Transport Channel and Optics

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1. Introduction

FY 1997 was the final year of the first phase public beamline construction started in FY 1994. It was also the first year of the second phase public beamline construction, which started with construction of a medium length bending magnet beamline into the Biomedical Imaging Center.

Following the successful operation of the storage ring at the end of the previous fiscal year, finalization of the beamlines started from the beginning of the fiscal year toward the user dedication planned for October. In April, the first trial operation of the standard in-vacuum undulator was made at BL47XU. The beam image at the front-end viewport astonished us by its smallness and brightness.

Optics alignment for the safety inspection planned in the middle of June started in May from BL02B2 as the first bending magnet beamline, followed by BL47XU as the first undulator beamline. For each beamline, it took less than one full day for the monochromatic x-rays to be introduced into the experimental hutch. The permission to operate these beamlines came from STA in early July, followed by permission for commissioning BL09XU, 41XU, 45XU, 01B1 and 04B1. Commissioning of these beamlines was carried out between July 7 and 12.

During the summer shutdown starting from July 13, we held SRI'97 at Himeji in August in which many contributions were made by the beamline group of the SPring-8.

Permission for commissioning for the remaining beamlines (BL10XU, 39XU, 08W, 23SU, 25SU, 27SU and 44B2) came from STA in mid-August. Commissioning of BL10XU, 39XU and 08W was carried out in September toward the user dedication on October 6.

User run started in October with eight public x-ray beamlines, an x-ray R&D beamline and a RIKEN dedicated x-ray beamline. Commissioning of a JAERI-dedicated x-ray beamline (BL14B1) started in November, followed by public soft x-ray beamlines from a twin helical undulator (BL25SU) in February and from an 8-figure undulator (BL27SU) in March.

2. Standard Monochromator

Two prototype double-crystal monochromators completed in the previous FY were thoroughly checked for angular precision of each axis as well as yaw and pitch of each translation stage. Observed results were satisfactory, so we decided to adopt the design of the prototype as the standard. Control software for the monochromators was developed on a workstation (WS) for beamline control. Synchronous control with the station equipment is designed to be made through a serial communication line between the station PC/WS and the beamline WS.

We installed prototype monochromators in BL02B1 and BL47XU. Similar monochromators were installed in BL01B1, BL09XU, BL10XU, BL39XU and BL41XU. This type of standard monochromator was also installed in BL14B1 (JAERI BL) and BL44B2 (RIKEN BL), and will be installed in BL11XU (JAERI BL), BL16XU (Industrial consortium BL), BL16B2 (Industrial consortium BL), BL20B2 (Medical Imaging BL), BL29XU (RIKEN Physics BL) and BL44XU (Osaka Univ. BL)

3. Optical Elements

3.1 Pin-Post Water Cooling of Si

Standard monochromators for x-ray undulator beamlines use a rotated-inclined geometry with pin-post water cooled Si. Fabrication of crystals for this purpose required a <110>-grown FZ Si ingot. We collaborated with Shinetsu Semiconductor Co., Ltd. to grow this unusual ingot. They succeeded in growing 3-inch diameter ingots in 1995, followed by 4-inch diameter ingots in 1997.

In addition to the original plan of fabricating pin-post crystals with an Au-diffusive bonding technique, Al-diffusive bonding was also tested to give better results in terms of residual bonding strain. Thermal tests with standard x-ray undulator beamlines when the ring current is 20 mA showed that there is only the slightest effect of heat load. However, a strain pattern due to the geometry of the water in- and outlets was observed.

We are now making new design studies, and an improved version of the pin-post crystal will be available in fall 1998.

3.2 Water Fin-Cooling of Si

Due to the smaller heat load in the bending magnet beamlines, we adopted fin-cooling by water of the Si for the monochromator crystals of these beamlines. During 20 mA ring current operation, we observed no thermal effects on the crystals.

Adjustable inclined geometry was tested to give XAFS data at the Pb K-edge. The combination of adjustable inclined geometry with saggital focusing was also tested. The results were promising but indicated the necessity of improving the crystal bender for better saggital focusing.

3.3 Diamond Crystals

We have been collaborating with Sumitomo Electric Industries (SEI) to synthesize large-sized, high-quality diamond crystals since 1994. We succeeded in obtaining (111) crystal plates with 10×7 mm^2 crystal plate by the end of the previous fiscal year. These were installed in both the double-crystal monochromator and the trichromator in BL45XU to deliver mono- and trichromatic beams to a small-angle x-ray scattering station and a protein crystallography station, respectively.

The diamond crystals were also used as phase retarders at BL39XU to prepare circular polarization with both right- and left-hand circularities. Fast switching of helicities enabled us to make modulation spectroscopy for x-ray magnetic circular dichroism.

The remaining issue regarding the diamond crystals is how to make the thickness smaller in order to improve transmittance. To achieve this, we are also collaborating with SEI toward a tentative target of 0.2 mm.

3.4 Total Reflection Mirrors

Total reflection mirrors for the initial x-ray beamlines were supplied by Oxford Instruments Co., Ltd. The test results on each beamline were, in general, very good.

In the standard configuration of a bending magnet beamline adopted at BL01B1 and BL02B1, we placed a collimating mirror as the first optics to male a parallel beam incident on the crystal monochromator, and a refocusing mirror after the monochromator. Adjustment of the entire system was made, at first, to search for the flat position of the second mirror by measuring crystal rocking curves in non-dispersive geometry with the monochromator crystal. The minimum width of the rocking curve gave the flat position of the second mirror. Then, the most appropriate bending condition was investigated by measuring crystal roking curves in dispersive geometry. The minimum width corresponds to the highest energy resolution, thus giving the most apropriate bending condition. The bending condition of the second mirror is adjusted by the focus image at the sample position.

An improvement of the energy resolution by 1/5 was observed by using the collimating mirror.

4. Commissioning

The key task in commissioning a transport channel and optics is to align the monochromator, that is, to introduce monochromatic x-rays to the experimental station. To simultaneously commission many beamlines, the beamline group developed a standard technique using BL47XU for the x-ray undulator beamline and BL02B1 for the bending magnet x-ray beamline. Many members of the Experimental Facility Division as well as personnel from RIKEN and JAERI joined this initial commissioning and were trained how to align the standard monochromators.

The first step of commissioning was to confirm the agreement between the light axis and the beamline axis. This was done by observing the beam position on a water-cooled copper block placed at the position of the first crystal in the monochromator. For every beamline, positional error was within 1 mm at most. Then, the copper block was replaced by the first crystal, and the second crystal was mounted. Double crystal alignment was made by mechanical and optical methods without using x-rays. Then the vacuum chamber was sealed and evacuated to start the alignment using x-rays. By this method, it usually took less than a few hours for the monochromatic x-rays to be introduced into the experimental station.

After the initial two beamlines, commissioning was made by each group responsible for their respective beamline.

5. New Public Beamline

A two-year project of constructing a 200 m long beamline from a bending magnet (BL20B2) into the Biomedical Imaging Building was approved. The proposed method for radiation shielding uses lead-shielded ducts instead of constructing a hutch.

This beamline has two experimental stations in the Biomedical Imaging building in addition to one experimental station in the Storage Ring building. These are used for R&D for novel medical imaging techniques as well as diffraction imaging such as x-ray topography using monochromatic x-rays.

Thanks are owed to all members of the Beamline and the Experimental Facility Division of JASRI for their great achievements in this fiscal year.