Polishing with Advanced Tool Paths to Optimize Surface Micro-structure and PSD

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Basis of the Zeeko Polishing Process

- Spherical "bonnet" creates a localized area of material removal of variable size ("influence function")

- Spot size is controlled independently by varying:

  - The axial position of the tool WRT the part, and therefore the degree to which the membrane is compressed against the part

  - The internal pressure of the working fluid within the tool is controlled separately
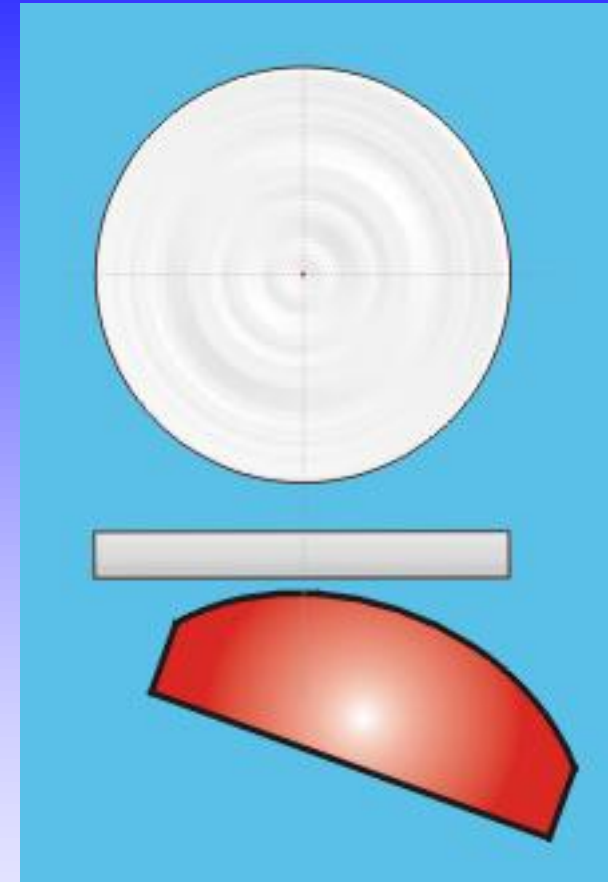
Tooling

The spherical bonnet tooling:

- is covered with standard polishing pads (e.g. polyurethane)

- is pressed into the surface of the workpiece by displacement Δz, creating a contact spot of known diameter

- is worked with standard polishing consumables (e.g. cerium oxide)

- delivers volumetric removal rates up to a few cubic millimeters per minute

The Zeeko Optics Machine Range

IRP 200

IRP 400

IRP 800

IRP1200
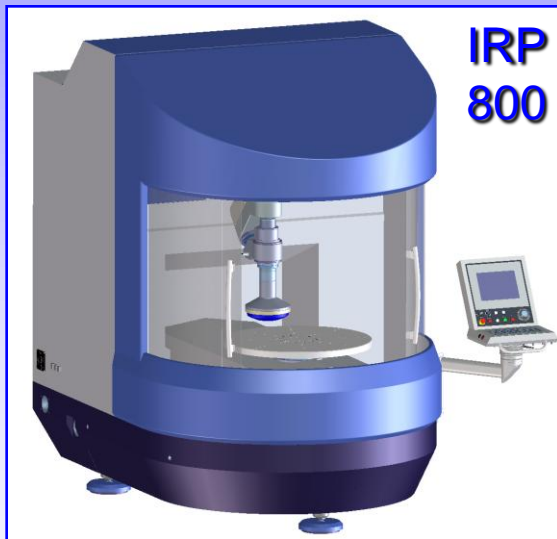
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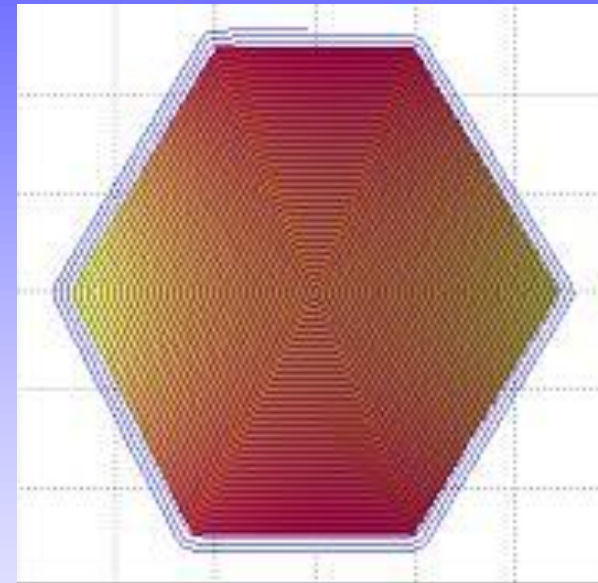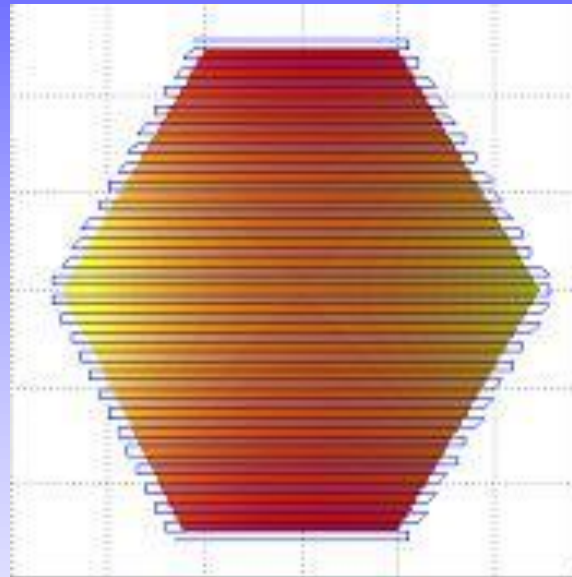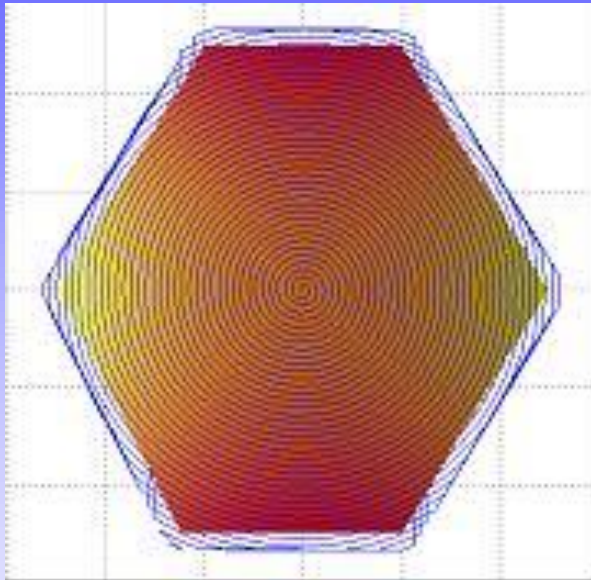TECHNOLOGIES

Zeeko Polishing Advantages

The Zeeko Classic polishing process:

- Uses standard polishing pads and slurries

- Pre-polishes from the ground blank condition

- Capable of polishing complex freeform geometries

- Able to polish a plethora of materials including optical glasses, ceramics and metals

- Is deterministic, resulting in reduced production times due to its high removal rate and repeatability

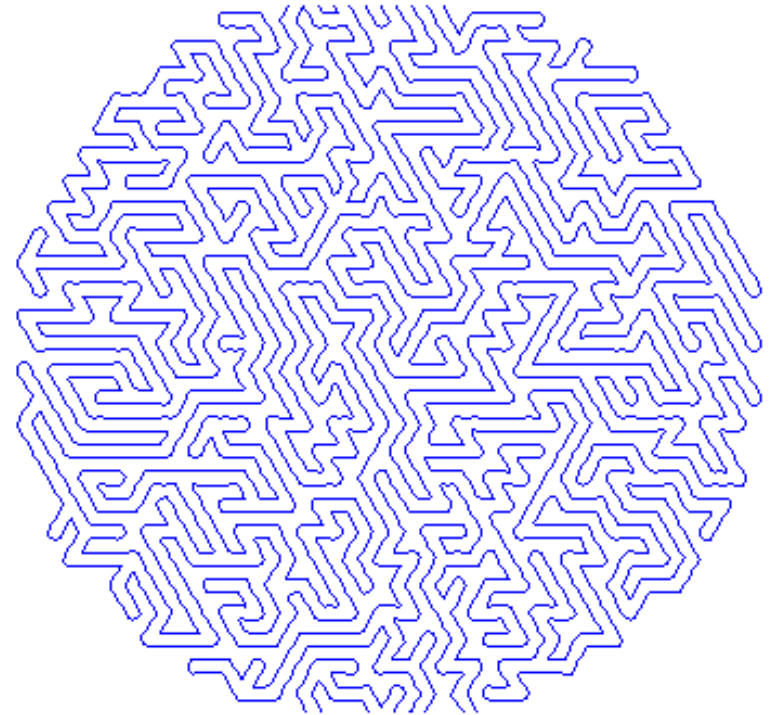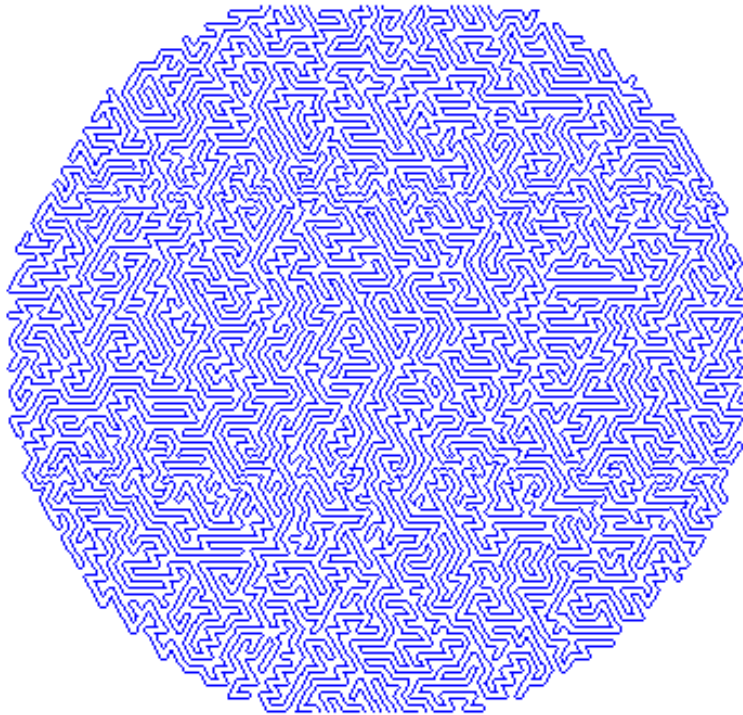ZEEKO™ LLC.
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Tool paths

The unicursal random tool path

- Never crosses itself
- Completely new pattern with each iteration
- Can be used with any continuous surface
- This tool path is compatible with Zeeko's *Precessions* software for corrective polishing
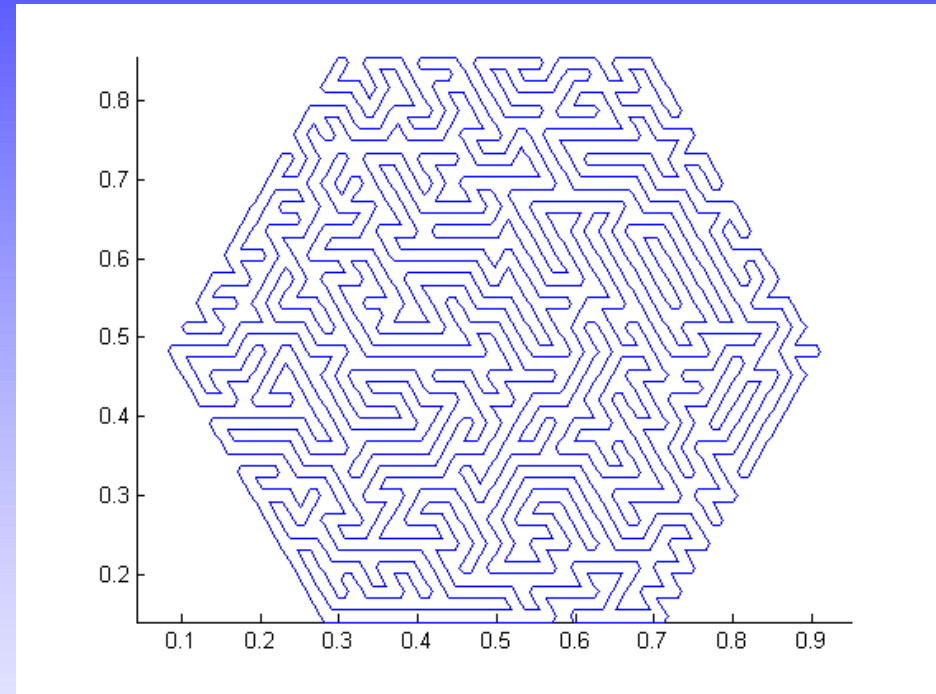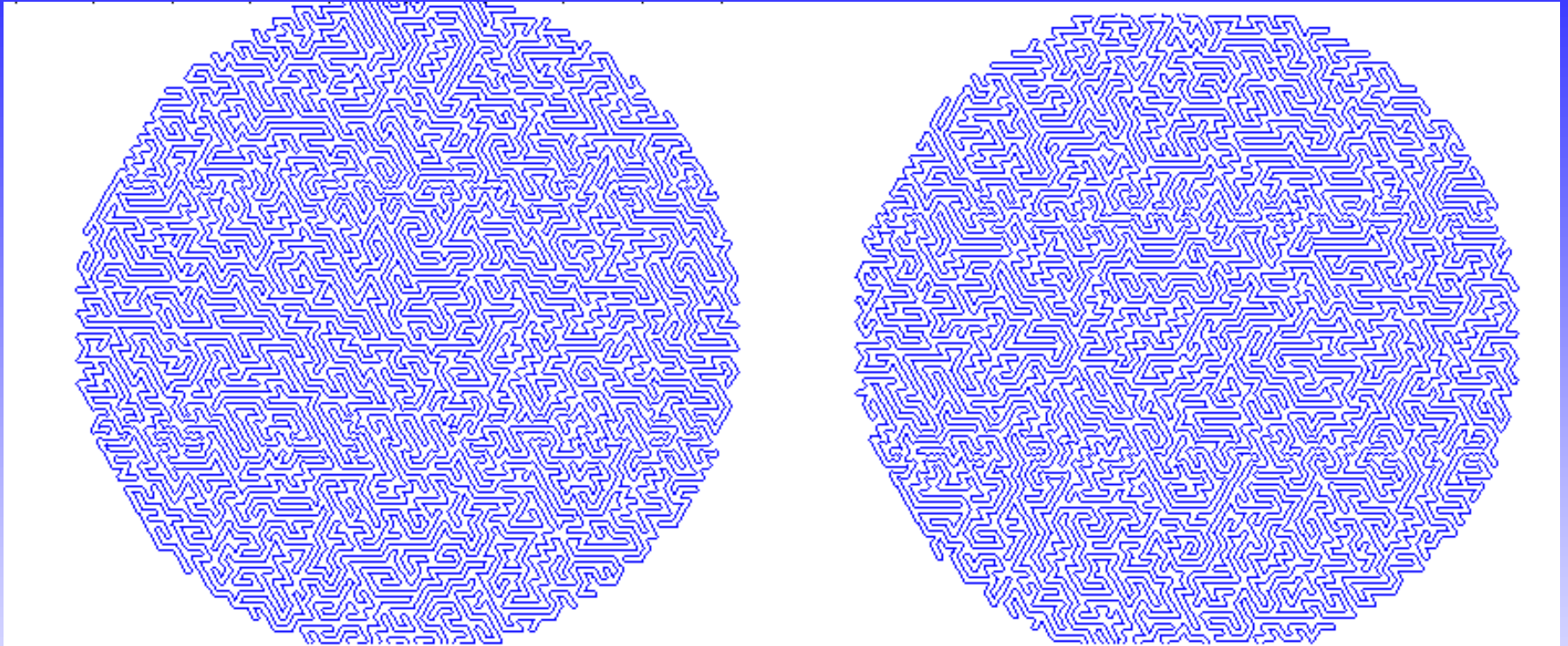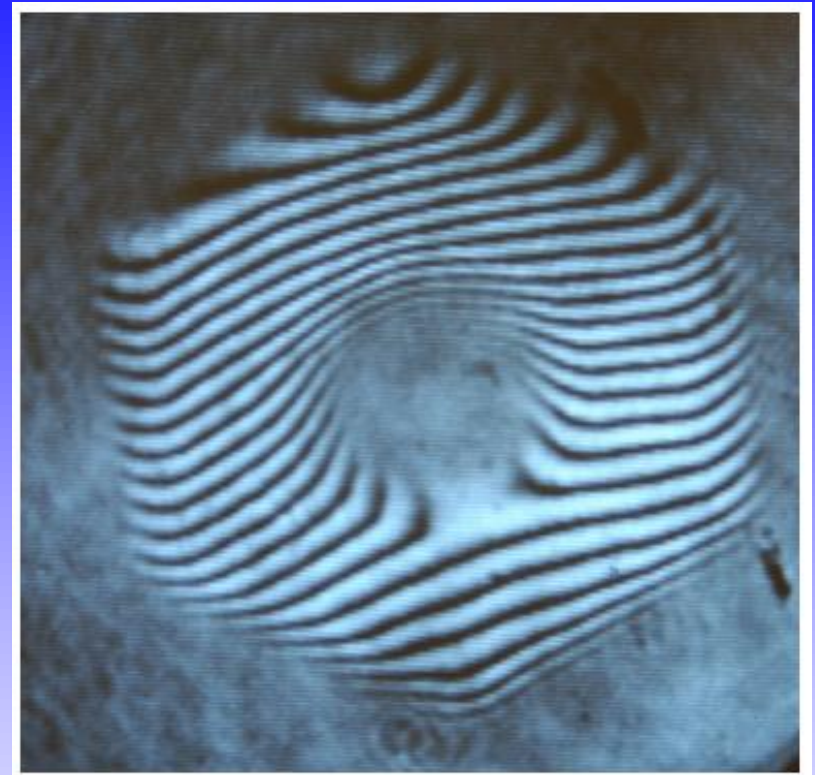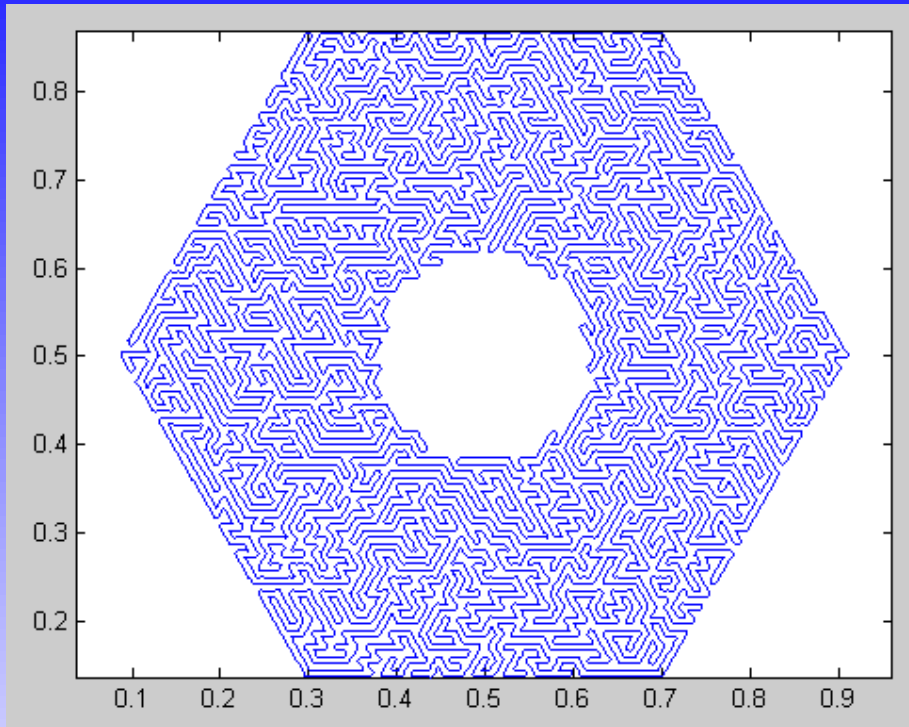
- A new pattern is produced with each iteration of the algorithm.

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- The density of the pattern can be varied.

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- The algorithm can be used with any continuous surface.

Two experiments are presented in this talk . . .

- A comparison of polishing with raster and random tool paths, with all other variables held constant

- Improving the PSD of a raster-polished region using a random tool path

A comparison between raster and random tool paths

- Two 20-mm diameter spots were polished on a pitch-polished flat part
- The pattern spacing on both paths was 0.35 mm.
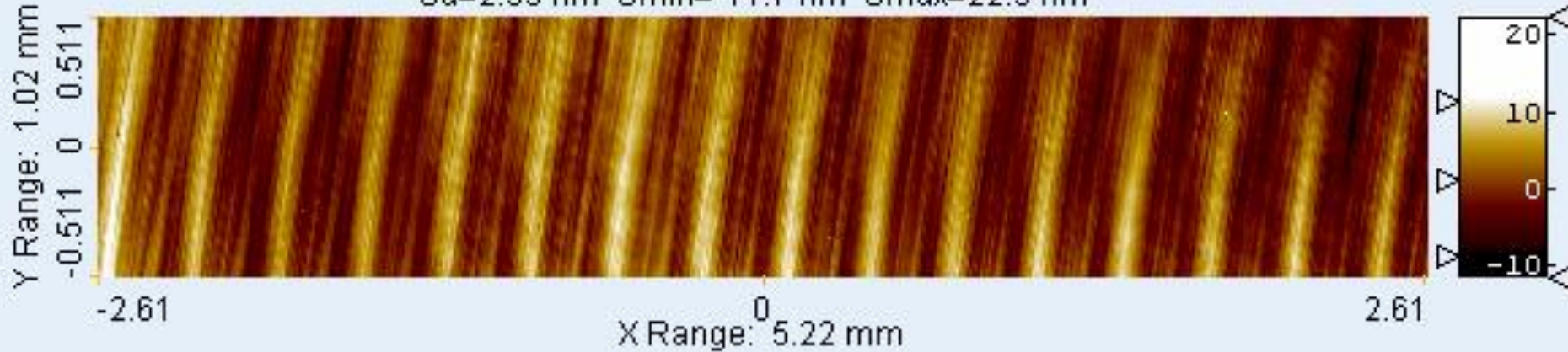- All other parameters were equal.

Feed rate: 100 mm/min
H-axis speed: 300 rpm
Precess angle: 15
10 mm spot

80 mm bonnet
Z-offset: 0.16 mm
Polishing time: 30 min

Raster polished region
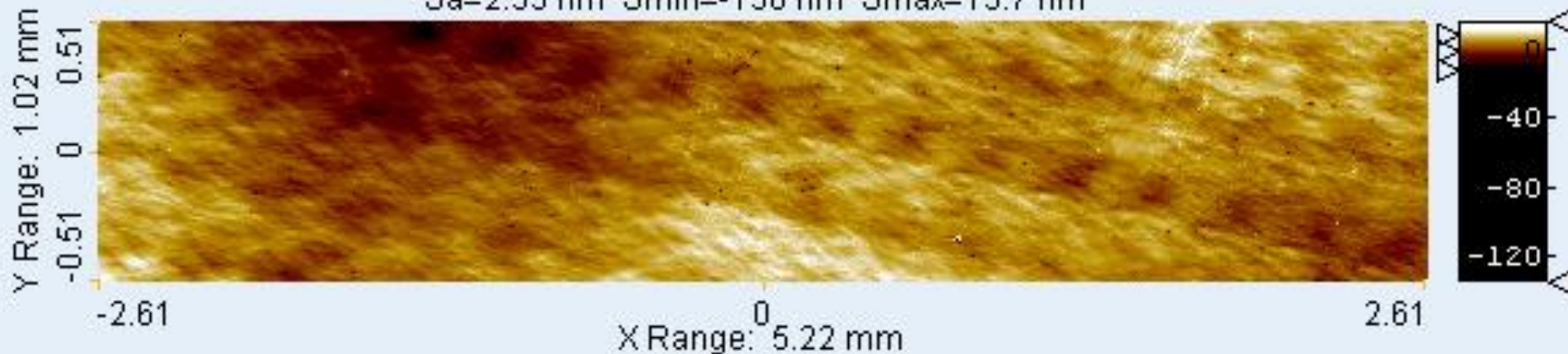
C:\Copy of MapvueAE\Data\TEMP.map
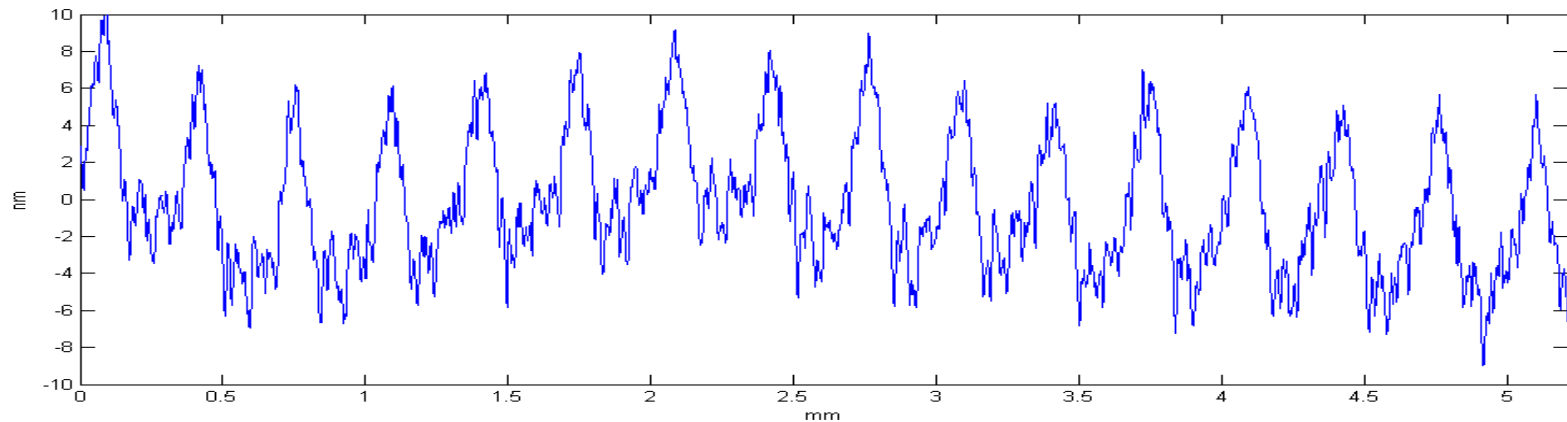
Sa=2.99 nm Smin=-11.7 nm Smax=22.3 nm
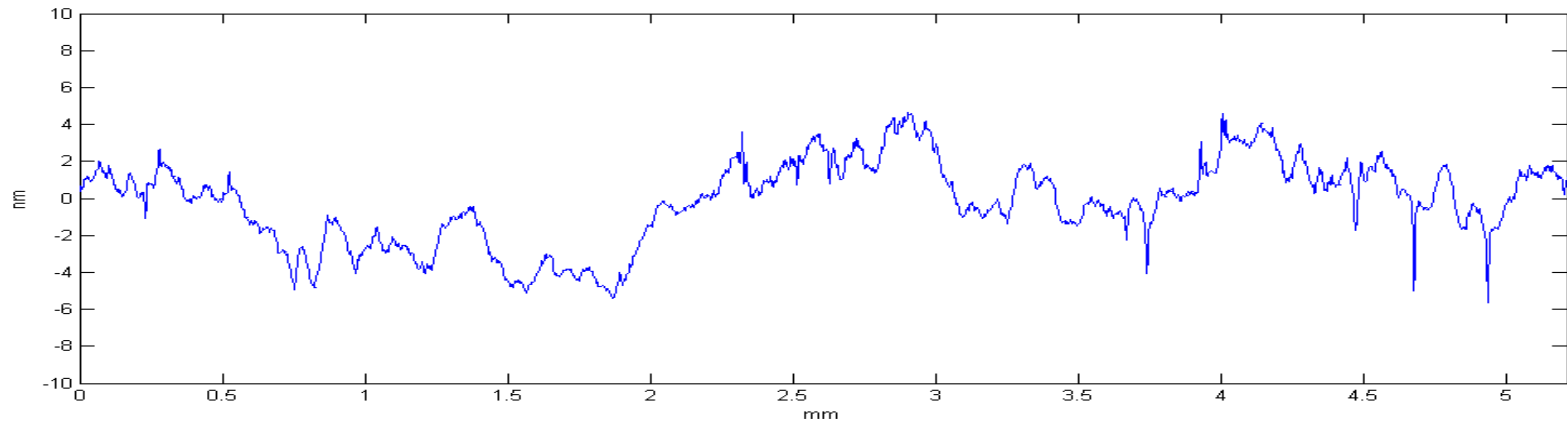

Random polished region

C:\Copy of MapvueAE\DataC:\Copy of MapvueAE\Data\TEMP.map

Sa=2.53 nm Smin=-136 nm Smax=15.7 nm

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Raster polished region profile

Random polished region profile

PSD Comparison
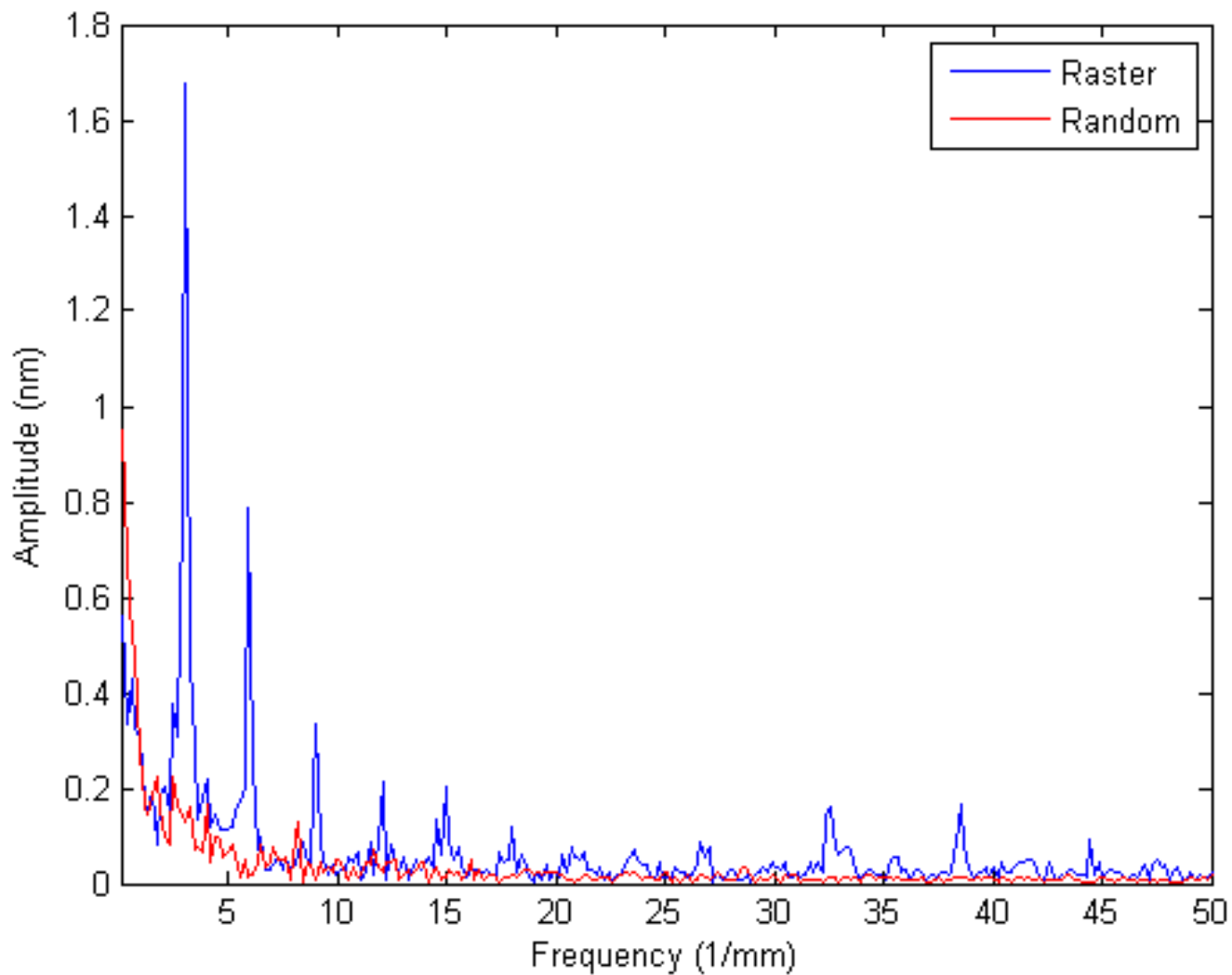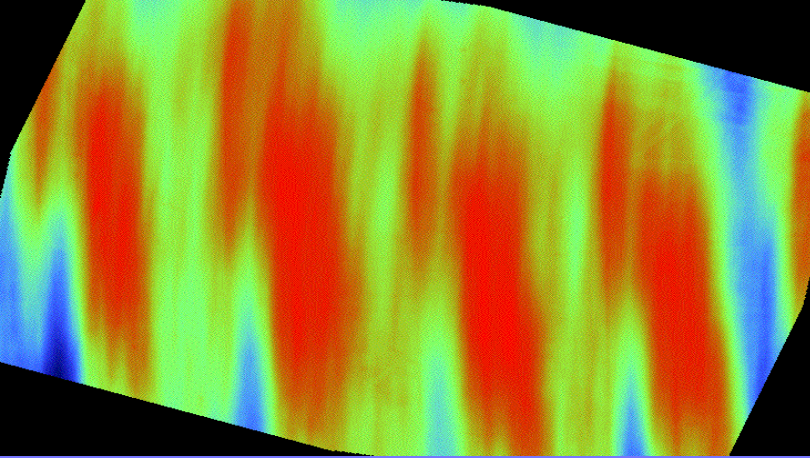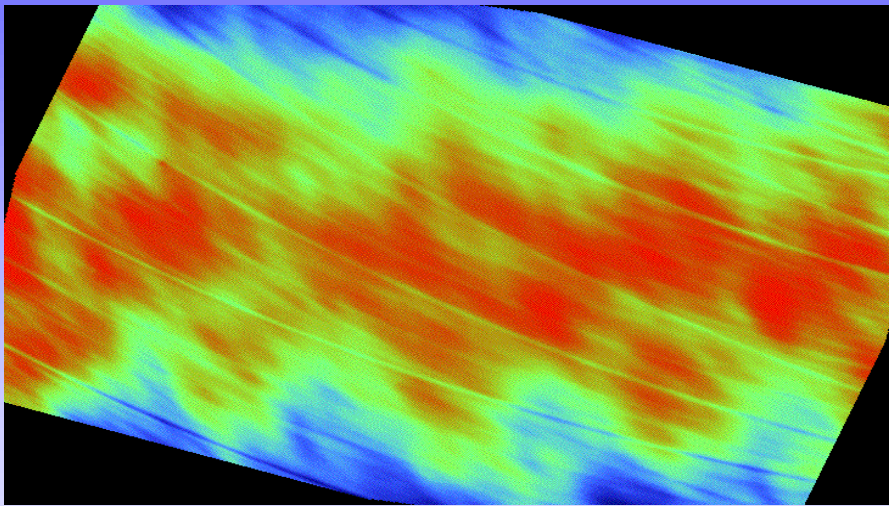
Improving PSD on a raster polished surface

- A 35mm diameter area on a glass flat was polished with a raster path to produce a surface with a periodic mid-spatial frequency feature.

- This region was then re-polished twice using random tool paths, resulting in an improvement in PSD.
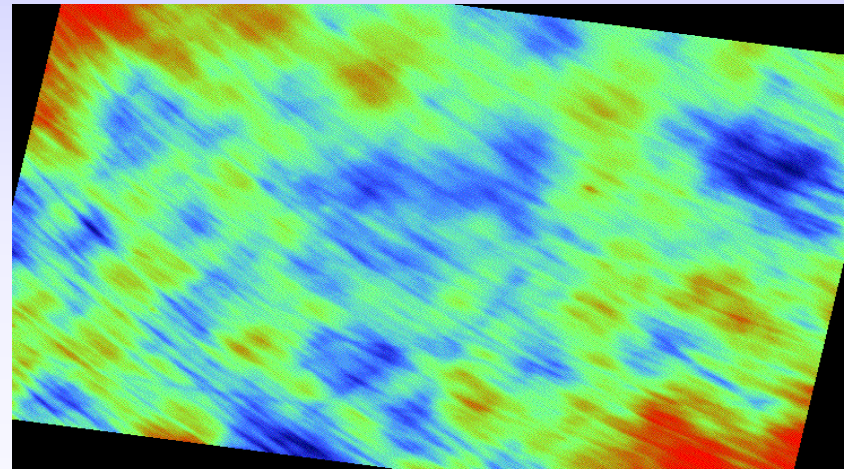
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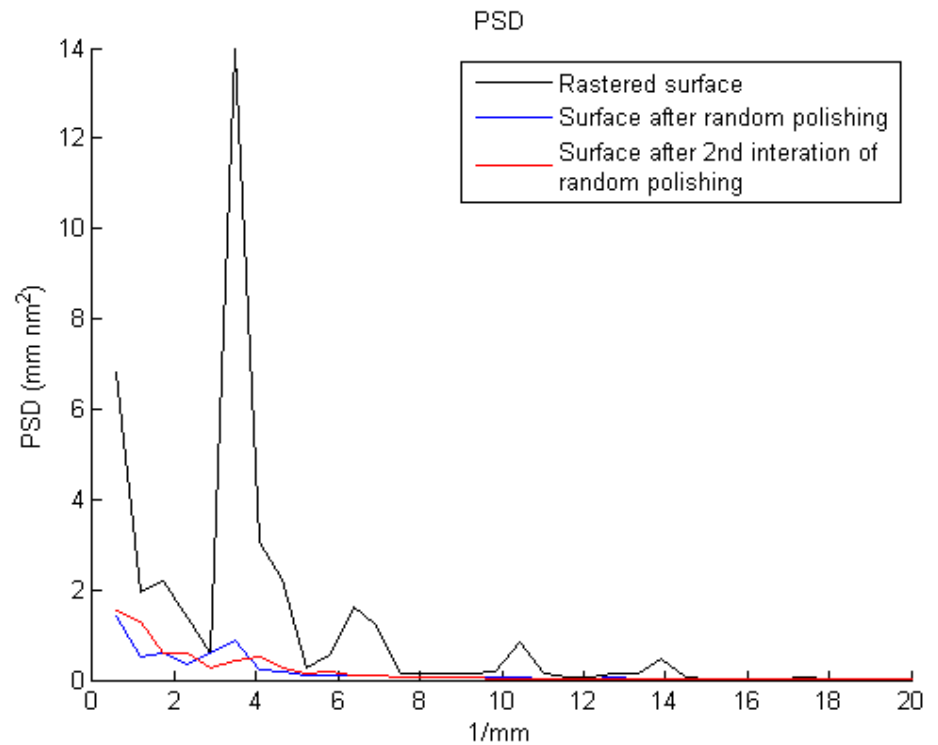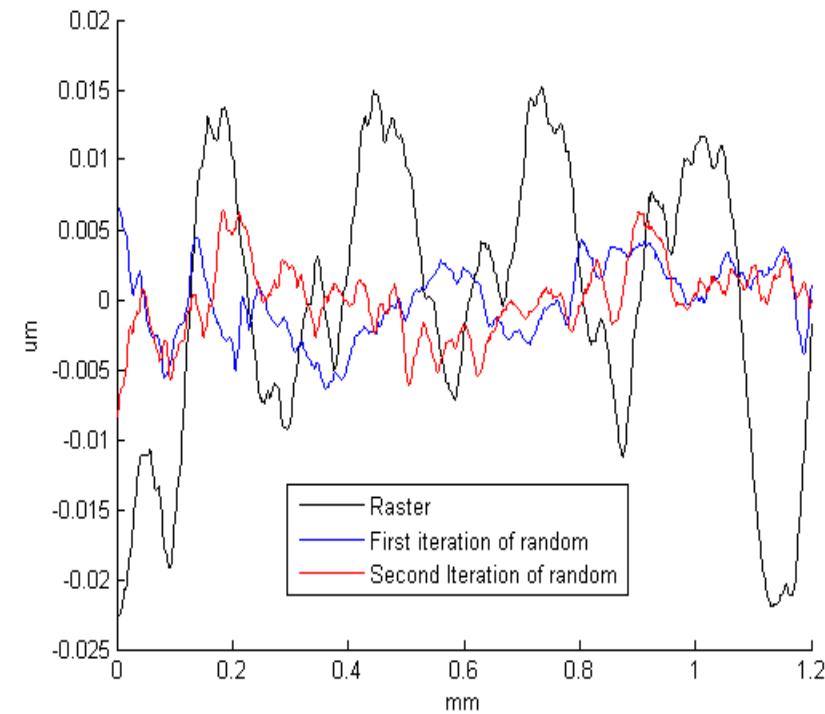
Surface after raster polish

Surface after 1st random polish

Surface after 2nd random polish

Surface characteristics

Surface texture statistics

	Ra (nm)	Rq (nm)	Rt (nm)
Rastered surface	8.10	10.29	114.47
After 1st random polish	6.55	7.85	43.37
After 2nd random polish	3.95	5.24	35.21

Future Work

- Improve the performance of the random tool path by using advanced interpolation methods in the CNC controller of the Zeeko machines.

- Integrate random tool paths with edge control.

- Integrate the random tool path into Zeeko's *Precessions*^{TM} software for corrective polishing.

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