Structural, Magnetic and Impedance Spectroscopic Analysis of $LaFeO_3$ Nano-particles

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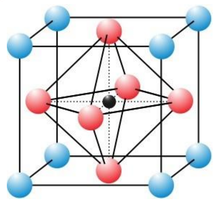
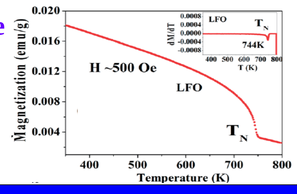
Abstract: **Physical properties are known to be drastically varied with crystallite size and in a multifunctional material this size reduction is seem to be interesting. The average particle size found to be in the order of 45nm. A distorted orthorhombic structure with *Pbnm* space group is possessed by this nanoparticle. From the bifurcation of ZFC and FC in low field, behavior of inverse susceptibility and the small hysteresis loop favors the material to be in a weak FM state well below the Neel temperature. The electrical behavior and the conduction mechanism above room temperature have been studied by cole-cole plot of the Impedance spectra. The high frequency depressed semi circles represent the grain conduction while the intermediate frequency semi circles appear may be due to grain boundary effect.**

Introduction

- **Perovskite rare earth compound oxides such as ABO_3 are very important in-organic functional materials and very interesting physical properties in the area of magnetism and ferroelectricity.**
- **Lanthanum orthoferrite, $LaFeO_3$, is one of the most important perovskite-type oxides and has been proposed for various applications such as solid oxide fuel cells, catalysts, chemical sensors.**

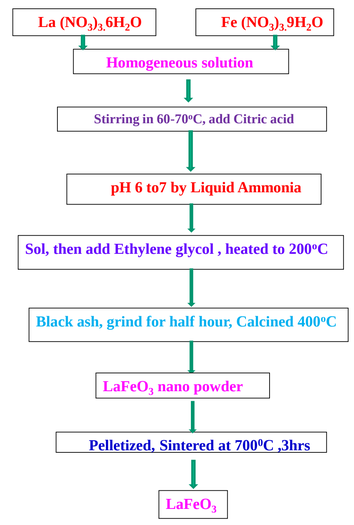


- **Anti-ferromagnetic with a Neel temperature T_N of 738 K.**
- **Transition from orthorhombic to rhombohedral at T~ 1260 K.**
- **3d electrons are responsible for magnetic ordering which induces lattice distortion.**
- **Magnetic ordering creates strong local electric field which is responsible for the onset of ferroelectric ordering. It's at RT multiferroics materials**



- **In this work an effort is made to investigate the impedance spectroscopy and magnetic properties of $LaFeO_3$**

Experimental Details



- **For the detailed structure, room temperature Powder X-Ray diffraction (XRD) is performed by Rigaku (Ultima IV) X-Ray diffractometer with Cu-Kα radiation.**
- **The detailed morphology, crystallite size is being measured using FESEM**
- **For the magnetic measurements of the materials, we have measured temperature dependence magnetization by using vibrating sample magnetometer (ppms-6000).**
- **Impedance measurement is being carried out using Hioki-3570 impedance. The measurement is repeated several times to check the reliability of the data.**

Results and Discussions

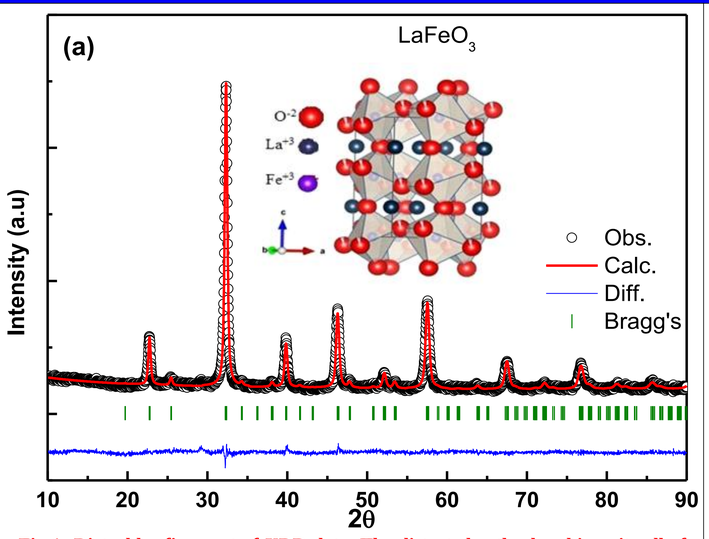
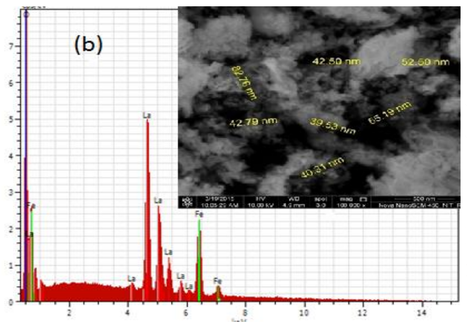


Fig 1: Rietveld refinement of XRD data. The distorted orthorhombic unit cell of LFO (inset).

- In this structure, Fe^{+3} ions surrounded by six neighboring O^{-2} ions forming FeO_6 octahedral.
- **It's shows single phase orthorhombic structure with *Pbnm* S.G .**
- **The unit cell parameters were found to be a = 5.5541Å, b = 5.5659Å *and* c = 7.8634 Å with other R_p = 22.6, R_{wp} = 15.9, R_{exp} = 12.27 and χ^2 = 1.68.**



- **The average particle size of the $LaFeO_3$ found to be around 45 nm with fine agglomerations of particles with irregular shape.**
- **From the EDAX spectra contain La, Fe, and O without any detectable impurity.**

Fig:1(b): EDAX spectrum and FESEM micrograph of LFO nanocrystal(inset).

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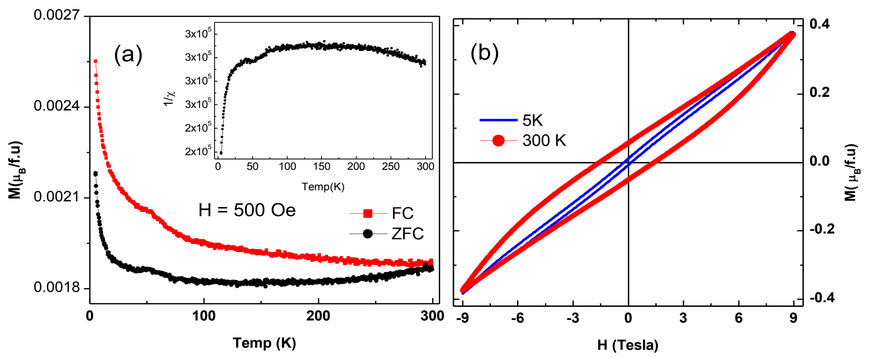

Fig 2: (a) M vs T at 500 Oe. Inverse susceptibility as a function of T (inset). (b) M vs H in T 5K and 300K.

- **A canted antiferromagnetic like behaviour of $LaFeO_3$ is confirmed from ZFC and FC curves , M-H loops confirmed it as weak ferromagnetic material.**

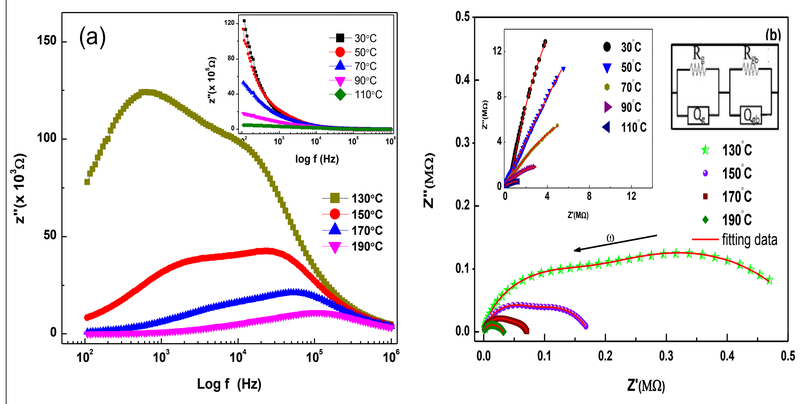

Fig3:(a) .Im Z or Z '' vs *f* at few representative temperatures, (b) Cole-Cole plots at different temperatures, Inset: equivalent circuit diagram.

- **The impedance decreases with increasing T.**
- **The relaxation peaks are absent in the temperatures a below 130˚C, in which two peaks are observed in 130-190˚C range.**
- **The curves are fitted with the RQ-RQ using equation $C = Q^{1/n} R^{(1-n)/n}$ in Zsimpwin software.**
- **Semicircles with departed centers from real axis, indicating non-Debye type relaxation.**

Conclusions

- Lanthanum orthoferrite has been synthesized by using sol-gel technique. Reitveld refinement of XRD pattern shows that the sample prepared with single phase, stoichiometric and crystallises in orthorhombic structure with *Pbnm* space group.
- **FESEM micrograph revealed that the powder is prepared with particle size is ~ 45 nm.**
- **A canted antiferromagnetic like behaviour of $LaFeO_3$ is confirmed from ZFC and FC curves , M-H loops confirmed it as weak ferromagnetic material.**
- **In the $LaFeO_3$ system, relaxations peaks were absent below 130˚C and above which grain and grain boundary relaxations were observed.**

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