Structural and dielectric properties of Zn doped LaFeO₃

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ReFeO₃ (Re = La, Gd, Nd, Sm etc.) perovskites termed as orthoferrites exhibit interesting magnetic, acoustic, optical and magneto-optical properties. Recently, several interesting novel properties have been discovered in rare-earth orthoferrites, such as ultrafast inverse opto-magnetic effects, ultrafast laser-induced spin-reorientation phase transitions switching, and multi-ferroicity. Perovskite structured (ABO₃) lanthanum orthoferrite, (LaFeO₃) is a multiferroic material which shows a wealth of complex physical properties caused by the coexistence of electrical and magnetic order parameters. Besides multiferroicity LaFeO₃ possesses high thermal stability and well defined structure thus providing potential applications in advanced technologies such as solid oxide fuel cells (SOFC), chemical sensors, catalysts etc.

Table 1: Lattice parameters, unit cell volume (V) and crystallite size (D) for LaFe_{1-x}Zn_xO₃ (0 ≤ x ≤ 0.2)

Parameters	X=0	X=0.10	X=0.20
a(Å)	5.5603	5.5617	5.5515
b(Å)	5.5536	5.5542	5.5617
c(Å)	7.8492	7.8559	7.8526
V(Å) ³	242.38	242.67	242.46
χ ²	1.26	1.51	1.44
D _s (nm)	45.818	43.007	46.912
D _w (nm)	39.2	31.86	46.824
Strain(10 ⁻¹)	-6.093	-8.082	-1.325

The structural and dielectric properties of nano-crystalline LaFe_{1-x}Zn_xO₃ (0.0 ≤ x ≤ 0.2) are investigated. These samples are synthesized using solid state reaction route. X-ray diffraction patterns with Rietveld analysis confirm the single phase nature of our samples. All the samples are formed in orthorhombic crystal symmetry with Pbnm space group. The Williamson-Hall (W-H) analysis is used to study the individual contributions of crystallite sizes and lattice strain on the peak broadening of the LaFeO₃ and doped samples (Figure 1). Crystallite sizes are found to be of nanometer range while the strain is of the order of 10⁻⁴ (Table 1). Dielectric constant as a function of frequency is measured in the frequency range of 75 kHz - 5MHz (Figure 2). All the samples exhibit decrease in real part of dielectric constant with the increase in frequency. The Zn doping increases the dielectric constant by three times as compared to host sample (LaFeO₃).

The colossal dielectric response is observed for all the doped samples. The enhancement in dielectric constant is attributed to the orientational polarization produced by the exchange of electrons between Fe³⁺/Fe²⁺ ions and also due to the distortion of FeO₆ octahedron by the introduction of Zn²⁺ ions which leads to the weakening of A-B sub lattice interaction, allowing less resistance to polarization and hence enhancement in dielectric constant.

Figure 1: The variation (shift) of most intense peak of LaFe_{1-x}Zn_xO₃ (0 ≤ x ≤ 0.2).

Figure 2: Frequency dependence of ε' for LaFe_{1-x}Zn_xO₃ (0 ≤ x ≤ 0.2) samples. The inset shows the view of ε' (ν) for LaFeO₃ (x=0.0)

References

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