| ESRF | **Experiment title:** **Monolithic 2D beam compressor for hard X-ray microbeams** | **Experiment number**: MI-631 |
|---|---|---|
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## Report:

In our previous ESRF experiments IH-MI-105 and MI-598 a silicon monolithic 2D X-ray magnifier was tested at the beam energies around 10 keV. In its version with two noncoplanar asymmetric {311} diffractors we were able to obtain about 15 times magnification [1]. In the version with (422)+2x(311) diffractors the beam could pass through three successive diffractors but the image quality, namely resolution, was rather poor. Imperfect surface finish, unintentional presence of a piece of lead sheet during measurements, or bad surface quality were suggested as the possible causes.

In this experiment, the same repolished monolithic silicon crystal with 2x(311)+(422) diffractors was used as X-ray demagnifier or beam compressor. For this purpose, the beam directions had to be reversed compared to the beam magnifier. We could obtain again a blurred image of the X-ray beam three times successively diffracted at 2x(311)+(422) diffractors. The spatial resolution was destroyed, no structure in the outcoming X-ray beam was observed when inserting a metal grid in the incident beam. The experiment was further performed with 2x(311) asymmetric diffractors only, which has the drawback that the incident and outcoming beams are not parallel.

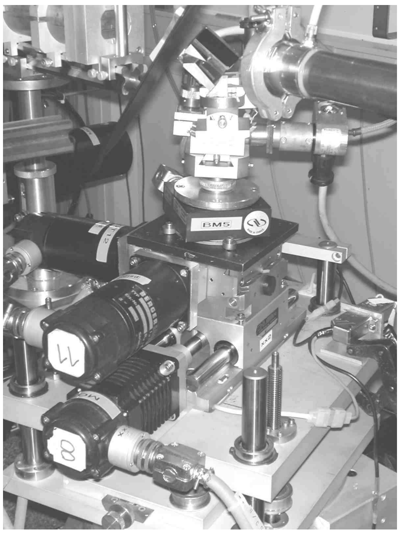


*Fig.1. Goniometer setting with monolithic X-ray beam compressor.*

The principle of the adjustment is the same as in the previous experiments: Crystal block with three diffractors is adjusted into the first diffraction in such a way that the reciprocal lattice vector of the first diffractor lies in the horizontal axis of the goniometer. By means of rotation crystal about the horizontal axis (Renninger scan) further multiple diffractions (both simultaneous and successive) can be obtained. All the necessary rotations and linear translations were provided by the goniometer setup at BM05. For the measurements, the monochromatized X-ray beam of the energy 9.5 keV was used. Scintillation detector and X-ray eye were used to find desired diffractions, primary and secondary slits of the beamline to define the incident beam, rectangular metal grids in the incident beam to form a structured incident beam (a system of microbeams at the output), and a fast medium resolution X-ray film and Frelon camera to record the X-ray images at the output side of beam compressor. Shielding the undesired radiation was not so critical as in the case of X-ray magnification.

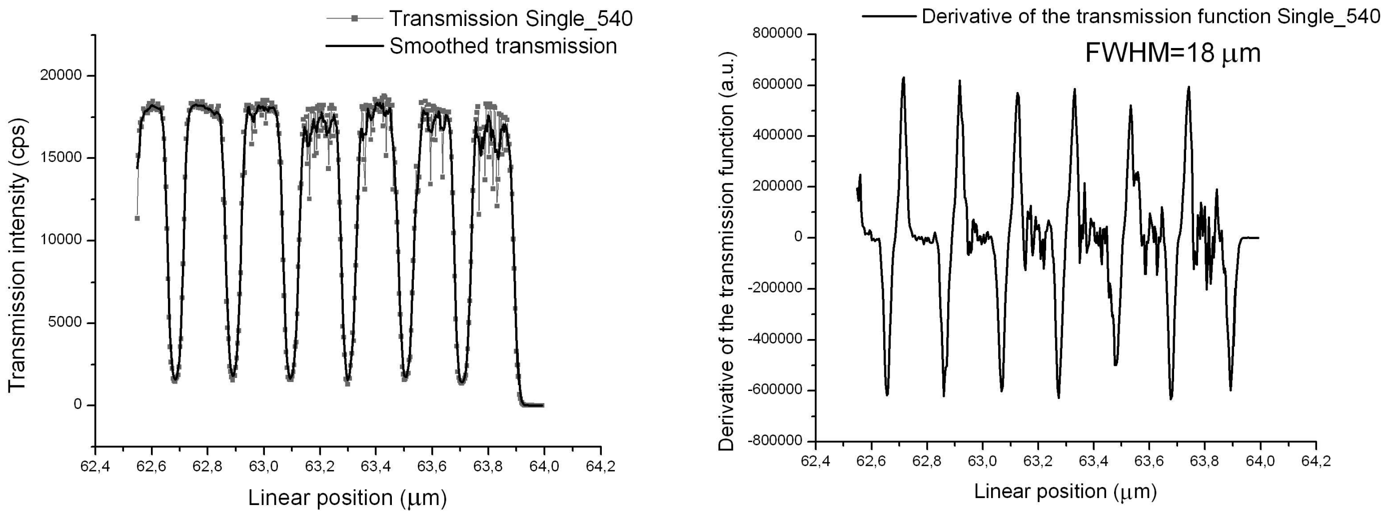
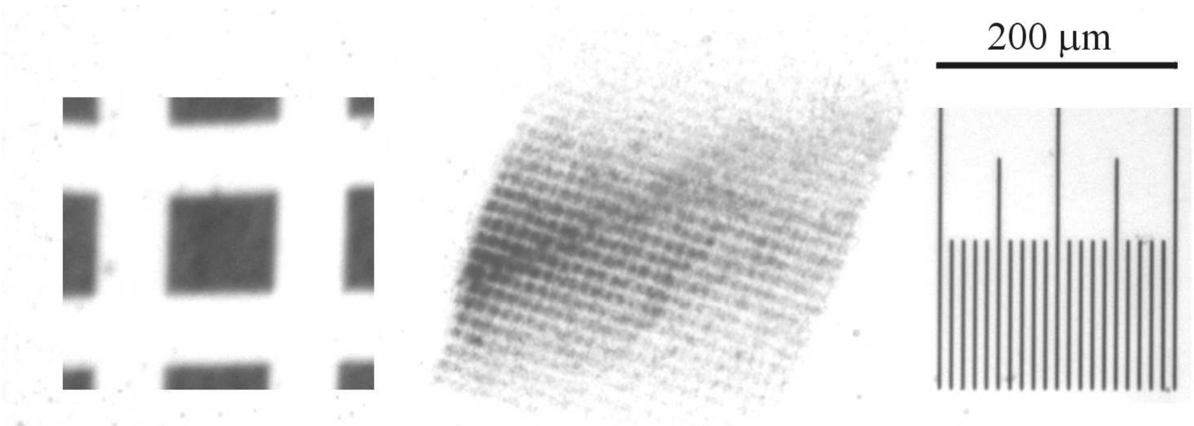



*Fig. 2.Transmission function of one single microbeam scanned with a microscopic grid (left) and its derivative giving the spatial resolution of 18 μm (right).*

Fig. 2 illustrates an indirect procedure to evaluate spatial resolution achieved. A beam of 0.1x0.1 $mm^2$ was formed by beamline slits and demagnified by the demagnifier. Microscopic grid was attached to detector arm and a transmission function was measured scanning the grid across the microbeam. Fig. 3 shows a direct procedure to evaluate the resolution. Fig. 3a) shows one window of a rectangular wire grid (68 μm windows and 45 μm wires), which was put into the incident beam and the demagnified image of this grid at the output of the X-ray beam compressor (b). The demagnification at the output side is about 10 and 13 times in vertical and horizontal direction, respectively. In due course, size of demagnified microbeams is below 10 μm, namely 7.6x9.9 μm (HxV), their separation is 3.3 μm horizontally and 4.3 μm vertically. In comparison with the X-ray magnifier, the exposition time on the same film decreased from 90 min to 2 min, which is another sign of real beam compression.




a) b) c)

*Fig. 3. More than 400 parallel X-ray microbeams (b) formed by a monolithic X-ray beam compressor at 9.5 keV by a wire grid (a) put into the incident beam. Microbeams size is 7.6x9.9 μm (HxV), their separation 3.3 μm horizontally and 4.3 μm vertically. Exposition time 2 min, film resolution not better than 2 μm. Fine scale lines in the inlet (c) are 10 μm apart.*

[1] Korytár D., Mikulík P., Ferrari C., Hrdý J., Baumbach T., Freund A., Kuběna A.: 2-D X-ray magnification based on a monolithic beam conditioner. J. Phys. D: Appl. Phys.**36** (2003) A65-A68.