A Large Ellipsoidal Mirror for Energy Tunable X-Ray Micro Analyses

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Design of an x-ray focusing mirror has significance for an x-ray microprobe with energy tunability. In the analytical sense, the upper limit of the tunable energy range should be as high as possible. However, it is widely known that the horizontal acceptance becomes extremely small with small glancing angles. Though a large ellipsoidal mirror was successfully used in micro x-ray fluorescence analysis[1] and micro XAFS measurements[2], the tunable energy range was limited up to 10 keV. Considering that the practical limitation of the surface polishing technique and that the small beam divergence expected with the SPring-8 synchrotron, a new ellipsoidal mirror was designed and fabricated, which covers x-ray energy up to 20 keV.

Fig.1 shows parameters for the newly designed ellipsoidal mirror. Magnification is 1/6, and the vertical and horizontal acceptances are 0.1 and 0.68 mrad, respectively. Even with the rms surface roughness of 10 Å, a reflectivity of approximately 50 % was expected for 15 keV x-rays. The mirror was fabricated from fused quartz and its surface was coated with Pt.

The performance of the ellipsoidal mirror was evaluated at the Photon Factory on the BL-4A. Fig. 2 shows the obtained reflectivity and calculated ones. A fairly good reflectivity is obtained for x-rays up to 20 keV, and the surface roughness of less than 10 Å has been realized. Fig. 3 shows the beam profile at the focal plane obtained with an xy translation scan of a pinhole whose diameter was 50 μm. The transmitted beam was monitored by an ionization chamber and the beam size (FWHM) was 0.2mm and 0.1 mm in horizontal and vertical direction, respectively. The photon flux at the beam spot was $2x10^{10}$ for 8 keV x-rays with the storage ring current of 300 mA. The gain of the photon flux density with the use of the ellipsoidal mirror is more than 100. Considering the source size of 1.38 mm(H) and 0.42 mm(V), the obtained beam size is larger than the designed one in vertical direction. That is presumably owing to the figure error in the meridional plane curvature.

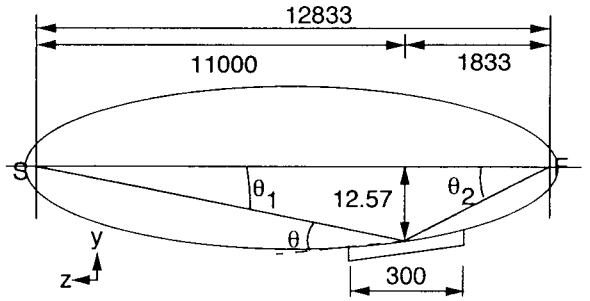

Fig.1. Designed mirror parameters in mm. θ=4, θ_1=1.14, θ_3=6.86 mrad

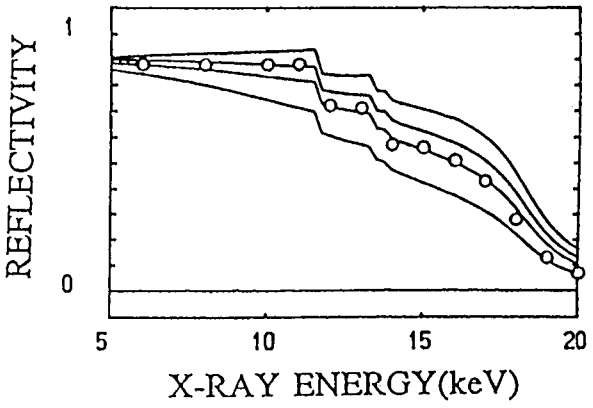

Fig.2 Obtained reflectivity (circle) and calculated ones(solid lines) with rms surface roughens of 0, 5, 7, and 10 Å (from upper to lower).

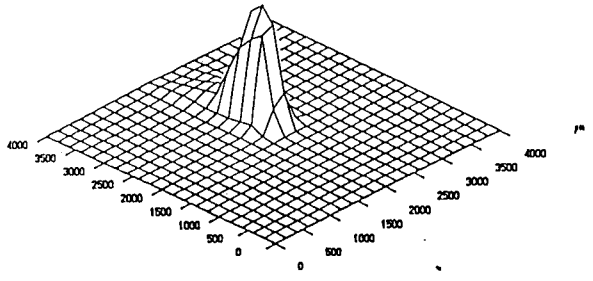

Fig.3 Beam profile obtained with 8 keV x-rays in μm.

References

[1] S. Hayakawa et al., Nucl. Instrum and Meth. B49, 555(1990).

[2] S. Hayakawa et al., Rev. Sci. Instrum. 62, 2545(1991).