Prospects of tomographic nanoscale imaging using high repetition rate laboratory based soft X-ray sources

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Abstracts: *We report about tomographic nanoscale imaging using a laboratory transmission x-ray microscope in the water window. In the second part of the talk we will present recent results on holography and coherent diffraction imaging using our high repetition rate XRL and discuss its potential for nanoscale imaging.*

Laboratory based laser driven short pulse x-ray sources like laser produced plasmas (LPP), high harmonic generation (HHG) and plasma x-ray lasers (XRL) exhibit a great potential for imaging and spectroscopy in the soft x-ray range. These sources are complementary to large scale facilities like synchrotrons or free electron lasers. LPP as well as XRL sources have been already successfully applied in nanoscale imaging in both life and material sciences. However, only few examples of high resolution three dimensional nanoscale images recorded with these sources exist. This is due to limited (in comparison with synchrotron sources) average photon flux and the lack of efficient x-ray optics. The first limitation can be overcome using high repetition rate (1 kHz and higher) pump lasers. The tremendous progress in development of multilayer x-ray optics for the extreme ultraviolet (EUV) range has also led to the availability of multilayer coatings for wavelengths outside the EUV region allowing e.g. efficiencies for a water window condenser optics of 2% or higher. For coherent lab based x-ray sources (e.g. HHG or XRL) new imaging schemes such like coherent diffraction imaging or Fourier transform holography paved the way to nearly wavelength limited resolution in 2D imaging.

In this talk, we report about tomographic nanoscale imaging using a LPP based laboratory transmission x-ray microscope (LTXM) in the water window. The soft X-ray radiation of the LTXM is provided by a laser-produced (1.3 kHz repetition rate, 0.5 ns pulse duration, 140 W average power) nitrogen plasma source, a multilayer condenser mirror, an objective zone plate (25/40 nm outermost zone width) and a back-illuminated CCD camera as detector. The sample stage of the LTXM allows a sample rotation in both directions, resulting in a total rotation angle of 120°. We will discuss the interplay between optimum average power of the driving laser, the efficiency of the condenser optics, the properties of the zone plate objective and the number of projections necessary to obtain a high resolution tomogram taking into account the depth of focus problem.

In the second part of the talk we will present recent results on holography and coherent diffraction imaging using our high repetition rate XRL. We will discuss advantages of these methods and its potential for nanoscale imaging.