Diffraction theory for azimuthally structured Fresnel zone plate
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Focusing and imaging of EUV and X-ray radiation has many applications. In the technical sciences there is, for example, strong interest in developing lithographic systems at these wavelengths. For life science applications, one is interested in high-resolution x-ray microscopy and spectroscopy. Since it is not practical to make conventional refractive lenses for these wavelengths, diffractive lenses are of interest based on the classical Fresnel zone plate (FZP) [1]. A simple FZP consists of alternating opaque and transparent rings, see Fig. 1 left. When making such a structure at the nanoscale out of a thin foil, the mechanical properties are difficult to handle. Significant progress is achieved by using a contiguous structure such as the photon sieve [2], see Fig. 1 center. This structure is very promising and the analytical description is straightforward [3]. However, the photon sieve consists of thousands of pinholes which makes design and fabrication rather complex. An alternative to the photon sieve is to maintain the structure of the classical Fresnel zone plate but to add bridges that hold the zones in place [4], see Fig. 1 right. We refer to this structure as “azimuthally structured FZP” (aFZP).

Fig. 1: Left: conventional FZP, center: photon sieve, right: azimuthally structured FZP

Here, the focusing properties of the aFZP were analyzed by using scalar diffraction theory. The structural parameters are the numbers of rings \( L \), the number of openings in the innermost ring \( M \) and the increase of the number of openings between neighboring rings (\( \Delta M \)). One finds, that for suitable choice of parameters very good focusing properties can be observed - very similar to those of the classical FZP (Fig. 2). Details of the theory can be found in [5].

Fig. 2: Focus generated by an aFZP for \( L = 10, M = 10, \Delta M = 1 \).