3D METROLOGY CONFERENCE

Basque Country, Spain, 2023

Measuring functionally critical nanometre scale surface deflections

- supporting metrology for medical sensor development -

Dr. Istvan Biro

27.09.2023

AGENDA

- Introduction of Heliotis AG & WLI
- Novel EU research projects with WLI:

  metrology for medical implant development

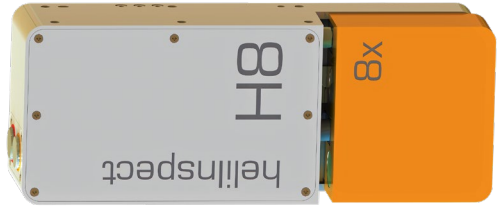
  - Form and deflection measurement
  - Glass laser welding verification
  - Nanometre-sized functional element measurement

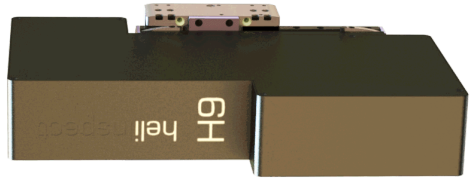
- Q & A

Heliotis - A Strong Partner

Specialized in 3D metrology for precision applications

- designing & building high precision sensors & instruments based on White Light Interferometry





- in-house development, assembly & quality assurance
- in-house research for novel applications & collaborative research projects

Innosuisse

Funded by the European Union

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… what can Heliotis White Light Interferometry do for you?

White Light Interferometry & Other Techniques

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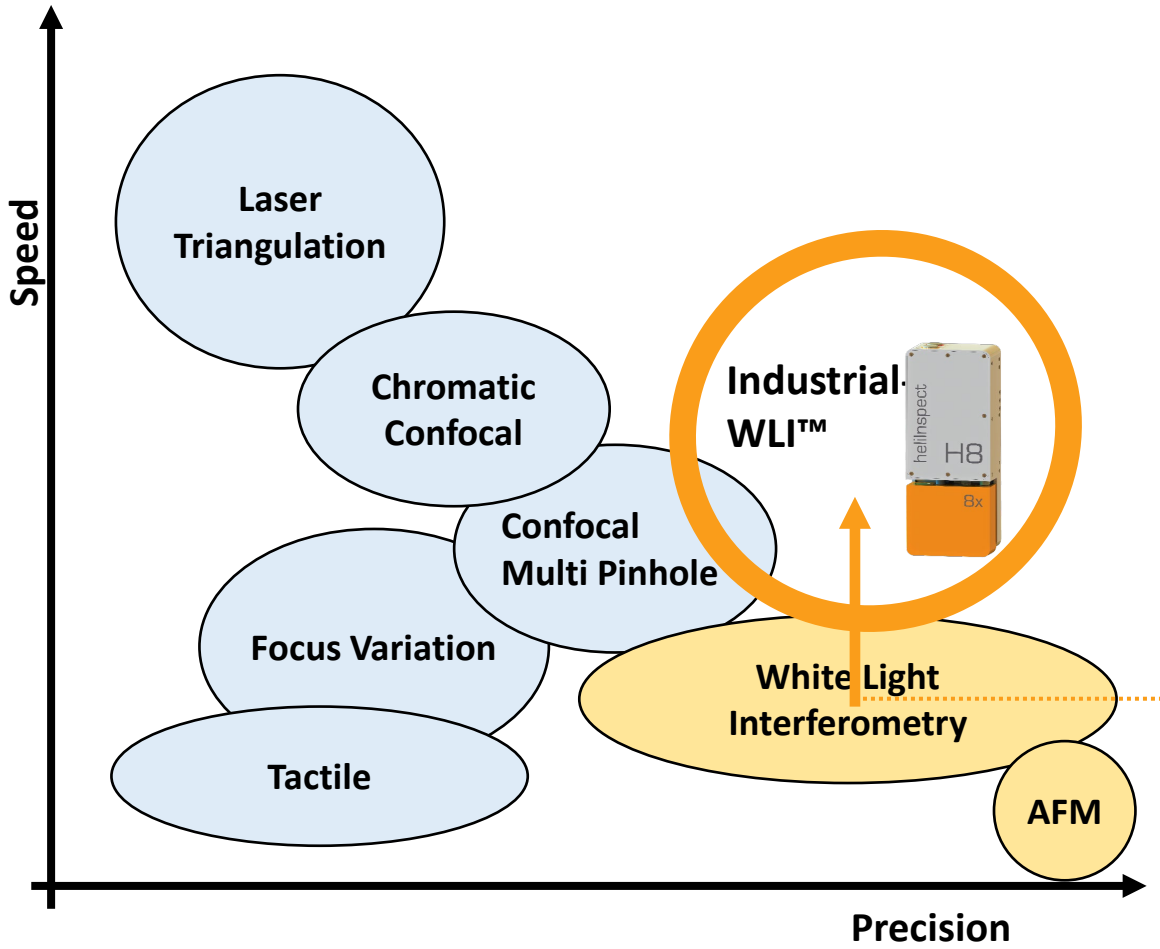
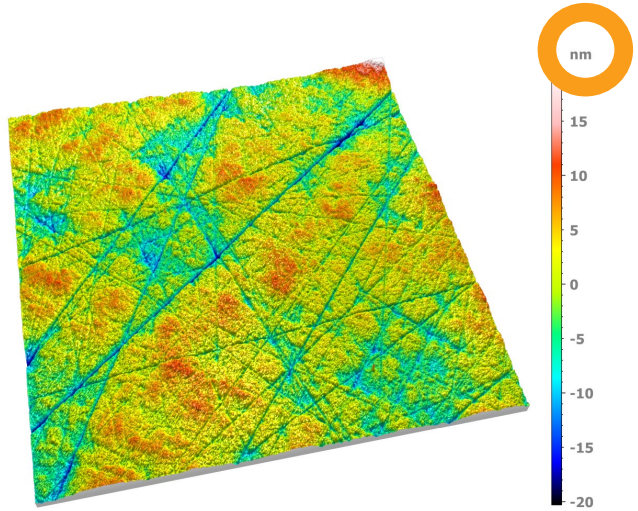
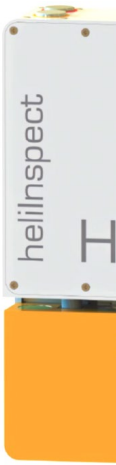
- **non-contact, optical 3D** measurement method
- **nanometer** resolution
- **Up to 100X faster** due to in-pixel processing (Heliotis)







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… what about research ?

MESOMORPH

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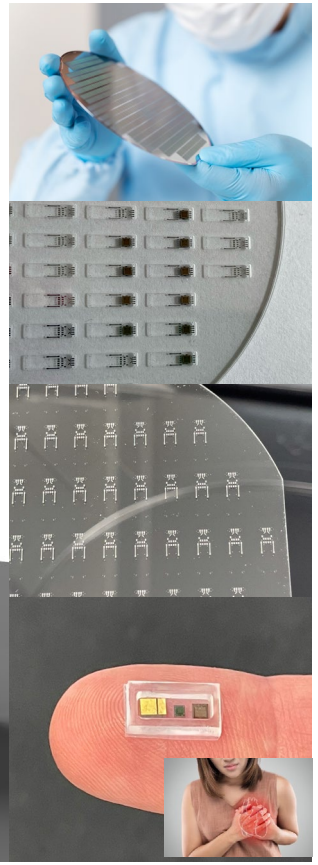
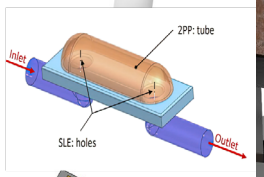
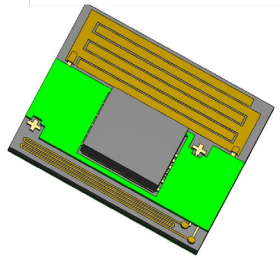
Funded by the European Union
Horizon 2020 - grant No 958417







- new generation of flexible, scalable manufacturing machines for high value and high volume manufacturing
- International, interdisciplinary consortium
- Combining:
  - Femtolaser
  - Two-Photon Polymerization
  - Atomic layer 3D nanoprinting
  - State-of-the-art metrology

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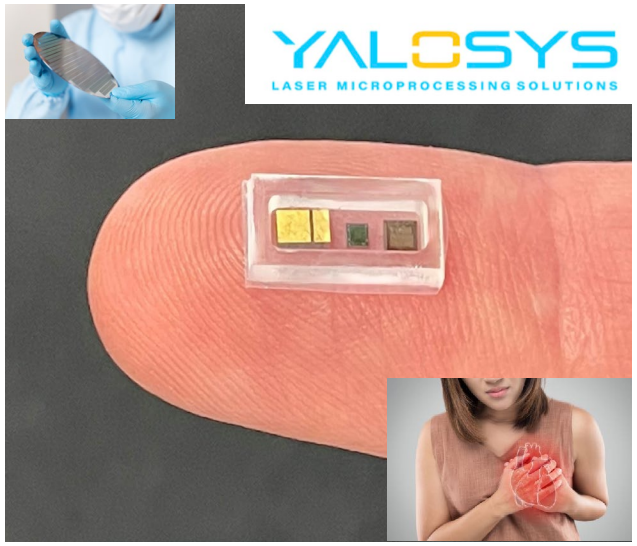
- Challenging use cases
  → this talk: cardiovascular implant

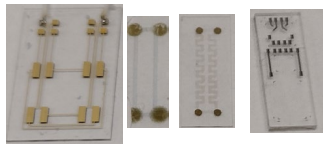
YALOSYS
LASER MICROPROCESSING SOLUTIONS

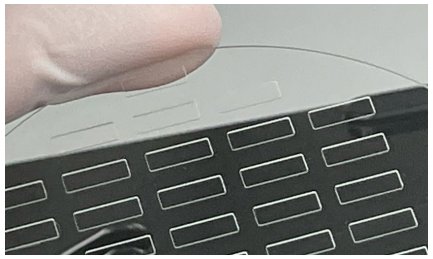
Prima Electro · SUPSI · IRIS PLAYGROUND FOR NEW IDEAS · heliotis advancing 3D metrology · YALOSYS LASER MICROPROCESSING SOLUTIONS · MCH TRONICS

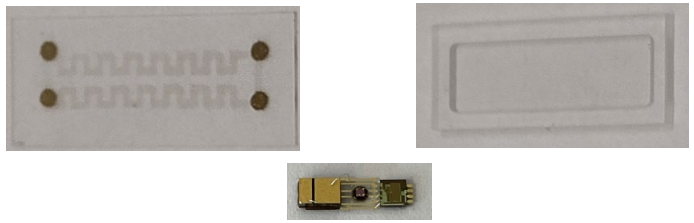
ATLANT 3D NANOSYSTEMS · OPIPHOTONICS · POLITECNICO DI TORINO · FAU FRIEDRICH-ALEXANDER UNIVERSITÄT ERLANGEN-NÜRNBERG · MORPHICA · CTFM Chemistry of Thin Film Materials · femtika · ST

Cardiovascular sensor





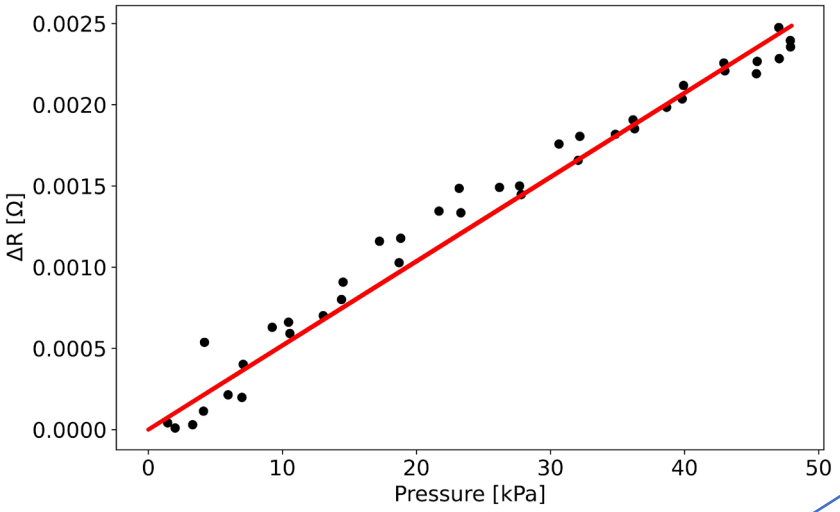


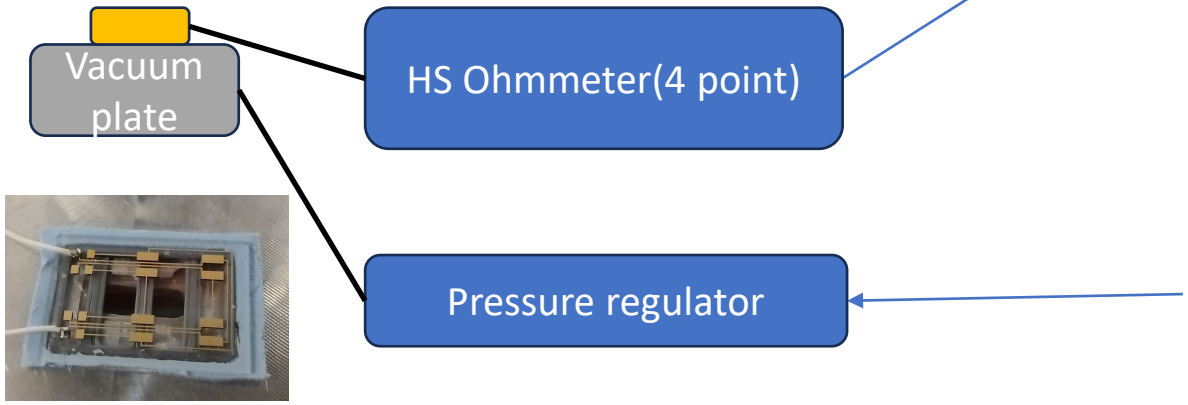


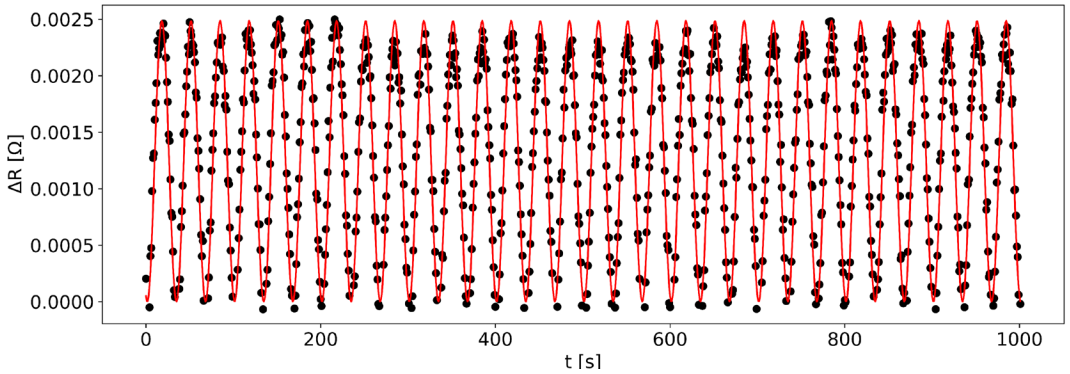
- Pressure monitoring implant
- Detection:
  - Glass membrane pressure deflection
  - Resistive sensing: atomic layer deposited nano-wire deflection
- Glass welding for sealing

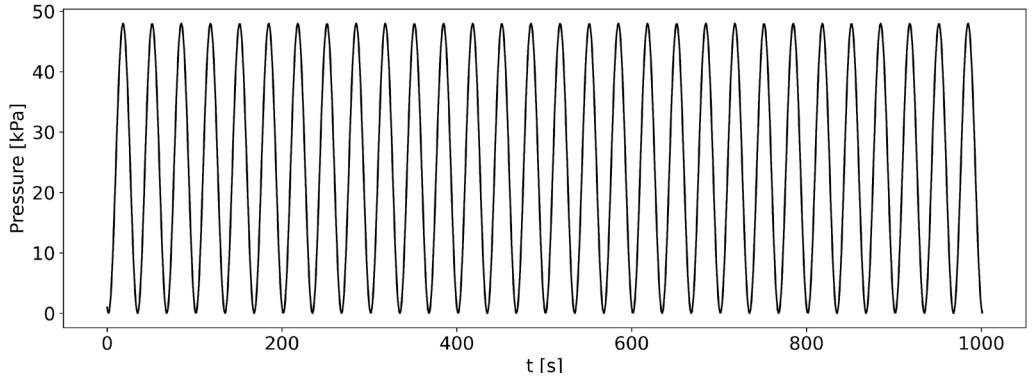
- Metrology: development & testing validation
  - New material / concept (behaviour?) → Deflection - pressure - resistance verification
  - Performance / safety → Glass welding verification
  - New process → surface deflection measurement for correct SADALP deposition
  - New process → SADALP nm thin wire verification (height, errors?)

Proof-of-concept: pressure-deflection-resistivity

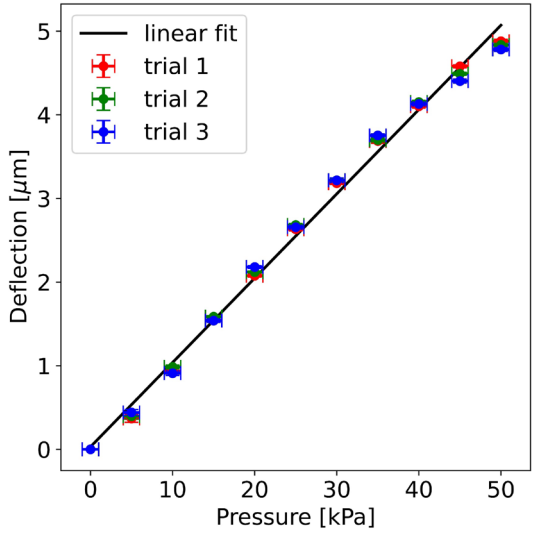




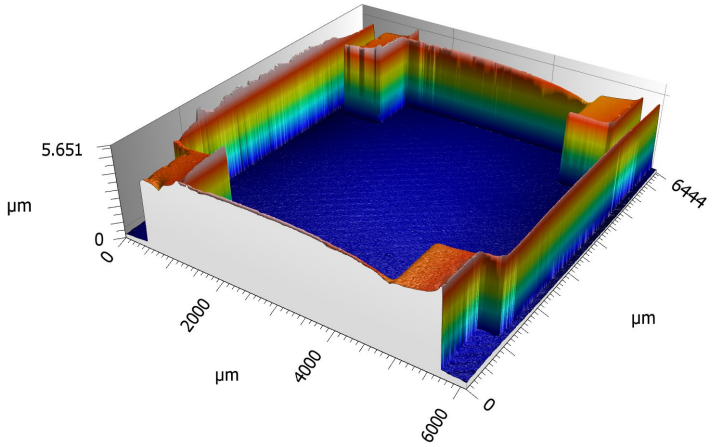




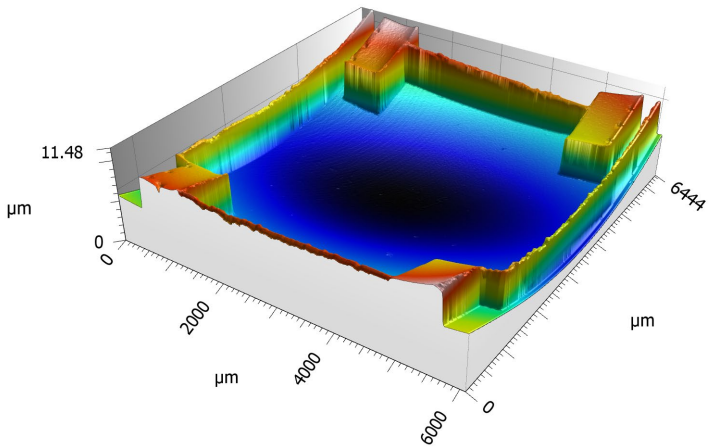
Proof-of-concept: pressure-deflection-resistivitv

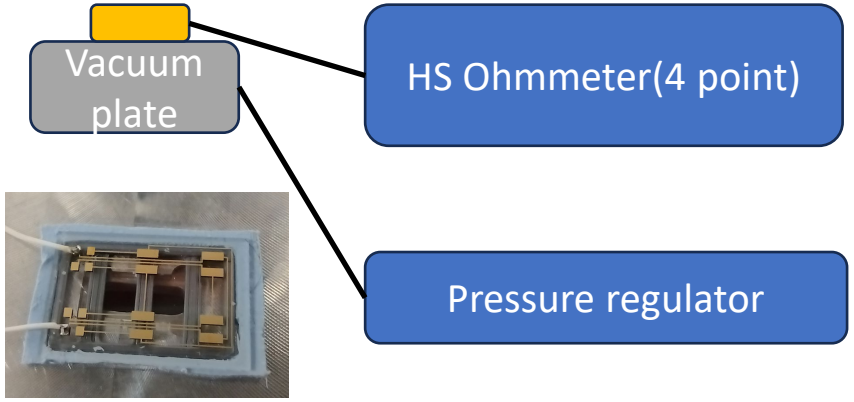


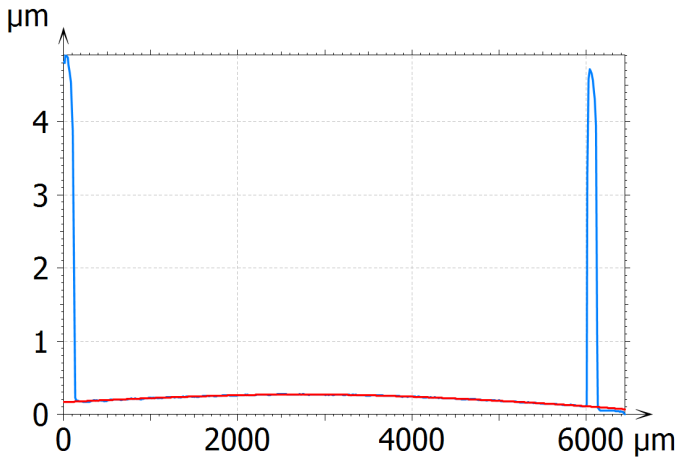
0kPa → natural shape

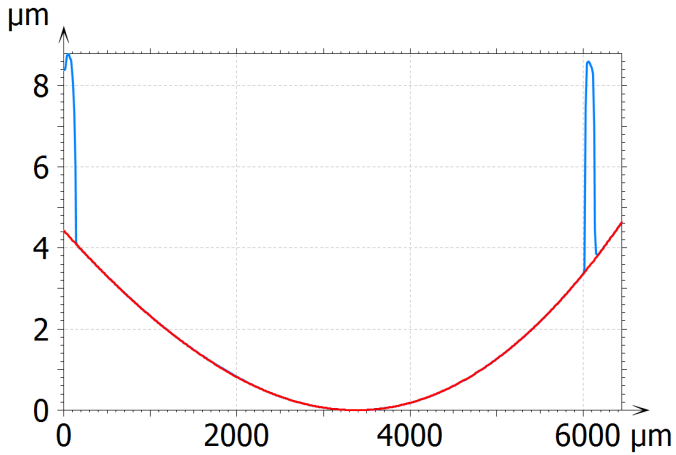


50kPa

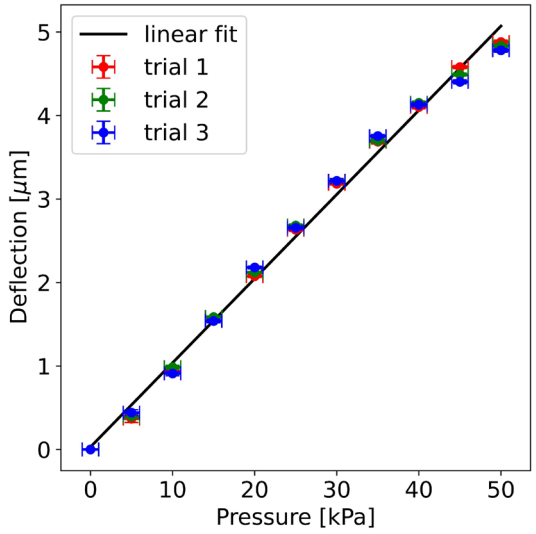


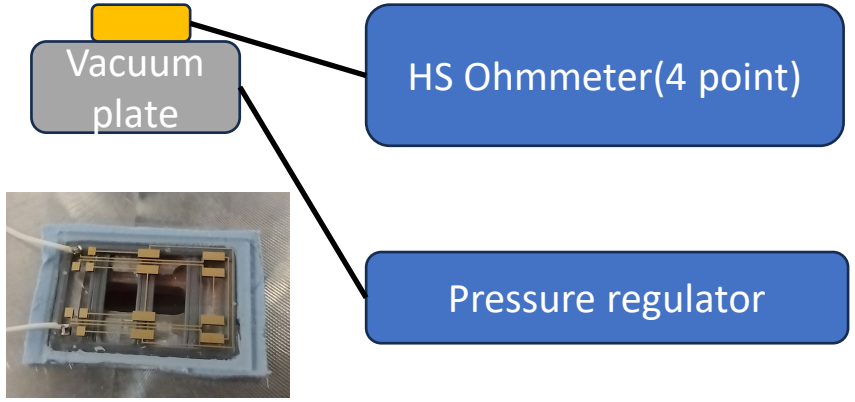


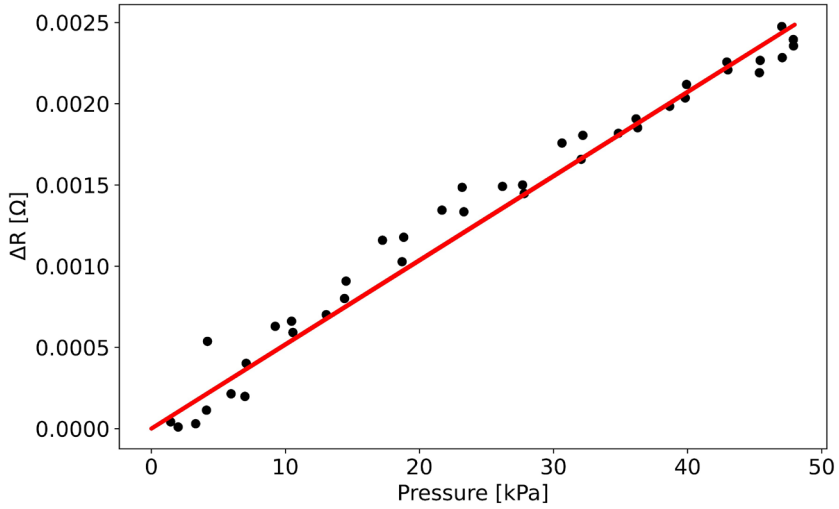




Proof-of-concept: pressure-deflection-resistivity







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… the details: metrology-guided development and quality assurance

Surface deflection: how to mount glass membrane?

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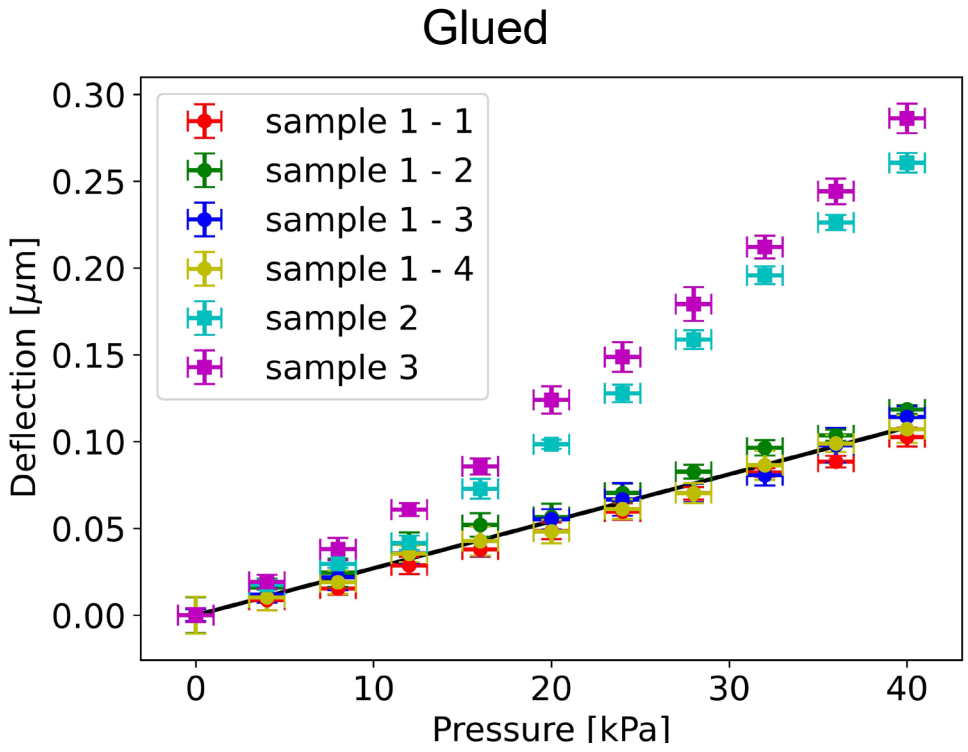
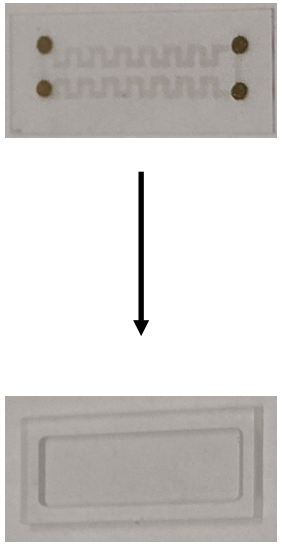
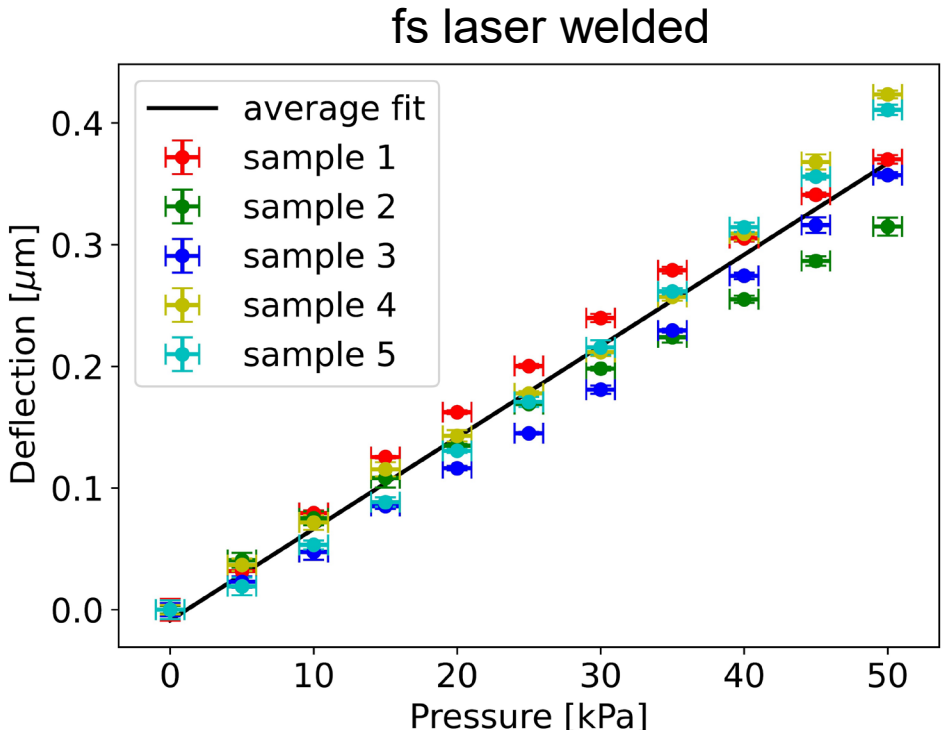
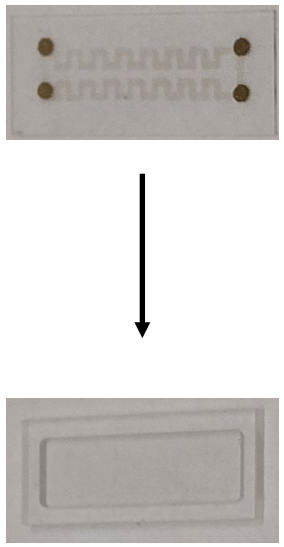




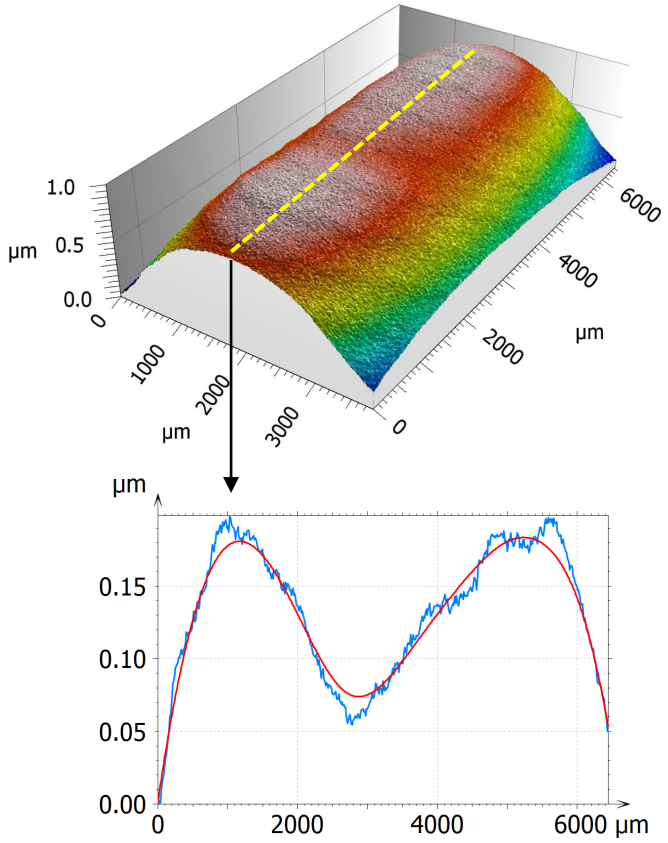


- Glued glass membrane deflects very reproducibly – but sample variation is huge
- Welded glass membranes are much better controllable (consistency)

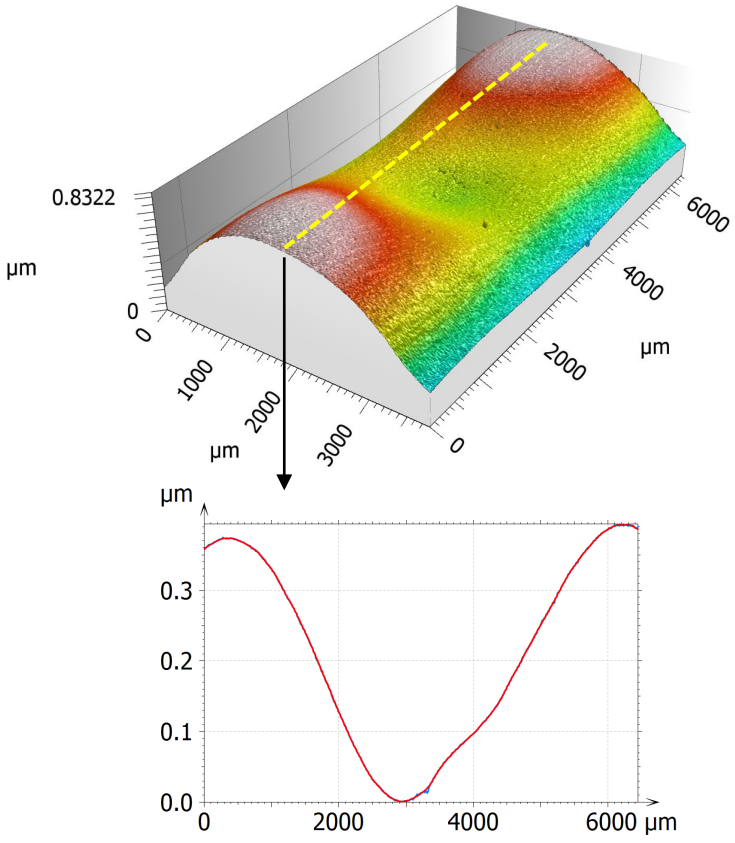
Surface deflection: how to mount glass membrane?



NO pressure → natural form

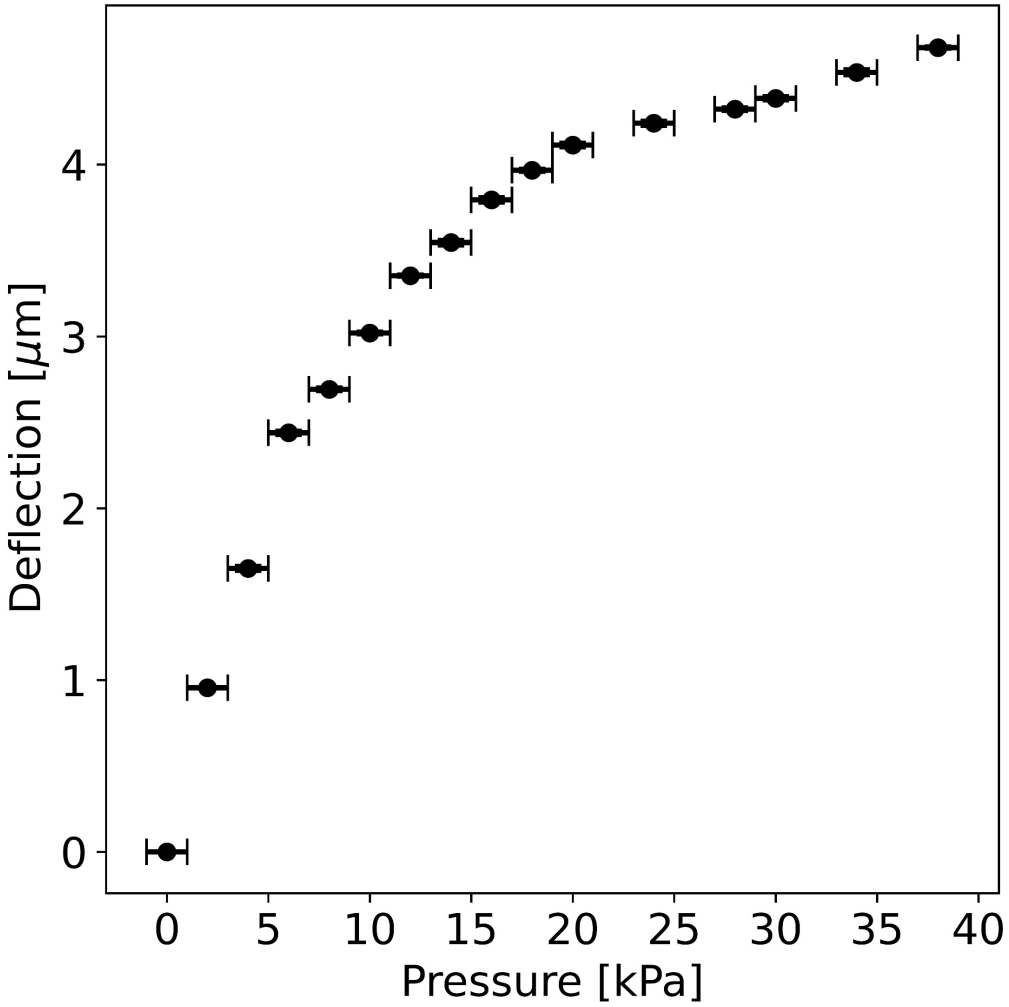


50kPa pressure



- Glass welding may induce stress, resulting in non-flat surfaces at 0 pressure
- This form has an impact on bending amount and location → need to control welding process

Weld sealing inspection – 1st method: deflection



- Leaks are indicated by non-linear deflection-response

Weld sealing inspection – 2nd method: tomography – or simply signal strength

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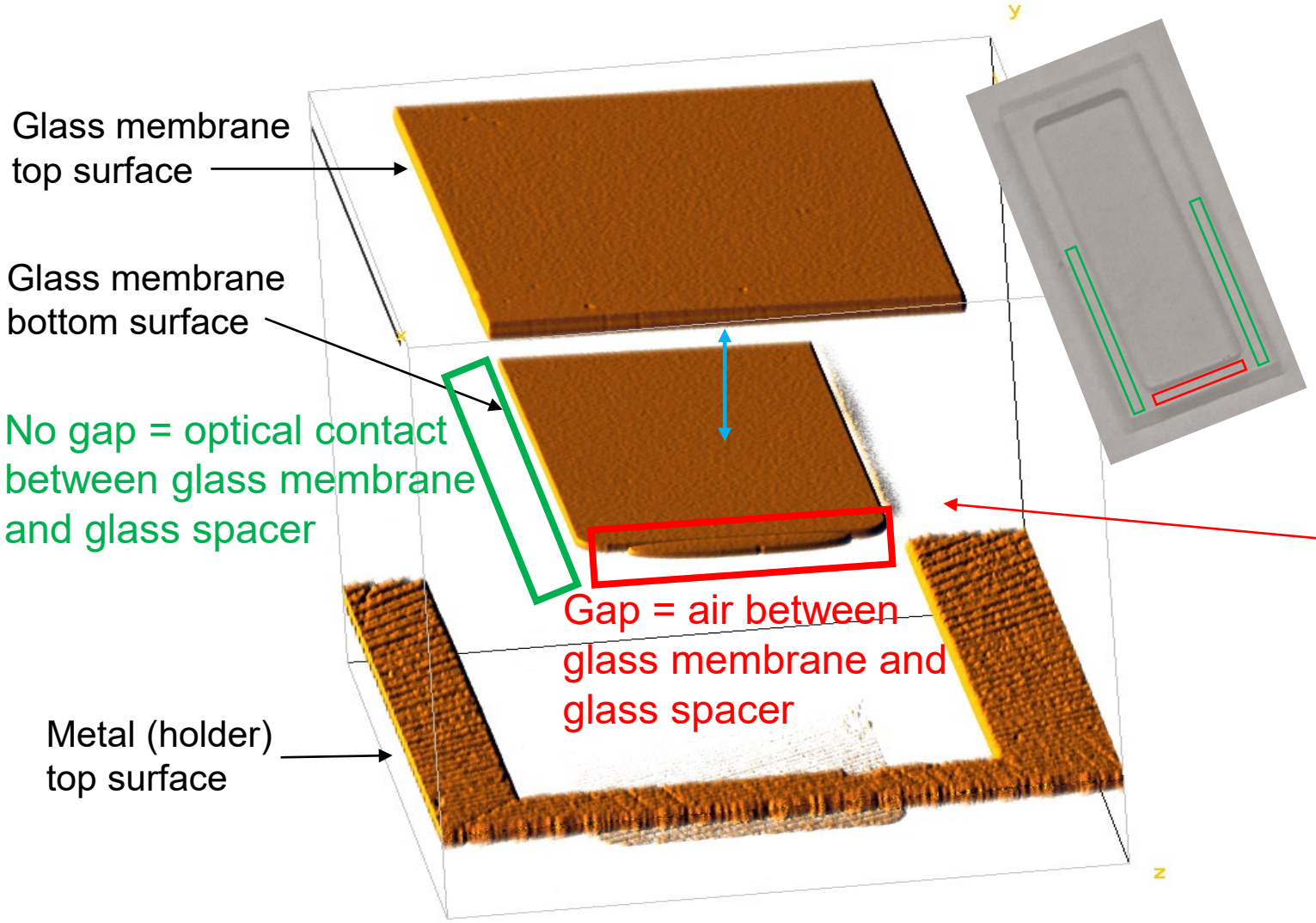
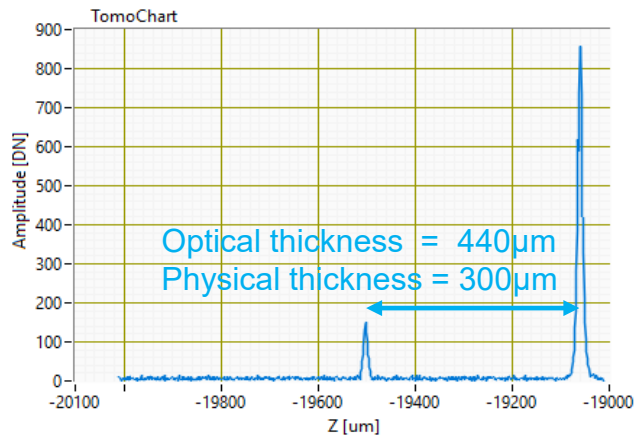


- WLI is tomographic:
  - Measure inside transparent material
  - Detect surfaces : **where optical index changes → reflections**
  - Measure thickness (e.g., glass slice)

→ Detect air gaps



Weld sealing inspection – 2nd method: tomography – or simply signal strength

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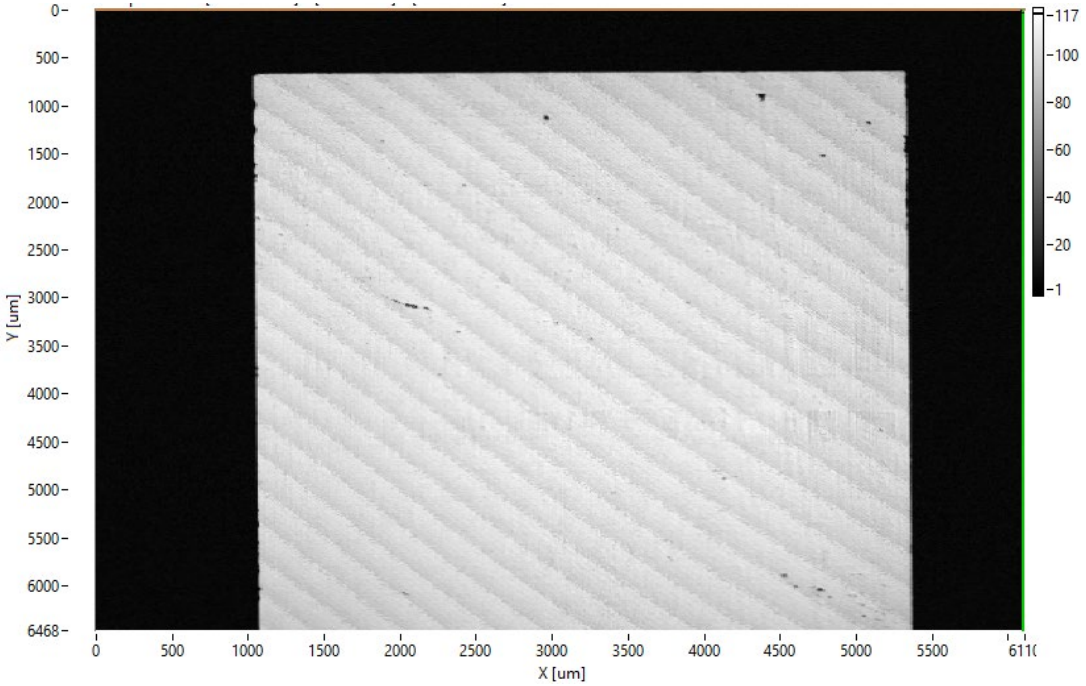
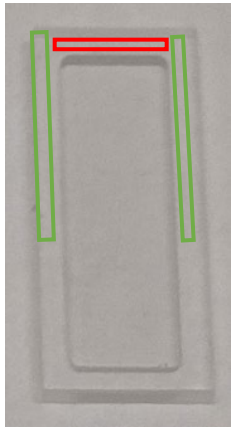
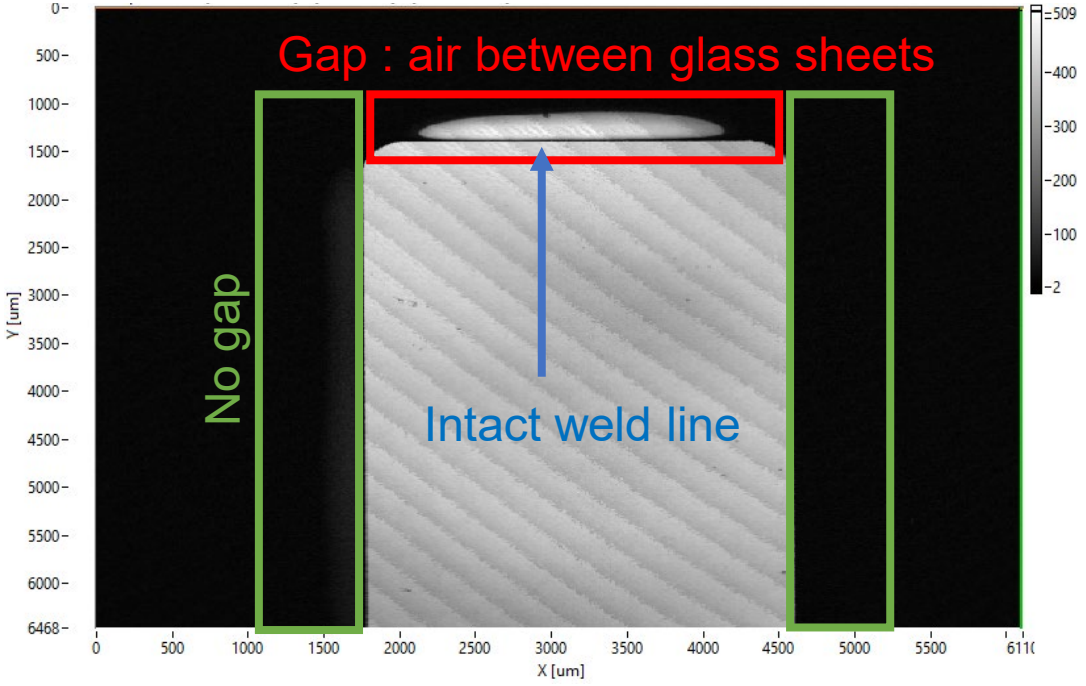
Top glass membrane surface





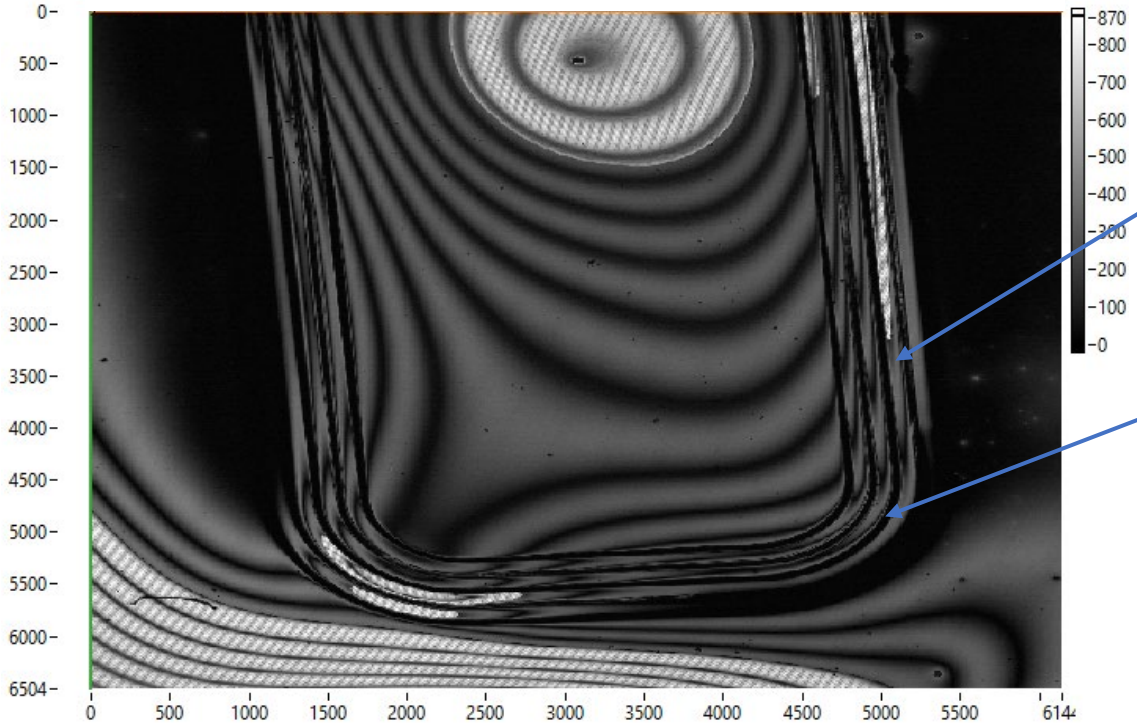
Bottom glass membrane surface, interface between glass sheets



- Simple detection of **nm** gaps from signal intensity (interference contrast) at optical interfaces

Weld sealing inspection – 2nd method: tomography – or simply signal strength

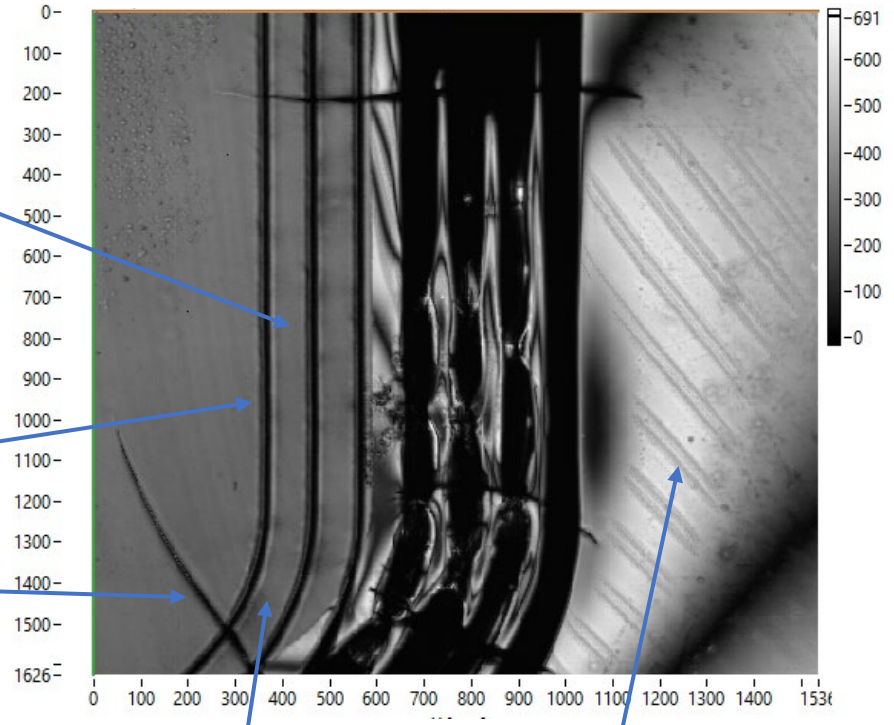
Two fs-laser welded glass sheets



several weld lines

Good weld (optical contact)

stress-crack

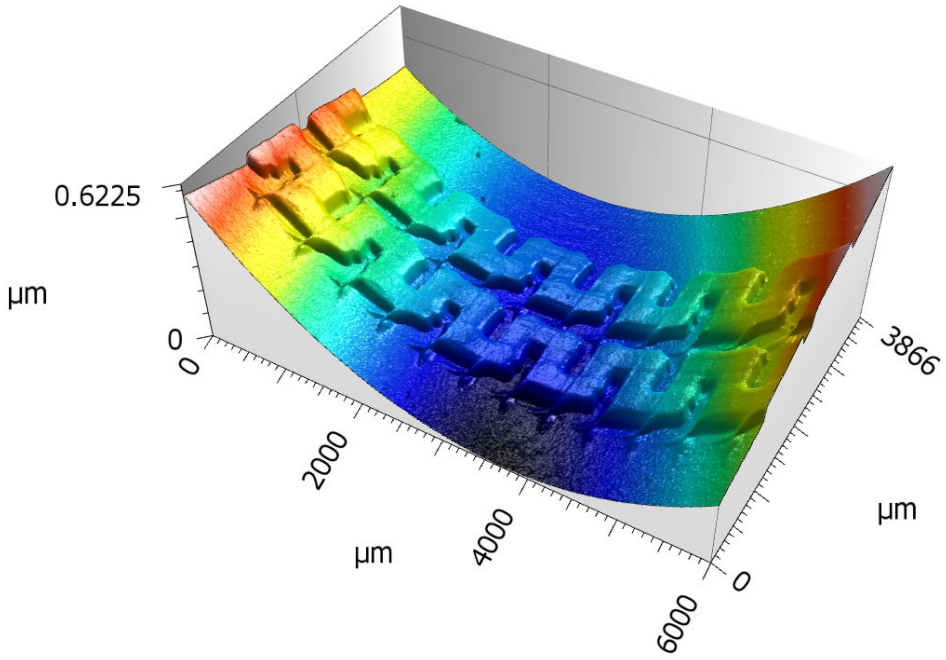


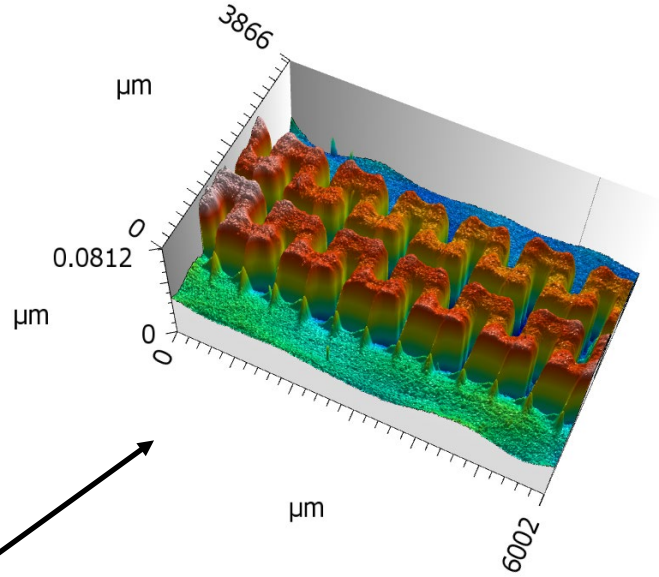
Narrow air gap

Wide air gap

- Gaps and weld defects can be detected

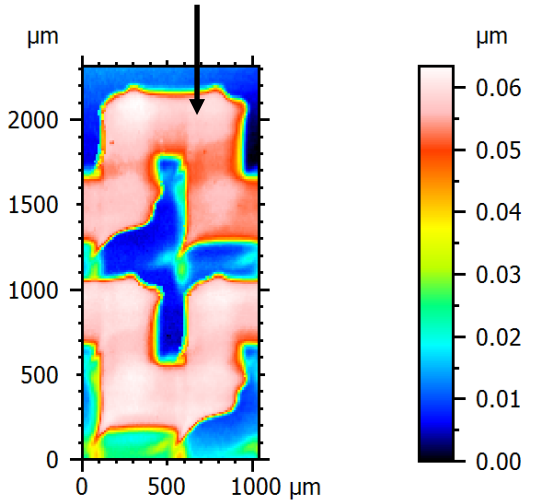
How about the ultra-thin “wire”?

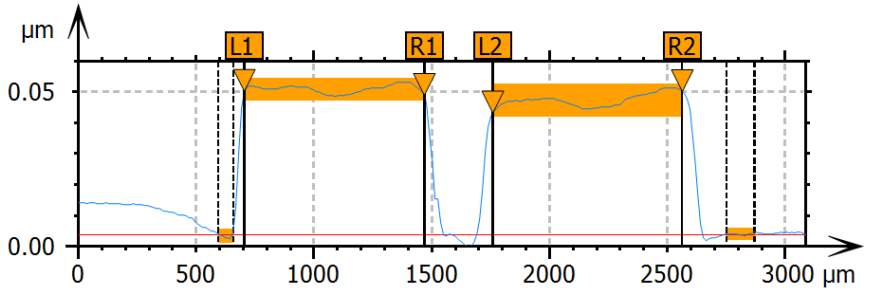




Form removal

few nm height variation

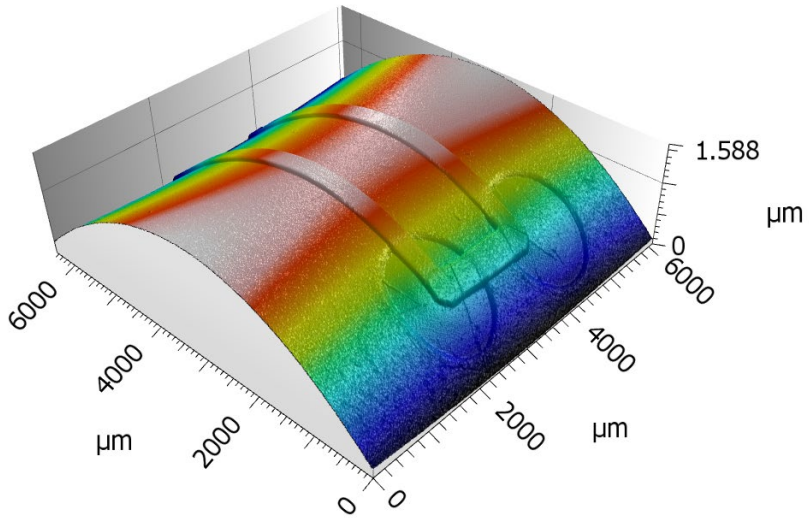




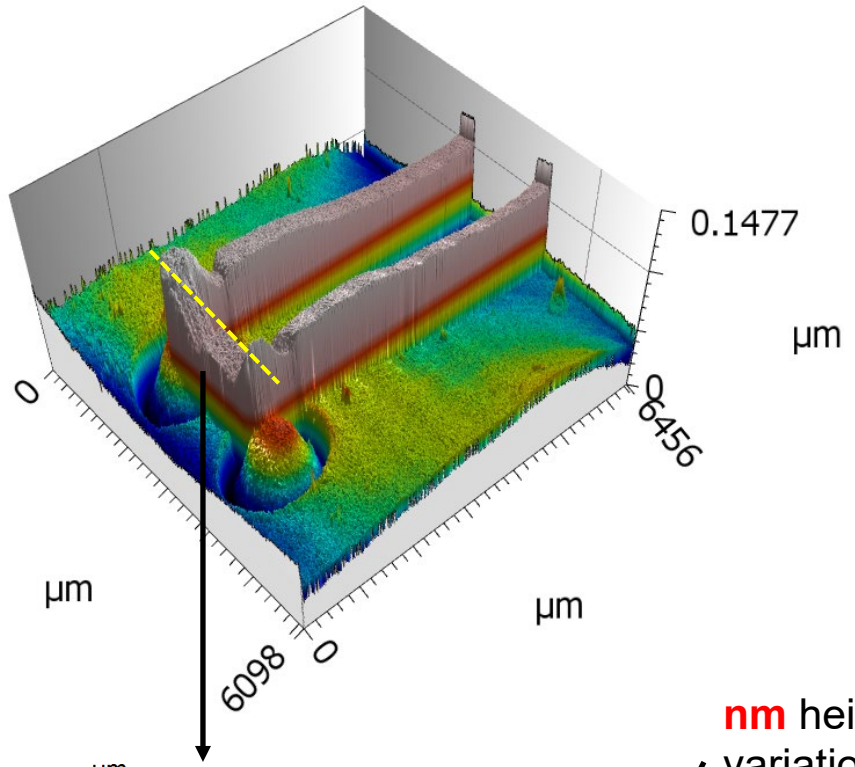
Parameters	Unit	Mean	Step 1	Step 2	
Width	µm	804.0	786.4	821.6	
Mean height	µm	0.04545	0.04727	0.04362	**Nominal: 50nm**

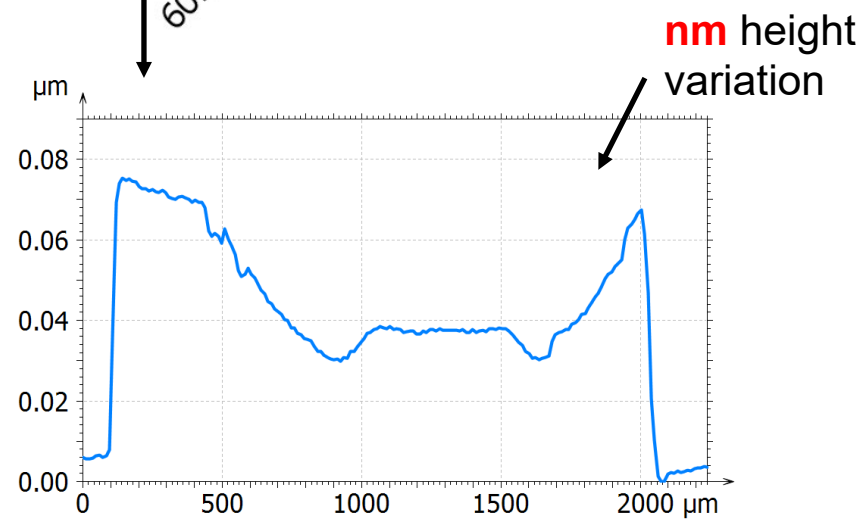
- **Few 10nm** thin TiO_2 (on glass) lines can be measured
- Uniformity can be verified, defects/cracks spotted

How about the ultra-thin “wire”?



Form removal



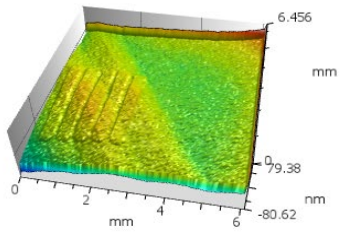


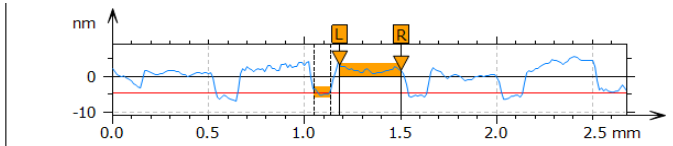
- **Few 10nm** thin TiO_2 (on glass) lines can be measured
- Uniformity can be verified, defects/cracks spotted

Ultra-thin “wire”? Capability verification

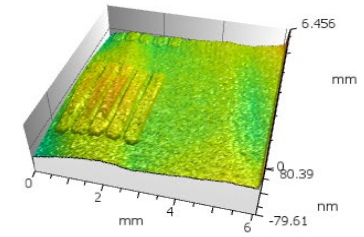
ATLANT : TiO_2 lines on glass, range 1-7nm

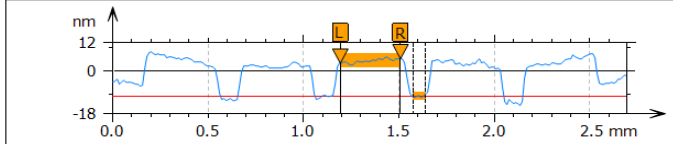
Heliotis WLI



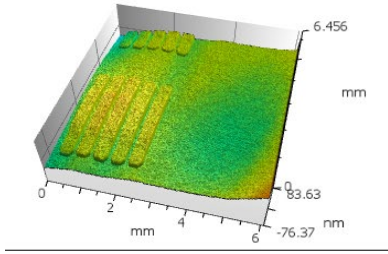


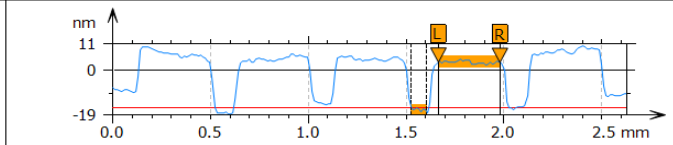
Parameters	Step 1	Unit	
Width	mm	0.3318	
Maximum height	nm	8.607	→ WLI measured (compensated)=1.59nm ;
Mean height	nm	6.370	→ Nominal=1.75nm



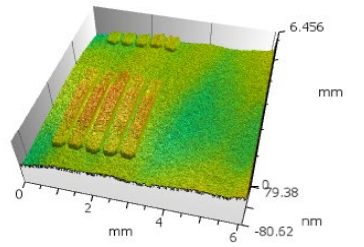


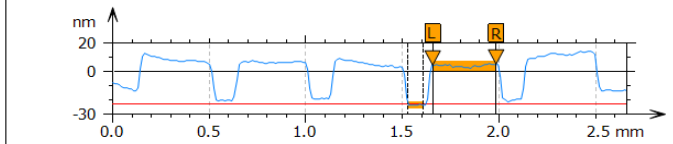
Parameters	Step 1	Unit	
Width	mm	0.3324	
Maximum height	nm	16.83	→ WLI measured (compensated)=3.87nm ;
Mean height	nm	14.97	→ Nominal=3.5nm





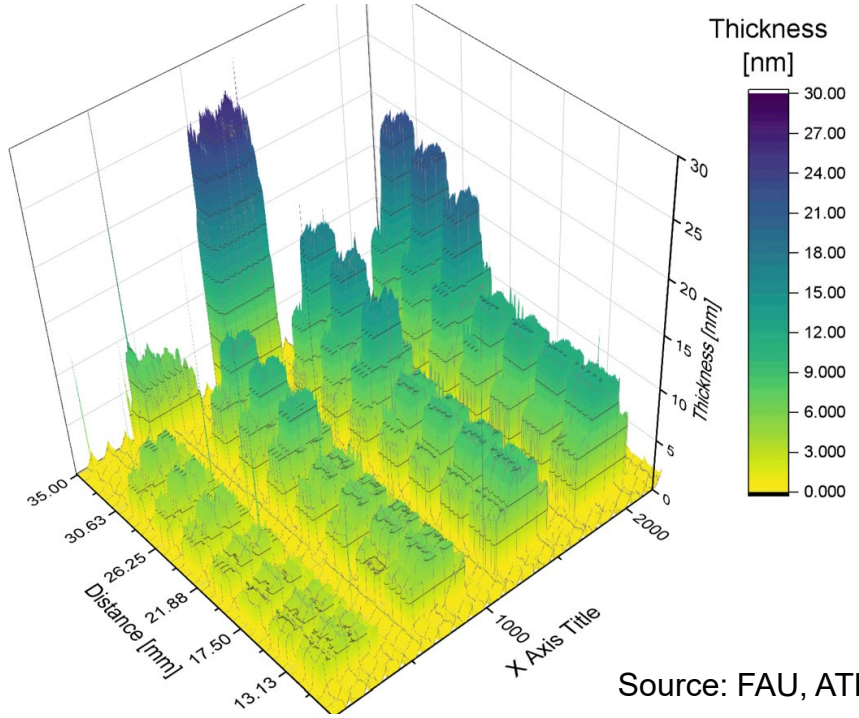
Parameters	Step 1	Unit	
Width	mm	0.3314	
Maximum height	nm	20.62	→ WLI measured (compensated)=5nm ;
Mean height	nm	19.22	→ Nominal=5.25nm





Parameters	Step 1	Unit	
Width	mm	0.3446	
Maximum height	nm	28.51	→ WLI measured (compensated)=7.08nm ;
Mean height	nm	27.11	→ Nominal=7nm

Ellipsometry



Source: FAU, ATLANT

- Few **nm** thin lines can be measured
- Ellipsometry-confirmed

How to (electrically) probe such wire? → how to measure resistance?

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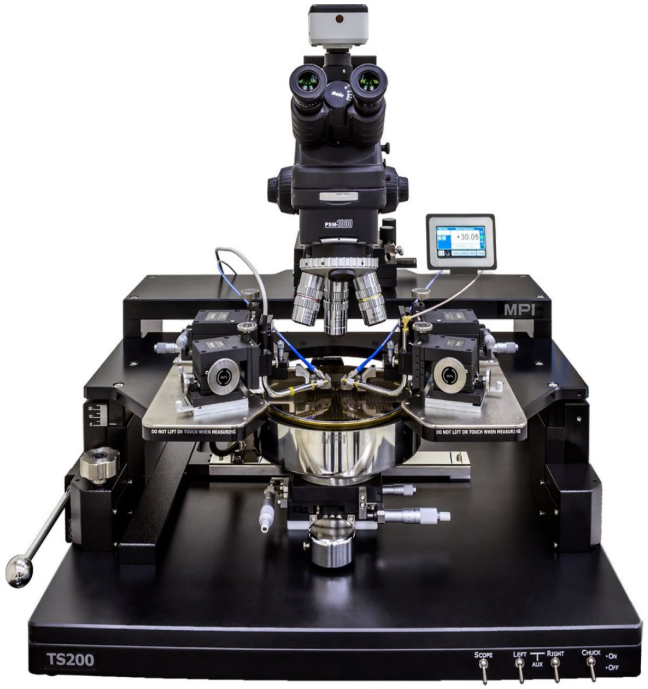
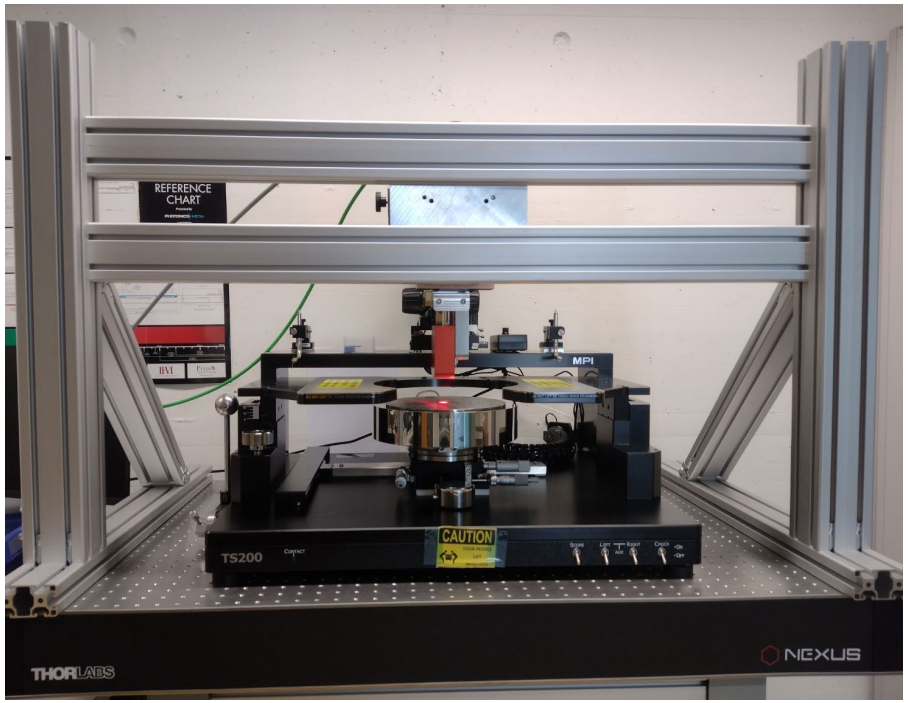
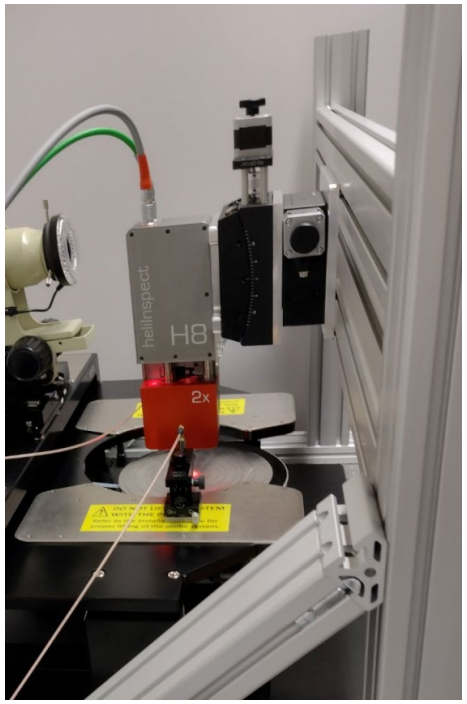
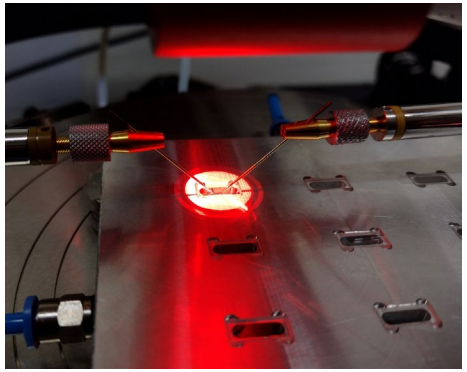


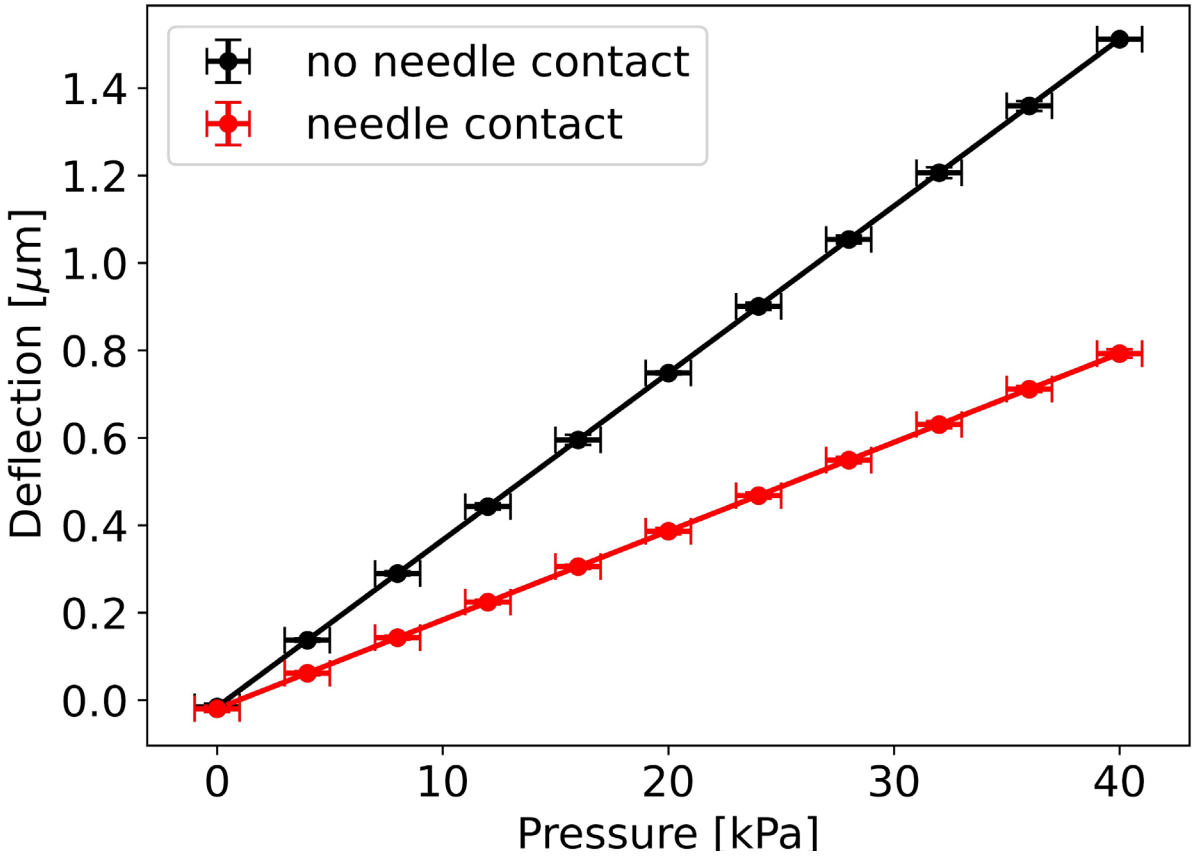






- Prober set-up with Heliotis WLI

How to (electrically) probe such wire?

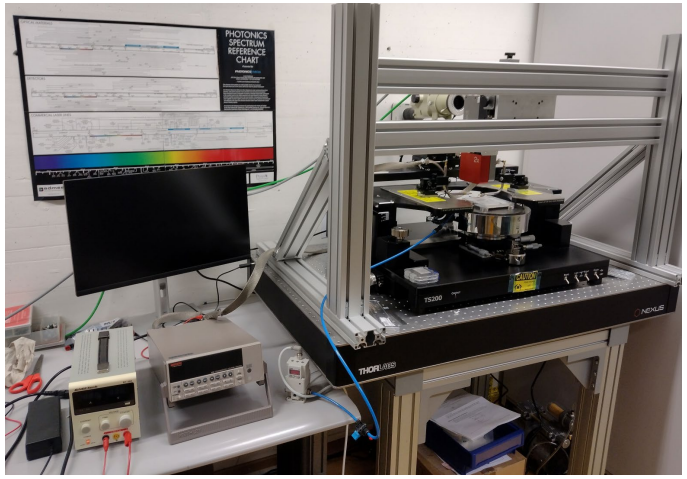


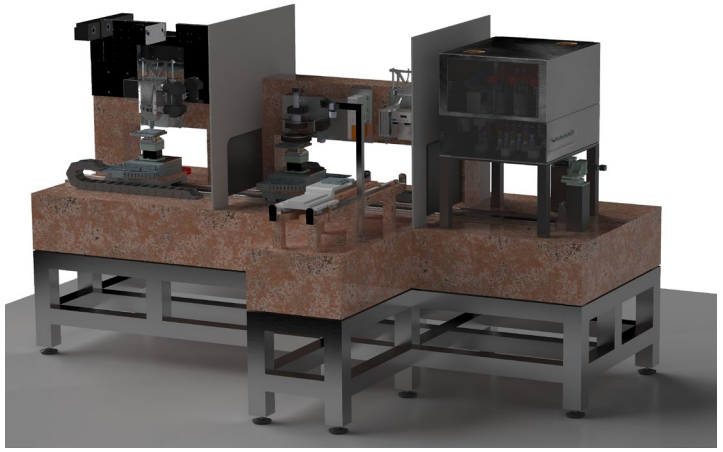
- Prober contact is sufficient to falsify results → wire bonding needed.

Outlook

- Optimization of atomic layer deposition and fs laser welding
- Electrical and deflection testing in larger number of samples
- Production control and quality inspection protocol development, using Heliotis white light interferometry

→ Seamless integration: same measurement device can be integrated, re-using the protocols and evaluation developed in the test-phase





Summary

- Successful application of Heliotis white light interferometry for novel medical implant research:
  - Form and deflection measurement
  - Glass laser welding verification
  - Nanometre-sized functional element measurement

- How about your metrology needs? → Heliotis is always looking for new collaborations

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Thank you!

Q & A

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Horizon 2020 - grant No 958417

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Extra slides

White Light Interferometry - Principle

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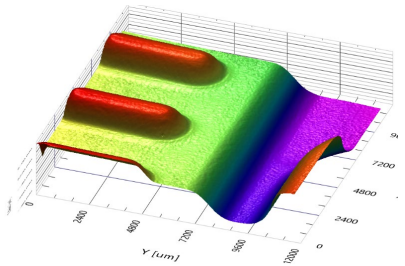
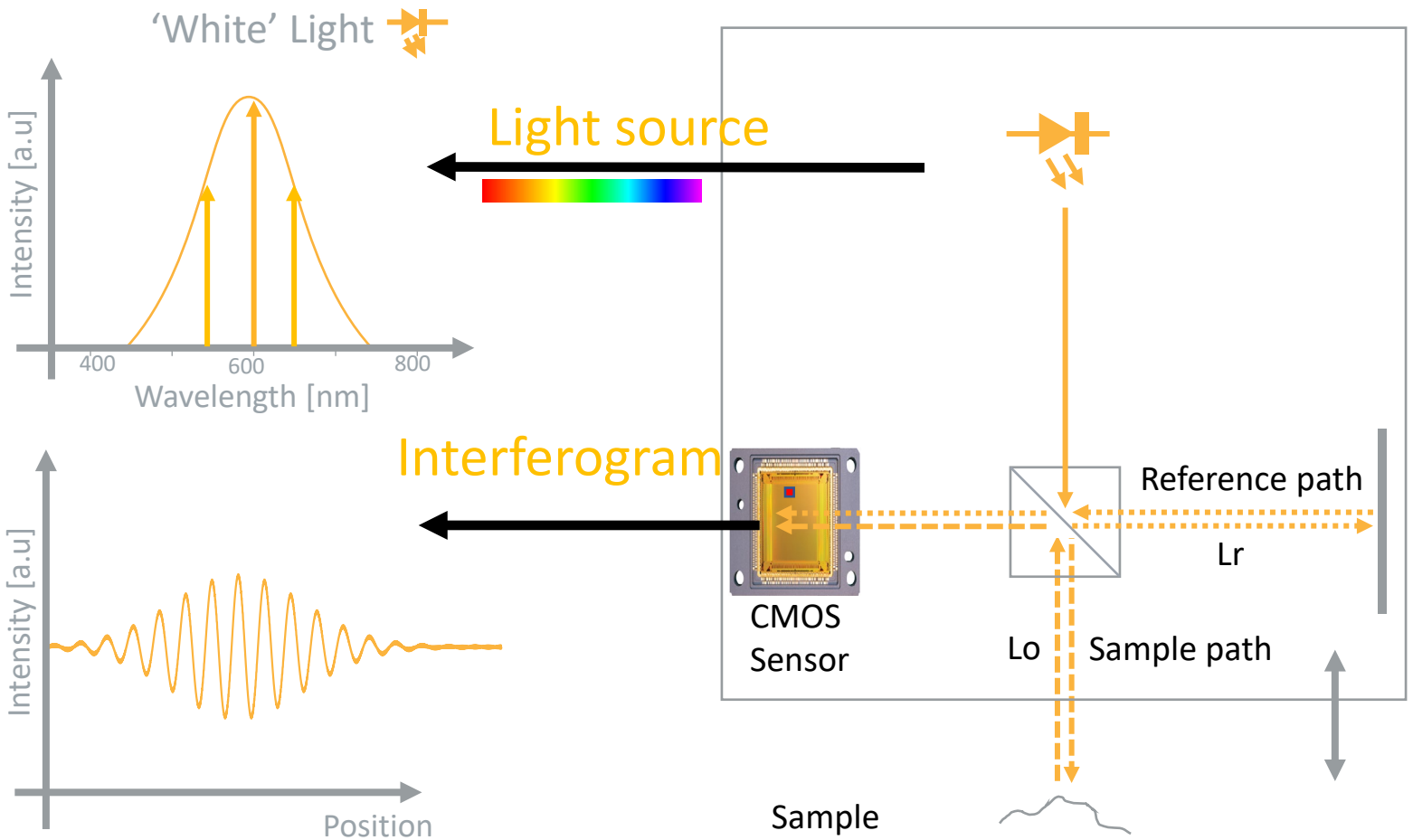
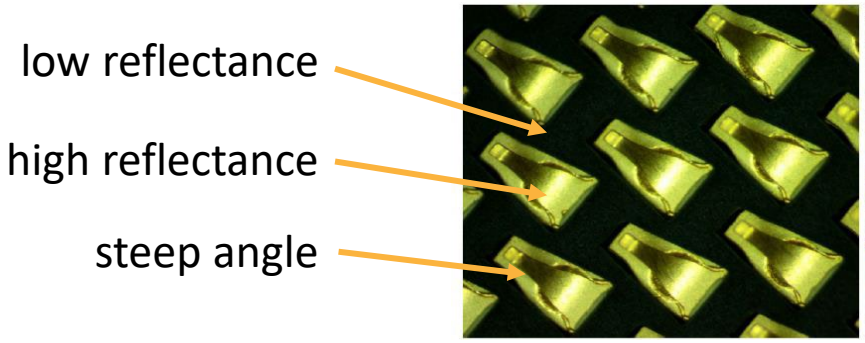
- principle: interferometry
- use “white” light
- record changing interferogram
- reconstruct 3D shape from changing interferogram – all pixels





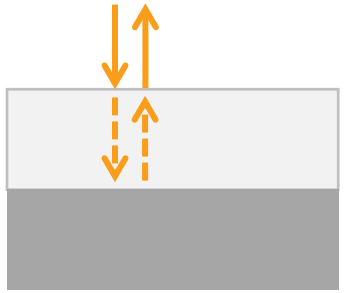
3D with absolute height & nanometer precision

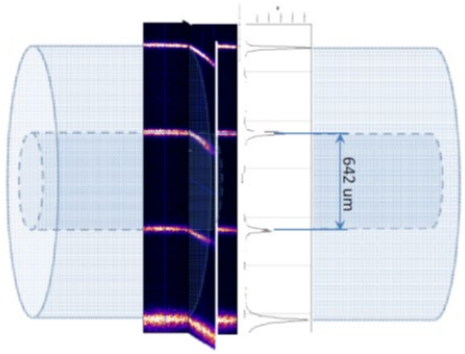
Heliotis White Light Interferometer Measurement Capability



Large intra-scene dynamic

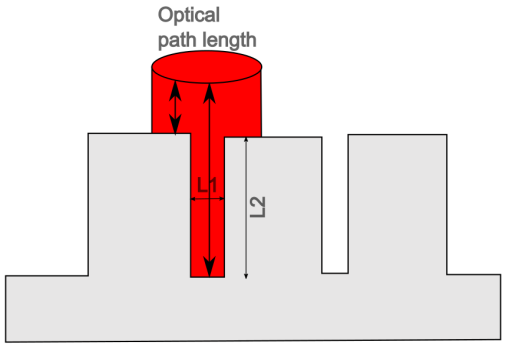
- dark & shiny surfaces
- steep & flat regions

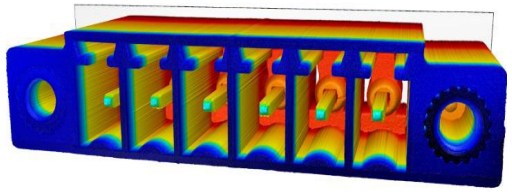




Measures multiple Surfaces

- WLI is inherently tomographic
- multiple interfaces are detected separately





Measures deep cavities

- no shadowing

Heliotis White Light Interferometer Measurement Capability

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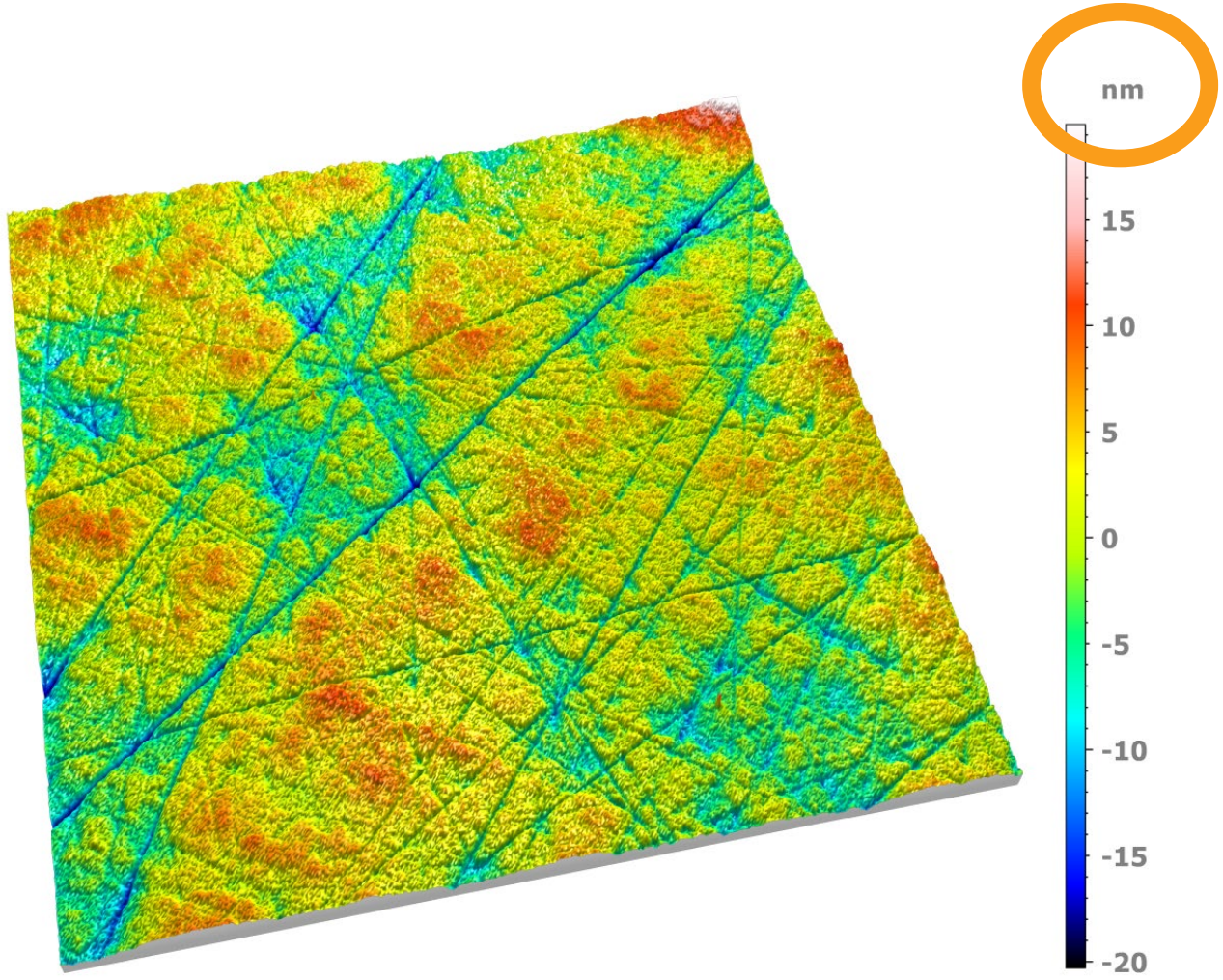

Very high z resolution

- nm Z measurements
- lateral resolution defined by variable optics

heliOptics™ WLI8		2 x	4 x	8 x	10 x	20 x	50 x	100 x
Field of view [mm²]		6.5 x 6.1	3.3 x 3.1	1.6 x 1.5	1.3 x 1.2	0.65 x 0.61	0.26 x 0.25	0.13 x 0.12
Optical resolution [µm]	H8	12	6	3	2.4	1.2	0.48	0.24(*)
	H8M	6	3	1.5	1.2	0.6	0.24(*)	0.12(*)

Configuration		3 x	2 x	1.5 x	1 x	0.8 x	0.5 x
Field of view [mm²]		4.10 x 4.35	6.14 x 6.53	8.19 x 8.70	12.29 x 13.06	15.36 x 16.32	24.58 x 26.11
Optical resolution [µm]	H9	8	12	16	24	30	48
	H9M	4	6	8	12	15	24