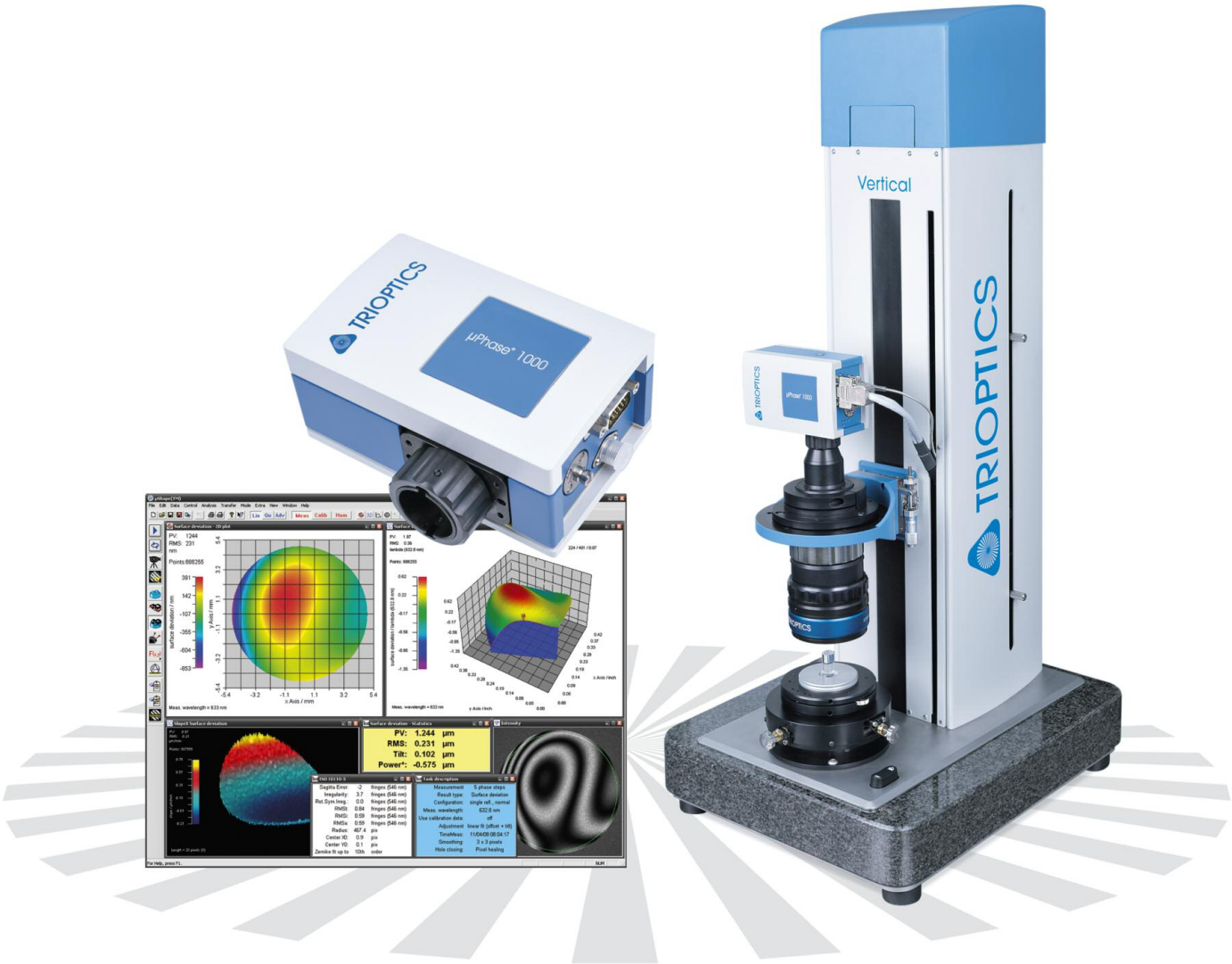
TRIOPTICS

TRIOPTICS GMBH · OPTISCHE INSTRUMENTE

µPhase® & µShape™

Compact and Modular Interferometers



Surface & Wavefront Metrology

AspheroMaster®

µPhase® WaveMaster®

OptiSurf®

Contents

As a leading company in the field of optical test equipment TRIOPTICS has taken over the µPhase® line of interferometers from FISBA OPTIK AG, Switzerland, in 2010. µPhase® perfectly supplements TRIOPTICS product portfolio and with TRIOPTICS worldwide subsidiaries and distributors µPhase® can now be offered a wider customer base in optical and other industries.

A close partnership with FISBA OPTIK AG enables TRIOPTICS to deliver µPhase® products in usual Swiss quality and to provide service for all µPhase® products. Furthermore, the acquisition of FISBA OPTIK Berlin at the same time guarantees continuity in the development of the interferometer software µShape™.

TRIOPTICS

µPhase® Interferometers

Measuring with Highest Accuracy

µPhase® interferometers offer objective and precise measurement results of surface and wavefront measurements - quickly and reliably.

µPhase® interferometers are compact, small and lightweight digital tools which can be used in almost any working environment. These measuring devices are perfectly complemented by the µShape™ measurement and analysis software to fulfill the highest expectations of quality management.

Measuring without Leaving Marks

The µPhase® Interferometer systems are used for measuring specular high precision components made of glass, plastic, metal or ceramic etc. The non-contact measurement method prevents damage to the sample under test, and gives the most exact evaluation of the entire surface or wavefront.

Strong Arguments for µPhase® Line of Interferometers

- Compact size and modularity enable adaptation to a variety of production and working environments
- Ultra wide measurement range of optics and surfaces with reflectivities from 0.3% to 100%
- Objective digital measurement prevent human errors
- Well structured and comprehensive software supports both production and laboratory use
- Unique combination of valuable features like Twyman-Green/Fizeau modus or the second camera for alignment of the lenses provide highest comfort using µPhase®

Modular System Providing Stand-alone Interferometers and Turnkey Solutions

TRIOPTICS offers µPhase® interferometers as self-contained modular parts as well as predefined turnkey solutions.

µPhase® customers especially appreciate the space saving and modular concept of µPhase® product line as it allows for flexible and cost-effective utilization of the instruments. The different parts of the µPhase® interferometer line are all compatible and form powerful measurement devices.

µShape™ Interferometer Software	µPhase® Sensors	
	µPhase® 500	µPhase® 1000

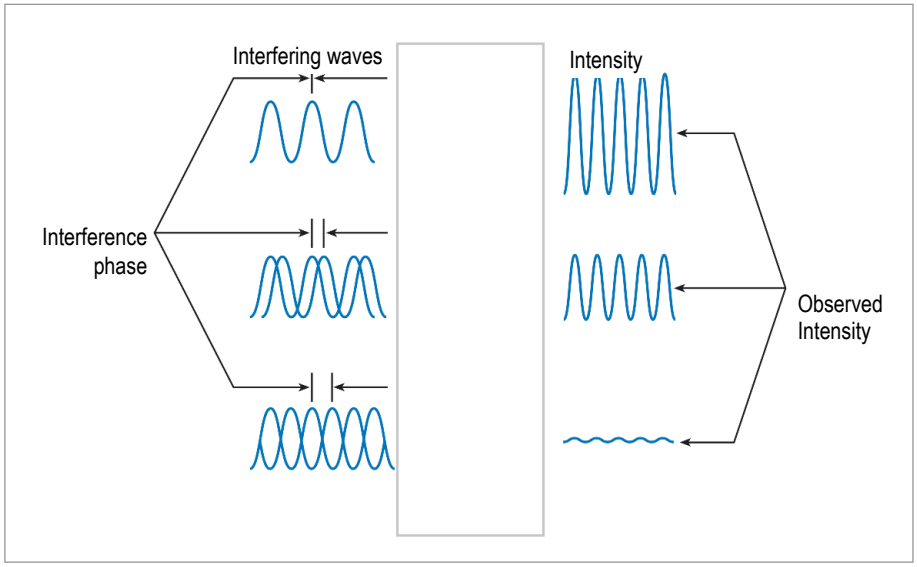
µPhase® Turnkey Solution (Sensor + Stand + Software)				
PLANO DOWN	PLANO UP SPHERO UP	VERTICAL	UNIVERSAL 100	PLANO 300

µLens Plano and Sphero Objectives
For the measurement of flat samples µLens PLANO objectives are required; for the measurement of spherical optics a µLens SPHERO objective is used with its basic µLens PLANO objective

µPhase® modular system

Interferometry

In interferometry coherent wavefronts are superimposed. The result of this superposition is a fringe pattern, the so-called interferogram. In case of two beam interference each fringe represents a constant phase difference between both waves. Thus the interferogram is a kind of a contour map of the test sample.



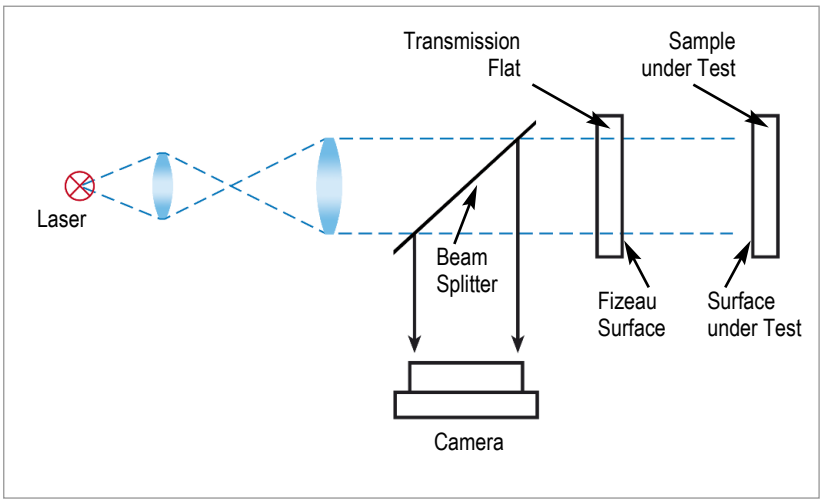
Interference principle

The standard design of an interferometer for surface shape testing consists of a collimated coherent light source which is divided by a beam splitter into two beams. The test beam is transformed by a beam shaping optics into a wavefront of nearly the same shape as the sample (commonly flat or spherical). Thus the rays of the test beam intersect the sample under test perpendicularly, are reflected in themselves and embossing the shape errors to the test wavefront. The modified test wavefront is recombined by the beam splitter with the reference beam, reflected at the internal interferometer reference surface, and imaged to the camera sensor. The space of both interferometer arms builds the test cavity. The interferometer measures the optical path difference (OPD) of this cavity for each point independently.

Fizeau Setup

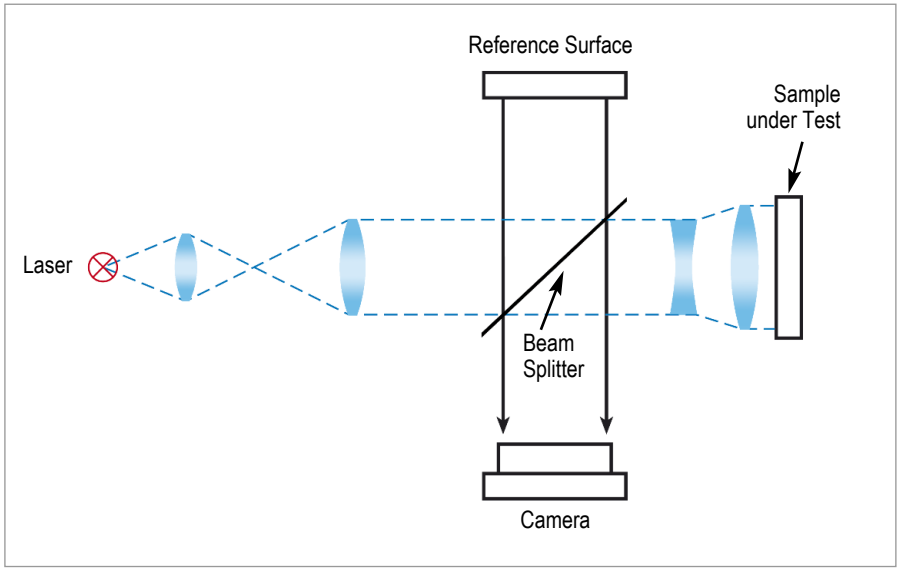
The most commonly used interferometer Setup

The last surface of the beam shaping optics is the so-called Fizeau surface. It has to have the same shape as the sample to be tested (commonly spherical or flat) and is placed concentricly into the optical path, so the individual rays intersect perpendicular to the Fizeau surface. The major part of the light passes the Fizeau surface and is reflected at the test surface. The returning light interferes with the part of the light reflected at the Fizeau surface. So the Fizeau surface acts as beam splitter as well as reference surface. The reference arm length is identical zero, so the cavity is build up by the gap between the Fizeau and the test surface. That is the reason why a Fizeau



Fizeau Setup

interferogram commonly directly shows the deviations of the test sample from the reference surface, i.e. Fizeau surface. The quality of the Fizeau surface determines the accuracy of the Fizeau interferometer. Fizeau surfaces are commonly available with a quality of λ/10 – λ/20 PV, on request also better.



Twyman-Green Setup

Twyman-Green Setup

The Most Flexible Interferometer Setup

A Twyman-Green interferometer is a modified Michelson interferometer. Here the beam splitter is separated from the reference surface. The advantage of this configuration is a higher flexibility, because both interferometer arms can be modified independently of each other. So the intensity of reference and test arm can be easily adapted to each other in order to get maximum fringe contrast. This is necessary for testing samples showing different reflectivities and increases the range of applications enormously. Only a maximum fringe contrast enables a maximum resolution in depth.

As reference surface a surface can be used that is inexpensive and accurately producible independent from the sample size. The adaption to the sample size is done by conventional beam shaping optics introduced to the test arm. Contrary to the beam shaping optics for Fizeau interferometers these optics do not require an expensive Fizeau surface as final surface.

As consequence of this flexibility the interference patterns are not caused by the sample errors only but also by the aberrations of the additional optics in both interferometer arms. However, nowadays samples are not anymore evaluated by visual inspection of the fringe pattern but by computer controlled analysis of the phase map causing the fringe pattern. During this analysis the aberrations of the additional optics can be easily considered. Finally the software provides an objective digital measurement result.

µPhase® 500 and µPhase® 1000 Sensors

Most Flexible Interferometer Sensors

These highly integrated phase-shifting Twyman-Green interferometer sensors meet the toughest demands for modern quality management. In combination with the measuring and analysis software µShape™ this high-performance precision measuring instrument provides information about the specimen's surface, wavefront or test objective aberration.

Advantages of µPhase® Sensors

- Compact size, modularity and arbitrary working orientation enable adaptation to different production and working environments
- Wide field of view alignment mode: Simple and fast alignment of the sample due to a second camera for alignment purposes
- High resolution cameras:
  µPhase® 500 (500x500 pixels),
  µPhase® 1000 (1000x1000 pixels)
- Measurement accuracy traceable to international standards
- High flexibility: convertable from Twyman-Green to Fizeau modus (on request)
- Standard measuring wavelength 632.8 nm; customized versions measuring at wavelengths from 355 nm to 1064 nm are also available upon request
- Simple and fast adaption to different reflectivities for optimal image contrast adjustment (µPhase® 1000)
- Object-plane focusing ability (µPhase® 1000 only)
- Robust, dust-proof housing

µPhase® Sensors are available in wavelengths 355 nm to 1064 nm

µPhase® Systems

A Variety of Complete Interferometer Systems

The µPhase® is available in various turnkey systems designed to cover the most common measurement tasks. They benefit from TRIOPTICS experience to design innovative, compact and user-friendly measurement systems.

µPhase® PLANO DOWN

All turnkey solutions are flexible and expandable due to their modular and compact design. A wide choice of test objectives from TRIOPTICS and third party manufacturers can be combined with the µPhase® interferometers and enable the perfect choice for each measurement task.

µPhase® PLANO DOWN
µPhase® PLANO UP & µPhase® SPHERO UP
The Perfect Interferometers for Use in Production

These extremely compact and cost effective turnkey interferometers are ideally suited for production. With their small footprint they can

be positioned next to the production machine and samples are measured directly after machining. These three interferometers differentiate in the position of the sample during the measurement process and the samples they can measure. µPhase® PLANO/SPHERO UP interferometers measure flat/spherical optics upwards, the sample is

µPhase® SPHERO UP and µPhase® PLANO UP

positioned on the top of the instrument. The µPhase® PLANO DOWN positions flat samples on the base of the instrument.

Advantages of µPhase® SPHERO UP, µPhase® PLANO UP, µPhase® PLANO DOWN

- For measuring various flat or spherical components
- Intuitive and easy handling enables the usage by untrained personnel
- Measuring range:
  µPhase® PLANO DOWN: flat surfaces
  Ø≤ 2 mm to 150 mm
  µPhase® PLANO UP: flat surfaces
  Ø≤ 2 mm to 100 mm
  µPhase® SPHERO UP: spherical surfaces, radius of curvature (convex) from 2 mm to 225 mm and diameters up to 55 mm (convex), concave surfaces, radius of curvature -3 to - 570; other on demand
- Small footprint
- Compact table configuration for cost-effective testing of larger series components right next to the production machine
- Suitable for integration into automated production lines
- µPhase® Sphero/Plano UP systems are vibration insensitive

µPhase® VERTICAL

The Flexible and Compact Interferometer for Lab and Production

This fully equipped turnkey interferometer is modular from design and can be individually configured for customer's requirements.

Advantages of µPhase® VERTICAL

- Universal interferometer system for production, workshop and laboratory
- Vertical setup
- Small footprint
- One moveable z-platform, second platform as an option
- Specimen support on tilt and X-Y translation table

µPhase® VERTICAL

- Transmission measurements possible
- Unique design for all kinds of reflection & transmission measurements
- Capability of transmission measurements in double-conjugate foci arrangement for spherical samples
- Measuring range for concave and convex spherical surfaces: Standard radius range from 1mm to 225 mm, diameter up to 55 mm with µLens Plano 50
- Integrated radius measuring unit
- Optional: Usage of CGHs for aspheric, toric or cylindrical surface measurement
- Motorized vertical z-axis
- Optional: Automatic radius measurement

µPhase® UNIVERSAL 100

Universal Horizontal Setup for all Kinds of Interferometric Measurements

Optimized for measurements in R&D µPhase® Universal 100 is the most flexible instrument of the µPhase® product line. The horizontal design enables the measurement of a large variety of lenses and components differentiating in size, radius and material.

µPhase® UNIVERSAL 100

Advantages of µPhase® UNIVERSAL 100

- The universal 4-inch measuring system for testing flat and spherical surfaces
- Measuring range for spherical and flat surfaces: Radii 10 mm, concave up to -3000 mm
- Diameter range up to 98 mm
- Radius measurement system integrated into sample support rail
- Horizontal design for long range of measurements
- Compatible with other commercially available 4" objectives
- Optional setup for measuring rotation-symmetrical aspheres in the diameter range from 10-80 mm, toric or cylindrical surface with CGH

µPhase® PLANO 300

Measuring Optics with Large Diameters

µPhase® PLANO 300 is ideally used in R&D labs or production when optics or multi-part polishing plates need to be measured.

µPhase® PLANO 300

Advantages of µPhase® PLANO 300

- Ideal system for measuring large flat areas, thickness variation and homogeneity of optical materials
- Ideal for shape testing of multi-part polishing plates
- Measuring range: 60-300 mm
- Vertical design measures downward, other configurations on request
- Heavy duty sample support & alignment for handling of heavy test blocks or polishing plates

µPhase® Customized
Customized Interferometer Systems

TRIOPTICS offers extensive support for specialized systems for applications beyond the scope of standard measuring systems. The µPhase® is very versatile with its high modularity and the compact design of the interferometer. This means that customized solutions for special measurement tasks can be implemented on the basis of standard components. The required components are selected and, if required, additional made-to-measure components and software modules are developed by our application and software engineers.

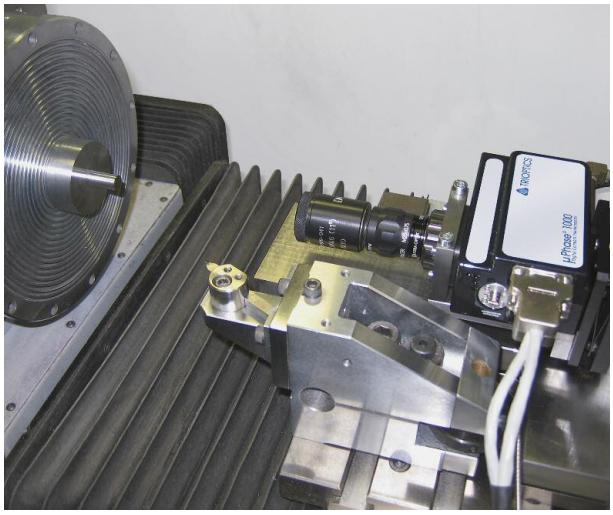
Applications

Surface Profiling in a Variety of Industries

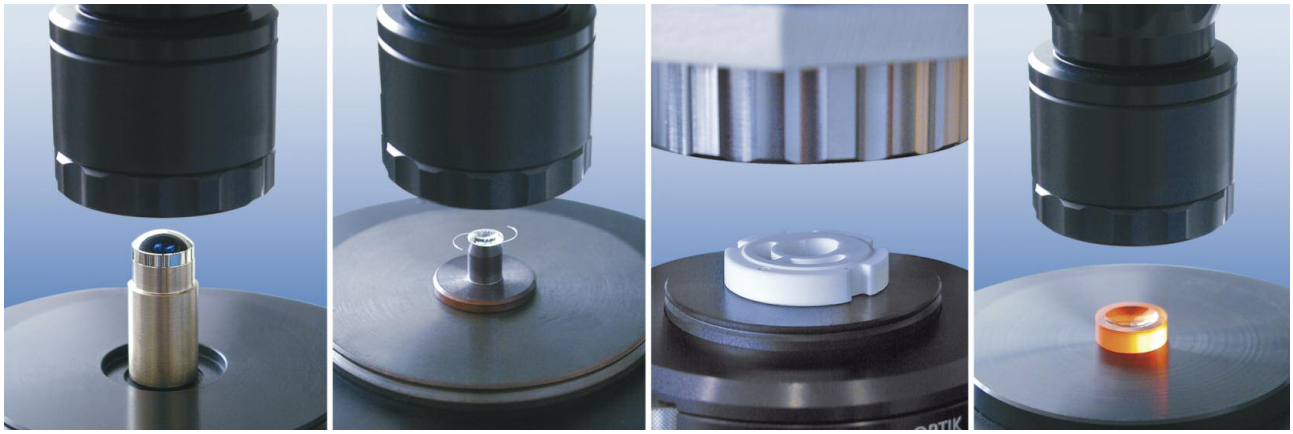
µPhase® is the interferometer with the widest spectrum of applications. With its modular concept, the compact design and the simple adaption to different reflectivities it allows not only for surface profiling of lenses but also for all kinds of components with reflectivities between 0.3% and 100%.

Components measured with µPhase® Interferometers

- Spherical, aspherical, cylindrical and toric optical surfaces
- Ophthalmology: Contact lenses, intraocular lenses and molds
- Adaptive mirrors
- Fiber endsurfaces
- Laser diode facettes
- Ball measurements of different materials
- Heat sinks
- Seal surfaces (e.g. metal, ceramic and synthetic materials)
- Automotive applications, e.g. fuel injection nozzles
- Medical applications, e.g. artificial hip-joint
- Ultra precision diamond turning machines with integrated µPhase® interferometer: The sample is measured directly in the machine, no need for time consuming and error prone replacement and alignment of the sample.



µPhase® integrated into a turning machine



µPhase® measuring molding tools for contact lenses, IOL, ceramic seal surface and plastic molding tool

µShape™ Interferometer Software

One of the Most Favorite Interferometer Software on the Market

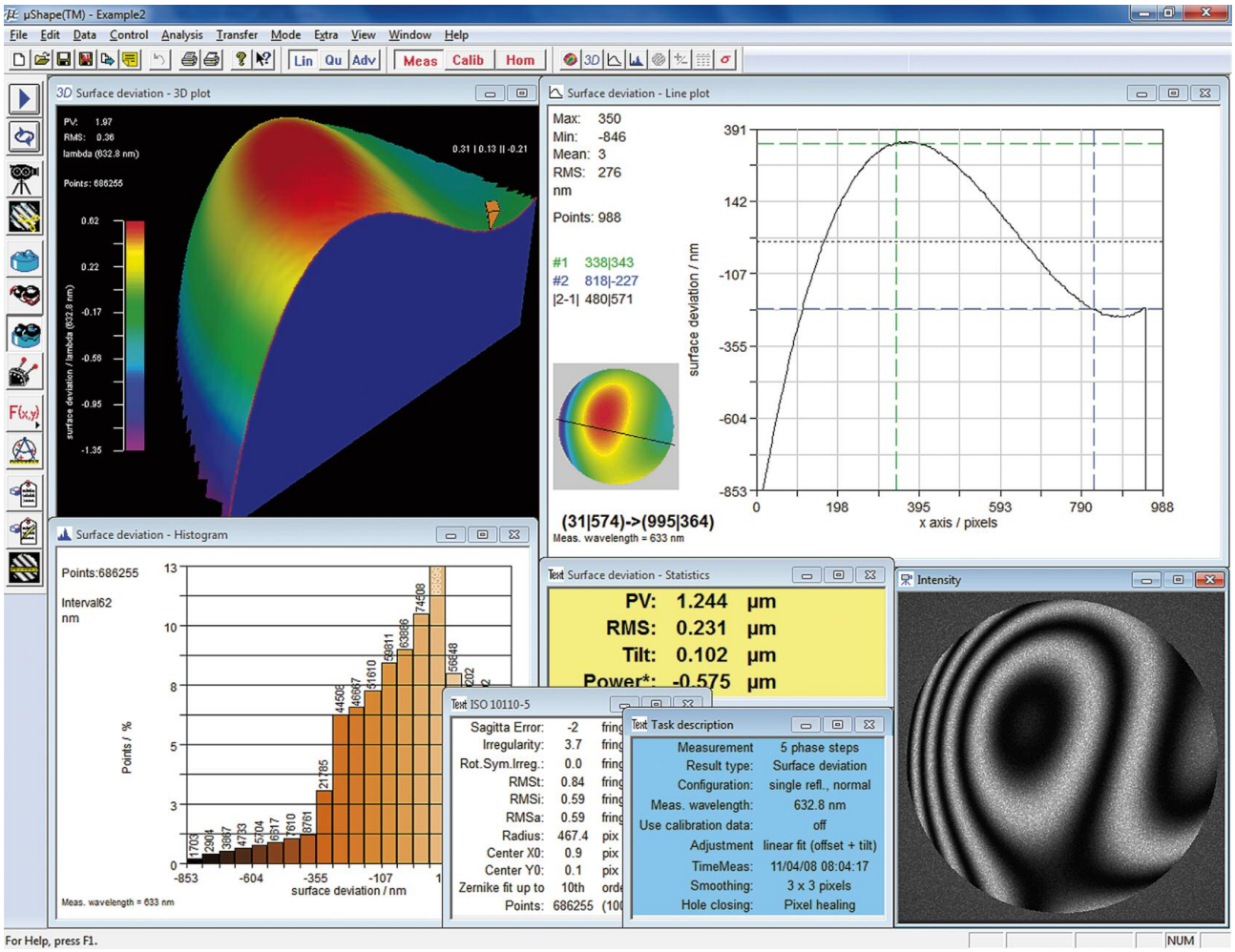
µShape™ Interferometer Software was originally developed for the µPhase® compact interferometers, today interferometers from other manufacturers work with µShape™, too.

With its clear and menu driven user interface µShape™ perfectly deals with the variety of measurement requirements and provides several modules which expand the capabilities of µShape™. Here it pays off that the interferometer software development team from TRIOPTICS Berlin, formerly FISBA OPTIK, Berlin, has more then 20 years of experience in software development, especially in the field of optical metrology. The advanced level of the software is demonstrated each time whenever the software is sold to support other interferometers on the market.

In general, µShape™ works with all Windows® systems including Windows® 7 and is designed for ease-of-use as well as full functionality. It controls and displays the measurement results, stores and documents all measurement raw data and ensures maximum transparency and traceability.

µShape™ Professional Software

The Professional version is the all-rounder amongst the µShape™ family. It is used for measuring the topography of flat, spherical,



Typical µShape™ Screen

cylindrical, toric and aspherical surfaces or wavefronts and is employed in production, laboratory and research. Add-on modules enable to adapt the software to custom specific demands. These modules can be added at any time even after the purchase.

The µShape™ Professional software is pre-installed on a state-of-the-art PC, included with every TRIOPTICS' µPhase® interferometer system.

General Functions of the µShape™ Measuring and Analysis Software

- Different levels with different access rights
- Shortcuts for most used program functions
- Comprehensive context-sensitive online help
- Various program modes enable the separate visualization of calibration and measuring processes and its parameters with an integrated live camera image
- Automatic updates of displays and images after every change of analysis parameters and new measurement
- Easily pre-configured templates for a wide range of measuring tasks and analyses
- Storage of all parameters and settings, including window size and position, with specimen data in µShape™ program file
- Graphic windows can be stored in several graphic formats (bmp, jpg,..)
- Export of individual parameters or of selected data fields as text, binary or other common file formats (e.g. QED, Zygo XYZ, DigitalSurf) for external processing
- The measurement results are presented in parameters or graphically as a cross section, in 2D or 3D
- Printout of selected graphic displays or of the entire window
- Measurement protocol shows the results at a glance and can be widely configured including the customer`s logo
- Access protection and configuration of add-on modules by dongle

Basic Measuring and Calibration Settings of µShape™ Software

- **Measuring parameters**
  Sets measuring parameters for any given measuring configuration: choice of phase measurement method, phase computation, and phase-shift wait times, separately for calibration and measurement of specimen.

- **Wavefront parameters**
  This function sets all parameters necessary for the computation of wavefronts, such as subtraction of calibration data; activation of various smoothing and holeclosing methods; compensation of adjustment errors for flat, spherical, cylindrical, aspherical and toric specimen; and geometrical operations (rotation, mirroring and data-field shift).

- **Masks**
  Sets geometrical elements (circles, ellipses, rectangles, squares and polygons) in any combination as transparent or opaque masks

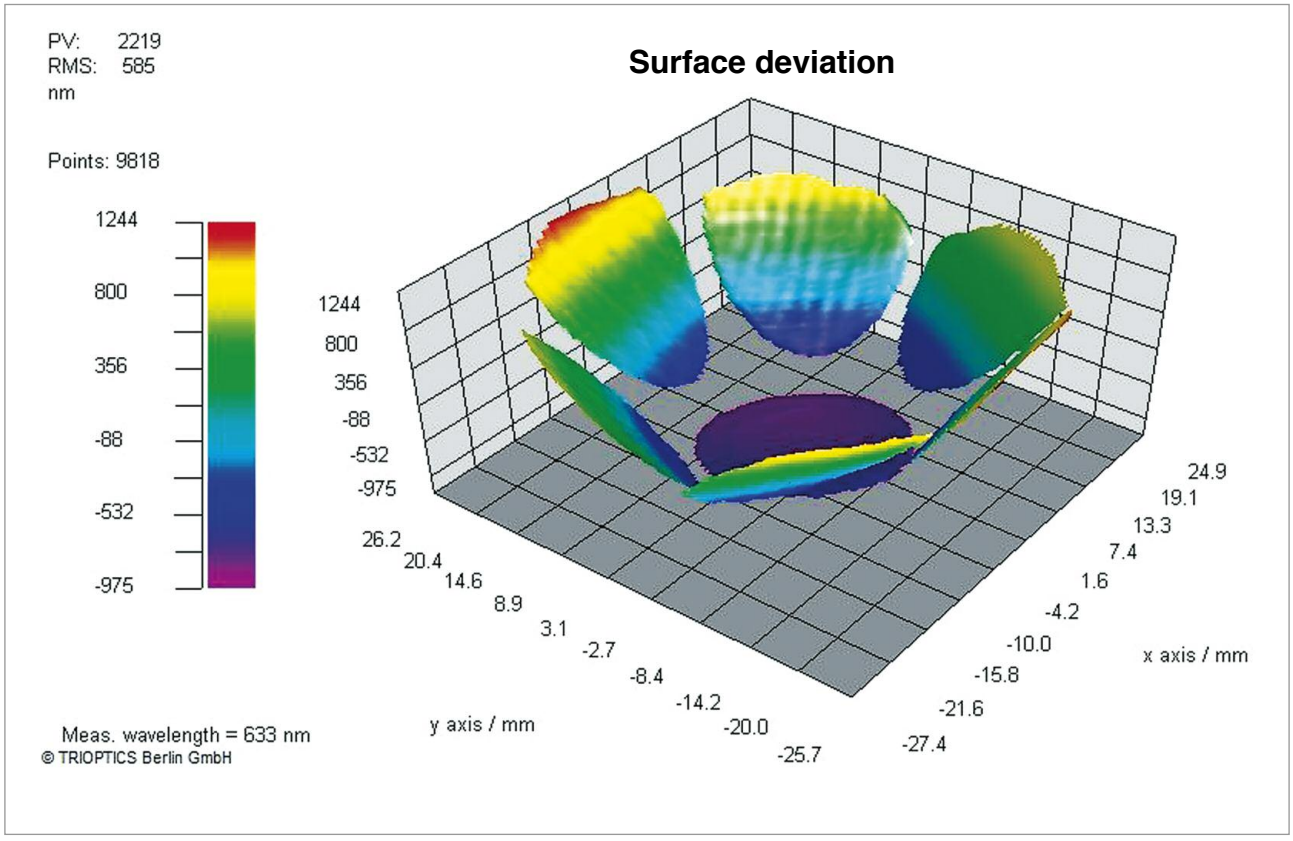
- **Configuration**
  Selects test setups, such as measurement of surfaces in perpendicular reflection, wavefronts in double transmission, automatic conversion of results and scaling of the measured field in units of length.

- **Visualization**
  Graphic display of data fields (intensity, phase image, measured data) displayed as a cross-section, 2D or 3D image. All parameters and statistical values in table form. Display of statistics, DIN and ISO parameters, Zernike and Seidel coefficients is available.

µShape™ Add-On Modules

For extended measurement tasks and further analysis the µShape™ software offers a great variety of add-on modules which can be added by the user if needed. Among these are:

- Analysis of aspherical surfaces in spherical or CGH setups
- Analysis of cylindrical or toric surfaces
- External communication interface for controlling the interferometer by external programs, e.g. in an automated system
- Measuring of homogeneity of glass plates
- MTF analysis of focal or afocal optical components and systems
- Measuring multiple apertures in one shot, e.g. on polishing heads
- Statistical analysis of multiple sub-apertures at the same time
- Prism and wedge measurement and analysis
- Considering known sample deviations e.g. deviations caused by the optical design
- Analysis of the tool offset of lathe machines
- Analysis of wafer plates
- Roughness and PSD analysis
- Static fringe analysis for fast measurements in instable environments



Multiple apertures

Special µShape™ Versions

In case where the powerful µShape™ Professional software does not meet the customers' needs TRIOPTICS offers special and customized software solutions.

µShape™ FastFringe Software

The FastFringe Software is designed for interferometers without phase-shifters. The measurement results are calculated by a static fringe analysis from a single interferogram. The analysis features are very similar to the µShape™ Professional with only a few exceptions not useful for non-shifting setups.

µShape™ Customized Software

The Customized version is an individual version of the Professional Software, which is specifically designed and created for special customer needs. A variety of add-on modules are available, enabling to extend the functions of the software.

Customized analysis and display functions, add-on modules or exclusive modules for customer specific measuring tasks are provided with the customized version of the software.

µShape™ Generic Package for Third-Party Interferometers

The µShape™ Generic Package can be used with the majority of commercial phase-measuring interferometers or individual interferometer setups.
Each package includes drivers for nearly all kinds of camera interfaces and optionally a piezo-element preamplifier. Contact TRIOPTICS for further details and an offer tailored to your needs.

µLens PLANO and SPHERO

The collimated test objectives µLens PLANO and the spherical objectives µLens SPHERO complement the µPhase® interferometry systems and allow for increased flexibility and modularity of the complete system.

The µLens PLANO objectives allow for measurements of flat surfaces or prisms in transmission from 2 mm - 150 mm. The spherical objectives µLens SPHERO enable to test spherical and aspherical surfaces with radii up to 225 mm (convex) and 98 mm diameter (convex), as well as optical systems in transmission.

Further Advantages:

- Existing µPhase® systems can be expanded easily and at low cost thanks to the modularity and compatibility of the objective design.
- Testing of small samples with radii of curvature under 1mm is possible.
- High measuring accuracy through minimum wavefront aberration of µPhase® and µLens SPHERO objectives.
- Field of view correction allows high measurement safety and interferometry with high fringe densities.

Select the Appropriate Objective from the Following Tables

Three Steps to Your Spherical Objective

1. Choose from "µLens SPHERO table" the spherical objectives which meets the requirement:

CXMAX > ROC > CXMIN or |ROC| > |CC Min|

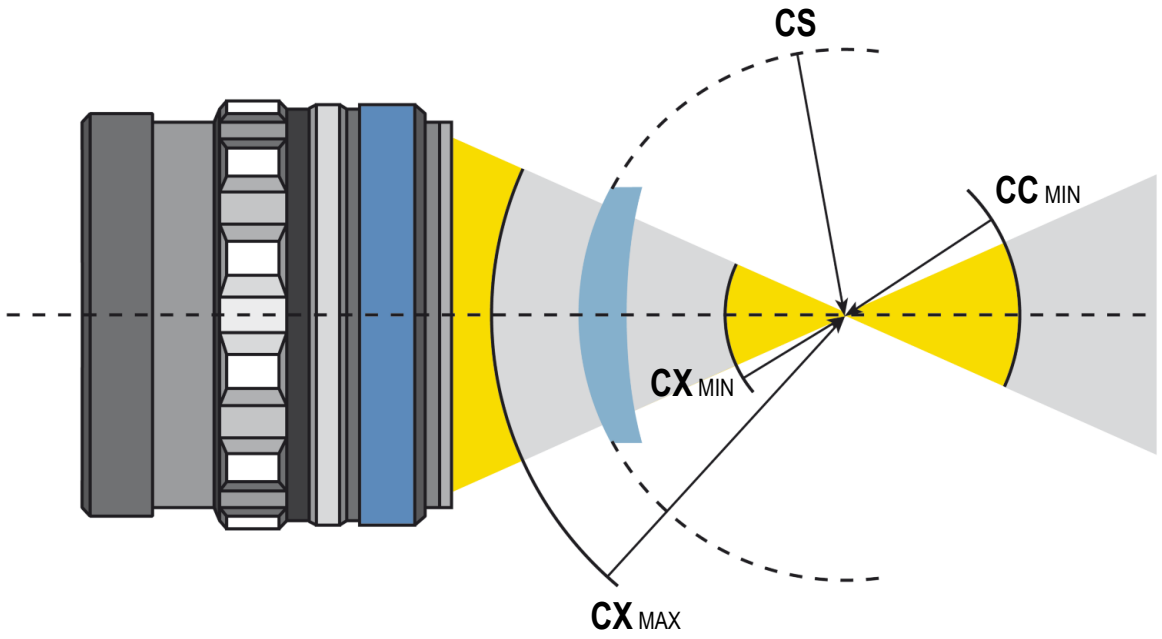
µPhase® objectives

2. Calculate the necessary f/# or max. diameter for the sample with

$$f/\# = \frac{\text{Radius of curvature of the sample (ROC)}}{\text{Diameter of the sample}}$$

and check if the objective is the right choice: check if the f/# of the choosen objective is smaller than the calculated value.

3. Choose from the table "µLens PLANO" the appropriate plano objective corresponding to the spherical objective



CX MAX = max. radius of curvature for convex surfaces
CX MIN = min. radius of curvature for convex surfaces
CC MIN = min. radius of curvature for concave surfaces

ROC = Radius of curvatures of the sample

µPhase® objective focussing range for imaging of spherical surface

µLens® PLANO Table

µLens PLANO	⌀ [mm/inch]	Sample diameter	Focusing Range [mm]*
µLens PLANO 2	2 / 0.079	0.2 - 2	0.6
µLens PLANO 10**	10 / 0.39	2 - 10	19
µLens PLANO 50	50.8 / 2	10 - 50.8	250
µLens PLANO 100***	101.6 /4	20 - 101.6	900
µLens PLANO 150***	152.4 / 6	30 - 152.5	2100

* Internal focusing only possible with µPhase® 1000 with µLens objectives tested according to TRIOPTICS standards. Focusing range begins at the outer lens surface
** Concave testing spacer required
*** Technical specifications for matching spherical objectives available on request

µLens SPHERO Table

µLens SPHERO objectives for combination with µLens PLANO 10

Description	f/#	NA	α [°]	CXmax*	CXmin*	CCmin*/**
µLens SPHERO 10 f/0.7	0.7	0.71	90°	8.0	2.2	-3.1
µLens SPHERO 10 f/1	1	0.50	60°	13.0	4.4	-6.0
µLens SPHERO 10 f/1.5	1.5	0,34	40°	20.0	8.4	-15.3
µLens SPHERO 10 f/3	3.0	0,17	19°	43.0	24.7	-330.3
µLens SPHERO 10 f/5.2	5.2	0,10	11°	73.0	52.0	-266.0

* Internal focusing only possible with µPhase® 1000
** Concave testing spacer requested

µLens SPHERO objectives for combination with µLens PLANO 50

Description	f/#	NA	α [°]	CXmax*	CXmin*	CCmin*
µLens SPHERO 50 f/0.7	0.7	0,71	90°	26	5	-6
µLens SPHERO 50 f/1	1	0,56	60°	45	10	-13
µLens SPHERO 50 f/1.5	1.5	0,34	40°	70	19	-30
µLens SPHERO 50 f/2.4	2.4	0,21	24°	130	45	-102
µLens SPHERO 50 f/4.2	4.2	0,12	14°	225	106	-573

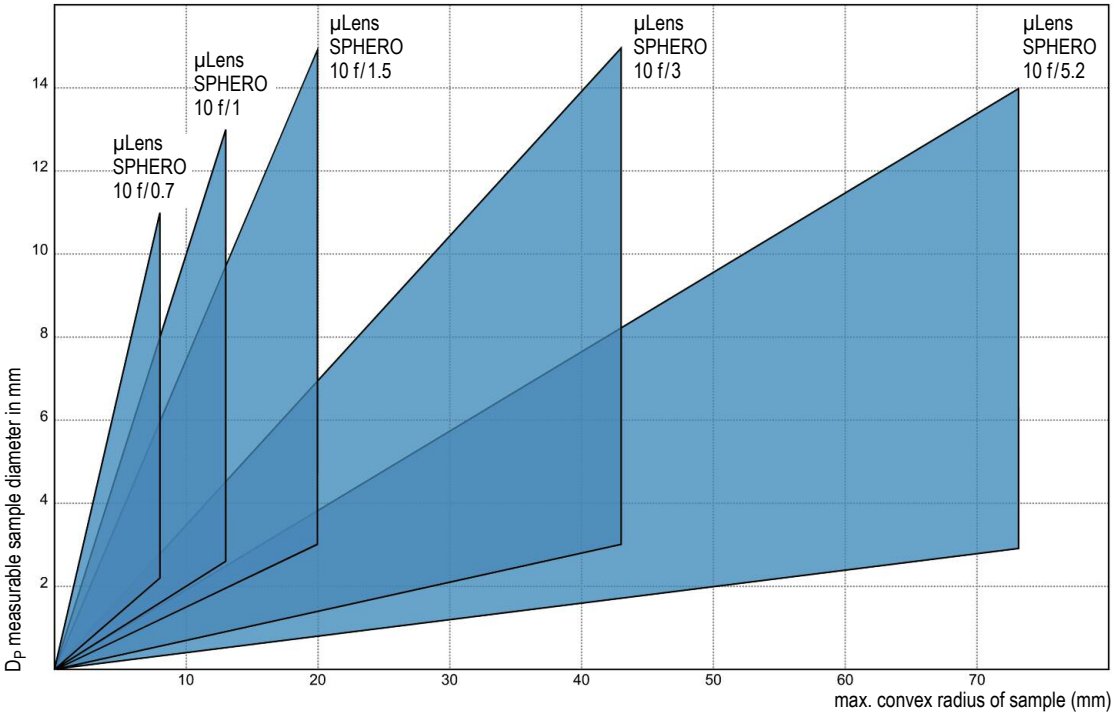
* Internal focusing only possible with µPhase® 1000

µLens SPHERO objectives for combination with µLens PLANO 100 and 150

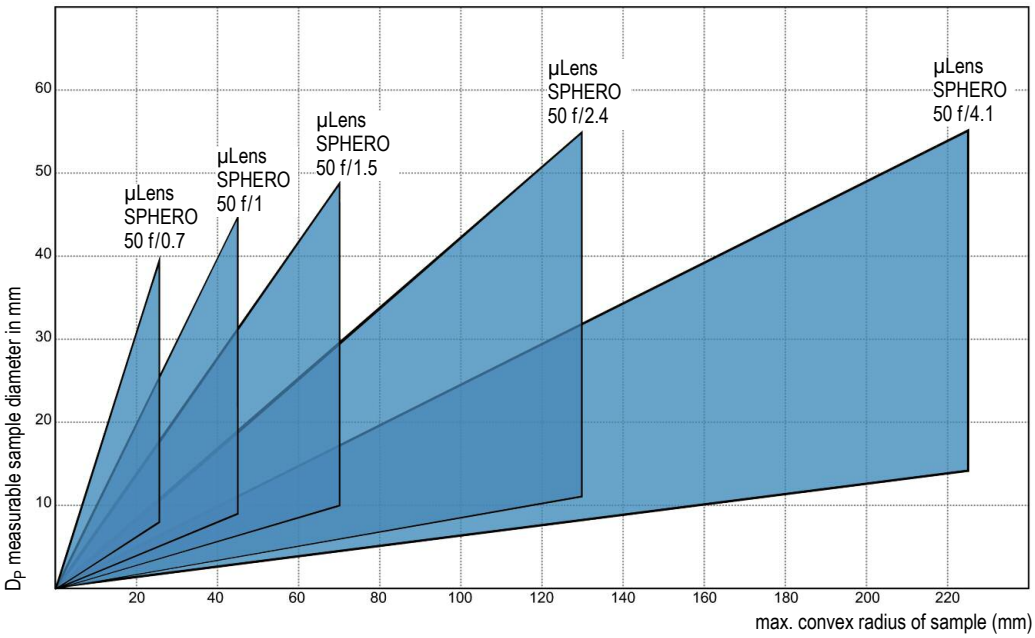
Information about objectives for the combination with µLens PLANO 100 and 150 on request.

Saw Tooth Diagram for the Selection of the Objective

µLens SPHERO objectives for combination with µLens PLANO 10



µLens SPHERO objectives for combination with µLens PLANO 50



µLens SPHERO objectives for combination with µLens PLANO 100 and 150 on request

Technical Data

µPhase® Sensors

Measurement Technique	Twyman-Green phase-shifting interferometer, convertable to Fizeau measurement mode
Measurement Capability	Measurement of surface topography of reflective surfaces and optics, and wavefronts of optical systems in transmission
Laser Wavelength	632.8 nm; option: any one wavelength between 335 and 1064 nm upon request
PV Repeatability (1)	λ / 400 (λ = 632.8 nm)
RMS Repeatability (2)	λ / 6500 (λ = 632.8 nm)
Measurement Uncertainty (3)	λ / 20 (λ = 632.8 nm), on request
Camera Resolution	µPhase® 500: 500 × 500 pixel µPhase® 1000: 1000 × 1000 pixel
Digitalization	8 bit
Laser Specifications	µPhase 500/1000 for 632.8 nm
Type of Laser	Frequency-stabilized HeNe laser
Laser Protection Class	µPhase® 500/1000: 2; Laser itself: 3A

(1) Measured PV-Repeatability of the quoted statistic is for 100 consecutive measurements of the same cavity, measured over 96% clear aperture with 16 phase averages per data set. The specification represents the 2σ value of each statistic.

(2) Measured RMS-Repeatability of the quoted statistic is for 100 consecutive measurements of the same cavity, measured over 96% clear aperture with 16 phase averages per data set. The specification represents the 2σ value of each statistic.

(3) The measurement uncertainty equals the surface of the calibration surface used for the interferometer calibration up to the specified value. TRIOPTICS supplies standard calibration surfaces with a certified accuracy of λ/20 (surface shape deformation). Higher qualities on request.

All measurements were performed on an isolated optical table.

µPhase® Turnkey Solutions

Standard ■
Option □

	µPhase® PLANO DOWN	µPhase® PLANO UP/SPHERO UP	µPhase® VERTICAL	µPhase® UNIVERSAL 100	µPhase® PLANO 300
Testing of flat surfaces	■	■	■	■	■
Testing of spherical surfaces		■	■	■	
Testing of aspheric, toric or cylindrical surfaces			□	□	
Testing of wavefronts in transmission			□	□	□
Absolute radius measurement			■	■	
Relative radius measurement		■	■	■	
Low vibration sensitivity		■	□		
Production use	■	■	■		■
Quality management use	■	■	■	□	■
R&D department use			■	■	■
Vertical measurement	■	■	■		■
Horizontal mesurement				■	□
Long radii measurement				■	
Modular / upgradeability	□	□	■	■	
Stage motorized / manual					
Manual			■	■	□
Motorized			□	□	
Special Features					
Encoder for radius/position measurement			■	■	
Data read-in from encoder to µShape™ evaluation software			■	□	
Second movable platform for transmission measurement			□	□	
Usage of CGHs for aspheres, cylinders or torics			□	□	
Stitching ability for large diameters				□	□
Integrated calibration flat					□
Stand-alone setup (no optical table needed)	■	■	□		□

TRIOPTICS

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