Study of Electronic Structure of CDW in Cr Using Resonant Soft X-ray Scattering

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Study of the modulations due to the inhomogeneous distribution of charges or spins in condensed mater physics is crucial because it strongly couples with the unusual physical properties as that observed in low dimensional materials, and correlated electron systems. Experimentally, the way to identify the existence of these modulations is the observation of the satellite reflections due to the formation of modulations. Conventionally, the study of atomic structure can be done by using x-rays, neutrons, or electron beams, but the study of charge or spin modulations is far more difficult because of the very week signals from these satellite reflections. However, this difficulty can be overcome by using the resonant x-ray scattering. It has been demonstrated the reflection signals could be largely enhanced as the incident x-ray energy crossing the absorption edges of the elements studied. For example, for the 3d transition metals, the use of x-rays with the energy at the *L*-edges can pump electrons from the 2*p* states to the available 3*d* states, consequently, the diffracted x-rays can be largely enhanced. Especially, the use of soft x-ray scattering is very helpfully in studying the electronic structure of 3d transition metal elements.

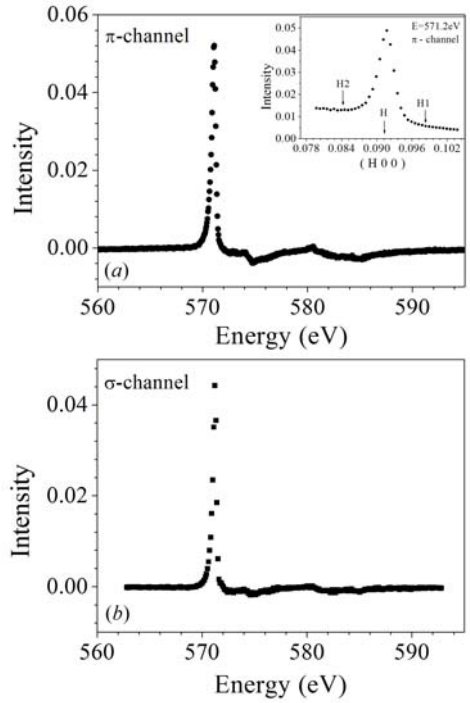

Fig. 1: Energy dependence of the CDW reflection in the different polarized channels (*a*): π-polarized channel, (*b*) σ-polarized channel. The inset shows the resonant reflection from CDW satellite reflection.

Chromium is a prototypical itinerant antiferromagnet forming a SDW state below the Ne'el temperature. Many studies have been carried out to reveal the electronic and magnetic properties of Cr. Among them, X-ray and neutron diffraction analyses have provided useful information about q-wavevector and the ordering of the SDW/CDW. Further, using high resolution x-ray scattering, Hill *et. al.* observed the spin-flip of SDW at about 120 K and the high ordered reflections of CDW, but they failed to observed the resonant signals from SDW or CDW at the Cr *K*-edge. As the outmost shells of Cr are the 3d states, in order to probe the dipole transition involving the excitation from the 2p core to the 3d states, it is therefore better to use the *L*-edge as that has been demonstrated in the cases of transition metal oxides. In this report, we present the detailed electronic structure correlating to the CDW using soft x-ray scattering.

As show in the inset of Fig. 1, a resonance of the CDW reflection was observed at (0.091 0 0) with π-polarized x-rays at 571.2 eV corresponding to the Cr L_3-edge on. In order to observe the energy dependence of the CDW reflection, we also performed the energy scan at the fixed Q. As the incident x-rat energy crossing the L_3, it also picks up the fluorescence signals. For getting the pure resonant signals of CDW reflection, we performed the energy scans at three different *q* positions (as marked H1, H, and H2 in the inset of Fig. 1-a), and then summed the intensities at H1 and H2, *i.e.*, $\frac{I_{H1}+I_{H2}}{2}$, as the average background. After subtracting the background from the peak profile obtained at *q*, a clear and pure resonant signal was obtained as showing in Fig. 1-a. The similar measurement was also taken on the σ-channel, i.e. the polarization vector of x-rays perpendicular to the scattering plane. We also observed the resonant signals from the CDW reflection at the σ-channel, shown in Fig. 1-b, with an almost identical intensity as that observed at π-channel. The result will be published shortly.