

UNIVERSITY GRANTS COMMISSION

BAHADUR SHAH ZAFAR MARG

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PROFORMA FOR SUBMISSION OF INFORMATION AT THE TIME OF SENDING
THE FINAL REPORT OF THE WORK DONE ON THE PROJECT

1. Name of Principal Investigator - **Dr. Shivanand Appanna Masti**
2. Name and Address of the institution: Dr. Ghali College Gadhinglaj
Tal - Gadhinglaj Dist Kolhapur
416502 (M.S.).
3. UGC approval no. and Date: **File No.-47-381/07(WRO) dated 6/5/2008**
4. Date of the implementation: **6/5/2008**
5. Tenure of the project: 6/5/2008 to 6/5/2010
6. Total grant allocated: Rs. 65000/-
7. Total grant received: Rs. 50000/-
8. Final expenditure: Rs. 65004/-
9. Title of the project: project **“Preparation, characterization and study of electrical and magnetic properties of Gd³⁺ substituted Mg-Zn Ferrites”**
10. Objective of the project: To observe the variations in the electrical and magnetic properties
Whenever Gd³⁺ is added to the Mg-Zn ferrite system.
11. Whether objectives were achieved: yes

12. Achievement from the project: To know the better insight of change in the properties of the ferrites when additives occupy the place of Fe atoms.

13. Summary of the findings:

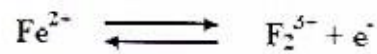
We preferred the standard ceramic oxide method for the preparation of ferrites under investigation. The compositions of the polycrystalline ferrites with the chemical formula $Zn_xMg_{1-x}Fe_{2-y}Gd_yO_4$ ($x = 0, 0.2, 0.4, 0.6, 0.8$ and 1.0 ; $y = 0.05$ & 0.10) have been prepared by using oxides of respective metals or raw material like,

1. Fe_2O_3 (Ferrous oxide)
2. ZnO (Zinc oxide)
3. MgO (Magnesium oxide)
4. Gd_2O_3 (Gadolinium oxide)

The X-ray diffractograms (XRDs) of the ferrite samples under investigation are presented showed the (hkl) planes (220), (311), (222), (400), (422), (511), (440), (620) and (563) planes. These are allowed of FCC crystal structure. Thus all samples under investigation are cubic spinel structure.

To study the dc resistivity, the graphs of $\log \rho$ versus inverse of temperature ($1000/T$) are plotted. The plots of samples having Zinc content, $x = 0, 0.2, 0.4$ and 0.6 show breaks in the linearity of the lines and changes in the slopes in the plots at the temperature equal to the Curie temperature T_c . At this temperature magnetic ordering of the material is destroyed. For the samples under investigation the resistivity decreases with increase temperature, which shows negative temperature coefficient of resistivity. The graph shows strong decrease in the resistivity with increasing temperature, which is attributed to the conductivity due to thermally activated

mobility of charge carriers. This nature of conductivity is attributed to the hopping of electrons between cations like Fe^{3+} and Fe^{2+} situated at octahedral (B) sites.



The plots of $\log \rho$ Vs $1000/T$ for the composition $x = 0.2, 0.4, 0.6$ show only one break, which is related to the temperature called Curie temperature. The plots for the composition with $x = 0.8$ and 1.0 and $y = 0.05, 0.10$ do not show any change in the slope of the line indicating that there is no change in the magnetic ordering of the samples. These samples are paramagnetic in nature at and above room temperature. The sample ZnFe_2O_4 i.e. $x = 1.0$ consists the absence of divalent ions on the octahedral sites. The electrical conduction in this ferrite can also be explained on the basis of the transport of charge carriers through cation vacancies present on octahedral sites. These cation vacancies may be created in these ferrites during the sintering process.

The activation energies (ΔE) have been calculated from the slopes of $\log \rho$ Vs $1000/T$ graphs, both in the ferromagnetic region and paramagnetic regions. It is found that, the activation energy for paramagnetic region (ΔE_p) are greater than that of ferromagnetic region (ΔE_f). This is attributed to the magnetic phase transition. The phase transition is known as order to disorder transition. In ferromagnetic, there is magnetic ordering while above Curie temperature magnetic disordering. This disordering provides resistance to the conduction. Therefore activation energy in Para region is greater than ferri region. The activation energy suggest that electron hopping mechanism for the conduction for the compositions $x= 0.2, y = 0, 0.05$, between the two equivalent octahedral sites.



The higher activation energy ($\Delta E > 0.3\text{eV}$) in the composition $x = 0, 0.2$; $y = 0.05$ suggest the conduction mechanism due to polaron hopping. An electron in the crystal lattice interacts through its electrical charge with the ions or the atoms of the lattice, to create a local deformation of the lattice. The deformation further follows the electron as it moves through the lattice. The combination of electron together with its strain field is known as 'Polaron'. On cadmium substitution, the activation energy is found to be decreased. The substituted cadmium ion invariably occupies the tetrahedral (A) site displacing iron from A-site to B-site, this provides increase in the concentration of iron ion on B-site and hence activation energy decreases.

It is also found that the electrical resistivity increases with Gd^{3+} substitution. The conduction in the ferrite is due to hopping of electrons among iron ions on B-sites. During the hopping, change in valency takes place. On substitution of Gd^{3+} activation energy, found to increase. The increase in resistivity is attributed to the decrease in mobility, on substitution of Gd^{3+} ions.

The compositions $x = 0, y = 0, 0.05$ and 0.10 shows negative slopes between T_s and T_c . This can be attributed to the phase transition to the cation migration and the cation ordering. When migration of the cation starts, the change in the slopes of resistivity curve takes place and it attains the temperature T_s , the spin alignment is forced to change. This change in the spin alignment takes place up to Curie temperature (T_c).

The thermo-emf of the samples under investigation were measured in the temperature range 300K to 750K with constant temperature difference equal to 10K . N-type semiconducting

behavior suggests that the conduction mechanism is predominantly electron hopping. On Gd^{3+} substitution, the Seebeck coefficient is found to be decrease. This may be due to Gd^{3+} ion occupies B-site, which results into decrease of Fe^{3+} ions of B-site. This substituted Gd^{3+} ion has stable valence (+3) and it does not contribute to the hopping process but provides hindrance to it.

The magnetic parameters like saturation magnetization, magnetic moment and $4\pi M_s$ were determined. From our study, it is found that M_s and n_B are increasing with increase in Zn^{2+} contents up to $x = 0.4$ and $y = 0, 0.05, \text{ and } 0.1$. This suggests that Neel's two sublattice model is applicable to the composition. The M_s and n_B increases for Gd^{3+} substitution which is attributed to the ferromagnetic ordering of Gd^{3+} .

The AC susceptibility measurements of ferrites were made in the temperature range from 300 K to 700 K on Helmholtz double coil setup operated at 263 Hz with the constant field of 7 Oe. From the graphs of normalized susceptibility (χ/χ_{RT}) versus temperature observed that the plot for $x = 0, y = 0$, the susceptibility slowly increases and reaches a peak value. It suddenly drops to zero. The sudden drop of χ/χ_{RT} curve shows the formation of single-phase cubic spinel. For the formation of composition $x = 0.2$, susceptibility is independent on temperature up to T_C and after T_C it suddenly drops to zero. The temperature independent susceptibility suggests that the composition $x = 0.2$ exhibit multidomain particles. The composition $x = 0.4$, and $x = 0.6, y=00$ shows exponential decrease in susceptibility beyond T_C indicates that the single to super paramagnetic. The composition $x = 0.8$ and 1.0 shows paramagnetic behavior. It is known that $CdFe_2O_4$ and $ZnFe_2O_4$ are paramagnetic at room temperature. Thus the data leads us to conclude that the magnesium ferrite with $y = 0.05$ and 0.1 substitution of Gd^{3+} predominately contains SD particles. Subsequently it was also found that substitution of Gd^{3+} , the Curie temperature of

magnesium ferrite decreases. Graphs for $x = 0.2$ and 0.4 , $y = 0.05$ and 0.1 shows temperature independent behavior of susceptibility exhibiting MD particles. Additional Gd^{3+} further decreases in Curie temperature were observed. Therefore it can be said that with increase in cadmium and chromium in magnesium ferrite, the SD nature particle was lowered. Thus addition of foreign ion the magnetic properties of $MgFe_2O_4$ are significantly modified. With substitution of Gd^{3+} in the composition shows further transition in domain structure from SD to MD and then SP nature with increases in cadmium content.

14. Contribution to the society: Especially this is research project which adds the knowledge of effect of additions of impurities in pure ferrite system. The ferrites are very important part of electronic and everyday life of human hence more work in this field will help in finding the new technologically better Material for the benefit of the society.

15. Whether any Ph. D. enrolled/ produced out of the project: No

16. No. of publications out of the project: Two papers communicated to the editor of Indian Journal of physics and Indian Journal of Pure and Applied Physics.



PRINCIPAL INVESTIGATOR



Principal
Dr. Ghali College
Gadhinglaj, Dist. Kolhapur