Influence of Oxygen content on the Gilbert damping constant at TaO_x/CoFeB interface

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Spin-orbit torque (SOT) induced magnetization switching in non-magnetic/ferromagnetic systems has attracted much attention for applications in spintronics devices [1,2]. Especially, the recent report on the SOT switching in oxide/ferromagnetic interfaces revealed a high spin-torque efficiency by tuning the surface oxidization [3]. However, a detail investigation of damping constant (α), which is one of the most important parameters to understand the magnetization switching in these systems, still remains unclear. Herein we evaluate α of TaO_x/CoFeB stack films by a broadband ferromagnetic resonance (FMR) measurement technique, and discuss the influence of oxygen content on α in these films in detail.

TaO_x (1 nm)/CoFeB (1.3 nm)/MgO (1.3 nm)/Ta (1nm) stack films were fabricated on thermally oxidized Si substrates by the RF sputtering at room temperature. TaO_x layers were formed by naturally oxidizing thin Ta layers at the different Oxygen pressure (P_{Oxygen}) of 0.3, 0.1, and 0.03 Pa. The post-annealing process was conducted at 250°C and 350°C in a vacuum.

Figure 1 shows the dependence of α and the interfacial anisotropy K_s on P_{Oxygen} for as-deposited and annealed stack films. K_s was evaluated by the equation: $K_s = (4\pi M_{s,\,eff} - 4\pi M_s)\times(t_{CFB}M_s/2)$ where the saturation magnetization was measured by VSM (M_s) and FMR measurements ($M_{s,\,eff}$), respectively; and t_{CFB} is the thickness of CoFeB layer. For every film, both α and K_s decrease as P_{Oxygen} increases, suggesting that these parameters correlated with each other [4]. On the other hand, the rate of the α enhancement by annealing in every surface oxidized film (Ta-O_x/CoFeB/MgO/Ta) is lower than that in the non-oxidized Ta/CoFeB/MgO/Ta (at 0 Pa) sample. These results suggest that surface oxidization in the Ta layer plays an important role in controlling the damping constant in this system.

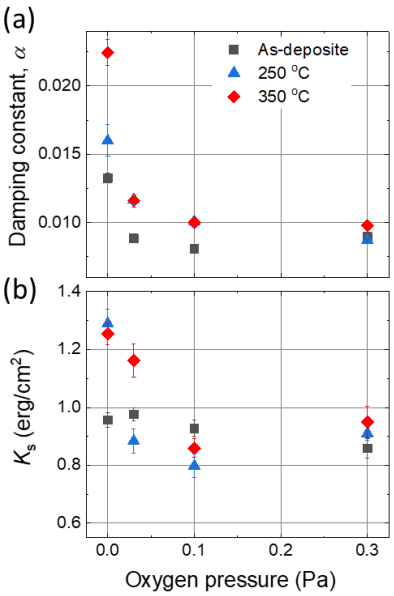

Fig. 1: Oxygen pressure dependence of α (a), K_s (b).

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References:

[1] R. Ramaswamy et al., Appl. Phys. Rev. 5, 031107 (2018). [2] H. Honjo et al., IEDM Tech. Dig. 28.5 (2019). [3] H. An et al., Nat. Commun. 7, 13069 (2016). [4] J. Sinha et al., Appl. Phys. Lett. 102, 242405 (2013).