

Optical non-contact 3D surface measurement for Quality Assurance of Solar and PV cell manufacturing

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NanoFocus AG
Oberhausen, Ettlingen

nanofocus[®]
see more 

founded in 1994

optical surface inspection:
development & production of
3D laser profilometer μ scan[®] &
3D confocal microscope μ surf[®]

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

> 500 installed systems



NanoFocus AG
HQ
Oberhausen
Germany



NanoFocus
Sales
Ettlingen
Germany

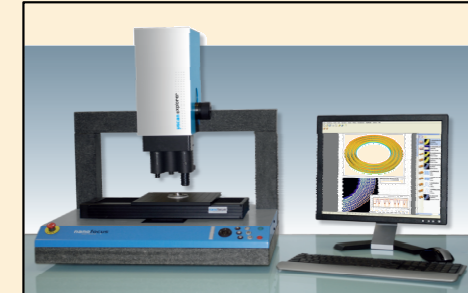
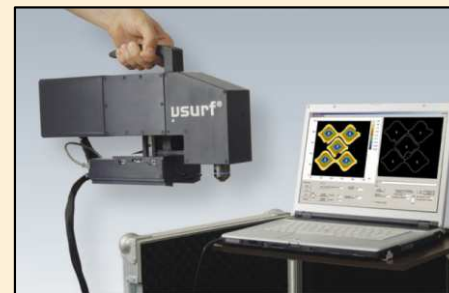
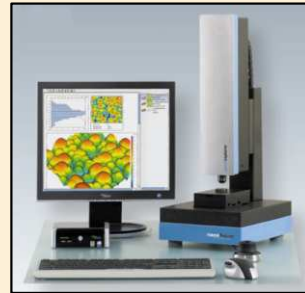


NanoFocus Inc.
Glen Allen, VA USA

Product Range

Standard products

(μ surf explorer, μ surf mobile, μ scan explorer)



Customized systems

(μ surf custom, μ scan custom, μ sprint custom)



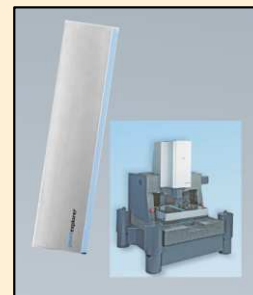
Business solution

(μ surf solar, μ surf cylinder, μ surf blade etc.)



Integration

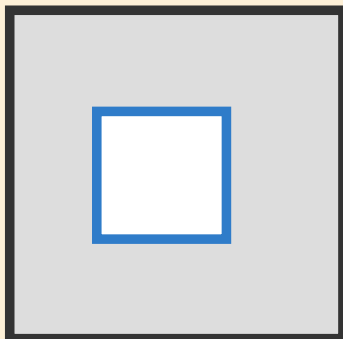
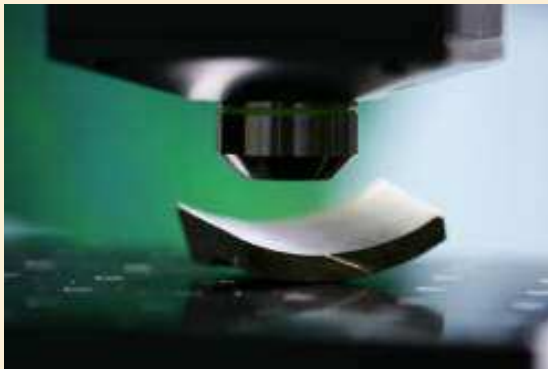
(μ surf OEM, μ scan OEM, μ sprint OEM)



Product Categories

μsurf®

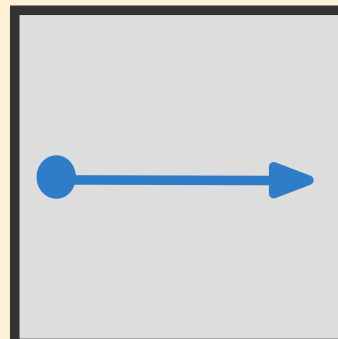
3D-Microscopy



- 3D-Structure
- Wear
- Tribology

μscan®

2D-Profilometry



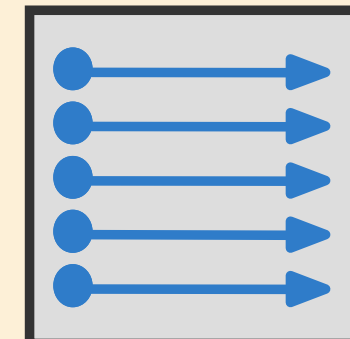
- 2D-Shape
- Roughness

μsprint®

3D-Profilometry

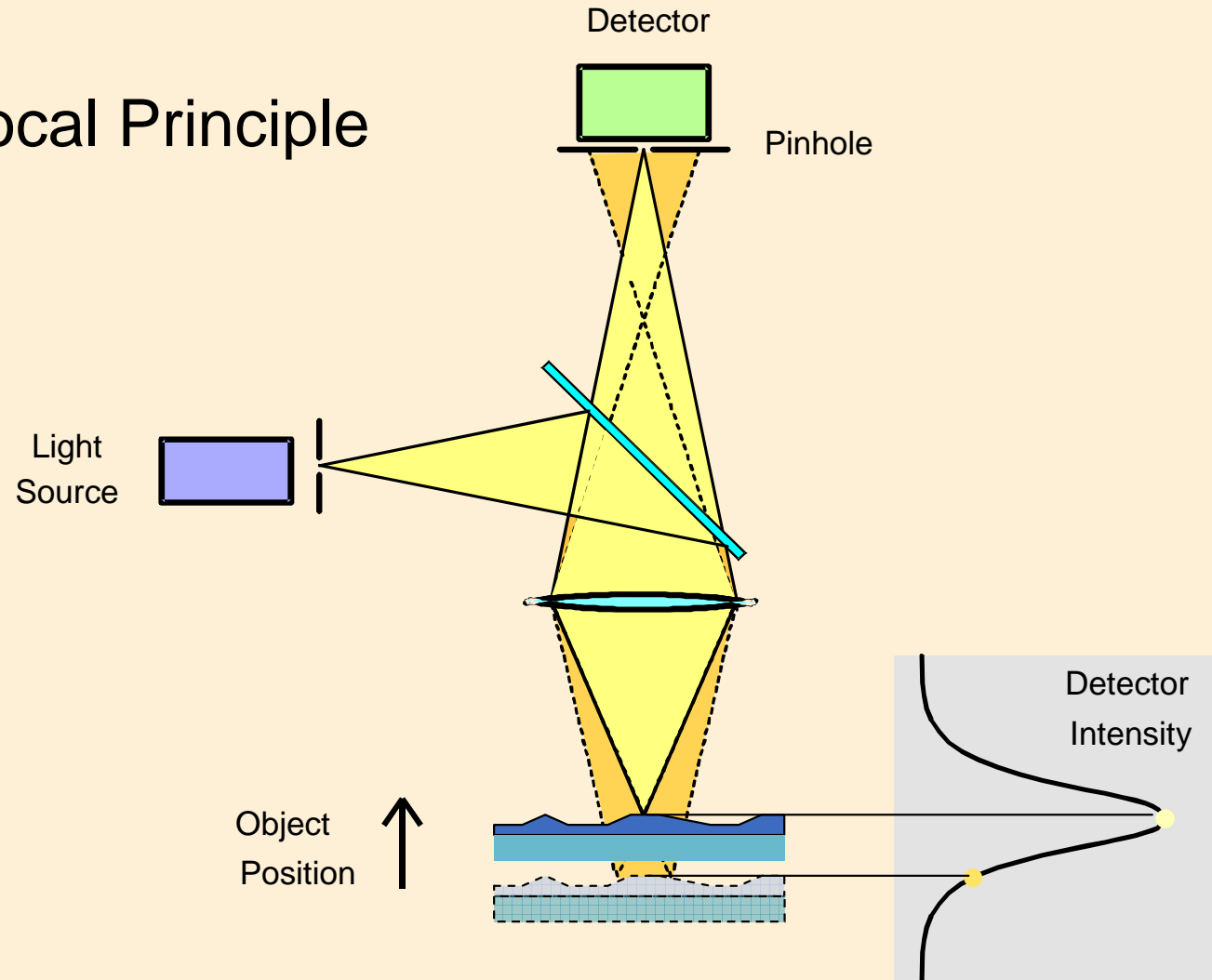


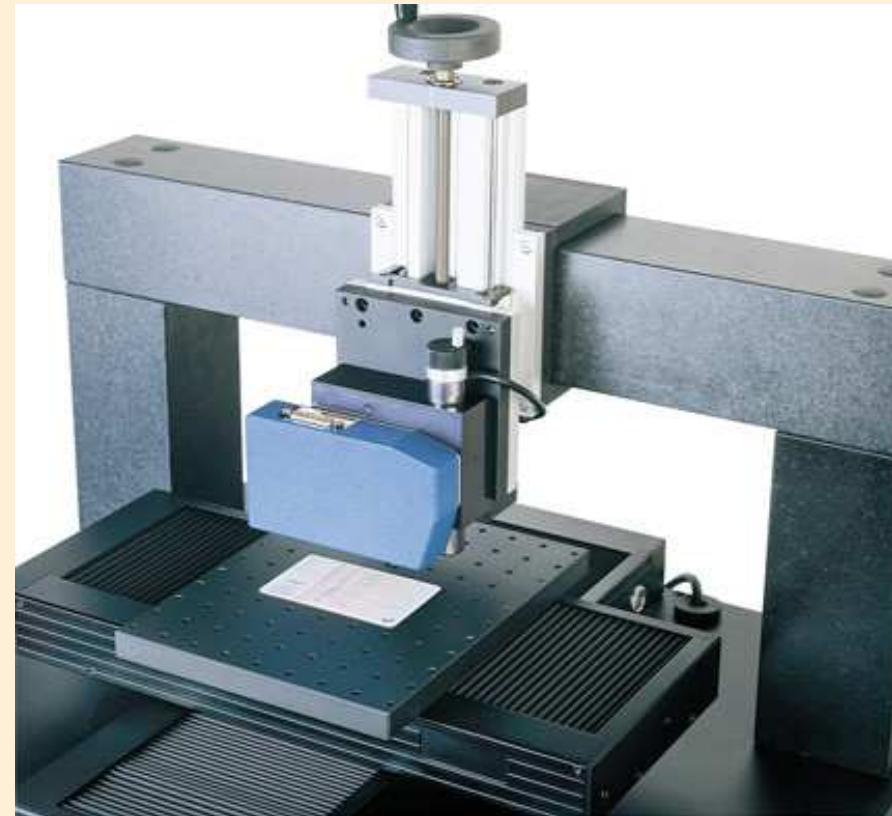
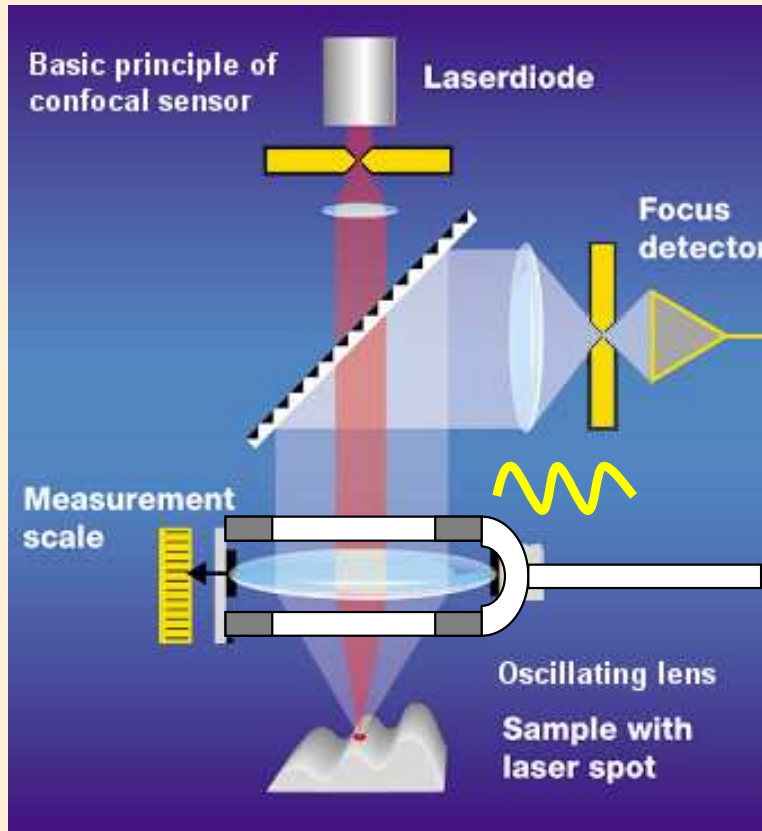
NEW



- 3D-Shape
- Defects
- Production Control

► Confocal Principle



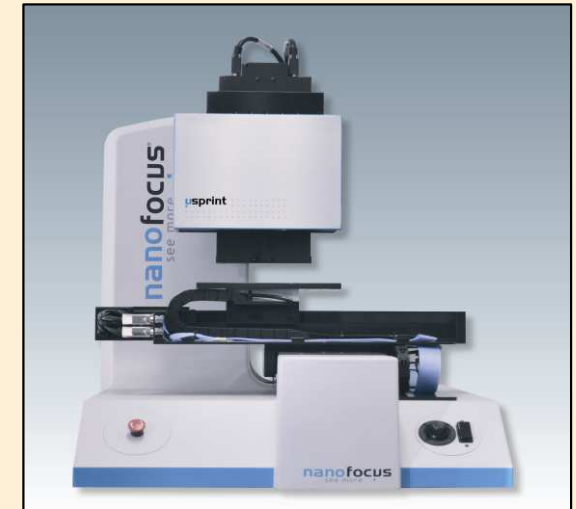
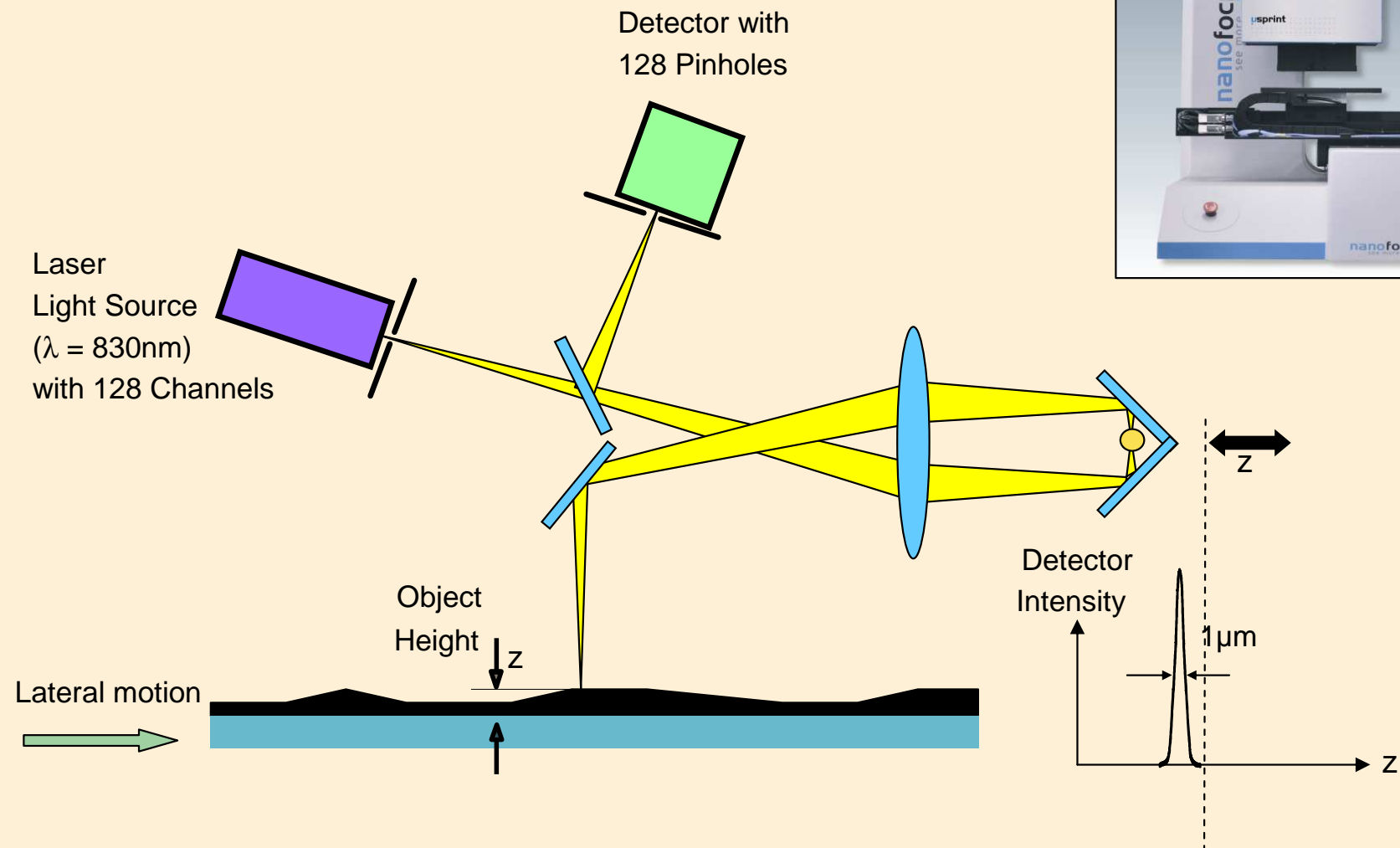


Confocal Point Sensor

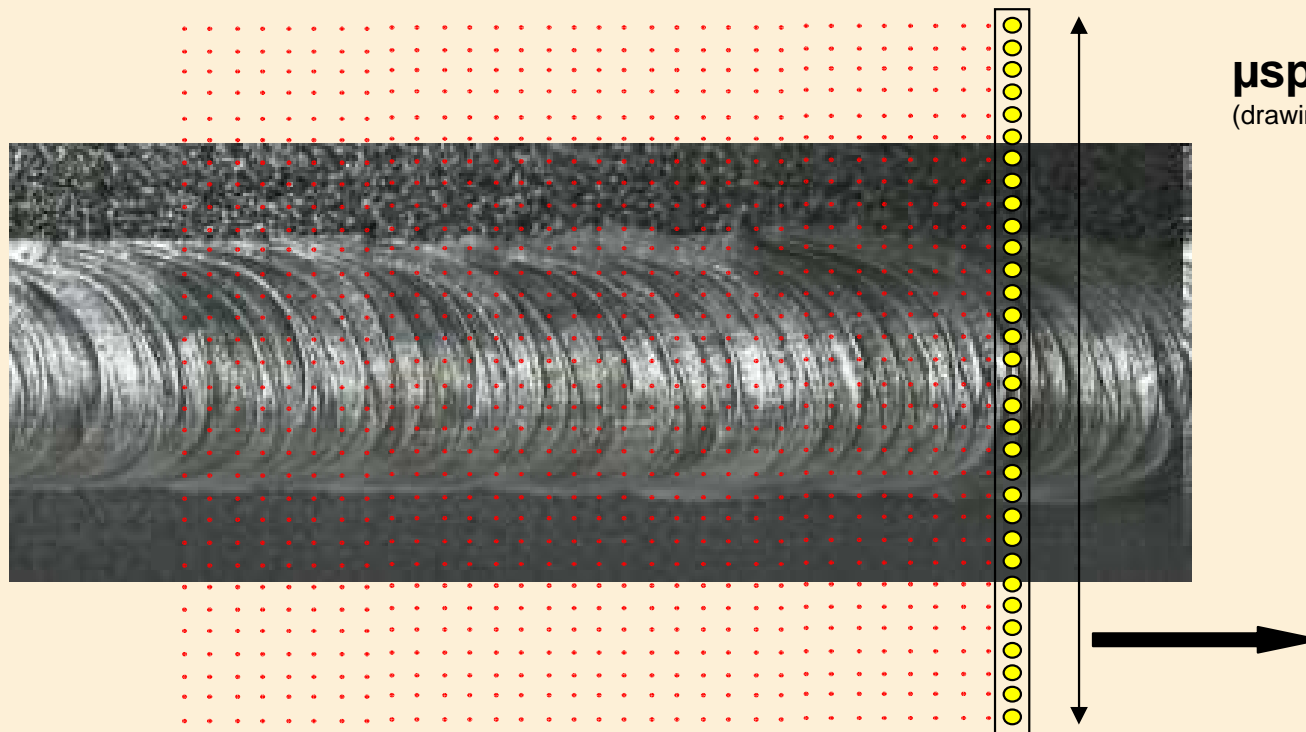
Scanning Profilometer μ scan with offset camera

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

μsprint Technology

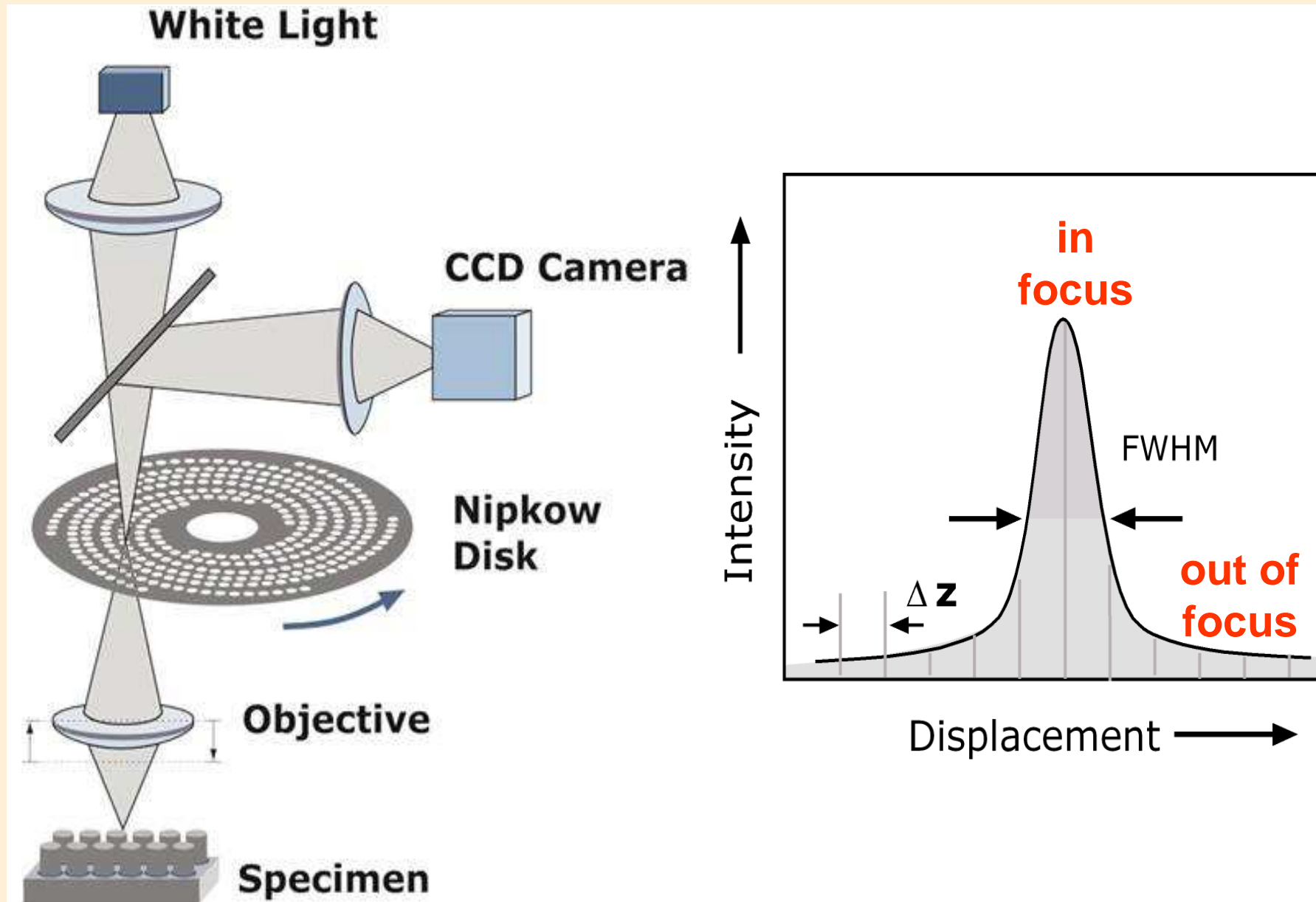


- ▶ 128 parallel channels
- ▶ scanning speed 54mm/s
- ▶ spot diameter 1μm



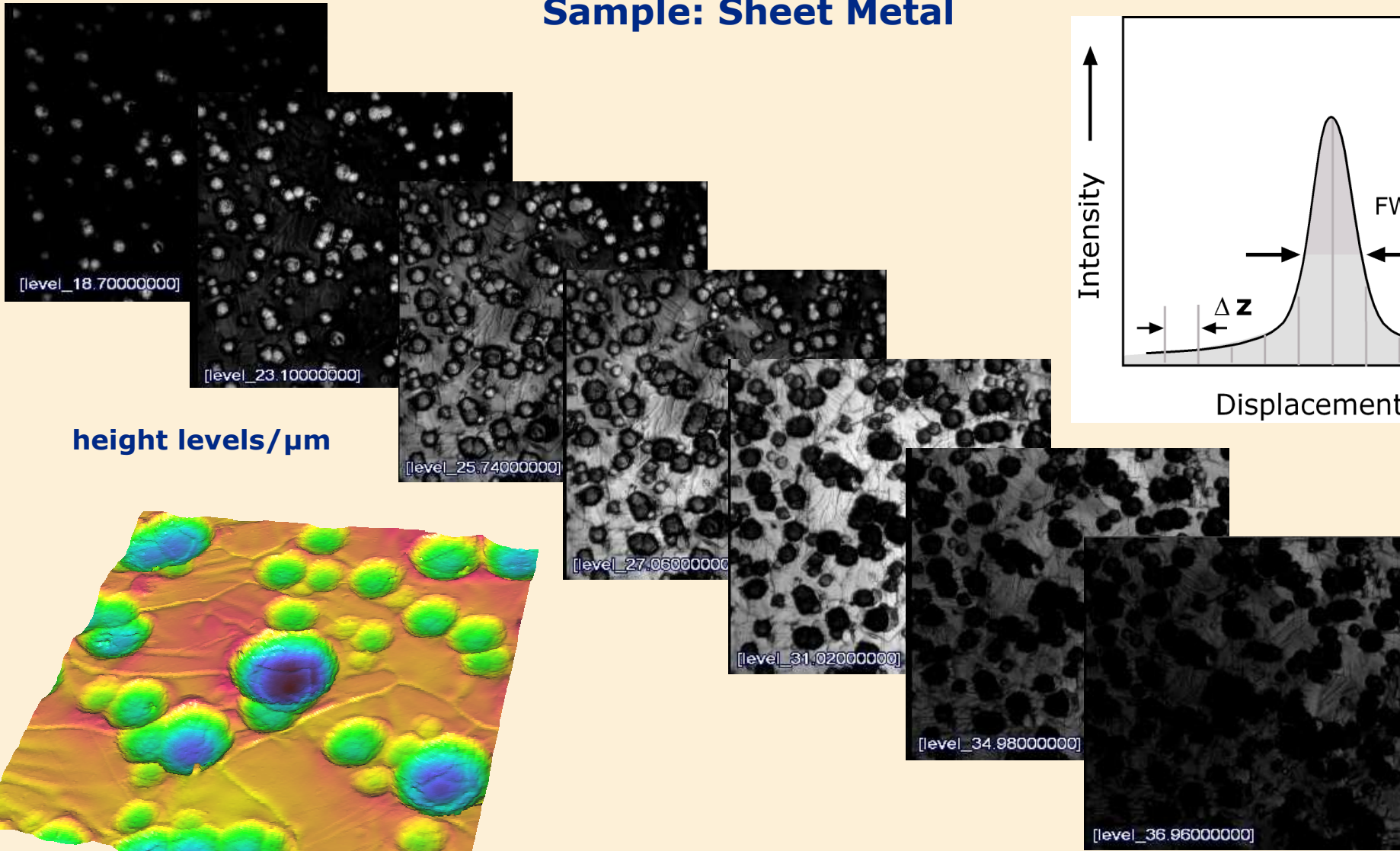
μsprint Scanning Principle
(drawing not true to scale)

Confocal Principle

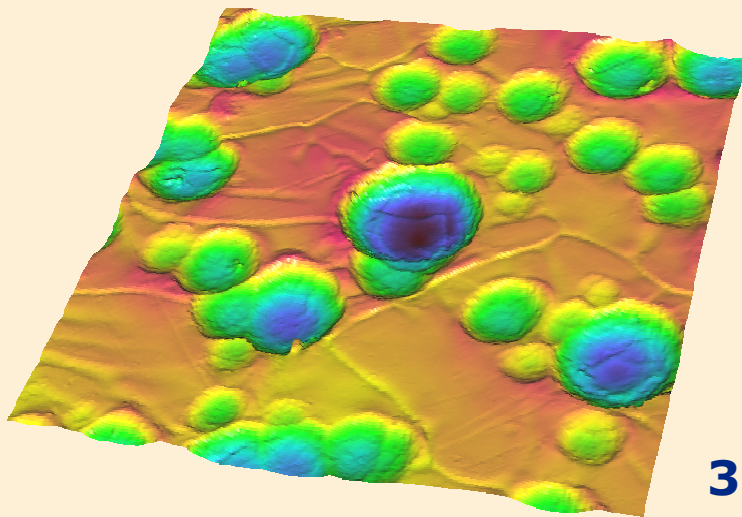
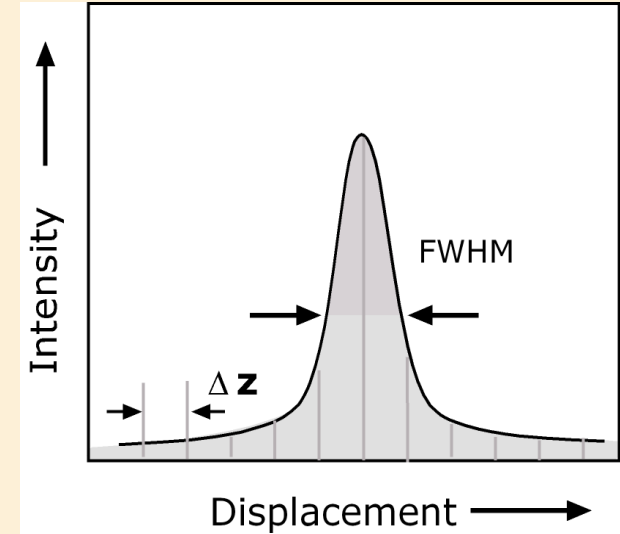


Confocal Imaging Sequence

Sample: Sheet Metal

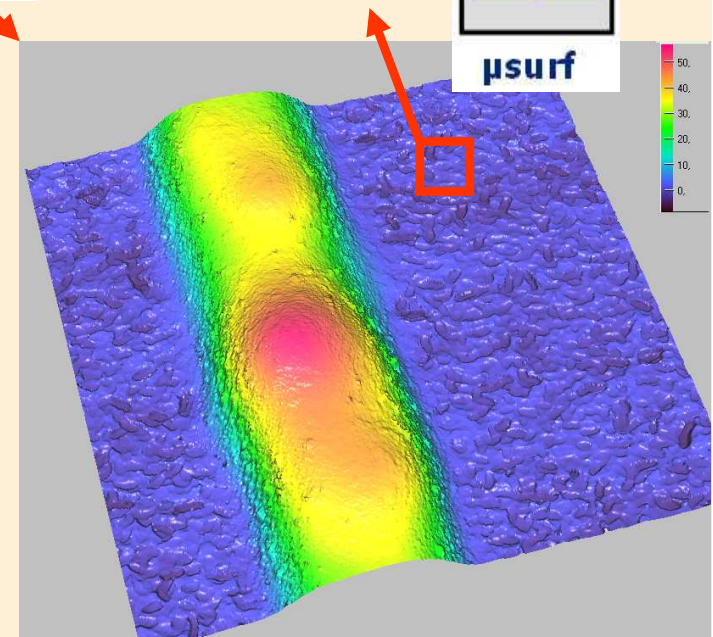
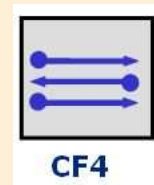
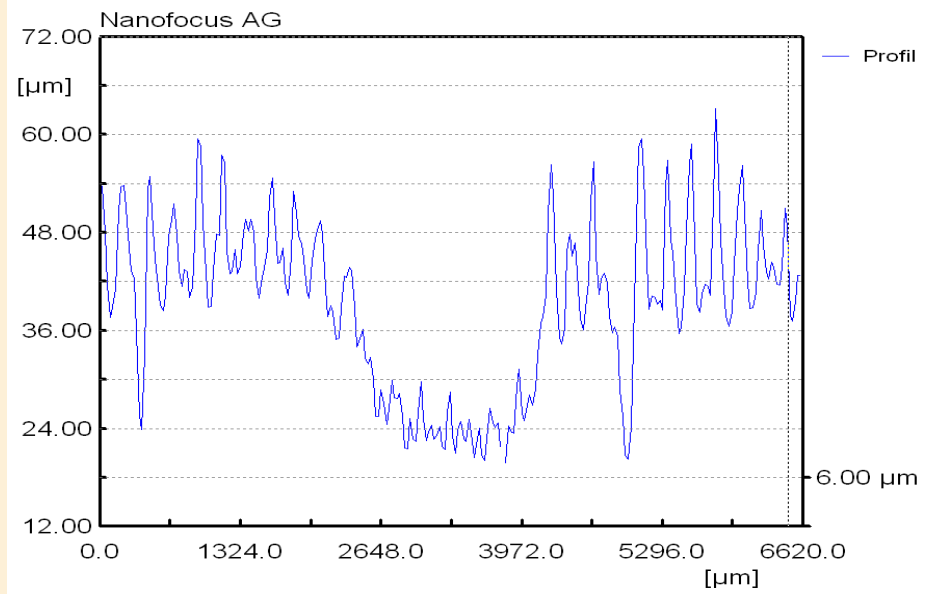
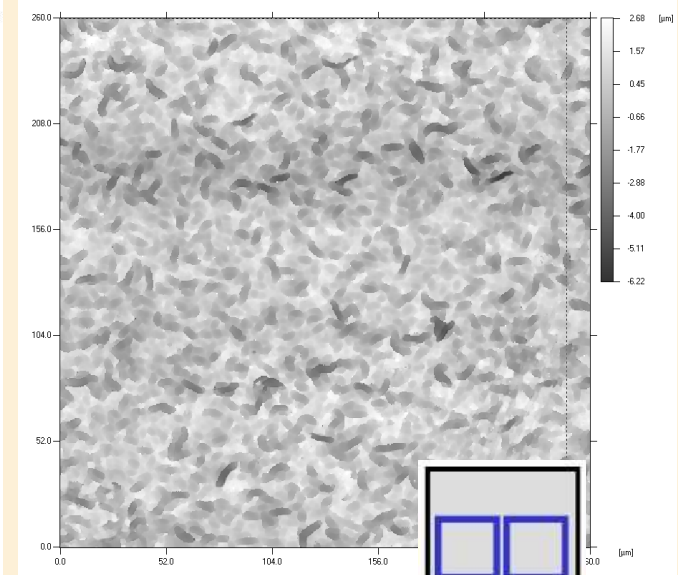
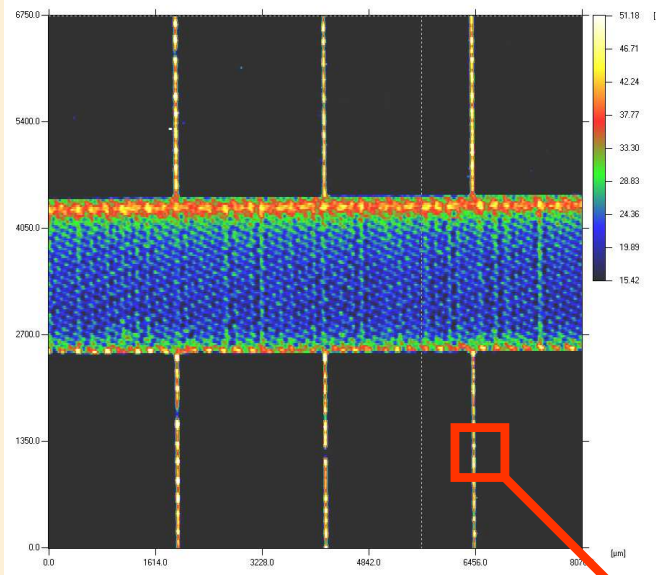
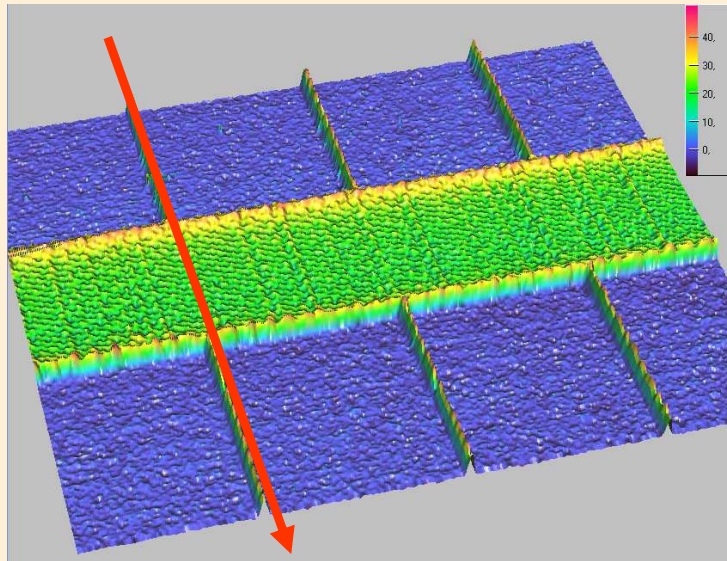


height levels/ μm

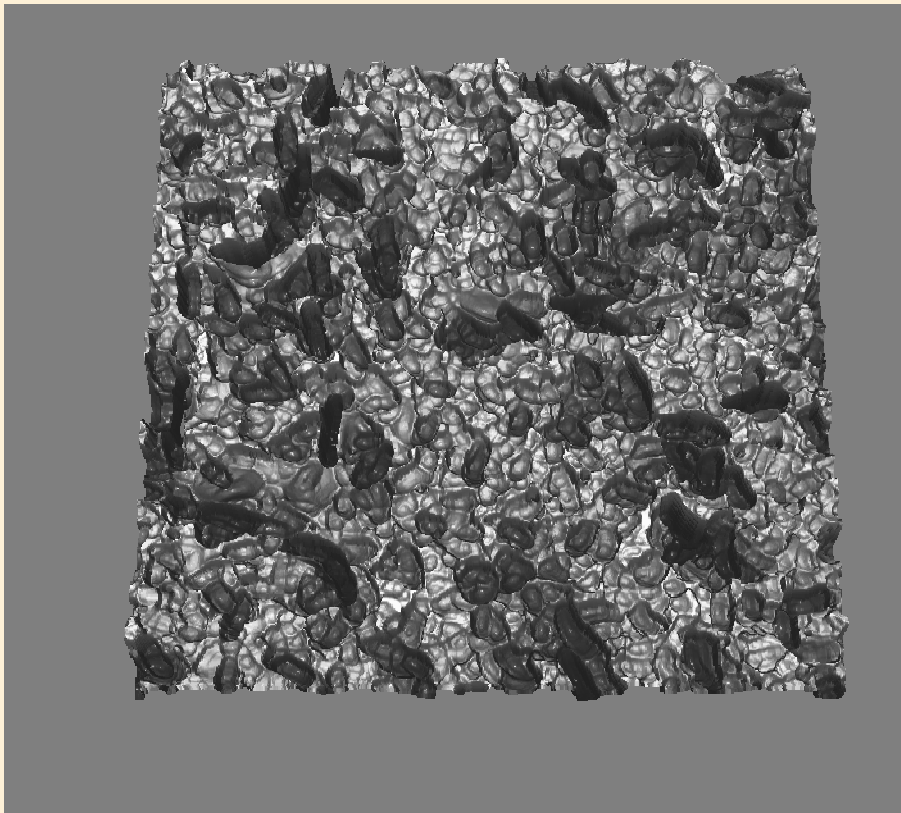


3D View

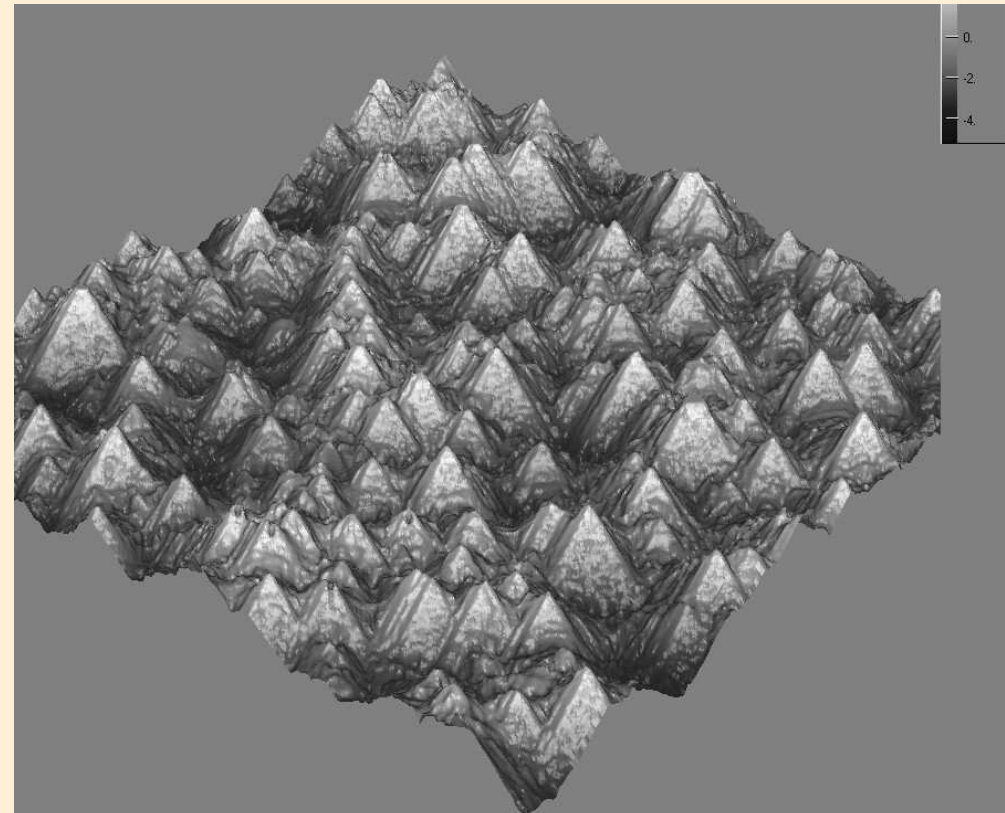
Measuring Task: Finger and Busbar



Surface analysis

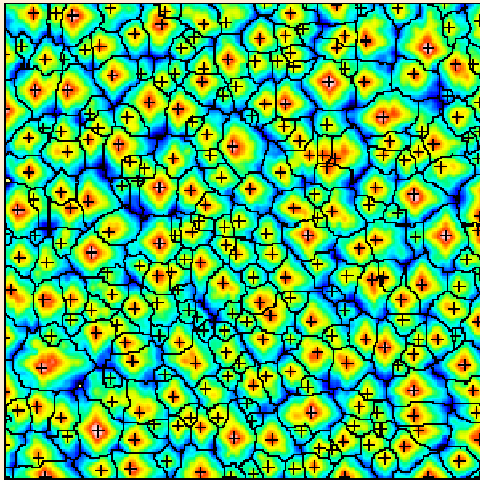


Etched multi Si



Etched mono Si

Analysis of pyramid structures

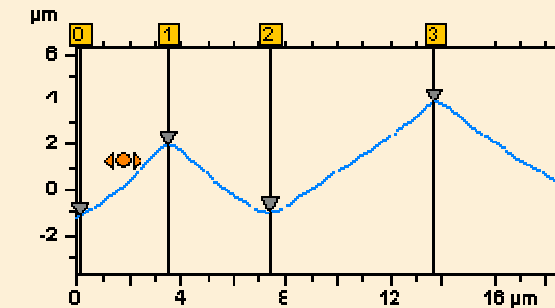
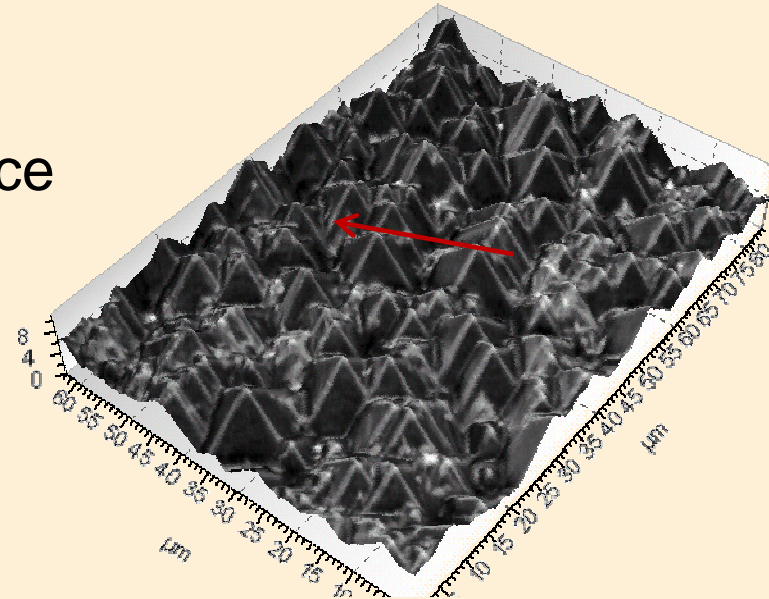


Number of motifs: 273
Mean Height: 1.57 μm
Mean Area: 52.9 μm^2

Mean pyramid angle: 42.3°

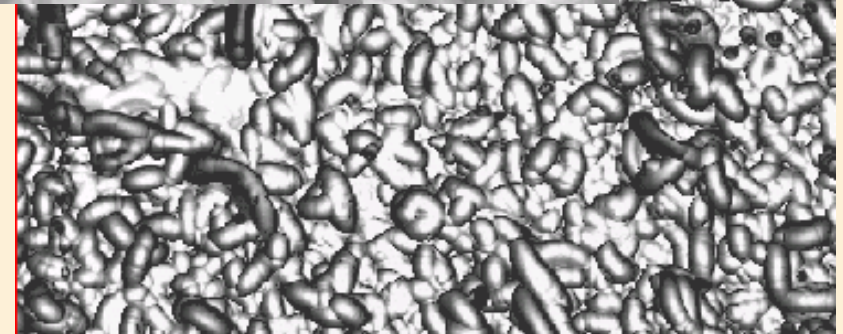
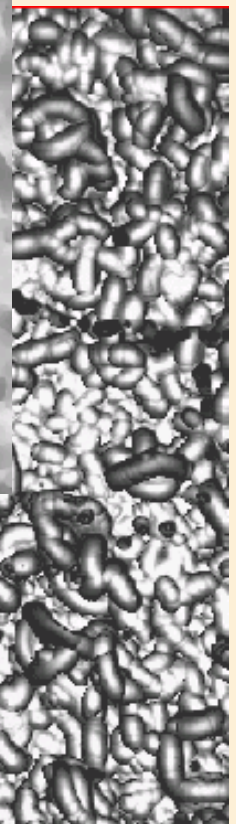
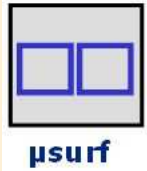
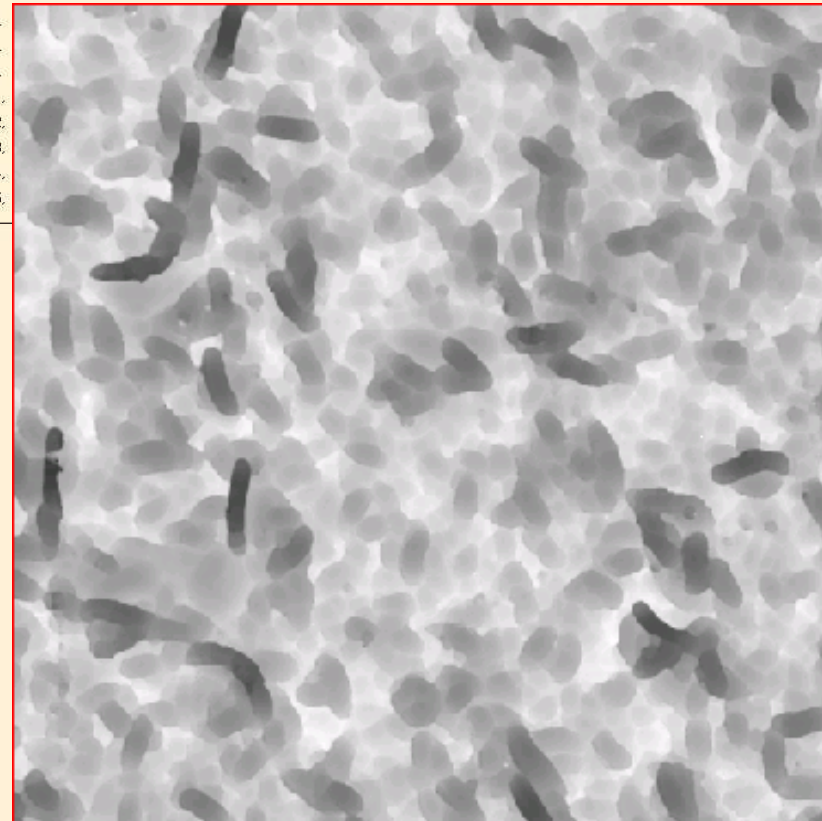
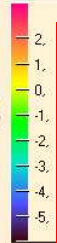
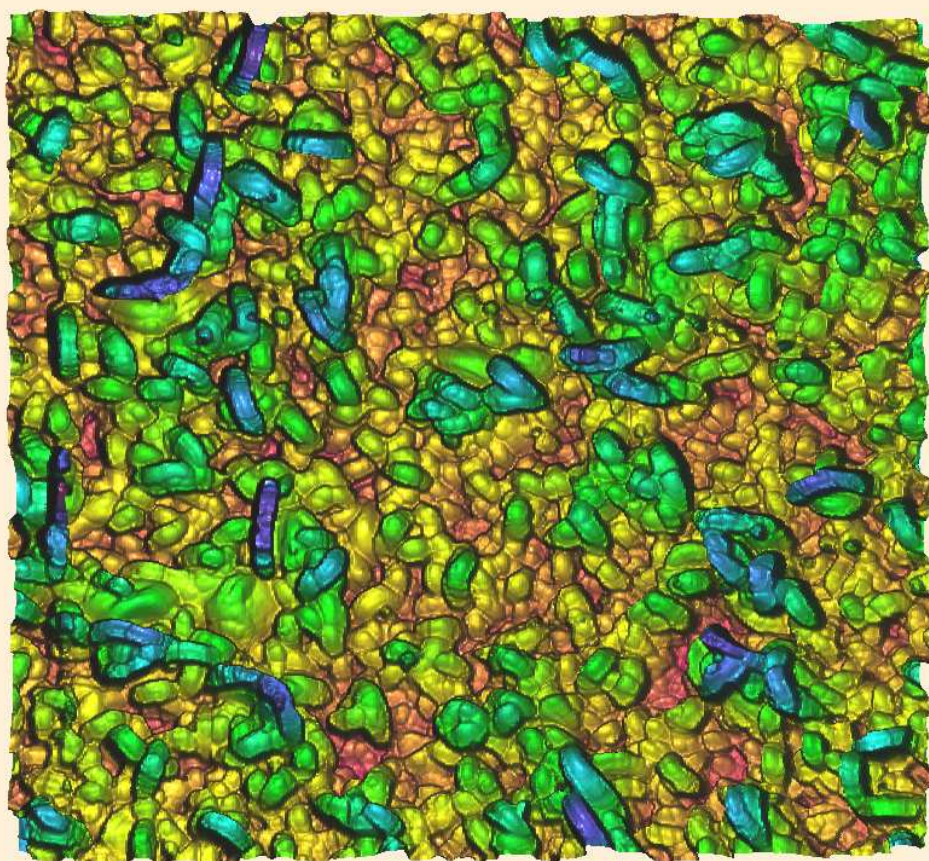
Mean pyramid height: 1.57 μm

Reliable surface
analysis



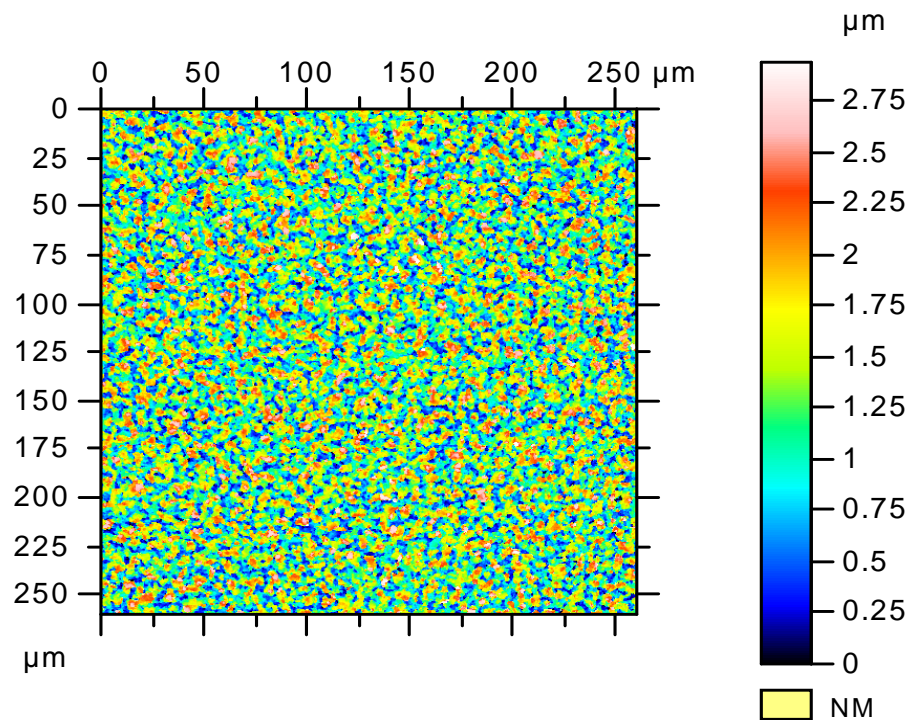
Horizontal distance :	0-1 3.37 μm	2-3 6.25 μm
Height difference :	3.19 μm	4.77 μm
Angle :	43.4°	37.4°

Solar Cells: etched Si



160S **Si, etched**

Thin-Film: Roughness on CIS



Latest 2D and 3D ISO-Parameters

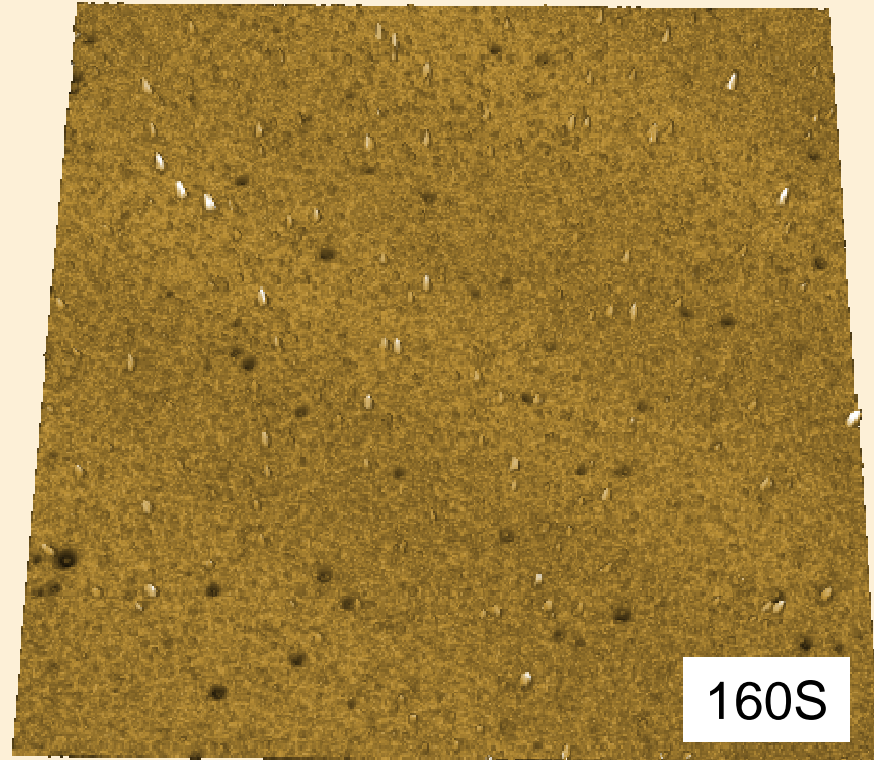
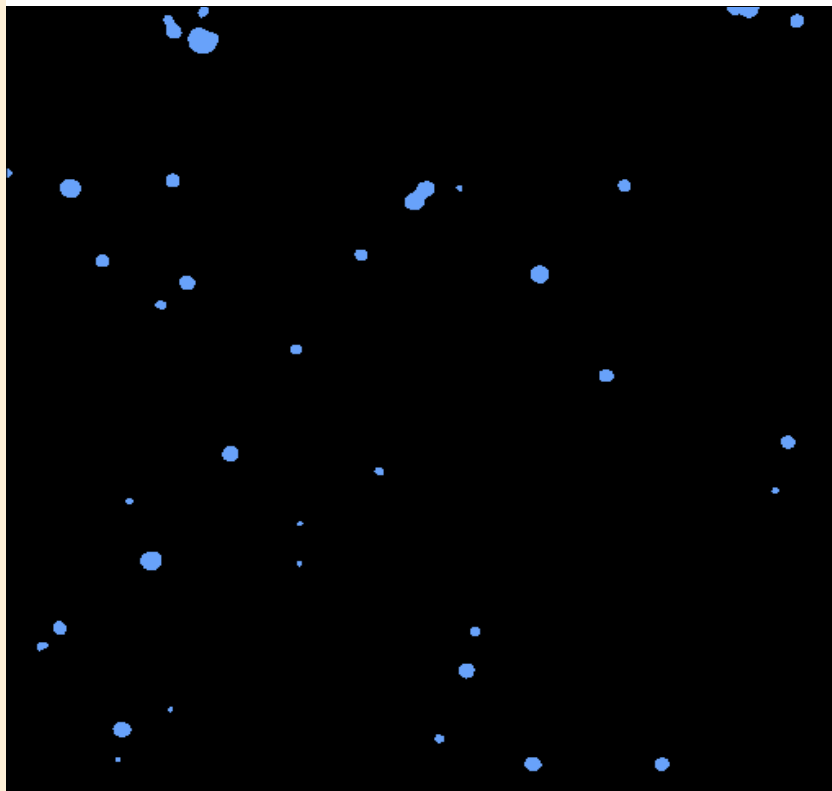
ISO 4287

		Mean	Std dev	Min	Max
Amplitude parameters - Roughness profile					
Rp	μm	1.41	0.142	1.13	1.65
Rz	μm	2.54	0.159	2.31	2.76
Ra	μm	0.468	0.0356	0.416	0.512
Material Ratio parameters - Roughness profile					
Rmr	%	25.3	7.66	16.5	42.2

ISO 25178

Height Parameters			
Sp	1.68	μm	
Sz	2.95	μm	
Sa	0.504	μm	
Functional Parameters			
Smr	14.4	%	<i>c = 1 μm under the highest peak</i>

Thin-Film: Pinhole Analysis



Number of grains: 36
Total area occupied by the grains: 611 μm^2 (0.87 %)
Density of grains: 0.000513 grains / μm^2 .

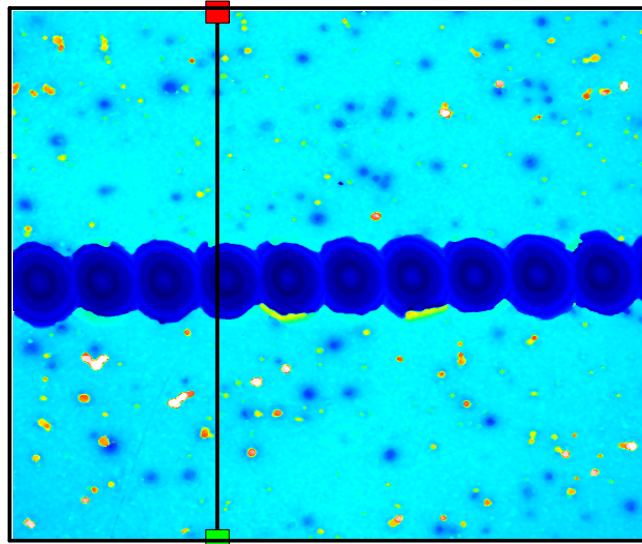
Area	= 17 μm^2	+/- 14 μm^2	
Mean diameter		= 4829 nm	+/- 1773 nm

Automated detection of
defects and particles

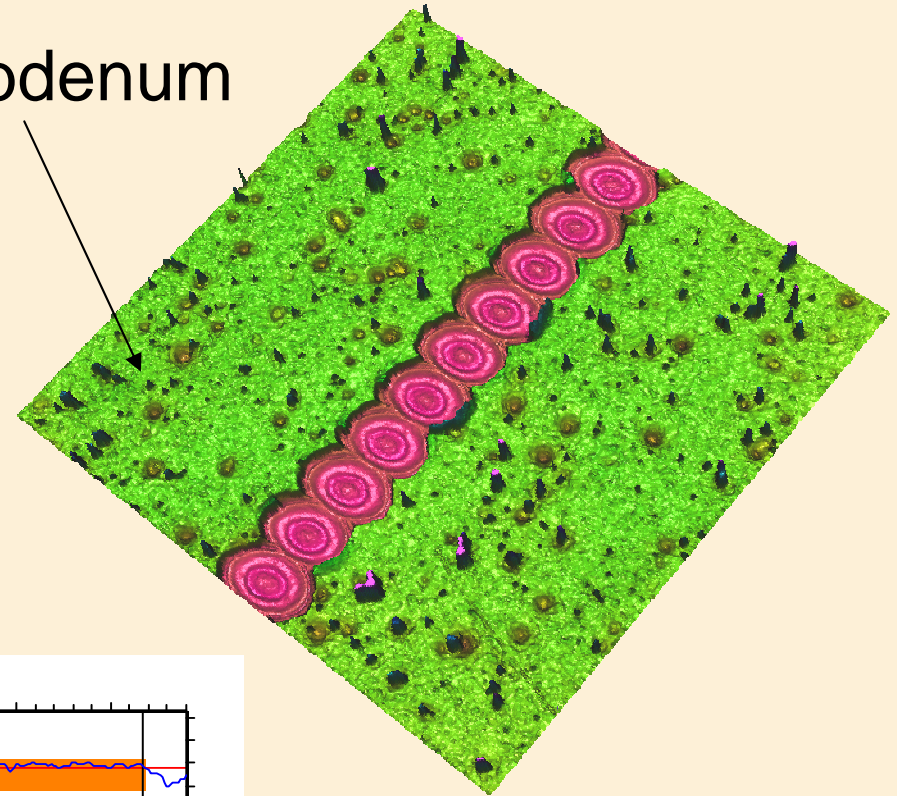
Thin-Film: Laser Scribes on Mo

Molybdenum

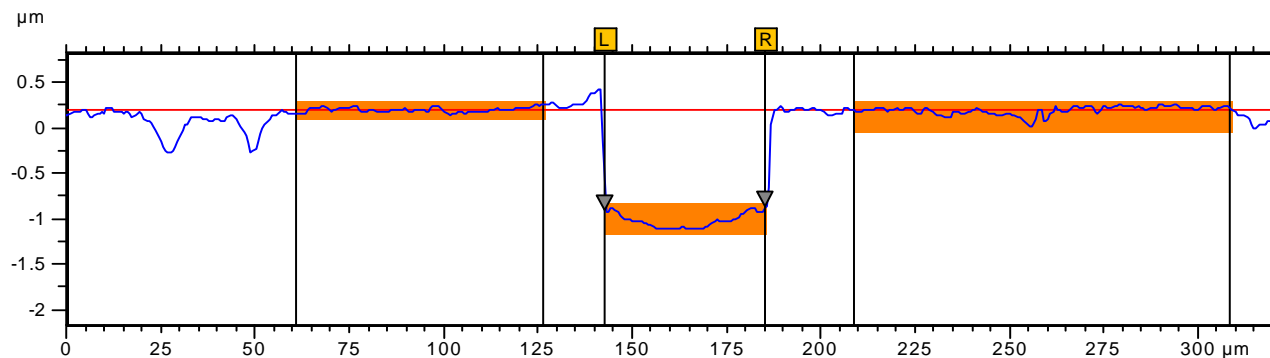
quality
assurance of
laser texture



Extracted profile

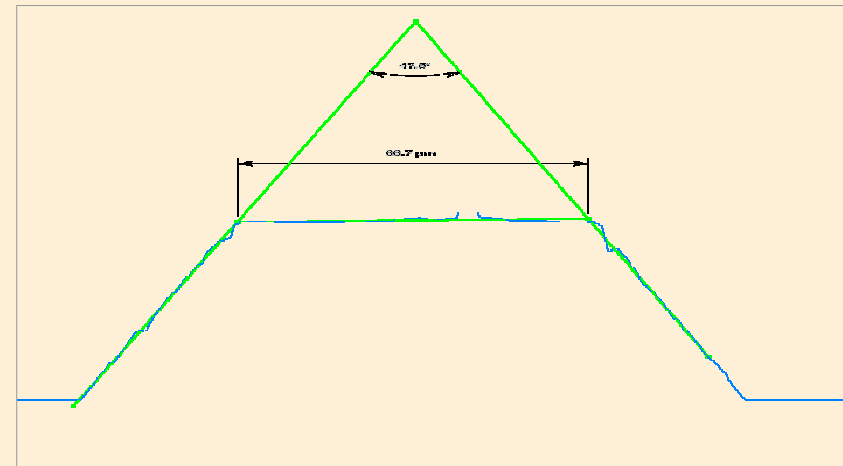
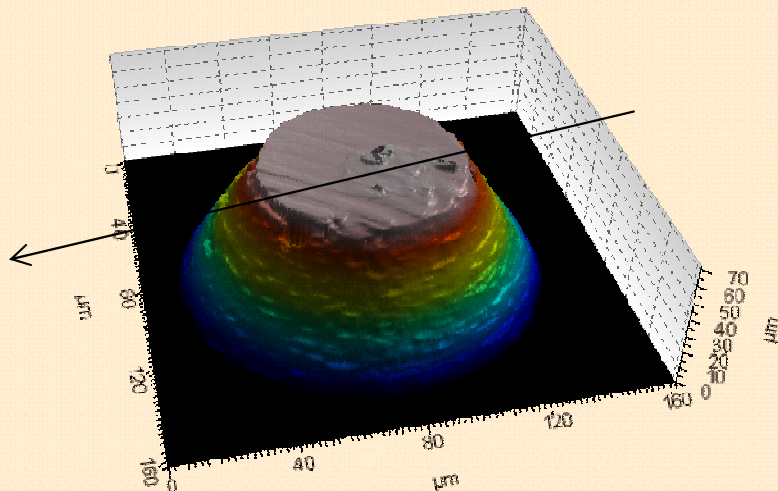


320S

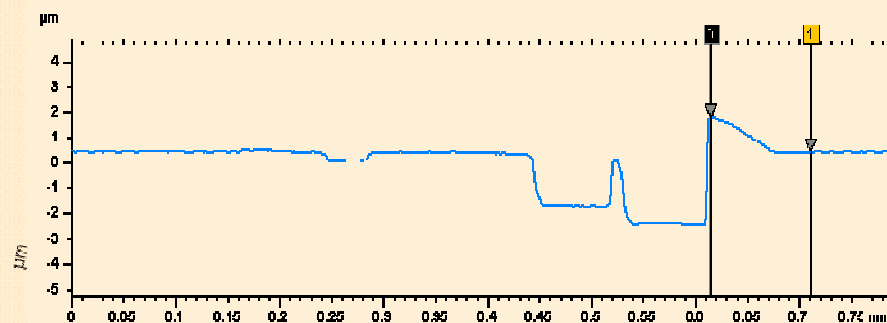
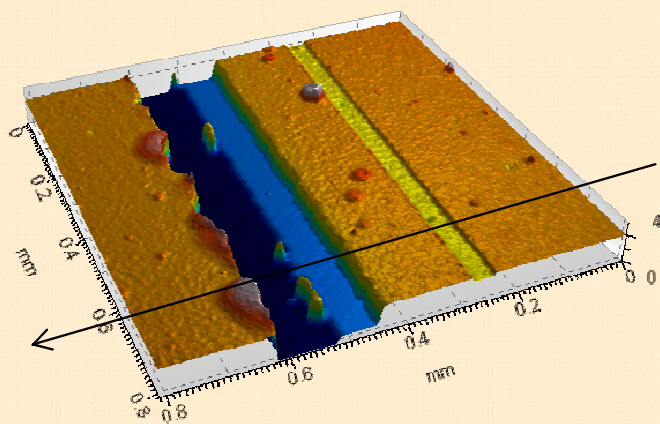


	1
Maximum height	1.31 μm
Mean height	1.21 μm
Width	43.2 μm

Scribe needle and scribe edges



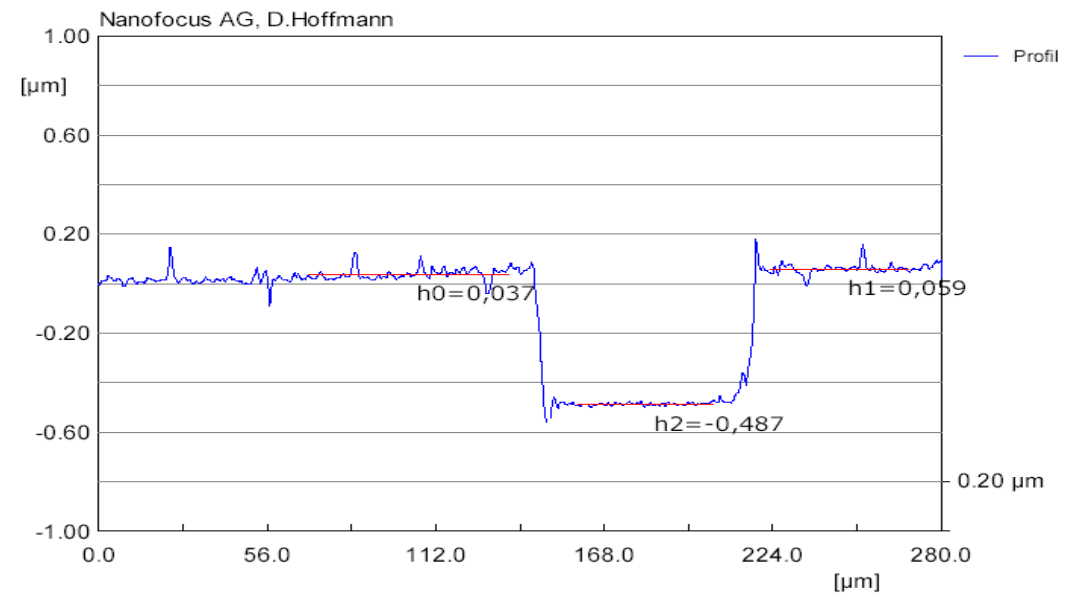
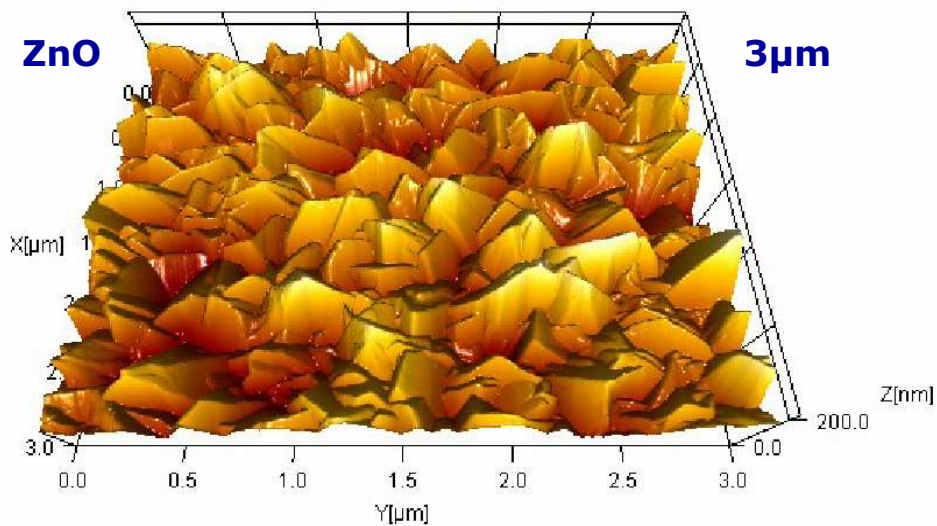
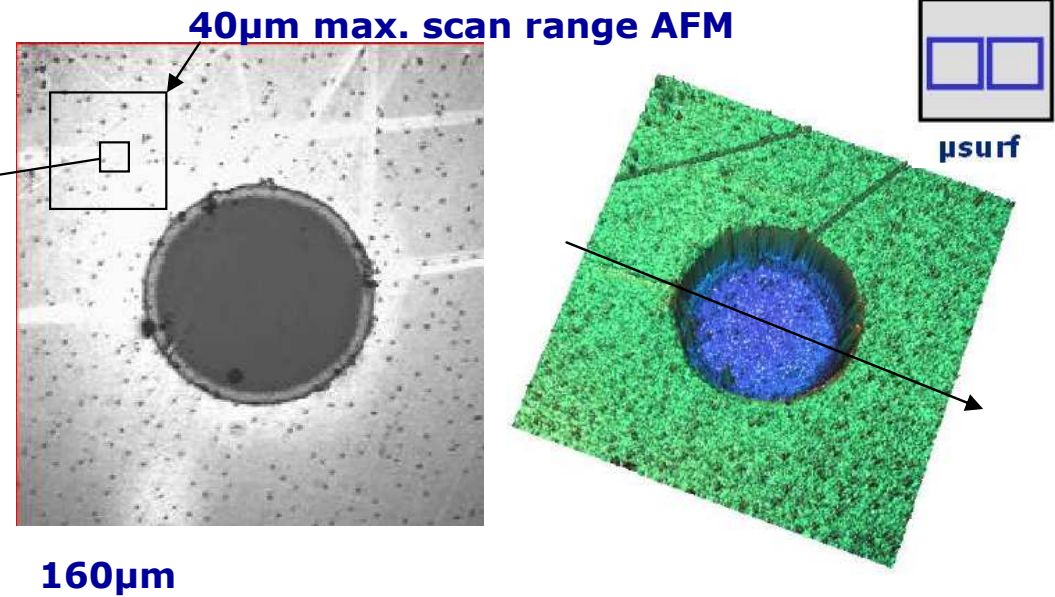
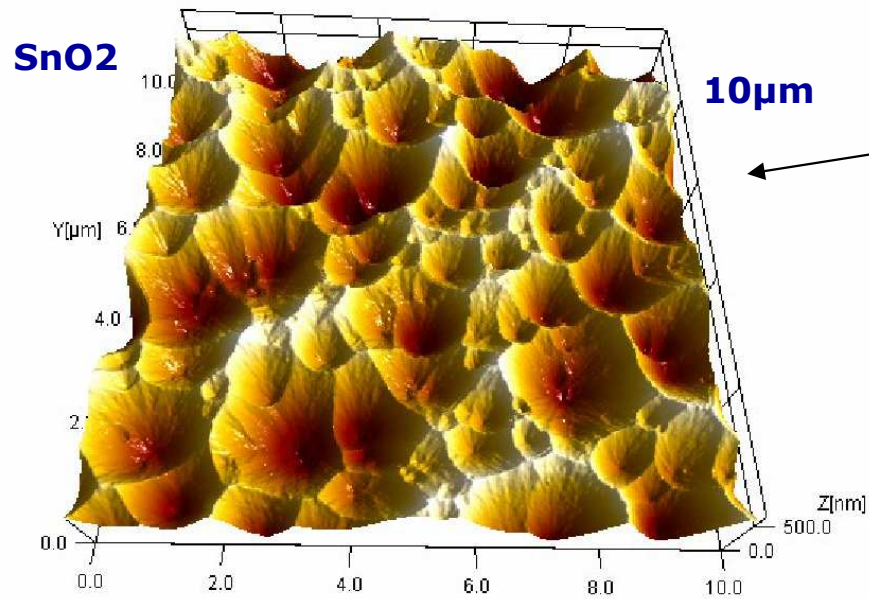
Geometry of
needles



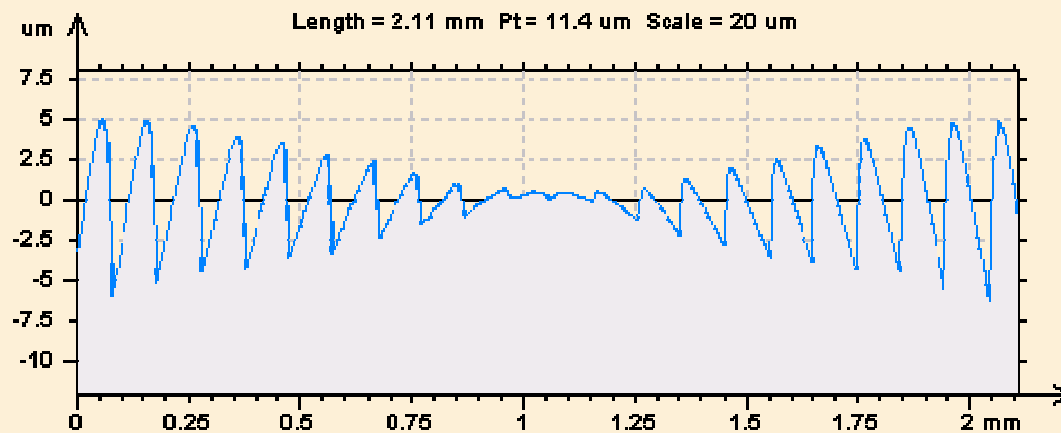
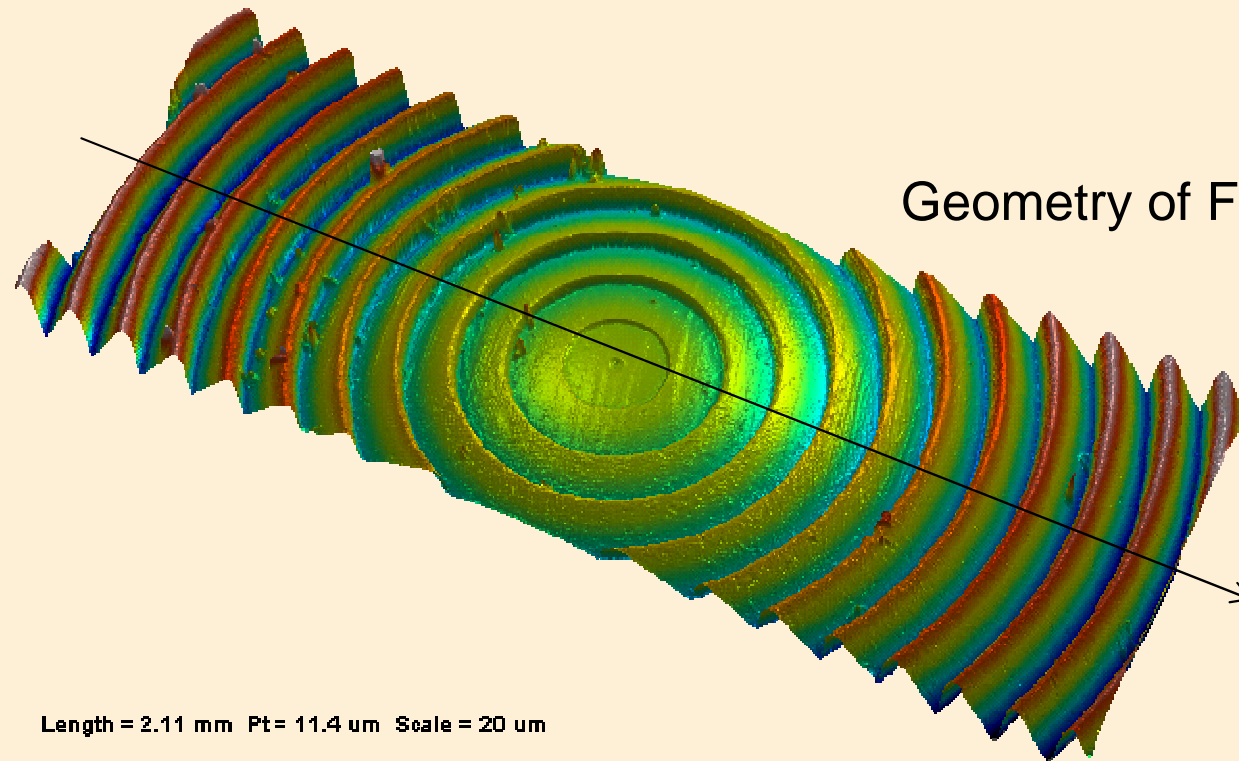
Analysis of
bulgings

0-1
Horizontaler Abstand : 0.0669 mm
Höhenunterschied der Punkte : -1.36 µm

Solar Cells (FZJ-IPV)

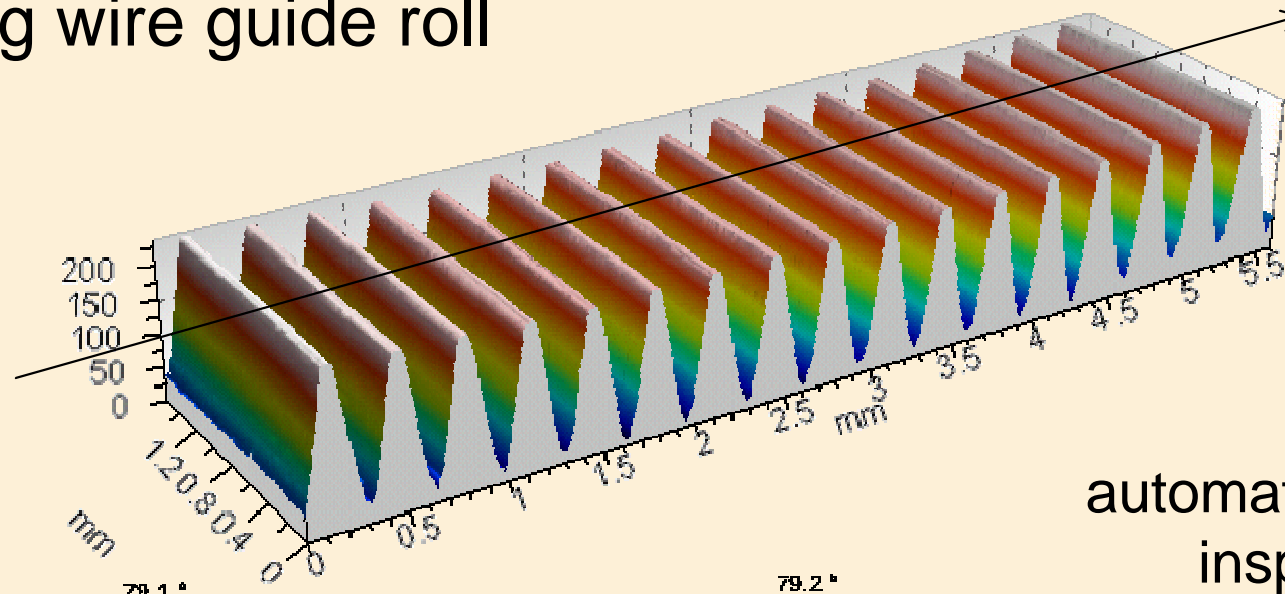


Measuring task: concentrator cells

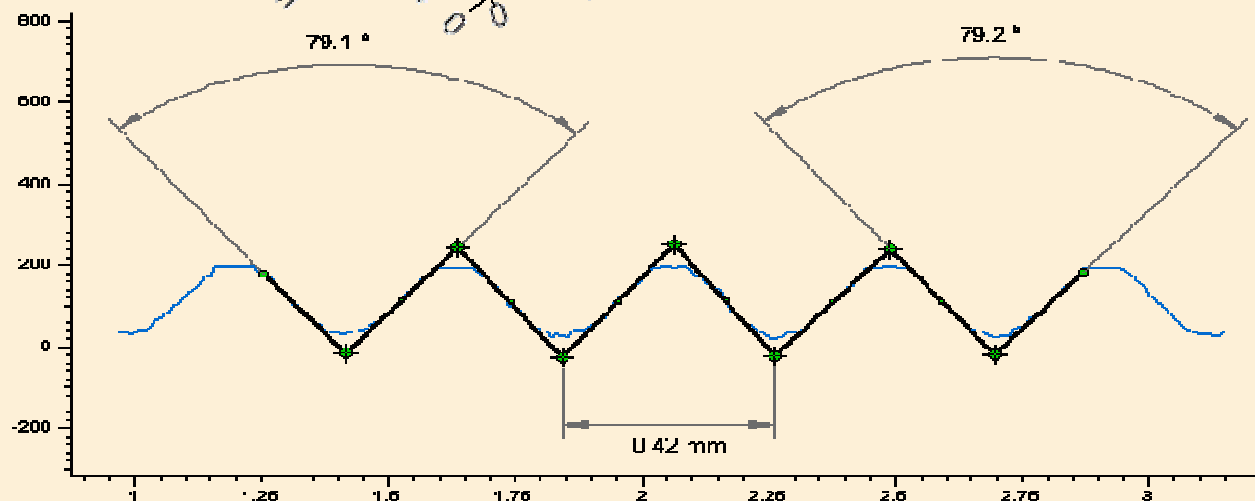


Measuring Task: Wire Guide Roll

Controlling wafer sawing process
by inspecting wire guide roll



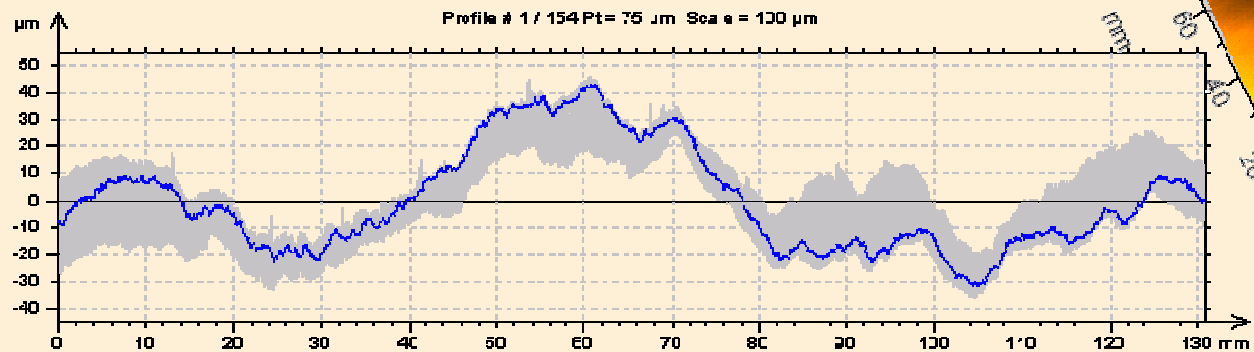
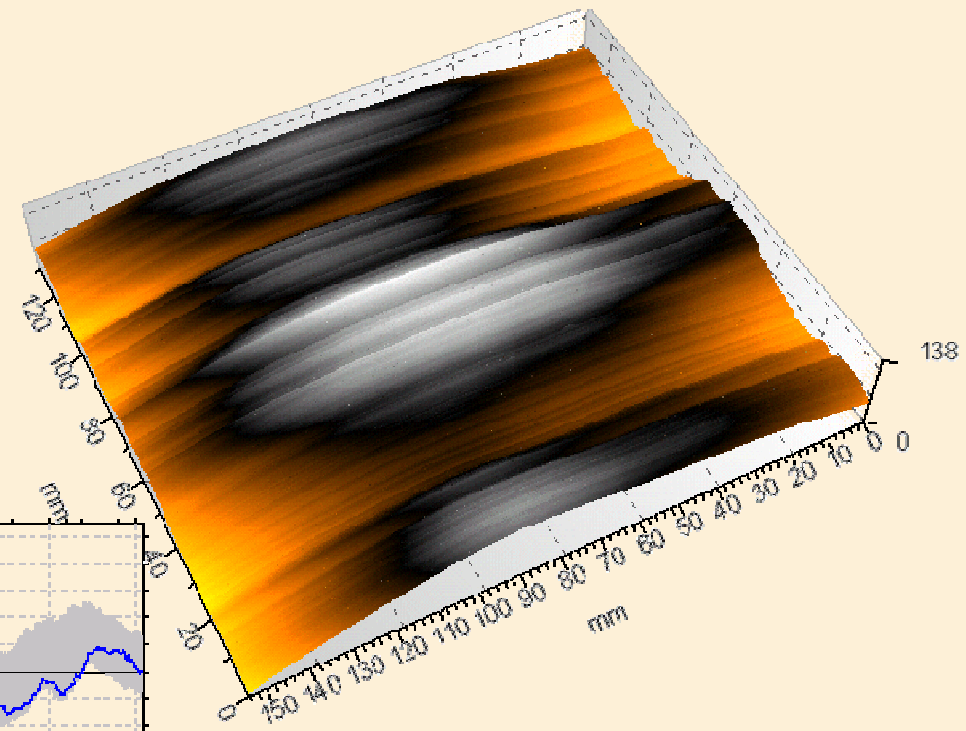
automated contour
inspection



Drawing not true to scale

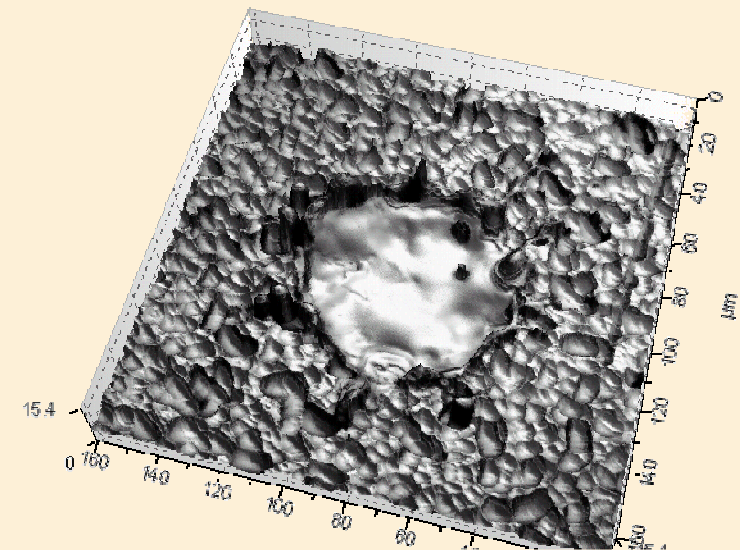
Measuring Task: Saw Marks

Measuring of a complete wafer within a few seconds



ISO 4287						
		Description	Mean	Std dev	Min	Max
Amplitude parameters - Roughness profile						
Rz	µm	<i>Rz: Maximum Height of roughness profile.</i>	1.51	0.0439	1.41	1.7
Ra	µm	<i>Ra: Arithmetic Mean Deviation of the roughness profile.</i>	0.326	0.00861	0.306	0.36
Amplitude parameters - Primary profile						
Pt	µm	<i>Pt: Total Height of raw profile.</i>	65.2	5.76	58.4	80.9
Amplitude parameters - Waviness profile						
Wt	µm	<i>Wt: Total Height of waviness profile.</i>	64.6	5.74	57.9	79.7

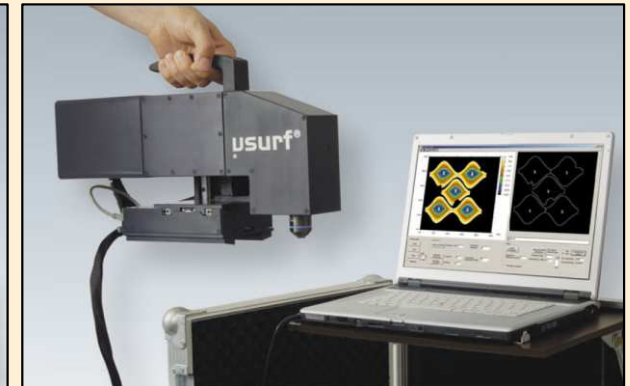
- ▶ Special development for crystalline solar cells
- ▶ 12 measurements within 1 minute (incl. positioning and analysis)
- ▶ Autofocus function for wavy surfaces (EFG)
- ▶ One solution for all kind of measuring tasks
- ▶ Mono-, poly- and EFG cells
- ▶ Measuring etched surfaces with antireflection layer
- ▶ nm-scale repeatability



Laser ablation on etched multi Si

Further applications

- ▶ Isolation Channel
- ▶ Back Side Metallization
- ▶ Micro Via
- ▶ Laser Marking
- ▶ Waviness
- ▶ Geometry of Fresnel Lens
- ▶ Soldering
- ▶ Transition Zone
- ▶ Etc.



µsurf solar

Solar Cell: References

