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$LaNi_{1-x}Co_xO_3$ as interconnection materials

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Abstract. Thermo Gravimetric Analyis (TGA) shows that incorporation of Co^{3+} considerably reduces the oxygen loss at high temperatures in $LaNiO_3$. Electrical resistivity of $LaNi_{1-x}Co_xO_3$ ($x \leqslant 0 \cdot 2$) is essentially independent of oxygen partial pressure in the 600–1000 K range.

1. Introduction

Rare earth perovskites of the type ABO_3 where A is a rare earth ion and B is a transition metal ion have been found to have potential applications such as components of solid electrolyte fuel cells (Tedmon *et al* 1969) and as cathode materials in alkaline solution zinc-air batteries (Meadowcraft 1970; Kudo *et al* 1975) (used in urban transport). Electrical and magnetic properties of these materials have been investigated extensively in recent years (Goodenough 1967, 1972, 1974; Rao 1974, 1977; Rao and Subba Rao 1970). We have been actively involved in the investigation of solid solutions of perovskites such as $LaNi_{1-x}Fe_xO_3$ and $LaNi_{1-x}$. Co_xO_3 in this laboratory for quite some time and we recently reported electronic and magnetic properties of $LaNi_{1-x}Co_xO_3$ ($0 \leqslant x \leqslant 1$) and $LaCo_{1-x}Fe_xO_3$ ($0 \leqslant x \leqslant 0 \cdot 5$) (Rao *et al* 1975). Our interest in the study of these materials was further strengthened because of their possible use as interconnecting materials in fuel cells. Interconnection materials must be stable both in air and fuel atmospheres (i.e., should have conductivity independent of oxygen partial pressure, etc.) and should be good electronic conductors. Kleinschmager and Reich (1972) have reported that the electrical resistivity of the system $LaO_{1 \cdot 5} \mid NiO_{1 \cdot 5} \mid CoO_{1 \cdot 33}$ (10|9|1) varies marginally with oxygen partial pressure. This composition roughly corresponds to $LaNi_{0 \cdot 9}Co_{0 \cdot 1}O_3$. It was, therefore, considered worthwhile to actually prepare solid solutions of finite compositions in the system $LaNi_{1-x}Co_xO_3$ and study their electrical properties.

2. Experimental

Samples of $LaNi_{1-x}Co_xO_3$, $x = 0 \cdot 1$ and $0 \cdot 2$, were prepared by mixed oxalate method (Rao *et al* 1975). They have rhombohedral structure with $a = 5 \cdot 41$ Å, $\alpha = 60 \cdot 69°$ and $a = 5 \cdot 40$ Å and $\alpha = 60 \cdot 76°$ respectively. TGA was carried out, using MOM-505 Derivatograph at a heating rate of 10°/min. Resistivity measurements were carried out employing four-probe technique using a locally fabricated cell. For a particular atmosphere, the conductivity cell was placed in a quartz jacket and the entire system was evacuated to a pressure less than one micron. The system was then flushed with the required gas and the entire system again evacuated. This process of flushing and evacuation was repeated a number of times and finally the atmosphere of the required gas was maintained in the closed system.

3. Results and discussion

$LaNiO_3$ loses oxygen in well defined equilibrium stages (Gai and Rao 1975; Obayashi and Kudo 1975). At 1390 K, $LaNiO_3$ decomposes to La_2NiO_4 and NiO; slightly below this temperature (1210 K), $LaNiO_3$ seems to undergo a rhombohedral-cubic transition. TGA curves of the samples of $LaNi_{1-x}Co_xO_3$ ($x = 0{\cdot}1$ and $x = 0{\cdot}2$) are shown in figure 1. We see that incorporation of Co^{3+} in $LaNiO_3$ reduces the oxygen loss considerably thus indicating the relative stability of these materials compared to pure $LaNiO_3$.

Resistivity data for the system $LaNi_{1-x}Co_xO_3$ ($x = 0{\cdot}1$ and $x = 0{\cdot}2$) are shown in figure 2. The resistivity of $LaNi_{1-x}Co_xO_3$ ($x = 0{\cdot}1$ or $x = 0{\cdot}2$) is essentially

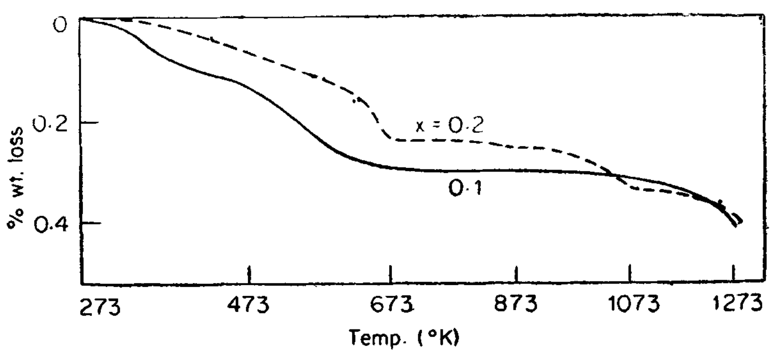

Figure 1. TGA curves of $LaNi_{1-x}Co_xO_3$.

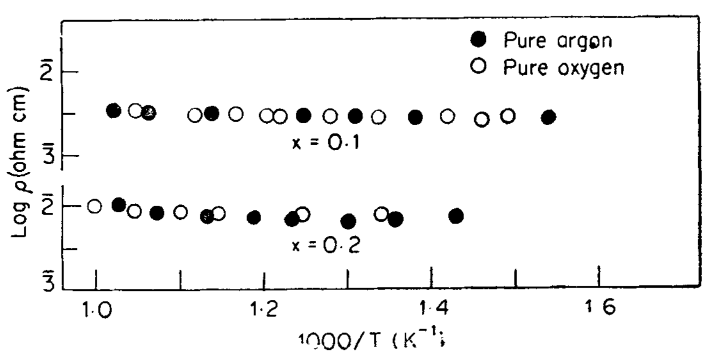

Figure 2. Plot of logarithm of electrical resistivity of $LaNi_{1-x}Co_xO_3$ against reciprocal of absolute temperature.

independent of oxygen partial pressure over the entire range of measurement (600–1000 K). It, therefore, appears that $LaNi_{1-x}Co_xO_3$ ($x = 0\cdot1$–$0\cdot2$) is a suitable candidate for use as interconnection material. $LaNi_{0\cdot9}Fe_{0\cdot1}O_3$, on the other hand, does not appear to be so since the resistivity varies appreciably with oxygen partial pressure. Actual use of $LaNi_{1-x}Co_xO_3$ in fuel cells, however, requires that the material be essentially inert and non-porous and these studies have yet to be carried out.

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References

Gai P and Rao C N R 1975 *Z. Naturforsch* **309** 1092
Goodenough J B 1967 *Czech. J. Phys.* **B 17** 304
Goodenough J B 1972 *Prog. Solid State Chem.* **5** 145
Goodenough J B 1974 in *Solid state chemistry* ed. C N R Rao (New York : Marcel Dekker)
Kleinschmager H and Reich A 1972 *Z. Naturforsch* **A 27** 363
Kudo T, Obayashi H and Gejo T 1975 *J. Electrochem. Soc.* **122** 159
Meadowcraft D B 1970 *Nature (London)* **226** 847
Obayashi H and Kudo T 1975 *Jpn. J. Appl. Phys.* **14** 330
Rao C N R 1974 *J. Indian Chem. Soc.* **51** 979 and refs. cited therein
Rao C N R 1977 Presidential address, Indian Science Congress (Chemistry Section)
Rao C N R, Om Parkash and Ganguly P 1975 *J. Solid State Chem.* **15** 186
Rao C N R and Subba Rao G V 1970 *Phys. Status Solidi* **1** 597
Tedmon C S Jr, Spacil H S and Mitoff S P 1969 *J. Electrochem. Soc.* **116** 1170