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# Detailed Measurement of Ti 2*p* Resonant X-ray Raman Scattering of $Ti_2O_3$ and its Polarization Dependence

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## Introduction

$Ti_2O_3$ is a typical MH type semiconductor having narrow band gap (< 0.1 eV). It is known that the Ti 3*d* states are strongly hybridized with the O 2*p* 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 2*p* resonant x-ray emission spectra (XES) of $Ti_2O_3$ have been reported only in polarized configuration [3]. In this study, we observed polarization dependence of the Ti 2*p* XRS as well as partial photon yield (PPY).

## Experimental

Powdered $Ti_2O_3$ was used in this experiment. $Ti_2O_3$ 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 2*p* resonant XES spectra of $Ti_2O_3$ 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 ($hv_{excitation}$ vs. $hv_{emission}$). 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(a) shows XAS spectra of $Ti_2O_3$ measured by total electron yield (TEY) method. The main structure originates from Ti 2*p* → 3*d* transition. The Ti 2*p* state is split into $2p_{3/2}$ and $2p_{1/2}$ by spin-orbit interaction and the unoccupied Ti 3*d* state is split into $t_{2g}$ and $e_g$ by ligand field (in $O_h$ 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

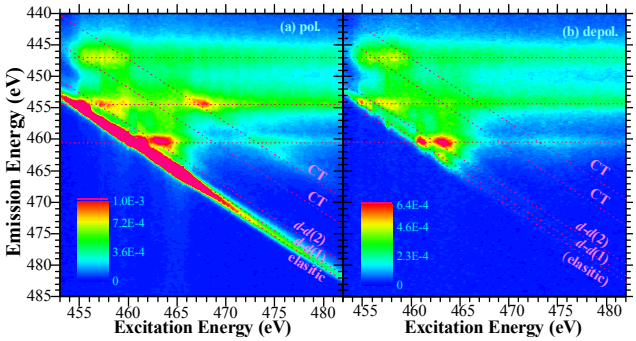


Fig.1. Contour plot of resonant XES spectra of $Ti_2O_3$ in (a) polarized and (b) depolarized configurations.

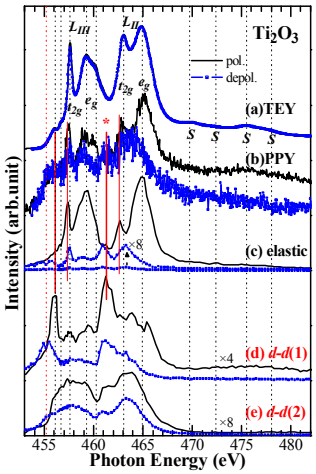


Fig.2. Polarization dependence of excitation spectra of $Ti_2O_3$. (a) Total electron yield, (b) Partial photon yield, (c) Elastic peak, (d)(e) *d-d* excitations.

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 ((d) ΔE=0.5~1.5 eV, (e) 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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