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

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Abstract

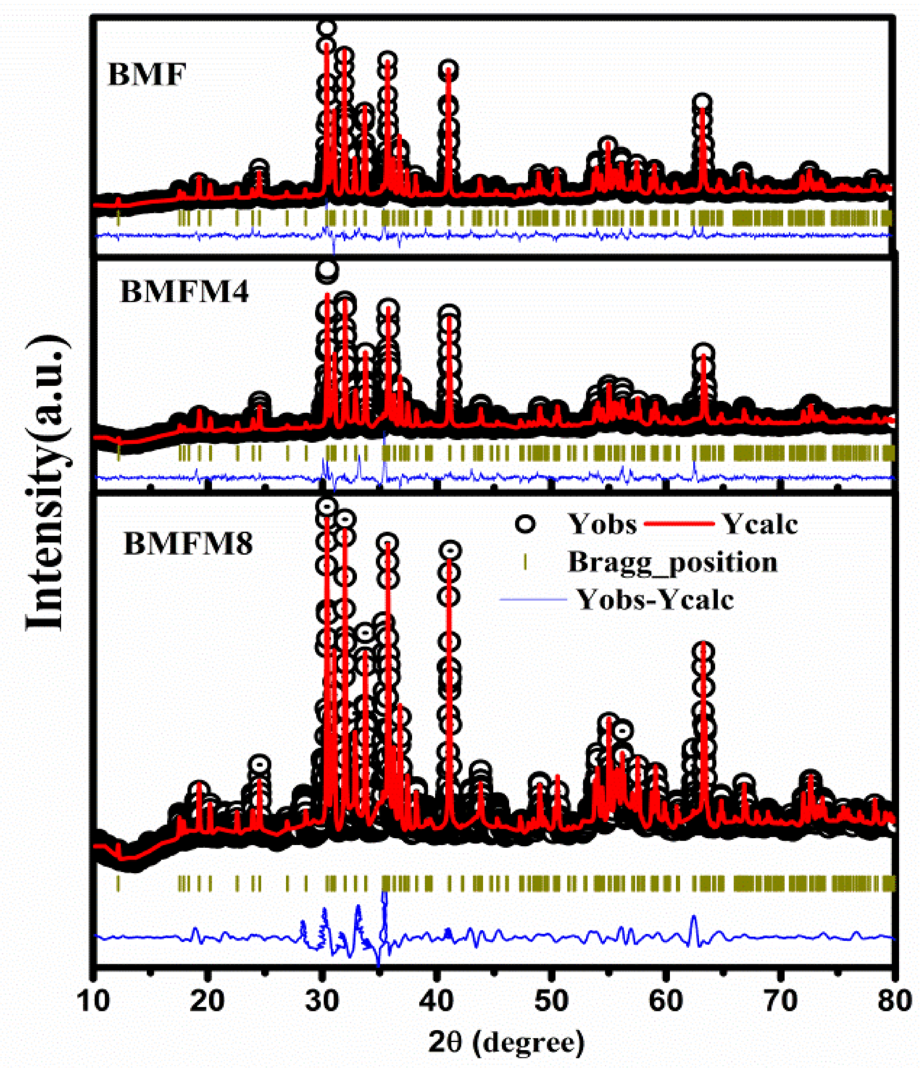
We have investigated structural, dielectric, magnetic and magnetodielectric (MD) properties of $Ba_2Mg_2(Fe_{1-x}Mn_x)_{12}O_{22}$ (x=0, 0.04, 0.08) hexaferrite. Rietveld refinement of X-ray data confirms the phase purity with rhombohedral crystal structure *(R-3m* space group). Mn substitution causes a substantial decrease in T_c from 647 K (BMF(x=0)) to 623 K (BMFM4(x=0.04)) and 621 K (BMFM8(x=0.08)) 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 ~49% and ~117% in BMFM4 and BMFM8 sample respectively in comparison to BMF. Substantial decrease in dielectric constant and switchable magnetodielectric effect is observed at room temperature.

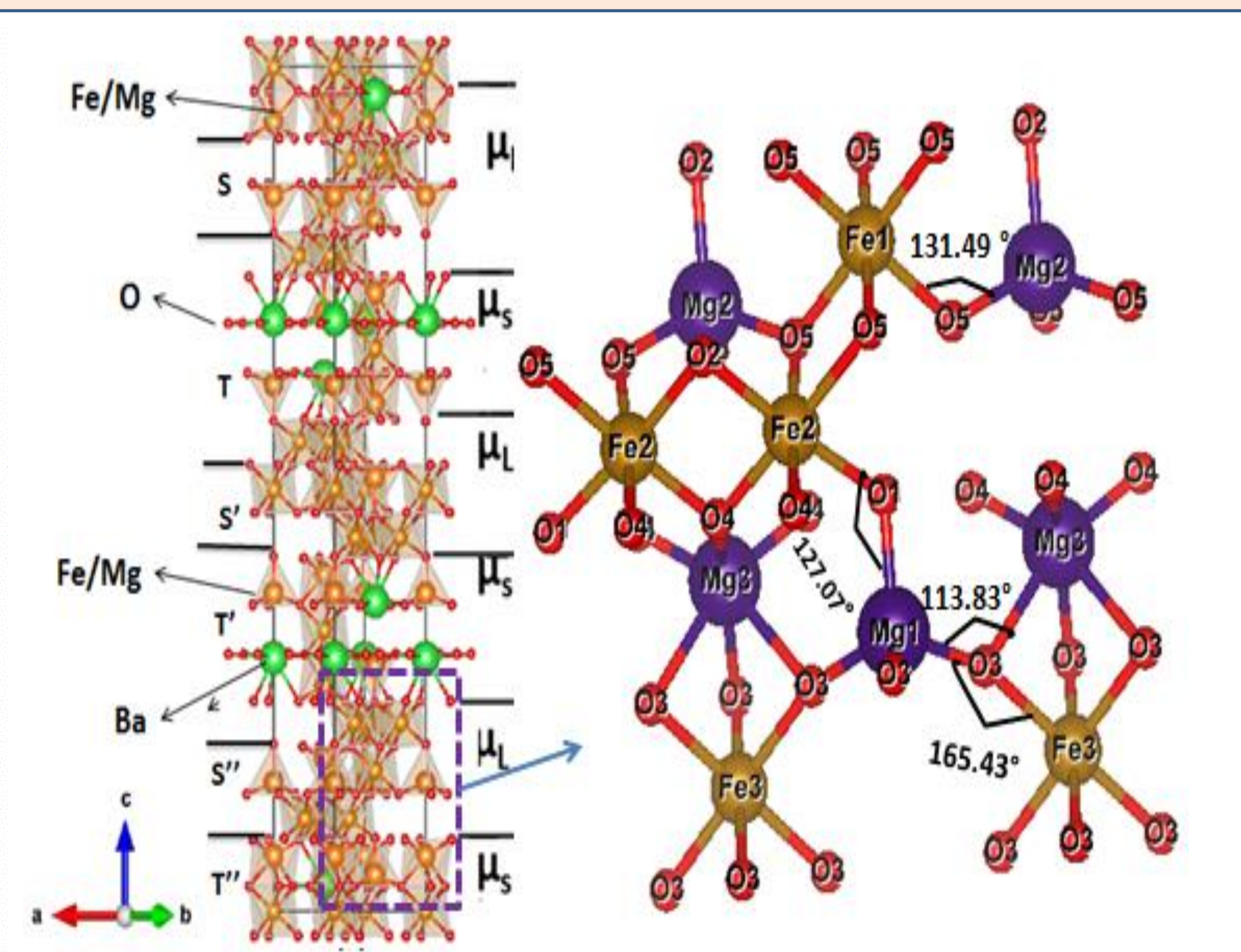
Introduction

- Hexaferrite materials continue to be interesting due to its potential electrical, dielectric and Magneto-electric coupling (MEC) properties at room temperature. [1]
- Recently, Y-type hexaferrite has attracted attention for their possibility of tailoring electrical, magnetic and ME properties by varying doping and sintering condition. [2]
- 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. [3]
- Several reports on hexaferrite mainly focused on magnetic properties but very few materials have both high resistivity and ME properties.
- controlled synthesis or suitable doping are one of the prominent process of getting enhanced properties in hexaferrite sample.

Experimental Results

Structural Characterization

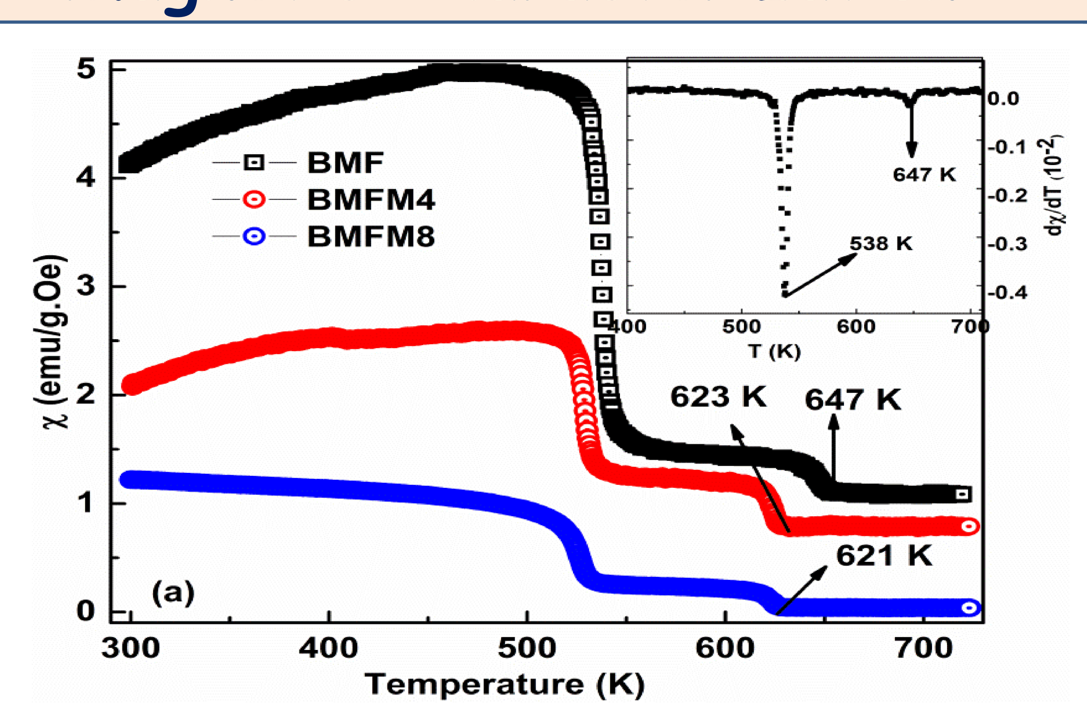


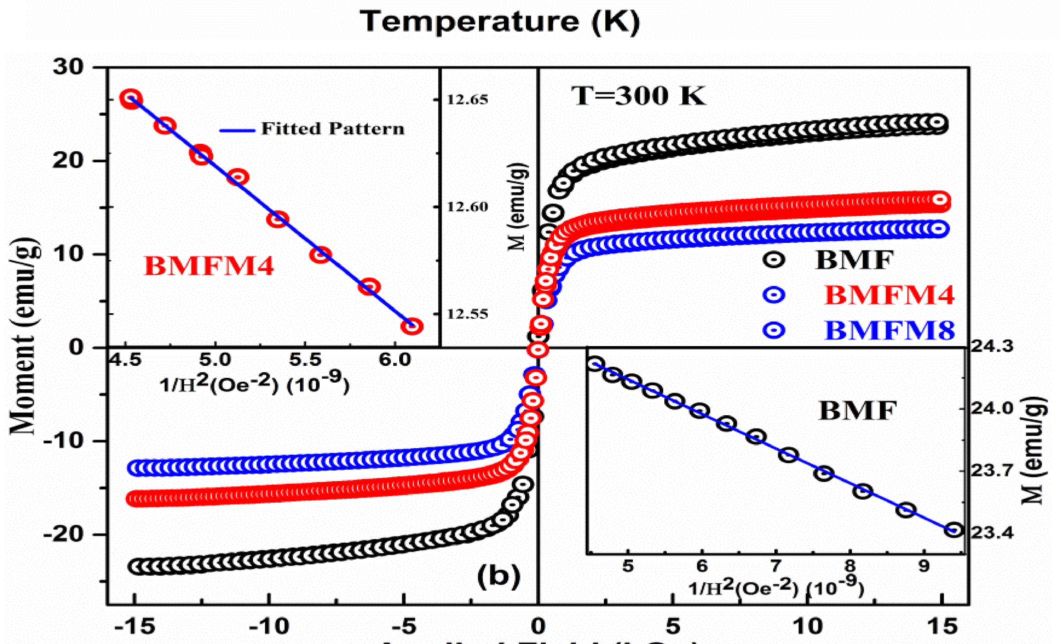


- XRD refinement confirms that all the sample are properly crystallize with space group R-3m.

Bond Angle	BMF	BMFM4	BMFM8
Mg2-O5-Fe1	131.49°	132.08°	132.38°
Mg3-O3-Mg1	127.07°	127.50°	127.00°
Mg1-O3-Fe3	165.43°	164.60°	164.53°
Fe2-O1-Mg1	113.83°	114.80°	118.90°

Magnetic Characterization



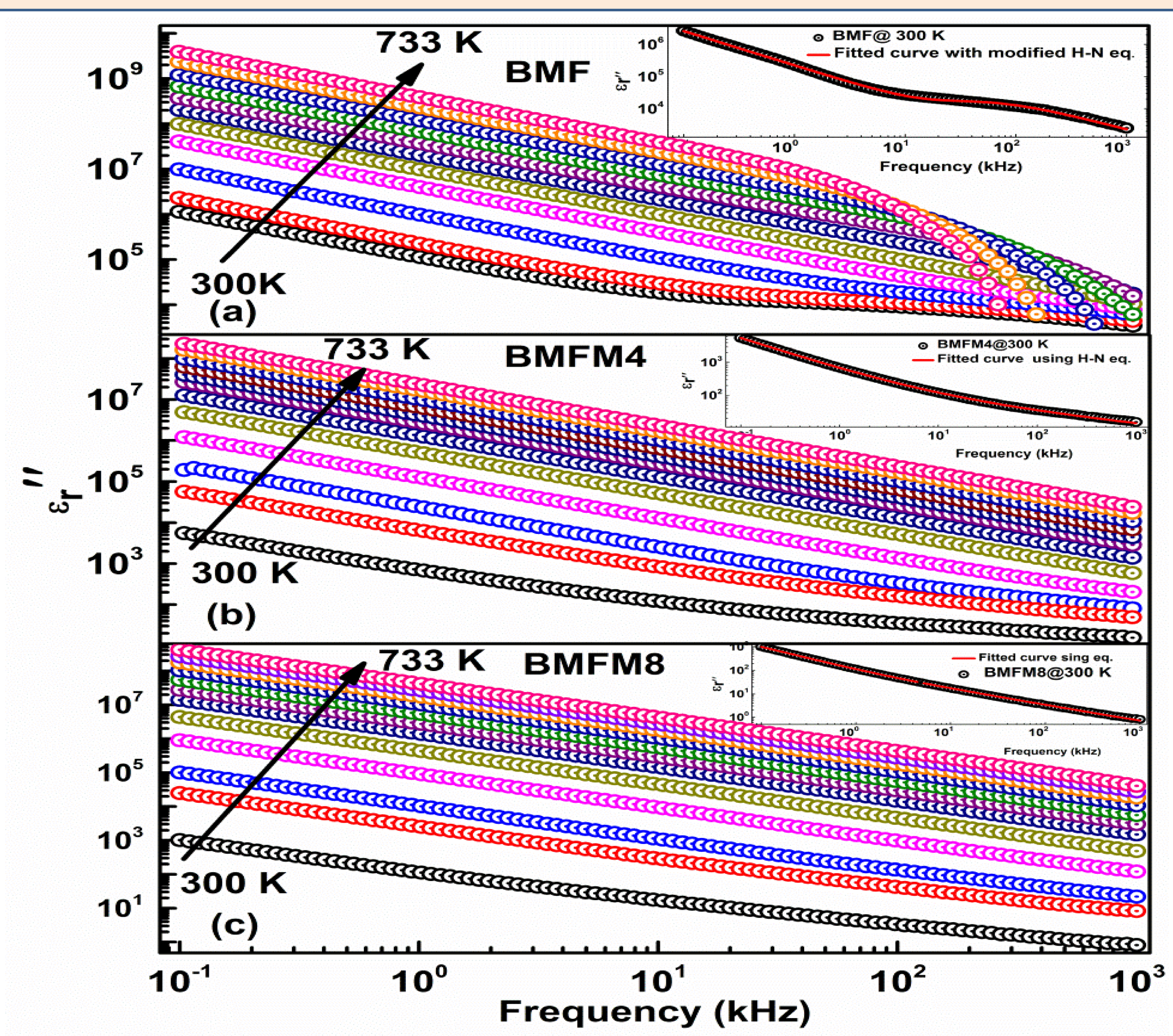


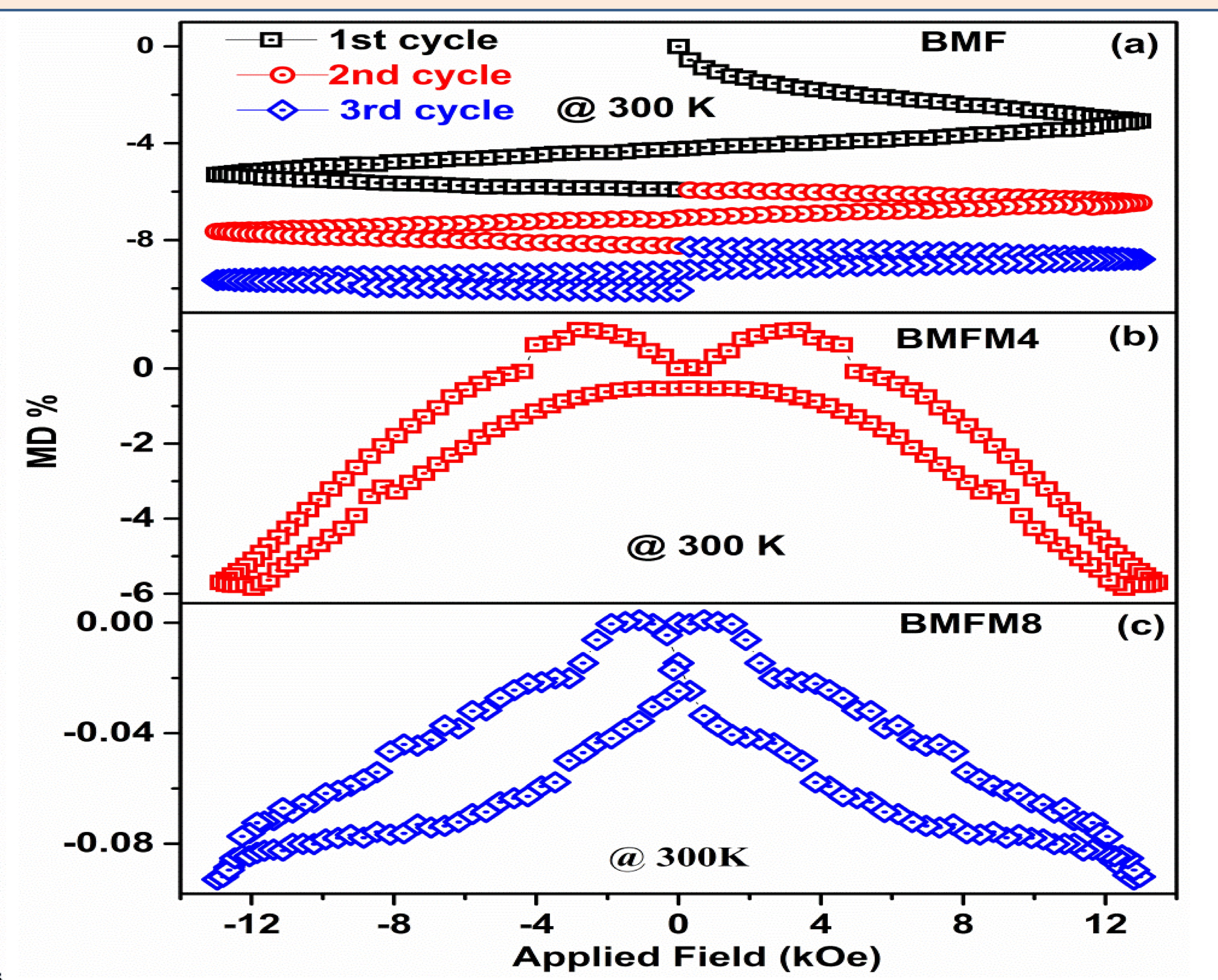
The law of approach to saturation magnetization (LAS)

$M = M_s(1 - A/H - B/H^2)$,M_s is saturation magnetization , *A* represents inhomogeneity, *B* is proportional to the K^2 (K is anisotropy constant)

T(K)	BMF		BMFM4		BMFM8	
	Ms (emugm^{-1})	K_1 (×10^5)	Ms (emugm^{-1})	K_1 (×10^5)	Ms (emugm^{-1})	K_1 (×10^5)
300	24.97	2.33	16.42	1.56	12.95	1.07
373	23.00	2.08	14.15	1.44	12.29	1.07
473	18.05	1.42	10.48	0.98	9.4	0.8
523	13.81	1.51	6.2	1.13	6.88	0.87
573	6.28	1.37	3.22	0.61	3.29	0.64
673	1.40	0.30	1.38	0.34	1.3	0.26

Dielectric and Magnetodielectric Characterization





H-N equation:

$$\varepsilon^*(\omega) - \varepsilon_\infty = \frac{\varepsilon_s - \varepsilon_\infty}{[1 + (i\omega\tau)^\alpha]^\beta} - i\left[\frac{\sigma_{dc}}{\epsilon_o \omega}\right]^n$$

$$MD\% = \frac{\varepsilon(H) - \varepsilon(0)}{\varepsilon(0)} \times 100$$

- Linear increase in MD% with H in BMF sample.
- Switchable MD effect in BMFM4 and BMFM8

Conclusions

- The Reitveld refinement data of prepared sample are single phase rhombohedral with space group R-3 m.
- Curie temperature (Tc) shifted to lower temperature with increasing Mn concentration in the sample may be due to change in super exchange angle in octahedral site.
- DecreseMaxwell-Wagner type relaxation mechanism present in all the samples.
- magnetocrystalline anisotropy constant (K) decreased by ~49% and ~117% in BMFM4 and BMFM8 sample respectively in comparison to BMF sample.
- Doping induced Switchable MD effect is observed at room temperature.

Acknowledgment

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