s4.m1.o3 Basics and Modern Applications of 2-D Bent Crystals.

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Processes in high-temperature plasmas, such as implosion of laser fusion pellets and amplification of spontaneous emission (x-ray lasing), can only be fully understood when sophisticated x-ray crystal diagnostics with space, time and spectrum resolution is used [1,2]. Moreover powerful femtosecond lasers enable optical pump x-ray probe experiments to be performed on the time scale of 100 fs if adequate x-ray optics is available [3,4]. These sorts of experiment require (i) high luminosity point-to-point imaging in narrow spectral channels, (ii) x-ray spectroscopy combined with 1-D spatial resolution and (iii) x-ray diffraction of ultra-short pulses.

In order to fulfill all the different demands of these x-ray diagnostic or real-time application experiments, several theoretical codes [5,6] have been developed to optimise design. X-ray topographic cameras and diffractometers were modified for fabrication and characterisation of 2-D bent crystals. Computer codes use either a wave optics approach of Bragg diffraction on the bent crystal including optical Fresnel diffraction terms, or a geometric ray-tracing approach with bent crystal reflection curves as weighting functions, calculated by Takagi-Taupin theory [7]. Design of the bent crystal spectrometers starts from wavelength (0.01 nm - 3 nm), curvature (radii: 50 mm - 2 m) and imaging parameters (1 - 30). Best results were obtained when structurally perfect wafers of Si, Ge, quartz and phthalate crystals were prepared whilst monitored by x-ray topography and diffractometry. After final check of x-ray imaging and reflection properties of the spherical or toroidal crystals, up to 10 bent crystals were simultaneously used in x-ray plasma diagnostic experiments.

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s4.m1.o4 Imaging using Bragg and Fresnel diffraction of hard X-rays.

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Coherent X-ray beams, as available at third-generation synchrotron radiation sources such as ESRF and APS, extend the possibilities of radiographic and topographic (Bragg diffraction) imaging and yield new and complementary information. Hard X-ray radiography and tomography are common techniques for medical and industrial imaging. They normally rely on absorption contrast. However, for the investigation of light materials or to distinguish, in absorbing samples, materials with very similar X-ray attenuation, absorption contrast may fail. In the case of phase imaging contrast arises from local variations in optical path length; the latter can vary with sample thickness, or through changes in the electronic and mass densities due e.g. to precipitates, reinforcing fibers in a composite, or holes. The phase variations across the beam produce contrast through Fresnel diffraction, or simple propagation from the sample to the detector. Phase imaging can be used in a qualitative way, mainly useful for edge-detection. Three-dimensional reconstruction of boundaries, such as between reinforcing particles and the matrix in a composite material, is feasible with the algorithm for absorption tomography. A more quantitative approach involves numerical retrieval of the phase from images recorded at different distances from the sample. The combination with tomography is called holotomography and allows to map at the micron scale the distribution of the electron or mass density. Holotomography was first demonstrated on a polystyrene foam resulting in the 3D mapping of the real part of the refractive index. This new approach was successfully applied in a study of the rheology of aluminium alloys casted in the semi-solid state. The combination of phase radiography and X-ray topography is an exciting development. The information on phase variations in the beam diffracted by a crystal, inaccessible through conventional topography, is made visible through the same technique of Fresnel diffraction. In the case of periodically poled ferro-electric crystals, the phase modulation in the Bragg diffracted beam originates from the phase shift between the structure factors of oppositely poled regions. A measurement of this phase difference provides quantitative information about atomic displacements and on the nature of the domain walls. erences

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