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Synthesis, characterization and electrical properties of the system $LaMn_xFe_{1-x}O_3$

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ABSTRACT

The system manganese substituted lanthanum ferrite viz. $LaMn_xFe_{1-x}O_3$ ($1.0 \leq x \geq 0$) was prepared by sol–gel autocombusion method. The structural characterization of the samples was carried out by X-ray diffraction technique and it is found that, the phase transfer from cubic to orthorhombic perovskite structure. The lattice parameter and crystallite size decrease with increasing Mn content. The phase formation of perovskite was revealed by thermal analysis technique. The surface morphology and elemental analysis of all the samples were carried out by scanning electron microscopy and energy dispersive X-ray spectroscopic technique, respectively. Electrical properties of the compounds show that, they exhibit semiconducting behavior. The substitution of manganese ions plays an important role in changing their structural, electrical and magnetic properties of lanthanum ferrite.

1. Introduction

The perovskites have very important structural, electrical and magnetic properties which are dependent on several factors such as, method of preparation, sintering temperature and time, chemical composition and substitution of various cations. The perovskite structure whose chemical composition is given by the general formula ABO_3 (A, rare earth metals and B, transition metals) has primitive cubic type of lattice [1,2]. Perovskites exhibit a variety of applications in electronics and magnetic materials [3]. At present, several chemical methods including ceramic, co-precipitation, sol–gel, and citrate precursor have been used to prepare perovskites [4–7].

In the present investigation, we focused on the synthesis of manganese substituted lanthanum ferrites powder was prepared by sol–gel autocombustion method. The aim of present work is to study the effect of manganese substitution of $LaFeO_3$ on structural, electrical properties of perovskites.

2. Experimental details

2.1. Synthesis technique

Crystalline powders of $LaMn_xFe_{1-x}O_3$ (where $x = 0.0, 0.2, 0.4, 0.6$ and 1.0) were prepared by sol–gel autocombustion method [8]. A.R. Grade anhydrous citric acid ($C_8H_8O_7$), manganese nitrate [$Mn(NO_3)_2{\cdot}4H_2O$] and ferric nitrate ($(FeNO_3)_3{\cdot}9H_2O$) were used as starting materials. The above nitrates were taken in appropriate proportions. An aqueous solution of citric acid was mixed with metal nitrate solutions and the few drops of concentrated HNO_3 were added to adjust the pH at 2. The mixed solution was kept on hot plate with continuous stirring at 70 °C. During the evaporation the solution becomes viscous and finally forms gel. The so formed gel was heated at 110 °C, when all remaining water was released from the mixture, the gel automatically burnt with glowing flints. The autocombustion was completed within a minute yielding the brown pulpy powders. The above powders were heated separately at 900 °C for 8 h to get final product. The granulated powders were pressed into pellets of 1.04 cm diameter under a pressure of 10 tonnes/cm^2 and thickness was adjusted to about 0.25 cm.

2.2. Characterizations

A computerised X-ray powder diffractometer (Philips PW-1710) with CuKα radiation (λ = 1.54056 Å) was used to identify the crystalline nature of the samples and to calculate lattice parameter and crystallite size. The lattice parameters were calculated for the cubic and tetragonal phase using following relations:

(a) For cubic phase $$\frac{1}{d^2} = h^2 + k^2 + \frac{l^2}{a^2} \quad (1)$$

(b) For orthorombic phase $$\frac{1}{d^2} = \frac{h^2}{a^2} + \frac{k^2}{b^2} + \frac{l^2}{c^2} \quad (2)$$

where a, b and c are lattice parameters, (hkl) is the Miller indices and d is the interplanar distance.

From the X-ray diffraction peaks, crystallite size was estimated using Debye Scherrer's formula [9]:

$$t = \frac{0.9\lambda}{\beta \cos\theta} \quad (3)$$

where symbols have their usual meaning.

The formation temperature of samples was checked by taking TGA/DTA curves on the SDT-2980 Ta instrument by heating the powders after autocombustion at a rate of 10 °C/min. from room temperature to 1000 °C in an air atmosphere. Scanning electron microscope (SEM) was used to study the morphology of the powders.

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