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
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, hardness and 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)
**3D Scratch Tester**
For Research and Quality Control

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.

**3D Scratch Tester Concept**
- Scratch Head With Automatic Depth Referencing
  - Precise normal and friction forces 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 indentation measures at various force scales.

**Next Generation Scratch Optical Analysis**
Comprehensive Analysis

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

**Perfect Combination Of Imaging And Data**

- 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, Indentation and Tribology Tester**
**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

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**ASTM, ISO, DIN Compliant**

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

**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.

**Instrumented Indentation**

- **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 20502**

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

**Standards**

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**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

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.

- 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

- Nano Scratch NST-1
  Down Force 1000 mN

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

### 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

Automatic Reports

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
Abbott-Firestone Curve - Extracted Profile

Area Of A Hole Or A Peak - Extracted Generator

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)

Silices - Leveled (3 points method)

Pseudo-color view of the surface image study - Mapped local properties
3D Scratch, Indentation and Tribology Tester

- 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

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.

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
- Paint, Varnishes
- Polymer
- Engine, Piston
- Brake pad
- Window

### Hard Coatings
- Coating Adhesion
- Wear resistance
- Scratch resistance
- Mechanical properties
- High temperature hardness

### Bio-Materials
- Coating Adhesion
- Wear resistance
- Scratch resistance
- Mechanical properties
- High temperature hardness

### Materials
- Coating Adhesion
- Wear resistance
- Scratch resistance
- Mechanical properties
- High temperature hardness

### Types of Analysis
- Micro scratch
- Indentation
- Tribometer
- High temperature tribometer
- High temperature hardness

### Industries
- Engine blocks
- Intake plastics
- Windshield
- Auto paint
- High performance coatings
- Tires

### Application Examples
- DLC coating of injectors
- Study of high temperature behavior of coatings
- Quality control of cutting tools
- Wear of prosthetics and implants
- Resistance of arterial implants (porous)
- Hardness of tablets and pills
- Scratch resistance of tiles
- Mechanical properties of metallic components
- Scratch resistance of architectural windows

### Semiconductor
- Thin Films
- Low K
- Dielectric layers
- MEMS, NEMS
- Hard Dies

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

### Decorative
- Jewelry
- Watches
- Decorated metal
- Cases
- Anti-Corrosion coating

### Miscellaneous
- Consumer Goods
- IOT Devices
- Solar
- Connectors
- 3D Materials
- Flexible Electronics

### Samples
- Paint, Varnishes
- Polymer
- Engine, Piston
- Brake pad
- Window

### Type of Analysis
- Coating Adhesion
- Wear resistance
- Scratch resistance
- Mechanical properties
- High temperature hardness

### How
- Micro scratch
- Indentation
- Tribometer
- High temperature tribometer
- High temperature hardness

### Industries
- Engine blocks
- Intake plastics
- Windshield
- Auto paint
- High performance coatings
- Tires

### Application Examples
- DLC coating of injectors
- Study of high temperature behavior of coatings
- Quality control of cutting tools
- Wear of prosthetics and implants
- Resistance of arterial implants (porous)
- Hardness of tablets and pills
- Studies of osteoporosis
- Cornea elasticity
- Contact lens friction
- Scratch resistance of tiles
- Mechanical properties in aerospace components

### Samples
- Thin Films
- Low K
- Coating layers
- MEMS, NEMS
- Hard Dies

### Type of Analysis
- Coating Adhesion
- Wear resistance
- Scratch resistance
- Friction coefficient
- Mechanical properties

### How
- Nano scratch
- Indentation
- Nano Tribometer

### Industries
- Semiconductors
- Electronics
- Data Storage

### Application Examples
- Characterization of wafers
- Quality control of optical components
- Scratch resistance of architectural windows
- Scratch resistant façade
- Decorative coating
- Wear of decorative coating
- Wear of paints on products

### Samples
- Paint, Varnishes
- Polymer
- Engine, Piston
- Brake pad
- Window

### Type of Analysis
- Coating Adhesion
- Wear resistance
- Scratch resistance
- Mechanical properties

### How
- Nano scratch
- Indentation
- Nano Tribometer

### Industries
- Semiconductors
- Electronics
- Data Storage

### Application Examples
- Characterization of wafers
- Quality control of optical components
- Scratch resistance of architectural windows
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- Decorative coating
- Wear of decorative coating
- Wear of paints on products
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

<table>
<thead>
<tr>
<th>Numerical Aperture (NA)</th>
<th>2.5X</th>
<th>5X</th>
<th>10X</th>
<th>20X</th>
<th>50X</th>
<th>100X</th>
</tr>
</thead>
<tbody>
<tr>
<td>Working Distance (mm)</td>
<td>10.3</td>
<td>9.3</td>
<td>7.4</td>
<td>4.7</td>
<td>3.4</td>
<td>2.0</td>
</tr>
<tr>
<td>FOV (μm)</td>
<td>6910x5180</td>
<td>3460x2190</td>
<td>1730x1300</td>
<td>860x510</td>
<td>350x260</td>
<td>170x130</td>
</tr>
<tr>
<td>Spatial Sampling (μm)</td>
<td>2.7</td>
<td>1.35</td>
<td>0.67</td>
<td>0.34</td>
<td>0.13</td>
<td>0.07</td>
</tr>
<tr>
<td>Spatial Resolution (L&amp;S 460nm) (μm)</td>
<td>1.87</td>
<td>1.08</td>
<td>0.47</td>
<td>0.35</td>
<td>0.26</td>
<td>0.20</td>
</tr>
<tr>
<td>Maximum Slope (arcsin(NA))</td>
<td>4</td>
<td>7</td>
<td>17</td>
<td>24</td>
<td>33</td>
<td>44</td>
</tr>
<tr>
<td>Vertical Resolution</td>
<td>Better than 0.01 nm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vertical RMS repeatability RMS</td>
<td>0.01 nm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vertical measurement range</td>
<td>Up to 10 mm</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Confocal Platform

<table>
<thead>
<tr>
<th>Numerical Aperture (NA)</th>
<th>5X</th>
<th>10X</th>
<th>20X</th>
<th>50X</th>
<th>100X</th>
</tr>
</thead>
<tbody>
<tr>
<td>Working Distance (mm)</td>
<td>23.5</td>
<td>17.5</td>
<td>4.5</td>
<td>1</td>
<td>0.3</td>
</tr>
<tr>
<td>Field of view (μm)</td>
<td>3460x2190</td>
<td>1730x1300</td>
<td>860x510</td>
<td>350x260</td>
<td>170x130</td>
</tr>
<tr>
<td>Spatial Sampling (μm)</td>
<td>1.35</td>
<td>0.67</td>
<td>0.34</td>
<td>0.13</td>
<td>0.07</td>
</tr>
<tr>
<td>Spatial Resolution (L&amp;S 460nm) (μm)</td>
<td>0.34</td>
<td>0.21</td>
<td>0.18</td>
<td>0.16</td>
<td>0.13</td>
</tr>
<tr>
<td>Maximum Slope (arcsin(NA))</td>
<td>9</td>
<td>17</td>
<td>27</td>
<td>53</td>
<td>72</td>
</tr>
<tr>
<td>Vertical Resolution (μm)</td>
<td>72.0</td>
<td>18.0</td>
<td>8.0</td>
<td>2.5</td>
<td>2.0</td>
</tr>
</tbody>
</table>

3D Scratch, Indentation and Tribology Tester

Rtec instruments
Scratch Tester + 3D Profilometer
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.