Valence Band Modification of Oxygen Exposed Aluminum

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Aluminum is the most abundant metal in the Earth's crust, and aluminum and aluminum oxide are widely used in the world [1, 2]. Also, aluminum is a metal that readily reacts with oxygen, so it is considered important to clarify the mechanism by which aluminum forms aluminum oxide. In this study, we used the photoelectron spectroscopy (PES) to investigate the valence band of aluminum exposed to an oxygen environment. We examined the changes in the valence band spectra of aluminum as the amount of oxygen exposure is varied in order to observe the mechanism of oxygen adsorption on the surface of the aluminum sample.

The PES measurement was carried out at the linearly polarized soft X-ray beamline BL-7 of SR center, Ritsumeikan University, using a hemispherical electron energy analyzer, SCIENTA SES2002. The valence band spectra were obtained by irradiating SR light of 40 eV. The energy resolution was set to be ~200 meV. The measurements were performed at room temperature under the UHV of ~3 × 10^{-8} Pa. The aluminum (Al) sample used in this study was a 0.50 × 10.0 × 10.0 mm polycrystalline aluminum plate with a purity of 99.999 % (Nilaco Co.). To investigate changes in the valence band spectrum of aluminum according to changes in the exposure level of oxygen, impurities on the aluminum surface were cleaned using Ar^+ sputtering (20 mA, 1 kV, P_{Ar}: 6.5 - 7.0 × 10^{-3} Pa) method. Oxygen was gradually introduced into the analysis chamber from 1 to 50000 L, where 1 L is defined as 1.3×10^{-4} Pa × 1 s.

Figure 1 summarizes the valence band spectra before and after oxygen exposure. When the oxygen exposure is low (0 to 10 L), there is no significant changes in the aluminum valence band spectra [Fig. 1(a)]. With increasing oxygen exposure, the structures around the binding energies of 9 eV and 4 eV due to O 2*p* appear and the energy gap opens [Fig. 1(b)(c)], indicating that oxygen is adsorbed on the surface of the aluminum sample to form aluminum oxide. Figure 1(c) shows that there is almost no change in the overall spectra after the oxygen exposure reaches 40000 L, maybe due to a certain 'critical' oxide-film thickness.

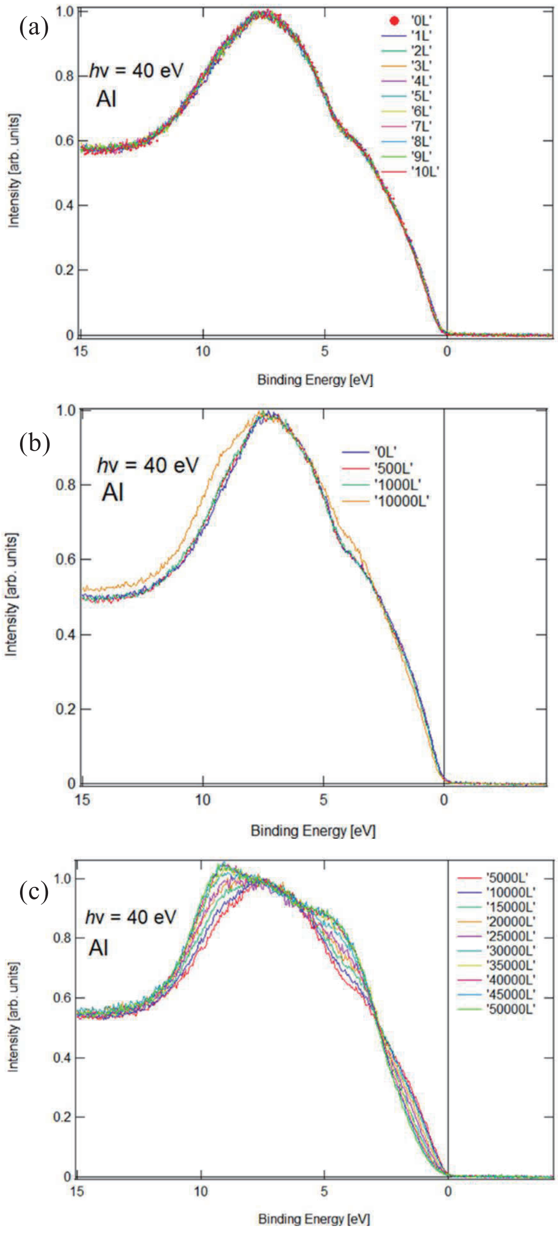

Fig. 1 Valence band spectra of aluminum before and after oxygen exposure. (a) 0 to 10 L. (b) 0 to 10000 L. (c) 5000 to 50000 L.

References

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[2] J. Cañas, *et al.*, Appl. Surf. Sci. **2021**, *535*, 146301.