Non-contact Topography Measurements of Large Areas with High Accuracy

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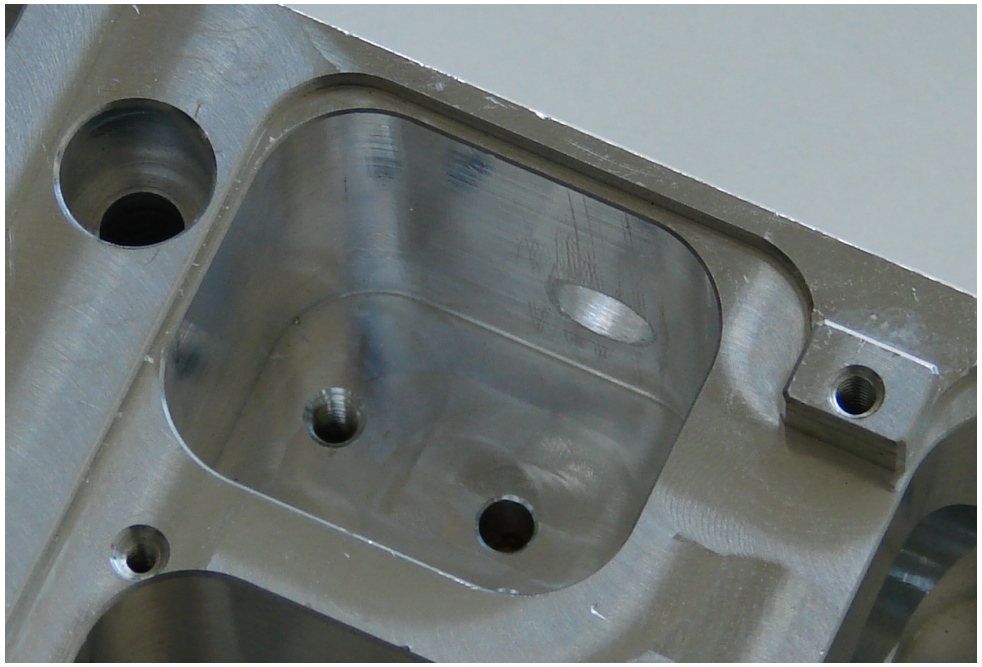
Contents

- Examplary task: A milled workpiece
- Why using White Light Interferometry?
- A bit of necessary theory
- Applications and options

Example: Milled Part



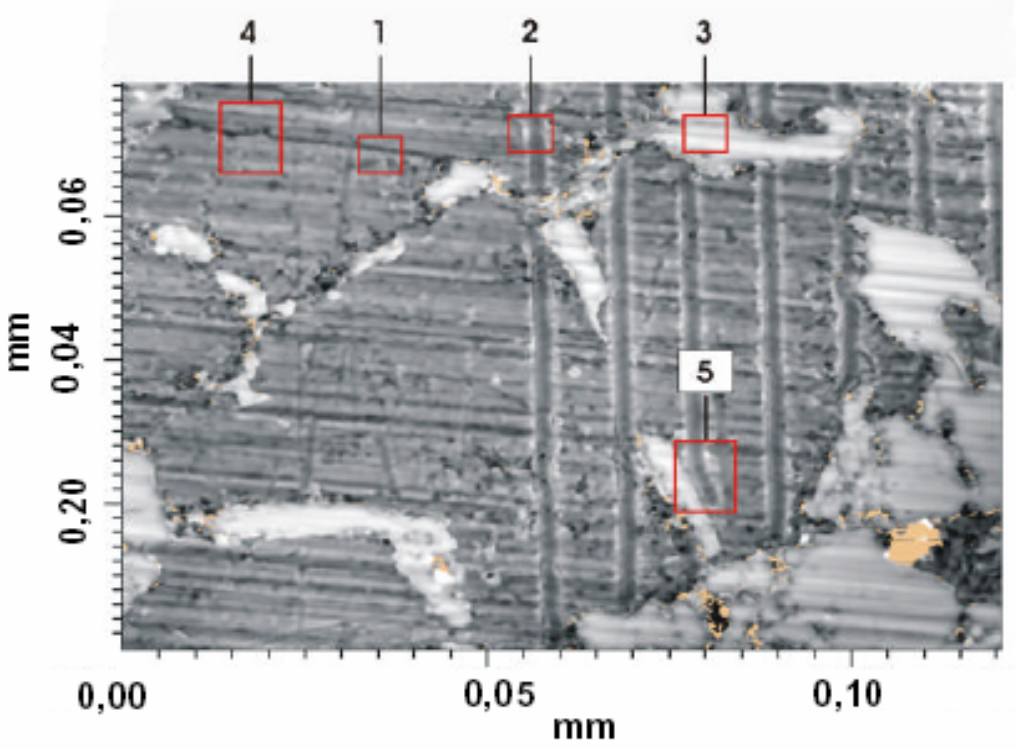
Dimensions of the sample: cm

Parameters to determine: Flatness, Step Height, Roughness, Diameters, Distances,…

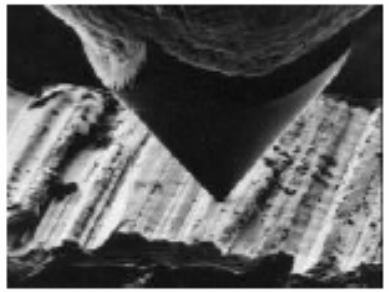
Tolerances: µm

Resolution of the Measurement System: << µm

Tactile Measurement



1. Machining groove
2. Stylus groove
3. Si Crystal (hard)
4. Al surface (soft)
5. Deviation of the stylus



Optical Measurement is: 2D, contactless and fast

Optical Measurement Principles

Triangulation:

Angle

- Confocal Microscopy
- Focus Methods
- Fringe Projection

Axial Resolution decreases with growing Field of View

Distance Measurement:

Time

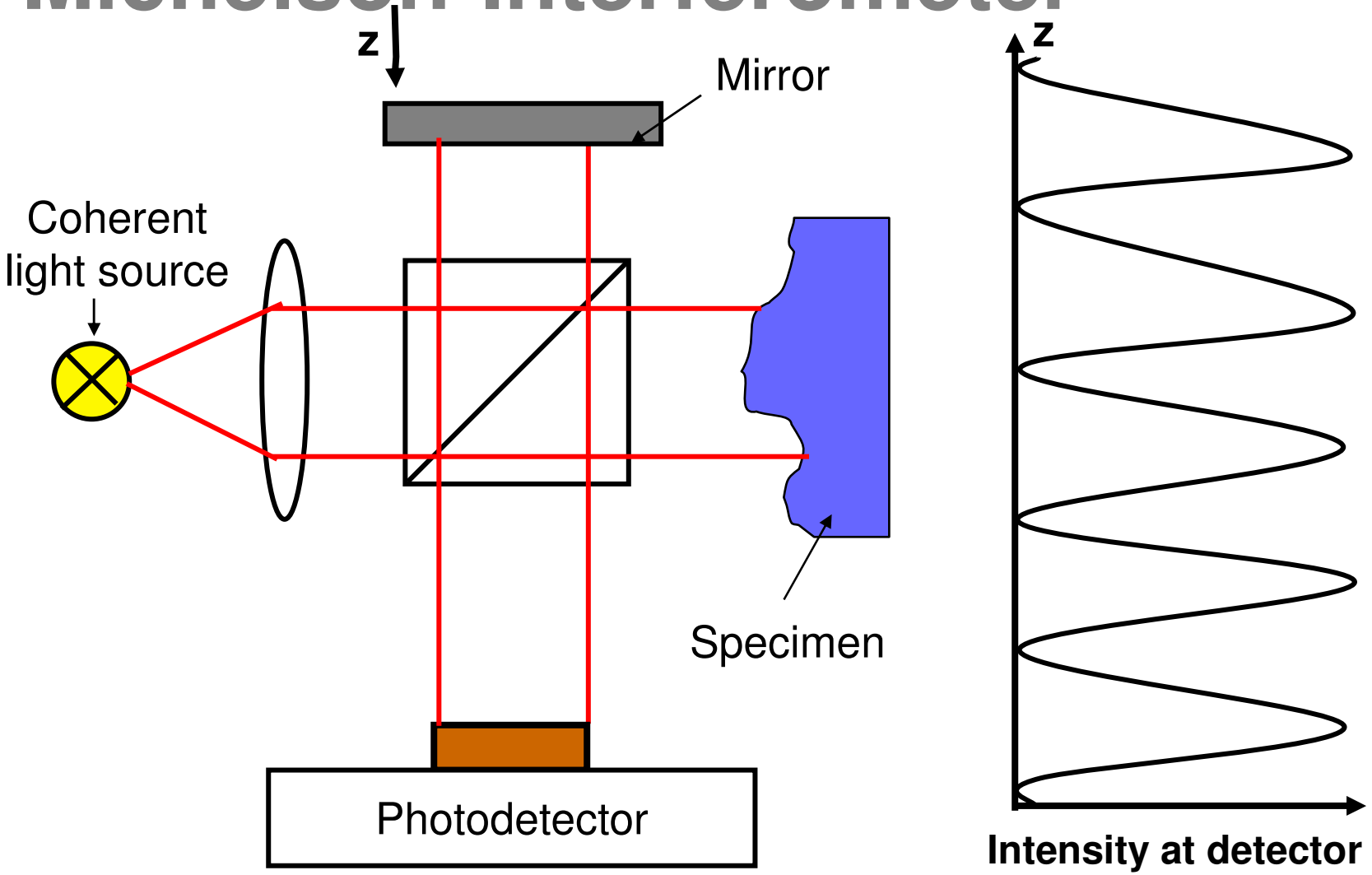
- White Light Interferometry
- Run-Time-Methods
- Interferometry

Axial Resolution is not field-dependent

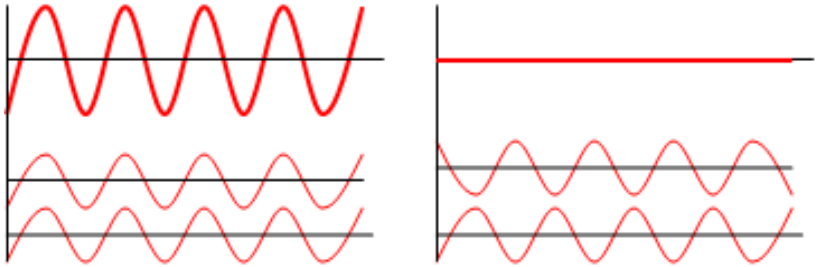
Advantages of White Light Interferometry

- “Run Time” -> z-Resolution not field dependent
- High axial Resolution in the nm-range
- Non-ambiguous Measurement
- On nearly any surface (rough, smooth, dark, shiny,..)
- Contactless
- Nearly no shadowing effects
- Step Heights up to 70 mm

Michelson-Interferometer



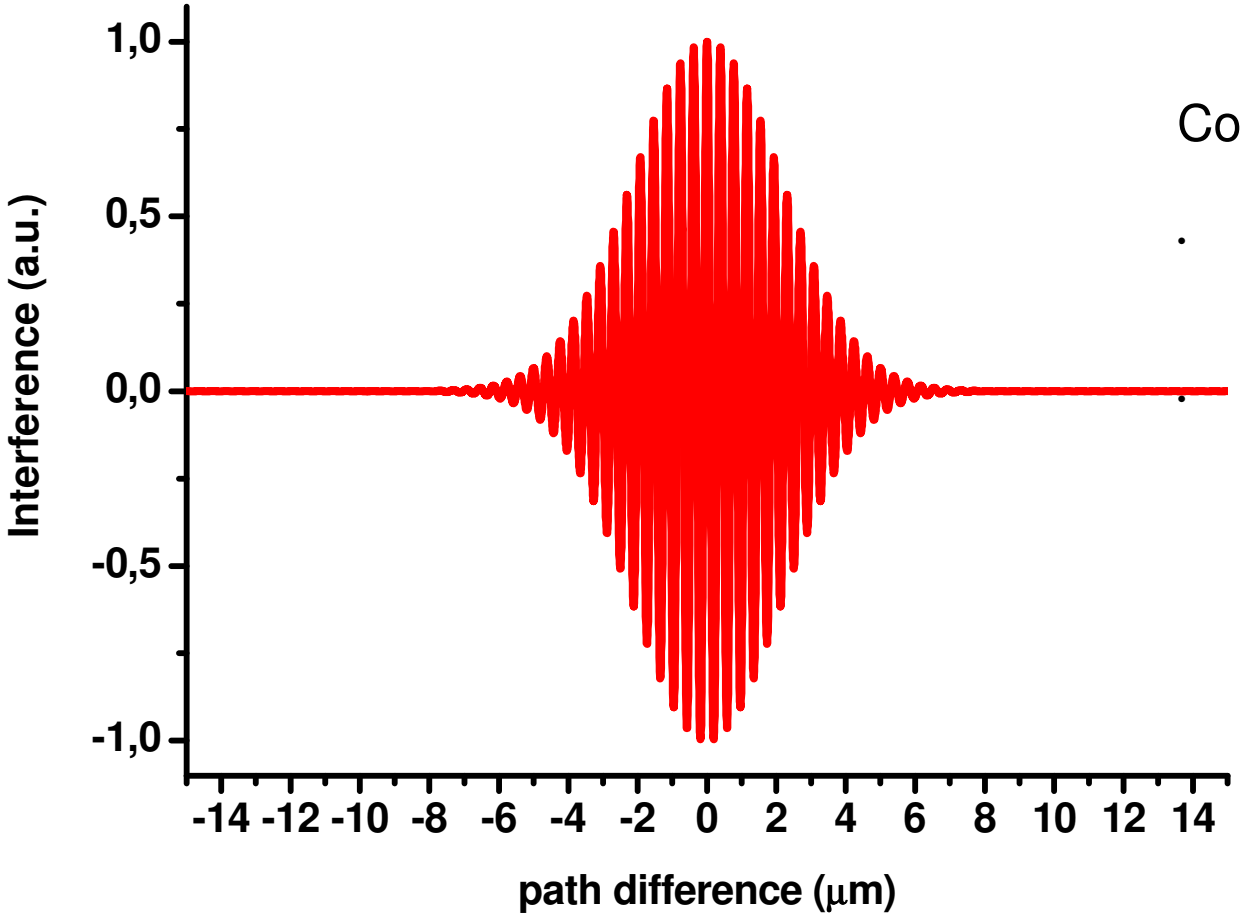
Constructive/Destructive Interference



In-phase monochromatic light shows constructive

out of phase monochromatic light shows destructive interference

Interference of White Light

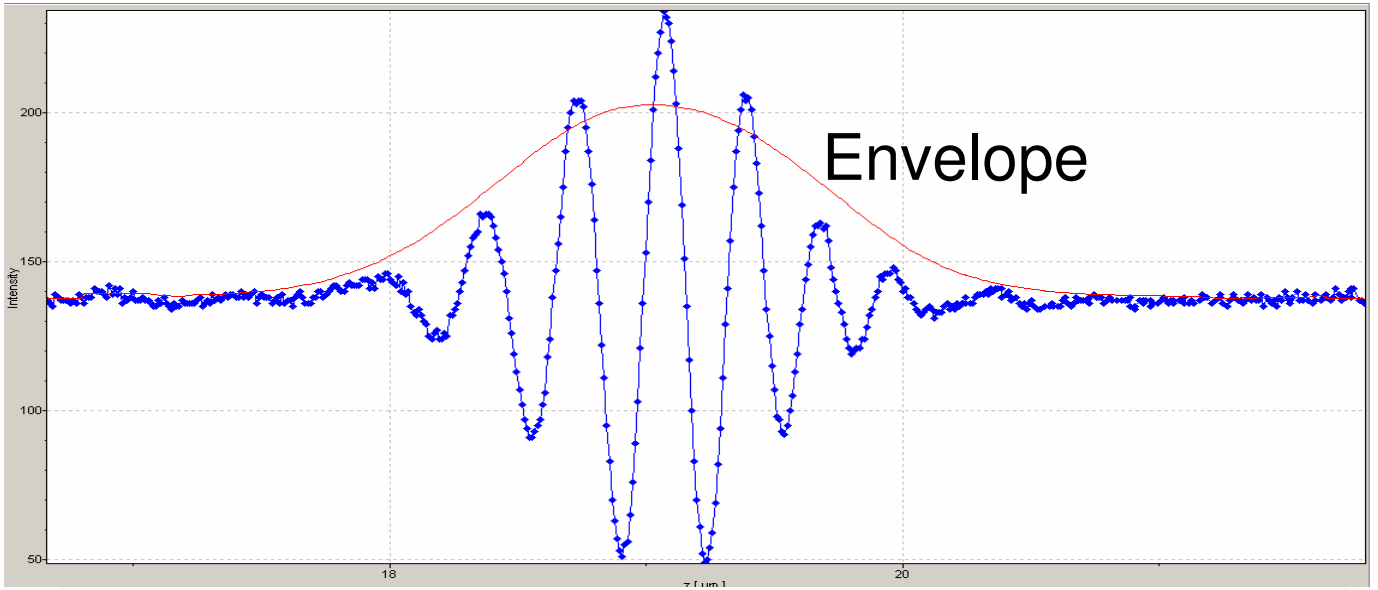


Corellogram:

- Interference only at a singular area
- This area ~ Coherence length L_c , where light can interfere

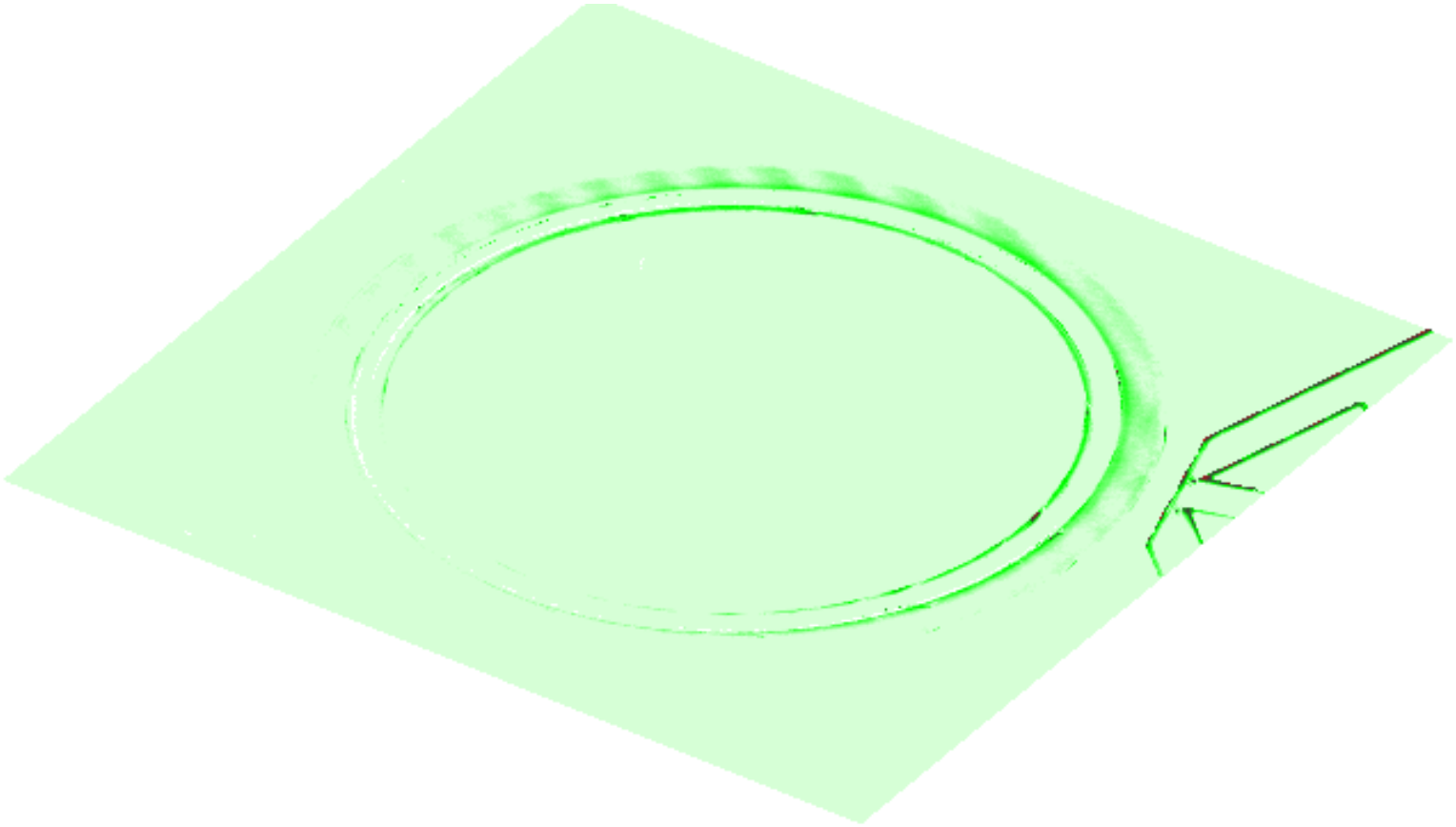
Measurement-Signal: “Correlogram”

Intensity



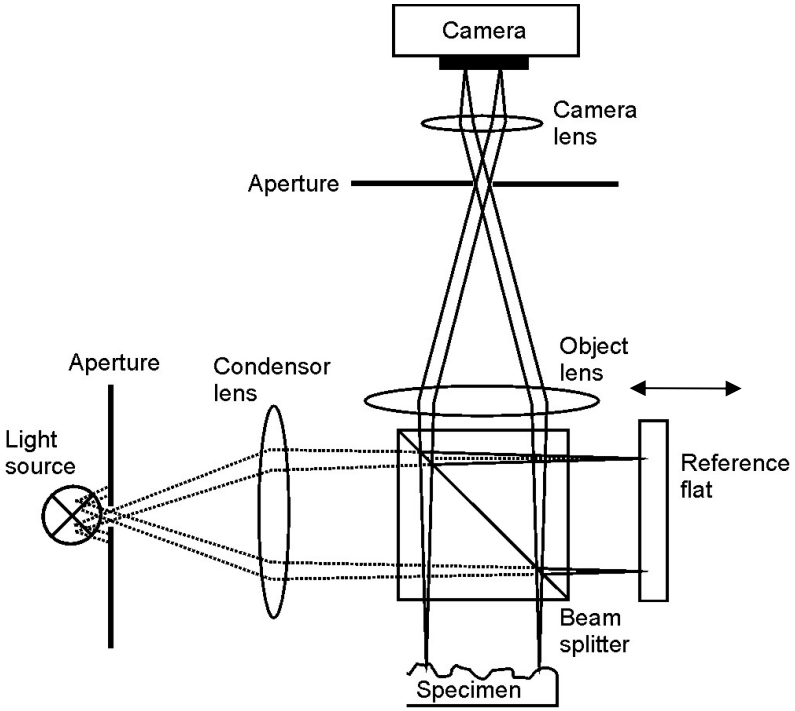
Axial Position (z)

Scanning White Light Interferometry:



Micro-Gear

Large Area Setup: Twyman-Green Interferometer



Telecentric: parallel light-beam

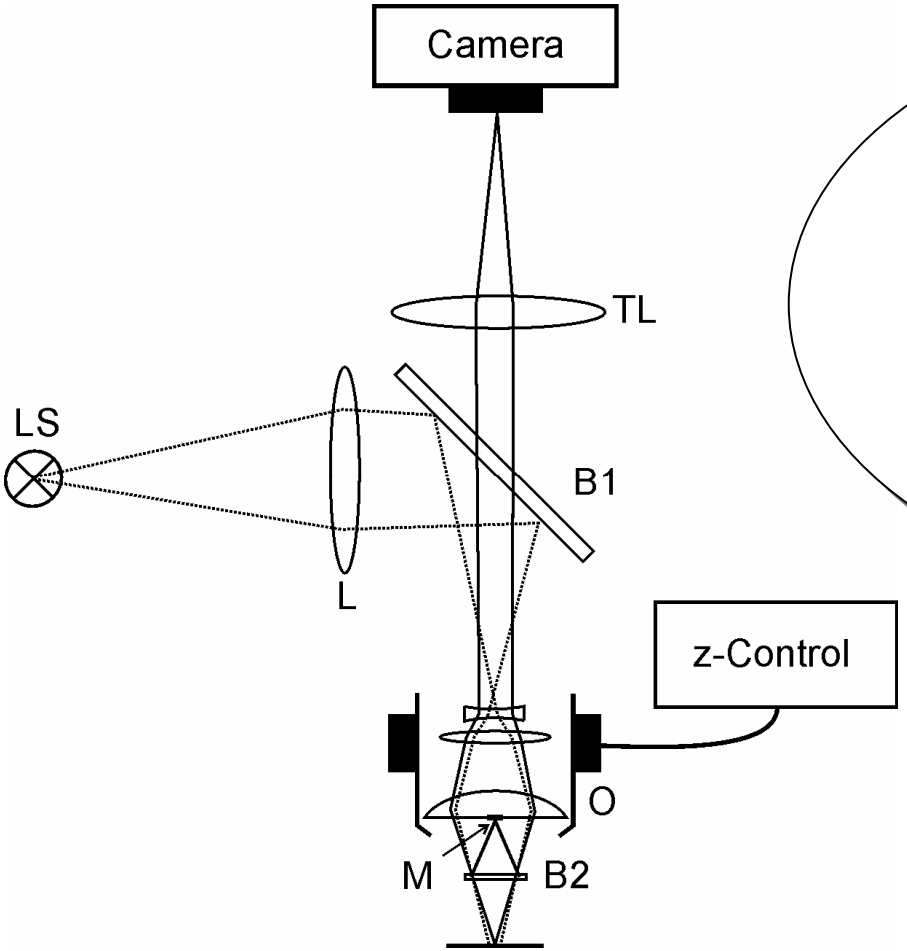
- no shadowing at edges
- additional Filter (or Compensation-pieces) in the reference arm possible
- large working distance up to 70 mm

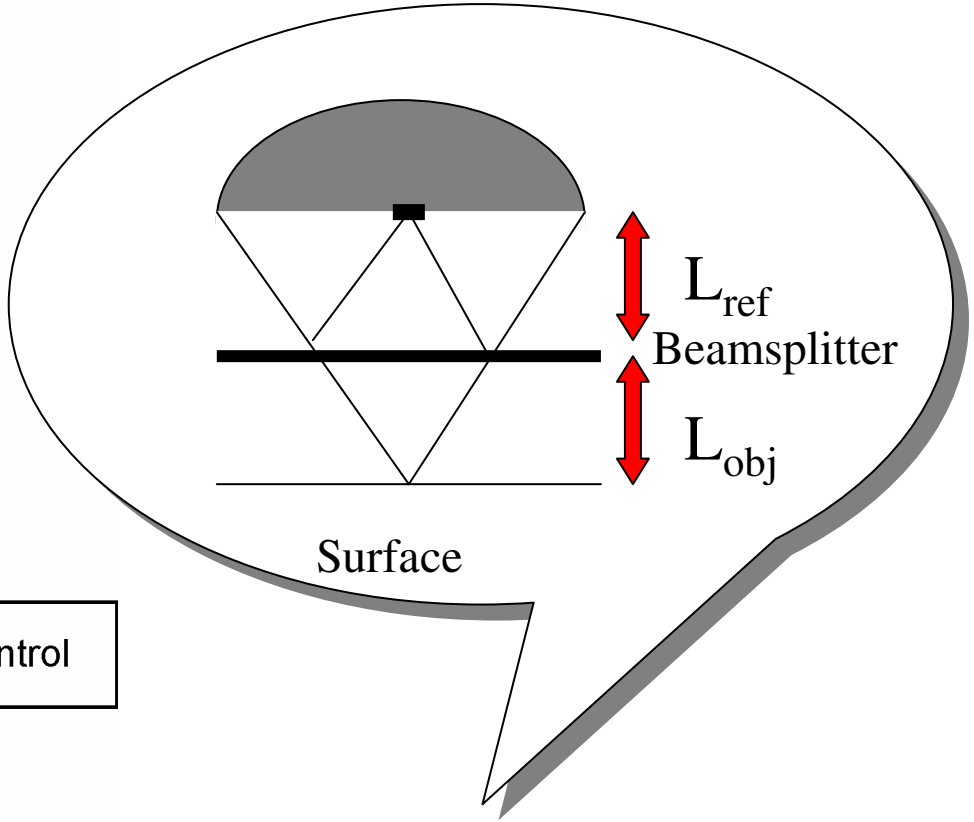
Horizontal resolution:

- Typical values:

  10 µm (Field of view: 10x13mm³)
  40 µm (Field of view: 30x40mm³)

Microscopic Setup for Fields < 4 mm and highest resolution



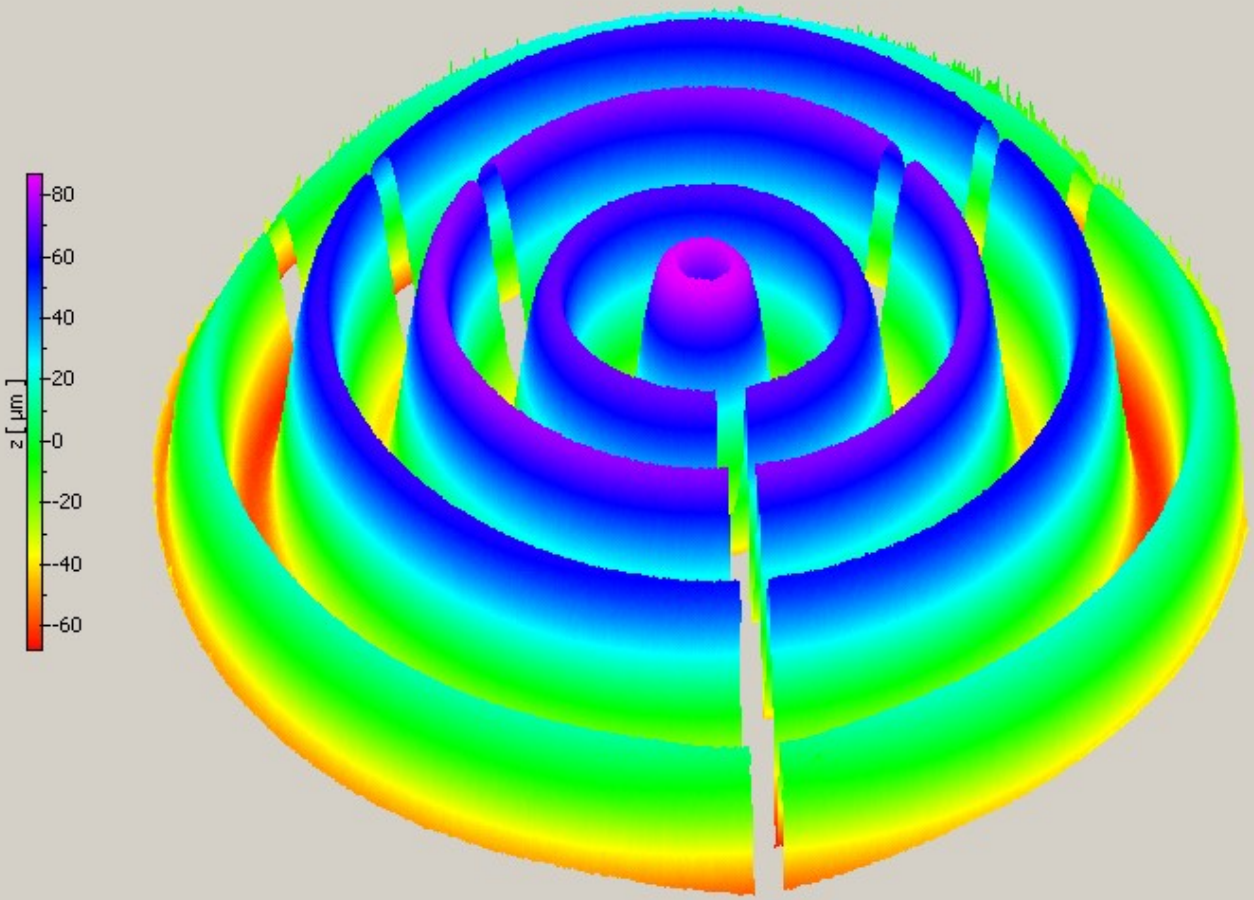


Mirau Objective

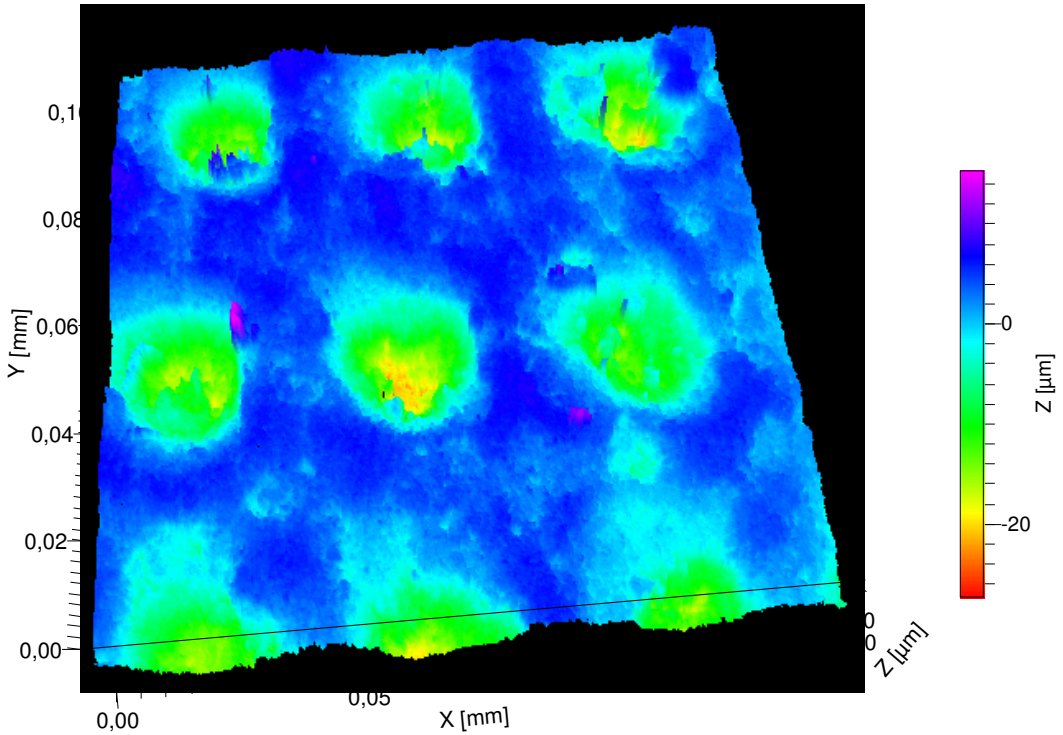
Applications

Membrane under exposure of pressure

Pressure dependent strain



Cups in a press cylinder



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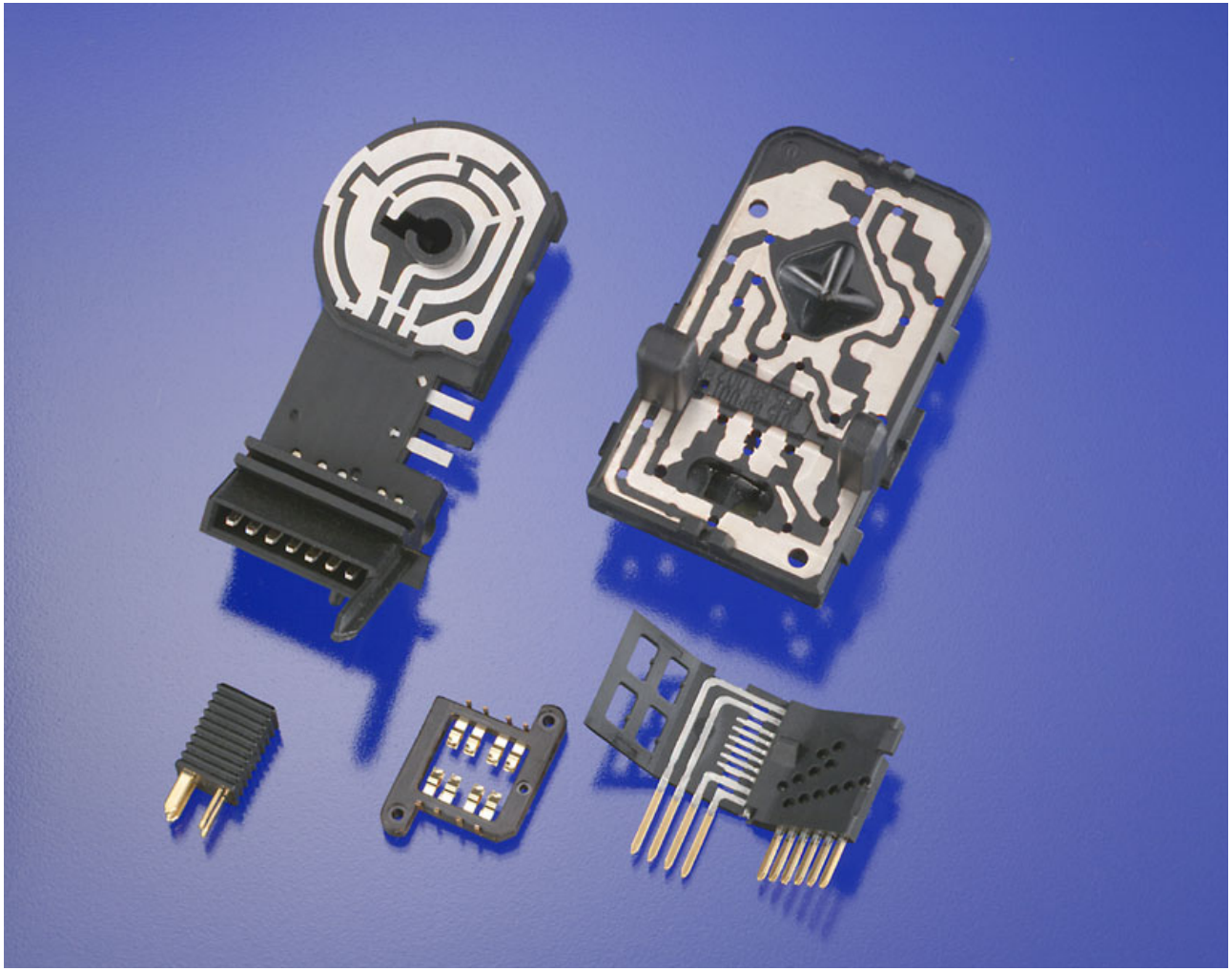
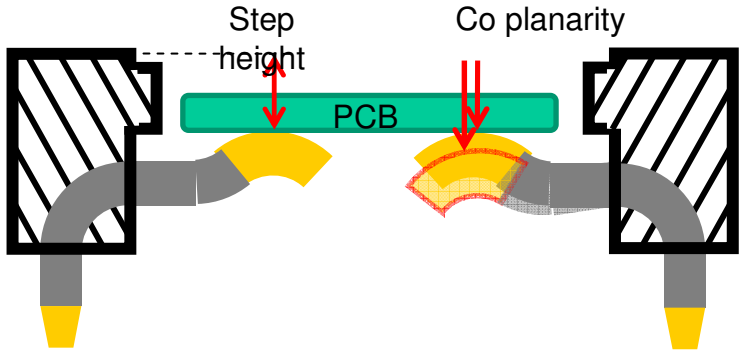
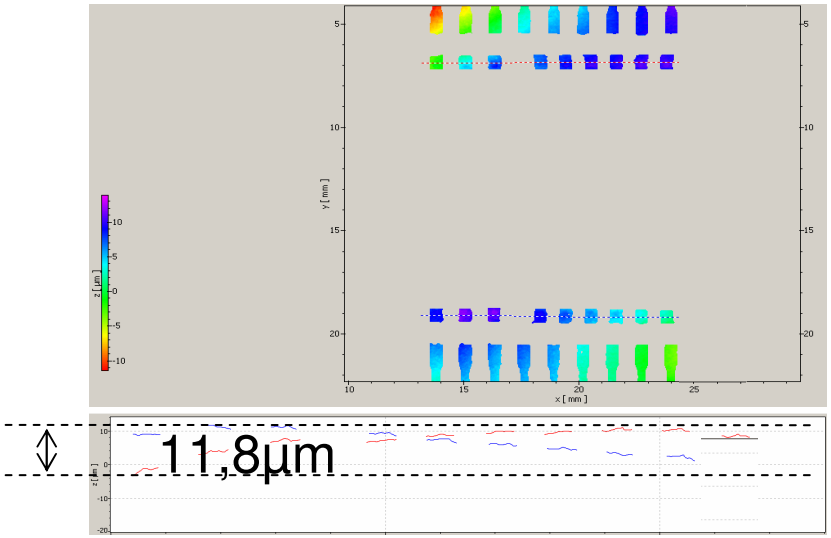
Circuit Boards and Connectors



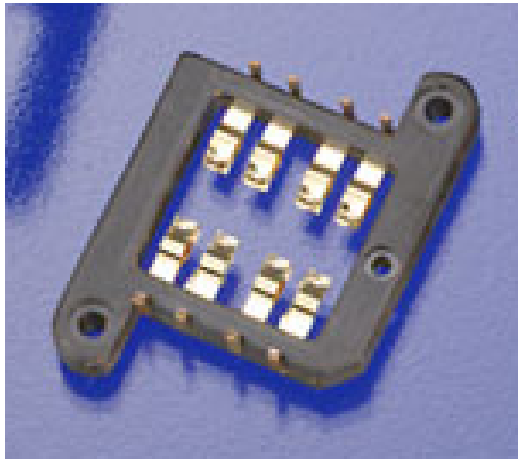
Electromechanical Hybrids

Co planarity and tolerances in an area of over 10 cm² with sub Micron accuracy

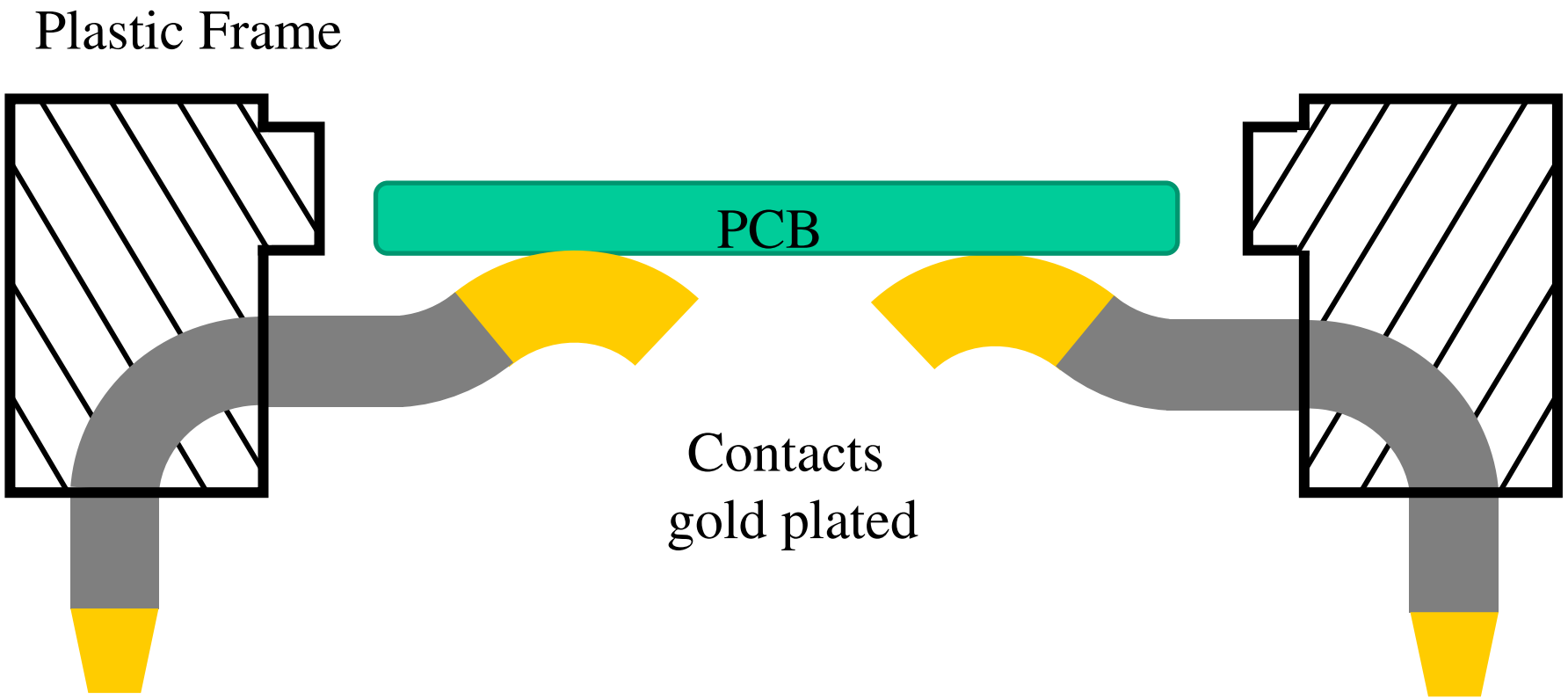




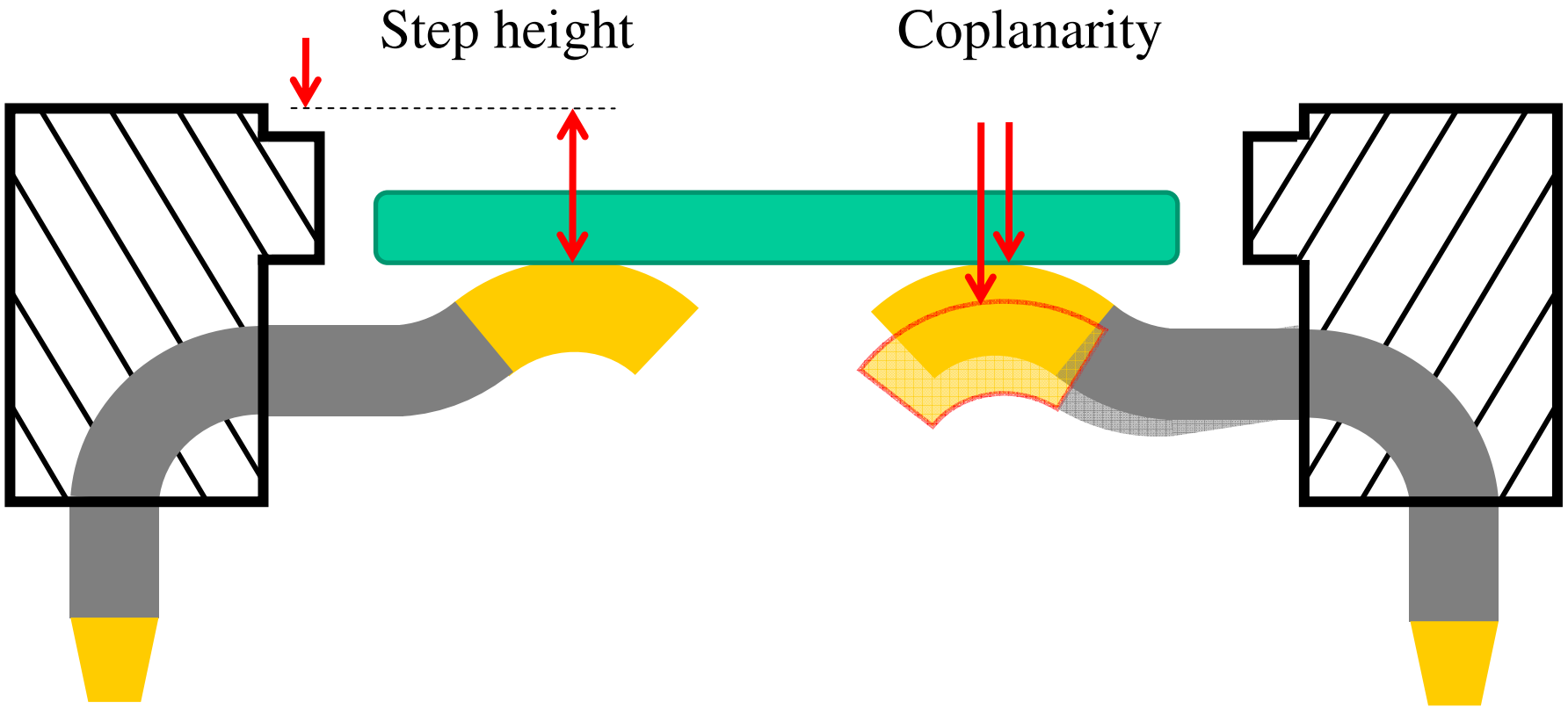
Hybridparts

Objekt	 
	Elektronikmontage in Hybridteile
Ziel	Kontrolle von Form, wie z.B. Komplanarität der Kontatkflächen und Oberflächeneingenschaften wie Kratzer und Rauigkeit
Vorteil	• Berührungsfreie Messung • Schneller, da aus einer Messung Konturen, Formen und Oberflächendaten gezogen werden können • Leichte Protokollierung der Messungen und Ergebnisse

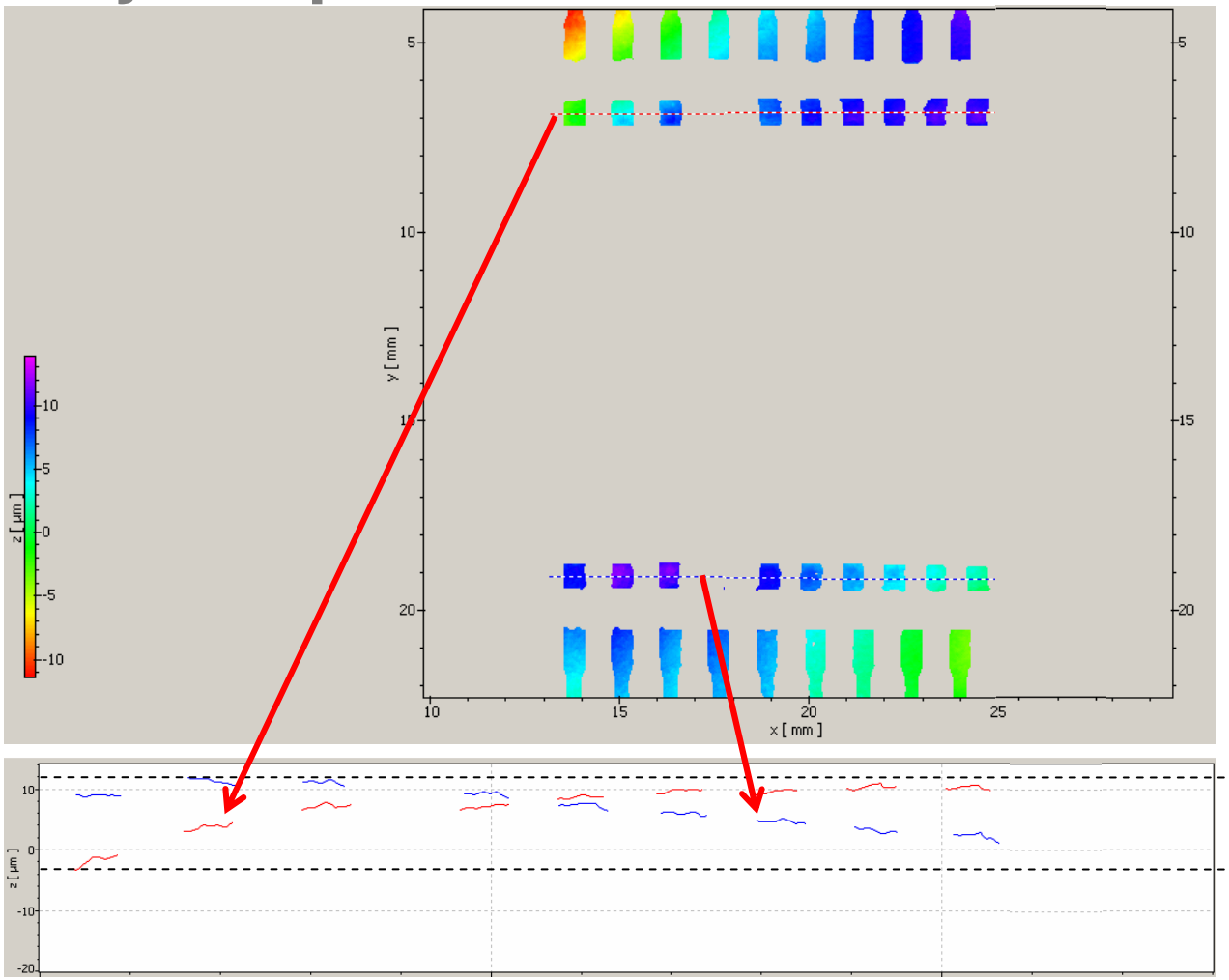
Hybrid parts



Hybrid parts: Measurment task

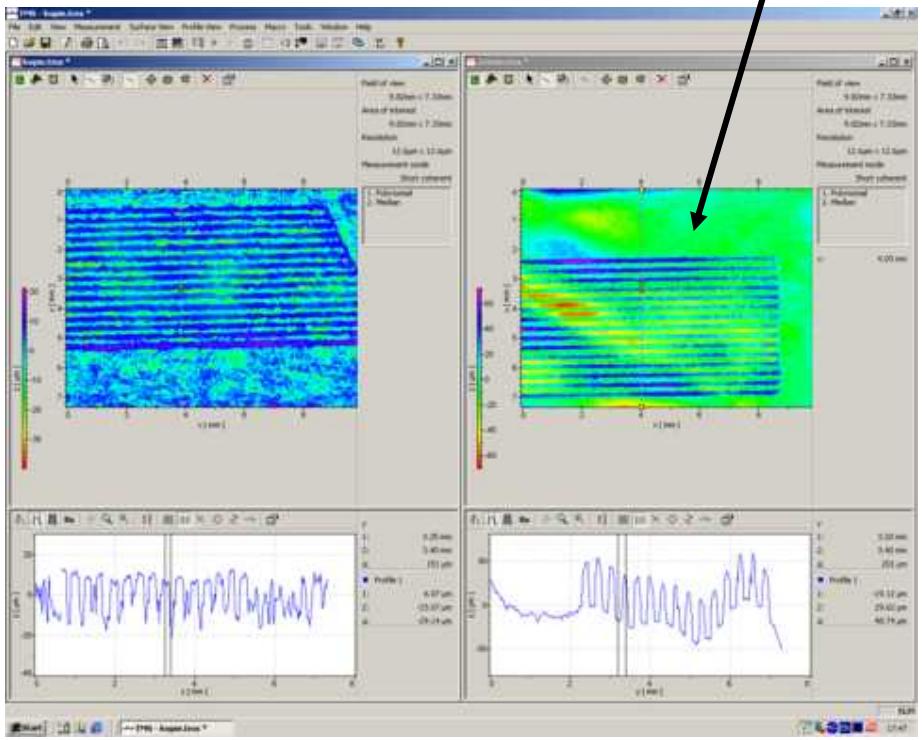


Hybrid parts: Evaluation



Coplanarity of the contact surfaces

Banknotes: Counterfeit or not?



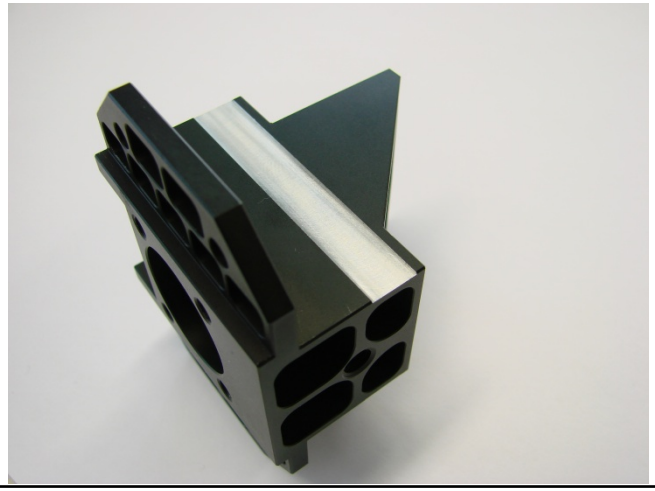
Counterfeit

Genuine

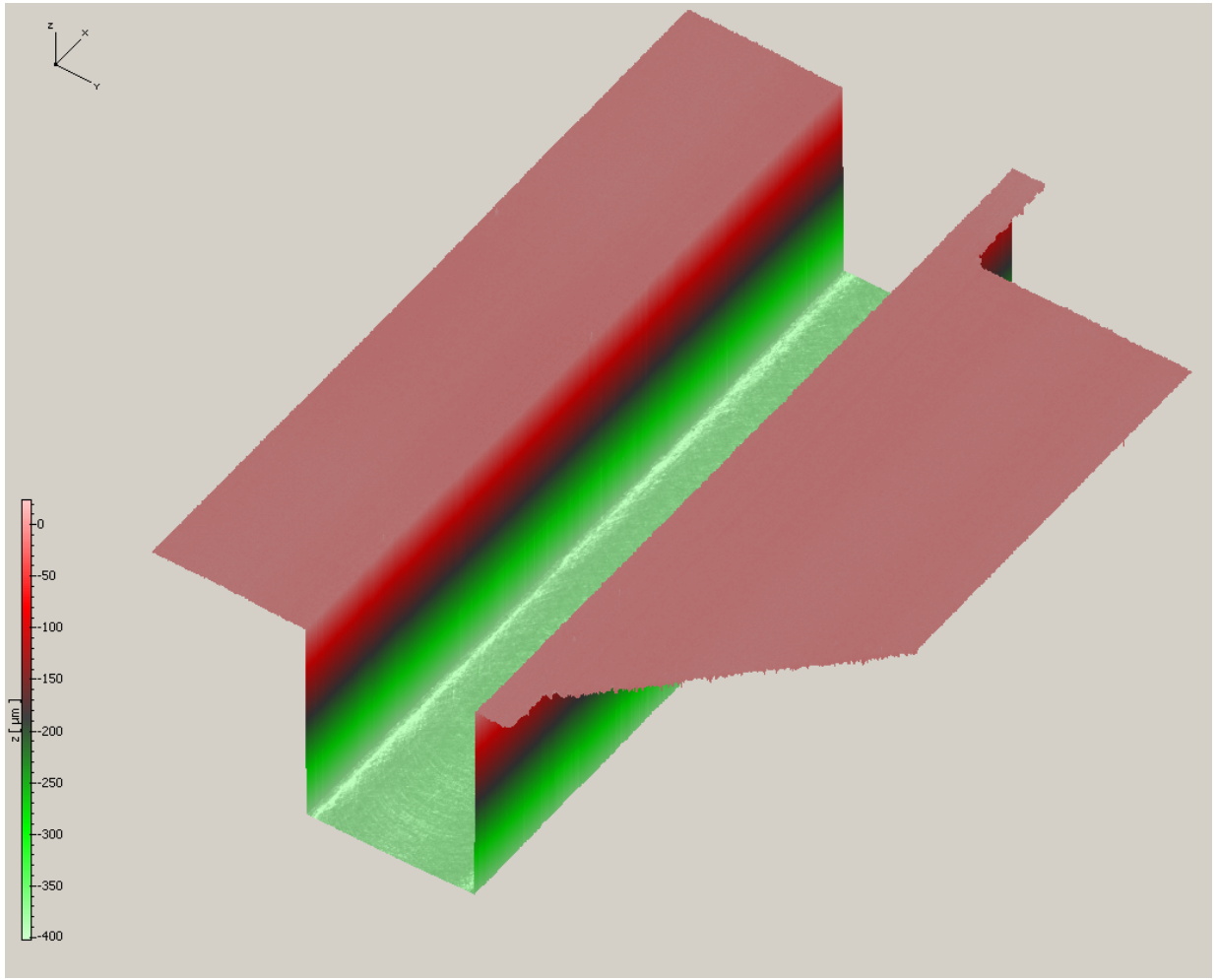
Polytec´s Solution to achieve reproducible results:

Automated Measurement and Evaluation using Macros in Visual Basic®

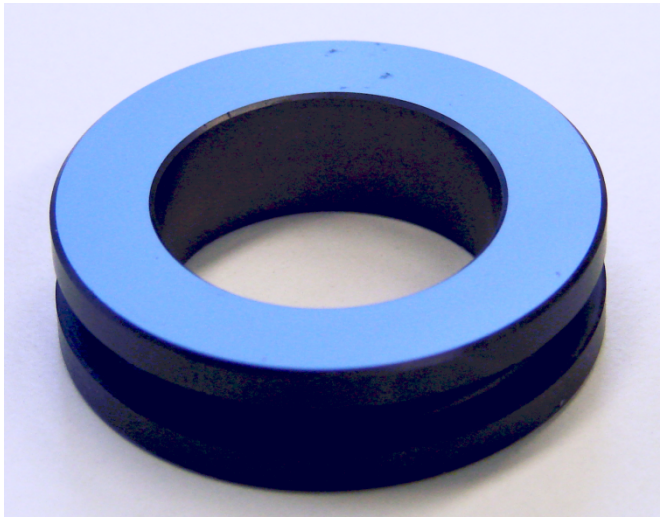
High and low reflective surfaces
Example: Anodized Surface

Object	
Task	A black anodized items should be checked at a milled groove with bare metal
Benefit	- Non contact measurements of sensitive surfaces and coping with high contrasts - Measure flatness and step heights at the same time

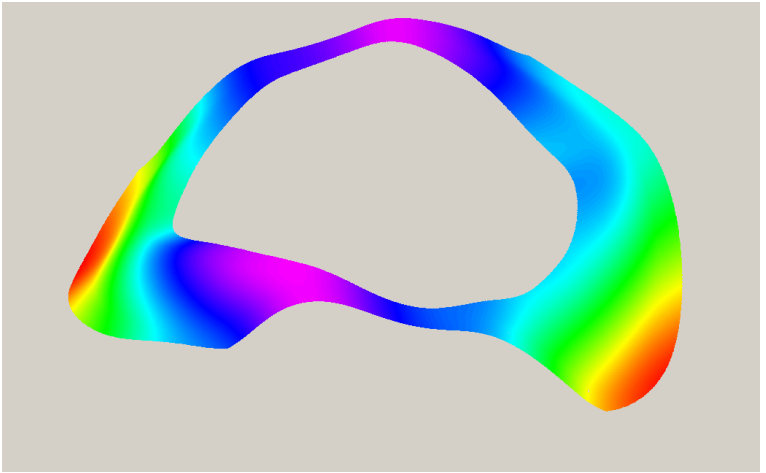
Solution: Combined Mesurement using Multiple Exposure Times



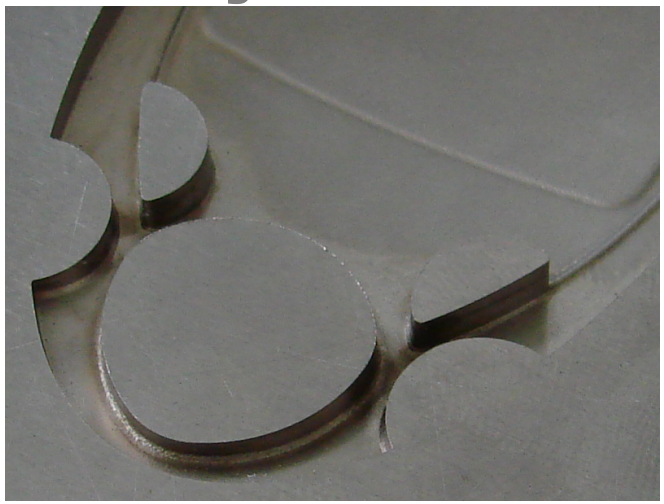
Precision Mechanics: Flatness



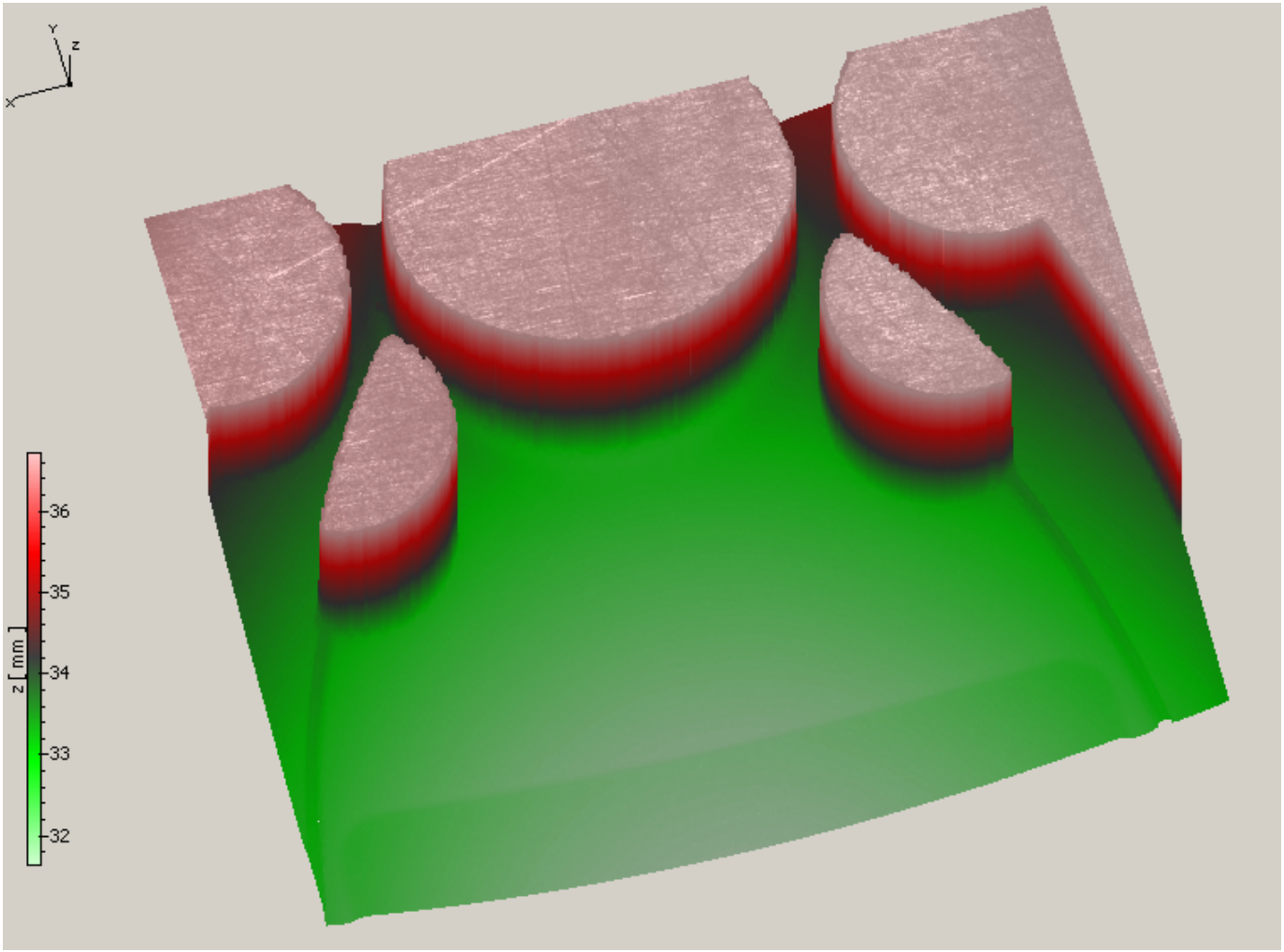
From deviations on the
Scale of Nanometers



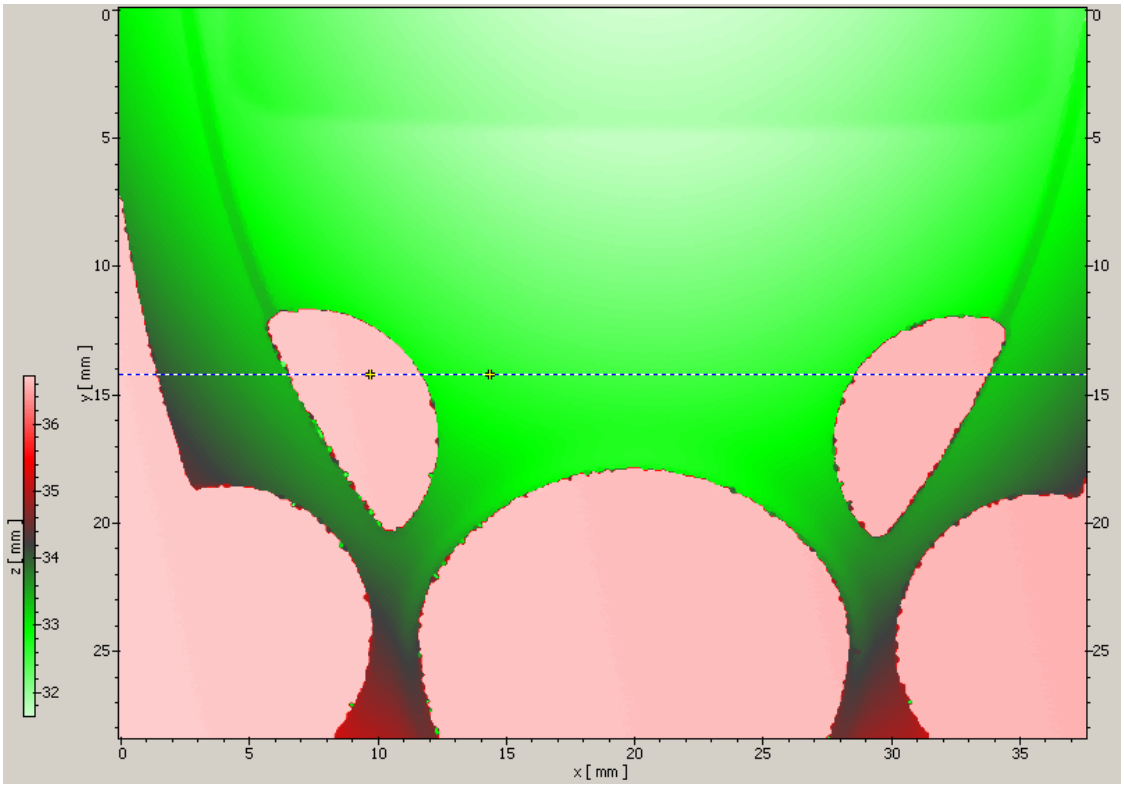
Plastic Injection Mould, Task

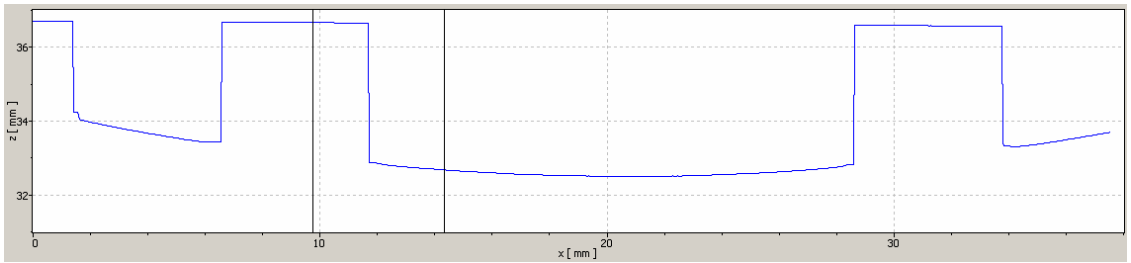
Object	
Goal	A three dimensional item should be measured. Step heights, lateral dimentions, and surface quality need to be checked
Benefit	• Both mould and finished part can be measured • No physical cross section is needed • Save time and money because an area can be measured in steed of a single profile. • Use the mould as long as possible before it wears • Use the same set of data for multiple analyses like roughness and contours

Plastic Injection Mould: Topography Measurement

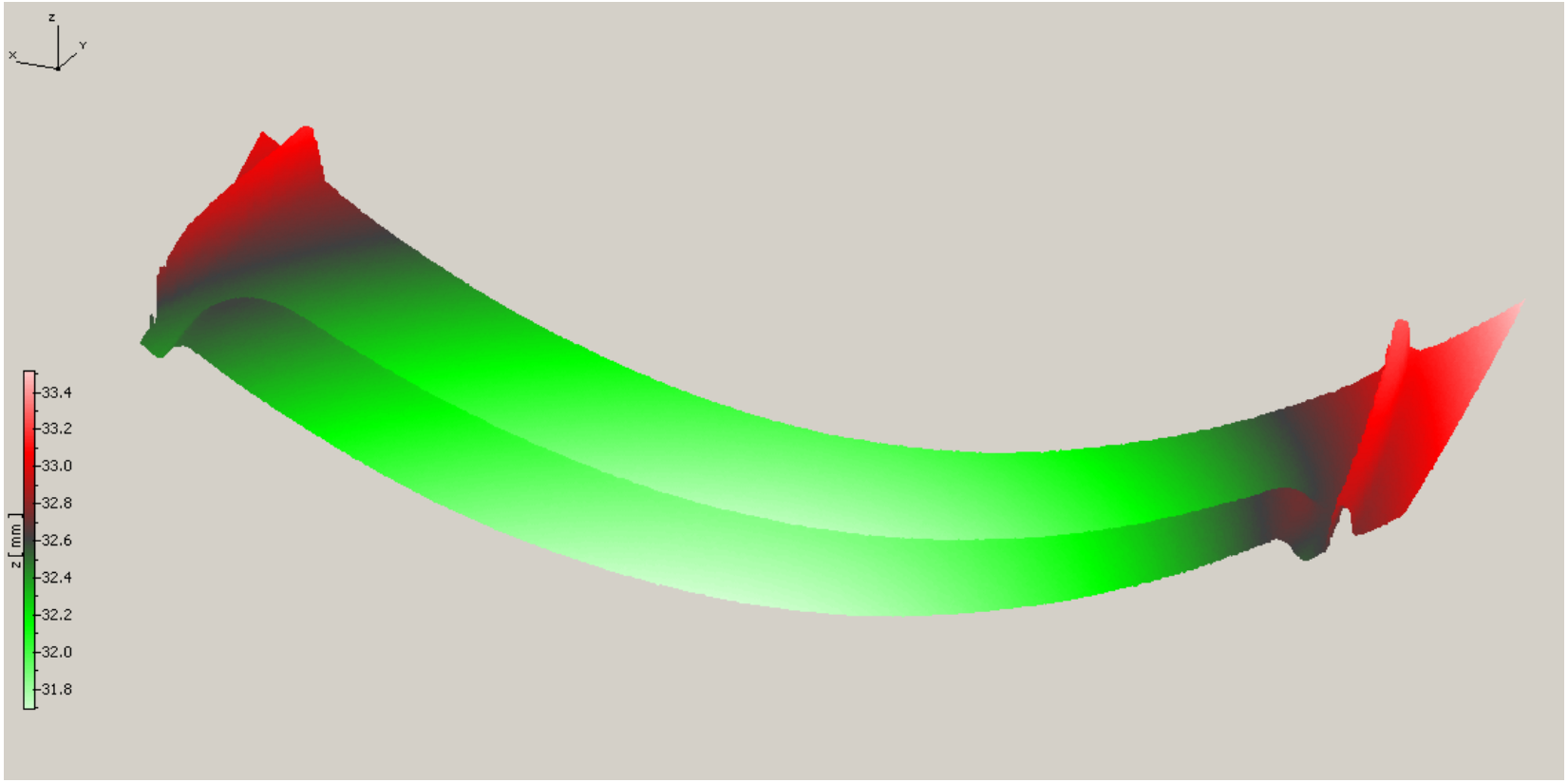


Step heights and lateral dimensions

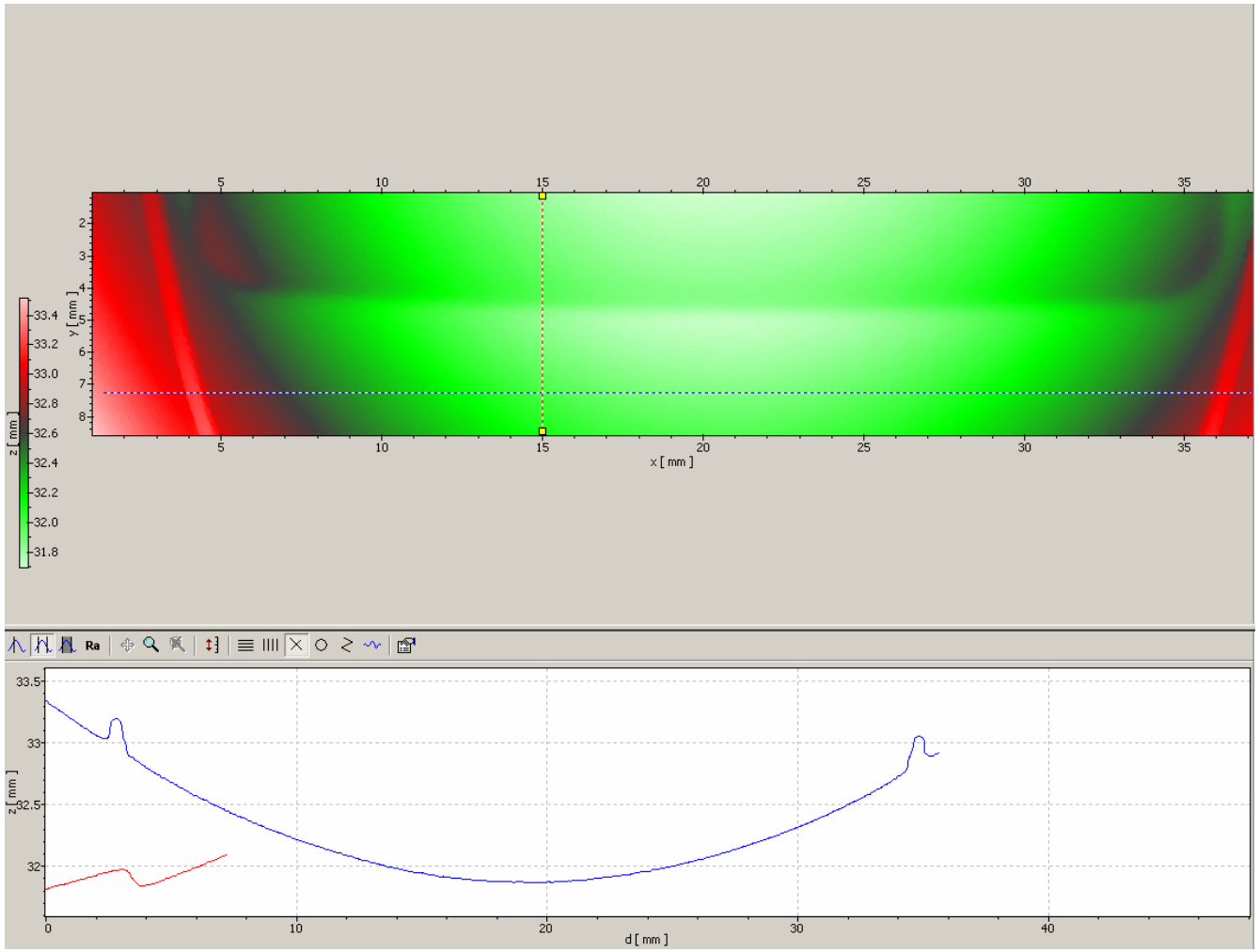




Form and Radius



Form and Radius



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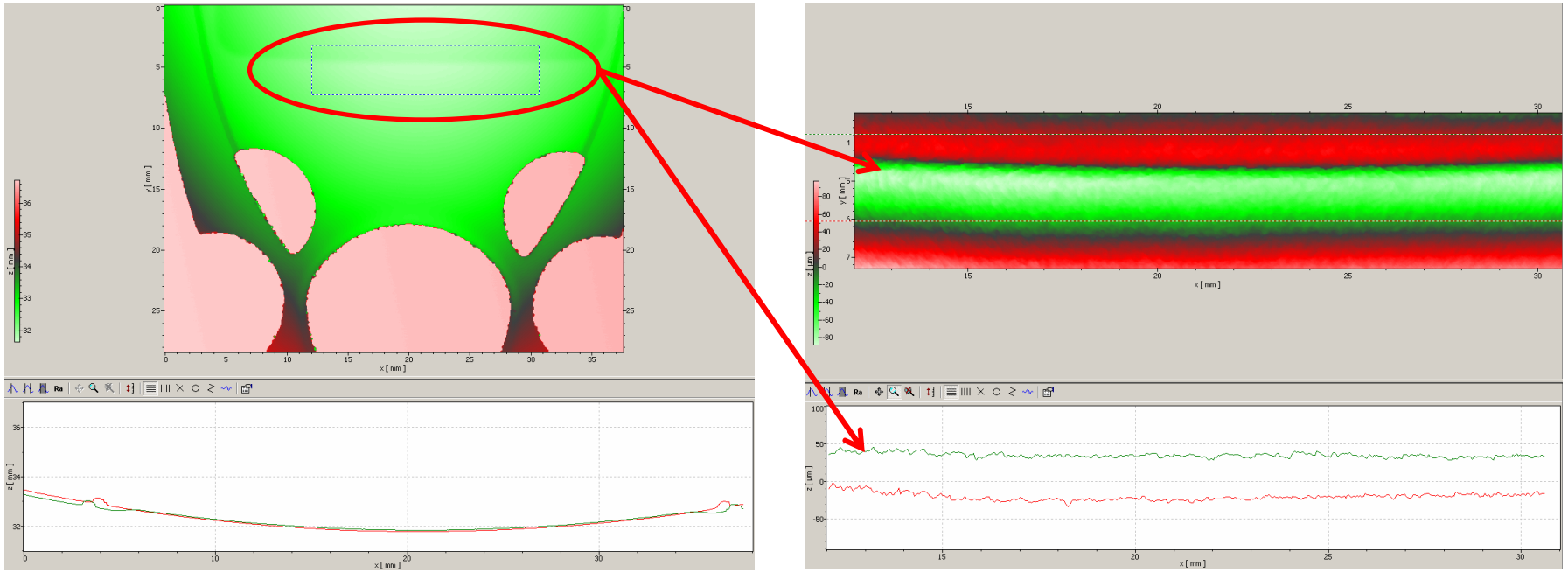
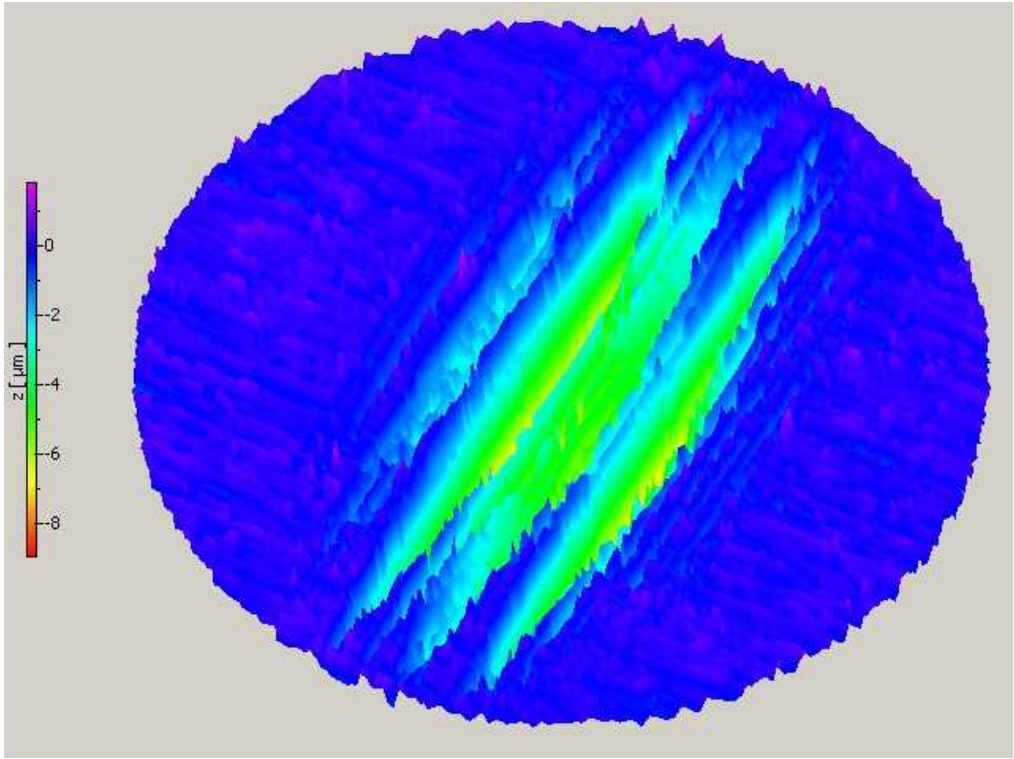
Shape

Micro-Structure

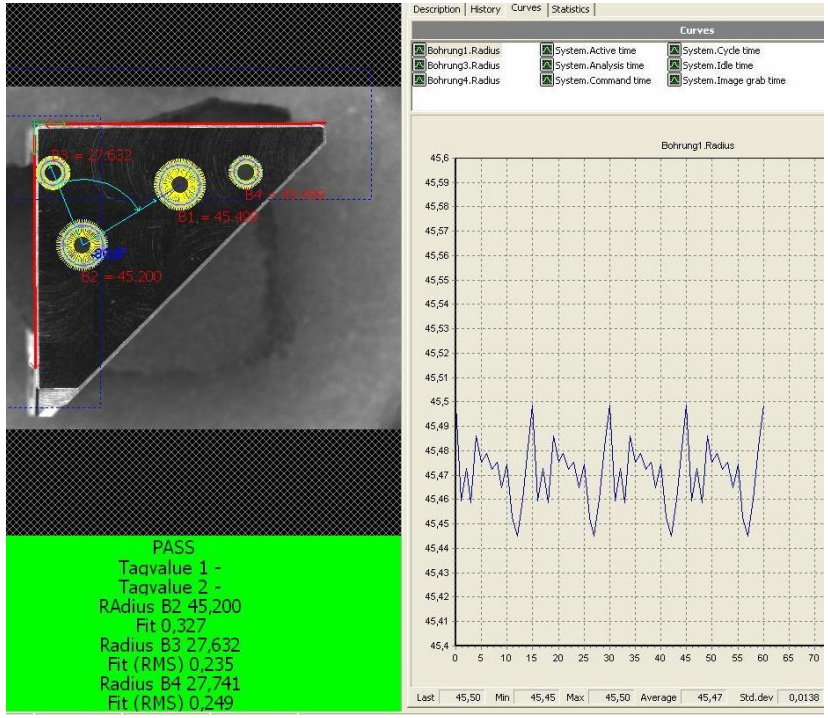


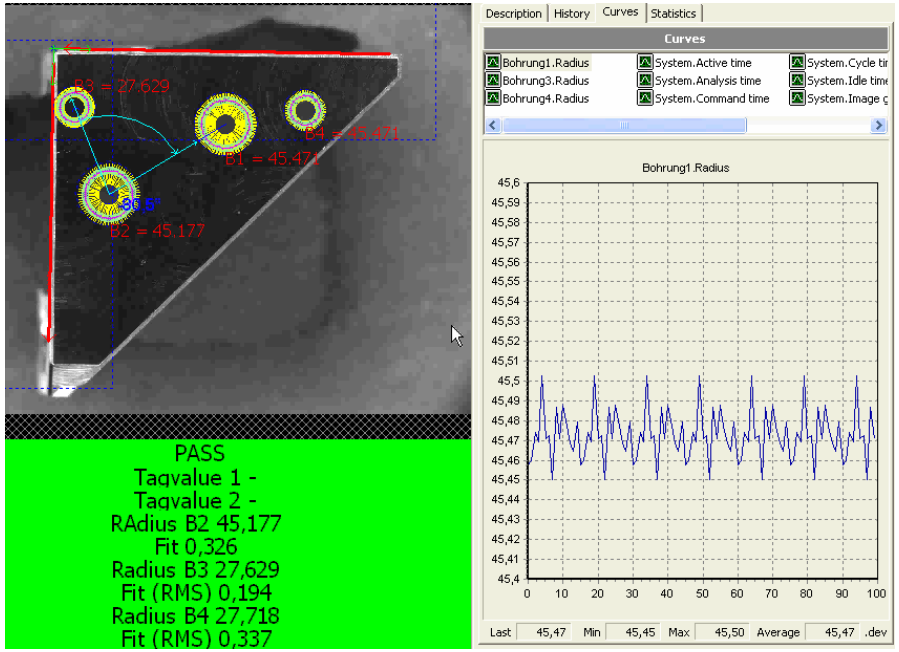
Optimization of lubricants in Tribology: Determination of wear volumes



Messung	Volumen
	x 10³ mm³
1	3,014
2	2,934
3	2,958
4	3,034
5	2,935
6	2,952
Mittelwert	
2,971	
Standardabweichung	
0,042	

Distances, Diameters, Edge-Postions: High lateral Resolution by Digital Image Processing

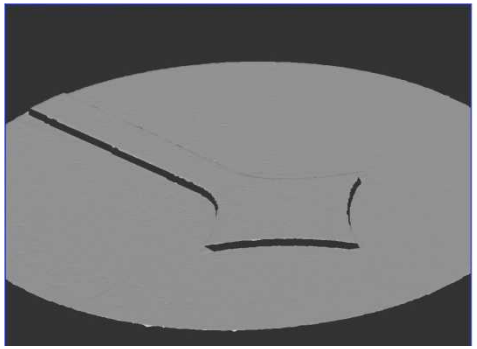




Lateral resolution in the micron range

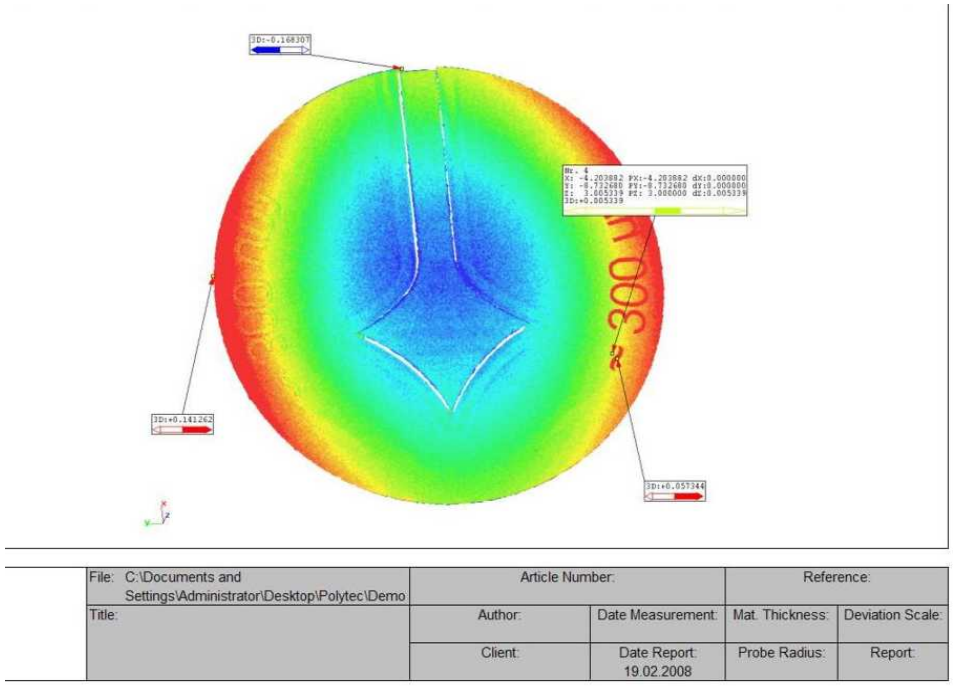
Very short measurement time

Reverse Engineering: Comparison between CAD-data and measured geometry



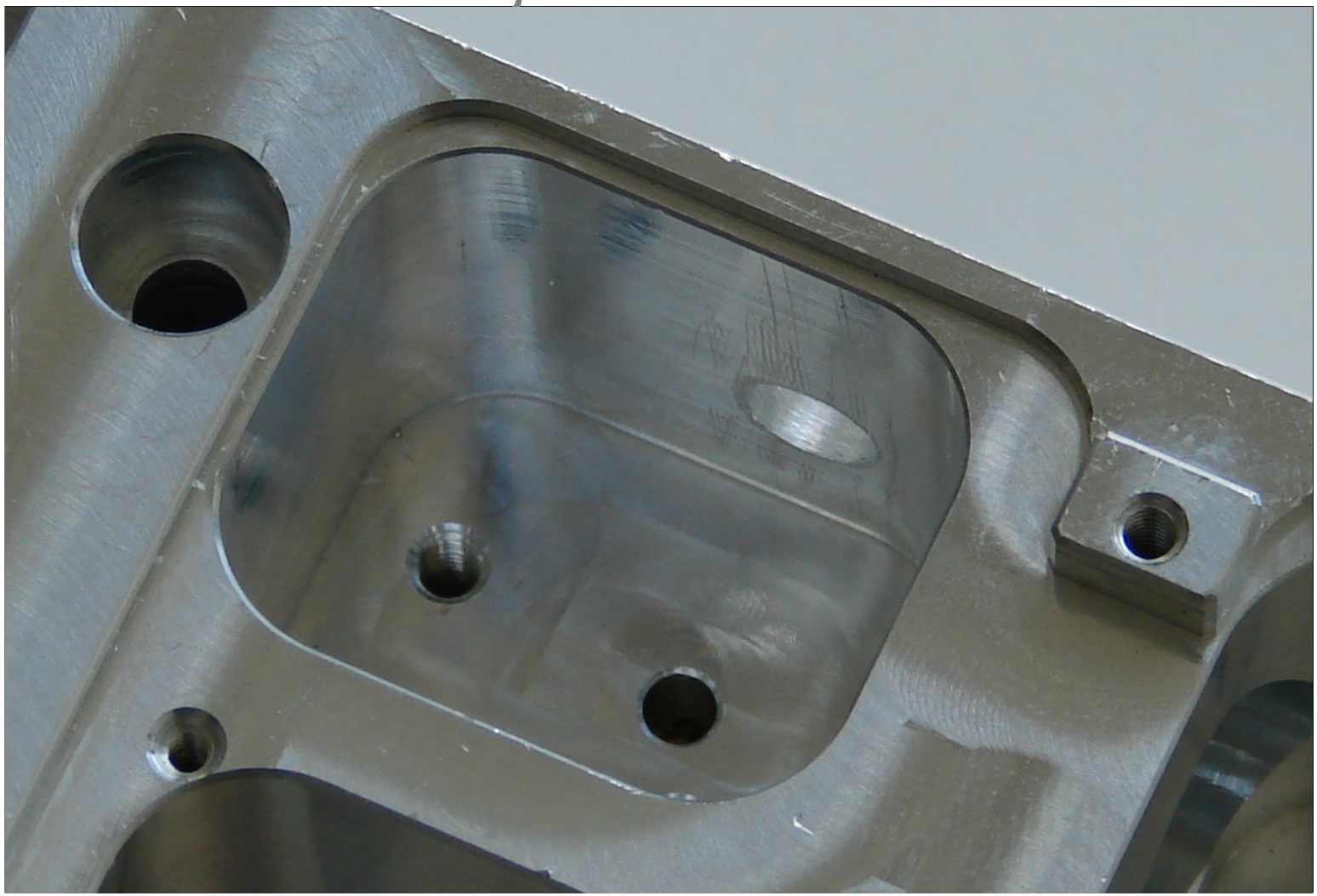
Measurement

CAD-data

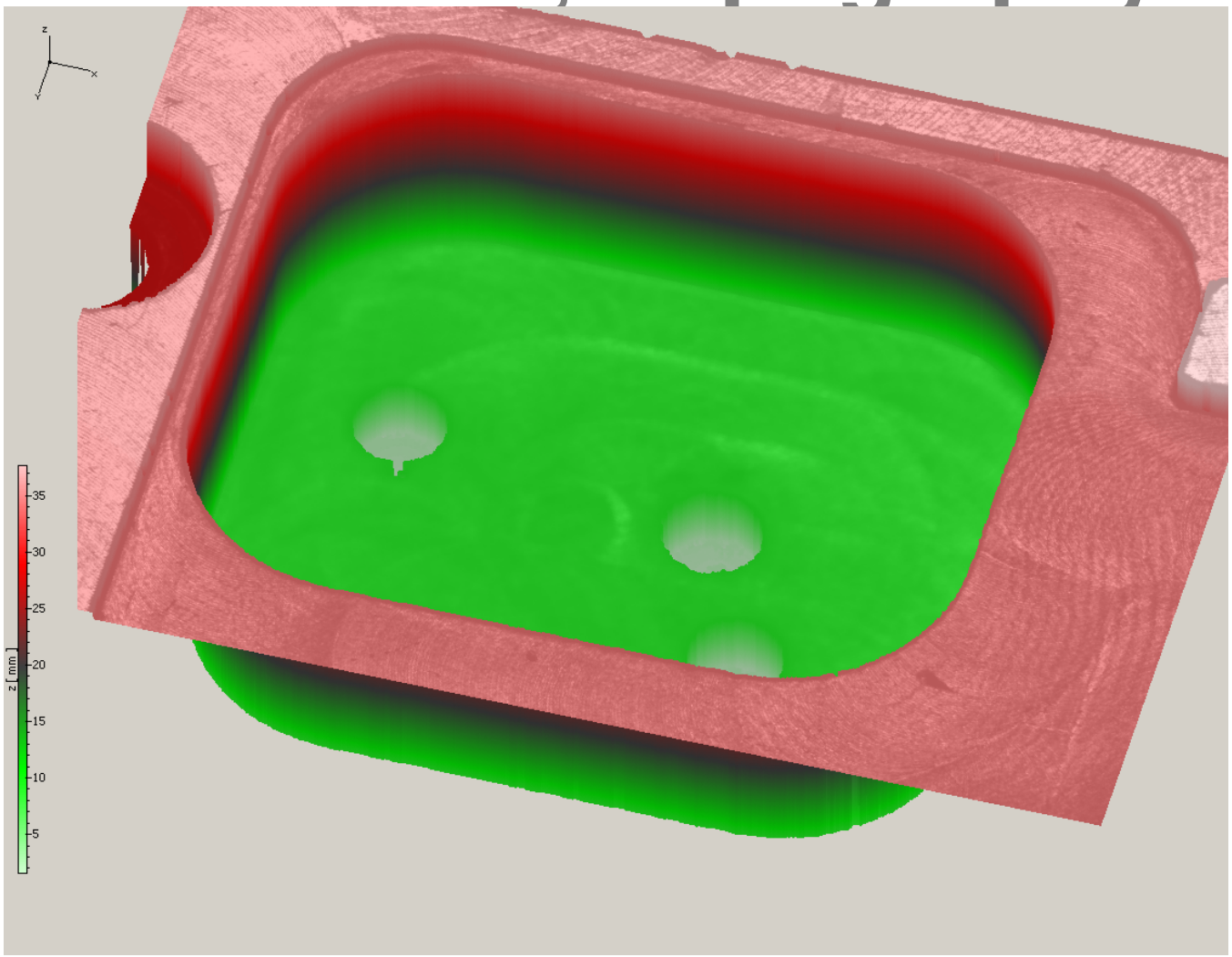


Deviation

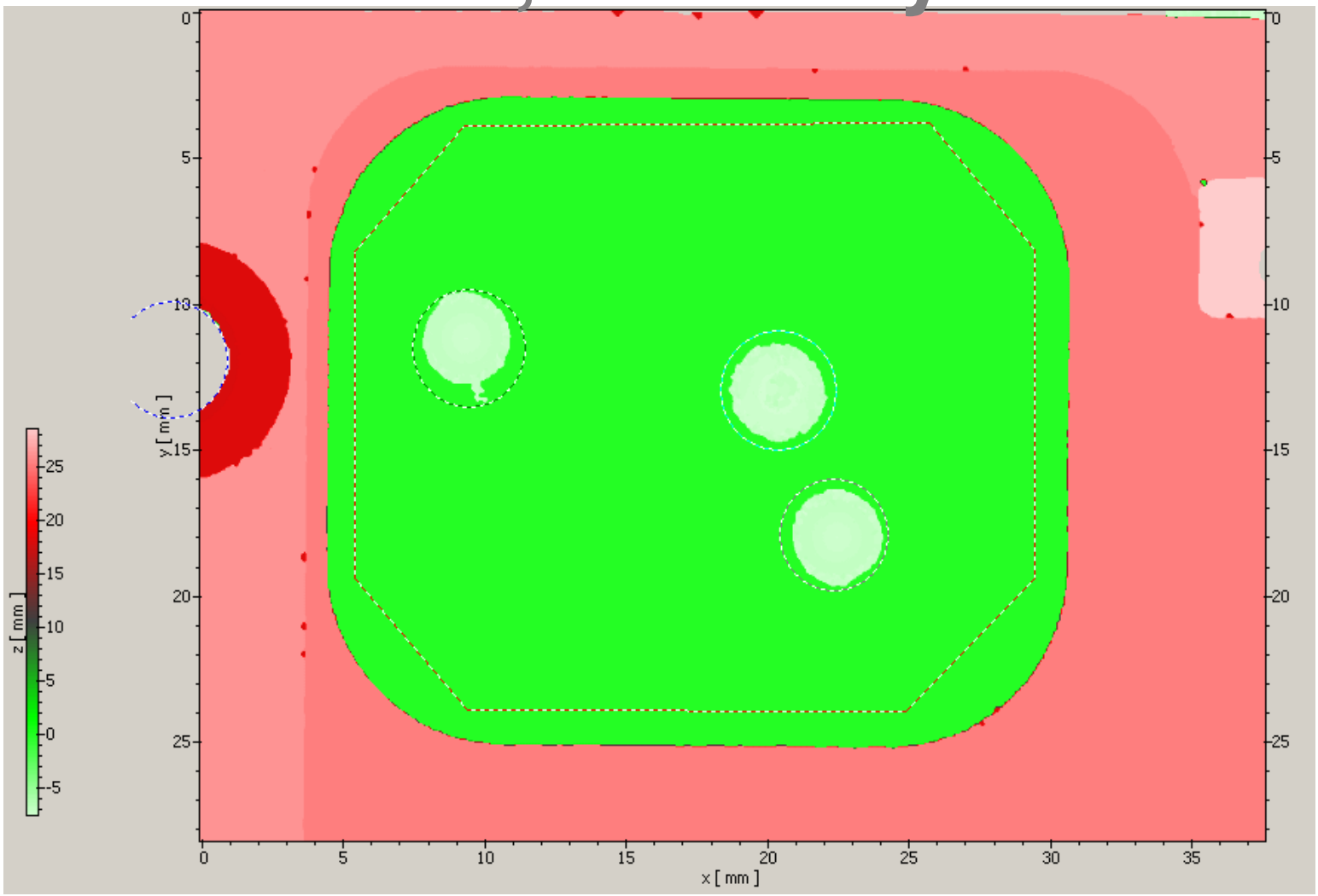
Milled Part, Photo



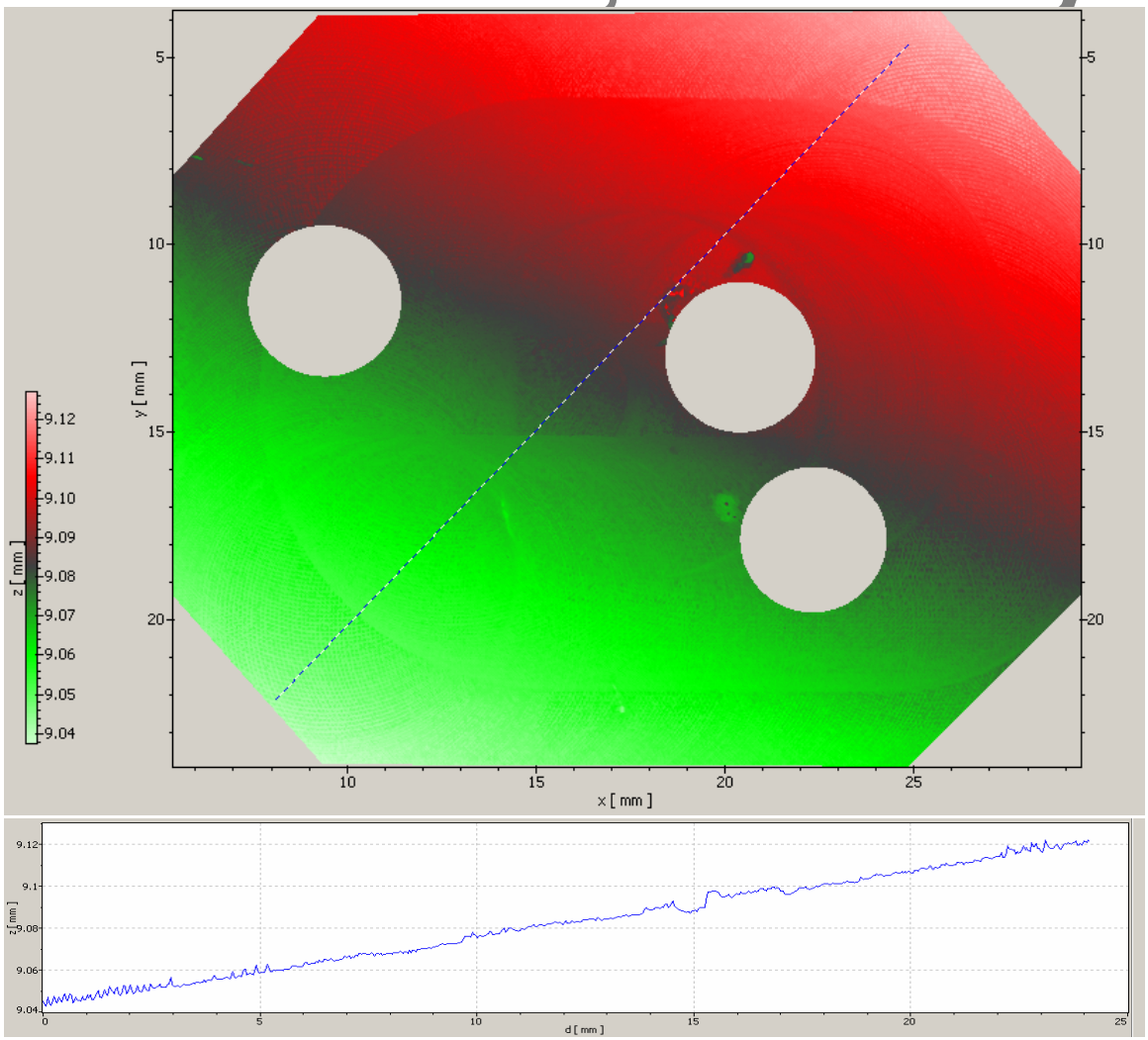
Milled item, Topography



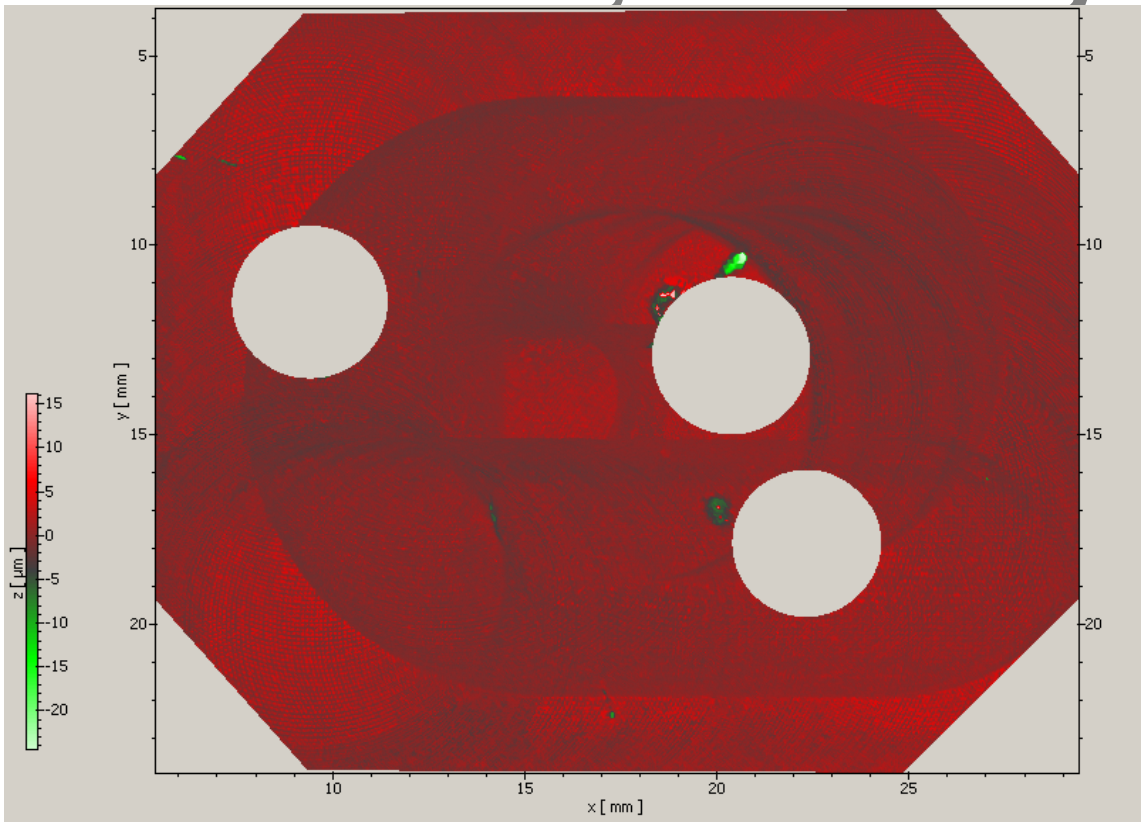
Milled Item, Planarity

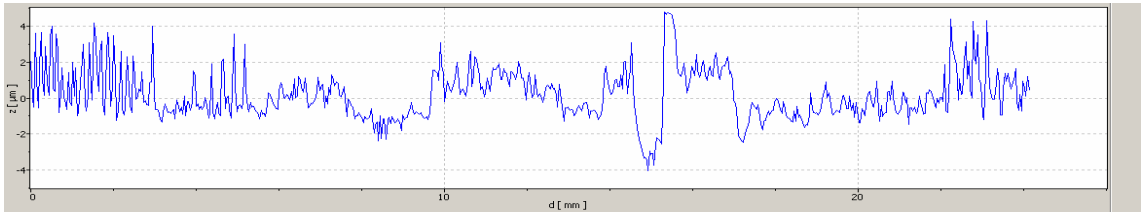


Milled Item, Planarity

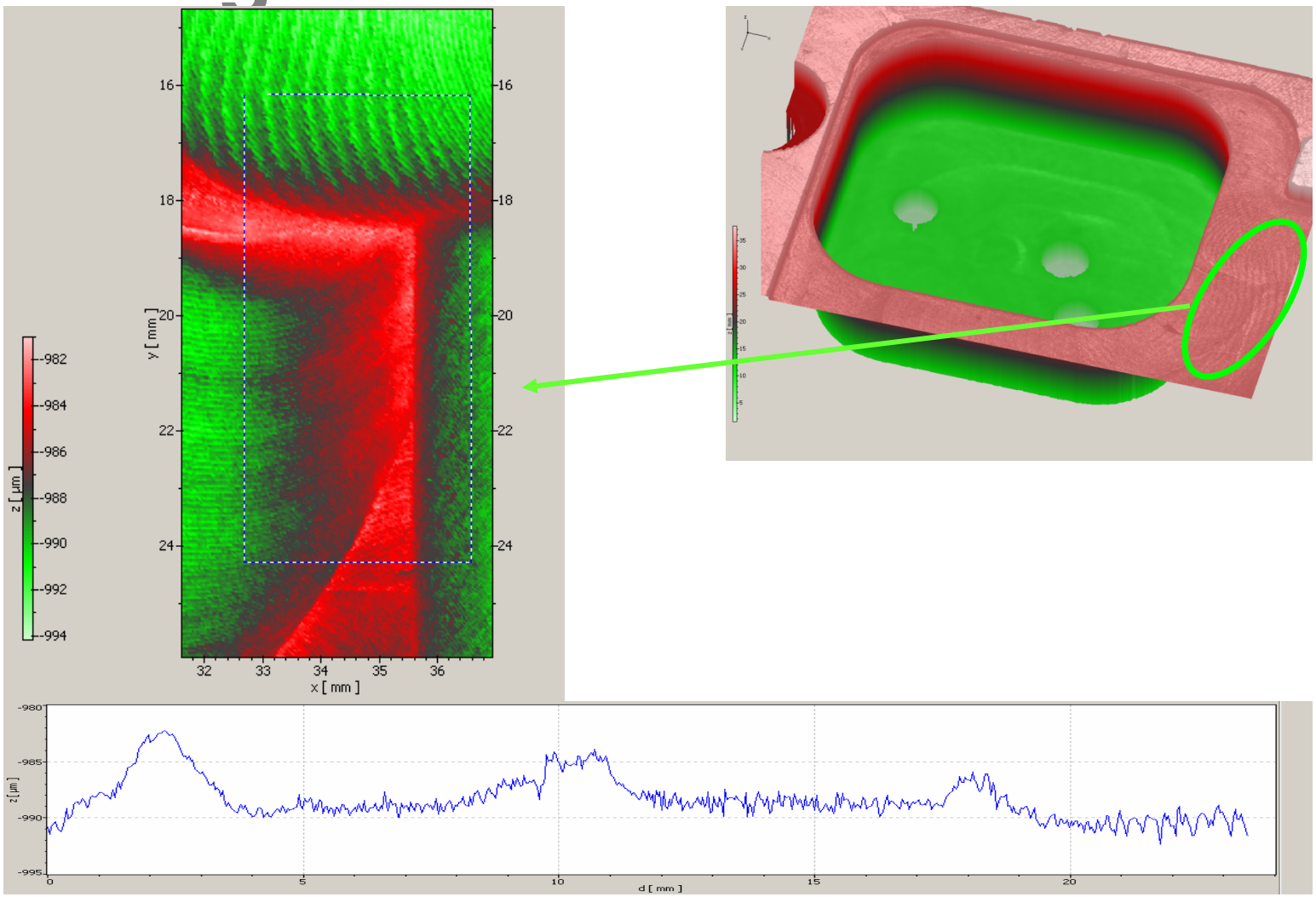


Milled Item, Planarity

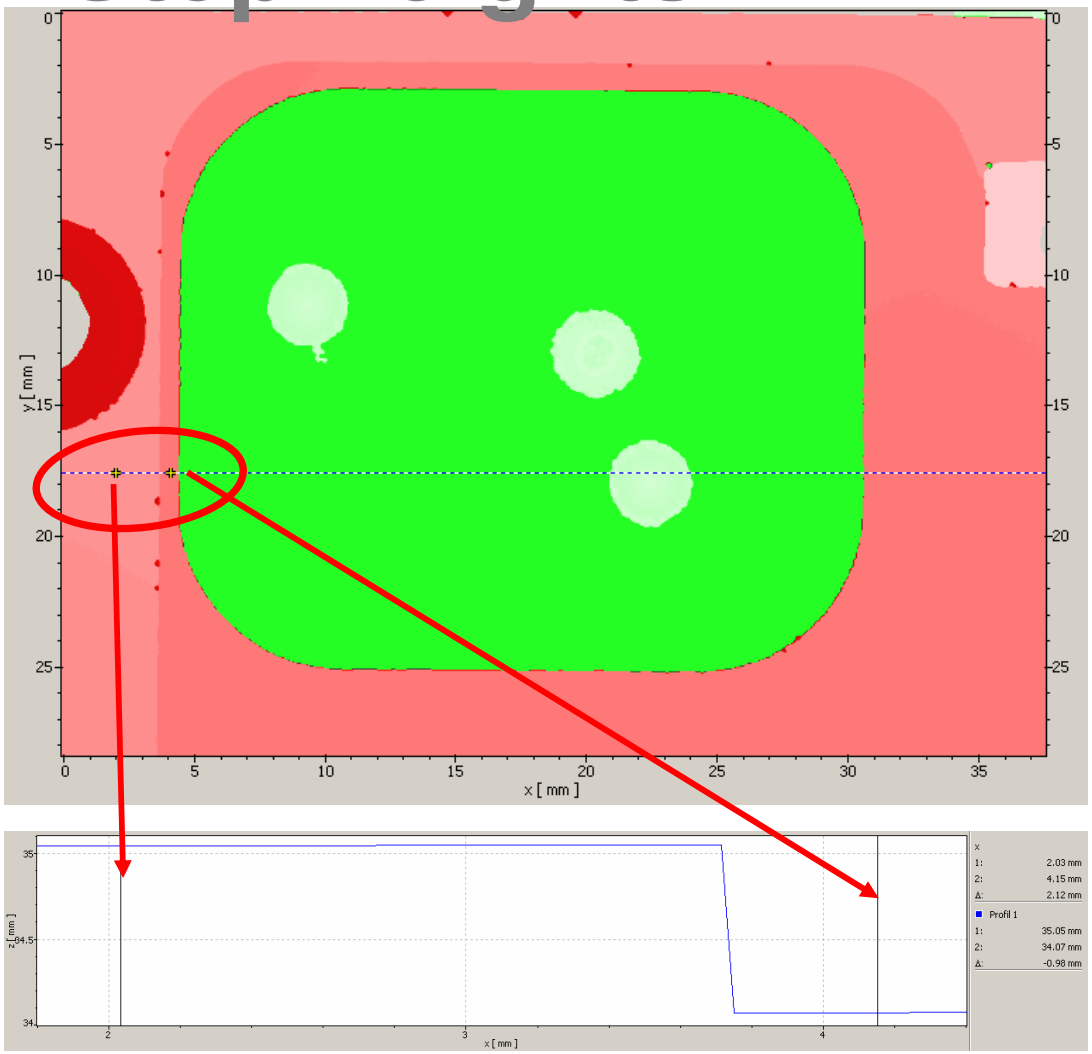




Roughness and Microstructure



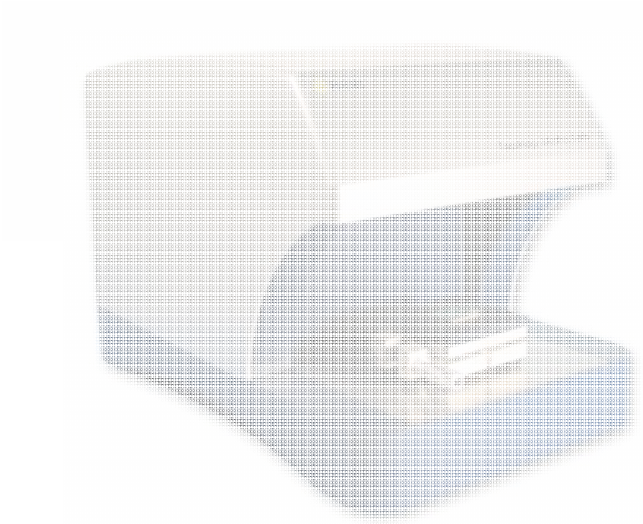
Step heights



The Systems

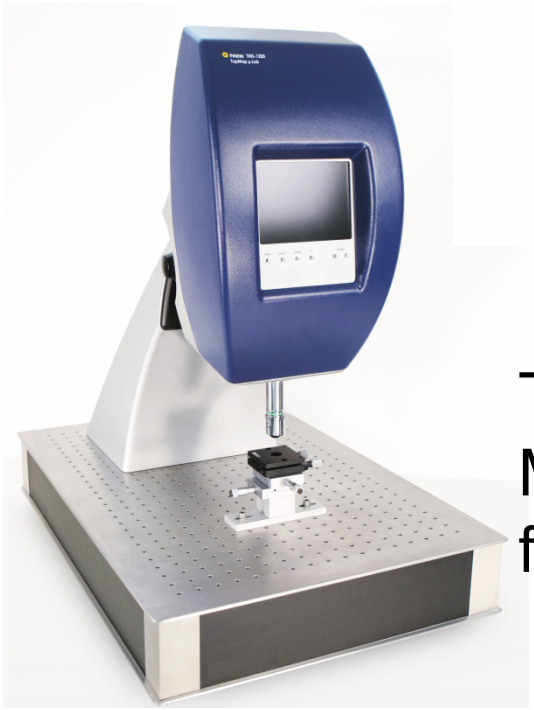
TMS 100:
Desktop Unit with the highest measuring volume: 30x40x70 mm
Axial Resolution: 20 nm

The Systems



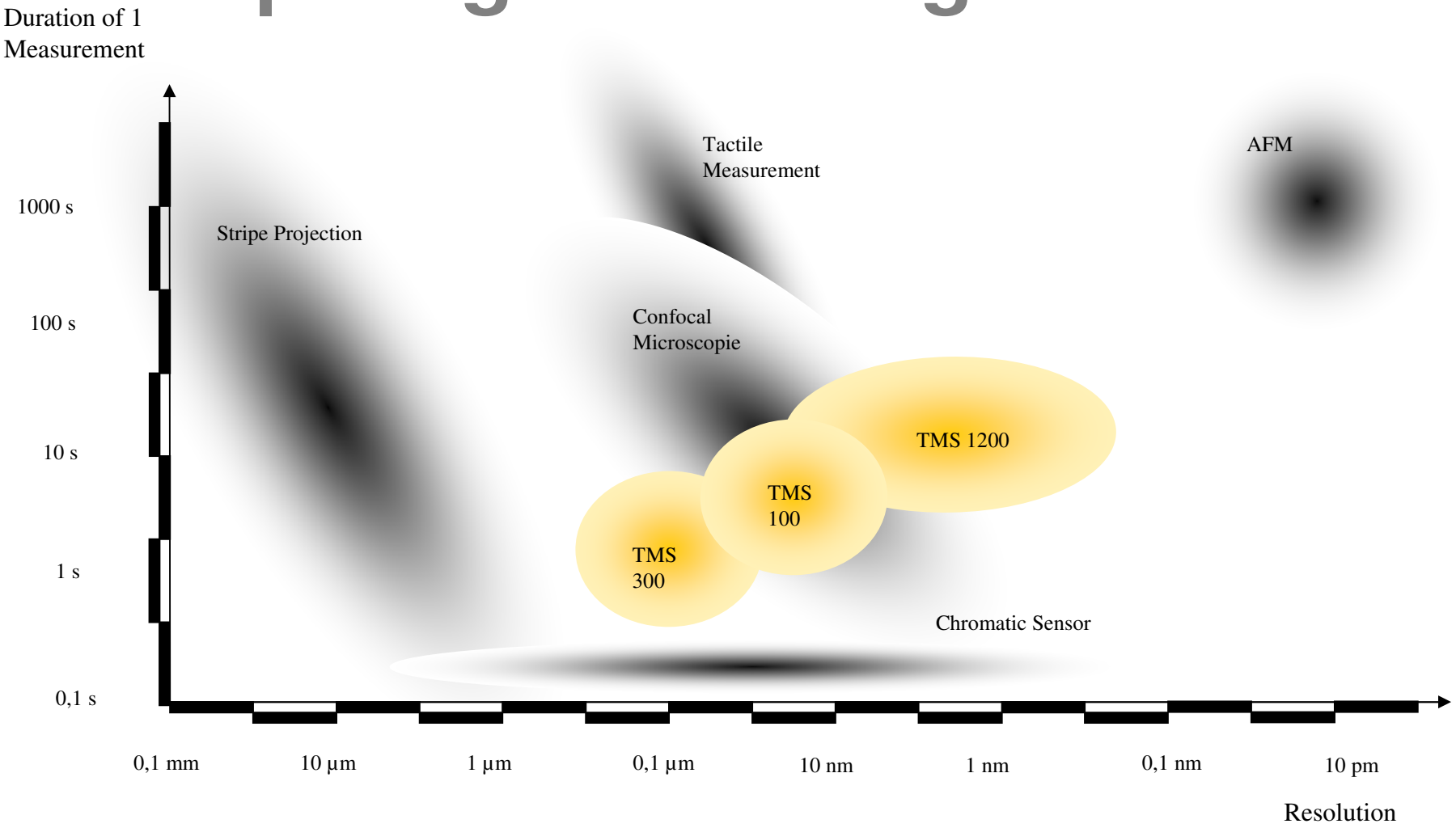
TMS 300:
Inline Unit for easy integration into test machines. Meas. Time: A few seconds
Field: 19 mm
Resolution < 40 nm

The Systems



TMS 1200:
Microscopic Setup
for highest resolution

Competing Technologies



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Now is the time to ask questions!