Spin Torque-Induced Vortex Oscillation in Co_2(Fe, Mn)Si Heusler Alloy

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Introduction Large amplitude oscillation with a high frequency purity is an essential property for a spin torque oscillator (STO) to be a core device in the future information and communication technology. We have recently developed STOs using Co_2(Fe, Mn)Si (CFMS) Heusler alloy, and demonstrated that the large giant magnetoresistance (GMR) effect in CFMS/Ag/CFMS leads to the achievement of large output power (P_{rf}) [1,2]. On the other hand, vortex STOs in which a magnetic vortex is formed in the free layer have an advantage in the oscillation coherency, and a high quality factor Q = 4000 has been reported [3] without using the phase-locking techniques. Although such high Q oscillation is desirable for the development of high performance STO, the magnitudes of P_{rf} for the vortex STOs are generally small due to the reduction of MR effect associated with the formation of vortex. In this study, we fabricated vortex STOs using an epitaxially-grown CFMS/Ag/CFMS film, and characterized their oscillation properties. We show that the high spin polarization of CFMS and the magnetization dynamics of the vortex provide with large P_{rf} and high Q oscillations.

Experiments Figure 1 shows a schematic illustration of the fabricated STO along with a measurement setup. The multilayer consisting of MgO (001) Subs.//Cr (20)/Ag (20)/CFMS (20)/Ag (5)/CFMS (30)/Ag (2)/Au (3) (in nanometer) was prepared by using an ultrahigh vacuum magnetron sputtering system. Then, the 30-nm-thick top CFMS layer was patterned into the circular shape with 240 nm in diameter. The thickness and the diameter of the top CFMS layer was chosen to stabilize magnetic vortices. From the GMR curves, the formation of vortices in the top CFMS layer was confirmed under zero bias current (I_{dc} = 0 mA). The spin torque oscillation properties of the fabricated STO was characterized by using a spectrum analyzer and a digital storage oscilloscope under in-plane magnetic field (H).

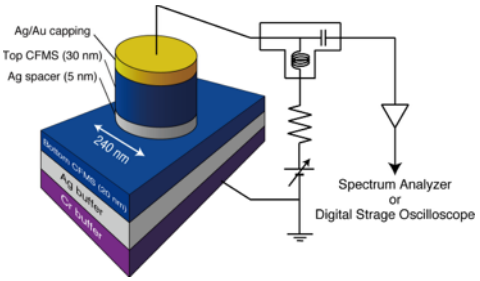

Fig. 1: Schematic illustration of the microfabricated STO and the measurement setup.

The fabricated STO showed spin torque oscillation around f = 600 MHz for I_{dc} > 2.5 mA with H < 600 Oe. Depending on I_{dc} and H, mode jumps were observed together with a remarkable broadening of the spectral linewidth (Δf) were observed. As the oscillation is stabilized, Δf was reduced to ~150 kHz, resulting in high Q exceeding 5000. Also, by optimizing the oscillation condition, P_{rf} = 10.3 nW and Q = 4000 were simultaneously achieved. These oscillation characteristics of the present STO suggest that the highly spin polarized Heusler alloys and magnetic vortex are promising for the enhancement of P_{rf} and Q at the same time.

References

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