J. Mountain Res., Vol - 3 pp. 63-71, December, 2008

COMPOSITIONAL DEPENDENCE OF THE LOSS TANGENT AND THE CURIE TEMPERATURE IN $BA_XSRI_{1-X}TIO_3$ FERROELECTRIC PEROVSKITES

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ABSTRACT

Dielectric loss measurements have been made for mixed crystals of $Ba_xSr_{1-x}TiO_3$ in the frequency range 0.1 KHz to 1000 KHz at different temperatures, using LCR- Meter (Model No.-PM6360). Using the measured experimental results of loss tangent, we have also calculated the parameters α, β and γ by using the empirical formula $[(T-T_c)\tan\delta = \omega(\alpha + \beta + \gamma T^2)]$ for different values of x (=0.0,0.2,0.4,0.6,0.8,1.0 etc) in $Ba_xSr_{1-x}TiO_3$. The impurity dependence of the shift in the Curie temperature is discussed. The Curie temperature of $Ba_xSr_{1-x}TiO_3$ increases with Increase of the impurity concentration of Ba on pure $SrTiO_3$ crystal. The results are in agreement with previous experimental results (Bahadur and Sharma,1975; Miura et.al., 1975; Zhang et.al.,1997).

Keywords: Ferroelectric perovskites, Loss tangent, Curie temperature.

INTRODUCTION

The perovskites materials are of considerable technological importance, particularly with regard to physical properties such as pyro and piezoelectricity, dielectric susceptibility, linear and nonlinear optic effects. Many of these properties are gross effects, varying enormously from one perovskites to another and differences in the crystal structures are hardly apparent. The change in the physical properties are also remarkable when one system is mixed with another to form a composite system, but their study helps in understanding the basic mechanism of mixed system formation. For example solid solution of $BaTiO_3$ with other ferroelectrics of same class and also with certain compounds which are not themselves ferroelectric posses ferroelectric properties and change in the composition of the solid solution make it possible to regulate the Curie point within broad range of temperature.

$Ba_xSr_{1-x}TiO_3$ exhibits a number of advantages over the formerly known ferroelectrics such as: high mechanical strength, resistance to heat and moisture, presence of ferroelectric properties within broad range of temperatures and ease of manufacturing. $Ba_xSr_{1-x}TiO_3$ has attracted universal attention of researchers and has found a wide practical application. MEMS based switches, capacitors, inductors, phase shifter and micro machined transmission lines and antennas find increasing applications in the recent years. Approaches towards the design and fabrication of two MEMS components such as phase shifters and switches, both making use of high dielectric barium strontium titanate (BST) thin films to performance characteristics are also presented.

The aim of present study is to measure loss tangent of $Ba_xSr_{1-x}TiO_3$ ceramic and to observe the compositional dependence upon loss tangent and the Curie temperature. Here we have first prepared $Ba_xSr_{1-x}TiO_3$ ceramic pellets for different values of x by conventional and SEM sintering methods and characterization is done with the help of X-ray diffraction method. The measurement are done with the help of LCR meter (Model No.-PM6306) in the frequency range 0.1 KHz to 1000 KHz. Using these measured values of loss tangent we have calculated the Curie temperature of $Ba_xSr_{1-x}TiO_3$ for different defect composition. The variation of the Curie temperature with the variation of defect concentration (x) in $Ba_xSr_{1-x}TiO_3$ ferroelectric perovskites is shown graphically.

DIELECTRIC MEASUREMENTS

The loss tangent is given by (Baluni and Naithani, 1886),

$$\tan\delta = k''/k', \qquad (1)$$

where k' and k" are real and imaginary parts of the dielectric constant respectively and are given by,

$$k' = 1 + \Delta C/C_0 \qquad (2)$$

and $$k'' = (d/A\varepsilon_0)(C_2Q_1 - C_1Q_2)/Q_1Q_2, \qquad (3)$$

Here $\Delta C = C'' - C'$, C" and C' are the capacitance's of the sample holder with and without the specimen at the maximum Q reflection respectively. Also C_0 is the geometrical capacitance of the sample given (in pF) by,

$$C_0 = 0.08854\, A/d, \qquad (4)$$

where A is area in cm^2 and d is the thickness is the pellet. Also Q_2, Q_1 and C_2, C_1 are the Q values and capacitances respectively of the of the sample holder with and without sample.

It is clear from above discussion that the parameter α strongly depends upon defect concentration (i.e. x) in $Ba_xSr_{1-x}TiO_3$. It increases with increase of impurity concentration in $Ba_xSr_{1-x}TiO_3$ and is determined by lattice imperfections and vanishes for pure single crystalline material. The parameters β and γ does not depend upon lattice defect and show intrinsic properties of pure single crystalline material. Our results are in good agreement With the results of other workers (Jiangying et. al., 2004; Abdelkef et. al., 2005; Samantaray et. al., 2005). Recently we have applied the Green's function technique on the specific heat at low temperature (Kumar et. al., 2008) and field dependent dielectric behaviour (Kukreti et. al., 2008) of $Ba_xSr_{1-x}TiO_3$ ferroelectric perovskitres.

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