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Synthesis and PTCR characterization of Ca-doped $BaTiO_3$ ceramics by proteic sol-gel method

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Abstract: When partially doped with trivalent cations at the barium sublattice, $BaTiO_3$-based ceramics are well known to exhibit a semiconductive character, accompanied by a positive temperature coefficient of resistivity (PTCR). Development of this electrical response in Ca-Doped $BaTiO_3$ was studied in this work using Er^{3+}, La^{3+} or Y^{3+} as the donor doping trivalent ion. The materials were prepared both through a modified polymeric precursor (Pechini) method, and by the proteic sol-gel method, followed by sintering at different temperatures ranging from 1200 to 1350 °C. The results obtained from direct and alternating current measurements show the clear picture of semiconducting and PTCR-type materials.

It is well known that perovskite-structured $BaTiO_3$ has a relatively high tolerance for many cation dopants, which are normally used to engineer the electrical properties of the material. In this way, $BaTiO_3$ has found a number of electro-optic, electromechanical and dielectric applications. Nevertheless, as recognized in literature, the largest commercial markets for this material seem to still be positive temperature coefficient resistors (PTCR) and multilayer ceramic capacitors (MLCC). When partially doped with trivalent cations at the barium sublattice, $BaTiO_3$-based ceramics are well known to exhibit a semiconductive character, accompanied by a positive temperature coefficient of resistivity (PTCR)(1). Development of this electrical response in Ca-Doped $BaTiO_3$ was studied in this work using Er^{3+}, La^{3+} or Y^{3+} as the donor doping trivalent ion.

The powders were synthesized by the proteic sol gel method(2), using as precursor materials aluminum, manganese, cobalt and chromium nitrates (P.A). In this method, the precursors are mixed with filtrate coconut water and homogenized by stirring until its complete dissolution (at room temperature).

Figure 1 presents the DTA/TG curves of the BCT dried resin at 100 °C/24h. As can be seen, the curves presented multiple thermal decomposition stages, showing endothermic and exothermic events. According to these results, the powders were calcined at 1100°C/2h and the BCT phase was achieved (Fig. 2). A small amount of $CaTiO_3$ was also observed.

In conclusions, the sintered ceramics presented a high relative density (at about 97%) and a homogeneous microstructure. The results obtained from direct and alternating current measurements show a clear picture of semiconducting and PTCR-type materials. It was observed that PTCR response is depending on synthesis method and donor doping ion.

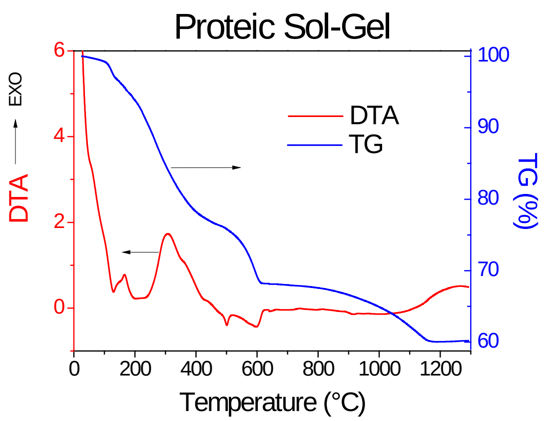

Figure 1 - DTA and TG curves (10°C/min) of the BCT resins

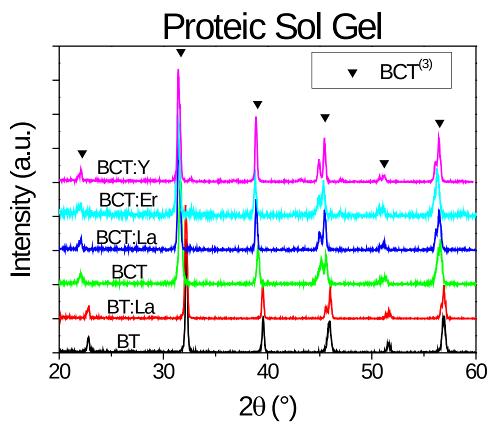

Figure 2 – XRD pattern of the BCT ceramics sintered at 1300 °C/2h

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