Magnetic and Transport Properties of Fe-Subtituted Manganites $La_{0.67}Ca_{0.33}Mn_{1-x}Fe_xMnO_3$

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Abstract

Specific heat, magnetic susceptibility and magnetoresistivity measurements have been performed on the polycrystalline samples of Fe-substituted manganites. The transition temperatures derived from the specific heat anomalies for $x = 0$, 0.01, 0.06 were in agreement with the position of the maximum slope of a.c. susceptibility. For compositions with $x = 0.10$ and 0.15 no transition was observed in the specific heat. A sharp increase in resistivity below 135 K and 125 K was observed in zero field for $x = 0.10$, and 0.15 respectively.

Key words: manganites; specific heat; magnetic properties

The electronic sub-micrometer scale phase separation into free conducting domains, ferromagnetically ordered via Double-Exchange (D-E) mechanism, is recently considered to be responsible for the colossal magnetoresistance (CMR) in manganite perovskites of the $R_{1-y}Ca_yMnO_3$ type [1]. The substitution of Fe^{3+} for Mn cations brakes D-E correlations and thus is expected to have a strong effect on the thermal, magnetic and transport properties [2]. We have performed extensive studies on the substituted compounds $La_{0.67}Ca_{0.33}Mn_{1-x}Fe_xO_3$. In this work, we report the AC magnetic susceptibility and specific heat data for the polycrystalline samples with $x = 0$, 0.01, 0.06, 0.06Fe^{57}, 0.10Fe^{57}, 0.15. Additionally, the effect of chemical pressure was checked by a partial substitution of Y for La in $La_{0.60}Y_{0.07}Ca_{0.33}MnO_3$ (LYCMO).

The AC susceptibility temperature dependences are shown in Fig. 1. The Curie temperature, T_C, was determined as the inflection point of the susceptibility curve.

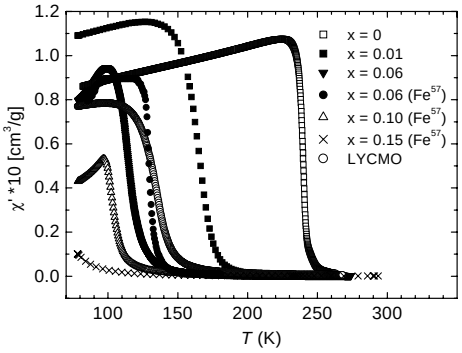

Fig. 1. The AC susceptibility temperature dependences for samples with $x = 0$, 0.01, 0.06, 0.10, 0.15 and for Y substituted sample.

With increasing Fe concentration the Curie temper-

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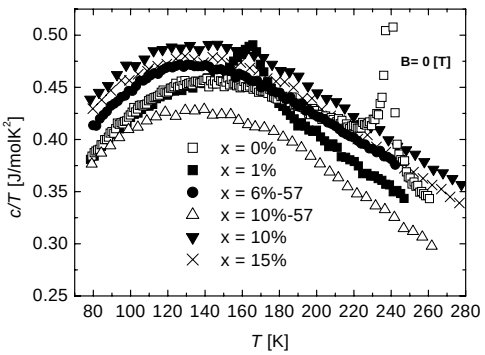

Fig. 2. Specific heat plotted as c/T vs. T for iron substituted manganites.

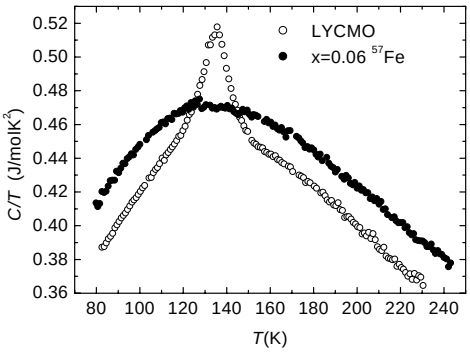

Fig. 3. Specific heat plotted as c/T vs. T for iron 0.06 Fe^{57} and Y substituted manganites.

ature T_C was found to decrease nonlinearly indicating a diminishing of magnetic interactions due to the blocking of double exchange by Fe. Sharp peaks in the specific heat at the transition temperature were observed for $x = 0$ and $x = 0.01$ (fig. 2). Moreover the specific heat absolute value is found to depend strongly on the sample preparation procedure, probably due to different oxygen content.

Under an applied magnetic field of 0.2 T the upward shift of the transition temperature was observed for $x = 0$, 0.01 and LYCMO. The gradual broadening of the peak with increasing x was observed. For $x = 0.06$ only a tiny kink is seen. The entropy released at the transition temperature apparently diminishes with increasing x suggesting that only certain regions within a sample are ferromagnetically ordered, or the sample is only partially ordered. It is interesting to note, that although the transition temperature T_C for $La_{0.60}Y_{0.07}Ca_{0.33}MnO_3$ is similar to that of $x = 0.06$, indicating a comparable magnetic interactions, LYCMO exhibits pronounced peak in heat capacity (Fig. 3). It suggests that the two systems have different types of magnetic inhomogeneities, possibly the magnetic clusters which seem to be different for $La_{0.67}Ca_{0.33}Mn_{0.94}Fe_{0.06}O_3$ and $La_{0.60}Y_{0.07}Ca_{0.33}MnO_3$, the materials with comparable magnetic interactions and similar χ_{AC} characteristics.

A sharp increase in resistivity below 135 K and 125 K was observed in zero field for $x = 0.10$, and 0.15 respectively. The resitivity measurements in applied magnetic field up to 8 T have revealed a giant magnetoresitivity effect in those samples. At high temperatures strong dependence on applied current for $x = 0.10$ and 0.15 was observed possibly due to an energy gap between conducting domains embedded in semiconducting medium.

Further investigations aimed at the correlation between different types of micro-domain structure (free domains or spin-glass type, directly connected or separated by energy barrier) and transport properties in these systems.

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