LEAPS League of European Accelerator-based Photon Sources

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WG 3 – Superflat – 17th October 2023

Report on Performance of candidate metrology techniques supporting manufacturing process of optics

Deliverable 3.7 (M44)

Frank Siewert

Mission: - how to verify the quality of high-end super-polished plane mirrors?

- how to support optimization and the finishing of high-end mirror?

- high-end optics of today are polished by deterministic finishing technology e.g.: IBF, EEM, CAP, MRJP, …

- the quality of metrology data is essential for the final achievement

Mission: - how to verify the quality of high-end super-polished plane mirrors?

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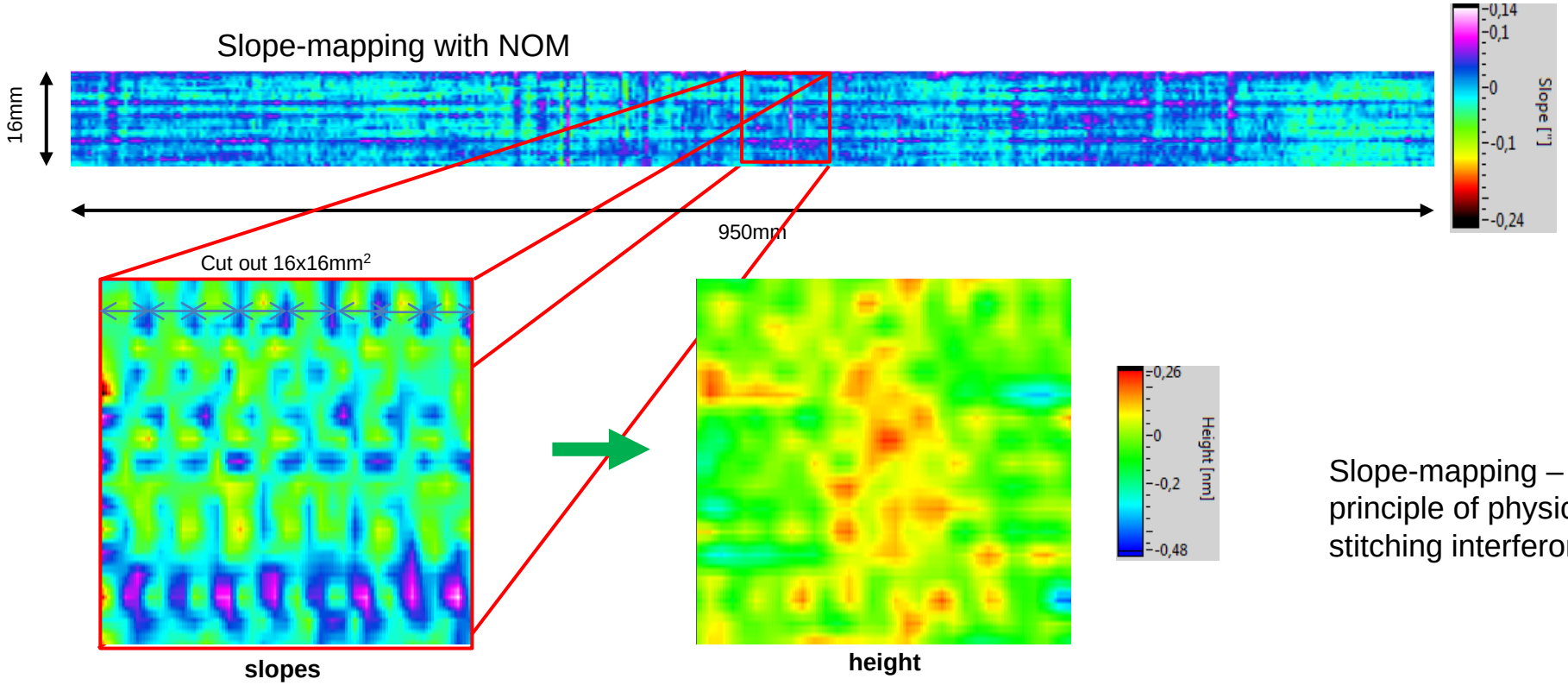
Mirror finishing based on stitching-Fizeau and stitching-micro interferometry



Slope-mapping – different principle of physics than stitching interferometry

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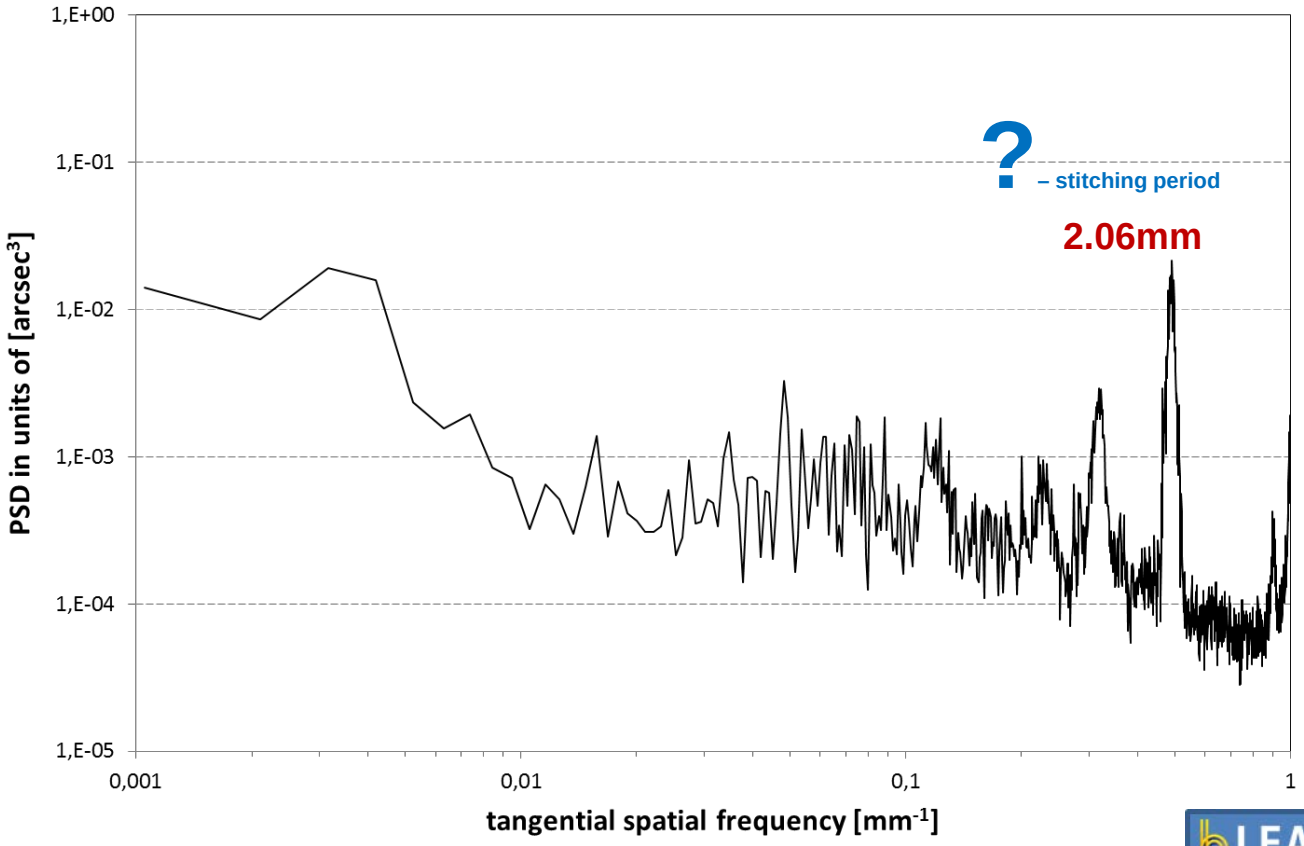

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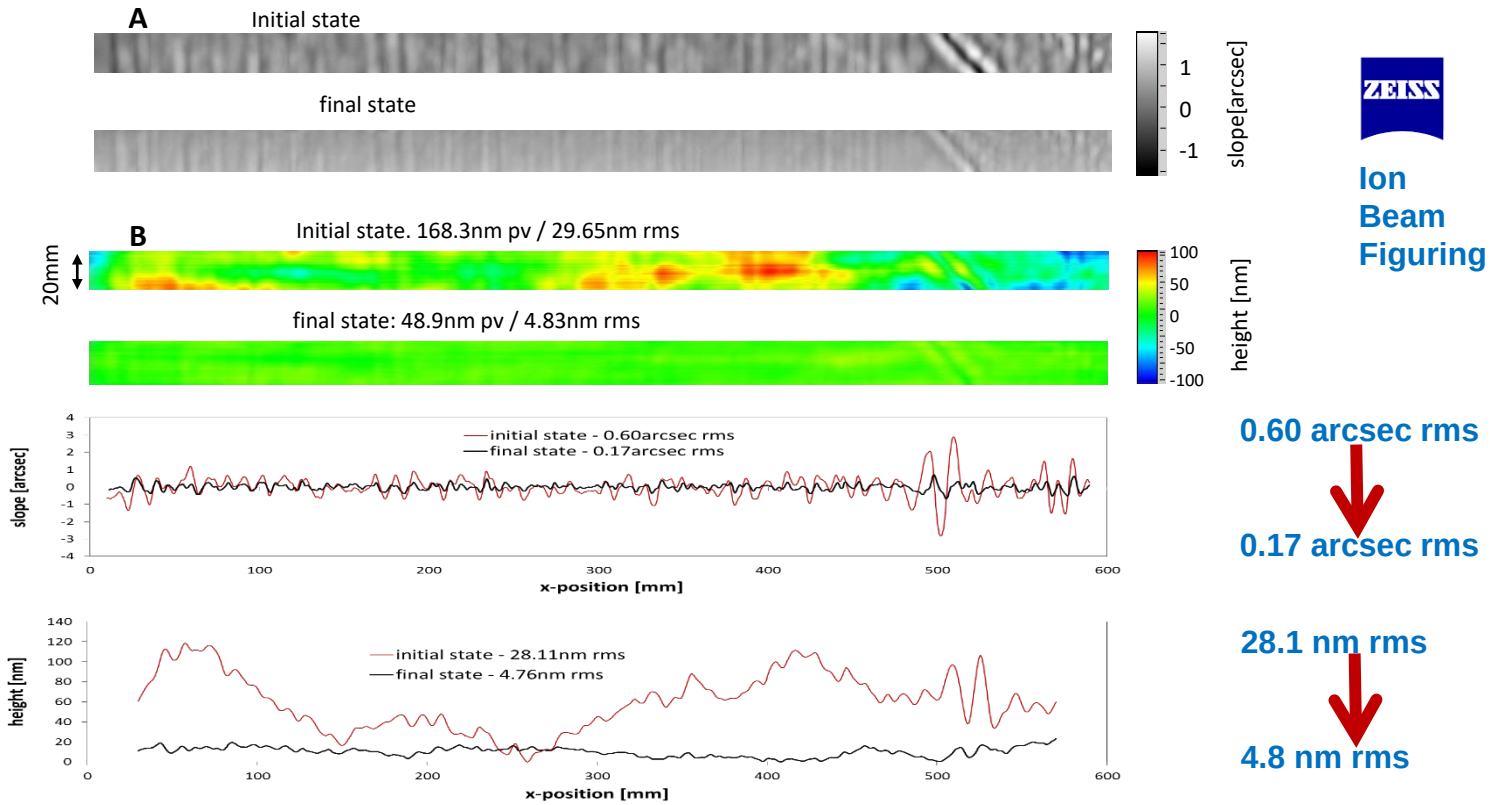
2D-data for mirror optimization (e.g. IBF)



ZEISS

Ion Beam Figuring

0.60 arcsec rms

↓

0.17 arcsec rms

28.1 nm rms

↓

4.8 nm rms

F. Siewert et al.; Proc. SPIE 11109 (2019); doi: 10.1117/12.2529308

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Questionnaire on on the performance of different method of metrology for the inspection and characterization of plane SR-mirror substrates (state of 2022)

Method	Principle	Spatial resolution	Pros	Cons	System can be calibrated	Usable at SR-lab/Industry	Additional comments
Fizeau single-pass interferometry	Interferometry	Depends on pixel size of CCD and zoom factor, but ~ 35 µm (with zoom) to 50 µm (without zoom)	• Easy to use / align • High spatial resolution • Fast • Provides 2D maps • Less sensitive to environment compared to other methods	• Limited by quality of reference flat (for Rc evaluation) • Limits in size of optic that can be measured (aperture of Fizeau)	Yes	Yes / Yes	Used by most vendors of X-ray mirrors
Fizeau double-pass interferometry	Interferometry	Depends on pixel size of CCD and zoom factor and angle of inclination, but < 1 mm	• Can measure long mirrors • Provides 2D maps	• More complicated to align than single-pass • Limited by quality of reference flat and reflector flat. • More complicated / numerous systematic errors	Yes	Yes / Yes	Not useful for < 100 nrad mirrors?
Stitching Fizeau interferometry	Interferometry	Similar to single-pass Fizeau	• Can measure long mirrors • Provides higher quality results than single-pass Fizeau • Provides 2D maps	• Stitching hardware needed • Stitching algorithms needed (can use PyLOSt)	Yes	Yes / Yes	Used by JTEC & TSESO, +?
Stitching micro-interferometry	Interferometry	Depends on objective magnification, typically a few µm at 2.5X	• Highest spatial resolution • Provides 2D maps	• Stitching algorithms needed (can use PyLOSt) • 2d Limited in sagittal direction • Limitations to measure large optics	Yes	Yes / Yes	Used by JTEC, but no other vendors?

Note: We take only noncontact / optical sensing methods into account!

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				• Uncertainties for spatial periods >100mm for flat mirror • Slow measurements			
Sharper	wavefront sensing	1.2 mm	• Can measure long mirrors • 2D slope maps	• Slow measurements • Sensitive to environment • Low spatial resolution • 2d Limited in sagittal direction to sensor size (without x-y stitching implementation)	Yes	Yes / no?	Expert system
LTP/NOM	angular deflection	1.5 to 2 mm	• Can measure long mirrors • Excellent repeatability	• Low spatial resolution, • Can be slow measurements (but depends on instrument and scan type) • 1D line profiles for most instruments • 2D area scans are time consuming	Yes	Yes / Yes	• Expert system • NOM is used by Crystal Scientific, but not calibrated or optimised
SAM*	angular deflection	Sub-mm to few mm	• Can measure long mirrors • Can produce 2D information map	• Computation speed is low • Currently a research instrument	Yes	Yes / no?	• Expert system • Can be used to characterize strongly curved optics

Note: We take only noncontact / optical sensing methods into account!

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Outlook / future plans:

- State of the table is of 2022
- New and recent developments:

  - fast NOM at Diamond
  - LTP-2020 at LBNL Berkeley
  - …

final results of MooNpics should be included

Final report at M44 as open to the public report
(could this be a paper at JoSR?)