World's Highest NA Submicron X-ray Optic Ever Achieved

Sigray, Inc. is pleased to announce the first demonstration of an axially symmetric x-ray optic with low submicron focusing (400 nanometer line-pair separation and ~700 nanometer FWHM) and high flux and flux density. The landmark achievement has been the result of intense research and development over the past 3 years, funded with internal funds and supported by major small business innovation in research (SBIR) grants from the Department of Energy, and the National Science Foundation.

Development of an axially symmetric achromatic optic with sub-micrometer resolution and large optical aperture has long been a dream for scientists and engineers for developing micro/nano-beam applications. Axial symmetry (symmetry along an axis, such as cylinders) are by far the dominant approach for almost all types of optics except for x-rays. The inherently large numerical aperture (NA) and large optical aperture of axially symmetric x-ray mirrors not only provides intense x-ray flux, but also harbors tremendous potential, as they theoretically could enable optics with low single-digit nanometer focusing. However, due to the tight tolerance of precise surface profiles and challenging surface smoothness, achieving a high performance axially symmetric optic with submicron focus has long been deemed a near-impossible dream.

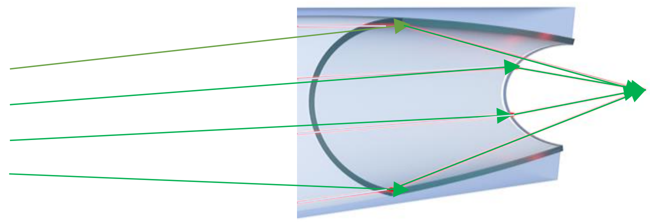
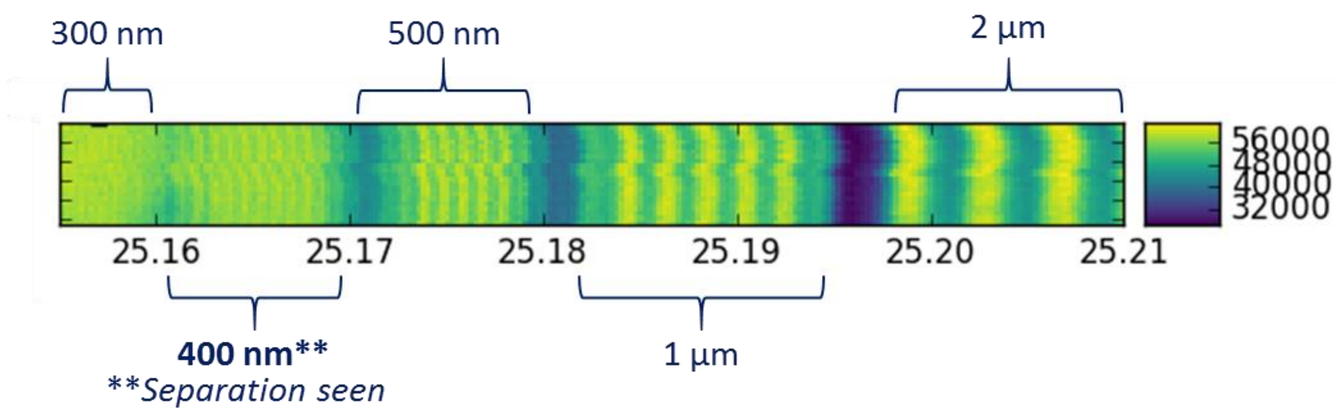


Figure 1 – One of Sigray's axially symmetric optic designs. Designs feature ellipsoidal, single paraboloidal, and double paraboloidal interior surfaces.

The parameters of the optic used in the experiment were: 640 micrometer (diameter) entrance optical aperture, 390 micrometer (diameter) exit optical aperture, 16mm working distance (the distance between the end of optic to focus). The x-ray energy used for the experiment was 12.2 keV.

Sigray has made groundbreaking developments to its proprietary ultraprecise shaping technique that fabricates optics with slope errors of less than 5urad and surface roughness on the order of Angstroms. Using this process, several optics with varying parameters were developed and tested at synchrotron light sources. Experimental demonstrations, performed in collaboration with scientists from the ALS at Lawrence Berkeley National Laboratory and NSLS II at Brookhaven National Laboratory verified a <800 nanometer FWHM spot, which could resolve 400 nanometer lines and spaces using resolution target standards.



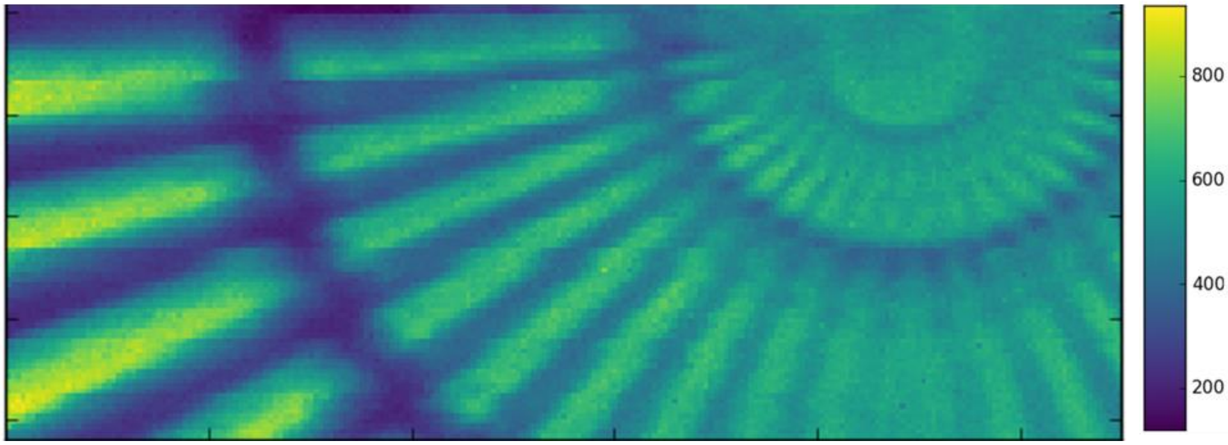


Figure 2 – Measurements on fluorescence standards. Shown are line pairs and Siemens star patterns of the Pt L line emission. Top: line-space resolution bars and spaces with 300, 400, 500, 1000, and 2000 nm widths from left to right. Bottom: Siemens star resolution pattern. Again, 400 nm line-space spokes (indicated by arrow) can be clearly resolved.

A publication on these results is being prepared with the collaborating scientists from the national laboratories. Additionally, follow-up extensive systematic characterization of the focusing properties is being planned in collaboration with Experimental Facility Group of ALS and his colleagues at the Advanced Light Source.

This achievement represents a major milestone in x-ray optic technology development. Future improvements to this high flux optic are being made to reach even higher resolution and to optimize performance across a variety of applications, including soft x-ray focusing. Previous generations of the optics design have already been adopted by several leading instrumentation researchers in the USA and Asia for developing new laboratory and synchrotron systems.