BL04B1
High Temperature and High Pressure Research

1. Introduction

BL04B1 is designed for high-temperature and high-pressure experiments using a large-volume press and is mainly used in earth and planetary science and the synthesis of new materials. BL04B1 operates as a bending magnet beamline and offers the capability to conduct energy-dispersive X-ray diffraction measurements and X-ray radiography observations using white X-rays. The X-rays emitted from the bending magnet are directly introduced into the experimental hutch. White X-rays with a wide energy range of up to 145 keV are utilized in measurements. This 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 completely by materials such as in high-pressure vessels.

This beamline has two optical hutches operated in tandem. 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 with DIA-type guide blocks is installed in the upstream hutch, while the SPEED-Mk.II Kawai-type high-pressure press with D-DIA–type and D-111-type guide blocks is installed in the downstream hutch. 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 large-volume presses with high-energy X-rays, we can routinely carry out the in situ observations of materials under high-pressure and high-temperature conditions of up to 100 GPa and 2500 K in the beamline.

In FY2024, we focused on improving the sound velocity measurement system and the oil control system for the differential ram.

2. Optical hutch 2 (SPEED-1500): Improvement of sound velocity measurement system

In the ultrasonic measurement system using the SPEED-1500 press, the ultrasonic transducer attached to the secondary anvil sometimes experienced weakened signals under high-temperature and high-pressure conditions—particularly at high temperatures—due to detachment from the secondary anvil or the performance degradation of the transducer caused by heat. To address these issues, in FY2024 we introduced a cooling system using compressed air, as shown in Fig. 1 for both the $LiNbO_3$ ultrasonic

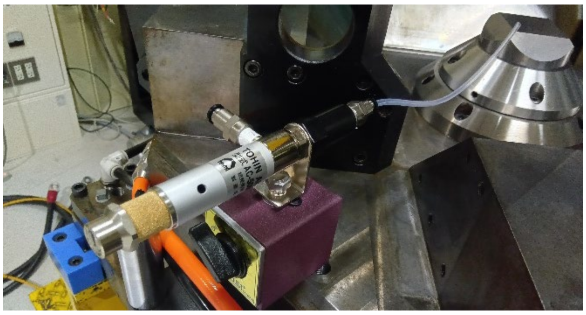

Fig. 1. Newly installed cooling system for the ultrasonic transducer with second anvils at optical hutch 2.

transducer and the bonded secondary anvil. With this improvement, the signal intensity at 1300 K has been increased up to 1.5 times for P-waves and 2.5 times for S-waves. Therefore, more stable measurements are expected in future experiments, particularly under even higher temperature conditions.

3. Optical hutch 3 (SPEED-Mk.II): Improvement of oil control system for differential ram

The SPEED-Mk.II press is frequently used for deformation experiments with D-DIA guide blocks and differential rams, as well as with D-111–type guide blocks. In these experiments, the hydraulic system for the D-ram requires that the plunger pump be retracted or advanced to a specific position before the next experiment. Previously, this adjustment was performed manually, resulting in frequent contact with the end sensor, which often caused the hydraulic system to shut down. In FY2024, the system was upgraded so that the intermediate position sensor of the plunger pump can be set to any desired position, allowing the pump to stop at that point. This enables the smooth resetting of the plunger pump before experiments.

Previously, the D-ram hydraulic controller could not be operated via external commands, and the set value had to be manually changed each time the D-ram displacement speed was changed. In this upgrade, we added the “REMOTE” tab with an external command control function, as shown in Fig. 2, allowing target values to be set remotely. A new press monitoring software program compatible with external command control in Fig. 3 has also been developed, enabling deformation experiments at arbitrary speeds.

Moreover, an external command control functionality was also added to the main hydraulic ram in this upgrade. In the future, improvements to the external control software will enable more advanced hydraulic system control.

Fig. 2. Newly developed hydraulic control system with external command control function (REMOTE tab) at optical hutch.

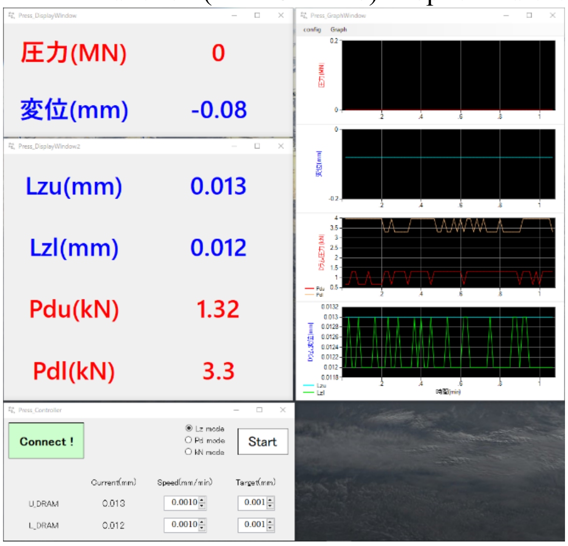

Fig. 3. Newly developed hydraulic pressure monitoring software with external control function at optical hutch 3.

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