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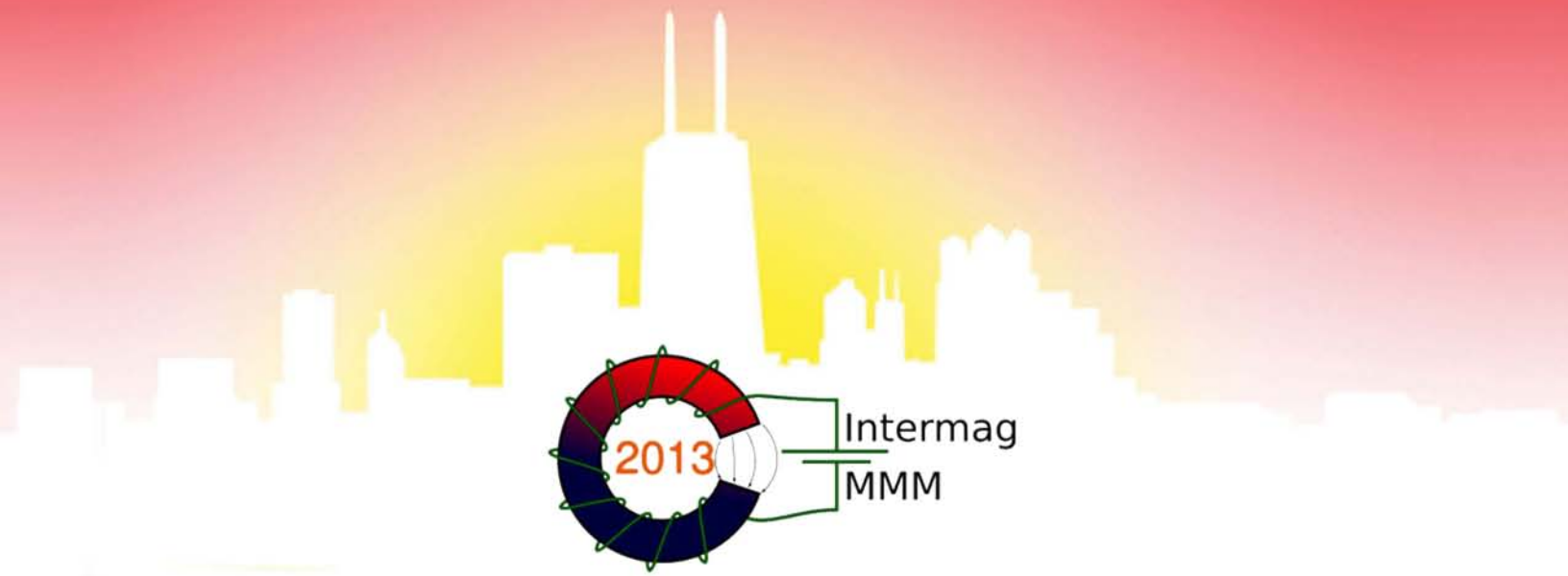

ABSTRACTS

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Zhang, S. Yunoki, E. Dagotto, and J.-M. Liu, Phys. Rev. B 84, 174413 (2011). 11. R. D. Johnson, L. C. Chapon, D. D. Khalyavin, P. Manuel, P. G. Radaelli, and C. Martin, Phys. Rev. Lett. 108, 067201 (2012). 12. J. S. Gardner, M. J. P. Gingras, and J. E. Greedan, Rev. Mod. Phys 82, 53 (2010). 13. C. Castelnovo, R. Moessner, and S. L. Sondhi, Nature 451, 42 (2008).

ES-08. Weak ferromagnetic behavior of $BiFeO_3$ at low temperature. *S. Han*[1] and C. Kim[1] *1. Department of Physics, Kookmin University, Seoul, Republic of Korea*

Even though $BiFeO_3$ has been reported to show weak ferromagnetic behavior at low temperature, it origin has not been clearly explained so far [1-2]. In this study, we have prepared $BiFeO_3$ by low temperature hydrothermal method and studied the weak ferromagnetic behavior of $BiFeO_3$ at low temperature. From the x-ray diffraction (XRD) measurement, the crystal structure of $BiFeO_3$ is determined to be rhombohedral with the space group of *R3c* at 295 K. Here the Rietveld refinement analysis was carried out by considering each Fe- and O- sites divided into two pairs and showed two different atomic positions for each of Fe- and O- sites. The Mö ssbauer spectra, measured at 295 and 4.2 K, were analyzed with 2-set sextet. And isomer shift (δ) values are between 0.28 and 0.40 mm/s, indicated the Fe^{3+} state. Also, the electric quadrupole shift (E_Q) value, due to lattice contribution in FeO_6 octahedral site, ranges from 0.03 to 0.10 mm/s. The area ratio showed the occupancy of FeO_6 octahedral sites. These results revealed the existence of distorted FeO_6 octahedral sites, as expected from Rietveld refinement and Mö ssbauer analysis. The magnetization hysteresis (M-H) curves measured at 295 and 4.2 K, show antiferromagnetism at 295 K. However, coercive force (H_C) at 4.2 K is higher than the value at 295 K, which is due to remanent moment, once again revealing the existence of distorted FeO_6 octahedral sites. Thermal agitation affects the magnetic moment at high temperature, explaining the absence of weak ferromagnetic behavior at 295 K and strong weak ferromagnetic behavior at 4.2 K.

[1] B. Ramachandran, and M. S. R. Rao, Appl. Phys. Lett. **95**, 142505 (2009). [2] K. Sardar, J. Hong, G. Catalan, P K Biswas, M. R Lees, R. I Walton, J. F Scott, and S. A T Redfern, J. Phys. Condens. Matter **24**, 045905 (2012).

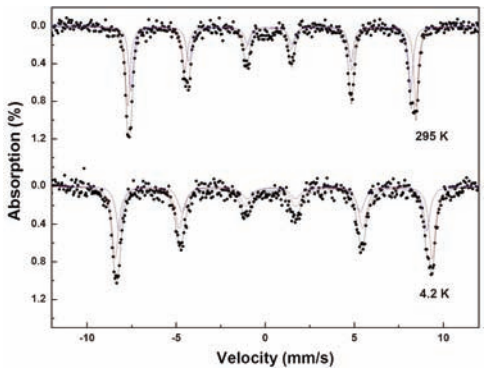

Fig. 1. Mössbauer spectra of $BiFeO_3$ at 295 and 4.2 K.

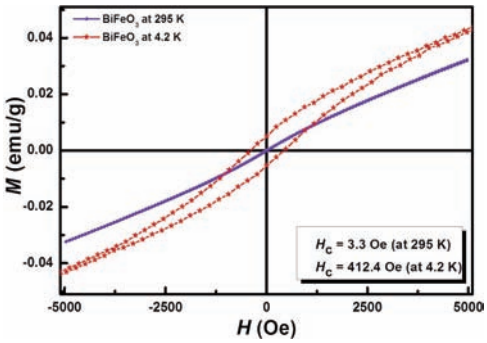

Fig. 2. Magnetic hysteresis loop of $BiFeO_3$ at 295 and 4.2 K.

ES-09. Size effect on multiferroic TbMn2O5 nanorods. *C. Yang*[1], Y. Chen[1], W. Huang[1], C. Weng[1], Y. Huang[1], Y. Chen[2] and M. Wu[2] *1. Department of Physics, Chung Yuan Christian University, Chung-Li, Taoyuan, Taiwan; 2. Institute of Physics, Academia Sinica, Nankang, Taipei, Taiwan*

The size effect on magnetoelectric properties of TbMn2O5 investigated by using a field emission transmission electron microscope, ac magnetic susceptibility, relative dielectric measurements, and varied temperature x-ray diffractions. Four types of nanorods with different axial lengths labeled as <LC> are studied. The <LC> equal to 48 nm, 64 nm, 101 nm, and 216 nm nanorods are all crystallized into an orthorhombic Pbam symmetry. All axial directions of the four types of nanorods are parallel to the c axis of the crystal. No such specified orientation of radial direction is found. The magnetic critical size of TbMn2O5 is found between <LC > = 64 nm and 101 nm. No similar critical length is observed at the ferroelectric ordering. This implies that the size effect broke the magnetoelectric coupling by destroying the magnetic ordering. Because of the size effect, the estimated maximal capacity of TbMn2O5 for memory device usage is at approximately 500 Gb/in^2. At low temperatures between T = 16 K and 27 K, a charge-ordering-like x-ray diffraction peak is found in the <LC > = 216 nm sample. This phenomenon may be associated with large structure distortion, thus causing the localization of charges between Mn and oxygen ions.

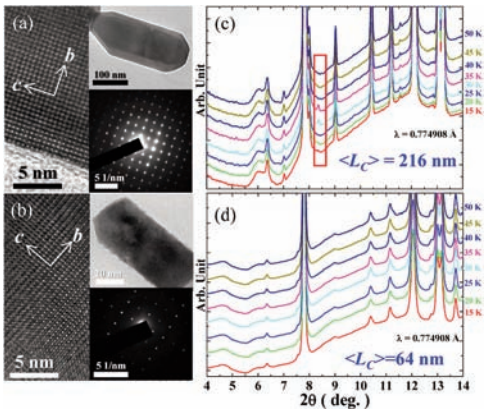

Figure 1. Selected FE-TEM images and corresponding SAED patterns of <LC> = 216 nm and (b) <LC> = 64 nm. The varied temperature X-ray diffraction patterns of (c) <LC> = 216 nm and (d) <LC> = 64 nm nanorods.