

Screening Effects in $2p$ core-level Photoemission of Transition Metal Oxides

Munetaka Taguchi¹, Ashish Chainani¹, Koji Horiba¹, Masaharu Matsunami¹, Yasutaka Takata¹, Kazuya Yamamoto¹, Tomoyuki Takeuchi¹, Makina Yabashi^{2,3}, Kenji Tamasaku², Yoshinori Nishino², Daigo Miwa², Tetsuya Ishikawa², Takayoshi Yokoya⁴, Eiji Ikenaga³, Keisuke Kobayashi³, Takashi Mochiku⁵, Kazuto Hirata⁵, Junya Hori⁶, Kiyotaka Ishii⁶, Fumihito Nakamura⁶, Takashi Suzuki⁶, Kiyochirou Motoya⁷, and Shik Shin^{1,8},

¹*Soft X-ray Spectroscopy Laboratory, RIKEN SPring-8 Center Sayo, Sayo, Hyogo, 679-5148, Japan*

²*Coherent X-ray Laboratory, RIKEN SPring-8 Center Sayo, Sayo, Hyogo, 679-5148, Japan*

³*JASRI/SPring-8 Center Sayo, Sayo, Hyogo, 679-5198, Japan*

⁴*Department of Physics, Faculty of Science, Okayama University, Tsushimanaka, Okayama, 700-8530, Japan*

⁵*National Institute for Materials Science, Tsukuba, Ibaraki 305-0047, Japan*

⁶*Department of Quantum Matter, ADSM, Hiroshima University, Higashi-Hiroshima, Hiroshima 739-8530, Japan*

⁷*Institute of Solid State Physics, University of Tokyo, Kashiwa, Chiba 277-8581, Japan*

In the present work, we report bulk sensitive hard x-ray photoemission spectroscopy (HX-PES) of transition metal (TM) $2p$ core-level for various TM oxides (titanium oxides, vanadium oxides, Sr doped LaMnO₃ and high-Tc cuprates), which we have carried out in the last few years. Unlike conventional soft x-ray (SX) PES, TM $2p$ core-level HX-PES spectra in the metallic phase show additional well-screened features with significantly large intensity in addition to the $2p^5 3d^n$ and $2p^5 3d^{n+1} \underline{L}$ features, where \underline{L} represents the ligand hole. These satellites were located at typically 1-2 eV lower binding energy than the $2p_{3/2}$ and $2p_{1/2}$ main line. The structure, position of the main peak and satellite structures were well explained by the cluster model (or impurity Anderson model) including intra-atomic multiplet structure and a metallic screening channel derived from the coherent states at Fermi Energy. The low binding energy satellite structure was attributed to screening from the coherent state.

The present approach reveals features that are hidden in SX-PES and shows importance of HX-PES as a reliable probe of bulk properties.