Proceedings of the 5th International Conference on Nanotechnology: Fundamentals and Applications
Prague, Czech Republic, August 11-13, 2014
Paper No. 288

Tuning Magnetic Properties of $BiFeO_3$ Thin Films by Controlling Rare-Earth Doping

Nguyen Hoa Hong, Ngo Thu Huong, Tae-Young Kim
Department of Physics & Astronomy, Seoul National University
Gwanak-gu, Seoul 151-747, South Korea
nguyenhong@snu.ac.kr ; ngothuhuong2013@gmail.com; tykim0922@gmail.com

Makio Kurisu
Department of Physics, Graduate School of Science and Engineering Ehime University
Matsuyama 790-8577, Japan
kurisu@ehime-u.ac.jp

Extended Abstract

$BiFeO_3$ (BFO) is a promising multiferroic material due to its high ferroelectric (1100 K) and antiferromagnetic (650 K) ordering temperatures. Previous reports have suggested that by reducing the dimensionality, the spiral magnetic ordering could be suppressed; therefore the magnetic properties could be modified. In BFO compouns, if Bi is partially substituted by a small amount of divalent or trivalent metal ions, or Fe is substituted by transition metal ion, a significant enhancement in magnetization can be achieved. Thin films of Rare Earth (RE) - doped BFO (where RE = Sm, Ho, Pr, Nd, and Eu) were grown on $LaAlO_3$ substrates by using pulsed laser deposition technique. All of films doping with 10% of RE show a single phase of rhombohedral structure. The saturated magnetization in the Ho- and Sm- doped films is much larger than those reported in literature, and was observed at a quite low field as of 0.2 T. In the case of Ho and Sm doping, the magnetization increases as the film becomes thinner, suggesting that the observed magnetism is mostly due to surface effect. In the case of Pr and Nd doping, the ferromagnetic phase is less favoured due to the fact that Fe^{2+} amount is not dominant. When the concentration of RE is increased up to 20%, the scenario has become more complicated. The Re-doped BFO films have experienced a structural transition from rhombohedral to either pure orthorhombic phase (Ho, Sm), or a mixed phase of orthorhombic and tetragonal (Pr, Nd), or pure tetragonal (Eu). As the results, magnetic properties of RE-doped BFO films have changes drastically. While 20% Ho/Sm-doped BFO films have magnetic moments reduced in comparision with 10% doping; the 20% Pr/Nd-doped BFO thin films, whose structure is a mixed phase, have magnetic moment improved as sequences of ratio of Fe^{2+}:Fe^{3+} increases. Our results give a guide for how to tune the ferromagnetism of BFO films by appropriate controlling the thickness, type of RE dopant and dopant concentration.

References

Kim T.-Y, Hong N. H., Sugawara T., Raghavender A. T., Kurisu M (2013), Room temperature ferromagnetism with large magnetic moment at low field in Rare-Earth-doped $BiFeO_3$ thin films, J. Physics: Condens. Matter 25, 206003.

Thakuria P., Joy P. A. (2010), High room temperature ferromagnetic moment of Ho substituted nanocrystalline $BiFeO_3$, J. Appl. Phys. 97, 162504.