoelectric field cooling and zero field cooling conditions. In Fig. 1, we show a schematic of the spin-Hall effect graphene/chromia test heterostructure, patterned to form a Hall-bar geometry. The resistance measured in the nonlocal spin-Hall configuration. The measurement is made below the Neel temperature of 307 K but is nonetheless close to room temperature. The non-local resistance measured in this geometry shows a maximum as the gate voltage is swept through the Dirac point, and the measured change in spin-Hall resistance is very large, of order 10^5 ohms. The spin-Hall signal is shown to persist beyond the Neel temperature of 307 K, and to persist instead all the way up to 350 K. This suggests that the signal is driven by strong spin-orbit coupling between the 2D layer and the chromia.

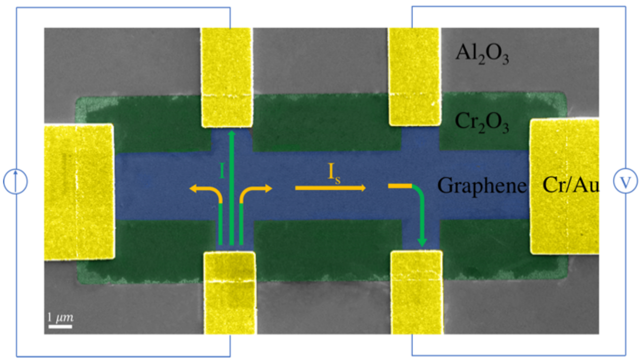

Figure 1. Pseudo color SEM image of the as-prepared graphene/Cr_2O_3 heterostructures. The scale bar is 1 μm.

3. Conclusions

These results are a step towards all-electric access to spin polarized currents at room temperature in graphene/Cr_2O_3 heterostructures, making them a highly promising system for future antiferromagnetic spintronic applications.

Acknowledgements

This research was supported by the National Science Foundation (NSF), through Grant No. NSF-ECCS 1740136, as well as by the nCORE, a wholly owned subsidiary of the Semiconductor Research Corporation (SRC), through the Center on Antiferromagnetic Magneto-electric Memory and Logic task ID 2760.001 and 2760.002.

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Appendix

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