BL05XU
R&D-ID

1. Introduction

BL05XU has two optical hutches, OH1 and OH2, and an experimental hutch (EH). In OH1, a double multilayer monochromator (DMM) and basic optical components such as diamond beam monitors have been installed and tested under high-heat-load conditions. In OH2, an atmospheric section called a high-energy test bench has been positioned upstream of a double-crystal monochromator (DCM) for conducting pilot experiments with a high-energy high-flux beam from DMM. In EH, small-angle scattering (SAXS) and wide-angle diffraction (WAXD) measurements have been performed with monochromatic X-rays from DCM.

2. Recent activities

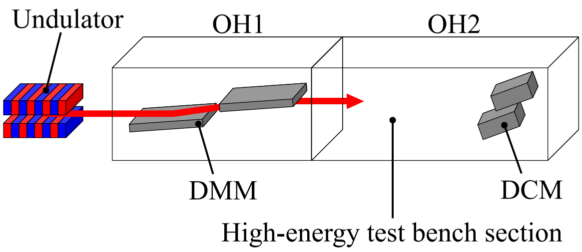

Fig. 1. Schematic of OH1 and OH2 at BL05XU.

In FY2020, we obtained a 100-keV beam with a flux of 1.3×10^{13} photons/s at the high-energy test bench section (Fig. 1). The high flux is achieved by using DMM designed to provide a 100-keV beam with a wide energy bandwidth of 1.0%. After the achievement of the so-called high-energy pink beam, we prepared experimental setups for pilot applications in which the high-energy pink beam is essential.

In FY2022, we constructed an apparatus for pair distribution function (PDF) measurements of liquids and glasses at the high-energy test bench section. PDF measurements of liquids and glasses particularly require high-flux X-rays rather than a high energy resolution. In addition, the 100-keV pink beam enables PDF measurements with a two times wider range of momentum transfer Q up to ~20 $Å^{-1}$ than that with an abundant photon energy of < 50 keV. The apparatus is based on a single-axis diffractometer with highly collimated double slits and point detectors (Fig. 2). The low and high 2θ angle ranges are covered by a CdTe point detector (Amptek) and a Ge point detector (Canberra).

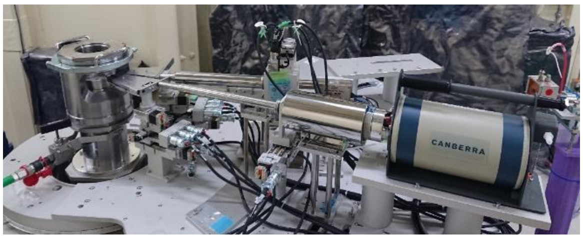

Fig. 2. Photograph of the *in situ* high-pressure PDF measurement apparatus at the high-energy test bench section.

PDF measurements of liquids and glasses under high-pressure and/or high-temperature conditions are in great demand. We have accomplished *in situ* high-pressure high-temperature PDF measurements by combining a Paris–Edinburgh (PE) cell into the apparatus. The PE cell enables high-pressure and high-temperature experiments up to ~7 GPa and ~2,000 ˚C for a sample of 1.2 mm diameter and 1.5 mm height. Figure 3 shows the measurement time dependence of the Faber–Ziman structure factor S(Q) of SiO_2 glass at 1.1 GPa. The structure factor of SiO_2 glass with a Q range up to ~20 $Å^{-1}$ under a high pressure of more than 1 GPa was successfully obtained with measurement times of 30–60 min.

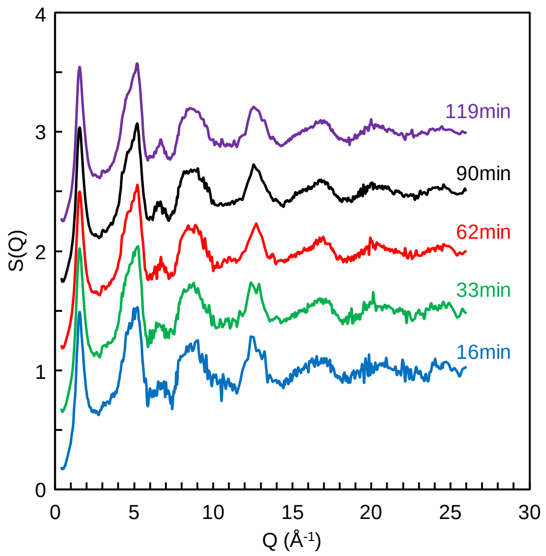

Fig. 3. Structure factor S(Q) of SiO_2 glass at 1.1 GPa with measurement times of 16, 33, 62, 90, and 119 min.

The structural origin of the anomalous properties of SiO_2 glass is of great interest in not only physics and chemistry but also geophysics. We found experimental evidence of a bimodal behavior in the translational order of silicon's second shell in SiO_2 glass under pressure [1]. SiO_2 glass showed a tetrahedral symmetry structure with separation between the first and second shells of silicon at low pressures, which corresponds to an S state structure reported in SiO_2 liquid. On the other hand, silicon's second shell collapsed onto the first shell at high pressures, and more silicon atoms were located in the first shell. These observations indicate the breaking of local tetrahedral symmetry in SiO_2 glass under pressure as well as in SiO_2 liquid.

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Reference:

[1] Kono, Y. et al., (2022). *Nat. Commun.* **13**, 2292.