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Short communication

Improved dielectric and magnetic properties in modified lithium-ferrites

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Abstract

Single phase polycrystalline lithium ferrites modified with Zn and Mn were synthesized by solid state reaction method. The prepared samples exhibit a markedly increased value in real part of dielectric constant (ε) and a lowest loss tangent (tanδ) for $x=0.04$ measured in the frequency range 70 Hz to 1 MHz. The saturation magnetic moment (M_s) varies non-monotonically for different values of x. A maximum value of $M_s=76$ emu/g has been found for $x=0.02$. Such results in lithium ferrite based ferrites being found rarely.

Keywords: C. Magnetic properties; Dielectric constant; Lithium ferrite

1. Introduction

The modified lithium ferrites are advantageous due to their application potentials in the microwave frequency range. Some of the attractive features of lithium ferrite, such as high Curie temperature, high saturation magnetization and square hysteresis loop properties offer many advantages over other spinel ferrites used in microwave and memory core applications. For example, these ferrite compositions are useful for the multilayer chip inductors which are important components for electronic products such as notebook computer, cellular phone etc [1–3]. A lot of investigations have been carried out to make further improvements in dielectric and magnetic loss tangents, anisotropy, coercive force, density, etc. Also, the interesting features are that their properties can be tailored by controlling the preparation methodology and type and amount of substituents. Some of the commonly used substituents in lithium ferrites are Zn, Ti, Mn, Ni, Co, etc. Effect of simultaneous substitution of Zn and Ti on lithium ferrites has also been reported earlier. Addition of MnO_2 in certain ferrites like lithium ferrite, Mn–Zn ferrite, Ni–Cu–Zn ferrite has been found to be an effective substitution to improve their properties [4–7]. The aim of the present work is to investigate the influence of Mn^{4+} substitution on the structural and magnetic properties of Li–Zn ferrites.

2. Experimental

Zn–Mn substituted Li-ferrites with compositional formula $Li_{0.49}Zn_{0.02}Mn_xFe_{2.49-x}O_4$ (x=0.00 to 0.06 in step of 0.02) were prepared using high purity (>99%) AR grade starting materials in powder form (Li_2CO_3, ZnO, MnO_2 and Fe_2O_3) by conventional solid state reaction route and then were pressed into circular pellets and finally these pellets were sintered conventionally [8]. Pellets were sintered at 1050 °C for 2 h using conventional furnace (at the rate of 5 °C/min). After sintering, the samples were characterized using Rikagu X-ray diffractometer using CuK_α ($\lambda=1.54$ Å) radiation. Dielectric

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constant and tanδ were measured as a function of temperature (30–150 °C) and frequency (70 Hz–1 MHz) using LCR meter (HP-4284A). Magnetic properties were studied using a Lake Shore 735 Vibrating Sample Magnetometer (VSM) Controller, Model 662, interfaced with a computer.

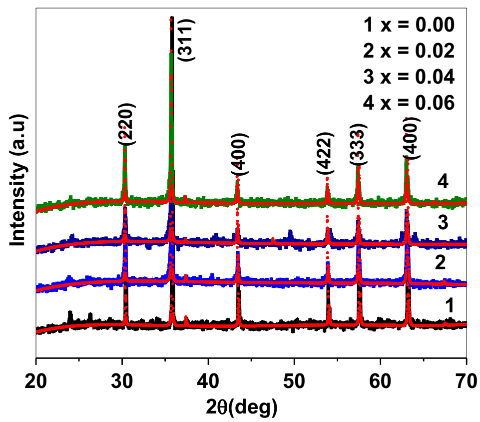

Fig. 1. XRD patterns for all values of x.

Table 1
The value of lattice parameter 'a', ε, tanδ and M_s of $Li_{0.49}Zn_{0.02}Mn_xFe_{2.49-x}O_4$ at room temperature (30 °C).

x	A (Å)	ε	tanδ	M_s (emu/g)
0.00	8.31758	111,732	0.24	30
0.02	8.33078	30,533	0.96	76
0.04	8.33442	3,994	0.38	49
0.06	8.33708	45,468	0.60	73

3. Results and discussion

X-ray diffraction (XRD) patterns for all the samples are shown in Fig. 1. All samples exhibit single cubic spinel phase with space group symmetry $Fd3m$. The pattern is indexed by using Rietveld method and the lattice constant is found to be increased with Mn^{4+} substitution. The lattice constant 'a' is given in Table 1. Frequency response of dielectric constant 'ε' and tangent loss 'tanδ' for all samples at room temperature is shown in Figs. 2 and 3, respectively. Very high value of ε is observed in all samples. Both ε and tanδ show a decreasing trend with increase in frequency, with the exception that there is only a small increase in tanδ beyond 100 kHz in case of sample with x=0.02 and 0.06 which may be due to some external factors. The decrease in ε with increase in frequency is due to the fact that at lower frequencies all types of polarizations like electronic, ionic, dipolar and interfacial polarization are present resulting in high ε is high but at higher frequencies the contribution from the bigger dipoles decreases which cannot oscillate with frequently changing field and only electronic polarization contributes to the dielectric polarization. The sample with x=0.04 shows small value of tanδ ($\sim$0.4) as compared to other samples. The values of ε and tanδ at 100 kHz room temperature are given in Table 1. Figs. 4 and 5 shows the variation of ε and tanδ with temperature in the range of 30 to 150 °C at 1, 10 and 100 kHz. The value of ε in ferrites is generally interpreted by assuming the mechanism of dielectric polarization to be similar to that of conduction process. Electron exchanges between the Fe^{3+}/Fe^{2+} ions at the B sites results in producing space charge polarization when an external field is applied across the sample. However, when the number of Fe^{2+} ions is expected to be higher in ferrite sample, polarization and hence the ε is expected to rise. In the

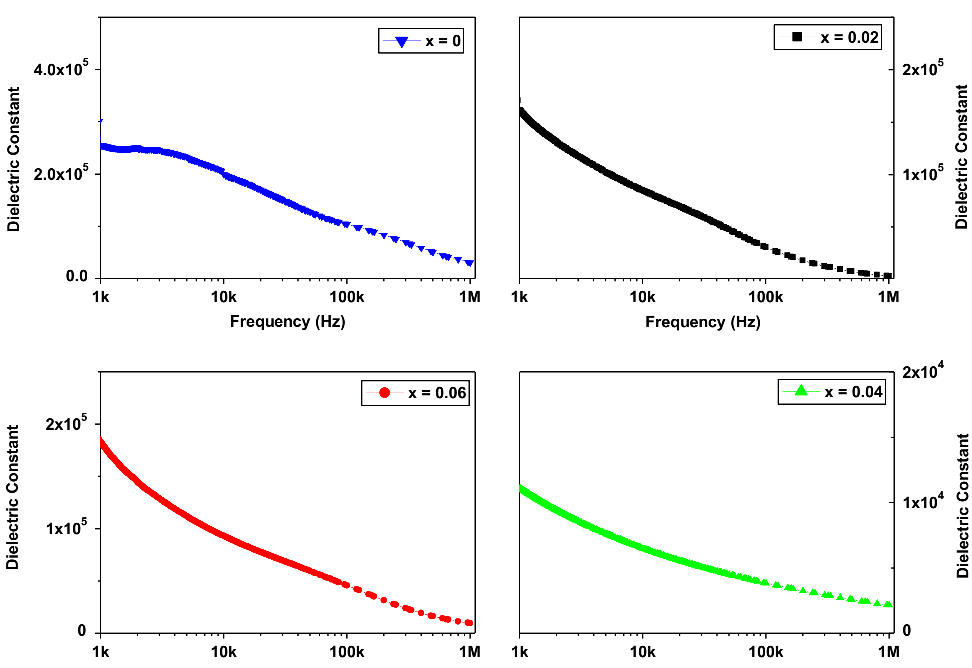

Fig. 2. Variation of ε as a function of frequency at room temperature.