X-ray nanometer focusing at the SSRF basing on multi-layer Laue lens

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Abstract:

There are many types of hard X-ray focusing devices utilizing reflection, refraction and diffraction optics. Zone plates have realized the highest resolution of 10-12 nm in the soft X-ray range [1]. Capability of focusing to 47 nm with a compound refractive lens has been experimentally demonstrated at wavelength of 0.06 nm [2]. A line focus with a width of 26 nm was achieved with a planar waveguide at photon energy of 13.3 keV [3]. Reflective mirrors have shown great progress recently with the advance of precision manufacturing techniques, and it breaks the 10 nm barrier in hard-X-ray focusing [4]. Diffractive optics is intrinsically well suited to achieve a high spatial resolution because a large numerical aperture (NA) can be achieved by diffraction. A novel approach to making diffractive optics with high NA is Multilayer-Laue-Lens (MLL) [5].

The MLL can be considered as a special type of zone plate and used in Laue geometry. It is fabricated by depositing the depth-graded multilayer inversely on a flat substrate then slicing and thinning the multilayer sample to an ideal cross-section depth. Compared with zone plates, MLL can reach a much larger aspect-ratio (cross section depth to the outermost layer thickness), which makes it capable of focusing hard X-rays with higher efficiency [6]. We designed and fabricated a multi-layer Laue lens (MLL) as a hard x-ray focusing device. WSi_2/Si and WSi_2/AlSi material combinations were chosen owing to their excellent optical properties and relatively sharp interface. The depth-graded multilayers were fabricated by using direct current (DC) magnetron sputtering technology. The stress was measured during the deposition, and stress comparison was made before and after Nitrogen reactive sputtering. After deposition, the thickness of each layer was determined by scanning electron microscopy (SEM) image analysis with the marking layer. Then, slicing, thinning and polishing processed were performed to make multilayer into MLL. The focusing property of the MLL was measured at the Shanghai Synchrotron Facility (SSRF). One-dimensional (1D) focusing resolutions of 92 nm are obtained at photon energy of 14 keV.

Keywords: multilayer Laue lens (MLL), hard X-ray, nano-focusing, synchrotron radiation, stress

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