Structural dielectric and magnetic properties of Gd and Ti co-doped BiFeO3 multiferroics at room temperature

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URI: http://lib.buet.ac.bd/xmlui/handle/123456789/3824
Date: 2015-12

Abstract:
Structural, dielectric and magnetic properties of BiFeO3 multiferroic samples, co-doped with magnetic Gd and non-magnetic Ti in place of Bi and Fe, respectively, were reported at room temperature. The nominal compositions of Bi0.9Gd0.1Fe1-xTixO3 (x = 0.00 - 0.25) ceramics were synthesized by conventional solid state reaction technique. X-ray diffraction patterns revealed that the substitution of Fe by Ti induces a phase transition from rhombohedral to orthorhombic at x > 0.20. Morphological studies demonstrated that the average grain size was reduced from ~1.5 µm to ~200 nm with the increase in Ti content. Due to Ti substitution, the dielectric constant was stable over a wide range of high frequencies (30 kHz to 20 MHz) by suppressing the dispersion at low frequencies. The dielectric properties of the compounds are associated with their improved morphologies and reduced leakage current densities probably due to the lower concentration of oxygen vacancies in the compositions. Magnetic properties of Bi0.9Gd0.1Fe1-xTixO3 (x = 0.00 - 0.25) ceramics measured at room temperature were enhanced with Ti substitution up to 20% compared to that of pure BiFeO3 and Ti undoped Bi0.9Gd0.1FeO3 samples. The enhanced magnetic properties might be attributed to the substitution induced suppression of spiral spin structure of BiFeO3. An asymmetric shift both in the field and magnetization axes of magnetization versus magnetic field curves was observed. This indicates the presence of exchange bias effect in these compounds notably at room temperature.

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The dielectric properties of BiFeO₃ nano-particles in the frequency range of 1 up to 5 MHz at RT revealed that the A.C. conductivity of the prepared samples reaches its maximum value in BF₅CO. By decreasing BiFeO₃ particle size as a result of doping with different Co ion concentrations, an enhancement in magnetization and a simultaneous suppression of the A.C. conductivity was observed. BiFeO₃ nano-materials doped with different concentrations of Cobalt oxide BiFe₁₋ₓCoxO₃ where (x = 0, 3, 5 and 10%), (BFO, BF₃CO, BF₅CO and BF₁₀CO), as shown in Table 1, in powder form have been prepared by a modified sol-gel method. The samples are highly conductive at room temperature and only partial polarization reversal takes place. Enhanced multiferroic properties of Y and Mn codoped multiferroic BiFeO₃ nanoparticles. A. Mukherjee • S. Basu • L. A. W. Green • N. T. K. Thanh • M. Pal. We are able to achieve improved magnetic and electric properties in chemically prepared nanocrystalline BFO by virtue of the beneficial effect of Y and Mn codoping. Phase purity and nanocrystalline nature of the samples have been confirmed using X-ray diffractometer and transmission electron microscope. In spite of room temperature multiferroicity, incorporation of BFO in practical devices has been hindered because of large leakage current induced by defects, such as impurities, non-stoichiometry and oxygen vacancies. Low magnetic moment and very weak magneto-electric coupling are other bottlenecks. Room temperature magnetic properties were investigated using Lakeshore’s (USA) vibrating sample magnetometer (VSM 7410). 3. Results and Discussions. Figure 1(a) shows Rietveld analysis for BiFeO₃ sample. A. T. Raghavender and N. H. Hong, “Effects of Mn doping on structural and magnetic properties of multiferroic BiFeO₃,” Journal of Magnetics, vol. 16, no. 1, pp. 19–22, 2011. View at Publisher · View at Google Scholar. I. Sosnowska, T. P. Neumaier, and E. Steichele, “Spiral magnetic ordering in bismuth ferrite,” Journal of Physics C: Solid State Physics, vol. 15, no. 23, p. 4835, 1982.