Upgrade of High Pressure Research Beamline BL10XU

Beamline **BL10XU** was one of the first public beamlines built at SPring-8, which was opened in 1997. It was designed for both high-pressure X-ray diffraction and high brilliance XAFS studies. In 2003, BL10XU was dedicated to high-pressure research using a diamond anvil cell (DAC). High-pressure X-ray diffraction experiments require high photon flux at high X-ray energies because of the limited opening angle for X-ray scattering and the high absorption by the diamond windows of the DAC. Moreover, a very intense and highly focused X-ray beam is indispensable for *in situ* X-ray diffraction experiments under extreme pressure-temperature conditions because of the very small sample size, typically 20 μm or smaller at multi-megabar pressures (> 200 GPa). Therefore, we proposed the optimization of a state-of-the-art high-pressure facility, and have upgraded the undulator and X-ray optics of BL10XU to make full use of the higher power and brilliance of SPring-8 and enhance high-pressure experiments with DAC techniques.

The X-ray source of beamline BL10XU was originally a SPring-8-standard 4.5-m-long in-vacuum X-ray undulator (32 mm periodic length and 140 periods) [1]. In summer 2007, the insertion device at BL10XU was exchanged for the in-vacuum X-ray hybrid undulator (24 mm and 186 period) installed at BL46XU in order to strongly enhance the flux in the 20-60 keV range, which is critical for high-pressure diffraction experiments (Fig. 1). The undulator upgrade included modifications to the existing front-end components.

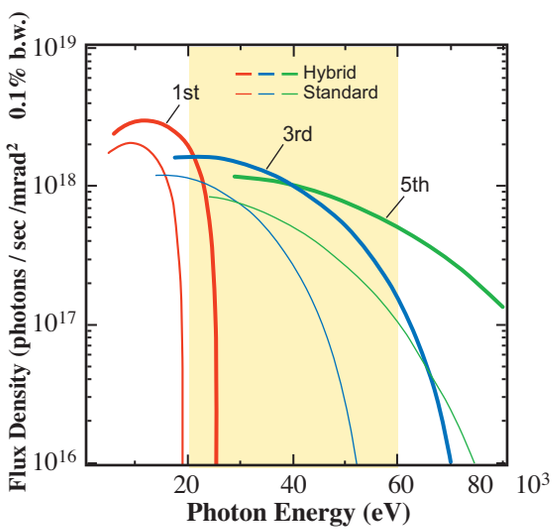

Fig. 1. Energy spectra of the on-axis flux density for standard and hybrid undulators at BL10XU. The spectra are calculated with SPECTRA [4].

The layout of the beamline BL10XU is shown in Fig. 2. The main X-ray optics components are the SPring-8-standard double-crystal monochromator

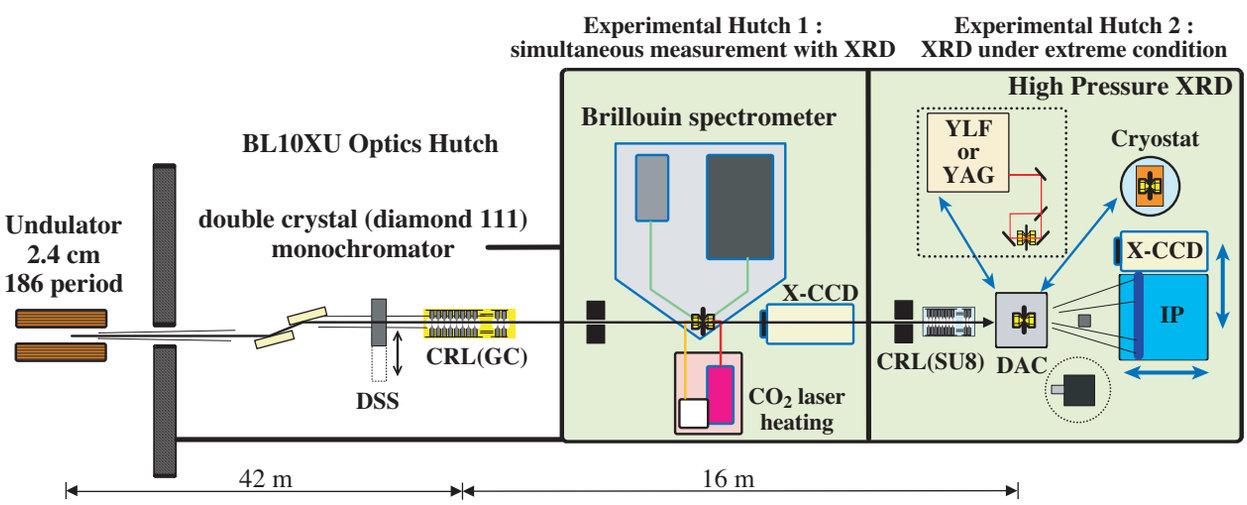

Fig. 2. Schematic layout of beamline BL10XU.

(DCM) located in the optics hutch 37.6 m from the source and an X-ray focusing lens in the optics and experimental hutches. The silicon 111 DCM had been previously operated in rotated-inclined geometry with pin-post cooling by water. To upgrade the beamline, a synthetic single-crystal diamond 111 DCM with indirect water-cooling was installed in 2006 [2]. The tunable photon energy now ranges from 8 to 58 keV using the diamond 111 reflection, in contrast with from 6 to 38 keV for the previous silicon 111 DCM.

X-ray focusing optics at high X-ray energies is essential in high-pressure experiments. At BL10XU, two types of new parabolic compound refractive lens (CRL) were installed in the upgrade. The upstream CRL is made from glassy carbon (GC) and is placed in the optics hutch at a distance of 42 m from the source. The GC-CRL is used as an X-ray collimating and/or focusing device for the high-energy beam (15-60 keV), resulting in photon density enhancement without increasing divergence of the X-ray beam due to its long focal distance (16 m). Another CRL made from SU-8 polymer [3] is installed in the experimental hutch 2 at a distance of 57.5 m from the source. The X-ray beam after passing through the DCM is collimated by the GC-CRL and is then focused to 10 μm by the SU-8 CRL. These upgrades of the undulator and X-ray optics at BL10XU allow us to collect high-quality X-ray diffraction data on materials subjected to extreme pressure of up to 400 GPa, corresponding to the conditions found at the center of our planet.

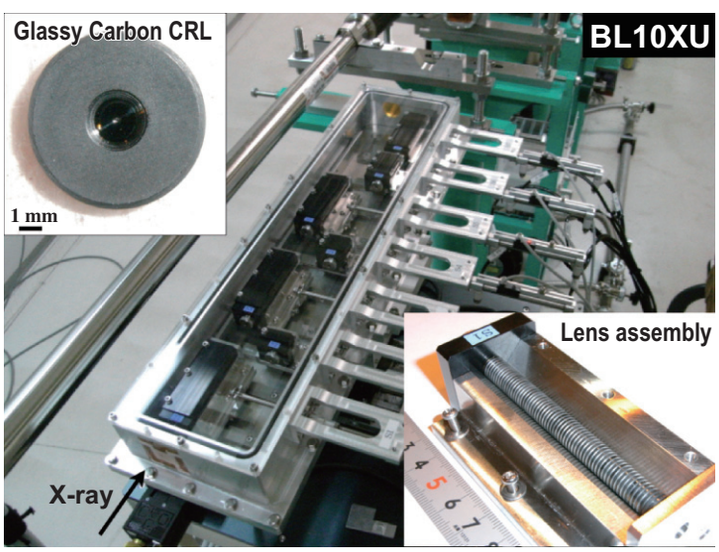

Fig. 3. Photographs of GC-CRL, lens assembly, and CRL device.

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References

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