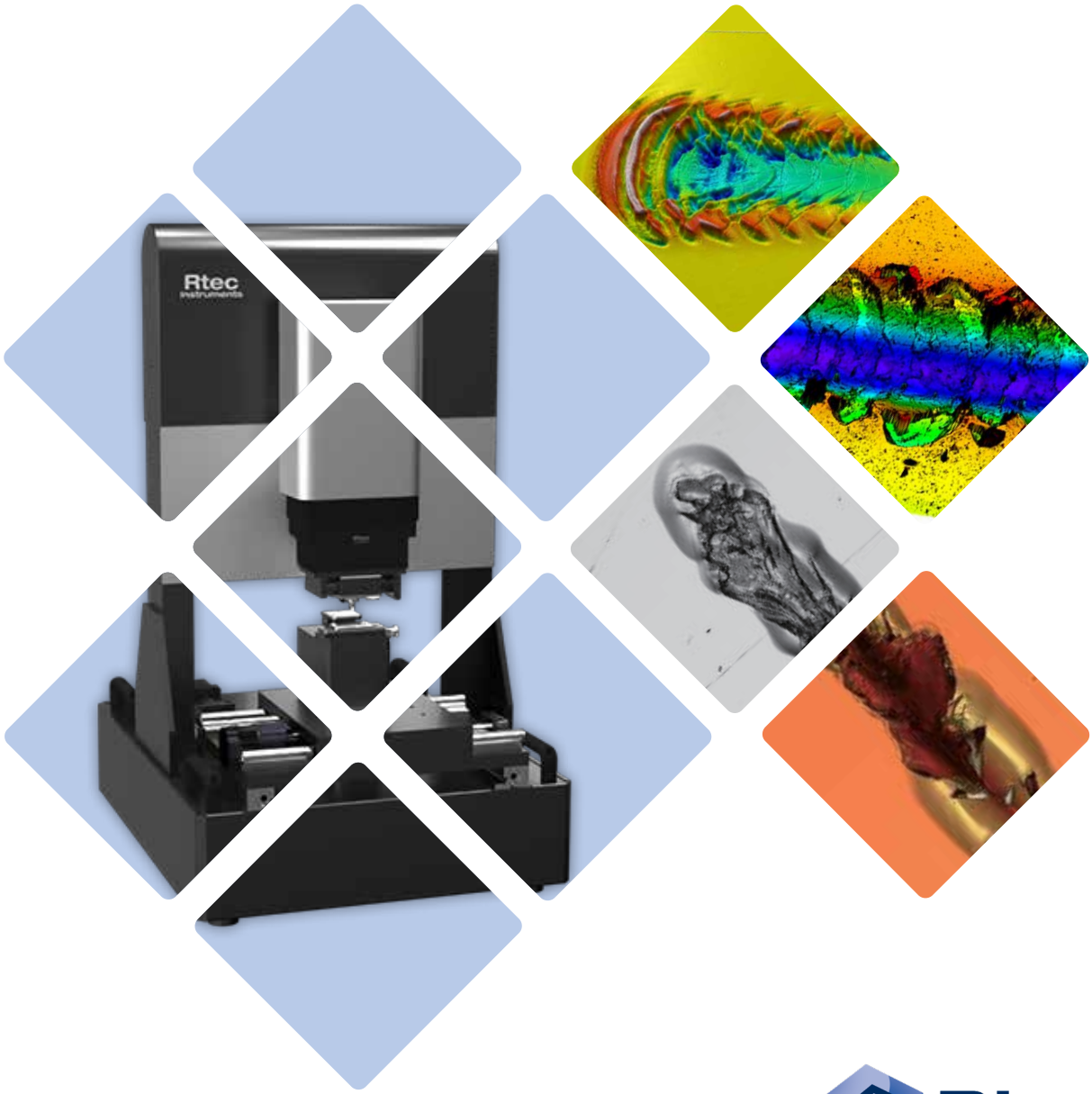
3D Scratch Tester

UST-2

Fully Automated
Nano, Micro and Macro Range

Thin Film/Coating Adhesion, Scratch Resistance, Hardness
Wear, Roughness, Film Thickness, Sub-Nanometer Topography



Rtec instruments

Why 3D Scratch Tester?

Traditional Scratch Test

A scratch test is performed to evaluate the adhesion and scratch resistance of coatings and solid surfaces. The test involves scratching the surface with a controlled force. The scratch tip is moved along the sample surface under constant, incremental or progressive load. At a certain load, the coating may fail. This failure is detected by means of measuring friction force, displacement and/or acoustic emission, together with observation under a 2D optical microscope. This was good enough for thick coatings or multi-layer coatings whose properties are not close to each other. With next-generation coatings, however, this traditional method doesn't always provide comprehensive information.

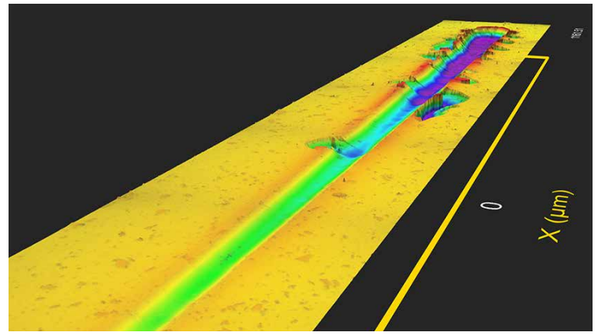
3D Scratch Test

Rtec Instruments UST-2 3D scratch tester combines a next-generation scratch test head and high resolution 3D profilometer. The test involves automatically taking a measurement of surface roughness, thickness, topography before and after a scratch test is done.

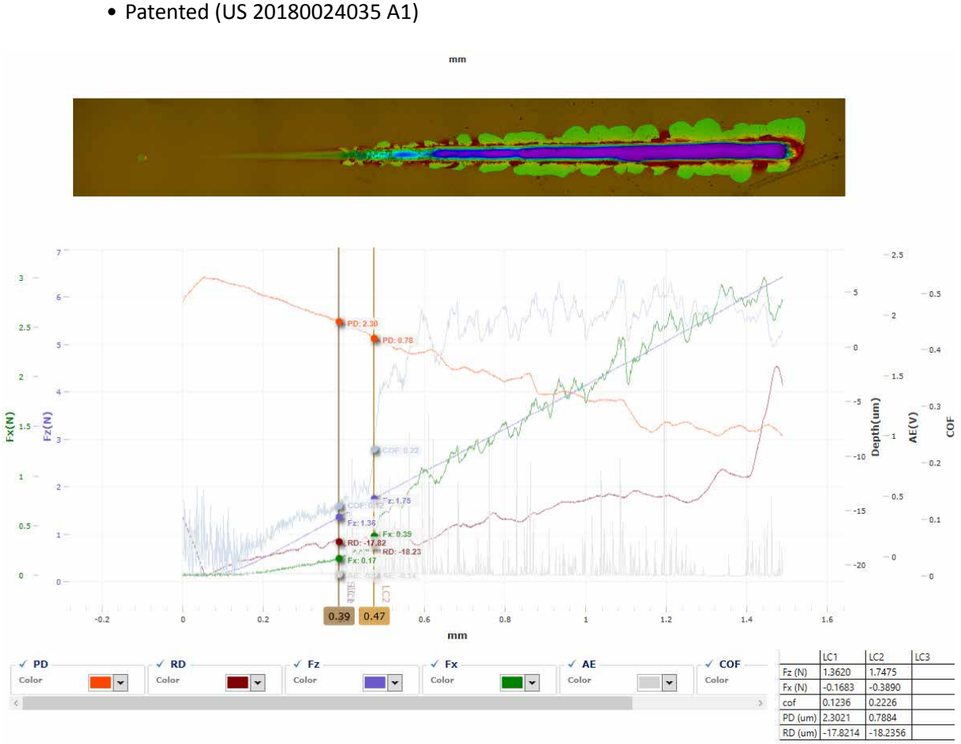
After the sample is mounted in the 3D scratch tester, it moves under 3D optical profilometer to evaluate surface topography. Once the image is taken, the sample moves under the scratch head and the scratch test is conducted at a given force. After the test, the sample automatically moves back under the 3D optical profilometer and a 3D image of the surface is taken.

The software automatically combines friction, displacement, acoustic and sub-nm 3D images together. This allows users to correlate adhesion and hardness to surface roughness and topography. The images generated provide the user with complete information on wear track and/or scratch width and depth, crack propagation, failure mode, roughness, volume etc.

What is a 3D Scratch Tester?



- Combination of high accuracy scratch tester and optical profilometer
- Comprehensive analysis of deformation and failures during scratch
- Finer view of surface and fracture during scratch
- Combination of 3D image with multi-signal data
- Patented (US 20180024035 A1)



	LC1	LC2	LC3
Fz (N)	1.3620	1.7475	
Fx (N)	-0.1683	-0.3890	
cof	0.1236	0.2226	
PD (um)	2.3021	0.7884	
RD (um)	-17.8214	-18.2356	

3D Scratch Tester

For Research and Quality Control

3D Scratch Tester Concept

The new method allows the user to run standard Scratch Tests, and automatically take sub-nm 3D images of the testing area before and after the test.

Scratch Head With Automatic Depth Referencing

Precise normal and friction forc-es measurements with accurate scratch depth measurement.

In-line Profilometer

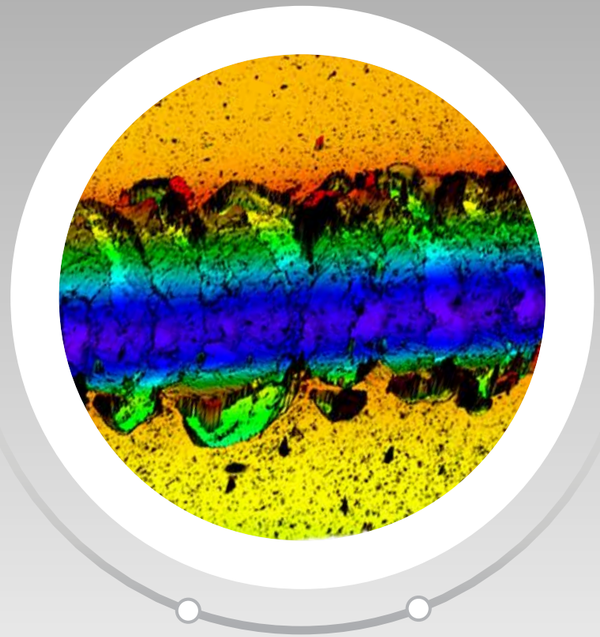
Sub-nm 3D image acquired across the entire scratch path. Automatic stitching and leveling of the 3D panorama for an easy and comprehensive analysis.

Indentation

Precise normal force control with high frame stiffness, yielding in-dentation measures at various force scales.

Next Generation Scratch Optical Analysis

Comprehensive Analysis



Perfect Combination Of Imaging And Data

Study effects of topography, surface finish, thickness on adhesion, and hardness of coatings and surfaces

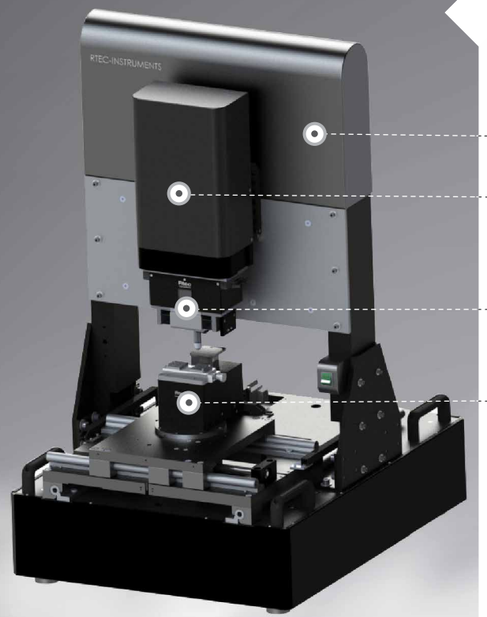
Surface Topography

Roughness, Coating Thickness, Texture, Scratch Volume, Depth, Width, Pile up

Mechanical Property

Adhesion, Friction, Durability. Critical Load LC1, LC2, LC3 determination

3D Scratch Configuration



- Open Platform
- Scratch Head
- Interchangeable High Resolution Load Sensor (Normal + Friction Forces)
- XY Stage

- 3D Profiler Imaging Head
- Interferometer / Confocal Microscope
- Controller 64 bit

ASTM, ISO, DIN Compliant

Transparent or Non-Transparent Surfaces Coating
Coating Thickness from Nanometers to Microns

Standards

Standards

ISO 20502
Fine Ceramics, Determination of adhesion of ceramic coatings by scratch testing.

ISO 20502
ISO 1518 Paint and Varnishes - scratch test.

DIN EN 1071-3
Advanced technical ceramics.

ASTM C1624
Standard test for adhesion strength and mechanical failures modes of ceramics coatings by quantitative single point scratch testing.

ASTM D7027
Evaluation of scratch resistance of polymeric coatings and plastics using and instrumented scratch machine.

ASTM D7187
Standard test method for measuring mechanistic aspects of scratch mar behavior of paint coatings by nano scratching.

ASTM G171
Standard test method for Scratch hardness

Instrumented Indentation

ISO 14577
Metallic materials – Instrumented indentation test for hardness and material parameters

ASTM E18 Rockwell Hardness

ASTM E2546 Instrumented Indentation

Traceable Standard Samples For Calibration

Test Samples, Coupons Finished Products

Standard Samples for Scratch

The tester is supplied with a certified standard sample for scratch module quick calibration check.

Standard Tips

The tester is supplied with certified standard, calibrated tips with various geometries.

Standard Samples for Imaging

The tester is supplied with a certified step height standard sample for the imaging module calibration.

Modular Scratch Module

Interchangeable scratch head to accommodate multiple testing ranges from nano to micro. The load range will depend on the application. The module can be changed in less than 2 minutes.

- Ultra-High Resolution
- Low Floor Noise
- Rigid Design
- Closed-Loop Force Control

Nano Scratch NST-1
Down Force 1000 mN

Macro Scratch HST-200
Down Force 50 N

Micro Scratch MST-50
Down Force 200 N*

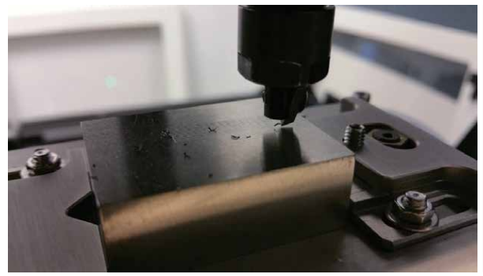
Heavy Duty HST-5K*
Down Force 5000 N*

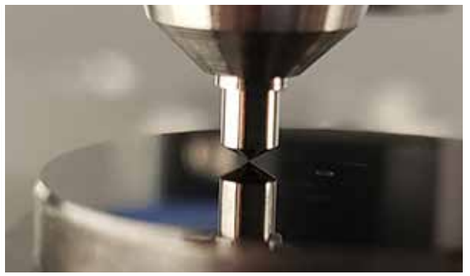
* On MFT Platform

User Friendly Interface, Easy Test Setup

Scratch Module

- Multiple ranges of normal and friction force modules for different applications
- Proprietary sensor design for ultra high precision in normal and friction force measurements
- Both normal and friction forces measured in 1 module
- Referential capacitance sensor for accurate scratch depth measurement





Interchangeable modules provides flexibility for future upgrades

Force Measurement

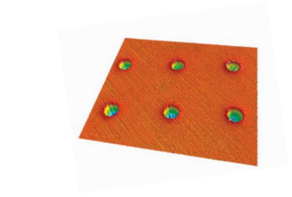
The multiple ranges available in the modules provide a great accuracy at the range of loads needed for the customer's application. The rigid Rtec Instruments' frame along with a proprietary sensor design provide accurate and optimized measures over a wide range of loads and different environmental conditions.

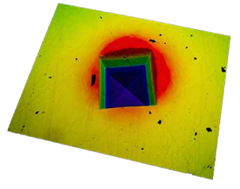
Additional Sensors and Environmental Control

- **Acoustic Emission Sensor** - Detects crack acoustic signatures emitted from the samples surface during scratch tests.
- **Electrical Contact Resistance** - Quantifies insulating film failure using electrical conductivity.
- **Temperature Chamber** - Investigate the effect of temperature on scratch resistance and adhesion.

Software

- Pre- and post-test scan by 3D imaging head
- Programmable automatic multiple scans
- 3D image auto stitching
- User-definable scratch modes and loading profile
- 3D surface profilometer data analysis integrated into all testing modes
- Simultaneous display of down force, friction force, scratch depth, acoustic emission, and contact electrical resistance sensors with 3D image
- Capacitance sensor for automatic reference
- Automatic sensor recognition
- Data saved in ASCII format
- Windows based operation system





Imaging Head Choice

Several imaging heads are available that can be combined with the scratch head. The choice of technique depends on the application.

- Surface Roughness
- Film Thickness
- Step Height
- Topography
- Scratch Volume
- Thin Film Stress (Curvature)
- Cracks, Defects
- Slope Measurement

Lambda Head

- White Light Interferometer
- Confocal Microscopy
- Dark Field Imaging
- Bright Field Imaging

Sigma Head

- White Light Interferometer
- Bright Field Imaging

Optical Microscope

- Bright Field Imaging

Confocal

Nipkow Confocal Most Advanced Confocal Microscopy

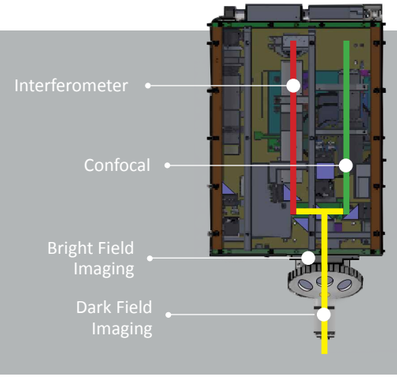
Rtec Nipkow Confocal offers faster speed and higher resolutions than conventional point confocal techniques (laser or chromatic confocal)

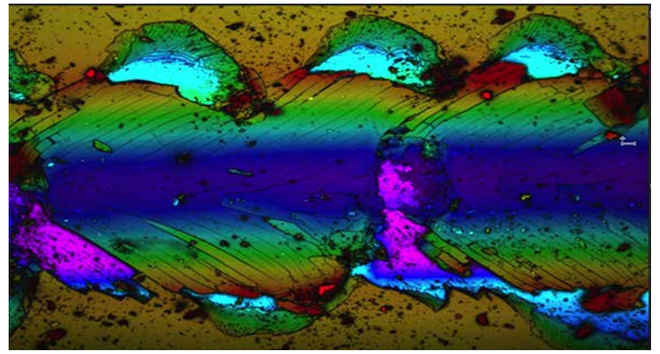
- Object Tilt Does Not Affect Data
- High Lateral Resolution
- Measures Steep Slopes
- Measures Transparent Surfaces
- Very Easy To Detect Surfaces

Imaging Mode

Sub nm automated
3D Images of Surfaces

- Surface roughness
- Film thickness
- Wear track, volume wear
- Step height
- Add on- Confocal Raman





- Spinning disc (Nipkow) confocal technology for fast vertical scanning
- Best technology for surface and sub-surface feature measurement
- Full field 3D characterization of steep slope analysis (Maximal slope: 72° vs. 44° from Interferometry)
- Highest lateral resolution in optical profiling. With 5 Mp digitalized resolution camera, spatial resolution down to 0.04um, best for surface feature and profiling measurement
- No limitation on surface roughness/surface reflectivity (from 0.05% to 100%)
- Both bright field and dark field optical DIC

Interferometry

Highest Z-Resolution in Non-Contact Profilometry

Rtec Interferometer uses Quad Band Lights to perform both White Light Interferometry (WLI) and Phase Shift Interferometry (PSI)

- Highest Z-resolution, sub-nanometer
- Both phases-shifting (PSI) and vertical scanning (VSI) imaging modes
- Z-resolution independent of magnification
- User-selectable four color LED light source (white, red-630 nm, green-530 nm, and blue-460 nm) improves lateral resolution and optical coherence (blue light provides highest lateral resolution)
- Up to 5MP digitalized camera

Roughness Analysis

Sub-nm Resolution

The tester comes with 6 objectives and a manual or automatic turret that can accommodate several objectives at once. Each lens comes with calibration and inspection settings on the tester. The three modes mount objectives with very high numerical aperture ratios.

Dual Mode

PSI and WLI modes

The tester can run both phase shift interferometry (for smooth samples) and white light interferometry (for smooth or rough samples).

Easy Operation

Pre Test Image

Sample moves under 3D profilometer to measure surface topography

Scratch Test

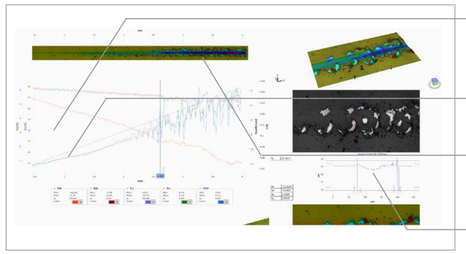
Single or multiple scratches using pre-defined recipes are performed

Post Test Image

The sample moves under profilometer to measure scratch area

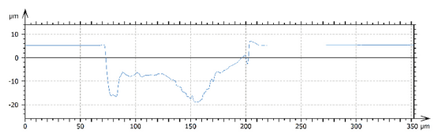
Report

Automatic Image, Adhesion, Friction, Depth, Roughness correlation reports are created



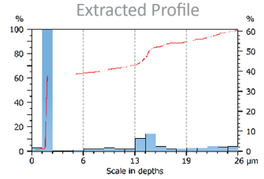
- Synchronized 3D, 2D, Image and data zoom
- Friction, Wear, Depth Data
- Image associated with the wear mark
- Roughness, Wear volume associated with the track

Profile Curve - Extracted Profile

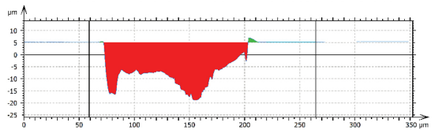


Parameters	Value	Unit
Layer	352	µm

Abbott-Firestone Curve - Extracted Profile



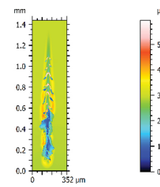
Area Of A Hole Or A Peak - Extracted Generator



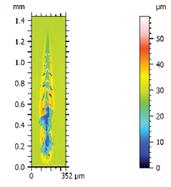
Parameters	Value	Unit
Maximum Depth	24.2	µm
Area Of The Hole	1872	µm²
Maximum Height	1.81	µm
Area Of The Peak	9.57	µm²

ISO 4287			
Amplitude Parameters - Roughness Profile			
Rp	5.23	µm	Gaussian filter, 0.08 mm
Rv	7.05	µm	Gaussian filter, 0.08 mm
Rz	12.3	µm	Gaussian filter, 0.08 mm
Rc	7.53	µm	Gaussian filter, 0.08 mm, ISO 4287 w/o amendme...
Rt	19.5	µm	Gaussian filter, 0.08 mm
Ra	1.73	µm	Gaussian filter, 0.08 mm
Rq	2.70	µm	Gaussian filter, 0.08 mm
Rsk	-0.189		Gaussian filter, 0.08 mm
Rku	5.26		Gaussian filter, 0.08 mm
Material Ratio Parameters - Roughness Profile			
Rmr	1.11	%	c = 1 µm under the highest peak, Gaussian filter, 0...
Rdc	1.49	µm	p = 20%, q = 80%, Gaussian filter, 0.08 mm

Automatic Reports



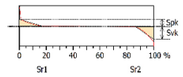
Pseudo-color view of the surface - Run-2017-05-12-113443



Pseudo-color view of the surface - Leveled (3 points method)

3D view of the surface - Leveled (3 points method)

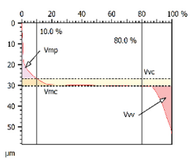
Sk parameters - Leveled (3 points method)



Information	
Fiber Settings	Unfiltered

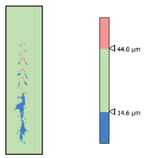
Parameters	Value	Unit	
Sk	0.979	µm	
Spk	9.90	µm	
Svk	18.3	µm	
Sr1	17.0	%	
Sr2	86.5	%	
Sa1	0.843	µm³/µm²	
Sa2	1.23	µm³/µm²	

Volume parameters - Leveled (3 points method)



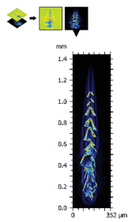
Parameters	Value	Unit	
Vmp	0.470	ml/m2	
Vmc	0.712	ml/m2	
Vvc	2.92	ml/m2	
Vvv	1.26	ml/m2	

Slices - Leveled (3 points method)



Parameters	Unit			
Projected Area	%	4.06	95.1	0...
Volume of Void	%	1.18	53.5	9...
Volume of Material	%	98.8	46.5	0...
Volume of Void	µm³/µm²	0.173	15.7	1...
Volume of Material	µm³/µm²	14.4	13.7	0...
Mean Thickness of Void	µm	0.173	15.7	1...
Mean Thickness of Material	µm	14.4	13.7	0...

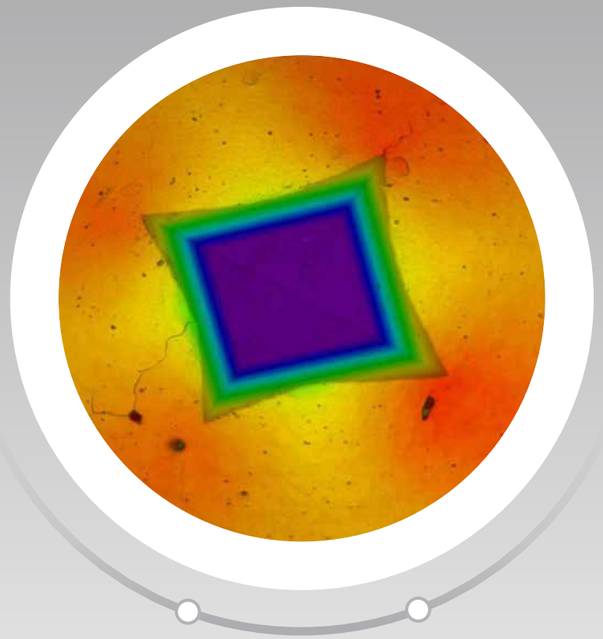
Pseudo-color view of the surface+image study- Mapped local properties



Information	
Layer	Image Layer

Hardness and Elastic Modulus

Measurements by Instrumented Indentation



Perfect Combination Of Indentation and Imaging Data

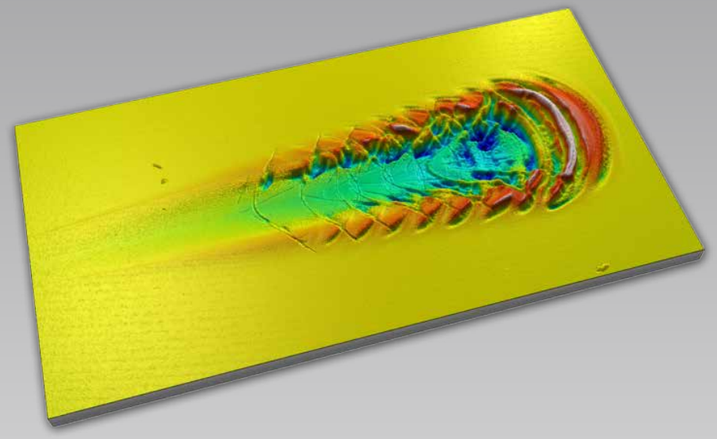
3D imaging providing new tools to investigate the effect of topography, thickness, surface processing and treatment on hardness and elastic modulus for coatings and materials.

Features

- One single head for indentation and scratch
- Compliant with ISO and ASTM standards
- Piezo actuator
- Capacitive displacement measurement
- Advanced data processing at 200kHz
- User's friendly software
- Easy test setup
- Multiple tip geometries: Berkovich, Cube Corner, Rockwell, Brinell, Knoop, Flat Punch...
- Multi sample testing

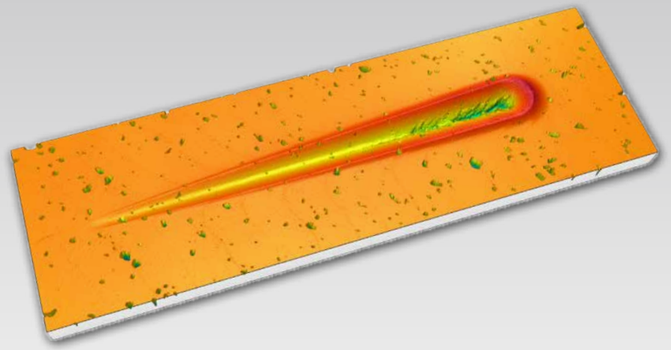
3D Profile For Every Surface

Different Scratch Damage Scales in One Instrument



Macro Scratch

Scratch on polymer material using a large tip to simulate macro size damage.



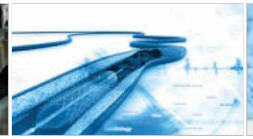
Micro Scratch

Scratch on automotive paint with damage to clearcoat simulating common car scratches.

Nano Scratch

Scratch on a smartphone screen exhibiting good scratch resistance prior to catastrophic failure.






	Automobile	Hard Coatings	Bio-Materials	Materials
Samples	• Paint, Varnishes • Polymer • Engine, Piston • Brake pad • Window	• TiN, WC, DLC, WC • Cutting tools, Drill • PVD, CVD, Coatings • Forming Tool • Thermal, Plasma spray Coating	• Implants, Stents • Bone, Tissue • Tablets, Pills • Drug Delivery • Artificial joints	• Ceramics • Polymers • Metals • Rubber • Composite
Type of Analysis	• Coating Adhesion • Wear resistance • Scratch resistance • Mechanical properties • High temperature hardness	• Coating Adhesion • Wear resistance • Scratch resistance • Mechanical properties • High temperature hardness	• Coating Adhesion • Wear resistance • Scratch resistance • Friction coefficient • Mechanical properties • Corrosion • Environmental materials testing	• Coating Adhesion • Wear resistance • Scratch resistance • Friction coefficient • Mechanical properties • High temperature hardness • Environmental materials testing
How	• Micro scratch • Indentation • Tribometer • High temperature tribometer • High temperature hardness	• Micro scratch • Indentation • Tribometer • High temperature tribometer • High temperature hardness	• Micro / Nano scratch • Indentation • Tribometer • Nano tribometer • Corrosion cell testing • Tribology in controlled environment	• Micro / Nano scratch • Indentation • Tribometer • High temperature tribometer • High temperature hardness • Tribology in humid / high pressure
Industries	• Engine blocks • Interior plastics • Windshield • Auto paint • High performance coatings • Tires	• Cutting tools • Machines • Automotive • Aerospace	• Biomedical • Pharmaceutical • Polymers	• Metallurgy • Textiles • Petroleum • Aerospace • Printing • Machines
Application Examples	• DLC coating of injectors • Thermal sprays in engine block • Clearcoat • Brake pads wear resistance • Tire material testing	• R&D characterization of new coatings • Quality control of DLC coating injectors • Study of high temperature behavior of coatings • Quality control of cutting tools	• Wear of prosthetics and implants • Resistance of arterial implants (stents) • Hardness of tablets and pills • Studies of osteoporosis • Cornea elasticity • Contact lens friction	• Scratch resistance of tiles • Mechanical properties of metallic components • Friction of textile parts • Evaluation of friction in chemical products • Lubricant properties in friction • Mechanical properties in aero space components




	Semiconductor	Optical	Decorative	Miscellaneous
Samples	• Thin Films • Low K • Passivation layers • MEMS, NEMS • Hard Disks	• Eye Glass, Lens • AR Coatings • Mirror • Touch Screen • Display Panels, LED, OLED	• Jewelry • Watches • Evaporated metal • Cases • Anti-Corrosion coating	• Consumer Goods • IOT Devices • Solar • Connectors • 2D Materials • Flexible Electronics
Type of Analysis	• Coating Adhesion • Wear resistance • Friction coefficient • Mechanical properties	• Coating Adhesion • Wear resistance • Scratch resistance • Friction coefficient • Mechanical properties	• Coating Adhesion • Wear resistance • Scratch resistance • Friction coefficient • Mechanical properties	• Coating Adhesion • Wear resistance • Scratch resistance • Friction coefficient • Mechanical properties • Temperature testing • Humidity / high pressure testing
How	• Nano scratch • Indentation • Nano Tribometer	• Nano / Micro scratch • Indentation • Tribometer	• Micro scratch • Indentation • Tribometer	• Micro scratch • Indentation • Tribometer • High temperature tribometer • High temperature hardness • Tribology in humid / high pressure
Industries	• Semiconductors • Electronics • Data Storage	• Optical, glass • Watches • Optical lenses • Architectural glass • Electronics displays	• Home appliances • Architectural paints • Plastics decorative • Consumer products	• Consumer goods • Solar • Electronics • Research materials • 2D materials • Electrical products • IOT
Application Examples	• Characterization of wafers • Qualification of deposition chambers • Low k dielectrics • Hard drive coatings	• Scratch resistant coatings for lenses • Quality control of optical components • Scratch resistance of architectural windows	• Scratch resistant faucet • Decorative coating • Wear of decorative coating • Wear of paints on products	• Test protective coatings of solar panels • Qualification of new materials • Testing of high pressure pump components • Hardness of protective coatings

Specifications

Platform

Bench Top
- Data Acquisition 200 kHZ
- Z Displacement 100 mm

XY Stage
- Range: 130 x 270 mm
- Motion resolution: 0.1 µm

Computer Console
- Latest: Windows OS
- LCD monitor

Environmental Control
- -50°C to 800°C
- 5 to 95% RH
- Liquid Chamber
- Corrosion Cell

Other Motions
- Rotary Stage up to 100 RPM
- Custom Motions

In-line Imaging

Various Imaging Modes
- White Light Interferometer
- Confocal
- Variable Focus
- High Magnification Microscope
- Atomic Force Microscope
- Dark Field
- Bright Field

Sensors
- Acoustic Sensor
- Electrical Contact Resistance
- Potentiostats
- Capacitive Sensors

Scratch Heads

NST-1
- Max Normal force 1 N
- Max friction force 1 N
- Displacement resolution: 0.1 nm

MST-50
- Max Normal force 50 N
- Max friction force 50 N
- Displacement resolution: 0.1 nm

HST-200
- Max Normal force 200 N
- Max friction force 200 N
- Displacement resolution: 0.1 nm

HST-5k (Requires MFT Platform)
- Max Normal force 5000 N
- Max friction force 1000/ 3000/5000 N
- Displacement resolution: 0.1 nm

Interferometry Objectives						
	2.5X	5X	10X	20X	50X	100X
Numerical Aperture (NA)	0.075	0.13	0.3	0.4	0.55	0.7
Working Distance (mm)	10.3	9.3	7.4	4.7	3.4	2
FOV (um)	6910x5180	3460x2590	1730x1300	860x650	350x260	170x130
Spatial Sampling (um) 5MP CCD	2.7	1.35	0.67	0.34	0.13	0.07
Optical Resolution (L&S 460 nm) (um)	1.87	1.08	0.47	0.35	0.26	0.20
Maximum Slope (arcsin(NA))	4	7	17	24	33	44
Vertical Resolution	Better than 0.01nm					
Vertical RMS repeatability RMS	0.01nm					
Vertical measurement range	Up to 10mm					

Confocal Platform									
	Standard Working Distance						Long Working Distance		
	5X	10X	20X	50X	100X	150X	20X	50X	100X
Numerical Aperture (NA)	0.15	0.3	0.45	0.8	0.9	0.95	0.4	0.6	0.8
Working Distance (mm)	23.5	17.5	4.5	1	1	0.3	19	11	4.5
Field of view (um)	3460x2590	1730x1300	860x650	350x260	170x130	120x90	860x650	350x260	170x130
Spatial Sampling 5MP	1.35	0.67	0.34	0.13	0.07	0.04	0.34	0.13	0.07
Optical Resolution (L&S 460nm)(um)**	0.94	0.47	0.31	0.18	0.16	0.15	0.35	0.23	0.18
Maximum Slope (arcsin(NA))	9	17	27	53	64	72	24	37	53
Vertical Resolution (nm)	72.0	18.0	8.0	2.5	2	1.8	10.1	4.5	2.5

About us

Rtec-Instruments develops and manufactures advanced imaging and surface mechanical property measurement solutions for research and industrial applications. Based in Silicon Valley, we are the leading provider of testing instrumentation such as tribometer, optical profilometer, 3D scratch tester and micro/nano hardness tester.

We share a philosophy that embraces collaboration and partnership with customers, leaders in academia and industry, to ensure that our products answer real needs with innovative solutions.

Rtec Instruments, US
1810 Oakland Road, Ste B
San Jose, CA, 95131, USA
Phone: +1 408 708 9226

Rtec Instruments, SA
Rue Galilée 6,
1400 Yverdon-les-Bains, Switzerland
Phone: +41 24 552 0260

Rtec Instruments, CN
Room 1002-2, Building 1, #69 Olympic St
Jianye District, Nanjing, China, 210019
Phone: +86 25 83210072,+86 18013892749

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