

Randomness Effect on Spin/Orbital Order in Perovskite RVO_3

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Introduction

Perovskite RVO_3 (R : rare earth elements or Y) shows two types of spin/orbital order by R -site substitution: G -type orbital order (G -OO) accompanied with C -type spin order (C -SO), and C -OO with G -SO[1]. On the other hand, the structural randomness, which is caused by the size mismatch of the R -site cations, destabilizes the C -SO/ G -OO but stabilizes the G -SO/ C -OO[2]. To clarify this anomalous behavior by the randomness, we synthesized the randomness induced RVO_3 : $Eu_{1-x}(La_{0.2542}Y_{0.7458})_xVO_3$. The magnitude of the randomness is proportional to x in compounds. The pure material ($x=0$) $EuVO_3$ undergoes only the C -SO/ G -OO. However, the other ordered state appears by increasing randomness. Then we clarified the orbital pattern of this phase by resonant X-ray scattering measurements.

Experiment

The single crystals $Eu_{1-x}(La_{0.2542}Y_{0.7458})_xVO_3$ were synthesized by floating-zone method. The resonant X-ray scattering measurements for randomness introduces material with $x = 1.0$ of this compounds with (100) surface were performed at beam line 4C. The incident X-ray was polarized and the energy tuned near V K -edge (~ 5.48 keV). In order to analyze whether the polarization of the scattered beam is parallel (π' polarization) or perpendicular (σ' one) to the scattering plane, we used a pyrolytic graphite (004) crystal.

Results and Discussion

Fig. 1 (a) shows the energy dependence of the intensity of (100) reflection at various temperatures. This reflection does not obey the extinction rule but corresponds to the propagation vectors for C -OO. The symmetry of the degenerated orbital states at each V^{3+} site can be investigated through azimuthal angle dependence of orbital reflections. As shown in Fig. 1 (b), the (100) reflection normalized by the (200) fundamental one at the V K -edge is maximum with the incident beam $E_i \parallel b$ configuration and nearly vanishes with $E_i \parallel c$. Model calculations for π' and σ' components in C -OO are also shown as red solid and dashed line, respectively. In our calculations, the atomic scattering tensor of each V^{3+} ion is the same as that in Ref. [3] and the structural distortion, estimated by the Rietveld analysis for the $x=1.0$ sample, is considered. The good agreement between the experimental and calculated data of each component indicates the existence of C -OO at the ground state.

Fig. 2 displays the temperature dependence of the normalized intensity of the (100) reflection with the $E_i \parallel b$ configuration at the V K -edge energy. As temperature is increased, the (100) intensity is reduced around T_{SO2} , which corresponds to the magnetic transition temperature measured by magnetization measurement. This fact indicates that not only spin but also C -type orbital order occur below T_{SO2} in the randomness induced compound $Eu_{1-x}(La_{0.2542}Y_{0.7458})_xVO_3$, $x = 1.0$.

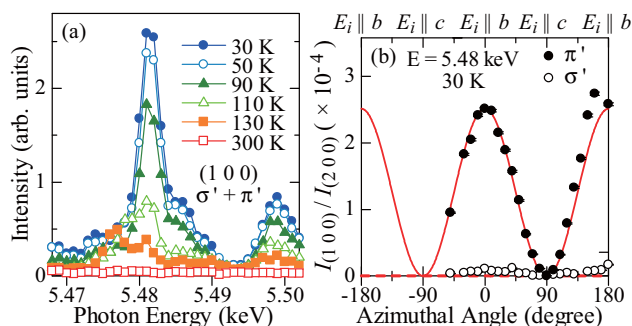


Fig. 1: (a) Photon-energy spectra of $\sigma' + \pi'$ component of (100) reflection. (b) Azimuthal angle dependence of (100) reflection of π' and σ' components normalized by (200) fundamental one.

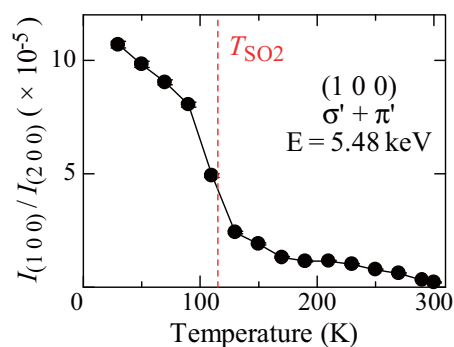


Fig. 2: Temperature dependence of integrated intensity of $\sigma' + \pi'$ component of the (100) reflection normalized by the (200) fundamental one at 5.48 keV. Vertical red line indicates the magnetic transition temperature T_{SO2} determined by magnetization measurement.

References

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