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Room temperature ferromagnetism in Ag doped $LaMnO_3$ nanoparticles

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ABSTRACT

Manganite containing La is a promising perovskite material as it has wide range of applications. In this piece of work, nanoparticles of $La_{1-x}Ag_xMnO_3$ samples ($0.00 \le x \le 0.09$) were synthesized using wet chemical method. The samples were characterized by thermal gravimetric analysis (TGA), field emission scanning electron microscopy (FE-SEM), differential thermal analysis (DTA), high-resolution transmission electron microscopy (HR-TEM), X-ray diffraction (XRD), infrared spectroscopic (FT-IR), and differential scanning calorimetry (DSC). The XRD study showed that all samples adopted the rhombohedral hexagonal structure with a space group of $R\bar{3}c$. The HR-TEM/FE-SEM images showed that the perovskite structure were successfully obtained. Investigation of the magnetic properties was conducted in a wide range of temperature to confirm the ferromagnetic-paramagnetic (FM-PM) presence around Curie temperature ($T_c \approx 270$ K). The shift of the Curie point to larger values was clearly observed for the samples by increasing the silver contents.

1. Introduction

Perovskite-type manganites were considered as the most interesting materials because of their excellent chemical and physical properties [1]. These properties include; the stability of the chemical compounds with temperature, higher charging in capacitors, the magneto caloric effect phenomena, ferromagnetic to paramagnetic transition, multiferric state, spin state transition and high melting point… etc. The perovskite manganites possessing a general formula ABO_3, in which A-site may be such a large element like Sr, La, Ba, Ca, K and Na while B-cation can be Mn, Ti, Co, Fe, Cr and Ni [2,3]. Based on these properties, their applications include; magneto resistive transducers, magnetic sensors, computer memory system, medical therapy, microwave ovens, oxide spintronic devices [4,5], photocatalysis and infrared detectors [6–8]. In addition, it is considered as an alternative to the conventional gas compression refrigeration techniques [9–11].

Moreover, the manganite compounds are environmentally safe, low cost, and there is no hazardous gas by-product [10]. Depending on the MCE theory, the compound should have magnetic ordering transition temperature (Tc) near room temperature (T_R). Moreover, the excellent compounds should have a significant change of magnetic entropy (ΔS_M) induced by applied low magnetic field change. According to the Curie Weiss law for ferromagnetism, materials with larger values of effective magnetic moment at the Curie temperature (Tc) have a large ΔS_M (T, H) [12].

Among perovskite manganites $LaMnO_3$ is an antiferromagnetic insulating material. However, an alkali or an alkaline rare earth cation substitution for La as a formula $La_{1-x}A_xMnO_3$ system gives rise to intriguing magnetic and electrical properties, i.e. large MCE that is comparable to that of Gd based alloys, near room temperature [13]. It is known that the magnetic properties are favored by A-site dopant in $La_{1-x}A_xMnO_3$ [14–16].

Partial substitution of La^{3+} with monovalent cations such as K^+, Na^+, and Ag^+ will support the double-exchange interaction between Mn^{3+} and Mn^{4+} pairs. Consequently, a desirable modification of magnetic properties and consequently of the magnetocaloric effect [17–19] could be easily achieved. The substitution of the rare earth cation with monovalent cations (Ag+, Na+, K+) in manganites is of specific concern as it leads to the valence exchange of Mn ions, but also to the variation of A-site cation radius and size disorder and therefore of the magnetic and electrical properties [20,21].

Recently, Ag substitution in $La_{1-x}A_xMnO_3$ system has exhibited good magnetic properties since each Ag^{1+} oxidizes two Mn^{3+} ions to Mn^{4+} ions that are favored by double exchange mechanism. The

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