BEHAVIOR OF THE TEMPERATURE DEPENDENCE OF DIELECTRIC CONSTANTS AND CURIE TEMPERATURE OF PT-IMPLANTED MODIFIED $BaTiO_3$, $KNbO_3$, $PbZrO_3$, $Pb_{0.88}LN_{0.08}Ti_{0.98}Mn_{0.02}O_3$ (LN =La, Eu) CERAMICS

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Abstract

Based on the multilayer capacitor concept, a metallic wire was implanted during ferroelectric ceramic fabrication process. With this particular way of doing the fabrication it could be achieve a new device: Ceramic-Controlled Piezoelectric (CCP). The temperature dependence (from room temperature) of dielectric constants was described for the implanted specimens.

Introduction

The major application of ferroelectrics is for capacitor, utilizing their high dielectric constant around the Curie Temperature (T_c). An increment in its capacity can be obtained if is added some internal layers [1], in this context a metallic insert into the ceramic modified its dielectric constant, thus a Pt-wire was implanted during the fabrication of ferroelectric ceramic. Pt-wire in total immersion in the ceramic acts as an electrode. The function of this extra electrode is the modification of permittivity of the ceramic ferroelectric or piezoelectric

Experimental

To prepare the ceramics, the conventional oxide mixture technique, was used [2]. The powders were mixed by ball-milling, for $Pb_{0.88}Ln_{0.08}Ti_{0.98}Mn_{0.02}O_3$ (Ln =La, Eu) ceramics [3], powders were pressed and calcined in a programmable oven, at 800°. After calcining, the powders were ground and ball-milled again. For all specimens, powders were pressed into discs of 10mm diameter and 2mm of thickness, during this process a Pt-wire was implanted into the ceramic. These discs were sintered from 800 to 1240°C according to the kind of ceramic, at the same time others samples without implant were processed together as reference.

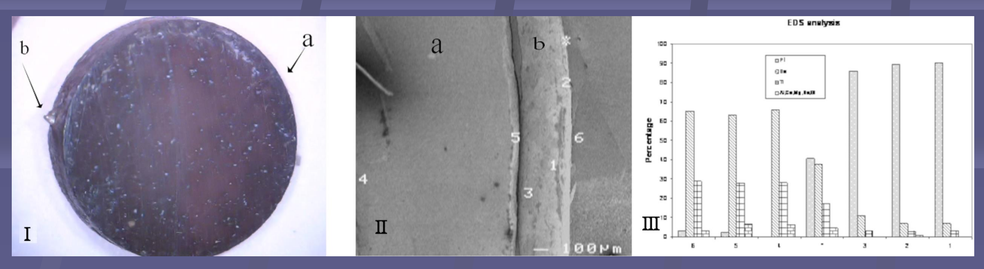


Fig 2 I) Single disk ceramic: a) ceramic b) Platinum wire, II) Photomicrograph of $BaTiO_3$ with 100μm resolution. III) EDS Analysis corresponding to the marked points.

Curie Temperature (T_c) was determined using a high temperature oven, Carbolite HTC 1600, increasing its temperature in a 5°C/min step until 160°C. The sample was dragged into the oven, and the ceramic capacitance was measured with an Beckman LM22A RLC at a 1kHz frequency.

The CCP was tested also by measure its dielectric constant while a variable voltage was applied in the extra-electrode

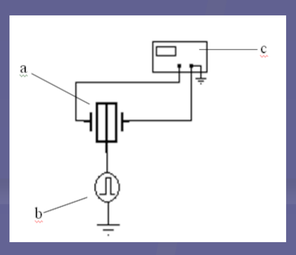
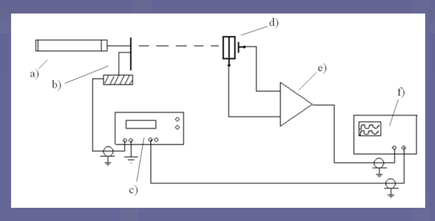


Fig 3 Experimental setup for test a CCP ($BaTiO_3$), a variable signal was applied in the control electrode while the dielectric constant was measurement a) CCP, b) Pulses generator with variable voltage, c) Capacity measurement

An optical probe was made by focus a laser beam over one side of the CCP and extracting a signal by the electrode control, laser beam was modulated by a mechanic chopper.

Fig 4 CCP As light laser sensor (633 nm). a) Laser, b) Chopper, c) Chopper control d) CCP, e) Amplifier, f) Oscilloscope.



Results

Single disks with Pt-wire implanted were obtained and shift T_c and dielectric constant variations among ceramics with Pt-wire and reference ceramics were found.

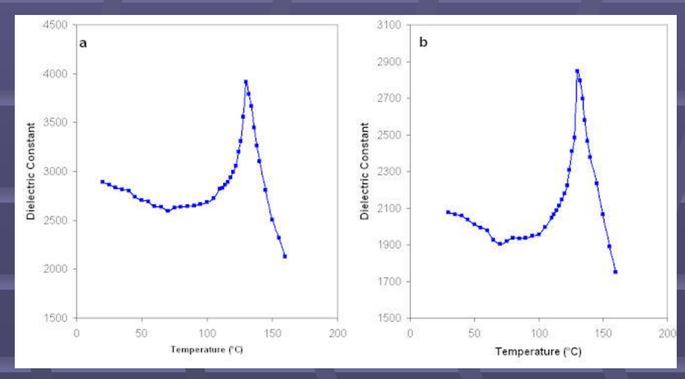


Fig 5 The temperature dependence of dielectric constants and point of phase transition a) $BaTiO_3$ as reference, without implant and b) Pt-implanted modified $BaTiO_3$

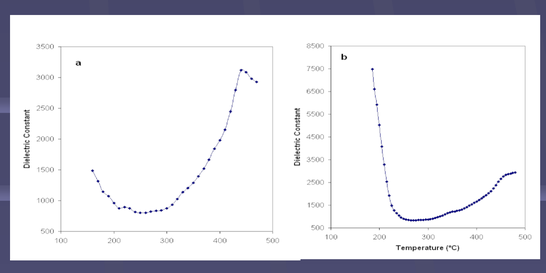


Fig 6 The temperature dependence of dielectric constants and point of phase transition a) $KNbO_3$, without implant and b) Pt-implanted modified $KNbO_3$

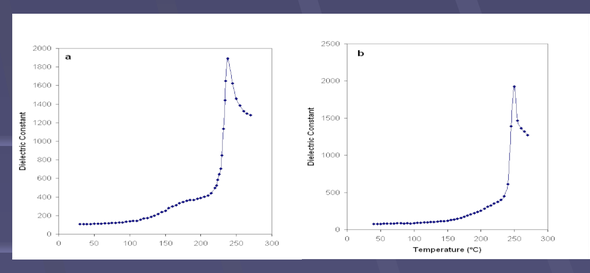


Fig 7 Temperature dependence of dielectric constants of the $PbZrO_3$ reference ceramic a) and b) ceramic with Pt-wire implant.

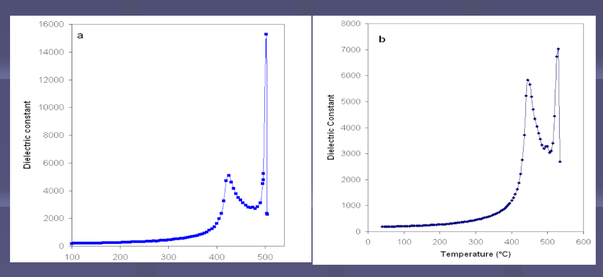
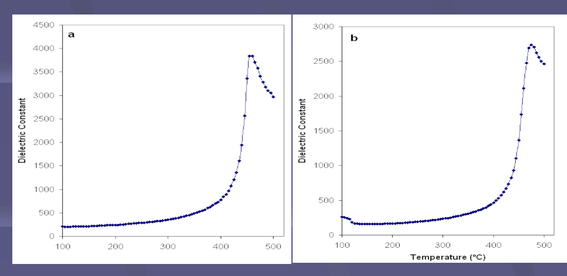


Fig 8Temperature dependence of dielectric constants of the $Pb_{0.88}La_{0.08}Ti_{0.98}Mn_{0.02}O_3$ reference ceramic a) and b) ceramic with Pt-wire implanted



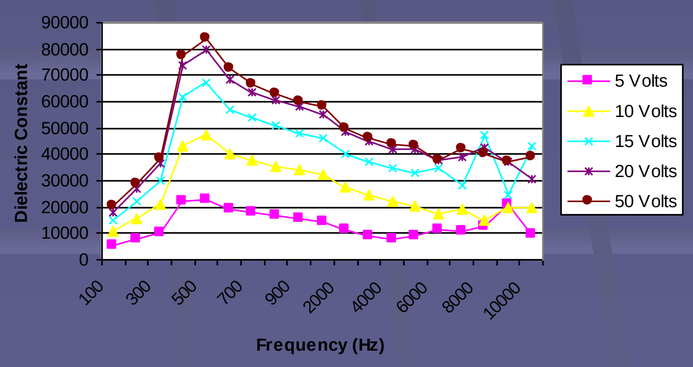


Fig 10 Dielectric constant behavior when an alternant electric field is applied in the electrode control at different frequencies and voltages with the experimental setup indicated in fig 3

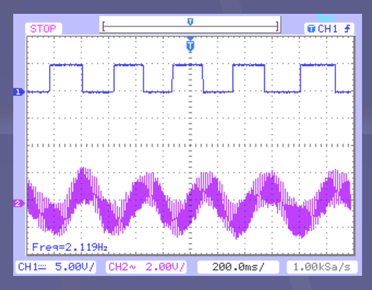


Fig 11 Signals obtained from the experimental setup showed in fig 4 the upper signal is from chopper control and lower signal obtained from CCP

Conclusions

Platinum-implant with its dimensions allowed the ceramics sintering, others tests with different diameter of platinum wire was made, but larger size did not permit the ceramic sintering.
A shift in T_c was found in four of five kind of ceramics under study, 9, 5, 5 and 3% for $KNbO_3$, $PbZrO_3$, $Pb_{0.88}La_{0.08}Ti_{0.98}Mn_{0.02}O_3$ and $Pb_{0.88}Eu_{0.08}Ti_{0.98}Mn_{0.02}O_3$ respectively.
From the dielectric constant graphs, it could be seen the same shape between Pt-implant and reference ceramics, so it is a no modified crystal structure signal.
CCP could be a useful device in many applications based on its modifiable dielectric constant.

References

[1] Uchino K: Ferroelectric Devices, Marcel Dekker, Inc., New York, United States, 2000.
[2] Jaffe B, Cook Jr, W. R. and Jaffe H: Piezoelectric ceramics, Academic Press, London, Great Britain, 1971
[3] R. González, “Fabricación de Cerámicas Piezoeléctricas de Pb0.88Ln0.08Ti0.98Mn0.02O3 (Ln = La, Sm, Eu) para el Desarrollo de Transductores Ultrasónicos y Sensores Piroeléctricos de Uso Biomédico”, Tesis de Maestría, Sección Bioelectrónica, Departamento de Ingeniería Eléctrica, CINVESTAV-IPN, México, 2003.