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The Polishing of Microelectronic Thin Films using Corrective Polishing Technology from the Optics Industry

by

Zeeko Ltd

A Novel Approach to the Polishing of Semi-conductor Surfaces

This technique is also applied to optical components, moulds, tooling, turbine blades, medical implant joints and many other precision components

Who is Zeeko?

- Zeeko Limited is a young company (registered in late 2000). It has developed an innovative approach to the production of precision surfaces for the semi-conductor, optical and mechanical markets using technology originated in University College London

- In mid 2002 - Zeeko announced a collaboration with the German optical machinery manufacturer – Loh Optikmaschinen of Wetzlar, Germany. Under that agreement Loh will manufacture and support Zeeko machines in many world markets

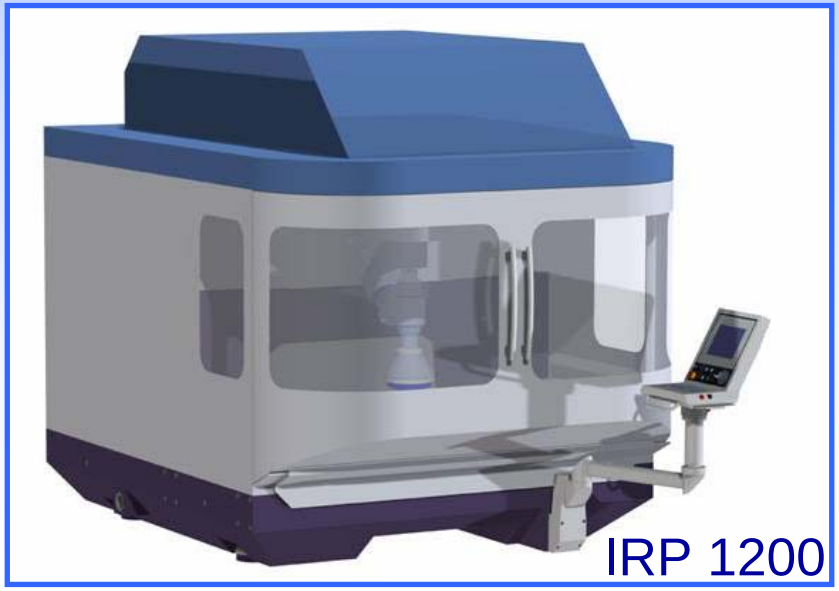
- Zeeko will develop similar collaborations to support its machines in other industries

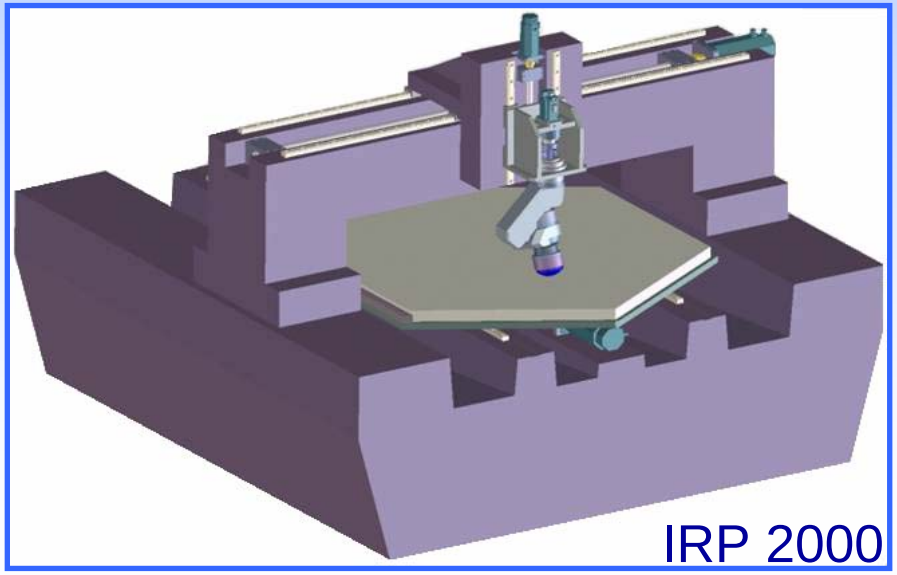
The Zeeko Optics Machine Range


IRP 200


IRP 400


IRP 800


IRP 1200


IRP 2000

Zeeko Machine Capacities

- IRP 200 – spiral polishing up to 200mm dia and rastered parts of up to 200mm x 200mm
- IRP 400 - spiral polishing up to 400mm dia and rastered parts of up to 400mm x 400mm
- IRP 800 - spiral polishing up to 800mm dia and rastered parts of up to 800mm x 800mm
- IRP 1200 - spiral polishing up to 1200mm dia and rastered parts of up to 1200mm x 1200mm
- IRP 2000 - raster polishing up to 2000mm x 2000mm

Originally Developed for Large Optics

- The ZeekoClassic process was originally conceived at University College London for the manufacture of large optical surfaces for astronomy applications
- It was subsequently developed for smaller components
- The latest developments known as ZeekoJet, make the process applicable to micro-optics and other applications outside of the optics industry

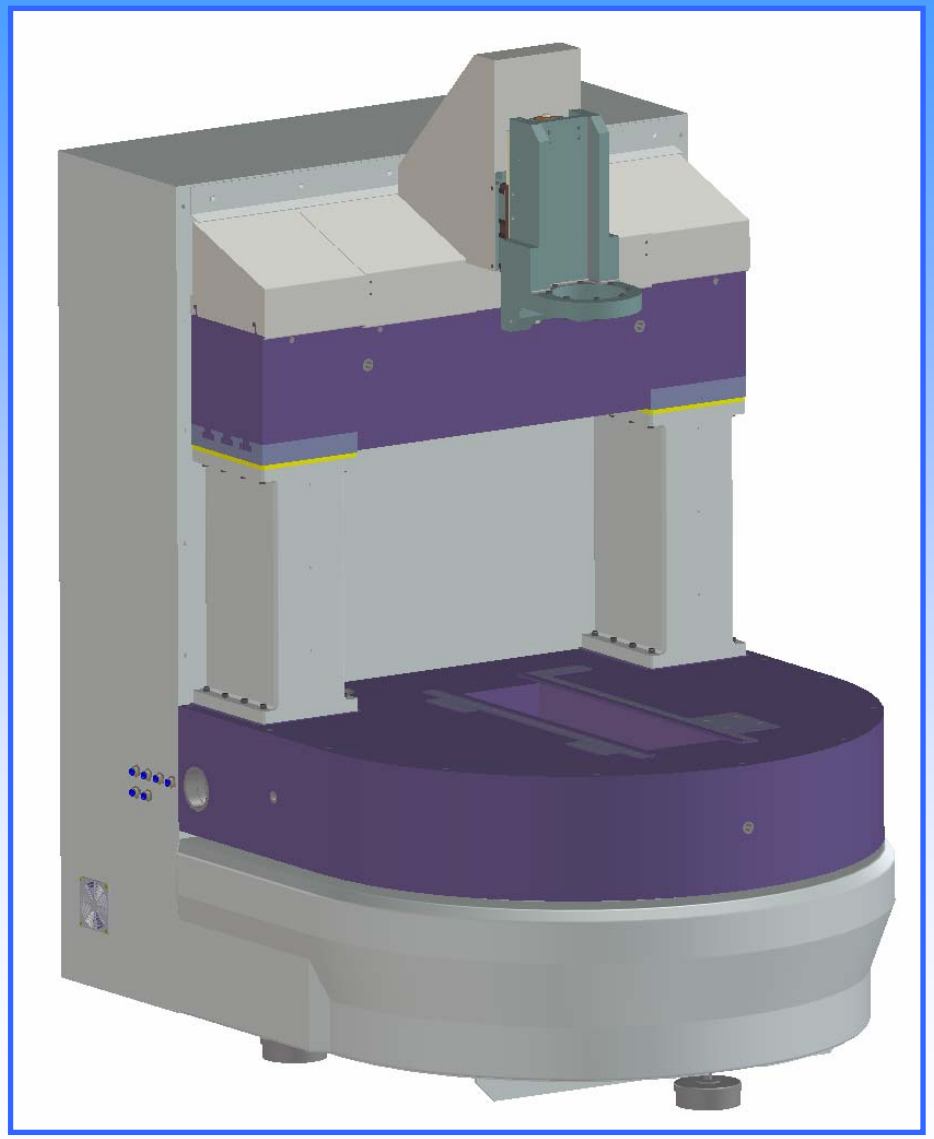
The Zeeko Process

- The Zeeko process utilises a variable geometry soft polishing tool creating a polishing “spot” on the surface being polished. The position and pressure of that “spot” is controlled by a 7 axis CNC machine tool controller
- The tool path is derived from an optimisation of polishing dwell times and based on the component’s error profile which is compared to its design profile. Given the correct metrology input the machine can corrective polish to fine limits and converging on the design parameters at rates of up to 90%
- Recent developments have resulted in the controlled and corrective polishing of semiconductor layers controlling thicknesses to +/- 10nm (reported later)

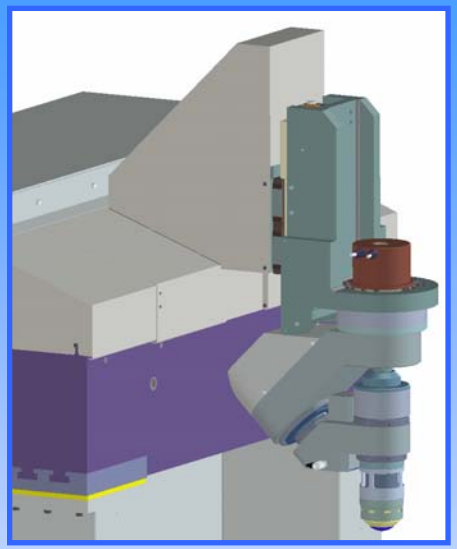
The Zeeko Machine Design

The IRP 400 machine with horizontal polishing table

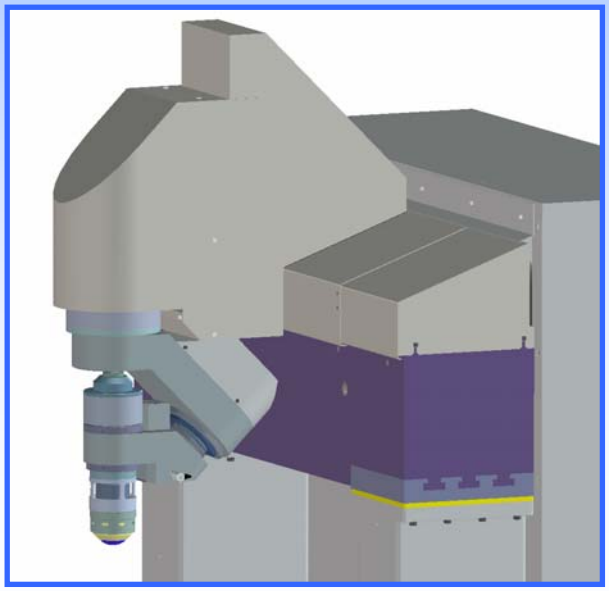
The Zeeko IRP 400 Machine Design



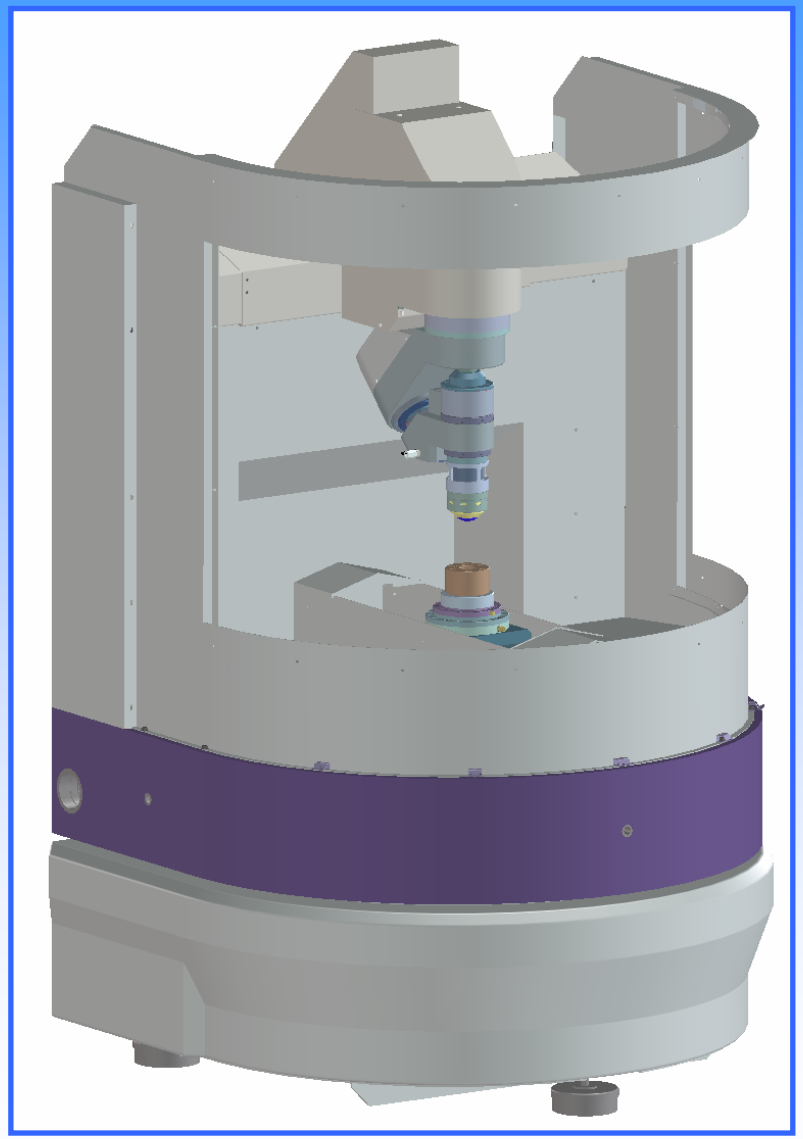
Granite base

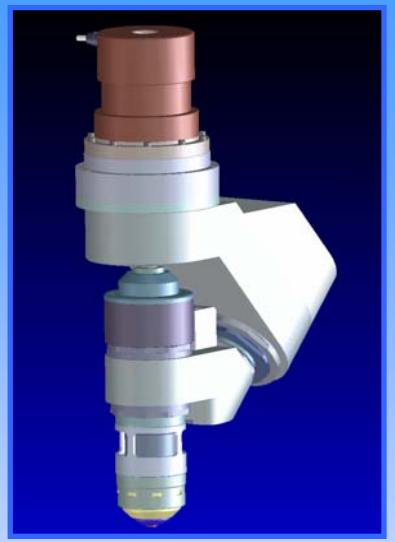


Precessing head design

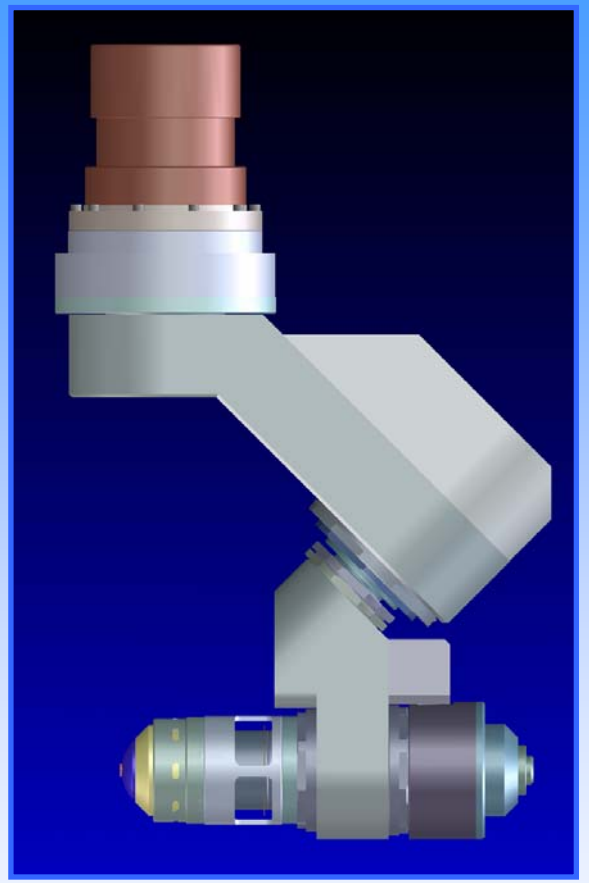


The Zeeko IRP 400 Machine Design



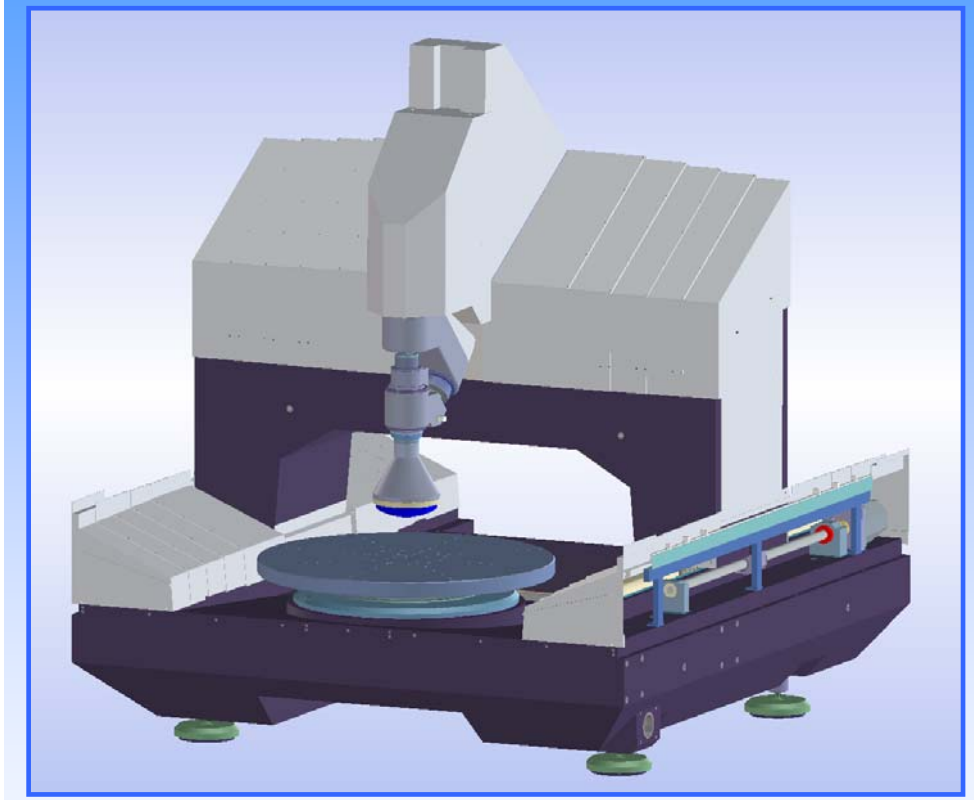


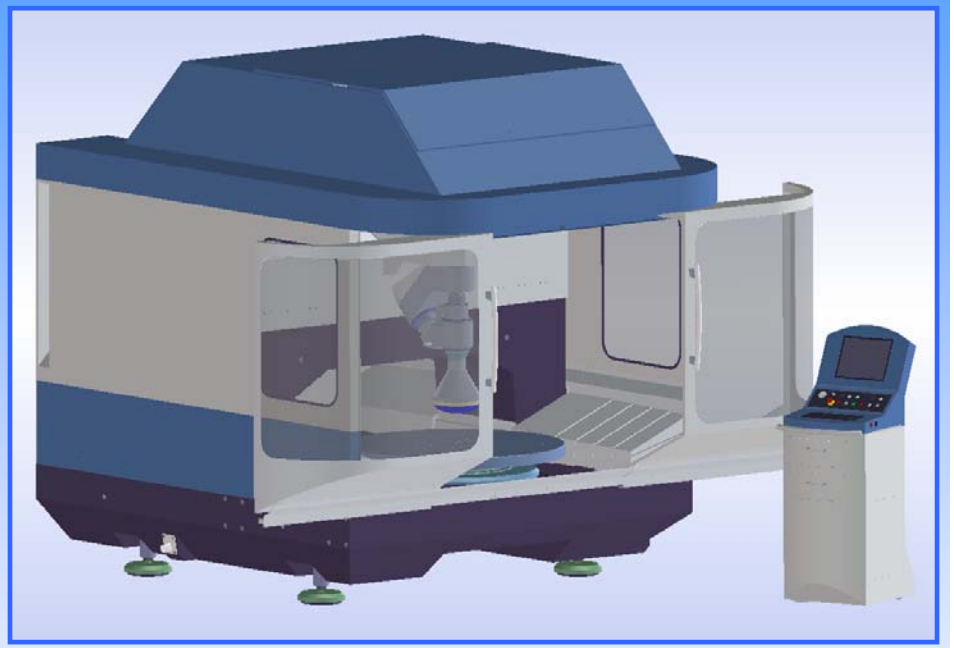
The virtual pivot



Variable head geometries achieved through compound angle effects

The Zeeko IRP 1200 Machine Design





The IRP 1200

The Zeeko Processing Techniques

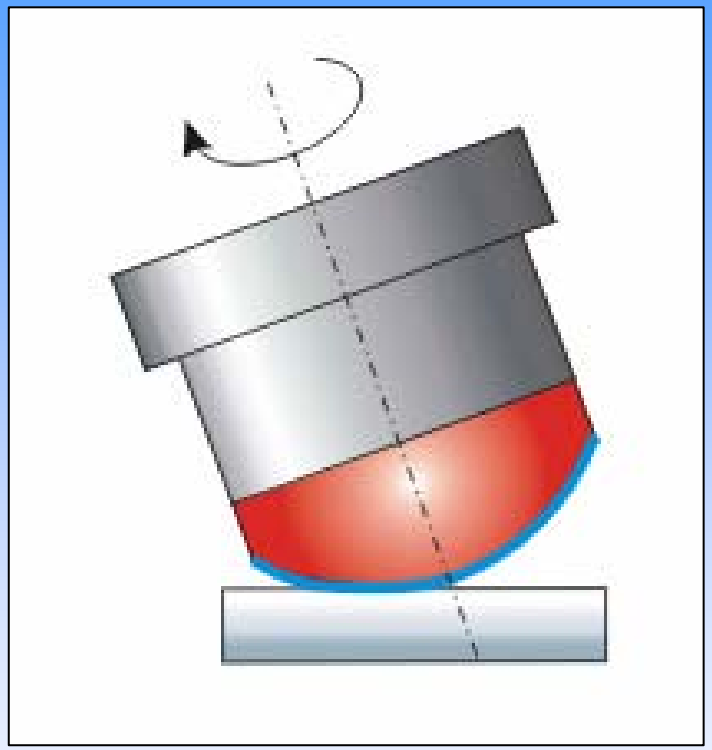
- The Zeeko Classic process utilizes a variable geometry soft polishing tool creating a polishing “spot” on the surface being polished. The position and pressure of that “spot” is controlled by a 7 axis CNC machine tool controller
- The ZeekoJet process uses a jet of abrasive polishing slurry to create the polishing spot on the subject surface and is then controlled in exactly the same way as ZeekoClassic
- All processes are automatic
- Operating costs are low

Technology Basics ZeekoClassic

- A pressurized adaptable soft tool is used to ‘figure’ and ‘finish’ the workpiece
- The tool path is determined from an optimisation routine derived from the original workpiece errors. The primary control factors being:
  - Polishing spot size
  - Dwell Time
  - Overlap
- Other factors can include
  - Workpiece – (C axis) speed
  - Pressure in the polishing head
  - Polishing head – (H axis) speed

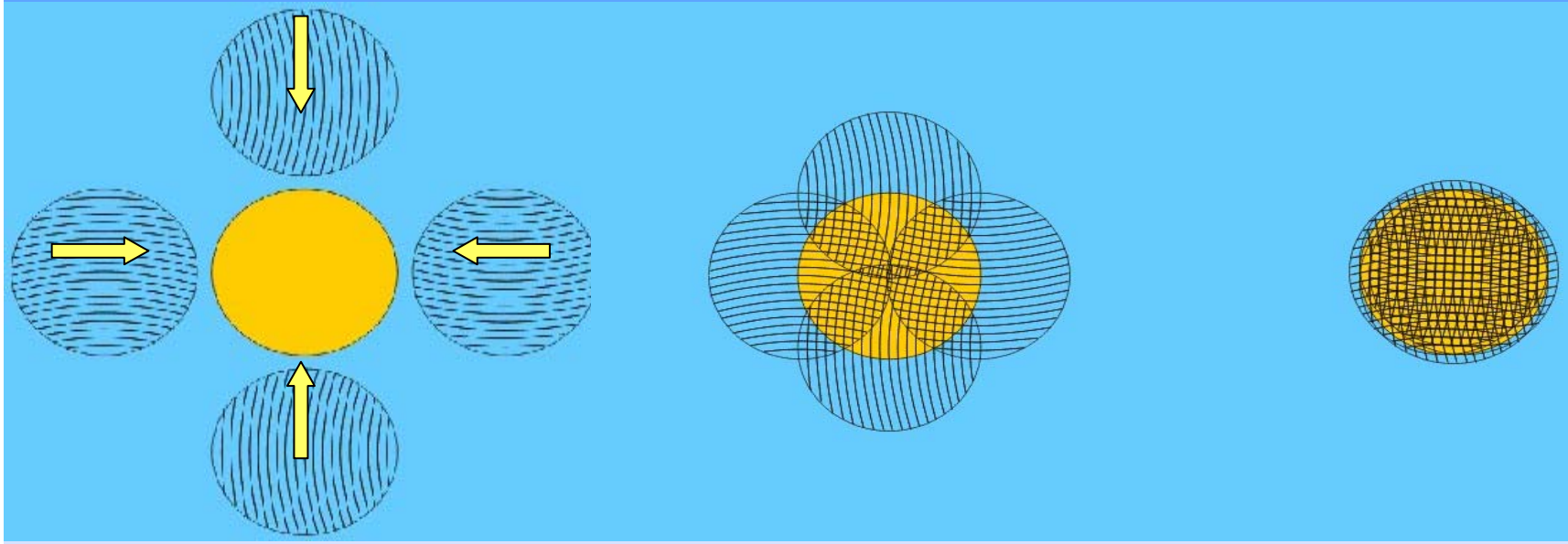
The Zeeko Classic Polishing Tool

- Bulged, pressurized sub-diameter membrane tool
- Provides:
  - Independently controlled ***size*** and ***hardness***
  - ***Spun about its axis*** for high removal rates
  - Covered with choice of ***polishing cloths***



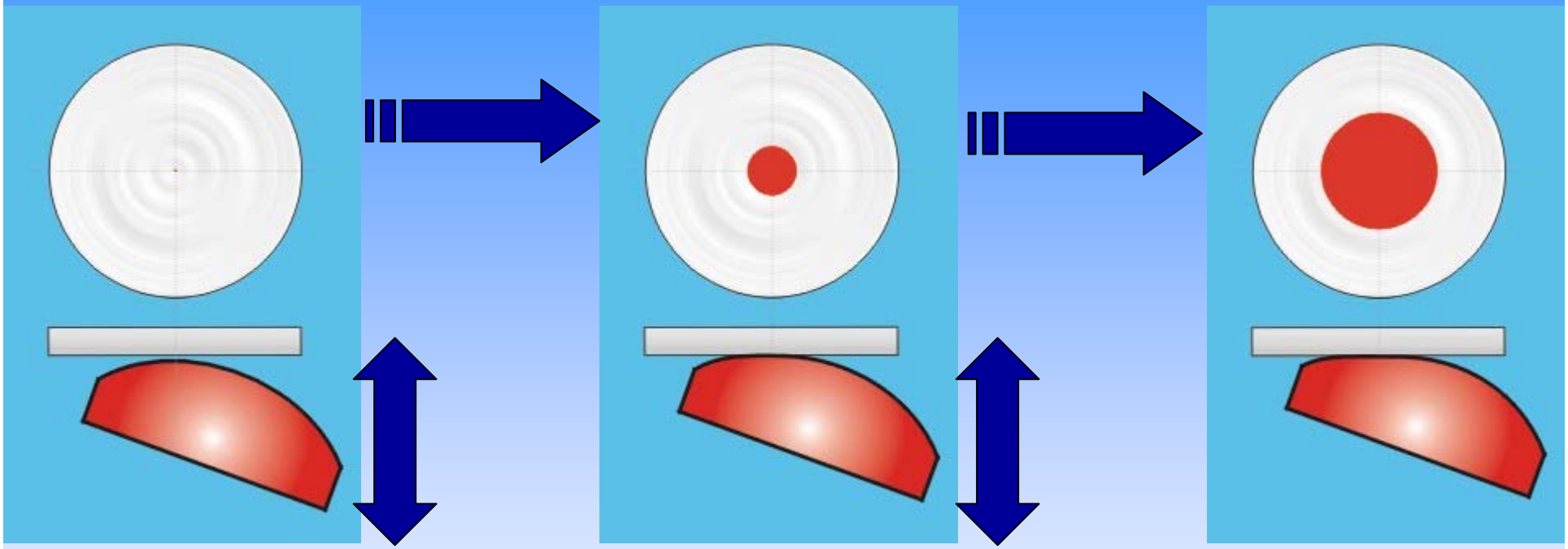
The Zeeko Polishing Head Precess Positions

Zeeko Polishing Texture Control



The four superimposed “Precess” positions create a fine averaging effect resulting in surface textures in the 2 – 5 Å level

Zeeko Polishing Spot Control



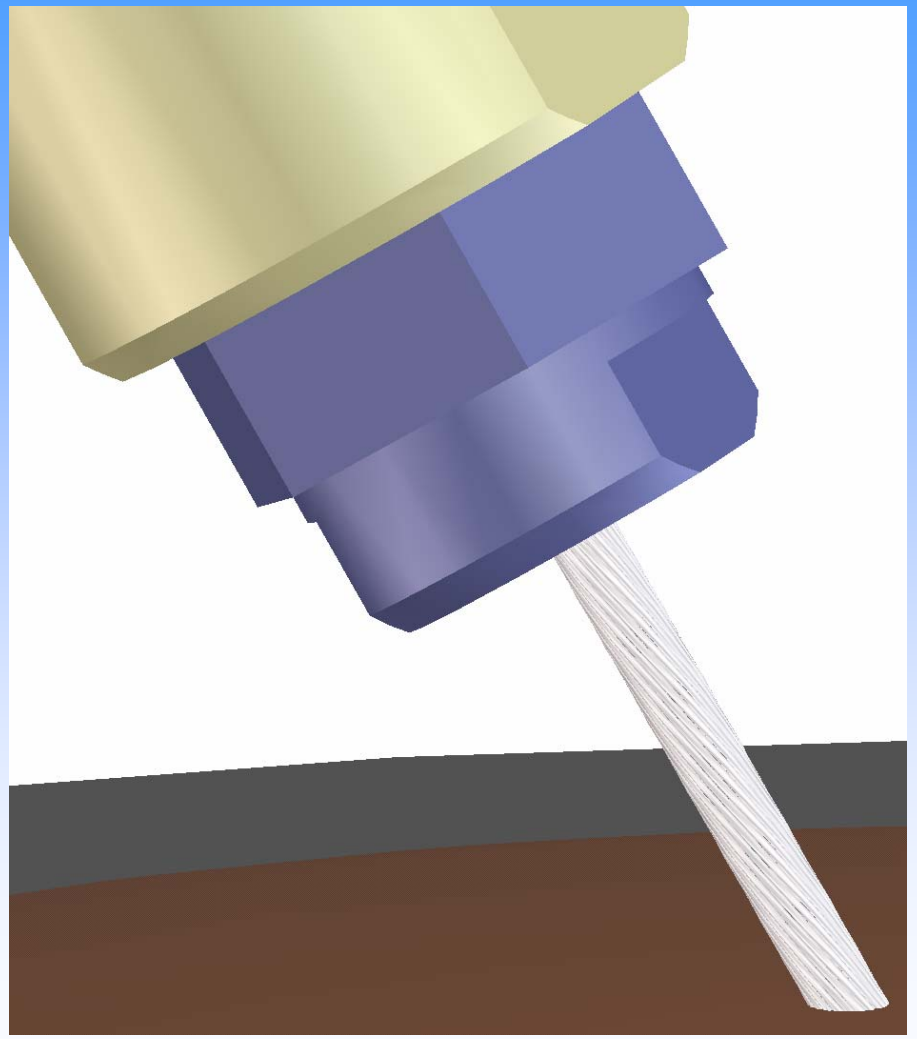
The Zeeko Process utilizes a polishing spot of variable size controlled by the physical position of the head relative to the subject surface. Pressure within the tool is controlled separately.

Technology Basics ZeekoJet

- The membrane tool is replaced by a fine pressurised “jet” of abrasive slurry
- The tool path is determined by exactly the same tool path and optimisation software as the ZeekoClassic process:
  - Polishing spot size
  - Dwell Time
  - Overlap
- Other factors can include
  - Workpiece – (C axis) speed
  - Pressure in the ZeekoJet

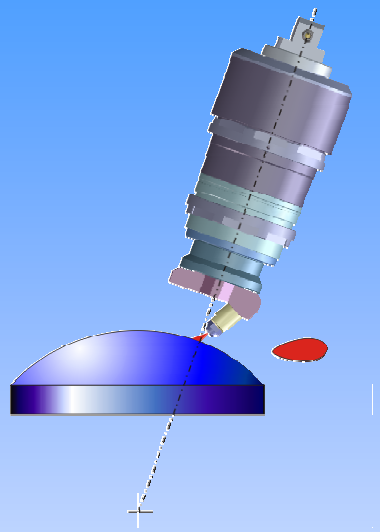
What is the ZeekoJet process?

- The ZeekoJet process replaces the variable geometry soft polishing tool with a controlled “jet” of slurry to create a polishing “spot” on the surface being polished. The position and pressure of that “spot” is again controlled by the Zeeko 7 axis CNC machine tool controller

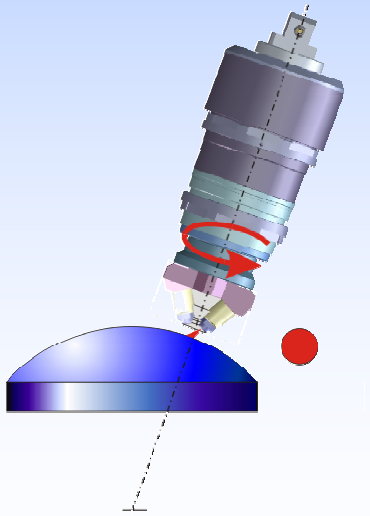


Zeeko-Jet

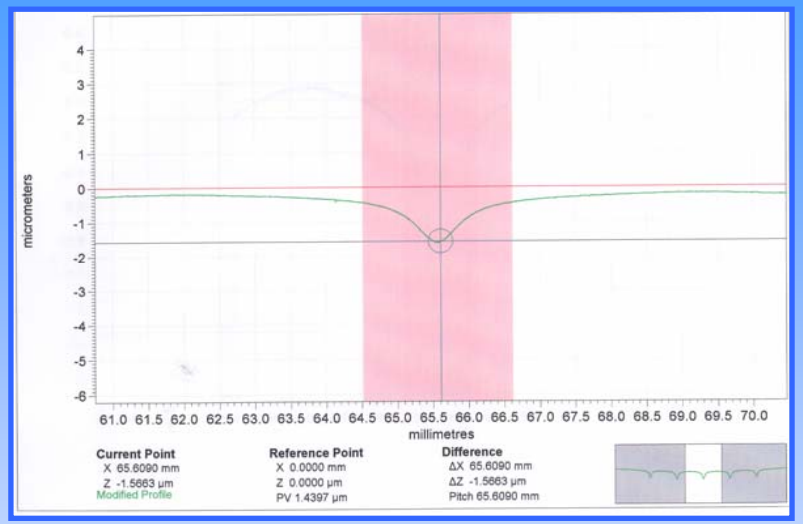
Zeeko-Jet produces an elongated spot as it impinges on the surface

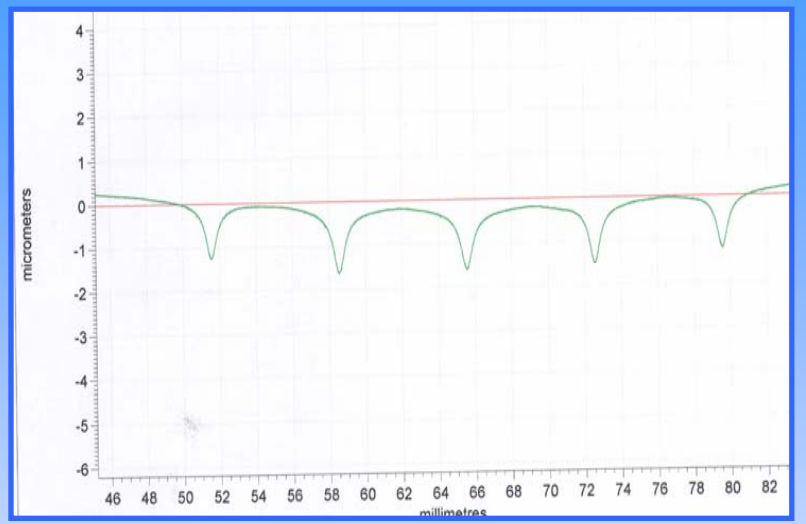


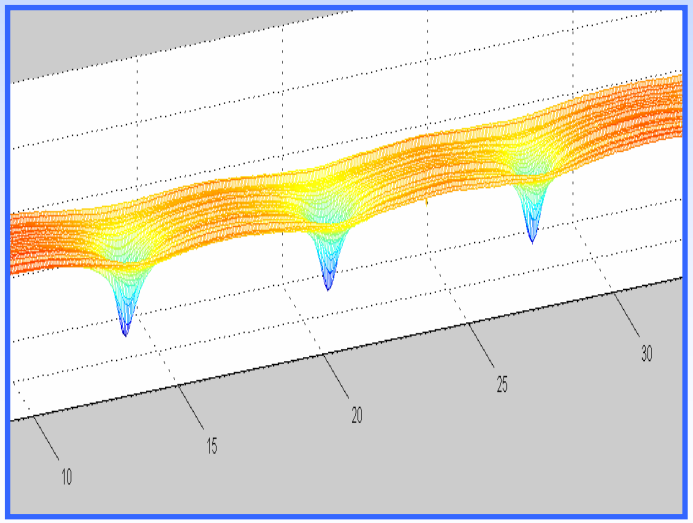
…and a circular spot as it is precessed and rotated

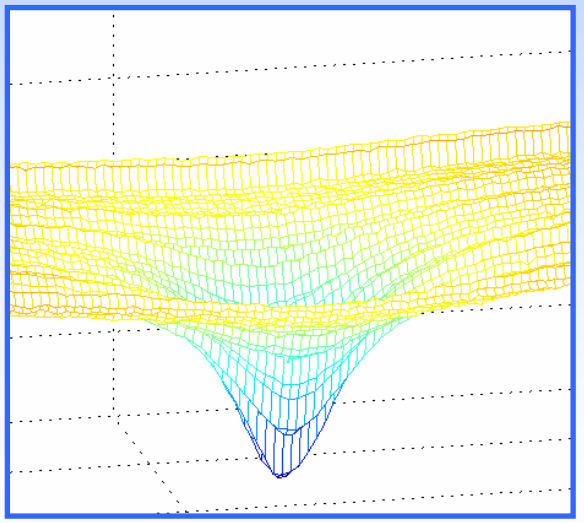


ZeekoJet – A Typical Gaussian Spot – 0.7mm dia.









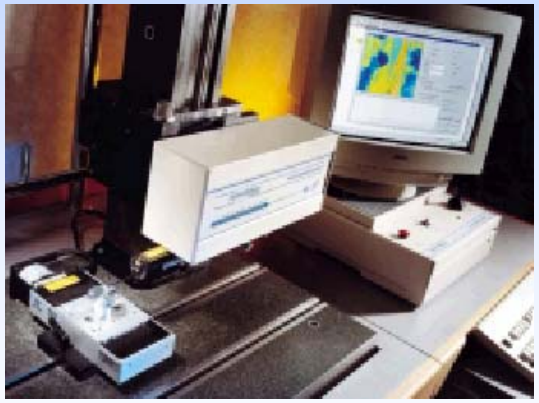
The Features of ZeekoJet

Some key features:

- Can create sharp edges and/ or “steps” on optical quality surfaces
- Polishes to the edge
- Can remove unwanted frequencies
- Overcomes physical constraints seen in some applications of the ZeekoClassic process
- A self-cleaning process
- Relatively contamination free
- Future developments promise faster removal rates

System Overview – *"Precessions"*

Metrology Data

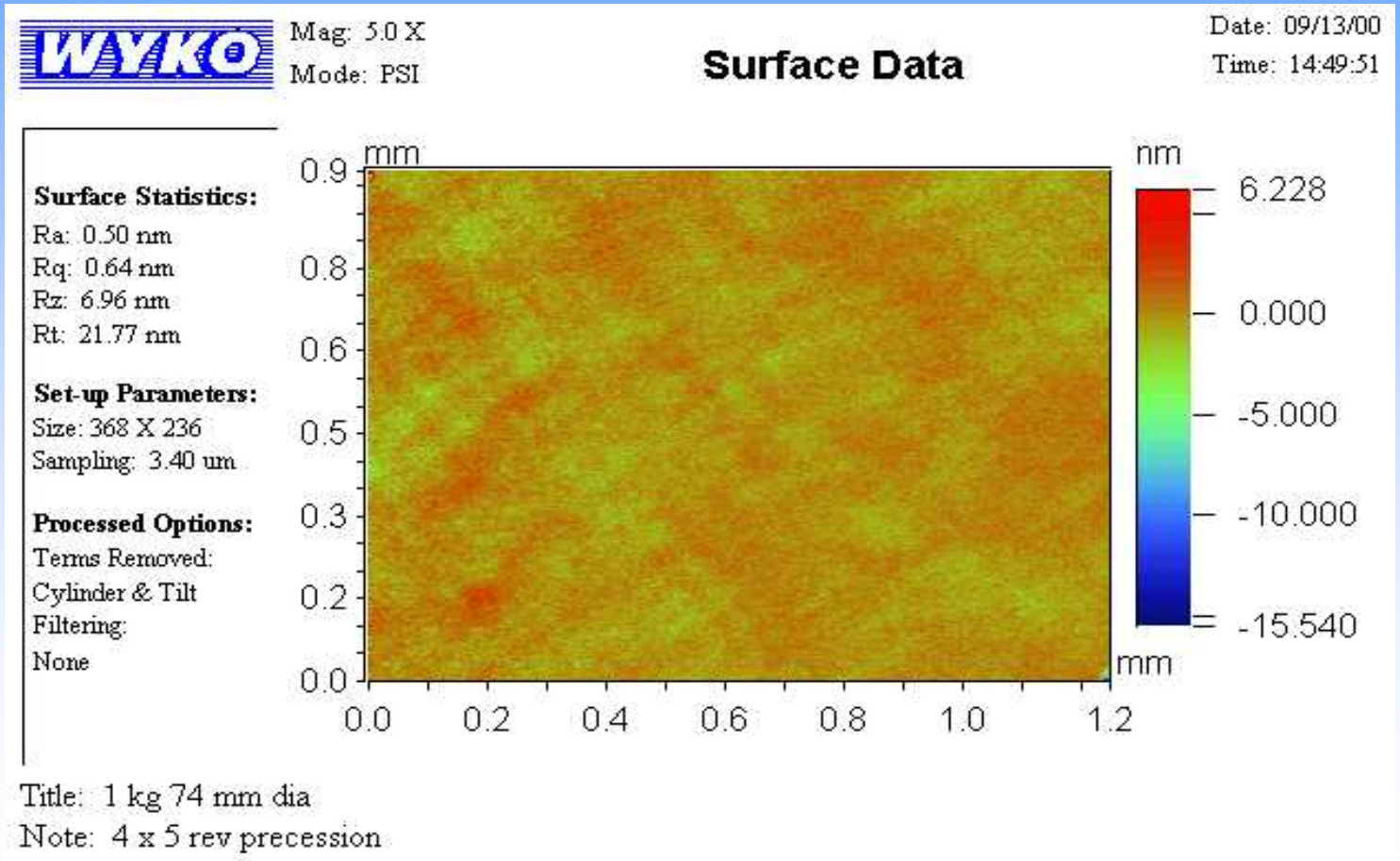


Design Data

Tool Path Output

Precessions

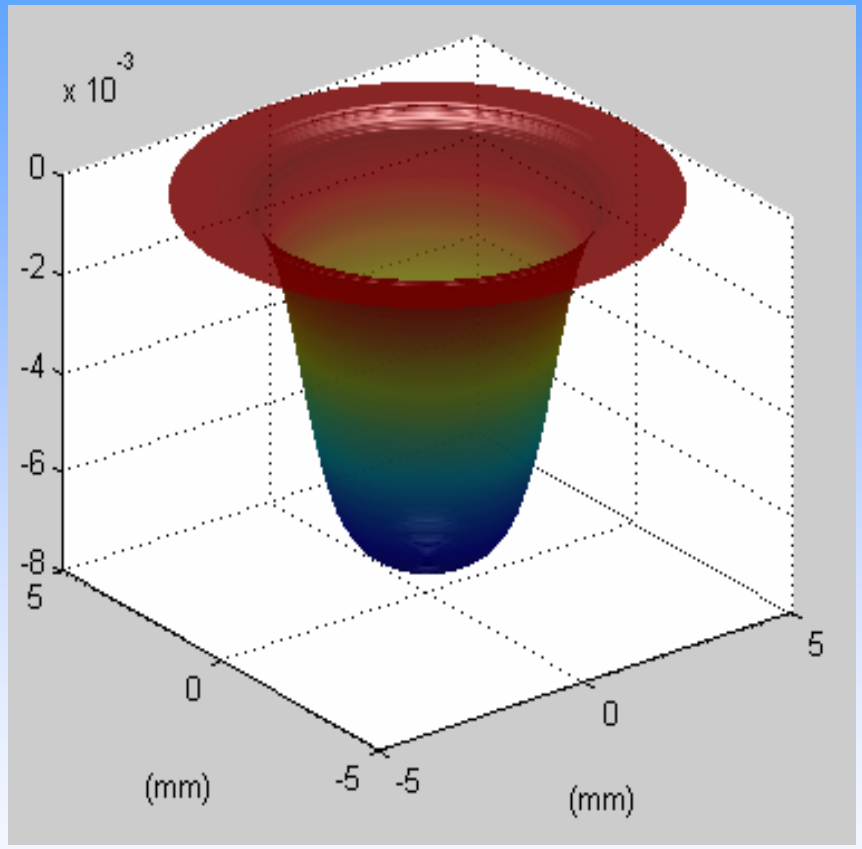
- Even with only 4 precess positions surface finish of better than 0.5nm Ra can be achieved



Surface with Tool Precession

Influence Function

- In order to determine the correct tool path and control criteria it is necessary to first generate an influence function
- The influence function in effect captures a ‘finger-print’ of the polishing regime and characterises the combined effects of:
  - Tool speed
  - Pressure
  - Polishing spot size
  - Polishing media
  - Material
  - Temperature



Recent Results Achieved on the Polishing Thin Films

The Process has:

- Maintained a constant depth of removal within +/- 10nm
- Been able to target an absolute film thickness of 90nm +/- 10nm
- Been able to correct a CMP surface with approx 150nm error also to +/- 10nm on variation and thickness in one pass

Possible Applications in the Semi-conductor Industry

- Strained Silicon substrate polishing
- The Dual Damascene Process
- In Process Polishing
- Display Technologies
- Post CMP Polishing
- Thin film polishing
- Certain MEMs applications
- Others yet to be determined

Suitable Materials

Almost anything that can be polished by other means. For example:

- Silicon and its oxides
- Germanium
- Aluminium and Copper
- Glass in all its forms
- Carbides and nitrides

Questions

Please address any questions or queries to Richard Freeman:

richard.freeman@zeeko.co.uk

Please visit http://www.servicecircle.biz to view video clips of the Zeeko Classic and the ZeekoJet processes in action!

User name: Zeekotech PW: semicon

Company Folders/Presentation with Animations

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Thank you for your attention