BL40B2
(Structural Biology II)

BL40B2 has been dedicated to small-angle X-ray scattering (SAXS)-related techniques since 1999. Currently, the beamline offers SAXS, ultra-small angle X-ray scattering (USAXS), wide-angle X-ray scattering (WAXS), and SAXS/WAXS simultaneous measurements. A structural scale can be probed from 0.15 nm to 600 nm by changing the wavelength and sample-to-detector distance. In addition to the transmission geometry to the general structural analysis, the grazing incidence (GI) geometry is also used to analyze polymer thin films. The light source is a bending magnet, and the generated white X-ray beam is monochromized by a Si (111) double-crystal monochromator system. Since the chosen wavelength is 0.071 nm and 0.191 nm, the anomalous SAXS (ASAXS) method is also available. Therefore, BL40B2 is widely used in many fields, including studies of polymers and colloids as well as biomaterials. Here, we report the SAXS/WAXS simultaneous measurement method using Eiger2 S 500K, which is used as the WAXS detector.

1. Upgrade of the WAXS detector

The flat panel detector (FPD, C9728DK; Hamamatsu Photonics) was introduced in March 2007, and the electronic board (C9728DK-10) was replaced with DCAM-API [1] in 2010. The detector system is now used as a WAXS detector in SAXS/WAXS measurements. There are advantages to a 14.5-mm thickness, 1.7-mm length from the case edge to the active area, and 51.6 mm × 51.6 mm detection area. However, FPD is difficult to analyze at a low intensity due to the high, fluctuating dark current noise. Additionally, it has problems with a low frame rate (maximum 3 Hz) and a different delay in each pixel readout.

Eiger2 (Dectris) is an X-ray photon counting area detector without readout noise or dark current. The pixel size is 0.075 mm × 0.075 mm, and the detection area is 77.3 mm × 38.6 mm. The maximum frame rate is 40 Hz. Table 1 shows the specifications of Eiger2 S 500K-BL40B2.

Compared to Pilatus, Eiger2 S 500K has compact body size and is lightweight. It also does not require water-cooling or dry air. However, the 9.73-mm length from the case edge to the active area is longer than that of FPD, which creates a spatial limitation in the arrangement of the Eiger2 as WAXS.

Figure 1 shows the SAXS/WAXS simultaneous measurement system constructed at the beamline. Here, the tip of the SAXS-vacuum path has a tapered cone shape in accordance with the tilt angle of Eiger2. The two-dimensional X-ray sensor in front of the detector is tilted to place the direct beam and the active area of detector close together, reducing the gap where the SAXS and WAXS cannot be detected. On the other hand, when scattering is measured with a tilted detector, the CeO_2 Debye ring becomes elliptical (Fig. 2a) and the scattered image of glassy carbon tends to decrease in intensity from the top to the both ends (Fig. 2b). Since it is difficult to identify the raw tilt image, a geometric correction is applied to the acquired image (Fig. 2c and 2d). The Debye ring can be modified to a ring shape. The intensity in the azimuthal distribution of the glassy carbon can be corrected uniformly. Image correction is important

Table 1. Technical specifications of Eiger2 S 500K-BL40B2

Modules	1
Sensor	Reverse-biased silicon diode array
Sensor thickness	0.45 mm
Pixel size (W × H)	0.075 × 0.075 mm^2
Pixel array format (W × H)	1030 × 514 pixels
Active area (W × H)	77.25 × 38.6 mm^2
Maximum frame rata	40 Hz
Readout time	Zero dead time
Number of thresholds	2 (independent)
Adjustable threshold range	3.5 to 11 keV
Image bit depth	32 bit
Dimensions (W × H × D)	100 mm × 140 mm × 92.4 mm
Weight	1.8 kg
Maximum count rate	2 × 10^6 photons/s/pix
Energy range	5.4 to 18 keV

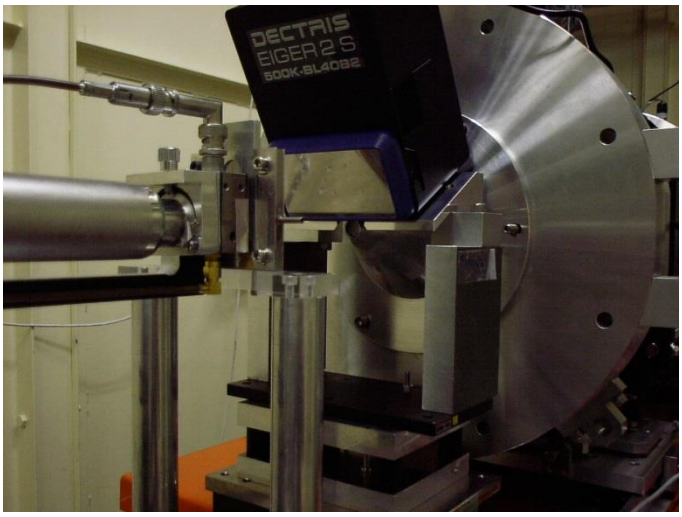

Fig. 1. SAXS/WAXS simultaneous measurement system at BL40B2. Eiger2 S 500K, which is used as a WAXS detector, is tilted at an angle of 30°. X-ray window of the SAXS vacuum path is under the detector. There is a Pilatus3 S 2M as a SAXS detector downstream of this path.

to promptly understand the widely spread scattering in the azimuth direction, especially in the horizontal and vertical directions. We hope that the SAXS/WAXS simultaneous measurement system of Eiger2 S 500K and Pilatus3 S 2M will be widely used.

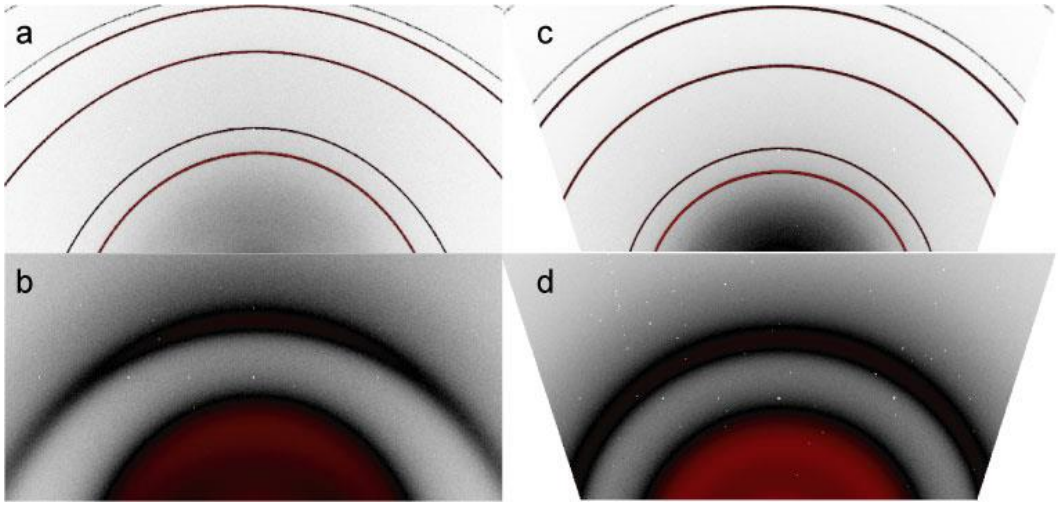

Fig. 2. WAXS images of (a) CeO_2 and (b) glassy carbon obtained using Eiger2 with X-ray energy of 12.4 keV. Normal direction of the beam corrected by the titled angle (c) in a and (d) in b.

2. Development of a detector control program for Eiger2

The Pilatus X-ray detector has a server system that inputs control commands via TCP/IP. On the other hand, the Eiger2 has a redesigned control function using the SIMPLON API [2] based on the HTTP/REST framework. We developed an Eiger2 control program for BL40B2 composed of program functions to rewrite the URL's value corresponding to each detector parameter. The program was completed by downloading HDF5 [3] data after the acquisition of scattering. If TIFF images are needed, automatic conversion from HDF5 to TIFF can also be selected.

3. Renovation of the air conditioner unit

Since the air conditioner unit of the experimental hutch was installed in 1999, we replaced it with a new one that is combined with spot cooling. It is useful for cooling because the temperature around the detector at the experimental hutch end is slightly higher.

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References:

[1] https://dcam-api.com
[2] SIMPLON 1.7 API Reference / User Manual of Eiger2 Detector Systems
[3] https://www.hdfgroup.org/solutions/hdf5