Characterization of Multilayer Laue Lens Quality by Caustic Simulation and Ptychographic Reconstruction

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Focusing hard X-rays down to tens of nanometers and beyond is challenging. Using the phenomena of diffraction by focusing the first order this size of focus may be achieved. Small focuses of hard X-rays can substantially increase the resolution when probing and imaging dense samples. In order to focus hard X-rays to a small first order spot size, the X-rays need to pass an array that is constructed according to the zone plate law first utilized as concentric rings in Fresnel Zone plates. A similarly operating array can be constructed by depositing very thin alternating layers of Si and WSi_2 using Magnetron Sputter Deposition (MSD). Sectioning of the MSD deposition will yield a thin multilayer stack also referred to as the lens that later selectively transmits and diffracts the coherent X-ray beam to the desired first order focus. For the quality of the focus the layer stack of the lens must closely match the thickness and arrangement of the deposited layers with those given by the zone plate law. Possible deviations arising from the deposition process need to be understood, simulated, quantified and adjusted. Critical as well as less critical process parameters need to be identified and the required process control put in place.
The influence of layer arrangement and thickness deviations on the resulting beam profile was modeled by using Fresnel-Kirchhoff propagation under assumption of a phase shift and absorption for the individual zones.
Test probe, focus and complex wave field were reconstructed from measurement data using algorithms supplied by the Institute of Structural Physics, TU Dresden