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Magnetic and dielectric properties of nanophase manganese-substituted lithium ferrite

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ABSTRACT

Nanocrystalline manganese-substituted lithium ferrites viz. $Li_{0.5}Fe_{2.5-x}Mn_xO_4$ $(2.5 \leq x \geq 0)$ were prepared by sol–gel autocombustion method. X-ray diffraction analysis confirmed that as the concentration of manganese increases the cubic phase changes to the tetragonal phase. The variation of saturation magnetization was studied as a function of manganese content. All the compositions indicate that they are ferrimagnetic in nature. The dielectric constant, dielectric loss tangent and ac conductivity of all samples were measured at room temperature as a function of frequency. These parameters decrease with increase in frequency for all of the samples. The substitution of manganese plays an important role in changing the structural and magnetic properties of these ferrites. The compositional variation of dielectric constant and d.c. resistivity shows an inverse trend of variation with each other.

1. Introduction

The polycrystalline ferrites have very important structural, magnetic and electrical properties that are dependent on several factors such as method of preparation, substitution of cations and microstructure, etc. Lithium ferrite and substituted lithium ferrites have interesting technological applications such as, cathode materials in lithium ion batteries [1–3]. They are used in microwave applications due to their high resistivity and low eddy current losses [4,5].

Many workers have studied the frequency dependence of the dielectric constant, dielectric loss tangent and ac conductivity of Li–Ni [6], Li–Co [7], Li–Mg [8] and Li–Ge [9] ferrite systems. However, no reports have been found in the literature on dielectric properties of Mn-substituted lithium ferrites. In the present work, the influence of manganese substitution on structural, magnetic properties, dc resistivity and dielectric properties of $Li_{0.5}Fe_{2.5-x}Mn_xO_4$ ferrite samples (where $x = 0.0$, 0.5, 1.0, 1.5, 2.0 and 2.5) is reported.

2. Experimental

2.1. Sample preparation

Polycrystalline ferrite samples having the general formula, $Li_{0.5}Fe_{2.5-x}Mn_xO_4$ ($x = 0.0$, 0.5, 1.0, 1.5, 2.0 and 2.5) were synthesized by sol–gel autocombustion method. High-purity AR grade ferric nitrate, manganese nitrate, lithium nitrate and citric acid were used for synthesis. The metal nitrate solutions were mixed in the required stoichiometric ratios in distilled water. The pH of the solution was maintained between 9 and 9.5 by using ammonia solution. The solution mixture was slowly heated to 100 °C with constant stirring to obtain a fluppy mass. The precursor powder was sintered at 700 °C for 8 h. The sintered powder was mixed with 2% polyvinyl alcohol as a binder and uniaxially pressed at a pressure of 8 t/cm^2 to form pellets.

2.2. Characterizations

The phase formation of the samples was confirmed by X-ray diffraction studies using a Philips PW-1710 X-ray diffractometer with CuKα radiation ($\lambda = 1.54056$ Å). The high field hysteresis loop tracer was used to measure the saturation magnetization of the samples. The dc resistivities of the samples were measured at room temperature by two probe method. The dielectric constant,

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