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Electronic correlation effects in $SrMoO_3$ revealed by photoemission spectroscopy

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Introduction

Photoemission spectroscopy has largely contributed to studying the effects of electronic correlation in transition-metal oxides (TMOs). In the case of $SrVO_3$, the width of the coherent part is ~ 60% of the band-structure calculation [1]. This result is consistent with specific heat measurements, which suggests $m^*/m_b \sim 2$, where m^* is the effective mass of the quasiparticle and m_b is the bare band mass. In the case of $SrRuO_3$, there is a good agreement between the experimental bulk spectrum and band-structure calculations [2]. This result does not agree with $m^*/m_b \sim 4$ from specific heat measurements, suggesting that the genuine coherent part exists only in the vicinity of the Fermi level (E_F). In this context it is important to study the effects of electronic correlation in $SrMoO_3$. From photoemission studies, we expect to see whether the genuine coherent part only near E_F in $SrRuO_3$ is a universal phenomenon in 4*d* TMO or not.

Experiment

The $SrMoO_3$ thin film was grown on $GdScO_3$ (110) substrates by the pulsed laser deposition method. The thickness of the thin lm was about 70 nm. The details of the fabrication were already described in Ref. [3]. Photoemission measurements were performed at BL-2C of Photon Factory (PF), High Energy Accelerators Research Organization (KEK). The spectra were taken by using a Scienta SES-2002 analyzer. The total energy resolution was ~ 100 meV. The position of E_F was determined by measuring the spectra of gold which has electrical contact with the sample. All the spectra were measured at room temperature.

Results and Discussion

Figure 1 (a) shows the valence-band photoemission spectra of a $SrMoO_3$ thin film at the emission angles of 0^o (NE: normal emission) and 60^o (NE + 60^o)The dashed lines show the tails of the O 2*p* bands. We can clearly see the Mo 4*d* band crossing E_F. In these spectra, surface effects are not negligible, and we need to extract the bulk component. The measured spectra can be expressed as

$$I(E) = \exp(-s/\lambda)I_{bulk}(E) + [1-\exp(-s/\lambda)]I_{surface}(E) , \quad (1)$$

where s is the thickness of the surface layer, λ is the photoelectron mean free path, and I_{bulk} and $I_{surface}$ denote the spectra of the bulk and the surface regions, respectively. We subtracted the tails of the O 2*p* bands as shown in Fig. 1 (a) (dashed lines), and used the mean free path of λ=10 Å, and the surface layer of 4 Å. Figure 1 (b) shows thus obtained bulk component after smoothing. We also performed a band-structure calculation using the WIEN2K package. We used a cubic perovskite structure with a lattice constant a = 3.976 Å. In Fig. 1 (b), we also showed the total density of states (DOS) broadened with a Gaussian of 0.3 eV (FWHM: a full width at half maximum) and an energy-dependent Lorentzian (FWHM = $0.2|E- E_F|$ eV) to account for the instrumental resolution and the lifetime broadening of the photohole, respectively. The experimental bandwidth is slightly broader than the calculated DOS. From the band-structure calculation, we obtain γ_b = 4.6 mJ/mol K^2 and from specific heat measurements γ= 7.9 mJ/mol K^2 [4]. We obtain $m^*/m_b = \gamma/\gamma_b \sim 1.7$, but this effect of electronic correlation is not observed, indicating that the genuine coherent part exists only near E_F. This phenomenon was also observed in another 4d system $SrRuO_3$, and is considered to be a universal behavior in 4*d* TMO.

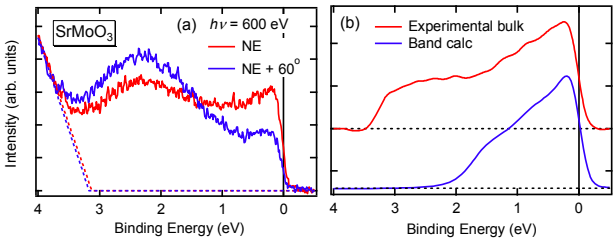

Fig. 1: (a) Valence-band Mo 4*d* photoemission spectra of a $SrMoO_3$ thin film at the emission angles of 0^o (NE) and 60^o (NE + 60^o). The dashed lines show the tails of the O 2*p* bands. (b) Comparison of the experimental bulk component and the band-structure calculation for $SrMoO_3$.

References

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