Analysis of Local Distortion in Cobalt Ferrite Thin Films by Magneto-optical Measurements

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Background Recently, large perpendicular magnetic anisotropy in spinel cobalt ferrite (CFO) thin films induced by introducing tetragonal strain was reported [1]. It was considered that this phenomenon is caused by a distortion of octahedron including Co^{2+} according to a theoretical prediction [2]. In order to understand the mechanism, the correlation between the magnetic anisotropy and the distortion have to be measured experimentally. In this study, we measured magneto-optical (MO) spectra of CFO films with distinct distortion and investigated the optical transition related to Co^{2+}.

Experimental methods Two types of CFO thin films were prepared by metal-organic decomposition (MOD) and reactive RF magnetron sputtering. The epitaxial CFO films (Co:Fe = 1:3) were prepared on MgO substrates by RF magnetron sputtering using Co-Fe alloy targets. The polycrystalline CFO films (Co:Fe = 1:2) were prepared on glass substrates (EAGLE XG, Corning Inc.) by MOD [3]. MOD solution (CoFe-O4(1:2), Kojundo Chemical Lab. Co., Ltd.) was spin-coated on glass substrates with 3000 rpm for 30 s. Then they were dried at 100 °C for 30 minutes, and were pre-annealed at T_{pa} = 310~350 °C for 30 minutes in air. Finally, those films were annealed at 730 °C for 10 hours in a nitrogen atmosphere (400 ml/min). MO spectra ranging 350 - 2100 nm were measured by a multi-channel MO spectrometer using the polarization modulation method [4]. The films were also characterized by X-ray diffraction (XRD) and vibrating- sample magnetometer (VSM).

Results and Discussion Figure 1 shows the Faraday rotation (θ_F) and ellipticity (η_F) spectra of two CFO thin films prepared by RF sputtering, thicknesses of these films was t = 23.3 nm, 50 nm, respectively. Figure 2 shows the Faraday rotation and ellipticity spectra of the CFO thin films prepared by MOD with different pre-annealing temperatures. It was found that structures due to Co^{2+}(Oh) - Fe^{3+}(Oh) charge transfer transition and Co^{2+}(Td) $^4A_2$-$^4T_1$ (P) crystal field transition were superimposed in 400 - 900 nm. In addition, a structure due to $^4A_2$-$^4T_1$ (F) crystal field transition of Co^{2+}(Td) was also observed. In this presentation, we will discuss about the correlation between the local distortion and the magnitude of the Faraday spectra.

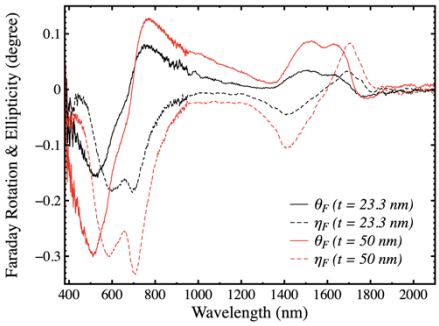

Fig. 1 θ_F and η_F of prepared two $Co_{0.75}Fe_{2.25}O_4$ thin films with t = 23.3 nm, 50 nm prepared by RF sputtering.

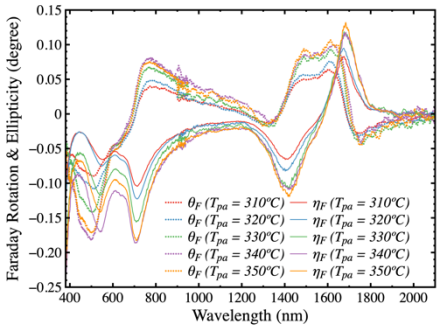

Fig. 2 θ_F and η_F of of $CoFe_2O_4$ thin films pre-annealed temperature prepared by MOD with different T_{pa} .

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Reference

[1] T. Niizeki et al., Appl. Phys. Lett., **103**, 162407(2013).
[2] J. Inoue et al., Mat. Res. Exp., **1**, 046106 (2014).
[3] K.Yasuda et al, Jpn. J. Appl. Phys., **59**, SEEA01 (2019)
[4] S. Wang et al., Jpn. J. Appl. Phys., **59**, SEEA02 (2019).