BL 37XU
Trace Element Analysis

1. Introduction

BL37XU is a hard X-ray undulator beamline for trace element analysis and chemical/elemental imaging dedicated to various X-ray spectroscopy methods, such as scanning X-ray micro-spectroscopy, full-field transmission X-ray micro-spectroscopy, depth-resolved XAFS, and ultratrace element analysis [1]. Using these methods, research is actively conducted to elucidate the properties and functions of materials through analyses of the morphology, element distribution, chemical state, and local structure. In FY2020, BL37XU operated smoothly and almost all users completed their user time as scheduled. In addition, the following two projects were undertaken: (1) A new illumination system was installed for full-field transmission spectroscopic imaging. (2) A damper was inserted between the Ge-Solid State Detector (SSD) and the table for optical components to improve the stability of scanning X-ray micro-spectroscopy.

2. Installation of beam-shaping condenser zone plate

In full-field transmission X-ray micro-spectroscopy, the illumination optics has been using a linearly tapered capillary condenser. Because the capillary condenser is of a total reflection type, it is highly efficient and has no chromatic aberration, so the focus does not change even when the energy is changed. However, the beam profile using the capillary condenser has an intensity distribution of 1/R (R: distance from the beam center), and the illumination is inhomogeneous, with high intensity at the center and low intensity around it [2]. Figure 1(a) shows the beam profile obtained using a capillary condenser. This inhomogeneity has led to the issue of differences in statistical accuracy for the acquisition of XAFS spectra.

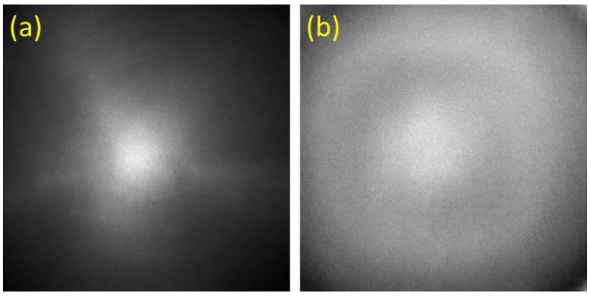

Fig. 1.Beam profile at focal point. (a) Capillary condenser and (b) BS-CZP.

In order to improve the beam profile uniformity, a beam-shaping condenser zone plate (BS-CZP), which was newly developed at BL47XU, was installed [3]. The BS-CZP consists of three layers with a total of 60 equally spaced lattice segments, and the overlap of the diffracted X-ray from each segment provides a uniform focusing profile. Figure 1(b) shows the beam profile obtained using the BS-CZP. The improved uniformity of the intensity distribution is expected to provide higher quality XAFS spectra over the entire field of view. Table 1 shows the intensity distribution at the X-ray energy of 8 keV as an example. The average intensity of the diffractive BS-CZP is 60% less than that of the total reflection capillary condenser, owing to its lower efficiency. However, the standard deviation of the intensity distribution obtained using the BS-CZP was improved by one order of magnitude compared with the case of using the capillary condenser.

Table 1. Intensity distribution at a focal point.

	Capillary condenser	BS-CZP
Max	39695	10285
Min	6262	6067
Mean	14269	8168
StdDev	5829	579

Figure 2 shows the layout of the imaging spectrometer system using the BS-CZP. Four types of order sorting aperture (OSA), namely, φ150, φ200, φ250, and φ300 μm, used to remove high-order diffracted X-rays from the BS-CZP are available depending on the sample size. For example, the space around the sample can be set from 30 to 130 mm at 7.7 keV. As for the chromatic aberration of the BS-CZP, the BS-CZP position can be fixed when the energy scan region, such as the XANES spectral region, is narrow.

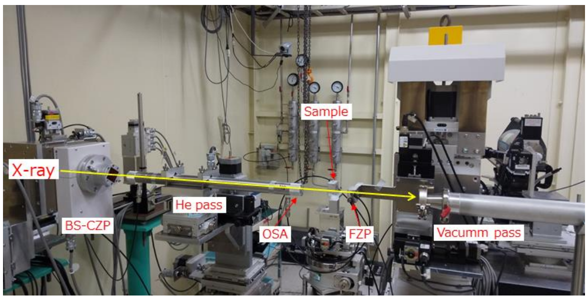

Fig. 2. Layout of full-field transmission spectroscopic imaging using BS-CZP.

3. Vibration reduction of Ge-SSD

In scanning X-ray micro-spectroscopy using a 100 nm focused beam by KB mirrors, the Ge-SSD is mainly used to detect fluorescence X-rays. The electrically cooled Ge-SSD (EGX10-06-CP5-PLUS-WC; Mirion Technologies) installed in FY2019 minimizes vibrations of the detector by using a fanless model that utilizes water cooling. Nevertheless, the focused beam size of 130 nm with the Ge-SSD was slightly larger than that of 90 nm without the Ge-SSD. This may be due to the vibrations of the cryo-pulse refrigerator. To solve this problem, a damper was inserted between the Ge-SSD and the table for optical components. Figure 3 shows focusing beam profiles obtained during the Ge-SSD operation. The damper completely blocks the vibration originating from the Ge-SSD; thus, it enabled the use of a 100 nm focused beam even when using the Ge-SSD.

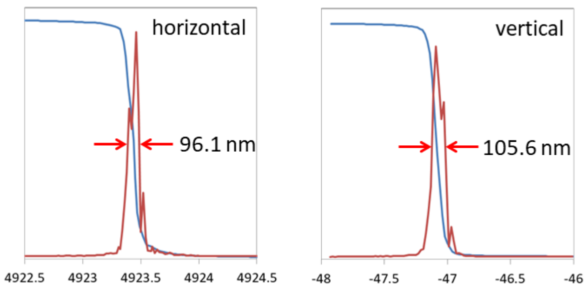

Fig. 3. Focusing beam profiles at 30 keV obtained during Ge-SSD operation.

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References:

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