SINGLE LINE SUBTITLE WITH A MAXIMUM OF APPROX. 90 CHARACTERS

Advances of Bruker White Light Interferometry technique and high magnification measurement application introduction

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Agenda

01

Why would you consider White Light Interferometry profiling technique?

White Light Interferometry
Inherent Benefits

Vertical resolution

Unmatched limit: 0.01nm

Unmatched independent from field of view or/and working distance.

Lateral resolution

Up to 0.38µm with Sparrow criterion

Preserve optimal resolution from each objective

Universal

Operate in all surfaces

Easy & Safe access with Long Working Distance

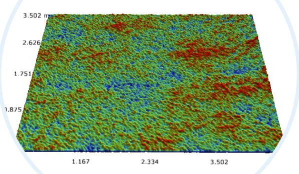
Robust in all conditions

Metrology

Interferometry certifies step height at metrology labs

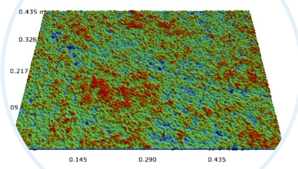
Invented by Bruker to match demanding quality control

Vertical resolution

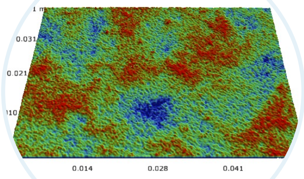


2.5x objective
Sa = 0.058nm

Sub-nm resolution for all FOV and WD

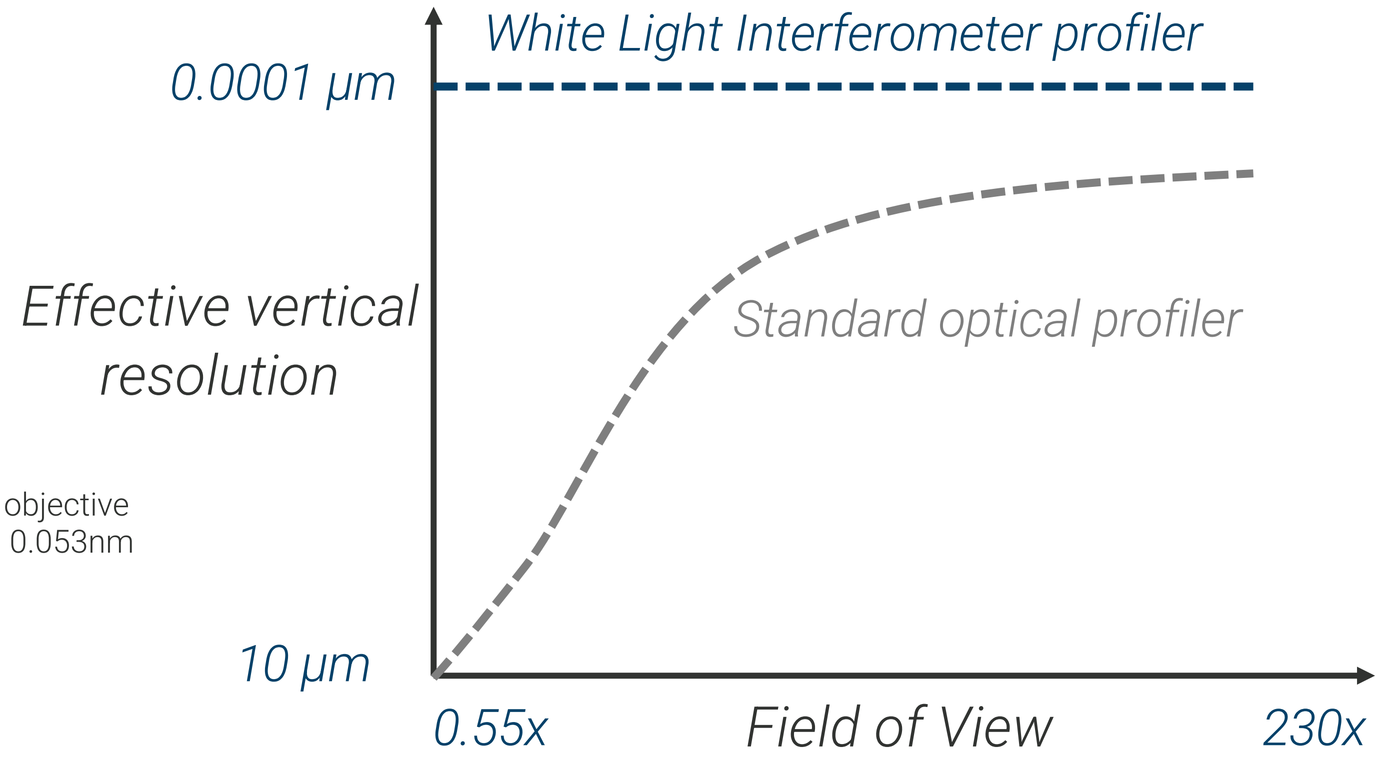


20x objective
Sa = 0.053nm



115x objective
Sa = 0.057nm

Field Of View
Working Distance



Best vertical metrology

WLI 3D Microscopy compared to Confocal Microscopy

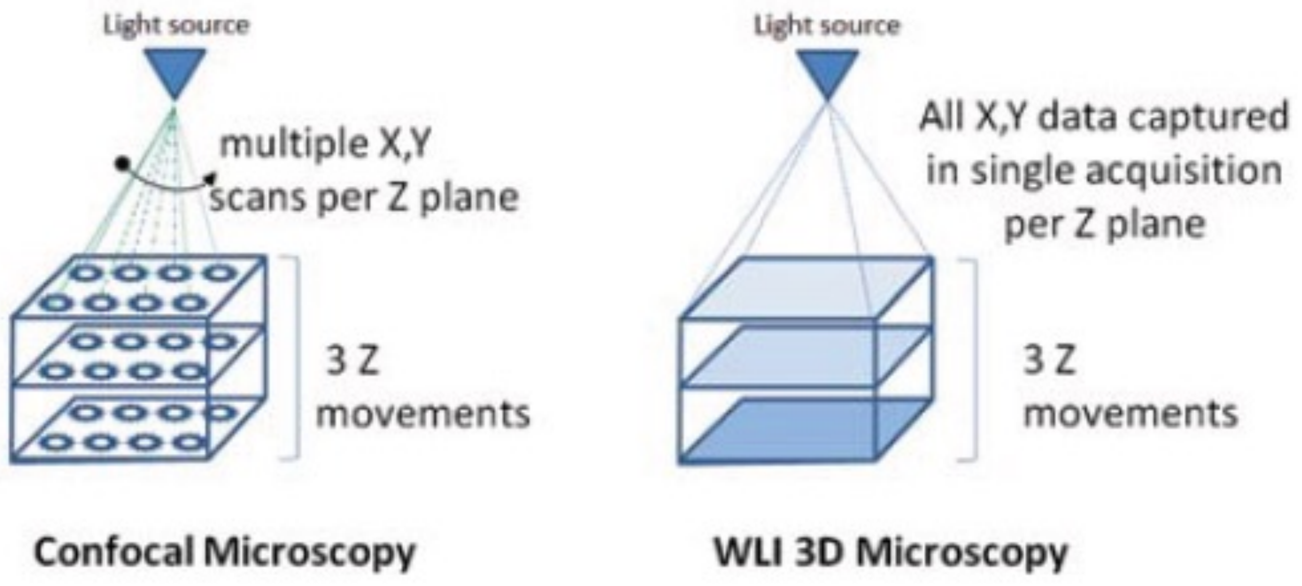


Figure 1. Diagram outlining different scanning methods used by confocal microscopes and 3-D microscopes. *Source: Bruker*

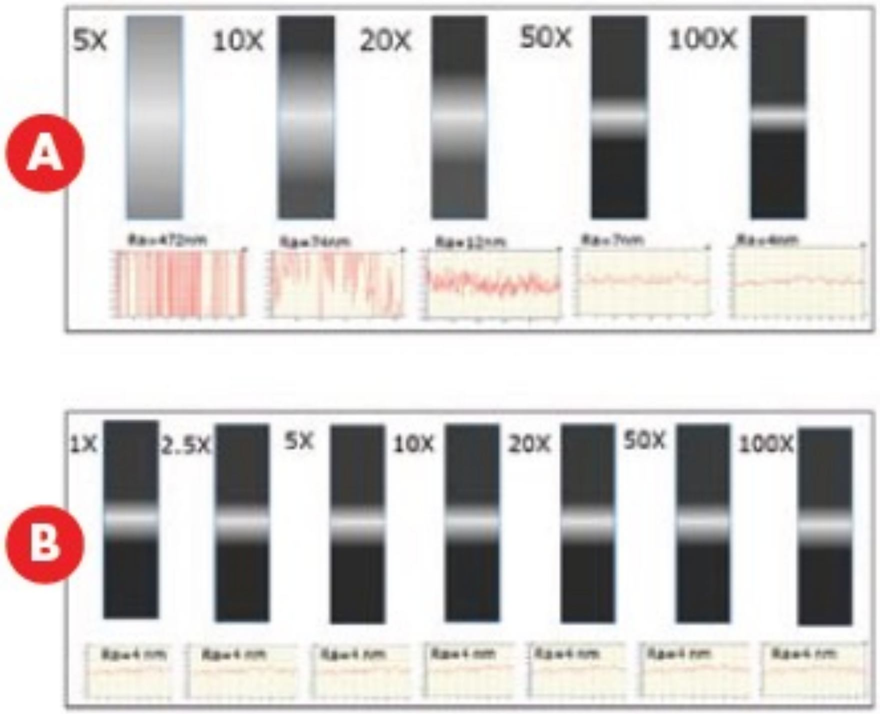
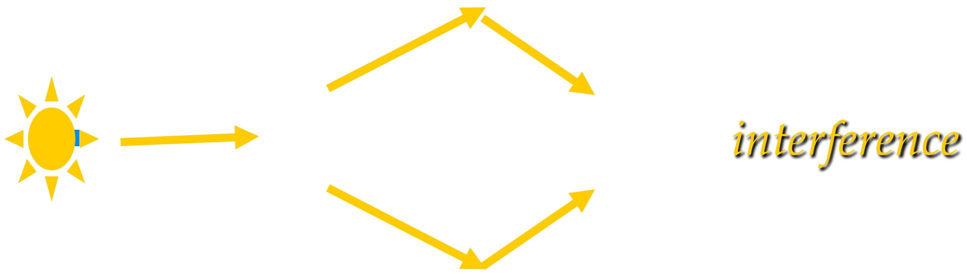
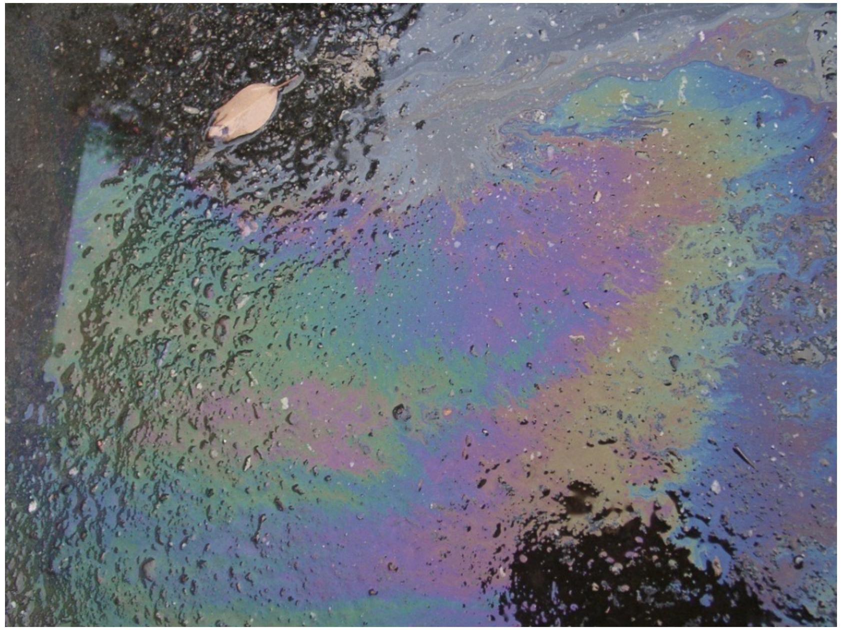


Figure 2. (A) Confocal microscopes produce only a strong and narrow signal at high magnification and wider, weaker signals for lower magnification objectives. (B) WLI microscopes provide a constant, narrow signal for all objectives. *Source: Bruker*

Taken from *Quality* magazine article

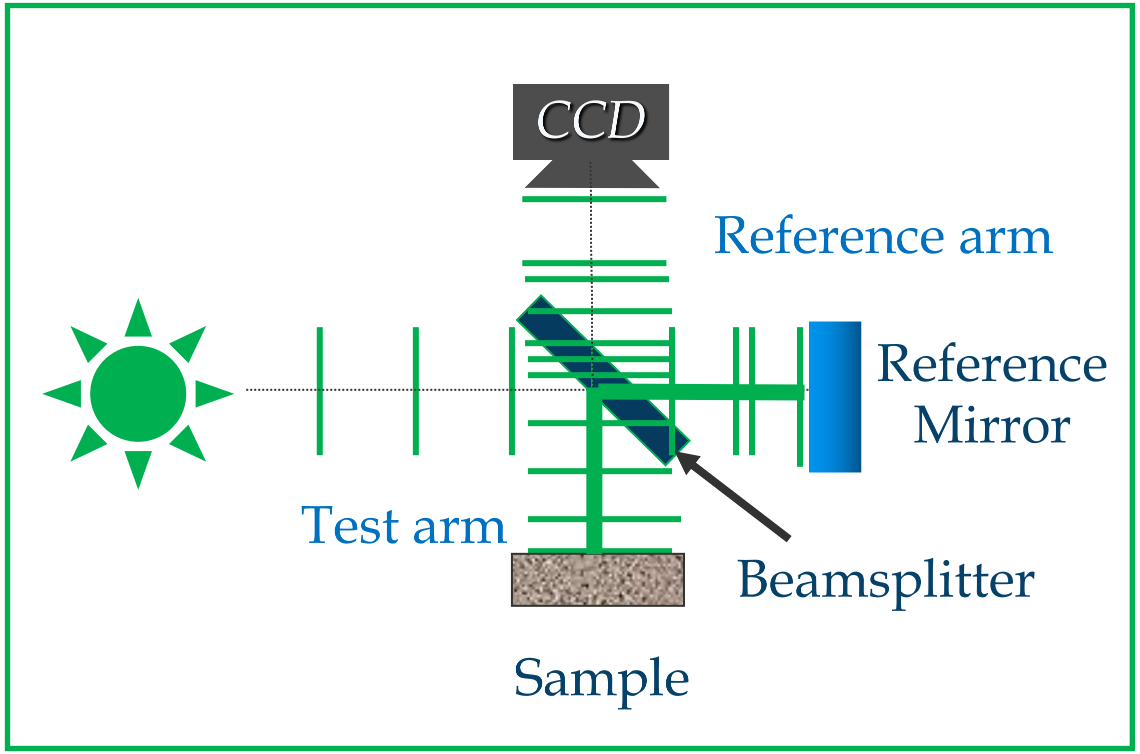
Interferometry, Interferometer: principle





Interferometer is an optical device that divides a beam of light exiting a single source (like a laser) into two beams and then recombines them to create an interference pattern. The combined pattern can be analyzed to determine the difference in paths the two beams traveled.

Typical interferometer: principle

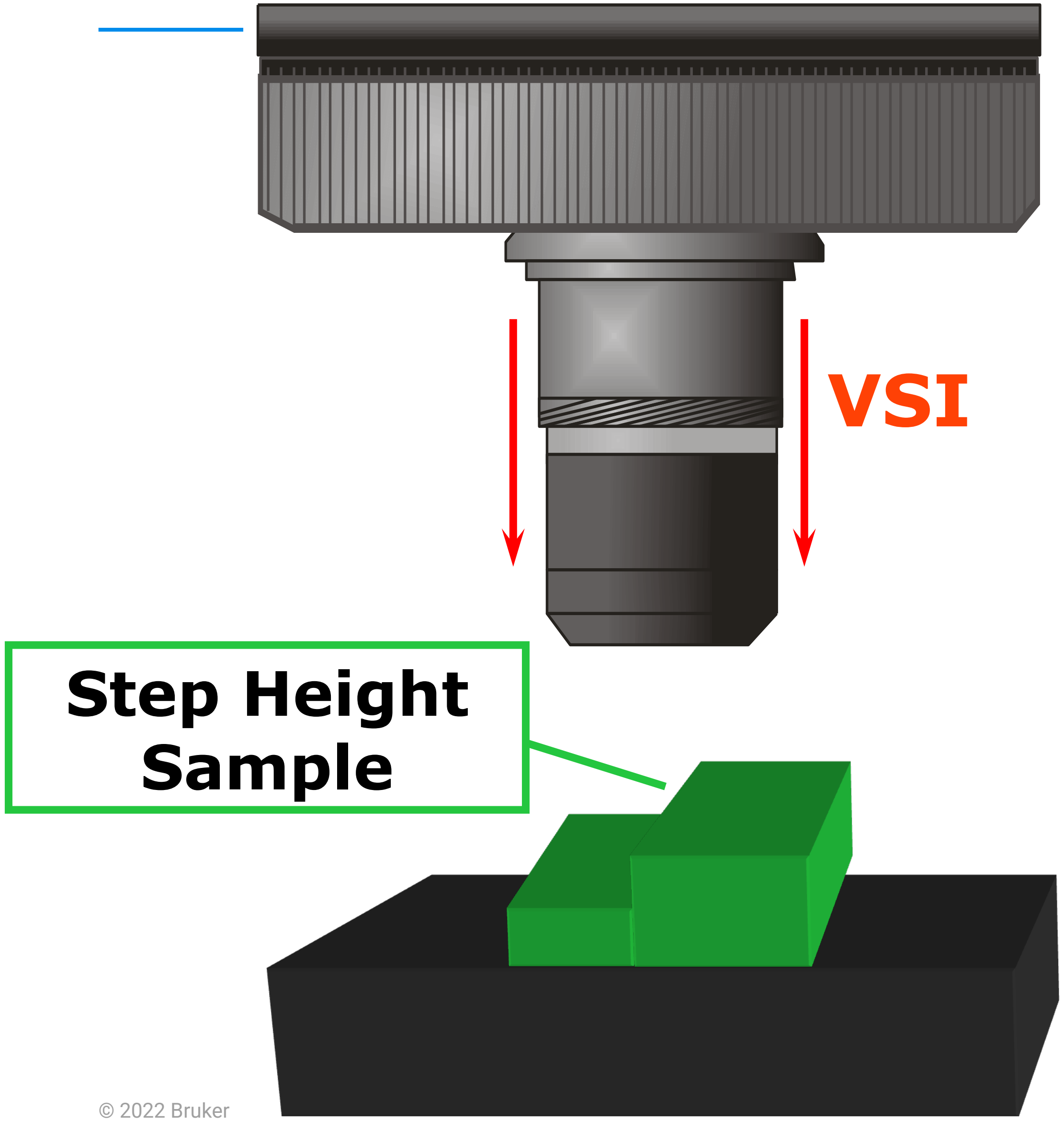


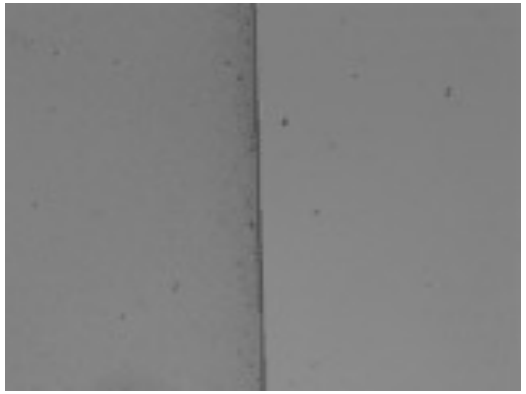
Optical Path Difference (OPD)
- difference in optical path lengths that beams travel in Reference and Test arms.

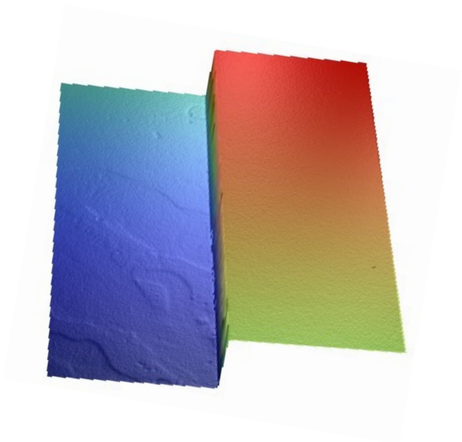
- The expanded beam exiting from the light source is divided by a Beamsplitter into two beams.
- One beam is reflected from the reference mirror, and the other one from the sample.
- These two beams are recombined by the beamsplitter to interfere.
- The imaging lens images the interferogram onto the CCD camera.

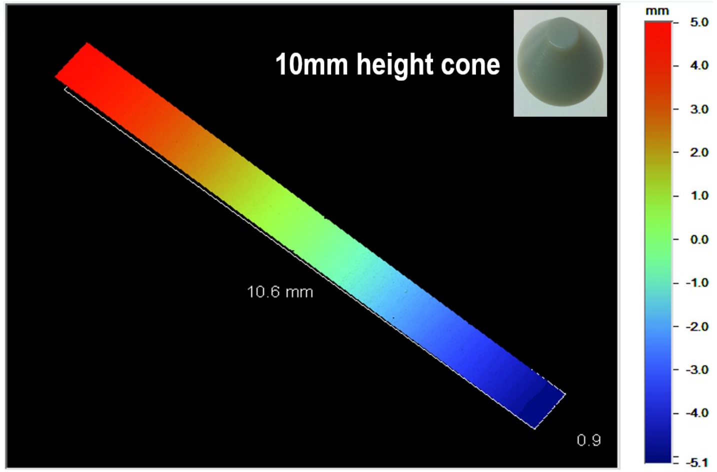
Demonstration of 3D Optical Scan

Step Height Measurement



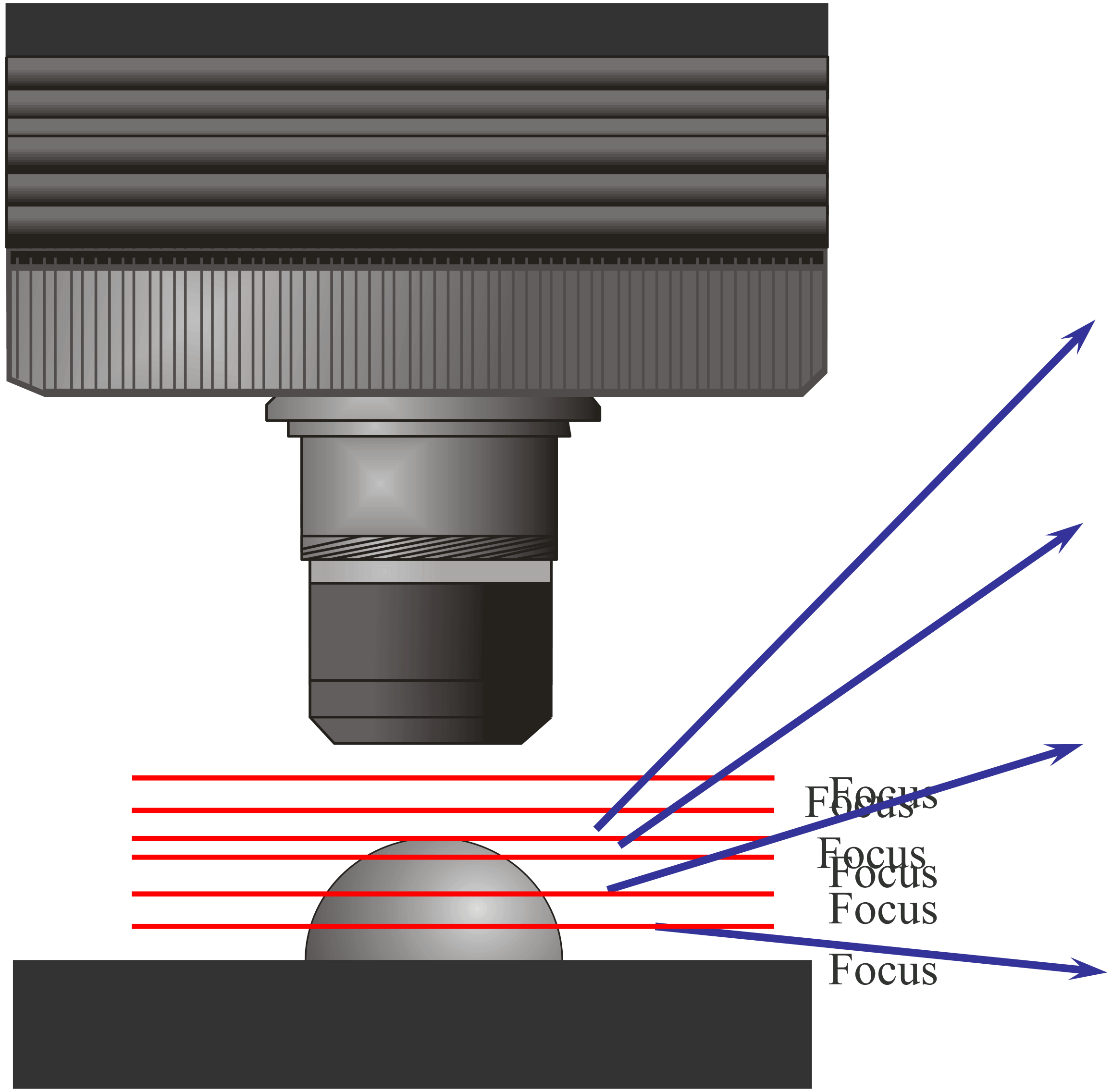


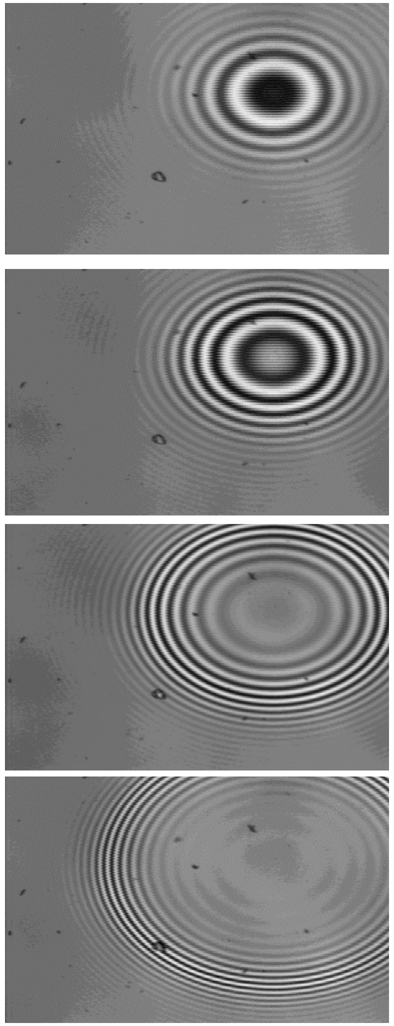


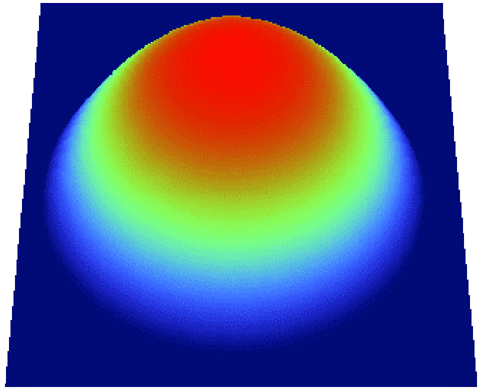


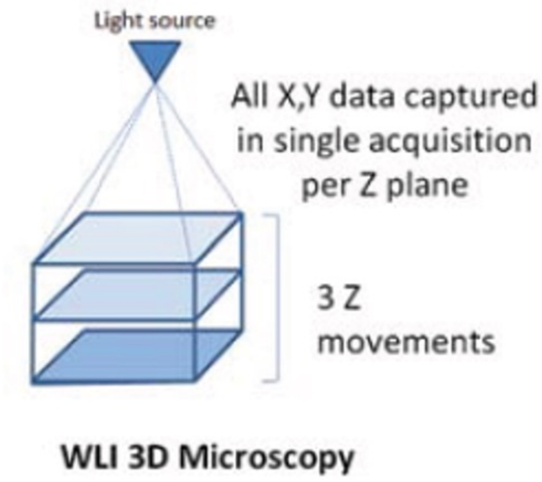
Demonstration of 3D Optical Scan

Hemisphere Measurement

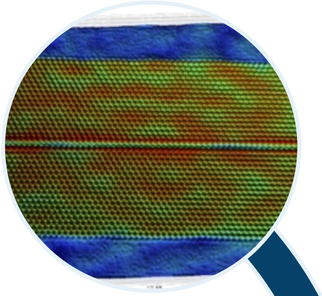






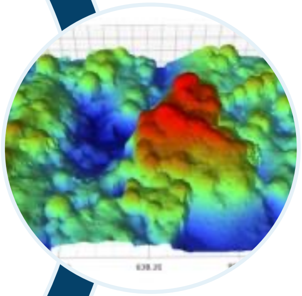


Lateral resolution

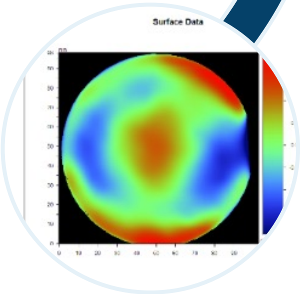


190nm diameter structure

From 100nm to 10's mm



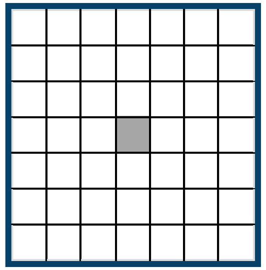
Additive manufactured 50µm powder



100mm sapphire wafer

- Deterministic calculation for focus

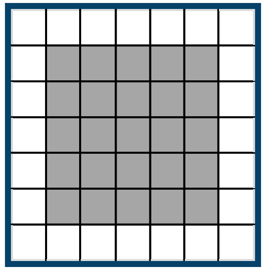
White Light Interferometry

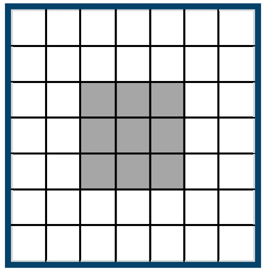


Direct height extraction for each pixel results in best lateral resolution

Ultimate lateral resolution

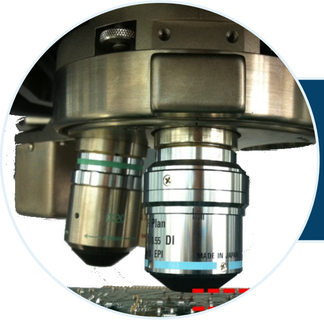
Digital Microscope Focus Variation



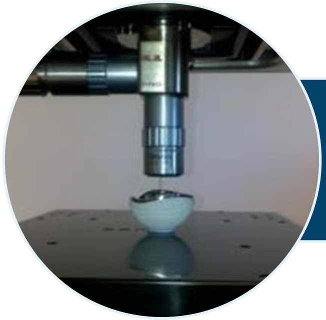


Multiple pixel averaged out for height extraction, lowering lateral resolution

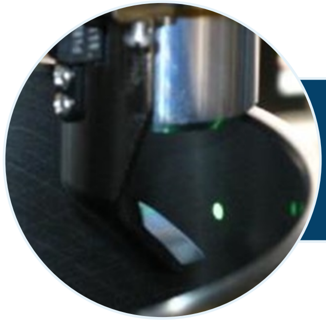
Universal
Easy Access & All type of surfaces



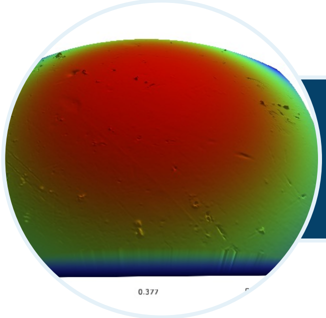
Safe operation @
high magnifications



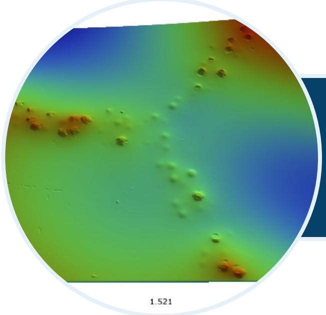
Improve access
with LWD objectives



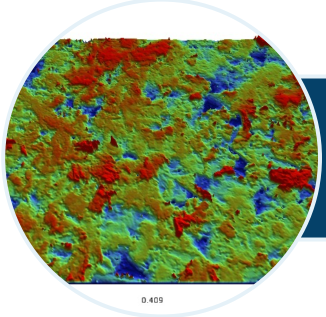
Access vertical walls



Shiny & Curved



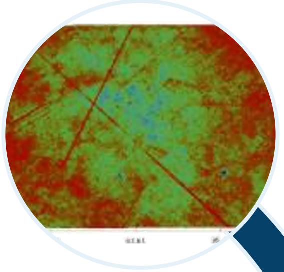
Transparent



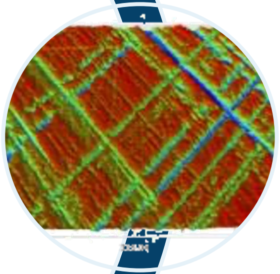
Black color

Metrology

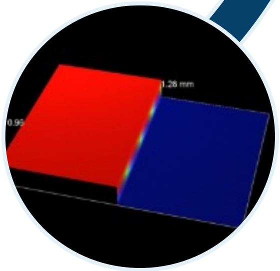
From 0.1nm roughness to mm step



Super smooth mirror
Sa=0.1nm



Cross-hatch pattern
on fuel engine
Sa=0.1µm



1mm step height

Trust in results

Repeatability tests

Step (µm)	1 σ (µm)	1 σ (%)
0.088	0.0001	0.08%
7.319	0.0030	0.04%
46.472	0.0265	0.06%

Measurement Number	Step Avg µm Always Always Step Height	Magnification Always Always Meta Data	Step Avg µm Always Always Step Height	Magnification Always Always Meta Data
1	8.4119	4.964	8.42476	49.8
2	8.4104	4.964	8.42784	49.8
3	8.4143	4.964	8.42597	49.8
4	8.4128	4.964	8.42856	49.8
5	8.4075	4.964	8.43183	49.8
6	8.4182	4.964	8.42962	49.8
7	8.4105	4.964	8.42864	49.8
8	8.4125	4.964	8.42883	49.8
9	8.4159	4.964	8.42984	49.8
10	8.4117	4.964	8.42920	49.8

$1\sigma = 0.003\mu m$ $1\sigma = 0.002\mu m$

02

Advances of Bruker White Light Interferometry technique

Hardware
Optimized for performances

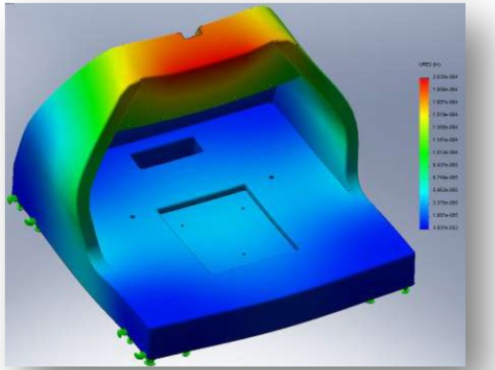
White+Green LEDs

Std:	5.876
Range:	24.126

White LED only

Std:	8.883
Range:	39.792

Step height repeatability

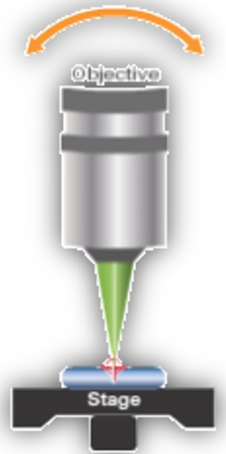


Dual LED
- Better metrology performances
- Higher repeatability

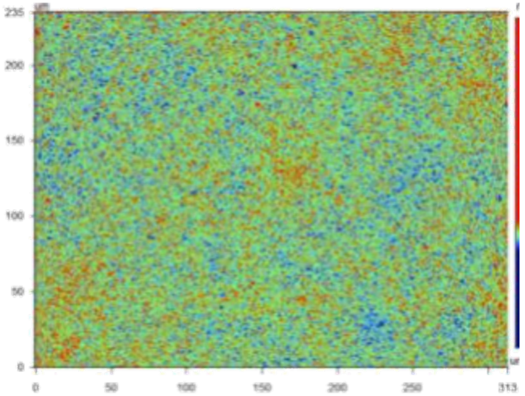
Motorized Tip/Tilt in head
- Increase reproducibility
- Full automation

Rigid dedicated supporting frame
- Tailor for 3D metrology
- Stable metrology

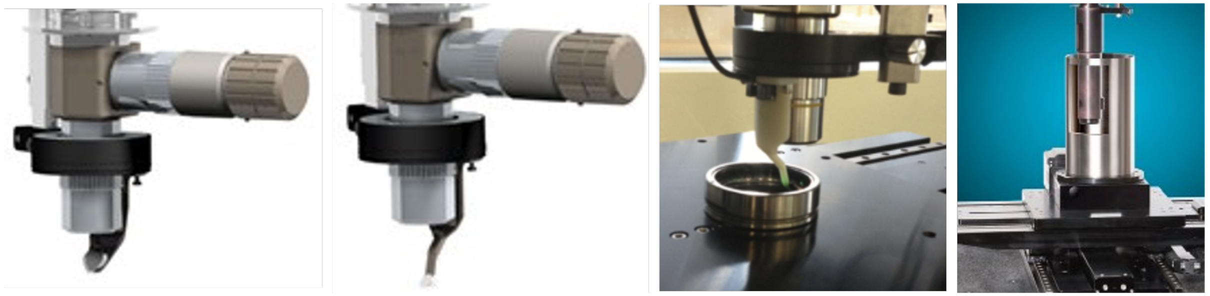
Optimized optical path
- Low reflectivity surfaces
- Top metrology performances

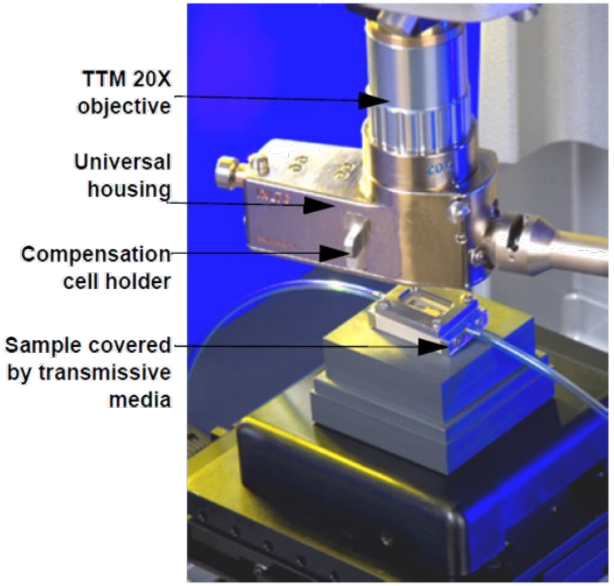


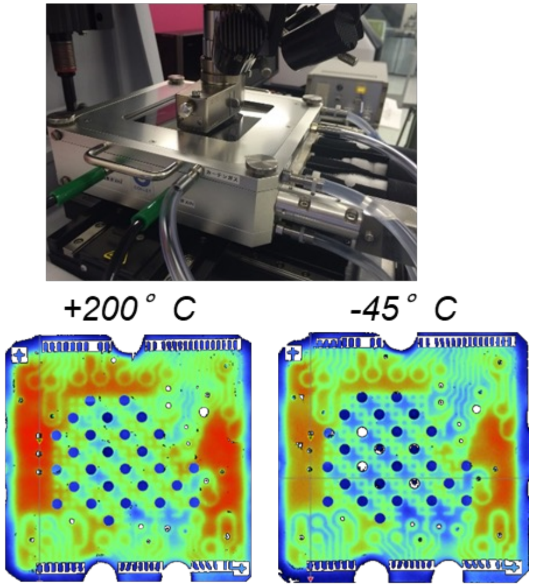
Anti-Reflective layer with 50x objective



Objectives
Tailored for challenges







Multiple Fold mirrors

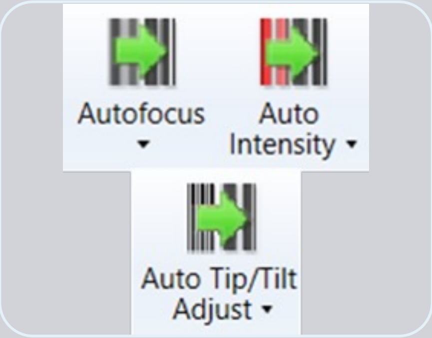
- Side wall roughness & waviness
- Diameter as small as ∅32mm
- Depth up to 150mm
- Combined with circumference stitching

Through Transmittive Media

- Encapsulated MEMS
- Environmental control (T, RH,…)
- Challenging High Aspect ratio trenches

Gain unique data

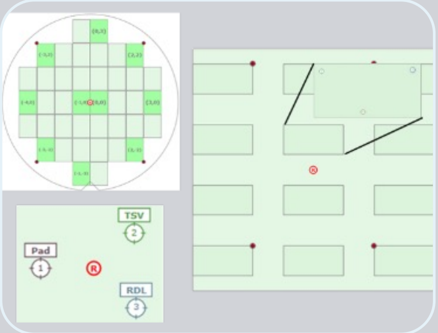
Complete Automation Suite
By default



1. Automatic best starting settings

Reproducible results

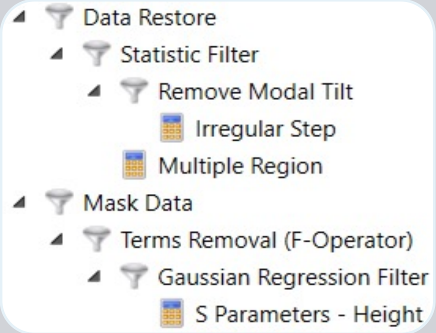
Robust operation



2. Flexible position definition

Versatile

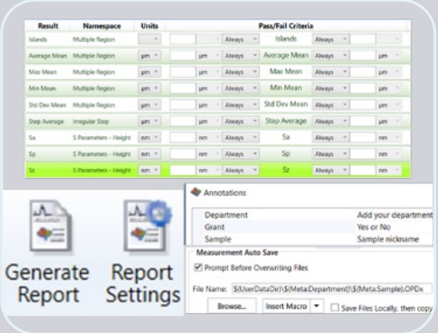
Easy setup



3. On-the-fly complete and multi-analysis data extraction

Throughput

Correlation

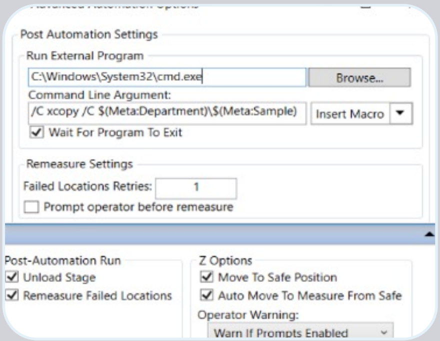


4. Wide range of automatically saved data

Topography

Results

Final report



5. Direct integration of post automation

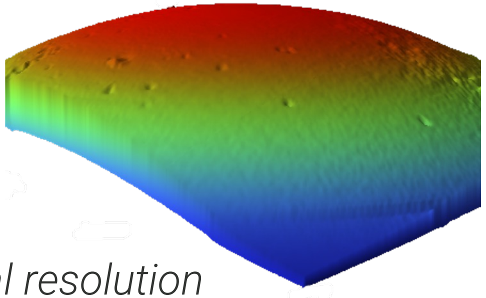
Result transfer

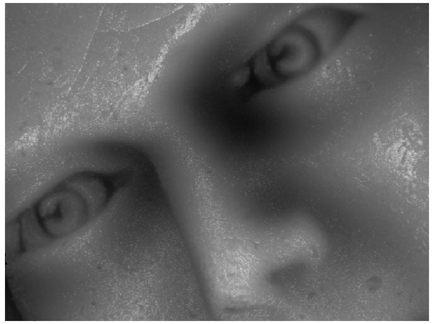
Archive

Sync with 3rd party software

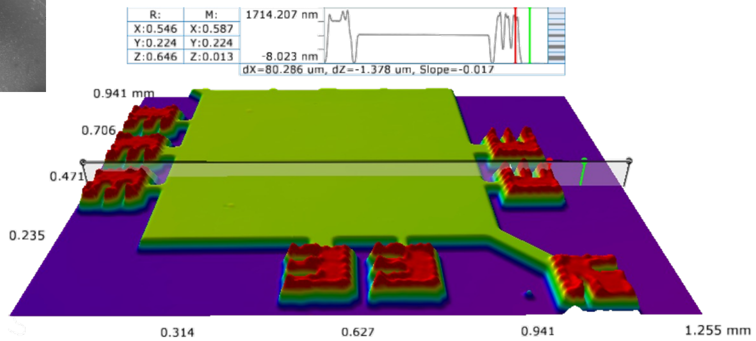
Universal Scanning Interferometry
Built-In Expertise, Self-adapting & Universal

Steady & Smooth slopes

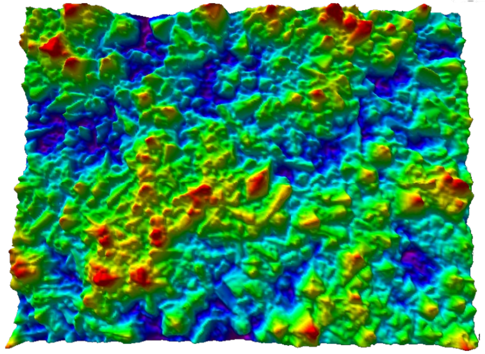




Large Field of View



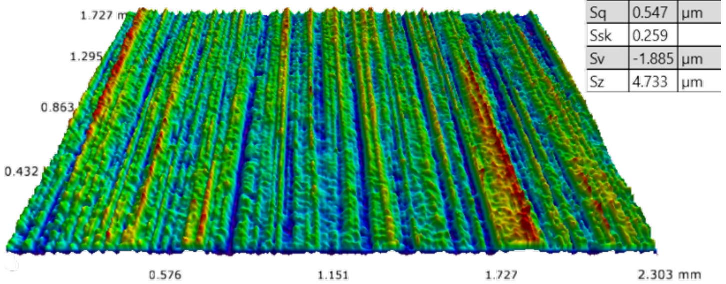
High lateral resolution

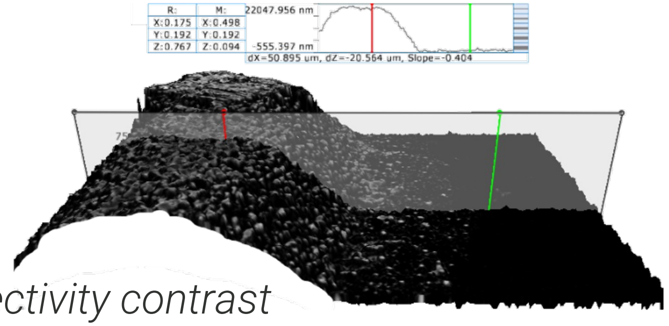


Ready to be used without expertise

Accurate stepped surface

Sa	0.44	µm
Sku	2.857	
Sp	2.848	µm
Sq	0.547	µm
Ssk	0.259	
Sv	-1.885	µm
Sz	4.733	µm

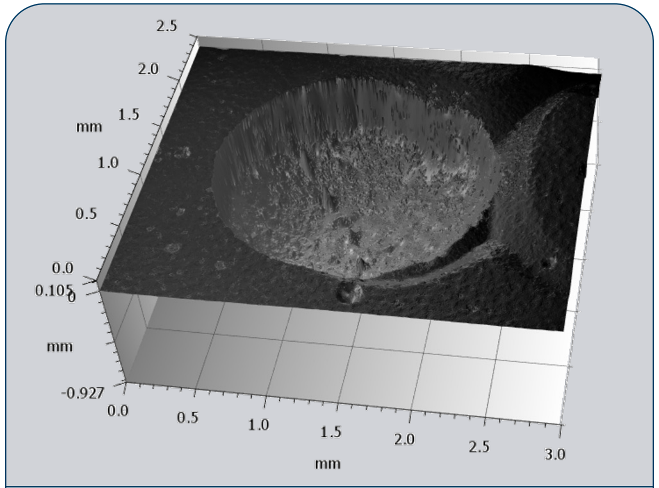




High reflectivity contrast

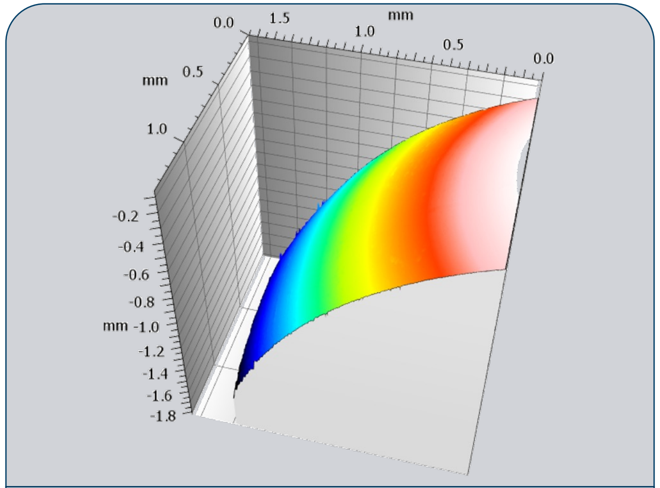
Accurate sub-µm roughness

Unique metrology robustness
Take on every challenge



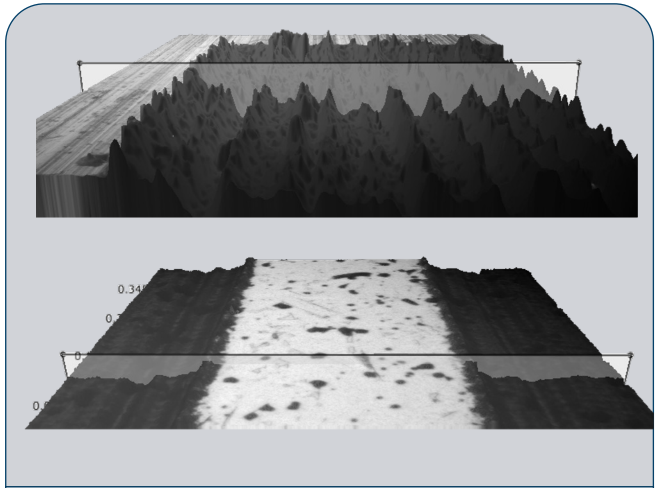
Rough & Dark

Corrosion pit on black anodized coupon

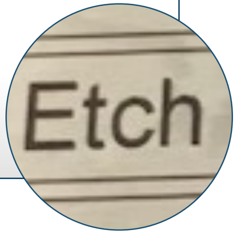


Rough & Reflective

Round metallic pin



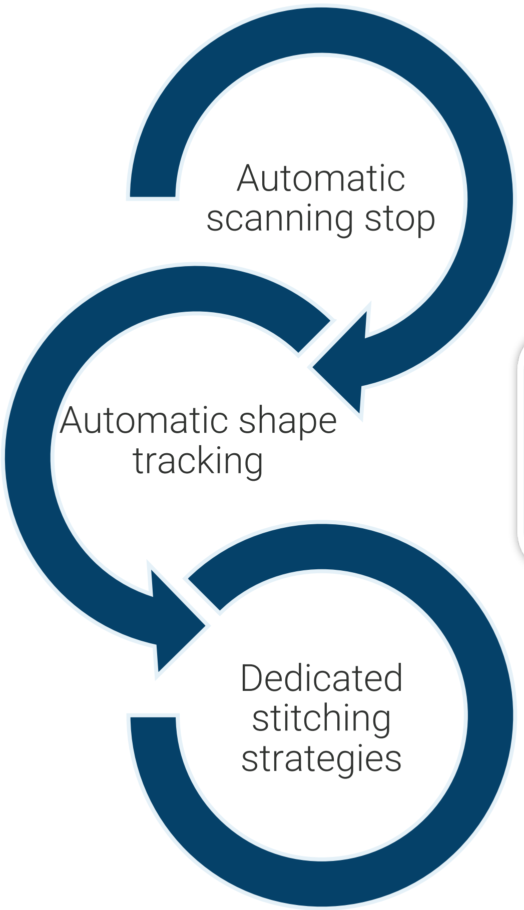
Dark & Reflective



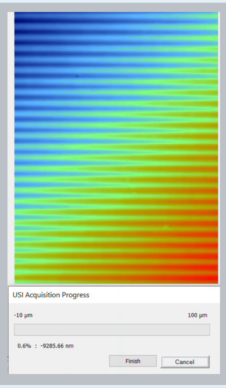
Laser textured surface
Laser cut on gold coating

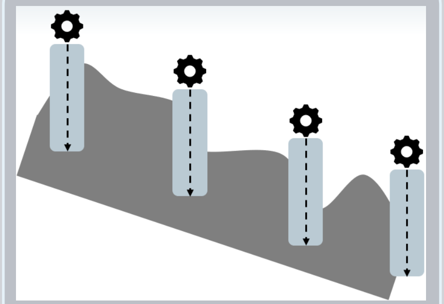
Power of WLI profiler implemented by Bruker

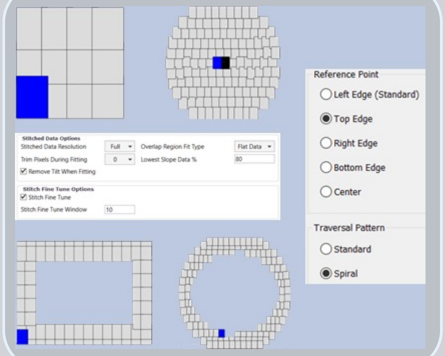
Unique stitching solutions
Throughput & Application specific



Short time to results







Auto-Scan

- Live interruption of vertical scan
- Based on % collected valid topography points

Throughput

Home Scanner

- Work out spread of topography vs. scan range
- Re-center scan for next scan
- Accommodate surface shape

Throughput

Stitching

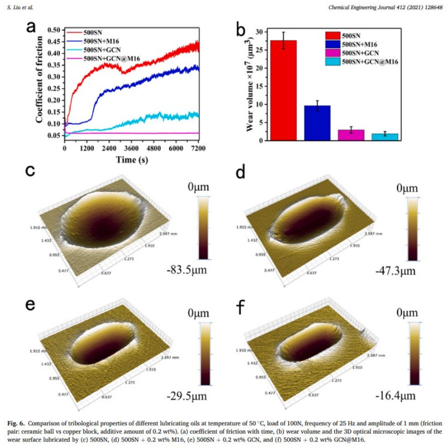
- Annular for tribology & manufacturing
- Cylindrical for tribology & manufacturing
- Spiral for optics

Full Solution

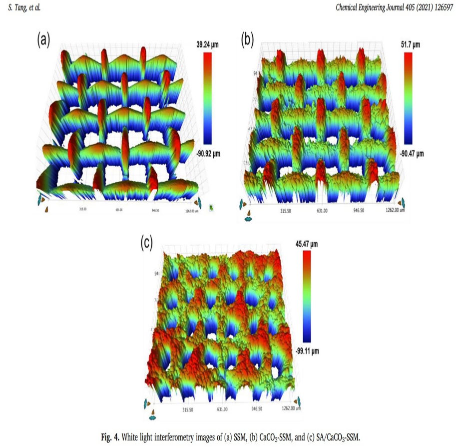
03

What are the top 8 applications by Bruker WLI in publication?

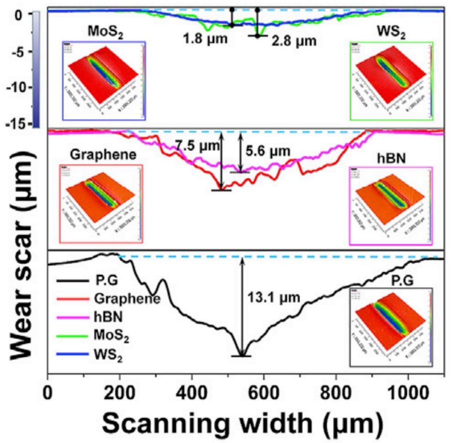
Top 8 applications typical data by Bruker WLI in publication



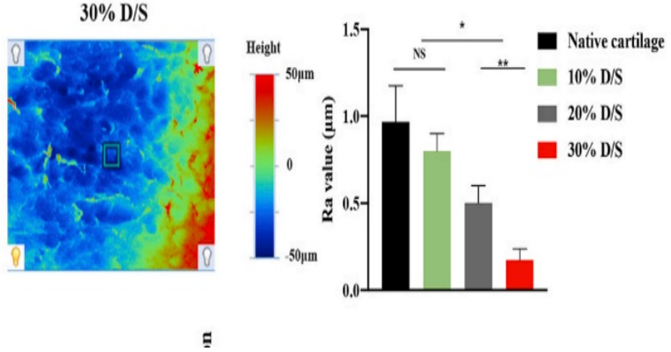
Tribology



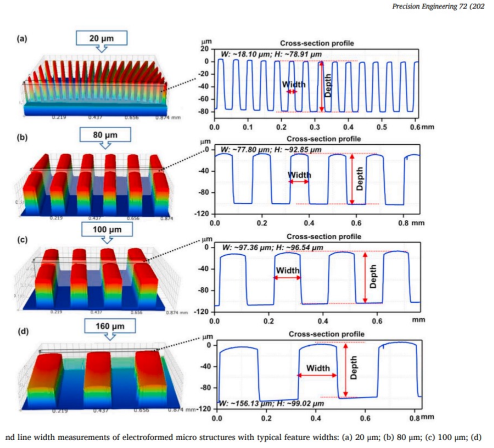
Surface property



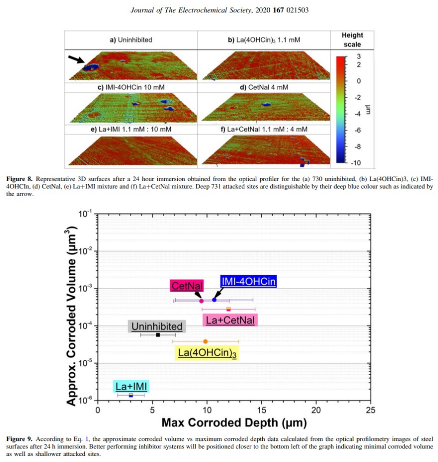
Lubrication



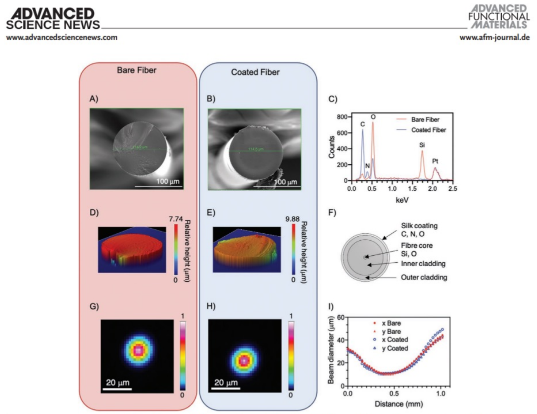
Medical device



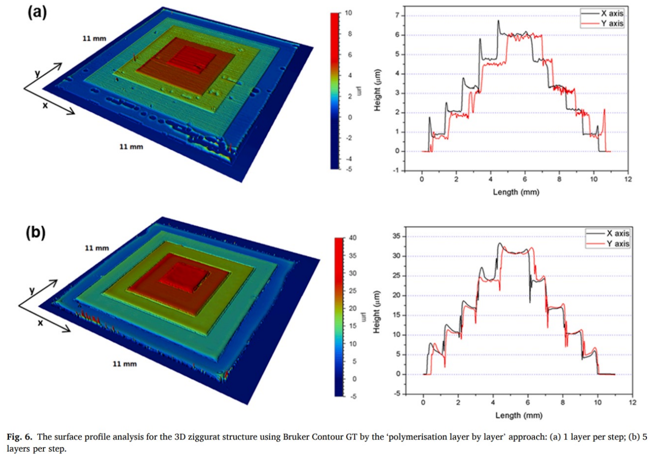
Micro manufacture &
Precision machining



Corrosion



Function materials



Additive Manufacturing

Why is Bruker WLI used for above research? - I

- **1, Tribology:** Quantify wear volume, depth/width of wear track, evaluate precisely without contact; even for wear mechanism studying together with SEM sometimes

- **2, Surface property:** Quantify surface texture/structure for studying Superhydrophobic, Surface Morphologies & Gloss Appearance, Antifouling, Oil/water separation, Superoleophobicity, Self-cleaning, Wettability, Self-healing, Biocompatibility, Anti-icing

- **3, Lubrication:** Quantify wear volume, depth/width of wear track, morphology investigation

- **4, Medical device/Biomaterials:** in-situ, non-contact direct observation; 3D dimensions for Microfluidic device; Surface finishing of stents, implants, etc.; Morphology, roughness for studying Biodegradation, Antifungal Efficacy, Adhesion strength, Functionalized surface, Antibacterial, Osteogenic

Why is Bruker 3D OM used for above research? - II

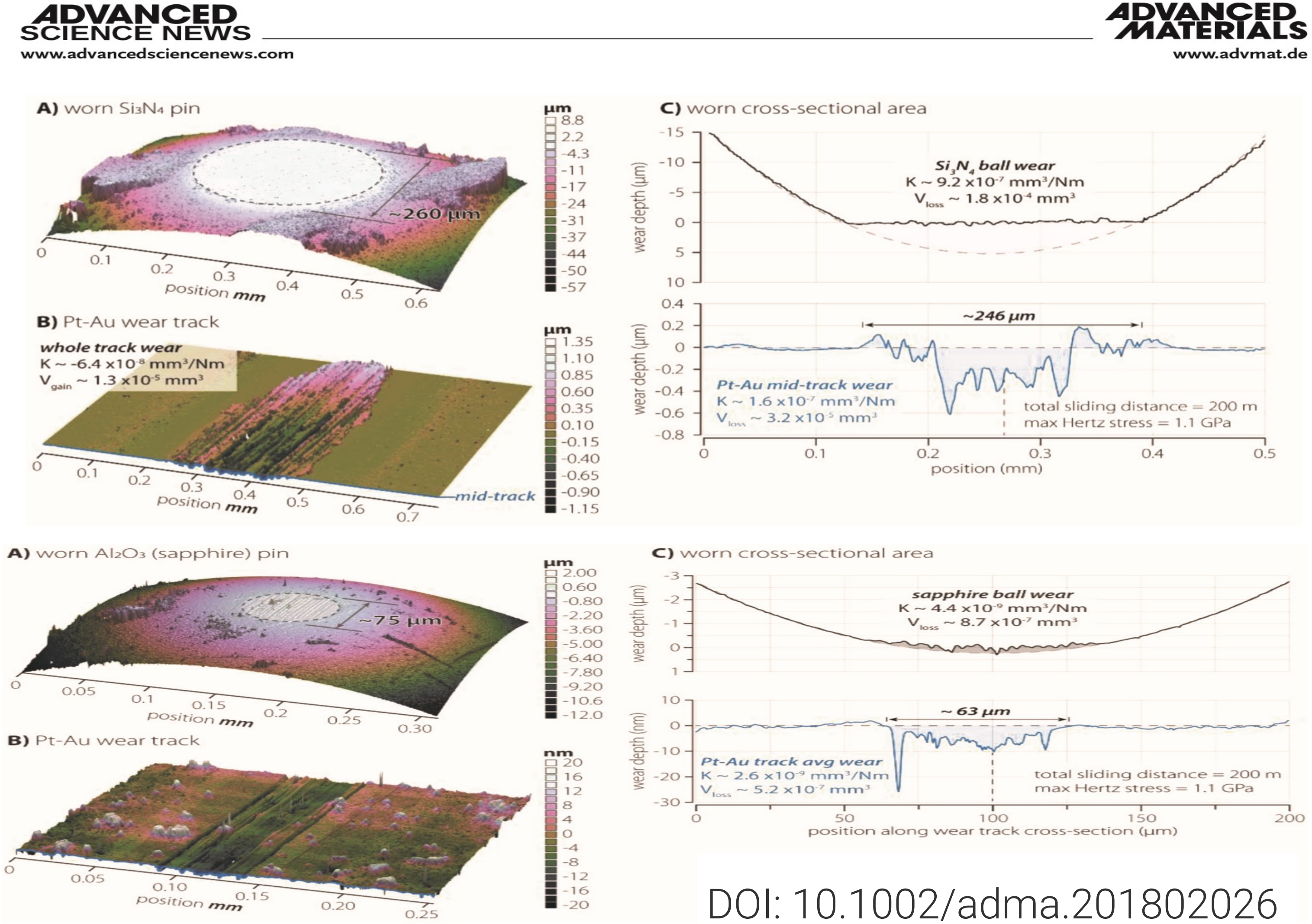
- **5, Micro manufacture & Precision machining:** 3D dimensions of device/structures, quantify surface finishing for ultra precision machining method validation, parameter optimization; Frequently used in laser texturing, precision drilling, ablation, cladding, and single-point diamond turning, micro electroforming, injection molding, etc

- **6, Corrosion:** Quantify corrosion depth/profile, corroded volume, for studying pitting, cavitation erosion, fretting corrosion, microbiologically influenced corrosion, galvanic corrosion, tribocorrosion, erosion–corrosion

- **7, Function materials:** Film thickness, structure depth, roughness measurement for electronics/optical/etc film/coating

- **8, Additive Manufacturing:** Surface topography/morphology characterization, process optimization

Tribology study

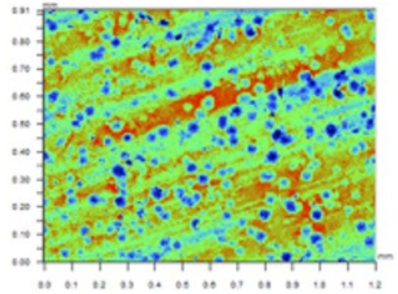


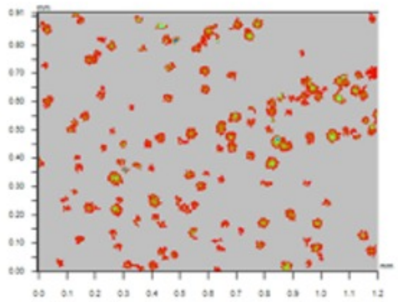
DOI: 10.1002/adma.201802026

Corrosion study

Mag: 5.1 X

Mode: VSI



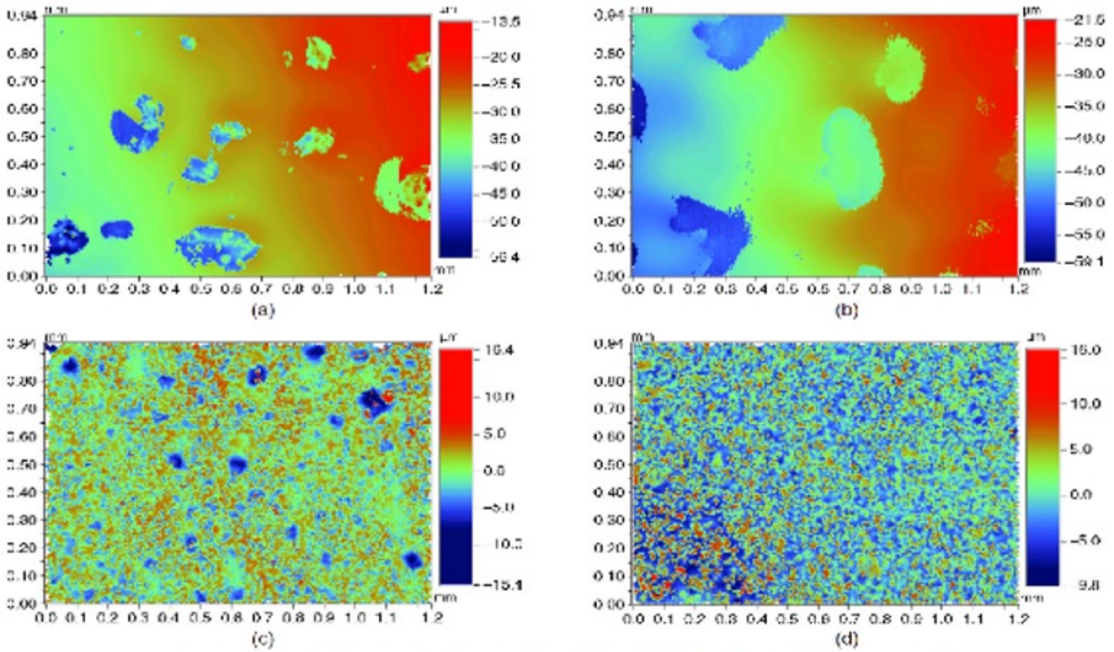


MultiRegion Analysis

Region	Mean (um)	Diameter (um)	Area (mm2)	Rv% (um)	Volume (um3)
84	-3.002	38.054	0.001	-4.567	-1799.938
85	-2.916	44.755	0.001	-4.375	-3096.113
86	-2.517	54.458	0.001	-3.537	-2860.571
87	-2.067	27.525	0.000	-2.598	-722.797
88	-2.379	143.674	0.005	-3.852	-12003.441
89	-2.003	24.869	0.000	-2.567	-650.465
90	-2.054	35.194	0.000	-2.556	-769.561
91	-2.004	25.604	0.000	-2.423	-725.695
92	-2.161	29.756	0.000	-2.983	-836.811
93	-2.330	48.645	0.001	-3.859	-2503.165
94	-2.311	72.611	0.002	-3.787	-3550.267
95	-2.560	40.735	0.001	-3.866	-2461.870
96	-2.243	30.417	0.000	-4.048	-1008.718
97	-2.880	54.525	0.002	-4.353	-5034.870
98	-2.812	110.301	0.003	-4.695	-8884.792
99	-2.133	52.653	0.001	-2.824	-1838.387
100	-2.512	74.810	0.002	-4.067	-5176.191
101	-2.428	31.592	0.000	-3.704	-1000.648
102	-2.401	31.592	0.001	-3.314	-1589.020
103	-2.412	40.894	0.001	-3.665	-2349.824
104	-2.523	30.301	0.001	-3.528	-1354.902
105	-2.281	55.304	0.001	-3.409	-2193.438
106	-1.961	57.487	0.001	-2.433	-2840.395
107	-2.570	95.290	0.002	-4.130	-3980.248
108	-2.152	36.305	0.001	-3.075	-1155.807
Average	-2.349	44.681	0.001	-3.551	-2184.592
Std Dev	0.290	20.851	0.001	0.782	1849.531
Range	1.555	120.458	0.005	4.583	11362.362

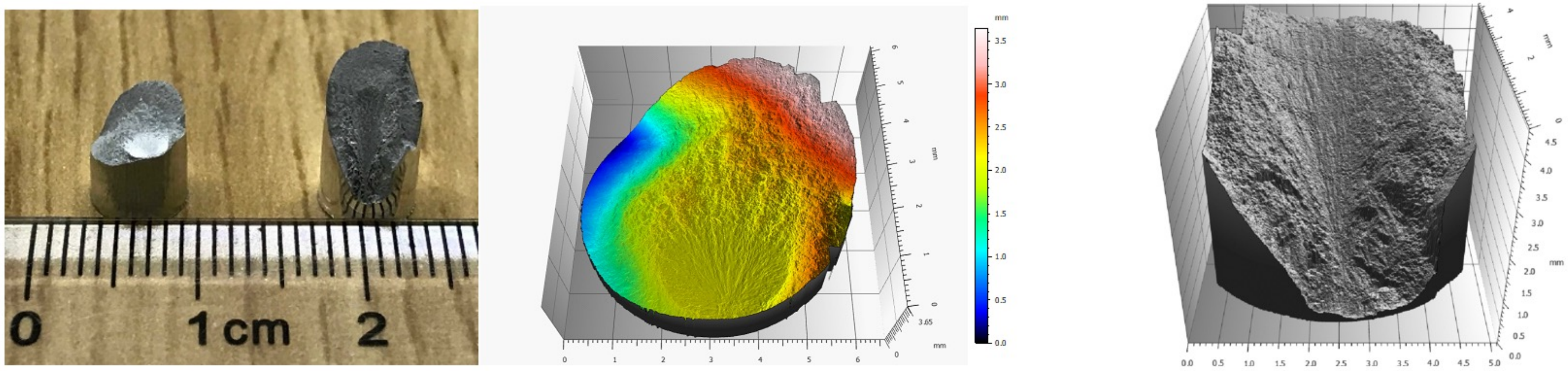
Title: Process A

Note:

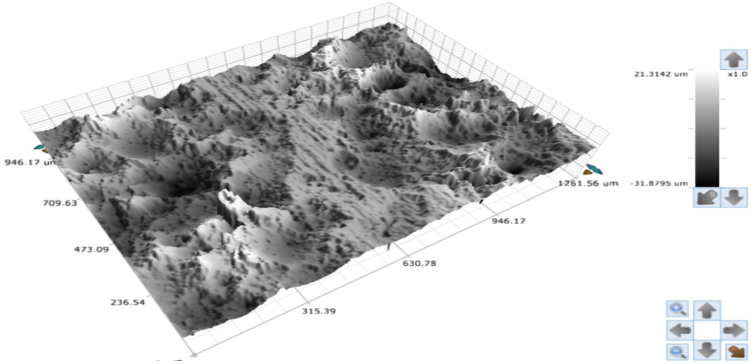


Two-dimensional views of inhibitor films for CI-A and CI-C after 24 h of static and dynamic exposures.

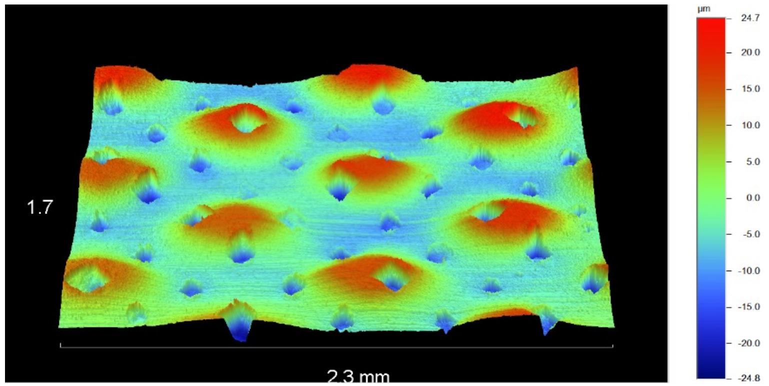
Other typical data by WLI on metal



Fracture analysis



Wear after shot peening



Al Foil for LIBs

04

High magnification measurement application

Optical resolution and lateral sampling

Two major lateral resolution limitations

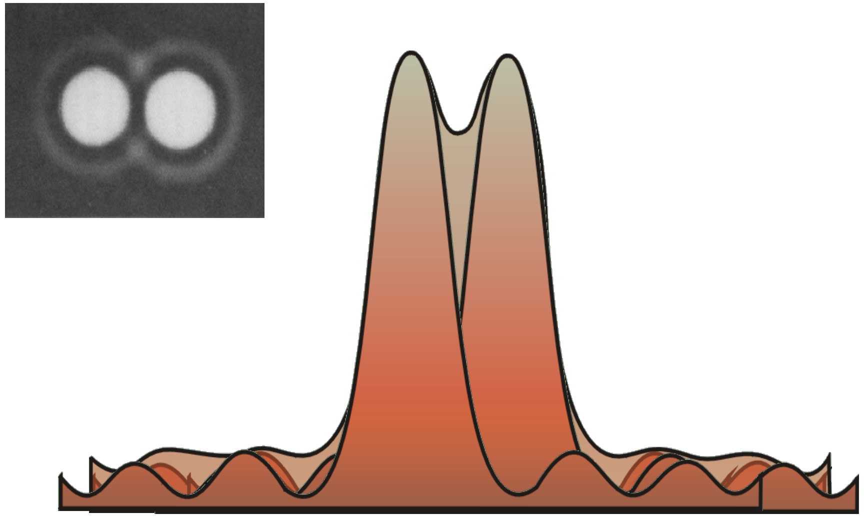
- Optical diffraction

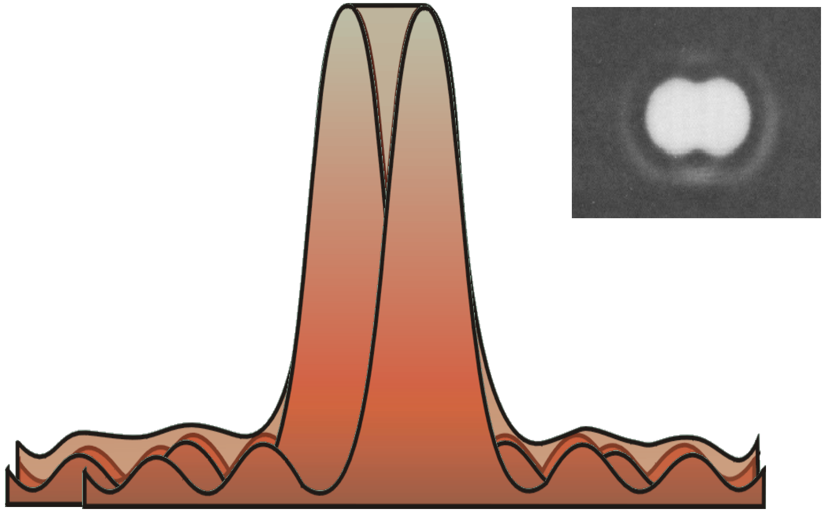
Higher NA optics and shorter wavelength provide better feature measurement

- CCD pixels

Higher number or smaller size pixel cameras does not necessarily provide better feature measurements

Optical resolution





2-point optical resolution for incoherent light:

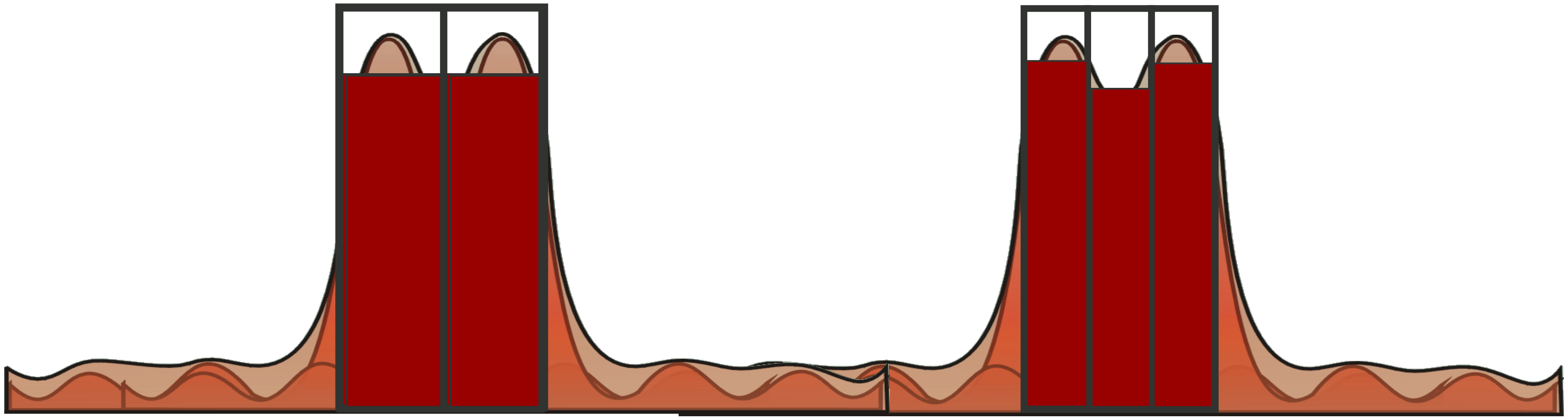
Rayleigh criterion

Points separation = 0.6 l / (NA)

Sparrow criterion

Points separation = 0.47 l / (NA)

Lateral resolution limits



System is limited by detector

Larger pixels limit image delivered by optics

System is limited by optics

More or smaller pixels do not help in resolving smaller features

Objectives

Wide selection of objectives for your application

- Standard objectives 2.5x, 5x, 10x, 20x, 50x, 115x
- Long working distance (34 mm): 2x, 5x, 10x, 20x
- Large area: 1x

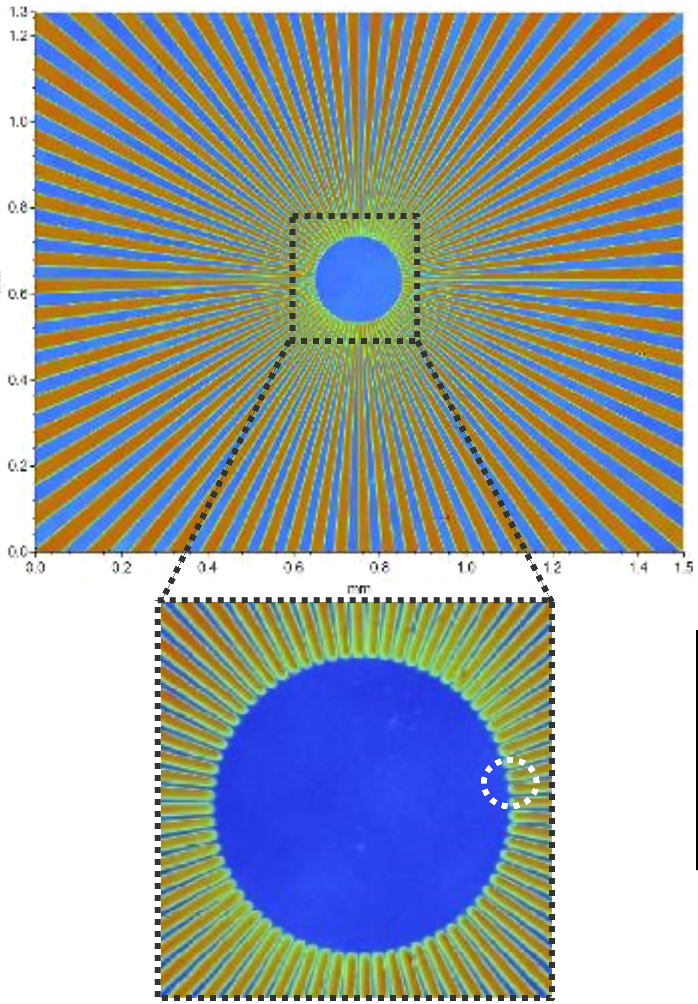
Large Field of View for new 5M CCD Combined with better lateral resolution

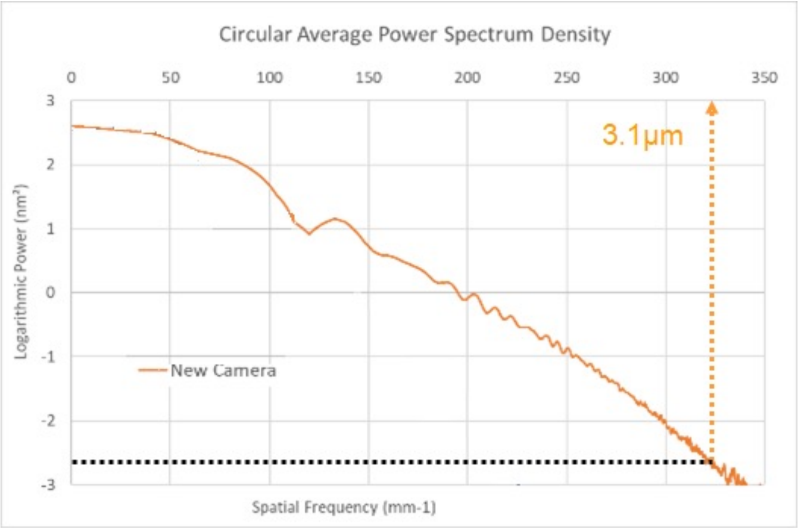
New ContourX

10x objective with 0.55 zoom

Full Image

Digital Zoom In





High repeatability

Mode	Step (µm)	1 σ (µm)	1 σ (%)
PSI	0.0884	0.0001	0.08%
USI	7.4745	0.0030	0.04%
VSI	46.4722	0.0398	0.09%

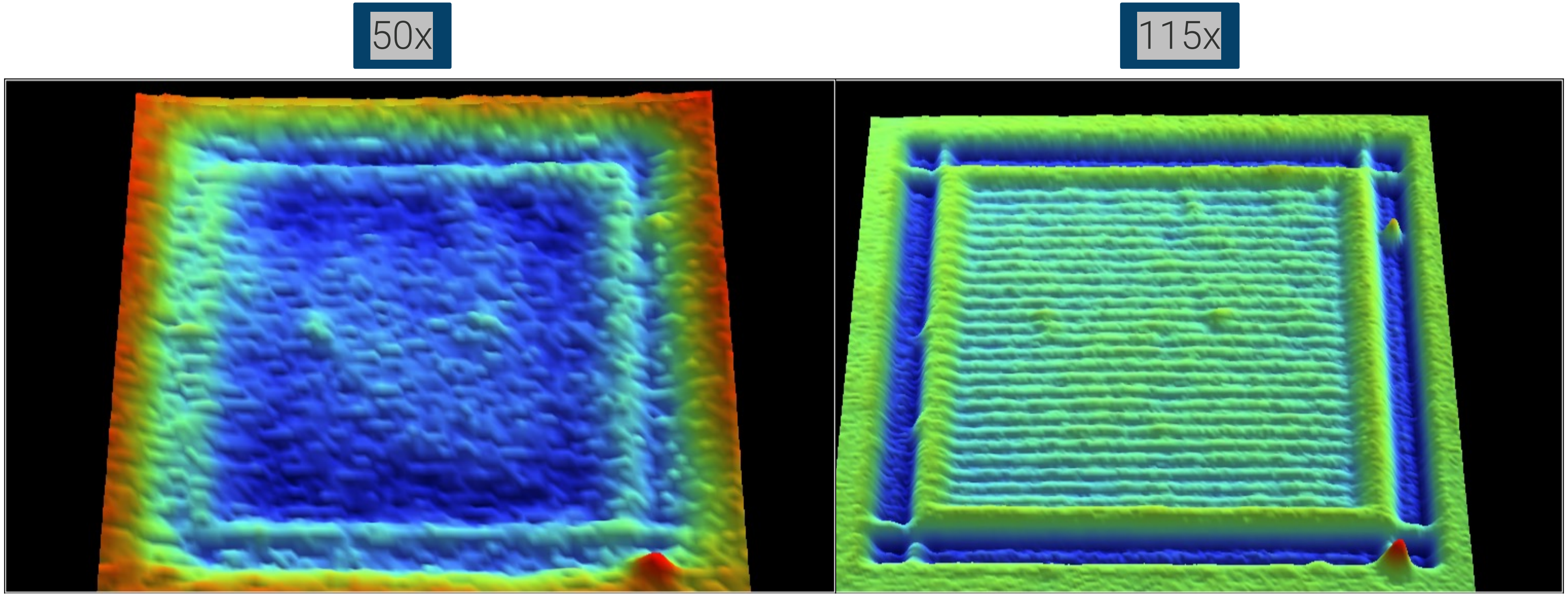
115x Objective Overview

- Designed for use on all Bruker 3D microscopes
- Increases the ability to measure steep slopes on smooth surfaces
- Increases the ability to measure small features

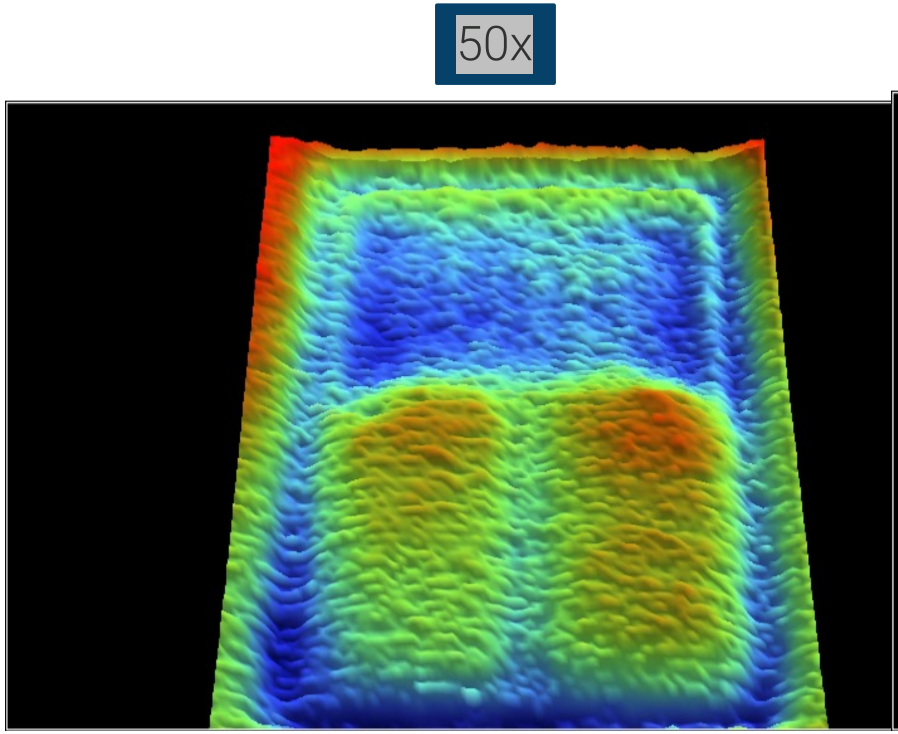
Specifications

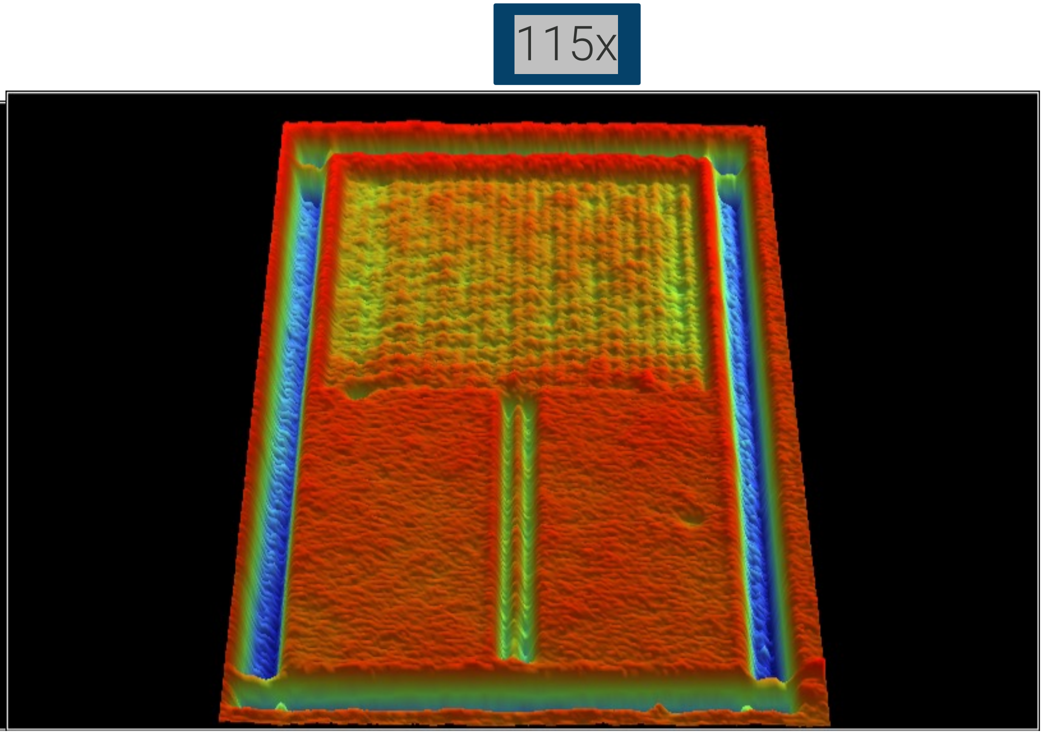
Feature	Specification
Magnification	115x
Interferometer Type	Mirau
Numerical Aperture	0.80
Working Distance	0.7 mm
Depth of Field	0.8 µm
Reference Surface Reflectivity	20%
Maximum Theoretical Slope on Smooth Surfaces	53 degrees
Lateral Resolution Using Sparrow Criterion	314 nm on Bruker ContourGT series and Bruker NT9XXX series 3D microscopes; 375 nm on prior models

Results
200nm Horizontal Lines (1x FOV-USI)



Results
200nm Horizontal Lines (1x FOV-USI)

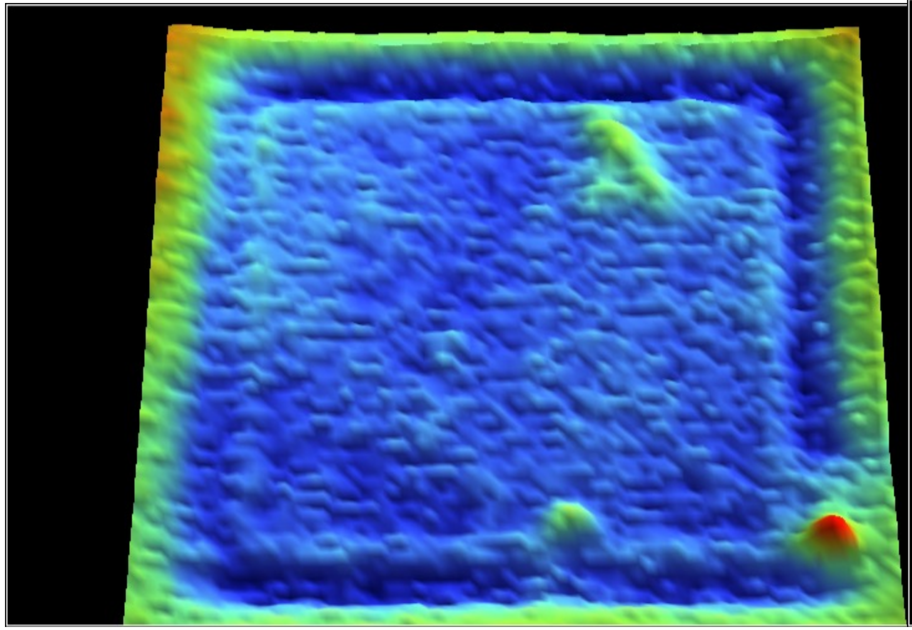




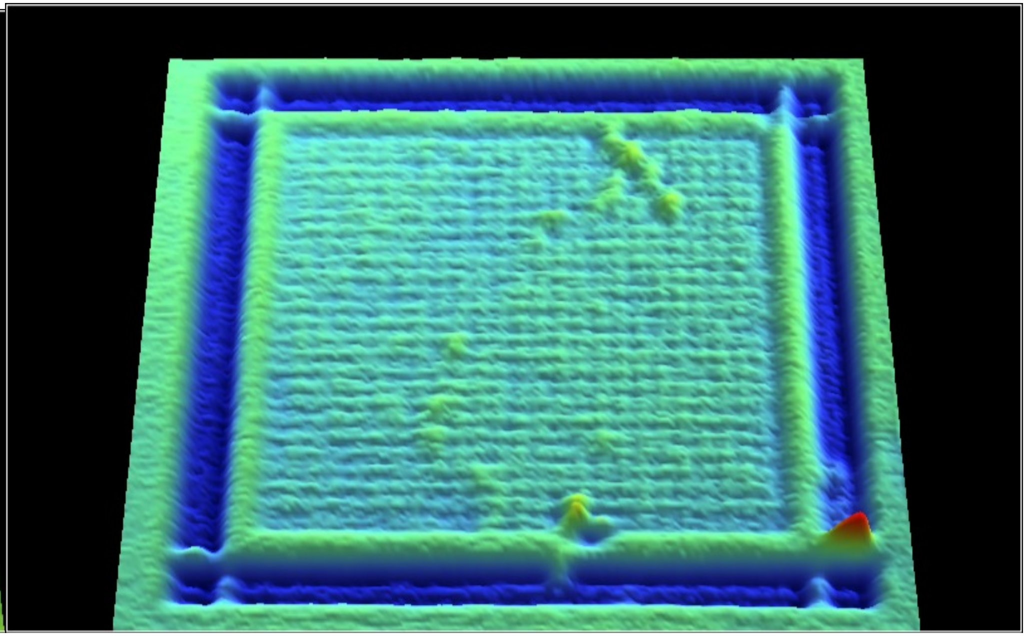
Results

200nm Grid (1x FOV-USI)

50x

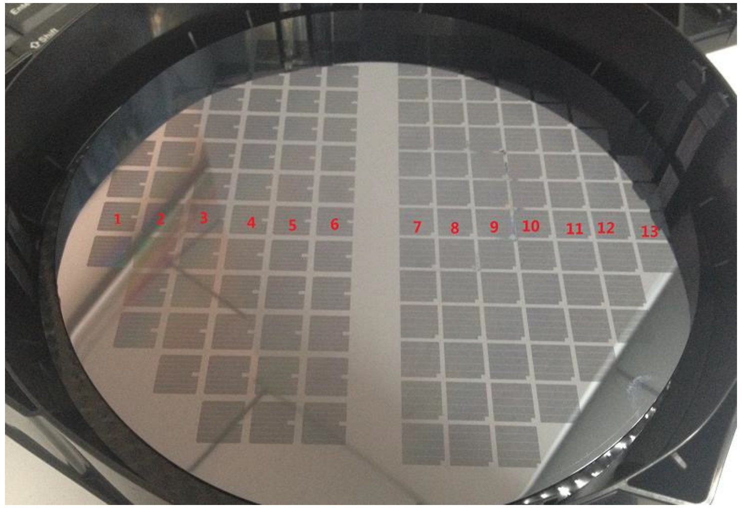


115x

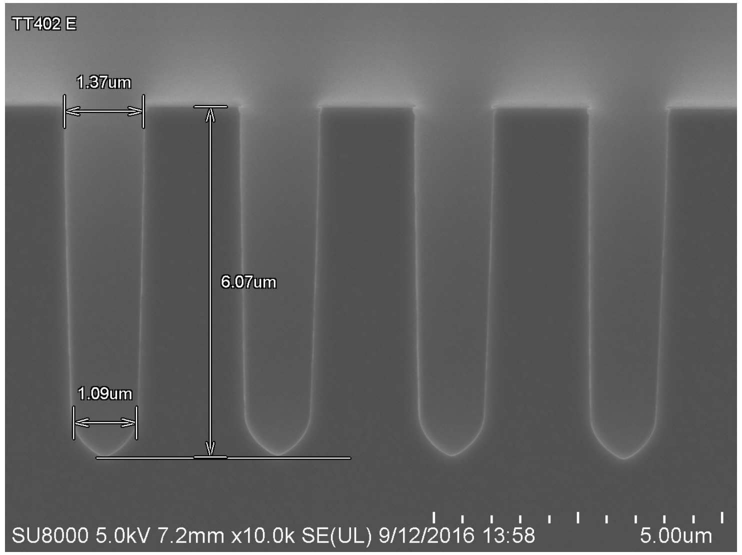


Power device

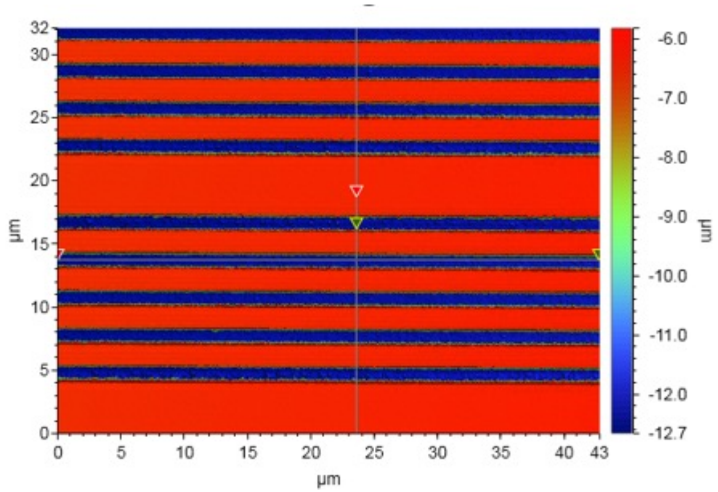
8-inch wafer trenches



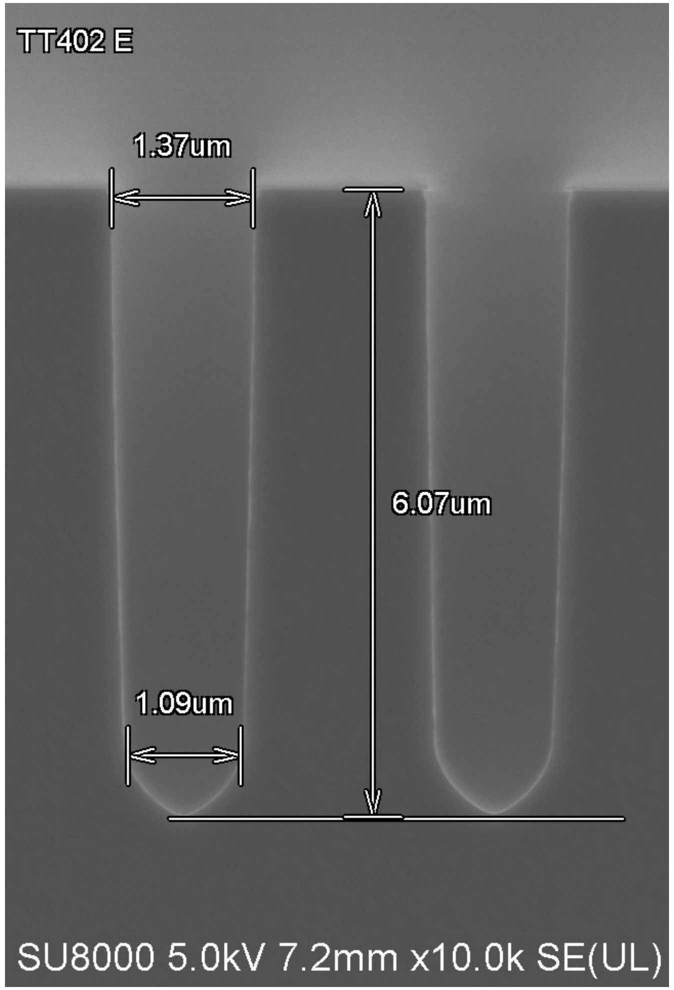
SEM Cross section



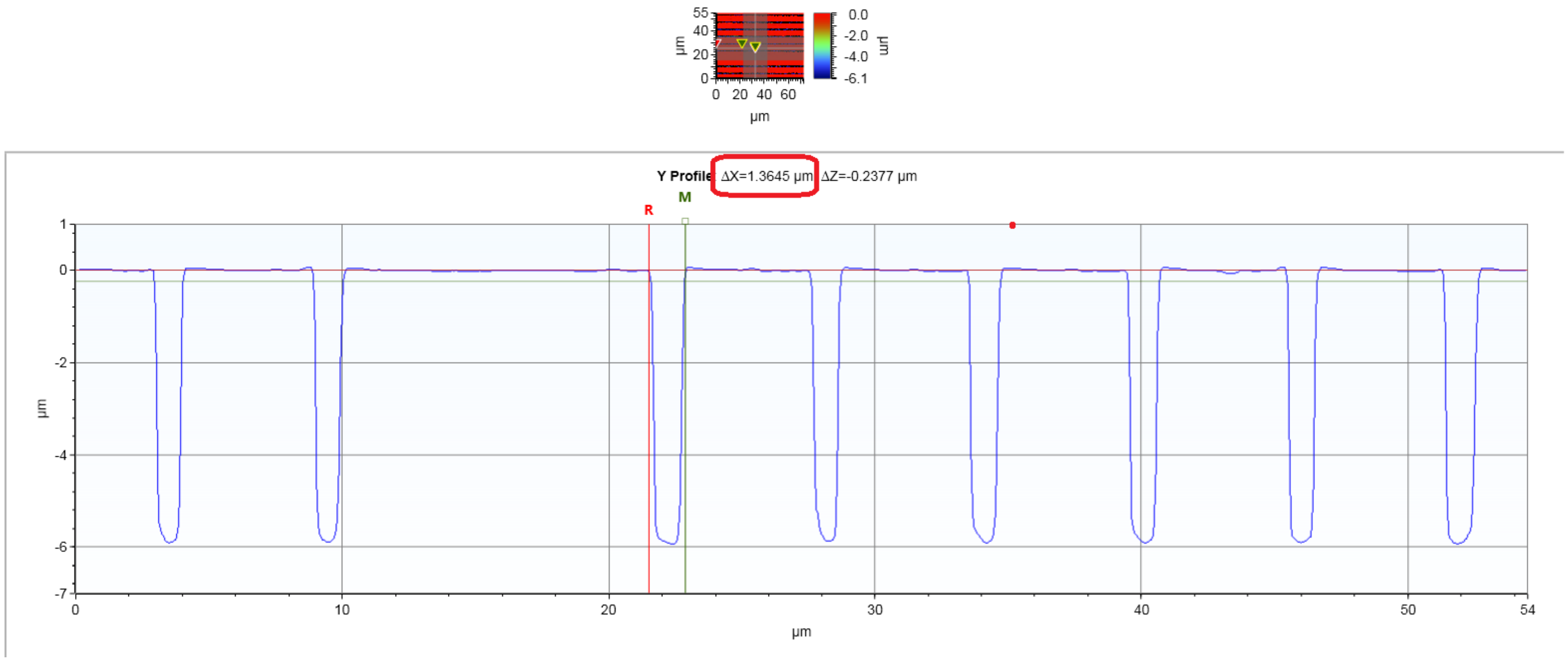
WLI direct measurement with 115x



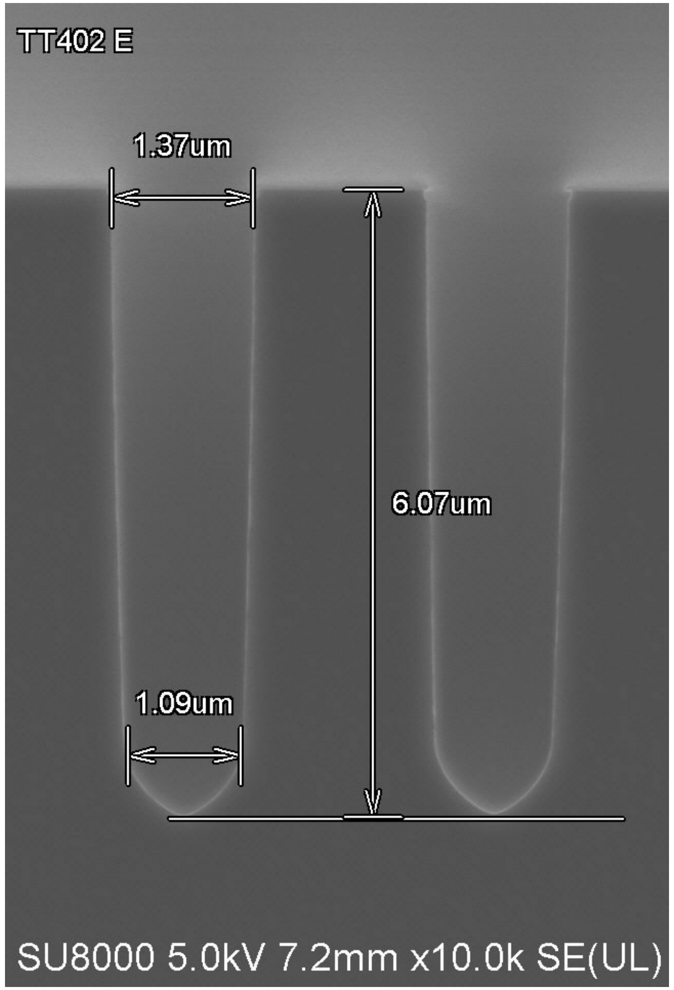
Power device： Top CD, 1.37 (SEM) vs. 1.36 (WLI)



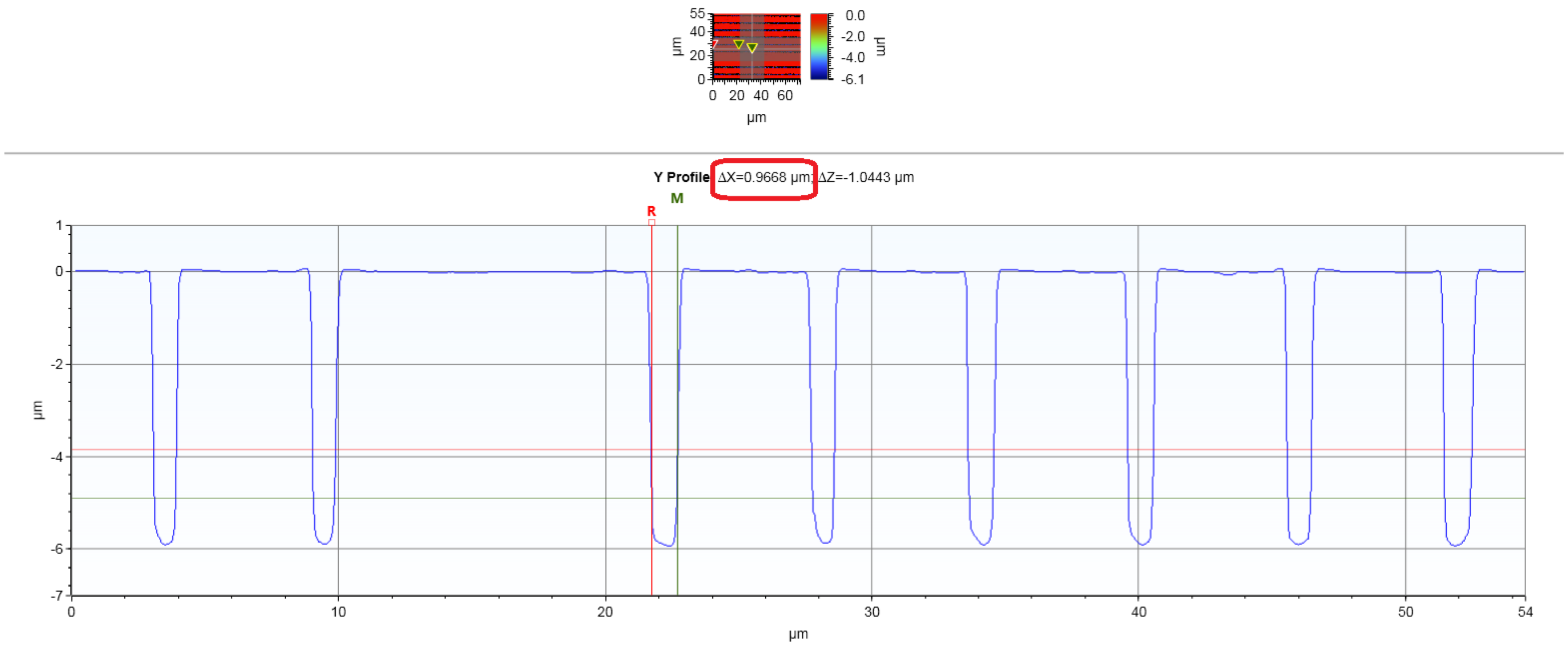
Top CD=1.36μm



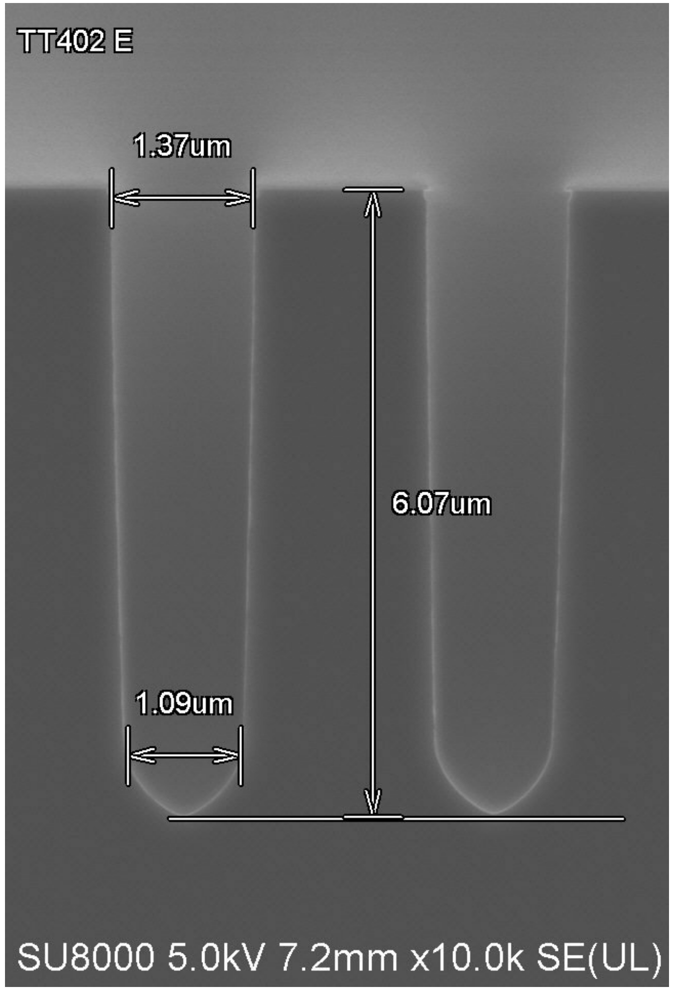
Power device： Bottom CD, 1.09 (SEM) vs. 0.97 (WLI)



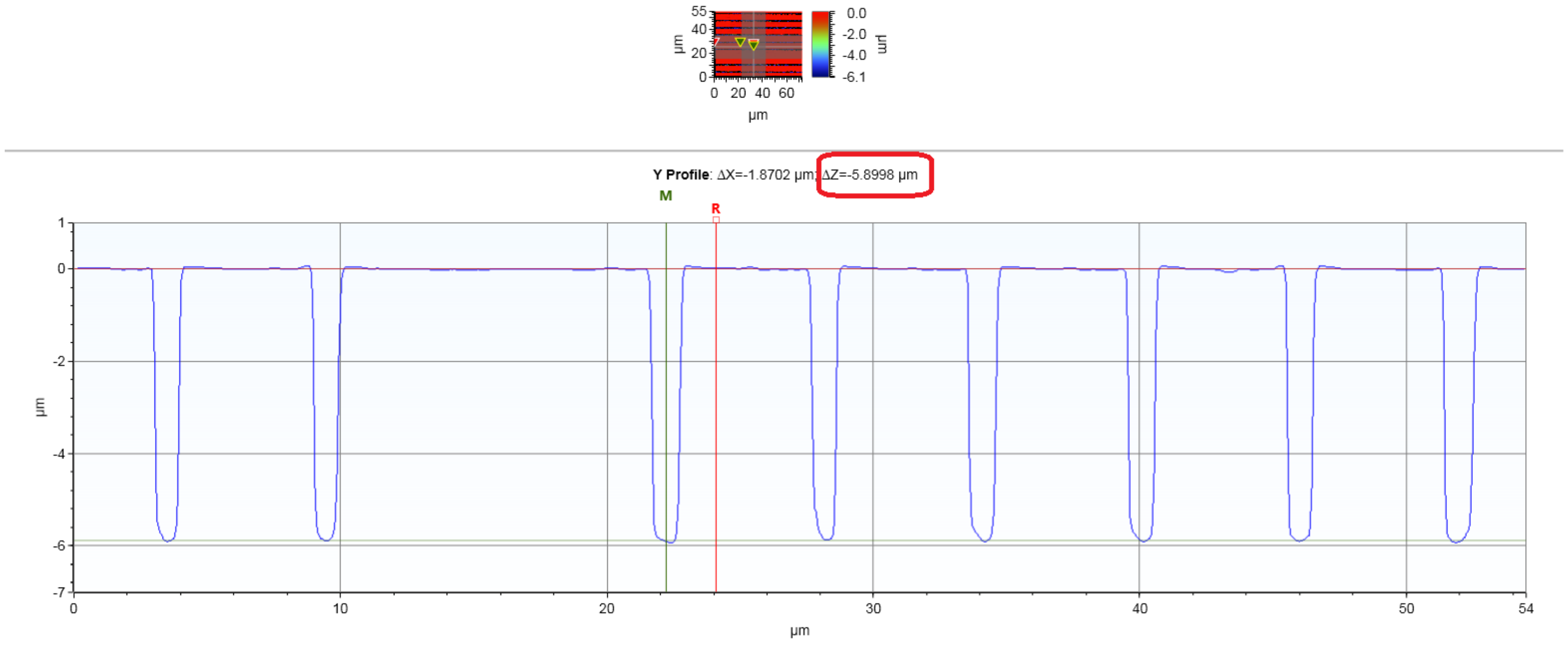
Bottom CD=0.97 µm



Power device： Depth, 6.07 (SEM) vs. 5.90 (WLI)

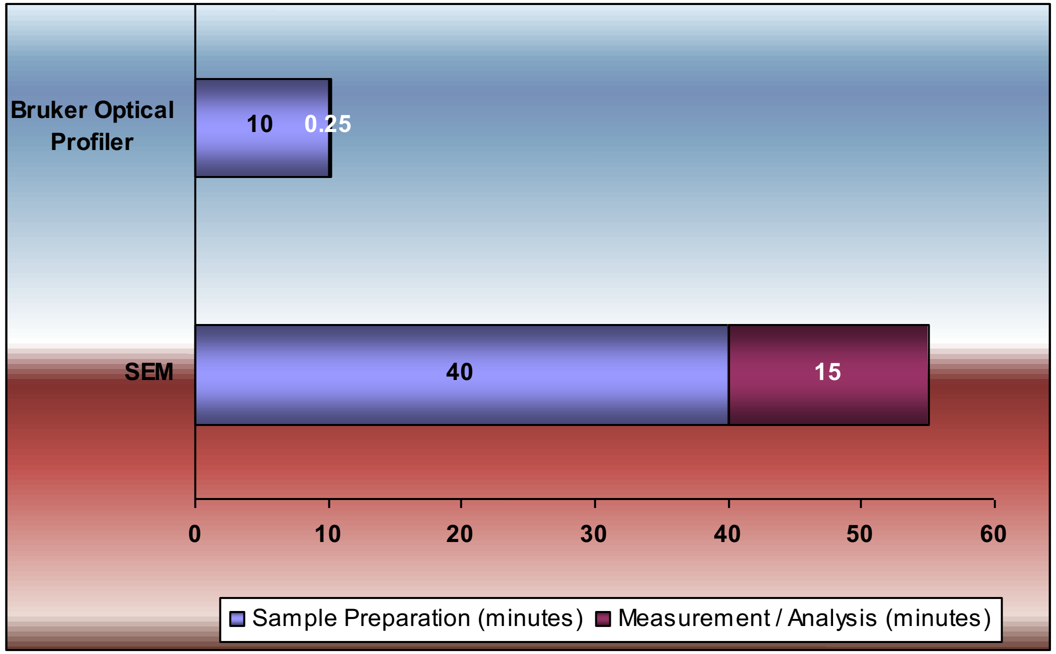


Depth =5.90 µm



Comparison between SEM vs. WLI

Time

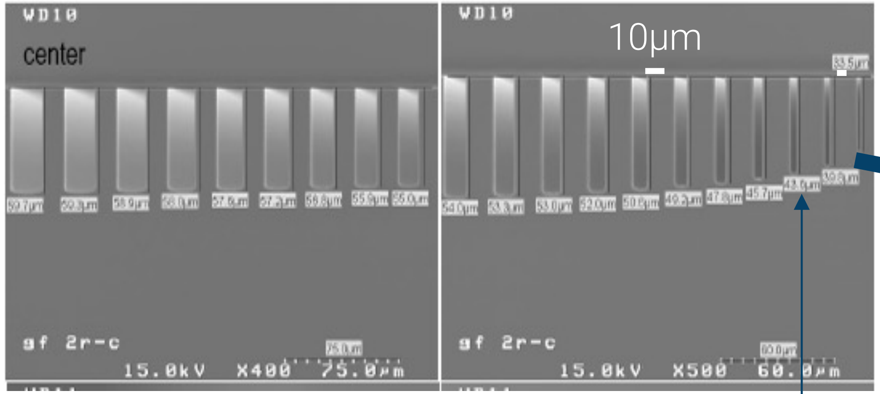


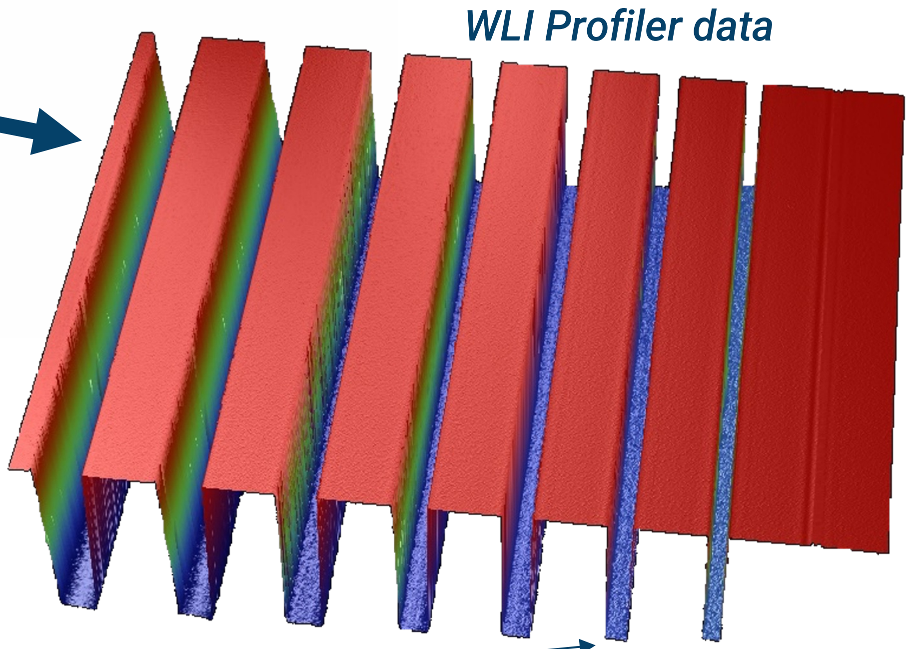
Broken vs. Non-Contact

- SEM:
  - Need broken wafer, cost very high
- WLI:
  - Direct measurement with non-contact method

TSV correlation: SEM vs. WLI

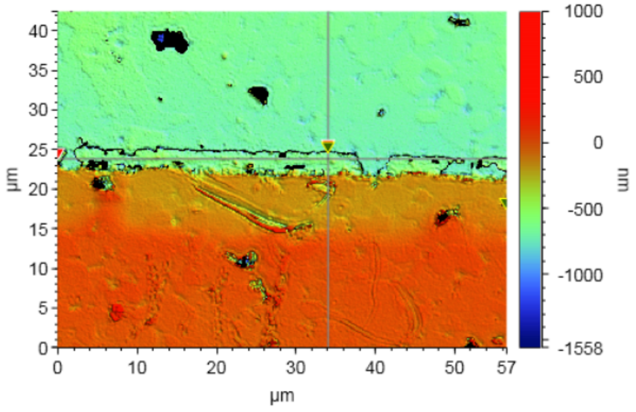
Location	Tr1	Tr2	Tr3	Tr4	Tr5	Tr6	Tr7	Tr8	Tr9	Tr10	Tr11	Tr12	Tr13	Tr14	Tr15	Tr16	Tr17	Tr18	Tr19	Tr20
CD (um)	1.0	2.0																		20
Center Si etch depth (um)	33.1	39.6	43.2	45.8	47.8	49.2	50.6	52.0	53.0	53.3	54.0	55.0	55.9	56.8	57.2	57.6	58.0	58.9	59.3	59.7
Edge Si etch depth (um)	34.4	41.3	45.1	47.8	49.8	51.2	52.6	54.0	54.3	55.7	56.4	56.7	57.6	58.0	59.7	59.7	59.7	60.6	61.0	61.0





5μm width
43μm depth

Crack width on ceramic specimen



Crack width=237nm

Keys to Measurement Success

- The 0.7mm (700um) working distance requires close proximity to the sample surface
  - This short working distance greatly increases the risk of contacting measurement surface
  - It is possible to make a long enough VSI scan to contact the measurement surface

- *The reference mirror inside the objective must occasionally be refocused*

- Due to small depth of focus autofocus must be used for PSI measurement to get the best results
  - Reference generation and removal should also be performed

05

Summary

Bruker Stylus and Optical Metrology
Products

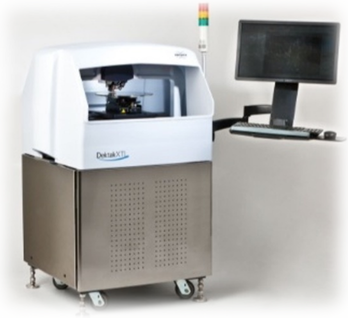
NPFLEX-LA Standalone
斜纹角测试

NPFLEX 1000 Standalone
机械零部件测试

Contour SP
半导体封装测试

Insight WLI
晶圆测试

DektakXT
6吋以下台阶仪

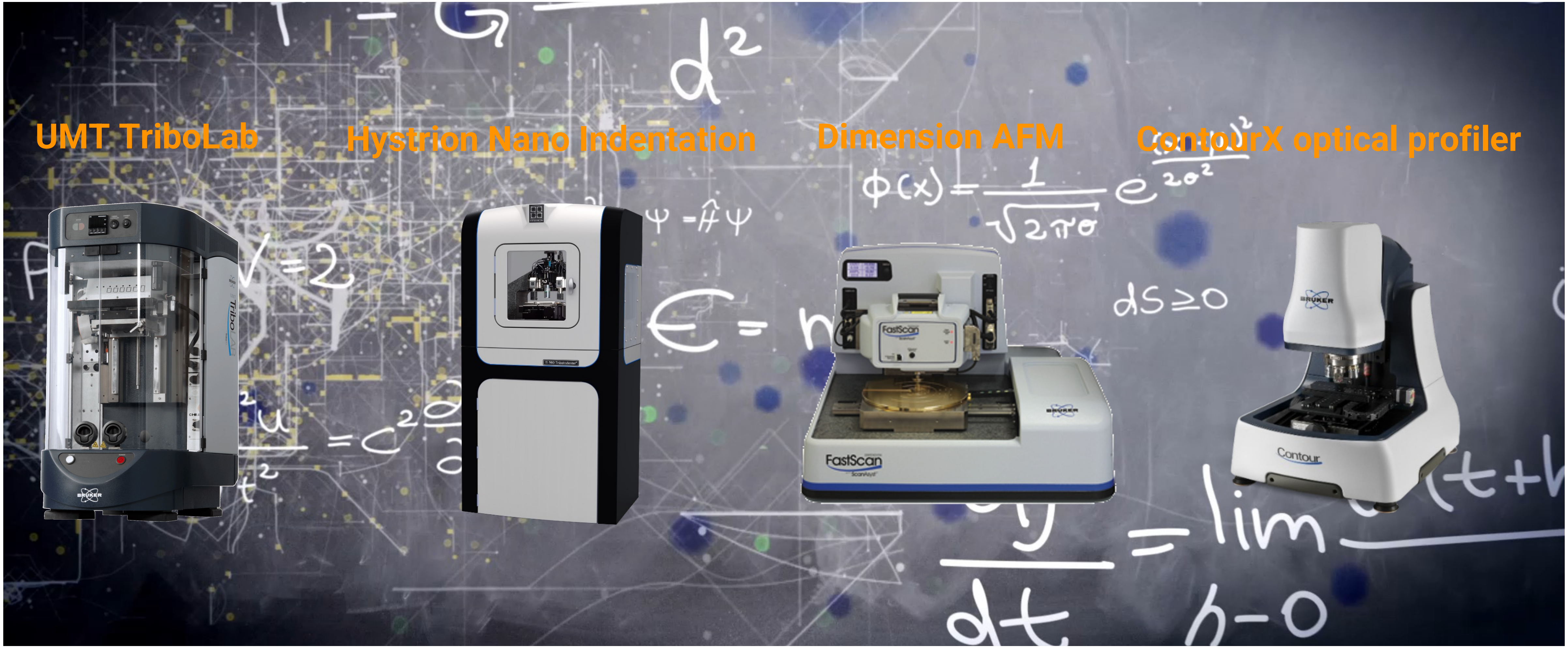


Dektak XTL
12吋台阶仪

ContourX Serial Benchtop
桌面式小型测试平台

ContourX 1000 Standalone
落地式测试平台

Bruker Nano Surface Metrology test and characterization platform



Thank you!

Name
Email or phone number

BRUKER

Innovation with Integrity