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STRUCTURAL AND ELECTRICAL PROPERTIES OF $La_{0.67}Ba_{0.33}MnO_3$ THIN FILM DEPOSITED ON CORNING GLASS AND FUSED SILICA

H. M. Albert Gan, K. P. Lim, S. K. Chen, S.A. Halim,
Z. A. Talib and H. W. Chin

Department of Physics, Faculty of Science, Universiti Putra Malaysia,
43400 UPM Serdang, Selangor, Malaysia

**Corresponding author: albert_ming86@hotmail.com*

ABSTRACT

Polycrystalline $La_{0.67}Ba_{0.33}MnO_3$ (LBMO) thin film deposited on corning glass (LBMO-C) and fused silica (LBMO-FS) substrate were studied. X-ray diffraction (XRD) pattern revealed that all samples shown hexagonal structure with space group of R-3c. LBMO structure experienced different lattice strain when deposited on different substrate. Compression along c-axis is observed for lower lattice strain. This distortion shifted the metal-insulator transition temperature (T_p) to higher temperature from below 90K to 92K for LBMO-FS. The maximum peak of %MR also observed near Tp which is at 108K (LBMO-FS). The highest %MR observed for LBMO-C was -29.34%.

Keywords: Magnetoresistance; Thin film

INTRODUCTION

Recently, thin film and nano-manganites which exhibit colossal magnetoreistance (MR) when external magnetic field is applied had been studied extensively due to its possiblility as next generation magnetoresistive sensing element [1, 2]. Lanthanum-based manganites perovskites in thin film have attracted many attentions [2, 3]. Some of them were interested towards the magnetic properties of thin films in a region of $T_p < T < T_c$ [4]. The physical properties of the films were substrate dependent. LBMO thin films deposited on single crystal substrates showed ferromagnetic behavior at room temperature. The lattice strain of LBMO/$LaAlO_3$ was relatively higher compared with LBMO/$SrTiO_3$ and hence distorted its structure. This caused the T_p shifted from 320K to 275K and affecting the magnetic domain structure [5, 6]. %MR effect is also substrate dependent. MR values of 22%, 30%, 33% and 26% were observed for LBMO films deposited on $SrTiO_3$, $NdGaO_3$, $LaAlO_3$ and MgO, respectively [6]. However, not much work had been done on amorphous substrate. Therefore, in this paper, effect of amorphous substrate on magnetoresistance, electrical, structural and magnetic properties of LBMO thin films were studied.

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METHODOLOGY

All thin film samples were deposited on amorphous substrate (corning, fused silica) by pulsed laser deposition method and post anneal at 700^0C for 4 hours in air. X-ray diffraction technique (XRD, Philips PW 3040/60) was used to study the structural properties of samples. The electrical resistance of the samples was measured by Lakeshore Hall Effect measurement system (HMS 7604) with /without applied field (10kG).

RESULTS AND DISCUSSION

XRD pattern of all samples are shown in Figure 1 and the Rietveld refinement data were shown in Table 1. All thin film samples deposited on amorphous substrate having hexagonal structure (R-3c) and match with ICSD standard of 98-007-7765. From Table 1, different lattice strains were observed due to the misfit between films and substrate. Larger lattice strain observed in LBMO-C (1.47%) compare to LBMO-FS (1.17%). Compression along *a* and *b* direction while elongation along *c*-axis observed in LBMO-C. Meanwhile, LBMO-C having bigger Mn-O-Mn bond angle (171.912^0) and longer Mn-O bond distance (1.958Å). This affected the electrical transport mechanism (Double Exchange and Jahn Teller) in the structure. Besides, crystallite size of LBMO-C is relatively smaller (174Å). Larger lattice strain might stretch or compress the samples and resulted smaller crystallite size.

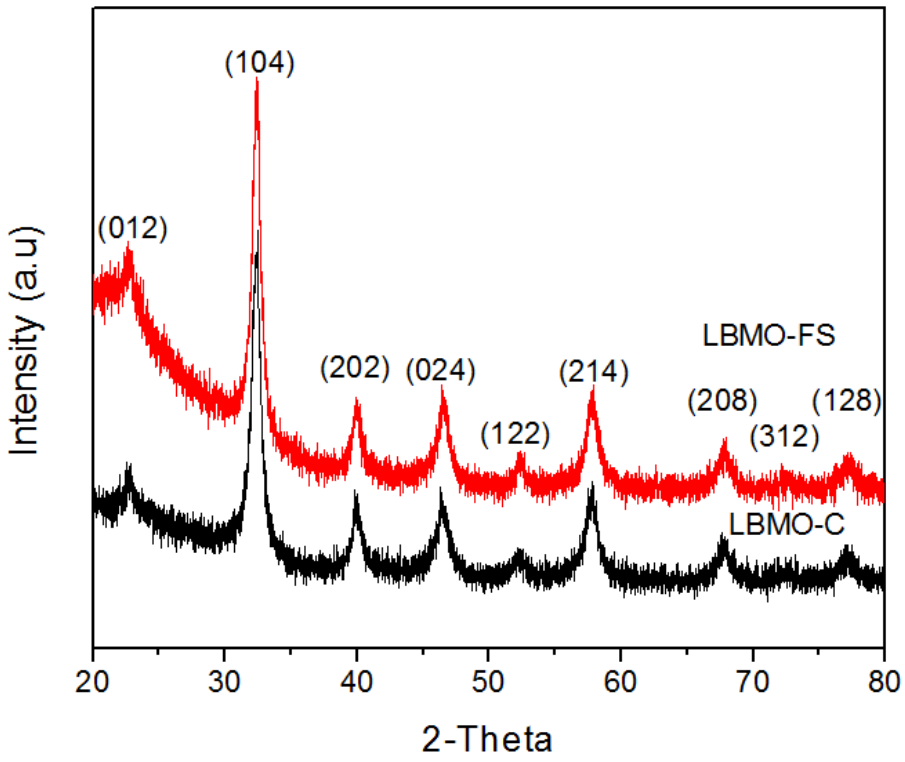

Figure 1: XRD Spectrum of LBMO-C and LBMO-FS

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Table 1: Rietveld Refinement Analysis Data

Sample	**LBMO-C**	**LBMO-FS**
space group	R-3c (167)	
Structure	Hexagonal	
a=*b*(Å)	5.520(1)	5.524(4)
c(Å)	13.540(5)	13.500(2)
V(Å^3)	357.706	356.692
Mn-O-Mn(^{0})	171.912	171.904
Mn-O(Å)	1.958	1.956
Rexp(%)	5.416	4.909
Rp(%)	4.720	4.216
GOF	1.209	1.183
Lattice strain	1.470%	1.170%
Crystallite size	174	195

The electrical resistance behavior of samples was shown in Figure 2. Resistance of both samples become lower with applied magnetic field because the electron spin is more align and easier to hop.

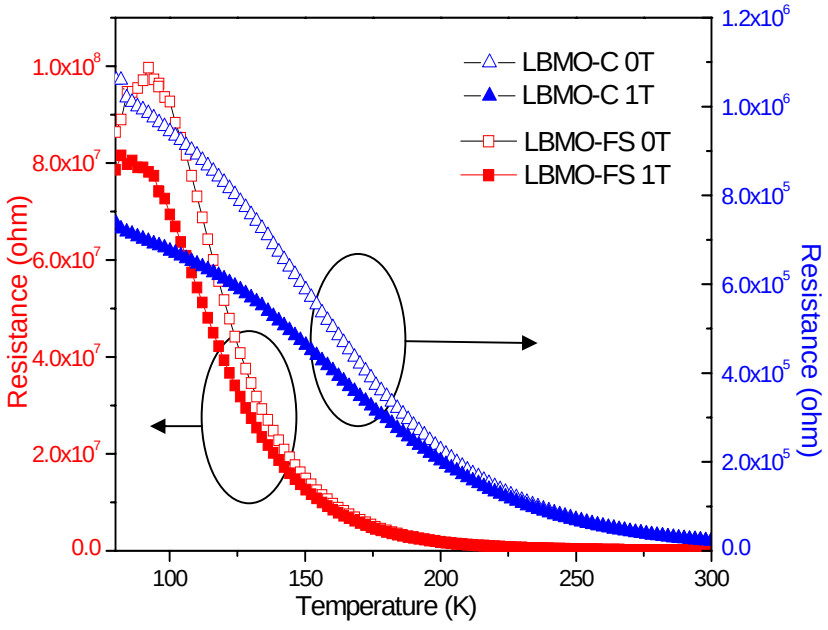

Figure 2: Resistance versus Temperature Plot for LBMO-C and LBMO-FS at 0T and 1T Applied Field

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However, at higher temperature (>170K), the localized e_g and t_{2g} spin in Mn (3-d orbital) atom are more random. Hence, they are less aligned even 1 tesla magnetic field is applied and this resulting only small reduction of resistance when observed. Metal-insulator transition temperature, $T_{p,}$ of LBMO-FS can be observed where the peak of resistance occurred at 92K. However, only insulator like behavior shown by LBMO-C indicated that T_p of LBMO-C was shifted to lower temperature (below 90K). Larger Mn-O-Mn bond angle and distance in LBMO-C sample weaken the double exchange mechanism where the electrons are hard to hop between Mn^{3+} and Mn^{4+} and shifted the T_p to lower temperature. Therefore, higher value of lattice strain shifted T_p to lower temperature.

Magnetoresistance curve for LBMO-C and LBMO-FS at variable temperature are shown in Figure 3. Both samples exhibit typical polycrystalline behavior of MR effect, where the MR% increases when temperature drops due to the co-existing of intrinsic and extrinsic MR behavior. LBMO-C showed its maximum MR (-29.34%, 10kG) at 90K. A maximum MR% peak (-25.88%, 10kG) was observed for LBMO-FS at 108K which is near with T_p (92K).

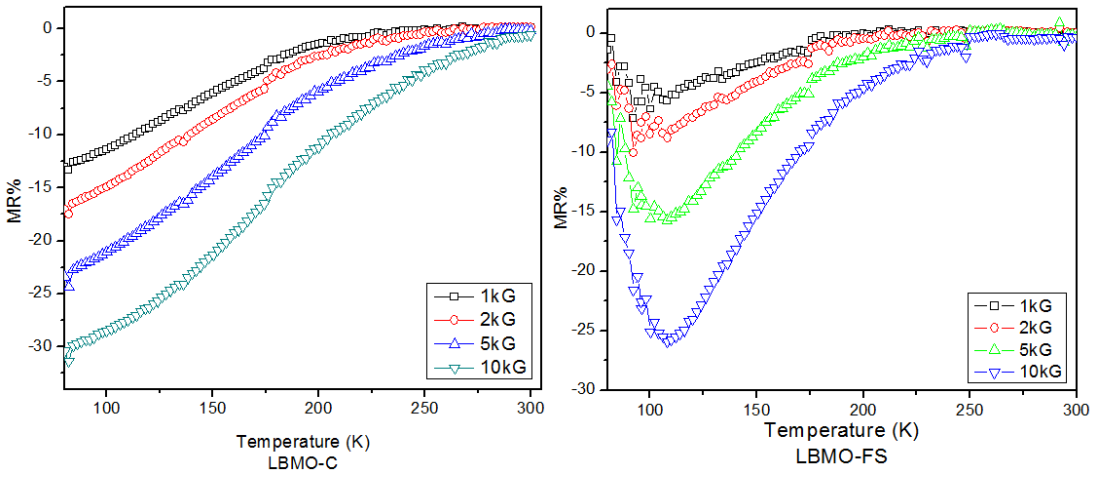

Figure 3: Magnetoresistance versus temperature Plot for LBMO-C and LBMO-FS at 1kG, 2kG, 5kG and 10kG

Low field magnetoresistance (LFMR) effect was shown from the MR% versus field plot (Figure 4). Two different gradients (0-1kG, 1k-10kG) were observed in LBMO-C at 120K and 160K. The effect, known as LFMR effect, was believed to be caused by the extrinsic effect where the spin-dependent scattering and/or spin-polarization tunneling across the grain surface/boundary as proposed by Hwang at al [7]. When the temperature rises, LFMR effect become smaller or weakens. This is because electron is easier to align and spin is more order at lower temperature.

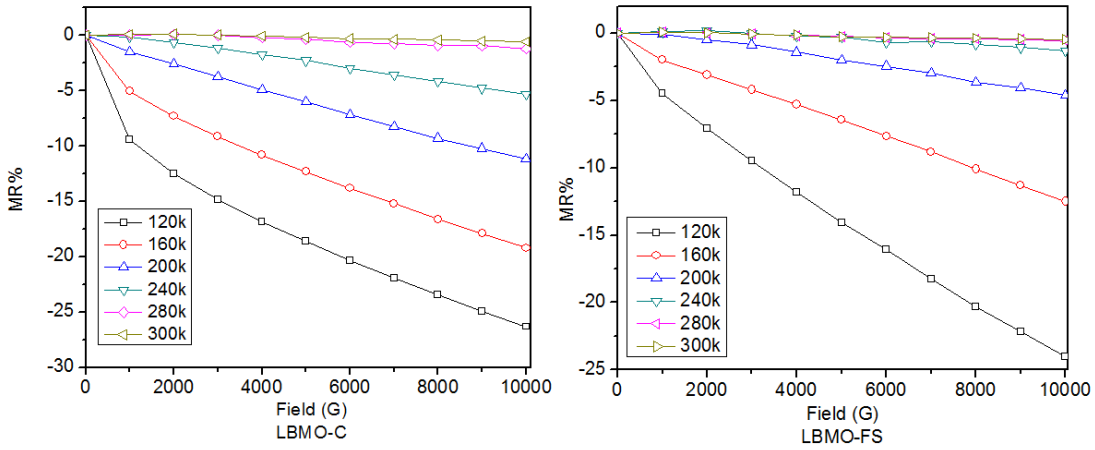

Figure 4: MR% versus Field at variable temperature for LBMO-C and LBMO-FS

Figure 5 shows the magnetic behavior of samples at room temperature. The straight line in the graph indicated that all samples having paramagnetic behavior at room temperature. LBMO-FS (3.5 emu/g) shows higher magnetization value than LBMO-C (0.96 emu/g). The different in magnetization value might due to different grain boundary condition and crystallite size of the samples.

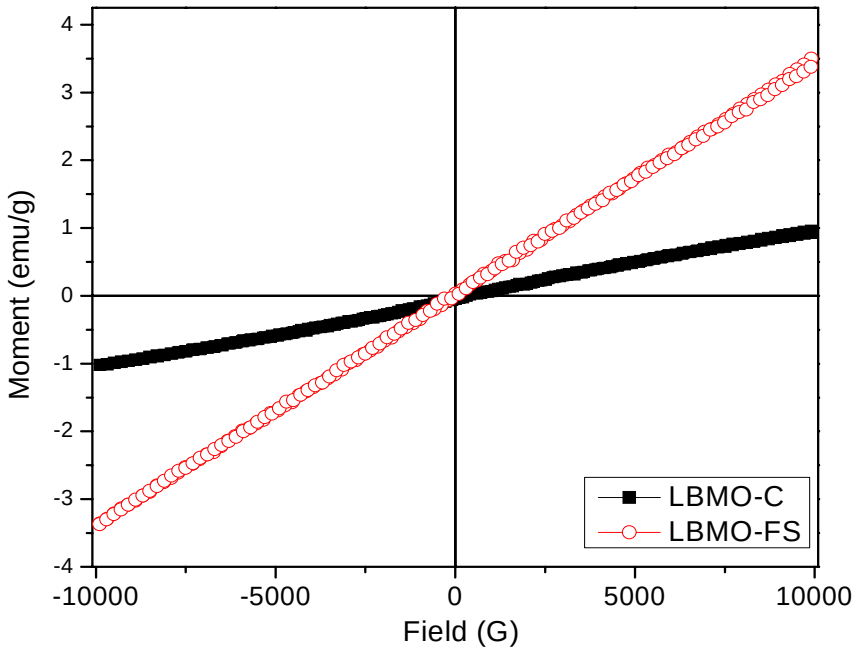

Figure 5: Magnetization versus Field at room temperature

CONCLUSION

LBMO thin film was deposited on different amorphous substrate via Pulsed Laser Deposition method. All samples shown hexagonal crystal structure with R-3c space group. Lattice strain occurred and was substrate dependence. Higher lattice strain promotes crystal structure distortion where the bond angle and distance is increased. This cause an elongation occurred in c-axis and compression in a-b plane and shifted T_p to low temperature (LBMO-C (<90K)). Stronger extrinsic MR effect was found in LBMO-C at 120K (-9.39 %MR) and 160K (-5.05 %MR) at 1kG.

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