Extremely Dense State Research (BL10XU)

1. Outline

The BL10XU beamline has an optical hatch and tandem experimental stations, high brilliance X-ray absorption fine structure (XAFS) station, and high pressure station. As a photon source, a standard in-vacuum type undulator was mounted at the low-β section in the SPring-8 storage ring; a high brilliance and quasi-monochromatized synchrotron radiation (SR) beam with a selective energy above 6 keV can be obtained by the undulator gap control. The performance of this light source is summarized in Table 1. In the optical hatch, the SR from the undulator was monochromatized by a Si(111) double crystal equipped in SPring-8 standard monochromator. A higher order harmonics light can be eliminated by a rhodium coated double mirror installed just before the experimental stations. This mirror was mainly used for XAFS experiments at a low energy region (< ~15 keV).

The high brilliance XAFS station aims for XAFS measurements of diluted systems such as surfaces, interfaces, and photo induced processes. In the high pressure station, it is possible to perform powder X-ray diffraction under high pressures up to 300 GPa generated by a diamond anvil cell (DAC). The activities of the instrumental constructions in these stations are described below.

2. High Brilliance XAFS Station

In the high brilliance XAFS station, a fluorescence-XAFS system with a Huber goniometer was installed. It has a cryostat system that can control the sample temperature between room temperature and ~ 15 K. One of the advantages of this system is that the polarization-dependence of XAFS can be easily obtained by changing of the azimuthal rotation angle while keeping the sample in the cryostat. For the measurements of the X-ray fluorescence from the sample, a 7-element Si (Li) detector and a data acquisition system were installed. The development of a 100-element monolithic Ge detector is the next to make this system more sophisticated. The combination of a high brilliance undulator beam and these multi-element detectors allows us to measure the XAFS spectra of very diluted atoms. The data processing for energy dispersive analysis and photon counting is performed by digital signal processors system (DXP, X-ray Instrum. Assoc.).

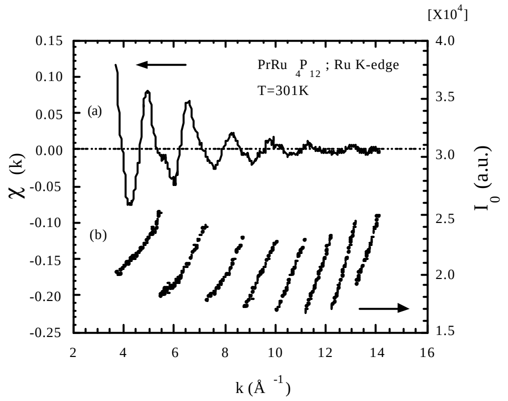

Fig. 1. (a) XAFS spectrum and (b) incident SR beam intensity for quasi-synchronized gap control.

Since the quasi-monochromatized SR is obtained by the undulator, it is necessary to synchronize gap control with a monochromator energy scan for XAFS measurements. Prior to the complete synchronization of undulator gap values at all data acquisition points, we perform quasi-synchronized gap control, in which the gap width is optimized once every set of several data points [1]. Figure 1 shows an example of the XAFS spectrum using the quasi-synchronized gap control. Figures 1 (a) and (b) indicate the Ru *K*-edge XAFS for $PrRu_4P_{12}$ and the incident SR beam intensity, respectively. Although discontinuous SR intensity is obtained by occasional gap control (Fig. 1 (b)), XAFS measurement could be made without a glitch (Fig. 1 (a)), indicating that the cancellation of intensity fluctuation is completely achieved in this system.

Table 1. Photon source specifications

Type	In-vacuum undulator
Undulator period	32 mm
Number of periods	140
Tunable energy range	> 6 keV
Brilliance	2×10^{19} ph/s/mrad^2/mm^2/0.1 % b.w. at 14.4 keV
Total power	5 kW
Power density	300 kW/mrad^2

3. High Pressure Station

Another experimental station was designed for the study of high pressure X-ray diffraction. A sample is enclosed in the DAC, which can generate high pressure, and the diffraction from the sample is detected by the imaging plate system.

Recently, we have also constructed a low-temperature DAC system, which enables us to investigate in the temperature region of 10 K-350 K as well as the pressure region up to 100 GPa. A purpose-built DAC is mounted on the cold head of a He closed-cycle cryostat. The DAC housing is made of CuBe for good thermal conductivity. Pressure can be applied by introducing the He gas into the diaphragm set in the DAC, and the pressure can be controlled by the He gas pressure controller. The pressure can be measured in-situ by Ruby luminescence through the Myler window of the cryostat housing. Using this system, X-ray diffraction experiments on SnI_4 at 10 K, 80 GPa have already been carried out, and the crystal structure was determined [2].

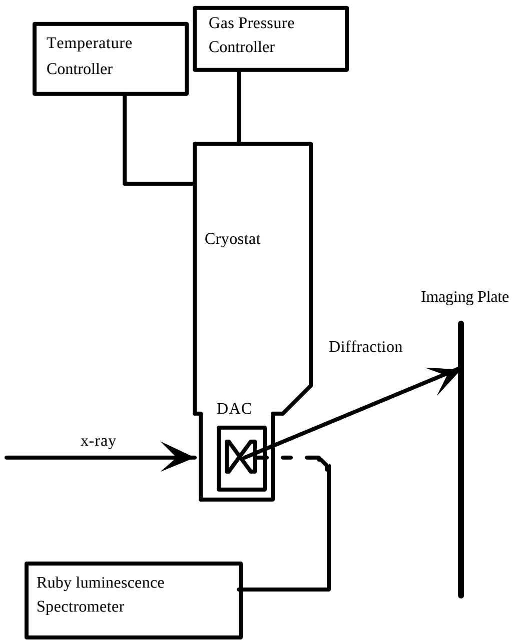

Fig. 2. Low-temperature DAC system.

References

[1] H. Oyanagi *et al*., J. Synchrotron Rad. (in press)
[2] N. Hamaya, private communication