//// CSM INSTRUMENTS

Technical Features 2014

ConScan Confocal COS

Certified Management System
SQS
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A company of Anton Paar

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//// Introduction

The ConScan Objective represents the perfect combination of fine resolution 3D confocal microscopy and the advantages of light microscopy. It opens up new possibilities in quantitative surface characterization in the micron range. It is the perfect addition to a CSM Platform testing system, especially for the topographic analysis of CSM's micro-range indentation imprints and scratch tracks. By scanning the sample surface in the x-y directions, the ConScan provides the micro-topographic structure of any type of surface (rough, as well as polished) for any type of material. This includes glossy, mate, transparent and opaque materials, which can prove extremely difficult to image with other conventional imaging systems.

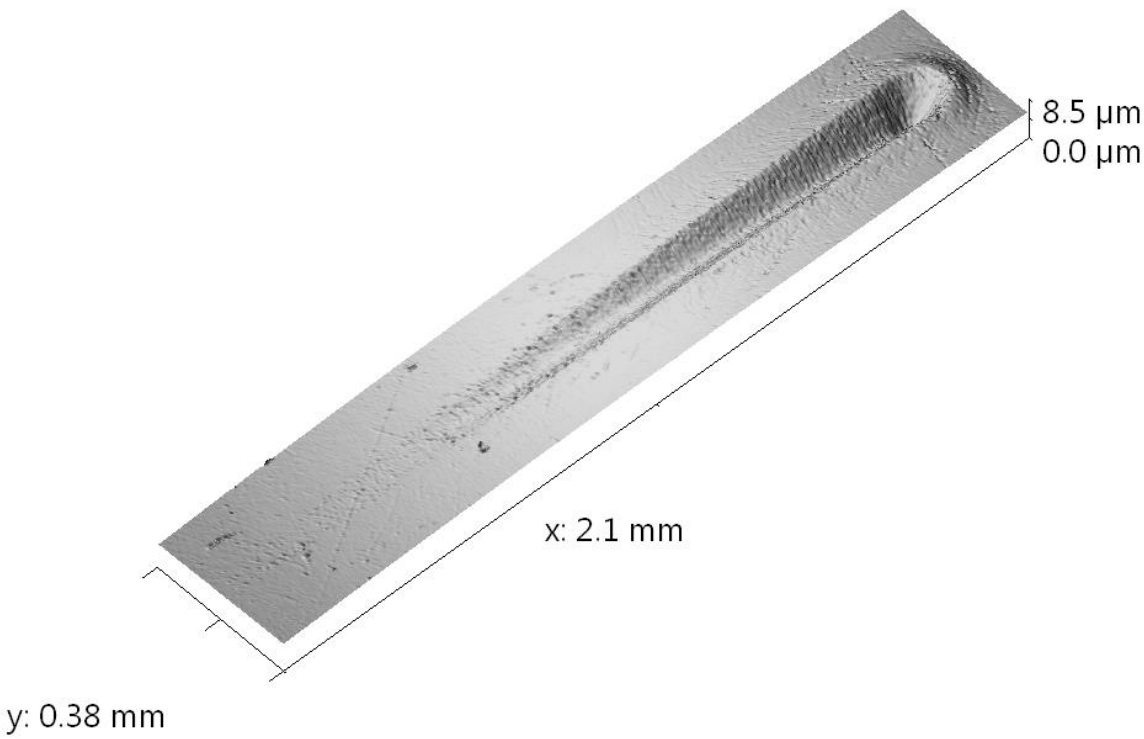


Fig.1 ConScan 3D image of polymer

//// Key Features

> Large scanning range

The ConScan Objective (i.e. white-light confocal objective) is installed as an imaging option on a CSM Platform, which generally includes a Scratch and/or Indentation head for mechanical surface measurements.

The configuration of the CSM Platform allows for a very wide range of sample geometries to be tested. The two different working areas offer large scanning ranges for various samples.

The majority of the images shown in this document are in the 10 x 10mm range.

Working areas by platform are:

- Compact Platform 120 x120 mm
- Open Platform 245 x 120 mm

(a) Compact Platform

(b) Open Platform

Fig.2 CSM Platform (Compact and Open)

> Non contact measurement & totally passive optical pen

The non-contact system allows measurement of sensitive, flexible and soft materials that could be damaged by a contact sensor. It offers the possibility to safely traverse surface features (edges, holes, step height…).

> Three dimensional images

CSM's method of Platform configuration allows for a very wide range of sample geometries to be tested. With our user-friendly image analysis software, transition from simple two-dimensional pictures to interactive three-dimensional images is easy.

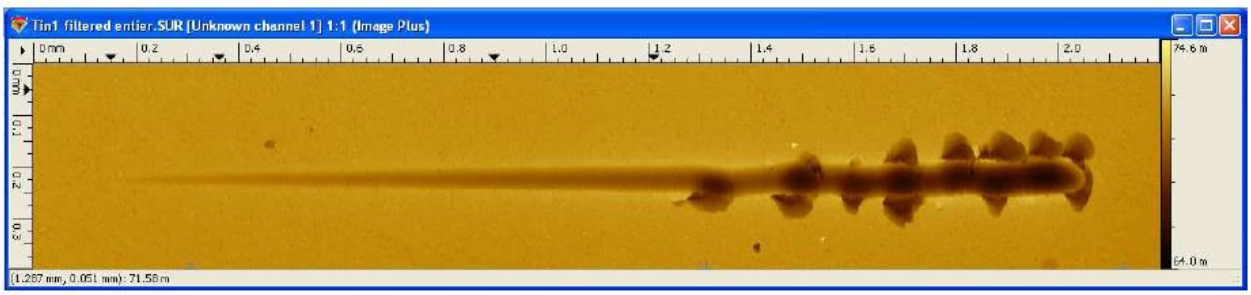


Fig.3 .Topview ConScan image of a 2-mm long scratch on a TiN sample

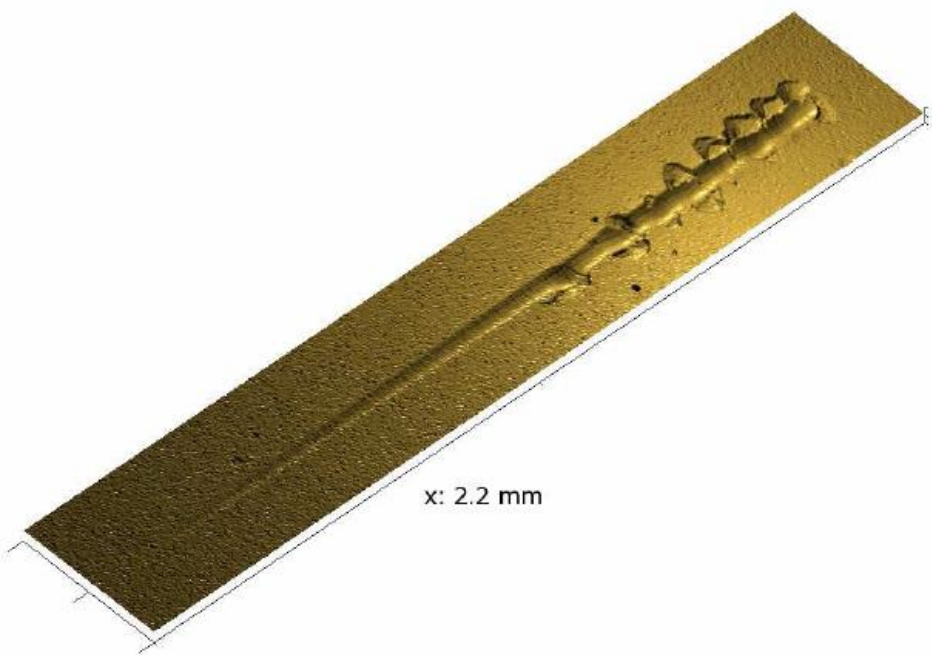


Fig.4 3-D ConScan image of a 2-mm long scratch on a TiN sample

//// Measurement Principles

> White light confocal microscopy

The concept behind confocal microscopy involves the use of the chromatic length aberration (CLA) principle. The first step in optical confocal analysis is to produce white light and direct it through a filtering optical component towards the surface of the sample. With use of the chromatic aberration caused by the dispersive lens, the white light is separated into its component wavelengths, each of which corresponds to a different z-coordinate in the optical axis. This separated light reaches the sample surface as a continuous wavelength-coded range of foci.

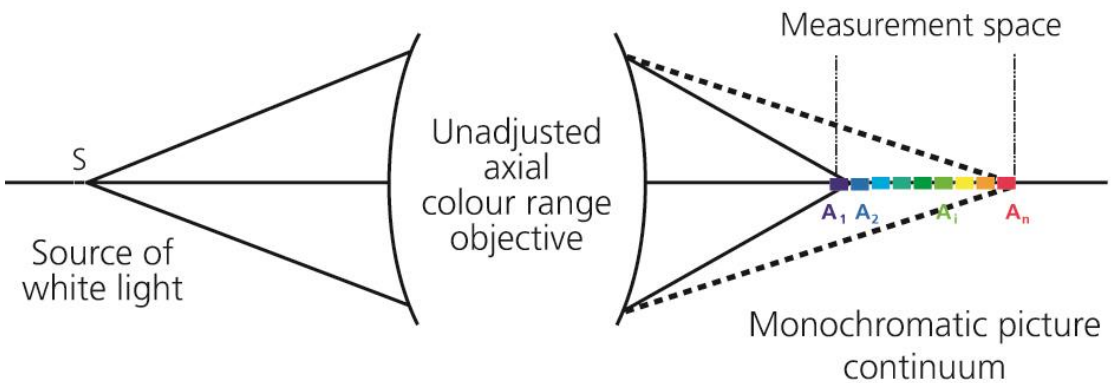


Fig.5 Chromatic coding principle

As each wavelength is represented at a different distance from the lens, the returning light waves will be different according to the height characteristics of that specific area of the sample. Therefore, the resultant spectrum can be regarded as a spectrophotometric signature of the material surface; spectral peaks represent the “height” of the sample at that focus point. The system scans over the surface of the sample, creating these spectral height signatures at sub-micron intervals, summating to an overall image with axial accuracy in the nanometer range.

> Image acquisition

- A single-point white light source directs polychromatic light through a filter towards the sample surface.
- The light then passes through a perfect chromatic lens which separates the white light into its component bands. Each wavelength is represented along the optical axis at a unique position from the lens.
- The wavelength-coded light bounces off the sample surface and travels through a pinhole to the spectrometer.
- The spectrum result is correlated to the height of the sample at that point.
- Using the system tables, the sample is moved under the scanning objective to produce an image of the entire surface.

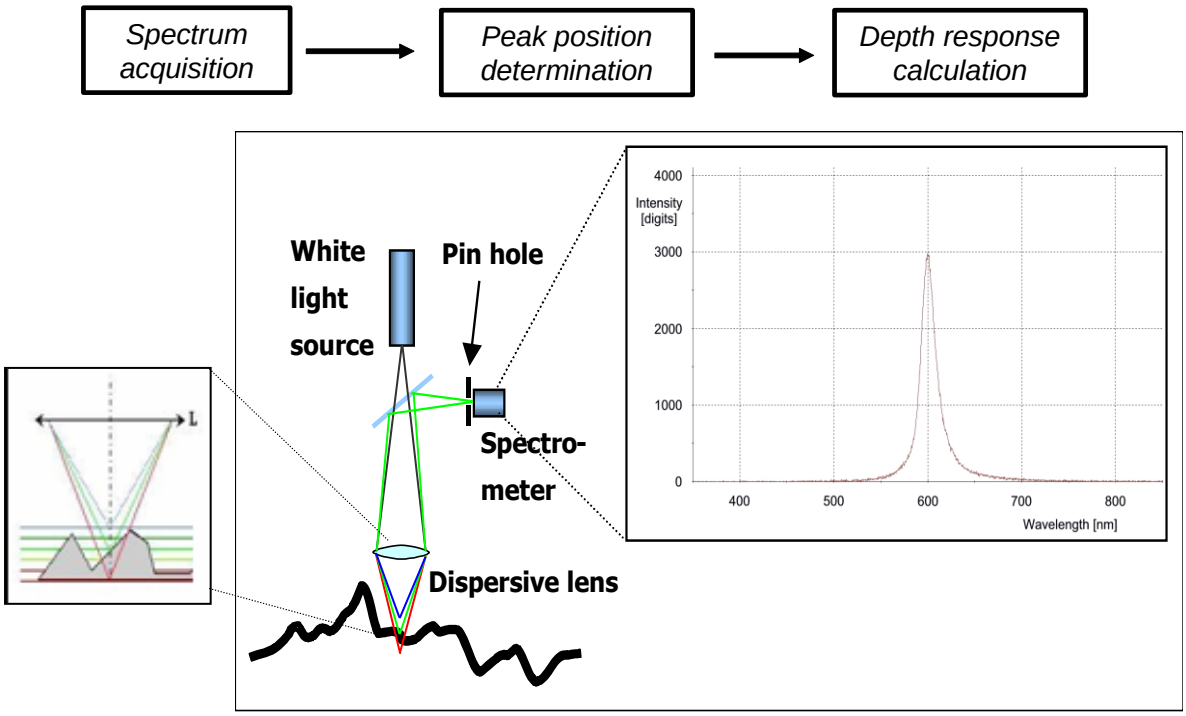


Fig.6 Image acquisition principles of the ConScan objective

> Image acquisition

- Confocal chromatic principles, non-contact measurement
- No sample preparation required
- In situ, fast real time measurements on all types of materials and surfaces
- Totally passive optical pen : no mechanical part in motion in the optical pen
- Interchangeable optical pen allowing different measuring range and axial resolution
- Large range of XY scanning (using instrument's XY tables)
- Profile measurement (direct or extracted)
- Create 2-D and 3-D images
- Perform measurement on transparent surfaces
- Image surface defects and testing deformations

//// Applications

> Profile and surface roughness analysis

As an integrated module on one of CSM's Platform systems, the ConScan adds distinct performance capabilities to your laboratory's facilities. This includes the optical profilometry of surface features and textures, performing post-analysis of the deformation caused by a scratch or indent test, and quantifying roughness, sink-in and pile-up behaviour. The instrument can be used to quickly characterize a material surface texture or imprinted pattern in multiple profiling modes, as well as image in multiple dimensions, as shown below.

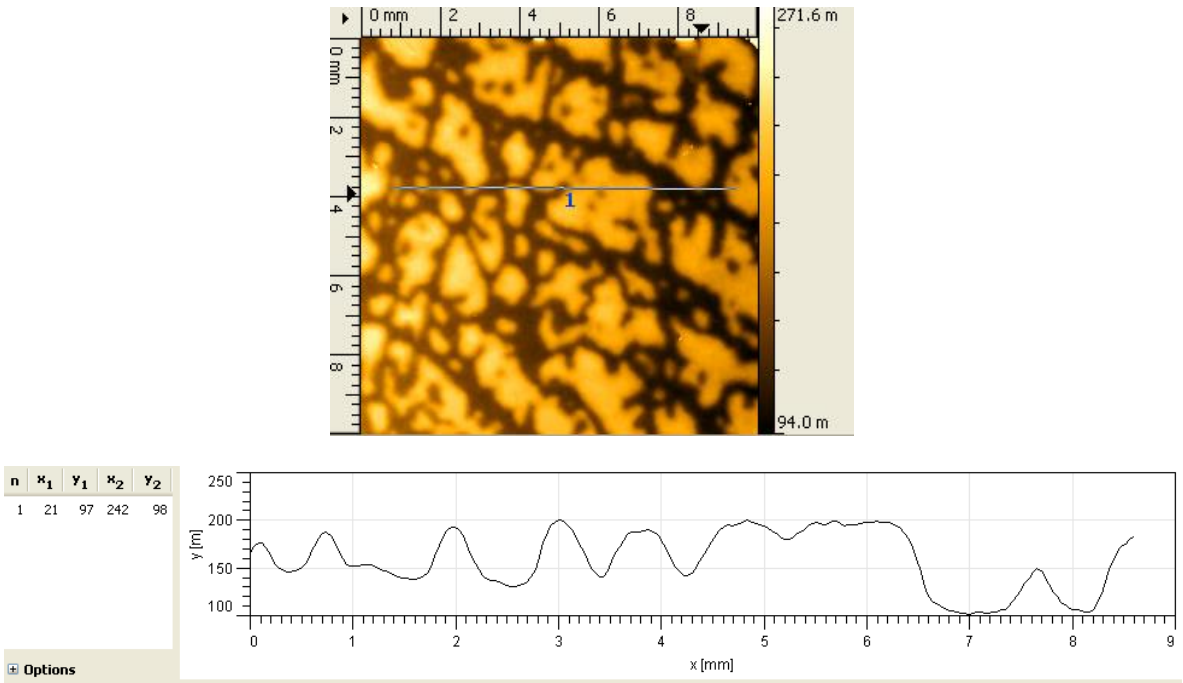


Fig.7 2-D image of a textured polymer resin plaque with profile extraction

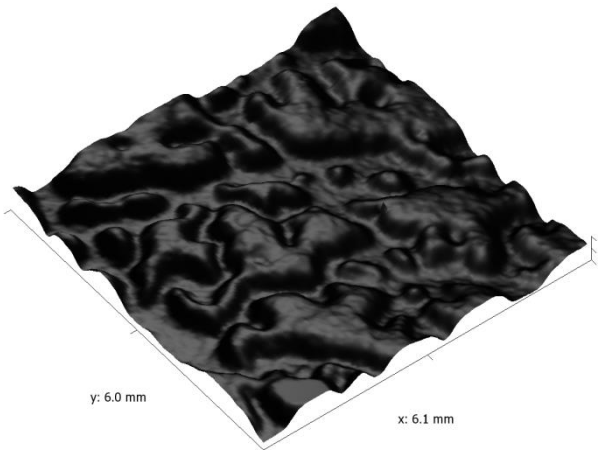


Fig.8 . 3-D image of a textured polymer resin plaque

> Scratch track deformation analysis

The ConScan is an excellent tool to quantify the deformation that occurs when a scratch test is performed. While that process reveals a great deal about the failure modes of a coating or material, a ConScan can provide a method for analyzing the plastic deformation that occurs within and around the scratch track. Using a CSM ConScan integrated with a scratch tester like our Micro Scratch Tester, we can directly obtain results like the height of deformation, volume of the scratch track void, volume of the piled-up material surrounding the scratch, width and angles of the scratch track, and layer thicknesses.

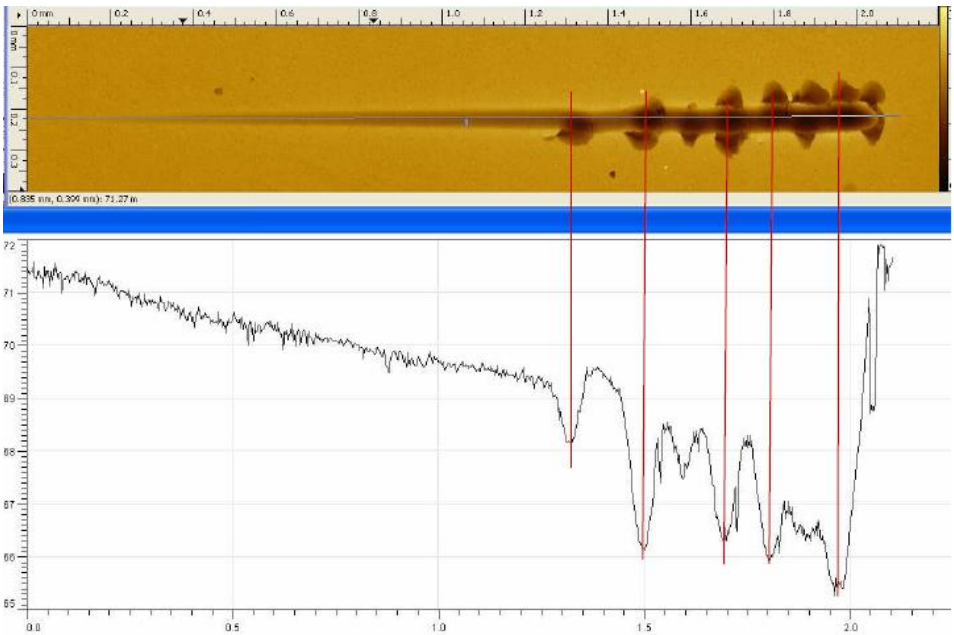
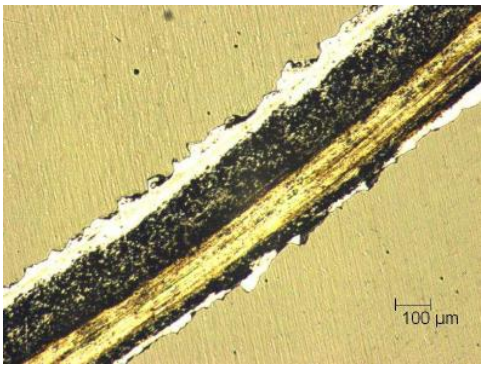


Fig.9 . Longitudinal profile along the scratch track of the TiN sample

> Tribological wear track



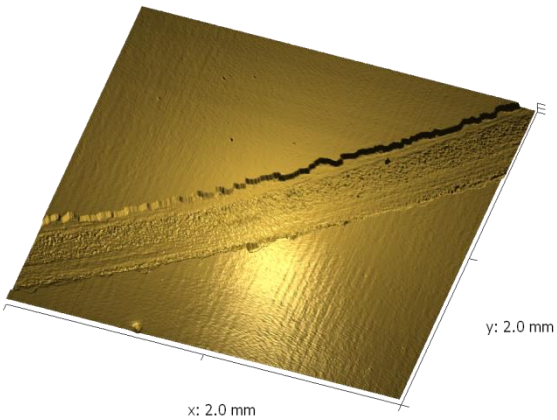
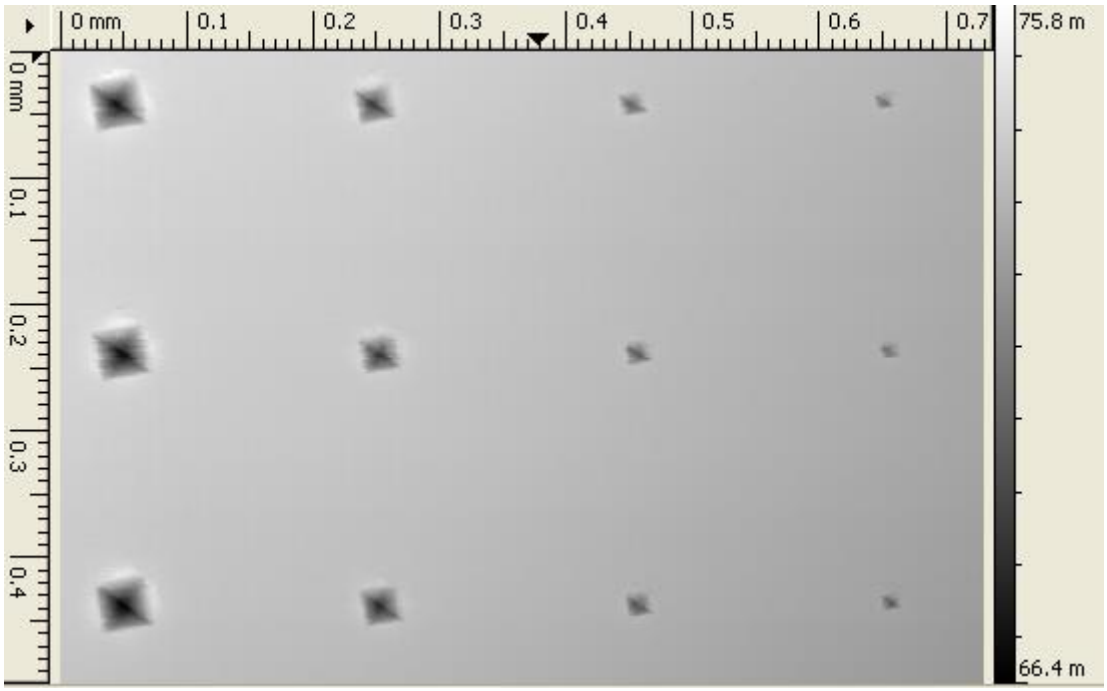


Fig.10 Wear track created by a tribological test on a TiCN sample

> Micro indentation tester



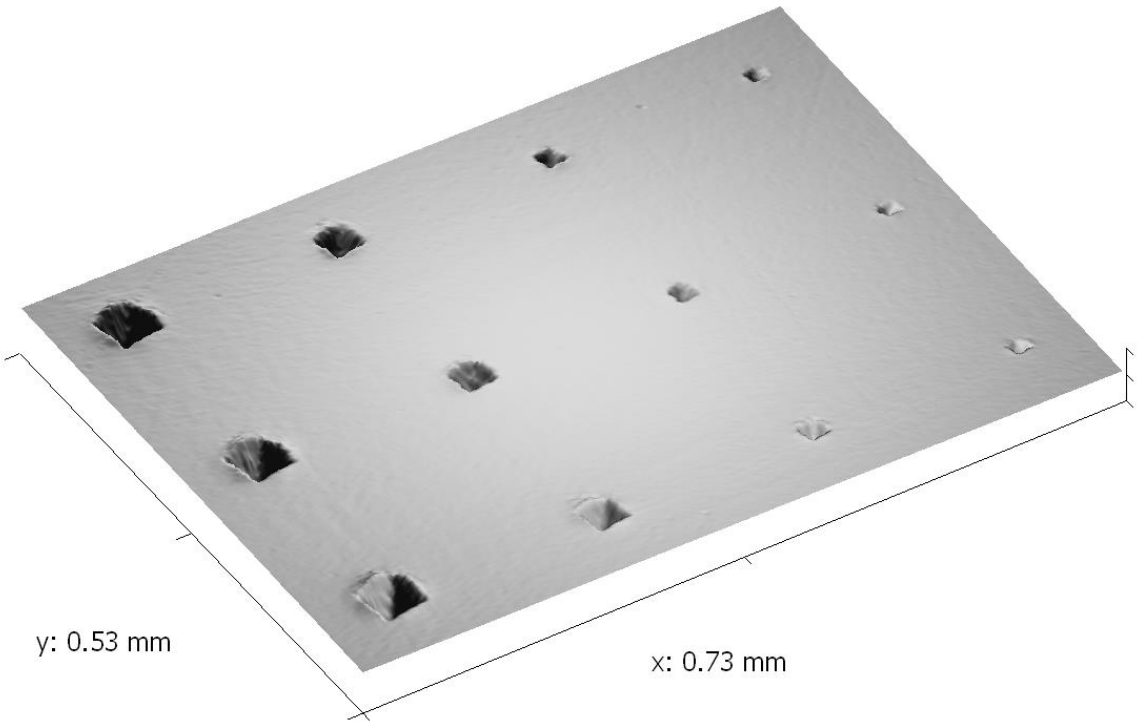
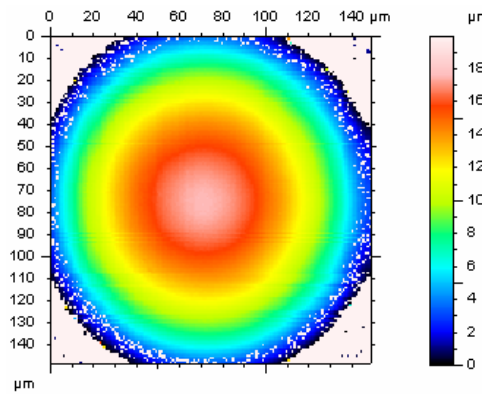
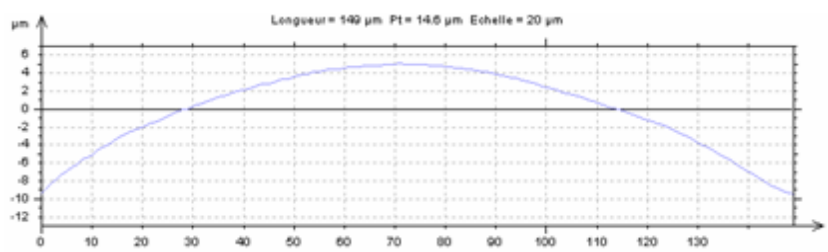


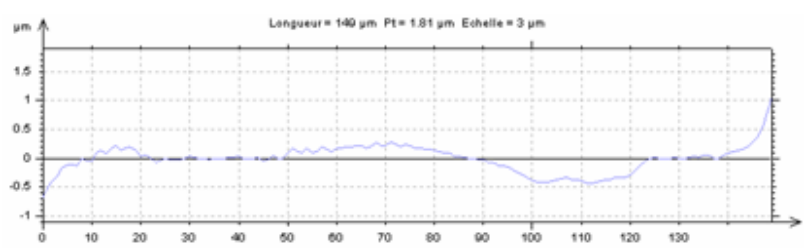
Fig.11 Microindents on a steel reference sample

> Quality-control of indenters

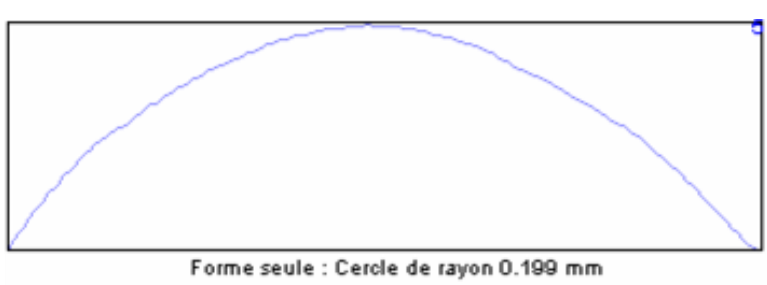




General profile



Spherical form removed for surface roughness determination



Calculation of indenter diameter with form alone

Fig.12 3-D image of an indenter used for Scratch testing

//// General Information

The ConScan Objective is installed as an imaging option on a CSM Platform, which generally includes a Scratch and/or Indentation head.

> Standard ConScan system includes

- ConScan white-light confocal objective (optical pen of 400 µm or 130 µm)
- Optical fiber cable, magnifier, chromatic lens
- Data acquisition software.
- Image analysis software
- Opto-electronic measurement unit.

> Visualization features

- Pseudo-color modeling & Pseudo-photo image modeling
- 3D line representation
- 3D continuous representation
- Single profiles and serial profiles

> Analysis features

- Levelling and form removal
- Hole analysis: volume, surface, perimeter, mean and max depths
- Distance and angle measurements
- Profile extraction in any direction
- 2D & 3D parameters (Ra, Rt, Rq, etc.)
- Perform zoom, rotation, inversion, symmetries
- More than 20 file formats supported (almost all existing profilers and topography instruments)

> Modular design of ConsCan objective

ConScan Objective:

Length:	from 209 mm to 255 mm, depending on the configuration
Diameter:	27 mm
Total weight:	from 190 g to 200 g, depending on the configuration

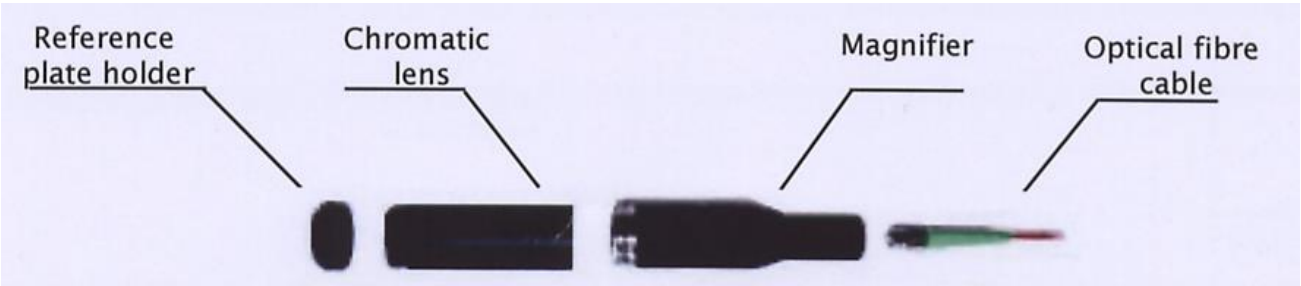


Fig.13 . Modular design of the ConScan objective

Chromatic lens and magnifier are combined to obtain the range of depth of field and spot size desired.

> Recommendations for use the ConScan objective

The range of analysis of the ConScan objective is well adapted for a combination with a Micro Scratch and/or Micro Hardness Tester

> Opto-electronic measurement unit

Fig.14 . Opto-electronic unit

> ConScan Confocal on CSM Platform

Fig.15 . Optical pen on a CSM platform

//// Technical Specifications

Chromatic Lens model	CL1	CL2
Measuring range	130 µm	400 µm
Working distance*	3.3 mm	11 mm
Axial resolution (1)	0.005 µm	0.012 µm
Axial accuracy (2)	0.02 µm	0.06 µm
Max. object slope (3)	± 43°	± 28°
Max. field of view	Open Platform: 245 x 120 mm Compact Platform: 145 x 70 mm Table Top Platform 70 x 70 mm	
Reference plate (4)	No	Yes
Magnifier model	MG2	MG2
Spot size diameter (microns)	2.2 µm	2.6 µm
Lateral resolution (microns)	1.1 µm	1.3 µm
Minimum thickness (microns)	7	15

* Larger measuring distance available on request

(1) Axial resolution : Static background noise. In other words, the smallest difference in altitude that can be experimentally measured on a fixed object.

(2) Axial accuracy : Maximal linear error on the Z-measuring range. Typically, this is the error between a known Z displacement and the Conscan measurement of that displacement.

(3) For specular (perfectly reflecting) samples. For diffusive objects the maximal object slope can reach 87°

(4) The reference plate acts as an absolute reference in the measuring field.

> Data acquisition

> Image Scanning

The image acquisition is performed with the confocal-based optical pen and Z-table fixed at one position. The X&Y tables are moving to scan the whole desired area of analysis. Therefore during an image acquisition, the X&Y tables scan the surface while the Z-table is fixed at a single position.

The X&Y displacement tables provide a very large area for analysis from :

- 245 x 120 mm with the Open Platform (OPX)
- 145 x 70 mm with the Compact Platform (CPX)
- 70 x 70 mm with the Table Top Platform (TTX)

The analysis area is generally limited to a smaller area of a few mm^2 where the main deformation of interest is analyzed: wear track, scratch track, microindent.

> Acquisition Time

The time of acquisition of an image is difficult to estimate because it depends on various parameters: materials light reflection (for example a material with poor light reflection will need a lower acquisition frequency), sample roughness, sample defects, resolution required…

As an example, a quick simple image could be obtained in a matter of 10-20 minutes while a high resolution high quality image (e.g. sample on Figure 10) would require an acquisition time of 2-3 hours.

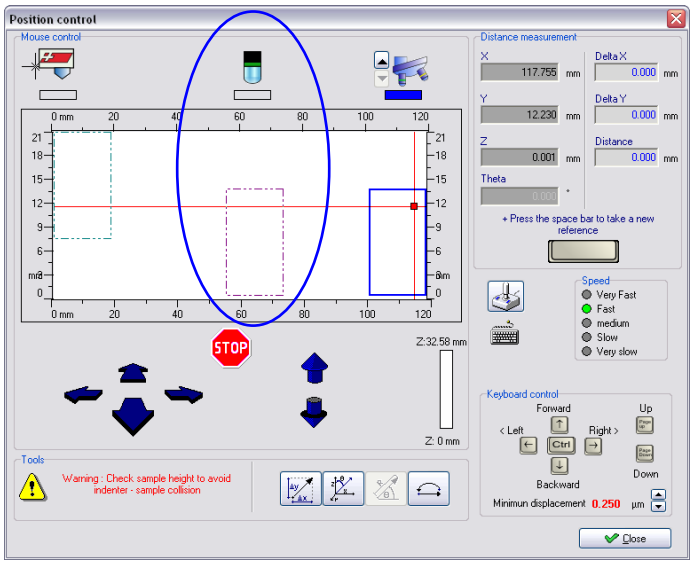
//// Software

> Full software package for data acquisition and analysis including

- CSM data acquisition software, fully integrated in scratch & indentation
- CSM image analysis software.

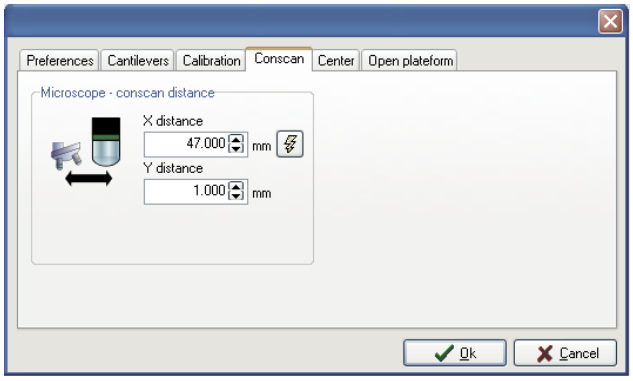
> General features

- Windows 7 Software
- Setup and configuration of experiments
- XY Position control for sample positioning and motion between measurements



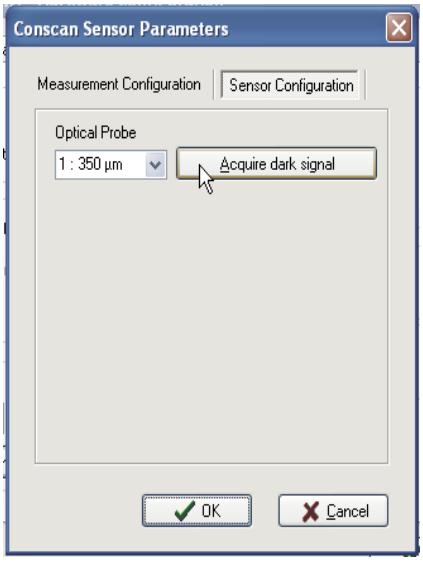
> Calibrating procedure

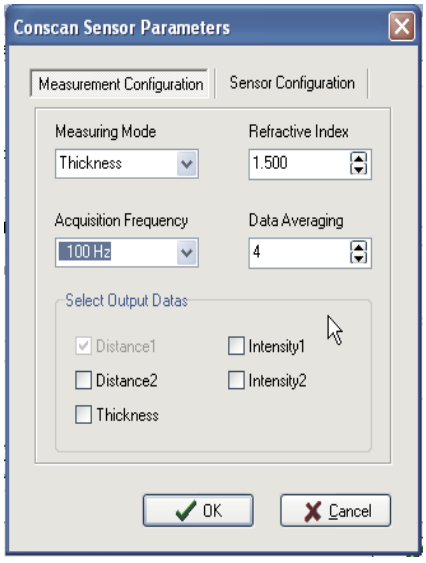
Conscan – Optical distance



> Acquisition parameters

> Sensor parameters





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