Contribution ID: **52** Type: **Invited talk**

Development of Kirkpatrick-Baez Mirrors at NSLS-II

Tuesday 27 August 2024 16:30 (20 minutes)

Introduction

Since 2018, we have been involved in R&D on X-ray mirror metrology and fabrication technologies. After five years of intense R&D efforts, we successfully integrated ion beam figuring (IBF) with advanced metrology, as seen in Fig. 1, demonstrating diffraction-limited hard X-ray mirror manufacturing capability (curved surfaces with up to a 0.6 mrad total slope) [1]. We have developed an IBF system, specifically for X-ray mirror fabrication. The 2D metrology feedback for IBF has been developed in parallel based on Fizeau stitching interferometry (FSI) and micro stitching interferometry (MSI), achieving sub-0.3 nm rms repeatability. Coupled with this, our multi-pitch nano surface profiler (MPNSP) for slope measurement with sub-30 nrad RMS facilitated cross-validation of metrology data across instruments with different principles. We also introduced optimization and control algorithms dedicated to sub-nm level IBF of optical surfaces. In the past two years, we confidently produced diffraction-limited KB mirrors and gratings for hard X-ray beamlines across the US.

Method and result

Figure 2 demonstrates an example of manufacturing a hard X-ray KB mirror for one beamline at NSLSII [1]. Starting from a spherical mirror shown in Fig. 2(a), the initial height and slope errors were 93.25 nm RMS, 3.12 μrad RMS, and 28.56 μrad RMS, respectively. After 15 cycles of IBF (about 5 hours), as shown in Fig. 2(b), the residual height and slope errors were reduced to 0.36 nm RMS, 0.15 μrad RMS, and 0.25 μrad RMS, respectively. These ultra-precision height and slope results were then confirmed by a cross-validation between our SI and NSP measurements. As shown in Fig. 2(c), the SI and MPNSP demonstrated extremely similar slope errors along the tangential direction, which proved the effectiveness of the proposed IBF-based KB mirror fabrication systems given in Fig. 1.

Reference

[1] Wang, T., Huang, L., Zhu, Y., Giorgio, S., Boccabella, P., Bouet, N., & Idir, M. (2023). Ion Beam Figuring System for Synchrotron X-Ray Mirrors Achieving Sub-0.2-μrad and Sub-0.5-nm Root Mean Square. Nanomanufacturing and Metrology, 6(1), 20.

Figure 1. In-house established optical fabrication and metrology solution.

Figure 2. (a) A KB mirror was fabricated from a spherical mirror. (b) The residual height and slope errors were reduced to < 0.5 nm RMS and < 0.16 μrad RMS, respectively. (c) The measurement results were cross-validated between our SI and NSP systems.

I plan to submit also conference proceedings

Yes

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Session Classification: Mikrosymposium 1/2: Beamline Optics and Diagnostics

Track Classification: 1. Beamline Optics and Diagnostics