



SUPERFLAT

## Task 3.3: Deterministic Figuring Techniques

### Diamond contribution to LEAPS WP3 (Superflat)

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Diamond Light Source

### Ion Beam Figuring (IBF) at Diamond

*Soleil, October 2023*



Co-funded by  
the European Union

 **LEAPS**  
**INNOVATION**

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# LEAPS-INNOV WP3 Superflat meeting @ Soleil

**Task 3.3: Development and characterisation of deterministic corrective figuring techniques for the production of reflective X-ray substrates**

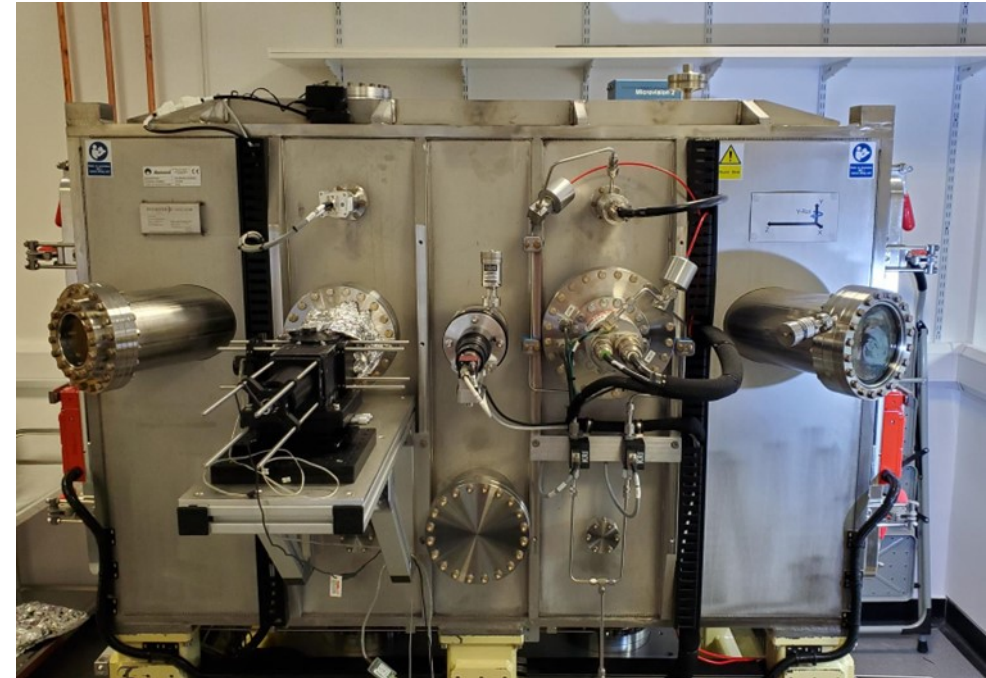
Contributors: **Diamond (Lead)**, HZB, ALBA-CELLS, ESRF, Soleil

## Task 3.3 Mandate

- Participants to explore characteristics & performance limits of candidate technologies for corrective figuring of reflective surfaces (IBF, differential deposition, ...)
- Participants to explore basic limits of surface processing developed in-house
- Participants to 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.

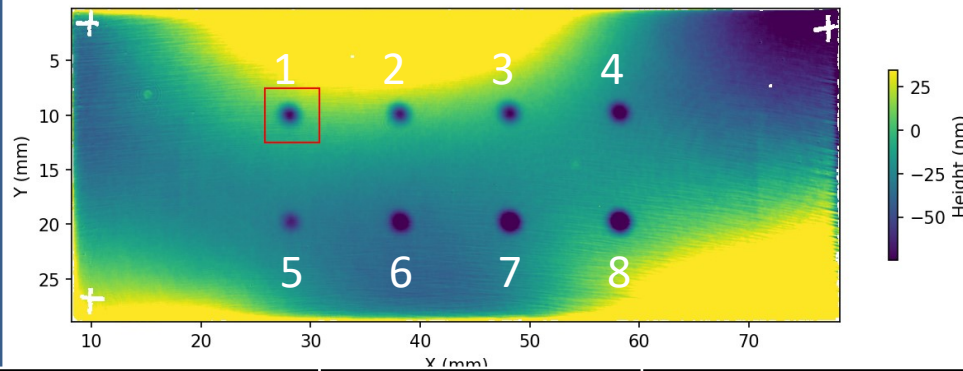
# Ion beam figuring (IBF) system at Diamond

- In-house developed (design, construction and commissioning)
- Research tool which can be modified and improved to suit our exact requirements
- On-board metrology for rapid turnaround between measurement and figuring loops
- Benefits from excellent in-house metrology
- Transportable to B16 Test beamline for combined X-ray at-wavelength metrology & IBF processing



❖ *Ion beam figuring and optical metrology system for synchrotron x-ray mirrors*  
Matthew Hand, Simon Alcock, Michael Hillman, Richard Littlewood, Simone Moriconi,  
Hongchang Wang and Kawal Sawhney, *Proc. SPIE*, **11109**, 111090A (2019)

# Temporal stability study of ion source



Same Aperture:  $\phi 1\text{mm}$

The ion beam is **stable** with time,  
The etching rate is nearly **constant**

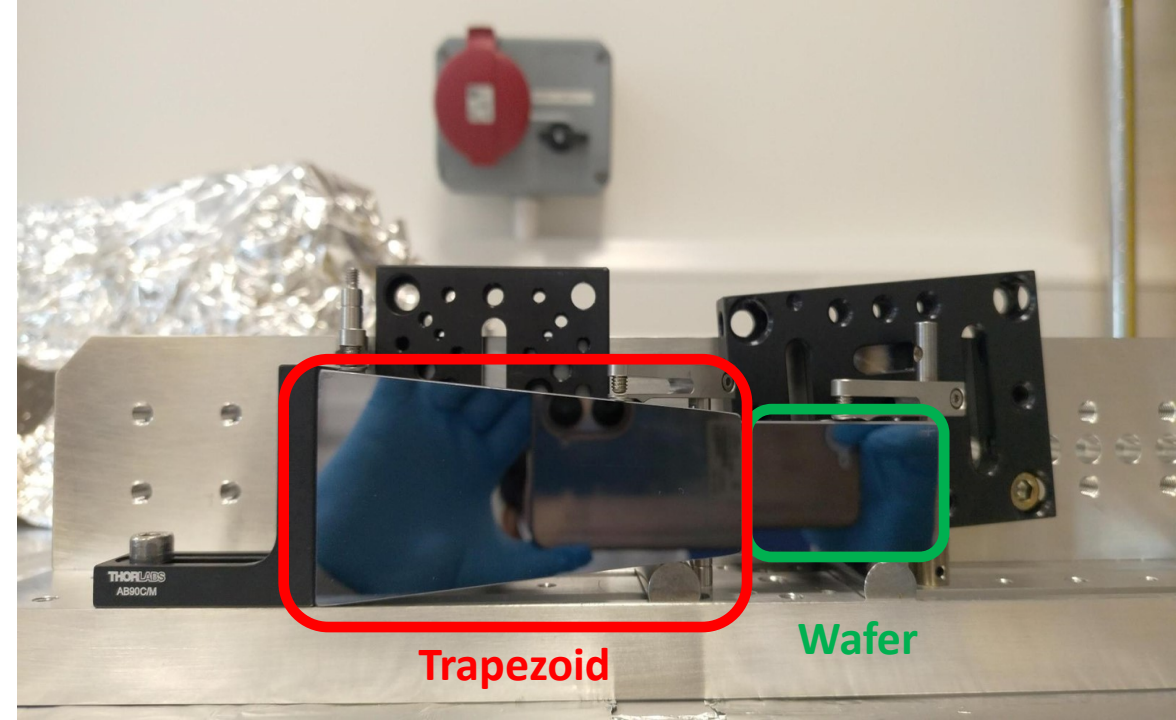
BRF crater No	Start Time (mins)	Etching time (s)	Etching rate (nm/s)	Depth (nm)	Sigma_X (mm)	Sigma_Y (mm)
1	0	240	0.33	79.2	0.61	0.60
2	10	240	0.33	79.2	0.63	0.61
3	20	240	0.32	76.8	0.63	0.61
4	30	240	0.32	76.8	0.63	0.62
5	-	120	0.32	38.4	0.60	0.59
6	-	240	0.31	74.4	0.62	0.62
7	-	360	0.31	111.6	0.64	0.64
8	-	480	0.31	148.8	0.65	0.64

March 2023



Silicon substrate Dimensions: 100 x 50 x 25 mm  
Radius of curvature:  $\sim 86$  m  
Before etching: height error: 3.9nm (rms)

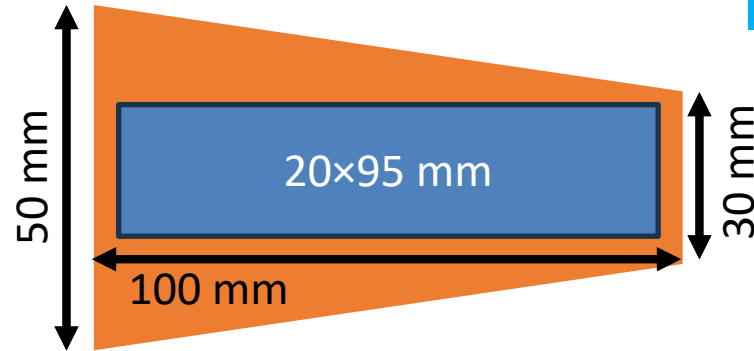
July 2023



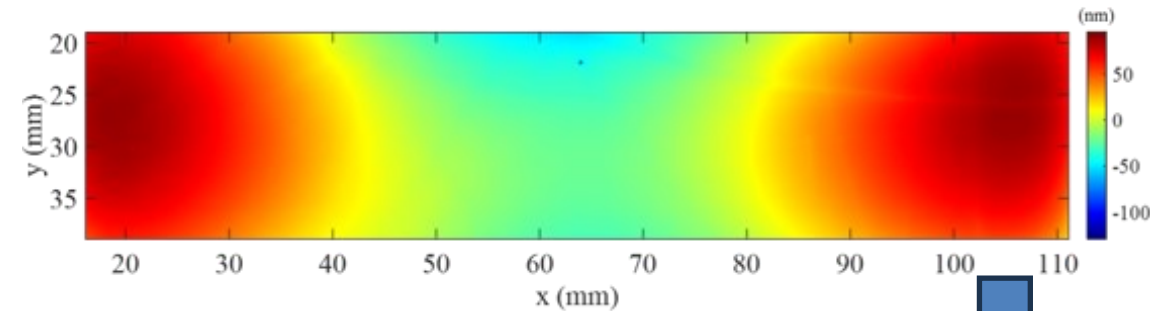
Silicon substrate Dimensions: 100 x 50 x 6 mm  
Radius of curvature:  $\sim 105$ km  
Before etching: height error: 40nm (rms)

# 2D shape + error correction of old Trapezoid mirror

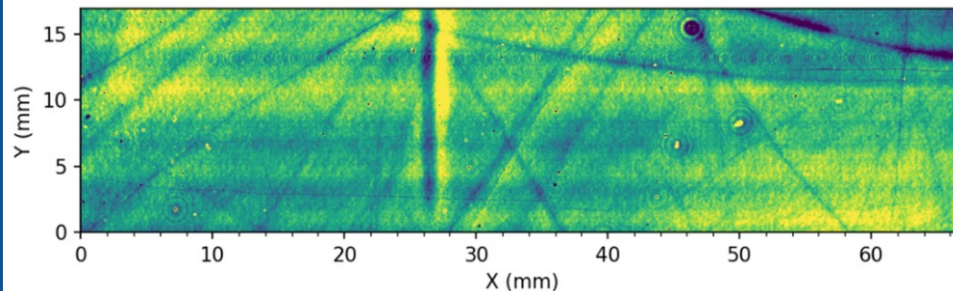
July 2023



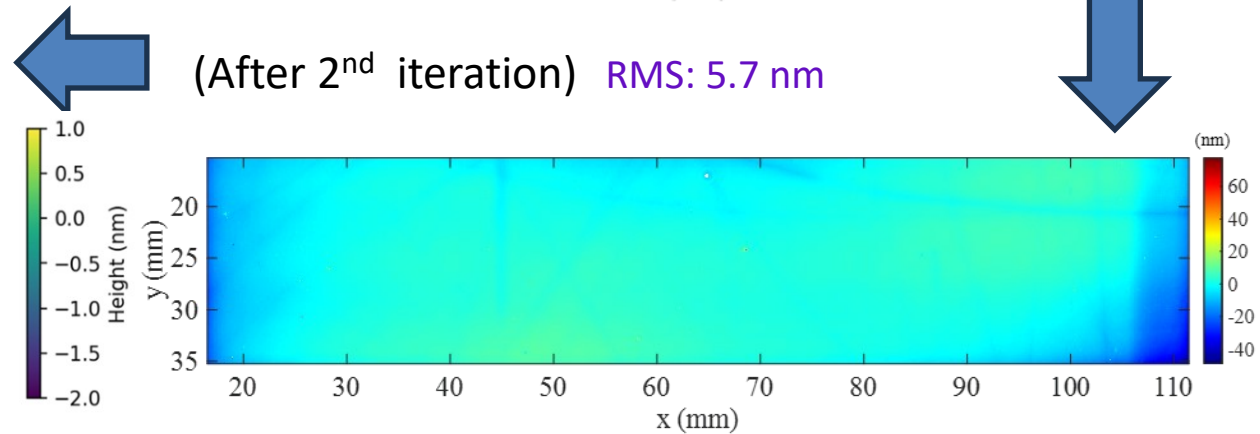
Before correction: RMS: 40 nm



(After 3<sup>rd</sup> iteration) RMS: 0.8 nm



(After 2<sup>nd</sup> iteration) RMS: 5.7 nm



- Height error reduced from 40 nm rms to 0.8 nm rms in active area 67mm×17 mm after 3<sup>rd</sup> iteration
- Slope error reduced to 230 nrad rms in the centre region of the mirror in the active length 60 mm
- Slope/height error is limited by bad scratches, which can't be further corrected by IBF process

# Summary + Outlook

- ✓ Excellent stability of ion source
- ✓ Optimization of IBF 2D correction software
- ✓ 2D correction of surface figure over multiple iterations
- *Further improvement of figure errors*
- *Correction of non-planar surfaces (ellipse, aspheric)*

**Dr. Riley Shurvinton**

PDRA (May, 2023)



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# Thanks for your attention