Hard X-ray diffraction-limited nanofocusing with unprecedentedly accurate mirrors

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Recently, at grand-scale synchrotron radiation facilities, modern X-ray microscopy with highly brilliant and coherent X-rays have been used to make detailed investigations on material characteristics, such as element distributions and chemical bonding conditions, of a variety of samples, including biological and medical samples. Nanofocused X-ray beams are necessary for nanometer-scale spatial microscopy analysis. X-ray focusing using a Kirkpatrick-Baez setup with two total reflection mirrors is a promising method, allowing highly efficient and energy-tuneable focusing.

In this presentation, we will report the development of ultraprecise mirror optics and the realization of a nanofocused hard-X-ray beam. The designed elliptically curved shapes were fabricated by a computer-controlled figuring system using plasma chemical vaporization machining (PCVM)[1] and elastic emission machining (EEM)[1], on the basis of surface profiles accurately measured by combining microstitching interferometry (MSI)[2] with relative angle determinable stitching interferometry (RADSI)[3]. Platinum-coated surfaces were employed for hard X-ray focusing with a large numerical aperture (NA). Focusing tests were carried out at the 1-km-long beamline (BL29XUL) of SPring-8. Fabricated mirrors having a figure accuracy of 2 nm peak to valley height give ideal diffraction-limited focusing at the hard X-ray region. The focal size, defined as the full width at half maximum in the intensity profile, was 36 nm × 48 nm at an X-ray energy of 15 keV[4]. We anticipate that nanofocused X-ray beams will bring about a marked improvement from the micrometer to nanometer range in the spatial resolution of all X-ray microscopy techniques.

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