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X-Ray Toroids

Optical fabrication techniques discussed to produce bent crystal analyzers that conform to toroidal surfaces for hard and soft x-ray applications including x-ray spectroscopy, ultrafast laser excited x-ray sources, imaging, and plasma diagnostics.

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Inradoptics

WHITE PAPER

X-Ray Toroids

The high quality of many synthetic crystals, coupled with state-of-the-art optical manufacturing and optical test methods, has made applications involving toroidally shaped crystals practical.

Curved x-ray crystal optics have been known and used for many years for focusing and analyzing x-ray emissions. Current applications of technological importance include the use of curved x-ray crystal optics in analytical chemistry micro-probes, for diagnosis via monochromatic imaging of hot plasmas, ^{1,2} and in ultra-fast probing of structural changes in materials.³

These crystal optics work by diffracting x-rays that satisfy the Bragg condition,

$$n\lambda = 2d \sin(\theta_b)$$

where n is an integer, λ is the wavelength, d is the spacing between adjacent crystal lattice planes, and θ_b is the Bragg angle referenced to the plane of the crystal.

By curving the crystal planes in two directions, to form a toroidal surface, focusing is possible (see Figure 2).

Figure 1. Size of an charged 6.0239 Å x-ray source using an Inrad Optics diffracted toroid.

Figure 2. Configuration showing the focusing geometry of a toroidally bent crystal. The radius of curvature in the horizontal plane is R_h and in the vertical direction the radius of curvature is R_v.

APPLICATIONS

The ability to focus, or image, an x-ray source from one point to another enables several unique applications. Some of these applications are described below.

Analytical Chemistry Micro-Probes

Spatially resolved chemical analysis can be done on surfaces by imaging a small x-ray target onto the analytical sample of interest and analyzing either electron

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