PhotonMEADOW 2023

Contribution ID: **16** Type: **Poster**

Fast shaping control of X-ray beams using a closed-loop adaptive bimorph deformable mirror

Recent technological advances at synchrotron and free electron laser facilities, including brighter X-ray sources, faster detectors, and automated sample handling, have led to an increasing demand to tailor the X-ray beam profile to the size and shape of the sample. For beamlines which routinely measure hundreds of samples per day, such changes need to be made rapidly and autonomously. Bimorph piezo-electric deformable mirrors are widely used to control the profile of the reflected X-ray beam. However, when operated in open-loop, such optics suffer from curvature drift when large and frequent changes are made. To resolve these issues, we have successfully demonstrated a high-resolution, real-time, closed-loop "adaptive"optical system capable of rapidly changing and stabilizing the shape of the X-ray beam. The bimorph's optical surface is continuously monitored by an array of Zygo ZPS absolute distance measuring sensors operating at 20 kHz. Surface corrections are autonomously applied to each piezo, with sub-500 picometre resolution, at a refresh rate of ~ 1 Hz, using a programable high-voltage power supply. After calibration of the X-ray wavefront at the B16 Test beamline using speckle scanning, the wavefront diagnostic was removed from the X-ray beam path. Non-invasive control of the reflected X-ray beam was then demonstrated, including variable beam size, or non-Gaussian profiles, such as flat-top intensity or multiple split-peaks with controllable separation and relative amplitude. Such changes can be applied in any order and in rapid succession without the need for invasive wavefront diagnostic sensors which block the X-ray beam for scientific usage.

Journal of Synchrotron Radiation Special Issue: will you submit your contribution?

yes

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Session Classification: Poster Session