ESRF	**Experiment title:** Coherent Diffraction Microscopy	**Experiment number:** MI-747
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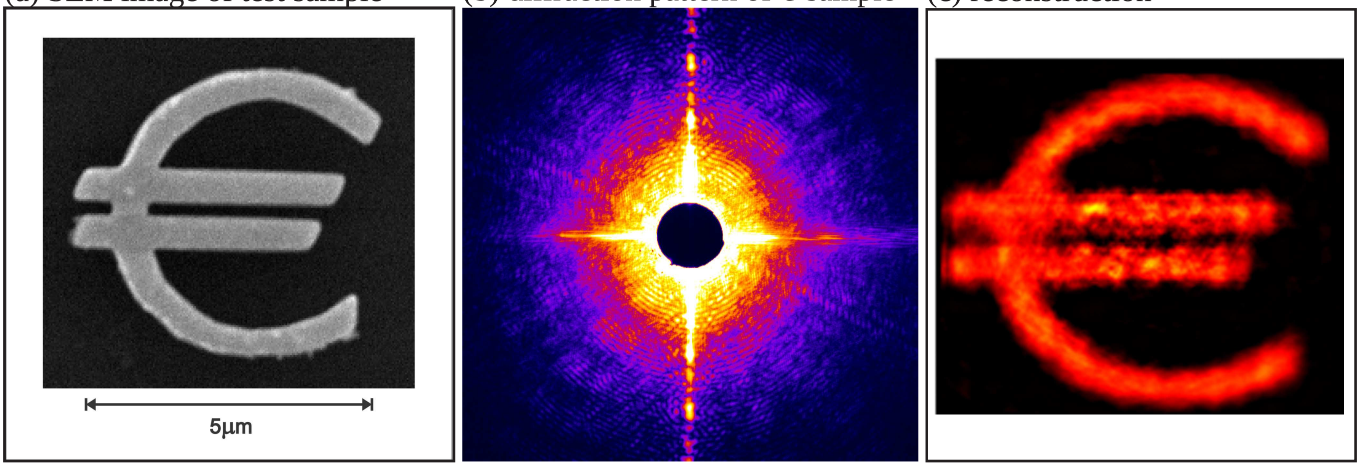
Report:

We performed coherent Fraunhofer diffraction experiments on a variety of small test samples. The aim of the experiment was to record far-field diffraction patterns in forward direction from coherently illuminated samples and reconstruct their real space transmission function by phase retrieval techniques. The test samples have a size between 3 and 10μm, are made of gold (150nm thickness) and were deposited on a Si_3N_4-membrane of 200nm thickness. Various shapes comprising parallel stripes and round features have been realized, including the 5μm-sized €-symbol shown in Fig. (a).

The experiment was setup at ID01. The x-rays from the low-β undulator source were monochromatized using a Si 111 double-crystal monochromator located 34m from the source. The second crystal of the monochromator was slightly sagittally bent. The monochromatic beam (7 and 10keV) was cut down in size to $40 \times 40\mu\mathrm{m}^2$ by a pair of polished slits located at 46m behind the source. A second pair of polished guard slits with a gap between 100 and 140μm was located 80cm behind the first pair of slits, about 20cm before the sample. Up to the sample, the whole beam path was kept in vacuum, with a small kapton window in front of the sample. The sample was kept in air.

Two detectors were used to record the diffraction pattern, one scintillator-based detector with high spatial resolution ($< 4\mu$m) to record the central part of the pattern and one directly illuminated CCD with (20μm pixel size) to record the diffraction pattern up to about 30nm resolution. The patterns recorded with both detectors were to be combined to cover a large Q-range of the diffraction pattern. Three beamstops with 0.3, 1, and 2mm diameter were used to block the central part of the diffraction pattern. The sample to detector distance was varied between 3.4 and 4m. The beam path from the sample to the detectors was evacuated, with a small kapton window behind the sample and several kapton windows in front of the detectors.



(a) SEM image of test sample (b) diffraction pattern of €-sample (c) reconstruction

After alignment of the setup, the diffraction patterns of the various test samples were recorded at $E = 10$keV and $E = 7$keV. Different guard slit and beamstop combinations were tested to minimize the slit scattering background in the diffraction patterns. Fig. (b) shows the diffraction pattern of the €-symbol recorded at $E = 7$keV with a 2mm beamstop. In the vertical direction, the strong scattering of the two horizontal bars is clearly visible. Circular fringes stem from the circular features in the object. Fringes are visible to the border of the detector, corresponding to approximately 30nm resolution. Similar diffraction patterns with a 1mm beamstop were successfully recorded. However, the diffraction pattern recorded with the 0.3mm beamstop contained strong slit scattering and contributions of higher harmonics.
Filling the missing central part of the diffraction pattern with the Fourier transformed SEM-image of the sample, the object was reconstructed as shown in Fig. (c). The reconstruction was made difficult by reduced fringe visibility in the diffraction pattern that is a result of reduced lateral coherence of the illumination. Evaluating the fringe visibility, an effective lateral coherence length below 2μm is found that lies well below the value expected for a low-β source. This is most probably due to vibrations of the monochromator and a slight sagittal bending of the second monochromator crystal, that focused the beam onto the detector and the sample for $E = 10$keV and $E = 7$keV, respectively. Unfortunately, a complete unbending of the crystal was technically not possible. In the future, a flat monochromator especially stabilized to reduce vibrations will help to preserve the lateral coherence at the sample position.
First results of this experiment were given in an oral presentation at XRM2005 in Himeji, Japan and will be published in the conference proceedings [1]. Further evaluation is in progress.

References

[1] A. Schropp *et al.*, in *X-Ray Microscopy (8th International Conference on X-ray Microscopy)*, *IPAP Conference Series*, edited by Y. Kagoshima (IPAP, Tokyo, 2005), to be published.