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Metal-insulator and spin structure transition in $Ca_{1-x}Ce_xMnO_3$ thin film studied by x-ray magnetic circular dichroism

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1 Introduction

Perovskite manganite has the chemical formula $R_{1-x}A_xMnO_3$, where R and A are a rare earth element and an alkali earth element, respectively. One can control the spin, orbital and charge ordering by changing the R, A and *x*. Manganite also attracted attention as a material showing giant magnetroresistance. In the case of thin films, one can also control the physical properties by changing their substrates through lattice distortion caused by the epitaxial strain [1].

Electron-doped systems such as $Ca_{1-x}Ce_xMnO_3$ (CCMO) have been extensively studied in addition to the hole-doped systems such as $La_{1-x}Sr_xMnO_3$ (LSMO). In CCMO, one can control the resistivity and the spin structure by substituting Ce for Ca. Xiang *et al.* [2] reported that the resistivity and the spin structure can be controlled by changing the substrates such as $YAlO_3$ (YAO), $NdAlO_3$ (NAO), and $LaSrAlO_4$ (LSAO). The phase diagram of CCMO with different substrates is shown in Fig. 1. Unfortunately, one cannot detect the magnetization of CCMO thin film on NAO substrate by SQUID measurements because of the strong paramagnetic signal from the substrate. X-ray magnetic circular dichroism (XMCD) measurements are useful to obtain the information about the magnetism of Mn in samples grown on NAO substrates. In the present work, we have obtained the information about the magnetic anisotropy of Mn in CCMO thin films grown on NAO substrates.

2 Experimental

Thin films of CCMO were fabricated by the pulsed laser deposition (PLD) method. The thickness of these samples was 40nm (100ML) and their surfaces are capped by $LaAlO_3$ layer (1nm). XMCD measurements were performed at BL-16A2 of KEK-PF with the total electron yield (TEY) method. Substitution ratio *x* of the samples with NAO substrates are *x*=0.01, 0.04 and 0.07. Measurements were performed at temperature *T*=30K with a magnetic field *H*=1T.

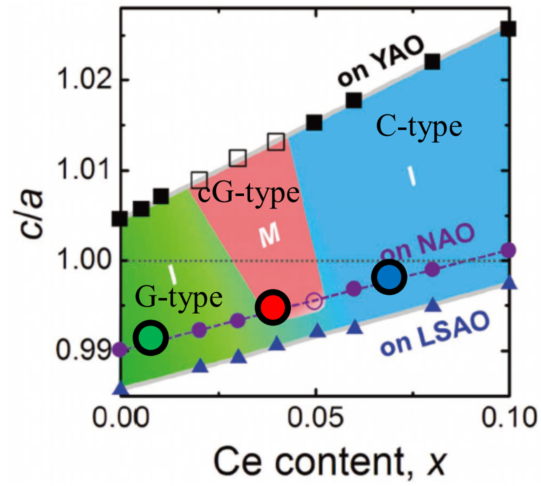

Fig. 1: Phase diagram of $Ca_{1-x}Ce_xMnO_3$ thin films grown on different substrates [1]. Green, red, and blue regions indicate G-type antiferromagnetic insulator, canted G-type antiferromagnetic metal, and C-type antiferromagnetic insulator, respectively. Samples studied here are marked by large circles.

3 Results & Discussion

Figure 2 shows the Mn 2*p*-3*d* XMCD spectra for CCMO with various doping concentrations grown on NAO. For *x*=0.01, the L_3 peak of $\theta = 60°$ is larger than that of $\theta = 0°$. θ is defined by the angel between the vector of incident light and the normal vector of the sample surface. On the other hand, the trend is opposite for *x*=0.04 and 0.07. Therefore, the *x*=0.01 sample has in-plane magnetic anisotropy, while those of *x*=0.04 and 0.07 samples have out-of-plane magnetic anisotropy.

From this result, we conclude that the magnetic anisotropy of *x*=0.04 (canted G-type AFM), is similar to that of *x*=0.07 (C-type AFI). This result is different from LSMO thin film in which the magnetic anisotropy depends on whether the ratio between the lattice constants *a* and *c* (*c*/*a*) is larger than one or not.

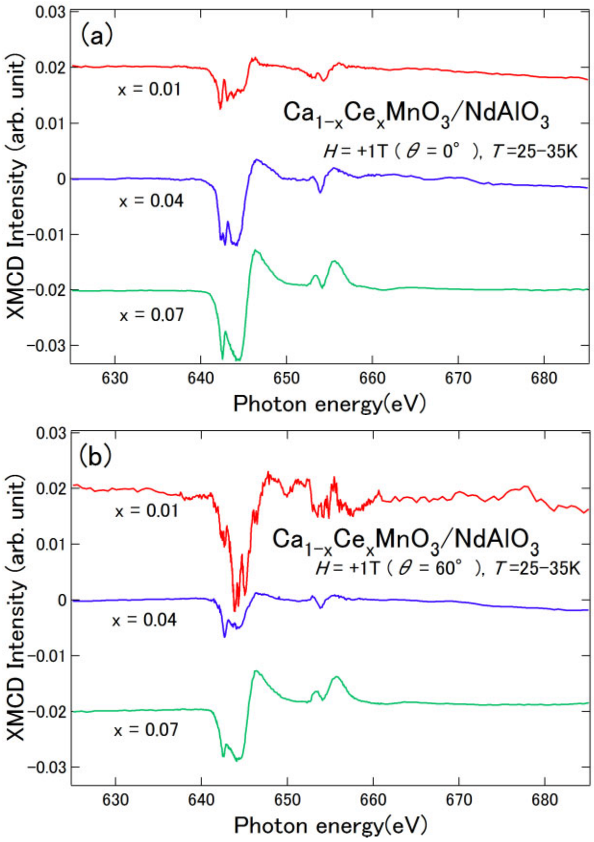

Fig. 2: Mn 2*p*-3*d* XMCD spectra for CCMO on NAO for various doping concentrations. Panels (a) and (b) show the spectra for θ=0**°** and 60**°**, respectively.

Reference

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