Study on the dynamic magnetic properties in Ta-O/Co-Fe-B stacks with different interface condition

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Recently, the spin-orbit torque (SOT) induced switching in oxide/ferromagnetic stacks has attracted much attention as a new method for spintronic device applications since the switching in these stacks showed a high efficiency by tuning the surface oxidization [1]. Since the high efficiency closely correlates to both of the dynamic magnetic properties and the interface condition in these stacks, a detailed understanding of their correlation is important from the scientific points of view. Herein we selected a Ta-O/Co-Fe-B stack as a typical oxide/ferromagnetic stack, and then studied the change in the dynamic magnetic properties by controlling the interface condition.

Ta-O (1 nm)/Co-Fe-B (1.3 nm)/MgO (1.3 nm)/Ta (1 nm) stacks were fabricated on thermally oxidized Si substrates by the RF sputtering. Ta-O layers were formed by naturally oxidizing thin Ta layers at the different oxygen pressure (P). The post-annealing process was conducted at a temperature (T_{an}) ranging from 523 K to 673 K in a vacuum to control the interfacial anisotropy (K_s). As for their dynamic magnetic properties, the effective saturation magnetization ($4\pi M_{s,\,eff}$) and the damping constant (α) were estimated using a broadband FMR measurement method.

Figure 1 shows the change in $4\pi M_{s,\,eff}$ and α with T_{an} for the stacks oxidized at different P. For all stacks, as T_{an} increases, $4\pi M_{s,\,eff}$ slightly decreases while α increases. At all T_{an} except 673 K, α values at P above 0.1 Pa are lower than that at P of 0.03 Pa. Furthermore, to get more insight, K_s was estimated by $K_s = (4\pi M_{s,\,eff} - 4\pi M_s)\times(t_{Co\text{-}Fe\text{-}B}M_s/2)$, where $t_{Co\text{-}Fe\text{-}B}$ is the Co-Fe-B layer thickness, and M_s is the saturation magnetization, and then was summarized in Fig. 1 (c) as a function of T_{an}. The variation in the absolute value of K_s for T_{an} is similar to the behavior in ref. [2] and their values at P above 0.1 Pa become lower than that at P = 0.03 Pa, meaning that α and K_s are correlated with each other in the surface oxidized stacks. On the basis of these results, it is suggested that the surface oxidization plays an important role in controlling α in these stacks.

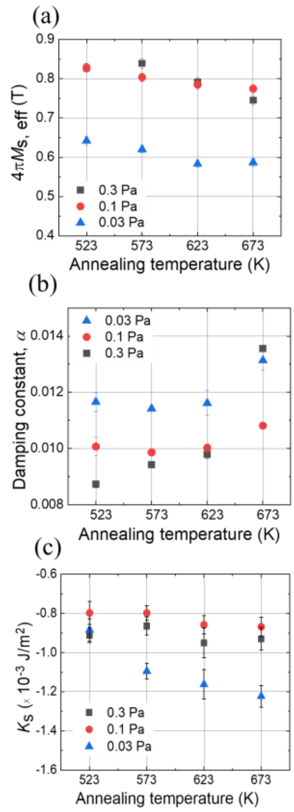

Fig. 1: Annealing temperature dependence of $4\pi M_{s,\,eff}$ (a), and α (b), K_s (c).

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