Hall effect in $La_{0.7}Ca_{0.3}MnO_3$

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Abstract

The Hall coefficients for $La_{0.7}Ca_{0.3}MnO_3$ epitaxial films with perovskite structure have been measured between 4.2K and 300K. The ordinary Hall coefficient showed the positive sign, but those below the same temperature showed the negative sign. The anomalous part of the Hall coefficients dependon the temperature and the magnetic field.

Key words: Hall coefficients;Hall effect for $La_{1-x}Ca_xMnO_3$;Perovskite manganese oxide;

1. Experiment

$La_{0.7}Ca_{0.3}MnO_3$ epitaxial films were prepared by the epitaxial glow method on the $SrTiO_3$substrate in 10m Torr. oxygen gas at 800°C[1]. These were supplied by Dr. Yotsuya (Technology Research Institute of Osaka Prefecture, Osaka594-1157, Japan). The epitaxial films have a dimension of 10mm in length, 10mm in width and 150nm in thickness. Electrodes for electrical measurements were made with silver paint. The magnetic field was applied at the right angle to the film surface. The resistances of the film were calculated by the voltages between the two electrodes in the film by passing the electric current. Two Hall voltages were measured by reversing the field direction at a fixed temperature and with a fixed current to remove the offset voltage caused by the asymmetric Hall terminals. The Hall resistivity $\rho_{xy}$was calculated from the differences of the two voltages with the current.

2. Results and Discussion

Figure 1 shows the resistance of $La_{0.7}Ca_{0.3}MnO_3$ epitaxial films as a function of temperature under magnetic fields. Figure 2 shows the Hall resistivity $\rho_{xy}$of

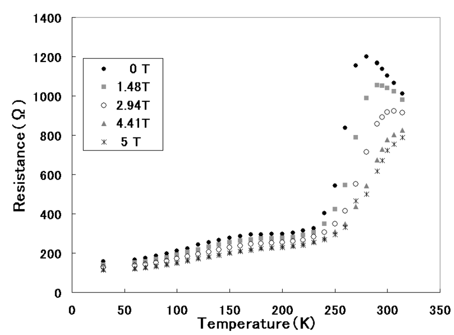

Fig. 1. Resistance of $La_{0.7}Ca_{0.3}MnO_3$ epitaxial film as a function of temperature with the applied magnetic filds.

$La_{0.7}Ca_{0.3}MnO_3$ epitaxial film as a function of applied magnetic field at 280K. $\rho_{xy}$is described in terms of an external field H as follows:

$$\rho_{xy} = R_H(H + (1 - N)M) + R_S M \qquad (1)$$

where R_H: ordinary Hall coefficient, M: a magnetization, N: a demagnetizing factor, R_S: an anomalous Hall coefficient. As the external field increases, M becomes smaller. Then we can estimate R_H from ρ_{xy} in a field 5T at respective temperatures. The ordinary Hall coefficient R_H of $La_{0.7}Ca_{0.3}MnO_3$ epitaxial film is shown as a function of temperature in Figure 3. It is estimated that R_S at each temperature becomes the intercept of ρ_{xy} curve to zero field by assuming R_H to

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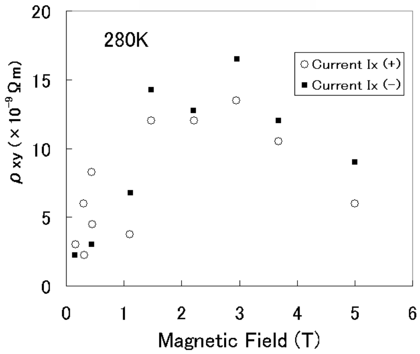

Fig. 2. Hall resistivity ρ_{xy} of $La_{0.7}Ca_{0.3}MnO_3$ epitaxial film as a function of the applied magnetic field at 280K.

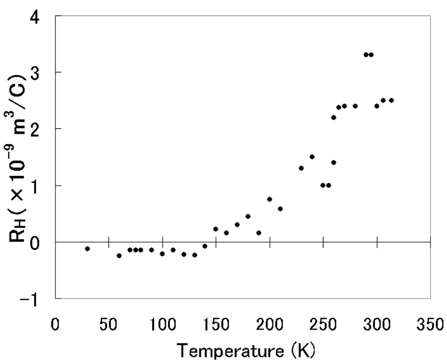

Fig. 3. Ordinary Hall coefficient R_H of $La_{0.7}Ca_{0.3}MnO_3$ epitaxial film as a function of temperature.

be nearly T independent. We can see that the ordinary Hall coefficient has the positive sign above 150K, however below the same temperature it shows the negative sign. Also we notice that the resistance of the film has a characteristic variation at 150K in Figure 1. It seems that some structural variation may happen in $La_{0.7}Ca_{0.3}MnO_3$ In Figure 4 we show the nominal carrier density n calculated from R_H using

$$RH = 1/en. \tag{2}$$

Near 270K, we would obtain n=$3\times10^{27}m^{-3}$. The lattice constant of the $La_{0.7}Ca_{0.3}MnO_3$ may be 3.84×10^{-10}m, the carrier density to a manganese atom is 0.17 1/Mn atom. Therefore if Ca concentration is 30%, the hole concentration is estimated to be 0.5 1/Mn^{4+}atom. Also at 100K, n=-$30\times10^{27}m^{-3}$ and the density is estimated 5 1/Mn^{4+}atom. Below 150K, it seems that the carrier exchanges the hole with the electron.

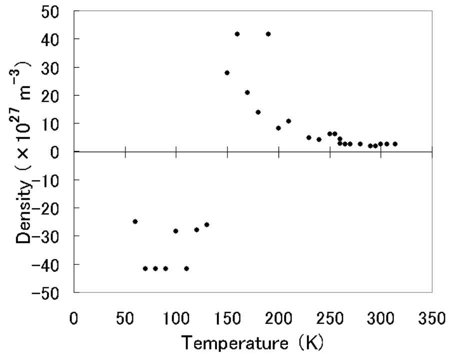

Fig. 4. Nominal carrier density n calculated form R_H using R_H=1/en.

References

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