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Preparation and Structural characterization of $Pb(Zr_{0.52}Ti_{0.48})O_3$ ceramics from solid state reaction method

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Abstract:- This paper presents research results on the electro–mechanical behavior of piezoelectric ceramics for use in actuator applications. The material being investigated is a lead zirconate titanate piezoelectric ceramic with the composition Pb $(Zr_{0.52}Ti_{0.48})O_3$. The X-ray diffraction study shows the formation of tetragonal structure. The sample is synthesized by the solid-state reaction method and then characterized by XRD, SEM and FT-IR.

Keywords:- Structural, FT-IR, PZT, solid solutions, XRD.

INTRODUCTION

The recent advances in Micro-Electro-Mechanical systems have created a strong interest in the fabrication of small piezoelectric transducers for various applications in the field of sensors and actuators, where they already have found industrial applications. Actuators that use direct expansion of piezoelectric materials are the most usual ones [1,2] but in such a case the displacement is rather small. The displacement is achieved by the strain induced unidirectional along an applied DC electric field, which makes possible extremely high accuracy in positioning. Therefore, this investigation was conducted to obtain structural and electrical properties of Lead Zirconate Titanate as a result of XRD, SEM, FT-IR.

EXPERIMENTAL PROCEDURE

The sample was prepared by the solid-state reaction method of PbO, ZrO_2 and TiO_2 were pre-calcined at 800^oC for 5 hrs. The mixed powders are pressed hydraulically to form disc shaped pellets 12 mm diameter and 1.8 mm thick, with 5wt% polyvinyl alcohol (PVA) as a binder. The pellets are stacked in a covered alumina crucible filled with PZ powders to prevent lead loss. Finally, the sintering is carried out a sintering temperature at 1250^oC for 2hrs to forms $Pb(Zr_{0.52}Ti_{0.48})O_3$ (PZT).

CHARACTERITION

"3.1Structural"
"3.11 XRD"

Room temperature XRD patterns of the sintered pellets of PZT are shown in Fig.1. The X-ray diffraction (XRD) spectra of the sintered samples are recorded in the 2θ range of 20° - 70° with step of 0.02° and scanning rate of 1°/min. These have sharp and single phase of the sample was confirmed by comparing the pattern with the earlier reported data which indicating better homogeneity and crystallization of the samples. All the reflection peaks were indexed and lattice parameters of the compounds were calculated using a powder diffraction refinement computer program (PowderX) [C. Dong, 1999] and the crystal structure is found to be tetragonal with space group p4mm [3]. The diffraction peaks of PZT were indexed according to previously reported results [4].

The value of lattice parameters 'c' of PZT ceramic composition were found to be 4.123 Å where as "a = b" is 4.008 Å. The estimated value of lattice strain (tetragonality) c/a is 1.029. The values bear a resemblance to tetragonal unit cell. The volume of the unit cell is found to be 73.441 $Å^3$. The bulk density of the sintered pellets was measured by Archimedes liquid displacement method and the relative density of the sample is found to be 94% of the theoretical density

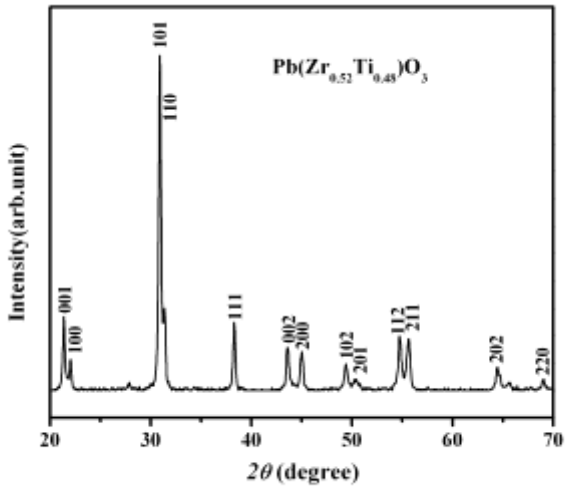

Fig.1. Room temperature powder X-Ray patterns of Pb $(Zr_{0.52}\ Ti_{0.48})O_3$

"3.12 Scanning electron microscopy"

Figure 2.shows the scanning electron micrograph (SEM) of sintered PZT ceramics. The micrographs indicate that the inhomogeneous distribution of polycrystalline grain throughout the surface of material. The average grain size calculated from the micrograph of PZT is 0.20 µm.

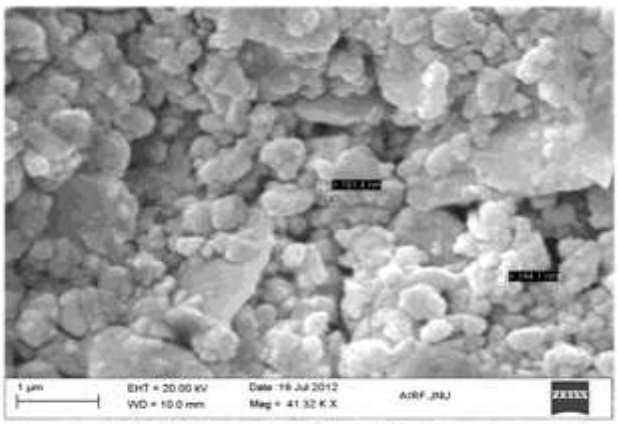

Fig. 2. SEM micrograph of $Pb(Zr_{0.52}Ti_{0.48})O_3$

"3.13FT-IR study"

Fourier transform infrared (FT-IR) spectra of polycrystalline $Pb(Zr_{0.52}Ti_{0.48})O_3$ ceramic compositions were carried out in the wave number range of 1200 – 400 cm^{-1}, using Perkin Elmer FT-IR spectrometer, the spectral resolution of the instrument is 0.4cm^{-1}. Before recording the transmission spectra, KBr powder was heated to evaporate the excess moisture and then thin pellets were made using the specimen powder and space pure KBr in the ratio 1:20 by weight shown in Fig. 3.There were two distinct absorption bands at 597 cm^{-1}(v_2), 536 cm^{-1}(v_1) observed. These absorption bands resemble with the reported FTIR observations of PZT ceramics.[25] In the perovskite structures the TiO_6 octahedral is responsible for two distinct vibration modes: one at 563 cm^{-1} attributed to bending vibration and another at 597 cm^{-1} due to stretching of octahedral [5,6]. The absorption bands v_1 represent bending modes while v_2 represent stretching modes in the BO_6 (TiO_3 and ZrO_3) octahedron in ABO_3 structure.

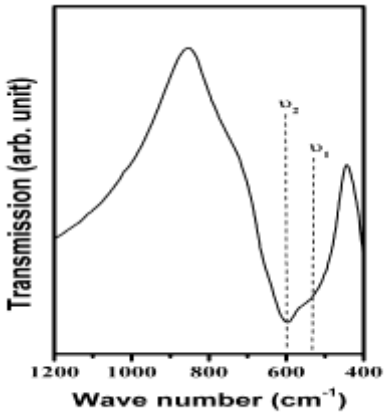

Fig. 3. Room temperature FTIR spectra for $Pb(Zr_{0.52}Ti_{0.48})O_3$ ceramic samples

CONCLUSION

In this work, the synthesis of PZT ceramics in the region of the morphotropic Phase Boundary (MPB) has been investigated. The ceramics exhibited a complete tetragonal phase for this samples PNZT ceramics prepared by a high-temperature, solid-state reaction technique reveal good homogeneity and formation of a single-phase compound with tetragonal structure. SEM indicates homogeneous distribution of polycrystalline grain throughout the surface of material..

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