RELAXATION BEHAVIOR OF THE REFLECTANCE SPECTRA of $Nd_{0.65}Ca_{0.35}MnO_3$

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Introduction

In doped manganese oxides, the coexistence of ferromagnetic metallic phase and the antiferromagnetic charge ordered insulating phase is considered to be the origin of colossal magnetoresistance effect. This coexistence of metallic and insulating phases could be also intimately related to the relaxation dynamics of electric and magnetic properties [1]. The slow dynamics has been reported several times in doped manganese oxides, however, the physical origin is rarely understood. In this work, we investigated the origin of the slow relaxation behavior of a doped manganese oxide using optical spectroscopy.

Experimental

We measured the reflectance spectra of $Nd_{0.65}Ca_{0.35}MnO_3$ single crystal grown by floating zone technique. We used the 30 T resistive magnet and McPherson monochrometer type spectrophotometer to obtain the near infrared and visible spectra. We obtained all of the spectra at liquid He temperature. The dc-resistance is measured by the conventional four probe technique.

Results and Discussion

$Nd_{0.65}Ca_{0.35}MnO_3$ single crystal that we measured, showed a drastic change of the resistance around 8.5 T. This change corresponds to the phase transition from the insulating phase to the metallic phase due to the melting of the charge ordered domains by the magnetic field. After the sample experiences the phase transition, the resistance of the sample can not recover the virgin state value before the phase transition. However, the resistance value slightly and slowly increases, after turning off the magnetic field. This increase is possibly due to the formation of antiferromagnetic charge ordered insulating droplets which can lead to the relaxation of the transport and magnetic properties [1].

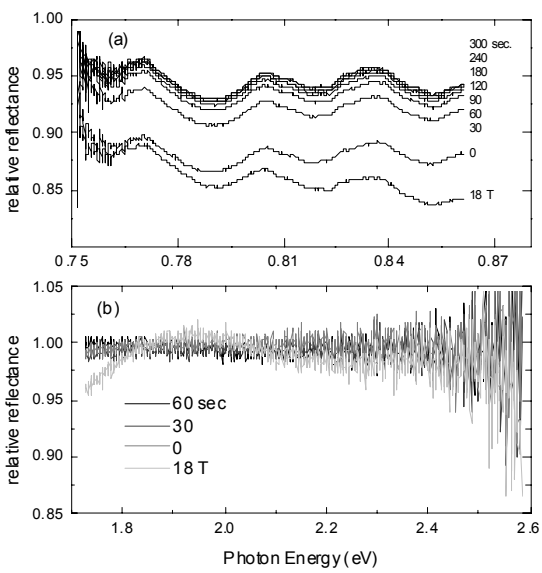

Figure shows the relative reflectance spectra normalized to the virgin state spectra before the phase transition. Fig. (a) shows the spectra of energy region between 0.75 ~ 0.85 eV. This energy region corresponds to the transition of electrons which is coupled to the lattice deformation, so called large polaron like response, according to the previous studies [2]. By applying 18 T, the reflectance drastically decreases, however, after turning off the magnetic field at zero second, the reflectance increase slowly, but still can not fully recover the value of the virgin state within 300 seconds. On the other hand, as shown in Fig. (b), the high energy (1.8 ~ 2.5 eV) spectra recover the virgin state value quite fast. This energy region corresponds to the transition of electrons between the neighboring Mn-ions across the Mott gap. These results suggest that the lattice deformation and its coupling to the electron are responsible for the slow relaxation behavior.

Conclusions

We observed the time dependent relaxation behavior in the reflectance spectra of $Nd_{0.65}Ca_{0.35}MnO_3$ single crystal. After turning off the magnetic field, the low energy spectra of electron-lattice coupling regime shows slow relaxtion (~ 100 sec) behavior, on the other hand, the high energy spectra of electron-electron interaction regime does not show such a slow relaxation behavior within our measurement resolution (~ 1 sec).

References

[1] Deac, I. G., *et al*., Phys. Rev. B, **65**, 174426 (2002) and references there in.
[2] Kim, M. W., *et al*., Phys. Rev. Lett., **89**, 16403 (2002).