Magnetic anisotropy constants and magnetic moments of Fe in $ThMn_{12}$-type $Sm(Fe_{1-x}Co_x)_{12}$ compounds

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The $ThMn_{12}$-type the $Sm(Fe_{1-x}Co_x)_{12}$ ($0 \leqq x \leqq 0.2$) compound films exhibit intrinsic hard magnetic properties superior to those of $Nd_2Fe_{14}B$ for x=0.2[1]. Therefore, it is important to investigate the origin of intrinsic magnetic properties such as magnetic anisotropy and magnetization of the $Sm(Fe_{1-x}Co_x)_{12}$ compound and their temperature dependence. In this work, we evaluated the magnetic anisotropy constant of the $Sm(Fe_{1-x}Co_x)_{12}$ films by using the anomalous Hall effect (AHE) torque measurements. The results were compared with the ab-initio calculations of the crystal field parameters at the Sm site using a spin model of $Sm(Fe_{1-x}Co_x)_{12}$ compounds. We also evaluated the magnetic moment of each Fe site in $Sm(Fe_{1-x}Co_x)_{12}$ films and their temperature dependence using the total reflection synchrotron-radiation Mössbauer spectroscopy method.

Epitaxial $Sm(Fe_{1-x}Co_x)_{12}$ films were prepared by an ultra-high vacuum magnetron co-sputtering system with the stacking structure of MgO(001) substrate/V(001)(10nm)/$Sm(Fe_{1-x}Co_x)_{12}$(288-325nm)/V(2nm) (x=0, 0.07, 0.2). Anomalous Hall effect was measured by using a physical property magnetic system (PPMS) with a maximum magnetic field of 14T. ^{57}Fe Mössbauer spectra were measured at RT and 250°C on the beamline BL11XU at SPring-8.

Fig.1 shows the temperature dependence of K_1 and K_2 for the $Sm(Fe_{1-x}Co_x)_{12}$ films with various Co contents. While K_1 monotonically decreases with increasing temperature, K_2 changes its sign from negative to positive with increasing temperature. This behavior is consistent with the effective spin model approach[2] based on the ab-initio calculation. Fig.2 shows the internal magnetic field of each Fe site and their magnetic moment as a function of Co content at RT and 250°C from the analysis of Mössbauer data. The fitting was performed using three independent spectra for the 8i, 8j and 8f Fe-sites. The site dependence of internal magnetic fields follows the sequence 8i > 8j > 8f, which corresponds to the previous Mössbauer measurement in $ThMn_{12}$ structure[3]. When the moment of Sm is assumed to be zero, the estimated saturation magnetization value without Co (x=0) is about 1.65T at RT, which is in a good agreement with the previously reported value[1]. The enhancement of magnetic moments was observed at each Fe site as increasing the Co content, which could be the reason for the magnetization enhancement of $Sm(Fe_{1-x}Co_x)_{12}$ compound.

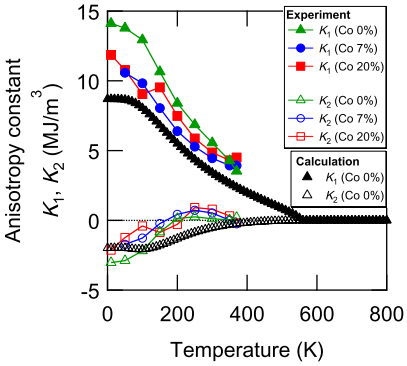

Fig.1 K_1, K_2 for $Sm(Fe_{1-x}Co_x)_{12}$ films as a function of temperature

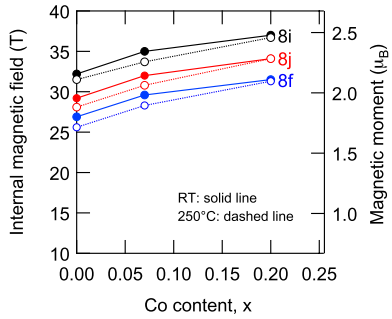

Fig.2 Internal magnetic field and magnetic moment at each Fe site for $Sm(Fe_{1-x}Co_x)_{12}$ films

Reference
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