# Round Robin Testing of the Optimax Optidome

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## ABSTRACT

OptiDomes are six-inch diameter concentric F/0.53 spherical fused silica domes manufactured by Optimax Systems Inc. The purpose of these domes is to act as a standard for metrology testing of various testing methods for measuring the surface quality, mechanical attributes and/or the transmitted wave front error of hemispherical/spherical domes. Each of the OptiDomes was fabricated to pre-specified quality levels including domes that have induced errors. This paper gives additional manufacturing information, detailed handling instructions, procurement information as well as initial measurement results.
**Keywords:** Dome, OptiDome, ALON, hemispherical spherical dome

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## 1. INTRODUCTION

As the need for concentric hemispherical/spherical domes increases, so does the need for production environment precision metrology. The OptiDome was created as a tool available to industry to develop emerging technologies and to adapt existing technologies to the unique challenges inherent in dome metrology. Attributes to be measured include concentricity of inner vs. outer surfaces, full aperture irregularity interferometry and full aperture transmitted wavefront measurement. Measurement methods include but are not limited to contact and non-contact thickness measurement, stitching interferometry, and large aperture interferometry.

## 2. DOME GEOMETRY

OptiDomes are six-inch diameter concentric F/0.53 spherical fused silica domes manufactured by Optimax Systems Inc. The nominal radius of each dome is 88.9mm with a constant wall thickness of 2.9mm and 164.64mm clear aperture. The inner and outer surface of the dome is to be concentric to within 0.005mm that is, a uniform wall thickness must be maintained within that specification. See figure 1.

Each of the OptiDomes was fabricated to pre-specified quality levels including domes that have intentionally induced errors. One of the OptiDomes will act as the “gold standard” fabricated with minimal error and two additional domes will contain intentional errors, such as wall thickness variation and surface irregularity. The domes will be serialized and characterized in-house to the best of our ability, but the errors will not be disclosed to those performing the mechanical attribute and full aperture measurement techniques. The intention of the “blind test” is to stimulate thought about measurement/characterization techniques for concentric domes with unknown errors and to allow for standard comparison between these techniques. Those taking part in the round robin testing will make their measurement results available to Optimax Systems.

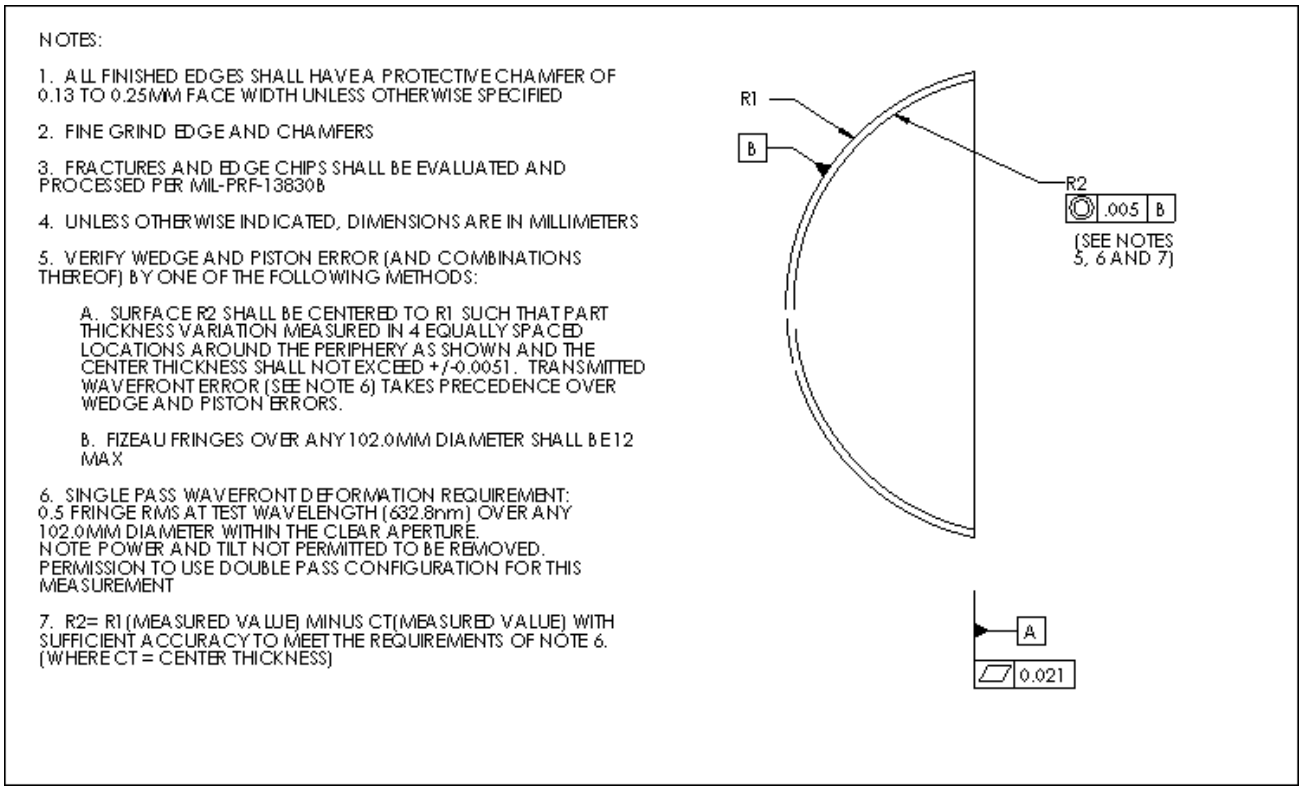


Figure 1.

## 3. MEASUREMENT METHODS USED IN FABRICATION

Measurement requirements for the OptiDome can be broken down into two segments relating to mechanical conformance and optical performance. As seen in figure 1, mechanical considerations relate to both center thickness and concentricity of the inner and outer surface. R2 is a calculated attribute as shown in note seven with consideration given to meeting the requirements of note six. Overall performance is determined by transmitted wavefront testing and takes precedence over centration and piston error. Domes are processed convex side first then mounted in such a way as to process the concave side. Material removal is monitored to simultaneously achieve proper center thickness and concave radius. See Figure 2. This measurement necessitates contact of the indicator probe tip onto the concave surface thereby putting the cosmetic integrity of that surface in jeopardy. Concentricity of the outer surface relative to the inner surface is measured by using a ball type micrometer with measurements taken in four places on the periphery of the part. Again, this is a contact type method and puts the surface at risk.

Measurement of both surface irregularity and transmitted wavefront error was performed using a Zygo (4) VeriFire high resolution phase shifting interferometer. Irregularity testing of both surfaces was performed with the part mounted in its processing block with TWE testing performed using a specially designed holding tool. See Figure 3.

figure 2.

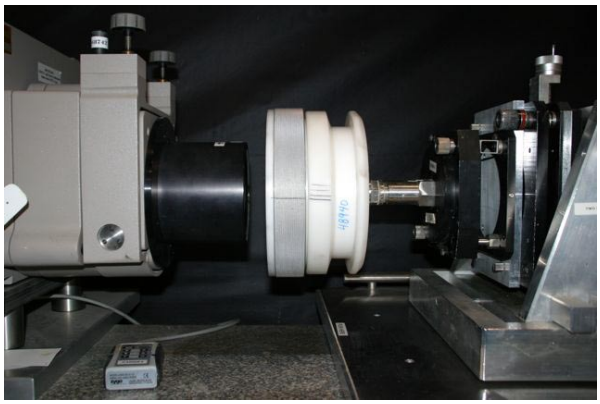

figure 3.

## 4. DETAILS OF HANDLING AND MOUNTING INSTRUCTIONS

The OptiDome has been configured with a mounting ring, a lens cap and cover and has been fitted to a foam lined high impact plastic case. See Figure 4. To facilitate a consistent mounting interface a stainless steel ring was fabricated to act as a precision mounting surface with an integrated set of handles to assist in attaching it to a test fixture. The dome itself was cemented to the mounting ring using RTV cement in such a way as to completely surround the periphery and flat face of the ring. This method of attachment assures a very resilient yet strong bond capable of allowing for any imperfections of the mount ring or test mounting structure. See Figure 5.

A document is included in the package that illustrates some suggested mounting methods and provides date with regards to mounting bolt circle and hole diameters. See Figure 6. A set of springs and shoulder bolts are provided to mount the ring to a test fixture in such a way as to assure tightening torque remains the same from test fixture to test fixture. See Figure 7.


figure 4.

figure 5

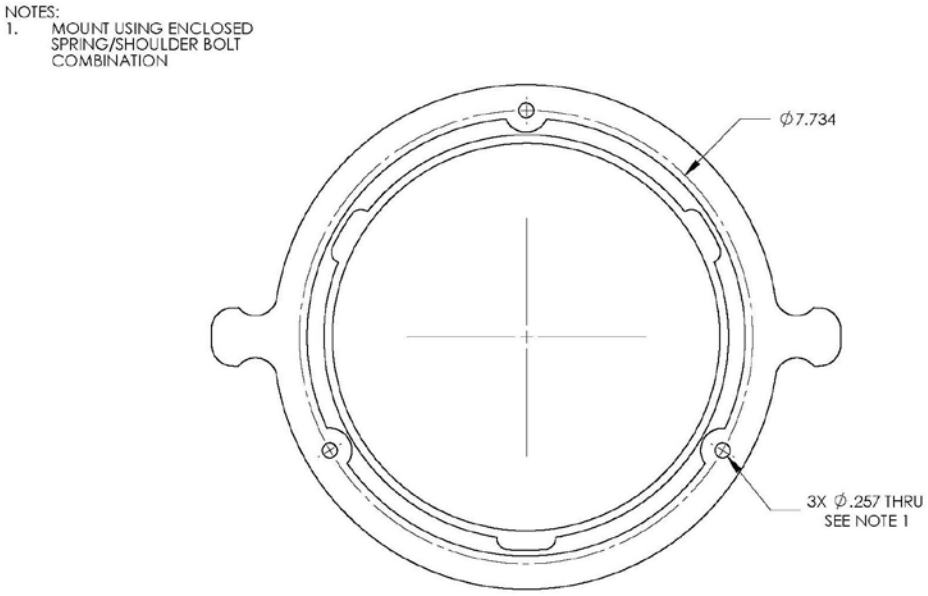


figure 6. .

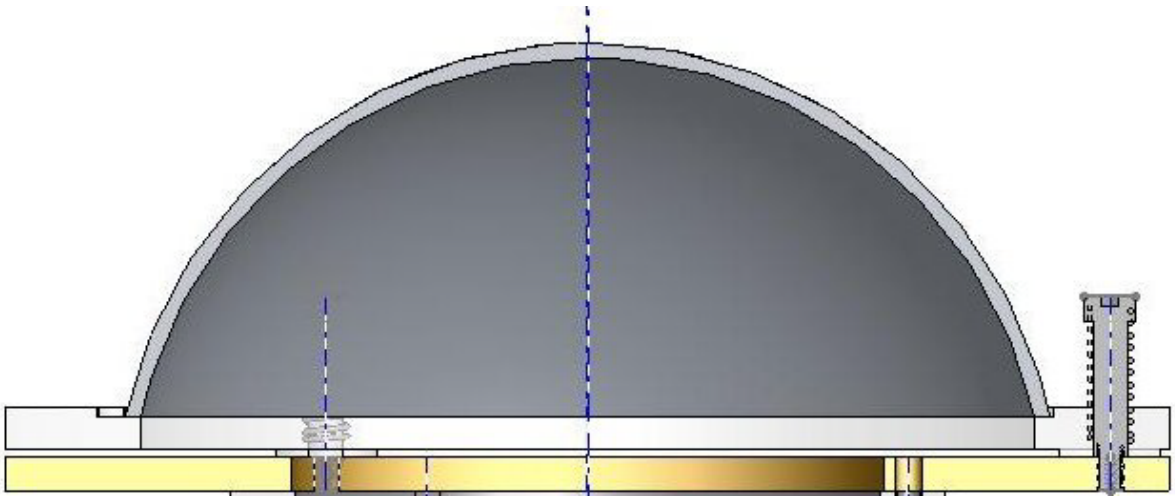

figure 7.

## 5. SUGGESTED ROUND ROBIN MEASUREMENT METHODS

Measurement methods and techniques used to measure a concentric dome may include but are not limited to non-contact thickness measurement devices, contact measurement devices and Interferometric instruments capable of full aperture coverage for both reflective testing and transmitted wavefront testing. Non-contact measuring instruments may include the Fogale Nanotech (1) system (see figure 8.) or the Lumetrics (2) OptiGuage (see figure 9.).

Fogale Nanotech Model LISW-LS400
Measurement range – 8 mm
Accuracy - 100 nm
Self calibrating electronics
Scan rate- 150Hz
Modular – 8 probe multiplex


figure 8.

Lumetrics OptiGuage:
Measurement range: 400 mm
Accuracy: ±1 µm
Measurement time: 1 - 20 s
Optical power: 16 mW at 1310 nm

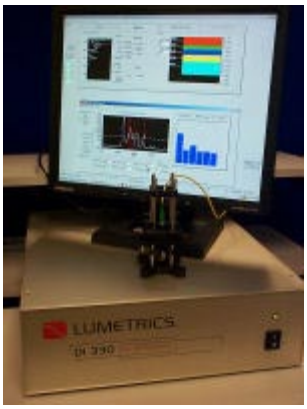


figure 9.

Full aperture interferometry for testing surface irregularity and transmitted wavefront can be accomplished in several different manners. Full aperture testing of the concave surface of the dome can be done conventionally by utilizing a f/0.65 transmission sphere. Coverage of the diverging beam would be sufficient to yield an interferogram of the entire clear aperture. To obtain full aperture coverage in measuring the convex surface in reflection an instrument of sufficient reference beam diameter must be used in conjunction with an appropriate transmission sphere. Another viable method is available by using the QED (3) Sub Aperture Stitching Interferometer or SSI. In this method a number of overlapping circular sub apertures are measured and then stitched together to yield an interferogram of the entire surface.

Full aperture testing of transmitted wavefront presents its own unique challenges. One viable method is again to place the concave surface in before the diverging beam using a f/0.65 transmission sphere then reflecting from a large diameter reference element. The challenge here is to produce a large diameter reference, roughly 300 mm in diameter to better than $20^{th}$ wave irregularity.

All methods mentioned here assume utilization of a phase shifting interferometer such as the Zygo (4) VeriFire high resolution interferometer.

## 6. PROCUREMENT

A total of three OptiDomes were manufactured and are available to those institutions or individuals wanting to utilize them for development of measuring instruments. To order an OptiDome contact sales@optimaxsi.com. A purchase order must be placed in the ammount of $10,000 however, billing against that purchase order will not take place unless the OptiDome is damaged or not returned. The OptiDome may be used for a period of one month then returned to Optimax. Extensions to that one month time period will be considered dependent upon demand by others wishing to obtain it. By utilizing the OptiDome as a means of obtaining data using new and existing technologies, the borrower agrees to share any data obtained as well as brief description of the method or technology used.

## 7. CONCLUSION

Given the growing demand for concentric domes a need exists for innovative technology to address dome metrology for high production environments. The OptiDome as a measurement artifact can serve as a tool for the development of these new technologies. Methods and technologies are mentioned here only as examples. It is hoped that given use of the OptiDome artifact, new technologies will emerge and existing technologies may be adapted and improved upon.

## REFERENCES

[1] Fogale nanotech inc., 1714 Lombard Street, San Francisco CA, 94123, (818) 206 8525
[2] Lumetrics Inc., 150 Lucius Gordon Drive, West Henrietta, New York 14586, 585-214-2455
[3] QED Technologies, 1040 University Avenue, Rochester, NY 14607, 585 256 6540
[4] Zygo Corporation, Laurel Brook Road, Middlefield, CT, 06455, 860-347-8506