Vacuum Support for a Large Interferometric Reference Surface

**Masaki Hosoda**, Robert. E. Parks, James. H. Burge

College of Optical Sciences
University of Arizona
Tucson, AZ 85721

mhosoda@optics.arizona.edu
Outline

• Background
• Purpose
• Requirements for the system
• Experiments for a simple model
• Simulations for an actual model
• Summary
• We try to measure a secondary mirror for a telescope by Fizeau type interferometer with 5mm gap as shown in the right Figure [1].

• In this case, the bending of the test plate caused by the gravity becomes a problem, since the test plate is flipped around after polishing the reference surface.

• Reducing an unexpected bending in the reference surface is required.

Purpose

• The scope of this study is to show an effectiveness of the vacuum support for the large interferometric reference surface by simulations.
  – Validate simulations by simple experiments.
  – A mechanical mount for the test plate is also discussed.
### Requirements

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Verifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Difference between simulation and experiment</td>
<td>&lt; 20 [%]</td>
</tr>
<tr>
<td>2. Supported with edge face</td>
<td>NA</td>
</tr>
<tr>
<td>3. Surface Slope Irregularity</td>
<td>&lt; 10 [nm/cm RMS]</td>
</tr>
<tr>
<td>4. Resonant Frequency</td>
<td>&gt; 30 [Hz]</td>
</tr>
<tr>
<td>5. Stability</td>
<td></td>
</tr>
<tr>
<td>- power</td>
<td>20 [nm]</td>
</tr>
<tr>
<td>- w/o power</td>
<td>3 [nm]</td>
</tr>
</tbody>
</table>
Experimental Setup 1

(D = 100mm, Thickness = 2.69mm)

- Vacuum Pump
- Reservoir
- O-ring
- Needle
- Leak Valve
- Scale
- Water
- Pressure Gage

Sensitive around air pressure
Cheap
Experimental Setup 2

- Wyko 6000
- Sample Mount
- Leak Valve
- Pressure Gage
- Reservoir
- Vacuum Pump
Experimental Setup 3

Monitor

3 chucks

Needle

Flat Surface

TF
Experimental Results (Power; Z4)

Max Difference : 9.6% at 275 Pa
Experimental Results ($\rho^4$ term; Z11)

Max Difference: 9.9% at 275 Pa
Design Concept 1

1.1m

Epoxy

Flexure

3 Lateral Supports

20mm

Invar

Screw

Hard contact point

3 Axial Supports
Design Concept 2

\[ P \ [N/m^2] = F \ [N] / A \ [m^2] \]

Test Plate

Load Cell (Futek LLB300) (Max: 500lb)

Plate

Molded Rolling Diaphragm

- 20 mm
- 5 mm
- 6.4 mm
- 18.8 mm
- 51.97 mm
Resonant Frequency

242.1 Hz
Pressure vs. Surface Slope Irregularity

Pressure vs. Surface Slope Irregularity of Test Plate

Stability (Power) : 2.34 nm < 20nm
Stability (w/o Power) : 0.38 nm < 3nm

0.75 nm/cm RMS at 2300 Pa
100 um tolerance at flexure causes 0.2 N-m moment at the test plate. This causes 2.71 nm/cm RMS surface slope irregularity.

Since this issue is independent from vacuum support,
(Total RMS) = SQRT((0.75 nm/cm)^2 + 3 x (2.71 nm/cm)^2) = 4.75 nm/cm RMS < 10 nm/cm RMS
Interferogram with Vacuum Support

Piston and Tilts are removed.

W/O Vacuum Support

W/ Vacuum Support
Interferogram with Vacuum Support

Piston, Tilts, and Power are removed.

W/O Vacuum Support

\[ \text{RMS} = 86.51 \text{ (nm)} \]

W/ Vacuum Support

\[ \text{RMS} = 8.026 \text{ (nm)} \]
Summary

• I did the simple experiment and the simulation to evaluate the vacuum support.
  – Difference between exp. and sim. was 10% < 20% in spec.
  – Surface slope irregularity was 4.75 nm/cm < 10 nm/cm in spec.
  – Resonant Frequency was 242.1 Hz > 30 Hz in spec.
  – Stability of Power was 2.34 nm < 20 nm
  – Stability of w/o Power was 0.38 nm < 3 nm

• The vacuum support for the large interferometric reference surface can be effective.

• Future Work
  – Detail design around the diaphragm
  – Check an effect of index change
  – Comparison with actual experiment