CHAPTER - VI

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SUMMARY AND CONCLUSIONS

Ferroelectric and ferromagnetic composite such as piezoelectric-piezomagnetic have attracted considerable attention as reported in the literature and are now being used more in practical applications. Perhaps the most common examples are magnetic sensors, transducers, isolators, waveguides etc. The recent interest and development of ferroelectric-ferromagnetic composites results from the recognition of the potential for enhanced performance and the increasing need for a combination of desired material properties that often cannot be obtained in single phase materials. Thus neither the ferrite nor ferroelectric exhibits magnetoelectric output but their suitable combination results in ME effect. Although there has been an emphasis on the practical development of such composite materials, work related to electrical conduction is relatively scant. Hence the present work communicates mainly electrical conduction in $MnFe_{1.8}Cr_{0.2}O_4$ – $BaTiO_3$ composites.

At the outset, a brief introduction to composites and their applications is given. Review of work done by other scientist working in this field is reported. Orientation of the present work is also discussed. The constituent phases namely ferrite and ferroelectric, which are well known, are introduced in brief to understand their behaviour in composites. The present composites are prepared by solid state sintering. Structural characterization is made using x- ray diffraction. X-ray diffractograms obtained for the constituent phases and their composites reveal no structural change in ferrite phase of the composites. However the case for 85% $BaTiO_3$ - 15% $MnFe_{1.8}Cr_{0.2}O_4$ is different, wherein the tetragonal distortion observed in barium titanate phase is very much small when compared to the pure barium titanate. This structural change may be one of the reasons for observing higher magnetoelectric sensitivity in this sample. This structural change is ascribed to relative isolation of ferrite formation and their effective utilization in affecting the constitution of $BaTiO_3$ structurally.

Dielectric dispersion, AC conductivity, variation of DC resistivity with temperature and thermoelectric power variation with temperature are studied to understand the nature of electrical conduction in these composites. Polaron hopping type of conduction takes place in the present ceramics. Anomalies are observed in the variation of dielectric constant with temperature. They are accounted by taking into consideration the magnetoelectric interactions, which take place at ferrite and ferroelectric grain boundaries. The transition temperatures for ferrite and ferroelectric phases in the composites are not matching with those observed in their single-phase constituent. The majority charge carriers are holes in pure Mn – Cr ferrite and X = 0.55 composite containing relatively larger amount of ferrite. Electrons are majority charge carriers in X = 1, 0.85 and 0.70 composite. The magnitude of thermoelectric power is greater than 100 microvolts per kelvin indicating the polaron hopping type of conduction.

The resistivity is maximum for X = 0.85 composite and minimum for X = 0.55 composite. This suggests that the addition of ferrite to the matrix of $BaTiO_3$ lowers the effective resistance of the composite. Magnetoelectric effect studied as a function of magnetic field shows a decrease in sensitivity with increase in magnetic field. This is attributed to the fact that strain produced in ferrite phase reaches saturation value for a particular magnetic field. This results in constant electric field, there by decreasing dE/dH with increase in H. Absence of ME effect in X=0.55 composite is attributed to the low value of resistivity offering a conducting path for the developed charges to leak.

The present composites with a suitable combination of constituents can be used to decrease or increase the $BaTiO_3$ transition temperature and $MnFe_{1.8}Cr_{0.2}O_4$ transition temperature. The type of charge carriers can be lowered and the resistivity can be lowered. Moreover the ME sensitivity was expected to the higher than that reported in the present work presuming Jahn-Teller distortion in the ferrite. Unfortunately, the present ferrite exhibits cubic spinel structure though often such ferrites tetragonal distortion. It is likely that a composite with a tetragonally distorted ferrite might show large ME effect.

REFERENCES

1. S. V. Suryanarayana, "Magnetoelectric Interaction phenomenon in Materials" Bull. Mater. Sci 17(7), (1994), 1259-1270.
2. AE Gelyasin Sov. Phy. Tech. Phy. 33 (11), 1988, 1361-1362.
3. KK Patankar, S. A. Patil, K. V. Sivakumar, R. P. Mahajan, Y. D. Kolekar, M. B. Kothale, Mat. Chem. Phys., 8667 (2000) 1-6.
4. Abrahms S. C. and Reve E. T. (1971), Ferroelectrics Vol. 2, 129, England.
5. Stanley K. J., "Oxide Magnetic Materials", Clarendon Press, New York, Chapt. 2 (1962)7.
6. Henry N. F. M. Lipson H. and Wooster W. A. "Interpretation of X-ray diffraction photographs", McMillan and Co. Ltd., London (1961).
7. R. P. Mahajan, Ph.D. Thesis, Deptt. of Physics, Shivaji University, Kolhapur (2000).
8. K.K. Patankar, K.V. Sivakumar, S. A. Patil, R. P. Mahajan, Physics Status Solidi (a) (in press).
9. J. VAN DEN Boomghaard, A.M.J.G., VAN RUN and J. VAN SUCHDELEN, ferroelectrics, 14 (1976) 727-728.
10. J. Van Den Boomgaard, R.A.J. Born J. Mater. Sci. 13(1978) 1538-1548.