Imaging experiments and detection devices at the FLASH

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Introduction With FLASH, a strong device with laser like properties is available. To determine some of the characteristics of this new source with radiation in the EUV spectral region we arranged two different experiments. First we focused the FEL beam with diffractive transmissive optics. This was done at 32 nm and 13.8 nm wavelength at the unfocussed beamline BL3 by using a zone plate based scanning microscope (CSTXM) [1]. Second we tested a new wavefront sensor setup for wavefront characterization [2].

Focussing experiment First we placed some thin foils as Zr, Si and Al into the beam. Since all of them kept alife we decided to build up a zone plate based scanning microscope at FLASH to determine the achievable focal spot size of the FEL beam. A schematic of the setup is shown in fig. 1.

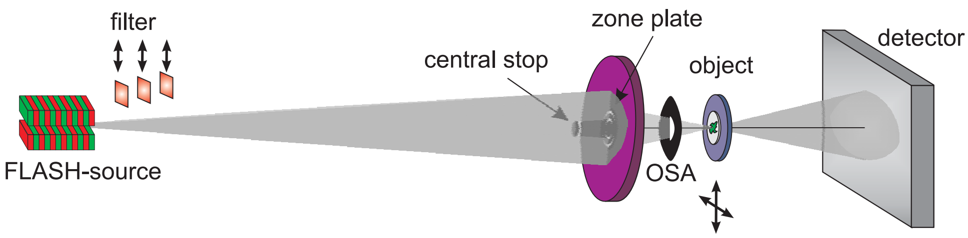
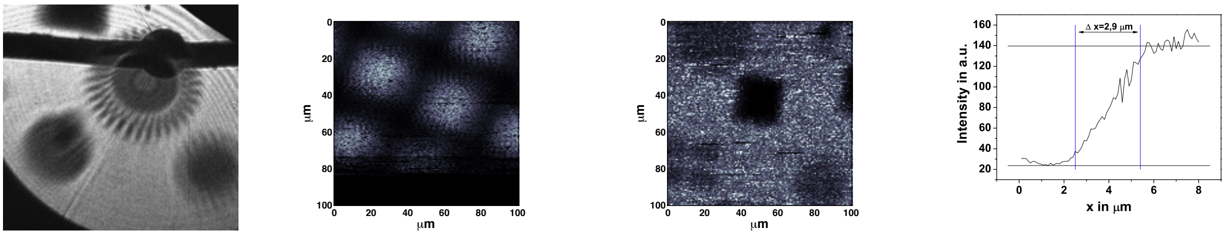


Figure 1: Schematic of the setup of the scanning microscope

To decrease the power and to be sure no damage will be caused to the zone plate some filters (160 nm Si with 200 nm Zr, 200 nm Zr and 300 nm Al) were placed between source and zone plate. The zone plate (ZP) is combined with a central stop (CS) and an order sorting aperture (OSA) to block other diffraction orders than the $+1^{st}$. On a piezo driven stage the object is placed in the focal plane of the ZP. This way the object can be scanned with a resolution of 1nm and a full travel range of 100x100 μm^2. The best possible resolution δ=120 nm of the setup is given by the ZPs outermost zonewidth dr_n=98 nm. As detector a simple EUV sensitive photodiode was used. To adjust the microscope the photodiode was replaced by a back illuminated CCD. As object a Ni-mesh normally used as calibration tool for electron microscopes and a structured Si_3N_4 membrane was used. The structures are different siemens stars and gratings.
Fig. 2 (a) shows a section of the Si_3N_4 membrane. The siemens stars have an outermost spoke width of 2 μm and 1 μm decreasing down to 100 nm. Additionally there are different types of gratings. For edge test homogeneous structured squares are existent, too.

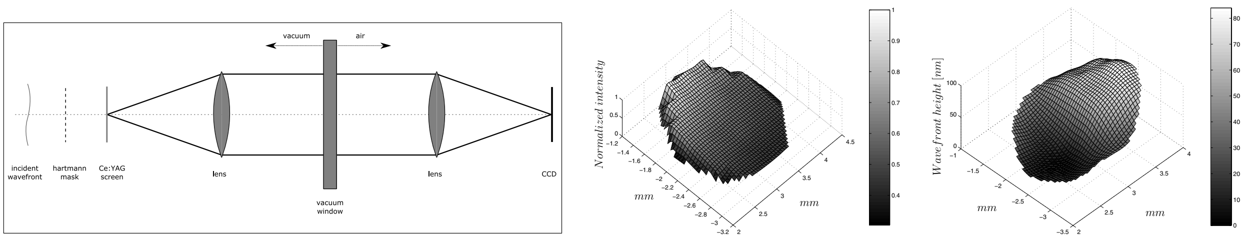
The images obtained with the CSTXM are given in fig. 2 (b-d). Image (b) is taken from the calibration grating. The grating period is 12.6 μm with a bar width of 5 μm. The siemens stars and gratings could not be resolved as one can see in (c). An analysed edge test (d) determines the resolution to $\delta \approx 3\,\mu$m. For the image recording one FEL pulse per pixel was used. The pulse substructure had not been used so the image was taken with five pixels per second. Due to the temporal shift of the FEL intensity the pixel to pixel fluctuation is very high, sadly as high as the normal signal.



(a) (b) (c) (d)

Figure 2: (a) Objects imaged with the zone plate onto a CCD. The exposure time was 10 s. Scanning microscopic image of an electron microscope calibration Ni-grating (b), of a Si_3N_4 wafer with the siemens stars and gratings (c) and the graph of an analysed edge (d). Exposure time was 1 pixel per pulse at 5 Hz.

Wavefront sensor Beside focusing, a new wavefront sensor, developed at RheinAhrCampus Remagen, was tested at beamline BL3 (unfocused beam) at a wavelength of 13.8 nm. This wavefront sensor is based on the Hartman principle and uses an indirect detection method. The spot pattern, obtained by illuminating a regular grid of subapertures, is converted to visible light by a Ce:YAG scintillator screen which, in turn, is imaged onto a CCD camera, located outside the vacuum system. Additional aberrations introduced by the imaging system are compensated in software after initial calibration of the setup. A schematic setup of the wavefront sensor is depicted in fig. 3.



(a) (b) (c)

Figure 3: (a) Schematic of the modified Hartmann wavefront sensor, suitable for operation in the X-ray spectral range. The spot pattern, obtained by sampling the incident wavefront, is detected by a Ce:YAG screen which is imaged onto a CCD-chip. Normalized beam intensity profile (b) and wavefront (b) of the unfocused VUV-FEL beam. Data was acquired at beamline BL3 operating at $13.8\,\mathrm{nm}$.

Due to this intermediate conversion, the wavefront sensing device is applicable to a large wavelength range in the EUV and X-ray spectral region.
In fig. 3 (b, c) the normalized beam intensity distribution and the acquired wavefront is shown.
The beam diameter was reduced to 2 mm by an aperture in front of the experiment. Since this aperture did not extract the central part of the beam,
intensity varies over the aperture region. The obtained wavefront shows some aberration. This will be subject to further evaluation.

References

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