E.M. Dufresne, dufresne@umich.edu; Report ID: dufresnee1.doc; Fig.1: dufresnee1F1.jpg; Fig. 2: dufresnee1F2.eps; MHATT-CAT; Instrumentation and Techniques

Li-based Compound X-ray Refractive Lenses

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Introduction

The development of Compound X-ray Refractive Lenses (CXRL) in recent years offers new possibilities for beamline optical elements.[1] Some advantages of using CXRL are their low cost, ease of alignment, and in-line focusing which does not modify the beam direction of propagation. They have strong chromatic aberration though, but this draw back can be used to filter the fundamental energy of a Si (111) monochromator. Since the focal length is energy dependent, only a narrow band of energies will be focused and passed through an aperture. CXRL can be used as a band pass filter, whereas mirrors are low pass filters. To provide horizontal flux collection at the MHATT-CAT 7ID beam lines, we are currently developing Li-based CXRL, following a recent idea proposed by Cederstrom et al.[2] They show that a parabolic depth profile can be obtained for a CXRL by setting a periodic array of triangular prisms to a small angle with respect to the beam.[2] Their approach is advantageous since it allows the focal length to be changed for different energies, and it also minimizes the dead layer thickness characteristic of CXRL which reduces their performance. Li was chosen because it is one of the materials with the largest phase shift per absorption length.

Methods and Materials

The first prototype was made by pressing a pipe tap into a thin Li foil. Fig. 1 shows this foil mounted on a UHV flange. This flange was inserted in a UHV tee, and the tee was evacuated to prevent ambient humidity from damaging the Li foil surface. The lens was aligned horizontally, and vertically in the beam with stepper motor driven stages. The jaw angle was rotated with respect to the beam to minimize the focal spot size. The beam line Si (111) monochromator was set to 10 keV. The lens was placed in the 7ID-B hutch 35.2 m from the source, and the focal spot was probed with an ion chamber apertured by a 10 μm horizontal slit. The aperture was scanned vertically in the 7ID-C hutch, 17.8 m downstream of the CXRL.

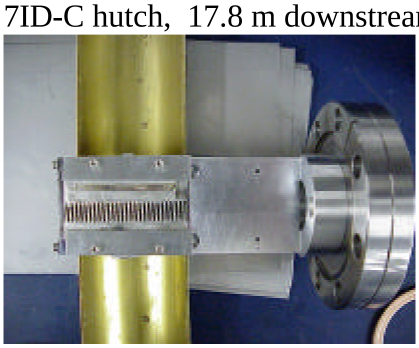

FIG 1. The first half of a Li CXRL made with a pipe tap (bottom imprint). Two half lenses are needed to make a complete parabolic lens[2].

Results

Fig.2 shows the beam profile with and without the CXRL in the beam. A gain of 1.5 was measured with the lens, and the beam size was reduced from 0.64 to 0.23 mm. The best spot size achieved was 178 μm, with a best gain of 1.8. From the known groove angle, pitch and index of refraction, we expect a focal lens of 16.4 m. From the thin lens formula, the focal length is 12 m, which shows good agreement with the lens parameters. The vertical source size is 40 μm. The demagnification ratio was approximately 2:1, and for ideal imaging, we would have thus expected an image size of about 20 μm. As shown in Fig. 2, the prototype had round edges and a rough figure which would blur the focus.

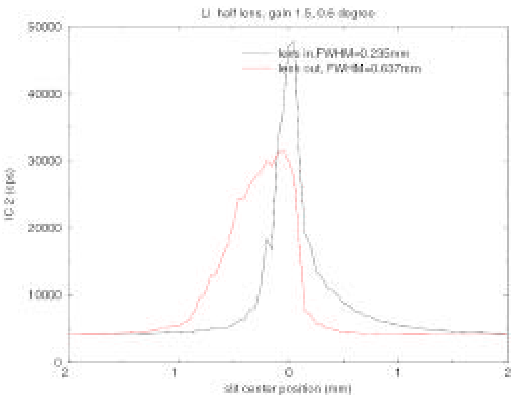

FIG. 2 An unfocused (red) and focused (black) 10 keV X-ray beam in the 7ID-C hutch.

Discussion

We have reported the first observation of focusing with Li CXRL. This preliminary work shows promise to provide horizontal and vertical focusing for work in the 7ID-C and D hutches. Work is currently in progress to improve the lens figure and optimize the lens parameter for the MHATT-CAT 7ID beamline.[3]

Acknowledgements

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Conference. Future work will be presented at the upcoming SRI 2001 and July SPIE conferences.