非磁性/強磁性体 2 層膜におけるスピン整流効果の材料依存性

Material dependence of the spin rectification effect in nonmagnet /ferromagnet bilayers

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Spin orbit torque (SOT) is one of the most attractive research topics of spintronics because it has a potential for the realization of next-generation memory device, SOT magnetoresistive random access memory. There are many methods for estimation of charge-to-spin conversion efficiency. Considering that the goal of SOT research is to switch the magnetization, direct detection of SOT magnetization switching should be the most reliable way. Recently, we demonstrated the detection of SOT magnetization switching by using the rectification signal under microwave irradiation (low frequency spin torque ferromagnetic resonance: LFST-FMR) [1]. This method does not need any complicated nanostructures such as magnetic tunnel junctions. Therefore, LFST-FMR is expected to realize agile research on various materials combination of nonmagnet (NM)/ferromagnet (FM) layers.

Figure 1 shows a schematic of fabricated device. NM/FM/cap layers were fabricated on MgO substrate by using rf magnetron sputtering or electron-beam deposition. Firstly, $Ni_{80}Fe_{20}$ (Py), Fe, and Co were employed as FM layer while Pt was used as NM layer for investigating FM-dependent characteristics. Figures 2(a) ~ 2(c) show the LFST-FMR signals under microwave with different frequencies for Pt/Py, Pt/Fe, and Pt/Co devices. Clear LFST-FMR signals were observed around external magnetic field, B_{ext} = 0 mT for all devices, indicating that the detection method of SOT-magnetization switching by using LFST-FMR is applicable to various kinds of FMs. Furthermore, LFST-FMR of Pt/Fe and Pt/Co were observed up to higher frequencies than that of Pt/Py. Such FM-dependent characteristics is well explained by the frequency dependence of the magnetic susceptibility [2]. Next, we changed NM layer from Pt to Ta to investigate NM-dependent characteristics. Figure 2(d) shows the LFST-FMR signals of Ta/Co device with different microwave frequencies. An additional magnetization-dependent background (BG) signal was observed even in the magnetic field (B_{ext}) region larger than the switching field. Surprisingly, the magnitude of BG signal of Ta/Co was equal to or larger than that of LFST-FMR, i.e., DC voltage around B_{ext} = 0 mT, which is different from Pt/FM cases. In this presentation, we discuss the origin of these FM and NM dependent characteristics in detail.

[1] M. Aoki *et al*., Phys. Rev. B **102**, 174442 (2020).
[2] M. Aoki *et al*., AIP adv., accepted.

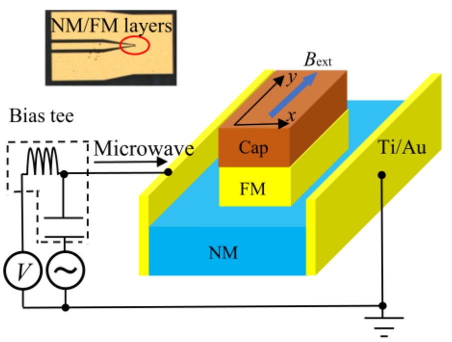

Fig.1. A schematic of device structure for the demonstration of LFST-FMR measurement.

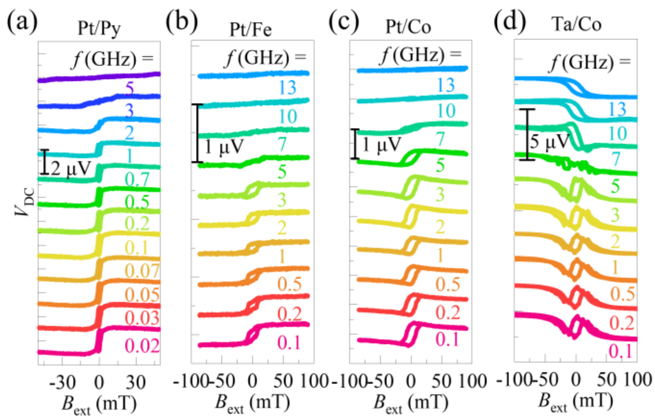

Fig.2. LFST-FMR of NM/FM devices. The applied microwave power was fixed to 5 dBm.