Progress in Measuring X-Ray Mandrel

NASA Mirror Tech Days

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Representative in North America and Europe for:

OKAMOTO optics

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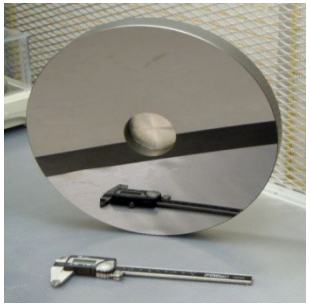
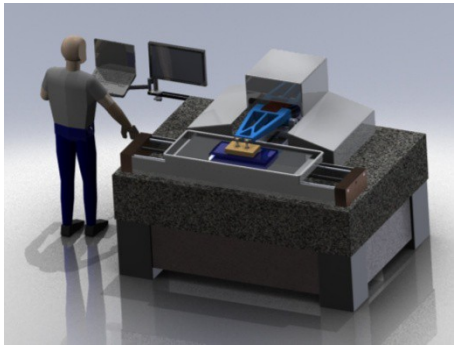
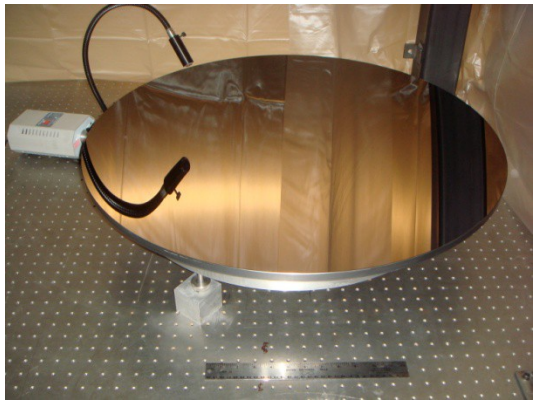
Aperture Optical Sciences, Inc

- Aperture Optical Sciences Inc. founded in 2010 by Flemming Tinker and Kai Xin, www.apertureos.com
- Our Business focus is the manufacture of precision optics and manufacturing technology development.
- We are a team of 15 employees, located in Central Connecticut.
- This presentation is a result of NASA Phase I SBIR contract.







NASA SBIR/STTR Technologies

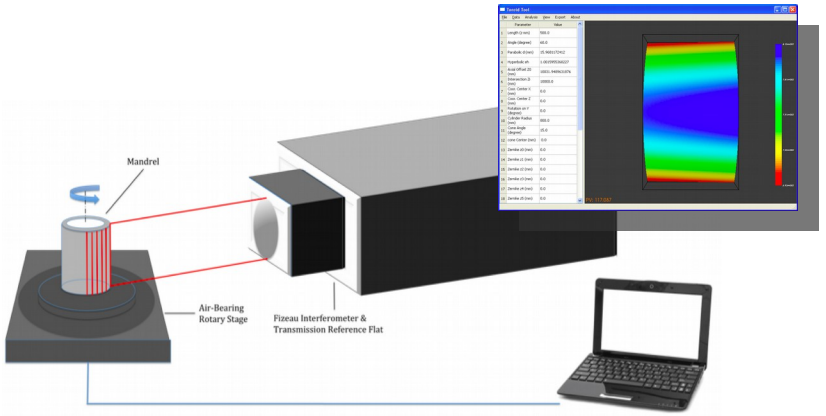
Proposal No. S2.04-9423 – Advanced Optical Metrology for XRAY Replication Mandrels and Mirrors

PI: Kai Xin PhD : Aperture Optical Sciences Inc. – Durham, CT

Identification and Significance of Innovation

Advanced x-ray observatories such as IXO and GenX will require thousands of thin shell mirror segments produced by replication using convex mandrels. Quality and cost effective manufacturing of these segments is dependent on the speed and effectiveness of the metrology we use in manufacturing and the ability to use accurate measurements to enable deterministic fabrication. AOS proposes development of an efficient and accurate metrology system to enable the manufacturing of sements with performance of 0.5 arc-second or better. A current method to test such mandrels is to stitch multiple meridional profiles acquired using a large aperture plano interferometer and an air-bearing actuated partholder. AOS will advance this method, by building an automated platform, driven by custom developed software, and implementing improvements that will enhance both the accuracy and efficiency of the test.

Expected TRL Range at the end of Contract (1-9): 3-4



Technical Objectives

1. Produce an automated metrology system that can demonstrate precision of measurement of high resolution line scans with uncertainty < 0. 2 arc-seconds
2. Measure low frequency form error using a coordinate measuring machine (CMM).
3. Stitch low frequency CMM data with overlayed high resolution line scans. Cone angle variation angle shoud be < 0. 1 arc-seconds. Resulting map should be in a form that may be used as a input for corrective finishing.

Work Plan

1. Acquire parts and build test platform
2. Calibrate Optical and Mechanical Measurements
3. Develop software to control the mechanical system for optical alignment
4. Make measurements of NASA provided mandrels

NASA and Non-NASA Applications

IXO Replication Mandrels
GenX mandrels and optics
Precision Cylindrical Optics
Large Format Aspheres
Low Mid-Spatial Period Optical Surfaces
Deterministic Low Cost Fabrication

Firm Contacts

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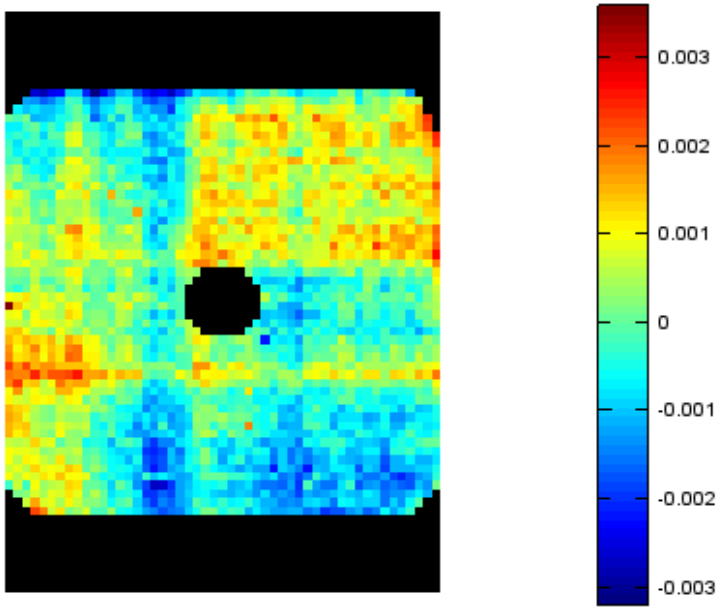
CMM Accuracy



This is 500x500mm CMM accuracy map by using a large SiC asphere as the calibration standard assuming it does not change during the test by more than 0.5 microns.

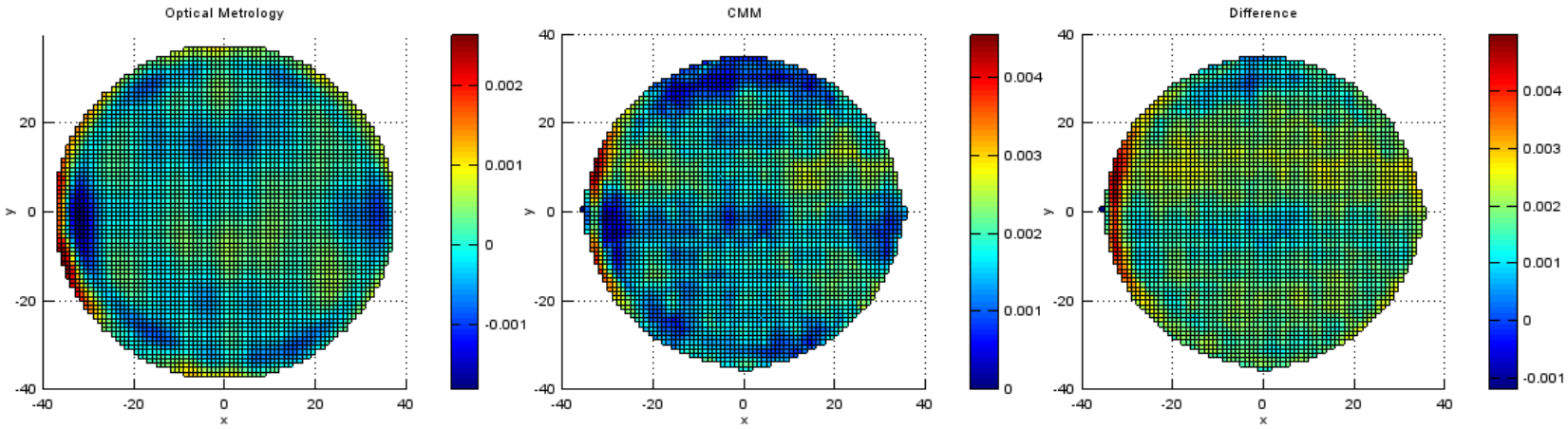
The plot is raw data for single point accuracy. This error contains probe dynamic errors, system form error, and environment noise on sloped surface.

At raw data level, we achieved ~+/-3 microns level accuracy on single point.

Low order form error is mostly astigmatism and less than 1 microns.

CMM is capable in probing mid spatial error (with system noise) and low order error (better than 1 micron in most case).

Comparing CMM with Optical Metrology



90-degree Parabola., Radius of Curvature=300, k=-1, Off-Axis distance=300
76.2mm diameter, 1.72mm sag, 0.859mm asphere departure from the best fit sphere

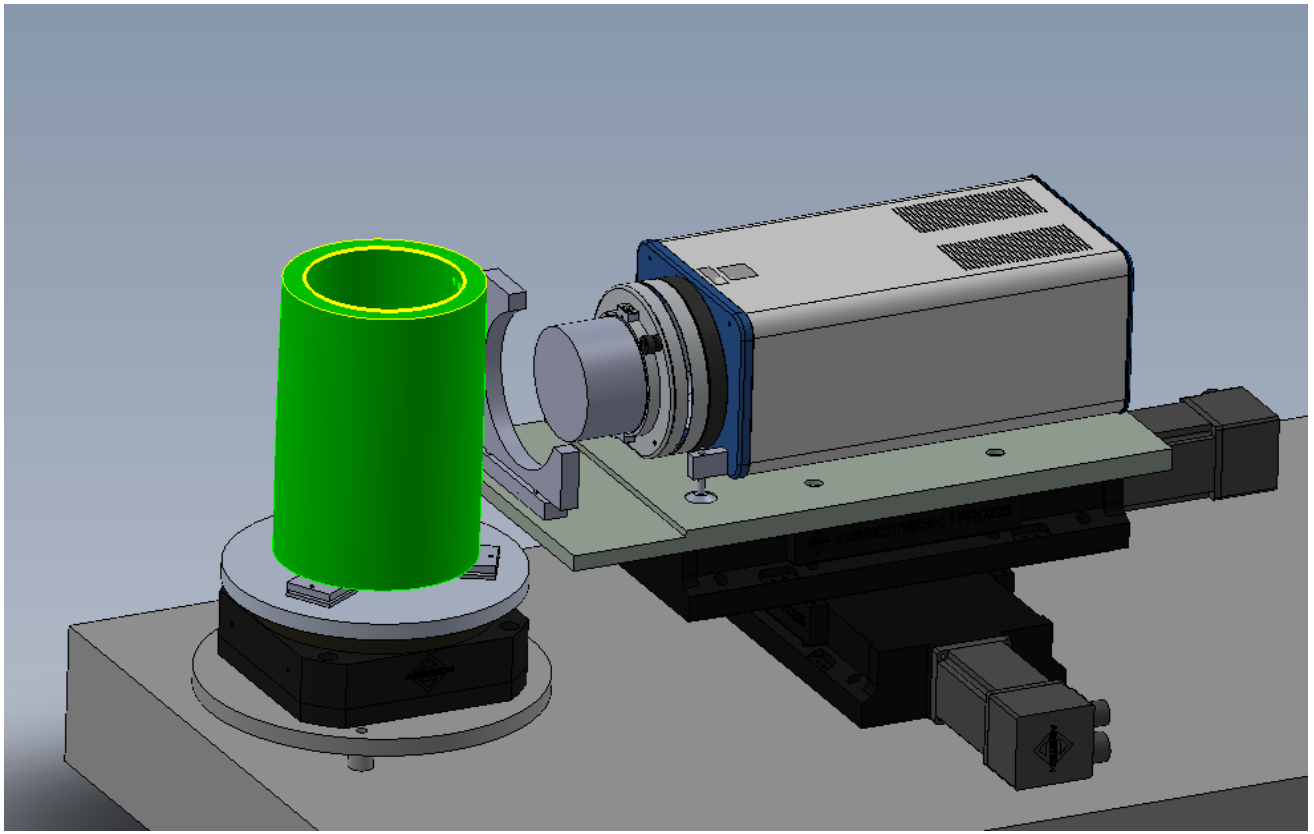
Large error at the left side is mainly due to high slope error in that region.

Good agreement in low order error and some of mid-spatial error.

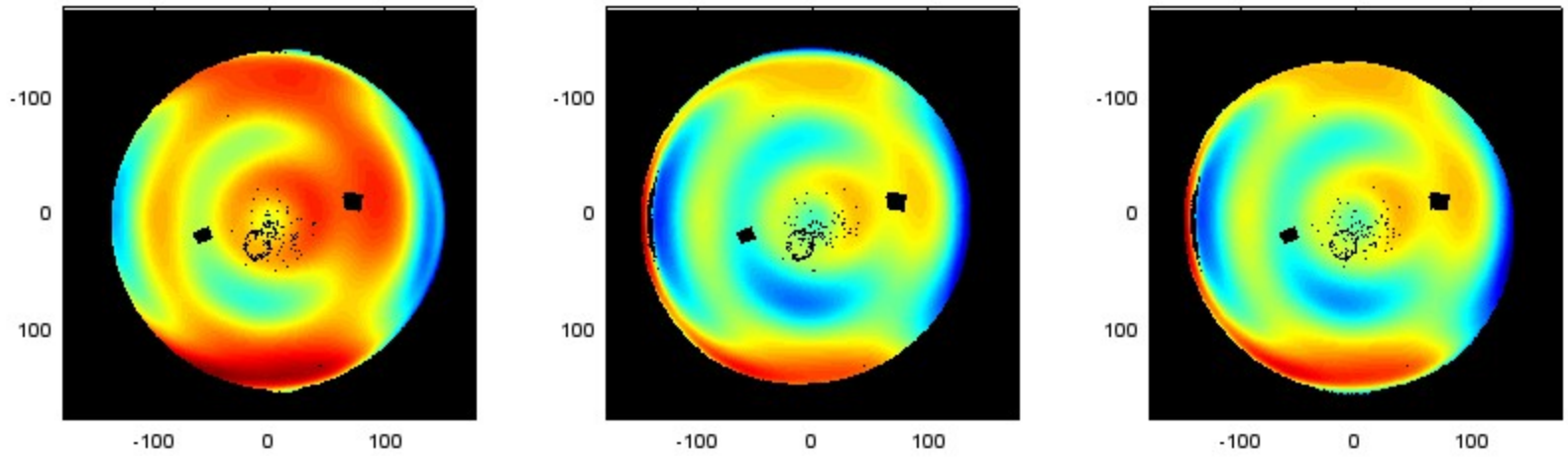
Optical metrology covers mid-spatial error with more detail but cannot determine low order error due to alignment.

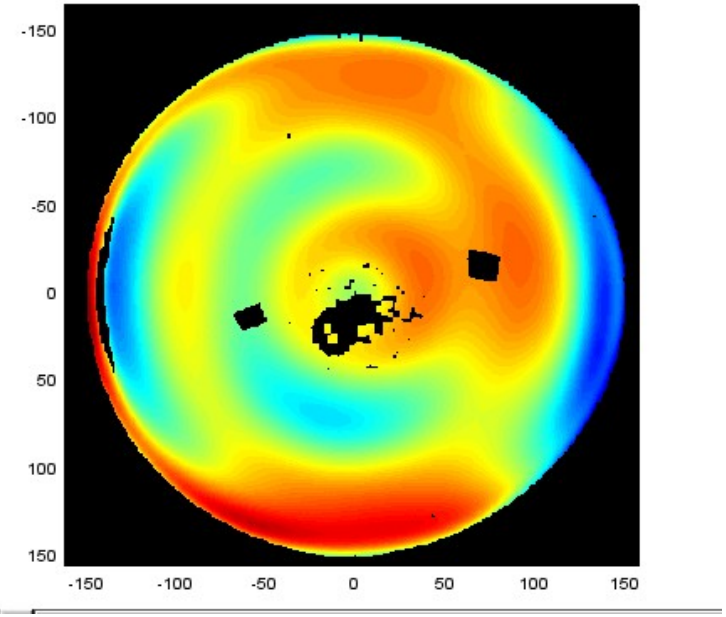
- Stitching is typically done in simple geometry: plane, sphere, or cylinder.
- For convex and cylinder shape mandrel, it is done in cylindrical motion.
- Precise cylindrical motion is important for the success.

Metrology Setup Layout



Actual Result on Asphere Stitching





Off axis parabola is stitched in the plano motion for testing a large off-axis parabola with small flat reference.

With the help of two fiducial markers, the three metrology data are aligned without position information.

Tilts is removed in alignment.