CHAPTER IV

Summary and Conclusion

4.1 SUMMARY AND CONCLUSION

Though ferrites were first known in the beginning of the century, an extensive work was carried out after 1950. The ferrites are ferrimagnetic oxides and have an important electrical and magnetic properties. Owing to these properties they have been very useful materials in electrical and electronic industries. Basically they are semi-conductors having resistivity values in the range 10^{-3} to 10^{+11} ohm.cm. They were developed with main objective of reducing eddy current losses particularly at high frequencies.

The preparation of ferrites is that way not a difficult task but since their properties depend on physical parameters as homogeneity, grain size, porosity, density etc. The emphasis is always been given on the manufacture with greater reliability of reproduction that is "tailor making of these materials". In the first chapter of this dissertation, the control of these parameters has been explained. While discussing the methods of preparation, the other methods are simply made mention of and the ceramic method has been discussed in detail. All the steps that are followed in this method are fully explained. The crystal structure of the ferrites is said to be spinel structure. In the same chapter this has been discussed giving importance to the inverse spinel structure. This has been explained by giving necessary figures. The conductivity mechanism in the ferrites is also discussed with giving the role of certain parameters such as temperature, impurity, composition and excess iron. Electrical switching, in general, has also been discussed and at the end of this chapter, the outline and orientation of the dissertation problem is discussed.

The second chapter is devoted for explanation of experimental technique that is followed in preparation of the system $Cu_xFe_{3-x}O_4$ and the X-ray diffraction work of the system. Copper ferrite has been prepared by standard ceramic method[1] in both stoichiometric and non-stoichiometric propertions and all the steps that has been actually followed are fully given. The pure oxides were obtained from Riddle Heiag Seize Honouer, Germany. The necessary calculations made are given which helps the reader to understand the ceramic method. The x-ray diffraction work was carried out at T.I.F.R. Bombay on PW 1051 Philips Diffractometer. The principle of diffractometer and also powder method are discussed. The x-ray diffractometer photographs of all the compositions of system $Cu_xFe_{3-x}O_4'$ are also given. The indexing of the reflecting planes is correctly done and characterization of crystal structure has been done, by making all the computations necessary for 'd' values and the lattice parameters. All the samples were slow cooled from above the reaction temperature and it was found that the axial ratio c/a is different for first three samples (x=1, 0.8, 0.6) and they are tetragonal with peculiar variation of c/a. This has been explained by plotting a graph of composition versus lattice constants. The last two samples (x=0.4, 0.2) are found to be having cubic crystal structure. The reflecting planes were found to agree well with the allowed reflections for spinel structure. Thus x-ray diffraction has revealed the change of crystal structure with composition and variation of c/a ratio in the tetragonal samples.

In the third chapter first few pages are given to discuss the experimental set up used for determination of I-V characteristics and the theories of switching behaviour such as VCNR, CCNR and memory have been discussed in short. The rest of pages are devoted to the results and discussion of the work carried out on the copper ferrite system. The major work of this dissertation is on switching behaviour in this system which is an interesting and important property which may lead its application in the electronic industry. Totally 20 different samples have been prepared with different composition and quenching temperatures. The stoichiometric slow cooled copper ferrite does not show switching behaviour at room temperature, however it is found that it exhibits switching at elevated temperatures. This property was attributed to Joule-self heating together with change of crystal structure. All the non-stoichiometric copper ferrites except composition x=0.2 also exhibit switching behaviour some at room temperature and some at elevated temperatures. The complete data on I-V characteristics has been presented giving graphs of each sample. However to save the space, the I-V characteristics on each sample at different temperatures are given together. The peculiar result which is reported[2] from the present work is that the I-V characteristics for the samples having cubic structure is of repeatative nature while for the sample having tetragonal crystal structure the first switching cycle is different from second and successive cycles. But second and successive cycles in tetragonal structured samples is very similar to that of cubic structure. Thus a structural change during electrical switching was predicted from I-V characteristic study. In order to confirm this structural change the x-ray diffractrometry of the samples was done after switching has taken place. It was found that the cubic structure (x=0.4) changes to tetragonal structure with $c/a > 1$ and this is in conformity with the previously reported work on Mossbauer effect. This change of crystal structure is attributed to Joule-self heating during switching experiment. The change of crystal structure observed after switching in tetragonal sample with x=1 is again peculiar, the c/a ratio changes over from $c/a > 1$ to $c/a < 1$. The diffractometric records obtained after switching in these samples are also presented and the 'd' values and lattice parameters are calculated.

The space charge limited currents (SCL) in copper ferrite system is an interesting property. After explaining the SCL currents in the third chapter itself, some calculations are carried out. From the graphs of log I versus log V and log (I/V) versus voltage (V), it is confirmed that the SCL currents do exist in the samples. However, these calculations could not be extended for all the samples in the system, owing to nonavailability of certain parameters in literature. Similarly, eventhough SCL currents were confirmed in these samples the observed $t.N_t$ values do not agree with the theoretical values of $t.N_t$.

The switching behaviour in stoichiometric copper ferrite was first reported by T. Yamashiro in 1973. The switching is expected to be more sensitive to the non-stoichiometric samples and therefore the above said work was carried out on both stoichiometric and non-stoichiometric copper ferrites in the pellet form. The properties of ferrites depend on physical parameters and therefore it is always difficult to control the final product. Hence one aims at tailor-making work of desired properties.

4.2 REFERENCES

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2. M.M.Todkar, S.A.Patil and A.S.Vainganker : Communicated, "Structural Change During Electrical Switching in Copper Ferrite". J.Phys.C.: Solid State Phys. (1981).

CONTRIBUTION TO SYMPOSIUM

The following papers were presented in Poster Session by M.M.Todkar himself in N.P.S.P. Symposium at I.I.T. New Delhi (December 1980).

1) A.S.Vaingankar, M.M.Todkar and S.A.Patil : "Switching Behaviour in Slow Cooled Copper Ferrite".

2) M.M.Todkar and A.S.Vaingankar : "Electrical Switching in Copper Ferrite".

3) S.A.Patil, M.M.Todkar and A.S.Vaingankar : "Switching Behaviour in Quenched Copper Ferrite".

COMMUNICATION

1) M.M.Todkar, S.A.Patil and A.S.Vaingankar : "Structural Change During Electrical Switching in Copper Ferrite", J.Phys.C.: Sobid State Physics (1981).

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