Proximity magneto-resistance calculations on graphene induced by magnetic insulators

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Graphene has been attracting great interest due to its fascinating characteristics for development of graphene-based devices in several fields. When it is placed on top of a magnetic insulator, it can acquire spin polarization [1]. The mechanism behind this phenomenon is known as proximity effect resulting from the hybridization of graphene's p_z orbitals with those of the neighboring magnetic material. Evidence of this effect is the emergence of exchange splitting in the graphene band structure reported experimentally [2,3] and theoretically [1,4]. Here we demonstrate the existence of proximity magnetoresistance (PMR) effect in graphene considering magnetic insulator proximity cases reported in Ref. [4]. The PMR calculations were performed using KWANT package, for yttrium iron garnet (YIG), cobalt ferrite (CFO), and two europium chalcogenides EuO and EuS [4]. The system studied consisted of two identical proximity induced magnetic regions of width W, length L and separated a distance d of a graphene sheet, with its ends connected to two leads. We found significant PMR (up to 100%) values defined as a relative change of graphene conductance with respect to parallel and antiparallel alignment of two proximity induced magnetic regions. Namely, for high Curie temperature (Tc) CFO and YIG insulators which are particularly important for applications, we obtained 22% and 77% at room temperature, respectively. For low Tc chalcogenides, EuO and EuS, the PMR is 100% in both cases, as shown in Figure 1. We also found that the PMR is robust with respect to the device dimensions as well as the edge termination of graphene. Our findings show that it is possible to explore spin polarized currents in graphene with no direct injection through magnetic materials. We acknowledge EU Programme Graphene Flagship.

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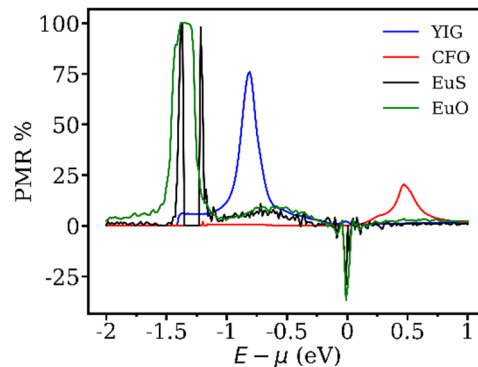
Figure 1: For a system of L = 36.4 nm, W = 29.5 nm and d = 1.5 nm, PMR curves for YIG, CFO, EuS and EuO smeared using T=300 K, 300 K, 16 K and 70 K respectively.