



SENSOFAR
METROLOGY

SYSTEM MANUAL



IFU90-01-EN, F
Software version: 7.4



TABLE OF CONTENTS

Chapter 1 - Welcome to S neox!	1
1.1 Basic features of your system.....	3
1.2 Software introduction	5
1.3 Service & Support.....	7
1.4 Important safety information	8
1.5 Copyright	11
Chapter 2 - Quick start guide	15
2.1 Quick Bar.....	18
2.2 Sample Inspection.....	21
2.3 Central Viewer.....	22
2.4 System Status	26
2.5 Acquisition Settings	27
2.6 Acquire a measurement	29
Chapter 3 - Sample Inspection	33
3.1 Objective Selection	36
3.2 Autolight & Autofocus	37
3.3 Color Correction	38
3.4 Inspection Viewer	41
3.5 Position & Motor Control.....	47
3.6 Light Control	50
3.7 Control Console & Joystick.....	54
3.8 Keyboard Shortcuts.....	55
Chapter 4 - Configuration & Calibration	57
4.1 XYZ options	61
4.2 Light options	62
4.3 Alignment options.....	63



4.4 System calibration options.....	65
4.5 Objective calibration.....	66
4.6 Your system is ready, now check it	75
Chapter 5 - Acquisition Settings	77
5.1 Measurement technique.....	79
5.2 Measurement type	83
5.3 Objective Selection	99
5.4 Area.....	100
5.5 Z-Scan	101
5.6 Layer.....	107
5.7 Autofocus	110
5.8 Light Settings	114
5.9 Threshold	116
5.10 Processing	117
5.11 Analysis.....	118
Chapter 6 - Thin Film Measurement	129
6.1 Single Point Measurements	131
6.2 Thickness Mapping	135
Chapter 7 - Recipes	139
7.1 Recipes: SMR & MMR.....	140
Chapter 8 - Errors & Diagnostics	157
8.1 Crash report.....	158
8.2 Restoring or re-installing the main controller	159
8.3 Hardware configuration	160
Chapter 9 - Appendix	163
9.1 System Preferences.....	164
9.2 Offline Extended Topography.....	173
9.3 Configuration Files	181
9.4 Tracking Extended Measurements	183
9.5 File Formats	186
9.6 Basic Parameters for System Operation.....	187



CHAPTER
1

WELCOME TO S NEOX!

This unique 3-in-1 technologies sensor head combines Confocal, Interferometry and Ai Focus Variation techniques, as well as thick and thin film measurement capabilities. The sensor head provides standard microscope imaging, confocal imaging, confocal profiling, interferometric profiling, active illumination 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, providing **Sensofar Metrology**'s system with unparalleled versatility, and enabling it to outperform all comparable systems on the market.

To help you familiarize yourself with your surface metrology system this user manual will guide you through the different measurement techniques and the acquisition software **SensoSCAN**, used to control the system. It provides a clear and intuitive user-friendly interface with which any measurement can be easily taken.

SensoVIEW is a software offering a comprehensive set of tools for displaying and analyzing measurements. The user is guided through the 3D environment, delivering a unique user experience. For applications requiring more advanced analysis tools, specific analysis software packages are optionally available.

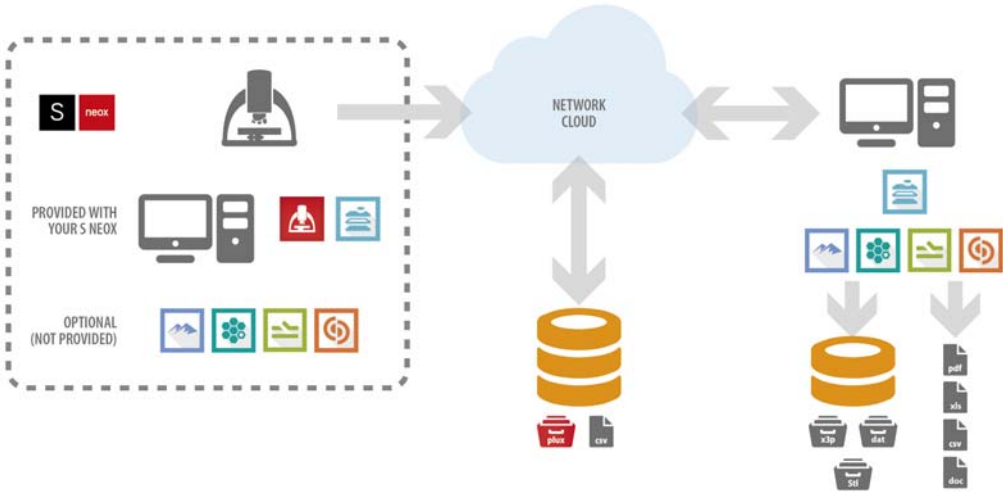
For powerful and flexible data manipulation we offer **SensoMAP**, a state-of-the-art surface analysis software based on Mountains technology. Typical uses for **SensoMAP** include off-line 2D/3D surface characterization in R&D departments and laboratories, and near-line process control in production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



SensoPRO is an optional tool for easy and rapid quality control. The operator only needs to load the sample and follow guided instructions. Plug-in based data analysis algorithms provide high-degree of flexibility. Available algorithms include *Bump*, *Hole*, *Pad*, *Step Height* and *Surface Texture*, among many others. New modules can be easily developed for other industry needs.

For Forensics applications we offer **SensoCOMP** and **SensoMATCH**. **SensoCOMP** is a software application that allows side-by-side visual comparison of two 3-dimensional surfaces. In addition it allows saving topographies in x3p format for file sharing according to Open Forensics Metrology Consortium best practices. **SensoMATCH** is an application that allows automating the objective comparison of 3-dimensional surfaces and provides a comparison score for every pair of surfaces and groups of surfaces.

All analysis software can be run on the computer serving the system, or other 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 analysis applications are run on the system computer, it is important not to do analysis while the system is taking a measurement, as this can reduce the performance.

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

1.1 Basic features of your system

Technologies

CONFOCAL

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. Spatial sampling can be reduced to 0.10 μm , which is ideal for critical dimension measurements. High numerical aperture (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°).

INTERFEROMETRY

PSI

Phase shift interferometers have been developed to measure the surface height of very smooth and continuous surfaces with sub-nanometer resolution. PSI profiling provides sub-nanometer vertical resolution for all numerical apertures (NA). Thus, very low magnifications (2.5X) can be employed to measure large fields of view with the same height resolution.

CSI

White-light Coherence Scanning Interferometry (also known as Vertical Scanning Interferometry VSI) have been developed to measure the surface height of smooth to moderately rough surfaces. CSI profiling provides nanometer vertical resolution for all NAs. The CSI algorithms enable the S neox to use all the available magnifications to profile shape features with the same height resolution.

Ai FOCUS VARIATION

Active illumination Focus Variation is an optical technology that has been developed for measuring the shape of large rough surfaces. Sensofar's implementation of this approach has been specifically designed to complement confocal measurements at low magnification. It has been improved with the use of active illumination to get more reliable focus location even on optically smooth surface. Highlights of the technology include high slope surfaces (up to 86°), highest measurement speeds (mm/s) and large vertical range measurements.

THIN FILM

Thin film measurement technique measures the thickness of optically transparent layers quickly, accurately, non-destructively and requires no sample preparation. The system acquires the reflectance spectrum of the sample in the visible range, and is compared with a simulated spectra calculated by the software, with layer thickness modification until the best fit is found. Transparent films from 50 nm to 1.5 μm can be measured in less than one second. Sample evaluation points are dependent on the objective magnification, which can be as low as 0.5 μm and to 40 μm .

Performance

AMAZING IMAGE QUALITY

The S neox uses a high-resolution camera sensor of up to 2448x2048 pixels in combination with high-resolution display of 3840x2160 pixels. The images acquired with S neox do not need to be up- or downscaled, so they always appear sharp, vivid and realistic on-screen.

MULTISPECTRAL WAVELENGTH LEDs

To optimize the light source for each application, S neox has four LED light sources inside its optical core: red (632 nm), green (532 nm), blue (460 nm) and white (580 nm). A shorter wavelength is used for applications in which the highest lateral resolution is required. Longer wavelengths provide greater optical coherence of up to 20 μm , which makes phase-shifting interferometry possible on smooth surfaces with a large area.

SEQUENTIAL COLOR

Red, green and blue LEDs are used to sequentially illuminate the surface under inspection. Three monochromatic images are taken and compounded into a high-resolution color image. The benefits of this approach are high color fidelity and saturation, as well as real pixel-to-pixel color information. S neox does not need to interpolate the color information between pixels.

1.2 Software introduction

SensoSCAN software has two different user interface modes: Inspection & Acquisition and Configuration & Calibration.

Inspection & Acquisition

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

- place the sample in the right position and focus on it using the [Central Viewer](#) or the Overview tool (if motorized XY stage is available)
- select the measurement parameters in preparation for a measurement

Depending on the options installed for your particular system, this mode can also be used to control the system's motorized stages (see [Position & Motor Control](#)).

Measured data is sent to the software application selected in [Analysis](#). By default measurements are sent to **SensoVIEW**. Refer to its user manual to learn about all its features. The manual is available in **SensoVIEW** software help menu as a pdf.

Configuration & Calibration

This mode can be accessed by clicking Configuration / Calibration in the menu or clicking on the Calibration icon on the [Quick Bar](#):



NOTE Configuration & Calibration is only visible/accessible to Administrators of the system.

Configuration & Calibration is used to:

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

Configuration & Calibration procedures are carried out using a high-quality flat mirror and a calibration specimen as a sample, both are provided with the system.

Using the 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 essential for obtaining accurate and meaningful 3D topography measurements.

To help the user become familiar with the system:

- Inspection & Acquisition mode is briefly summarized to provide an overview of the interface
- Extensive details are provided for [Sample Inspection](#) and [Acquisition Settings](#)

- [Configuration & Calibration](#) routines are described - only for system Administrators
- 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 additional help is needed to use the system, contact [Service & Support](#).

1.3 Service & Support

Contact

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

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

Sensofar-Tech, S.L.
Parc Audiovisual Catalunya
Ctra. BV1274, KM 1
08225 Terrassa, Spain

Tel.: +34 937 001 492
Fax: +34 937 860 116

support@sensofar.com
www.sensofar.com

Sensofar and all recognized Distributors can supply all system components and spare parts and carry out any necessary calibrations and repairs.

Updates & Upgrades

Software updates (defect fixing in current version) are available for free.

When a new software version is made available that adds features and/or is compatible with new components, customers with previous versions might be able to upgrade depending upon their system configuration. New software versions might require installing new components at additional costs. For more information, please contact your local Distributor.

NOTE The license serial number is required to update/upgrade a system.

Locating your Serial Number

To locate your Serial Number (SN), open the **SensoSCAN** software. Click on Menu > Help > About... The *About* panel will open and your SN and version will be shown.

It is also visible on the label behind the controller.

1.4 Important safety information

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

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



WARNING

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



WARNING

The computer is the main controller of the system. It has already been optimized for performance, thus 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 system will also void the manufacturer's warranty.

System updates

We have set a custom configuration regarding the Windows update procedure. These settings must not be altered in order to ensure the correct performance of the system.

Our custom configuration prevents the drivers updates. The automatic reboot of the computer that often follows an update has also been disabled.

Power specifications

- AC line input
- Voltage range: 100–240 V alternating current (AC), 3.0 A Max
- Frequency: 50–60 Hz single phase
- Power: 270 W
- Fuse rating: 4 A
- Fuse model: S501-4-R 250 V 5x20 mm



WARNING

In 220V connections a protective earth (PE) conductor is required.

**WARNING**

The only intended use for this power output is to connect the Five Axis power supply. Do not connect other devices.



The only way to disconnect the power completely from your S neox 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 cords is within easy reach so that you can unplug the computer or display if necessary.

Use a CO₂ fire extinguisher in case of fire.

**WARNING**

There is a fan and a heat sink on the electronic controller to avoid overheating and burning. In case of fire, do not block the air access and heat flow.

Do not carry out repairs yourself

Do not attempt to open your system. If your system needs a service, contact the local distributor or support service.

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 neox.

Important handling information**Operating environment**

- *Temperature:* 10 °C to 35 °C (recommended 20 ± 1 °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 neox

Before you lift or re-position your S neox, lock the active vibration isolation table, shut down the system and disconnect all cables.



WARNING

At least two people are required to lift and carry the system.

General maintenance

Clean your system

If you need to clean your system, follow these instructions:

- Turn off your computer and display.
- Clean the system with a soft cloth dampened with water. Do not use detergent.
- 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:

- Place optical paper over the reference mirror.
- Use one or two drops of acetone.
- 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 [Configuration & Calibration](#) chapter. In general, objectives should only be calibrated when they are first mounted.

1.5 Copyright

Copyright: Sensofar-Tech, S.L., 2001 - 2020

This document contains proprietary and confidential information of Sensofar-Tech, S.L.

The contents of this document may not be copied nor duplicated in any form, in whole or in part, without prior written consent from Sensofar-Tech, S.L.

By purchasing this product, the Purchaser(s) and/or any subsequent legitimate owner(s) of the product, henceforth referred to as “the Purchaser”, agree(s) to abide by the terms of this Agreement and read and recognize the following set of definitions appertaining to the intellectual-property items and trademark references as can be found throughout this User Manual.

Sensofar-Tech, S.L. provides the information and data included in this document for the Purchaser's benefit, but Sensofar-Tech, S.L. cannot entirely verify and test all of this information in all circumstances, particularly information relating to non-Sensofar-Tech, S.L. manufactured products. Sensofar-Tech, S.L. makes no warranties or representations relating to the quality, content or adequacy of this information. Every effort has been made to ensure the accuracy of this manual. However, Sensofar-Tech, S.L. assumes no responsibility for any errors or omissions in this document. Sensofar-Tech, S.L. shall not be held liable for any errors or for incidental or consequential damage in connection with the furnishing, performance or use of this User Manual or the examples herein.

Sensofar-Tech, S.L. assumes no responsibility for any damage or loss resulting from the use of this User Manual, loss or claims by third parties that may arise through the use of this product, any damage or loss caused by deletion of data as a result of malfunction or repair or any other damage related to the use of this product or associated documentation. The information in this document is subject to change without notice.

Definitions of Intellectual Property and Trademark Attributions

This section is intended to ensure proper attribution and honoring of any and all trademarks and intellectual-property items in terms of attribution to their respective owners as mentioned in this User Manual. The reader is encouraged to consult this section whenever uncertainty presents itself as to the terms, their meaning within the User Manual, and the trademarks and intellectual-property items they stand to identify, whether by themselves or in conjunction with other terms and items.

Sensofar® is a registered trademark of Sensofar-Tech, S.L.; Microsoft and Windows are either trademarks or registered trademarks of Microsoft Corporation in the United States and/or other countries. All other products, brand names and company names are trademarks or registered trademarks of their respective owners.

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: March 2020

We, Sensofar Tech S.L., declare under our sole responsibility that the product

Product type: Non-contact 3D Optical Profiler
Product name and model: S neox 090

is in accordance with the essential requirements of the following directives:

Low Voltage Directive 2014/35/EU

EMC Directive 2014/30/EU

RoHS directive 2011/65/EU

The following standards have been applied:

EMC	IEC 61326-1:2012 (EN 61326-1:2013) <i>Electrical equipment for measurement, control and laboratory use - EMC requirements</i>	
Emission	UNE-EN 55011:2011+A1:2011	UNE-EN 61000-3-3:2009 UNE-EN 61000-3-2: 2006+A1:2010+A2:2010
Immunity	UNE-EN 61000-4-2:2010 UNE-EN 61000-4-3:2007+ A1:2008+A2:2011 UNE-EN 61000-4:2005+A1:2010+CORR:2011	UNE-EN 61000-4-5:2007+CORR:2010 UNE-EN 61000-4-6:2009 UNE-EN 61000-4-8:2011 UNE-EN 61000-4-11:2005
Safety	IEC 61010-1:2010/Corr.1:2011 (UNE-EN 61010-1:2011) <i>Safety requirements for electrical equipment for measurement, control and laboratory use.</i>	


and carries the CE marking accordingly:

CE 0370

Manufacturer:

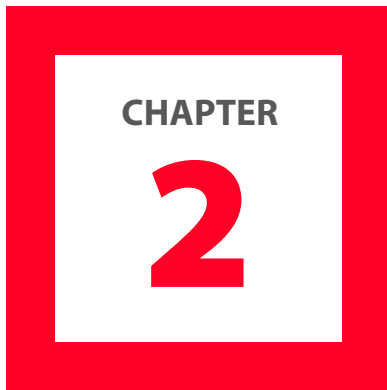
Sensofar-Tech, S.L.
Ctra. BV-1274, km 1
E-08227 Terrassa - Spain

Research and Development Manager
Dr. Roger Artigas



SENSOFAR-TECH, S.L.
T. +34 93 700 14 92
F. +34 93 706 01 16
www.sensofar.com

Terrassa, March 26, 2019



CHAPTER
2

QUICK START GUIDE

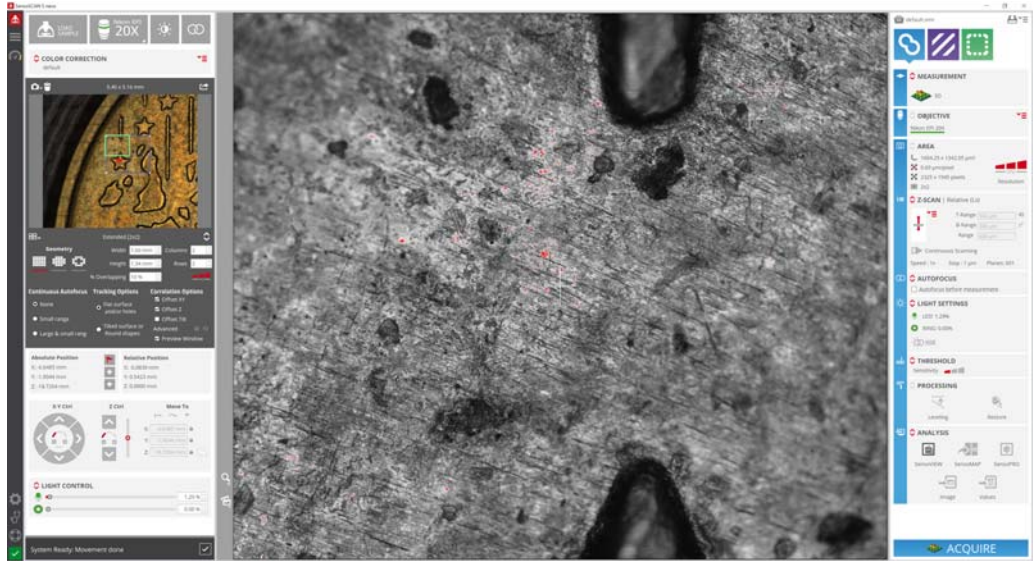
SensoSCAN requires a username and a password to log in. See [System Preferences / Users](#) to learn how to manage users. To have full access to **SensoSCAN**'s functions, log in with Administrator (password: adm1234).

The user interface has two modes: Inspection & Acquisition and Configuration & Calibration. After the login, the software enters the Inspection & Acquisition mode.



Inspection & Acquisition

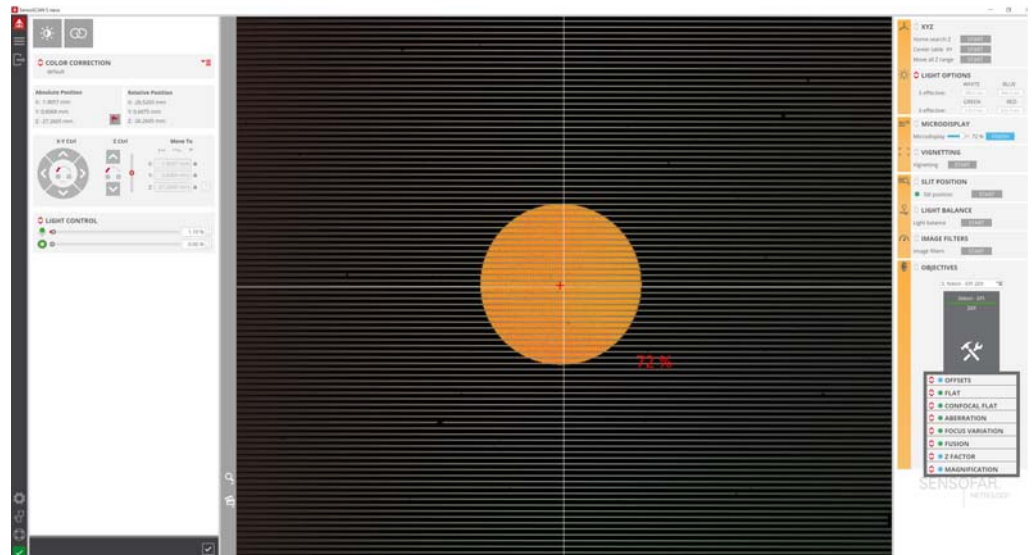
This mode comprises five principal interaction areas: toolbar on the left, settings for **Sample Inspection** next to the toolbar, the **System Status** below the Sample Inspection, the **Central Viewer** area in the center, and **Acquisition Settings** to the right.



SensoSCAN interface overview when in Inspection & Acquisition mode

Configuration & Calibration

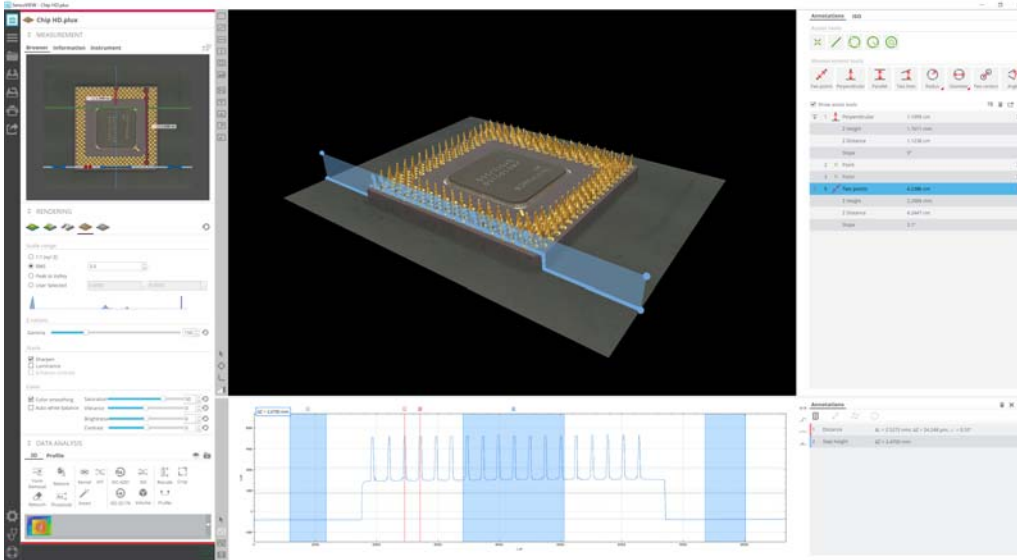
This mode comprises the same five principal interaction areas, with a less extended Sample Inspection pane and **Configuration & Calibration** tools to the right instead of Acquisition Settings.



SensoSCAN interface overview when in Configuration & Calibration mode

Analysis software

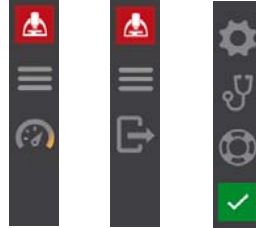
Measurements are displayed and analyzed in **SensoVIEW** or an alternative analysis software. After acquisition, data is transferred to **SensoVIEW** and its screen is automatically shown maximized. At any time you can press F5 or use windows controls to move the focus from **SensoSCAN** to **SensoVIEW** and vice-versa.



SensoVIEW interface overview

2.1 Quick Bar

The quick bar contains quick access icons to general software tools. At the top there is the menu and an icon to switch between Inspection & Acquisition and Configuration & Calibration modes. At the bottom there are the [System Preferences](#), Diagnostics, Help and [System Status](#) icons.



Quick Bar view in Inspection & Acquisition mode

The Quick Bar icons



This icon opens the menu with File, Configuration, Help, Service and Exit tools. The ones that are used more often have an icon in the toolbar itself.

File	Offline extended topography
Configuration	
Help	
Service	
Exit	

File menu

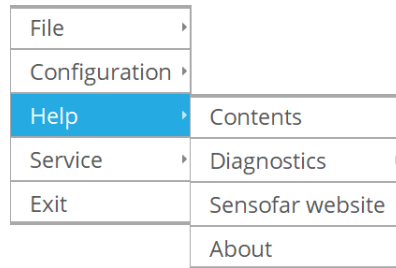
Selecting **File / Offline extended topography** provides access to a tool that imports and stitches a collection of individual topographies. For more information see [Offline Extended Topography](#) in the [Appendix](#).

File		
Configuration	Calibration	
Help	Reset	Reset objectives configuration
Service	System preferences	Reset objectives calibration
Exit	Sample parallelism	Reset light balance

Configuration menu

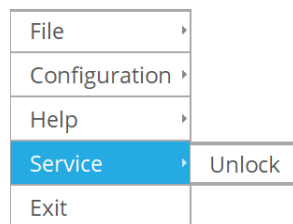
Configuration menu can be used to enter [Configuration & Calibration](#) mode, to reset some configurations and calibrations for all objectives and to enter [System Preferences](#). Sample parallelism is an alignment process reserved for special cases.

It is also possible to reset calibrations for one specific objective in the objective's configuration and calibration tool.



Help menu

Selecting **Help / About** opens a system window showing the following information - the program version, the serial number of the system, the company and the user.



Service menu

The **Service** menu is for technical service users and should be unlocked by a qualified user.

Exit closes **SensoSCAN**.



This icon switches to [Configuration & Calibration](#) mode.



This icon exits Configuration & Calibration mode.



This icon (also **Help / Diagnostics** in the Menu) opens a diagnostics menu that provides access to technical log files. Normally, these log files are not 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.

More information regarding diagnostics can be found in the [Errors & Diagnostics](#) chapter.



This icon achieves the same as selecting **Help / Contents** from the Menu. Both actions open this system manual.



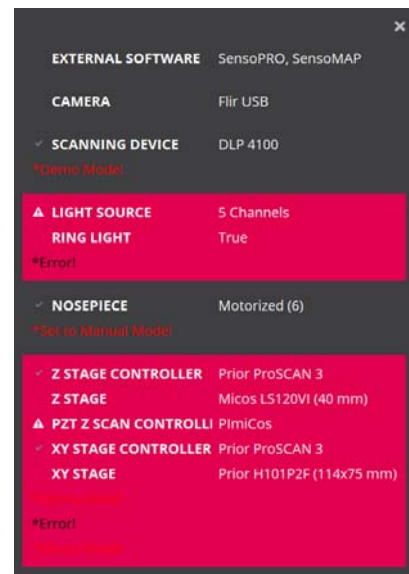
This icon (also **Configuration / System Preferences**) provides access to [System Preferences](#).



This icon shows the current system status and opens [System Status](#) window.

The symbol shows a large green tick when a device has performed a function and is ready to perform the next function, a red warning icon when a device is not correctly initiated, as well as other symbols (depending on the activity).

Clicking the system status symbol reveals detailed information about the system, the configuration and any errors and warnings:



System status examples: ready (left) and hardware errors (right)

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 & Calibration / XYZ options](#) for more information.



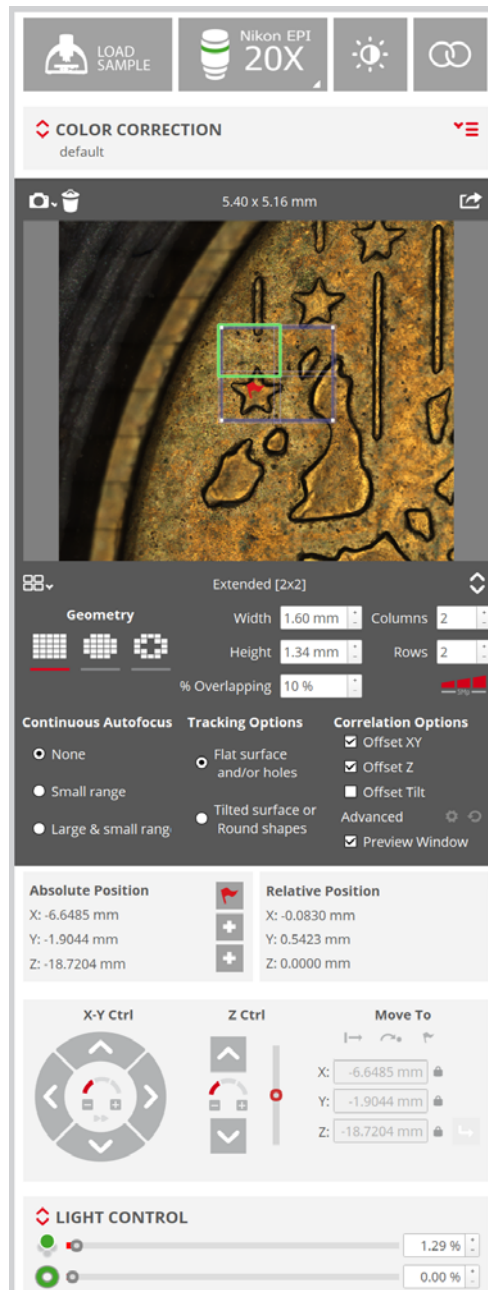
When the program executes Z stage movement, be careful not to trap your fingers between the moving parts.

2.2 Sample Inspection

In this area on the left of the Inspection & Acquisition interface, the user will find tools for the initial sample inspection. Many of these settings are also carried over to their counterparts in [Acquisition Settings](#), i.e. some are also valid for the acquisition process.

The tools available here include:

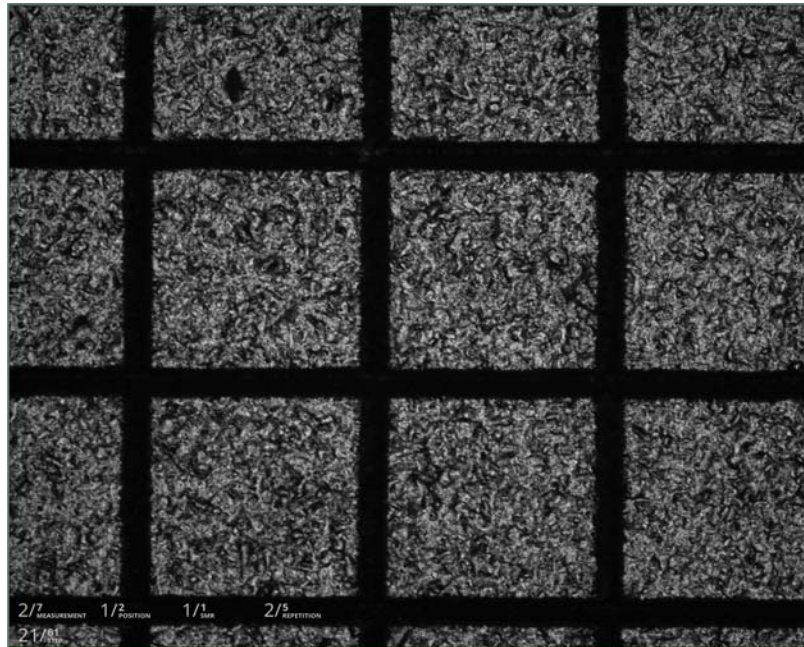
- Providing a Sample ID (see [Sample Inspection](#) and further details for use in [System Preferences / Sample ID](#))
- Loading a sample (see [Load Sample](#))
- Selecting the type of objective (see [Objective Selection](#))
- Automatically set the sample illumination (see [Autolight & Autofocus](#))
- Automatically set the best focus (see [Autolight & Autofocus](#))
- Enable/disable [Color Correction](#) and calibrating the correction
- Take an inspection viewer image to navigate the sample or define extended measurements layout (see [Inspection Viewer](#))
- Absolute and relative XYZ movements (see [Position & Motor Control](#))
- Manually control the motorized stages (see [Position & Motor control](#))
- Manually control the intensity and color of illumination (see [Light Control](#))



Overview of the settings available for Sample Inspection

2.3 Central Viewer

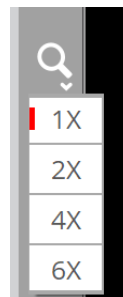
When in Inspection & Acquisition mode, the information about the steps, FOV's (fields of view) & MMR repetition during the scanning is visible over the live image.



Real time information during acquisition in central viewer live image

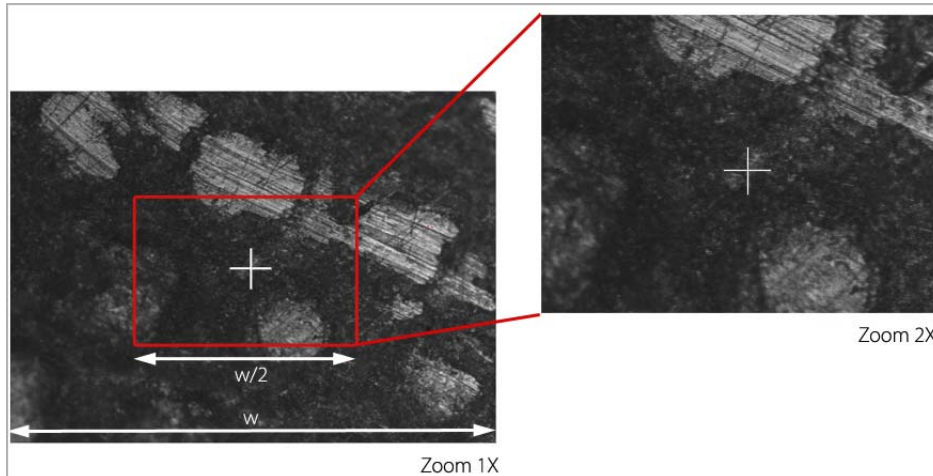
Zoom level

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 technique in conjunction with black & white 3D topography measurements (see [Acquisition Settings](#) to learn how to select these settings).



Zoom level in the Central Viewer

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



Zoom level increase example

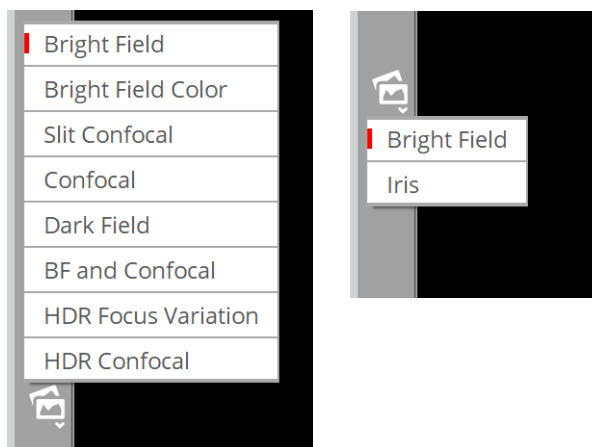
After the measurement, the zoom factor is saved in the measurement result and shown in parentheses in the measurement report area in **SensoVIEW**.

WARNING

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.

Viewer options

There are several live image types available depending on the current objective. See [System Preferences / Live Image](#) to learn how to configure the list of live image types to show only the ones you need.



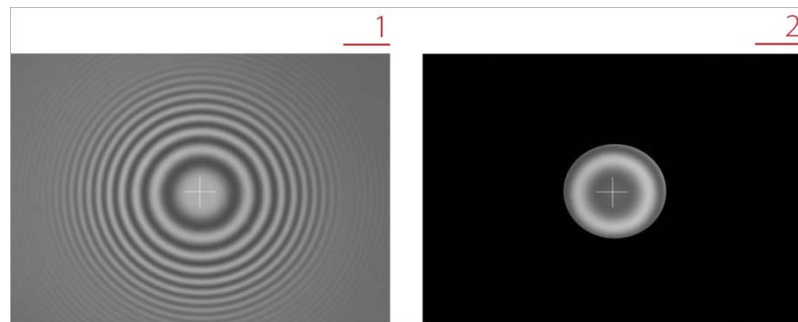
Live image type options - bright field objective on the left and interferometric objective on the right.

Bright field objectives (Confocal & Ai Focus Variation)

- Bright field: a monochromatic bright field image
- Bright field Color: a color bright field image created by sequentially illumination with R, G and B single LEDs
- Slit Confocal: a tool that helps in focusing the sample - the image view projects a slit pattern on the surface
- Confocal: a confocal image acquired with a monochromatic LED
- Dark field: contours are shown bright (generated with a digital filter)
- Bright field and Confocal: Bright field and Confocal images are condensed in the vertical (Y) direction
- HDR Focus Variation
- HDR Confocal

Interferometry objectives

- Bright field: a bright field 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). This image is not available with white light, only with monochromatic light. When bright field image is using white light the system automatically switches to green light while Iris live image is selected and switches back to white light when bright field image is selected.



Viewer options for interferometry objectives

Moving XY with the Central Viewer

Any feature visible in the FOV can be centered in the Central Viewer by placing the mouse cursor on the feature and double clicking with the left button.



Double-click a feature to center it in the Central Viewer

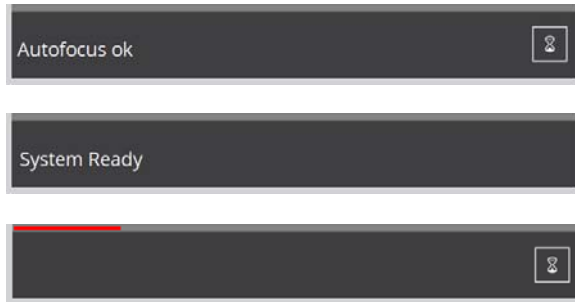
To move any feature to any part of the Central Viewer, use the mouse to click and drag.



Click & Drag a feature to any position within the Central Viewer

2.4 System Status

An area below the [Sample Inspection](#) area shows information about the procedure that is currently running. It includes a symbol that shows a tick when a process finishes without error as well as other symbols (depending on the activity). It also includes a progress bar:



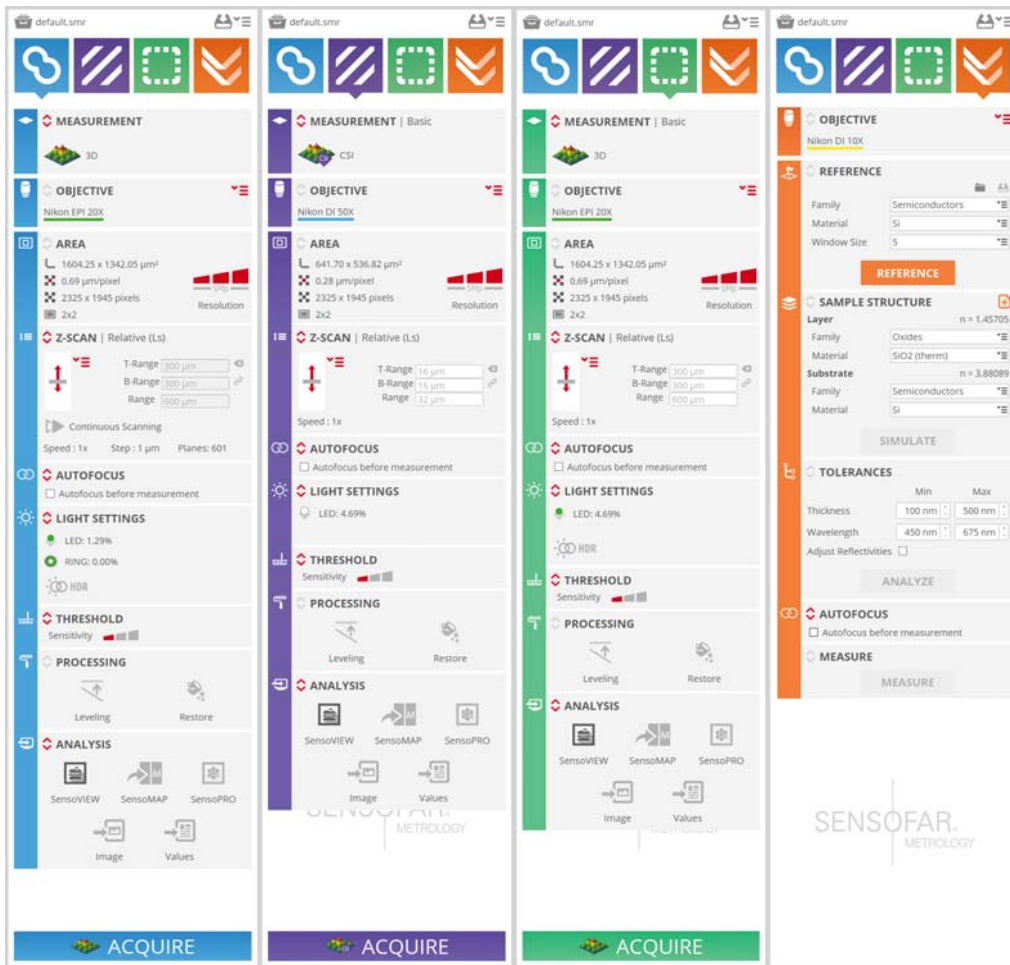
System process information

2.5 Acquisition Settings

Setting measurement parameters

This area to the right of the Inspection & Acquisition mode lists all settings that must be defined before acquiring a new measurement. Some settings are determined by changes made in [Sample Inspection](#). Others must be defined here in the order provided by the interface, from top to bottom.

Available settings depend on the Measurement technique and the Measurement type.




Acquisition settings for Confocal, Interferometry, Ai Focus Variation and Thin Film Measurement

For Confocal, Interferometry and Ai Focus Variation the settings are grouped into these categories:

- The **Measurement technique** - Confocal, Interferometry, Ai Focus Variation and Thin Film Measurement (optional)
- The **Measurement type** (surface, image, coordinate, thickness, etc.)
- **Objective Selection**
- The measurement **Area** (determined by [Inspection Viewer](#)) and the resolution options

- The vertical **Z-Scan** parameters
- Whether, and what type of **Autofocus** should be performed before a measurement
- **Light Settings**
- The **Threshold**
- **Processing** settings
- **Analysis** options

Basic settings are always visible but additional advanced settings can be modified by clicking  icon to see them.

Once these settings have been made, clicking **Acquire** will trigger the measurement process. Upon completion of a successful measurement, the interface will automatically send the results to **SensoVIEW** (if enabled in the Analysis options).

For Thin Film Measurement it is required to define a combination of settings and actions that are grouped into these categories:

- Reference
- Sample structure
- Tolerances
- Measure

Thin Film Measurement result is displayed in the **SensoSCAN** screen at the right bottom.

See the detailed description in the Acquisition Settings chapter for a more detailed description of all acquisition settings.

2.6 Acquire a measurement

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 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, [Sample Inspection](#), [Acquisition Settings](#) and **SensoVIEW**'s user manual should all be considered essential reading.

Before measurements are to be acquired, a system warm-up time of roughly ten minutes is recommended.

3D Auto feature


3D Auto is an automated measurement mode for [Confocal, Interferometry](#) (CSI) and [Ai Focus Variation](#) Measurement techniques that is recommended for non expert users. 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 predefined initialization routine and subsequently acquires a measurement over a single FOV. More detail on the 3D Auto measurement can be found in Acquisition Settings.

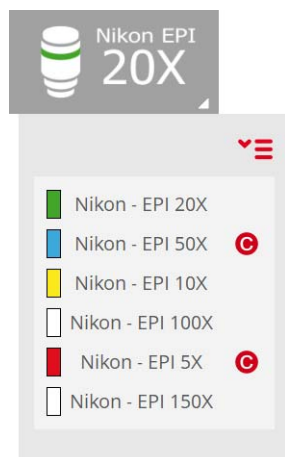
NOTE 3D Auto is for a single field-of-view (FOV) only. It can be used routinely for straightforward (but not mirror-like) surfaces to obtain highly qualitative measurement results. Unknown, and more complicated and structured surfaces are best measured manually by an experienced technician.

Quick start guide to manual measurement


The following very briefly outlines the steps needed to take a measurement manually.

Focusing on the sample

Choose an **appropriate** (and **calibrated**) objective by simply clicking on the tab  in the [Objective Selection](#) to reveal the available objectives:



Objective Selection pane

NOTE Not yet calibrated objectives are highlighted with a red circle  (see [Objective calibration](#)).

Focusing a bright field objective

Choose the bright field objective that you want to use (preferably a 20X EPI), and position the sample. For fast focusing of the sample (on smooth surfaces), choose Slit Confocal live image in the [Central Viewer](#). A parallel slit pattern will be projected onto the surface.

NOTE Be careful with high magnification objectives that have low working distance.

Use the coarse control buttons on the Control Console (button z up moves the sample up, and button z down moves the sample down) to position the surface at the working distance of the objective. Slowly move the Z motor 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. For this, select Bright field live image and use the Joystick on the Control Console or the software motor control to move the stage until the desired region is within the field-of-view (FOV). If this region is very difficult to find, try using a lower magnification objective.

Once the region of the surface is located switch again to Slit Confocal live image and continue to use the motor options on the Control Console 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, choose Iris live image. 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:

- Measurement technique
- Measurement type
- Appropriate objective

- Measurement area (including any stitching options)
- Z-Scan parameters
- Autofocus
- Light options
- Threshold
- Processing
- Analysis

If you have a three dimensional structure, you can inspect it either by acquiring an [Image capture](#) 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 in Confocal and Interferometry or with Thin Film Measurement technique. In all cases, capturing an image using the [Inspection Viewer](#) can help considerably when inspecting the sample during the measurement preparation, when checking the measurement positions before measurement, and when setting up an automatic procedure.


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 strategy 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, Interferometric or Ai 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 range 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

There are three different strategies for defining Z scan range: relative, absolute and dual. See [Acquisition Settings](#) chapter to learn how to use them.

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 3D topography measurement. If this is the case, check that both the strategy 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.

Once the acquisition is complete, the interface will automatically change to **SensoVIEW**.

CHAPTER
3

SAMPLE INSPECTION

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. In order to capture an overview of the sample, one must first understand the function of these tools.

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



The Sample Inspection pane



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.



Sample ID label at Sample Inspection top area

Details on how to configure and use this tool are given in System Preferences section in the **Appendix**.

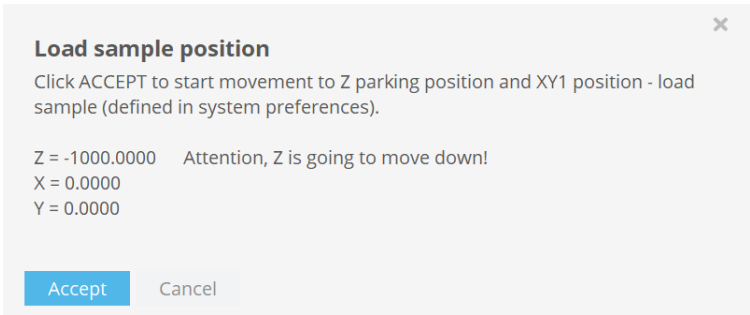
Load Sample

The “Load Sample” button performs a predefined XYZ movement to help the user load and unload the sample.



Load Sample icon at Sample Inspection top area

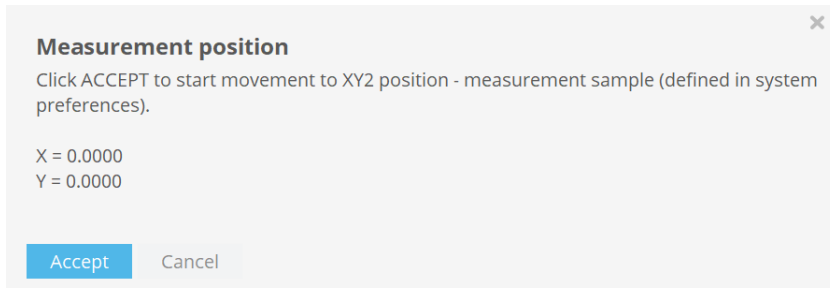
When the user clicks on “Load Sample”, the software displays the “Load sample position” window. Click on the “Accept” button to start loading a new sample. The system will move Z up to the parking position. For safety down movements are not allowed and in the case that the current Z is higher than parking position defined in **System Preferences / Positions** movement will not be done. The default value is -1 mm.




Load sample position window

The system then moves XY to position 1 which is defined in the **System Preferences / Positions**. The default values are X center (0 mm) and Y range/2 (forward) to unload and load the sample easily.

Once at position 1, the system displays the “Measurement position” window. The user can then unload the current sample and load the next one. Then, the user must click Accept. The system moves XY to position 2 (the default values are X center and Y center) and Z remains fixed.




Measurement position window

In order to avoid the Z stage crashing into the sample, the “Load Sample” prevents it from moving back to its original position. If the Z position is going to be very similar, the user can “Define Reference” with  before starting to “Load Sample” and use “Go to Reference” once the process has finished in order to set the system at the desired XYZ position. See Position & Motor Control for more information.




If Z position varies from one sample to the next, do not use “Go to Reference” and focus the sample manually instead.

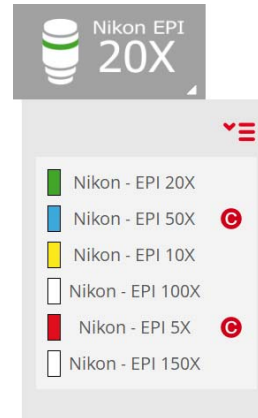
If the **Sample ID** function is enabled, the user will be able to identify the sample during the load process. If this function is disabled click on the *Sample ID* icon  to open Sample ID window where the sample can be identified.

3.1 Objective Selection



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 bright field and interferometry objectives. These are listed in the product guide, used to determine which objectives are purchased with the system. After system installation and configuration purchased objectives are available in the software.

Fixed objective properties such as WD and NA are displayed in the objective's configuration tool (inside [Configuration & Calibration](#) mode). Other properties are dynamic because they depend on the acquisition settings: pixel size and minimum Z range.

SensoSCAN only shows all objectives that are available but not all may be appropriate for the current Measurement type. 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 forced to be the same in the [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.



WARNING

It is very important to use the correct objective when acquiring. 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.

3.2 Autolight & Autofocus

The Autolight and Autofocus commands are two automated routines available in [Sample Inspection](#):



The Autolight (left) and Autofocus (right) 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. By default saturated pixels are shown in red, this can be disabled in [System Preferences / Live Image](#), so that these pixels are shown as white.

NOTE Autolight only adjusts the single, co-linear LED sources, 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.

The Light Control pane (or the [Control Console & Joystick](#)) can be used to manually set the light level at any time. Choice of LED and other advanced light settings can be set in Light Control pane.

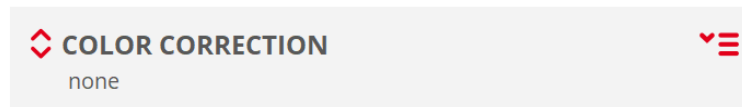
Autofocus

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 (or by choosing the appropriate button on the Control Console & Joystick), a small and/or large Autofocus routine is performed for the current FOV (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 or by using the Control Console & Joystick.

More information about the use of the Autofocus function elsewhere in the system, in particular for [Extended Measurements](#) and including advanced settings, can be found in the [Autofocus](#) section of [Acquisition Settings](#).

3.3 Color Correction



Color Correction in Inspection Settings

The Color Correction function is used to correct for color bias in images acquired with **SensoSCAN**.

NOTE Color Corrections are objective-specific - switching to a different objective will hide any Color Corrections that are not related to the new objective.

NOTE Color Correction is not programmed to account for the optional ring light. If color fidelity and accuracy are important, make sure the intensity of the ring light (if installed) is set to zero for all color image tasks, including Color Correction acquisitions.

Color images are acquired by successively illuminating the sample with the red, green and blue LEDs. Each color channel is captured with the (monochromatic) digital camera, and the resulting color image is a composite of the individual channels.

Color bias in images can arise due to, for example, the relative intensities of the RGB LEDs themselves, and/or due to the specific spectral reflectivity of a sample at the wavelengths of the individual RGB LEDs (i.e. compared to the overall spectral reflectivity seen from a neutral white light source). By calibrating color using a white surface with reflective properties similar to the sample being studied (e.g. for ceramics, a similar white ceramic material), color bias in the captured image can be reduced so as to yield better color accuracy.

The Color Correction drop-down menu has default and none options as standard. Other options are available when user-defined calibrations have previously been performed (in the examples below, paper is a user-defined Color Correction that has been previously acquired and saved):

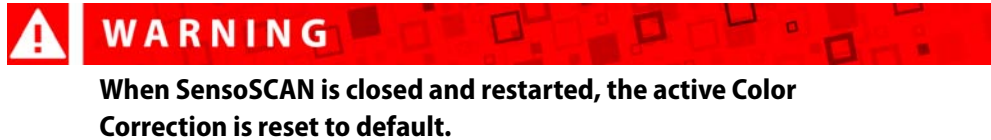


Drop-down menu showing available Color Correction options

- **default** (always visible): applies default (objective's calibration) Color Correction
- **none** (always visible): no Color Correction is applied
- **paper** (available only if previously acquired): loads a user-defined Color Correction made on paper

The default Color Correction is not good for all surface types - that is, due to the differing surface properties between samples, it is necessary to acquire user-defined Color Corrections in some cases. For example, the Color Correction obtained for an aluminum mirror may work very well for other shiny surfaces with similar spectral reflectivity, but will fail for scattering surfaces, such as paper or ceramics.

When capturing a Color Correction, the user must choose a clean region on the sample (or an alternative, but similarly reflecting material) that is as white as possible, with no color structuring. Upon completion, it appears as a Color Correction option in the drop-down menu shown above and is immediately applied to all color images.



Capturing a Color Correction image

Clicking the red up/down arrows  on the left of the Color Correction pane closes or opens the extended pane, respectively:

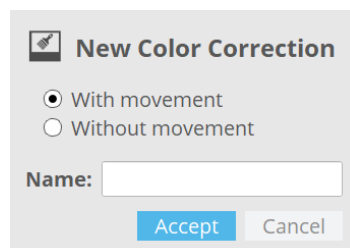


Color correction pane

The figure above shows the current chosen Color Correction (in this case sample) as well as the buttons for:

- **NEW**: creating a new Color Correction
- **SAVE**: saving the current Color Correction
- **DELETE**: deleting the current Color Correction (user-defined Color Corrections only)

To capture a Color Correction image, press New - the following dialog appears:



Capturing a new Color Correction

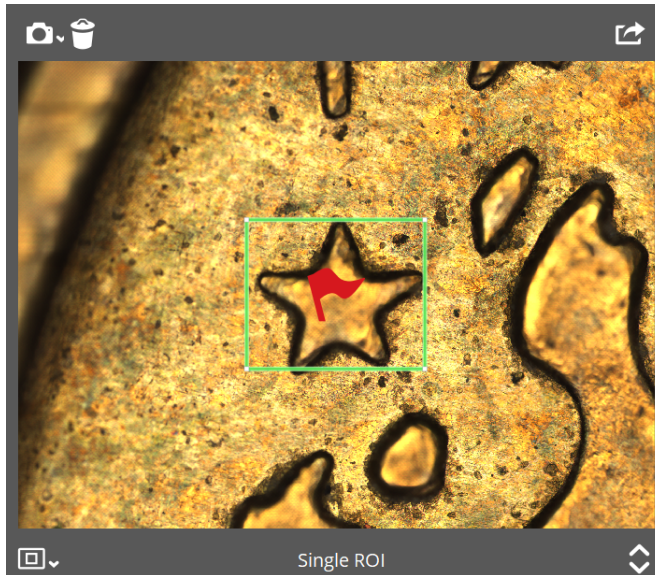
With movement and *Without movement* options simply specify whether the sample is moved underneath the objective so that different regions of the sample are used to generate an average Color Correction. Choose the required option, enter an appropriate name and then click Accept. An image is acquired (*Without movement*) or an average of multiple images is acquired (*With movement*) using each of the four LEDs. This process utilizes the **Flat** configuration routine to account for inhomogeneous illumination across the FOV and establishes the white balance for the image. Upon completion of the capture, the new Color Correction is immediately applied to all color images.

Once the Color Correction has been applied, the Flat-field and White balance options shown above can be used to specify how it is used:

- **Flat-field** is by default active. Deactivating the Flat-field option removes the correction for the equalization of the illumination across the FOV.
- **White balance** is by default active. Deactivating White balance removes the correction for the white balance in the final image.

3.4 Inspection Viewer





The Inspection Viewer is used to acquire an image of the surface, for inspection and region-of-interest location purposes. The (extended) Inspection Viewer pane is also used to define acquisition layout when it is necessary to acquire measurements over regions of the sample that go beyond a single FOV ([Extended Measurements](#)).



The Inspection Viewer panel

The dimensions at the bottom of the pane show the dimensions for the current view on the sample. By placing the cursor over the viewer pane, the image can be panned by grabbing with the mouse or trackpad, and zoomed directly at the cursor location by scrolling (particularly useful with large extended measurements).


The following options are available within the standard viewer pane:

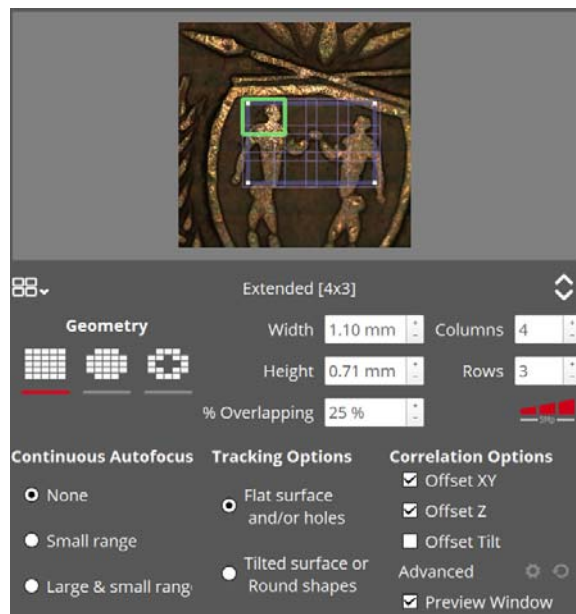
- : Set the area and do a new capture. The sample is automatically scanned under the objective, capturing 3x3, 4x5, 5x6, 6x7 or 7x8 FOVs (standard options), or up to 150 x 150 FOVs (i.e. custom, depending on the options selected in the drop-down menu). The individual FOV images are stitched together to form an extended sample view (scene). Note that the F10 shortcut repeats the last capture.
- : Delete the current view.
- : Export the current image or scene (view) as an image using the format specified in [System Preferences](#) / General.
- : Select single Area (1 FOV measurement) or Stitching Area (Extended measurement). When Stitching Area is selected the pane extends to reveal more options (see next section).

3.4.1 Extended Measurement

When the system is equipped with a motorized XY stage, it is capable of acquiring Extended Measurements. It does this by acquiring individual – but partly overlapping – FOVs for the selected objective, scanning the sample accordingly, and stitching the individual measurements together as a patchwork when acquisition is complete. The shape and extent of the surface area for these Extended Measurements, as well as how adjacent FOVs should be acquired and positioned (i.e. relatively on the Z axis) can be configured within **SensoSCAN** using the extended **Inspection Viewer** pane.

NOTE Stitching Area is not available for some image capture and Measurement types. More information can be found in [Measurement type](#).

If Stitching Area is available for the chosen Measurement type, then choosing it in the **Inspection Viewer** panel extends it to reveal more options (see image below, or alternatively, simply click the drop-down icon ):



Stitching Area options in the Inspection Viewer pane

The settings made here in the extended pane determine the area, geometry, autofocus, tracking and correlation options (including advanced options) for any subsequent acquisition.

Geometry settings

Three basic geometries are available: rectangular, circular and annular. Various dimension parameters pertaining to the different geometries can be set manually:

- **Rectangular:** the number of rows and columns, the degree of overlap between FOVs, and dimensions in mm for each FOV
- **Circular:** the number of rows, the degree of overlap between FOVs, and dimensions in mm for the circular ring (outer diameter only)
- **Annular:** the number of rows, the degree of overlap between FOVs, and dimensions in mm for the annular ring (inner & outer diameter)

Note that by changing columns, rows or scene size for any one of these geometries, all other dimension parameters are automatically re-calculated to match (i.e. to optimize the measurement). The maximum number of rows and columns in each case is 175 x 175.

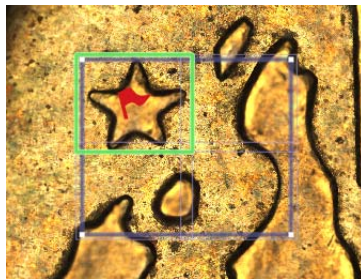


WARNING

If the number of rows or columns is set so that an Extended Measurement would move the XY stage beyond its travel range, an attempted acquisition will fail with an error message.

Interactive overlay

The area layout is displayed as an interactive overlay on the current scene. The overlay shows the current FOV (outlined in green), the selected measurement area (blue, bold), and how the various FOVs will overlap (blue, light). By grabbing the anchor points in the overlay and dragging to move, expand or contract the total measurement area, the dimension parameters for any chosen geometry can be visually adjusted as necessary.



Area layout

Just as for manual changes to the selected measurement area, the parameters in the extended viewer pane are modified and optimized automatically to mirror any changes made in the overlay.

NOTE For annular and circular geometries, regions of FOVs that lie outside the measurement area are automatically deactivated (i.e. shown darkened on the overlay) and are not measured.

Once the geometry settings have been selected, the overlay displays an optimized mesh of single FOVs as defined by the chosen number of columns and rows. By moving the mouse over the overlay, the individual FOVs are highlighted. The user can interact with this mesh by selecting individual FOVs, or by clicking and dragging to select many FOVs at the same time. The following options can be set by right-clicking the selection:

- **Set start:** sets the selected FOV in the grid to be the region of measurement that is in focus when ACQUIRE is pressed.
- **Enable/Disable:** FOVs can be enabled or disabled as necessary. Disabled FOVs are shown darkened on the overlay, and are not measured.
- **Invert all:** disables all enabled FOVs and vice-versa.

Overlap

This is the amount of overlapping area between contiguous FOVs. The default overlap is 10%, but it can also be set up to 50%. The greater the overlap, the more single measurements are needed to cover the desired area.

Continuous Autofocus

The use of Autofocus for the **initial** FOV in an Extended Measurement is enabled in [Acquisition Settings](#). If Continuous Autofocus is enabled in the [Inspection Viewer](#), Autofocus is used for each **subsequent** FOV. When Autofocus is enabled, the acquisition of extended images will be slower. It is recommended for irregular shapes or heavily structured surfaces.

NOTE If Autofocus fails for any FOV, the Z starting point for that FOV will be the same as for the previous FOV.

Tracking options

The tracking options refer to the Z-Scan trajectory between the adjacent FOVs of an Extended Measurement, as well as to the checking/managing of the points measured in the regions of adjacent FOVs. There are two predefined options:

- **Flat surface and/or holes:** no Z offset between FOVs (unless Continuous Autofocus is active) and no control of a minimum number of measured points.
- **Tilted surface or round shapes:** the following Z offset is extrapolated from a parabolic function fitted to the previous FOV surface. The Z-Scan range remains fixed. It requires a minimum number of measured points.

NOTE When a Set start FOV has been modified by the user (i.e. not the 'upper leftmost' FOV), selecting Tilted surface or round shapes introduces a 4s interval at the start of the acquisition. This is to warn the user that light and focus will need to be re-checked when the system moves to the initial FOV to begin the acquisition. If no adjustment is required, the user can press any key to start the measurement immediately. If the light and the focus have to be adjusted, the user can simply modify the focus position to stop the 4 second countdown. Once the light and the focus are correct, the user **MUST** press a key to start the measurement (the [keyboard shortcuts](#) F2, F3 and F8 can be pressed during the countdown to cancel it).

The subject of Z-Scan tracking and the issues associated with each approach are discussed in detail in the [Appendix](#).


Correlation options

There are three options to choose from:

- **XY** – FOVs are stitched using the best fit in the XY plane, as if seen from above, without considering the changes in Z (height).
- **Z** – stitching done by considering the height differences between two consecutive FOVs.
- **Tilt** – works best for large area acquisitions (high number of measured FOVs or low magnification objectives). It corrects the tilt that may appear on the FOVs near the edges of the acquisitions as a result of the XY table movement.

**WARNING**

Tilt is not enabled by default because it can have negative effects on the stitching of smaller areas, as it can remove a tilt that does not exist.

Multiple correlations can be selected at the same time by checking the corresponding checkbox. By not checking any boxes the result is shown without any adjustment. Additional options are available by clicking the  icon.

NOTE

The default settings work on most cases and usually there is no need to alter the additional options. These options are complex and should only be altered by very experienced users who know what to expect when applying each setting.

Activating the Preview checkbox at the bottom of the correlation options provides a preview of the stitched result in the [Stitching Preview](#) window after Acquisition has successfully completed. There the user can switch between the different correlation options and adjust any necessary settings to achieve the best result before it is shown in **SensoVIEW**.

For more information about the available settings and the stitching preview window go to [Offline Extended Topography](#) in the [Appendix](#).

Pause/Stop the acquisition process

The acquisition process can be interrupted by pressing Pause on the keyboard. The following options are then available to the user on a Lost Topography dialog:

- **Retry FOV:** A further dialog window appears that provides basic means to (i). adjust the light intensity, and (ii). adjust the Z-Scan range. Note that these changes are applied only to the current (failed) FOV - if they should be applied to all remaining FOVs, select the option Apply to following FOVs. By clicking Accept, the acquisition continues as originally planned, first repeating the acquisition of the current (failed) FOV.
- **Skip FOV:** Do not retry current FOV (keep current measurement) and move on to the next FOV.
- **Finish:** Stop the acquisition and display the FOVs already measured.
- **Cancel:** Cancel the entire acquisition.


Large area measurements

The reason for this hardware/software option is to enable the acquisition and analysis of very large areas, i.e. up to the maximum range of the XY stage (150 mm x 150 mm or 300 mm x 300 mm). An acquisition of this type thus involves many FOVs.

When attempting an acquisition over a large area, it is important to be aware of the following points:

- A large number of FOVs requires longer acquisition times, during which the system must remain stable and free of disturbances.

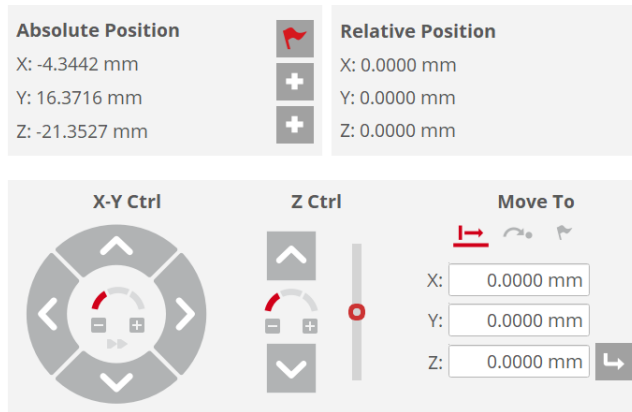
- This type of acquisition requires large amounts of installed RAM. If necessary, **SensoSCAN** will automatically **reduce the resolution** to make sure that the desired number of FOVs can be successfully acquired. For largest area measurements resolution is reduced to minimum value (all elements in resolution icon are in gray color) which is not available for user selection in the **Acquisition Settings**.

A system-forced change in resolution is indicated in the pane with a small warning triangle -  - clicking the triangle to dismiss it indicates to the system that the user has acknowledged the change. The resolution indicated here matches that shown/selected in the Area pane.

- Stitching of adjacent FOVs must be performed over many FOVs.

Just as for any other acquisition, large area measurements can be saved as a Recipe (see [Recipes](#)) and reused later, or on other systems.


3.5 Position & Motor Control



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 each motorized axis.
- **Relative Position** is relative to a user-defined reference point that can be set (and repeatedly reset) by clicking the Define Reference icon  for any available locations. Up to three references can be set. It is possible to choose between them by right clicking on the mouse. Left clicking on the mouse calls up a dialog with three possible options - Overwrite reference with current position, Delete reference, and Cancel.

NOTE Only one reference can be active at a time, in order to show the relative distance or to apply a movement.

Motor control

Movement and positioning of the stages can be controlled via **SensoSCAN** using the software motor control pane. A little time spent playing with the X-Y Ctrl and Z Ctrl controls with a sample visible in the viewer pane will quickly provide adequate explanation of their function.

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 X, Y & Z movement or absolute coordinates as needed, and then confirming the command by clicking . These options are available in the “Move to” section of the Position & Motor control pane.

Movement range XY

The XY movement is ultimately limited by the travel limits of the stage, but there are additional software and hardware limit controllers. To acquire data, or to be able to move along the XY axes, the system has to be within the XY software limits as defined in the [configuration files](#) StageX.xml and StageY.xml.

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 for moving Z downwards 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.

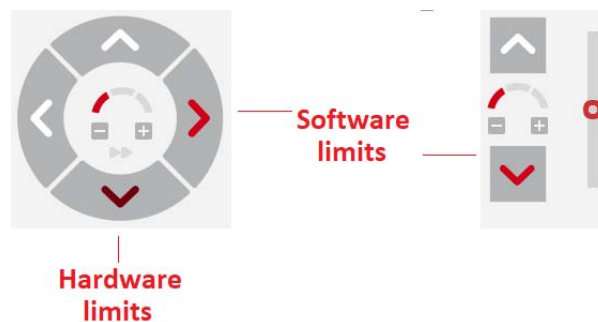


WARNING

The Z stage position shown in the position display corresponds to the Z stage controller, even in a system that has a piezo stage.

Movement beyond software/hardware limits

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



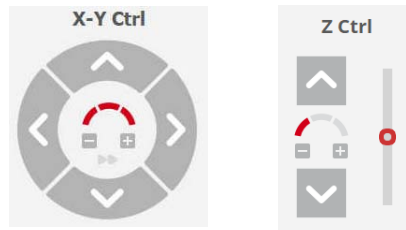
Position & Motor Control limits warning colors

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

By default, the Joystick is blocked when Z is beyond the software limits. When moving down and the lower software limit is reached, motion ceases. This helps avoid the objective touching and possibly damaging the sample. To disable Joystick blocking and allow movement between software and hardware limits, StageZ.xml can be edited appropriately.

Stage speed

The speed of the motorized stages is represented by three arc sectors:



It can be adjusted by clicking the corresponding sector or by clicking on the +/- icons. By default the slowest speed is set.

- XY Stage: clicking on the ►► icon enables the fastest speed.
- Z Stage: the slider allows for very small movements in the Z axis.

3.6 Light Control

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, 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 option 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 both the [Inspection Viewer](#) and the [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 each LED is controlled by a 16-bit microcontroller PWM signal. For any selected (or system pre-selected) LED source, the ideal light intensity 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).

The system has four single, co-linear (axial) light sources - a blue LED (460 nm), a green LED (532 nm), a red LED (632nm) and a white light LED (center 580 nm). The LEDs are generally used as follows:

Technique	Red	Green	Blue	White
Confocal		default		No
Interferometry - PSI		default		
Interferometry - ePSI				default
Interferometry - CSI				default
Ai Focus Variation		default		No

The default measurement LED is often green for measurement configurations only requiring a single wavelength, simply because microscope optics are optimized for this wavelength. However, white light LEDs are specified by particular interferometric Measurement techniques, and R, G and B LEDs are used sequentially to capture color images.

Depending on the application requirements, it may be preferable to choose another wavelength. Note, however, that while **SensoSCAN** will allow the user to select non-default LEDs for all Measurement techniques, this may not always yield a meaningful measurement result - this will depend on the particular system configuration and the measurement parameters selected.

The white LED is not available for Confocal and Ai Focus Variation.

Ring light

The ring light (Green) is an option 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 Ai [Focus Variation](#) and [Confocal Fusion](#) measurement techniques.

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).

NOTE [Color Correction](#) is not programmed to account for the ring light. If color fidelity and accuracy are important, make sure the intensity of the ring light (if installed) is set to zero for all color image tasks.

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

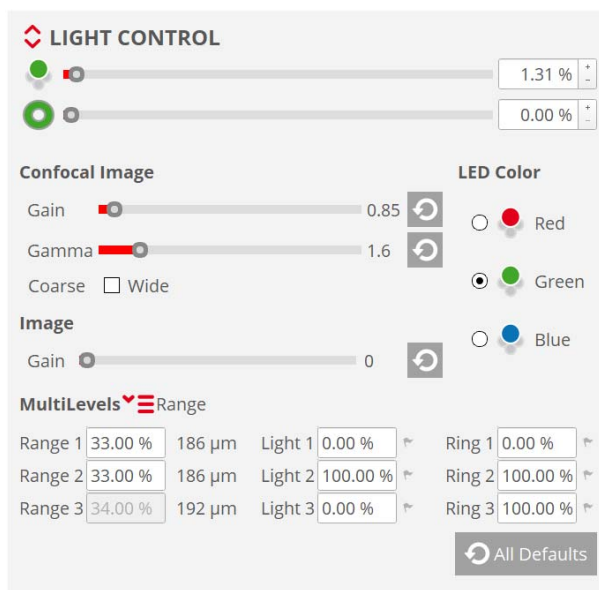
Objective	Ring model
EPI 2.5X (225MUE12030), 0.075NA, 6.5WD	Model 1
EPI 5X (225MUE12050), 0.15NA, 23.5WD	Model 1
EPI 10X (225MUE12100), 0.3NA, 17.5WD	Model 2
EPI 20X (225MUE12200), 0.45NA, 4.5WD	Model 2

Linking to Acquisition Settings

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.

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.

The advanced settings are:

- Confocal Image Gain is applied to the confocal image:
 - Decreasing the gain reduces the contrast in the confocal image.
 - 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 Smart > Despiking filter can be applied in **SensoVIEW**.
- Confocal Image Gamma value is a multiplicative exponential factor. Decreasing the gamma value yields greater contrast in the confocal image.
- Confocal image coarse factor to adjust the width of the slits used to obtain a confocal image. Depending on the objective family, NA and magnification Confocal uses by default Wide or Narrow factor. Then the light control allows to change to the other option:
 - For objectives where default is Wide, the user can select Narrow when higher resolution is required.
 - For objectives where the default is Narrow, the user can select Wide when more light is required.
- Image Gain is applied to the camera. 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.




WARNING

Changing camera image gain globally affects ALL measurements. The only exception to this is the **Configuration & Calibration mode, where the CCD camera always works with the default gain value.**

- Image Gamma is applied to the camera, and it is only available for interferometry. Increasing Image Gamma yields greater contrast in the image. This can be useful to make the interferometric fringes stand out more.

NOTE

Clicking the reset icon  for any slider returns the value to the default.

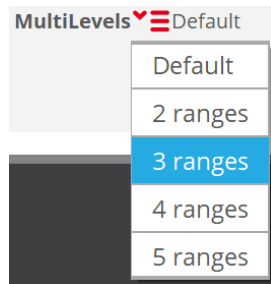
Some samples require an adjustment in advanced light options, so the window remains open unless the drop-down arrows are toggled. While the window is open, the user can change the settings and the result is shown on the live image. This allows adjustment of the confocal gain or the LED selection while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



Multi-levels range options

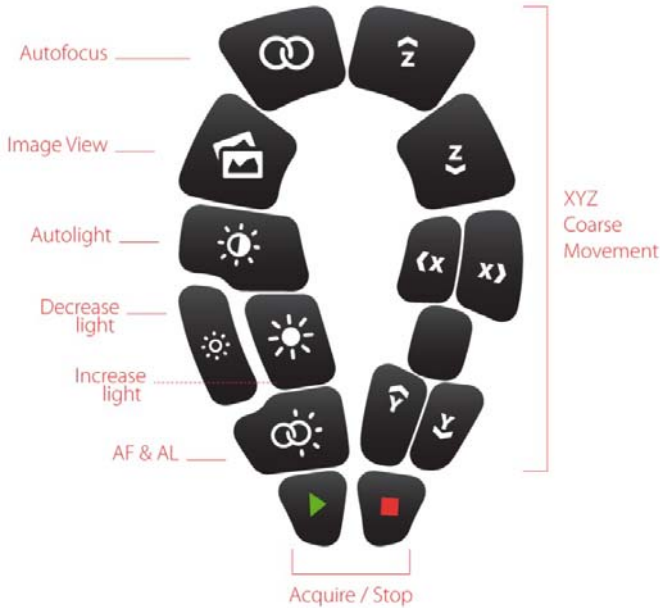
- Range: This divides the scan into ranges (up to 5) of variable height, where individual light intensities can be set for each range. This option is useful, for example, for step-like structures, in which the top and bottom materials have very different reflectivity, or for narrow and deep holes and trenches, in which the amount of light reflected from the deepest region of the sample is too low.
- If the ring light is installed, all selected MultiLevels will need to be set for the selected single LED source (i.e. all **Light n**), and for the ring light (all **Ring n**):

Range 1	<input type="text" value="33.00 %"/>	186 μm	Light 1	<input type="text" value="0.00 %"/>	↕	Ring 1	<input type="text" value="0.00 %"/>	↕
Range 2	<input type="text" value="33.00 %"/>	186 μm	Light 2	<input type="text" value="100.00 %"/>	↕	Ring 2	<input type="text" value="100.00 %"/>	↕
Range 3	<input type="text" value="34.00 %"/>	192 μm	Light 3	<input type="text" value="0.00 %"/>	↕	Ring 3	<input type="text" value="100.00 %"/>	↕

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

3.7 Control Console & Joystick

The functionality of the Control Console & Joystick is illustrated in the following diagram:



Buttons on the Control Console

Image View control switches from current Live Image to the best image for focusing a sample, depending on the current objective: Slits (bright field) or Iris (interferometric).

AF & AL control does Autolight and Autofocus (bright field objectives) or Autolight with Z-Scan and Autofocus (interferometry objectives).

Stop control is the same as pressing ESC key, it cancels current acquisition or process.

The Control Console & Joystick can also be used to control the three axes of the motorized stage. Tilting the Joystick right to left or backward to forward moves the stage in X and Y directions, respectively. Turning the Joystick control clockwise or counterclockwise slowly moves the Z axis down or up, respectively. To move rapidly up or down on the Z axis, or left and right on XY axes, press the appropriate coarse movement buttons.

Motor movement can be stopped at any time during sample preparation by pressing the Stop button.

3.8 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	Configuration & Calibration
F1	Help	X	X
F2	Autofocus	X	X
F3	Autolight	X	X
F4	Acquire (new measurement)	X	
F5	Switch to SensoVIEW	X	X
F6	Toggle between Iris or Slit Confocal (depending on the selected objective) and previous view	X	X
F7	Switch between maximum light intensity and the previous intensity	X	X
F8	Autolight and Autofocus (bright field objectives) Autolight with Z-Scan and Autofocus (interferometry objectives)	X	X
F9	Acquisition: Switches between the small cross-hair (or nothing - see System Preferences) and a large cross-hair Configuration & Calibration: Switches between nothing and a large cross-hair	X	X
F10	Repeat previous Inspection Viewer capture (stitched images)	X	
Spacebar	Stop the Single FOV measurement after acquiring 21 planes (Confocal and Focus Variation) or 50 images (CSI and ePSI) and go to Data & Analysis. Pause Stitching Area measurement at the end of current FOV acquisition.	X	

CHAPTER 4


CONFIGURATION & CALIBRATION

The Configuration & Calibration mode can be accessed by clicking Calibration icon  or selecting **Configuration / Calibration** from the Menu icon.

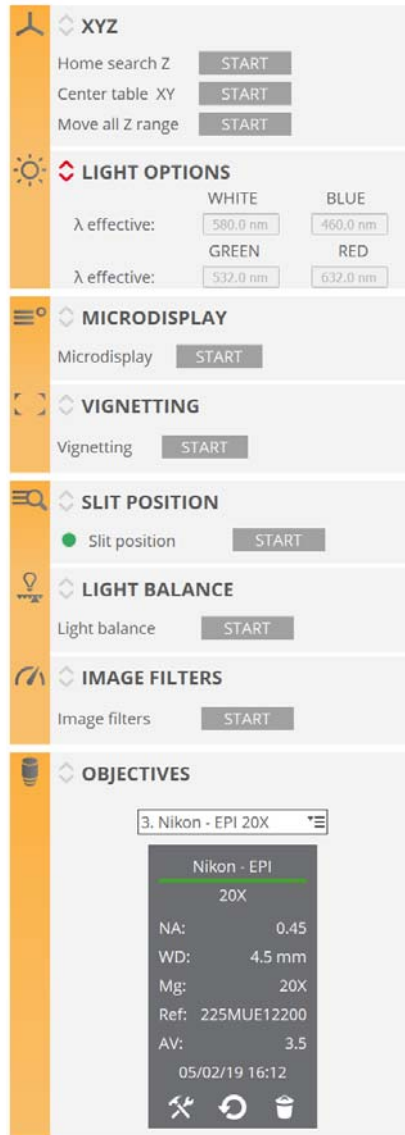
The Configuration Menu also provides access to dialogs for globally resetting the following:

- objective configurations
- objective calibrations
- light balance

Resetting any of these configurations – except for light balance – automatically closes the software in order to apply the changes.

To leave the Configuration & Calibration mode, select either Configuration / Exit calibration from the Menu icon, or click the Exit icon  on the left of the [Quick Bar](#).





The calibration tools

NOTE In order to avoid improper instrument configuration, this mode should only be selected by trained users.

4.0.1 Calibration

Sensofar systems are calibrated during the verification and calibration process at Sensofar, after the manufacturing process and before shipping the system to end users/customers. Different parts of the system are calibrated in a different way and with different frequency over time. This section describes general concepts related to calibrations.

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

How often is the system calibrated?

The advantage of Sensofar's systems is our patented technology having no moving parts in the sensor head, there are no maintenance and alignment issues, and the effective lifetime of the sensor head is not limited by mechanical wear and tear. Our systems are equipped with XYZ stages to place the sensor head at the measurement position and scan along Z.

XY Stage

The manufacturing process assures correct position of mechanical limit switches and good performance in terms of accuracy and repeatability. The calibration of XY center is only needed after installing the system the first time, if the system is moved to another place and if XY stage position is manually moved while system is off.

NOTE If the system is transported or the XY Stage is manually moved, recalibrating the XY Stage is necessary (i.e. center table).

Z Stage

The manufacturing process assures correct position of mechanical limit switches and good performance in terms of accuracy and repeatability. The calibration of Z Home is only needed after installing the system the first time, if the system is moved to another place or if the Z stage movement has failed due to mechanical obstacle (such as pressing the objective down onto a sample).

In addition, multiple measurements are performed with each single objective in different step height standards, to check repeatability, accuracy and measurement speed and adjust Z factor if required. The Z factor calibration is recommended to do after the system is installed on place. After that, no calibration is needed as long as the temperature is stable (± 1 °C), the system is not moved and the weight of the objectives remains the same.

NOTE The Z factor calibration is performed for each objective with a specific step height standard at Sensofar. Repeatability and accuracy for each objective are measured after a long set of measurements. We save those calibration values (Z factors) in our database in case the customer needs them later on but we are not setting them into the system because these values will slightly change after transport.

Objectives

It is possible to calibrate the different aberrations of each objective as well as the magnification in case it is needed.

- Bright field objectives

The objectives do not need to be calibrated daily. As long as the temperature is stable (± 1 °C), the system is not transported, and the objectives are not moved, calibrating the objectives is not needed. Nonetheless, we strongly recommend calibrating all the objectives every six months.

- Interferometry objectives

The objective reference mirror calibration is only needed when the surface roughness to be measured with PSI is lower than the roughness of the reference mirror itself.

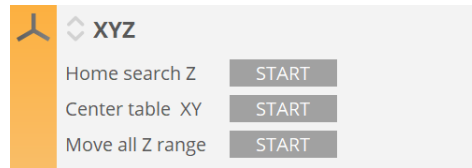
What standards are available for calibrating the system?

We have several standard tools for different calibration procedures:

- Z Stage calibration
 - PR001001 - Step height 10 μm SIMETRICS (Sensofar traceable)
 - PR000853 - Step height 10 μm SIMETRICS (PTB traceable)
 - PR000854 - Step height 1 μm SIMETRICS (PTB traceable)
- Objectives calibration
 - ESPEJCAL20 - Calibration mirror
 - PR001149 - Lateral calibration standard (NPL traceable)
 - PR001417 - Calibration specimen

Next sections describe each individual Configuration & Calibration option.

4.1 XYZ options



XYZ calibration tools

- Home Search Z determines the top position for Z-Scan using 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. Finally it will move to Z parking position (-1.000 mm by default).

Go to [System Preferences / Positions](#) to define a preferred parking position (default -1.000 mm) where the stage moves following a Home Search call.

- Center table XY executes a movement in the X and Y direction to search for the middle point of the stage. It then moves to this point and defines XY home in this position.

WARNING

Center table must be executed the first time that the stage is manually moved and/or installed. When the program executes this movement, it is important to ensure that nothing blocks the stage displacement.

- The Move all Z range function performs a movement along the entire Z axis. This maintenance action must be done once a year.

WARNING

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

Editing limits

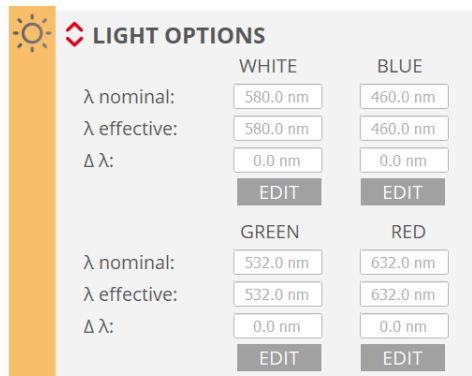
The travel limits are the limit positions that the software has enabled.

In the **SensoSCAN** folder (C:\ProgramData\Sensofar\SensoSCAN 7.3\Configuration), there are StageX.xml, StageY.xml and StageZ.xml [Configuration Files](#) that can be used to edit travel limits. In all cases, all editable values cannot be higher than the physical limits.

4.2 Light options

The Light Options pane is used to fine tune the given wavelength of the white or monochrome light source(s) 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 allowed difference between the nominal and the effective wavelength is 100 nm.

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



Light options tools

4.3 Alignment options

Microdisplay and Vignetting

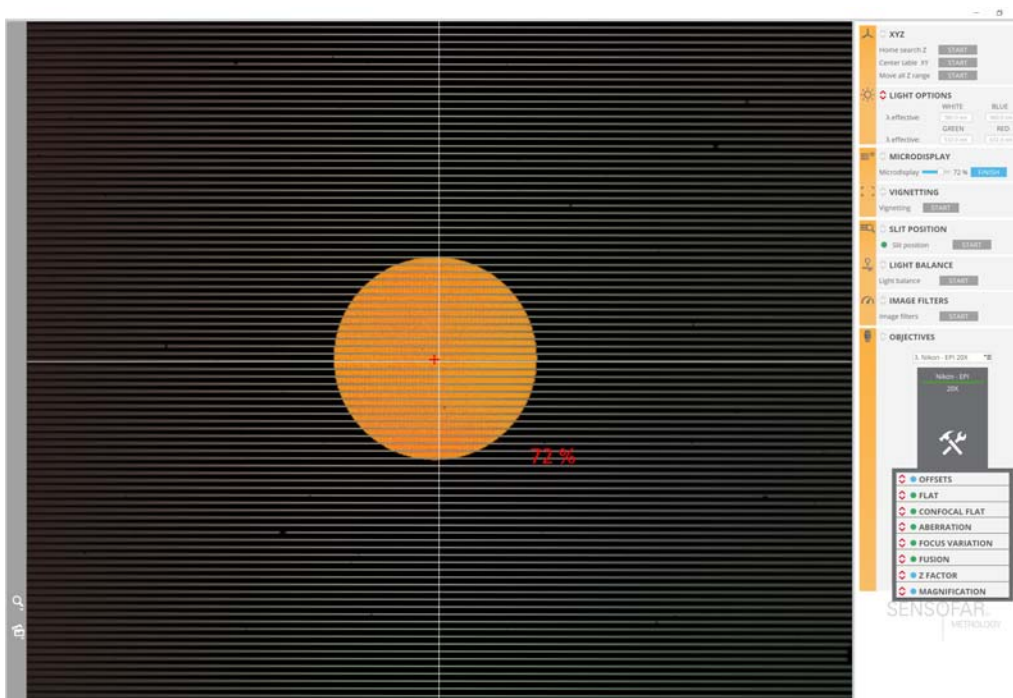
These options help the user to check the alignment of the system. To do this, place 20X EPI objective, select green LED and focus on the flat mirror supplied with the system. Ensure that the mirror is well focused.



WARNING

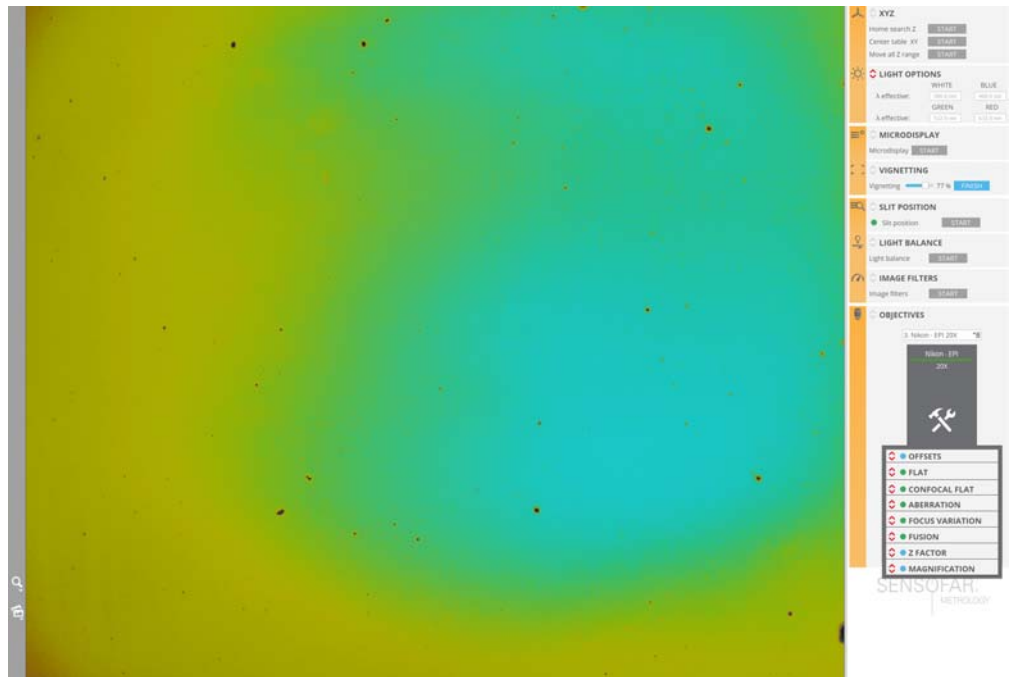
If the mirror is slightly tilted, level the XY stage until the entire surface of the mirror is in focus. The alignment process must be done with the sample focused in the “null fringes” condition.

Now click Start in the Microdisplay pane. A measurement bar showing the level of alignment between the slit pattern and the camera will appear. The result must be higher than 50%. If it is lower, please contact [Service & Support](#). The same value will appear on the Live image, together with a red cross. This cross and the composition of slits and iris images will be useful for service engineers in case an action is required.



Microdisplay tool

In order to manually check the microdisplay alignment any time, select Iris live image, focus on the mirror and do an Autolight. Press F9 to display a cross-hair on the live image. Cross-hair color is red when slit positions have not been calibrated and user selected color otherwise. Default cross-hair color is white and it can be changed in [System Preferences / Live Image](#).



Vignetting tool

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](#). Live image shows a false color mode that highlights non-uniformities and will be useful for service engineers in case an action is required.

4.4 System calibration options

Slit Position, Light Balance and Image Filters

The system calibration process, valid for all objectives, is carried out by following three steps. To start, focus on the flat mirror supplied with the system with a 20X objective and green LED. Ensure that the mirror is well focused:

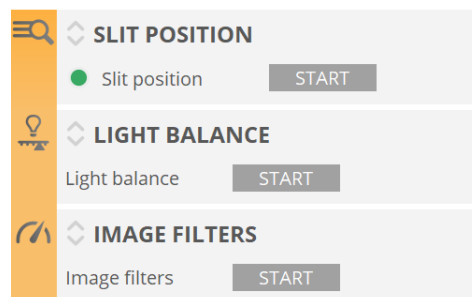
- first, click Start in the Slit Position pane. If the line positions are correct, this option will draw the detected lines in red. If the slits are in wrong positions, the software will identify the problem.
- next, in order to calibrate the light intensity for the 4 single LEDs to be balanced along the intensity range, 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 for current system computer).



Slit position, light balance and image filters tools


4.5 Objective calibration

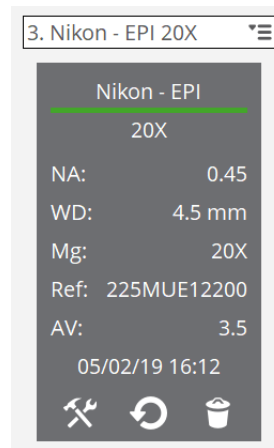
The objectives pane is used to specify which objectives are installed on the nosepiece:

- only the objectives that are part of the system configuration are available
- non-calibrated objectives are designated with 

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 important because 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), magnification (Mg), the reference (Ref) and the activation version (AV) are shown directly when an objective in the list is selected. Further properties and calibration tools are revealed by clicking on the tool icon  at the bottom of the objective information pane.



The objective information pane

Date and time of last calibration is also visible at the bottom of the properties list.

Calibration

This procedure is needed when adding or changing objectives, or when periodically re-calibrating objectives. Objective re-calibration is advised at least once every 6 months, or more often in severely fluctuating temperature environments.



WARNING

Objectives must be calibrated by specialists. Improper calibration may lead to the results having strong residual flatness errors.



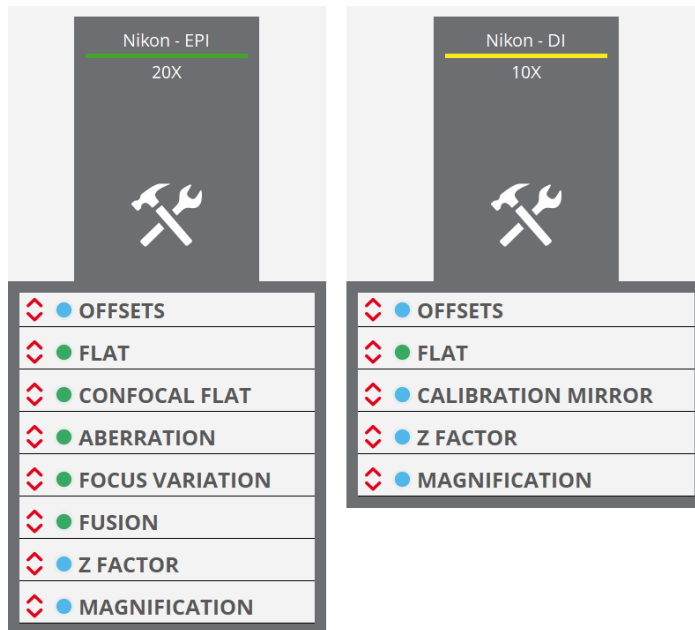
WARNING

Eye damages may be caused while looking through the lens.

Note that calibration changes can be reset using the defaults icon at the bottom of the objective information pane.

NOTE If the slit position is not correct, a bright field objective cannot be calibrated.

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

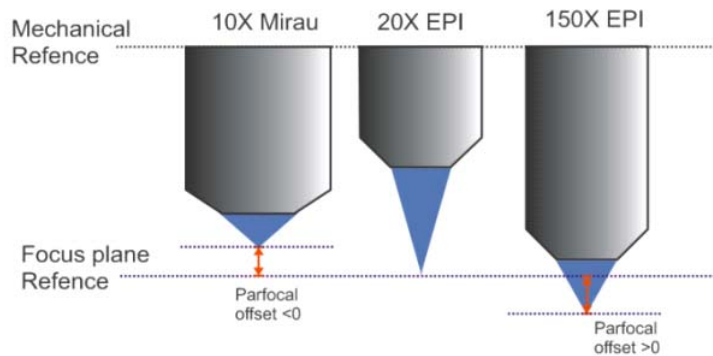


Objective tools: bright field (left) and interferometric (right)

■ OFFSETS

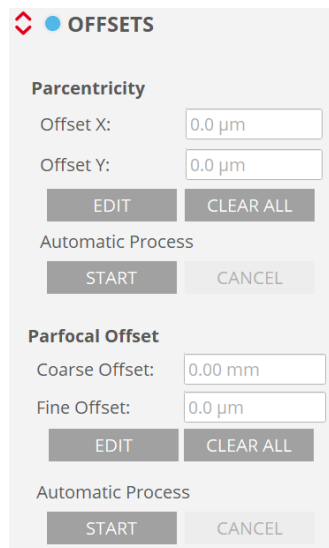
Parcentricity offset is used to correct for any XY offset between objectives in order to ensure that all of them image the same position of the sample. Once corrected, a sample feature is not changing XY position in [live image](#) when different objectives are used to observe it.

The Parfocal offset is used to calibrate the focus plane for different objectives (see figure below). When the focus plane for a different objective lies above that of the reference, the Parfocal offset value is negative.



Focus plane for different objectives

There are two Parfocal offsets: coarse and fine. The coarse offset is defined by default in the configuration files and is usually 0 μm. 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.



Offsets tool

NOTE When executing the Parfocal calibration routine, the system cycles the motorized nosepiece through all available objectives and obtains a correction for each one.

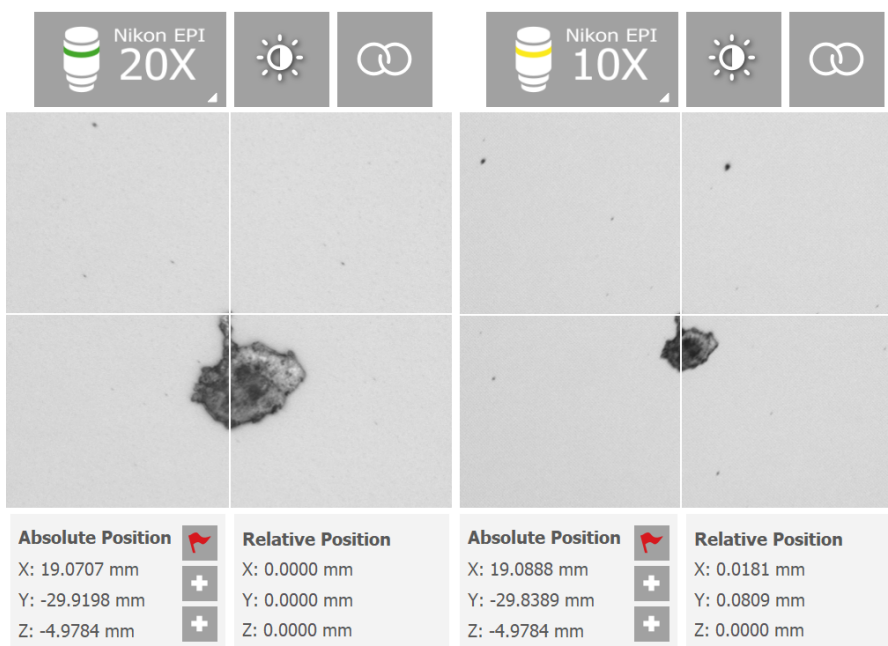
Both offsets can be calibrated both manually and automatically. For an automatic process the user will be guided. The steps for a manual calibration are explained below.

Manual Parcentricity offset calibration

1. Select the 20X EPI objective and focus on a clearly distinguishable feature of the sample. Use the F9 shortcut to display a cross-hair on the screen in order to center the feature more easily

NOTE The zoom tool can be useful during this calibration to achieve a more precise placing of the sample.

2. Define reference
3. Change to another objective
4. Focus the same feature in the center of the **Central Viewer**. Move the XY stage manually or double click on the feature to center it automatically
5. Check the relative XY position with respect to the defined reference



The same feature is focused in the center with two different objectives. The relative XY position of the second image has changed with respect to the reference objective of the first image

6. Input these exact values in the X and Y offset box, using the same sign, and save. Make sure to do the appropriate unit conversion
7. Repeat steps 3-6 for all necessary objectives
8. To check the calibration, focus on the feature and cycle through all the objectives that have this offset calibrated. The feature should always be displayed in the middle of the Central Viewer

Manual Parfocal offset calibration

1. Select the objective of highest magnification and focus on a particular region of the sample. It is recommended to change the live image to Slit Confocal (bright field objectives) or Iris (interferometric objectives) to focus more easily
2. Define reference
3. Change to another objective
4. Focus on the same region of the sample
5. Check the relative Z position with respect to the defined reference
6. Input this value in the Fine offset box, using the same sign, and save. Make sure to do the appropriate unit conversion
7. Repeat steps 3-6 for all necessary objectives
8. To check the calibration, focus on the region and cycle through all the objectives that have this offset calibrated. The region should always be in focus

■ FLAT (calibration mirror ESPEJCAI20)

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

For interferometric objectives, the routine must be done slightly out of focus to prevent the effect of interference fringes on the illumination.



Flat tool for confocal objectives

■ CONFOCAL FLAT (calibration mirror ESPEJCAI20)

This calibration allows to have a more homogeneous confocal image and as a consequence better acquisitions. The calibration consists on the acquisition of 2 topographies for each monochromatic LED (R,G,B) over the mirror specimen.

NOTE This calibration is mandatory.



Confocal Flat tool

■ **ABERRATION (calibration mirror ESPEJCAL20)**

Microscope optics aberration causes the best focal point at each zone within the field of view to be located at different heights. This is not perceived by someone looking through the binocular or with a CCD camera, but Confocal and Ai Focus Variation algorithms are able to profile such aberration with high resolution when measuring a calibration mirror. Aberration is superimposed to the surface shape but it can be calibrated. The procedure is to measure the topography of the calibration mirror using Confocal technique. The result of this measurement is called flatness error and will be subtracted from all topography measurements done with Confocal and Ai Focus Variation techniques once this calibration step is done.



Aberration tool

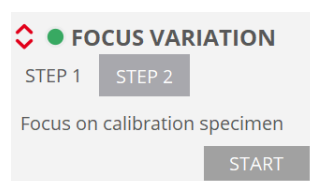
Follow these steps to calibrate the aberration. Adjust the light and the focus and click on Start. The calibration procedure will run automatically. The calibration is performed using RGB LEDs and consists of the following steps:

- Autolight and Autofocus
- Topography Coarse Shift Single Sampling
- Topography Coarse Shift Double Sampling

If the calibration procedure fails, check that the mirror is flat and in focus (use slit live image), light intensity is correct (use brightfield image and auto-light function) and Z stage is scanning fine (use auto-focus function). Repeat the calibration and if the problem persists please contact [Service & Support](#) for support.

■ **Ai FOCUS VARIATION (calibration specimen PR001417)**

For low magnification objectives the flatness error is slightly different for Confocal and Ai Focus Variation. Using the aberration calibrated with Confocal technique shows a residual flatness error in the Ai Focus Variation measurements. This residual flatness error is especially visible in extended topography measurements where several FOV are stitched together. **SensoSCAN** allows calibration of the flatness error using Ai Focus Variation technique for objectives up to 20X magnification. This calibration is optional and if not done, Confocal aberration calibration is used in Ai Focus Variation measurements.



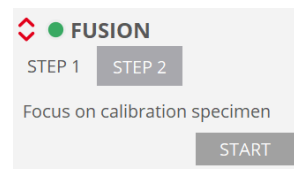
Focus Variation tool

Place the calibration specimen PR001417, focus it coarsely and find a clean area (free of scratches and dust particles). Press START button to start the process. The calibration procedure will run automatically. The calibration is performed using RGB LEDs and consists of the following steps:

- Autolight and Autofocus
- Grid of topographies 4x5
- Processing to obtain average aberration shape

■ FUSION (calibration specimen PR001417)

Best focal point for Confocal and Ai Focus Variation technique are not exactly the same, there is an offset that depends on the depth of focus of the objective. This offset must be calibrated and used in the Fusion algorithm that combines Confocal and Ai Focus Variation techniques. The procedure is to measure the calibration specimen PR001417 using both techniques and measure the offset in height between them. Press START button to start the process.



Fusion tool



WARNING

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

■ Z FACTOR

The Z Factor is used to calibrate the linearity of the profiler's Z stage. It requires a calibration sample with known height parameters, such as a step height standard. Follow these steps to calibrate the Z factor:

1. Place a step height standard and acquire with a Z Factor of 1.0000 (default value)
2. Measure the step height value in **SensoVIEW**
3. Go to the calibration screen and input the data in the Step Height measurement menu. The value "h nominal" corresponds to the known value of the step, while "h measured" corresponds to the value measured in **SensoVIEW**
4. Once both values are entered, the factor will change accordingly. The factor is the ratio between the nominal and the measured step height
5. Check the calibration taking another acquisition. The new measured value in **SensoVIEW** should be similar to the nominal value

**WARNING**

An incorrect value of the Z Factor may result in larger or smaller measured height. If you doubt the accuracy of the value, reset to 1.0000.

For bright field objectives, the user can calibrate up to two Z Factors; one for the linear stage (LS) and another for the piezo stage (PZT). For interferometric objectives there are up to three Z Factors available to calibrate. The LS factor is used for CSI and ePSI measurements, there is a separate factor for PSI measurements and finally a PZT factor if the piezo stage is available.

Z Factor tool for bright field (left) and interferometric (right) objectives

■ 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 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 $\pm 1\%$ of the nominal value.

Magnification tool

■ CALIBRATION MIRROR (calibration mirror ESPECJCAL20)

Interferometric objective reference mirror has a roughness of few nanometers that should be removed from the measurements if the goal is to measure roughness of very smooth surfaces using PSI technique. This step is optional.

To calibrate an interferometry objective (available for PSI only), adjust focus and light intensity and 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 'null fringes' condition.

4.6 Your system is ready, now check it

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

4.6.1 3D Performance for bright field objectives

1. Focus the calibration mirror surface and find a very clean area.
2. Select the green LED and adjust the light.
3. Select the following acquisition parameters:
 - **Technique:** Confocal
 - **Measurement:** 3D
 - **Objective:** the objective you want to check
 - **Area:** HD (5Mp disabled)
 - **Z Scan:**
 - Continuous scanning: disabled
 - Speed factor: 1X
 - Average images: 1
 - **Z Range:** choose a range that gives a minimum of 30 planes
 - **Threshold:** medium (second level)
4. Press *ACQUIRE* and wait until the measurement is displayed in **SensoVIEW**.
5. Save the topography. Repeat the measurement.
6. Subtract the previously saved topography using the *Create subtract layer* option available in **SensoVIEW**. The appearance of the subtracted topography will be flat random noise.
7. Apply a polynomial *Form Removal* operator of 7th degree to the subtracted topography in order to remove low frequencies.
8. The system noise is defined as $N_m \approx \frac{Sq}{\sqrt{2}}$. To find its value apply the *Rescale* operator with a factor of 0.707. Check the noise value to ensure that the system is under specifications.



WARNING

If the vertical resolution value (Sq) of the measured surface does not meet the specifications check that analysis options are correct. Review that you are not getting wrong results due to having “use previous analysis” option enabled in [System Preferences](#).

9. Repeat the entire process for each objective.
10. If a given objective does not meet the specifications, the calibration procedure must be performed again.

4.6.2 3D Performance for interferometry objectives

1. Focus the calibration mirror surface and find a very clean area.
2. Obtain null fringes by rotating the wheels of the tip-tilt stage.
3. Select the white LED and adjust the light.
4. Select the following acquisition parameters:
 - **Operation Mode:** Interferometry
 - **Measurement:** 3D CSI
 - **Objective:** the objective you want to check
 - **Area:** HD (5Mp disabled)
 - **Z Scan:**
 - Continuous scanning: disabled
 - Speed factor: 1X
 - **Z Range:** 15 μm
 - **Threshold:** medium (second level)
5. Press *ACQUIRE* and wait until the measurement is displayed in **SensoVIEW**.
6. Save the topography. Repeat the measurement.
7. Subtract the previously saved topography using the *Create subtract layer* option available in **SensoVIEW**. The appearance of the subtracted topography will be flat random noise.
8. Apply a polynomial *Form Removal* operator of 7th degree to the subtracted topography in order to remove low frequencies.
9. The system noise is defined as $N_m \approx \frac{Sq}{\sqrt{2}}$. To find its value apply the *Rescale* operator with a factor of 0.707. Check the noise value to ensure that the system is under specifications.



WARNING

If the vertical resolution value (Sq) of the measured surface does not meet the specifications check that analysis options are correct. Review that you are not getting wrong results due to having “use previous analysis” option enabled in the Analysis menu.

10. Repeat the entire process for each objective.
11. If a given objective does not meet the specifications, check environmental vibrations.

CHAPTER 5

ACQUISITION SETTINGS



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 independently of the **Measurement technique** (Confocal, Interferometry or Ai 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.

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](#), see also [Extended Measurements](#)). Other parameters, as discussed in the following sections, are set in Acquisition Settings.

The [Processing](#) pane allows to process the data before it is sent to external software to be analyzed. The available operators are Leveling and Restore.

The [Analysis](#) pane is used to direct data acquired with the system to external software ([SensoVIEW](#), [SensoMAP](#) and [SensoPRO](#)) or to [Export Image](#).

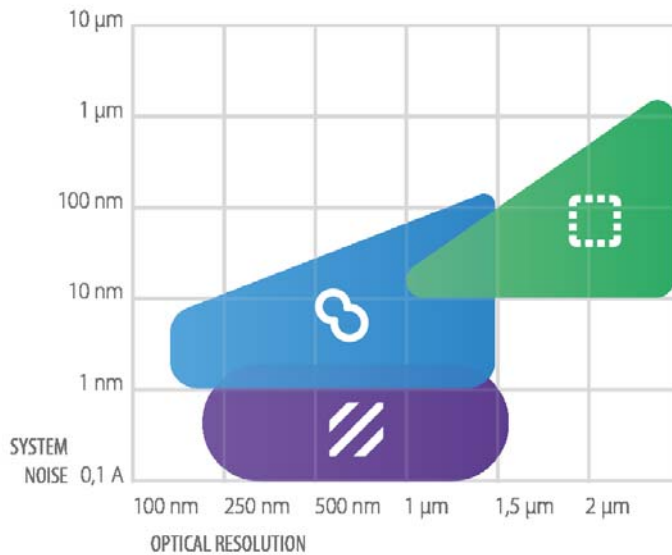
Recipes are an important tool for repetitive data acquisition cycles. Recipes allow the user to save and reload predefined parameter sets that typically apply to a given application (Single Measurement Recipe, SMR) and/or that are used to automate complicated measurement processes involving many separate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

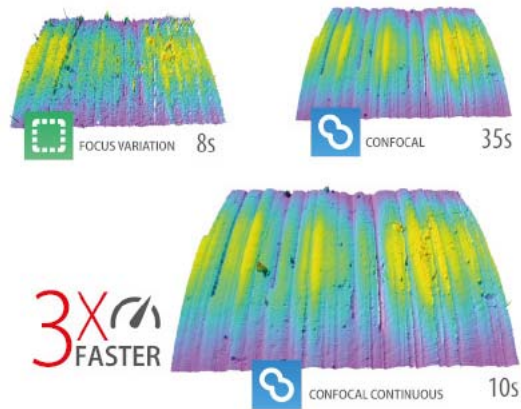
When all settings and options have been selected, click Acquire to perform the measurement. Once finished, the result will be sent to [SensoVIEW](#).

5.1 Measurement technique

The system combines 3 optical technologies (Confocal, Interferometry and Ai Focus Variation). 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:

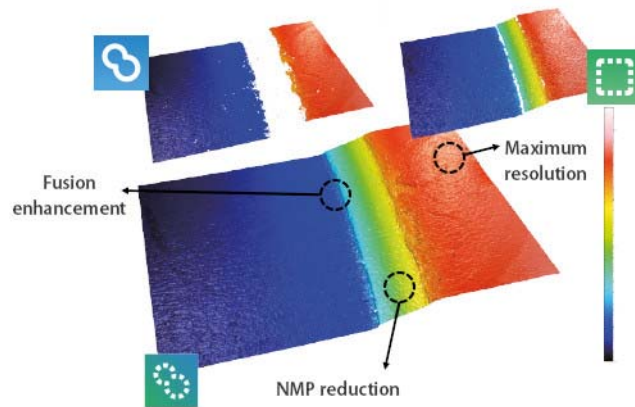


- **Confocal profilers** have been developed to measure the surface height of smooth to very rough surfaces. Confocal profiling provides the highest lateral resolution that can be achieved by an optical profiler. Thus, spatial sampling can be reduced to 0.10 μm, which is ideal for critical dimension 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. Sensofar's multiple co-linear LED implementation in the system can also provide color and information.
- Classical Confocal technique requires in-plane scanning to get a Confocal image and is achieved by moving in Z plane by plane. There are two types of Z scan methods for the Confocal technique:
 - **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 Ai 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 Ai Focus Variation (left, 8s), Continuous Confocal (middle, 10s), Confocal (right, 35s)

- Confocal Fusion** refers to another proprietary measurement technique that draws the best out of Sensofar's Confocal and Ai Focus Variation techniques by using a unique smart algorithm that yields the most reliable data from a single scan. Where neither Confocal or Ai 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.



Confocal Fusion example

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. Different interferometry techniques have different strengths and weaknesses dependent upon the measurement task (see also [Measurement algorithms](#)):
 - Phase shift interferometry (**PSI**) is best used to measure the surface height of very smooth, level and (more or less) continuous surfaces with step heights less than 120 nm. PSI profiling can yield exceptional vertical resolution (down to 0.01 nm) for all numerical apertures (NA) - thus, very low magnifications

(2.5X) can be employed to measure a large field-of-view with no sacrifice in vertical resolution.

- White-light vertical scanning interferometry (VSI), also known as Coherence Scanning Interferometry (**CSI**), is best used where PSI fails, i.e. on smooth to moderately rough, discontinuous and varying surfaces (e.g. due to tilt, structuring, step heights greater than 120nm, etc.). CSI profiling provides nanometer vertical resolution for all NAs. The CSI algorithms enable the system to use all the available magnifications to profile shape features with the same height resolution.
 - Extended phase shift interferometry (**ePSI**) is a **variation of PSI** that is best used only on very smooth surfaces that also feature step heights greater than 120nm. ePSI profiling provides sub-nanometer vertical resolution for all numerical apertures (NA) - thus, very low magnifications (2.5X) can be employed to measure a large field-of-view with no sacrifice in vertical resolution. Note that, compared to CSI, the technique is relatively slow and there also are some memory limitations, so ePSI is only advantageous for the case mentioned and when sub-nm resolution is required.
- **Ai Focus Variation** is an optical technology that has been developed to measure 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. The technique can provide color information while measuring on steep flanks and very rough surfaces. This combination of these measurement capabilities complements confocal measurements at low magnification. Two particular aspects pertain to the Sensofar implementation of Focus Variation:
- It has been improved with the use of active illumination to get more reliable focus location even on optically smooth surfaces.
 - The measurement algorithm has been optimized to give better results on steep surfaces when using HDR.

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** interface through the use of color schemes.



Blue signifies Confocal, purple Interferometry, and green Focus Variation

Thin Film Measurement (optional)

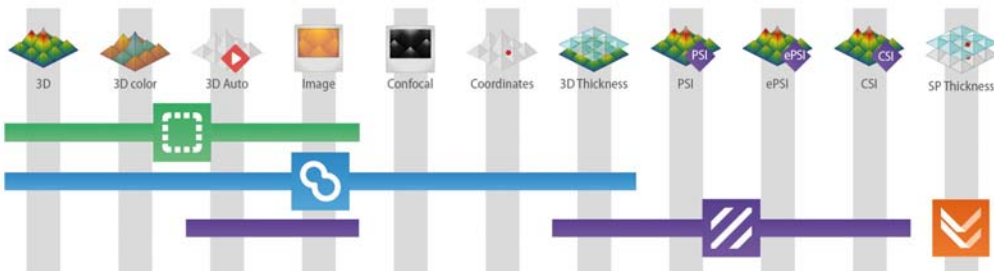
This technique is only available when the system has the optional PZT Z scan device. It is a single point measurement technique that measures transparent films from 50 nm to 1.5 μm. It requires a completely different approach than Confocal, Interferometry and Ai Focus Variation. See the next chapter to learn how to use it.



Thin Film Measurement settings

5.2 Measurement type

The available Measurement types depend on the selected Measurement technique:



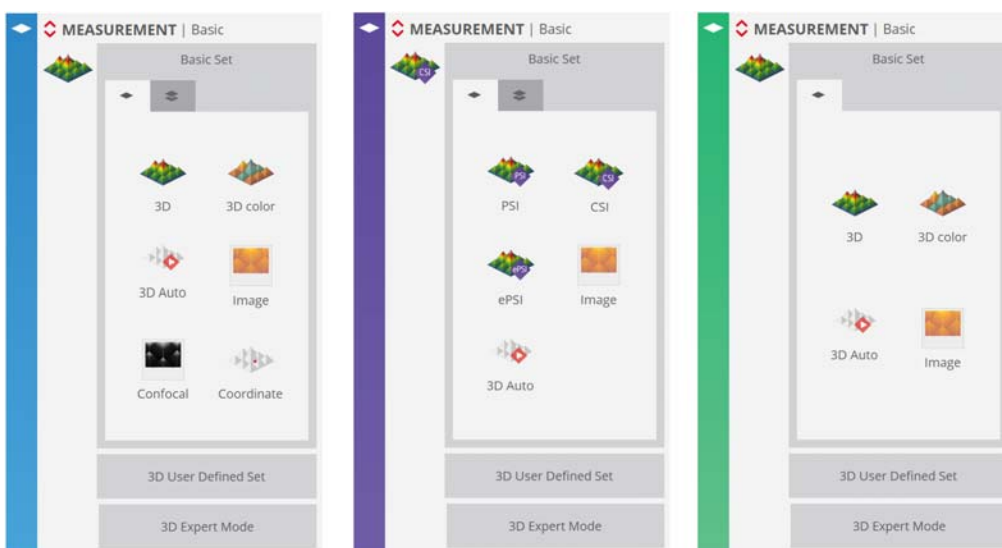
When switching between Measurement techniques and subsequently between Measurement types, the system and **SensoSCAN** parameter options are automatically trimmed to those permissible for the selected measurement configuration. Some of these changes occur 'under the hood' and are not user-configurable. 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 useless.

To access the different Measurement types, click the red up/down arrows on the upper left of the Measurement pane:

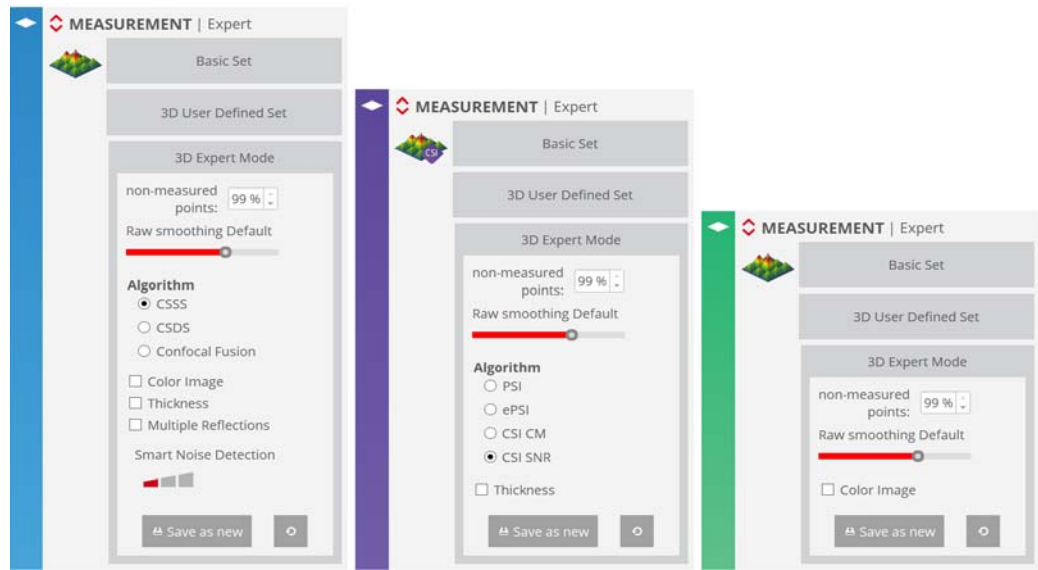


Basic Set standard Measurement types for Confocal, Interferometry and Focus Variation, respectively

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, a **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.

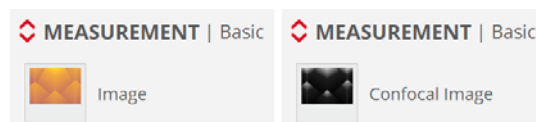


3D Expert Mode for Confocal, Interferometry and Focus Variation, respectively

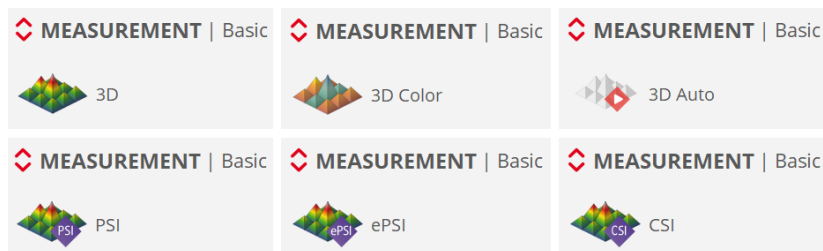
5.2.1 Basic Mode

The basic suite of Measurement types include:

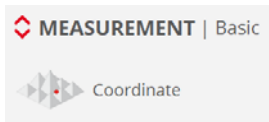
- Image capture:



- 3D surface measurements:



- Coordinate measurements:



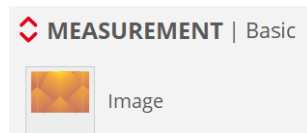
- Thickness measurements:



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 Image capture

Images

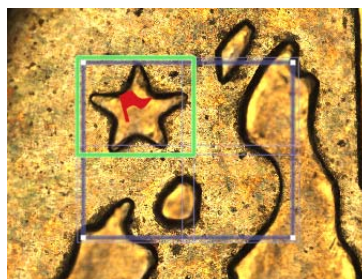


An image can be captured directly from the camera using a bright field or an interferometry objective.

NOTE When an image is taken, accurate color fidelity requires [Color Correction](#) for the sample surface being examined.

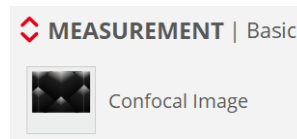
To acquire an image, simply [set the area](#) (single or extended) and click on the Acquire button. **SensoSCAN** drives the system appropriately and shows the result in **SensoVIEW**.

If an [Inspector Viewer](#) image has been captured, the extended area selected by the user is shown as an overlay in this image, together with the starting FOV (green rectangle). The Extended Measurement area is shown as a light rectangular grid laid over the blue rectangle (measurement area less overlap). The user can change the extended area interactively by clicking and dragging on the anchor points on the overlay.

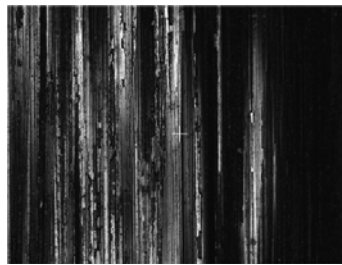


Area layout

Confocal images



A confocal image can be acquired when the Confocal Measurement technique is selected. It preserves the signal for those areas that are within the depth of focus of the objective, showing the pixels in focus in white and the pixels out of focus in black:

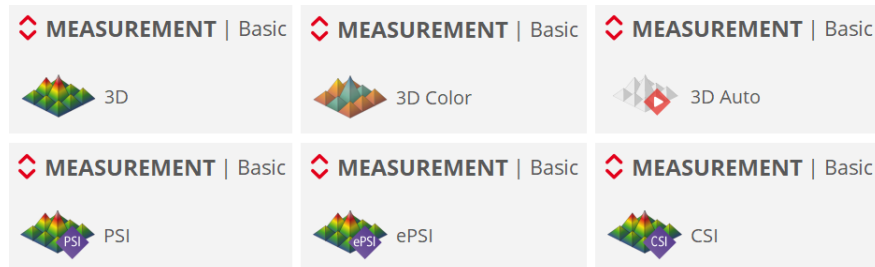


Confocal image

An extended confocal image is also available.

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

5.2.1.2 3D topography



A 3D topography measurement acquires the current FOV of the objective. An extended 3D topography measurement covers an area that is greater than the FOV of the objective by acquiring multiple FOVs. Options for setting the shape of an Extended Measurement, including options for deactivating individual FOVs, can be found in [Extended Measurements](#).

All Measurement techniques - Confocal, Interferometry and Ai Focus Variation - can be used to acquire a 3D topography (single FOV and extended). Information regarding the individual algorithms used in each case can be found in [Measurement algorithms](#).

NOTE The Extended Measurement option is only available for configurations that include an XY motorized stage and the Extended Measurement Module.

NOTE The 3D color measurement is not available for interferometric techniques.

Single 3D topography measurement

To measure a single 3D topography measurement, place the sample under the objective and focus. Then set the desired 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 Ai Focus Variation image in each plane. Once all of the optical information has been acquired, the software calculates the metrological data and switches to **SensoVIEW** 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 default resolution HD).

Technology	Objective	Z-Scan
Confocal	20X	4 mm
Focus Variation	20X	4 mm
CSI	-	136 μ m

There are two ways to prematurely stop the measurement:

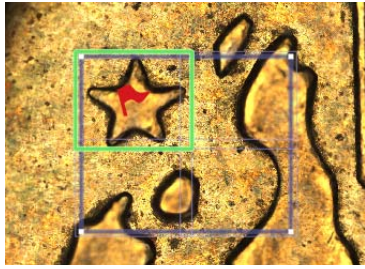
Option	STOP function
Esc	Cancel the measurement and lose the data. The software shows an Acquisition Error message.
Space	Stop Z-scan available after acquiring at least 21 planes (Confocal and Focus Variation) or 50 images (CSI and ePSI) and process the measurement.

Extended 3D topography measurement

To measure an extended 3D topography measurement, place the sample under the objective and focus. Next, choose the desired settings following these steps:

- **select the objective**
- set **Extended Measurements** options
- set **Z-Scan** and **Z-Scan tracking options**
- set **Threshold**
- set **Lights Settings**

If an **Inspector Viewer** image has been captured before defining an extended image, the chosen extended area is shown as an overlay in this image, together with the starting FOV (green rectangle). The Extended Measurement area is displayed as a blue rectangle, over which it shows the overlap of different FOVs, represented as a light blue grid. The user can change the extended area interactively by clicking and dragging on the anchor points on the overlay.



Area layout

SensoSCAN automatically calculates how many single measurements (FOVs) are needed to fill the desired area. Once the user has clicked Acquire, the software makes the initial measurement with the selected Z-Scan and Threshold values. Subsequent measurements are made in accordance with the tracking options and any Autofocus and Light Settings, taking in the full FOV of the objective minus a user-defined amount of overlapping area.

Resolution	FOVs (total)	Area (FOVs)
5 Mpx	120	10x12
HD	480	20x24
SD	1920	40x48
8	7857	81x97
16	30625	175x175

Limited to 381 Mpx or 3 GB (no color)

If the Set start FOV has been set (see [Extended Measurements](#)) together with Tilted surface or round shapes, a 4s interval is introduced at the start of the acquisition. This is to warn the user, that light and focus will need to be re-checked when the system moves to the initial Set start FOV to begin the acquisition. If no adjustment is required, the user can press any key to start the measurement immediately. If the light and the focus have to be adjusted, the user can simply modify the focus position to stop the 4 second countdown. Once the light and the focus are correct, the user **MUST** press a key to start the measurement (the [keyboard shortcuts](#) F2, F3 and F8 can be pressed during the countdown to cancel it).

When all measurements have been completed, the software calculates the stitching parameters to correct slippage of the sample and the mechanics, and copies all the data to a final result. Finally, the software switches to the **SensoVIEW**'s screen, where the stitched measurements are treated as a single topography.

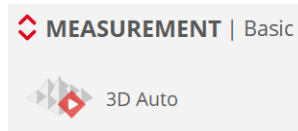
There are three ways to prematurely stop an Extended Measurement:

Option	STOP function
Esc	Cancel the measurement and lose the data. The software shows an Acquisition Error message.
Spacebar	Stop Z-scan available after acquiring at least 21 planes (Confocal and Focus Variation) or 50 images (CSI and ePSI) and process the measurement.
Pause	Show the Lost Topography dialog window.

Each measurement is saved in a temporary folder (the default folder path is C:\TMP\ExtendedMeasurements). This is useful if the software crashes in the middle of the Extended Measurement process, because then it is possible to stitch the individual measurements using the "Offline extended topography" option in the File menu (see [Offline Extended Topography](#) in the [Appendix](#)).

NOTE PLUX files corresponding to previous FOVs will be deleted from the folder every time an Extended Measurement process is started.

3D Auto



3D Auto is an automated acquisition mode for Confocal, Interferometry (CSI) and Ai 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 coordinate 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 **SensoVIEW** 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 choice of objective and (for multi-LED systems) the ability to toggle color in the acquisition (to toggle color, see [System Preferences](#)). More exactly:

- 3D Auto is 'single FOV only', so there are no [Extended Measurement options](#)
- 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

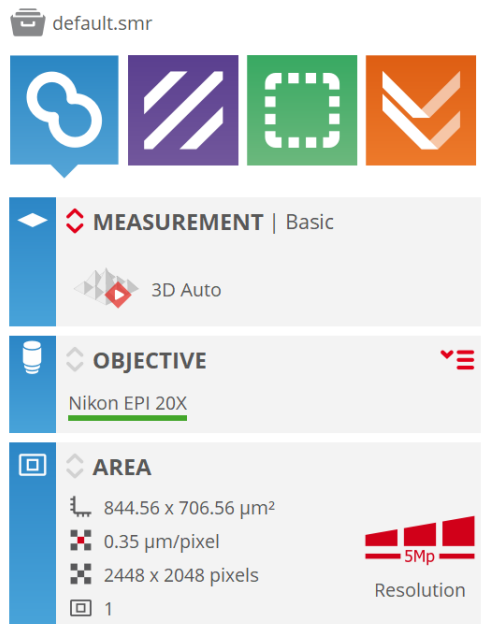
- the **Threshold** options are not user-selectable and finally, 3D Auto cannot be used within a **Recipe**

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

WARNING

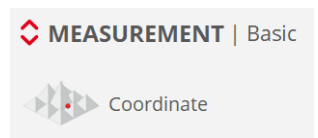
If a surface is not compatible with any of the restrictions listed above (e.g. special illumination required), then it is best measured manually using the other Measurement types available in Basic Mode, or by using a pre-configured Application for that particular type of structure (see 3D Expert Mode).

It is possible to use 3D Auto to get the basic settings for a 3D acquisition and then optimize the measurement or create a Recipe by selecting the 3D measurement after 3D Auto acquisition.



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

5.2.1.3 Coordinates



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.

Following a successful coordinate acquisition, **SensoSCAN** does not switch to **SensoVIEW**. Instead, the measurement is stored to file (C:\TMP\Coordinates.txt) and shown on the system progress information.

NOTE Coordinate measurements can only be acquired using the Confocal technique.

NOTE The MMR coordinate option is only available for configurations that contains a XY motorized stage (for simple coordinate acquisitions it is not needed).

The coordinates file is stored under C:\TMP\Coordinates.txt. Each row of the resulting file contains X, Y and Z coordinates of each measured point (given in micrometers, values are separated by a white space):

```
0.000000 -0.000000 -32247.368
1000.000000 -0.000000 -32246.891
2000.000000 -0.000000 -32246.441
3000.000000 -0.000000 -32245.945
4000.000000 -0.000000 -32245.537
```

To obtain a coordinate measurement with more than one point, the user must create an appropriate **Multiple Measurement Recipe (MMR)** (see Recipes chapter to learn how to use them). Once the user has clicked the Acquire button, the software moves the sample from point to point, and records the position of the Z coordinate in a file according to MMR result settings.

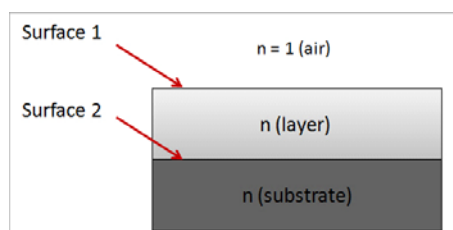
The format of Non-measured points (NMP) can be chosen in **System Preferences**, in the **General** tab. The user can choose between Nan, Infinite and Zero.

Displaying coordinate data sets as a surface

By selecting File / Import / Coordinates a coordinate text file with a minimum of 10 values can be imported into **SensoVIEW** and displayed as a topography.

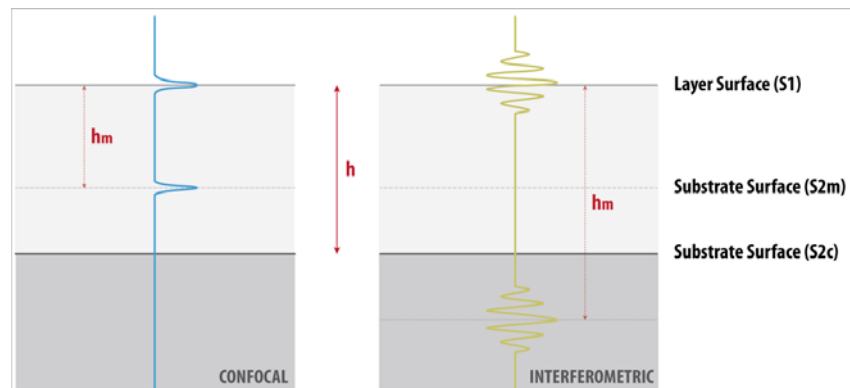
5.2.1.4 Thickness

Thickness is available for confocal and interferometric techniques. Both 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.



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 $1\ \mu\text{m}$ (on smooth surfaces) can be resolved within a FOV of several $100\ \mu\text{m}$. 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.

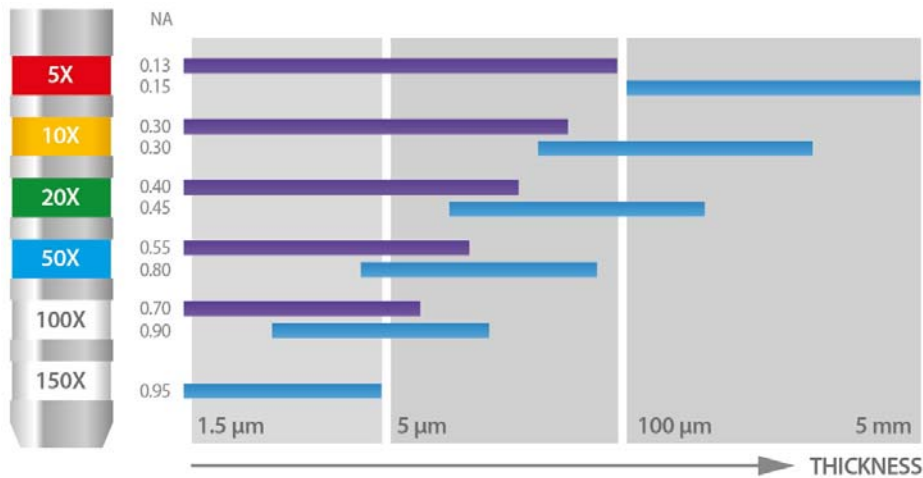
Interferometric thickness measurements

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 $1\ \mu\text{m}$ up to several $100\ \mu\text{m}$ 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

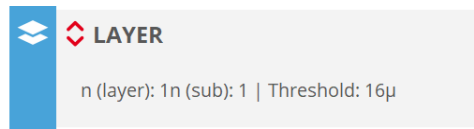
and with very low contrast. Typically, magnifications of 50x and higher limit the measurable thin film thicknesses to some microns.



Typical objective limits when measuring thickness

Layer parameters

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 indices 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

Thin Film Measurement (optional)

Additional thickness measurement capability, is available in systems equipped with PZT Z Scanner. Details on using this optional hardware accessory are provided in the [Thin Film Measurement](#) chapter.

3D areal thickness



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. Just as for topography measurements, a single or extended thickness measurement can be made.

NOTE When choosing the correct Z-Scan parameters, both surfaces must pass through the focus.

The stitching process uses either the upper or lower surface, as determined by the selection made in the **Layer** pane - this should be the most continuous surface. If the stitching algorithm fails during measurement, the behavior of the software will be the same as for an **extended 3D topography**.

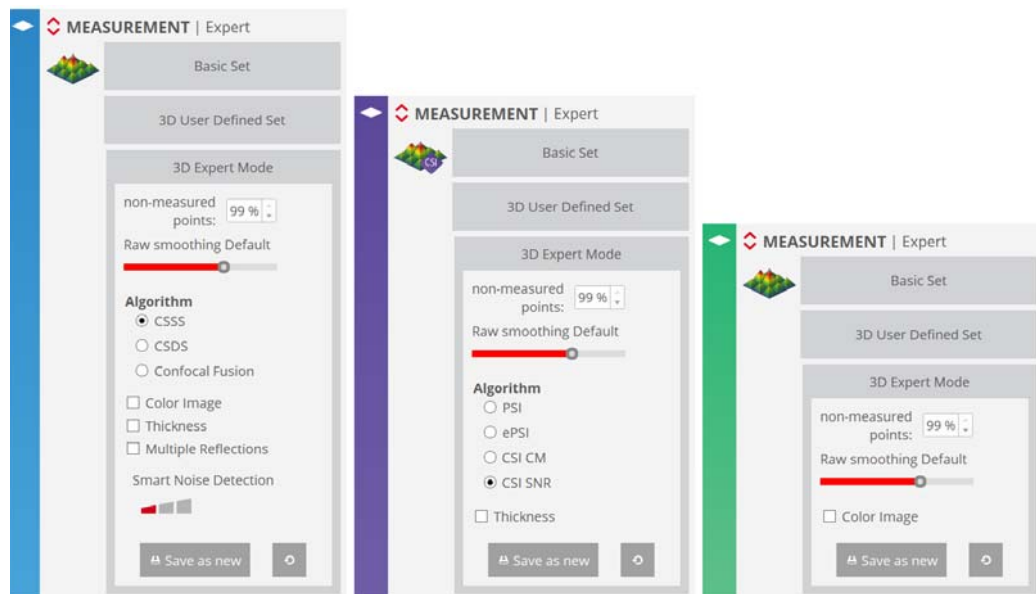
After the measurement of each single FOV, the signal at each point is analyzed and is used to classify the surface points in order to determine which are the most reliable. These points are then used to estimate the upper and lower surfaces. In accordance with these estimates, the remaining surface points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

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

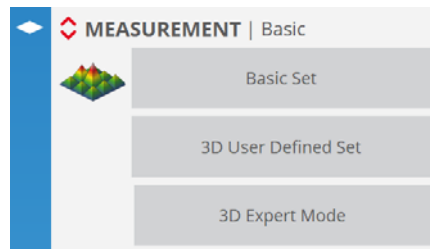


3D Expert Mode for Confocal, Interferometry and Focus Variation, respectively.

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

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 indicating 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, Ai Focus Variation) or the envelope function (CSI Interferometry) while 3D topographies are being acquired. The allowed values are None, Low, Default and High, 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.

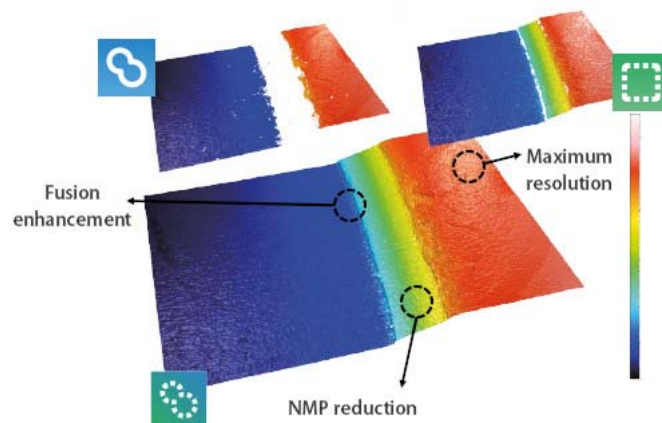
5.2.2.2 Measurement algorithms

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 three types of confocal imaging - coarse shift single sampling (CSSS), coarse shift double sampling (CSDS) and Confocal Fusion:

- 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 - 0° and 90°. 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.
- 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 Ai 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.

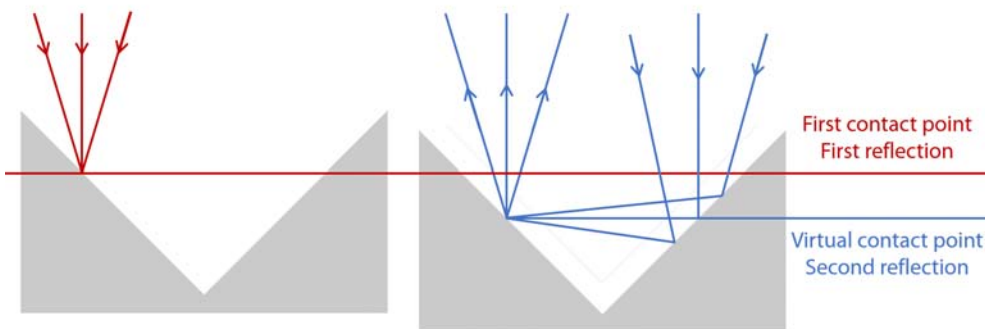


Confocal Fusion example

Other options include:

- If Color Image is enabled, the measurement will acquire color bright field 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 Reflections 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.

- Smart Noise Detection algorithm detects possible noise during the confocal acquisition and avoids spikes in technical surfaces. There are three possible level of detection: low, medium, high. Any non-expert 3D confocal topography applies the medium value by default.

Interferometry

There are three interferometric acquisition modes - phase shifting interferometry (PSI), extended phase shifting interferometry (ePSI) and vertical scanning interferometry (VSI) also known as Coherence Scanning Interferometry (CSI).

- PSI: these measurements are divided into two steps. First, **SensoSCAN** scans along the wavelength range to determine the plane in which the maximum contrast of the interferogram is found. Then, starting at this point, **SensoSCAN** will take 9 images to acquire the phase map.
- ePSI: the difference between PSI and ePSI is that the maximum range for PSI is limited to the coherence length of the light source used. For smooth and continuous surfaces, this can be as long as 4 microns. For surfaces containing sharp edges (such as MEMs), the maximum range for PSI is limited to $\lambda/4$, i.e. approximately 120 nm. ePSI extends the range of the 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.

- CSI: there are two algorithms for the CSI 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.

Other options include:

- Unwrapping: (PSI only): there are 2 unwrapping algorithms:
 - Quality: very slow, but suitable for rough or discontinuous surfaces
 - Goldstein: faster, but quality is lower
- Remove fringes (PSI only): primarily a cosmetic option, this removes the fringe (contrast) pattern so as to improve the displayed measurement
- Thickness (CSI only, SNR only): select this option for interferometric 3D areal thickness measurements

Ai Focus Variation

If Color Image is enabled, the measurement will acquire color bright field 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.

5.3 Objective Selection

The choice of objective made in [Sample Inspection](#) is 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.

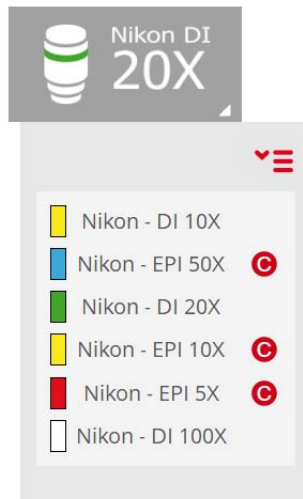



WARNING

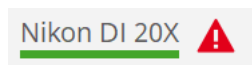
It is very important to select the right objective before acquiring measurements. If the selected objective does not coincide with the objective that is actively being used, the result will be completely useless.

Accessing objective options

Click on the tab  to view the selection options:

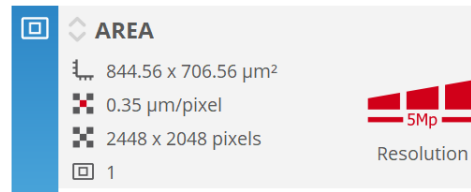


As described in [Sample Inspection](#) chapter, available objectives that have not yet been calibrated are highlighted in this list with a . The status of any uncalibrated objectives is also highlighted in the objectives pane in Acquisition Settings:



Non-calibrated objective warning

5.4 Area



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 is based on the FOV cropping geometries set and various FOV options selected in [Extended Measurements](#) options, and also depends on the [Measurement type](#).

The only selectable option available in this pane relates to the Resolution of the measurement, regardless of single or [Extended Measurements](#). 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. Default system resolution is HD.

- 5 Mpx: 2448x2048 pixels (resolution 1)
- HD: 1224x1024 pixels (resolution 2)
- SD: 612x512 pixels (resolution 4)
- 8: 306x256 pixels (resolution 8)
- 16: 154x128 pixels (resolution 16)

In [Extended Measurements](#), 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. Lower resolution mean fewer measured points, thus the topographic detail in the measurement result is reduced.

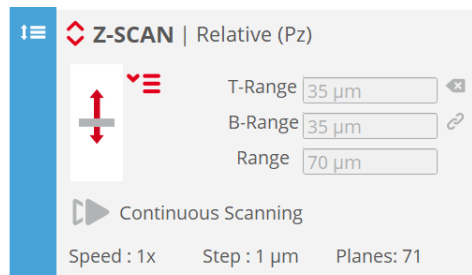
The resulting pixel size for the chosen (or calculated) resolution is indicated in the pane, in the [Extended Measurements](#) pane, and is also listed in the Measurement information in **SensoVIEW**.

NOTE In the special case of large area extended measurements, Resolution can be set by the system to 16 (16x16 pixels) - this value is not user-selectable and is thus not available in the user interface. On switching back from an [Extended Measurements](#) to a single FOV, Resolution is set automatically to HD.




5.5 Z-Scan

The Z-Scan pane is used to select the format and define the direction, length and speed of scanning along the Z-axis (i.e. vertically). Most options available in the Z-Scan pane remain unchanged across all Measurement techniques, with the exception of PSI.

NOTE Z-Scan movement for the PSI technique is pre-configured by the system. Editing of the Z-Scan options for the PSI Measurement technique is thus disabled.




Z-Scan pane in Acquisition Settings

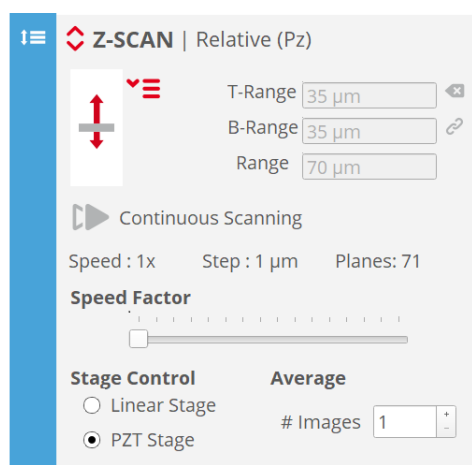
In general, standard initial values are shown, as determined by **SensoSCAN** for the current Measurement parameter configuration. Values can be edited from the standard values by simply clicking the appropriate icons to the right -   . Due to the fact that **SensoSCAN** makes some basic assumptions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

For Confocal technique the option “Continuous Scanning” enables the Continuous Confocal technique. If disabled, default discrete scanning Confocal technique will be used.

The Z-Scan pane also displays which stage control will be used to acquire the measurement - linear stage (*LS*) or piezo (*PZT*), depending on the system configuration and the Z-Scan range. If a piezo-stage is installed in the system, it will be the default option as long as the Z-Scan range is smaller than the piezo range.

NOTE The linear stage will always perform all Z movements for autofocus and between measurements, even if the system has a piezo-sensor.

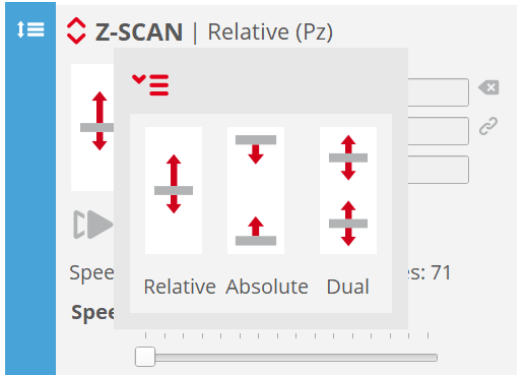
Advanced options are summarized in Z-pane and can be accessed by clicking the red up/down arrows :



Advanced options are visible in the extended Z-Scan pane

5.5.1 Z-Scan options

There are 3 kinds of Z-Scan - Relative, Absolute and Dual. These are accessed by clicking the drop-down icon :



Relative, Absolute & Dual Z-Scan types

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. Nominally these values are "Objectives Working Distance (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:

$$\text{Planes} = \frac{\text{Range}}{\text{Step}}$$

For example, 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.

NOTE If the speed factor is increased, the step also increases. The maximum step value corresponds to the fastest speed.

Family	Objective	NA	Optimum Step (μm)	Maximum Step (μm)
EPI	1X	0.03	120	120
EPI	2.5X	0.075	35	245
EPI	5X	0.15	12	120
EPI	10X	0.30	2	16
EPI	20X	0.45	1	16
EPI	50X	0.80	0.2	3.2
EPI	50X	0.95	0.1	1.6
EPI	100X	0.90	0.2	3.2
EPI	150X	0.90/0.95	0.1	1.6
ELWD	20X	0.40	1	16
ELWD	50X	0.60	0.3	4.8
ELWD	100X	0.80	0.2	3.2
OIL	50X	0.9	0.2	3.2
OIL	100X	1.4	0.1	1.6
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	20X	0.50	1	16

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 regions in the measurement, and non-measured points will be shown. 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 21 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.

Absolute Z-Scan

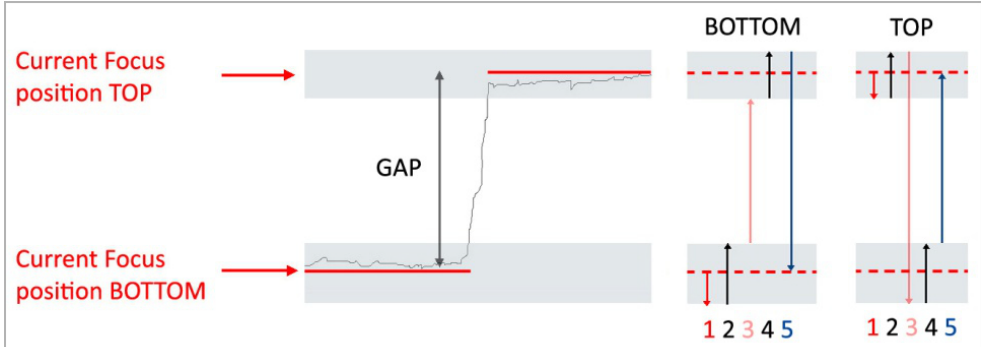
While Relative and Dual Z-Scan are defined relative to the current focus position, Absolute Z-Scan allows the user to define the Z-Scan range by setting the absolute Z coordinates for the upper and lower positions (Z-Top and Z-Bottom, respectively). Alternatively, a start value (top or bottom) can be 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 B-ref/T-ref). Now enter the desired scanning T-Range and B-Range for both planes. In addition, enter the Gap distance.



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

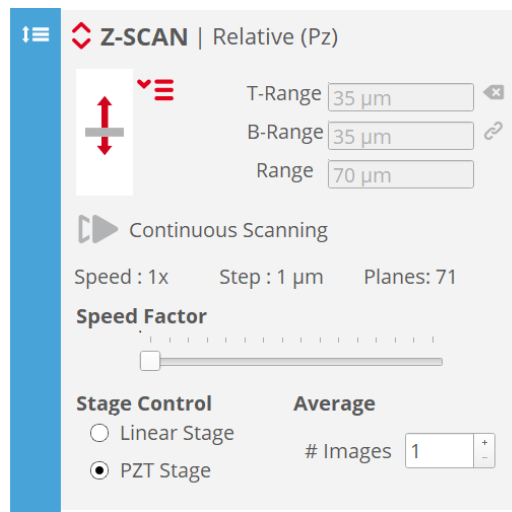
WARNING

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

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



Z-Scan advanced options menu

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.

Continuous Confocal and Ai Focus Variation techniques offer a speed factor of 0.3x which provides better repeatability at the cost of slower speed.

CSI interferometry offers speeds 1x, 3x and 5x. For speeds higher than 1x the algorithm is changed to center of mass (CM), described in the 3D Expert mode section.



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 which stage control will be used to acquire the measurement - linear stage (LS) or piezo (PZT), depending on the system configuration and the Z-Scan range. If a piezo-stage is installed in the system, it will be the default option as long as the Z-Scan range is smaller than the piezo range.

Average

Two are 2 approaches to averaging measurements:

- Average Images (available for Confocal & PSI)
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 Ai Focus Variation, PSI, ePSI & CSI)
This is useful for averaging 3D data, and can also be used to reduce system instabilities such as external vibrations. The function of Average Scans will vary depending on the stage control used. For the Ls stage control, the selected number of phase maps are acquired and then averaged. In contrast, for the piezo stage control, the selected number of scans are performed and then averaged to give a unique phase map.

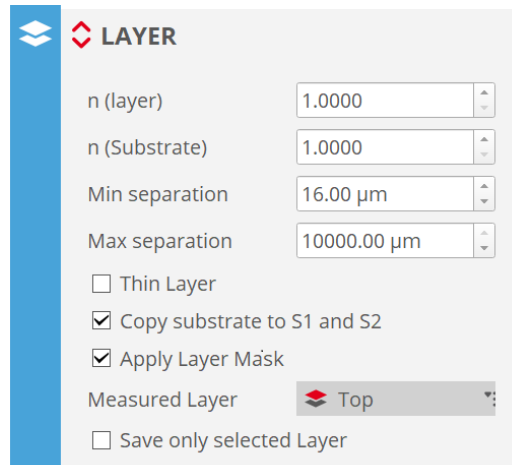


WARNING

Average setting is common for all techniques and must be checked when changing technique to avoid using Average when it is not required.

5.6 Layer

The measurement algorithms for [Confocal and Interferometry 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)

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.

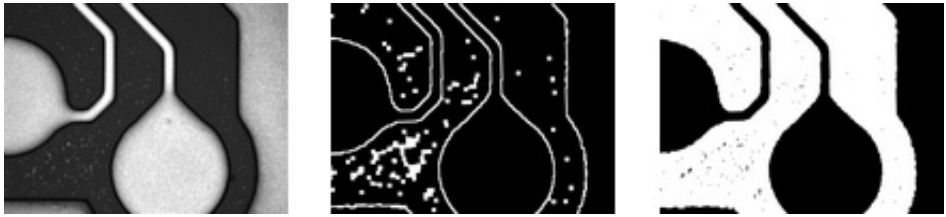
NOTE For Min/Max separation, the values given should correspond to the apparent layer thickness as would be expected when moving between the two surface focal positions with the Z stage. **SensoSCAN** will automatically correct for refractive index when displaying the results.

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.

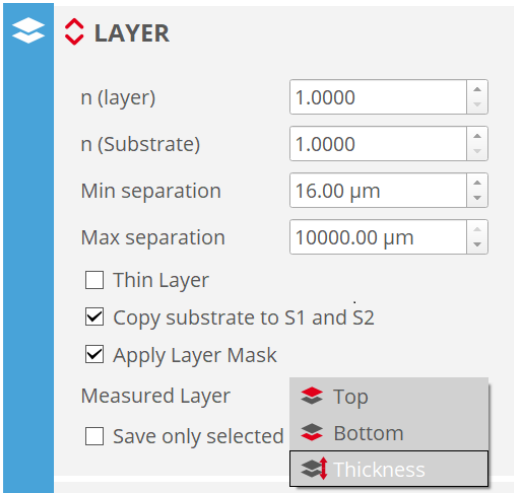
NOTE Each objective has a minimum thickness threshold associated with it in **SensoSCAN**. User settings are ignored if the values given are lower than the objective's threshold.

- 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: the function of the drop-down option Measured Layer varies, depending on whether a single FOV or an Extended Measurement has been specified:



Measured Layer menu

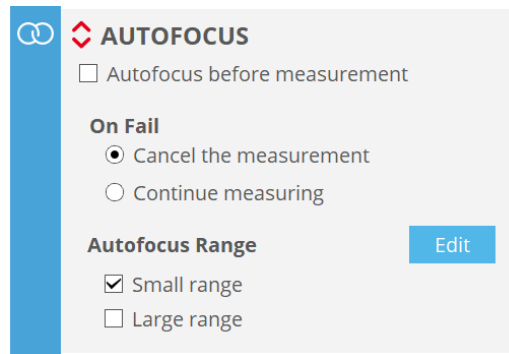
- **Single FOV:** following a successful measurement, only the selected surface or layer topography (3D) is displayed. By default, both surfaces (and thus also the layer thickness) are saved in the result file and are directly accessible in **SensoVIEW**. This can be restricted to the chosen Measured Layer by activating the Save only selected layer option.
- **Extended Measurements:** the selected layer or surface is created as an areal topography (3D) and will be saved in result file and shown in **SensoVIEW** following a successful measurement. The remaining data are not included as part of the result and are discarded by the software.

When selecting the Top or Bottom surface in either case, the measurement obviously defaults to a surface topography and is no longer a thickness measurement.

Finally, note that the selected Measured Layer is also used to assess the non-measured points, regardless of whether over a single FOV or for an Extended Measurement.

5.7 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. The focus can be manually optimized at any time using the motor controls or by using the Control Console, 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.

NOTE With an Extended Measurement, this option only enables Autofocus before the acquisition of the initial FOV - Autofocus for subsequent FOVs is enabled in the extended [Inspection Viewer](#) pane.

General options in the extended pane are:

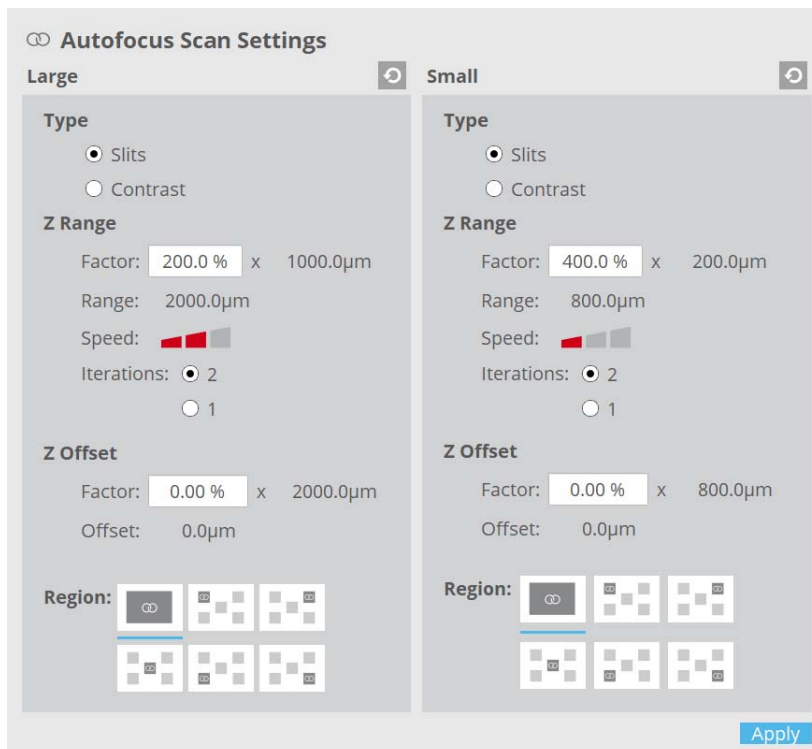
- in case Autofocus fails, there is a choice of 2 options: Cancel the measurement and Continue measuring
- there are 2 possible scanning ranges for Autofocus small and large - one or both can be selected, and refer to the travel range in determining the best focus. Small and large values for the individual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

For PSI, the PSI search fringes option is shown at the top of the extended Autofocus pane. When enabled, this optimizes the focus based on the fringe pattern established by the system, thus leading to an improved acquisition, but also typically adding a few seconds to each measurement time. For measurements where searching for fringes is not necessary (e.g. repetitive measurements on the same surface), or where speed is a priority, PSI search fringes can be disabled.

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 the settings using the Edit button, followed by Apply to confirm the changes:



The Autofocus Scan Settings edit pane

- Type settings are only available for brightfield objectives. You can choose between Slits (default) and Contrast:
 - Slits uses a pattern of parallel, equally spaced fringes projected on the surface to focus.
 - Contrast uses the contrast of the stack images to calculate the best focus for each pixel. This algorithm improves the acquisition time while maintaining the same accuracy as using the Slits algorithm, as long as the surface is textured.
- Range factor (%) increases or reduces the maximum range, Large Autofocus factor can be increased up to 200% and Small Autofocus factor up to 400%
- 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 \pm Range/4)

NOTE These settings are used for all Autofocus functions - the exception to this is for the [calibration of objectives](#), where **SensoSCAN** will always use 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

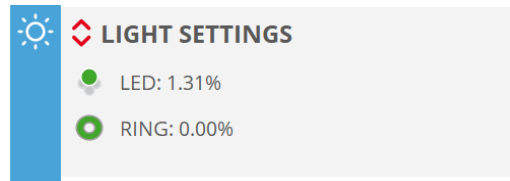
- If a bright field objective is selected, the Autofocus scans over an objective-specific vertical range and looks for the best position of the overall image. For bright field objectives, the ratio between small and large is 5. The estimated time required for the Autofocus routine depends on the numerical aperture and the chosen algorithm (Slits or Contrast).
- If an interferometric objective is selected the large Autofocus is performed with Slits Confocal image and green light to allow increasing Z scanning speed beyond the limitations of the interferometry technique.
- 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.
- The maximum range can be increased by disabling the scanning safety distance in [System Preferences / General](#). Nevertheless, the maximum range is limited by the system's available memory.

Family	Objective	NA	WD (mm)	Maximum Range (µm)	Autofocus Range	
					small (µm)	large (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	6000	3250	3250
EPI	5X	0.150	23.50	23000	2400	11750
EPI	10X	0.300	17.50	17000	400	2000
EPI	20X	0.450	4.50	4000	200	1000
EPI	50X	0.800	1.00	500	80	400
EPI	50X	0.800	2.00	1500	80	400
EPI	50X	0.950	0.35	176	80	175
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	160
EPI	150X	0.900	1.50	1000	40	200
EPI	150X	0.950	0.30	150	40	150
EPI	150X	0.950	0.20	100	40	100
ELWD	20X	0.400	13.00	12500	200	1000
ELWD	20X	0.400	19.00	18500	200	1000

Family	Objective	NA	WD (mm)	Maximum Range (μm)	Autofocus Range	
					small (μm)	large (μm)
ELWD	50X	0.550	10.10	9600	100	500
ELWD	50X	0.600	11.00	10500	60	300
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	400	2000
SLWD	20X	0.350	24.00	23500	200	1000
SLWD	20X	0.300	30.00	29500	200	1000
SLWD	50X	0.400	22.00	21500	100	500
SLWD	100X	0.700	6.50	6000	40	200
SLWD	100X	0.600	10.00	9500	40	200
WI	10X	0.300	3.50	3000	400	1750
WI	20X	0.500	2.00	1500	200	1000
WI	60X	1.000	2.00	1500	80	400
CORR	20X	0.450	7.40	6900	200	1000
CORR	20X	0.450	10.9	10400	200	1000
CORR	50X	0.700	3.9	3400	40	200
CORR	100X	0.850	1.3	800	80	400
CORR	100X	0.850	1.2	700	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



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. The illumination options made in Light Control are valid throughout the system.

With the new HDR acquisition mode for Confocal and Ai Focus Variation techniques it is possible to measure samples containing very bright to extremely shaded 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.

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

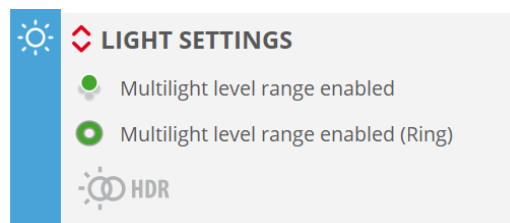


Light Setting pane, with the new HDR acquisition mode

NOTE HDR is not available for Confocal Continuous scanning.

NOTE Measurements taken with Focus Variation HDR are limited to a speed factor of 0.3x. The Z scan range is maintained the same as for a speed factor of 1x.

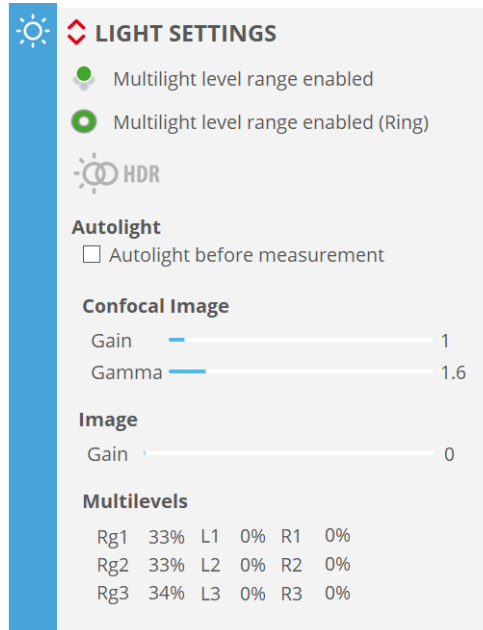
If **MultiLevels** is activated by selecting range, the pane changes to reflect this:



Light Setting pane, with MultiLevels activated

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.



Light Setting pane Advanced options

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

When Autolight is enabled, the light level used during acquisition can be fine-tuned with the Autolight factor. If a value smaller than the default 1.00 is entered, the light intensity used during acquisition will be lower than the intensity selected by the Autolight function. On the other hand, if this value is above 1.00, more light will be used during the acquisition.

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 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

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.

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



Threshold pane and Sensitivity editor

Sensitivity can now be set to any value between 0 and 99.99:

- setting Threshold to 0 equates to measuring all points regardless of signal quality
- setting Threshold to 99.99 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 Processing



Processing pane in Acquisition Settings

In this pane it is possible to apply processing settings to the data before sending it to an External Analysis Software. The available settings are:

- Leveling – It uses all the points of the surface to remove a predominant tilt, leaving a leveled sample. It uses an algorithm which removes a plane.
- Restore – Automatically restores any non-measured points.

Both settings are also available in **SensoVIEW**. The advantage of enabling the operators in Processing is that the operators are applied automatically and consecutively, whereas in **SensoVIEW** the user must apply each operator manually and separately. This is ideal when multiple measurements with similar processing options have to be taken, as the user does not have to apply the same operator to each individual acquisition. If you want more control over the operators, **SensoVIEW** offers advanced settings.

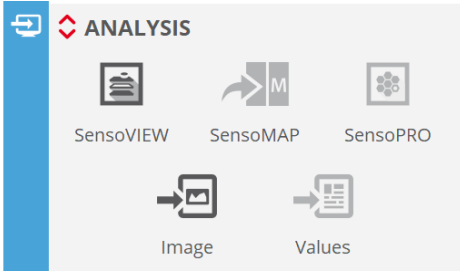
If operators are selected in the processing pane the order by which these operators will be applied is the following:

1. A leveling is done
2. Non-measured points are restored


5.11 Analysis

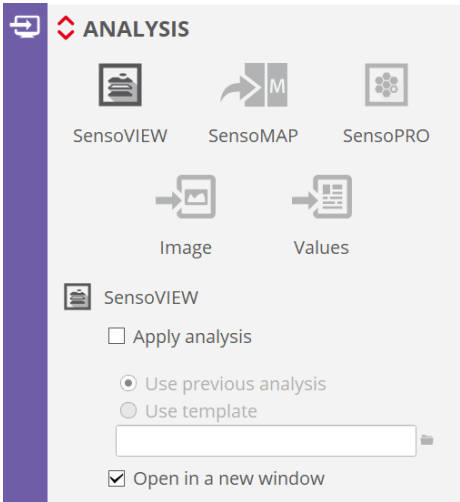
SensoSCAN acquires one single measurement if no Recipe (i.e. default.smr) or a Single Measurement Recipe (SMR) is used. Alternatively, **SensoSCAN** can acquire a series of measurements by means of a Multiple Measurement Recipe (MMR). See [Recipes](#) chapter for more details about using recipes.

The Analysis window is used to direct data acquired with the system to **SensoVIEW** software (**SensoMAP** or **SensoPRO**), Export Image or Export Values.



Analysis window

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 .

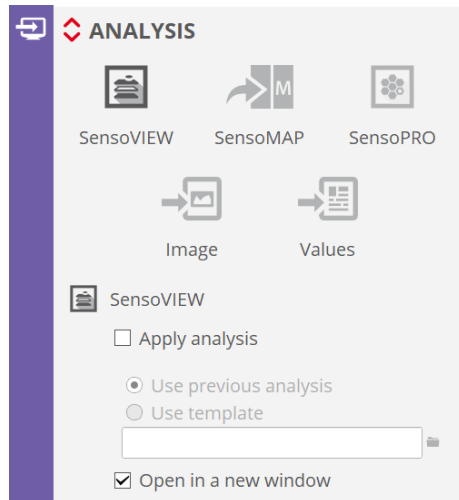


Analysis window with Advanced options displayed

5.11.1 SensuVIEW

When sending measurement to **SensuVIEW** there are two options:

- Analyze every measurement manually starting from raw data.
- Enable *Apply analysis* to apply a predefined analysis to the new measurement result. The predefined analysis can be the analysis applied to the last measurement (*Use previous analysis*) or the analysis defined by a template (*Use template*).



Analysis pane selecting SensoVIEW

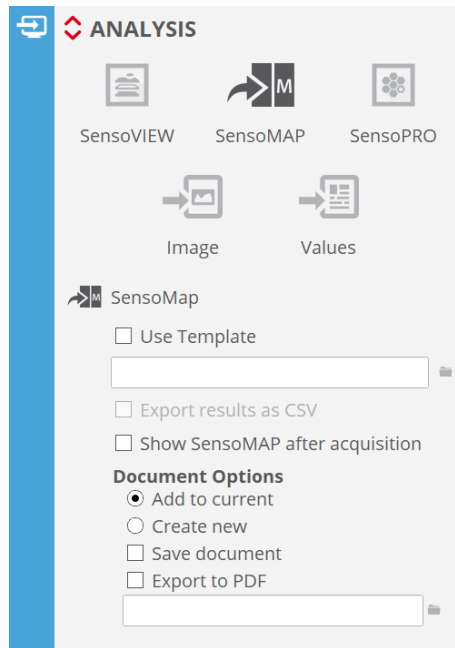
NOTE When “Open in a new window” is enabled every acquisition will be sent to a new **SensoVIEW** window. This is useful for comparing multiple measurements.

5.11.2 SensoMAP

There are three ways of analyzing system 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 (*.plx 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 system files or setup **SensoSCAN** to automatically analyze the results using a Multiple Measurement Recipe (see [MMR set-up](#)).


The Analysis options depend on whether acquisition is [single](#) or [multiple](#).



Analysis window with Advanced options displayed (for MMR)

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

SMR analysis

Options for how the measurement is handled together with **SensoMAP** are accessed by clicking on the red up/down arrows  in the 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.
- Export to PDF: the analysis is saved as a pdf file. This feature is only available for SensoMAP 7 and onwards.

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 (*.plx) and a time stamp.


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

MMR analysis

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 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

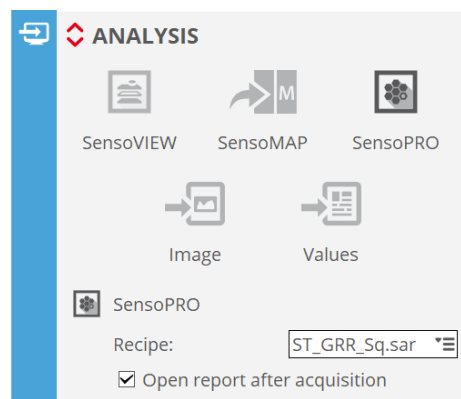
- and Use Template is **not** enabled, the file name is the MMR's base name.
Example: MMRRecipe.mnt
- If Create new is enabled:
 - and Use Template is enabled, the file name is composed by the template name and the *.plux file extension. Example: template zRGB --- TopoRecipe_R0001.mnt
 - and Use Template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

5.11.3 SensoPRO

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 analysis settings depend on whether the acquisition is [single](#) or [multiple](#).



Analysis settings selecting SensoPRO

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**.

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

SMR analysis

Options for how a measurement is handled together with **SensoPRO** are accessed by clicking on the red up/down arrows in the 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 report after acquisition: a successful measurement will be automatically displayed if the option has been enabled in the **SensoPRO** recipe.

The results from the data analysis are exported as an *.xlsx or *.csv file, depending on the **SensoPRO** Recipe 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).

MMR analysis

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

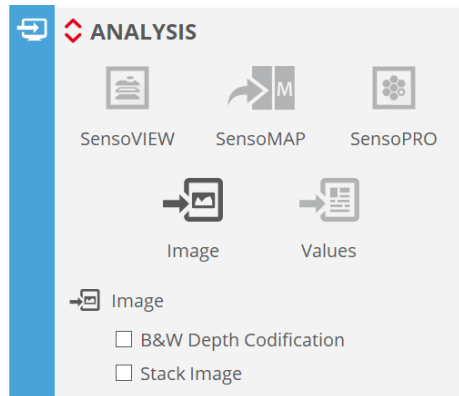
Configuration of SensoPRO options has to be done in the SMR. That is, an MMR will only send the results obtained using the SMRs that have SensoPRO enabled.

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

Document naming rules

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

5.11.4 Export Image



Analysis settings selecting Image to export

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 Image)	Confocal Interferometry Focus Variation	Full Image
Single & Extended 3D topography	Confocal Focus Variation	B&W Depth Codification image Stack Image Color Extended Focus Image (only for 3D color)
	Interferometry	B&W 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, *.png, *.bmp and *.jpg in [System Preferences](#)).

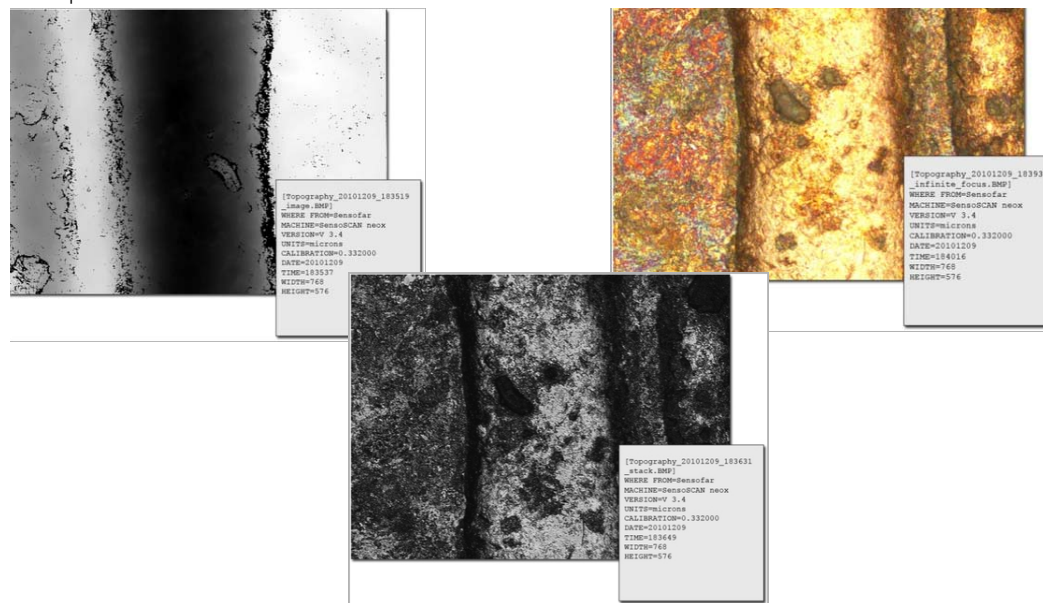
Images	File
B&W Depth Codification image	*_z.*
Stack	*_stack.*
Color Extended Focus	*_image.*

The calibration file contains the following fields:

Field Name	Description	Example
WHERE FROM	Acquisition application name	SENSOSCAN
MACHINE	Acquisition machine name	S neox
VERSION	Application version	7.2
UNITS	Units in the XY axis [microns or nanometers]	microns
CALIBRATION	XY distance per pixel	1.660000
DATE	Day of measurement	30/05/2019
TIME	Time of measurement	19:14:01
WIDTH	Image width	2448
HEIGHT	Image height	2048
ZUNITS	Units in the Z axis [microns or nanometers]	microns
ZCALIBRATION	Z distance per level of gray	0.007843
ZLOWER	Z lowest point	-25.564058
ZUPPER	Z highest point	33.877487


The bold fields are only visible for B&W depth codification images.

Examples:



B&W Depth Codification, Stack and Color Extended Focus images (left to right)

Follow these steps to use this feature:

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

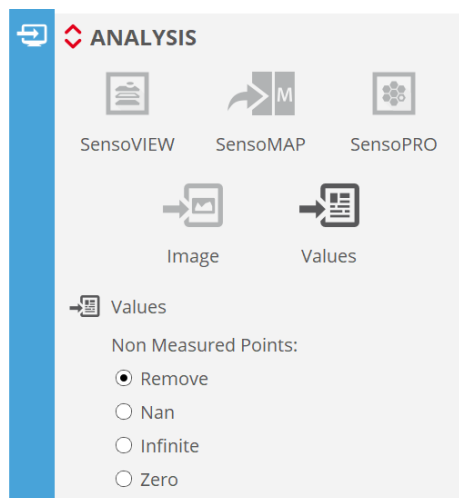
After acquisition, the image and *.cal file will be saved automatically to the current path (default C:\TMP, or the user-selected measurement folder).

NOTE The measurement file (*.plx) 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).

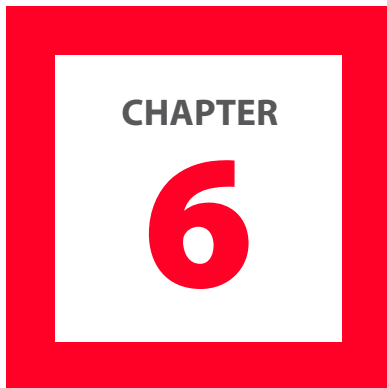
Export full option is also available from the OS Menu Bar and from **SensoVIEW**'s Quick Bar.

5.11.5 Export Values

Export Values option in 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, infinite or zero).



Analysis settings selecting Values to export



CHAPTER
6

THIN FILM MEASUREMENT

This measurement technique allows measuring a thin film layer with thickness ranging from 50 nm to 1.5 μm at the center of the field of view (single point measurement). It is based on spectroscopic reflectometry. The reflectivity of a sample with a thin film layer depends on the layer thickness. Layer thickness can be calculated by comparing the measurement of the measured reflectivity with the theoretical reflectivity for a given sample structure.

Surface reflectivity can be measured from spectrums of light reflected on the sample, which in turn can be obtained from interferometry scanning along Z. Currently this technique is only available for systems with optional piezo Z stage.

To carry out a thin film thickness measurement a well-known reference material is used to calibrate system spectrum for a given light source configuration and a given objective. Next step will be to locate the measurement point on the surface, specify sample structure (layer and surface materials) and analysis tolerances (thickness and wavelength ranges) and measure (do interferometry scanning and process it to obtain thickness result).

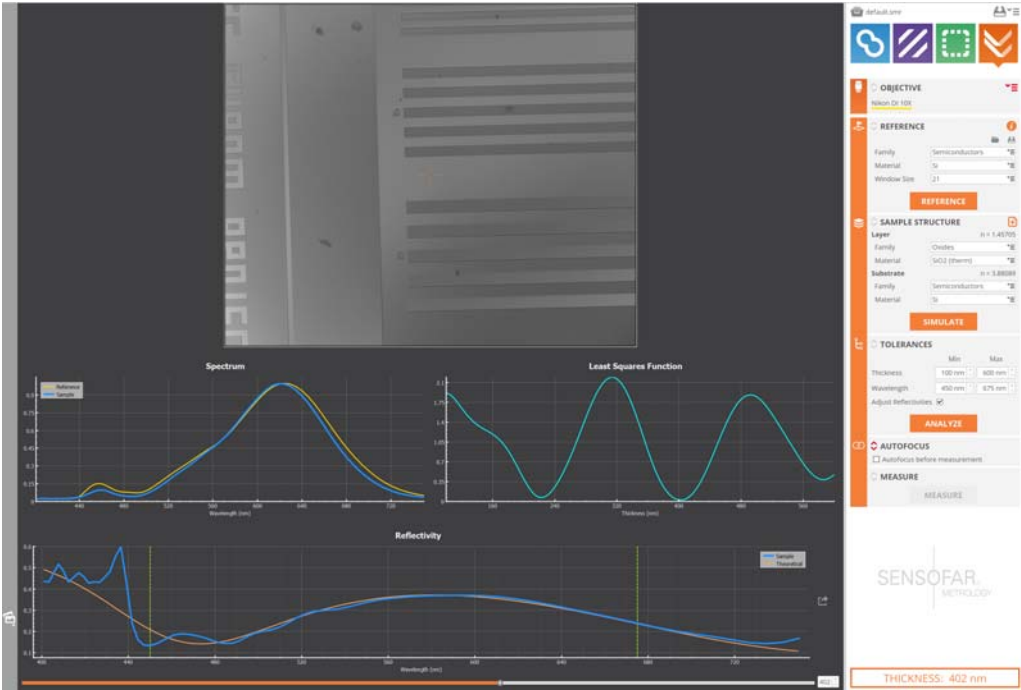
The software calculates the sample reflectivity and tries to match it with the theoretical reflectivity of the sample structure for different layer thickness using a Least Squares Function. The minimum of that function in the specified thickness range is the thickness result.



WARNING

Thickness range adjustment in Tolerances is critical and must include actual thickness in order for the result to be accurate.

Acquisition screen layout is as shown in the image below. Live image is at the top of the central area. It shows full field of view at less resolution than other acquisition modes but good enough to inspect the sample. Below live image there are two plots: the Spectrum at the left and the Least Squares Function at the right side. Below there is the Reflectivity plot that shows the measured reflectivity (blue curve) and the theoretical reflectivity (orange). This plot has a selector to allow displaying theoretical reflectivity at different thickness. Moving the slider or specifying the value in the spinbox changes the orange curve to show the reflectivity of the sample structure for a given layer thickness.



Thin Film Measurement example

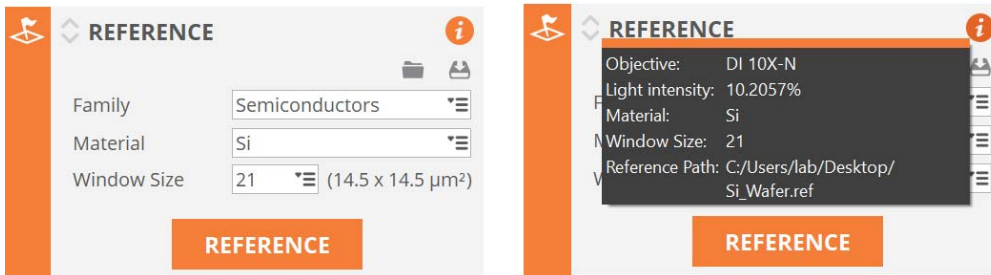
NOTE Plots are reset when a new Reference is acquired. Afterwards they are updated any time we do Measure, Analyze or Simulate.

6.1 Single Point Measurements

The procedure to obtain a single point thickness measurement has 4 steps:

6.1.1 Step 1. Make a Reference

In this step the user will measure the Spectrum on a reference sample.

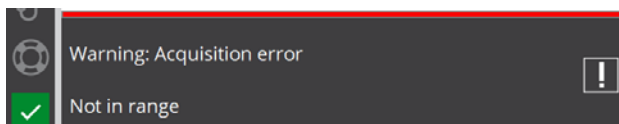


Reference settings (left) and information (right)

- Select reference material. A database of materials is provided, organized by families.
- Select window size. It determines the size of the observation spot at the center of the field of view that is used to characterize the spectrum. The list shows options of size in pixels that are converted to size in micrometers for the current objective. Although display is at low-resolution, full resolution is used for acquisition and window size refers to pixels on the camera.
- Place the reference sample.
- Select the objective, focus the sample and adjust light intensity.
- Adjust tip & tilt to get close to null fringes.
- Click REFERENCE.

WARNING

Plots are reset and Spectrum plot displays the new reference spectrum. In case of Z scan being done out of focus the notification area shows an error message and the plots are empty.



To avoid making the reference each time the user wants to measure, references can be saved and loaded. Once a reference has been measured (or loaded) an information icon appears on the screen. If the user places the mouse on it, the software shows reference settings: objective, light intensity, material, window size and reference path and filename.



WARNING

To achieve reliable thickness measurements it is very important to use the same objective and exactly the same light intensity setting that was used to make the reference. Otherwise, even though the results might seem correct they would not be reliable. For this reason software does not allow acquisition with settings that do not match reference settings.

TIP: Choose a reference material with a similar reflectivity to sample's one, so both scanings are made with enough contrast and without saturation. Do not do a reference without checking that light adjustment is suitable for both reference and acquisition.

6.1.2 Step 2. Define the sample structure

In this step the user will specify substrate and layer materials. A database of materials is provided, organized by families but you can import or create additional materials in case layer material is not standard.

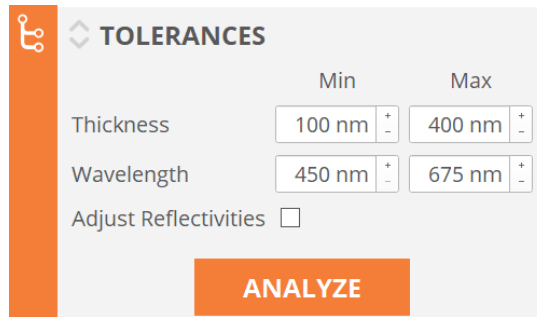
SAMPLE STRUCTURE	
Layer	n = 1.45705
Family	Oxides
Material	SiO2 (therm)
Substrate	n = 3.88089
Family	Semiconductors
Material	Si
SIMULATE	

Sample structure determines the theoretical reflectivity (orange curve in the Reflectivity plot).

SIMULATE button can be used to update the Reflectivity plot after editing sample structure (if there was a measurement done it resets the Least Squares Function and thickness result). The range of thickness for which the theoretical reflectivity is calculated depends on defined Tolerances (see step 3).

6.1.3 Step 3. Define the tolerances

In this step the thickness and wavelength ranges will be defined.

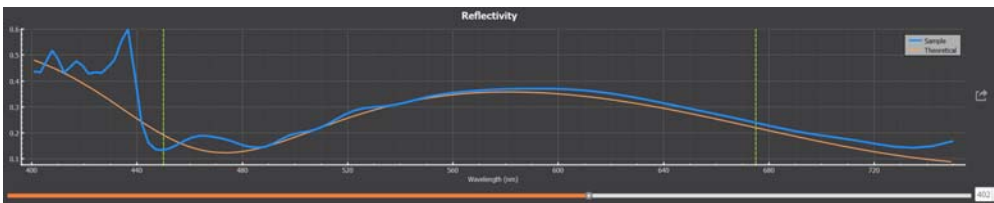


Tolerances settings

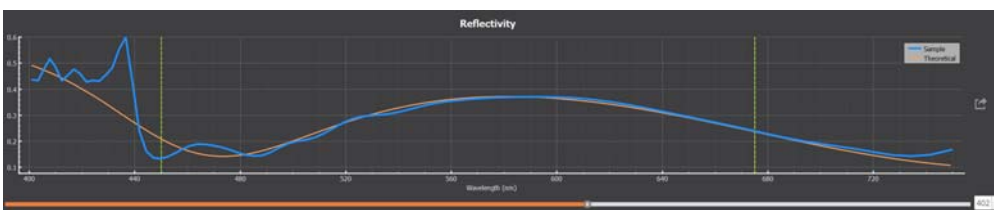
Thickness minimum and maximum values define the range of thicknesses used to calculate the Least Squares Function (spacing is 1 nm, minimum is 0 nm and maximum is 1500 nm).

Wavelength tolerances define which range of reflectivity will be used to calculate the Least Squares Function (minimum is 450 nm, maximum is 700 nm and range should be at least 100 nm).

Adjust Reflectivities can be used to change the Reflectivity plot. Note that it doesn't change the Analysis result. When it is disabled the plot shows the reflectivities used for analysis and measurement. When it is enabled the theoretical reflectivity amplitude is adapted to match the sample reflectivity and the offset between them is removed. This modified visual information can help expert users to evaluate the thickness measurement result.



Adjust Reflectivities disabled



Adjust Reflectivities enabled

ANALYZE button can be used to recalculate Least Squares Function and thickness result. It is only enabled if the user has measured the sample before (see step 4). It is very useful in case sample structure or tolerances have to be modified after MEASURE.

6.1.4 Step 4. Measure

- Place the sample
- Focus the sample
- Adjust tip & tilt to get close to null fringes
- Click MEASURE

Reflectivity plot shows the measured reflectivity and the theoretical reflectivity for the sample structure at result thickness. By changing the thickness value in the spinbox next to the slider or by moving the slider, the theoretical reflectivity will change according to selected thickness value.

The Least Square Function plot shows the similarity of the measured reflectivity and the theoretical reflectivity along thickness tolerance range. Thickness result corresponds to the minimum of this curve.

Thickness result is shown at the bottom right side of the screen. If the result, the minimum of Least Square Function, is at the edge of thickness tolerances a warning icon is shown to indicate that user must broaden thickness tolerances.

THICKNESS: 402 nm

Least Square Function minimum inside thickness tolerances

THICKNESS: 400 nm




Least Square Function minimum at the edge of thickness tolerances



WARNING

Thickness range adjustment in tolerance widget is critical and must include actual thickness in order to the result to be accurate. When measurements are automated (thickness mapping) points where Least Square Function minimum is at the edge of thickness tolerances will be have NaN value in the results file.

Export button  allows exporting measured reflectivity in a text file. Every row contains the wavelength in nanometers and the reflectivity value.

6.2 Thickness Mapping

In order to obtain a multiple point thickness measurements the user can manually move to desired positions, click MEASURE and get the thickness result in the graphical user interface. If the user wants to automatically export thickness results to a text file (mapping) he must create a Multiple Measurement Recipe (MMR). The procedure consists of three steps:

6.2.1 Step 1. Create the Single Measurement Recipe (SMR)

Like in other measurement techniques the user can save the [Acquisition Settings](#) as an SMR. The only difference is that thin film SMRs require the reference to be saved in a file. For this reason the software does not allow saving an SMR if the reference is not saved.

When an SMR is loaded the software automatically loads the reference.



WARNING

At SMR load, SMR corresponding objective and light intensity will be overwritten by reference objective and light intensity.

6.2.2 Step 2. Create the Multiple Measurement Recipe (MMR)

Once the user has an SMR they can create an MMR that measures at a set of pre-defined positions. Thickness results are saved in ".txt" file with the following format: one row for every measured point. Every row has X, Y and Thickness values separated by a space. X and Y are in millimeters while Thickness is in nanometers.

6.2.3 Step 3. Acquire MMR

The user can load an MMR and acquire.

Materials database

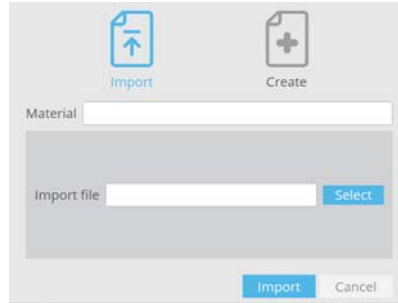
A database of materials is provided, organized by families. **Common** family groups the materials that are used more often as substrate or layer such as Si and SiO₂. Other families group materials by type such as **Semiconductors** and **Oxides**.

In case layer material is not standard the user can import or create additional materials. These materials will be added to "User defined" family. Click "+" button to open the database add material tool.

There are two tabs: Import and Create

Import

The user can select a ".txt" or ".dat" file that contains the refractive index and extinction coefficient for each wavelength within the range from 400 nm to 750 nm. The file format must be comma separated without any space: " λ, n, k ". The wavelength spacing must be 1 nm.



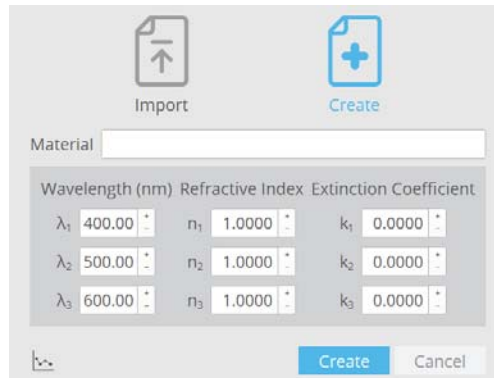
Import window

Create

We allow creating a material using Cauchy model by just giving the values of refractive index and extinction coefficient for three wavelengths:

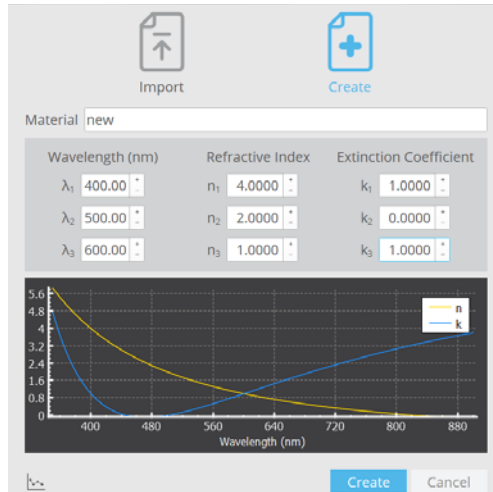
The user can show / hide a plot showing **n** and **k** along wavelength range.

If it is okay, click Create button at the bottom right side. Otherwise cancel it to close this tool.



Create window

It is possible that the Cauchy model is not suitable for the material. In this case we recommend creating the file and importing it.



Create window with plot

Delete

It is possible to delete a User Defined material by clicking “-” button. This button is only visible if the material the user wants to delete is selected as Layer material.

CHAPTER
7

RECIPES


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). They are available if the system configuration includes the optional Automated Procedures Module (APM).

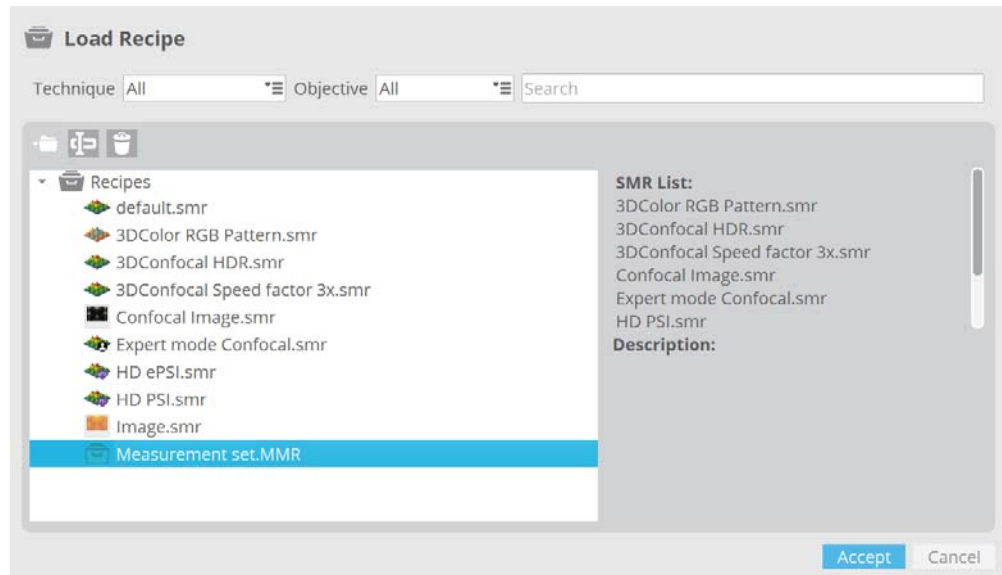


Access to Recipes is via icons at the top of the Acquisition Settings pane



7.1 Recipes: SMR & MMR

The icon  opens a dialog that allows the user to load either single (SMR) or multiple measurement recipes (MMR):



Load Recipe


This dialog offers several features, useful in the task of finding and loading the appropriate recipes. To start off, recipes can be filtered by technique and objective. To further simplify the search, any recipe from the list can be searched for by name. Folders can be created to organize the recipes by dragging and dropping them in the corresponding folder. It is also possible to rename and delete any recipe except “default.smr”.

NOTE The default recipe is updated every time **SensoSCAN** is closed. The [Acquisition Settings](#) at the time of closing the software overwrite the settings of the recipe.

By choosing a recipe from the list a description will be displayed on the right part of the dialog. If there is an error with the recipe, it will be displayed above the description. For the case of an MMR, the full list of SMRs that it contains will be shown. 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 recipe

The Default recipe 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 usually 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 automated 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. For example, MMRs can be used to acquire measurements from different XY locations. At each XY location, several measurements can be acquired 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.



WARNING

The system uses the fastest XYZ trajectory to move between two XYZ coordinates. Therefore, trajectories between the Positions listed in a MMR must be free of obstacles. See MMR set-up.

NOTE

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 shows how many files have been measured (or not), the time required and the status. If the user clicks on Explore Measurements, the software opens the path to the measurements to be displayed.

Managing recipes

Recipes (SMRs and MMRs) can be created via the recipes drop-down menu  :

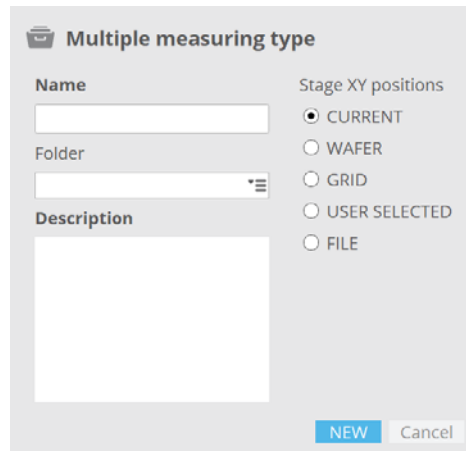
- Through the *Save* option, the current **Acquisition Settings** overwrite the previous recipe.
- The *Save as* option opens the Save Recipe dialog. The available options in this dialog are similar to the options in the Load Recipe dialog; the user can filter, organize, rename and delete recipes. Additionally, the user can write an optional description for a new recipe.
- MMRs can be created with the *New MMR* option.

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

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*):

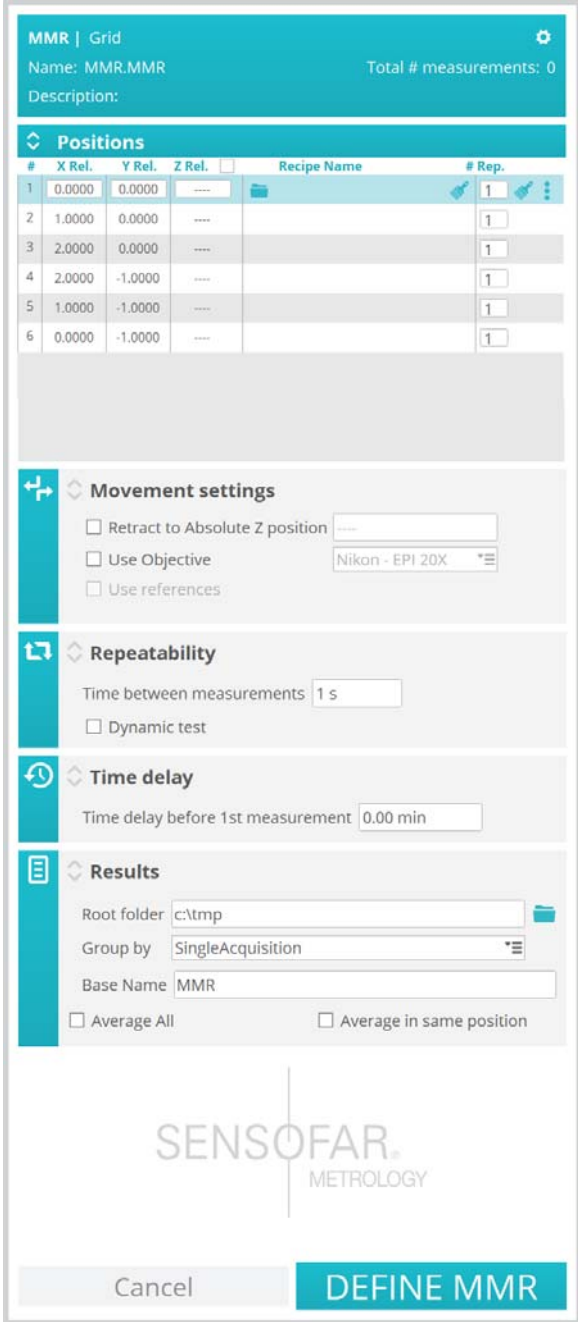


Multiple measurement create positions dialog

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

7.1.1 Creating an MMR

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



MMR | Grid
Name: MMR.MMR Total # measurements: 0
Description:

#	X Rel.	Y Rel.	Z Rel.	Recipe Name	# Rep.
1	0.0000	0.0000	----		1
2	1.0000	0.0000	----		1
3	2.0000	0.0000	----		1
4	2.0000	-1.0000	----		1
5	1.0000	-1.0000	----		1
6	0.0000	-1.0000	----		1

Movement settings

Retract to Absolute Z position

Use Objective: Nikon - EPI 20X

Use references

Repeatability

Time between measurements: 1 s

Dynamic test

Time delay

Time delay before 1st measurement: 0.00 min

Results

Root folder: c:\tmp

Group by: SingleAcquisition


Base Name: MMR




Average All Average in same position

Cancel DEFINE MMR

MMR settings

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 measurement locations under Positions (if not already specified by the choice of MMR):

- define absolute X & Y position values and the starting Z-Scan value
- click on the  icon to select an appropriate SMR and specify the number of repetitions
- repeat for any other necessary measurement Positions - if necessary, parameters can be copied to any other Positions using the paste tool 
- deletions can be made using the 
- under Bind Positions and Sample IDs (only visible if Use Sample ID has been activated in [System Preferences](#) / Sample ID):
 - define the total number of Sample ID's
 - tie (bind) one or more Positions to each Sample ID. It is possible to assign more than one position to each Sample ID. In case of multiple positions, separate them by commas.

Example:

Id #1 - positions: 1-4, 6, 8-10

Id #2 - positions: 5,7
- under Movement Settings enable or disable the following:
 - the Retract to Absolute Z Position option
 - Use Objective: when selected, selection of an objective is enabled in the drop-down menu
 - Use references: when selected, the Movement settings pane extends to enable user-defined reference positions

NOTE Movement Settings is not available for all position systems, in which case this section of the pane will be disabled.

- under Repeatability:
 - set the parameter Time between measurements
 - 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 enable or disable Average all and Average in same position

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

A report, summarizing the MMR will be displayed. By choosing Edit, the parameters of the MMR can be adjusted. To return to the standard Inspection & Acquisition interface choose Exit.

If Use references is enabled, when the user clicks the Acquire button, the software asks for the defined References to be set. If the XYZ start position is not the current position, the software asks for confirmation before movement. Once the system is at the start position the user can refocus the sample.

7.1.1.1 MMR set-up

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

Recipe naming

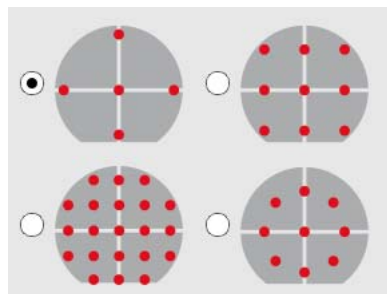
The following characters are not allowed:

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

Positions

Different measurement locations (Positions) can be defined when creating or editing the MMR. The options are:



- *Current*: the current stage values are used.
- *Wafer*: the measurement locations are defined by the predefined distributions of measurement locations relative to the center of the wafer (0,0,0). It is assumed that the wafer is placed at the center of the XY stage. There are four options with different layouts and numbers of points:



The distance between two points must be set in the die pitch edit box. The positions are automatically loaded into the table. The final list is comprised of absolute XY and undefined Z coordinates.

A measurement process using an MMR created with the Wafer option takes as a Z coordinate the actual coordinate of the system when Acquire is triggered. Thus the first step before a wafer is measured must be to focus the wafer surface and the second step is to press Acquire. For automated systems, it is assumed that the wafer surface is always in a position that can be found by means of Autofocus tools.

- *Grid*: the measurement locations are defined by entering the number of columns and rows of the measurement positions and their spacing. The user must enter the spacing in X and Y between the center of the FOVs. The positions will be automatically loaded into the table. This will create relative coordinates for XY, and set Z to undefined.

- *User selected:* the XY stage joystick can be used to manually define the measurement locations (absolute coordinates) and add this position to the MMR with the button . It is also possible to add or delete a position by clicking the right button . When adding a new position, the position is automatically cloned and the user is able to edit its values.
- *File:* the measurement locations can be loaded from an ASCII file. This is a plain text file (ASCII) that has two sections - the reference positions are in the section labeled References and the measurement locations in the section Measures.

The positions can be absolute or relative. It must be tagged as [References Relative] or [Measures Relative] for relative positions and [References] or [Measures] for absolute positions. In order to convert a relative position to an absolute one, it is necessary to define the center (0, 0) of these coordinates. That is why the first action after clicking the acquire button is to ask the user where this center position is placed.

References and Measures consist of 3 values (X, Y and Z, in millimeters and up to 4 decimal places) separated by spaces. The Z position can be blank for References and Measures. When the user defines References (up to 3) they will appear in the Use references option.

Here is a sample file with reference positions:

```
[References]
-1.0000 0.0000 -27.4000
 1.0000 3.0000 -27.4000
[Measures]
-2.6843 26.1442 -27.4000
-7.6705 26.1442 -27.4000
-7.6645 22.3005 -27.4000
```

Here is a sample file without reference positions:

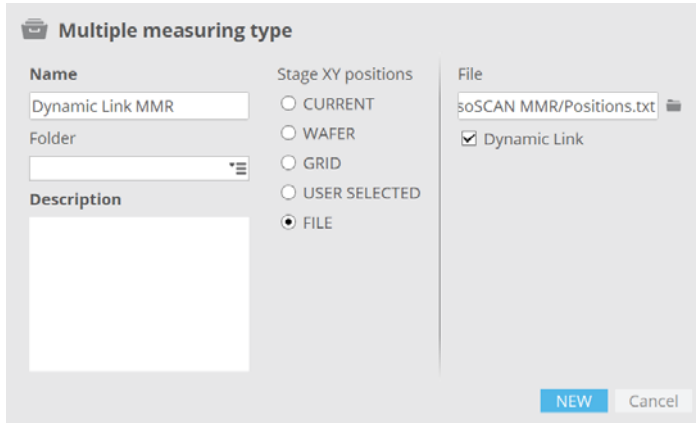
```
[References]
[Measures]
-2.6843 26.1442 -27.4000
-3.6705 26.1442 -27.4000
-4.6645 22.3005 -27.4000
```

If the Z position is defined, the user can enable or disable it on the list by clicking on the checkbox.

NOTE These are all converted to absolute positions by adding the actual XYZ coordinate of the system when Acquire is triggered.

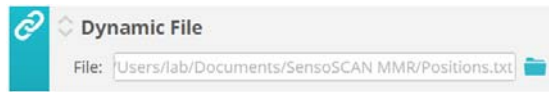
Dynamic Link

This option allows the user to change the positions and references through a file linked to a MMR. The usual File MMR loads positions and references from a file, if these positions are to be changed, another file has to be loaded. Dynamic Link MMR connects the values shown in **SensoSCAN** and the values in the *.txt file.



Dynamic Link MMR creation dialog

The path of the file is shown in a widget called “Dynamic File”. The user can select another file with positions and references, or change the values of the current file editing the *.txt file.

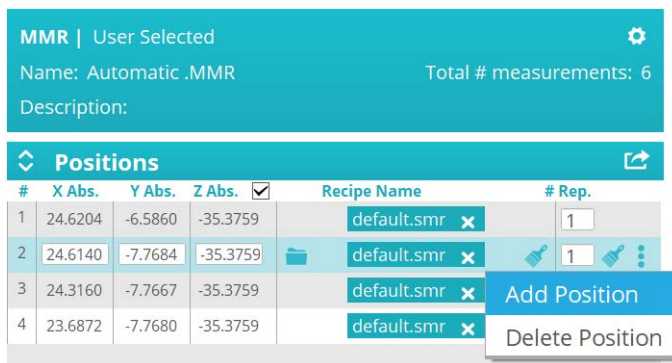


MMR Dynamic File

For this type of MMR only the first row of the table can be modified. All changes will be automatically applied to the rest of the table, this includes recipes and repetitions. Editing the *.txt file will not erase the recipes and repetitions. If references were defined, they are maintained.

Defining the MMR refreshes the values. Once defined, in the MMR summary screen, the file can also be updated through the icon . Starting the acquisition refreshes the file as well.

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




MMR positions list with Export button

MMR log files contain exportable relative coordinates from MMR.

There is a menu to the right of each position enabling the possibility to delete or add a position. When you add a position it is automatically cloned and the user is able to edit its values.

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.

Movement settings

- The Retract to Absolute Z Position option is available to avoid collisions between the sample and the objective. The user must take into account the working distance of the measurement objective and the fact that the system will otherwise use the fastest XYZ trajectory to move between two XYZ coordinates. The user of the system is responsible for ensuring that this condition is met.

WARNING

The system uses the fastest XYZ trajectory to move between two XYZ coordinates. The trajectories between the positions listed in a MMR must thus be free of obstacles.

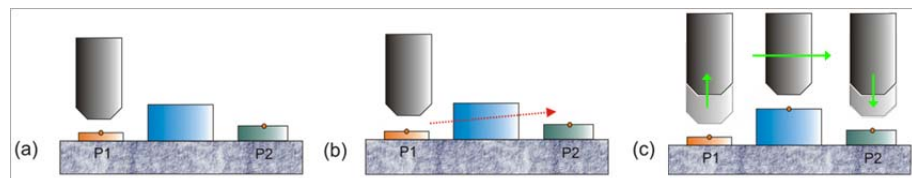


Figure (a) shows an example of a sample layout in which the trajectory of the measurement objective between positions 1 and 2 is not free. If the MMR is defined to move from P1 to P2, the objective will collide with the obstacle (see Figure [b]).

In this case, the user must enable the Retract to Absolute Z Position option and define a Z position to avoid collisions (see Figure [c]). Then, the **system** will move to the absolute position defined in the edit box before any movement is undertaken between the two positions.

Note that the XYZ movement between the two positions is performed with the objective used for the last measurement in the origin position. If the first measurement in the target position is not the same, the objective is changed once the system has reached the target position.

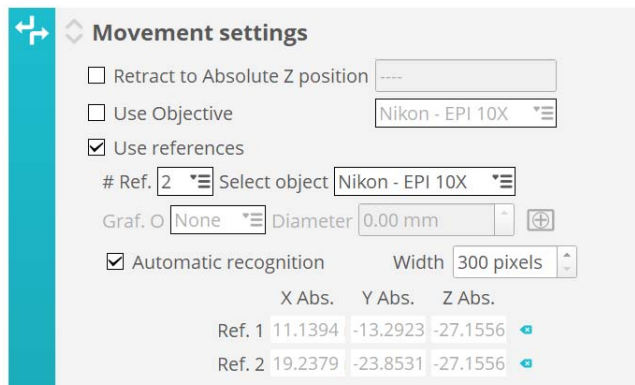
- Use Objective: allows selection of a specific objective other than that chosen under **Objective Selection**.
- Use references: these are fixed points (or markers) on a sample. The Positions can be related to these markers.
- Automatic recognition: enabling this option, the user does not need to do a manual operation when the MMR starts. **SensoSCAN** will move to each of the nominal positions, by applying the recognition pattern learned before. In case of a successful match, the software will correct the positions automatically. Ideal for automation of the fiducial recognition and correction without any human interaction.

The user must apply a two-steps procedure:

- Introduce the width/height of the ROI in which the reference will be enclosed
- Move the stage to place the reference inside the defined ROI with the objective set for references and click to the reference definition button. It is necessary to repeat this step for each reference. **SensoSCAN** will individually save each image to recognize them in future processes.

NOTE The reference must be inside the FOV of the nominal position.

NOTE Use references is not available if the selected Positions option for the MMR is Current or Grid.



	X Abs.	Y Abs.	Z Abs.
Ref. 1	11.1394	-13.2923	-27.1556
Ref. 2	19.2379	-23.8531	-27.1556

MMR movement settings

References are useful when a sample has been removed from the system and is then replaced to take another measurement. Usually, the sample is not replaced in exactly the same position and the system does not measure the proper positions. If References have been defined for the original measurement, they can be used to properly re-locate the measurement points. This is also useful when you are measuring different samples of the same type.

NOTE Samples rotated with an angle higher than 10° will not be detected.

Before measurement, the system will go to these reference positions and ask the user to center them. From the corrections introduced by the user, the system determines the error in the sample position and corrects it.

To use this feature, simply enable Use references.

NOTE Use references is not available if the selected Positions option for the MMR is Current or Grid.

Before the reference positions can be defined (by clicking the flag), the user needs to select some options:

- # Ref.: either 2 or 3 References can be used. The use of 2 References corrects the shift, rotation and scale (but assumes that the scale is the same in X and Y). The use of 3 References enables the system to determine X and Y scaling errors individually. References can either be set at the origin or be user-defined. Incomplete definitions are indicated with a warning triangle:

	X Abs.	Y Abs.	Z Abs.
Ref. 1	0.0000 mm	0.0000 mm	-20.0000 mm
Ref. 2	---	---	---

- Graf. O.: an alignment aid can be overlaid on the image to help center the References. The options are None, Cross and Circle. When None is selected, the usual cross-hair will be displayed. When Circle is selected, a circle of the diameter defined in the edit box (in mm) will be displayed. When Cross is selected, a width of the cross defined in the edit box (in mm) is displayed.
- Select object: the user must select which objective will be used to take images at the References.

NOTE The objective used to define the References must also be used to inspect the sample before Acquire is clicked.

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 D in XYZ after each measurement and return to the starting point before the next one.

Time delay

A time delay before the first measurement can be defined. This can be used to let the system settle from any environmental vibrations. It is also particularly useful if an MMR must be launched automatically at a programed time, without a system administrator being present to start it.

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 2018	Time: 18h 28m 17s
MMR Folder: C:\Sensofar\Measure_26_May_2018_18_28_17		



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:
 - 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 2018	Time: 18h 28m 17s
SMR: Topo.SMR	Positions: 1	Repetitions: 1
Files: C:\Sensofar\Measure_26_May_2018_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 2018	Time: 18h 28m 17s
SMR: Topo.SMR	Positions: 1	Repetitions: 3
Files:		
C:\Sensofar\Measure_26_May_2018_18_28_17\R0001_Topoplux		
C:\Sensofar\Measure_26_May_2018_18_28_17\R0002_Topoplux		
C:\Sensofar\Measure_26_May_2018_18_28_17\R0003_Topoplux		

- If the number of positions is more than one:
 - a If the number of repetitions of the SMR is one, the file name consists of a position tag (PXXXX) and the SMR name.

Example:

Root folder: C:\Sensofar		
Base name: Measure	Date: 26 May 2018	Time: 18h 28m 17s
SMR: Topo.SMR	Positions: 2	Repetitions: 1
Files:		
C:\Sensofar\Measure_26_May_2018_18_28_17\ P0001_Topo.plux		
C:\Sensofar\Measure_26_May_2018_18_28_17\ P0002_Topo.plux		

- b If the number of repetitions of the SMR is more than one, a sub-folder is created for each position. The name of the sub-folder consists of P and a number between 1 and 9999 (PXXXX). The files are saved in the sub-folder according to the position in which they were measured. The file name consists of the SMR name and the repetition tag.

Example:

Root folder: C:\Sensofar		
Base name: Measure	Date: 26 May 2018	Time: 18h 28m 17s
SMR: Topo.SMR	Positions: 2	Repetitions: 2
Files:		
C:\Sensofar\Measure_26_May_2018_18_28_17\ P0001\R0001_Topo.plux		
C:\Sensofar\Measure_26_May_2018_18_28_17\ P0001\R0002_Topo.plux		
C:\Sensofar\Measure_26_May_2018_18_28_17\ P0002\R0001_Topo.plux		
C:\Sensofar\Measure_26_May_2018_18_28_17\ P0002\R0002_Topo.plux		

- If the total number of SMR is more than one:
 - 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 2018	Time: 18h 28m 17s
SMR1: Topo.SMR	Positions: 1	Repetitions: 1
SMR2: Image.SMR		
Files:		
C:\Sensofar\Measure_26_May_2018_18_28_17\Topo.plux		
C:\Sensofar\Measure_26_May_2018_18_28_17\Image.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 2018	Time: 18h 28m 17s
SMR1: Topo.SMR	Positions: 1	Repetitions: 2
SMR2: Image.SMR		
Files:		
C:\Sensofar\Measure_26_May_2018_18_28_17\Topo\R0001_Topo.plux		
C:\Sensofar\Measure_26_May_2018_18_28_17\Topo\R0002_Topo.plux		
C:\Sensofar\Measure_26_May_2018_18_28_17\Image\R0001_Image.plux		
C:\Sensofar\Measure_26_May_2018_18_28_17\Image\R0002_Image.plux		

- If the number of positions is more than one, a sub-folder is created for the SMR. The name of the sub-folder is the name of the SMR.
- a** If the number of repetitions of a SMR is one, the files are saved in the SMR sub-folder. The file name consists of a position tag (PXXX_) and the SMR name.

Example:

Root folder: C:\Sensofar		
Base name: Measure	Date: 26 May 2018	Time: 18h 28m 17s
SMR1: Topo.SMR	Positions: 2	Repetitions: 1
SMR2: Image.SMR		
Files:		
C:\Sensofar\Measure_26_May_2018_18_28_17\Topo\P0001_Topo.plux		
C:\Sensofar\Measure_26_May_2018_18_28_17\Topo\P0002_Topo.plux		
C:\Sensofar\Measure_26_May_2018_18_28_17\Image\P0001_Image.plux		
C:\Sensofar\Measure_26_May_2018_18_28_17\Image\P0002_Image.plux		

- b** If the number of repetitions of a SMR is more than one, a sub-folder is created for each position. The name of the sub-folder consists of P and a number between 1 and 9999 (PXXX). The files are saved in the sub-folder according to the SMR used in each position. The file name consists of the SMR name and the repetition tag.

Example:

Root folder: C:\Sensofar		
Base name: Measure	Date: 26 May 2018	Time: 18h 28m 17s
SMR1: Topo.SMR	Positions: 2	Repetitions: 2
SMR2: Image.SMR		
Files:		
C:\Sensofar\Measure_26_May_2018_18_28_17\P0001\Topo\R0001_Topo.plux		
C:\Sensofar\Measure_26_May_2018_18_28_17\P0001\Topo\R0002_Topo.plux		
C:\Sensofar\Measure_26_May_2018_18_28_17\P0001\Image\R0001_Image.plux		
C:\Sensofar\Measure_26_May_2018_18_28_17\P0001\Image\R0002_Image.plux		
C:\Sensofar\Measure_26_May_2018_18_28_17\P0002\Topo\R0001_Topo.plux		
C:\Sensofar\Measure_26_May_2018_18_28_17\P0002\Topo\R0002_Topo.plux		
C:\Sensofar\Measure_26_May_2018_18_28_17\P0002\Image\R0001_Image.plux		
C:\Sensofar\Measure_26_May_2018_18_28_17\P0002\Image\R0002_Image.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.

7.1.1.2 MMR 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.
 - For undefined Z coordinates (for example in Wafer recipes), the system uses the current Z coordinate when Acquire is triggered. In this case, the system assumes that the sample is in focus before Acquire is triggered. For automated systems, it is assumed that the surface can be focused by means of an Autofocus tool.
 - Relative XY coordinates, the system adds to every XY coordinate the actual XY coordinate of the system when Acquire is triggered.

- If the MMR makes use of References:

The system waits to allow the user to start Center references. Press any key to start the process.



WARNING

References are defined by absolute coordinates XYZ during the MMR creation. Do not use References if the Z position between the sample used to create the MMR and the samples you are going to measure is not very close. If the Z difference is high, the system may collide with the sample when it moves to the nominal XYZ position of a Reference.

The system checks that the current objective matches the objective that will be used to center the References. If this is not the case, the system automatically positions the objective or asks the user to position it if the system has a manual nosepiece.

Then, the system moves to the nominal position for Reference 1 and waits for the user to center Reference 1. Press Accept to set center Reference 1. Then, the system moves to the nominal position for Reference 2 and waits for the user to center Reference 2. Press Accept to set center Reference 2. If MMR uses 3 References, the system moves to the nominal position for Reference 3 and waits for the user to center Reference 3.

When all of the References have been centered, the system uses the actual reference positions to correct the XYZ positions in the MMR list. The Z coordinate is corrected by the average offset between the nominal Z position and the actual Z position of the References. XY coordinates are corrected for translation and rotation if two References are used and also for scale if 3 References are used.

Finally, it waits 4 seconds for the user to begin the measurement. If no key is pressed and no Z adjustment is initiated during this time, the system automatically starts to measure. If the user starts to adjust the Z position before the countdown has finished, then the system waits until a key is pressed (hot keys F2, F3 and F8 can be pressed during the countdown and will stop it).

In this step, the user can refocus the Z position and adjust the light. The difference between the actual Z position and the nominal Z position for this point in the MMR list is the Z offset. This offset is applied to all the points in the MMR list.

■ If MMR does not make use of References:

The system checks whether the actual position matches the first position in the MMR list. If not, the software asks for confirmation before moving to the first position.

Then, the system checks that the current objective matches the objective that will be used by the first SMR in the first position. If not, it automatically places the objective or asks the user to place it if the system has a manual nosepiece.

Finally, it waits 4 seconds for the user to begin the measurement. If no key is pressed and no Z adjustment is initiated during this time, the system automatically starts to measure. If the user starts to adjust the Z position before the countdown has finished, then the system waits until a key is pressed (hot keys F2, F3 and F8 can be pressed during the countdown and will stop it).

In this step, the user can refocus the Z position and adjust the light. The difference between the actual Z position and the nominal Z position for this point in the MMR list is the Z offset. This offset is applied to all the points in the MMR list.

■ 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

- If an MMR does not make use of References, the Center references steps are not required.
- Asking for confirmation steps is not required if the system is remotely controlled or a Control of Production system is used.
- Center references is a manual operation and is required even in production control and remotely controlled systems.



CHAPTER
8

ERRORS & DIAGNOSTICS

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](#).



8.1 Crash report

If the software fails unexpectedly it will allow the user to automatically send the failure to Sensofar. The information sent will help identify the root cause of the failure and pro actively fix the issue in our next **SensoSCAN** versions.

Once a report is submitted a "Crash Id" will be assigned and then automatically sent to our software team, the report will include all basic information to evaluate and try to fix any reported software crash. Fixes, if available, will be included in the next software versions.

Please fill in the feedback report form.

FEEDBACK REPORT SENSOFAR.
METROLOGY

Software quit unexpectedly. We are sorry for the inconvenience.
 A problem caused the program to stop working correctly. Click Report to send the report to Sensofar. This report contains diagnostic information which may help Sensofar improve its products.
 All information is treated as confidential and is only used to improve future versions of this program.

Problem Description

Please can you tell us what happens before the crash to reproduce and solve the issue?

If provided, we may contact you with additional information about this error.

Name (optional):

Email Address (optional):

Note: Your email address will never be sold or used for marketing purposes.

Crash report dialog

Additionally, a zip file is generated and stored in the folder C:\tmp\CrashReports. It contains information that technical service support may request in order to perform a proper diagnostic.

The user can always manually generate a report zip and/or a backup zip through the file menu, **Help / Diagnostics**.

NOTE Connection to the Internet is required to send a Crash report.

8.2 Restoring or re-installing the main controller

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



WARNING

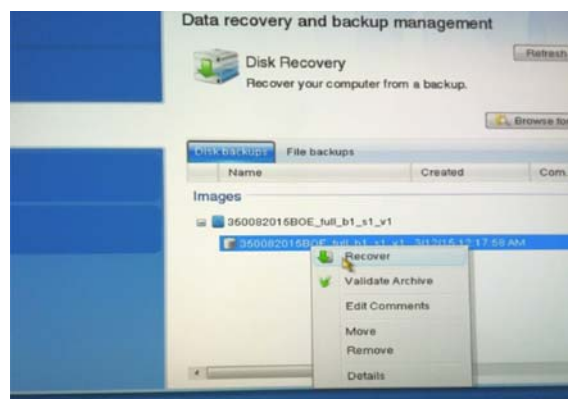
Do not restore or reinstall the main controller without contacting your Distributor beforehand.



WARNING

This process will delete all calibrations and configurations, as well as created recipes and measurements.

1. Switch on the main controller (PC). Note that you may have to access the Start up menu pressing “Esc” at the start up sequence to select the USB as the boot unit.
2. Boot up from Sensofar’s USB memory stick provided with the system.
3. The 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. 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. 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.

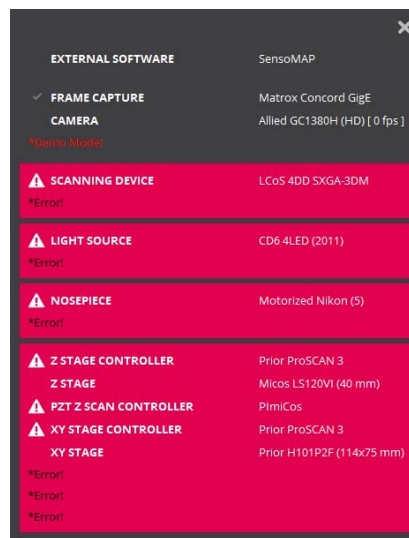
8.3 Hardware configuration

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

The user can also check the **System Status** panel to display the error messages:



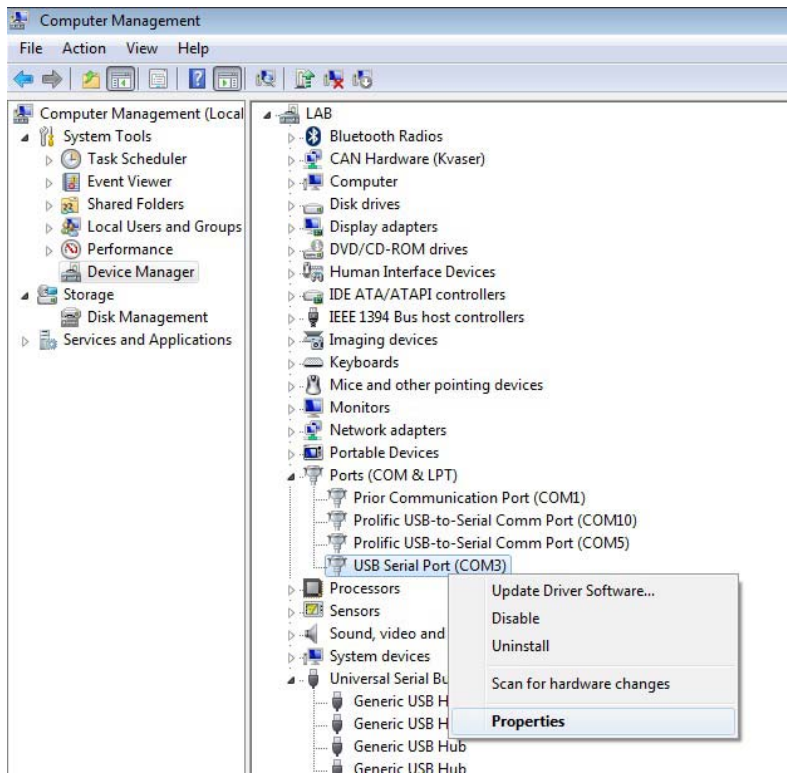
System Status panel

Cause A – Ports need to be configured

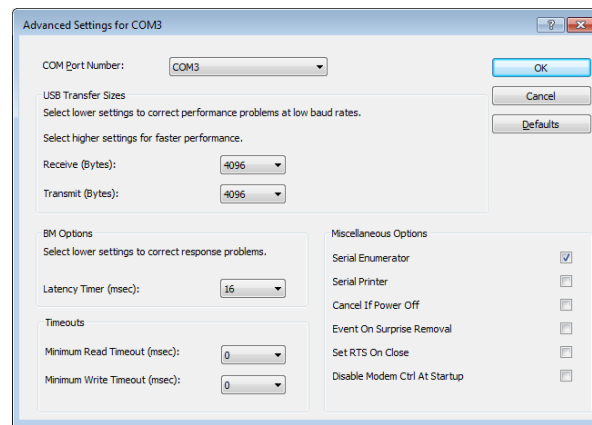
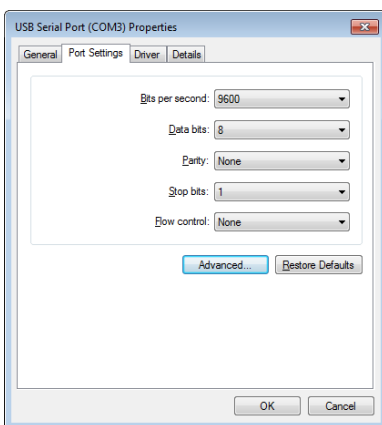
1. Check the ports configuration in device manager panel. The configuration must be as follows:

Description	Windows identifier name	Ports (COM)
XYZ Controller	USB Serial Port	COM1
Illumination Control	USB Serial Port	COM3
Motorized Nosepiece	USB Serial Port	COM4
Piezo Stage Motor	USB Serial Port	COM5

2. Click onto START icon and go to Control Panel > System and Security > System > Device Manager.
3. If not, right click onto the port and select Properties.



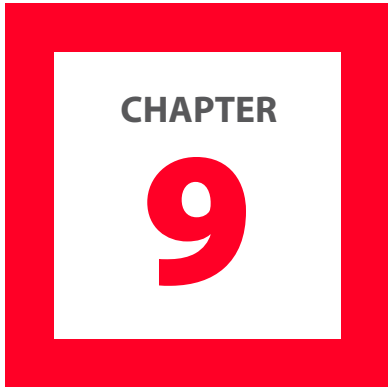
4. In the 'Port Settings' tab, select 'Advanced...'



WARNING

Check that COM1 has latency timer set to 1.

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




APPENDIX

All globally relevant information as well as background topics from other chapters are collected here.



9.1 System Preferences

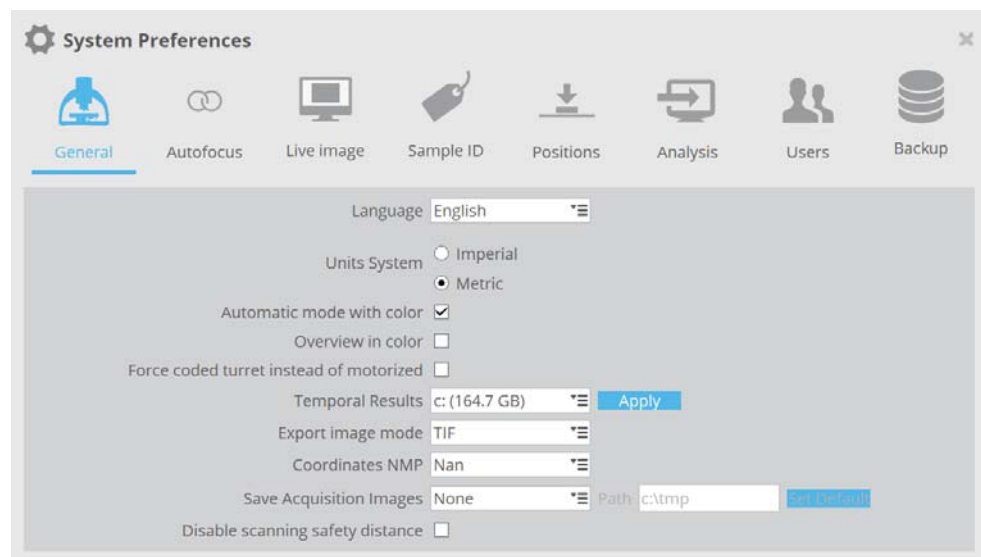
System Preferences can be accessed by clicking the  icon in the **Quick Bar** when in **Inspection & Acquisition** mode, or choosing Configuration / System Preferences from the Menu icon.



The Quick Bar bottom area with System Preferences icon

The System Preference categories are organized as tabs.

General



System Preferences menu displaying General settings

The options here allow setting of:

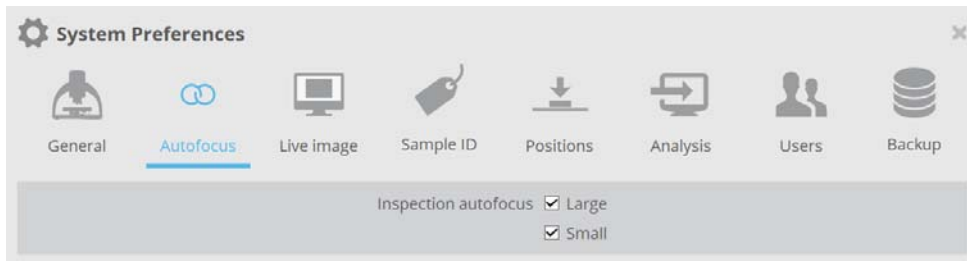
- Language: the user interface language for **SensoSCAN**.
- Units System: select between imperial or metric system.
- Automatic mode with color: this toggles the color mode for **3D Auto**.
- Overview in color: Enabling this option shows the overview in color. Disabling it shows the overview B&W.
- Force coded turret instead of motorized: It is possible to command the motorized nosepiece like a codified to minimize the possibility of crashed lenses.
- Temporal Results folder. The software saves measurements in C:\tmp folder except for measurements acquired with MMR that are saved in the root folder defined in the MMR. This allows linking to external analysis software tools such

as **SensoVIEW** for display and analysis of individual measurements. By default this folder is “C:\tmp” but for computers with small SSD “C:\” drive this may not be optimum. When the software is run for the first time the user selects the drive where this temporal folder is created. It is possible to modify the drive by selecting another drive. The software applies a backup of the current temporal results folder in “oldtmp” folder in the same drive before creating the temporal results folder in the new drive.

- Export image mode: set the file extension for the exported images.
- Coordinates NMP: allows to define the format of non-measured points. The options are Nan, Infinite or Zero.
- Save Acquisition Images: it is possible to save the confocal or interferometric images during the scanning. The path where these will be saved must be defined here. The format of the saved images is bmp.
- Disable scanning safety distance: the safety distance is defined as “Objectives Working Distance (WD)- 500 μm ” for objectives with $\text{WD} > 1000 \mu\text{m}$ and $\text{WD} / 2$ otherwise, thus it depends on the selected objective. Enabling this option changes the safety distance to $\text{WD} - 100 \mu\text{m}$, increasing the maximum Z-scan range.

NOTE The maximum range is limited by the system’s available memory and the resolution.

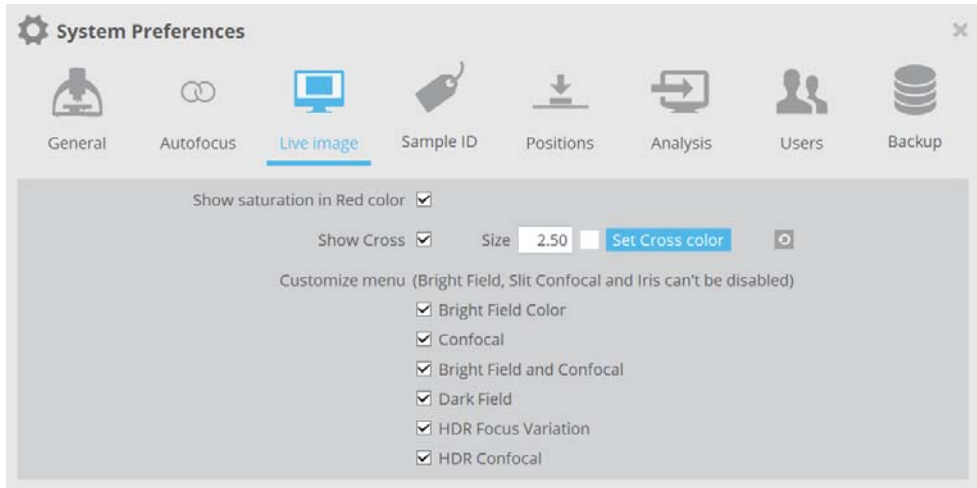
Autofocus



Autofocus settings in System Preferences

The options here determine whether large and/or small Autofocus routines are used when performing the **Autofocus** command in **Sample Inspection**. Information on the advanced options for these routines can be found in the **Acquisition Settings** chapter.

Live Image

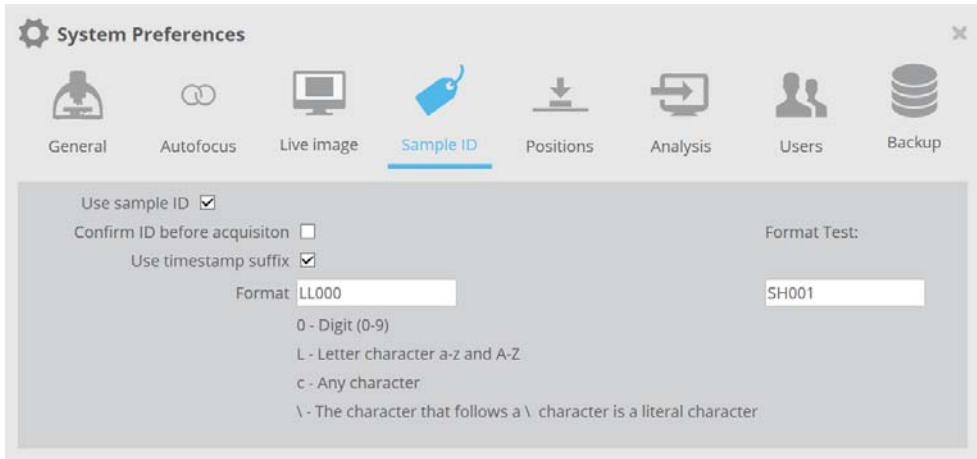


Live Image settings in System Preferences

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 at any time, regardless of whether none, or a small cross-hair is selected here.
- The remaining options visible here determine which options are available in the **Central Viewer's** image type selector. Bright field, Slit Confocal and Iris can't be disabled.

Sample ID



Sample ID settings in System Preferences

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.

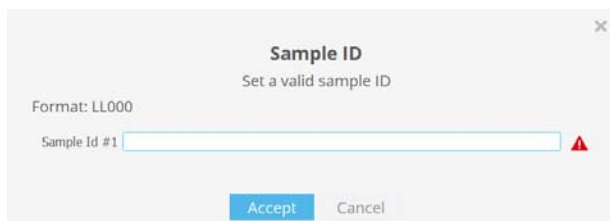
Sample ID options are as follows:

- 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:

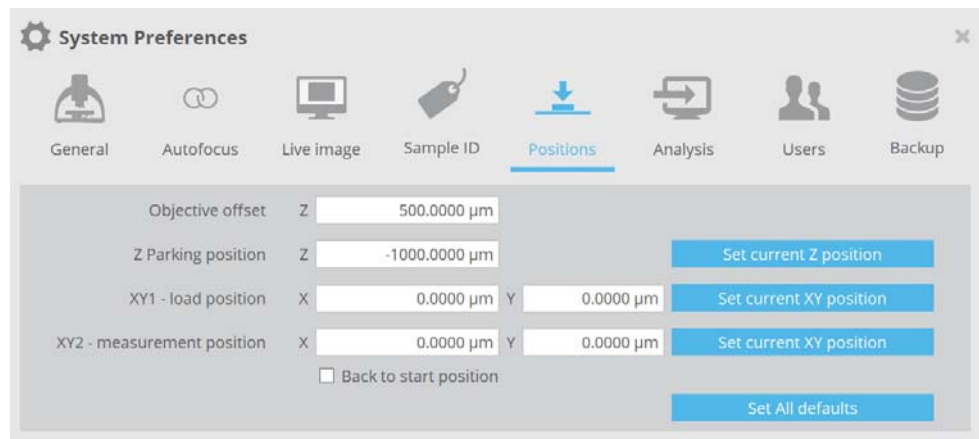


- Confirm ID before acquisition allows the user to check the Sample ID once more before acquisition.
- Use timestamp suffix in the file name to specify the acquisition time. When enabled, every acquisition with a sample ID tag will carry a timestamp with the following format: "ID_YYYYMMDD_hhmmss.plux".

If case of duplication (multiple measurements acquired with the same Sample ID) a timestamp will be added even if the option is not enabled in System Preferences, as a way to distinguish between measurements.

- 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).

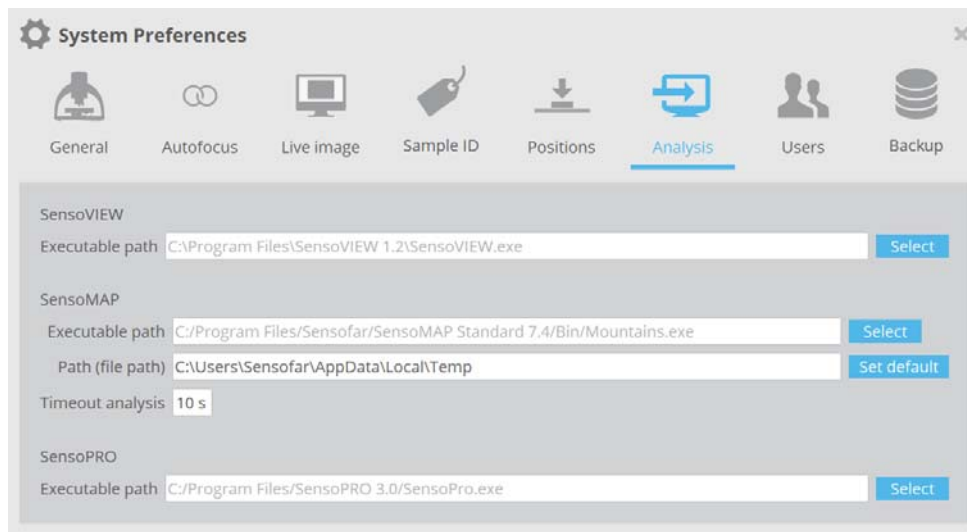
Positions



Positions settings in System Preferences

- Z parking position is where Z stage moves at the first step of **Load Sample** process and at the last step of a Home Search process. Default value is -1 mm. The value can be edited or can be set to current Z position. Valid values are those within the Z stage travel range (by default from -100 micrometers to -40000 micrometers).
- XY1 load position is where XY stage moves at the first step of Load Sample process. Default value is X center (0) and Y front (Y travel range/2). The value can be edited or can be set to current XY position.
- XY2 measurement position is where XY stage moves at the last step of Load Sample process. Default value is X center (0) and Y center (0). The value can be edited or can be set to current XY position.
- Back to start position is an alternative way to define XY2 measurement position. Default value is disabled. When it is enabled XY2 measurement position defined in previous item is not used, instead the system uses the XY position where the user starts Load Sample process.
- Set All defaults resets default position settings.

Analysis



Analysis settings in System Preferences

- The executable path for **SensoVIEW**, **SensoMAP** and **SensoPRO** can be defined here. When these are correctly given, **SensoSCAN** can automatically call the external analysis software when required.

- **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** pings **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.

Users

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** distinguishes between three different levels of users and their associated rights:

- **Administrator**: can manage System Preferences, can perform **Configuration & Calibration** tasks and has all the rights of an Advanced Operator.

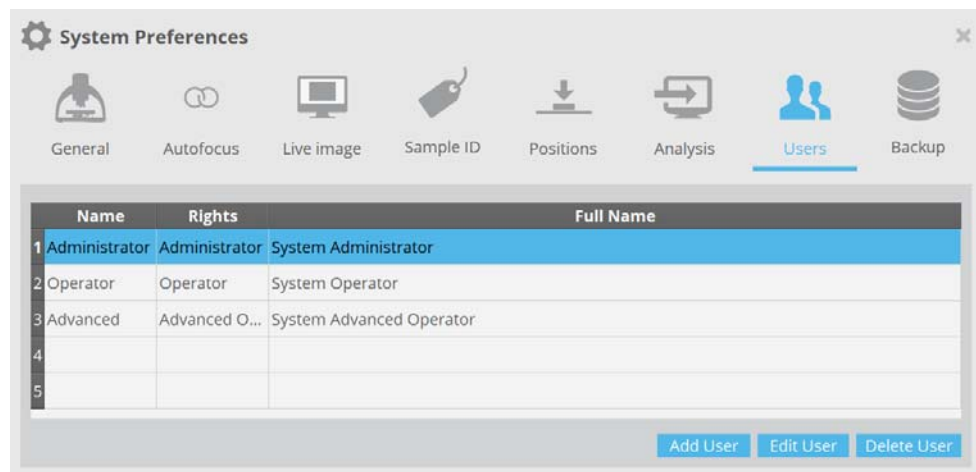
- **Advanced:** can configure measurement and create recipes, and has all the rights of an Operator.
- **Operator:** can load recipes, acquire and save/load data and perform analysis.

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	

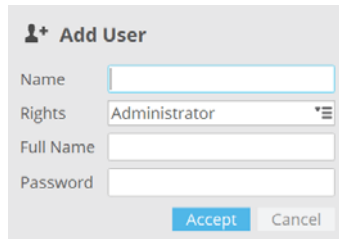
User rights and the default passwords after initial installation (and following re-installation)

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):



Users 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:



The 'Add User' dialog box contains the following fields and controls:

- Name:** A text input field.
- Rights:** A dropdown menu currently set to 'Administrator'.
- Full Name:** A text input field.
- Password:** A text input field.
- Buttons:** 'Accept' (blue) and 'Cancel' (grey).

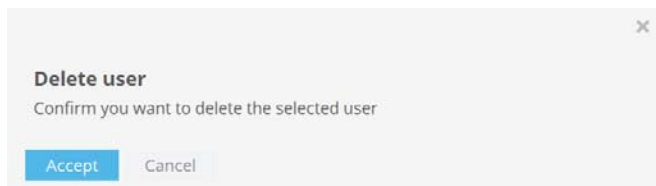
Using the Edit User dialog to edit the details for user Operator

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:

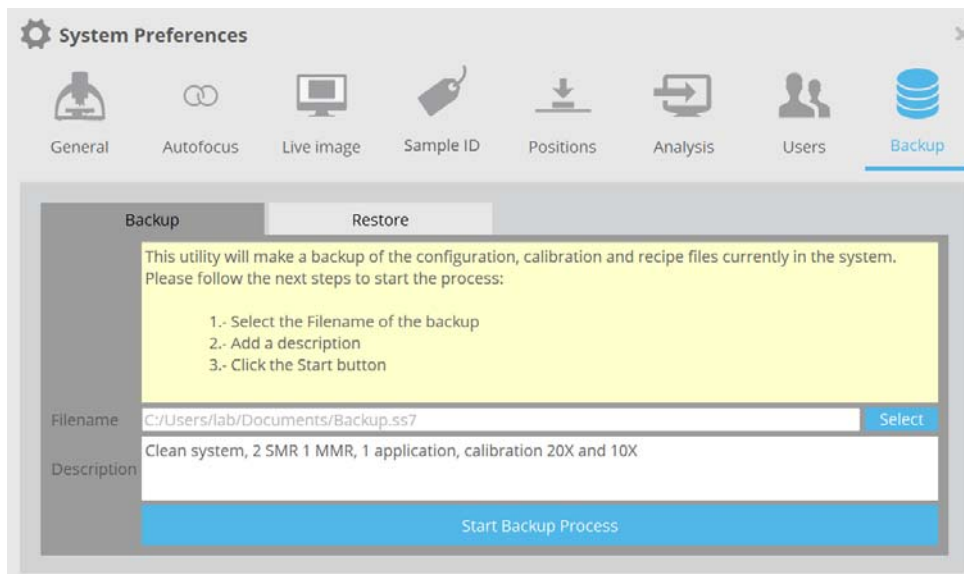


The 'Delete user' dialog box contains the following elements:

- Title:** 'Delete user'
- Text:** 'Confirm you want to delete the selected user'
- Buttons:** 'Accept' (blue) and 'Cancel' (grey).

Using the Delete User option to delete the profile for the user Operator

Backup



The 'System Preferences' window shows the 'Backup' settings. The 'Backup' tab is selected, and the 'Restore' tab is also visible. The main content area contains the following instructions and fields:

- Instructions:** 'This utility will make a backup of the configuration, calibration and recipe files currently in the system. Please follow the next steps to start the process:'
- Steps:**
 - 1.- Select the Filename of the backup
 - 2.- Add a description
 - 3.- Click the Start button
- Filename:** A text input field containing 'C:/Users/lab/Documents/Backup_ss7' and a 'Select' button.
- Description:** A text input field containing 'Clean system, 2 SMR 1 MMR, 1 application, calibration 20X and 10X'.
- Start Button:** A large blue button labeled 'Start Backup Process'.

Backup settings in System Preferences

This option allows the user to save the system configuration through a backup, to be restored in the future. The backup file is a compressed zip file with a .ss7 extension.

■ Backup

To perform a backup the user must select the folder where the backup will be saved and write a description (optional). During the backup process the following files are copied:

- Applications and Recipes
- Calibrations
- Configurations
- Thin Film materials and Users databases
- SNXXX.hcf file

■ Restore

To retrieve the files the user must choose the path where the backup was saved. Once the backup file is selected, some relevant information saved in the backup file will be shown on the screen, such as user, date, version, description and serial number.

NOTE **SensoSCAN** must close to apply the changes. It will be done automatically, after the restore process a dialog will appear, informing the user.

The Backup/Restore process is useful when the user wants to uninstall and install the current version without having to repeat the calibration and keeping the recipes.

NOTE Repeating the calibration is strongly recommended in order to achieve the most metrologically accurate results.

Another useful application for the Backup/Restore process consists of maintaining the configuration whenever a version upgrade has to be done. The user can back up all the relevant files and restore them in the new version without having to repeat the calibration. However, a new version could have changes in the calibration, which is why it is recommended to perform another calibration process.

NOTE Backup/Restore only works for **SensoSCAN 7.2** and newer versions.



WARNING

The restore process can delete information of the current installation, such as recipes and configurations. A backup before a restore is recommended.




9.2 Offline Extended Topography

To access this window select File / Offline Extended Topography on the Quick Bar. The window allows the user to choose which FOVs to stitch, and to apply the appropriate settings before obtaining the final result.

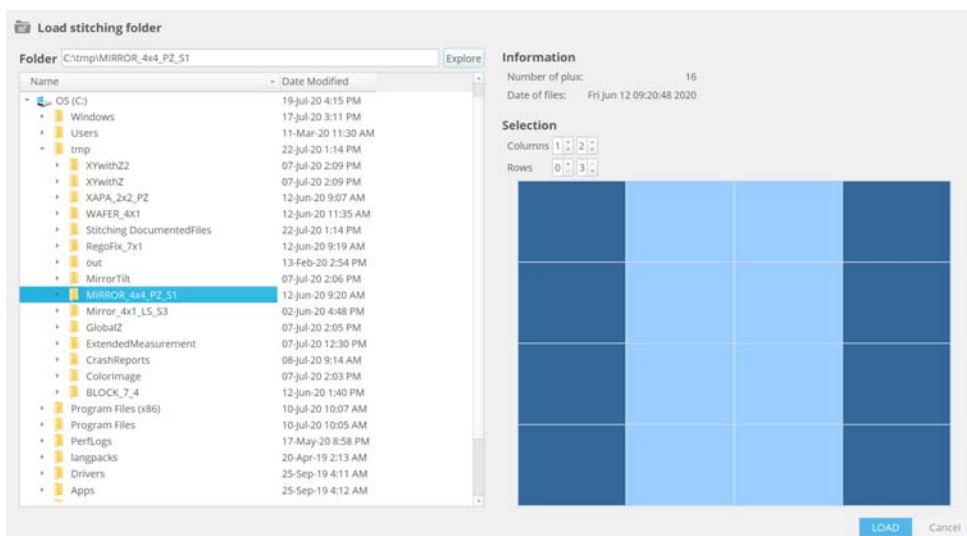
9.2.1 Quick Bar



The following actions can be performed by clicking on the icons from the Quick Bar:

-  opens the path of the currently loaded folder
-  loads a folder with files to stitch
-  closes the offline stitching window

9.2.2 Load stitching folder window

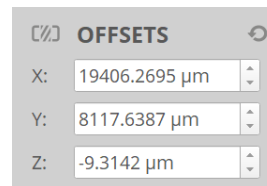


Load stitching folder window

This window allows the user to choose the files to stitch. On the left side of the pane the user can choose the folder where the files are located. By default, the tmp folder is expanded.

The right side of the pane displays basic information such as the number of plux files and the date the measurements were acquired, as well as controls to select which rows and columns will be stitched. The FOVs that will be used are represented by a lighter shade of blue.

9.2.3 Offsets



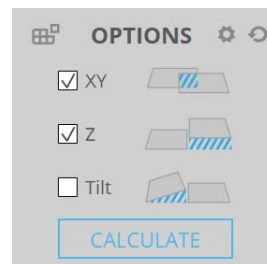
Offsets pane

Select any FOV to see its current XYZ offset, which corresponds to the distance from the center of the FOV to the center of the axis located in the middle.

The FOVs can be manually moved to change the offset by clicking and dragging or by using the keyboard arrows.

The icon  restores the default offsets.

9.2.4 Options




Options pane

There are three correction options to choose from:

- **XY** – FOVs are stitched using the best fit in the XY plane, as if seen from above, without considering the changes in Z (height).
- **Z** – stitching done by considering the height differences between two consecutive FOVs.
- **Tilt** – works best for large area acquisitions (high number of measured FOVs or low magnification objectives). It corrects the tilt that may appear on the FOVs near the edges of the acquisitions as a result of the XY table movement.



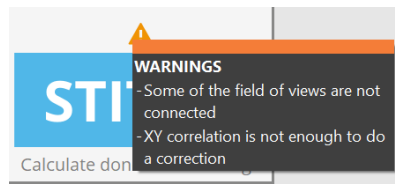
Tilt is not enabled by default because it can have negative effects on the stitching of smaller areas, as it can remove a tilt that does not exist.

Multiple correlations can be selected at the same time by checking the corresponding checkbox. By not checking any boxes the result will be shown without any adjustment. Additional options are available by clicking the  icon.


NOTE The default settings work on most cases and usually there is no need to alter the additional options. These options are complex and should only be altered by very experienced users who know what to expect when applying each setting.

Once the necessary settings are adjusted click on CALCULATE to preview the final result. Each time CALCULATE is clicked the selected settings are applied to the original FOVs, as to not apply the same settings twice. The only exception is the XY offset, which is always applied to the last offset performed. To apply the options to the original XY offset restore the default offsets before clicking CALCULATE.

If there is a problem during the analysis a warning icon will appear; hover the mouse over the icon to see a brief description of the error:



In this case use the advanced settings to adjust the configuration. The advanced settings can help solve those cases that could not be solved with the standard settings. If the warning is related to a particular correction option disable it to see if the stitching adjustment improves.

Use the  icon to return to the default settings.

Advanced settings

XY Settings

Source

Algorithm

Range 85%

Threshold 80%

Z Settings

Kind

Algorithm

Tilt Settings

Algorithm

Corrections

Vignetting

Aberration

Filter

Leveling

Noise

Prune

Kind

Cutoff

Final Result

Crop

Resample

Cancel

Advanced settings pane

The settings available in this pane should only be changed in those cases when the default settings do not provide the desirable results. For most cases it is not necessary to adjust the advanced settings. The user must be aware of the effect of each setting before changing them.

XY Settings

- **Source:** corresponds to the data layer that will be used to perform the XY correction. The options are Stack, Color, DataZ and Nan. The final stitching will be applied to all data layers.
 - Stack is selected by default because it works for most cases and it is the fastest; the others can be chosen for those cases where the performance using Stack is not ideal.
 - If the individual FOVs have been acquired in color this information can be used by choosing Color.
 - DataZ works best if there are distinct structures present on the surface which can be used to correlate two different FOVs.
 - Nan uses non-measured points to correlate FOVs, which is useful when there are many non-measured points or large holes.
- **Algorithm:** the kind of mathematical analysis to be applied. The options are None, Correlation, Features and Median Correlation.
 - Correlation is the default option; images are correlated by using a Fourier Transform to analyze every pixel.
 - None leaves the FOVs invariant, it is the same as not enabling the XY option outside the advanced settings.
 - Features looks for very distinct structures that are repeated in consecutive FOVs to stitch them together.
 - Median Correlation does the correlation of all FOVs, finds the median displacement, and applies it.
- **Range:** this setting only has an effect if the chosen algorithm is Correlation or Median Correlation (Features always uses range 100%).

The higher the range, the higher the displacement (error) that can be detected within the overlapping region but with less accurate results. Lower range values mean smaller search regions, achieving more accurate displacement results. Nevertheless, if the search region is too small the results will not be correct. Set low values only for those cases where the misalignment is known to be small.

- **Threshold:** all previous options have a quality degree, meaning that they can improve or worsen the final result. If the quality threshold is not surpassed, a warning icon will appear to inform the user and the XY correction will not be applied. It is counterproductive to apply a correction that worsens the original information, so this warning appears when that may be the case. By decreasing the threshold the quality degree will become lower, thus the correction will be more tolerant but the results could be incorrect.

Z settings

- **Kind:** how the Z offset is calculated for each region of overlapping. To calculate the offset choose:
 - Mean, which finds the mean of the overlapping
 - St. Dev., which finds the mean of the overlapping but discards those points that are farther away than the standard deviation
 - Median (default), which finds the median of the overlapping
 - Histogram, which looks at the highest point of the histogram
- **Algorithm:** The options are None, Grow and Global.
 - None does not correct the Z, this is the same as not enabling the Z option outside the advanced settings.
 - Global (default): a system of equations is used to minimize the offset differences, by moving all FOVs up and down until the error is the smallest possible.
 - Grow: the stitching is done one by one in a sequence; one neighbor is stitched to a FOV, then another, and so on.

Tilt Settings

- **Algorithm:** The options are None and Global.
 - None does not correct the tilt, this is the same as not enabling the tilt option outside the advanced settings.
 - Global (default): a system of equations is used to minimize the offset differences, by moving all FOVs up and down until the error is the smallest possible.

Corrections

- **Vignetting:** corrects the Stack image using measured data. This setting usually improves the Stack image result because the flat calibration of each objective is done on a mirror, which can result in some vignetting effects to be left without correcting for samples of different reflectivity. The options are None, Common, Median and Mean.
 - None: the Stack image is not corrected.
 - Common (default) searches for the vignetting of all FOVs and finds the best correction.
 - Mean calculates the mean of the Stack image, works better on smooth samples.
 - Median calculates the median of the Stack image, works better on smooth samples.

- **Aberration:** used to achieve a better result on smooth samples that have not been measured correctly. The options are None, Mean and Median.
 - None: no calibration is subtracted.
 - Mean: the mean calibration is subtracted from each FOV.
 - Median: the median calibration is subtracted from each FOV.

Filter

These options are applied to each individual FOV before the stitching.

- **Leveling:** choose whether to remove the main plane from each FOV before the stitching by selecting Plane or keep the original tilt by selecting None.
- **Noise:** choose whether to remove the noise present on each FOV or not (None) and the intensity of the filter (Low, Medium, or High).
- **Prune:** surfaces surrounded by non-measured points and that are smaller than this value will be deleted.
- **Kind:** choose the output surface. None leaves the surface as it is, Roughness generates an S-L surface and Waviness an S-F surface.
- **Cutoff:** set the cutoff wavelength which separates the roughness from the waviness. Wavelength above the cutoff are assigned to waviness, and below to roughness.

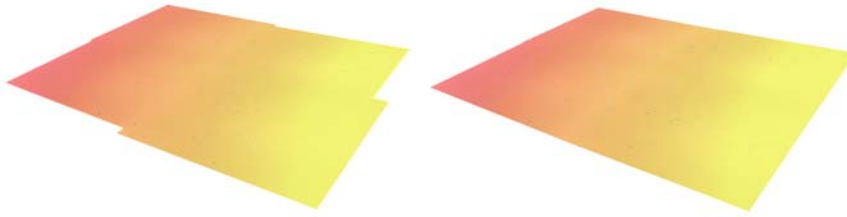
Final Result

These options are also available outside the advanced settings menu. For more information, see the section below.

- **Crop:** choose if the stitched result should have its edges cropped or not.
- **Resample:** if wanted, the topography can be resized to achieve a different resolution. The different options are None (no resampling), HD, 2K, 4K and 8K.

9.2.5 Final Result

When FOVs are being stitched, the end result may be such that the borders are not uniform. Enable this setting to trim the borders, leaving a straight edge.



Crop disabled (left) and enabled (right)

Resample the result to a user selected resolution. This is done by taking the largest side of the topography - it can either be the horizontal or the vertical side - and it resizes it to the selected resolution. The other side is resized accordingly to maintain the original aspect ratio. The options are:

Resolution	Largest side
None	As is
HD	1080
2K	2048
4K	4096
8K	8192

9.2.6 Render Type

Choose between the following ways to visually present the result:

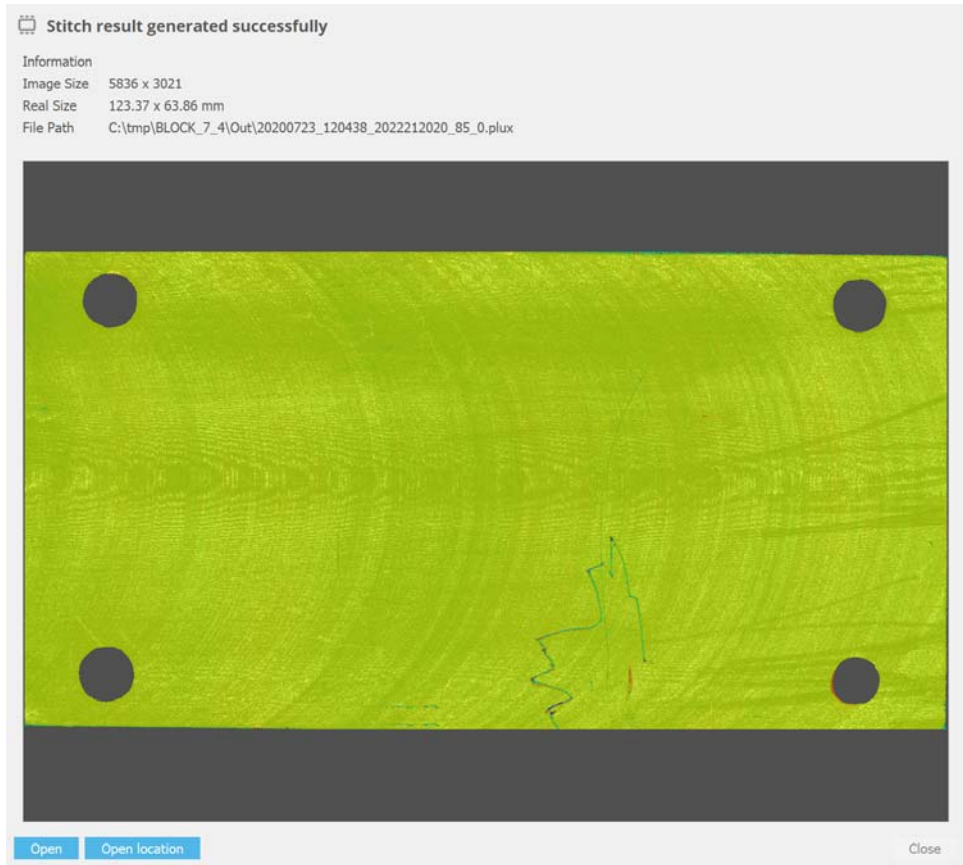
- False Color + Stack. This is the default option
- Stack / Real Color. If the topography has been acquired with a color camera the true color can be displayed. Otherwise select this option to see only the Stack without the False Color representation.

This pane is only for visual purposes and it does not affect the stitching result.

9.2.7 Stitch

When all settings have been adjusted, click on stitch to join all the FOVs. A pop-up window will appear showing the preview of the final result, as well as the image size and path. The user can choose to open the file, to open the location where the file is saved or to close the window.

NOTE Clicking on “Stitch” merges the data but clicking on “Calculate” does not, it applies the correction options and advanced settings.



Stitch result preview window

Every stitch result is saved in a folder named “Out”, located inside the folder with the files used to perform the stitching. As a result, the user does not have to repeat the stitching process to see the final result.

9.3 Configuration Files

This section outlines the initialization settings which are determined by the contents of *.xml configuration files.

These files can be found in the following folder: "C:\ProgramData\Sensofar\SensoSCAN 7.x\Configuration". Their settings are usually configured during system installation. 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.

The StageZ.xml file configures these options for the Z stage (the file contains more fields but only these are used by the system):

Section	Description
MIN_VALUE	Sets the minimum Z position in microns. Default is -40000
MAX_VALUE	Sets the maximum Z position in microns. Default is -100
MAX_SPEED	Sets the maximum stage speed in microns/second. Default is 3500
JOYSTICK_SPEED	Sets the joystick speed in microns/second. Default is 1500
BACKLASH	Sets the backlash compensation in microns. The default value is 15
PARKING_POSITION	Sets the parking position in micrometers. Default value is -1000
OBJECTIVE_OFFSET	Sets Z offset in microns. Used when changing the objective with a motorized nosepiece (move Up, rotate objective, move Down). Default is 500

The StageX.xml and StageY.xml files configure these options for the X / Y stages (files contain more fields but only these are used by the system):

Section	Description
MIN_VALUE	Sets the minimum X/Y position in microns. Default is -TravelRange/2.
MAX_VALUE	Sets the maximum X/Y position in microns. Default is TravelRange/2
MAX_SPEED	Sets the maximum stage speed in microns/second. Default is 20000.
JOYSTICK_SPEED	Sets the joystick speed in microns/second. Default is 20000.

Section	Description
REVERSED	Invert axis values. Not inverted (false) or inverted (true). Default value for X stage is true. Default value for Y stage is false.
STABILIZATION_TIME	Sets a wait time to let the system settle (stabilize) before acquiring a new FOV in Extended Measurements. Default depends on the XY stage type.

9.4 Tracking Extended Measurements

Tracking options

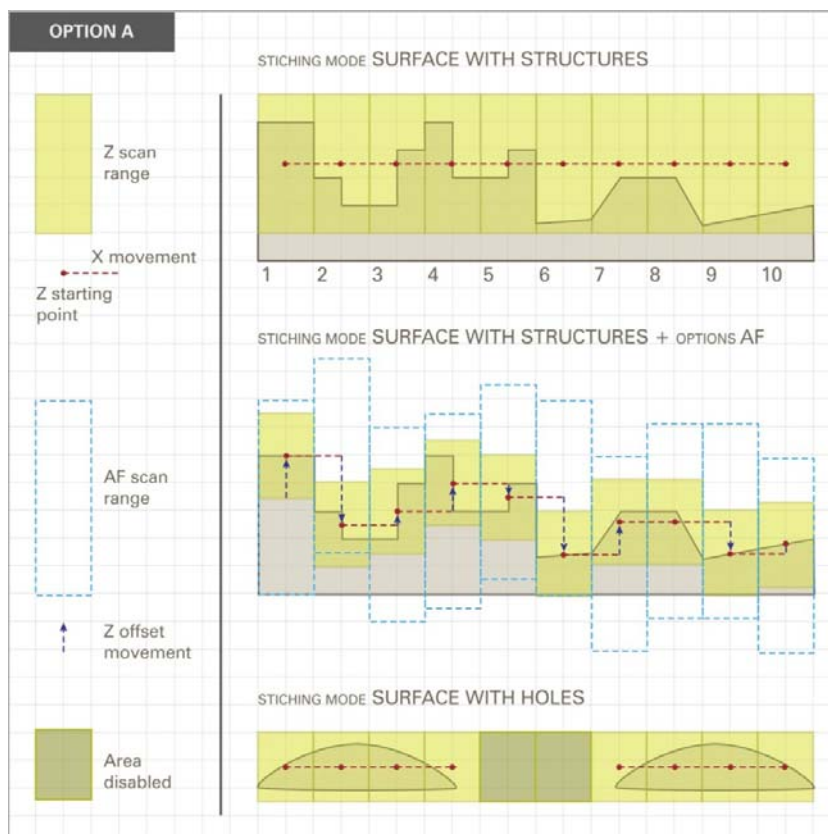
The tracking options refer to the Z-Scan trajectory between FOVs, as well as checking/managing the points measured in the overlapping areas of an Extended Measurement. There are three pre-defined options:

■ A: Flat surfaces and/or holes

This mode moves between adjacent FOVs without any Z offset. The Z starting position will thus be the same for each FOV. The exception to this is when Continuous Autofocus is enabled, in which case the system will attempt to more or less follow the shape of the surface.

The percentage of measured points at the stitching interfaces is not checked. Consequently, the measurement will not stop, even if some parts or a full single 3D measurement have not been measured.

For samples with holes or annular and round shapes, some areas without points can be disabled in order to reduce the file size and measurement time.



Tracking trajectories for flat surfaces and holes

■ B: Tilted surfaces or curved shapes (following a parabolic surface)

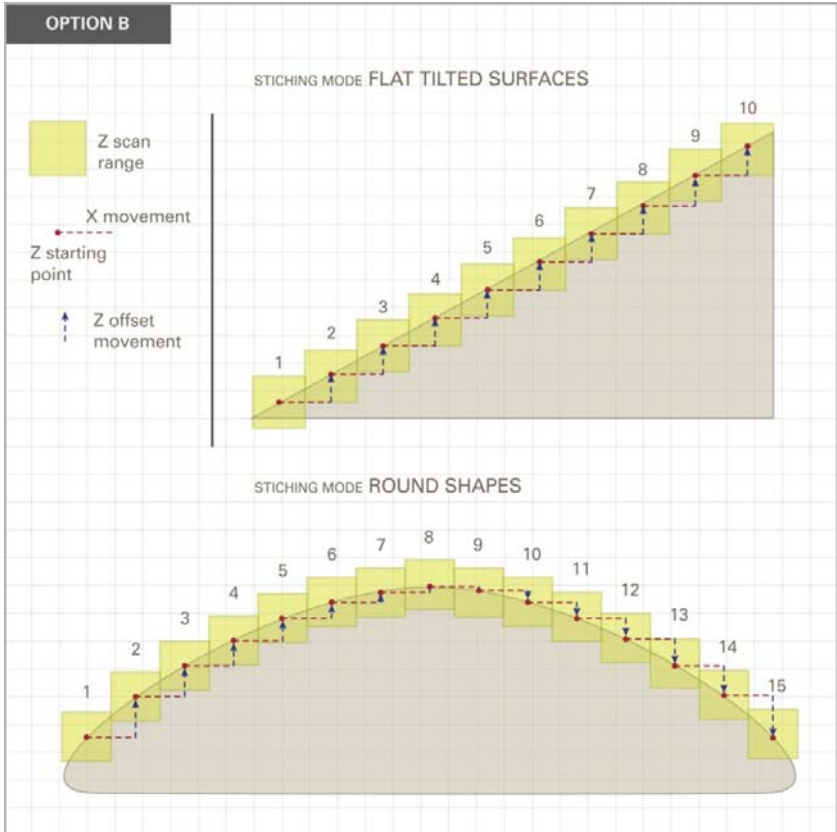
This mode determines the next FOV Z offset from a parabolic function that best fits the Z contour of the previous FOV. The Z-Scan range remains fixed.

This option checks the percentage of measured points at the stitching interfaces. If there is not enough information in a particular FOV to stitch together two contiguous 3D measurements, **SensoSCAN** first tries to repeat the acquisition by increasing the range up to 4x. If the acquisition fails again, **SensoSCAN** will show a Lost Topography dialog with the following options:

- **Retry FOV:** A further dialog window appears that provides basic means to (i). adjust the light intensity, and (ii). adjust the Z-Scan range. Note that these changes are applied only to the current (failed) FOV - if they should be applied to all remaining FOVs, select the option Apply to following FOVs. By clicking Accept, the acquisition continues as originally planned, first repeating the acquisition of the current (failed) FOV.
- **Skip FOV:** Discard current, and move on to the next FOV.
- **Finish:** Stop the acquisition and display the FOVs already measured.
- **Cancel:** Cancel the entire acquisition.

There are two situations where changing the measurement parameters can be useful:

- The Z-Scan range is out of focus and/or too short. In this case, try refocusing the sample and/or increasing the Z-Scan range.
- The slope in these regions is too steep. In this case, try lowering the Threshold and/or increasing the light intensity. If the problem persists, try to obtain a new measurement with a higher NA objective.



Tracking trajectories for tilted and curved surfaces

The following table summarizes the properties of each mode:

Mode	Z path	Measured points checked?	Action when stitching fails
Flat surfaces and/or holes	No prediction	No	Continue measurement
Tilted surfaces and curved shapes	Follows parabolic surface	Yes (must be > 50%)	Show Lost Topography window

9.5 File Formats

Not all **SensoSCAN** versions generate the same files after an acquisition:

- **SensoSCAN 5.x** saves measurements in the *.plu format
- **SensoSCAN 6.0** through **6.3** save measurements automatically in both the *.plux and the *.plu format
- **SensoSCAN 6.4, 6.5, 6.6** and **SensoSCAN 7.x** save by default only the *.plux format

NOTE While the *.plu and *.plux formats are conceptually similar, they are structurally different.

NOTE There are two versions of *.plux files. **SensoSCAN 7.3** introduces a new *.plux version (1.1) with an improved description about the measurement and a different pre-processing of the stack image layer.

File format compatibility between **SensoSCAN** and **SensoVIEW**

The interchangeability between the new *.plux and the older *.plu formats is limited to the import of a *.plu file into **SensoVIEW** (select **File / Import / Import plu** from the Menu icon). Only the raw data of the measurement is imported from the *.plu file.

File format compatibility between **SensoPRO LT** and **SensoPRO**

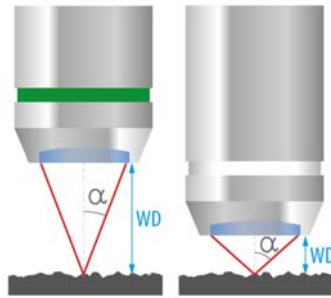
32-bit versions of **SensoPRO** (designated as **SensoPRO LT**) are only compatible with *.plu files. Users of **SensoPRO LT** will need to activate the Save as *.plu option in [System Preferences](#).

64-bit versions of **SensoPRO** (**SensoPRO 3.x** and later) are compatible with *.plux files.

9.6 Basic Parameters for System Operation

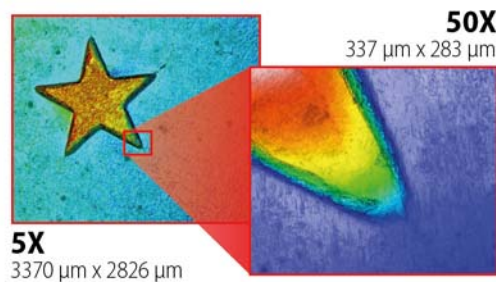
This section covers general concepts that will help with the operation of the S neox system and that help to understand the product specifications.

- Numerical aperture (NA): determines the largest slope angle on the surface that can be measured and affects the optical resolution. Its mathematical expression is $NA = n \cdot \sin \alpha$, where n is the index of refraction of the working medium (air, water or oil) and α is the maximum half-angle of the light cone that enters or exists the lens.



Maximum half-angle for a low magnification objective (left) and a high magnification objective (right)

- Working distance (WD): distance taken from the end of the objective at which the focus plane is found.
- Field of view (FOV): region of the measured sample that is seen in the Central Viewer. It depends on the magnification; FOVs are smaller for high magnification objectives.

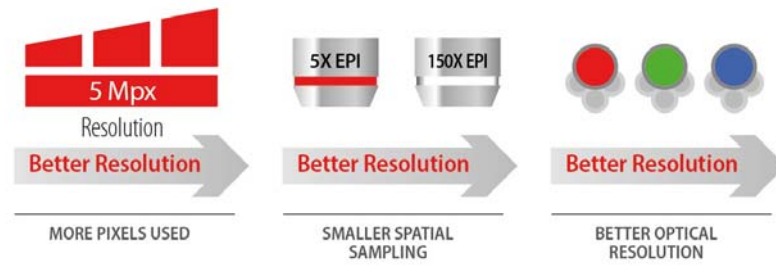


FOV of a low magnification objective (left) and a high magnification objective (right) showing the same sample

- Resolution: smallest detectable distance between two features of the sample.

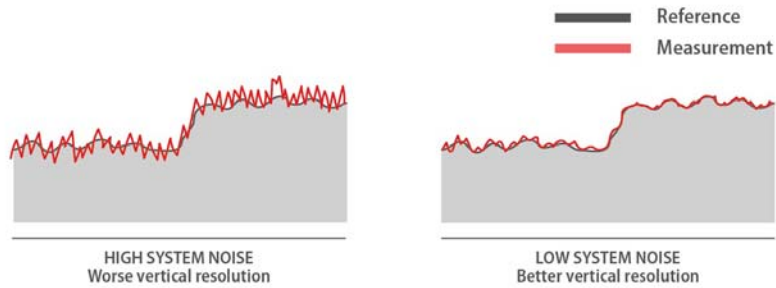
Lateral resolution depends on the number of camera's used pixels and the dimensions of the FOV. The resolution is better if more pixels are used or if higher magnification objectives are chosen, as this results in smaller spatial sampling.

For better optical resolution use monochromatic light sources with lower wavelength, such as the blue LED.



Ways of improving the resolution

Vertical resolution is related to the system noise. The least amount of system noise can be achieved by measuring with Interferometry. For the Confocal and the Ai Focus Variation techniques the system noise depends on the NA of the objective; low NA objectives lead to noisier measurements.



System noise on a lower NA objective (left) and a higher NA objective (right)



SENSOFAR is a leading-edge technology company that has the highest quality standards within the field of surface metrology.

Sensofar Metrology provides high-accuracy optical profilers based on confocal, interferometry, Ai focus variation and fringe projection techniques, from standard setups for R&D and quality inspection laboratories to complete non-contact metrology solutions for in-line production processes.

The Sensofar Group has its headquarters in Barcelona, also known as a technology and innovation hub in Europe. The Group is represented in over 30 countries through a global network of partners and has its own offices in Asia, Germany and the United States.

HEADQUARTERS

SENSOFAR METROLOGY

Parc Audiovisual Catalunya

Ctra. BV-1274, KM 1

08225 Terrassa (Spain)

T. +34 937 001 492

F. +34 937 860 116

info@sensofar.com

www.sensofar.com



