ESRF

ESRF	**Experiment title:** **Optimization of V-shaped X-ray monochromators**	**Experiment number**: MI-987
Beamline: BM05	**Date of experiment**: from: 2.12.2009 to: 6.12.2009	**Date of report**:
Shifts: 12	**Local contact(s)**: Tamzin Lafford	*Received at ESRF:*

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Report:

The aim of the experiment was to test various mechanisms of the correction of refraction induced misalignment of two successive diffractors in V-channel monochromators and in this way to increase their intensity throughput. In addition, imaging properties of optimized V-channel monochromators were tested.

Compared to standard symmetrical or asymmetrical channel-cut monochromators with parallel channel walls the channel-cut monochromators with nonparallel channel walls (V-shaped monochromators) offer a possibility of beam footprint management, namely 1D beam expansion or compression. The effect is controlled by the asymmetry factor in both diffractors. In [1] a standard Ge (220) V-shaped monochromator for CuKα_1 with equal asymmetries (asymmetry angles 9°) and with total asymmetry factor of 5 is presented. Even with the asymmetry factor of 10 the two diffraction curves at channel walls are significantly overlapped and the total transmitted intensity is high. This overlap decreases with the increase of the asymmetry angles and for asymmetries more than 10 the intensity is too low for the V-shaped monochromators to be used.

Several ways how to increase the overlap of rocking curves at opposite channel walls were tested at this experiment, namely via a lattice parameter change (composition and temperature induced), using unequal asymmetries in the two diffractors [1, 2], and using a plastic wedge in the channel. The necessary angular shift of 15" between the two diffractors at opposite channel walls of a V-21 monochromator was obtained by 0.3% Si in graded GeSi single crystal and by a temperature difference of about 30 °C. Using two crossed V-channel monochromators 2D beam footprint managment for imaging purposes was tested.

To perform the experiments the infrastructure of the BM05 optics beamline with standard tunable Si (111) double crystal monochromator was used. Two times successively diffracted beam was measured (rocking curves, peak intensity, beam footprint homogeneity) at several energies around 8 keV in beam expanding mode. FReLoN camera with resolution 10 μm and Medipix camera with resolution 55 μm were used for measurements. By means of the optimized setup, we have studied objects in absorption, transmission and phase contrast. For ABI analysis [3] , the rocking curve imaging (RCI) software was used. [4].

In the experiment with linearly graded GeSi V-21 monochromator more than 2 times higher intensity throughput compared to pure Ge V-21 monochromator was observed for the beam energy of 8047.78 keV. This intensity gain was even higher for the beam energy of 9 keV. Figure 1 shows the outgoing beam inhomogeneities in linearly graded GeSi V-21 monochromator due to growth striations.

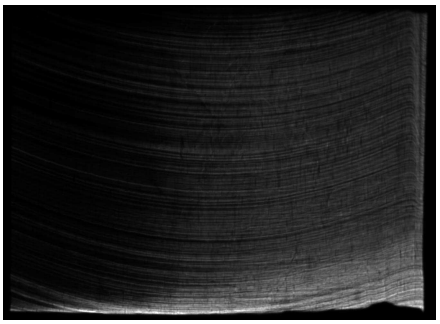
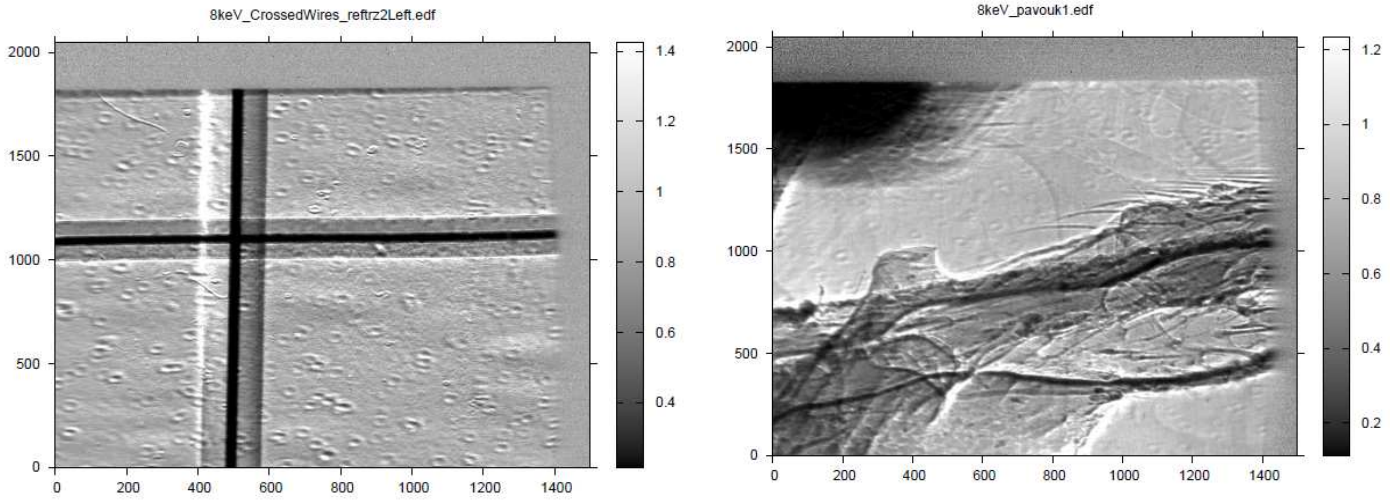


Fig. 1. Growth stiations in GeSi V-21 monochromator.

In the experiment with thermally tuned pure Ge V-21 monochromator the intensity gain of more than 3 times for the temperature difference of 30°C at the channel walls was obtained. Using RCI analysis material and temperature induced inhomogeneities were identified.

Results of the experiment with plastic prism and multiprism inserted into channel of V-21 monochromator indicate also the intensity increase, however, in thicker parts of the prism the absorption dominates the refraction induced intensity gain.

In the experiment with two crossed V-channel imaging monochromators optimized via unequal asymmetries up to 50 times 2D magnification was obtained depending on the photon beam energy over 8 keV as shown in Fig. 2.



a) *b)*

Figure 2. 2D magnified image of a cross made of W/B wire (15 μm W core) (a) and of a spider's leg (b).

[1] Korytár, D., Ferrari, C., Mikulík, P., Germini, F., Vagovič, P., and Baumbach, T.: *High resolution 1D and 2D crystal optics based on asymmetric diffractors.* In: Modern Developments in X-Ray and Neutron Optics. Series: Springer Series in Optical Sciences, Vol. 137. Eds. Erko, A. et al. Berlin: Springer 2008. ISBN: 978-3-540-74560-0. P. 501-512 and references therein.

[2] Ferrari C., Korytár D., Verdi N.: V-shaped asymmetric cut crystals for high intensity-high resolution monochromators, http://www.synchrotron-soleil.fr/images/File/instrumentation/cost/REZ-costweb/ferrari.pdf

[3] Baruchel J., Bleuet P., Bravin A., Coan P., Lima E., Madsen A., Ludwig W., Pernot P., Susini J.: Advances in synchrotron hard X-ray based imaging. C. R. Physique 9(2008) 624

[4] Mikulík P., Lübbert D., Pernot P., Helfen L., and Baumbach T., Applied Surface Science 253, 188–193 (2006).