Magnetic and anomalous dielectric behavior of Mn modified $Ba_2Mg_2Fe_{12}O_{22}$ hexaferrite

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Abstract: We have investigated structural, dielectric, magnetic and magnetoelectric (ME) properties of $Ba_2Mg_2(Fe_{1-x}Mn_x)_{12}O_{22}$ (x=0, 0.04, 0.08) hexaferrite. Rietveld refinement of X-ray data confirms the phase purity with rhombohedral crystal structure *(R-3m* space group). An anomalous behaviour of fitted parameters obtained from dielectric and impedance spectroscopy near $\mathbf{T_c}$ (Curie temperature) is explained in terms of Maxwell-Wagner interfacial polarization effect. Mn substitution causes a substantial decrease in $\mathbf{T_c}$ from 647 K (parent sample) to 623 K (4% Mn doped) which is due to modification in super exchange angle of Fe at octahedral sites. Our results confirm the decrease in magnetocrystalline anisotropy constant (K) by ~54% and coercive field (H_c) by ~12 % due to formation of Bloch wall upon Mn doping. Evidence of ME coupling at room temperature is reported in all Mn doped samples.

1. INTRODUCTION

Hexferrite materials continue to be interesting due to their remarkable electrical, magnetic, ME properties, and potential applications in electronic devices [1]. Recently, Y-type hexaferrite has attracted attention for their possibility of tailoring electrical, magnetic and ME properties by varying doping and sintering condition. It is reported that, the magnetic ordering in Y-type $BaSrCoZnFe_{12}O_{22}$ can be modulated by Al doping at Fe site, which tunes magnetic anisotropy by decreasing polyhedral distortion [2]. Several reports on hexaferrite mainly focused on magnetic properties but very few materials have both high resistivity and ME properties. This can be achieved by either controlled synthesis or suitable doping.

2. RESULTS AND DISCUSSION

2.1. Dielectric Study

Fig. 1 shows fitting of imaginary part of dielectric permittivity in frequency range (100 Hz ≤ f ≤ 1 MHz) for pure and 4% Mn doped sample at 300 K. The anomalous behaviour of fitted parameters obtained from different temperatures (300 K ≤ T ≤ 720) is plotted in set of fig. 1 for pure sample.

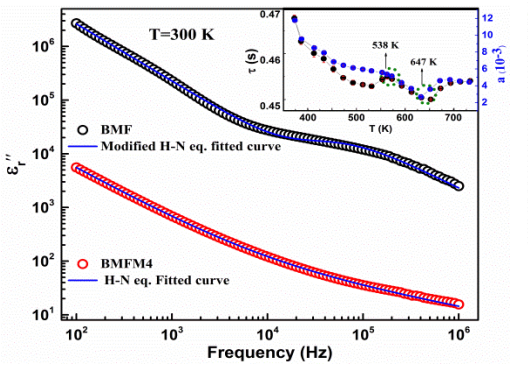
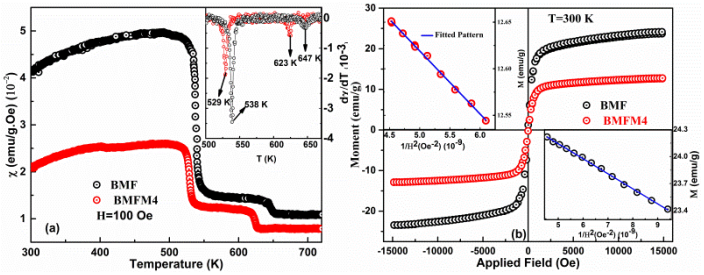


Fig.1 Dielectric permittivity (ε″) versus frequency plot at 300 K of BMF (x=0) and BMFM4 (x=0.04), solid line is fitted curve by normal and modified H-N (Havriliak–Negami) eq. Inset of fig. 1 is relaxation time (τ), exponent (a) versus temperature plot of BMF

The anomalous behaviour is explained in terms of Maxwell-Wagner effect by dielectric and impedance measurements. The decrease in inhomogeneity in the sample by considering grain and grain boundary contribution due to doping is elucidated by hoping conduction mechanism.

2.2. Magnetization Study

Fig. 2 (a) shows the temperature dependence of magnetic susceptibility of pure and 4% Mn doped sample from 300 to 720 K measured under an applied DC magnetic field of 100 Oe. The decrease in $\mathbf{T_c}$ on the doped sample is correlated with the change in super-exchange interaction of Magnetic ions in octahedral sites. Fig. 2(b) shows the M-H loop of pure and 4% Mn doped samples. Inset of Fig. 2 (b) are the fitted M-H curve in high field regime. The decrease in M_s, H_c, K and H_A due to doping has been explained in terms of super-exchange interaction and formation of Bloch wall [3]. All these results will be further correlated with structural, magnetic, dielectric and ME properties of all Mn doped concentrations.



(b) M-H at 300 K, inset of fig. (b) Shows fitting of M-H in saturation region by Law of Approach (LoA) eq.

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