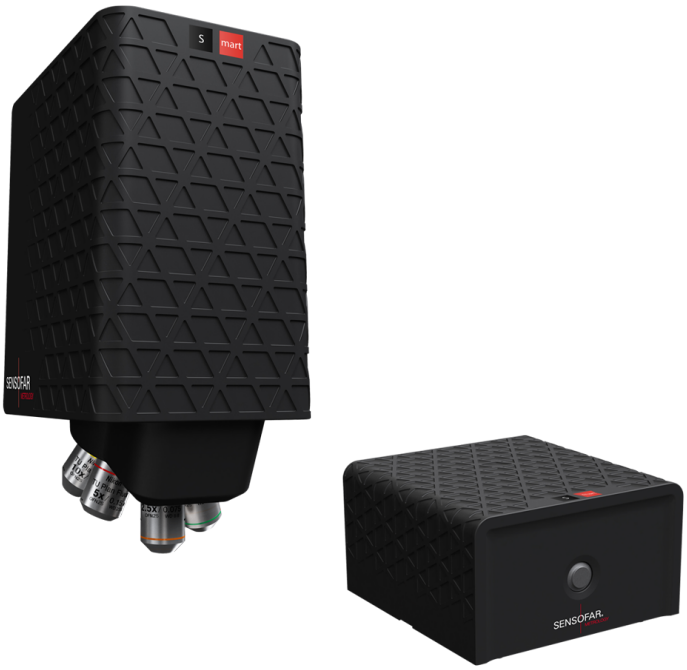
S mart

Installation Manual



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CHAPTER 1

What makes up your S mart?

Names of components and optional parts

S mart is a modular system with several optional parts. It is composed of a system unit, an electronic controller and a main controller.

System unit Electronic controller Main controller

Technical specifications

System weight

Component	Weight [kg]
Sensor head	6.0
Electronic controller	1.8
Main controller & Screen	14.7
Average objective	0.2
Full S mart with one objective	**25.7**

Mechanical dimensions

Specifications of the objectives

	Brightfield							Interferometric				
MAGNIFICATION	2.5X	5X	10X	20X	50X	100X	150X	5X	10X	20X	50X	100X
NA	0.075	0.15	0.30	0.45	0.80	0.90	0.95	0.13	0.30	0.40	0.55	0.70
WD (mm)	6.5	23.5	17.5	4.5	1.0	1.0	0.2	9.3	7.4	4.7	3.4	2.0
FOV[1] (µm)	7016x5280	3508x2640	1754x1320	877x660	351x264	175x132	117x88	3508x2640	1754x1320	877x660	351x264	175x132
Spatial sampling[2] (µm)	5.16	2.58	1.29	0.65	0.26	0.13	0.09	2.58	1.29	0.65	0.26	0.13
Optical resolution[3] (µm)	2.23	1.11	0.55	0.37	0.20	0.18	0.17	1.29	0.55	0.41	0.30	0.23
Measurement time[4] (s)	>3s							>3s				

	Confocal						VSI				
Vertical resolution[5] (nm)	–	75	25	8	3	2	1	1				
Maximum slope[6] (º)	–	8	14	21	42	51	71	8	14	21	25	42

	Focus variation
Min. measurable roughness	Sa > 10 nm
Maximum slope (º)	up to 86º

1 Maximum field-of-view with 2/3" camera and 0.5X optics. **2** Pixel size on the surface. **3** L&S: Line and Space, half of the diffraction limit according to the Rayleigh criterion. Values for white LED. Spatial sampling could limit the optical resolution for interferometric objectives. **4** For brightfield objectives, 21 scanning planes (confocal). **5** System noise measured in a calibration mirror placed perpendicular to the optical axis. **6** On smooth surfaces, up to 86º on rough surfaces.

Note: If you need another objective to complete your system or solve new applications, do not hesitate to contact your Sensofar distributor or send a request to info@sensofar.com.

CHAPTER 2

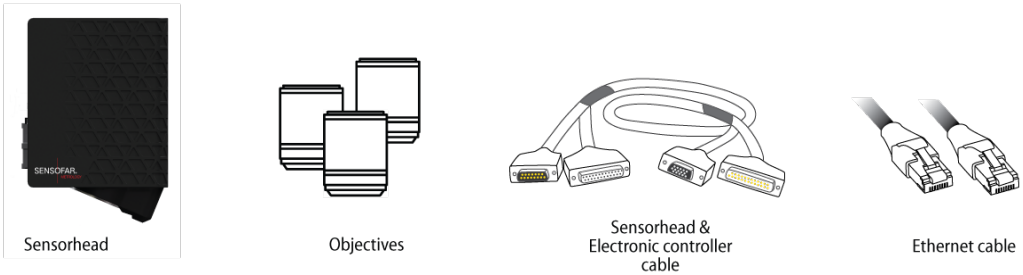
What is in the box?

The S mart control electronics, sensor head and computer were carefully inspected, both electrically and mechanically, before shipment. The operating system (Microsoft® Windows 8) and the acquisition software (SensoSCAN) were also installed before shipment.

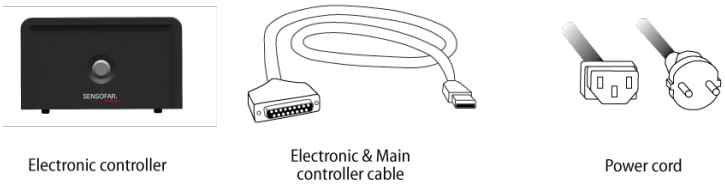
Important: When you receive the instrument, unpack it and check for any obvious signs of physical damage that may have occurred during transit.

The S mart consists of several default modules and optional modules that depend on the configuration of the system. The following items are shipped with the S mart system for each module.

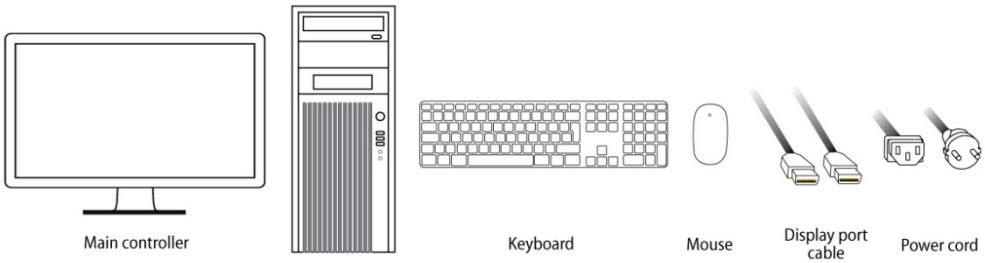
Sensor head module



Electronic controller module

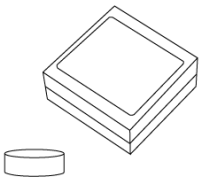


Main controller module

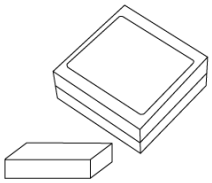


Others

USB recover system



Reference mirror



Calibration specimen

Software

SensoPRO LT

SensoMAP

CHAPTER 3

How to install your S mart in 5 steps

Important: Read all the installation instructions (and the Safety Information starting in Chapter 6) carefully before you first use the system.

Check the device's electrical connections when you use it for the first time. Check whether the device should be connected to 110 V or 220 V. The system's power connection must have earth connection.

Warning: Any improper use or connection of the components may cause irreversible damage.

Step1. System assembly

Assemble the mechanical parts that support the S mart sensor head and other mechanical parts.

Sensor head

Option A – With adaptor plate (recommended option)

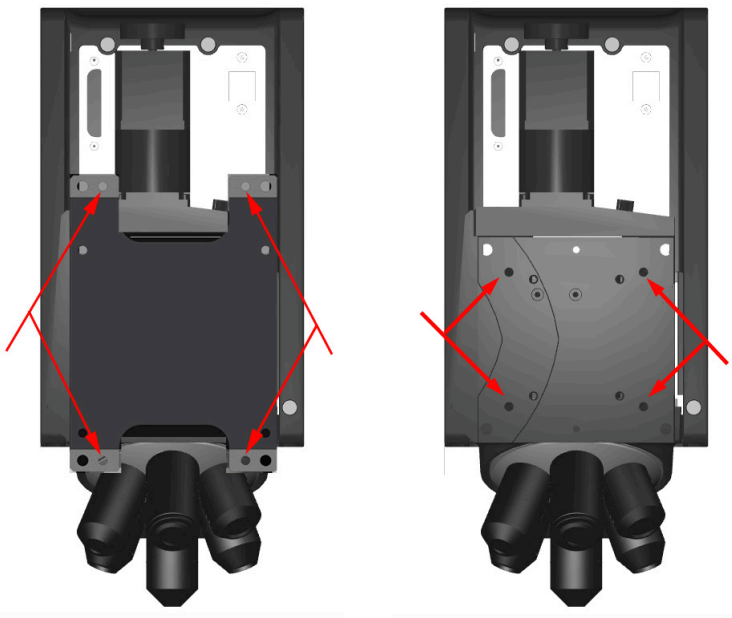
1. Use four M6x25 screws to attach the adaptor plate to its support, as shown in the diagram.

Option B – Without adaptor plate

1. Remove the adaptor plate unscrewing the four M6 screws.
2. Use four M6 screws to attach the sensor head to its support, as shown in the diagram. Length will depend on the support (minimum 20 mm).

   Note: Take into account that the minimum screw length inside the motor must be 6 mm and the maximum screw length inside is 8 mm.

   Warning: Fix the sensor head to its support with a pressure of 6 Nm (the use of a torque wrench is highly recommended).



Objectives

1. Mount the objectives in the nosepiece.

   Warning: Thread the adapter on to the interferometry objectives before you mount them.
   Warning: Don't look through the objectives if the system is working.
   Warning: Don't touch motorized nosepiece during the automatic movements.

Electronic and main controllers

1. To avoid vibrations, set up a separate table for the electronic and main controllers, but still positioned close enough so that they can easily be switched ON/OFF.

   Warning: Don't block system air vents.

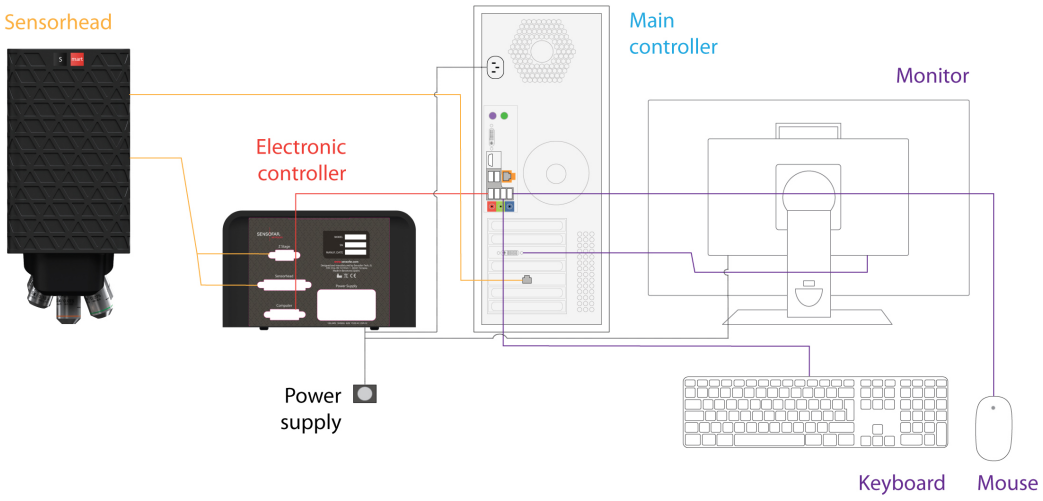
Step2. Cable connections

The following diagram and explanation shows how to plug in all the connection cables and electronics.

Warning: Plug all the connectors into the right places. Any errors in the connections can cause irreversible damage to the system.

Warning: All cables and connectors should have a minimum bend radius of 6 times the diameter of the cable. For instance, for the cable connecting the S mart sensor to the controller (Ø 8 mm) the minimun bend radius is **48 mm.**

1. The **sensor head** has two cables: one for the sensor head and one for the Z stage. These must be connected to the 'Sensor head' connector and the 'Z Stage' connector on the electronic controller respectively.
2. The **ethernet cable** is connected from Ethernet connector on the 'Sensor head' to the Ethernet connector on the main controller.
3. The **controller cable** is connected from the 'Computer' connector on the electronic controller to the USB port with the red label on the main controller.
4. The **keyboard** and the **mouse** are connected to the USB ports on the main controller.
5. The **monitor** is connected from the display port on monitor device to the display port on the main controller (external graphic card).
6. The **power cords** should be connected and the power supply checked (110-240 V AC 50-60 Hz).



Optional Parts

Software: SensoMAP or SensoPRO LT dongle

The SensoMAP or SensoPRO LT dongle key is connected to one of the USB ports on the main controller. If there are no free USB ports on the main controller, see how to install a USB hub to connect the dongle.

Step3. Start up

The following power-up procedure must be followed before the start of every S mart session.

Important: Ensure that all the cables are connected correctly.

1. Press the power button on the main controller (PC). Wait until Windows® 8 shows the login window and login.

   Warning: S mart users must have administrator rights on Windows®8.

2. Wait until all windows services have been loaded and press the power button on the electronic controller.

   Warning: Wait approx. 40 s between switching on the electronic controller and starting up the software.

3. Double click on the SensoSCAN software icon.

4. When SensoSCAN is started, the login window prompts the user to enter a username and a password. To enter with administrator rights, the username is **Administrator** and the password is **adm1234**. For more information on user rights, see the User Manual.

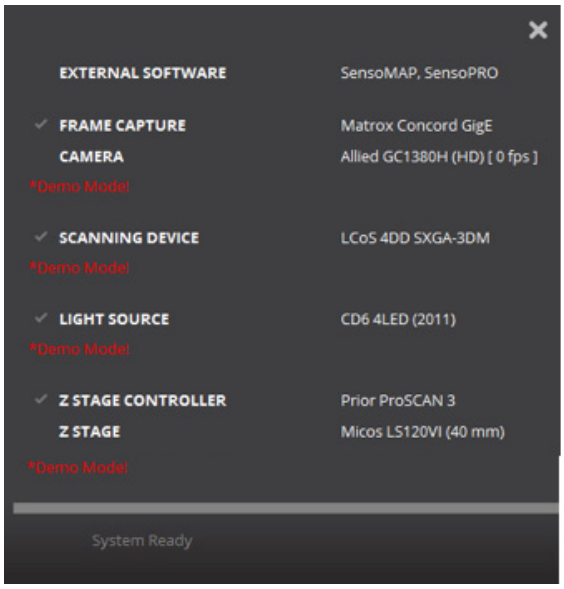
   SensoSCAN starts in Inspection & Acquisition mode. The Display & Analysis mode is shown once a new measurement has been acquired or a previous measurement has been loaded from file. Configuration & Alignment mode is displayed when the appropriate option is selected from the toolbar. See the User Manual for more details on using these modes.

5. The toolbar at the bottom of the Central Viewer shows the status of the system and information about the procedure that is currently running.

   The status may be:

Status	Color	Description
OK	Background	System is working properly
Demo	Background	System is working properly in demo mode
Warning	Blue	System is working but there are warnings
HW Error	Red	A hardware error has been found
System Exception	Red	A Software Exception has occurred, restart the software

   System Status shows a green tick when the device has started up correctly or a red cross when the device has not initiated correctly. Clicking on this icon reveals the System Status panel – this panel reveals detailed information about errors and warnings. If the system does not initiate correctly, check the cause of error and contact the local distributor (see Chapter 7).



Step4. Calibration

The following procedures are carried out in the Configuration & Alignment mode. To enter this mode, choose Configuration from the toolbar. More information can be found in the User Manual.

Z Options

Z Options provides information about the Z stage installed in the system, its status and the travel limits.

Warning: Don't put the fingers on the Z stage.

1. *Home Search Z* – Click on the *START* button. The Z stage will move towards the upper limit switch until it is triggered. It will then move away slowly until the limit switch opens again. At this point, it will move a safe distance away from the limit switch (0.150 mm) and will set the Z = 0.000 coordinate at this position.

   Warning: The *Home Search Z* function can only be executed if the Z position is below the parking position.

2. *Move all Z range* – Click on the *START* button to perform a movement along the entire Z axis. This maintenance test must be done once a year.

   Warning: *Move all Z range* must be executed the first time that the program is installed. When the program executes this movement, it is important to ensure that nothing blocks the stage movement.

Alignment options

The following steps will check the alignment achieved during the manufacturing process.

In order to manually check the system alignment press F9 and a cross will be displayed on the live image. To remove the cross press F9 again.

1. Place the flat calibration mirror supplied with the S lynx on to the microscope sample plate and focus on it.

2. Position the 20X EPI objective and select *Slit Confocal* from the Image View options. Ensure that the mirror is well focused. If the mirror is slightly tilted or tipped, recalibrate the XY table position until the entire image of the mirror is in focus.

3. Move the Z stage until the slit pattern is perfectly focused on the whole screen. The best focus position is obtained when the pattern shows the thinnest slit appearance. This position can be achieved by using the fine movement of the software joystick.

4. Adjust the illumination by clicking the *Autolight* button.

5. Then click *Start* in the Microdisplay pane. A measurement bar showing the amount of alignment between the slit pattern and the camera will appear. The result must be better than 50%. If it is worse, please contact Service & Support.

6. Now click *Start* in the Vignetting pane to check the illumination uniformity. The result for this measurement bar must be better than 50%. If it is worse, please contact Service & Support.

Calibration options

The following three calibration steps will check the alignment achieved in the manufacturing process.

1. To start, focus on the flat mirror supplied with the S lynx with a 20X objective. Ensure that the mirror is well focused.

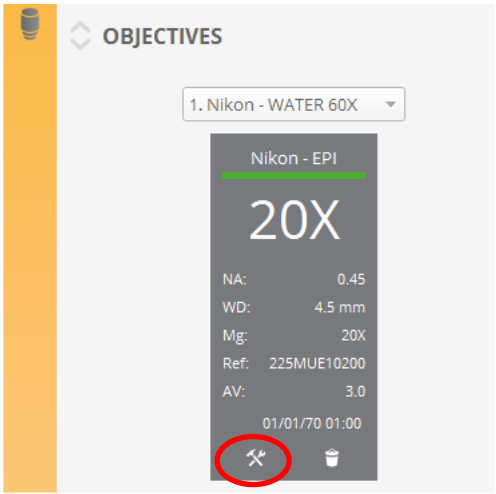
2. Click *START* in the *Slit Position* pane. If the slit position calculation is carried out successfully, SensoSCAN will show the nominal position of every slit with a red line. If the slits are in the wrong position the software will identify the problem and will show the message '*Wrong Slit Position*'.

3. Finally, click *START* in the *Image Filters* pane to optimize filter performance (maximizes the speed, depending to the computer).

Objective calibration

The *Objectives* pane is used to select which objectives are installed on the nosepiece. Only the objectives that are part of the system configuration are available. The number of objectives that can be selected depends on the nosepiece.

Properties of the objective, such as NA, WD, and reference number are shown directly when an objective has been selected. Calibration options are revealed by clicking on the tool icon at the bottom of the objective's info pane.



Selection and ordering of the available objectives:

1. Select the objective that you are currently using from the available objectives. A list of available objectives appears when clicking on the down arrow.

2. Objectives can be added to the list by clicking the "**+**" button for any empty positions in the list. Objectives can be deleted from the list by selecting them individually and then clicking on the recycle bin icon.

3. Order them in the list by removing from current position and adding in a new empty position. Positions on the list can also be left blank if required.

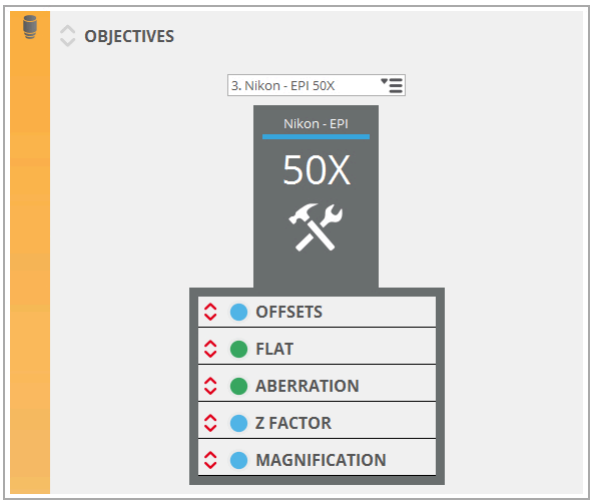
   Warning: This is a critical step if the system has a motorized nosepiece. The order of the objectives in the list has to match those on the nosepiece.

Calibrate the available objectives:

4. Before calibrating an objective, ensure first that the tip-tilt is properly aligned.

5. Rotate the revolving objective nosepiece to position the objective to be calibrated and select the objective from the list (be aware of the working distance of the objective). If the system has a motorized nosepiece, click only on the objectives list.

6. Click on the tool icon at the bottom of the objective's info pane to reveal the calibration procedures.



7. Place the flat calibration mirror supplied with the S lynx on the microscope sample plate.

8. Focus the mirror coarsely (use the *Slit Confocal* image for brightfield objectives and the *Iris* image for interferometric objectives).

9. Change to the *Brightfield* image and adjust the light by clicking *Auto*.

10. Find a very clean area on the mirror (free of scratches and dust particles). If this is not possible, clean the reference mirror (see *Chapter* 6).

11. Open the *Flat* option that is used to correct non-uniform illumination within the field-of-view. To perform the *Flat* procedure, click on the *START* button. The software automatically runs a process to correct for non-uniform

illumination. When complete, the red traffic light will change to green. Click *FINISH* to end the process. To return to the previous setting click *CANCEL*.

Warning: To perform a *Flat* using an interferometric objective, move some microns above the focus position at which the sample is out of focus (avoiding the interferometric fringes).

12. Aberration. Press the *START* button to correct the objective's aberration (brightfield only). The objective calibration procedure will run automatically using the installed LED. Click *FINISH* to end the process. When complete, red traffic light will change to green. To return to the previous setting click *CANCEL*.

    Warning: If the image is saturated, the acquisition will be wrong. Move Z up and down to make sure that the maximum fringe contrast is not saturated.

13. Focus Variation. It is recommended to carry out this calibration if extended topographies are performed using objectives from 2.5X to 20X. Must be done with calibration specimen. Press the *START* button to correct the focus variation objective's aberration.
14. Fusion calibration is required to perform 3D measurements with Confocal Fusion. Must be done with calibration specimen. Press the *START* button to correct the offset between Confocal and Focus Variation.
15. Click on *TOOL* to exit of the calibration objective procedure.
16. Repeat this procedure for each objective.

Step 5. Shut down

The following shut down procedure must be followed before powering down the system.

1. Close the SensoSCAN application by clicking on window close button, or simply by using the menu. Wait until the system closes the application correctly.
2. Press the power button on the electronic controller in order to switch it off.
3. Shut down the main controller by selecting *Start* and then choosing the *shut down* option.

Using this procedure the system will be disconnected in the correct way.

CHAPTER 4

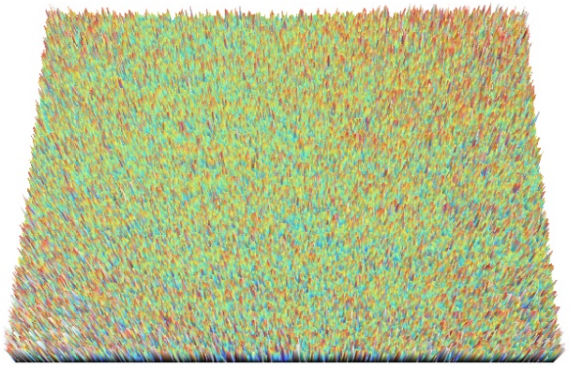
Your system is ready, now check it

Note: Read the user manual for more information about SensoSCAN.

Following alignment and calibration procedures, the S mart is ready to take measurements. Nevertheless, it is best to check that the objective alignment and calibration are correct. The test has to be performed with the same flat calibration mirror supplied with the S mart.

3D Performance for brightfield objectives

1. Focus the mirror surface and find a very clean area.
2. Adjust the light.
3. Select the following acquisition parameters:
    a. **Technique**: Confocal
    b. **Measurement**: 3D
    c. **Objective**: the objective you want to check
    d. **Area**: full
    e. **Z Scan**:
        i. Speed factor: 1X
        ii. Average images: 1
    f. **Z Range**: choose a range that gives a minimum of 30 planes
    g. **Threshold**: maximum (third level)
4. Press *ACQUIRE* and wait until the measurement is displayed.
5. Save the 3D. Now repeat the measurement.
6. The appearance of the subtracted topography will be a flat random noise.



7. Check the rms value and ensure that the S mart is within specifications (see Chapter 1).
8. Repeat the entire process for each objective.
9. If the vertical resolution value (Sq) of the measured profile for a given objective does not meet the specifications, the calibration procedure must be performed again.

3D Performance for interferometry objectives

1. Focus the mirror surface and find a very clean area.
2. Obtain null fringes by rotating the wheels of the tip-tilt stage.
3. Adjust the light.
4. Select the following acquisition parameters:
    a. **Operation Mode**: Interferometry
    b. **Measurement**: 3D VSI
    c. **Objective**: the objective you want to check
    d. **Area**: full
    e. **Z Scan**:
        i. Speed factor: 1X
    f. **Z Range**: 15 µm
    g. **Threshold**: medium (second level)
5. Press *Acquire* and wait until the measurement is displayed.
6. Save the topography. Now repeat the measurement.
7. Choose the Fast Fourier Transform (FFT) filter from the *Add Operator* option to subtract high frequencies (High Pass fc 1%).
8. Check the rms value and ensure that the S mart is under specifications (see Chapter 1).
9. Repeat the entire process for each objective.
10. If the vertical resolution value (Sq) of the measured profile for a given objective does not meet the specifications, check environmental vibrations.

CHAPTER 5

Troubleshooting

Read the troubleshooting tips when you have a problem.

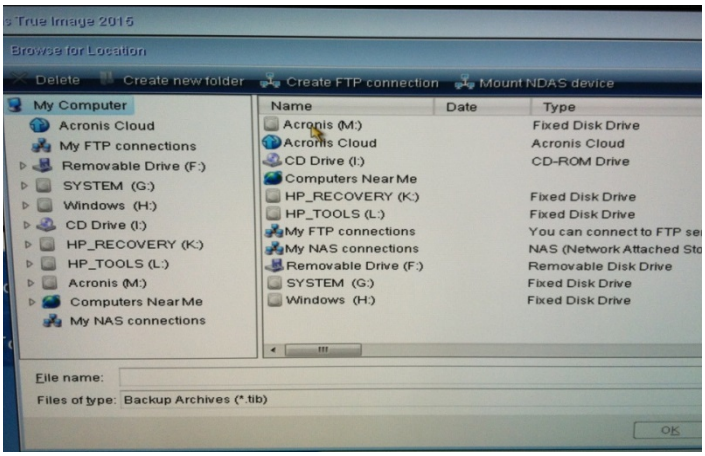
Warning: Do not attempt to open your S lynx. If your S lynx needs a service, see 'Sensofar Service & Support' in Chapter 7.

Restoring or reinstalling the main controller

If you have software or hardware problem with your S mart, Acronis provides repair and restore services that may eliminate problems and can even restore your software to its original factory settings.

Do not restore or reinstall the main controller without the support service. Ask your distributor for assistance.

1. Attach the **USB recovery system** device in a USB port.
2. Switch on the main controller (PC).
3. As soon as you see the prompt press number **1**. Then, Acronis software will start.
4. On the **Home** panel, click **Recover**.
5. On the **Data recovery and backup management** panel, select *Browse for backup*… option.
6. Then, select the Acronis partition (fixed disk drive) and click OK.



7. Select the file corresponding to the system that needs to be restored which is identified with its serial number. Then, click OK.
8. Select the file of the system that has to be restored from the list.

9. Then, click on the right button and select the *Recover* option.

10. When the recovery process is finished, remove the USB dongle and restart the computer.

Hardware configuration

Problem 1 – Hardware configuration not found

Error messages when SensoSCAN is started:

- **Error 1-15. Invalid controller validation**
- **Error 1-13. LED Board invalid port**
- **Error 1-15. Cannot connect camera: device not found**

Cause A – Starting up the system too quickly

Solution A:

1. Follow the steps described at Chapter 3 to shut down (step 6) and start up (step 3)
2. If the problem continues, please go to Solution B.

Cause B – Ports need to be configured

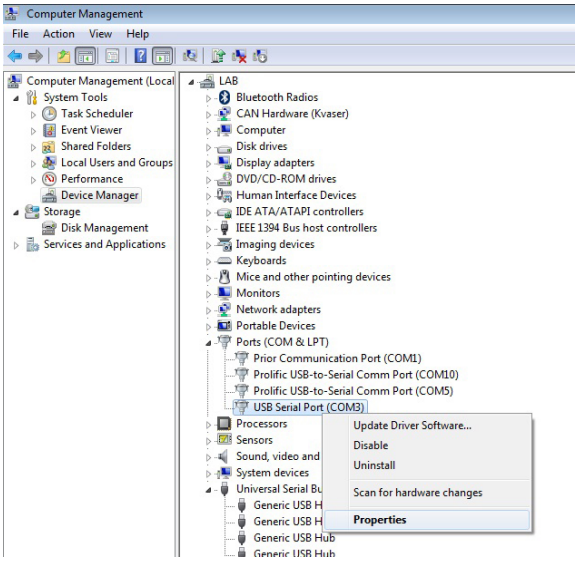
Solution B:

1. Check the ports configuration in device manager panel. The configuration must be as follows:

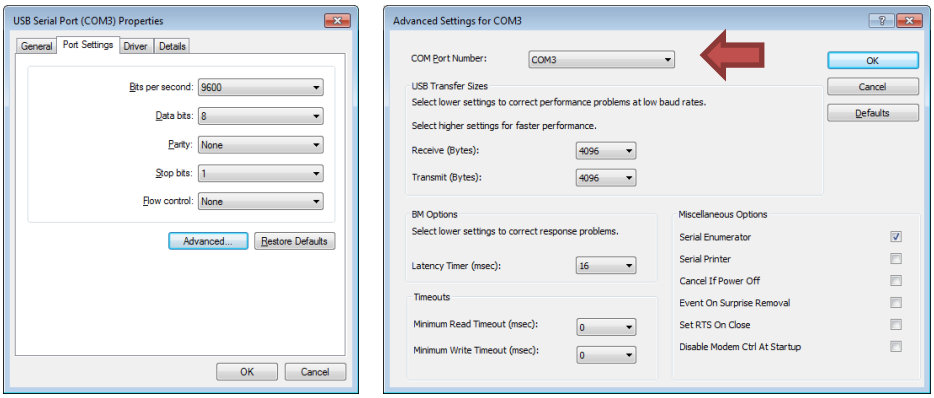
Hardware device	Ports (COM)
USB serial port (LED board)	COM3
Prolific USB (Motorized nosepiece board)	COM4

2. Click on the *START* icon and go to *Control Panel* > *System and Security* > *System* > *Device Manager*.

3. If the configuration is not correct, right click on the corresponding port and select *Properties*.



4. In the "Port Settings" tab, select "Advanced…".



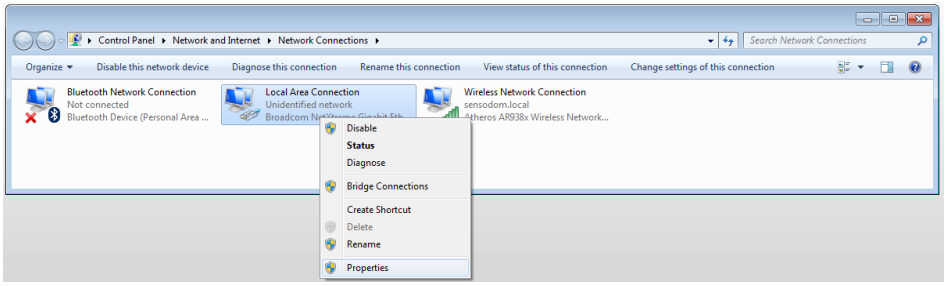
5. Select the correct port number in "COM Port Number" and click on *OK* button.

Problem 2 – How to change the camera's IP address?

Note: The user can change the camera's private IP address, although when SensoSCAN is started more time will be required in order to find the IP address that has been allocated.

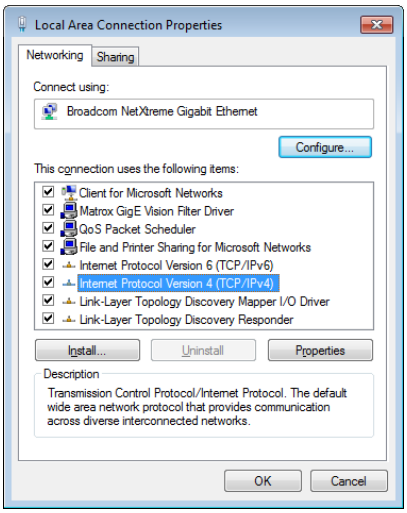
1. Click onto *START* icon and go to *Control Panel* > *Network and Internet* > *Network and Sharing Center* > *Change Adapter Settings*.

2. Right click onto *Local area connection* (device name: Intel® Gigabit CT Desktop) and select *Properties*.



3. In the *Networking* tab, select *Internet Protocol Version 4 (TCP/IPv4)*.

4. With the protocol *Internet Protocol Version 4 (TCP/IPv4)* highlighted, click onto *Properties*.



5. The configuration of the Internet (TCP/IP) must be:
    a. IP address: 169.254.89.190
    b. Subnet mask: 255.255.255.0

CHAPTER 6

Safety & maintenance of your S mart

This Chapter provides important information about safety procedures, routine maintenance, and general considerations for using your S mart.

For your safety and that of your equipment, follow these rules for handling and cleaning your S mart. Keep these instructions handy for reference by you and others.

Warning: The computer is the main controller of the S mart. It has already been optimized for performance, so external software and/or other drivers must not be installed in the system. Any modification to the main controller will automatically void the manufacturer's warranty.

Note: Incorrect storage or use of the S mart will also void the manufacturer's warranty.

Important safety information

Warning: Failure to follow these safety instructions could result in fire, electric shock or other injury or damage.

System updates

Do not attempt to update windows. Windows update must be disabled.

Power specifications

- AC line input
- Voltage ranges: 100–240 V alternating current (AC)
- Current: Maximum of 12 A (high voltage range) or 5 A (low voltage range)
- Frequency: 50–60 Hz single phase
- Power: 210 W
- Fuse rating: 4 A
- Fuse model: S501-4-R 5x20 mm

The only way to disconnect the power completely from your S mart is to unplug the power cord from the main and electronic controller power supplies. To disconnect your display completely, you must also unplug its power cable from the power outlet.

Make sure that at least one end of the device's power cord is within easy reach so that you can unplug the computer or display when necessary.

Use a CO_2 fire extinguisher in case of fire.

Do not carry out repairs yourself

Do not attempt to open your S mart. If your S mart needs a service, contact the local distributor or support service. See 'Sensofar Service & Support' in Chapter 7.

If you open your equipment or install other items, you risk damaging it. Such damage is not covered by the limited warranty on your S mart.

Important handling information

Operating environment

- *Temperature*: 21 ± 2 °C
- *Relative humidity*: 5 to 80%
- *Altitude*: < 2000 m
- *Vibration*: Required for vibration isolation frequencies in the range of 1 to 120 Hz
- *Acoustic noise:* should not exceed 75 dBC

Carrying your S mart

Before you lift or re-position your S mart, shut it down and disconnect all cables.

General maintenance

Clean your S mart

If you need to clean your S mart, follow these instructions:

1. Turn off your computer and display.
2. Clean the S mart with a soft cloth dampened with water. Do not use detergent.
3. The lenses should only be cleaned with a blower.

Note: Do not use alcohol, aerosol sprays, solvents or abrasives that might damage the finish on the case.

Clean the reference mirror

If you need to clean the reference mirror, follow these instructions:

1. Place optical paper over the reference mirror.
2. Use one or two drops of acetone.
3. Then, slide the optical paper smoothly taking with it the dust particles on the mirror. Never rub hard, as this can scratch the mirror.

Objective calibration process

A description of the complete calibration process can be found in the corresponding Chapter of this Installation Manual. In general, objectives should only be calibrated when they are first mounted.

CHAPTER 7

Warranty

Sensofar care service & support

If you have any problems with the **S mart** you can contact the support service, even if the warranty has expired. Sensofar can supply all **S mart** components. The contact details are shown below.

Sensofar TECH, S. L.
Parc Audiovisual Catalunya
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F. +34 93 786 01 16
support@sensofar.com
www.sensofar.com

You can also contact your local distributor; please check our website for contact details.

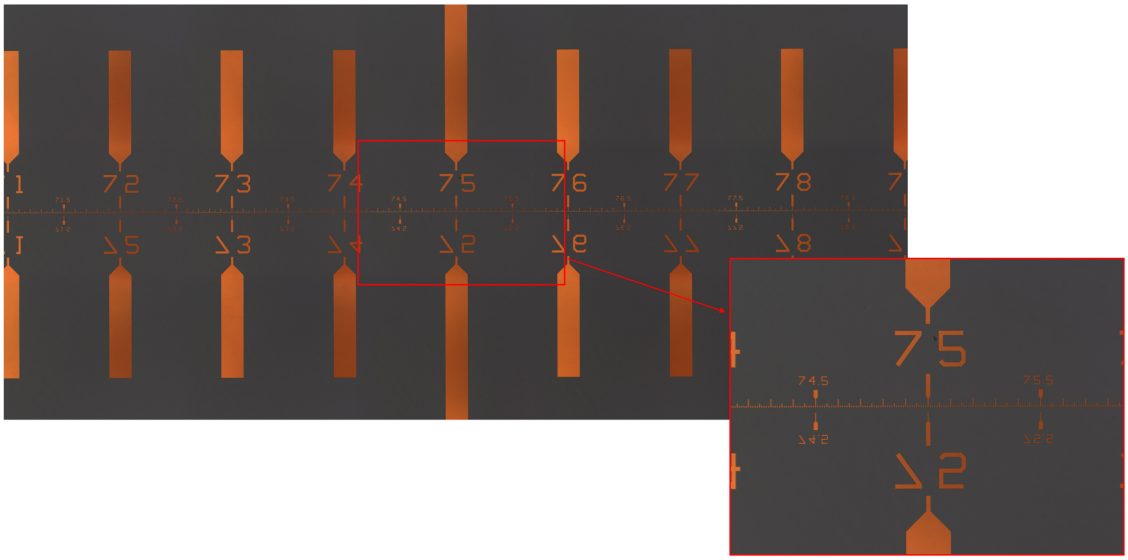
Locating your SN

To locate your SN, open the SensoSCAN software. Click on Help menu > About… The *About* panel will open and your SN and version will be shown.

APPENDIX

Objective magnification calibration

Objective magnification can be calibrated with the use of a calibrated standard rule. A thin step height standard from Ted Pella contains a zone were an equally spaced rule is engraved.



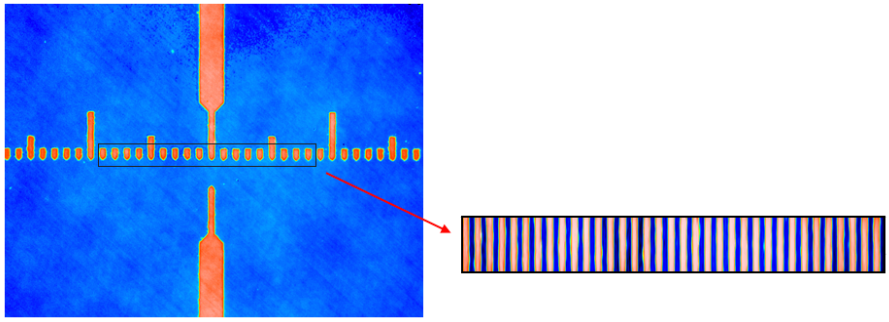
To calibrate the magnification, follow the next steps (in orange there is one example to calibrate a 50X EPI objective):

SensoSCAN

1. Open the Objective Calibration in the calibration screen and type in a value for the magnification of the working objective one whole unit lower. For example, for a 50XEPI, type in a magnification of 49.000000.
2. Measure a single topography with a field-of-view that contains only the ruling. Save this topography.
3. Now open the Objective Calibration and type in a value for the magnification of the working objective one whole unit higher. For example, for a 50X EPI, type in a magnification of 51.000000.
4. Measure a single topography with a field-of-view that contains only the ruling. Save this topography.

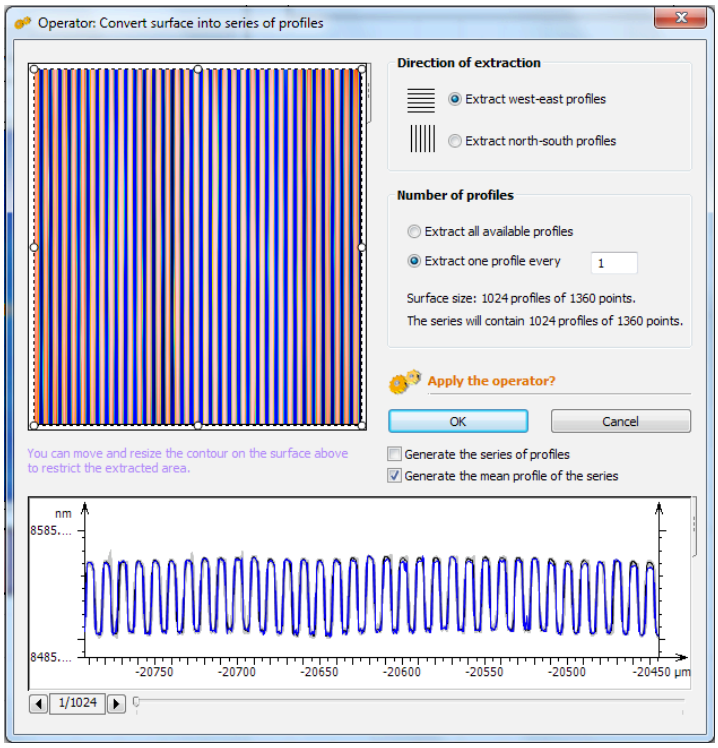
SensoMAP

5. Open the first topography in SensoMAP.
6. Use the *Zoom* operator to zoom only the ruled section.



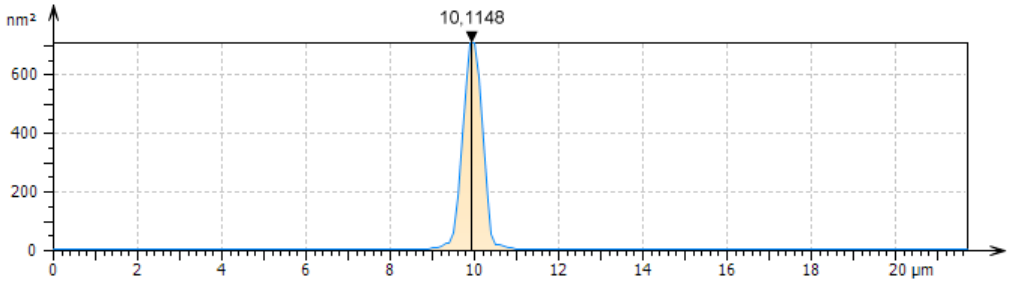
7. Apply the *Convert surfaces into series of profiles* operator. Select the following options:

a. Extract west-east profiles
b. Extract one profile every 1
c. Enable *Generate the mean profile of the series* option
d. Disable the *Generate the series of profiles* option



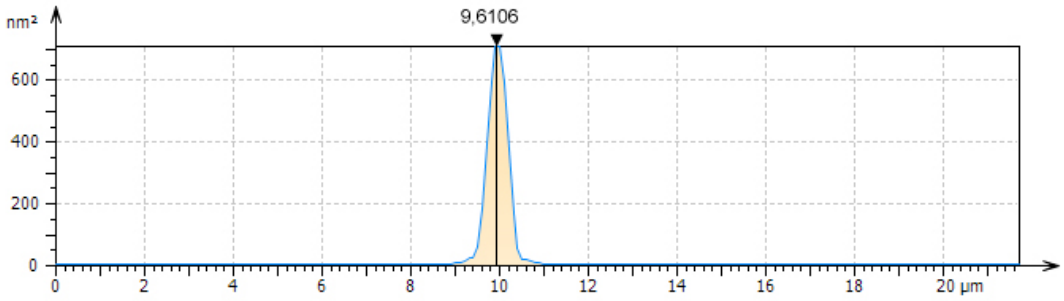
8. Now, to the profile obtained apply the *Average Power spectrum density* study. A graph like the following appears, with several peaks corresponding to the principal frequencies of the ruling. The major frequency is related to the pitch of the ruling.

9. Write the number that appears on the peak close to 10.0 microns. In the example for the first magnification at 49X, the frequency of the rule is 10.1148.



Information	
Zoom factor	x16
Nb iterations	256
Smoothing	5

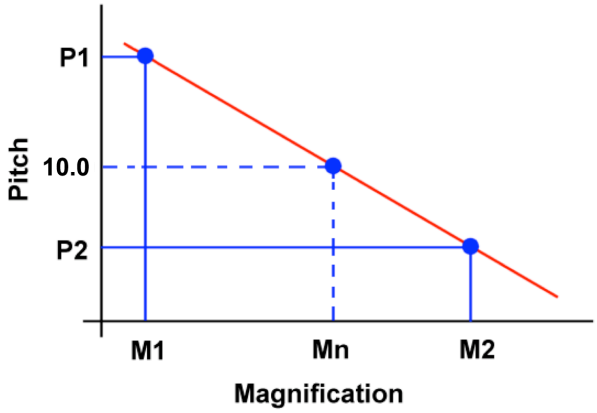
10. Now repeat steps 5 to 9 for the second topography.



Information	
Zoom factor	x16
Nb iterations	256
Smoothing	5

11. In this example, the result for 51X magnification is a frequency of 9.6106.

12. A linear interpolation between these two points leads to a calibration line were the nominal value of the magnification can be retrieved by simply knowing the true value of the pitch.



Calling the variables in the following way:

M1: first magnification
P1: Frequency obtained for the first magnification
M2: Second magnification
P2: Frequency obtained for the second magnification
Pn: Nominal frequency
Mn: Real magnification

The real magnification is retrieved using the following formula:

$$M = \left(\frac{M2 - M1}{P2 - P1} \right) (Pn - P1) + M1$$

SensoSCAN

13. Open the Objective Calibration and enter the value of M.

14. Measure a single topography and check with SensoMAP that the main frequency is 10.0.

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Regulatory Compliance Information

Sensofar-Tech, S.L. declares that the S mart system is in compliance with essential requirements and other relevant provisions of directives EN 61326-1:2006, EN 61010-1:2011.

European Union — Disposal Information

The above symbol means that according to local laws and regulations your product should be disposed of separately from household waste. When this product reaches the end of its life, take it to a collection point designated by the local authorities. Some collection points accept products for free. The separate collection and recycling of your product at the time of disposal will help conserve natural resources and ensure that it is recycled in a manner that protects human health and the environment.

Registration of this Manual, May 2017

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METROLOGY

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User Manual
S lynx / S mart & SensoSCAN 6.6

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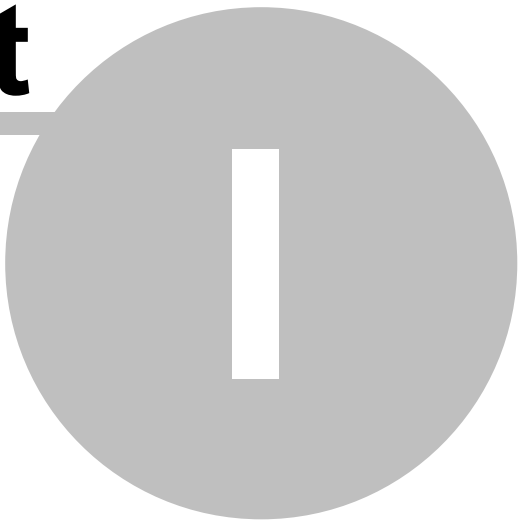
Part



1 Welcome to SensoSCAN 6.6

Thank you for acquiring a Sensofar surface metrology system

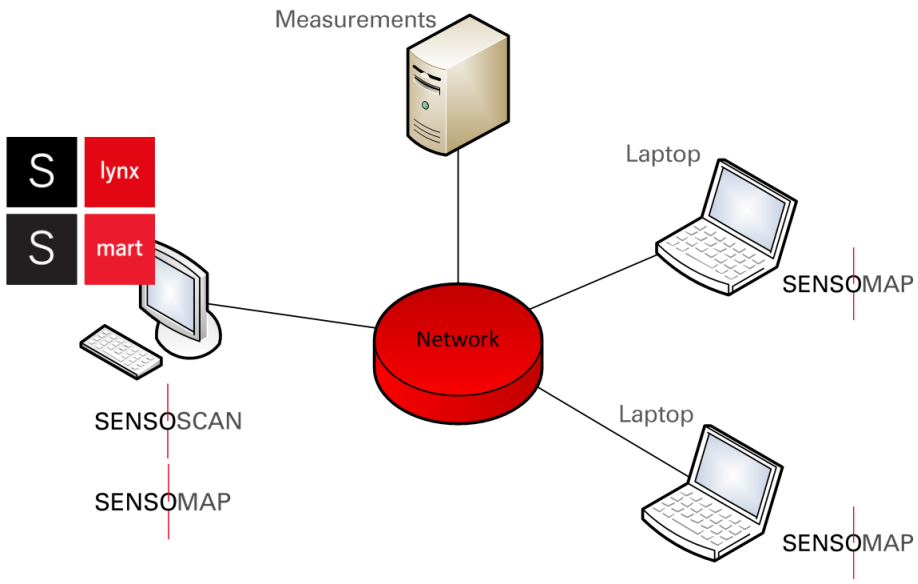
Sensofar's unique 3-in-1 technology sensor head combines Confocal, Interferometry and Focus Variation measurement techniques as well as thick and thin film measurement capabilities. The sensor head provides standard microscope imaging, confocal imaging, confocal profiling, interferometric profiling, focus variation profiling, and high-resolution thin film thickness measurement - all in a single instrument. The robust and compact design is based on a microdisplay approach with no moving parts. This unique combination of technologies leads the field of optical profilometry, enabling Sensofar's surface metrology systems to outperform all comparable systems on the market.

To help you familiarize yourself with your **S mart** or **S lynx** surface metrology system, this User Manual will guide you through the different measurement techniques/types, the various analytical options and other features.

The system is controlled by **SensoSCAN**. It provides the interface with which any measurement can be easily taken and includes a basic set of tools for displaying and analyzing the data. It's extremely simple and ergonomic interface enables the user to very rapidly obtain the required measurement.

For more powerful data manipulation, **SensoMAP**, based on Mountains technology and available as an option, is a state-of-the-art surface analysis software. Typical uses for **SensoMAP** include off-line 2D/3D surface characterization in R&D departments and laboratories, and near-line process control in production facilities (usually 2D).

Both **SensoSCAN** and **SensoMAP** applications can be run on the computer serving the system, or on several computers, as shown below:



The main advantage of distributing the applications is that existing data can be analyzed while new data is being acquired.

> **Note:** When both applications are run on the same computer, it is very important not to use **SensoMAP** for analysis while the **S neox** system is taking a measurement, as this

can reduce the performance.

Lastly, it is possible to run specific commands and events of the SensoSCAN Core remotely using an SDK (S mart only). If the SDK is part of your system, check the specific documentation for more details.

To learn more about using the system for surface metrology, please visit www.sensofar.com to access application examples and research papers.

1.1 New features

- **HDR acquisition for Focus Variation measurements**

With the new HDR acquisition mode it is possible to measure samples containing very bright to extremely shade areas. This is achieved by capturing and then combining several different, narrower range, exposures of the same surface. Otherwise, measurement fails either on bright or dark areas resulting in many non-measured points. It is only available for Focus Variation.

HDR features the best system performance for micromanufacturing (EDM, milling, laser, additive manufacturing, etc.), medtech (dental implants), tooling and forensics markets and applications.

It can be selected in the light source settings.

- **Export to DAT file format automatically using a SMR**

Export Values option in external analysis pane allows the user to export the DAT file automatically when SMR or MMR is used. Optionally, it is possible to define how to define the non-measured points (remove, nan, inf or zero).

- **Import relative XYZ positions from file to an MMR**

Up to now, the SensoSCAN was able to import from the file absolute XYZ positions to an MMR. This new feature allows one to import relative positions with the same file format and just adding the tag [References Relative] or [Measures Relative] depending on if we add references or positions.

- **Export XYZ positions from MMR**

By clicking on the export button, the software generates a *.txt file with the positions introduced in the MMR with the format the SensoSCAN accepts to import XYZ positions.

- **MMR log files contain exportable relative coordinates from MMR**

- **Export data in matrix format available on file menu**

Selecting File / Export data in matrix format from menu Bar exports the measurement result with a matrix format. This format has the values of the X axis in the first row and the values of the Y axis in the first column. The rest of the matrix are the Z values of the surface.

- **Automatic parcentricity correction during objectives calibration (available for motorized XY stages)**

An automatic process is used to correct small XY deviations between objectives in order to ensure that all of them are focused in the same position of the sample (available for motorized XY stages). The user will be guided to follow the process.

- **Save confocal or interferometric images during the scanning**

Save confocal or interferometric images: the system saved the confocal or interferometric images during the scanning. The path where it will be saved must be defined.

-

- **New export formats: STL & X3P**

Once the system has measured a topography, it is possible to export it from the export menu into new formats:

- STL: File format supported by many types of 3D software & commonly used for prototyping, printing, etc.
- PCL: 3D point cloud data file format
- X3P: File format for surface metrology adopted by academic, industry, and government labs for use in firearm forensics.

- **Customize non-measured points' value for exporting functions**

Non-measured points (NMP) are usually exported by default as QNAN0 value. Now, SensoSCAN allows the user to export to several options: Remove, NAN, INF or ZERO. Click on export settings to configure this function.

- **Select the cut-off values of the ISO filter operator dynamically**

- **Imperial system of units available in general section of System Preferences**

- **Preview PLUX content in MS explorer**

Now it's possible to preview the topography content directly in MS explorer. This is useful when you want to open a measurement. By activating the preview view, in the open dialog the user can select the proper measurement to open and preview the topography with ease.

1.2 Introduction

Overview

SensoSCAN software has three different user interface modes: Inspection & Acquisition, Display & Analysis and Configuration & Alignment.

Inspection & Acquisition

On start-up, the software always initially shows Inspection & Acquisition mode. This mode is used to:

- place the sample in the right position and focus on it using the Central Viewer
- select measurement parameters in preparation for a measurement

This mode can also be used to control the system's motorized stage.

Display & Analysis

Display & Analysis mode is displayed after a new measurement has been acquired, or when a previous measurement has been loaded from file.

In this mode, the results can be observed in two or three dimensions, with different colors, zooms and scales. One can also analyze the measurement, e.g. by removing a surface term to align the measurement (for example, tilt), by applying a filter to obtain roughness and waviness parameters (according to various surface texture standards), or by cropping to the area of interest, etc. etc..

Configuration & Alignment

This mode can be accessed by selecting **Configuration / Calibration** from the Menu Bar.

> **Note:** Configuration & Alignment is only visible/accessible to Administrators of the system.

Configuration & Alignment is used to:

- select software options and hardware components
- align and calibrate the objectives.

Calibration & Alignment procedures are carried out using a high-quality flat mirror as a sample.

Using the SensoSCAN 6 interface

It is important to fully familiarize yourself with the interface, the controls and the functionality of the software. Understanding of the technologies used in the system and the features available in the **SensoSCAN** software, as well as experience in measurement of comparable materials/structures, are absolutely essential for obtaining accurate and meaningful 3D topography and 2D profile measurements. To help the user become familiar with the system:

- A Quick Start Guide to acquiring measurements is provided.
- Inspection & Acquisition mode is briefly summarized to provide an overview of the interface.
- Extensive details are provided for Sample Inspection, Acquisition Settings and Display & Analysis.
- Configuration & Alignment routines are described - only visible and available to Administrators of the system.

- An Errors & Diagnostics guide is also provided.
- Finally, details of System Preferences and all other globally relevant topics can be found in the Appendix.

If all attempts at mastering the interface fail, you can of course turn to Sales & Support for help.

1.3 Service & Support

Service & Support

If you have any problems with your system, you can contact your local Service & Support center (usually your local Distributor). You are welcome do this even if the warranty on your system has expired.

The contact details for Sensofar HQ in Spain are shown below:

Sensofar-Tech, S.L.
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Ctra. BV1274, KM 1
08225 Terrassa, Spain
Tel.: +34 937 001492
Fax: +34 937 860116
support@sensofar.com
www.sensofar.com

An up-to-date list of regional Distributor addresses can be found online. Sensofar and all recognized Distributors can supply all components and spares for the system and carry out any necessary calibrations and repairs.

Updates & Upgrades

When a major new system version is made available, customers with previous versions might be able to update/upgrade at a special rate, depending upon the existing configuration. For more information, please contact your local Distributor.

Note: The license serial number is required to update/upgrade to a new major version.

1.4 Important safety information

Important safety information

The following simple rules are important to successful operation and to ensure long lifetime of your system:

- Keep this User Manual in a safe place, as it contains important safety information and operating instructions. Check for updates if appropriate.
- Make sure the AC power cord of the system is properly earthed.
- In case of fire, try to use a CO_2 fire extinguisher if possible.
- DO NOT use detergent to clean any part of the system. Lenses should be cleaned ONLY with an air blower, while any non-optical surfaces should be cleaned ONLY with a damp cloth.

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Registration or Update of this Manual: January 2018

Part II

2 Quick Start Guide

Introduction

Understanding of the technologies used in the system and the features available in the **SensoSCAN** software, as well as experience in measurement of comparable materials/structures, are absolutely essential for obtaining accurate and meaningful 3D topography and 2D profile measurements. It is strongly recommended that the user fully familiarizes him- or herself with the system before trying to acquire reliable results. Thus, Inspection & Acquisition, Sample Inspection, Acquisition Settings and Display & Analysis should all be considered essential reading.

3D Auto feature

3D Auto is an automated measurement mode for Confocal, Interferometry (VSI) and Focus Variation Measurement techniques that is available for measurements in Basic Mode. When selected, the user must simply place the sample correctly and then manually focus (see below). By clicking Acquire, **SensoSCAN** automatically determines the appropriate measurement parameters using a pre-defined initialization routine and subsequently acquires a measurement over a single FOV. More detail on the 3D Auto measurement can be found in Acquisition Settings.

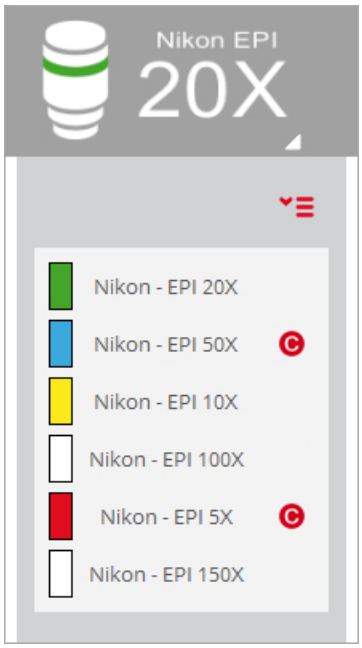
> **Note:** 3D Auto can be used routinely for straightforward (but not mirror-like) surfaces to obtain highly qualitative measurement results. Unknown, and more complicated and structured surfaces are best measured manually by an experienced technician.

Quick start guide to manual measurement

The following very briefly outlines the steps needed for taking a measurement manually.

Focusing on the sample

Start the software - when ready, it will automatically display Inspection & Acquisition mode. Choose an appropriate (and calibrated) objective by simply clicking on the tab in the Objective Selection pane to reveal the available objectives:



Objective Selection pane

> **Note:** Not yet calibrated objectives are highlighted with a red circle (see Objective Calibration).

Before calibrating any objective, and also if very precise measurements are to be acquired, a warm-up time of roughly ten minutes is recommended.

Focusing a brightfield objective

Choose the brightfield objective that you want to use (preferably a 20x EPI) and position the sample. For fast focusing of the sample (on smooth surfaces), check that Acquisition Settings is set to Confocal, locate the Central Viewer options at bottom center of the interface and choose *Slit Confocal* from the menu. A parallel slit pattern will be projected onto the surface.

> **Note:** Be carfeul for high magnification objectives that have low working distance

Use the motor controls to position the surface at the working distance of the objective. You will see the unfocused image of the sample in the Central Viewer. Slowly move the sample until the image becomes bright. If the sample has low reflectivity, use the Light Control slider to increase the amount of light, but try to avoid saturating the camera (signified by red pixels).

At this point, you can already start searching for the region of the sample to be measured. If this region is very difficult to find, try using a lower magnification objective.

Once the surface is almost in focus, continue to use the motor controls until the slit pattern structure appears in the Central Viewer pane. If you have a flat, smooth sample almost all of the slits will be focused at the same time. For rough or tilted samples you will only see the slit pattern in the regions of the surface that are well focused.

Focusing an Interferometry objective

Choose the interferometry objective you want to use and position the sample. In general, interference fringes appear in a very narrow plane centered on the best-focused position of the sample.

If the sample is rough, it is relatively straightforward to simply focus on the sample itself. For very smooth samples, check that Acquisition Settings is set to Interferometry, locate the Central Viewer options at bottom center of the interface and choose *Iris* from the menu. An iris is seen when the sample is out of focus - this is the reflection of the interferometry objective on the reference mirror and its focus does not change with the position of the sample. When the sample is almost focused, a second iris reflection appears. This second reflection will coincide with the first one when the sample is properly positioned at the focus of the objective.

When the sample is in focus, the light intensity must be adjusted. If some of the pixels are saturated due to excessive light intensity, the software shows these regions in red. For flat samples, increase the intensity to just below saturation. For rough, tilted or structured samples, check for saturation at different focus positions and set the light intensity appropriately.

Acquisition parameters

There are various parameters in Inspection & Acquisition mode that must be selected before a measurement can be made. They include: the Measurement technique, the Measurement type you want to obtain, selecting the appropriate objective, setting the Z-Scan parameters, Autofocus and any required light options, choosing a Threshold value, and any External Analysis options.

If the sample has a marked lay direction and you want to measure the structure perpendicular to the lay, you probably need a profile measurement. Alternatively, if you have a three dimensional structure, you can inspect it either by acquiring an image or by measuring the 3D topography. Finally, if you have a thin or thick layer or coating on a substrate, you can measure the layer with the thickness options.

Last but not least, it is essential to choose the right objective for the measurement. If the measurement technique does not coincide with the chosen objective, the result will be completely useless. It is also important to set the appropriate direction and total scanning length along the Z-axis.

Setting Z-Scan

Once the sample has been focused and the measurement parameters selected, it is important to ensure that the range for the Z-Scan (vertical) displacement is appropriate. If the range is too large, the measurement will take a long time. If the range is too small, some zones in the measurement will have no confocal, interferometry or focus variation information (i.e. the measurement will exhibit non-measured points).

To avoid problems with the Z-Scan range setting, the software checks that the selected absolute values are within a certain interval that varies according to the objective and the kind of measurement selected. For example, if the upper value could cause a collision with the objective, the software will automatically reduce the setting to the maximum value of the allowed interval for that objective. In contrast, if the setting is too low, it will be increased automatically to the minimum value of the allowed interval, to ensure that there is enough information when the sample is swept through the focus.

Any value within the allowed interval is acceptable to the system. Nonetheless, the Z-Scan range setting should ideally be as close as possible to the optimum value for each measurement. This optimum value can be estimated by simply moving the sample along the Z-axis:

- move the stage down until the slit pattern or the interferometric fringes are not in focus on any part of the sample
- note the Z position (or click the *Define Reference* icon to set this as *zero*)
- now move the stage up beyond the ideal focus until the pattern is again not focused for any part

of the sample

- note the new Z position and measure the difference between the two Z positions
- increase this value by roughly 20% and use the result in the Z-Scan edit pane

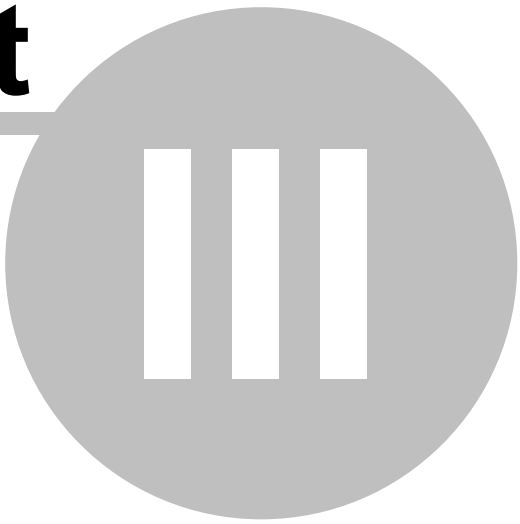
As stated earlier, if the range is too small, there will be no optical information for some zones in the measurement, and the results will exhibit non-measured points at the upper and/or lower extremes of the 2D profile or the 3D topography measurement. If this is the case, check that both the direction and the starting point of the Z-Scan are correct. If they are not, increase the Z-Scan range value.

Acquisition

When all settings and options have been selected, click *Acquire* to perform the measurement - if you have not already done so, you will be asked to provide a Sample ID.

When the acquisition is complete, the interface will automatically change to Display & Analysis mode.

Part

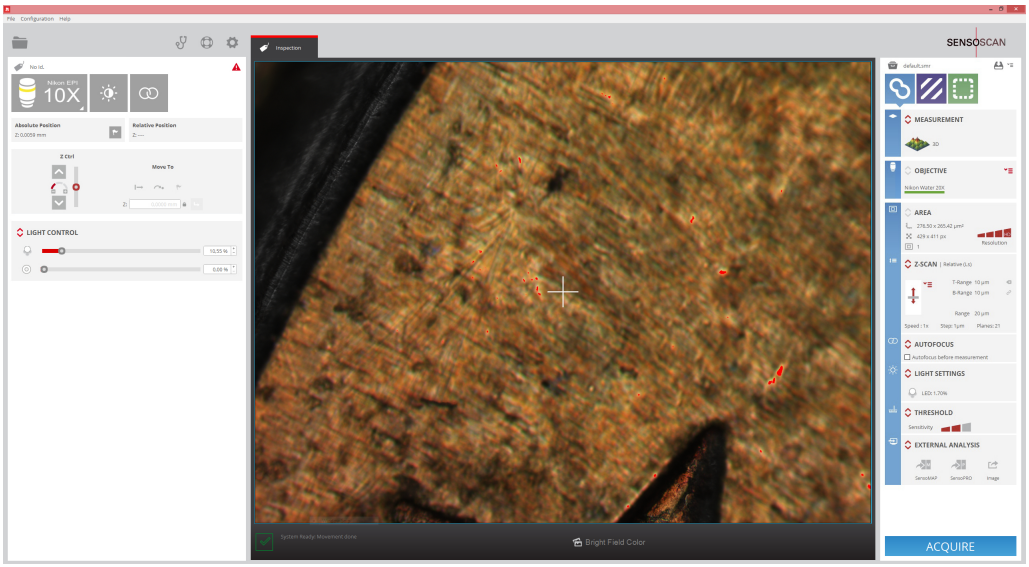


3 Inspection & Acquisition

Introduction

This Chapter provides **a very brief overview** of the Inspection & Acquisition mode, so that the user can begin to familiarize him- or herself with the interface layout.

Inspection & Acquisition mode itself comprises three principal interaction areas: settings for Sample Inspection on the left, the Central Viewer area, and Acquisition Settings to the right.



SensoSCAN interface overview when in Inspection & Acquisition mode

Detailed descriptions for the function and the use of all individual controls, can be found in Sample Inspection and Acquisition Settings.

3.1 Quick Bar tools

Overview

This section describes the functionality provided by the traditional OS Menu Bar and the various icons visible in **SensoSCAN 6**'s Quick Bar when in Inspection & Acquisition mode.

Quick Bar view in Inspection & Acquisition mode

Note: While some of the functionality described here does remain accessible from the traditional Operating System Menu Bar, most features are now more easily available via **SensoSCAN 6**'s Quick Bar. In the following, the functionality accessible from the Quick Bar will be described - functionality (also) available from the traditional Operating System Menu Bar is indicated in **green**.

The Quick Bar icons

This icon opens the **File / Open** dialog of the OS, allowing a previous measurement to be loaded from file. Note that **SensoSCAN 6** saves all measurements as **.plux* files. This file format contains the raw measurement together with a list of any Data Analysis options available within **SensoSCAN 6** that were applied to that measurement. See Appendix for further information relating to the **SensoSCAN** file formats.

The Menu Bar options **File / Import / Import plu** and **File / Import / Import coordinates** (not available in the Quick Bar) both relate to the import of data for Display & Analysis tasks - please refer to the appropriate section.

This icon (also **Help / Diagnostics)** opens a diagnostics menu path that provides access to technical log files. These log files are not normally relevant for everyday measurement tasks.

This information can, however, be very useful when troubleshooting problems with the system, for example in order to remotely reproduce or understand customer issues. In this case, all or specific log files may be requested by a technician or by Service & Support for diagnostic analysis.

At the bottom of the diagnostics pane opened with the icon, there are two options for securing a system back-up for diagnostic purposes:

- *Generate backup zip*: Creates a zip with all the configuration, calibration, logs, etc. files used by the system.
- *Generate report zip*: Same as *Generate backup zip* but does not copy large files.

More information regarding diagnostics can be found in the Errors & Diagnostics.

This icon achieves the same as selecting **Help / Contents** from the Menu Bar. Both actions open this User Manual.

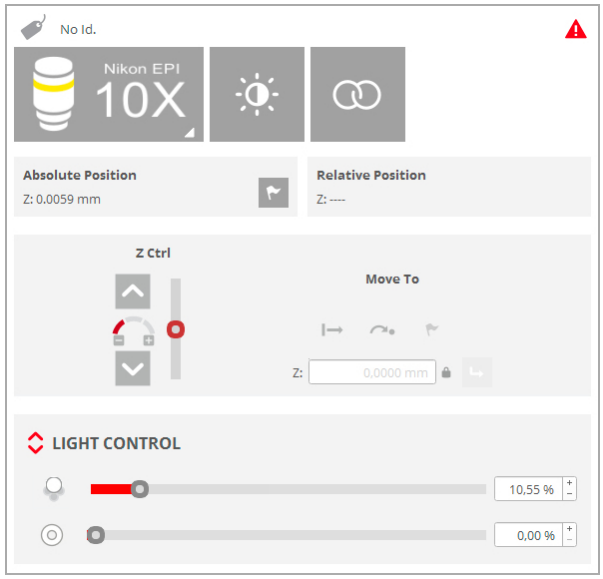
Selecting **Help / About** from the Menu Bar (not available from the Quick Bar) opens a system window showing the following information: the program version, the serial number of the system, the company and the user.

This icon (also **Calibration / System Preferences**) provides access to System Preferences and to User Profiles.

3.2 Sample Inspection

Overview

In this area on the left of the Inspection & Acquisition interface, settings are made for the initial sample inspection. Some of these settings are also carried over to their counterparts in Acquisition Settings, i.e. some are also valid for the acquisition process.



Overview of the settings available for Sample Inspection

The parameter options available here include:

- providing a Sample ID (see Sample Inspection and further details for use in System Preferences)
- selecting the type of objective (see Objective Selection)
- automatically set the sample illumination (see Autolight & Autofocus)
- automatically set the best focus (see Autolight & Autofocus)
- absolute and relative Z-stage position (see Position & Motor control)
- manually control the motorized Z-stage (see Position & Motor control)
- manually control level of illumination (see Light Control)

3.3 Central Viewer

Overview

When in Inspection & Acquisition mode, the Central Viewer shows the visible field-of-view (FOV) of the objective.

The Central Viewer pane shows the visible FOV

Depending on the viewer options selected at bottom center, a number of different image views and zoom levels can be selected (see section below). The options available here will depend on the Measurement technique, on the Measurement type, and whether anything has been enabled/disabled in System Preferences.

Access to image and zoom level options - not all options are available for all measurement configurations/objectives

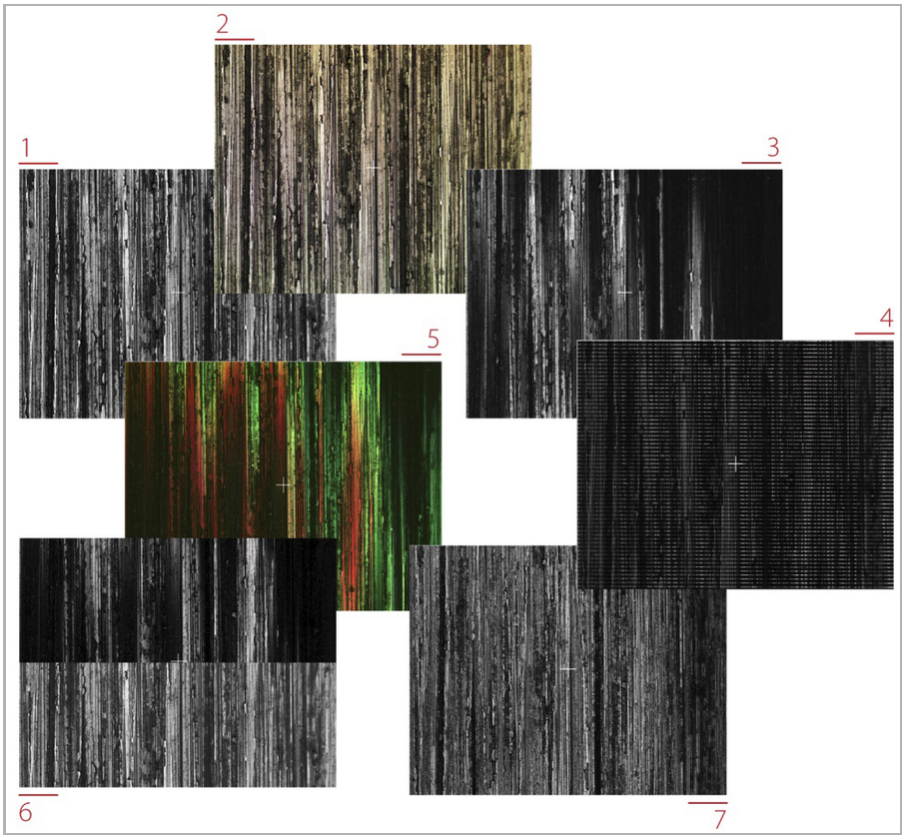
Viewer options

The Central Viewer options vary according to the Measurement technique and the Measurement type as these determine the appropriate objective. Note also that some viewer options can be enabled/ disabled in System Preferences.

The different viewer options are:

Brightfield objectives (Confocal & Focus Variation)

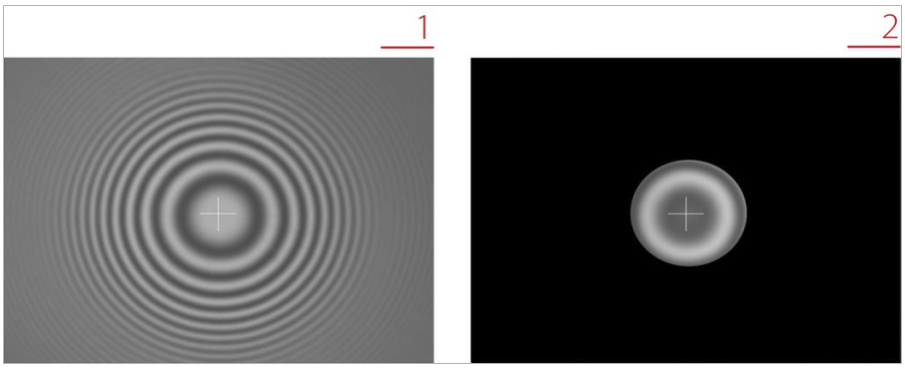
- *Brightfield:* a monochromatic brightfield image (1)
- *Confocal*: a confocal image (3)
- *Slit Confocal*: a tool that helps in focusing the sample - the image view projects a slit pattern on the surface (4)
- *Brightfield and Confocal*: *Brightfield* and *Confocal* images are condensed in the vertical (Y) direction (6)
- *Darkfield*: contours are shown bright (generated with a digital filter) (7)



The different viewer options for brightfield objectives (image options 2 and 5 are not available for the S mart and S lynx)

Interferometry objectives

- *Brightfield*: a brightfield image (1)
- *Iris:* a tool that helps focus the sample - the image view projects a circular iris, the sample is brought into focus when two equal irises overlap (2)

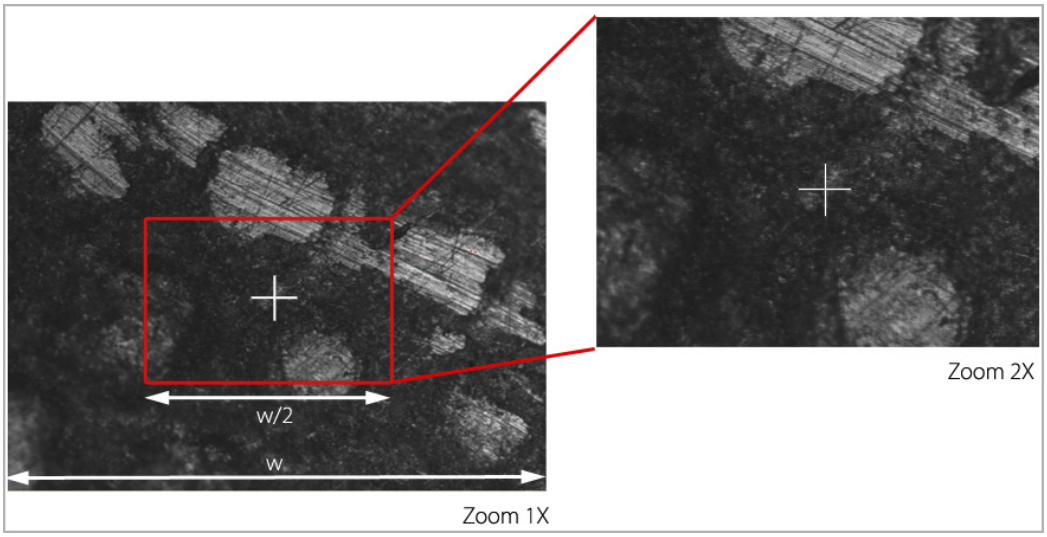


Viewer options for interferometric objectives

Zoom level

The zoom level is a tool that modifies the field-of-view (FOV) in the Central Viewer. Zoom is only available when using the Confocal Measurement technique in conjunction with black & white 3D topography measurements.

The size of the FOV decreases from the center of the optical axis when the zoom factor is increased.



Zoom level in the Central Viewer

The cross that appears is positioned on the central slit and thus does not always coincide with the real center of the FOV. For this reason, although the zoom is always applied to the image center, this apparent displacement of the cross could give the illusion of a possible zoom error.

After the measurement, the zoom factor is shown in parentheses in the measurement report area in Display & Analysis mode.

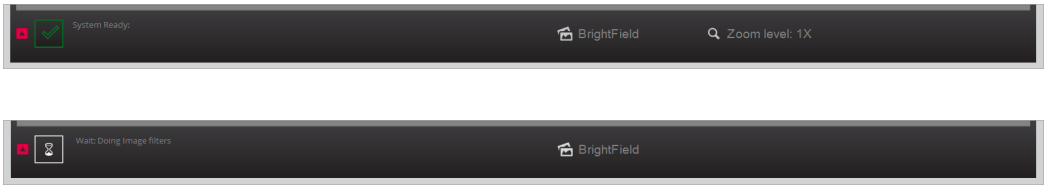
Live Image via SDK

When the system is operated via the SDK, the live image visible on the Central Viewer can be sent from the Core application to an external application over a TCP/IP connection. Details of how to set up the connection correctly are given in the SDK User Manual.

3.4 System Status toolbar

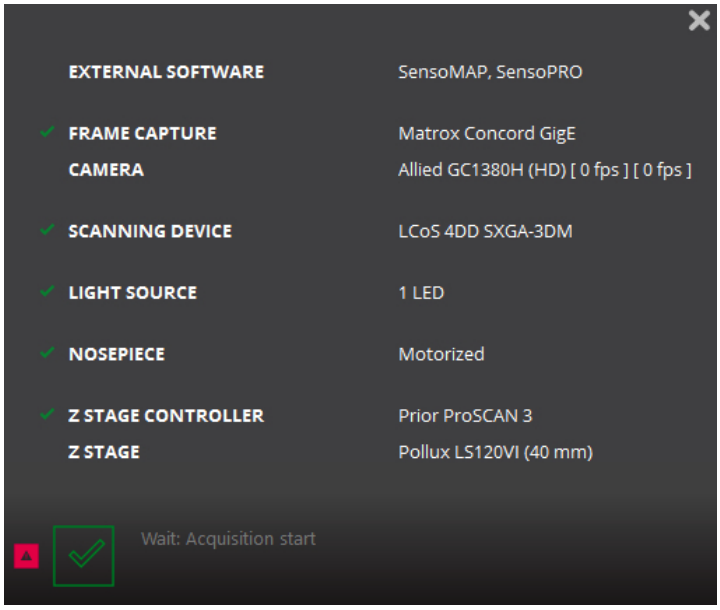
System status & information

A bar below the Central Viewer shows the status of the system and information about the procedure that is currently running.



System status bar

The larger symbol shows a large green tick when a device has performed a function and is ready to perform the next function, a large red cross when a device is not correctly initiated, as well as other symbols (depending on the activity). Clicking the little system status symbol to the left reveals detailed information about the system, the configuration and any errors and warnings:

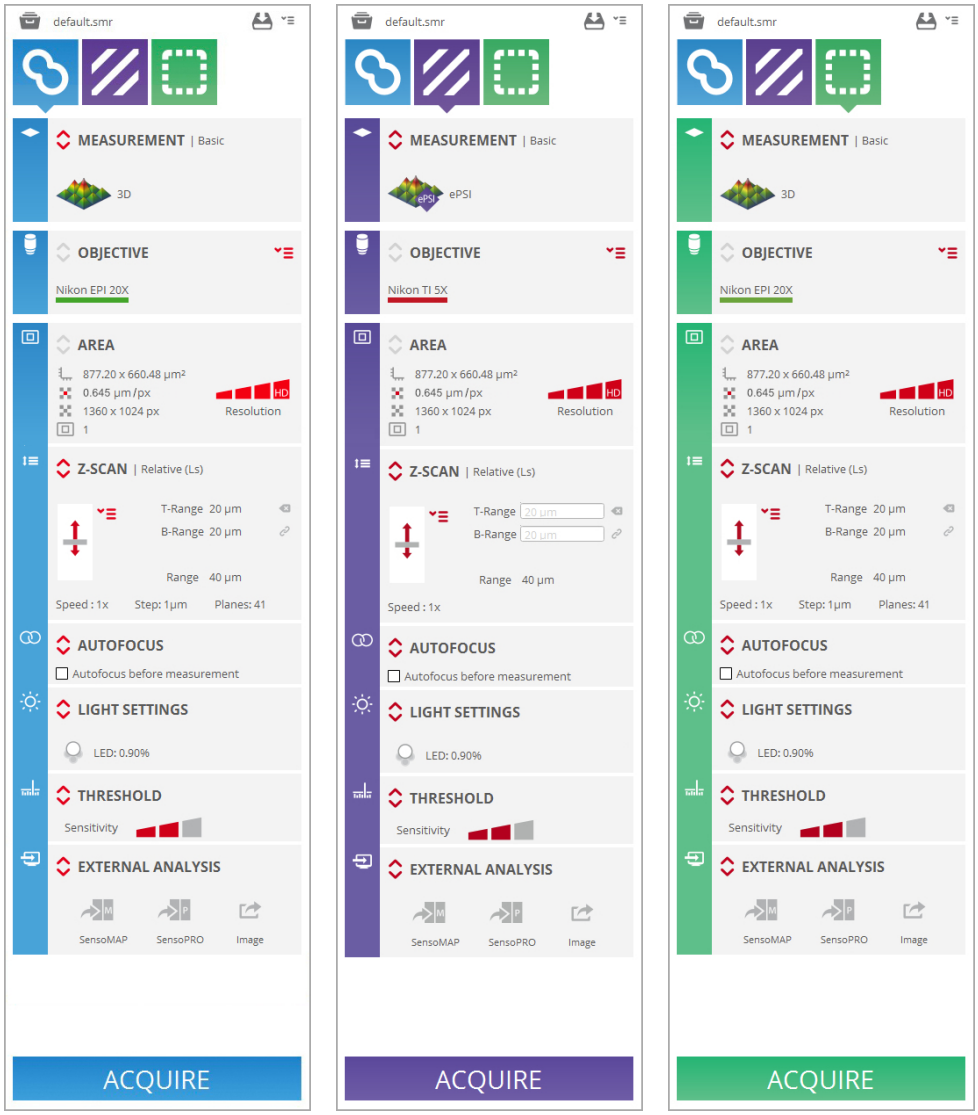


For example, one possible warning is *A full Z stage movement is required* - i.e. the Z stage needs to move through its entire range at least once a year for maintenance purposes and this warning is shown if this movement has not been performed. Refer to Configuration & Alignment for more information.

3.5 Acquisition Settings

Setting measurement parameters

This area to the right of the Inspection & Acquisition interface lists some parameters determined by settings made in Sample Inspection, or other measurement parameters appropriate to the Measurement technique, the Measurement type, as well as additional measurement options.



The parameter options available here include:

- the Measurement technique - Confocal, Interferometry, Focus Variation
- the type of measurement desired (surface, profile, coordinate, thickness etc.)
- choice of objective (if different from that chosen in Sample Inspection, i.e. if unlocked)
- the measurement area and resolution options
- the vertical scan parameters
- whether, and what type of Autofocus should be performed ahead of a measurement
- Light Settings (if different from that chosen in Sample Inspection, i.e. if unlocked)
- the Threshold, and

- External Analysis options (if required)

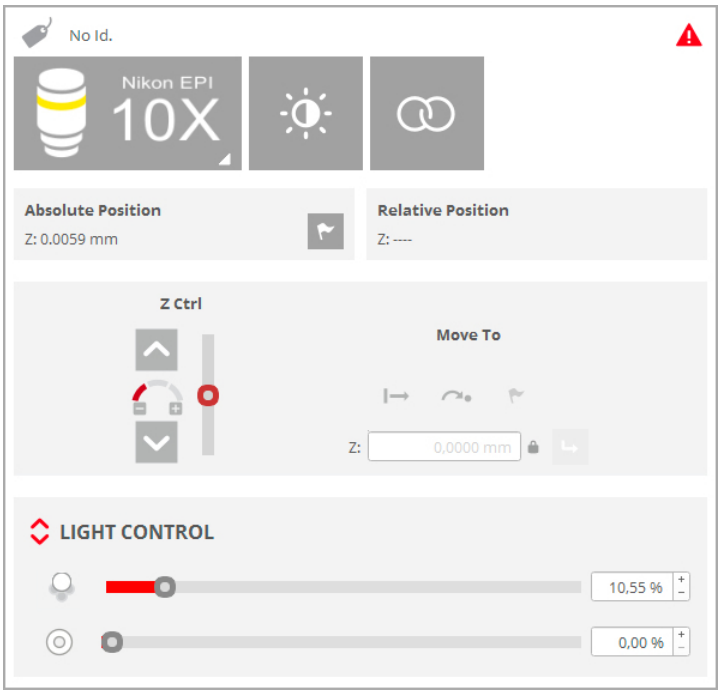
Once these settings have been made, clicking *Acquire* will trigger the measurement process. Upon completion of a successful measurement, the interface will automatically change to the Display & Analysis mode.

Part IV

4 Sample Inspection

Introduction

Before performing a measurement on a sample, it is necessary to locate the regions of interest on the sample. This is achieved using lighting, focusing and positional controls in order to obtain the best initial sample view.



The Sample Inspection pane

The function and purpose of the tools available in the Sample Inspection pane are detailed in the following sections.

Sample ID

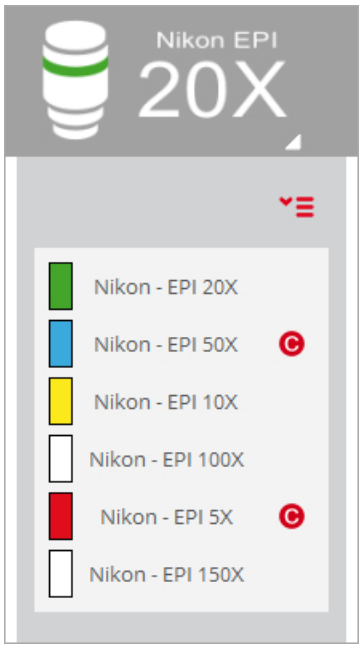
An important aspect for traceability for many applications is the ability to give samples a specific Sample ID. This is possible in **SensoSCAN** by activating the option in System Preferences. Discussion of how to handle naming strategies, either for individual samples or for multiple acquisitions/samples via an MMR, is discussed there also.

4.1 Objective Selection

Overview

The Objective Selection pane shows which of the objectives mounted on the nosepiece is currently installed in the optical axis:

To select an objective, click on the tab in the lower right hand corner to reveal any other objectives available for the current Measurement type:



Drop-down menu for Objective Selection

The system can be equipped as standard with a variety of brightfield and interferometry objectives. These are listed in the table below:

Family	Objective	NA	WD (mm)	Pixel Size (µm)	Minimum Range (µm)
EPI	1x	0.03	3.80	12.90	1900
EPI	2.5x	0.075	8.80	5.16	720
EPI*	2.5x	0.075	6.50	5.16	720
EPI*	5x	0.15	23.50	2.58	360
EPI*	10x	0.30	17.50	1.29	60

Family	Objective	NA	WD (mm)	Pixel Size (µm)	Minimum Range (µm)
EPI*	20x	0.45	4.50	0.65	20
EPI	50x	0.80	1.00	0.26	4
EPI	50x	0.80	2.00	0.26	4
EPI	50x	0.95	0.35	0.26	4
EPI	100x	0.90	1.00	0.13	4
EPI	100x	0.90	2.00	0.13	4
EPI	100x	0.95	0.32	0.13	2
EPI	150x	0.90	1.50	0.09	2
EPI	150x	0.95	0.30	0.09	2
ELWD	20x	0.40	13.00	0.09	2
ELWD	20x	0.40	19.00	0.65	20
ELWD	50x	0.55	10.10	0.65	20
ELWD	50x	0.60	11.00	0.26	10
ELWD	100x	0.80	3.50	0.26	10
ELWD	100x	0.80	4.50	0.13	4
SLWD	10x	0.20	37.00	0.13	4
SLWD	20x	0.35	24.00	1.29	60
SLWD	20x	0.30	30.00	0.65	20
SLWD	50x	0.45	17.00	0.65	30
SLWD	50x	0.40	22.00	0.26	10
SLWD	100x	0.70	6.50	0.26	10
SLWD	100x	0.60	10.00	0.13	4
WI	10x	0.30	3.50	0.13	4
WI	20x	0.50	2.00	1.29	60
WI	60x	1.00	2.00	0.65	20
CORR	20x	0.45	7.40	0.22	4
CORR	20x	0.45	10.9 – 10.0	0.65	20
CORR	50x	0.70	3.9 – 3.0	0.65	20
CORR	100x	0.85	1.2 – 0.85	0.26	4
CORR	100x	0.85	1.3 – 0.95	0.13	4
TI	2.5x	0.075	10.30	0.13	4
TI	5x	0.13	9.30	5.16	10

Family	Objective	NA	WD (mm)	Pixel Size (µm)	Minimum Range (µm)
DI	10x	0.30	7.40	2.58	10
DI	10x	0.30	7.40	1.29	10
DI	20x	0.40	4.70	0.65	10
DI	50x	0.55	3.40	0.26	10
DI	100x	0.70	2.00	0.13	10

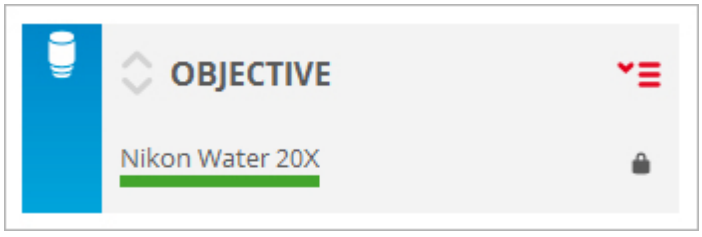
Objectives marked with a * are also compatible with ring light

SensoSCAN only shows the objectives that are appropriate for the current Measurement type. For example, if a profile measurement is selected, the objective window will show only brightfield objectives. If an objective is available but not calibrated, the software will show a , indicating that the objective still needs to be calibrated.

Linking to Objective Selection in Acquisition Settings

The choice of objective made in Sample Inspection is by default forced to be the same in Acquisition Settings. The reverse is also true - changing the objective chosen under Acquisition Settings forces the same change under Sample Inspection. The objective selection is thus mirrored throughout the system.

This behavior can be disabled in System Preferences. When disabled, a padlock icon appears in the Objective Selection pane under Acquisition Settings:



By clicking on the icon and thus opening the lock, the selection of a different objective in Acquisition Settings is enabled. For example, an alternative objective can be chosen to that selected for Sample Inspection. By closing the lock, the objective shown in Acquisition Settings again mirrors that chosen in Sample Inspection.

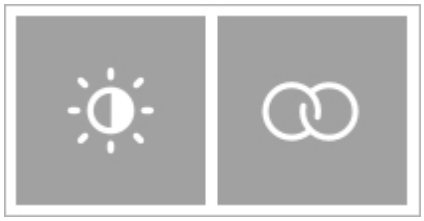
> **Warning:** It is very important to use the correct objective when acquiring measurements. If the selected objective does not coincide with the objective that is actually installed in the optical axis, the result will be meaningless and there is a risk of collision of the objective with the sample.

More information on the choice of objectives can be found in Objective Selection in Acquisition Settings.

4.2 Autolight & Autofocus

Overview

The Autolight and Autofocus commands are two automated routines available in Sample Inspection:



The Autolight (left) and Autofocus commands in Sample Inspection

Autolight

The Autolight command is used to automatically set the ideal light intensity for the surface in focus. The light intensity illuminating the surface is automatically set so that no more than 5% of the camera pixels are saturated (saturated pixels are shown in red).

> **Note:** Autolight only adjusts the single, co-linear LED source, there is no control over the optionally available ring light (see Light Control).

While this function may be adequate for most surfaces, other surfaces or samples may need to have the light manually adjusted. For example, when the surface is tilted, only a small portion of the surface is in focus and Autolight can set too much light. By contrast, some samples with high reflective regions or spots can require more light than that set by the Autolight function.

Further options for controlling the brightness of installed LED can be found in Light Control. The Light Control pane can be used to manually set the light level at any time.

Autofocus

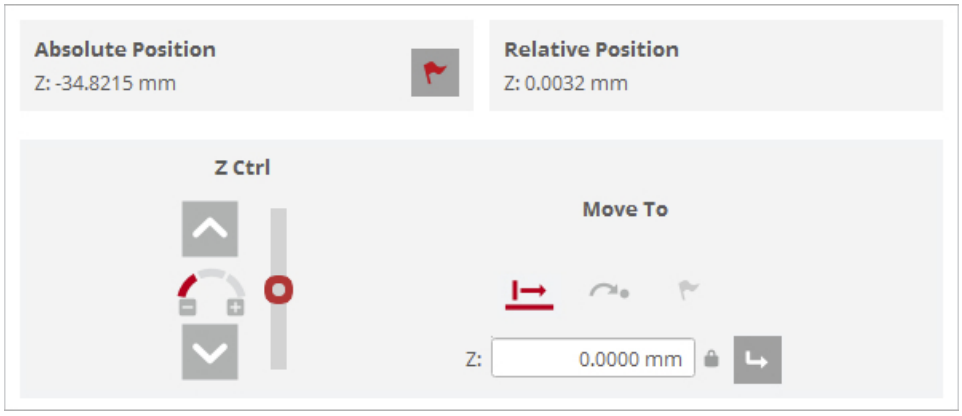
The Autofocus command triggers a routine used by the system to fine focus the sample, in order to optimize the initial Z-position for measurement. By clicking the Autofocus button, a *small* and/or *large* Autofocus routine is performed (options for whether *small* and/or *large* are used in this routine are found in System Preferences).

The focus can be manually adjusted at any time using the motor controls.

More information about the use of the Autofocus function elsewhere in the system, including advanced settings, can be found in the Autofocus section of Acquisition Settings.

4.3 Position & Motor control

Overview



Position & Motor Control panes in Inspection Settings

Position

The absolute and relative coordinates are displayed on the panes *Absolute Position* and *Relative Position*, respectively:

- *Absolute Position* is relative to the zero (center) position of the motorized axis.
- *Relative Position* is relative to an user-defined reference point that can be set (and repeatedly reset) by clicking the *Define Reference* icon for any available locations (see below). Resetting *Relative Position* calls up a dialog with three possible options - *Overwrite* reference with current position, *Delete* reference, and *Cancel*.

Motor control

Movement and positioning of the Z-Scan stage can be controlled via **SensoSCAN** using the software motor control pane.

Relative movement from the current position, movement to an absolute position, or relocation to the reference point can be readily achieved by choosing the appropriate icon , respectively, entering the desired Z movement or absolute coordinates as needed, and then confirming the command by clicking .

Movement range Z

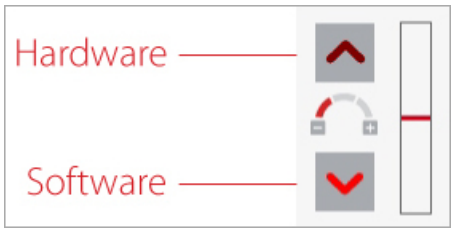
The Z movement is limited to the travel limits of the system. Note that there is also a variable safety limit determined in the software that is linked to the working distance of the selected objective.

> **Warning:** If the objective selected in **SensoSCAN** is not the same as the actual objective in the profiler, the software may allow a large Z-Scan value that could cause the objective to crash into the sample.

The Z-Scan range also has software and hardware limit controllers. To acquire data or to be able to move along the Z axis, the system has to be within the Z software limits as defined in the *configuration file StageZ.xml*.

Movement beyond software/hardware limits

When the Z position is beyond hardware or software limits, this status is indicated interactively in the software motor control graphics:

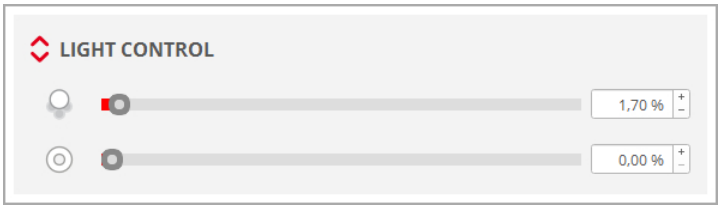


In this situation, the user cannot acquire data and no movement is allowed except when using the motor control pane to return within the limits.

4.4 Light Control

Overview

The Light Control pane is used to adjust the light on the sample.



Light Control in Inspection Settings, also showing the controls for the optionally available ring light

The single LED icon shows the color of the currently active LED source (default for **S mart** and **S lynx** is white, optional R, G or B for **S mart**), whose intensity can be changed using the slider control, and/or the input field to the right.

The ring icon in the pane above indicates the intensity controls for the ring light.

> **Note:** The ring light is an optionally available extra for certain S line systems, and is only compatible with a few specific objectives (see below).

Note that too much light incident on the digital camera is indicated by red pixels in Central Viewer. Nominally, a level of 5% over-saturated pixels is tolerated by the system, and this is the level targeted by the Autolight function.

Single LED source

The light intensity of the LED is controlled by a 16-bit microcontroller PWM signal. The ideal light intensity for the image camera can be set automatically by choosing Autolight. Alternatively, the light intensity can be changed manually by moving the slide bar or simply changing the value on the right of the pane. The light intensity is scaled from 0% (lowest intensity) to 100% (highest intensity).

> **Note:** The active LED is automatically switched off when **SensoSCAN** switches to Display & Analysis mode.

Ring light

The ring light is an optional extra that has been designed for applications with very particular lighting requirements, for example, for samples exhibiting regions of high slope. It is also beneficial for Focus Variation and Confocal Fusion measurement techniques in general.

It can be used in combination with a single LED source, although the ring light is not controlled by the Autolight function, so the intensity must be set manually. The ring light can be used in an SMR, thus also in an MMR, and is also compatible with MultiLevels (see below).

There are two ring light models, that are compatible with the following Nikon objectives:

Objective	Ring model
EPI 2.5X (225MUE12030), 0.075NA, 6.5WD	Model 1
EPI 5X (225MUE12050), 0.15NA, 23.5WD	Model 1
EPI 10X (225MUE12100), 0.3NA, 17.5WD	Model 2
EPI 20X (225MUE12200), 0.45NA, 4.5WD	Model 2

Linking to Acquisition Settings

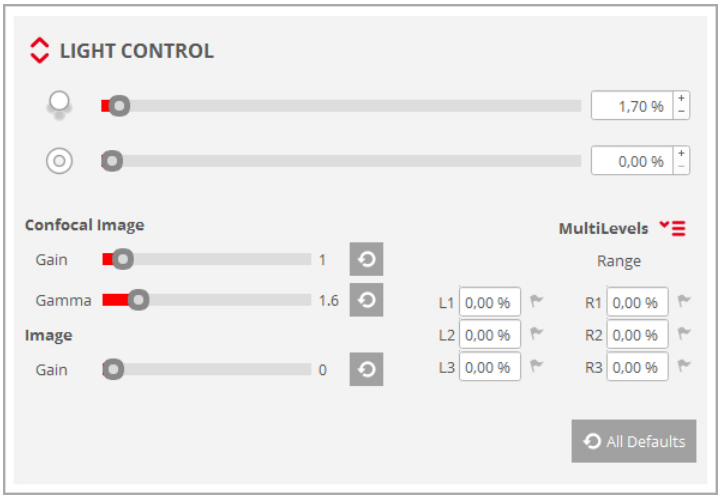
By default, the illumination settings chosen in Light Control are forced (or mirrored) over to Light Settings in Acquisition Settings. There is no provision for changing the illumination in the Light Settings pane, thus the illumination options made in Light Control are valid throughout the system.

This behavior can be disabled in System Preferences. When disabled, a padlock icon appears in the Light Settings pane in Acquisition Settings:

- By clicking on the icon and thus opening the lock, it is now possible to change the illumination settings under Light Control without changing those in Light Settings.
- By closing the lock, the illumination settings chosen in Light Control are again forced over to those visible in Light Settings.

Advanced settings

By clicking the drop-down arrows , the Light Control pane extends to reveal advanced options:



Advanced Light Control settings

Aside from MultiLevels (see below), and the ability to change the active single LED, the remaining advanced options revealed here apply exclusively to the image acquired on the integrated digital camera.

These are:

- *Confocal Image Gain* is applied to the confocal image:

  (i). Decreasing the gain reduces the contrast in the confocal image.

  (ii). Increasing the gain gives the confocal image greater intensity. This can be useful for areas of the sample in which the reflectivity is low (due to the material properties, surface structure, high slope, etc.). However, confocal image noise is also increased, and, depending on the Threshold, some noisy peaks may appear in the measurement. In this instance, a remove noise filter can be applied in Data Analysis.

- The *Confocal Image Gamma* value is a multiplicative exponential factor. Decreasing the gamma value yields greater contrast in the confocal image.
- *Image Gain* is applied to the camera.

Warning: Changing camera image gain globally affects ALL measurements taken. The only exception to this is the Configuration & Alignment mode, where the CCD camera always works with the default value of gain.

- Clicking the reset icon for any slider returns the value to the default.
- Like other light options, the image gain is saved in the SMR. Conversely, loading an SMR can result in a change in the image gain.

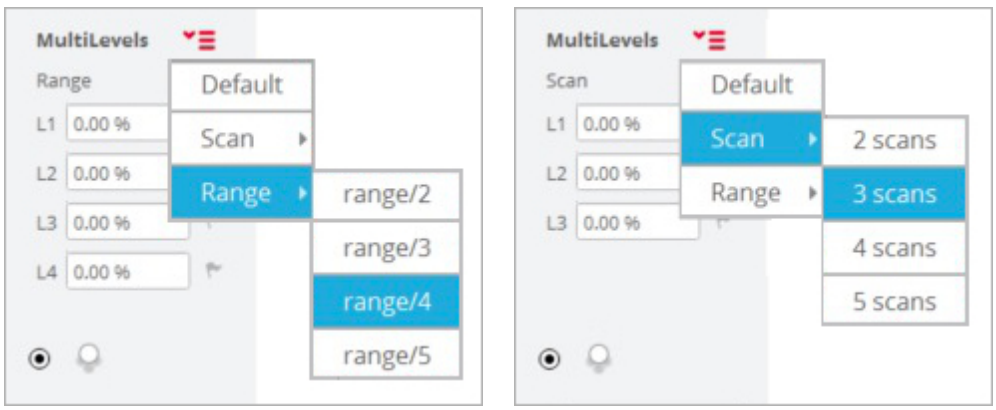
Some samples require an adjustment in advanced light options, so the window remains open unless the drop-down arrows are toggled. While the window is open, the user can change the settings and the result is shown on the live image. This change allows adjustment of the confocal gain while moving Z up and down or changing the image mode.

MultiLevels

MultiLevels implements multiple light intensities in the same measurement - this applies to all active light sources (*L* for LED, *R* for ring).

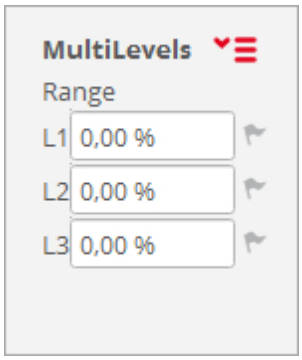
Note: It is best to change the level of light at a Z position for which none of the sample is in focus. If part of the sample is in focus, erroneous results will be obtained for these points.

The different options are accessed by clicking the red drop-down menu :

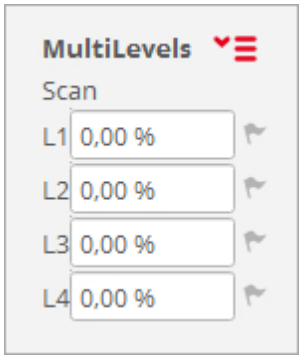


There are 3 basic approaches:

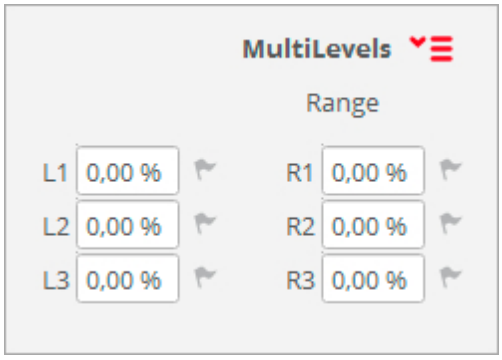
- *Range*: This divides the scan into ranges (up to 5), where individual light intensities can be set for each range. This option is useful, for example, for step-like structures, in which the top and bottom materials have very different reflectivity, or for narrow and deep holes and trenches, in which the amount of light reflected from the deepest region of the sample is too low.



- *Scan*: This iteratively repeats the scan for up to 5 different light intensities. In analogy with HDR for photography, a composite high-contrast image with minimum omitted data points is created from the best sections of up to 5 separate scans.



Note: If the ring light is installed, all selected MultiLevels for *Range* or *Scan* will need to be set for the selected single LED source (i.e. all *Ln*), and for the ring light (all *Rn*):



- *Default*: no change in light intensity (effectively *n*=1 for *Range* or *Scan*).

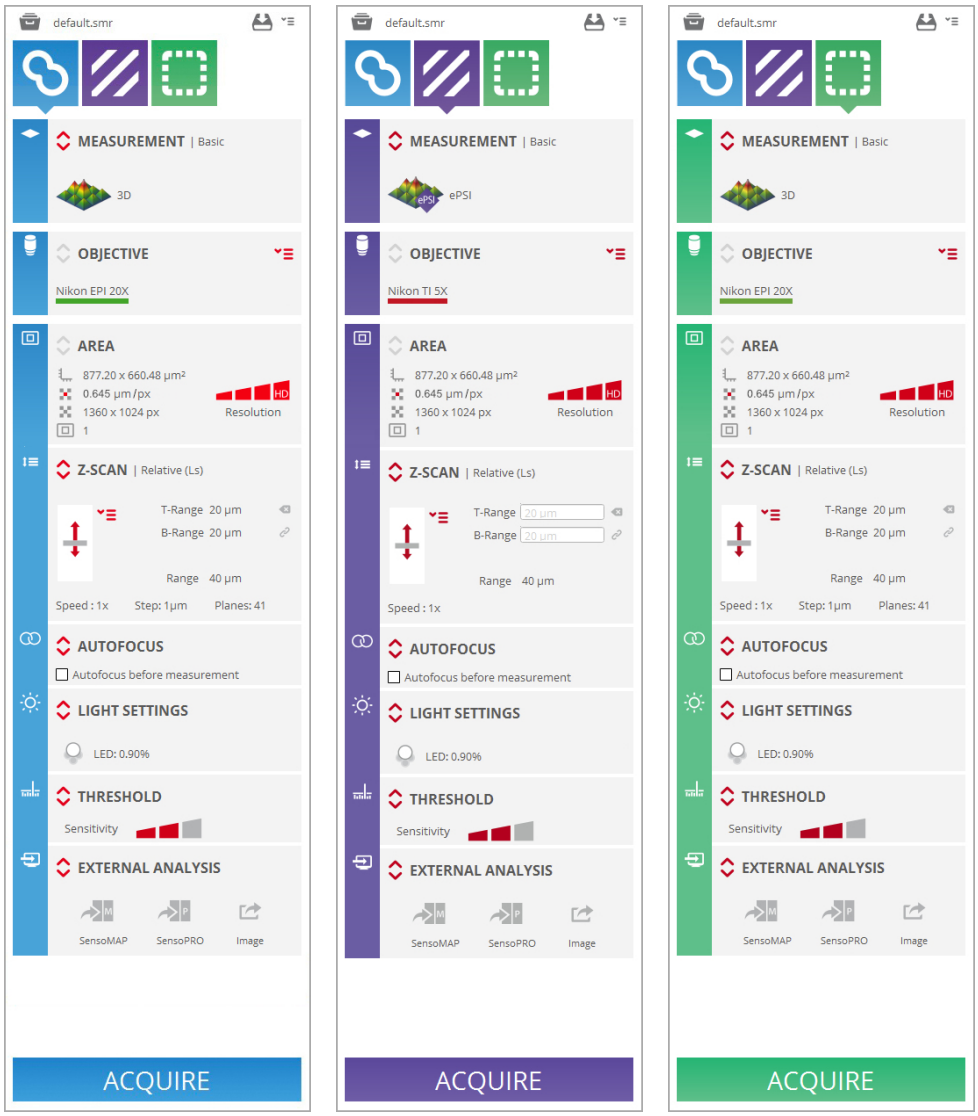
Part V

5 Acquisition Settings

Introduction

The Acquisition Settings interface is used to set the technique, type and appropriate parameters for a measurement. The exact configuration depends on the nature of the surface to be measured (smooth, rough, structured) and the application for which a measurement needs to be made.

To streamline the experience for the user, the Acquisitions settings interface has been designed to appear more or less the same independent of the Measurement technique (Confocal, Interferometry or Focus Variation). Some changes are made to the interface when switching between techniques, although these are actually largely associated with the specific Measurement types available to that technique. Other changes occur 'under the hood' (and these are usually not user-configurable anyway).



The Acquisition Settings interface remains more or less the same independent of the Measurement technique.

As will have become obvious in the previous Chapters, and so too in the next sections of this Chapter,

some of the parameters required for a measurement are determined by options set in Sample Inspection (see e.g. linking of Light Control to Light Settings). Other parameters, as discussed in the following sections, are set in Acquisition Settings.

The External Analysis pane is used to direct data acquired by the system to external software (**SensoMAP** and **SensoPRO)** or to Export Image.

Recipes are an important tool for repetitive data acquisition cycles. Recipes allow the user to save and reload predefined parameter sets that typically apply to a given application (Single Measurement Recipe, SMR) and/or that are used to automate complicated measurement processes involving many separate SMRs (Multiple Measurement Recipe, MMR).

When all settings and options have been selected, click *Acquire* to perform the measurement - if you have not already done so, you will be asked to provide a Sample ID (if the user enables "Use Sample ID" and "Confirm ID before acquisition" in system preferences.

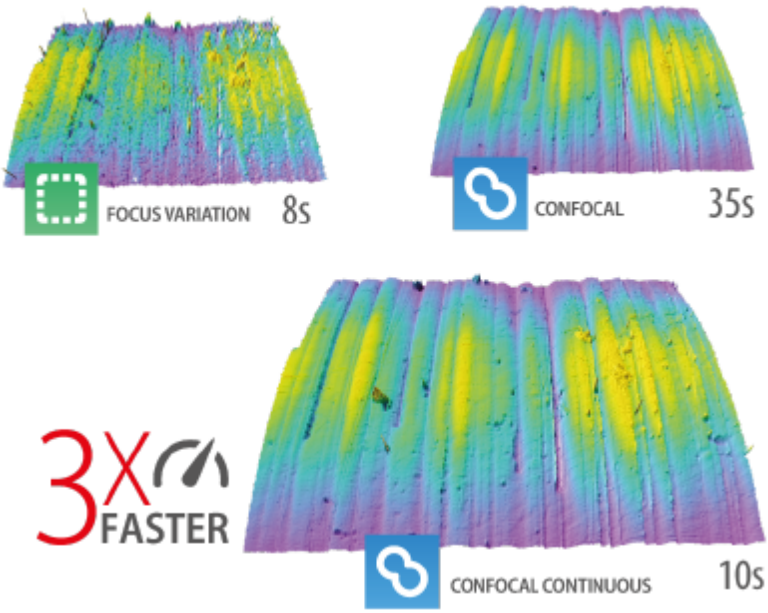
When all settings and options have been selected, click *Acquire* to perform the measurement. When complete, the interface will automatically change to Display & Analysis mode.

5.1 Measurement technique

Overview

The system innovatively makes use of three optical technologies (Confocal, Interferometry and Focus Variation) because their complementary strengths can be applied to negate any shortcomings of any single technology for the sample being measured. In this way, the system provides the best possible measurements on the widest range of surfaces.

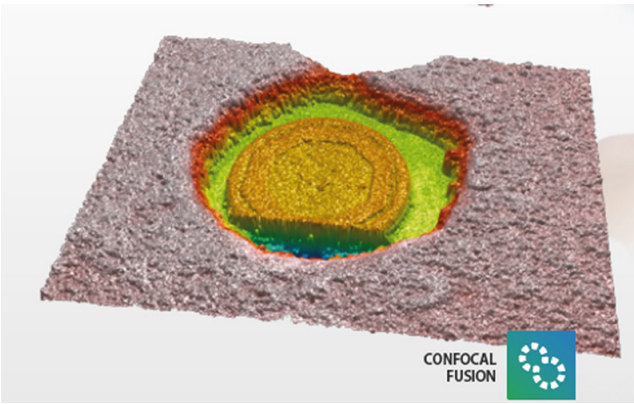
- **Confocal profilers** have been developed to measure the surface height of smooth to very rough surfaces. Confocal profiling provides the highest lateral resolution that can be achieved by an optical profiler. Thus, spatial sampling can be reduced to 0.10 µm, which is ideal for critical dimension measurements. High NA (0.95) and high magnification (150x) objectives are available to measure smooth surfaces with steep local slopes over 70° (for rough surfaces up to 86°). The proprietary confocal algorithms provide vertical repeatability on the nanometer scale.
- **Confocal derivatives**: There are two derivatives of Sensofar's Confocal implementation that set the corresponding S line systems even further apart from the competition. These Measurement techniques are reserved for 3D Expert Mode acquisitions:
  - Continuous Confocal refers to a proprietary measurement technique that represents a revolutionary step in confocal measurement technology. With Continuous Confocal, Sensofar has successfully developed a confocal technique that utilizes a continuous z-axis scan. Acquisition speed is comparable to focus variation, and is roughly 3x faster than Sensofar's own Confocal approach while maintaining comparable repeatability and accuracy. Continuous Confocal is an ideal solution for Quality Control tasks where speed is a key factor, and is essential for reducing acquisition times for large area and extensive z-axis scans.



Acquisitions of the same sample with Focus Variation (left, 8s), Continuous Confocal (middle, 10s), Confocal (right, 35s)

  - Confocal Fusion refers to another new and proprietary measurement technique that draws

the best out of Sensofar's Confocal and Focus Variation techniques by using a unique smart algorithm that yields the most reliable data from a single scan. Where neither Confocal or Focus Variation can provide ideal results, Confocal Fusion surpasses the limitations of both techniques to provide high-quality measurements over spatially highly varying surfaces. It is ideal for highly complex or technical surfaces exhibiting both steep rough and steep smooth areas, and where a traditional confocal approach alone would fail to capture the surface adequately.

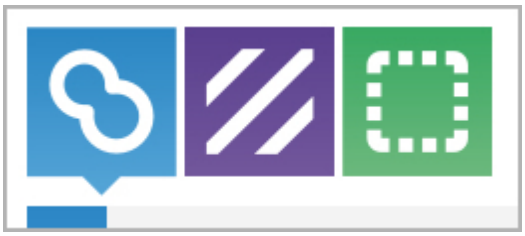


For those needing ISO norm compatibility, both Continuous Confocal and Confocal Fusion measurements still conform to ISO 25178 requirements.

- **Interferometry** has the highest vertical resolution of any optical technique. White-light vertical scanning interferometry (VSI) is best used to measure smooth to moderately rough, discontinuous and varying surfaces. VSI profiling provides nanometer vertical resolution for all NAs. The VSI algorithms enable the system to use all the available magnifications to profile shape features with the same height resolution.

- **Focus Variation** is an optical technology that has been developed for measuring the shape of large rough surfaces. Highlights of the standard focus variation technology include high slope surfaces (up to 86°), highest measurement speeds (mm/s) and large vertical range. In general, the technique can provide color information, can measure on steep flanks and very rough surfaces, but it cannot measure very smooth surface roughness, such as that on a silicon wafer. This combination of measurement capabilities is mainly used for tooling applications. Two particular aspects pertain to the **Sensofar** implementation of Focus Variation:
  - The measurement algorithm has in particular been optimized to give better results on steep surfaces when using MultiLevels.
  - In many respects, Focus Variation is an ideal complement to the Confocal approach, and a new proprietary **Sensofar** technique - Confocal Fusion (see above) - takes specific advantage of this aspect.

When switching between Measurement techniques, the system is automatically optimized and settings parameters are trimmed to those permissible for the chosen Measurement type. Visual distinction between the different Measurement techniques is provided in the **SensoSCAN 6** interface through the use of color schemes.

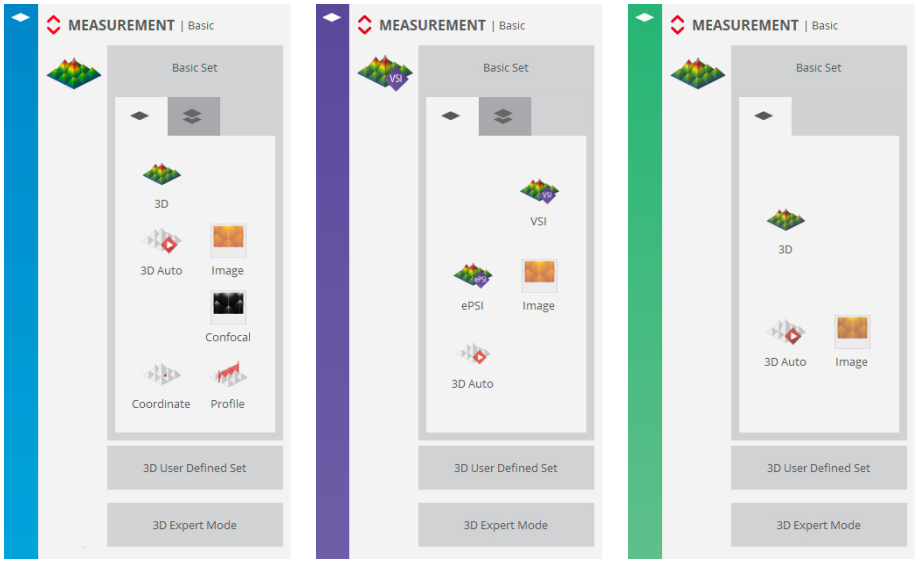


Blue signifies Confocal, purple Interferometry, and green Focus Variation

5.2 Measurement type

Overview

The available Measurement types depend on the selected Measurement technique:



Basic Set standard Measurement types for Confocal, Interferometry and Focus Variation, respectively

When switching between Measurement techniques and subsequently between Measurement types, the hardware and **SensoSCAN 6** parameter options are automatically trimmed to those permissible for the selected measurement configuration. Some of these changes occur 'under the hood' and are not user-configurable. Others are readily visible as changes in the interface, such as changing drop-down dialogs and 'disappearing' options in the interface.

All of these points (and others) are largely associated with differences between, or physics-based restrictions of, the permissible Measurement type for any selected technique. Despite the configuration changes performed by the system, note that there are still some instances where the user can still configure measurements for which the results will be subject to error.

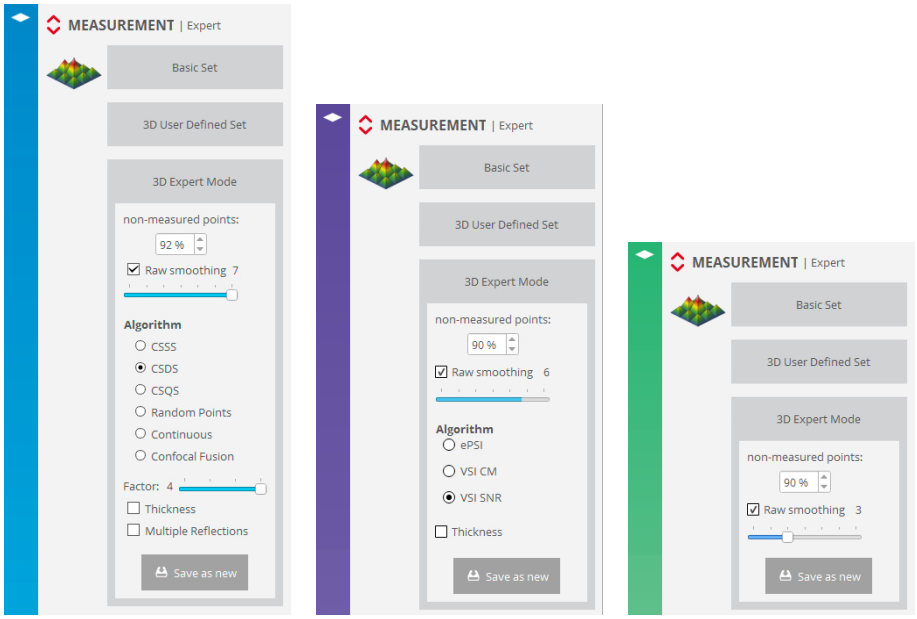
> **Warning:** It is very important to select the correct objective before performing measurements. If the selected objective does not coincide with the objective that is being actively used, the result will be completely useless.

Accessing Measurement types

To access the different Measurement types, click the red up/down arrows on the upper left of the Measurement pane. For Confocal, Interferometry and Focus Variation techniques, the standard Measurement types are visible in the Basic Set pane (see figure above). As already inferred, not all standard Measurement types are available for all Measurement techniques.

In order to provide a concise overview, it is convenient to first collect the different Measurement types into two general groups - measurements on surfaces and measurements of thickness. These will be discussed in the following sections in association with use of the basic set of Measurement types.

In addition to the basic set of Measurement types, an 3D Expert Mode is available. In this mode, the user has access to individual settings for measurement algorithms as well as proprietary **Sensofar** Measurement techniques, and other options. By enabling individual selection of these options, the expert user can create new user-defined Measurement types specific to particular applications. When saved, these so-called *Applications* are listed under 3D User Defined Set.



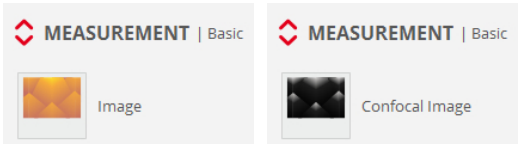
3D Expert Mode

5.2.1 Basic Mode

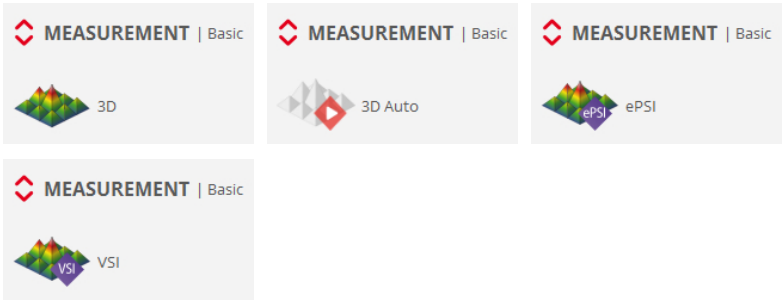
Overview

The basic suite of Measurement types include:

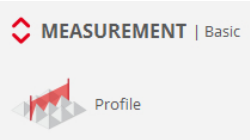
- image capture:



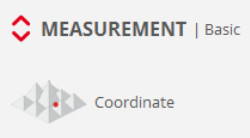
- 3D surface measurements:



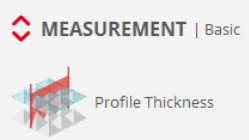
- profiles:



- coordinate measurements:



- thickness measurements:



Depending on the system, the choice of Measurement technique, the availability of any of these Measurement types is determined by the **SensoSCAN** software.

For each of the basic Measurement types, the optimal system configuration and choice of algorithm is pre-determined.

If more control and flexibility is needed for any one application, the user can switch to 3D Expert Mode and configure application-specific Measurement types (so-called *Applications*) themselves.

5.2.1.1 Surfaces

Overview

Surface Measurement types are used to acquire images, a 3D topography, a 2D profile or a single coordinate measurement from a sample. In most cases the surface is defined by an air-sample interface.

3D Auto feature

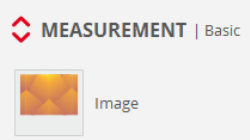
3D Auto is an automated measurement mode for Confocal, Interferometry (VSI) and Focus Variation Measurement techniques that is available for measurements in Basic Mode. When selected, the user must simply place the sample correctly and then manually focus. By clicking *Acquire*, **SensoSCAN** automatically determines the appropriate measurement parameters using a pre-defined initialization routine and subsequently acquires a measurement over a single FOV.

More detail on the 3D Auto measurement can be found in Surfaces / 3D.

5.2.1.1.1 Image

Overview

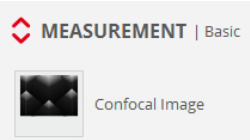
Images



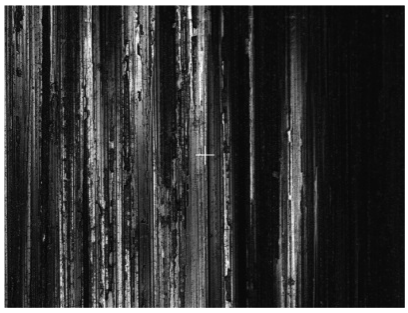
An image can be captured directly from the camera using a brightfield or an interferometric objective. For single LED systems, as is the case for the **S lynx** and **S mart**, this image is in B/W.

To acquire an image, simply click on the *Acquire* button. **SensoSCAN** drives the microdisplay appropriately and shows the result in Display & Analysis mode.

Confocal images



A confocal image can be acquired when the Confocal Measurement technique is selected.



Confocal image

Note: SensoSCAN acquires confocal images according to the confocal algorithm selected (CSSS is used as default, e.g. when using Measurement types in Basic Mode).

5.2.1.1.2 3D

Overview

A 3D topography measurement acquires the current FOV of the objective.

All Measurement techniques - Confocal, Interferometry and Focus Variation - can be used to acquire a

3D topography. Information regarding the individual algorithms used in each case can can be found in Measurement algorithms.

Single 3D topography measurement

To measure a single 3D topography measurement, place the sample under the objective and focus. Then set the required FOV, the Z-Scan range and the Threshold and click on the *Acquire* button.

For a given Z-Scan range, **SensoSCAN** automatically calculates the number of planes to be acquired and the required Z-Scan movement, in accordance with the Measurement technique and Measurement type. It then drives Z-Scan to obtain a confocal, interferometry or focus variation image in each plane. Once all of the optical information has been acquired, the software calculates the metrological data and switches to Display & Analysis mode to show the result.

> **Note:** As each image requires a large amount of RAM, the number of planes that can be acquired is limited by the selected Resolution and the Z-Scan range (maximum number of planes in memory 1000 at Resolution 1).

Technology	Objective	Z-Scan
Confocal	20x	2 mm
Focus Variation	20x	1 mm
VSI	-	206 µm
ePSI	-	275 µm

There are two ways to prematurely stop the measurement:

Option	STOP function
Esc	Cancel the measurement and lose the data. The software shows an Acquisition Error message.
Space	Stop the measurement after acquiring 21 planes (Confocal and Focus Variation) or 50 images (VSI and ePSI) and go to Data & Analysis.

3D Auto

3D Auto is an automated acquisition mode for Confocal, Interferometry (VSI) and Focus Variation Measurement techniques. 3D Auto has primarily been designed i). as a quick route to presentable data for the inexperienced, and ii). to provide a quick snapshot of a sample, for example for demonstration purposes. While 3D Auto can be routinely used to obtain highly qualitative results, it has not been designed as a replacement for the experienced user who is responsible for generating highly qualified measurements.

Note: As its name implies, this Measurement type is for 3D surfaces - 3D Auto can be used to measure areal topographies, but it can not be used for surface thickness, neither (directly) for 2D profile measurements.

When selected, the user must simply place the sample correctly and then manually search for and optimize the focus. By clicking *Acquire,* **SensoSCAN** firstly implements a pre-defined initialization routine to automatically determine the appropriate measurement parameters. If this routine is successful, **SensoSCAN** subsequently acquires a measurement over a single FOV. Following a successful acquisition, the result is shown in Display & Analysis mode and can be examined and analyzed as normal.

Note: If the initialization routine fails to determine adequate parameters for a measurement, a warning is shown. No acquisition is made.

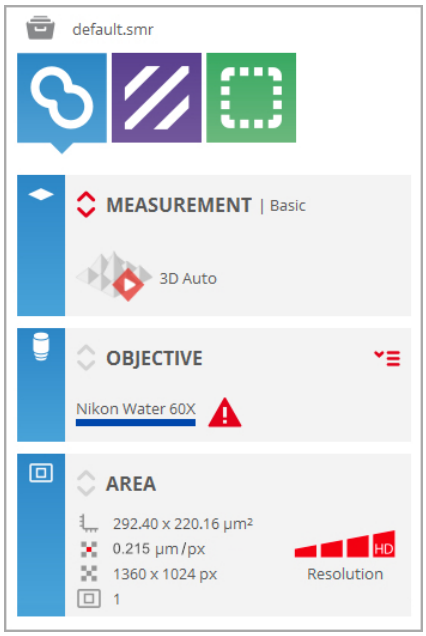
3D Auto options

When selecting 3D Auto, the Inspection & Acquisition UI is automatically changed (reduced) to reflect this automated mode - there are no options available to the user other than the installed objective. For single-LED systems, as is the case for the **S mart** and the **S lynx**, the measurement is in B/W. More exactly:

- the resolution in the Area pane defaults to *HD* and is not user-selectable
- the type of Z-Scan is not user-selectable
- there are no Autofocus options available to the user
- there no advanced lighting options available to the user
- the Threshold options are not user-selectable
- and finally, 3D Auto cannot be used within a Recipe

Note: The nature of the 3D Auto initialization routine means that it's ability to successfully acquire measurements on 'mirror-like' samples is not guaranteed. For such samples, the user should instead take a measurement manually.

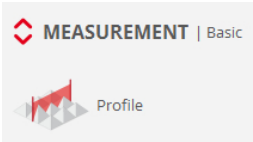
Warning: If a surface is not compatible with any of the restrictions listed above (e.g. special illumination required), then it is best measured manually using the other Measurement types available in Basic Mode, or by using a pre-configured *Application* for that particular type of structure (see 3D Expert Mode).



The reduced interface in Acquisition Settings when *3D Auto* has been selected

5.2.1.1.3 Profile

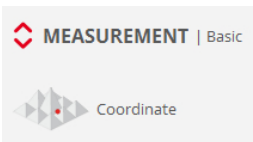
Overview



Using the Confocal technique, this Measurement type determines the surface profile at points situated along the central slit of the pattern imaged on the sample. The result of a profile is similar to that obtained with a mechanical contact instrument, but where the length of the measurement is limited by the FOV of the selected objective. A profile is by far the fastest measurement (about 3 s) that can be taken with the system, and is very useful for checking measurement parameters such as the Z-Scan range and Threshold. A profile measurement is also recommended for samples that have a marked lay direction.

5.2.1.1.4 Coordinates

Overview



A coordinate is a measurement of one point. The Z position is calculated as the average of the heights at the center of the FOV measured with a single profile.

Following a successful acquisition, **SensoSCAN** does **not** switch to Data & Analysis mode. Instead

the measurement is stored to file (*C:\TMP\Coordinates.txt*).

Note: Coordinate measurements can only be acquired using the Confocal technique.

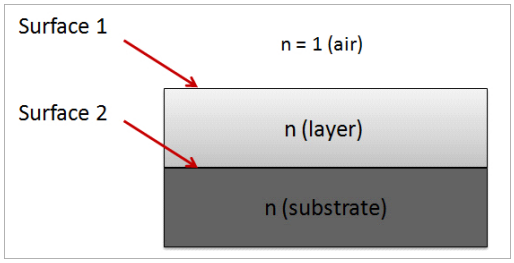
Displaying coordinate data sets as a surface

By selecting **File / Import / Import coordinates** from the Menu Bar (not available from the Quick Bar), a coordinate text file with a minimum of 10 values can be imported into **SensoSCAN** and displayed as a topography - see Display & Analysis / Quick Bar tools. Once **SensoSCAN** has loaded the file, it creates the corresponding **.plux* file and shows it in Display & Analysis mode as a new result.

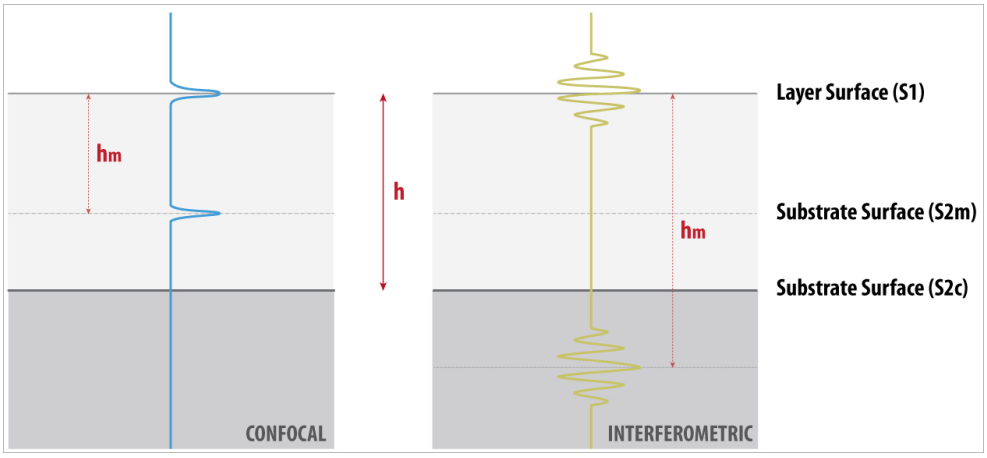
5.2.1.2 Thickness

Overview

With the **S mart** and the **S lynx**, both Confocal and interferometric techniques can be used to measure the surfaces and thickness of a single transparent layer, or of a transparent foil. Both Measurement techniques do this by effectively acquiring signal from both the upper (air-layer) surface and the lower (layer-substrate or layer-air) surface - the layer/foil thickness is then simply the difference between these 2 surfaces. Confocal thickness measurements include 2D profile and 3D topography measurements. Interferometric thickness measurements (VSI only) only include 3D measurements.



As conventional measurement algorithms are designed to deal with an axial response from only one surface, measurements of transparent layers and foils can lead to incorrect results if this aspect is not properly taken into account. The measurement of both surfaces is further complicated by refraction in the layer, affecting confocal and interferometric approaches differently (see image below). The appropriate tools for this task are thus specially designed thickness measurement algorithms.



Confocal thickness measurements

For confocal measurement of thin films, the image of the lower surface appears closer to the upper interface due to image refraction within the transparent layer. This imposes a fundamental limitation to this technique - only layers thicker than the width of the axial response of the objective can be resolved.

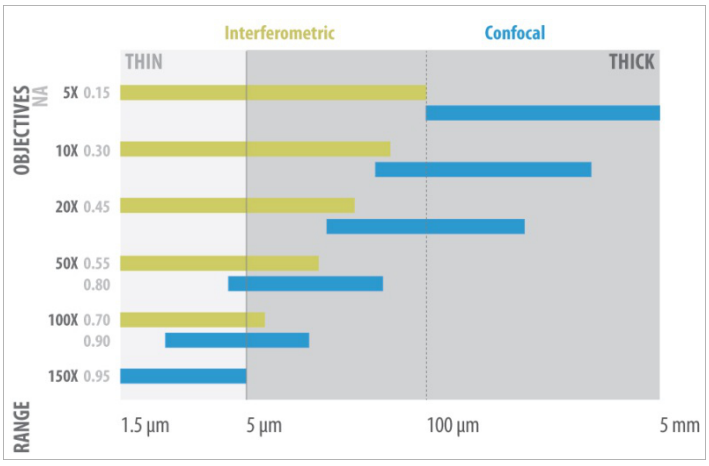
For practical purposes, the smallest axial response is achieved using highest numerical aperture (highest magnification objective). Layers as thin as 1 µm (on smooth surfaces) can be resolved within a FOV of several 100 µm. Low NA (low magnification) objectives limit the Confocal technique to thicker samples. In this case, very thick transparent materials up to several millimeters can be measured.

Interferometric thickness measurements

For interferometric measurements, there are two opposing effects. The image of the lower surface is refracted in the layer and thus appears closer to the upper surface, while the interferometric fringes from the lower surface are located below the lower surface (typically by the same amount as the refraction index of the transparent layer). The lower surface image and the fringes are thus not in the same plane, and measurement of the lower surface topography is blurred.

For low magnification objectives (low NA), the depth-of-focus of the objective is relatively long and this effect is not very critical. Thin layers can be measured from less than 1 µm up to several 100 µm with a very large FOV.

For high magnification objectives, such as 50x, the depth-of-focus decreases and the image of the lower surface gets even closer to the upper surface, making the image of the fringes very blurred and with very low contrast. Typically, magnifications of 50x and higher limit the measurable thin film thicknesses to some microns.



Typical objective limits when measuring thickness

Important points to note

The thickness measurement algorithms are designed to deal with axial responses that contain information from two surfaces. In order to obtain the correct results, the algorithms need to be fed appropriate refractive indicies for the particular sample configuration. These values are entered using the Layer pane that appears in Acquisition Settings when the corresponding Measurement type is chosen:

The Layer pane that appears in Acquisition Settings for thickness measurements

5.2.1.2.1 3D areal thickness

Overview

Using either Confocal or interferometric Measurement techniques, this Measurement type determines the upper and lower 3D areal surfaces as well as the 3D areal thickness of a transparent layer or foil. In principal, the procedure is exactly as that for a 3D topography measurement, with the addition of the layer values in the Layer pane.

> **Note:** When choosing the correct Z-Scan parameters, both surfaces must pass through the focus.

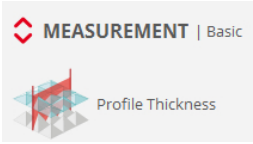
After measurement, the signal at each point is analyzed and is used to classify the surface points in order to determine which are the most reliable. These points are then used to estimate the upper and lower surfaces. In accordance with these estimates, the remaining surface points are processed to obtain measurements for both surfaces where possible.

The next step is to calculate the measured thickness as the difference in height between the two surfaces. The sample properties are used to calculate a correction factor and to obtain correct thickness values. Finally, the true location for the lower surface is calculated by subtracting the thickness from the upper surface.

The two surfaces (and thus also the thickness) is saved as a **.plux* file in the current **SensoSCAN** data folder. The file is named automatically.

5.2.1.2.2 2D thickness

Overview



Using the Confocal technique, this Measurement type determines the upper and lower surface profiles as well as the thickness of a transparent layer or foil at points situated along the central slit of the

pattern imaged on the sample. The measurement parameter settings are the same as those used for a surface profile, with the addition of the layer values in the Layer pane, and the fact that interpolation is not allowed.

> **Note:** When choosing the correct Z-Scan parameters, both surfaces must pass through the focus along the full length of the profile.

After the measurement of each single profile, the signal at each point is analyzed and is used to classify the surface points in order to determine which are the most reliable. These points are then used to estimate the upper and lower surfaces. In accordance with these estimates, the remaining surface points are processed to obtain measurements for both surfaces where possible.

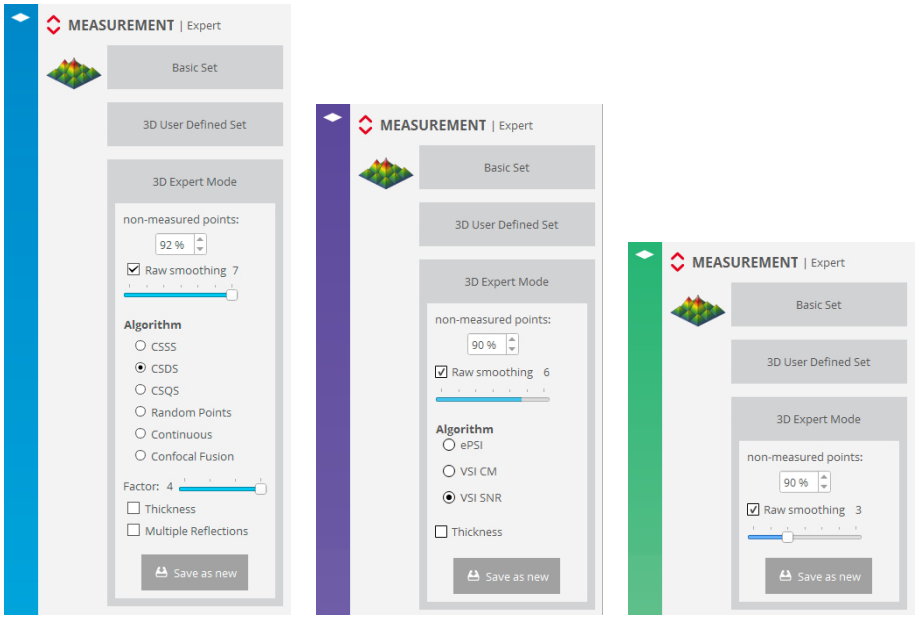
The next step is to calculate the measured thickness as the difference in height between the two surfaces. The sample properties are used to calculate a correction factor and to obtain correct thickness values. Finally, the true location for the lower surface is calculated by subtracting the thickness from the upper surface.

The two surfaces (and thus also the thickness) is saved as a **.plux* file in the current **SensoSCAN** data folder. The file is named automatically.

5.2.2 3D Expert Mode

Overview

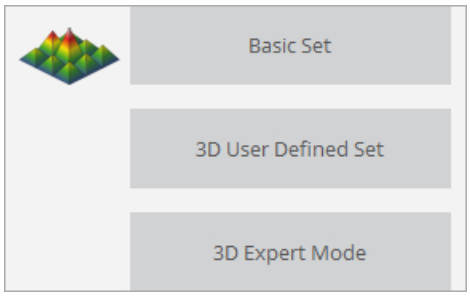
In addition to the standard Measurement types, an 3D Expert Mode is available for each Measurement technique:



3D Expert Mode

In this mode, experienced users can create new Measurement types specific to particular applications or surface configurations. Some of the options available in 3D Expert Mode are common to all Measurement techniques. Other options are specific to the selected Measurement technique. These are discussed in the following sections.

Once the user has optimized the settings for the particular application, the user can save the configuration as a new Measurement type - these are known as *Applications*. *Applications* appear under *3D User Defined Set:*



Applications are useful because 3D Expert Mode is not available for use in Recipes. The workaround is thus to create *Applications* with the required parameter settings and use these in a Recipe instead. A further advantage of this approach is that *Applications* can be shared with multiple systems.

5.2.2.1 Common pre-processing options

Overview

The following options are common to all Measurement techniques:

- *Maximum non-measured points* - This value is between 0% and 100%, and refers to the maximum acceptable percentage of points that are not measurable. If the measurement has a percentage of *non-measured points* exceeding this value, **SensoSCAN** displays a message that there are too many lost pixels and remains in acquisition mode. No results are shown.
- *Raw smoothing* - This is used to smooth images (Confocal, Focus Variation) or the envelope function (Interferometry) while 3D topographies are being acquired. The allowed values are 1 - 7, where higher values yield a greater effect. The goal of *Raw smoothing* is to reduce measurement noise while maintaining the maximum lateral resolution.

Note: The *Raw smoothing* option should be enabled as a matter of routine.

5.2.2.2 Measurement algorithms

Overview

Configuration in 3D Expert Mode provides access to algorithms and options other than those used as default in Basic Mode. The features and function of these algorithms and options are explained below.

Confocal

The system synchronizes the projected microdisplay images and the CCD camera to build a confocal image. This is done through the continuous projection of parallel, equally spaced slits. The slits can be in different projection directions. There are four types of confocal imaging: *coarse shift single sampling* (CSSS), *coarse shift double sampling* (CSDS), *coarse shift quadruple sampling* (CSQS) and *random points:*

- CSSS: In *coarse shift single sampling*, the microdisplay projects parallel slits onto the X axis. The slits are spaced 4 pixels apart and they are scanned for each confocal image (best

synchronization). This yields a fast acquisition rate. However, by enabling this fast mode, the slits are continuously scanned in the Y direction (fastest synchronization). This is a good algorithm for smooth or moderately rough surfaces with low magnification, or for all kinds of surfaces with a high numerical aperture and high magnification objectives.

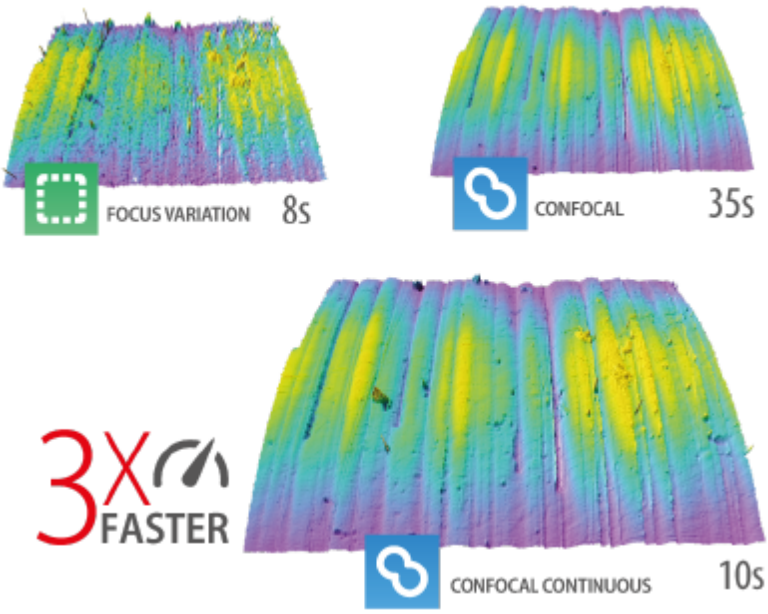
- CSDS: *Coarse shift double sampling* is the same as single sampling. However, parallel lines are projected in both directions: 0º and 90º. To obtain the confocal image, 4 images are acquired parallel to the X-direction and 4 parallel to the Y-direction. CSDS is a good algorithm for almost all kinds of surfaces, from very smooth to moderately rough, and for all magnifications.
- CSQS: *Coarse shift quadruple sampling* is the same as double sampling. However, parallel lines are projected in four directions: 0º, 45º, 90º and 135º. The parallel slits are spaced 4 pixels apart. To obtain the confocal image, 4 parallel images are acquired in each direction. Coarse shift quadruple sampling is a good algorithm for structures with circular geometry.

Note: *Factor* - All coarse shift modes have a period parameter that defines the width and therefore the spacing between the projected slits. The default value is 4-pixel spacing. A *Factor* of 2 selects 8-pixel spacing, a *Factor* of 3 leads to 12-pixel spacing, etc.. The default period is suitable for most surfaces and should only be changed when sample features such as roughness or geometry reduce the amount of reflected light. For example, very steep and smooth surfaces, such as those of prisms in which the local slopes can reach more than 45º along several microns, require a *Factor* between 4 and 8.

Warning: Calibration is performed using the optimum factor for the selected objective (1 or 2). For smooth surfaces, if the user changes the period parameter, the topography can be affected by increasing the peak-to-valley parameter.

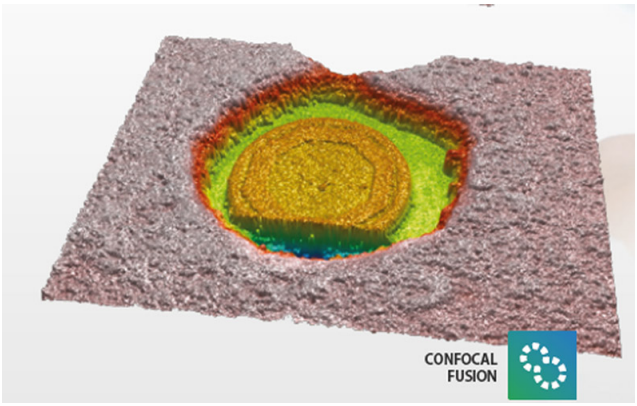
- *Random points*: With this algorithm, the system scans a cloud of points distributed on the microdisplay. To get one confocal image, various CCD camera images for several configurations of the points are needed. This is a good algorithm for very rough surfaces and for repetitive steep-sloped surfaces (arrays) such as PSS (patterned sapphire structures).

- Continuous Confocal refers to a proprietary measurement technique that represents a revolutionary step in confocal measurement technology. With Continuous Confocal, Sensofar has successfully developed a confocal technique that utilizes a continuous z-axis scan. Acquisition speed is comparable to focus variation, and is roughly 3x faster than Sensofar's own Confocal approach while maintaining comparable repeatability and accuracy. Continuous Confocal is an ideal solution for Quality Control tasks where speed is a key factor, and is essential for reducing acquisition times for large area and extensive z-axis scans.



Acquisitions of the same sample with Focus Variation (left, 8s), Continuous Confocal (middle, 10s), Confocal (right, 35s)

- Confocal Fusion refers to another new and proprietary measurement technique that draws the best out of Sensofar's Confocal and Focus Variation techniques by using a unique smart algorithm that yields the most reliable data from a single scan. Where neither Confocal or Focus Variation can provide ideal results, Confocal Fusion surpasses the limitations of both techniques to provide high-quality measurements over spatially highly varying surfaces. It is ideal for highly complex or technical surfaces exhibiting both steep rough and steep smooth areas, and where a traditional confocal approach alone would fail to capture the surface adequately.

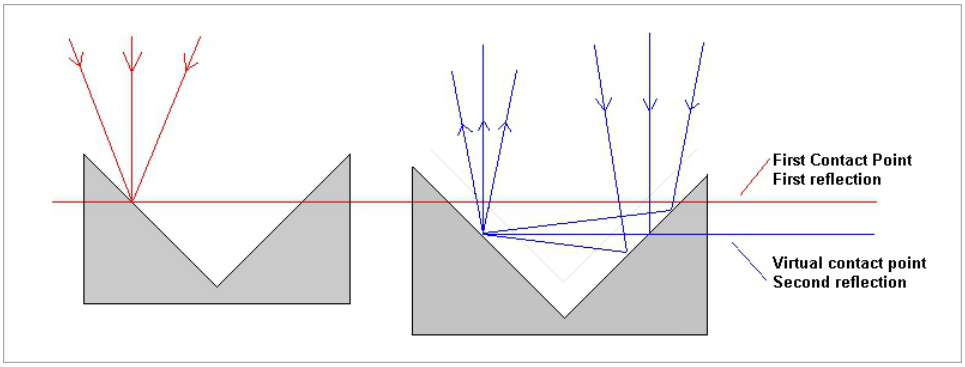


For those needing ISO norm compatibility, both Continuous Confocal and Confocal Fusion measurements still conform to ISO 25178 requirements.

Other options include:

- If *Color Image* is enabled, the measurement will acquire color brightfield images during vertical scanning and assign to each pixel the color of the image obtained at the z position where the surface was in focus.
- If *Thickness* is enabled, the algorithm is adjusted to deal with axial responses that contain information from two interfaces. The Layer pane appears in Acquisition Settings so that the algorithms for 3D areal and 2D profile thickness measurements can be properly configured.

- *Multiple Reflections*: This option is used for samples that can exhibit multiple reflections, for example, for samples that have transparent coatings, multilayer structures or retro-reflecting geometries. If this option is enabled, **SensoSCAN** examines each data point on the surface for the location of the first peak in the axial response, and only uses this value (even in samples where the reflection from subsequent surfaces is stronger than that from the first).



One type of surface structure that could lead to multiple reflections

Warning: *Multiple Reflection*s should only be used if there indeed are multiple reflections on the surface. If none are present, the measurement may contain many lost pixels and unreliable values. Note that Threshold adjustment is critical - if it is too low, further unreliability (noisy data) will be introduced into the measurement.

Interferometry

There are two interferometric acquisition modes - extended phase shifting interferometry (ePSI) and vertical scanning interferometry (VSI).

- ePSI: ePSI extends the range of conventional PSI in that ePSI acquires PSI data within the coherence length of the light source (in this case, a white LED). It then shifts its Z position, but still overlaps some of the measurable PSI range, and acquires more PSI data. The coinciding parts of both data sets are correlated, and finally both measurements are stitched together.
- VSI: There are two algorithms for the VSI technique:
  - *center of mass* (CM): The CM algorithm computes the center of mass of the fringe envelope on-the fly, with the advantage that there are then no memory-related Z range limitations.
  - *smart noise resistant* (SNR): SNR locates the position of the peak of the fringe envelope. To do this, a stack of interferograms need to be retained in memory for processing, thus leading to memory-related Z range limitations. SNR is the default algorithm because it results in less system noise.

One more option applies to thickness measurements only:

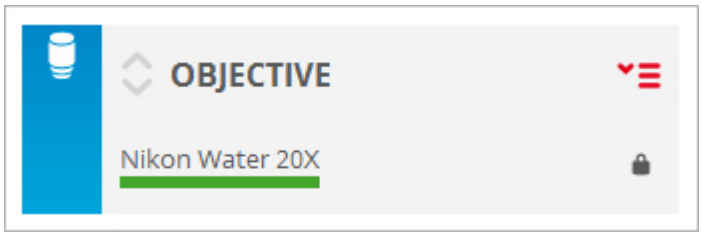
- *Thickness* (VSI only, SNR only): select this option for interferometric 3D areal thickness measurements.

5.3 Objective Selection

Overview

The choice of objective made in Sample Inspection is by default forced to be the same in Acquisition Settings. The reverse is also true - changing the objective selection under Acquisition Settings forces the same change under Sample Inspection. The objective selection is thus mirrored throughout the system.

This behavior can be disabled in System Preferences. When disabled, a padlock icon appears in the Objective Selection pane under Acquisition Settings - as long as the lock is closed, the objectives shown in Sample Inspection and in Acquisition Settings match:

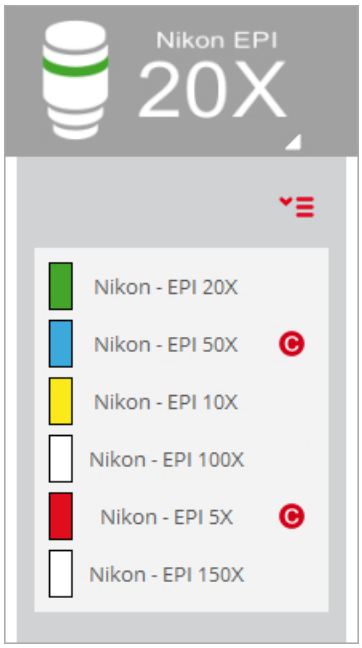


By opening the lock, the selection of other objectives within Acquisition Settings is enabled (for example, an alternative objective to that chosen for Sample Inspection). By closing the lock, the objective shown in Sample Inspection is forced to that chosen in Acquisition settings.

> **Warning:** It is very important to select the right objective before acquiring measurements. If the selected objective does not coincide with the objective that is actively being used, the result will be completely useless.

Accessing objective options

Click click on the tab to view the selection options:



As described in Chapter 4, Objective Selection, available objectives that have not yet been calibrated are highlighted in this list with a . The status of any uncalibrated objectives is also highlighted in the objectives pane:

Non-calibrated objective warning for linked (left) and non-linked objectives

Motor control with non-linked objectives

Be aware that when the active objective installed in the profiler does not match up with the selection in **SensoSCAN**, height adjustment of the sample to obtain best focus can result in damage to the sample. This can occur because **SensoSCAN** allows for a working distance specific to the selected objective.

> **Warning:** If the objective selected in **SensoSCAN** is not the same as the actual objective in the profiler, the software may let you enter a large Z-Scan value that could cause the objective to crash into the sample.

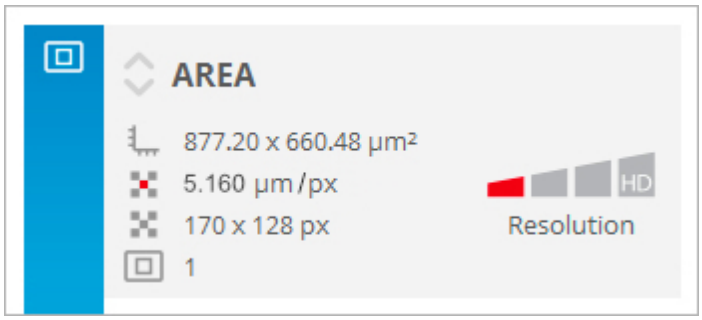
5.4 Area

Area options

The Area pane in Acquisition Settings

SensoSCAN automatically calculates the real area seen by the objective and shows the result in the Area pane. This calculation depends on the Measurement type and various measurement parameters.

The only selectable option available in this pane relates to the *Resolution* of the measurement. Changes to the resolution are made by clicking the required *Resolution* segment in the Area pane:



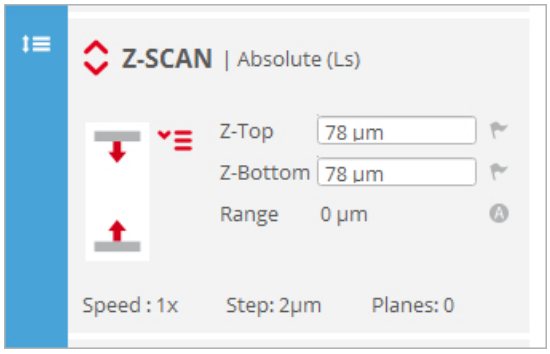
The same overall settings as above, but at a lower resolution

The highest resolution corresponds to one measurement point per camera pixel. Lower resolutions are achieved by binning camera pixels - 2x2, 4x4 or 8x8. In general, *Resolution* is changed automatically to keep the number of measured points below the maximum that can be acquired, and this depends on the system's available memory. Obviously, lower resolution means that fewer points are measured, and the topographic detail in the measurement result is thus reduced.

5.5 Z-Scan

Overview

The Z-Scan pane is used to select the format/direction, length and speed of scanning the sample along the Z-axis. The options available in the Z-Scan pane remain unchanged across all Measurement techniques.

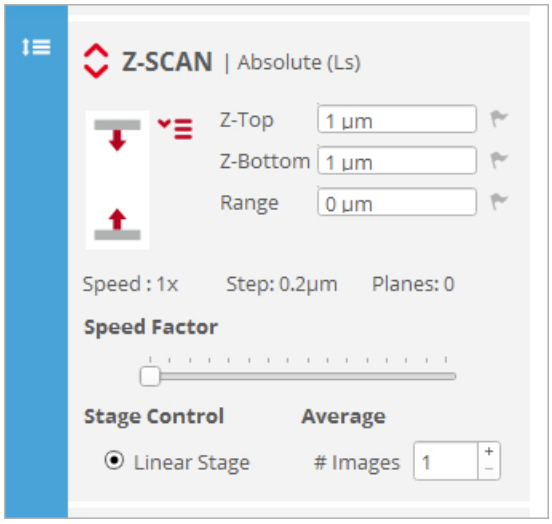


Z-Scan pane in Acquisition Settings

In general, standard initial values are shown, as determined by **SensoSCAN** for the current Measurement parameter configuration. Values can be edited from the standard values by simply clicking the appropriate icons to the right - . Due to the fact that **SensoSCAN** makes some basic assumptions and performs some internal checking, these values are semi-interactive - changing just one will automatically adjust the others unless these are also manually overwritten.

The Z-Scan pane also displays the stage control used to acquire the measurement (for the **S mart** and **S lynx**, this is the linear stage, *Ls*).

Advanced options are accessed by clicking the red up/down arrows :

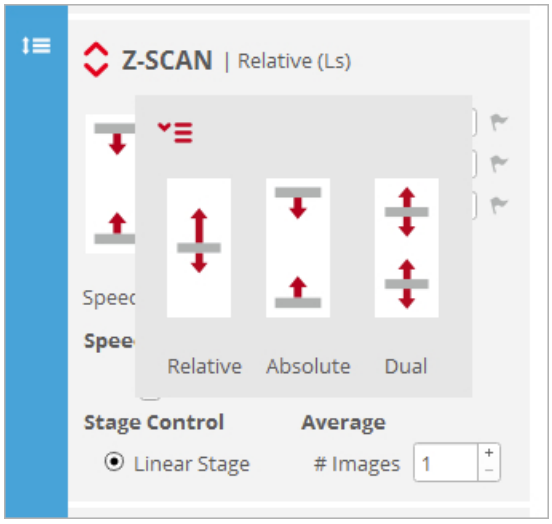


Advanced options are visible in the extended Z-Scan pane

5.5.1 Z-Scan options

Relative, Absolute and Dual

There are three kinds of Z-Scan: *Relative*, *Absolute* and *Dual*. These are accessed by clicking the drop-down icon :



***Relative*, *Absolute* & *Dual* Z-Scan travel options**

Note that swapping between *Relative*, *Absolute* and *Dual* introduces a minor and unimportant change in the nomenclature of the upper and lower Z-Scan parameters.

The available Z-Scan range is always an interplay between the overall height of the sample, the objective safety distance specified internally (i.e. a built-in buffer zone immediately below the objective) and the software and hardware travel limits of the system. Values for the objective safety distance are listed in a table in the Autofocus section. Nominally these values are (WD - 500 µm) for objectives with WD > 1000 µm, otherwise it is WD / 2.

Relative Z-scan

The simplest scanning option is the *Relative* scan about an initial Z-Scan location (usually the current position).

For a surface measurement, Z-Scan must be initially positioned somewhere between its most extreme (lowest & highest) focal positions. For a thickness measurement, Z-Scan must be initially positioned between the two surfaces of the layer or the foil within the current (i.e. measurement) FOV. Note that the vertical starting position must not be centrally between the extreme (lowest & highest) focal positions - by an appropriate choice of *T-Range* and *B-Range* values, the vertical axis can be scanned asymmetrically about the initial position.

Once the user has determined and entered the desired range, the software calculates the number of planes needed to carry out the measurement and shows the result in the Z-Scan pane. This calculation is based on the internal values given for the optimum step for each objective.

For Confocal or Focus Variation measurements, if the user has entered a 20 µm range with the 50x EPI objective, the software will acquire 100 planes in steps of 0.2 µm. If the 150x EPI objective is used, the software will acquire 200 planes in steps of 0.1 µm.

Family	Objective	NA	Optimum Step (µm)	Maximum Step (µm)
EPI	2.5x	0.075	24	384
EPI	5x	0.15	12	192
EPI	10x	0.30	2	32
EPI	20x	0.45	1	16
EPI	50x	0.80/0.95	0.2	3.2
EPI	100x	0.90	0.2	3.2
EPI	100x	0.95	0.1	1.6
EPI	150x	0.90/0.95	0.1	1.6
ELWD	20x	0.40	1	16
ELWD	50x	0.55/0.60	0.5	8
ELWD	100x	0.80	0.2	32
SLWD	10x	0.20	2	32
SLWD	20x	0.30/0.35	1	16
SLWD	50x	0.40/0.45	0.5	8
SLWD	100x	0.60/0.70	0.2	3.2
WI	10x	0.30	2	32
WI	20x	0.50	1	16
WI	60x	1.00	0.2	3.2
CORR	20x	0.45	1	16
CORR	50x	0.70	0.2	3.2
CORR	100x	0.85	0.2	3.2

For profile thickness measurements, the brightfield objectives with an optimum Z-Scan step of 0.2 µm is reduced to 0.05 µm and for 0.1 µm it is reduced to 0.03 µm.

The Z-Scan range has some limitations. When the range is too large, the measurement will take a long time. If the range is too small, there will be no information for some zones in the measurement, and non-measured points will appear. To avoid these problems, the software automatically checks either the range or the total number of planes. If the Z-Scan range is not large enough for the measurement, the software will change it to produce a minimum number of planes. Alternatively, the software will change the range to the maximum allowed value when the step and the resolution are greater than the maximum allowed by the available memory.

Measurement type	Minimum number of planes
Profile measurement	51
Coordinate measurement	51
3D measurement	21

Absolute Z-Scan

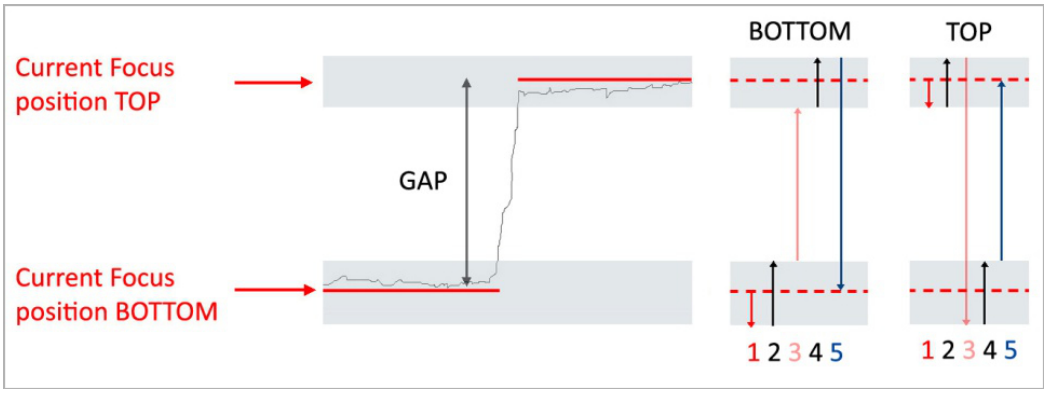
While *Relative* and *Dual* Z-Scan are defined relative to the current focus position, *Absolute* Z-Scan allows the user to define the Z-Scan range by setting the absolute Z coordinates for the upper and lower positions (*Z-Top* and *Z-Bottom*, respectively). Alternatively, a start value (top or bottom) can be set, and then the *Range*.

If the Z-Scan range is not large enough for the measurement, the software will not allow a position to be selected. Consequently, the user has to increase the range by moving up or down to obtain the required minimum Z-Scan range.

Dual Z-Scan

Dual Z-Scan is best used to measure samples with a high discontinuous step, i.e. there is simply no point in scanning the step.

The sample is focused initially either at the top or the bottom, and this starting position must be selected in the Z-Scan pane (toggle between T-Ref / B-Ref). Now enter the desired scanning *T-Range* and *B-Range* for both planes. In addition, enter the *Gap* amount.



BOTTOM option - (1) movement before scanning, (2) movement during bottom scanning, (3) from the end of bottom scanning to the start of top scanning, (4) movement during top scanning, (5) return to the start position. TOP option - (1) movement before scanning, (2) movement during top scanning, (3) from the end of top scanning to the start of bottom scanning, (4) movement during bottom scanning, (5) return to the start position

Warning: To use the *B-Ref* direction, one must focus below the lowest point of the sample in the desired Z start position. To use the *T-Ref* direction, one must focus above the highest point of the sample.

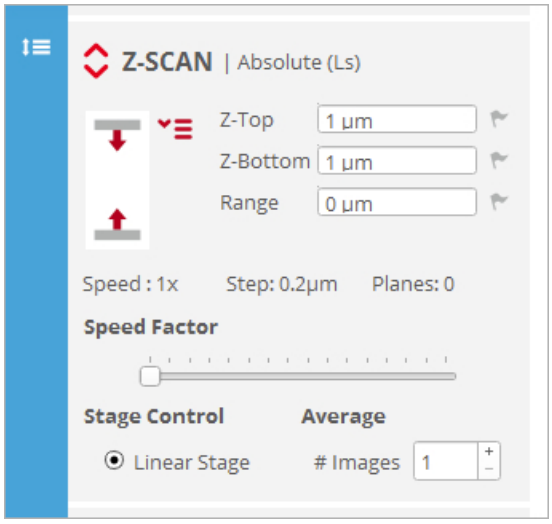
Once the *Acquire* button has been clicked, the software acquires the first region, moves up or down by

the *Gap* amount (without acquisition), and then acquires the second region. The result is treated as a regular measurement. The effect of the speed factor on the number of planes scanned along the top and bottom ranges is the same as in a single Z scan.

5.5.2 Z-Scan advanced options

Optimizing Z-Scan

Advanced options are accessed by clicking the red up/down arrows ⇕:



Speed factor

The speed factor can be used to reduce the measurement time. A speed factor of 1x means that the software will perform the measurement using the optimum step between planes. With a value of 2x, the software will acquire the measurement using a double step size and half the number of planes. A maximum of 16x is allowed. An increase in the speed factor reduces the measurement time, but also has a negative effect on the system's performance. The optimum speed factor depends on the roughness of the sample. The user must check to see which speed factor is the acceptable maximum for any one application.

> **Warning:** Speed factors above 4x can lead to loss of accuracy for rough surfaces. Speed factors above 2x can lead to the appearance of fringe-like structures superimposed over the real one. Check the correct speed factor for your sample in order to achieve the required accuracy.

Stage control

The Stage Control section in the Z-Scan pane displays the stage control used to acquire the measurement (linear stage, *Ls*).

Average

Two are 2 approaches to averaging measurements:

- *Average Images* (available for Confocal)

  This maintains the Z plane for every Z-Scan step and the selected number of images of the

camera are then averaged to create a single image in each plane. The system then moves on to the next Z plane and repeats the process. This is used to greatly reduce the noise in the final measurement.

- *Average Scans* (available for Focus Variation & VSI)

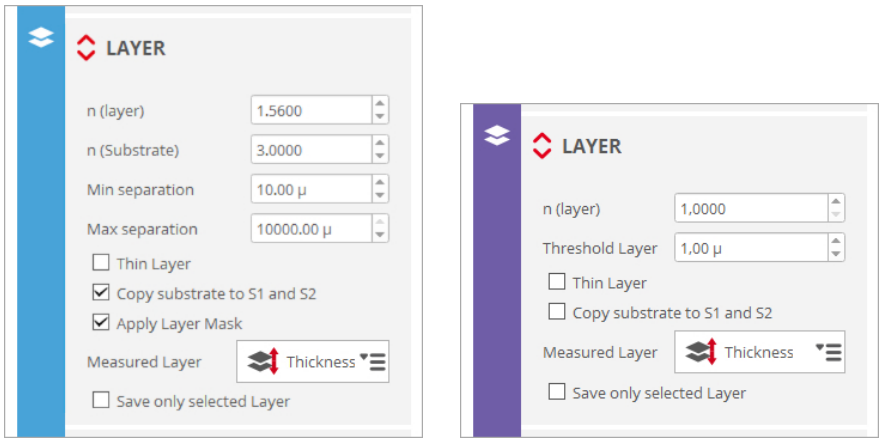
  This is useful for averaging 3D data, and can also be used to reduce system instabilities such as external vibrations. With *Ls* stage control, the selected number of phase maps are acquired and then averaged.

Warning: If the image is saturated, the measurement will be inaccurate. Move Z up and down to make sure (in particular for Interferometry) that the maximum fringe contrast is not saturated.

5.6 Layer

Overview

The measurement algorithms for Confocal and interferometric thickness measurements are designed to deal with axial responses that contain information from two surfaces. In order to obtain the correct results, the algorithms need to be fed appropriate parameters for the particular sample configuration. These values are entered using the Layer pane that is only visible in Acquisition Settings when the corresponding Measurement type is chosen:



The (extended) Layer pane, visible in Acquisition settings for thickness measurements (blue for Confocal, purple for Interferometry)

Thickness measurement parameters

The available parameters are as follows:

- *n (layer)* refers to the refractive index of the layer or film itself (use three significant digits if possible)
- *n (substrate)* (Confocal only) refers to the refractive index of the substrate below the layer (use three significant digits if possible)
- *Min/Max separation* (Confocal only) sets a lower/upper limit for the distance of the lower layer surface from the upper (topmost) layer surface, respectively. Taken together this determines a proximity window for the lower layer surface. Default values are 0 and 10 mm, respectively.

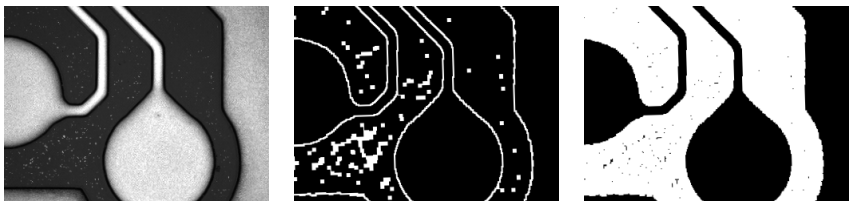
Note: For *Min/Max separation*, the values given should correspond to the apparent layer thickness as would be expected when moving between the two surface focal positions with the Z stage. **SensoSCAN** will automatically correct for refractive index when displaying the results.

Note: The correction for refractive index can be disabled by setting *n (layer)* to 1.000. This saves a little overhead in the calculation, and is useful, for example, if the user simply wants to explore/locate holes in a layer.

- *Threshold Layer* (Interferometry only) sets a minimum optical separation for the two main signal peaks. Regardless of the cause of a peak, if it is closer to the main peak than this distance, it will be excluded from the analysis.

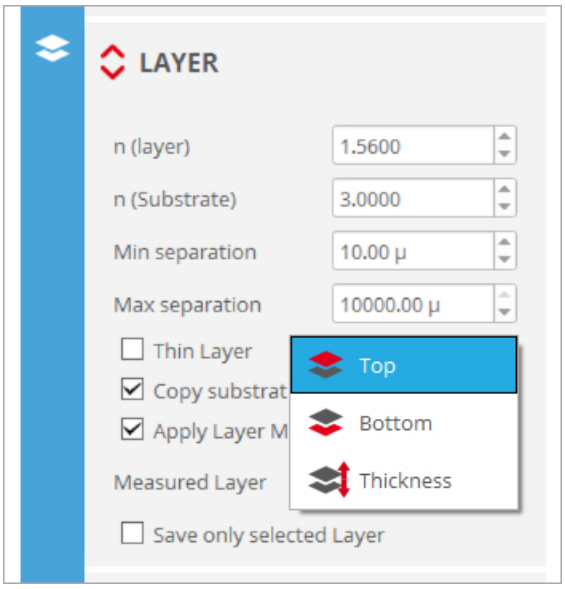
Note: Each objective has a minimum thickness threshold associated with it in **SensoSCAN**. User settings are ignored if the values given are lower than the objective's threshold.

- *Thin Layer* activates a special algorithm designed for layers of less than 2 µm.
- *Copy substrate to S1 and S2*: For points where the lower and upper layer surfaces have no values (for example, because the coating has a hole at that location), this option copies the values for the lower surface (i.e. the substrate) to both surfaces (not to be confused with the Restore operator, which generates substitute data by interpolation).
- *Apply Layer Mask* (Confocal only): Together with the setting *Copy substrate to S1 and S2*, this option makes use of the stack image (below left) to define outlines (below, middle) and then a mask (below, right). This results in segmentation of the surface into three types of points:
  - Layer points (dark pixels in the stack image below left) are analyzed using the thickness algorithm.
  - Non-layer (surface) points (bright pixels in the stack image) are analyzed using a surface algorithm.
  - Layer edge points are at the interface between the upper two sets of point types, and are set as 'non-measured'.



Stack image, outline and surface mask, as used with the *Apply Layer Mask* option

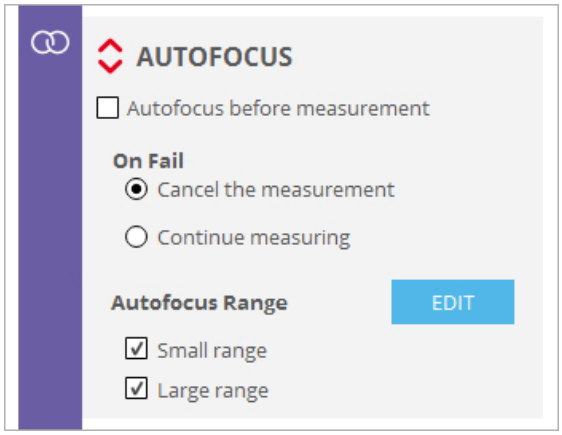
- *Measured Layer*: Following a successful measurement, only the selected surface or layer topography (3D) or profile (2D) is displayed, although both surfaces (and thus also the layer) are still directly accessible in Display & Analysis and can be saved to file. This can be restricted to the chosen *Measured Layer* by activating the *Save only selected layer* option, in which case (when selecting the *Top* or *Bottom* surface) the measurement obviously defaults to a surface topography (or profile for 2D) and is no longer a thickness measurement. The selected *Measured Layer* is also used to assess the non-measured points.


LAYER
n (layer)
1.5600
n (Substrate)
3.0000
Min separation
10.00 µ
Max separation
10000.00 µ
Thin Layer
Copy substrat
Apply Layer M
Measured Layer
Save only selected Layer
Top
Bottom
Thickness

5.7 Autofocus

Overview

The Autofocus command triggers a routine used by the system to fine focus the sample, in order to optimize the initial Z-position for measurement. The focus can be manually optimized at any time using the motor controls, or automatically adjusted by clicking the Autofocus button in Sample Inspection.



The (extended) Autofocus pane in Acquisition Settings

By enabling *Autofocus before measurement* in the Autofocus pane in Acquisition Settings, the focus is automatically adjusted before acquisition commences. The accuracy will not be the same as for manual focusing performed by a human operator, but the accuracy and repeatability is good enough to make this feature useful.

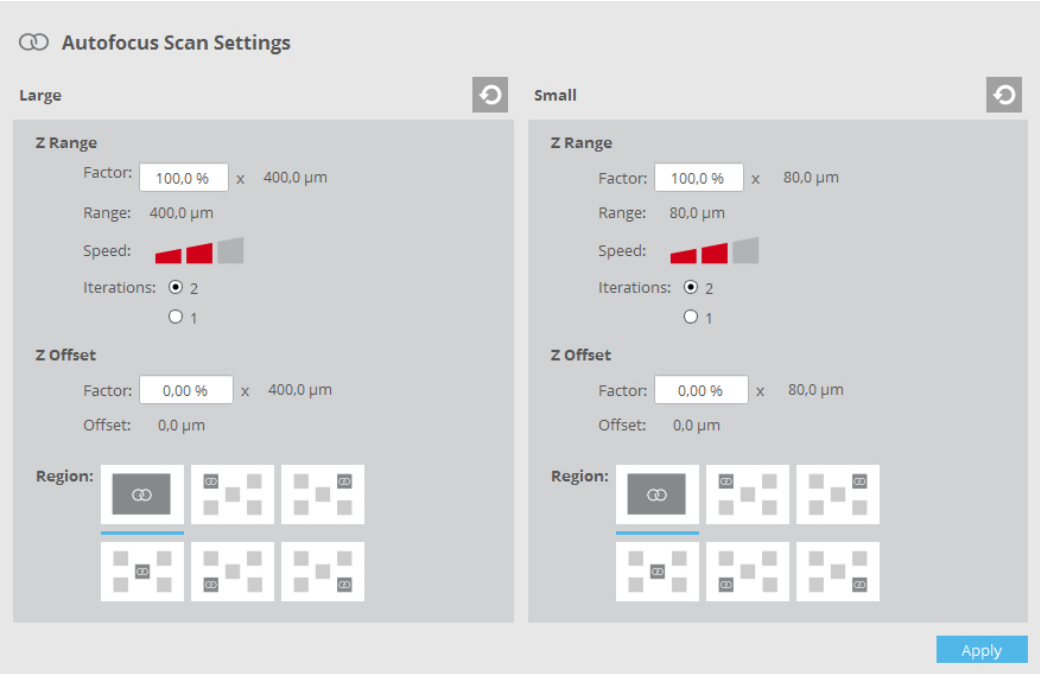
Advanced options

General options in the extended pane are:

- in case Autofocus fails, there is a choice of 2 options: *Cancel the measurement* and *Continue measuring*
- there are 2 possible scanning ranges for Autofocus *small* and *large* - one or both can be selected, and refer to the travel range in determining the best focus. *small* and *large* values for the individual objectives can be found in the table below.

Editing Autofocus ranges

Default Autofocus settings have been defined to obtain a balance between performance (accuracy and repeatability), speed and range. However, for specific applications, these settings may not be ideal. Access and change settings using the *Edit* button, followed by *Apply* to confirm the changes:



The Autofocus Scan Settings edit pane

- *Range factor* (%) increases or reduces the maximum range
- *Speed factor* determines the time taken (*slow*, *default* or *large*)
- *Iterations*: 2 or 1 iterations to home in on the best focal position
- *Z Offset* specifies an offset to the movement made during the Autofocus routine (from 0 to ± Range/4)

Note: These settings are used for all Autofocus functions - the exception to this is for the calibration of objectives, where SensoSCAN will use always the default settings.

Finally, the *Region* option determines which areas of the FOV are used to determine the best focus - the default area (the entire FOV) or specific sub-regions of the FOV.

Important points to note

- If a brightfield objective is selected, the Autofocus scans over an objective-specific vertical range and looks for the best position of the overall image. For brightfield objectives, the ratio between *small* and *large* is 5. The estimated time required for the Autofocus routine depends on the numerical aperture. For *small* Autofocus it is between 3.5 and 4.5 seconds and for *large* Autofocus it is between 4 and 6 seconds.
- If the Z-Scan range chosen here by the user is larger than the maximum allowed range for the installed objective, SensoSCAN will automatically reduce the Z-Scan range accordingly. Z step is then also reduced to keep the number of planes. Z-Scan is performed by moving Z at a constant speed. Thus the Z step between planes determines the speed of the Z movement.
- If the nominal Z speed is greater than the maximum, the actual Z speed is set to the maximum. Z step is then reduced and the number of planes is increased to keep the same Z-Scan range.

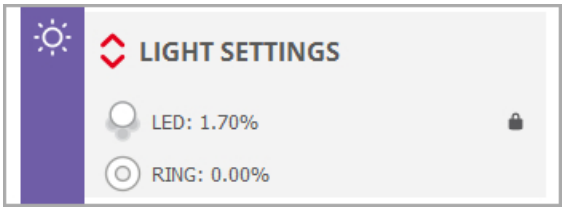
Family	Objective	NA	WD	Maximum Range	Autofocus Range	
					small	large
			(mm)	(µm)	(µm)	(µm)
EPI	1X	0.030	3.80	3300	1900	1900
EPI	2.5X	0.075	8.80	8300	4400	4400
EPI	2.5X	0.075	6.50	6100	3250	3250
EPI	5X	0.150	23.50	23000	2304	11520
EPI	10X	0.300	17.50	17000	384	1920
EPI	20X	0.450	4.50	4000	192	960
EPI	50X	0.800	1.00	500	80	400
EPI	50X	0.800	2.00	1500	80	400
EPI	50X	0.950	0.35	175	80	400
EPI	100X	0.900	1.00	500	80	400
EPI	100X	0.900	2.00	1500	80	400
EPI	100X	0.950	0.32	160	40	200
EPI	150X	0.900	1.50	1000	40	200
EPI	150X	0.950	0.30	150	40	200
EPI	150X	0.950	0.20	100	40	200
ELWD	20X	0.400	13.00	12500	192	960
ELWD	20X	0.400	19.00	18500	192	960
ELWD	50X	0.550	10.10	9600	96	480
ELWD	50X	0.600	11.00	10500	96	480
ELWD	100X	0.800	3.50	3000	80	400
ELWD	100X	0.800	4.50	4000	80	400
SLWD	10X	0.200	37.00	36500	384	1920
SLWD	20X	0.350	24.00	23500	192	960
SLWD	20X	0.300	30.00	29500	192	960
SLWD	50X	0.450	17.00	16500	96	480
SLWD	50X	0.400	22.00	21500	96	480
SLWD	100X	0.700	6.50	6000	38.4	192
SLWD	100X	0.600	10.00	9500	38.4	192
WI	10X	0.300	3.50	3000	384	1750
WI	20X	0.500	2.00	1500	192	960
WI	60X	1.000	2.00	1500	80	400

Family	Objective	NA	WD	Maximum Range	Autofocus Range	
CORR	20X	0.450	7.40	6900	192	960
CORR	20X	0.450	10.9 - 10.0	10400 - 9500	192	960
CORR	50X	0.700	3.9 - 3.0	3400 - 2500	38.4	192
CORR	100X	0.850	1.2 - 0.85	700 - 425	80	400
CORR	100X	0.850	1.3 - 0.95	800 - 475	80	400
TI	2.5X	0.075	10.30	9800	100	1000
TI	5X	0.130	9.30	8800	100	1000
DI	10X	0.300	7.40	6900	100	1000
DI	20X	0.400	4.70	4200	100	1000
DI	50X	0.550	3.40	2900	100	1000
DI	100X	0.700	2.00	1500	100	1000

Values of the Autofocus scan range for common objectives

5.8 Light Settings

Overview

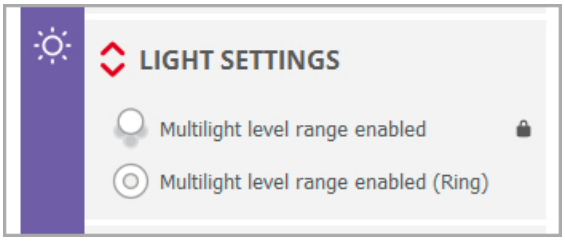


Light Setting pane, also showing the optionally available ring light

By default, the illumination options set in Light Control, or those pre-selected by the system, are forced (mirrored) over to Light Settings. There is no provision for changing the illumination in the Light Settings pane. The illumination options made in Light Control are valid throughout the system.

This behavior can be disabled in System Preferences - a padlock icon then appears in the Light Settings pane. By clicking on the icon and thus opening the lock, it is now possible to change the illumination settings under Light Control without changing those in Light Settings. By closing the lock, the illumination settings chosen in Light Control are again forced over to Light Settings.

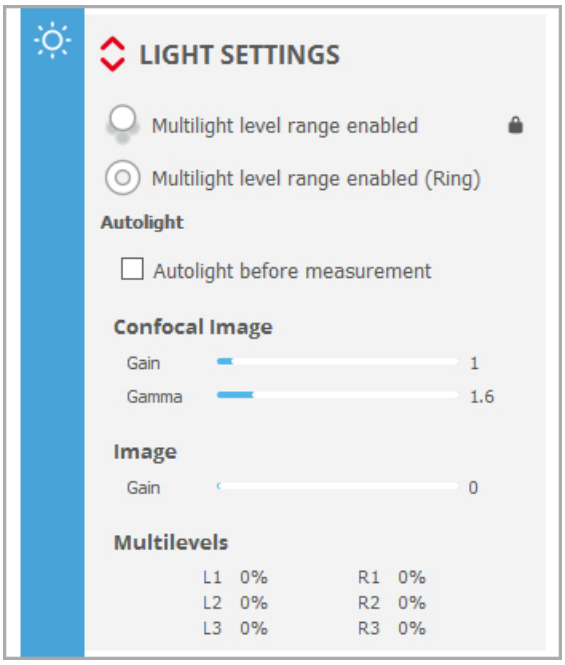
If MultiLevels is activated by selecting *scans* or *range*, the pane changes to reflect this:



Note: The LED is automatically switched off when **SensoSCAN** switches to Display & Analysis mode.

Advanced options

The Light Settings pane extends to reveal the advanced light settings selected in Light Control - as explained above, the light intensity and the currently active light source(s) are forced to those values shown in Light Control. There is thus no provision for changing the illumination options in the Light Settings pane.



Enabling Autolight before measurement sets the system to perform an Autolight routine before each measurement.

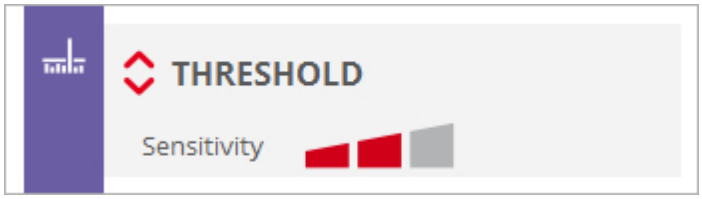
Note: When the surface is out of focus, Autolight may select a light level that is not suitable for a measurement. Therefore, *Autolight before measurement* should only be used together with *Autofocus before measurement*. Note that the *Autolight before measurement* option is not available when more than one level of light is selected (MultiLevels), and also that there is no Autolight control over the the optionally available ring light.

Note: To obtain accurate interferometric measurements, avoid saturation in the fringes. Move through Z to make sure that the maximum fringe contrast is not saturated.

5.9 Threshold

Overview

The Threshold setting decreases or increases system sensitivity to the optical signal by setting a lower level of measurement reliability - below this level, data points are ignored.



Threshold pane in Acquisition Settings

Sensitivity can be set to nominal values of 1, 3 or 5 using the graduated icon in the Threshold pane.

> **Note:** The actual values used (at the camera pixels) are dependent upon the Measurement type and other system-dependent factors. **SensoSCAN** calculates the values automatically for the chosen measurement configuration.

Advanced options

For advanced users, the Threshold value can be edited manually:

Sensitivity can now be set to any value between 0 and 100 (actually, 99.99):

- setting Threshold to 0 equates to measuring all points regardless of signal quality
- setting Threshold to 100 equates to the maximum theoretical intensity, in which case no points will be measured

The default value for Threshold for all Measurement techniques is 5. If the measurement contains too many lost pixels, first try increasing the illumination (without causing saturation), then try reducing the Threshold.

In general, avoid using low values in order to minimize noise. For example, using a value below 3 on a rough surface may cause spikes to appear.

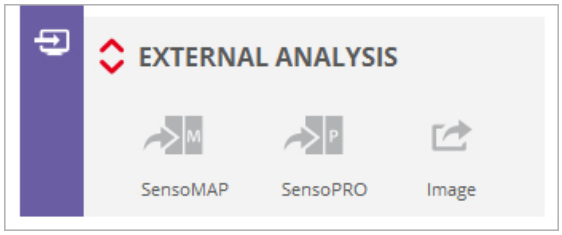
> **Note:** Threshold takes into account *Confocal Gain* and therefore it does not need to be increased when increasing *Confocal Gain* in Light Settings.

5.10 External Analysis

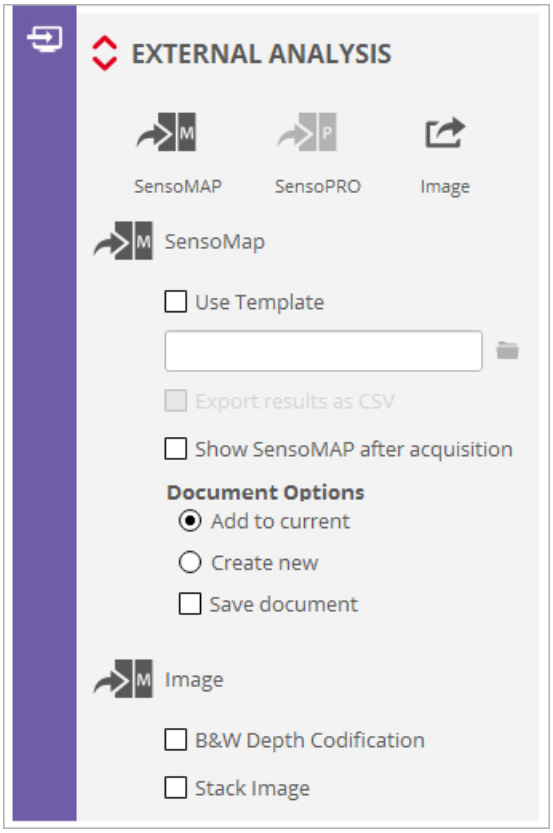
Introduction

SensoSCAN acquires one single measurement if no Recipe or a Single Measurement Recipe (SMR) is used. Alternatively, **SensoSCAN** can acquire a series of measurements by means of a Multiple Measurement Recipe (MMR).

The External Analysis window is used to direct data acquired with the system to external software (**SensoMAP** and **SensoPRO)** or to Export Image.



To enable each option, click on the label name(s) - advanced options for each selection can then be accessed by clicking on the red up/down arrows .



Note: SensoPRO must be running alone in conjunction with **SensoSCAN**. Additionally **SensoPRO** must be initialized as an Administrator of the **SensoPRO** software in order to properly configure the communication. More information can be found in the dedicated User Manual for **SensoPRO**.

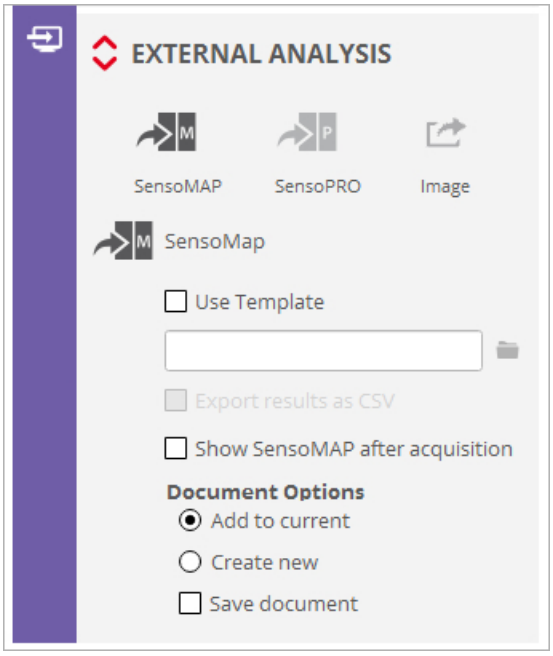
5.10.1 SensoMAP

Overview

There are three ways of analyzing data using **SensoMAP**:

- The first option is to manually load data into **SensoMAP**. The user saves the measured data using **SensoSCAN** menus and manually loads data into **SensoMAP**. **SensoSCAN** saves the data using a proprietary file format (**.plux* files) that **SensoMAP** can load.
- The second option is to automatically load measured data into **SensoMAP** (SMR analysis). The user must enable an automatic connection with **SensoMAP**. When this option is enabled, new data is automatically transferred to **SensoMAP**.
- The third option is to automatically analyze a series of measurements (MMR analysis). The user can either apply a **SensoMAP** template to a directory that contains a series of files or setup **SensoSCAN** to automatically analyze the results using a Multiple Measurement Recipe (MMR).

The External Analysis options depend on whether acquisition is single or multiple.



A detailed description of the **SensoMAP** application is found in its own help.

5.10.1.1 SMR analysis

SMR analysis options

Options for how the measurement is handled together with **SensoMAP** are accessed by clicking on the red up/down arrows in the External Analysis pane.

- *Use Template*: The selected template is used by **SensoMAP** to analyze the measurement. When the user checks this option, the folder button is enabled, allowing the user to select a template.
- *Export results as CSV*: This option can only be used together with a template. Note that there

are no analysis results to export *unless* the template obtains exportable values from the data analysis. Results of the analysis performed by **SensoMAP** will be exported into a comma-delimited file. The name of the **.csv* file is automatically generated according to document naming rules detailed below.

- *Show SensoMAP after acquisition*: A successful measurement will be automatically displayed in **SensoMAP**.
- *Document Options*: **SensoMAP** documents consist of a set of data, operators, illustrations and parameters, amongst others:
  - *Add to current*: The measurement is loaded into the current document in **SensoMAP**.

Warning: If the current document contains more data than is required by a selected template, **SensoMAP** will discard some data and this may cause misleading results.

  - *Create new*: The measurement is loaded into a new **SensoMAP** document.

Warning: If *Create new* is active, any previous document currently open in **SensoMAP** will be lost.

  - *Save document*: The updated or new **SensoMAP** document will be automatically saved. The usual workflow is to enable *Save document* when the *Create new* option is enabled, but *not* enable it when *Add to current* is enabled. The name of the **SensoMAP** document *(*.mnt)* is automatically generated according to document naming rules detailed below.

Document naming rules

If *Use Template* is checked, the name is composed of the template name and a time stamp.

If *Use Template* is unchecked, the name depends on the type of measurement. The name is composed of a fixed extension (**.plux*) and a time stamp.

The file is saved to the current path, as defined in System Preferences.

5.10.1.2 MMR analysis

MMR analysis options

After acquiring an MMR, the measured data is saved in files using a predefined folder structure. At the end of the acquisition of all measurements, the measurements that have been selected to be analyzed using **SensoMAP** are sent to **SensoMAP** folder by folder.

Warning: Configuration of **SensoMAP** options has to be done in the SMR. That is, an MMR will only send the results obtained using the SMRs that have **SensoMAP** enabled.

Options for how the measurement is handled together with **SensoMAP** are accessed by clicking on the red up/down arrows in the External Analysis pane.

- *Use Template*: Templates allow the same analysis to be performed, or the same report to be given on the new data. The usual workflow is to enable this option when a series of measurements needs to be analyzed. When enabled, the selected template is used by **SensoMAP** to analyze the measurement. When the user checks this option, the folder button is enabled, allowing the user to select a template.

- *Export results as CSV*: This option can only be used together with a template. Note that there are no analysis results to export *unless* the template obtains exportable values from the data analysis. Results of the analysis performed by **SensoMAP** will be exported into a comma delimited file. The name of the **.csv* file is automatically generated according to document naming rules detailed below.
- *Show SensoMAP after acquisition*: A successful measurement will be automatically displayed in **SensoMAP**.

Note: When data is the result of an MMR, it is not sent to **SensoMAP** until the entire MMR acquisition process has finished. If *Show SensoMAP after acquisition* is enabled, **SensoSCAN** sends measured data to **SensoMAP** but the window remains blank.

- *Document Options*: **SensoMAP** documents consist of a set of data, operators, illustrations and parameters, amongst others:
  - *Add to current*: All the measurements grouped in the same result folder are loaded into the same document. A new document is created for each result folder.

Warning: If the current document contains more data than is required by a selected template, **SensoMAP** will discard some data and this may cause misleading results.

  - *Create new*: Each measurement of the series is loaded into a new document in **SensoMAP**, i.e. one document for each **.plux* file.
  - *Save document*: **SensoMAP** documents are saved automatically. This usual workflow is to enable *Save document* when the result of the analysis of the series of measurements is the **SensoMAP** document itself, but *not* enable it when the results of interest are the values exported to as a **.csv* file. The name of the **SensoMAP** document (**.mnt*) is automatically generated according to document naming rules detailed below.

Document naming rules

The documents are saved in the same folder as **.plux* files (folder structure for MMR results).

The **.csv* file name will be the template name. One single **.csv* file will be created for each folder of **.plux* files analyzed.

- If Add to current is enabled:
  - and *Use Template* is enabled, the file name is composed of the template name and the MMR's base name. Example: *template zRGB --- MMRRecipe.mnt*
  - and *Use Template* is *not* enabled, the file name is the MMR's base name. Example: *MMRRecipe.mnt*
- If Create new is enabled:
  - and *Use Template* is enabled, the file name is composed by the template name and the *.plux* file extension. Example: *template zRGB --- TopoRecipe_R0001.mnt*
  - and *Use Template* is *not* enabled, the file name is the name of the **.plux* file except for the extension (**.mnt*). Example: *TopoRecipe_R0001.mnt*

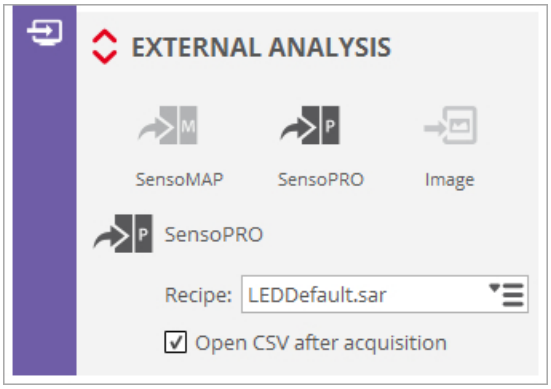
5.10.2 SensoPRO

Overview

There are three ways of analyzing data using **SensoPRO**:

- The first option is to manually load data into **SensoPRO**. The user saves the measured data using **SensoSCAN** menus and manually loads data into **SensoPRO**. **SensoSCAN** saves the data using a proprietary file format (**.plux* files) that **SensoPRO** can load.
- The second option is to automatically load measured data into **SensoPRO** (SMR analysis). The user must select a predefined SMR. When this option is enabled, new data is automatically transferred and analyzed to **SensoPRO**.
- The third option is to automatically analyze a series of measurements (MMR analysis).The user can either apply a **SensoPRO** recipe to a directory that contains a series of **.plux* files or setup **SensoSCAN** to automatically analyze the results obtained by a Multiple Measurement Recipe (MMR).

The external analysis settings depend on whether acquisition is single or multiple.



A detailed description of the **SensoPRO** application is found in its own manual.

5.10.2.1 SMR analysis

SMR analysis options

Options for how a measurement is handled together with **SensoPRO** are accessed by clicking on the red up/down arrows in the External Analysis pane.

- *Recipe*: **SensoPRO** recipes allow the same analysis to be repeatedly performed, or a report to be made on the new data. Select a Recipe as appropriate.
- *Open CSV after acquisition*: A successful measurement will be automatically displayed as a **.csv* file.

The results from the data analysis are always exported as an **.xml*, **.xls* or **.csv* file, depending on the **SensoPRO** configuration. The name of the file is automatically generated according to document naming rules detailed below.

Document naming rules

The name is composed of the Recipe name and a timestamp.

The file is saved to the current path (measurement folder, i.e. where the last measurement was saved or loaded).

5.10.2.2 MMR analysis

MMR analysis options

After acquiring an MMR, the measured data is saved in files using a predefined folder structure. At the end of the acquisition of all measurements, the measurements that have been selected to be analyzed using **SensoPRO** are sent to **SensoPRO** folder by folder.

> **Warning:** Configuration of **SensoPRO** options has to be done in the SMR. That is, an MMR will only send the results obtained using the SMRs that have **SensoPRO** enabled.

Options for how the measurement is handled together with **SensoPRO** follows exactly the same description as for External Analysis of MMR measurements with **SensoMAP**.

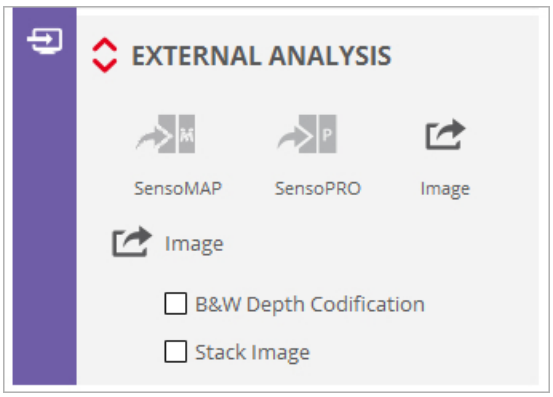
Document naming rules

The documents are saved in the same folder as **.plux* files (the folder structure for the MMR results).

The **.csv* file name will be the SMR name. One single **.csv* file will be created for each folder of **.plux* files that is analyzed.

5.10.3 Export Image

Overview



Export Image allows the user to export a pixel map from **SensoSCAN** with maximum resolution. Available images are dependent upon the Measurement type (images and 3D topographies only):

Measurement type	Measurement technique	Exportable Images
Image (Image & Confocal)	Confocal Interferometry Focus Variation	Full image
Single 3D topography	Confocal Focus Variation	BW Depth Codification image Stack Image
	Interferometry (ePSI & VSI)	BW Depth Codification image Stack Image

The selected image is saved in two files - an image file and a calibration file (*.cal). The image file has different tags depending on the chosen image format (selectable between *.tif, *.tiff, *.fp-tiff, *.png, *.bmp and *.jpg in System Preferences).

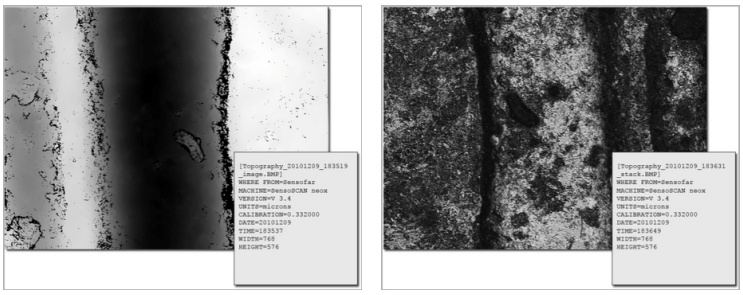
Images	File
BW Depth Codification image	*-depth.*
Stack	*-stack.*

The calibration file contains the following fields:

Field Name	Description	Example
WHERE FROM	Acquisition application name	SENSOSCAN
MACHINE	Acquisition machine name	S mart or S lynx
VERSION	Application version	6.2
UNITS	Units in the XY axis [microns or nanometers]	microns
CALIBRATION	XY distance per pixel	1.660000
DATE	Day of measurement	30/05/2015
TIME	Time of measurement	19:14:01
WIDTH	Image width	1360
HEIGHT	Image height	1024
ZUNITS	Units in the Z axis [microns or nanometers]	microns
ZCALIBRATION	Z distance per level of gray	0.007843
ZLOWER	Z lowest point	-0.999579

The bold fields are only visible for BW depth codification images.

Examples:



BW Depth Codification and Stack images (left to right)

Follow these steps to use this feature:

- Enable Export Image in the External Analysis pane
- Click on the red up/down arrows to reveal the options and select desired image type

After acquisition, the image and **.cal* file will be saved automatically to the current path (default *C:\TMP*, or the user-selected measurement folder).

> **Note:** The measurement file (**.plux*) can be saved to the current path (measurement folder) or in a distinct folder selected by the user. However, the exported image is always saved to the current path (measurement folder).

An Export Graphic option is also available from the OS Menu Bar and from **SensoSCAN**'s Quick Bar when in Display & Analysis mode.

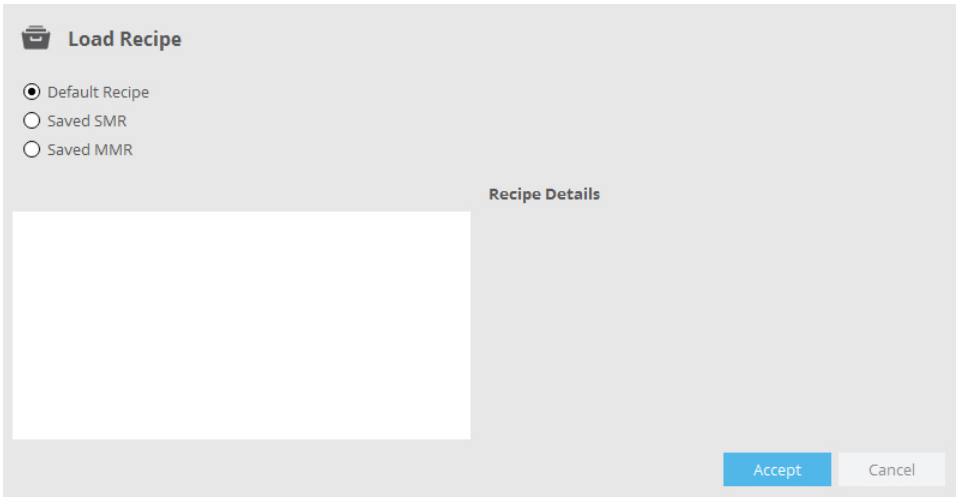
5.11 Recipes: SMR & MMR

Overview

Access to Recipes is via icons at the top of the Acquisition Settings pane

Recipes allow the user to select predefined scanning parameters that typically optimize a given application (Single Measurement Recipe, SMR) and/or that are used to automate an extensive measurement process (Multiple Measurement Recipe, MMR).

The icon opens a dialog, allowing the user to load either default, single (SMR) or multiple recipes (MMR):



By choosing the appropriate type (SMR or MMR), a list of available recipes will appear. By choosing one from the list, any description given will be displayed. When choosing an SMR, the corresponding *Acquisition Settings* will become visible. The name of any loaded recipe will be visible at the top of the *Acquisition Settings* pane.

Default

The *Default* option is used to load the measurement default settings (i.e. image acquisition). This measurement can be carried out right after system setup, even without objective calibration.

Depending on their needs, users can redefine the default SMR. For example, if the user normally measures moderately rough surfaces with the Confocal technique, this measurement setting can be saved as the *default.smr* using the *Save as* command (see drop-down menu).

Single Measurement Recipe (SMR)

The Single Measurement Recipe (SMR) is used to load the measurement settings from a stored file. This function is useful for automating processes when the user needs to take a large number of measurements under the same conditions.

Multiple Measurement Recipe (MMR)

This function is useful for automating a measurement process. MMRs are used to acquire several measurements at a single location by simply utilizing a list of SMRs. MMRs can also be used to repeat measurements in the same position, for example to assess evolution or to obtain average measurements.

The MMR can be canceled during the measurement by pressing the *Esc* key.

At the end of the measurement, a report is displayed. The report also shows which files have been measured (or not), the time required and the status. If the user clicks on *Explore Measurements*, the software opens a dialog box that allows the user to select the measurement to be displayed.

Managing recipes

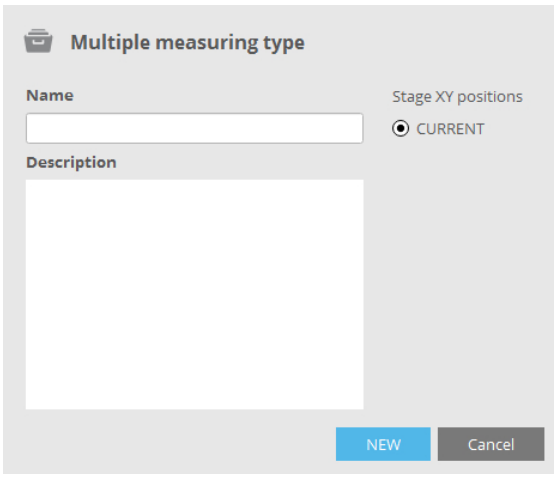
Recipes (SMRs and MMRs) can be saved, renamed (using *Save as*) and deleted, and MMRs can be created via the recipes drop-down menu .

When saving an SMR, all the the current parameters selected for a measurement - the Measurement technique, the Measurement type, the objective, and settings for Area, Z-Scan, Autofocus, Light Settings and Threshold, as well as External Analysis and any Data Analysis settings - are saved together with the recipe.

Note: Data Analysis options must be applied while in Display & Analysis mode.

Note: Before defining an MMR, all the required SMRs must first be created.

When creating an MMR, the MMR must initially be given a name, a brief description and a position system must be chosen - all of these can be changed in the subsequent dialog after confirming with *New*):

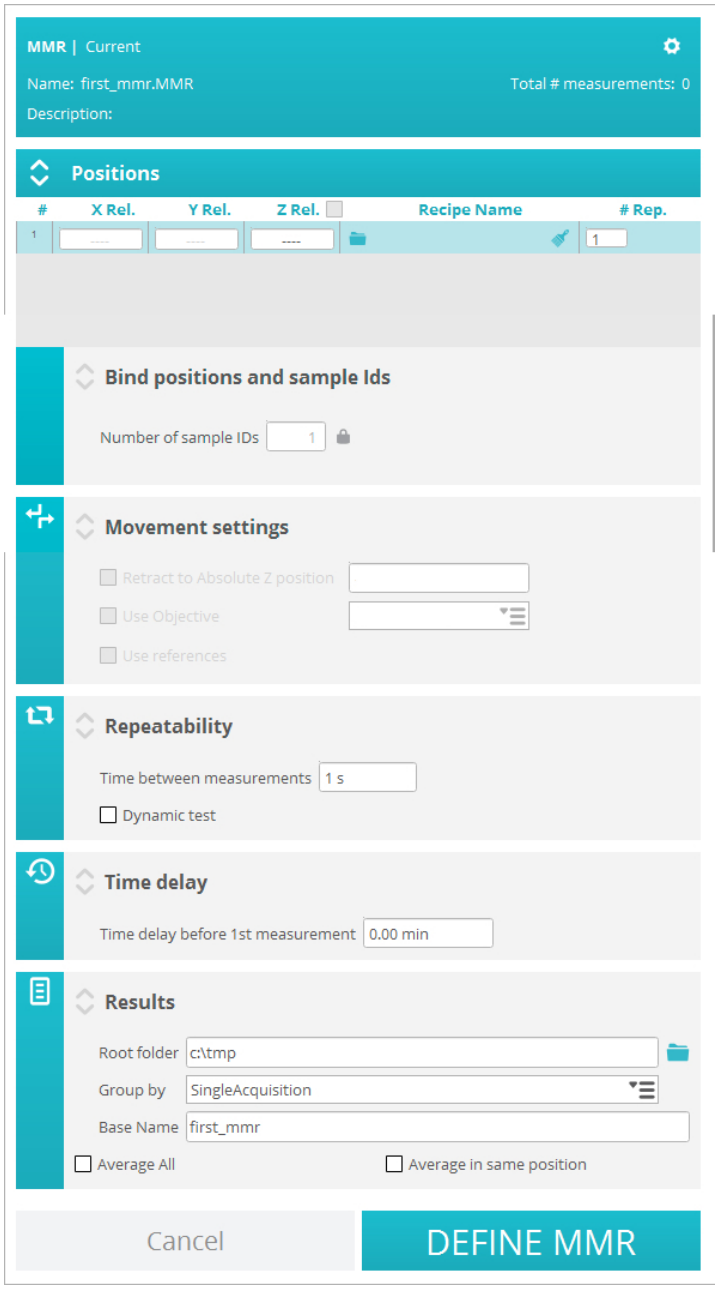


Confirming with *New* then reveals the define MMR pane (see next section).

5.11.1 Creating an MMR

Overview

The MMR configuration dialog contains all the tools required for creating an MMR:



The following outlines the steps needed (see MMR set-up for individual step details):

- if necessary, click on the icon to redefine the name, change the description and/or re-select the type of MMR given previously
- define *Positions* (for the **S mart** and **S lynx** there is only one *XY* position as there is no motorized *XY* stage):
  - define the starting Z-Scan value
  - click on the icon to select an appropriate SMR and specify the number of repetitions
  - deletions can be made using the icon
- under *Bind Positions and Sample IDs* (only visible if *Use Sample ID* has been activated in System Preferences):
  - define the total number of *Sample ID*'s

    - tie (bind) one or more the *Positions* to each *Sample ID*
- under *Movement Settings* are disabled for the **S mart** and **S lynx** systems, as there is no *XY* stage, or it is not motorized, respectively
- under *Repeatability* set the parameter *Time between measurements* and enable or disable *Dynamic test*
- under *Time delay* insert a value for *Time delay before 1st measurement* (in minutes)
- under *Results* define *Root folder*, *Group by* and *Base Name*, as well as enabling or disabling *Average all* and *Average in same position*

Finally, upon completion of the settings, confirm by clicking *Define MMR*.

A report, summarizing the MMR is now displayed. By choosing *Edit*, the parameters of the MMR can be adjusted, or the user can return to the standard Inspection & Acquisition interface by choosing *Exit*.

5.11.1.1 MMR set-up

Overview

In creating an MMR, the user must consider a number of points and options - these are described below.

Recipe naming

The following characters are not allowed:

- \ in recipe names
- & < > in the recipe description

Positions

For the **S mart** and **S lynx** systems there is only one coordinate option:

- *Current*: The current stage position is used.

Bind Positions and Sample IDs

This pane is only visible if *Use Sample ID* has been activated in System Preferences. When activated, proceed as follows to tie *Positions* (measurement locations) to specific *Sample ID*'s:

- Unlock the padlock by clicking, define the total number of *Sample ID*'s, and re-lock the padlock by clicking again - a corresponding number of text fields appears.
- Tie (bind) one or more the *Positions* to each *Sample ID* - hover the cursor over a text field to reveal a tip overlay with possible examples and the required syntax. Naturally, all measurement locations used here must exist in the *Positions* listing in the pane above when *Acquire* is selected.

Repeatability

The *Repeatability* options are used for repetitive measurements in the same *XY* position.

- *Time between measurements*: A time delay between measurements to help reduce the effect of instabilities
- *Dynamic test:* Enabling this option will move the system a given distance along Z after each measurement and return to the starting point before the next one.

Time delay

A time delay before the first measurement can be introduced. This can be used to let the system settle from any environmental vibrations.

Results

The results of MMR measurements are the measurement files (*.plux) and a report file (*MMR.log*) that contains information about the measurement. The following settings tell the system where to save the files: *Root folder* and *Base Name.* The user can also select how to group the measurements by *SingleAcquisition*, *Day*, *Weekdays*, *Week*, *Month* or *AllTogether*.

Each time an MMR measurement completes, a new folder is created in the root folder. This is the MMR folder. The name of the MMR folder consists of the *Base Name* and a time stamp.

Example:

Root folder: C:\Sensofar		
Base name: Measure	**Date**: 26 May 2008	**Time**: 18h 28m 17s
MMR Folder: C:\Sensofar\Measure_26_may_2008_18_28_17		

Warning: If the MMR folder already exists, the system asks whether it should be overwritten.

If the *Group by* option is *not* *SingleAcquisition*, the folder name will additionally be composed as follows:

- *Group by Day* will generate *Basename* + *_Day_Month_Year*
- *Group by Weekdays* will generate *Basename* + *_Weekday_Month_Year*
- *Group by Week* will generate *Basename* + *_YearWeek_Year*
- *Group by Month* will generate *Basename* + *_Month_Year*
- *Group by AllTogether* will generate *Basename*

Result files are organized inside this folder according to the following rules:

- **If the total number of SMR is one:**

1. If the number of positions is one, the files are saved in the MMR folder. No sub-folder is created.

a. If the number of repetitions of the SMR is one, the file name consists of the SMR name.

Example:

Root folder: C:\Sensofar		
Base name: Measure	**Date**: 26 May 2008	**Time**: 18h 28m 17s
SMR: Topo.SMR	**Positions**: 1	**Repetitions**: 1
Files: C:\Sensofar\Measure_26_may_2008_18_28_17\ Topo.plux		

b. If the number of repetitions of the SMR is more than one, the file name consists of the SMR name and the repetition tag.

Example:

Root folder: C:\Sensofar		
Base name: Measure	**Date**: 26 May 2008	**Time**: 18h 28m 17s
SMR: Topo.SMR	**Positions**: 1	**Repetitions**: 3

Files:
C:\Sensofar\Measure_26_may_2008_18_28_17\ Topo_R0001.plux
C:\Sensofar\Measure_26_may_2008_18_28_17\ Topo_R0002.plux
C:\Sensofar\Measure_26_may_2008_18_28_17\ Topo_R0003.plux

- **If the total number of SMR is more than one:**

1. If the number of positions is one:

   a. If the number of repetitions of a SMR is one, the files are saved in the MMR folder. The file name consists of the SMR name.

   Example:

Root folder: C:\Sensofar		
Base name: Measure	**Date**: 26 May 2008	**Time**: 18h 28m 17s
SMR1: Topo.SMR **Positions:** 1		**Repetitions**: 1
SMR2: Profile.SMR		
Files:		
C:\Sensofar\Measure_26_may_2008_18_28_17\ Topo.plux		
C:\Sensofar\Measure_26_may_2008_18_28_17\ Profile.plux		

   b. If the number of repetitions of a SMR is more than one, a sub-folder is created for the SMR. The name of the sub-folder is the name of the SMR. The file name consists of the SMR name and the repetition tag.

   Example:

Root folder: C:\Sensofar		
Base name: Measure	**Date**: 26 May 2008	**Time**: 18h 28m 17s
SMR1: Topo.SMR **Positions:** 1		**Repetitions**: 2
SMR2: Profile.SMR		
Files:		
C:\Sensofar\Measure_26_may_2008_18_28_17\Topo\Topo_R0001.plux		
C:\Sensofar\Measure_26_may_2008_18_28_17\Topo\Topo_R0002.plux		
C:\Sensofar\Measure_26_may_2008_18_28_17\Profile\Profile_R0001.plux		
C:\Sensofar\Measure_26_may_2008_18_28_17\Profile\Profile _R0002.plux		

The system can additionally be set to save the average of each SMR recipe in the same position, and in all positions:

- *Average All*: The average of all the individual data measured with the same recipe in all positions will be saved in the corresponding Recipe MMR folder.
- *Average in same position*: The average of all the individual data measured for each location with the same recipe will be saved in the corresponding position MMR folder.

5.11.1.2 MMR performance

Factors influencing performance

- If the MMR's list of *Positions* has:
  - One single undefined *XYZ* coordinate, the system measures at the current coordinate

when *Acquire* is triggered.

- When a key has been pressed or the countdown has finished, the system starts the measurement of the first SMR.
  - If the SMR includes Autofocus, the system will execute Autofocus prior to each measurement. Autofocus will be executed with the current light setting.
  - If SMR includes Autolight, the system will execute Autolight after Autofocus and before each measurement. Note that Autofocus repeatability errors will have an influence on the Autolight result.

- There are two Z-Scan ranges for Autofocus: *small* and *large*

  Depending on the sample shape, use either *small* or a combination of *small* and *large*. If the differences in the focus positions within the sample are large, the application may require a different objective for Autofocus than for measurement.

- If the system has a motorized nosepiece, this MMR will run automatically.

Further Notes

- *Asking for confirmation* steps are not required if the system is remotely controlled or a Control of Production system is used.

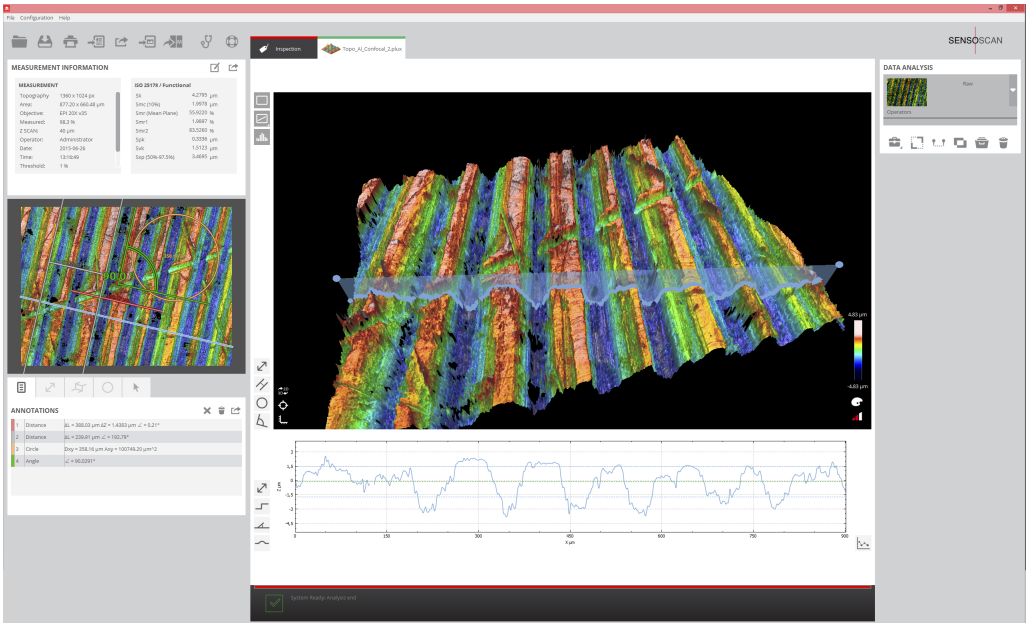
Part VI

6 Display & Analysis

Introduction

Display & Analysis mode is shown automatically either following an *Acquire* sequence or after a measurement has been loaded from file.

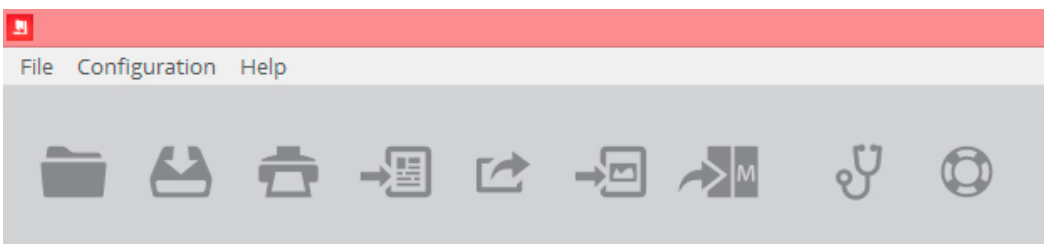
> **Note:** Although the **S lynx** and **S mart** acquires 3D measurements only in B/W, **SensoSCAN**'s Display & Analysis mode is still capable of loading and displaying 3D and 2D measurements from more capable systems such as the multiple-LED **S neox**. Example images shown in this Chapter of the User Manual may have been acquired with the **S neox**. The only restriction is that the *True Color* rendering option (available only to multiple-LED systems) is not available for non- **S neox** systems, although rendering of B/W 3D surface measurements (i.e. those taken with a single LED) can still show depth via color coding.



Display & Analysis mode

In this mode, one sees the measurement information, parameters for any active ISO Standards, the 2D image or 2D profile in a supplementary viewer pane on the left, any annotations made, the 3D image or 2D profile of the raw or analyzed data in the Central Viewer, and details of any Data Analysis options applied to the raw measurement (right).

Note also that the Quick Bar shows a different set of icons:



Quick Bar view in Display & Analysis mode

The exact details for the measurement seen in this mode depend on several factors:

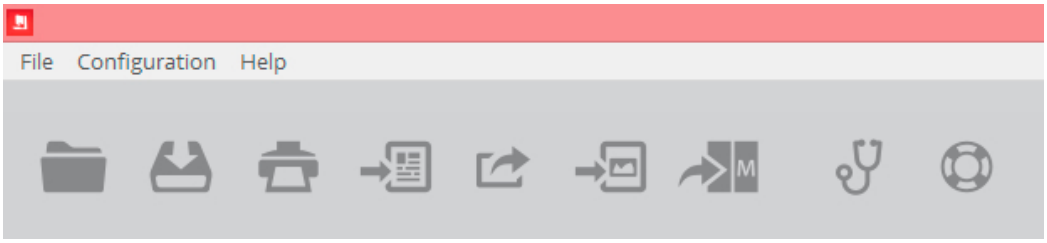
- the type of measurement made, e.g. image, coordinate, 2D profile, 3D topography, etc. affects the details of the measurement information
- if any ISO Standards have been activated, supplementary statistical values corresponding to the different parameters will appear under Measurement Information
- for a surface measurement, the 2D & 3D images can be toggled between the two image viewer panes
- if any Annotations and/or critical dimensions and other measurements have been applied, these will appear in the associated pane
- if a cross-section of a 3D measurement has been applied, the profile will appear under the Central Viewer pane
- the zoom value for any 3D images and 2D profiles can be changed by scrolling with the mouse in the corresponding viewer
- the rotation and inclination of an 3D image can be changed by grabbing and dragging with the mouse

Note: If any layers (zoomed views, etc.) have been applied via the Data Analysis options, these will globally affect the determined values for any parameters mentioned above. That is, all parameters will only be valid only for the current/active/visible region of interest (portion or whole).

6.1 Quick Bar tools

Quick Bar: Overview

This section describes the functionality provided by the various icons visible in **SensoSCAN 6**'s Quick Bar when in Display & Analysis mode.



Quick Bar view in Display & Analysis mode

Note: While some of the functionality described here does remain accessible from the traditional Operating System Menu Bar, most features now more easily available via **SensoSCAN 6**'s Quick Bar. In the following, the functionality accessible from the Quick Bar will be described - functionality (also) available from the traditional Operating System Menu Bar is indicated in **green**.

You can use the Quick Bar to load, save or export a measurement, save or print a report of the data, push the raw data over to **SensoMAP** and other data manipulation software (if available), or to export specific details visible in Display & Analysis mode (images, annotations, etc.).

The Quick Bar also provides access to this Help document as well as to System Preferences.

The Quick Bar (in Display & Analysis mode)

This folder icon opens the standard **File / Open** dialog of the OS, allowing a previous measurement to be loaded from file.

Note that **SensoSCAN 6.x** saves all measurements as **.plux* files. This file format contains the raw measurement together with a list of the Data Analysis options that were applied. On loading a previous measurement, the software automatically enters Display & Analysis mode and (re-)applies all the Data Analysis options used before the measurement was last saved to file. See Appendix for further information relating to **SensoSCAN**'s file formats.

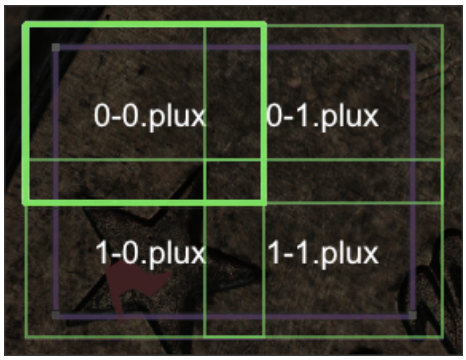
Selecting **File / Offline extended topography** from the Menu Bar (not available from the Quick Bar) provides access to a tool that imports and stitches a collection of individual topographies. Important points to note are:

- The 4 different stitching correlation options - *None*, *Smart*, *Z* & *XYZ* - are as follows:
  - *None*: The topographies are stitched without any adjustment.
  - *Smart* (the default algorithm): The topographies are stitched using an iterative algorithm. This algorithm is useful for samples with holes or non-measured areas, or for flat surfaces

measured by VSI or PSI.

- *Z*: Rows are stitched to one another by calculating the Z correlation between them. This option is suitable for smooth surfaces with structures.
- *XYZ*: The software will also take into account the correlation in the XY axis. At high magnifications, XY stage accuracy errors can be introduced into the topographies, in which case the XYZ correlation is recommended. It is suitable for surfaces such as grids.

- File nomenclature must comply with SensoSCAN's own format when saving Extended Measurements (e.g. with the S neox), namely y-x.plux, where y refers to the location in the column and x refers to the location in the row (both starting with '0'), i.e.:



Once **SensoSCAN** has loaded the file, it creates an extended **.plux* file and shows it in Display & Analysis mode as a new result. This option is also available as a call from the SDK.

Selecting **File / Import / Import plu** from the Menu Bar (not available from the Quick Bar) enables import of a **.plu* file (the file format for **SensoSCAN 5** and earlier). See Appendix for further information on using **.plu* and **.plux* files within **SensoSCAN 6**.

Selecting **File / Import / Import coordinates** from the Menu Bar (not available from the Quick Bar) enables import of a coordinate text file (from an external source or e.g. from an Spectroscopic Reflectometry MMR file - see, for example Surfaces / Coordinates). For files with a minimum of 10 values, **SensoSCAN** displays the topography by interpolating the values between the given coordinates. For a thickness measurement, **SensoSCAN** also generates the thickness topography.

- When selected, a dialog appears to determine if the color map will be related to a Z value or a thickness (multi-)layer.
  - The file format for surface coordinates is: *Xvalue [Space] Yvalue [Space] Zvalue*, e.g.

    42827.52000 -78.76000 -37701.167772

    42927.52000 -78.76000 -37702.055028

    43027.52000 -78.76000 -37702.189472
  - The file format for thickness is: *Xvalue [Space] Yvalue [Space] Th1 [Space] … ThN*, e.g.

    42827.52000 -78.76000 113.167772

    42927.52000 -78.76000 114.055028

    43027.52000 -78.76000 113.189472

Note: Any non-measured points are given by the 'NAN' text.

- Once **SensoSCAN** has loaded the file, it creates the corresponding **.plux* file and shows it in Display & Analysis mode as a new result.

This icon opens the standard **File / Save** dialog of the OS, allowing the current measurement to be saved, or a previously loaded measurement to be saved under the same name or a different name.

Note that **SensoSCAN 6.x** saves all measurements as **.plux* files. This file format contains the raw measurement together with a list of the Data Analysis options that were applied. See Appendix for further information relating to **SensoSCAN**'s file formats.

New measurements are named automatically by using a tag comprising the Measurement type, the date and hour, e.g. *Topography_20150601_183210.plux*. If necessary, the user can change to a preferred nomenclature within the **File / Save** dialog, or simply rename the file normally within the OS.

Selecting **File / Save as RAW** from the Menu Bar (not available from the Quick Bar) creates a new **.plux* file by permanently applying all filters, operators and layers that are currently active in Display & Analysis mode to the raw data of the measurement. See Appendix for further information.

Note: See below for exporting a measurement in the **.dat* format.

This icon opens a standard report print function that has been integrated into **SensoSCAN 6**. The pre-formatted data measurement report can be either sent directly to any available printers or saved to file (PDF or SVG).

The print function previews the report before printing. All information for the report is taken from the settings for the current measurement. The parameters shown are the ones selected in the measurement information section. The logo can be personalized copying the new one on C:\tmp folder under the name logo.png. Choosing the appropriate icon in the preview window then sends the preview to the printer, generates a PDF file or generates an SVG file, respectively.

This icon opens an export dialog so that the measurement can be exported in the **.dat* format. Points to note when saving a measurement to the **.dat* format are:

- scale units are micrometers (µm)
- the Z value assigned to any non-measured points is 1000001 µm
- in the **.dat* format, the raw data is saved as text. If the display is in three dimensions, such as 3D or contour, the file contains three columns: the first and the second are the X and Y

coordinates respectively, and the third is the Z-axis data. Otherwise, the file contains two columns: the first is the X-axis (horizontal) coordinate and the second is the Z-axis (vertical) data. For example, if the display is a profile, the file will contain X and Z values. The resolution of the data is as follows: X and Y: 9.999 µm, and Z: 9.999999 µm.

This icon opens up an *Export Graphic* dialog (see also **File / Export graphic**). This option allows the user to export the 3D measurement or 2D profile visible in the Central Viewer pane in the format specified in System Preferences. The exact image visible here - and thus also exported - will depend on the active layer and any Data Analysis options applied to that layer. See also Export Image.

This icon exports full resolution images to the user folder. The file format is selectable between **.tif, *.tiff*, **.fp-tiff*, **.png*, **.bmp* and **.jpg* under System Preferences (**.tif, *.tiff*, **.fp-tiff* format only for Grand Format system).

This icon sends the current raw measurement or a previously loaded measurement to the **SensoMAP** or other software. So that the data can be transferred, the **SensoMAP** software must be running.

> **Note:** Only the raw measurement is passed onto **SensoMAP** - any Data Analysis options applied in **SensoSCAN** are NOT carried over. Use *Save as RAW* (see above) as a workaround to this.

SensoMAP is based on Mountains technology and is a state-of-the-art surface analysis software. Typical uses for **SensoMAP** include off-line 2D/3D surface characterization in R&D departments and laboratories, and near-line process control in production facilities (usually 2D). **SensoMAP** is available as an option from Sensofar.

This icon (also **Help / Diagnostics)** opens a diagnostics menu path that provides access to technical log files. These log files are not normally relevant for everyday measurement tasks.

This information can, however, be very useful when troubleshooting problems with the system, for example in order to remotely reproduce or understand customer issues. In this case, all or specific log files may be requested by a technician or by Service & Support for diagnostic analysis.

At the bottom of the diagnostics pane opened with the icon, there are two options for securing a system back-up for diagnostic purposes:

- *Generate backup zip*: Creates a zip with all the configuration, calibration, logs, etc. files used

by the system.

- *Generate report zip*: Same as *Generate backup zip* but does not copy large files.

More information regarding diagnostics can be found in the Errors & Diagnostics.

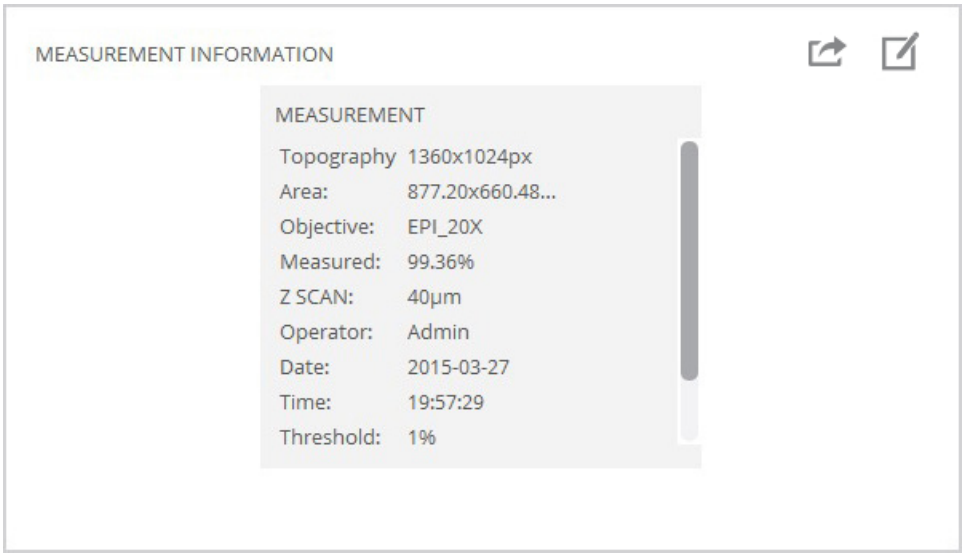
This icon is the same as selecting **Help / Contents** from the Menu Bar. Both open this User Manual.

Additionally, selecting **Help / About** from the Menu Bar (not available from the Quick Bar) opens a system window showing the following information: the program version, the serial number of the system, the company and the current user.

6.2 Measurement Information

Viewing Measurement Information

The Measurement Information pane always shows the basic details of the measurement:



Measurement information for an acquired measurement or for a measurement loaded from file (no ISO Standards active)

These values reflect the settings chosen for the measurement: Measurement type, area measured, the percentage of successfully measured points, Z-scan, user, the time required for the acquisition, (multi-) light settings, effective pixel size, etc. etc..

The percentage of data points successfully acquired is given by the term *Measured*. For 3D topography measurements this value can be 100%, but is usually less (i.e. there are non-measured data points). For 2D profiles and for images this value is not given. Note that use of the Restore and Retouch operators can change this value.

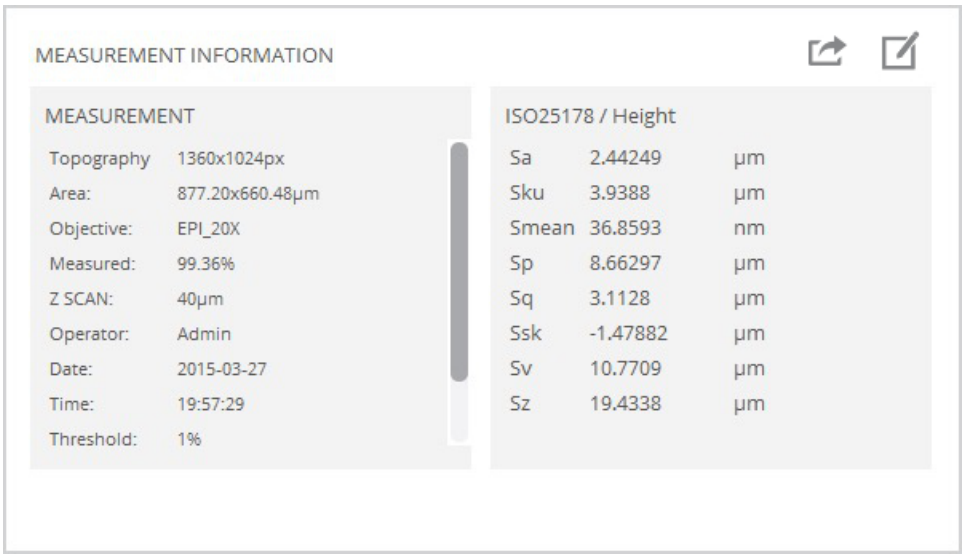
Viewing ISO Standards parameters

The Measurement Information pane can also show values corresponding to any active parameters chosen from the ISO Standards that have been implemented in **SensoSCAN 6**.

> **Note:** The topic of ISO Standards is discussed extensively in the Appendix, and will not be repeated here.

The different ISO Standards can be accessed by clicking the parameters configuration icon and activating/deactivating individual parameters or parameter families as desired. If this icon is not visible, it is because (further) options for this Measurement type are not available (e.g. for 2D profiles and for images).

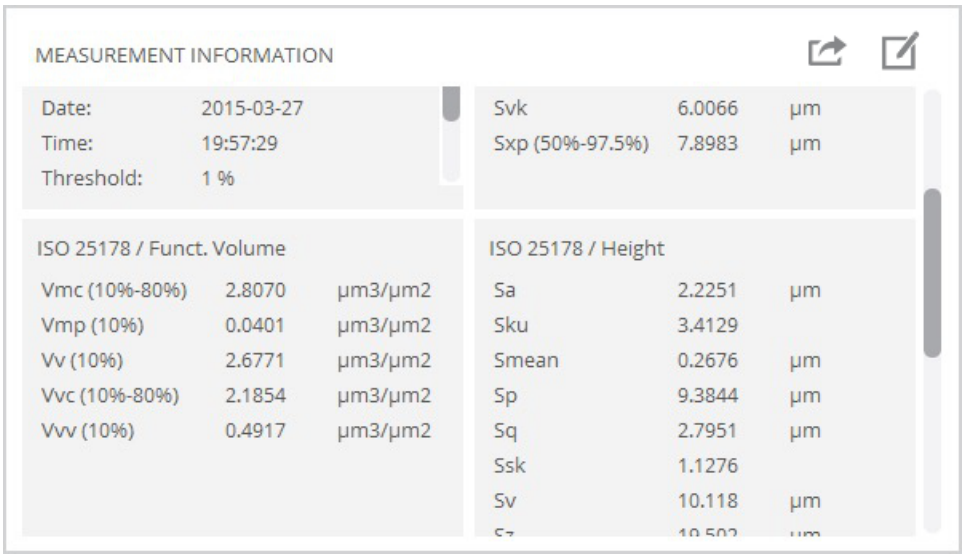
Upon exiting the configuration dialog, the values for any active ISO Standards parameters, or for complete parameter families, are now also visible in the Measurement Information pane:



Supplementary 3D Surface Texture parameters according to ISO 25178 / Height

The displayed information contains, for example, the point with the maximum height (*Sp*), the point with the minimum height (*Sv*), the average (*Smean*), the peak to valley (*Sz*), the root mean square (*Sq*) and the *Sa* (for 3D views).

When many parameters have been activated, they appear in a separate panel for each parameter family. It may be necessary to scroll in the Measurement Information pane in order to make specific parameters visible:



Multiple parameter families are made visible by scrolling

The values can be exported by clicking on the export icon . The *.csv file contains the parameter name, units and values. Units are automatically selected depending on the value.

Important points to note for ISO Standards

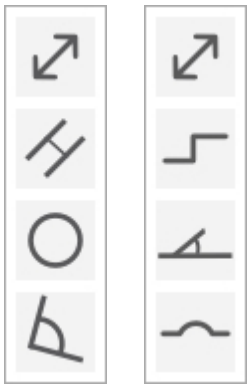
- Different ISO Standards apply to the various Measurement types, thus it is important to note that there are different ISO Standards for 3D and for 2D measurements.

- For 2D measurements (profiles), the calculated parameters take into account any Data Analysis options (operators, filters) that have been applied and exclude any Restored pixels. Refer to ASME B46.1 or DIN 4768 standards for roughness and waviness parameters.
- The parameter values displayed following an acquisition are only valid if the data has been analyzed (processed) according to ISO regulations.
- Spatial parameters can only be calculated when all the points have a height value. Therefore, when measured points are not 100%, the measurement must be Restored.

6.3 Annotations

Overview

Various Annotations can be made to a measurement to highlight and measure specific features of a 3D topography measurement, of a 2D profile measurement, of the 2D section through a 3D measurement (profile) or (in some cases) of the histogram of a 3D measurement. Tools for creating Annotations are placed bottom left of the Central Viewer ('mouse over' for tips):



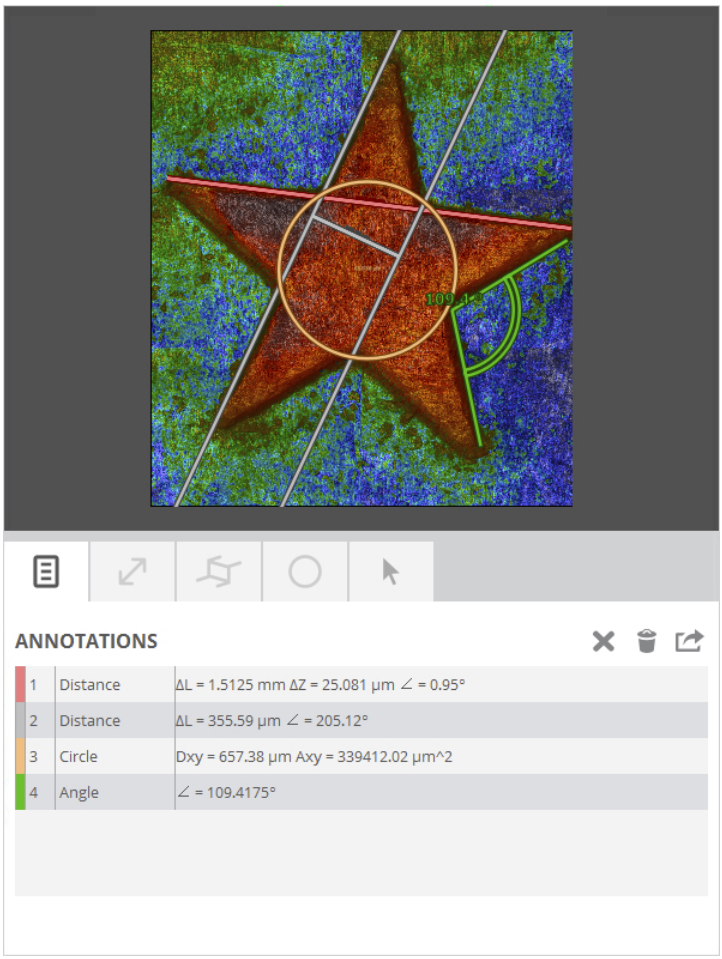
3D surface (left) and 2D profile annotation tools

There are four Annotation types for 3D surface measurements - *distance*, *parallel*, *circle* and *angle* (top to bottom) - and four Annotation types for 2D profiles and histograms - *distance, step height, radius* and *angle* (top to bottom). These appear and can in most cases be adjusted interactively on the appropriate display. Their associated dimensions and/or parameters also appear on the same display.

Any Annotations applied to a surface or to a profile and their associated dimensions and/or parameters are also listed in a pane positioned below the supplementary viewer (see image below), both as a complete list and grouped together based on type. Using additional the icons in the Annotations pane , Annotations can be deleted individually, deleted all together or exported as a table (**.csv*), respectively.

3D Annotation tools

The four annotation tools for 3D areal measurements - *distance*, *parallel*, *circle* and *angle* - are straightforward to use and are illustrated well in the image below. By clicking each tool icon, the interactive tool appears in the 2D representation of the 3D surface. Its position and size can be changed by simply grabbing the anchor points with the mouse and adjusting as necessary.



Critical dimensions can be annotated onto the result to label and highlight features and to show their dimensions

2D annotation tools

The four 2D Annotation types - *distance, step height, radius* and *angle* - are designed to be used on measured 2D profiles and on 2D profiles of 3D measurements, in some cases on histograms of 3D measurements (*distance* and *step-height* only).

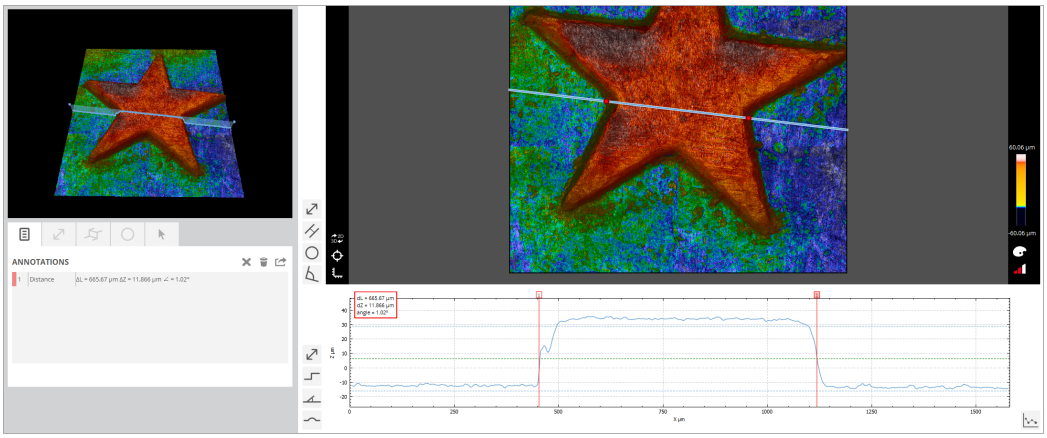
Their use is a little more complex than for 3D Annotations. Note that:

- for a 3D areal measurement, the user first needs to define a 2D profile of the surface or choose the histogram option - the associated profile and Annotations appear in the 2D profile pane below the Central Viewer
- for a 2D profile measurement, the profile itself appears in the Central Viewer, as do the Annotations applied
- in all cases, the overall size and scaling of the Annotation will match the scaling option chosen for the viewer (see icon lower right of 2D profile viewer)
- as for 3D, all 2D Annotations are listed in the pane on the left of the Display & Analysis interface (note that for a 2D profile measurement, the supplementary viewer is not available)

Distance

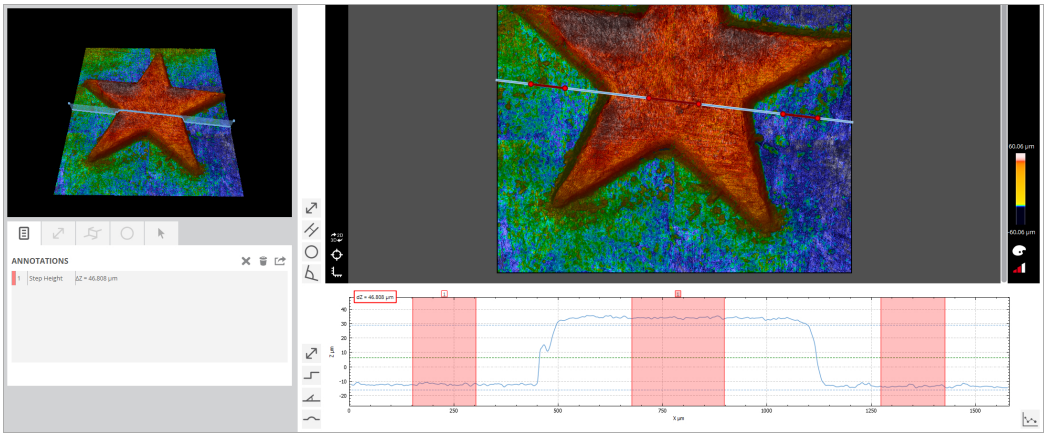
Once the desired 2D profile has been defined or the histogram option chosen, clicking the appropriate

icon activates the *Distance* tool. Now define any two points on the profile using the 'click - hold - drag - release' function of the mouse. Both points can be re-positioned by grabbing with the the mouse.



Step-height

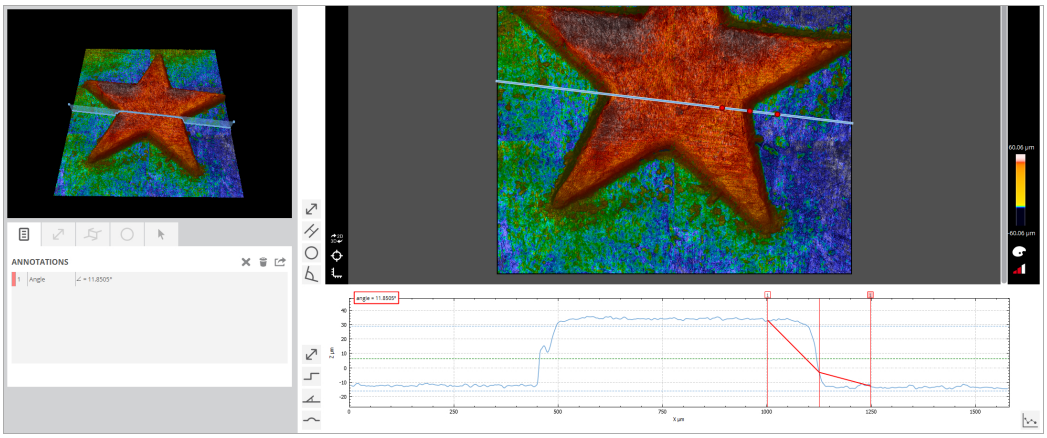
The Step-Height tool is an automated routine that acts only on the viewable 2D profile. It is not user-editable. Once the desired 2D profile has been defined or the histogram option chosen, next use the mouse to zoom and scroll the profile so that only the desired region of interest (ROI) is visible. Next click the appropriate icon - the *Step-Height* tool is then activated by simply clicking anywhere on the ROI.

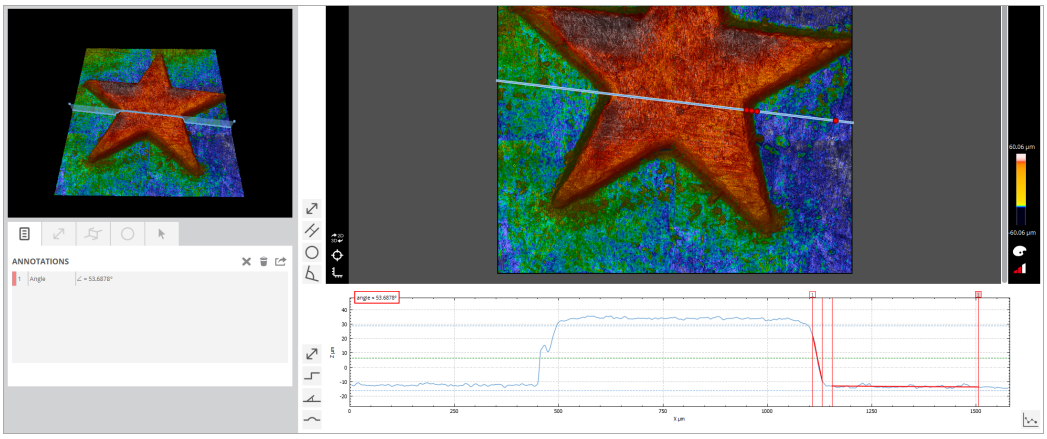


Angle

Once the desired 2D profile has been defined, clicking the appropriate icon activates the *Angle* tool. Now define two points on the profile using the 'click - hold - drag - release' function of the mouse. Four points now appear on the profile - the central two points initially overlap. All four points can be re-positioned by grabbing with the the mouse - for example, so that two unconnected planes can be compared.

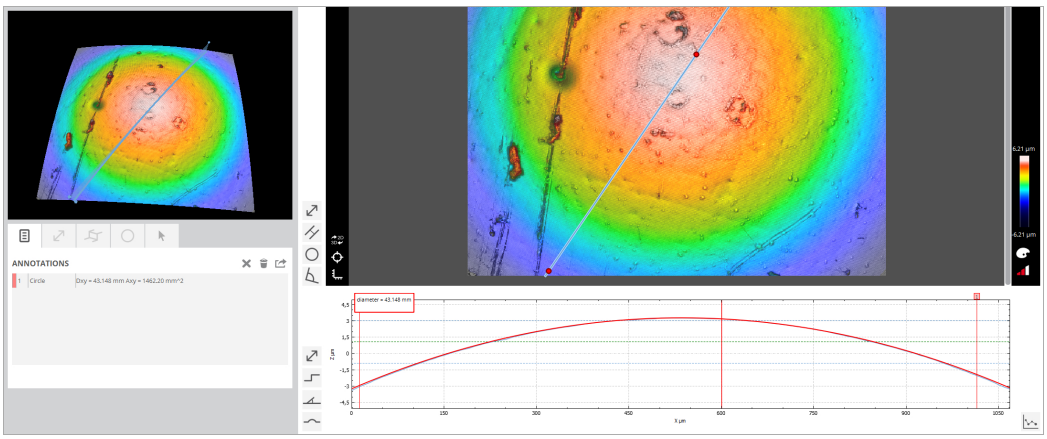
> **Note:** Don't forget to account for scaling (see icon lower right of 2D profile viewer) when the resulting angle appears to be much less than the apparent angle seen in the profile viewer.





Radius

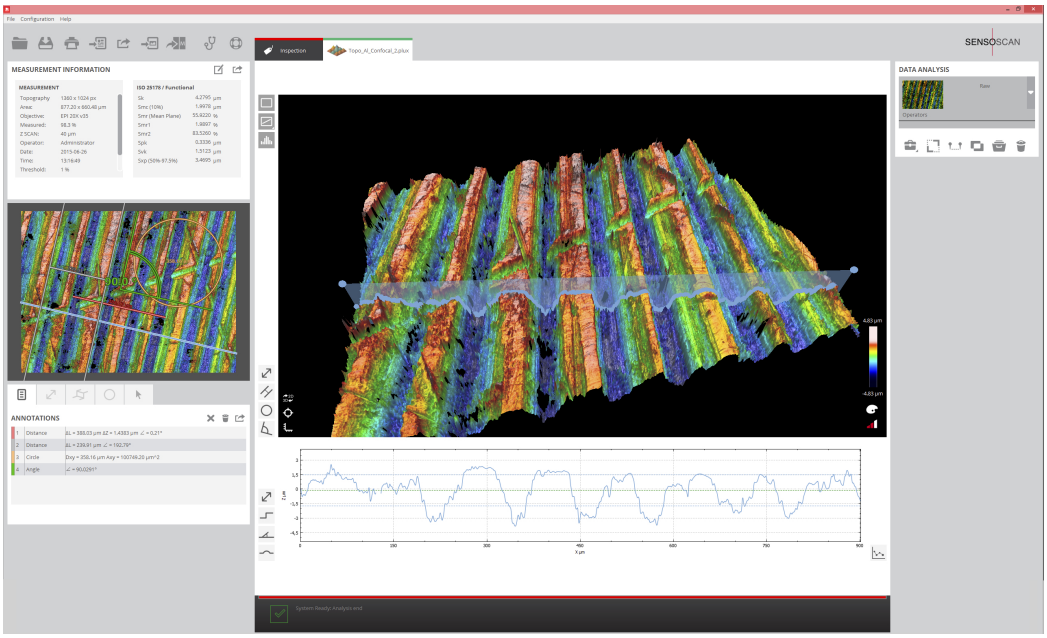
Once the desired 2D profile has been defined, clicking the appropriate icon activates the *Radius* tool. Now define any two points on the profile using the 'click - hold - drag - release' function of the mouse. Three points appear on the profile (three points are required for the fit to a circle). Each point can be re-positioned by grabbing with the the mouse.



6.4 Measurement Display

Overview

In Data & Analysis mode, the Central Viewer changes its layout and options from that in Inspection & Acquisition so that the measurement can be displayed appropriately. Any available viewer features and options will depend on the Measurement type - most of the those discussed below are largely applicable only for 3D surface measurements.



Display & Analysis mode

For displaying images and 3D topography measurements, the user can choose between *Clean*, *Profile* and *Histogram* using the icons on the upper left:

***Clean*, *Profile* and *Histogram* tool icons (top to bottom)**

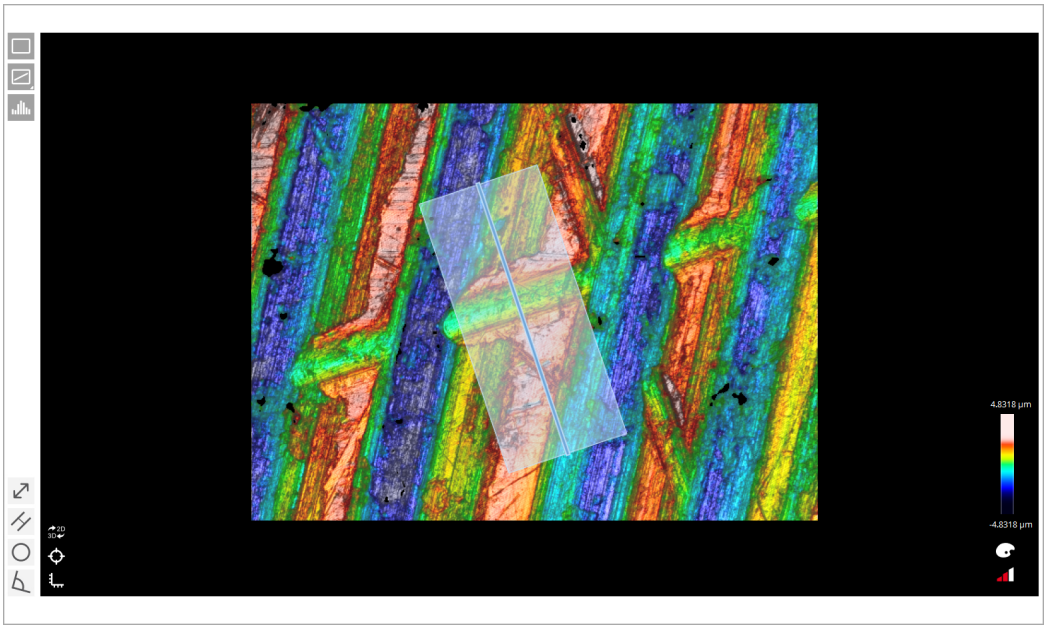
The *Clean* tool icon displays the raw measurement. Re-selecting *Clean* at a later stage removes either of the following two display options, *Profile* and *Histogram*.

If the acquired measurement is 3D or an image, clicking the *Profile* tool icon displays a cross-section through the image as an overlay on the Central Viewer and supplementary viewer, while the 2D profile of this cross-section is displayed below the Central Viewer (see image above):

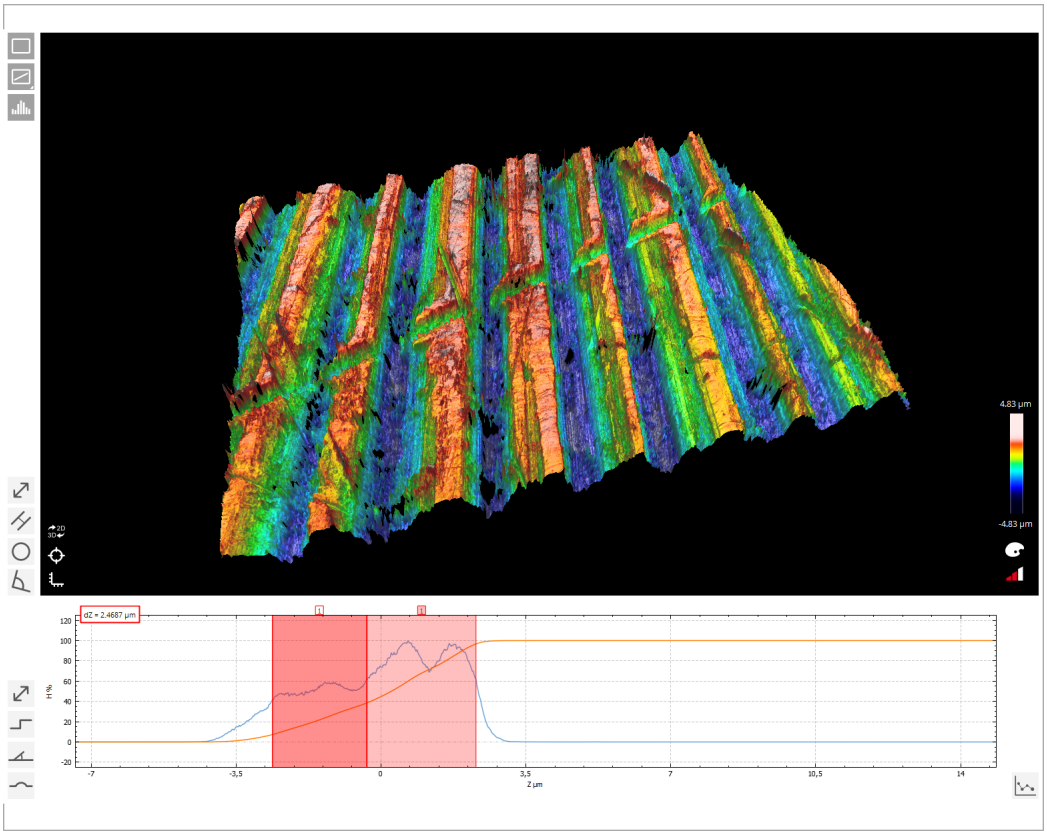
- by grabbing (click & hold) the line overlay or the end points with the mouse, either in the 2D or 3D view, the exact position and length of the profile can be set interactively

- right-clicking the *Profile* tool icon provides access to 3 standard profiles (vertical, horizontal and 45 degrees)
- by right-clicking the line overlay in the viewer, the breadth of the profile can be extended to cover a wider ROI - the 2D profile displayed below the Central Viewer is the average profile for the selected ROI

Note that all necessary 3D operator and filter steps should be first applied to the 3D measurement, followed by activation of the *Profile* tool. Once the desired 2D profile has been selected, 2D operators and filters can then be applied to the measurement.



Alternatively, a histogram of the image or data can be displayed using the *Histogram* tool icon. The histogram is displayed below the Central Viewer. It shows the percentage of measured points per Z coordinate interval. The histogram value is thus equal to the portion of total measured points that fall into this Z interval. This display is useful for surface analysis, such as step height measurements (see Annotations).

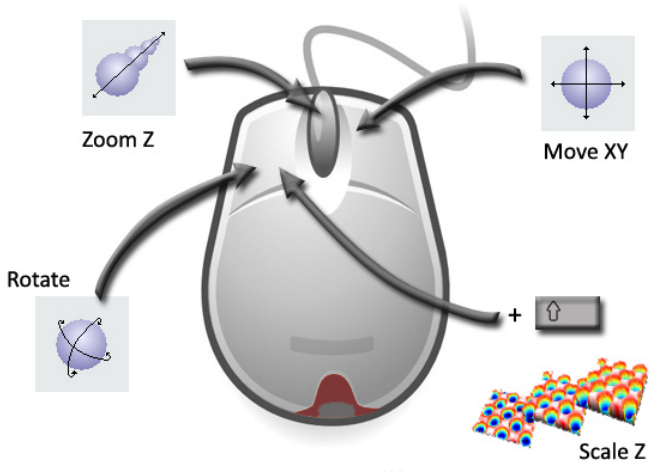


Histogram plot below the 3D display, with *Step Height* Annotation applied

Various Annotation tools can be used - dependent on whether an image, a 3D measurement or a 2D profile - to determine separations between points, widths or diameters of features, step heights and dimensions of other features visible in the raw data. The Annotations are mostly interactively editable on either viewer pane or on the 2D profile below the Central Viewer. Annotations can be viewed in groups, individually removed and exported using options in the Annotations pane.

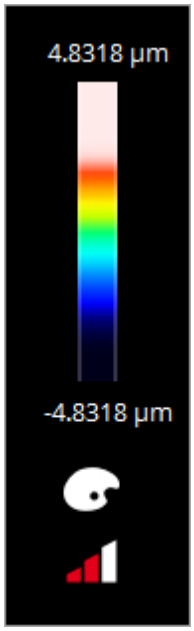
The 3D display and the 2D depiction of the same data can be toggled between the Central Viewer & supplementary viewer by clicking the appropriate icon. The 3D view can also be reset and/or rulers applied (image export with Z axis scaling can be toggled in System Preferences):

3D surfaces can be rotated, translated or scaled by clicking and dragging on the screen using the mouse. The surface can be rotated by pressing the left button of the mouse, scaled by pressing the left button of the mouse and the shift key simultaneously, and translated by pressing the right button and zooming by moving the scroll.



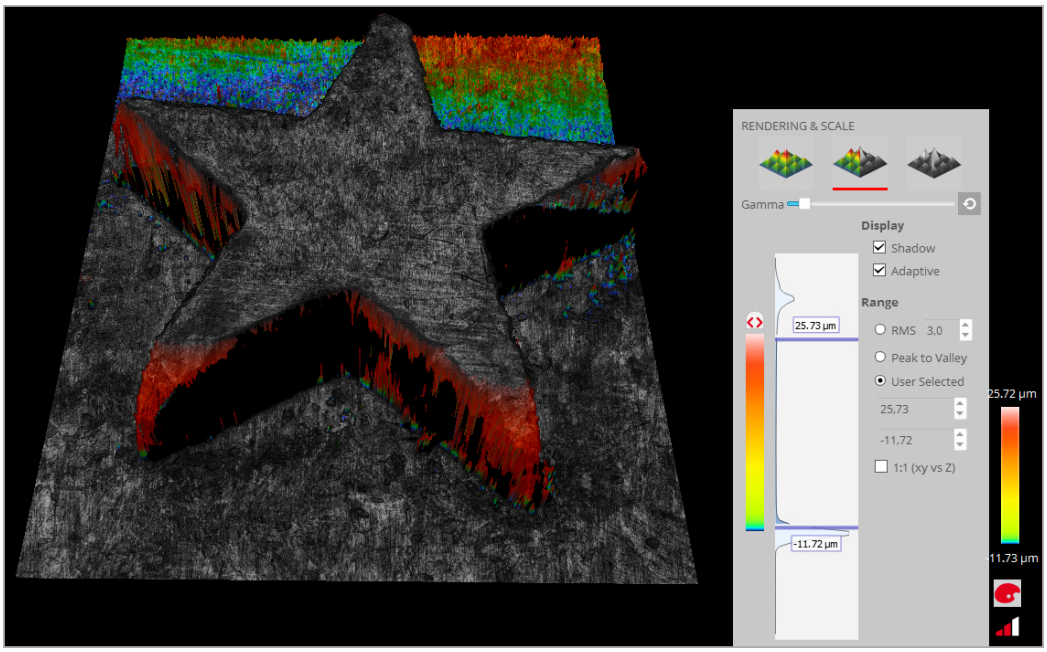
Rendering & Scale

Display (rendering & scale) of the raw or 'operated' measurement can be changed by clicking on the tool icons in the lower right hand corner of the Central Viewer:



The vertical compression of the image can be determined using the 3 bars below the palette icon (compressed, normal and extended).

When clicking on the palette icon, rendering options are then revealed in an overlay panel. Note that the overlay panel can be re-positioned with the mouse.



Rendering & Scale overlay panel, showing the different options

The rendering options include:

- *Visualization* options (icons across the top of the pane):
  - *False color*, *False color + Stack*, *True color* and *Directional luminance* color options are available depending on the image type (color image, 3D measurement, etc.).
- Image *Gamma*
  - This slider can be used to modify contrast in the render. By clicking the icon at the right hand end of the slider, the *Default* value can be selected.
- *Display* checkbox options:
  - *Shadow*, available for *False color* and *False color + Stack*, throws shadowing across the render to better highlight detail
  - *Adaptive*, available for *False color* and *False color + Stack*, makes the color scaling non-linear to better show detail across (multiple) flat sections on the surface
  - *Luminance*, available for *True color* (**S lynx** only), boosts the light output (luminance) of the render, which can be useful for showing detail on surfaces with 'flat' lighting
  - Note that there are no *Display* checkbox options for *Directional luminance*. However, when this visualization option is chosen, a rotary dial appears to specify the direction of illumination (light and shadow) across the render.
- *Range* selection (determines the height/color coding for all *Visualizations*):
  - The *RMS* option displays the Z interval between the average point minus the selected rms value, and the average point plus the rms. The highest and lowest colors of the color scale are assigned to the extremes of this interval, where the rms value can be specified by the user.
  - The *Peak to Valley* option displays the Z interval between the maximum and minimum measured values, and assigns the highest color to the highest point of the measurement

(max), and the lowest color to the lowest point (min).

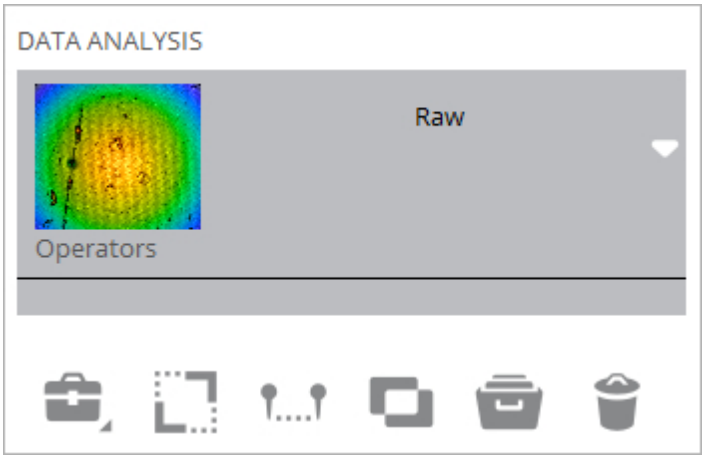
- The *User Selected* option allows the user to specify the maximum and minimum of the scale. The initial *User Selected* option is limited to the *Peak to Valley* range, but these values can be changed manually by directly typing into the parameter windows. Also note that by moving the sliders on the histogram manually as desired, at any time, the display automatically switches to *User Selected* mode.

- *1:1 (XY vs. Z)* display option:
  - *1:1 (XY vs. Z)* is a special *Peak to Valley* mode that renders the image on the same scale for all axes, i.e. scaling of the Z axis is the same as for X and Y.

Note that colormap selection can be toggled between *Full Color* (RGB)*, Black & White*, *Yellow & Red* and *Viridis* (HSV-based, provides easier visual interpretation) by clicking on the small icon at the top of the color scale. Lastly, the background color for the render can be changed in System Preferences.

6.5 Data Analysis

Overview



SensoSCAN 6 provides a comprehensive suite of operators and filters for examination and analysis of a measurement. The user has the opportunity to:

- Retouch - set the selected data points to 'non-measured'
- Restore - interpolate missing (non-measured) data in a measurement
- apply form removal (plane, sphere, polynomial)
- Cropping, layer subtraction, profile extraction
- etc.

Some of these operators and filters are '3D only', '2D only' or can be applied to either. This is indicated in the following subsections.

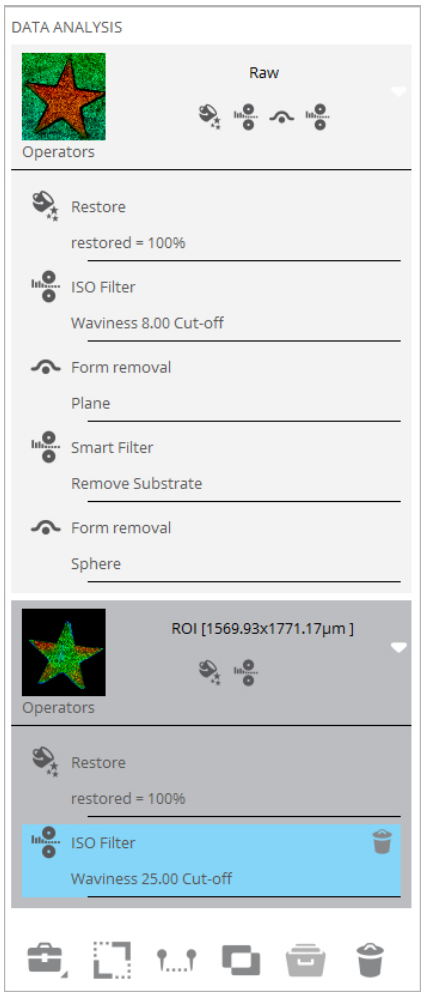
More complicated data analysis and even data processing (i.e. modifying the data) are reserved for external applications, such as **SensoPRO**.

Operators and Layers in SensoSCAN 6

In normal use, the raw data of a measurement always remains unmodified in **SensoSCAN 6**. This remains the case even over repeated 'open, analysis and save' cycles of an existing measurement. In Data & Analysis, one can only apply a linear sequence of reversible filters, operators and layers to the data, yielding different visualizations of the measurement.

> **Note:** Use *Save as RAW* to permanently apply filters, operators and layers to a measurement. See Appendix for further information.

New data layers can be generated from the raw data by cropping, by creating a 2D profile (section) through a 3D measurement or by subtracting another data set from the current measurement. Thickness measurements can be extracted into upper, lower or thickness layers. Other operators can then be applied individually to each new layer.



Note: Deleting an operator will also delete successive operators as well as any new layers that depend on it.

When saving a measurement to file, all data layers, the operators currently applied to each layer, and their order are saved together with the raw data. When the file is re-opened, the raw data is loaded and the operators and layers reapplied in the same order. Operators and layers can be deleted, and/or other operators and layers added, and the measurement can then be re-saved with the new operator and layer set, or saved as a new file under another name.

6.5.1 Restore & Retouch

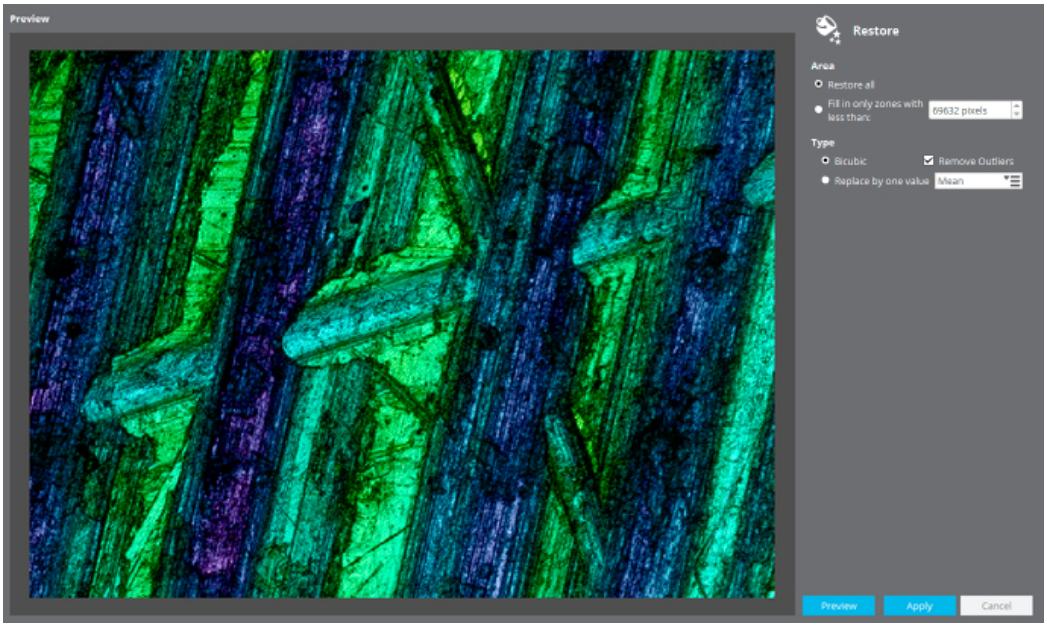
Restore (2D/3D)

The Restore operator is used to fill (replace) non-measured data points with more usable values. This is done either by using adjacent 'good' data to interpolate a replacement value, or by simply replacing all non-measured points with a fixed value. The options available are:

- *Area*
  - *Restore all* applies the change to all non-measured points in the measurement.
  - Alternatively, selecting *Fill in only zones with less than ...* means that only clusters of adjacent non-measured points below a user-defined number of points will be Restored

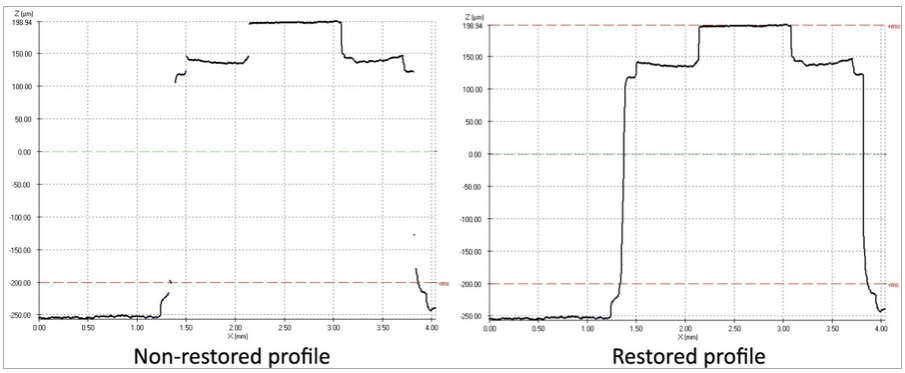
(larger regions are thus left unchanged).

- *Type:*
  - *Bicubic* refers to the algorithm used for adjacent good data when interpolating values for non-measured points.
  - ... *Bicubic* can be used together with *Despiking* to first remove erroneous data (outliers, or spikes) in the measurement (also available under Filters).
  - *Replace by one value* replaces the non-measured points with the *Minimum*, *Mean* or *Maximum* value in the measurement.



Options in the Restore pane

In case of large areas with non-measured points, the problem areas are filled using a constant value (the minimum height), calculated for all points of the surface.



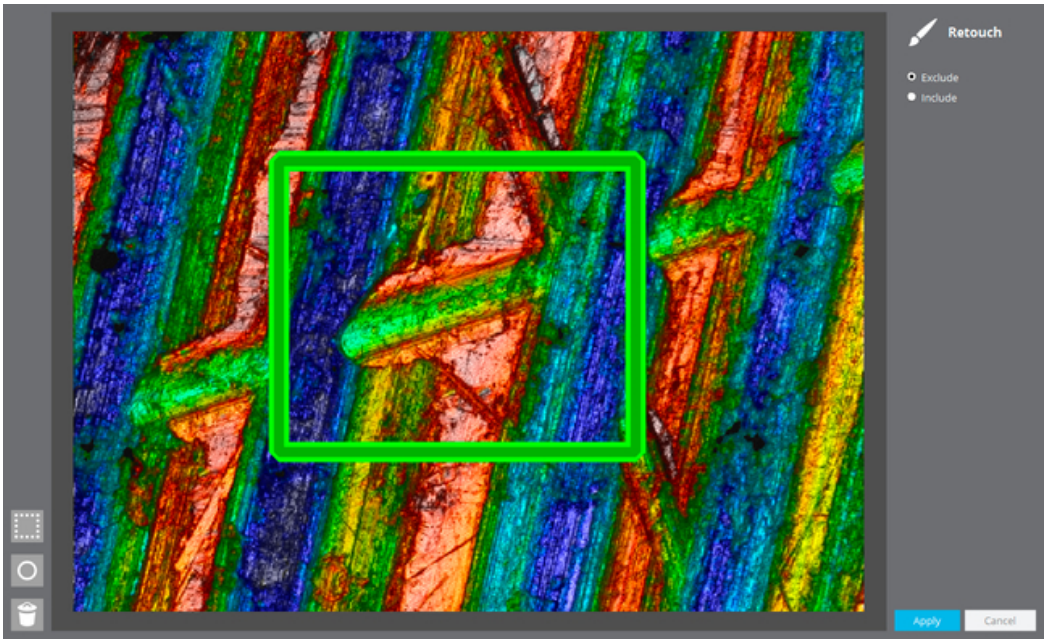
This function should not be confused with by the option *Copy substrate to S1 and S2* (Interferometry only) found in the Layer pane (and which is thus only relevant for Thickness measurements). This option substitutes in real data to fill apparent gaps in a coating, whereas the Restore operator generates replacement values via interpolation from the surrounding points.

Retouch (areal 3D only)

The Retouch operator is used to set a range of data points as 'non-measured'.

When using the Retouch operator, the user can select single or even mixed multiple rectangular area and oval/circular regions of the measurement (see icon tools to the left of the pane).

The *Exclude* / *Include* option toggles which regions of the measurement are Retouched - *Exclude* means that the user-selected regions are changed to be 'non-measured', *Include* means that the regions outside of those selected are changed to be 'non-measured'.



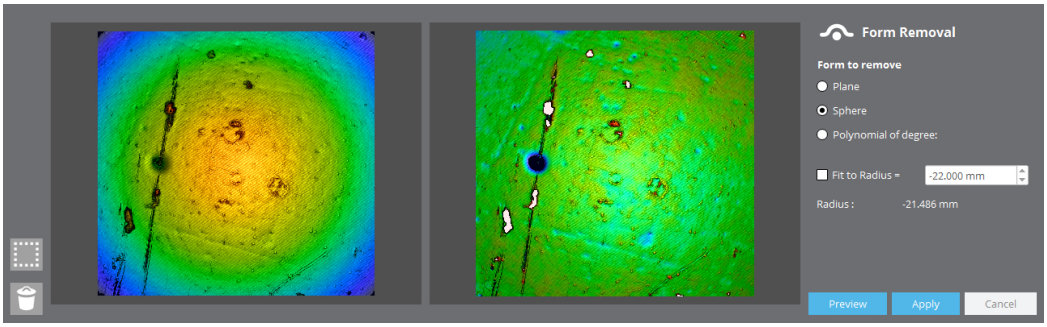
Use Retouch to set data points to non-measured - *Exclude* will only change those data points outside of the square, *Include* will change those data points inside

Using the Retouch operator followed by the Restore operator, noisy or 'out-of-range' data can be removed and then filled using Restore (interpolation).

6.5.2 Form Removal

Overview

The Form Removal operator is used for samples that need to be leveled due to a tilt (linear form), an inherent spherical component, or that exhibit or possess an unwanted polynomial term.



Plane (3D only) or *Line* (2D only) fits the best linear mathematical function and removes it from the measurement. This option is most useful for those samples that have been measured with a significant tilt. The operator can be used on the whole measurement, on a selected triangular or rectangular area of the sample (see icon tools to the left of the pane), or (for a 2D profile) between two user-specified points.

Sphere (3D only) or *Circle* (2D only) fits a nonlinear mathematical function, removes it, and shows the radius of curvature. The radius of curvature can be fixed by the user by enabling *Fit to Radius* and entering the desired value - the software removes the sphere with the set radius that best fits the measured results. The operator can be used on the whole measurement or on a selected rectangular area of the sample.

Polynomial (3D only) removes a multiple order polynomial surface or line (max. 12 orders) from the measurement. The operator can be used on the whole measurement, on a selected triangular or rectangular area of the sample (see icon tools to the left of the pane), or (for a 2D profile) between two user-specified points.

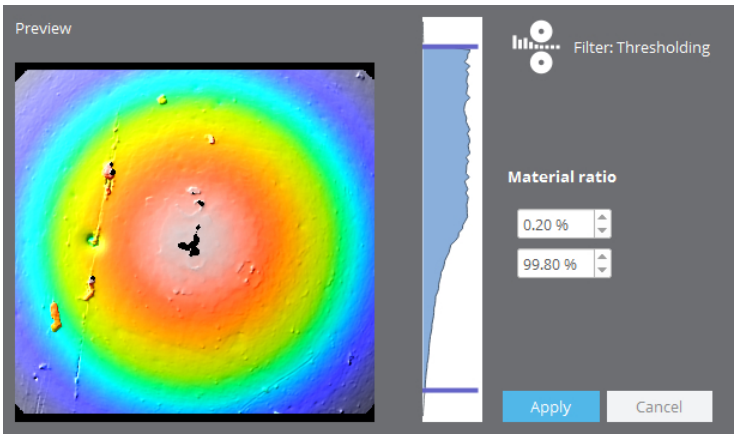
6.5.3 Filters

Overview

The Filter operators (*Thresholding*, *Smart*, *Kernel*, *ISO* and *FFT*) are used to modify the raw measurement data based on available statistical information. One can filter to remove roughness or waviness parameters, analyze the measurement according to surface texture standards, or simply apply median and enhancement filters.

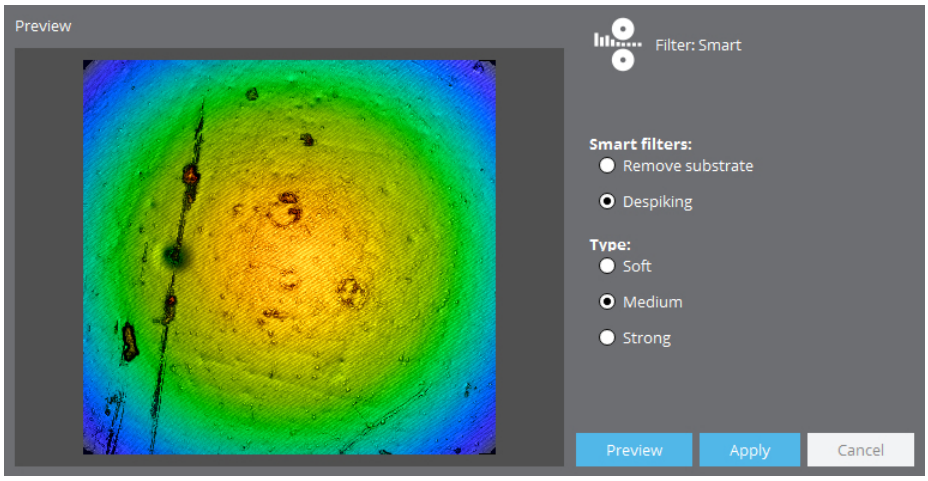
Thresholding (3D only)

Filters the data by adjusting sliders on a histogram of the data 'fitness'.



Smart (3D only)

Filters the data by either removing the substrate or de-spiking:

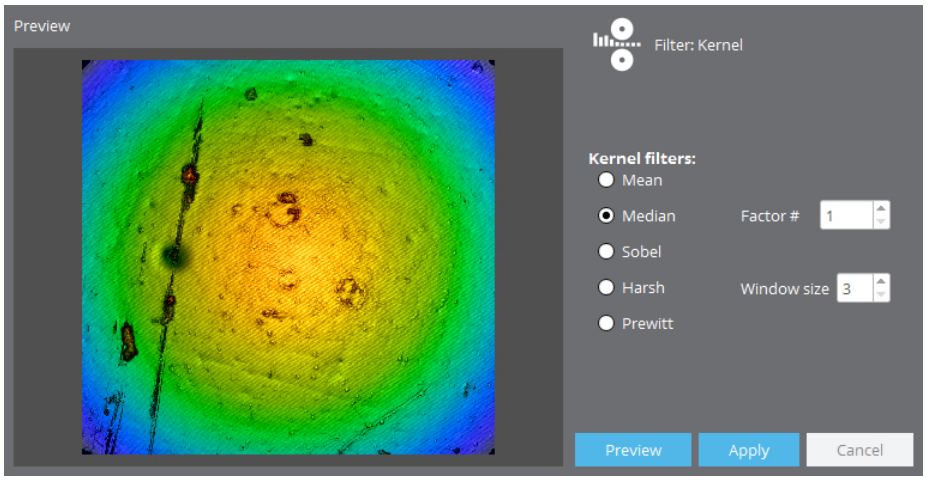


The *Remove substrate* filter is designed to remove the substrate from the measurement when the surface comprises a substrate with some structure. It is useful when the goal is to analyze the shape and characteristics of the structures, but not the substrate. The substrate points are points that have a Z value that is very similar to the average value of the whole surface: (Zavg - Zrms) < Z < (Zavg + Zrms).

The *Despiking* filter is designed to delete noise peaks from the surface. To distinguish which are good or noise points, the software calculates the average and the standard deviation in an area of 5x5 pixels for each 3D measurement pixel. Then, if the values are too different, these points are rejected and classified as lost pixels. The filter has three levels: soft, medium and strong. This filter is useful when confocal or CCD gain has to be used to increase the confocal signal because the sample has low reflectivity. The measured topography then has a lot of noise points and this filter allows them to be set as non-measurable points.

Kernel (2D/3D)

Filters the data by applying various algorithms (Mean, Median, Sobel, Harsh and Prewitt):

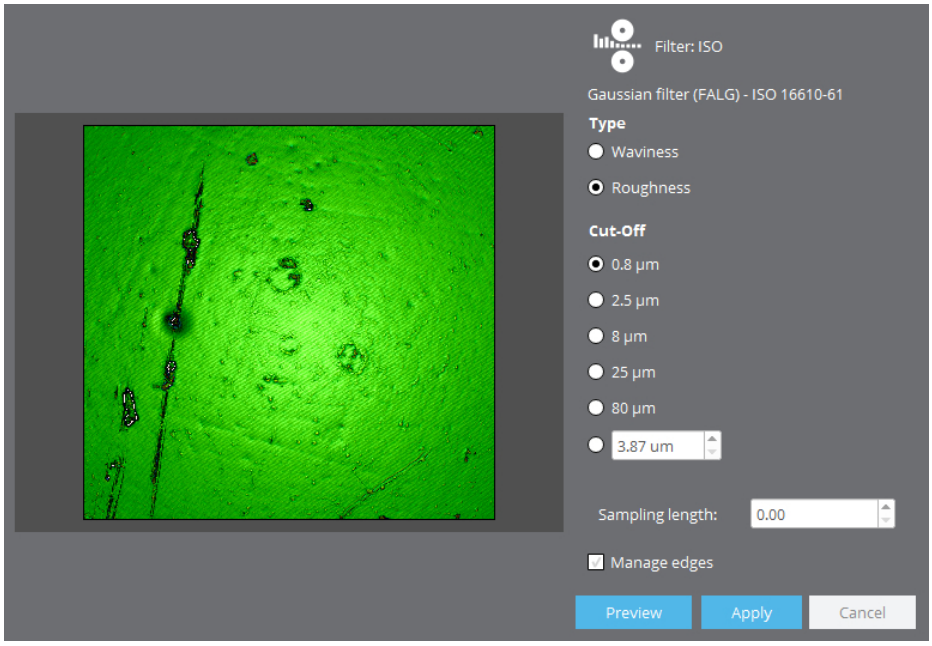


The Kernel filters are applied in a neighborhood of NxN pixels. The *Mean* and *Median* filters are used to smooth the measurement. The *Harsh* filter is used to sharpen the measurement. In contrast, the Sobel and Prewitt filters are used to show slopes in two different directions.

Examples of filters: (a) Harsh, (b) Sobel and (c) Prewitt

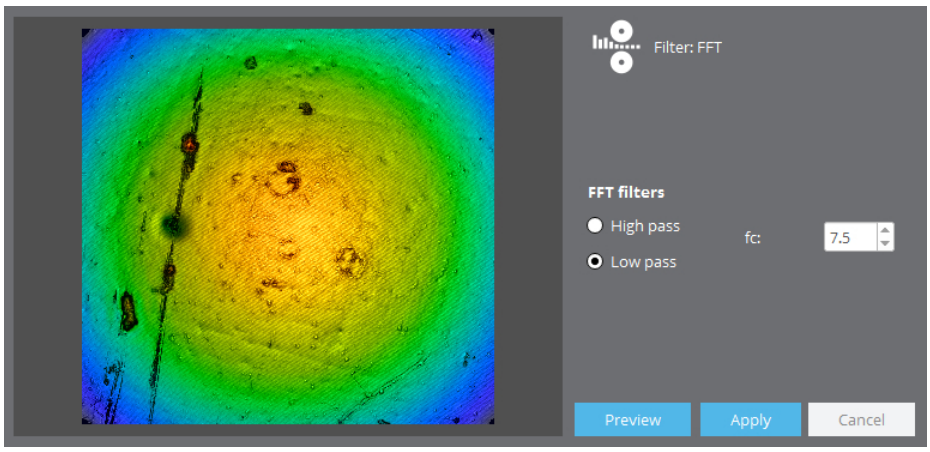
ISO (2D/3D)

Filters the data according to ISO 16610-61 standards by removing either waviness or roughness:



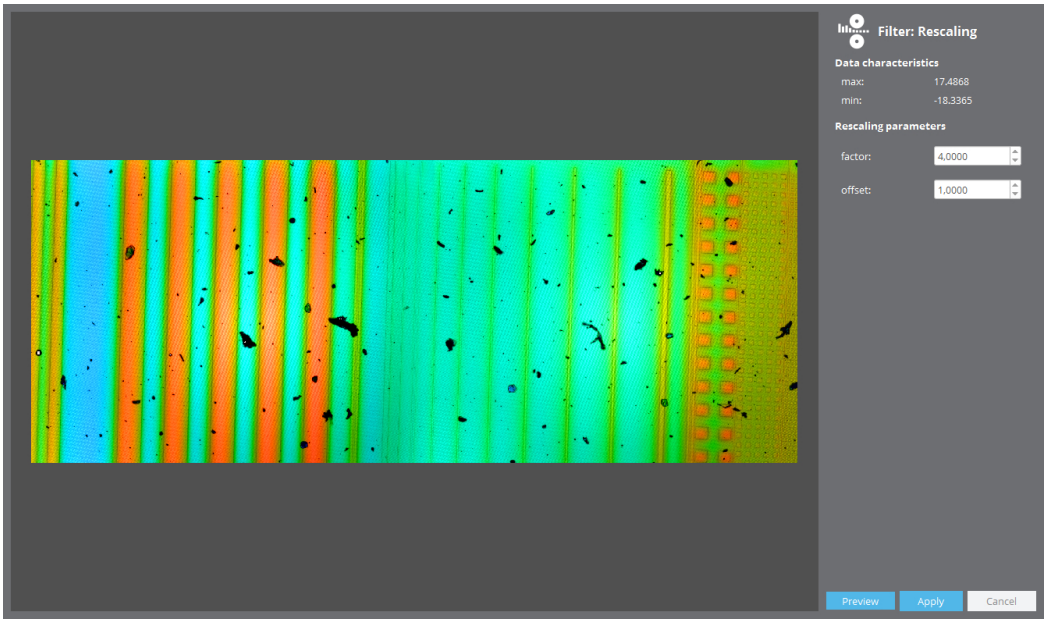
FFT (2D/3D)

Filters the data by applying either a high pass or low pass FFT. The frequency cut-off is defined as a percentage of the maximum - values between 0.1 and 99.9% are accepted.



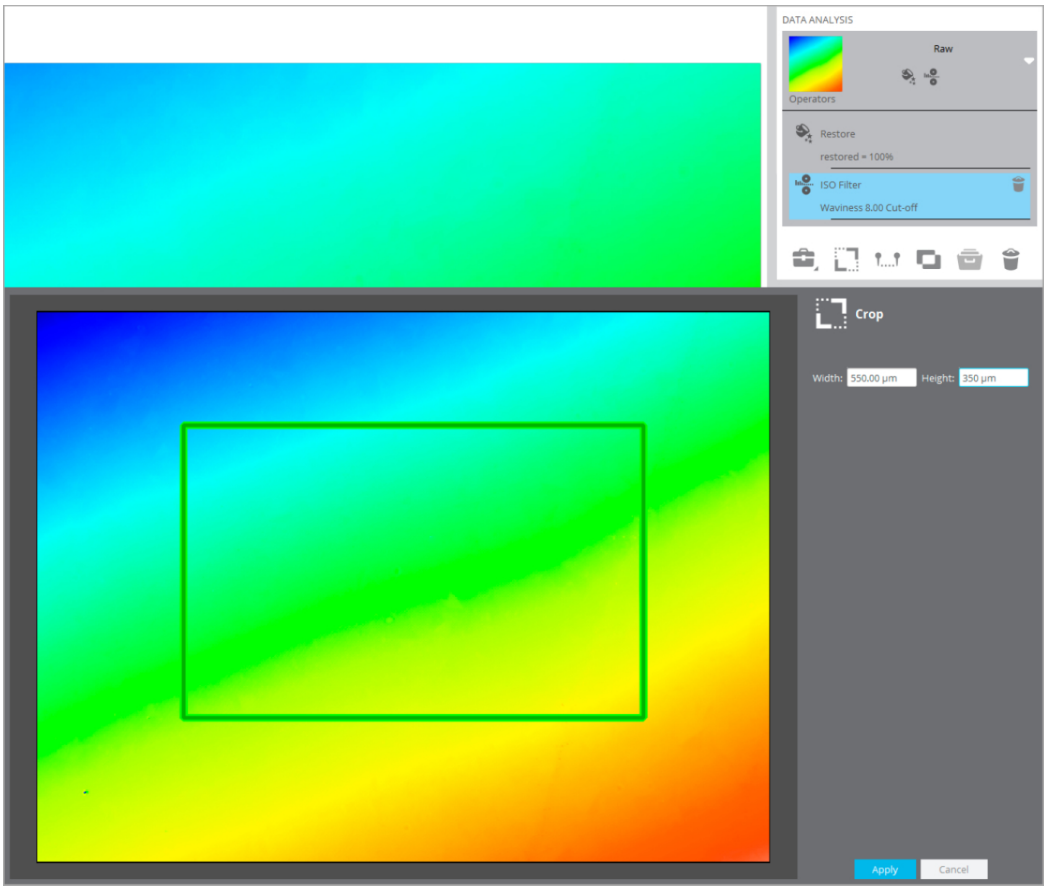
Rescale

This operator applies a user-defined vertical factor (between 0.0 and 100.0) and a user-defined vertical offset (between -1000.0 and 1000.0) to the data.



6.5.4 Cropping, Layers, Subtract

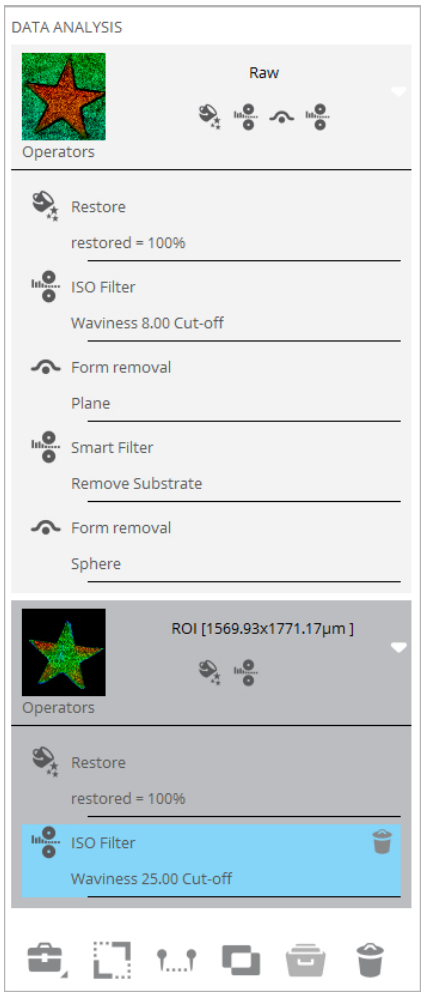
Overview



New layers can be extracted from the raw measurement or from an 'operated' measurement (raw measurement plus operators). All are 'areal only (3D)' operations.

- *Create Cropped Layer*: The region of interest (ROI) to be retained can be sized directly/ interactively by using the input boxes or by grabbing and dragging the corners of the green overlay, respectively. Values are relative to the top left-hand corner (origin) of the green overlay - entering values that would extend the ROI beyond the measurement limits (right, down) simply repositions the origin accordingly. Note also that the values are 'sticky', meaning that they are retained from acquisition to acquisition, and even between restarts of **SensoSCAN**. If a subsequent measurement is smaller than the sticky values, **SensoSCAN** defaults to 150 microns x 150 microns or an appropriate smaller size.
- *Create Profile Layer*: Generates a new profile layer based on the positioning of the interactive section created by the *Profile* tool. First, all necessary 3D operator and filter steps should be applied to the measurement, followed by activation of the *Profile* tool. Once the desired 2D profile has been selected, 2D operators and filters can then be applied to the measurement.
- *Create Subtracted Layer*: Choosing this option opens a dialog to load a previous measurement that is subtracted from the current measurement. Only raw values are used in the subtraction - any filters and operators applied to either data set will be ignored.

Additional filters and operators can be successively applied to any new layer to achieve the desired analysis:



Note: Deleting an operator will also delete successive operators as well as any new layers that depend on it.

6.5.5 Templates

Overview

As discussed elsewhere regarding file formats in **SensoSCAN 6**, the software saves and loads files in the **.plux* format. This format type contains only the raw data of a measurement together with any filters and operators that were active in Data & Analysis. In normal use, the raw data remains unmodified under all circumstances, while the filters, operators and layers listed in the file can be changed by subsequently re-loading the file, making changes to the analysis, and then re-saving the file.

As the filters, operators and layers listing is effectively separate, this can be used as an analysis Template. Templates are valid for both 2D and 3D measurements.

Template usage

Templates are used to apply pre-determined sequences of filters, operators and layers to repeated measurements.

Note: Templates can only be applied to raw data. All previous filters, operators and layers must be removed.

To apply a template to a measurement, choose the *Apply Analysis Template* icon in the Data Analysis pane and choose an appropriate **.plux* file. The filters, operators and layers listing in the chosen file will be applied to the current measurement in the exact same order as in the parent (template) **.plux* file.

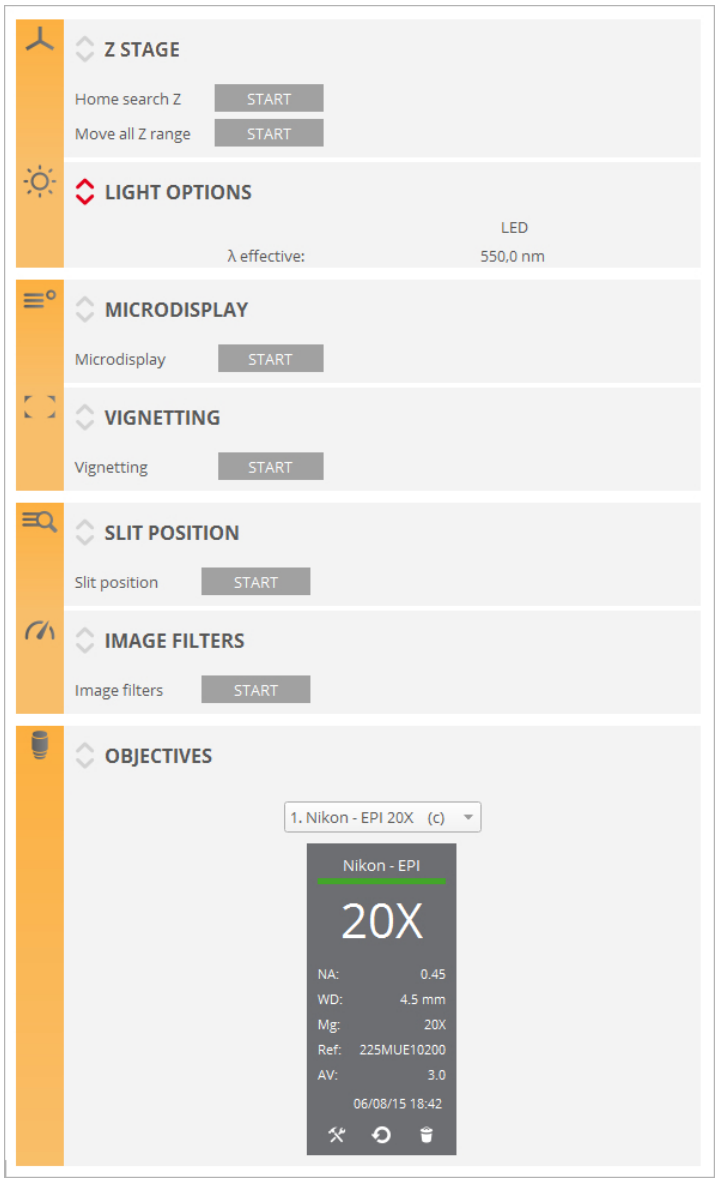
Part VII

7 Configuration & Alignment

Introduction

The Configuration & Alignment mode can be accessed by selecting **Configuration / Calibration** from the Menu Bar.

Note: More detailed information on the calibration and alignment procedures detailed here can be found in the Installation Manual for the system.



Note: In order to avoid improper configuration of the instrument, this mode should only be selected by trained users.

The OS Menu Bar also provides access to dialogs for globally resetting the following:

- objective configurations
- objective calibrations

- light balance

To leave the Configuration & Alignment mode, select either **Configuration / Exit calibration** from the Menu Bar, or click the Exit icon on the left of the Quick Bar.

7.1 Z Stage

Overview

- *Home Search Z* determines the top position for Z-Scan. Two types of *Home Search* methods are available depending on the hardware available:
  - *Home Search* based on Limit Switches. The Z stage will move towards the upper limit switch until it is triggered. It will then move away slowly until the limit switch opens again. At this point it will move a safety distance away from the limit switch (0.150 mm) and will set the Z = 0.000 coordinate at this position.
  - *Home Search* based on an external encoder. The Z stage will move upwards until it finds the home signal from the external encoder. It will then move down slightly and it will reproach the position of the Z encoder home signal at a lower speed until it finds the home signal again. This procedure finds the home signal with higher precision. The system will set the Z = 0.000 coordinate at this position. If the upper limit switch is found before finding the home signal from the encoder the system will move away from the limit switch 5 mm and will restart the *Home Search* sequence again.
- The *Move all Z range* function performs a movement along the entire Z axis. This maintenance test must be done once a year.

Warning: *Move all Z range* must be executed the first time that the program is installed. When the program executes this movement, it is important to ensure that nothing blocks the stage displacement.

Editing limits

The travel limits are the limit positions that the software has enabled.

In the **SensoSCAN** folder (*C:\Program Files\SensoSCAN 6.x\Configuration)*, there is a *StageZ.xml* file that can be used to edit these travel limits. In all cases, all editable values cannot be higher than the physical limits.

The *StageZ.xml* file can be used to define a preferred parking position (default -1.000 mm) following a *Home Search* call. This value is also used in the initialization of systems using the *autoreference* command (not **S neox**), i.e. it can be used to set a preferred parking position when the system is used repetitively for a single application.

7.2 Light options

Overview

The Light Options pane is used to fine tune the given wavelength of the white or monochrome light source installed in the system. The software shows the nominal wavelength for each LED (λ nominal), the effective wavelength (λ effective) that the user can edit, and the difference between these two values ($\Delta\lambda$). The maximum difference between the nominal and the effective wavelength is 100 nm.

To restore the default settings, click on the appropriate reset icon when editing each LED setting.

7.3 Alignment options

Microdisplay and Vignetting

These options help the user to check the alignment of the system. To do this, focus on the flat mirror supplied with the system. Ensure that the mirror is well focused. If the mirror is slightly tilted, recalibrate the XY table until the entire surface of the mirror is in focus.

Now click *Start* in the Microdisplay pane. A measurement bar showing the amount of alignment between the slit pattern and the camera will appear. The result must be better than 50%. If it is worse, please contact Service & Support.

Now click *Start* in the Vignetting pane to check the illumination uniformity. The result for this measurement bar must be better than 50%. If it is worse, please contact Service & Support.

In order to manually check the system alignment press F9 and a cross-hair will be displayed on the live image. This will be white if the system is properly aligned, red if not. To remove the cross-hair press F9 again.

7.4 Calibration options

Slit Position, Light Balance and Image Filters

The system calibration process is carried out by following three steps. To start, focus on the flat mirror supplied with the system with a 20x objective. Ensure that the mirror is well focused:

- first, click *Start* in the Slit Position pane. If the line position is correct, this option will draw the detected lines in red. If the slits are in the wrong position, the software will identify the problem.
- next, in order to calibrate the light intensity for the 4 single LEDs to make them as equal as possible, click *Start* in the Light Balance pane.

Warning: If Light Balance is applied, the user must perform a Flat of each objective again.

- finally, click *Start* in the Image Filters pane to optimize filter performance (maximizes the speed, depending on the computer).

7.5 Objective calibration

Overview

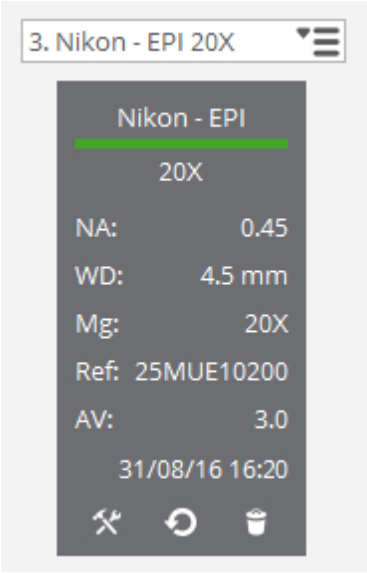
The objectives pane is used to specify which objectives are installed on the nosepiece:

- the number of objectives that can be selected depends on the nosepiece installed
- only the objectives that are part of the system configuration are available
- non-calibrated objectives are designated with C

Objectives can be deleted from the list by selecting them individually and then clicking on the recycle bin icon. Objectives can be added to the list by clicking the '**+**' icon for any empty positions in the list. This simple 'delete & add' procedure can also be used to re-order objectives in the selection list.

> **Note:** This is an important step if the system has a motorized nosepiece. The order of the objectives in the list must match the order of those on the nosepiece.

Properties of the objective, such as numerical aperture (NA), working distance (WD) and the reference number are shown directly when an objective in the list is selected. Further properties are revealed by clicking on the tool icon at the bottom of the objective information pane.



The objective information pane

Calibration

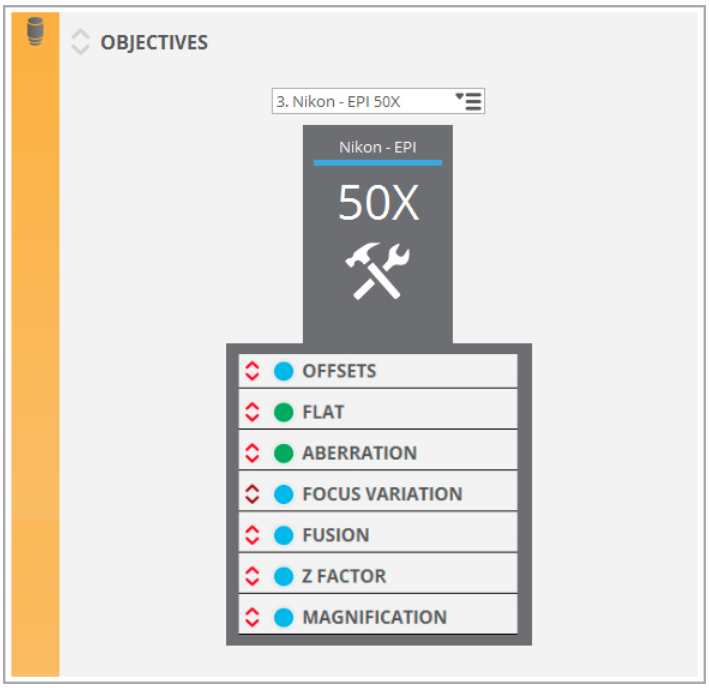
The objective calibration procedure is detailed in the Installation Manual for the system. This procedure is needed when adding or changing objectives, or when periodically re-calibrating objectives. Objective re-calibration is suggested once every 6 months, or more often in severely fluctuating environments.

> **Warning:** Objectives must be calibrated by specialists. Improper calibration may lead to the results having a strong spherical aberration.

To calibrate an objective, please refer to the Installation Manual for the system. Note that calibration changes can be undone using the rewind icon at the bottom of the objective information pane

Note: If the slit position fails for a brightfield objective, it cannot be calibrated.

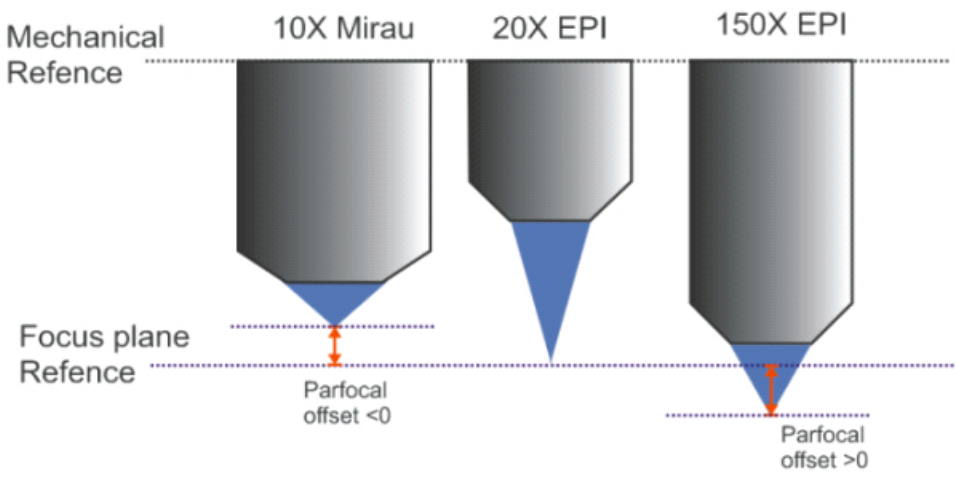
For user information, the most important aspects of the available objective calibrations are listed below:



- *OFFSETS*
  - *Parcentricity* offset is used to correct for any *XY* offset in the position of each FOV in an image overview.
  - The *Parfocal* offset is used to calibrate the focus plane for different objectives (see figure below). The reference objective is 20x EPI. When the focus plane for a different above lies above that of the reference, the *Parfocal* offset value is negative.

    There are two *Parfocal* offsets: coarse and fine. The coarse offset is defined by default in the configuration files. The fine offset should be defined by the user for each objective. Fine offset can correct a *Parfocal* error up to 250 µm. The *Parfocal* offset is the sum of the coarse and fine offsets.

Note: *Parfocal* corrections are only available for motorized nosepieces. When executing the *Parfocal* calibration routine, the system cycles the motorized nosepiece through all available objectives and obtains a correction for each.



- *FLAT (calibration mirror)*

  Used to correct for non-uniform illumination and color across the FOV. This routine is also utilized when acquiring a new Color Correction.

- *ABERRATION (calibration mirror)*

  Adjust the light and the focus and click on *Start*. The calibration procedure will run automatically. The calibration is performed using all four LEDs and consists of the following steps:

  - Autolight before AF
  - Autofocus
  - Autolight (Intensity) on *Slit Confocal*
  - Autolight (Intensity) on brightfield image
  - Topography *Coarse Shift Single Sampling* (light intensity of AL brightfield)
  - Topography *Coarse Shift Double Sampling* (light intensity of AL brightfield): sets light level to slit light intensity
  - Profile: sets light level to brightfield intensity

  If the calibration procedure fails, please contact Service & Support for more information

- *FOCUS VARIATION (calibration specimen)*

  It is recommended to carry out this calibration if extended topographies are performed using objectives from 2.5X to 20X. Adjust the light and the focus and click on *Start*. The calibration procedure will run automatically. The calibration is performed using all four LEDs and consists of the following steps:

  - Autolight before AF
  - Autofocus
  - Extended topography 4x5

- *FUSION (calibration specimen)*

  It checks for any *Parfocal offset* discrepancy between Confocal and Focus Variation Measurement techniques, and corrects any Focus Variation data that is folded into the Confocal Fusion result accordingly.

Warning: Fusion calibration is required to perform any 3D measurement with Confocal Fusion.

- *Z-FACTOR*

  Used to calibrate the sub- or super-linearity of the profiler's Z stage. This requires a calibration sample with known height parameters. First, measure the step height with a Z-Factor 1.000000 and look for the result. Then, correct the result using the proper multiplication factor or by entering the values of the nominal and measured step height, and click on Save. The factor is the ratio between the nominal and the measured step height.

Warning: An incorrect value of the *Z-Factor* may result in larger or smaller data. If you doubt the accuracy of the value, reset to 1.000000.

  For brightfield objectives, the user can calibrate *Z-Factor* for each Z-Scan device, linear stage or piezo. For interferometry objectives, the user can calibrate *Z-Factor* for PSI, VSI and ePSI and for each Z-Scan device.

- *MAGNIFICATION*

  This option has been made available to counter minor drifting in effective objective magnification caused my the optics 'working' within the objective housing (usually an issue in severely fluctuating environments). This effect is minute, but becomes important when sub-nanometric resolution/accuracy is essential.

Warning: recalibrating the magnification of an objective is not a trivial task and should not be carried out by inexperienced users of the system.

  The default value is the nominal magnification of the objective. This value can be changed only within ±1% of the nominal value. Full instructions and requirements for recalibrating the magnification of an objective can be found in the Installation Manual.

- *CALIBRATION MIRROR*

  To calibrate an interferometry objective (available for PSI only), click *Start*.

Warning: If the image is saturated, the acquisition will be wrong. Move Z up and down to make sure that the maximum fringe contrast is not saturated.

  Only the PSI technique will use the calibration to remove the topography of the reference mirror from the measurements. The procedure automatically acquires topographies from 10 positions on the calibration mirror that are then averaged. In order to obtain a valid calibration, the sample must be focused in the 'zero fringes' condition.

Part VIII

8 Configuration Files

Introduction

This chapter outlines the initialization settings for the **S mart** and **S lynx** systems, which are determined by the contents of **.xml* configuration files.

These files and their settings must be configured during initial installation of the software. They can be edited using any text editor.

> **Warning:** To restore the configuration files, close the program and delete the existing ones. When **SensoSCAN** is re-opened, it will generate default configuration files.

8.1 Z Stage

Overview

The *StageZ.xml* file configures the different options for the Z-Scan stage.

Section	Description
MAX_SPEED	Sets the maximum stage speed in microns/second. Default is 20000.
CALIBRATION_FACTOR	Scales the motor calibration. Default is 1.000.
BACKLASH	Sets the backlash compensation in microns. The default value depends on the hardware installed in the system.
MECHANICAL_OFFSET	Offsets the axis in microns. The offset is added to the default travel range. Used in granite stages as the optical axis (not used as the theoretical 0).
REVERSED	Invert axis values. Not inverted (1) or inverted (-1).
PARKING_POSITION	Sets the parking position. Default is -1.000 mm.
OBJECTIVE_OFFSET	Sets Z offset in microns. Default is 0.

Part IX

9 Errors & Diagnostics

Introduction

This chapter briefly addresses errors associated with acquisition and diagnostics for the hardware system.

In general, non-solvable acquisition errors and repetitive hardware issues that are not easily fixed should be reported to Service & Support.

9.1 Error Warnings & Codes

Overview

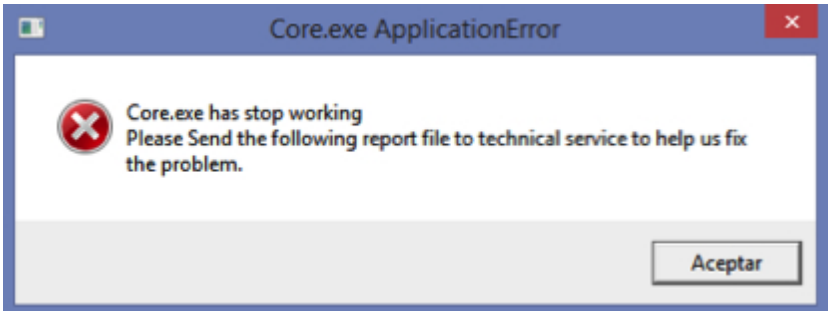
Previous versions of **SensoSCAN** have shown simple error codes on screen that needed subsequent manual identification and troubleshooting. Starting with **SensoSCAN 6**, these simple error windows are replaced by a window which shows the error code, a short description of the affected process, parameter or component, and (if available) possible troubleshooting options.

Acquisition problems which prove difficult to solve, or repetitive hardware issues should be reported to Service & Support.

9.2 Diagnostics

Overview

When the software detects an exception, it shows a windows message:



By clicking the accept button, it automatically opens a folder in which a zip file (core or gui) has been generated. This file contains the necessary information (application dump & log files) that technical service support must receive in order to perform a proper diagnostic.

For technical service actions it is sometimes also useful to check each hardware component (LED, motor, camera …) individually. In the Core menu, and using the technical service password, is possible to check each hardware component directly:

Part

10 Appendix

All globally relevant information as well as background topics from other Chapters are collected here.

10.1 System Preferences

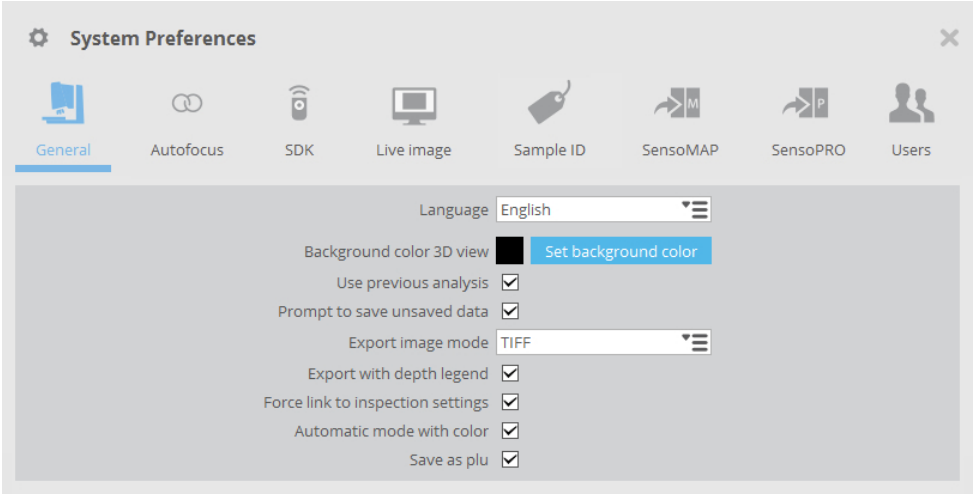
Overview

System Preferences can be accessed by clicking the icon in the Quick Bar when in Inspection & Acquisition mode, or choosing **Calibration / System Preferences** from the Operating System Menu Bar:

The Quick Bar when in Inspection & Acquisition mode

The System Preference categories are organized as tabs.

General



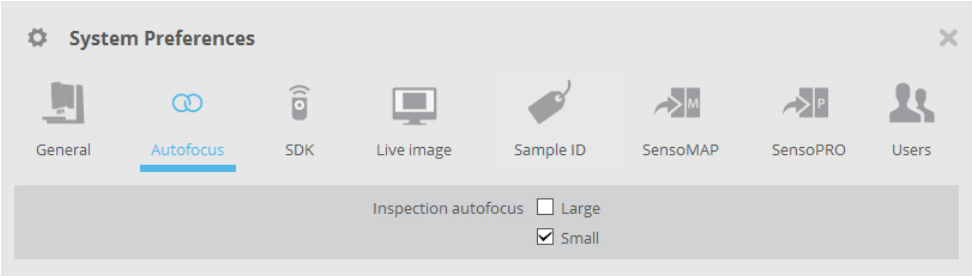
General settings in System Preferences

The options here allow setting of:

- *Language*: The preferred language for **SensoSCAN 6.**
- *Background color 3D view*: The preferred background color for 3D views.
- *Use previous analysis*: Force previous Data Analysis options to be automatically applied to a new measurement.
- *Prompt to save unsaved data*: A prompt when unsaved data may be lost.
- *Export image mode*: Choice of file format when exporting images (e.g. in Display & Analysis).
- *Export with depth legend*: Export the 3D image with the Z axis scaling visible in Measurement Display.
- *Force link to inspection settings*: Force Objective Selection and Light Settings in Acquisition Settings to match those set in Sample Inspection.

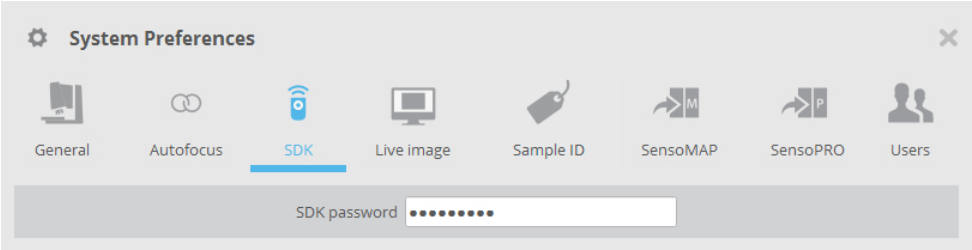
- *Automatic mode with color*: for multi-LED systems (currently only the **S neox**) this toggles the color mode for 3D Auto
- *Save as *.plu*: **SensoSCAN 6.0** through **6.3** automatically save measurements in both *the new *.plux* and the older *.plu* format*. Starting with **SensoSCAN 6.6**, saving additionally in the older *.plu* format is now user-selectable with this option.

Autofocus



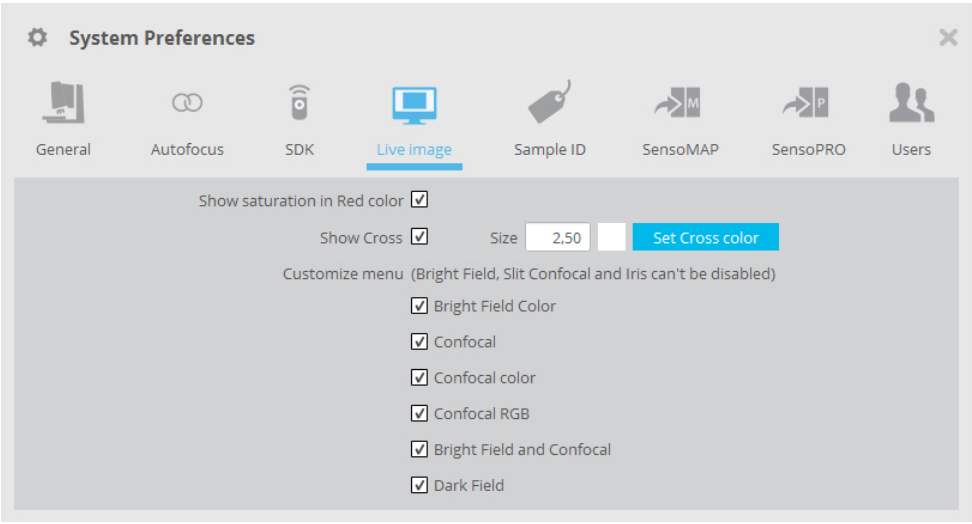
The options here determine whether *large* and/or *small* Autofocus routines are used when activating the Autofocus command in Sample Inspection. Information on the advanced options for these routines can be in Chapter 5 (Autofocus in Acquisition Settings).

SDK



The password for activating the SDK link can be entered here.

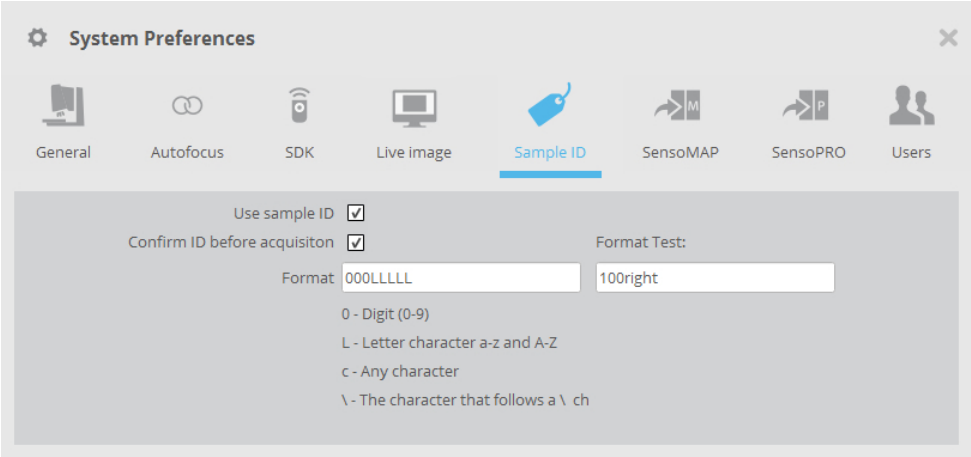
Live Image formats



The options here determine which viewer options are shown in the Central Viewer:

- *Show saturation in RED color* highlights saturated camera pixels in red
- *Show Cross* places a small cross-hair on the center of the Central Viewer. The cross-hair is user-customizable in width (0.5 - 5.0 pixels, widths of less than 1 pixel are dithered) and in color (default is white - a permanent, non-changeable red color indicates that the slit calibration procedure needs to be performed). Note that the F9 keyboard shortcut can be used to toggle to a large cross-hair, regardless of whether none, or a small cross-hair is selected here.
- The remaining options visible here (in part subject by the system's installed LED) determine which options are available in the Central Viewer's image type selector.

Sample ID



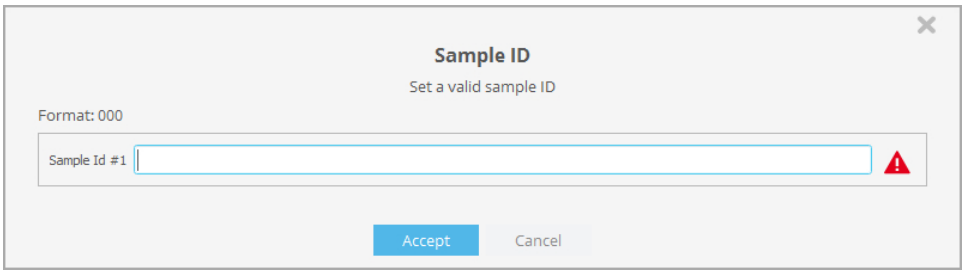
The Sample ID feature allows the user to label the measurement according to an identification. The subsequent measurement will exhibit the ID inside the file as well as in the file name.

When the user is programming an MMR, the MMR can be used with only a single Sample ID, or with multiple IDs by mapping the positions with their specific identification.

Sample ID options are as follows:

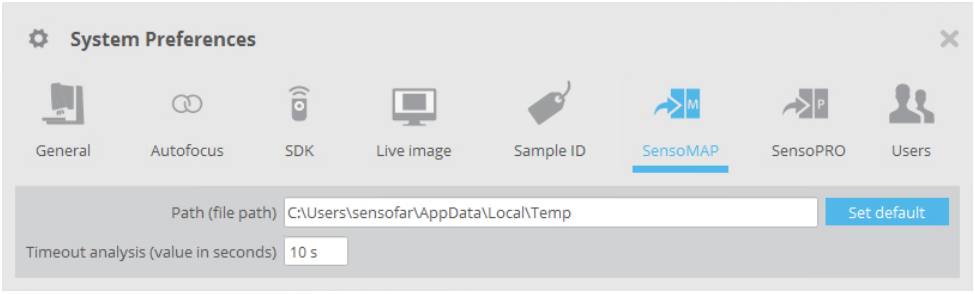
- *Use Sample ID* toggles the option of using a specific Sample ID. On activation, either the existing Sample ID is shown at the top of the Sample inspection pane:

... or the 'No ID' name tag icon can be clicked to reveal a pane where a new name can be entered using the keyboard (i.e. user-defined), or scanned from a list or from the sample by using a barcode reader. Note that, until a valid name has been given, a small red warning triangle is shown:



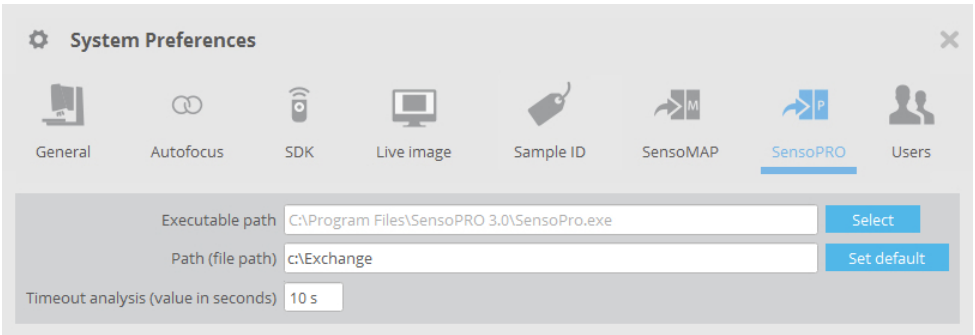
- *Confirm ID before acquisition* allows the user to check the Sample ID once more before acquisition.
- *Format* options allow a specific nomenclature strategy to be implemented. That is, the nomenclature is nominally freely selectable, but it can be restricted to a specific alphanumeric format by entering the corresponding definition into the *Format* field (see example in the System Preferences Sample ID pane above).

SensoMAP



- The file path for measurement files to be processed in **SensoMAP** can be defined here.
- When **SensoSCAN** is configured to push measurements to **SensoMAP** for analysis, **SensoSCAN** must wait until **SensoMAP** has finished processing the last measurement before **SensoSCAN** can push over the next. Normally **SensoSCAN** poles **SensoMAP** for the status, and makes the next acquisition as soon as **SensoMAP** is ready. The Time analysis duration determines the maximum dwell time per measurement file that **SensoSCAN** waits before posting a warning message. Time analysis should thus be set to be greater than the nominal time required by **SensoMAP** to analyze each measurement in the users particular configuration.

SensoPRO



- Used to define the location of the **SensoPRO** executable and the path for files. When these are

correctly given, **SensoSCAN** can automatically call **SensoPRO** when required.

User Profiles

For **SensoSCAN 6**, the User Profiles dialog is found within System Preferences of the main **SensoSCAN** application. With the User Profiles dialog, Administrators of the system can manage the users and their associated rights.

Managing user profiles

In order to help organizations that have acquired a system to administer the use and maintenance of the system, **SensoSCAN 6** distinguishes between three different levels of users and their associated rights:

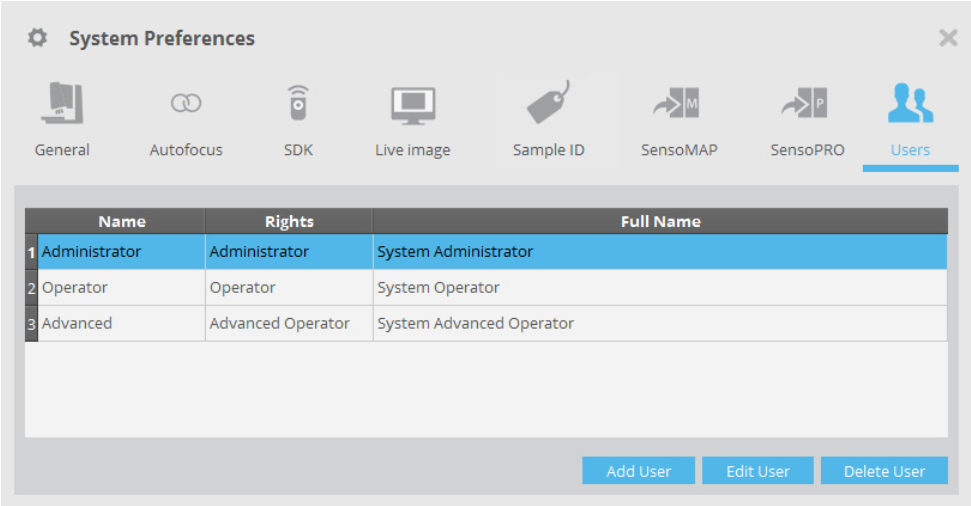
- **Administrator:** can manage System Preferences, can perform Configuration & Alignment tasks and has all the rights of an Advanced Operator.
- **Advanced:** can configure measurement and create recipes, and has all the rights of an Operator (User).
- **Operator (User):** can load recipes, acquire and save/load data and perform analysis.

After initial installation (and also following re-installation) the user list contains by default one user of each type. The table below shows the three default users, their rights and the associated default password:

User	Rights	Default Password
Administrator	System Preferences	adm1234
	Calibration & Alignment	
Advanced	Save Recipes	adv1234
	Configure Acquisition	
Operator	Load Recipes	ope1234
	Acquire Data	
	Perform Analysis	
	Save/Export Data	

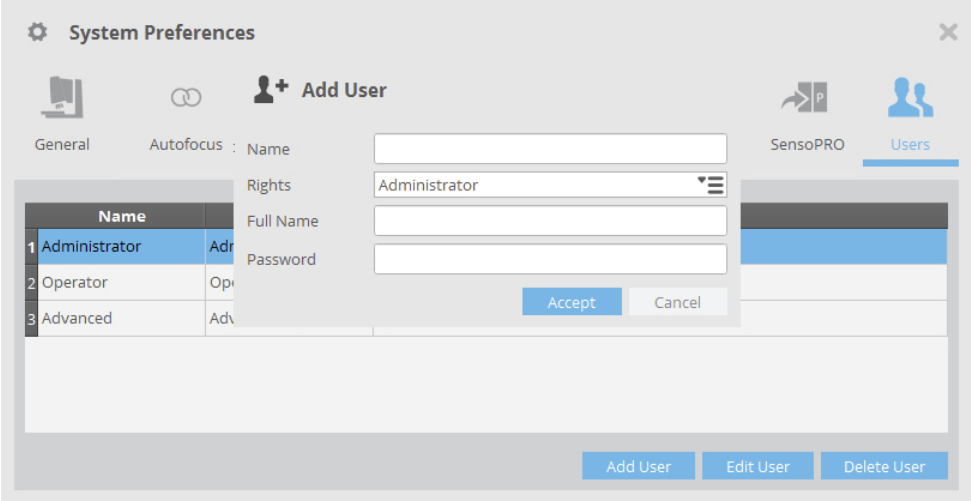
User rights and the default passwords after initial installation (and following re-installation)

The default users can be used 'as is', or they can be edited as required, or new users can be added. An Administrator can access the users tab in order to manage all users of the system (*Add* / *Edit* / *Delete*):



User tab in System Preferences

Clicking *Add User* or *Edit User* reveals a drop-down dialog, in which the details and rights for a new user can be given, or where those for an existing user in the list can be changed, respectively:



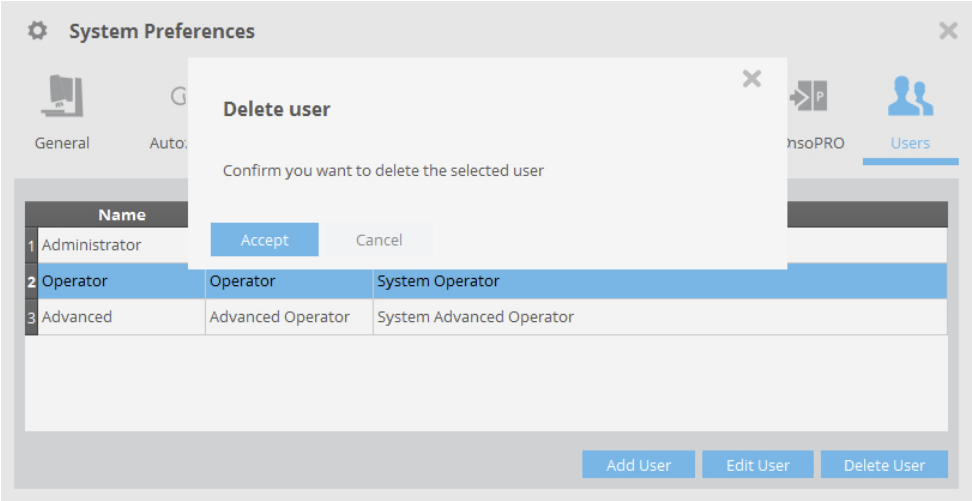
Using the *Edit User* dialog to edit the details for user *Operator*

After adding a new user or after making any changes to a user profile, simply click *Accept* to confirm the changes and return to the user profiles dialog.

Note: The user name and password may contain any combination of available symbols, numerals and upper/lower case type.

Note: In the event that a user profile can no longer be loaded by the system, the profile should simply be deleted and then recreated by an Administrator.

Clicking *Delete User* reveals a drop-down dialog with which the chosen profile can be deleted:



Using the *Delete User* option to delete the profile for the user *Operator*

10.2 File Formats

Overview

When saving a measurement in **SensoSCAN,** the raw data is always preserved. To achieve this, the file formats used contain the raw measurement data together with a list of the Data Analysis options that were applied to that measurement in the version of **SensoSCAN** saving the file. On opening a saved file in **SensoSCAN**, the raw data is loaded, and if the version of SensoSCAN is compatible, the suite of Data Analysis options that were saved in the measurement file are also loaded are reapplied in the render (visualization). The following versions of SensoSCAN save different formats:

- **SensoSCAN 5.x** saves measurements in the **.plu* format.
- **SensoSCAN 6.0** through **6.3** save measurements automatically in both the new **.plux* and the older **.plu* format.
- **SensoSCAN 6.6** saves by default only the new **.plux* format, but saving additionally in the older **.plu* format is user-selectable (see *Save as *.plu* option in System Preferences).

While the **.plu* and **.plux* formats are conceptually similar, they are structurally different.

File format compatibility between SensoSCAN 5 and SensoSCAN 6

The interchangeability between the new **.plux* and the older **.plu* formats is limited to the import of a **.plu* file into **SensoSCAN 6.x** (select **File / Import / Import plu** from the Menu Bar). As indicated above, only the raw data of the measurement is imported from the **.plu* file, nothing else.

File format compatibility between SensoPRO LT and SensoPRO

32-bit versions of **SensoPRO** (designated as **SensoPRO LT**) are only compatible with **.plu* files. Users of **SensoPRO LT** will need to activate the *Save as *.plu* option in System Preferences.

64-bit versions of **SensoPRO** (**SensoPRO 3.x** and later) are compatible with **.plux* files.

Raw data preservation

As described above, when saving a measurement in **SensoSCAN,** the raw data is always preserved. A direct consequence of this is that, when in Display & Analysis mode, data can be visualized using the available filters, operators and layers, but the raw data is not permanently modified. If desired, a measurement that has been previously saved can be loaded into **SensoSCAN** and the suite of filters, operators and layers can be edited, and the file re-saved with the new suite of Data Analysis options.

Save as RAW option

There are some instances where modified data is required for further (e.g. external) analysis.

Starting with **SensoSCAN 6.3**, a *Save as RAW* option in the **File** menu can be selected, which permanently applies the active filters, operators and layers to the raw data of a measurement before saving:

- a **.plux* file is generated containing only the modified data, with no record of the filters, operators and layers previously active,
- the display and render in Display & Analysis mode changes accordingly - the modified data is shown as if it were a new measurement.

10.3 ISO Standards

Overview

The *ISO 25178: Geometric Product Specifications (GPS) – Surface texture: areal* standard is an International Organisation for Standardisation collection of international standards relating to the analysis of 3D areal surface texture. It is the first international standard taking into account the specification and measurement of 3D surface texture, and in particular defines 3D surface texture parameters and the associated specification operators. It also describes the applicable measurement technologies, calibrations and methods, together with the physical calibration standards and calibration software that are required.

A major new feature incorporated into the standard is coverage of non-contact measurement methods, already commonly used by industry, but up until now lacking a standard to support quality audits within the framework of ISO 9000. The move brings (e.g. optical) 3D surface metrology methods into the standards domain.

Useful sources of reference can be found here and here.

The 3D areal surface texture parameters are calculated for the entire surface, and comprise the following families:

- height parameters: the statistical distribution of height values along the Z axis (discussed in more detail below)
- spatial parameters: the spatial periodicity of the data, specifically its direction
- hybrid parameters: the spatial shape of the data
- functions and related parameters: parameters are calculated from the material ratio curve (Abbot-Firestone curve), and
- parameters related to segmentation: parameters are derived from a segmentation of the surface into motifs (dales and hills)

Height parameters

For convenience, the height parameters are listed below. These involve only the statistical distribution of height values along the Z axis:

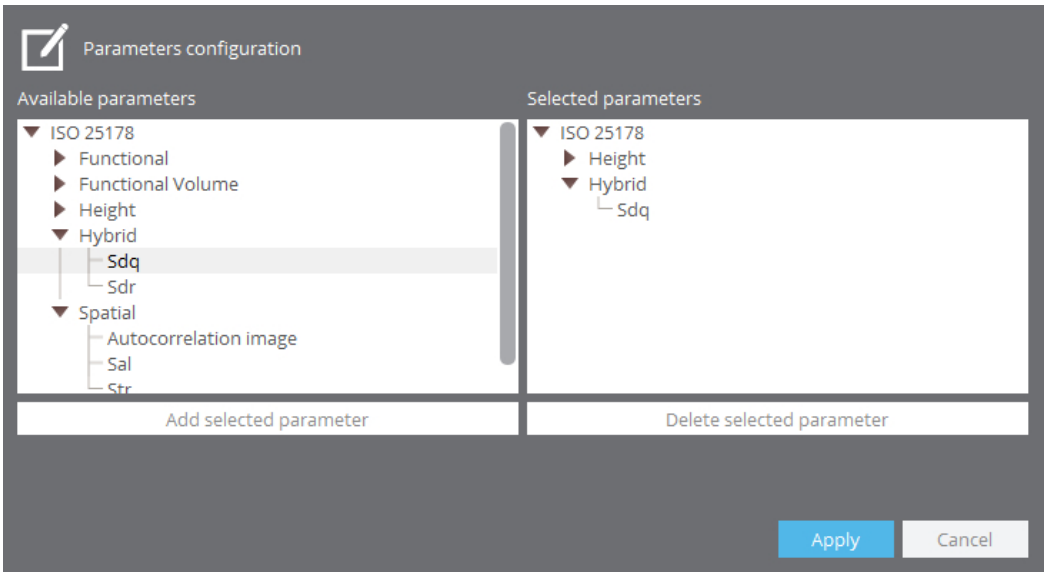
Property	Description	Comments
Sq	root mean square height	The rms height of all data points from the mean surface height (µm), aka rms roughness. An overall measure of the texture comprising the surface, typically used to specify optical surfaces.
Ssk	skewness	Skewness of the height distribution relative to Sq. Figuratively, the shift of the heights of all measured points to lower or higher values compared an ideal bell curve distribution. Useful in specifying honed surfaces and monitoring for different types of wear conditions.
Sku	kurtosis	Kurtosis of the height distribution relative to Sq. Figuratively, the predominance of extreme peaks or pits for all measured points compared to an ideal bell curve distribution.
Sp	maximum peak height	The distance between the mean surface height and the highest point within the data (µm). Value is generated from a single point and is often unrepeatable. Typically used for surfaces that will be used in a sliding contact application.
Sv	maximum pit depth	The distance between the mean surface height and the lowest point within the data (µm). Value is generated from a single point and is often unrepeatable. Typically used when pit depths relating to fluid retention may be of concern, such as for lubrication and coating systems.
Sz	maximum height	Sum of the largest peak height value and the largest pit depth value (µm). Value is generated from a two single points and is often unrepeatable. Typically used for sealing surfaces and coating applications.
Sa	arithmetic mean height	The arithmetic mean height of the surface (µm), aka average roughness. An overall measure of the texture comprising the surface, typically used for machined surfaces.

The Height family of Surface Texture parameters

Configuring ISO Parameters in SensoSCAN

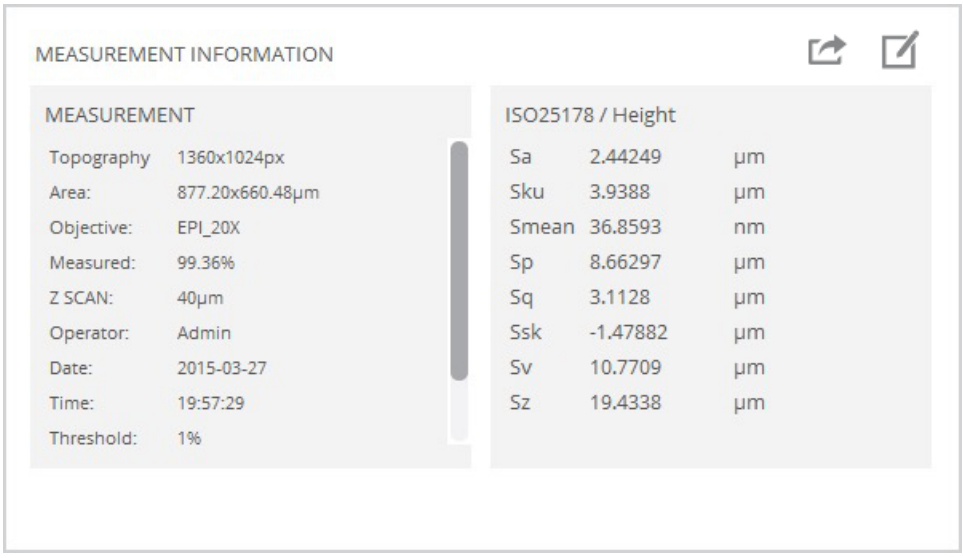
The measurement information panel can additionally show values corresponding to any active parameters chosen from the ISO Standards. The different ISO Standards can be accessed by clicking

the parameters configuration icon and activating/deactivating individual parameters or parameter families as desired. If this icon is not visible, it is because (further) options for this Measurement type are not available (e.g. for 2D profiles and for images).



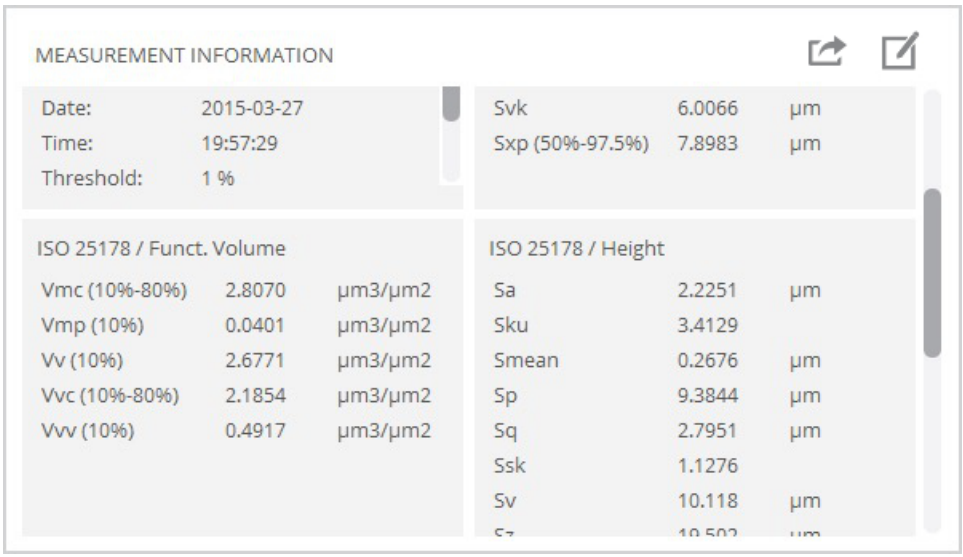
Activating/deactivating ISO Standards in the parameter settings dialog

The parameters for any activated ISO 25178 Standards - if applicable to the Measurement type - are then visible in the measurement information panel for a completed or loaded measurement:



Supplementary 3D Surface Texture parameters according to ISO 25178 / Height

As more parameters or parameter families are added, more parameter panels are added to measurement information:



Adding further parameters and parameter families add additional parameter panels to the measurement information

10.4 Keyboard Shortcuts

Save time with Keyboard Shortcuts

A number of keyboard shortcuts are available in the various different modes. Keyboard shortcuts are keys or key combinations that invoke a specific software task.

Keyboard shortcut	Task	Inspection & Acquisition	Display & Analysis	Calibration & Alignment
F1	Help	√	√	√
F2	Autofocus	√		
F3	Autolight	√		√
F4	Acquire (new measurement)	√		
F5	Switch to Inspection & Acquisition		√	
F6	Toggle between Brightfield and Slit Confocal (depending on the selected objective)	√		√
F7	Switch between maximum light intensity and the previous intensity	√		√
F8	Autolight and Autofocus (brightfield objectives) Autolight with Z-Scan and Autofocus (interferometry objectives)	√		√
F9	*Acquisition*: Switches between the small cross-hair (or nothing - see System Preferences) and a large cross-hair *Configuration & Alignment*: Switches between nothing and a large cross-hair	√		√
F10	Repeat previous overview capture (stitched images)	√		
Spacebar	Stop the measurement after acquiring 21 planes (Confocal and Focus Variation) or 50 images (VSI and ePSI) and go to Data & Analysis.	√		

10.5 SDK

SensoSCAN Software Development Kit

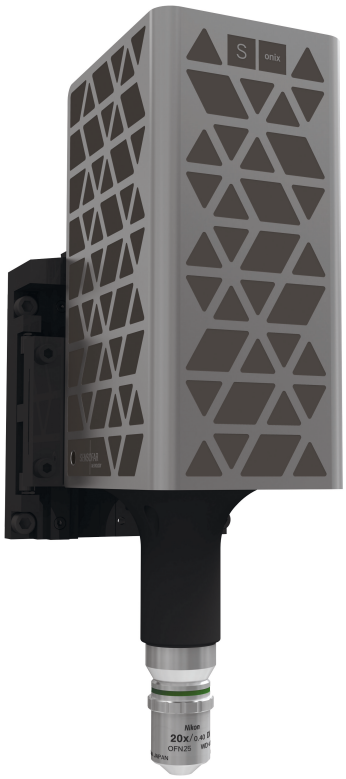
It is possible to run specific commands and events of the **SensoSCAN Core** remotely using the **SensoSCAN** software development kit (SDK). The link to the SDK from **SensoSCAN** is activated by entering the Password in System Preferences.

The SDK provides the tools and protocols needed to create proprietary applications that are able to communicate and manage **SensoSCAN**. Developers can choose the platform and language as the basis for their applications without constraint. **SensoSCAN** SDK commands and events provide a means to remotely inspect a sample and perform measurements based on acquisition *Recipes*. Once a proprietary application has been developed using **SensoSCAN** SDK, it can be used with multiple systems.

If the SDK is part of your system, check the specific documentation for more details.

S onix

Installation Manual



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CHAPTER 1

What makes up your S onix?

Names of components and optional parts

S onix is a modular system with several optional parts. It is composed of a system unit, an electronic controller and a main controller.

System unit

Electronic controller

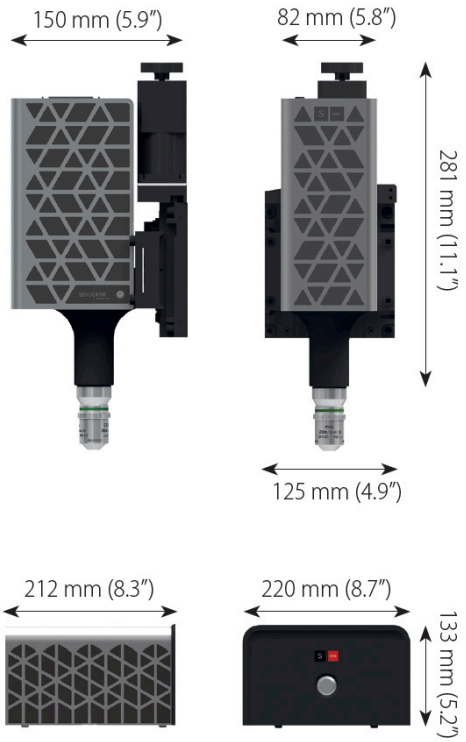
Main controller

Technical specifications

System weight

Component	Weight [kg]
Sensor head	4.1
Electronic controller	2.5
Main controller & Screen	13.1
System monitor	6.1
Average objective	0.2
Full S onix with one objective	**20.1**

Mechanical dimensions



Specifications of the objectives

Interferometric

MAG	2.5X	5X	10X	20X	50X	100X
NA	0.075	0.13	0.30	0.40	0.55	0.70
WD (mm)	10.3	9.3	7.4	4.7	3.4	2.0
FOV[1] (µm)	5040 x 3780	2520 x 1890	1260 x 945	630 x 472	252 x 189	126 x 94
Spatial sampling[2] (µm)	7.88	3.94	1.97	0.98	0.39	0.19
Optical resolution[3] (µm)	2.23	1.29	0.55	0.41	0.30	0.23
Measurement speed[4] (µm/s)	25					

VSI

Vertical resolution[5] (nm)	1					
Maximum slope[6] (º)	3	8	14	21	25	42

1 Maximum field of view with 1/3" camera and 0.375X optics. **2** Pixel size on the surface. **3** L&S: Line and Space, half of the diffraction limit according to the Rayleigh criterion. Values for white LED. Spatial sampling could limit the optical resolution for interferometric objectives. **4** Measurement speed 1X. **5** System noise measured in a calibration mirror placed perpendicular to the optical axis. **6** On smooth surfaces.

Note: If you need another objective to complete your system or solve new applications, do not hesitate to contact your Sensofar distributor or send a request to info@sensofar.com.

CHAPTER 2

What is in the box?

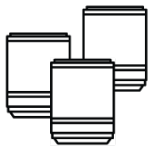
The S onix control electronics, sensor head and computer were carefully inspected, both electrically and mechanically, before shipment. The operating system (Microsoft® Windows 8) and the acquisition software (SensoSCAN) were also installed before shipment.

Important: When you receive the instrument, unpack it and check for any obvious signs of physical damage that may have occurred during transit.

The S onix consists of several default modules and optional modules that depend on the configuration of the system. The following items are shipped with the S onix system for each module.

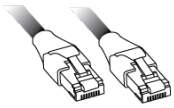
Sensor head module

Sensorhead



Objectives

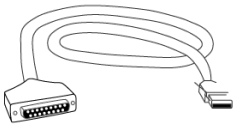
Sensorhead & Electronic controller cable



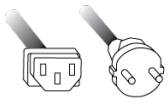
Ethernet cable

Electronic controller module

Electronic controller

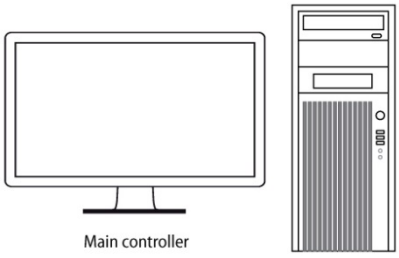


Electronic & Main controller cable



Power cord

Main controller module

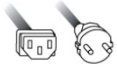


Main controller

Keyboard

Mouse

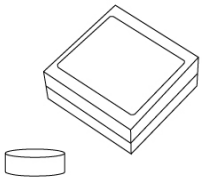
Display port cable



Power cord

Others

USB recover system



Reference mirror

Software

SensoPRO LT

SensoMAP

CHAPTER 3

How to install your S onix in 5 steps

Important: Read all the installation instructions (and the Safety Information starting in Chapter 6) carefully before you first use the system.

Check the device's electrical connections when you use it for the first time. Check whether the device should be connected to 110 V or 220 V. The system's power connection must have earth connection.

Warning: Any improper use or connection of the components may cause irreversible damage.

Step1. System assembly

Assemble the mechanical parts that support the S onix sensor head and other mechanical parts.

Sensor head

Option A – With adaptor plate (recommended option)

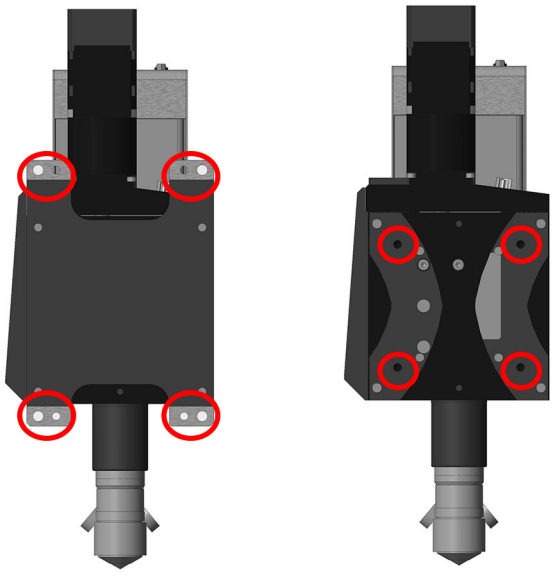
1. Use four M6x25 screws to attach the adaptor plate to its support, as shown in the diagram.

Option B – Without adaptor plate

1. Remove the adaptor plate unscrewing the four M6 screws.
2. Use four M6 screws to attach the sensor head to its support, as shown in the diagram. Length will depend on the support (minimum 20 mm).

   Note: Take into account that the minimum screw length inside the motor must be 6 mm and the maximum screw length inside is 8 mm.

   Warning: Fix the sensor head to its support with a pressure of 6 Nm (the use of a torque wrench is highly recommended).



Objectives

1. Mount the objectives in the nosepiece.

   Warning: Thread the adapter onto the interferometry objectives before you mount them.
   Warning: Don't look through the objectives if the system is working.

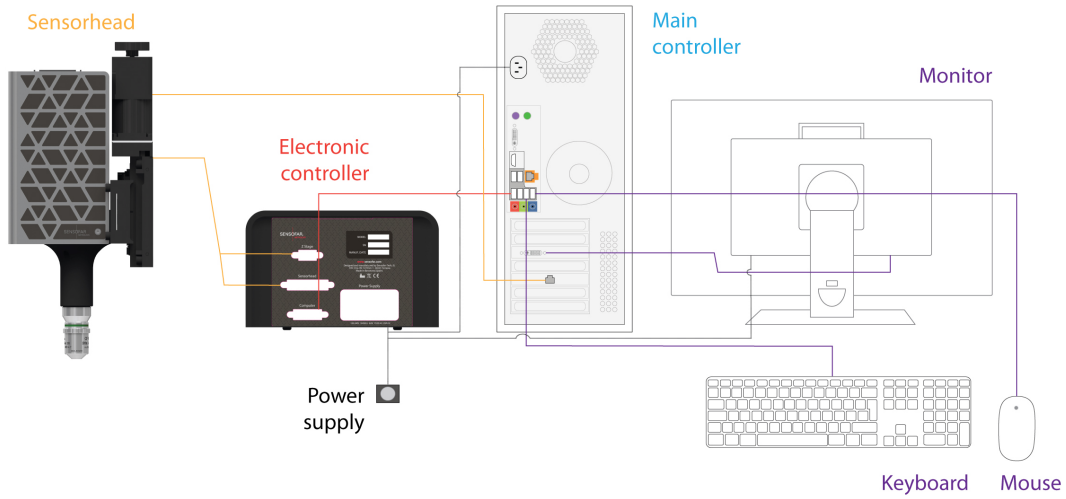
Electronic and main controllers

1. To avoid vibrations, set up a separate table for the electronic and main controllers, but still positioned close enough so that they can easily be switched ON/OFF.

   Warning: Don't block system air vents.

Step2. Cable connections

The following diagram and explanation shows how to plug in all the connection cables and electronics.



Warning: Plug all the connectors into the right places. Any errors in the connections can cause irreversible damage to the system.

Warning: All cables and connectors shall have a minimum bend radius of 6 times the diameter of the cable. For instance, for the cable connecting S onix sensor to controller (Ø 8 mm) the min. bend radius shall be **48 mm.**

1. The **sensor head** has two cables: one for the sensor head and one for the Z stage. These must be connected to the 'Sensor head' connector and the 'Z Stage' connector on the electronic controller respectively.
2. The **ethernet cable** is connected from Ethernet connector on the 'Sensor head' to the Ethernet connector on the main controller.
3. The **controller cable** is connected from the 'Computer' connector on the electronic controller to the USB port with the red label on the main controller.
4. The **keyboard** and the **mouse** are connected to the USB ports on the main controller.
5. The **monitor** is connected from the display port on monitor device to the display port on the main controller (external graphic card).
6. The **power cords** should be connected and the power supply checked (110-240 V AC 50-60 Hz).

Optional Parts

Software: SensoMAP or SensoPRO LT dongle

The SensoMAP or SensoPRO LT dongle key is connected to one of the USB ports on the main controller. If there are no free USB ports on the main controller, see how to install a USB hub to connect the dongle.

Step3. Start up

The following power-up procedure must be followed before the start of every S onix session.

Important: Ensure that all the cables are connected correctly.

1. Press the power button on the main controller (PC). Wait until Windows® 8 shows the login window and login.

   Warning: S onix users must have administrator rights on Windows®8.

2. Wait until all windows services have been loaded and press the power button on the electronic controller.

   Warning: Wait approx. 40 s between switching on the electronic controller and starting up the software.

3. Double click on the SensoSCAN software icon.

4. When SensoSCAN is started, the login window prompts the user to enter a username and a password. To enter with administrator rights, the username is **Administrator** and the password is **adm1234**. For more information on user rights, see the User Manual.

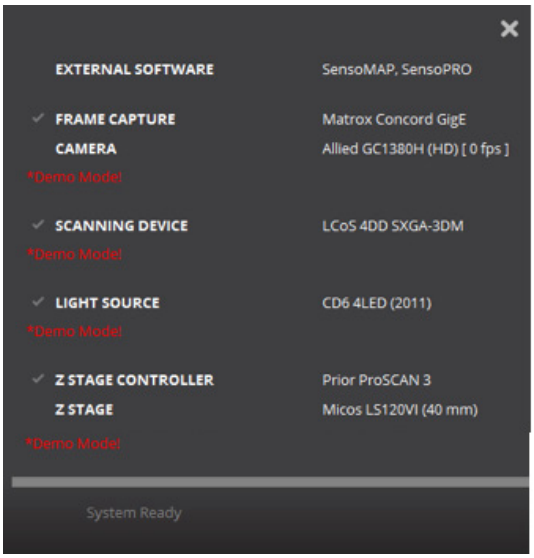
   SensoSCAN starts in Inspection & Acquisition mode. The Display & Analysis mode is shown once a new measurement has been acquired or a previous measurement has been loaded from file. Configuration & Alignment mode is displayed when the appropriate option is selected from the toolbar. See the User Manual for more details on using these modes.

5. The toolbar at the bottom of the Central Viewer shows the status of the system and information about the procedure that is currently running.

   The status may be:

Status	Color	Description
OK	Background	System is working properly
Demo	Background	System is working properly in demo mode
Warning	Blue	System is working but there are warnings
HW Error	Red	A hardware error has been found
System Exception	Red	A Software Exception has occurred, restart the software

   System Status shows a green tick when the device has started up correctly or a red cross when the device has not initiated correctly. Clicking on this icon reveals the System Status panel – this panel reveals detailed information about errors and warnings. If the system does not initiate correctly, check the cause of error and contact the local distributor (see Chapter 7).



Step4. Calibration

The following procedures are carried out in the Configuration & Alignment mode. To enter this mode, choose Configuration from the toolbar. More information can be found in the User Manual.

Z Options

Z Options provides information about the Z stage installed in the system, its status and the travel limits.

> **Warning:** Don't put the fingers on the Z stage.

1. *Home Search Z* – Click on the *START* button. The Z stage will move towards the upper limit switch until it is triggered. It will then move away slowly until the limit switch opens again. At this point, it will move a safe distance away from the limit switch (0.150 mm) and will set the Z = 0.000 coordinate at this position.

   > **Warning:** The *Home Search Z* function can only be executed if the Z position is below the parking position.

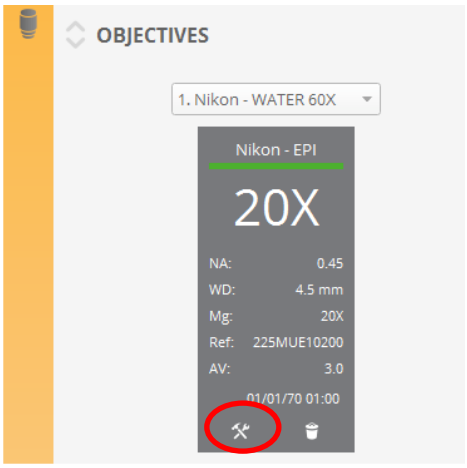
2. *Move all Z range* – Click on the *START* button to perform a movement along the entire Z axis. This maintenance test must be done once a year.

   > **Warning:** *Move all Z range* must be executed the first time that the program is installed. When the program executes this movement, it is important to ensure that nothing blocks the stage movement.

Objective calibration

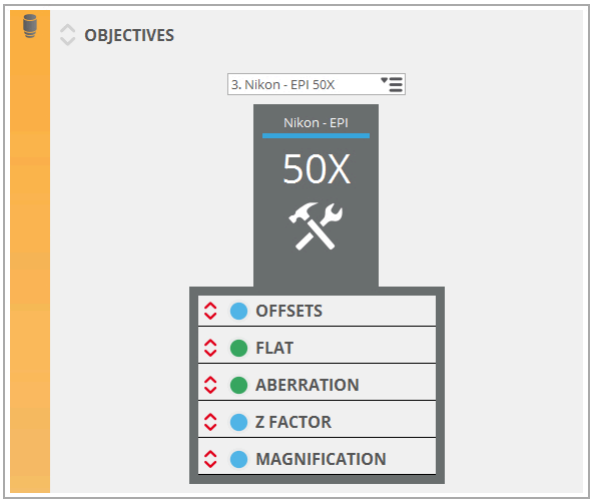
The *Objectives* pane is used to define the objective currently installed on the nosepiece.

Properties of the objective, such as NA, WD, and reference number are shown directly when an objective has been selected. Calibration options are revealed by clicking on the tool icon at the bottom of the objective's info pane.



Calibrate the available objectives:

1. Click on the tool icon at the bottom of the objective's info pane to reveal the calibration procedures.



1. Place the flat calibration mirror supplied with the S onix on the microscope sample plate.
2. Focus the mirror coarsely (use the *Iris* image).
3. Change to the *Brightfield* image and adjust the light by clicking *Auto*.
4. Find a very clean area on the mirror (free of scratches and dust particles). If this is not possible, clean the reference mirror (see *Chapter* 6). Now move some microns above the focus position, thus avoiding the interferometric fringes.
5. Open the *Flat* option that is used to correct non-uniform illumination within the field-of-view. To perform the *Flat* procedure, click on the *START* button. The software automatically runs a process to correct for non-uniform illumination. When complete, the red traffic light will change to green. Click *FINISH* to end the process. To return to the previous setting click *CANCEL*.
6. Click on the *TOOL* button to exit of the calibration objective procedure.

Step 5. Shut down

The following shut down procedure must be followed before powering down the system.

1. Close the SensoSCAN application by clicking on window close button, or simply by using the menu. Wait until the system closes the application correctly.

2. Press the power button on the electronic controller in order to switch it off.

3. Shut down the main controller by selecting *Start* and then choosing the *shut down* option.

Using this procedure the system will be disconnected in the correct way.

CHAPTER 4

Your system is ready, now check it

Note: Read the user manual for more information about SensoSCAN. You can find the manual at Start > Programs > SensoSCAN > Docs or SensoSCAN software > Help > Contents.

After the alignment and calibration procedures, the S onix is ready to take measurements. Nevertheless, it is best to check that the objective alignment and calibration are correct. The test has to be performed with the same flat calibration mirror supplied with the S onix.

3D Performance for interferometry objectives

1. Focus the mirror surface and find a very clean area.
2. Adjust the light.
3. Select the following acquisition parameters:
    a. **Operation Mode**: Interferometry
    b. **Measurement**: 3D VSI
    c. **Objective**: the objective you want to check
    d. **Area**: full
    e. **Z Scan**:
        i. Speed factor: 1X
    f. **Z Range**: 15 µm
    g. **Threshold**: medium (second level)
4. Press *Acquire* and wait until the measurement is displayed.
5. Save the topography. Now repeat the measurement.
6. Choose the Fast Fourier Transform (FFT) filter from the *Add Operator* option to subtract high frequencies (High Pass fc 1%).
7. Check the rms value and ensure that the S onix is under specifications (see Chapter 1).
8. Repeat the entire process for each objective.
9. If the vertical resolution value (Sq) of the measured profile for a given objective does not meet the specifications, check environmental vibrations.

CHAPTER 5

Troubleshooting

Read the troubleshooting tips when you have a problem.

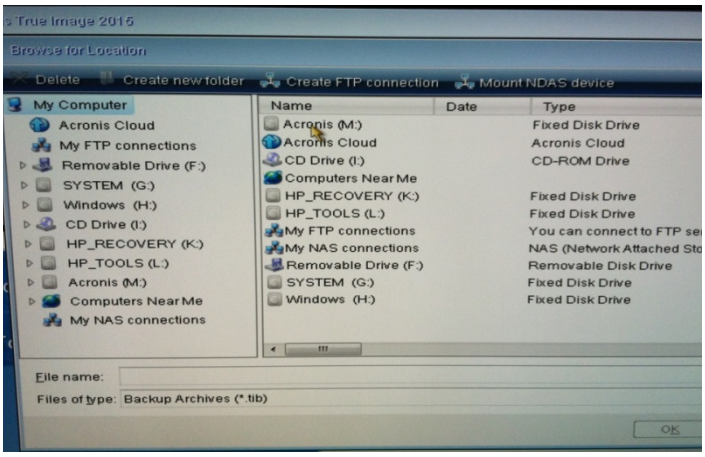
Warning: Do not attempt to open your S onix. If your S onix needs a service, see "Sensofar Care Service and Support" on Chapter 7.

Restoring or reinstalling the main controller

If you have software or hardware problem with your S onix, Acronis provides repair and restore services that may eliminate problems and can even restore your software to its original factory settings.

Do not restore or reinstall the main controller without the support service. Ask your distributor for assistance.

1. Attach the **USB recovery system** device in a USB port.
2. Switch on the main controller (PC).
3. As soon as you see the prompt press number **1**. Then, Acronis software will start.
4. On the **Home** panel, click **Recover**.
5. On the **Data recovery and backup management** panel, select "Browse for backup…" button.
6. Then, select the Acronis partition (fixed disk drive) and click OK.



7. Select the file corresponding to the system that needs to be restored which is identified with its serial number. Then, click OK.
8. Select the file of the system that has to be restored from the list.

9. Then, click on the right button and select the Recover option.

10. When the recovery process is finished, remove the USB dongle and restart the computer.

Hardware configuration

Problem 1 – Hardware configuration not found

Error messages when SensoSCAN is started:

- **Error 1-15. Invalid controller validation**
- **Error 1-13. LED Board invalid port**
- **Error 1-15. Cannot connect camera: device not found**

Cause A – Starting up the system too quickly

Solution A:

1. Follow the steps described at Chapter 3 to shut down (step 6) and start up (step 3)
2. If the problem continues, please go to Solution B.

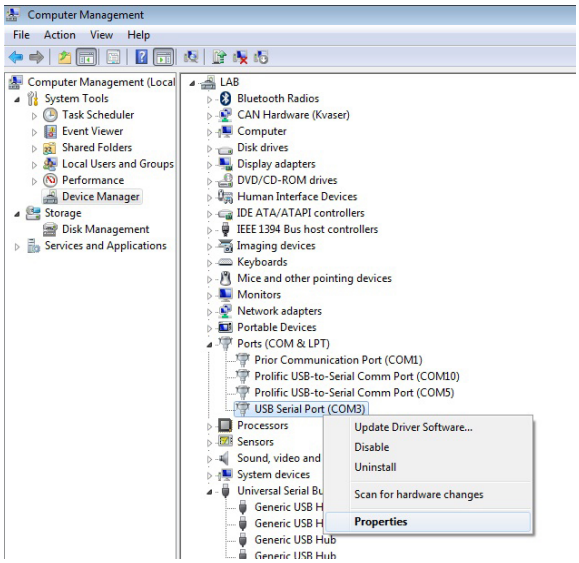
Cause B – Ports need to be configured

Solution B:

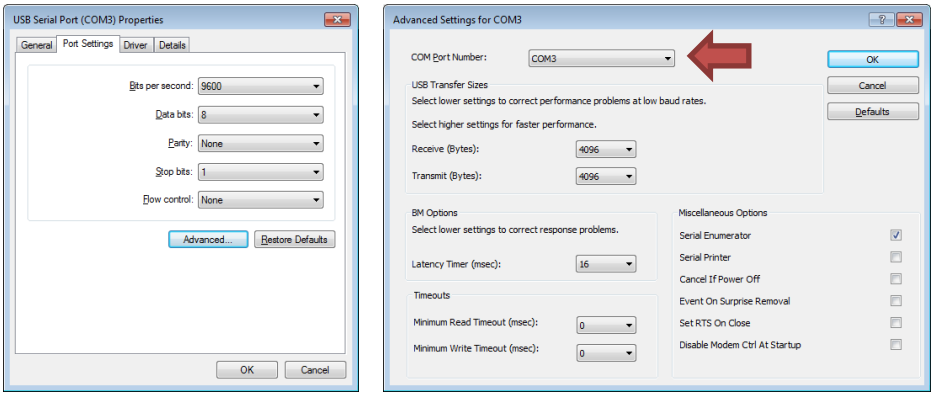
1. Check the ports configuration in device manager panel. The configuration must be as follows:

Hardware device	Ports (COM)
USB serial port (LED board)	COM3

2. Click on the *START* icon and go to *Control Panel* > *System and Security* > *System* > *Device Manager*.
3. If the configuration is not correct, right click on the corresponding port and select *Properties*.



4. In the "Port Settings" tab, select "Advanced…".



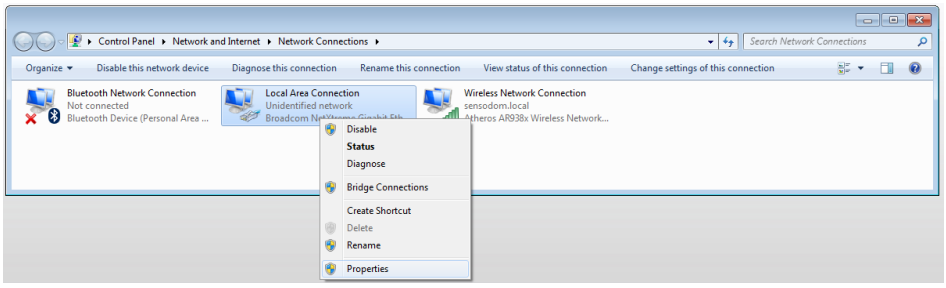
5. Select the correct port number in "COM Port Number" and click on *OK* button.

Problem 2 – How to change the camera's IP address?

Note: The user can change the camera's private IP address, although when SensoSCAN is started more time will be required in order to find the IP address that has been allocated.

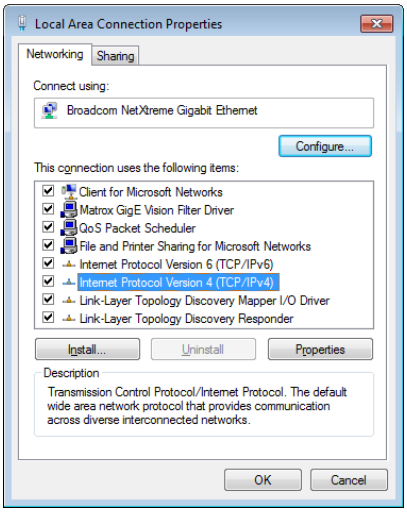
1. Click onto *START* icon and go to *Control Panel* > *Network and Internet* > *Network and Sharing Center* > *Change Adapter Settings*.

2. Right click onto *Local area connection* (device name: Intel® Gigabit CT Desktop) and select *Properties*.



3. In the *Networking* tab, select *Internet Protocol Version 4 (TCP/IPv4)*.

4. With the protocol *Internet Protocol Version 4 (TCP/IPv4)* highlighted, click onto *Properties*.



5. The configuration of the Internet (TCP/IP) must be:
    a. IP address: 169.254.89.190
    b. Subnet mask: 255.255.255.0

CHAPTER 6

Safety & maintenance of your S onix

This Chapter provides important information about safety procedures, routine maintenance, and general considerations for using your S onix.

For your safety and that of your equipment, follow these rules for handling and cleaning your S onix. Keep these instructions handy for reference by you and others.

Warning: The computer is the main controller of the S onix. It has already been optimized for performance, so external software and/or other drivers must not be installed in the system. Any modification to the main controller will automatically void the manufacturer's warranty.

Note: Incorrect storage or use of the S onix must void the manufacturer's warranty.

Important safety information

Warning: Failure to follow these safety instructions could result in fire, electric shock or other injury or damage.

System updates

Do not attempt to update windows. Windows update must be disabled.

Power specifications

- AC line input
- Voltage ranges: 100–240 V alternating current (AC)
- Current: Maximum of 12 A (high voltage range) or 5 A (low voltage range)
- Frequency: 50–60 Hz single phase
- Power: 210 W
- Fuse rating: 4 A
- Fuse model: S501-4-R 5x20 mm

The only way to disconnect the power completely from your S onix is to unplug the power cord from the main and electronic controller power supplies. To disconnect your display completely, you must also unplug its power cable from the power outlet.

Make sure that at least one end of the device's power cord is within easy reach so that you can unplug the computer or display when necessary.

Use a CO_2 fire extinguisher in case of fire.

Do not carry out repairs yourself

Do not attempt to open your S onix. If your S onix needs a service, contact the local distributor or support service. See "Sensofar Care Service and Support" in Chapter 7.

If you open your equipment or install other items, you risk damaging it. Such damage is not covered by the limited warranty on your S onix.

Important handling information

Operating environment

- *Temperature*: 21 ± 2 °C
- *Relative humidity*: 5 to 80%
- *Altitude*: < 2000 m
- *Vibration*: Required for vibration isolation frequencies in the range of 1 to 120 Hz
- *Acoustic noise:* should not exceed 75 dBC

Carrying your S onix

Before you lift or re-position your S onix, shut it down and disconnect all the cables and cords connected to it.

General maintenance

Clean your S onix

If you need to clean your S onix, follow these instructions:

1. Turn off your computer and display.
2. Clean the S onix with a soft cloth dampened with water. Do not use detergent.
3. The lenses should only be cleaned with a blower.

Note: Do not use alcohol, aerosol sprays, solvents or abrasives that might damage the finish on the case.

Clean the reference mirror

If you need to clean the reference mirror, follow these instructions:

1. Place optical paper over the reference mirror.
2. Use one or two drops of acetone.
3. Then, slide the optical paper smoothly taking with it the dust particles on the mirror. Never rub hard, as this can scratch the mirror.

Objective calibration process

A description of the complete calibration process can be found in a separate Chapter. In general, objectives should only be calibrated when they are first mounted.

CHAPTER 7

Warranty

Sensofar care service & support

If you have any problems with the **S onix** you can contact the support service, even if the warranty has expired. Sensofar can supply all **S onix** components. The contact details are shown below.

Sensofar TECH, S. L.
Parc Audiovisual Catalunya
Ctra. BV-1274, KM1
E-08225 Terrassa, Spain
T. +34 93 700 14 92
F. +34 93 786 01 16
support@sensofar.com
www.sensofar.com

You can also contact your local distributor; please check our website for contact details.

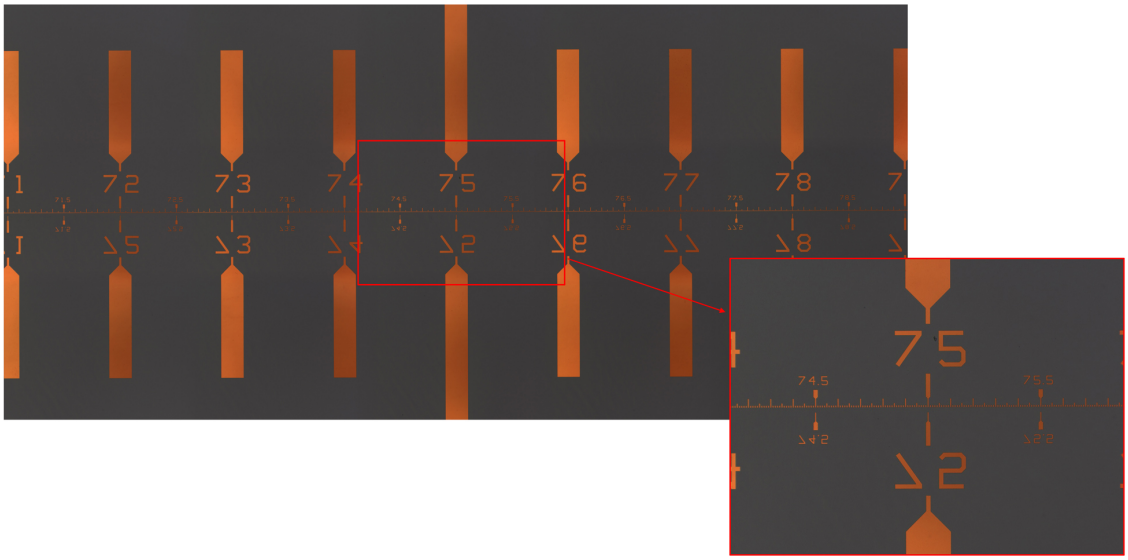
Locating your SN

To locate your SN, open the SensoSCAN software. Click on Help menu > About… The *About* panel will open and your SN and version will be shown.

APPENDIX

Objective magnification calibration

Objective magnification can be calibrated with the use of a calibrated standard rule. A thin step height standard from Ted Pella contains a zone were an equally spaced rule is engraved.



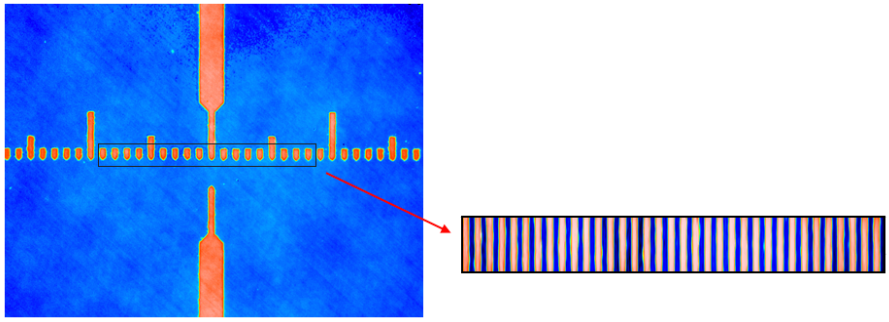
To calibrate the magnification, follow the next steps (in orange there is one example to calibrate a 50X EPI objective):

SensoSCAN

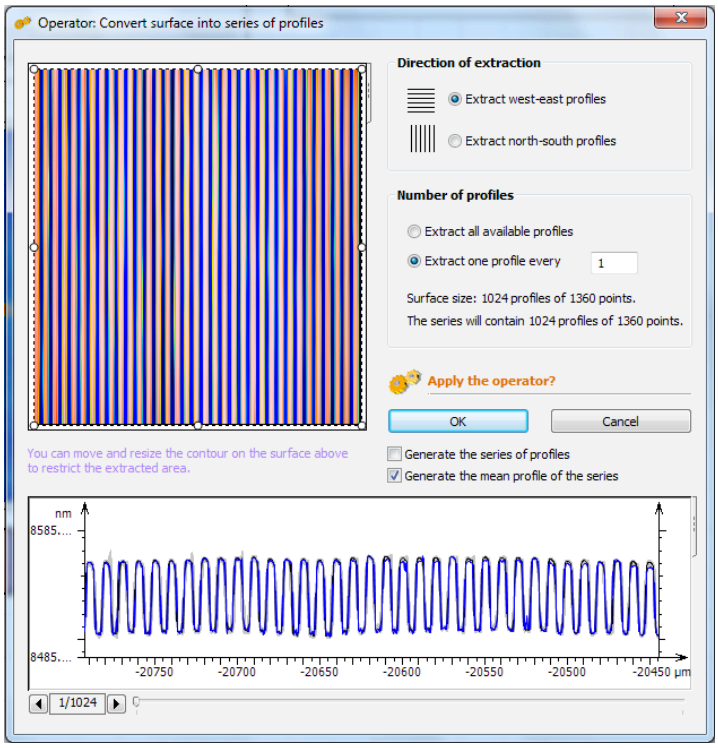
1. Open the Objective Calibration in the calibration screen and type in a value for the magnification of the working objective one whole unit lower. For example, for a 50X EPI, type in a magnification of 49.000000.
2. Measure a single topography with a field-of-view that contains only the ruling. Save this topography.
3. Now open the Objective Calibration and type in a value for the magnification of the working objective one whole unit higher. For example, for a 50X EPI, type in a magnification of 51.000000.
4. Measure a single topography with a field-of-view that contains only the ruling. Save this topography.

SensoMAP

5. Open the first topography in SensoMAP.
6. Use the *Zoom* operator to zoom only the ruled section.

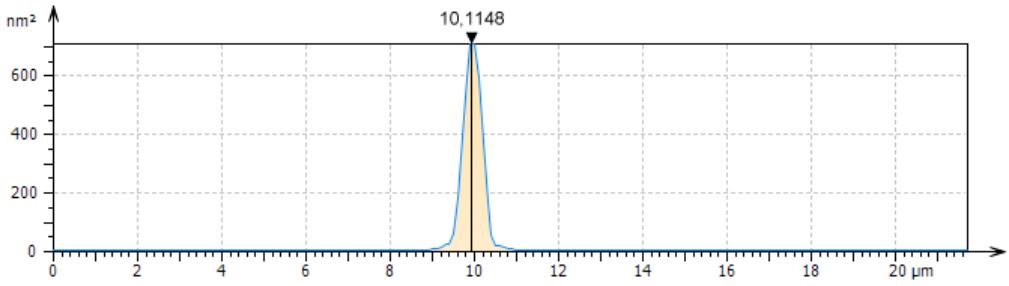


7. Apply the *Convert surfaces into series of profiles* operator. Select the following options:
   a. Extract west-east profiles
   b. Extract one profile every 1
   c. Enable *Generate the mean profile of the series* option
   d. Disable the *Generate the series of profiles* option



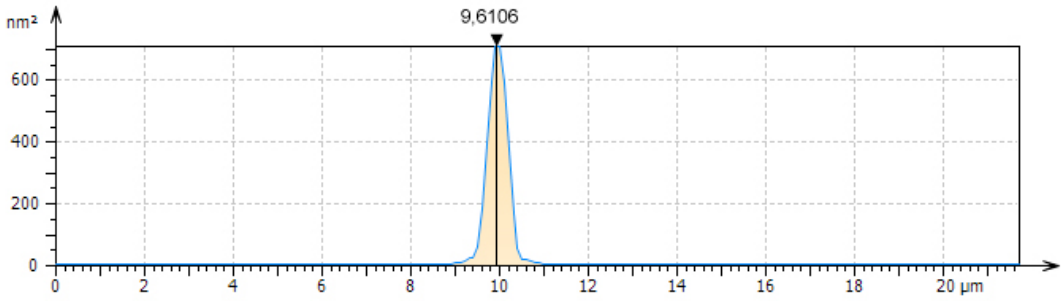
8. Now, to the profile obtained apply the *Average Power spectrum density* study. A graph like the following appears, with several peaks corresponding to the principal frequencies of the ruling. The major frequency is related to the pitch of the ruling.

9. Write the number that appears on the peak close to 10.0 microns. In the example for the first magnification at 49X, the frequency of the rule is 10.1148.



Information	
Zoom factor	x16
Nb iterations	256
Smoothing	5

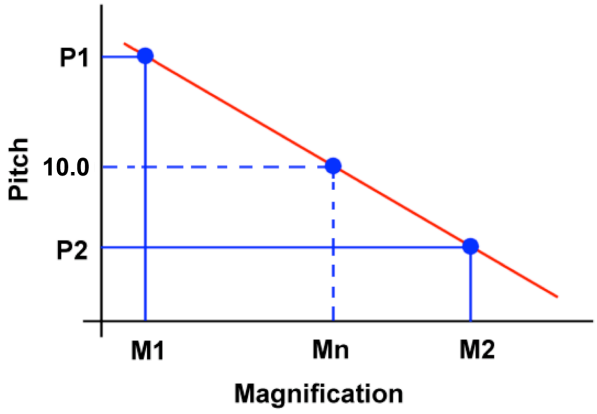
10. Now repeat steps 5 to 9 for the second topography.



Information	
Zoom factor	x16
Nb iterations	256
Smoothing	5

11. In this example, the result for 51X magnification is a frequency of 9.6106.

12. A linear interpolation between these two points leads to a calibration line were the nominal value of the magnification can be retrieved by simply knowing the true value of the pitch.



Calling the variables in the following way:

M1: first magnification
P1: Frequency obtained for the first magnification
M2: Second magnification
P2: Frequency obtained for the second magnification
Pn: Nominal frequency
Mn: Real magnification

The real magnification is retrieved using the following formula:

$$M = \left(\frac{M2 - M1}{P2 - P1} \right) (Pn - P1) + M1$$

SensoSCAN

13. Open the Objective Calibration and enter the value of M.

14. Measure a single topography and check with SensoMAP that the main frequency is 10.0.

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Regulatory Compliance Information

Sensofar-Tech, S.L. declares that the S onix system is in compliance with essential requirements and other relevant provisions of directives EN 61326-1:2006, EN 61010-1:2011.

European Union — Disposal Information

The above symbol means that according to local laws and regulations your product should be disposed of separately from household waste. When this product reaches the end of its life, take it to a collection point designated by the local authorities. Some collection points accept products for free. The separate collection and recycling of your product at the time of disposal will help conserve natural resources and ensure that it is recycled in a manner that protects human health and the environment.

Registration of this Manual, April 2016

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User Manual
S onix & SensoSCAN 6.6

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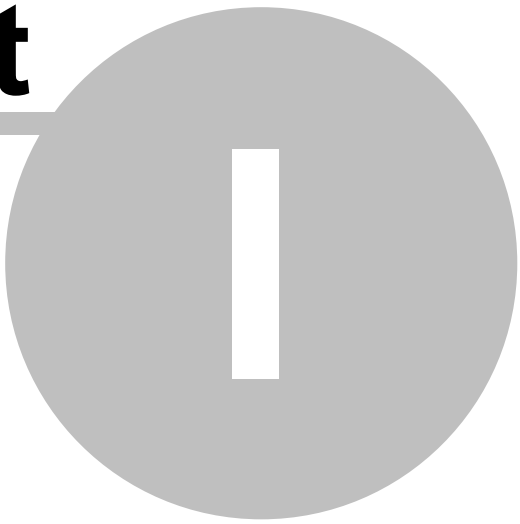


1 Welcome to SensoSCAN 6.6

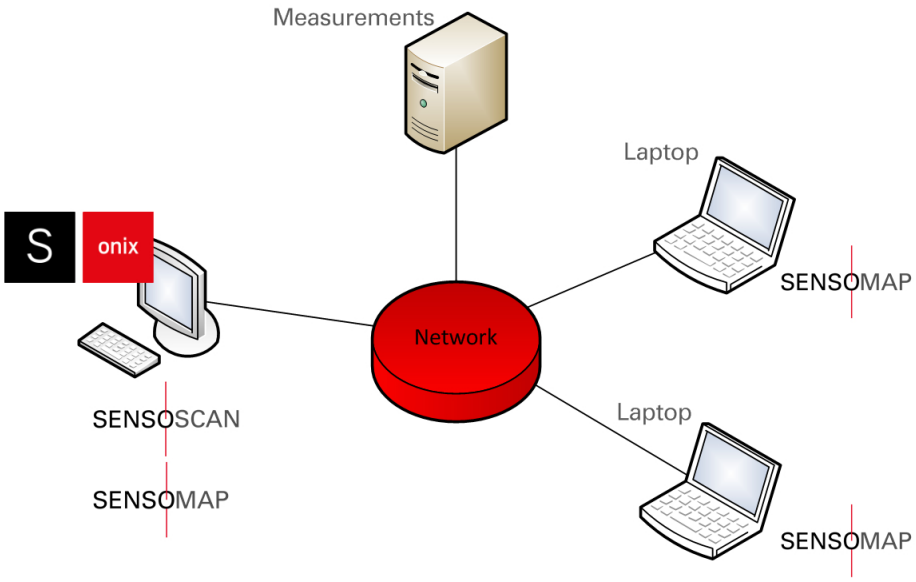
Thank you for acquiring a Sensofar surface metrology sensor

The **S onix** sensor head provides standard microscope imaging, interferometric profiling and high-resolution thin film thickness measurement. To help you familiarize yourself with your **S onix** surface metrology sensor, this User Manual will guide you through the different measurement options, the various analytical options and other features.

The system is controlled by **SensoSCAN**. It provides the interface with which any measurement can be easily taken and includes a basic set of tools for displaying and analyzing the data. It's extremely simple and ergonomic interface enables the user to very rapidly obtain the required measurement.

For more powerful data manipulation, **SensoMAP**, based on Mountains technology and available as an option, is a state-of-the-art surface analysis software. Typical uses for **SensoMAP** include off-line 2D/3D surface characterization in R&D departments and laboratories, and near-line process control in production facilities.

Both **SensoSCAN** and **SensoMAP** applications can be run on the computer serving the **S onix** sensor, or on several computers as illustrated below:



The main advantage of distributing the applications is that existing data can be analyzed while new data is being acquired.

> **Note:** When both applications are run on the same computer, it is very important not to use **SensoMAP** for analysis while the **S neox** system is taking a measurement, as this can reduce the performance.

Lastly, it is possible to run specific commands and events of SensoSCAN remotely using an SDK. If the SDK is part of your system, check the specific documentation for more details.

To learn more about using the system for surface metrology, please visit www.sensofar.com to access application examples and research papers.

1.1 New features SensoSCAN 6.6

- **HDR acquisition for Focus Variation measurements**

With the new HDR acquisition mode it is possible to measure samples containing very bright to extremely shade areas. This is achieved by capturing and then combining several different, narrower range, exposures of the same surface. Otherwise, measurement fails either on bright or dark areas resulting in many non-measured points. It is only available for Focus Variation.

HDR features the best system performance for micromanufacturing (EDM, milling, laser, additive manufacturing, etc.), medtech (dental implants), tooling and forensics markets and applications.

It can be selected in the light source settings.

- **Export to DAT file format automatically using a SMR**

Export Values option in external analysis pane allows the user to export the DAT file automatically when SMR or MMR is used. Optionally, it is possible to define how to define the non-measured points (remove, nan, inf or zero).

- **Import relative XYZ positions from file to an MMR**

Up to now, the SensoSCAN was able to import from the file absolute XYZ positions to an MMR. This new feature allows one to import relative positions with the same file format and just adding the tag [References Relative] or [Measures Relative] depending on if we add references or positions.

- **Export XYZ positions from MMR**

By clicking on the export button, the software generates a *.txt file with the positions introduced in the MMR with the format the SensoSCAN accepts to import XYZ positions.

- **MMR log files contain exportable relative coordinates from MMR**

- **Export data in matrix format available on file menu**

Selecting File / Export data in matrix format from menu Bar exports the measurement result with a matrix format. This format has the values of the X axis in the first row and the values of the Y axis in the first column. The rest of the matrix are the Z values of the surface.

- **Automatic parcentricity correction during objectives calibration (available for motorized XY stages)**

An automatic process is used to correct small XY deviations between objectives in order to ensure that all of them are focused in the same position of the sample (available for motorized XY stages). The user will be guided to follow the process.

- **Save confocal or interferometric images during the scanning**

Save confocal or interferometric images: the system saved the confocal or interferometric images during the scanning. The path where it will be saved must be defined.

- **New export formats: STL & X3P**

Once the system has measured a topography, it is possible to export it from the export menu into new formats:

- STL: File format supported by many types of 3D software & commonly used for prototyping, printing, etc.
- PCL: 3D point cloud data file format
- X3P: File format for surface metrology adopted by academic, industry, and government labs for use in firearm forensics.

- **Customize non-measured points' value for exporting functions**

Non-measured points (NMP) are usually exported by default as QNAN0 value. Now, SensoSCAN allows the user to export to several options: Remove, NAN, INF or ZERO. Click on export settings to configure this function.

- **Select the cut-off values of the ISO filter operator dynamically**

- **Imperial system of units available in general section of System Preferences**

- **Preview PLUX content in MS explorer**

Now it's possible to preview the topography content directly in MS explorer. This is useful when you want to open a measurement. By activating the preview view, in the open dialog the user can select the proper measurement to open and preview the topography with ease.

1.2 Introduction

Overview

SensoSCAN software has three different user interface modes: Inspection & Acquisition, Display & Analysis and Configuration & Alignment.

Inspection & Acquisition

On start-up, the software always initially shows Inspection & Acquisition mode. This mode is used to:

- place the sample in the right position and focus on it using the Central Viewer
- select measurement parameters in preparation for a measurement

This mode can also be used to control the system's motorized stage.

Display & Analysis

Display & Analysis mode is displayed after a new measurement has been acquired, or when a previous measurement has been loaded from file.

In this mode, the results can be observed in two or three dimensions, with different colors, zooms and scales. One can also analyze the measurement, e.g. by removing a surface term to align the measurement (for example, tilt), by applying a filter to obtain roughness and waviness parameters (according to various surface texture standards), or by cropping to the area of interest, etc. etc..

Configuration & Alignment

This mode can be accessed by selecting **Configuration / Calibration** from the Menu Bar.

> **Note:** Configuration & Alignment is only visible/accessible to Administrators of the system.

Configuration & Alignment is used to:

- select software options and hardware components
- align and calibrate the objective.

Calibration & Alignment procedures are carried out using a high-quality flat mirror as a sample.

Using the SensoSCAN 6 interface

It is important to fully familiarize yourself with the interface, the controls and the functionality of the software. Understanding the features available in the **SensoSCAN** software, as well as experience in measurement of comparable materials/structures, are absolutely essential for obtaining accurate and meaningful measurements. To help the user become familiar with the system:

- A Quick Start Guide to acquiring measurements is provided.
- Inspection & Acquisition mode is briefly summarized to provide an overview of the interface.
- Extensive details are provided for Sample Inspection, Acquisition Settings and Display & Analysis.
- Configuration & Alignment routines are described (only visible and available to Administrators of the system).
- Finally, details of System Preferences and all other globally relevant topics can be found in the

Appendix.

If all attempts at mastering the interface fail, you can of course turn to Sales & Support for help.

1.3 Service & Support

Service & Support

If you have any problems with your system, you can contact your local Service & Support center (usually your local Distributor). You are welcome do this even if the warranty on your system has expired.

The contact details for Sensofar HQ in Spain are shown below:

Sensofar-Tech, S.L.
Parc Audiovisual Catalunya
Ctra. BV1274, KM 1
08225 Terrassa, Spain
Tel.: +34 937 001492
Fax: +34 937 860116
support@sensofar.com
www.sensofar.com

An up-to-date list of regional Distributor addresses can be found online. Sensofar and all recognized Distributors can supply all components and spares for the system and carry out any necessary calibrations and repairs.

Updates & Upgrades

When a major new system version is made available, customers with previous versions might be able to update/upgrade at a special rate, depending upon the existing configuration. For more information, please contact your local Distributor.

Note: The license serial number is required to update/upgrade to a new major version.

1.4 Important safety information

Important safety information

The following simple rules are important to successful operation and to ensure long lifetime of your system:

- Keep this User Manual in a safe place, as it contains important safety information and operating instructions. Check for updates if appropriate.
- Make sure the AC power cord of the system is properly earthed.
- In case of fire, try to use a CO_2 fire extinguisher if possible.
- DO NOT use detergent to clean any part of the system. Lenses should be cleaned ONLY with an air blower, while any non-optical surfaces should be cleaned ONLY with a damp cloth.

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Regulatory Compliance Information

Sensofar-Tech, S.L. declares that the system is in compliance with the requirements of the Low Voltage directive 2014/35/EU, the EMC directive 2014/30/EU and the RoHS directive 2011/65/EU and carries the CE marking accordingly.

European Union - Disposal Information

The above symbol means that according to local laws and regulations your product should be disposed of separately from household waste. When this product reaches the end of its life, take it to a collection point designated by the local authorities. Some collection points accept products for free. The separate collection and recycling of your product at the time of disposal will help conserve natural resources and ensure that it is recycled in a manner that protects human health and the environment.

Registration or Update of this Manual: January 2018

Part II

2 Quick Start Guide

Introduction

Understanding of the features available in the **SensoSCAN** software, as well as experience in measurement of comparable materials/structures, are absolutely essential for obtaining accurate and meaningful measurements. It is strongly recommended that the user fully familiarizes him- or herself with the system before trying to acquire reliable results. Thus, Inspection & Acquisition, Sample Inspection, Acquisition Settings and Display & Analysis should all be considered essential reading.

3D Auto feature

3D Auto is an automated measurement mode for the Interferometry (VSI) technique that is available for measurements in Basic Mode. When selected, the user must simply place the sample correctly and then manually focus (see below). By clicking *Acquire*, **SensoSCAN** automatically determines the appropriate measurement parameters using a pre-defined initialization routine and subsequently acquires a measurement over a single FOV. More detail on the 3D Auto measurement can be found in Acquisition Settings.

> **Note:** 3D Auto can be used routinely for straightforward (but not mirror-like) surfaces to obtain highly qualitative measurement results. Unknown, and more complicated and structured surfaces are best measured manually by an experienced technician.

Quick start guide to manual measurement

The following very briefly outlines the steps needed for taking a measurement manually.

Focusing on the sample

Start the software - when ready, it will automatically display Inspection & Acquisition mode.

> **Note:** If the objective has not yet calibrated, it will be highlighted with a red circle (see Objective Calibration).

Before calibrating any objective, and also if very precise measurements are to be acquired, a warm-up time of roughly ten minutes is recommended.

Position the sample. In general, interference fringes appear in a very narrow plane centered on the position of the sample. that is best in focus

If the sample is rough, it is relatively straightforward to simply focus on the sample itself. For very smooth samples, an iris is seen when the sample is out of focus - this is the reflection of the interferometry objective on the reference mirror and its focus does not change with the position of the sample. When the sample is almost focused, a second iris reflection appears. This second reflection will coincide with the first one when the sample is properly positioned at the focus of the objective.

When the sample is in focus, the light intensity must be adjusted. If some of the pixels are saturated due to excessive light intensity, the software shows these regions in red. For flat samples, increase the intensity to just below saturation. For rough, tilted or structured samples, check for saturation at different focus positions and set the light intensity appropriately.

Acquisition parameters

There are various parameters in Inspection & Acquisition mode that must be selected before a measurement can be made. They include: the Measurement type, correctly setting the Z-Scan parameters, Autofocus and any required light options, choosing a Threshold value, and any External Analysis options. If you have a three dimensional structure, you can inspect it either by acquiring an image or by measuring the 3D topography. Alternatively, if you have a thin or thick layer or coating on a substrate, you can measure the layer with the thickness option.

Setting Z-Scan

Once the sample has been focused and the measurement parameters selected, it is important to ensure that the range for the Z-Scan (vertical) displacement is appropriate. If the range is too large, the measurement will take a long time. If the range is too small, some zones in the measurement will have no interferometric information (i.e. the measurement will exhibit non-measured points).

To avoid problems with the Z-Scan range setting, the software checks that the selected absolute values are within a certain interval that varies according to the objective and the kind of measurement selected. For example, if the upper value could cause a collision with the objective, the software will automatically reduce the setting to the maximum value of the allowed interval for that objective. In contrast, if the setting is too low, it will be increased automatically to the minimum value of the allowed interval, to ensure that there is enough information when the sample is swept through the focus.

Any value within the allowed interval is acceptable to the system. Nonetheless, the Z-Scan range setting should ideally be as close as possible to the optimum value for each measurement. This optimum value can be estimated by simply moving the sample along the Z-axis:

- move the stage down until the interferometric fringes are not in focus for any part of the sample
- note the Z position (or click the *Define Reference* icon to set this as *zero*)
- now move the stage up beyond the ideal focus until the pattern is again not focused for any part of the sample
- note the new Z position and measure the difference between the two Z positions
- increase this value by roughly 20% and use the result in the Z-Scan edit pane

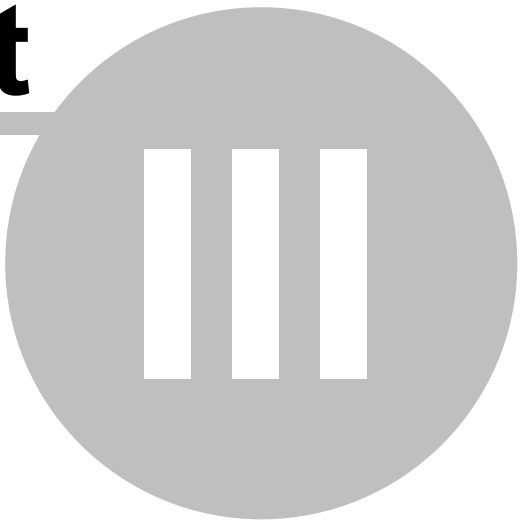
As stated earlier, if the range is too small, there will be no optical information for some zones in the measurement, and the results will exhibit non-measured points at the upper and/or lower extremes of the measurement. If this is the case, check that both the direction and the starting point of the Z-Scan are correct. If they are not, increase the Z-Scan range value.

Acquisition

When all settings and options have been selected, click *Acquire* to perform the measurement - if you have not already done so, you will be asked to provide a Sample ID (if the user enables "Use Sample ID" and "Confirm ID before acquisition" in system preferences.

When the acquisition is complete, the interface will automatically change to Display & Analysis mode.

Part

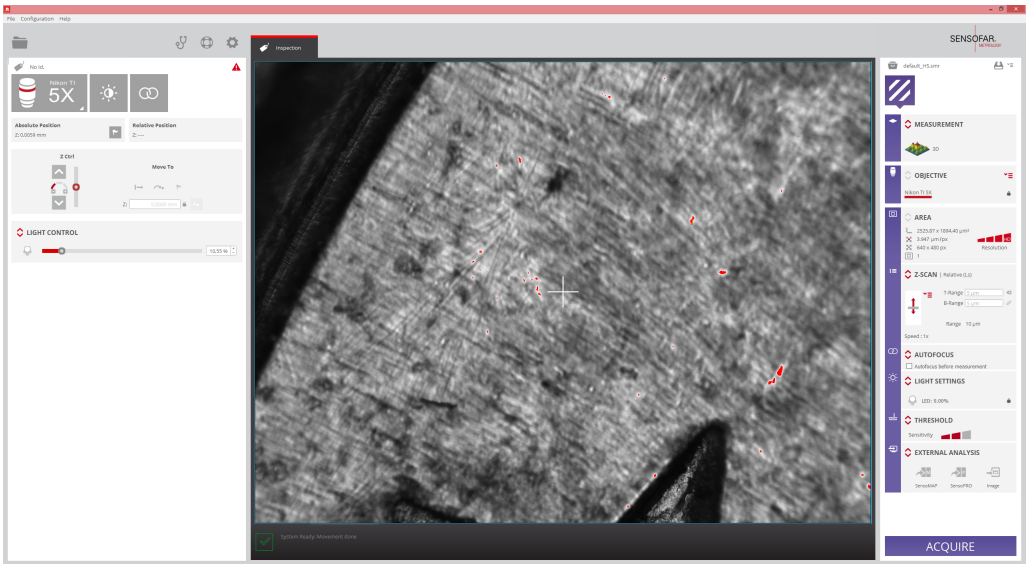


3 Inspection & Acquisition

Introduction

This Chapter provides **a very brief overview** of the Inspection & Acquisition mode, so that the user can begin to familiarize him- or herself with the interface layout.

Inspection & Acquisition mode itself comprises three principal interaction areas: settings for Sample Inspection on the left, the Central Viewer area, and Acquisition Settings to the right.



SensoSCAN interface overview when in Inspection & Acquisition mode

Detailed descriptions for the function and the use of all individual controls, can be found in Sample Inspection and Acquisition Settings.

3.1 Quick Bar tools

Overview

This section describes the functionality provided by the traditional OS Menu Bar and the various icons visible in **SensoSCAN 6**'s Quick Bar when in Inspection & Acquisition mode.

Quick Bar view in Inspection & Acquisition mode

Note: While some of the functionality described here does remain accessible from the traditional Operating System Menu Bar, most features are now more easily available via **SensoSCAN 6**'s Quick Bar. In the following, the functionality accessible from the Quick Bar will be described - functionality (also) available from the traditional Operating System Menu Bar is indicated in **green**.

The Quick Bar icons

This icon opens the **File / Open** dialog of the OS, allowing a previous measurement to be loaded from file. Note that **SensoSCAN 6** saves all measurements as **.plux* files. This file format contains the raw measurement together with a list of any Data Analysis options available within **SensoSCAN 6** that were applied to that measurement. See Appendix for further information relating to the **SensoSCAN** file formats.

The Menu Bar options **File / Import / Import plu** and **File / Import / Import coordinates** (not available in the Quick Bar) both relate to the import of data for Display & Analysis tasks - please refer to the appropriate section.

This icon (also **Help / Diagnostics)** opens a diagnostics menu path that provides access to technical log files. These log files are not normally relevant for everyday measurement tasks.

This information can, however, be very useful when troubleshooting problems with the system, for example in order to remotely reproduce or understand customer issues. In this case, all or specific log files may be requested by a technician or by Service & Support for diagnostic analysis.

At the bottom of the diagnostics pane opened with the icon, there are two options for securing a system back-up for diagnostic purposes:

- *Generate backup zip*: Creates a zip with all the configuration, calibration, logs, etc. files used

by the system.

- *Generate report zip*: Same as *Generate backup zip* but does not copy large files.

More information regarding diagnostics can be found in the Errors & Diagnostics.

This icon achieves the same as selecting **Help / Contents** from the Menu Bar. Both actions open this User Manual.

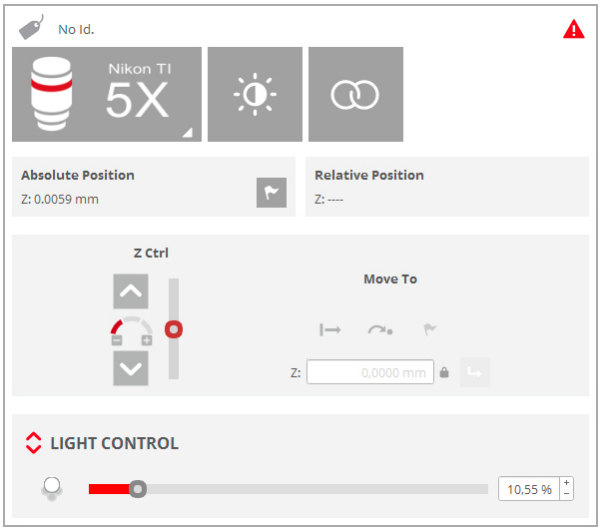
Selecting **Help / About** from the Menu Bar (not available from the Quick Bar) opens a system window showing the following information: the program version, the serial number of the system, the company and the user.

This icon (also **Calibration / System Preferences**) provides access to System Preferences and to User Profiles.

3.2 Sample Inspection

Overview

In this area on the left of the Inspection & Acquisition interface, settings are made for the initial sample inspection. Some of these settings are also carried over to their counterparts in Acquisition Settings, i.e. some are also valid for the acquisition process.



Overview of the settings available for Sample Inspection

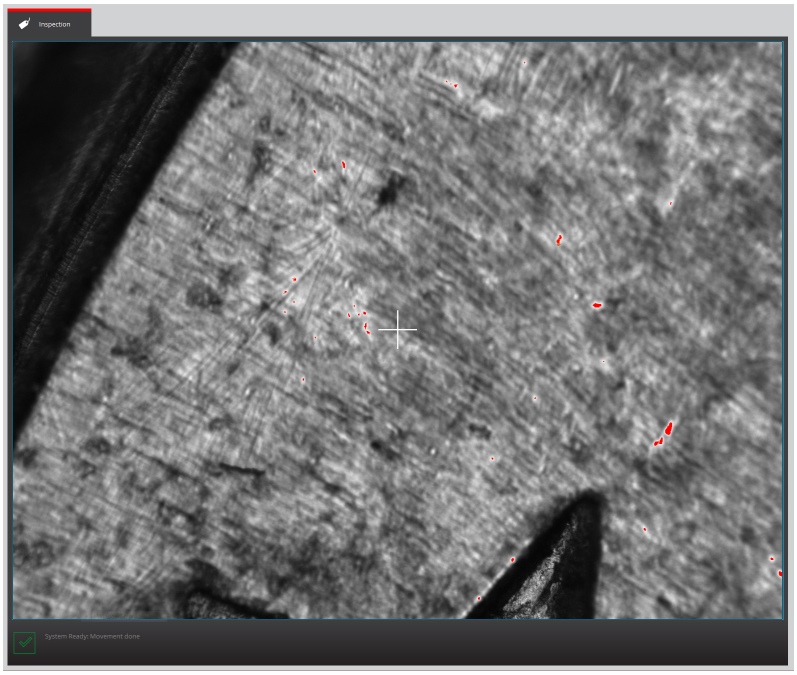
The parameter options available here include:

- providing a Sample ID (see Sample Inspection and further details for use in System Preferences)
- automatically set the sample illumination (see Autolight & Autofocus)
- automatically set the best focus (see Autolight & Autofocus)
- absolute and relative Z-stage position (see Position & Motor control)
- manually control the motorized Z-stage (see Position & Motor control)
- manually control level of illumination (see Light Control)

3.3 Central Viewer

Overview

When in Inspection & Acquisition mode, the Central Viewer shows the visible field-of-view (FOV) of the objective.



The Central Viewer pane shows the visible FOV

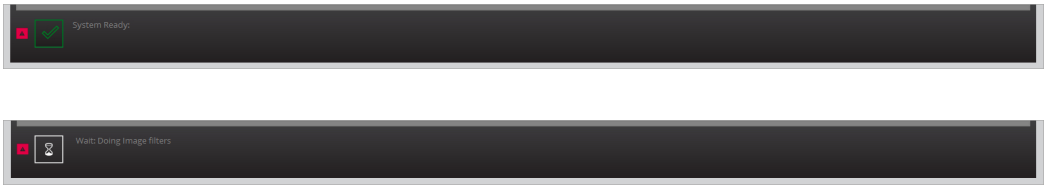
Live Image via SDK

When the system is operated via the SDK, the live image visible on the Central Viewer can be sent from the Core application to an external application over a TCP/IP connection. Details of how to set up the connection correctly are given in the SDK User Manual.

3.4 System Status toolbar

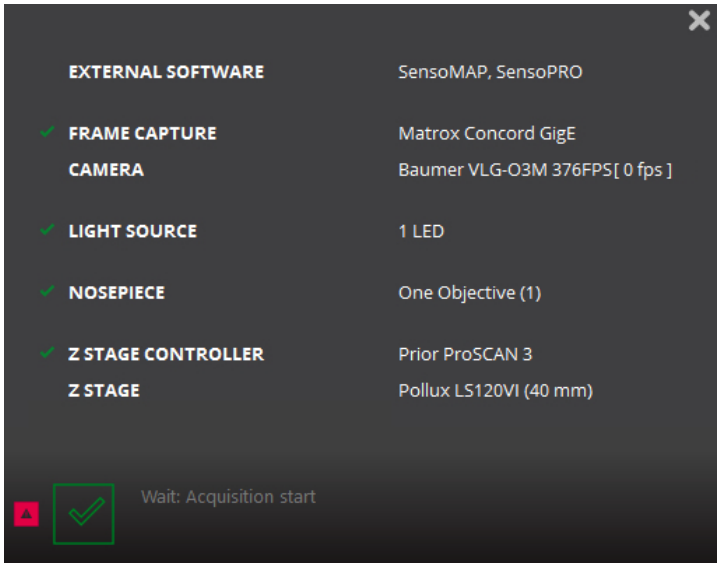
System status & information

A bar below the Central Viewer shows the status of the system and information about the procedure that is currently running.



System status bar

The larger symbol shows a large green tick when a device has performed a function and is ready to perform the next function, a large red cross when a device is not correctly initiated, as well as other symbols (depending on the activity). Clicking the little system status symbol to the left reveals detailed information about the system, the configuration and any errors and warnings:

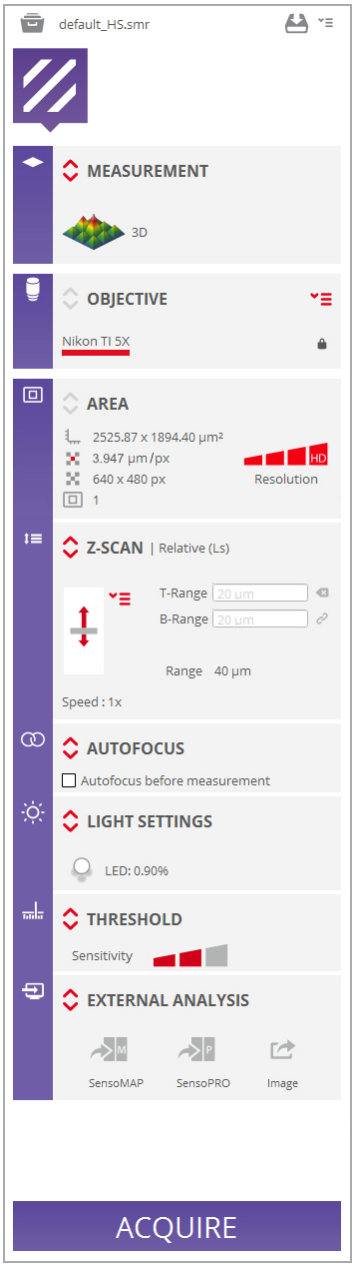


For example, one possible warning is *A full Z stage movement is required* - i.e. the Z stage needs to move through its entire range at least once a year for maintenance purposes, and this warning is shown if this movement has not been performed. Refer to Configuration & Alignment for more information.

3.5 Acquisition Settings

Setting measurement parameters

This area to the right of the Inspection & Acquisition interface lists some parameters determined by settings made in Sample Inspection, or other measurement parameters appropriate to the Measurement type, as well as additional measurement options.



The parameter options available here include:

- the Measurement technique desired
- choice of objective (if different from that chosen in Sample Inspection, i.e. if unlocked)
- the measurement area and resolution options
- the vertical scan parameters
- whether, and what type of Autofocus should be performed ahead of a measurement

- Light Settings (if different from that chosen in Sample Inspection, i.e. if unlocked)
- the Threshold, and
- External Analysis options (if required)

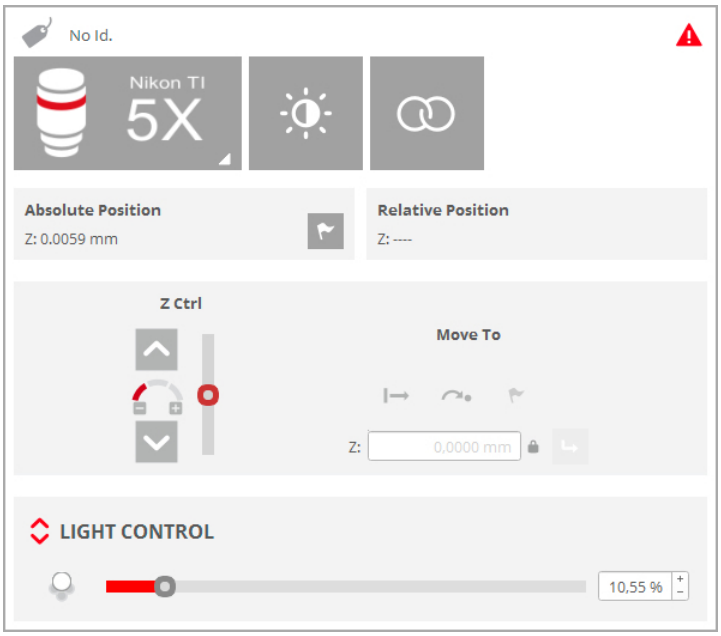
Once these settings have been made, clicking *Acquire* will trigger the measurement process. Upon completion of a successful measurement, the interface will automatically change to the Display & Analysis mode.

Part IV

4 Sample Inspection

Introduction

Before performing a measurement on a sample, it is necessary to locate the regions of interest on the sample. This is achieved using lighting and focusing controls in order to obtain the best initial sample view.



The Sample Inspection pane

The function and purpose of the tools available in the Sample Inspection pane are detailed in the following sections.

Sample ID

An important aspect for traceability for many applications is the ability to give samples a specific Sample ID. This is possible in **SensoSCAN** by activating the option in System Preferences. Discussion of how to handle naming strategies, either for individual samples or for multiple acquisitions/samples via an MMR, is discussed there also.

4.1 Objective Selection

Overview

The Objective Selection pane shows which objective is mounted on the nosepiece:

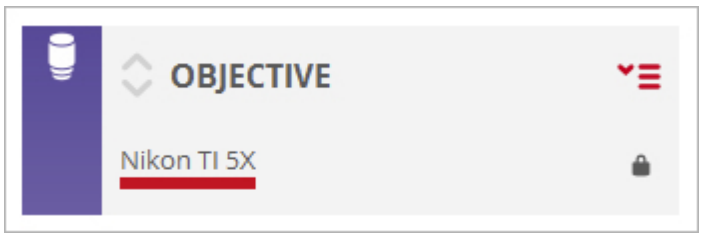
Drop-down menu for Objective Selection

The sensor can be equipped as standard with a variety of interferometry objectives. If an objective is installed but has not yet been calibrated, this will be indicted with a .

Linking to Objective Selection in Acquisition Settings

By default, the objective shown in Acquisition Settings is the same as that in Sample Inspection. The reverse is also true - changing the objective chosen under Acquisition Settings forces the same change under Sample Inspection. The objective selection is thus mirrored throughout the system.

This behavior can be disabled in System Preferences. When disabled, a padlock icon appears in the Objective Selection pane under Acquisition Settings:



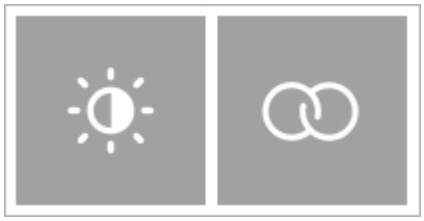
By clicking on the icon and thus opening the lock, the selection of a different objective in Acquisition Settings is enabled.

More information on the choice of objectives can be found in Objective Selection in Acquisition Settings.

4.2 Autolight & Autofocus

Overview

The Autolight and Autofocus commands are two automated routines available in Sample Inspection:



The Autolight (left) and Autofocus commands in Sample Inspection

Autolight

The Autolight command is used to automatically set the ideal light intensity for the surface in focus. The light intensity illuminating the surface is automatically set so that no more than 5% of the camera pixels are saturated (saturated pixels are shown in red).

While this function may be adequate for most surfaces, other surfaces or samples may need to have the light manually adjusted. For example, when the surface is tilted, only a small portion of the surface is in focus and Autolight can set too much light. By contrast, some samples with high reflective regions or spots can require more light than that set by the Autolight function.

Further options for controlling the brightness of the installed LED can be found in Light Control. The Light Control pane can be used to manually set the light level at any time.

Autofocus

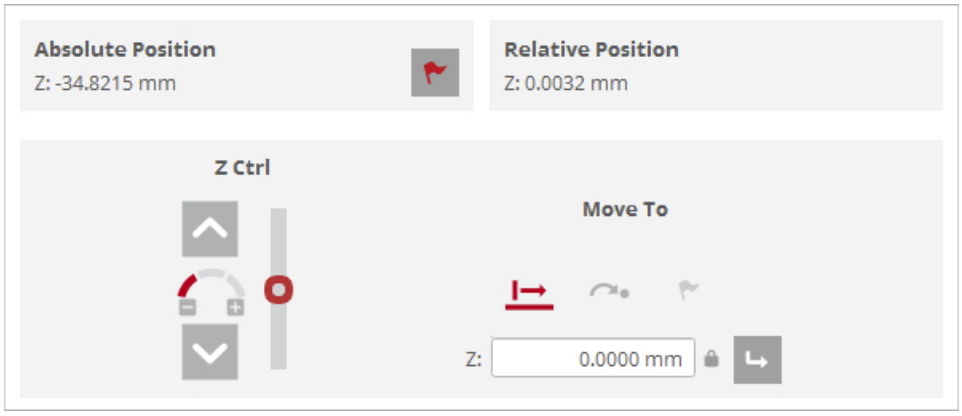
The Autofocus command triggers a routine used by the system to fine focus the sample, in order to optimize the initial Z-position for measurement. By clicking the Autofocus button, a *small* and/or *large* Autofocus routine is performed (options for whether *small* and/or *large* are used in this routine are found in System Preferences).

The focus can be manually adjusted at any time using the motor controls.

More information about the use of the Autofocus function elsewhere in the system, including advanced settings, can be found in the Autofocus section of Acquisition Settings.

4.3 Position & Motor control

Overview



Position & Motor Control panes in Inspection Settings

Position

The absolute and relative coordinates are displayed on the panes *Absolute Position* and *Relative Position*, respectively:

- *Absolute Position* is relative to the zero (center) position of the motorized axis.
- *Relative Position* is relative to an user-defined reference point that can be set (and repeatedly reset) by clicking the *Define Reference* icon for any available locations (see below). Resetting *Relative Position* calls up a dialog with three possible options - *Overwrite reference with current position*, *Delete reference*, and *Cancel*.

Motor control

Movement and positioning of the Z-Scan stage can be controlled via **SensoSCAN** using the software motor control pane.

Relative movement from the current position, movement to an absolute position, or relocation to the reference point can be readily achieved by choosing the appropriate icon , respectively, then entering the desired Z movement or absolute coordinates as needed, and finally confirming the command by clicking .

Movement range Z

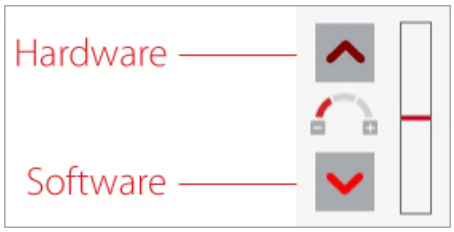
The Z movement is limited to the travel limits of the system. Note that there is also a variable safety limit determined in the software that is linked to the working distance of the selected objective.

> **Warning:** If the objective indicated in **SensoSCAN** is not the same as the actual objective in the profiler, the software may allow a large Z-Scan value that could cause the objective to crash into the sample.

The Z-Scan range also has software and hardware limit controllers. To acquire data or to be able to move along the Z axis, the system has to be within the Z software limits as defined in the *configuration file StageZ.xml*.

Movement beyond software/hardware limits

When the Z position is beyond hardware or software limits, this status is indicated interactively in the software motor control graphics:

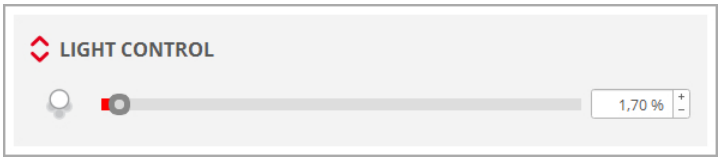


In this situation, the user cannot acquire data and no movement is allowed except when using the motor control pane to return within the limits.

4.4 Light Control

Overview

The Light Control pane is used to adjust the light on the sample.



Light Control in Inspection Settings

The single LED icon shows the color of the currently active LED source LED (for the **S onix** white only), whose intensity can be changed using the slider control, and/or the input field to the right.

Note that too much light incident on the digital camera is indicated by red pixels in Central Viewer. Nominally, a level of 5% over-saturated pixels is tolerated by the system, and this is the level targeted by the Autolight function.

Single LED source

The light intensity of the LED is controlled by a 16-bit microcontroller PWM signal. The ideal light intensity for the image camera can be set automatically by choosing Autolight. Alternatively, the light intensity can be changed manually by moving the slide bar or simply changing the value on the right of the pane. The light intensity is scaled from 0% (lowest intensity) to 100% (highest intensity).

> **Note:** The active LED is automatically switched off when **SensoSCAN** switches to Display & Analysis mode.

Linking to Acquisition Settings

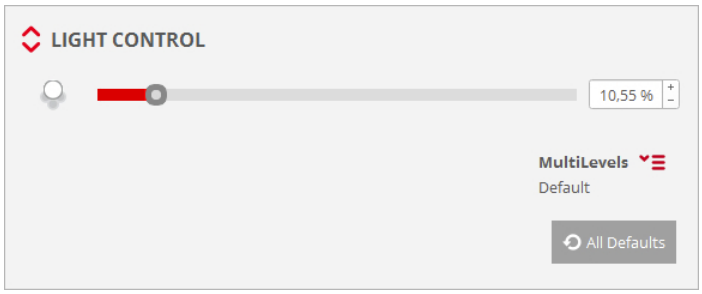
By default, the illumination settings chosen in Light Control are forced (or mirrored) over to Light Settings in Acquisition Settings. There is no provision for changing the illumination in the Light Settings pane, thus the illumination options made in Light Control are valid throughout the system.

This behavior can be disabled in System Preferences. When disabled, a padlock icon appears in the Light Settings pane in Acquisition Settings:

- By clicking on the icon and thus opening the lock, it is now possible to change the illumination settings under Light Control without changing those in Light Settings.
- By closing the lock, the illumination settings chosen in Light Control are again forced over to those visible in Light Settings.

Advanced settings

By clicking the drop-down arrows , the Light Control pane extends to reveal advanced options:



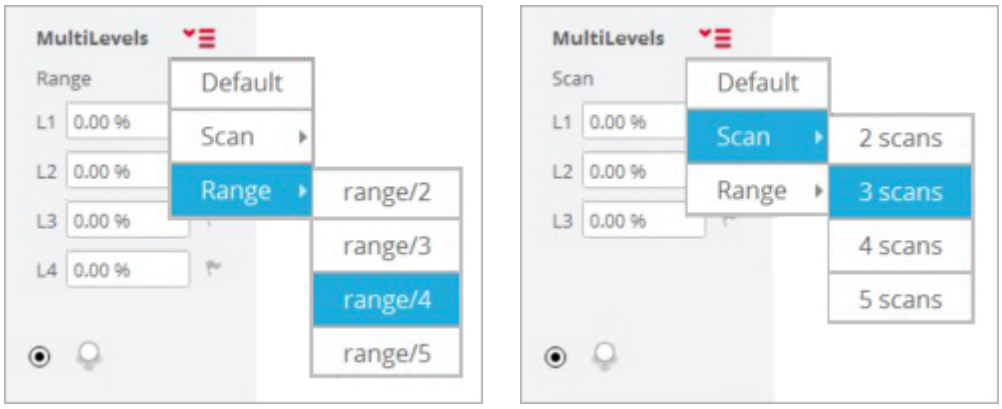
Advanced Light Control settings

MultiLevels

MultiLevels implements multiple light intensities in the same measurement.

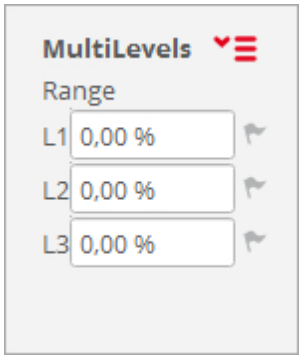
> **Note:** It is best to change the level of light at a Z position for which none of the sample is in focus. If part of the sample is in focus, erroneous results will be obtained for these points.

The different options are accessed by clicking the red drop-down menu :



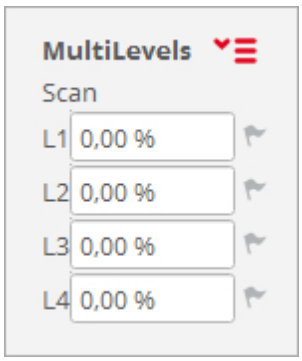
There are 3 basic approaches:

- *Range*: This divides the scan into ranges (up to 5), where individual light intensities can be set for each range. This option is useful, for example, for step-like structures, in which the top and bottom materials have very different reflectivity, or for narrow and deep holes and trenches, in which the amount of light reflected from the deepest region of the sample is too low.



- *Scan*: This iteratively repeats the scan for up to 5 different light intensities. In analogy with HDR

for photography, a composite high-contrast image with minimum omitted data points is created from the best sections of up to 5 separate scans.



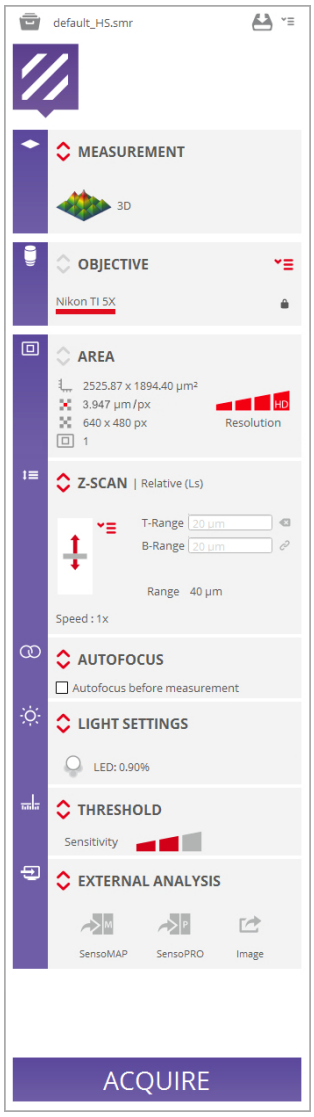
- *Default*: no change in light intensity (effectively *n*=1 for *Range* or *Scan*).

Part V

5 Acquisition Settings

Introduction

The Acquisition Settings interface is used to set the Measurement type and appropriate parameters for a measurement. The required overall configuration depends on the nature of the surface to be measured (smooth, rough, structured) and the application for which a measurement needs to be made.



The Acquisition Settings interface.

As will have become obvious in the previous Chapters, and so too in the next sections of this Chapter, some of the parameters required for a measurement are determined by options set in Sample Inspection. Other parameter settings, as discussed in the following sections, are made in Acquisition Settings.

The External Analysis pane is used to direct data acquired by the system to external software (**SensoMAP** and **SensoPRO)** or to Export Image.

Recipes are an important tool for repetitive data acquisition cycles. Recipes allow the user to save and

reload predefined parameter sets that typically apply to a given application (Single Measurement Recipe, SMR) and/or that are used to automate complicated measurement processes involving many separate SMRs (Multiple Measurement Recipe, MMR).

When all settings and options have been selected, click *Acquire* to perform the measurement - if you have not already done so, you will be asked to provide a Sample ID (if the user enables "Use Sample ID" and "Confirm ID before acquisition" in system preferences.

When all settings and options have been selected, click *Acquire* to perform the measurement. When complete, the interface will automatically change to Display & Analysis mode.

5.1 Measurement technique

Overview

The **S onix** sensor makes exclusive use of an interferometric Measurement technique. Interferometry has the highest vertical resolution of any optical technique. The white-light vertical scanning interferometry (VSI) utilized in the **S onix** sensor is best used to measure smooth to moderately rough, discontinuous and varying surfaces. VSI provides nanometer vertical resolution for all NAs, so that the VSI algorithms enable the sensor to use all the available magnifications to profile shape features with the same height resolution.

5.2 Measurement type

Overview

Basic Set standard Measurement types for Interferometry

When switching between Measurement types, the hardware and **SensoSCAN 6** parameter options are automatically trimmed to those permissible for the selected measurement configuration. Some of these changes occur 'under the hood' and are not user-configurable. Others are readily visible as changes in the interface, such as changing drop-down dialogs and 'disappearing' options in the interface.

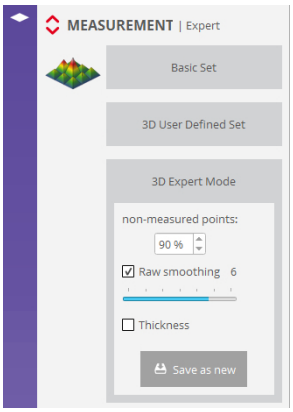
All of these points (and others) are largely associated with differences between, or physics-based restrictions of the permissible Measurement type. Despite the configuration changes performed by the system, note that there are still some instances where the user may still be able to configure measurements for which the results will be subject to error.

Accessing Measurement types

To access the different Measurement types, click the red up/down arrows on the upper left of the Measurement pane. The standard Measurement types are visible in the Basic Set pane (see figure above).

There are effectively only two different Measurement types - measurements on surfaces and measurements of thickness. These will be discussed in the following sections in association with use of the Basic Set of Measurement types.

In addition to the basic set of Measurement types, an 3D Expert Mode is available. In this mode, the user has access to settings for measurement algorithms and other options. By enabling individual selection of these options, the expert user can create new user-defined Measurement types specific to particular applications. When saved, these so-called *Applications* are listed under 3D User Defined Set.



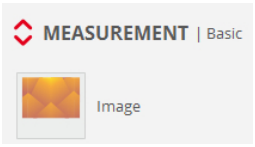
3D Expert Mode

5.2.1 Basic Mode

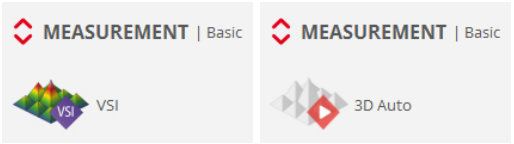
Overview

The basic suite of Measurement types include:

- image capture:



- 3D surface measurement:



- thickness measurement:

For each of the basic Measurement types, the optimal system configuration and choice of algorithm is pre-determined.

If more control and flexibility is needed for any one application, the user can switch to 3D Expert Mode and configure application-specific Measurement types (so-called *Applications*) themselves.

5.2.1.1 Surfaces

Overview

Surface Measurement types are used to acquire images or a 3D topography measurement from a sample. In most cases the surface is defined by an air-sample interface.

3D Auto feature

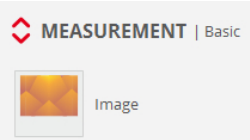
3D Auto is an automated measurement mode that is available for measurements in Basic Mode. When selected, the user must simply place the sample correctly and then manually focus. By clicking *Acquire*, **SensoSCAN** automatically determines the appropriate measurement parameters using a pre-defined initialization routine and subsequently acquires a measurement over a single FOV.

More detail on the 3D Auto measurement can be found in Surfaces / 3D.

5.2.1.1.1 Image

Overview

Images

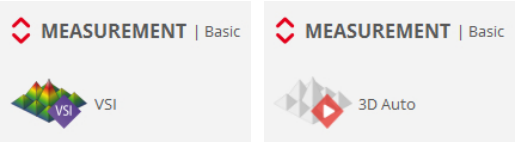


An image can be captured directly from the camera using an interferometric objective. For single LED systems, as is the case for the **S onix** sensor, this image is in B/W.

To acquire an image, simply click on the *Acquire* button. **SensoSCAN** shows the result in Display & Analysis mode.

5.2.1.1.2 3D

Overview



A 3D topography measurement acquires the current FOV of the objective. Information regarding the specific interferometry algorithm used can be found in Measurement algorithms.

Single 3D topography measurement

To measure a single 3D topography measurement, place the sample under the objective, focus and optimize the illumination. Then set the Z-Scan range and the Threshold and click on the *Acquire* button.

For a given Z-Scan range, **SensoSCAN** automatically calculates the number of planes to be acquired and the required Z-Scan movement, in accordance with the Measurement type. It then drives Z-Scan to obtain an interferometric image in each acquisition plane.

Note: As each image requires a large amount of RAM, the number of planes that can be acquired is limited by the selected Resolution and the Z-Scan range (maximum number of planes in memory 1000 at Resolution 1).

Technology	Objective	Z-Scan
VSI	-	206 µm

Once all of the optical information has been acquired, the software calculates the metrological data and switches to Display & Analysis mode to show the result.

There are two ways to prematurely stop the measurement:

Option	STOP function
Esc	Cancel the measurement and lose the data. The software shows an Acquisition Error message.
Space	Stop the measurement after acquiring 50 images and go to Data & Analysis.

3D Auto

3D Auto is an automated acquisition mode that has primarily been designed i). as a quick route to presentable data for the inexperienced, and ii). to provide a quick snapshot of a sample, for example for demonstration purposes. While 3D Auto can be routinely used to obtain highly qualitative results, it has not been designed as a replacement for the experienced user who is responsible for generating highly qualified measurements.

Note: As its name implies, this Measurement type is for 3D surfaces - 3D Auto can be used to measure areal topographies, but it can not be used for surface thickness.

When selected, the user must simply place the sample correctly and then manually search for and optimize the focus. By clicking *Acquire,* **SensoSCAN** firstly implements a pre-defined initialization routine to automatically determine the appropriate measurement parameters. If this routine is successful, **SensoSCAN** subsequently acquires a measurement, and subsequently shows a successful acquisition in Display & Analysis mode, where it can be examined and analyzed as normal.

Note: If the initialization routine fails to determine adequate parameters for a measurement, a warning is shown. No acquisition is made.

3D Auto options

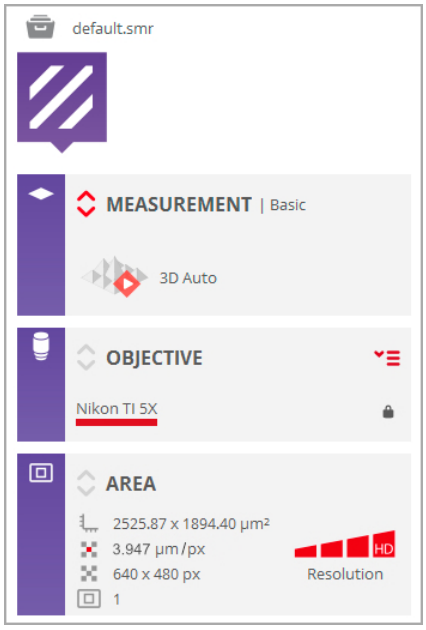
When selecting 3D Auto, the Inspection & Acquisition UI is automatically changed (reduced) to reflect this automated mode - there are no options available to the user other than the installed objective. More exactly:

- the resolution in the Area pane defaults to *HD* and is not user-selectable

- the type of Z-Scan is not user-selectable
- there are no Autofocus options available to the user
- there no advanced lighting options available to the user
- the Threshold options are not user-selectable
- and finally, 3D Auto cannot be used within a Recipe

Note: The nature of the 3D Auto initialization routine means that it's ability to successfully acquire measurements on 'mirror-like' samples is not guaranteed. For such samples, the user should instead take a measurement manually.

Warning: If a surface is not compatible with any of the restrictions listed above (e.g. special illumination required), then it is best measured manually using the other Measurement types available in Basic Mode, or by using a pre-configured *Application* for that particular type of structure (see 3D Expert Mode).

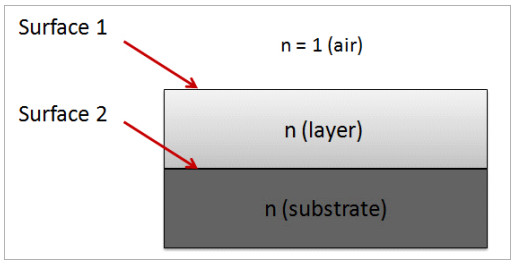


The reduced interface in Acquisition Settings when *3D Auto* has been selected

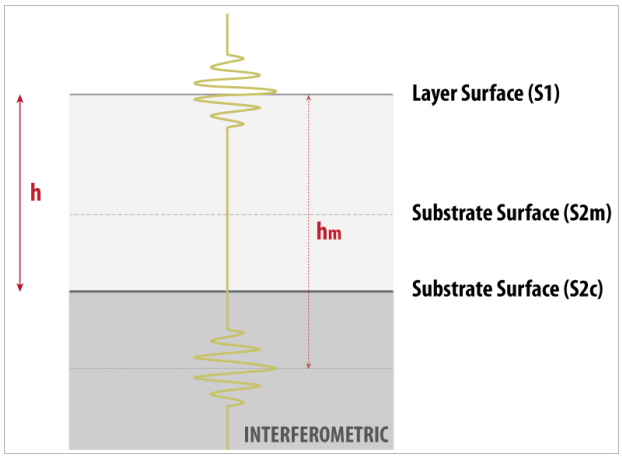
5.2.1.2 Thickness

Overview

With the **S onix**, the interferometric technique can also be used to measure the surfaces and thickness of a single transparent layer, or of a transparent foil. It does this by acquiring signals from both the upper (air-layer) surface and the lower (layer-substrate or layer-air) surface - the layer/foil thickness is then simply the difference between these two surfaces. This approach yields a 3D measurement.

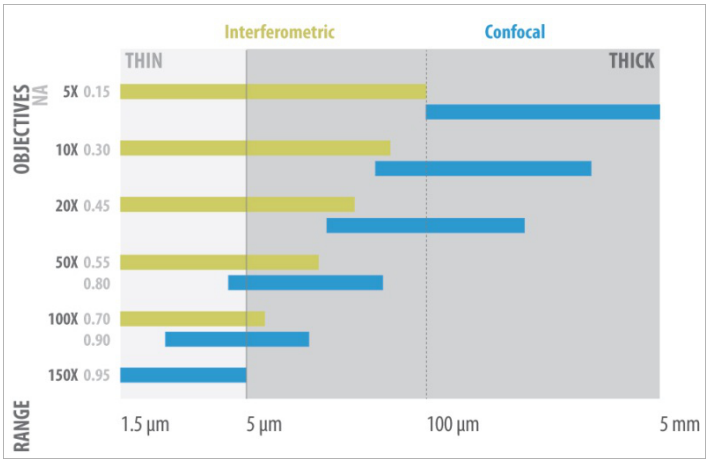


As conventional measurement algorithms are designed to deal with an axial response from only one surface, measurements of transparent layers and foils can lead to incorrect results if this aspect is not properly taken into account. The measurement of both surfaces is further complicated by refraction in the layer (see image below).



For interferometric measurements, there are two opposing effects. The image of the lower surface is refracted in the layer and thus appears closer to the upper surface, while the interferometric fringes from the lower surface are located below the lower surface (typically by the same amount as the refraction index of the transparent layer). The lower surface image and the fringes are thus not in the same plane, and measurement of the lower surface topography is blurred.

- For low magnification objectives (low NA), the depth-of-focus of the objective is relatively long and this effect is not very critical. Thin layers can be measured from less than 1 µm up to several 100 µm with a very large FOV.
- For high magnification objectives, such as 50x, the depth-of-focus decreases and the image of the lower surface gets even closer to the upper surface, making the image of the fringes very blurred and with very low contrast. Typically, magnifications of 50x and higher limit the measurable thin film thicknesses to some microns.



Typical objective limits when measuring thickness

Important points to note

The thickness measurement algorithms are designed to deal with axial responses that contain information from two surfaces. In order to obtain the correct results, the algorithms need to be fed appropriate refractive indicies for the particular sample configuration. These values are entered using the Layer pane that appears in Acquisition Settings when the corresponding Measurement type is chosen:

The Layer pane that appears in Acquisition Settings for thickness measurements

5.2.1.2.1 3D areal thickness

Overview

This Measurement type determines the upper and lower 3D areal surfaces as well as the 3D areal thickness of a transparent layer or foil. In principal, the procedure is exactly as that for a 3D topography measurement, with the addition of the layer values in the Layer pane.

> **Note:** When choosing the correct Z-Scan parameters, both surfaces must pass through the focus.

After measurement, the signal at each point is analyzed and is used to classify the surface points in order to determine which are the most reliable. These points are then used to estimate the upper and

lower surfaces. In accordance with these estimates, the remaining surface points are processed to obtain measurements for both surfaces where possible.

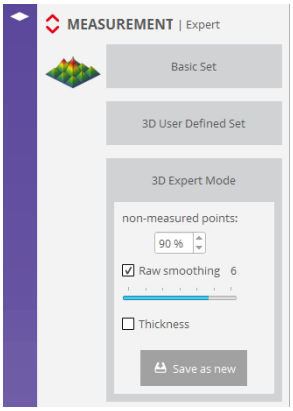
The next step is to calculate the measured thickness as the difference in height between the two surfaces. The sample properties are used to calculate a correction factor and to obtain correct thickness values. Finally, the true location for the lower surface is calculated by subtracting the thickness from the upper surface.

The two surfaces (and thus also the thickness) is saved as a **.plux* file in the current **SensoSCAN** data folder. The file is named automatically.

5.2.2 3D Expert Mode

Overview

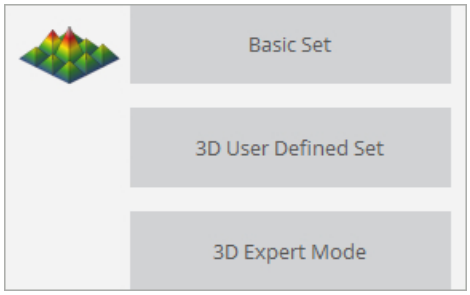
In addition to the standard Measurement types, an 3D Expert Mode is available:



3D Expert Mode

In this mode, experienced users can create new Measurement types specific to particular applications or surface configurations. The options available in 3D Expert Mode are discussed in the following sections.

Once the user has optimized the settings for the particular application, the user can save the configuration as a new Measurement type - these are known as *Applications*. *Applications* appear under *3D User Defined Set:*



Applications are useful because 3D Expert Mode is not available for use in Recipes. The workaround is thus to create *Applications* with the required parameter settings and use these in a Recipe instead. A further advantage of this approach is that *Applications* can be shared with multiple systems.

5.2.2.1 Measurement algorithms

User-selectable options

Configuration in 3D Expert Mode provides access to options other than those used as default in Basic Mode. The features and function of these options are explained below:

- *Maximum non-measured points* - This value is between 0% and 100%, and refers to the maximum acceptable percentage of points that are not measurable. If the measurement has a percentage of *non-measured points* exceeding this value, **SensoSCAN** displays a message that there are too many lost pixels and remains in acquisition mode. No results are shown.
- *Raw smoothing* - This is used to smooth the envelope function while 3D topographies are being acquired. The allowed values are 1 - 7, where higher values yield a greater effect. The goal of *Raw smoothing* is to reduce measurement noise while maintaining the maximum lateral resolution.

  Note: The *Raw smoothing* option should be enabled as a matter of routine.

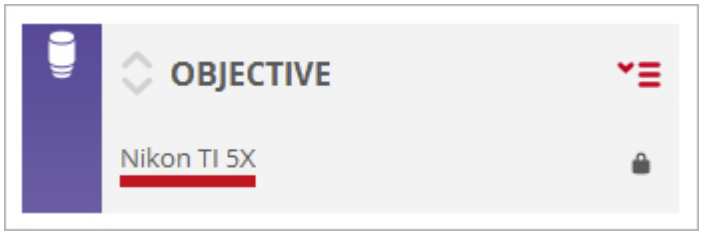
- *Thickness*: select this option for interferometric 3D areal thickness measurements.

5.3 Objective Selection

Overview

The objective visible in Sample Inspection is by default forced to be the same in Acquisition Settings. The reverse is also true - changing the objective selection under Acquisition Settings forces the same change under Sample Inspection. The objective selection is thus mirrored throughout the system.

This behavior can be disabled in System Preferences. When disabled, a padlock icon appears in the Objective Selection pane under Acquisition Settings - as long as the lock is closed, the objectives shown in Sample Inspection and in Acquisition Settings match:



By opening the lock, the selection of other objectives within Acquisition Settings is enabled (for example, an alternative objective to that chosen for Sample Inspection).

As described in Chapter 4, Objective Selection, if the objective has not yet been calibrated it will be highlighted with a red circle C. This status is also highlighted in the objectives pane under Acquisition Settings:

Non-calibrated objective warning for linked (left) and non-linked objectives

Motor control with non-linked objectives

Be aware that if the active objective actually installed in the profiler does not match up with that indicated in **SensoSCAN**, height adjustment of the sample to obtain best focus can result in damage to the sample. This can occur because **SensoSCAN** allows for a safe operating distance that is specific to the indicated objective.

> **Warning:** If the objective selected in **SensoSCAN** is not the same as the actual objective in the profiler, the software may let you enter a large Z-Scan value that could cause the objective to crash into the sample.

5.4 Area

Area options

The Area pane in Acquisition Settings

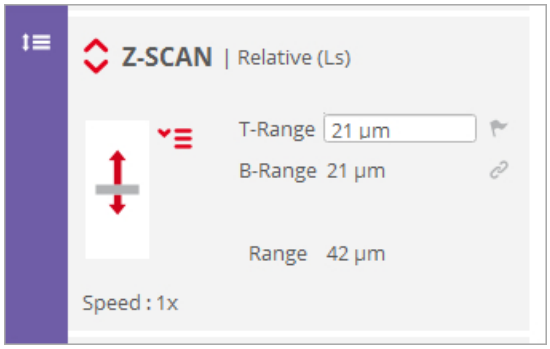
SensoSCAN automatically calculates the real area seen by the objective and shows the result in the Area pane. This calculation depends on the Measurement type and various measurement parameters.

The only selectable option available in this pane relates to the *Resolution* of the measurement. Changes to the resolution are made by clicking the required *Resolution* segment in the Area pane. The highest resolution corresponds to one measurement point per camera pixel. Lower resolutions are achieved by binning camera pixels - 2x2, 4x4 or 8x8. Naturally, lower resolution means that fewer points are measured, and the topographic detail in the measurement result is thus reduced.

5.5 Z-Scan

Overview

The Z-Scan pane is used to select the format/direction, length and speed of scanning the sample along the Z-axis.

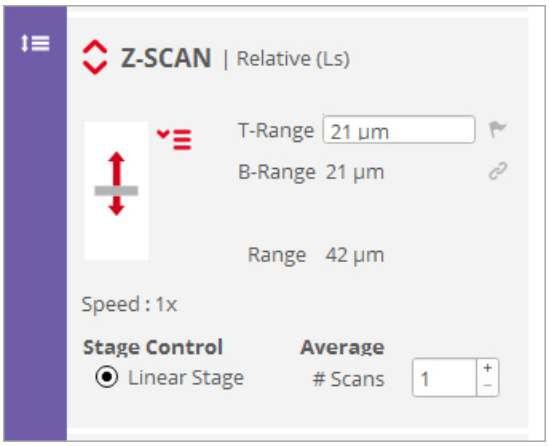


Z-Scan pane in Acquisition Settings

In general, standard initial values are shown, as determined by **SensoSCAN** for the current Measurement parameter configuration. Values can be edited from the standard values by simply clicking the appropriate icons to the right - . Due to the fact that **SensoSCAN** makes some basic assumptions and performs some internal checking, these values are semi-interactive - changing just one will automatically adjust the others unless these are also manually overwritten.

The Z-Scan pane also displays the stage control used to acquire the measurement - for the **S onix** sensor this is the linear stage (*Ls*).

Advanced options are accessed by clicking the red up/down arrows :



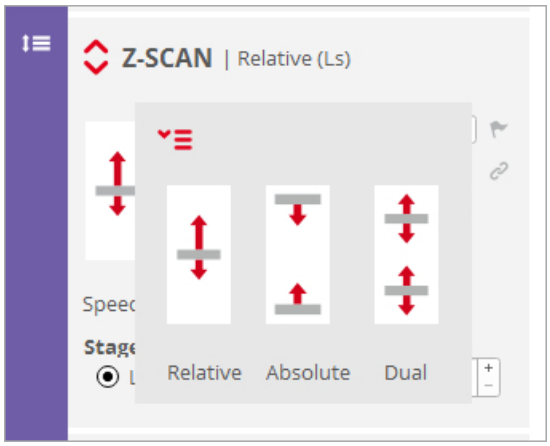
Advanced options are visible in the extended Z-Scan pane

5.5.1 Z-Scan options

Relative, Absolute and Dual

There are three kinds of Z-Scan: *Relative*, *Absolute* and *Dual*. These are accessed by clicking the drop-

down icon :



***Relative*, *Absolute* & *Dual* Z-Scan travel options**

The available Z-Scan range is always an interplay between the overall height of the sample, the objective safety distance specified internally (i.e. a built-in buffer zone immediately below the objective) and the software and hardware travel limits of the system. Values for the objective safety distance are listed in a table in the Autofocus section. Nominally these values are (WD - 500 µm) for objectives with WD > 1000 µm, otherwise it is WD / 2.

Note that swapping between *Relative*, *Absolute* and *Dual* introduces a minor and yet uncritical change in the nomenclature of the upper and lower Z-Scan parameters.

Relative Z-scan

The simplest scanning option is the *Relative* scan about an initial Z-Scan location (usually the current position).

For a surface measurement, Z-Scan must be initially positioned somewhere between its most extreme (lowest & highest) focal positions. For a thickness measurement, Z-Scan must be initially positioned between the two surfaces of the layer or the foil within the FOV. Note that the vertical starting position must not lie centrally between the extreme (lowest & highest) focal positions - by an appropriate choice of *T-Range* and *B-Range* values, the vertical axis can be scanned asymmetrically about the initial position.

Once the user has determined and entered the desired range, the software calculates the number of planes needed to carry out the measurement and shows the result in the Z-Scan pane.

The Z-Scan range has some limitations. When the range is too large, the measurement will take a long time. If the range is too small, there will be no information for some zones in the measurement, and non-measured points will appear. To avoid these problems, the software automatically checks either the range or the total number of planes. If the Z-Scan range is not large enough for the measurement, the software will change it to produce a minimum number of planes (for the **S onix**, 21). Alternatively, the software will change the range to the maximum allowed value when the step and the resolution are greater than the maximum allowed by the available memory.

Absolute Z-Scan

While *Relative* and *Dual* Z-Scan are defined relative to the current focus position, *Absolute* Z-Scan allows the user to define the Z-Scan range by setting the absolute Z coordinates for the upper and lower

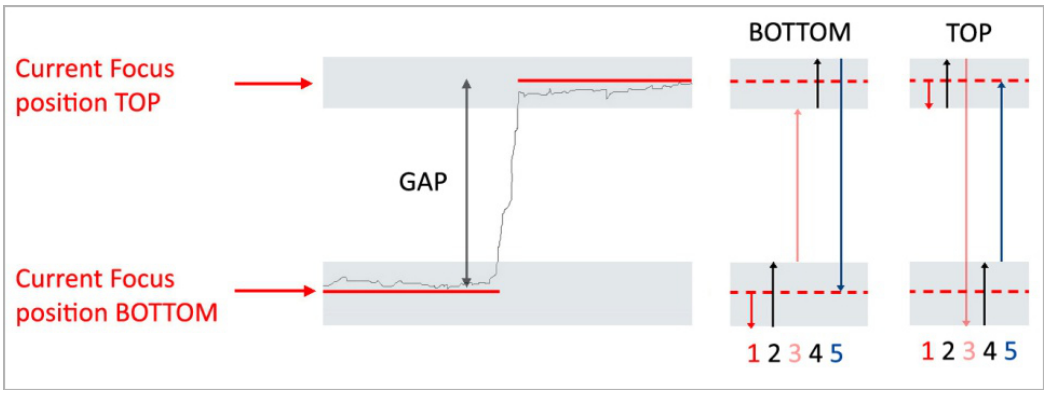
positions (*Z-Top* and *Z-Bottom*, respectively). Alternatively, a start value (top or bottom) can be set, and then the *Range*.

If the Z-Scan range is not large enough for the measurement, the software will not allow a position to be selected. Consequently, the user has to increase the range by moving up or down to obtain the required minimum Z-Scan range.

Dual Z-Scan

Dual Z-Scan is best used to measure samples with a high discontinuous step, i.e. there is simply no point in scanning the step.

The sample is focused initially either at the top or the bottom, and this starting position must be selected in the Z-Scan pane (toggle between T-Ref / B-Ref). Now enter the desired scanning *T-Range* and *B-Range* for both planes. In addition, enter the *Gap* amount.



BOTTOM option - (1) movement before scanning, (2) movement during bottom scanning, (3) from the end of bottom scanning to the start of top scanning, (4) movement during top scanning, (5) return to the start position. TOP option - (1) movement before scanning, (2) movement during top scanning, (3) from the end of top scanning to the start of bottom scanning, (4) movement during bottom scanning, (5) return to the start position

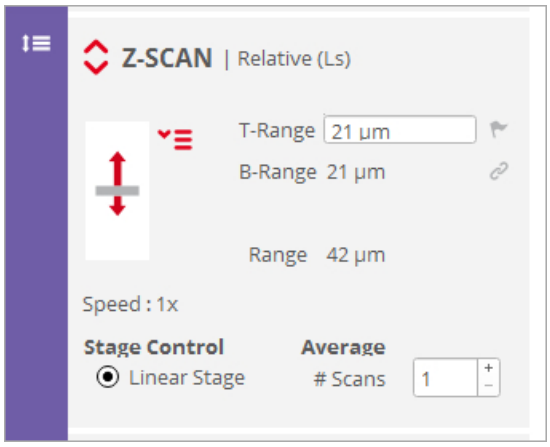
Warning: To use the *B-Ref* direction, one must focus below the lowest point of the sample in the desired Z start position. To use the *T-Ref* direction, one must focus above the highest point of the sample.

Once the *Acquire* button has been clicked, the software acquires the first region, moves up or down by the *Gap* amount (without acquisition), and then acquires the second region. The result is treated as a regular measurement. The effect of the speed factor on the number of planes scanned along the top and bottom ranges is the same as in a single Z scan.

5.5.2 Z-Scan advanced options

Optimizing Z-Scan

Advanced options are accessed by clicking the red up/down arrows :



Speed factor

The speed factor influences the measurement time. A speed factor of 1x means that the software will perform the measurement using the optimum step between planes. Maximum 3x.

Stage control

The Stage Control section in the Z-Scan pane displays the stage control used to acquire the measurement (for the **S onix** this is the linear stage, *Ls*).

Average

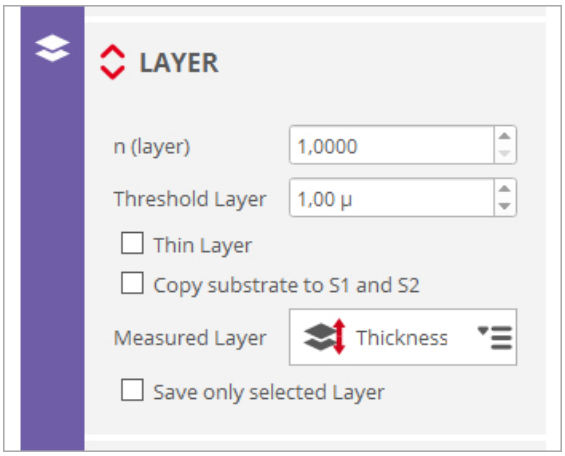
Average Scans is useful for averaging 3D data, and can also be used to reduce system instabilities such as external vibrations. With *Ls* stage control, the selected number of phase maps are acquired and then averaged.

> **Warning:** If the image is saturated, the measurement will be inaccurate. Move Z up and down to make sure that the maximum fringe contrast is not saturated.

5.6 Layer

Overview

The measurement algorithm for interferometric thickness measurements are designed to deal with axial responses that contain information from two surfaces. In order to obtain the correct results, the algorithm need to be fed appropriate parameters for the particular sample configuration. These values are entered using the Layer pane that is only visible in Acquisition Settings when the corresponding Measurement type is chosen:



The (extended) Layer pane, visible in Acquisition settings for thickness measurements

Thickness measurement parameters

The necessary parameters are as follows:

- *n (layer)* refers to the refractive index of the layer or film itself (use three significant digits if possible)
- *Threshold Layer* sets a minimum optical separation for the two main signal peaks. Regardless of the cause of a peak, if it is closer to the main peak than this distance, it will be excluded from the analysis.

  Note: Each objective has a minimum thickness threshold associated with it in **SensoSCAN**. User settings are ignored if the values given are lower than the objective's threshold.

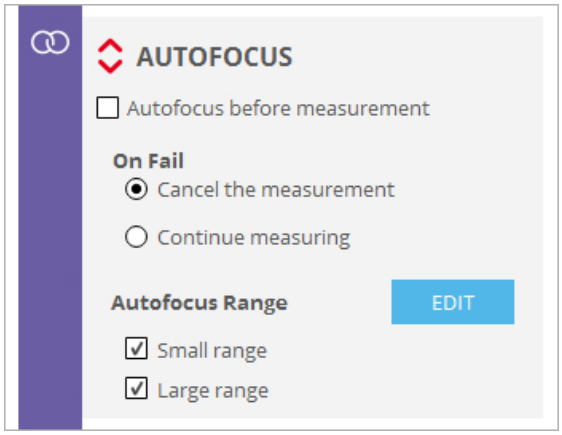
- *Thin Layer* activates a special algorithm designed for layers of less than 2 µm.
- *Copy substrate to S1 and S2*: For points where the lower and upper layer surfaces have no values (for example, because the coating has a hole at that location), this option copies the values for the lower surface (i.e. the substrate) to both surfaces (not to be confused with the Restore operator, which generates substitute data by interpolation).
- *Measured Layer*: Following a successful measurement, only the selected surface or layer topography is displayed, although both surfaces (and thus also the layer) are still directly accessible in Display & Analysis and can be saved to file. This can be restricted to the chosen *Measured Layer* by activating the *Save only selected layer* option, in which case (when selecting the *Top* or *Bottom* surface) the measurement obviously defaults to a surface topography and is

no longer a thickness measurement. The selected *Measured Layer* is also used to assess the non-measured points.

5.7 Autofocus

Overview

The Autofocus is a routine used by the system to fine focus the sample, in order to optimize the initial Z-position for measurement. The focus can be manually optimized at any time using the motor controls, or automatically adjusted by clicking the Autofocus button in Sample Inspection.



The (extended) Autofocus pane in Acquisition Settings

By enabling *Autofocus before measurement* in the Autofocus pane in Acquisition Settings, the focus is automatically adjusted before acquisition commences. The accuracy will not be the same as for manual focusing performed by a human operator, but the accuracy and repeatability is good enough to make this feature useful.

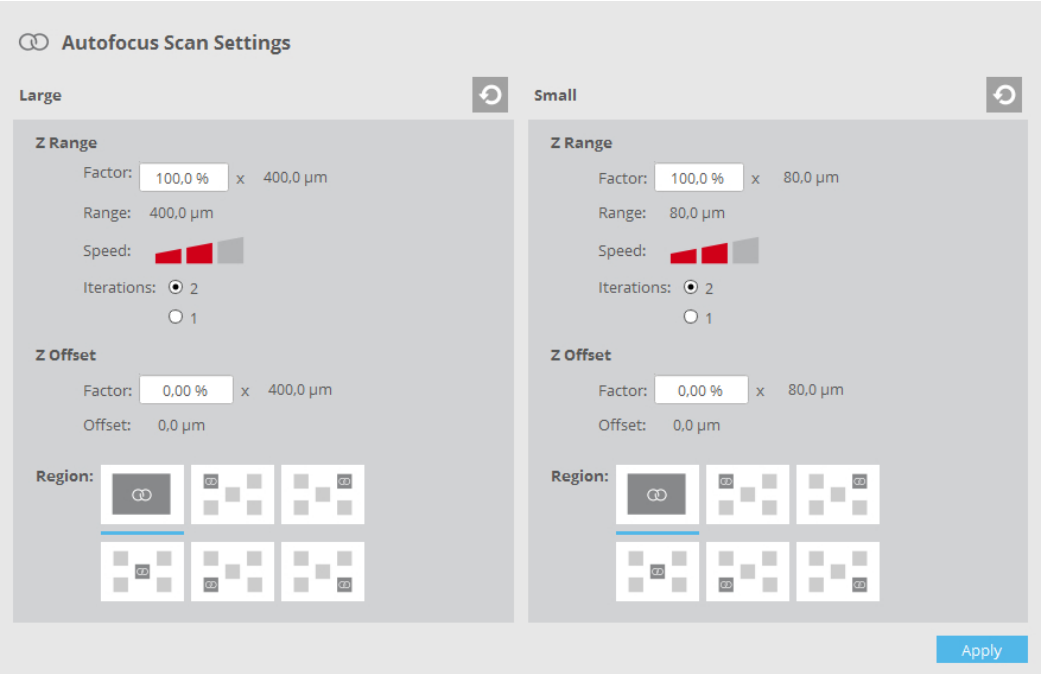
Advanced options

General options in the extended pane are:

- in case Autofocus fails, there is a choice of two options: *Cancel the measurement* and *Continue measuring*
- there are two possible scanning ranges for Autofocus *small* and *large* - one or both can be selected, and refer to the travel range in determining the best focus. *small* and *large* values for the individual objectives can be found in the table below.

Editing Autofocus ranges

Default Autofocus settings have been defined to obtain a balance between performance (accuracy and repeatability), speed and range. However, for specific applications, these settings may not be ideal. Access and change settings using the *Edit* button, followed by *Apply* to confirm the changes:



The Autofocus Scan Settings edit pane

- *Range factor* (%) increases or reduces the maximum range
- *Speed factor* determines the time taken (*slow*, *default* or *large*)
- *Iterations*: two or one iterations to home in on the best focal position
- *Z Offset* specifies an offset to the movement made during the Autofocus routine (from zero to ± Range/4)

Note: These settings are used for all Autofocus functions - the exception to this is for the calibration of objectives, where SensoSCAN will use always the default settings.

Finally, the *Region* option determines which areas of the FOV are used to determine the best focus - the default area (the entire FOV) or specific sub-regions of the FOV.

Important points to note

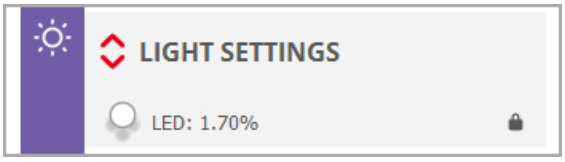
- The estimated time required for the Autofocus routine depends on the numerical aperture. For *small* Autofocus it is between 3.5 and 4.5 seconds and for *large* Autofocus it is between 4 and 6 seconds.
- If the Z-Scan range chosen here by the user is larger than the maximum allowed range for the installed objective, SensoSCAN will automatically reduce the Z-Scan range accordingly. Z step is then also reduced to keep the number of planes. Z-Scan is performed by moving Z at a constant speed. Thus the Z step between planes determines the speed of the Z movement.
- If the nominal Z speed is greater than the maximum, the actual Z speed is set to the maximum. Z step is then reduced and the number of planes is increased to keep the same Z-Scan range.

Family	Objective	NA	WD	Maximum Range	Autofocus Range	
					small	large
			(mm)	(µm)	(µm)	(µm)
TI	2.5X	0.075	10.30	9800	100	1000
TI	5X	0.130	9.30	8800	100	1000
DI	10X	0.300	7.40	6900	100	1000
DI	20X	0.400	4.70	4200	100	1000
DI	50X	0.550	3.40	2900	100	1000
DI	100X	0.700	2.00	1500	100	1000

Values of the Autofocus scan range for common objectives

5.8 Light Settings

Overview



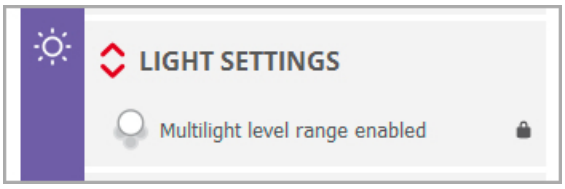
Light Setting pane

By default, the illumination options set in Light Control, or those pre-selected by the system, are forced (mirrored) over to Light Settings. There is no provision for changing the illumination in the Light Settings pane. The illumination options made in Light Control are valid throughout the system.

This behavior can be disabled in System Preferences - a padlock icon then appears in the Light Settings pane. By clicking on the icon and thus opening the lock, it is now possible to change the illumination settings under Light Control without changing those in Light Settings. By closing the lock, the illumination settings chosen in Light Control are again forced over to Light Settings.

> **Note:** Unlinking objectives will most likely lead to the need for different Light Settings between inspection and measurement.

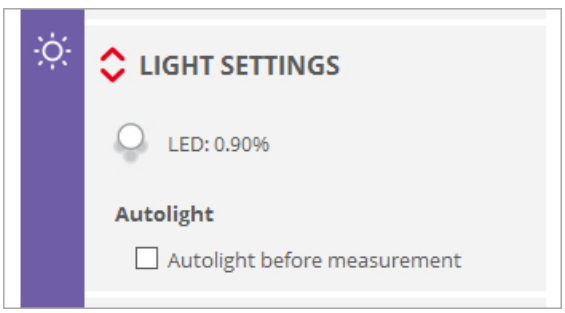
If MultiLevels is activated by selecting *scans* or *range*, the pane changes to reflect this:



> **Note:** Any selected LEDs are automatically switched off when **SensoSCAN** switches to Display & Analysis mode.

Advanced options

The Light Settings pane extends to reveal the advanced light settings selected in Light Control - as explained above, the light intensity and the currently active light source are forced to those values shown in Light Control. There is thus no provision for changing the illumination options in the Light Settings pane.



Enabling Autolight before measurement sets the system to perform an Autolight routine before each measurement.

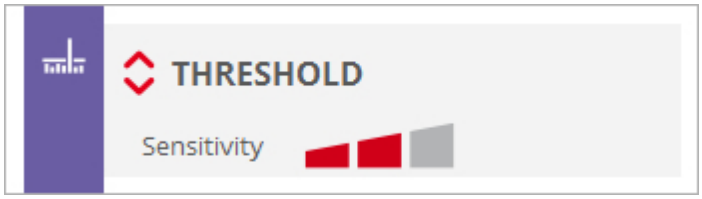
Note: When the surface is out of focus, Autolight may select a light level that is not suitable for a measurement. Therefore, *Autolight before measurement* should only be used together with *Autofocus before measurement*. Note that the *Autolight before measurement* option is not available when more than one level of light is selected (MultiLevels).

Note: To obtain accurate interferometric measurements, avoid saturation in the fringes. Move through Z to make sure that the maximum fringe contrast is not saturated.

5.9 Threshold

Overview

The Threshold setting decreases or increases system sensitivity to the optical signal by setting a lower level of measurement reliability - below this level, data points are ignored.



Threshold pane in Acquisition Settings

Sensitivity can be set to nominal values of 1, 3 or 5 using the graduated icon in the Threshold pane.

> **Note:** The actual values used (at the camera pixels) are dependent upon the Measurement type and other system-dependent factors. **SensoSCAN** calculates the values automatically for the chosen measurement configuration.

Advanced options

For advanced users, the Threshold value can be edited manually:

Sensitivity can now be set to any value between 0 and 100 (actually, 99.99):

- setting Threshold to 0 equates to measuring all points regardless of signal quality
- setting Threshold to 100 equates to the maximum theoretical intensity, in which case no points will be measured

The default value for Threshold is 5. If the measurement contains too many lost pixels, first try increasing the illumination (without causing saturation), then try reducing the Threshold.

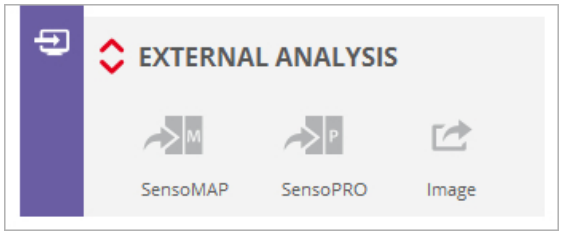
In general, avoid using low values in order to minimize noise. For example, using a value below 3 on a rough surface may cause spikes to appear.

5.10 External Analysis

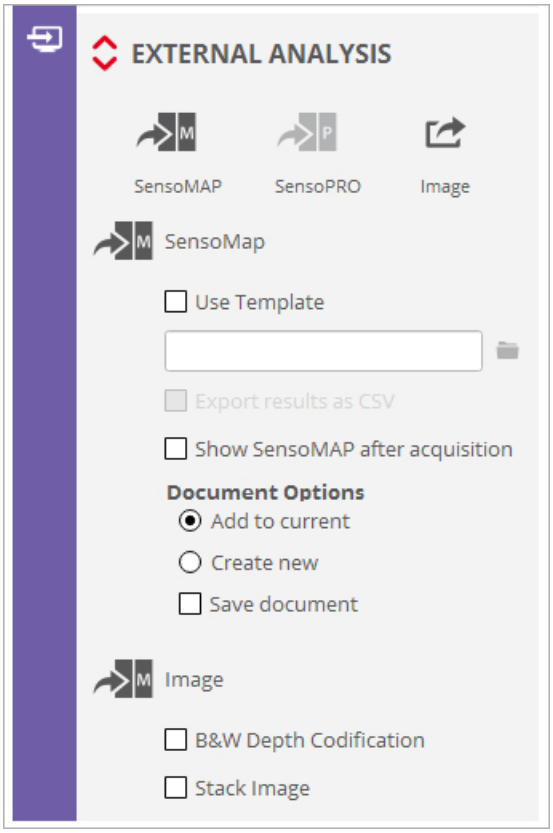
Introduction

SensoSCAN acquires one single measurement if no Recipe or a Single Measurement Recipe (SMR) is used. Alternatively, **SensoSCAN** can acquire a series of measurements by means of a Multiple Measurement Recipe (MMR).

The External Analysis window is used to direct data acquired with the system to external software (**SensoMAP** and **SensoPRO)** or to Export Image.



To enable each option, click on the label name(s) - advanced options for each selection can then be accessed by clicking on the red up/down arrows .



Note: SensoPRO must be running alone in conjunction with **SensoSCAN**. Additionally **SensoPRO** must be initialized as an Administrator of the **SensoPRO** software in order to properly configure the communication. More information can be found in the dedicated User Manual for **SensoPRO**.

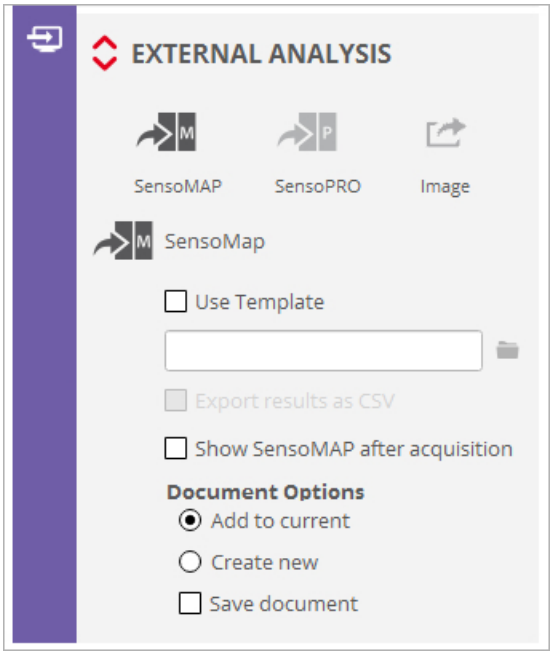
5.10.1 SensoMAP

Overview

There are three ways of analyzing data using **SensoMAP**:

- The first option is to manually load data into **SensoMAP**. The user saves the measured data using **SensoSCAN** menus and manually loads data into **SensoMAP**. **SensoSCAN** saves the data using a proprietary file format (**.plux* files) that **SensoMAP** can load.
- The second option is to automatically load measured data into **SensoMAP** (SMR analysis). The user must enable an automatic connection with **SensoMAP**. When this option is enabled, new data is automatically transferred to **SensoMAP**.
- The third option is to automatically analyze a series of measurements (MMR analysis). The user can either apply a **SensoMAP** template to a directory that contains a series of files or setup **SensoSCAN** to automatically analyze the results using a Multiple Measurement Recipe (MMR).

The External Analysis options depend on whether acquisition is single or multiple.



A detailed description of the **SensoMAP** application is found in its own help.

5.10.1.1 SMR analysis

SMR analysis options

Options for how the measurement is handled together with **SensoMAP** are accessed by clicking on the red up/down arrows in the External Analysis pane.

- *Use Template*: The selected template is used by **SensoMAP** to analyze the measurement. When the user checks this option, the folder button is enabled, allowing the user to select a template.
- *Export results as CSV*: This option can only be used together with a template. Note that there

are no analysis results to export unless the template obtains exportable values from the data analysis. Results of the analysis performed by **SensoMAP** will be exported into a comma-delimited file. The name of the **.csv* file is automatically generated according to document naming rules detailed below.

- *Show SensoMAP after acquisition*: A successful measurement will be automatically displayed in **SensoMAP**.
- *Document Options*: **SensoMAP** documents consist of a set of data, operators, illustrations and parameters, amongst others:
  - *Add to current*: The measurement is loaded into the current document in **SensoMAP**.

Warning: If the current document contains more data than is required by a selected template, **SensoMAP** will discard some data and this may cause misleading results.

  - *Create new*: The measurement is loaded into a new **SensoMAP** document.

Warning: If *Create new* is active, any previous document currently open in **SensoMAP** will be lost.

  - *Save document*: The updated or new **SensoMAP** document will be automatically saved. The usual workflow is to enable *Save document* when the *Create new* option is enabled, but not enable it when *Add to current* is enabled. The name of the **SensoMAP** document *(*.mnt)* is automatically generated according to document naming rules detailed below.

Document naming rules

If *Use Template* is checked, the name is composed of the template name and a time stamp.

If *Use Template* is unchecked, the name depends on the type of measurement. The name is composed of a fixed extension (**.plux*) and a time stamp.

The file is saved to the current path, as defined in System Preferences.

5.10.1.2 MMR analysis

MMR analysis options

After acquiring an MMR, the measured data is saved in files using a predefined folder structure. At the end of the acquisition of all measurements, the measurements that have been selected to be analyzed using **SensoMAP** are sent to **SensoMAP** folder by folder.

Warning: Configuration of **SensoMAP** options has to be done in the SMR. That is, an MMR will only send the results obtained using the SMRs that have **SensoMAP** enabled.

Options for how the measurement is handled together with **SensoMAP** are accessed by clicking on the red up/down arrows in the External Analysis pane.

- *Use Template*: Templates allow the same analysis to be performed, or the same report to be given on the new data. The usual workflow is to enable this option when a series of measurements needs to be analyzed. When enabled, the selected template is used by **SensoMAP** to analyze the measurement. When the user checks this option, the folder button is enabled, allowing the user to select a template.

- *Export results as CSV*: This option can only be used together with a template. Note that there are no analysis results to export unless the template obtains exportable values from the data analysis. Results of the analysis performed by **SensoMAP** will be exported into a comma delimited file. The name of the **.csv* file is automatically generated according to document naming rules detailed below.
- *Show SensoMAP after acquisition*: A successful measurement will be automatically displayed in **SensoMAP**.

Note: When data is the result of an MMR, it is not sent to **SensoMAP** until the entire MMR acquisition process has finished. If *Show SensoMAP after acquisition* is enabled, **SensoSCAN** sends measured data to **SensoMAP** but the window remains blank.

- *Document Options*: **SensoMAP** documents consist of a set of data, operators, illustrations and parameters, amongst others:
  - *Add to current*: All the measurements grouped in the same result folder are loaded into the same document. A new document is created for each result folder.

Warning: If the current document contains more data than is required by a selected template, **SensoMAP** will discard some data and this may cause misleading results.

  - *Create new*: Each measurement of the series is loaded into a new document in **SensoMAP**, i.e. one document for each **.plux* file.
  - *Save document*: **SensoMAP** documents are saved automatically. This usual workflow is to enable *Save document* when the result of the analysis of the series of measurements is the **SensoMAP** document itself, but *not* enable it when the results of interest are the values exported to as a **.csv* file. The name of the **SensoMAP** document (**.mnt*) is automatically generated according to document naming rules detailed below.

Document naming rules

The documents are saved in the same folder as **.plux* files (folder structure for MMR results).

The **.csv* file name will be the template name. One single **.csv* file will be created for each folder of **.plux* files analyzed.

- If Add to current is enabled:
  - and *Use Template* is enabled, the file name is composed of the template name and the MMR's base name. Example: *template zRGB --- MMRRecipe.mnt*
  - and *Use Template* is not enabled, the file name is the MMR's base name. Example: *MMRRecipe.mnt*
- If Create new is enabled:
  - and *Use Template* is enabled, the file name is composed by the template name and the *.plux* file extension. Example: *template zRGB --- TopoRecipe_R0001.mnt*
  - and *Use Template* is not enabled, the file name is the name of the **.plux* file except for the extension (**.mnt*). Example: *TopoRecipe_R0001.mnt*

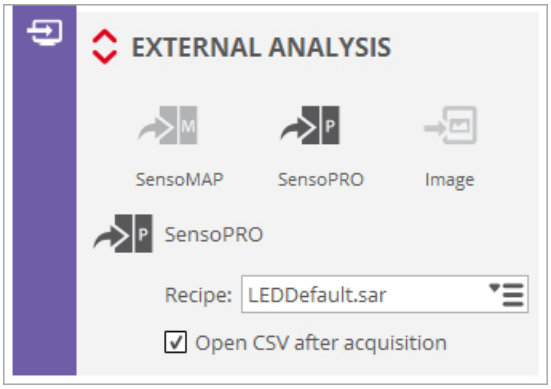
5.10.2 SensoPRO

Overview

There are three ways of analyzing data using **SensoPRO**:

- The first option is to manually load data into **SensoPRO**. The user saves the measured data using **SensoSCAN** menus and manually loads data into **SensoPRO**. **SensoSCAN** saves the data using a proprietary file format (**.plux* files) that **SensoPRO** can load.
- The second option is to automatically load measured data into **SensoPRO** (SMR analysis). The user must select a predefined SMR. When this option is enabled, new data is automatically transferred and analyzed to **SensoPRO**.
- The third option is to automatically analyze a series of measurements (MMR analysis).The user can either apply a **SensoPRO** recipe to a directory that contains a series of **.plux* files or setup **SensoSCAN** to automatically analyze the results obtained by a Multiple Measurement Recipe (MMR).

The external analysis settings depend on whether acquisition is single or multiple.



A detailed description of the **SensoPRO** application is found in its own manual.

5.10.2.1 SMR analysis

SMR analysis options

Options for how a measurement is handled together with **SensoPRO** are accessed by clicking on the red up/down arrows in the External Analysis pane.

- *Recipe*: **SensoPRO** recipes allow the same analysis to be repeatedly performed, or a report to be made on the new data. Select a Recipe as appropriate.
- *Open CSV after acquisition*: A successful measurement will be automatically displayed as a **.csv* file.

The results from the data analysis are always exported as an **.xml*, **.xls* or **.csv* file, depending on the **SensoPRO** configuration. The name of the file is automatically generated according to document naming rules detailed below.

Document naming rules

The name is composed of the Recipe name and a timestamp.

The file is saved to the current path (measurement folder, i.e. where the last measurement was saved or loaded).

5.10.2.2 MMR analysis

MMR analysis options

After acquiring an MMR, the measured data is saved in files using a predefined folder structure. At the end of the acquisition of all measurements, the measurements that have been selected to be analyzed using **SensoPRO** are sent to **SensoPRO** folder by folder.

> **Warning:** Configuration of **SensoPRO** options has to be done in the SMR. That is, an MMR will only send the results obtained using the SMRs that have **SensoPRO** enabled.

Options for how the measurement is handled together with **SensoPRO** follows exactly the same description as for External Analysis of MMR measurements with **SensoMAP**.

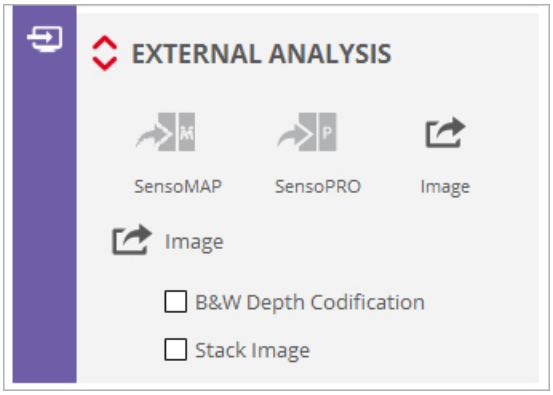
Document naming rules

The documents are saved in the same folder as **.plux* files (the folder structure for the MMR results).

The **.csv* file name will be the SMR name. One single **.csv* file will be created for each folder of **.plux* files that is analyzed.

5.10.3 Export Image

Overview



Export Image allows the user to export a pixel map from **SensoSCAN** with maximum resolution. Available images are dependent upon the Measurement type (images and 3D topographies only):

Measurement type	Measurement technique	Exportable Images
Image	Interferometry	Full image
Single 3D topography	Interferometry	BW Depth Codification image Stack Image

The selected image is saved in two files - an image file and a calibration file (**.cal*). The image file has

different tags depending on the chosen image format (selectable between **.tif, *.tiff*, **.fp-tiff*, **.png*, **.bmp* and **.jpg* in System Preferences).

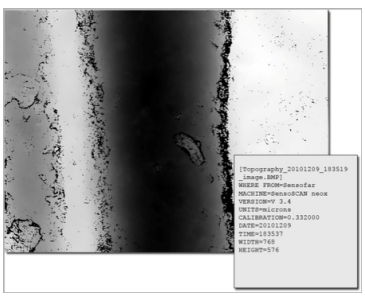
Images	File
BW Depth Codification image	*-depth.*
Stack	*-stack.*

The calibration file contains the following fields:

Field Name	Description	Example
WHERE FROM	Acquisition application name	SENSOSCAN
MACHINE	Acquisition machine name	S onix
VERSION	Application version	6.2
UNITS	Units in the XY axis [microns or nanometers]	microns
CALIBRATION	XY distance per pixel	1.660000
DATE	Day of measurement	30/05/2015
TIME	Time of measurement	19:14:01
WIDTH	Image width	1360
HEIGHT	Image height	1024
ZUNITS	Units in the Z axis [microns or nanometers]	microns
ZCALIBRATION	Z distance per level of gray	0.007843
ZLOWER	Z lowest point	-0.999579

The bold fields are only visible for BW depth codification images.

Examples:



BW Depth Codification and Stack images (left to right)

Follow these steps to use this feature:

- Enable Export Image in the External Analysis pane
- Click on the red up/down arrows to reveal the options and select desired image type

After acquisition, the image and **.cal* file will be saved automatically to the current path (default *C:\TMP*, or the user-selected measurement folder).

> **Note:** The measurement file (**.plux*) can be saved to the current path (measurement folder) or in a distinct folder selected by the user. However, the exported image is always saved to the current path (measurement folder).

An Export Graphic option is also available from the OS Menu Bar and from **SensoSCAN**'s Quick Bar when in Display & Analysis mode.

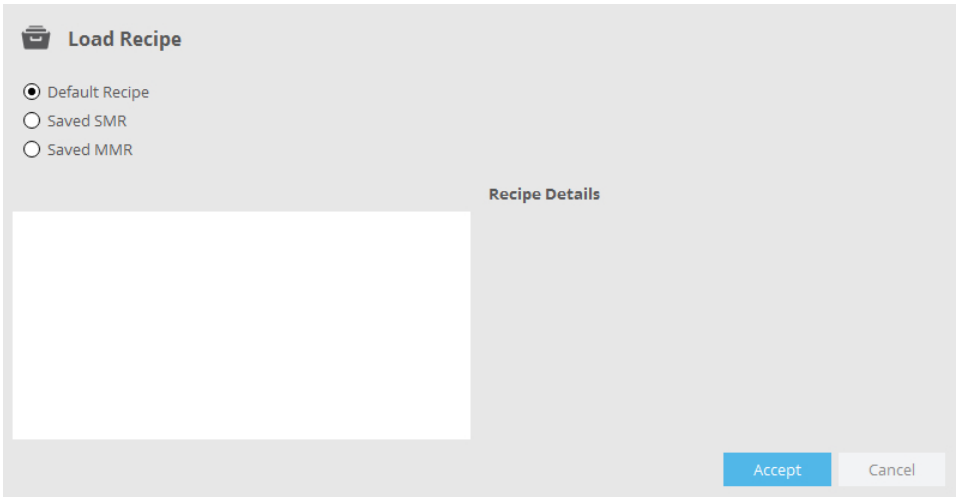
5.11 Recipes: SMR & MMR

Overview

Access to Recipes is via icons at the top of the Acquisition Settings pane

Recipes allow the user to select predefined scanning parameters that typically optimize a given application (Single Measurement Recipe, SMR) and/or that are used to automate an extensive measurement process (Multiple Measurement Recipe, MMR).

The icon opens a dialog, allowing the user to load either default (for the **S onix** *default_HS.smr*), single (SMR) or multiple recipes (MMR):



By choosing the appropriate type (SMR or MMR), a list of available recipes will appear. By choosing one from the list, any description given will be displayed. When choosing an SMR, the corresponding *Acquisition Settings* will become visible. The name of any loaded recipe will be indicted at the top of the *Acquisition Settings* pane.

Default

The *Default* option is used to load the measurement default settings (i.e. image acquisition, for the **S onix** *default_HS.smr*). This measurement can be carried out right after system setup, even without objective calibration.

Depending on their needs, users can redefine the default SMR by simply using the *Save as* command to replace the default SMR (see drop-down menu).

Single Measurement Recipe (SMR)

The Single Measurement Recipe (SMR) is used to load the measurement settings from a stored file. This function is useful for automating processes when the user needs to take a large number of measurements under the same conditions.

Multiple Measurement Recipe (MMR)

This function is useful for automating a measurement process. MMRs are used to acquire several measurements at a single location by simply utilizing a list of SMRs. MMRs can also be used to repeat measurements in the same position, for example to assess evolution or to obtain average measurements.

The MMR can be canceled during the measurement by pressing the *Esc* key.

At the end of the measurement, a report is displayed. The report also shows which files have been measured (or not), the time required and the status. If the user clicks on *Explore Measurements*, the software opens a dialog box that allows the user to select the measurement to be displayed.

Managing recipes

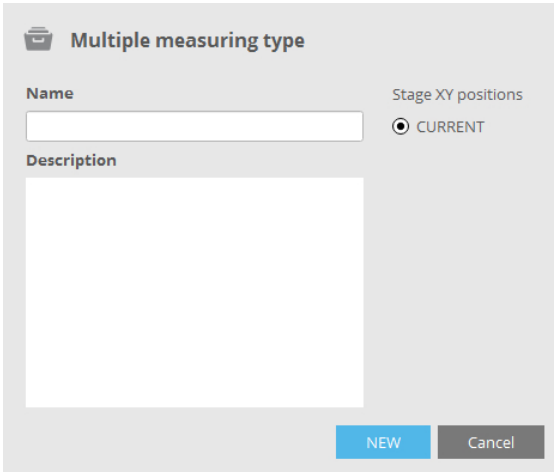
Via the recipes drop-down menu , recipes (SMRs and MMRs) can be saved, renamed (using *Save as*) and deleted, and MMRs can also be created.

When saving an SMR, all the the current parameters selected for a measurement - the Measurement type, the objective, and settings for Area, Z-Scan, Autofocus, Light Settings and Threshold, as well as External Analysis and any Data Analysis settings - are saved together with the recipe.

Note: Data Analysis options must be applied while in Display & Analysis mode.

Note: Before defining an MMR, all the required SMRs must first be created.

When creating an MMR, the MMR must initially be given a name and a brief description (all of these can be changed in the subsequent dialog):

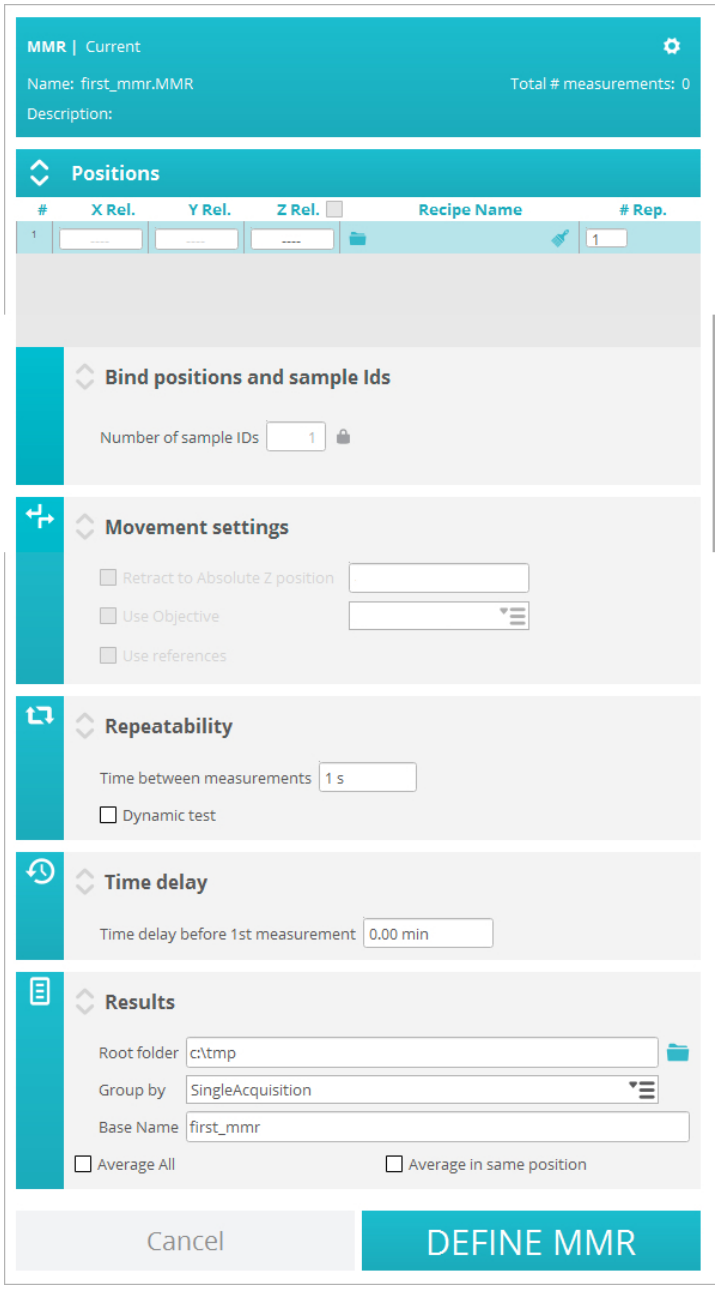


Confirming with *New* then reveals the define MMR pane (see next section).

5.11.1 Creating an MMR

Overview

The MMR configuration dialog contains all the tools required for creating an MMR:



The following outlines the steps needed (see MMR set-up for individual step details):

- if necessary, click on the icon to redefine the name and/or change the description
- define *Positions* (for the **S onix** there is only one XY position as there is no XY stage):
  - define the starting Z-Scan value
  - click on the icon to select an appropriate SMR and specify the number of repetitions
  - deletions can be made using the icon
- under *Bind Positions and Sample IDs* (only visible if *Use Sample ID* has been activated in System Preferences):
  - define the total number of *Sample ID*'s
  - tie (bind) one or more the *Positions* to each *Sample ID*

- under *Movement Settings* are disabled for the **S onix** sensor, as there is no *XY* stage
- under *Repeatability* set the parameter *Time between measurements* and enable or disable *Dynamic test*
- under *Time delay* insert a value for *Time delay before 1st measurement* (in minutes)
- under *Results* define *Root folder*, *Group by* and *Base Name*, as well as enabling or disabling *Average all* and *Average in same position*

Finally, upon completion of the settings, confirm by clicking *Define MMR*.

A report, summarizing the MMR is now displayed. By choosing *Edit*, the parameters of the MMR can be adjusted, or the user can return to the standard Inspection & Acquisition interface by choosing *Exit*.

5.11.1.1 MMR set-up

Overview

In creating an MMR, the user must consider a number of points and options - these are described below.

Recipe naming

The following characters are not allowed:

- \ in recipe names
- & < > in the recipe description

Positions

For the **S onix** sensor there is only one coordinate option as there is no XY stage:

- *Current*: The current stage position is used.

Bind Positions and Sample IDs

This pane is only visible if *Use Sample ID* has been activated in System Preferences. When activated, proceed as follows to tie *Positions* (measurement locations) to specific *Sample ID*'s:

- Unlock the padlock by clicking, define the total number of *Sample ID*'s, and re-lock the padlock by clicking again - a corresponding number of text fields appears.
- Tie (bind) one or more the *Positions* to each *Sample ID* - hover the cursor over a text field to reveal a tip overlay with possible examples and the required syntax. Naturally, all measurement locations used here must exist in the *Positions* listing in the pane above when *Acquire* is selected.

Repeatability

The *Repeatability* options are used for repetitive measurements in the same XY position.

- *Time between measurements*: A time delay between measurements to help reduce the effect of instabilities
- *Dynamic test:* Enabling this option will move the system a given distance along Z after each measurement and return to the starting point before the next one.

Time delay

A time delay before the first measurement can be introduced. This can be used to let the system settle from any environmental vibrations.

Results

The results of MMR measurements are the measurement files (*.plux) and a report file (*MMR.log*) that contains information about the measurement. The following settings tell the system where to save the files: *Root folder* and *Base Name.* The user can also select how to group the measurements by *SingleAcquisition*, *Day*, *Weekdays*, *Week*, *Month* or *AllTogether*.

Each time an MMR measurement completes, a new folder is created in the root folder. This is the MMR folder. The name of the MMR folder consists of the *Base Name* and a time stamp.

Example:

Root folder: C:\Sensofar		
Base name: Measure	**Date**: 26 May 2008	**Time**: 18h 28m 17s
MMR Folder: C:\Sensofar\Measure_26_may_2008_18_28_17		

Warning: If the MMR folder already exists, the system asks whether it should be overwritten.

If the *Group by* option is *not* *SingleAcquisition*, the folder name will additionally be composed as follows:

- *Group by Day* will generate *Basename* + *_Day_Month_Year*
- *Group by Weekdays* will generate *Basename* + *_Weekday_Month_Year*
- *Group by Week* will generate *Basename* + *_YearWeek_Year*
- *Group by Month* will generate *Basename* + *_Month_Year*
- *Group by AllTogether* will generate *Basename*

Result files are organized inside this folder according to the following rules:

- **If the total number of SMR is one:**

1. If the number of positions is one, the files are saved in the MMR folder. No sub-folder is created.

a. If the number of repetitions of the SMR is one, the file name consists of the SMR name.

Example:

Root folder: C:\Sensofar		
Base name: Measure	**Date**: 26 May 2008	**Time**: 18h 28m 17s
SMR: Topo.SMR	**Positions**: 1	**Repetitions**: 1
Files: C:\Sensofar\Measure_26_may_2008_18_28_17\ Topo.plux		

b. If the number of repetitions of the SMR is more than one, the file name consists of the SMR name and the repetition tag.

Example:

Root folder: C:\Sensofar		
Base name: Measure	**Date**: 26 May 2008	**Time**: 18h 28m 17s
SMR: Topo.SMR	**Positions**: 1	**Repetitions**: 3

Files:
C:\Sensofar\Measure_26_may_2008_18_28_17\ Topo_R0001.plux
C:\Sensofar\Measure_26_may_2008_18_28_17\ Topo_R0002.plux
C:\Sensofar\Measure_26_may_2008_18_28_17\ Topo_R0003.plux

- **If the total number of SMR is more than one:**

1. If the number of positions is one:

   a. If the number of repetitions of a SMR is one, the files are saved in the MMR folder. The file name consists of the SMR name.

   Example:

Root folder: C:\Sensofar		
Base name: Measure	**Date**: 26 May 2008	**Time**: 18h 28m 17s
SMR1: Topo.SMR **Positions:** 1		**Repetitions**: 1
SMR2: Profile.SMR		
Files:		
C:\Sensofar\Measure_26_may_2008_18_28_17\ Topo.plux		
C:\Sensofar\Measure_26_may_2008_18_28_17\ Profile.plux		

   b. If the number of repetitions of a SMR is more than one, a sub-folder is created for the SMR. The name of the sub-folder is the name of the SMR. The file name consists of the SMR name and the repetition tag.

   Example:

Root folder: C:\Sensofar		
Base name: Measure	**Date**: 26 May 2008	**Time**: 18h 28m 17s
SMR1: Topo.SMR **Positions:** 1		**Repetitions**: 2
SMR2: Profile.SMR		
Files:		
C:\Sensofar\Measure_26_may_2008_18_28_17\Topo\Topo_R0001.plux		
C:\Sensofar\Measure_26_may_2008_18_28_17\Topo\Topo_R0002.plux		
C:\Sensofar\Measure_26_may_2008_18_28_17\Profile\Profile_R0001.plux		
C:\Sensofar\Measure_26_may_2008_18_28_17\Profile\Profile _R0002.plux		

The system can additionally be set to save the average of each SMR recipe in the same position, and in all positions:

- *Average All*: The average of all the individual data measured with the same recipe in all positions will be saved in the corresponding Recipe MMR folder.
- *Average in same position*: The average of all the individual data measured for each location with the same recipe will be saved in the corresponding position MMR folder.

5.11.1.2 MMR performance

Factors influencing performance

- If the MMR's list of *Positions* has:
  - One single undefined XYZ coordinate, the system measures at the current coordinate when

Acquire is triggered.

- When a key has been pressed or the countdown has finished, the system starts the measurement of the first SMR.
  - If the SMR includes Autofocus, the system will execute Autofocus prior to each measurement. Autofocus will be executed with the current light setting.
  - If the SMR includes Autolight, the system will execute Autolight after Autofocus and before each measurement. Note that Autofocus repeatability errors will have an influence on the Autolight result.

- There are two Z-Scan ranges for Autofocus: *small* and *large*

  Depending on the sample shape, use either *small* or a combination of *small* and *large*. If the differences in the focus positions within the sample are large, the application may require a different objective for Autofocus than for measurement.

Further Notes

- *Asking for confirmation* steps are not required if the system is remotely controlled using the SDK.

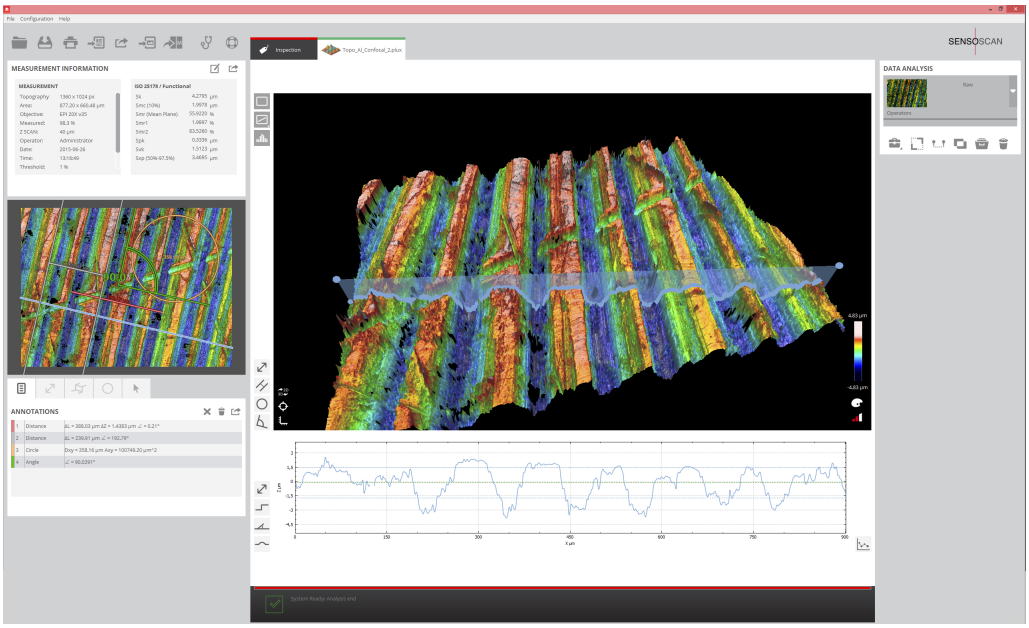
Part VI

6 Display & Analysis

Introduction

Display & Analysis mode is shown automatically either following an *Acquire* sequence or after a measurement has been loaded from file.

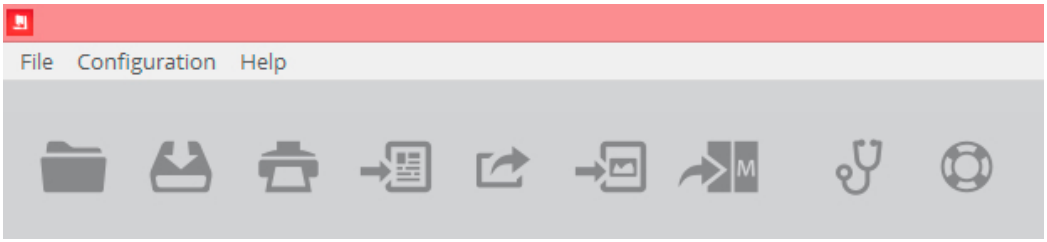
> **Note:** Although the **S onix** only acquires 3D measurements and only in B/W, **SensoSCAN**'s Display & Analysis mode is still capable of loading and displaying 3D and 2D measurements from more capable systems such as the multiple-LED **S neox**. Example images shown in this Chapter of the User Manual may have been acquired with the **S neox**. The only restriction is that the *True Color* rendering option (available only to multiple-LED systems) is not available, although rendering of B/W 3D surface measurements (i.e. those taken with a single LED) can still show depth via color coding.



Display & Analysis mode

In this mode, one sees the measurement information, parameters for any active ISO Standards, the 2D image or 2D profile in a supplementary viewer pane on the left, any annotations made, the 3D image or 2D profile of the raw or analyzed data in the Central Viewer, and details of any Data Analysis options applied to the raw measurement (right).

Note also that the Quick Bar shows a different set of icons:



Quick Bar view in Display & Analysis mode

The exact details for the measurement seen in this mode depend on several factors:

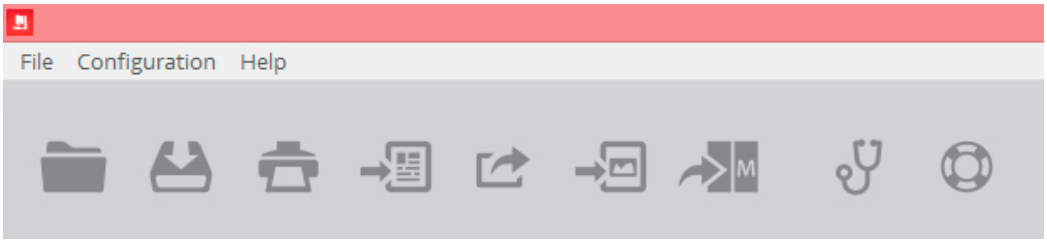
- the type of measurement made, e.g. image, 3D topography, etc. affects the details of the measurement information
- if any ISO Standards have been activated, supplementary statistical values corresponding to the different parameters will appear under Measurement Information
- for a surface measurement, the 2D image & 3D render can be toggled between the two image viewer panes
- if any Annotations and/or critical dimensions and other measurements have been applied, these will appear in the associated pane
- if a cross-section of a 3D measurement has been applied, the profile will appear under the Central Viewer pane
- the zoom value for any 3D images can be changed by scrolling with the mouse in the corresponding viewer
- the pitch and yaw of an 3D image can be changed by grabbing and dragging with the mouse

Note: If any layers (zoomed views, etc.) have been applied via the Data Analysis options, these will globally affect the determined values for any parameters mentioned above. That is, all parameters will only be valid only for the current/active/visible region of interest (portion or whole).

6.1 Quick Bar tools

Quick Bar: Overview

This section describes the functionality provided by the various icons visible in **SensoSCAN 6**'s Quick Bar when in Display & Analysis mode.



Quick Bar view in Display & Analysis mode

Note: While some of the functionality described here does remain accessible from the traditional Operating System Menu Bar, most features now more easily available via **SensoSCAN 6**'s Quick Bar. In the following, the functionality accessible from the Quick Bar will be described - functionality (also) available from the traditional Operating System Menu Bar is indicated in **green**.

You can use the Quick Bar to load, save or export a measurement, save or print a report of the data, push the raw data over to **SensoMAP** and other data manipulation software (if available), or to export specific details visible in Display & Analysis mode (images, annotations, etc.).

The Quick Bar also provides access to this Help document as well as to System Preferences.

The Quick Bar (in Display & Analysis mode)

This folder icon opens the standard **File / Open** dialog of the OS, allowing a previous measurement to be loaded from file.

Note that **SensoSCAN 6.x** saves all measurements as **.plux* files. This file format contains the raw measurement together with a list of the Data Analysis options that were applied. On loading a previous measurement, the software automatically enters Display & Analysis mode and (re-)applies all the Data Analysis options used before the measurement was last saved to file. See Appendix for further information relating to **SensoSCAN**'s file formats.

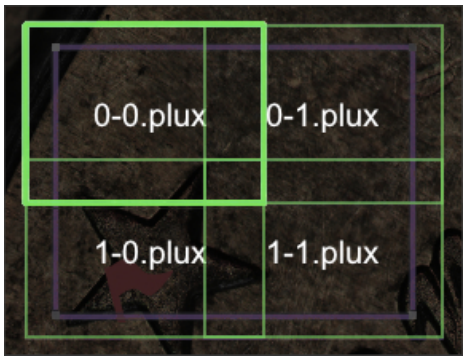
Selecting **File / Offline extended topography** from the Menu Bar (not available from the Quick Bar) provides access to a tool that imports and stitches a collection of individual topographies. Important points to note are:

- The 4 different stitching correlation options - *None*, *Smart*, *Z* & *XYZ* - are as follows:
  - *None*: The topographies are stitched without any adjustment.
  - *Smart* (the default algorithm): The topographies are stitched using an iterative algorithm. This algorithm is useful for samples with holes or non-measured areas, or for flat surfaces

measured by VSI or PSI.

- *Z*: Rows are stitched to one another by calculating the Z correlation between them. This option is suitable for smooth surfaces with structures.
- *XYZ*: The software will also take into account the correlation in the XY axis. At high magnifications, XY stage accuracy errors can be introduced into the topographies, in which case the XYZ correlation is recommended. It is suitable for surfaces such as grids.

- File nomenclature must comply with SensoSCAN's own format when saving Extended Measurements (e.g. with the S neox), namely y-x.plux, where y refers to the location in the column and x refers to the location in the row (both starting with '0'), i.e.:



Once **SensoSCAN** has loaded the file, it creates an extended **.plux* file and shows it in Display & Analysis mode as a new result. This option is also available as a call from the SDK.

Selecting **File / Import / Import plu** from the Menu Bar (not available from the Quick Bar) enables import of a **.plu* file (the file format for **SensoSCAN 5** and earlier). See Appendix for further information on using **.plu* and **.plux* files within **SensoSCAN 6**.

Selecting **File / Import / Import coordinates** from the Menu Bar (not available from the Quick Bar) enables import of a coordinate text file (e.g. from an external source). For files with a minimum of 10 values, **SensoSCAN** displays the topography by interpolating the values between the given coordinates. For a thickness measurement, **SensoSCAN** also generates the thickness topography.

- When selected, a dialog appears to determine if the color map will be related to a Z value or a thickness (multi-)layer.
  - The file format for surface coordinates is: *Xvalue [Space] Yvalue [Space] Zvalue*, e.g.

    42827.52000 -78.76000 -37701.167772

    42927.52000 -78.76000 -37702.055028

    43027.52000 -78.76000 -37702.189472
  - The file format for thickness is: *Xvalue [Space] Yvalue [Space] Th1 [Space] … ThN*, e.g.

    42827.52000 -78.76000 113.167772

    42927.52000 -78.76000 114.055028

    43027.52000 -78.76000 113.189472

Note: Any non-measured points are given by the 'NAN' text.

- Once **SensoSCAN** has loaded the file, it creates the corresponding **.plux* file and shows it in Display & Analysis mode as a new result.

This icon opens the standard **File / Save** dialog of the OS, allowing the current measurement to be saved, or a previously loaded measurement to be saved under the same name or a different name.

Note that **SensoSCAN 6.x** saves all measurements as **.plux* files. This file format contains the raw measurement together with a list of the Data Analysis options that were applied. See Appendix for further information relating to **SensoSCAN**'s file formats.

New measurements are named automatically by using a tag comprising the Measurement type, the date and hour, e.g. *Topography_20150601_183210.plux*. If necessary, the user can change to a preferred nomenclature within the **File / Save** dialog, or simply rename the file normally within the OS.

Selecting **File / Save as RAW** from the Menu Bar (not available from the Quick Bar) creates a new **.plux* file by permanently applying all filters, operators and layers that are currently active in Display & Analysis mode to the raw data of the measurement. See Appendix for further information.

Note: See below for exporting a measurement in the **.dat* format.

This icon opens a standard report print function that has been integrated into **SensoSCAN 6**. The pre-formatted data measurement report can be either sent directly to any available printers or saved to file (PDF or SVG).

The print function previews the report before printing. All information for the report is taken from the settings for the current measurement. The parameters shown are the ones selected in the measurement information section. The logo can be personalized copying the new one on C:\tmp folder under the name logo.png. Choosing the appropriate icon in the preview window then sends the preview to the printer, generates a PDF file or generates an SVG file, respectively.

This icon opens an export dialog so that the measurement can be exported in the **.dat* format. Points to note when saving a measurement to the **.dat* format are:

- scale units are micrometers (µm)
- the Z value assigned to any non-measured points is 1000001 µm
- in the **.dat* format, the raw data is saved as text. If the display is in three dimensions, such as 3D or contour, the file contains three columns: the first and the second are the X and Y coordinates respectively, and the third is the Z-axis data. Otherwise, the file contains two

columns: the first is the X-axis (horizontal) coordinate and the second is the Z-axis (vertical) data. For example, if the display is a profile, the file will contain X and Z values. The resolution of the data is as follows: X and Y: 9.999 µm, and Z: 9.999999 µm.

This icon opens up an *Export Graphic* dialog (see also **File / Export graphic**). This option allows the user to export the 3D measurement or 2D profile visible in the Central Viewer pane in the format specified in System Preferences. The exact image visible here - and thus also exported - will depend on the active layer and any Data Analysis options applied to that layer. See also Export Image.

This icon exports full resolution images to the user folder. The file format is selectable between **.tif, *.tiff*, **.fp-tiff*, **.png*, **.bmp* and **.jpg* under System Preferences.

This icon sends the current raw measurement or a previously loaded measurement to the **SensoMAP** or other software. So that the data can be transferred, the **SensoMAP** software must be running.

> **Note:** Only the raw measurement is passed onto **SensoMAP** - any Data Analysis options applied in **SensoSCAN** are NOT carried over. Use *Save as RAW* (see above) as a workaround to this.

SensoMAP is based on Mountains technology and is a state-of-the-art surface analysis software. Typical uses for **SensoMAP** include off-line 2D/3D surface characterization in R&D departments and laboratories, and near-line process control in production facilities (usually 2D). **SensoMAP** is available as an option from Sensofar.

This icon (also **Help / Diagnostics)** opens a diagnostics menu path that provides access to technical log files. These log files are not normally relevant for everyday measurement tasks.

This information can, however, be very useful when troubleshooting problems with the system, for example in order to remotely reproduce or understand customer issues. In this case, all or specific log files may be requested by a technician or by Service & Support for diagnostic analysis.

At the bottom of the diagnostics pane opened with the icon, there are two options for securing a system back-up for diagnostic purposes:

- *Generate backup zip*: Creates a zip with all the configuration, calibration, logs, etc. files used

by the system.

- *Generate report zip*: Same as *Generate backup zip* but does not copy large files.

More information regarding diagnostics can be found in the Errors & Diagnostics.

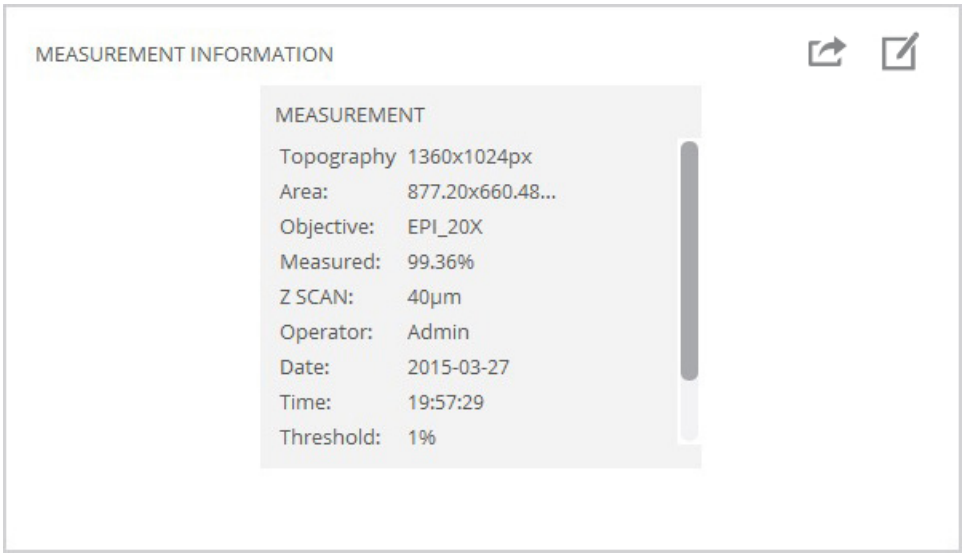
This icon is the same as selecting **Help / Contents** from the Menu Bar. Both open this User Manual.

Additionally, selecting **Help / About** from the Menu Bar (not available from the Quick Bar) opens a system window showing the following information: the program version, the serial number of the system, the company and the current user.

6.2 Measurement Information

Viewing Measurement Information

The Measurement Information pane always shows the basic details of the measurement:



Measurement information for an acquired measurement or for a measurement loaded from file (no ISO Standards active)

These values reflect the settings chosen for the measurement: Measurement type, area measured, the percentage of successfully measured points, Z-scan, user, the time required for the acquisition, (multi-) light settings, effective pixel size, etc. etc..

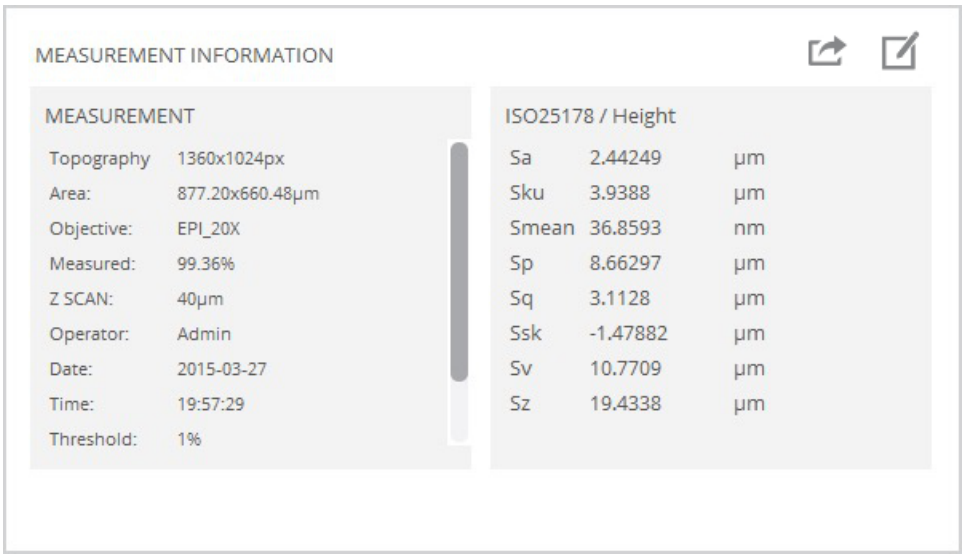
The percentage of data points successfully acquired is given by the term *Measured*. For 3D topography measurements this value can be 100%, but is usually less (i.e. there are non-measured data points). For 2D profiles and for images this value is not given. Note that use of the Restore and Retouch operators can change this value.

Viewing ISO Standards parameters

The Measurement Information pane can also show values corresponding to any active parameters chosen from the ISO Standards that have been implemented in **SensoSCAN 6**.

> **Note:** The topic of ISO Standards is discussed extensively in the Appendix, and will not be repeated here.

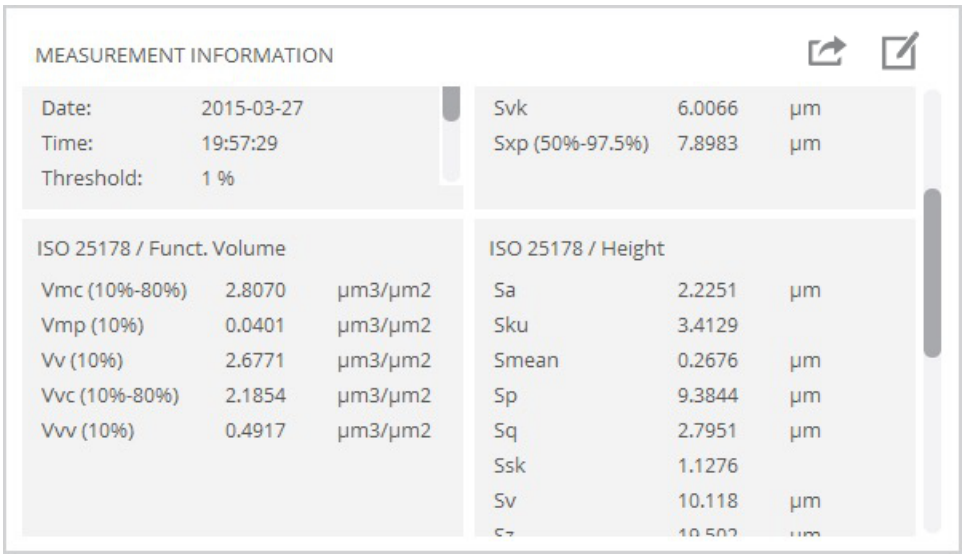
The different ISO Standards can be accessed by clicking the parameters configuration icon and activating/deactivating individual parameters or parameter families as desired. If this icon is not visible, it is because (further) options for this Measurement type are not available (e.g. for images). Upon exiting the configuration dialog, the values for any active ISO Standards parameters, or for complete parameter families, are now also visible in the Measurement Information pane:



Supplementary 3D Surface Texture parameters according to ISO 25178 / Height

The displayed information contains, for example, the point with the maximum height (*Sp*), the point with the minimum height (*Sv*), the average (*Smean*), the peak to valley (*Sz*), the root mean square (*Sq*) and the *Sa* (for 3D views).

When many parameters have been activated, they appear in a separate panel for each parameter family. It may be necessary to scroll in the Measurement Information pane in order to make specific parameters visible:



Multiple parameter families are made visible by scrolling

The values can be exported by clicking on the export icon . The *.csv file contains the parameter name, units and values. Units are automatically selected depending on the value.

Important points to note for ISO Standards

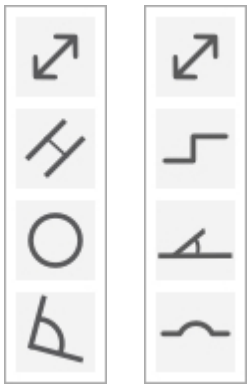
- Different ISO Standards apply to the various Measurement types, thus it is important to note that there are different ISO Standards for 3D and for 2D measurements.

- The parameter values displayed following an acquisition are only valid if the data has been analyzed (processed) according to ISO regulations.
- Spatial parameters can only be calculated when all the points have a height value. Therefore, when measured points are not 100%, the measurement must be Restored.

6.3 Annotations

Overview

Various Annotations can be made to a measurement to highlight and measure specific features of a 3D topography measurement, of a 2D profile measurement, of the 2D section through a 3D measurement (profile) or (in some cases) of the histogram of a 3D measurement. Tools for creating Annotations are placed bottom left of the Central Viewer ('mouse over' for tips):



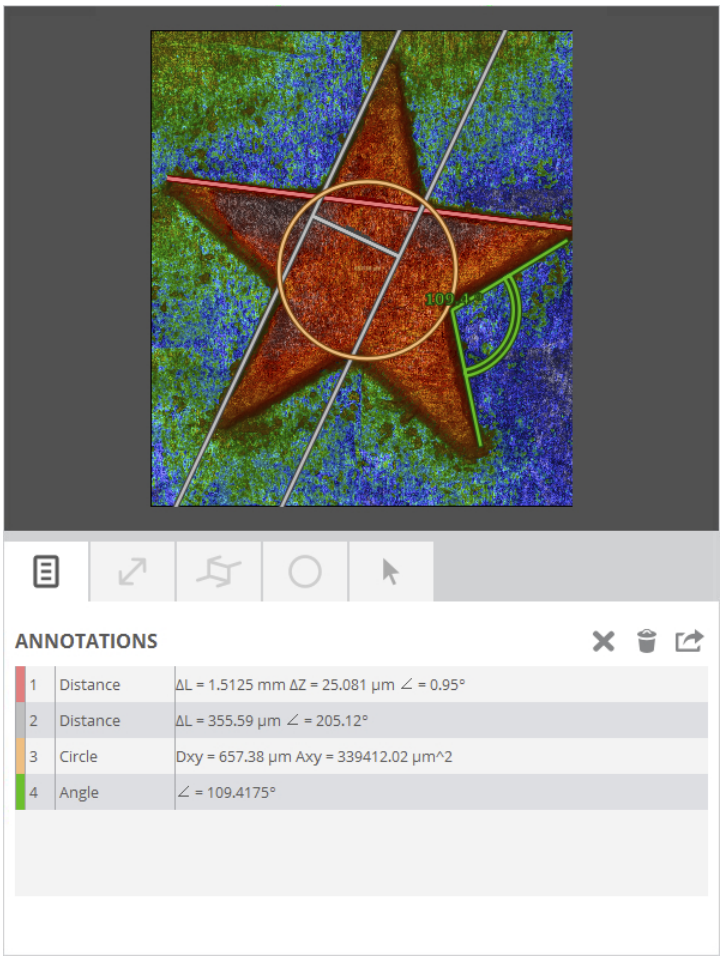
3D surface (left) and 2D profile annotation tools

There are four Annotation types for 3D surface measurements - *distance*, *parallel*, *circle* and *angle* (top to bottom) - and four Annotation types for 2D profiles and histograms - *distance, step height, radius* and *angle* (top to bottom). These appear and can (in most cases) be adjusted interactively on the appropriate display. Their associated dimensions and/or parameters also appear on the same display.

Any Annotations applied to a surface or to a profile, as well as their associated dimensions and/or parameters, are also listed in a pane positioned below the supplementary viewer (see image below), both as a complete list and grouped together based on type. Using additional the icons in the Annotations pane , Annotations can be deleted individually, deleted all together or exported as a table (**.csv*), respectively.

3D Annotation tools

The four annotation tools for 3D areal measurements - *distance*, *parallel*, *circle* and *angle* - are straightforward to use and are illustrated well in the image below. By clicking each tool icon, the interactive tool appears in the 2D representation of the 3D surface. Its position and size can be changed by simply grabbing the anchor points with the mouse and adjusting as necessary.



Critical dimensions can be annotated onto the result to label and highlight features and to show their dimensions

2D annotation tools

The four 2D Annotation types - *distance, step height, radius* and *angle* - are designed to be used on measured 2D profiles and on 2D profiles of 3D measurements, in some cases on histograms of 3D measurements (*distance* and *step-height* only).

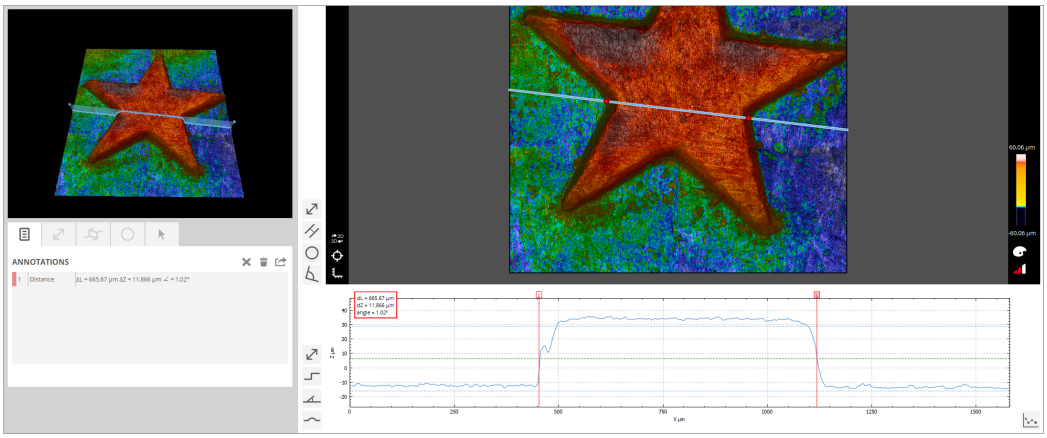
Their use is a little more complex than for 3D Annotations. Note that:

- for a 3D areal measurement, the user first needs to define a 2D profile of the surface or choose the histogram option - the associated profile and Annotations appear in the 2D profile pane below the Central Viewer
- for a 2D profile measurement, the profile itself appears in the Central Viewer, as do the Annotations applied
- in all cases, the overall size and scaling of the Annotation will match the scaling option chosen for the viewer (see icon lower right of 2D profile viewer)
- as for 3D, all 2D Annotations are listed in the pane on the left of the Display & Analysis interface (note that for a 2D profile measurement, the supplementary viewer is not available)

Distance

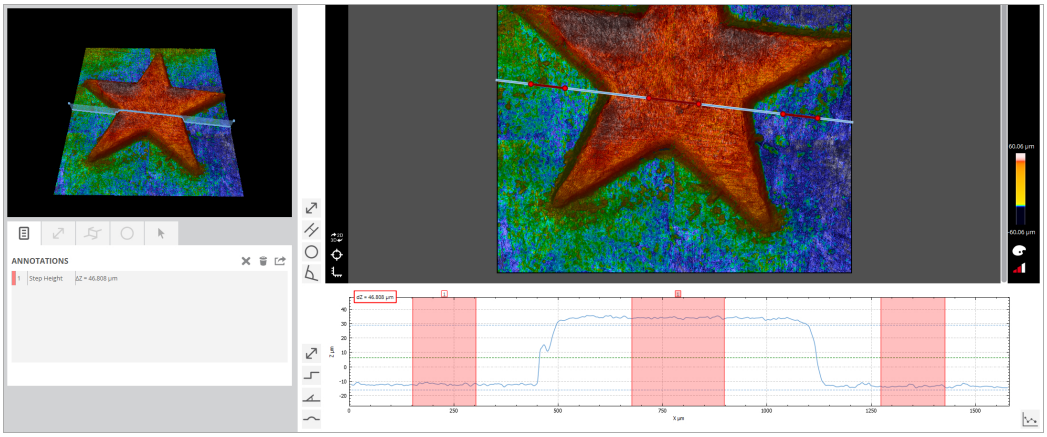
Once the desired 2D profile has been defined or the histogram option chosen, clicking the appropriate

icon activates the *Distance* tool. Now define any two points on the profile using the 'click - hold - drag - release' function of the mouse. Both points can be re-positioned by grabbing with the the mouse.



Step-height

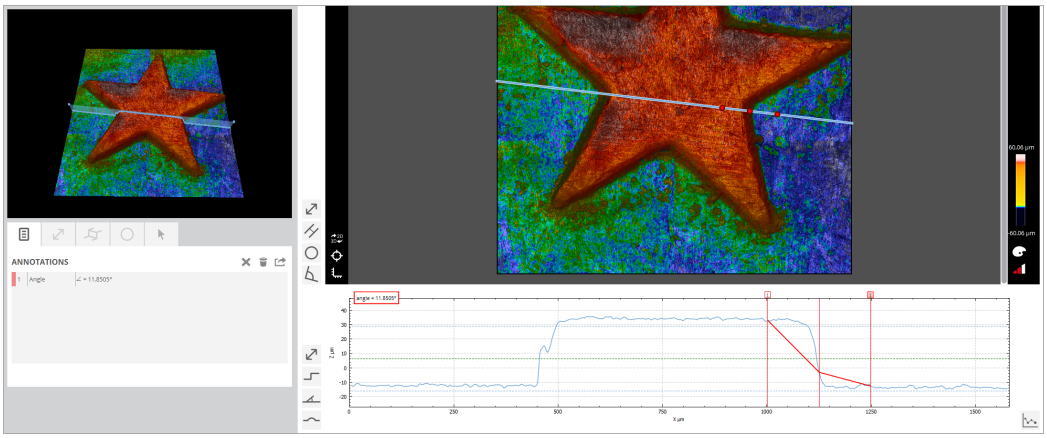
The Step-Height tool is an automated routine that acts only on the viewable 2D profile. It is not user-editable. Once the desired 2D profile has been defined or the histogram option chosen, next use the mouse to zoom and scroll the profile so that only the desired region of interest (ROI) is visible. Next click the appropriate icon - the *Step-Height* tool is then activated by simply clicking anywhere on the ROI.

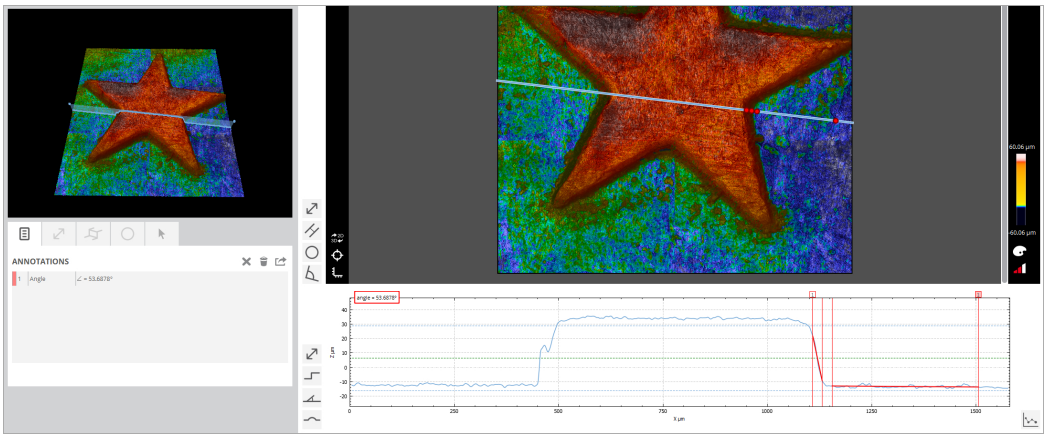


Angle

Once the desired 2D profile has been defined, clicking the appropriate icon activates the *Angle* tool. Now define two points on the profile using the 'click - hold - drag - release' function of the mouse. Four points now appear on the profile (the central two points initially overlap). All four points can be re-positioned by grabbing with the the mouse - for example, so that two unconnected planes can be compared.

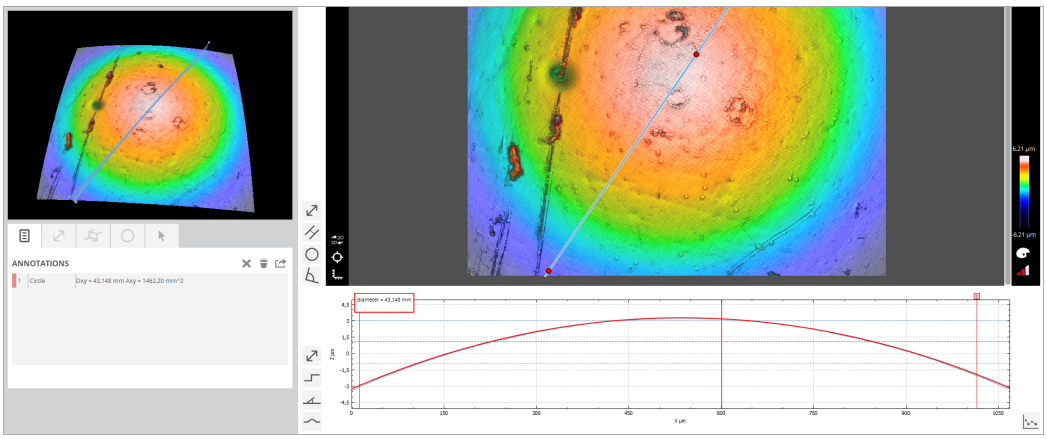
> **Note:** Don't forget to account for scaling (see icon lower right of 2D profile viewer) if the resulting angle appears to be much less than the apparent angle seen in the profile viewer.





Radius

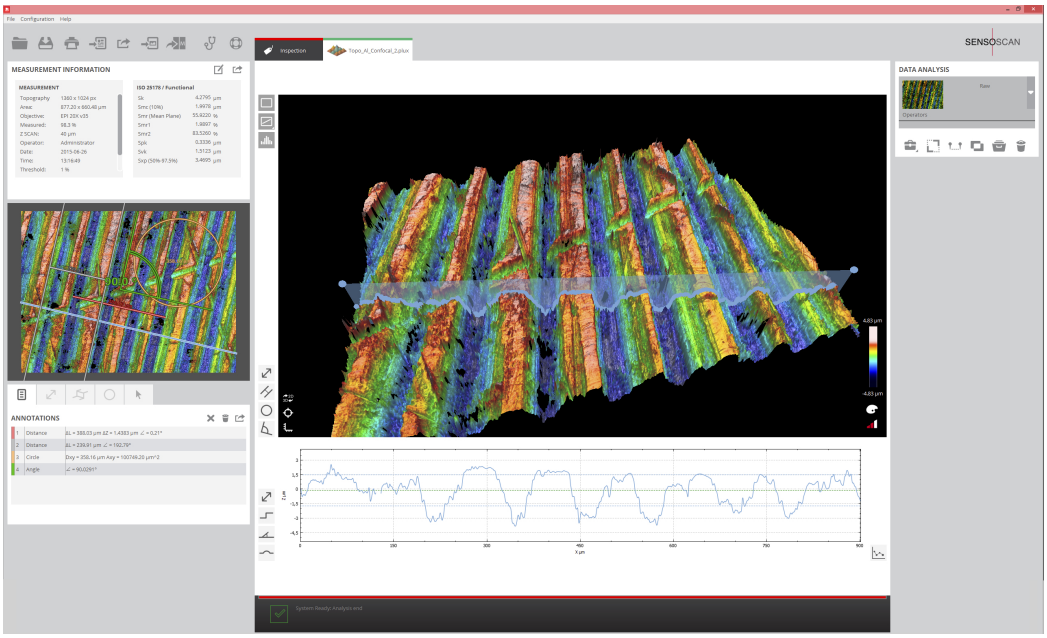
Once the desired 2D profile has been defined, clicking the appropriate icon activates the *Radius* tool. Now define any two points on the profile using the 'click - hold - drag - release' function of the mouse. Three points appear on the profile (three points are required for the fit to a circle). Each point can be re-positioned by grabbing with the the mouse.



6.4 Measurement Display

Overview

In Data & Analysis mode, the Central Viewer changes its layout and options from that in Inspection & Acquisition so that the measurement can be displayed appropriately. Any available viewer features and options will depend on the Measurement type - most of the those discussed below are largely applicable only for 3D surface measurements.



Display & Analysis mode

For displaying images and 3D topography measurements, the user can choose between *Clean*, *Profile* and *Histogram* using the icons on the upper left:

***Clean*, *Profile* and *Histogram* tool icons (top to bottom)**

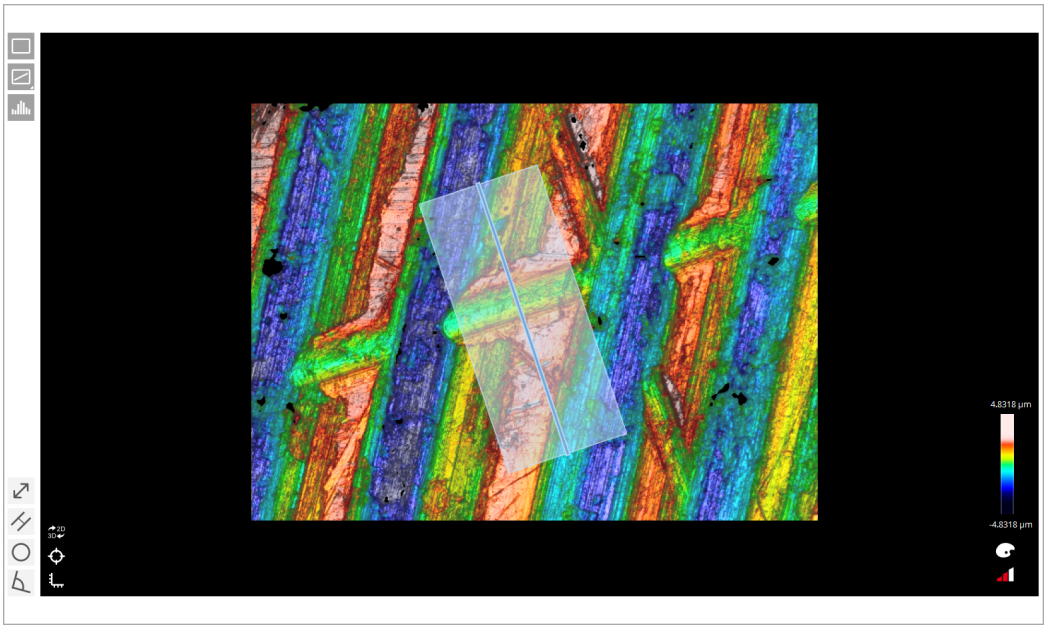
The *Clean* tool icon displays the raw measurement. Re-selecting *Clean* at a later stage removes either of the following two display options, *Profile* and *Histogram*.

If the acquired measurement is 3D or an image, clicking the *Profile* tool icon displays a cross-section through the image as an overlay on the Central Viewer and supplementary viewer, while the 2D profile of this cross-section is displayed below the Central Viewer (see image above):

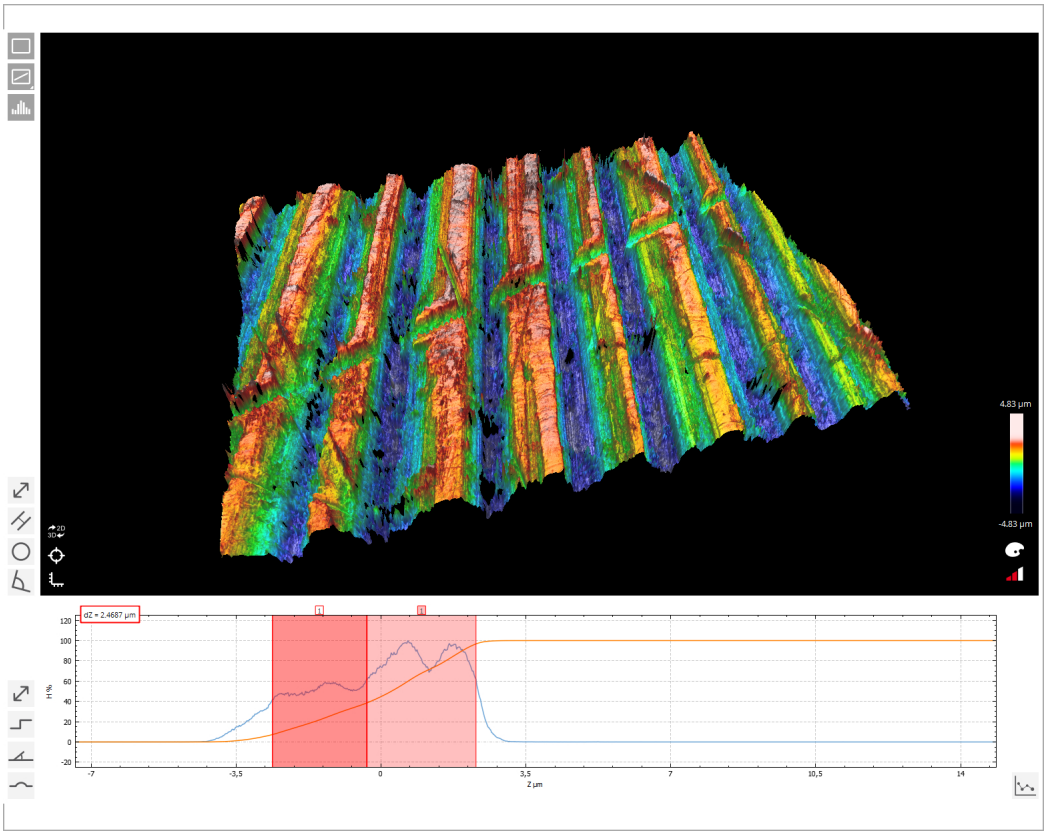
- by grabbing (click & hold) the line overlay or the end points with the mouse, either in the 2D or 3D view, the exact position and length of the profile can be set interactively

- right-clicking the *Profile* tool icon provides access to 3 standard profiles (vertical, horizontal and 45 degrees)
- by right-clicking the line overlay in the viewer, the breadth of the profile can be extended to cover a wider ROI - the 2D profile displayed below the Central Viewer is the average profile for the selected ROI

Note that all necessary 3D operator and filter steps should be first applied to the 3D measurement, followed by activation of the *Profile* tool. Once the desired 2D profile has been selected, 2D operators and filters can then be applied to the measurement.



Alternatively, a histogram of the image or data can be displayed using the *Histogram* tool icon. The histogram is displayed below the Central Viewer. It shows the percentage of measured points per Z coordinate interval. The histogram value is thus equal to the portion of total measured points that fall into this Z interval. This display is useful for surface analysis, such as step height measurements (see Annotations).

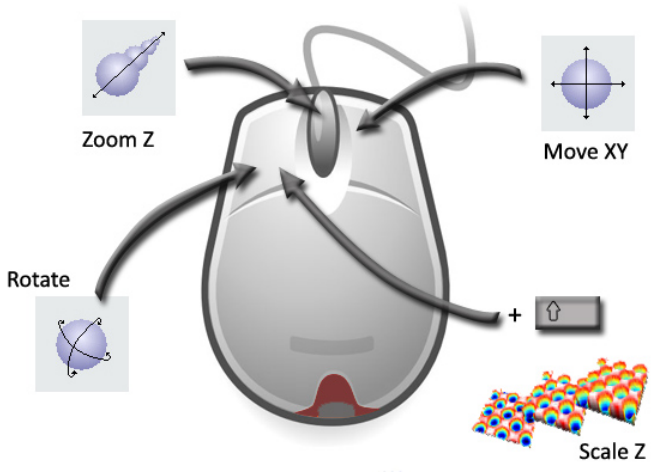


Histogram plot below the 3D display, with *Step Height* Annotation applied

Various Annotation tools can be used - dependent on whether an image, a 3D measurement or a 2D profile - to determine separations between points, widths or diameters of features, step heights and dimensions of other features visible in the raw data. The Annotations are mostly interactively editable on either viewer pane or on the 2D profile below the Central Viewer. Annotations can be viewed in groups, individually removed and exported using options in the Annotations pane.

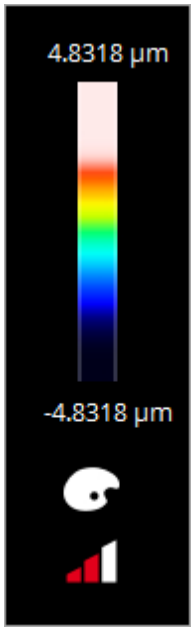
The 3D display and the 2D depiction of the same data can be toggled between the Central Viewer & supplementary viewer by clicking the appropriate icon. The 3D view can also be reset and/or rulers applied (image export with Z axis scaling can be toggled in System Preferences):

3D surfaces can be rotated, translated or scaled by clicking and dragging on the screen using the mouse. The surface can be rotated by pressing the left button of the mouse, scaled by pressing the left button of the mouse and the shift key simultaneously, and translated by pressing the right button and zooming by moving the scroll.



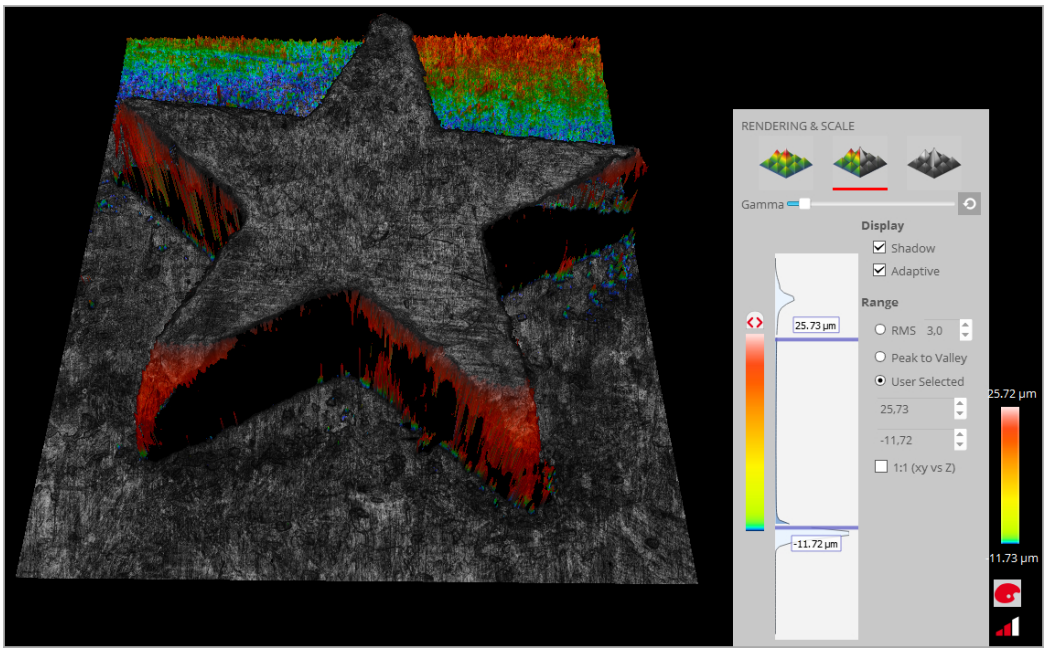
Rendering & Scale

Display (rendering & scale) of the raw or 'operated' measurement can be changed by clicking on the tool icons in the lower right hand corner of the Central Viewer:



The vertical compression of the image can be determined using the 3 bars below the palette icon (compressed, normal and extended).

When clicking on the palette icon, rendering options are then revealed in an overlay panel. Note that the overlay panel can be re-positioned with the mouse.



Rendering & Scale overlay panel, showing the different options

The rendering options include:

- *Visualization* options (icons across the top of the pane):
  - *False color*, *False color + Stack*, and *Directional luminance* color options are available depending on the image type (color image, 3D measurement, etc.).
- Image *Gamma*
  - This slider can be used to modify contrast in the render. By clicking the icon at the right hand end of the slider, the *Default* value can be selected.
- *Display* checkbox options:
  - *Shadow*, available for *False color* and *False color + Stack*, throws shadowing across the render to better highlight detail
  - *Adaptive*, available for *False color* and *False color + Stack*, makes the color scaling non-linear to better show detail across (e.g. multiple) flat sections on the surface
  - Note that there are no *Display* checkbox options for *Directional luminance*. However, when this visualization option is chosen, a rotary dial appears to specify the direction of illumination (light and shadow) across the render.
- *Range* selection (determines the height/color coding for all *Visualizations*):
  - The *RMS* option displays the Z interval between the average point minus the selected rms value, and the average point plus the rms. The highest and lowest colors of the color scale are assigned to the extremes of this interval, where the rms value can be specified by the user.
  - The *Peak to Valley* option displays the Z interval between the maximum and minimum measured values, and assigns the highest color to the highest point of the measurement (max), and the lowest color to the lowest point (min).
  - The *User Selected* option allows the user to specify the maximum and minimum of the

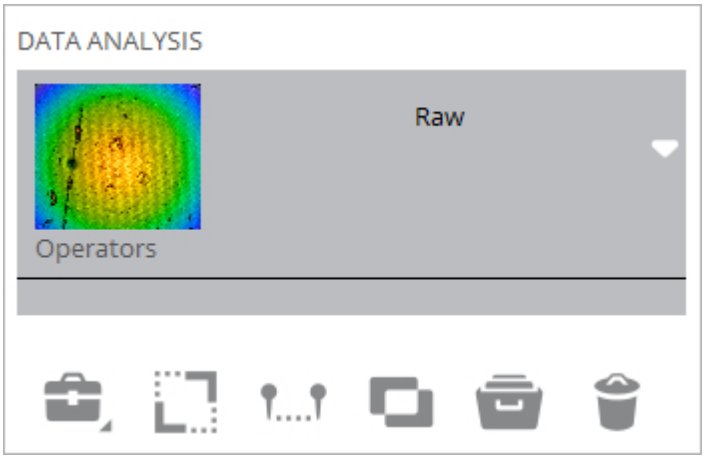
scale. The initial *User Selected* option is limited to the *Peak to Valley* range, but these values can be changed manually by directly typing into the parameter windows. Also note that by moving the sliders on the histogram manually as desired, at any time, the display automatically switches to *User Selected* mode.

- *1:1 (XY vs. Z)* display option:
  - *1:1 (XY vs. Z)* is a special *Peak to Valley* mode that renders the image on the same scale for all axes, i.e. scaling of the *Z* axis is the same as for X and Y.

Note that colormap selection can be toggled between *Full Color* (RGB)*, Black & White*, *Yellow & Red* and *Viridis* (HSV-based, provides easier visual interpretation) by clicking on the small icon at the top of the color scale. Lastly, the background color for the render can be changed in System Preferences.

6.5 Data Analysis

Overview



SensoSCAN 6 provides a comprehensive suite of operators and filters for examination and analysis of a measurement. The user has the opportunity to:

- Retouch - set the selected data points to 'non-measured'
- Restore - interpolate missing (non-measured) data in a measurement
- apply form removal (plane, sphere, polynomial)
- cropping, layer subtraction, profile extraction
- etc.

Some of these operators and filters are '3D only', '2D only' or can be applied to either. This is indicated in the following subsections.

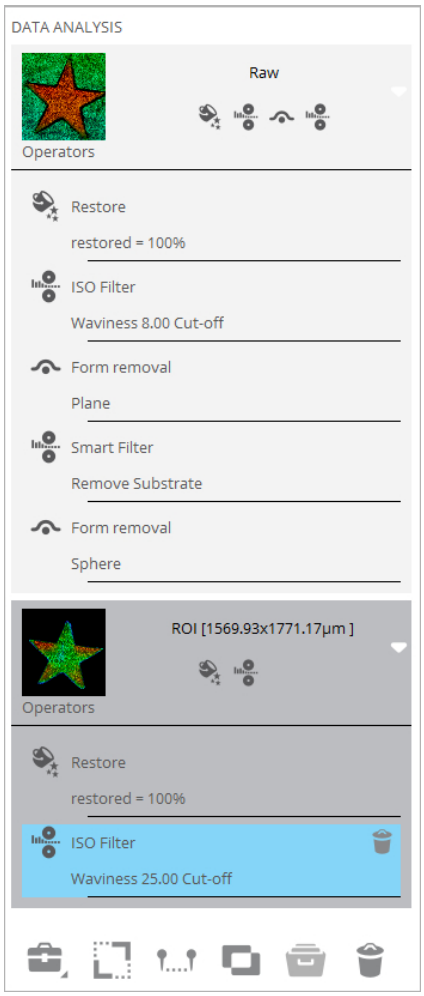
More complicated data analysis and even data processing (i.e. modifying the raw data) are reserved for external applications, such as **SensoPRO**.

Operators and Layers in SensoSCAN 6

In normal use, the raw data of a measurement always remains unmodified in **SensoSCAN 6**. This remains the case even over repeated 'open, analysis and save' cycles of an existing measurement. In Data & Analysis, one can only apply a linear sequence of reversible filters, operators and layers to the data, yielding different visualizations of the measurement.

> **Note:** Use *Save as RAW* to permanently apply filters, operators and layers to a measurement. See Appendix for further information.

New data layers can be generated from the raw data by cropping, by creating a 2D profile (section) through a 3D measurement or by subtracting another data set from the current measurement. Thickness measurements can be extracted into upper, lower or thickness layers. Other operators can then be applied individually to each new layer.



Note: Deleting an operator will also delete successive operators as well as any new layers that depend on it.

When saving a measurement to file, all data layers, the operators currently applied to each layer, and their order are saved together with the raw data. When the file is re-opened, the raw data is loaded and the operators and layers reapplied in the same order. Operators and layers can be deleted, and/or other operators and layers added, and the measurement can then be re-saved with the new operator and layer set, or saved as a new file under another name.

6.5.1 Restore & Retouch

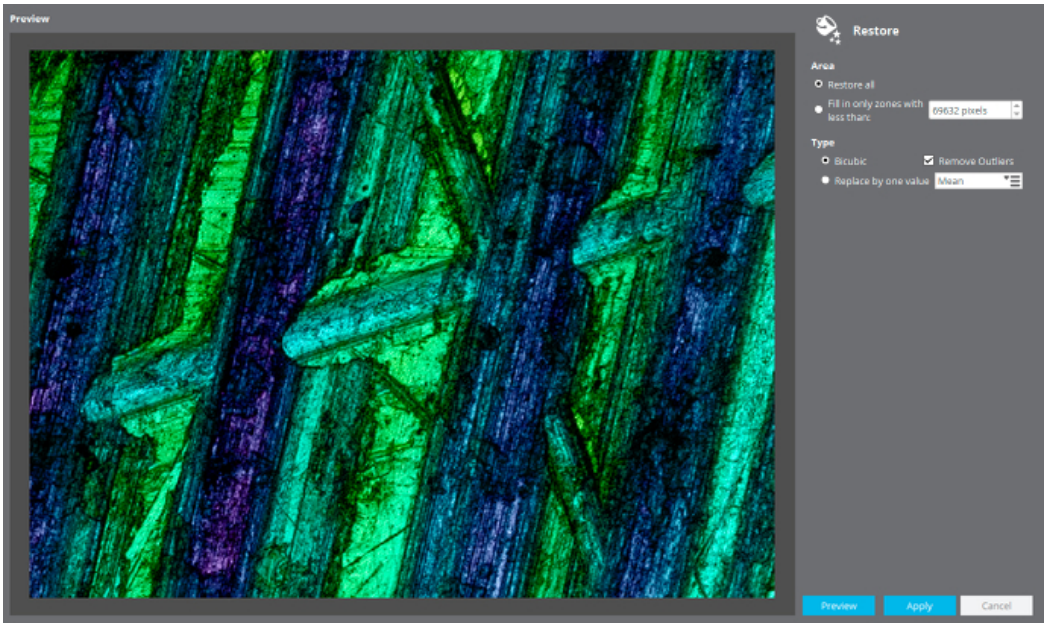
Restore (2D/3D)

The Restore operator is used to fill (replace) non-measured data points with more usable values. This is done either by using adjacent 'good' data to interpolate a replacement value, or by simply replacing all non-measured points with a fixed value. The options available are:

- *Area*
  - *Restore all* applies the change to all non-measured points in the measurement.
  - Alternatively, selecting *Fill in only zones with less than ...* means that only clusters of adjacent non-measured points below a user-defined number of points will be Restored

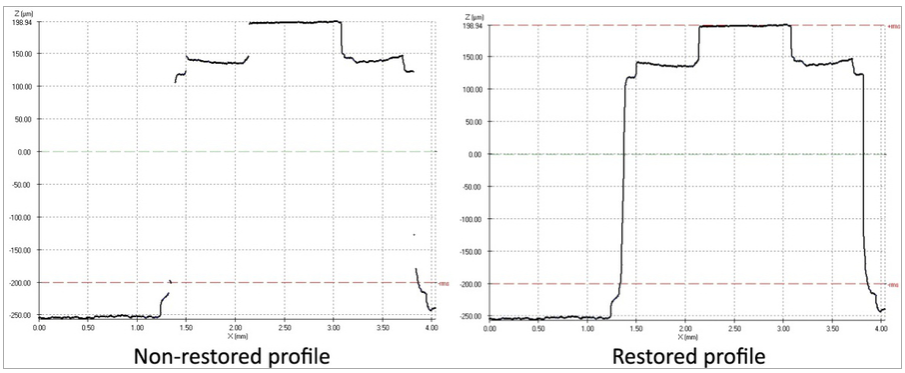
(larger regions are thus left unchanged).

- *Type:*
  - *Bicubic* refers to the algorithm used for adjacent good data when interpolating values for non-measured points.
  - ... *Bicubic* can be used together with *Despiking* to first remove erroneous data (outliers, or spikes) in the measurement (also available under Filters).
  - *Replace by one value* replaces the non-measured points with the *Minimum*, *Mean* or *Maximum* value in the measurement.



Options in the Restore pane

In case of large areas with non-measured points, the problem areas are filled using a constant value (the minimum height), calculated for all points of the surface.



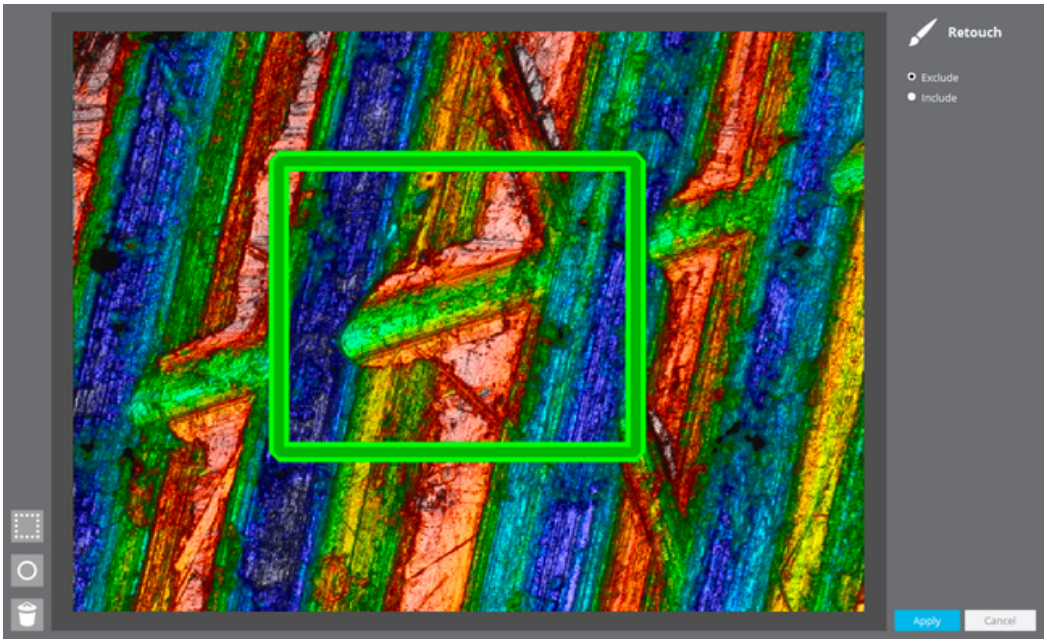
This function should not be confused with by the option *Copy substrate to S1 and S2* found in the Layer pane (and which is thus only relevant for Thickness measurements). This option substitutes in real data to fill apparent gaps in a coating, whereas the Restore operator generates replacement values via interpolation from the surrounding points.

Retouch (areal 3D only)

The Retouch operator is used to set a range of data points as 'non-measured'.

When using the Retouch operator, the user can select single or even mixed multiple rectangular area and oval/circular regions of the measurement (see icon tools to the left of the pane).

The *Exclude* / *Include* option toggles which regions of the measurement are Retouched - *Exclude* means that the user-selected regions are changed to be 'non-measured', *Include* means that the regions outside of those selected are changed to be 'non-measured'.



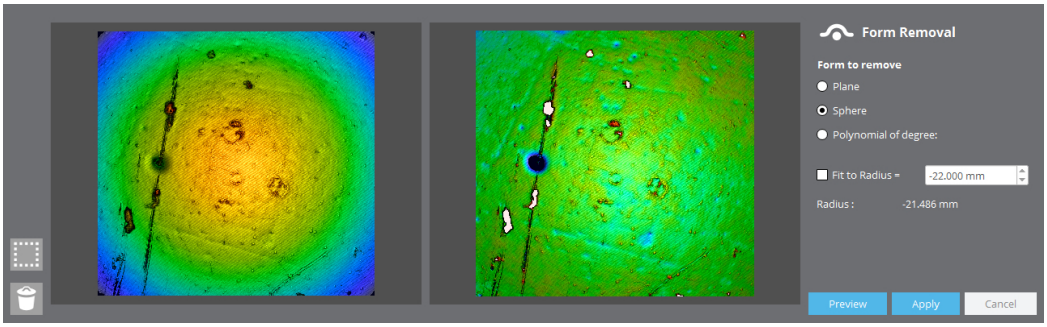
Use Retouch to set data points to non-measured - *Exclude* will only change those data points outside of the square, *Include* will change those data points inside

Using the Retouch operator followed by the Restore operator, noisy or 'out-of-range' data can be removed and then filled using Restore (interpolation).

6.5.2 Form Removal

Overview

The Form Removal operator is used for samples that need to be leveled due to a tilt (linear form),due to an inherent spherical component, or because it exhibits an unwanted polynomial term:



- Plane (3D only) or Line (2D only) fits the best linear mathematical function and removes it from the measurement. This option is most useful for those samples that have been measured with a significant tilt. The operator can be used on the whole measurement, on a selected triangular or rectangular area of the sample (see icon tools to the left of the pane), or (for a 2D profile) between two user-specified points.
- Sphere (3D only) or Circle (2D only) fits a nonlinear mathematical function, removes it, and shows the radius of curvature. The radius of curvature can be fixed by the user by enabling Fit to Radius and entering the desired value - the software removes the sphere with the set radius that best fits the measured results. The operator can be used on the whole measurement or on a selected rectangular area of the sample.
- Polynomial (3D only) removes a multiple order polynomial surface or line (max. 12 orders) from the measurement. The operator can be used on the whole measurement, on a selected triangular or rectangular area of the sample (see icon tools to the left of the pane), or (for a 2D profile) between two user-specified points.

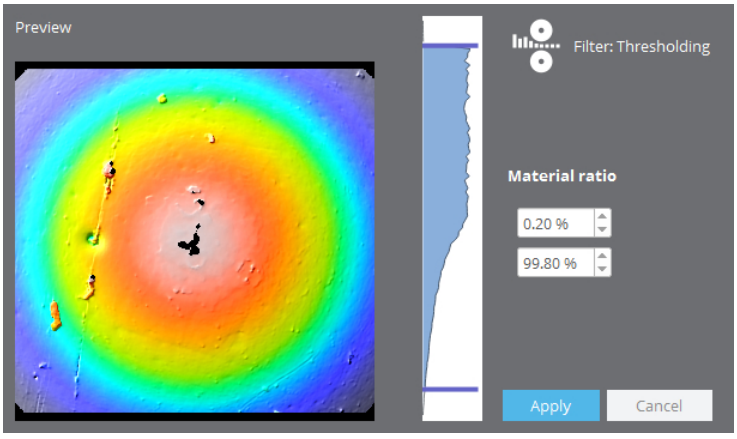
6.5.3 Filters

Overview

The Filter operators (*Thresholding*, *Smart*, *Kernel*, *ISO* and *FFT*) are used to modify the raw measurement data based on available statistical information. One can filter to remove roughness or waviness parameters, analyze the measurement according to surface texture standards, or simply apply median and enhancement filters.

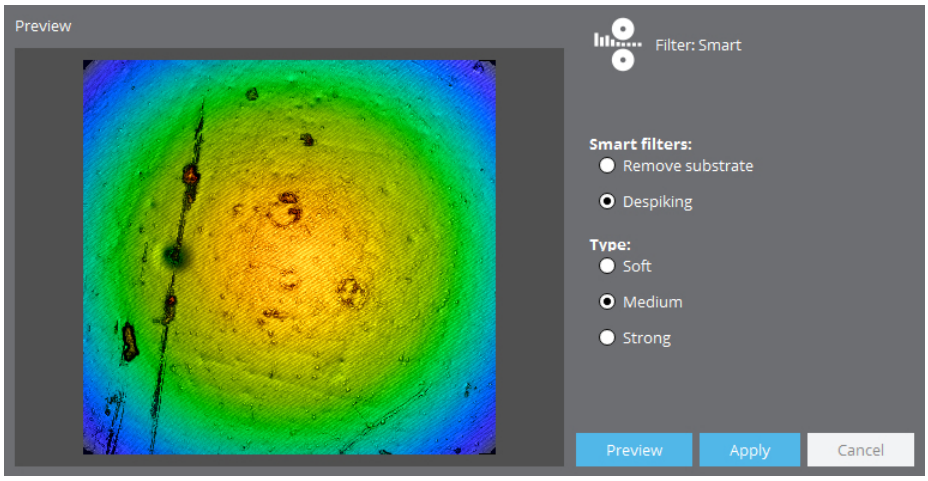
Thresholding (3D only)

Filters the data by adjusting sliders on a histogram of the data 'fitness'.



Smart (3D only)

Filters the data by either removing the substrate or de-spiking:

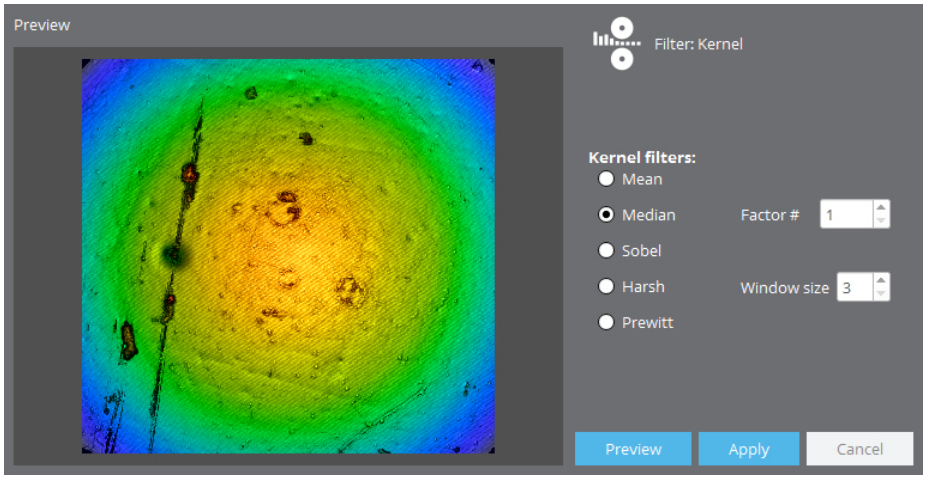


The *Remove substrate* filter is designed to remove the substrate from the measurement when the surface comprises a substrate with some structure. It is useful when the goal is to analyze the shape and characteristics of the structures, but not the substrate. The substrate points are points that have a Z value that is very similar to the average value of the whole surface: (Zavg - Zrms) < Z < (Zavg + Zrms).

The *Despiking* filter is designed to delete noise peaks from the surface. To distinguish which are good or noise points, the software calculates the average and the standard deviation in an area of 5x5 pixels for each 3D measurement pixel. Then, if the values are too different, these points are rejected and classified as lost pixels. The filter has three levels: soft, medium and strong.

Kernel (2D/3D)

Filters the data by applying various algorithms (Mean, Median, Sobel, Harsh and Prewitt):

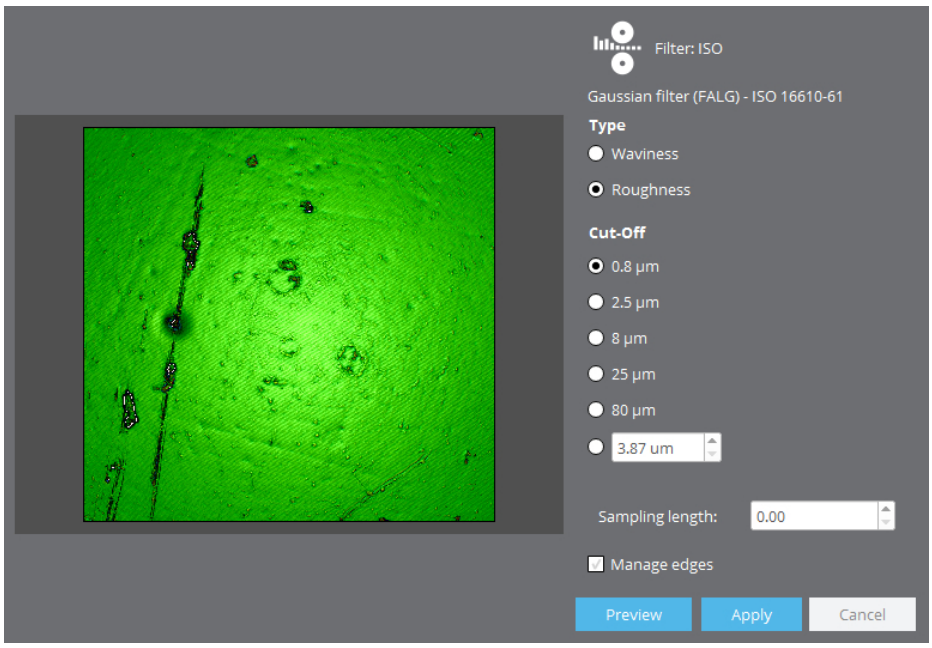


- Kernel filters are applied in a neighborhood of NxN pixels
- Mean and Median filters are used to smooth the measurement
- Harsh filter is used to sharpen the measurement
- Sobel and Prewitt filters are used to show slopes in two different directions

Examples of filters: (a) Harsh, (b) Sobel and (c) Prewitt

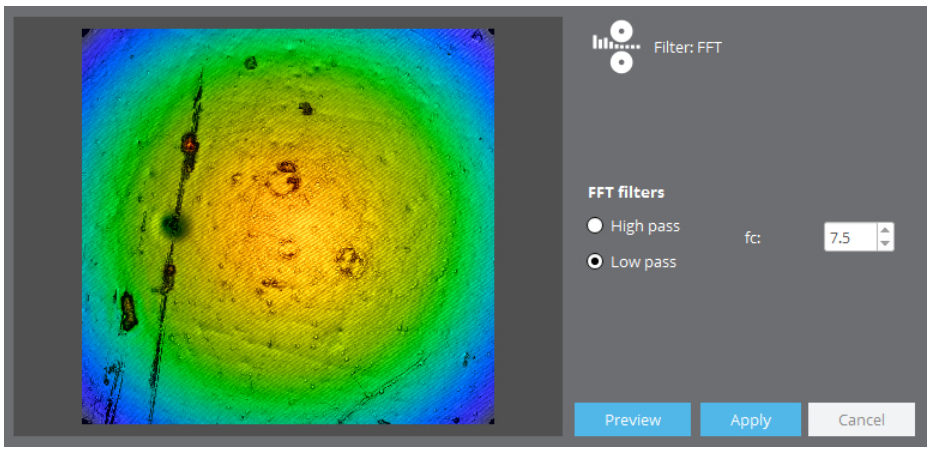
ISO (2D/3D)

Filters the data according to ISO 16610-61 standards by removing either waviness or roughness:



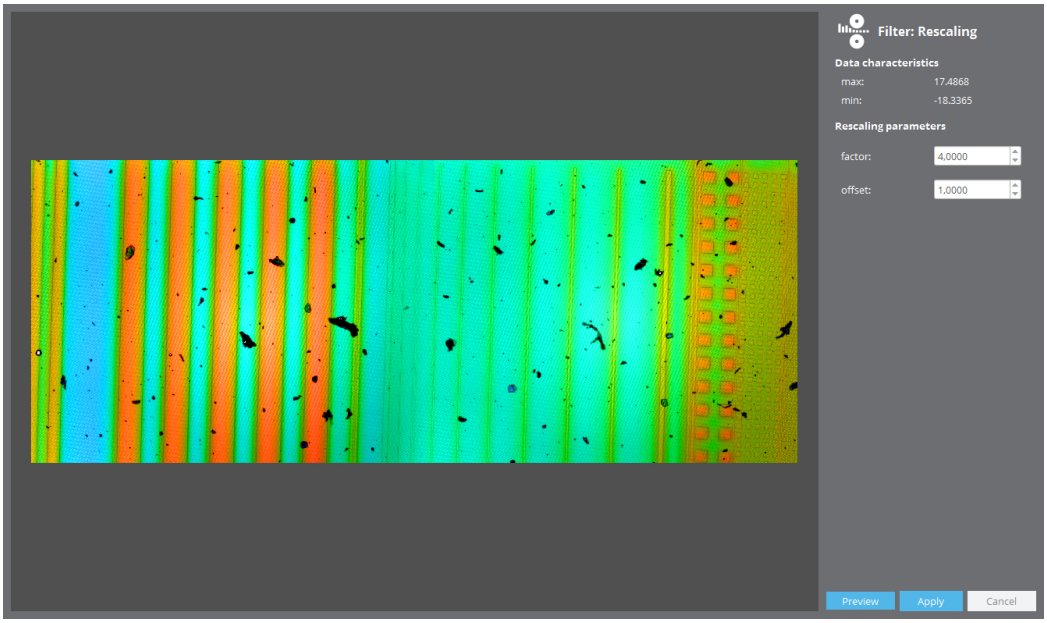
FFT (2D/3D)

Filters the data by applying either a high pass or low pass FFT. The frequency cut-off is defined as a percentage of the maximum - values between 0.1 and 99.9% are accepted.



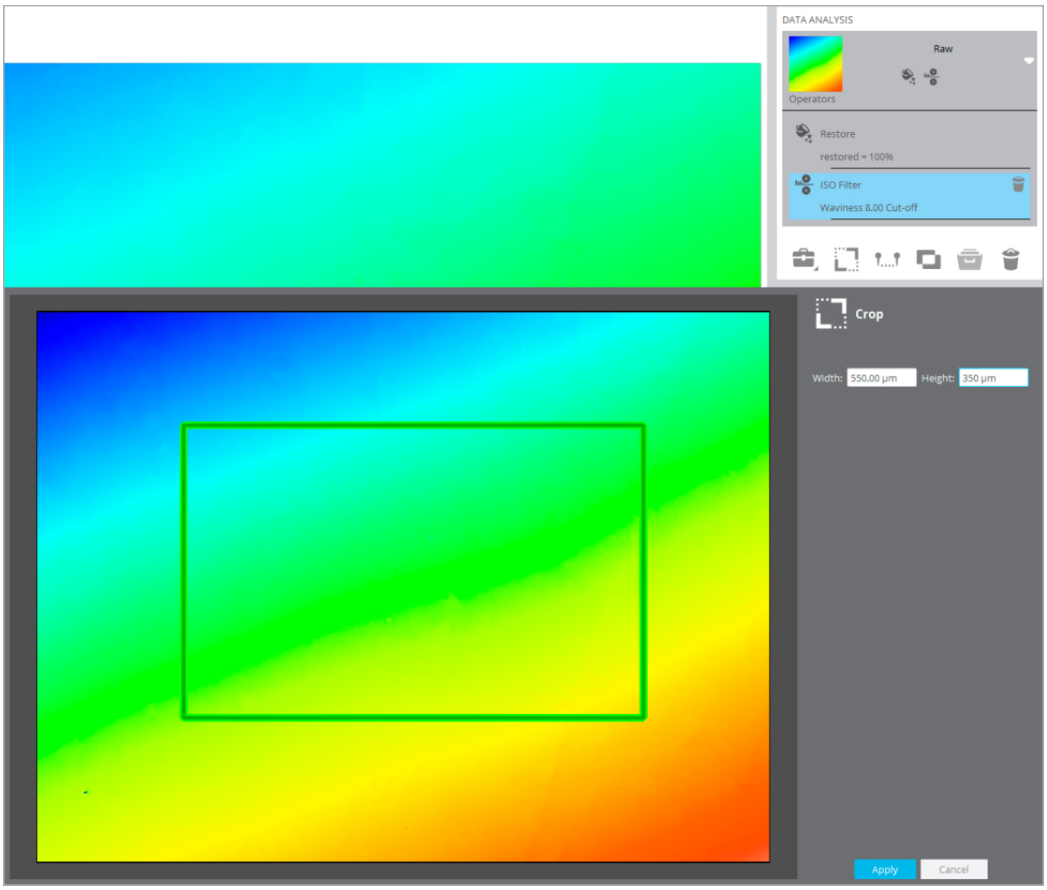
Rescale

This operator applies a user-defined vertical factor (between 0.0 and 100.0) and a user-defined vertical offset (between -1000.0 and 1000.0) to the data.



6.5.4 Cropping, Layers, Subtract

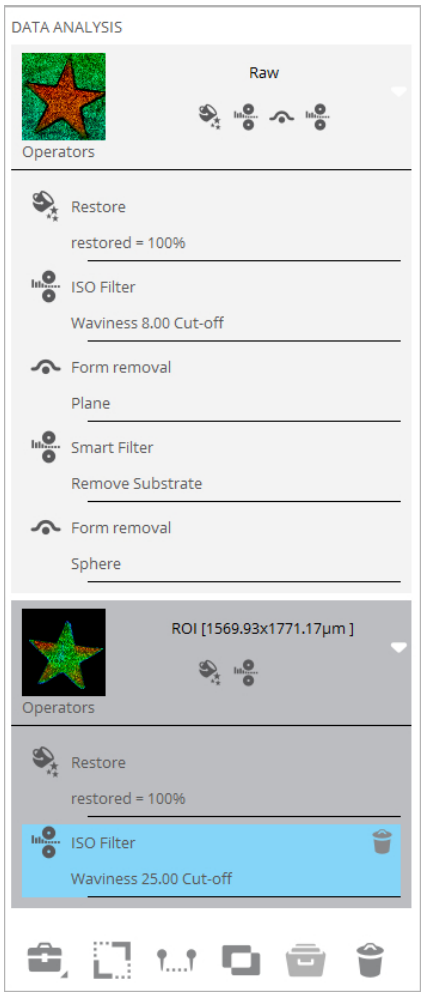
Overview



New layers can be extracted from the raw measurement or from an 'operated' measurement (raw measurement plus operators). All are 'areal only (3D)' operations.

- *Create Cropped Layer*: The region of interest (ROI) to be retained can be sized directly/ interactively by using the input boxes or by grabbing and dragging the corners of the green overlay, respectively. Values are relative to the top left-hand corner (origin) of the green overlay - entering values that would extend the ROI beyond the measurement limits (right, down) simply repositions the origin accordingly. Note also that the values are 'sticky', meaning that they are retained from acquisition to acquisition, and even between restarts of **SensoSCAN**. If a subsequent measurement is smaller than the sticky values, **SensoSCAN** defaults to 150 microns x 150 microns or an appropriate smaller size.
- *Create Profile Layer*: Generates a new profile layer based on the positioning of the interactive section created by the *Profile* tool. First, all necessary 3D operator and filter steps should be applied to the measurement, followed by activation of the *Profile* tool. Once the desired 2D profile has been selected, 2D operators and filters can then be applied to the measurement.
- *Create Subtracted Layer*: Choosing this option opens a dialog to load a previous measurement that is subtracted from the current measurement. Only raw values are used in the subtraction - any filters and operators applied to either data set will be ignored.

Additional filters and operators can be successively applied to any new layer to achieve the desired analysis:



Note: Deleting an operator will also delete successive operators as well as any new layers that depend on it.

6.5.5 Templates

Overview

As discussed elsewhere regarding file formats in **SensoSCAN 6**, the software saves and loads files in the **.plux* format. This format type contains only the raw data of a measurement together with any filters and operators that were active in Data & Analysis. In normal use, the raw data remains unmodified under all circumstances, while the filters, operators and layers listed in the file can be changed by subsequently re-loading the file, making changes to the analysis, and then re-saving the file.

As the filters, operators and layers listing is effectively separate, this can be used as an analysis Template. Templates are valid for both 2D and 3D measurements.

Template usage

Templates are used to apply pre-determined sequences of filters, operators and layers to repeated measurements.

Note: Templates can only be applied to raw data. All previous filters, operators and layers must be removed.

To apply a template to a measurement, choose the *Apply Analysis Template* icon in the Data Analysis pane and choose an appropriate **.plux* file. The filters, operators and layers listing in the chosen file will be applied to the current measurement in the exact same order as in the parent (template) **.plux* file.

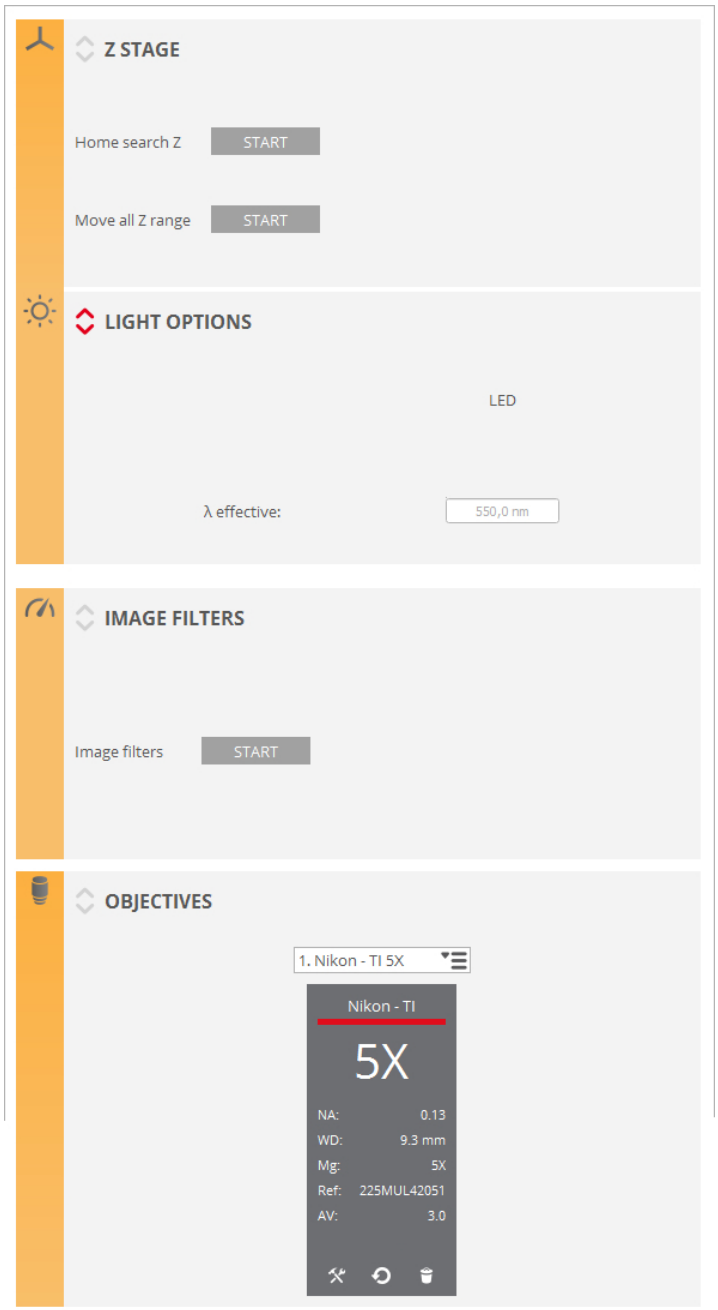
Part VII

7 Configuration & Alignment

Introduction

The Configuration & Alignment mode can be accessed by selecting **Configuration / Calibration** from the Menu Bar.

Note: More detailed information on the calibration and alignment procedures detailed here can be found in the Installation Manual for the system.



Note: In order to avoid improper configuration of the instrument, this mode should only be selected by trained users.

The OS Menu Bar also provides access to dialogs for globally resetting the following:

- objective configurations
- objective calibrations
- light balance

To leave the Configuration & Alignment mode, select either **Configuration / Exit calibration** from the Menu Bar, or click the *Exit* icon on the left of the Quick Bar.

7.1 Z Stage

Overview

- *Home Search Z* determines the top position for Z-Scan. Two types of *Home Search* methods are available depending on the hardware available:
  - *Home Search* based on Limit Switches. The Z stage will move towards the upper limit switch until it is triggered. It will then move away slowly until the limit switch opens again. At this point it will move a safety distance away from the limit switch (0.150 mm) and will set the Z = 0.000 coordinate at this position.
  - *Home Search* based on an external encoder. The Z stage will move upwards until it finds the home signal from the external encoder. It will then move down slightly and it will reproach the position of the Z encoder home signal at a lower speed until it finds the home signal again. This procedure finds the home signal with higher precision. The system will set the Z = 0.000 coordinate at this position. If the upper limit switch is found before finding the home signal from the encoder the system will move away from the limit switch 5 mm and will restart the *Home Search* sequence again.
- The *Move all Z range* function performs a movement along the entire Z axis. This maintenance test must be done once a year.

Warning: *Move all Z range* must be executed the first time that the program is installed. When the program executes this movement, it is important to ensure that nothing blocks the stage displacement.

Editing limits

The travel limits are the limit positions that the software has enabled.

In the **SensoSCAN** folder (*C:\Program Files\SensoSCAN 6.x\Configuration)*, there is a *StageZ.xml* file that can be used to edit these travel limits. In all cases, all editable values cannot be higher than the physical limits.

The *StageZ.xml* file can be used to define a preferred parking position (default -1.000 mm) following a *Home Search* call. This value is also used in the initialization using the *autoreference* command, i.e. it can be used to set a preferred parking position when the system is used repetitively for a single application.

7.2 Light options

Overview

The Light Options pane is used to fine tune the given wavelength of the LED installed in the system. The software shows the nominal wavelength for the LED (λ nominal), the effective wavelength (λ effective) that the user can edit, and the difference between these two values ($\Delta\lambda$). The maximum difference between the nominal and the effective wavelength is 100 nm.

To restore the default settings, click on the appropriate reset icon when editing the LED setting.

7.3 Calibration options

Image Filters

To start the system calibration process, focus on the flat mirror supplied with the system with a 20x objective. Ensure that the mirror is well focused and that illumination is optimized. Finally, click *Start* in the Image Filters pane to optimize filter performance (maximizes the speed, depending on the computer).

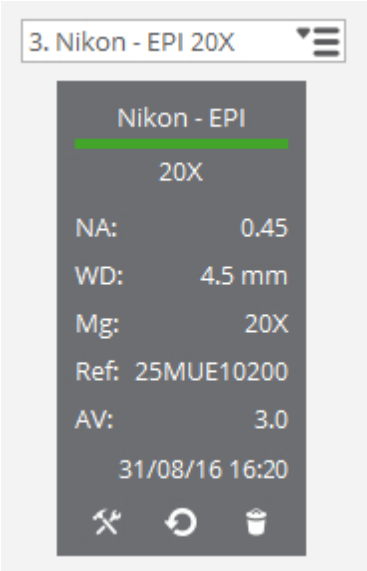
7.4 Objective calibration

Overview

The objectives pane is used to specify which objective is installed on the nosepiece:

- the objective can be deleted from the list by selecting it and then clicking on the recycle bin icon
- an objective can be added by clicking the '+' icon
- only the objectives that are part of the system configuration are available
- non-calibrated objectives are designated with C

Properties of the objective, such as numerical aperture (NA), working distance (WD) and the reference number are shown directly when an objective in the list is selected. Further properties are revealed by clicking on the tool icon at the bottom of the objective information pane.



The objective information pane

Calibration

The objective calibration procedure is detailed in the Installation Manual for the system. This procedure is needed when adding or changing objectives, or when periodically re-calibrating objectives. Objective re-calibration is suggested once every 6 months, or more often in severely fluctuating environments.

> **Warning:** Objectives must be calibrated by specialists. Improper calibration may lead to the results having a strong spherical aberration.

To calibrate an objective, please refer to the Installation Manual for the system. Note that calibration changes can be undone using the rewind icon at the bottom of the objective information pane

For user information, the most important aspects of the available objective calibrations are listed below:

- *Z-FACTOR*

  Used to calibrate the linearity of the profiler's Z stage. This requires a calibration sample with

known step height parameters. First, measure the step height with a Z-Factor 1.000000 and look for the result. Then, correct the result using the proper multiplication factor or by entering the values of the nominal and measured step height, and click on Save. The factor is the ratio between the nominal and the measured step height.

Warning: An incorrect value of the *Z-Factor* may result in larger or smaller data. If you doubt the accuracy of the value, reset to 1.000000.

- *MAGNIFICATION*

  This option has been made available to counter minor drifting in effective objective magnification caused by the optics 'working' within the objective housing (usually only an issue in severely fluctuating environments). This effect is minute, but becomes important when sub-nm resolution/accuracy is essential.

Warning: recalibrating the magnification of an objective is not a trivial task and should not be carried out by inexperienced users of the system.

The default value is the nominal magnification of the objective. This value can be changed only within ±1% of the nominal value. Full instructions and requirements for recalibrating the magnification of an objective can be found in the Installation Manual.

Part VIII

8 Configuration Files

Introduction

This chapter outlines the initialization settings for the **S onix** sensor, which are determined by the contents of **.xml* configuration files.

These files and their settings must be configured during initial installation of the software. They can be edited using any text editor.

> **Warning:** To restore the configuration files, close the program and delete the existing ones. When **SensoSCAN** is re-opened, it will generate default configuration files.

8.1 Z Stage

Overview

The *StageZ.xml* file configures the different options for the Z-Scan stage.

Section	Description
MAX_SPEED	Sets the maximum stage speed in microns/second. Default is 20000.
CALIBRATION_FACTOR	Scales the motor calibration. Default is 1.000.
BACKLASH	Sets the backlash compensation in microns. The default value depends on the hardware installed in the system.
MECHANICAL_OFFSET	Offsets the axis in microns. The offset is added to the default travel range. Used in granite stages as the optical axis (not used as the theoretical 0).
REVERSED	Invert axis values. Not inverted (1) or inverted (-1).
PARKING_POSITION	Sets the parking position. Default is -1.000 mm.
OBJECTIVE_OFFSET	Sets Z offset in microns. Default is 0.

Part IX

9 Errors & Diagnostics

Introduction

This chapter briefly addresses errors associated with acquisition and diagnostics for the hardware system.

In general, non-solvable acquisition errors and repetitive hardware issues that are not easily fixed should be reported to Service & Support.

9.1 Error Warnings & Codes

Overview

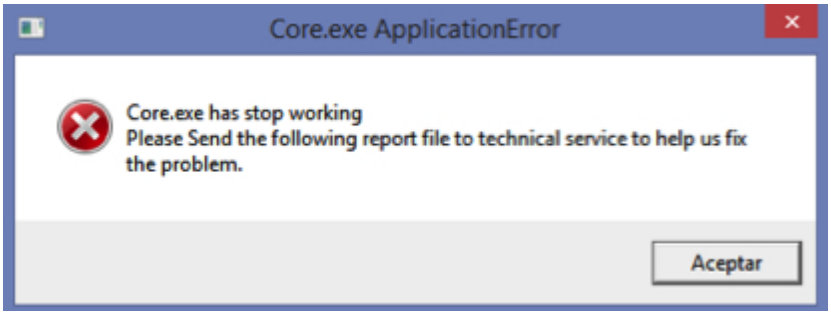
Previous versions of **SensoSCAN** have shown simple error codes on screen that needed subsequent manual identification and troubleshooting. Starting with **SensoSCAN 6**, these simple error windows are replaced by a window which shows the error code, a short description of the affected process, parameter or component, and (if available) possible troubleshooting options.

Acquisition problems which prove difficult to solve, or repetitive hardware issues should be reported to Service & Support.

9.2 Diagnostics

Overview

When the software detects an exception, it shows a windows message:



By clicking the accept button, it automatically opens a folder in which a zip file (core or gui) has been generated. This file contains the necessary information (application dump & log files) that technical service support must receive in order to perform a proper diagnostic.

For technical service actions it is sometimes also useful to check each hardware component (LED, motor, camera …) individually. In the Core menu, and using the technical service password, is possible to check each hardware component directly (some of these options will not be available for the **S onix**):

Part

10 Appendix

All globally relevant information as well as background topics from other Chapters are collected here.

10.1 System Preferences

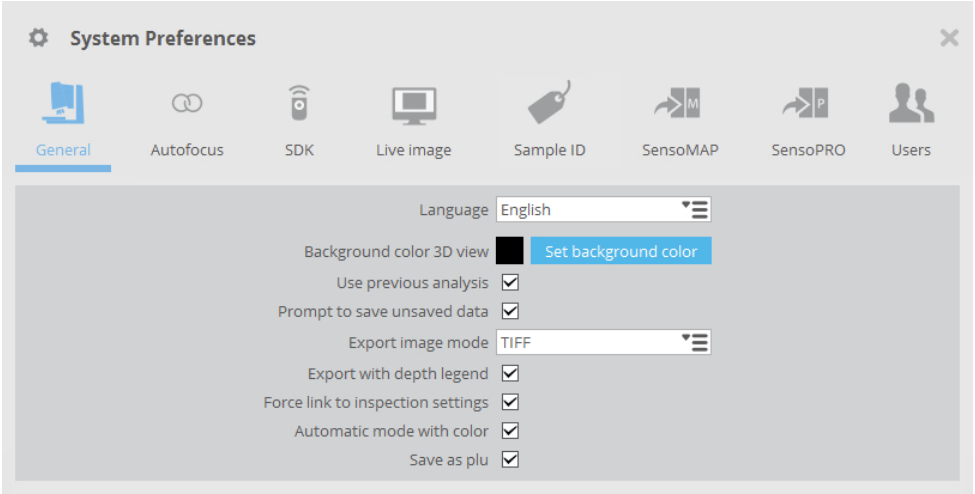
Overview

System Preferences can be accessed by clicking the icon in the Quick Bar when in Inspection & Acquisition mode, or choosing **Calibration / System Preferences** from the Operating System Menu Bar:

The Quick Bar when in Inspection & Acquisition mode

The System Preference categories are organized as tabs.

General

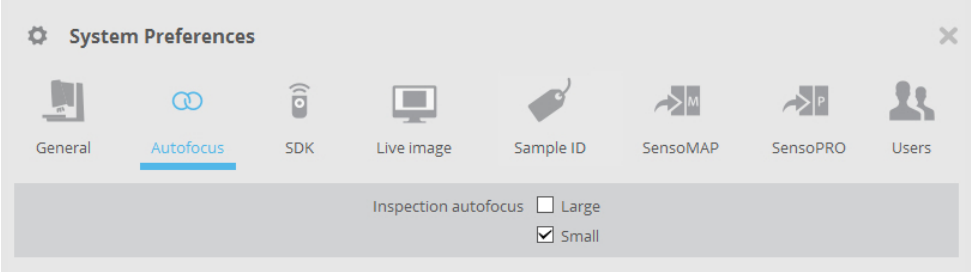


The options here allow setting of:

- *Language*: The preferred language for **SensoSCAN 6.**
- *Background color 3D view*: The preferred background color for 3D views.
- *Use previous analysis*: Force previous Data Analysis options to be automatically applied to a new measurement.
- *Prompt to save unsaved data*: A prompt when unsaved data may be lost.
- *Export image mode*: Choice of file format when exporting images (e.g. in Display & Analysis).
- *Export with depth legend*: Export the 3D image with the Z axis scaling visible in Measurement Display.
- *Force link to inspection settings*: Force Objective Selection and Light Settings in Acquisition Settings to match those set in Sample Inspection.
- *Automatic mode with color*: For 3D Auto, this toggles the color mode (color / no color).
- *Save as *.plu*: **SensoSCAN 6.0** through **6.3** automatically save measurements in both *the new*

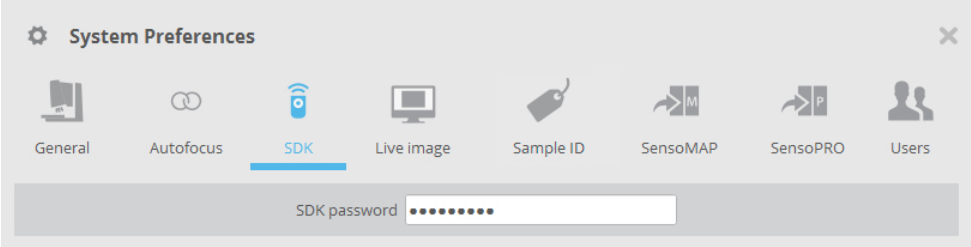
*.plux and the older *.plu format. Starting with **SensoSCAN 6.6**, saving additionally in the older *.plu format is now user-selectable with this option.

Autofocus



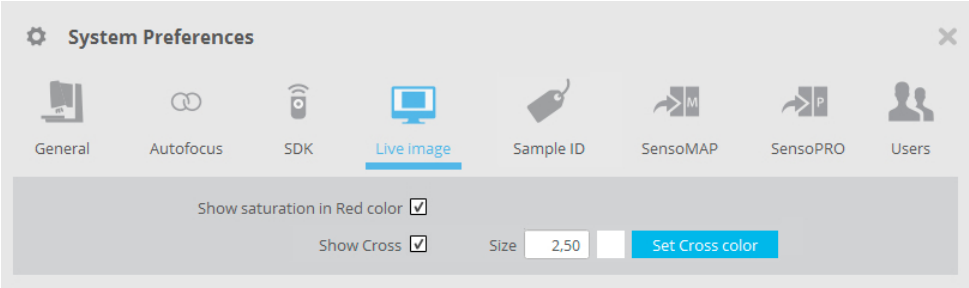
The options here determine whether *large* and/or *small* Autofocus routines are used when activating the Autofocus command in Sample Inspection. Information on the advanced options for these routines can be in Chapter 5 (Autofocus in Acquisition Settings).

SDK



The password for activating the SDK link can be entered here.

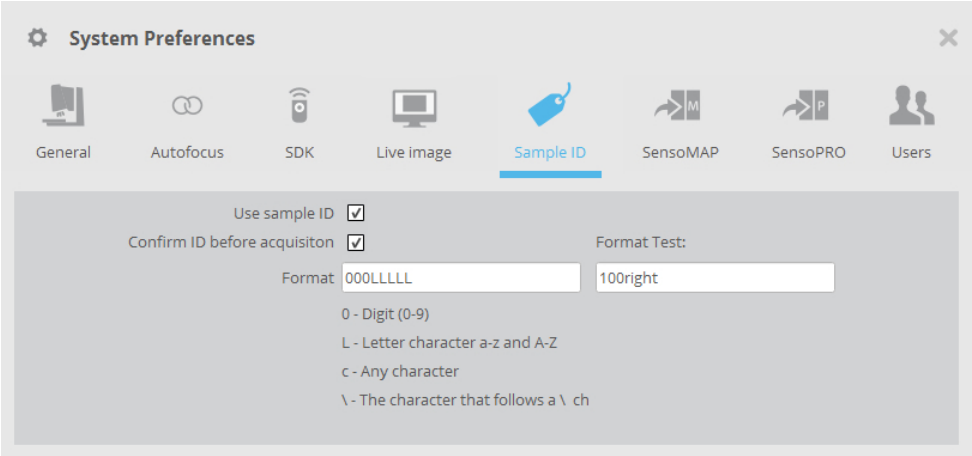
Live Image formats



The options here determine which viewer options are shown in the Central Viewer:

- *Show saturation in RED color* highlights saturated camera pixels in red
- *Show Cross* places a small cross-hair on the center of the Central Viewer. The cross-hair is user-customizable in width (0.5 - 5.0 pixels, widths of less than 1 pixel are dithered) and in color. Note that the F9 keyboard shortcut can be used to toggle to a large cross-hair, regardless of whether none, or a small cross-hair is selected here.

Sample ID



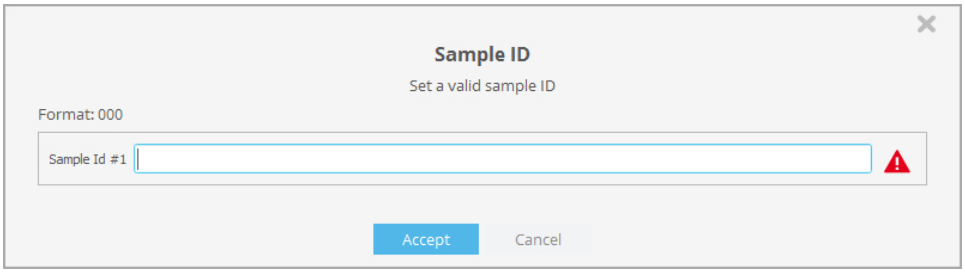
The Sample ID feature allows the user to label the measurement according to an identification. The subsequent measurement will exhibit the ID inside the file as well as in the file name.

When the user is programming an MMR, the MMR can be used with only a single Sample ID, or with multiple IDs by mapping the positions with their specific identification.

Sample ID options are as follows:

- *Use Sample ID* toggles the option of using a specific Sample ID. On activation, either the existing Sample ID is shown at the top of the Sample inspection pane:

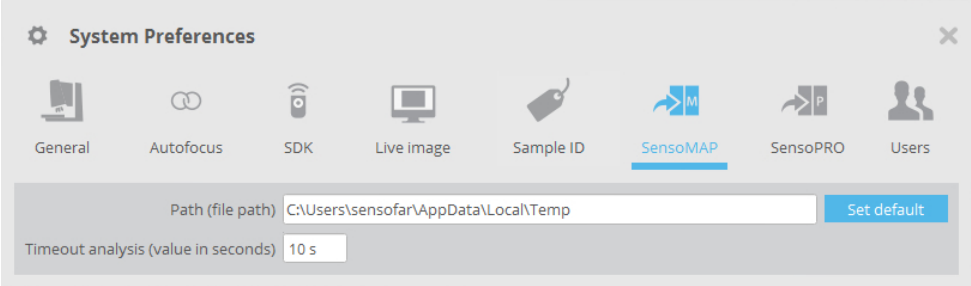
... or the 'No ID' name tag icon can be clicked to reveal a pane where a new name can be entered using the keyboard (i.e. user-defined), or scanned from a list or from the sample by using a barcode reader. Note that, until a valid name has been given, a small red warning triangle is shown:



- *Confirm ID before acquisition* allows the user to check the Sample ID once more before acquisition.
- *Format* options allow a specific nomenclature strategy to be implemented. That is, the nomenclature is nominally freely selectable, but it can be restricted to a specific alphanumeric

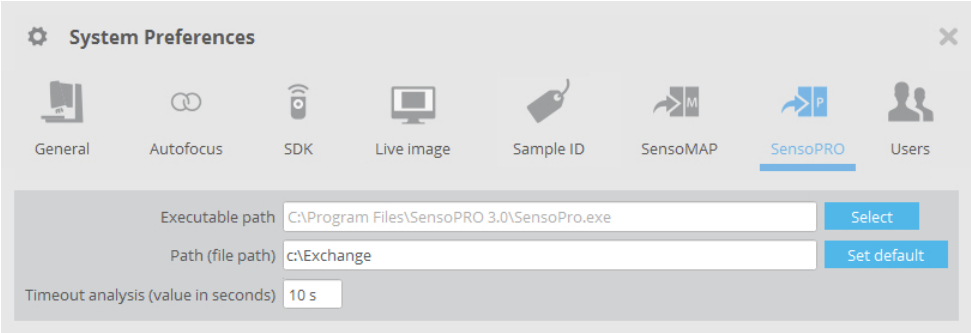
format by entering the corresponding definition into the *Format* field (see example in the System Preferences Sample ID pane above).

SensoMAP



- The file path for measurement files to be processed in **SensoMAP** can be defined here.
- When **SensoSCAN** is configured to push measurements to **SensoMAP** for analysis, **SensoSCAN** must wait until **SensoMAP** has finished processing the last measurement before **SensoSCAN** can push over the next. Normally **SensoSCAN** poles **SensoMAP** for the status, and makes the next acquisition as soon as **SensoMAP** is ready. The Time analysis duration determines the maximum dwell time per measurement file that **SensoSCAN** waits before posting a warning message. Time analysis should thus be set to be greater than the nominal time required by **SensoMAP** to analyze each measurement in the users particular configuration.

SensoPRO



- Used to define the location of the **SensoPRO** executable and the path for files. When these are correctly given, **SensoSCAN** can automatically call **SensoPRO** when required.

User Profiles

For **SensoSCAN 6**, the User Profiles dialog is found within System Preferences of the main **SensoSCAN** application. With the User Profiles dialog, Administrators of the system can manage the users and their associated rights.

Managing user profiles

In order to help organizations that have acquired a system to administer the use and maintenance of the system, **SensoSCAN 6** distinguishes between three different levels of users and their associated rights:

- **Administrator:** can manage System Preferences, can perform Configuration & Alignment tasks

and has all the rights of an Advanced Operator.

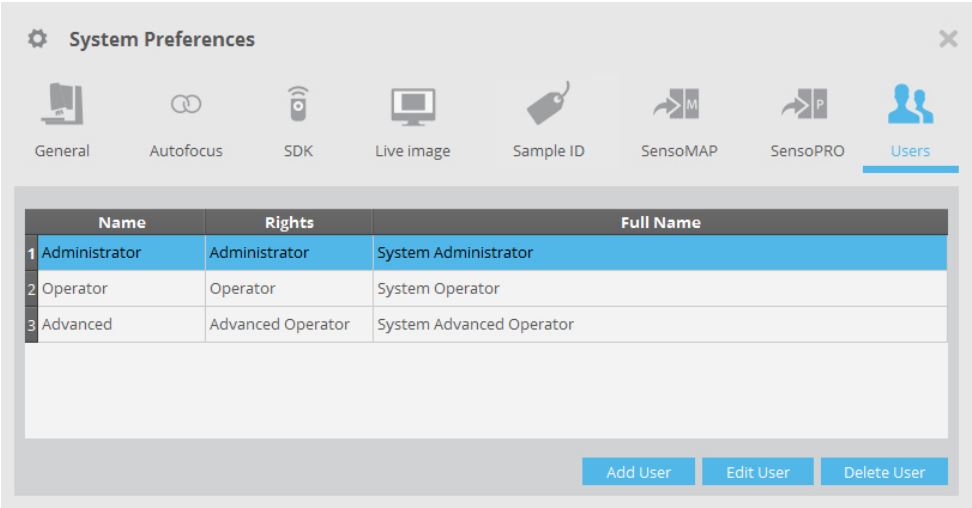
- **Advanced:** can configure measurement and create recipes, and has all the rights of an Operator (User).
- **Operator (User):** can load recipes, acquire and save/load data and perform analysis.

After initial installation (and also following re-installation) the user list contains by default one user of each type. The table below shows the three default users, their rights and the associated default password:

User	Rights	Default Password
Administrator ↓	System Preferences	adm1234
	Calibration & Alignment	
Advanced ↓	Save Recipes	adv1234
	Configure Acquisition	
Operator ↓	Load Recipes	ope1234
	Acquire Data	
	Perform Analysis	
	Save/Export Data	

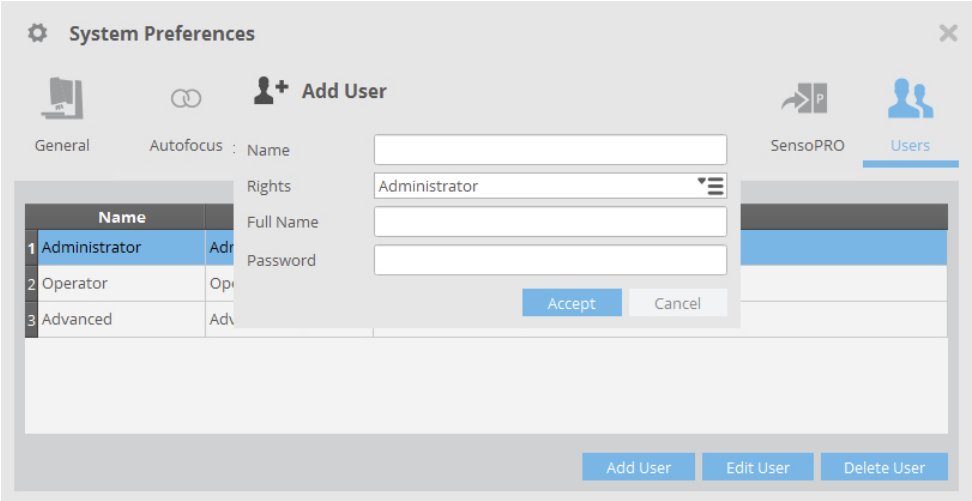
User rights and the default passwords after initial installation (and following re-installation)

The default users can be used 'as is', or they can be edited as required, or new users can be added. An Administrator can access the users tab in order to manage all users of the system (*Add* / *Edit* / *Delete*):



User tab in System Preferences

Clicking *Add User* or *Edit User* reveals a drop-down dialog, in which the details and rights for a new user can be given, or where those for an existing user in the list can be changed, respectively:



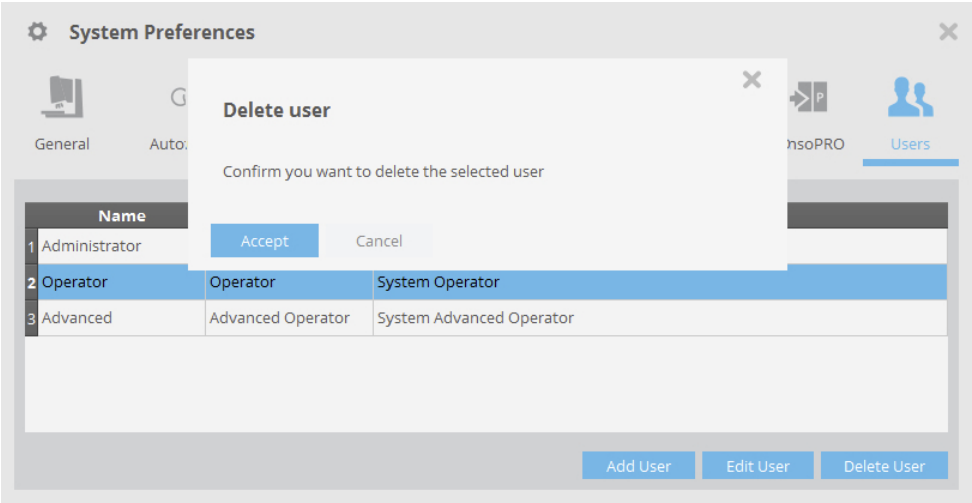
Using the *Edit User* dialog to edit the details for user *Operator*

After adding a new user or after making any changes to a user profile, simply click *Accept* to confirm the changes and return to the user profiles dialog.

Note: The user name and password may contain any combination of available symbols, numerals and upper/lower case type.

Note: In the event that a user profile can no longer be loaded by the system, the profile should simply be deleted and then recreated by an Administrator.

Clicking *Delete User* reveals a drop-down dialog with which the chosen profile can be deleted:



Using the *Delete User* option to delete the profile for the user *Operator*

10.2 File Formats

Overview

When saving a measurement in **SensoSCAN,** the raw data is always preserved. To achieve this, the file formats used contain the raw measurement data together with a list of the Data Analysis options that were applied to that measurement in the version of **SensoSCAN** saving the file. On opening a saved file in **SensoSCAN**, the raw data is loaded, and if the version of SensoSCAN is compatible, the suite of Data Analysis options that were saved in the measurement file are also loaded are reapplied in the render (visualization). The following versions of SensoSCAN save different formats:

- **SensoSCAN 5.x** saves measurements in the **.plu* format.
- **SensoSCAN 6.0** through **6.3** save measurements automatically in both the new **.plux* and the older **.plu* format.
- **SensoSCAN 6.6** saves by default only the new **.plux* format, but saving additionally in the older **.plu* format is user-selectable (see *Save as *.plu* option in System Preferences).

While the **.plu* and **.plux* formats are conceptually similar, they are structurally different.

File format compatibility between SensoSCAN 5 and SensoSCAN 6

The interchangeability between the new **.plux* and the older **.plu* formats is limited to the import of a **.plu* file into **SensoSCAN 6.x** (select **File / Import / Import plu** from the Menu Bar). As indicated above, only the raw data of the measurement is imported from the **.plu* file, nothing else.

File format compatibility between SensoPRO LT and SensoPRO

32-bit versions of **SensoPRO** (designated as **SensoPRO LT**) are only compatible with **.plu* files. Users of **SensoPRO LT** will need to activate the *Save as *.plu* option in System Preferences.

64-bit versions of **SensoPRO** (**SensoPRO 3.x** and later) are compatible with **.plux* files.

Raw data preservation

As described above, when saving a measurement in **SensoSCAN,** the raw data is always preserved. A direct consequence of this is that, when in Display & Analysis mode, data can be visualized using the available filters, operators and layers, but the raw data is not permanently modified. If desired, a measurement that has been previously saved can be loaded into **SensoSCAN** and the suite of filters, operators and layers can be edited, and the file re-saved with the new suite of Data Analysis options.

Save as RAW option

There are some instances where modified data is required for further (e.g. external) analysis.

Starting with **SensoSCAN 6.3**, a *Save as RAW* option in the **File** menu can be selected, which permanently applies the active filters, operators and layers to the raw data of a measurement before saving:

- a **.plux* file is generated containing only the modified data, with no record of the filters, operators and layers previously active,
- the display and render in Display & Analysis mode changes accordingly - the modified data is shown as if it were a new measurement.

10.3 ISO Standards

Overview

The *ISO 25178: Geometric Product Specifications (GPS) – Surface texture: areal* standard is an International Organisation for Standardisation collection of international standards relating to the analysis of 3D areal surface texture. It is the first international standard taking into account the specification and measurement of 3D surface texture, and in particular defines 3D surface texture parameters and the associated specification operators. It also describes the applicable measurement technologies, calibrations and methods, together with the physical calibration standards and calibration software that are required.

A major new feature incorporated into the standard is coverage of non-contact measurement methods, already commonly used by industry, but up until now lacking a standard to support quality audits within the framework of ISO 9000. The move brings (e.g. optical) 3D surface metrology methods into the standards domain.

Useful sources of reference can be found here and here.

The 3D areal surface texture parameters are calculated for the entire surface, and comprise the following families:

- height parameters: the statistical distribution of height values along the Z axis (discussed in more detail below)
- spatial parameters: the spatial periodicity of the data, specifically its direction
- hybrid parameters: the spatial shape of the data
- functions and related parameters: parameters are calculated from the material ratio curve (Abbot-Firestone curve), and
- parameters related to segmentation: parameters are derived from a segmentation of the surface into motifs (dales and hills)

Height parameters

For convenience, the height parameters are listed below. These involve only the statistical distribution of height values along the Z axis:

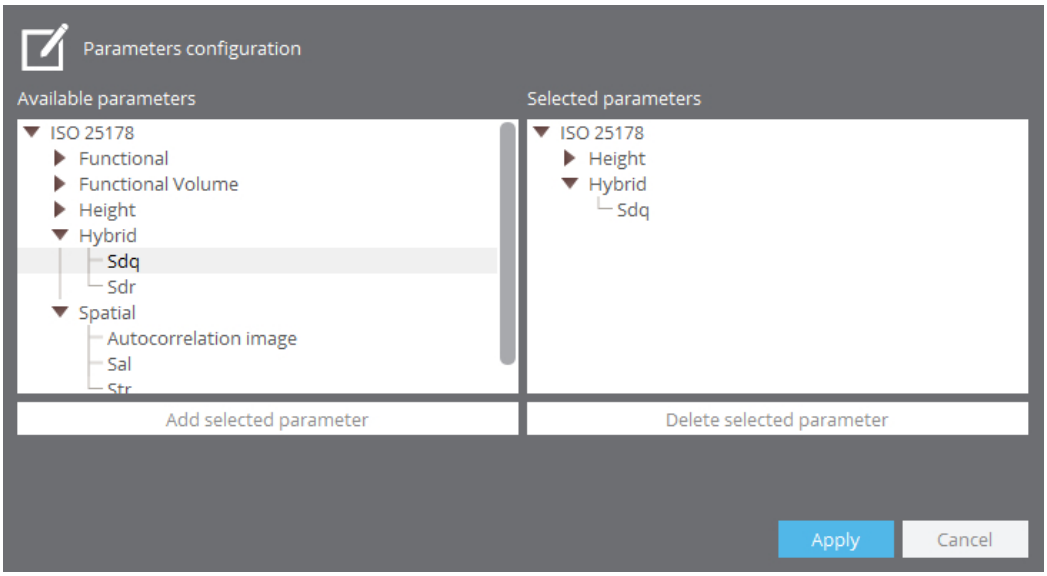
Property	Description	Comments
Sq	root mean square height	The rms height of all data points from the mean surface height (µm), aka rms roughness. An overall measure of the texture comprising the surface, typically used to specify optical surfaces.
Ssk	skewness	Skewness of the height distribution relative to Sq. Figuratively, the shift of the heights of all measured points to lower or higher values compared an ideal bell curve distribution. Useful in specifying honed surfaces and monitoring for different types of wear conditions.
Sku	kurtosis	Kurtosis of the height distribution relative to Sq. Figuratively, the predominance of extreme peaks or pits for all measured points compared to an ideal bell curve distribution.
Sp	maximum peak height	The distance between the mean surface height and the highest point within the data (µm). Value is generated from a single point and is often unrepeatable. Typically used for surfaces that will be used in a sliding contact application.
Sv	maximum pit depth	The distance between the mean surface height and the lowest point within the data (µm). Value is generated from a single point and is often unrepeatable. Typically used when pit depths relating to fluid retention may be of concern, such as for lubrication and coating systems.
Sz	maximum height	Sum of the largest peak height value and the largest pit depth value (µm). Value is generated from a two single points and is often unrepeatable. Typically used for sealing surfaces and coating applications.
Sa	arithmetic mean height	The arithmetic mean height of the surface (µm), aka average roughness. An overall measure of the texture comprising the surface, typically used for machined surfaces.

The Height family of Surface Texture parameters

Configuring ISO Parameters in SensoSCAN

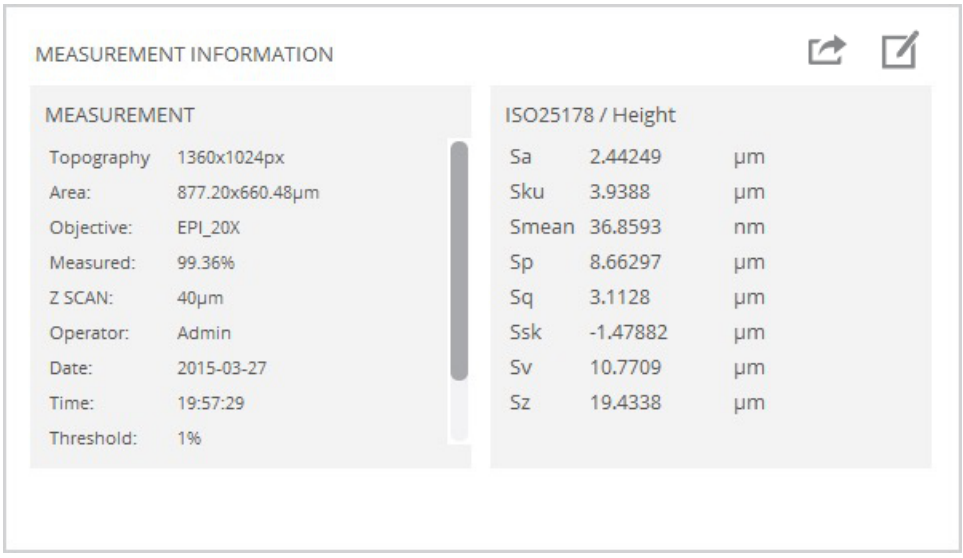
The measurement information panel can additionally show values corresponding to any active parameters chosen from the ISO Standards. The different ISO Standards can be accessed by clicking

the parameters configuration icon and activating/deactivating individual parameters or parameter families as desired. If this icon is not visible, it is because (further) options for this Measurement type are not available (e.g. for 2D profiles and for images).



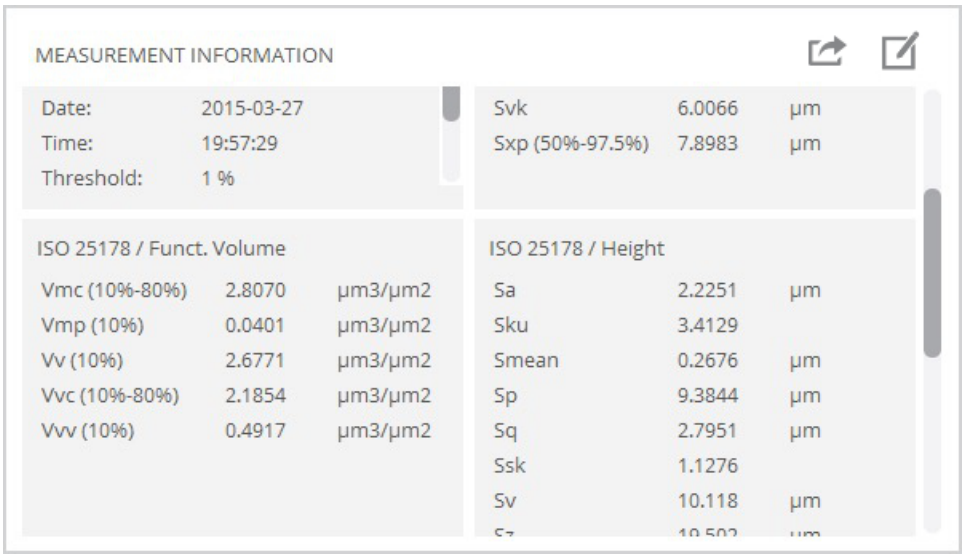
Activating/deactivating ISO Standards in the parameter settings dialog

The parameters for any activated ISO 25178 Standards - if applicable to the Measurement type - are then visible in the measurement information panel for a completed or loaded measurement:



Supplementary 3D Surface Texture parameters according to ISO 25178 / Height

As more parameters or parameter families are added, more parameter panels are added to measurement information:



Adding further parameters and parameter families add additional parameter panels to the measurement information

10.4 Keyboard Shortcuts

Save time with Keyboard Shortcuts

A number of keyboard shortcuts are available in the various different modes. Keyboard shortcuts are keys or key combinations that invoke a specific software task.

Keyboard shortcut	Task	Inspection & Acquisition	Display & Analysis	Calibration & Alignment
F1	Help	√	√	√
F2	Autofocus	√		
F3	Autolight	√		√
F4	Acquire (new measurement)	√		
F5	Switch to Inspection & Acquisition		√	
F7	Switch between maximum light intensity and the previous intensity	√		√
F8	Autolight and Autofocus (brightfield objectives) Autolight with Z-Scan and Autofocus (interferometry objectives)	√		√
F9	*Acquisition*: Switches between the small cross-hair (or nothing - see System Preferences) and a large cross-hair *Configuration & Alignment*: Switches between nothing and a large cross-hair	√		√
F10	Repeat previous overview capture (stitched images)	√		
Spacebar	Stop the measurement after acquiring 50 images and go to Data & Analysis.	√		

10.5 SDK

SensoSCAN Software Development Kit

It is possible to run specific commands and events of the **SensoSCAN Core** remotely using the **SensoSCAN** software development kit (SDK). The link to the SDK from **SensoSCAN** is activated by entering the Password in System Preferences.

The SDK provides the tools and protocols needed to create proprietary applications that are able to communicate and manage **SensoSCAN**. Developers can choose the platform and language as the basis for their applications without constraint. **SensoSCAN** SDK commands and events provide a means to remotely inspect a sample and perform measurements based on acquisition *Recipes*. Once a proprietary application has been developed using **SensoSCAN** SDK, it can be used with multiple systems.

If the SDK is part of your system, check the specific documentation for more details.