Gilbert damping in magnetic multilayers with perpendicular anisotropy

T. Kato[1], K. Adachi[2], Y. Kusanagi[3], S. Okamoto[3], N. Kikuchi[3], O. Kitakami[3], S. Iwata[4]
[1] Department of Electrical Engineering and Computer Science, Nagoya Univ., Nagoya 464-8603, Japan
[2] Department of Quantum Engineering, Nagoya Univ., Nagoya 464-8603, Japan
[3] Institute of Multidisciplinary Research for Advanced Materials, Tohoku Univ., Sendai 980-8577, Japan
[4] Eco-Topia Science Institute, Nagoya Univ., Nagoya 464-8603, Japan

The magnetic materials with large perpendicular magnetic anisotropy (PMA) and low Gilbert damping constant are quite attractive since they not only have sufficient thermal stability but enable efficient writing in microwave assisted magnetic recording (MAMR) and spin transfer torque based magnetic random access memory (STT-RAM). Recently, we have studied the relationship between Gilbert damping α and PMA of Co-based multilayers, and reported that the α is closely related with thickness ratio of the multilayers, while almost independent of their PMA[1, 2], suggesting the possibility to obtain the multilayers with high PMA and low damping. In this talk, we summarize the Gilbert damping and anisotropy field of the Co-based multilayers which were evaluated independently by time resolved magneto-optical Kerr effect (TRMOKE) and coplanar waveguide ferromagnetic resonance (CPW-FMR), and discuss systematically the variation of the PMA and Gilbert damping with their layered structures.

Co / Ni, Pd, Pt multilayers with various layered structure were prepared on thermally oxidized Si substrates by a DC magnetron sputtering system. TRMOKE spectra were measured by pump-probe method using high-power fiber laser with λ = 1560 nm. During the measurements, an external field H_{ext} up to 8 kOe was applied in the direction of 45 deg from the film normal. For CPW-FMR measurements, rf current was fed into CPW by a vector network analyzer, and the complex scattering parameter S_{21} was recorded varying an rf frequency under an static field along film normal direction to estimate the resonance frequency f_{res} and linewidth Δf.

Figure 1 (a) shows t_{NM} / t_{Co} dependence of H_{keff} estimated from the TRMOKE and CPW-FMR measurements, where t_{Co} is the thickness of Co and t_{NM} is the thickness of Pt or Pd. Closed and open circles represent the data of the Co/Pt multilayers estimated by TRMOKE and CPW-FMR, respectively, and closed squares are the data of Co/Pd by TRMOKE. From Fig. 1 (a), the H_{keff} was confirmed to be roughly proportional to $1/t_{Co}$ at a constant t_{NM}. Although there are slight deviations between H_{keff} estimated from TRMOKE and CPW-FMR, overall tendency was similar to each other. The TRMOKE and CPW-FMR also show the similar results on t_{NM} / t_{Co} dependence of α as shown in Fig. 1 (b). The Gilbert damping α of the multilayers are proportional to t_{NM} / t_{Co} although the H_{keff} is independent of t_{NM} / t_{Co}. The linear tendency of α on t_{NM} / t_{Co} is considered to be explained by the spin pumping model[3]. The slope of α was dependent on the noble metal as shown in Fig. 1 (b). The Co/Pt has larger slope than Co/Pd, which may reflect the difference of the spin diffusion length between Pt and Pd.

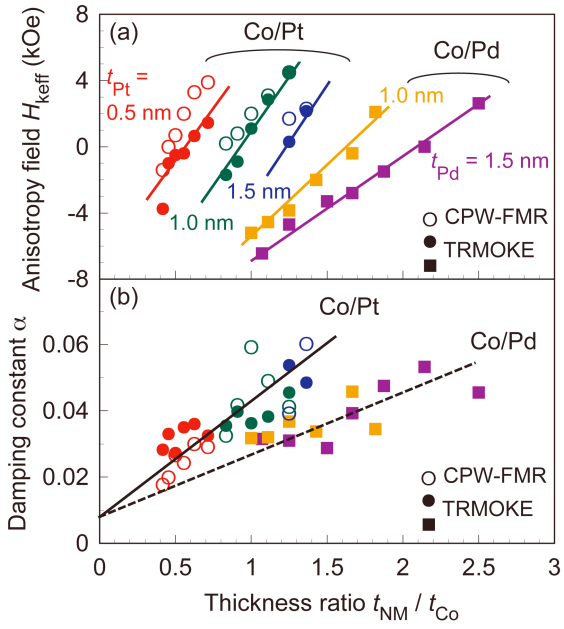

Fig. 1 Dependences of (a) H_{keff} and (b) α on the thickness ratio t_{NM}/t_{Co}. Closed and open symbols are the data estimated by TRMOKE and CPW-FMR, respectively.

Reference

1) T. Kato *et al.*, IEEE Trans. Magn., **47**, 3036 (2011).
2) T. Kato *et al.*, IEEE Trans. Magn., **48**, 3288 (2012).
3) Y. Tserkovnyak *et al.*, Phys. Rev. Lett., **88**, 117601 (2002).