Parallel Multiorder Imaging with Nanometer Resolution using Multilayer Zone Plates (MZP)

Jakob Soltau\textsuperscript{a}, Jesper Wallentin\textsuperscript{b}, Tim Salditt\textsuperscript{a} and Markus Osterhoff\textsuperscript{a}

\textsuperscript{a}Institute for X-ray Physics, University of Göttingen, Germany,  
\textsuperscript{b}Synchrotron Radiation Research, Lund University, Sweden

Author Email: jakob.soltau@uni-goettingen.de

At modern synchrotrons, in many imaging setups, x-ray optics such as zone plates are used to focus hard x-rays down to a few nanometer spot size for the illumination of a sample [1]. Generally, order sorting apertures (OSA) are used to reduce the illumination to only the plus first order focal spot. This means, however, that the possible information of the illumination by other orders is lost and the efficiency of the imaging setup is greatly reduced.

In a recent experiment at the PETRA III endstation GINIX@P10, an MZP [2,3] without an OSA has been used in a scanning microscopy setup at 13.8 keV to image with a pixel detector the structure of nanowires (180 nm wide, 3 µm long). It can be demonstrated that such in one single scan the images of the first positive and the first negative order can be detected and than separated numerically (see fig. 1). While the illumination by the plus first order corresponds to the size of the focal spot which is only few nanometers, the illumination by the negative order yields to a field of view about twice the size of the zone plate and therefore is in the range of tens of micrometers. This allows us to achieve with the plus first order a detailed STXM image of the nanowire dominated by absorption contrast and additionally a large-field of view hologram from the minus first order with the phase information encoded in its diffraction patterns.

In order to increase the contrast of the hologram, a new geometrically based method is developed, which superimposes the information of all individual scan images. This method is more robust and faster than ptychography; it can be combined with holographic phase retrieval to a quantitative imaging technique (see fig. 1, right).

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<thead>
<tr>
<th>+1.order: STXM</th>
<th>-1.order: hologram</th>
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<td><img src="image1.png" alt="Image" /></td>
<td><img src="image2.png" alt="Image" /></td>
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**Figure 1:** Sample: single cell nanowires (180 nm · 3 µm) with electrical contacts for current measurements. \textbf{Left}: the intensity distribution of an STXM scan with 99·99 scan points and step size of 20 nm generated by the plus first order focal spot. \textbf{Right}: the hologram of the nanowires reconstructed from the detector images generated by the minus first order within the same scan and its holographic phase retrieval by CTF reconstruction.

**References**