ESRF

Experiment title: Development of CRLs for hard x-ray full field microscopy, magnifying high resolution microtomography, and fluorescence element microtomography	**Experiment number:** MI-506

Beamline: ID22	**Date of experiment:** from: 18/09/2002 to: 23/09/2002	**Date of report:** February 28, 2003 *Received at ESRF:*
Shifts: 15	**Local contact(s):** A. Somogyi	

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Report:
This beamtime was used for two purposes, the characterization of newly developed *nanofocusing lenses (NFL)* and the improvement of fluorescence microtomography techniques, in particular in view of improved spatial resolution.
The nanofocusing lenses made at the Aachen University are planar parabolic lenses made of Si with extremely small radii of curvature ($R = 1 - 3\mu$m, $N = 100$) allowing for focal distances in the millimeter range at hard x-ray energies (cf. Fig. 1(a)). This allows one to generate a microbeam of sub-micrometer dimensions (also in the horizontal direction) at short distances ($L_1 = 42$m) from a high-β undulator source. The planar lenses require the use of a crossed geometry to obtain two dimensional focusing. A special lens stage was designed to bring the dual lens setup close the sample (see Fig. 1(b)).

Figure 1(a)

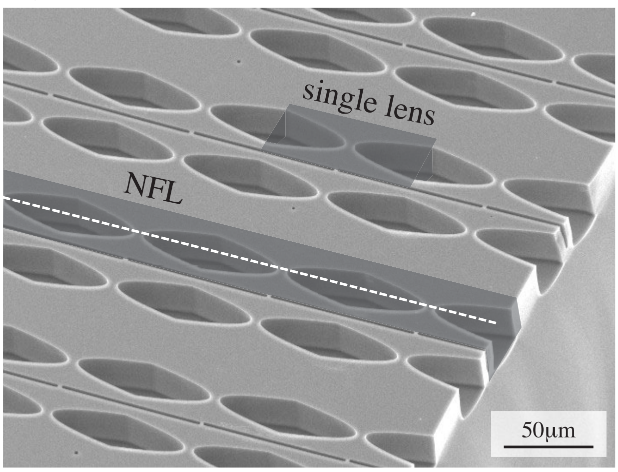
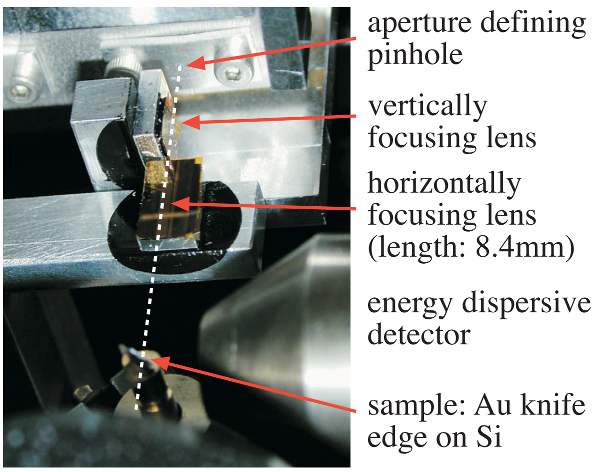


Figure 1(b)



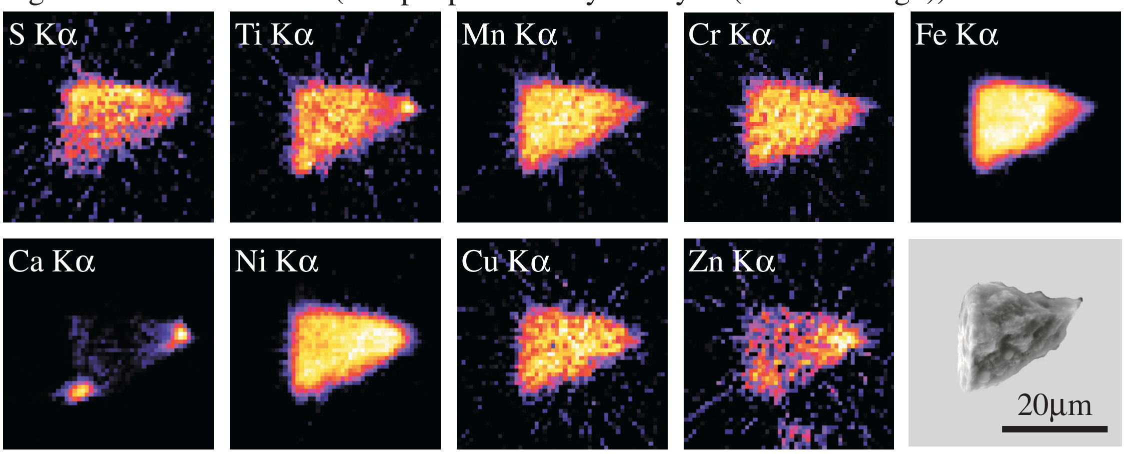
The beam profile was measured by a fluorescence knife-edge technique. At 25keV, a horizontal image distance $L_{2h} = 15.6$mm was realized with an NFL with $N = 100$ single lenses ($R = 2.15\mu$m). A second NFL ($N = 50$, $R = 2.0\mu$m) focused the beam vertically a distance $L_{2v} = 26.7$mm behind its center. Both lenses were aligned such that their focal planes coincided at the sample position. The lateral full width at half maximum beam size was determined to 380×210nm^2 with a flux of $1.2 \cdot 10^8$ph/s at 25keV. Details of the results and future prospects of these lenses are published in a recent Appl. Phys. Lett. [1].

The mechanical stability of the lens stage and the repeat accuracy of the sample stage used for scanning (knife-edge and fluorescence tomography) is not sufficient to fully exploit the potential of the microbeam produced by nanofocusing lenses. In particular, larger demagnifications are conceivable that can reduce the microbeam vertically to well below 100nm. At the Aachen University, we are currently designing and building a compact and more stable setup.

To increase the flux in the microbeam, we inserted a Be parabolic refractive lens ($N = 136$, $R = 208\mu$m) into the beam path 1100mm before the NFL. The Be produced a virtual image of the source about 400mm behind the NFL, focusing the beam into the NFL's aperture. As a result, the flux in the microbeam was increased to $4.6 \cdot 10^9$ph/s. In this setup, the horizontal demagnification was reduced from 2700 to 750, leading to an increased horizontal beam size of 1.2μm (FWHM).

This microbeam was used to record 3 fluorescence microtomograms of plant samples and one of a micrometerorite. As an example, a virtual section throught the micrometeorite is shown in Figure 2 for various elements together with an electron micrograph of the meteorite (lower right image in Figure 2). The tomogram was recorded with a translational step size of 600nm (Nyquist theorem fulfilled). 70 projections with 52 translational steps each were recorded. The exposure time was 2s per point.

Figure 2: Micrometeorite (Sample provided by G. Flynn (U. Plattsburgh))



The tomographic slices shown in Fig. 2 were reconstructed using filtered back projection. A detailed analysis using a self-consistent attenuation correction is in progress.

[1] C. G. Schroer, M. Kuhlmann, U. T. Hunger, T. F. Günzler, O. Kurapova, S. Feste, F. Frehse, B. Lengeler, M. Drakopoulos, A. Somogyi, A. S. Simionovici, A. Snigirev, I. Snigireva, C. Schug, W. H. Schröder, *Appl. Phys. Lett.*, **82** (9), 1485 (2003)