ABSTRACT

One of the most extensively studied groups of ceramic materials belongs to the class of dielectric materials. Dielectric materials are electrical insulators. As a group of dielectric, ferroelectric ceramics are important electronic materials having a wide range of industrial applications such as high frequency devices, electromechanical transducers and electric capacitors etc. Among ferroelectric materials, lead titanate ($PbTiO_3$) is one of the potentially useful materials with a highly polar perovskite structure (ABO_3). It is difficult to prepare pure-phase $PbTiO_3$ ceramics with high density because of a high c/a ratio which gives rise to stress in this material. However A/B-site substitution by appropriate cation acts as stress stabilizer. The role of substituent in lead titanate ceramic is mainly to reduce its tetragonality and maintain the optimal structure-property correlation desirable for a number of potential applications.

This work is mainly focused on the synthesis and characterization of lanthanum and manganese modified lead titanate nanoceamics. Modification of A site by La^{3+} and B site Mn^{4+} is carried out in order to know the suitability of the substituting elements for the enhancement of various (thermal, structural, microstructural, dielectric, ferroelectric, piezoelectric and impedance) properties. The synthesis process is carried out by mechanothermal method. Thermal gravimetric analysis confirms the phase formation at low temperature (400 ^{o}C). HRXRD pattern exhibits that modifications do not distort or change the tetragonal structure of lead titanate, but decrease tetragonality. The reduction in tetragonality causes shifting of Curie temperature towards lower temperature side with La/Mn substitution. Ferroelectric hysteresis behavior is studied for all the compounds at room temperature. It is also observed that the value of coercive field decreases with increase in lanthanum concentration and increases with Mn. A lossy nature of loops is attributed to the oxygen vacancy defect. Complex impedance spectroscopy, in terms of a simultaneous analysis of the complex impedance, electric modulus is used to investigate the electrical behavior of the proposed ceramics. Complex impedance spectra indicate the possibility of the bulk and grain boundary contribution at higher temperatures and also about the temperature-dependent relaxation phenomena. Modulus analysis results agree well with complex impedance predictions for electrical transport processes in the system. Almost same activation energies evaluated from impedance and modulus relaxation plots confirmed the existence of single relaxation carrier. Temperature dependent ac conductivity data suggests that the value of activation energies decreases with increasing frequency. Conductivity behaviour with respect to frequency obeys Jonscher power law; $\sigma(\omega) = \sigma_{dc} + A\omega^n$. The non linear least squares fitting shows that value of frequency exponent "n" lies in the limit $0 \le n \le 1$.

Keywords: Dielectrics, Ferroelectrics, Thermal Properties, Structural Properties, Dielectric Behaviour, Electrical Properties, Conductivity Analysis.