Neutron Diffraction Study of Cluster-Glass State in $Sr_{1-x}La_xRuO_3$

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$SrRuO_3$ exhibits ferromagnetic order below T_C = 160 K. Photoemission experiments showed that the density of states at Fermi level is dominated by the Ru 4*d* state and the overall distribution of the Ru 4*d* and O 2*p* states are well reproduced by band structure calculations. These results suggest that the ferromagnetic order is caused by the itinerant Ru 4*d* electrons and can be described within the context of the band structure based Stoner theory.

On the other hand, an incoherent feature is observed in the photoemission experiments. Optical spectroscopy measurements have also shown that the charge dynamics deviates from the prediction of Fermi liquid theory. Moreover, angle-resolved phoemission, magneto-optic Kerr efect, and optical spectroscopy experiments revealed that the ferromagnetic exchange splitting persists above T_C, and thus, the presence local moments has been proposed. This clearly contradicts with the band structure based Stoner theory. These results indicate that the Ru 4*d* electrons have a duality of itinerant and localized natures.

Solid solutions $Sr_{1-x}La_xRuO_3$ are of interest, since the increase in Ru-O distance caused by doping La changes the electronic state and may enhance the electronic correlation effect. Recently, we have shown that the ferromagnetic order is strongly suppressed with increasing x, and the ordered state varies from ferromagnetic to cluster-glass states for $x \geq 0.3$.(J. Phys. Soc. Jpn. **83**, 064712 (2014)) We also revealed that this system is metallic and the density of states around Fermi level is dominated by the itinerant Ru 4*d* state over the whole La concentration range investigated ($0 \leq x \leq 0.5$). Therefore, the spatially inhomogeneous cluster-glass state seems to be originating from the itinerant Ru 4*d* state.

In the present study, we have performed neutron powder diffraction experiments on $Sr_{0.7}La_{0.3}RuO_3$, which shows cluster-glass order at around 10 K, to characterize the cluster-glass states in a microscopic level. The neutron powder diffraction experiments were carried out using the powder diffractometer Echidna at the Australian Nuclear Science and Technology Organisation's OPAL facility.

Figure 1 shows the temperature dependence of the (101) and (020) reflections, which are expected to have the largest magnetic contributions associated with the ferromagnetic order, measured at 1.4 and 50 K. As seen in the difference plot the peak width of the magnetic reflection is comparable to that of the nuclear peaks, and thus, the magnetic reflection seems to be originated from a long-range ferromagnetic order. This result suggests that the magnetic correlation length increases with decreasing temperature, and the cluster-glass state gradually changes to the ferromagnetic long range ordered state for $Sr_{0.7}La_{0.3}RuO_3$.

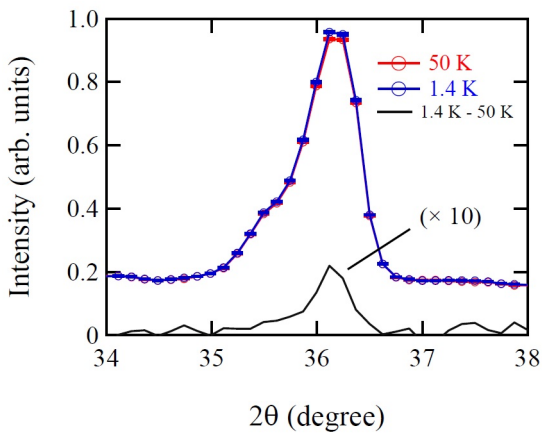

Fig. 1. The temperature dependence of the (101) and (020) reflections.