# Towards sub-100 nm X-ray microscopy for tomographic applications

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We aim to achieve a resolution below 100 nm in X-ray microscopy images for tomographic applications. The size of the X-ray focal spot is one of the important factors contributing to the attainable resolution in X-ray projection imaging. Especially for tomographic application, the use of X-ray focusing optics to overcome the influence of bigger focal spot sizes is not ideal due to the very small focusing depths they introduce. Contrast formation in the detector plane also depends on the absorption and phase contrast transfer functions [1] and hence object structures could be completely wiped out at spatial frequencies that otherwise wouldn't suffer yet from the finite X-ray focal spot size.

The X-ray focal spot size is determined by the electron beam size and the shape/size of the volume in the target material where the X-rays are produced. Monte Carlo simulation studies [2] are being performed to determine the influence of target material, target thickness, support material and electron beam characteristics on the radial distribution and flux of the X-rays leaving the target.

The influence of the geometrical and operational set-up of the X-ray microscope on the contrast transfer functions was studied analytically and verified experimentally. In a magnifying configuration the distance between X-ray source and object should be kept as small as possible to maintain absorption contrast for the smallest details. The first zero crossing of the absorption contrast function can also be pushed to higher spatial frequencies by increasing the X-ray energies.

Using a 30 keV electron beam on a 100 nm thick gold target and a zoom of ~ 380x, structures close to 100 nm could be visualized in X-ray projection images of a ATN/XRESO-50HC (NTT-AT Nanofabrication Co.) resolution pattern. A complete loss of absorption contrast due to the zero crossing of the absorption contrast transfer function was only expected for structures around 70 nm. This seems to indicate that the X-ray focal spot size is currently the limiting factor. SEM images of the resolution pattern, obtained with the same settings for the electron beam as used for the X-ray imaging could resolve 50 nm structures, signifying that the electron beam size is not setting the lower limit on the X-ray focal spot size in our set-up. We are diligently working to improve the resolution below 100 nm in the near future using further results of the on-going target optimization.

[1] A. Pogany et al., Rev. Sci. Instrum. 68 (7), 1997, pp 2774-2782
[2] S.Jan et al., Phys. Med. Biol. 49 (19) , 2004, pp 4543