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Orbital ordering and the impurity effect in layered manganites observed by resonant x-ray scattering

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Introduction

Manganites are intensively studied because of their unique features such as colossal magnetresistance and multiferroics. When impurity ions are substituted for the manganese ion in the compound, a new local electronic state often emerges. In this study we have investigated the impurity effect on a typical orbital ordered system, a layered manganite, using resonant x-ray scattering (RXS) technique to reveal experimentally the new state emerged by substitution of impurity ions.

Experimental Results

A layered manganite $La_{0.5}Sr_{1.5}MnO_4$ shows orbital ordering below 220 K. We have studied how the ordering state is changed by the substitution of Fe, Cr and Ga ions for Mn ions using a RXS technique at absorption edge energy of Mn. Figures 1 shows energy dependences of (5/4 5/4 0) reflection with π-polarization in $La_{0.5}Sr_{1.5}MnO_4$ and $La_{0.5}Sr_{1.5}Mn_{0.97}T_{0.03}O_4$ (T=Fe, Cr, Ga) near Mn K-absorption edge energy. The inset is the extended figure of vertical scale.

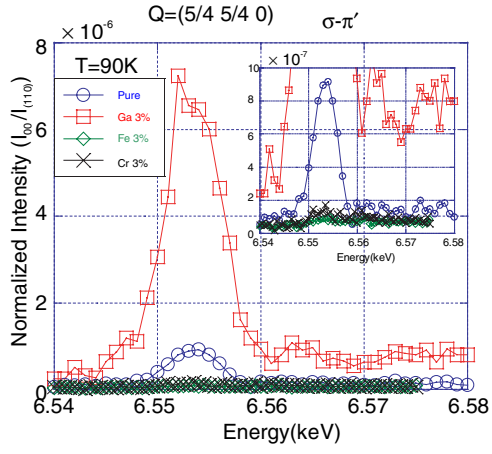

Figure 1. Energy dependence of orbital ordering reflection (5/4 5/4 0) in $La_{0.5}Sr_{1.5}MnO_4$ and $La_{0.5}Sr_{1.5}Mn_{0.97}T_{0.03}O_4$ (T = Fe, Cr, Ga) near Mn K-edge energy.

These RXS intensities reflect the order parameters of the orbital orderings. These intensities in the figures are normalized by the intensity of the fundamental Bragg reflection (110). The RXS intensities of $La_{0.5}Sr_{1.5}Mn_{0.97}Fe_{0.03}O_4$ and $La_{0.5}Sr_{1.5}Mn_{0.97}Cr_{0.03}O_4$ have almost disappeared. On the other hand the RXS intensity of $La_{0.5}Sr_{1.5}Mn_{0.97}Ga_{0.03}O_4$ is larger than that of the pure system ($La_{0.5}Sr_{1.5}MnO_4$). This result indicates that the orbital ordering state almost collapses by the 3% substitution of Fe and Cr while the ordering is enhanced by the 3% substitution of Ga.

Figure 2 shows temperature dependence of (5/4 5/4 0) reflection in the pure system and Ga doped compound. They have almost the same temperature dependence but the RXS intensity of Ga doped compound is about nine times larger than that of the pure system.

In pure system, the orbital ordering is suppressed by the strong fluctuation due to the combination of La and Sr. The enhancement of the orbital ordering by the substitution of Ga may be ascribed to the decrease of this fluctuation.

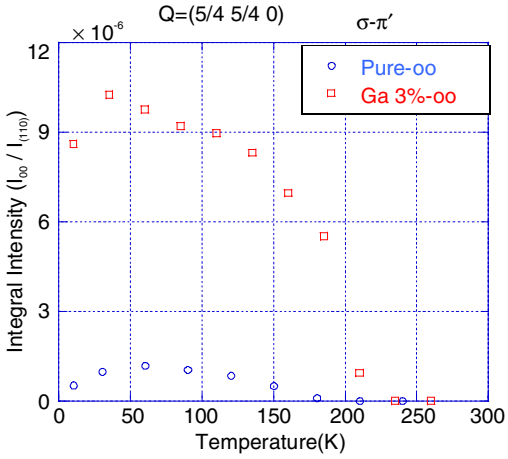

Figure 2. Temperature dependence of orbital ordering reflection (5/4 5/4 0) in $La_{0.5}Sr_{1.5}MnO_4$ and $La_{0.5}Sr_{1.5}Mn_{0.97}Ga_{0.03}O_4$ near Mn K-edge energy.

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