Title

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

Authors

Merthe, Daniel J.
Goldberg, Kenneth A.
Yashchuk, Valeriy V.
et al.

Publication Date

2011-10-07

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

Daniel J. Merthe[1], Kenneth A. Goldberg[2], Valeriy V. Yashchuk[1], Sheng Yuan[3], Richard Celestre[1], James Macdougall[2], Wayne R. McKinney[1], Iacopo Mochi[2], Gregory Morrison[1], Tony Warwick[1], Howard A. Padmore[1]

[1]Advanced Light Source, Lawrence Berkeley National Laboratory, Berkeley, CA, 94720 USA
[2]Center for X-Ray Optics, Lawrence Berkeley National Laboratory, Berkeley, CA, 94720 USA
[3]OmniVision Technologies, 4275 Burton Drive, Santa Clara, CA, 95054 USA

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.

Abstract has been submitted to SPIE Optics and Photonics 2011, Conference OP322: Advances in Computational Methods for X-Ray Optics II (San Diego, August 21-25, 2011)