Detailed Measurement of Ti 2p Resonant X-ray Raman Scattering of Ti$_2$O$_3$ and its Polarization Dependence

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Introduction

Ti$_2$O$_3$ is a typical MH type semiconductor having narrow band gap ($< 0.1$ eV). It is known that the Ti 3d states are strongly hybridized with the O 2p state. The Ti compounds have attracted the interest of researchers because of their strong hybridization energies, resulting many-body effects in high energy spectra [1, 2]. Detailed measurement of Ti 2p resonant x-ray emission spectra (XES) of Ti$_2$O$_3$ have been reported only in many-body effects in high energy spectra [1, 2].

Detailed measurement of Ti 2p resonant x-ray emission spectra (XES) of Ti$_2$O$_3$ have been reported only in many-body effects in high energy spectra [1, 2]. In this study, we observed polarization dependence of the Ti 2p XRS as well as partial photon yield (PPY).

Experimental

Powdered Ti$_2$O$_3$ was used in this experiment. Ti$_2$O$_3$ has corundum structure with trigonal Bravais lattice, including TiO$_6$ octahedron. SXE spectrometer at BL2c was used in both polarized and depolarized configuration. The incident slit width of spectrometer is set to 10 μm corresponding to about 0.3 eV resolution.

Results and Discussions

Figure 1 shows contour plot of Ti 2p resonant XES spectra of Ti$_2$O$_3$ in (a) polarized and (b) depolarized configurations. About one hundred spectra of XES were observed with changing excitation energies and these were plotted to the contour graph (1/ν$_{excitation}$ vs. 1/ν$_{emission}$). In the figure, Ti L fluorescence lines having same emission energies are indicated by horizontal dotted lines, while the x-ray Raman scattering (XRS) peaks are indicated by oblique lines. The lowest oblique line is an elastic scattering, next two lines correspond to XRS by d-d excitations, and upper two lines correspond to that by charge transfer (CT) excitations.

Fig.2 shows XAS spectra of Ti$_2$O$_3$ measured by total electron yield (TEY) method. The main structure originates from Ti 2p → 3d transition. The Ti 2p state is split into 2p$_{3/2}$ and 2p$_{1/2}$ by spin-orbit interaction and the unoccupied Ti 3d state is split into t$_{2g}$ and e$_g$ by ligand field (in O, approximation). CT satellites (S) were observed at about 13 eV above each main structure. Fig 2(b) shows polarization dependence of partial photon yield (PPY) spectra, which was plotted integrated emission intensities in each XES. The PPY spectra show remarkable polarization dependence, while the TEY does not. Furthermore, the PPY shows novel structure at about 461 eV (*), where TEY shows no peak. The result suggests that the excitation corresponding to the structure decays just radiatively. Fig.2(c) shows intensity of elastic scattering (intensity in ΔE=-0.5~0.5 eV from excitation energy), which was extracted from XRS spectra in Fig.1. Fig.2(d) and (e) shows intensity of d-d excitations (ΔE=0.5~1.5 eV, (d) ΔE=1.5~5.0 eV). The low energy d-d excitation in Fig.2(d) shows very strong peak at 461 eV, suggesting the novel structure in PPY originates from the d-d excitation.

References


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