X-ray photoelectron spectroscopy of partially oxidized ultrathin films of 4d refractory metals deposited by e-beam physical vapor deposition

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The X-ray photoelectron spectroscopy (XPS) spectra of electron-doped 4d transition metal oxides show multiple peaks due to the final-state screening effect of conduction carriers [1, 2]. Occasionally these 'extra' peaks get confused as originating from other oxidation states of the cation. The theoretical analysis of the XPS spectra of d^1 and n-doped d^0 transition metal oxides pointed out that such multiple peaks are not always originating from other ions but are intrinsic to the material [1].

We have grown ultrathin films of partially oxidized 4d refractory elements (Nb and Mo) on $SrTiO_3$ (111) substrates by using e-beam physical vapor deposition. The samples were grown by varying the flow of oxygen from 0.00 to 0.30 SCCM (Samples: Nb_0.00 to Nb_0.30), which varied the pressure of the growth chamber from $1x10^{-11}$ to $1.7x10^{-6}$ mbar, respectively. The films were in contact with air before the XPS measurements to purposefully introduce native oxide Nb_2O_5 [3]. The valence band and Nb 3d XPS spectra are shown in Fig. 1 (a) and (b) respectively. We performed a careful fitting of Nb 3d XPS spectra by considering the various NbO_x reported. Starting from Nb_0.00 containing Nb^0 and Nb^{5+} and the seemingly fully oxidized Nb_0.30 containing Nb^{5+}, we estimated the positions of satellite peaks originating from the screening effect of conduction carriers. We also noticed a dependence of this satellite peak upon the carrier density near the Fermi level. A comparison with the Nb 3d XPS spectra of conducting perovskite $SrNbO_3$ and insulating perovskite $AgNbO_3$ (gathered from other projects) provided further proof for this argument. We observed a similar effect when this experiment was repeated on MoO_x. This work provides experimental confirmation of the final-state screening effect in electron-doped all oxides of BO_x (B=Nb and Mo).

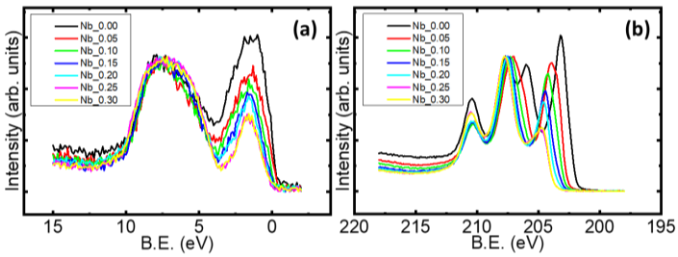

Fig. 1 The XPS spectra of (a) valence band and (b) Nb 3d of NbO_x films grown under different flows of oxygen (Sample code Nb_X implies X SCCM of oxygen)

References

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