Optical elements for dynamically broadening the focus of micro-focus optics at synchrotron X-ray beamlines

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Focusing X-ray Optics are widely used at X-ray synchrotron radiation sources allowing focal spot sizes of under one micrometre to be routinely achieved. The ability to change to size of the focal spot over a range from sub one micrometre to tens of micrometers without loss of X-ray flux is advantageous for many experiments. For example, in macromolecular crystallography experiments, the ability to increase the focused beam size at the sample would allow the beam size to be matched to the sample size thereby minimizing radiation damage. For microprobe experiments, a variable probe size allows different length scales to be probed efficiently. To match the time scales for high-throughput, highly-automated experiments at high brightness synchrotron radiation sources, it is essential that the changes in the focused beam size can occur rapidly and sub one second changes are being demanded.

We have developed reflective and refractive optics that modifies the focused beam wavefront from X-ray focusing optics in order to broaden the focused beam profile. In the case of reflective optics, we have demonstrated an elliptical focusing mirror with custom surface profiles in parallel lanes running the length of the mirror using a precision translation to rapidly position each lane in the X-ray beam to provide different focal profiles. For refractive optics, we have fabricated planar X-ray refractors from the polymer SU-8 and demonstrated that the focused beam profile may be varied by translating refractors into the beam upstream of a focusing X-ray mirror.

The technique is now being implemented at the Diamond Lights Source VMXm macromoleculer crystallography beamline using a seven lane mirror to generate beam sizes in the range from 0.5 μm to 10 μm with sub-one second switching.

References

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