

The background features a technical illustration of an optical system. It shows a light source at the top left, with light rays passing through a series of lenses and mirrors. The rays are depicted as white lines against a blue, semi-transparent background. The overall design is clean and professional, typical of a technical presentation.

# **Optical Quality Control for Industry: Applicable in Laboratory up to Inline-Inspection**

Dr. Josef Frohn  
NanoFocus AG  
Oberhausen, Ettlingen

**founded in 1994**

**optical surface inspection:**  
development & production of  
**3D laser profilometer  $\mu$ scan<sup>®</sup> &**  
**3D confocal microscope  $\mu$ surf<sup>®</sup>**

**main markets:**  
**automotive, micro technology,**  
**medical, forensic, electronics,**  
**printig**

> 500 installed systems



NanoFocus AG  
HQ  
Oberhausen  
Germany



NanoFocus  
Sales  
Ettlingen  
Germany

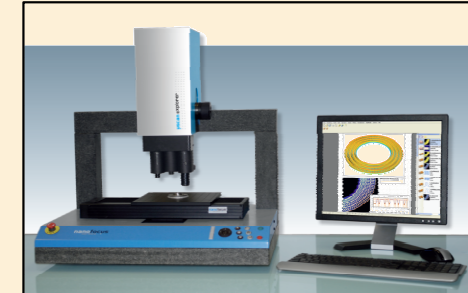
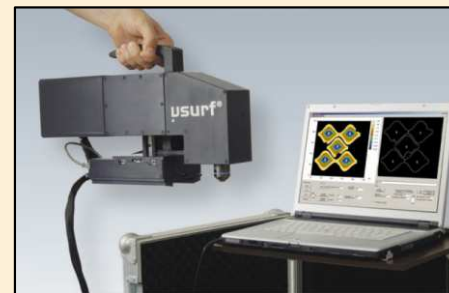


NanoFocus Inc.  
Glen Allen, VA USA

# Product Range

## Standard products

( $\mu$ surf explorer,  $\mu$ surf mobile,  $\mu$ scan explorer)



## Customized systems

( $\mu$ surf custom,  $\mu$ scan custom,  $\mu$ sprint custom)



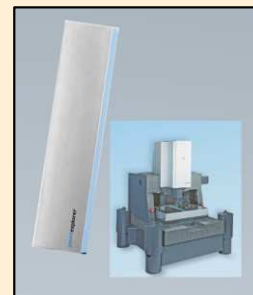
## Business solution

( $\mu$ surf solar,  $\mu$ surf cylinder,  $\mu$ surf blade etc.)



## Integration

( $\mu$ surf OEM,  $\mu$ scan OEM,  $\mu$ sprint OEM)



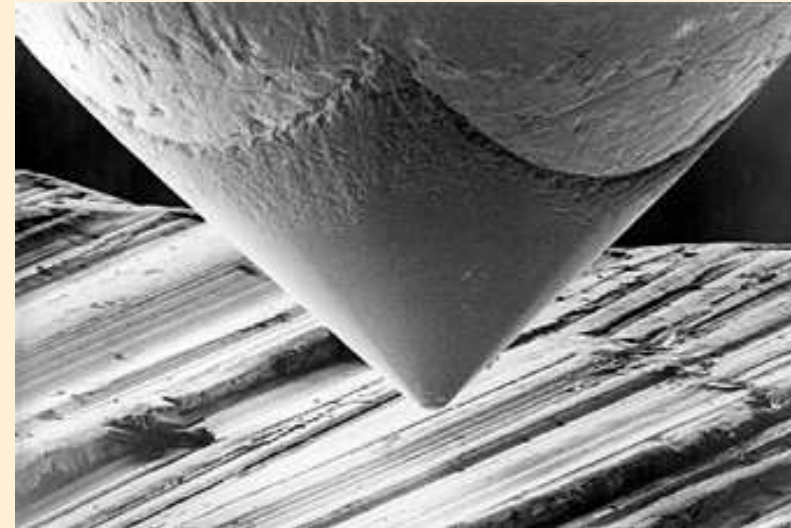
# Conventional Surface Measurement



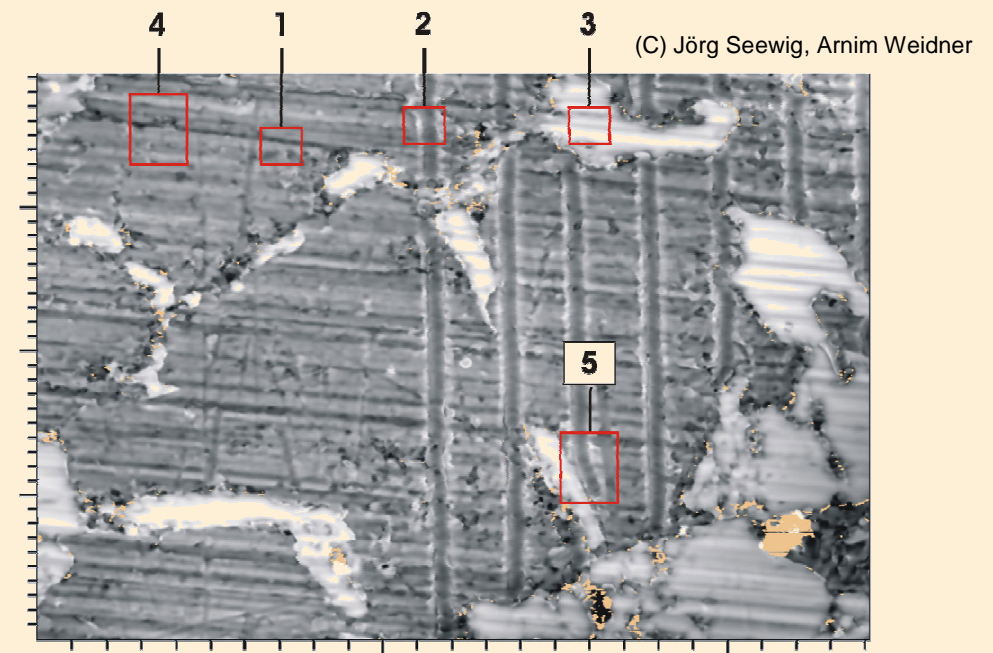
## stylus profilometer

according to DIN/ISO standards,  
but

- touching, sometimes destructive
- 3D measuring awkward to do
- fragile setup
- slow
- wear of probe (costs!)



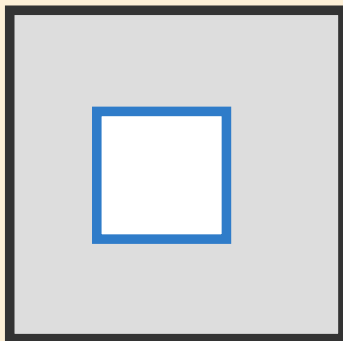
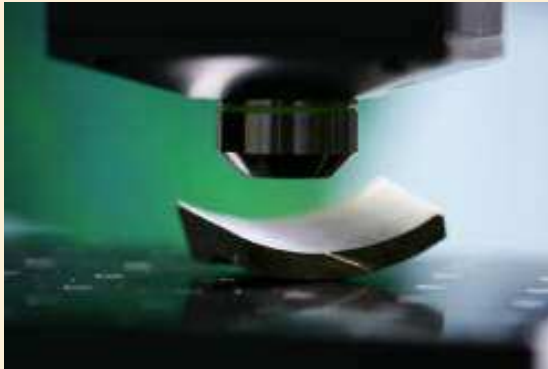
diamond tip on sheet metal (Dr. Hillmann, PTB)



# Product Categories

## $\mu$ surf®

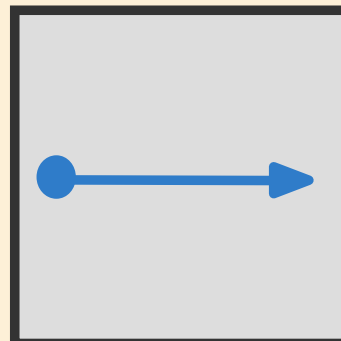
3D-Microscopy



- 3D-Structure
- Wear
- Tribology

## $\mu$ scan®

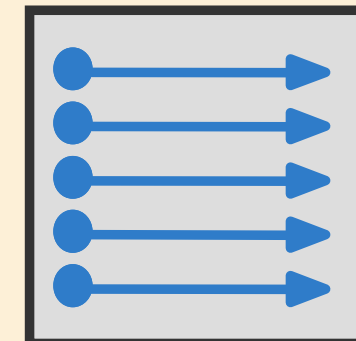
2D-Profilometry



- 2D-Shape
- Roughness

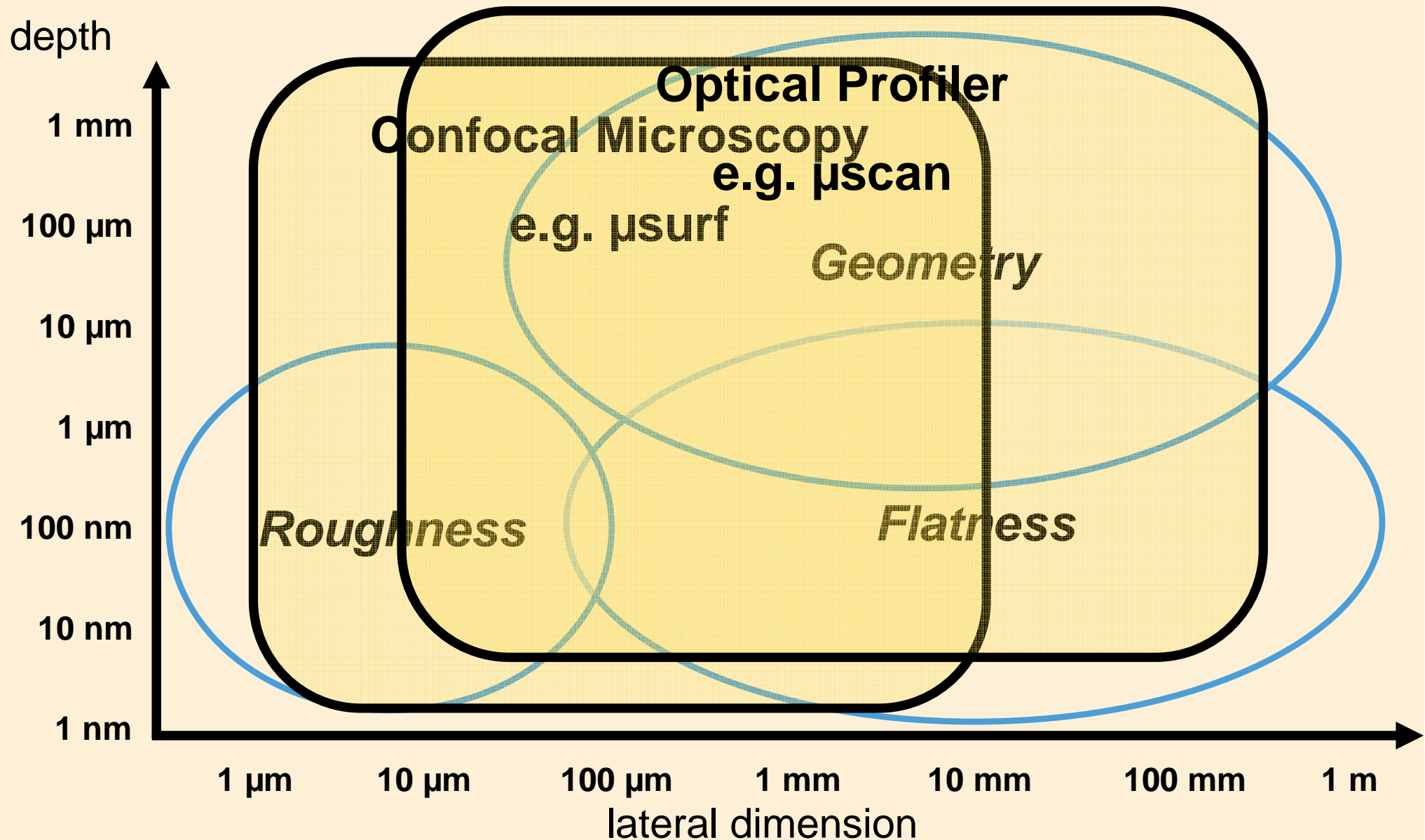
## $\mu$ sprint®

3D-Profilometry

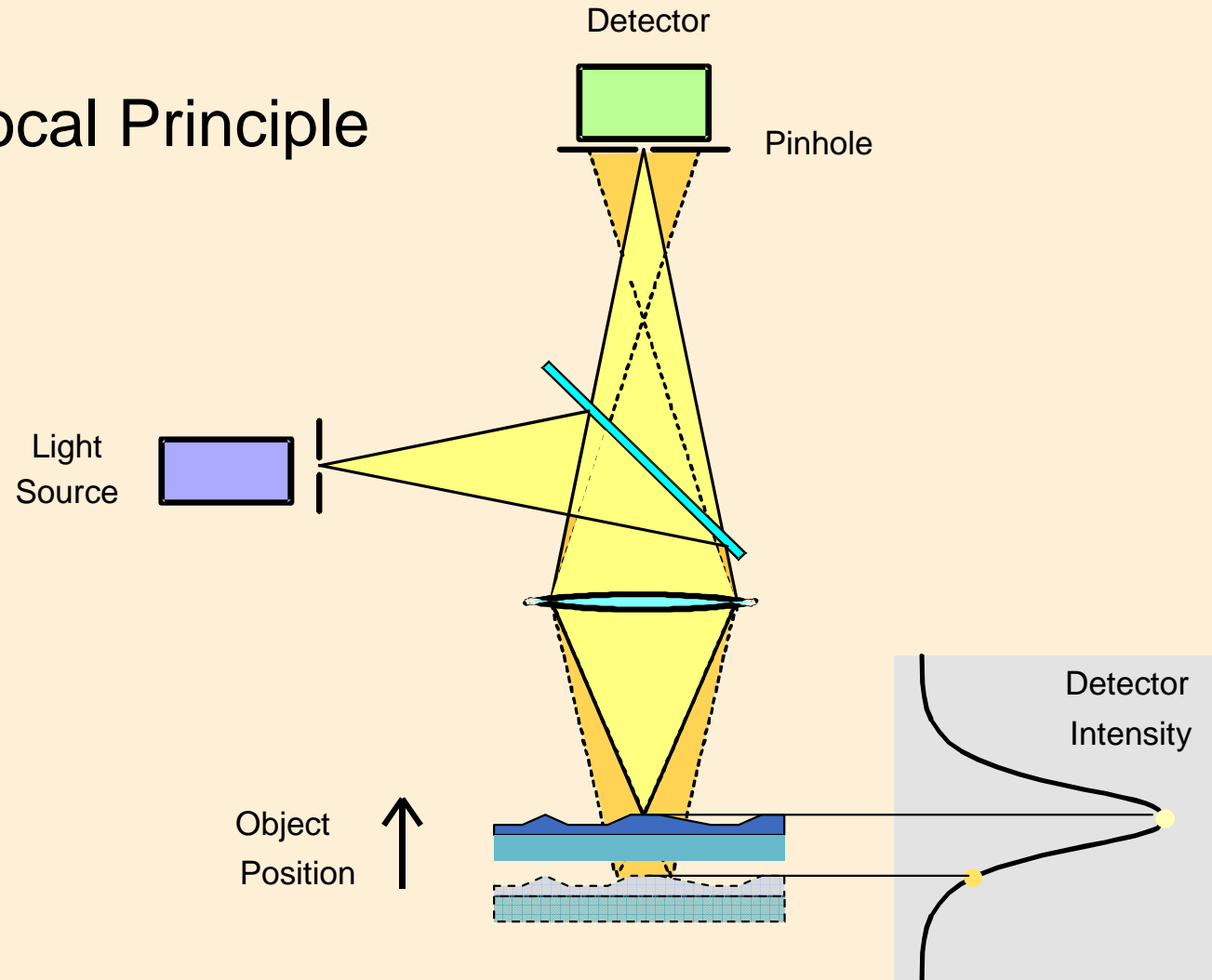


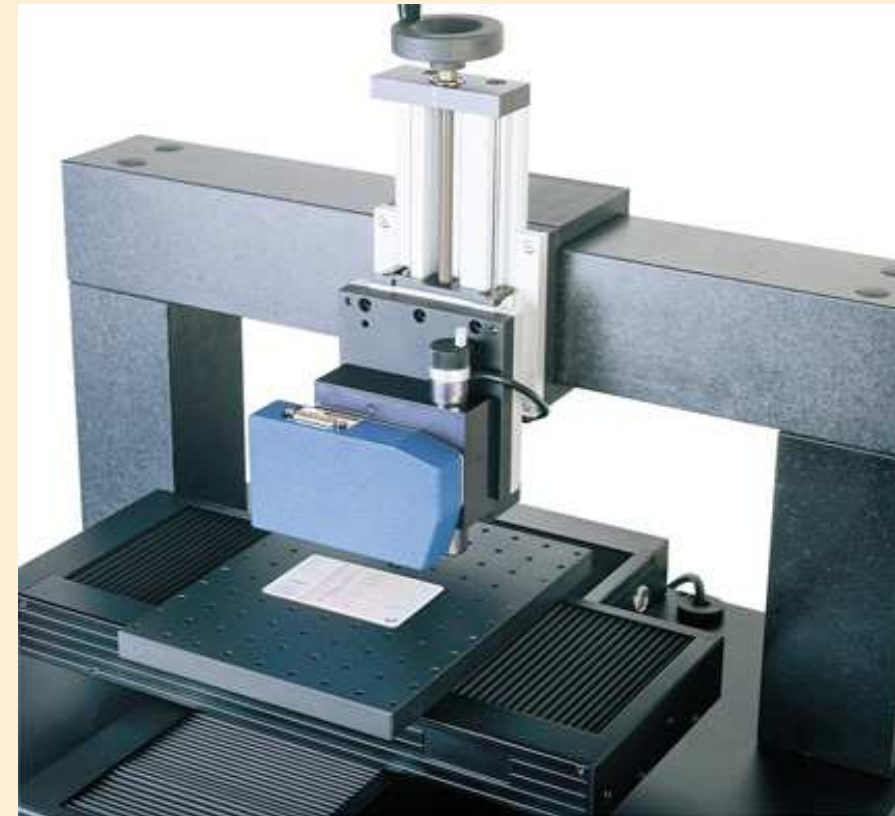
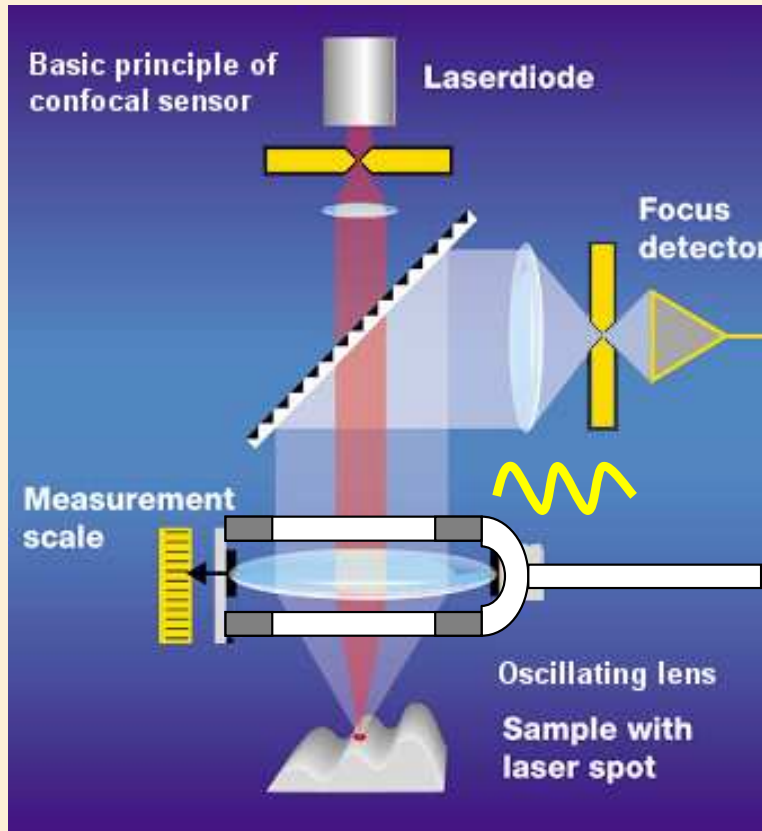
- 3D-Shape
- Defects
- Production Control

# Range of Application



## ► Confocal Principle





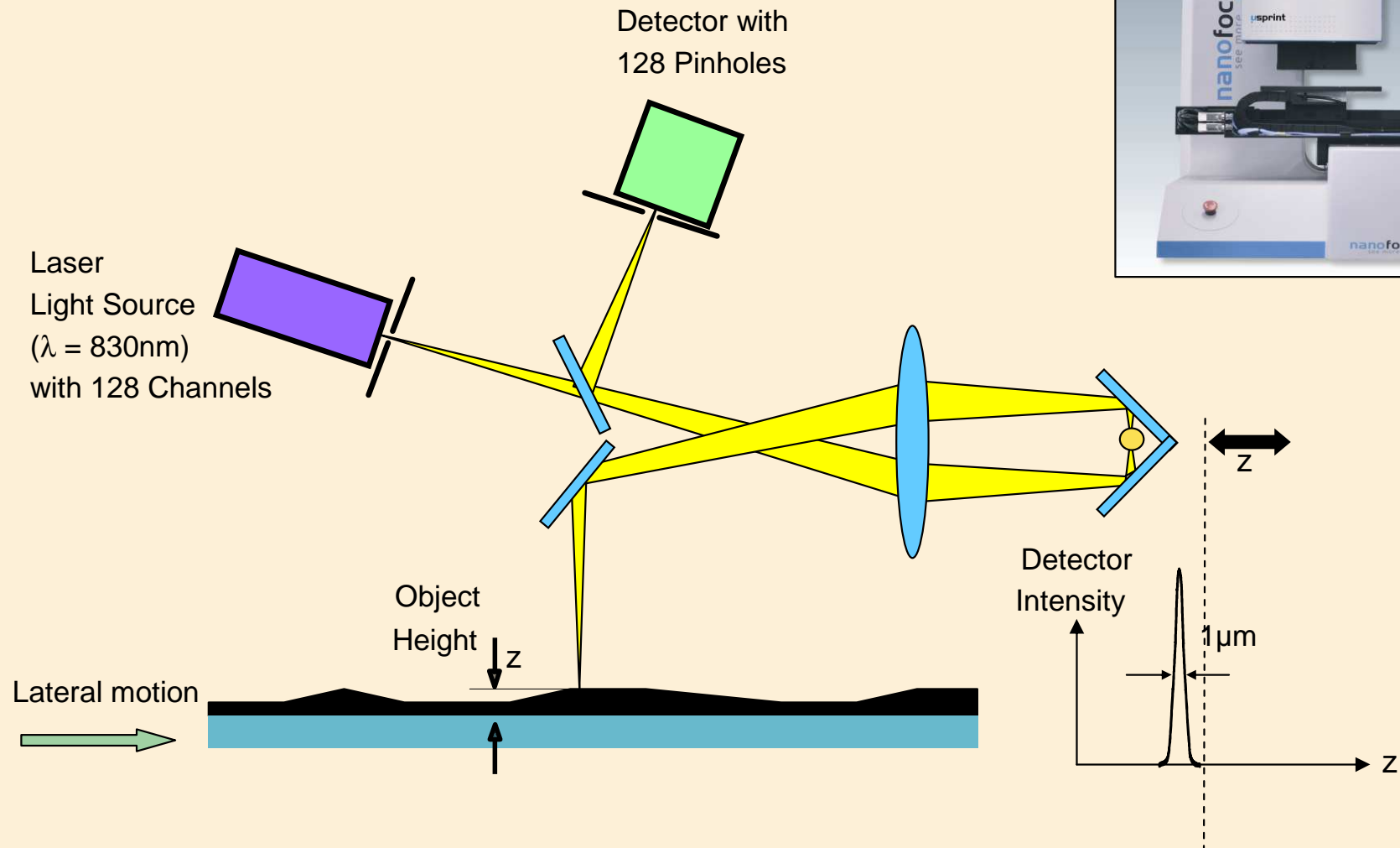
**Confocal Point Sensor**

**Scanning Profilometer  $\mu$ scan with offset camera**

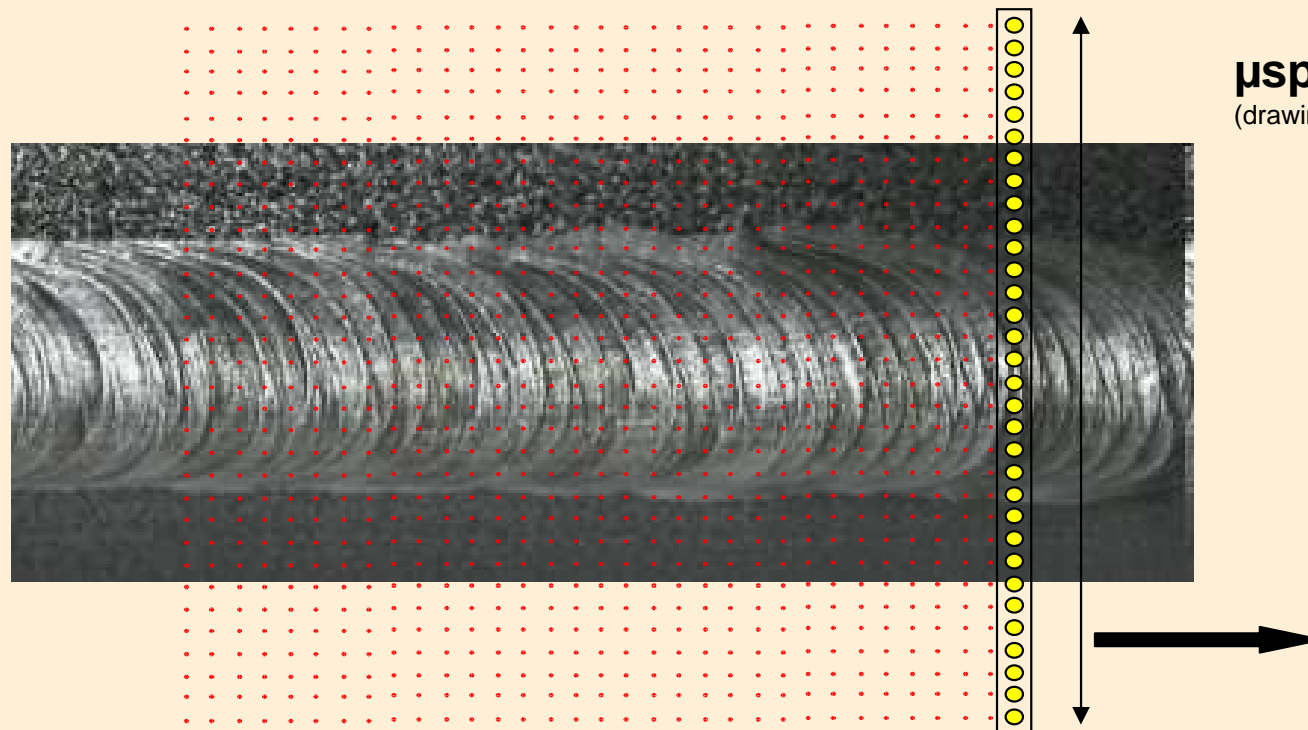
Scanning by means of multi profile measurements with point sensors:  
autofocus, chromatic whitelight, confocal point, holographic



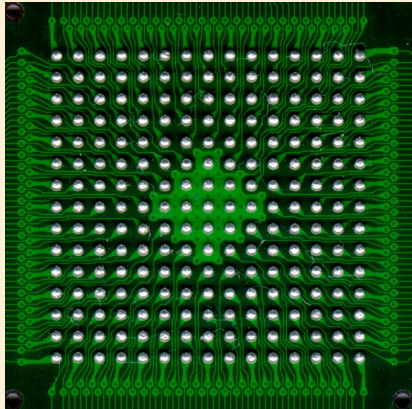
# Technology $\mu$ sprint



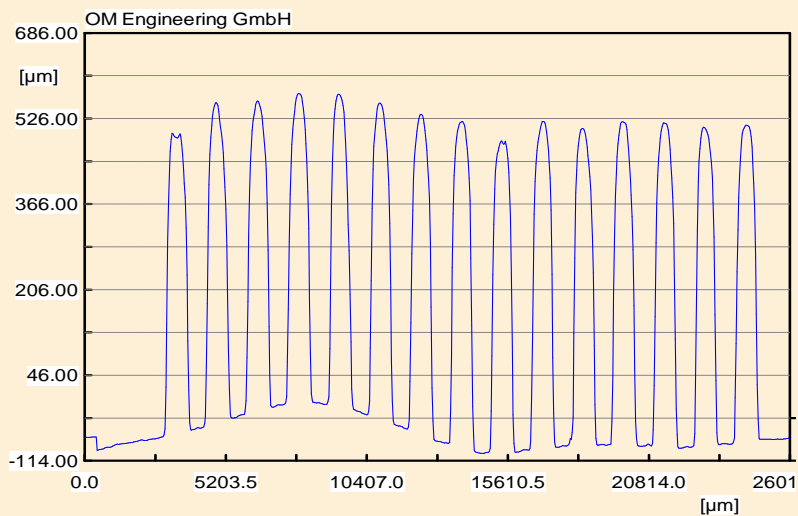
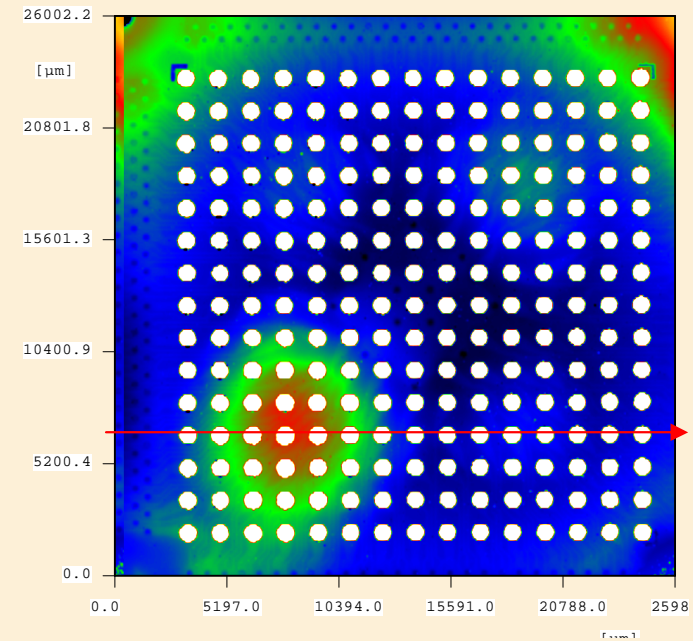
- ▶ 128 parallel channels
- ▶ scanning speed 54mm/s
- ▶ spot diameter 1μm



**μsprint Scanning Principle**  
(drawing not true to scale)

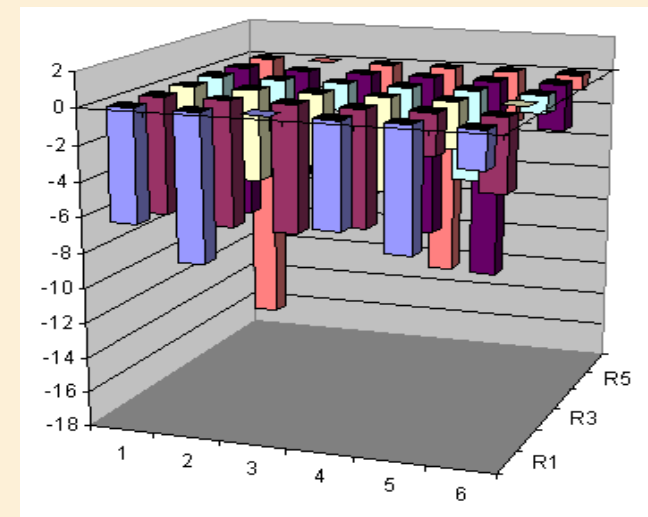


## Warpage

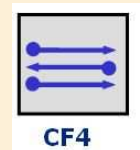
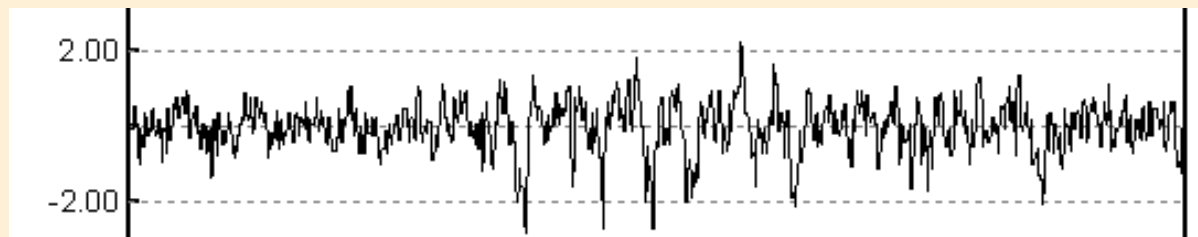
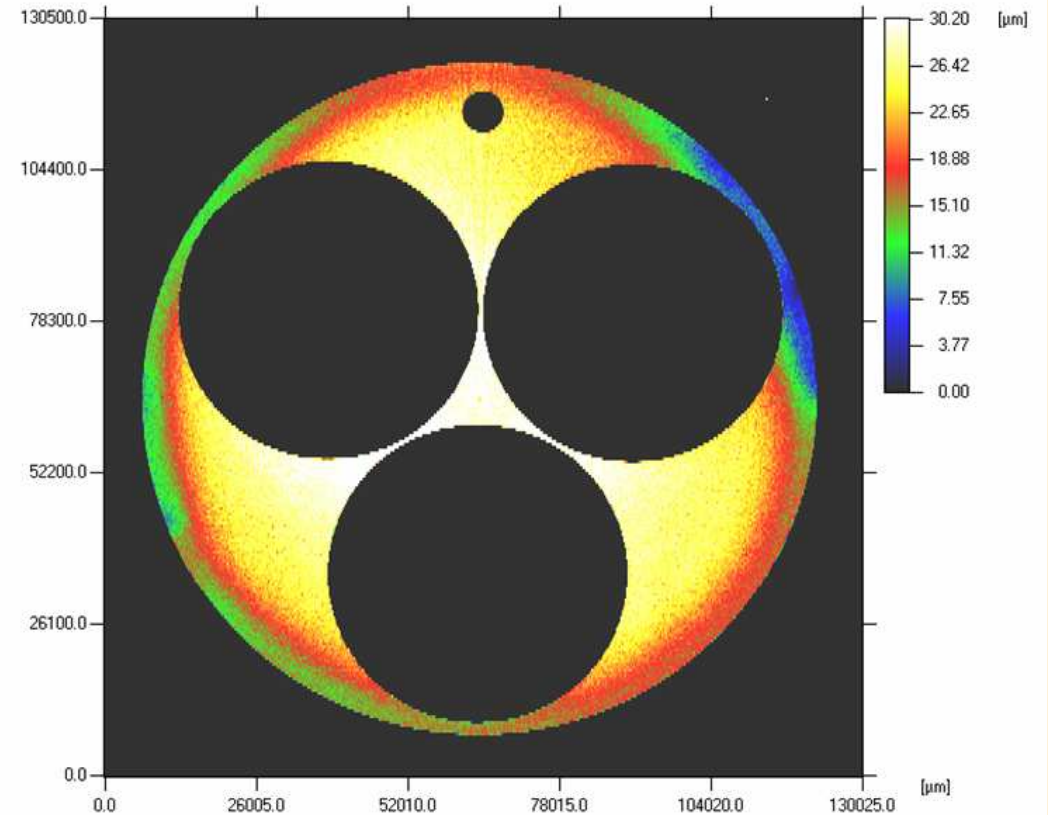
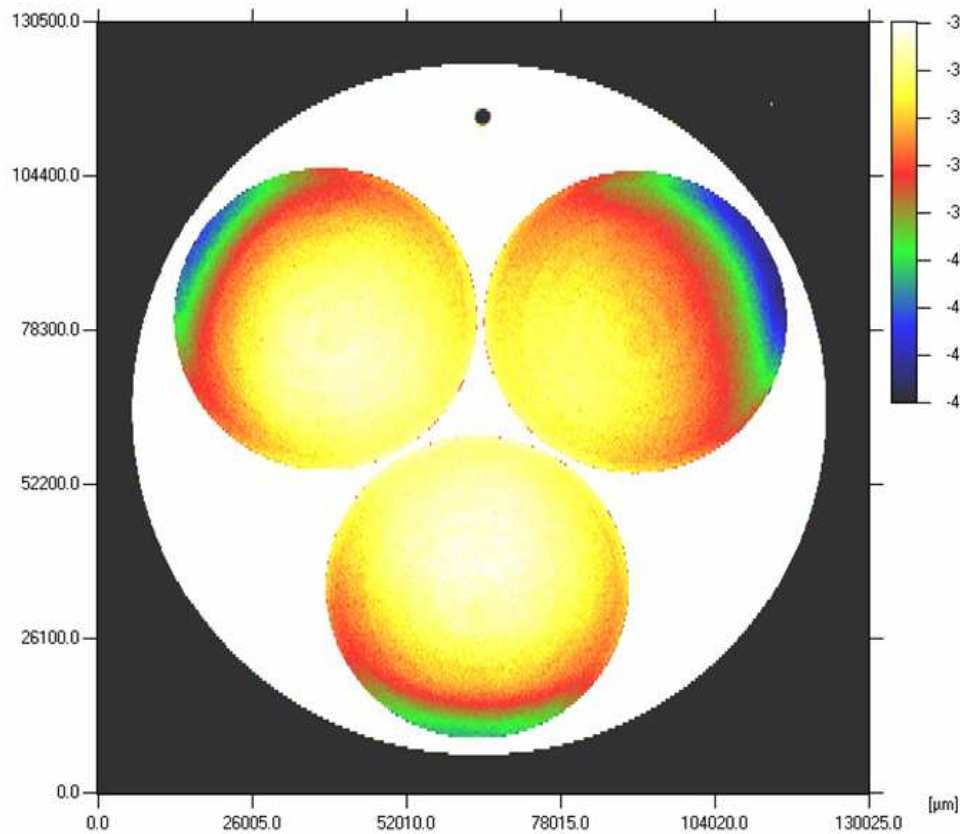


## 2D Profile

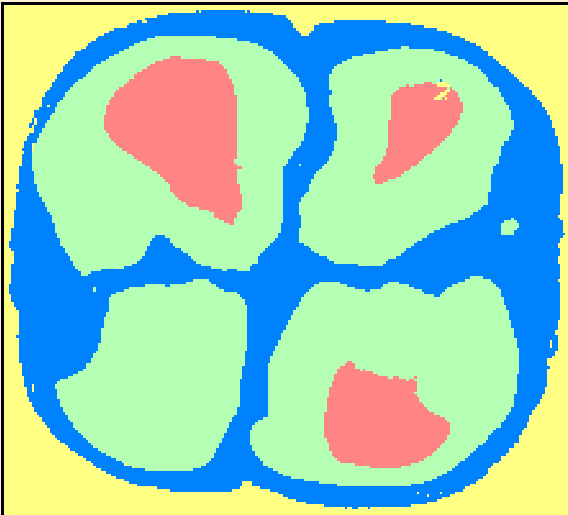
## Co-planarity



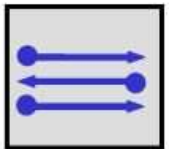
# Wafer Carrier



# Tooth Crown



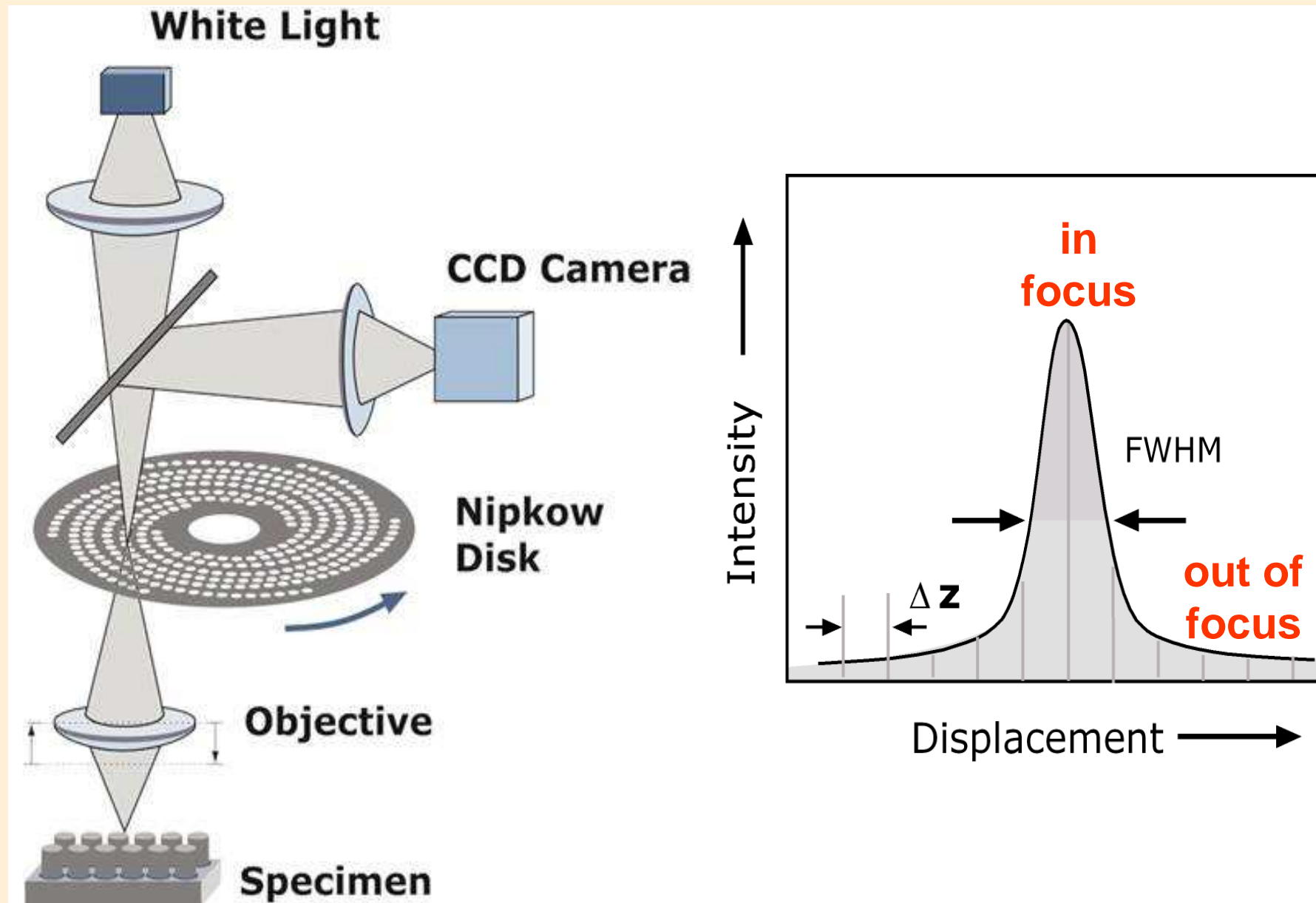
	Blue	Green	Red
Area (%)	33.6	53.3	13
Volume of material (%)	92.6	36.5	4.66
Mean thickness of material (mm)	1.37	0.213	0.0193



CF4

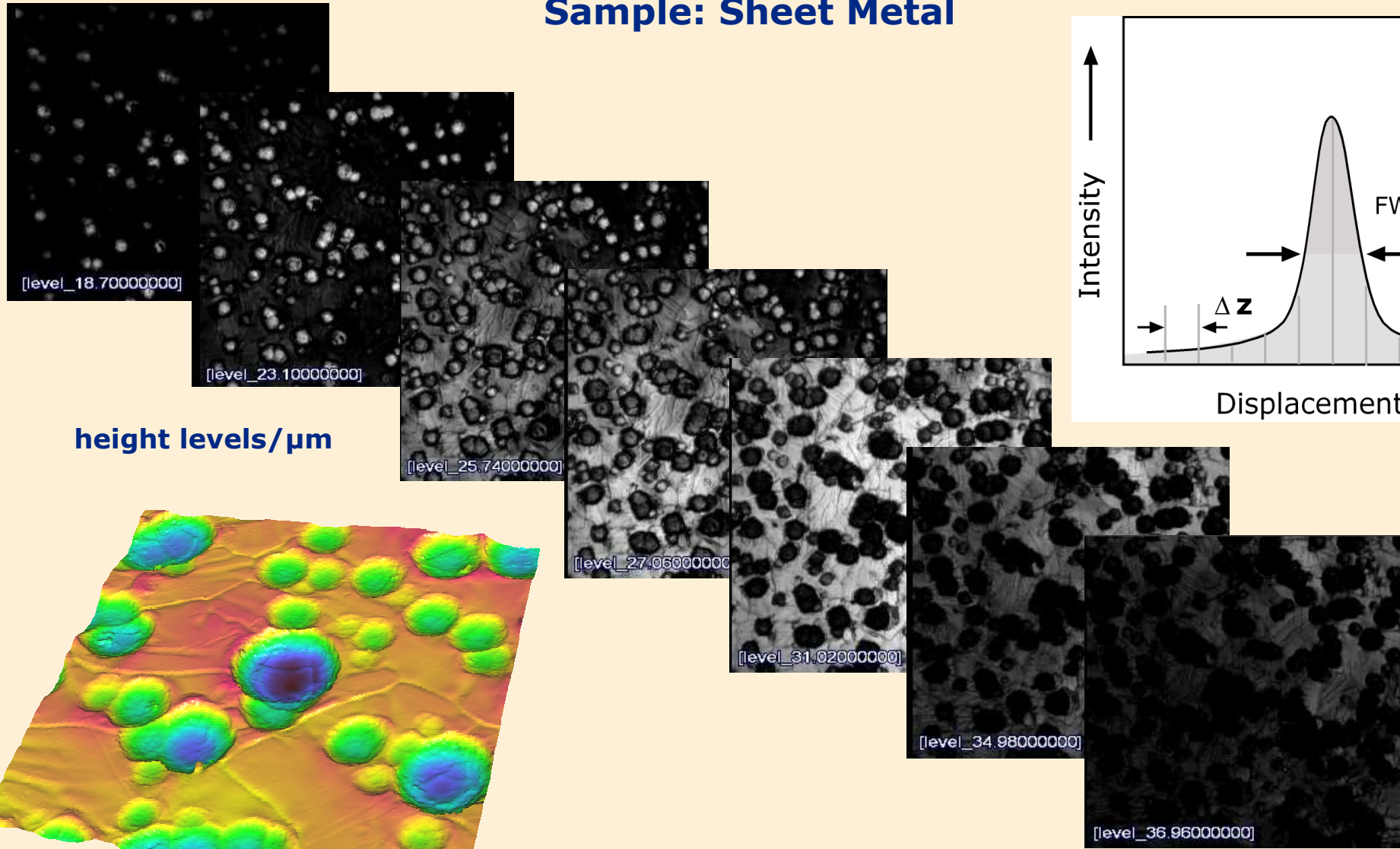
evaluation of wear

# Confocal Principle

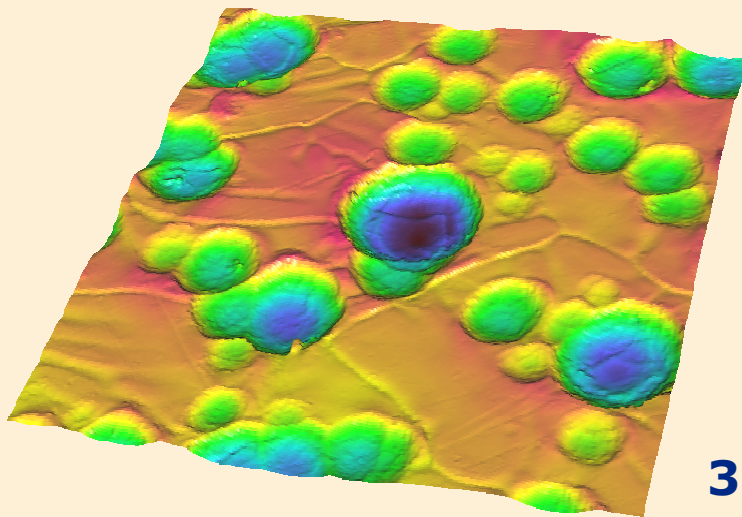
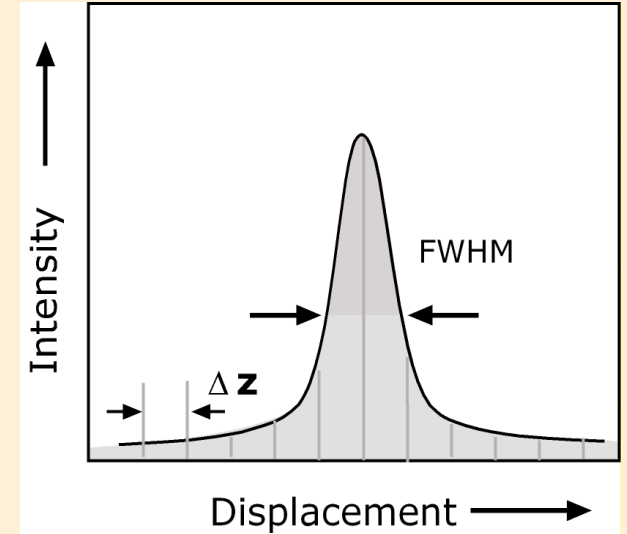


# Confocal Imaging Sequence

## Sample: Sheet Metal

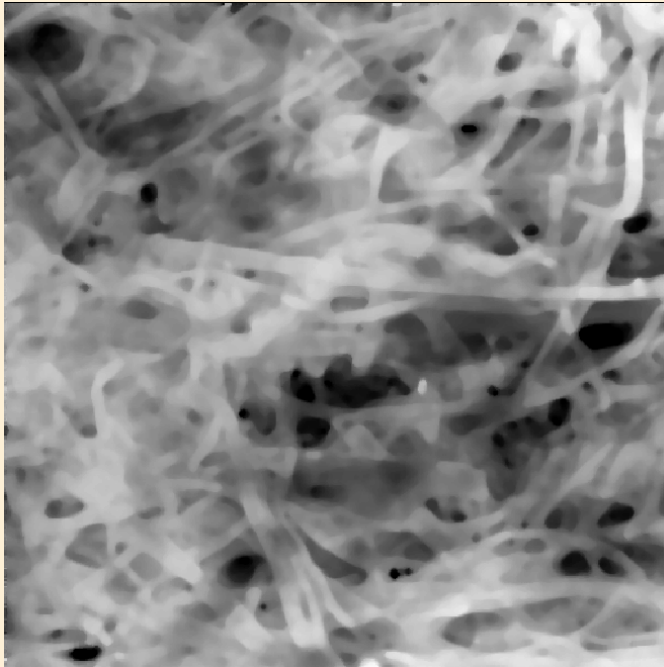


height levels/ $\mu\text{m}$



3D View

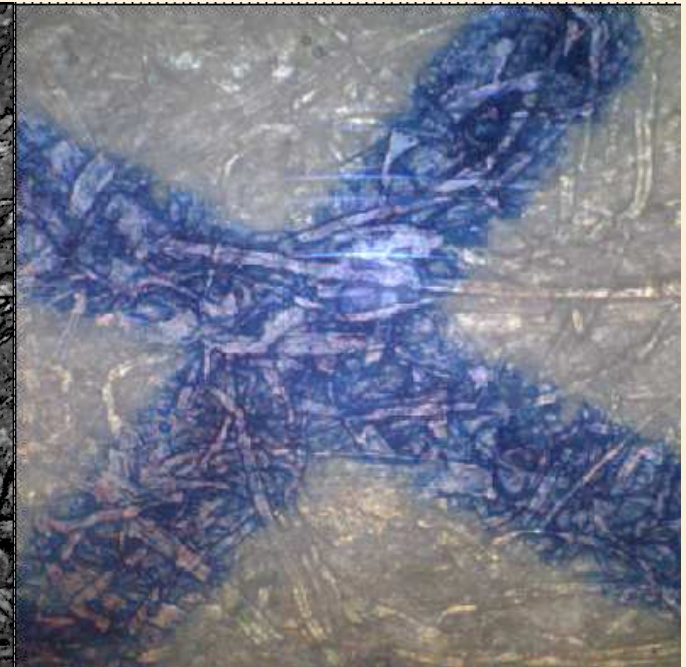
# Topo – reflection – color



**height - CFM**

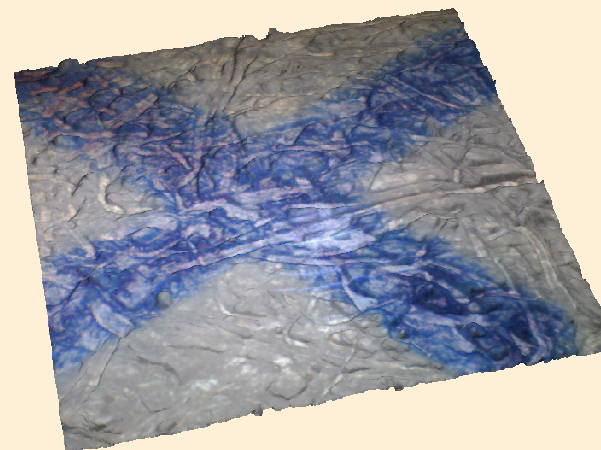


**reflection - CFM**



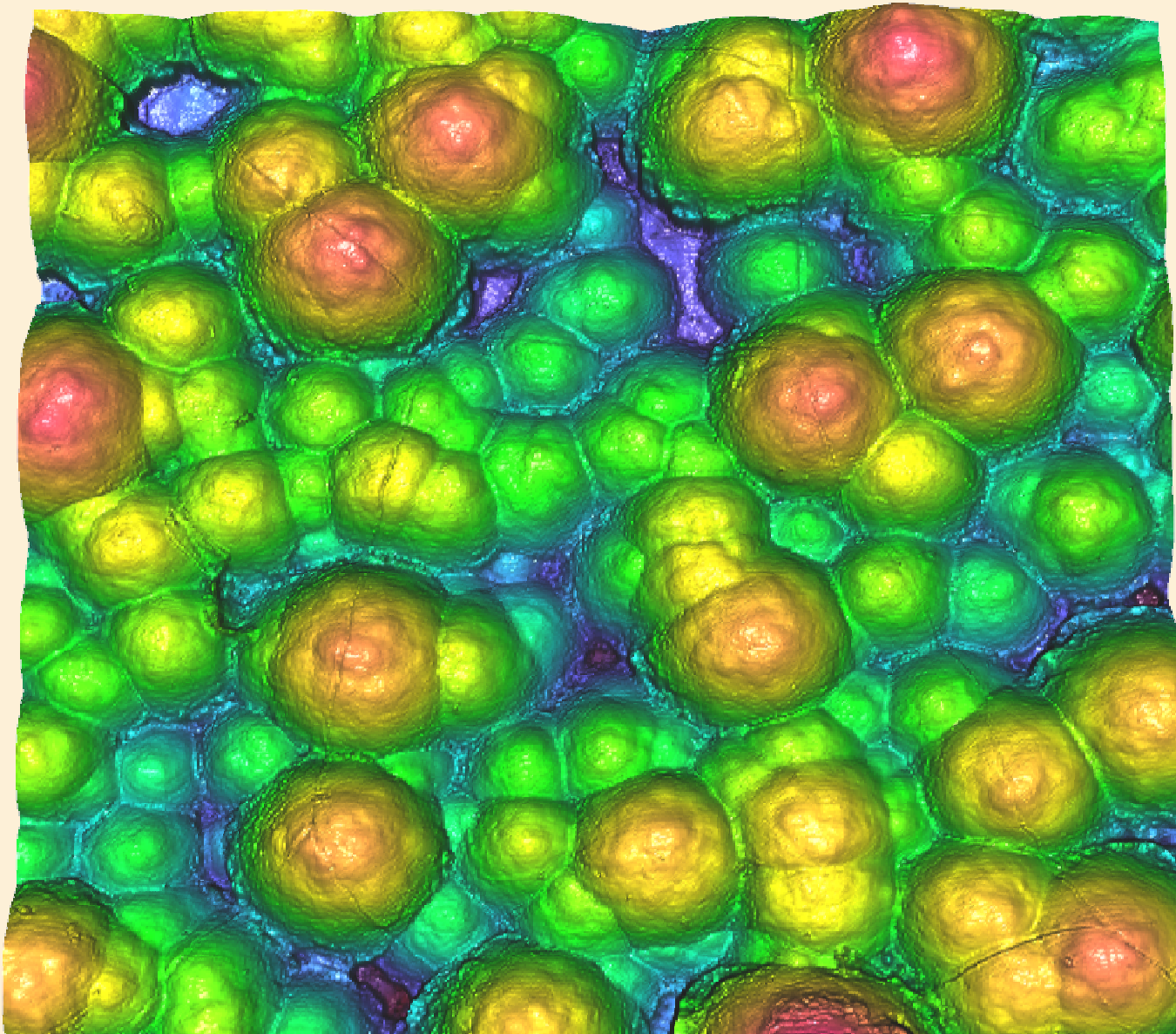
**reflection - brightfield**

800S





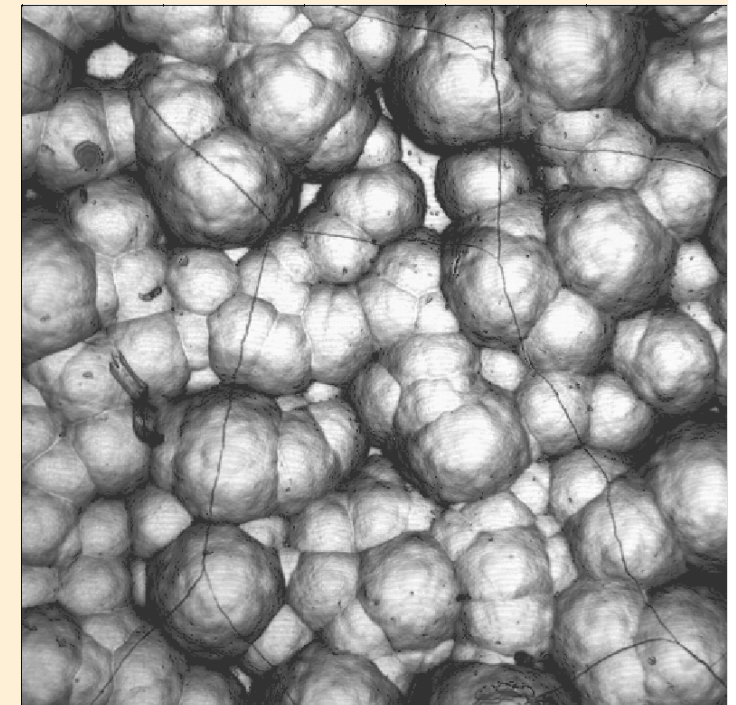
# Result: Steel Production Roll



Topocrome

160S /  $\Delta Z=13\mu\text{m}$

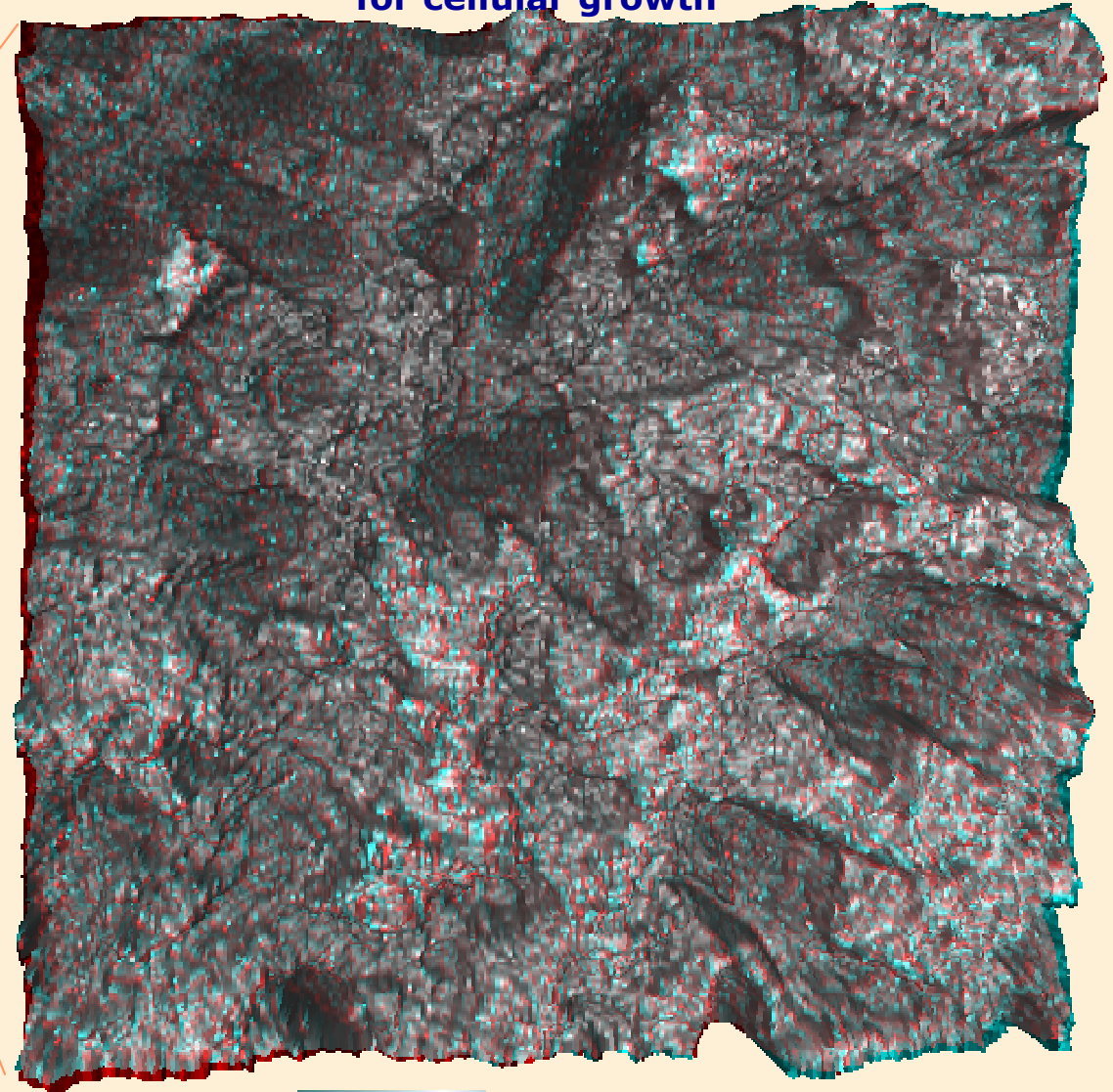
Reflection



## Dental Implants



optimized surface structure  
for cellular growth



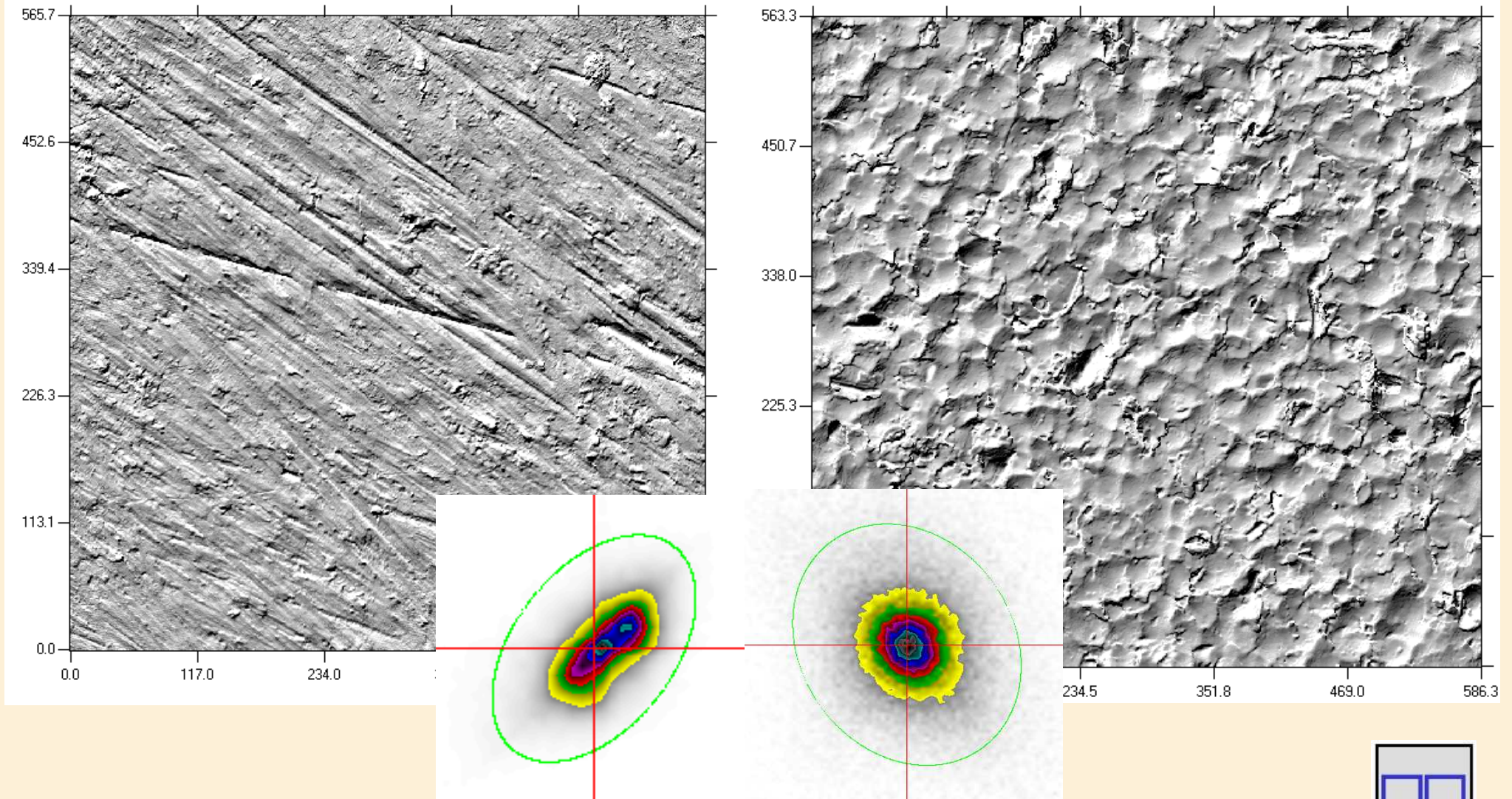
## Artificial hip joints



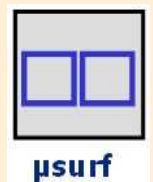
3D

320 x 320  $\mu\text{m}^2$

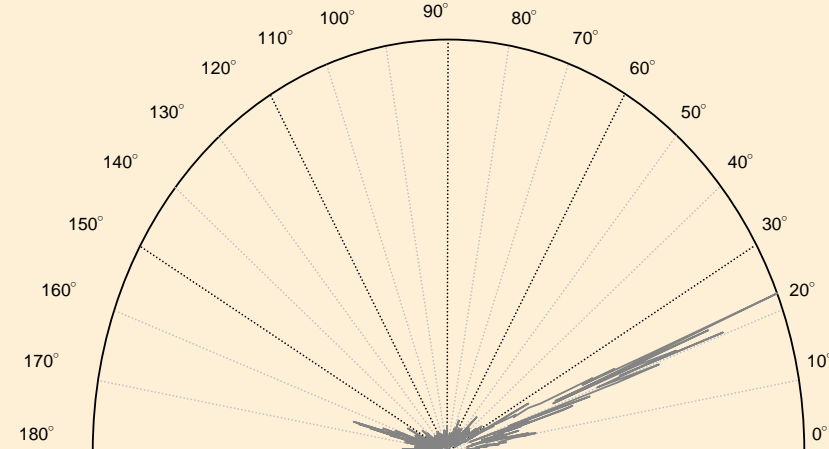
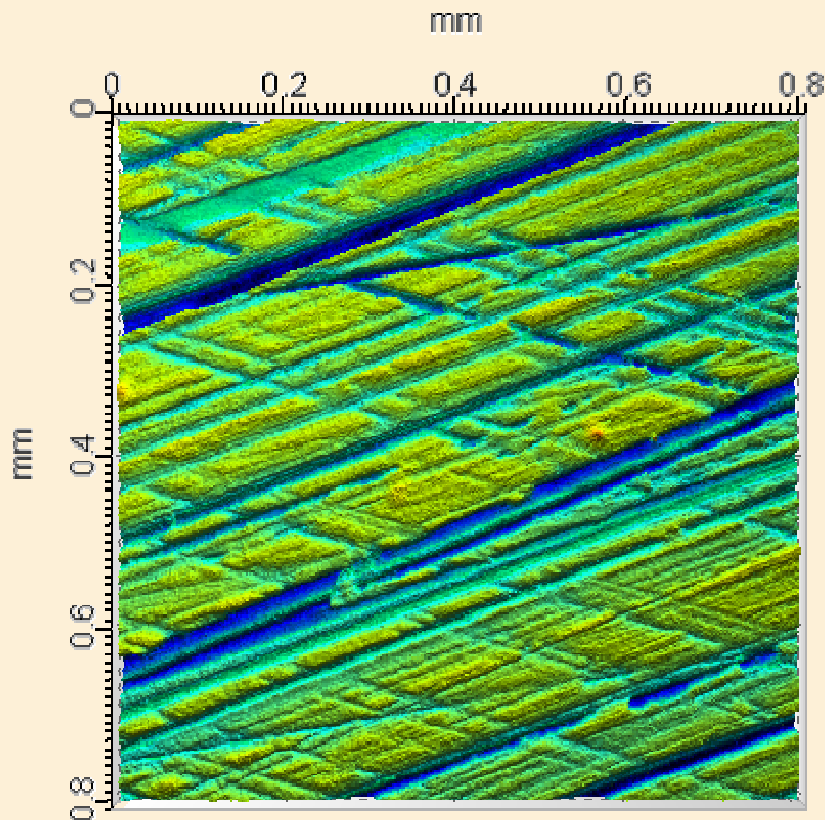
# Application: Implants



Roughness Gradient Distribution



► evaluation of texturing direction

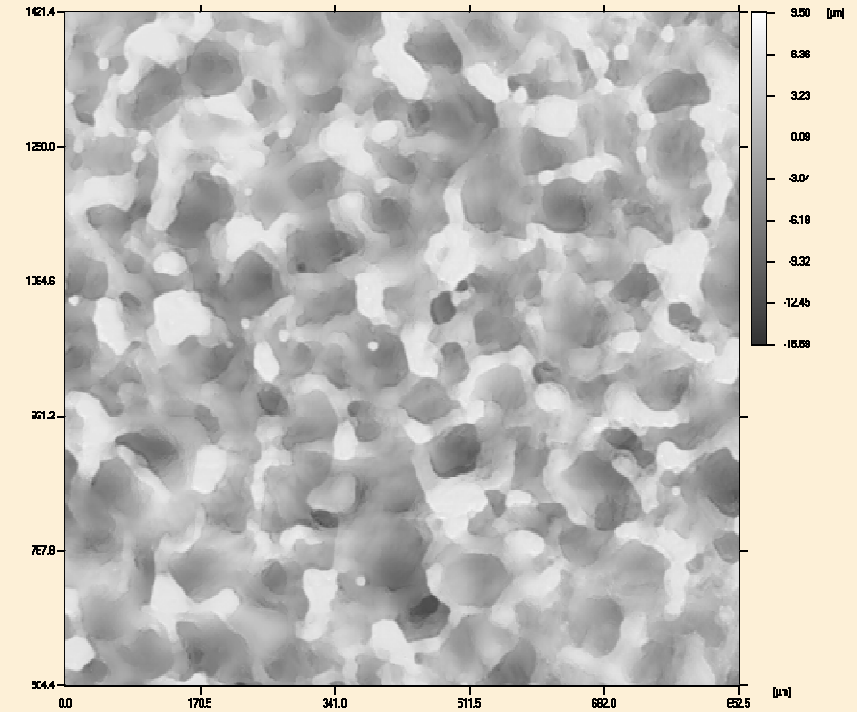
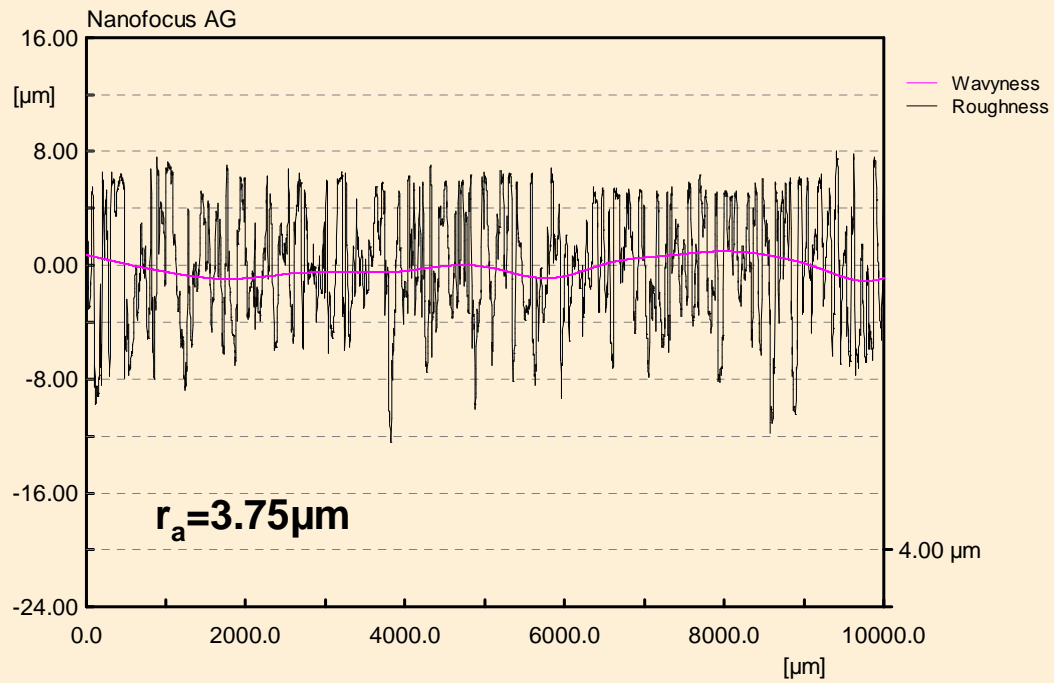


Isotropie: 3.94 %  
Erste Richtung: 22.5°  
Zweite Richtung: 17.1°

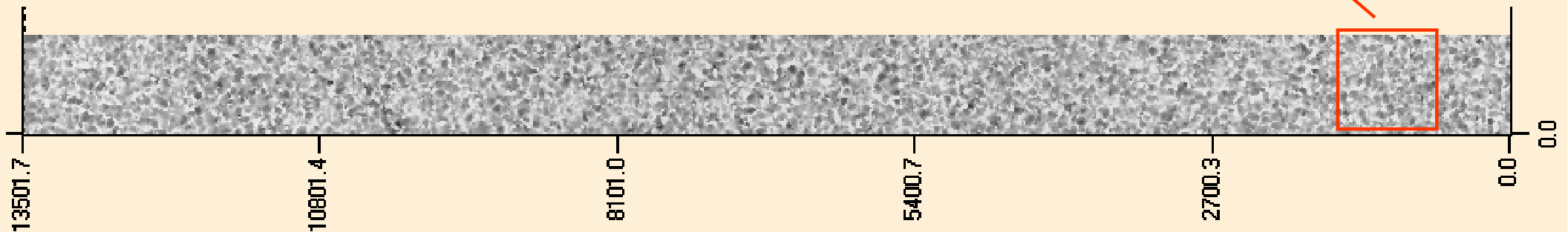
ISO 25178			
Raum-Parameter			
Str	0.0394		Textur-Aussehensverhältnis der Oberfläche
Std	22.5	°	Textur-Richtung der Oberfläche

- spatial parameter Str describes the isotropy of the surface
  - Str close to 1: isotrope
  - Str close to 0: non isotrope
  
- spatial parameter Std describes preferred direction in case of non isotropic surfaces

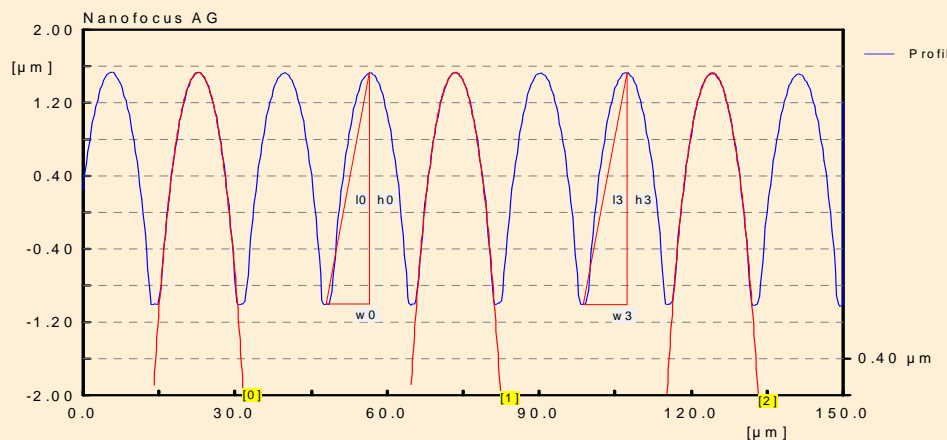
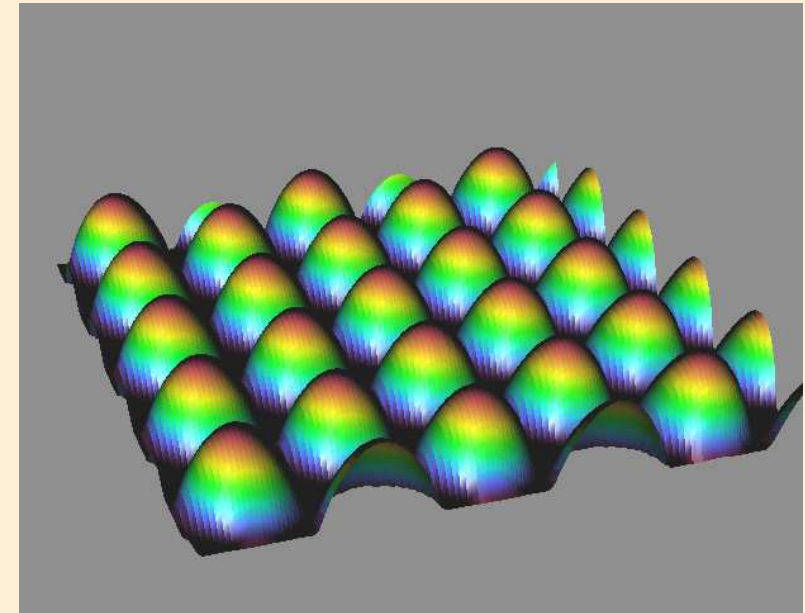
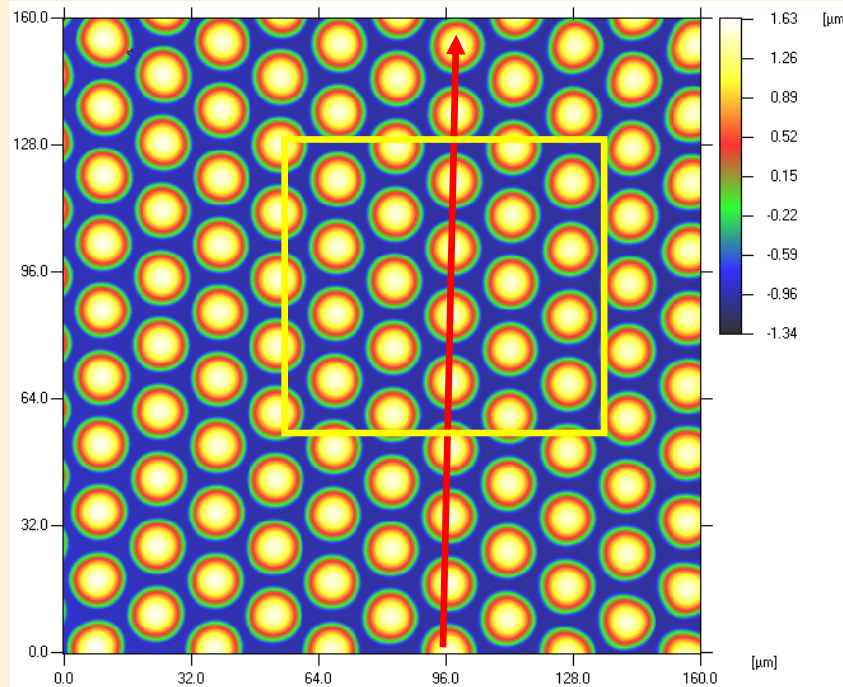
# EDT: $\mu$ surf mobile 1 x 16



$\mu$ surf mobile on a roll, 800S, 1x16 stitching: 1mm x 13mm x 25 $\mu\text{m}$



# Microlens Array



## Profile values

Radius (0) = 12,94  $\mu\text{m}$   
 Radius (1) = 12,91  $\mu\text{m}$   
 Radius (2) = 13,30  $\mu\text{m}$

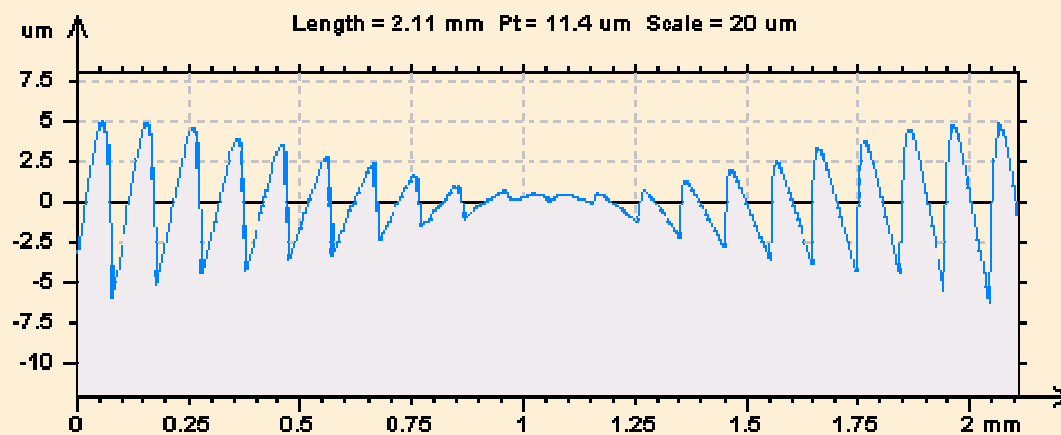
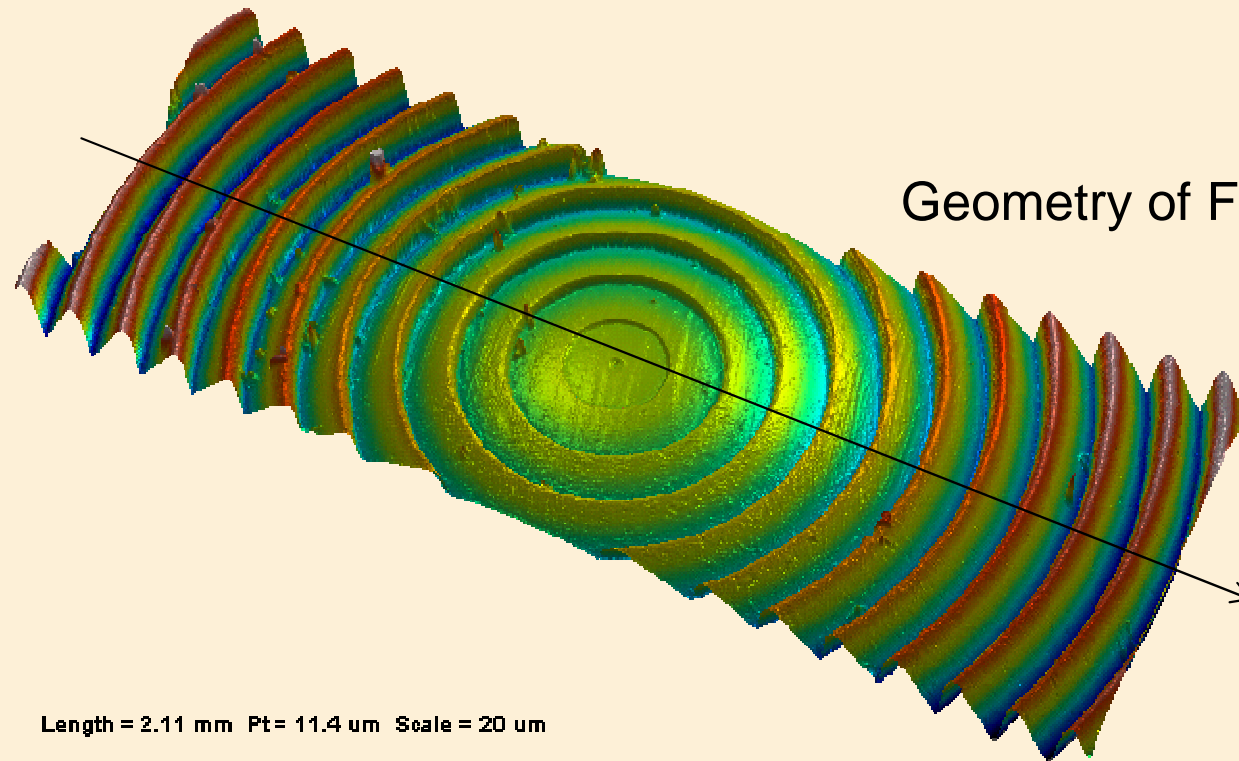
## Form 0

Width  $w_0$  = 8,57  $\mu\text{m}$   
 Height  $h_0$  = 2,53  $\mu\text{m}$   
 Length  $l_0$  = 8,94  $\mu\text{m}$   
 Angle = 16,44°

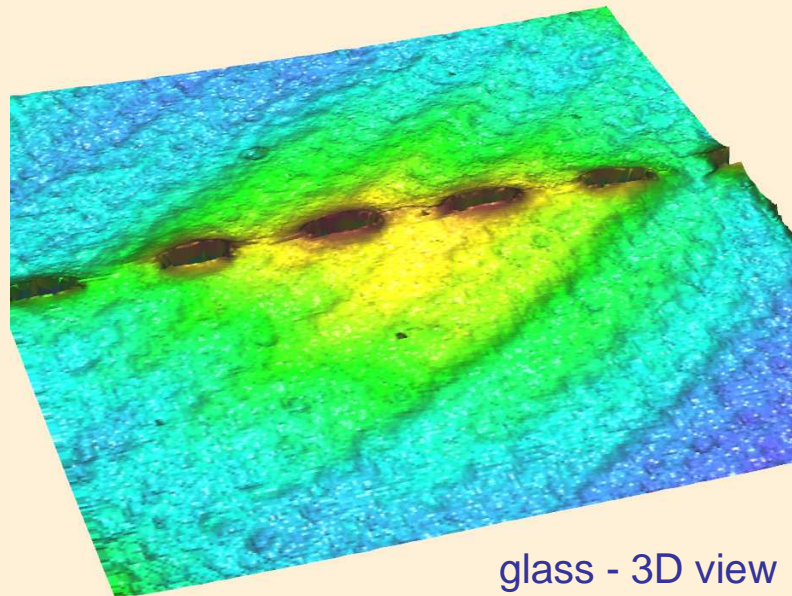
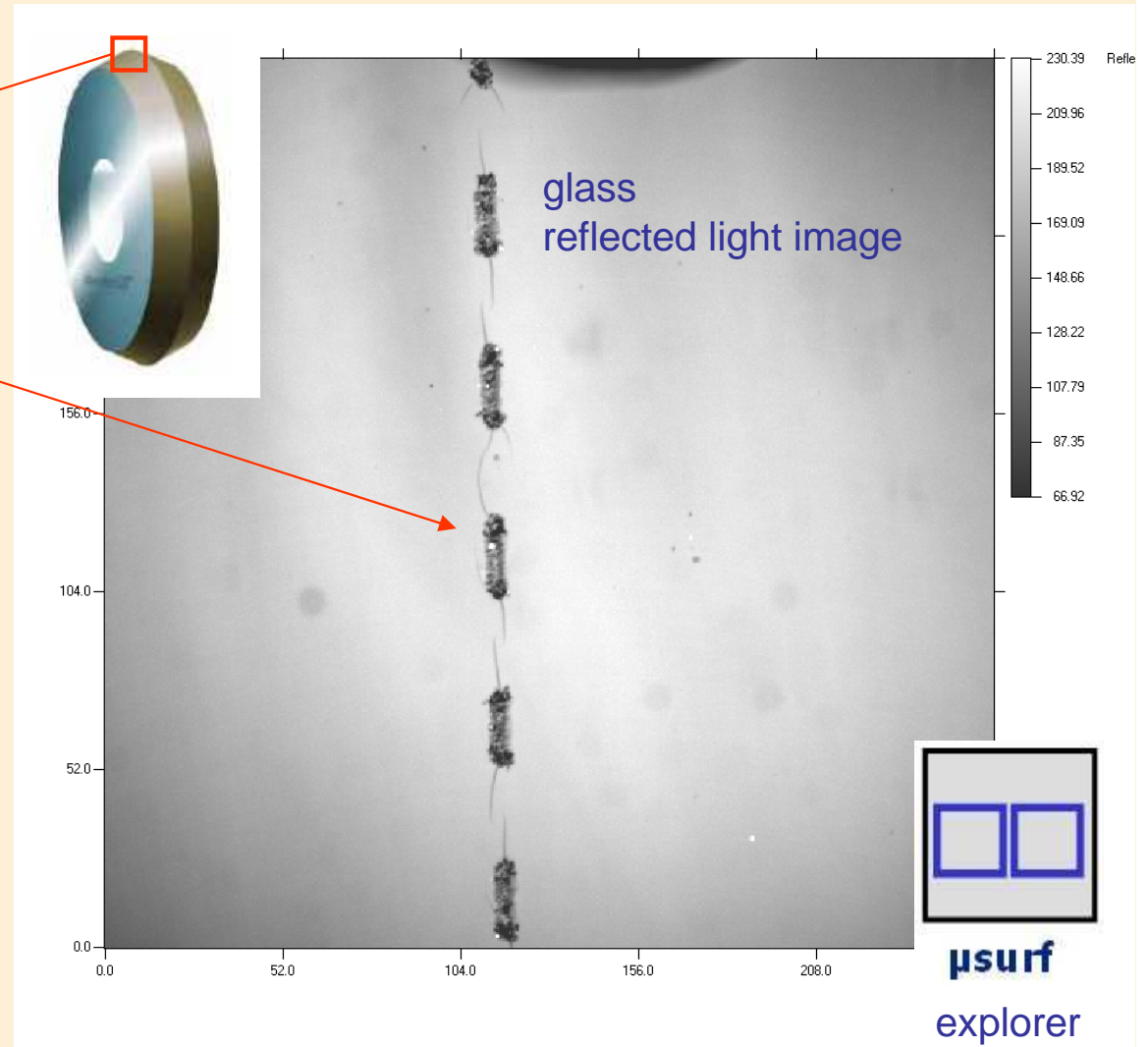
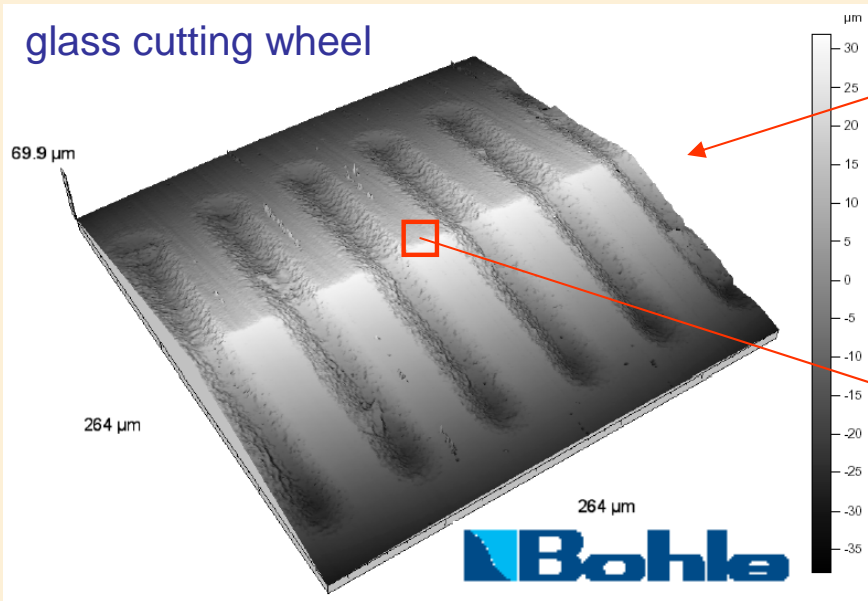
## Form 3

Width  $w_3$  = 8,86  $\mu\text{m}$   
 Height  $h_3$  = 2,53  $\mu\text{m}$   
 Length  $l_3$  = 9,21  $\mu\text{m}$   
 Angle = 15,94°

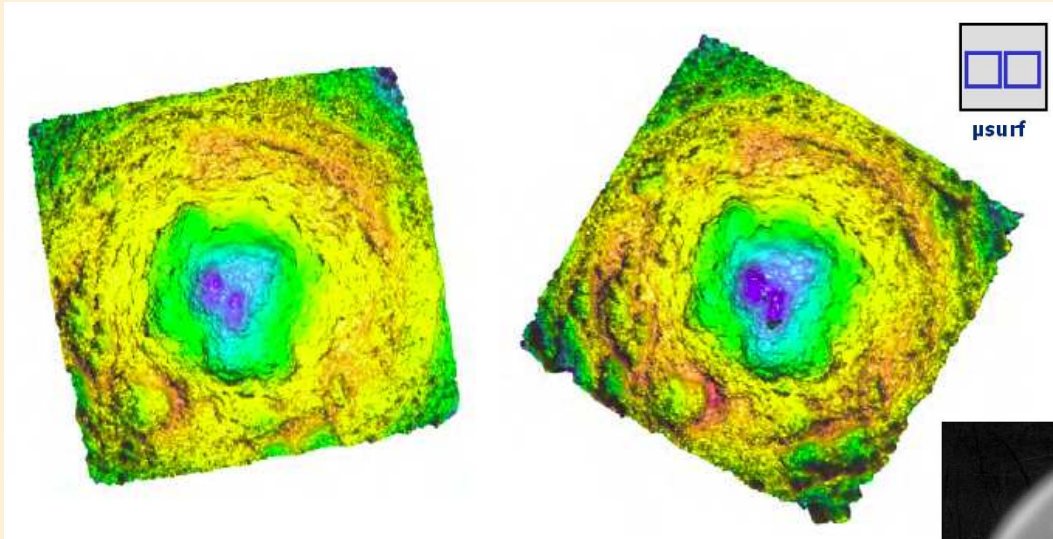
# Measuring task: concentrator cells



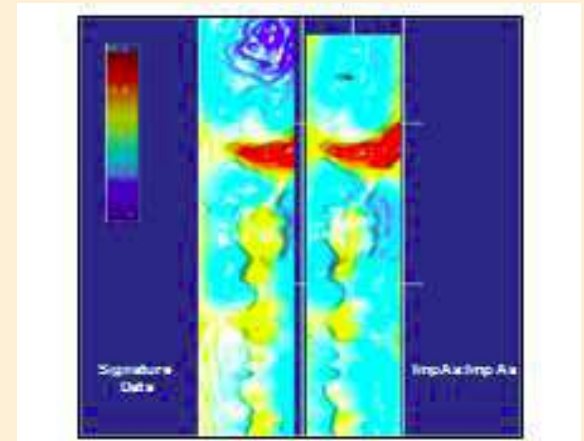
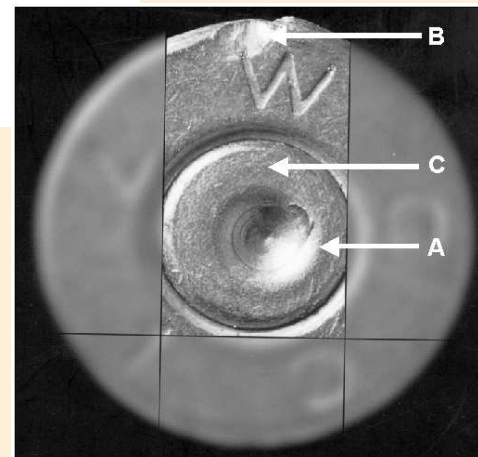
# Laser Machining



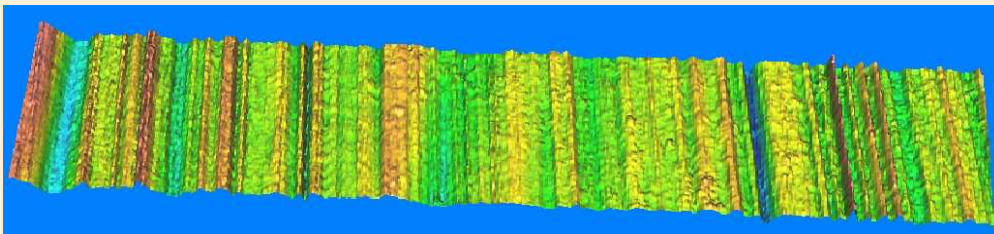




bulet casing - firing pin impression



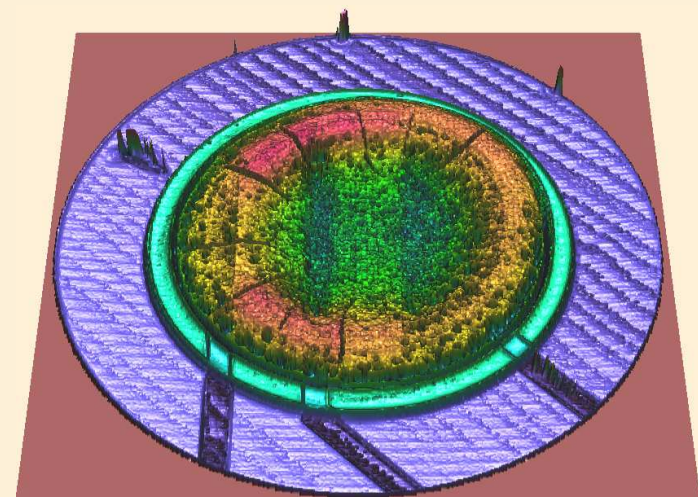
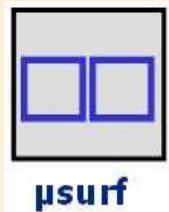
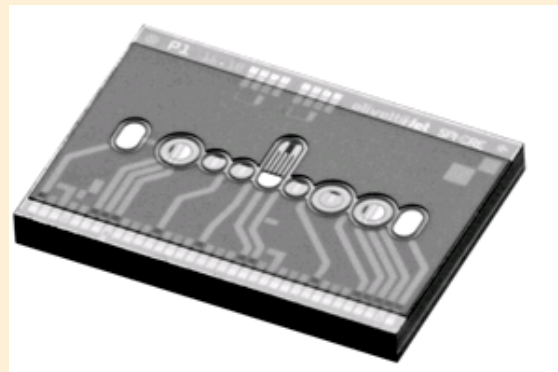
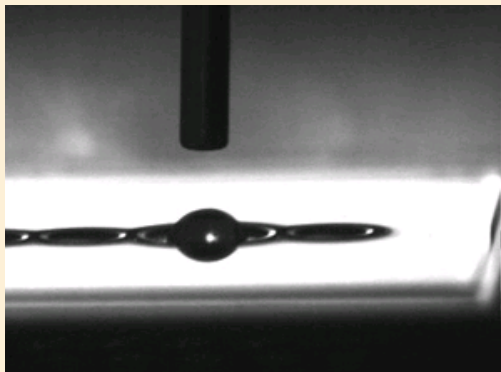
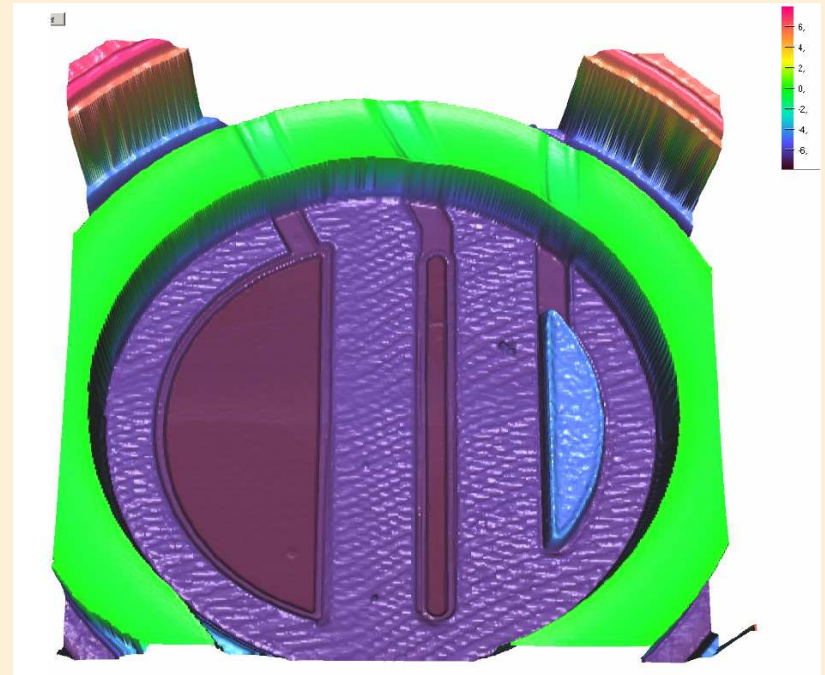
Ballistics Identification  
**BULLETTRAX™-3D**  
3D Bullet Acquisition Unit

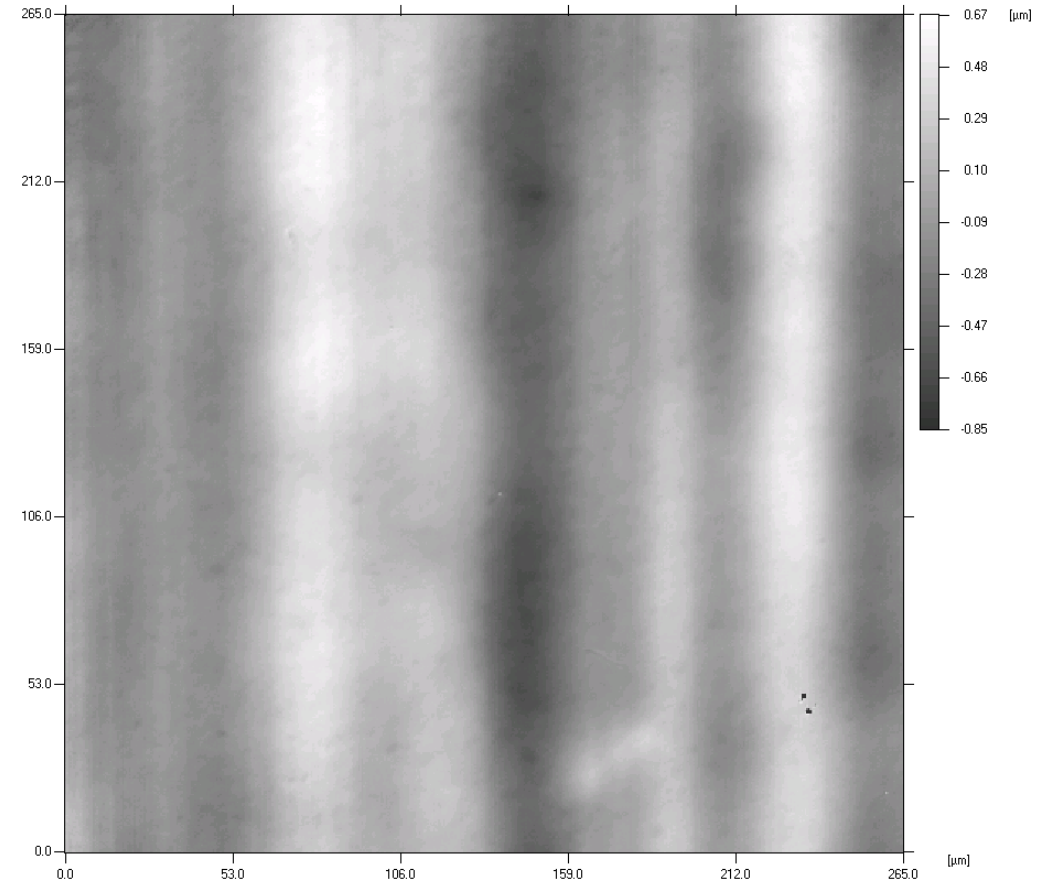
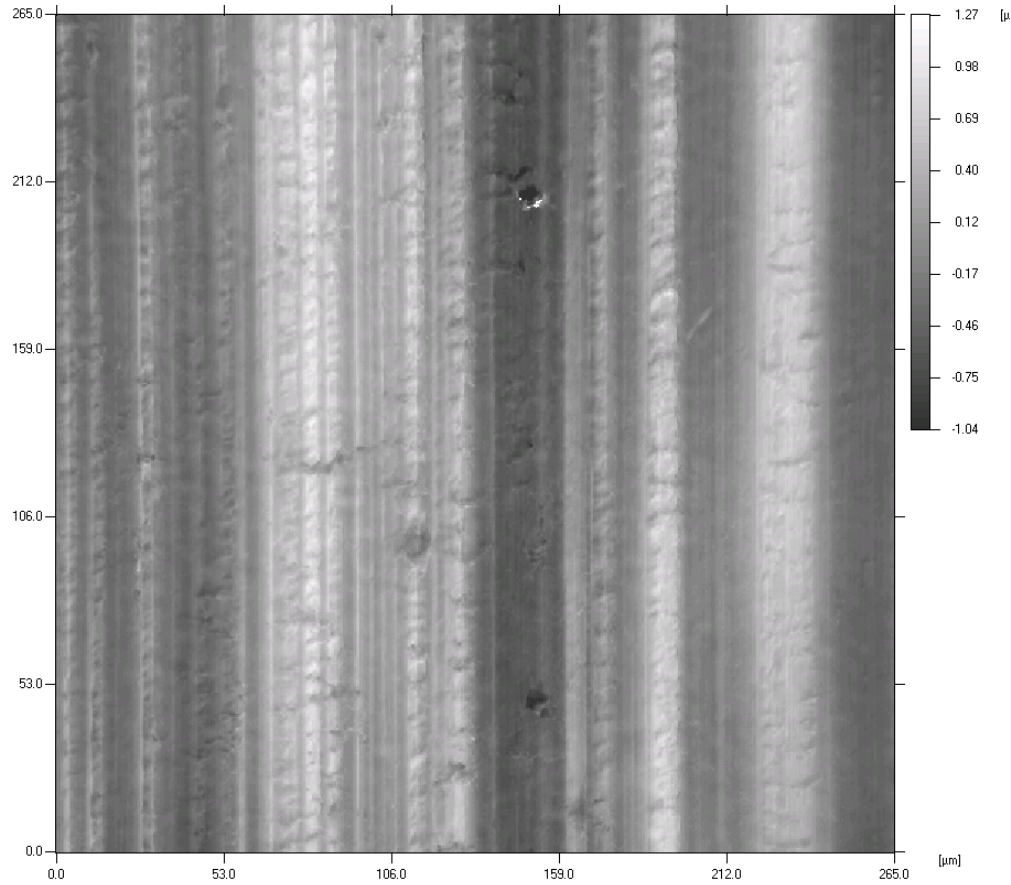


bolt cutter



# Micro Systems



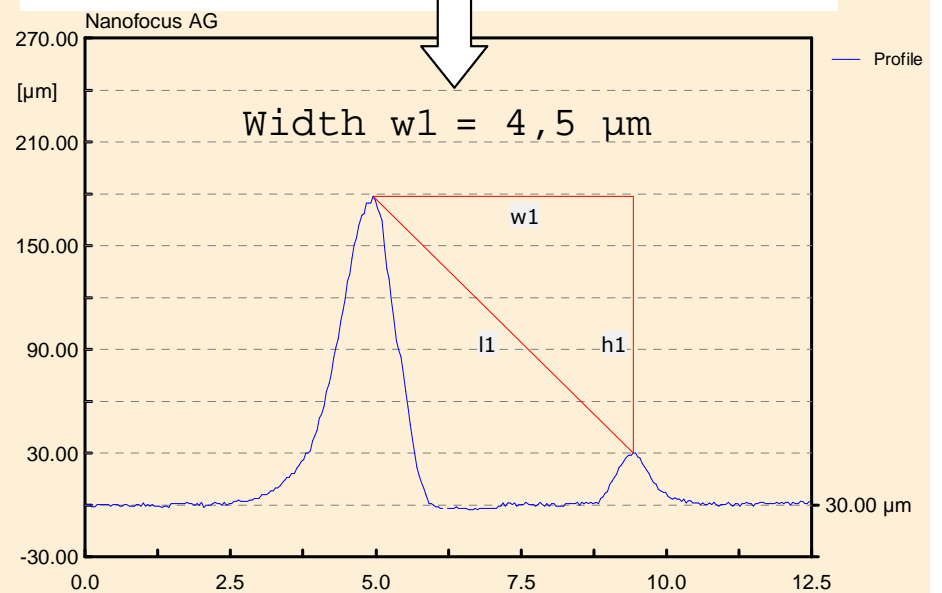
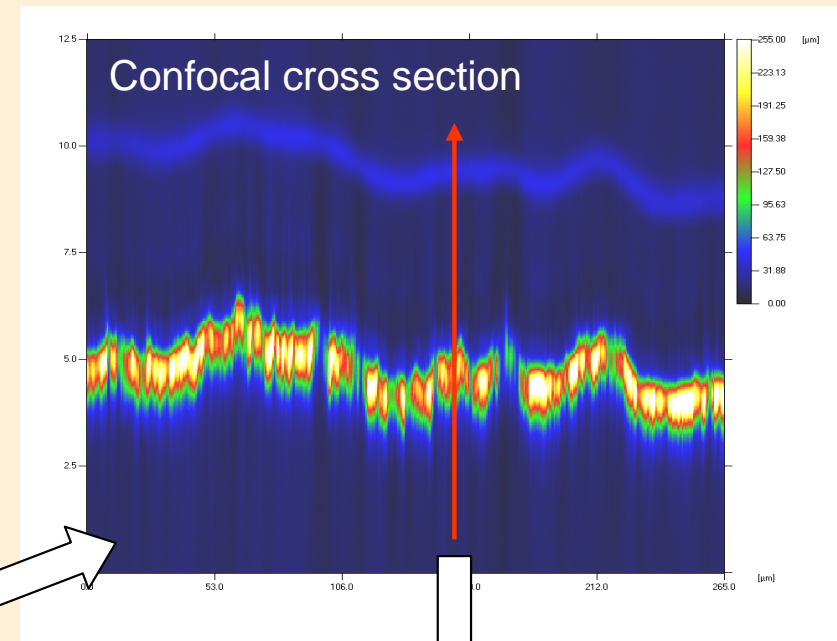
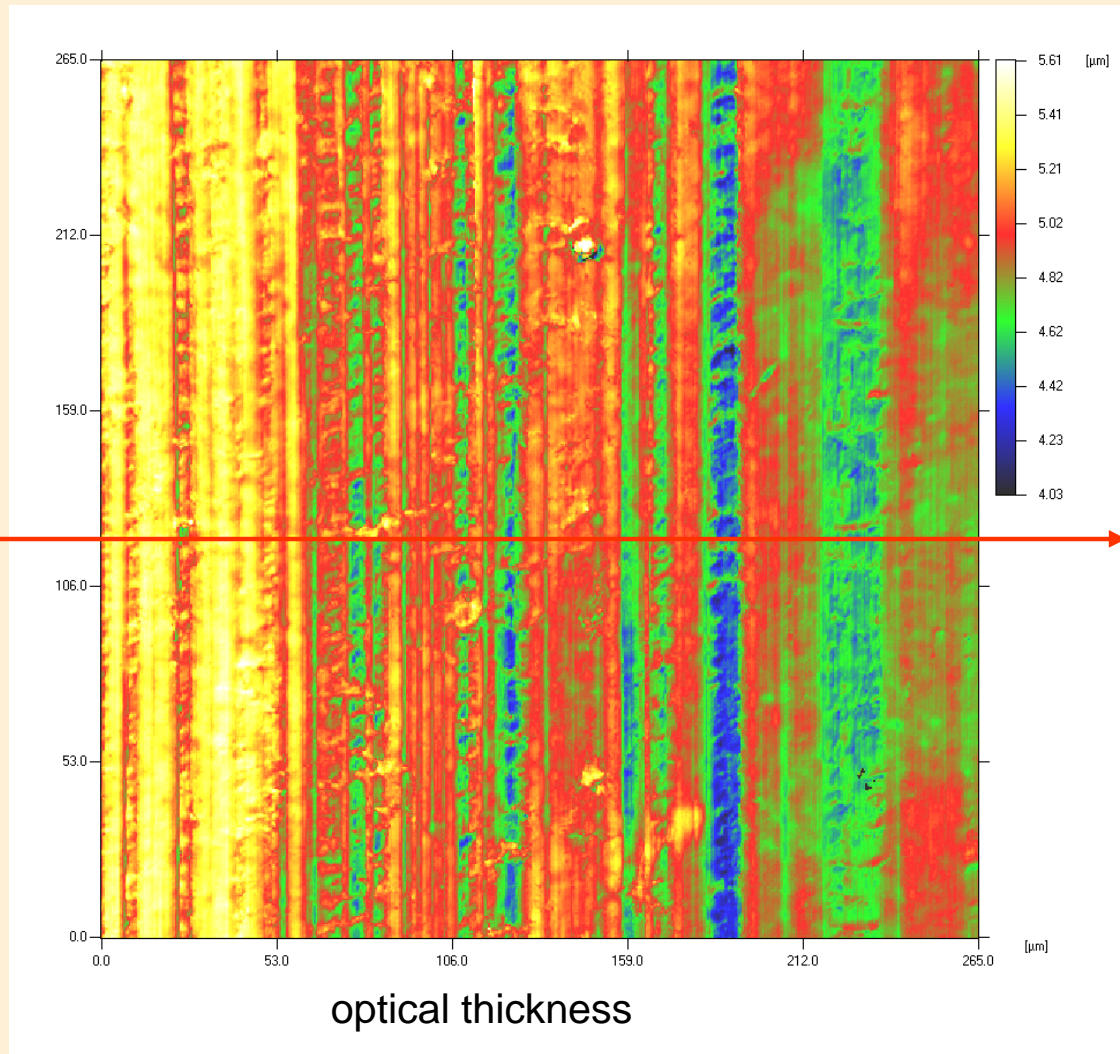


**Substrate surface**

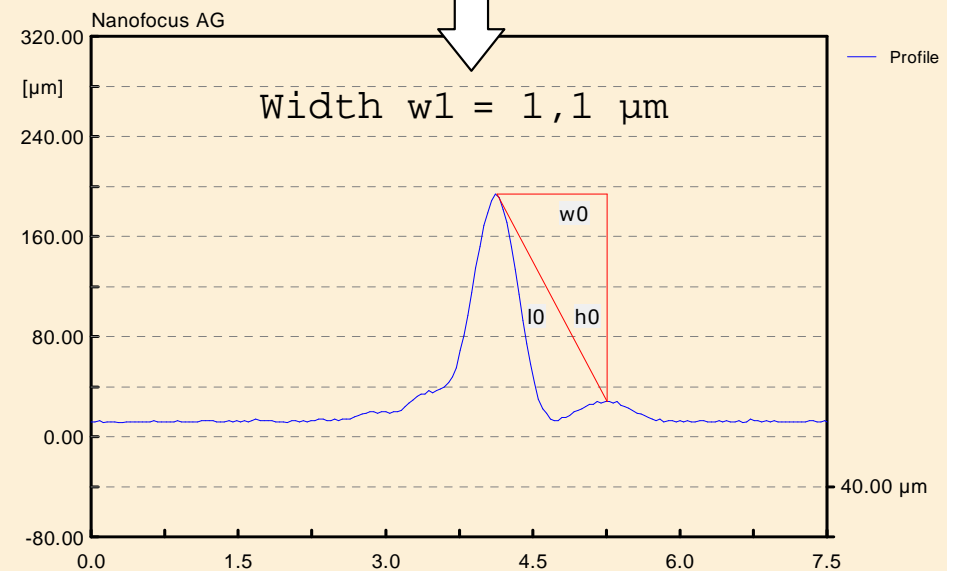
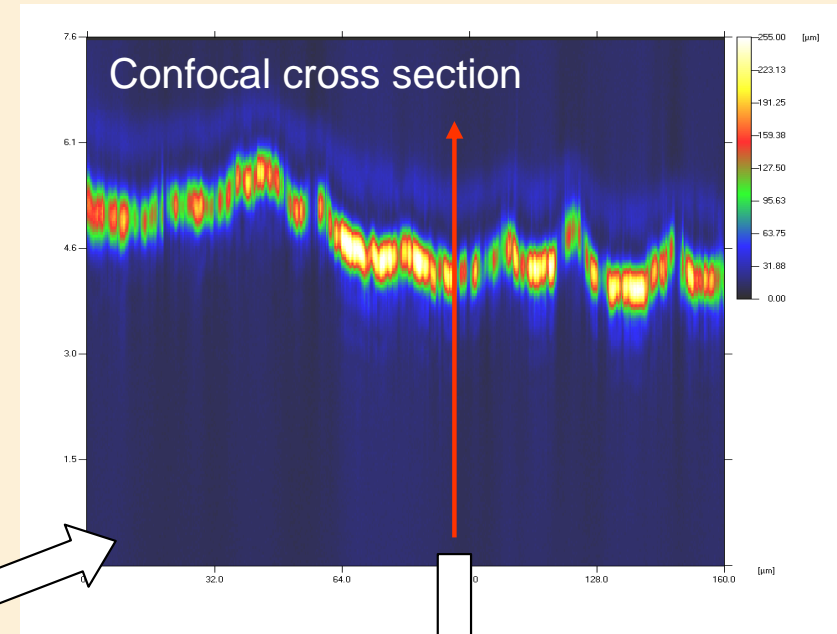
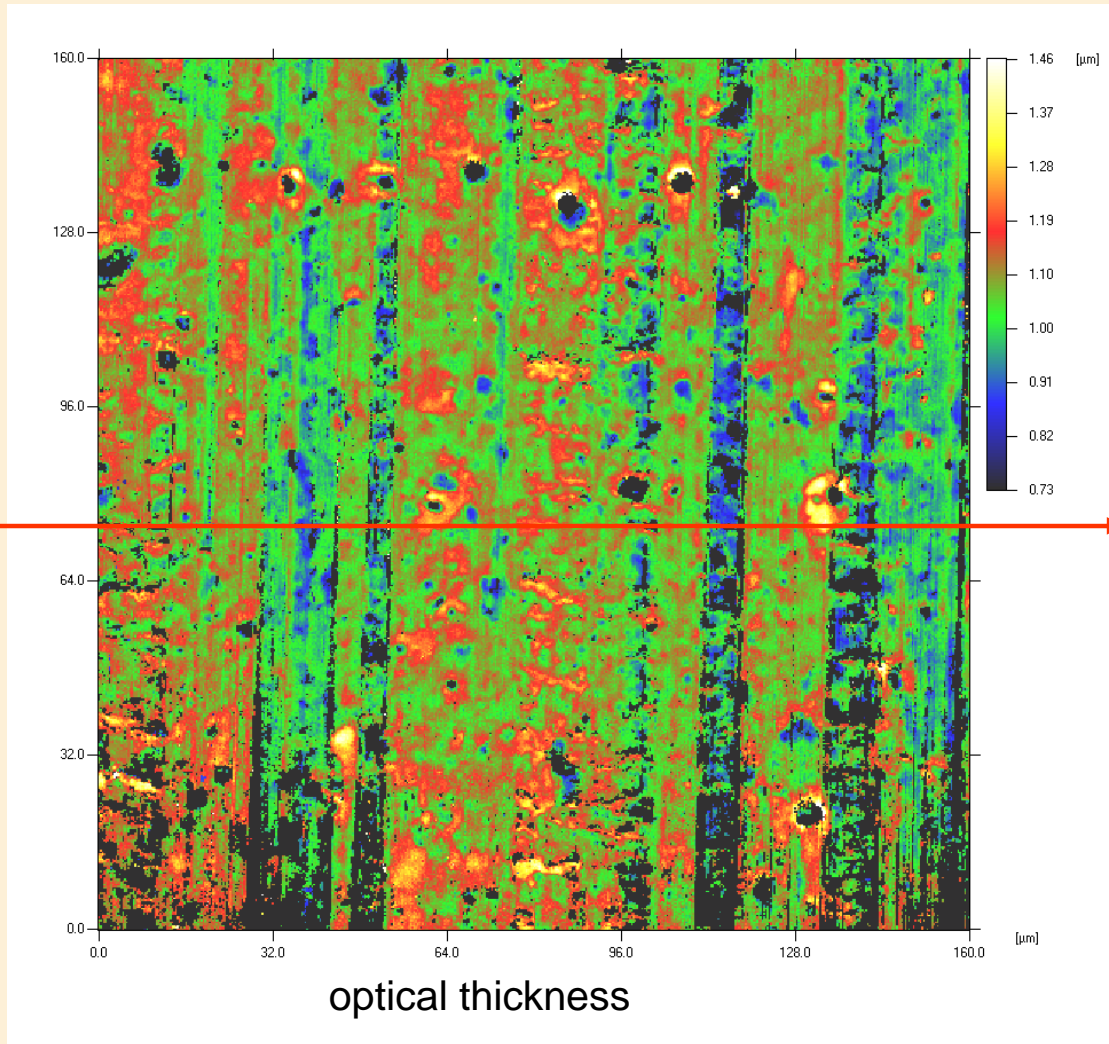
**Coating surface**

**sample#2-260S**

# Thickness sheet#2



# Thickness sheet#4



sample#4-160S

## Correlation of topography measurements of NIST SRM 2460 standard bullets by four techniques

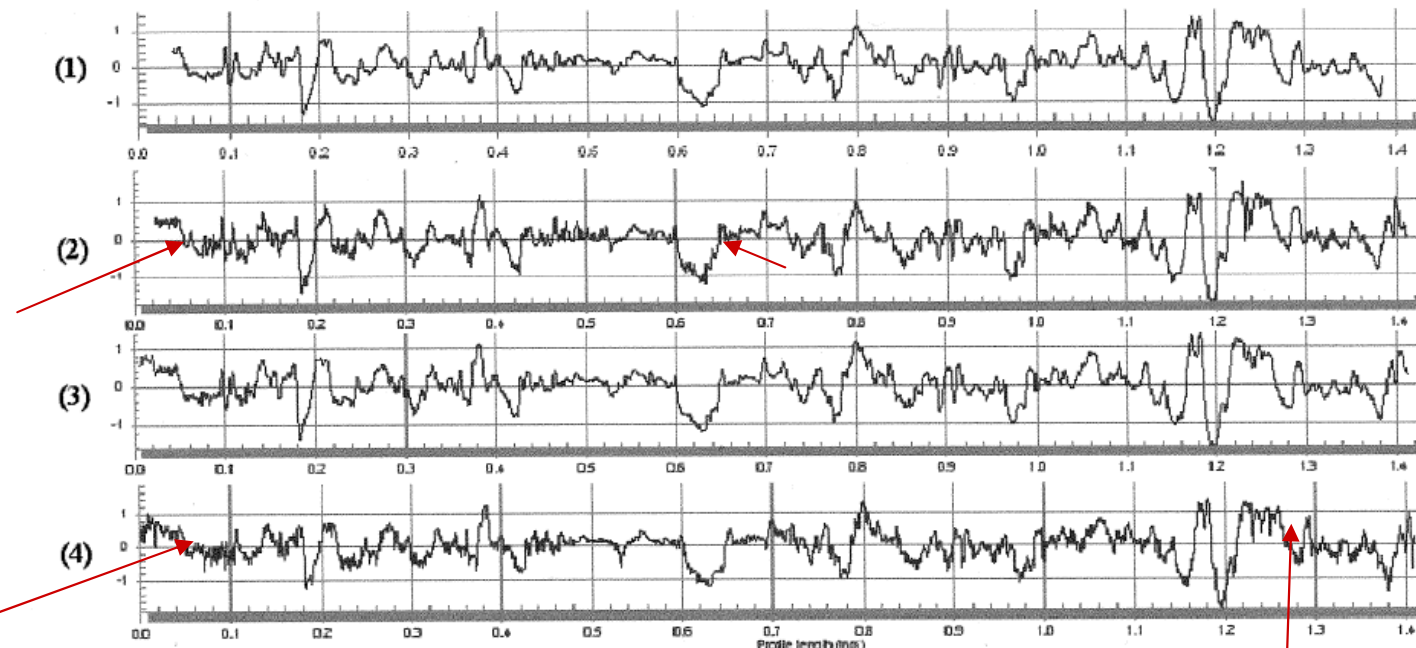
J Song, T Vorburger, T Renegar, H Rhee<sup>1</sup>, A Zheng, L Ma<sup>2</sup>, J Libert and S Ballou  
National Institute of Standards and Technology (NIST) Gaithersburg MD 20899 USA.

<sup>1</sup> Guest Researcher from the Korea Advanced Institute of Science and Technology (KAIST) Daejeon Korea.

<sup>2</sup> Guest Researcher from the Catholic University of America Washington DC 20064 USA.

**B Bachrach and K Bogart**  
Intelligent Automation Inc. (IAI) Gaithersburg MD 20855 USA.

E-mail: junfeng.song@nist.gov



Stylus  
Reference

WLI

NanoFocus  
μSurf

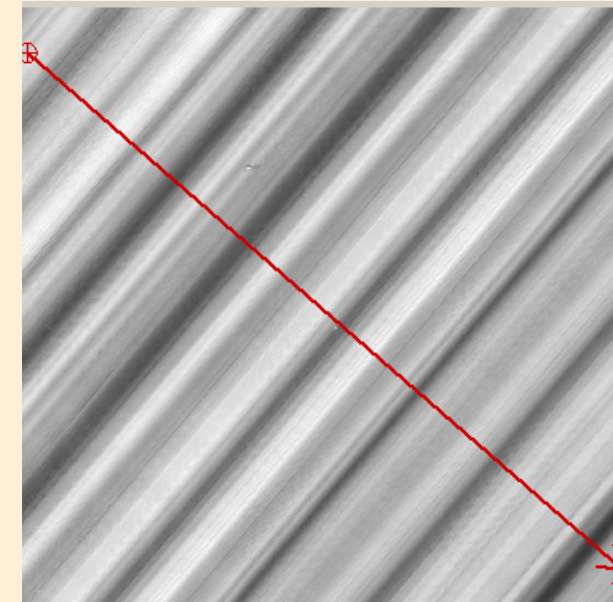
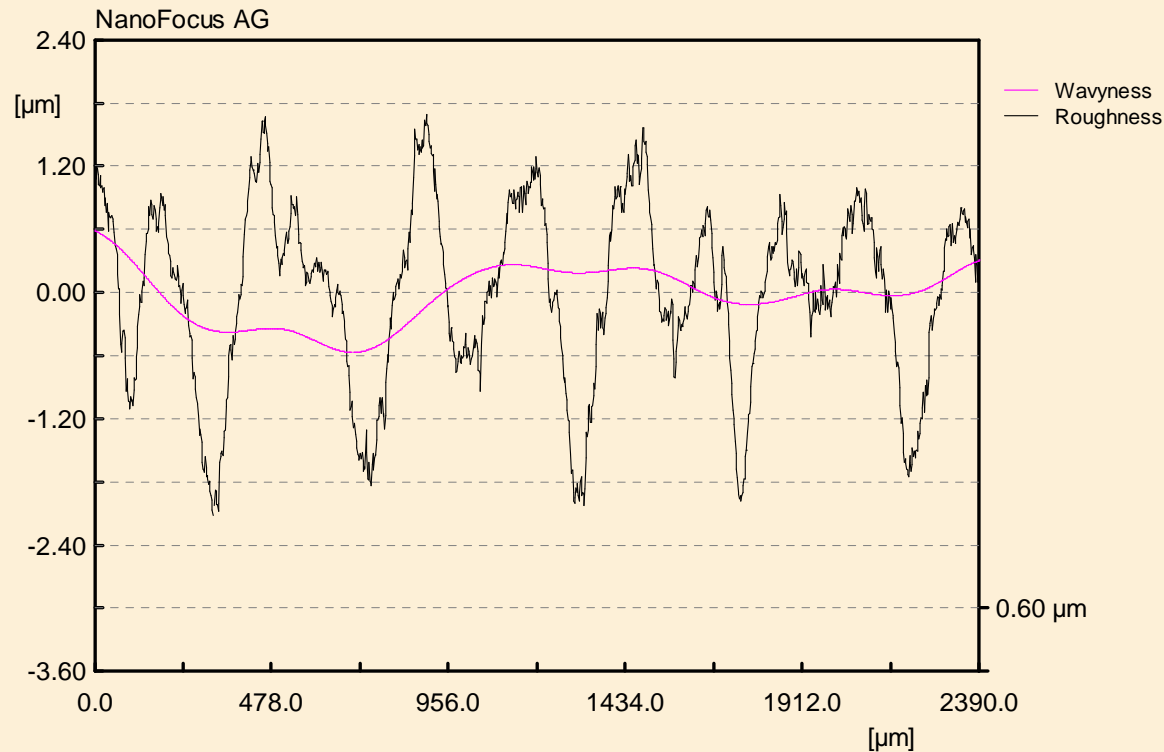
Laser Scanning  
Conf. Micr.

**Figure 2.** The profile of a standard bullet is measured by four techniques. 1) Stylus instrument,  $CCF_{max} = 99.6\%$ ; 2) Interferometric microscope,  $CCF_{max} = 92.1\%$ ; 3) Nipkow disk confocal microscope,  $CCF_{max} = 99.0\%$ ; 4) Laser scanning confocal microscope,  $CCF_{max} = 95.3\%$ . The vertical unit is  $\mu\text{m}$ , the horizontal unit is mm.

Source:

**NIST**

# Roughness Standard



## Roughness parameters

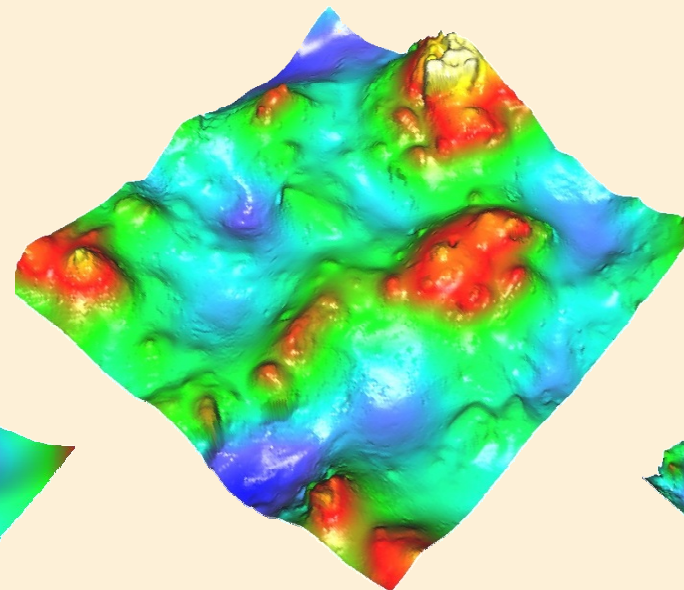
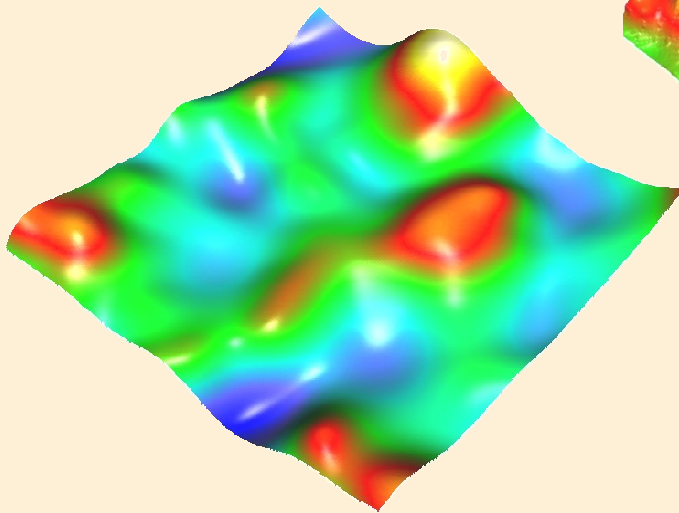
Filter	=	DIN EN ISO 11562
LC (CutOff)	=	0,800 mm
Lr	=	0,800 mm
NeedleFilter	=	0,000 mm
No of Lr N	=	3
Not conform with DIN EN ISO 4287		
Conform with DIN EN ISO 4288		
Ra	=	0,680 $\mu\text{m}$
Rz	=	3,498 $\mu\text{m}$
Rt	=	3,822 $\mu\text{m}$
Rq	=	0,857 $\mu\text{m}$
Rmax	=	3,800 $\mu\text{m}$
Rms S.	=	00,053
Wt =	=	1,159 $\mu\text{m}$
SEP 1940II(prEN 10049 C=0,5 $\mu\text{m}$ )		
Rpc	=	33,369 1/cm

**specimen: roughness standard, rotated**  
**lens: 800XS (20x, NA0.6)**  
**area: 2.68 x 2.68 mm<sup>2</sup>**  
**mode: 3 x 3 stitching, 1370 x 1370 data points**  
**z-stack: 120 frames (2.1s/image)**  
**total acquisition time < 1min**

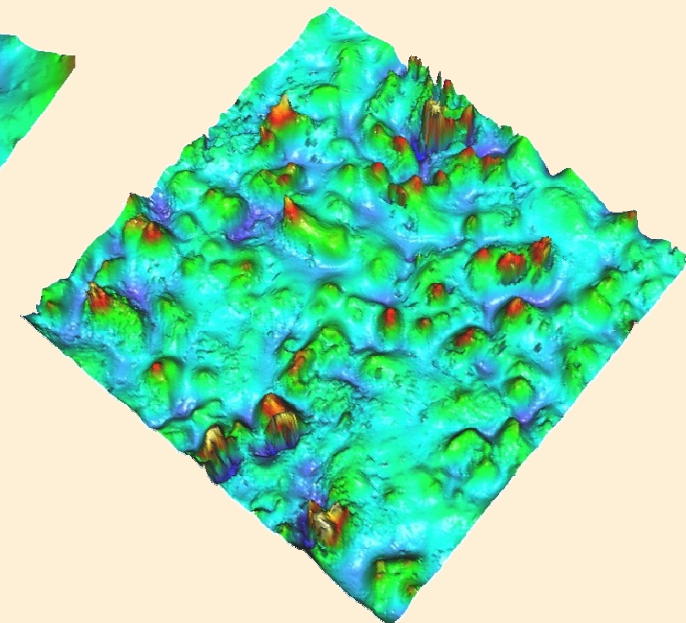
Surface structure consists of amplitudes of different wavelength:

surface raw data

waviness

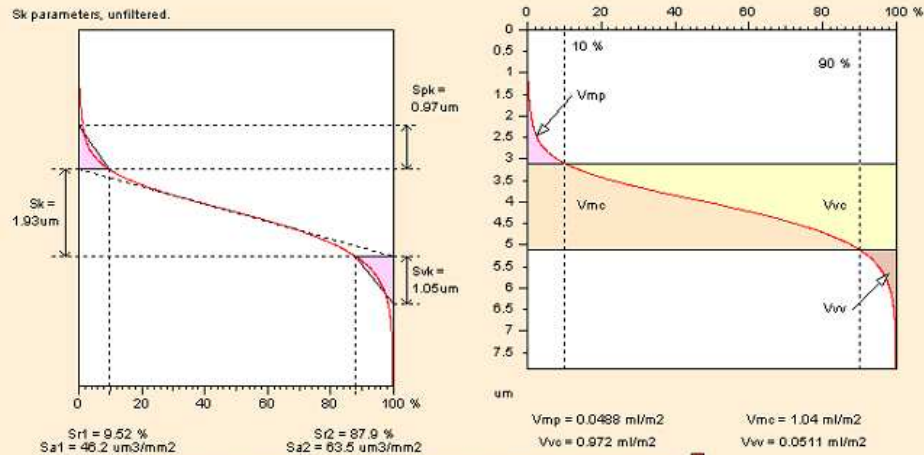


roughness





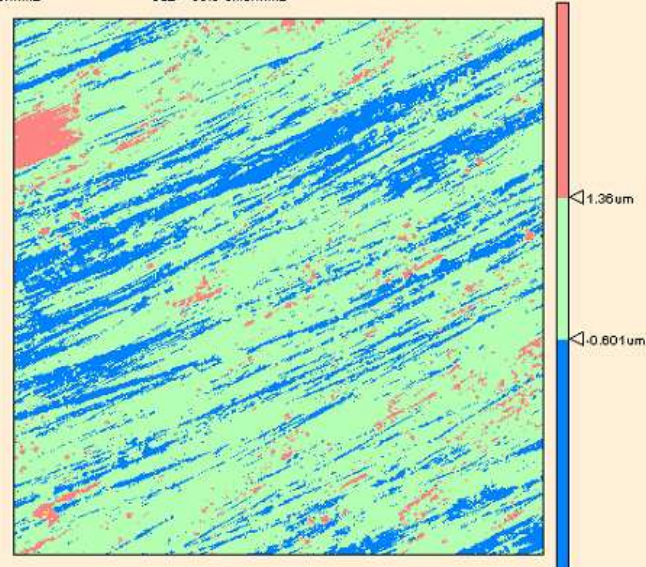
## Bearing ratio analysis



## ISO parameters (2D and 3D), functional parameters

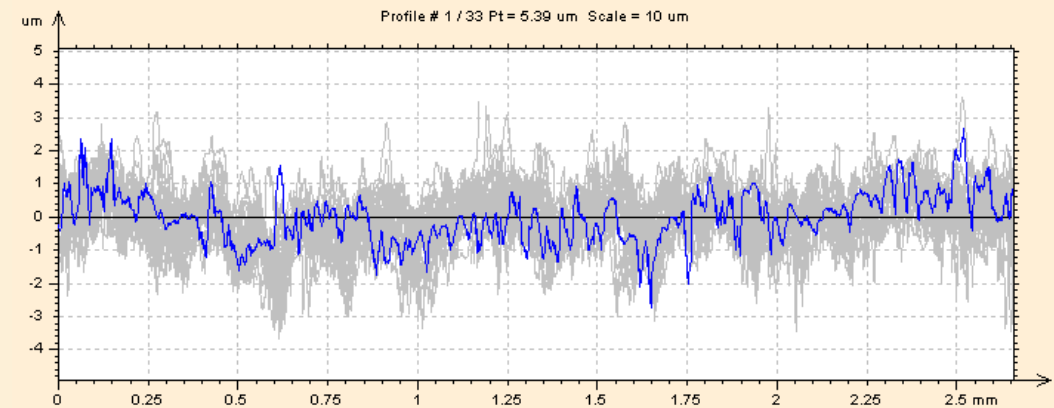
ISO 25178			ISO 4287		
Height Parameters			Amplitude parameters - Roughness profile		
<b>Sa</b>	0.642	um	<b>Ra</b>	0.445	um
<b>Sq</b>	0.843	um	<b>Rq</b>	0.569	um
<b>Ssk</b>	-0.0508		<b>Rsk</b>	-0.177	
<b>Sku</b>	4.27		<b>Rt</b>	4.23	um
<b>Sp</b>	4.07	um	<b>Rz</b>	2.93	um
<b>Sv</b>	3.81	um	Material Ratio parameters - Roughness profile		
<b>Sz</b>	7.88	um	<b>Rmr</b>	5.27	%
			<b>Rdc</b>	0.918	um

*Ra: Arithmetic Mean Deviation of the roughness profile.*  
*Rq: Root-Mean-Square (RMS) Deviation of the roughness profile.*  
*Rsk: Skewness of the roughness profile.*  
*Rt: Total Height of roughness profile.*  
*Rz: Maximum Height of roughness profile.*  
*Rmr: Relative Material Ratio of the roughness profile.*  
*Rdc: roughness profile Section Height difference*



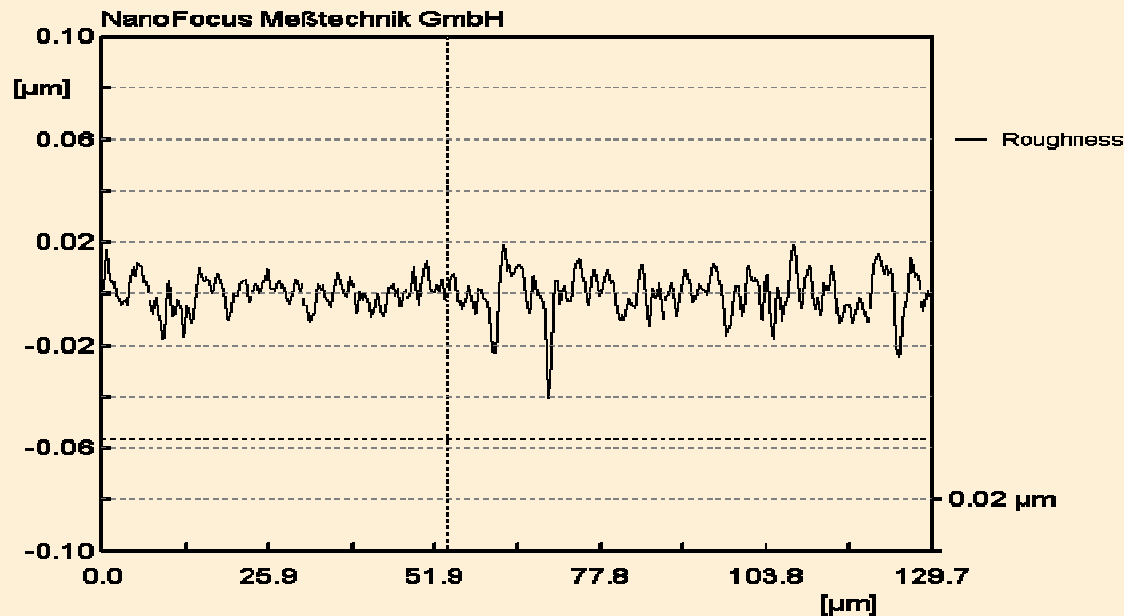
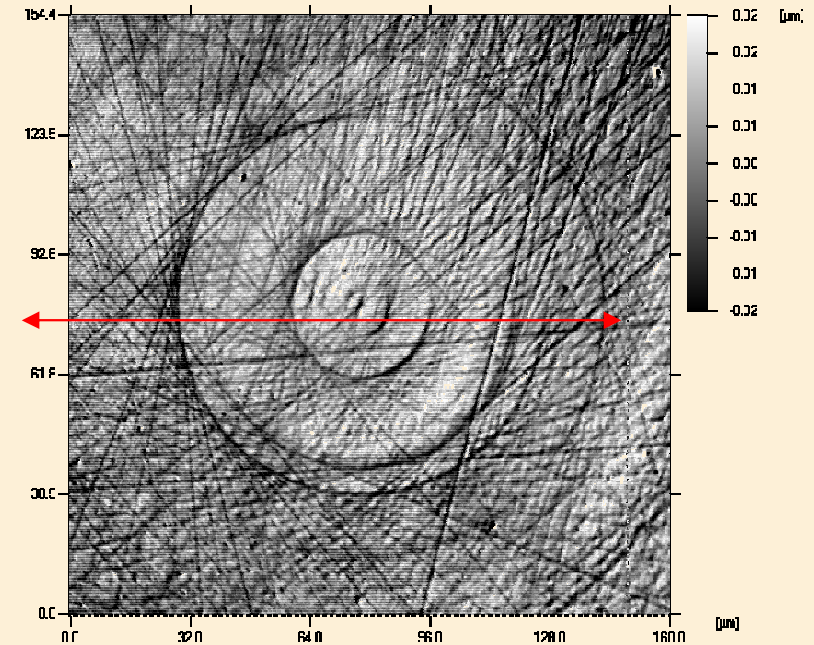
	■	□	■
Projected Area (%)	21.5	74.4	4.18
Volume of void (%)	3.87	64.5	99.1
Volume of material (%)	96.3	35.5	0.862

## Advanced profile analysis



# Wafer Backside Grinding

## Confocal System $\mu$ Surf 100x optics

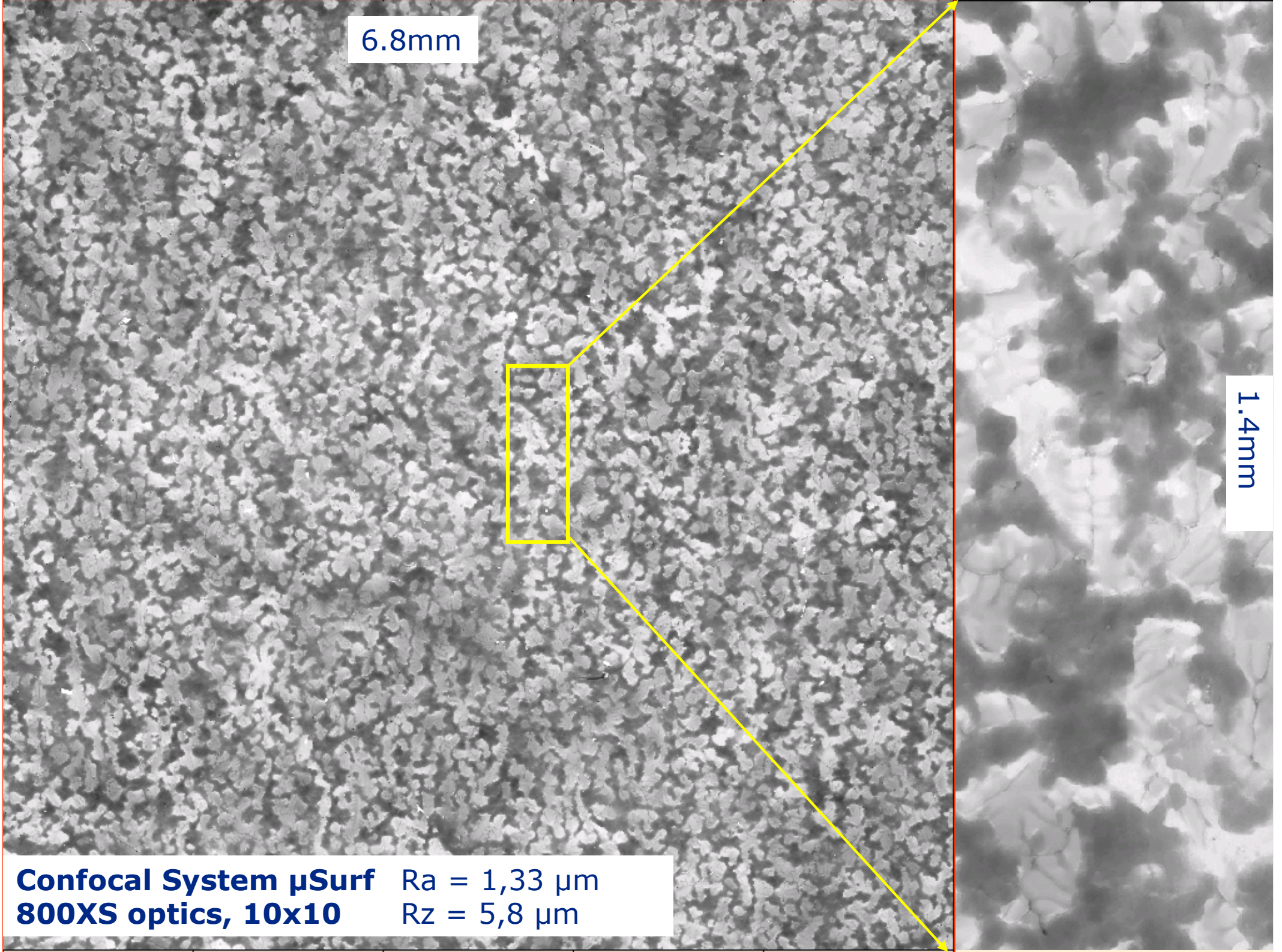


$R_a = 0.005 \mu\text{m}$   
 $R_z = 0.038 \mu\text{m}$

6.8mm

1.4mm

**Confocal System  $\mu$ Surf** Ra = 1,33  $\mu$ m  
**800XS optics, 10x10** Rz = 5,8  $\mu$ m



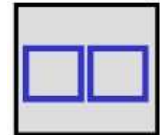
# Wear Test



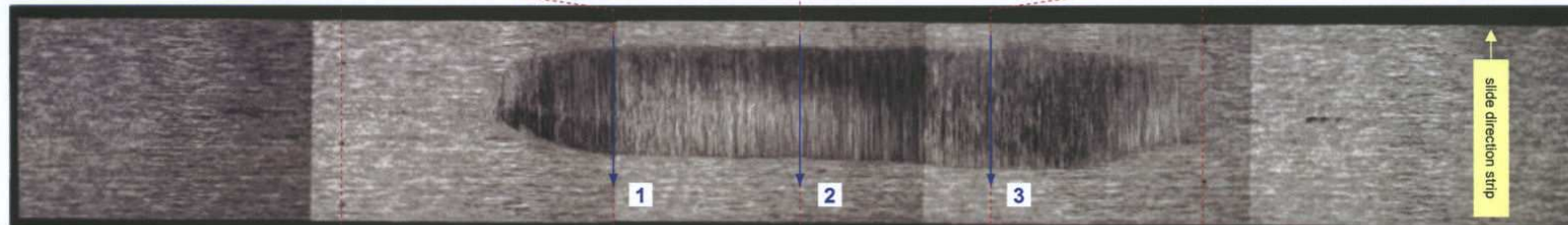
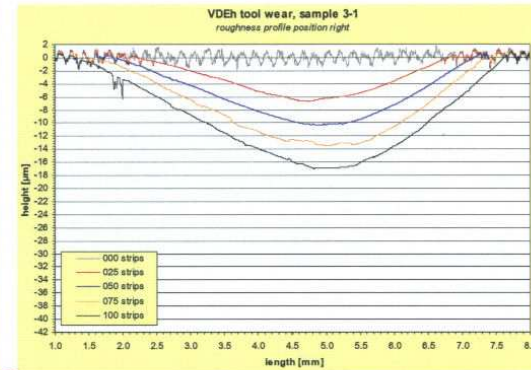
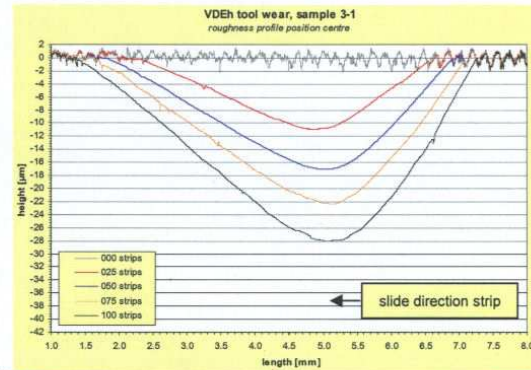
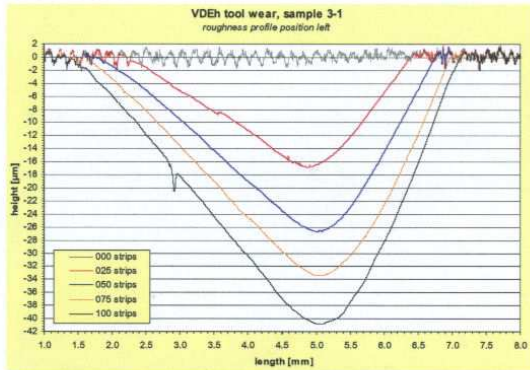
## VDEh tool wear roughness investigation VDEh 3\_1: strip EZ DC05 + GPTH9491 (PACcode: 20050131)

Appelman  
Landskroon

mobile



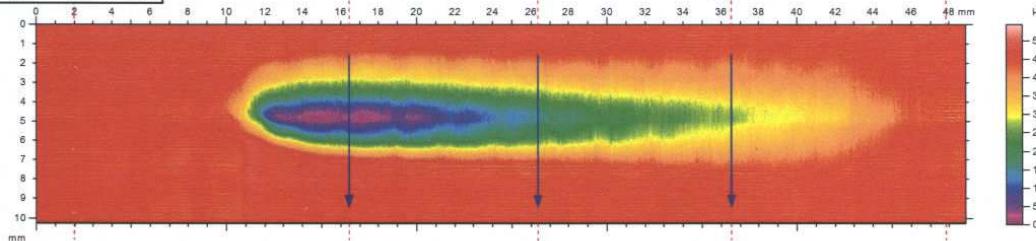
µsurf



preview video  
camera

Pt-waarde [µm]	VDEh 3_1				
# strips	0	25	50	75	100
lineprofiel 1	2.2	16.9	26.8	33.5	40.8
lineprofiel 2	2.3	11.0	17.1	22.4	28.1
lineprofiel 3	2.0	6.8	10.4	13.5	17.0
average	2.2	11.6	18.1	23.1	28.6
stdev	0.2	5.1	8.3	10.0	11.9

VDEh 3_1		Initiele ruwheid
$\lambda_c$ : 0.8 mm (n=6)		gem. stdev
Ra	[µm]	0.50 0.09
Rsk		-0.25 0.08
RPc(±0.5)	[pks/cm]	6.49 0.85
Rz	[µm]	3.00 0.11
Rp	[µm]	1.32 0.07
Rv	[µm]	1.68 0.06



Materials and Surface Analysis

MSAnr.: 2070388

**nanofocus**  
see more

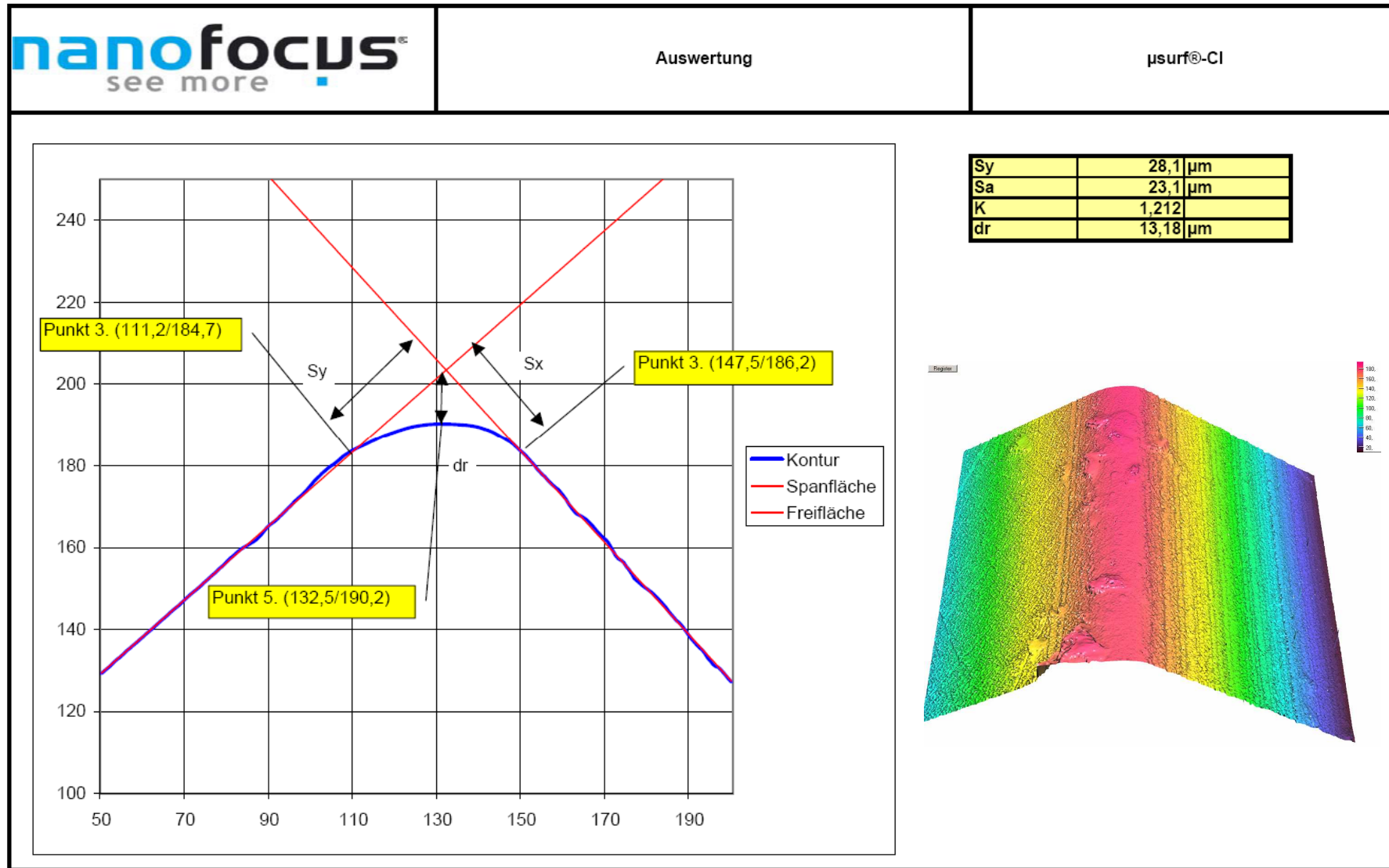
**lens: 3200S (5x)**  
**area: 10 x 50 mm<sup>2</sup>**  
**18x4 stitching**



**3rd European Fuchs Symposium**  
**18./19.Jun.2007**

**Tool wear in pressing of zinc-plated and coated steel sheets**  
Werkzeugverschleiß bei der Umformung von verzinktem und beschichtetem Stahlblech  
Chiel Dane, Corus Research Development & Technology

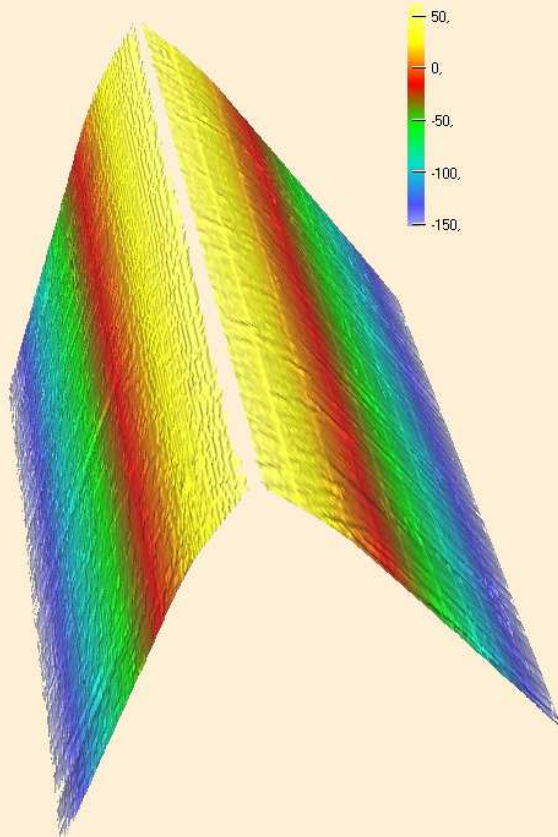
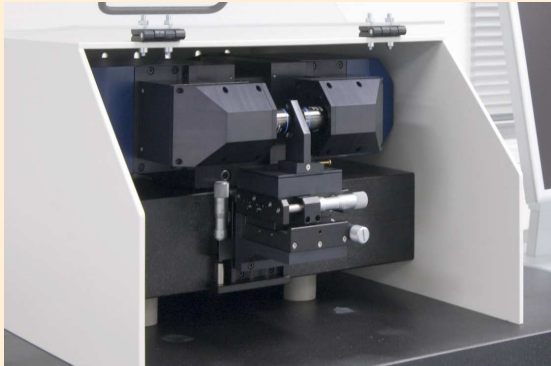
# Evaluation: tool wear



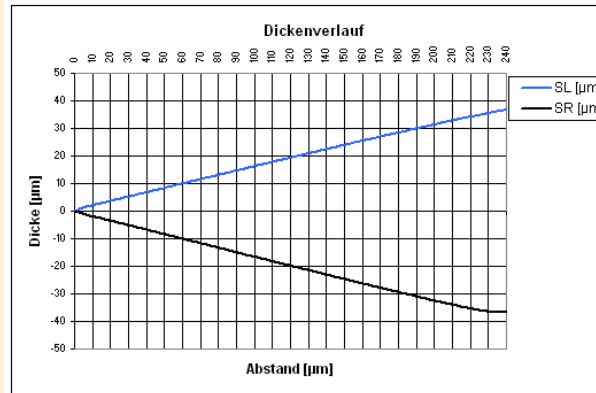
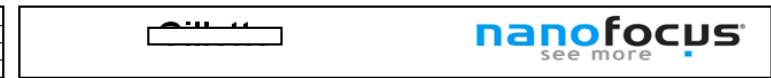
Auswertung mit NF-ActiveX-Modul (Kantenverschleiss)

(Mittelung über mittleren Bildbereich (geringer verschmutzter Bereich))

# Blade Inspection



System	µSurf TW111 320	Datum	29.01.2007
Benutzer	Marcus Grigat	Uhrzeit	15:40:22
Probe	Probe 4		
Beschreibung			

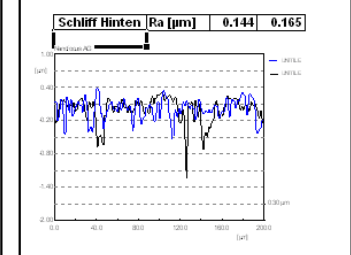
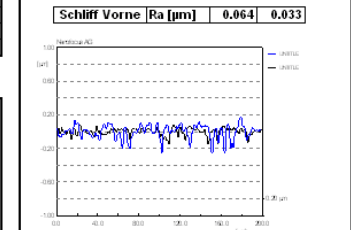
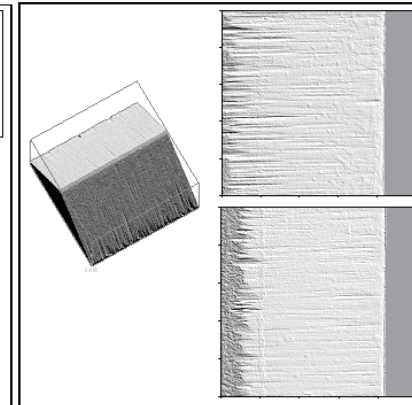
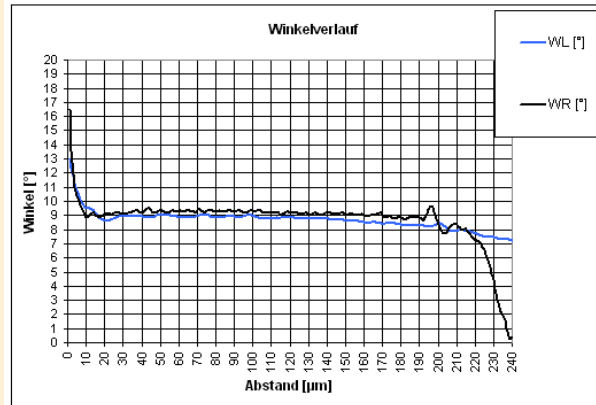
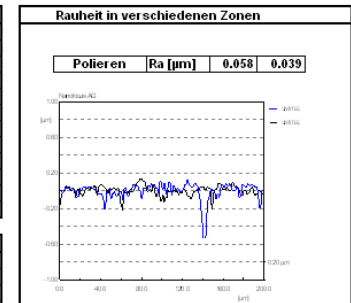


**Spitzengeometrie**

x [µm]	D [µm]	SL [µm]	SR [µm]	Delta [µm]	WL [°]	WR [°]
0	0.00	0.00	0.00	0.00		
1	0.69	0.60	0.77	-0.09	12.97	16.50
2	1.13	1.02	1.24	-0.11	12.35	13.59
3	1.55	1.45	1.66	-0.10	11.80	11.97
4	1.96	1.86	2.05	-0.09	11.27	10.99
5	2.32	2.23	2.41	-0.09	10.84	10.41
6	2.68	2.60	2.77	-0.09	10.42	10.08
7	3.04	2.96	3.12	-0.08	10.08	9.78
8	3.37	3.30	3.45	-0.08	9.85	9.45
9	3.70	3.64	3.77	-0.07	9.62	9.12
10	4.02	3.96	4.08	-0.06	9.55	8.89

**Facettenauswertung**

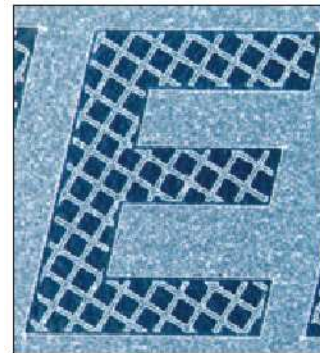
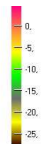
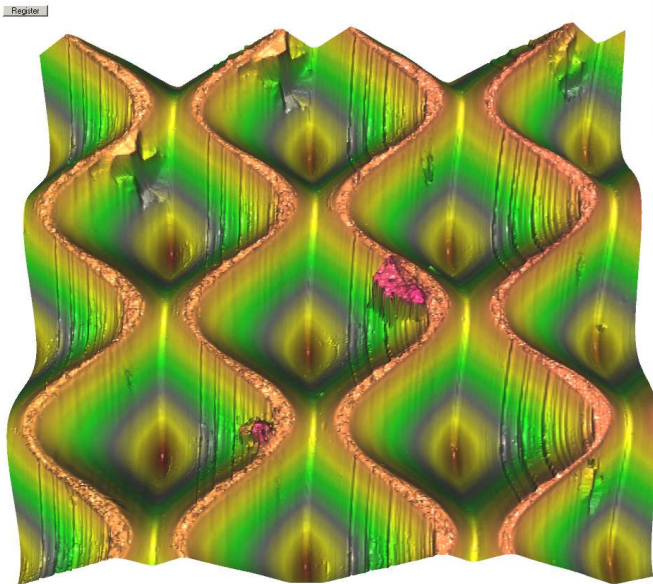
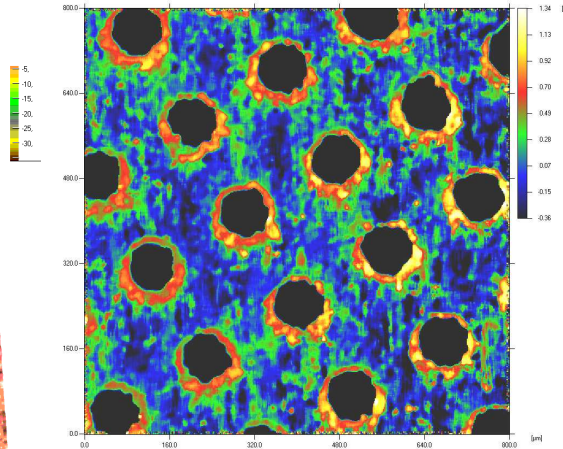
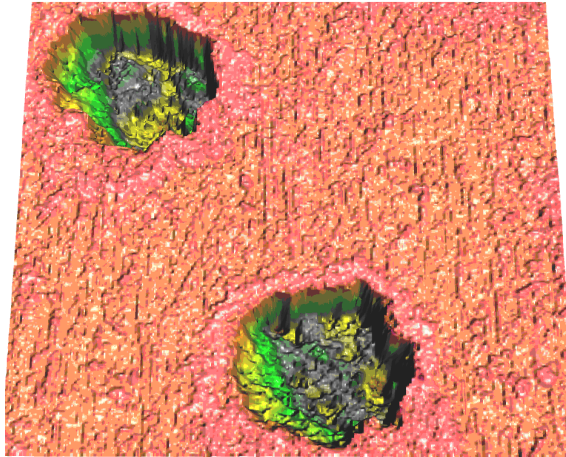
	WL [°]	WR [°]	Delta [°]
Schliff	8.86	9.23	-0.37
Polieren	13.6	9.1	4.57
Schliff	162.6	181.3	-18.77



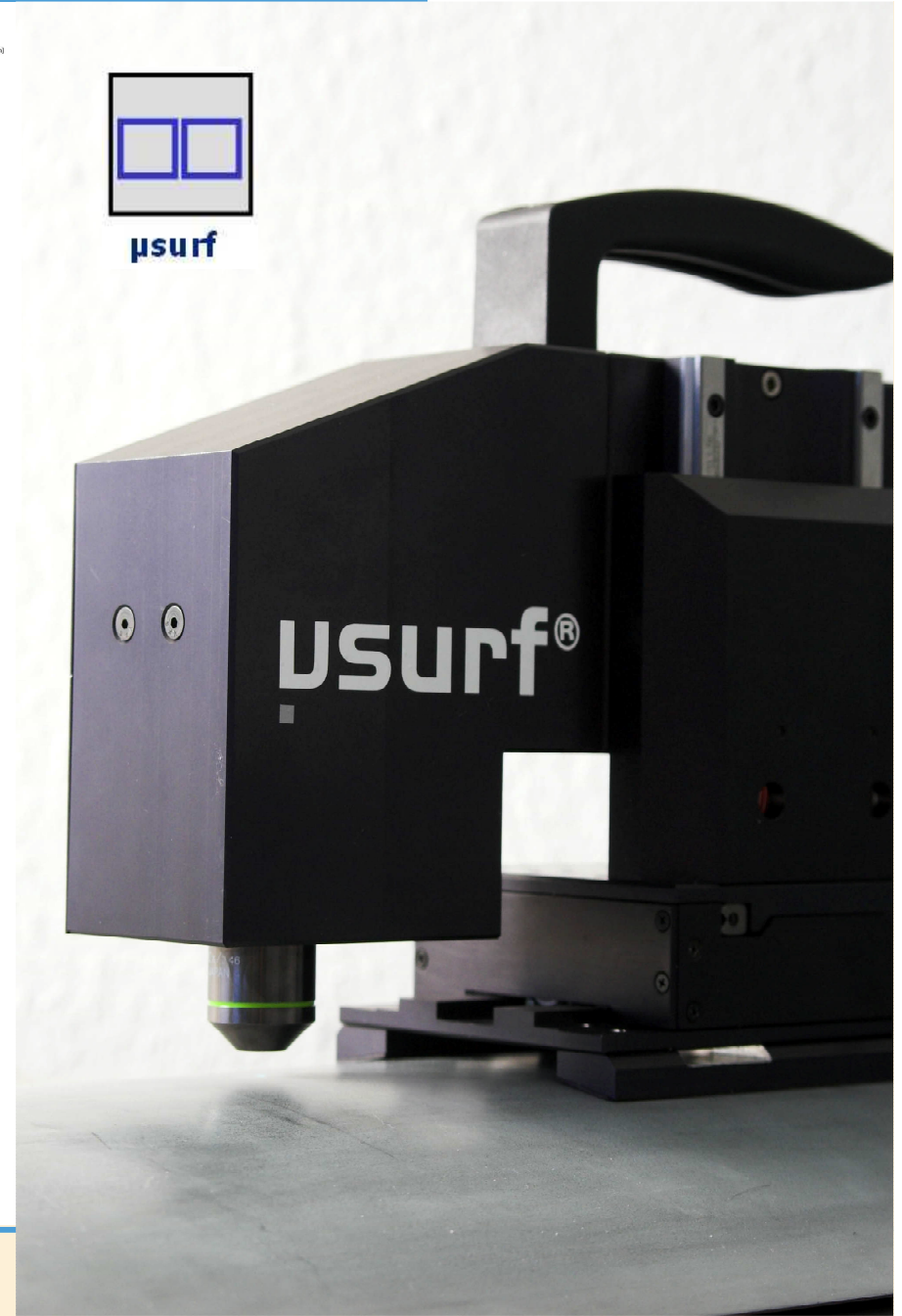
- recording of both sides without moving the sample
- auto calibration enables absolute thickness measurement
- geometry, symmetry, roughness
- non contact

# Printing Cylinders

Laser (800S, Zoom)

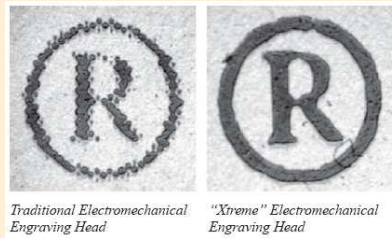
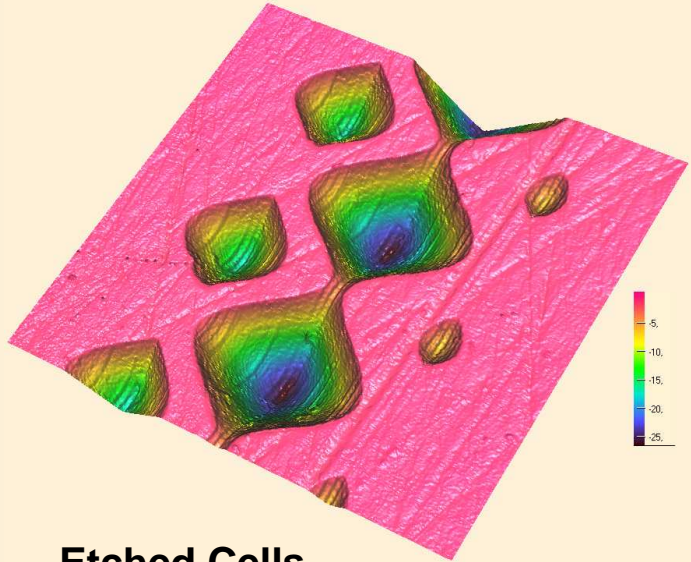


Stylus (320S)

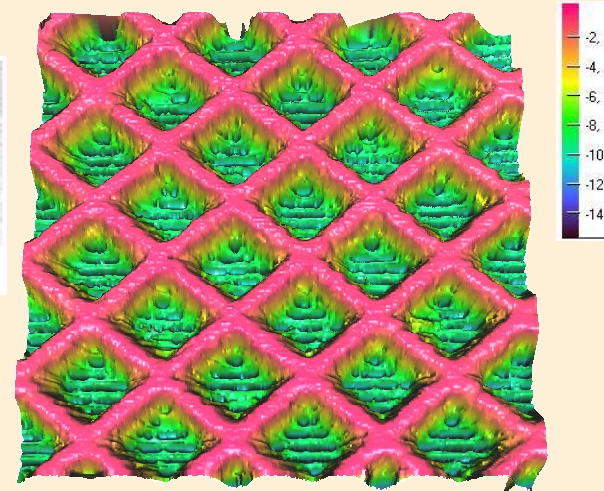


# Gravure - Examples

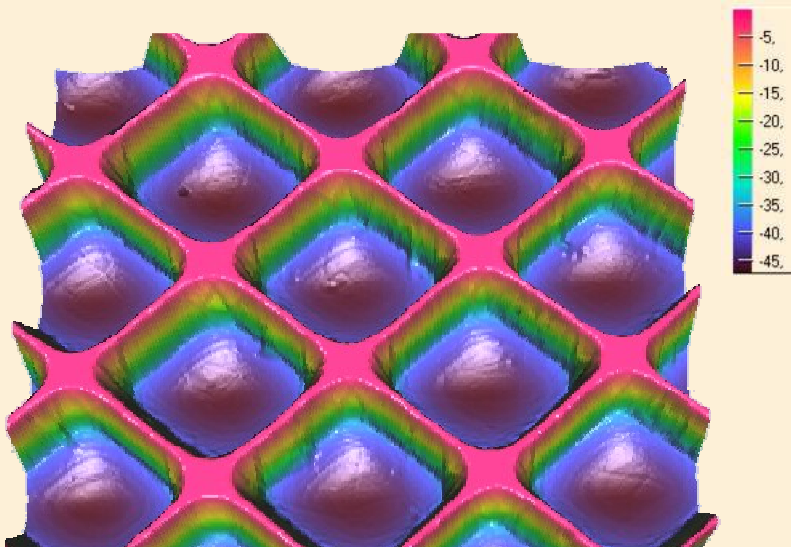
## Electromechanical Gravure



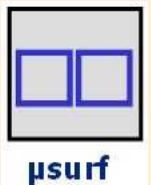
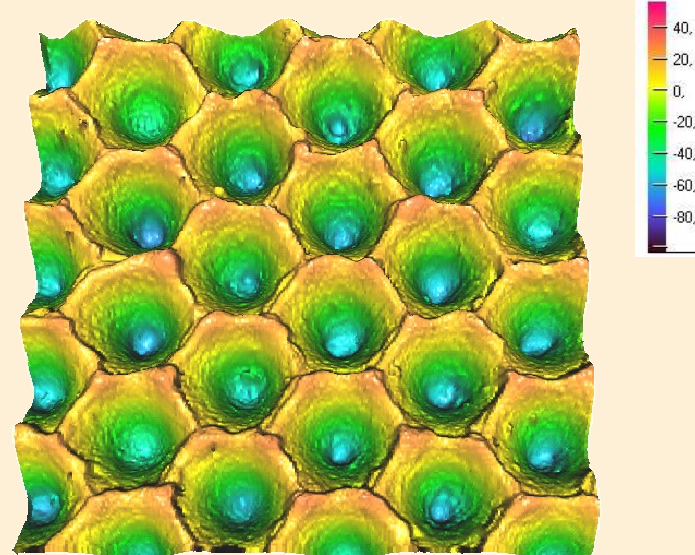
## Extreme Gravure



## Etched Cells



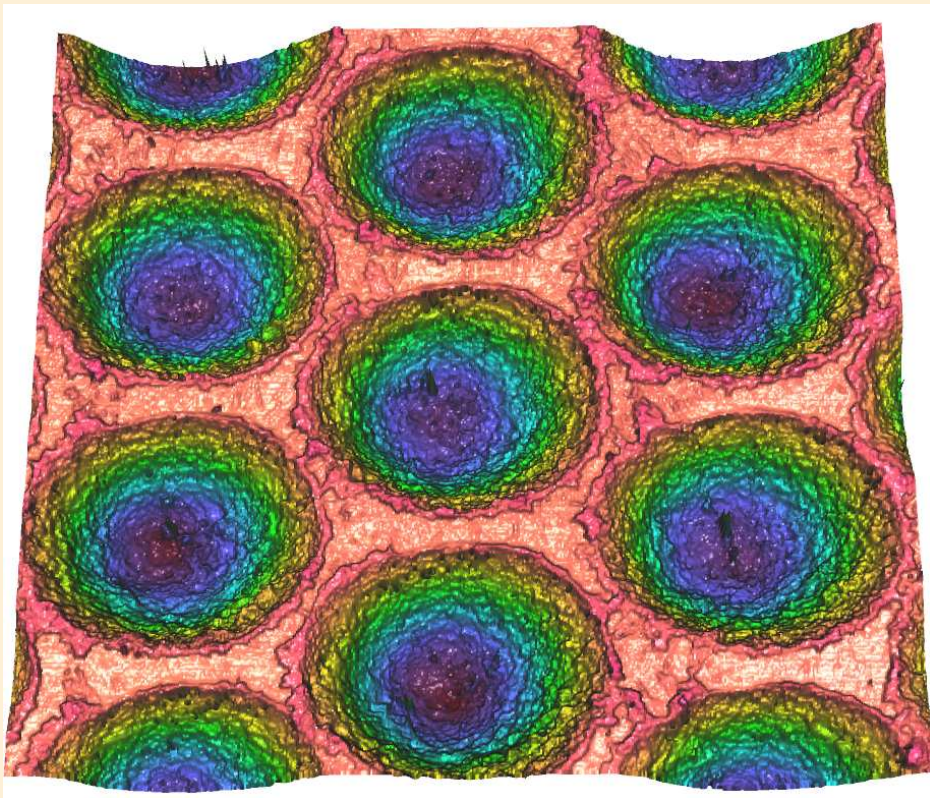
## Anilox



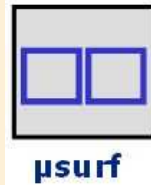


# Gravure on Printing Roll

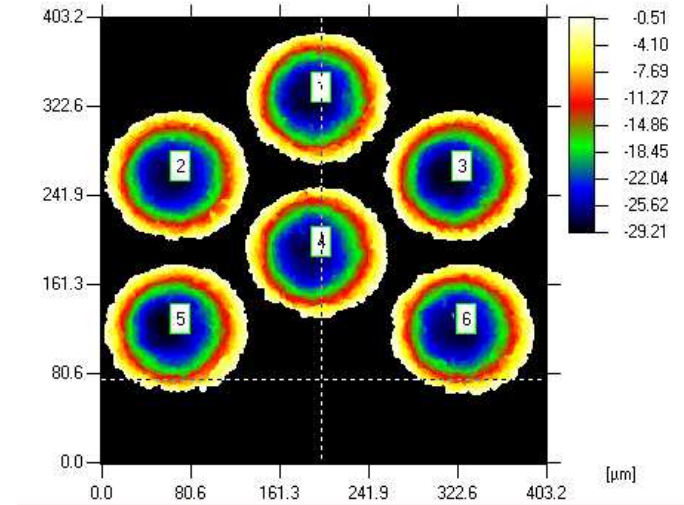
## Laser Gravure 320S



### 1. Measurement

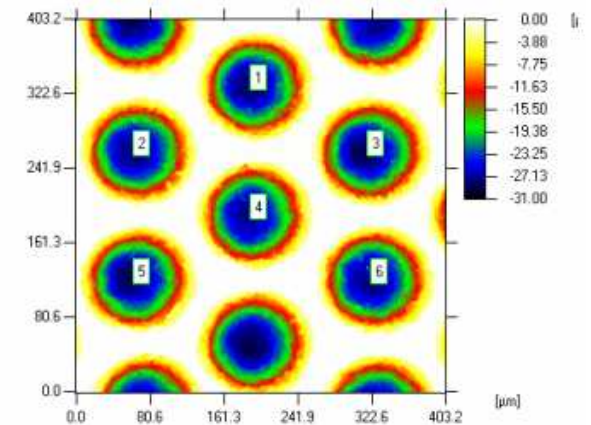


### 2. Segmentation

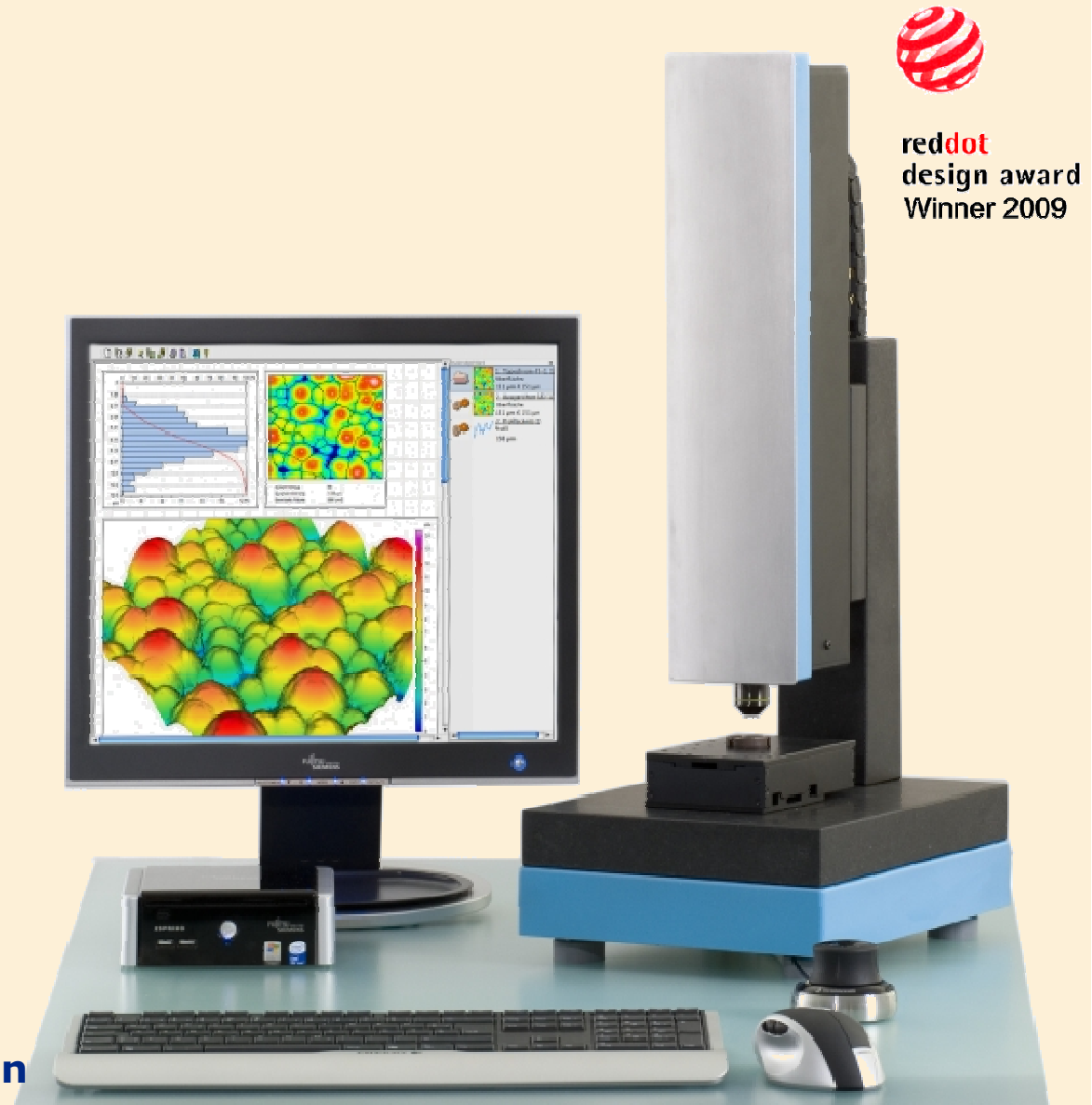


### 3. Report Sheet

Raster	74,94				
Fläche	11944,1	$\mu\text{m}^2$			
Tiefe	28,60	$\mu\text{m}$			
Volumen	9,59	$\text{ml}/\text{m}^2$			
Breite	130,47	$\mu\text{m}$	Länge	117,58	$\mu\text{m}$



- **robust design**
- **high precision**
  - **high resolution**
  - **large flank angles**
  - **high dynamic range**
- **fast area measurement**
- **non-contact**
- **symmetric, optimized light path**
- **simple operation**
- **flexible software package**
- **x, y, z motorized**
- + **LED light source**
- + **compact MPD**
- + **internal controller w. USB interface**
- **limited in sample size and automation**



# μsurf Workplace with MP 500

**nanofocus**  
see more



## large gantry with

- 300mm x 300mm stages
- vacuum chuck
- active vibration isolation
- offset camera
- SC1000 controller

# NanoFocus Customers (Automotive)



# NanoFocus Customers (Electronics, Hybrid)

