

Characterization of an In-Situ Interferometry Setup

Jayson Shiau¹, Ray Conley², Jun Qian², Lahsen Assoufid², Scott Izzo³

¹Northern Illinois University, ²X-ray Science Division, Argonne National Laboratory, ³APS Engineering Support Division, Argonne National Laboratory

Introduction



Figure 1: The APS Modular Deposition System incorporates in-situ metrology and an ion-beam figuring system for figure correction of mirrors up to 1.4 m long

- The future APS upgrade (<https://www1aps.anl/APS-Upgrade>) will provide x-ray beams with unprecedented low emittance and high brightness at high x-ray energies.
- To preserve the intrinsic properties and coherence of these x-ray beams, the APS will require mirrors and thin film optics with unprecedented quality. For example, mirrors with <1 nm figure error and <0.15 nm surface roughness may be required.
- To meet these future requirements, the APS/XSD Optics Group designed and commissioned an advanced modular deposition system (MDS) [1]. This system incorporates an in-situ ion-beam figuring and metrology system, which will provide surface figure measurement and correction for mirrors up to 1.4 m long.
- In-situ metrology measurements will be done through a vacuum using a high speed interferometer (FizCam2000) with the reference mirror mounted on an in-house-developed gimbal inside the MDS sputtering chamber.
- The aim of this project is to study the effect of the vacuum chamber window (VCW) on the measurement of a surface under test (SUT)

Experimental Setup

- Figure below shows the in situ interferometer configuration
- Preliminary tests to study the effect of the vacuum port were carried out in the APS metrology laboratory. Measurements were performed both in vacuum using a test chamber and at atmospheric pressure. The present work focuses on measurements at atmospheric pressure using the setup shown in Figure 3 below.

Figure 2: Design and a 3-D drawing of the in situ interferometer and IBF system.

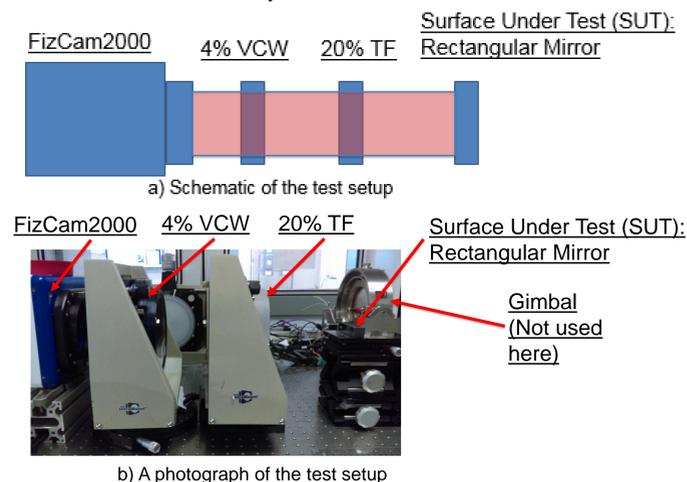


Figure 3: Experiment setup used to assess the effect of the vacuum port window on the interferometer measurement. The interferometer is a FizCam2000 from 4-D Technologies Inc.

Experimental Measurements

Description:

- Goal: Evaluate the effect that the vacuum chamber window (VCW) has when measuring the surface under test (SUT). To this end, the following measurements were performed:
 - Stationary measurements (with/without VCW): Took 5 measurements in 1 minute increments with same setup
 - Stationary difference subtractions: Subtracted each measurement from one another to observe the difference profiles
 - VCW tilt measurements: Took measurements for different VCW tilt angles in step sizes of 0.36 degrees up to 1.81 degrees
 - VCW tilt difference subtractions: Subtracted each tilt measurement from one another to observe the difference profiles
 - RMS (root mean squared) and Pv (robust peak-to-valley) of the difference were evaluated.
- Ideally, difference subtractions should result in a line profile of 0, but actual measurements are affected by measurement noise as well as by systematic errors due to the interferometer optical system aberrations and ray trace errors.

Results and Discussion

Example Process for Stationary Difference Subtraction with VCW:

- Subtract the two profiles

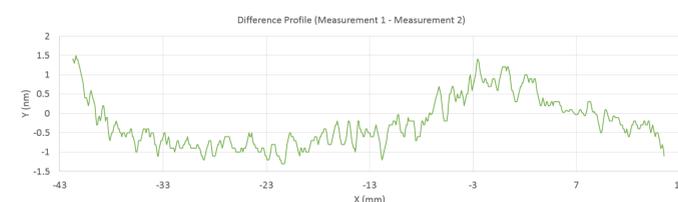
Measurement 1



Measurement 2

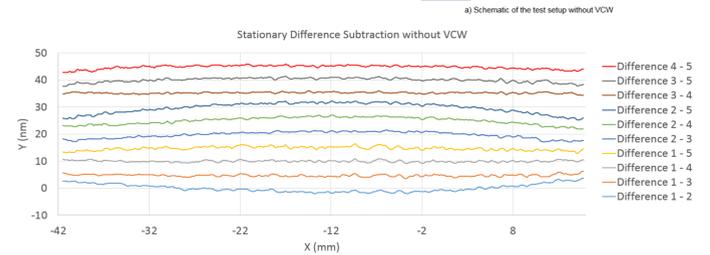


- To obtain the following difference profile

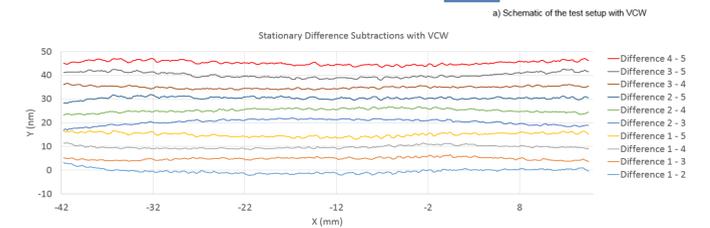


- Stationary difference profiles are plotted together in the results section in 2 graphs: one with VCW, one without VCW
- The effect of tilting the VCW is also explored with difference profiles taken over different angles and offset in the graph seen in the results section (all with respect to 0)
- Due to the limited amount of time, the surface profiles of the measurements could not be thoroughly analyzed for conclusive results
- The measurement data included can only suggest certain results and would need more time for a thorough investigation

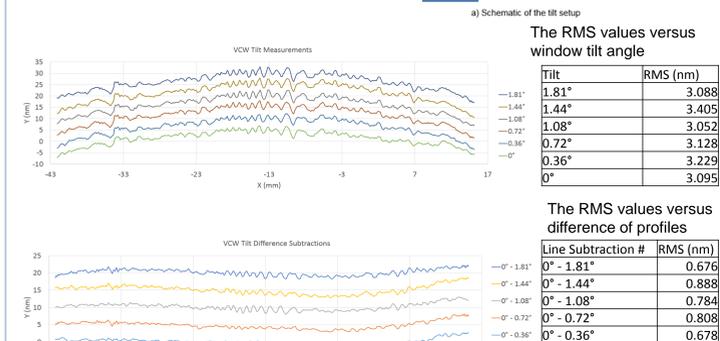
Stationary Difference Subtraction without VCW



Stationary Difference Subtraction with VCW



VCW Tilt Measurements and Difference Subtractions



- 10 difference subtraction profiles were used to look at the effect of the VCW on SUT measurements (noise level is similar throughout all measurements)
- Stationary measurements (taken in 1 minute increments) show stability of the setup over 5 minutes to show machine stability
- Tilt subtraction shows profiles for each of the angles as well as the differences with respect to the 0° measurement

Conclusion

The data suggests the VCW has negligible effect on the measurement. Further experimenting will be conducted to verify this finding.

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References

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