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Magnetic Properties and Electrical Resistivity of Zr^{4+} Substituted Li-Zn Ferrite

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Abstract: The effect of Zr-substitution on the physical and magnetic properties of $Li_{0.3+0.5x}Zn_{0.4}Zr_xFe_{2.3-1.5x}O_4$ ferrites (x=0.0, 0.01, 0.02, 0.03 and 0.05), prepared by the standard ceramic method, has been studied. It is found that the saturation magnetization increases up to x=0.02 and then it decreases. On the other hand, the initial permeability increased while the Curie temperature remained almost constant with increasing x. The behavior of coercivity and remanence ratio was discussed. The composition dependence of the dc electrical resistivity is found to support the hopping conduction mechanism.

Key words: Initial permeability, magnetization, hysteresis, ferrites, Li-Zn ferrites, magnetic properties, electrical resistivity

INTRODUCTION

Li-Zn ferrites are low cost materials and have important magnetic and electrical properties for technological applications. It is known that the intrinsic parameters of ferrites, such as magnetization, initial permeability, Curie temperature and resistivity depend on the chemical composition, heat treatment and type of additive or substituted ions[1]. Also, the rectangularity of B-H loop is also found to increase with increasing defects that hinder the magnetic domain wall motion in the grains[2]. The influence of *additives*, such as Na_2O, CaO, Sb_2O_3 and ZrO_2 on the structure, magnetic and electrical properties of Li-Zn ferrites were previously reported[1, 3]. This work is devoted to study the effect of Zr^{4+} *substitution, but not addition,* on the magnetic properties and electrical resistivity of Li-Zn ferrite.

MATERIALS AND METHODS

Ferrite samples with the chemical formula $Li_{0.3+0.5x}Zn_{0.4}Zr_xFe_{2.3-1.5x}O_4$ (x=0.0, 0.01, 0.02, 0.03 and 0.05) were prepared by the usual standard ceramic method. High purity oxides, 99.99%, of ZnO and Fe_2O_3 with Li_2CO_3 and ZrO_2 were mixed together according to their molecular weight ratios. The mixture of each sample was ground to a very fine powder and then presintered at 800 ^oC for 6 h. The presintered mixture was ground again and pressed at room temperature, under a pressure of $7x10^8$ Pa, into tablet and toroidal forms. They were finally sintered at 1050 ^oC for 3 h and then slowly cooled to room temperature. X-ray diffraction patterns were performed using a diffractometer of type X`Pert Graphics and identified with Cu $K_\alpha$ radiation. The theoretical X-ray density, $d_x$, of the samples was calculated according to the formula ($d_x=8M/Na^3$) where M is the molecular weight, N is Avogadro`s number and a is the lattice parameter. The density, d, of each sample was measured in bidistilled water using Archimedes' principle. The porosity percentage P(%) was calculated according to the relation $P=100[1-(d/d_x)]\%$. The magnetization M, at room temperature, was measured using the vibrating sample technique. The magnetizing field ranged from 0.0 up to 1.4 Tesla. A toroidal sample of each composition was used as a transformer core for measuring the initial permeability, μ_i, which was measured as a function of temperature at a constant frequency f=10 KHz. The value of μ_i was calculated using Poltinnikov`s formula[4], $V_s=K\mu_i$, where V_s is the induced voltage in the secondary coil and $K=\mu_o n_p n_s I_p A\omega/L$; n_p and n_s are the number of turns of the primary and secondary coils respectively, I_p is the current in the primary coil, A is the cross-sectional area of the sample, ω is the angular frequency and L is the average path of the magnetic flux. Moreover, the coercive field and remanence were determined from the hysteresis loop. The disc samples were used for the electrical resistivity measurements at room temperature. Each sample was inserted between two platinum electrodes where In-Hg was used as a contact material.

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