Title
At-wavelength metrology and diffraction-limited focusing of bendable soft x-ray KB mirrors

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At-wavelength metrology and diffraction-limited focusing of bendable soft x-ray KB mirrors


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Realizing the full experimental potential of high-brightness, next generation synchrotron and free-electron laser light sources requires the development of reflecting x-ray optics capable of brightness preservation, and high-resolution nano-focusing. At the Advanced Light Source (ALS) beamline 5.3.1, we are developing broadly applicable, high-accuracy, in situ, at-wavelength wavefront measurement techniques to surpass 100-nrad slope measurement accuracy for diffraction-limited Kirkpatrick-Baez (KB) mirrors.

The at-wavelength methodology we are developing relies on a series of wavefront-sensing tests with increasing accuracy and sensitivity, including scanning-slit Hartmann tests, grating-based lateral shearing interferometry, and quantitative knife-edge testing. We will describe the original experimental techniques and alignment methodology that have enabled us to optimally set a bendable KB mirror to achieve a focused, FWHM spot size of less than 150 nm, with 1 nm (1.24 keV) photons at 3.3 mrad numerical aperture. The predictions of wavefront measurement are confirmed by the knife-edge testing.

The side-profiled elliptically bent mirror used in these one-dimensional focusing experiments was originally designed for a much different glancing angle and conjugate distances. Visible-light long-trace profilometry was used to pre-align the mirror before installation at the beamline. This work demonstrates that high-accuracy, at-wavelength wavefront-slope feedback can be used to optimize the pitch, roll, and mirror-bender forces in situ, using procedures that are both deterministic and repeatable. Supported by the U.S. Department of Energy under Contract No. DE-AC02-05CH11231.

Keywords: metrology of x-ray optics, synchrotron radiation, nano-focusing, shearing interferometry, Hartman test, knife edge measurement.

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