WP3 Superflat: Deliverable 3.5

"Systematic study of performance of different deterministic processing methods for X-ray reflective optics"

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LEAPS INNOVATION

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Deliverable 3.5: Systematic study of performance of different deterministic processing methods for X-ray reflective optics

- D3.5: “Task participants will use their metrology capabilities to investigate … currently available processing methods to **validate their potential to produce complex freeform surface** topographies in complement to the flat surfaces which form the basis of the PCP”
- Experimental study: Oct 2023 to Oct 2024 (~1 year)
- Analysis of results & report writing (Oct 2024 to March 2025)

→ Report due March 2025 (M48)

Processing methods

Investigate performance of:

- Ion beam Figuring (IBF): commercial + Diamond + ?
- Magnetorheological finishing (MRF): Winlight-Bertin (WB), TSESO, +?
- Fluid jet polishing mechanical removal (FJP-m), : WB + ?
- Fluid jet polishing chemical removal (FJP-c), like EEM@JTEC: WB
- Differential deposition (DD): ESRF + ?

Experimental study

In many cases, polishers start with traditional, non-deterministic polishing to create flat or spheric surfaces, then move onto deterministic polishing techniques to:

- create required asphere (e.g. ellipse)
- improve low- & mid-spatial frequency errors (slope / height errors)

Macro-polishing

- improve high-spatial frequency errors (micro-roughness)

Micro-polishing

For the experimental study, we need to:

- Define prescriptive features to be created by processing
- Define quantitative “metrics” for comparison

Macro-polishing

- Rate of surface correction (nm per sec): ability to make corrections in a reasonably time
- Removal depth (or addition) before problems occur! (limits the deviation from freeform)
- Time stability of “correction function” (e.g. does IBF removal function change over time?)
- Smallest in-plane removal (e.g. shape of correction function), which defines minimum spatial periods which can be corrected

- Accuracy of motion stages (i.e. controlling speed & position of correction function)
- Fiducialisation of correction function (i.e. reliably hit correct location on optical surface)

Micro-polishing

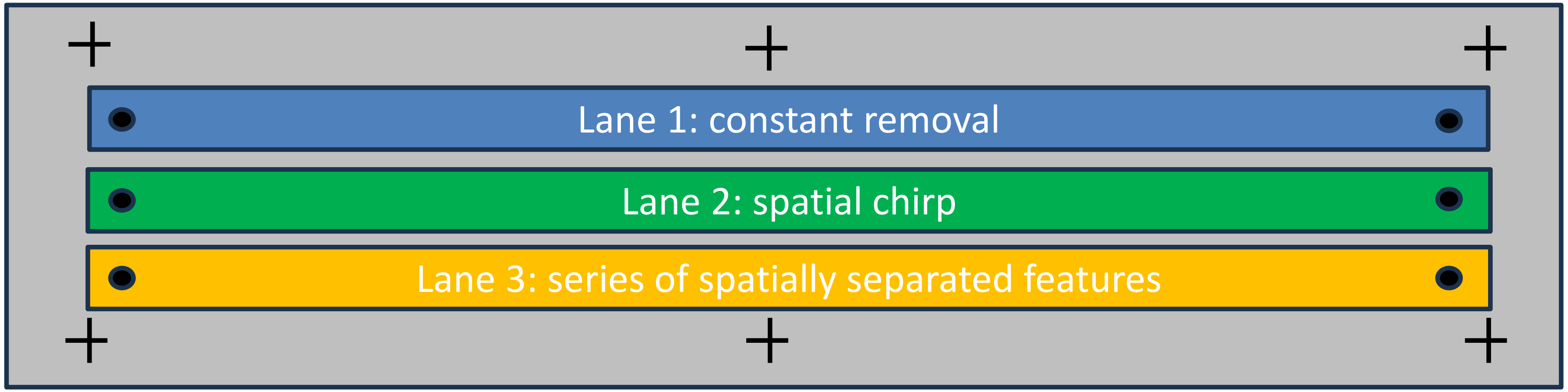
- Micro-roughness of corrected region (using micro-interferometry & AFM)?
- Surface texture? (ensure features are random, with minimal texture)
- Atomic scale defects (using AFM)?
- Sub-surface damage?
- Surface or sub-surface contamination? (e.g. incorporation of particles from processing onto / into optical surface)

Experimental study

- Pre-measured samples provided to each optical polishing facility
- Polishers instructed to create several “features” at specific regions on optical surface (to enable a like-for-like comparison):
  - Uniform layer removal
  - Tool removal function
  - Spatially-varying pattern: e.g. chirp

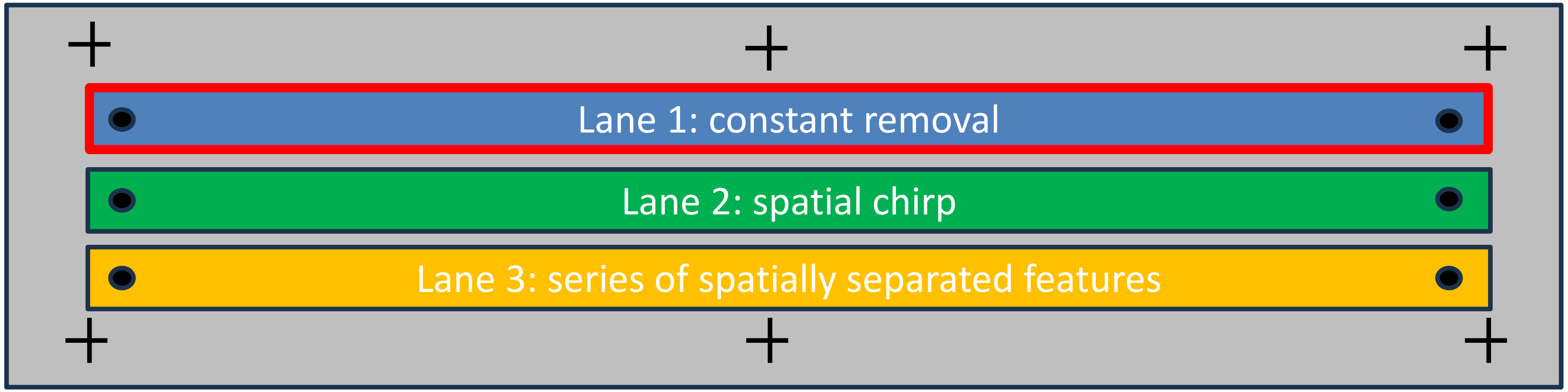
Optical surface: 3 x lanes

- Lane 1: constant “removal” (can be compared to before processing + micro-roughness)
- Lane 2: spatially-varying pattern (e.g. chirp, sinusoid)
- Lane 3: series of separate features (e.g. “craters” of varying depth and width)
- Fiducial crosses (outside optical area) + dots (at beginning and end of each “lane”)



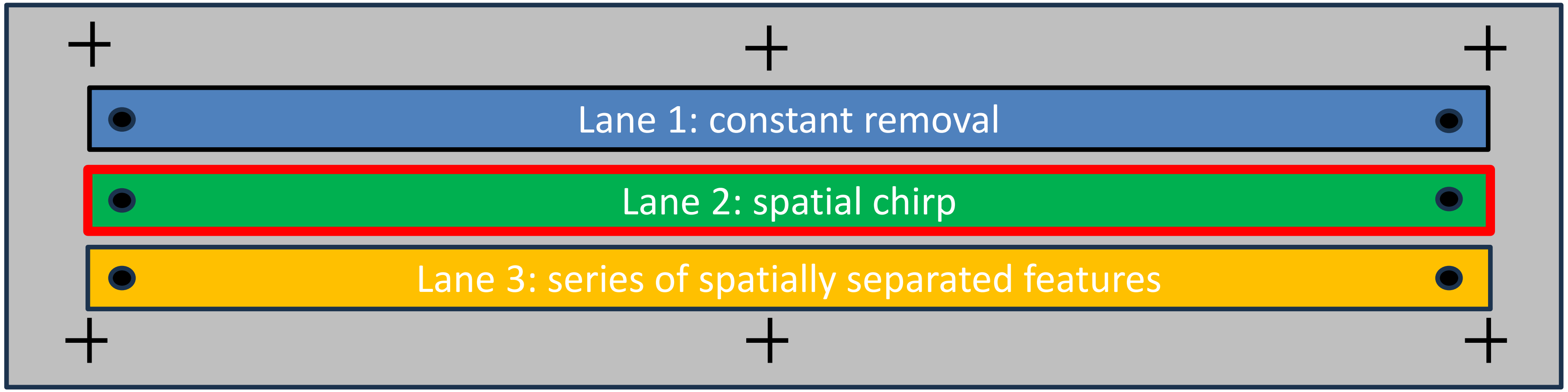
Optical surface: Lane 1

- Lane 1: constant "removal":
  - Time stability of "correction function"
  - Micro-roughness change?
  - Appearance of texture?



Optical surface: Lane 2

- Lane 2: spatial chirp
  - Accuracy of motion stages (i.e. controlling speed & position of correction function)
  - Fiducialisation of correction function (i.e. reliably hit correct location on surface)



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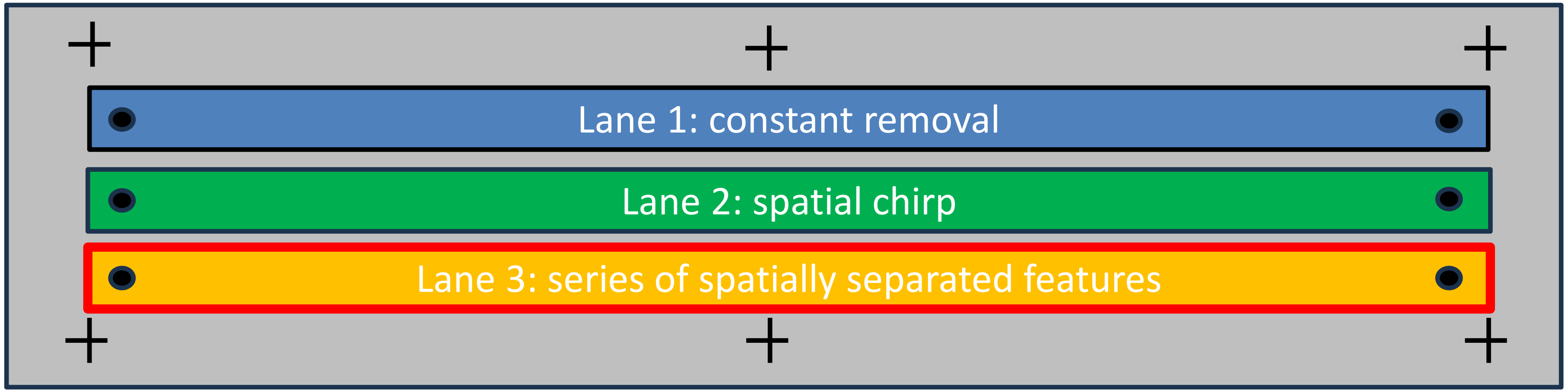
Optical surface: Lane 3

- Lane 3: series of separate features (e.g. "craters" of varying depth and width)
  - Smallest in-plane removal (e.g. shape of correction function)
  - Accuracy of motion stages (i.e. controlling speed & position of correction function)
  - Fiducialisation of correction function
  - Removal depth (or addition) before problems occur!



Metrology instruments

- Fizeau, LTP, NOM: macro-polishing quality (e.g. constancy of removal)
- Micro-interferometry: size of features + mid- & high-spatial texture
- AFM: atomic scale defects & high-spatial texture
- X-ray diffuse scattering?

Samples

- Samples?
  - Diamond has 10 silicon (100) wafers: 100 mm (long) x 30 mm (wide) x 5 mm (thick).

    Type/Dopant: N/Phos; Resistivity: >0,01ohm cm; Finish: SSP
  - ESRF has super polished Si samples (50x25x7) which could be made available
- Who can process samples? TSESO, WB, ESRF, Diamond, + ? Externals: JTEC, Zeiss, ?
- Diamond to coordinate measurement & analysis procedure
- Minimise the size of round-robin for speed? Who else would like to measure?

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Next steps

- Agree on features to be added to optical surface
- Contact Industrialists to discuss if they can create these features
- Revise feature list based on industrial feedback
- Finalise list of who wants to measure the samples (likely only after correction)

Actions

- Define basic concept for lanes
- Speak with Suppliers to find out what's possible
- Finalise specs

- IOM Leipzig (plasma jet polishing – Frank)
- LightMachinery (Canada) for Fluid jet polishing?
- SilX or hdfviewer for NeXus file viewing.
- Speak with Diamond SciComp about NeXus