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Impurity effect on orbital ordering studied by resonant x-ray scattering

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Introduction

The charge, spin, and orbital ordering states in perovskite-type transition metal oxides and the doped compounds have attracted much interest because of their intriguing phenomena such as high Tc superconductivity, colossal magnetoresistance effect, magnetoelectriceffect and so on.When impurity ionsaresubstituted for the transition metal ions in these compounds, a new local electronic state often emerges. For example, in a high Tc superconductor the substituted Zn ions for Cu ions, a quasiparticle scattering resonance at the Zn sites is observed with the strong suppression of superconductivity around the Zn sites. However, there are few studies of impurity effect on orbital ordering. In this study we have investigated the impurity effect on atypical orbital and charge ordered system, a layered manganite,using resonant x-ray scatting (RXS)

Experimental Results

A layered manganite$La_{0.5}Sr_{1.5}MnO_4$shows charge and orbital ordering below 220 K. We have studied how the ordering states are changed by the substitution ofFe, Ga ions for Mn ions using a RXS technique at absorption edge energy (E_A) of Fe andGa as well as Mn.

Figures 1 and 2 show energy dependences of (4/5 4/5 0) reflection with π-polarization and (3/2 3/2 0) reflection with σ-polarization, respectively, 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=Ga, Fe) near Mn, Ga, and Fe K-absorption edge energies. These RXS intensities reflect the order parameters of orbital and charge ordering. These intensities in the figures are normalized by the intensity of the fundamental Bragg reflection (110). The RXS intensities of $La_{0.5}Sr_{1.5}Mn_{0.97}Fe_{0.03}O_4$ have almost disappeared. On the other hand the RXS intensities of $La_{0.5}Sr_{1.5}Mn_{0.97}Ga_{0.03}O_4$are larger than those of the pure system ($La_{0.5}Sr_{1.5}MnO_4$).This result indicates that the charge and orbital ordering states almost collapse by the 3% substitution of Fe while the orderings are enhanced by the 3% substitution of Ga. The azimuthal angle dependence of the RXS in the Ga doped sample was two-fold symmetry, which suggests thatthe orbital pattern is the same as that of the pure system.
We have tried to get the RXS at E_A of Ga and Fein order to study the surrounding orbital state of Ga and Fe sites. However, we could not detect any RXS signal of Ga edge as well as Fe edge within our experimental error. This means the local orbital state aroundthe Ga site is quite isotropic in the ab-plane of the compound.

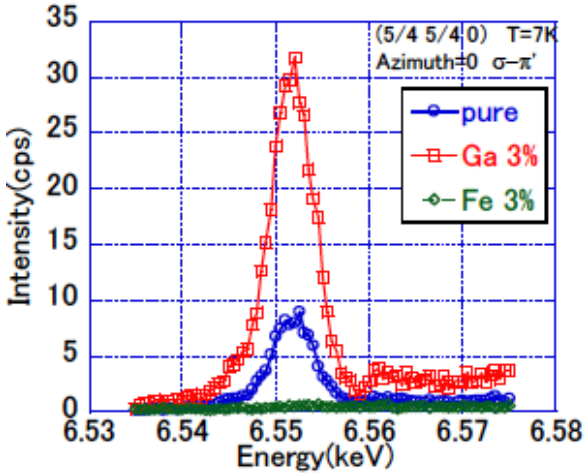

Figure 1. Energy dependence of orbital ordering reflection (4/5 4/5 0) in $La_{0.5}Sr_{1.5}MnO_4$ and $La_{0.5}Sr_{1.5}Mn_{0.97}T_{0.03}O_4$(T=Ga, Fe) near Mn K-edge energy.

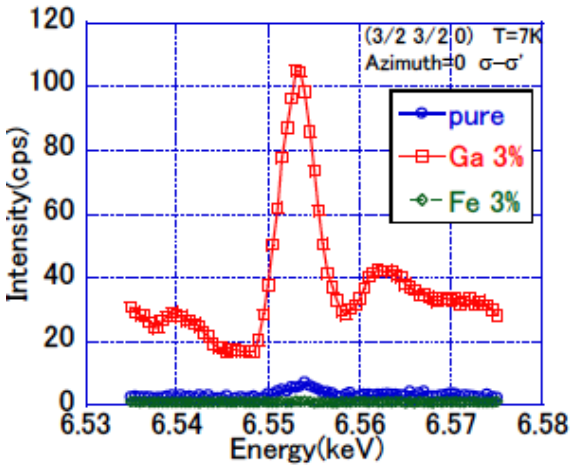

Figure 2. Energy dependence of charge ordering reflection (3/2 3/2 0) in $La_{0.5}Sr_{1.5}MnO_4$ and $La_{0.5}Sr_{1.5}Mn_{0.97}T_{0.03}O_4$ (T=Ga, Fe) near Mn K-edge energy.

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