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Studies of Rare-Earth-Doped $BiFeO_3$ Ceramics

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Rare-earth (RE) (Eu^{3+}, Gd^{3+}, Tb^{3+}, and Dy^{3+})-doped $BiFeO_3$ (BFO) ceramics were prepared by a modified solid-state reaction method, which adopted higher heating as well as cooling rates during sintering process. All the fabricated samples showed ferroelectric hysteresis loops with a remnant polarization of 21–35 $\mu C/cm^2$. A piezoelectric coefficient (d_{33}) of $\sim$48 pC/N was obtained and this value was showed to be composition independent. The pyroelectric properties of our samples were studied as a function of temperature. Generally, the pyroelectric coefficient slightly decreased with temperature, and this is attributed to the increase of electrical conduction at higher temperatures. Among the different doped BFO ceramics, Gd-doped samples exhibited the largest pyroelectric coefficient of 146 $\mu C/m^2K$ at room temperature. For the magnetic properties, slim hysteresis loop with remnant magnetizations of 0.016–0.044 emu/g were obtained in all the doped samples. Our results revealed that the RE-doped BFO ceramics posses an improvement in both the electrical and magnetic properties. On the basis of our studies, we demonstrate that RE-doped BFO is a potential candidate for magnetoelectric device applications.

Introduction

Magnetoelectrics are the class of materials exhibiting the coexistence of magnetic and ferroelectric ordering. These materials can be applied in both magnetic as well as ferroelectric devices. Bismuth ferrite ($BiFeO_3$, BFO), one of the very few known magnetoelectric materials having a strong linear coupling term, exhibits antiferromagnetic ordering and ferroelectric behavior with high Neél temperature ($T_N \sim 370^\circ C$) and Curie temperature ($T_c \sim 830^\circ C$).[1] Despite possessing a high T_c, bulk BFO exhibits weak ferroelectric behavior, i.e. its remnant polarization P_r is only $\sim$3.5 $\mu C/cm^2$.[2]

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