Effect of Oxygen Content Variation on Phonon Heat Transport in $La_{0.75}Ca_{0.25}MnO_{3+\delta}$

M. Ikebe, H. Fujishiro and M. Numano

Faculty of Engineering, Iwate University, 4-3-5 Ueda, Morioka 020-8551, Japan

$La_{0.75}Ca_{0.25}MnO_3$ (LCMO) is a typical system which exhibits the colossal magnetoresistance (CMR). Now it is widely admitted that an important key factor which stages CMR and other dramatic physical phenomena is the strong electron-phonon interaction enhanced by the Jahn-Teller (JT) effect, together with the double exchange mechanism.

In this report, we present the thermal conductivity $\kappa(T)$, the thermal diffusivity $\alpha(T)$ and the thermal dilatation $dL(T)/L$ of $La_{1-X}Ca_XMnO_{3+\delta}$. The oxygen content δ was determined by iodometric titration. The emphasis is placed on the Ca concentration X=0.25, where LCMO shows the first-order-like ferromagnetic (FM) phase transition at T_c. $La_{0.75}Ca_{0.25}MnO_{3.033}$ (δ=0.033) shows a typical metal-insulator transition at T_c. Above T_c, the electrical conduction is due to the hopping JT small-polarons and the resistivity $\rho(T)$ increases with decreasing temperature T. $\rho(T)$ drops by about one order at T_c and $\rho(T)$ behaves metallic below T_c. The electrical conduction below T_c is probably due to JT large-polarons. With decreasing oxygen contents from δ=0.033, $\rho(T)$ is rapidly increased over the entire temperature range and the metallic $\rho(T)$ almost disappears for $\delta\approx0$.

$\kappa(T)$ of $La_{0.75}Ca_{0.25}MnO_{3.033}$, which is overwhelmingly due to phonons, is very small above T_c and slightly increases with increasing temperature. $\kappa(T)$ sharply increases at T_c and then gradually increases with decreasing T, taking a maximum at around T_M=35 K. In the nonmetallic samples, $\kappa(T)$ above T_c is almost the same as that of the metallic sample, while $\kappa(T)$ below T_c is drastically reduced. The sharp κ increase at T_c and the gradual κ increase below T_c is wiped out in the nonmetallic FM samples. Analyses suggest that the $\kappa(T)$ is limited by the phonon scattering by JT small-polarons above T_c and by the phonon scattering by large-polarons below T_c down to T_M. The $\kappa(T)$ results have made clear that the phonon scattering by JT large-polarons is quite sensitive to the mobility μ and the phonon scattering is drastically enhanced with decreasing μ of large-polarons. The thermal dilatation $dL(T)/L$ suggests that the local JT lattice distortion is closely related to the mobility of the polarons, and the phonon scattering by the polarons are determined by the local JT distortion of oxygen octahedra around the Mn^{3+} spins.