Lander University Flats and 11" Spin-Cast Epoxy Mirror Tests – No. 2

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*** Preliminary ***

Introduction

At the request of Lisa Brodhacker from Lander University, we evaluated four small epoxy-substrate flats (Nos. BLB-31.1 to BLB-31.4) and an additional 11 inch diameter spin-cast epoxy prototype mirror (No. 2, KLB-161) for optical performance. The testing protocol matches the March 12, 2011 and October 15, 2011 reports on other Lander mirrors.

Equipment

Thorlabs HeNe Laser & flats
Bath interferometer
Olympus EM500 DSRL
Casio Exlim EX-S5
Watec 902H2 Ultimate CCD video camera (30fps) and Canon ZR85 DVR
Meade 60mm aperture 350mm refractor

Mirror Descriptions

Figure 1. From left to right BLB-31.1 to BLB-31.4 Lander epoxy-substrate flats.

Figure 2. Lander flats from above. To the eye the flats appear flat and the surfaces mostly defect-free.

Table 1 - Lander Flats				
Flat No.	**Composition**	**Diameter (in)**	**Weight w/container (oz)**	**Notes**
BLB-31.1	2-layer: epoxy, thin epoxy	4.5	11	Smooth, small ridge on surface
BLB-31.2	1-layer: thin epoxy, metal cell	6	8	Smooth
BLB-31.3	2-layer: epoxy, epoxy w/microspheres	4.5	8	Small ripples
BLB-31.4	3-layer: epoxy, thin silicone rubber, thin epoxy	4.5	13	Small ripples, fingerprint

Interferograms

We were stymied in trying to test the flats with our interferometers. The non-silvered, semi-opaque material absorbed a lot of the laser flux. Also, the bottom of the container showed through and scattered light from the BLB-31.1 and especially the BLB-31.2 flats.

We re-built our interferometers several times, with configuration seen in Figures 3A to 3C, to try to test a large flat area. Our preferred method would use a folded-path Bath interferometer as seen in Figure 3A, but this interferometer configuration failed miserably because it required two reflections off of the unsilvered substrate. Very little light was returned as a result. Also, the mirror containers had edges which vignette the image thereby preventing using an angle of incidence promoting total reflection.

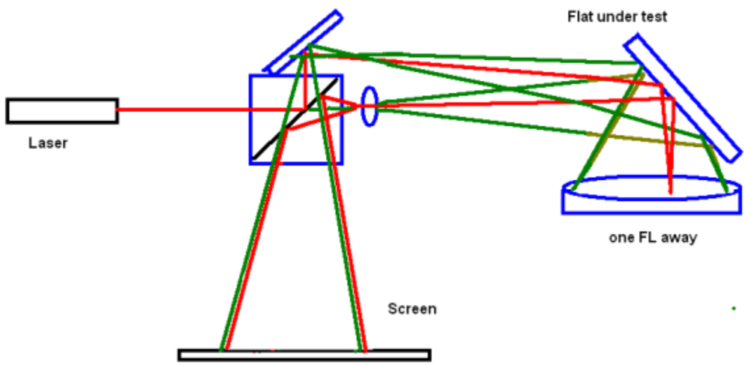


Figure 3A. Folded Path Bath interferometer for testing flats.

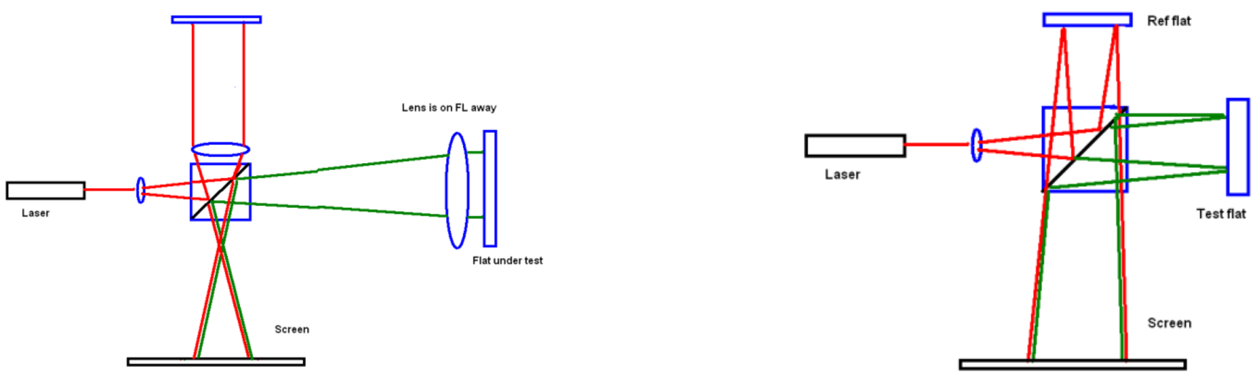


Figure 3B&C. Variants on the Twyman-Green interferometer configuration.

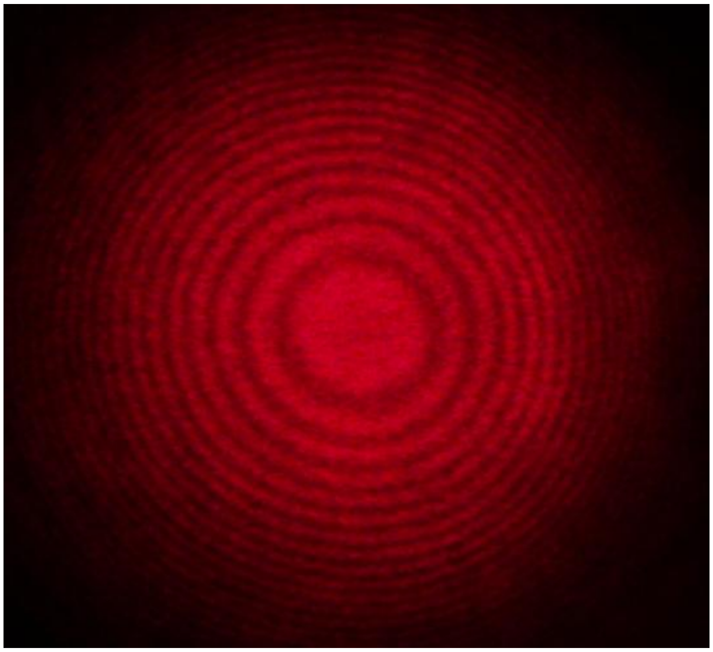


Figure 4. A T-G interferogram (Figure 3C configuration) of a 15 mm diameter region of the BLB-31.1 flat.

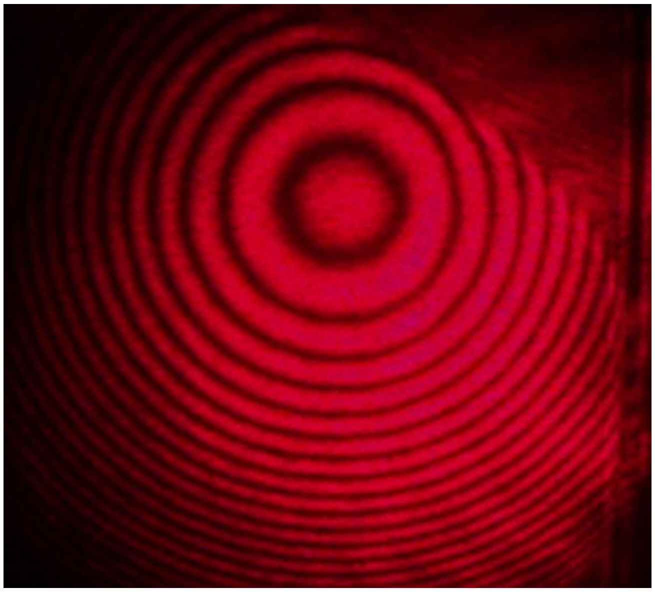


Figure 5. Comparison interferogram of a Thorlabs silvered flat made with the same configuration as used in Figure 4.

The circular appearance of the fringes in Figure 4 compared with the commercial flat seen in in Figure 5 indicates that the 15 mm diameter local surface in the region tested is flat to within less than a wavelength. The size of the beamsplitter limited the size of the test region. A larger beamsplitter is needed. One of the other interferometer configurations would sample a larger test region if the mirrors were silvered prior to test.

Reflectance Tests

We decided to test a 60 mm diameter region of the flats by reflecting an image of a distant test target into a small Meade refractor. The test target was at a distance of 75 feet. The flat was set to 45 degrees so the angle of incidence and reflection off the flat surface were 22.5 degrees. Figures 5 to 8 show the experimental setup.

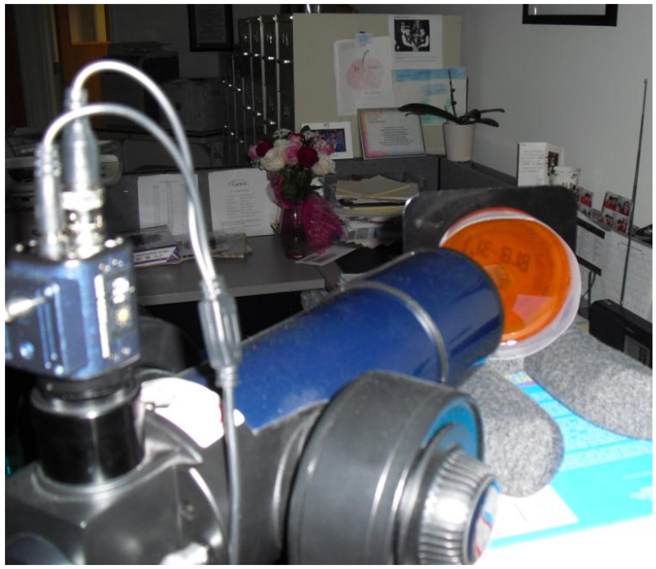


Figure 5. 60 mm Meade refractor with CCD video camera aimed at one of the flats.

Figure 6. The white test spot is 4.5 inches in diameter so it subtends 1031 arc seconds at the flat under test (17.2 arc minutes).

Figure 7. Video recording equipment. The Canon DVR, GPS time insertion device, and monitor are seen.

Figure 8. Image of the test target with no flat in use (aimed directly at the target).

The reflected light off of the flats was low in most cases resulting in images which are darker and have more read noise than the Figure 8 image. Some characteristic frames follow.

Figure 9. Image from light reflected off a 60 mm diameter region of the BLB-31.1 flat. Aberrations limit the resolution of the image to a couple of arc minutes.

Figure 10. Image from light reflected off a 60 mm diameter region of the BLB-31.2 flat. Aberrations limit the resolution of the image to about 20 to 30 arc seconds.

Figure 11. Image from light reflected off a 60 mm diameter region of the BLB-31.3 flat. Overall reflectivity of this flat was much higher. Aberrations limit the resolution of the image to about one arc minute.

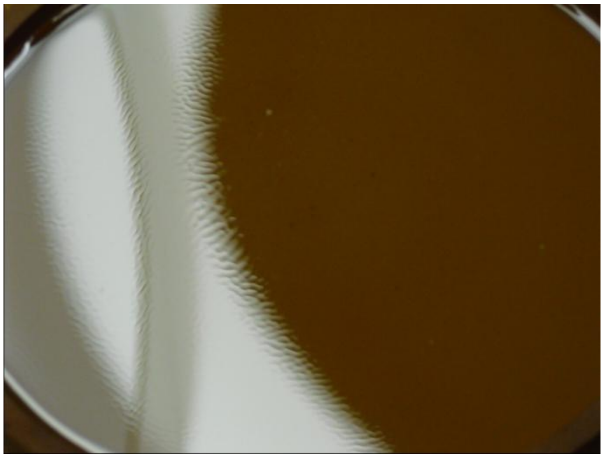
Figure 12. Image from light reflected off a 60 mm diameter region of the BLB-31.4 flat. Aberrations limit the resolution of the image to about 5 arc minutes or worse.

The reflectance tests show that the BLB-31.2 flat, with its single thin epoxy layer on a metal surface, has a superior surface to the other flats. The other flats show local regions which are flat, but not to the degree seen overall with BLB-31.2.

11” Spin-Cast Epoxy Mirror Tests - No. 2

We ran a few tests on an additional Lander 11” spin cast epoxy mirror numbered KLB-161. Like the first 11” Lander mirror (KLB-157) we tested, this mirror was fabricated in a CNC’ed foam shell. Up close, the mirror shows a thin raised edge of about a millimeter width due to surface tension during the epoxy fabrication process. No fingerprints are visible on the surface.

Figure 13. Lander KLB-161 11” spin-cast epoxy mirror as delivered.



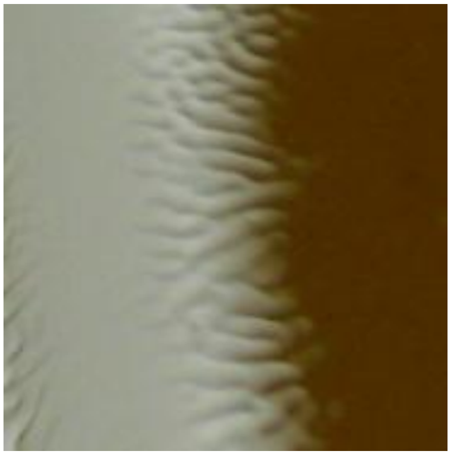


Figure 14A & B. The surface of the mirror had fine ripples preventing capturing fringes with an interferometer.

To test this mirror we set up a 1.75” diameter flashlight with 28 LEDs at a distance of 182”. The focus appeared at about 31” indicating a mirror focal length of about 26” and a speed of *f*/2.4.

Figure 15. 1.75" diameter LED flashlight source for spin-cast mirror test.

Figure 16. Returned image from the spin-cast mirror. Some astigmatism is apparent. Mainly, the individual LEDs are not visible presumably due to the high-frequency ripple. The resolution is about 3 to 5 arc minutes.