White Beam X-ray Diffraction (BL28B2)

1. Introduction

BL28B2 is the second white X-ray beamline from a bending magnet source in SPring-8. The beamline is designed to accommodate various applications using white X-rays, but the major station equipment is currently optimized to perform state-of-the-art X-ray diffraction imaging applications using third generation light sources. Source characteristics of this beamline are the same as those for other bending magnet beamlines.

The beamline is covered with two connected radiation shielding hutches. Since white X-rays are guided to both of them, these hutches are treated as optics hutches that have enough shielding capability for white X-rays. The available X-ray energy ranges from 3 keV to more than 100 keV.

The upstream hutch (Optics hutch 1) houses a transport channel, while the downstream one (Optics hutch 2) contains a set of station equipment.

The station equipment mainly consists of an optics diffractometer, a sample diffractometer, and other devices for conditioning the incident beam and sample environment.

2. Transport Channel

The synchrotron light of this beamline should be guided through a concavity in the concrete shielding wall of the accelerator, as with other B2 lines of SPring-8. Therefore, the front end of the beamline is extended to the 32 m position from the source point, although the beamline comes out of the shielding wall at the 25 m position from the source.

The structure of the transport channel is based on the white X-ray standard. An exhaustion unit is placed just after the Be window assembly of the front end, followed by a water cooled four-jaw slit, the second exhaustion unit, a screen monitor, and a final water cooled Be window. The final window is placed at the 40 m position from the source. These transport components, except for the final window, are in optics hutch 1. The final window, and a gamma-ray stopper located downstream of the beamline, are in optics hutch 2.

A front end shutter is used as the main shutter of the beamline. There is no downstream shutter as a transport channel component.

3. Station Equipment

3.1 Incident Beam Conditioner

The white X-rays through the final Be window are guided to the conditioning assembly for the incident beam. The assembly consists of a precision four-jaw slit to define the beam shape, an attenuator unit to moderate the beam intensity as well as to filter out the lower energy X-rays, and a fast operating shutter for accurate control of the exposure time.

3.2 Optics Diffractometer

The optics diffractometer is placed just downstream of the conditioning assembly for optional use of either a single- or multi-bounce crystal monochromator. A horizontally deflected beam from the monochromator will be guided to the sample diffractometer when a monochromatic beam is used.

The optics diffractometer has full circle ω-2θ vertical rotation axes. On the ω-table is mounted a full circle goniometer with horizontal rotation axis. Stepping motors with the common finest steps of 0.001 deg drive these three axes. For fine adjustment of the monochromator crystal orientation, a goniometer-head is attached to either the vertical ω-table or the horizontal rotation table. The goniometer head has two crossed translation mechanisms driven by stepping motors with the finest steps of 0.002 mm and strokes of ± 20 mm. It also has two crossed tilting mechanisms driven by stepping motors with 0.002 deg finest steps and ± 15 deg strokes.

When white X-rays are guided to the sample diffractometer, no optical elements such as crystal monochromators are mounted on the optics diffractometer. In addition to the crystal monochromators, the diffractometer could be used to align refractive lenses or capillary optics to make a focused beam.

3.3 Sample Diffractometer

The sample diffractometer, shown schematically in Fig. 1, is the main station equipment of this beamline, placed downstream of the optics diffractometer. It is mounted on a long translation stage to match the rotation center to the X-ray beam, which may be deflected by the monochromator crystal on the optics diffractometer. The translation stage is driven by a stepping motor with the finest step of 0.002 mm and strokes of ± 800 mm. The base goniometer is a vertical axis ω–2θ. The ω is a full circle goniometer while the rotation range of 2θ is limited to ± 120 deg. On the 2θ-table is mounted another ω–2θ goniometer with a horizontal rotation axis. Stepping motors with common finest steps of 0.001 deg drive all goniometer axes.

A goniometer head to adjust the sample orientation is mounted on the vertical ω-table. The goniometer head has xyz translation mechanisms driven by stepping motors with the finest steps of 0.002 mm and strokes of ± 20 mm. It also has two crossed tilting mechanisms driven by stepping motors with 0.002 deg finest steps and ± 7.5 deg strokes.

Detectors such as X-ray TV will be mounted on a translation stage attached to the horizontal 2θ–table. This stage driven by a stepping motor moves with the finest step of 0.002 mm within the range of ± 200 mm.

Maximum load of the sample diffractometer is designed to be more than 100 kgf, so the various apparatus used to control of the sample environment have been adapted.

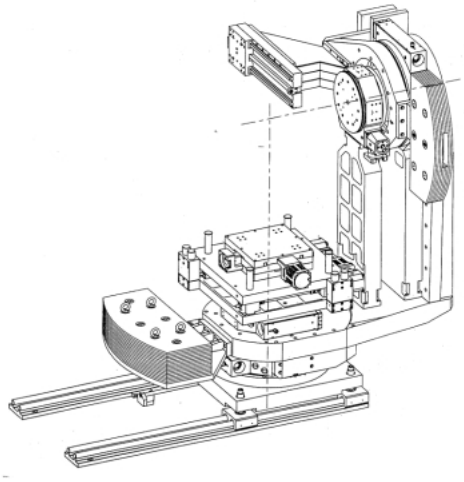

Fig. 1. Schematic view of sample diffractometer.

3.4 Sample Environment Control

A low temperature stage and a high temperature stage have been prepared as apparatus for controlling the sample environment.

The low temperature stage is a He cryostat with a manual full circle orientator. It has a 30 mm diameter sample space. The designed temperature range is between 3.8 K and 300 K with a stability of ± 0.1 K. Expected cool down time is 90 min.

The high temperature stage uses infrared heating. It allows a sample size of up to 10 mm width. The designed temperature range is from room temperature to 1,770 K with a stability of ± 0.1 K. Expected heat up time is 1 min when the temperature is below 1,660 K. To avoid oxidation of the sample, the room for the sample is evacuated by a turbo-molecular pump. A sample orientator with two motorized rotation axes and a manual translation axis are used with the stage.

4. Detectors and Control System

Conventional detectors (ionization chamber and NaI detector) used as SPring-8 standards are used to adjust sample orientation. X-ray films, emulsion plates and an X-ray TV system are currently being considered as imaging detectors.

The control system for this beamline is the SPring-8 standard one.