Reconstruction of BL-3 to use focused X-ray for XAFS and XRF analyses

Misaki Katayama, Kazuhiko Ozutsumi, and Yasuhiro Inada

Department of Applied Chemistry, College of Life Sciences, Ritsumeikan University, 1-1-1 Noji-Higashi, Kusatsu 525-8577, Japan.

The XAFS beamline BL-3 was reconstructed for grading up to the beamline with the focused hard X-ray beam in 2010. A focusing mirror was installed at the position of 4.5 m from the light source point, the new experimental hutch was built (Figure 1). The layout of new BL-3 is depicted in "Beamline Status" in this volume.

The focusing mirror is made of Si single crystal and coated by Pt of 100 nm thickness and its dimension is 40 mm (width) × 35 mm (thickness) × 500 mm (length). The shape of the mirror is toroidal with the geometrical focusing ratio of 1:1. The glancing angle of the focusing mirror is designed as 8.73 mrad, and the corresponding cut-off energy is 9.1 keV. The beam reflected at the mirror has the inclination of 17.45 mrad. At the focus point of 9.0 m from the light source point, the X-ray beam size (FWHM) is about 1 mm (V) × 2 mm (H) (Figure 2), which is in agreement with the calculated value. The photon flux is 1.0×10^9 cps at 5 keV, 5.5×10^8 cps at 6 keV, 2.3×10^8 cps at 7 keV, 7.6×10^7 cps at 8 keV, and 2.2×10^7 cps at 9 keV, where these values were measured with the Si(220) monochromator and they were normalized

Figure 1 Focusing mirror of BL-3 (left) and inside of new experimental hutch (right).

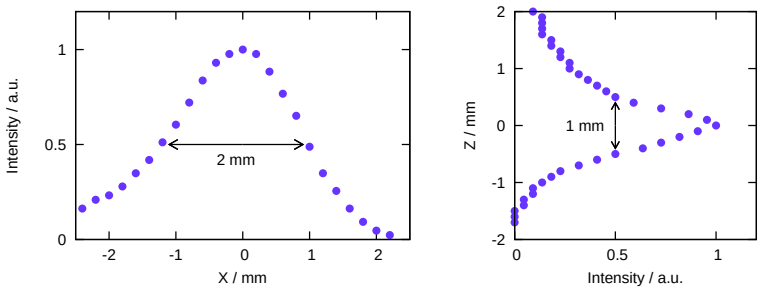

Figure 2 Beam profile at focus point.

to 300 mA of SR ring current. Figure 3 compares the photon flux of XAFS beamlines of SR Center with those of Photon Factory.

Upgrading of the beamline was effective in not only the flux but the energy resolution. The crystal surface of the monochromator and the vertical width for the rear slit of the monochromator affect the energy resolution in BL-3. With the unfocused beam, the vertical width of the slit was needed to be opened to obtain the X-ray intensity. By using the focusing mirror, the horizontal acceptance of the synchrotron radiation increased to 8.8 mrad. This allowed to reduce the vertical width of the slit. A typically energy resolution is $\Delta E/E \approx 2.5 \times 10^{-4}$ at 5 keV.

With making the new experimental hutch, a three-elements Ge solid state detector (SSD) was prepared as the standing detector for the XAFS measurement of fluorescence mode and for the X-ray fluorescence analysis. The SSD enables the XAFS measurement of more dilute or thinner samples. Figure 4 shows some spectra for aqueous solutions measured with the focusing X-ray beam and the 3-element SSD. Each measurement was performed in the time scale of 0.5–1 hour. The XAFS measurement for the sample of ~100 ppm of 3d transition metal is enabled. The energy resolution of the detector is 0.2 keV at 5 keV. The signal processing system of the SSD is controlled from the same Windows PC as the XAFS measurement. Therefore, users can easily switch both the X-ray fluorescence analysis and the XAFS measurement for each sample.

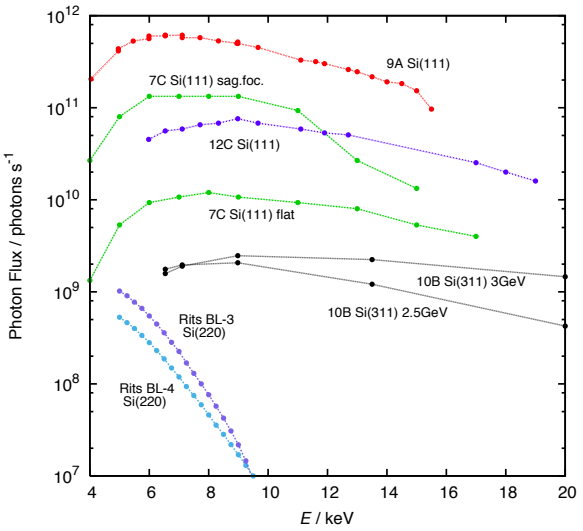

Figure 3 Photon flux of XAFS beamline of SR Center and Photon Factory (KEK).

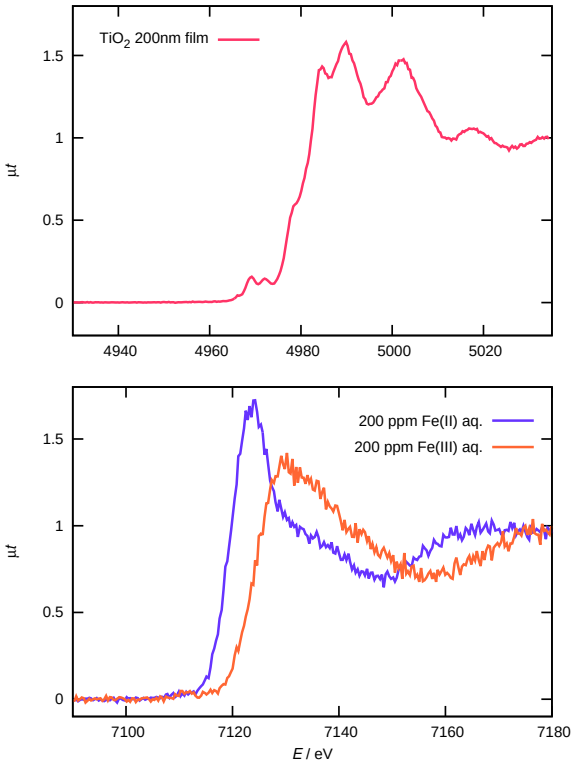

Figure 4 XAFS spectra measured with 3-elements SSD at BL-3.