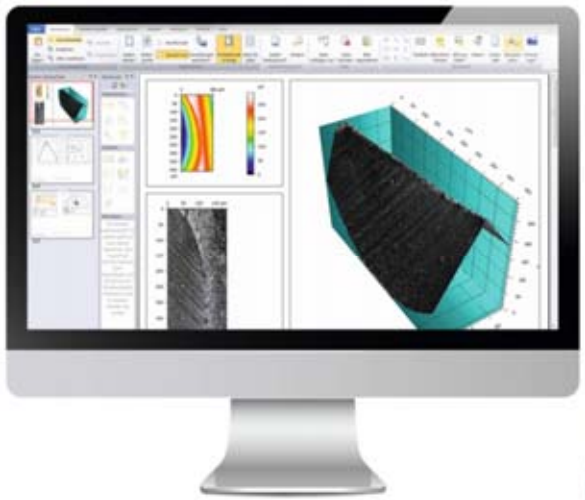
confovis

Optical 3D measurements capture the entire surface with nanometer precision

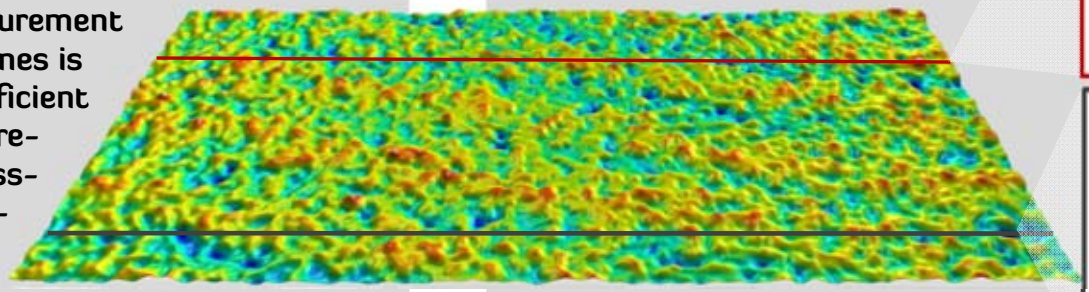


Traceability of any structure to the „gold standard“ of stylus profilometers as used by Germany’s National Metrology Institute PTB

Abstract

The surface is an important function parameter, which decisively determines the product properties.
Confovis measures the surface entirely and provides comprehensive measurement data.

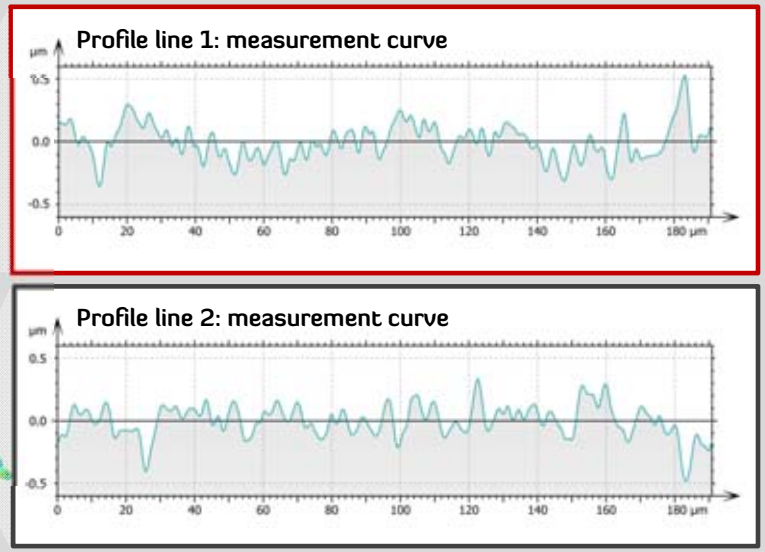
The 2D measurement with profile lines is no longer sufficient for the comprehensive assessment of functional surfaces.



Whereas with the 3D measurement there are extensive data of the whole surface area available.

More than 2D...

- **2D and 3D function parameters** (profile and areal based)
- **Volume parameters**
- **Texture direction**



3D measurement = gain of information

Company history

2007	Development of a new technology: the confocal measurement with structured illumination; First patent application
2009	Company foundation
2009	Product launch: confocal scan head ConfoCam®
2010	Partnership with Nikon Metrology
2012	Successful market entry; More than 25 installed systems in the market
2014	Product launch: ConfoCam© as 2-in-1 scan head › measures as well with focus variation as with structured illumination microscopy SIM
2015	Product launch: FocusCam© scan head for surface analysis just focus variation
2016	Product launch: highly integrated measurement system Confovis DUO Vario

The **confovis GmbH** is located in the Technology and Innovation Park (TIP) Jena, Germany

In cooperation with:

Nikon

Digital Surf Surface Intelligence

MountainsT

UNI STUTTGART

MÄRZHÄUSER WETZLAR

Technology comparison

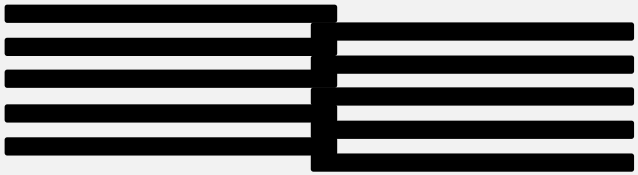
	Roughness ≤ Rz 0,1 µm	Form	Steep Flanks	Roughness according to standards	Measure-ment speed for a area	Artefact-free measurements results	Investment cost / price	Measuring date density/ transparency
Structured Illumination Microscopy (SIM)								
Focus Variation (FV)								
Confocal Laser Scanning								
Interferometry								
Stylus Profilometers								

In theory the stylus profilometer would be the most common choice when a measurement system is needed that is able to measure all of the above mentioned measuring tasks. But in practice, especially when analysing randomly distributed microstructures, this measuring method is not suitable. There would be an advantage for the combinated use of Structured Illumination Microscopy (SIM) and Focus Variation (FV).

Two measurement principles via one optical beam path

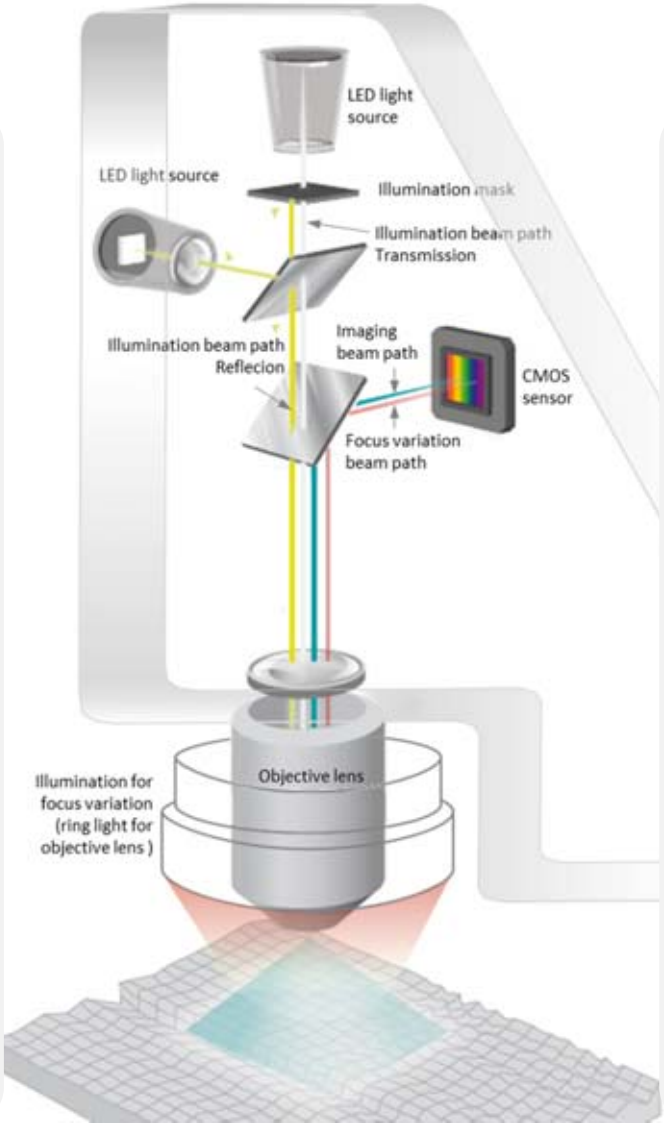
Structured Illumination Microscopy (SIM)

1. Imaging of two phase-shifted gratings on the sample
2. Evaluation of the contrast difference between the gratings



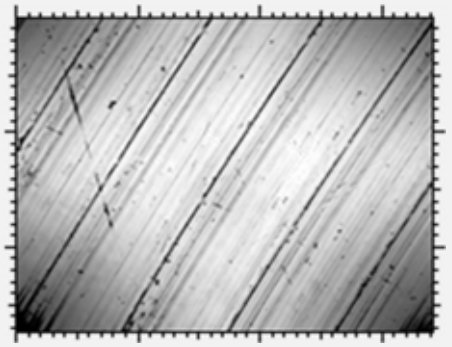
Measurement of:

- Fine-finished surfaces
- Standard-compliant roughness (DIN EN ISO 13565 + 4287/4288) and traceable to independent standards e.g. Halle KNT 4070/03



Focus variation principle (FV)

1. Illumination of the sample
2. Evaluation of the contrasts in the image, resulting from the micro-structure of the sample surface



Measurement of:

- Steep flanks → with ring light; ideal for cutting geometries
- Form and contour

USPs of the Confovis measurement systems

Focus variation + structured illumination microscopy (SIM)

Steep flank angle of above 80° as well as the 3D analysis of finest surfaces using confocal measurement

Free of contributing artefacts

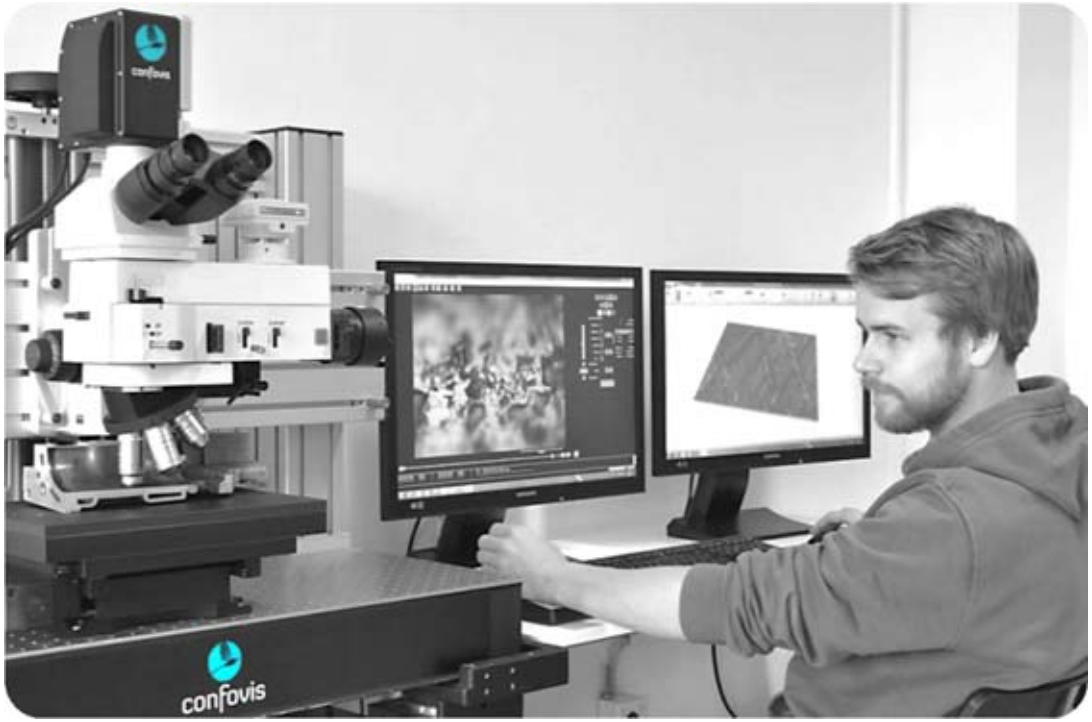
Very low coherence and speckle effects through patented measurement method

Cost savings

Lower acquisition and training costs, because just one measurement system, which combines two measurement methods is needed; No additional changeover required

User friendly

Easy to use, automated measuring; Familiar evaluation methods with established MountainsMap®-Software



Time savings

Effective measurements: Output of high data density (for areas that are relevant for roughness measurements) as well as low data density (for areas needed for contour analysis) in one point cloud

Products

ConfoSurf CLV150

High precision down to nanometre range
Compact measuring system
Focus variation + Structured Illumination Microscopy (SIM) in one system
Suitable for small samples
Compatible accessories for handling and positioning

Scan module: optional as FocusCam® for measurement only with focus variation or as ConfoCam® for confocal measurement and with focus variation

Confovis DUO Vario

Focus variation + Structured Illumination Microscopy (SIM) in one system
Expanded work and measurement area for large and heavy samples
Large field of view + high lateral resolution (confocal)
Optional: motorized rotate/swivel table for 360° stitching of components + global coordination system

Benefits of the scan module:
Measures confocal as well as with focus variation

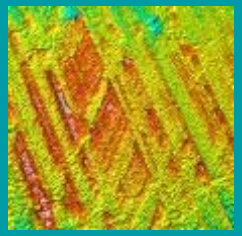
Confocal: optionally with violet, green or red LED light source

ConfoDisc CL200/CL300

High precision down to nanometre range Fast analysis of wafer microstructures
For wafer sizes up to 12”
Automated measurements, e.g. critical dimensions
Compatible accessories for handling and positioning

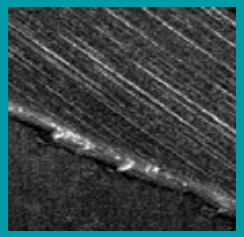
Ideal measurement systems for:

Automotive industry

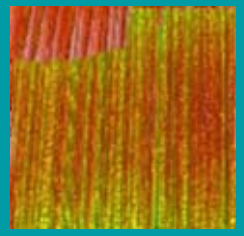
- Roughness
- Micro lead twist
- Micro geometries
- Volume+ function parameters

Tool/mechanical engineering

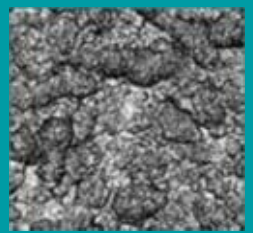
- Cutting-edge of PKD/MKD cutting tools
- Threading tools
- Grinding wheels
- Micro tools

Tribology

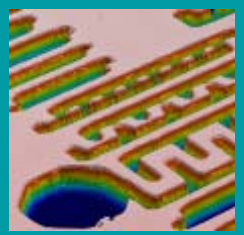
- Volume+ function parameters
- Oil retention volume
- Endurance run diagnosis
- Roughness

Medical technology

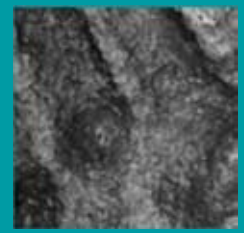
- Implants
- Joints
- Stents
- Sensors

Semiconductor industry

- Line/Space, Circles, Bumps...
- Overlays
- Through Silicon Vias (TSV)
- Saw cuts
- Etched structures

Additives processing

- Roughness
- Micro geometries
- Volume parameters
- Texture

References and partners

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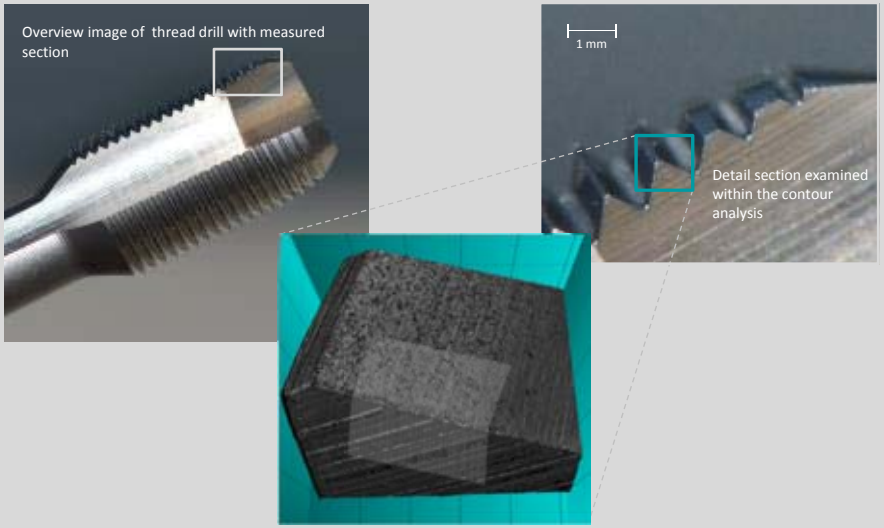
Cooperation partners:

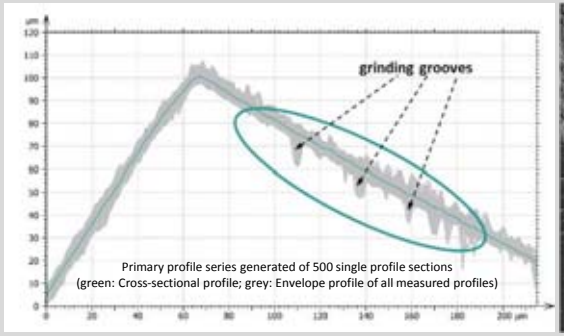
Cutting-edge measurement with Focus Variation

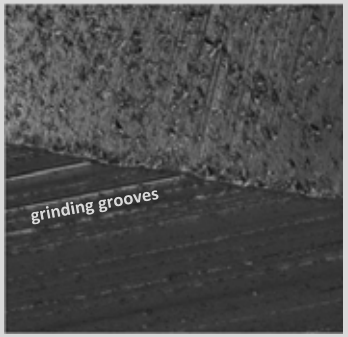
confovis

Geometries with large angles can be captured with the Focus Variation Principle.

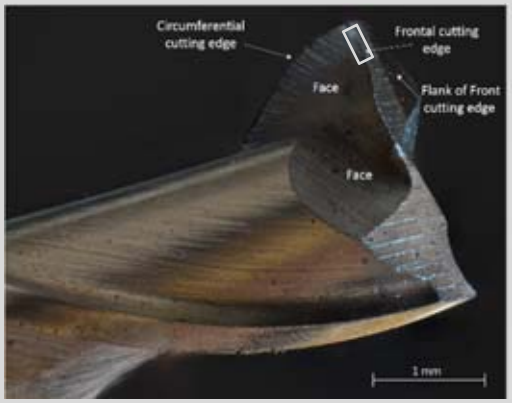
Form measurement with Focus Variation
Example: solid carbide thread drill

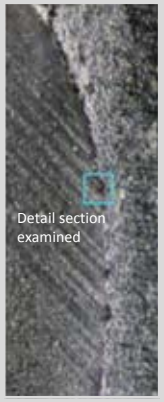




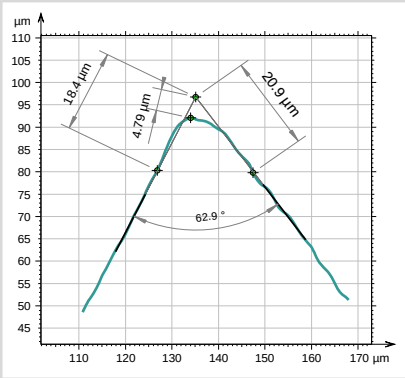


Form measurement with Focus Variation
Example: Drill slot milling cutter





Cutting-edge analysis, e.g. using K factor



K factor = 0.88

This value indicates, that the cutting-edge radius is pulled more strongly to the rake face.

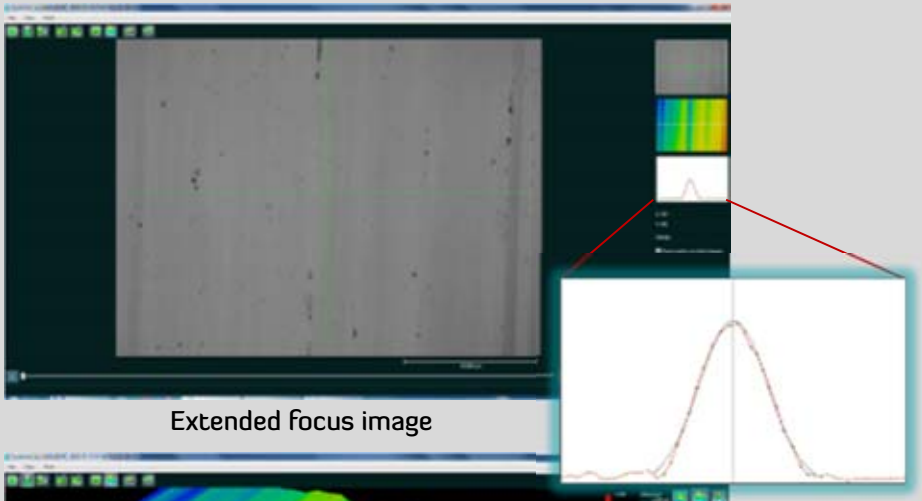
Δr = 4.71 µm

This value discloses information about the flattening of the edge.

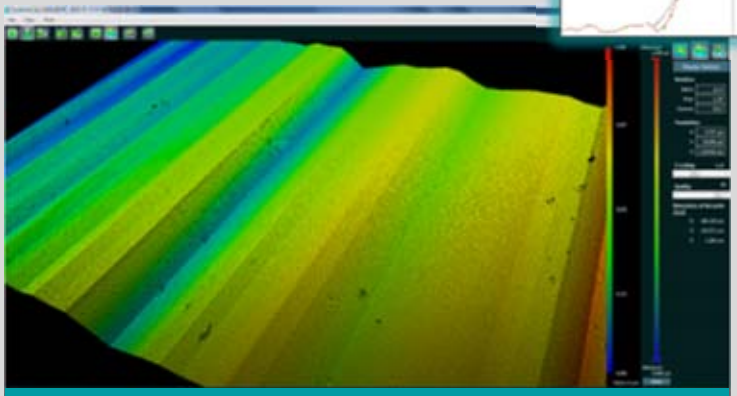
Two measuring principles via one optical beam path

Determine finest roughness (using the Halle standard KNT4070/03)

Structured Illumination Microscopy (SIM)

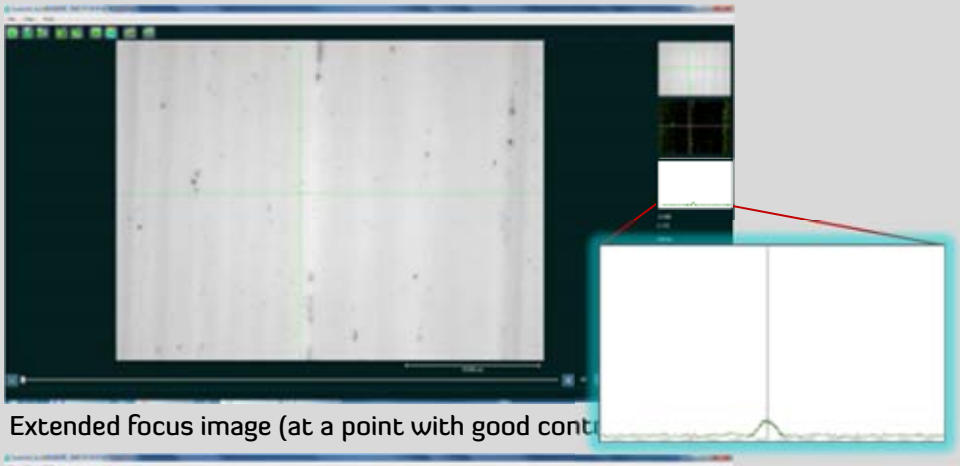


Extended focus image

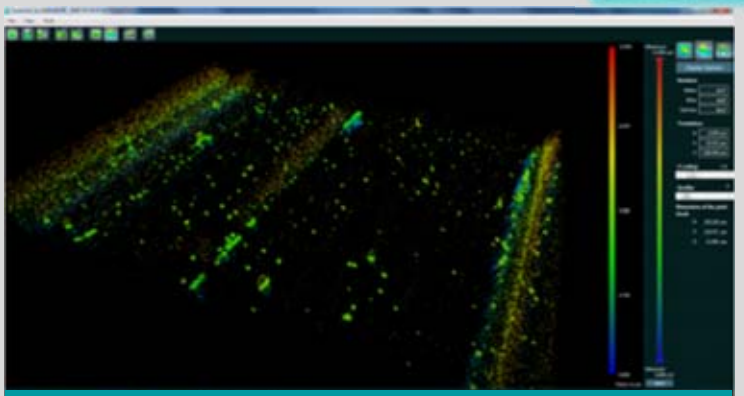


3D image (measured points 99.5%)

Focus Variation (FV)



Extended focus image (at a point with good cont



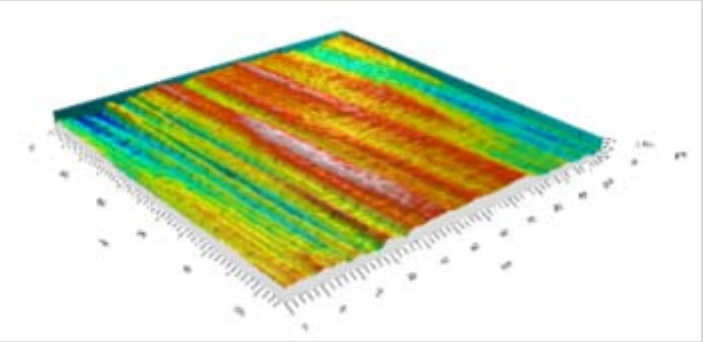
3D image (measured points < 10%)

Roughness in the fine-finished flute

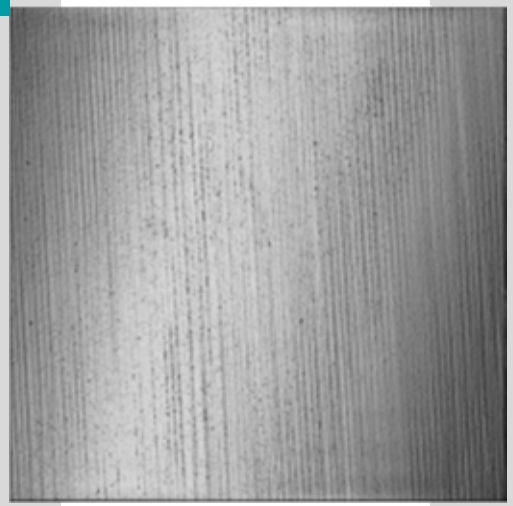
For example: usual milling cutter (item: YG-1, E5E50060)

The following example of a milling tool shows that no comprehensive tool analysis is possible with one measurement principle alone. For the determination of roughness values in the flute, only the high-resolution confocal measurement technology provides reliable measurement values. The focus variation principle is ideal for measuring forms and contours, but not for roughness measurements.

Structured Illumination Microscopy (SIM)

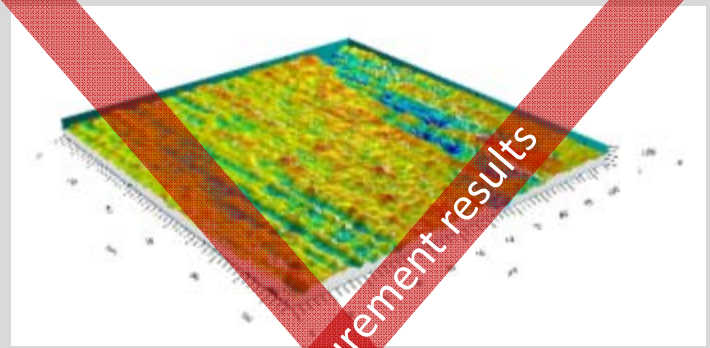


ISO 25178			
Height Parameters			
Sa	0.0272	µm	*Arithmetic mean height*
Sq	0.0324	µm	*Root-mean-square height*
Sz	0.192	µm	*Maximum height*
Functional Parameters (Stratified surfaces)			
Spk	0.0173	µm	*Reduced summit height*
Sk	0.0853	µm	*Core roughness depth*
Svk	0.0298	µm	*Reduced valley depth*
Smr1	4.59	%	*Upper bearing area*
Smr2	85.1	%	*Lower bearing area*
Identity card			
NMP ratio:	0.00 % (0 Pts)		



Extended focus image shows the fine-finished surface in the flute

Focus Variation (FV)



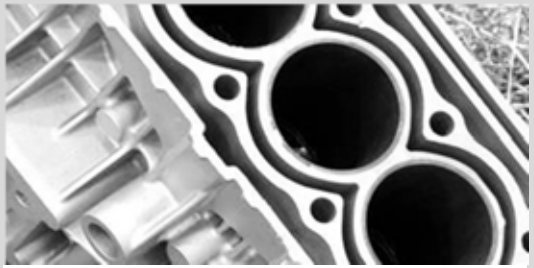
Incorrect measurement results

ISO 25178			
Height Parameters			
Sa	0.177	µm	*Arithmetic mean height*
Sq	0.231	µm	*Root-mean-square height*
Sz	1.95	µm	*Maximum height*
Functional Parameters (Stratified surfaces)			
Spk	0.13	µm	*Reduced summit height*
Sk	0.496	µm	*Core roughness depth*
Svk	0.383	µm	*Reduced valley depth*
Smr1	7.15	%	*Upper bearing area*
Smr2	83.8	%	*Lower bearing area*
Identity card			
NMP ratio:	6.64 % (62922 Pts)		

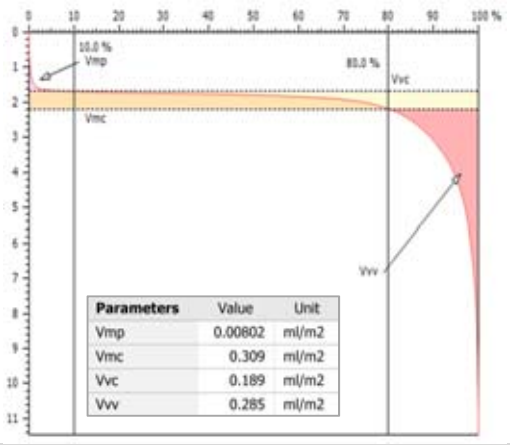
Application: Automotive Industry

Honing structures at the cylinder

Form measurement with Focus Variation



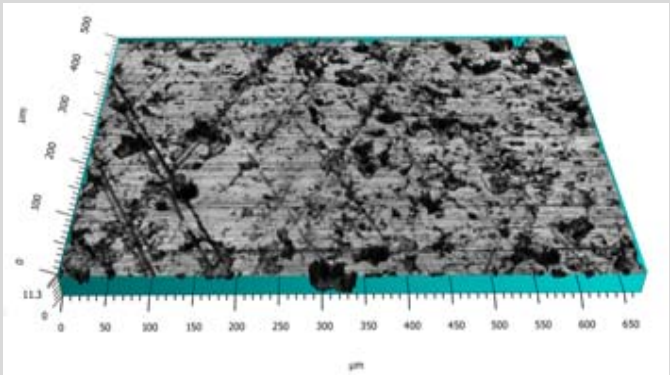
Determination of the SL-Surface:



Parameters	Value	Unit
Vmp	0.00802	ml/m2
Vmc	0.309	ml/m2
Vvc	0.189	ml/m2
Vvv	0.285	ml/m2

Analysis of the surface with Structured Illumination Microscopy (SIM)

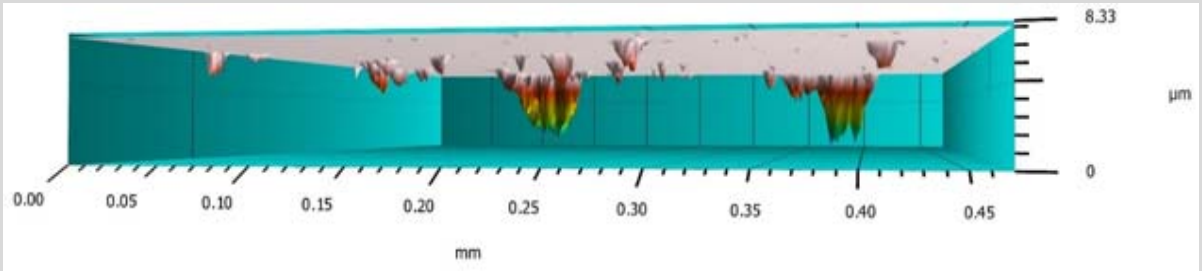
3D image of the cylinder structure



Parameters	Value	Unit
Sk	0.264	µm
Spk	0.245	µm
Svk	2.32	µm
Sr1	4.77	%
Sr2	69.8	%
Sa1	0.00583	µm3/µm2
Sa2	0.351	µm3/µm2

Analysis of the SL-Surface; Robuste Gaussian filter 0.08mm

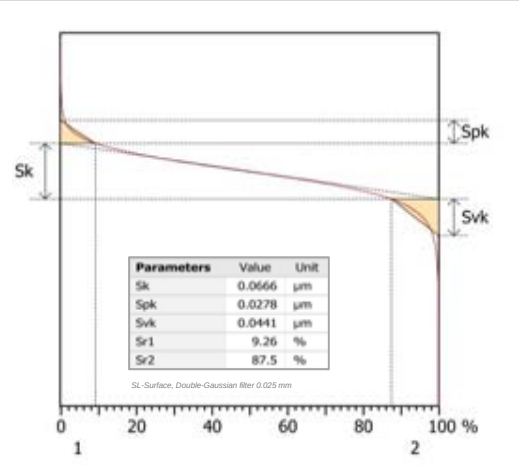
3D image of the pores after the separation of the surface

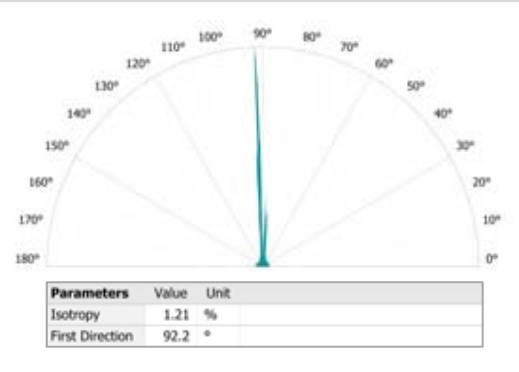


Application: Tribology

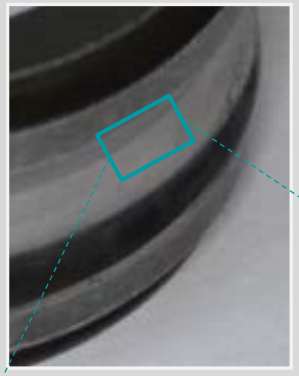
Deep groove roller bearing (inner ring)

Determination of areal function parameters

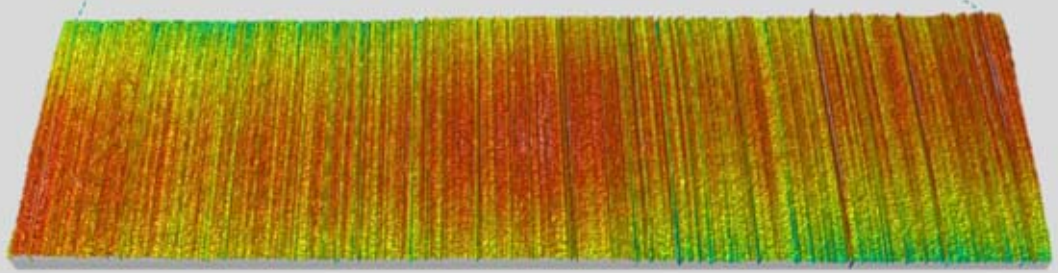




Determination of R- and Rk-parameters with Structured Illumination Microscopy (SIM)



ISO 4287			
Amplitude parameters - Roughness profile			
Rz	0.145	µm	*Gaussian filter, 0.025 mm*
Ra	0.0181	µm	*Gaussian filter, 0.025 mm*
ISO 13565			
ISO 13565-2			
Rk	0.057	µm	*Double-Gaussian filter, 0.025 mm*
Rpk	0.024	µm	*Double-Gaussian filter, 0.025 mm*
Rvk	0.0398	µm	*Double-Gaussian filter, 0.025 mm*
Mr1	8.31	%	*Double-Gaussian filter, 0.025 mm*
Mr2	87.2	%	*Double-Gaussian filter, 0.025 mm*

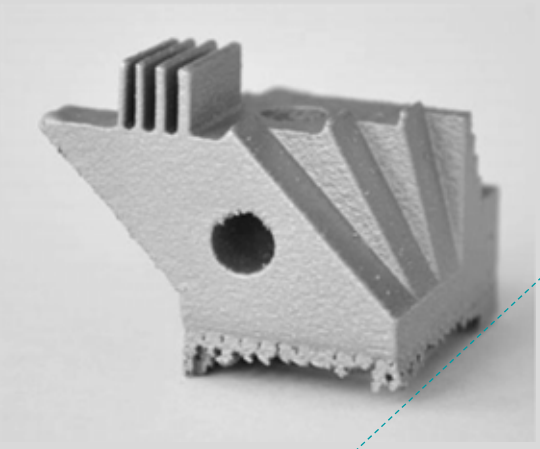


3D image of the S-F-surface

Application Additive manufacturing

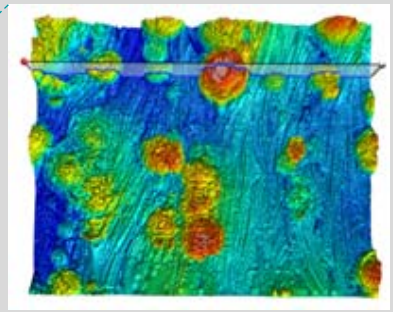
Selective Laser Sintering (SLS)

With SLS manufactured blank

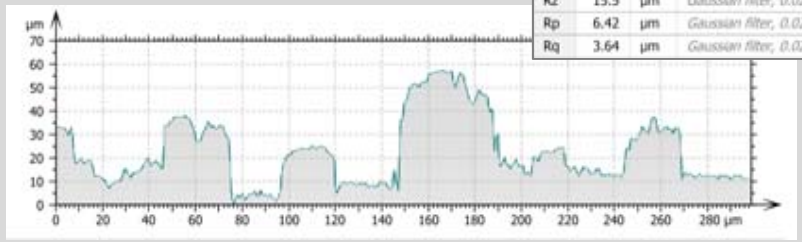


Detail image of the surface

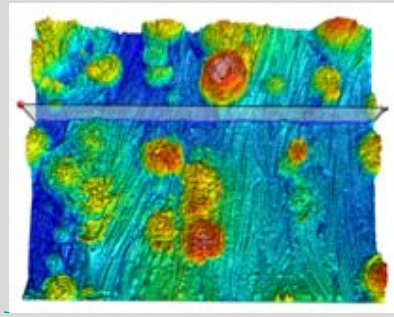
2D and 3D characterisation of the surface with Structured Illumination Microscopy (SIM)



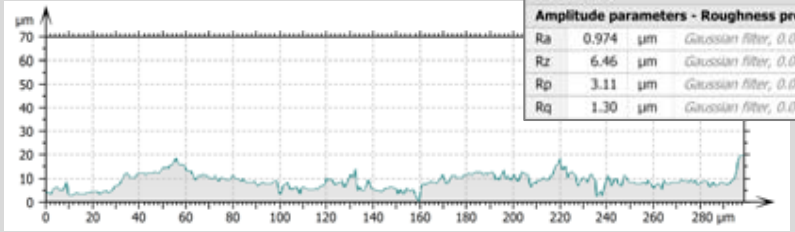
Profile line 1



ISO 4287			
Amplitude parameters - Roughness profile			
Ra	2.88	µm	Gaussian filter, 0.025 mm
Rz	15.5	µm	Gaussian filter, 0.025 mm
Rp	6.42	µm	Gaussian filter, 0.025 mm
Rq	3.64	µm	Gaussian filter, 0.025 mm



Profile line 2



ISO 4287			
Amplitude parameters - Roughness profile			
Ra	0.974	µm	Gaussian filter, 0.025 mm
Rz	6.46	µm	Gaussian filter, 0.025 mm
Rp	3.11	µm	Gaussian filter, 0.025 mm
Rq	1.30	µm	Gaussian filter, 0.025 mm

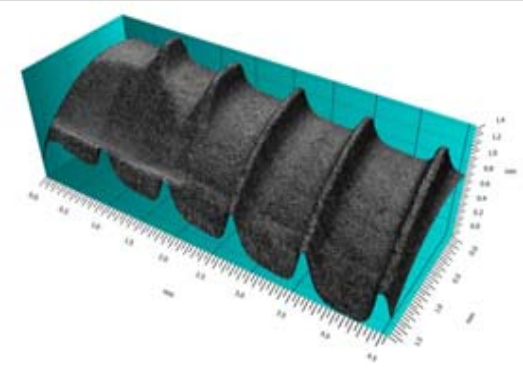
S-parameters determined at the S-F surface:

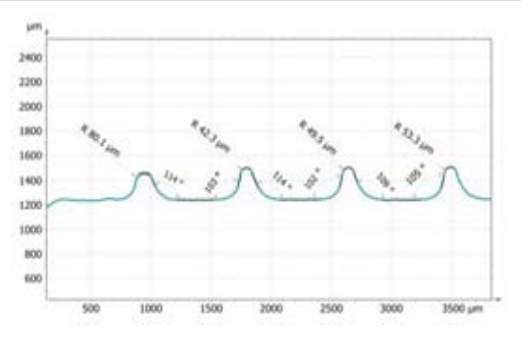
ISO 25178		
Height Parameters		
Sa	8.44	µm
Sq	10.9	µm
Sz	71.5	µm

Application: Medical Technology

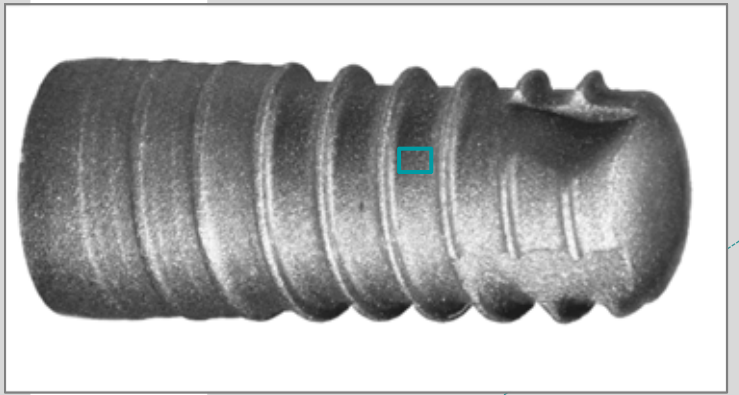
Thread of dental implant

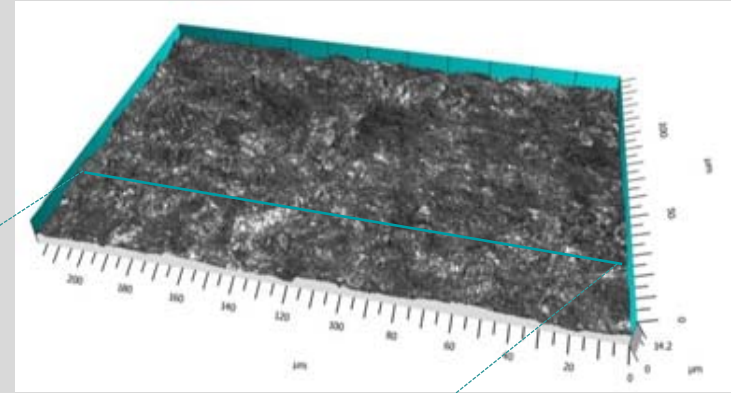
Form measurement with Focus Variation

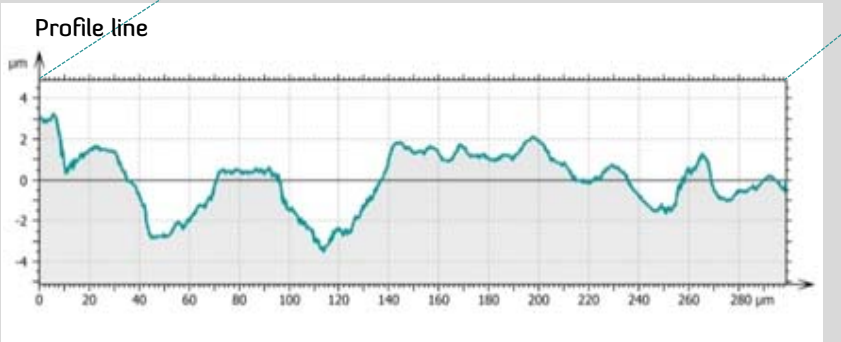




Determination of roughness by means of Structured Illumination Microscopy (SIM)







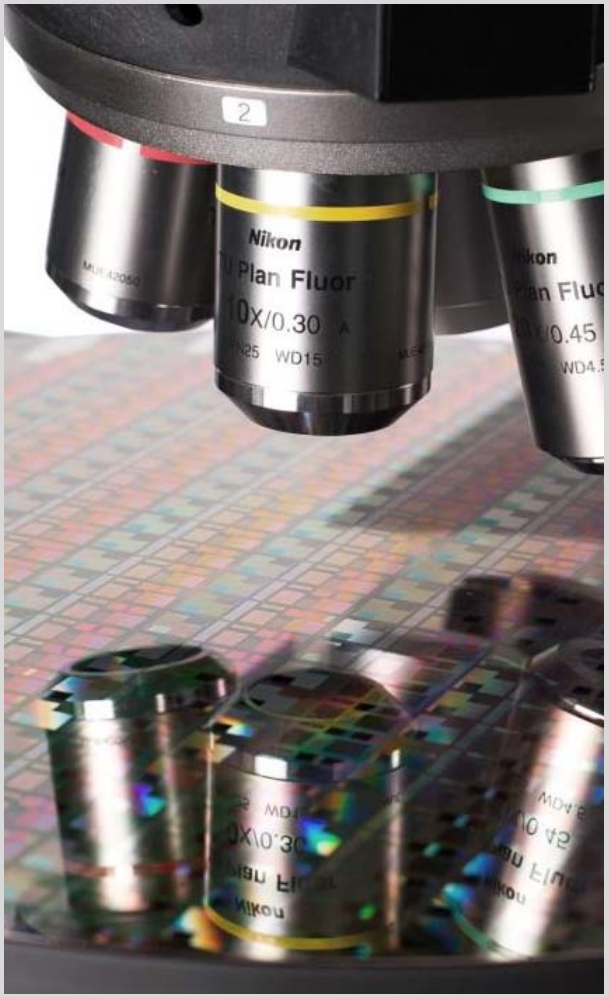
ISO 4287			
Amplitude parameters - Roughness profile			
Ra	0.194	µm	*Gaussian filter, 0.025 mm*
Rz	0.946	µm	*Gaussian filter, 0.025 mm*
Rq	0.241	µm	*Gaussian filter, 0.025 mm*
Rp	0.471	µm	*Gaussian filter, 0.025 mm*

ISO 25178		
Height Parameters		
Sa	0.523	µm
Sz	11.3	µm
Sq	0.691	µm
Sp	5.44	µm

Analysis of SL-Surface; Gaussian filter 0,025 mm

Application: Semiconductor Industry

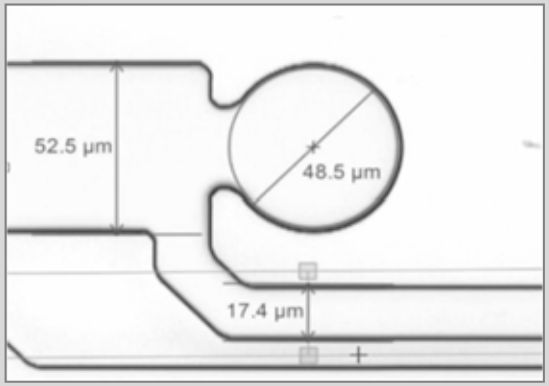
Automated wafer analysis



The wafer measurment system CL200/CL300 is ideal for wafer and MEMS analysis. With the pattern recognition and receipt based high volume date acquisition, the user gets quick and reliable results.

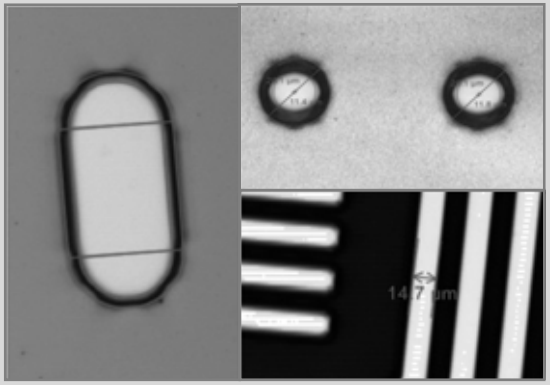
Automated profile measurements at 3D structures:

- Pattern recognition
- Measurements according to receipts
- Wafer-Mapping
- Auto-Alignment
- Multi Pattern Measurement



More pattern in data base:

- Long Holes
- Line Space Distances
- Angles
- Film Thickness
- Step Heights

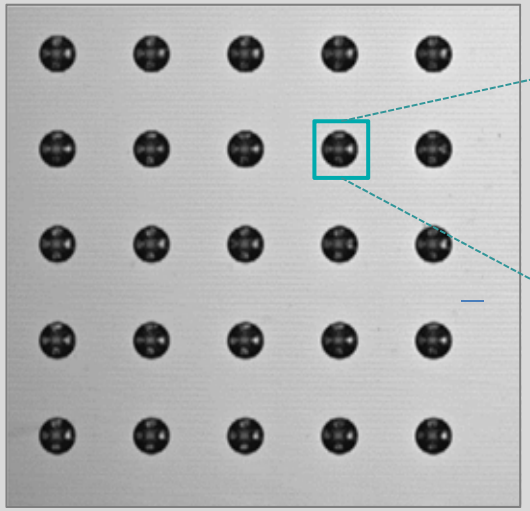


Application: Semiconductor Industry

Automated wafer analysis

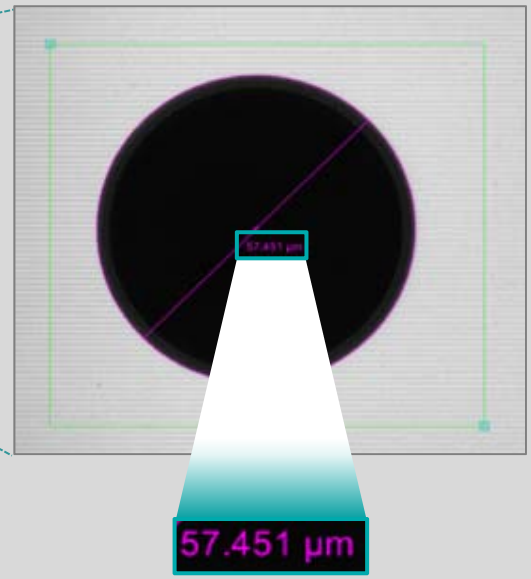
Measuring TSVs with ConfoViZ® Software

Detail image of TSVs at a Wafer

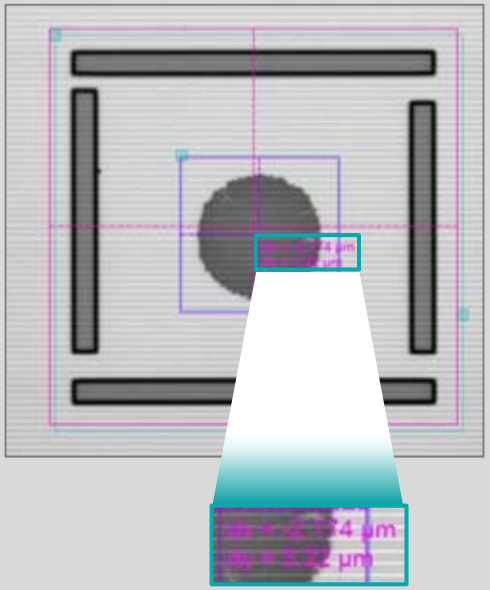


Automated measurements with extended evaluating algoritm

Evaluation of the diameter with automated measurement algorithm

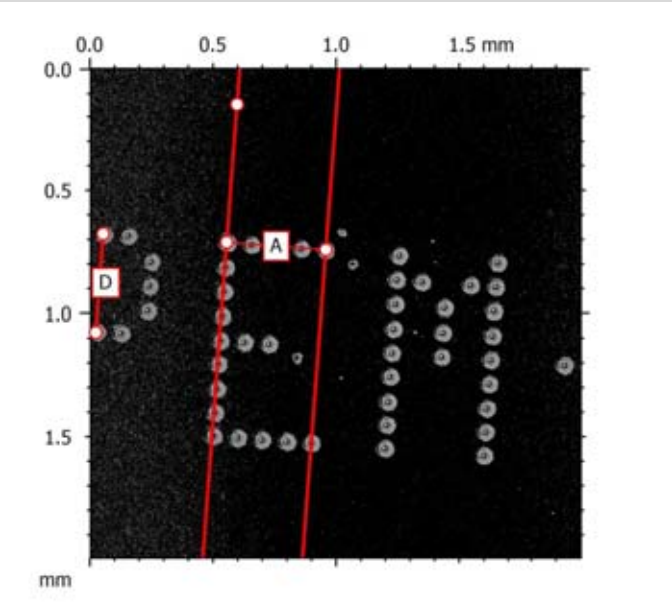


Evaluation of the overlay of vertically interconnected wafers in 3D-integration



Application: Laser Processing

Laser structures on wafer

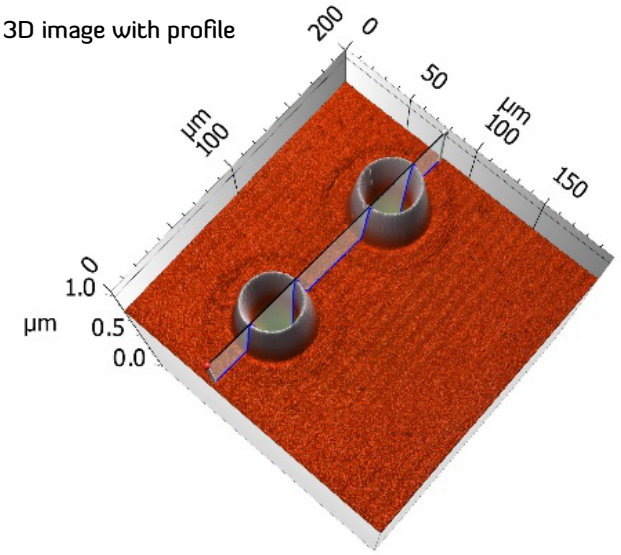


Parallel lines	A	Unit
Distance	0.405	mm

Distances	D	Unit
HDist	0.401	mm

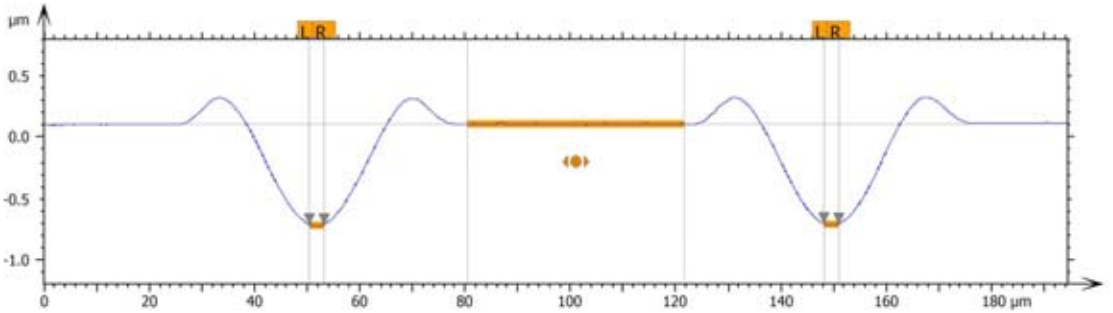
Analysis of the surface with Structured Illumination Microscopy (SIM)

3D image with profile



Results of step height measurement

Parameters	Unit	Step 1	Step 2
Width	µm	2.95	2.95
Maximum height	µm	0.822	0.829
Mean height	µm	0.816	0.823



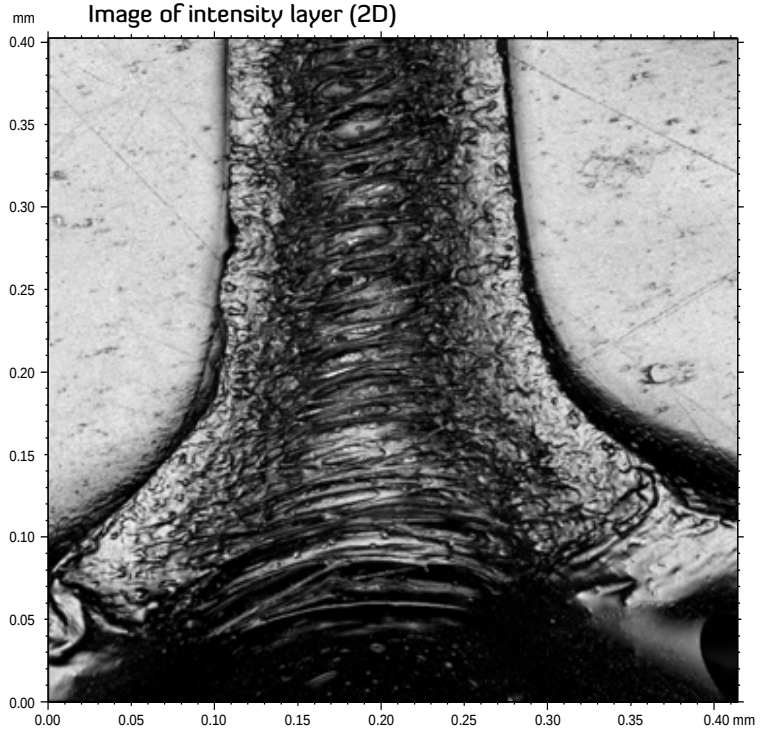
Application: Laser Processing

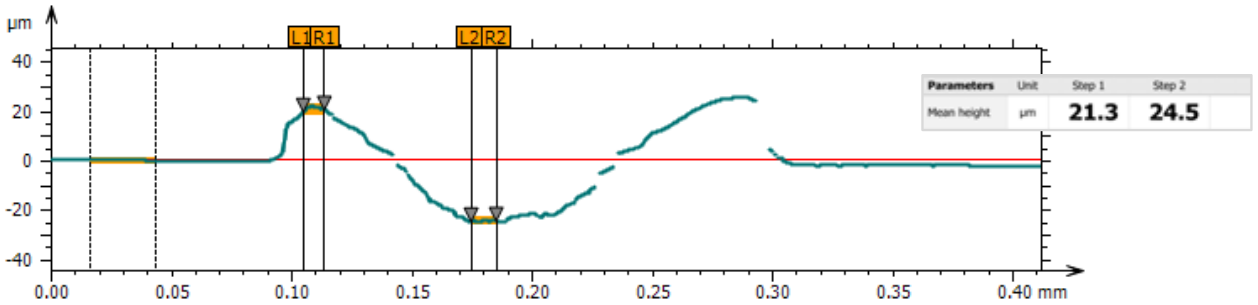
Laser-structured plastic sample (black)

Measurement of depth and width are recurring standard applications for studying lasered structures.

Confovis measures these using high precision confocal measuring technology, in particular its patented method of structured lighting.

There are many more parameters than structural depth by which the energy input of laser pulses can be characterized, e.g. by the roughness at the base of the structure.





Technical data: ConfoCam DUO Vario

Objective lenses and optical parameters	*Optical magnification and numerical aperture*	*Working distance (mm)*	*Acceptance angle[1] (degree)*	*Field of view => confocal[2] (µm × µm)*	*Field of view => focus variation[3] (µm × µm)*
	5×/0.15	23,5	8,6	2540 × 2540	3687 × 3379
	10×/0.30	17,5	17,5	1270 × 1270	1843 × 1689
	20×/0.45	4,5	26,7	630 × 630	921 × 844
	20×/0.60	1,0	36,9	630 × 630	918 × 760
	50×/0.95	0,4	71,8	254 × 254	368 × 337
	50×/0.60	11,0	36,9	254 × 254	368 × 337
	100×/0.95	0,4	71,8	127 × 127	184 × 169
Image pixel resolution	3352 × 3072 pixels => focus variation (10.3 MP)				
	2568 × 2568 pixels max. => confocal (6.6 MP)				
Optical resolution according to Rayleigh	267 nm (objective lenses with 0.95 numerical aperture and 415 nm light wavelength)				
Lateral measurement uncertainty[4]	0.055 µm				
Vertical measurement uncertainty[5] based on noise at	3.5 nm (objective lens 20×/0.60)				
	3.0 nm (objective lens 50×/0.95)				
	2.8 nm (objective lens 100×/0.95)				
Vertical resolution [6]	Up to 9 nm (objective lens 50×/0.95) and 10 nm (Objective lens 20×/0.6)				
Movement resolution of z-drive	1 nm				
Illumination	LED 415 nm (violet), 521 nm (green), 634 nm (red)				
Measurement speed	15 frames per second at 2568 × 2568 pixels with confocal measurements and Camera Link interface				
Measurement range z axis	20 mm				
Maximum height of work piece	200 mm				
Scanning stage size	Up to 500 mm × 500 mm				
Travel range in x and y	Up to 300 mm × 300 mm. other sizes on request				
Image data processing and measurements	2D: distance, height, angle, constructed elements, profile roughness based on DIN EN ISO 4287				
	3D: lateral distance, 3D distance, height, angle, constructed points, area, volume, areal roughnee according to DIN EN ISO 25178				
	Additional: alignment, form removal, filters, noise cut, reporting				

Confovis applies the definitions of the Fair Data Sheet Initative (Version 1.2a, 2016/04/01), refer to http://www.optassyst.de/fairesdatenblatt/
The Nyquist-Shannon sampling theorem is fulfilled with all objective lenses.

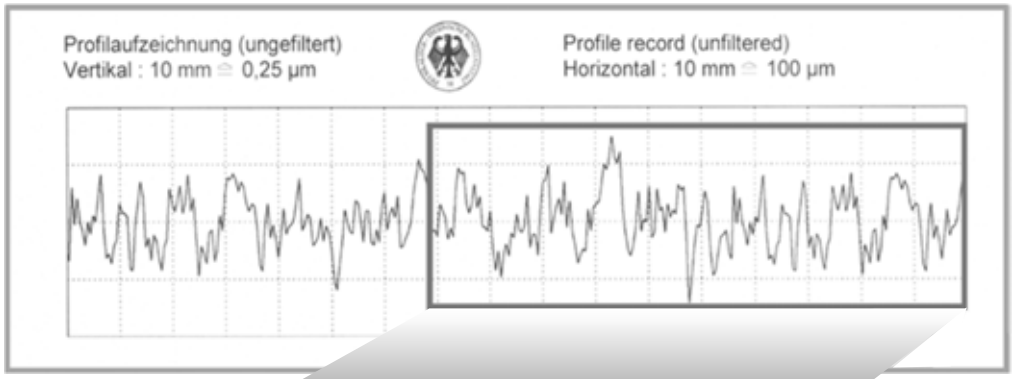
[1] according Fair Data Sheet, paragraph 2.2.6
[2] maximum values for F.N. 18 (F.N. 20 for objective 20×/0.60)
[3] maximum values for F.N. 25
[4] according Fair Data Sheet, paragraph 2.2.7
[5] according Fair Data Sheet, paragraph 2.4.1
[6] according Fair Data Sheet, paragraph 2.4.2

Standard-compliant roughness measurement

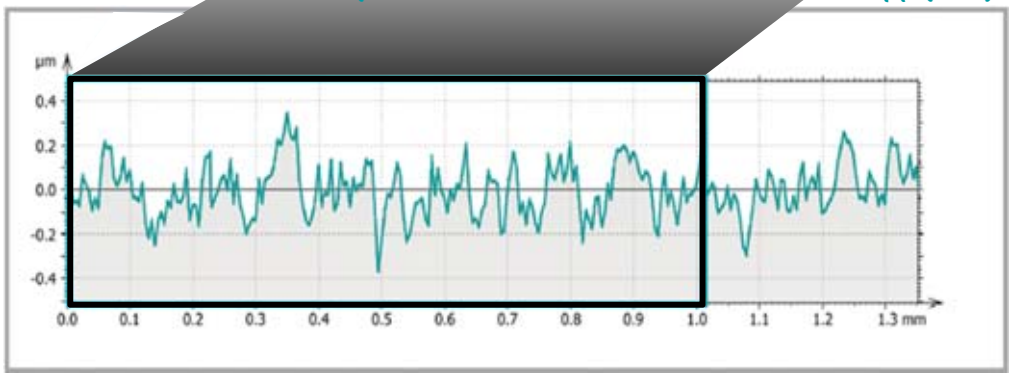
of roughness standard Halle KNT 4070/03

Determination of parameters Ra, Rz, Rpk, Rvk, Rk, Mr1, Mr2 using the superfine Halle roughness standard, certified by PTB

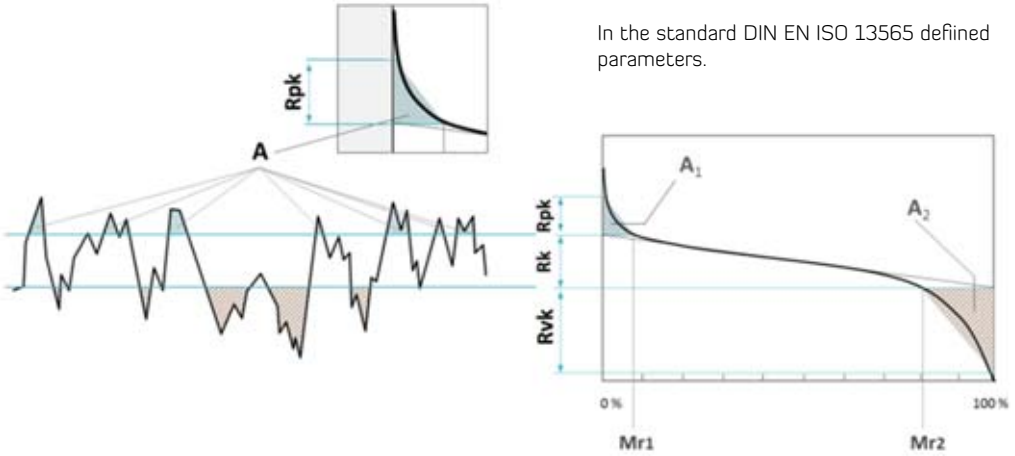
Excerpt from the PTB calibration certificate



Confovis measurement (with Structured Illumination Microscopy (SIM)



In the standard DIN EN ISO 13565 defiined parameters.



Measuring results of calibration certificate (grey) und Confovis values (green)

	Mean Value	Min. *	Max. *	Confovis Measured values
Ra [nm]	87,4	84,8	90,0	84,8
Rz [nm]	481,8	467,3	496,3	494,0
Rpk [nm]	73,2	65,9	80,5	70,2
Rk [nm]	277,9	264,0	291,8	272,2
Rvk [nm]	100	90,0	110,0	91,5
Mr1 [%]	11,7	11,5	11,9	11,7
Mr2 [%]	88,4	86,6	90,2	86,5

Gaussian filter 0,25 mm

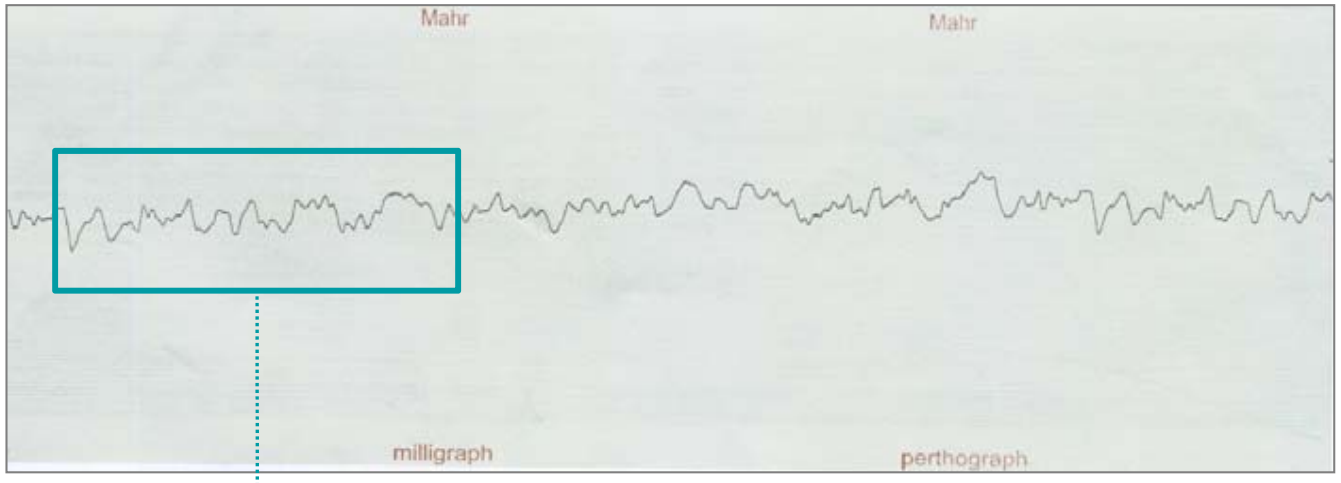
* incl. measuring uncertainty

Standard-compliant roughness measurement

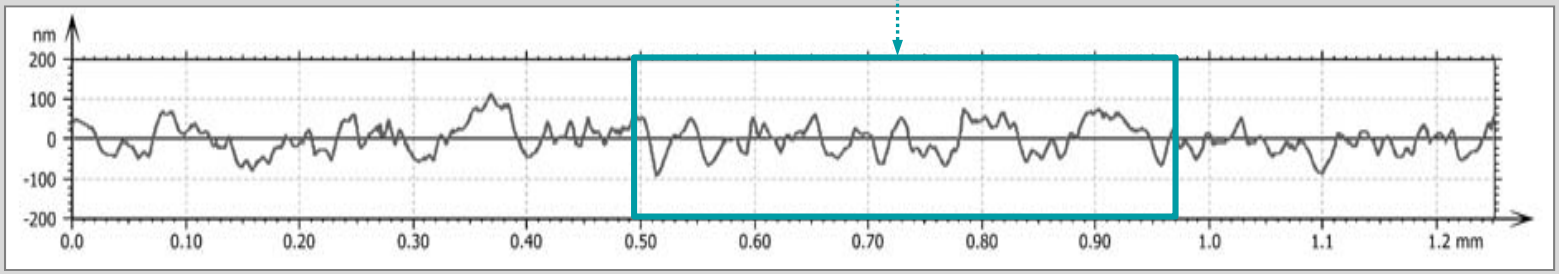
Roughness standard KNT 4070/03 series

Certificate record roughness standard 26 nm

- Ra = 0.026 µm
  Rz = 0.145 µm
  Rmax = 0.170 µm



Confovis measurement result



ISO 4287			
Amplitude parameters - Roughness profile			
Ra	0.0248	µm	*Gaussian filter, 0.25 mm*
Rz	0.161	µm	*Gaussian filter, 0.25 mm*
Other 2D Parameters			
Roughness profile parameters			
Rmax	0.191	µm	*Gaussian filter, 0.25 mm*

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