CHAPTER VI
"CONCLUSION AND SUGGESTIONS"
6.1 CONCLUSIONS

The present work had been aimed at investigating the modification in the structural, electrical, magnetic and m"ossbauer properties of substituted BiFeO₃ prepared by solution combustion method and successively substituted with varying amounts of lanthanum and cobalt ions. A resume of the main conclusions drawn from the present work is given below:

Structural study XRD reveals that BiFeO₃ have R3c space group rhombohedral structure. Lanthanum and Cobalt-substituted nano multiferroic BiFeO₃ system \([\text{Bi}_{1-x}\text{La}_x\text{FeO}_3; \text{BiCo}_x\text{Fe}_{1-x}\text{O}_3}\) (\(x = 0.0, 0.05, 0.10, 0.15, 0.20, 0.25\)) were synthesized using solution combustion method. La ions hinders formation of second phase and indicating \(\text{La}^{3+}\) enters into BFO lattice. Cobalt substitution leads to extra phase \(\text{Bi}_{1.2}\text{Co}_{0.8}\text{O}_{18.8}\) with BiFeO₃ structure.

Lattice constant for BiFeO₃, \(\text{Bi}_{1-x}\text{La}_x\text{FeO}_3\) and \(\text{BiCo}_x\text{Fe}_{1-x}\text{O}_3\) with \(x = 0.05, 0.10, 0.15, 0.20\) and 0.25 concentration, changes slightly linearly with the La and Co content, which can be attributed to the slightly change ionic radius of \(\text{La}^{3+}\) (1.032 Å) than that of \(\text{Bi}^{3+}\) (1.030 Å) ions and \(\text{Co}^{3+}\) (0.54 Å) than that of \(\text{Fe}^{3+}\) (0.55 Å).

The values of the particle size as obtained from TEM images are in good agreement with the one, calculated from XRD patterns.

The experimental values of density show similar trend as to that of X-ray density and also shows slight variation in porosity with La and Co substitution for \(x = 0.0, 0.05, 0.10, 0.15, 0.20, 0.25\) and no uniform trend was observed in the porosity percentage calculated for all the samples.

Transmission electron microscopy (TEM) study confirms the particle size of nano crystallites and also have spherical size.
The d. c. resistivity of Bi_{1-x}La_xFeO_3 and BiCo_xFe_{1-x}O_3 ceramic samples prepared by solution combustion method is three orders higher than the value of resistivity obtained for BiFeO_3 (BFO). The observed variation of d. c. resistivity as a function of concentration have been explained on the basis of blocking of Verwey’s hopping mechanism.

The variation of dielectric constant reveals the dispersion due to Maxwell interfacial polarization and is in agreement with Koops phenomenological theory. Similar to the dielectric constant, the dielectric loss also decreases smoothly with increasing frequency.

Polarization–Electric Field loop at room temperature is not really saturated due to large leakage current in the sample.

Saturation magnetization (M_s) increases with increasing La and Co concentration from x = 0.0 to x = 0.25.

Magnetic susceptibility of Bi_{1-x}La_xFeO_3 ceramic samples exhibits a rather sharp transition as compared to the BFO sample. On increasing the doping content of La from x = 0.05 to 0.25, the antiferromagnetic Neel temperature increases upto 415 °C and the magnetic susceptibility of BiCo_xFe_{1-x}O_3 ceramic for x = 0.05, 0.10, 0.15, 0.20 and 0.25 concentration increases in the low temperature range and decreases in the high temperature range i.e. near Neel temperature T_N ~ 370 °C, which indicates antiferromagnetic behaviour.

Differentially scanning calorimetry (DSC) study have confirms the antiferromagnetic Neel temperature, which is found to be increased with lanthanum and cobalt concentration for BiFeO_3, Bi_{1-x}La_xFeO_3 and BiCo_xFe_{1-x}O_3 ceramic with x = 0.05,
0.10, 0.15, 0.20, and 0.25, respectively.

Room temperature Mössbauer spectra of BiFeO₃, Bi₁₋ₓLaₓFeO₃ and BiCoₓFe₁₋ₓO₃ ceramic nano powder are fitted to be two sextets and one doublet indicating the ferromagnetic ordering, which is further confirmed by the room temperature M–H measurements. No signal of Fe²⁺ is detected for all samples. The cycloid structure of bulk BiFeO₃ was partially destroyed in BiFeO₃ nano particles which contribute to the weak ferromagnetic behaviour at room temperature.

Substitution of La³⁺ and Co²⁺ ions in BiFeO₃ improves both electrical and magnetic properties.

6.2 SUGGESTIONS FOR FUTURE WORK

The following suggestions are being made for further experimental work and possible extension of this work:

1. To reduce the leakage current and verify the current conduction mechanism at higher temperature.

2. To study ME coupling coefficient of BiFeO₃ and La; Co doped BiFeO₃.

3. To study electric and magnetic properties with codoped La and Co in BiFeO₃.

4. Study of low dimension size effect in BiFeO₃ multiferroic system.

5. Study of ferroelectric and ferromagnetic properties of BiFeO₃ and La; Co doped BiFeO₃ thin films.

6. Mössbauer spectroscopy can be done at various temperatures to study the magnetic hyperfine fields at different iron sites. Mössbauer spectroscopy can also be used to investigate type of spin–spin relaxation and magnetic clusters relaxing.