Application of Interferometric Metrology to Corrective Polishing of Precision Surfaces

Roger Morton

Operations Director - Zeeko Limited

6th February 2008

Introduction

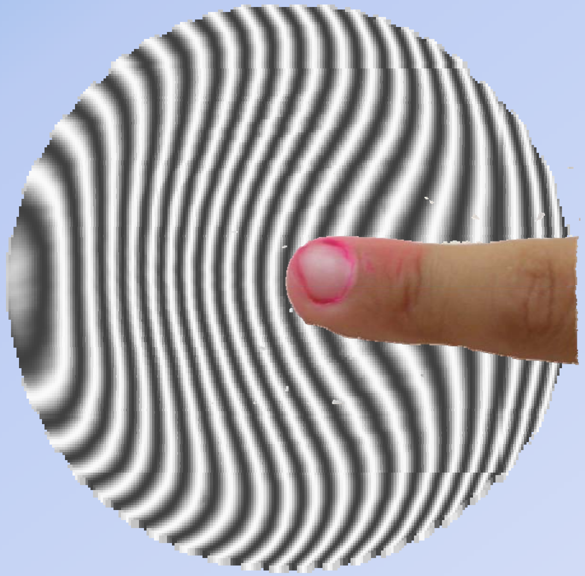
- Interferometery plays a key role in the process loop when polishing precision optics and other surfaces. The methodology used will be explored highlighting how to exploit it’s strengths together with how to use complementary metrology to mitigate some of its limitations

Corrective Polishing Machines

- Product range from 200mm capacity to 1200mm capacity

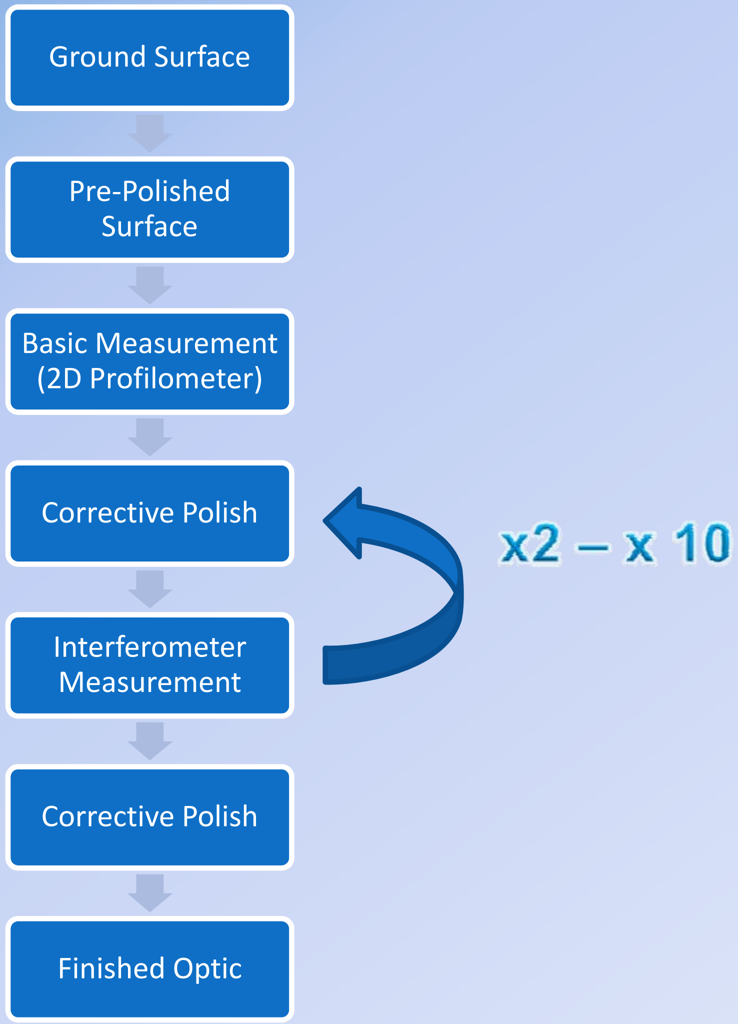
What is Corrective Polishing?

- Put simply, the high points are differentially polished in preference to the low points
- Traditionally this has been done by hand using a ‘fringe’ patterns and hand polishing
- More recently phase shifting interferometers have replaced light boxes and test plates and CNC polishers have replaced the finger



Basic Process Flow of Corrective Polishing

- As can be seen the interferometer measurement plays a vital role in the overall process and typically provides the mainstay of metrology input



Ground Surface

Pre-Polished Surface

Basic Measurement (2D Profilometer)

Corrective Polish

Interferometer Measurement

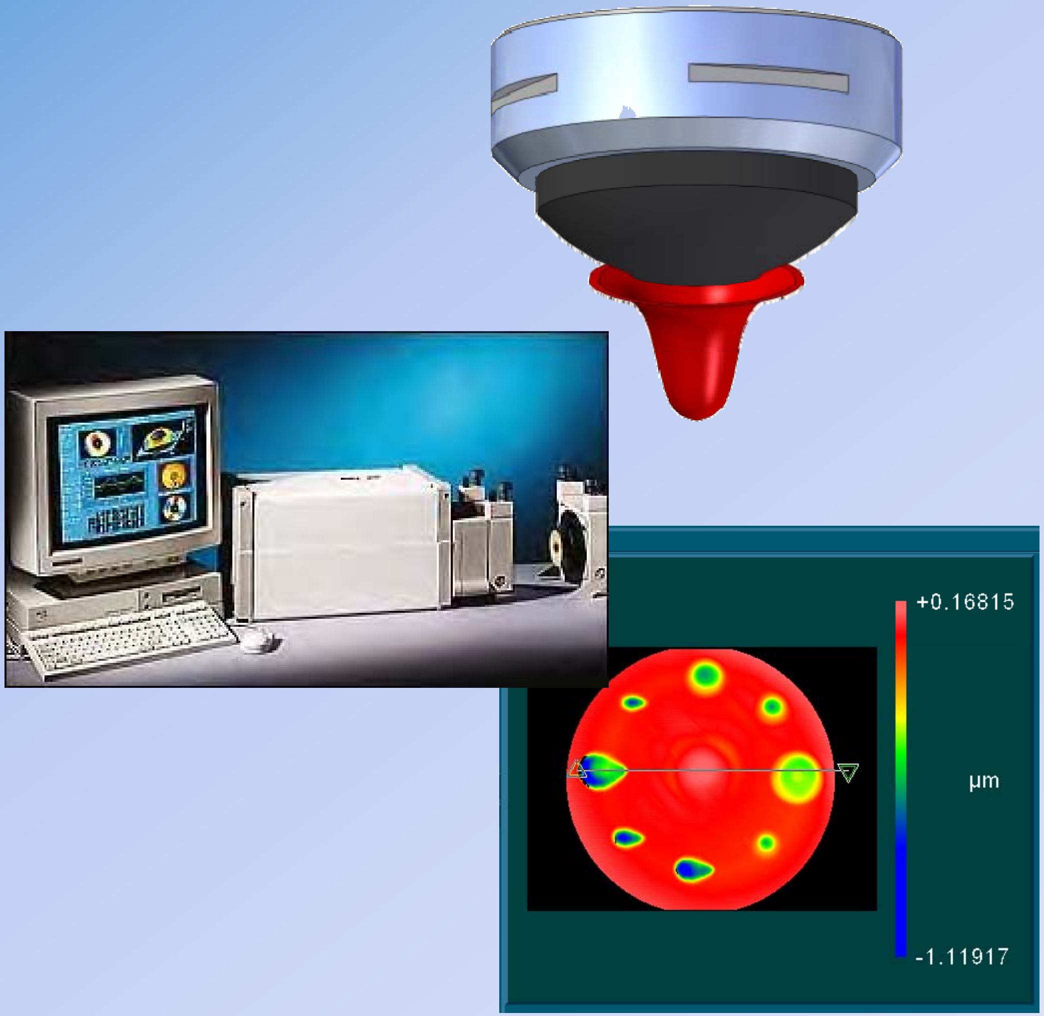
Corrective Polish

Finished Optic

x2 – x 10

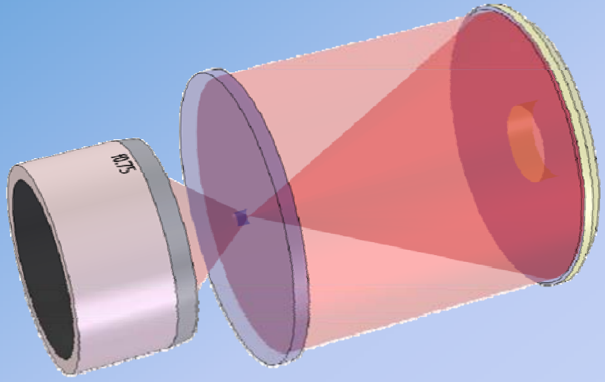
Basic principle of Zeeko process

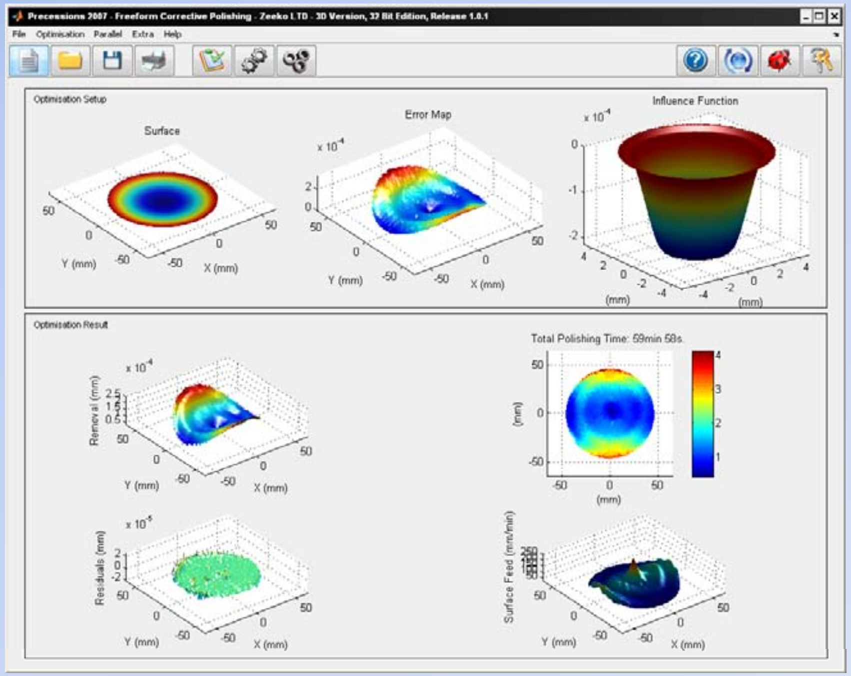
- A series of ‘spots’ are polished in sample glass using known parameters
- Spots are measured using an interferometer to characterise shape & depth



Basic principle of Zeeko process

- Part is measured to derive an error map
- An optimiser is used to calculate a dwell time map
- Dwell time map is then converted to CNC tool-path

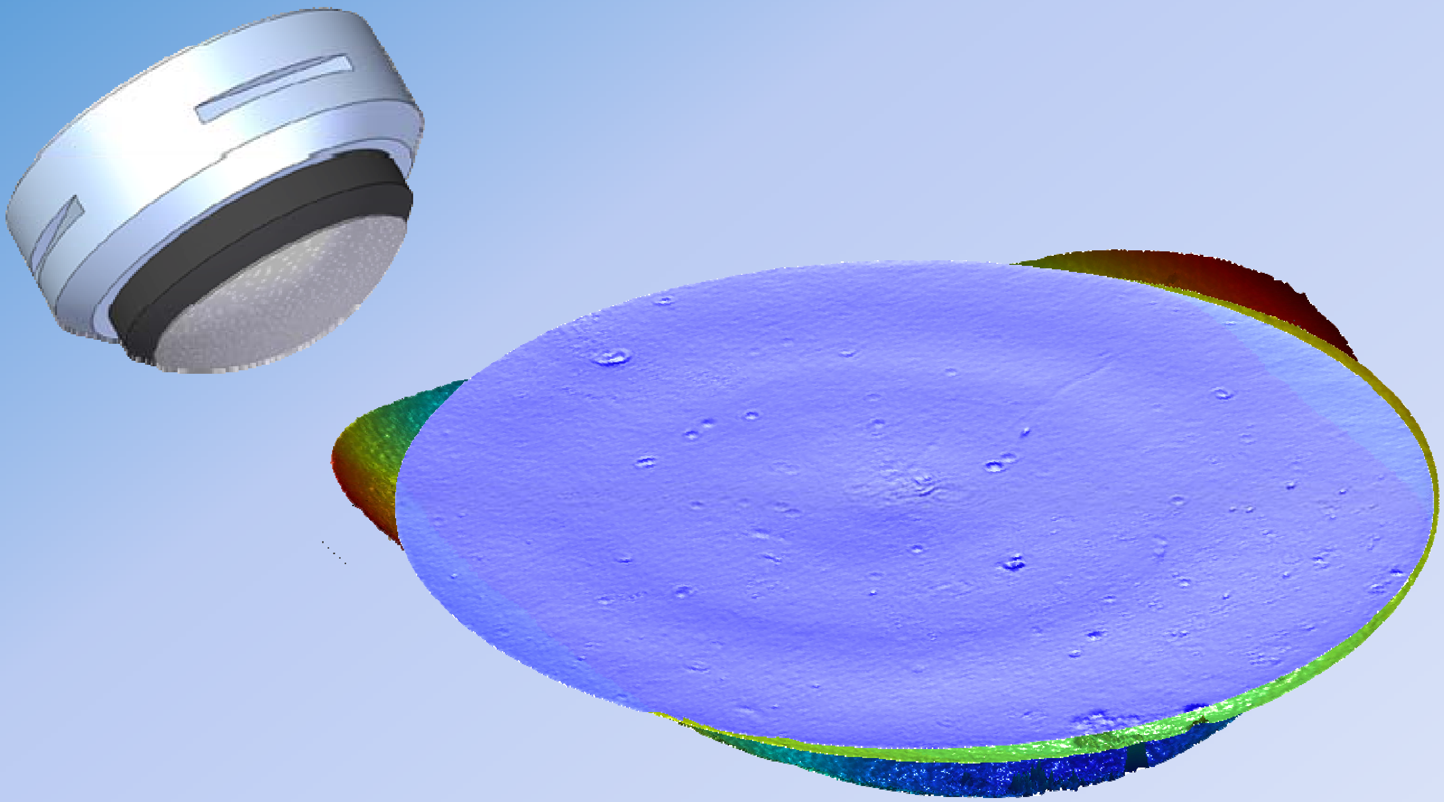




Total Polishing Time: 59min 58s.

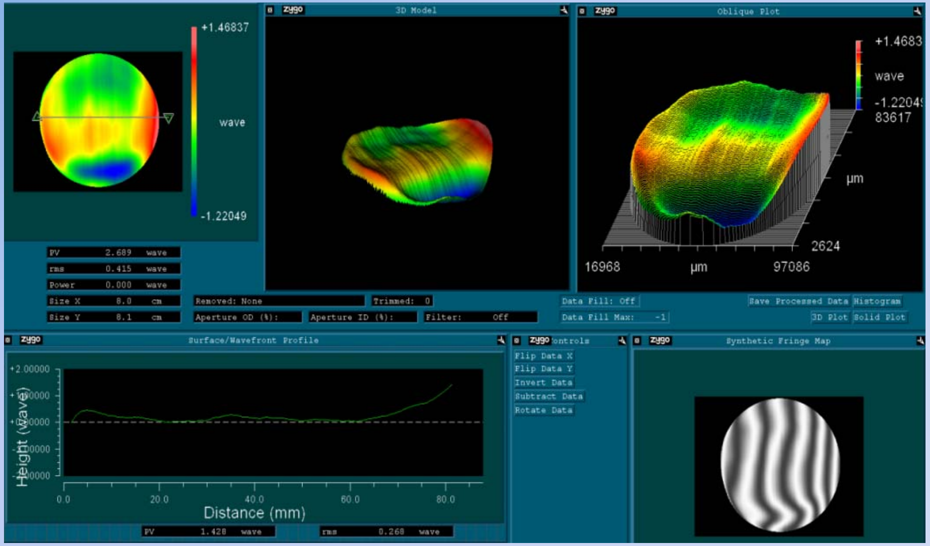
CNC Corrective Polishing

- Tool path is then run on the machine



Interferometer Strengths

- Provides a full 3D image of the surface
- Measurement time is only a few seconds
- Very accurate in the height domain (typically <50nm) and significantly better with error mapping


PV 2.689 wave
rms 0.415 wave
Power 0.000 wave
Size X 8.0 cm
Size Y 8.1 cm
Removed: None
Trimmed: 0
Aperture OD (%):
Aperture ID (%):
Filter: Off
Data Fill: Off
Data Fill Max: -1
PV 1.428 wave
rms 0.268 wave

Interferometer limitations

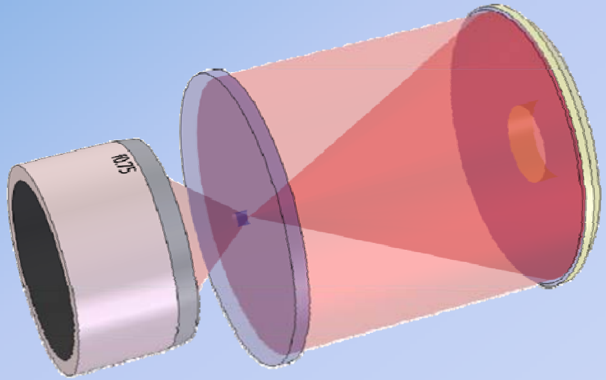
- Can require complex set-up
  - particularly for aspheric surfaces
- Struggle to measure high slopes
  - Causes loss of data
- Image Distortion
  - Features may not be exactly where you think they are
- Image Orientation
  - Concave surfaces are usually inverted
  - Vertical I/F often have a 90° rotation

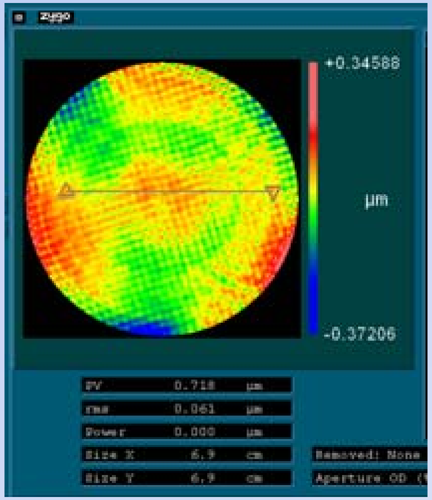
Mitigating the limitations

- Although Interferometers do suffer from some significant limitations, the use of complementary metrology can often help achieve a workable solution

Complex Set-Up

- Measurement of aspheres often requires the use of expensive CGH lenses or double path tests and which are complicated to set-up and often suffer from incomplete images
- The introduction of the Zygo Verifire has made the measurement of aspheres much simpler for many applications

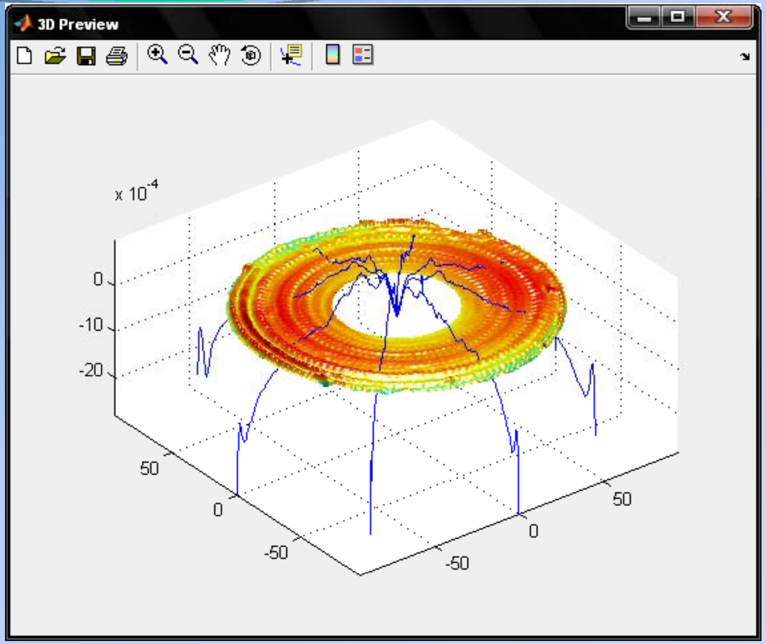


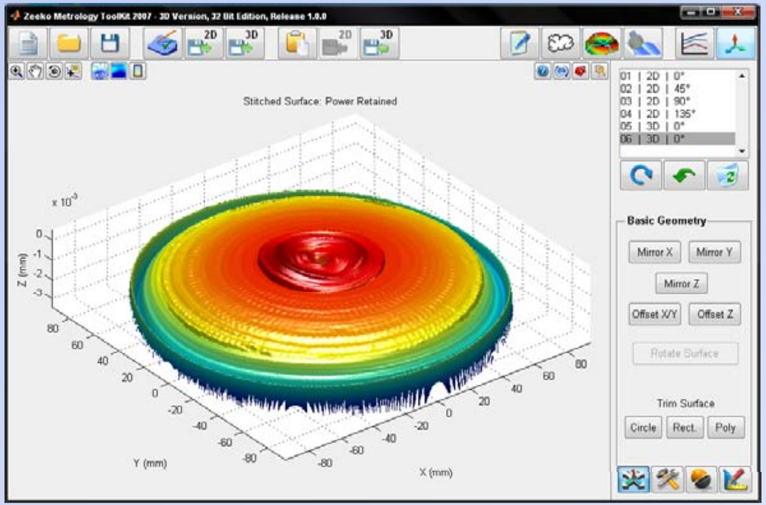


PV 0.718 µm
rms 0.061 µm
Power 0.000 µm
Size X 6.9 cm
Size Y 6.9 cm
Removed: None
Aperture OD

High Slope Surfaces

- In Sub-Aperture polishing high surface slopes often occur at the edges of an optic – which results in data loss
- Using 2D profilometery in conjunction with Zeeko's metrology toolkit – data can be stitched together to 'fill-in' the missing data





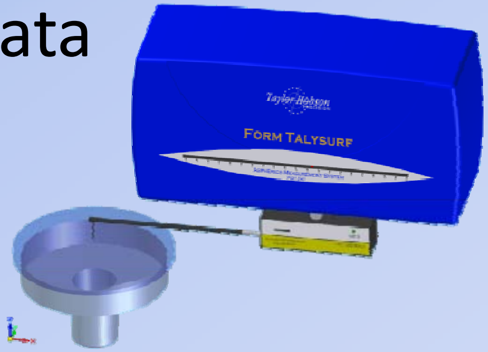
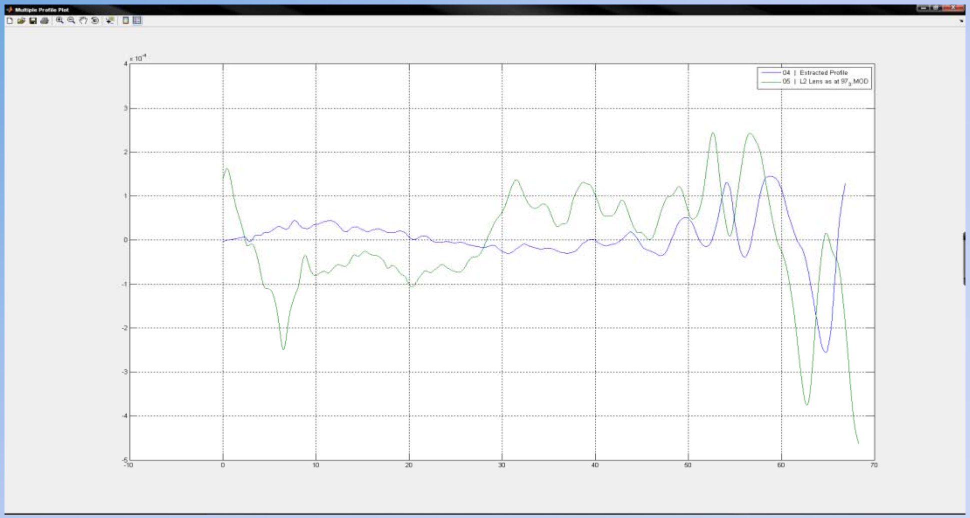


Image Distortion

- Most interferometers will distort the image in the spatial domain – such distortion can be as much as 14% depending on the set-up and transmission lens used e.g.
- If uncorrected, these distortion will limit the accuracy that can be attained



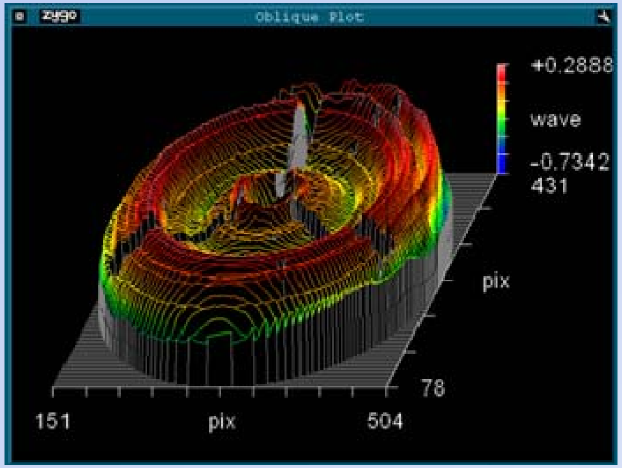


Image Distortion

- By using a ‘distortion mapping’ technique in Zeeko’s metrology toolkit then these limitation can be drastically minimised

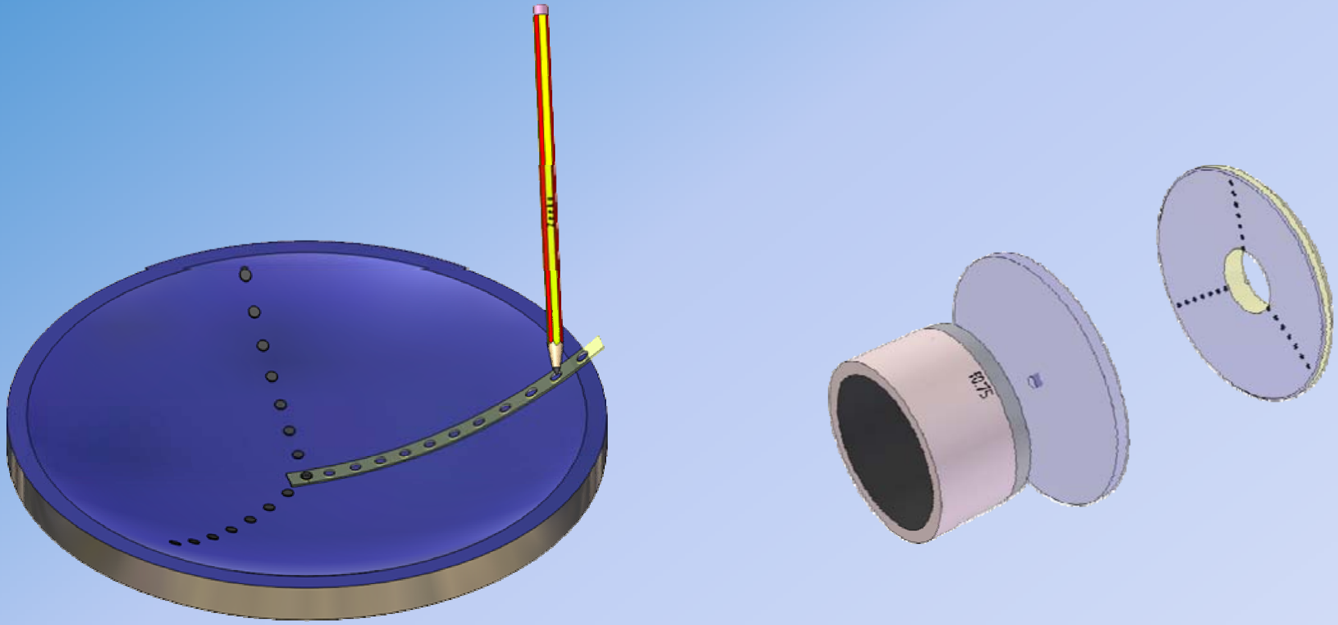


Image Orientation

- Avoiding the problem of Image Orientation is basically down to using due diligence by the operator
- One easy solution but rarely used is that of ‘fiducials’ marked on the surface of the optic – preferably outside the usable clear aperture but still within the ‘imageable’ area

Summary

- Interferometers are a key tool for any optical component manufacturing process
- With care they can be used for more than just quality confirmation – indeed they form an essential part of any corrective polishing process
- Knowledge of their limitations and careful marriage of complimentary metrology such as CMM's, profilometers etc can increase the value in the overall manufacturing process