Structural, Microstructure and Impedance Spectroscopy analysis of Zn$^{2+}$ doped LaFeO$_3$ Nanoparticles

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Abstract: Physical properties are known to be drastically varied with chemical pressure and crystallite size in a multifunctional material. In this work various concentrations of Zn (0 < x < 0.2) in the Fe site of LaFeO$_3$ are prepared by wet-chemical route. The average particle size is of the order of 40-50 nm. The concentration dependendent electrical behavior and the conduction mechanism at room temperature have been studied in detail by Cole-Cole plot of the Impedance and modulus 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 structural, microstructure and the impedance spectroscopy of LFO with Zn doped samples

Experimental Details

- For the detailed structure, room temperature Powder X-Ray diffraction (XRD) is performed by Rigaku (Ultima IV) X-Ray diffractometer with Cu-K$_\alpha$ radiation.
- The detailed morphology, crystallite size is being measured using FESEM
- 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 LFO with Zn doped XRD data. Inset variation of most intense peaks and the distorted orthorhombic unit cell of LFO (inset).
- In this structure, Fe$^{3+}$ ions surrounded by six neighboring O$^-$ ions forming FeO$_6$ octahedron.
- It’s shows single phase orthorhombic structure with Pham S.G.
- The unit cell volume of the sample increases with increases doping % in Zn.
- Ionic radii of Fe$^{3+}$ (0.64nm) and Zn$^{2+}$ (0.74 nm)

Fig.2: FESEM micrograph of LFO with Zn doped Nano particles.

- The average particle size of the LFO with Zn doped found to be around 40-50nm with fine agglomerations of particles with spherical shape.

Fig.3: (a) Z’(f) and (b) M’(f) spectra of LFO with Zn doped at RT

- The relaxations peaks appeared and shifting higher frequency region in Z”
- M” spectra highlight smallest grain capacitance and suppressed electrode

Conclusions

- Lanthanum orthoferrite has been synthesized by using sol-gel technique. Rietveld refinement of XRD pattern shows that the samples prepared with single phase, stoichometric and crystallises in orthorhombic structure with Pham space group.
- The shifting of most intensity peaks towards lower 20 values with higher doping reveals more and more distortion of four FeO$_6$ octahedron surrounding Zn$^{2+}$ in the Fe-O plane.
- FESEM micrograph revealed that the powder is prepared with particle size is ~ 40 to 50 nm.
- In the LaFeO$_3$ system, relaxations peaks were absent at RT, grain and grain boundary relaxations were observed in Zn doped system.

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Reference