

Optical Capabilities for Measurement of Arrays

IMOG Measurement Subgroup

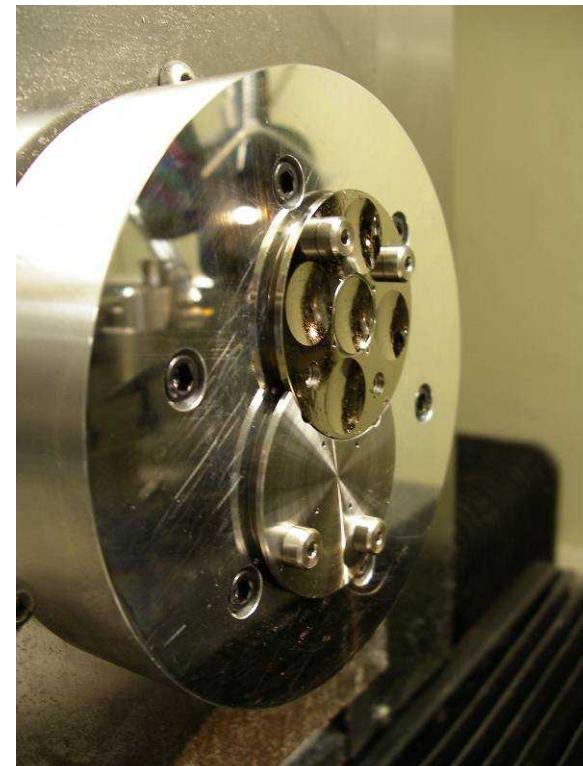
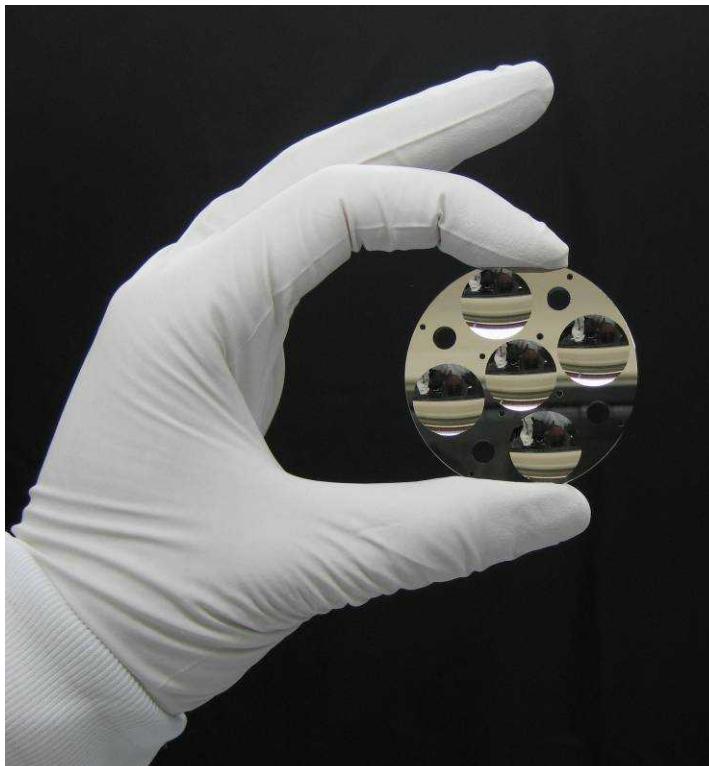
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A Challenging Optical Array

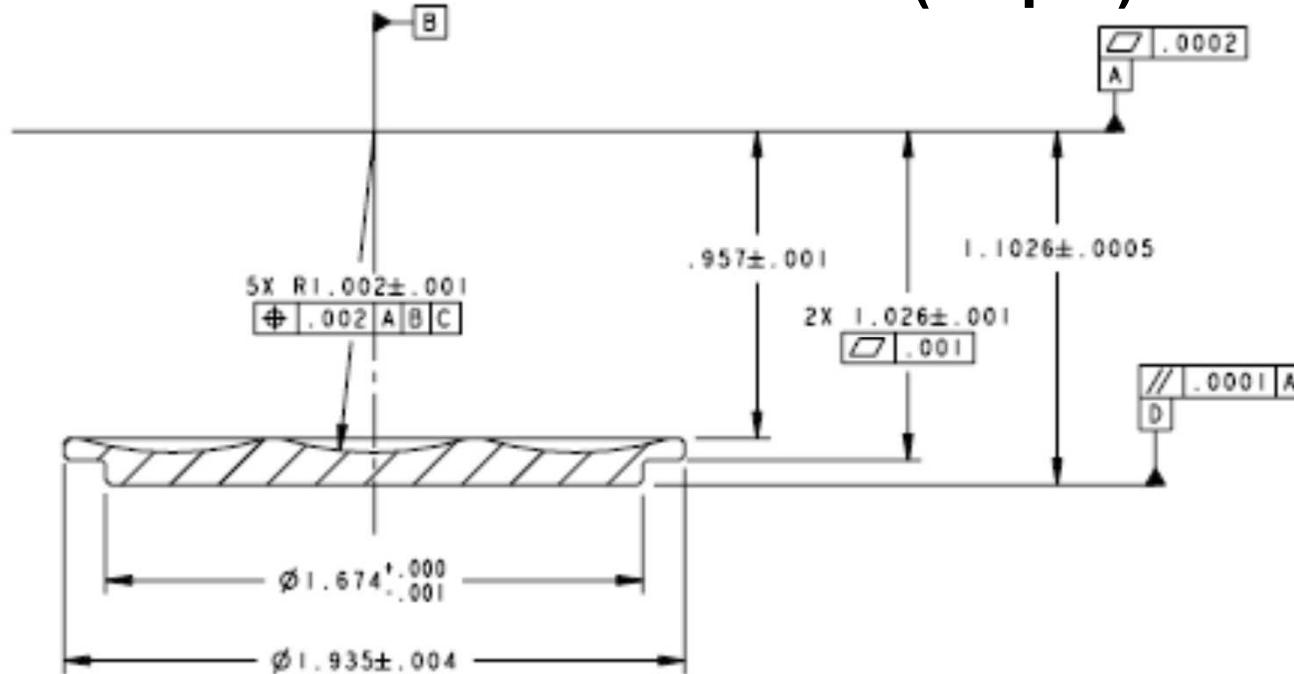
- Diamond Turning a 5 optic metrology target
- Refixtured the part with each optic on center and a counterbalance to control vibration





Measuring the array

- Primary datum is a best fit plane through 5 points
- Each of 5 optics has very shallow section of sphere to measure – leads to CMM inaccuracy
- Non-contact measurement is desired as form/finish callout was 31nm RMS (1.2 μ in)

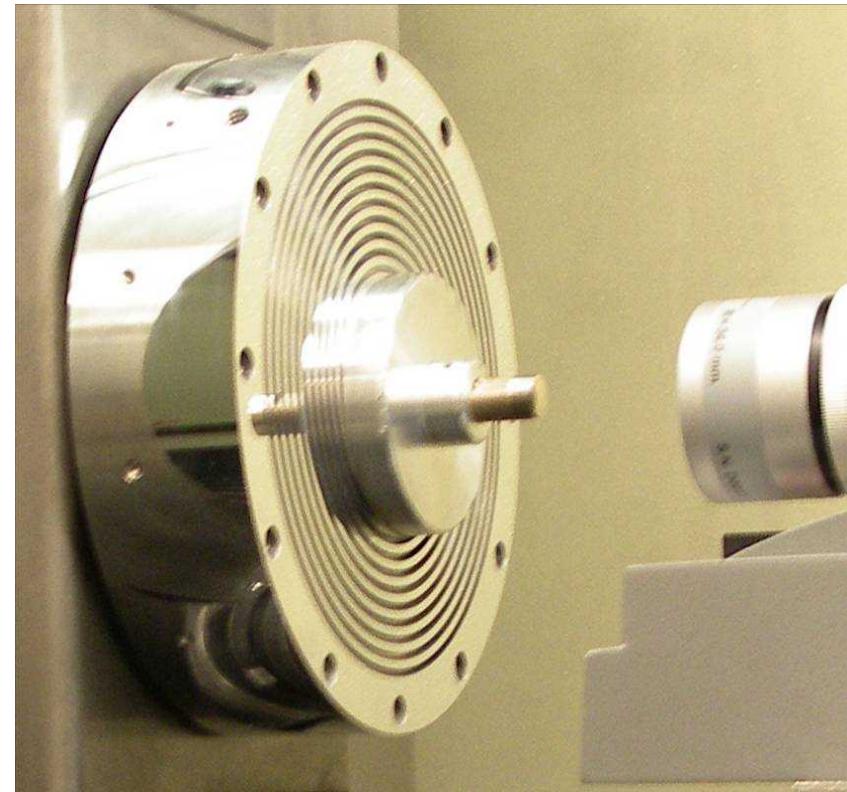




Also for tool centering

- **Tool centering Process**
 1. Cut sphere on test part
 2. Measure sphere
 3. Recenter part to better than 1um
 4. Repeat up to 8 times

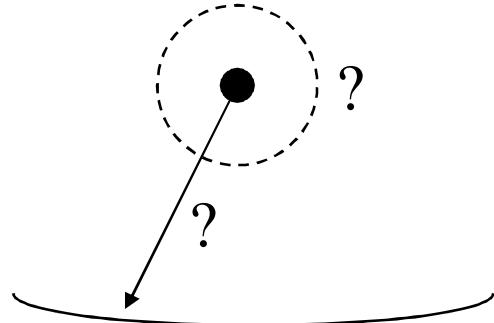
**On-machine measurement by
Interferometer saves 20-30
minutes per tool**



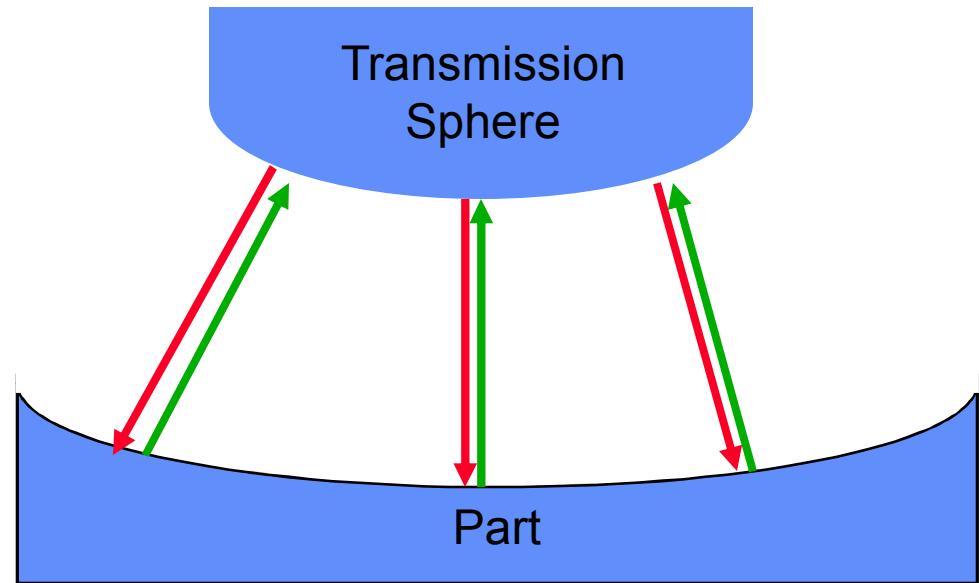


Why use an interferometer?

- It is a **comparison mode measurement** (more accurate than absolute mode)
- Measures the tiny difference between a spherical wavefront (spherical standard) and the spherical part



Small Arc Measurement
Very Sensitive to Point Accuracy
(approaching a plane)



The phase interferometer is a comparison measurement.



Axes for the Interferometer

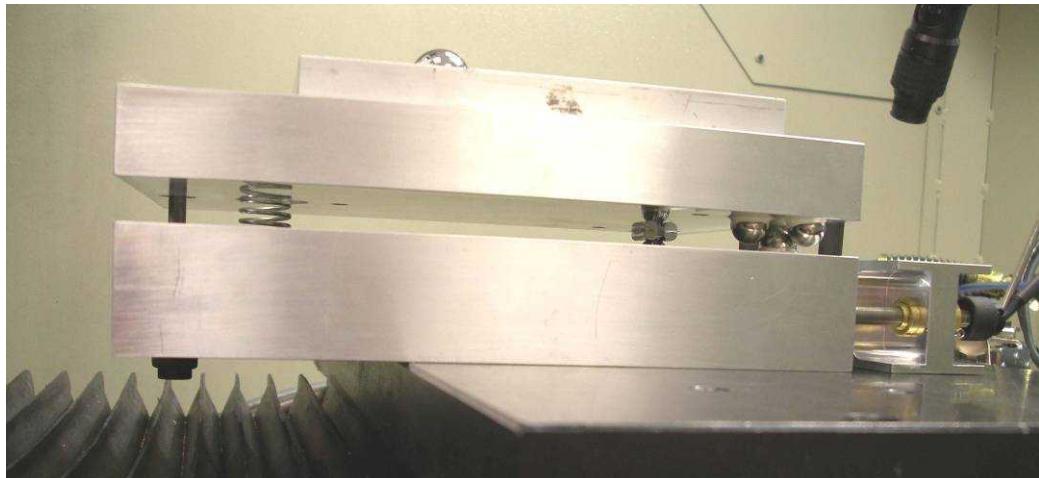
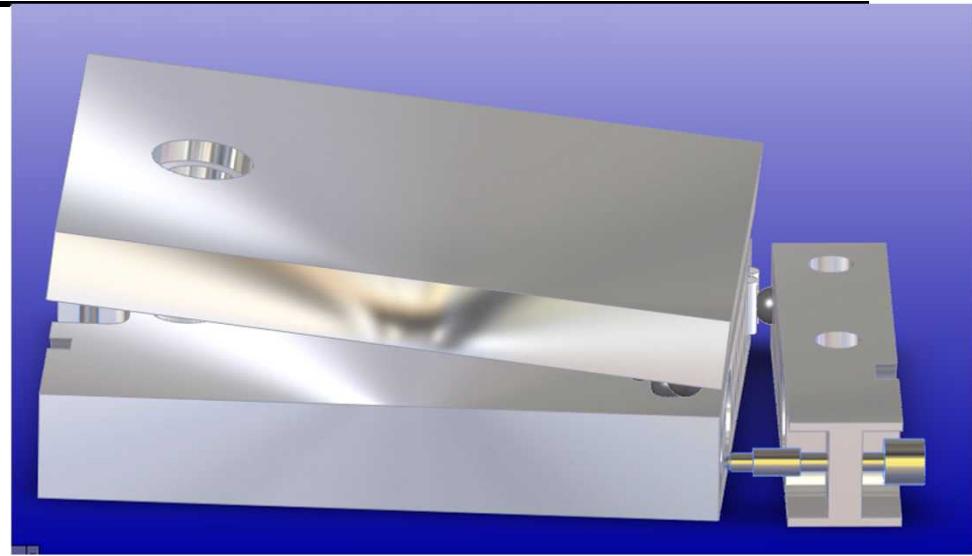
- The interferometer's focal point must be aligned with each of the 5 optics' focal points
- Use the diamond turning machine
 - <250nm positioning error, high stiffness, 8.6nm axis resolution
 - Vibration Isolated
 - Temperature Controlled Environment





An Pitch-Yaw Mount for the Interferometer

- 80 TPI Screws – 0.3 arcsecond Yaw resolution
- Kinematically mounted plates for high repeatability
- Spring Preloaded – low backlash
- Mounts to machine's std. mounting hole pattern





Zygo on the Moore (350FG)

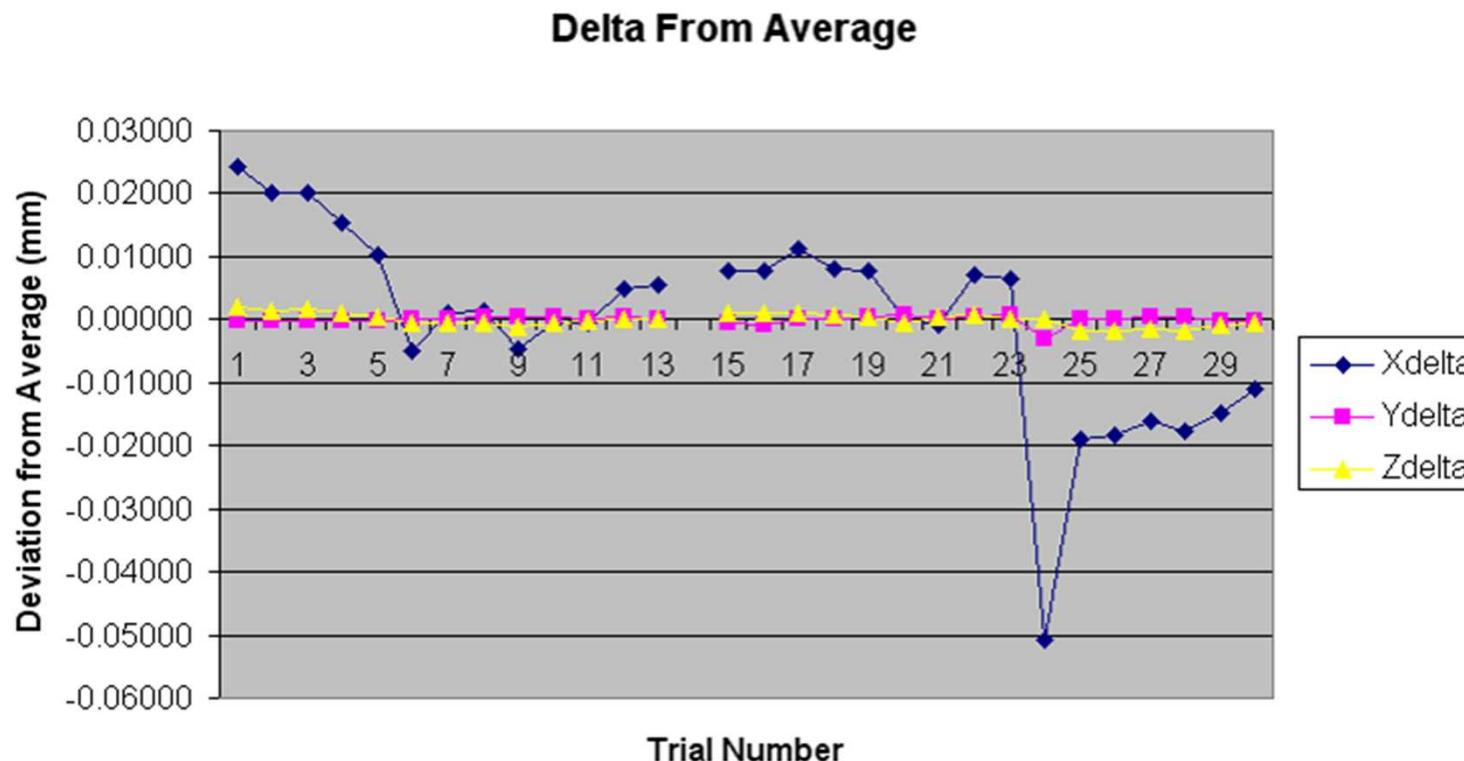
- Interferometer on Kinematic mount to allow removal during machining
- Can be used for form, position, and radius measurements
- Allows measurement of parts without removing them from the machine for fast turnaround





How good is it?

- Performed a 3 operator GR&R
- Measured the same part 10 times each, alternating users
- 1 experienced user, 2 novice





Expanded Uncertainty

- **Error Budget Items**
 - **Reproducibility**
 - **Machine Axis Positioning**
 - **Thermal (interferometer)**
 - **Interferometer Angular Alignment**
 - **Kinematic Mount (lightly oiled, 3 ball/6 cyl.)**

K factor = 2	Ux(um)	Uy(um)	Uz(um)
Expanded Uncertainty	10.34889	4.688596	3.301373



Final Thoughts

- **Very useful measurement method**
- **Mount/Measurement is very sensitive to X**
 - Leave interferometer in the machine between tests when possible
- **Provided capability to measure arrays that weren't measurable otherwise**
- **Makes tool setting very fast**