Combined projection microscopy and fluorescence micro-analysis using multilayer coated KB-optics

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Dynamically bent graded multilayers set in the KB-geometry are developed at the ESRF as an extremely efficient device to focus undulator radiation to spots below 100 nm [1]. The smallest 2D focus reached so far with this device is 80 nm in both directions, whereas it is of the order of 40 nm in one dimension. On one hand, the ultimate limits of this focusing approach are now better understood and on the other hand these systems are used as main optical element in dedicated nanofocus end-stations.

Two different fields benefit particularly from the combination small focus / high flux: projection microscopy and X-ray fluorescence mapping. In projection microscopy [2] 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. For tomography, scans are acquired at different focus-sample distances. This yields variable magnifications, but also different effective propagation distances. Two approaches for phase retrieval are considered: first this configuration can be considered as a magnified version of holotomography [3], or alternatively as coherent diffraction imaging with a curved wavefront. The former approach typically yields a direct, but approximate solution, whereas the latter is iterative, but more complete. This high resolution 3D imaging technique is applied in practice 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 and 3D reconstruction procedure adapted to flat samples.

In fluorescence imaging the sample is scanned through the focal plane while the spectrum of the emitted 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. First applications of this method in the field of neurochemistry at the sub-cellular level have been demonstrated.

References

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