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MAGNETOTRANSPORT AND ELECTRICAL PROPERTIES OF COLOSSAL MAGNETORESISTIVE $La_{0.8}Sr_{0.2}MnO_3$ AT DIFFERENT SINTERING TEMPERATURE

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ABSTRACT

The magnetotransport and electrical properties of $La_{0.8}Sr_{0.2}MnO_3$ (LSMO) compounds prepared by simple chemical co-precipitation route and sintered at 1120°C, 1220°C and 1320°C were studied. All the samples are indexed in the rhombohedral structure with R3C space group. From this study, T_{IM} remained nearly constant (~290K) for samples sintered at 1120°C and 1220°C. Resistivity values were fitted with several equations in the metallic (ferromagnetic) region. Whereas at insulating (paramagnetic) region, variable range hopping (VRH) and small polaron hopping (SPH) models were used to estimate the density of states at Fermi level, N (E_F), and activation energy of the electron.

Keywords: LSMO; manganite; resistivity;

INTRODUCTION

Magnetoresistance (MR) is a property of magnetic material which is crucial for a rapid development of new technologies due to the close correlation between structural, electrical and magnetic properties [1]. LSMO possess the highest value of Curie temperature (T_c) and combines low carrier density with high spin polarization of charge carriers among perovskite-structured $Ln_{1-x}A_xMnO_3$ manganite systems that makes it very promising in room-temperature applications [2]. The flow of charge ordering in magnetic material may be affected by the structural, magnetic or inhomogeneities of charges [3].

An attempt has been made to explain the low temperature resistivity (metallic region) data by fitting with the equations $\rho = \rho_o + \rho_2 T^2$ and $\rho = \rho_o + \rho_{2.5} T^{2.5}$ [4]. Small polaron hopping model and variable range hopping model were utilized to estimate the activation energy (E_a), T_o values and the density of states at Fermi level ($N(E_F)$) [5].

It is well known that change in the grain size has direct consequence on the electronic and magneto-transport properties of a system [6]. Sintering temperature has a prominent effect on the properties of the grain boundary, which plays an important role in determining the electrical transport behavior of the composites [7]. Therefore, it is interesting to investigate the effect of different sintering temperature on the magneto-transport and electrical properties of $La_{0.8}Sr_{0.2}MnO_3$.

EXPERIMENTAL

Samples were prepared by simple chemical co-precipitation route using high purity (99.9 %) powders of La_2O_3, $Sr(NO_3)_2$ and $MnCO_3$. The powders were reground and pressed into pellets and sintered at 1120°C, 1220°C and 1320°C for 24hours. X-ray (XRD) diffraction analysis using a Siemens D5000 diffractometer with CuK_α (λ= 1.542 Å) radiation was used to determine the phase purity and structure of the samples. The morphology of the samples was observed by using a scanning electron microscope (SEM, JEOL 6400). Four-point probe technique was used to measure the insulator-metal transition temperature (T_{IM}).

RESULT AND DISCUSSION

Figure 1 shows the X-ray powder diffraction (XRD) patterns for all samples. The XRD results for all samples are successfully indexed with rhombohedral perovskite structure (space group R3C). Figure 3 shows the SEM micrographs of the samples. The size of grains increased from 1.53 μm at 1120°C to 1.61 μm at 1220°C, and 5.29 μm at 1320°C.

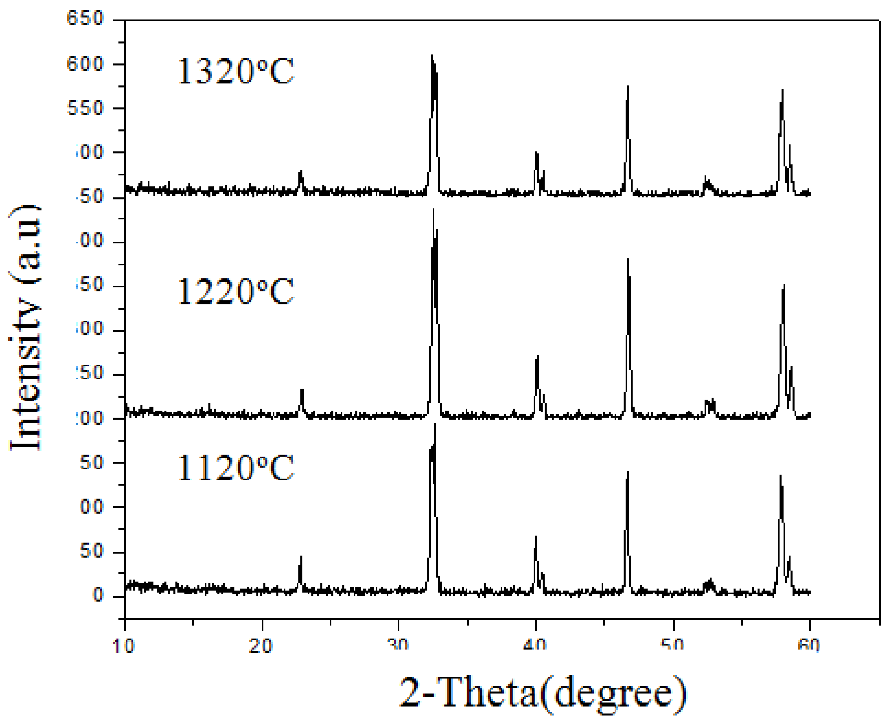

Figure 1: X-ray diffraction patterns of $La_{0.8}Sr_{0.2}MnO_3$

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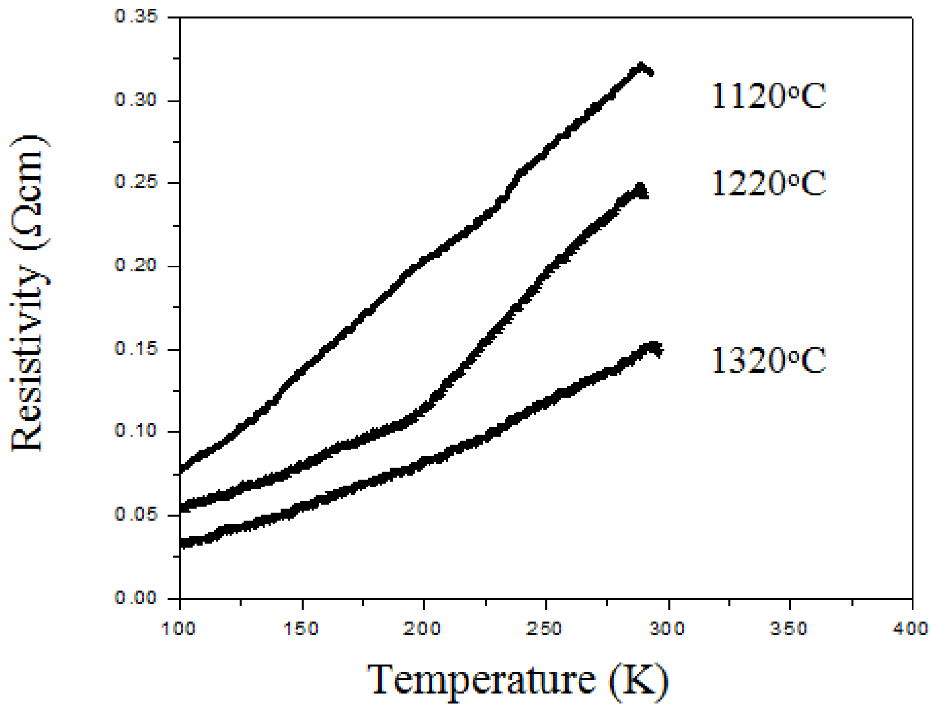
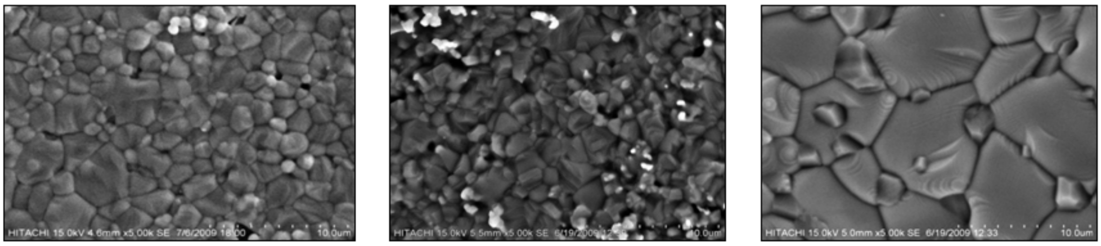


Figure 2: Resistivity versus temperature curves of $La_{0.8}Sr_{0.2}MnO_3$

Table 1: Electrical resistivity, grain sizes, T_{IM} and density of $La_{0.8}Sr_{0.2}MnO_3$ sintered at 1120°C, 1220°C, and 1320°C

Sintering temperature (°C)	Grain size (μm)	T_{IM} (K)	Density (g/cm³)
1120	1.53	290	5.33
1220	1.61	290	5.87
1320	5.29	294	5.89

The resistivity as a function of temperature graph shows the T_{IM} for samples sintered at 1120°C and 1220°C are almost constant (~290K) (Figure 2). Table 1 shows that, T_{IM} values are very dependent on the growth of the grain. The decreased in grain size increased magnetically disordered states in the surface of the grains therefore double exchange (DE) mechanism is weakened and resistivity is enhanced [3]. In addition, Ewe et al. [5] reported that the increase in sintering temperature increased the grain sizes and also the T_{IM} value [5]. It is observed that the grain boundary became more obvious with increasing of sintering temperature as shown in Figure 3. Grain boundary played a dominant role in enhancing the scattering of the conducting electron [6].



(a) (b) (c)

Figure 3: Scanning electron micrographs of $La_{0.8}Sr_{0.2}MnO_3$ sintered at (a) 1120°C, (b) 1220°C, and (c) 1320°C

Table 3 shows the value of activation energy (E_a) and density of states at Fermi level ($N(E_F)$). E_a *was* found to decrease with increasing sintering temperature. With an increase in the grain size, the interconnectivity between the grains is increased, enhancing the possibility of conduction electron to hop to the neighboring sites, thereby decreasing the E_a value [4]. Table 3 shows that $N(E_F)$ values increase with decreasing T_o values. The rising of T_o values was due to the bending of the Mn-O-Mn angle that reflected the narrowing of the bandwidth [5]. Sintering temperature affect the position of the atoms in the LSMO lattice, thus changing the Mn-O-Mn bond angle [8]. $N(E_F)$ reflects the carrier effective mass (or narrowing of the band-with) which in turn, resulting in drastic change in the resistivity and sharpening of the resistivity peak at the vicinity of T_{IM} [5].

Table 3: Pre-factor (, ρ_o), activation energy (E_a), T_o and density of states Fermi level $N(E_F)$ of $La_{0.8}Sr_{0.2}MnO_3$ sintered at 1120°C, 1220°C, and 1320°C

Sintering temperature (°C)	ρ_o (Ω cm K^{-1})	E_a (meV)	T_o (K)	$N(E_F)$
1120	1.1×10^{-3}	50	1.2×10^{3}	1.5×10^{22}
1220	8.4×10^{-4}	116	7.8×10^{7}	2.2×10^{17}
1320	5.2×10^{-4}	13	2.4×10^{5}	7.1×10^{19}

CONCLUSIONS

Effects of sintering temperature on electrical and magneto transport properties of $La_{0.8}Sr_{0.2}MnO_3$ manganite were studied. T_{IM} values for all samples are almost constant with increasing sintering temperature (~291 K). In the ferromagnetic (metallic) region, the resistivity may originate from grain boundary, electron-electron scattering and electron-magnon scattering process with low mean deviation. Increasing in sintering temperature leads to decrease in Mn-O-Mn bending angle. High sintering temperature helps to promote the growth of LSMO grains and hence shifted T_{IM} to higher temperature range.

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