BL27SU
Soft X-ray Photochemistry

1. Introduction

BL27SU is a soft X-ray undulator beamline dedicated to soft X-ray spectroscopy and microscopy under ambient pressure (helium) or high-vacuum conditions. The beamline consists of two branches, named B-branch and C-branch. The B-branch provides higher X-ray energies of 2.1–3.3 keV using a Si (111) channel-cut monochromator, and the incident X-ray beam is focused to a diameter of about 15 μm at the sample position using Kirkpatrick–Baez (KB) mirrors [1, 2]. This branch is mainly available for physicochemical analysis based on the elemental X-ray fluorescence (XRF) mapping and micrometer-scale X-ray absorption fine structure (μ-XAFS) measurements. The C-branch is equipped with a varied-line-spacing plane grating monochromator (VLS-PGM), which was upgraded in FY2018 [3]. The XRF mapping, μ-XAFS measurement, and X-ray emission spectroscopy (XES) are available in the lower X-ray energy range of 0.17–2.2 keV at this branch.

In FY2023, the X-ray fluorescence detection system was modified to a soft X-ray absorption spectroscopy system under atmospheric pressure using differential exhaust in the C-branch. In the B-branch, a high-spatial-resolution scanning micro-spectroscopy system using Fresnel zone plate (FZP) focusing optics was constructed and its performance was evaluated.

2. Modification of Fluorescence Detection System for Differential Exhaust System

An X-ray absorption measurement system under atmospheric pressure using a differential pumping system was developed to perform soft X-ray measurements under conditions closer to those in actual environments and has been utilized by many users. This equipment can apply total electron yield (TEY) and partial fluorescence yield (PFY), and these two methods supply different depth information. However, recently, there have been frequent problems with the silicon drift detector (SDD), and thus, the SDD can no longer be used. Therefore, a photodiode (PD) detector was installed as an alternative to the SDD to examine the quality of data obtained by a total fluorescence yield (TFY) method.

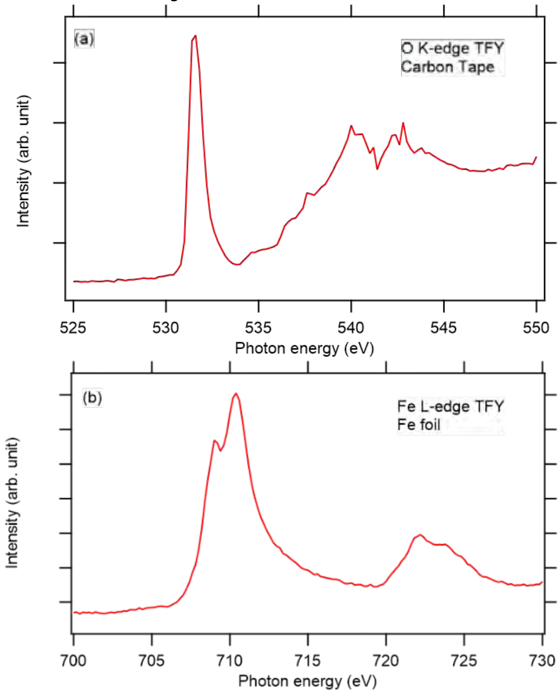

Fig. 1. XAS spectra of (a) O K-edge spectrum of carbon tape and (b) Fe L-edge spectrum of Fe foil measured by PD.

Figure 1 shows XAS spectra of the (a) O K-edge of carbon tape and (b) Fe L-edge of Fe foil. Both spectra are of good quality. Therefore, as a measure to prevent accidents involving SDD, fluorescence measurements under atmospheric pressure should, in principle, be made by TFY measurement using PD from now on, and the PFY measurement using SDD should only be employed when PD is unable, to obtain data of sufficient quality.

3. Installing New Focusing System

Until now, micro-spectroscopy at the B-branch has been performed using the KB mirror system permanently installed in the beamline. There is a growing need for micro-spectroscopy with a higher spatial resolution than currently available (15 μm). Therefore, we have developed a micro-spectroscopy system that meets such needs by using a focusing system with FZP.

The upstream configuration for the new focusing system is different from that of the conventional focusing optical system (KB mirror) that collimates incident X-rays. In the latter, the longitudinal focusing mirror is not bent and the transverse focusing mirror is evacuated. The focusing unit, shown in Fig. 2, consists of a beam stop, FZP (FZP-D300 μm-DR50 nm1-ZM500Ni-2500 eV), and an order-selecting aperture (OSA).

Using the constructed focusing optics, a test pattern was measured by scanning transmission X-ray microscopy to evaluate the actual beam size. Figure 3 shows the result of scanning micro-spectroscopy measurements of the test pattern measured at 2500 eV. As a result, patterns down to 1.0 μm (500 nm vertically) were distinguished, achieving a spatial resolution 10 times better than those of the conventional systems.

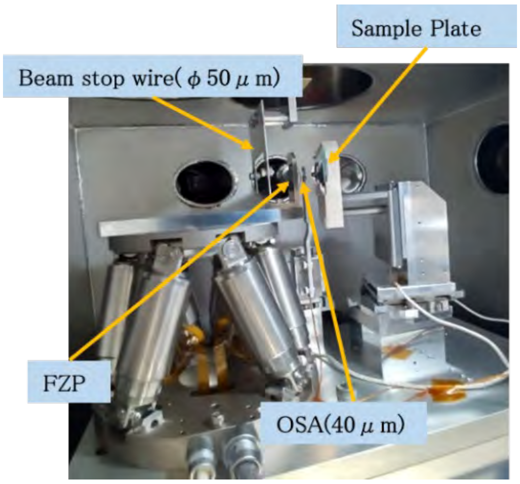

Fig. 2. Photograph of the focusing system.

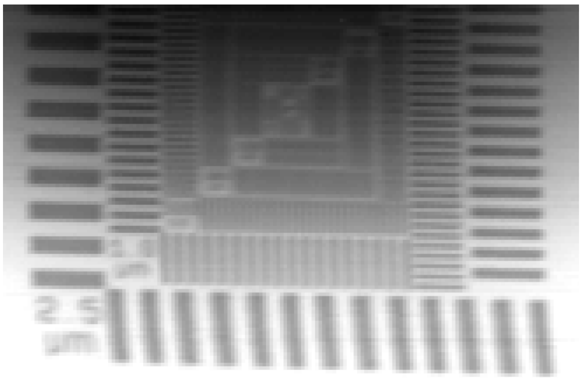

Fig. 3. Resulting image obtained by scanning transmission X-ray microscopy.

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References:

[1] Tamenori, Y. et al. (2011). *SPring-8/SACLA Annual Report FY2010*, 74–75.
[2] Tamenori, Y. et al. (2013). *SPring-8/SACLA Annual Report FY2012*, 69–71.
[3] Tsuruta, K. & Tamenori, Y. (2019). *SPring-8/SACLA Annual Report FY2018*, 56–58.