Application Note

AN008: Concave Pad Array for Improved DM Throw and Control

Introduction

Standard deformable mirrors (DM) are designed with flat pad arrays. Based on a suggestion from Ed Pogue at a recent HELJTO Technical Review Meeting, AgilOptics successfully manufactured a concave pad array which closely matches the curvature of the membrane while under actuation. Testing of this special device is ongoing.

Spherical Curvature

The pad array was made by simply bending an already prepared thin silicon wafer and gluing the bent wafer while deformed. **Figure 1** shows the mechanics of making the curved pad array. Since the new pad array was only twice as thick as the original pad array it can be handled in the same manner as the old array.

Specifically, the pre-formed and coated pad array was bent after gold deposition, allowing the electro-deposition mask to be used in the flat condition. The pad array was easily bonded to the mirror membrane frame in a normal manner and the wire bonding was done exactly the same as with a flat pad array. If the pad array could not be bent, machining a concave surface and making specially curved masks would have been very expensive. Since the silicon needed to flex only about 30µm, fracture was avoided.

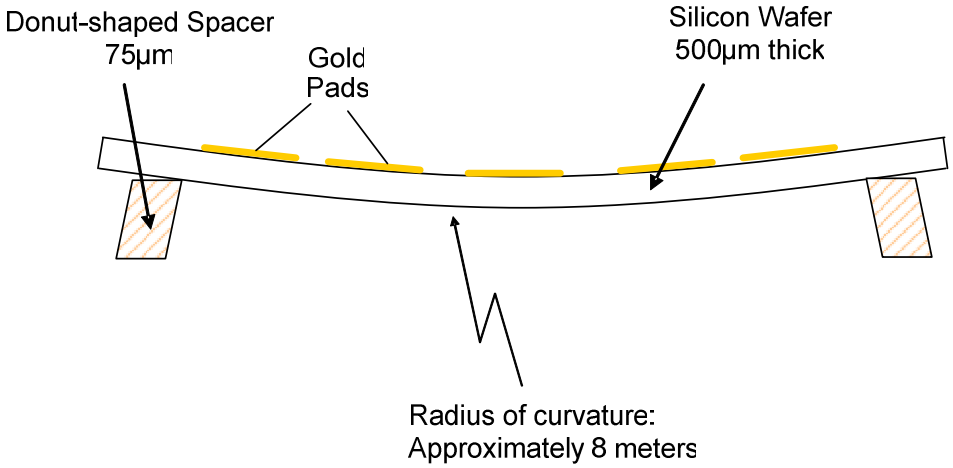

Figure 1 Construction details of Bowed Pad Array

Figure 2 shows an interferogram of the pad array after bending and bonding. Note that the concave nature of the pad array shows up as a series of concentric circles, which are very nearly centered over the diameter of the part. Our estimate is that the sagitta of the bend is about one half of the 75µm spacer height, 37.5µm. This is consistent with the measurements on the interferometer.

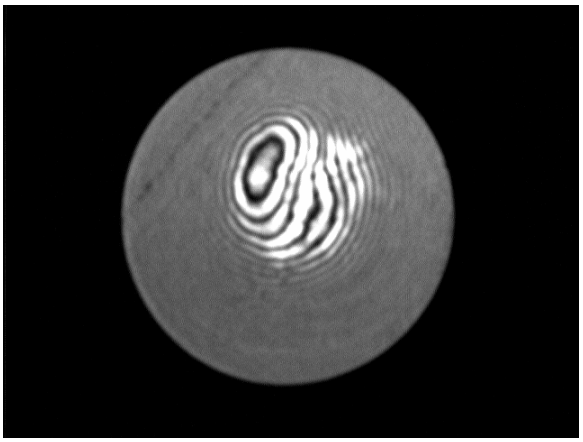

Figure 3 Interferogram of the concave pad array with no membrane

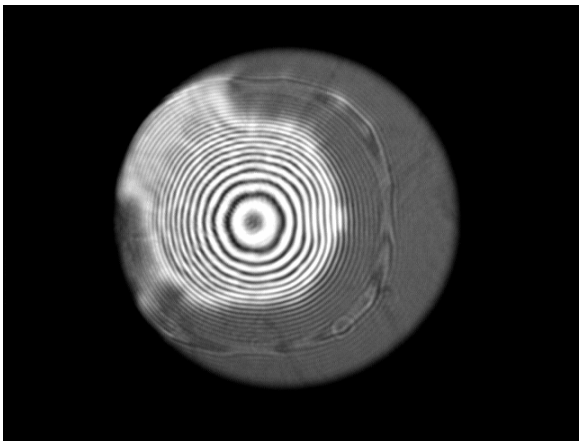

Figure 2 Interferogram of a 30mm membrane at 380V using the concave pad array

Once fabricated, a 30mm membrane mirror was bonded to the concave pad array, the wiring completed, and the mirror tested. **Figure 3** is an interferogram of the 30mm mirror at 380 volts. Our current maximum testing voltage is 400V.

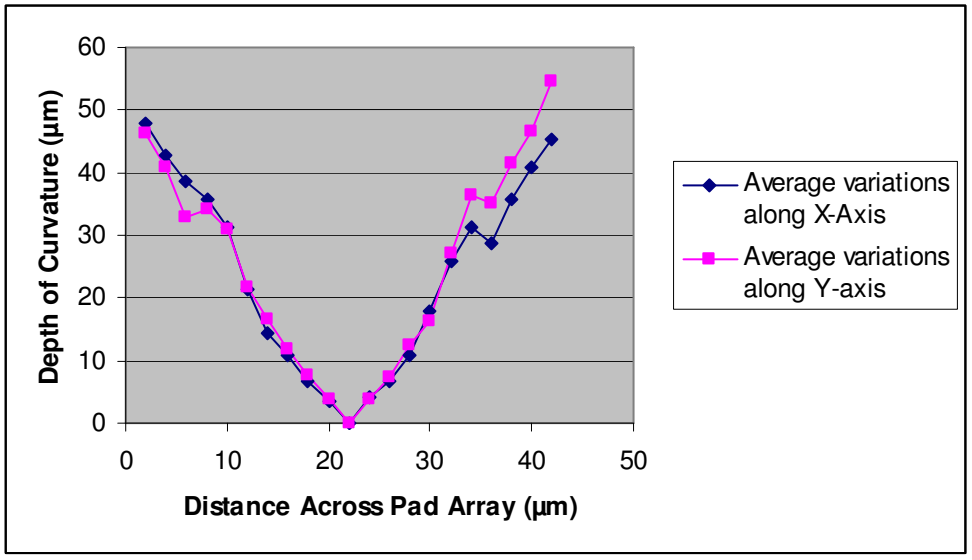

Figure 4 Graph of average measurement variations across pad array and depth of the curvature.

The mirror showed several novel characteristics.

1) Normal pull-down of the membrane was substantially reduced at the lower voltages.
2) The mirror was able to withstand 400 volts, more than enough to snap-down a normal 30mm mirror.
3) Concentricity of the rings was excellent, even though this particular mirror had one bad actuator.

The mirror radius of curvature was estimated by measuring the focal length of a collimated laser beam (from the Zygo interferometer). Based on a focal length of 24 feet (roughly 8 meters) at 400 volts the mirror was pulling down 7µm. Under the same conditions, the interferometer showed about 20 rings at λ = 0.63µm, equating to about 6µm of displacement.

We are still trying to understand the pros and cons of this design. Since the spacers between the membrane and the plane of pad array were 40µm, it may make sense to try a smaller spacing to lower the operational voltage down to the 0 - 300 volt range.

A range of voltages were applied to the novel mirror and these are summarized below.

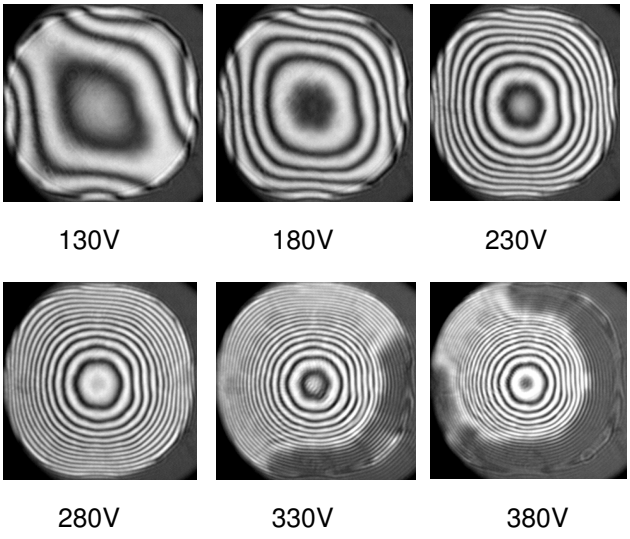

Figure 5 30mm Conformal Deformable Mirror active at various voltages

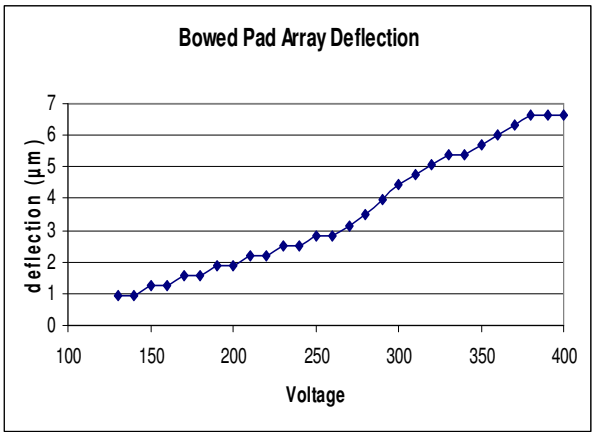

Figure 6 Conformal DM Deflection

What Can Deformable Mirrors Do?

- Correct Optical Aberrations
- Laser Beam Shaping
- Optical Image Enhancement

Deformable mirrors are revolutionizing laser and optical systems by replacing static components with dynamic optics. Deformable mirrors (DM) are adaptive optics with dynamic faces able to optimize or change the characteristics of reflected light for a specific application. With time-varying control, a DM can focus a beam at several different points at different times or it can replace a lens in an optical system. Deformable Mirrors can improve optical images in telescopes, cameras, and other imaging systems.

For further information and discussion about how deformable mirrors work and how they will solve your optical problems see the manuals for HVDD, Clarifi, and the application notes available on the Web.

http://www.agiloptics.com/AppNotes.htm

http://www.agiloptics.com/downloads.htm