Pathway to the preparation of perfect focusing synchrotron mirrors

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Present and future[1] world-leading light sources are being designed and optimized to enable the routine production of coherent-X-ray beams with nanometer-size area, which is of great interest in X-ray spectroscopy and imaging applications[2]. In contrast to other methods employed to focus X-rays, reflective optics has a number of advantages, including unlimited entrance aperture and absence of chromatic aberrations. The first one leads to a higher collecting power and throughput, the second one to the possibility of operating in a wide spectral range without re-alignment of the optical layout. Nevertheless, nanofocusing performance imposes requirements on the fabrication of reflective optics that are not readily achievable today by industry-qualified processes. The fabrication process should provide surface shapes of extremely high accuracy (figure errors less than 10 nm *peak-to-valley*), moreover aspherical to avoid geometrical aberrations, and smooth (*root mean square* roughness less than 0.3 nm) to minimize scattering and image blurring.

In this work we describe a novel fabrication scheme conceived to realize the final surfacing of nanofocusing synchrotron X-ray mirrors. The method combines non-contact mirror-surfacing tools (ion beam sputtering and differential deposition) with two at-wavelength on-line metrology instruments as monitoring probes of the figure and finish errors. The setup is configured at the metrology beamline of the ESRF and allows switching from one characterization method to the other without affecting the environment at the mirror level. Information on the mirror figure is extracted from the interferograms obtained with an X-ray shearing interferometer placed in the reflected beam so that the effect of all process parameters on the mirror figure can be monitored in-situ and in real-time[3]. The monitoring of the surface finish is obtained by collecting X-ray diffuse scattering diagrams using a 2D detector, from which the Power Spectral Density characterizing the optical properties of the mirror surface are derived directly.[4-8]

The experiments presented anticipate the possibility of realizing a short feedback loop for machining a mirror capable of nanofocusing performance in the X-ray domain.

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