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Technical Development of a Cell Assembly for High-P&T Neutron Experiments using a Cubic Anvil Apparatus at the J-PARC

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A DIA-type cubic anvil apparatus with a maximum load of 1500 tonf is planned to be installed at the high-pressure neutron beamline PLANET (BL11) of J-PARC for neutron experiments under high pressure and high temperature. In the neutron experiments with the DIA-type apparatus, diffracted and transmitted neutron beams will pass through anvil gaps and will be detected using a couple of detectors with 90-degree geometry and an imaging device for in situ neutron diffraction and radiograph measurements, respectively. A multi-anvil 6-6 (MA 6-6) assembly is scheduled to be adopted as a compression system for the neutron experiments with the DIA-type apparatus at the PLANET because the MA 6-6 assembly has several merits comparing to a traditional single-stage cubic anvil system; such as a good compatibility with the optical system for the neutron diffraction and radiograph measurements, quick replacement of the anvil assembly activated by neutrons, precise anvil alignment of anvils, simple process of anvil replacement and low running cost.
In the J-PARC project with the DIA-type apparatus, target P-T conditions to generate as a first step are 10 GPa and 1500 K (15 GPa and 2000 K in near future) to understand behavior of hydrogen in minerals and magma at P-T conditions of the upper mantle. The P-T conditions are required to be generated with beam fluxes of diffracted and transmitted neutron as high as possible in order to reduce measurement time. The MA 6-6 assembly should be optimized for the neutron experiment because the present MA 6-6 assembly was designed for synchrotron X-ray experiments and requirements for cell materials is different between in-situ neutron and X-ray experiments. We discussed strategy about technical development of the MA 6-6 cell assembly for the neutron experiment with project members of the Japan Atomic Energy Agency, and made the following plans. First, the following materials will be tested as parts of the assembly; tungsten carbide with Ni binder (MF10, Fuji Die) and semi-sintered ZrO_2(OZ-8C, Mino Ceramic) for the anvil and the pressure medium, respectively. Second, a truncated edge length of the anvil will be increased from 5 mm to 10 mm to increase sample volume. Third, surface area of a bottom of a second-stage anvil will be enlarged to increase applicable press load from 400 tonf to 1500 tonf. Forth, the anvil gap will be increased adopting hard gaskets, and grooves on anvil surfaces along the beam paths will be tested in order to increase the neutron beam fluxes to the detectors. Recently, the semi-sintered $ZrO_2$was tested as a pressure medium using a cubic anvil apparatus MADONNA-1500 and the MA 6-6 assembly with WC anvils with a truncated edge length of 3.0 mm. In the test experiments, sample pressure was successfully generated to 14 GPa at room temperature. We will introduce further progress for the development of the cell assembly.

Keywords: J-PARC, PLANET, neutron, high pressure, cubic anvil apparatus, multi-anvil 6-6 assembly