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Low temperature study of resistivity of $Sm_{0.6}Sr_{0.4}MnO_3$

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ABSTRACT

This work is devoted to the study of the octahedral distortion in the Sm0.6Sr0.4MnO3 composite and its influence on the electromagnetic transport (colossal magnetoresistance CMR). Comparison between the MR of $Sm_{0.6}Sr_{0.4}MnO_3$ which was prepared in different Laboratories (Cairo University, CU, and Petersburg Nuclear Physics Institute, PNPI) was held. In both it was prepared using the same standard solid state reaction. The lattice parameters are the same in both samples. However, there are differences in MR values. At T = 84.4K, MR measured at PNPI is 81.7% at magnetic field; H = 2.4T while MR measured at CU is 90.7% at magnetic field; H = 2T and 96.4% at H = 3T. The tilt angle of MO_6 octaherda for both samples calculated and has different values. This may lead to deviation in the MR values.

KEYWORDS

Structure;
Octahedral;
Distortion;
Colossal;
Magnetoresistance;
Manganite.

INTRODUCTION

In recent years, there has been a lot of interest in rare earth manganese perovskites due to their technological applications and the fascinating physical phenomena they exhibit, such as clossal magnetoristance (CMR), metal-insulator transition (MI) and charge ordering (CO)[1-3]. These compounds could be used as a magnetic storage media (RAMs of computers) and magnetic sensors. The general chemical formula is $R_yA_{1-y}MnO_3$, where R is a rare earth element and A is a divalent element. These compounds are known to crystallize with the orthorhombic distortion of the perovskite-like structure[4]. The R sites are surrounded by quite distorted 12 oxygen atoms polyhedron while the oxygen octahedral around the Mn ones are less distorted. When an octahedron is tilted in some particular way, it causes tilting of the neighboring octahedra[5]. This tilt in octahedral is very important in defining the magnetic and electric exchange interaction between transition metal element e_g and O 2p orbitals of such a compounds. The first order approximation of tilts are defined in ref.[5] according to the following formula: [b] tilt ~ $(180-\alpha)/2$ and [c] tilt ~ $(180-\beta)/2$ where α and β are $\angle$Mn-O1-Mn and $\angle$Mn-O2-Mn angles, respectively. These angles are the basic parameters in the magnetic and the electric transport behavior in this compound because they govern the interaction between the two Mn ions.

A comparison between the MR of $Sm_{0.6}Sr_{0.4}MnO_3$ which was prepared in different Laboratories (Cairo University, CU and Petersburg Nuclear Physics Insti-

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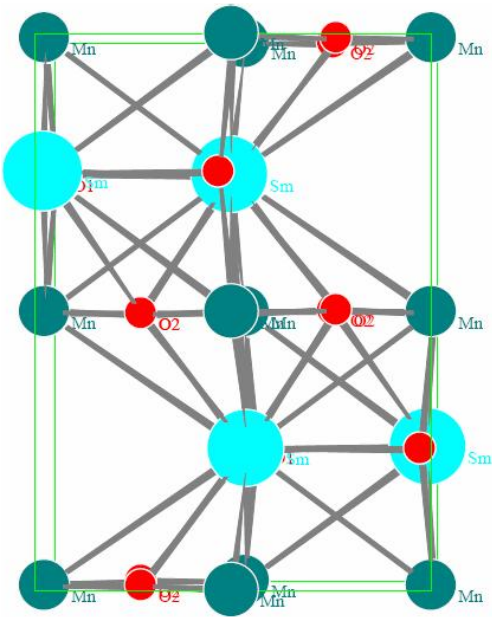

Figure 1 : Crystal structure representation of $Sm_{0.6}Sr_{0.4}MnO_3$ which is prepared at CU

TABLE 1 : Lattice constants and Mn-O bond lengths of $Sm_{0.6}Sr_{0.4}MnO_3$

$Sm_{0.6}Sr_{0.4}MnO_3$	a (Å)	b (Å)	c (Å)	Mn-O1 (Å)	Mn-O2 (Å)	Mn-O2 (Å)
Sample No 1 (CU)	5.434	7.681	5.465	1.934	2.035	1.819
Sample No 2 (PNPI)	5.435	7.661	5.433	1.951	1.960	1.940

tute, PNPI) is presented in this work.

EXPERIMENTAL

The $Sm_{0.6}Sr_{0.4}MnO_3$ was prepared using standard solid state reaction method (in both Cairo University CU and Petersburg Nuclear Physics Institute PNPI Laboratories). The details of preparation and resistivity measurements in both Laboratories are given in ref.[6,7].

RESULTS AND DISCUSSION

The crystal structure of $Sm_{0.6}Sr_{0.4}MnO_3$ (prepared in both CU and PNPI) has the same orthorhombic structure of space group P_{nma} (Space group No 62). The crystal structure of $Sm_{0.6}Sr_{0.4}MnO_3$ which is prepared at CU is represented in figure 1. The lattice parameters and Mn-O bond lengths of $Sm_{0.6}Sr_{0.4}MnO_3$ are given in TABLE 1.

It is clear that, there is a good agreement for the lattice constants in both samples however, a difference was found only in the bond length of Mn-O. This deviation in the result of the bond length can be attributed to the different values of the octahedral tilting (MnO_6). The tilt of MnO_6 is calculated according to the well known formula given in ref.[5]. The tilt angles of sample No 1 are [b] tilt ~ 6.8755° and [c] tilt ~1.05725° and they have small values compared with those calculated for the sample No 2; [b] tilt ~ 10.65° [c] tilt ~ 10°. This is an indication that in the sample No 1 there is less distortion on the MO_6 octahedron than that in the Sample No 2.

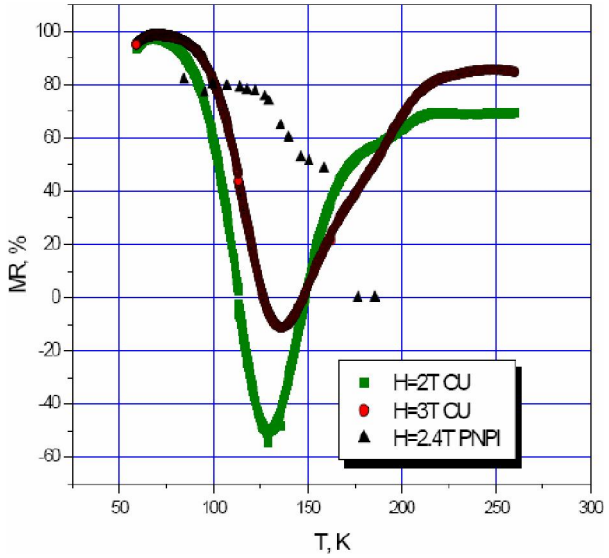

Figure 2 : Magnetoresistance of $Sm_{0.6}Sr_{0.4}MnO_3$ at different applied magnetic fields

The MR is deduced from the resistivity measurements (in the presence and the absence of the magnetic field) given in ref.[6,7] according to the well known formula[8];

$MR = [(\rho_H - \rho_0)/\rho_0] \times 100, \%$

The MR of $Sm_{0.6}Sr_{0.4}MnO_3$ (Sample No 1) is measured as a function of temperature at different magnetic fields; 2T and 3T and is illustrated in figure 2. It is quite clear that colossal magneto-resistance CMR is observed at temperature T = 70K; CMR values at magnetic fields for sample No 1 at 2T and 3T are 97%, 98.7%, respectively. The precedence in this work is the remarkable value of MR at T = 260K (not so far from room temperature) where MR takes the values 69.4% and 83.3% for magnetic field values at 2T to 3T, respectively.

It is worthwhile to compare MR measurements of $Sm_{0.6}Sr_{0.4}MnO_3$ with those reported by S.M.Dunaevsky et. al.[7]. They obtained an MR value for sample

No 2 at magnetic field 2.4T which is 81.71% at T = 84.4K (Figure 2). Moreover, their curve in figure 2 shows a decrease in MR with the increase in the temperature. In spite of both $Sm_{0.6}Sr_{0.4}MnO_3$ samples have the same structure (lattice constant are almost the same) and are prepared using the same method (solid state reaction) they have different MR values. The thermal treatment during preparation, are not the same which may lead to the difference in the tilt of MnO_6 octahedra and hence in the MR values. It is also well known that, the exchange interaction between Mn e_g and O 2_p orbital is governed by the Mn-O1-Mn and Mn-O2-Mn angles which are the basic parameters in determining the magnetic and the electronic behavior of this compound. So we can conclude that the less distortion in the MnO_6 octahedra in sample No.1 leads to the increase in CMR value which became more than the corresponding value in sample No 2.

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