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 140 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 series, 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 30 GPa and 2000 K in the beamline.

2. Update of the driving system of SPEED- Mk.II

Almost 20 years have passed since the installation of the large-volume high-pressure press SPEED-Mk.II, and there have been frequent failures in the control system of the press stage. For example, the control touch panel broke down in 2019, the electromagnetic brake power supply broke down in the same year, and the linear scale broke down in 2020. In addition, in many cases, the replacement parts for these devices have already been discontinued and there are no successors available. Therefore, in order to continue using the SPEED-Mk.II in the future, the control system must be completely updated to current products.

In this update, we worked with the RIKEN engineering team to explore alternatives and proceeded with the update step by step. In the final stage, we replaced the servo amplifier controller (6 axes), electromagnetic brake (4 axes), linear scale (6 axes), and control touch panel. We will continue to update the programmable logic controller to make the system usable for the next 20 years.

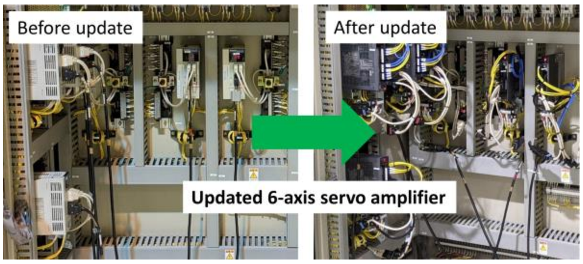

Fig. 1. Servo amplifier controller before and after update (6 axes).

3. Installation of new chain block & D111 guide block in SPEED- Mk.II experimental hatch

The in situ observation of deformation under high pressure and high temperature using high-brilliance X-rays at BL04B1 has been carried out to quantitatively understand the flow characteristics of deep Earth materials at the Earth's mantle and inner core. However, the upper limit of the pressure generated by the D-DIA-type guide block is limited at less than 20 GPa. The D-DIA-type guide block, which is usually used in single-stage pressurization, was combined with a Kawai-type cell and used in a two-stage apparatus for deformation experiments at about 24 GPa, but in this case, it was difficult to control the deformation geometry accurately.

In order to address this situation, it was considered to combine the existing SPEED-Mk.II press with D111-type guide blocks to form a D111-type system. The development and introduction of the D111-type guide block were led by Dr. Nishihara of Ehime University, and the exchange method between the D-DIA-type guide block and the D111-type guide block was discussed by the facility side. Since the weight of the guide block reaches about 700 kg, the existing overhead crane (rated load: 490 kg) cannot be used. Therefore, a new chain block with a rated load of 1000 kg and a support frame were newly installed. The D111-type device is a larger version of DT-Cup, a high-pressure deformation experimental device developed by Hunt et al. 2014 [1]. The name of the device, "D111", comes from the initial letters of the word "deformation" and the fact that the direction of compression and deformation is "111". In this device, the opposing upper and lower second-stage anvils of the 111-Kawai-type multi-anvil device are driven independently by hydraulic pistons to achieve well-controlled deformation experiments under high pressures.

This type of device has been installed in several research institutes in Japan over the past few years, but this one is not only the largest in size, but can also generate the highest load, 10 MN for the main ram and 4.6 MN for the differential ram. It has already been shown that the D111 apparatus can perform deformation experiments up to about 30 GPa, which is much higher than the upper pressure limit of the D-DIA apparatus, and the newly

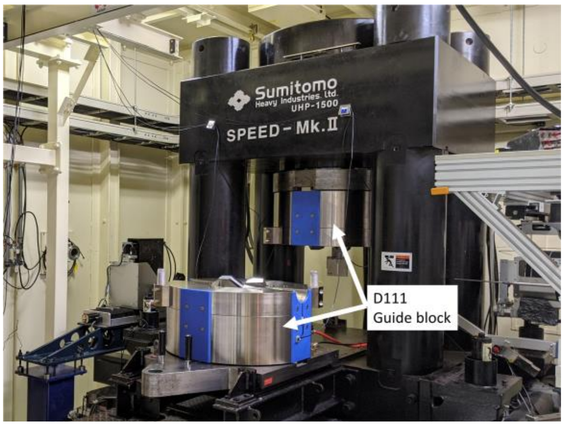

Fig. 2. D111 guide block installed on the SPEED-Mk.II.

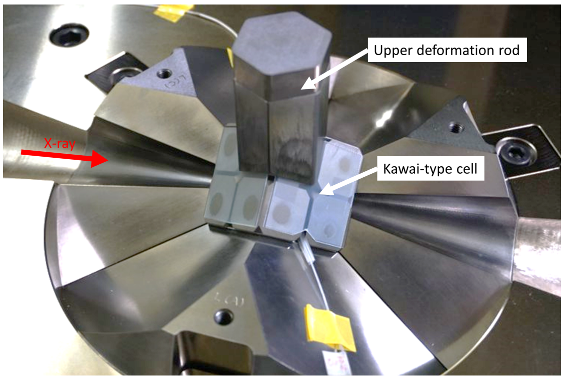

Fig. 3. The Kawai cell is placed on the D111 guide block, and the hexagonal metal column is the upper deformation rod.

introduced guide block will make it possible to perform such high-pressure experiments in combination with the high-brilliance X-rays of SPring-8 for the first time.

Yuji Higo[*1], Yoshinori Tange[*1], and Michitaka Takemoto[*2]

[*1] High-pressure Materials Structure Team, Diffraction and Scattering Group I, Diffraction and Scattering Division, Center for Synchrotron Radiation Research, JASRI

[*2] Engineering Support Group, Center for Synchrotron Radiation Research, JASRI

Reference:

[1] S.A. Hunt et al. (2014). *Review of Scientific Instruments* **85**, 085103.