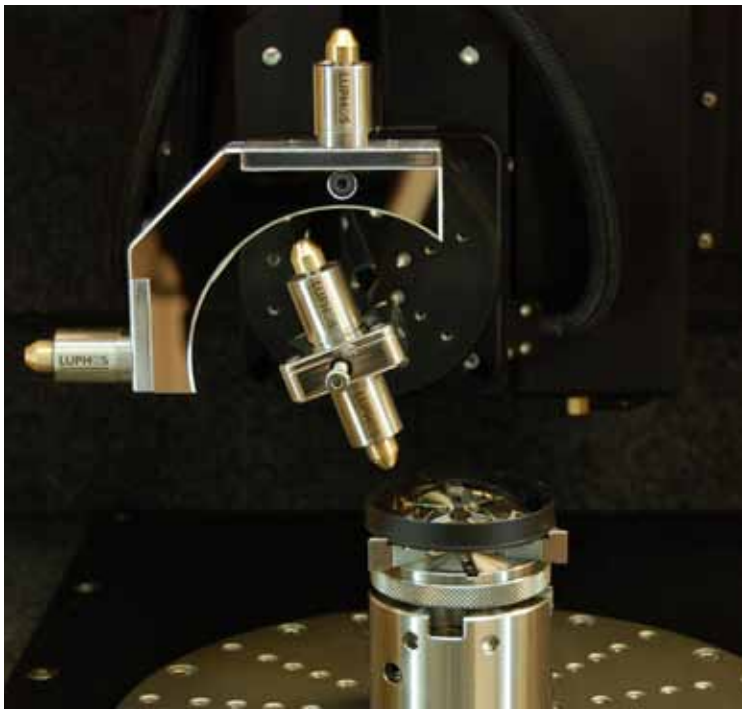
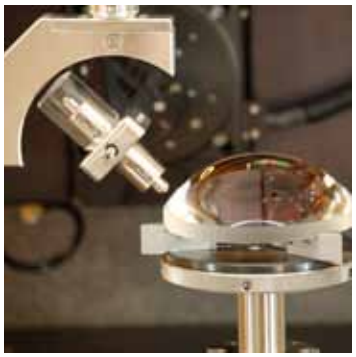
TAYLOR HOBSON®

LUPHOS
Light matters

LUPHOScan

Fast non-contact 3D form measurement of aspheric optics





Your turn-key solution for ultra precision metrology

AMETEK®
ULTRA PRECISION TECHNOLOGIES

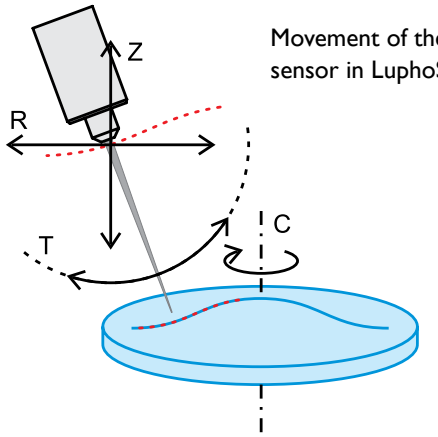
LuphoScan platforms are interferometric, scanning metrology systems based on MWLI® technology (multi-wavelength interferometry). They are designed to perform ultra precision non-contact 3D form measurements mainly of rotationally symmetric surfaces such as aspheric lenses.

Contents

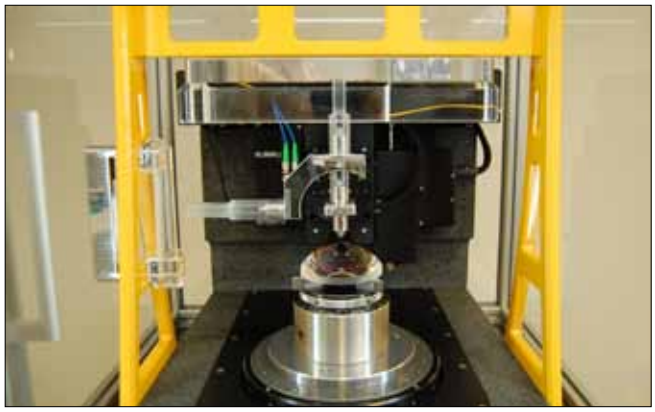
LuphoScan systems offer crucial benefits with regard to 3D form measurements of high quality optical surfaces

- Investigation of any rotationally symmetric surface
  Aspheres, spheres, flats and slight freeforms
- Ultra high, reproducible accuracy
  ≤ ± 50 nm
- Almost every material
  Transparent, specular, opaque, polished, ground
- Large spherical departures
  Unrestricted, e.g. can measure pancake or gullwing surfaces, and profiles with points of inflection
- Steep slopes
  Up to 90° (i.e. measurement of hemispheres)
- Highly flexible*
  Measures segmented surfaces, annular optics, rectangular surfaces, surfaces with diffractive structures, axicons
- Complete lens characterisation*
  Lens thickness, wedge error, decentre error, lens–mount positioning
- Diameters
  Up to 260 mm or 420 mm
- Fast measurement speeds
  E.g. 1:58 min (Ø = 30 mm, Roc = 60 mm, 100 points / mm^2),
  or 5:29 min (Ø = 130 mm, Roc = 150 mm, 50 points / mm^2)

*Add-ons, see pages 8-11



Movement of the object sensor in LuphoScan platforms

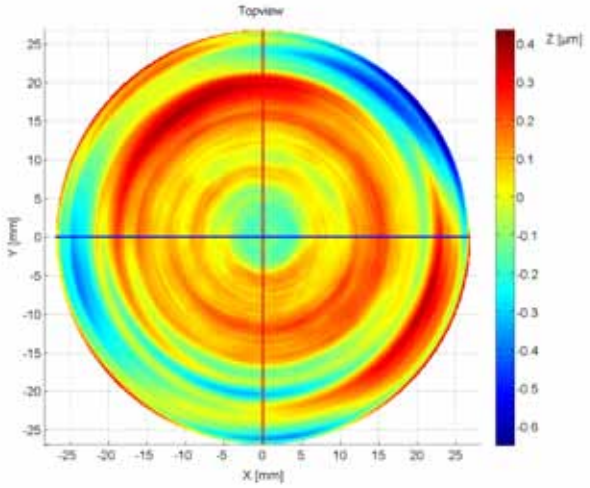


The LuphoScan measuring platform

Optical metrology based on MWLI technology

Features

LuphoScan platforms enable straightforward form measurements of aspheres, spheres, flats and slight freeforms. Key benefits of the systems include fast measurement speeds, high flexibility with regard to uncommon surface shapes (e.g. flat apexes or profiles with points of inflection), and maximum object diameters up to 420 mm. Due to the employed MWLI® sensor technology various different surface types such as transparent materials, metal parts, and ground surfaces can be scanned.

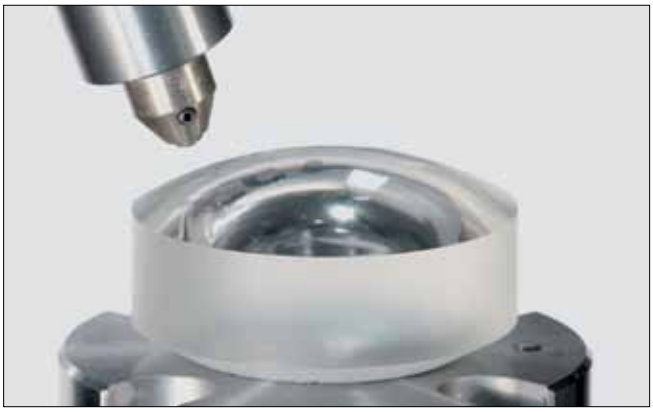


Deviation of an asphere from its design shape

Measurement principle

The scanning process is accomplished by means of an MWLI point sensor (MWLI– multi-wavelength interferometer) and four precision stages. The MWLI point sensor continuously measures the distance to the object surface under test. Objects are rotated by means of a 360 degree rotary stage (C), while the position of the sensor is controlled by 2 linear stages (enabling horizontal (R) and vertical (Z) movements) and 1 rotary stage (T). In standard operation mode the sensor is presented normal and equidistant to the surface. It is controlled to follow the profile of an ideal counterpart of the specimen. During a measurement the C stage rotates the object and the other stages move the probe so as to perform a spiral scan over the whole surface (see figure). The resultant point cloud reveals shape deviations and defects of the object surface.

High accuracy due to unique reference concept



Measurement accuracy

Due to the use of a sophisticated arrangement of reference sensors and a unique reference frame concept, the systems enable ultra high measurement accuracies better than ± 50 nm (2σ).

Reference frame concept

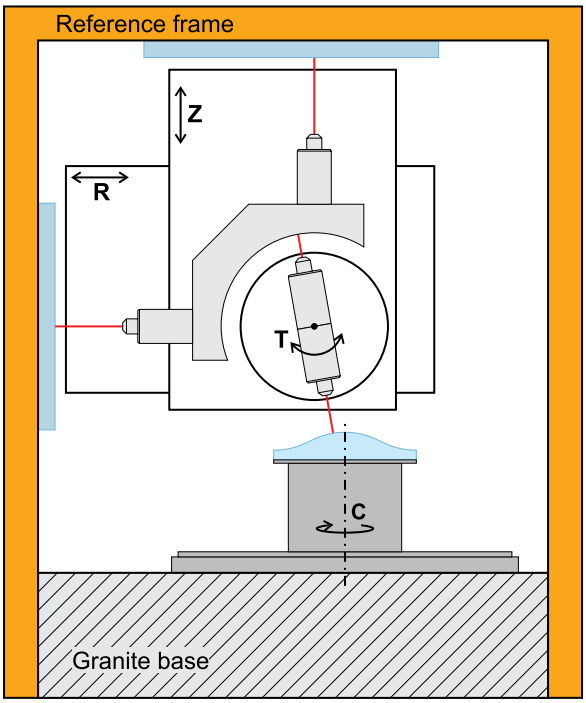
Each LuphoScan platform comprises an Invar reference frame that can be considered as an open loop metrology frame. Three reference sensors together with one cylindrical and two plane mirrors facilitate continuous determination of the position of the object sensor within this frame. In accordance with the Abbe principle, this concept enables compensation of all first order errors due to the mechanical R, Z and T axes. The reference frame concept in conjunction with the extremely high accuracy of the MWLI® sensor technology and an ultra precise C stage guarantee a form measurement accuracy better than ± 50 nm (2σ) and a reproducibility better than ± 20 nm (2σ).

Positioning of optics

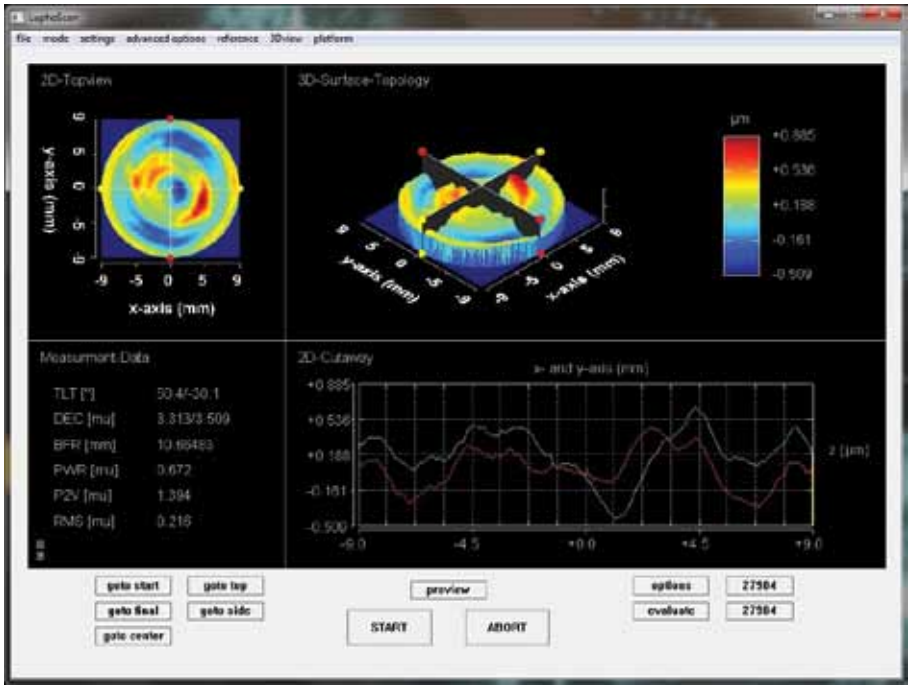
By default the platforms come with a hydraulic expansion chuck. A lens still stuck to the expansion arbor from its production process, can be measured straight away. One just puts in the lens, tightens the expansion chuck, invokes a previously defined measurement procedure, and starts the measurement. The whole process can easily be accomplished in less than a minute. The adjustment accuracy of this solution is sufficient for all standard measurement situations. Tilt and shift of the specimen are automatically identified and corrected. Unmounted lenses can be held in a 3-jaw chuck (optional).

Calibration

All required reference objects are included. The calibration procedure for adapting the platform to temperature changes can easily be conducted by the user. The complete cycle takes around 15 min.



Reference frame and layout of probe stages (R, Z, T) and object stage (C)



Screenshot of the LuphoScan software

Intuitive software for easy control and data analysis

Data input and measurement procedure

LuphoScan platforms come with a software package that enables complete control of the system, predefinition of measurement procedures, analysis of measurement results, and print out of test reports. Measurements usually start by putting in a surface description, e.g. by entering the radius of curvature, conic constant, and even and uneven aspheric coefficients of the part under test. Subsequently the software displays the trajectory of the object sensor, enabling a straightforward check whether the correct description has been entered. In addition, the software provides an easy way for comparison with a SAG table. The data density can be user adjusted and the program suggests an optimal setting for minimal measurement times. During measurements a countdown shows the remaining time.

Data analysis

After a measurement has been finished a topview, a 3D view and cutaways of the error map are shown. Several tools are available for analysing the data. Tilt and shift compensation, as well as best fit subtraction (spheric or aspheric) can be separately switched off and on. Further features include sophisticated adjustment of apertures and various filtering tools, such as low pass or high pass filters, filters for eliminating peaks caused by dust particles etc. The measurement data can be interpreted as being obtained from a polished or ground surface (after the measurement!). Errors can be displayed perpendicular with respect to the ideal surface or in the direction of the optical axis of the tested surface. Of course, all standard parameters such as Power, PV, RMS, and Zernicke values are displayed.

Data export

Measurement data can be exported as 3D sets or 2D line scans. Besides the native software formats X, Y, Z, dN or dZ (3D) and X, Z, dN or dZ (2D) various further formats are available. For instance, data can be exported in Zygos MetroPro XYZ format (3D) and Taylor Hobsons MOD and PRF formats (2D). These formats enable straightforward utilisation in the production line, e.g. for corrective polishing.

LuphoScan technology offers maximum flexibility

Main field of application

LuphoScan platforms are designed to measure 3D topologies of rotationally symmetric surfaces such as concave and convex aspheric lenses. Due to the stage layout most of the lenses that fit in the machine can be measured. There are no restrictions with regard to spherical departure, uncommon apex shapes (e.g. flat apexes), steep slopes, or profiles that exhibit inflection points. In standard operation mode the theoretical description of the surface under test has to be provided, based on the radius of curvature, the conic constant and the aspheric coefficients (even and uneven). By default the platform's software package enables measurement of polished or ground parts.

Ground lenses

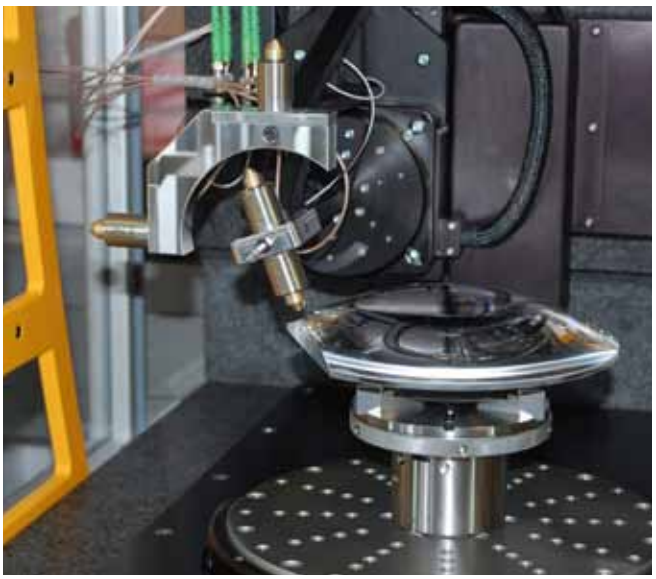
The unique MWLI approach also enables measurement of rough surfaces such as ground lenses. The platforms are therefore able to measure a lens in all its states from the green body through to the ultra precision polished lens with the same measuring machine.

Special shapes

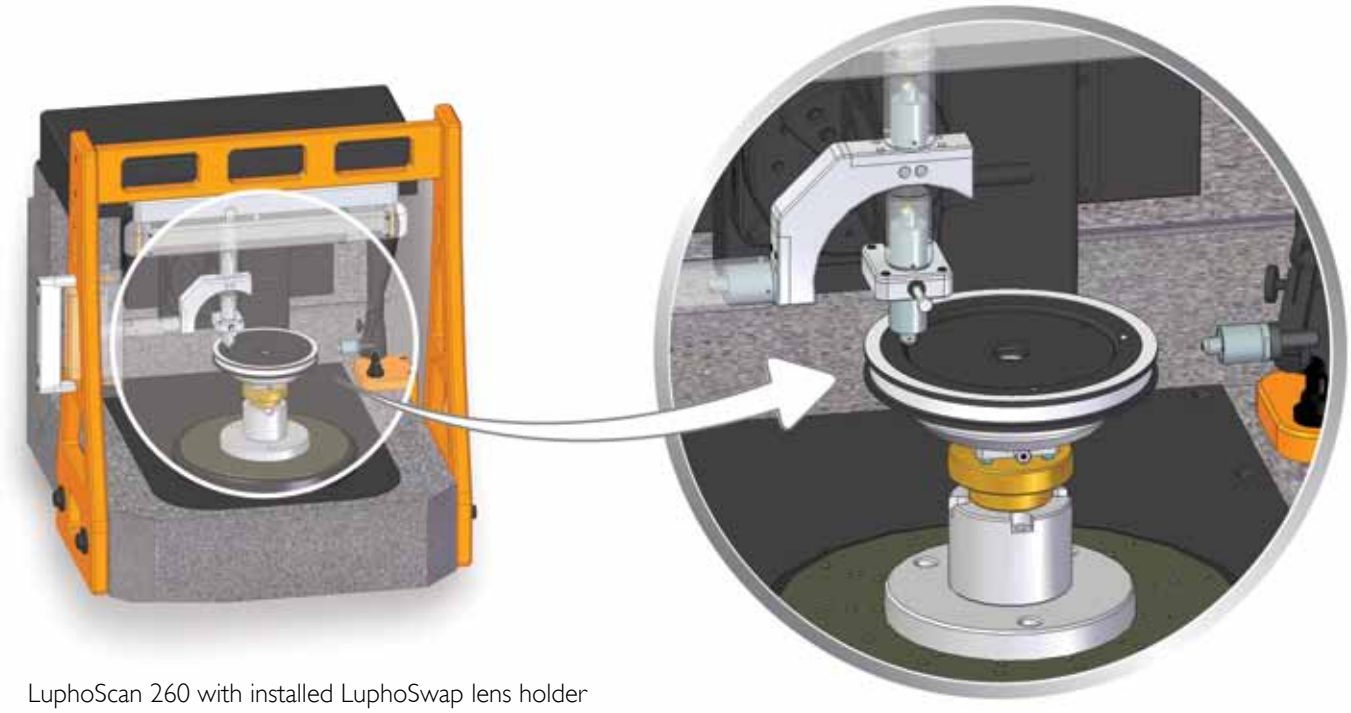
Although the platforms are designed to measure rotationally symmetric parts, they are also able to measure slight freeform parts, if the departure from an aspheric, spheric or flat shape is small. Examples include ellipsoidal X-ray mirrors or beam shaping elements.

Further applications

Besides the standard measurement applications, it is also possible to utilise LuphoScan platforms for complete characterisation of optical elements by means of the LuphoSwap extension (see page 8-9). This tool facilitates thickness measurement of lenses, as well as determination of wedge and decentre errors. In addition, several add-on software modules are available that enable straightforward measurement of discontinuous optics such as segmented surfaces including rectangular parts, annular optics, or surfaces with diffractive steps, and axicons (see page 10-11 for a complete list).



Measurement of a segmented aspheric lens



LuphoScan 260 with installed LuphoSwap lens holder

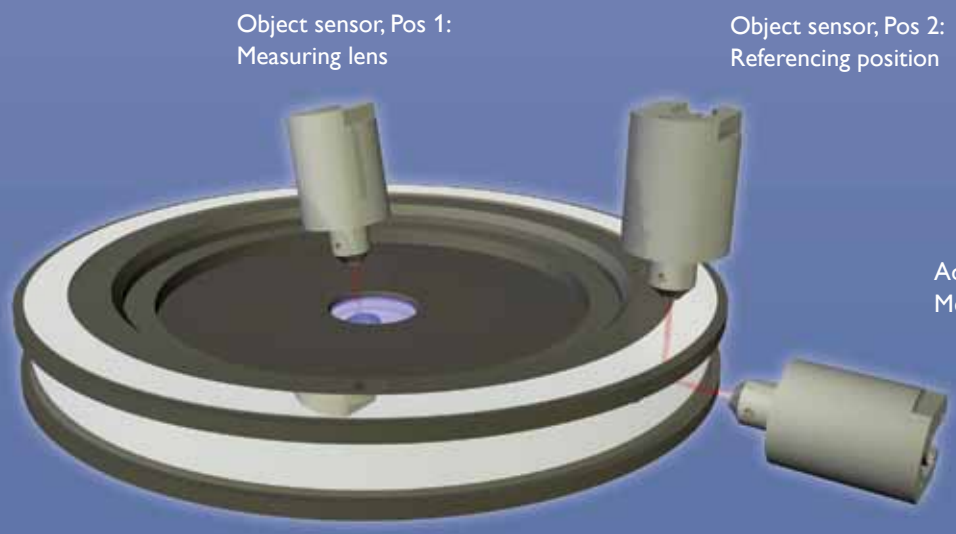
Complete form error characterisation of optical parts by LuphoSwap extension

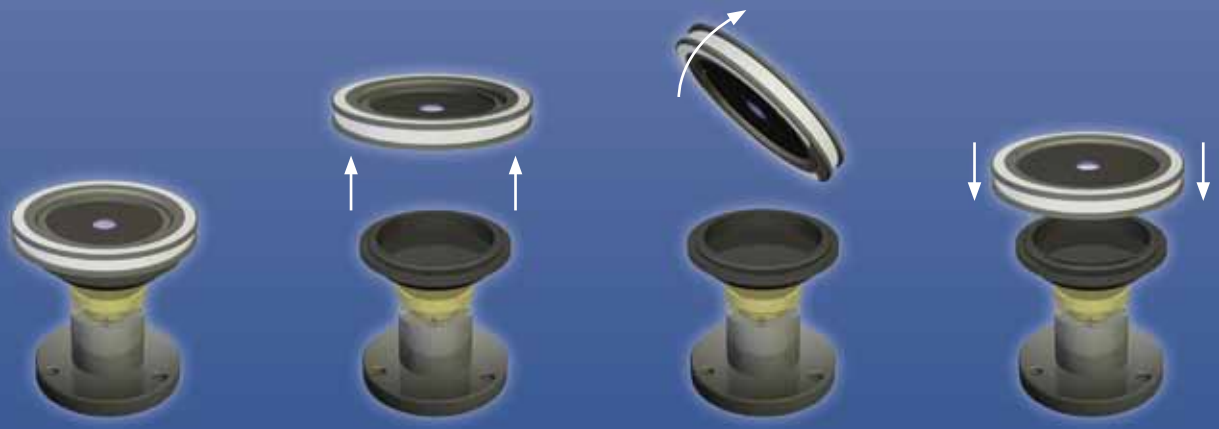
Achievements

LuphoSwap is an extension available for LuphoScan 260 and LuphoScan 420 platforms that enables complete characterisation of both surfaces of a lens. The two surfaces are measured successively. A unique measurement concept enables absolute correlation of the results measured on both sides. That is, at the same time as the form errors are measured this tool determines the exact lens thickness, the wedge and decentre errors of the two surfaces and their rotational orientation. In addition, the lens–mount positioning can be assessed. This powerful tool is based on the absolute measurement capability of the LuphoSmart sensor technology, a unique holder concept, and on an additional (runout) reference sensor.

Measurement principle

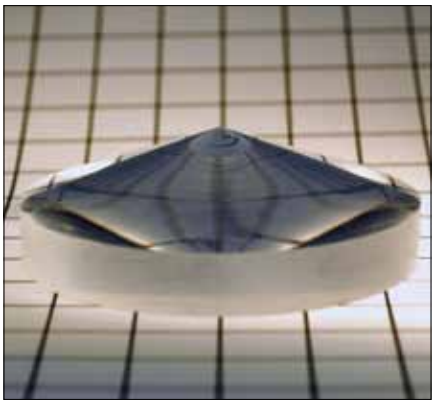
As in standard operation mode, the theoretical description (including Roc, conic constant and aspheric coefficients) is entered – but now for both sides. The lens under test is then mounted in the special LuphoSwap holder and the measurement of the first surface is started as usual. Subsequently the lens with the holder is turned over as shown in the figure and the second surface is measured as usual. In addition to the standard scanning procedure, the object sensor is controlled in a way to measure the exact orientation of each surface with respect to the calibrated LuphoSwap holder. In this way the software can automatically determine all geometric parameters (thickness) and errors of the test lens (form, wedge and decentre). Hence, using this tool is as easy as performing any other measurement of the same lens in standard LuphoScan platforms.



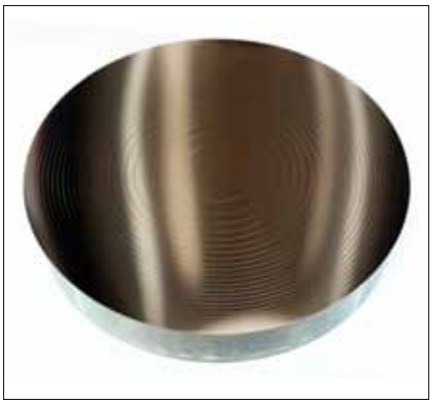


The turning of the LuphoSwap holder including a lens

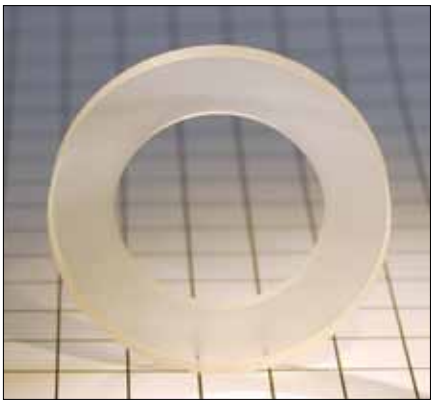
Object dimensions	Diameter	5 … 70 mm
	Thickness	2 … 25 mm
	Maximal slope	± 60°
Object materials		Transparent (e.g. glass), Opaque (e.g. ceramic, metal)
Lens thickness determination		± 0.5 µm
Wedge error determination (Roc = 50 mm)		± 5''
Orientation of both optical surfaces		Wedge, Decentre



Axicons with angles from 0 up to 90 degrees



Asphero-diffractive lens



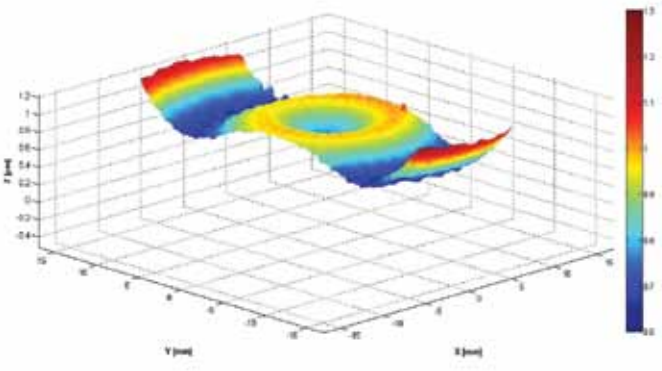
Annular asphere

Augmented flexibility through software add-ons

Module 1: Segmented lenses

This module allows for testing lens segments such as rectangular optics. The platforms still control the stages to perform continuous spiral scans. Signals that do not stem from an object surface are automatically identified and omitted.

- Underlying surface shapes: Aspheres, Spheres, Flats
- Form measurement accuracy: ± 50 nm (2σ)
- Automated surface masking
- Can be combined with the "Annular lenses" module and the "Axicons" module



Deviation of a segmented asphere from the design curvature

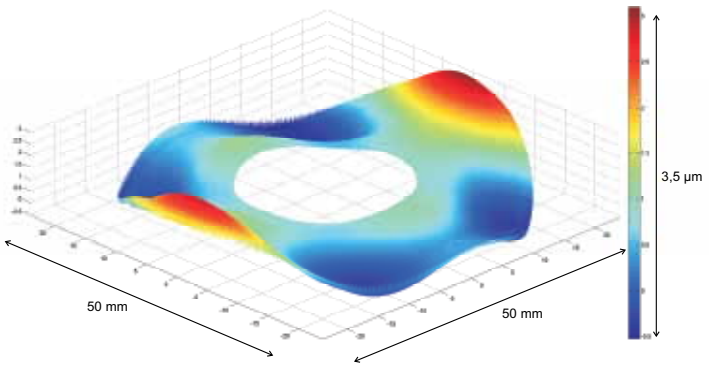
Several add-on software modules are available for LuphoScan platforms that enable straightforward measurement of various, discontinuous optics. The modules are based on the absolute measurement capability of the MWLI sensor technology. They facilitate 3D form measurements of segmented lenses, annular lenses, axicons, cones, and asphero-diffractive lenses. Every module comes with a sophisticated data analysis tool. In addition, all the standard data options are available, and of course, the modules work for every material that can be tested in LuphoScan platforms.

Measuring an aspheric lens segment

Module 2: Annular lenses

This add-on equips LuphoScan platforms with adapted measurement procedures in order to assess annular lenses with same form measurement accuracy as for standard aspheric lenses.

- Object shapes: Aspheres, Spheres, Flats
- Form measurement accuracy: ± 50 nm (2σ)
- Large spherical departures
- Adjustable inner and outer diameters: 0…260 mm or 420 mm
- Can be combined with "Segmented Optics" module

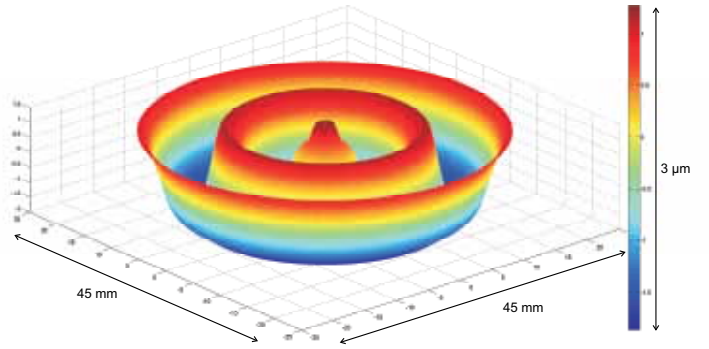


Deviation of an aspheric annular lens from the design curvature

Module 3: Axicons

Adds measurement capability that enables highly accurate assessment of form and angular errors of axicons.

- Object shapes: Axicons, truncated cones
- Form measurement accuracy: ± 25 nm (2σ)
- Angle measurement accuracy: up to 0.001°
- Determination of slope (Best fit slope)

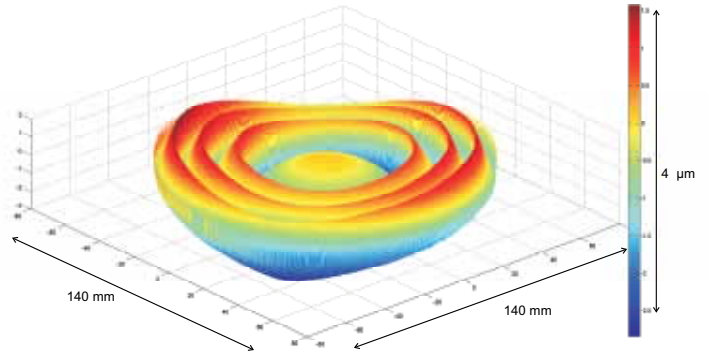


Deviation of an axicon from the corresponding ideal cone

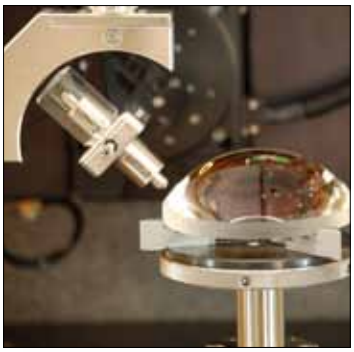
Module 4: Asphero-diffractive lenses

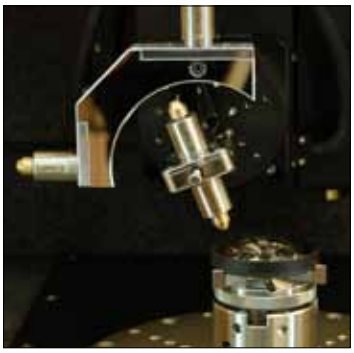
This tool enables non-contact inspection of the 3D deviations of asphero-diffractive lenses from the underlying aspheric design shape. Diffractive steps can be automatically removed.

- Underlying surface shapes: Aspheres, Spheres, Flats
- Diffractive structures: Vertical steps
- Step heights up to ± 600 µm
- Arbitrary no. of zones per lens
- Form measurement accuracy: ± 50 nm (2σ)
- Determination of step heights
- Removal of steps during analysis



Raw 3D measurement data of a diffractive lens with vertical surface steps





The LuphoScan 260 and 420

Variety of platform configurations

Platform sizes

The LuphoScan platform technology is available in three different sizes and in different measuring configurations. The platform size determines the maximal object diameter that can be measured by a system. Maximal measurable diameters are 260 mm and 420 mm. In addition, depending on the customer's main application a system can be configured for measuring a larger variety of concave or convex parts.

Platform design

A LuphoScan measuring system consists of the actual measuring platform, a measuring table, controller of actuators, a protective cover, and a control and evaluation computer. The measuring platform itself is placed on a breadboard that is uncoupled from mechanical vibrations by means of a pneumatic vibration damping system with automatic re-leveling. The granite base of the platform allows for very little influence on the measuring system due to fluctuations in temperature. The yellow reference frame to which both linear reference mirrors are attached is made from Invar and thus has a low thermal expansion coefficient. Additionally, the linear reference mirrors are equipped with protective elements against air turbulences, in order to reduce the effects of air fluctuations on the distance measurement.

Usability

The platforms are designed for use in production environments. Due to uncoupling from mechanical influences and due to employing materials with low thermal expansion coefficients in conjunction with short measurement times, the systems guarantee highly accurate, reproducible measurement results also when placed in the production hall. A temperature stability of ±1°C is typically sufficient. After commissioning including a basic calibration, a user can easily execute a 15-minute calibration procedure enabling the platform to adapt to temperature changes.

LuphoScan configurations			
Models		LuphoScan 260 (A, B)	LuphoScan 420 (A, B)
Maximum object diameter		260 mm	420 mm
Maximal SAG heights	Convex	55 mm, 50 mm	80 mm, 75 mm
	Concave	-20 mm, -30 mm	-30 mm, -50 mm
Maximal diameter with 90° slope		75 mm, 55 mm	105 mm, 65 mm
Hydraulic expansion chuck		HD25	HD25, HD40
Maximum object weight		25 kg	50 kg
Machine dimensions (w x d x h)		85 cm x 100 cm x 186 cm	100 cm x 115 cm x 186 cm
Measurement time (3D topology)		Plane, Ø =25 mm	0:55 min (16 points/mm²), 1:36 min (100 points/mm²)
		Sphere, Roc = 60 mm, Ø = 40 mm	2:19 min (16 points/mm²), 2:36 min (100 points/mm²)
		Sphere, Roc = (±) 80 mm, Ø = 80 mm	4:10 min (16 points/mm²), 5:18 min (100 points/mm²)

Technical data

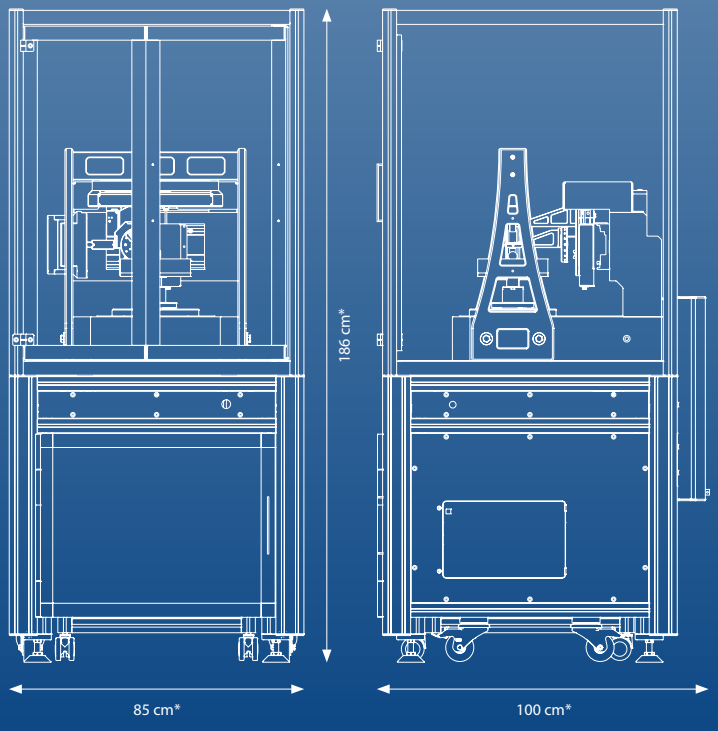
Measurement system		
Models	LuphoScan 260	LuphoScan 420
Machine type	4-axis (3 mechanical bearings, 1 air bearing)	
Measurement principle	Scanning point interferometry	
Sensor technology	Fibre optics based multi-wavelength interferometer (MWLI®)	
Scanning mode (3D)	Spiral, equidistant, normal	
Measurement volume (diameter x height)	260 mm x 75 mm	420 mm x 100 mm
Maximum tilt	90°	
Reference system	3 MWLI® sensors	
	Invar frame	
	1st order R, Z, T axis error compensation	

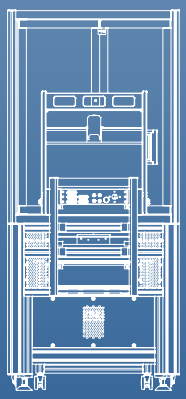
Object parameters		
Surface shapes	Aspheric, spheric, flat, slight freeform	
Surface finish	Polished, rough, transparent, specular, opaque	
Reflectivity range	0.1 % ... 100 %	
Spherical departure	Unrestricted (object sensor follows ideal profile)	
Maximal diameter with 90° slope	75 mm	105 mm
Maximum object diameter	260 mm	420 mm
Maximum object weight	25 kg	50 kg

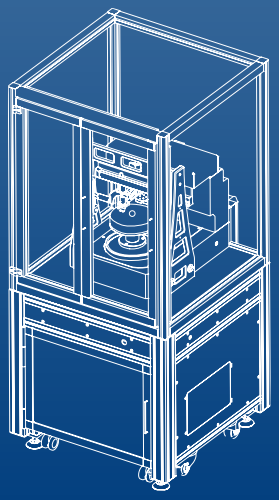
Machine characteristics		
Object mount	Hydraulic expansion chuck (HD25 or HD40), optional: 3-jaw chuck (D = 22…200 mm)	
Internal data rate	2500 Hz	
Wavelength range	1530 nm ... 1610 nm	
Laser classification	Class 1	
	Continuous wave output (CW), < 1 mW	
Machine dimensions (w x d x h)	85 cm x 100 cm x 186 cm	100 cm x 115 cm x 186 cm
Machine weight	450 kg	600 kg
Compressed air requirement	6..10 bar, 20 litre/min	
Electrical power requirement	230 VAC, 50/60 Hz, < 700 W	

Measurement characteristics			
Accuracy (2σ) (angle of incidence ≤ ± 1°)	polished	Ra < 1 µm	1 µm ≤ Ra ≤ 3 µm
	± 50 nm	± 250 nm	± 1 µm
Longitudinal resolution	0.1 nm		
Spotsize	4 µm		
Lateral resolution (points per mm²)	(adjustable:) 0.1 ... 2×10⁵		

Data handling		
Parameter input		Aspheric coefficients (even, uneven)
Measurement data		3D, 2D linescan
Data export formats	3D	Zygo MetroPro XYZ, X,Y,Z,dN (ASCII, binary), X,Y,Z,dZ (ASCII, binary)
	2D	Taylor Hobson MOD, Taylor Hobson PRF, X,Z,dN (ASCII, binary), X,Z,dZ (ASCII, binary)
Data analysis		3D surface visualisation, adjustable cross-section, 2D graphics, filtering (LPF, HPF, Gaussian), best-fit radius, aspheric fit, PV, RMS, tangential & radial errors, measurement report (PDF)







* Dimensions of LuphoScan 260

TAYLOR HOBSON®

AMETEK®
ULTRA PRECISION TECHNOLOGIES

The Metrology Experts

Established in 1886, Taylor Hobson is the world leader in surface and form metrology and developed the first roundness and surface finish measuring instruments.

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