Materials Science

8B/2009G529

Preparation and magnetic property of $BiMnO_3$ nanocrystals in mesoporous silica

Takayuki TAJIRI*[1], Hiroyuki DEGUCHI[2], Masaki MITO[2], Atsushi KOHNO[1]
[1]Faculty of Science, Fukuoka University, Fukuoka 814-8550, Japan
[2]Fuculty of Engineering, Kyushu Institute of Technology, Kitakyushu 804-0180, Japan

Introduction

It is interesting to investigate nano scale materials since the significant influence of the surface state and the finite size yield remarkable properties as compared with those of bulk crystal. We synthesized the multiferroic compound $BiMnO_3$ nanocrystals in the pores of SBA-15 and investigated their magnetic properties [1]. Bulky $BiMnO_3$ shows ferromagnetic and ferroelectric transition at $T_M \approx 100$ K and $T_E \approx 750$ K, respectively [2]. $BiMnO_3$ has superexchange interaction which is responsible for the ferromagnetic state, and is subject to complex orbital ordering due to the heavily distorted MnO_6 octahedral structure. Thus, the multiferroic property of $BiMnO_3$ strongly depends on its structure, and so its properties should suffer modification as the particle size reaches the nanometer size.

Experimental

The $BiMnO_3$ nanocrystals were synthesized in the one-dimensional pores of SBA-15 with a diameter of 8 nm by soaking the SBA-15 in a stoichiometric aqueous solution of $BiCl_3$ and $Mn(CH_3COO)_2{\cdot}4H_2O$. Then, the soaked samples were dried and calcinated in an oxygen atmosphere. The powder XRD measurement of the $BiMnO_3$ nanocrystals in the SBA-15 was accomplished using a synchrotron radiation X-ray diffractometer at BL-1B and BL-8B of the Photon Factory of KEK. The incident X-ray energy was 18 keV. The magnetic properties of $BiMnO_3$ nanoparticles were measured using a SQUID magnetometer.

Experimental results

Figure 1 shows the powder XRD patterns for $BiMnO_3$ nanocrystals in the SBA-15 and the SBA-15 at room temperature. The broad background peak at around $2\theta = 10$ ° originated from the glass capillary. The diffraction pattern for the $BiMnO_3$ nanocrystals showed some Bragg peaks, which suggested the presence of the $BiMnO_3$ nanocrystals and the impurity phases which were considered BiOCl and/or Bi_2SiO_5 shown by circle symbols in Fig. 1. The average size of the nanocrystals was estimated to be about 14 nm, based on the diffraction peaks and on the results of calculations using Scherrer's equation.

Figure 2 shows the temperature dependence of the DC magnetic susceptibility and the inverse of the susceptibility of the $BiMnO_3$ nanocrystals. The susceptibilities showed the ferromagnetic ordering at 98 K which was similar to the ferromagnetic transition temperature for bulk crystal. A pronounced irreversibility between field cooled (FC) and zero filed cooled (ZFC) susceptibilities due to the superparamagnetic behavior was observed. However, the inverse magnetic susceptibility between 100 and 300 K was fitted by means of the Curie-Weiss equation with a negative value, $\Theta = -34$ K. In addition, the magnetization curve indicated the appearance of antiferromagnetic behavior rather than ferromagnetic one. The magnetic measurement results for $BiMnO_3$ nanocrystals showed both ferromagnetic and antiferromagnetic behaviors, whereas $BiMnO_3$ bulk crystal consistently shows ferromagnetic behavior.

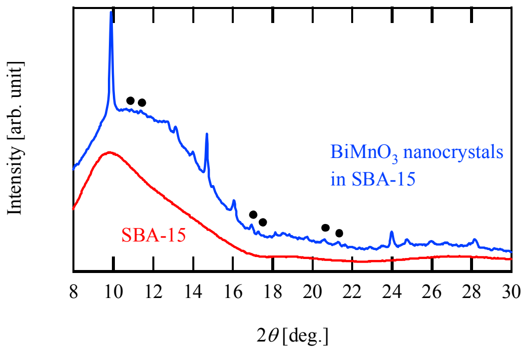

Fig 1. XRD patterns of $BiMnO_3$ nanocrystals and SBA-15. The circle indicates peaks of impurity compounds.

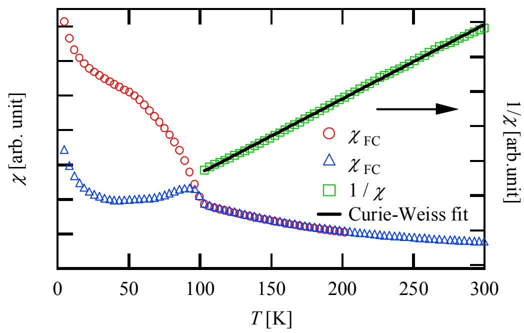

Fig 2. Temperature dependence of the susceptibility and the inverse of susceptibility for $BiMnO_3$ nanocrystals in the SBA-15 under an external field of $H = 100$ Oe

References

[1] T. Tajiri et al., J.Phys: Conf. Ser. 150, 042198 (2009).
[2] T. Kimura et al., Phys. Rev. B 67, 180401 (2003)

* tajiri@fukuoka-u.ac.jp