Temperature dependence of Gilbert damping constant in amorphous Co-Fe-B thin films

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Soft amorphous Co-Fe-B thin films have attracted extensive interest thanks to the low Gilbert damping constant (α), high spin polarization which are beneficial to spintronics devices such as MRAM, spin-torque oscillator, and the spin-based logic systems. Even though α in Co-Fe-B thin films has been widely investigated, the details about the effect of temperature on α, which are important for further development of those devices, are not understood fully. Herein we evaluate α at various temperatures of amorphous Co-Fe-B thin films with the different thicknesses by a broadband ferromagnetic resonance (FMR) measurement technique, and discuss the effect of temperature on α in these films in detail.

Figs. 1 (a), (b), and (c) show the temperature dependence of the effective saturation magnetization ($4\pi M_{s,eff}$), the inhomogeneous field (ΔH_0), and α for Co-Fe-B thin films with the thickness of 5, 10, and 15 nm, respectively. In Fig. 1 (a), $4\pi M_{s,eff}$ slightly increases as the temperature decreases. The thinner the film is, the smaller $4\pi M_{s,eff}$ is obtained, which might be due to the enhancement of the surface anisotropy. On the other hand, the temperature dependence of ΔH_0 (Fig. 1 (b)) and α (Fig. 1 (c)) for all samples look more featured, namely, as the temperature decreases, these parameters slightly increase down to 150 K and then markedly increase below 150 K, which might be similar to that of the electrical conductivity [1]. Moreover, the increment of α with the temperature in the film with 5-nm-thickness becomes larger, which might be ascribed to the magnetic inhomogeneity such as the anisotropy dispersion. On the basis of these results, it can be suggested that the tendency of damping in each Co-Fe-B film with temperature is mainly consistent with the behavior of damping expected by intra-band transition.

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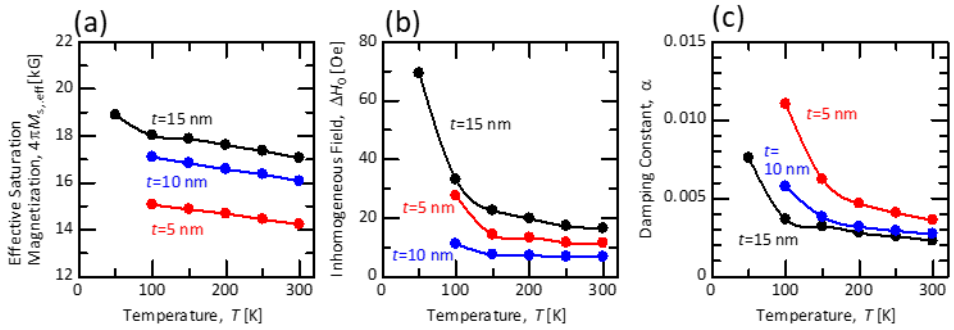

Fig. 1. Temperature dependence of $4\pi M_{s,eff}$ (a), ΔH_0 (b), and α (c) for various Co-Fe-B films.