Development of Focusing Mirror for Small-Angle X-Ray Scattering Optics

Yoji INOKO[1], Hitoshi YAMAOKA[2], Tomoya URUGA[2], Masaki YAMAMOTO[3], Tetsurou FUJISAWA[3] and Etsuo ARAKAWA[4]

1) Department of Biophysical Engineering, Faculty of Engineering Science, Osaka University, Toyonaka, Osaka 560, Japan
2) The SPring-8 Project Team, The Institute of Physical and Chemical Research (RIKEN), Wako, Saitama 351-01, Japan
3) The Institute of Physical and Chemical Research (RIKEN), Wako, Saitama 351-01, Japan
4) Photon Factory, National Laboratory for High Energy Physics, Tsukuba, Ibaraki 305, Japan

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As one of the public beamlines at SPring-8, A beamline for small-angle X-ray scattering (SAXS) experiments on biological macromolecules was proposed by the Macromolecular SAXS subgroup in the SPring-8 Users Society. The conceptual design of the beamline and the R&D program necessary to the success of our beamline project were continued up to now [1,2]. Here we report the R&D work on a mirror system for the SAXS optics on an undulator beamline. This work was carried out in 1990-1992 with a financial support from the SPring-8 Project Team and in cooperation with the experimental group of the Project Team.

A crucial requirement in the instrumentation of the SAXS beamline is the precise focusing of primary beams to produce well-collimated X-ray beams at the sample. In the optical design, we proposed vertical and horizontal focusings of undulator beams which were independently achieved by a double-mirror system [3] composed of two bent triangular mirrors [4].

A mirror bender [5] for the horizontal focusing was designed and built. The fabrication of a benderfor the vertical focusing was omitted since the vertically focusing mirror had the same bending mechanism as the horizontally focusing one. Two platinum-coated quartz mirrors of 30cm (height) x 10cm (width) x 1cm (thickness) and 30cm x 10cm x 0.5cm, and a non-coated quartz mirror of 30cm x 10cm x 1cm were prepared. Figure 1 shows the assembly of them. The optical and mechanical qualities of the products were tested by using CuKα radiation from a conventional X-ray generator.

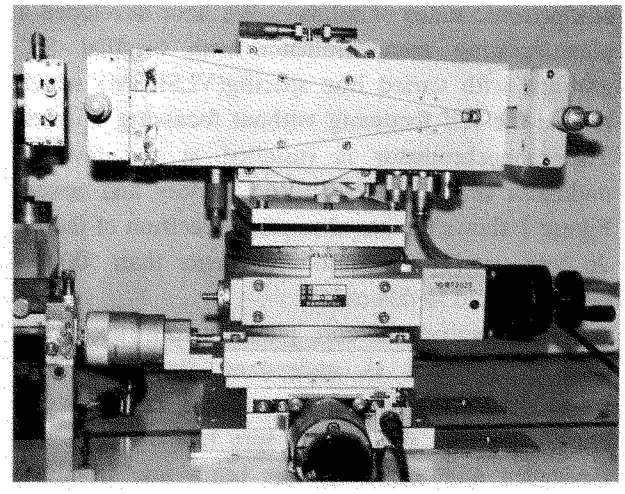

Fig.1. Prototype two-point bender on which a non-coated triangular shaped mirror of fused quartz is mounted.

The reflectivities of the three mirrors were examined. The platinum-coated quartz mirror had a reflectivity of 55% at a glancing angle of 8mrad for X-rays of 1.5Å and the non-coated mirror a 96% reflectivity at a 3mrad glancing angle. The surface roughness was estimated to be about 8Å rms for the platinum-coated mirrors and less than 2Å rms for the non-coated mirror from the reflectivity curve. The 2Å rms roughness of the non-coated mirror was in good agreement with those of the polished surfaces of the three mirrors by interferometrical measurement. Evidently the metal-coating roughened the reflecting surface of mirror. No positional dependence of the reflectivity of the surface except the base and apex was observed for all the three mirrors, showing a good optical quality.

The focusing test was done on the bender combined with the platinum-coated mirror of 1cm thickness at 1:1-4:1 demagnification ratios for a short source-to-mirror distance (1.2m) and a strong demagnification of 10:1 ratio for a long distance

(32m). The measurement with the latter focusing geometry was done at the long X-ray beamline facility in the Institute of Space and Astronautical Science. It was shown that the size of the focal spot was almost equal to that predicted from the demagnification ratio. These results show that the system has a high performance as a focusing mirror at a large bending radius.

References

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