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Multiferroic and magnetoelectric properties of $BiFeO_3$-$CoFe_2O_4$-poly(vinylidene-flouride) composite films

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ABSTRACT

Multiferroic thick nanocomposite films of $(1 - x)(0.3CoFe_2O_4\text{-}0.7BiFeO_3)\text{-}x$Polyvinylidene difluoride (CFO-BFO/PVDF) with x variations 0.20, 0.30 and 0.40 were synthesized using hot press method. Detailed measurements of structural, dielectric, magnetic and magnetoelectric data have been reported. Structural characterization reveals the presence of all the three distinct phases viz. CFO, BFO and PVDF. The dielectric loss as low as 0.05 has been observed for composite film with 40 mol% of PVDF. The AC conductivity ($5.9 \times 10^{-8}\,\Omega^{-1}\,cm^{-1}$) of composite film ($x = 0.40$) is found to be much lower as compared to CFO-BFO ceramic. The electric poling of composite film (with $x = 0.30$) leads to substantial increase in saturation ($2M_s$) and remnant magnetization ($2M_r$). A significant magnetoelectric effect with magnetoelectric voltage coefficient (α_{ME}) ~ 22.128 mV/cm Oe has been observed for composite film with $x = 0.40$, which is possibly a consequence of implicit mechanical interaction between CFO and BFO through PVDF matrix. Hence these nanocomposite films hold a great potential to be promising candidates for multiferroic devices.

1. Introduction

Magnetoelectric multiferroics are considered to be promising materials both scientifically and technologically, and have been widely investigated over the last few decades [1–3]. These materials are characterized by the coupling between electronic and magnetic degrees of matter, where a change of electric polarization has been observed on application of magnetic field, and vice versa. This coupling can arise intrinsically, or extrinsically, mediated by elastic coupling between magnetostrictive and piezoelectric phases [4,5]. These materials are potential candidates for multiple memory state elements, high density storage and spintronics [3,6]. The single phase ME materials are intrinsically ME materials which show a small ME coupling at low temperatures, a restriction for their use in technological applications. Among the widely investigated multiferroic materials, $BiFeO_3$ (BFO) based single-phase systems have attracted the maximum attention owing to its multiferroic properties at room temperature. Indeed, BFO is antiferromagnetic below T_N ~ 653 K and ferroelectric below T_c ~ 1103 K, having a rhombohedrally distorted perovskite structure corresponding to *R3c* with G-type antiferromagnetic behavior [7,8]. The emergence of BFO as a leading multiferroic candidate arises due to its high remnant polarization (~90 μC/cm^2) and magnetization (~1.0 Bohr magneton per unit cell) found in the thin films,

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