27p-PB2-5

Determination of Penetration Depth of Transverse Spin Current in (001) Oriented Ferromagnetic Films by Spin Pumping

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In magnetic tunnel junctions (MTJs), while a polarized current is injected to a ferromagnetic layer, there is a transfer of angular momentum of the flowing electrons to the magnetization of the layer in which they are absorbed. This concept of spin transfer torque was predicted independently by Slonczewski and Berger [1, 2], and later confirmed through the magnetization reversal in magnetic multilayer nano-pillars [3]. The scale over which this mechanism of transfer takes place is called penetration depth of the transverse spin current and it is usually denoted by λ. In this work, we have investigated penetration depth in (001) oriented ferromagnetic films.

Films with structure of MgO-sub./Cr(40)/Co_2MnSi(20)/Cu(5)/$Co_{50}Fe_{50}$(d)/Cu(10) (in nm) were epitaxially grown by dc magnetron sputtering. Co_2MnSi Heusler alloy was used as highly polarized spin injection layer for the spin pumping effect [4]. We have determined the penetration depth by the mean of peak-to-peak line widths of ferromagnetic resonance (FMR) absorption line shape recorded for various thickness of $Co_{50}Fe_{50}$ following the theoretical approach previously developed for a polycrystalline films [5].

Fig. 1 shows the $Co_{50}Fe_{50}$ thickness dependence of FMR line width of Co_2MnSi. Solid circles are experimental results and a solid line is fitted result by theoretical model. We have determined spin penetration depth of the (001) oriented $Co_{50}Fe_{50}$ is ca. 2.7 nm. In addition to the determination of the penetration depth, we also estimated the mixing conductance in each non-magnetic/ferromagnetic junction ($4.7\times10^{19}m^{-2}$ at Cu/$Co_{50}Fe_{50}$ and $6.3\times10^{19}m^{-2}$ at Co_2MnSi/Cu).The values of estimated mixing conductance are reasonable.

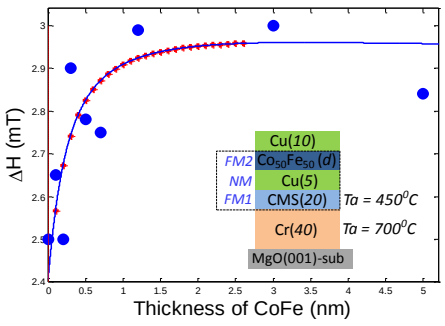

Fig. 1: Peak-to-peak line widths of FMR versus the thickness of CoFe.

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