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Piezoelectric Characterization of $BiFeO_3$ – $PbTiO_3$ Multiferroic Ceramics

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Abstract – (0.6)*$BiFeO_3$*-(0.4)*$PbTiO_3$* multiferroic ceramics were synthesized by high-energy ball milling and reactive sintering in specific forms (bars and disc) for ferroelectric, magnetic and piezoelectric characterizations. X-ray diffraction analyses revealed a morphotropic phase boundary between the tetragonal and rhombohedral phases in powdered samples, and a rhombohedral phase for sintered ones. The hysteresis measurements showed ferroelectric and weak-ferromagnetic behaviors. Piezoelectric characterizations, as a function of temperature (d_{31} and g_{31} coefficients) indicated that the (0.6)*$BiFeO_3$*-(0.4)*$PbTiO_3$* compound have potential to be applied in high temperature piezoelectric devices.

(x)$BiFeO_3$-(1-x)$PbTiO_3$ (xBF-1-xPT) ceramics display piezoelectric [1], ferroelectric [2] and weak ferromagnetic [3] behaviors, and have been extensively studied due to their enormous potential to be applied in high temperature multifunctional devices, as transducers, sensors and actuators. These solid solutions also present a morphotropic phase boundary between rhombohedral and tetragonal phases at around x = 0.3 [1]. A weak ferromagnetic behavior was observed in 20 mol% La modified 57BF-43PT ceramics [2], while the ferro-paralectric phase transition of the 0.70BF-0.3PT was observed at around 462 K [3].

In this work, 0.6BF-0.4PT ceramics were synthesized by high-energy ball milling and conventional reactive sintering. The samples were hydrostatically pressed in specific forms appropriated for piezoelectric measurements (bars and disc) and were sintered in air at 1065 ºC for 1 h. The structural characterizations were carried out with a Shimadzu XRD - 7000 diffractometer, with Cu K_α radiation. The ceramic bodies were poled in a 2 kV/mm electric bias field and the piezoelectric characterizations were performed by using the resonant method. A E4980 Agilent LCR bridge was used to determine resonance and anti-resonance frequencies that can be used for calculating piezoelectric coefficients. The XRD analyses (Figure 1) show a morphotopic phase boundary between rhombohedral (R3m) and tetragonal (P4mm) phases in *0.6*BF-*0.4*PT powders. The $g_{31} = 9.10^{-3}$ Vm/N and $g_{15} = 92.10^{-3}$ Vm/N piezoelectric coefficients were determined at room temperature and presented values higher than those of PZT-EC-64 ($g_{31} = 11\ .10^{-3}$ Vm/N and $g_{15} = 39\ .10^{-3}$ Vm/N, for example. With temperature increasing, the g_{31} and d_{31} coefficients (Figure 2) present two distinct thermally stable regions. They are found in temperatures ranging from 20 °C to 100 °C, and from 250 °C to 300 °C. This thermal stability for piezoelectric coefficients at high temperatures attests the efficiency of 0.6BF-0.4PT ceramics for high temperature piezoelectric applications, as mechanical transducers and high power actuators.

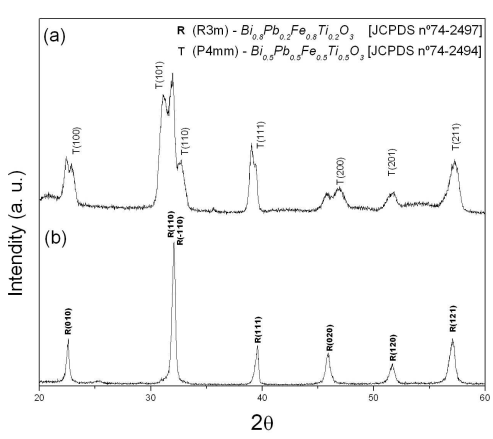

Figure 1: XRD results for the (0.6)$BiFeO_3$–(0.4)$PbTiO_3$ compound. (a) powder (b) ceramic

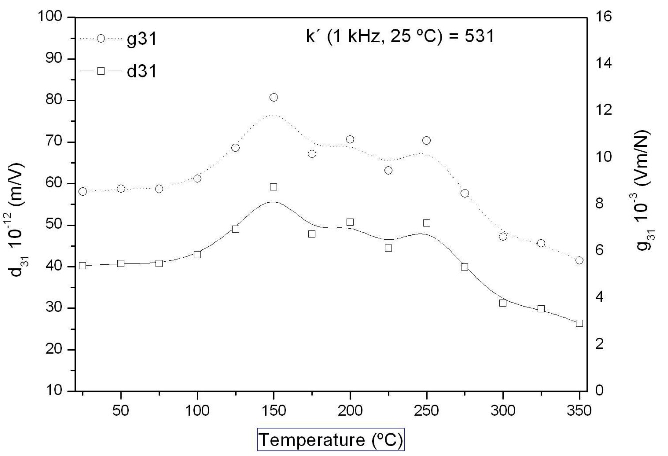

Figure 2: d_{31} and g_{31} piezoelectric coefficients for the (0.6)$BiFeO_3$–(0.4)$PbTiO_3$ ceramic sample as a function of temperature.

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