Magnetic anisotropy change of MgO | SiO_2 capped Co-Fe-B by annealing in atmosphere

Osaka Univ.[1], CSRN-Osaka[2], ULVAC Inc.[3]

°Minori Goto[1,2], Ryo Ishikawa[3], Hikaru Nomura[1,2], and Yoshishige Suzuki[1,2]

E-mail: goto@spin.mp.es.osaka-u.ac.jp

A magnetic skyrmion is a topological spin texture that has attracted attention because of its diverse physical phenomena and possibilities of applications. Recently, various applications utilizing the Brownian motion of skyrmions have been reported [1-3]. However, because skyrmion Brownian motion is sensitive to the change in magnetic properties, the change in the magnetic potential and vanishing skyrmions have often been observed due to the change in magnetic properties of skyrmion film during microfabrication and observation processes. The possible origin of the change is atom migration such as boron diffusion in Co-Fe-B [4] or oxidation of capping. Although the annealing enables to avoid such the change, the typical annealing process takes approximately 1 hour in vacuum. In this study, we performed annealing for 3 min in atmosphere to shorten the annealing process and to avoid the change in magnetic properties.

The film stack of Ta (5.9) | $Co_{16}Fe_{64}B_{20}$ (1.22) | Ta(0.27) | MgO (1.6) | SiO_2 (2.9) was deposited on the thermally oxidized silicon substrate. The film was post-annealed in atmosphere and vacuum at various temperature. Figure 1(a) shows the perpendicular magnetic field dependence of normalized magneto-optical Kerr effect (MOKE) signal with various annealing processes; as deposited, 200 ℃ for 3 min in atmosphere, and 200 ℃ for 1 h in vacuum. While the annealing in vacuum suppresses the perpendicular anisotropy, that in atmosphere enhances it as shown in Fig 1(b). Moreover, the skyrmion is observed in 250 ℃ annealed sample at 15 ℃ as shown in the inset of Fig 1(b) and shows Brownian motion. While the temporal variation is observed with as deposited and 150 ℃ annealed sample, it is not observed with more than 200 ℃ annealed ones. These results suggest that, because of oxidation of capping layer, oxygen density of MgO | Ta interface is modulated by annealing, which induces the increase in perpendicular anisotropy of $Co_{16}Fe_{64}B_{20}$.

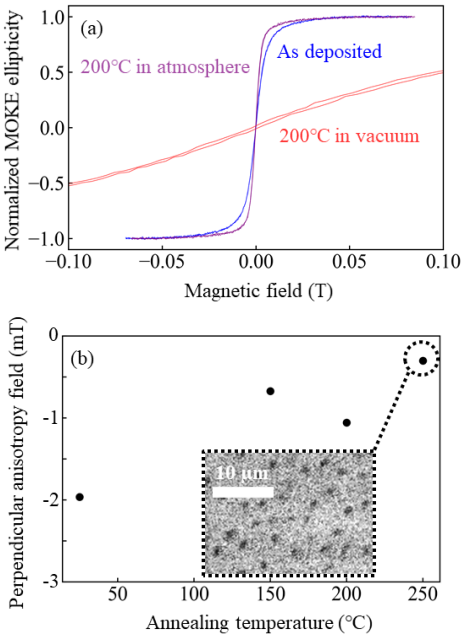

Figure 1 (a) Normalized MOKE ellipticity of films with different annealing processes measured at 20 ℃. (b) Dependence of perpendicular anisotropy field measured at 20 ℃ on temperature of annealing in atmosphere. Inset is MOKE microscope image of 250 ℃ annealed sample observed at 15 ℃.

This research was supported by the ULVAC Inc., JSPS KAKENHI Grant Number JP20H05666, and JST CREST Grant Number JPMJCR20C1.

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