

# Surface Materials Tester

SMT-5000



Hardness, Elastic Modulus, Scratch Resistance,  
Coating Adhesion, Friction Coefficient , Wear,  
Film Thickness, Roughness, 3D Topography

# Rtec-Instruments

## New evolutions in surface materials testing

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As surfaces become more and more complex in different applications and products, the investigation of their mechanical properties requires a new generation of instruments.

The SMT-5000 instrument answers the need of both researchers and quality control engineers. The wide testing range allows the SMT instruments to test coatings, bulk materials, real components across several industries and applications.

### The source of our leadership

The SMT instruments are the first answer to the increasingly complex testing requirements for surfaces across many industries– from liquid to ultra hard solid materials. Rtec-Instruments' SMT provides a combination of multiple investigative techniques to measure surfaces on one platform.

For example, with one run, a combination of coating adhesion, hardness, thickness, surface roughness, and 3D image data come together for a conclusive comprehensive analysis.

In addition, each instrument's modularity provides access to diverse testing techniques and load ranges on same platform.



### Precision manufacturing

All critical parts of Rtec-Instruments products are manufactured in our in-house machine shop using high precision CNC machines. This thorough control over manufacturing guarantees that all critical mechanical parts are designed and manufactured to the highest accuracy and reliability following our high internal quality standards.



### Constant innovations

To successfully answer to the ever evolving testing needs, our highly experience scientists and application engineers constantly innovate with new products and applications. We regularly partner with industries and universities using our chain of direct offices globally.



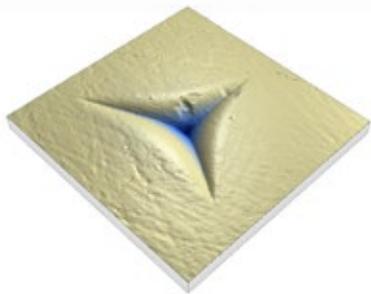
### Robust and reliable

With design and manufacturing in-house, Rtec-Instruments provides unequalled robust platforms with a high level of measuring accuracy. Born from industry requirements, Rtec-Instruments also provides "turn-key" testing solutions for many industry specific international standards.

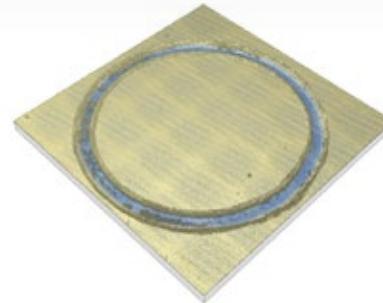
# Complete solution for surface investigation

All in one easy-to-use platform

## Scratch testing

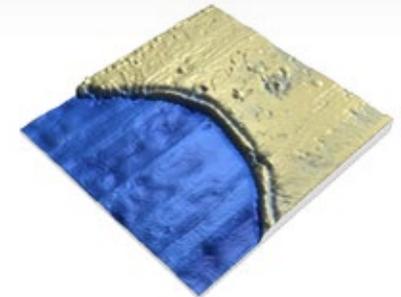


- Coating adhesion
- Scratch resistance
- Mar resistance
- Scratch hardness



## 3D profilometry

- Surface topography
- Failure analysis
- Morphology
- Defect analysis



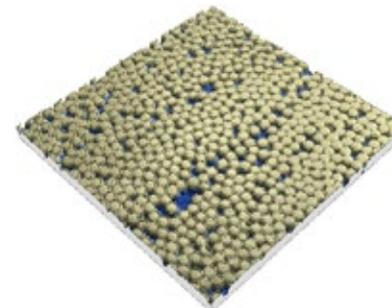
## Instrumented indentation

- Hardness
- Elastic modulus
- Storage/loss modulus
- Creep
- Stress-strain curves
- Fracture toughness



## Tribology

- Friction coefficient
- Wear rate
- Lifetime studies
- Tribological behavior



## Spectral reflectance

- Non-destructive and fast coating thickness
- Optical constants



## Rtec-Instruments Key Features

### High accuracy sensor

Our patented capacitive technology provides unequaled accuracy, stability and resolution for force measurements in single or multiple axis. (Patent US 10,775,247 B1)

### Combination of Indentation and Scratch Module (IST)

The IST module provides both indentation and scratch testing in one single module.

Both normal and lateral forces are measured in the head for higher accurate force sensing.

### Large Load Range

In addition to multiple techniques, the SMT measurement modules are offered in many different force ranges yielding a single instrument capable of covering from mN to 200 N.\*

### In-line 3D Profilometry

The 3D profilometer provides Confocal, White Light Interferometry, Bright & Dark fields and Versatile Focus imaging in one module.

All techniques are available in-line with testing modules to provide an unequaled imaging capability. (Patent US 10,024,776 B2)

### True Modularity

The SMT-5000 platform can receive multiple interchangeable measurement modules covering Instrumented Indentation, Scratch, Tribology, 3D Profilometry and Coating Thickness.

Module changes are done in less than 2 min.

### Non Destructive Film Thickness

Based on spectroscopic reflectance, film thickness measurement (FTM-100) module provides a super fast and direct non contact film measurement.

# SMT-5000

## Combination Scratch, Indentation, and In-line 3D Profilometry

Indentation, scratch heads

Automatic XY stage

3D profilometer

Film thickness probe

Automatic Z stage



# Instrumented Indentation

## Hardness and Elastic Modulus

Our Instrumented Indenter Testers are high precision instruments used to measure mechanical properties of thin films, coatings or any bulk materials.

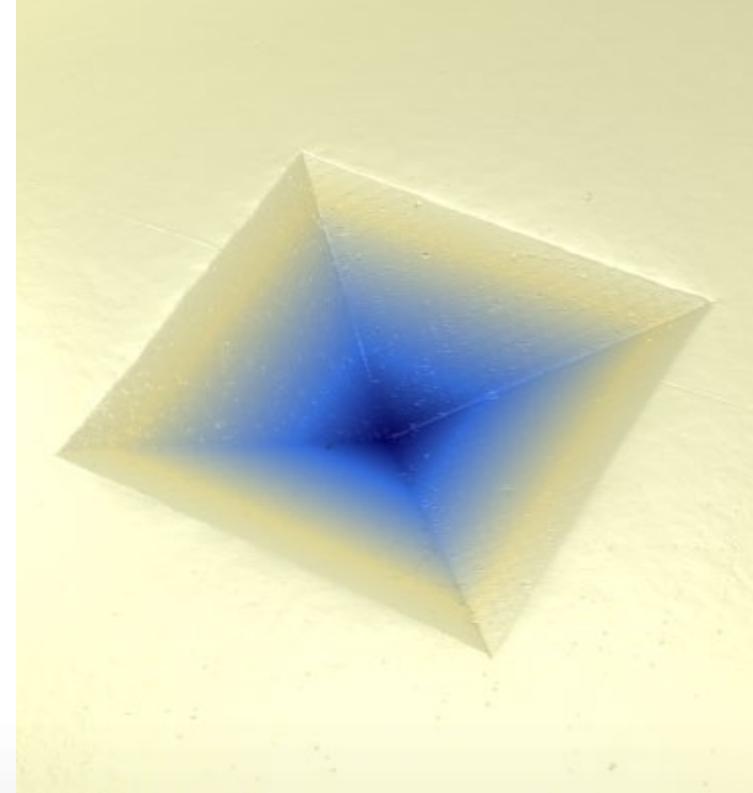
Properties such as hardness and elastic modulus, creep, fatigue can be determined on almost any type of material from soft to hard, and from fragile to brittle.

Using the latest actuation (piezo) and sensing technologies (capacitive sensors), the SMT quantify the properties of surfaces from nano to micro ranges.

Instrumented Indentation Testing (IIT) involves pressing an indenter of known geometry into a surface while controlling and measuring the force and displacement.

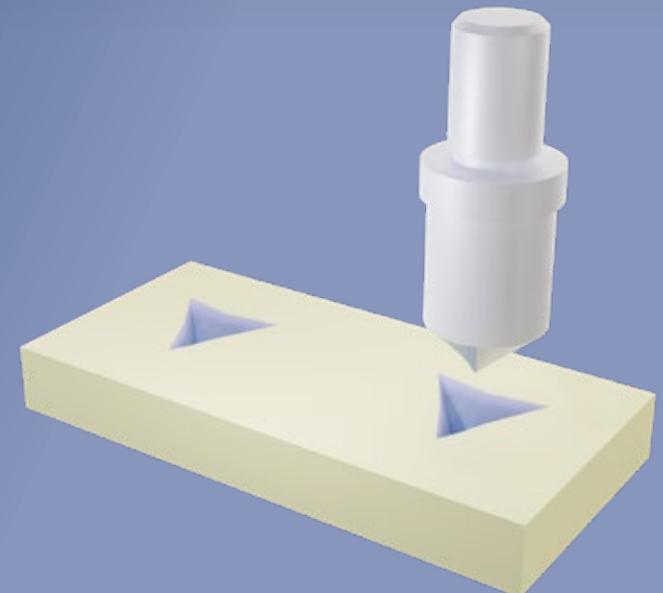
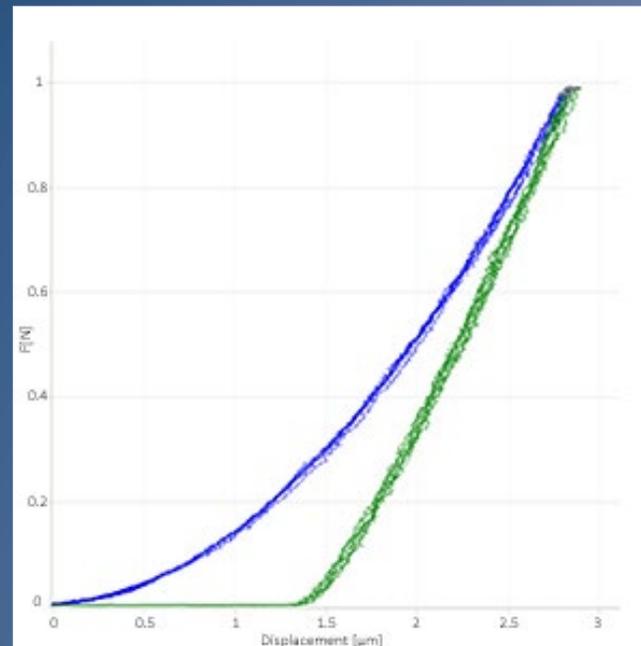
The resulting load-displacement curves are used to calculate hardness and elastic modulus among other things.

Although traditional hardness measures remain available (Knoop, Rockwell, Vickers), the IIT technique adds the ability to measure the elastic modulus of the material tested.



## Key Features of Indentation Testers

- Exchangeable modules to cover multiple load ranges from mN to 200 N
- Unmatched performance with patented capacitive sensor technology
- Berkovich, Vickers, Spherical, Cube Corner, Knoop, ... indenter tip
- Handling of large and heavy load and samples (50 cm; 10 kg)
- Motorized stage 150 mm x 150 mm for automatic mapping
- Automated 3D microscopy inspection



# Scratch Testing

## Coating adhesion and scratch resistance

A scratch is created by dragging a tip of known geometry to the surface of a sample of interest. As the tip is moved along the surface, the normal load applied to the tip is either kept constant or increased linearly.

In the case of coatings, the linear increase of the normal force increases the severity of contact providing the ability to observe critical failures of the coating, the interface and possible removing of the coating from the substrate.

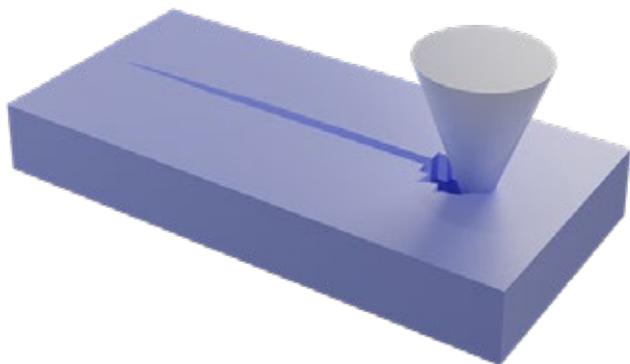
The combination of data and 3D imaging provides a complete picture of the effects of forces on deformation and failures of the surfaces.

Two types of scratch results can be evaluated on the SMT instruments:

- The scratch resistance: what is the permanent deformation left into the surface for a given load?
- The scratch adhesion: what normal force is required to break the bond between substrate and coating?

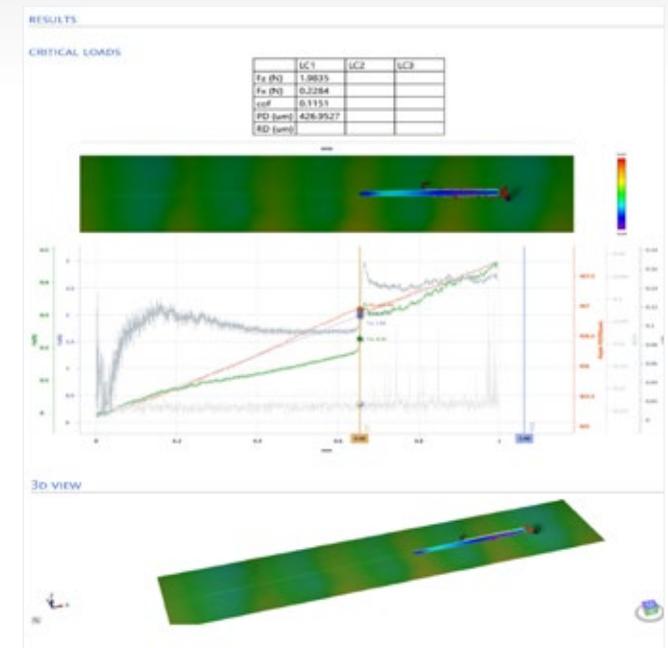


Following the scratch, images are taken of the entire scratch to provide the user with complete information on wear track, scratch width and depth, crack propagation, failure mode, roughness, volume lost and more.



## Key Features of Scratch Testers

- Interchangeable scratch head to accommodate multiple testing ranges from nano to macro
- Combination of high accuracy scratch tester and 3D optical profilometer (US 10,024,776 B2)
- The best sensitivity friction force thanks to combined tangential force sensors in the head and not beneath the sample
- Tests with temperature, humidity and/or tribo-corrosion cell
- Measurement on flat or curved surfaces



# Tribology

## Wear and coefficient of friction

Wear and coefficient of friction studies can easily be conducted on the SMT instruments to measure life and durability of surfaces.

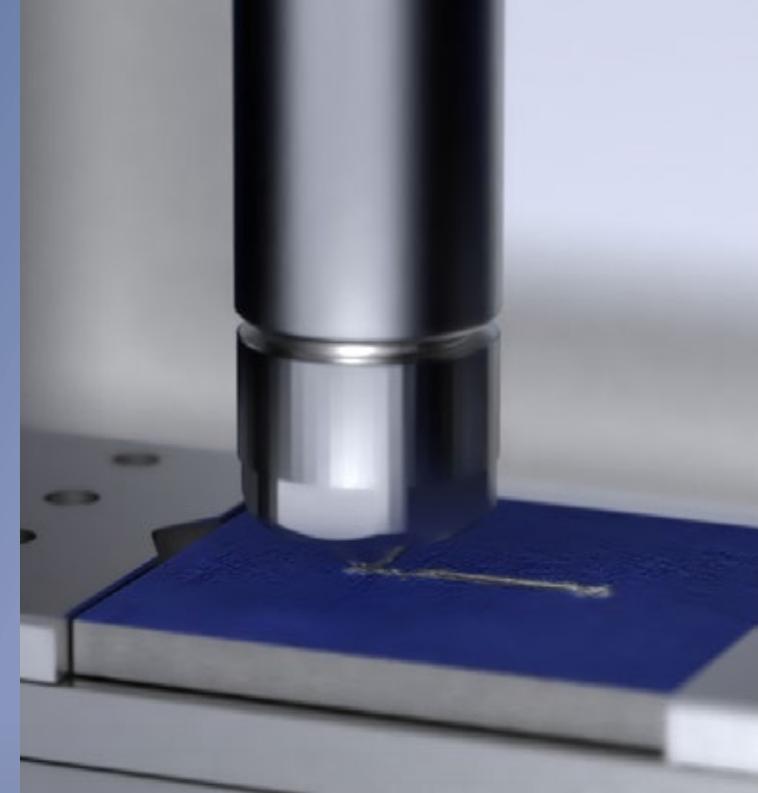
Combining the high-resolution profilometer with the tribometer setup (a sliding contact under known normal force), the wear of the surface can be easily measured as a function of time and forces.

The real time down force and speed control allows the creation of materials fingerprint

across wide range of test parameters such as wear rate, static friction, dynamic friction.

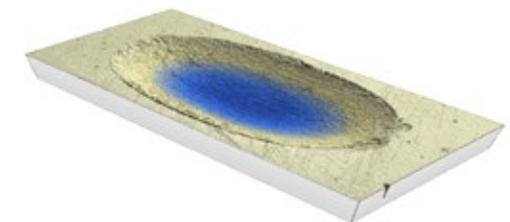
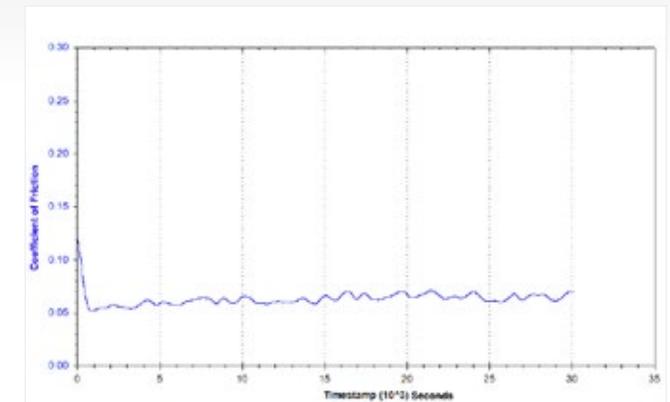
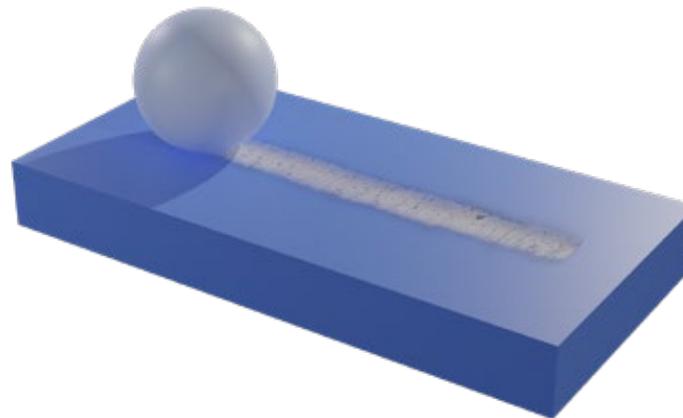
Since SMT sensors measure both normal and tangential forces, the evolution of the coefficient of friction can be easily monitored with different loading, speed and contact geometry configurations.

The combination with our patented in-line 3D profilometry provides an unique and automated comprehensive characterization of surface changes vs time.



## Features of the Tribometers

- Nano to macro tribology with fast exchangeable load cells
- Tribo-corrosion capability
- Linear and rotating sample displacement
- Testing conditions with heating, cooling, liquid or humidity
- Automatic program of test-stop on friction, penetration, ECR, ...
- Patented in-line profilometer with automatic stitching technology (US 10,024,776 B2)



# Film Thickness

## Ultra fast coating thickness determination

The film thickness measurement module uses spectral reflectance to obtain the thickness of a coated surfaces.

Spectral reflectance relies on the interaction of the coating surface with light to calculate the thickness.

The comparison of incident light to reflected light from the different interfaces below the surface of the sample, allows the measure of optical constants,

thickness and surface roughness.

Interpretation of the reflection data is fairly intuitive and easy to understand, especially in the case of relatively thick films.

Thickness information is, primarily, contained in the frequency of reflectance spectrum oscillations, while optical constants (more precisely – optical contrast i.e. difference between optical constants at the interface) information is contained in the amplitude of the oscillations.

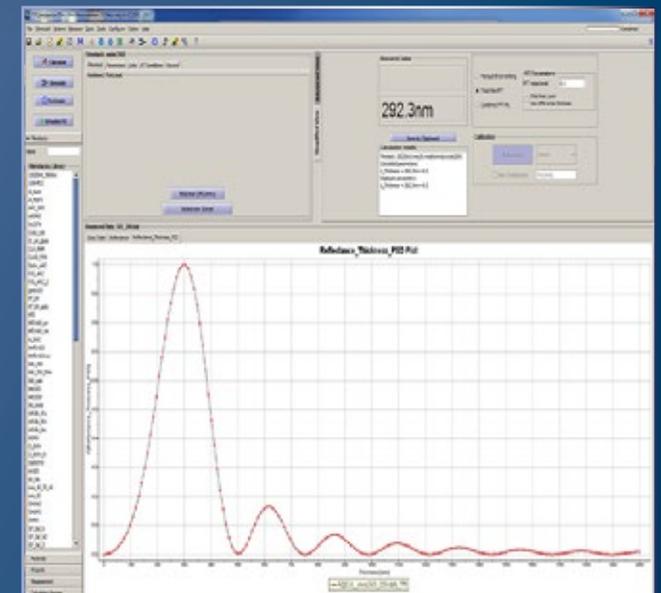
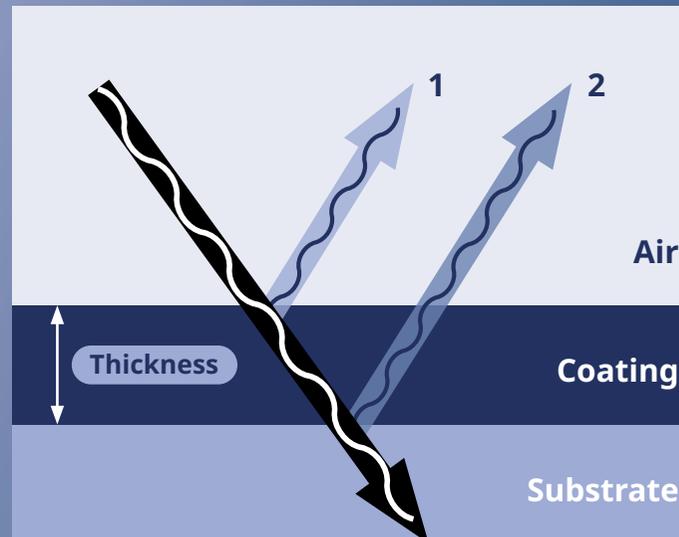
Naturally, our full package includes an easy-to-use software to record all measurements and produce statistics.



## Key features of film thickness

- Extensive materials library (500+)
- Real-time, one-click measurement and analysis of thickness, n&k and roughness measurement
- Ease of use, no expert knowledge required
- Powerful analysis package scaling correction, multi-sample measurement, dynamic measurement.
- History of analysis: recall/display measurement results and statistics

### Test Principle

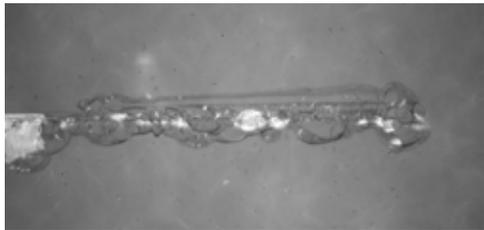


# 3D Universal Profilometer

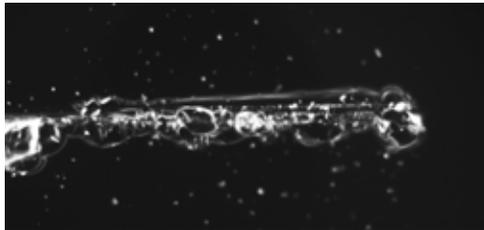
Rtec-Instruments holds the patent for in-line profilometry (US 10,024,776 B2). This capability allows for the sample surface to be imaged automatically using 3D profilometry at any point during the test.

Different imaging techniques are available for the users:

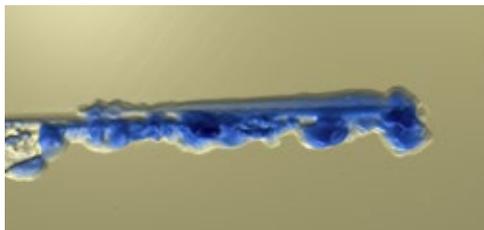
Example on a smartphone screen



Bright Field



Dark Field



3D Topography

## Spinning Disc Confocal

Optimized to look at steep slopes, transparent, translucent surfaces. Provides fast highest XY resolution 3D imaging and topography

## White Light Interferometry

Optimized to look at smooth, flat surfaces. Provides fast, highest Z resolution 3D imaging and topography of the surface

## Bright and Dark Fields

Imaging provides two different ways to look at the surface with different illumination. Dark field is often used to identify small cracks that show up as bright on the dark background.

## Variable Focus Imaging

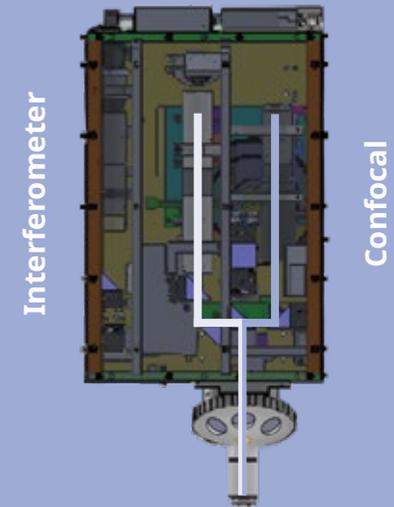
In Variable Focus Imaging, a series of photographs taken of the same objects, on different focal planes, are analyzed to create an entirely in-focus final image.

## Stitching

This mode offers the automatic imaging of large surfaces at high magnifications.

## Imaging Mode

Sub nm automated 3D images of surfaces  
2 paths with 2 cameras

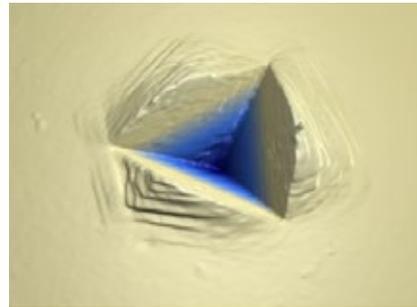


- Surface roughness
- Film thickness
- Wear track
- Volume wear
- Step height
- Add-on - Confocal Raman

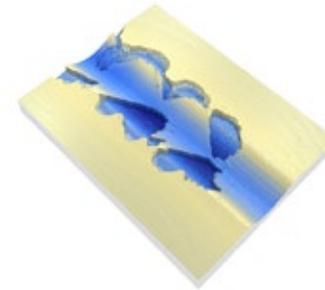


# 3D Microscope With Multiple Imaging Modes

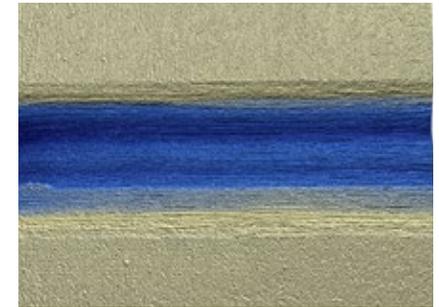
## The Most Powerful Package of Analysis On The Market



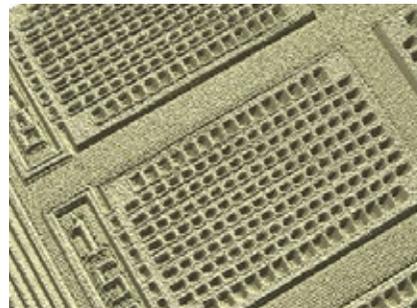
Berkovich indentation



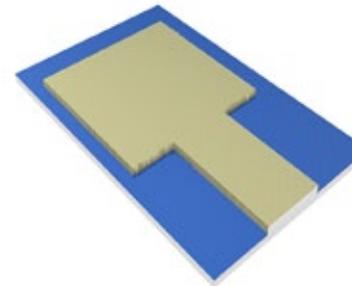
Scratch adhesive delamination



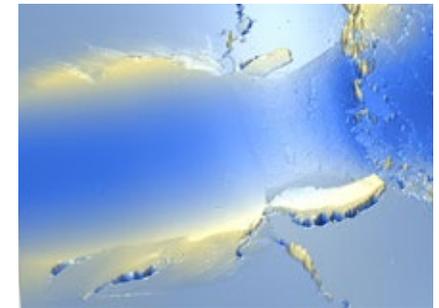
Tribology wear



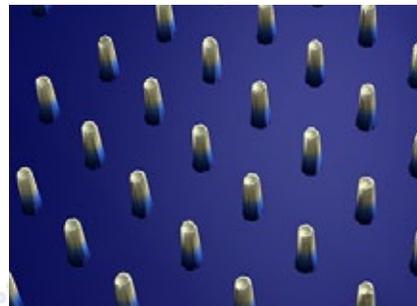
Wafer topography



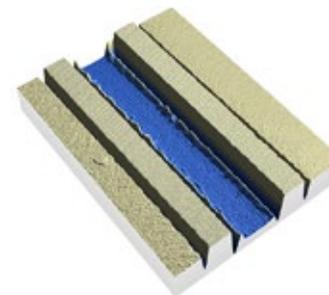
Z calibration sample



Cracks on thermal spray



Wafer bumps



Micro fluid chip



Ink on paper

# Controlled Environment

## ● Liquid Chamber



Liquid containers are available to test under liquid for both indentation and scratch modules.

The baths ensure constant wetting of the contact during the test.

Some recirculation and heating options can also be added for the fluid.

## ● Corrosion



Studies of surfaces under corrosion environments are made possible with the corrosion cell option. A robust three electrode measurement system has a corrosion cell typically made from peek material or potentiostat. This allows quantification of the synergistic effect of corrosive media on surface mechanical properties.

During the test, the setup simultaneously measures current, voltage, down force, friction force, temperature, and acoustic emissions in real-time.

## ● Humidity Chamber



Humid environment can have tremendous effects on properties of surfaces and coatings.

A special humidity enclosure is available to study the effect of humidity on tribological and mechanical properties of surfaces and coatings.

## ● Hot and Cold Temperature



To study the effect of temperature on the surface properties, a heating / cooling module provides sample temperature control during the testing of the surface.

The temperature control is fully automated and synchronized with the software.

# Testing Modules

	Description	Measurement heads
<b>IST</b> Indentation Scratch Tester	<p>This module provides both indentation and scratch capabilities.</p> <p>It is available in different load ranges (from mN to 50 N) and provides the measures of normal and tangential forces along with vertical displacement.</p> <p>Both normal and tangential forces are measured on the indenter tip.</p>	 <p>The image shows the IST measurement head, which is a compact, rectangular device with a black top and bottom section and a silver central section. The Rtec Instruments logo is visible on the silver section. A small, cylindrical indenter tip is attached to the bottom.</p>
<b>IIT</b> Instrumented Indentation Tester	<p>This module provides indentation capability.</p> <p>It is available in different load ranges (from mN to 50 N) and provides the measures of normal force along with vertical displacement.</p> <p>This module can be used or instrumented indentation and traditional hardness tests.</p>	 <p>The image shows the IIT measurement head, which is a rectangular device with a black top section and a yellow-orange bottom section. The Rtec Instruments logo is visible on the yellow-orange section. A small, cylindrical indenter tip is attached to the bottom.</p>
<b>UST</b> Universal Scratch Tester	<p>This module provides scratch capability.</p> <p>It is available in different load ranges (from mN to 200 N) and provides the measure of normal and tangential forces along the scratch path.</p> <p>Normal and tangential forces are measured on the scratch tip offering a higher measurement sensitivity and accuracy.</p>	 <p>The image shows the UST measurement head, which is a larger, more complex device with a black top section and a silver base. The Rtec Instruments logo is visible on the black section. A small, cylindrical indenter tip is attached to the bottom.</p>

# Software

The SMT instruments come standard with a control software and a data analysis software.

This allows the user to continue to run the instrument while analyzing data from previous tests.

## MFT Software

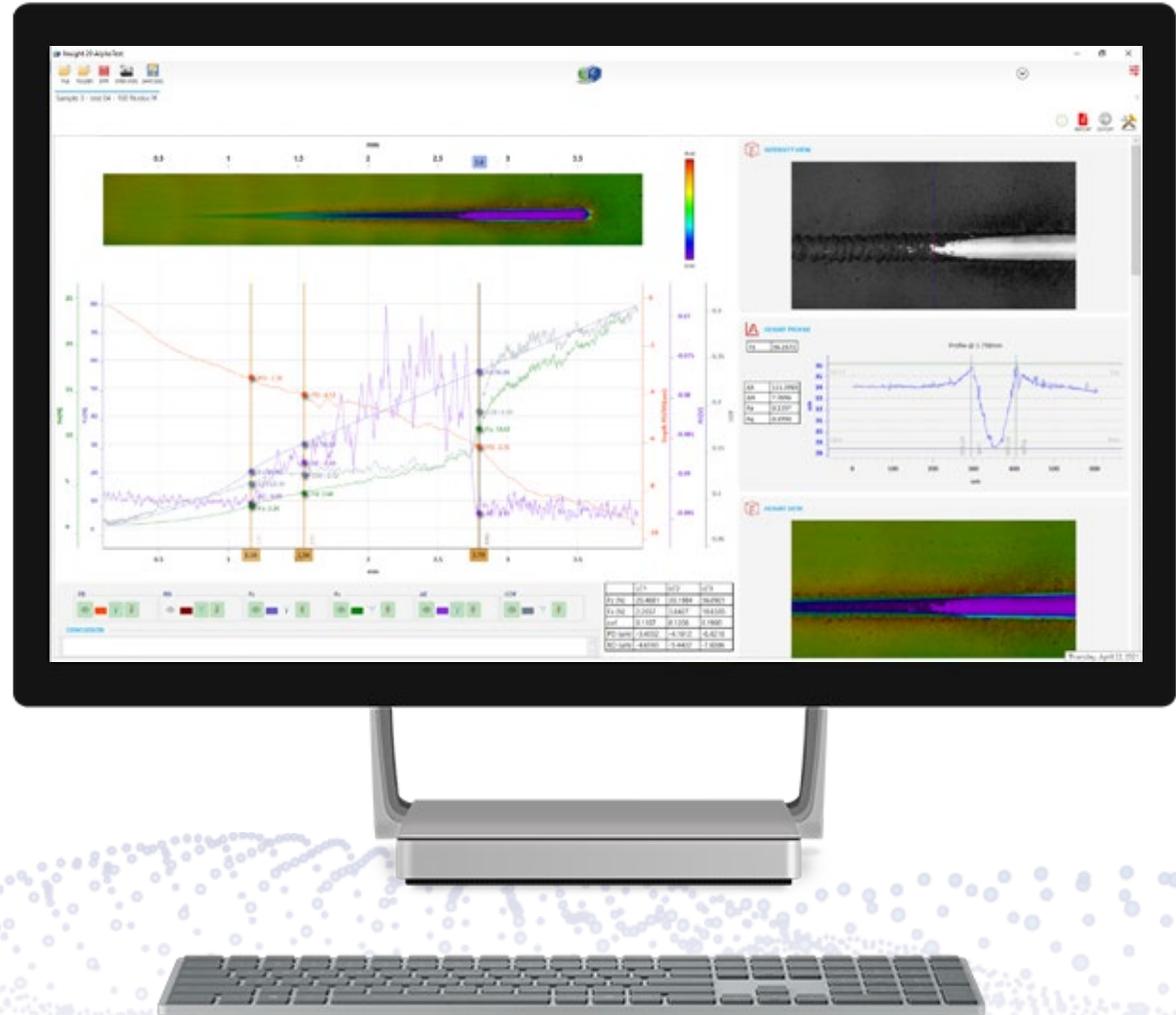
This software controls the instrument and is used to set up the test parameters.

The tests can be as simple as loading a test recipe and clicking start, or as advanced as programming each motion of the instrument while recording different data.

## Insight Software

Allows for the full data analysis of indentation, scratch, tribology and other tests.

The software allows for combined analysis of 3D profilometer images and data acquired during the tests.



# Standardized Testing

The SMT-5000 comes with several test specific standards for data traceability and quick platform checkup. The instruments also come with standard test recipes to ensure normalized testing.

Instrumented Indentation	Fused Silica, BK7, tungsten and hardness blocks
Scratch	DLC coating - BCR 692
3D profilometer	Standard step heights and roughness standards (100 nm and 1 micron)
Wear	E52100 standard test sample
Film thickness	10 nm coated sample

The SMT instruments comply with many different testing standards. The below table presents a non-exhaustive list of possible standards:

Indentation	ASTM E2546, ASTM B933, ASTM D785, ASTM E140	ISO 14577, ISO 6508, ISO 6507, ISO 4516	DIN 50359, DIN 55676 JIS B7734
Scratch	ASTM C1624, ASTM G171, ASTM D7027, ASTM D7187	ISO 20502, ISO 19252, ISO 1518	DIN EN 1071-3
Tribology	ASTM G99, ASTM G132, ASTM G133, ASTM F732	ISO 20808, ISO 7148, ISO 18535	DIN EN , EN 1071-13, DIN 50324, DIN 51834
3D profilometry	ASTM D4172	ISO 25178	

# Applications & Industries

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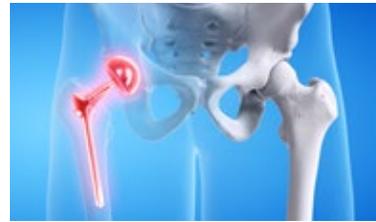
## Automobile

- Paint, varnish
- Polymer
- Engine, piston
- Thermal spray
- Window



## Hard Coating

- TiN, WC, DLC, WC
- Cutting tools, drill
- PVD, CVD coatings
- Forming tool
- Thermal, plasma spray



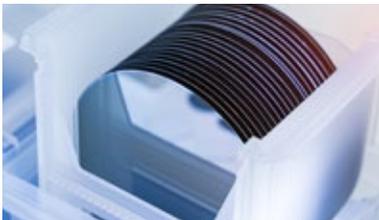
## Bio-Materials

- Implants, stents
- Bone tissue
- Tablets, pill
- Drug delivery
- Artificial joints



## Materials

- Ceramics
- Polymers
- Metals
- Rubber
- Composite



## Semiconductor

- Thin films
- Low-K films
- Passivation layers
- MEMS, NEMS
- Hard disks



## Optical

- Eye glass, lens
- AR coatings
- Mirror
- Touch screen
- Display panels, LED



## Decorative Coatings

- Jewelry
- Watches
- Evaporated metal
- Cases
- Anti-corrosion coating



## Miscellaneous

- Consumer goods
- IoT devices
- Connectors
- 2D materials
- Flexible electronics

# Specifications

## SMT Platform

	SMT-5000
XY axis [mm]	150 x 150
XY speed [mm/s]	up to 50
Z [mm]	100

\*Larger XY Ranges Available

## Coating thickness

	FT-100
Light source	Halogen
Wavelength [nm]	400 - 1100
Thickness range [μm]	0.01 to 75
Precision [nm]	<0.01
Accuracy [nm]	1

## Instrumented Indentation

IIT	1	50
Maximum load [N]	1	50
Load resolution [μN]	0.01	6
Maximum displacement [μm]	1000	1000
Displacement resolution [nm]	0.01	0.03

\* More displacement ranges available: 100 μm, 500 μm

## Scratch

UST	1	50	200
Maximum load [N]	1	50	200
Load resolution [μN]	0.01	6	100
Friction force [N]	1	50	200
Friction resolution [μN]	0.01	6	100
Maximum displacement [μm]	1000	1000	1000
Displacement resolution [nm]	0.01	0.03	1.5

\* More displacement ranges available: 100 μm, 500 μm

## 3D Universal Profilometer

See our Universal Profilometer catalog for specifications

## Instrumented Indentation and Scratch

IST	1	50
Maximum load [N]	1	50
Load resolution [μN]	0.01	6
Friction force [N]	1	50
Friction resolution [μN]	0.01	6
Maximum displacement [μm]	1000	1000
Displacement resolution [nm]	0.01	0.03

\* More displacement ranges available: 100 μm, 500 μm



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