Seminar

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Institute for Plasma Research

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Title: Dielectric and Ferroelectric Properties of Sodium Bismuth Titanate based Lead-free Ternary System

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Date: 23rd February 2024 (Friday)

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Venue: Committee Room No. 3, IPR

Abstract

Lead free ferroelectrics being environmentally benign are gradually established as a pioneering class of engineering materials for capacitor applications. This is because of the fast response times and ability to release the stored energy in the shortest possible time (<μsec). Despite of such advantages, one of the major pitfalls of the ferroelectric ceramics is their sharp phase transition temperature which limits the preservation of stable permittivity over a broad temperature range. One of the effective strategies to overcome this drawback may be simultaneous enhancement of dielectric permittivity and its large temperature stability by instilling diffuse phase transition into the system (relaxor nature). Such unique behaviour is known to be the consequence of temperature dependent dynamics of nano sized polar regions (PNRs) within the ferroelectric matrix. The dynamics of PNRs can be greatly modulated by introducing chemical inhomogeneities and valance mixing at the A/B-site of perovskite ceramics. In this regard, (1-*x*) $Na_{0.5}Bi_{0.5}TiO_3$-*x*$SrTiO_3$ (NBT-ST) ceramics seem to be prospective owing to their high degree relaxor activity (due to the dynamics of PNRs) at higher concentrations of ST, superior dielectric and ferroelectric response over a wide temperature range. However, it's low Curie temperature (T_C) and relatively high dielectric loss at excessive temperatures hinders its application at elevated temperatures. This shortcoming may be addressed by introducing a high T_C material such as $K_{0.5}Na_{0.5}NbO_3$ (KNN) as an end member to the binary NBT-ST. Apart from that, KNN is known to impede the long-range ferroelectric order of the parent matrix and establish local heterogeneities, thereby increasing its temperature stability. In conjunction with the above-mentioned facts, a ternary ceramic series based on NBT is designed by keeping ST concentration fixed at 20 mol% (a phase boundary composition) and varying the amount KNN. The ternary system, (0.8-*x*) NBT-0.2ST-*x*KNN ($0.00 \leq x \leq 0.1$) synthesized by solid state reaction is of specific

interest as it not only demonstrates a clear ferroelectric to relaxor transition at room temperature but also shows improvement in relaxor response with increase in KNN concentration. The structural and micro-structural investigations have been performed using X-ray diffraction, Raman spectroscopy (both at room temperature and temperature dependent), and field emission scanning electron microscopy (FESEM). In order to ensure the ferroelectric to relaxor crossover, dielectric and ferroelectric studies were carried out. To probe into the relaxor response of the samples, the experimental data has been analyzed by fitting into various models like modified Curie-Weiss law, Vogel-Fulcher law, Power law, Cheng's Model. Impedance spectroscopic technique is also employed to strengthen the study on the relaxor behaviour of the samples.