Room temperature thermal properties of $Pb(Fe_{1/2}Nb_{1/2})O_3$ ferroelectromagnetic ceramics

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The thermal properties of ferroelectromagnetic $Pb(Fe_{1/2}Nb_{1/2})O_3$ ceramics obtained using the conventional ceramic method at different sintering temperatures between 850°C and 1000°C by stoichiometric mixing of the corresponding oxides and using different kinds of precursors, have been investigated for the first time. In particular the thermal conductivity was calculated from the measured values of thermal diffusivity and specific (volume) heat capacity using the photoacoustic technique and the temperature relaxation method, respectively. Whereas no influence of the kind of precursor used for sample preparation on the thermal conductivity (k) was observed, we have found that the value of k depends on sintering temperature and has a maximum for samples synthesized at 900°C, regardless of the use of precursors or not. This paper shows that such feature is determined by the competition of the thermal conductivity mechanisms inside the grains and those at the grain boundaries in combination with the morphologic features.

Keywords: Thermal diffusivity; thermal conductivity; specific heat capacity; ferroelectromagnetic; multiferroic; lead iron niobate (PFN).

Se determinan por primera vez las propiedades térmicas de la cerámica ferroelectromagnética $Pb(Fe_{1/2}Nb_{1/2})O_3$ obtenida utilizando el método cerámico convencional a diferentes temperaturas de sinterización, entre 850°C y 1000°C, mezclando estequiométricamente los óxidos correspondientes y utilizando diferentes tipos de precursores. En particular, la conductividad térmica se calculó a partir de los valores medidos de la difusividad térmica y el calor específico (a volumen constante) utilizando la técnica fotoacústica y el método de relajación térmica, respectivamente. Aunque no se observó ninguna influencia del tipo de precursor utilizado en la preparación de la muestra sobre la conductividad térmica (k), se encontró que el valor de k depende de la temperatura de sinterización y alcanza su valor máximo para las muestras sinterizadas a 900°C, sin importar si se utilizaron precursores o no. Este artículo muestra que esta propiedad está determinada por una combinación de los mecanismos de conducción dentro del grano con los que suceden en la frontera de grano y las características morfológicas.

Descriptores: Difusividad térmica; conductividad térmica; calor específico; ferroelectromagnético; multiferroico; niobato de plomo y niobio (PFN).

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1. Introduction

Multiferroics are materials of great scientific and technological interest because they show coexisting features such as ferro- or antiferromagnetism, ferroelectricity, or ferroelasticity/shape memory effects [1-5]. In the last few years the ferroelectric and antiferromagnetic single phase compound with perovskite structure lead iron niobate [$Pb(Fe_{1/2}Nb_{1/2})O_3$, PFN for short], in which electric and magnetic order coexist, has been widely investigated [6-16]. Although detailed, systematic studies about their physical properties have been reported before, to the best of the authors' knowledge, reports on their room temperature thermal properties are not yet available in the literature. Thus the main objective of this work is the evaluation of the thermal properties of PFN ceramics and we focus our attention on the influence of the sintering temperature and the effects of different kinds of precursors used for sample preparation on the thermal conductivity.

2. Experimental

The PFN ceramic samples studied here were obtained using the conventional ceramic method. One group of samples, labeled PFNoxides, were produced from calcined powders synthesized by solid state reaction of reagent grade iron, niobium and Pb oxides (Fe_2O_3, Nb_2O_5 and PbO respectively) in stoichiometric amounts. The other two groups were obtained by the B-site precursor method using the ferrocolumbite ($FeNbO_4$) as precursor, which has been recognized as an effective way to obtain a pure perovskite phase in lead-based systems. They were labeled PFN1075 (when the monoclinic phase $FeNbO_4$ precursor synthesized at 1075°C was used) and PFN1200 (the orthorhombic phase $FeNbO_4$ precursor synthesized at 1200°C was used). The samples were sintered at different temperatures between 850°C and 1000°C. More details about the fabrication process are given in previous reports [7,9].