ESRF	**Experiment title:** Hard x-ray fluorescence microtomography and scanning microscopy with sub-micrometer resolution using refractive x-ray lenses	**Experiment number:** MI-704
Beamline: ID13	**Date of experiment:** from: Dec. 13, 2004 to: Dec. 20, 2004	**Date of report:** March 1, 2005
Shifts: 18	**Local contact(s):** M. Burghammer	*Received at ESRF:*

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Report:

During the second beam time of this long term project, a prototype for a fluorescence nanotomography station based on nanofocusing lenses (NFLs, Fig. 1 (left)) [1, 2, 3] was commissioned. This was done in particular in preparation of two user experiments (ME-887 and ME-889) carried out in Jan. and Feb. 2005. The nanotomography station was designed and built at Aachen University and integrated into the microprobe setup in EH2 of ID13, 47m from the source (Fig. 1 (right)). A new generation of silicon NFLs fabricated with 4"-wafer technology was used to generate a nanobeam that was characterized by a fluorescence knife edge technique. The optics were tested at 21keV and 15.2keV. At 21keV, the smallest lateral beam size was achieved, i. e., $50 \times 50\text{nm}^2$ (Fig. 2). In this experiment, the nanofocusing lenses have a focal distance of $f_h = 10.7\text{mm}$ and $f_v = 19.0\text{mm}$, imaging the low-β in-vacuum undulator source (effective size $\approx 150 \times 60\mu\text{m}^2$ (FWHM)) in 4400×2460 fold demagnification onto the sample position. The expected nominal focus size of $46 \times 50\text{nm}^2$ is in good agreement with the measured result. As nearly nominal focusing was achieved, it can be expected that future improvements of the focus size down to 20nm are conceivable for the current setup [4]. The origin of the tails of the focus found in all measurements sofar is currently under investigation. The experiments were carried out in 16-bunch mode. A flux of $3 \cdot 10^7$ph/s was measured in the nanobeam, corresponding to about $1.7 \cdot 10^8$ph/s at a ring current of 200mA. A next generation of boron lenses was tested that was made with an improved lithographic fabrication scheme. However, as in the previous experiment, the wafer flatness was still not sufficient to guarantee homogeneous focusing over the full depth of the lens. Sufficiently flat boron wafers will hopefully be available soon.

In preparation of fluorescence scanning experiments, the fluorescence from several (NIST) standards was measured to determine the sensitivity of the setup. The evaluation of the spectra is in progress.

Figure 1

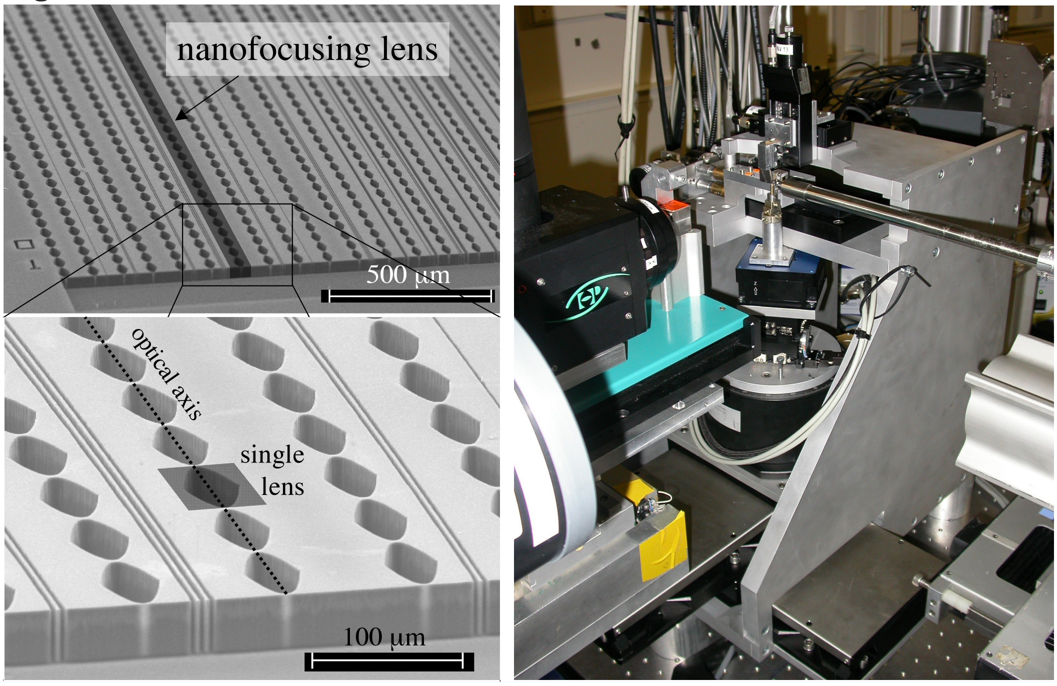
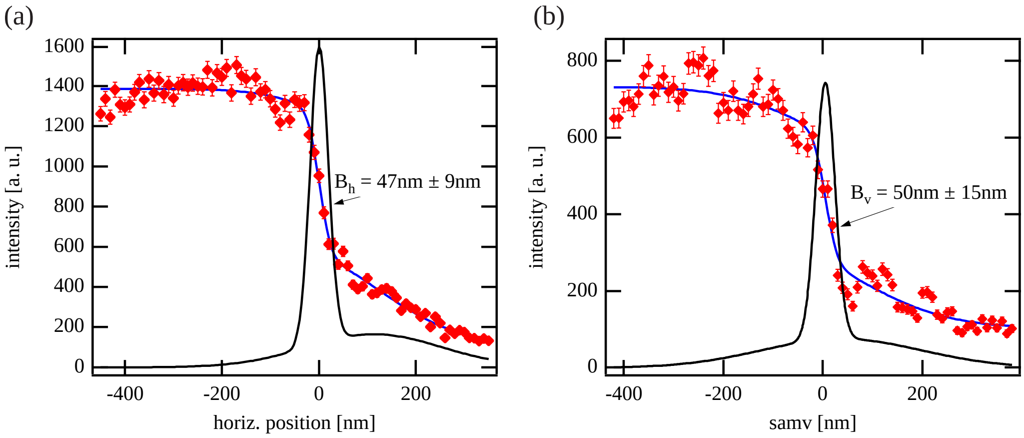


Figure 2



In conclusion of this part of the long term project, several routes for the improvement of the setup were identified. The mechanical stability of the setup will be improved by replacing some of the stages used for alignment by magnetic mounts to generate a more compact and stable setup. In addition, active vibration damping will be introduced. A next generation of refractive x-ray lenses, so-called *adiabatically focusing lenses* will be fabricated in silicon [4]. A publication in APL of the current results is in preparation.

References

[1] C. G. Schroer *et al.*, Appl. Phys. Lett. **82**, 1485 (2003).

[2] C. G. Schroer *et al.*, in *Design and Microfabrication of Novel X-Ray Optics II*, Vol. 5539 of *Proceedings of the SPIE*, edited by A. S. Snigirev and D. C. Mancini (SPIE, Bellingham, 2004), pp. 10–19.

[3] O. Kurapova *et al.*, in *Design and Microfabrication of Novel X-Ray Optics II*, Vol. 5539 of *Proceedings of the SPIE*, edited by A. S. Snigirev and D. C. Mancini (SPIE, Bellingham, 2004), pp. 38–47.

[4] C. G. Schroer and B. Lengeler, Phys. Rev. Lett. **94**, 054802 (2005).