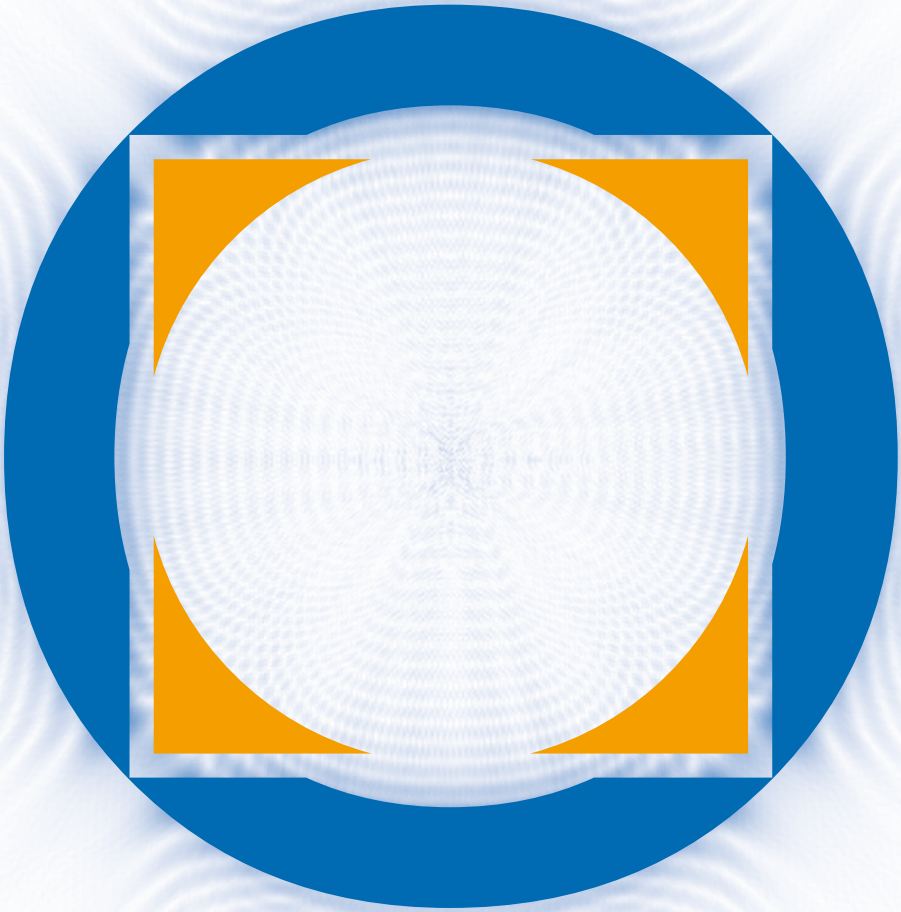
OPTOCRAFT

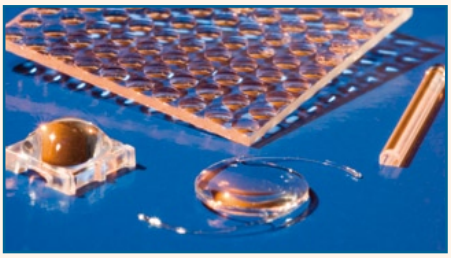
OPTICAL METROLOGY



Unleashed Wavefront Technology

OPTOCRAFT – Unleashed wavefront technology

Individual demands – qualified realization



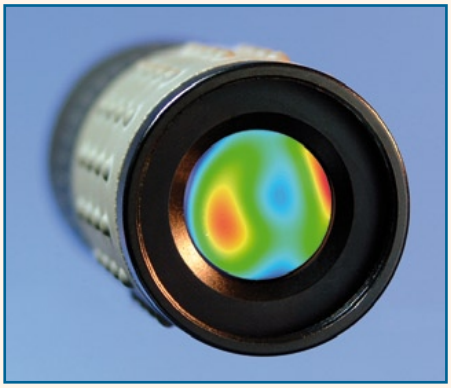
Manufacturers of plastic optics, aspheres, micro- or wafer-based optics will increasingly have to replace traditional measurement approaches by superior methods allowing for higher wavefront dynamics or speed. Progress in the manufacturing technology of optical elements, systems and lasers accompanies the growing demands for the related quality assurance systems.

Optocraft analyses the demands and supports its customers on this individual basis, even if standard solutions are not available. Thus, Optocraft's extended product range includes standard wavefront sensors and optics testers as well as custom interferometers or diffractive optics.

Quality you can rely on

The customer community of Optocraft is working in the high-precision optics industry, laser industry and ophthalmology fields. They use high-quality Optocraft products in order to guarantee the reliability and the quality of their own products. Reproducible measurements fulfill the needs of a complete quality assurance standard. Optocraft pays special attention to the precision of the components used in its products. The continuous improvement of the high intrinsic accuracy of the metrology systems is a key task of the daily work at Optocraft.

Dynamics, accuracy, stability, usability



The standard Optocraft metrology systems use the Shack-Hartmann wavefront sensor principle. This wavefront sensor utilizes a micro lens array to split the wavefront into a multitude of subbeams which are detected by a camera. The algorithmic evaluation of the multi-spot image yields the shape of the wavefront. They are generally resistant to vibrations and cover a wide range of challenging metrology tasks. Optocraft's sensors excel by their exceptionally high dynamics and stability. For instance, the large dynamic range for measuring the wavefront curvature and the automatic functions for intensity control facilitate locating the optimum adjustment position even for unfavourable starting points.

The OPTOCRAFT GmbH – established by conviction

When fascination and know-how meet a promising fundamental technology, the decision to market a research topic is not difficult. Johannes Pfund and Mathias Beyerlein, both PhD graduates of the chair for optics of the University of Erlangen-Nuremberg in Germany, founded Optocraft GmbH in 2001. The many years of experience and the dedication of the Optocraft team allow to distill the know-how to powerful metrology systems.

Over the last years Optocraft successfully applied technical creativity for the benefit of its customers. Optocraft's all time mission is to provide unleashed wavefront technology!

Standard metrology products

	Samples	Parameters	Products	Page
Beam testing and profiling	Laser Diodes LEDs Excimer Laser Systems	M^2 Radius of Curvature Wavefront, PSF Alignment	SHSLab ShearCam	4 15
Apheres and Standard Optics	Spheres Aspheres Cylindrical optics Objectives	Wavefront, PSF, MTF Focal Length, Centration Surface Deviation Radius of Curvature Alignment	SHSLab SHSInspect	4 12
Micro Optics	Spheres Aspheres Cylindrical optics Objectives Wafer-based Micro Optics	Wavefront, PSF, MTF Focal Length, Centration Surface Deviation Radius of Curvature Alignment	SHSInspect SHSAutolab Interferometer	12 16 19
Automated Testing	Plastic optics Micro Optics Objectives	Wavefront, PSF, MTF Focal Length, Centration Surface Deviation Radius of Curvature Alignment	SHSAutolab	16

Custom made products

	Applications	Products	Page
Laser Beam Shaping	Gaussian to Flat top Arbitraty Shapes	DOE	18
Asphere Testing	Diffractive Null-lens Elements General Wavefront Shapers	DOE	18
R&D, OEM	Integration into customer metrology systems Research Institutes doing wavefront measurements	SHSLab Custom Products	4 19

SHSLab – Wavefront Sensor System

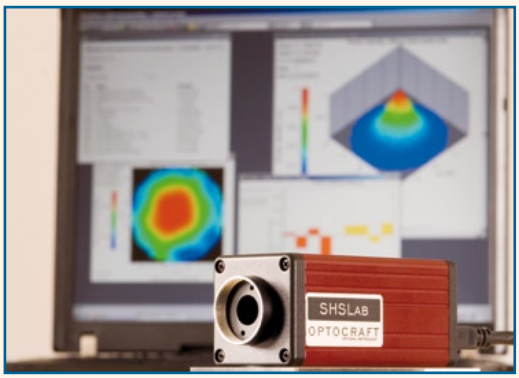
SHSLab

The Shack-Hartmann wavefront sensor system SHSLab is an unique tool for

- Characterizing lasers,
- Testing optics and
- Alignment of optical systems.

It is widely used in optical and laser industry and in research and development.

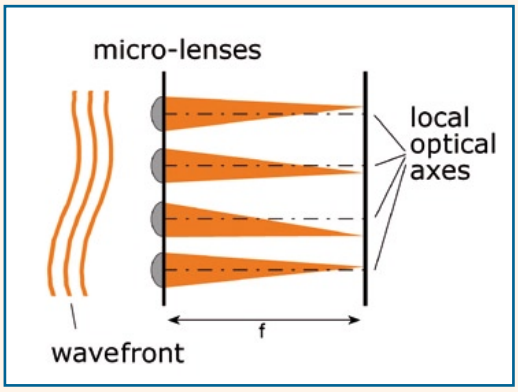
Customers using SHSLab take advantage of its outstanding features and save time and money in their daily metrology tasks.



SHSLab wavefront sensor system

What is a Shack-Hartmann sensor?

The Shack-Hartmann sensor SHSLab represents a physical realization of a „raytracer": The local slope of the wavefront is transformed into an array of focal spots by means of a microlens array. The wavefront aberrations are calculated from the positions of spots via numerical integration.



Wavefront is measured by using microlenses

Why using a Shack-Hartmann sensor?

Due to its technical principle Shack-Hartmann sensors measure wavefronts without the need for simultaneous presence of reference wavefronts. This is an advantage over interferometry that demands special precautions concerning stability and coherence of the measured and the reference wavefront. Shack-Hartmann sensors work in single shot technique and thus enable fast and rugged operation:

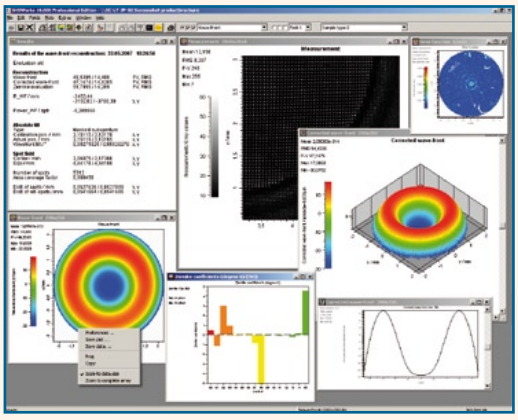
- Single shot
- High inherent stability
- Broad spectral range
- Potential for high dynamic range
- Potential for high accuracy

SHSLab = SHSCam + SHSWorks

SHSLab features several unique properties (see table on page 7 for details) that are based on finest hardware components and thorough software engineering.

SHSCam is the hardware consisting of camera, microlenses and cabling.

SHSWorks is the comprehensive software package that is available in different configurations (see also page 8).

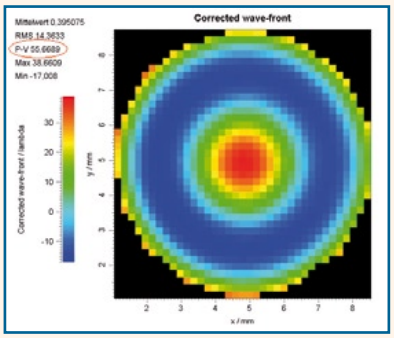


SHSWorks wavefront sensor software

SHSLab – Wavefront Sensor System

Why SHSLab?

Optocraft's SHSLab exploits the potential of the Shack-Hartmann wavefront sensor technology. SHSLab offers high dynamic range, excellent accuracy, stability and reliability.



Extreme dynamic range of SHSLab UHR: pure spherical aberration with >50λ (peak-to-valley)

Extreme linear and dynamic range

Based on its sophisticated hardware and software components SHSLab is able to measure wavefronts with extreme linear and dynamic range:

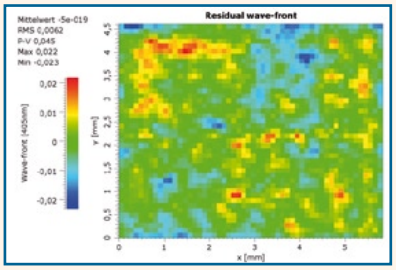
Linear range (absolute tilt feature): wavefronts with a large global tilt (±10 degree) can be directly measured with high accuracy.

Dynamic range: wavefronts with extreme asphericity can be measured. The local radius of curvature can be as low as 10mm, i.e., 100 dptr.

The SHSLab features work without moving parts or sequential techniques, thus not compromising the high evaluation speed.

Excellent basic accuracy

SHSLab provides an excellent "basic accuracy" which is defined as the accuracy that can be achieved without subtracting reference measurements. The basic accuracy is typically better than λ/15. This is especially helpful in testing lasers and laser systems where often a calibration measurement is difficult or even not available at all.



Basic accuracy of SHSLab HR 405nm below λ/20 (peak-to-valley)

High reliability and measurement speed

Due to the outstanding quality of its components the SHSLab systems offer a high reliability in daily metrology applications. SHSLab delivers reproducible results under difficult environmental conditions.

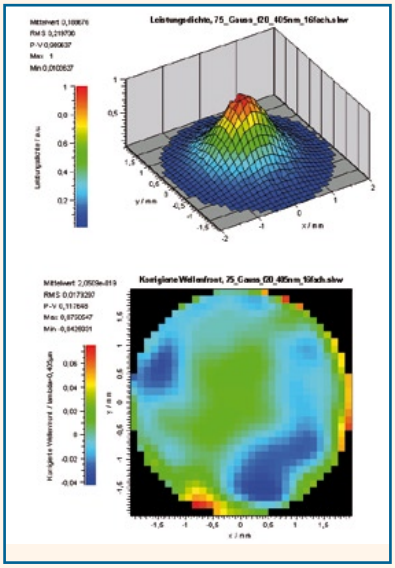
Including evaluation and display of the results the repetition rate of standard SHSLab systems is 5 to 30Hz depending on the sensor type.

Application example for SHSLab

Laserbeam characterisation

SHSLab HR-110-FW is a Shack-Hartmann sensor especially suited for measuring small laser beams.

Here, the measurement of a laser beam of a 405nm laser diode is shown. Functions and parameters like wavefront, aberrations, power density, PSF, wavefront radius of curvature, beam diameter (ISO 11146) and M^2 are readily available. Here, the measured M^2 value is 1.10.



Advantages of SHSLab

- No reference wavefront necessary because of high basic accuracy
- Extreme dynamic range: $2x10^4$
- High intensity dynamics: 1:500
- High evaluation speed: 12 Hz

SHSCam – Wavefront Sensor Head

SHSCam is thoroughly designed and fabricated using finest electronic, mechanical and microoptical components. Thus, SHSCam provides the technical basis for high accuracy wavefront measurements.

Optocraft offers several standard versions of SHSCam using cameras with different chip size and resolution and microlens arrays with different design parameters. An overview of these sensor versions is shown in the table on the next page.

Beyond standard SHSCam, Optocraft designs and fabricates custom-made sensors individually adapted to the customers need.

SHSCam wavefront sensor head

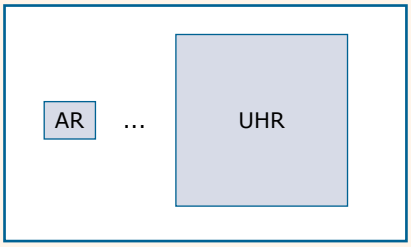
How to choose a suitable SHSCam?

The elementary specifications that have to be determined during the selection process are:

- Size of detection area
- Lateral resolution versus angular resolution
- Spectral bandwidth

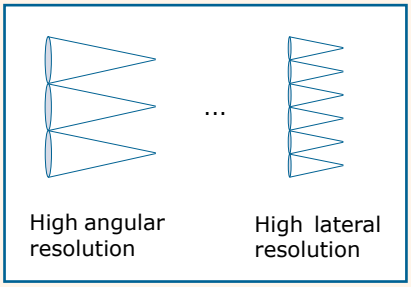
Size of the detection area

One basic question to be decided is which size the detection area of the sensor has to cover. From the application point of view one has to decide whether auxiliary optics such as telescopes can be used to increase or decrease the effective detection area. Of course, a larger detection area mostly increases the lateral resolution.



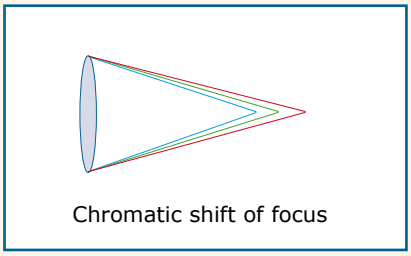
Lateral versus angular resolution

Balancing lateral versus angular resolution is another important degree of freedom to be determined. This fundamental trade off should be optimized for a specific application. For instance, increasing the focal length will yield higher angular resolution. However, the size of the individual microlenses has to be increased at the same time and thus results in a lower lateral resolution.



Spectral bandwidth

One of the main advantages of SHSLab is that it can principally be used at a broad range of wavelengths. Due to underlying microoptical principles the broader the bandwidth the less optimized the sensor will be with respect to resolution or dynamics. This principle does not put hard restrictions on the usage, but should be taken into account for selected applications to yield optimum measurement results.



Chromatic shift of focus

Optocraft‘s experts will assist in the evaluation of your application and the selection of the most suitable SHSLab version.

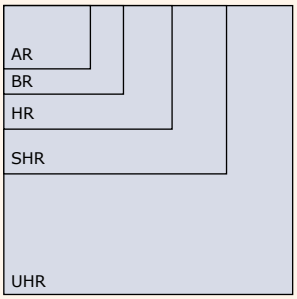
SHSCam – Product Specifications

SHSCam for 375 ... 1064 nm

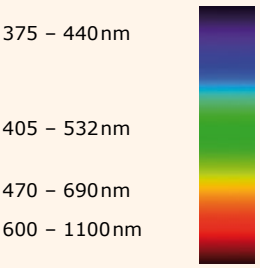
	Detection area	Lateral resolution	Greyscales	Evaluation rate[1]	Angular accuracy per microlens[1]	Angular accuracy of all spots of SHSCam[1]	Minimum local wave-front curvature[1]	Basic accuracy in pv of wavefront[1, 2]	Repeatability in rms of wavefront difference[1]
	mm×mm		Bit	Hz	µrad	µrad	mm	nm	nm
SHSCam AR	4.7×3.5	36×27	8	15	160	5	9	40	2
SHSCam BR	6.4×4.8	43×32, 49×37, 58×43	10	10	100, 160, 230	3, 4, 5	14, 9, 6	40, 45, 50	2, 2, 3
SHSCam HR	8.9×6.6	59×44, 69×51	8, 12	10	140, 220	3, 4	14, 9	40, 50	2, 3
SHSCam SHR	11.7×8.9	78×59	8, 10	10	160	2	14	60	2
SHSCam UHR	15.1×15.1	101×101, 116×116	8, 10	4	160, 250	2, 2	14, 9	90, 90	2, 3

	Dimension (mm)	Weight (kg)	Camera bus
SHSCam AR	30×30×30	0.1	FW
SHSCam BR	44×29×58	0.15	FW
SHSCam HR	45×45×115	0.27	FW
SHSCam SHR	40×50×120	0.35	CL
SHSCam UHR	51×51×47/85	0.2	CL/GE

Detection areas



Typical wavelength ranges for broadband sensors[3]



SHSCam for UV or NIR[4]

	Wavelength (nm)	Lateral resolution	Bit	Detection area (mm)	Evaluation rate (Hz)	Camera bus
SHSCam UV	193 (375)	69×68	10	9.0×9.0	10	LVDS
SHSCam IR1580	1500–1580	41×32	8	6.2×4.8	15	Analog
SHSCam IR1310	1000–1310	37×29	8	9.0×7.1	15	USB
SHSCam IR1700	1000–1700	20×16	12	9.6×7.7	20	USB, CL

Options	Accessories
Workstation/Notebook	C-Mount grey filters, C-Mount iris stop
Absolute-Tilt (masked microlens)	Calibration lightsources (e.g. 405, 470, 532, 635, 790, 1064 nm)
	Laser beam expander (1/2×, 1/4×, 1/8× and vice versa)
	Compact module for testing in reflected light available

[1] Typically specified values for standard parameters without averaging

[2] "Out of box" accuracy, i.e., pv deviation on maximum circular diameter without subtraction of a reference wavefront

[3] Other wavelength ranges possible

[4] Please ask for detailed specification

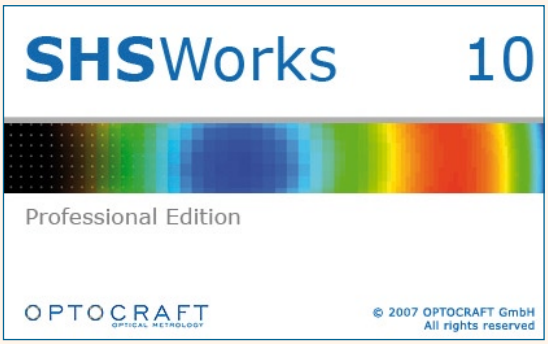
SHSWorks – Wavefront Metrology Software

SHSWorks is a comprehensive metrology software package covering nearly every functionality one could desire in daily metrology business.

SHSWorks provides

- Ease of use: SHSWorks offers comprehensive algorithms for tuning key parameters automatically.
- Flexibility: nearly every parameter can be set explicitly in case it is necessary.
- Accuracy and reliability: through many years of development SHSWorks.

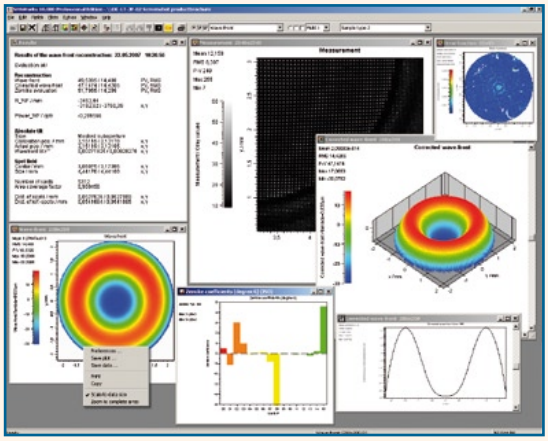
SHSWorks is available in two different packages (see table on p. 9).



Which applications can be covered?

No matter whether the wavefront under investigation is aberrated by refraction, reflection or diffraction, SHSWorks provides an answer by means of adequate evaluation functions. SHSWorks is the ideal tool for

- Laser beam characterization
- Measurement of optics in transmission
- Measurement of optics in reflection
- Alignment of optical systems
- Adaptive optics applications



SHSWorks user interface

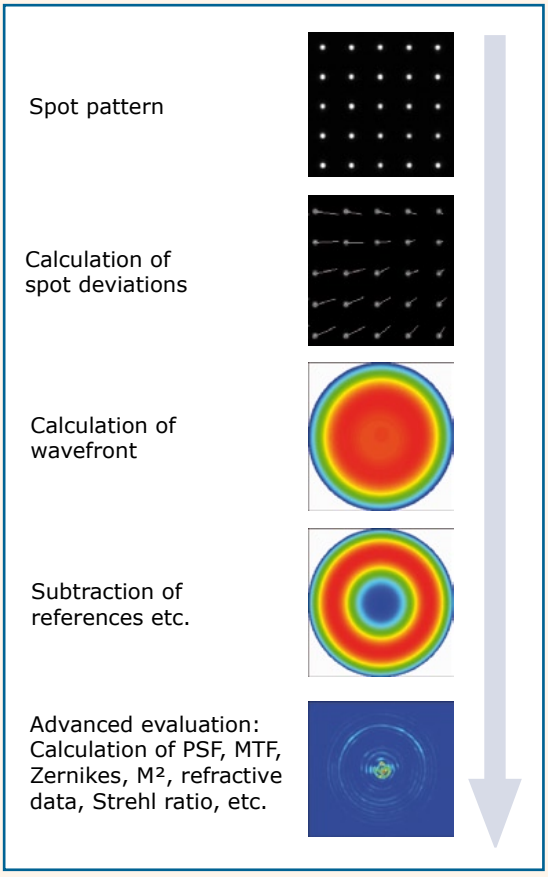
How does SHSWorks work?

Starting from the calculated position and intensity of the spots in a first step the wavefront is derived. After that various advanced evaluations can be carried out: special representations such as Zernike polynomials can be calculated or optical functions such as the point-spread- (PSF) or the modulation-transfer-function (MTF).

Also integral numbers such as wavefront tilt, refractive power, M^2 or the common Strehl ratio are calculated and displayed by SHSWorks.

After the algorithms are carried out, the results can be displayed numerically and graphically, can be summarized in a passfail analysis tool and can be transferred to other software by using data link functionality.

The complete evalution process is available in real-time or offline.



Evaluation process of SHSWorks

SHSWorks – Features and Specifications

Selected functions and features

Absolute tilt – SHSWorks uses a special method for registration of the position of the total spot field on the camera chip. By this means extreme global wave-front tilts can be measured. Thus, even for measurement tasks with poor pre-alignment (e.g., in automation) an accurate and deterministic feedback is provided.

Extended spot assignment – In normal Shack-Hartmann systems the evaluation of steep wavefronts leads to strong ambiguities. SHSWorks comprises an unique algorithm for solving these problems: wavefronts with a local curvature down to about 10mm can be measured reliably.

Comprehensive calibration features – SHSWorks offers calibration functions such as subtracting a dark reference and subtracting a wavefront reference. Beyond these, so called synthetic references can be used to account for special aspherical wavefronts that are generated by optical components and systems by design.

Auto functions – Several key parameters such as frame offsets, spot thresholds and spot sizes have to be adjusted during a Shack-Hartmann evaluation. These parameters are of critical importance with respect to highest possible accuracy and reliability. For key evaluation parameters SHSWorks offers powerful functionality for automatic adjustment.

Automation and integration – In many applications it is necessary to transfer data from SHSWorks to other software for further processing (e.g., storage to database, automation, further evaluation, etc.). For this purpose SHSWorks offers two powerful functions, a TCP/IP link and a SHSUser.DLL.

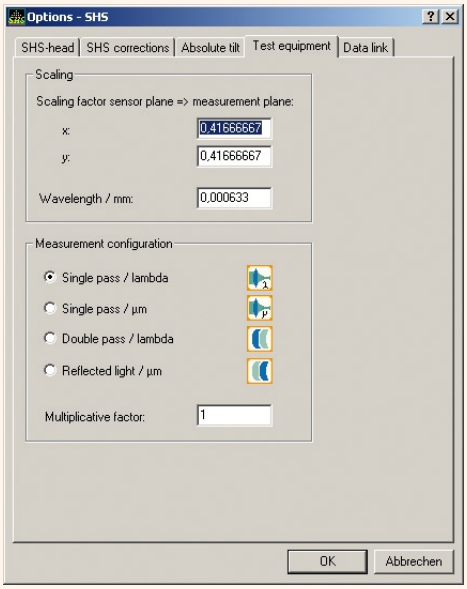
SHSWorks Pro and Std packages

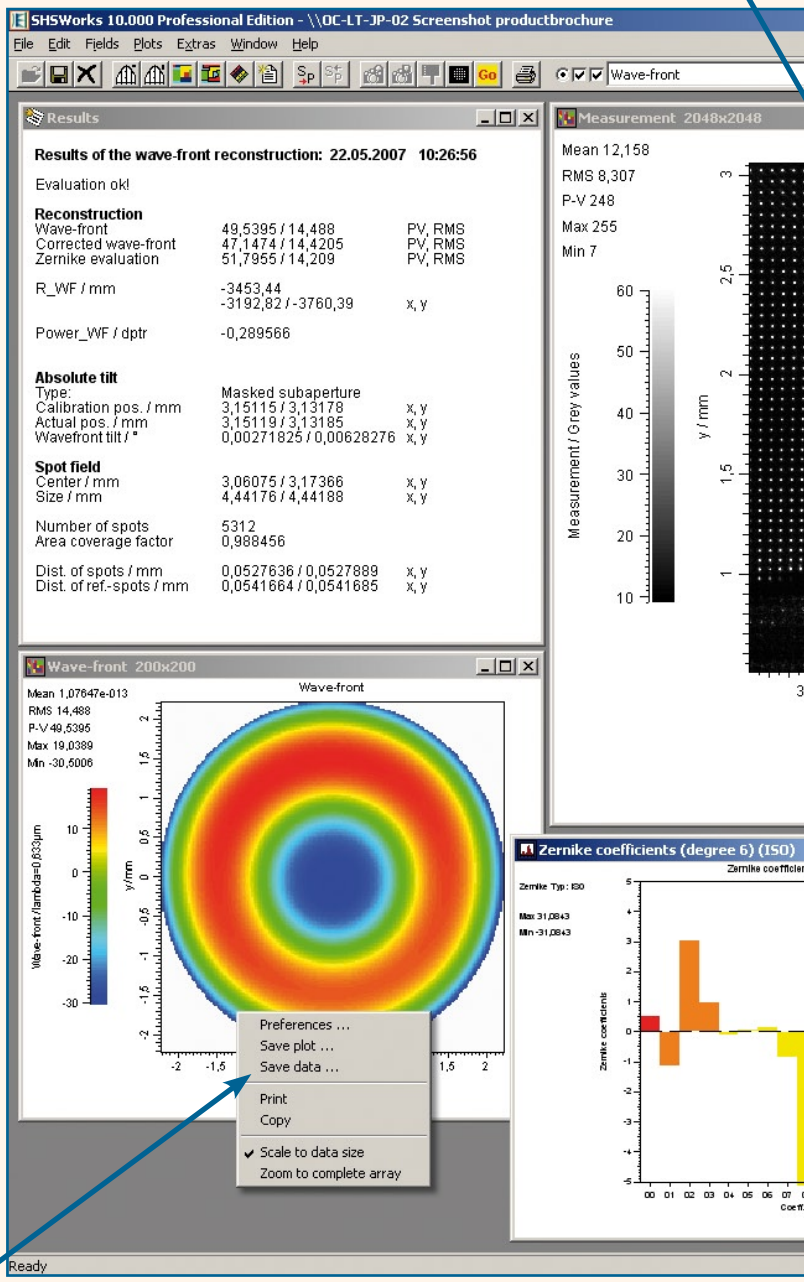
		Pro	Std
Measured data	Spot positions and spot intensities	×	×
	Wave-front	×	×
	Zernike analysis (ISO, Born & Wolf)	×	×
	PSF, MTF	×	
	Refractive data: sphere, cylinder, prism	×	×
	Focal length, centration etc.	×	×
Advanced functionality			
	High dynamic range	×	×
	Absolute tilt feature	×	×
	Fast evaluation	×	×
	Beam diagnostics (M^2)	×	×
	Auto functions for parameters	×	×
	Predefined parameter sets for different test configurations	×	×
	Online data access with SHSUser.DLL or TCP/IP	×	×
	Archiving functions	×	×
	Access restriction for production environment	×	
	Pass/Fail analysis	×	
	Synthetic reference features	×	×
	Vision control camera (VCC)	×	
	Length measurement tool accessible	×	×
System data			
Grabber and bus systems	CameraLink, FireWire 1394, GigE, LVDS, USB, …	×	×
Resolution	Up to 4096x4096 pixels	×	×
Greyscale	Up to 16 Bit	×	×
Evaluation rate	Up to 30 Hz	×	×
Operating system	Microsoft Windows XP	×	×
Trigger function	External/internal (TTL/software trigger)	×	×

SHSWorks – Screen Overview

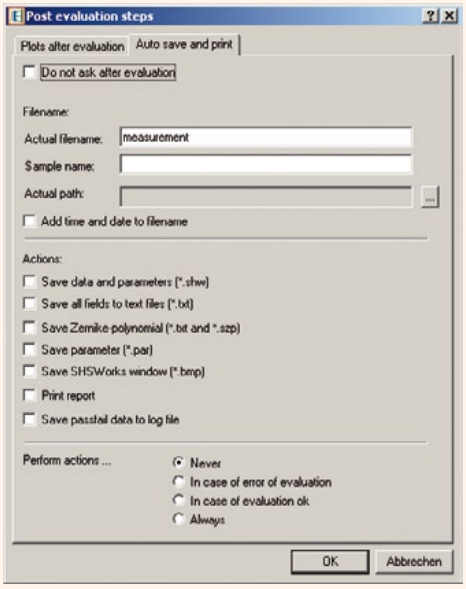
Different camera and bus types

System configuration



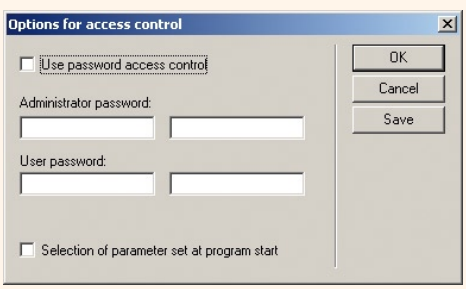


Advanced reporting routines



Export of all plots and data

Different access modes



2D, 3D, co
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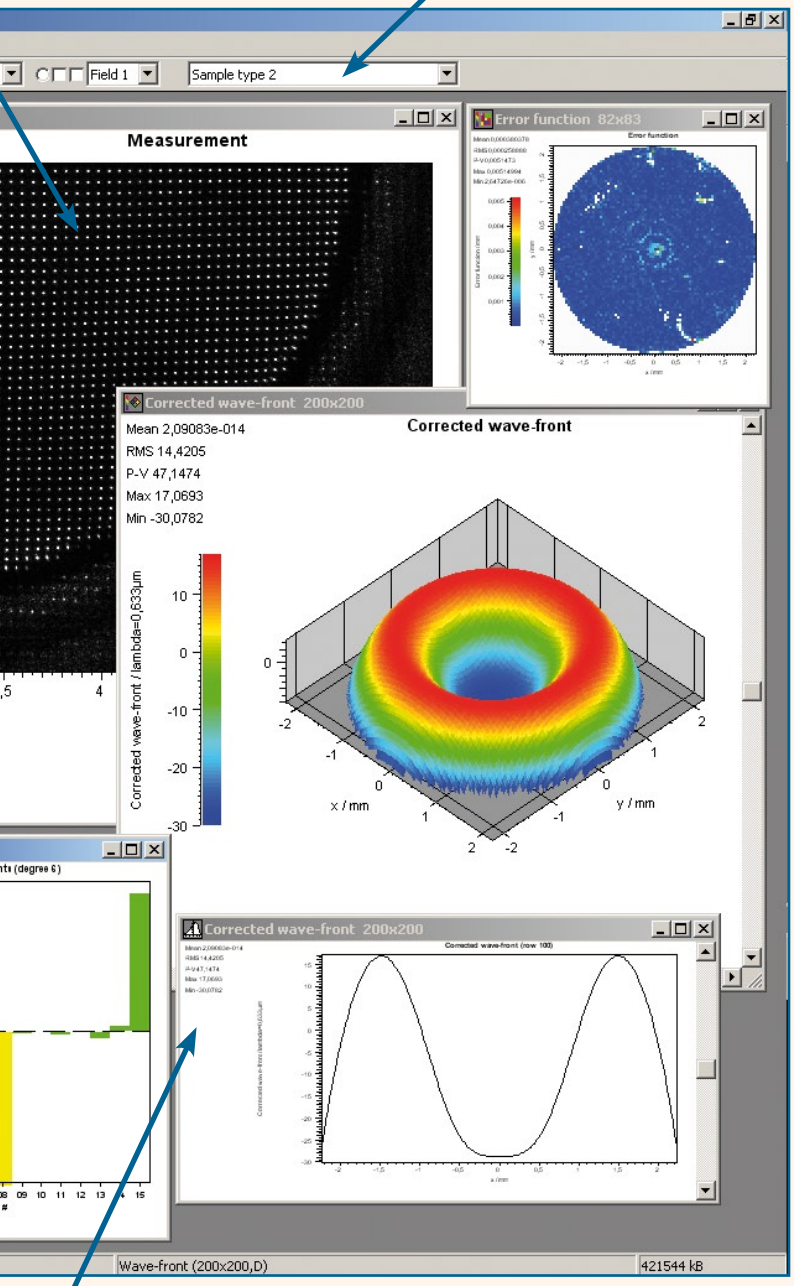
SHSWorks – Screen Overview

Predefined configurations



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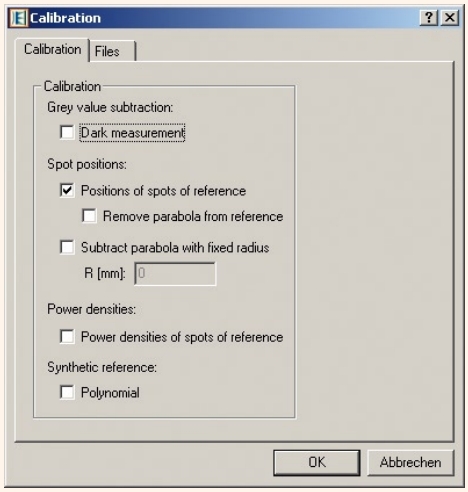
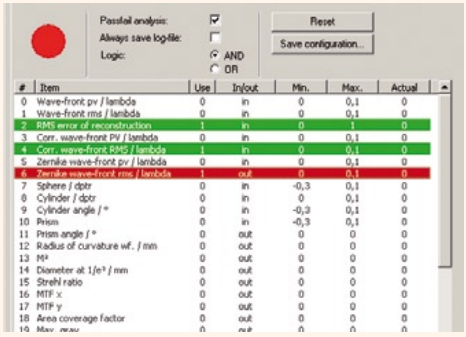
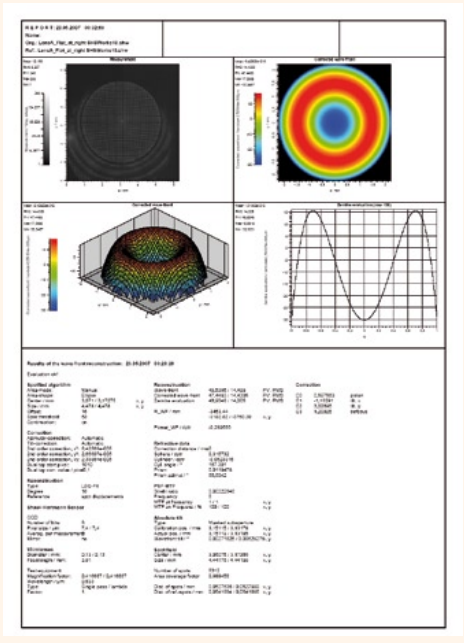
Comprehensive calibration features



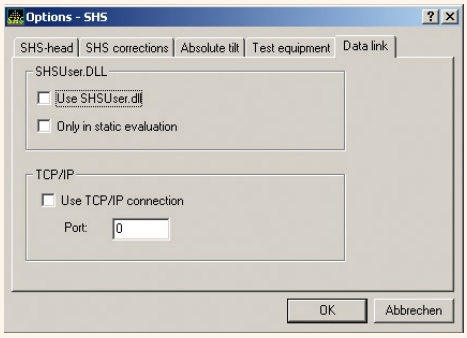
Pass/fail analysis



Flexible reporting



External data link



SHSInspect – The Versatile Manual Optics Tester

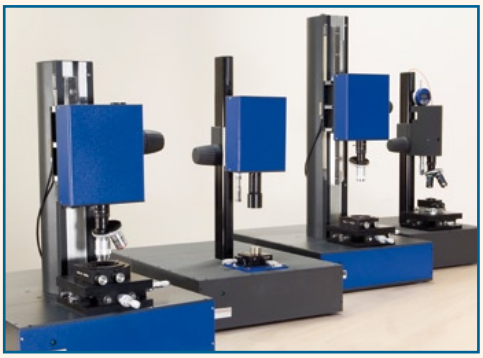
SHSInspect is the versatile manual optics tester for

- Aspheres, spheres, cylinders
- Micro-optical systems
- Objectives
- Flat optics and filters

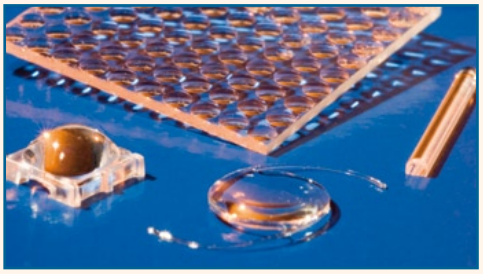
It is widely used by manufacturers of mobile phone objectives, contact lenses, telescopes, data-storage systems, consumer optics, etc.

Preconfigured systems that provide a comfortable, easy-to-use access to nearly all desirable optical parameters are available for a range of standard applications. For special applications, the platform can be tailored to meet exactly the customer's requirements.

The core of the platform are Optocraft's SHSLab wavefront sensors that are integrated into the optical modules.



SHSInspect-TL-RL-UHR



Typical samples for SHSInspect

Standard Modules of the SHSInspect

- Platform: Sample mount and alignment, illumination optics
- Lightsource(s): Fiber-coupled, standard wavelength: 635nm, integrated into the body of the platform.
- RL (=reflected light) module: Test of surface deviations
  SHSCam sensor
  Plane or spherical sample illumination
- TL (=transmitted light) module: Test of function and performance
  SHSCam sensor
  Relay optics
- VCC (vision control camera) module: Visual inspection of the sample, high precision alignment

Application Dependent Selection of SHSInspect Modules

	Wavefront	MTF, PSF, Strehl	EFL	BFL	Surface deviations	Radius of curvature	Centration	Chromatic aberrations	High precision sample alignment	Sample defects
Platform	×	×	×	×	×	×	×	×	×	×
Light source	×	×	×	×	×	×	×	×	×	×
RL-module				×	×	×			×	
SHSCam for RL-module				×	×	×			×	
TL-module	×	×	×	×			×	×	×	×
SHSCam for TL-module	×	×	×	×			×	×	×	×
VCC module									×	×
Auxiliary light sources								×		

SHSInspect – Modules Overview

Platform

Illumination optics	plane or spherical illumination
Sample alignment	x, y (13mm travel), α,β (±2°, 0.004° resolution)
Sample mount	customer specific
Standard vertical stand	coarse and fine vertical alignment (resolution: 10µm) of light source, height: 300mm
Size and mass	length × width × height, mass
SHSInspect compact basic	400mm × 320mm × 120mm + stand, 16kg
SHSInspect compact pro	540mm × 400mm × 120mm + stand, 22kg
SHSInspect table	790mm × 860mm × 750mm + stand, 80kg
Powersupply	110V … 240V

Light source

Fiber coupled single mode fiber, adjustable intensity

Standard wavelength	635nm
Wavelength range	405nm … 1064nm (other wavelengths on request)

RL-module (reflected light module)

Also available as stand-alone.

Sample types	convex and concave, flat optics, spherical, aspherical, cylindrical
Sample diameter	0.2mm … 1000mm for concave (other diameters with auxiliary optics) 0.2mm … 50mm for convex (other diameters with auxiliary optics)

TL-module (transmitted light module)

Sample types	Positive, negative, afocal, spherical, flat, aspherical, cylindrical	
Sample diameter	SHSInspect compact basic:	1mm … 28mm
	SHSInspect compact pro:	0.2mm … 28mm
	SHSInspect table:	0.2 … 100mm
Numerical aperture	0 … 0.9	

VCC-module (vision control camera; add-on to TL-module)

Camera for the visual inspection of the sample.

Applications	size measurement, defect recognition (scratches etc.), precise mask alignment, exact alignment of conjugate sensor and sample planes

Options and accessories

Custom made modules	tailored measurement systems for non-standard applications
Ultra stable vertical stand	fine alignment: 200µm / revolution; height: up to 1000mm
Position encoder (z-position)	0.1µm resolution, connection to SHSWorks software
Sample alignment	γ (azimuthal rotation), differential micrometer screws
Motorized sample alignment	PC or joystick controlled
Relay telescopes	optimum adaptation of sample diameter to SHSCam sensor size
Auxiliary optics	different microscope objectives and illumination optics
Computer	state-of-the-art workstation or laptop

SHSInspect – Implementation Examples

SHSInspect-TL-SHR-2"

SHSInspect-TL-SHR-2" is a measuring tool for elements with a diameter up to 53mm.

Parameters like wavefront, corrected wavefront, MTF, PSF, EFL, and centering are readily available. The system is both suitable for the manufacturer's final inspection and the customer's reception inspection. The shown version was tailored to the testing of molded 2" lenses.

SHSInspect-TL-SHR-2"

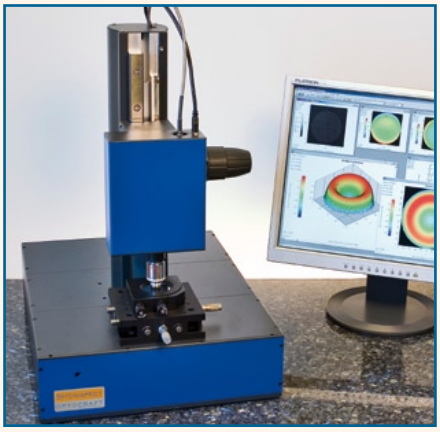
Platform:	SHSInspect-table
Light source:	λ=635nm, coupled to single-mode fiber
SHSCam:	SHR-150-CL, lateral resolution: 78×59 microlenses, CameraLink interface
TL-module:	comprises a relay telescope with magnification 1:7.1
Vertical stand:	ultra stable version, height: 950mm, travel: 650mm
Illumination:	spherical illumination (NA=0.2), plane wave illumination with auxiliary collimation lens

SHSInspect-TL-RL-UHR

The SHSInspect-TL-RL-UHR is designed for the measurement of small, strong aspheres.

Equipped both with a transmitted and reflected light module, advanced alignment strategies can be used which allow for the precise tip/tilt (<150µrad) and lateral positioning of the sample.

Due to the high dynamic range of the SHSCam UHR sensor, single components of an objective, e.g., for cellular phone cameras which are not individually corrected can be measured.

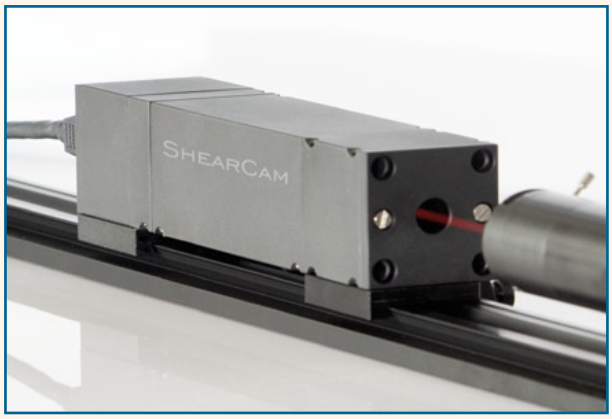


SHSInspect-TL-RL-UHR

Platform:	SHSInspect compact pro
Light source:	λ=635nm, coupled to single-mode fiber
TL-module:	equipped with different relay telescopes, sample diameter: 0.2mm … 5mm
SHSCam-TL:	UHR-130-CL, lateral resolution: 101x101 microlenses, CameraLink interface
RL-module:	internal magnification 1:1, collimated beam, diameter 16mm
SHSCam-RL:	BR-110-FW, lateral resolution: 58x43 microlenses, Firewire interface
Vertical stand:	ultra stable version, height: 650mm, travel: 350mm
Illumination:	plane wave illumination, different microscope objectives for high NA spherical illumination
Accessories:	position encoder (0.1µm resolution) for precise measurements of BFL and illumination from a defined distance from the vertex of the sample (comparison to synthetic reference)

ShearCam – The Laser Beam Collimator

Collimation of "difficult" beams



ShearCam is OPTOCRAFTs handy tool for visual inspection and collimation of laser and LED beams. Contrary to classical shear plates, "difficult" laser beams with

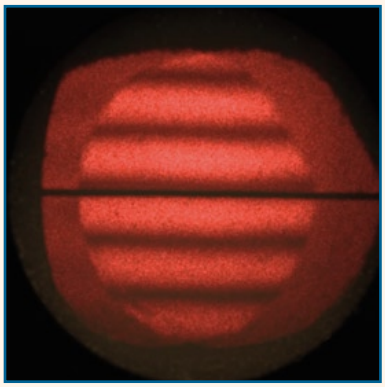
- low coherence
- small diameters

can easily be measured. ShearCam still shows high contrast for temporally partial coherent light sources such as certain laser diodes or even LEDs, which cannot be collimated by means of conventional shear plates (see example below).

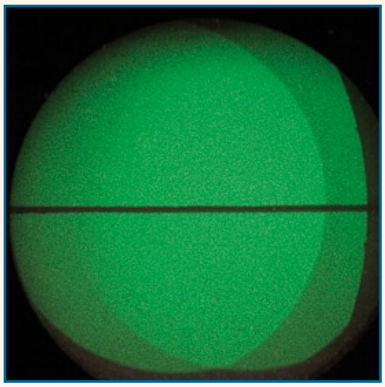
It is available for different ranges of wavelengths and diameters. ShearCam is low cost and straight forward to use.

Range of collimation applications:

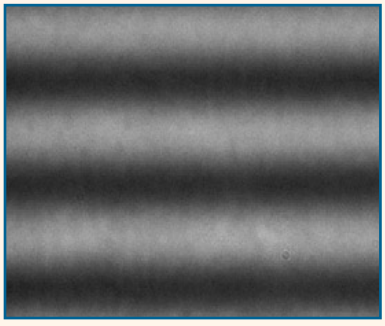
- Beams of laser diodes and LEDs
- Small beam diameters
- CD/DVD pickups
- General collimation alignment tasks



Collimated beam from a laser diode with classical shear plate



Collimated beam from LED module with classical shear plate



Collimated beam from LED module with ShearCam

Specifications

System	Interferometric tool for laser beam collimation Extended range for small diameters Extended coherence range Alternative to shearplates	
Powerful performance	Highest accuracy due to interferometric measurement method Extraordinary contrast even in case of partial temporal and spatial coherence, even for LEDs Digital camera for comfortable usage and archiving	
Technical data	Beam diameter: ROC precision: Wavelength range: Camera: Vision and archiving functions: Size: Weight:	1mm … 5mm 100m (for beams with 5mm diameters) 193nm … 1064nm (different versions) 8 Bit, 658×494 Pixel live video, load, save, print 40mm × 40mm × 200mm 600g

SHSAutolab – Automated Optics Testing

SHSAutolab for 100% control of optics

SHSAutolab is the platform for automated quality assurance and optics fabrication. It speeds up the workflow, ensures product quality thanks to reliable control measurements and also enables optimization of final optical systems that use the tested optical components. SHSAutolab keeps the total measurement time low and thus allows for 100% control of wafer-based, array-manufactured or molded optics and micro-optics. Single elements for examples packaged in trays can also be handled. SHSAutolab can be profitably applied for the final inspection at the manufacturer´s site. Even for large quantities of micro-optical components, the manufacturer can provide complete test reports for each individual component. Obviously, the pass/fail analysis can be automated.

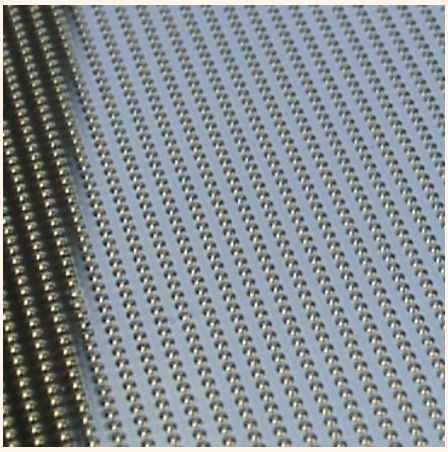
SHSAutolab fulfills the demand for easy handling by full automation and allows for the complete mapping of the measured results.

SHSAutolab for wafer-based micro lenses

Series testing and adjustment of micro-optics

The SHSAutolab platform for wafer-based optics is provided through successful cooperation of two strong business partners: AMICRA Microtechnologies and OPTOCRAFT Optical Metrology. The automation and the handling of the test samples is performed by the reliable Amicra technical equipment. In SHSAutolab, high-precision handling and positioning assisted by sophisticated software for automation work seamlessly together with the optical measurement technology provided by Optocraft.

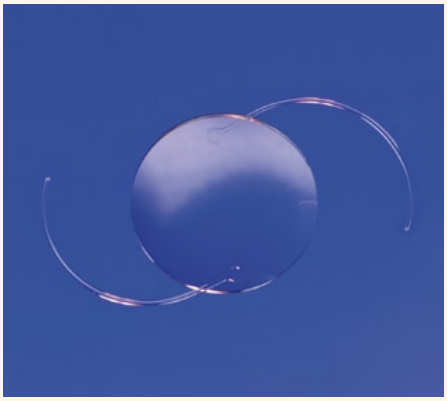
Several versions of the SHSAutolab are available to cover a wide range of optical and technical products to be tested. Individual measurement setups allow for the characterization of the test samples in a transmission or a reflection constellation. Moreover, the SHSAutolab platform can be expanded for the automated assembly of micro-optical systems. The feedback during adjustment provided by wavefront measurements and information from image processing allows for a range of assembly strategies. The usage of the SHSLab wavefront measurement technology enables high-precision measurements coupled with the suppression of external vibrations and other disturbing influences.



Silicon micro lens array

Tesing of Ophthalmic Optics (IOL, Contacts)

SHSAutolab is also available with options suitable for series measurment of ophthamlmic optical products such as intra-ocular lenses (IOLs) or contacts. The measurements will be performed according to applicable standards and allow for individual tracking of the samples. Both, dry and wet measurements are possible.



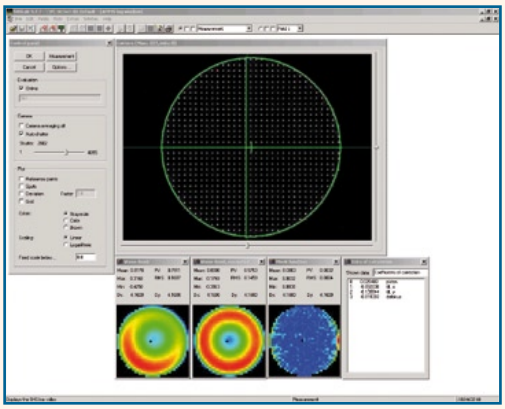
Intra ocular lens

SHSAutolab – Applications and Parameters

Application in optical testing

SHSAutolab is well-qualified for the characterization of:

- Micro-lenses for telecom applications
- Lenses for optical storage applications
- Camera objectives for mobile devices
- Optics for automotive vision systems
- Miscellaneous micro lenses or micro-optical systems
- Semiconductor laser modules (e.g., VCSELs)



Measurement of a individual lens on a wafer

Characterization parameters

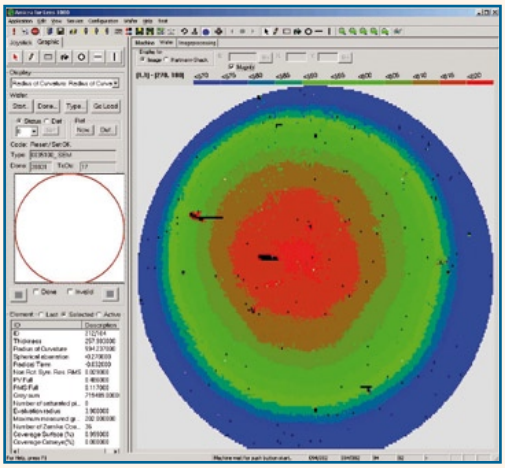
Depending on the principal measurement constellation, various parameters can be registered. All parameters can be handled by a pass/fail-analysis or can for instance be mapped onto a wafer. The SHSAutolab is also capable of characterizing single elements. The following parameters can be measured:

Transmitted light setup:

- Imaging quality: wave-front, PSF, MTF, etc.
- Imaging parameters: focal length, chromatic errors etc.
- Laser beam parameters

Reflected light setup:

- Surface deviation
- Radius of curvature
- Thickness



Mapping of ROC on a micro lens wafer

System assembly

The SHSAutolab platform can also be used for the high-precision assembly of micro optical systems. Because both wavefront and image information are used for adjustment feedback, positioning can be optimized simultaneously for speed and final product performance.

Software for automation and measurement

Although the SHSAutolab software provides many features for the customization of measurement and evaluation parameters, easy operation is ensured. Several automation modes for the choice of parameters allow an intuitive handling. The high dynamic range for the curvature of the wavefront and the automatic intensity control help finding the ideal measurement position even for unfavorable starting points of the prealignment.

The wide-ranging options for series measurement automation, mapping and export of data permit the seamless connection to subsequent production steps or to other tools for further evaluation. The deployment of SHSAutolab during the development speeds up the optimization of the process parameters and quickly enables a high yield.

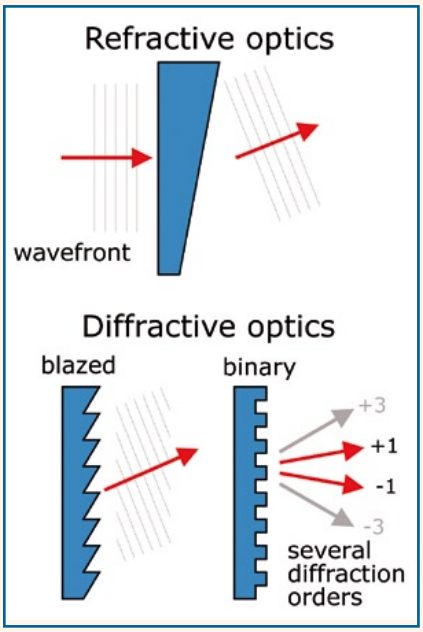
DOE – Diffractive Optical Elements

Principle

The principle of diffractive optical elements, DOEs (also called computer-generated holograms, CGHs, if patterned lithographically), is based on the diffraction of light. The transition from a refractive to a diffractive optical element can be graphically understood by the removal of material which causes a phase delay of a multiple of the associated wavelength. Hence, a diffractive element has a wavelength dependency which must be considered for the particular application. This dependency can be actively used for wavelength filtering or for achromatization. Compared to their refractive counterparts, DOEs are thin, structured elements which save space and weight.

Application-specific solutions

To calculate the pattern of DOEs or CGHs, Optocraft uses its extensive design software that has been developed during many years of research. This software tool allows to encode not only simple optical elements, such as lenses and gratings, but also more complex functions described by polynomials. Iterative Fourier methods (IFTA) are also included as well as geometrical calculation methods, such as inverse ray-tracing (IRT). Depending on the application, the DOE can be manufactured for example as binary amplitude mask or as quasi-continuous phase mask. In addition to the design and the production, Optocraft offers the dimensioning of optical systems, including DOEs, feasibility studies are performed for the customer's DOE application. Moreover, special attention is drawn to the use of DOEs as a null-lens in combination with the wavefront sensor SHSLab for the testing of aspherical lenses and surfaces.



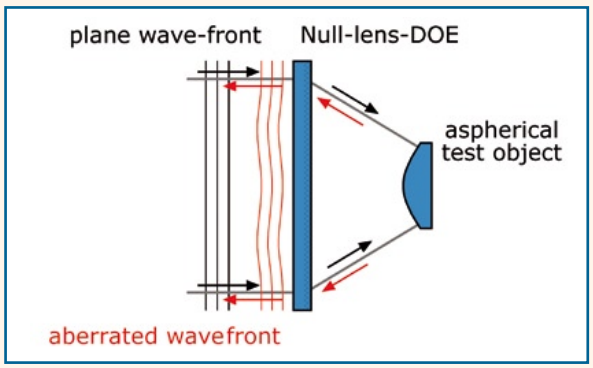
Refractive and diffractive optics

DOE for aphere testing

Application examples

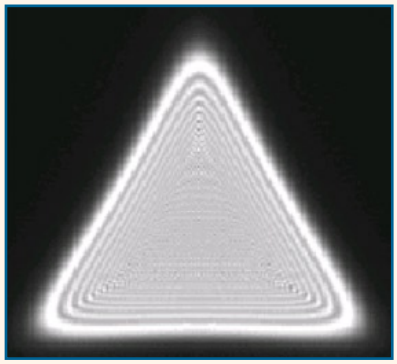
DOE for wave-front shaping

Setup for testing aspherical surfaces. The DOE has the function of a null-lens, i.e., it is carrying the reference information of the aspherical surface shape.



DOE for beam shaping

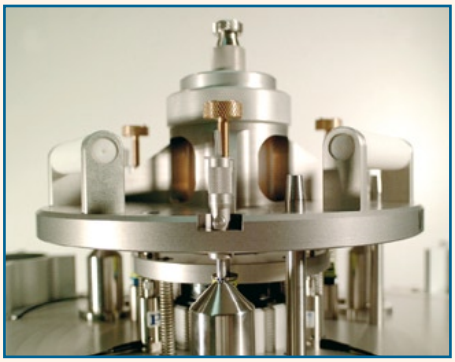
Generation of an equilateral triangle in a target focal plane. The input beam impinging on the round hologram has a homogeneous intensity.



Custom made products, Studies and Services

Comprehensive knowledge

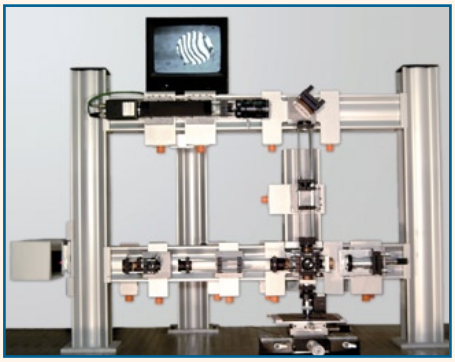
Optocraft combines its know-how in the areas of interferometry, wavefront sensing and mirco-optics to serve the customers needs. For instance, Optocraft offers two basic types of interferometers for micro optics measurements which are not available elsewhere. Customized systems may comprise diffractive null optics (DOE), shearing units as well as our standard SHSLab sensors. Optocraft also provides a phase shifting interferometry software which is individually adapted to the various types of interferometers.



Custom Fizeau Interferometer

Twyman-Green interferometer

The Twyman-Green interferometer for surface measurement of micro optics uses several features to optimize the measurement of micro lenses with small diameters and ROCs in the range of down to 100µm. Partial coherent illumination and zoom optics facilitate the measurement and deliver reproducible and reliable results.



Twyman-Green interferometer for micro lenses

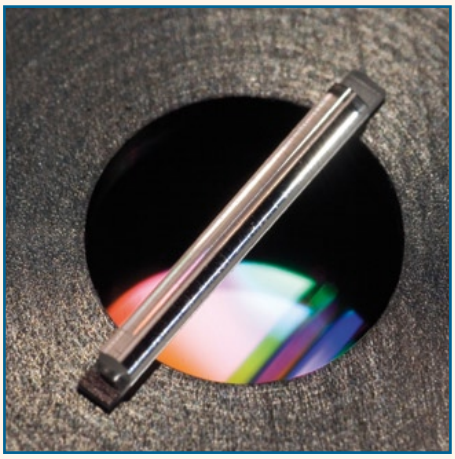
Mach-Zehnder interferometer

Spherical or plane micro optics

Measuring micro optics in transmission requires special precautions which are fulfilled by the Mach-Zehnder interferometers. It can be toggled for spherical or plane illumination to cover a wide range of sample types from high numerical aperture lenses to plane optics.

Fast axis collimation (FAC) lenses

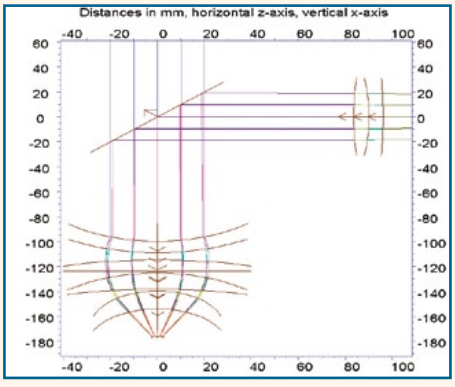
A special version allows for high precision and high lateral resolution measurements of FAC cylindrical lenses with high numerical aperture. This Mach-Zehnder interferometer is utilizing a DOE as null optics and allows for transmission measurement of FAC lenses with numerical aperture exceeding 0,8.



FAC lens inside Mach-Zehnder interferometer

Studies and services

Feasibility studies and metrology services allow the customer to evaluate the quality of the aimed metrology system. Inhouse design capabilities and experimental experience ensure a straight forward approach towards a capable solution.



Optics design simulation

How to reach us

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