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Two-step sintering and dielectric properties of translucent nanocrystalline $BaCaTiO_3$ ceramics

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Abstract: Translucent $BaTiO_3$ ceramics with an average grain size of 350 nm have been achieved through two-step sintering method. The ceramics also presented an homogeneous microstructure and a high dielectric constant about 3000 at room temperature.

Barium titanate ($BaTiO_3$ – BTO) is a ferroelectric material widely applied in the electronics industry both in single crystal and ceramic forms. Because of its very high permissivity (ε =1500-4000) with suitable doping, it has been used extensively as the dielectric in ceramic capacitors with outstanding properties. Recent advances in microelectronics and communications have led to the miniaturization of multi-layer ceramic capacitors (MLCC), and further reduction of the grain size of the dielectric layer below the 1 µm limit will be required in few time. However, the physical size reduction of the ferroelectrics materials has created a significant effect on polarization, and this could represent a limitation for the miniaturization process. Nevertheless, besides the technological implications, the existence of a critical size for the ferroelectricity has also been of fundamental interest [1,2].

Due to difficulties in preparing dense BTO ceramics with fine grains through conventional sintering processes, several alternative routes have been studied such as the Spark Plasma Sintering [2,3] and Hot Isostatic Pressing [4]. Recently, a two-step sintering method has been proposed to achieve dense ceramic bodies without significant grain growth by Chen and Wang [5]. In this method the green ceramics bodies are first heated up to an initial temperature (first step) to achieve a sufficiently high starting density in which the pores become subcritical and unstable, due to capillary action. In the second step, the samples are cooled down at a final temperature and kept for a long time until the maximum density will be obtained. Thus, in this work we have studied the densification and dielectric properties of the $BaTiO_3$ ceramics sinterized through tow-step sintering method.

Figure 1 shows the micrographs of the BTO ceramic sintered at T_1 = 1225 °C/1mim and T_2 = 1150 °C/ 20h. In this condition, the samples presented translucent with an average grain size of 350 nm and high relative density about 98 %. Figure 2 presents the temperature dependence of the dielectric constant and dielectric loss for the BTO ceramic. It was observed a broad peak in the transition area and a high dielectric constant of more than 3000 was obtained.

In conclusion, we have achieved dense nanocrystalline and translucent ceramics with high dielectric constant through the two-step method.

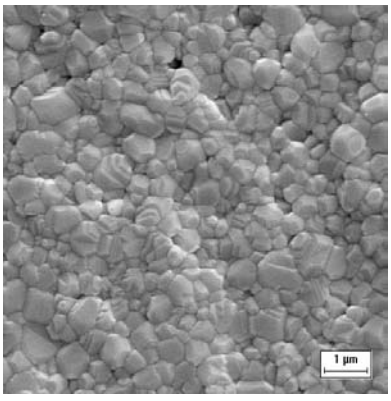

Fig. 1. SEM micrographs of the $BaTiO_3$ ceramics sintered at 1175 °C by the two-step method.

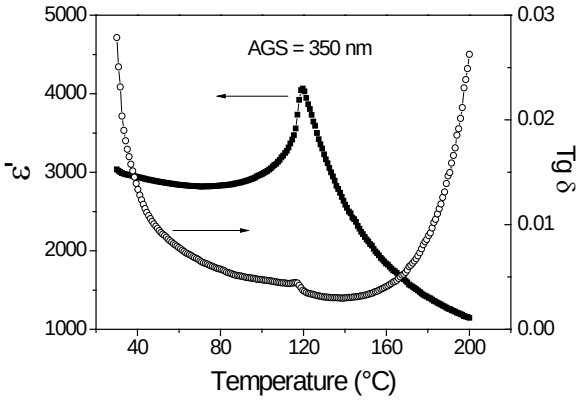

Fig. 2. Temperature dependence of the dielectric constant and dielectric loss (tan δ), at 1 kHz.

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