MULTILAYERS FOR FOURTH GENERATION X-RAY SOURCES

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The current development of fourth-generation X-ray light sources (synchrotrons and x-ray free electron lasers) with unique properties such as short wavelength, ultrafast pulse duration, high fluence, and spatial coherence, open up new science applications. By using ultrafast x-ray pulses of 100 fs or less in duration it is possible, for example, to record structural information from a sample before radiation damage destroys it. The resolution limitations of current X-ray optics, and also their liability to destruction by intense pulses, can be overcome by the "lensless" methods of coherent X-ray diffractive imaging and Fourier-transform X-ray holography. Such methods should be applicable down to scale lengths of interatomic distances with reproducible samples, such as uncrystallized macromolecules, virus particles, and protein complexes.

In this presentation we will discuss x-ray optics, in particular novel diffractive imaging camera, based on laterally-graded multilayer mirror that is used to reflect the diffracted wavefront from a weakly scattering, non-crystalline object onto a CCD detector. This camera design was successfully used at different wavelengths (between 4.5 nm and 32 nm) with the new short-pulse, intense, soft x-ray source, FLASH (Free Electron LASer in Hamburg) at DESY (Deutsches Elektronen Synchrotron, Hamburg, Germany). The mirror acts as a bandpass filter both for wavelength and angle, and is tailored so that rays of correct wavelength emanating only from a volume centered on the sample reflect to the CCD. As the wavelength is reduced the multilayer fabrication becomes more difficult, and tolerances become tighter. However, the concept will certainly be applicable for the full range of the fundamental wavelength of the FLASH FEL and at other soft-X-ray FELs under consideration (i.e. between 4 nm and 60 nm). The mirror solves the particular problem of the extreme intensity of the pulses, which are focused to greater than 10^{14} W/cm^2 and which create plasma from all materials in the 20 μm focus. We have recorded over 30,000 diffraction patterns at the FLASH free-electron laser with no observable mirror damage or degradation of performance.

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