High-Resolution Soft X-ray Resonance Inelastic Scattering (SXRIXS) Studies of Bulk Electronic States of V_xO_y and Cr_xO_y

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Photoelectron spectroscopy is a powerful tool to study the electronic structures of various solids. In the case of strongly correlated electron systems, however, the surface electronic states accessible by the conventional photoelectron spectroscopy are often much different from the bulk electronic states, raising hot controversies over several decades [1-3]. By using hard X-rays and providing high kinetic energies to photoelectrons, this problem can be partially suppressed. In many systems, 5 to 10 percents of the spectral weight results still from the surface electronic structures. In addition, hard X-ray angle resolved photoelectron spectroscopy (HAXARPES) is suffered from the extremely low photoionization cross sections and the dramatic momentum broadening caused by the Debye-Waller factor. In this respect, the photon-in and photon-out bulk-sensitive experiment with high energy resolution as well as momentum resolution such as soft X-ray resonance inelastic scattering (SXRIXS) is much more favorable than photoelectron spectroscopy to probe the genuine bulk electronic structures. Its applicability to any insulator systems is thought to be very attractive to understand the change of electronic structures through phase transitions, too.

In our SXRIXS experiments, the metal-insulator transition systems VO_2 and V_2O_3 were studied in addition to CrO_2, which is known to be a semimetal ferromagnet. Since the surface of (100) epitaxially grown CrO_2 is easily covered by insulating Cr_2O_3, its bulk electronic

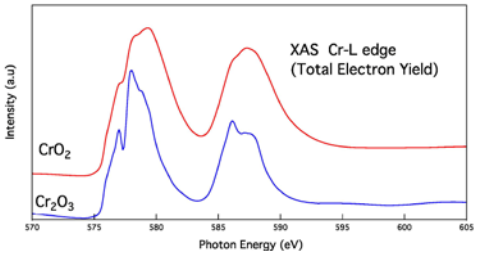

Fig.1 Cr 2p core absorption spectra.

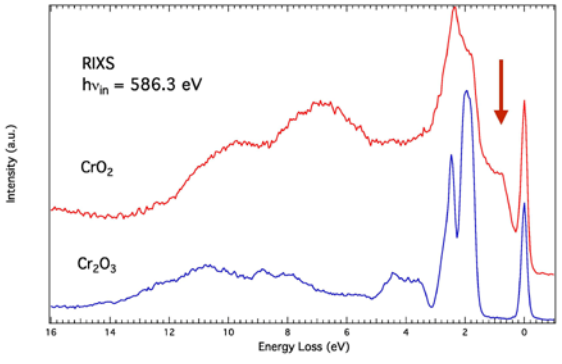

Fig.2 Cr 2p SXRIXS of CrO_2 and Cr_2O_3.

structures were veiled and not fully revealed by photoemission yet [3]. The Cr 2p absorption spectra (XAS) measured by means of the total electron yield and SXRIXS are shown in Fig.1 for epitaxially grown CrO_2 and single crystal Cr_2O_3 at room temperature. It must be mentioned that the bulk sensitivity is much higher in the case of SXRIXS than the case of XAS by total electron yield. Clear differences are observed in both XAS and SXRIXS between CrO_2 and Cr_2O_3. Excitation hν dependence as well as incidence light polarization dependence are measured with good statistics.

In the case of VO_2, detailed measurements were made above and below the metal insulator transition (MIT) temperature of ~340K. Since the V-V dimerization takes place along the c-axis in the insulator phase, clear polarization dependence was observed as seen in Fig.3.

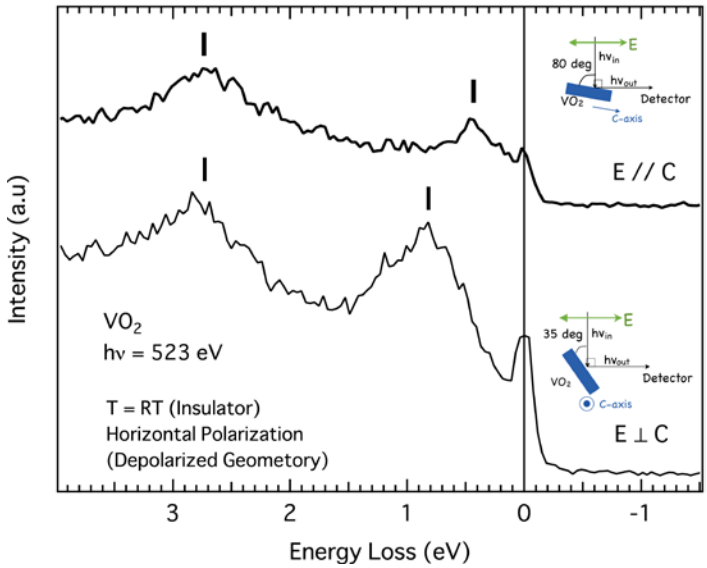

Fig.3 Polarization dependence of the SXRIXS spectra of VO_2 at hν=523 eV in the insulator phases. The c-axis of the rutile was set to nearly parallel to and perpendicular to the electric field vector of the incident horizontally polarized synchrotron radiation light.

These results are now in analysis in comparison with theoretical calculations and further experiment is planned for CrO_2 to be performed by SXRIXS with applying external magnetic field.

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