Randomness Effect on Spin/Orbital Order in Perovskite RVO₃

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Introduction

Perovskite RVO₃ (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 RVO₃: Euₓ(La₀.2542Y₀.7458)VO₃. The magnitude of the randomness is proportional to x in compounds. The pure material (x=0) EuVO₃ 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 Euₓ(La₀.2542Y₀.7458)VO₃ 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 pyrolitic 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 V⁵⁺ 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 E₁∥b configuration and nearly vanishes with E₁∥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 V⁵⁺ 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 E₁∥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 Euₓ(La₀.2542Y₀.7458)VO₃ x = 1.0.

References


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