//// CSM INSTRUMENTS

Technical Features 2014

Revetest® Scratch Xpress Plus (RSX+)

Revetest® Scratch Xpress Plus

Certified Management System
SQS
ISO 9001

SWISS MADE

www.csm-instruments.com

csm Instruments
A company of Anton Paar

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//// Introduction

CSM Instruments has specifically designed, based on its 25 years of experience in scratch testing, a dedicated measuring module for scratch, wear and profilometry.

Thanks to Revetest® Xpress Plus's unique force feedback loop control, the force applied on the sample is not affected by the surface topography.

Moreover, the Prescan procedure allows to measure the real penetration depth during the scratch and to characterize the elastic recovery using the Postscan procedure.
US Patent 6,520,004

These important features make the Revetest® Xpress Plus a real reliable instrument for both coating-substrate adhesion and surface anti-scratch resistance characterization.

The RSX+ is equipped with a thorough, easy-to-use software package that allows the user to perform scratch tests in a wide variety of testing modes, including simple scratch, advanced scratch test (with Prescan and Postscan), scratch map, scratch map by stage, user defined scratch, etc.

The Revetest® Xpress Plus Tester instrument is globally regarded as the paradigm system for characterizing hard-coated materials, with a typical coating thickness of several microns. Coatings may be organic or inorganic, covering Tribological, magnetic and decorative applications, i.e. PVD, CVD, PECVD, metallization and passivation layers, friction and wear protective coatings. Substrates include metals, alloys, semiconductors, glass, minerals, refractive and organic materials.

CSM Instruments is the world leader in scratch testing with more than 1000 Revetest instruments sold worldwide.

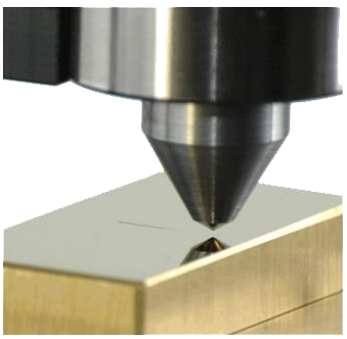


Fig.1 Scratch principle

Characterization of hard coatings, generally deposited by Physical Vapor Deposition (PVD) or Chemical Vapor Deposition (CVD), represents the typical applications of the Revetest Scratch Tester.

Scratch Tests are performed for quality-control of manufactured parts or for evaluation of new developed coatings.

These PVD coatings can be found in numerous industries ranging from automotive parts (parts in diesel injector common rail) to cutting tools and decorative parts.

These ceramic coatings are generally showing a rather brittle behavior, and the delamination or the damaged modes are easy to record. It is subsequently interesting to investigate the modes of damages observed and have a classification of the different coatings according to the results of Scratch test.

Cohesive

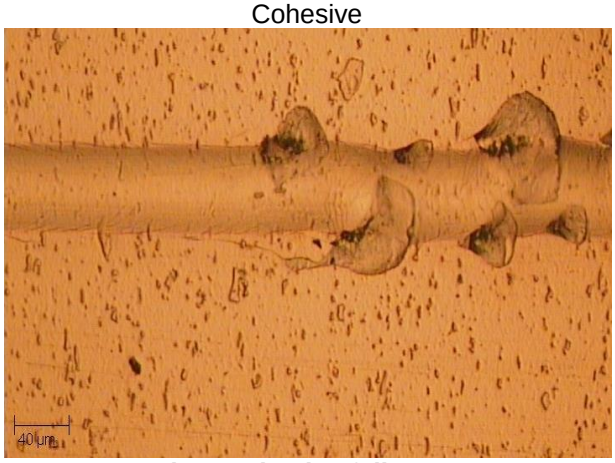


Fig.2 Cohesive failure

Adhesive

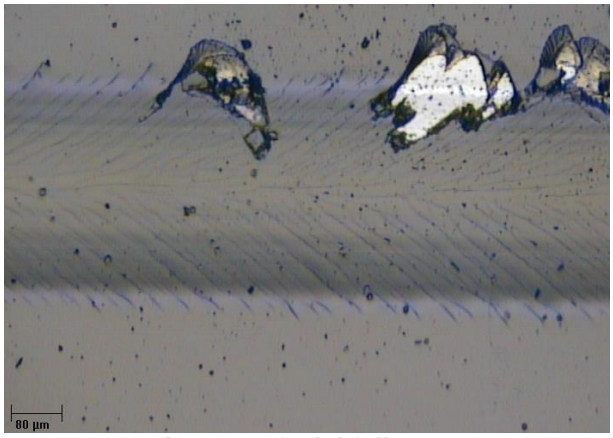


Fig.3 Interfacial failure

//// Key Features

Based on their 30 years of experience in scratch testing, CSM Instruments has specifically designed an instrument for Scratch and Wear testing of hard coatings. The key advantages of this instrument are further explained below.

> Active force feedback loop control

The CSM Instruments Revetest is the only commercially available system in the Revetest Scratch range having a force sensor and an active force feedback. The design of the Revetest measurement head includes the association of force and depth sensors. These unique features provide fast response time, great accuracy and great flexibility for all kinds of scratch measurements. The normal force is perfectly controlled throughout the measurement.

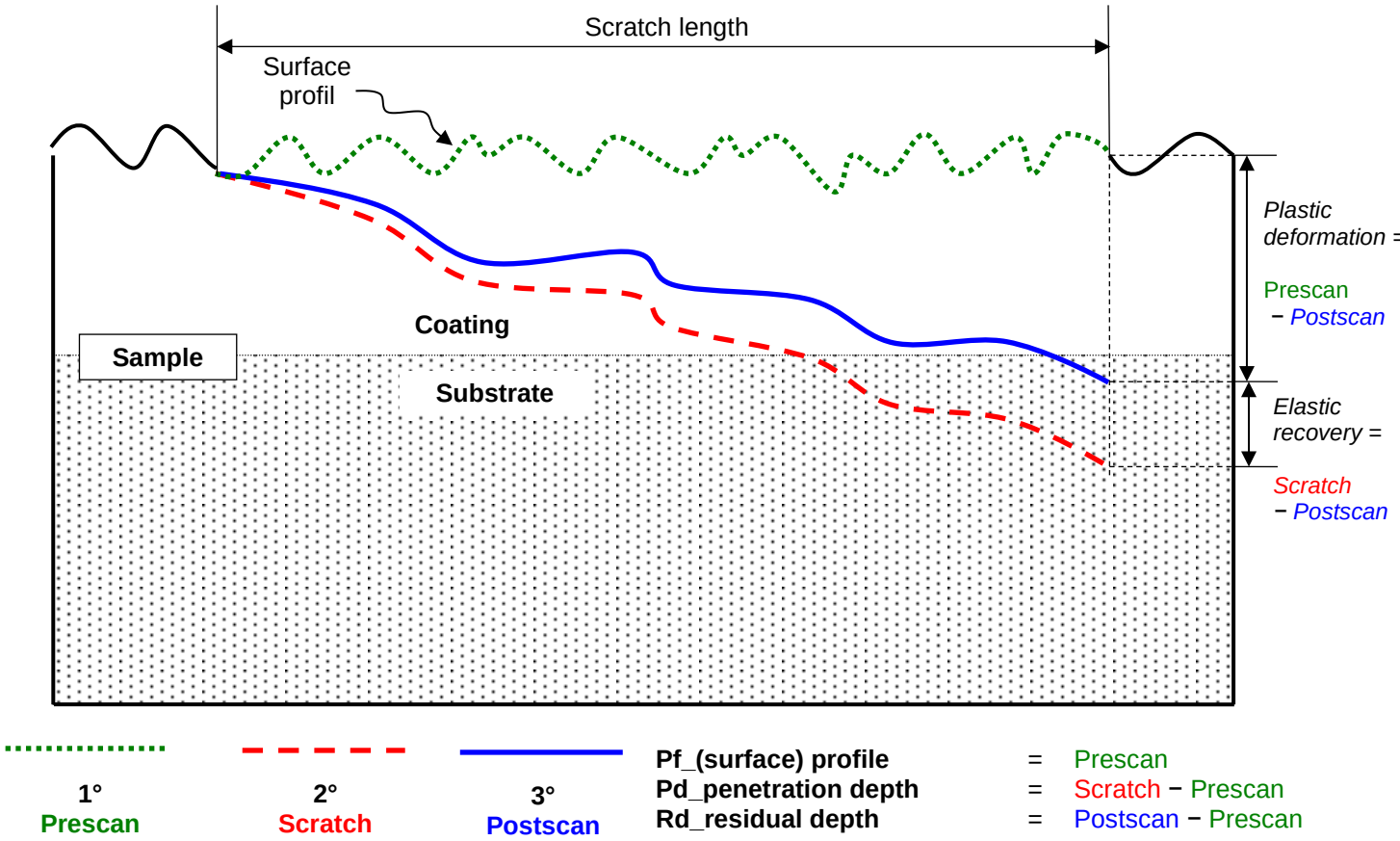
> High flexibility on scratch measurements

The changes of the indenter tips on the indenter holder are easy and quick. Tips of different diameters and angles are available. The same indenter holder can be used for different kinds of tips: spherical tips (1, 2, 5, 10, 20, 50, 100, 200, 400, 500, 800 µm tips with open angles of 120° or 90°), Berkovich, Vickers, Knoop …

>Prescan and Postscan Patented (US.6,520,004 B1)

Is an acquisition of true depth data by correction of the surface profile with pre- and post-scanning the surface with very low loads (typically without deforming the material if min. specified cantilever loads are applied).

Process and results



> High Frame Stiffness

- Marble frame provides high frame stiffness 0.36 µm/N

> Numerous scratch testing capabilities

- Progressive, constant or incremental loading
- Single pass or multiple passes (multipass)

> Measurements on curved and uneven surface

- Curved samples up to 3 mm

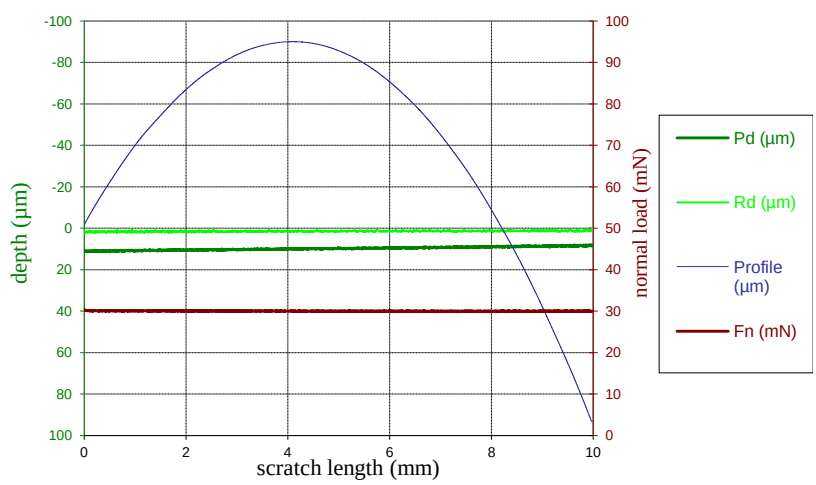


Fig.4 Perfect Force signal due to CSM Instruments unique Active force feedback loop control

Without a fast force feedback system, a slope on the sample surface would result in a deviation from the programmed normal force (the force increases going up a slope and decreases going down). The CSM Instruments Revetest Scratch system, due to its unique force sensor control, detects this deviation and the active force feedback corrects this deviation. The Revetest system is capable of reliable measurements on uneven and curved surfaces. The Revetest Scratch Tester provides the same results on the opposite slopes of a curved sample.

//// General Information

> Complete Revetest® Scratch Xpress Plus Tester system includes

- Scratch head assembly
- Motorised sample manipulation X table 70 mm
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-
-
-
- Rockwell C diamond indenter
- Touch Screen 15'' (1024x768 pixel)
- Optical objective x 10 for magnification x 300
- Complete operating and data analysis software package: scratch analysis

Options:

- Ruggedized X stage for multipass 70mm
- Y motorized table 70 mm
- Y manual table 25 mm
- Optical imaging system
- Objective x5, x10 or x20 (Turret must be added for having 2 to 4 objectives simultaneously)
- Friction measurement module
- Friction table
- Acoustic emission detector (Vallen type)
- Penetration depth measurement

> Dimensions

- RSX+: 360 x 470 mm, 600 mm height
- Touch screen: 380 x 310 mm, 300 mm height
- Total weight: 57.5 kg

> Recommendations for use of the RSX+

- The instrument should be placed on a table isolated from mechanical vibrations
- Temperature-controlled room (preferable)

//// Measurement Principle

- The indenter is lowered until it is in contact with the sample surface. The table moves at a defined speed and the applied load produces a scratch on the sample surface
- The indentation load is applied by an electro-motor assembly.
- The applied load is monitored with a load cell. This load cell is connected to a feedback system to very accurately control the applied load.
- The penetration depth is monitored by a LVDT sensor.
- Cracking events are recorded using an acoustic sensor (Vallen type).
- Friction is measured by lateral deformation through LVDT sensor.

> Advantages

- Very accurate measurement of both the applied load and the penetration depth
- Tangential force recording, coefficient of friction measurements
- Control feedback loop system for easy measurement on curved surfaces
- Profile, Prescan and Postscan of the sample surface **Patented (US.6,520,004 B1)**

//// Revetest® Xpress Plus Specifications

> Normal load

Normal load	Range
Load **[N]**	0 - 200
Resolution **[mN]**	3

> Friction load

Friction load	Range
Max. Load **[N]**	0 - 200
Resolution **[mN]**	3

> **Optional** Depth (LVDT sensor)

Depth	Range
Depth **[µm]**	1000
Resolution **[nm]**	1.5

> Scratching speed

	Min	Max
Speed **[mm/min]**	0.4	600

> Scratch tables

Scratch length **[mm]**	70
Inline scratch inspection **[mm]**	30

> Indenters

- Rockwell C Diamond
- Tip radius 10, 20, 50, 100, 200, 400, 800 µm
- Hard Metal Tip (radius 10 µm)

> Positioning unit

- Two electromechanical translation tables (X/Y) allow accurate sample positioning.
- Calibration of distance between indenter and optical imaging system.
- Each table uses a continuous current motor driving the screw shaft.

> Loading system

The load is applied using a spring acting on a cantilever beam, in turn acting on the indenter shaft. The spring is compressed due to the rotation of a servo motor.

Spring

- Spring constant: 5.65 N/mm

Motor

- Loading rate: up to 600 N/min

The motor speed is controlled by a feedback loop both for current and rotational speed.

> Load cell vibro-meter

- Range: 20 kgf, in compression and tension
- Full scale output (FSO): 2.0 mV/V nominal
- Non linearity: <± 0.015 % FSO
- Zero return: <± 0.015% FSO
- Operating temperature range: − 20 to + 80 degree C
- Thermal zero shift: <± 0.001% FSO/ degree C
- Overload capacity: 150% FSO

> Vertical Displacement Sensor

The vertical displacement sensor determines the penetration depth of the indenter in the material during and after the scratch test. It enables also the operator to use the RSX+ as a medium load instrumented hardness tester. It can also determine the depth of the wear track after a wear test.

> Displacement measurement LVDT

- Indenter displacement range: ± 500 μm
- Displacement resolution:
  - in the ± 100 μm scale: ± 1.5 nm
  - in the ± 500 μm scale: ± 7.5 nm

> Acoustic Emission Sensor

Acoustic Emission has been used for several years to detect on-line the critical loads for cohesive and adhesive coating failures. A new acoustic module developed by the European leader in acoustic emission, Vallen Systeme GmbH, as part of a European project, is now available as an option for the RSX+. The new Acoustic Emission module determines exactly when a crack occurs. The module gives a trigger signal to the computer when a failure event happens; using this trigger signal and the other signals logged during the test (linear velocity, applied load …), the computer determines exactly where the failure has occurred. Correlating the acoustic emission signal with the scratch track brings a lot of useful information.

- Central frequency: 150 kHz
- Dynamic range: 65 dBae
- Maximum amplification: 200’000 x

> Friction Monitoring

The friction force is measured with a spring table under the sample consisting of a LVDT position detector. The specifications are similar to the load cell range 20 kgf in compression and tension.

> Linear Displacement Tables

The positioning table is composed of two linear displacement tables. The tables are fitted with a high efficiency ball screw drive and square rail linear bearings to provide load carrying capability, accuracy and repeatability. Two servo motors are coupled to the tables with an anti-backlash coupling. The control of the displacement tables is performed by a feedback loop for current, speed and position.

>Platform specifications

The CSM Instruments Platform specifications are the following.

Motorized tables **[mm]**	RST /RSX+	Rotary encoder resolution **[nm]**
X	70	33
Y[1)]	70	33

[1)] *In option for RSX +*

Manual tables **[mm]**	RST /RSX+	Manual repositioning sensitivity **[µm]**
Y	25	10
Z coarse (Approach)	30	500
Z fine (Focus)	3	10

Usable areas with optical analysis X x Y **[mm]**	30 x 70

The usable areas of analysis indicate the areas of possible automated analysis in the X and Y directions.

>Repositioning accuracy

Standard repositioning table: ± 1 µm

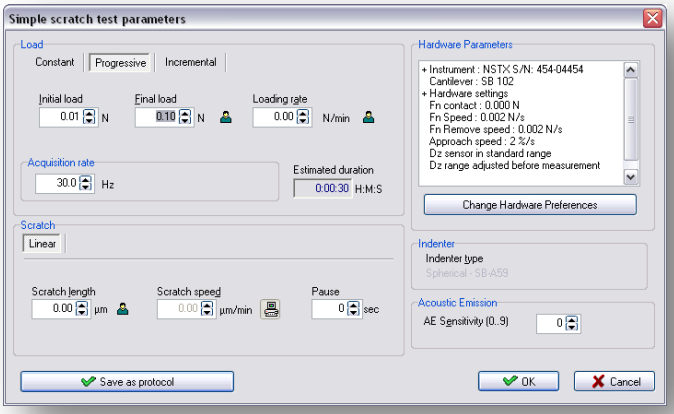
//// Scratch Software V4.0

>General features

Win 7 compatible

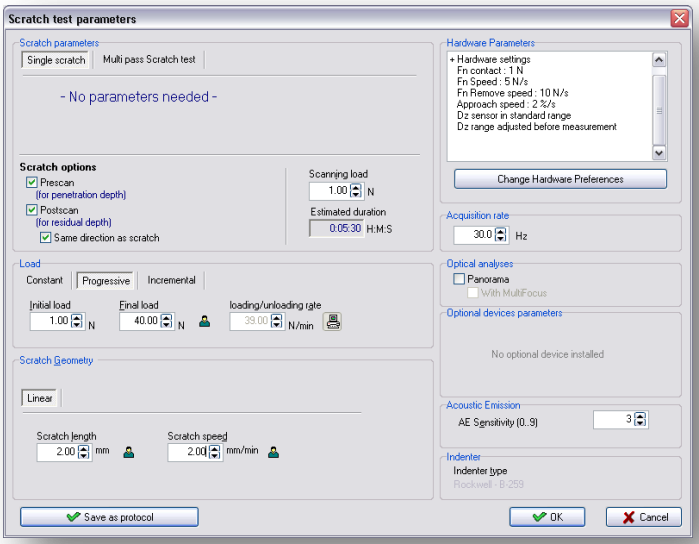
> Simple scratch test

- Parameters:
  - Constant load/ progressive load or incremental load (both with initial/final/loading rate)
  - Scratch length, scratch speed
  - Hardware preferences
  - Possibility to perform an indentation when selecting a zero scratch length



> Advanced scratch test modes

- Scratch type parameters:
  - Single scratch
  - Multipass scratch (unidirectional or bidirectional / wear test)
- Scratch options parameters:
  - Prescan (low load scanning to measure the profile before scratching)
  - Postscan (low load scanning to measure the profile after scratching)
    Patented (US.6,520,004 B1)
- Load parameters:
  - Constant load
  - Progressive load (initial/final/loading rate)
  - Incremental load (initial/final/loading rate)



Prescan and Postscan must have the Depth Sensor installed.
Different features depend on the options installed.

//// Video Imaging

High resolution camera (1280 x 1024 pixels)

The addition of a microscope fitted with a digital camera on the RSX+ enables the user to automatically correlate the scratch track with the different signals (friction force, penetration depth, acoustic emission signal). When a failure event is recorded by the acoustic emission, the software can record the position of this failure event and move the sample under the microscope at this very position to take a picture of the failure event.

> Microscope

1. The measuring head and the microscope are mounted side-by-side and linked by the two X- and Y-translation tables

2. Video microscope magnification from 200x to 800x

3. Allows a specific sample site to be selected

4. Modular focusing unit

- Stroke	30	mm
- Coarse focusing	5.2	mm/rotation
- Fine focusing	0.1	mm/rotation
- Distance optical axis Mounting surface	141	mm

5. Objectives available

- 5x	Working distance	20.0	mm
- 20x	Working distance	1.3	mm
-10x[1)]	Working distance	10.6	mm

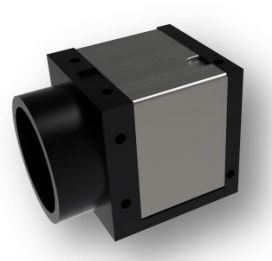
1)Only for RSX+

6. Revolving Nosepieces - 4 objectives max

> E2V CMOS Camera

High Resolution Camera:

1.	Resolution	1280x1024
2.	Sensor	High Quality 1/2" e2v CMOS sensor with square pixels
3.	Scanning	Progressive scan
4.	Frame Rate	Up to 60 fps
5.	Mount adapter	C-Mount
6.	Interface	USB 2.0
7.	Power supply	Via USB (<1.5W)
8.	Size (H x W x D)	34 x 32 x 34.4 mm
9.	Weight	75g



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