BL04B1
High Temperature and High Pressure Research

1. Introduction

BL04B1 is a bending magnet beamline, where energy-dispersive X-ray diffraction measurements and X-ray radiography observations using white X-rays are available. The X-rays emitted from the bending magnet are directly introduced into the experimental hutch, and white X-rays with a wide energy range up to 145 keV are utilized in measurements. The beamline is also equipped with a compact Si(111) double-crystal monochromator, which makes it possible to perform angle-dispersive X-ray diffraction measurements and X-ray radiographic observations using monochromatic X-rays with the photon energy between 30 and 60 keV. These high-energy X-rays allow us to conduct X-ray observations for samples surrounded totally by materials such as high-pressure vessels.

The beamline has two experimental hutches in tandem, and a large-volume press with a maximum load of 1500 tons is installed in each hutch. These large-volume presses make it possible to carry out high-pressure and high-temperature experiments. The SPEED-1500 Kawai-type high-pressure press (DIA-type press, upstream hutch) and the SPEED-Mk.II Kawai-type high-pressure press (D-DIA–type press, downstream hutch) are installed. The SPEED-Mk.II has differential rams (D-RAM) inside, which move independently of the main ram, and we can conduct deformation experiments under high-pressure and high-temperature conditions. By utilizing the large-volume presses with high-energy X-rays, one can routinely carry out in situ observations of materials under high-pressure and high-temperature conditions up to 100 GPa and 2500 K in the beamline.

2. Remote system for high-pressure control interface in SPEED-Mk.II press

The COVID-19 pandemic has restricted users' long-haul travel, often making it difficult for them to come to SPring-8 to conduct experiments over the past few years. Because of this situation, many beamlines at SPring-8 have been developing remote

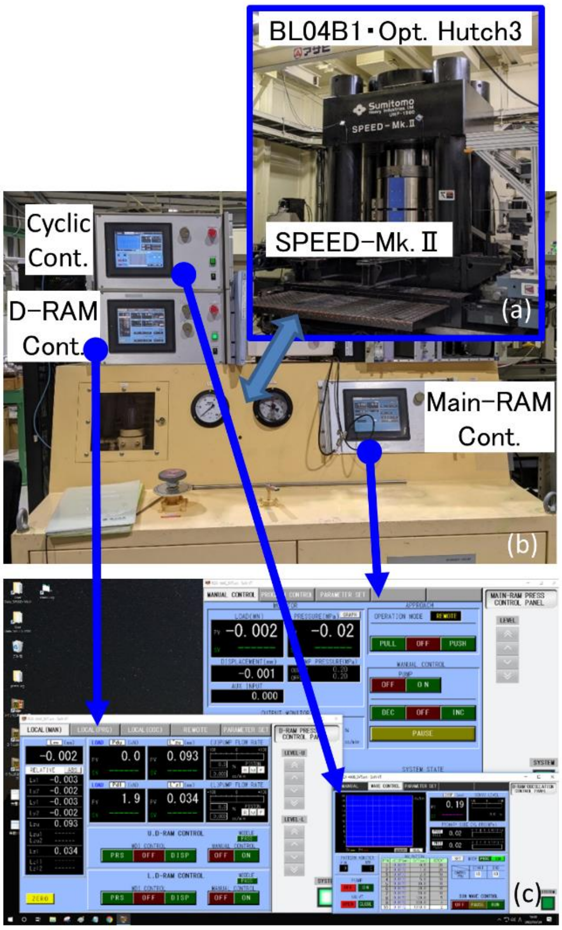

Fig. 1. (a) Large-volume SPEED-Mk.II press, (b) oil pressure control system, and (c) remote control software.

experimental setups, and we have been considering the development of such an R&D infrastructure for high-pressure experiments at BL04B1. In SPEED-Mk.II at BL04B1, the press and optical stage system, measurement system, heating system, and so forth are controlled by a PC, so they can be operated remotely using a remote desktop application. However, only the oil hydraulic control system for large presses has an independent control system, so it has been impossible to make it online. Therefore, the control software of the oil hydraulic control system was updated to support remote operation.

A communication unit was added to the existing PLC, and new control software was developed for the PC. Figure 1 shows an overview of this control software and the existing control unit, enabling control from a PC instead of the existing touch panel. This development has made it possible to develop the infrastructure for the remote operation of high-pressure experiments. In the future, we will implement safety measures related to communication and control and establish the rules for the operation. We realize the remote operation of high-temperature and high-pressure experiments, which was considered to be relatively difficult.

3. Water-cooling four-blade incident slit

The incidence slit of Optical Hutch 2 in BL04B1 had been used for about 10 years, and the stage was malfunctioning due to rust, and water leakage accidents were frequently occurring due to the aging of cooling hoses and connectors. This incident slit is located at the most upstream part of the experimental hutch and is in a harsh environment exposed to the heat load from white X-rays and ozone gas generated by X-rays. The incidence slit was renewed because it was already difficult to repair. The slits have been changed from a thrust-type slit to four-plate slits, eliminating the possibility of slit-to-slit collisions and enabling the faster opening and closing of slits. Figure 2 shows the slit introduced in this study. It is possible to control the motor independently for each blade, and all the blades could be controlled simultaneously to significantly reduce the slit opening and closing time. However, X-ray damage to the linear scale is still occurring, and we will improve the X-ray shielding in the future.

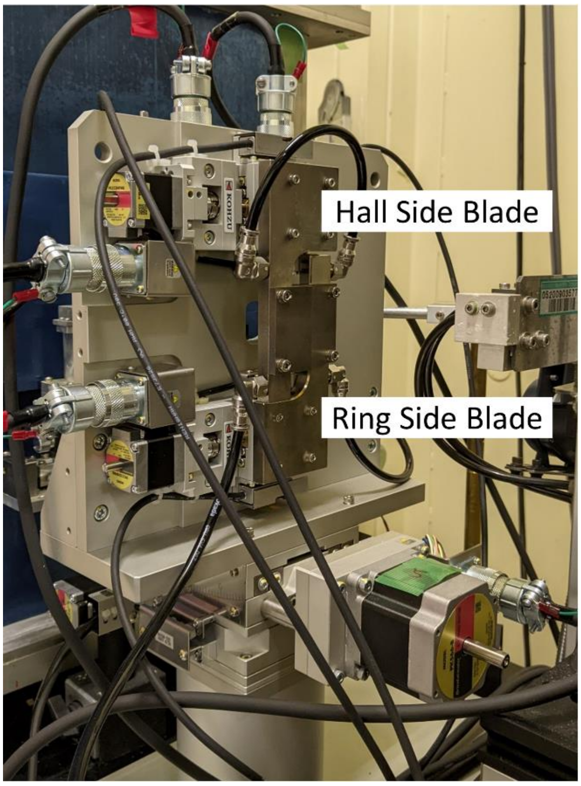

Fig. 2. Water-cooling four blade incident slit installed in the BL04B1.

4. Rotary high-speed slit

High-speed time-resolved measurement techniques for X-ray diffraction and X-ray absorption imaging in seconds to milliseconds are needed in high-pressure experiments to understand earth dynamics phenomena such as earthquakes and volcanic (magma) activity. In deformation experiments under deviatoric stress, the simultaneous measurement of macroscopic strain from X-ray absorption images and microscopic stress from X-ray diffraction is particularly important, requiring rapid changes in incident X-ray beam size.

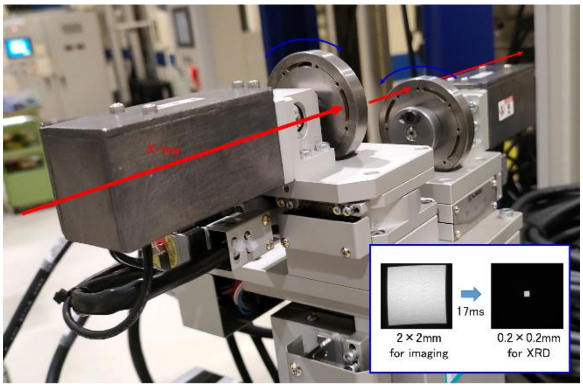

Fig. 3. Rotary high-speed slit.

This rotating slit can switch between a large-area X-ray beam for X-ray imaging and a narrow X-ray beam for X-ray diffraction using two rotating disks with large and small slits (Fig. 3). The rotational speed of this rotating slit is up to 2160 rpm, and each blade has four symmetrical slits that can switch slit widths in a short period of time up to about 144 Hz (6.9 ms). In the future, synchronization with the measuring instrument will be established to realize high-speed automatic measurement.

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