Gimbal Mechanical and Optic Interferometry Testing

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Argonne Optics Group
X-Ray Science Division

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Introduction and Motivation

Purpose: The APS Modular Deposition System (MDS) **(Fig. 1)** is designed to fabricate advanced thin film-based x-ray optics including standard single and multilayer optics; grated multilayer optics; and profile coated focusing mirrors. It incorporates multiple capabilities including in-situ metrology, ion beam surfacing processing and correction, and multiple gas reactive sputtering. *In-situ* metrology monitors the shape of the mirror during the coating process. Correcting of imperfections through ion milling and thin film deposition prior to removal from the vacuum involves:

- High-speed interferometer **(Fig. 2)** attached to vacuum chamber **(Fig. 1 Fizeau)**
- Reference optic mounted on gimbal **(Fig. 3)** inside vacuum chamber

The gimbal tilts and tips, adjusting to the normal axis of the interferometer. The roll accommodates a three-flat test for absolute metrology.

Scope of Project: Determine performance and verify mechanical specifications for the gimbal prior to placement within the vacuum chamber.

Work Accomplished:

- Performed mechanical testing and calibration of the gimbal's pico- and stepper motors for precision and stability of the system.
- Characterized gimbal system using a reference mirror with interferometry.

Deposition Chamber and Gimbal

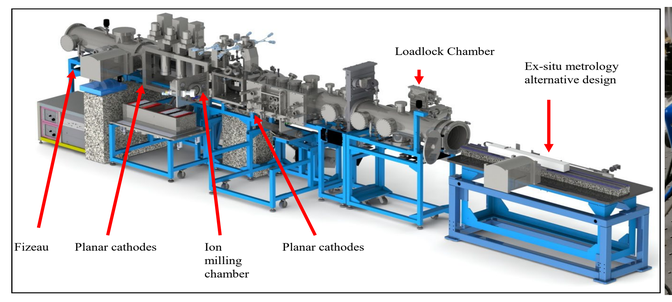

Figure 1: Modular Deposition System

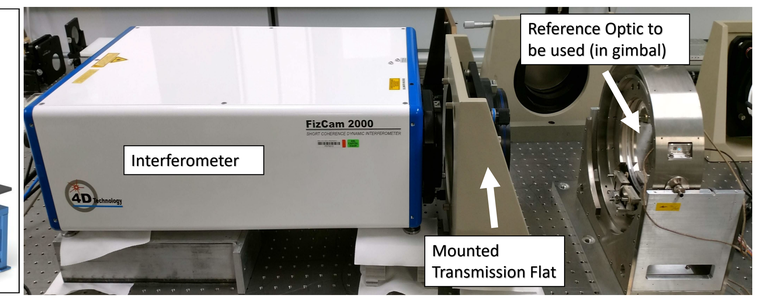

Figure 2: FizCam 2000 Interferometer and Setup

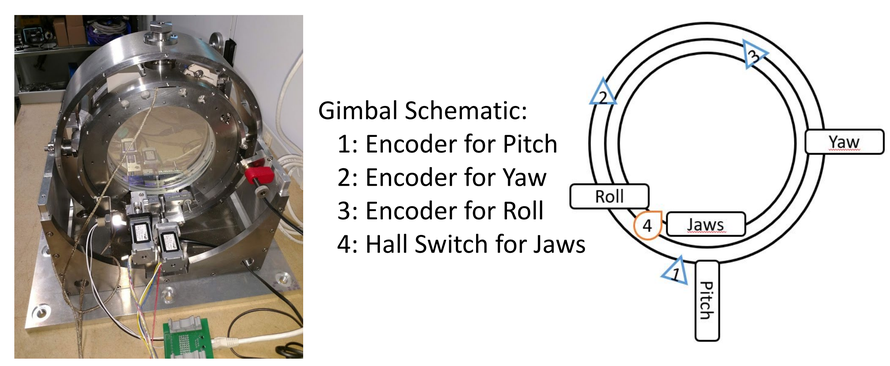

Figure 3: Gimbal and Schematic

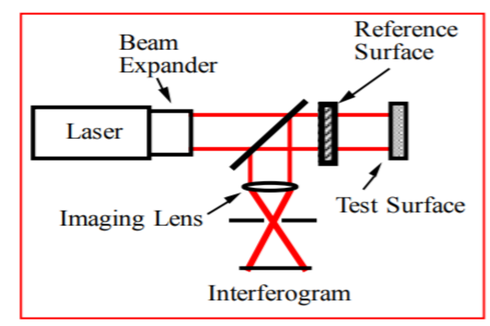

Figure 4: Fizeau Interferometry Schematic

Gimbal Mechanical Analysis

Pico and Servo motor parameters are shown in the Table 1.

The steps taken for motion analysis were:

1) Integrated pico-motors and servo drivers with EPICS (PVs)
2) Created HMI with CaQtDM for ease of manipulation
3) Determined Standard Operating Procedures and safe motion limitations
4) Calibrated steps per count and converted for proper engineering units
5) Scanned motors using EPICS to determine backlash and slippage limitations **(Fig. 5-7)**
6) Converted controls to feedback from motor counts (Relative) to Renishaw encoders (Absolute)
7) Moved System to Metrology Lab for Interferometry integration

	nm/counts	nrad/count	Required Precision	Min Angle (deg)	Max Angle (deg)
Pitch	1	7.857		-1.8°	2.67°
Yaw	1	9.69		-5.5°	2.8°
Roll	1	11.24	10 microns	≈14.37°	≈340.49°

Table 1. Motor Parameters

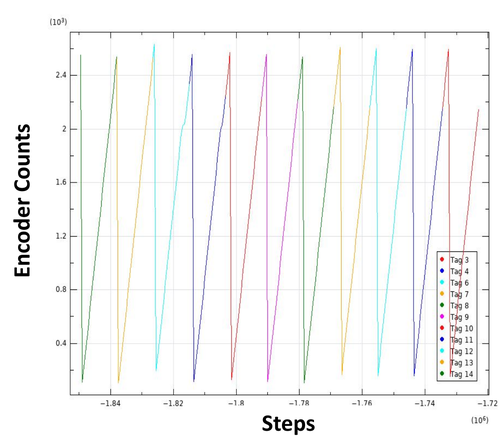

Figure 5. Roll Hysteresis

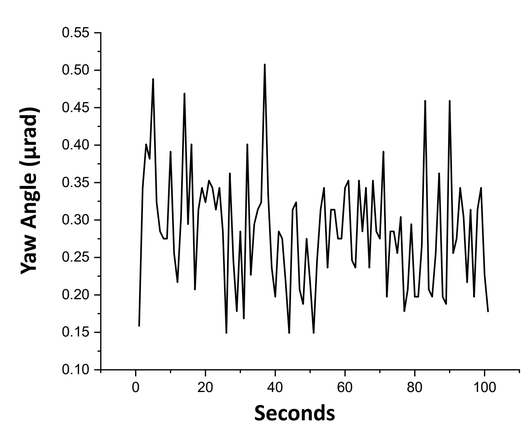

Figure 6. Yaw Stability

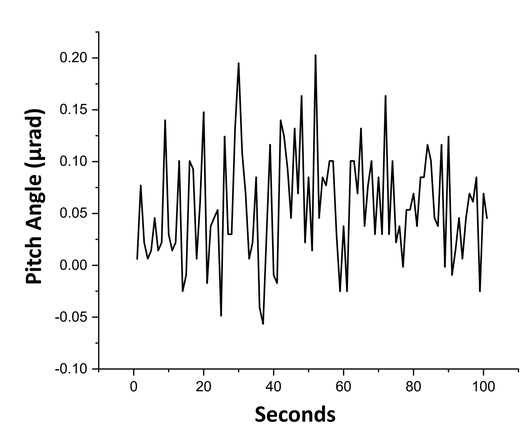

Figure 7: Pitch Stability

Optical Interferometry

4D Technology's FizCam2000 short coherence dynamic interferometer measured the surface of the reference optic using Fizeau interferometry **(Fig. 4)**. The interferometry completed involved the subsequent steps:

1) Angle analysis for pitch **(Fig. 8 and 9)** and yaw
2) Rotational evaluation of gimbal optic
3) Measurements and comparisons of mirrors from stationary transmission flat 1 **(Fig. 10)**, flat 2 **(Fig. 11)**, and flat 3 **(Fig. 12)**

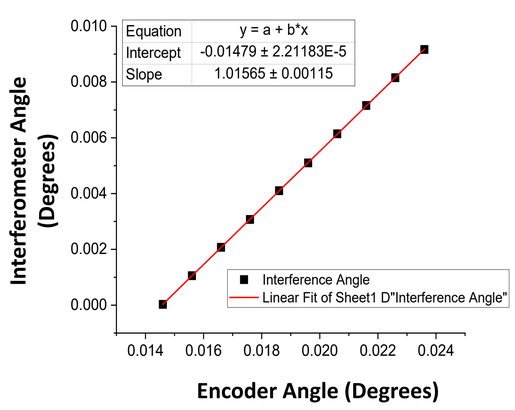

Figure 9. Pitch Angle Analysis (Pos Direction)

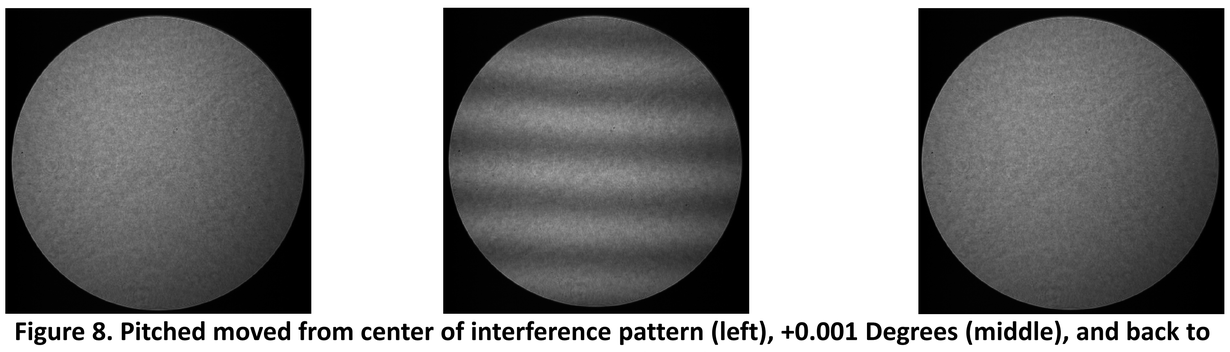

Figure 8. Pitched moved from center of interference pattern (left), +0.001 Degrees (middle), and back to the center (right)

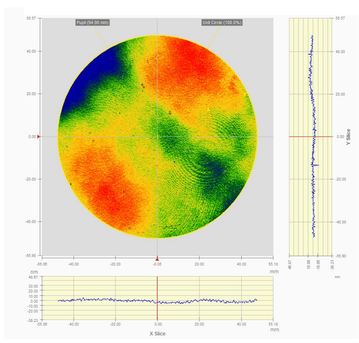

Figure 12. Transmission Flat 1: Stationary

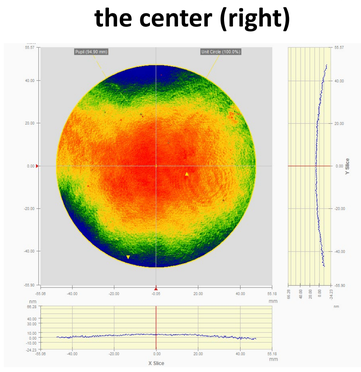

Figure 13. Transmission Flat 2: Stationary

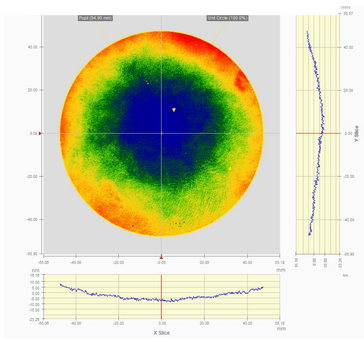

Figure 14. Transmission Flat 3: Mounted on Gimbal

Conclusion and Future

- The calibrated gimbal is precise, stable, and ready for interferometry within MDS
- The stability when settled is within 100 nanometers
- The CaQtDM HMI is ready to integrate within the MDS control structure
- The precision of movements is within the needed requirements, as seen in the interference patterns
- The surface mapping using the interferometer is exact and able to accurately give the shape of the mirrors
- The next step is to place the gimbal into the vacuum and re-calibrate it for final use with the MDS and FizCam2000

Acknowledgements

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