BL27SU
Soft X-ray Photochemistry

1. Introduction

BL27SU is a soft X-ray undulator beamline dedicated to soft X-ray spectroscopy and microscopy under normal ambient pressure (helium) or high-vacuum condition. The beamline consists of two branches named B and C. The B-branch provides higher X-ray energy of 2.1–3.3 keV using a Si (111) channel-cut monochromator, and the incident X-ray is focused onto an approximately 10 μm spot at the sample position using Kirkpatrick–Baez (KB) mirrors [1,2]. This branch is mainly available for physicochemical analysis based on elemental X-ray fluorescence (XRF) mapping and micrometer-scale X-ray absorption spectroscopy (μ-XAS) measurements. The C-branch is equipped with a varied-line-spacing plane grating monochromator (VLS-PGM), which was upgraded in FY2018 [3]. XRF mapping, μ-XAFS measurement, and X-ray emission spectroscopy (XES) are available at a low X-ray energy range of 0.17–2.2 keV at this branch.

One of the important applications of BL27SU is spectromicroscopy for various sample analyses (e.g., trace element analysis), which takes advantage of the high brilliance of a light source, and we are continuously improving the spectromicroscopy apparatus in this beamline. Here, we report two upgrades on the spectromicroscopy apparatus performed in FY2021.

2. Preparation of transmission X-ray microscopy (TXM) at C-branch

At the C-branch, no fixed apparatus for spectromicroscopy measurement has been installed, and thus a portable apparatus is used for this purpose. The recently prepared apparatus is designed to measure full-field type imaging XAS system called transmission X-ray microscopy (TXM-XAS) [4,5]. In FY2021, this apparatus was upgraded for the further use of TXM. For this purpose, the sample stages were redesigned to reduce vibration. A trapezoidal three-position holding mechanism with an aluminum eight-hole plate (used at world STXMs) was adopted for the sample holder to increase flexibility between STXM and our TXM (Fig. 1).

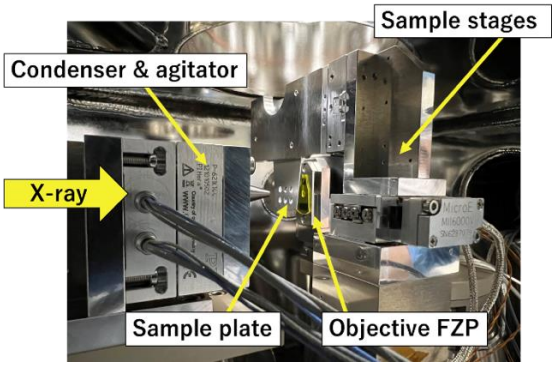

Fig. 1. Redesigned stages and capillary condenser system in TXM main chamber.

3. Upgrade of condenser system installed on TXM-XAS apparatus

For TXM-XAS measurement, the condenser system has been improved to obtain a more homogeneous illumination on the sample. In the TXM-XAS, we used a half-focusing-type polycapillary composed of tiny borosilicate glass channels in an array configuration (X-ray Optical Systems Inc.) as a condenser. Figure 2(a) shows the I_0 image obtained using the polycapillary condenser. Owing to capillary focusing, the field of view is restricted by

the focal beam size and the photon distribution is inhomogeneous. To solve this problem, the condenser has been mounted on an XY piezo scanner, which is an agitator to achieve the desired field of view on the I_0 image. The typical irradiation area of the TXM-XAS has been enlarged to about 40 μm × 40 μm by this modification.

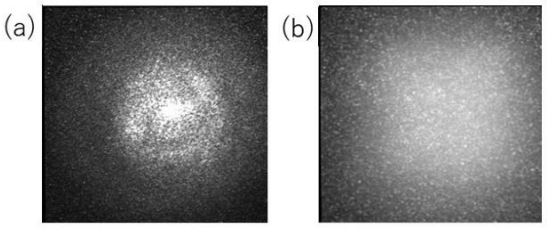

Fig. 2. Beam profile of I_0 image. (a) Polycapillary condenser. (b) Polycapillary condenser with agitator.

The spatial resolution was evaluated using the upgraded TXM-XAS. Figure 3 shows transmitted X-ray image of a chart pattern acquired at 280 eV, where the size of one pixel on the detector is approximately 18 nm. The 100 nm lines and spaces are clearly separated. The spatial resolution was evaluated by observing the vertical and horizontal intensity profiles obtained at the red lines indicated in Fig. 3. Figures 4(a) and 4(b) indicate the horizontal and vertical intensity profiles, respectively. The spatial resolution was evaluated as 108 and 90 nm, respectively, from the full width at half maximum (FWHM) by Gaussian fitting.

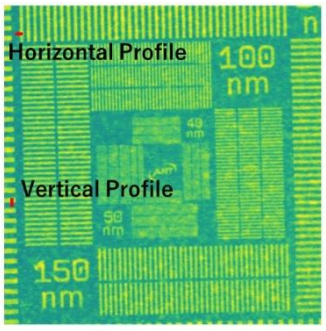

Fig. 3. Transmitted X-ray image of a chart pattern by TXM-XAS with the agitator operation. The incident X-ray was 280 eV.

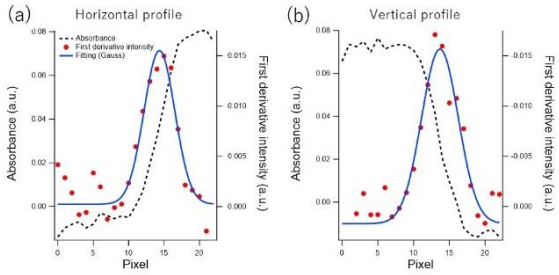

Fig. 4. The horizontal (a) and vertical (b) profiles of absorbance have been obtained from the red lines in Fig. 3. The black dotted line, red circle, and solid blue line indicate the absorbance, differential intensity profile, and Gaussian fitting, respectively.

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References:

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