Electrical transport properties of $La_{1-x}Sr_xFeO_3$*

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Abstract. $La_{1-x}Sr_{-x}FeO_3$ $(0 \cdot 1 \leqslant x \leqslant 0 \cdot 4)$ samples exhibit nearly the same low resistivity value around the Neél temperatures. Above T_N, electrons seem to become itinerant as suggested by Mössbauer data.

1. Introduction

Extensive studies have been carried out recently on the $Ln_{1-x}Sr_xCoO_3$ (Ln=rare earth) system (Bhide *et al* 1975; Rao *et al* 1975; Rao and Om Parkash 1977). Electrical resistivity and thermopower data indicate that $Ln_{1-x}Sr_xCoO_3$ becomes metallic beyond $x = 0 \cdot 3$. Mössbauer spectra of $La_{1-x}Sr_xCoO_3$ $(x \leqslant 0 \cdot 125)$ at room temperature show two resonances due to Co^{4+} and Co^{3+}; for $0 \cdot 125 < x < 0 \cdot 5$, however, only a single resonance peak is observed. This observation shows that cobalt ions in the latter samples have a time-averaged electronic configuration between Co^{3+} and Co^{4+}. Furthermore, while the Mössbauer spectra of $La_{1-x}Sr_xCoO_3$ $(x \leqslant 0 \cdot 125)$ at 78K were similar to the room temperature spectra, the spectra of samples with $0 \cdot 125 < x < 0 \cdot 5$ exhibit hyperfine structure due to ferromagnetism. It is interesting to compare the Mössbauer results on $La_{1-x}Sr_xCoO_3$ with those reported for the analogous $La_{1-x}Sr_xFeO_3$ (Shimony and Knudsen 1966; Gallagher and MacChesney 1968). The end member $LaFeO_3$ $(x = 0)$ of this system is an antiferromagnetic $(T_N \approx 750K)$ insulator. For compositions $x = 0 \cdot 0$ through $x = 0 \cdot 3$, Shimony and Knudsen (1966) observed two resonances at 300K in the Mössbauer spectra due to Fe^{3+} and Fe^{4+} states, the Neél temperatures for these compositions being higher than 300K. For compositions $x \geqslant 0 \cdot 4$, they observed a single resonance in the Mössbauer spectra at 300K with an isomer shift lying between that of Fe^{3+} and Fe^{4+} ions, T_N in these samples being lower than 300K. Even in the samples with $x < 0 \cdot 4$, there was a single resonance above T_N. It appears that electron transfer in these systems is so fast above T_N that the different iron nuclei see the same chemical environment, thereby giving rise to an average oxidation state of Fe^{3+} and Fe^{4+} as evidenced in the Mössbauer spectra.

Unlike the $La_{1-x}Sr_xCoO_3$ system, the $La_{1-x}Sr_xFeO_3$ system has not been examined employing electrical resistivity and thermopower measurements. We have,

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therefore, carried out electrical resistivity and thermopower measurements on $La_{1-x}Sr_xFeO_3$ ($x = 0·1$ through $x = 0·4$) to throw some light on the electrical transport properties of this system and to see if such measurements are consistent with the Mössbauer data.

2. Experimental

Ceramic samples of $La_{1-x}Sr_xFeO_3$ were prepared with $x = 0·1$, $0·2$, $0·3$ and $0·4$. Appropriate mixtures of Fe_2O_3, $SrC_2O_4.H_2O$ and $La_2C_2O_4.xH_2O$ were thoroughly ground and calcined at $1200°$ C for nearly 12 hr. The calcined mixtures were finely ground and pressed into discs to be fired at $1300°$ C for final sintering. The sintering process was repeated for a number of times with intermittent grinding. X-ray diffraction patterns of the sample were taken to ascertain that the reaction was complete and no oxide impurity was left over. However, the high temperature needed to prepare these samples causes oxygen deficiency especially in strontium-rich samples. In view of this, the samples were first heated in oxygen atmosphere at $900°$ C for three days and then the temperature was reduced to room temperature in steps of $100°$ C each day maintaining oxygen flow throughout. Four-probe electrical conductivity and thermopower measurements were carried out with an apparatus fabricated in this laboratory.

3. Results and discussion

The plots of logarithm of electrical resistivity against $1/T$ for different compositions ($x = 0·0$, $0·1$, $0·2$ and $0·4$) of $La_{1-x}Sr_xFeO_3$ are shown in figure 1. The
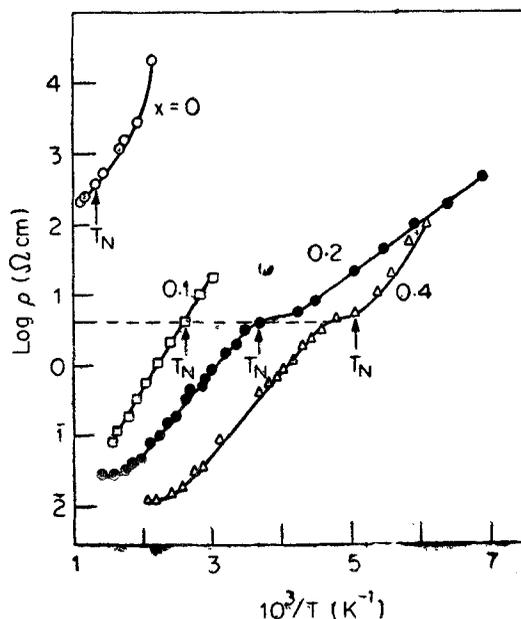

Figure 1. Plot of logarithm of resistivity ($\log \rho$) against reciprocal of temperature for $La_{1-x}Sr_xFeO_3$.

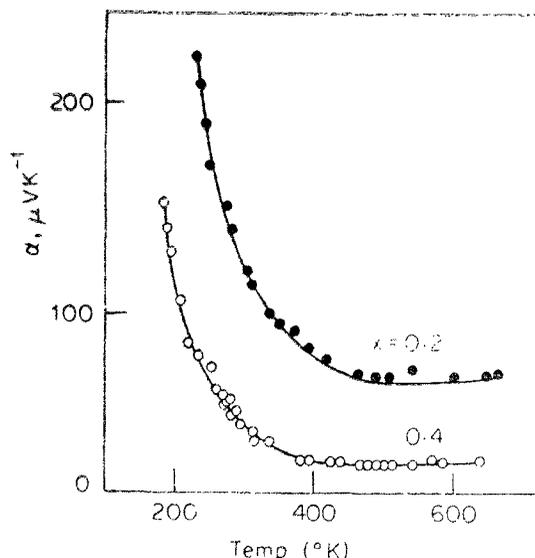Figure 2. Plot of thermopower, a, against temperature for $La_{1-x}Sr_xFeO_3$.

resistivity plots for all these compositions show decrease in resistivity with rise in temperature indicating semiconductor behaviour. Unlike the $La_{1-x}Sr_xCoO_3$ system, we do not observe metallic behaviour even at $x = 0.4$. All the compositions show an abrupt change in the slope of the resistivity plots around the Néel temperatures. The Néel temperature is 200K for $x = 0.4$ compared to 285K for $x = 0.2$. It is interesting that the resistivity for all the compositions of $La_{1-x}Sr_xFeO_3$ is nearly the same around the Néel temperature where there are breaks in $\log p$ vs $1/T$ curves (see figure 1). This seems to indicate that electrons may become itinerant above T_N. Indeed, the resistivity values for all the compositions are fairly low (≈ 5 ohm cm) in the region of T_N. It is possible that below T_N, the resistivity has $T^{-1/4}$ behaviour due to variable range hoping typical of oxide systems with Anderson localisation (Rao and Om Parkash 1977). Above T_N, the resistivities of all the samples continue to decrease as expected.

The variation of thermopower, a, with temperature for the compositions $x = 0.2$ and $x = 0.4$ of $La_{1-x}Sr_xFeO_3$ are shown in figure 2. The thermopower, a, decrease markedly with increase in temperature and becomes essentially constant at temperature higher than T_N indicating itinerant electron behaviour.

Acknowledgements

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