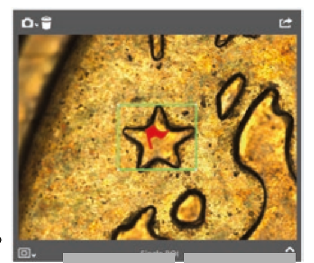
MEASUREMENT Workflow

1 **SAMPLE INSPECTION**
Locate the regions of interest on your sample. Roughly focus the sample, apply autofocus and autolight, and get an overview with a low magnification objective.



2 **TECHNOLOGY AND OBJECTIVE**
Use the technology decision flowchart to select the proper starting point for your measurements.
20X

3 **MEASUREMENT TECHNIQUE**
Select which type of measurement you want to perform and obtain.

4 **AREA**
The area is defined by the objective. Choose the resolution. Use the stitching module to increase the measured area.
5 Mpx
Resolution

5 **AUTOFOCUS**
Focus on the sample to optimize the initial Z position for measurement. Use the autofocus mode for ease.

6 **Z SCAN**
Select the Z scanning range and the speed.
Absolute Relative Dual

7 **LIGHT SETTINGS**
Adjust the intensity of the light source. Use autolight feature for ease.
51,31%

8 **THRESHOLD**
Increase or decrease the sensitivity.
Sensitivity

9 **EXTERNAL ANALYSIS**
Acquired data will be opened by the selected analysis software:
SensoVIEW SensoPRO SensoMAP

10 ACQUIRE

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3D Optical Profiler

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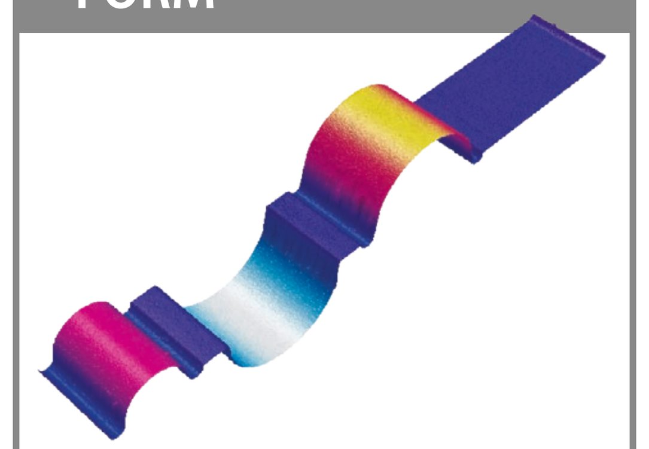
TECHNOLOGY DECISION Flowchart

What type of measurement do you need?

TOPOGRAPHY — What do you need to measure?

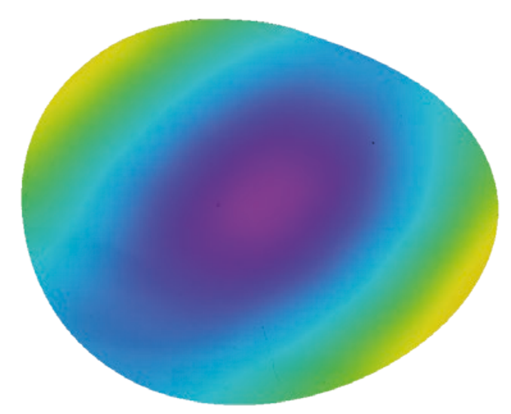
FORM



5X EPI > 20X EPI — High speed for large Z scan ranges

20X DI > 50X DI (ePSI) — For very smooth surfaces

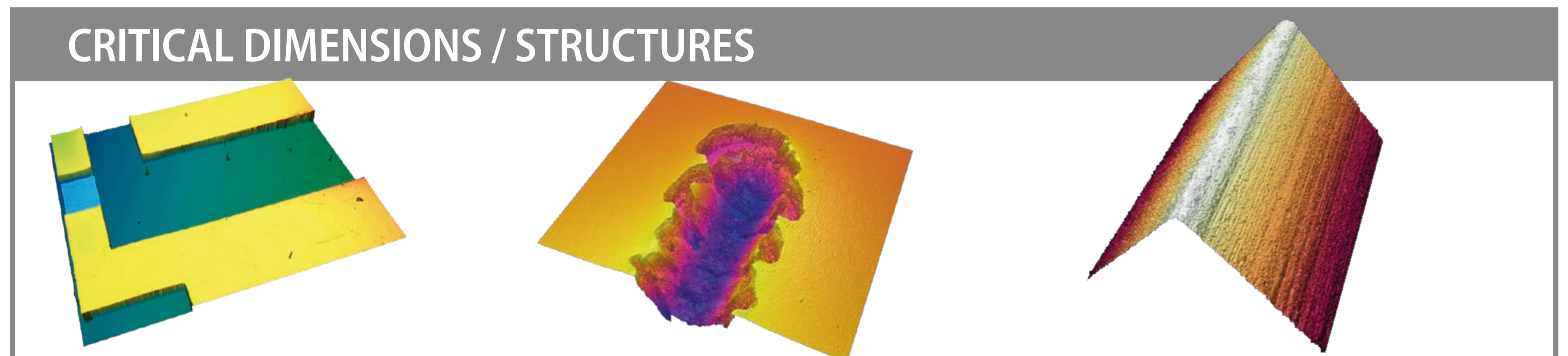
FLATNESS



0.65X MI > 5X TI (ePSI) — Large FOV for a fast and accurate acquisition

FLT ISO 12781

CRITICAL DIMENSIONS / STRUCTURES

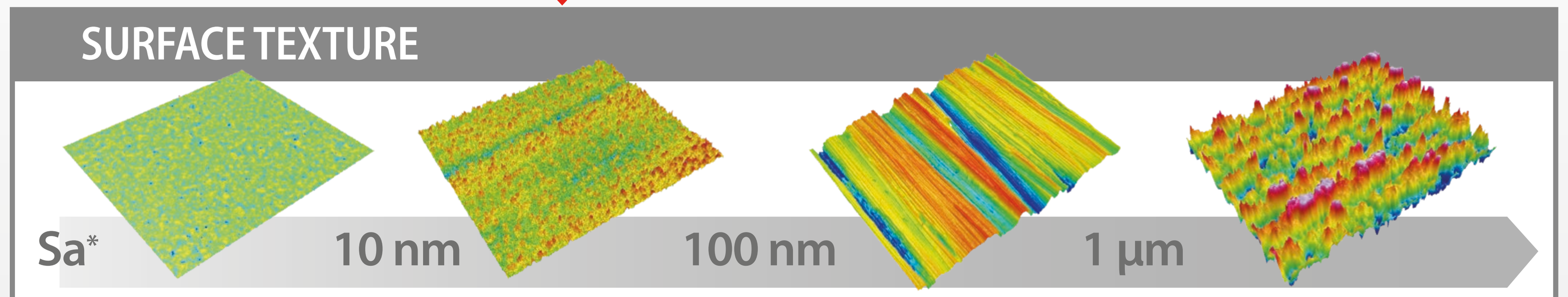


Vertical distances / step-like structures
2.5X TI > 100X DI (ePSI) — High accuracy and repeatability
10X SLWD > 100X SLWD — For holes/trenches with high aspect ratio

Lateral distances / irregular structures
10X EPI > 150X EPI — The best spatial resolution and the widest range of surfaces

Radiuses / structures with high slopes
5X EPI > 50X EPI — Up to 86º slopes measurements
50X EPI > 150X EPI — For small radiuses and features

SURFACE TEXTURE



Sa* 10 nm 100 nm 1 µm

10X DI > 100X DI (PSI) — Down to 0.01 nm measurement noise to provide the best vertical resolution

10X DI > 100X DI (ePSI) — Overcomes the limitation of traditional PSI while maintaining subnanometric resolution

20X EPI > 50X EPI; 20X DI > 100X DI (CSI) — High repeatability, good compromise between lateral and vertical resolution

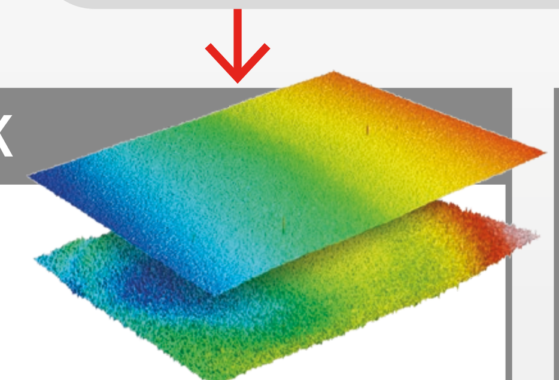
10X EPI > 20X EPI; 5X EPI > 20X EPI — Fast measurements of large Z scans and areas through the stitching module

Sa ISO 25178 | Ra ISO 21920 | Ra ISO 4287

* These are only indicative values and they should not be taken as absolute references.

THICKNESS — Is your layer thick (≥1.5 µm) or thin (<1.5 µm)?

THICK



5X EPI > 150X EPI — Confocal is preferred for thicker films

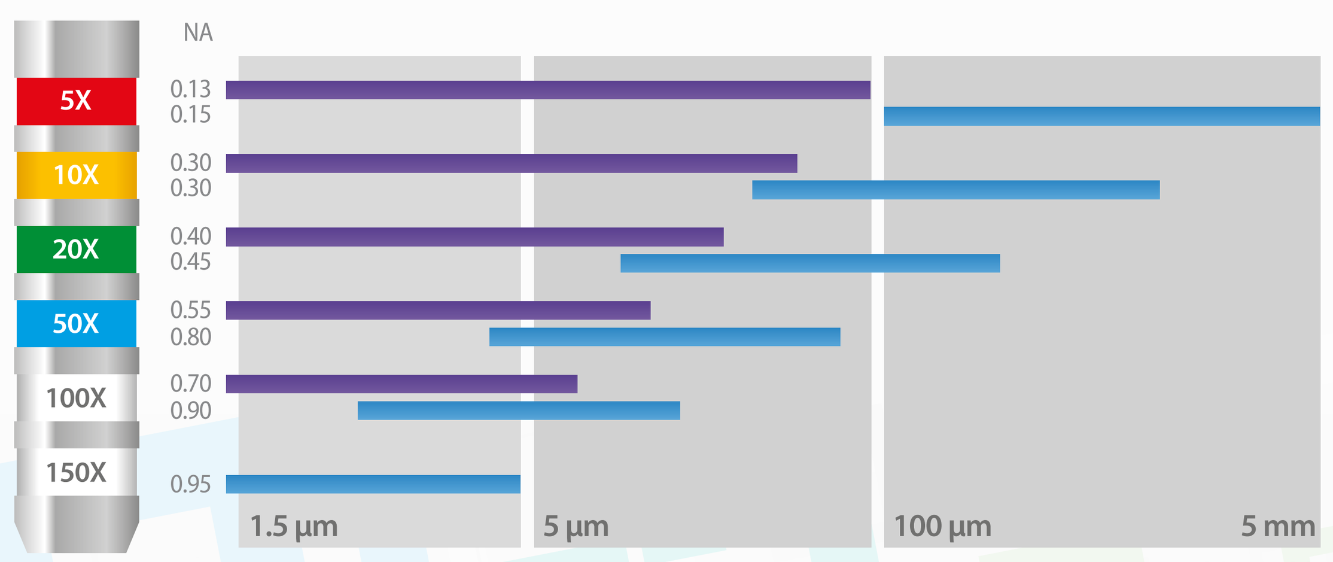
2.5X TI > 100X DI — CSI for thinner films

THIN

10X DI — Nanometer-scale thickness measurements with low magnification

MEASUREMENT TECHNIQUE

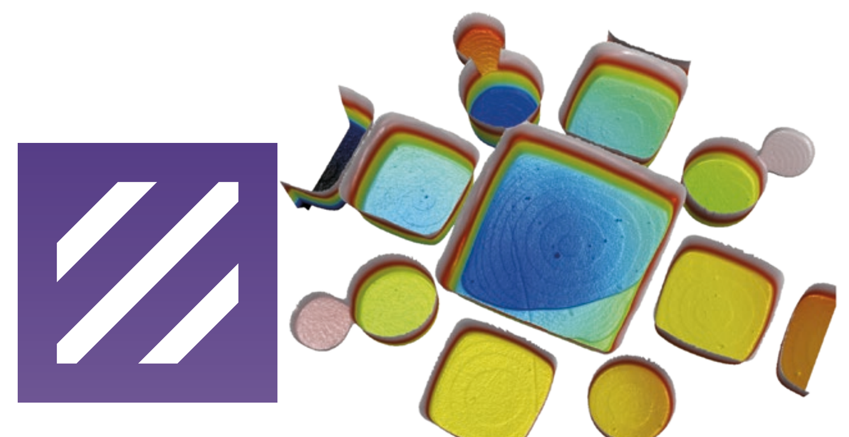
3D THICKNESS OBJECTIVE SELECTION GUIDE



Our 4-in-1 technologies

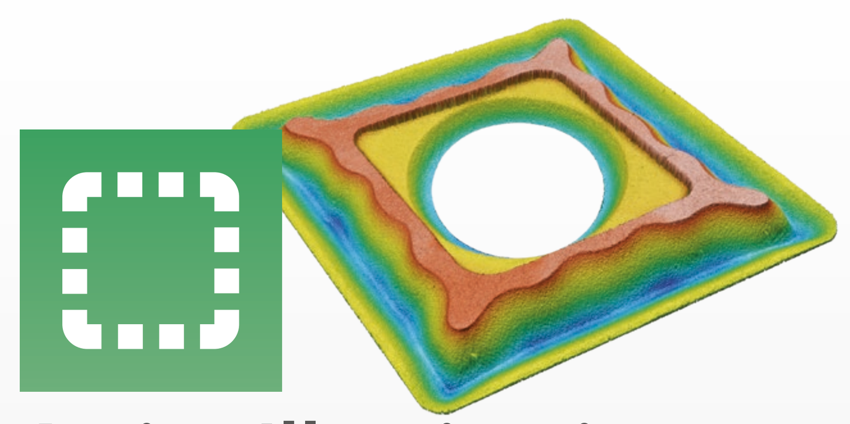
Confocal

- Best lateral resolution: 140 nm
- Slopes up to 70º for smooth surfaces and 86º for rough surfaces
- Continuous confocal: speed comparable to AiFV
- High repeatability, down to 1 nm system noise
- Thickness measurements from 1.5 µm to several mm



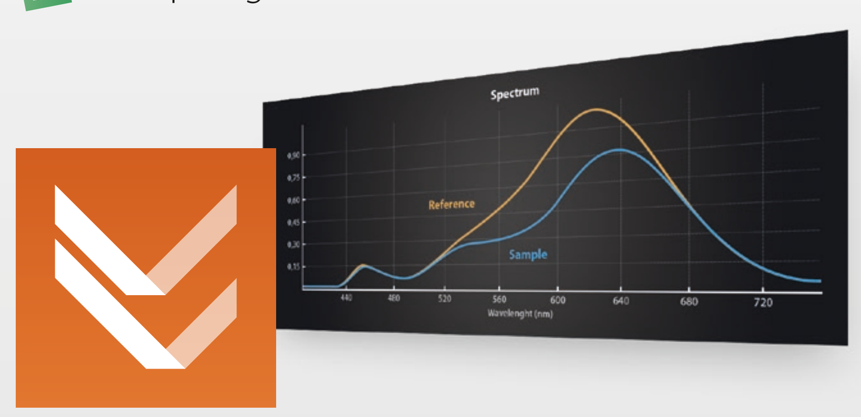
Interferometry

- Large FOVs with nanometer system noise no matter the objective
- PSI: 0.01 nm system noise
- Thickness measurements from 1.5 µm to 100 µm



Active Illumination Focus Variation

- Measures slopes up to 86º on scattering surfaces
- Active illumination allows measurement on smooth surfaces too
- Fastest acquisition, 200 planes in 3 s
- Multiple light sources



Spectroscopic Reflectometry

- Transparent films from 50 nm to 1.5 µm
- Acquisition in less than 5 s
- One objective can cover all the range
- Different spot sizes (3.5 µm to 40 µm)

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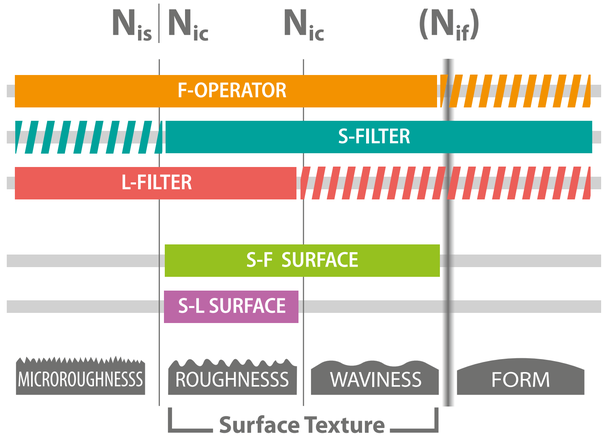
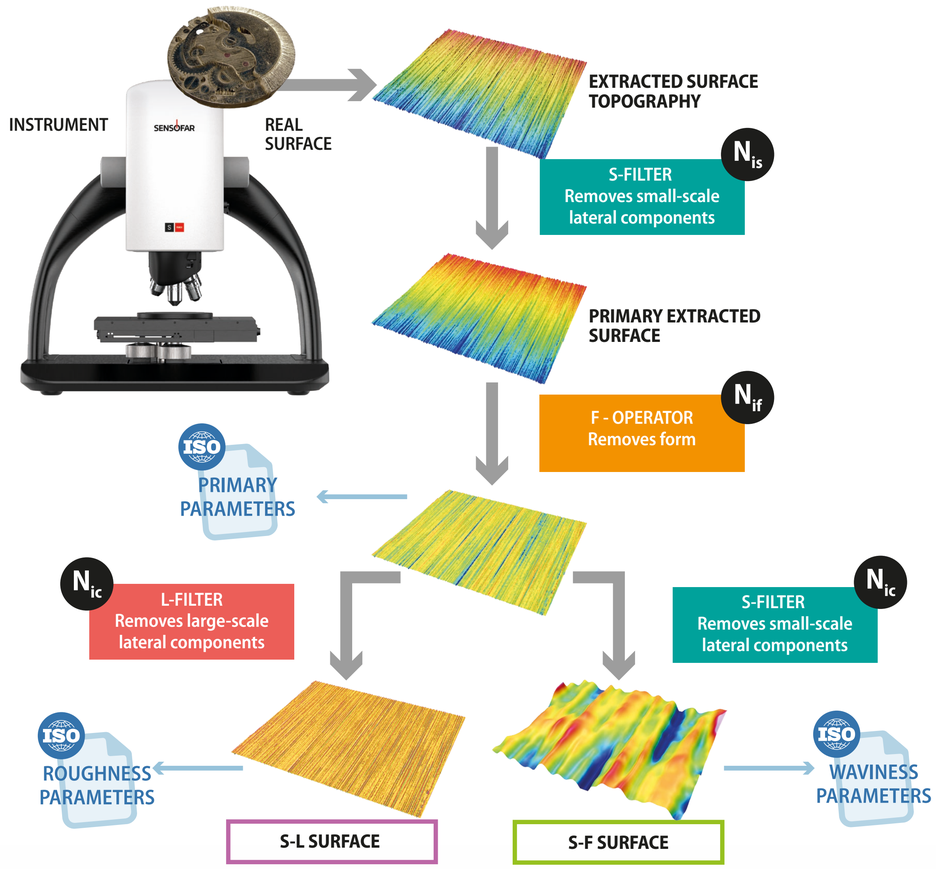
ISO 25178 SURFACE FILTERING

For surface texture characterization, filtering is essential to select your scale of interest. The following schemes are based on the definitions included in ISO 25178 part 2 regarding the different types of filters, operators and surfaces applied to areal measurements.



S and L filters are by default Gaussian filters with an associated nesting index (N_{is}, N_{ic}) that must be provided with your measurement results. These values and the specific F-operator may be different depending on your application.



Surface Texture Metrology

The following terms and definitions are specified by **ISO 25178** part 700 and part 600, describing essential concepts of areal topography measuring instruments. Sensofar systems are in accordance to this standard, providing a truly reliable instrument for surface characterization.

METROLOGICAL WORKFLOW

Any metrology instrument must fulfill it before providing any result.

CALIBRATION → ADJUSTMENT → VERIFICATION → PERFORMANCE SPECIFICATION

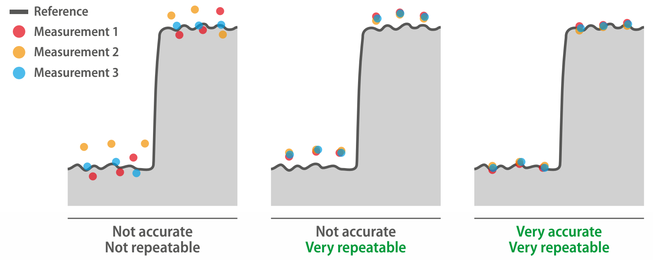
The S neox has been **calibrated** to estimate the metrological characteristics using a traceable calibration standard, **adjusted** to correct systematic errors and **verified** to match the calibrated value. Finally, the **performance specifications** are checked, and the instrument characteristics, such as accuracy and repeatability, are provided with your system [Table 2].

Accuracy and repeatability[6] [TABLE 2]

Standard	Value	U , σ	Technique
Step height	48600 nm	U=300 nm, σ= 10 nm	Confocal & CSI
	7616 nm	U=79 nm, σ= 5 nm	Confocal & CSI
	941.6 nm	U=7 nm, σ= 1 nm	Confocal & CSI
	186 nm	U=4 nm, σ= 0.4 nm	Confocal & CSI
	44.3 nm	U=0.5 nm, σ= 0.1 nm	PSI
	10.8 nm	U=0.5 nm, σ= 0.05 nm	PSI
Areal roughness (Sa)[7]	0.79 µm	U=0.04 µm, σ=0.0005 µm	Confocal, AIFV & CSI
Profile roughness (Ra)[8]	2.40 µm	U=0.03 µm, σ=0.002 µm	Confocal, AIFV & CSI
	0.88 µm	U=0.015 µm, σ=0.0005 µm	Confocal, AIFV & CSI
	0.23 µm	U=0.005 µm, σ=0.0002 µm	Confocal, AIFV & CSI

6 Objective used for Confocal and Ai Focus Variation 50X 0.80 NA and for CSI and PSI 50X 0.55NA. Resolution 1220x1024 pixels. All measurements are done using PZT. Uncertainty (U) according to ISO/IEC guide 98-3:2008 GUM:1995, K=1.96 (95% confidence level). σ according to 25 measures. **7** Area of 1x1 mm. **8** Profile of 4 mm length.

Calibration of the system is recommended every six months (see "Configuration and alignment" chapter on the SensoSCAN S neox user's manual).



METROLOGICAL CHARACTERISTICS

These are the concepts used to characterize and calibrate the S neox.

- **Measurement noise (N_m):** noise floor added to the output signal occurring during the normal use of the system. Closely related to the concept of "vertical resolution" of the system [Table 1].
- **Residual flatness (Z_{FLT}):** deviation of the measured topography of an ideally flat object from a plane, also known as "flatness error".
- **Amplification coeficient of the Z-axis (α_z or Z factor):** slope of the linear regression line obtained from the response function. This function describes the relation between the actual quantity and the measured quantity.
- **Topographic spatial resolution (W_R):** describes the ability of a surface topography measuring instrument to distinguish closely spaced surface features. Represented by "Optical resolution" in [Table 1].

STATISTICS FOR METROLOGY

The following brief descriptions of statistical concepts are applied to metrology and will help you understand the performance specifications of your system, according to **NPL** (National Physical Laboratory).

- **Uncertainty:** generic term for the quantification of doubt in a measured value. It is shown as an expanded uncertainty U in [Table 2].
- **Precision:** dispersion of a number of measurements when repeated. More often called repeatability, quantified by the standard deviation σ in [Table 2].
- **Accuracy:** qualitative term describing the closeness of a measured value to the true value. Low values of U and σ with respect to the measured value provide high accurate systems.

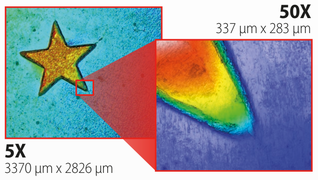
Learn more about metrology through our **WEBINARS**

FIND OUT MORE

Basic Parameters for System Operation

Here are some useful concepts that will help you through the operation of the S neox system. These will help to understand all the product specifications of your optical metrology tool for surface measurement.

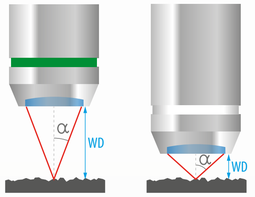
FIELD OF VIEW (FOV): area of the sample that is measured; depends on the magnification.



MAG	FOV [1] (µm)
2.5X	6756 x 5652
5X	3378 x 2826
10X	1689 x 1413
20X	845 x 707

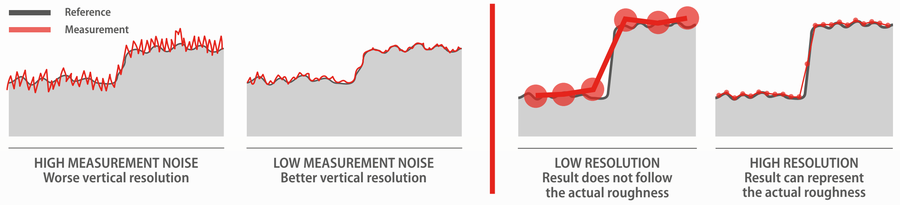
MAG	FOV [1] (µm)
50X	338 x 283
100X	169 x 141
150X	113 x 94

NUMERICAL APERTURE (NA): determines the largest slope angle on the surface that can be measured and affects 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 cone of light that enters or exits the lens.



WORKING DISTANCE (WD): distance taken from the end of the objective at which the focus plane is found.

RESOLUTION: smallest detectable distance between two features of the sample. For 2D images, lateral resolution depends on: **i)** the number of used pixels of the camera and **ii)** the dimensions of the field of view. It can be pixel-size limited (spatial sampling) or optically-limited (optical resolution). For the 3D case, vertical resolution is related to the measurement noise, check "Surface Texture Metrology".



[TABLE 1]

	Brightfield																				Water imm.	Interferometry						
MAG	2.5X	5X	10X	20X	20X	50X	50X	50X	100X	100X	100X	150X	150X	20X ELWD	50X ELWD	100X ELWD	10X SLWD	20X SLWD	50X SLWD	100X SLWD	22X WI	2.5X	5X	10X	10X	20X	50X	100X
NA	0.075	0.15	0.30	0.45	0.60	0.80	0.80	0.95	0.90	0.90	0.95	0.90	0.95	0.40	0.60	0.80	0.20	0.30	0.40	0.60	0.50	0.075	0.13	0.10	0.30	0.40	0.55	0.70
WD (mm)	6.50	23.5	17.5	4.5	3.0	1.0	2.0	0.35	1.0	2.0	0.32	1.5	0.2	19	11	4.5	37	30	22	10	3.30	10.3	9.3	25.0	7.4	4.7	3.4	2.0
Spatial sampling [1] (µm)	2.76	1.38	0.69	0.34	0.32	0.13	0.13	0.13	0.07	0.07	0.07	0.05	0.05	0.34	0.13	0.07	0.69	0.34	0.13	0.07	0.35	2.76	1.38	0.69	0.69	0.34	0.13	0.07
Optical resolution [2] (µm)	1.87	0.94	0.47	0.31	0.23	0.18	0.18	0.15	0.16	0.16	0.15	0.15	0.14	0.35	0.23	0.18	0.70	0.47	0.35	0.23	0.28	1.87	1.08	0.83	0.47	0.35	0.26	0.20
Measurement noise [3] (nm)	300	100	30	8	6	4	4	3	3	3	2	2	1	10	5	3	50	20	15	10	–	PSI/ePSI 0.1 nm (0.01 nm with PZT) CSI 1 nm						
Maximum slope [4] (°)	4	9	17	27	37	53	53	72	64	64	72	64	72	24	37	53	12	17	24	37	30	4	7	7	17	24	33	44

1 Pixel size on the surface. **2** L&S: Line and Space. Values for blue LED. **3** System noise measured as the difference between two consecutive measures on a calibration mirror placed perpendicular to the optical axis. For interferometry objectives, PSI, 10 phase averages, values obtained in a VC-E vibration environment. The 0.01 nm are achieved with Piezo stage scanner and temperature controlled room. Values for green LED (white LED for CSI). Resolution HD. **4** On smooth surfaces, up to 71°. On scattering surfaces, up to 86°. **5** Maximum field of view with 3/2" camera and 0.5X optics.

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