Dynamic X-ray Diffraction of Multilayer Laue Lens
다층 박막 Laue 렌즈의 X-선 정적 회절

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The possibility of imaging at near-atomic resolution using x-rays has been a dream ever since the short-wavelength nature of x-rays was demonstrated by von Laue and coworkers nearly a century ago. Even today the scientific impact of atomic-scale focusing of electromagnetic radiation would be deep and broad, because x-ray microscopy provides capabilities (ability to penetrate, sensitive and accurate element and structural information) that are complementray to other high-resolution microscopies. Although hard x-rays can in principle be focused to spot sizes on the order of their wavelength (0.1nm), this limit has ever been approached because of the difficulty in fabricating the optics - indeed, it has not even been clear what type of optics will work. Recent progress in mirrors, zone plates, and refractive lenses has pushed the frontier for hard x-ray focusing into the 25-50 nm range, which may be near the practical limit for these approaches. We have exploring a new type of x-ray optic, dubbed a multilayer Laue lens(MLL) as shown in Fig. 1.

MLL has the potential to focus x-rays to nanometer dimensions approaching the atomic scale resolution. Theoretical studies have shown that a focal size of 1 nm or even smaller can be achieved by MLL optics. We have reported a 16 nm line focus at aan energy of 19.5 keV, and wedged MLL structure needed for a 1 nm focus has been demonstrated[1-3].

MLL operates in the volume diffraction regime ranging from multibeam kinematic scattering applicable to a thin Fresnel zone plate, to dynamical diffraction applicable to a crystal. Unlike a thin zone plate, its behavior can depend strongly on the angle of the layers with respect to the incident beam. Since MLL refracts x-rays in the small angles with a transmission Laue geometry, measurement of diffraction profiles at the far-field is very important. Far-field diffraction patterns are an approximation of wave profile at the focus position. And, the diffraction efficiency can also be estimated from far-field diffraction profiles. In this presentation, we measured the diffraction profiles of MLL to determine the focusing capability of MLL, and calculated the diffraction properties that were compared to the measured data[4].

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[1] H. C. Kang *et al.* Physical Review Letters **96**, 127401 (2006).
[2] H. C. Kang. *et al.* Applied Physics Letters 92, 221114 (2008).
[3] H. Yan *et al.* Physical Review B. 76 115438 (2007).
[4] H. C. Kang *et al.* unpublished (2009).

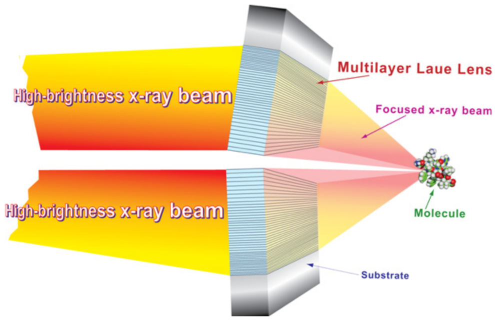

Figure 1. Schematic illustration of MLL.

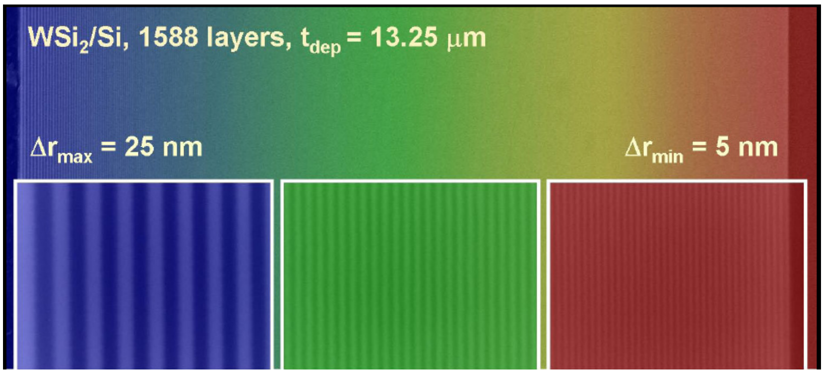

Figure 2. SEM image of fabricated MLL with an outermose zone width of 5 nm. This device was tested to focus x-rays to 16 nm at a x-ray energy of 19.5 keV.

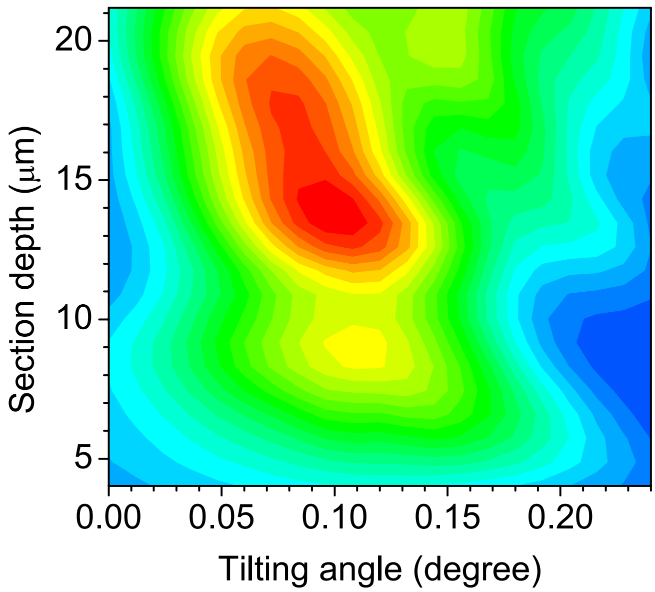

Figure 3. The contour map of diffraction efficiencies as a function of section depth and tilting angle. The data was measured from the sample shown in Fig. 2.