PLu neox

3D Optical Profiler

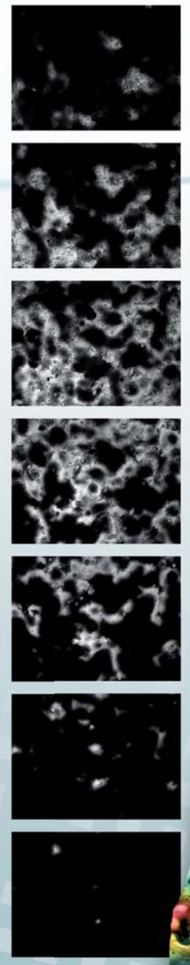
SENSOFAR®

SENSOFAR TECHNOLOGY

In recent years, interferometers and confocal imaging profilers have been competing in the non-contact surface metrology market. Both devices can accurately and reliably measure surface topographies on the scale of millimeters to sub-nanometers.

Now, Sensofar has made a breakthrough in non-contact optical 3D profiling: the **neox**. This sensor head combines both confocal and interferometry techniques, as well as thick and thin film measurement capabilities. The combination of techniques makes the **neox** a unique system that outperforms all existing optical profilers.

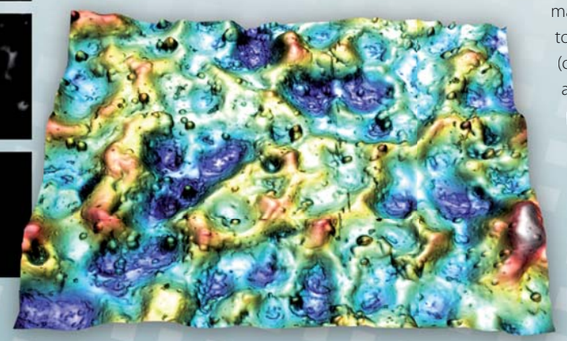
In addition to its compact and robust design, the **neox** is a complete tool that is ideal for obtaining a fast, non-invasive assessment of the micro- and nano-geometry of technical surfaces in multiple configurations: from the standard setup for R&D and quality inspection laboratories to sophisticated, customized solutions for online process controls.



Confocal profiling

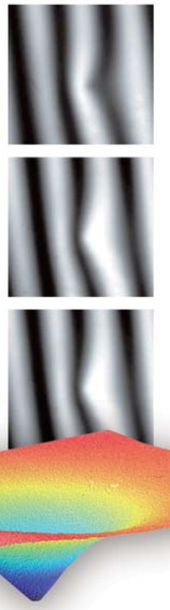
Confocal profilers have been developed to measure the surface height of smooth to very rough surfaces. A confocal imaging system provides high contrast images by eliminating out-of-focus light. The sample is scanned vertically in steps so that every point on the surface passes through the focus. The height of the surface at each pixel location is found by detecting the peak of the narrow axial response. As only local areas of the surface are illuminated simultaneously, in-plane raster scanning is required to build up the axial response (i.e. the confocal image) at each vertical step.

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 magnification (150X and 200X) objectives are available to measure smooth surfaces with steep local slopes (over 70º). The **neox** has extremely high light efficiency and an unlimited intrinsic measurement range. The proprietary confocal algorithms provide vertical repeatability on the nanometer scale. Super-long working distance (SLWD) objectives are available to measure high aspect ratio features, large steps and steeply sloping samples. Step height measurements can also be made in structured or stratified samples that contain dissimilar materials.



Interferometry

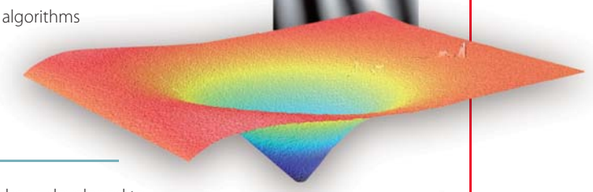
In an interferometer, a light beam passes through a beam splitter, which directs the light to both the surface of the sample and a built-in reference mirror. The light reflected from these surfaces recombines and a fringe interference pattern is formed.



PSI profiling

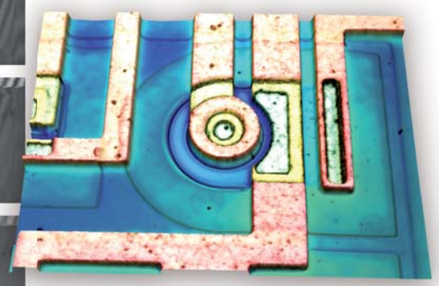
Phase shift interferometers have been developed to measure the surface height of very smooth and continuous surfaces with sub-nanometer resolution. The sample, which must be in focus, is scanned vertically in a few steps that are a very precise fraction of the wavelength. The profiling algorithms produce a phase map of the surface, which is converted to the corresponding height map by means of a suitable unwrapping procedure.

PSI profiling provides sub-nanometer vertical resolution for all numerical apertures (NA). Very low magnifications (2.5X) can be employed to measure large fields of view with the same height resolution. However, the measurement range is limited to a few micrometers by the coherence length. PSI algorithms enable the **neox** to profile shape features on the nanometer scale, and to assess texture parameters of super smooth surfaces on the sub-nanometer scale.



VSI profiling

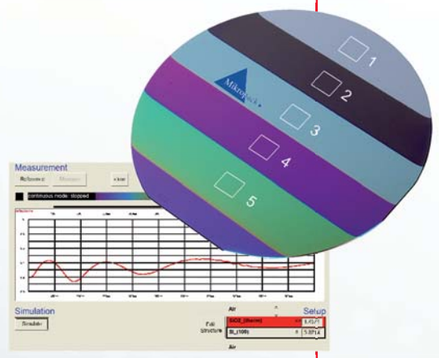
White-light vertical scanning interferometers have been developed to measure the surface height of smooth to moderately rough surfaces. Maximum fringe contrast occurs at the best focus position for each point on the surface of the sample. The sample is scanned vertically in steps so that every point on the surface passes through the focus. The height of the surface at each pixel location is found by detecting the peak of the narrow fringe envelopes.



VSI profiling provides nanometer vertical resolution for all NA. The VSI algorithms enable the **neox** to use all the available magnifications to profile shape features with the same height resolution. The measurement range is intrinsically unlimited, although in practice it is limited to the working distance of the objective. Scan speeds and data acquisition rates can be very fast, although this leads to a significant loss of vertical resolution.

Thin Film

Spectroscopic reflectometry is one of the preferred methods for measuring thin films because it is accurate, nondestructive, very fast and requires no sample preparation. In spectroscopic reflectometry, the surface is illuminated with white light. Light is reflected at the different interfaces of the thin film structure. All reflections are superposed coherently and interferential effects occur. As a result, the intensity of the reflected light shows variations in wavelength that depend on the thickness and refractive index of the different layers of the thin film structure. Software compares the real measured spectrum with a simulated one and optimizes the thicknesses of the thin films until the best fit is attained.



The **neox** can also be used as a high lateral resolution thin film measurement system. It works very well for single foils, membranes or single thin layers on a substrate, and it can also deal with more sophisticated structures (up to ten layers on a substrate). Transparent films from 10 nm to 20 µm can be measured in less than one second with a thickness resolution of 0.1 nm and a lateral resolution up to 5 µm.

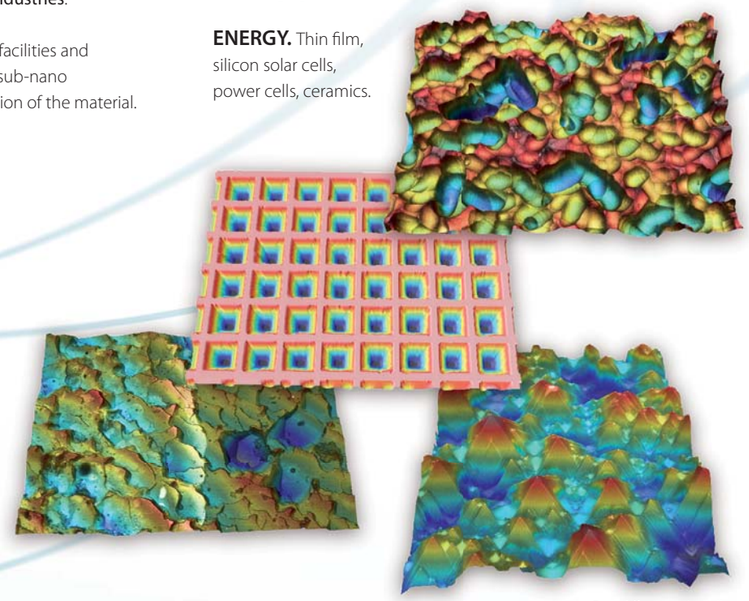
MARKETS & APPLICATIONS

The PLu Series plays a key role in demanding industries such as **the semiconductor, biomedical, and biotechnology industries**.

Sensofar optical profilers are installed in many R&D facilities and quality control departments for micro-, nano- and sub-nano applications to analyze the 3D surface characterization of the material.

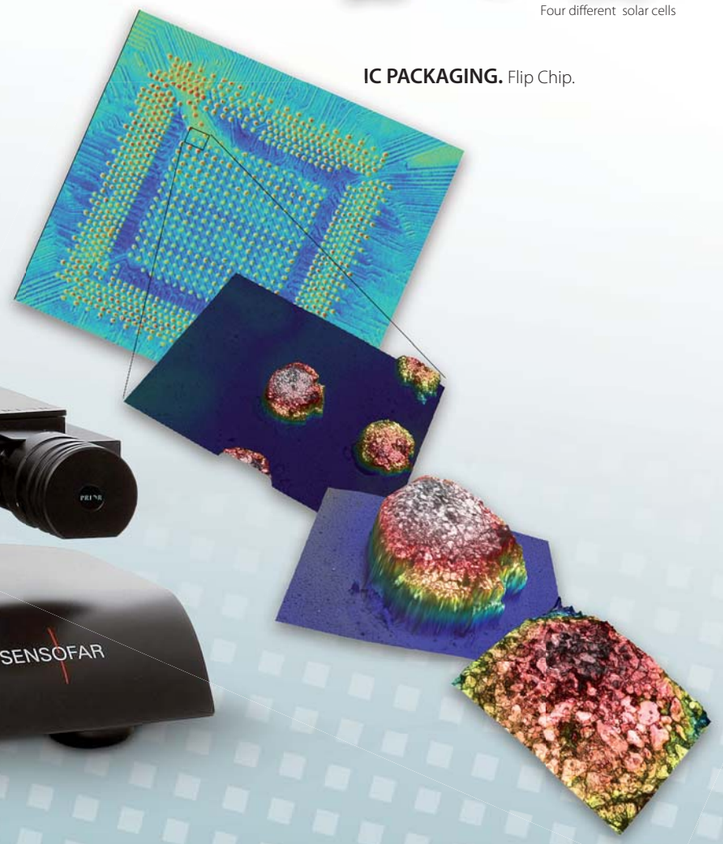
Applications

ENERGY. Thin film, silicon solar cells, power cells, ceramics.



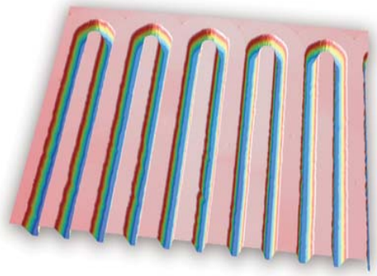
Four different solar cells

IC PACKAGING. Flip Chip.



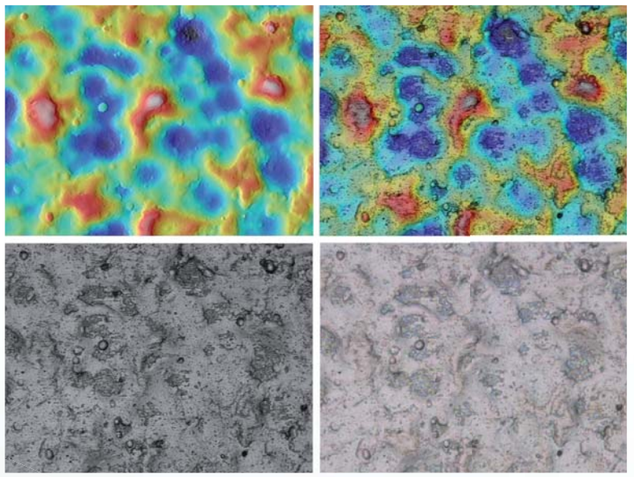
Flip Chip. Zoom on a stanium ball

BIOMEDICAL. Microfluidics, passivation, drug and hygiene coatings, catheter, balloon, stents.



Fluidodinamycs channels

MATERIALS. Roughness, tribology, hardness test, fatigue.

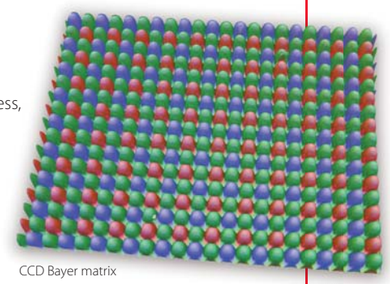


Steel

SEMICONDUCTOR. Photoresists for masks, thickness, of Si thin membranes, insulation, MEMs.

MEM's

OPTICS. Transmission, roughness, anti-fog, hardness coatings, profile of aspherics.

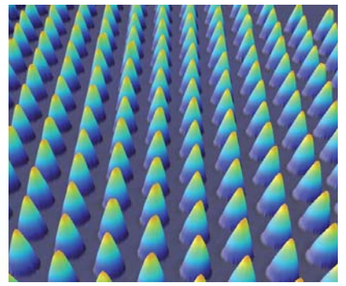


CCD Bayer matrix

FLAT PANEL DISPLAY. RGB cells, photospacers, coatings, defect analysis.

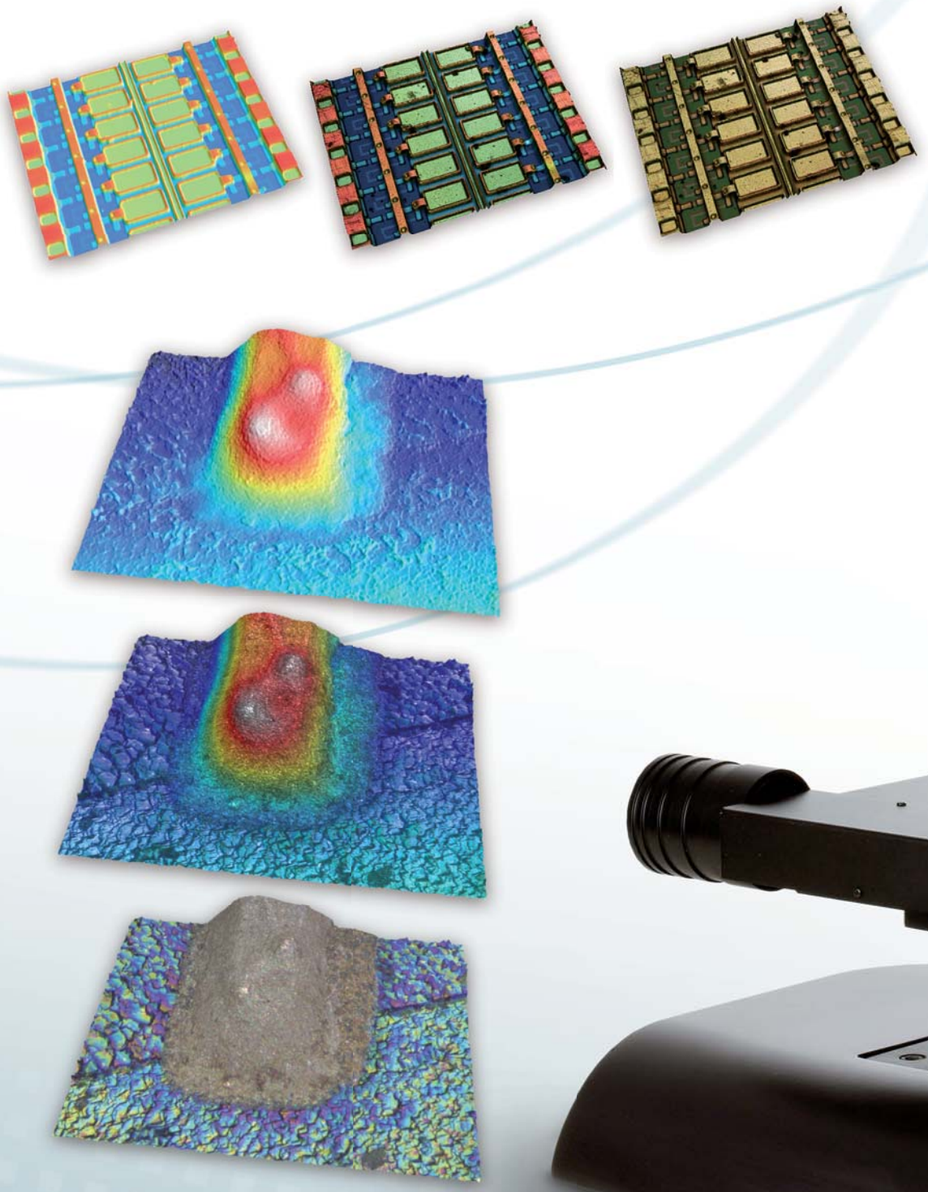
LCD, RGB Filter

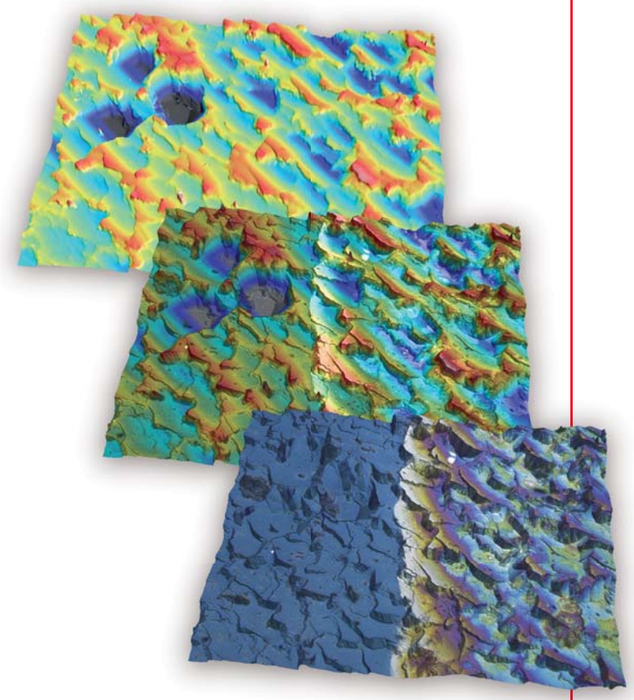
LED. Emission substrate.



LED structures

INSTRUMENT



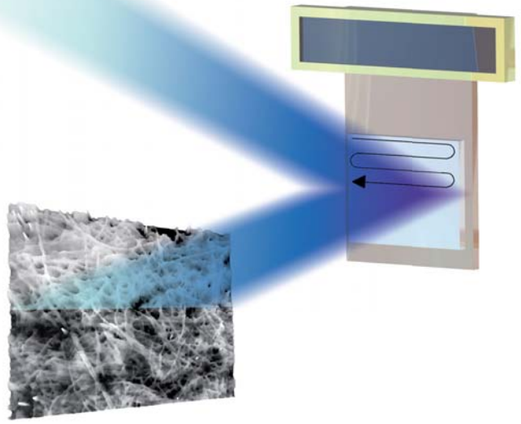


The **neox** is an optical profiler that has been developed by Sensofar using propietary technology. The extremely high light efficiency of the illumination hardware and the high contrast algorithms are the main advantages of Sensofar's confocal arrangement. These features make the system ideal for measuring steep slopes, rough and reflective surfaces and samples containing dissimilar materials. The high quality interferometry optics and the integrated piezo scanner are the key elements to interferometric profiling. This technology is ideal for measuring very smooth to moderately rough surfaces. The combination of these techniques provides an endless range of applications.

The **neox** can be used for standard bright-field color microscopy imaging, confocal imaging, 3D confocal profiling, PSI, VSI and highresolution thin film thickness measurements.

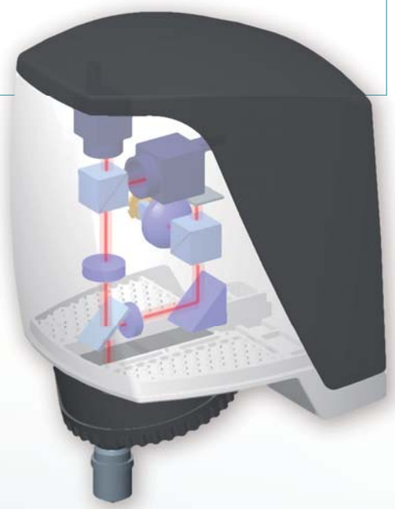
The robust and compact design, which is based on microdisplay technology and has no moving parts, also makes this sensor head suitable for OEM applications. The extremely simple and ergonomic software interface enables the user to obtain the measurement very fast, by simply choosing the right objective and focusing and selecting the appropriate acquisition technique.

SYSTEM PERFORMANCE



Microdisplay-based confocal scanning

Existing confocal microscopes use mirror scanning heads, which are movable mechanisms that limit lifetime and degrade pixel dithering at high magnifications. For confocal scanning, the **neox** uses the Sensofar's patented technology, which is based on a microdisplay. The microdisplay is based on ferroelectric liquid crystal on silicon (FLCoS), a fast switching device with no moving parts that makes the scanning of confocal images fast and very stable with an unlimited lifetime.



Color CCD camera

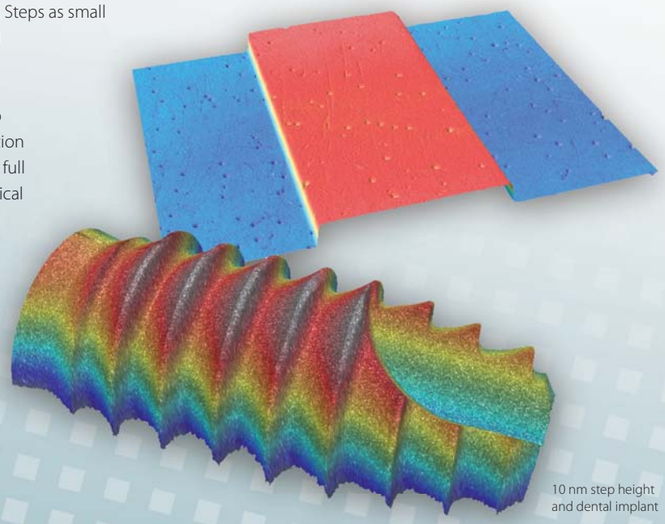
The **neox** uses a black and white, high-speed, high-resolution CCD camera as the system's metrological detector. A color camera can be used for bright-field surface inspection. This makes it easy to identify the features of the sample under analysis. In addition, an infinite focused color image can be obtained from topography measurements. The system acquires color images during vertical scanning and assigns to each pixel the color of the image obtained at the z position where the surface was in focus. The infinite focused color image can be used to create impressive 3D views of the measurements.

Dual vertical scanner

The dual vertical scanner consists of a motorized stage and a piezo for the highest scanning range and the highest measurement accuracy and repeatability. The linear stage has a 40-mm travel range and high position accuracy. Steps as small as 10 nm can be made, which is ideal for confocal scanning.

The integrated piezo scanner has a range of up to 200 µm, with piezo resistive sensors for high position resolution of 0.2 nm and 1 nm of accuracy on the full travel range. Existing scanning stages with an optical encoder have 30 nm of uncertainty, which limits system repeatability and accuracy.

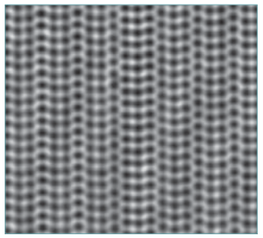
The **neox**, with its unique combination of a linear stage and a piezo scanner, has the highest accuracy, linearity and repeatability on the market, with a measurement range from 0.1 nm to several mm.



10 nm step height and dental implant

Integrated spectroscopic reflectometer

Practical limits for confocal and interferential methods for film thickness measures are to the order of 1 µm, and limited to a single layer. The **neox** incorporates a spectroscopic reflectometer through an optical fiber for the measurement of thin films, with thicknesses ranging from 10 nm and up to 10 layer stacks. The optical fiber is imaged through the microscope's objectives. Thus, thin films can be measured with spots as small as 5 µm. The measurement is undertaken with the integrated LED light source, which provides real-time bright-field images of the sample and simultaneous thin-film measurements.



Diffraction-limited structures of 0.2 µm. Courtesy of Obducat technologies. www.obducat.com

Dual LED

Two high-power LEDs are integrated into the light source. A white LED is used for color bright-field inspection, thin-film metrology, VSI and ePSI, and a blue LED is used for high-resolution confocal imaging and PSI. The short wavelength of the blue LED increases the lateral resolution to 0.15 µm (L&S) and improves PSI noise to 0.01 nm of vertical resolution.

An objective lens for each application

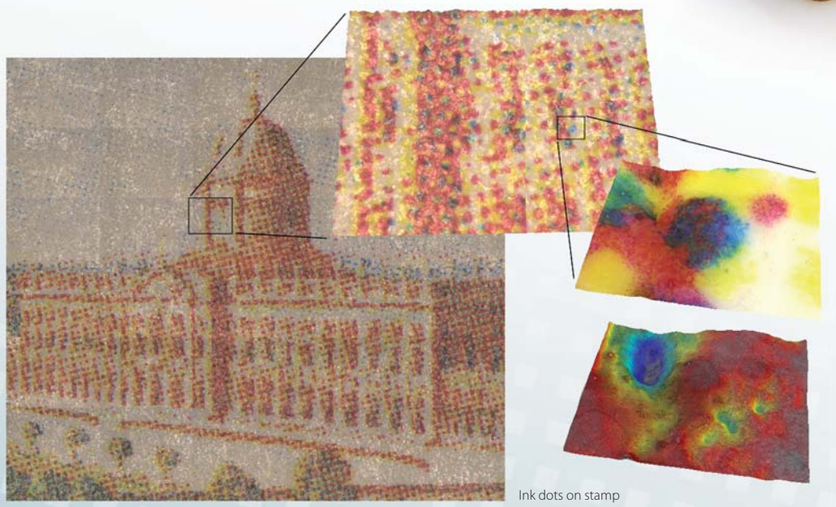
The **neox** uses premium CFI60 Nikon objectives lenses, which have the largest working distance for each NA. Over 50 lenses are available. Each one suits a specific application: high NA is used for confocal imaging and profiling, with a magnification range of 2.5X to 200X, super-long working distance, extra-long working distance and water immersion objective lenses; collar ring adjustment for focusing through transparent media up to 2 mm thickness; and interferential objectives lenses of 2.5X to 100X magnification, with reference mirror correction and incorporated tip-tilt.

Other objective lenses for specific applications are also available.

Please visit **www.sensofar.com** for more information.

High speed (12.5 confocal fps)

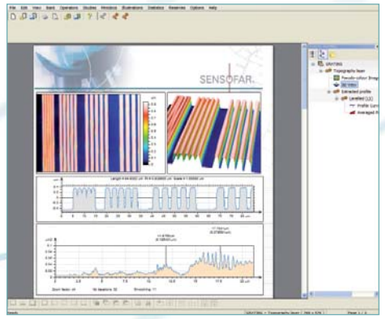
The fast switching speed of the FLCoS microdisplay and proprietary confocal algorithms lead to a confocal rate of 12.5 confocal images per second. Due to this high frame rate, vertical 3D scanning is performed at 8 planes/s, which means that the scanning speed for confocal 3D measurements ranges of 0.5 to 350 µm/s. Interferential scanning and profile measurements are performed at 50 fps, which means that the vertical scanning speed is up to 800 µm/s. A typical measurement time that includes calculations after the scan is less than 5 seconds.



Ink dots on stamp

SOFTWARE

SensoSCAN software provides an interface with which any measurement can easily be taken, as well as a basic set of tools for displaying and analyzing data. **SensoSCAN** uses OpenGL technology to provide complete 3D surface visibility at any angle. Automated measurements are obtained using the Recipes and Sequence tool. A fully automated process (measurement and analysis) can be undertaken in combination with two external software applications: **SensoMAP** or **SensoPRO**.



SensoSCAN features:
- Brightfield/confocal image, topography, stitching and thickness measurements.
- Automated measurements using the Recipes and Sequence tool.
- Interactive 2D and 3D surface views.
- A basic set of display and analysis tools.
- Integration of standards for 2D parameters.

SensoPRO features:
- Fully automated monitoring of the production process.
- Controls the external devices that handle the samples, such as wafer loaders or SCARA robots using the SECS protocol.
- Plug-in-based data analysis algorithms provide a high degree of flexibility. Current capabilities include BGA bump, VIA, copper traces, solder resistance and anchor critical dimension analysis for the IC packaging industry. New modules can be easily customized to other industry needs.

SensoMAP, which is based on Mountains technology from Digital Surf, is state-of-the-art surface analysis software. R&D departments and production facilities use Mountains for 2D/3D surface characterization.

SensoMAP is a suitable tool for monitoring and evaluating surface changes during the life cycle of a material or component. SensoMAP software is completely modular. Four different levels (basic, FFT, Plus and Turbo) and five modules (4F Series, Contour, Grains & Particles, Statistics and Stitching) are available.

SensoMAP features:
- A full set of tools for carrying out advanced analysis, including different surface views and operators.
- An intuitive desktop environment.
- Fast data reporting.
- Automated analysis by applying the same analysis workflow to different measurement data sets.
- Integration of standards: ISO 25178, which is the first international standard on 3D areal surface texture, EUR 15178 EN and full support for 2D parameters.
- Advanced, multilingual environment that makes the software user-friendly. Six European languages, Japanese and Chinese are available.

Visit **www.sensofar.com** for additional information.

SPECIFICATIONS

Confocal objectives						
	5X	**10X**	**20X**	**50X**	**100X**	**150X**
Working Distance (mm)	23.5	17.5	4.5	1.0	1.0	0.3
NA	0.15	0.30	0.45	0.80	0.90	0.95
FOV (µm) [1]	2546 x 1509	1270 x 950	636.61 x 477.25	254.64 x 190.90	127.32 x 95.45	84.83 x 63.60
Spatial sampling (µm) [2]	3.32	1.66	0.83	0.33	0.17	0.11
Optical Resolution (L&S) (µm) [3]	0.93	0.47	0.31	0.17	0.15	0.14
Maximum Slope [4]	8º	14º	21º	42º	51º	71º
Vertical Resolution (nm) [5]	<100	<50	<20	<3	<2	<1
Confocal Frame rate (frame/s)	12.5 fps					
Scanning speed (µm/s)	20 - 320	10 - 160	5 - 80	1 - 16	1 - 16	0.5 - 8
Typical measurement time (s) [6]	5					

Interferometry objectives						
	2.5X	**5X**	**10X**	**20X**	**50X**	**100X**
Working Distance (mm)	10.3	9.3	7.4	4.7	3.4	2.0
NA	0.055	0.15	0.30	0.45	0.55	0.7
FOV (µm) [1]	5093 x 3818	2546 x 1909	1270 x 950	637 x 477	254 x 190	127 x 95
Spatial sampling (µm) [2]	6.64	3.32	1.62	0.83	0.33	0.17
Optical Resolution blue (L&S) (µm) [3]	2.55	0.93	0.46	0.31	0.25	0.20
Optical Resolution white (L&S) (µm) [3]	3.04	1.11	0.56	0.37	0.30	0.24
Maximum Slope [4]	3.15º	8.6º	14º	21º	25º	42º
Vertical Resolution (nm) PSI [7] **Vertical Resolution (nm) ePSI** [7]	<0.1 nm (down to 0.01 nm with PZT)					
Vertical Resolution (nm) VSI [8]	1 nm					
Vertical Range PSI (µm)	5 µm					
Vertical Range ePSI (µm)	100 µm					
Vertical Range VSI (mm)	10 mm					
Scanning speed (µm/s)	PSI: 3-15 µm/s VSI/ePSI: 4-18 µm/s					
Typical measurement time (s) [9]	PSI: 3 s VSI: 10s ePSI: 30s					

1) Maximum field of view with ½" camera and 0.5X optics.
2) Pixel size on the surface
3) Half of the diffraction limit according to the Rayleight criterion. L&S: Line and Space. Blue wavelength 460 nm, and White central wavelength 550 nm.
4) On smooth surfaces
5) System noise measured as the difference between two consecutive measures with 2 confocal image averages on a calibration mirror placed perpendicular to the optical axis.
6) For 21 scanning planes.
7) System noise measured as the difference between two consecutive measures with 10 phase averages on a calibration mirror placed perpendicular to the optical axis. Vibration isolation activated. The 0.01 nm are achieved with Piezo stage scanner and temperature controlled room.
8) System noise measured as the difference between two consecutive measures on a calibration mirror placed to the perpendicular axis. Vibration isolation activated.
9) For 10 µm scan range

Other Specifications

Measurement Array: 576 x 768
Bright Field Frame Rate: 50 fps
Other Objectives Are Available.
Confocal: Water immersion, Super Long Working Distance, Extra Long Working Distance, Collar Ring depth focusing correction
Interferometry: Variable reflectance, Michelson, Mirau and Linnik
Sample Size: from 40 mm to 500 mm. Larger under request
Sample Reflectivity: from 0.1% to 100%
Display Resolution: 0.01 nm
Vertical Scanning Range: 40 mm with Linear Stage. Up to 200 µm with Piezo stage
Linearity: better than 0.05%. <0.5 µm/mm with Linear Stage, and <50 nm/100 µm with PZT

Step Height Repeatability: 0.1%
Roughness Repeatability: <0.2%
Step Height Accuracy: 0.5%

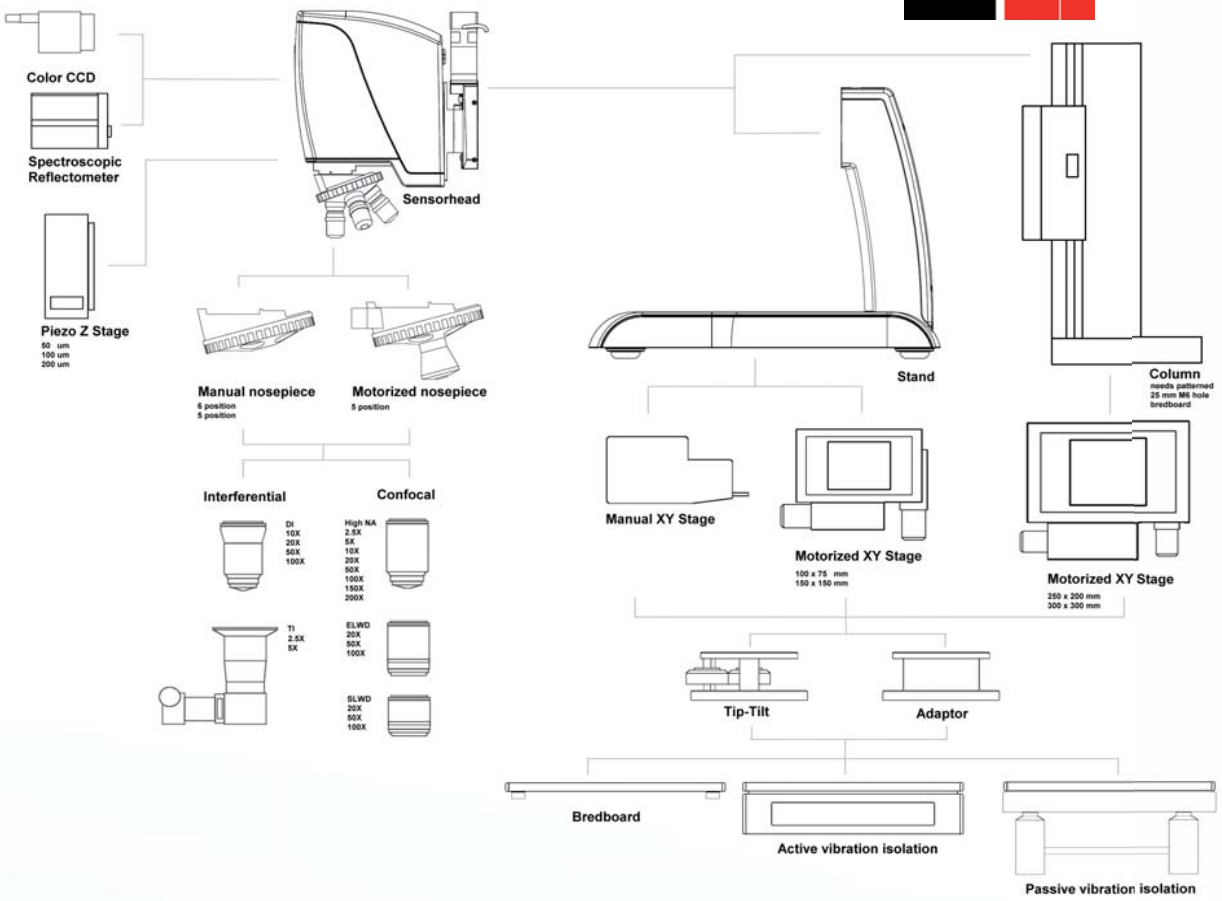
Environment

Temperature: 5ºC to 40ºC
Humidity: <80% RH
Altitude: <2000 m

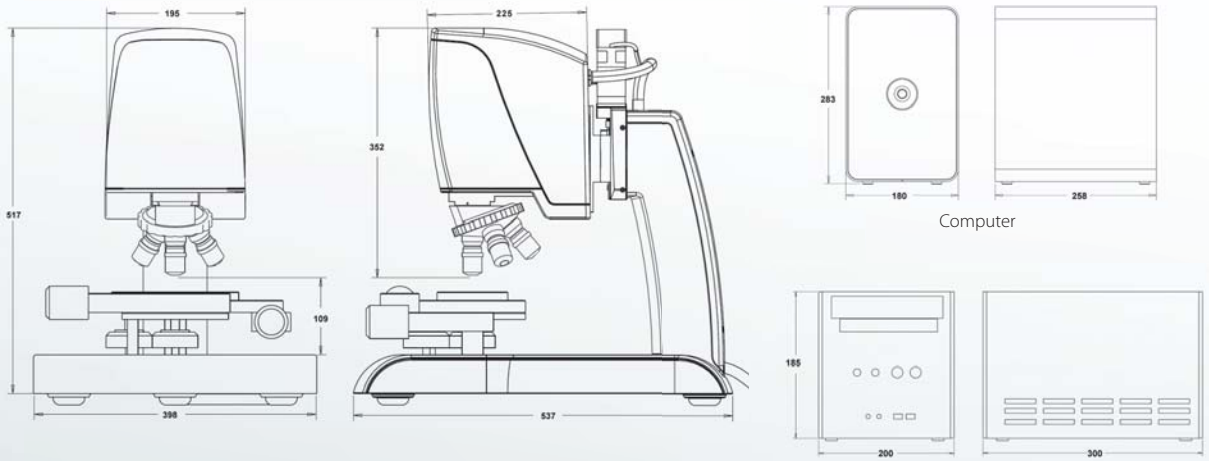
Power Requirements

Input Voltage: 110/220Vac, single phase 50/60Hz

System Configuration



Dimensions (unit: mm)



SENSOFAR is a leading-edge technology company operating at the highest quality standards within the field of non-contact surface metrology. We provide high-accuracy optical profilers based on interferometry and confocal techniques. From standard setups for R&D and quality inspection laboratories, to complete non contact metrology solutions for online production processes, Sensofar is offering a technology enabling our customers to achieve the most challenging breakthroughs, particularly in semiconductor, precision optics, data storage, display devices, thick and thin films and material testing technologies, in more than 15 countries through Channel Partners and with own office in Japan.

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