Electrical and Dielectric Properties of Aluminium Titanate

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Abstract - Aluminum titanate (Al2TiO5) ceramics have a low thermal expansion coefficient, which results in excellent thermal shock resistance, low young's modulus, moderate strength, and low wettability by liquid metals. It is due to these properties that make the Al2TiO5 suitable for high-temperature applications where thermal shock resistance and thermal insulation is required, such as components of internal combustion engines, exhaust port liners, metallurgy and thermal barriers. Solid state diffusion method is the most commonly used for the preparation of titanates. X-ray diffraction and scanning electron microscopy (SEM) are the most commonly used techniques for the determination of crystal structure. Unit cell, cell parameters, crystallite size, stress, strain are the parameters that can be evaluated from the XRD data. Surface morphology i.e.grain size, grain boundaries, etc, dislocations, twin boundaries etc and the composition are the structural parameters that can be evaluated from the SEM and EDAX data. The Electrical conductivity and thermoelectric power measurements are used for understanding the conduction mechanism. The change of the dielectric constant (ε) depends on the grain size affecting stress distribution in the grain. The grain size dependence of (ε) has been investigated in ferroelectric materials.

Keywords - thermal expansion, electrical, dielectric, aluminium titanate.

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1. Introduction

Aluminum titanate (Al2TiO5) is an excellent refractory and thermal shock resistant material due to its relatively low thermal expansion coefficient and high melting point (18600C). Crystallographic anisotropy in the thermal expansion coefficient is mainly responsible for the development of micro cracks during cooling from the sintering received red mud, leached residue (calcined at 800oC). RD Skala et al (1) have carried diffraction, structure and phase stability studies on aluminum titanate. Their results reveal the disordering of Ti and Al atoms in the metal 1 and metal 2 states and increasing substation of Al for the Ti atoms in the crystal structure which is responsible for the decomposition of Al2TiO5 observed between 900 and 12800C. Due to the combination of the aforementioned physical and mechanical properties, aluminum titanate and its composites are potential materials for applications as liquid metal flow regulators, risers, thermocouple sleeves, burner nozzles, ceramic filters, etc. (2-4).

2. Experimental Details:

Sample (Al2TiO5) used in the present investigation is Stoichiometric in ratio. Raw Materials of reagent grade (Purity of Powders were Higher than 99%) Al2O3 is weighed in an electronic single pan balance. Then the weighed material is transferred into agate mortar and ground the mixture for over four hours, dried and calcined. The ground mixture was taken in an Alumina Crucible and is kept in an electrical Silicon carbide furnace that can be heated up to 1350°C. The furnace was made from a four SiC rods. The temperature was varied from 30°C to 1000 0C (~10 OC per minute). The mixture was kept at those temperatures for 36 hours for calcination. This method allowed homogenization of the mixture. Formation of Al2TiO5 was confirmed by powder X-ray diffraction method. X-ray diffraction profile was recorded at room temperature with Seifert X-ray diffractometer using Ni-filtered Cu-Kα radiation (λ = 1.54056Å) at a rate of 2°/min. in the range of 10°-90°.

3. Conclusion:

Many of the oxide dielectric compounds belong to family of ceramics called perovskites (5).The adoptable perovskite structure gives rise to materials that have a wide array of electrical properties.The materials which are widely used for dielectric resonators (DR) have perovskite or perovskite-related structures. Figure3.1 depicts experimental observation of variation of dielectric constant with temperature for. Al2TiO5. Figure 3.2 depict experimental observation of variation of dielectric constant with frequency for. Al2TiO5. Figure 3.3 depicts experimental observation of variation of dielectric loss with temperature for Al2TiO5.Figure 3.4depicts experimental observation of variation of dielectric loss with frequency for Al2TiO5.

Two probe D.C. Electrical conductivity measurements were carried on the series of copper doped strontium titanate sample pellets Sr1-xCuxTiO3 (0.1to 0.9), Al2TiO5, CuAl2TiO6 and CuTiO3. The electrical conductivity measurements were made from room temperature to 700K. The diagram of the electrical conductivity cell used in the present investigation was shown in the figure 2.5. A sample for which electrical conductivity to be measured was kept in the conductivity cell. The conductivity cell was then kept in the furnace. The resistance of the sample at room temperature was directly measured using Keithley multimeter model DMM 2700. The temperature was slowly increased and resistance was measured as a function of temperature up to 900K.

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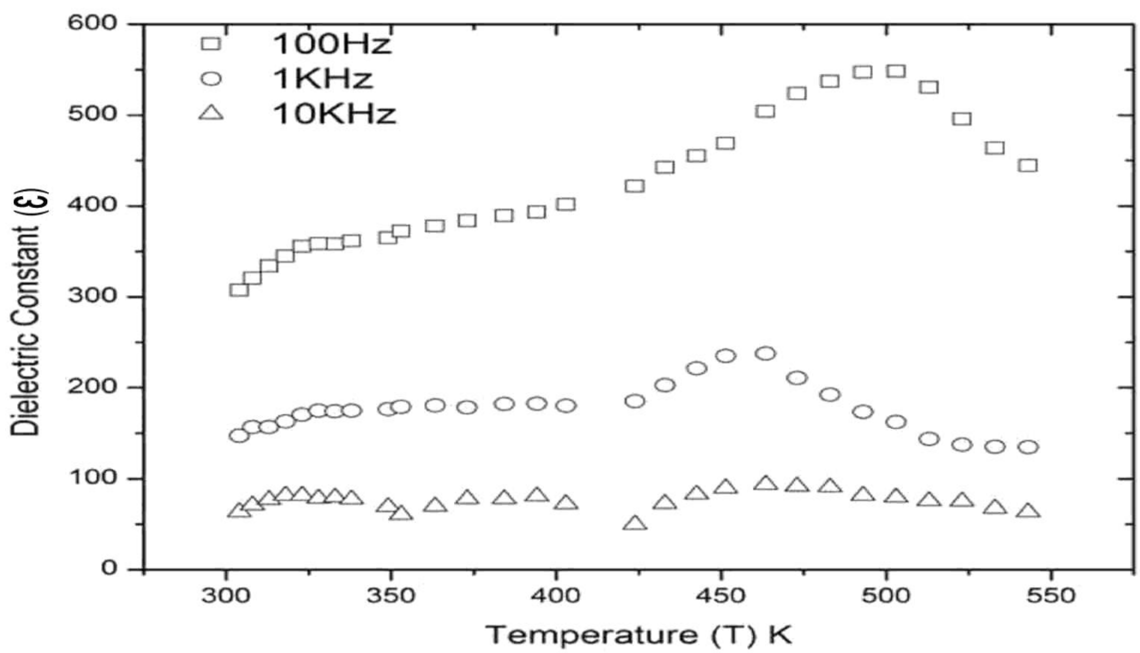

Fig.3.1 Temperature variation of Dielectric Constant of Al_2TiO_5

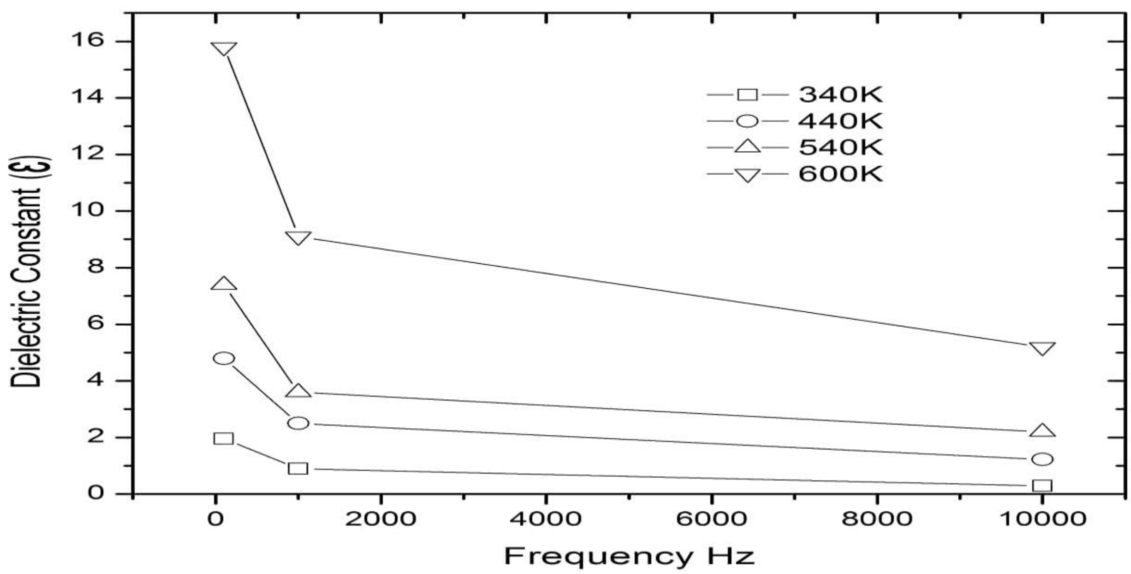

Fig3..2. Frequency dependence of Dielectric Constant of Al_2TiO_5

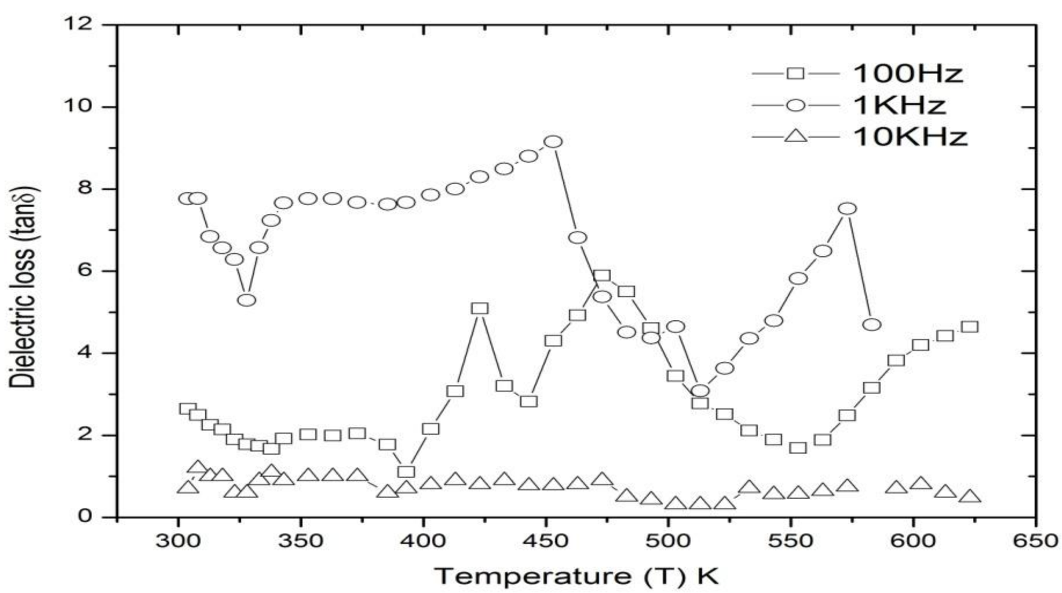

Fig3.3. Temperature variation of Dielectric loss of Al_2TiO_5

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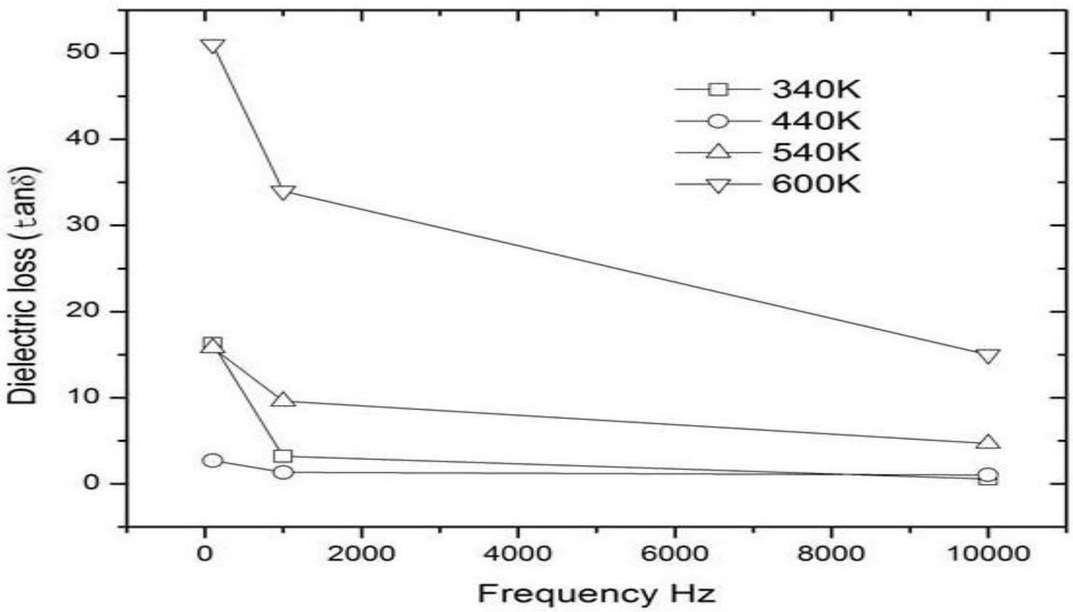

Fig.3.4. Frequency dependence of Dielectric loss of Al_2TiO_5

References:

[1] R.D. Skala a, D. Li, I.M. Low Journal of the European Ceramic Society 29 (2009) 67
[2] B. Freudenberg Concise Encyclopedia of Advanced Ceramic Materials, 1st ed. R.J. Brook, ed., Pergamon Press, Oxford, United Kingdom, (1991) 20
[3] N. Nagai, S. Wada, Y. Murana, S. Ikada, K. Watanabe, S. Matsueda, and M. Ogawa: U.K. Patent Application GB2302826A(1997)
[4] F. Odaka and E. Tanuma: U.S. Patent 5 (1997) 676
[5] Annna E McHale Phase Diagrams and Ceramic Processes, Chapman and Hall, New York (1997) 139