Hard X-Ray Scanning Microscopy with Fluorescence and Diffraction Contrast

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bmb+f Großgeräte der physikalischen Grundlagenforschung

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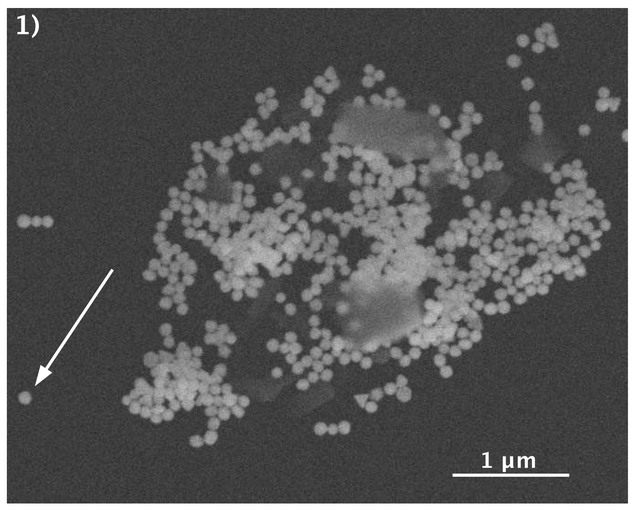
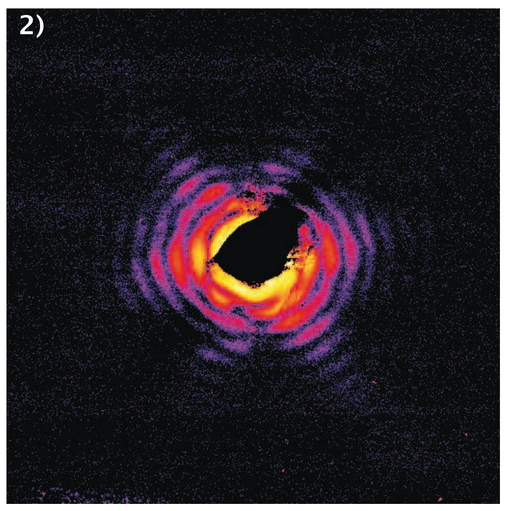
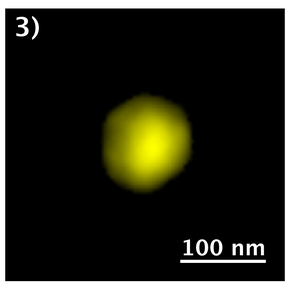
ESRF

Coherent Diffraction Imaging







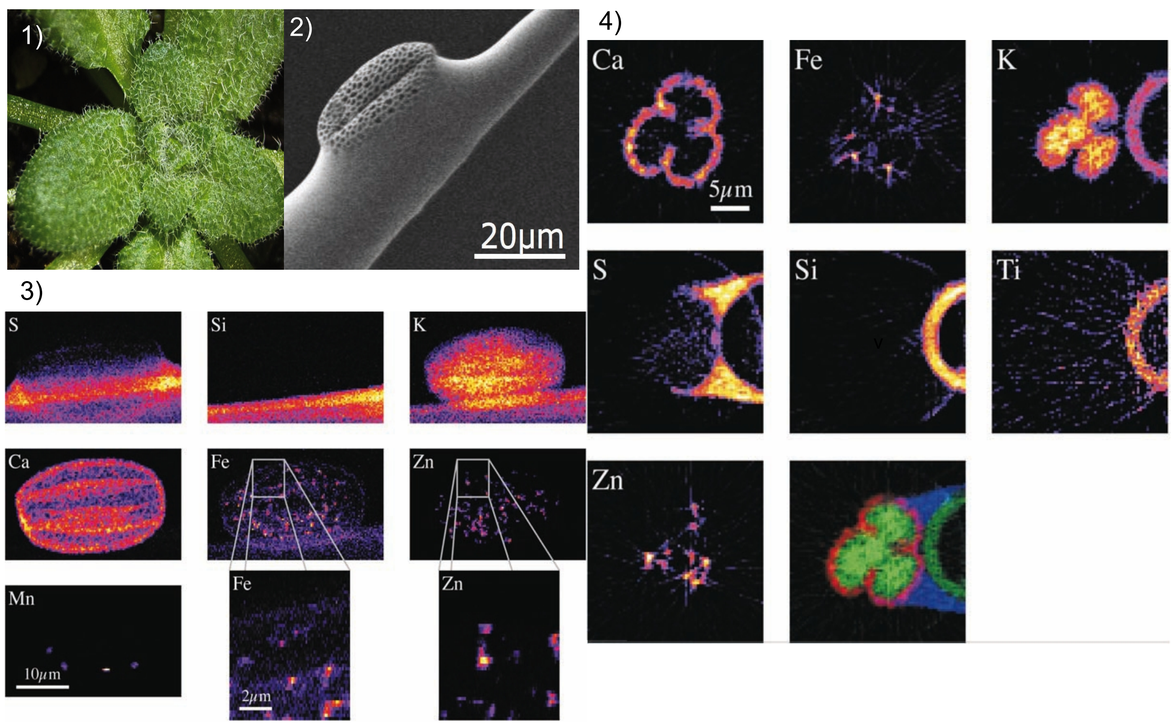
1) Scanning electron micrograph of gold particles (diameter ≈ 100 nm) deposited on a Si_3N_4-membrane.

2) Diffraction pattern (logarithmic scale) recorded of the single gold particle pointed to by the arrow in 1).

3) Reconstructed projected electron density of the gold nanoparticle shown in 1).

- Illumination with a nanobeam of 100 x 100 nm^2 size in focus, an energy of E = 15.25 keV, and a flux of 10^8 ph/s (exposure time 10 x 60 s).
- Reconstruction by using the diffraction pattern shown in 1) and the hybrid input-output (HIO) method together with a so-called shrink wrap algorithm.
- 200 independent reconstructions.
- 191 converged to similar enantiomorphs of the gold particle. These were combined to an average reconstruction shown in 3).
- Spatial resolution between 3.8 nm and 7.6 nm (~ 5 nm by phase retrieval transfer function).

Fluorescence Mapping and Tomography



Fluorescence experiment on a pollen of *Arabidopsis thaliana*.

1) Photograph of Arabidopsis thaliana.

2) Scanning electron micrograph of the pollen used in the experiment. The pollen was glued to a glass capillary.

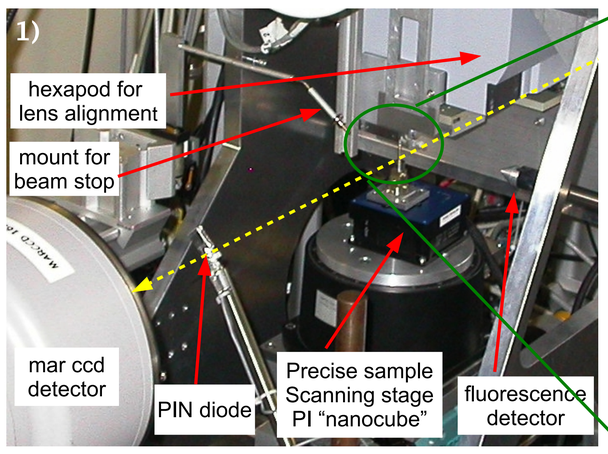
3) Two-dimensional element distribution mapping with a resolution of 100 nm.

4) Tomographic reconstruction of the element distribution within the pollen. The lateral resolution was 300 nm.

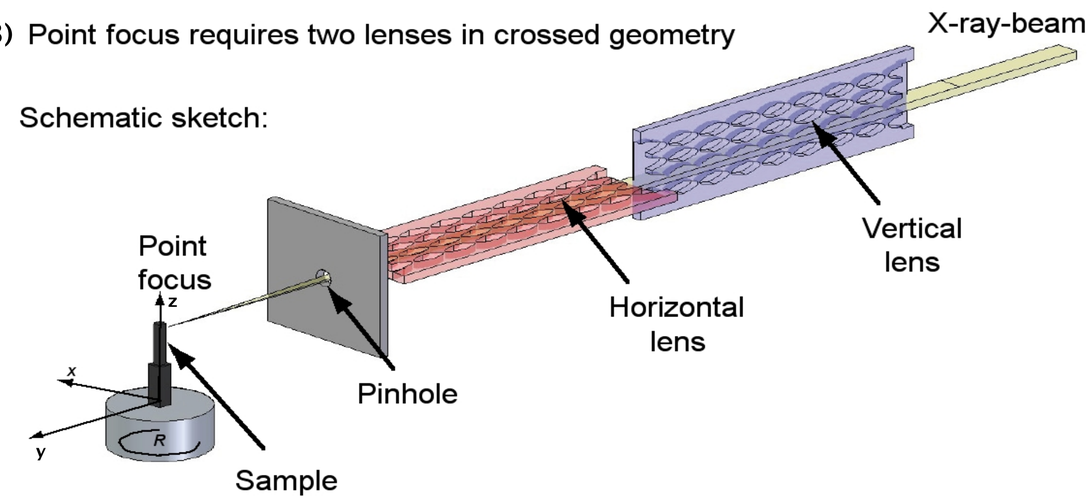
References

- C. G. Schroer et al, Coherent X-Ray Diffraction Imaging with Nanofocused Illumination , *Phys.Rev.Lett.*, **101**(9), 090801, 2008.
- C. G. Schroer et all, Hard x-ray nanoprobe on refractive x-ray lenses, *Appl.Phys.Lett.,* **87**, 124103, 2005.

Experimental Setup



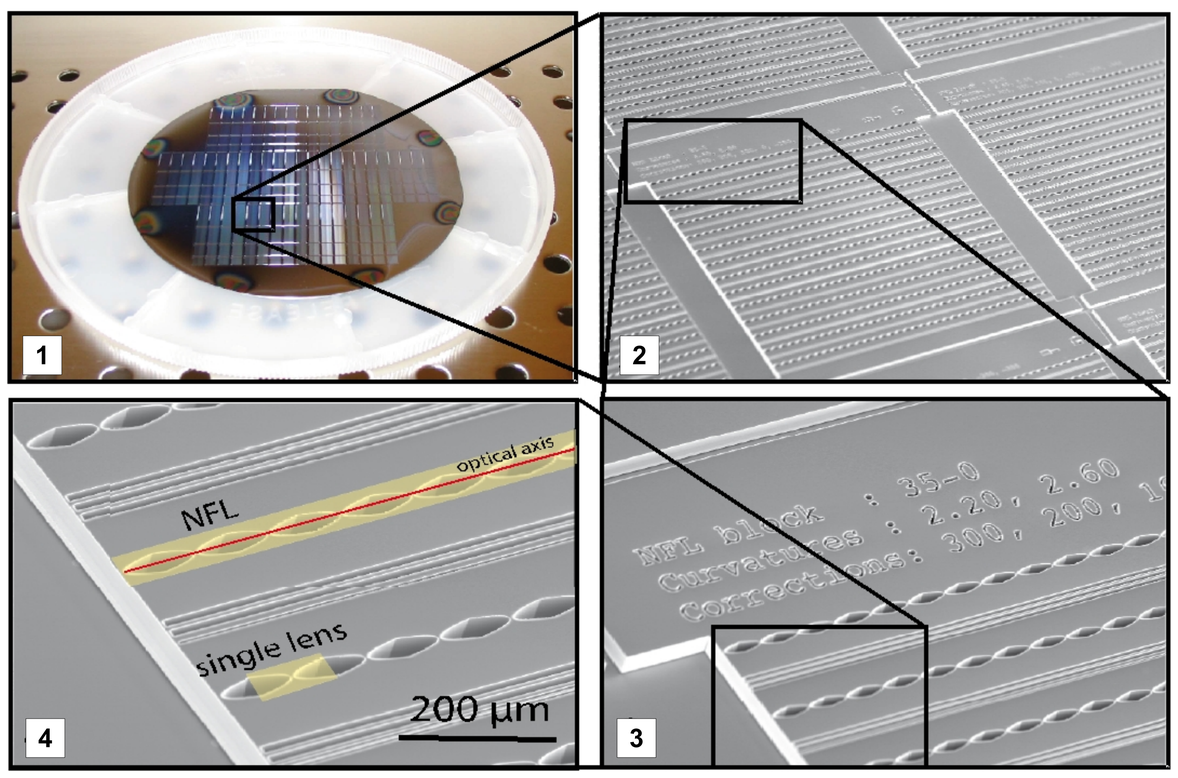
3) Point focus requires two lenses in crossed geometry



1)/2) Foto of the experimental setup as realized at ID 13, ESRF.

- There are several detectors such as a mar ccd camera, a high resolution x-ray camera, an energy dispersive detector and a PIN diode.
- The x-ray beam (yellow dashed line) is focused in two directions by crossed nanofocusing lenses shown in 3). The horizontal lens is fixed to the setup and can be aligned using a hexapod table on which the whole experiment is set up. The vertical lens is then adjusted by means of a mini hexapod.
- The sample is mounted on a high-precision piezo stage and can be scanned through the beam.
- A SiLi-detector detects the fluorescence light from the sample and a mar ccd detector records the diffraction pattern.

Focusing Device: NFL



- 1) Lenses made by 4-inch silicon wafer technology. There are 14 identical chips of a set of lenses arranged on the wafer shown in 1). Each chip holds more than 40000 single structures with 16 blocks of lenses.
- On each block there are 14 lenses with 2 different radii of curvature and 7 different corrections for under-etching. The different blocks contain different numbers of single lenses in a row, 2)/3).
- 2) Scanning electron microscope image of one block.
- 3) An individual bar code is structured into the wafer in between the lenses to ease the process of alignment of the lenses in the beam.

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