Multilayer Growth for the Multilayer-Laue-Lens Project*

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The goal of this project is to understand the principles and discover the optimum fabrication methods for Multilayer Laue Lens (MLL) x-ray optics. These optics have the potential to achieve a spatial resolution of below 10 nm, and are particularly well suited for hard x-rays. The technical approach is to first grow a depth-graded multilayer on a flat substrate and then section the multilayer to focus the x-rays in a transmission geometry at an optimum section depth and tilt angle for a high focusing efficiency. A major challenge for the multilayer growth is to deposit with sufficient accuracy a large number of layers. We have prepared a multilayer of 728 layers with thicknesses gradually increasing from 10 to ~58 nm according to the Fresnel zone formula, for a total thickness of 12.43 μm. The multilayers were grown on Si(100) substrates using dc magnetron sputtering on WSi_2 and Si targets. Layer thicknesses were checked with SEM images on MLL multilayers and x-ray reflectivity measurements on test uniform multilayers. Compensation for the decay in the growth rates was incorporated in an automated deposition program. The multilayers were subsequently sectioned and polished and tested in x-ray nanofocusing experiments. At 19.5 keV, using one multilayer section (corresponding to a quarter of the aperture of the fully assembled MLL), the x-rays was focused down to ~60 nm, which is very close to the theoretical resolution.

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