Transport Channel and Optics

1. Introduction

The Optics Group had another very productive year in 1999. The year began with the assembling works of four new bending-magnet beamlines (BL02B2 [1], 04B2 [2], 28B2 [3] and 40B2), targeting the hardware completion by the end of March. Simultaneously, the finalization of the integrated beamline design works was carried out for the long-undulator beamline (BL19XU [4]), the medical undulator beamline (BL20XU), the one-kilometer extension of BL29XU [5,6] as well as the infrared beamline (BL43IR) [7-10]. The procurement process for these beamlines had been finished by the end of March, together with the new building for the one-kilometer beamline.

Work on the commissioning of the newly constructed bending-magnet beamlines was conducted before the summer shutdown, in collaboration with the Experimental Station Group and some outside users. In parallel, construction of the radiation shielding hutches [11] for the two X-ray undulator beamlines (BL35XU [12], 40XU [13]) was started, followed by the assembly of the beamline components. Some preparatory work for the construction of the one-kilometer beamline was conducted, especially for the precise positioning of the long vacuum ducts [14].

Commissioning of the X-ray undulator beamlines started in the autumn beamtime. Conceptual design studies for two new public beamlines were also started in late autumn. One is an undulator beamline for surface and interface structure analysis (BL13U), and the other is a bending-magnet beamline for industrial applications (BL19B2).

A new experimental hutch was constructed for one of the R&D beamlines, BL46XU, which had had only an optics hutch. A standard Huber multi-circle diffractometer was equipped in the experimental hutch for the R&D of high-energy applications. As the third R&D beamline, BL38B1 started construction with a similar design to BL40B2.

Most of the X-ray beamlines described here are based on the "standardization concept" for components [14,15], vacuum system [16], radiation shielding hutches [11], optics [17-21], interlock system [22] and control system [23].

2. New Beamlines

Although some of the following descriptions of the new beamlines can be seen in the previous Annual Report of SPring-8, we will repeat them for the convenience of readers.

2.1 BL02B2 [1]

This *powder diffraction* beamline from a bending magnet was completed in March 1999. Since the beamline's user group strongly requested a parallel incident beam to the sample, the beamline optics starts with a parabola mirror followed by a double-crystal monochromator. The parabola mirror is configured by bending a Rh-coated flat mirror of 1 m length. For this, a mirror support with bending and water-cooling mechanisms is installed upstream of the monochromator. A standard adjustable-inclined double-crystal monochromator [17-20] is used in the beamline. Since the mirror shape is controlled by bending, focusing at the sample position is also available by changing the bending radius.

2.2 BL04B2 [2]

This *high-energy X-ray* beamline from a bending magnet was completed in March 1999. A single-bounce, constant deflection-angle crystal monochromator is installed in the beamline in a horizontally dispersive geometry. The Bragg angle of the monochromator is fixed at three degrees. The current monochromator crystal is a 700 mm long Si (111) plate. Horizontal focusing of the beam is achieved by cylindrically bending the crystal. A standard mirror support with bending and indirect cooling mechanisms is used for the monochromator. Monochromator crystals of Si (220) and Si (311) are also available.

2.3 BL28B2 [3]

This *white X-ray diffraction* beamline from a bending magnet was completed in March 1999. It has no monochromators or mirrors.

Instead, the beamline has a water-absorber to eliminate low energy X-rays. A high-speed shutter mechanism is also installed in addition to the standard main beam shutter to control precisely the exposure time of X-ray topography.

2.4 BL35XU [12]

This beamline is for high-resolution inelastic scattering with a back-scattering crystal monochromator and analyzer. The source undulator is a planar, in-vacuum one with 32 mm magnetic period and 4.5 m total length. A cryogenically cooled silicon double-crystal monochromator in the standard mechanism is installed as a pre-monochromator. A back-scattering monochromator of spherically arranged silicon pillars is located at a position ~80 m from the source. A Si 111 double-crystal *beam displacer* is used for the back-scattered beam to separate its beam axis from that of the incident beam. A bent cylindrical mirror is used to focus the beam at the sample position.

2.5 BL40B2

This *focussed monochromatic X-ray beamline* from a bending magnet was completed in March 1999. It is used for wide/small angle scattering/diffraction from macro-molecules. Its beamline optics is an adjustable-inclined double-crystal monochromator followed by a bent cylindrical mirror coated with Rh. The beamline has non-connected optics and experimental hutches for the access to the existing BL41XU.

2.6 BL40XU [13]

This *high-flux* beamline from an X-ray undulator saw the first beam in autumn. The undulator is a helical, in-vacuum one with 40 mm magnetic period and 4.5 m total length. The beamline has no crystal monochromator. Two bent flat mirrors in Kirkpatrik-Baez configuration focus the central cone of the undulator radiation at the sample position. The first mirror is made of Si and is cooled indirectly by water. The second mirror is made of quartz and is uncooled. Two separate standard mirror supports with bending mechanisms are used for the KB configuration.

2.7 BL43IR [7-10]

This is the first *infrared* beamline at SPring-8 to be completed within FY 1999. A special design is used for the optics and transport channel. A detailed description of the beamline can be seen in separate articles in this volume.

2.8 BL13XU

An X-ray undulator beamline for surface/interface structure analysis was designed as a public beamline. The beamline optics consists of a standard double-crystal monochromator and two-bounce, horizontally deflecting mirrors with horizontal focusing mechanism. The beamline will be completed by the end of March 2001.

2.9 BL19B2

A bending-magnet beamline for industrial applications was designed as a public beamline. The beamline optics consists of a standard double-crystal monochromator and two-bounce, vertically deflecting mirrors with vertical focusing mechanism.

A new building extending the storage ring building was designed to accommodate the end station of this beamline.

3. Optics Upgrade

3.1 Standard mMonochromator Upgrade [19,20]

One and half year experience in the operation of standard double crystal monochromators for both X-ray undulator and bending magnet beamlines reveals that their precision and performance are quite satisfactory. However, minor revisions were made for the monochromators for the second phase beamlines to improve controllability and exchangeability. The vacuum chambers, which used to be different between the bending magnet type and undulator type, are standardized with the CF152 in- and outlet light path flanges. Zero-length conversion flanges (CF152-CF70) are used for the undulator type. Horizontal translations perpendicular to the beam axis for both first and second crystal were changed from manual to stepping motor driven. Horizontal translation of the vacuum chamber perpendicular to the beam axis was newly introduced.

In order to reduce vibrations in the coolant path, some of the flexible bellow-tubes were replaced by solid tubes.

3.2 Pin-post Crystal Upgrade [20,24]

For the standard double-crystal monochromator for undulator beamlines, the first crystal is cooled by water flowing in the pinpost structure just underneath the irradiated surface. To fabricate the pin-post water path structure, we have been developing a strain-free diffusive bonding technique. We found no thermal problems in our world-strongest undulator beamlines. However, the initial design of the water path was found to introduce pressure-induced strain. Accordingly, we made a new design and fabricated some prototype crystals. Pressure-induced strain was greatly suppressed by this new design, though some bonding strain still remained and the curvature of the bonded surface was found to introduce macroscopic bending of the crystal. We collaborated with NEC to reduce the macroscopic bending and found a solution for it.

The first prototype of the improved crystal will be available from FY 2000.

3.3 Cryogenic Cooling [25]

Liquid nitrogen cooling of the undulator monochromator was tested at an optics R&D beamline (BL47XU). Copper blocks at the temperature of liquid nitrogen indirectly cooled both the first and the second crystals. The test result is fairly good as reported from ESRF and APS. However, we found some operational problems in our present system, so that we will start a new development of the liquid nitrogen circulating system with a liquid He refrigerator.

3.4 Phase Retarder R&D and Modulation Spectroscopy [26,27]

Highly perfect and large-size diamond crystals synthesized by Sumitomo Electric Industry Co. Ltd. widen the applications of the diamond crystal to SR X-ray optics. One of the most promising features of this is for the X-ray phase retarder, which converts linear polarization to circular polarization. Owing to the birefringence effects in the dynamical diffraction of X-rays, left-hand circularity (LHC) and right-hand circularity (RHC) is easily switched only by slightly changing the crystal orientation.

We developed a PZT-driven bi-stable crystal oscillator, which give rise to LHC and RHC alternatively at two stable positions with an oscillation frequency of more than 40Hz. The output currents of two ionization chambers are lock-in amplified in synchronization of the PZT oscillation. This technique was successfully applied to the measurement of magnetic circular dichroism (MCD) for transition metal compounds and other materials. MCD data accumulated in 30 min with this method are proved to have a higher quality than those accumulated in 10 hrs at the elliptical multipole wiggler beamline at the Photon Factory.

3.5 Saggital Focusing [28]

The optics group has been developing a novel mechanism of crystal bending for the dynamic saggital focusing. The mechanism is to be used for the second crystal of the standard bending-magnet X-ray monochromator. Our technical concern is to keep the fixed exit feature of the double crystal monochromator with varying bending radius.

With some modification from the initial design, the bending mechanism became nearly perfect. We succeeded in obtaining a fairly good focus point up to 60 keV without violating the fixed exit features.

We are planning to test the saggital focusing for inclined-geometry, which we could extend the available energy range up to 150 keV.

4. Mirror Characterization Facility

SPring-8 has prepared to set up a mirror characterization facility, which became available from October 1999. It is equipped with; a long trace profiler, Wyko interferometer, and Zygo interferometer. Together with the activity of Prof. Kinoshita of Himeji Institute of Technology, we will have the most advanced mirror characterization facility in Japan at the SPring-8 site.

The facility was temporarily opened in the Biomedical Building, but will be moved to a newly equipped clean room in RIKEN Physics building in September 2000.

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