スピントルク強磁性共鳴法を用いた面内磁化反転の検出

In-plane magnetization switching detected by spin torque ferromagnetic resonance

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Magnetization switching using spin orbit torque (SOT) [1] has been investigated intensively, because it enables a low power consumption and high endurance magnetoresistive random access memory. For in-plane magnetization materials, fabrication of spin valves such as a magnetic tunnel junction is generally required. Such additional and complicated fabrication procedures impede a wide variety of material search for spin orbit materials. In this study, we demonstrated in-plane magnetization switching of a single $Ni_{80}Fe_{20}$ (Py) layer on platinum (Pt) layer by using the spin rectification effect under ferromagnetic resonance (FMR) condition [2]. Under the irradiation of microwave with a frequency of several GHz, two FMR spectra are obtained when the magnetic field is swept from large negative field to positive one. The absolute value of resonance field is decreased with decreasing the microwave frequency, and finally, the field range of two FMR spectra are superimposed on each other. In this case, we can distinguish between two different magnetization directions from difference in voltage at specific magnetic field, corresponding to the two FMR spectra.

Figure 1 shows a schematic of the fabricated device. Pt/Py/MgO/Cu layers and a Au/Ti coplanar wave guide was fabricated on the MgO substrate. In the magnetization switching measurements, a large magnetic field at $\theta = 15^{o}$ was applied to initialize the magnetization direction. After removing the magnetic field, a low frequency microwave (0.5 GHz) was applied and a dc voltage induced by FMR was measured. After stopping the microwave irradiation, a pulse current (pulse width: 1 ms) was applied into the Pt layer. Magnetization switches to -*y* direction when the SOT generated by the spin Hall effect in Pt and/or Oersted field generated by the charge current in Pt are sufficient. Then, dc voltage induced by FMR was measured again. When the magnetization is successfully switched, a clear difference in dc voltage between before and after application of the pulse current is detected. Figure 2 shows the normalized voltage difference between before and after application of the pulse current as a function of dc charge current. A successful magnetization switching was confirmed above 1.55×10^{7} A/cm^2. In the presentation, we will also report the relationship between detection sensitivity of the magnetization switching and size of the ferromagnetic layer.

[1] H. W. Tseng et al., Science **336**, 555 (2012). [2] L. Liu et al. , Phys. Rev. Lett. **106**, 036601 (2011).

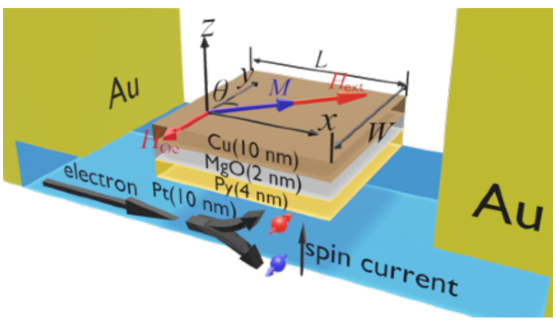

Fig.1. A schematic of device structure for demonstration of current induced magnetization switching.

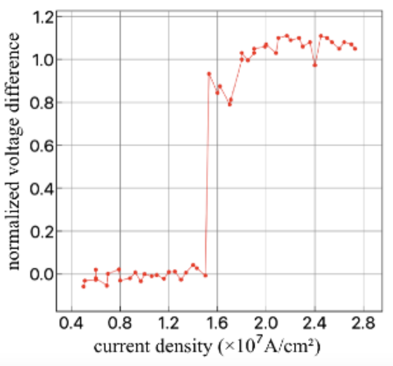

Fig. 2. Normalized voltage difference between before and after application of the pulse current as a function of dc charge current.