Interfacial Dzyaloshinskii-Moriya interaction energy density and Gilbert damping at the Ir/Co interface

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I. Introduction

The interfacial Dzyaloshinskii-Moriya interaction (iDMI)I is known to arise at the interface due to inversion symmetry breaking and large SOC in heavy metals (HM). The iDMI manifests itself by forming spiral spin configurations with a preferred chirality. Therefore, it plays an important role in the dynamics of the chiral domain wall (DW), and the skyrmion formation. Brillouin light scattering (BLS) measurement is powerful tool to investigate the iDMI and magnetic anisotropy related with SOC phenomena. In this study, we experimentally investigate the iDMI energy (D), surface anisotropy(K_S), and Gilbert damping linked a spin-pumping effect at the spin-orbit coupled Ir/Co interface by employing BLS.

II. Experiment

We prepared a Ta(4 nm)/Ir(4 nm)/Co(t_{Co})/AlO_x(2 nm) sample was deposited on a thermally-oxidized Si wafer. The Co layer was deposited wedged shape in the range of 1 to 3 nm. In order to break the inversion symmetry, a 2-nmAlOx capping was used on the top of the Co layer. The magnetic properties of the samples were studied by Brillouin light scattering(BLS) with a Sandercock (3+3) type Fabry-Perot interferometer. The light source is a single frequency 532 nm a DPSS laser with output power of about 300 mW. Back scattering geometry used to observe the light scattered by thermal excitations with an in-plane wavenumber $q_{\parallel}$=0.0167 nm^{-1} with the angle of incident as 45^o. Magnetic field of up to 0.98 T were applied parallel to the film plane and perpendicular to the scattering plane.

III. Results and Discussion

From the systematic BLS measurement, we obtained the frequency difference ($\triangle f$) due to the non-reciprocal spin wave propagation, which can directly determine the iDMI energy density. The correlation between $\triangle f$ and the D is given by

$$\Delta f = \frac{2\gamma D}{\pi M_S} k_x,$$

where γ, D, k_x, and M_s are gyromagnetic ratio, the iDMI energy density, propagating spin wave vector, and saturation magnetization. Figure 1(a) indicates a result of the iDMI energy density as a function of inverse Co thickness. As a result, the iDMI energy at the Ir/Co interface is relatively smaller than the case of at the Pt/Co and the sign of iDMI is the same with our previous reports. Whereas, surface anisotropy and saturation magnetization are significantly improvement (not shown). Figure 1(b) shows the Gilbert damping constant extracted from linewidth of BLS spectra as a function of inversr Co thickness. The measured α versus t_{Co}^{-1} and a linear dependency with a finite y-intercept is seen. The physical meaning of the damping at ($t_{\mathrm{Co}} \rightarrow \infty$) is the damping constant (α_{bulk}) of bulk cobalt. In these measurements, we determined that $\alpha_{\mathrm{bulk}} \sim 0.012$, which is in good agreement with the magnetic damping constant for bulk Co (= 0.011).

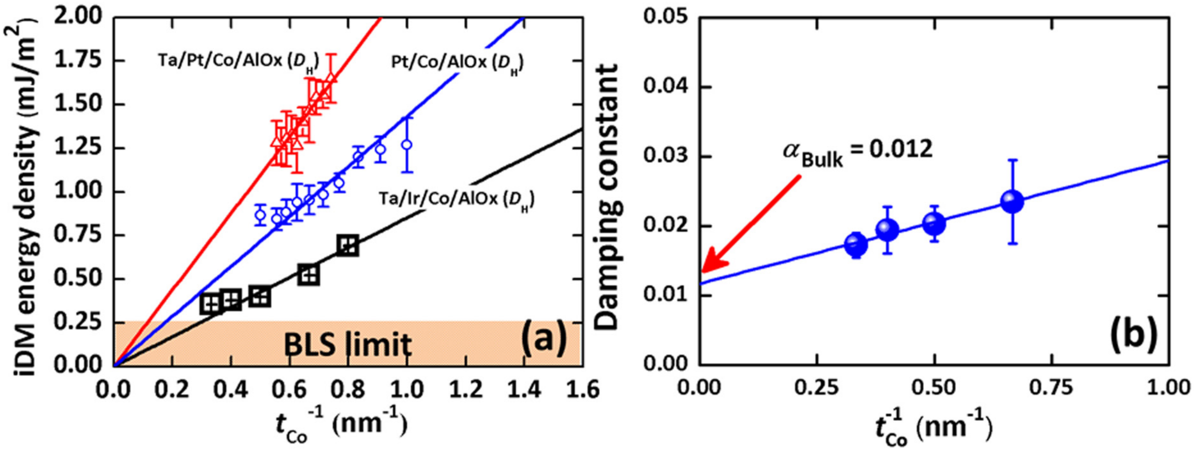

Fig. 1. (a) The iDM energy density as a function of t_{Co}^{-1}. (b) The Gilbert damping parameters as function of t_{Co}^{-1}. The extrapolated α for infinitely thick Co is approximately 0.012

IV. References

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