Electronic structure of $V_{1-x}W_xO_2$ thin films investigated by soft x-ray photoelectron spectroscopy

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There has been a considerable interest in controlling the metal-insulator transition temperature (T_{MI}) of VO_2 from the viewpoint of both device application and basic understanding of the metal-insulator transition (MIT). The substitution of W ions for V ions in VO_2 films ($V_{1-x}W_xO_2$) shows an interesting behavior of the T_{MI} [1]. In a lower doping region ($x \leq 0.08$), the T_{MI} decreases with increasing x, leading to a metallic conductivity in almost all the temperature in a narrow doping region at around $x = 0.08$. With further increasing x, another insulating phase appears: in the higher doping region ($0.08 \leq x \leq 0.33$), the T_{MI} monotonically increase again. The re-entrant behavior strongly suggests that there are different effects of W doping on MIT for the lower and higher doping regions.

In this study, we have performed soft x-ray photoelectron spectroscopy (PES) to reveal the effect of W doping on the electronic structure of VO_2 thin films. $V_{1-x}W_xO_2$ ($0 \leq x \leq 0.33$) thin films with thicknesses of 30–40 nm were fabricated on Nb-doped TiO_2 (001) substrate by a pulsed laser deposition method [1].

Figure 1 shows the PES spectra near the Fermi level (E_F) of $V_{1-x}W_xO_2$ films taken at room temperature (metallic phase: solid lines) and 140 K (insulating phase: dotted lines). For $x = 0$ and 0.04 films, a peak at E_F with a broad satellite structure around 1.3 eV is observed for metallic phase, while a prominent peak at 1.0 eV for insulating phase. It is noted that the satellite structure at metallic phase has different binding energy with the main peak of the insulating one. The spectral behavior across the MIT is consistent with the previous PES results of bulk VO_2 [2], indicating the Peierls-like gap formation in this doping region. Meanwhile, highly doped samples ($x \geq 0.08$) show spectral weight transfer from coherent to incoherent part across MIT, suggesting that these films are Mott-Hubbard type insulator. These results suggest that the origin of MIT is different between the lower and higher W doping region.

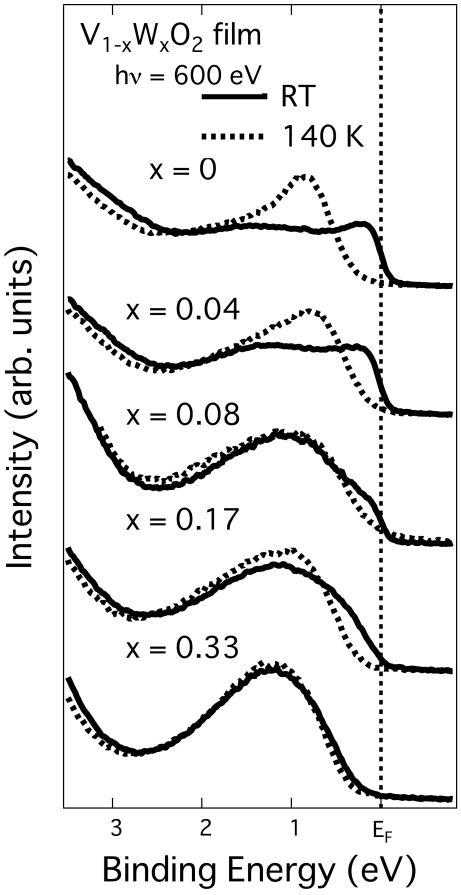

Figure 1: PES spectra of $V_{1-x}W_xO_2$ thin films

[1] K. Shibuya *et al.*, Appl. Phys. Lett. **96**, 022102 (2 010) [2] T. C. Koethe *et al.*, Phys. Rev. Lett. **97**, 116402 (2006)