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LETTER

Specific heat of the $Ba_{0.7}Sr_{0.3}Ti_{1-y}Zr_yO$ (y = 0, 0.03, 0.05, 0.1) ferroelectric ceramics obtained by the temperature relaxation method

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In the last few years great interest has developed around $Ba_{1-x}Sr_xTiO_3$ (BST) or BST-based materials due to their great potential for technological applications such as integrated capacitors, ferroelectric memory and many others [1–3]. Thermal properties of materials used in the design and construction of electronic devices must be taken into account since heat will be unavoidably generated in a working electronic circuit. The behavior of the devices as their temperature change and their ability to store and dissipate heat will affect their performance and lifetime therefore their thermal properties cannot be neglected. Despite the extended use of the BST ceramic system, knowledge of the thermal properties is still scarce. For this reason a study of the heat capacity (C_p) and specific heat (c_p) of $Ba_{0.7}Sr_{0.3}Ti_{1-y}Zr_yO_3$ (y = 0, 0.03, 0.05 0.1) ceramic samples obtained by the Temperature Relaxation Method (TRM) [4] is presented.

There are several methods reported in the literature to obtain the specific heat capacity of materials [5]. The TRM, also known as Temperature Increment Under Constant Illumination Method [6] selected among others, because of its effectiveness and simplicity, has been employed for thermal characterization of different type of materials such as semiconductors [7], zeolites [8], ceramics [9], woods [10] and foods [11] among others. It is based on the fact that the relaxation of a closed system can be studied by perturbing an initial equilibrium state and monitoring the behavior in time of the variable of interest, such as the absolute temperature T. If the deviation from equilibrium is small enough, the temperature relaxation will follow the exponential law $T = T_0 e^{-(t/\tau)}$, where t is the time, T_0 is the initial value of the temperature T, and τ is the relaxation time constant [12]. In the case presented here, τ will depend on the specific heat capacity as will be evident in what follows.

The nominal composition of the samples is given by $Ba_{0.7}Sr_{0.3}Ti_{1-y}Zr_yO_3$ (y = 0, 0.03, 0.05, 0.1). The samples were prepared using a traditional ceramic method [13] by mixing reagent grade $SrCO_3$, $BaCO_3$, TiO_2 and ZrO_2 in an agate mortar for 2 h. The resulting powder was die pressed into 22 mm diameter, 10 mm thick pellets and calcined for 2 h at 1,100 °C in air. The calcined pellets were ground again for 3 h, die pressed into 10 mm diameter, 1 mm thick disks and sintered in air at 1,350 °C for 4 h.

To measure their specific heat, the samples were adiabatically suspended inside a stainless steel calorimeter at a working pressure of $\approx 10^{-3}$ Torr. The calorimeter was provided with two glass windows. One was used to shine uniformly distributed white light on the sample while the second one was used for alignment and observation purposes. A chromel-alumel thermocouple was fixed on the back face of the sample for temperature control. Both surfaces of the samples were painted black to enhance light absorption and to push the emissivity (ε) as close as possible to one as stated in the calculations presented below. The temperature behavior of the samples with time was conveniently monitored with a temperature controller (Model 760 Eurotherm Controls Inc.) (Fig. 1).

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