SENSOFAR®

Plμ 2300
Optical Imaging Profiler

Hardware configuration guide

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Sensofar product overview

Plμ Standard

PLμ standard is a laboratory oriented system based on white light confocal imaging technology. The proprietary imaging algorithms make the PLμ able to measure down to 1 nm repeatability without any vibration-isolation system. A great variety of objectives from 10X to 150X can be chosen with numerical apertures up to 0.95, being possible to profile optically smooth surfaces with local slopes up to 70 degrees. Additional motorized stages makes possible to measure several square millimetres using stitching algorithms.

Plμ 2300

PLμ 2300 is an independent sensorhead that combines interferometrical and confocal techniques. The use of any of the two techniques is chosen in the optical profiler just by clicking a button in the software. When using confocal objectives the PLμ 2300 has all the powerful features of the PLμ standard. While using interferential objectives, PLμ 2300 use PSI and VSI interferential technologies to measure down to 0.1 nm repeatability.

Sensofar product overview

Custom hardware

The PLμ can be mounted on sensorhead custom hardware. This opens the possibility of using it in a production line or for inspection of large samples. Confocal imaging technology is less sensitive to vibration, allowing the PLμ 2300 sensorhead to be mounted on a robotic arm.

Plμ 4300

The Sensofar's PLμ 4300 is an optical profiler for the 3D measurement of surfaces and thin films. The unique combination of Interferometrical optical profiling and Spectroscopic Reflectometry on the same sensorhead makes the PLμ 4300 the only system in the market able to measure 3D profiles, roughness and thickness of opaque and transparent materials with sub-nanometer resolution.

Plμ 1300

PLμ 1300 is a portable Optical Imaging Profiler capable of measuring 3D information of technical surfaces with the use of Interferometric or Confocal technologies. The sensor has been designed to have all the optical components sealed. This allows using the profiler in dusty environments. PLμ 1300 has been designed for control of production environments where the samples are big and heavy and cannot be moved or cut to be inspected by a laboratory based profiler.

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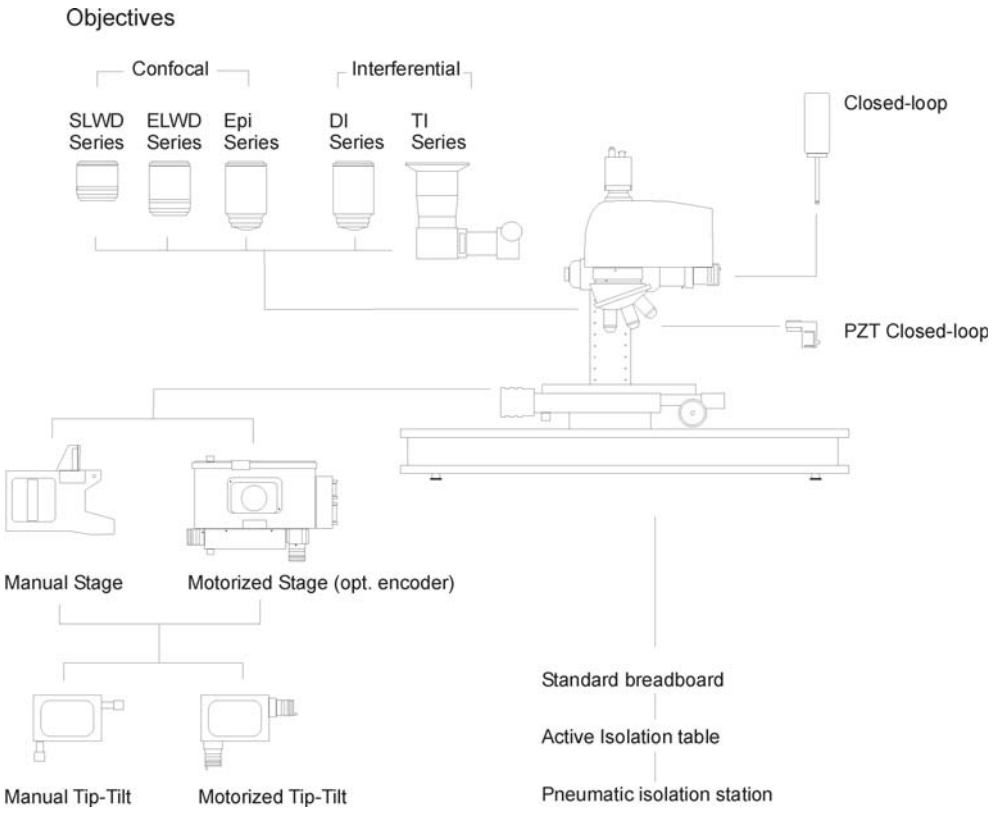
PLμ 2300 Hardware configuration

PLμ 2300 is usually shipped with a control electronics box containing all the driving electronics, and the computer. The system can be assembled on the top of this electronics box, but this is not required. Extension cables can be ordered for configurations needing only the sensorhead in a production line. If the system has to be assembled on the top of the electronics box, then there is the possibility to order a standard breadboard or an active vibration isolation sys-tem.

The sensorhead can be mounted either, on an aluminum column or on a low thermal expansion granite column. The sample is placed under the objective and sitting is on the top of a manual XY stage on a motorized stage. For interferometrical measurements, it is highly recommended to use a Tip-Tilt.

The PLμ 2300 can be configured with standard objectives and interferometrical objectives. The simplest option uses standard objectives with high numerical aperture to measure within the field of view of the objective. Using confocal mode, PLμ measures sin-gle profiles and multiple profiles, up to 35, conventional and confocal



images, single topographies and thicknesses. Adding a motorized stage the profile length is increased up to 100 mm by profile stitching and larger topographies can be measured using the extended topography and stitching algorithms.

There is the possibility to use interferometrical objectives to measure with both, PSI and VSI interferometrical techniques. For 10X to 50X magnifications PLµ is able to use DI objectives, being compatible with the standard nosepiece. If a 2.5X or a 5X TI is used, then there is only the possibility to use one objective at a time.

Finally, the system uses an open loop stepper motor to scan the Z axis as a default with 30 mm travel length. If a close loop is needed there are two possibilities: use an external sensor for the full range with ±50 nm repeatability, or use a PZT vertical scanner with 400 µm travel length and 0.5 nm repeatability.

Objectives specifications

The PLμ 2300 can use three different types of confocal objectives. The EPI objectives are designed to have the highest numerical apertures, up to 0.95, working very close to the surface. These objectives give the highest repeatability of the system and are ideal for flat and thin samples. The ELWD and SLWD series are objectives of Extra Long Working Distance and Super Long Working Distance, up to 21 mm. They have low numerical aperture and are used in samples where the objective can collide physically. The PLμ 2300 can also use interferential objectives. The TI series are based on Michelson interferometer with an external reference mirror mounted on two tip-tilt screws. The DI series are Mirau objectives that create the interference internally by dividing the wavefront with a beamsplitter. The TI series are used for low magnification and have low numerical aperture, being objectives for the measurement of very flat and thin samples. The DI series can have up to 0.55 NA.

Confocal objectives

	Working Distance (mm)	Numerical Apperture	Field of View[1]	Spatial Sampling	Maximum Slope	rms (3σ)[2] (nm)
5X EPI	23.5	0.15	2730 x 2050	3.56	8.5º	<100
10X EPI	17.3	0.3	1260 x 946	1.64	14º	<40
20X EPI	4.5	0.45	625 x 468	0.81	21º	<20
50X EPI	1.0	0.8	273 x 205	0.35	42º	<4
100X EPI	1.0	0.9	126 x 94	0.16	51º	<2
150X EPI	0.3	0.95	91 x 68	0.10	71º	<1
20X ELWD	13.0	0.4	625 x 468	0.81	19º	<20
50X ELWD	10.1	0.55	273 x 205	0.35	27º	<8
100X ELWD	3.5	0.8	126 x 94	0.16	42º	<4
20X SLWD	24.0	0.35	625 x 468	0.81	16º	<20
50X SLWD	17.0	0.45	273 x 205	0.35	21º	<8
100X SLWD	6.5	0.7	126 x 94	0.16	35º	<4

Confocal objective 20X EPI

Interferential objectives

	Working Distance (mm)	Numerical Apperture	Field of View[1]	Spatial Sampling	Maximum Slope	rms (3σ)[2] (nm)
2.5X TI[3]	10.3	0.055	4975 x 3730	6.48	3.2º	PSI[4]: 0.1nm
5X TI[3]	9.3	0.1	2490 x 1860	3.24	5.6º	
10X DI	7.4	0.23	1245 x 943	1.62	13.1	
20X DI	4.7	0.3	614 x 460	0.80	17.7º	VSI[5]: 1nm
50X DI	3.4	0.42	245 x 184	0.32	25º	

Interferential objective 5X TI

Interferential objective 50X DI

(1) Using a CCIR 1/2 inch CCD camera (768 x 576 pixels) and 0.5X optical tube lens.
(2) Difference between two consecutive measurements on a high quality calibration mirror.
(3) TI series are mounted without a nosepiece. No other objectives can be used while using one TI objective.
(4) PSI 0.1nm rms with null fringes using PZT close-loop scanning device.
(5) VSI 1nm rms with null fringes using PZT close-loop scanning device.

Objectives slection guide

Depending on the application, the sample under test and the conditions of the emplacement of the profiler, the selection of the objective is sometimes difficult. Usually, the best way to choose the set of objectives is testing the instrument at the local distributor.

PLμ 2300 uses interferential and confocal objectives. If the profiler is located in a non isolated environment, it is very difficult to perform interferential measurements, and confocal measurements at high magnifications. If the profiler is vibration isolated, then any objective can be used. The TI series 2.5X and 5X Michelson-interferential objectives cannot be used simultaneously with other objectives.

It is very difficult to classify all the surfaces characteristics in a table. The following tries to do this by classifying the sample under test by its surface finish and geometry.

Surface under test description	Optical technique	Objective needed	Description
Optically smooth with high local slope. Eg. Microlenses	Confocal	50 X EPI 100 X EPI	Necessity of high light efficiency and high numerical aperture
Optically smooth with low local slopes (flat samples). Surface finish in the mm range and few nm features. Eg. MEM's	Confocal Interferential with VSI	10 X DI 20 X DI 50 X DI 50 X EPI 100 X EPI 150 X EPI	Necessity of high repeatability, moderate numerical aperture and low to high magnification
Optically smooth with low local slope and high lateral dimensions.	Interferential with PSI	2.5 X TI 5 X TI	Necessity of low magnification and high repeatability
Optically rough and large lateral dimensions features	Confocal	10 X EPI 20 X EPI	Necessity of topography stitching and moderate numerical aperture for low magnification
Optically rough and small features	Confocal	50 X EPI 100 X EPI	Necessity of high numerical aperture and high magnification
High aspect ratio	Confocal	From 20 X SLWD to 100 X SLWD	Necessity of low numerical aperture and Super Long Working Distance

PLμ 2300 Stages

The user has to place and center manually the sample under the microscope. The total travel length is 150 x 150 mm (6 x 6 inches). This stage allows measuring a sample within the field of view of the magnification of the objective. Centering samples under high magnification can be sometimes very difficult.

Manual stage

The user can center the sample by using an external joystick or the virtual joystick of the software. The total travel length is from 100x72 mm up to 300x300 mm depending on the model. This stage allows to measure with the same capabilities than the previous manual stage plus the extended profile and extended topography. In that case, the system automatically moves the sample and measures contiguous fields of view, stitching the results and getting larger measurements areas.

Motorized stage

Motorized stage with encoders offers the same measurement capabilities of the previous motorized stage but using linear optical encoders to achieve down to 1 µm of repeatability and 1 µm of accuracy.

Motorized stage with encoders

Manual Tip-Tilt stage is used to balance the tilt of the surface under measurement. It allows placing the surface perpendicularly to the optical axis. Interferometrical measurements using Phase Shifting take great benefit of it, placing the surface at a position called Null Fringes. This is the position where PSI gives the best results. It is not so necessary to balance the surface for confocal technique.

Manual Tip-Tilt

PLμ 2300 Nosepieces

The standard nosepiece can hold up to 6 different objectives simultaneously, including confocal and DI interferential. An adapter is necessary to fit the interferential objectives. The objective is manually selected by the user by rotating the position of the nosepiece and choosing the right objective in the software.

Standard nosepiece

Motorized nosepiece

Motorized nosepiece can hold up to 5 objectives simultaneously, including confocal and DI interferential. To select an objective there are two alternatives. By clicking the software to the desired objective, the hardware automatically changes position of the nosepiece, or by using the nosepiece controller. In that case, the software takes care for the change and automatically recognizes the current objective.

To fit a TI interferential objective is necessary to use a special adapter. When using a 2.5X or 5X objective, the system is not able to use any other objective.

TI objective adapter

PLμ 2300 Sensorhead

PLμ 2300 sensorhead is the heart of the system. It uses microdisplay technology to be able to acquire in confocal and interferometrical modes and a high power LED as a light source with a wavelength of 460 nm (blue light). The standard configuration includes a high speed CCIR CCD, open-loop stepper motor with 30 mm travel length and a standard nosepiece with a 20XEPI objective.

Plμ sensorhead

PLμ 2300 Column holder

The standard Column holder supplied with PLμ is made of aluminum. There are four different positions to place the sensorhead spaced 25 mm. The maximum sample height is 100 mm.

A granite column holder is also available. This offers high thermal stability and the possibility to place the sensorhead at different Z positions being able to measure samples as large as 500 mm.

Standard aluminium column

Granite column

PLμ 2300 Scanning devices

Basic Z-axis motor is an open loop scanning device based on a stepper motor. This motor fits directly to the microscope stroke and uses the fine movement to get 50 nm repeatability. The z-axis can be moved with the joystick with high accuracy and up to 1.5 mm/s. This Z scanning device is included in all PLμ 2300. In the case of using this motor for PSI measurements, the repeatability of the systems goes down to 0.1 nm.

External optical length gauge

PZT close-loop Z axis

Basic open-loop stepper Z axis motor

PZT Close-loop z-axis is an option for PLμ 2300. This scanning device has a total travel length of 400 μm with 0.5 nm repeatability. It improves the interferential measurements with repeatability down to 0.01 nm.

External length gauge is fitted to the top of the sensorhead. It senses the position of the scanner with 50 nm of repeatability for the full 30 mm travel range. This option is useful for coordinate measurements as well as for large samples.

PLμ 2300 Baseamounts

PLμ 2300 has to be assembled in a holed breadboard. Because confocal is less sensitive to vibration, when using the PLμ 2300 in a confocal mode, it is not necessary to use a vibration isolation table. Standard breadboard is non-vibration isolated flat table made of steel. They are available in different dimensions and weights.

Standard breadboard

In contrast, when using PLμ 2300 in a vibration environment, it is necessary to isolate it, both for confocal and interferential acquisition. The active vibration-isolation table is an intelligent device that senses the vibration and compensates it actively by using fast actuators. The isolated frequency range goes from 0.7 Hz to 1KHz, and can hold up to 140 Kg. Its dimensions are only 500 by 600 mm, being the ideal device for small room.

Active vibration-isolation table

Pneumatic vibration-isolation stations are used to isolate from low to moderate frequencies, while keeping smooth movements. The non-active principle is based on air pressure, and this device is a solution for large room.

Pneumatic vibration-isolation station

PLμ 2300 Reference mirror

A reference mirror of high surface finish quality (lambda/20) is included in all PLμ. It is used to calibrate the confocal objectives.

Reference mirror

PLμ 2300 Calibration standard

Optional calibration standard can be used to check the accuracy of the system, as well as to calibrate the step height measurement. All calibration standards are made of glass with a chromium layer and various step heights are available, from few nm to some tens of microns. Different step heights are used to calibrate different confocal objectives or different interferential acquisition modes.

Calibration standard

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