Study of Spin Transfer Torque in $Co_2Fe_xMn_{1-x}Si$ Heusler Alloy

The generation of pure spin current (J_S) and its effect on the switching of the magnetization by spin transfer torque via spin orbital torque have been subject of vivid research in last one decade [1]. The efficient switching of magnetization via spin current depends on the damping properties of the magnetic materials. $Co_2Fe_xMn_{1-x}Si$ (CFMS) has a low damping coefficient, therefore, we prepared bilayers MgO(100)/CFMS (20 nm)/Pt (t_{Pt} = 3, 5, 7, 10, 20 nm) for the investigations of spin pumping and inverse spin Hall effect (ISHE).

Thin films of CFMS are grown on MgO(100) substrates using magnetron sputtering. The sample structure was MgO/CFMS (20 nm)/Pt (t_{Pt} = 3, 5, 7, 10, 20 nm). The growth of CFMS thin films were epitaxial on the MgO substrate, which was confirmed *in situ* using reflection high energy electron diffraction. The samples were investigated for the damping properties using ferromagnetic resonance (FMR) in the frequency range of 6 to 17 GHz. Fig.1 shows the graph between line width (ΔH) and frequency for t_{Pt} = 3, 5, 10 nm, which was extracted by FMR absorption peaks. The ΔH was fitted using Kittel formula [2] for extracting the damping coefficient (α). The values of α were obtained to be 0.0053, 0.0109, 0.0131 for t_{Pt} = 3, 5, 10 nm, respectively. It is clear from the values of the α that the thickness of Pt is very important, which is affecting the interfaces and hence dissipation of angular momentum. This enhancement of the α may be due to spin pumping. To confirm this, we performed ISHE measurements at the frequency of 7.0 GHz. Fig. 2 shows the FMR and ISHE measurements. To quantify the spin pumping contribution, we fitted the measured ISHE voltage using Lorentzian function with taking into account the symmetric and anti-symmetric parts of linewidth:

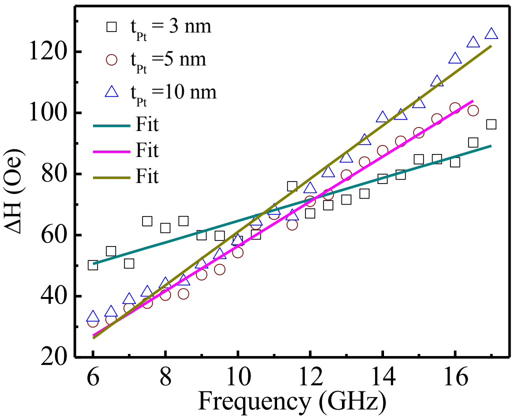

Fig. 1 Frequency dependent line width graph (ΔH) for the sample t_{Pt} = 3 nm (rectangle), 5 nm (circle), 10 nm (triangle). Solid lines are fit with Kittel formula for evaluation of α.

$$V_{meas} = V_{sym}\frac{(\Delta H)^2}{(H-H_{res})^2+(\Delta H)^2} + V_{Asym}\frac{2\Delta H(H-H_{res})}{(H-H_{res})^2+(\Delta H)^2}, \quad (1)$$

where H_{res} is the resonance magnetic field. The values of symmetric component and anti-symmetric component are evaluated as V_{sym} = -1.01037 μV and V_{Asym} = -0.574601 μV, respectively. Therefore, it can be concluded that the spin pumping is the dominating in our bilayer samples. However, angle dependent ISHE measurements are required for excluding other galvanometric effects like anomalous Hall effect or anisotropic magnetoresistance. These measurements are in progress.

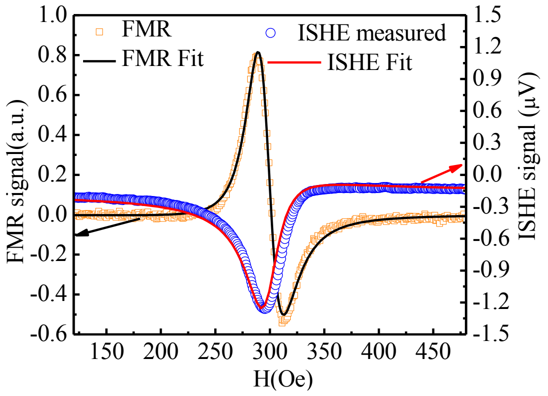

Fig. 2 ISHE voltage and FMR signal versus applied field (open symbol). The red solid line is the fit using Lorentzian function (1).

References

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[2] C. Kittel, Phys. Rev. 73, 155 (1948).

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