Electronic State Analysis of Carbon Material on Optics Produced by SR Irradiation

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The beamlines at synchrotron radiation (SR) facilities consist of mainly mirrors and gratings (optics) in order to produce desired photon. Although these optics are installed in ultrahigh vacuum (UHV) chamber (~10^{-8} Pa), the surfaces irradiated with SR are covered with carbon contamination due to the residual gases such as hydrocarbon. Since the carbon contamination causes the difficulty to measure the C *K*-edge near-edge X-ray absorption fine structure, various procedures, e.g., ultraviolet (UV)/ozone cleaning, to remove the carbon contamination have been reported [1]. The carbon contamination is considered to be graphite-like one, deduced from the photon intensity spectra after the contaminated optics [1]. However, it is very difficult to directly investigate the electronic structures of the contaminated optics surface. In this study, we have prepared the SR irradiated Au-coated Si samples and investigated the electronic states during UV/ozone cleaning.

The experiments were performed at the linearly polarized soft X-ray beamline BL-7 of SR center, Ritsumeikan University. Au-coated Si samples were introduced into the UHV beamline chamber and irradiated by SR. Then, the samples were transferred to the X-ray photoelectron spectroscopy (XPS) chamber immediately. For the UV/ozone cleaning, the samples were irradiated by UV under the oxygen (O_2) pressure of ~100 Pa. After the UV/ozone cleaning, the chamber was evacuated to ~10^{-6} Pa and the samples were *in-situ* transferred to the XPS chamber. The XPS measurements were performed at room temperature under the UHV of ~8×10^{-8} Pa using an Al Kα source ($h\nu$ = 1486.6 eV) and a hemispherical electron energy analyzer, SCIENTA SES2002.

Figure 1 shows wide range XPS spectra of the samples. After the SR irradiation, the intensity of C 1*s* core level is stronger than that of Au 4*f* core level. After the initial UV irradiation in oxygen for ~4 hours [O_2+UV (~4 h)], the intensity of C 1*s* core level decreases while that of O 1*s* core level increases. It should be noted that neither UV irradiation in vacuum (without O_2) nor O_2 exposure changed XPS spectra significantly (not shown). Further UV irradiation in oxygen [O_2+UV (~90 h)] makes the intensities of Au core-levels prominent, indicating that the carbon materials on the optics can be removed. It

is noteworthy that the relative intensity of O 1*s* and Au 4*p* core-levels does not increase but decreases though the intensity of O 1*s* core level becomes stronger than that of C 1*s* core level.

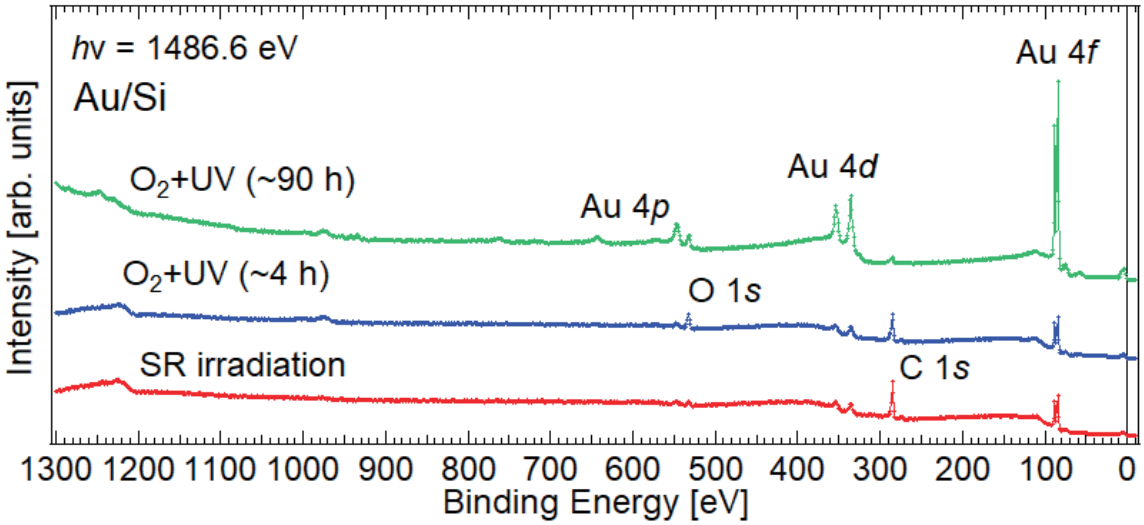

Fig. 1 Wide range XPS spectra of Au/Si surfaces.

Figure 2 shows normalized C 1*s* XPS spectra of the samples. The C 1*s* peak after the SR irradiation is located at ~284.5 eV and can be assigned to graphitic C=C and/or C-C bonds [2]. Since the so-called contamination C 1*s* peak-position was different (not shown), graphite-like carbon materials are found to be produced on the Au-coated Si samples after the SR irradiation, as previously reported [1]. After the initial UV irradiation in oxygen [O_2+UV (~4 h)], a new structure appears around the binding energy of ~289 eV, indicating that the C=O and/or O-C=O bonds [2] form during the UV/ozone cleaning. This spectral change confirms that the carbon on the surface does react with the oxygen radicals created by UV/ozone. These two components remain after further UV irradiation in oxygen [O_2+UV (~90 h)] although the intensity ratio of two components and the total intensity (Fig. 1) change.

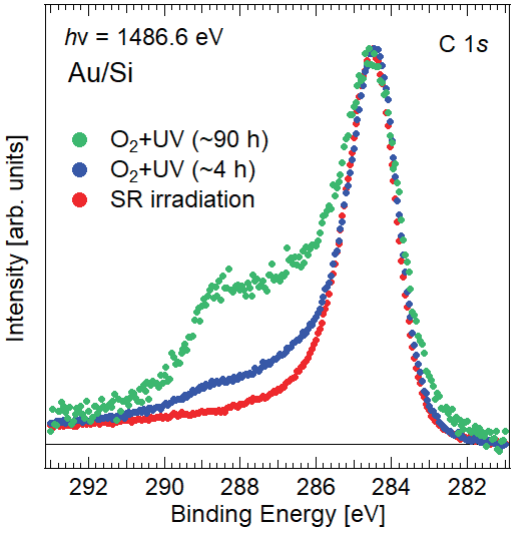

Fig. 2 C 1*s* XPS spectra of Au/Si surfaces.

References

[1] A. Toyoshima, T. Kikuchi, H. Tanaka, J. Adachi, K. Mase, and K. Amemiya, *J. Synchrotron Rad.*, **2012**, *19*, 722.

[2] X. Chen, X. Wang, and D. Fang, *Fuller. Nanotub. Carbon Nanostructures*, **2020**, *28*, 1048.