BL28B2
White Beam X-ray Diffraction

1. Introduction

BL28B2 is dedicated to multiple techniques using white beam in several fields. It is a bending magnet beamline that uses white X-rays from a bending magnet source without passing through any optical devices. Techniques include (1) X-ray diffraction, (2) dispersive-type time-resolved X-ray absorption fine structures (DXAFS), (3) microbeam radiation therapy (MRT), and (4) X-ray imaging. The beamline supports various experiments such as fundamental research for radiation therapy, evaluation of structure materials using white X-ray diffraction imaging, observation of dynamic structural changes during chemical reaction processes in catalysis and fuel-cell batteries using DXAFS, and three-dimensional observations of metallic objects and fossils using high-energy X-ray microtomography. To improve measurement techniques using this beamline, research and development of experimental techniques and instruments were conducted in FY2020. This report describes the main activities.

2. Beamline upgrades

2-1. Diffraction

The absorber and shutter were relocated from optics hutch 2 to optics hutch 1 in order to reduce scattered X-rays from these devices and to reduce the vibration transmitted to the sample during shutter operation. Figure 1 shows a photograph of the absorber and shutter at optics hutch 1. The absorber device has eight windows with a size of 60 mm × 15 mm on an aluminum disk with a diameter of 200 mm. Table 1 shows the metal foils and plates attached to the window. On the blank window, an additional metal foil is attached depending on the experiment. Three absorber devices are prepared as shown in Fig. 1.

The shutter operates with compressed air and can open at a minimum of 100 ms or less. The shutter plate is 15-mm-thick lead. These devices are air-cooled by fans.

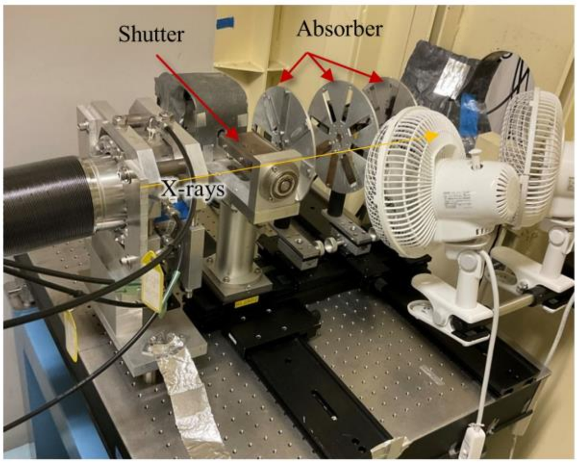

Fig. 1. Photograph of absorber and shutter at optics hutch 1.

Table 1 Absorber foils and plates.

Window / Absorber	0	1	2	3	4	5	6	7
1			Al 1.0mm	Al 2.0mm	Al 4.0mm	Al 8.0mm		
2			Cu 1.0mm	Cu 2.0mm				
3			Fe 1.2mm	Fe 2.4mm	W 0.1mm	W 0.2mm	W 0.4mm	W 0.8mm

2-2. DXAFS

With the higher-harmonics reduction mirror used in DXAFS, a mirror retracting mechanism was introduced in FY2019, allowing the use of white X-ray beams and X-rays reflected by an upstream multilayer mirror [1]. However, the heights of the mirror chamber and beryllium (Be) window had to be adjusted independently because the movable range of the Be window had to be larger than that of the mirror chamber to allow those beams to pass to the downstream hutch.

In FY2020, these height adjustment mechanisms were improved, as shown in Fig. 2. A stepping motor was attached to the mechanism that moves the entire mirror chamber, and the Be window was installed on the motorized stage with the adjustment mechanism in the height direction. Consequently, the position adjustment of the mirror and Be window can be performed simultaneously and smoothly while emitting the X-ray beam.

In addition, the bellows that connect the mirror chamber and Be window were replaced with welded bellows. This replacement achieved a reduction in distance between the mirror chamber and the Be window while maintaining the required movable range of the Be window, allowing scatterers such as absorbers to be installed downstream of the Be window as shown in Fig. 1.

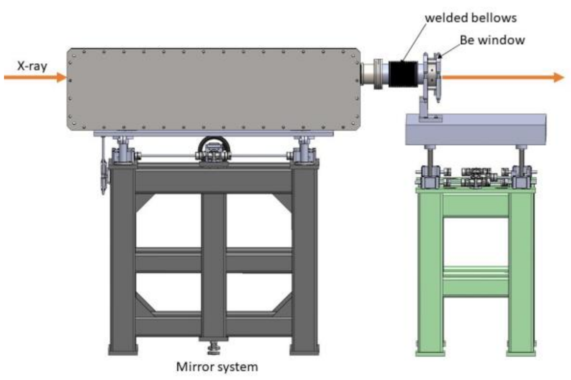

Fig. 2. Higher harmonics reduction mirror system and Be window with the height adjustment mechanism.

2-3. High-energy X-ray microtomography

High-energy X-ray microtomography using white X-rays has a considerable advantage for observing metallic objects in terms of its high penetration power. A simple heavy metal absorber makes it possible to use high-energy white X-rays with a peak energy of around 200 keV [2]. In this energy region, therefore, a thick and heavy metal is required to completely stop the high-energy X-rays. In X-ray microtomographic measurements, so-called dark images without any input signals are required to correct background signals on the digital camera used as part of a visible-light conversion-type X-ray imaging detector. In the previous measurement, a main beam shutter (MBS) in the beamline was used to obtain dark images during the measurement. Although the MBS completely shut the X-rays down, it requires some time to open and close it. In addition, access to the beamline workstation is required to operate the MBS remotely. To overcome this problem, a small and simple shutter for high-energy X-ray microtomography was developed. The concept is as follows: an absorbing material in the shutter can stop the incident high-energy X-rays and it should be able to be operated easily and quickly. A schematic drawing of the shutter is shown in Fig. 3(a). Tungsten blades of 20 mm thickness were attached to both sides of an aluminum frame. Under the closed condition, the total thickness of the tungsten blades is 40 mm. Therefore, high-energy X-rays with a peak energy of 200 keV can be stopped by these tungsten blades. The external view of the assembled shutter is shown in Fig. 3(b). Under the opened condition, an effective aperture size of 50 mm (H) × 4 mm (V) can be obtained. To operate this heavy shutter, a rotary solenoid (RSR20/20-CAB0, Takano Co., Ltd.) with a high torque performance was used. By using a dedicated control board, it can be easily operated by means of an external trigger. To evaluate the speed of opening and closing of this shutter, a moving process was observed with a high-speed camera (FASTCAM Nova S12, Photron). The opening took 79 ms, whereas the closing took 70 ms. Therefore, the shutter could be operated within 80 ms for both opening and closing processes. This is useful to incorporate acquisition processes of dark images into a tomographic measurement. In addition, software for the remote operation of the shutter was also developed. In actual use, this shutter is set just downstream of a rotating absorber, which is used to extract high-energy white X-rays with a peak energy of around 200 keV. Since the rotating absorber absorbs the heat load of white X-rays, there is no need to cool the shutter itself while air cooling is required for the rotating absorber. A set of rotating absorber and shutter can also be installed at optics hutch 1 as well as other absorbers as shown in Fig. 1.

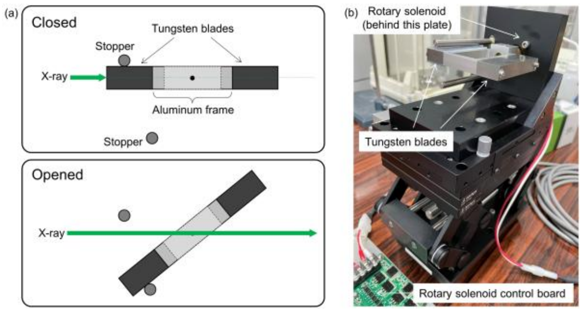

Fig. 3. (a) Schematic of the concept of the shutter under closed and opened conditions. (b) Exterior view of the assembled shutter.

Masato Hoshino*1, Kentaro Kajiwara*2, Kazuo Kato*1 and Masahiro Yasutake*1

*1 Spectroscopy and Imaging Division, Center for Synchrotron Radiation Research, JASRI

*2 Diffraction and Scattering Division, Industrial Application Division, Center for Synchrotron Radiation Research, JASRI

References:

[1] Hoshino, M. Umetani, K. Kato, K. & Kajiwara, K. (2020). *SPring-8/SACLA Annual Report FY2019*, 55–58.

[2] Hoshino, M. Uesugi, K. Shikaku, R. & Yagi, N. (2017). *AIP Adv.* **7**, 105122.