



# Multi Function Tribometer

## MFT-5000



Wear, Friction, Coefficient of Friction, Adhesion,  
Scratch Hardness & Resistance, Film Thickness,  
Step Height, Hardness, Modulus, Fretting, High  
Temperature, Cryogenic



# Quality Control

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- Wear
- Friction
- Coefficient of Friction
- Adhesion
- Scratch Hardness
- Scratch, Mar Resistance
- Film Thickness
- Step Height
- Hardness
- Modulus
- Fracture Toughness
- nm Resolution 3D Images
- Wear Track, Volume Wear
- Radius of Curvature
- Cracks, Features, Defects
- Chemical Properties
- Fretting
- Tensile, Compression
- High Temperature Hardness

## **Multi ASTM, DIN, ISO Tests On The Same Platform**

Run both standard and non-standard tests on coupons or real components

## **Wide Load Range - Nano, Micro, Macro**

Interchangeable load cells to allow a wide range of force ranging from mN to 12,000 N

## **Several Easy To Interchange Test Modules**

Test coatings, materials, lubricants across wide test conditions

## **Integrated In-line 3D Profilometer**

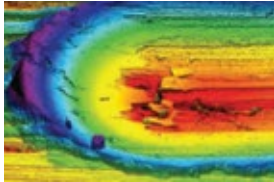
Study surface roughness, volume wear, and topography change with test time

## **Multi Function Or Single Function Configurations**

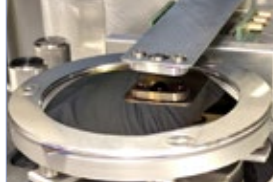
The tester can be configured as a single function test or multi function

# Research & Development

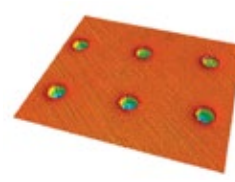
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3D Imaging



Tribology



Mechanical Tests

## Industry Standard Platform

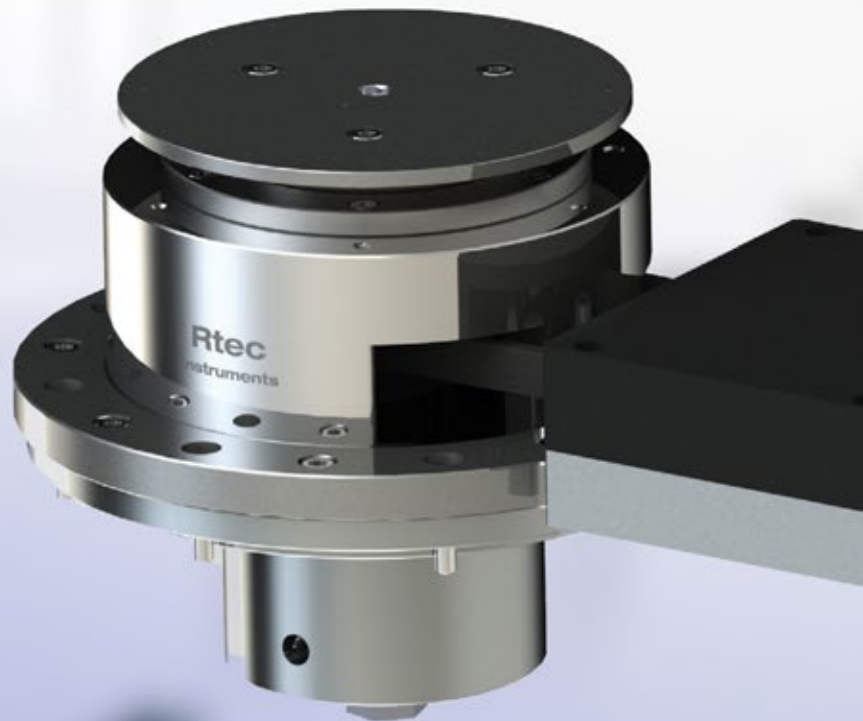
The patented (US10132733B2) state-of-the-art Rtec-Instruments Multi Function Tribometer, the MFT-5000, is globally regarded as the most versatile and technologically advanced tribometer.

The tribometer offers break-through technology in tribology equipment— with ultra low resolution and negligible thermal drift force sensors, highest speeds, widest environmental control range, and ultra accurate stroke control. In addition, the patented integrated 3D profilometer analyzes surface change vs. time.

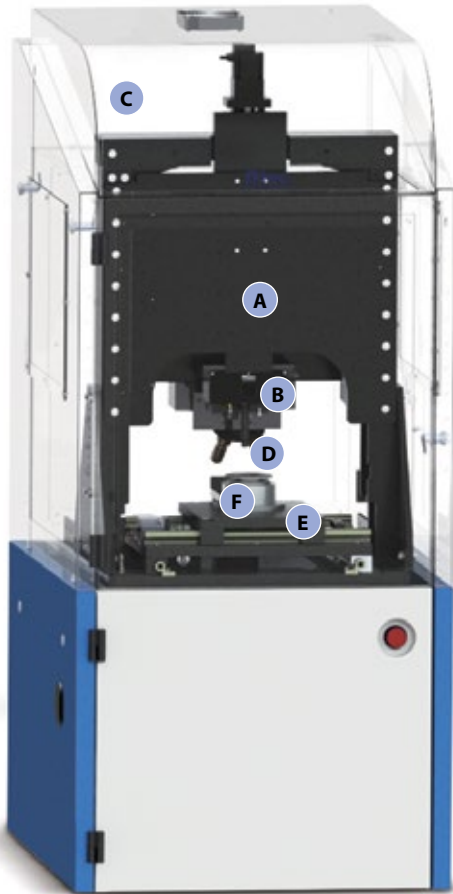


Tribology And Mechanical Tester

With Integrated 3D Profilometer



# Tribometer Configuration



(A)

## Upper Z Stage

High precision multiple Z stages to move load cell, profilometer, etc., each independently on the Z-axis.

(B)

## Force Sensor

Interchangeable load cell across a wide range from mN to 12,000 N.

(C)

## Open Platform

U channel design, high Z access provides large working area.

(D)

## In-line Profilometer

In-line universal 3D Profilometer to image test area automatically with nm resolution. The Lambda profilometer has four imaging modes on the same head (confocal + interferometer + dark field + bright field).

(E)

## XY Stage

The 130 x 270 mm high precision XY stage moves test modules between test and image positions. The stage can also be used for slow-speed reciprocating tests, scratch tests, custom motion tests, and more.

(F)

## Changeable Test Modules On Top of XY Stage

The interchangeable test modules perform several tests on the same platform (rotary, reciprocating, block on ring, fretting, scratch, etc.). The modules are mounted using fast exchange with automatic recognition on top of the XY stage.

# A **Tribometer** That Comprehensively Characterizes **Surface Change vs. Time**



## Tribology Mode

Several Modules Available for Tests

**Nano Load**

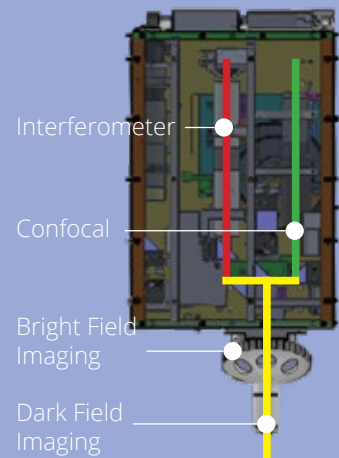
**Micro Load**

**Macro Load**

- Rotary Motion
- Linear Motion
- Horizontal Rotation Motion
- Upper Rotation
- Fretting

## Imaging Mode

Sub nm automated 3D Images of Surfaces



- Surface Roughness
- Film Thickness
- Wear Track
- Volume Wear
- Step Height
- Add on - Confocal Raman



# Patented In-line Profilometer With Automatic Stitching Technology Optimized for Tribology Testing

(US 20180024035 A1)

- **Steep Slopes**

Universal profilometer capable of imaging wear tracks with steep slopes

- **Auto Stitch Entire Samples**

High precision XY stage that allows to scan and stitch entire wear track automatically.

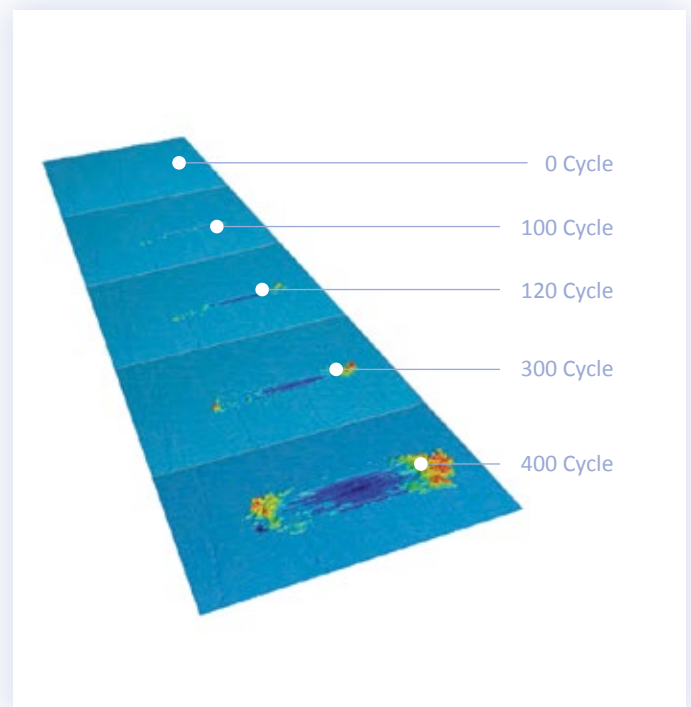
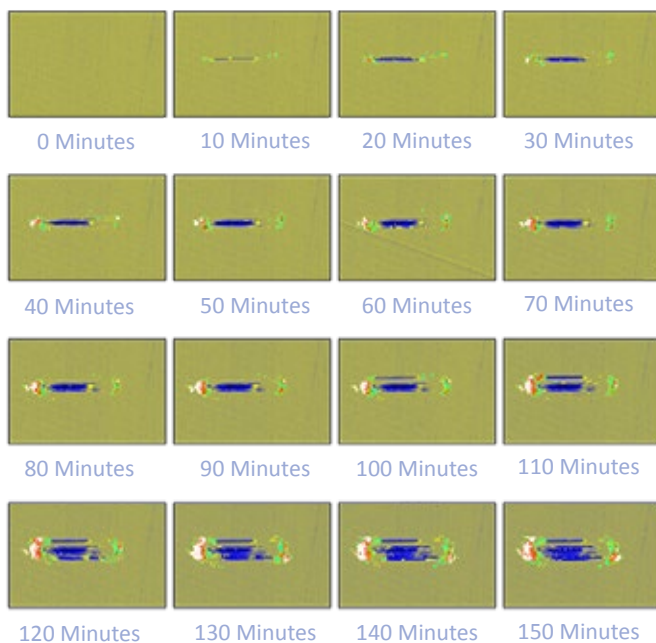
- **Rough, Dark, Smooth Surfaces**

The universal profilometer can scan any material (transparent, dark, corroded, flat, curved).

- **Image with Liquids**

Confocal microscopy can image samples under liquid media.

## Sub nm 3D Image of Wear Mark Progression During Test

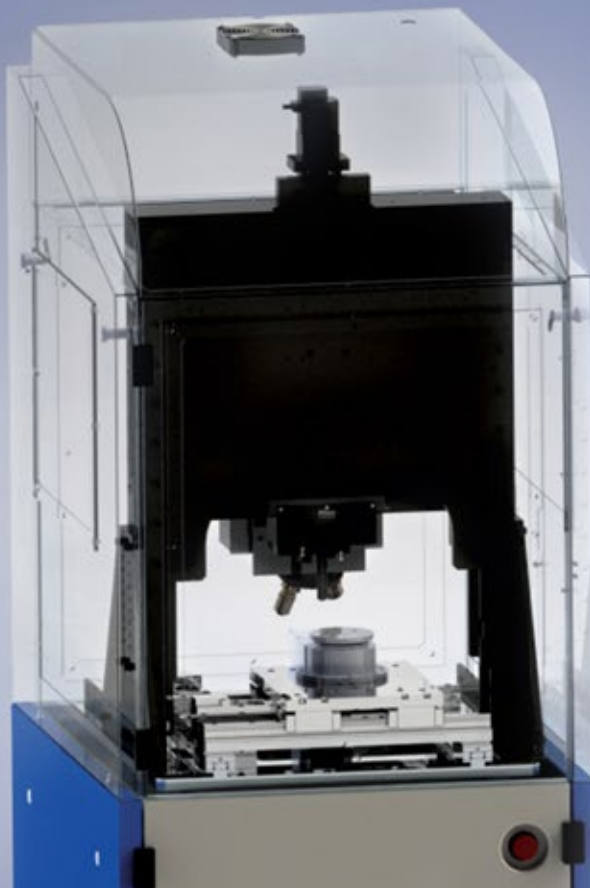


# Industry Leading Specification

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## Technology

- Stroke Control from 5 microns
- High Torque Motors, 50 Nm @ 1000 RPM
- High Frequency Capacitive and Piezo Sensors
- In-line Confocal + Interferometer Profilometer
- Widest Environmental Range -120 to 1200°C
- Voice Coil and Flexure Based Actuators

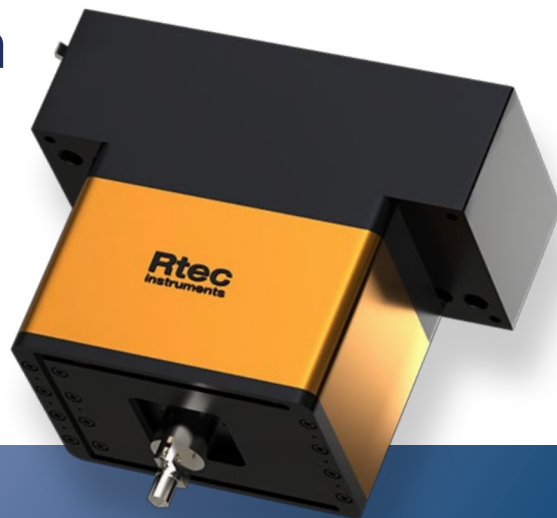


Highest Resolution and  
Negligible Thermal  
Drift Robust Design  
To Minimise Sensor  
Damage



# Wide Range Of Sensors With Patented Technology

Capacitive Sensor



- Automatic Recognition
- Fast Exchange
- Highest Resolution
- Low Floor Noise

The tester can mount various interchange force sensors easily. Each sensor has an automatic recognition feature, calibration file to maintain optimized performance on testing parameters.

Based on the application, a sensor from various types of load cells can be selected.

- **Capacitive Load Cells** - Highest resolution load cells with negligible thermal drift.
- **Piezo Load Cells** - Sensors to measure data at the highest frequency.
- **Strain Gauge Load Cells** - Sensors with widest load range - mN to 12,000 N.



Strain Gauge Sensor



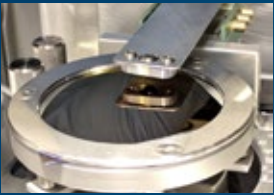
Piezo Sensor

## Other Types

Torque Sensors / 1D, 2D, 6D Sensors / In-line Dynamic Torque Sensors  
Patent # 1017938GB2

# Modular Drives With Fast Exchange

## Modular Design For Maximum Versatility



MFT-5000 runs tests across a wide range of forces and applications using its modular concept. Various interchangeable modules can be added to the same platform based on the intended application. The modular nature of this tester allows it to test coatings, bulk materials, lubricants, real components, etc.

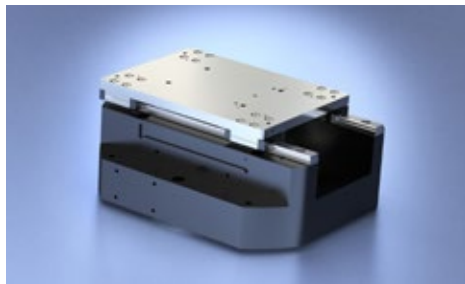
The test modules are quickly swapped. In addition, the testing modules, load cells, and lower test drives come with a fast exchange mechanism that allows the user to easily change test configurations.

The software and hardware automatically recognize the test module and runs each test with ease.

## Commonly Used Drives



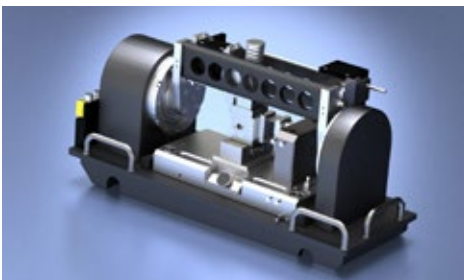
Rotary Drive



Reciprocating Drive



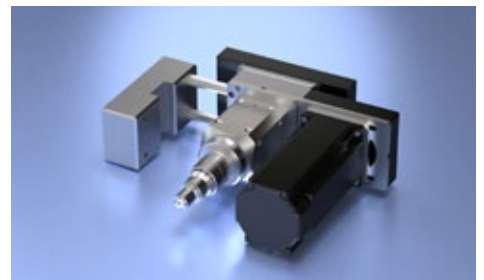
Block on Ring Drive



Fretting Drive



MTM, EHL Drive



Upper Rotary Drive

# Environmental Chambers

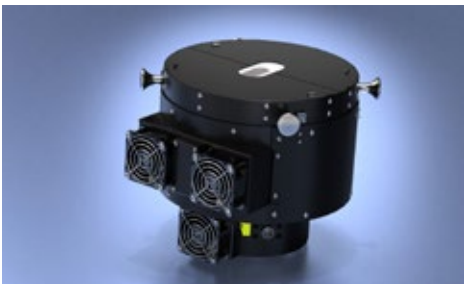
-120°C to 1200°C, Tribo-Corrosion, Vacuum, High Pressure, and More

- Automatic Recognition
- Ease of Use
- Same Software
- Future Field Add-ons
- Cost Effective

The tester comes with several environmental chambers options. The chambers are typically mounted on top of room temperature drives. Using interchangeable chambers, a wide range of -120 to 1200°C, controlled humidity, and vacuum up to 10<sup>-7</sup> torr are achievable. Some setups also allow the MFT-5000 to heat both upper and lower samples separately to simulate real-life situations.

The advanced control system allows temperature measurement at multiple points simultaneously. All the chambers are closed-loop controlled, and the requested conditions are controlled using the software automatically. In addition, the PID for different ranges of chambers is automatically loaded once an option is mounted.

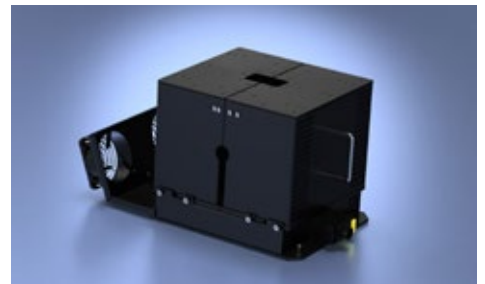
## Environmental Chambers



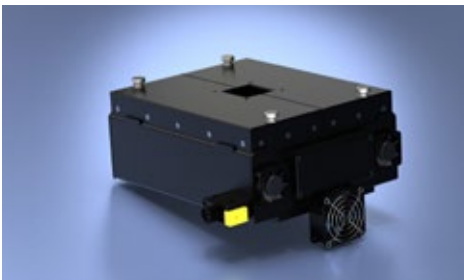
1000°C



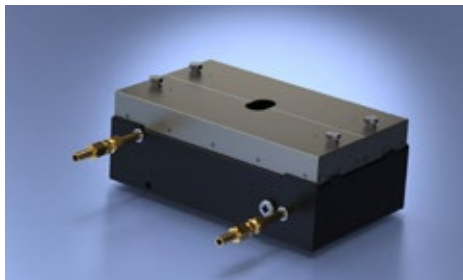
Salt Spray



500°C



1200°C



-50°C



-120°C



# Oil, Lubricant Tests, and More

Multiple ASTM, DIN, ISO, and Stribeck Curves



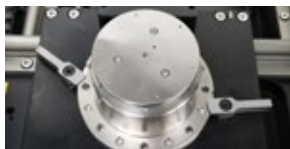
HFRR



Cryogenic



Block on Ring



Rotary



Torque



Tapping Torque



Piston Ring Cylinder Liner



Bearings



4 Ball



Brake Testing



Timken, OK, Grease



Tribo Corrosion



SRV



Low COF, Superlubricity



MTM Rolling Sliding



Reciprocating



Scratch Test



High Temperature



Cutting Tools



Fretting



1200°C Hot Hardness

# Sturdy Design

The Universal Tribometer is ideally suited for Industrial Tribology involving lubricants, additives, oils, metalworking fluids, and many more. The sturdy design includes various lubricant dispensing systems, speeds ranging from 0.001 RPM to 30,000 RPM, and temperature control. Because of this, the MFT-5000 precisely develops, characterizes, provides quality control. A few of the standard tribology tests and features are described below.

- Lubricant Recirculation
- High Speed Containers
- Temperature Control
- All Regimes
- Automatic Stribeck
- Up to 12,000 N Force
- Real Components
- Low Friction Measurement at High Loads
- Ultra High Torque Motors
- Certified Reference Calibration Oil, Samples

## HFRR

The High Frequency Reciprocating module HFRR is used for evaluating diesel fuel lubricity. The ball slides against a disk with a 1 mm stroke at a frequency of 50 Hz. ASTM D6079, D7688, CEC F-06-A-96, ISO 12156-1, IP450, BS-EC590

## Linear Oscillating/Fast Reciprocating Test, SRV Test, Piston Ring/Cylinder Liner

The standard test determines extreme pressure, friction wear properties of greases, solid bonded films, gear/hydraulic fluids, and lubricant oils. All tests are done in oscillation mode under controlled environmental conditions. ASTM G119, G174, G133, G203, G204, G206, D5706, D5707, D6425, D7217, D7420, D7594, D7421, DIN 51834, ASTM G181, G206, and more.

## Thrust Washer

This test assesses friction and wear parameters of self-lubricated materials in thrust washers, such as ASTM D3702.

## 4 Ball Wear, 4 Ball EP

4 ball wear module measures wear-preventing properties of lubricants and greases in sliding and rolling applications; 4 Ball EP measures lubricant extreme pressure properties. The test involves rotating one ball on three stationary balls under controlled environmental conditions. ASTM D-2266, D-4172, D-5183, D-2596, D-2783 and DIN 51350, IP 239,300.

## Tapping Torque, Twist Compression

Tapping torque module characterizes friction, wear, torque, etc., during forming and machining. The test involves tapping/drilling using taps of various standard sizes on materials of choice. Twist compression is designed to measure friction and adhesion in metal forming. The test involves slowly rotating a ring on top of the material of choice.

## Block on Ring, Timken EP

The block on ring module is typically used to evaluate friction, wear of materials or lubricant/grease where a ring/bearing/shaft is rotated under axial load. ASTM G77, D2509, D2714, D2782, D2981, D3704 and more.

## MTM

Study various sliding rolling ratios with upper and lower rotary motions from -200% to 200% ratio. Wide speed range to achieve -6 to 6 m/s to cover the entire lubrication regime

## Pin, Ball on Disk

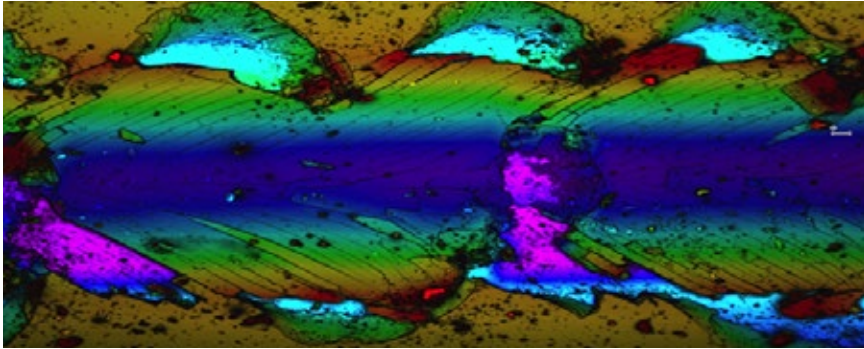
The module measures friction during sliding using pin/ball on disk setup. ASTM G99, G132, DIN 50324, and more.

## Stribeck Curve

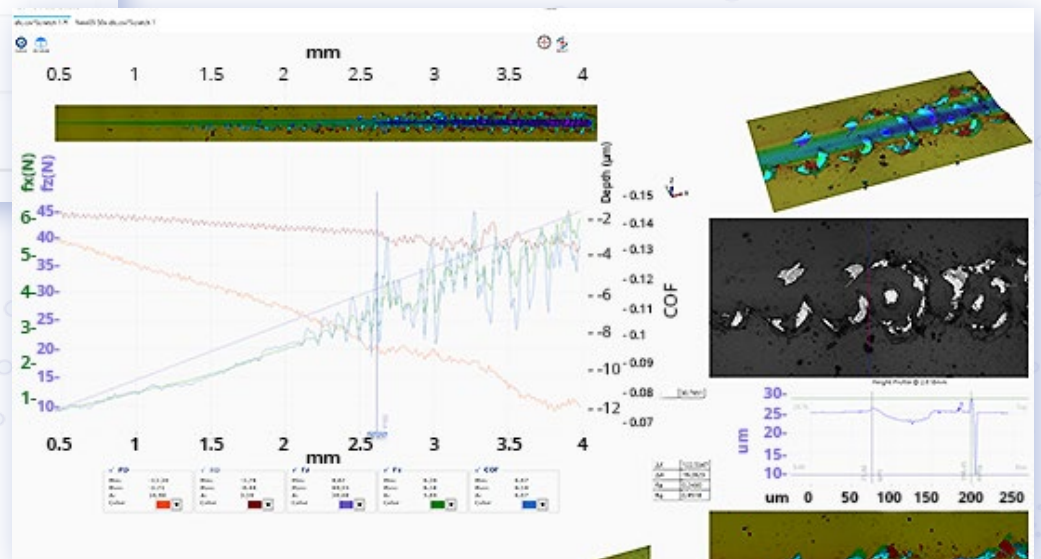
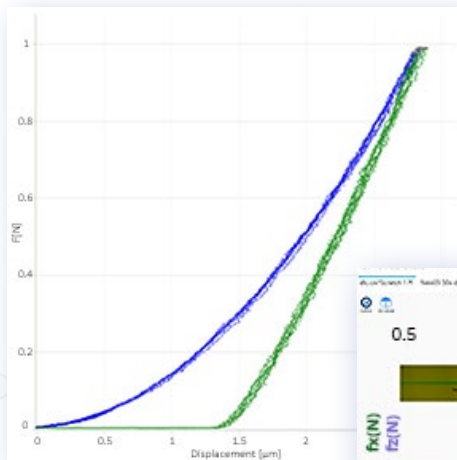
Stribeck curve displays the evolution of the coefficient of friction as a function of load, velocity, and viscosity. Users can change the load and velocity to plot Stribeck Curves with ease in all modules automatically.

# Coatings and Materials

Scratch nm to mm Thick Coatings High Temperature



- Hard Coatings
- Polymer Coatings
- Paints
- Soft Coatings
- Optical Lenses
- Decorative Coatings
- Real Components
- 2D Materials
- Thermal Spray Coatings

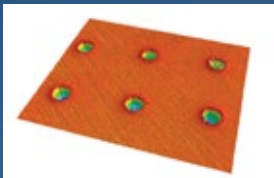




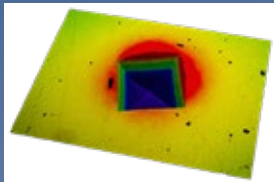
# Scratch, Hot Hardness, Adhesion



Scratch Module



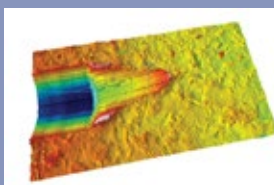
Spherical Indents



Vicker's Indent



Hydrogels - Contact Area Change vs. Force



Wear Mark

## Coatings Adhesion, Scratch, and Mar Resistance

The scratch test quantifies the adhesion and scratch hardness of coatings. With the advent of new deposition methods and technologies, thinner coatings are finding their way into every aspect of our life. Coatings are present on LCD displays, phones, cutting tools, gems, glass, automobiles, medical devices, etc. The quantitative coating adhesion scratch test is a simple, practical test that has been around for a long time. But reliable, reproducible, and comprehensive tests require precise control of the test system configuration and its testing parameters.

The scratch test requires applying a load on the sample that needs to be tested with a spherical or custom tip. During the process of applying the load, the sample is moved at a constant velocity, and several parameters such as Friction ( $F_x$ ), Downforce ( $F_z$ ), Coefficient of friction (COF), displacement ( $Z$ ), acoustic emission (AE), temperature, etc., are measured in-situ.



## Mechanical Tests - Hot Hardness, 3-4 Point Bending

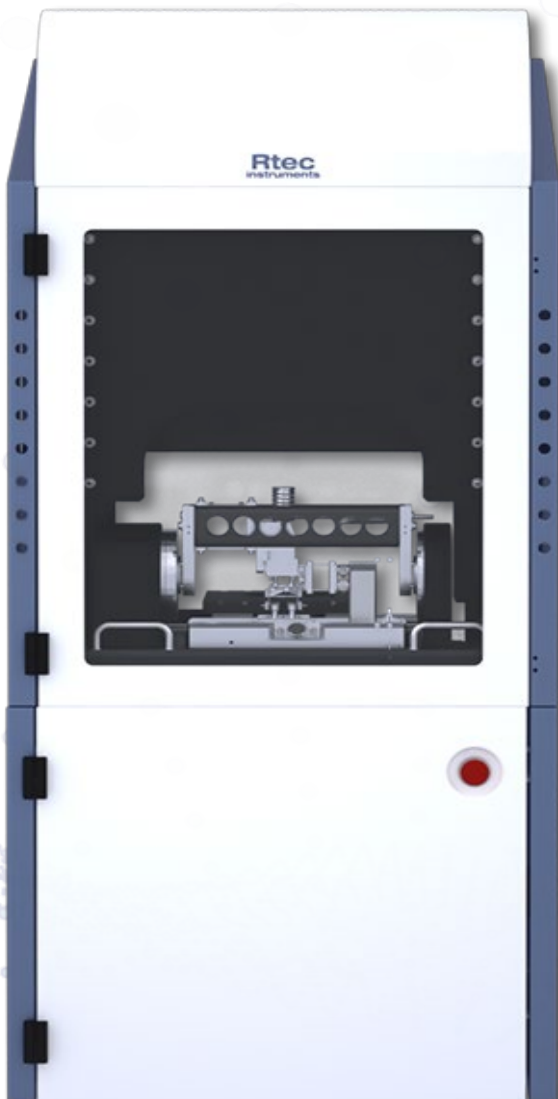
The tribometer measures and monitors forces and displacement in all axis. The multi-axis force measurement allows it to run several standard mechanical tests such as hardness, 3-4 point bending, tensile, compression, fatigue, torsion, and fretting tests. All these tests can be done using any of the environmental chambers.

# Fretting With Unmatched Performance

## Voice Coil

Fretting test modules cover a wide test load range. Technology break through in voice coil control, high frequency signal processing algorithms are capable of running fretting wear tests with less than 5  $\mu\text{m}$  stroke.

The test module comprehensively characterizes fretting wear from micron to macro scale. Ultra sensitive piezo-based load cells, combined with a robust design, high stiffness holders, and low floor noise, provides quantitative fretting wear characterization of materials, interfaces, thin films, and components.



## Real-time Stroke Control

### The Smallest Controllable Stroke - less than 5 $\mu\text{m}$ to 4 mm, up to 500 Hz

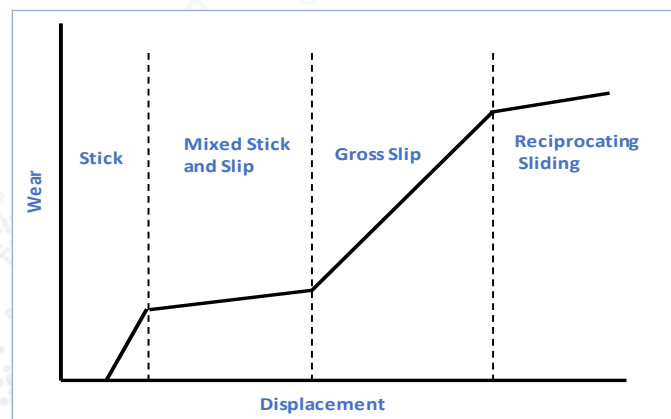
Real-time stroke, frequency monitoring, and correction using LVDT.

## High Reliability - Flexure Design

The flexural suspension guides the magnet assembly without bearings.

## High Frequency Response Force Sensors

Measure friction force with ultra-high accuracy at high frequency reciprocating tests using our Piezo-based sensors.



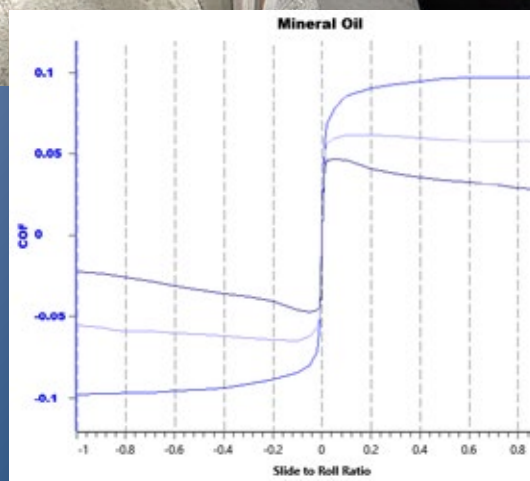
Regime Schematics



## MTM

Traction module to measure frictional properties of lubricated contacts under a wide range of sliding rolling ratios. Friction change vs. load, speed, and temperature reflect several fundamental properties valuable for assessing and comparing lubricants, greases, liquids, materials, etc.

The module can operate at high sliding to rolling ratio using two independently controlled closed-loop servo drives. A wide speed range from -6 to 6 m/s allows covering the entire lubrication regime. Standard configuration typically involves independently rotating 19.05 mm steel ball against a rotating 46 mm steel disc. Real-time downforce, traction force, and speed data automatically create Stribeck curves across the desired temperature range.



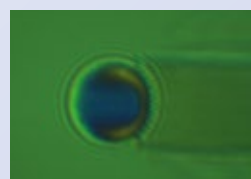
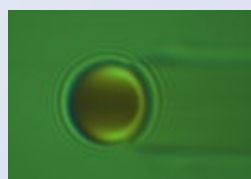
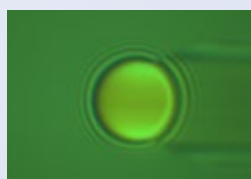
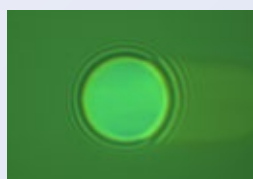
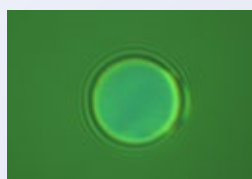
## EHL - Ultra Thin Film Measurement Module



Elastohydrodynamic Lubrication is a regime where significant elastic deformation of the surfaces takes place that alters the shape and thickness of the lubricant film in the contact.

Our fully automated EHL module allows for studying film thickness across a wide range of speeds, loads, and temperatures. In addition, high precision interferometric optics and ease of use enable measuring the oil film thickness with nm level accuracy.

The test involves running a steel ball across coated glass disks. Real-time downforce, speed, and friction data allow for an effortless combination of film thickness and tribological information. Our software automatically calibrates the system, runs the recipes, and processes film thickness using advanced algorithms that can be traced to field pioneers.



# Nano Tribology

Ultra Low Friction, nm to Micron Films, Coatings

- 2D Materials
- Polymers
- Soft Coatings
- Paints
- Lens
- Optical Coatings
- Displays

- Negligible Thermal Drift Force Sensors

- Capacitive Load Sensors With High Resolution

- COF Measurement  $< 0.002$



## Superlubricity, 2D Materials, DLC Low Friction Force Measurements

The nano tribometer modules allow comprehensive friction, wear, and adhesion characterization over nano to micro scale. Ultra sensitive capacitive load cells, combined with low floor noise and a robust design, provide quantitative tribology characterization of interfaces, thin films, 2D materials, superlubricity, and much more. The tests can be done in the air, vacuum chamber, or a controlled inert gas atmosphere. In addition, the wear mark can be easily imaged using an in-line profilometer and Raman spectrometer to automatically characterize roughness, wear, and chemical property across the track.



# Precision At Best

## Superlubricity

The tribometer uses decoupled capacitive load cells to measure friction at a COF 0.001 level even at high down forces (1 N, 10 N, etc.). The unique design, controlled environmental conditions, and high-resolution sensors measure 2D materials' friction and superlubricity with ease.

## In-situ Confocal Raman Spectroscopy

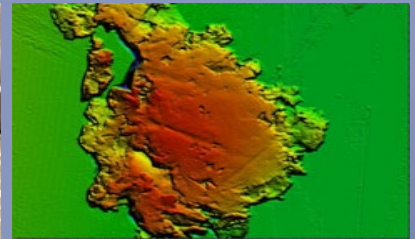
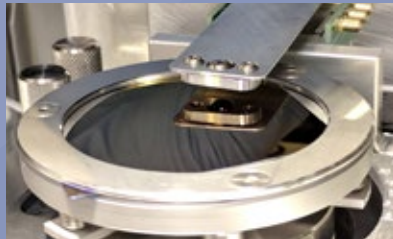
In-line confocal Raman spectroscopy can be added to the tribometer. The confocal mode allows high resolution imaging of the chemical property of locations within the wear mark. The XY stage allows stitching of the Raman maps across the entire wear track. The test can be performed in air, inert gas, or in a vacuum chamber.

## Touch Screen, Display, and Glass

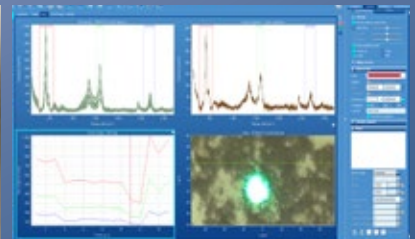
The tribometer uses a 6D sensor and closed-loop XY stage to create customized motions, such as butterfly, circular, and zig-zag, that simulate any kind of profile. The test accurately simulates finger motion on touch screens and quantifies perception.

## Contact Area vs. Force

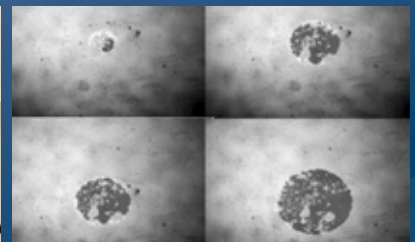
The surface adhesion module can be added to the tribometer to analyze real-time contact area vs. force using an imaging system that is placed under the sample. This calculates surface adhesion and also observes the interface in real-time.



Ball on disk setup for nanotribology agglomerated particles on a coating.



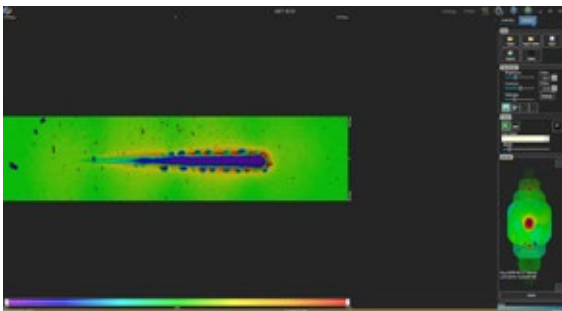
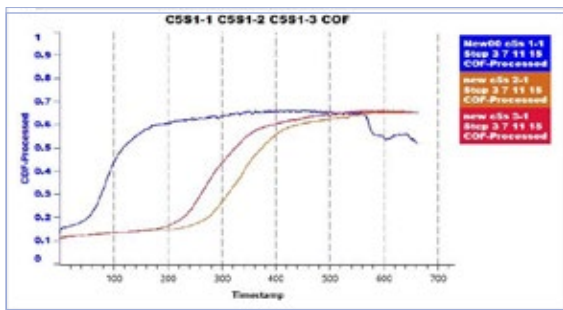
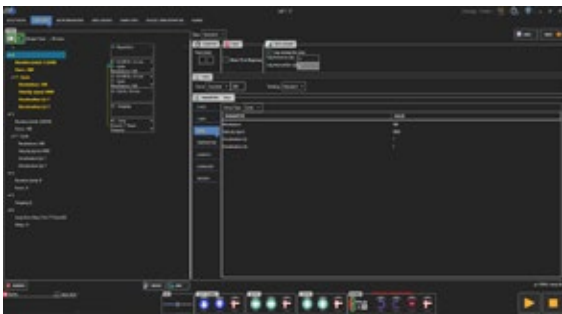
Vacuum chamber with in-line Raman and profiler Raman spectrometer data on a wear mark.



A test showing hydrogel against a coated glass slide. Real-time contact area analysis vs. force.

# Software

The tester comes with a powerful operation, statistical and image analysis software. All software is Windows-based and is very easy to learn and operate. The software runs the tool in advanced mode for experienced users or simple mode for new users or operators. The data can be saved in a proprietary format or ASCII format.



## Abort Criteria

The user's defined logical criteria can stop at each test step.

## Automatic Recognition

The testing system recognizes load cells and automatically drives the associated calibrations files.

## Recipe Driven

Each test can be controlled by a series of command blocks forming a protocol or "recipe." The recipes are saved and easily drive the instrument.

## Easy to learn

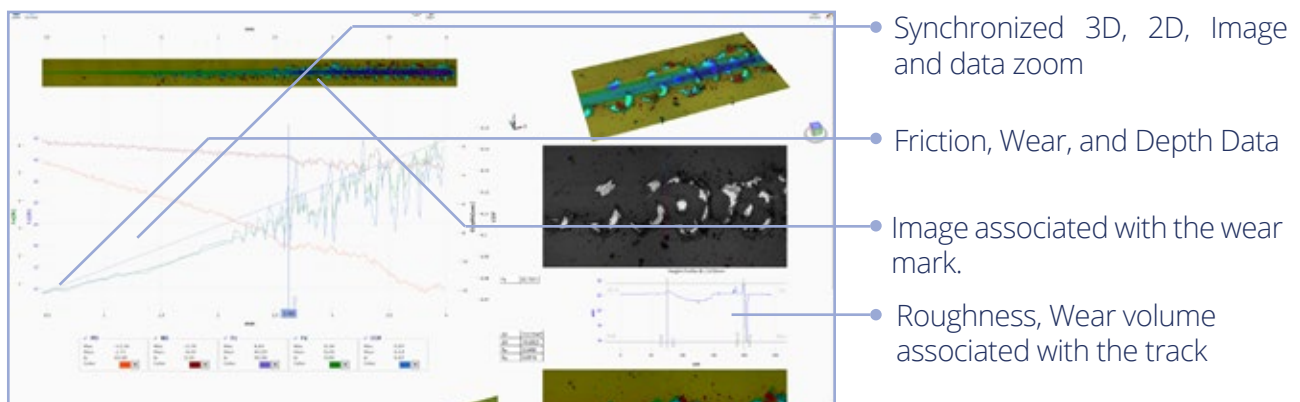
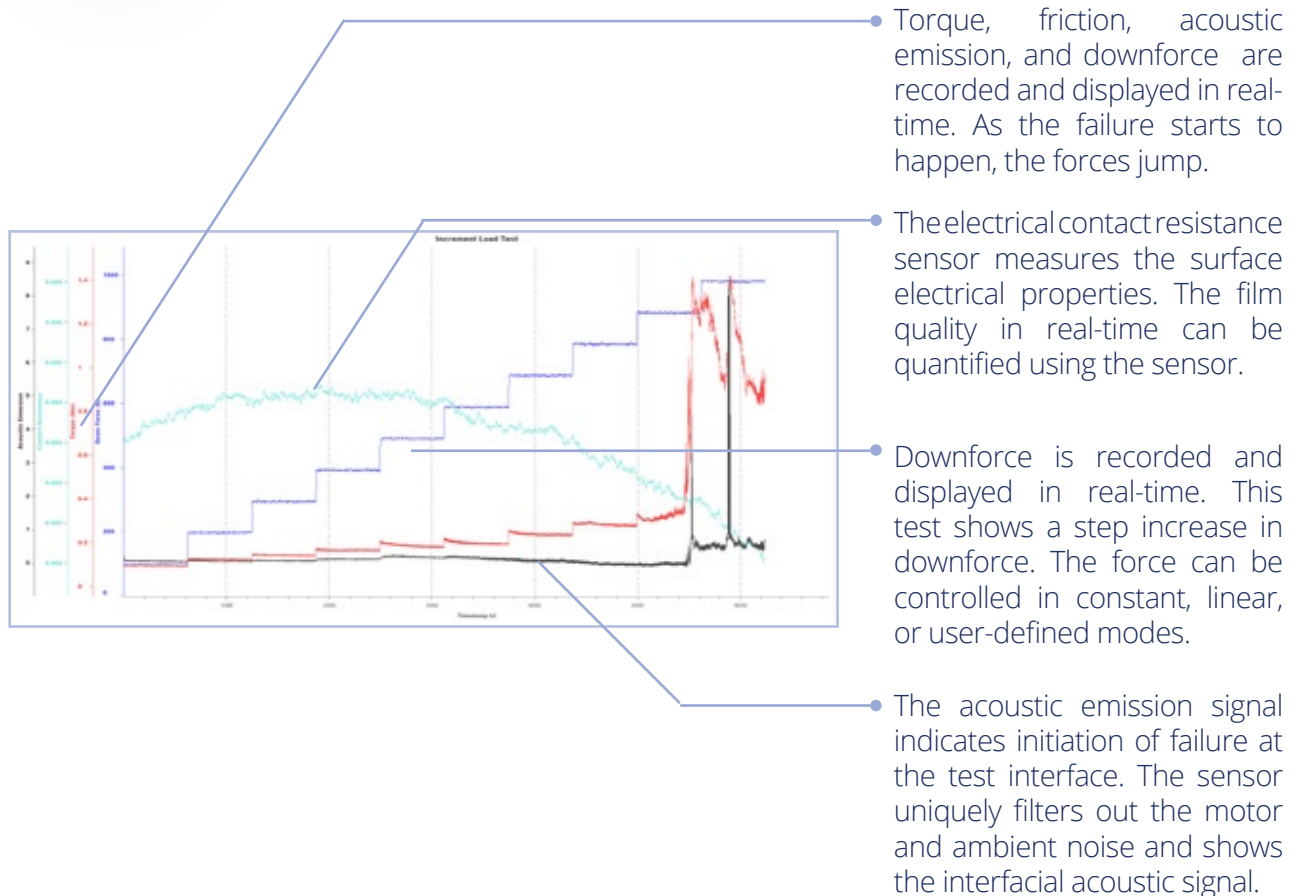
The software is intuitive and easy to learn.

## Test Library

The instrument comes with a series of test protocols that match the user's applications and can easily be modified.



# Automatic Image, Tribology Data Correlation



# Wide Applications

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The versatility of the tester allows the tribometer to play an essential role in several applications. It can be used for thin or thick films, lubricants, materials, soft materials, hydrogels, biomaterials, smooth or rough surfaces, flat or rough surfaces, transparent or opaque surfaces, nano or macro scale, coating or bulk materials, and more.

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## High Temperature

- Hot Hardness Tester (up to 1200°C)
- High Temperature Tribology (up to 1200°C)

## Lubricants, Grease

- Block on Ring, Timken OK
- 4-Ball EP and Wear
- HFRR
- Twist Compression
- SRV
- Tapping Torque, Cutting, Drilling
- Piston Ring Cylinder Liner
- MTM

## Mechanical

- Hot Hardness
- 3, 4 Point Bending
- Adhesion

## Cryogenic

- Low Temperature Tribology (from -120°C)

## Corrosion Testing

- Tribo Corrosion
- Salt Spray

## High Pressure

- Compressor

## Friction Wear

- Rotary Pin on Disk Tribometer, Ball on Disk
- Reciprocating
- Brake Materials Tribology
- Fretting
- Low Friction, Nano Tribology
- Biotribology

## Coatings

- Scratch Test, Adhesion, Hardness
- 2D Materials, Low Friction Coatings
- Fretting
- Pin on Disk, Ball on Disk
- Reciprocating
- Fracture Toughness
- High Temperature Tribology up to 1200°C
- Scratch and Mar Resistance

## Industrial

- Brake Materials Screening
- Optical Lens
- Cutting Tools, Hard Coatings
- Piston Ring Cylinder Liner
- High Pressure Chamber
- Aerospace Tribology
- Textile
- Bearings
- Additive Manufacturing

## Platform Specification

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- Floor Standing- Micro, Macro
- Bench Top- Nano, Micro
- Data Acquisition 200 kHz

### XY Stage

- Range: 130 x 270 mm
- Motion Resolution: 0.1  $\mu$ m
- Maximum Speed: 50 mm/s

### Multiple Z Stages

- Max Speed: 10 mm/s, 500  $\mu$ m/s
- Motion Resolution: 0.25  $\mu$ m, 10 nm

### Computer Console

- Latest Windows OS
- LCD monitor

### Facilities Requirement

- Power Requirements: 110 VAC/ 240 VAC /480 VAC

### Environmental Chambers (Optional)

- -120°C up to 1200°C
- 5 to 90% RH
- Vacuum
- Liquid
- Inert gas
- Corrosion
- Salt Spray
- High Pressure

## Surface Inspection

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### Various Imaging Modules

- White Light interferometer
- 3D Confocal Microscope
- Variable Focus
- Raman Spectrometer
- High Mag. Microscope
- Atomic Force Microscope

### Additional Sensors

- Potentiostats
- Acoustic Emission
- Electrical Resistance
- pH Probes

## Test Modules

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### Various Mechanical Heads

- Tribometer
- Indentation
- Scratch
- Mechanical

### Lower Drives

All drives are in addition to drives mentioned in platform specification

### Rotary Drive

- Range 360°
- Max Speed up to 30000 RPM
- Min Speed 0.001 RPM (low speed drive)

### Fast Reciprocating Drive

- Speed up to 80 Hz
- Stroke 0.1 mm to 30 mm

### Long Stroke Fast Reciprocating

- Speed 35 Hz
- Stroke 40 mm at 40 Hz

### Fretting Drive

- Speed up to 500 Hz
- Stroke 5  $\mu$ m to 4 mm

### Block On Ring Drive

- Range 360°
- Speed up to 7000 RPM

### MTM

- -200 to 200% ratio
- -6 to 6 mm/s
- Up to 180°C



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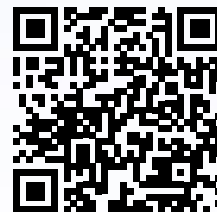
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