BL27SU
Soft X-ray Photochemistry

1. Introduction

BL27SU is a soft X-ray undulator beamline dedicated to spectroscopy and microscopy under ambient pressure (helium) or high-vacuum conditions. The beamline has two branches, called the B- and C-branches.

The B-branch provides high X-ray energies of 2.1–3.3 keV using a Si (111) channel-cut monochromator. The incident X-ray beam is focused to a spot of about 15 μm at the sample position using Kirkpatrick–Baez (KB) mirrors [1, 2]. This branch is mainly used for physicochemical analysis based on 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]. This branch covers lower X-ray energies of 0.17–2.2 keV and is available for XRF mapping, μ-XAFS measurements, and X-ray emission spectroscopy (XES).

In FY2024, the XES chamber in the C-branch was modified to maintain high-vacuum conditions during sample exchange.

2. Modification of X-ray emission spectroscopy chamber to maintain high-vacuum conditions

At BL27SU, approximately 40% of experiments are conducted using the XES chamber. However, during sample exchange, it was necessary to break the vacuum (~10^{-5} Pa) in the chamber and then evacuate it again. As a result, several issues arose: sample replacement required about two to three hours; the vacuum had to be released very slowly to avoid damaging the detector; and the replacement position was elevated, making the procedure itself difficult.

Therefore, the sample exchange mechanism of the XES chamber was improved, enabling sample replacement without breaking the chamber vacuum. In this upgrade, a sample exchange tank (sample tank) was connected to the XES chamber via a gate valve, allowing the tank to be evacuated independently of the chamber (Fig. 1). In addition, a sample stage was installed inside the XES chamber, enabling safe sample exchange at a lower position.

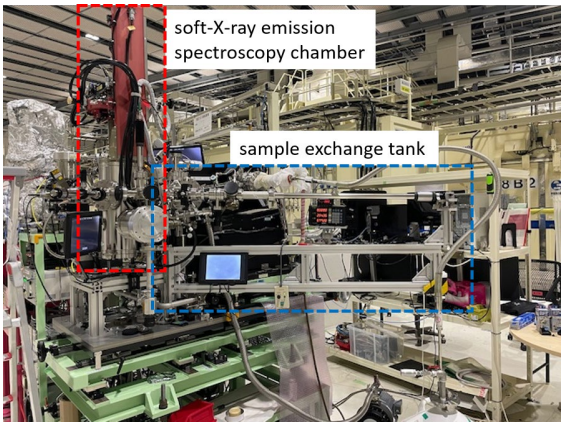

Fig. 1. Photograph of the modified XES chamber.

The sample exchange procedure is as follows. After the sample tank is evacuated, the gate valve connecting it to the XES chamber is opened, and the sample exchange rod with the sample holder (Fig. 2) is inserted from the sample tank into the XES chamber.

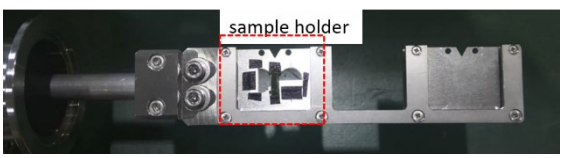

Fig. 2. Photograph of the sample exchange rod.

The measured sample holder is removed from the sample stage in the XES chamber and transferred to the sample exchange rod, after which a new sample holder is placed on the sample stage. This completes the sample replacement procedure. The entire operation can be easily performed while monitoring images from the camera mounted on the viewport (Fig. 3). The procedure can be carried out without breaking the vacuum in the XES chamber, and sample replacement is completed within approximately 15 min.

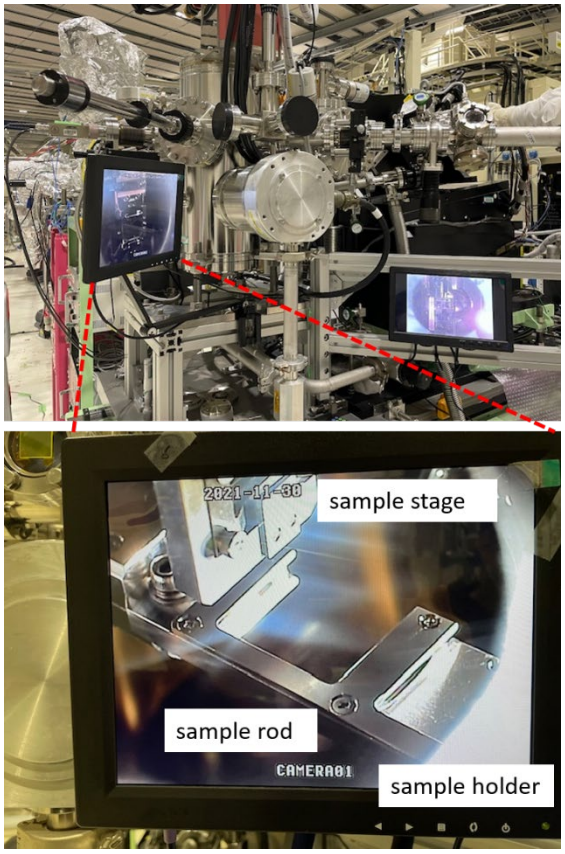

Fig. 3. Image from the camera showing the sample exchange procedure.

In summary, the modifications to the XES chamber significantly improved the efficiency and safety of the sample exchange process, making the procedure simpler, safer, and much faster. As a result, the time required for sample replacement has been reduced from several hours to approximately 15 min, greatly enhancing the experimental throughput at BL27SU.

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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.