Electrical spin injection and detection in GaAs with ferromagnetic metal/MgO junctions

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The effective spin injection from ferromagnetic metals (FM) into semiconductors (SC) is essential for the semiconductor spintronics. The intrinsic conductance mismatch between FM and SC is known to prevent efficient spin injection and can be overcome by using a tunnel barrier at the interface.

In this study, we report enhanced electrical spin injection and detection in a Fe/MgO/GaAs junction and CoFeB/MgO/GaAs up to room temperature. The epitaxial MgO/GaAs layers were *in-situ* grown by a molecular beam epitaxy (MBE). Modulation doping in the vicinity of the interface promotes tunneling transport by reducing the depletion layer of Schottky barrier, and the I-V characteristics of the junction of samples show typical combination of tunneling and slight Schottky barrier, Fig. 1 (a), (b). Large spin accumulation represented by the voltage difference (ΔV = 6.3 mV at 10 K when I = -0.9 mA) between the baseline and the dip of Hanle curve is observed from Fe/MgO/GaAs junction at various temperature range and sustained up to 400 K when an out-of-plane magnetic field is applied, Fig. 1 ©.

The finite roughness of the FM/oxide interface induces the local magnetostatic fields, and this local fields greatly change the spin accumulation and precession in SCs. [1] The inverted Hanle caused by the local fields also observed when an in-plane magnetic field is applied, Fig. 2. The Lorentzian fitting of the Hanle curve from Fe/MgO/GaAs gives 234 ps spin lifetime of n-doped GaAs, and this is a lower bound since the local field suppresses spin lifetime at the interface.

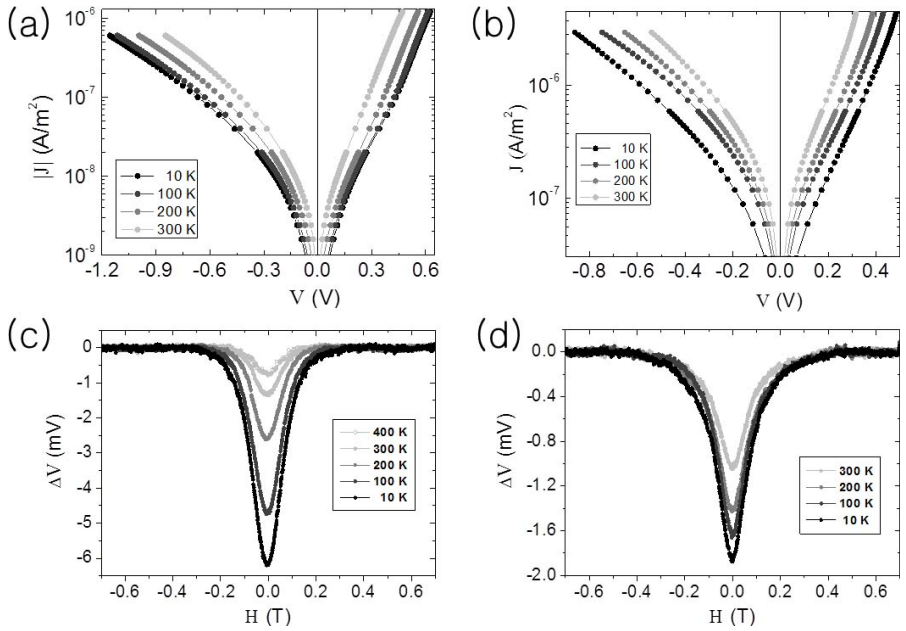

Fig. 1 The graph of the current density vs. bias voltage of (a) Fe/MgO/GaAs and (b) CoFeB/MgO/GaAs junctions. Hanle curves from the junctions of (c) Fe/MgO/GaAs and (d) CoFeB/MgO/GaAs with respect to temperatures when I = -0.9 mA and – 1 mA, respectively.

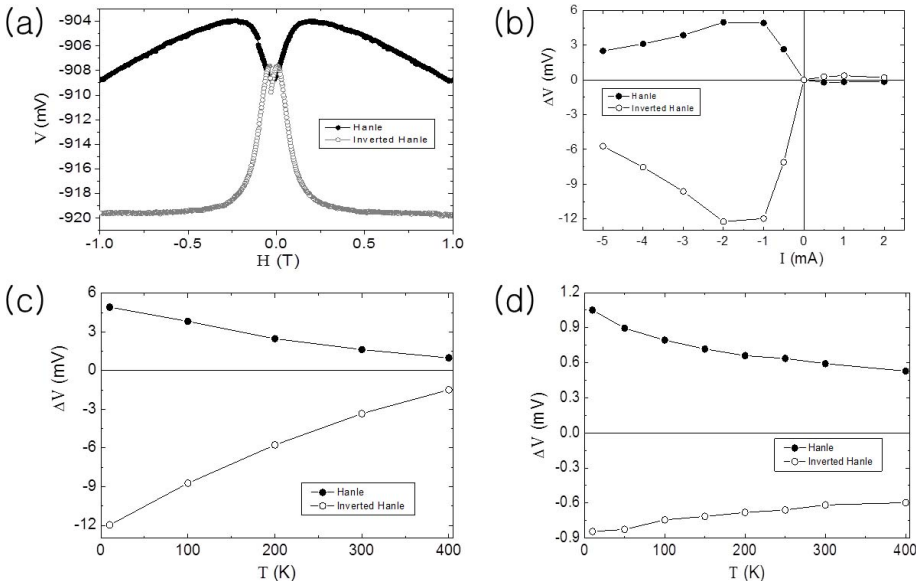

Fig. 2 (a) normal Hanle and inverted Hanle graph of Fe/MgO/GaAS sample when I = -1 mA at 10 K. (b) The plot of the bias current dependence of normal and inverted Hanle of Fe/MgO/GaAs at 10 K. The graphs of temperature dependence of normal and inverted Hanle of (a) Fe/MgO/GaAs and (b) CoFeB/MgO/GaAs samples when I = -1 mA.

[1] S. P. Dash *et al.*, Phys. Rev. B 84, 054410 (2011).