Development of pseudo-perfect X-ray optics using refractive compensators

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Increasingly sub-micron beam sizes are being used for experiments on modern X-ray synchrotron sources. The trend is to go down to tens of nanometre in focused beam sizes, with an ultimate aim of achieving single-digit nanometre beam sizes; especially with the advent of very-low emittance storage rings. Such small focus sizes are however still difficult to achieve. In many cases, the ultimate spatial resolution achieved is limited by the capabilities of the present-day fabrication methods for X-ray optics. Mirror figure error, defined as the height difference function between the actual mirror surface and the ideal elliptical profile, causes a distortion of the wavefront for X-rays reflecting from the mirror. The distorted wavefront when propagated to the focal plane result in an aberrated focal spot, which prevents diffraction-limited focusing from being realised. In the same way, aberrations introduced in the focusing by parabolic X-ray lenses caused by manufacturing imperfections also degrades performance. At Diamond Light Source, we are developing custom designed refractive optics that can be used to locally cancel out the wavefront distortion caused by imperfect manufacturing of X-ray optics [1]. Corrector optics for both X-ray mirrors and X-ray lenses have been developed. We demonstrate with measurements on B16 Test beamline [2] at Diamond a reduction in the size of the focal spot of a characterised test mirror by a factor greater than 10 times. This technique could be used to correct existing synchrotron beamline focusing and nanofocusing optics providing a highly stable wavefront with low distortion for obtaining smaller focus sizes. We present our latest results showing improvement in focused beam size from both X-ray mirrors and X-ray lenses.

References

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