Impurity effect on charge/orbital orderings in layered manganites observed by resonant x-ray scattering

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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 charge/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.

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 Cr, Fe and Ga ions for Mn ions using a RXS technique at absorption edge energy of Mn. Figures 1 and 2 show energy dependences of (3/2 3/2 0) reflection and (5/4 5/4 0) reflection 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=Cr, Fe, Ga) near Mn K-absorption edge energy. The insets are the extended figures of vertical scale. RXS intensities of (3/2 3/2 0) reflection and (5/4 5/4 0) reflection reflect the order parameters of the charge orderings and the orbital orderings respectively. 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 in T=10K. On the other hand the RXS intensity of $La_{0.5}Sr_{1.5}Mn_{0.97}Ga_{0.03}O_4$ is observed and its intensity is smaller than that of the pure system ($La_{0.5}Sr_{1.5}MnO_4$). This result indicates that the charge/orbital ordering states are suppressed by the substitution of impurity ions, but the degrees of suppression of orderings vary with impurity ions.

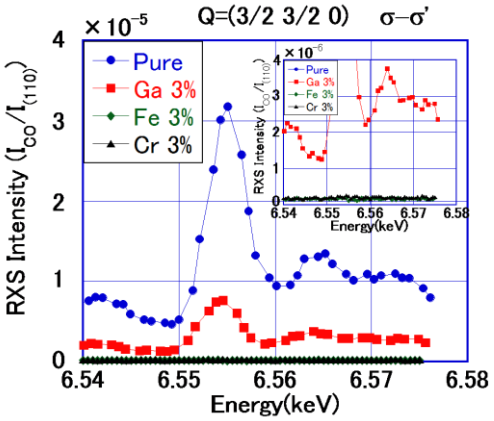

Figure 1. Energy dependence of RXS intensities of (3/2 3/2 0) reflection in $La_{0.5}Sr_{1.5}MnO_4$ and $La_{0.5}Sr_{1.5}Mn_{0.97}T_{0.03}O_4$ (T = Cr, Fe, Ga).

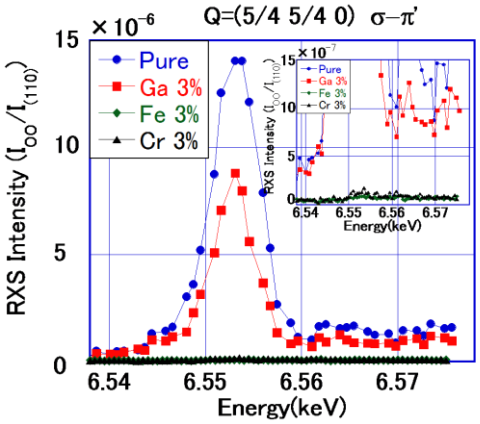

Figure 2. Energy dependence of RXS intensities of (3/2 3/2 0) reflection in $La_{0.5}Sr_{1.5}MnO_4$ and $La_{0.5}Sr_{1.5}Mn_{0.97}T_{0.03}O_4$ (T = Cr, Fe, Ga).