ESRF	**Experiment title:** 2D x-ray waveguides with pre-focussed beam: Development of novel imaging technique	**Experiment number:** MI 770
Beamline: ID22	**Date of experiment:** from: 14 April 2005 to: 21 April 2005	**Date of report:** September 9, 2005
Shifts: 18	**Local contact(s):** Remi Tucoulou	*Received at ESRF:*

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Report:
Based on the achievements of experiment MI 686 [1] the aim of this experiment was to develop new imaging techniques applying the coherent and diverergent nano-beam exiting a two-dimensionally confined x-ray waveguide.

- **Scanning Fluorescence Holography**: Due to the divergence of the waveguide beam the achievable resolution depends crucially on the distance between the sample and the waveguide exit. In this experiment the sample consisted of a lithographically prepared gold structure on a Si foil and the flourescence signal was measured at the Au L_α line. The experimental setup allowed to decrease the distance between the waveguide and the sample down to approximately 160 micron. A knife edge scan (Fig. 1) of the gold structures showes a FWHM of about 190 nm.

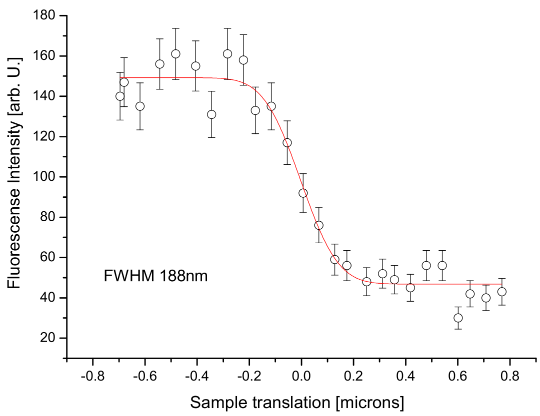

Fig. 1: A knife-edge scan of a gold sample in the waveguide beam demonstrates a spatial resolution below 200 nm (FWHM of fitted error function).

- **Lens-less imaging**: For the first time we could take a magnified image of an object in the waveguide beam (Fig. 2b–2d). A gold wire of roughly 6 micron thickness is well resolved using a 2D detector with 60 micron pixel size. Brigth fringes are visible at both edges of the wire indicating the coherence of the beam. However, the relatively low efficiency and large pixel size of the detector still limit the image quality. The far-field diffraction patterns of some waveguides show unexpected structures that disturb the image. Fig. 2e and Fig. 2f show sequently measured far-field diffraction patterns of two identically prepared waveguides on the same substrate. While the diffraction pattern of one waveguide (e) is heavily disturbed the other one (f) shows the expected Gaussian-like shape.

  For future experiments significant improvements may be expected by the use of a more efficient direct illumination CCD detector with smaller (20 micron) pixel size. Also the divergence of the beam may be further increased using waveguides with heavier cladding material (i.e. larger critical angle) compared to Si used here and decreasing the photon energy that was 12 keV in the present experiment.

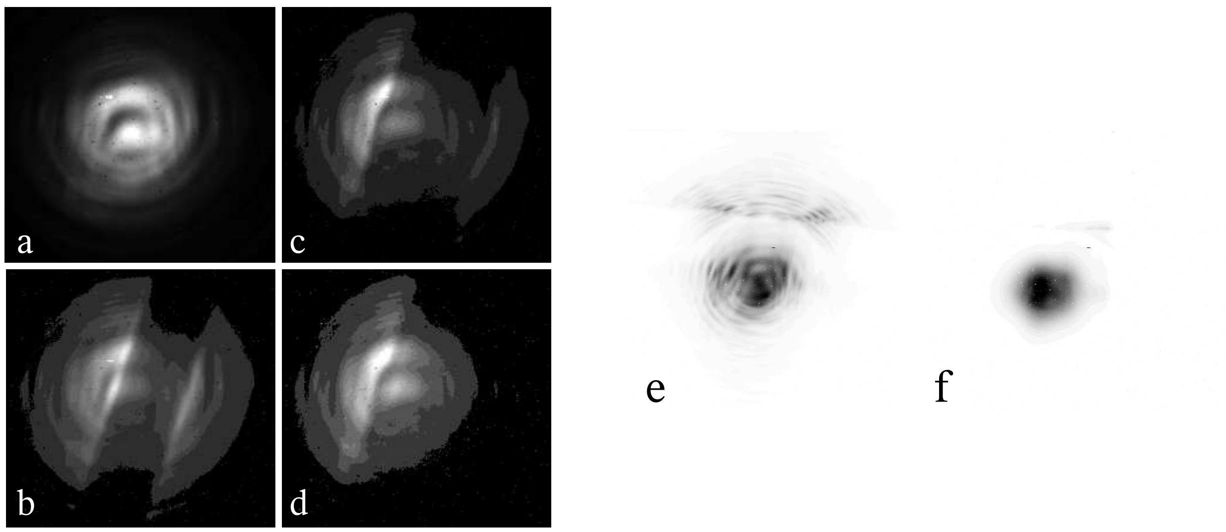

Fig. 2: Images of a 6 micron thick Au fiber in the waveguide beam: (a) waveguide beam without sample, (b)–(d) images taken at decreasing waveguide-to-sample distances corresponding to an increasing degree of magnification. The quality of the waveguide beams varies strongly for the individual waveguides (e,f).

References

[1] A. Jarre, C. Fuhse, C. Ollinger, J. Seeger, R. Tucoulou, and T. Salditt, *Two-Dimensional Hard X-Ray Beam Compression by Combined Focusing and Waveguide Optics*, Phys. Rev. Lett. **94** 074801 (2005).