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In Situ Removal of Carbon Contamination from Optics in a VSX Undulator Beamline, BL-13A, Using Oxygen Activated by 0th-Order Synchrotron Radiation

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1 Introduction

When optics are irradiated with synchrotron radiation (SR) in the presence of residual hydrocarbon gases, they are contaminated with carbon [1]. The carbon contamination leads to a significant decrease in the reflectivity in the vacuum ultraviolet and soft X-ray (VSX) region. The photon flux loss in the carbon *K*-edge region is especially critical because it reduces the quality of experimental data, such as near-edge X-ray absorption fine structure (NEXAFS), resonant photoemission, and resonant soft X-ray emission spectra. *In situ* SR-activated oxygen cleaning seems to be most advantageous because optics can be cleaned by exposing them to oxygen at 10^{-2} Pa for 15 hours under 0th order SR irradiation [2]. In the present paper we report results of *in situ* SR-activated oxygen cleaning of optics in a VSX undulator beamline, BL-13A at Photon Factory [3].

2 Experiment

The VSX undulator beamline, BL-13A, has a Monk-Gillieson-type monochromator to cover a wide photon-energy range with a high energy resolution. The details of BL-13A have been described elsewhere [4,5]. Briefly, BL-13A consists of a focusing pre-mirror (M1), a plane mirror (M2), two varied-line-spacing plane gratings (VLSGs, 300 and 1000 lines/mm), an exit slit, and two focusing post-mirrors (M3, 2-m:2-m focusing; M3′, 2-m:6-m focusing). M1, M2, the VLSGs, M3, and M3′ are coated with a gold film with a thickness of 1000 Å or 500 Å. While the SR is vertically reflected by M1, M3, and M3′, it is horizontally reflected by M2 and the VLSGs. Dry oxygen with a purity of 99.9% was supplied by using variable leak valves attached to the beamline.

3 Results and Discussion

Figure 1 shows photon intensity spectra measured with the 300-lines/mm VLSG and M3 before and after *in situ* SR-activated oxygen cleaning. The exit slit was fixed at 30 μm. The photon intensity was measured by using a silicon photodiode (AXUV-100, International Radiation Detectors, Inc.). On the basis of the NEXAFS spectra of graphite [6], we ascribed the sharp dip at 285.1 eV to the C 1*s* → π^* transition of graphite-like carbon with a flat-on configuration on M1 and M3, and the sharp dip at 291.5 eV mainly to the C 1*s* → σ^* transition of graphite-like carbon with a flat-on configuration on M2 and the VLSG. The oxygen pressures in the M1, M2/VLSG, and M3/M3′ chambers were in the range 2×10^{-4} to 6×10^{-4} Pa, 5×10^{-3} to 1.5×10^{-2} Pa, and 1×10^{-5} to 4×10^{-5} Pa, respectively. M1, M2, the 300-lines/mm VLSG, and M3 were irradiated with 0th-order SR for 20 h. The averaged ring current was 450 mA. The photon intensity dips in the carbon *K*-edge region reduced to 2–5% after the cleaning. Since these absorption energies are different from those before the cleaning (285.1 and 291.5–291.9 eV), we ascribe them to the carbon contamination in the bulk of the gold film of the optics. The base pressure of the beamline recovered to 10^{-7}–10^{-8} Pa in one day without baking. The beamline can be used without additional commissioning. The interaction of oxygen molecules with photoelectrons emitted from the optics seems to play a dominant role in the removal of carbon contamination. Therefore, *in situ* SR-activated oxygen cleaning is suitable for optics in undulator beamlines where a high photon flux is easily achieved.

References

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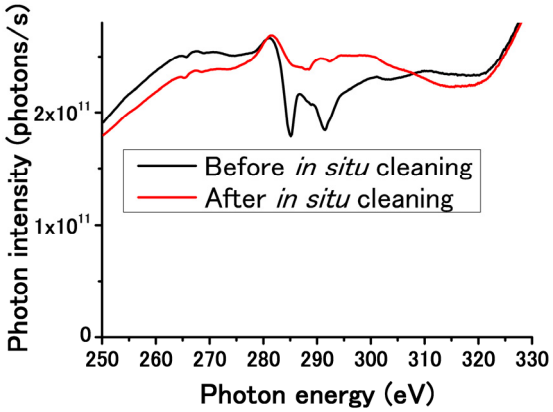

Fig. 1: Photon intensity spectra measured before and after the *in situ* SR-activated oxygen cleaning; the measurements were made with the 300-lines/mm VLSG and M3.