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Magnetic and dielectric studies of Fe substituted sillenite phase Bismuth Cobaltite nanoparticles

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Abstract. $(Bi_{13}Co_{12})CoO_{40}$ (BCO) and $(Bi_{13}Co_{5.5}Fe_{6.5})CoO_{40}$ (BCFO) nanoparticles are prepared by sol-gel auto combustion method. The x-ray diffraction study (XRD) reveals cubic crystal structure with space group I23. Surface scanning via atomic force microscopy shows the particle size decreases from 100nm to 75nm on partially substituting Fe at Co site. At room temperature, BCO is paramagnetic and shows signature of magnetic ordering at 30K, which seems to be competing paramagnetic and antiferromagnetic behaviour. No sign of magnetic disorder is seen, though indication of magnetic frustration is seen. Interestingly, the Fe substituted BCFO shows large magnetic disorder (even at room temperature) with strengthening ferromagnetic ordering as the temperature is lowered. The low temperature dielectric and magnetodielectric measurement shows dominance of extrinsic contributions, through-out the temperature range for BCO. For BCFO, the behaviour may be divided under two regions viz., intrinsic (< 260K) and extrinsic (> 260K). Relaxation in both the regions is described by Arrhenius behaviour with activation energies 0.25 eV and 0.04 eV in the extrinsic and intrinsic regions respectively. Most interestingly, the dielectric loss decreases by one order for Fe substituted sample. The Haverliak - Negami equation is found to better describe the observed relaxation data.

Introduction

Multiferroics materials have drawn considerable attention[1,2] due to their complex spin, charge and lattice interactions[3, 4]. Single phase multiferroics are very rare[5] and that's why efforts are being made to improvise the multiferroic property of existing compounds by various chemical substitutions[6-8]. At the same time, researchers are also looking for alternate single phase multiferroics, which may be derived from the existing one via partial or complete substitution[9-11].

In this regard, considerable efforts are being made to obtain single phase bismuth cobaltite, as an analogue to bismuth ferrite, a well-known prototype single phase multiferroic compound. It has been found that bismuth cobaltite ($BiCoO_3$) prepared by high pressure technique, exhibits large spontaneous polarization and C-type antiferromagnetism having T_N ~ 470K in its tetragonal phase[12-15]. This compound is found to be isostructural with ferroelectric tetragonal $PbTiO_3$ with the space group P4mm[12]. Due to the large tetragonality (c/a= 1.27) in comparison to $PbTiO_3$ (c/a= 1.06), $BiCoO_3$ exhibits huge spontaneous polarization ($179\mu C/cm^{-2}$)[16]. Also, because of

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