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Electric and Magneto Transport Studies Of $La_{0.7}A_{0.3}mno_3$ (A = Sr, Ba) Thin Films Grown Using Chemical Solution Deposition

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ABSTRACT- $La_{0.7}A_{0.3}MnO_3$ (where, A = Sr, Ba) manganite nanostructured thin films have been grown on LAO (100) substrate using Chemical Solution Deposition (CSD) technique. The Insulator-Metal (I-M) transition temperature, T_P of ~368K and ~330K were obtained for LSMO and LBMO films respectively. Magnetoresistance (MR) vs. Field (H) isotherms reveal that MR enhances in the vicinit of T_P and decreases at low temperature. The current-voltage (I-V) measurements carried out on these films in the temperature range 82K - 300K shows a linear I-V behavior up to 300K for LSMO film with a slight non-linearity at room temperature. The LBMO film exhibits an unusual non-linearity in I-V characteristics in the temperature range studied which may be attributed to inhomogeneous distribution of strain resulting due to the nonuniform microstructure of LBMO film. Fitting of the electrical transport measurements in $I \propto V^n$ shows that, the Spin-flip scattering becomes dominant around T_P in these film which is also reflected in MR studies.

KEYWORDS: CSD, Epitaxial nature, Low-field magnetoresistance, High-field magnetoresistance, Spin polarized tunneling.

I. INTRODUCTION

The discovery of CMR effect in the rare-earth mixed valent manganites, $R_{1-x}A_xMnO_3$ (R = rare earth element, A=divalent ion) exhibiting colossal magnetoresistance (CMR) ~ 99% which makes these compounds the strong candidates for application in bolometric and magnetic field sensors *[1]*. It is well known that, from the application point of view, the material should be in the form of film. Various film deposition techniques such as Pulsed Laser Deposition (PLD), RF Sputtering, etc. are being used for obtaining good quality films. Chemical solution Deposition (CSD) method for thin film growth has number of advantages over the conventional methods as it is a cost-effective, easier method which requires low reaction temperature. Also it yields high quality thin films of desired thickness.

Because of the strong coupling between spin, charge, and orbital degrees of freedom CMR perovskite manganites typically exhibit a rich variety of electronic and magnetic properties.

Several reports are available on studies on I-V characteristics of manganites to understand transport properties and low field magnetoresistance due to the grain boundaries *[2],[3],[4]-[6]*. In this communication, the results of the temperature dependent I-V studies and MR on LBMO and LSMO manganite thin films grown by CSD method have been discussed.

II. EXPERIMENTAL DETAILS

The LBMO and LSMO films were prepared using CSD technique. Stoichiometric amounts of required metal acetates were dissolved in the mixture of acetic acid and water. This mixture is heated and stirred continuously till a clear solution was obtained which was used for deposition of films on single crystal LAO substrates using automatic spin coater unit. Deposited films were then annealed in oxygen atmosphere at 1000 °C for 12 hrs.

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Both the LBMO and LSMO films were characterized for structural, transport and magnetotransport properties by XRD, surface morphology, R-T and MR measurements with and without applied field using Quantum design PPMS facility at TIFR, Mumbai. I-V measurements were taken using four probe method in the range of 77 K to RT. MR vs. H isotherms at various temperatures ranges from 10 K to 330K for LBMO and LSMO films.

III. RESULTS AND DISCUSSION

Both the LBMO and LSMO films are found to be highly epitaxial and (h00) oriented on single crystal LAO (h00) substrates. From R-T measurements, the insulator-metal transition temperatures, T_p were found to be ~ 330 K and ~ 368 K for LBMO and LSMO films respectively.

To understand the mechanism of electronic charge transport in nanostructured LSMO and LBMO thin films, I-V characteristics were measured in CIP geometry as a function of temperature. The maximum current applied to the films was 1 mA and different temperatures at which I-V data were collected are 82 K, 110K, 150 K, 200 K and 300 K. I-V measurements show similar behavior for forward and reverse applied voltages and hence I-V characteristics for increasing bias voltages have been displayed in fig.1. I-V behavior is slightly nonohmic which can be best fitted in power law of the form

$$I \propto V^n$$

where, n=1-2, is temperature and field dependence parameter [6],[7]. Nonlinearity increases slightly with temperature in LSMO film which is depicted from the fits with n - values increases from 1.02 to 1.1 from 82 K to RT. I-V behavior is highly nonlinear for LBMO film as depicted from the fits with n-value changes from 1.002 to 1.4 from 82 K to RT. The observed nonlinearity in I-V behavior of LBMO film [fig. 1(C)] can be understood as follows:

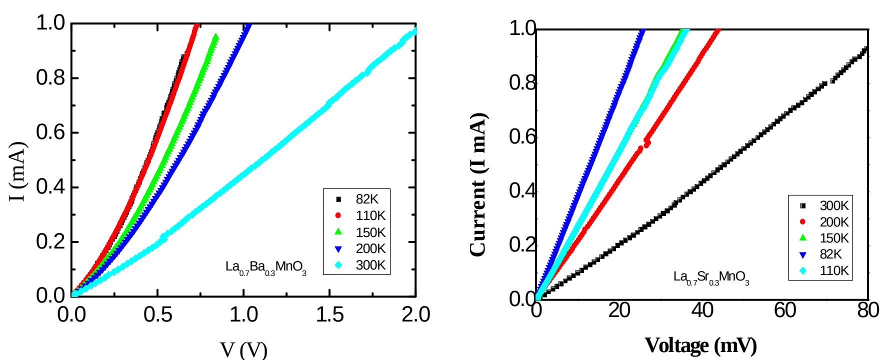

Fig. 1 Current-Voltage plots for LBMO and LSMO at different temperatures

The existence of large compressive strain in LBMO film (~3 %) leads to highly nonuniform distribution of strain which in turn results into two different regions, a highly strained region acting as an insulator while low strained region acts as a metallic region. Therefore, the small insulating regions surrounded by metallic ones behave as a small thin barrier between two metallic regions. Consequently, the tunnelling through these insulating regions causes the nonlinearity in the I-V characteristics [8].

MR vs. H isotherms varying from 10 K to 330K for LBMO and LSMO films are shown in Fig 2. In manganites, MR effect originates due to the two different kinds of reasons. Firstly, at very low temperature, LFMR effect mainly arises due to the spin dependent scattering process at insulating grain boundaries [8],[9],[10] while HFMR is associated with the increased connectivity between the grains owing to the reorientation of disordered spins at interface at high fields and reduction in pinning of Mn ions at grain surface [8]-[10]. Secondly, at T_P, CMR effect is ascribed to the field induced suppression in spin disorder at Mn-O-Mn coupling [8]

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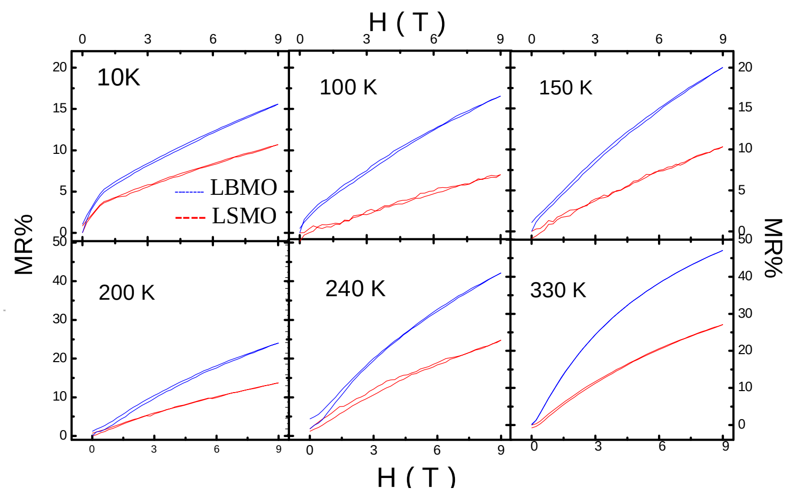

Fig. 2 MR vs H isotherms at various temperatures for LBMO and LSMO films.

At 10K, LSMO films show almost negligible LFMR and HFMR, while LBMO film exhibits LFMR and HFMR ~ 5% and ~15% respectively. However, no steep rise in LFMR behavior has been observed at 10K with temperature clearly suggesting the absence of low temperature grain boundary effect in these highly epitaxial LRMO films. At intermediate temperatures [100-240K], the low field and high field MR increases progressively with applied fields and temperatures. The MR saturates and becomes maximum at T_P which is common behavior for both the films.

Around T_P, the subsequent values of maximum LFMR and HFMR are 5% and 47% for LBMO [at 330K] respectively, while near around RT (at 330K) LSMO exhibits MR ~5% and 27% corresponding to LFMR and HFMR values. The observed appreciable rise in MR at T_P in both the films may be attributed to the field induced delocalization of charge carriers due to the structural disorder at grain boundaries and at Mn-O-Mn bond angles [8].

IV. CONCLUSION

In summary, the high quality LSMO and LBMO manganite thin films were deposited using low cost and simple chemical route. MR and I-V studies indicate the dominant electronic transport in metallic regime via the spin flip scattering in LSMO film and tunneling through disorder metallic interfaces in LBMO film.

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