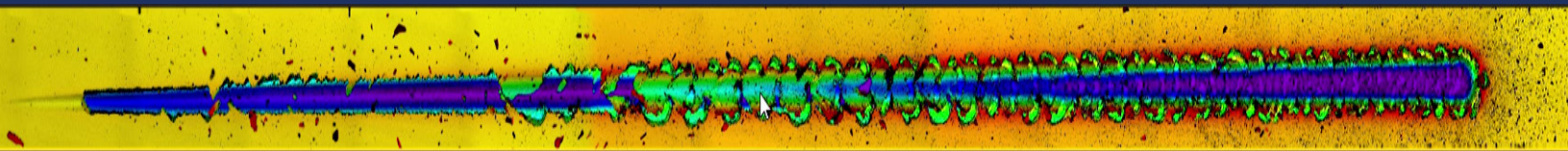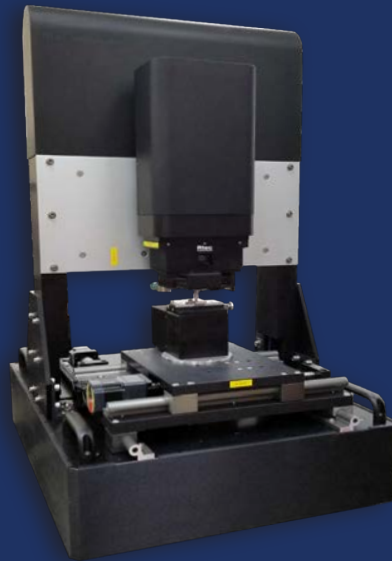# 3D Scratch Tester

Thin Film/ Coating Adhesion, Scratch Resistance, Hardness

Wear, Roughness, Film Thickness, Sub-Nanometer Topograph

Scratch Tester **+** 3D Profilometer

Fully Automated

Nano, Micro and Macro Range

What is a **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 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 with significantly different properties between layers. With next-generation coatings, however, this traditional method doesn't always provide comprehensive information.

3D Scratch Test

3D scratch combines 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 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 pre-programmed force. After the test, the sample automatically moves back under the 3D optical profilometer and a 3D image of 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.
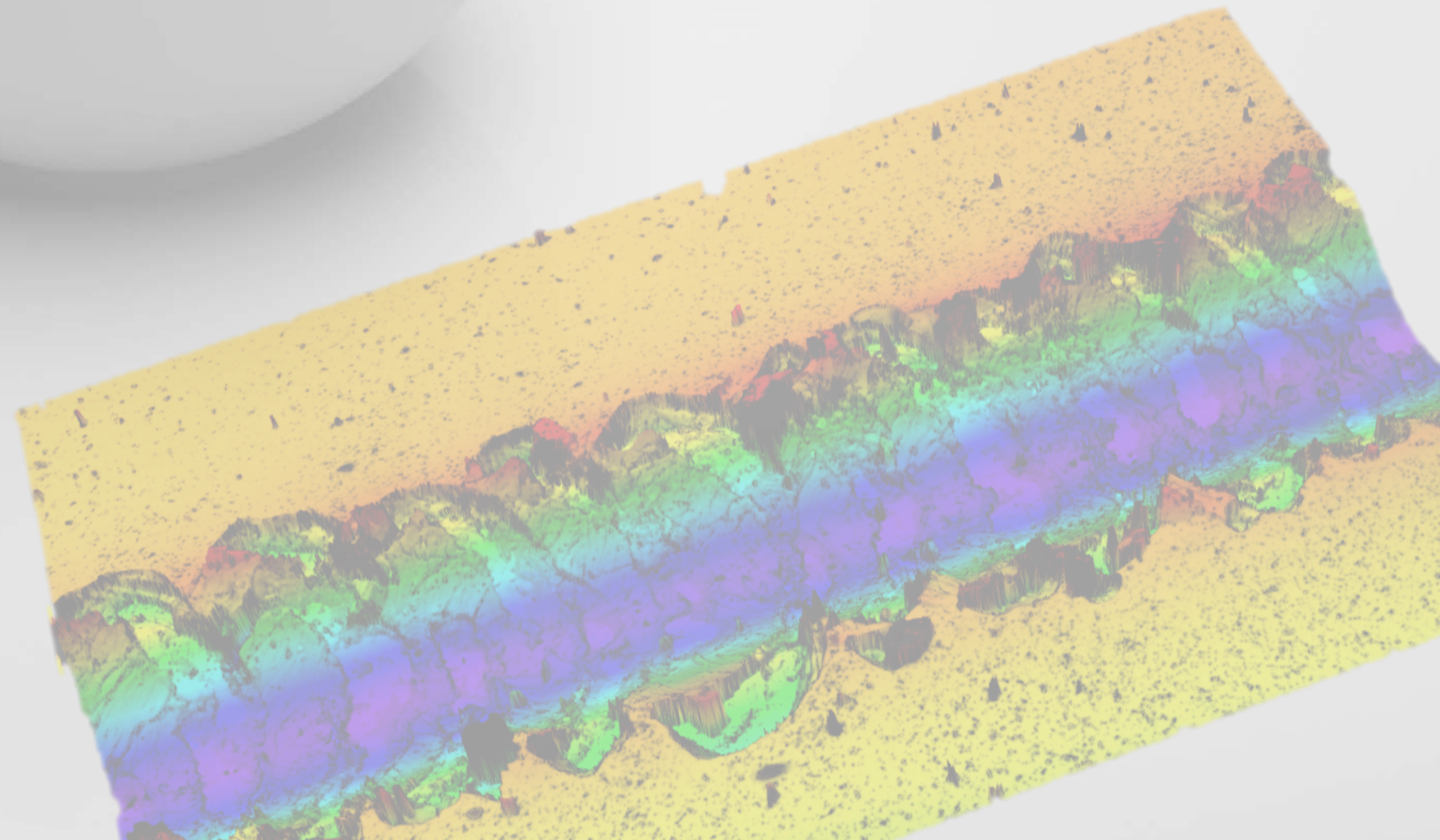
Sub-nm **3D** Profilometry

Why **3D** Scratch Tester?

Higher Accuracy on Detecting Coating Failure

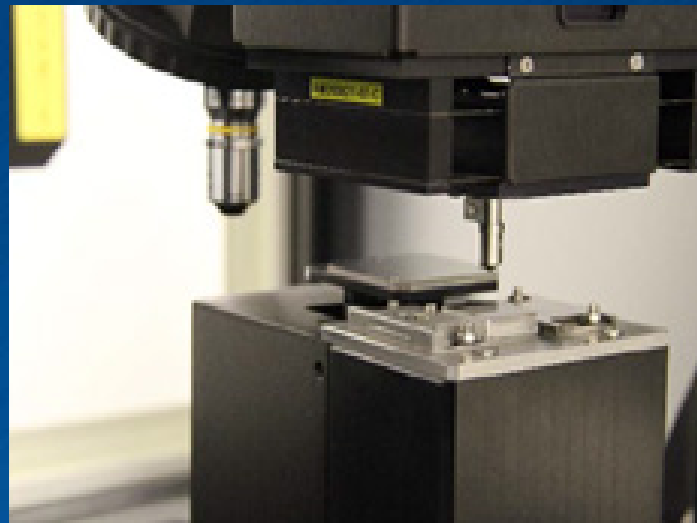Multiple Layer Coatings with Similar Mechanical Properties

Comprehensive Analysis with 3D Imaging Correlation

Next-Generation Coatings and 3D Materials

3D Scratch Tester

For Research and Quality Control

Next Generation Coatings Analysis

Comprehensive Analysis

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 .

Combination A Necessity

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

Scratch Head With Automatic Depth Referencing

Precise down force, friction and motorized capacitance sensor for scratch depth measurement.

In-line Profilometer

Sub-nm 3D Image across entire wear track is automatically stitched to create complete 3D profile for easy analysis
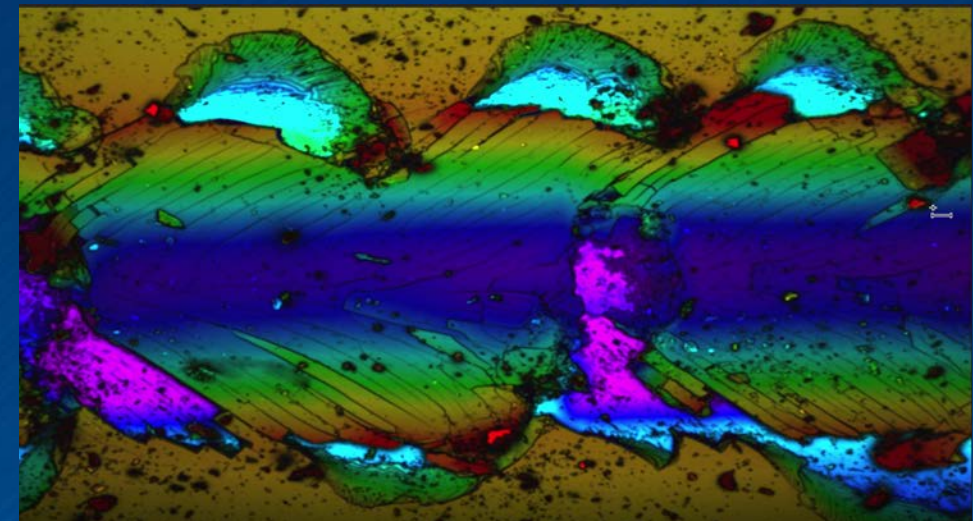
Surface Topography

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

Mechanical Property

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

Indentation

Precise down force , ultra stiff design, capacitance sensors allows to measure indentation hardness at various scales

ASTM, ISO, DIN Compliant

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

ISO 1518 Paint and Varnishes - scratch test.

DIN EN 1071-3 Advanced technical ceramics.

ASTM C1624 - Standard test for adhe-sion 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

ISO 14577 Instrumented Indentation

ASTM E18 Rockwell Hardness

ASTM E2546 Instrumented Indentation

Traceable Standard Samples For Calibration

Transparent or Non-Transparent Surfaces Coating

CoatingThickness from Nanometers to Microns

Test Samples, Coupons

Finished Products

Automobile
- Paint, Varnishes
- Polymer
- Engine, Piston
- Brake Pad
- Window

Hard Coating
- TiN, WC, DLC, WC
- Cutting tools, Drill
- PVD, CVD Coatings
- Forming Tool
- Thermal, Plasma spray Coating

Bio-Materials
- Implants, Stents
- Bone, Tissue
- Tablets , Pills
- Drug Delivery
- Artificial joints

Materials
- Ceramics
- Polymers
- Metals
- Rubber
- Composite

Semiconductor
- Thin Films
- Low K
- Passivation layers
- MEMS, NEMS
- Hard Disks

Optical
- Eye Glass, Lens
- AR Coatings
- Mirror
- Touch Screen
- Display Panels, LED, OLED

Decorative Coatings
- Jewelry
- Watches
- Evaporated metal
- Cases
- Anti-Corrosion coating

Miscellaneous
- Consumer Goods
- IOT Devices
- Solar
- Connectors
- 2D Materials
- Flexible Electronics

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 radius.

Standard Samples for Imaging
The tester is supplied with a certified standard sample for imaging module for quick calibration check.

Easy Operation

Automatic Reports

Pre Test Image

Sample moves under 3D profilometer to measure surface topography
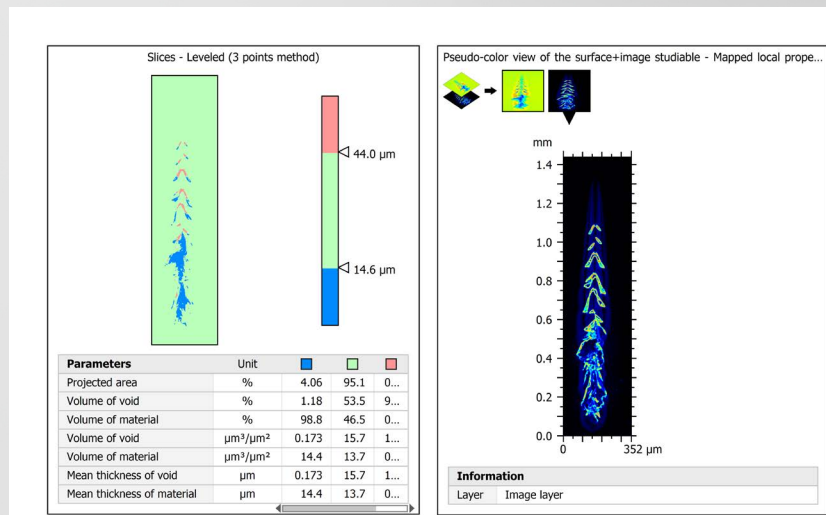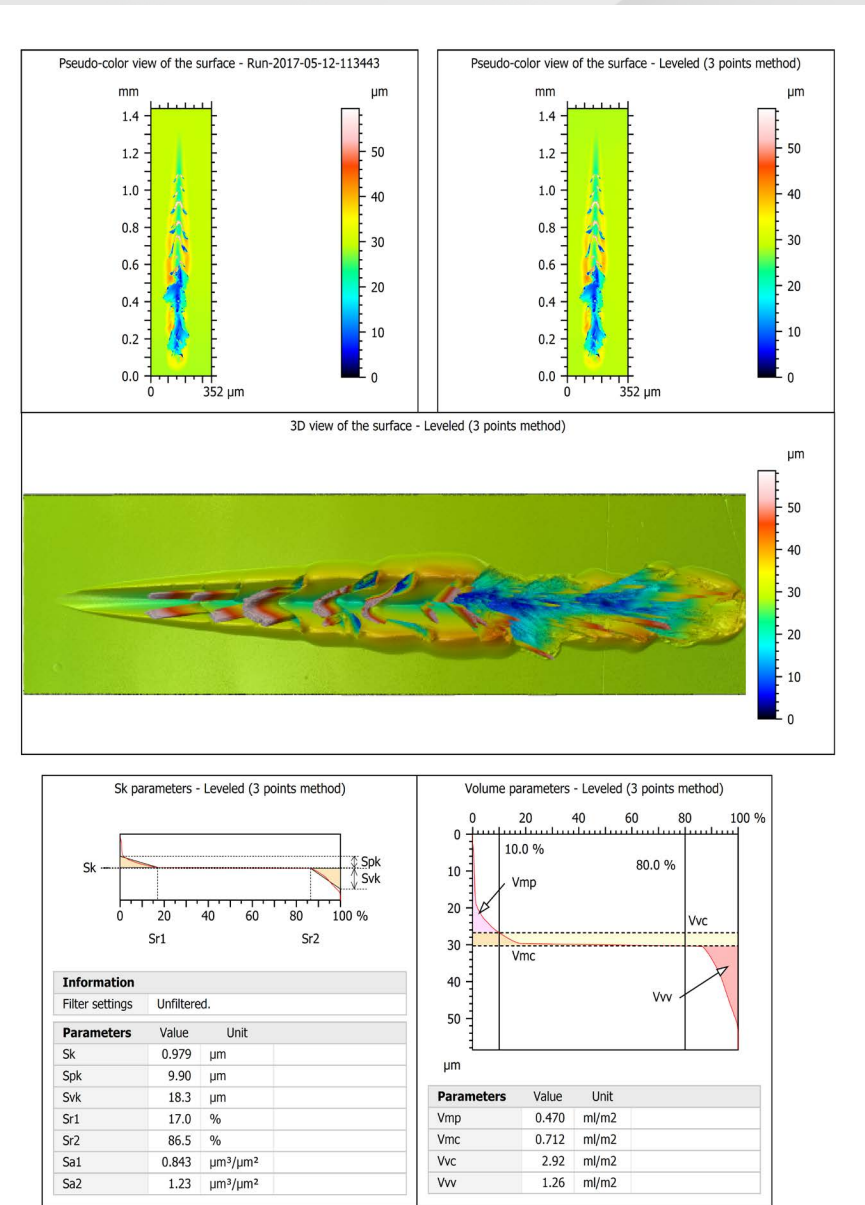
Scratch Test

Single or Multiple scratches using pre-defined recipes are performed
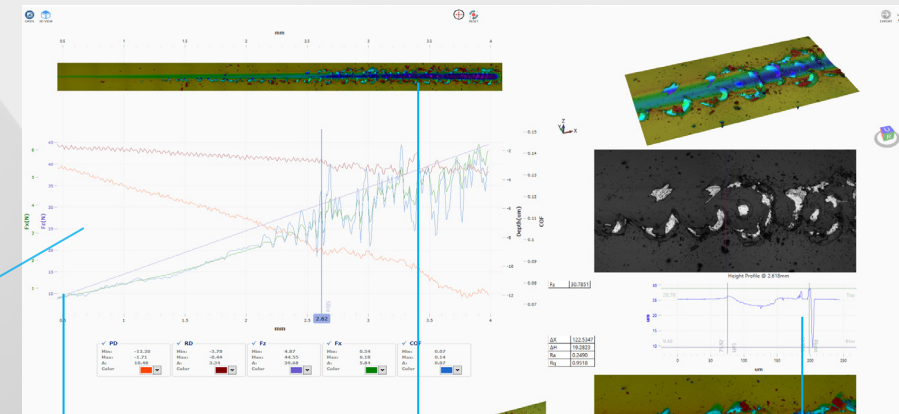
Post Test Image

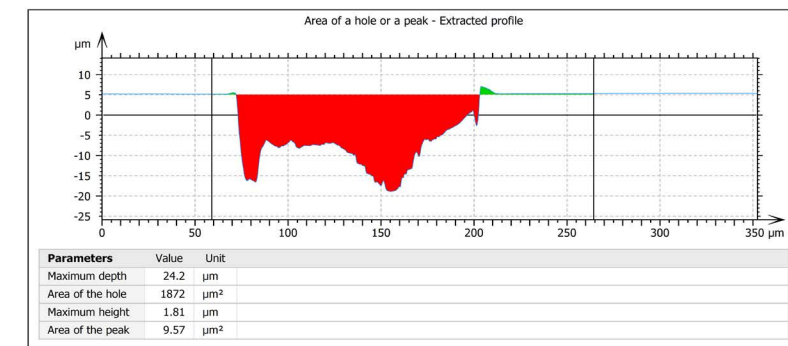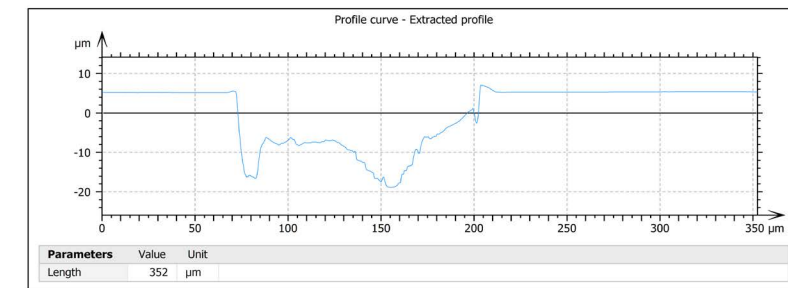The sample moves under profilometer to measure scratch area

Report

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

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

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)

Volume parameters - Leveled (3 points method)

Information	
Filter 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

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)

Pseudo-color view of the surface+image studiable - Mapped local prope...

Parameters	Unit			
Projected area	%		4.06	95.1
Volume of void	%		1.18	53.5
Volume of material	%		98.8	46.5
Volume of void	µm³/µm²		0.173	15.7
Volume of material	µm³/µm²		14.4	13.7
Mean thickness of void	µm		0.173	15.7
Mean thickness of material	µm		14.4	13.7

Information	
Layer	Image layer

Profile curve - Extracted profile

Parameters	Value	Unit
Length	352	µm

Area of a hole or a peak - Extracted profile

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

Abbott-Firestone curve - Extracted profile

Scale in depths
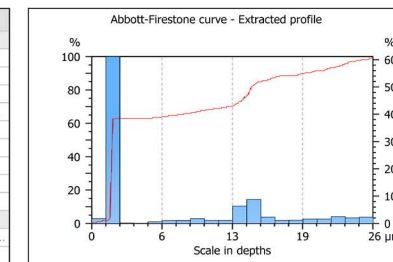
Scratch Head Choice

Easy-to-interchange scratch head for changing the testing range from nano to macro. The choice of range depends on the application. It takes less than 2 minutes to exchange the testing head.

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

Imaging Head Choice

Several imaging heads choices are available that can be mounted in-line 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

Nano Scratch NST-1

For Coating <1000nm

Down Force 1000mN

Micro Scratch MST-50

For Coating <10um

Down Force 50N

Macro Scratch HST-200

For Coating >5um

Down Force 200N*

Lambda Head

White Light Interferometer
Confocal Microscopy
Dark Field Imaging
Bright Field Imaging

Sigma Head

White Light Interferometer
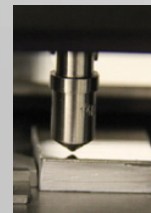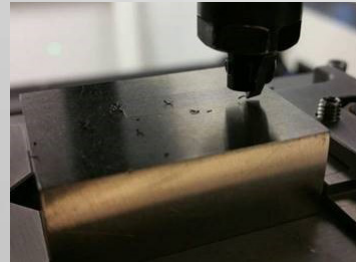Bright Field Imaging

Optical Microscope

Bright Field Imaging

Heavy Duty HST-5K *

For Coating >200 um

Down Force 5000N*

* On MFT Platform

Scratch Head

Software

Optimized for any sample and multiple applications

Proprietary sensor design for ultra-high precision friction force measurement

In-situ capacitance sensor for measuring scratch dept

- 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, contact electrical resistance sensors with 3D image
- Capacitance sensor for automatic reference
- Automatic sensor recognition
- Data saved in ASCII format
- Windows based operation system

Easy to Interchange the Heads

Flexibility for Future Upgrades

User Friendly , Recipe Based

Basic And Advanced Operation Mode

Force Measurement

Force measurement accuracy depends primarily on the sensor and the platform design. Rtec 3D Scratch Tester has a rigid design and proprietary sensors that are optimized to work under a wide range of load and various environmental conditions. The sensors are calibrated with high precision at our manufacturing facility.

Add-on Sensors and Environmental Control

- Acoustic Emission Sensor - detects acoustic waves emitting from the surface during the test
- Electrical contact Resistance - quantifies film failure
- Temperature Chamber - multiple range chambers are available
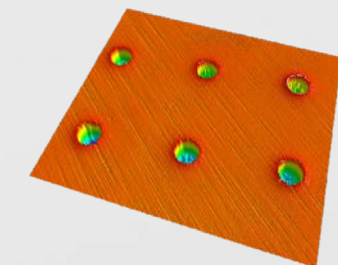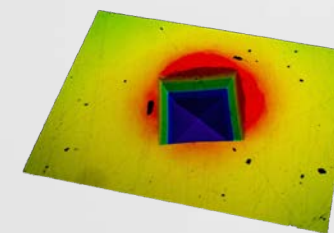
Confocal

Nipkow Confocal
Most Advanced
Confocal Microscopy

Rtec Nipkow Confocal offers faster speed and higher resolutions than conventional point confocal techniques (laser or chromatic confocal)
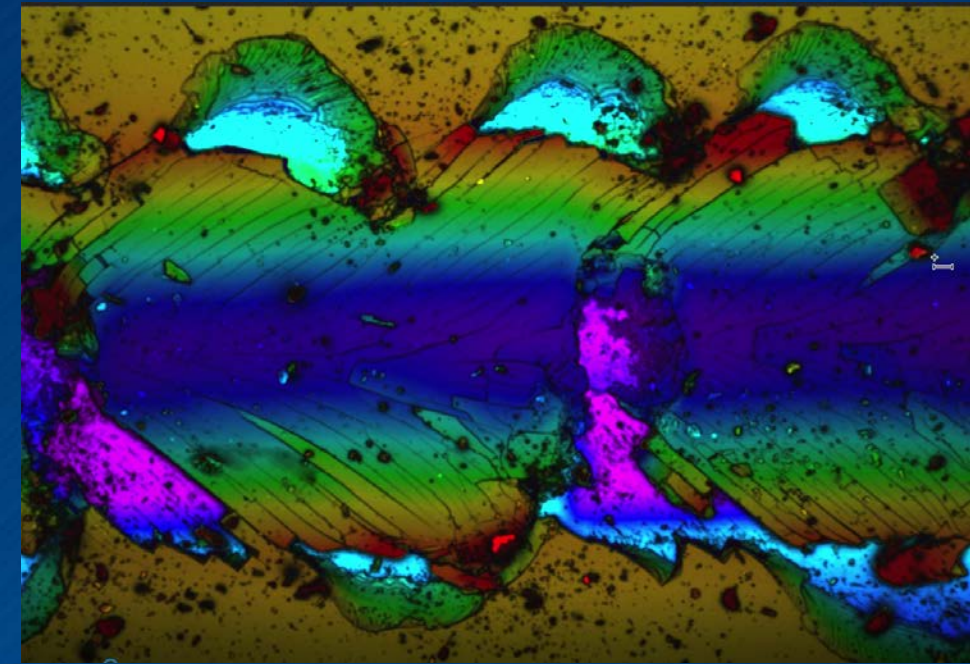
- Spinning disc (Nipkow) confocal technology for fast vertical scanning
- Best technology for surface and sub-surface feature measurement
- Full field 3D characterization of steep slope analysis (Maximal slope: 72° vs. 44° from Interferometry)
- Highest lateral resolution in optical profiling. With 5Mp 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%)
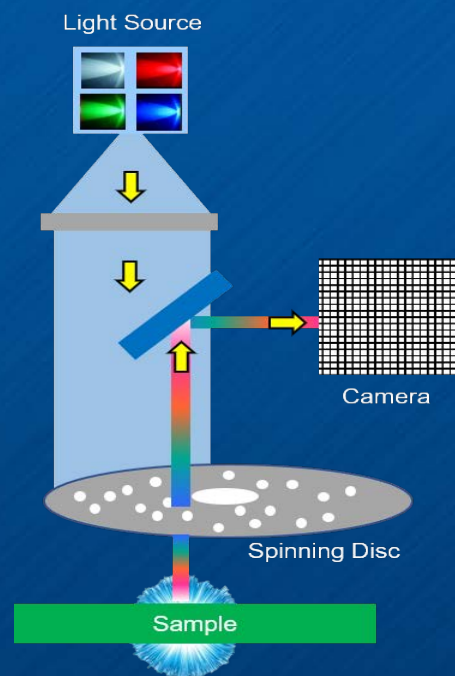- Both bright field and dark field; optical DIC

Object Tilt Does Not Affect Data

High Lateral Resolution

Measures Steep Slopes

Measures Transparent Surfaces

Very Easy To Detect Surfaces

Light Source

Camera

Spinning Disc

Sample

Wide Objective Lens Selection

Steep Slope Analysis

Confocal microscopy allows data collection from steep slopes 72° vs. 44° for interferometry. This is due to the fact that confocal microscopy allows to use wide range of objectives, which have numerical apertures more than 0.9.
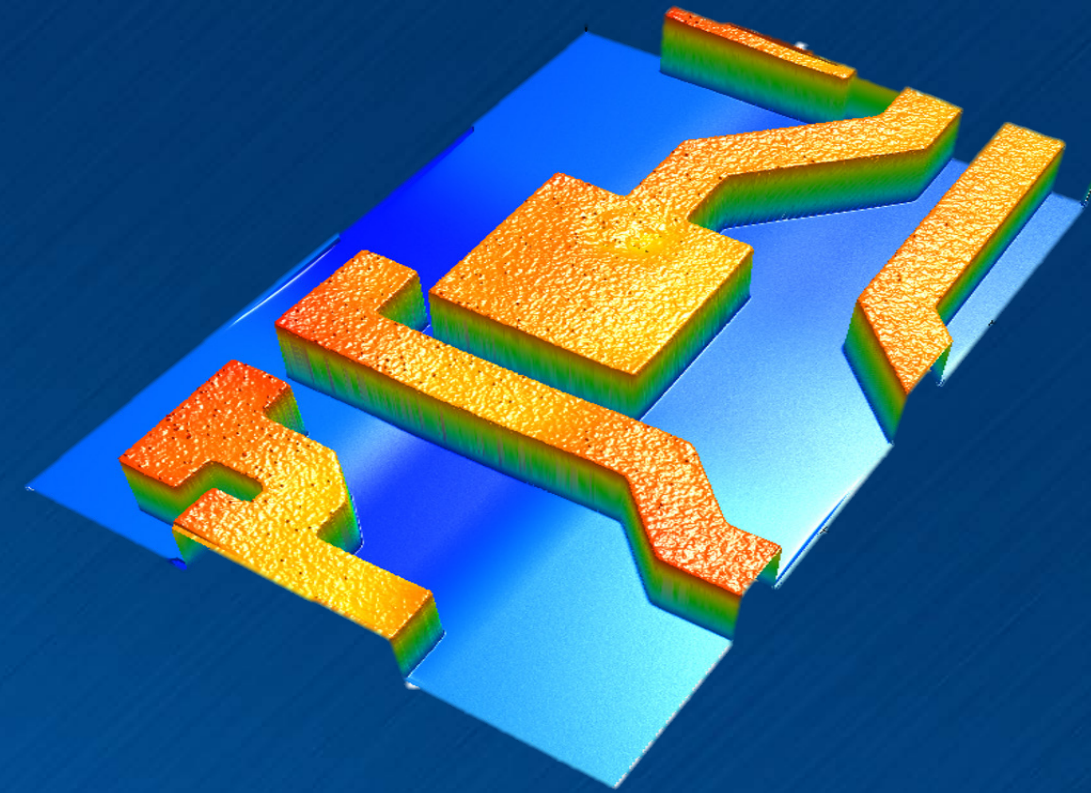
Transparent Surfaces, Sub Surface

Signal Only from Focus

Confocal microscopy allows only the light from focus to enter via infinite small pin-hole. This allows it to scan any kind of sample and surface. As a result, the profiler can easily scan transparent samples, sub-surfaces features.
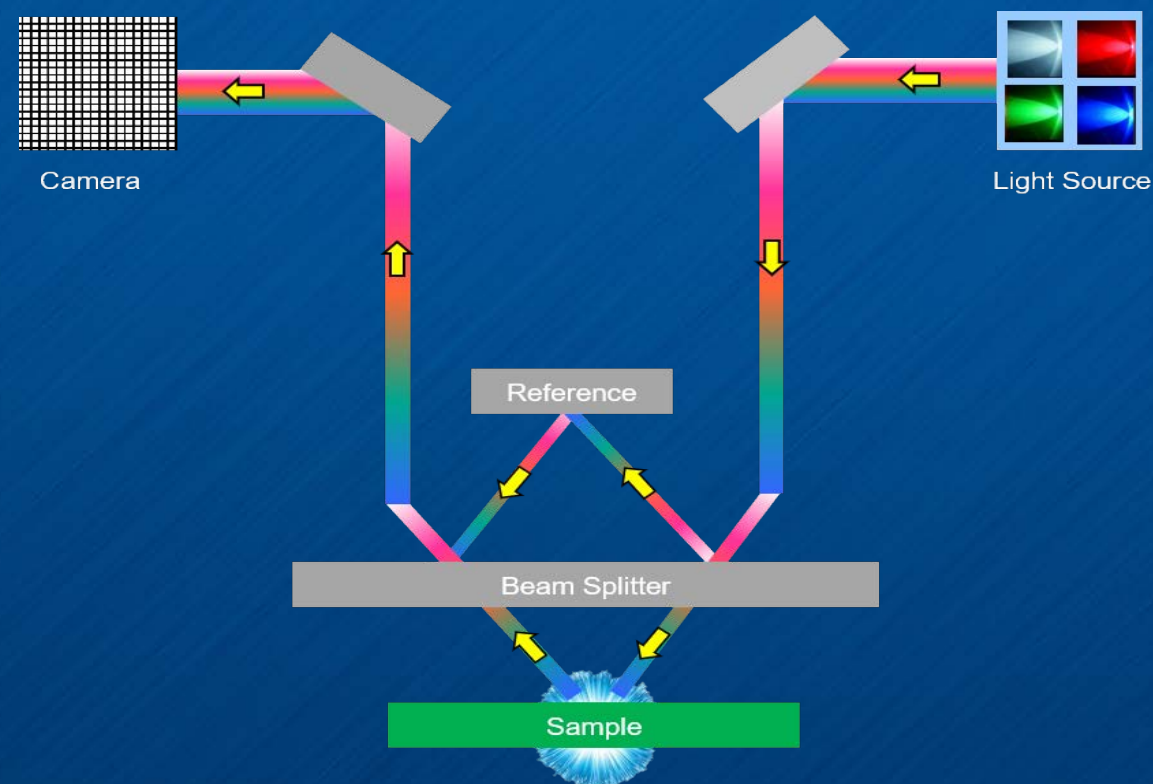
Interferometry

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)

Camera

Light Source

Reference

Beam Splitter

Sample

- 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-630nm, green-530nm, and blue-460nm) 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 objective manual or automatic turret that can accommodate several objectives. Each lens comes with calibration and inspection settings on the tester. The three mode allows to mount objective 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).

Platform
•Floor standing or Table top
•XY stage
•Displacement 0.01um resolution
• Standard 150x150mm travel, optional 200x250mm

Scratch Heads (Interchangeable)
Model NST-1 (for Nano scratch)
•Max Load 1N
•Load Noise Floor (RMS) : 0.1 uN
 •Displacement Resolution : 0.1 nm

Model MST- 50 (for Micro scratch)
•Max Friction Force 10/50N
• Load Noise Floor (RMS) : 60/300 uN
•Displacement Resolution: 0.1 nm

Model HST-200 (for Macro Scratch)
•Max Friction Force 200N
• Load Noise Floor (RMS) : 2400 uN
•Displacement Resolution: 0.1 nm

Model HST- 5K (for Macro Scratch on Ultra Thick Coating, > 200um)
 (On MFT Platform)
•Max Friction Force 5000N
•Displacement Resolution: 0.1 nm

In-line Imaging
•White light interferometer
•White light interferometer + Confocal
•Microscope
•AFM

Environment
•From -30C to 800C
•Humidity controlled chamber

Sensors
•Acoustic sensor
•Electrical Contact Resistance

Facilities Requirement
•Power Requirements: 90 - 240 VAC, 50/60 Hz

Computer Console
•Control Software and Data Analysis Software,
•Windows 10 Operating System
•CD-RW drive, Network interface
•Monitor, keyboard, mouse

About us

Rtec-Instruments develops and manufactures advanced imaging and surface mechanical properties measurement instruments for research and industrial applications. Based in Silicon Valley California, we are a leading provider of testing instrumentation such as tribometer, optical profilometer, scratch tester and micro hardness tester.

We share a philosophy that embraces collaboration and partnership with customers and other leaders in academia and industry to ensure that our products answer real needs with innovative solutions. Our San Jose, California, headquarter houses all research, development, manufacturing and application support operations.