Synthesis and physical properties of pyrochlore iridium oxides $Pb_{2-x}Ca_xIr_2O_{7-y}$

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Abstract

Pyrochlore iridium oxides $Pb_{2-x}Ca_xIr_2O_{7-y}$ (x=0.0, 0.2, 0.4, 0.6, 0.8) were prepared by solid state reaction. The electrical resistivity and the magnetic susceptibility were measured between 4.2 and 300 K. These compounds show metallic conductivity and obey the Curie-Weiss law with temperature independent term. The metallic conductivity of $Pb_2Ir_2O_7$ is suppressed by the Ca substitution for Pb site.

Key words:
pyrochlore oxide, metallic oxide, spin frustration

1. Introduction

Recently, the pyrochlore oxide $Cd_2Re_2O_7$ has been reported to exhibit superconductivity at $\sim$ 1 K. [1,2] Metallic pyrochlore oxides are very attractive in terms of magnetic frustration system. Pyrochlore oxide $Pb_2Ir_2O_{7-y}$ has been reported to show a good metallic conductivity [3,4]. However, physical properties in detail are not revealed. We have synthesized solid solution $Pb_{2-x}Ca_xIr_2O_{7-y}$ and measured its electrical resistivity and magnetic susceptibility between 4.2 and 300 K.

2. Experimental

The polycrystalline samples of $Pb_{2-x}Ca_xIr_2O_{7-y}$ were prepared from PbO, $CaCO_3$, and IrO_2 by solid state reaction. The phase identification was performed by powder X-ray diffraction (XRD) profile experiment. Electrical resistivity measurements were conducted by usual d.c. four-probe method. Magnetizations were measured with a SQUID magnetometer.

3. Results and discussions

The all peaks in the XRD profiles of $x = 0.0, 0.2$ can be indexed by a cubic pyrochlore lattice, from which lattice parameters were obtained to be 10.276 and 10.268 Å, respectively. The small difference from the previously reported value 10.271 Å for $x = 0.0$ [3] may come from oxygen non-stoichiometry. The samples of $x = 0.4, 0.6, 0.8$ included a small amount of impurity phase, *e.g.*, Ca_2IrO_4, IrO_2, however, the lattice parameters obey the Vegard's law as shown in Fig. 1, which suggests that the Ca substitution for the Pb site would be achieved in $Pb_{2-x}Ca_xIr_2O_{7-y}$.

Figure 2 shows the temperature dependence of normalized resistivity $\rho/\rho_{300\mathrm{K}}$ with that at 300 K in $Pb_{2-x}Ca_xIr_2O_{7-y}$. The inset of Fig. 2 shows the Ca content x variation of the resistivity at 4.2 and 300 K. The metallic conductivity of $Pb_2Ir_2O_{7-y}$ is suppressed by the Ca substitution for Pb site. As the Ca content (x) increases, the temperature gradient of resistivity

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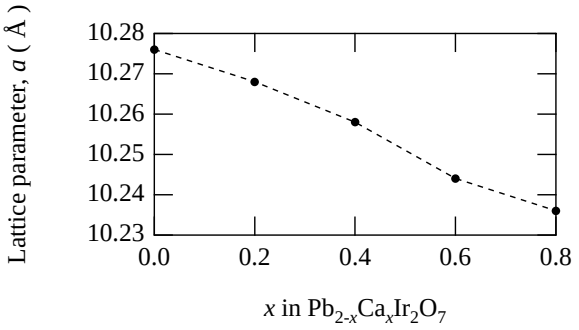

Fig. 1. Ca content (x) variation of lattice parameter (a) in $Pb_{2-x}Ca_xIr_2O_7$.

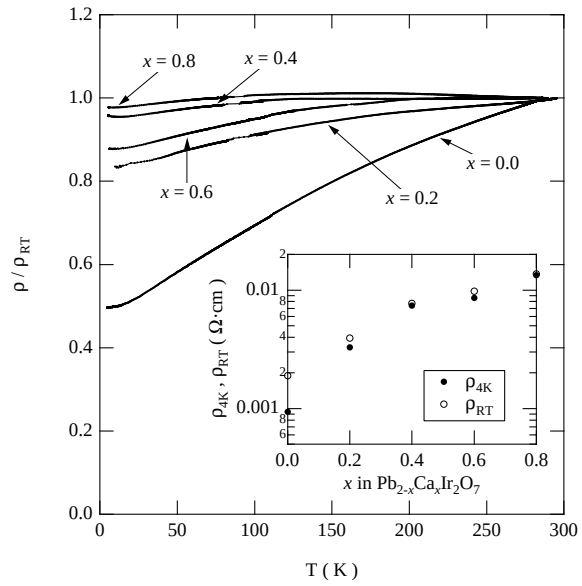

Fig. 2. Temperature dependence of normalized resistivity (ρ/ρ_{300K}) in $Pb_{2-x}Ca_xIr_2O_{7-y}$. The inset shows the Ca content x variation of the resistivity at 4.2 and 300 K.

is smaller. The t_{2g} bandwidth of these compounds is very sensitive to their crystal structure [5,6].

The magnetic susceptibility (χ) of $Pb_{2-x}Ca_xIr_2O_{7-y}$ obeys the Curie-Weiss law with a temperature independent term, *i.e.*, $\chi = C/(T-\Theta) + \chi_{TIP}$. Figure 3 shows the Ca content x variations of the fitted parameters (the effective moment μ_{eff} estimated from the Curie constant C, the Weiss temperature Θ, and the temperature independent susceptibility χ_{TIP}). The μ_{eff} and the negative Θ in these metallic compounds may suggest a localized character of electrons antiferromagnetically interacting with each other. The χ_{TIP} may come from the Pauli paramagnetism and the Van Vleck paramagnetism.

The systematic study in $Pb_{2-x}Ca_xIr_2O_{7-y}$ has been proceeding now. So far, no superconductivity can be found in this system. The further information in detail

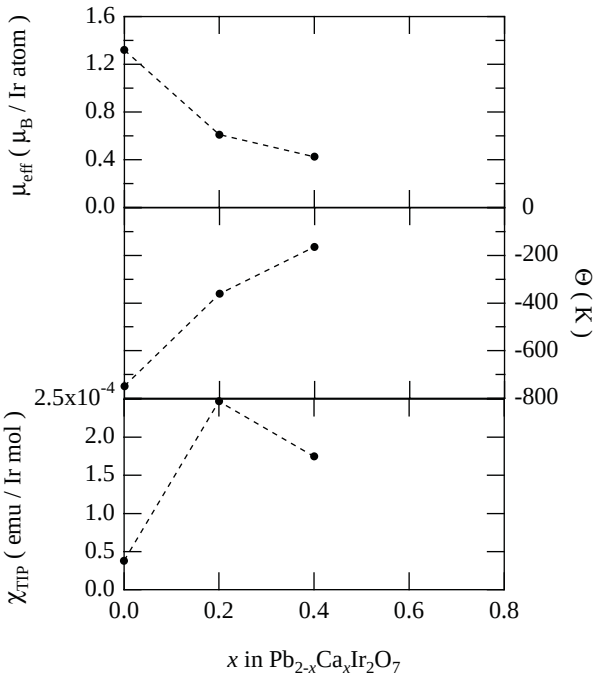

Fig. 3. Ca content x variations of effective moment μ_{eff}, Weiss temperature Θ, and temperature-independent term χ_{TIP} in $Pb_{2-x}Ca_xIr_2O_{7-y}$.

will be reported elsewhere.

Acknowledgements

This study was supported by a Grant-in-Aid on priority area 'Novel Quantum Phenomena in Transition Metal Oxides', from Ministry of Education, Science, Sports and Culture, and also supported by a Grant-in-Aid Scientific Research of Japan Society for Promotion of Science(12046241, 12440195, 12740364)

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