INTRODUCTION

The increasing demand for high performance and sophisticated piezoelectric devices and transducers requires high quality piezoelectric materials and innovation in transducer design continues to be the driving force for the development of new piezoelectric materials. Piezoelectric ceramics based on PZT type perovskite are currently the material of choice, since they offer high piezoelectric activity and electromechanical coupling as well as a large range of high strains, dielectric constants and low dielectric loss. Traditional applications of piezoelectric ceramics include buzzers, speakers, sonars, ultrasonic transducers for nondestructive testing, transducers for medical diagnostics, actuators for precise positioning systems, ultrasonic motors, vibration control and so forth. The large area of application of piezoelectric materials is based on the fundamental property of such materials to develop an electric charge when subjected to a mechanical stress and vice versa.

OBJECTIVES

- To develop a soft type piezoceramic material with stable properties against temperature;
- The material should be based on doped lead titanate lead zirconate solid solutions;
- To chose the proper type and amount of dopants so as to produce a material with high coupling factor, dielectric constant, mechanical quality factor and displacement constant and low dielectric losses within a large temperature interval, at least up to about 200 °C;
- To use such a material for the fabrication of a high-performance ultrasonic sensor;
- To design a high quality ultrasonic siren due to be efficiently used for performing acoustic emission in air.

EXPERIMENTAL

The method used for the preparation of the material was the solid state reaction of oxide constituents. The raw materials were oxides and carbonates of p.a. purities. The chemical formula was Pb0.85Sr0.15Bi0.01Nb0.05Ni0.06Zr0.48Ti0.41O3. The reasons to chose this composition consisted in the known enhancing effect of these additives on the piezoelectric properties of the basic PZT material. Sr increases the dielectric permittivity and charge constant d31. Bi is effective in suppressing the grain growth and Nb and Ni increase the electromechanical coupling coefficient and decrease the dissipation factor tanδ. Some supplementary additives like CeO2, SiO2 and PbO were also used in a total amount of 3%. The oxides were mixed for 6 h in a planetary ball mill in methanol medium, and calcined at 850 °C for 3 h. The calcined product was wet milled for 24 h in a planetary ball mill, at a ball/powder weight ratio of 2:1, in order to produce a fine submicronic powder with an increased reactivity. The pressed samples were sintered at 1270 °C for 6 h.

THE MATERIAL

We have measured the temperature dependence of the main parameters between room temperature and the Curie point. The results are shown in figures 1(a)–(f). The most remarkable thing about these results is that nearly all piezoelectric parameters, except charge and voltage constants, show a rather constant and steady variation with temperature over a large temperature interval up to nearly 250 °C after which their values drop much more rapidly to zero (k31, Qm, d31 and g33) or increase to very high values (εr and tanδ) by approaching the Curie temperature, due to the sudden depoling effect of ceramic. Such a behavior is beneficial for transducers in that they can be safety and efficiently used up to 250 °C, without any major risk to alter their functionality, but the most secure and recommended upper limit of working temperature must be taken at 200 °C.

RESULTS

Two PZT disks of 20 mm diameter and 0.45 mm thickness, were glued on the two sides of a brass disk (21 mm diameter, 0.1 mm thickness). The poling directions of the disks were parallel. When an alternating emf at resonant frequency is applied to them, a stationary movement is generated. In order to increase the acoustic emission of the resonator in free space (air) an impedance matching between the high impedance ceramic and the low impedance air is necessary. This was achieved by arranging through theoretical considerations to oscillate in the high frequency audio range. A rigid cardboard conical horn will improve the impedance match between the resonator and the surrounding air, allowing a high intensity sound to be emitted in an angle of ~π/2 rad. The siren can be used as a high intensity sound in alarm systems.

SUMMARY

Associating two PZT disks into a bimorph with an intermediate metallic plate produces an acoustical resonator which can be dimensionally arranged through theoretical considerations to oscillate in the high frequency audio range. A rigid cardboard conical horn will improve the impedance match between the resonator and the surrounding air, allowing a high intensity sound to be emitted in an angle of ~π/2 rad. The siren can be used as a high intensity sound in alarm systems.