

6th OCLA Symposium
Optical Coatings for Laser Applications

Beyond high power laser mirrors

Daniel Heinert & Holger Hartung

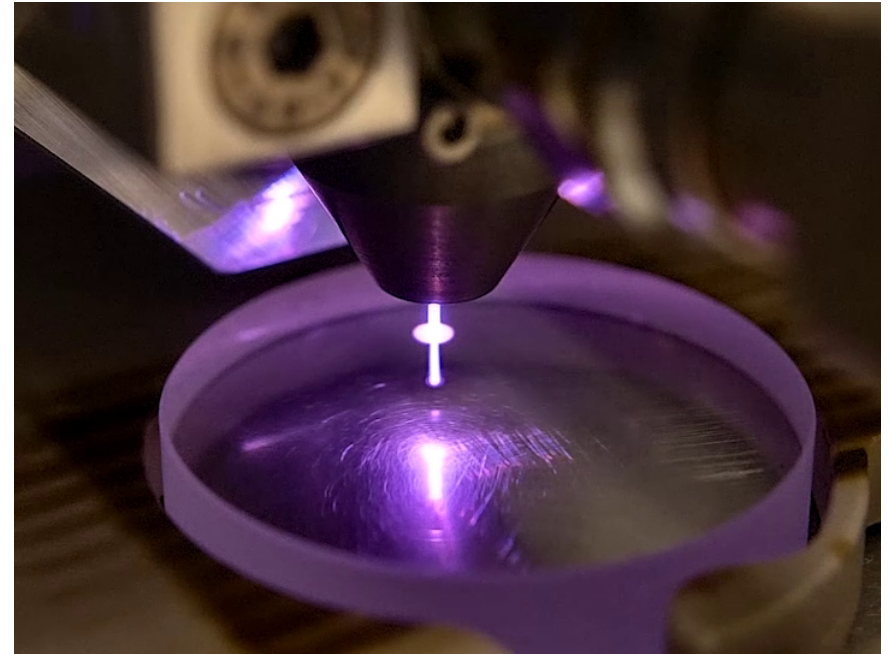
Agenda

- PICCOS (plasma induced chemical correction of optical surfaces)
 - principle and process characteristics
 - surface profile correction
 - surface profile creation
- lithographically structured layers
 - fabrication technologies
 - mono layer vs. multi layer
 - applications & investigations
 - structured HR mirrors
 - reflectivity, LIDT



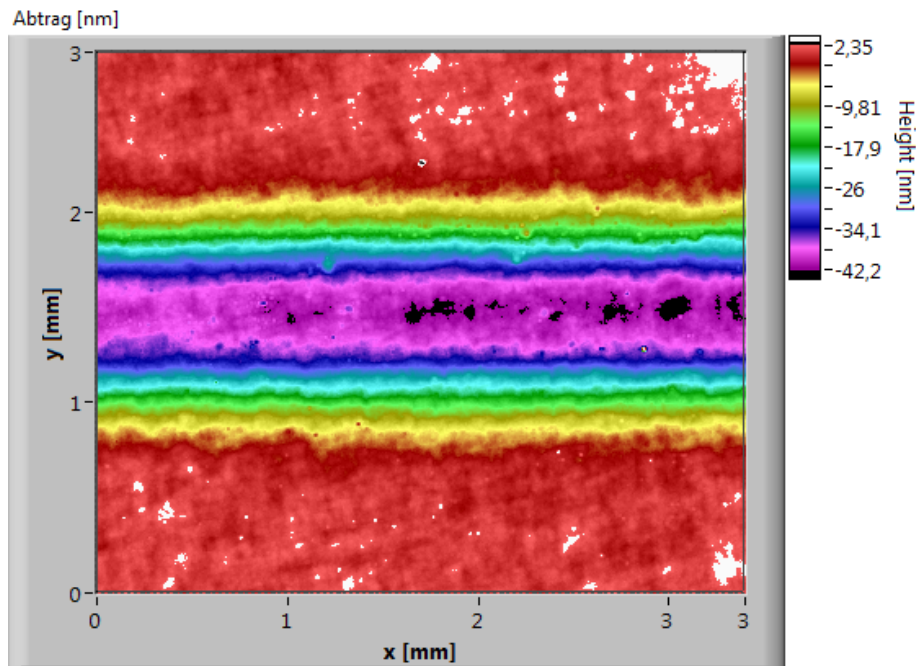
PICCOS - plasma induced chemical correction of optical surfaces

- atmospheric process
- microwave driven plasma
- fluoric plasma – CF_4 gas
- carrier gas Helium
- shielding gas Nitrogen
- material removal given by dwell time
- none contact processing
 - no sub-surface damage creation
 - exposing sub surface damage



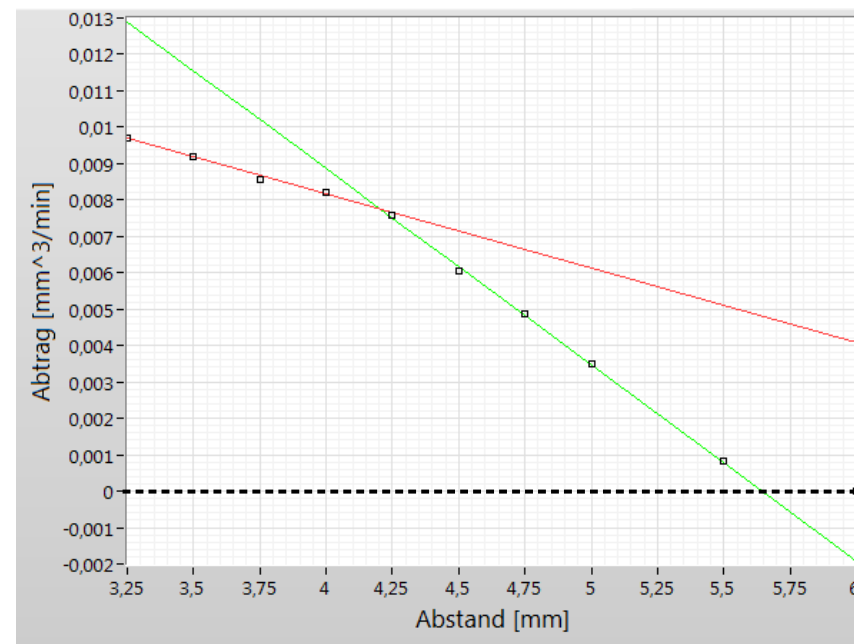
PICCOS - process characteristics

line etching – line width ~1 mm



$$5.31 \cdot 10^{-3} \text{ mm}^3/\text{min} = 5.31 \cdot 10^6 \text{ } \mu\text{m}^3/\text{min}$$

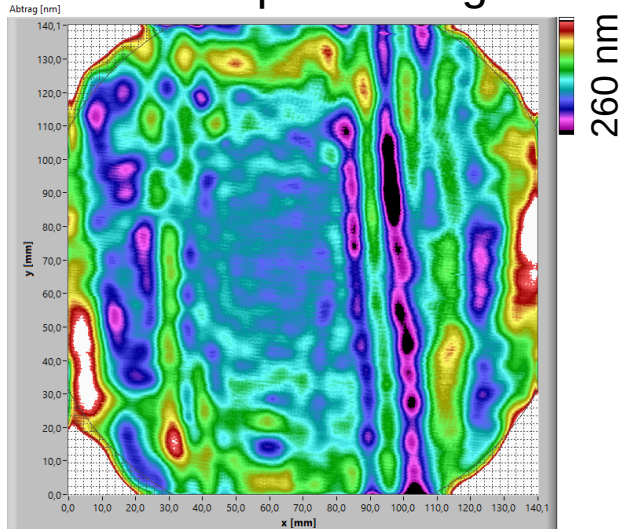
distance from surface



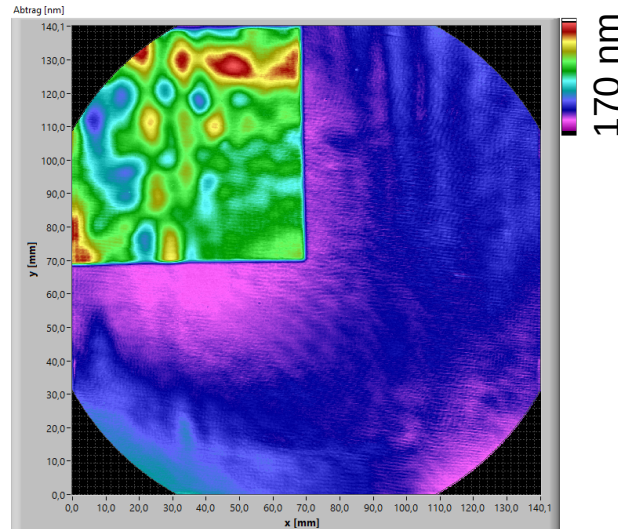
2 etching regimes

PICCOS - application: surface profile correction

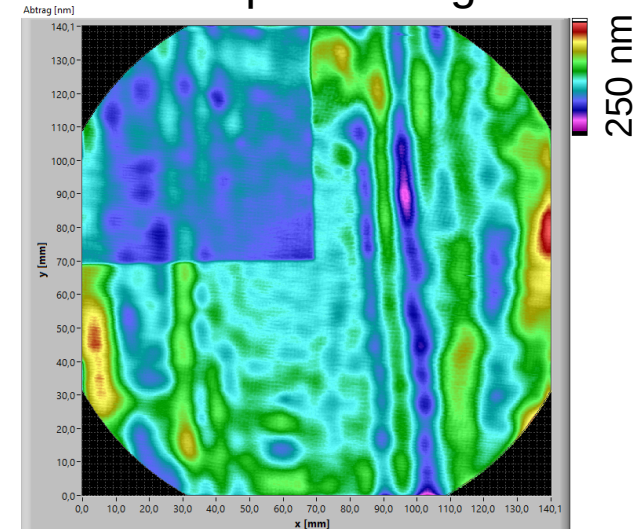
before processing



etch removal



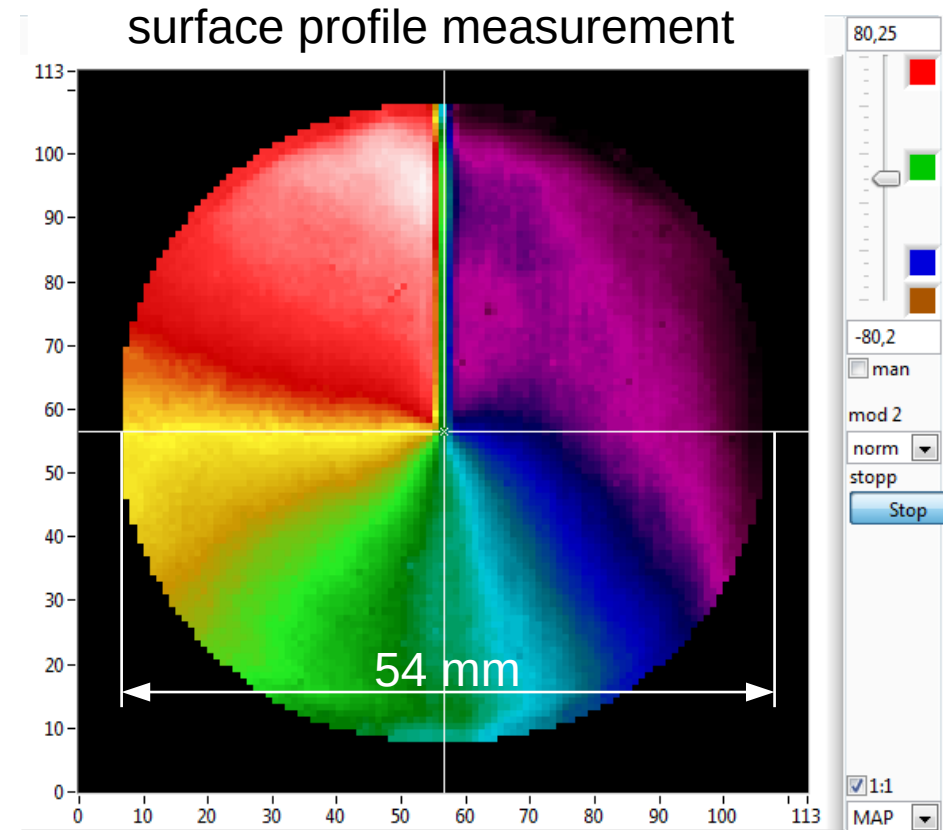
after processing



- surface correction with small footprint
- variations of the etching rate
- iterative processing recommended

PICCOS - application: surface profile creation

- etching profile calculation
given minimal feature size
- spiral pattern for phase dislocation generation
- step height 150 nm
- minimal step width ~1 mm



lithographically structured layers - fabrication processes

etching vs. aperture coating vs. Lift-Off

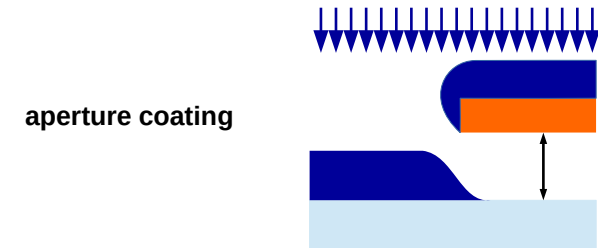
- etching:

- standard for chromium, gold, nickel, ...
- dielectric layers etching by hydrofluoric acid



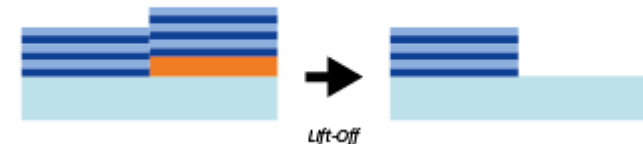
- coating through an aperture

- width of transition zone given by coating technology and distance



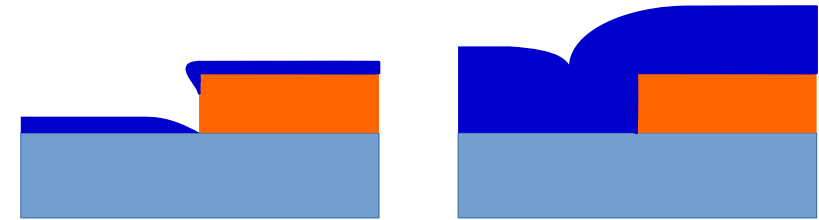
- Lift-Off:

- feasible with every coating material
- standard technology for thin single layers
- adapted resist processing for multi-layer systems



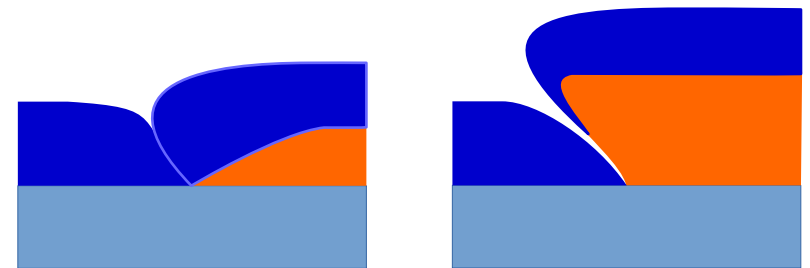
lithographically structured layers - Lift-Off

- standard technology for thin (metallic) layers
 - resist height > layer thickness
 - low coating times
 - low heat deposition
- multi layer HR-mirrors
 - more than ~20 layers – stack height of some μm
 - coating times several hours
 - resist blistering, nitrogen out gassing
- Lift-Off with adapted resist treatment:
 - thermal treatment for resist hardening
 - standard sputter coating
 - lift-off by chemical solvents
 - different behavior of positive or negative resist



thin coating

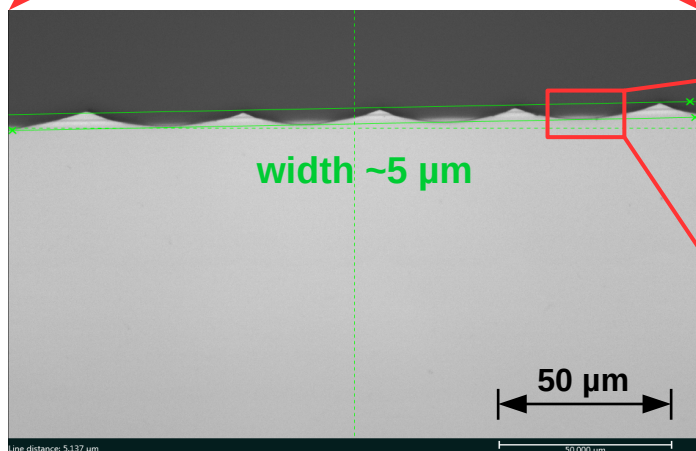
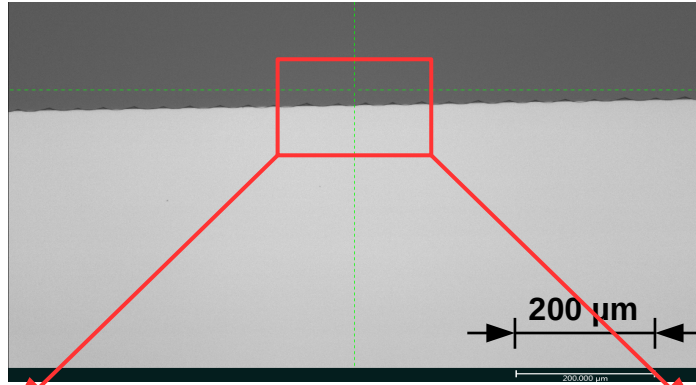
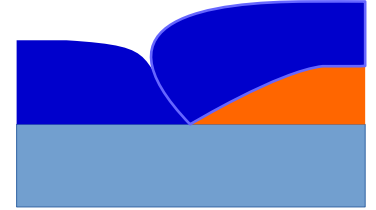
thick coating



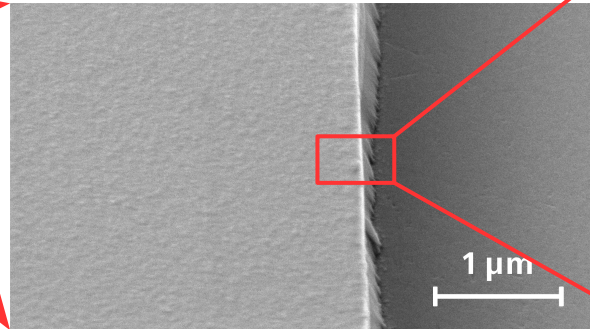
positive tone resist

negative tone resist

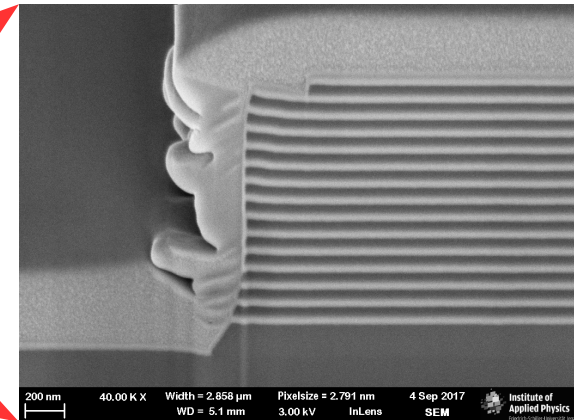
lithographically structured layers



- positive tone photo resist
- „predetermined breaking point“
- transition zone in the range of layer thickness
- feature size limited
- no „holes“ in HR-mirrors



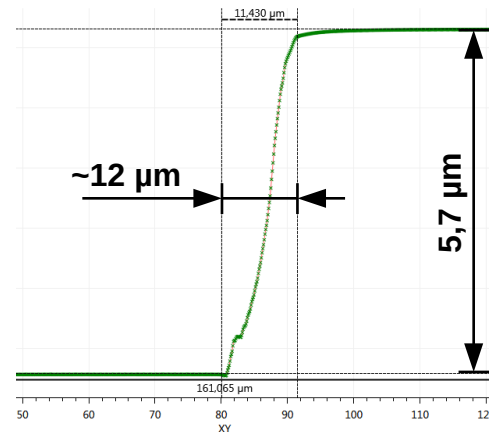
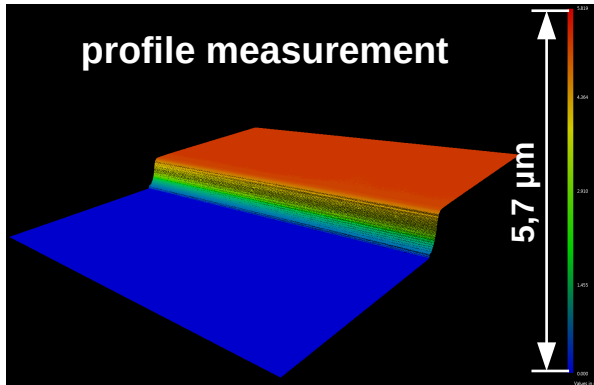
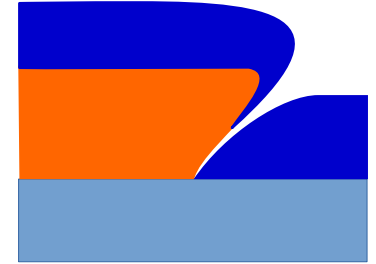
FIB – profile



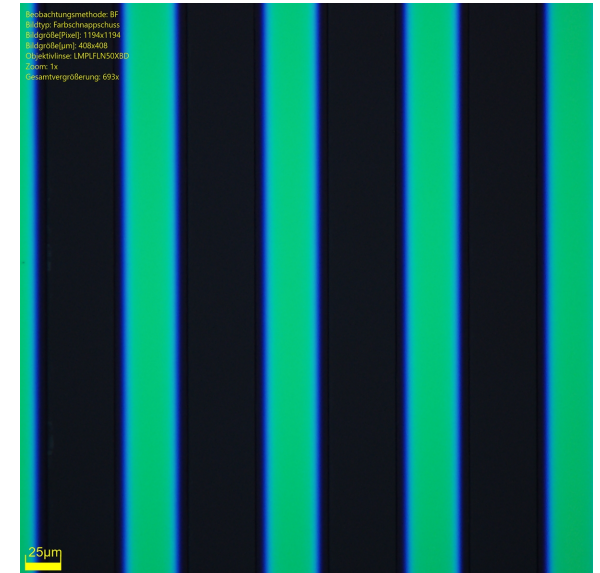
lithographically structured layers



- negative tone photo resist
- bulged resist structure
- layer thickness gradient
- no sharp edges
- lower limit for feature size

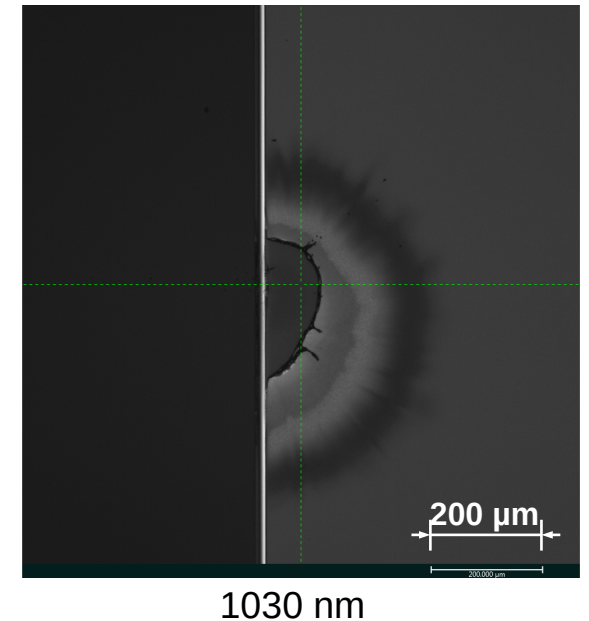
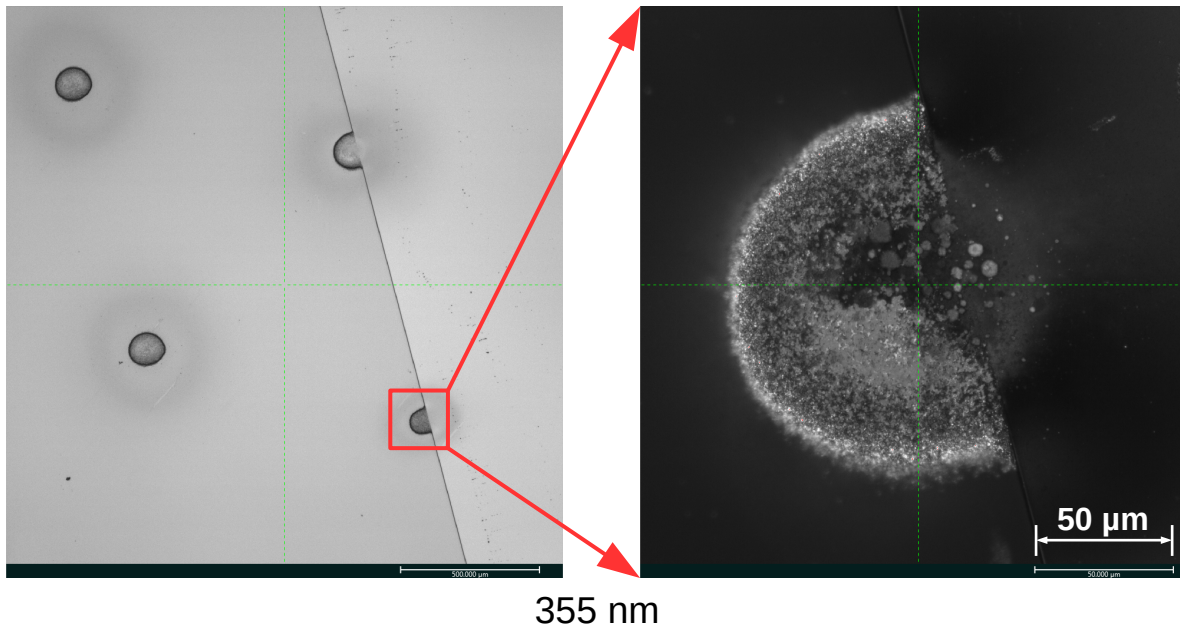


HR500 grating – period 100 μm



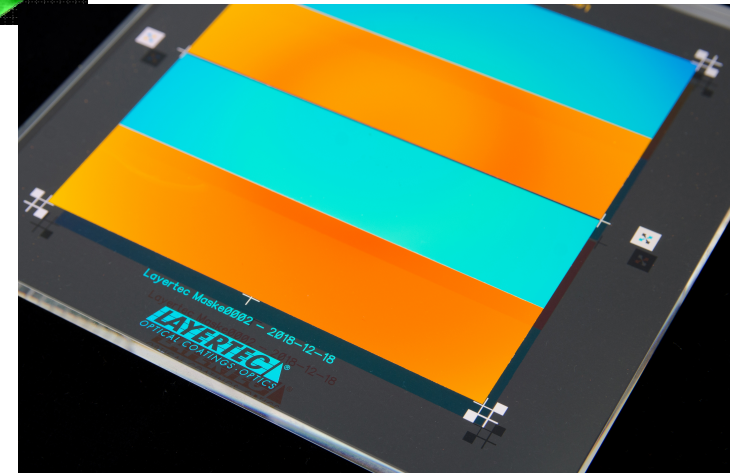
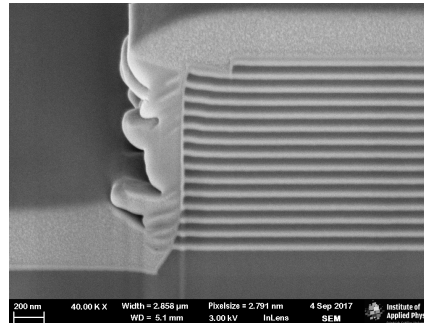
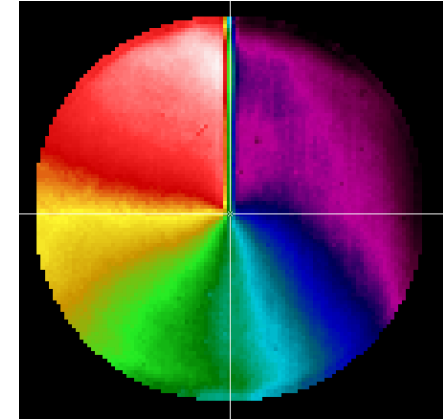
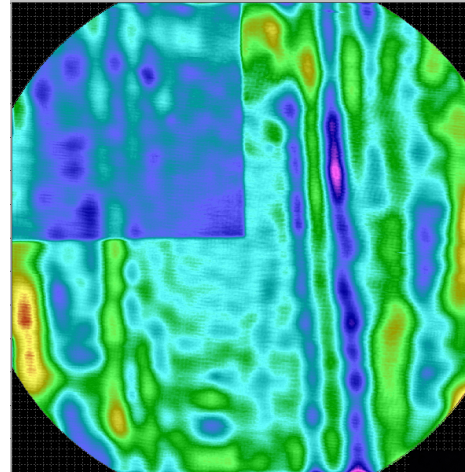
lithographically structured layers – LIDT

- R-on-1 measurement on structured HR mirrors
 - 355 nm, 7 ns, 100 μm beam spot – $7 \pm 2 \text{ J/cm}^2$ (10^5 -on-1)
 - 1064 nm, 7 ns, 270 μm beam spot – $255 \pm 55 \text{ J/cm}^2$



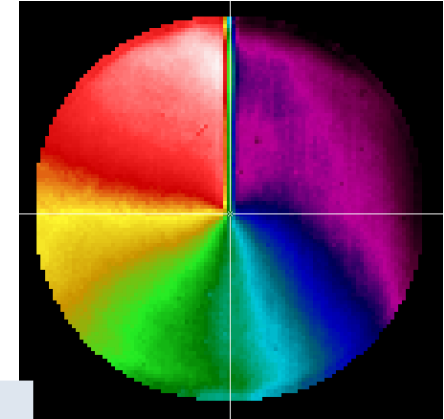
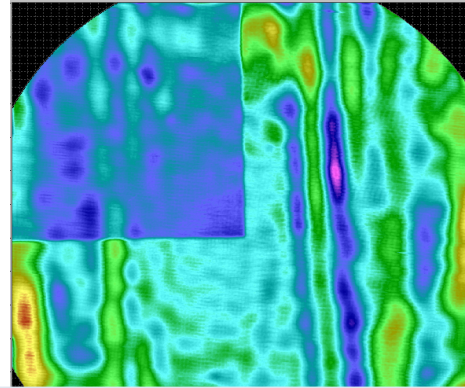
Conclusion

- PICCOS
 - surface profile correction
 - surface profile creation
- lithographically structured layers
 - structured HR mirrors
 - LIDT comparable to unstructured mirrors



Conclusion

- PICCOS
 - surface profile correction
 - surface profile creation
- lithographically structured layers
 - structured HR mirrors
 - LIDT comparable to unstructured mirrors



thank you for your attention

