Iterative Phase Retrieval from Incomplete Coherent Diffraction Patterns

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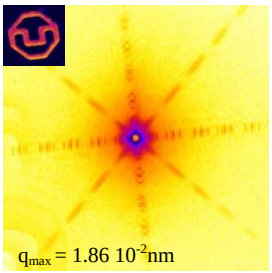
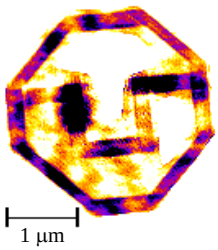
Coherent x-ray diffraction imaging (CXDI) is a suitable method to determine the structure of small, non-periodic objects up to a resolution on the nanometer length scale [1,2]. It can be considered as a microscopic technique providing information on structural properties of micro- and nano-objects in a variety of scientific fields, e.g. whole-cell imaging [3] and mesoporous structures.

In order to develop the method a new setup was designed and built. It allows for the in-vacuum sample positioning with nanometer accuracy in all three dimensions. Furthermore, a high resolution x-ray detector with an effective pixel size of 0.65µm is available to monitor the incoming beam intensity distribution as well as for slit and sample alignment. The diffraction patterns were recorded by a directly illuminated CCD with a pixel size of 20µm. Additionally, a rotation stage is foreseen for tomographic 3D-methods. Using this movable setup a first experiment was carried out at beamline ID10C, ESRF.

The reconstruction results of experimental data are strongly influenced by the quality of the measured coherent diffraction pattern. First of all, partial coherence effects reduce the visibility of interference fringes which can lead to artifacts in the reconstructed image. Furthermore, a certain amount of low frequency data is lost due to the beam-stop, additional parasitic scattering from the slit blades or a contribution of third harmonic photons in the central part of the diffraction pattern. The missing data can be provided either directly by using simulated diffraction data from a low resolution image, e.g. a SEM-image, or by using a tight support in order to confine the number of possible solutions at low frequencies.
In fig. a) the measured diffraction pattern of a lithographically prepared gold structure (size of 3µm and thickness of 150nm) is shown.
A first reconstruction result from this data set is presented in fig. b).



a) Diffraction pattern of a gold pattern (TU-Dresden logo)



b) Reconstruction of a)

In this presentation we will show the reconstruction results from experimental data obtained at the ESRF and discuss the reconstruction artifacts that can emerge if the data are incomplete.

[1] J. Miao, et al., Nature, **400**, 342 (1999)
[2] H. Chapman et al., JOSA A, **23**, 1179-1200 (2006)
[3] D. Shapiro et al., PNAS, **102**, 15343 (2005)