# Electrical spin injection into graphene using h-BN tunnel barrier

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Graphene is a promising material for spintronics applications because of its long spin diffusion length. By inserting tunnel barrier in between a ferromagnetic electrode (F) and graphene, electrical spin injection and detection have been demonstrated in lateral graphene spin valve devices. So far, all of the reported experiments used either polycrystalline or amorphous tunnel barrier, thus obtained tunnel spin polarization is still few tenth of %. Fabrication of a high quality single crystal tunnel barrier between F and graphene is desired for much larger spin injection efficiency.

Recently, a hexagonal boron nitride (h-BN) has been recognized as another two-dimensional crystal system similarly to the graphene and used as high quality substrate for the graphene. It can be exfoliated to atomically thin layer, thus ideal material as a tunnel barrier. In this work, we fabricated graphene spin-valve device using a monolayer (ML) of h-BN as a tunneling barrier between F and graphene. From non-local magnetoresistance (MR) measurement, spin injection and detection has been demonstrated for the first time.

The device structure is schematically depicted in Fig. 1. By using dry transfer technique, a ML of h-BN is transferred on a 2-3 layer thick graphene. Ferromagnetic permalloy (Py) and non-magnetic (NM) Au/Ti electrodes are fabricated using EB lithography and EB evaporation. Two terminal I-V curve is measured in between F and NM electrodes at 30 K as shown in Fig. 2(a). I-V curve exhibits non-linear characteristics and suggests the successful fabrication of tunnel barrier in between FM and graphene. A non-local MR $R_{NL}$ is measured as shown in Fig.2(b). We observed spin signal $\Delta R_{NL}$ of 0.4 Ω. $\Delta R_{NL}$ is robust against elevating temperature and $\Delta R_{NL}$=0.3 Ω has been observed even at RT. We also measured Hanle curve in perpendicular magnetic field and extracted various important parameters such as spin diffusion constant and spin relaxation time which will be discussed at the presentation.

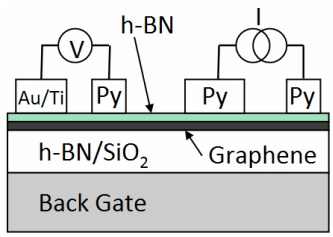


Fig. 1: Schematic illustration of the graphene spin-valve device with a ML thick h-BN tunneling barrier.

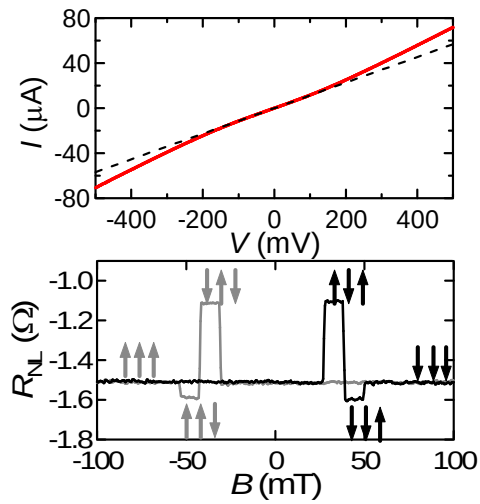


Fig. 2: (a) I-V and (b) $R_{NL}$ measured at 30K. Arrows indicate magnetization direction of Py electrodes.