7A, 16A/2008G194

Interference effects on plasmon losses in core-level photoemission spectra

Yoshihiro MIYAGAWA[1], Nobuhiko KAWAI[1], Tatsuro MIKI[1], Misato KAZAMA[1], Yusuke OHORI[1], Takuma KANEKO[1], Takehisa KONISHI[1], Hiroshi SHINOTSUKA[2], Takashi FUJIKAWA[1], Ryohei SUMII[3], Masako SAKAMAKI[3], Kenta AMEMIYA[3]
[1]Graduate school of Advanced Integration Science, Chiba University, 1-33 Yayoi-cho, Inage, Chiba 263-8522, Japan
[2]NIMS, Tsukuba, Ibaraki 305-0047, Japan
[3]KEK-PF, Tsukuba, Ibaraki 305-0801, Japan

Introduction

Photoelectron spectra from simple metals show plasmon loss peaks which accompany main peaks due to the excitation of plasmon [1]. The excitation processes are usually classified into intrinsic loss and extrinsic loss. The former is caused by sudden creation of a core hole and the latter is owing to the inelastic scattering by valence electrons after the photoelectron excitation. In addition, because final states of the two processes cannot be discriminated, there can be quantum interference, giving rise to negative contributions in general [2]. In order to confirm the above theoretical prediction, we measured excitation energy and polarization dependence of the photoemission spectra from (001) surface of Al, and compare the results with theoretical calculations.

Theory

When a photoelectron with momentum **p** is excited by X-ray with energy ω, single-loss photoemission intensity at loss energy of ω_m is written as [3]

$$I(\mathbf{p};\omega) = 2\pi \sum_m |\langle f_{\mathbf{p}}^- |\Delta|\phi_c\rangle S_m + \langle f_{\mathbf{p}}^- | v_m g(\epsilon_p + \omega_m)\Delta|\phi_c\rangle S_0|^2$$
$$\times \delta(E_0 + \omega - E_0^* - \omega_m - \epsilon_p)$$

The first and second term stand for intrinsic and extrinsic loss respectively.

Experimental

The crystal was cleaned by Ar^+ ion bombardment under 5.7×10^{-7} Torr and annealing to 620 K. After the cleaning cycles, LEED spots showed a well-ordered surface. The photoemission experiments were performed using a SES-2002 electron analyzer at BL-7A and 16A of KEK-PF.

Results and Discussion

Figure 1 shows Al 2p plasmon loss peaks measured in horizontal plane using horizontal and vertical linearly polarized light, detected along the atomic rows of the [110] direction. The spectra are normalized to the intensity of the main peak. Plasmon peaks shift to higher binding energy as the photon energy decreases. This is observed more clearly in the spectra taken with horizontally polarized light. This is in agreement with theoretical prediction (Fig. 2). The interference of the two processes has negative contribution and it becomes larger as the photon energy decreases. Thus the interference term causes apparent shift of the plasmon peaks to higher binding energy. In many of the literature, the total plasmon loss peak intensity has been considered to be the simple sum of the intrinsic and extrinsic loss processes [1]. Our results indicate the significance of the interference term. Quantitative analysis is under way and will be reported elsewhere.

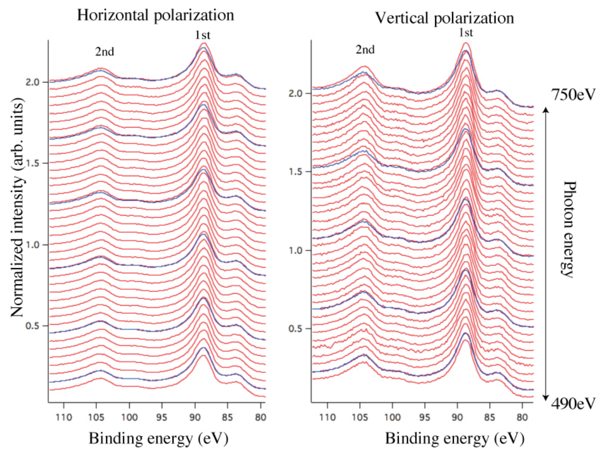

Fig. 1. Al 2p first and second plasmon loss peaks. Blue lines are the spectra at E_{photon} = 490 eV for comparison.

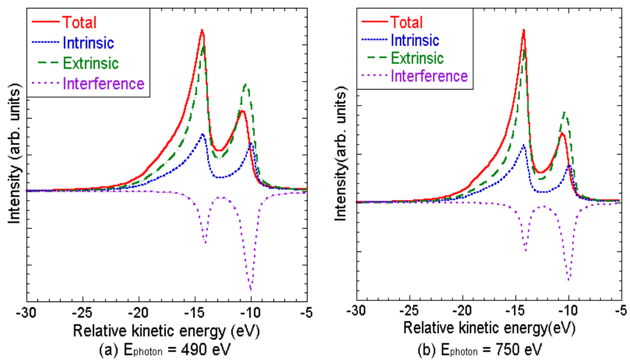

Fig. 2. Calculated first plasmon loss spectrum at photon energy of (a) 490 eV (b) 750 eV using horizontally polarized light. The peak at lower/higher kinetic energy corresponds to the bulk/surface plasmon excitation.

References

[1] S. Hüfner, Photoelectron Spectroscopy (Springer, 1995).
[2] T. Uwatoko *et al.*, J. Surf. Sci. Jpn. **22**, 497 (2001).
[3] T. Fujikawa *et al.*, e-J. Surf. Sci. Nanotech. **6**, 263 (2008).

*miyagawa@graduate.chiba-u.jp