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Study of Conduction mechanism Of Barium Titanate ceramic

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***Abstract*— Impedance measurements have been performed on a sintered polycrystalline single phased perovskite $BaTiO_3$. The ceramic is found to crystallise in tetragonal phase. The frequency dependent conductivity is observed to follow double power law $\sigma(\omega) = \sigma o + A1\omega^{s1} + A2\omega^{s2}$. The ac conductivity analysis depicts two dispersion regions resulted due to grains and grain boundaries. The results revealed three types of conduction mechanisms namely; long range hopping, short range hopping and localised motion. The value of activation energy is obtained 0.89 eV from Arrhenius type temperature dependence of dc conductivity in the temperature range 583K-673K.**

***Index Terms*— Ceramics, Impedance Spectroscopy, Perovskite, Rietveld Refinement**

I. INTRODUCTION

Impedance spectroscopy has emerged as a powerful technique for characterization of electrical microstructure of different materials. Impedance and modulus formalisms lend us an insight to the resistance and capacitance imparted by various intrinsic and extrinsic factors like grains, grain boundaries and electrodes [1, 2]. Ac conductivity can also be used to obtain different relaxation mechanisms which help in demarcating the input of grain and grain boundaries to the overall conductivity in case of polycrystalline materials. In the present system which is barium titanate various conduction mechanisms have been studied via conductivity formalism.

II. EXPERIMENTAL DETAILS

Polycrystalline Barium titanate sample was synthesized using high temperature solid state reaction technique using A.R. grade (purity≥99.0%) chemicals. The sintered ceramic was structurally characterized by using a Rigaku Miniflex-II X-ray diffractometer, using Cu-Kα radiation detector. Impedance measurement of the sintered pellets was done using impedance phase analyser over frequencies 10 Hz to 7 MHz in a temperature range of 573-673 K.

III. RESULTS AND DISCUSSION

The phase composition of the sintered ceramic was studied using XRD analysis. Fig. 1 displays the XRD spectra of BaTiO3. Formation of single phased ceramic was confirmed by the JCPDS file no. 05-0626. The ceramic crystallised with sharp peaks in tetragonal phase as depicted by the splitting of reflections (002 and 200) in region around diffraction angles, 2θ, of 45°. Fig.2 shows the frequency dependence of conductivity at selected temperatures. The low frequency plateau region (I) is associated to the dc conductivity followed by two dispersive regions, (II and III) as the frequency increases. The lower frequency dispersion region (II) may be attributed to the presence of grain boundaries (large capacitance values) and the higher frequency one (III) to the grains (small capacitance values). Also, the step like increase in conductivity with frequency shows case of a potential well with multiple barrier heights [1]. The phenomenon of conductivity dispersion in solids is generally analyzed using Jonsher power law [3]

$$\sigma(\omega) = \sigma_o + A\omega^s \quad (1)$$

where, σo is the dc conductivity, A is pre-exponential factor and s is the fractional component, both 'A' and 's' are temperature and material dependent [4].

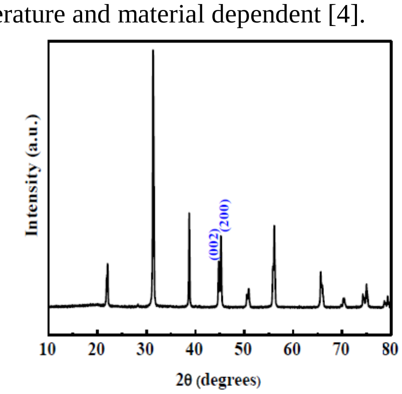

Fig.1 XRD pattern of barium titanate at RT.

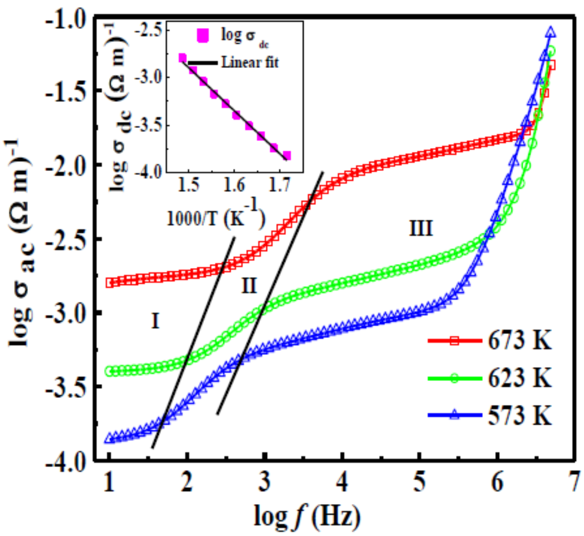

Fig.2 Frequency dependence of ac conductivity at different Temperatures. Inset: Dc conductivity of barium titanate.

For explanation of two dispersive regions in the present system, the equation (1) can be modified as [5, 6],

$$\sigma(\omega) = \sigma_o + A_1\omega^{s_1} + A_2\omega^{s_2} \quad (2)$$

The term σo gives the dc conductivity which arises due to long range translational hopping of charge carriers. The second term is associated with region II, where the exponent s1 (0<s1<1) corresponds to short range translational hopping. The third term may be associated with the III region with s2 lying between 0 and 2 corresponding to a localised motion [5]. The inset of fig. 2 displays dc conductivity in the temperature range 583K-673K, which depicts Arrhenius type temperature dependence. The dc activation energy obtained is 0.89 eV.

IV. CONCLUSION

Single phased barium titante was successfully synthesized with tetragonal phase. The ac conductivity shows three regions depicting three types of conduction mechanisms namely, long range hopping, short range hopping and localised motion. The Arrehenius plot was used to obtain the activation energy (0.89 eV).

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