| ESRF | **Experiment title:**<br>**Monolithic 2-D magnifying system for hard X-ray high resolution imaging** | **Experiment number**:<br>MI-598 |
|---|---|---|
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## Report:

The aim of this experiment was to continue in the study of imaging properties of monolithic 2-D magnifying devices for hard X-ray radiation [1] with a modified monolithic device enabling the incident and outcoming X-ray beams to be parallel. This was a reasonable condition for the optics to be applicable for synchrotron sources because of compatibility with dominantly horizontal arrangement of synchrotron radiation equipment in hutches. For this aim, X-ray magnified imaging of suitable objects and measurements of the spatial resolution of the system both in absorption radiographic and phase contrast modes were suggested. Decreasing the wavelength the increase of magnification up to the optimum value for the maximum resolution, as given by theoretical results of Spal [2], was supposed.

The experiment was performed at the Optical beamline BM05 and monochromatic beam 8-10 keV

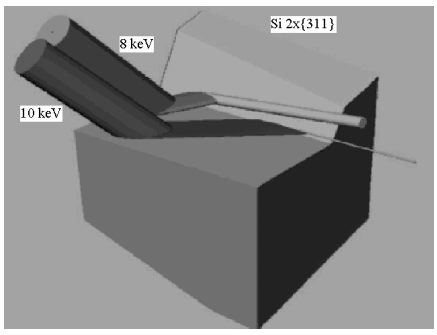


*Fig. 1a. Monolithic X-ray magnifier/ demagnifier (magnification 25 times at the energy of 10.0 keV) with nonparallel incident and outcoming beams for two energies For details see [1].*

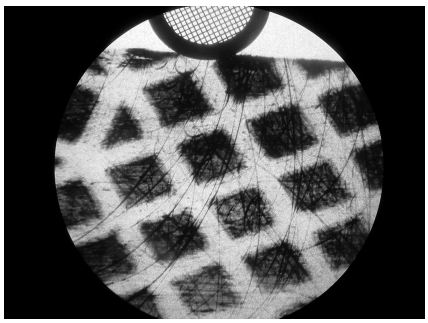

*Fig. 1b. Microscopic Cu #300 mesh grid (upper grid) and its X-ray magnified image (lower grid) as taken by the device from Fig. 1. X-ray magnification 15 times at 9.6 keV.*

was used. Fig.1a shows the shape of the crystal used in the previous experiment IH-MI-105, Fig. 1b shows a microscopic mesh as an object and its X-ray magnified image [1]. The next version of the magnifier studied in this experiment was shaped to give the magnification of about 100 times at the beam energy of 10 keV and is supplemented by a (422) diffractor which would provide parallel incident and outcoming beams. This diffractor should be pure symmetrical not to distort the image, but in order to avoid breaking the crystal it was prepared as symmetrical inclined.

The principle of the adjustment of the system is obvious: Crystal block with three diffractors is adjusted into the first diffraction in such a way that the corresponding diffraction vector $\mathbf{h}^1$ is in the horizontal axis of the goniometer. By means of rotation of the crystal about this axis (Renninger scan) further multiple diffractions (both simultaneous and successive) can be obtained. It is advantageous to start at lower energy to have less asymmetry. Care must be taken to adjust linear position of the crystal in order for the beams to be able to pass through the crystal block according to the model. We used the beam energy of 9.6 keV and 9.8

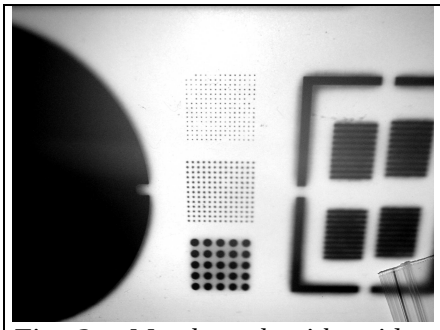

*Fig. 2a. Metal mask with grids of small, medium and big circular holes, periodicity of 126, 147, and 387 μm, respectively.*

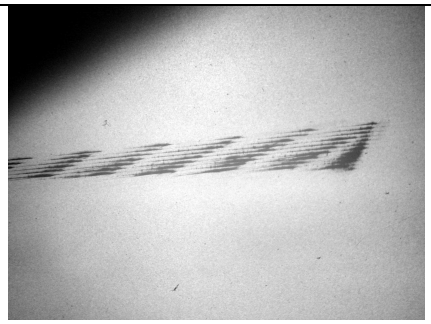

*Fig. 2b. Top grid, 21-times 1D magnification. Beam energy 9.6 keV.*

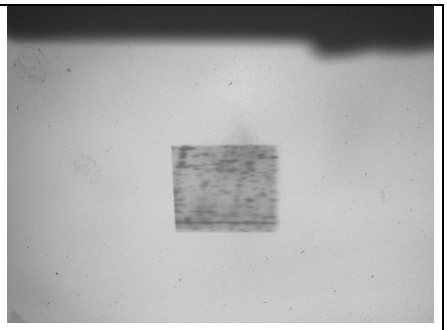

*Fig. 2c. The 3rd harmonic image of source through the crystal indicating inhomogeneities in the beam.*

*Fig. 2d. 2D magnification – along upper edge 21-times, along right edge 26-times, upper grid from Fig. 2a. Image distorted (elongated) mainly along the upper edge.*

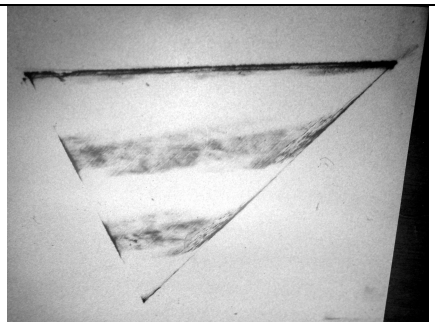

*Fig. 2e. 2D magnification - big grid with 204 μm pitch. The images of neighboring holes along the upper edge overlap which degrades resolution.*

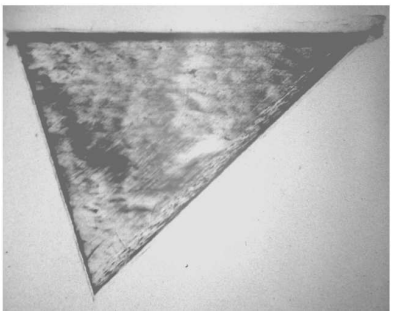

*Fig. 2f. 2D magnification without any object – inhomogeneous contrast, probably due to surface damage and distortions in the direction along the upper edge.*

keV, scintillation detector and X-ray eye to obtain desired diffractions, high resolution X-ray film and Frelon camera to record the X-ray images after the first, second and third diffractions. As several peaks were found, careful shielding of the beams by means of thin lead sheets had to be performed to get only the desired beams. Partial results obtained are presented in Fig.2.

As a result, three times successively diffracted beam was obtained and its spot recorded. Several kinds of metallic grids were used as objects but only the biggest one gave reasonable results. The quality of spots has not reached the quality of images from the previous experiment (see Fig. 1). Image recorded by Frelon camera was of lower quality than images taken on film. We were not successful when trying to get images at the energy increased to 10 keV. Degradation of resolution in one direction, mainly in comparison with previous experiment, is the main problem to fulfill all the aims stated in the proposal. In this regard, the effect of using inclined symmetric diffraction instead of noninclined should be considered. In addition, we have already started measures to improve technology of surface preparation for complex surfaces.

References


[1] D. Korytár, P. Mikulík, C. Ferrari, J. Hrdý, T. Baumbach, A. Freund, A. Kubena: J. Phys. D: Appl. Phys.**36** (2003) A65

[2] R. D. Spal: Phys. Rev. Lett. **86** (2001) **14** 3044