BL 40XU
High Flux

1. Introduction

BL40XU mainly utilizes the fundamental peak of a helical undulator radiation as a quasi-monochromatic X-ray beam without a crystal monochromator. The fundamental undulator radiation has an energy peak width of 2% and a flux as high as 1×10^{15} photons/s at 12 keV. Utilizing these beam characteristics, various experiments such as diffraction, scattering, and imaging are conducted. Experimental hutch (EH) 1 is used for various experiments, including time-resolved SAXS/WAXS measurements, while EH 2 is used for crystallography and pump-probe experiments.

2. EH 1

EH 1 usually supports time-resolved X-ray diffraction, X-ray single-molecule measurements, and microbeam diffraction/scattering experiments on mainly bio-soft materials. In the case of soft materials, the structural change caused by the external modulation of the experimental environment is often tracked on a wide time and space scale by SAXS/WAXS measurements. In FY2020, we upgraded the WAXS detector system for simultaneous SAXS/WAXS measurements. We restored the YAG-Nd laser that was permanently installed at BL40XU to improve the convenience of obtaining information on a wide time and space scale.

A photon-counting X-ray detector, Eiger2 S 500k (Dectris, Switzerland), was introduced as the WAXS detector during simultaneous SAXS/WAXS measurements instead of the conventional flat panel detector (C9728DK-10, Hamamatsu Photonics, maximum frame rate: 3 Hz). The details of the comparison of the flat panel sensor and the same photon-counting WAXS detector installed at BL40B2 were shown in the FY2018 annual report [1].

Table 1. Technical specifications of Eiger2 S 500K installed at BL40XU.

Sensor and its thickness	Si 0.45 mm
Pixel size (W × H)	0.075×0.075 mm^2
No. of pixels (W × H)	1030 × 514 pixels
Active area (W × H)	77.25×38.6 mm^2
Maximum frame rate	40 Hz
Energy range	5.4 to 18 keV
Dimensions (W×H×D)	100 mm × 140 mm × 92.4 mm
Weight	1.8 kg

Due to the lightweight and compact detector, we can place the detector in any location and orientation in simultaneous SWAXS measurements. Figure 1 shows one of the configurations in simultaneous SWAXS measurements for wide angle coverage in WAXS, the diffraction pattern of a cerium (IV) oxide (CeO_2) with a camera length of about 100 mm, and its profile for this configuration that covered the Q-range of 3.7 to 8.4 1/Å with an incident X-ray of 15 keV. The maximum frame rate is 40 Hz, which is expected to cover most of the soft-matter sample in the SWAXS measurement. However, in cases where measurements on the order of milliseconds or sub-milliseconds are required, we recommend the use of a standalone detector, an X-ray image intensifier [2] (V7739P, Hamamatsu Photonics, Japan), and a high-speed camera (AX200, Photron, Japan) with a limited Q-range.

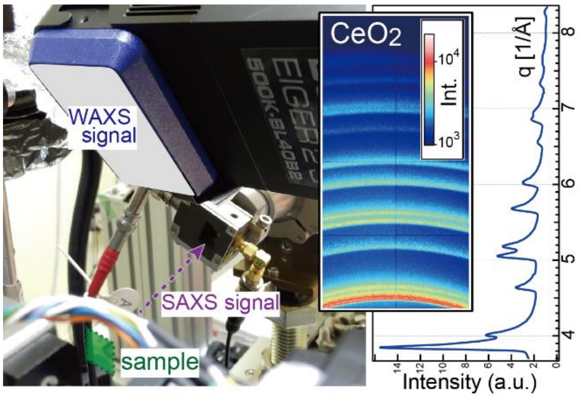

Fig. 1. WAXS detector, Eiger2 S 500K, installed at BL40XU in SAXS/WAXS simultaneous measurements. The inset figure and the figure on the right show the 2D-WAXS image obtained from the cerium (IV) oxide sample and its WAXS profile, respectively, using an incident X-ray of 15 keV. In this case, the WAXS profiles covered the Q-range of 3.7 to 8.4 1/Å.

In time-resolved measurements, optical triggering is effective for instantaneously changing the experimental conditions around the sample, and BL40XU has been using the permanently installed YAG: Nd laser (Surelite II-10, Continuum, CA) for this purpose (Fig. 2, top). However, since the output power has dropped to less than 70% of the catalog value, the system was modified at the request of the users. By replacing and repairing the principal components (Pockels cells and THG crystals) of the laser system, we were able to stabilize the operation at catalog values (measured values, 645 mJ (1064 nm), 282 mJ (532 nm), and 162 mJ (355 nm)). In addition, we updated the laser synchronization system with a digital delayed pulse generator (DG645, Stanford Research Systems) and/or a preset scaler (N-TM 105a, Technoland Co., Japan). The new system can be used for synchronization with our own and user-brought-in equipment. Figure 2 (bottom) shows an actual example of laser application in a sub-millisecond time-resolved WAXS measurement. The improved laser system is expected to be used for light-triggered experiments using caged compounds, etc.

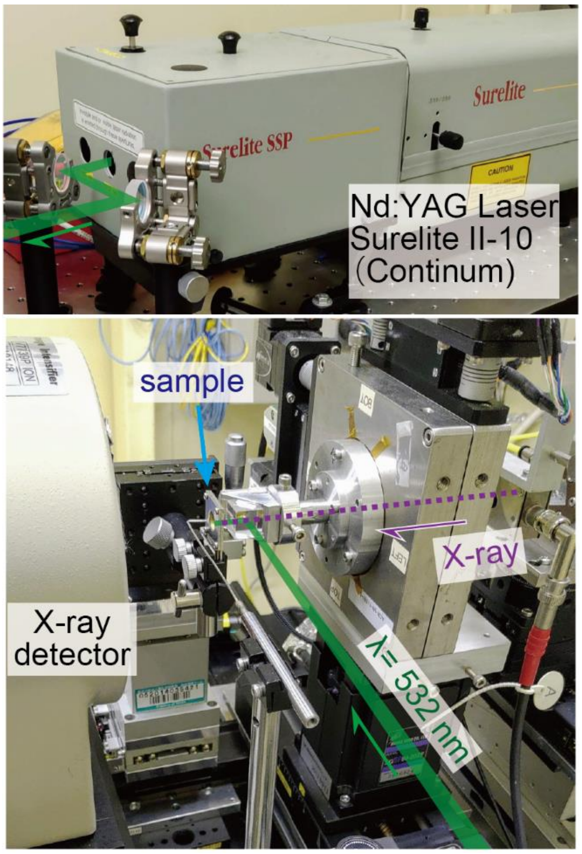

Fig. 2. Nd:YAG laser flash system in experimental hutch 1 (top) and its application to time-resolved WAXS measurement (bottom).

3. EH 2

EH 2 supports single-crystal X-ray diffraction, diffraction mapping using a focused beam, and time-resolved X-ray imaging experiment.

For single-crystal X-ray diffraction

measurement, low-temperature equipment is one of the essential tools to control the measurement condition. Cooling the crystal can suppress atomic vibration and enhance the diffraction intensity. In particular, diffraction spots at a higher angle are important for determining the crystal structure with high accuracy.

At BL40XU, the nitrogen-gas-flow-type low-temperature equipment is available. The measurement temperature can be set at 90 to 400 K. To maintain the temperature stability, the low temperature equipment was replaced in FY 2020.

Figure 3 is a picture of the new low-temperature equipment. The temperature range is almost the same as the previous one. The stability of the low-temperature region, however, is improved because of the new type of helium compressor.

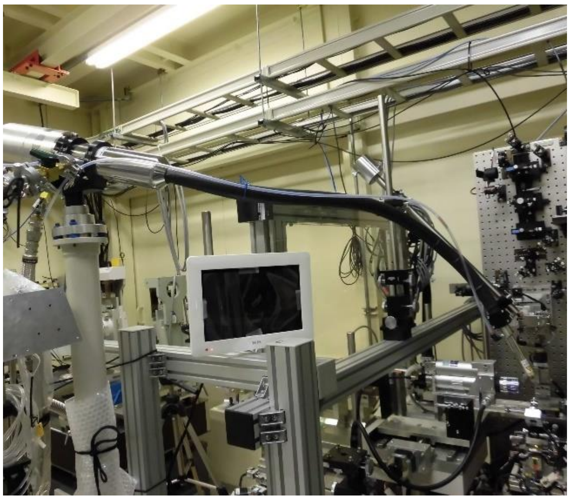

Fig. 3. Low-temperature equipment in EH 2.

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References:

[1] Ohta, N. & Sekiguchi H. (2019). *Spring-8/SACLA Annual Report FY2018*, 78–80.
[2] Yagi, N. & Aoyama K. (2015). *J. Instrum.* **10**, T01002.