INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

Name of the Student : Bipul Deka

Roll Number : 11612112

Programme of Study : Ph.D.

Thesis Title: Dielectric and Magnetic Properties of Fe and Ti Based Perovskite Oxides

Name of Thesis Supervisor(s) : Prof. S. Ravi and Prof. A. Perumal

Thesis Submitted to the Department/ Center : Physics

Date of completion of Thesis Viva-Voce Exam : 16-02-2018

Key words for description of Thesis Work : Dielectric relaxation; ferromagnetism; exchange bias; Nyquist plots

---

SHORT ABSTRACT

The present PhD thesis deals with extensive investigation of magnetic and dielectric properties of (1) $YFe_{1-x}Mn_xO_3$ (x = 0 to 0.3), (2) $Bi_{1-x}Sm_xFeO_3$ (x = 0 to 0.3), (3) $PbTi_{1-x}Fe_xO_3$ (x = 0 to 0.3) and (4) $BaTi_{1-x}Fe_xO_3$ (x = 0 to 0.3) samples.

Study of complex impedance spectra, dielectric constant and ac electrical conductivity of $YFe_{1-x}Mn_xO_3$ (x = 0 – 0.3) compounds elucidates the role played by both grains and grain boundaries in shaping the dielectric relaxation. The relaxation is attributed to the short-range movement of oxygen vacancies. The Nyquist plots of complex impedance were analyzed by fitting them to an equivalent electrical circuit. This circuit contains three parts connected in series: first one is the electrode resistance (R_E); second one is the parallel combination of resistance and capacitance of grains (R_G ,C_G) and the third one is the parallel combination of resistance and constant phase element of grain boundaries (R_{GB}, Q_{GB}). Mn substitution is found to decrease the Néel temperature from 646 K to 428 K and induce spin reorientation transition at low temperature from Γ_4 ($A_xF_yG_z$) to Γ_1 ($G_xC_yA_z$) spin configuration. The spin reorientation transition temperature is found to increase from 81 K for x = 0.1 to 295 K for x = 0.3. These samples exhibit interesting exchange bias behavior above room temperature with a maximum exchange bias field of 1.2 kOe at 413 K.

The frequency dispersions of complex dielectric permittivity of $Bi_{1-x}Sm_xFeO_3$ (x = 0 – 0.3) compounds were best explained in terms of Havriliak-Negami equation along with conductivity contribution towards permittivity. The relaxation dynamics is explained in terms of polaron hopping across Fe^{2+} and Fe^{3+} ions within the grains and short-range movement of oxygen vacancies at the grain boundaries. The Nyquist plots were analyzed by fitting them to an equivalent electrical circuit comprising parallel $R_GQ_GC_G$ (for grains) and $R_{GB}Q_{GB}C_{GB}$ (for grain boundaries) elements connected in series to electrode resistance. Ferromagnetic like behavior with a clear opening in $M - H$ loop was observed for samples with $x \geq 0.15$. We have also observed the presence of exchange bias like behavior for x = 0.15 and 0.2 samples.

Analysis of imaginary part of impedance (Z'') and electric modulus (M'') for $PbTi_{1-x}Fe_xO_3$ (x = 0 to 0.3) samples suggest the presence of three electroactive regions and they are identified as grains, grain boundaries and surface layers. The Nyquist plots are analyzed by fitting them to an equivalent electrical circuit comprising parallel $R_{SL}C_{SL}$ (for surface layers) and $R_{GB}Q_{GB}C_{GB}$ (for grain boundaries) elements connected in series to grain resistance R_G. The resistance values corresponding to three electroactive regions exhibit the positive temperature coefficient behavior. The samples with x = 0.25 and 0.3 show ferromagnetic behavior at room temperature with transition temperature (T_C) 650 K and 660 K respectively. The observed ferromagnetism is explained in terms of double exchange interaction in $Fe^{3+} – O^{2-} – Fe^{4+}$ networks. The coercivity of the samples increases with increase in temperature upto certain temperature and is discussed in the framework of coupling between magnetic and the electric ordering.

The ferroelectric transition temperature of $BaTi_{1-x}Fe_xO_3$ (x = 0 to 0.3) samples is found to shift downwards towards the room temperature with increase in Fe concentration. Room temperature ferromagnetism is observed for x = 0.15 – 0.3 samples. The ferromagnetic transition temperature of the samples are found to be in the range of 397 K for x = 0.15 to 460 K for x = 0.3. The magnetic interaction is discussed in terms of formation of bound magnetic polaron.

Thus the present thesis demonstrates the successful introduction of ferromagnetism and exchange bias behavior in two of the above series. In addition to that the origin of dielectric relaxation and electrical conductivity in the above series is well understood.