3D phase contrast tomography

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Phase imaging can be instrumentally very simple at third generation synchrotrons due to the spatial coherence of the X-ray beam, provided by the small cross-section of the source and, on the imaging beamline ID19, to the large source-to-specimen distance of 145 m. Phase images can be understood as resulting from Fresnel diffraction, i.e. simple propagation. They can be used in two distinct modes. When the specimen-to-detector distance *D* is 'small', the phase discontinuities are revealed through fine fringes. These can be used as the input for approximate three-dimensional reconstruction. On the other hand, the Fresnel fringe systems that turn the images into an in-line hologram can be used to retrieve the phase distribution, through a holographic reconstruction process, based on the use of a series of images, taken at different distances from the sample. The phase maps are used as the input for tomographic reconstruction, yielding quantitatively the 3D distribution of the electron density (holotomography).
In order to overcome in an efficient way the resolution limit of hard X-ray detectors (of the order of one micron) image magnification can be obtained in a projection microscope by focusing the beam upstream of the sample. Using a Kirkpatrick-Baez mirror system, beams with diameter below 90 nm have been obtained at 20 keV. A very high flux (up to 10^{12} ph/s) is obtained by using the first multilayer coated mirror to select a given undulator harmonic. The magnification allows to improve very significantly the spatial and time resolution of phase contrast imaging. Putting the object in the focus and through a scanning procedure micro-fluorescence maps of selected portions of the specimen are obtained. This gives, at a very fine scale, element specific information complementary to the micro-structural information obtained by phase imaging.
Future needs in the field of coherent 3D imaging with respect to source properties, X-ray optics and detector technology will be considered.