Journal of Magnetism and Magnetic Materials 102 (1991) 181–183
North-Holland

Magnetic loss studies on lithium zinc ferrites

R. Raman [a], V.R.K. Murthy [a] and B. Viswanathan [b]

[a] *Department of Physics,* [b] *Department of Chemistry, Indian Institute of Technology, Madras-600 036, India*

Received 28 November 1990; in revised form 15 April 1991

The magnetic spectral studies on lithium zinc ferrites have been carried out by two independent measurements. The results of rf frequency studies indicate the existence of the domain wall resonance. The microwave absorption studies at various static magnetic fields indicate the rotational resonance. These phenomena strongly depend on zinc content.

1. Introduction

In recent years, the lithium ferrite system [1,2] has been used for microwave and low frequency applications. Various substitutions have been incorporated to achieve desired electric and magnetic properties. The useful frequency range of ferrite is limited by the onset of relaxation process either because the permeability begins to fall at a somewhat lower frequency or the losses rise sharply. Hence the knowledge of the frequency dependence on initial permeability and loss is necessary. Reports of magnetic spectral studies on various ferrite materials are available in literature [3–5]. The present paper aims at discussing the magnetic spectra at radio frequencies and microwave absorption studies on lithium zinc ferrites. The samples have the chemical formula $Li_{0.5-x/2}Fe_{2.5-x/2}Zn_xO_4$ with $x = 0.0$, 0.1, 0.3 and 0.6 and are represented as A, B, C and D respectively.

2. Experimental part

Toroidal shape samples of outer and inner diameter 2.5 and 1.3 cm and thickness of about 0.5 cm, were used for the permeability measurement. The samples were prepared by double stage sintering with firing temperature at 900 °C. Bismuth oxide flux material was added to ensure good densification. A noncapacitative winding [6] was used for permeability measurements. A HP LCR bridge was used for the measurements of initial permeability and loss in the frequency range from 10 kHz to 10 MHz at 300 K. Microwave absorption at 9.17 GHz was carried out using a standard X-13 klystron bench. Thin rectangular slab of ferrite sample was kept in a rectangular waveguide E plane configuration. The power absorption at various static magnetic fields was measured.

3. Results and discussion

The frequency variation of initial permeability and loss at 300 K are shown in figs. 1 and 2 respectively. The initial permeability curve for polycrystalline ferrites are made up of two mechanisms viz., wall motion and spin rotation [7]. The respective initial permeability equations are,

$$(\mu - 1)_{\text{rot}} = \mu_0 M_s^2 / 2K,$$

$$(\mu - 1)_{\text{wall}} = \tfrac{3}{16} M_s^2 D / \gamma,$$

where M_s is the saturation magnetization, K the anisotropy constant which is the sum of magnetocrystalline and magnetoelastic anisotropies, D the average grain size and γ the domain wall energy which is directly proportional to $\sqrt{K}$. From figs. 1

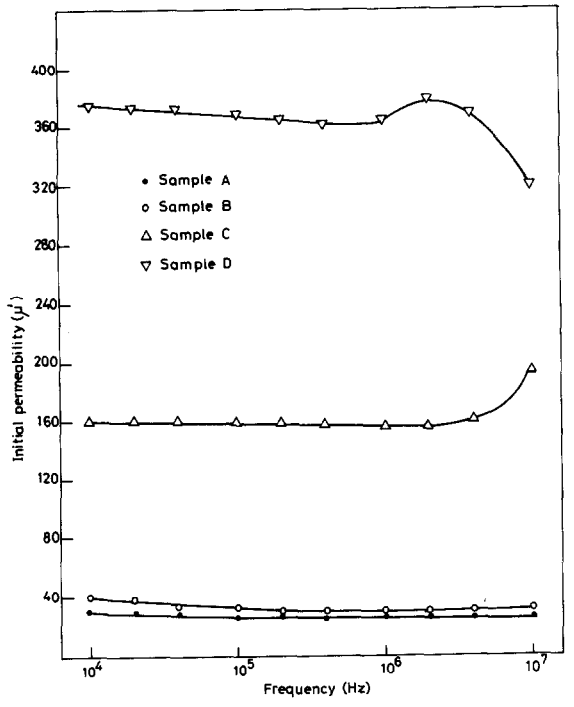

Fig. 1. Variation of initial permeability μ' with frequency.

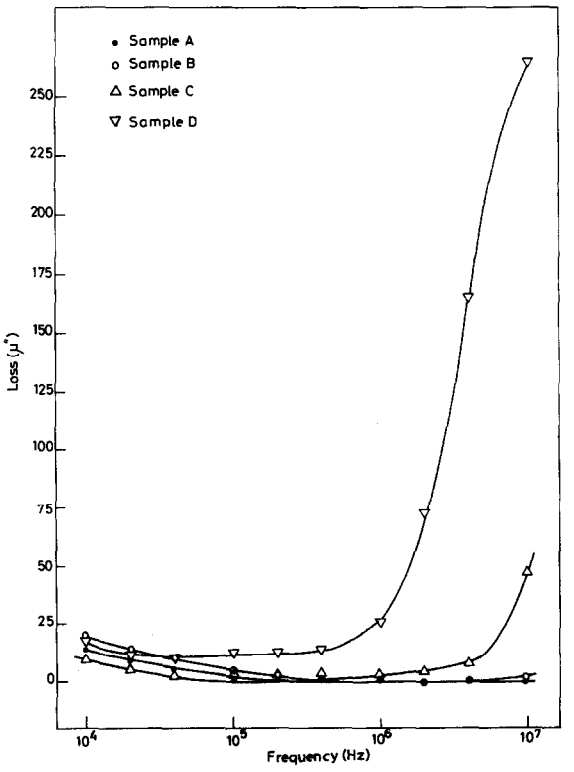

Fig. 2. Variation of loss μ'' with frequency.

and 2, the existence of a relaxation type mechanism is observed for the sample D in the range of frequencies under investigation. This kind of relaxation is attributed to domain wall resonance [4]. Domain wall resonance for other samples may occur at higher frequencies. The effect of zinc is to decrease the anisotropy constant K. This is the reason why the onset of domain wall resonance takes place at relatively lower frequencies for the sample D.

Microwave power absorption at various static magnetic fields is shown in fig. 3. From the general resonance conditions, power absorption should increase with magnetic field. But from fig. 3 it is seen that the power absorption decreases with magnetic field at the lower field region for all the samples except sample D. However at higher fields the usual resonance absorption starts. Since the applied magnetic field is parallel to the plane of the samples the samples can be magnetized to near saturation with a field of about 1 kOe. The decrease in the absorption at the lower magnetic field region is due to the decrease of rotational

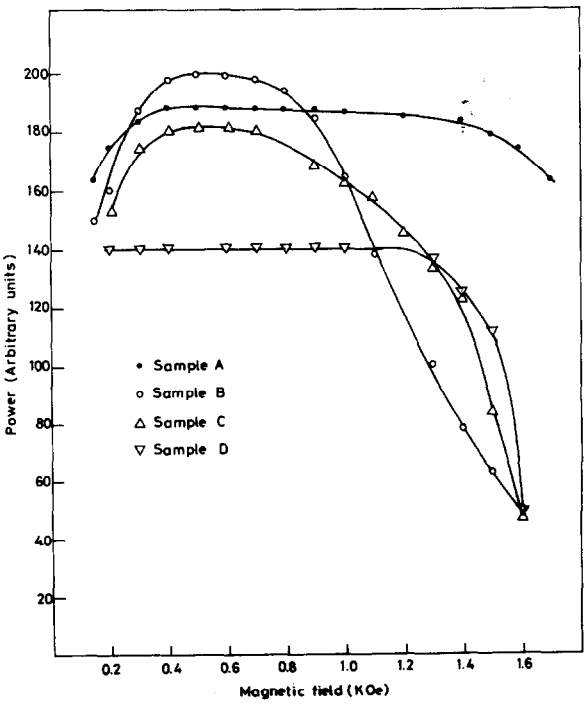

Fig. 3. Variation of microwave power abosorption with magnetic field.

resonance absorption which vanishes upon saturation. However the results of sample D indicates that the rotational resonance does not occur at the frequency of study. This process may occur at the lower microwave frequency side. It is interesting to mention that the domain wall resonance also occurs at relatively lower frequency region for sample D.

4. Conclusions

Permeability is made up of domain wall and rotational mechanisms. There exists a radio frequency domain wall resonance and microwave frequency rotational resonance. The addition of zinc decreases the frequency of resonance. The rotational resonance can be understood by subjecting a ferrite with a dc magnetic field and a microwave field.

Acknowledgement

Financial assistance from CSIR, New Delhi is gratefully acknowledged.

References

[1] P.D. Baba, G.M. Argentina, W.E. Courtney, G.F. Dionne and D.T. Temme, IEEE Trans. Magn. MAG-8 (1972) 83.
[2] William Simmonet and Automio Hermosin, IEEE Trans. Magn. MAG-14 (1978) 903.
[3] J.L. Snoek, Physics 14 (1948) 207.
[4] G.T. Rado, Rev. Mod. Phys. 25 (1953) 81.
[5] L.A. Davidov, S.A. Poltinnikov and M.F. Bryzhina, Sov. Phys. Solid State 7 (1965) 596.
[6] J. Smit and H.P.J. Wijn, Ferrites (Philips Technical Library, Eindhoven, 1959).
[7] A. Globus and P. Duplex, IEEE Trans. Magn. MAG-2 (1966) 441.