Thermoelectric properties of n- and p-type polycrystalline $Pr_{1-x}Sr_xMnO_3$ ($0.1 \leqq x \leqq 0.9$)

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Introduction Thermoelectric energy conversion is a technology that attracts renewed interest as a new energy resource. There is a finite coupling between the electrical and entropy currents, which is known as the thermoelectric phenomena, i.e., the Seebeck or the Peltier effects because electrons or holes in solid carry the electricity together with the entropy. The thermoelectric energy conversion generates energy from the temperature gradient and the heat flow. Thus the thermoelectric energy conversion efficiency is defined by the ratio between the output electrical power with the thermal entropy flux. By optimizing the efficiency with respect to a load resistance, the maximum efficiency $\eta_{\max}$ is obtained as a monotonically increasing function of the dimensionless figure of merit of the thermoelectric material ZT. A higher temperature with a larger temperature difference gives a larger $\eta_{\max}$. Therefore, oxides are quite attractive in this respect because of the chemical stability in air at high temperature. After the discovery of the thermoelectric oxide Na_xCoO_2,[1] oxide thermoelectrics using 3d transition-metal oxides have been extensively investigated.

3d transition-metal oxides Compared with other thermoelectric materials, 3d transition-metal oxides are quite unique in the sense that (i) the electron correlation is strong enough to make the Heikes formula[2]: $S = -\frac{k_B}{e}\frac{\partial \ln g}{\partial N} \cong -86[\mu V/K]\ln\left(\frac{g_3}{g_4}\frac{x}{1-x}\right)$, where the ratio $\frac{g_3}{g_4}$ is determined by the Hund's rule coupling, x is the carrier concentration of quadribalent ions, and S is the Seebeck coefficient, (ii) the resistivity is barely metallic in which the mean free path is of the order of the unit cell length, and (iii) the spin fluctuation significantly affects the thermoelectric properties.

Results and Discussion By using such oxides, we have fabricated polycrystalline $Pr_{1-x}Sr_xMnO_3$ ($0.1 \leqq x \leqq 0.9$) using a solid-state reaction method. Figure 1 shows the temperature dependence of the power factor of $Pr_{1-x}Sr_xMnO_3$ ($0.1 \leqq x \leqq 0.9$). The positive S values of x=0.1 and 0.2 confirm that the dominat electrical carriers are holes.On the other hand, the negative S values of $0.3 \leqq x \leqq 0.9$ confirm that the dominant electrical carriers are electrons. The figure of merit Z was calculated from the following formula $Z = S^2/(\rho\alpha Cd)$, where α, C, d are the thermal diffusivity, specific heat capacity, and density, respectively. Figure 2 shows the temperature dependence of ZT of $Pr_{1-x}Sr_xMnO_3$ ($0.1 \leqq x \leqq 0.9$). In particular, ZT shows maximum value of 0.06 for x=0.7 sample.

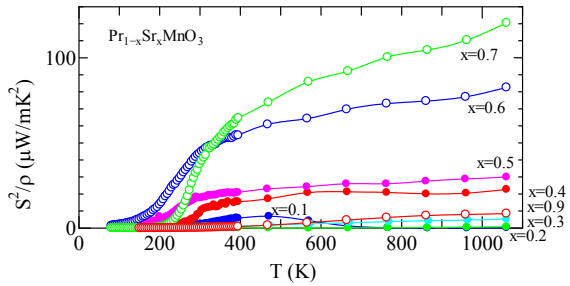

Fig.1 Temperature dependence of the power factor S^2/ρ($\times 10^{-6}$W/mK^2).

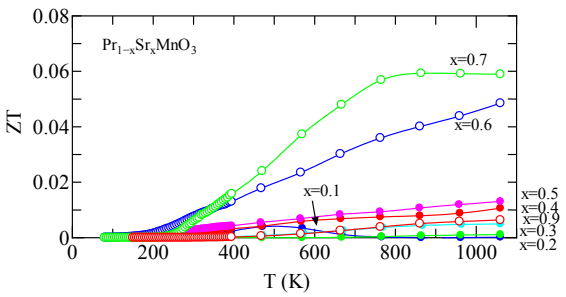

Fig.2 Temperature dependence of the dimensionless figure of merit ZT.

References

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2) W.Koshibae, K.Tsutsui, and S.Maekawa, Phys. Rev. B**62**, 6869 (2000).