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Investigation on magnetic and magnetocaloric properties in the Pb-doped manganites $La_{0.78}Ca_{0.22-x}Pb_xMnO_3$($x = 0$, 0.05 and 0.1)

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A B S T R A C T

We present an investigation on structural, magnetic and magnetocaloric properties of $\mathbf{La_{0.78}Ca_{0.22-x}Pb_xMnO_3}$ ($x = 0$, 0.05 and 0.1) polycrystalline compounds prepared by conventional solid-state reaction method. Rietveld refinement of X-ray powder diffraction (XRD) patterns shows that all samples crystallize in the orthorhombic structure, with the ***Pnma*** space group. Magnetization as a function of temperature shows that all samples exhibit a paramagnetic (PM) – ferromagnetic (FM) phase transition at the Curie temperature T_C which increases from 202 K to 242 K for $x = 0$–0.1, respectively. The magnetic-entropy changes,ΔS_M, were calculated from the field dependence of magnetization data using the Maxwell's thermodynamic relation. The magnetic entropy change $|\Delta S_M^{max}|$ decreases from 6.9 J kg^{-1} K^{-1} for $x = 0$ to 5.53 J kg^{-1} K^{-1} for $x = 0.1$, while the relative cooling power (RCP) also decreases from 274 to 241 J kg^{-1}, respectively, under an applied magnetic field of 5 T. All of the investigated manganites exhibit a second-order magnetic phase transition at T_C, which is also confirmed by Arrot plot and Landau's theory. Also, by normalizing the $\Delta S_M(T,H)$ curves to their respective $\Delta S' (= \Delta S_M(T)/\Delta S_M^{max})$ value we indicate that all these curves of the samples are collapsed onto a universal master curve. In addition, field dependence of the magnetic entropy change showing the power law dependence$\Delta S_M^{max} \propto (\mu_0 H)^n$, at the T_C is also analyzed. The obtained '**n**' values are 0.64, 0.75 and 0.97 for $x = 0$, 0.05 and 0.1 respectively, which confirms that our samples does not follow the mean field model. The deviation from the mean field behavior for all the samples demonstrates an existence of short-range ferromagnetic order in the samples.

1. Introduction

Manganites with a general formula $Ln_{1-x}AE_xMnO_3$ (Ln = rare earth metal, AE = alkaline earth metal) have been an intensive topic in scientific studies and potential technological applications due to their charge and orbital ordering phenomena, magnetic phase transitions, colossal magnetoresistance (CMR) effect as well as magnetocaloric effect (MCE) [1,2]. Magnetic refrigeration (MR) is a technology based on MCE of magnetic solids upon application of an external magnetic field. The MCE is an intrinsic property of a magnetic material and is defined as the temperature change in magnetic materials as a result of alignment of spins when the material is exposed to an external magnetic field.

Magnetic refrigeration near room temperature is of special interest because of its considerable advantages such as, high energy efficiency, small volume and environmental friendliness over conventional gas refrigeration [3,4]. The key issue in using magnetic refrigeration at room temperature is to find a suitable material that produces a large entropy change and temperature change [5,6]. The rare-earth metal Gd has been considered as one of the most suitable refrigerant in room temperature magnetic refrigeration but its expensive cost ($4000/kg) push the search for new materials that are cheaper but displaying larger MCEs [7,8].

Recent studies proved that manganites are one of such suitable

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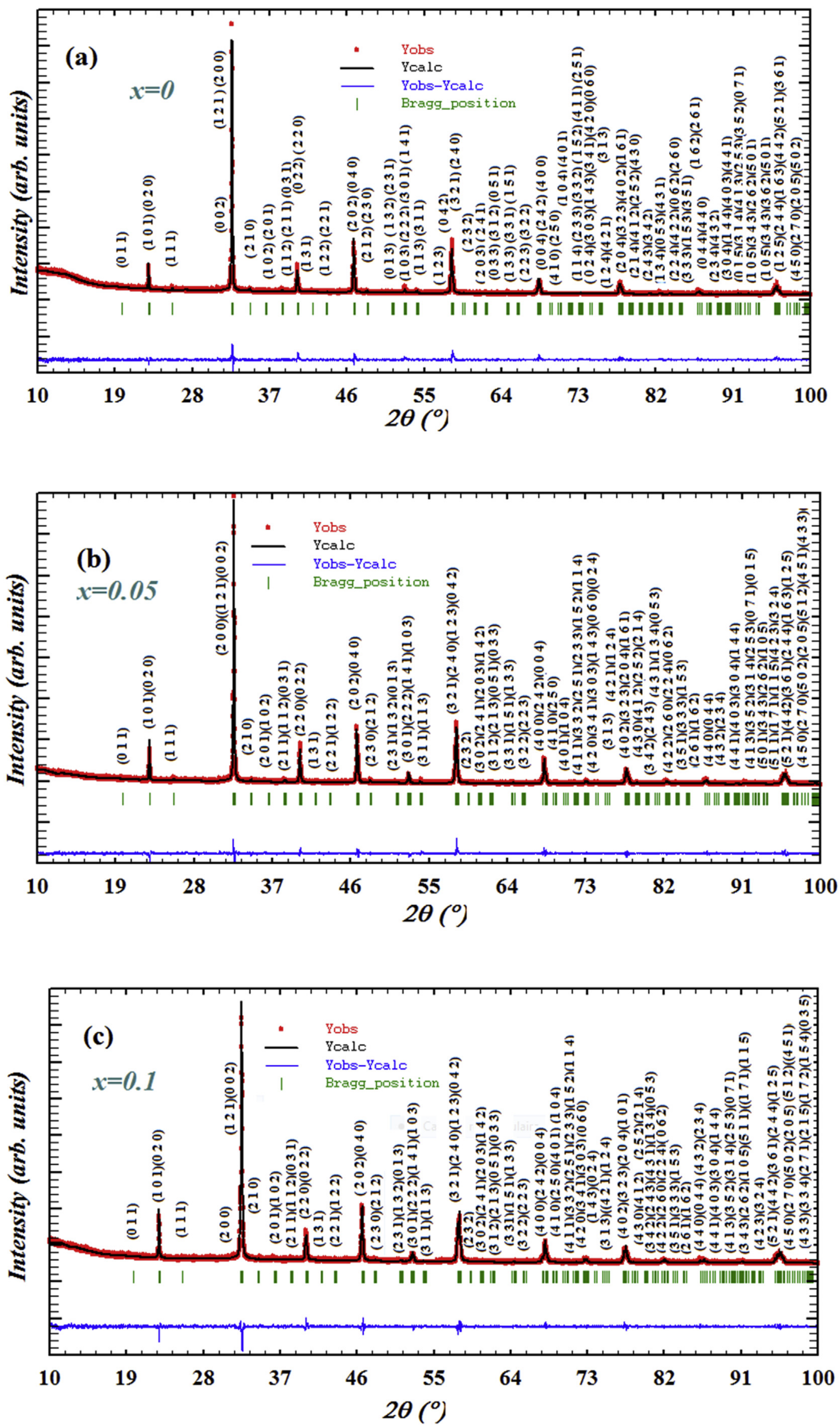
(a)
x=0
Yobs
Ycalc
Yobs-Ycalc
Bragg_position
Intensity (arb. units)
10 19 28 37 46 55 64 73 82 91 100
2θ (°)
(b)
x=0.05
Yobs
Ycalc
Yobs-Ycalc
Bragg_position
Intensity (arb. units)
10 19 28 37 46 55 64 73 82 91 100
2θ (°)
(c)
x=0.1
Yobs
Ycalc
Yobs-Ycalc
Bragg_position
Intensity (arb. units)
10 19 28 37 46 55 64 73 82 91 100
2θ (°)