CHAPTER VII
SUMMARY, RESULT
AND
DISCUSSION
SUMMARY, RESULT AND DISCUSSION:

There are many reports regarding the ferroelectric properties of pb(Fe$_{0.5}$Nb$_{0.5}$)$_{O_{3}}$ and its solid solution. However, to the author's knowledge, there have been few reports on the perovskite compound A(Fe$_{0.5}$ Nb$_{0.5}$)$_{O_{3}}$, (A = Ba, Sr & Ca) and A(B$_{0.5}$Nb$_{0.5}$)$_{O_{3}}$, (B = Cr, Mn, Fe, Co, In) Which is free of pb. The author reported the pyroelectric, dielectric and electrical conductivity of these compounds [1,2]. To investigate the possibility of ferroelectric in these compounds. We have carried out an intensive study. Its dielectric, ferroelectric, pyroelectric properties can be affected by its own stoichiometry and microstructure and by the effect of a host of ions that can enter into solid solution. A given ion can have radically different effect on the nature of the dielectric, ferroelectric and pyroelectric properties depending on its concentration and its effects on stoichiometry.

The dielectric, ferroelectric and crystallographic, properties of A(Fe$_{0.5}$Nb$_{0.5}$)$_{O_{3}}$ can be suitably modified by doping impurities in A-site ion sublattice. In this respect intensive work has been conducted particularly on.
Ba(Fe$_{0.5}$Nb$_{0.5}$)O$_3$. Since this ceramic specimen was easily fabricated compared with others. In the recent years, dielectric anomalies of oxides ceramics at relatively low frequencies have attracted much attention and many papers have been published [3-7].

Solid solutions of $\text{(Ba}_x\text{Sr}_{1-x})\text{(Fe}_{0.5}\text{Nb}_{0.5})\text{O}_3$ have been prepared by the usual sintering technique [8,9]. The lattice parameter of isovalent doped with BFN measured at room temperature using X-ray diffractometric technique. Using the intensity data Debye-Waller factor and mean square amplitude factor were calculated. It is observed that, the value of mean Debye-Waller factor (B) as a function of composition in BSN ceramic is highly non-linear. The presence of ions of different size in mixed ceramic creates a local strength in the lattice [10,11]. Because of the size the atomic displacement in mixed ceramics have a static component resulting in a static contribution to the Debye-Waller factor.

From the pyroelectric and hysteresis loop the temperature dependance of the spontaneous polarization has been obtained to within 10% accuracy. At the temperature $T$ where $(T/T_C) > 1$. It
was found that \( P_s^2 \propto |T-T_C| \) and \( \epsilon^{-1} \propto |T-T_C| \), in accordance with thermodynamic theory. The temperature dependance of the coercive field has been measured and found to obey a power law. The parameter engaged in the statistical dipolar theory of ferroelectrics are derived. From the dielectric constant and hysteresis measurements, allowing a distinction between dipolar and atomic polarization. The free energy was expressed as a function of the polarization and the coefficients were determined by the dielectric properties.

Suitably composition in BSFN ceramic showed sharp anomalies in the temperature dependance of their pyroelectric response near the transition temperature with an addition of Sr the \( T_C \) of BSFN can be suitably adjusted for room temperature pyroelectric applications. In the present studies we focussed on the BSFN compositions especially pyroelectric coefficient has a maximum value at 100 mole % of \( \text{Ba}^{2+} \) then it decreases upto 50 mole % and later on it increases. The composition dependance of pyroelectric properties resemble that of other ferroelectric ceramics [12-14]. Maximum value of spontaneous polarization was observed for 100 mole
% of Ba$^{2+}$ then decreases up to 50 mole % of Ba, later on it increases.

The observed anomalies were due to a simultaneous change in the electrical conductivity as explained by Roitaberg [15] for LiTaO$_3$ single crystal. Niobium accelerates densification. Doping increases the concentration of lattice vacancies, thereby increasing the rate of diffusion and densification [16,17].

The dielectric constant was studied versus temperature at 1 KHz in the temperature range from 27°C to 450°C. Substitution of iso-valent in A-site in BFN decreases the Curie temperature and dielectric constant too. Curie constant is calculated in all the compositions. The effect is similar to that observed in PZT ceramics modified by Sr$^{2+}$ on A-site [18-20]. In each of measurements pronounced anomalies were observed at the ferroelectric Curie temperature. Clearly indicating a transition of the second-order [21].

The shape of the $\epsilon$ versus temperature curves as function of $X$ represented here is different form curves of other ferroelectric compounds. These have high non-linearity, [22-24], of the dielectric constant. Figure 6.1 curve leads to more
significant broadening of phase transition. The availability of high non-linearity of dielectric constant and broadened the transition make solid solutions of \((\text{Ba}_x\text{Sr}_{1-x})(\text{Fe}_{0.5}\text{Nb}_{0.5})\text{O}_3\) candidates for use as temperature stable ferroelectric variable capacitors.

The significant contribution to the changes in ferroelectric properties of BFN under the influences of doping is attributed to change in both numbers of dipoles per unit volume and the unit dipole moment.

The interesting feature of these results is the variation of \(\epsilon\) with the change of densities. Decrease of \(\epsilon\) with decreasing density has been reported for LiTaO\(_3\) ceramics [25] and compressed TGS powders [26]. These results were attributed to the presence of internal fields, which cause such variations.

The composition of BSFN decreased the Curie temperature may be attributed to decreases in polarizability of A-site cations. Under these circumstances the dipoles at the large cation site interact weakly with those at the Nb\(^{5+}\) sites in BFN resulting in a decrease of \(T_c\). Similar phenomenon has been reported for other ferroelectrics.
materials [27-32].

The peak values of coercive field increases as dopent concentration increases up to 20% and then decreases for higher concentrations. The observed high value of coercive field of modified BFN containing 20% Ba\(^{2+}\) was attributed a rather more solid state interaction that takes place in ferroelectric material. This might be due to pronounced increase of density with the addition of host ions. Effect of doping keeps the grain size small and there by expedites densifications [33].

BFN ceramics of different densities can be prepared by controlling the sintering procedures and chemical composition [34-37]. The variety of defects appearing in compounds as result of doping. The change in concentration of impurities in such materials not only changes degree of compensation but it can change a mechanism of conduction as well. The dielectric, pyroelectric and ferroelectric properties of modified BFN with isovalent showed abnormal, anomalous dependencies on small change in composition and density. These ceramics materials have favorable mechanical characteristics and they can be readily fabricated in large size from low cost starting materials.
AIM OF FUTURE WORKS:

The profile of anomalous use in $\varepsilon$ at $T_C$ non-linearity of Sr$^{2+}$ in BFN and the other perovskite ferroelectric ceramics still remains a many complicated problem difficult to explain. The reason for those are that the phenomenon seems to exist in the polycrystalline grain boundaries, the nature of which are strongly dependant on the impuruties, atmospheric condition and their diffusion process.

Since the dielectric constant varies with frequency, even at low frequencies the time dependance of the electric displacements can not be neglected for the type of frequencies used in pyroelectric detection. Therefore it is necessary to study the $\varepsilon$ varies with frequency.

Conditions responsible for diffusion of phase transitions in ferroelectric ceramic as well as the diffusion mechanism itself remain problems of physics of ferroelectrics to be thoroughly studied. The absorption spectra study may help to understand the machanism of DPT with relaxational polarization technique.

Disordering the growth of defect concentration and irregularity in distributions of A and B ions
in BFN is commonly supposed to enhance diffusion of the DPT. Degree of diffusion is usually determined from the shape of the $\epsilon$ varies temperature curve. Though the structure is very simple, it proved exceedingly difficult to determine the small displacements. Part of this difficulty is inherent in the well-known phase problem in diffraction analysis and in the existence of a centre of symmetry in a undistorted structure considerable difficulties arise also from the thermal oscillation parameters. The determination of the oxygen parameters with X-ray is particularly difficult in presence of much heavier lattice constituents, Neutron diffraction is a much more suitable tool in this case. The scattering factor of an atom thermally oscillating with a mean square displacement (Debye). Thus the X-ray and neutron analysis can give information on the thermal oscillations. The refinement in modern X-ray analysis techniques has led not only to the introduction of individual temperature corrections for different kinds of atoms in a lattice but also to anisotropic temperature factors.
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