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Effect of Cr Substitution in $Sr_2V_{1-x}Cr_xFeAsO_3$

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1 Introduction

$Sr_2VFeAsO_3$, an iron-based superconductor with a perovskite-type blocking layer, is characterized by a superconducting ground state without any chemical substitution [1]. To elucidate what parameter is a key for superconductivity and the physical properties, a systematic study of chemical substitution is a powerful tool. In the present study, we synthesized polycrystalline samples of Cr-substituted $Sr_2V_{1-x}Cr_xFeAsO_3$ and performed the Cr K-edge x-ray absorption spectroscopy to determine the valence of Cr.

2 Experiment

Polycrystalline $Sr_2V_{1-x}Cr_xFeAsO_3$ with $x = 0.2$ were synthesized by solid-state reaction starting from SrO, $SrAs_2$, V_2O_3, Cr_2O_3, and Fe [2]. Sample quality was checked by x-ray diffraction and energy dispersive x-ray spectroscopy. The Cr K-edge x-ray absorption spectroscopy measurement was carried out at BL-4C of Photon Factory in KEK, Japan. Absorption spectra were measured in the transmission mode with the energy range of 5980–6020 eV.

3 Results and Discussion

Figure 1(a) shows Cr K-edge x-ray absorption spectra for $Sr_2V_{1-x}Cr_xFeAsO_3$ with $x = 0.2$ as well as four reference chromium oxides: Cr, Cr_2O_3, Sr_2CrO_4, and $CaCrO_4$. It has been established that the energy position of the absorption edge is shifted to higher energies as the oxidation state increases. Figure 1(b) shows the energy derivative of the absorption spectra. We determined the edge positions by the peak energies in Fig. 1(b), corresponding to the inflection points. Clearly, the edge positions of the reference compounds in the present study vary linearly with the Cr valence as shown in the inset of Fig. 1(a). The edge of $Sr_2V_{1-x}Cr_xFeAsO_3$ lies near that of Sr_2CrO_4, indicating that the valence of introduced Cr atoms is 4+.

Given that the valence of V atoms is close to 3+ [3], Cr substitution corresponds to electron doping. Superconductivity in $Sr_2VFeAsO_3$ is not very sensitive with Cr substitution [2], suggesting that the electron filling is not a primary parameter determining a superconducting transition temperature. Chemical substitution into a blocking layer does not make a large impact on superconductivity as long as competing orders are absent. It should be noted that the antiferromagnetic alignment of Cr^{3+} moments was suggested in fully substituted compound $Sr_2CrFeAsO_3$ ($x = 1$) [4]. With further substituting Cr above the composition investigated here, the Cr valence would gradually change from 4+ to 3+.

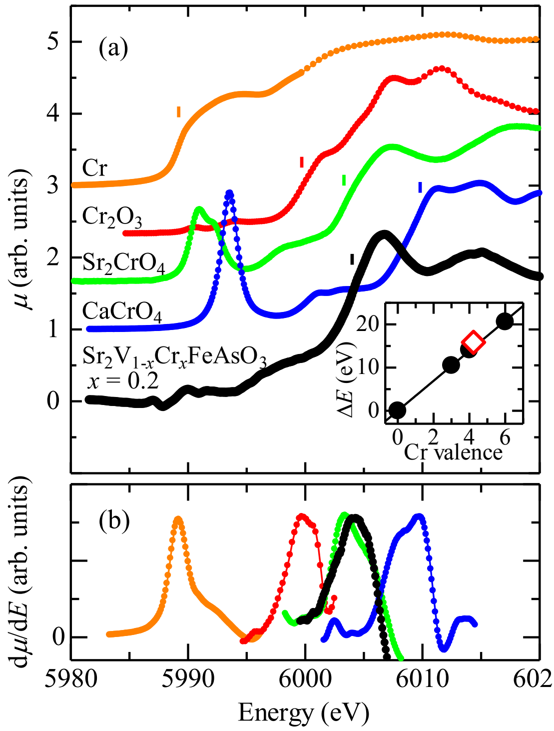

Fig. 1: (a) Normalized x-ray absorption spectra for $Sr_2V_{1-x}Cr_xFeAsO_3$ ($x = 0.2$) and reference chromium oxides. Bars indicate the edge positions determined by the inflection point. Inset shows energy positions of the Cr K-edge with respect to the Cr metal as a function of the oxidation state. A diamond indicates $Sr_2V_{1-x}Cr_xFeAsO_3$. (b) Energy derivative of the absorption spectra. The edge energy was determined by the peak position.

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References

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