Manipulation of two magnon scattering amplitude in ferromagnet/antiferromagnet bilayer structure

Tokyo Tech.[1], Keio Univ.[2], °Hiroto Sakimura[1,2], Akio Asami[2], Ji Shi[1], Kazuya Ando[2]

E-mail: sakimura.h.aa@m.titech.ac.jp

Recently, intensive study on the usability of antiferromagnetic materials (AFMs) in spintronics is accelerated because of their robustness against external magnetic fields and potential for terahertz applications. It has been reported that some of AF insulators (AFIs) exhibit highly efficient spin transport properties (1); however, these studies have not considered the effect of two magnon scattering (TMS) induced at the interface of ferromagnet (FM) and AFM(2). TMS generally appears where a non-periodic perturbation exists in crystals and has a critical influence on spin current generation in FMs. Therefore, its interpretation can lead to further understanding of spin transport in AFIs.

In this work, we investigated the amplitude of TMS in SiO_2-cap (3 nm)/$Ni_{81}Fe_{19}$ (Py, 8 nm)/ NiO (t_{NiO}) layered structure fabricated on SiO_2 substrates with several NiO (polycrystalline) thicknesses t_{NiO}. Each layer was deposited by RF magnetron sputtering at room temperature. We measured the ferromagnetic resonance (FMR) spectra by rotating the external field in a direction normal with respect to the sample surface (Fig.1 (a)). θ_H dependence of resonance spectra is shown in Fig.1 (c). The amplitude of TMS was evaluated from the out-of-plane angular (θ_H) dependence of full width of half maximum ($\mu_0\Delta H$) of the resonance spectra, which reflects the strength of the intrinsic and extrinsic magnetic damping. Figure 1 (d) shows the θ_H dependence of $\mu_0\Delta H$ for t_{NiO} = 0 and 12.5 nm samples. Because their behaviors are distinct to one another, it can be interpreted that their origins of extrinsic magnetic damping are distinct as well. The amplitude of TMS was then estimated from the difference between $\mu_0\Delta H$ at θ_H = 90° and 0°, since larger value of in-plane linewidth ($\mu_0\Delta H_{90°}$) than that of out-of-plane one ($\mu_0\Delta H_{0°}$) is caused by the existence of TMS in this case(2,3,4). It is obvious that the contribution of TMS gets larger with the increase of t_{NiO} (Fig.1 (e)). This enhanced TMS is not induced by the NiO surface roughness Δt because it is almost constant in the t_{NiO} range of our measurement as can be seen in Fig.1 (b) confirmed by XRR and AFM.

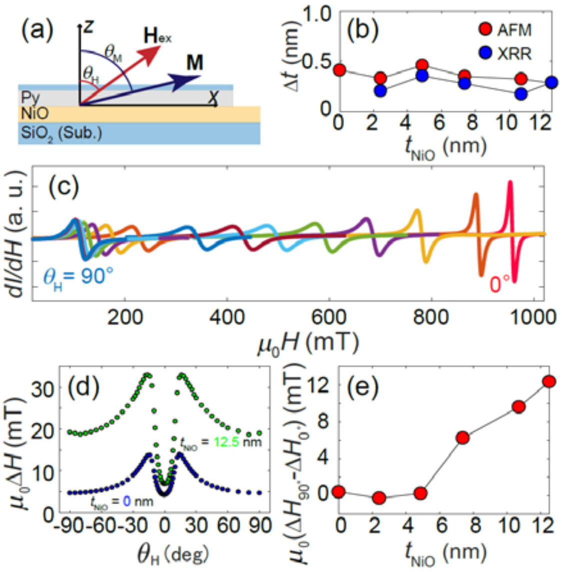

Fig. 1 (a) Sample structure and measurement geometry. (b) t_{NiO} dependence of NiO surface roughness Δt. (c) FMR resonance spectra of t_{NiO} = 10 nm for several θ_H. (d) θ_H dependence of $\mu_0\Delta H$. (e) t_{NiO} dependence of $\mu_0(\Delta H_{90°} - \Delta H_{0°})$.

Our results indicate that the interfacial exchange magnetic field produced by NiO is the origin of the enhanced TMS. This result suggests a non-negligible influence of TMS on spin transport in FM/AFM systems. This also offers a way to tune the TMS amplitude in FM by controlling the thickness of an adjacent AFM layer.

1) H. Wang, *et al*., Phys. Rev. B **110**, 220410(R) (2015).

2) M. C. Weber, *et al*., J. Appl. Phys. **99**, 08J308 (2006).

3) D. Roy, *et al*., J. Phys. D: Appl. Phys. **48**, 125004 (2015)

4) M. J. Hurben, *et al*., J. Appl. Phys. **83**, 4344 (1998).