Spin injection enhancement by electric field effect in a ferromagnet-semiconductor hybrid structure

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In order to investigate the electric field effect on the injection efficiency, the lateral spin valve device on semiconductor channel was fabricated. The channel consists of an inverted heterostructure with an $In_{0.53}Ga_{0.47}As$ active layer. The channel is patterned by the ion-milling and the resulting width is 8μm. The carrier concentration and the electron mobility of the 2DEG channel at T= 20 K (150 K) are n_S = 1.52 × 10^{12} (1.56 × 10^{12}) cm^{-2} and μ_e = 29 000 (18 000) $cm^2V^{-1}s^{-1}$, respectively.

Using non-local (Geometry A) and local (Geometry B) spin valve geometries, the spin injection efficiencies with and without an electric field are extracted. The magnitudes of the measured signals from two geometries are determined by the spin injection efficiency of injection and detection sides. In Geometry A, the bias current crosses the injection interface between ferromagnetic electrode and semiconductor but the charge current or the electric field does not exist at the detection interface. In Geometry B, however, the identical current crosses both injection and detection interfaces so the same electric field is induced at the junctions. At T = 20 K, the spin injection efficiency is increased from 3.2% to 7.0% with a current of 1 mA which produces electric field at the junction. As shown in fig. 1(b), temperature dependence of measurements shows that the spin injection efficiency does not weaken with an electric field. The reason is that the electric field effect compensates the thermal smearing of injection efficiency at higher temperature.

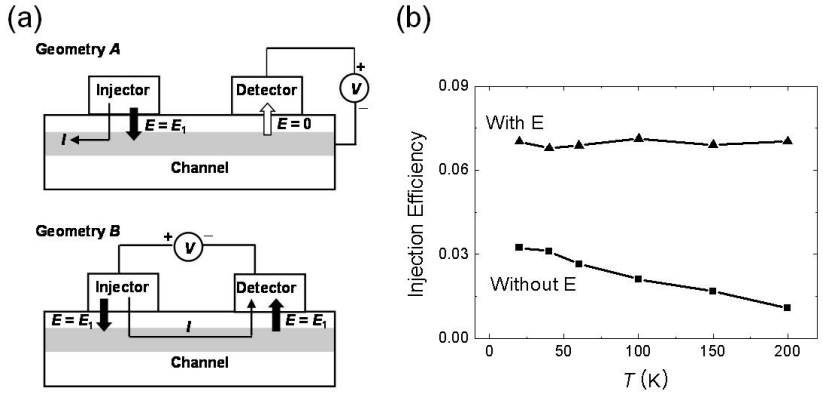

Figure 1. Electric field effect on spin injection efficiency. (a) Non-local (Geometry A) and local (Geometry B) measurement geometries. (b) Temperature dependence of injection efficiencies with and without electric field.