Transport Channel and Optics

One and a half year's experience in operation of standard double crystal monochromators for both X-ray undulators and bending magnet beamlines demonstrated their precision and performance. However, minor revisions were made on the monochromators for the second phase beamlines to improve controllability and exchangeability. Vacuum chambers, which used to be differentiated between the bending magnet (BM) and undulator (U) types, have been standardized with the CF152 inlet and outlet light path flanges. Zero-length conversion flanges (CF152-CF70) are used for the U-type. Horizontal translations perpendicular to the beam axis for both first and second crystals were changed from manual to stepping-motor driven. Horizontal translation of the vacuum chamber perpendicular to the beam axis was also introduced.

In the standard undulator's double-crystal monochromator, the first crystal is cooled by water flowing into the pinpost structure just underneath of the irradiated surface (Figure 1). To fabricate the pinpost water path structure, we are developing a strain-free diffusive bonding technique [1]. We found no thermal problems in our (world's strongests) undulator beamlines. However, the initial design of the water path (Figure 2) was found to introduce pressure-induced strain. Accordingly, we made a new design (Figure 3) and fabricated some prototype crystals. Pressure-induced strain has been greatly suppressed by this new design, although some bonding strain still remains. We are now working to improve the bonding process in collaboration with NEC Corp..

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

Near-perfect and large-size diamond crystals synthesized by Sumitomo Electric Industry Co. Ltd. have widened the applications of the diamond crystal to SR X-ray optics [2]. One of the most promising is that for an X-ray phase retarder [3-5], which converts linear polarization to circular polarization. Owing to the birefringence effects in the dynamical diffraction of X-rays, easy switching of the left-hand circularity (LHC) and right-hand circularity (RHC) throught slight changes in the crystal orientation is realized. We developed a PZT-driven bi-stable crystal oscillator which gives rise to LHC and RHC alternatively at two stable positions with an oscillation frequency of more than 40 Hz. The output currents of two ionization chambers are lock-in amplified in synchronization with the PZT oscillation. This technique was successfully applied to the measurement of magnetic circular dichroism (MCD) for transition metal compounds and other materials [6]. The MCD data accumulated in 30 min by this method was proven to have higher quality than the data accumulated in 10 hrs at elliptical multipole wiggler beamline at the Photon Factory.

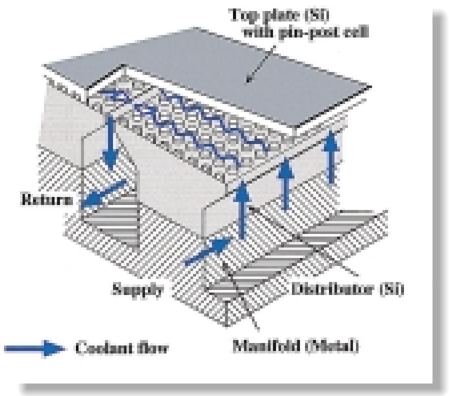

Figure 1: Pinpost water cooling.

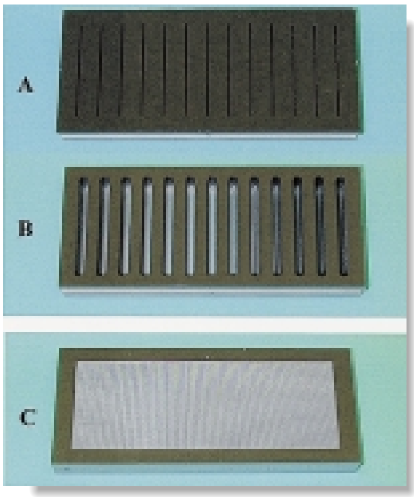

Figure 2: Initial-design pinpost crystal: (A) water distributor (bonded side), (B) water distributor (rear side) and (C) top plate with pins.

Figure 3: Improved-design pinpost crystal: (A) water distributor (bonded side), (B) top plate with pins before mechano-chemical polishing.

The Optics Group has been developing a novel mechanism of crystal bending for dynamic sagittal 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 along monochromator with a varying bending radius [7]. With some modification from the initial design, the bending mechanism became nearly perfect. We could obtain a fairly good focus point at 40 keV without affecting the fixed exit feature.

In collaboration with Shin-Etsu Semiconductor Co. Ltd., SPring-8 is developing a large diameter <110>-grown FZ silicon crystal for various crystal monochromators. The advantage of the <110>-grown crystal is that we can cut large size (111), or more generally (hkk), plates that are parallel to the growth axis. In 1995, when we started the collaborative development, the technical limit of the maximum diameter was 3 inches and that of the maximum length was around 500 mm. However, in 1997 Shin-Etsu succeeded in growing 4-inch diameter ingots and the maximum length now exceeds 700 mm. These ingots are routinely used for monochromator crystals, in particular for the rotated-inclined crystals in X-ray undulator monochromators where such a large crystal plate is essential to accomodate the long footprint on the surface.

For the development and fabrication of the newly designed crystal optical elements, SPring-8 set up a crystal machining facility (Figure 4) that includes a numerically controlled (NC) cutting machine with diamond saw, a NC diamond milling machine, a grinding machine for silicon and a mechano-chemical polishing machine for silicon. The crystal stage for the cutting and milling machines are compatible with that of the X-ray diffractometer, which enables accurate agreement between the cut surface and the desired crystal orientation. Most of the trial fabrications of the crystal optical elements can, in principle, be made in-house. For the off-line test of these crystal optical elements, two sets of versatile multiple-axis diffractometers were equipped with rotating-anode X-ray generators as the X-ray source. The two diffractometers were identical, components were fully compatible and have the same design principle as many similar diffractometers in the SR beamlines.

SPring-8 is preparing to set up a mirror characterization facility, which will be operational from October 1999. This facility will be equipped with a Long Trace Profiler, Wyko interferometer and Zygo interferometer. Incorporating the work of Prof. Kinoshita of the Himeji Institute of Technology, we will have the most advanced mirror characterization facility in Japan at the SPring-8 site.

Figure 4: Crystal fabrication facilities at SPring-8: (A) grinder, (B) diamond cutter, (C) diamond milling machine and (D) mechano-chemical polisher.

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