Chemical State Change of Pt(111) under Oxygen Exposure

Muneaki Tani and Masaru Takizawa
Department of Physical Sciences, Faculty of Science and Engineering, Ritsumeikan University, 1-1-1 Noji-higashi, Kusatsu 525-8577, Japan

Precious metal catalysts, such as Pt, which accelerate the CO oxidation reaction, are widely employed in exhaust gas purification catalysts for automobiles and other vehicles. In our previous research [1], we focused on studying Cu-Pt alloys, which have gained attention as an alternative material. To advance our investigation into alternative materials, it is critical to initially verify the precise chemical state changes of Pt(111). In this study, we conducted surface cleaning using Ar^+ sputtering and annealing. Subsequently, we examined the chemical state changes upon exposing the cleaned surface to oxygen, utilizing synchrotron radiation spectroscopy.

The measurements were performed at synchrotron radiation photoelectron spectroscopy (PES) beamline BL-7 of the SR Center, Ritsumeikan University. Ar^+ sputtering was conducted for 1 hour at an acceleration voltage of 1 kV and an Ar pressure of 6.5×10^{-3} Pa. Annealing was carried out by gradually increasing the temperature, holding it at 800 °C for 10 minutes, and then gradually decreasing the temperature over a total duration of 30 minutes. The PES spectra were obtained by using a hemispherical electron energy analyzer, SCIENTA SES2002. The energy resolution was set to be ~200 meV. The measurements were performed at room temperature under the UHV of $\sim 3 \times 10^{-8}$ Pa.

Figure 1 shows the chemical state changes observed after multiple annealing cycles. Specifically, the peaks corresponding to binding energies of 9 eV and 20 eV in the untreated surface exhibit clear reduction following repeated annealing. Furthermore, the removal of adsorbed oxygen and other elements from the surface leads to an enhanced presence of Pt 4*f* on the surface.

Figure 2 shows the chemical state changes after oxygen exposure (0 to 1000 L). The peak at 7 eV after oxygen exposure increases slightly. Simultaneously, the peak intensity of the Pt 4*f* spectrum gradually decreases and shifts slightly toward higher binding energy side with oxygen adsorption on the surface. Based on these results, it is confirmed that the surface component of Pt(111) decreases due to oxygen adsorption, leading to an increase in binding energy resulting from oxygen bonding.

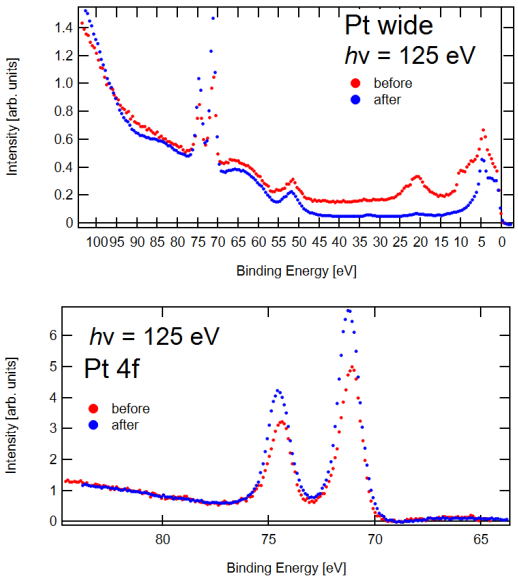

Fig. 1 PES spectra (wide region and Pt 4*f*) of Pt(111) before and after multiple annealing cycles.

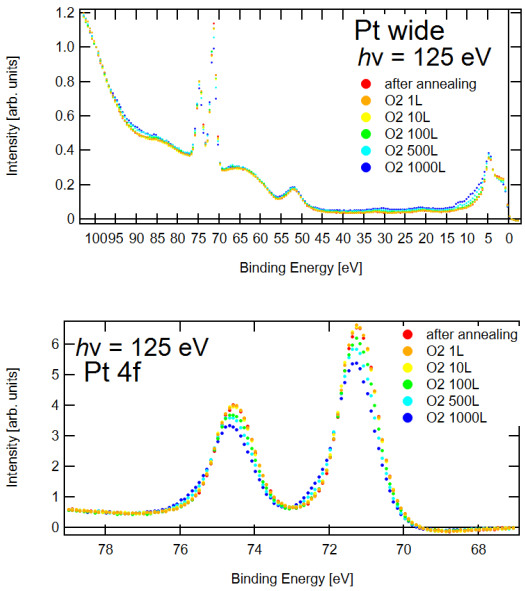

Fig. 2 PES spectra (wide region and Pt 4*f*) of Pt(111) before and after oxygen exposure.

Reference

[1] M. Yoshimi, Master thesis, **2022**.