X-ray imaging techniques exploiting the coherence properties of light

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Since the advent of third generation synchrotrons, the spatial coherence of the beam plays an important role in several imaging modalities. At the micron scale, parallel beam micro-tomography is a mature technique and among the most oversubscribed facilities at the ESRF. Phase contrast tomography is particularly suited for soft materials and complex biomaterials due to the enhanced contrast and reduced dose requirements. Holotomography includes a phase retrieval step based on images acquired at different distances and provides quantitative 3D maps of the electron density [1].

Improvements in hard X-ray optics open the way to extend these possibilities to much higher spatial resolutions. Multilayer coated bent surfaces (Kirkpatrick-Baez, KB optics) allow efficient, large bandwidth, focusing down to the 40 nm level in one-dimension and 80 nm in two-dimensions [2], with a unique flux of 10^{12} photons/s. Two different fields benefit particularly from the combination small focus / high flux: projection microscopy and X-ray fluorescence mapping. In projection microscopy [3] the sample is set at a small distance downstream or upstream of the focus and a magnified Fresnel diffraction pattern is recorded on a medium resolution detector set at a large distance from the focus. This technique is applied in 3D using either zoom tomography, i.e. local tomography on samples exceeding the field of view [4], or using laminography, i.e. a particular scanning geometry adapted to flat samples. In fluorescence imaging the sample is scanned through the focal plane while the spectrum of the emitted X-ray fluorescence is recorded with an energy dispersive detector. This rich probe, complementary to transmission imaging, provides element specific information and allows imaging and quantifying trace elements [5]. The combination of projection microscopy and fluorescence mapping turns out to be particularly powerful.

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