An electrical spin injection from perpendicularly magnetized FePt into GaAs/AlGaAs two dimensional electron gas channel

○大杉 廉人[1]、間野 由布子[1]，好田 誠[1]、新田 淳作[1]（1. 東北大工）

○Rento Ohsugi[1], Yuuko Mano[1], Makoto Kohda[1], Junsaku Nitta[1] (1.Tohoku Univ..)

E-mail: ohsugi@dc.tohoku.ac.jp

An electrical spin injection from a ferromagnetic metal into a semiconductor is one of the important techniques for spintronic devices. While the spin injection experiments have been done with in-plane magnetized electrodes, for the application of spintronics devices such as a spin transistor [1], perpendicular spin injection into 2-demensionnal-electron-gas (2DEG) is preferable. However, it is still a challenging task because of low spin detection efficiency in 2DEG and complicated device fabrication process. In this study, we investigate an electrical spin injection from a perpendicularly magnetized FePt electrode into a GaAs/AlGaAs 2DEG channel by optimizing a hetero-structure and interfacial resistances of injection/detection electrodes.

Figure1 (a) indicates a fabricated layer structure, and its thicknesses and doping densities. To effectively detect spin in 2DEG, we put the 2DEG channel at shallow position 45 nm below electrodes. Figure1 (b) shows measurement set-up for two terminal electrical Hanle signals. By applying current from FePt to Fe electrode via 2DEG, injected spins flow into Fe electrode, and generates a spin dependent voltage signal due to spin dependent transmission of spin polarized current. The gap between the injector and detector is 1 μm. Figure1 (c) exhibits magnetic field (H_y) dependent spin signal resulting from the precession and diffusion of spins. Here, the FePt injector and the Fe detector in Figure1 (b) were magnetized along perpendicular- and x-directions, respectively. The injected perpendicular spins under negative magnetic field (-0.1 T) along y-direction were rotated and aligned to parallel to the magnetization of Fe detector. While, in the case of positive magnetic fields (+0.1 T), spins were aligned to anti-parallel to the magnetization of Fe detector. These parallel and anti-parallel configrations result in the low and high resistant at the Fe/GaAs interface due to the spin-density-state dependent tunneling of spin polarized current. This is so-called Hanle effect. By fitting the Hanle curve, we extracted spin lifetime of 400 psec, which is consistent with that of 2DEG GaAs in previous study [2].

[1] J. Wunderlich *et al.*, *Science* **330**, 1801 (2010).[2] G. Wang, *et al*, Nat. Comm. **4**, 2372(2013).

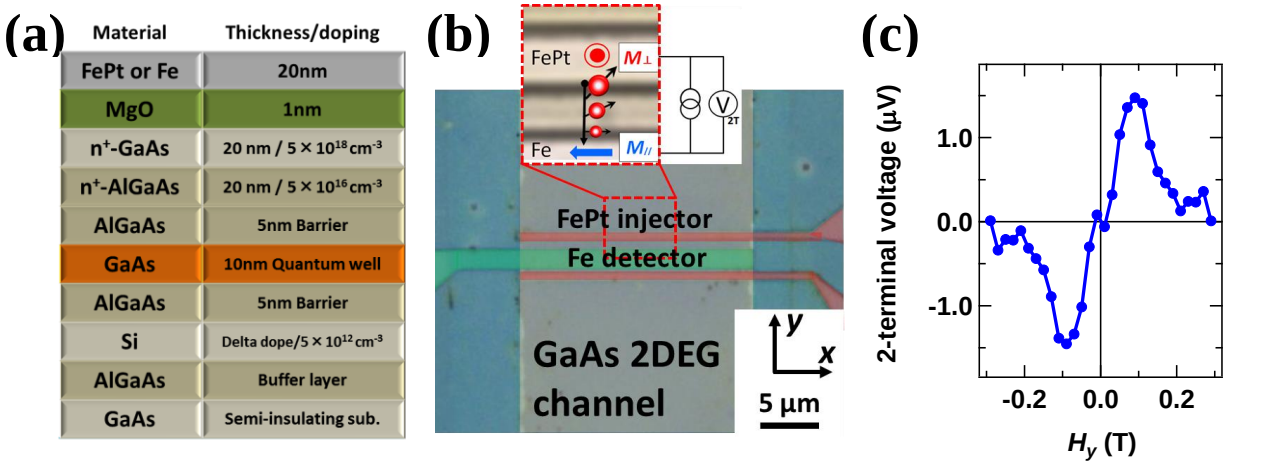

Fig.1 (a) Layer structure and thickness of fabricated sample, (b) A picture of 2DEG spin injection/detection device. Red electrodes are FePt/MgO perpendicularly magnetized spin injectors (1μm width). A green electrode is an Fe in-plane spin detector (2 μm width), (c) Two terminal voltage between FePt / 2DEG / Fe electrodes at positive current +50 μA. The gap between the FePt injector and the Fe detector is 1 μm.

© 2016年 応用物理学会