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Bendable Focusing X-Ray Optics for the ALS and the LCLS/FEL: Design, Metrology, and Performance

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We review the recent development of bendable x-ray optics used for focusing of beams of soft and hard x-rays at the Advanced Light Source (ALS) at Lawrence Berkeley National Laboratory and at the Linac Coherent Light Source (LCLS) x-ray free electron laser (FEL) at the Stanford Linear Accelerator Center (SLAC) National Accelerator Laboratory. For simultaneous focusing in the tangential and sagittal directions, two elliptically cylindrical reflecting elements, a Kirkpatrick-Baez (KB) pair [1], are used. Because fabrication of elliptical surfaces is complicated, the cost of directly fabricated tangential elliptical cylinders is often prohibitive. Moreover, such optics cannot be easily readjusted for use in multiple, different experimental arrangements, e.g. at different focal distances. This is in contrast to flat optics that are simpler to manufacture and easier to measure by conventional interferometry. The tangential figure of a flat substrate is changed by placing torques (couples) at each end. Depending on the applied couples, one can tune the shape close to a desired tangential cylinder, ellipse or parabola. We review the nature of the bending, requirements and approaches to the mechanical design, describe original optical and at-wavelength techniques for optimal tuning of bendable optics and alignment on the beamline [2], and provide beamline performance of the bendable optics used for sub-micro and nano focusing of soft x-rays.

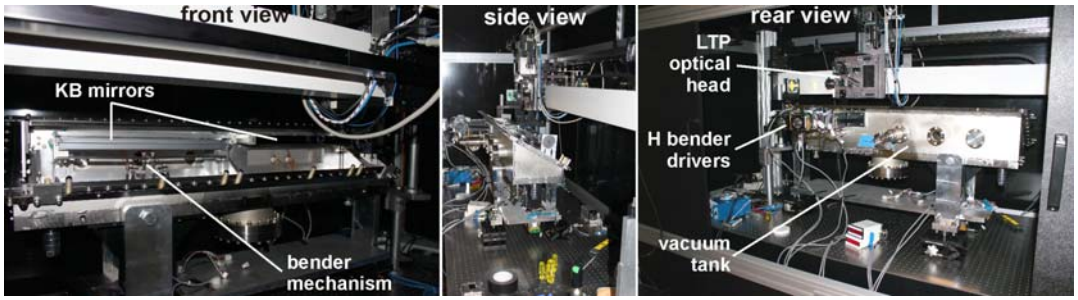

Figure 1: Bendable KB mirrors used at the SLAC/FEL AMO beamline. Two mirrors with 400 mm long substrates are shown in a vacuum tank on the ALS Long Trace Profiler optical table to be characterized and adjusted to the elliptical shapes optimized for three different focus distances.

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