Dielectric and thermal properties of xPbTiO$_3$-(1 − x)SrTiO$_3$ Polycrystals

E. MARTÍNEZ
CICESE, Physics of Materials Graduate Program, Km. 107 Carr. Tijuana—Ensenada, C.P. 22800, BC. México

S. GARCÍA, E. MARIN, O. VASALLO
Facultad de Física-IMRE, Universidad de la Habana, Vedado, La Habana 10400, Cuba

G. PEÑA-RODRÍGUEZ, A. CALDERÓN
CICATA-IPN, Legaria 694, 11500 México D.F.

J. M. SIQUEIROS
Centro de Ciencias de la Materia Condensada, UNAM C.P. 2681, B.C., México
E-mail: jesus@ccmc.unam.mx

$SrTiO_3$ and $PbTiO_3$ perovskites are combined to form the xPbTiO$_3$-(1 − x)SrTiO$_3$ (PST) solid solution. In this work, a study of its dielectric and thermal properties is reported as a function of $PbTiO_3$ content. The dielectric properties of the xPbTiO$_3$-(1 − x)SrTiO$_3$ solid solution are determined through a thermoelectric analysis technique and hysteresis measurements. Such measurements made at room temperature for all compositions show the influence of one component upon the other resulting in a response to the electric field that involves a strained lattice behavior. A limiting case of antiferroelectric-like behavior is observed for $x = 0.5$. The thermal properties such as the specific heat capacity (c) and thermal diffusivity (α) were determined using a photoacoustic technique (PA) and the temperature relaxation method (TRM). The thermal conductivity was calculated from the results obtained for c and α. © *2004 Kluwer Academic Publishers*

1. Introduction
Nowadays, there is considerable interest in crystalline and polycrystalline ferroelectric materials due to their many known and potential applications [1]. In the design of devices based in ferroelectrics, it is very important to take into account the thermal properties of the involved materials, because the rate at which the generated heat inside the device dissipates, may determine its performance and lifetime [2]. As an example, to enhance the operating parameters of integrated pyroelectric IR-sensors the thermal properties must be improved for the optimal functioning. A low thermal conductivity is essential for materials used as pyroelectric detectors [3]. It is well known that thermal properties of dielectric ceramics, especially the ferroelectric ones, are directly related to their microstructure where phonon propagation accounts for the transport of thermal energy. Therefore, the understanding of the correlation between microstructural aspects and thermal properties is of great importance [2]. That is, since the dielectric behavior is temperature dependent, their response to heat exchange phenomena will be of relevance, whether they are used as pyroelectric detectors, memory elements or high permittivity capacitors. Heat capacity and thermal conductivity are fundamental in fixing the resistance to thermal stresses and also determine operating temperatures and temperature gradients [2]. Solid solutions such as $(Pb_xSr_{1-x})TiO_3$ have received some attention when looking for a material with intermediate properties (dielectric properties) between those of the extreme compositions ($PbTiO_3$ and $SrTiO_3$) [4–6], however, the knowledge of the thermal properties for mixtures of $PbTiO_3$ and $SrTiO_3$ perovskites has not been reported before.

In this work we investigate the dielectric and thermal properties of a system that consist of a mixture of $PbTiO_3$ and $SrTiO_3$ perovskites that we call xPbTiO$_3$-$(1-x)$SrTiO$_3$. Among the thermal properties studied are the specific heat capacity (c), the thermal diffusivity (α) and the thermal conductivity (k) for xPbTiO$_3$-$(1-x)$SrTiO$_3$ ($x = 0.1, 0.3, 0.5, 0.7, 0.9$) ceramic samples using a photoacoustic (PA) technique [7, 8] and the temperature relaxation method (TRM) [9].

2. Experimental procedure
High purity (>99.9%) $PbTiO_3$ and $SrTiO_3$ powders were used for the preparation, via the conventional ceramic technique, of the nominal composition xPbTiO$_3$-$(1 - x)$SrTiO$_3$, where x is 0.1, 0.3, 0.5, 0.7 and 0.9. The powders were mixed in an agate mortar with ethyl alcohol for 2 h and heated at 1300°C for 2 h. The resulting powders were uniaxially die-pressed at