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Structural, Microstructural and Ferroic Characterizations of the $BiFeO_3$ Multiferroic Magnetoelectric Compound Obtained by High-Energy Ball Milling

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Abstract – $BiFeO_3$ magnetoelectric compound had its synthesis optimized via high-energy ball milling technique for grain size reduction, as well as its sintering process, via conventional route, for high density improvement. A thermal analysis was carried out and its transition temperatures (T_N = 378 °C and T_C = 816 °C) were determined, and also confirmed by electric and magnetic characterizations.

Multiferroic magnetoelectric materials have attracted much attention because they can exhibit simultaneous effects of ferroelectricity and ferromagnetism in the same phase, and a linear coupling behavior between magnetization and polarization. This coupling between ferroelectric and ferromagnetic orders allowing the possibility of a new degree of freedom what enable the development of multiple-state memories, making possible storage data in both electric or magnetic orders. Furthermore, they have potential application as electric-field-controlled magnetic devices, and transducers with magnetically modulated piezoelectricity [1].

The $BiFeO_3$ compound is a multiferroic magnetoelectric material that has been wakened great attention because of its magnetoelectric behavior at room temperature. $BiFeO_3$ is ferroelectric until T_C ~ 770-830°C, and antiferromagnetic until TN ~ 370°C [2]. A widely study of electric and magnetic properties of $BiFeO_3$ have been conducted, however, a adequate study of this intrinsic properties still being hindered because of the easy formation of secondary phases during synthesis and the low resistivity of samples[3,4]. In this context high-energy ball milling technique has emerged as an interesting technology for processing nanostructured ceramic powders [5], which can improve the quality of samples reducing defects and porosity, as can be seen in figure 1.

In this work a study of high-energy milling, temperature and time of calcinations of $BiFeO_3$ powders and ceramics were carried out, and the best sample obtained was chose for ferroic characterizations. The $BiFeO_3$ sample was characterized electrically (dielectric and electric hysteresis analysis), magnetically, and thermal analysis, figure 2, was also carried out.

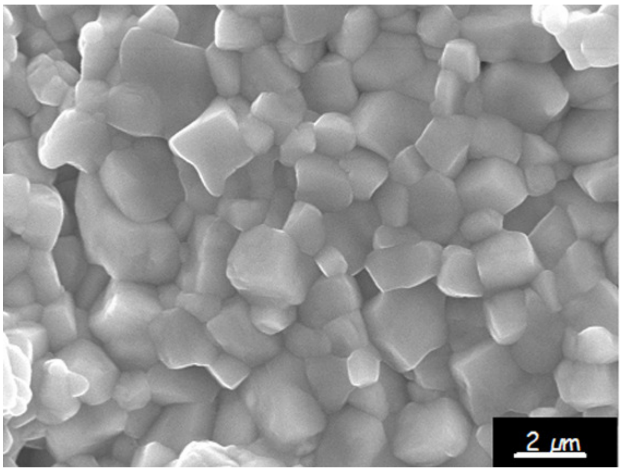

Figure 1: Scanning electron microscopy image of $BiFeO_3$ sintered sample obtained by conventional sintering of high-energy ball milled (60 min/200 rpm) powders.

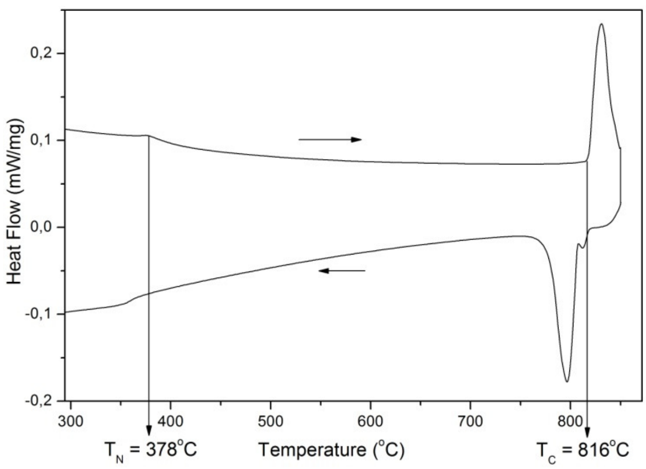

Figure 2: Differential scanning calorimetry signal of the high-energy ball milled BiFeO3 powder. T_N – Neél temperature and T_C – Currie (ferroelectric) temperature.

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