Zwick / Roell

Product Information

ZHN - Universal Nanomechanical Testing System

CTA: 98975 106725

ZHN Nanoindenter in special housing

Changing of sample holder

Applications

The universal nanomechanical tester is designed for the determination of hardness and Young's Modulus on materials and coating systems. The nano and micro ranges are compliant to the standard EN ISO 14577 (instrumented indentation method for determining hardness and other material parameters of metallic materials and coatings). The nanomechanical tester can also perform cyclic indentation tests and indentation tests with superimposed oscillation.

Due to its high modularity, it is more than a nanoindenter or hardness tester. When used with a **measuring head (NFU)** it serves as:

- Nanoindenter/hardness tester, depending on the measuring head used, for measurements between 0.05 mN to 20000 mN
- Micro compression testing instrument in the same force range
- Fatigue tester up to 2 Hz quasi-static or up to 300 Hz with dynamic module
- Dynamic mechanical tester (DMA) up to approximately 100 Hz with dynamic module
- For surface profile measurement and with dynamic module, also for stiffness/modulus mapping
- Scratch and wear tester without coefficient of friction measurement
- for fast mapping of hardness and Young's modulus up to 10 measurements per minute

With a **second measuring head for lateral force displacement curves (LFU)**, it can be used as:

- Scratch tester with frictional force measurement
- Oscillating scratch tester (vibration of the specimen perpendicular to the scratch direction)
- Micro wear tester for reversing wear
- Micro fretting tester (lateral oscillation) with dynamic module
- Shear tester
- Measuring device for elastic lateral deformation. The following can be derived:
  - Lateral contact stiffness
  - Poisson's ratio
  - Lateral failure mechanisms

Typical areas of use

- Coating development from soft (polymer) to hard (diamond-type coatings)
- Determination of critical stresses for cracking or plastic deformation
- Hard material coatings for tools and as scratch protection
- Protective coatings on glass
- Paints and sol-gel coatings
- Automated measurement of hardness traverses on transverse cross-section
- Nano coatings for sensors and MEMS/NEMS
- Biological materials
- Matrix effects in alloys (mapping)
- Ceramic materials and composites

PI 901 723

Product Information

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- Ion-implanted surfaces
- Damage analysis in microelectronics

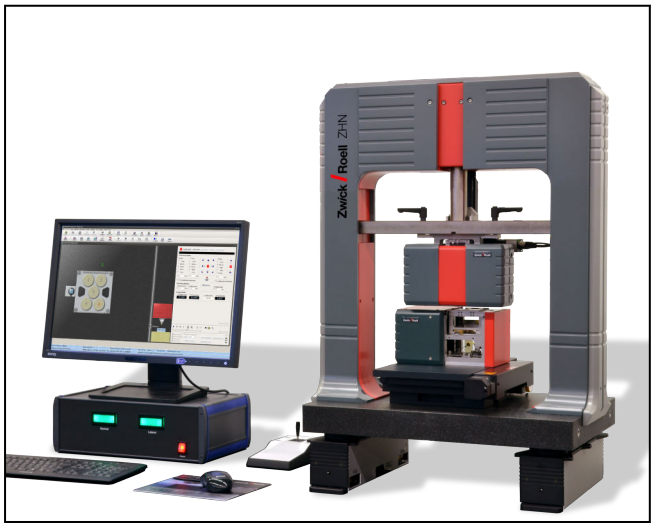
Advantages and features

- Modern software, with clearly structured design
- Stiff frame design with indenter axis exactly in the movement axis (no tilting moment)
- High degree of modularity provided by:
  - interchangeable measuring heads in normal (20 N / 2 N / 0.2 N) and lateral directions, allowing realistic modeling of loading conditions
  - unique tandem optics (developed for space travel) with 2 cameras; can be expanded for up to 4 different magnifications
  - software structure features function / application modules for hardness and Young's modulus tests, scratch test, cyclic indentation test and indentation test with superimposed oscillation
- Various specimen holders available, including holders with insulated specimen carriers for tip – specimen contact resistance measurement
- Ample room in all directions, with precise step size and high resolution:
  - X-direction: 100 mm
  - Y-direction: 200 mm
  - Z-direction: 70 mm
- New enclosure design with improved thermal and acoustic insulation

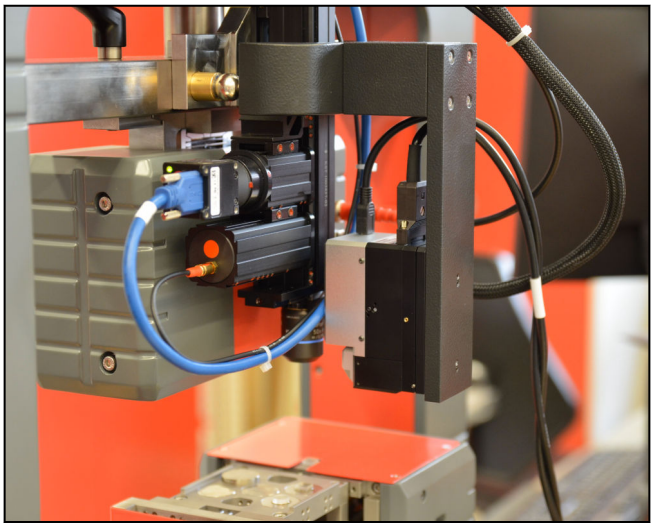
Optics

- 50x objective lens - the optical path is directed to two cameras via beam-splitters and intermediate lenses
- Within the optical image it is possible to
  - define measuring points
  - measure distances and perimeters
  - review and display existing measuring points at the push of a button
  - control lighting and image parameters
  - show scales and recording times
- Elimination of mechanical lens-changing enables high positioning-accuracy and rapid switching between magnifications
- High-quality imaging is possible even for low-reflection surfaces such as glass
- Autofocus function establishes the correct height for a sharp image
- Automatic generation of images of measuring points (programmable)
- Overview image composed of individual images with large depth of field

CTA: 98980 140317



ZHN with NFU, LFU, PC, electronics and vibration damper



AFM mounted at the rear of a ZHN

All data at ambient temperature.

Subject to change in the course of further development.

Product Information

ZHN - Universal Nanomechanical Testing System

A testing concept offering versatility and flexibility

The ZHN universal nanomechanical tester is derived from ASMEC's proven nanoindenter technology. In this first-time development, two measuring heads are combined in the normal (nanodindenter principle) and lateral (scratch tester principle) directions, operating completely independently of each other with nanometer resolution. Lateral force-displacement curves can now be measured for the first time, allowing more material parameters to be obtained than was previously possible (see Typical Applications). This includes measurement of the lateral stiffness and purely elastic lateral deformation of the specimen.

The 2-column load frame features single central lead-screw drive and precision guidance, ensuring stiffer frame design, while the indenter axis is located exactly in the movement axis. No tilting moment occurs and Abbe errors are eliminated. Device stiffness is more than 10^6 N/m, eliminating the need for correction and greatly simplifying calibration of the area function.

In contrast to instruments by other manufacturers, both measuring heads operate in both tensile and compression directions, enabling indentation tests with a superimposed oscillation as well as cyclic fatigue tests.

Properties of measuring head

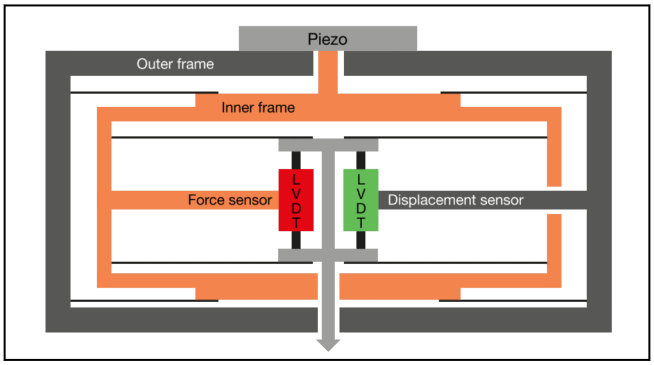
The device can operate with force and displacement control in open-loop mode (only maximum force/ displacement is controlled) or closed-loop mode (each individual measuring point is controlled). The maximum data rate is 1000 points per second, enabling even very fast measurements.

Sophisticated software enables both convenient control and rapid programming of measuring positions, while operator-friendly configuration of measuring positions via point and click is available in the overview image. In addition, a variety of unique evaluations are available in the software modules, including determination of stress/ strain curves for metals from instrumented indentation tests using spherical indenters.

Normal Force Unit (NFU)

- Movement in the normal direction and high stiffness in the lateral direction thanks to the double leaf-spring system
- Robust construction
- No inductive sensor stop in the event of an overload and thus no damage
- The shaft can bear heavier weights without leaving the measurement range Any kind of customer-specific probes can be easily used

CTA: 98903



Principle of NFU 2.0 (Normal Force Unit)

Lateral Force Unit (LFU)

- Specimen grips with the specimen in the middle of perpendicularly positioned leaf springs
- Can move easily in the lateral direction without a vertical change to the specimen position if sufficient stiffness in the normal direction exists
- Force generation decoupled from the force measurement
- Application and measurement of lateral forces without lateral movement possible

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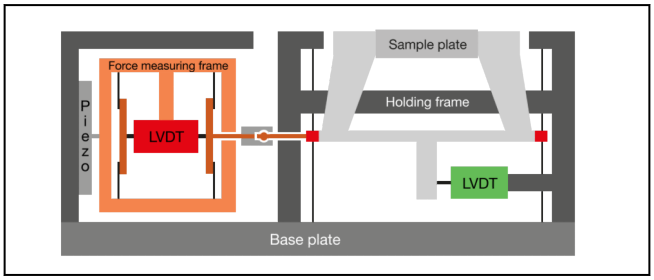

Principle of Lateral Force Unit (LFU)

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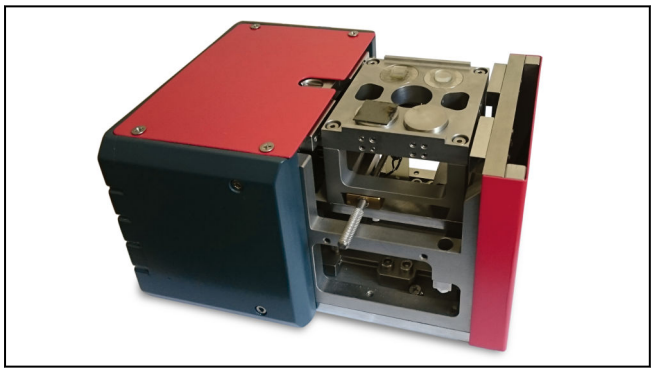

Second measuring head (LFU) with holder for 5 specimens

All data at ambient temperature.

Subject to change in the course of further development.

Product Information

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Control of the precision stages

The ZHN nanoindenter is designed for fully automatic measurement series with more than 1000 possible measuring positions. The dedicated control software InspectorX gives a complete overview of the actual positions of the three precision stages and allows easy control with step sizes below 1 µm. When the sample is positioned under the microscope, an image of the sample surface is shown in the same window instead of the stage positions.

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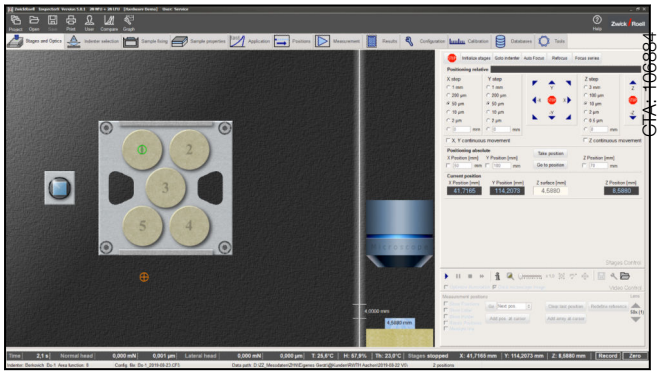
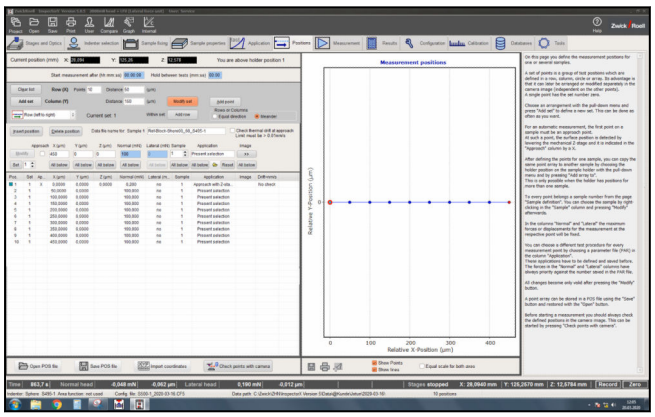


Control of the precision stages

Definition of the measuring positions

Any number of positions can be programmed optionally in lines, columns, grids or in irregular arrangement. Unique features are the possibility to define different measuring procedures for every position and to automatically generate pictures with two different magnifications before and after the measurement using the autofocus function. Comprehensive sample information can be assigned to every position and will be stored in data files.

CTA: 98949

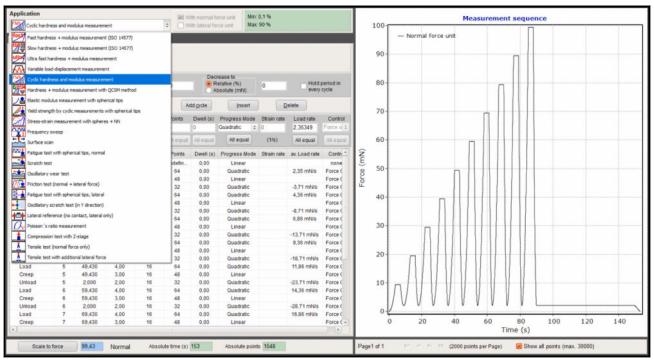


Definition of the measuring positions

Definition of the measuring procedure

A large number of predefined applications that may be selected by a simple mouse click is available. Procedures (test cycles) with any number of load-unload segments can be programed and modified in a very flexible manner - with force and displacement control. Force or displacement, measuring time and data rate of a segment can be defined in “open loop mode” while in “closed loop mode” the number of data points and the dwell time per point may be set in addition.

CTA: 106884



Definition of the measuring procedure

Evaluation of measurement data

Load-displacement curves or other data can be graphically presented, compared, averaged or exported in different formats (ASCII, EXCEL, BMP, WMF, etc.). Comprehensive and flexible correction routines are available for data evaluation. Parameters for the analysis and the presentation of results can be stored in configuration files and exchanged among others.

The correction of data (zero point correction, thermal drift correction) as well as averaging of measuring curves with equal load and cycle can be carried out manually or automatically, so that the results are eventually presented to the user in a table. Almost any number of data files can be read and analyzed simultaneously. Averaged and corrected curves can be stored automatically in seperate files.

All data at ambient temperature.

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Technical data
Basic instrument

Item No.	1011428	
Dimensions (H x W x D)	790 x 640 x 390	mm
Weight	approx. 105	kg
Voltage	230	V
Optics		
Tandem microscope with two video cameras	1280 x 1024 pixels, USB 3.0 connection	
Lighting	green LED, max. rating 1 W	
Lens	50 x[1] [5 x][2]	
Working distance	0.38 / 10.6 [3] [10.6]	mm
Optical magnification to 23" (Camera 1/ Camera 2)	1000x / 3350x [100x / 335x]	
Field of view (Camera 1/Camera 2)	324 x 259 µm / 96 x 77 µm [3.2 x 2.6 mm / 0.97 x 0.77 mm]	
Pixel resolution small/large (Camera 1/ Camera 2)	254 nm / 76 nm [2540 nm / 760 nm]	
Stage system		
X-stage travel	100 mm, step size 50 nm	
Y-stage travel	200 mm, step size 50 nm	
Z-stage travel	70 mm, step size 10 nm	
Maximum specimen size (X x Y x Z)	80 x 80 x 60	mm
Maximum length of a scratch test	25[4]	mm

1) included in delivery
2) 5x lens with manual position adjustment, see Optics Versions
3) long-distance lens, see Optics Versions
4) depending on smoothness of specimen surface

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NFU (normal force unit) measuring head

Item No.	1050945	1016415	1016416	
Test load F_{max}, standard[1)]	± 20	± 2	± 0.2	N
Test load, min. Fmin, standard[1)]	Approx. 2	Approx. 0.2	Approx. 0.05	mN
Digital resolution, force measurement	≤ 0.2	≤ 0.02	≤ 0.002	µN
Background noise, force measurement	≤ 30[2)]	≤ 3[2)]	≤ 0.3[2)]	µN
Displacement, max.	± 200[1)]	± 200[1)]	± 200[1)]	µm
Digital resolution, displacement measurement	≤ 0.002	≤ 0.002	≤ 0.002	nm
Background noise, displacement measurement index 2	≤ 0.4	≤ 0.3	≤ 0.3	nm
Background noise, displacement measurement (1 σ for closed-loop mode)	≤ 0.15	≤ 0.15	≤ 0.15	nm
Dimensions				
Height	162.6	163	158	mm
Width	232	232	200	mm
Depth	109	109	50	mm
Dynamic module[3)]				
Oscillation frequency, max.	300	300	100	Hz
Frequency, max. for stiffness evaluation	90	70	30	Hz
Data acquisition rates	40	40	40	kHz
Max. force amplitude of oscillation	> 500	> 50	> 13	mN
Weight, approx.	4	4	1.5	kg

1) Compression (e.g. instrumented indentation test) and tensile (e.g. adhesion measurements on liquids)
2) All 1 σ at 8 Hz and for use of active vibration damping. With passive vibration damping, approximately 4x greater.
3) Only in conjunction with the QCSM software module

LFU measuring head (Lateral Force Unit)

Item No.	1021148	
Test load, max. (Fmax), lateral[1)]	approx. 2	N
Digital resolution, force measurement	≤ 0.02	µN
Background noise, force measurement	≤ 6	µN
Travel, max.[1)]	approx. 75	µm
Digital resolution, displacement measurement	≤ 0.002	nm
Background noise, displacement measurement	≤ 0.5	nm

1) compression and tensile

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Optic options

As standard, the tandem microscope and 50x lens is included in the ZHN scope of supply A 50x lens with extended working distance is available as an option. Furthermore, there is a 5x lens or white light interferometer available as the second objective lens.

Description	ArticleNumber
Long-distance lens 50x for tandem microscope for ZHN • Large working distance of 10.6 mm (otherwise 0.38 mm) • Additional charge, replaces the standard lens 50x	**1016479**
Lens 5x as second lens for tandem measuring microscope • Includes lens slider (manual) for changing between lenses With two different magnifications	**1011431**
White light interferometer SmartWLI for ZHN nanoindenter • Optical profilometer as module for the ZHN when using ZHN optics with two cameras Components: • Mirau lens 50x, working distance 3.4 mm, Numerical aperture 0.55 • Piezo positioner MIPOS 500 SG RMS with control unit E-754-300 • Piezo positioner MIPOS 500 SG RMS with control unit E-754-300 • smartVIS3D library for sensor functionalities for integration into 3rd party Windows software and for automation • MountainsMap ® Imaging Topography V9 software for the visualization and evaluation of 3D data surface parameters, selection, visualization and evaluation of profile sections, automatic execution of predefined evaluation procedures up to the creation of measurement reports • Manual lens slider for switching between the lenses	**1121526**

Connecting an AFM to the ZHN

Nanoindentation and atomic force microscopy (AFM) can be combined in a single system to enable comprehensive, (semi) automated analysis. As a first step the atomic force microscope measures the surface roughness; this helps to define the minimum indentation depth. The specimen is then positioned under the nanoindenter to allow a mechanical analysis to be performed at the same location. In the final step this location can be moved back below the AFM to allow characterization and understanding of stress-induced properties such as material “pile-up” and “sink-in” or cracks around the indent. These effects may then influence the values obtained for hardness and Young's modulus.

Description	ArticleNumber
NaniteAFM C1000 atomic force microscope for standard measuring modes: static force (contact), dynamic force, force modulation, spreading resistance, phase contrast, magnetic force, electrostatic force **including:** • Nanosurf C1000 control electronics (24/32-bit), including scripting interface for external control of system (COM Interface) • NaniteAFM measuring head (110 µm x 110µm x 20µm), with high-resolution cameras, top and side view • NaniteAFM measuring-head support - precision mount, for installation in ZwickRoell nano-indenter • NaniteAFM Sample Stage 204 – additional system mount, including passive vibration insulation • NaniteAFM tool set • AFM specimen set for large measurement ranges • AFM measuring tips for static measuring modes (10 pieces) • AFM measuring tips for dynamic measuring modes (10 pieces)	**1025985**

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InspectorX software

Description	ArticleNumber
InspectorX control and evaluation software *(available in German or English)* • incl. autofocus and focusing module • Software module for automatic focusing of specimen surface and for performing focusing to generate a composite image with large depth of field • Analysis software for evaluation of registering indentation measurements as per EN ISO 14577, comprehensive evaluation and correction routines	**1023952**
InspectorX in version 5.5.8 • Delivery of InspectorX will be in version 5.5.8	**1120460**
InspectorX in version 5.5.5 • Delivery of InspectorX will be in version 5.5.5	**1120459**
InspectorX in version 5.5.3 • Delivery of InspectorX will be in version 5.5.3	**1110979**
InspectorX in version 5.3 • Delivery of InspectorX will be in version 5.3	**1102288**
InspectorX in version 5.14 • Delivery of InspectorX will be in version 5.14	**1093308**
Data processing software InspectorX (2. Licence) • Software for the analysis of force indentation depth curves measured with the ZHN according to ISO 14577 including comprehensive export functions, special analysis and correction functions	**1073594**

For use with NFU (LFU optional):

Description	ArticleNumber
QCSM module (Quasi Continuous Stiffness Measurement) • Software module for depth-dependent measurement of hardness and Young's modulus at one and the same measuring position by superimposing small oscillations in the displacement and force signal in the frequency range between 2 and 300 Hz, stiffness analysis up to 75 Hz	**1016455**
Module for scratch and wear tests • Software module for the performance of scratch and wear tests using the X-Y table (NFU) or using the LFU (additional determination of the lateral force, e.g. friction coefficient)	**1016456**
Profilometer module • Software module for 2-dimensional imaging of the surface with a spherical tip using the X-Y table (NFU) or with the LFU (higher travel resolution)	**1016457**
Stress/strain curve module • Software module for calculating the stress/strain curves of metals from indentation tests with spherical tips and using neuronal networks	**1016458**
Elastic fit module • Software module for fitting elastic force/indentation depth curves for indentations using ball indenters in materials with up to 3 coatings for determination of Young's modulus for the uppermost coating or the indenter radius	**1016459**
Module for shear testing, tensile testing and compression testing • Software module for shear tests with X-table or LFU and for tensile test or compression test with Z-crosshead NFU (hardware, e.g. specimen grip, not included)	**1021526**

The functionalities of the different software modules depend on the equipment of the ZHN. For example, when performing scratch tests with the NFU, the X-Y table is used. If an LFU is also connected, this unit is also used during the procedure, i.e. the accuracy of the LFU (instead of the X-Y table) can be used. In both cases, however, the scratch test module must also be specified.

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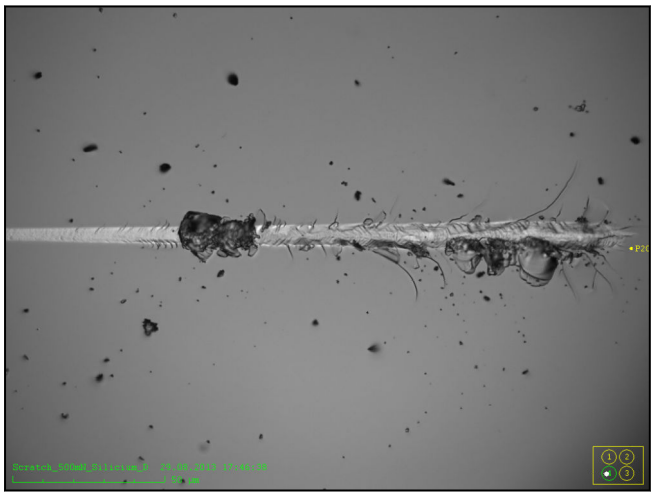
Only in conjunction with LFU

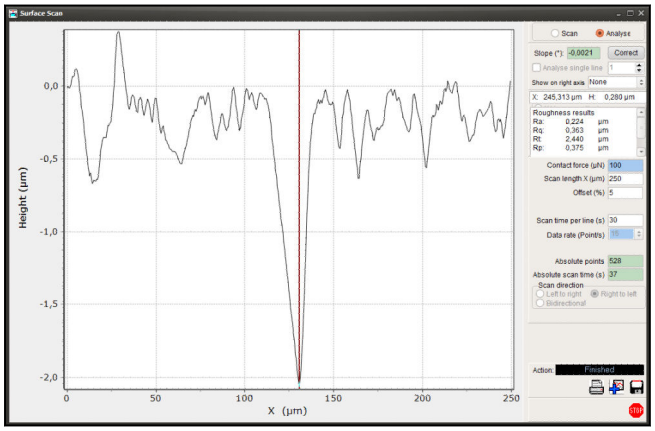
Description	ArticleNumber
Oscillating scratch test module • Software module for performing scratch tests through movement of the specimen support pad with simultaneous vibration of the specimen perpendicular to the pad and using the Lateral Force Unit (LFU) • Loading the specimen in two dimensions simplifies generating coating failures. Additionally the lateral stiffness of the specimen is available as an additional measurement parameter.	**1018038**

CTA: 98955



Scratch test on a coating on silicon, Fmax 500 mN

CTA: 98954



Scan perpendicular to a scratch test with 100µN contact force