BL-3C, BL-14B/2014G021

Development and application of variable-magnification x-ray Bragg magnifier

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1 Introduction

Bragg magnifiers have been widely used for hard x-ray focusing, topography, radiography and full-field microscopy at x-ray beamlines of synchrotron facilities. In the conventional Bragg magnifier based on asymmetric x-ray diffraction by a nearly perfect crystal, an incident beam is either expanded or compressed in one direction (in the plane of diffraction). The magnification factor, M, is given by

$$M = \frac{\sin(\theta_B + \alpha)}{\sin(\theta_B - \alpha)}, \qquad (1)$$

where θ_B is the Bragg angle and α is the angle between the crystal surface and the diffracting lattice planes. To date, two methods have been used for changing the magnification factor, *M*: one is to change the asymmetric angle, α, by replacing the magnifier crystal, and the other is to change the Bragg angle, θ_B, by tuning the x-ray wavelength. These methods, however, usually require rearrangement of the optics and are not practical in most cases. Accordingly, most experiments have been performed using a fixed magnification factor, hindering the use of the x-ray magnifier. To overcome this problem, we have developed a novel x-ray Bragg magnifier of variable magnification. Figure 1 schematically shows our variable-magnification x-ray Bragg magnifier. By changing the azimuth angle, ϕ, we can control the magnification factor, *M*.

$$M = \frac{\cos\alpha \sin\theta_B + \sin\alpha \cos\theta_B \sin\phi}{\cos\alpha \sin\theta_B - \sin\alpha \cos\theta_B \sin\phi} \qquad (2)$$

Here we report the measured spatial resolution of the magnifier at the vertical wiggler beamline BL-14B. [1]

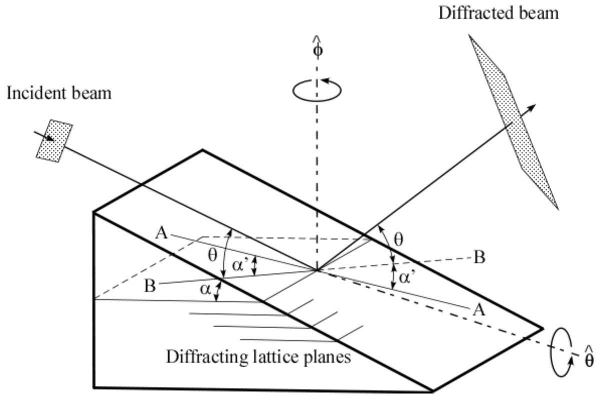

Fig. 1 Variable-magnification x-ray Bragg magnifier.

2 Experiment and Results

The experimental setup is schematically shown in Fig. 2. The white beam from the vertical wiggler was monochromatized at a wavelength of 0.112 nm by a pair of Si(111) crystals. The size of the incident beam was limited to 4 mm (H) × 4 mm (V) in size by a slit. The beam transmitted through a sample was either expanded or magnified by a Si(220) asymmetric magnifier crystal (α = 14º, θ_B = 16.96º) in the horizontal plane. The beam diffracted by the magnifier was observed by a fiber-coupled x-ray CCD camera (Photonic Science Ltd., X-ray Coolview FDI 40mm). The effective pixel size was 23 μm (H) × 23 μm (V) and the number of pixels was 1384 (H) × 1032 (V).

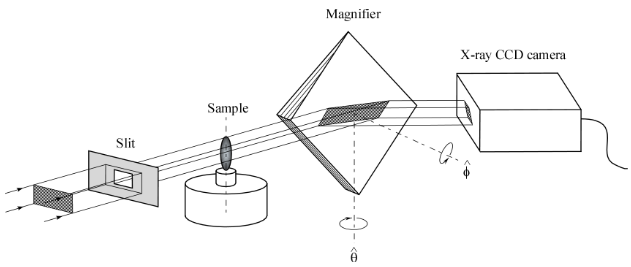

Fig. 2 Experimental setup.

We observed x-ray test charts at ϕ = −90º, −60º, −30º, 0º, 30º, 60º and 90º. The estimated spatial resolution is shown in Fig. 3. The solid line shows the theoretical values. It is clearly seen that the experimental values agree well with the theoretical values.

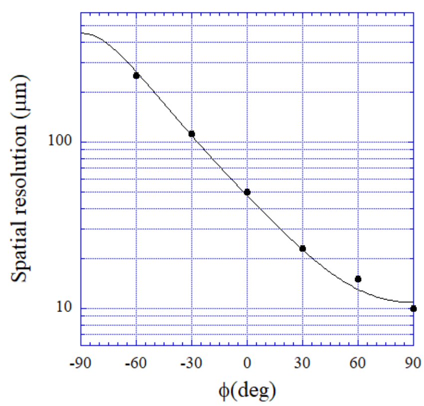

Fig. 3 Estimated spatial resolution.

Reference

[1] K. Hirano *et al.*, *Nucl. Instrum. and Methods in Phys. Res. A* **741**, 78 (2014).

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