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ELECTRICAL AND MAGNETIC PROPERTIES OF Sm DOPED $La_{2/3}Ca_{1/3}MnO_3$

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ABSTRACT

The effect of the substitution of Sm in the colossal magnetoresistance (CMR), $La_{0.67}Ca_{0.33}MnO_3$ ceramics has been studied. A series of x = 0.0, 0.01, 0.02, 0.03, 0.04 and 0.1 of $(La_{1-x}Sm_x)_{2/3}Ca_{1/3}MnO_3$ were prepared using a solid state reaction method. The magnetic and electrical properties have been investigated by a.c. magnetic susceptibility and DC electrical resistance measurement. The metal to insulator temperature T_P shifted to lower temperature as Sm doping increases, which indicates the loss of ferromagnetic order. The Curie temperature, T_C of each samples also shifted towards lower temperature as the Sm content increases. For samples with x = 0.03 and x = 0.1 the ac susceptibility display sharp peak suggesting a spin glass behaviour.

Keywords: Colossal Magnetoresistance, Manganites, Susceptibility and Spin Glass

INTRODUCTION

The perovskite manganite, $La_{1-x}A_xMnO_3$ (A = divalent alkaline earth metal, i.e. Ca^{+2}, Sr^{+2}, B^{+2} and Pb^{+2}) exhibit very interesting magnetic and electrical properties [1], such as the colossal (large) effect. The research in this area is very important to the technology of the magnetic read head devices. The phenomenon of CMR effects, explained by Zener through the double exchange mechanism, occurs in the phase transition from a paramagnetic insulator at high temperature to the ferromagnetic metal at low temperature T_P [3]. Above the metal-insulator transition temperature, T_P, the sample shows activated behavior ($d\rho/dT<o$) or behaves like a semiconductor material. The $LaMnO_3$ is an antiferromagnetic insulator due to the super exchange antiferromagnetic coupling interaction between the Mn^{3+} and Mn^{4+} ions. When La^{3+} in is substituted with divalent ions such as Ca^{2+}, Sr^{2+}, Ba^{2+} and Pb^{2+} [9] there is a conversion of the proportional number of Mn^{3+} to Mn^{4+} .The hopping of electrons between the mixed Mn^{3+} / Mn^{4+} valence states causes the conductivity and ferromagnetism ordering simultaneously. The competition between the ferromagnetic and antiferromagnetic interactions determines the magnetic properties in the doped $LaMnO_3$. However when the electron hops between the valence electronic states of Mn^{3+} /Mn^{4+} it mediates the conduction and this hopping determines the electrical properties [9-10]. In this study we report the preparation and the characterizations of $(La_{1-x}Sm_x)_{0.67}Ca_{0.33}MnO$ with nominal concentrations (x = 0.0, 0.01, 0.02, 0.03, 0.04 and 0.1).

EXPERIMENTAL:

Polcrystalline samples of $(La_{1-x}Sm_x)_{0.67}Ca_{0.33}MnO$ (x=0.00 to 0.1) were prepared via solid-state reaction using high purity (99.9%) of La_2O_3, Sm_2O_3, $CaCO_3$ and $MnCO_3$. The powders were ball- milled for 6 hours with acetone as a medium. The mixture was then dried by heating up to 120 °C. The resulting powders were calcined at 900 °C for 12 hours. After that the calcined powders were reground and sieved in order to ensure good homogeneity. The resulting mixtures were pressed into pellets and sintered at 1300 °C for 24 hours in air. The magnetic properties of the samples were measured by Ac susceptibility measurements using Lake Shore AC susceptometer (Model 7000). The samples were heated from 30K to 300K at fixed frequency 125HZ with magnetic field ranging from 0.1Oe to 10Oe. The resistance of samples measurement was performed by conventional four-point probe method with temperature range from 20K to 300K in zero magnetic fields.

RESULT AND DISCUSSION

The temperature dependence of the susceptibility for all the samples at 0.1Oe is as shown in Fig.1 and Fig. 2. Upon cooling, the paramagnetic-ferromagnetic transition is observed in Fig.1, for samples with x = 0.0, 0.01, 0.02 and 0.04. Fig. 2 shows, the susceptibility as a function of temperature for x = 0.03 and x = 0.1. At low temperature, the susceptibility formed into a cusp for both x = 0.03 and x = 0.1. This indicates the possibility of a

spin glass behavior [7-8]. It was suggested by Sundaresan et al that the spin glass states arises due to a strong competition between the ferromagnetic and antiferromagnetic interaction [8].

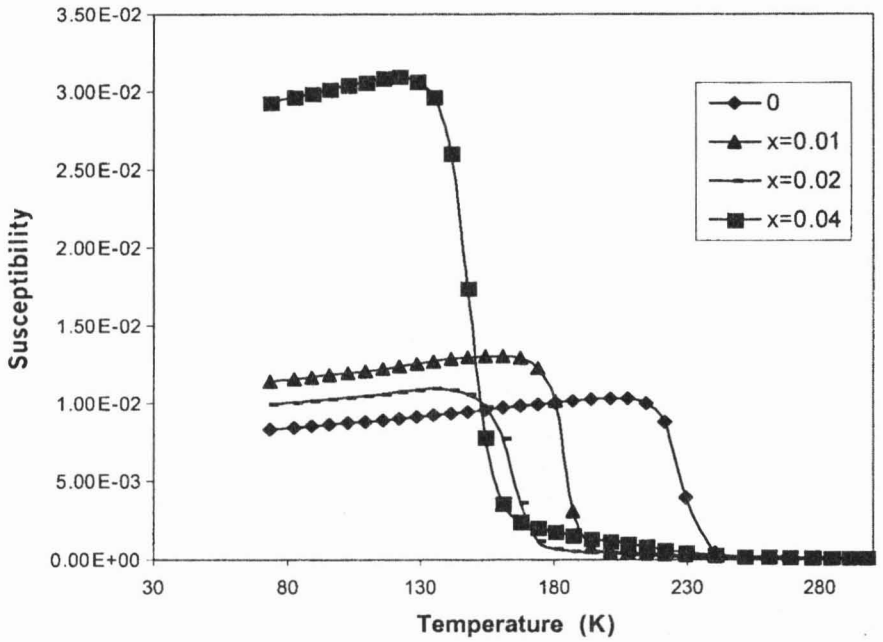

Fig. 1: Temperature dependence of susceptibility of LSCM system at H=0.1 Oe.

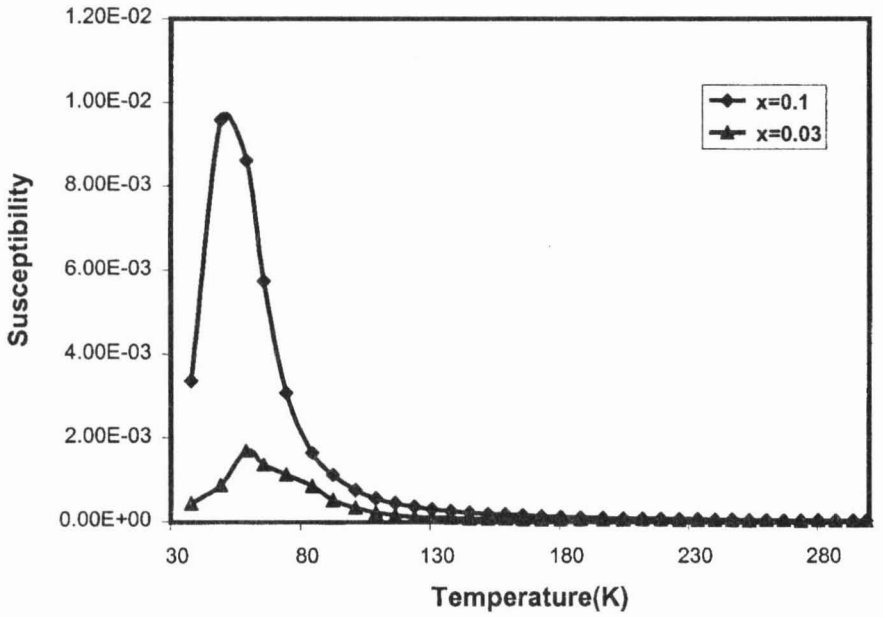

Fig. 2: Temperature dependence of susceptibility of LSCM system at H = 0.1Oe with x = 0.03 and 0.1

Fig. 3 shows the normalized resistance of LSCMO as a function of temperature in the absence of the external magnetic field. As the samarium concentration increase the T_P shifted to a lower temperature. Above T_P all samples show semiconducting transport properties. However, below T_P all samples show the metallic behavior. As the Samarium concentration increases the T_C and T_P decreases gradually as shown in Fig. 4. The replacement

of La by Sm leads to weak the ferromagnetic interaction as the x increases. Similar behavior has also been reported in other system i.e Tb doped LCMO [6]. T_{cusp} is 89K and 82K for x = 0.03 and x = 0.1 respectively. Fig. 4 also shows the phase change from paramagnetic insulator to paramagnetic metal and into ferromagnetic metal for doping concentration less than 0.03. While for samples with concentration more than 0.03 the phase change involves transition from paramagnetic insulator to ferromagnetic insulator and finally into ferromagnetic metal or spin glass state. This could be due to the decreasing influence of the double exchange interaction as the concentration of Sm increases.

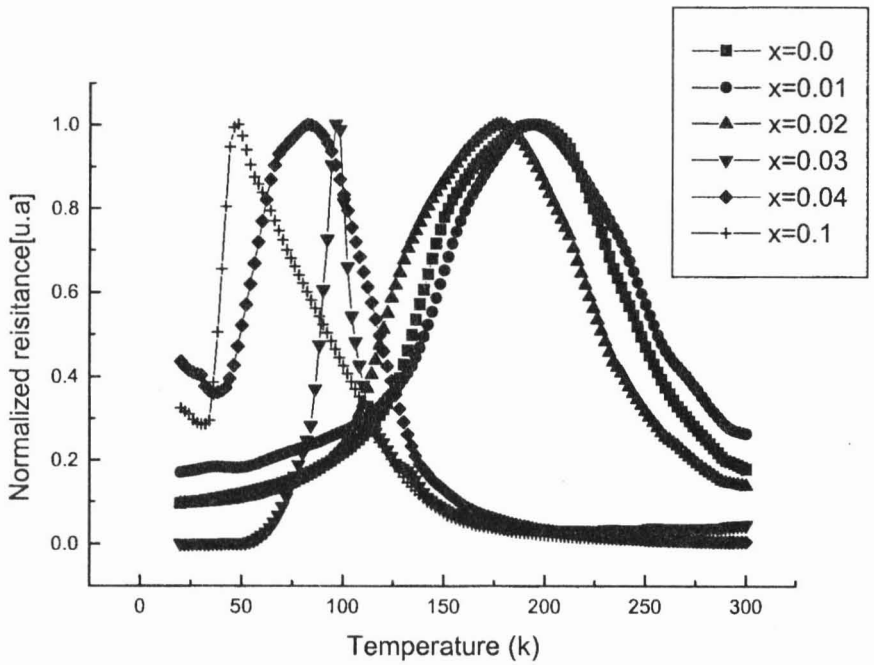

Fig. 3: Normalized Resistance as a function of Temperature for LSCMO system

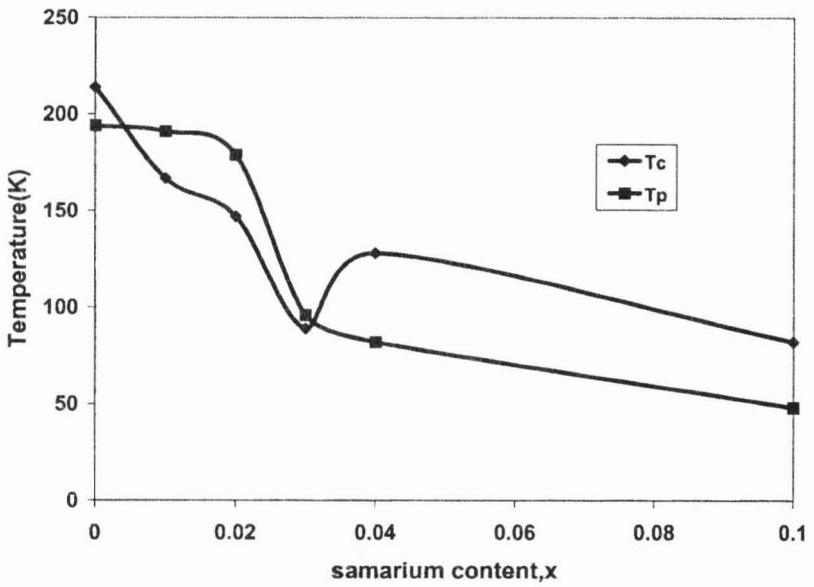

Fig. 4: Temperature as a function of Samarium content of LSCMO system

CONCLUSION

In summary, substitution of La with Sm in the $(La_{(1-x)}Sm_x)_{0.67}Ca_{0.33}MnO_3$ leads to decrease in T_C. The decrease in T_C is related to weakness of DE ferromagnetic all samples [6]. All the samples exhibit a common feature of transition from paramagnetic (PM) state to ferromagnetic (FM) state. A T_{SG} was observed at 89K and 82K for x = 0.03 and x = 0.1 respectively. At the concentration of about 0.03, the metal-insulator state coexists with the ferromagnetic-paramagnetic state.

REFERENCES

[1] N.Kobayashi, M.Isa, T.Nishizaki, M. Fujiwara, Journal of Magnetism and Magnetic Material, **177-181** (1998) 875.

[2] J. H. Hao, Z.S.Li, H. K. Wong, Journal of Material Science and Engineering **B83** (2001) 70

[3] G. Turilli and F. Licci. J. Phy. Rev. B **54(18)** 13052

[4] John B. Goodenough. J. Appl. Phy. **81(8)** (1997) 5330

[5] K. H. Ahn, X. W. Wu, K. Liu, and C. L.Chien, J. Appl. Phys, **81(8)** (1997) 5505

[6] J.Blasco, j Garcia, J M de Teresa, M R Ibarra, P A Algarable and C Marquina. J. Phy. Condens. Matter **8** (1996) 7427

[7] K. Veera Krishna Meera, V. Ravindranath, M.S. Ramachandra Rao, J. Alloys and Compounds **326** (2001) 98

[8] A. Sundaresan, A. Maignan, and B. Raveau. J. Phy. Rev. B **56** (1997) 5092