6th OCLA Symposium
Optical Coatings for Laser Applications

Beyond high power laser mirrors

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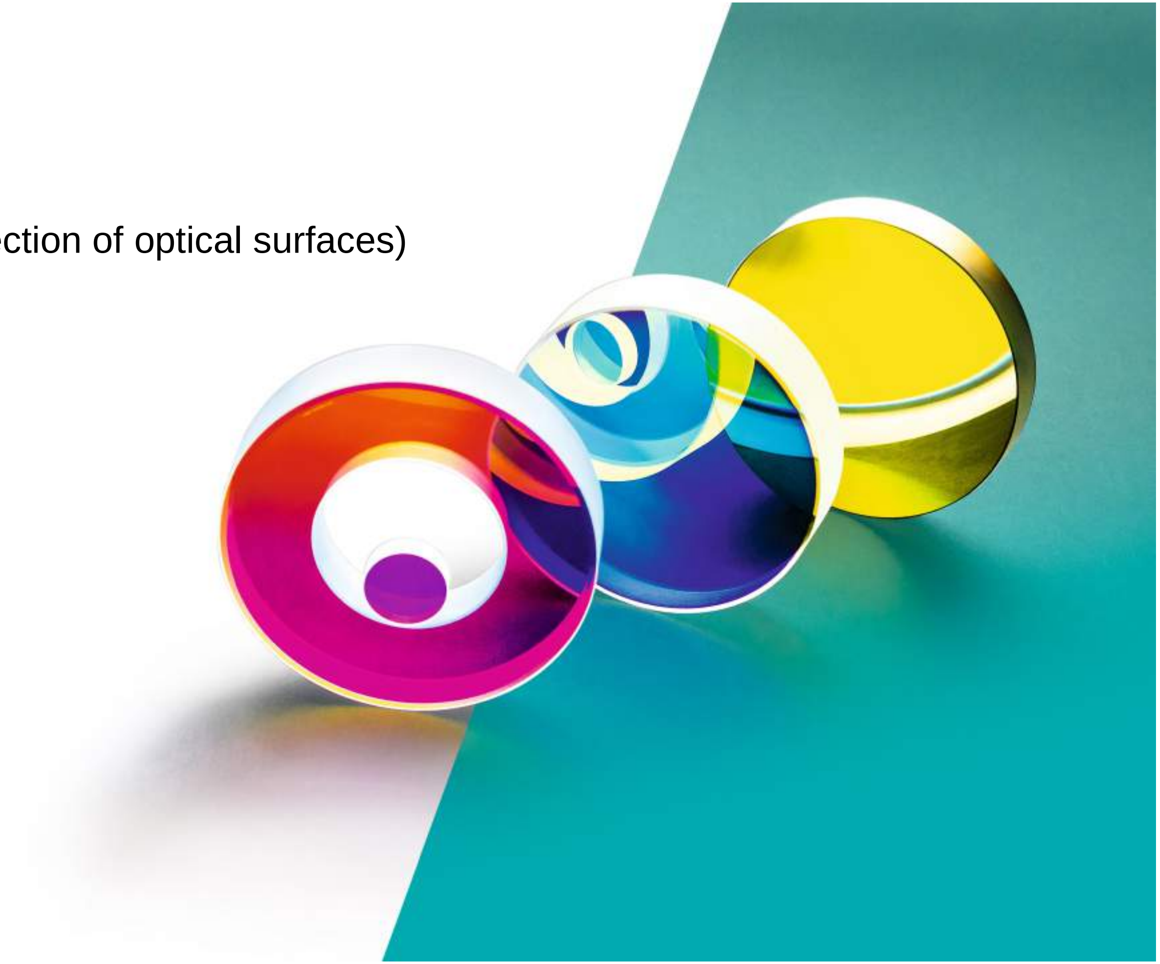
Agenda

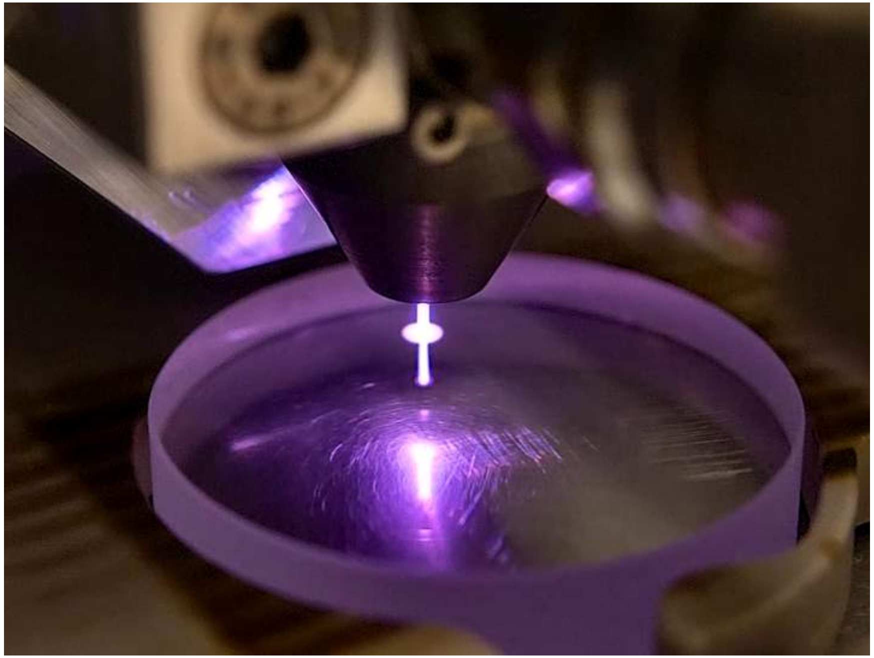
- PICCOS (plasma induced chemical correction of optical surfaces)
  - principle and process characteristics
  - surface profile correction
  - surface profile creation
- lithographically structured layers
  - fabrication technologies
  - mono layer vs. multi layer
  - applications & investigations
 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



PICCOS - plasma induced chemical correction of optical surfaces

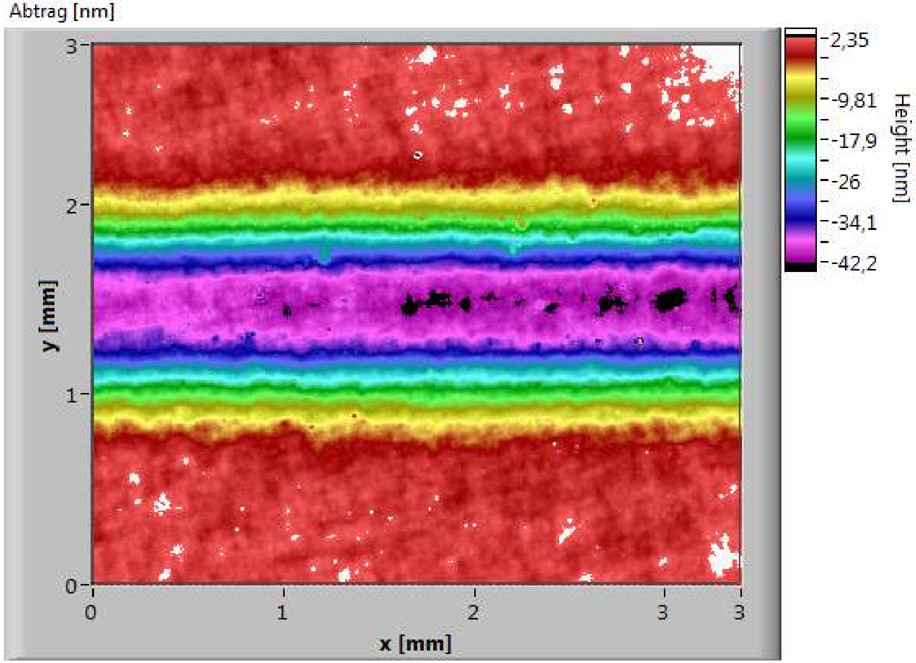
- atmospheric process
- microwave driven plasma
- fluoric plasma – CF_4 gas
- carrier gas Helium
- shielding gas Nitrogen
- material removal given by dwell time

- none contact processing
  - no sub-surface damage creation
  - exposing sub surface damage

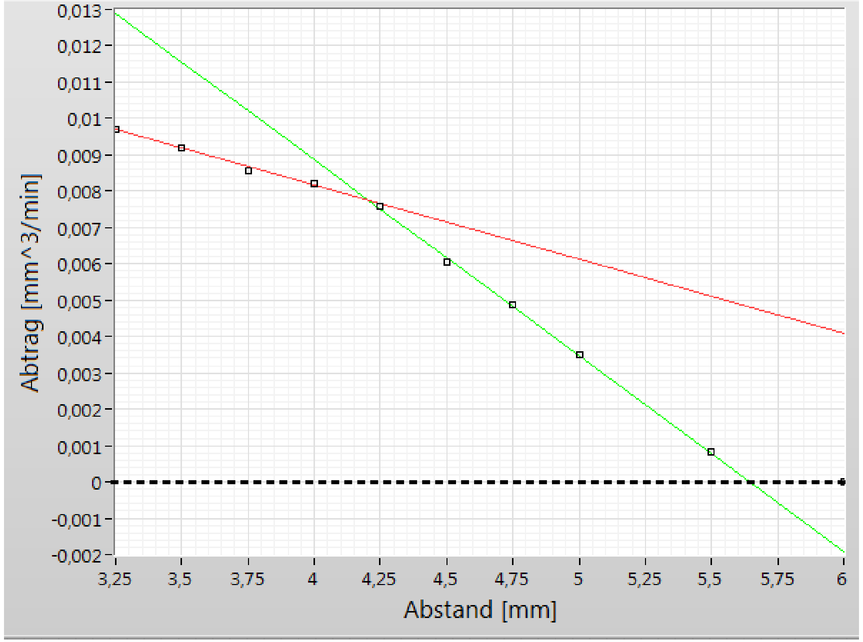


PICCOS - process characteristics

line etching – line width ~1 mm



distance from surface

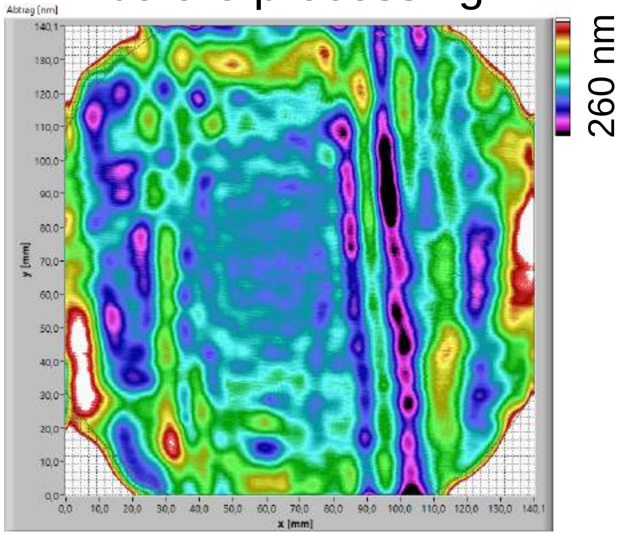


5.31*10^{-3} mm³/min = 5.31*10^{6} µm³/min

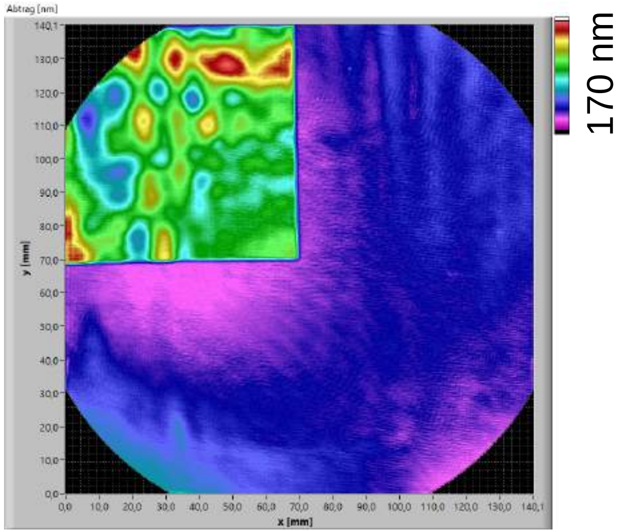
2 etching regimes

PICCOS - application: surface profile correction

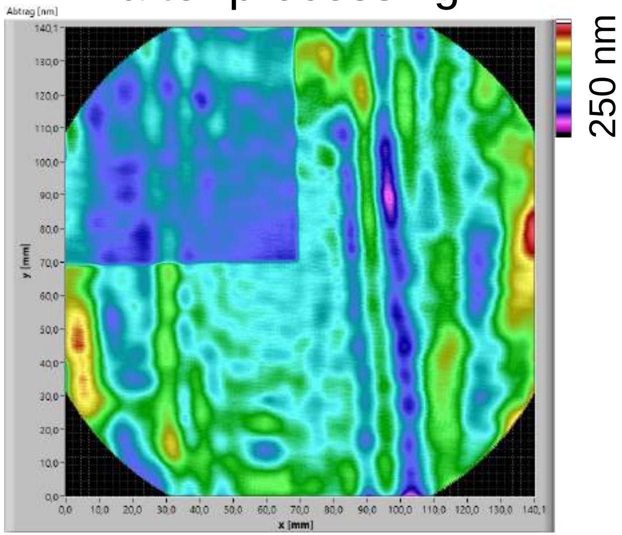
before processing



etch removal



after processing



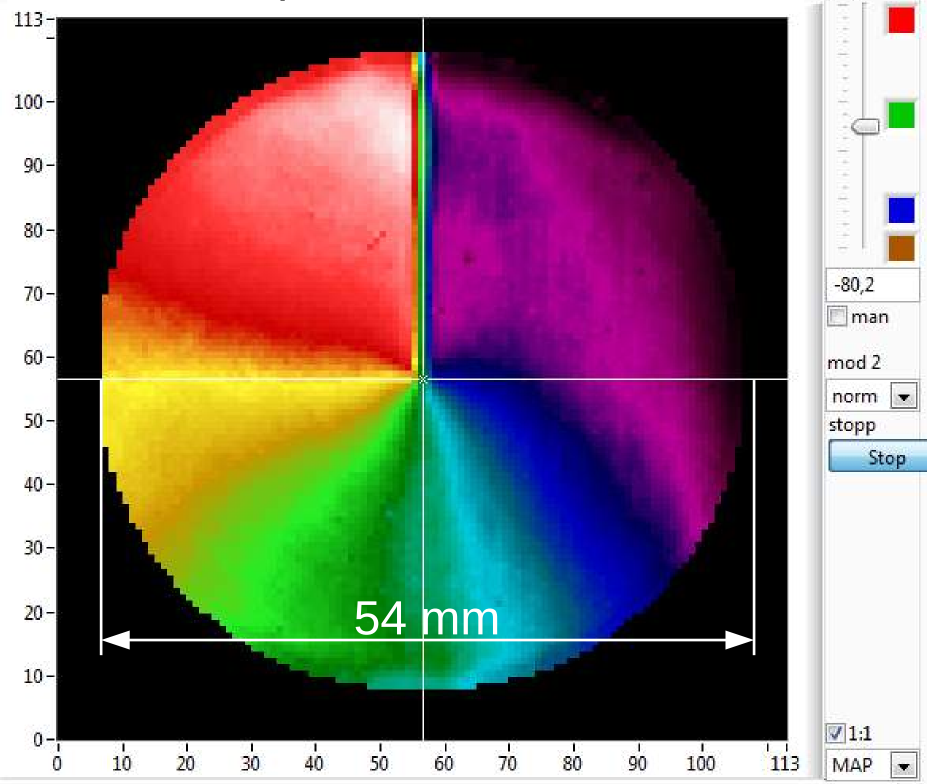
- surface correction with small footprint
- variations of the etching rate
- iterative processing recommended

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

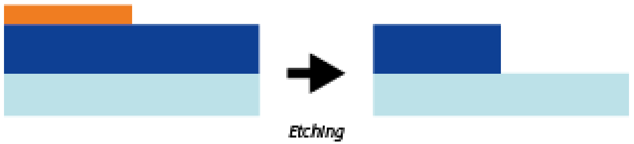
surface profile measurement



lithographically structured layers - fabrication processes

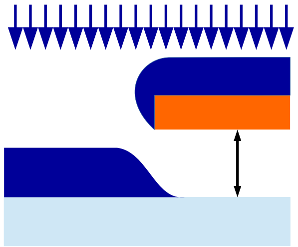
etching vs. aperture coating vs. Lift-Off

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

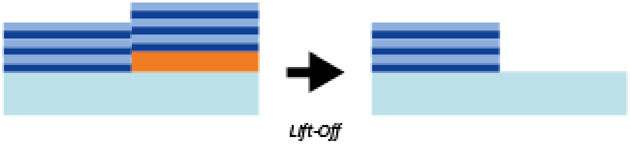


- coating through an aperture
  - width of transitione zone given by coating technology and distance

aperture coating



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

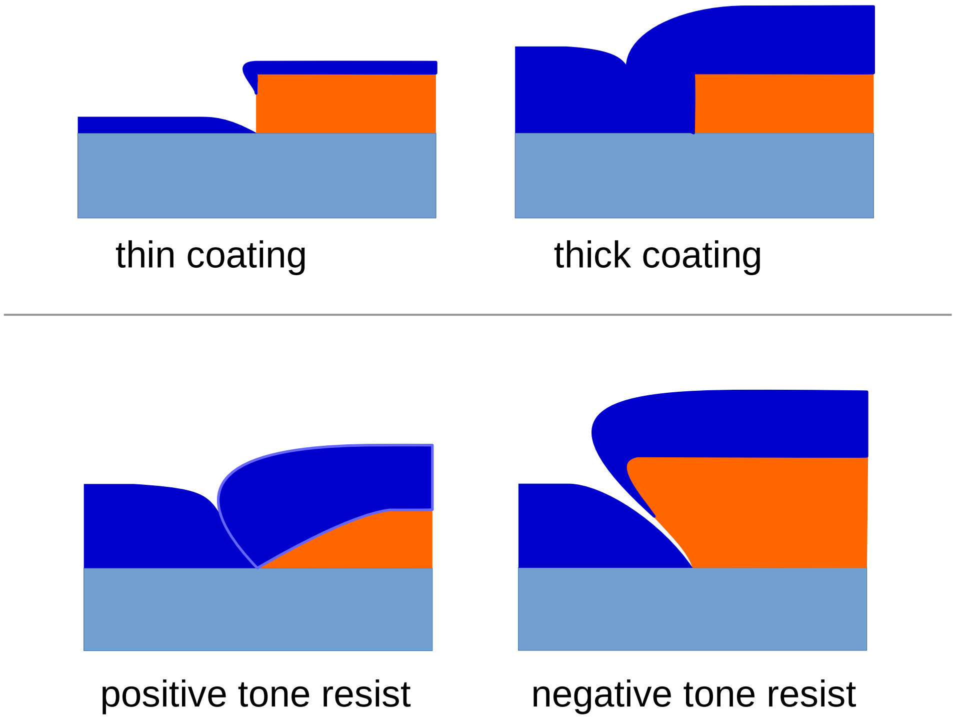


lithographically structured layers - Lift-Off

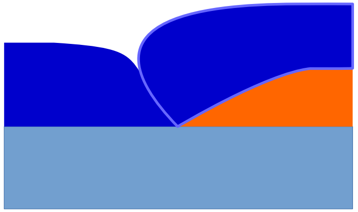
- standard technology for thin (metallic) layers
  - resist height > layer thickness
  - low coating times
  - low heat deposition

- multi layer HR-mirrors
  - more than ~20 layers – stack height of some µm
  - coating times several hours
  - resist blistering, nitrogen out gassing

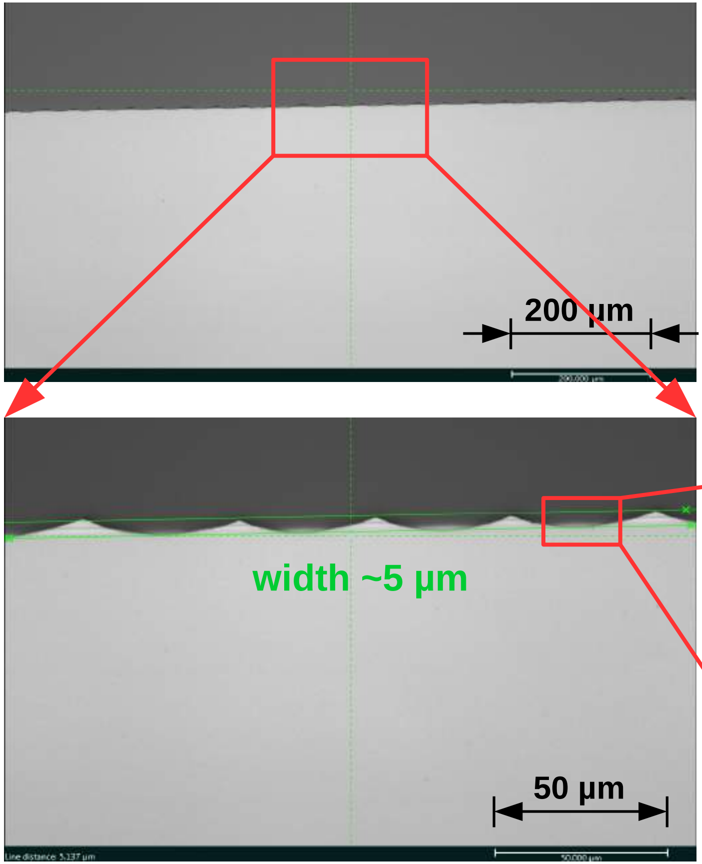
- Lift-Off with adapted resist treatment:
  - thermal treatment for resist hardening
  - standard sputter coating
  - lift-off by chemical solvents
  - different behavior of positive or negative resist

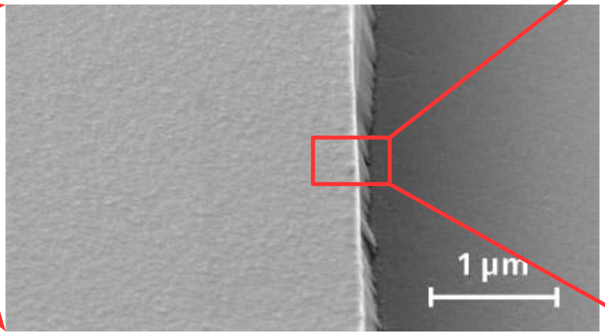


lithographically structured layers

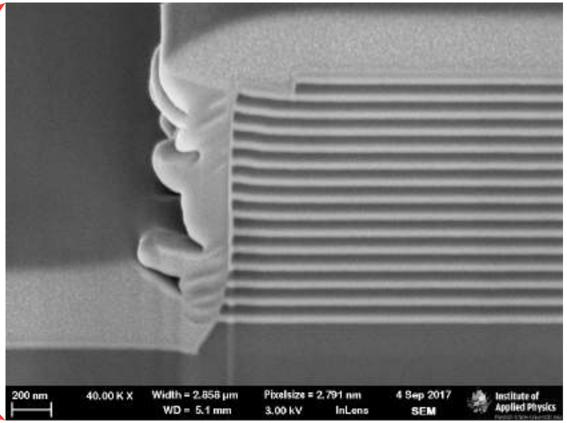


- **positive tone photo resist**
- „predetermined breaking point“
- transition zone in the range of layer thickness
- feature size limited
- no „holes“ in HR-mirrors

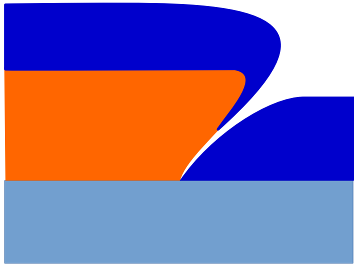




FIB – profile

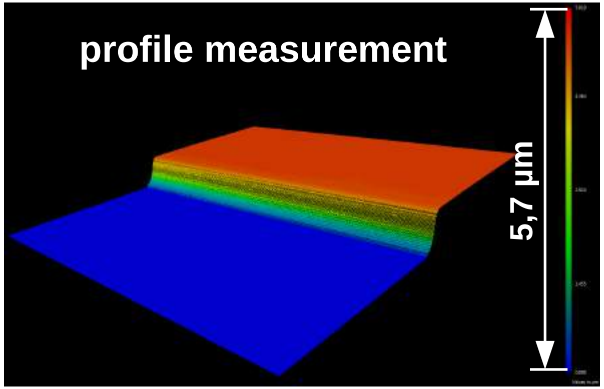


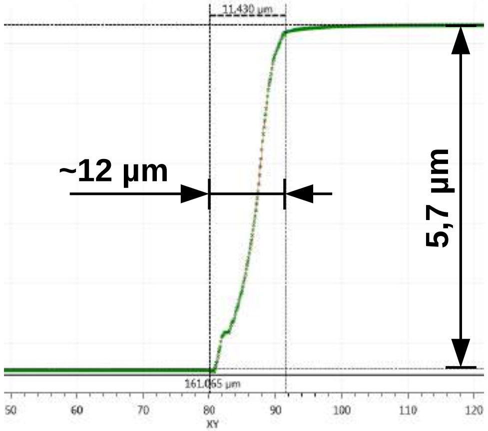
lithographically structured layers



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

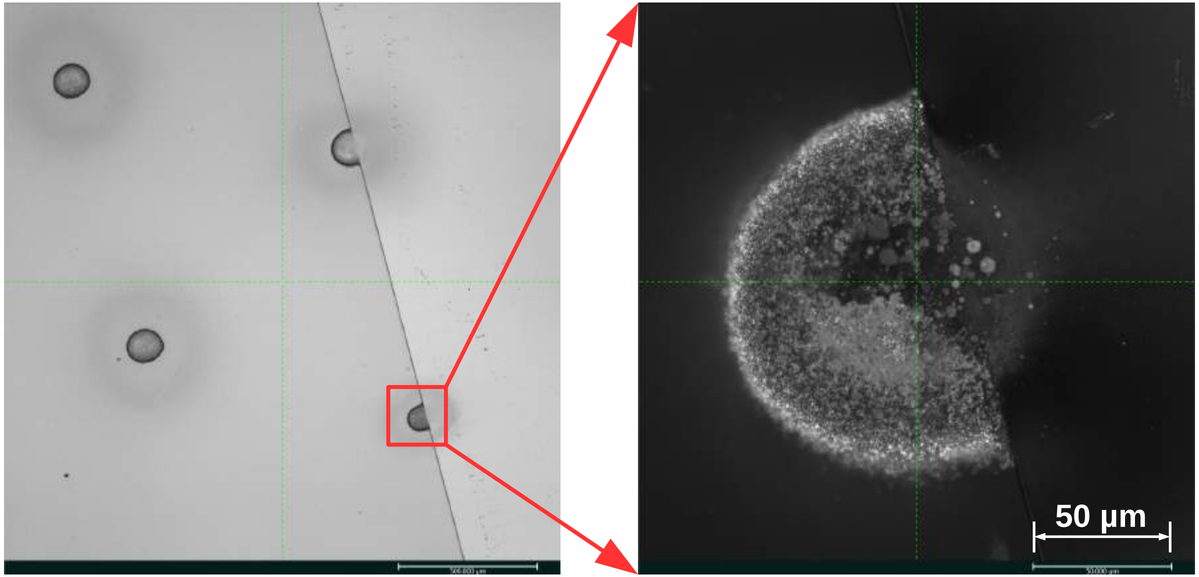
HR500 grating – period 100 µm



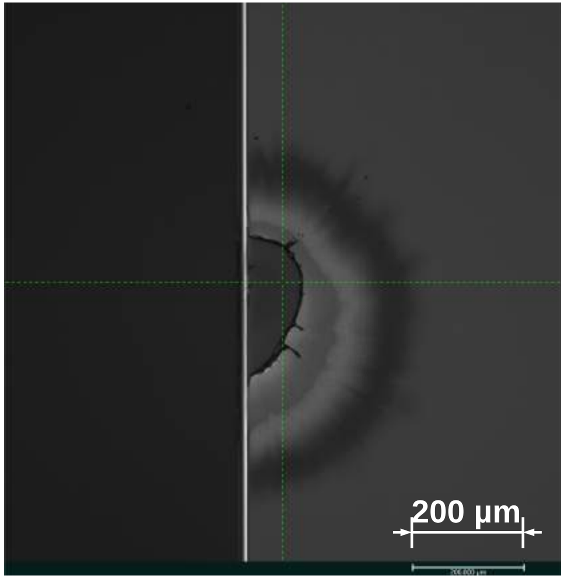


lithographically structured layers – LIDT

- R-on-1 measurement on structured HR mirrors
  - 355 nm, 7 ns, 100 µm beam spot – 7 ± 2 J/cm² (10^5-on-1)
  - 1064 nm, 7 ns, 270 µm beam spot – 255 ± 55 J/cm²

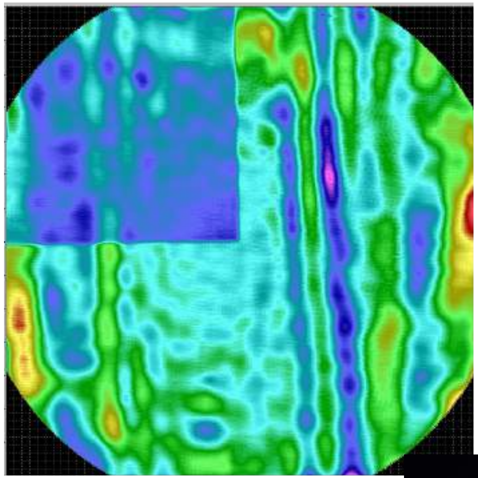


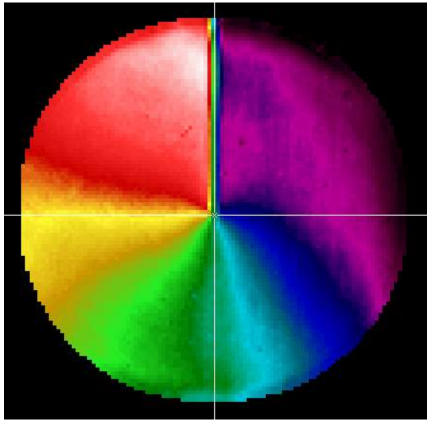
355 nm



1030 nm

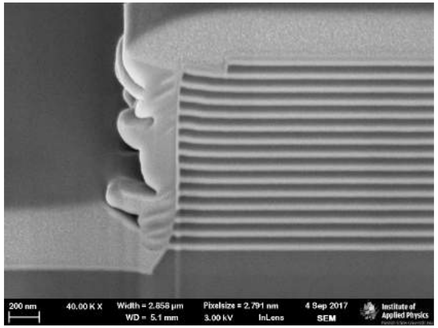
Conclusion

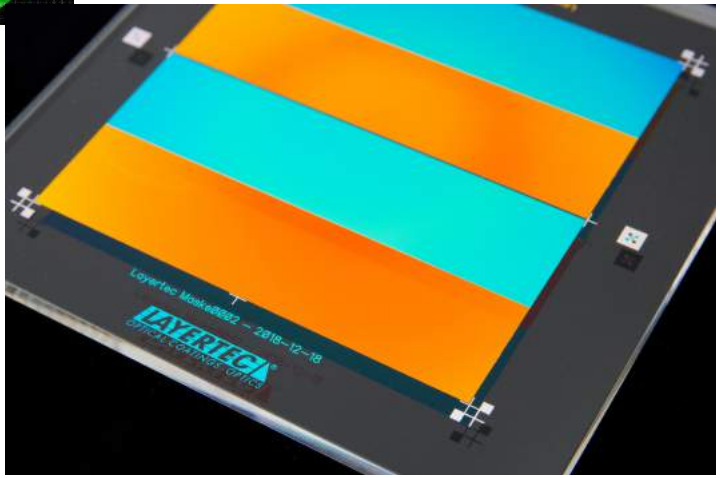




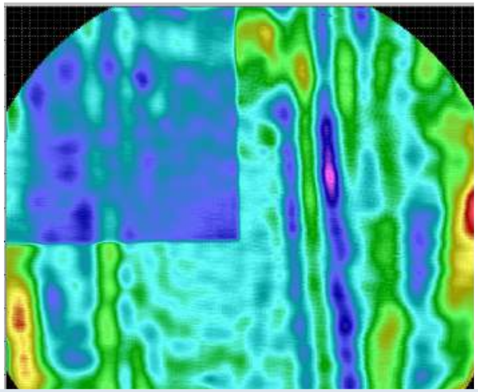
- PICCOS
  - surface profile correction
  - surface profile creation

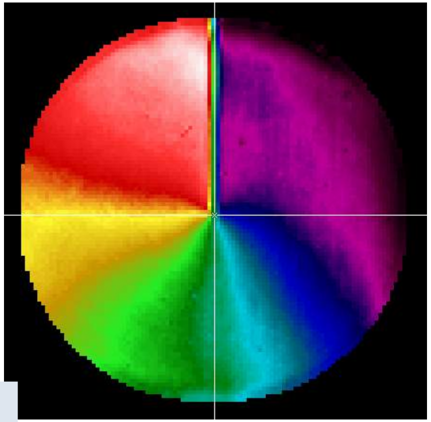
- lithographically structured layers
  - structured HR mirrors
  - LIDT comparable to unstructured mirrors





Conclusion





- PICCOS
  - surface profile correction
  - surface profile creation

thank you for your attention

- lithographically structured layers
  - structured HR mirrors
  - LIDT comparable to unstructured mirrors