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# Electrical and dielectric properties of PZT based ferroelectric ceramics

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**Abstract** – Lanthanum modified lead zirconate titanate (PLZT) ceramics with a Zr/Ti (90/10) ratio and 7 at% lanthanum content were obtained using the standard ceramic method. The structural and ferroelectric measurements were carried out by using x-ray diffraction technique and Sawyer-Tower circuit, respectively. On the other hand, the electrical and dielectric properties were investigated from the Impedance Spectroscopy (IS) technique in a wide temperature and frequency range.

Ceramic samples were prepared by the traditional ceramic method [1], from the nominal composition $(Pb_{1-x}La_x)(Zr_{0.90}Ti_{0.10})_{1-x/4}O_3$, where $x$ = 7 at% La (hereafter labeled as PLZT 7/90/10). The stoichiometric mixture of high purity powders (PbO, $ZrO_2$, $TiO_2$, $La_2O_3$) was prefired at 800 °C in air for 1 h. The calcined powders were milled and conformed as thick disks by cold-pressing and sintering in air at 1250 °C for 1 h, in a well-covered platinum crucible in order to minimize the evaporation of reagents. The structural analysis was performed by the x-ray diffraction (XRD) technique, using a D-5000 powder diffractometer (Bruker AXS), with $CuK_\alpha$ radiation in a $2\theta$ range of 10–85 degrees and a scan step of 0.02 degrees. Electrodes were fabricated on the parallel faces of the samples using Ag paste, by a heat treatment at 590 °C. The dielectric properties were performed by using an Agilent 4284A Precision LCR Meter in the temperature and frequency range of 30–500 °C and 100 Hz–1 MHz, respectively.

An antiferroelectric (orthorhombic) perovskite phase structure (*Pbam*) (not shown here) was obtained for the studied composition, which is in agreement with the phase diagram for the PLZT system [1]. On the other hand, the ferroelectric properties revealed a slim-like hysteresis loop for the studied PLZT composition, even at a very high applied electric field, which is typical of the antiferroelectric behavior. Fig. 1 shows the temperature dependences of the real ($\varepsilon'$) and imaginary ($\varepsilon''$) parts of the dielectric permittivity for the PLZT 7/90/10 composition, obtained at several frequencies. As can be observed, the temperature corresponding to the maximum real dielectric permittivity ($T_m$), for the studied PLZT composition, shown to be frequency independent for all the analyzed frequency range. The maximum value of the losses factor ($\varepsilon''_{max}$) was obtained for a temperature ($T_{\varepsilon''max}$) close to that observed for the real dielectric permittivity ($T_m$), as expected for a thermodynamic phase transition. As can be seen in Fig. 2, results obtained from the impedance spectroscopy analyses for the PLZT 7/90/10 samples, revealed the existence of two semicircles, which are strongly frequency dependence and can be related to the grain and grain boundary effects. Such obtained behavior revealed to be intensified with the increase of the temperature from 450 °C up to 500 °C.

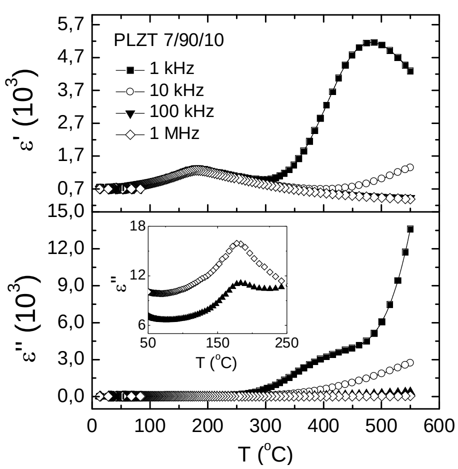


**Figure 1:** Temperature and frequency dependence of the dielectric permittivity (ε´ and ε´´).

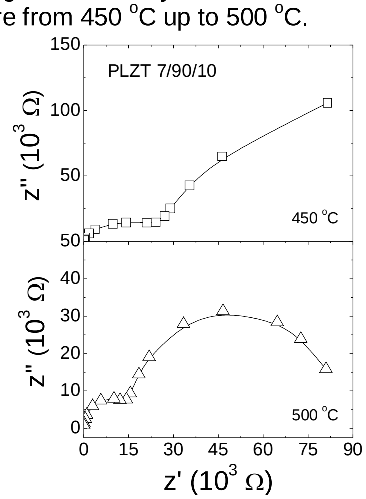


**Figure 2:** Complex impedance diagram, at two selected temperatures, above the temperature of the phase transition.

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**References**

[1] Y Xu, Ferroelectric Materials and Their Applications, Elsevier Science Publishers, Netherlands, 1991.