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Unusual Ferromagnetic Clusters and Crystal Structure Freezing by the Local Distortion Effect on La doped $Ho_{0.8}La_{0.2}Mn_2O_5$

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RMn_2O_5 is a series of multiferroics with the antiferromagnetic transition temperature around 40K. By doping larger La ions at Ho sites, with the ratio of 20%, an unusual weak ferromagnetic transition accompanying the crystal lattice constants freezing due to the local distortion effect was observed. A very weak FM phase is observed for temperature lower than 150K and saturated below 85K as shown in Figure 1. This weak FM phase is confirmed to be consisted of FM clusters by magnetization and magnetic hysteresis measurements. The AFM phase is not affected by the existed FM phase and manifests an AFM phase transition at 40K, similar to its parent compound $LaMn_2O_5$. Interestingly, the lattice constants of this compound are frozen below 150K, as shown in Figure 2. By investigating this sample by a higher resolution X-ray diffraction in Spring-8, Japan, a continuous change on local structure in 150~100K, while maintains its lattice constants, is responsible for the "Freezing" phenomena. Since the local structure change is mainly a distortion of one Mn^{+3} ions which align the Z shape of the center plane of MnO_6 octahedrons and the base plane of MnO_5 pyramids into a line, a specific mode of phonon is enhanced that may create a dynamic ferromagnetic short range ordering contributing to the observed weak FM phase.

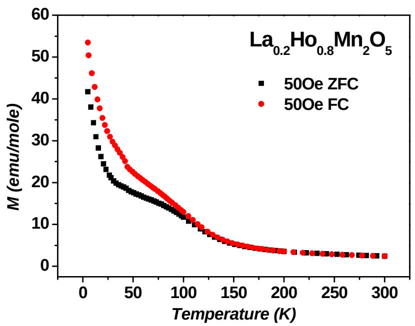

Fig. 1. Magnetization as a function of Temperature of a $Ho_{0.8}La_{0.2}Mn_2O_5$ compound. An unusual ferromagnetic cluster phase is observed below 150K.

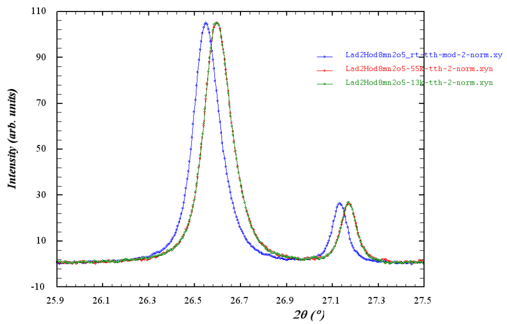

Fig. 2. The Freezing of the lattice constants of $Ho_{0.8}La_{0.2}Mn_2O_5$ compound below 150K.

EB11

Quantitative Study of the Strain-mediated Magnetoelectric Coupling in Non- lead based Piezoelectric and Ferromagnetic Composite Materials

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With growing worldwide interests toward utilizing multiferroic materials for the novel memory and sensor devices, there have been numerous efforts to synthesize a magnetoelectric composite composed of ferromagnetic and piezoelectric materials. In this composite, external magnetic field induces magnetostriction in the ferromagnetic material and it can be transferred to the piezoelectric material through the interface strain coupling. As a result, electric polarization or voltage is generated in the piezoelectric material to realize significant magnetoelectric effects in the composite. To date, $Pb(Zr,Ti)O_3$ (PZT) have been mostly used as a piezoelectric material due to its superior electromechanical properties over the other piezoelectrics near room temperature. On the other hand, for environmental considerations, many efforts are recently being made to find other piezoelectric materials with no or less Pb that can outperform the PZT [1,2]. With this current situation in mind, herein, we report quantitative measurements on the magnetoelectric susceptibility for new magnetoelectric composites that have non- or less-Pb piezoelectric materials and ferromagnetic materials. For the measurements, we have used a highly sensitive magnetoelectric susceptometer that has been recently realized in our group [3]. The piezoelectric materials we have tested include $(Na,K)NbO_3$-$LiNbO_3$ and $(BiScO_3)$-PZT and the ferromagnetic materials $Co(Fe,A)_2O_4$ (A=Mn, Ga, Cr) and Terfenol. With various fabrication and sintering conditions, we will try to extract optimal condition to realize the largest magnetoelectric susceptibility in each composite, and compare the value with the existing data based on the PZT materials. The quantitative data will be useful to find a clue toward realizing non- or less-Pb based magnetoelectric sensors.

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