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MAGNETOTRANSPORT PROPERTIES OF $SM_{0.5}SR_{0.5}MNO_3$ MANGANITES

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ABSTRACT

We presented the results of magnetotransport analysis, x-rays analysis, of $Sm_{0.5}Sr_{0.5}MnO_3$ polycrystalline manganites. x-rays analysis indicate that samples are polycrystalline with a lattice parameter of 5.76Å. Temperature dependence of resistance showed a peak characteristic of the insulating-metallic state at $T_{MI}\approx100K$. The sample showed the colossal magnetoresistance effect under magnetic fields between 0T and 5T.

RESUMEN

Presentamos los resultados de magnetotransporte y de rayos-x realizadas en manganitas policristalinas de $Sm_{0.5}Sr_{0.5}MnO_3$. El análisis de rayos-x mostró que las muestras son policristalinas con un parámetro de red de 5.76Å. La dependencia de la resistencia con la temperatura presentó un pico $T_{MI}\approx100K$, característico de la transición metal-aislante en este tipo de materiales. Además, cuando a la muestra se le aplicó un campo magnético de 5T. se observó el efecto de magnetosresistencia colosal de aproximadamente 500%.

INTRODUCTION

The perovskite-type manganese oxides, $Ln_{1-x}A_xMnO_3$ (*Ln* = La, Sm, Gd, Nd, Y; *A*=La, Ba, Sr, Ca), has attracted much recent attention due to the observations of the colossal magnetoresitance effect [1-3]. The pure compounds $AMnO_3$ are antiferromagnetic insulators (AFMI). Upon doping Ln^{3+} ions by A^{2+} both Mn^{3+} and Mn^{4+} are present. The correlation between the magnetism and electrical properties has been qualitatively understood on the basis of the double-exchange (DE) model [4]. With the substitution of Ln and A a competition between antiferromagnetic super exchange and ferromagnetic DE interaction have been observed [2,4]. A prominent feature of these materials is a large maximum in the resistivity near the Curie temperature is obtained with the magnetoresistance measurements [2,3]. The T_C in the perovskite manganite $R_{1-x}Sr_xMnO_3$ *(R=La, Pr, Nd, Sm)* are very sensitive to the tolerance factor (doping level and the degree of lattice distorsion) which are closely relevant to the carrier kinetic energy [5]. In the $Sm_{0.5}Sr_{0.5}MnO_3$ composition, Mn atom has mixed valence Mn^{3+} and Mn^{4+}, where $Ln^{3+}=Sm^{3+}$ and $A^{2+}=Sr^{2+}$.

In this work, we report the preparation and characterization of $Sm_{0.5}Sr_{0.5}MnO_3$ polycrystalline to study its structural, electrical and magnetresistance properties. Perovskites of this type have triggered a renewed interest on these materials for their magnetic properties and technological applications.

EXPERIMENT

Polycrystalline samples of $Sm_{0.5}Sr_{0.5}MnO_3$, were prepared by the conventional solid-state reaction method. A well-mixed stoichiometric mixture of *La_2O_3, $CaCO_3$, $SrCO_3$, Sm_2O_3, and MnO_2* (with purities of 99.9%) were calcined at temperatures between 1000°C and 1200°C in air for 24h. The product thus obtained was reground, palletized, and pressing 8 ton/cm^2. The resulting samples were further homogenized at 1100°C in air for 5h and then were cooled at rate of 5°C/min down to 850°C during 12h and finally quenched to room temperature. Structural characterization of the samples was performed with x-ray analysis. Resistance was measured by the conventional four-probe method in the interval from 10K to 300K with samples of 8 mm diameter and 2 mm thick. Magnetoresitance measurements were realized under magnetic fields between 0-5T.

RESULTS AND DISCUSSION

X-rays analysis of the samples shows peaks with different orientations indicating that the sample is polycrystalline. With the peak position of the film we obtain a lattice parameter of 5.76Å nm. Fig. 1, top curve, shows the resistance versus temperature measurements obtained at zero field cooling for a $Sm_{0.5}Sr_{0.5}MnO_3$ sample. Here, one observes a resistance peak characteristic of the transition from metallic state to an insulating paramagnetic state (PMI) $T_{MI}\approx 105K$, and a Curie temperature $T_C\approx 71K$ was obtained in the maximum of dR/dT-T curve. In the same figure we show temperature dependence of resistance for $Sm_{0.5}Sr_{0.5}MnO_3$ taken in cooling run with applied magnetic field of 5T. Under an external magnetic field of 5T the position of resistance peak T_{MI} is shifted to 115K, the Curie temperature take a 86K value, and the resistance decreases dramatically corresponding to significant magnetoresitance (MR). At Curie temperature obtained correspond the tolerance factor f≈0.971 [6].

The tolerance factor f is defined as $f = \frac{(r_A + r_0)}{\sqrt{2}(r_B + r_0)}$, where r_A, r_B and r_0 are ionic radio of the perovskite A, B(Mn) site of the cations and oxygen, respectively.

The temperature dependence of the magnetoresistance of polycrystalline $Sm_{0.5}Sr_{0.5}MnO_3$ defined as $MR\% = \frac{R(T,0) - R(T,5T)}{R(T,5T)}$, is showed in the Fig. 2. The maximum of MR%(T) curve at T~86K, which is close Curie temperature, corresponds to 593% value. This effect is called colossal magnetoresitance (CMR), and is characteristic of this kind of material. At temperature below and above of T~86K the CMR decrease significantly.

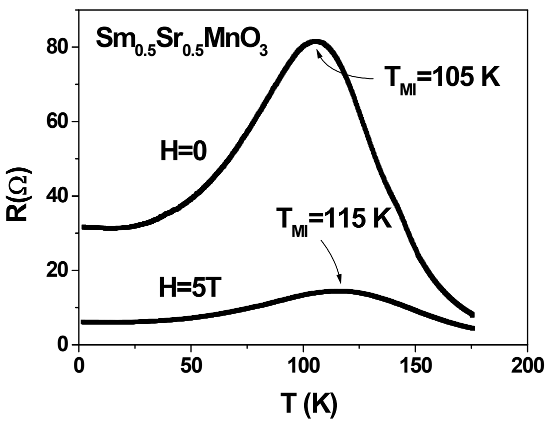

Fig.1. Resistance versus temperature for a $Sm_{0.5}Sr_{0.5}MnO_3$ sample at zero field and 5T

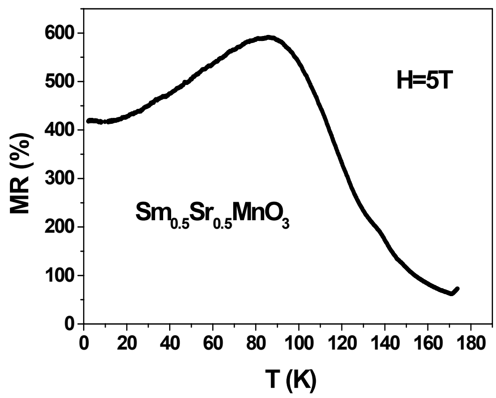

Fig.2. MR versus temperature for same sample of Fig. 1

On the other hand, Fig. 3 shows the magnetic dependence of resistance of $Sm_{0.5}Sr_{0.5}MnO_3$ sample at temperatures above and below of Curie transition $T_C \approx 71K$ obtained at zero magnetic field. Resistance as function of magnetic field was measured in increasing and decreasing of magnetic field runs at 130K and 15K respectively. The curves at $130K > T_C$ shown a small hysteresis, while that the curves measured at 15K show larger hysteresis, which is indicative of the ferromagnetic character of the $Sm_{0.5}Sr_{0.5}MnO_3$ sample. Most immediately noticeable is a change in the low-field response from a behavior $\left(\frac{\partial R}{\partial H}\bigg|_{H=0} = 0 \right)$ predominantly quadratic

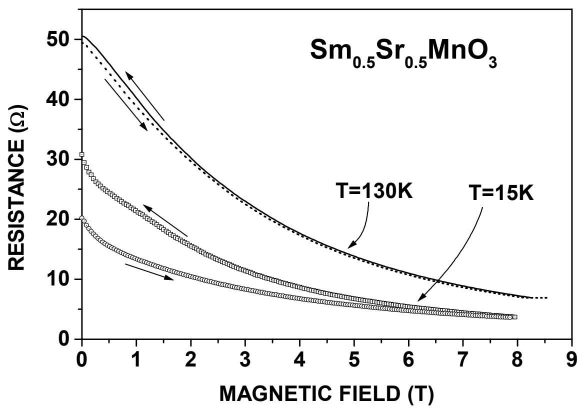

Fig. 3. Isothermal curves of R(H) for $Sm_{0.5}Sr_{0.5}MnO_3$ sample at 15K and 130K

for T>T_C to linear $\left(\left.\frac{\partial R}{\partial H}\right|_{H=0} < 0 \right)$ for T<T_C following a Curie-Weiss form. of R(H) curve a $\left.\frac{\partial R}{\partial H}\right|_{H=0} \approx -30\,\Omega\,T^{-1}$ value was obtained. High values of $\left.\frac{\partial R}{\partial H}\right|_{H=0}$ are important for technological applications in magnetic sensors

CONCLUSIONS

In summary, we have achieved prepare $Sm_{0.5}Sr_{0.5}MnO_3$ polycrystalline samples. $Sm_{0.5}Sr_{0.5}MnO_3$ samples showed CMR of 593% at ~86K. A hysteretic behavior of R(H) curves at 15K with a $\left.\frac{\partial R}{\partial H}\right|_{H=0} \approx -30\,\Omega T^{-1}$ was obtained.

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REFERENCES

[1]. G.H. Jonker, J.H. Van Santen, Physica XVI, **3**, 337, 1950
[2]. F. Damay et al, J. Appl. Phys. **82** (1997)6181
[3]. M. Bibes et al, Appl. Phys. Lett., **75** (1999)1372
[4]. C. Zener, Phys. Rev. **81**, 440 (1951)
[5]. Maignan et al., J. Appl. Phys. **79** (1996)7891
[6]. Y. Tokura, Fundamental Features of Colosal Magnetoresistive manganese Oxides, in "*Colossal Magnetoresistance Oxides*" Ed. Y. Tokura, Gordon and Breach Science Publishers (2000)33.