CHAPTER — VI

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SUMMARY AND CONCLUSIONS

Ferrites occupy an important place in the field of electronics and computer technology. They have advanced to a position of technological prominence in the last few decades. They are being extensively studied from the point of view of understanding their behavior and applications. Recently, there has been considerable advances in the understanding of the relationship between microstructural characteristics and physical behavior of ferrites. The increased knowledge of such a relation has led to the development of desired microstructure in ferrites and also to the refinement of their manufacturing processes. The field of ceramic science and technology is therefore continuously developing. In the light of these developments the present ferrite technology is growing.

In the present case, the Magnesium Zinc ferrites have been studied. This ferrite system has been particularly selected because of the recent interest in Zinc containing ferrites. The addition of Zinc in the normal ferrites has led to very interesting electrical and magnetic properties (1, 2). Secondly, the electrical and magnetic properties of these ferrites have been found to be sensitive to their condition of preparation. In order to reveal the role of

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composition, heat treatment and microstructure in governing their electrical and magnetic properties the following studies have been undertaken.

1. Preparation of Mg-Zn ferrites with a general formula $Mg_xZn_{(1-x)}Fe_2O_4$ (x=0.0, 0.2, 0.4, 0.6, 0.8 and 1.0).

2. X-ray diffraction studies to confirm the formation of spinal phase compounds and calculation of lattice parameters and interplaner distances.

3. Electrical conductivity measurements to gain information regarding the conduction mechanism and to determine Curie temperatures.

4. Magnetization measurements to know about their saturation magnetization.

5. SEM studies to characterize their microstructures.

Chapter I describes the general features of ferrites. The historical developments, crystal structure, electrical and magnetic properties of ferrites are briefly discussed here. The applications of ferrites and the orientation of the problems are included at the end of the chapter.

Chapter II deals with the preparation of ferrites. The methods of ferrite preparation are briefly reviewed. The ceramic method has been dealt with in somewhat more detail, since it is used in the present case. The compounds were prepared by homogenizing the component oxides (AR grade Mgo, ZnO and Fe_2O_3) and twice sintering them at 1100° C for 15 hours and 30 hours respectively. The pellets were pressed and sintered for carrying out electrical and magnetic measurements.

X-ray diffraction patterns of the samples were taken using a computerized XRD unit at the Mineralogical Institute, University of Mysore, Mysore. Filtered Fek radiation (λ = 1.93604 A°) was used for crystal structure analysis. The lattice parameters and interplaner distances were calculated by using the standard formulae for the cubic system. The diffraction maxima have been indexed in the light of the natural spinel ($MgAl_2O_4$) structure. The variation of lattice parameters with the content of Zinc in the samples suggests that the Vegard's law in obeyed. Lattice parameter increases linearly with Zn content. It is least for $MgFe_2O_4$ (8.378 A°) and maximum for $ZnFe_2O_4$ (8.431 A°). Since no other extra lines are observed in the diffractometer charts, the formation of the spinel structure is confirmed.

The results regarding the electrical resistivity measurements of our sample are reported in Chapter III. The electrical resistivity of the samples in the pellet form was measured using the two probe technique in the temperature range 30°C to 750°C. The slope of the log ρ Vs. $10^3/T$ curves changes at the Curie point. The change in the slope has been attributed to the effect of magnetic ordering and conducting mechanisms of ferrites. The activation energy for conduction in ferrites has been calculated by using the relation $\rho = \rho_o \exp(\Delta E/KT)$. In general, the activation energy for conduction in the ferrimagnetic region is less, compared to the paramagnetic region.

The Curie temperatures have been recorded at a point on the log ρ Vs. $10^3/T$ curve where it changes its slope.

The Curie temperature values recorded graphically show a decreasing trend as the content of Zinc in the sample increases. Zinc ferrite is normal spinel in nature. As the content of Zinc in the sample increases, the tendency of Zn^{2+} ions to occupy A sites, being more, more and more Zn^{2+} ions divert towards the A sites. The fall of resistivity of the samples with more and more addition of Zinc has been explained by saying that Zinc tends to impede the hopping of polarons on its increase till the sample become antiferromagnetic. The lowering of T_c values also suggests the fact that some Mg^{2+} ions also transfer to the A sites. Trends being the same, the conductivity values for samples sintered for 15 hours are found to be less than the samples sintered for 30 hours at the same sintering temperature. These aspects of conductivity have been explained on the basis of microstructural changes during sintering.

The measurements of magnetic properties on ferrites are contained in Chapter IV PART-A. To carry out hysteresis measurements, the hysteresis loop tracer supplied by M/s Arun Electronics, Bombay, was used. Nickel blocks were used for the calibration of the instrument. It has been observed from the curves showing variation of M_s and μ_B values as a function of Zinc content in the samples, both M_s and μ_B increase upto the presence of certain amount, reach a maximum and then decrease. This has been explained on the basis of Neel two sublattice model. The fall of M_s and μ_B on addition of Zinc can not be, however, explained on the basis of Neel two sublattice model. Triangular arrangement of spins or the Yafet-Kittel three sublattice model has to be taken help of in order to explain such a fact. On addition of Zinc A-B interaction is weakened while B-B interaction goes through a change in its tendency from ferromagnetic to antiferromagnetic type. This interpretation also supports the decrease in Curie temperature of the samples observed in the present case. As far as Zinc ferrite is concerned, A-B interaction is absent and B-B interaction leads to the alignment of equal number of magnetic ions in opposite direction. This assigns zero magnetization to $ZnFe_2O_4$. Magnetization values for sample sintered for 30 hours have been found to be more than the similar values for samples sintered for 15 hours, the trend regarding variation of M_s and μ_s values with Zinc percentage being the same. Microstructural variation during sintering have been used to take care of such difference in values.

Chapter IV PART-B deals with the IR studies. Far IR spectra of the ferrite samples were recorded in the range for 600 cm^{-1} to 200 cm^{-1}. The samples show four bands characteristic of spinel ferrites. The high frequency band (ν_1) has been attributed to tetrahedral metal ion-oxygen complexes and the low frequency band ν_2 to octahedral metal ion-oxygen complexes. The intensity of the third band ν_3 increases with divalent octahedral metal ion concentration. This is in good agreement with the earlier reports in case of cobalt-Zinc and nickel-Zinc ferrites (3,4). The fourth band ν_4 is weak and its presence only can be served. Such a band has been associated with the lattice vibrations of the system.

The last chapter is devoted for the microstructural aspects of ferrites.

The scanning electron micrographs of these ferrite are presented at the end of this chapter. Relevant theory for ceramic microstructure, control of grain size, porosity, hot pressing and microstructure and magnetic properties are given here. A true structure property co-relationship study in ceramics involves a deliberate change in microstructure by giving different heat treatments and then analyzing the properties in the light of developed microstructure. Though such an approach has not been followed strictly,here the observed microstructure is clear enough to show the grain structure and porosity distribution etc. The decrease in porosity is clearly observed from the micrographs for the samples sintered for longer timings. The mechanism of pore growth combined with grain growth gives rise to the formation of a microstructure in which the residual porosity is only present in intergrannular pores. The figs.5.1 and 5.2 give a representative picture for Magnesium-Zinc ferrites.

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