Diffractive X-ray Optics for Synchrotrons and Free Electron Lasers

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X-rays are excellent probes for the investigation of matter using scattering, imaging and spectroscopic techniques, offering high penetration capability, spatial and temporal resolution, along with elemental and chemical sensitivity. Accelerator-based photon sources such as the Swiss Light Source and the new x-ray laser SwissFEL at the Paul Scherrer Institute (PSI) play a key role in these analytical techniques as they offer beams with unique brilliance.

This presentation will give an overview on developments of x-ray instrumentation and experimental techniques based on diffractive optics. These optical elements are designed for with short wavelength radiation ranging from the vacuum ultraviolet to hard x-rays and play a key role in the shaping, direction, and detection for a variety of experiments. In contrast to other kinds of x-ray optics such as mirrors and lenses, diffractive optics allow for precise control of the optical wave front and the realization of complex optical functionalities. The key challenges lie in the fabrication of the diffractive structures by advanced nanolithography techniques, as they need to provide dimensions and placement accuracies down to the nanometer scale.

Many applications of these devices include x-ray imaging techniques. The x-ray optics developed at PSI provide spatial resolution down to the 10 nm range, and are designed exploit phase contrast mechanisms or spectroscopic information. Moreover, recent developments of optics for beam splitting and the manipulation of x-ray wave fronts open up new opportunities for time resolved measurements of ultra-fast processes at x-ray lasers.