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Structural and Electrical Characterization of Nanostructured $SrTi_{1-x}Fe_xO_{3-\delta}$

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Abstract – $SrTi_{1-x}Fe_xO_{3-\delta}$ (x= 0.0 to 0.75) nanostructured samples have been synthesized using a modified polymeric precursor method. The effect of the addition of iron on the structural and electrical properties was investigated by X-ray diffraction, Infrared spectroscopy, X-ray absorption spectroscopy and impedance spectroscopy. It was observed that the presence of Fe^{3+} ions in the $SrTiO_3$ lattice creates oxygen vacancies and that the electrical conductivity increases rapidly with the iron content.

In the last decades compounds with perovskite structure and ABO_3 formula (A and B are cations while O is the oxygen anion) have been intensively studied due their interesting physical properties as for example, the ferroelectricity, piezoelectricity, photoluminescence [1-3]. More recently, perovskite nanostructured compounds have been found to be promising materials in current science and technology. In this context, the $SrTi_{1-x}Fe_xO_{3-\delta}$ nanostructured compounds has been the object many studies because the substitution of Ti^{4+} by Fe^{3+} atom creates different types of defects in the structure which have a significative effect on the sensing properties of this system [4,5].

The conventional way to prepare $SrTi_{1-x}Fe_xO_{3-\delta}$ compounds is based on the solid-state reaction between $SrCO_3$, TiO_2 and Fe_2O_3 at relatively high processing temperature (> 1100^{o}C) [4,5]. In order to decrease particle sizes to a nanoscale, microsized samples have been subjected to ball milling during up to120 hours, which may introduce impurities into them. On the other hand, the synthesis of nanostructured materials by a chemical route appears to be a good alternative to obtain nanostructured powder samples without such inhomogeneities and at low temperature (< 800^{o}C) [6].

In this work, we present the results concerning the synthesis of nanostructured $SrTi_{1-x}Fe_xO_{3-\delta}$ powders (x= 0.0 to 0.75) by using a modified polymeric precursors method. Electron scanning microscopy images show that the particle size is around 50 nm. X-ray diffraction measurements indicated that samples present a single cubic $SrTiO_3$ phase forming a solid solution. Moreover, no evidence of a secondary phase was found by X-ray diffraction measurements. The vibrational band related to the FeO_6 octahedra was identified by infrared spectroscopy indicating the presence of iron ions in the $SrTiO_3$ lattice. In order to investigate the valence state of iron ions, X-ray absorption (XANES) spectra at Fe K-edge were collected. The analysis of XANES spectra indicates the predominance of Fe^{3+} ions which induces the formation of oxygen vacancies (Vö). The presence of Fe^{3+} ions contributes to the electrical conductivity which increases with the increase of Fe content. It was observed that, with the increasing Fe^{3+}, the materials move from an insulator to a semiconductor.

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