ABSTRACT

The research work in this investigation describes synthesis of a novel series of magnetodielectric (or spintronic) materials of $Li_{0.5(1-x)}Zn_xFe_{(2.5-x/2)}O_4$, $x \leq 1.0$, ferrites. This includes a detailed study of the crystal structure and microstructure with magnetic, optical, and transport properties useful for pertinent applications in microwave devices, microelectronics, sensors, catalysts. In optimizing their functional values, a series of $Li_{0.5(1-x)}Zn_xFe_{(2.5-x/2)}O_4$ was prepared of small crystallites by a simple chemical method involving an auto-combustion of a liquid precursor in a polymer structure. A specific objective is to vary the Zn^{2+} content(x) which can tune dielectrics, electrical conductivity as well as the photonics with useful magnetic properties. Such small crystallites represent single magnetic domains. The aim of this work is two folds: one from the application point of view of such materials and the other from fundamental aspects. In application part, the main objective is to develop a large magnetodielectric with useful magnetic properties, whereas in the fundamental part, the motive is to analyze thermal, structural, magnetic, transport, and optical properties in correlation to the microstructure.

The work is presented in seven chapters as follows. Chapter-1 provides a general introduction on the basic research interest and overview of the physics of different ferrite materials, a statement of the problem, review of the literature along with motivation behind choosing this research work, important properties and possible applications of such magnetoceramics. This chapter presents a general introduction to the basic research interest on stabilizing a nanostructured $Li_{0.5(1-x)}Zn_xFe_{(2.5-x/2)}O_4$ with a bonded surface layer of carbon. Chapter-2 deals with the experimental details of the synthesis process and characterization methods adopted for evaluating the different properties. The structural (in terms of X-ray diffraction and microstructure), magnetic, transport, and optical properties obtained for the synthesized materials under selective experimental conditions are presented in four different Chapters 3-6. Chapter-3 describes the phase formation and microstructural analysis of the samples of varied compositions. Chapters-4 deals with studies on the effects of a partial $2Zn^{2+} \rightarrow Li^{+}Fe^{3+}$ substitution on the magnetic properties. The saturation magnetization M_s decreases regularly on increasing a partial $2Zn^{2+} \rightarrow Li^{+}Fe^{3+}$ substitution, converting a ferrimagnetic $\rightarrow$ paramagnetic phase at room temperature. An H_c-value as large as 147.5 Oe is obtained along with a moderate M_s = 66.8 emu/g and remanent M_r/M_s = 0.17 (measured at 300 K) in a specific composition of x = 0 Zn^{2+}-content (annealed at 400 °C). The substitution suppresses the T_C from ~850 K to 16 K at $x = 0 \rightarrow 1.0$. The electrical and transport properties as described in Chapter-5 demonstrate the effect of the partial $2Zn^{2+} \rightarrow Li^{+}Fe^{3+}$ substitution on the electronic transport in correlation to the magnetism. Chapter-6 deals with vibrational, electronic, and XPS spectra for the $Li_{0.5(1-x)}Zn_xFe_{(2.5-x/2)}O_4$ (x = 0.3). The phonon and electronic bands illustrate how the surface ions and oxygen vacancies vary in a carbon layer bonds on the crystallites and when it is etched out progressively by thermal annealing at increased temperatures. A summary and conclusion of the major findings of this work are briefed in Chapter-7 along with its future scope of work.

Keywords: Auto-combustion process; Nanostructures; Ferrites; Magnetic properties; Dielectric properties; Spintronics