Ultimate Optics Testing

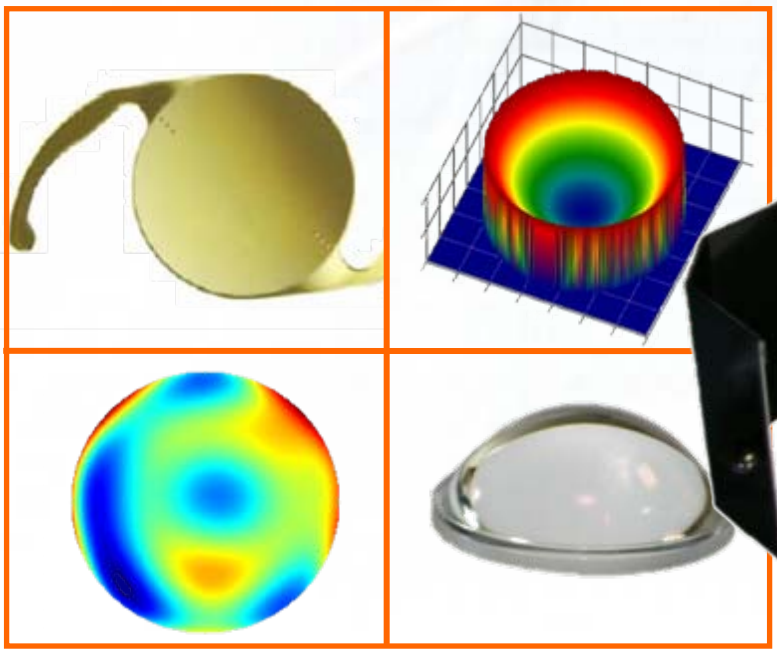
WaveGauge®

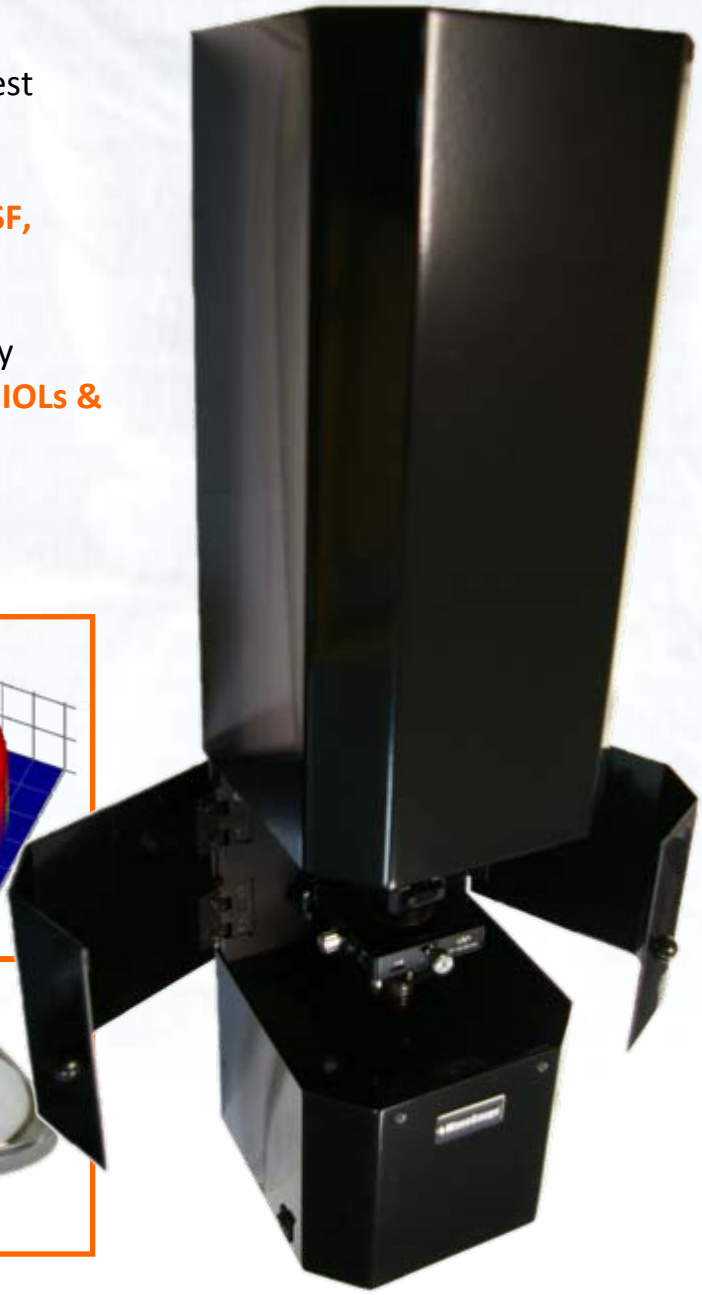
New Generation Of Optics Tester

Unrivaled performance based on latest advances in wavefront analysis

A step beyond for measuring **MTF, PSF, Aberrations**

Meet the most demanding metrology requirements of latest **aspherics** and **IOLs & Contact** lenses





High End Lens Tester for Research & Production Lines

PhaseView®
The Digital Wavefront Company

WaveGauge® - The Highest Resolution Lens Tester

WaveGauge® are turnkey solutions based on Digital Wavefront Technology designed to meet the most demanding requirements for quality assurance, research & development and production environments. **WaveGauge®** provides real time analysis of lenses with high speed, accuracy and unprecedented resolution. Simultaneous intensity and high-resolution wavefront mapping enables surface quality visualization and aberration analysis of most complicated lenses with spherical, aspheric or toric shape.

All critical parameters in lens testing such as MTF, PSF, aberrations, surface quality, can be accurately measured and compared with lens design or reference data.

Automation

For on-line production requirements, motorized tray with several lenses can be implemented and automatically driven by the software.

A broad range of applications

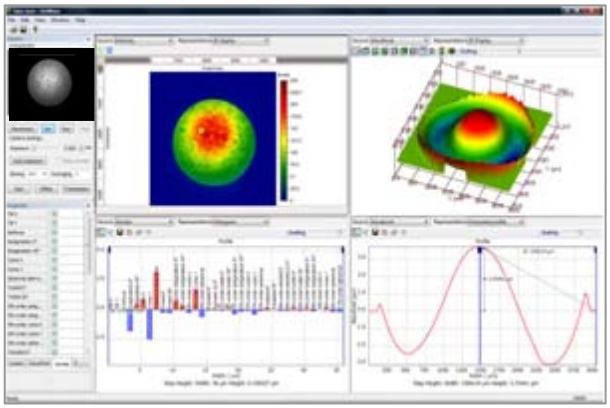
Microlenses in mobile phones, digital cameras, pickup lenses for optical storage drives, single aspherics used to build compact imaging systems.

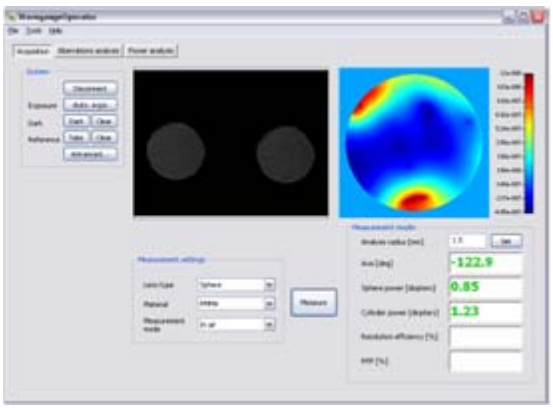
Ophthalmic lenses such as contact lenses, monofocal spherical, cylinder, toric, as well as multifocal Intraocular lenses (IOL).

Designed for Ultimate Performance

WaveGauge® system has been designed in transmission setup to optimize measurements of optical power, aberrations and MTF. Standard configuration contains specially designed collimated light source, a lens holder and PhaseView's **Digital Wavefront Camera®**. All parts are fully enclosed in an ergonomic packaging to avoid parasitic light and contamination coming from dust and particles.

The software includes a supervisor level adapted to R&D tasks with various ways of displaying results and extended analysis features and an operator level for routine and production purpose with pass / fail analysis to increase productivity and throughput.





WaveGauge® - Lens Testing Without Compromise

Conventional methods have various limitations for measuring aspherics and ophthalmic lenses, those limitations include either resolution and dynamic range, measurement speed, sensitivity to vibrations or non measured parameter such as modulation transfer function.

Interferometers and Shack-Hartmann based wavefront sensors are the leading technologies for lens testing. Nowadays, wavefront sensing is considered in this market as cutting-edge technology with numerous advantages: flexibility, reliability, vibration free and as cost effective metrology tool.

WaveGauge® systems are based on **Digital Wavefront Cameras®** that represent state-of-the art wavefront sensing technology as new generation of wavefront sensors offering strong value added versus conventional Shack-Hartmann sensors.

High Dynamic Range compared to Interferometers

Shack-Hartmann wavefront sensors and Digital Wavefront Cameras® are both able to measure wavefronts with strong aberrations which are not accessible with interferometers. The lack of dynamic range in interferometers is solved at the expense of diffractive null optics that need to be designed for each type of measured lens which is less flexible and much more expensive.

High Resolution compared to Shack-Hartmann sensors

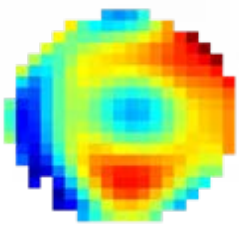
Digital Wavefront Cameras® provide high resolution native wavefront maps as their spatial resolution is directly related to CCD resolution. Instead of using lenslet array for detecting wavefront distortion, Digital Wavefront Cameras® use intensity signal to extract phase information thereby overcoming the inherent limitation of Shack-Hartman sensors: number of lenslets (spatial resolution) over dynamic range.

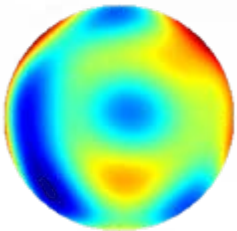
The additional advantage is that the intensity image in Digital Wavefront Cameras® is similar to CCD camera's image, and not only a series of dots that are not meaningful in terms of information about lens properties. In other words, with Digital Wavefront Cameras®, "what you see is what you measure".

Combining high dynamic range and high spatial resolution, WaveGauge® can produce highly repeatable measurements of both low-order and high-order aberrations for any complex lens design and meets the most demanding requirements of high-end R&D laboratories and production facilities.

Shack-Hartmann sensors

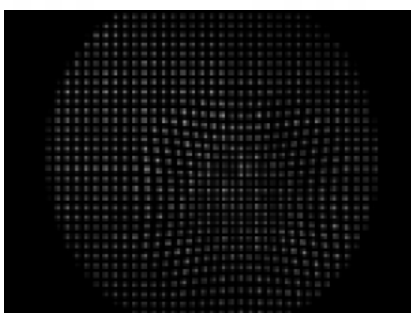
- Low spatial resolution
- Intensity though series of dots

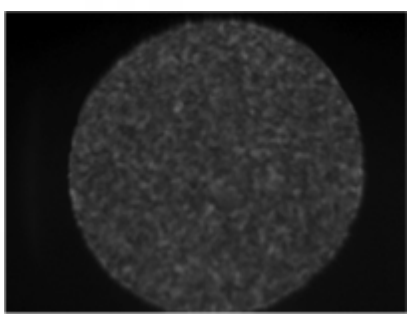




Digital Wavefront Cameras

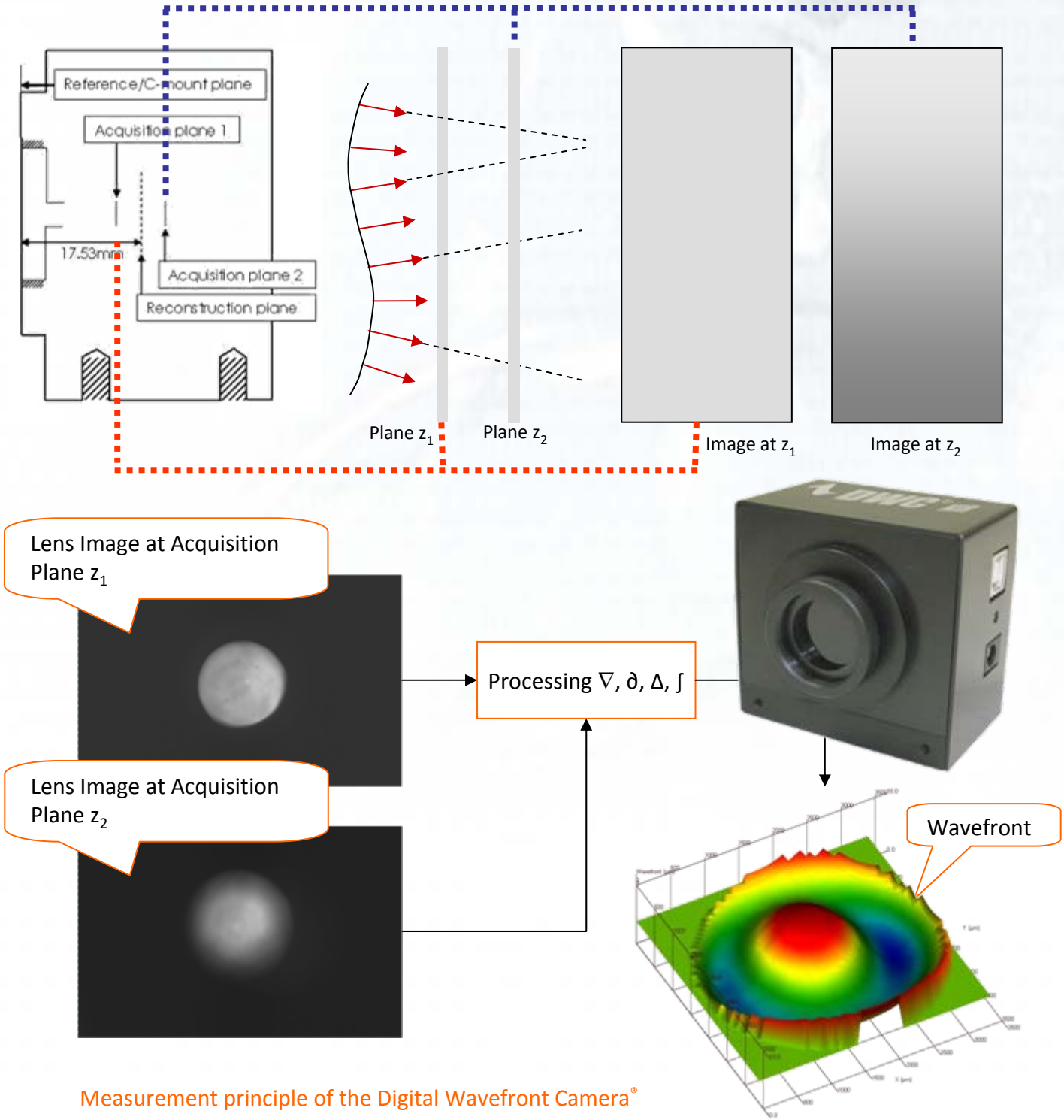
- High spatial resolution
- Full Intensity image



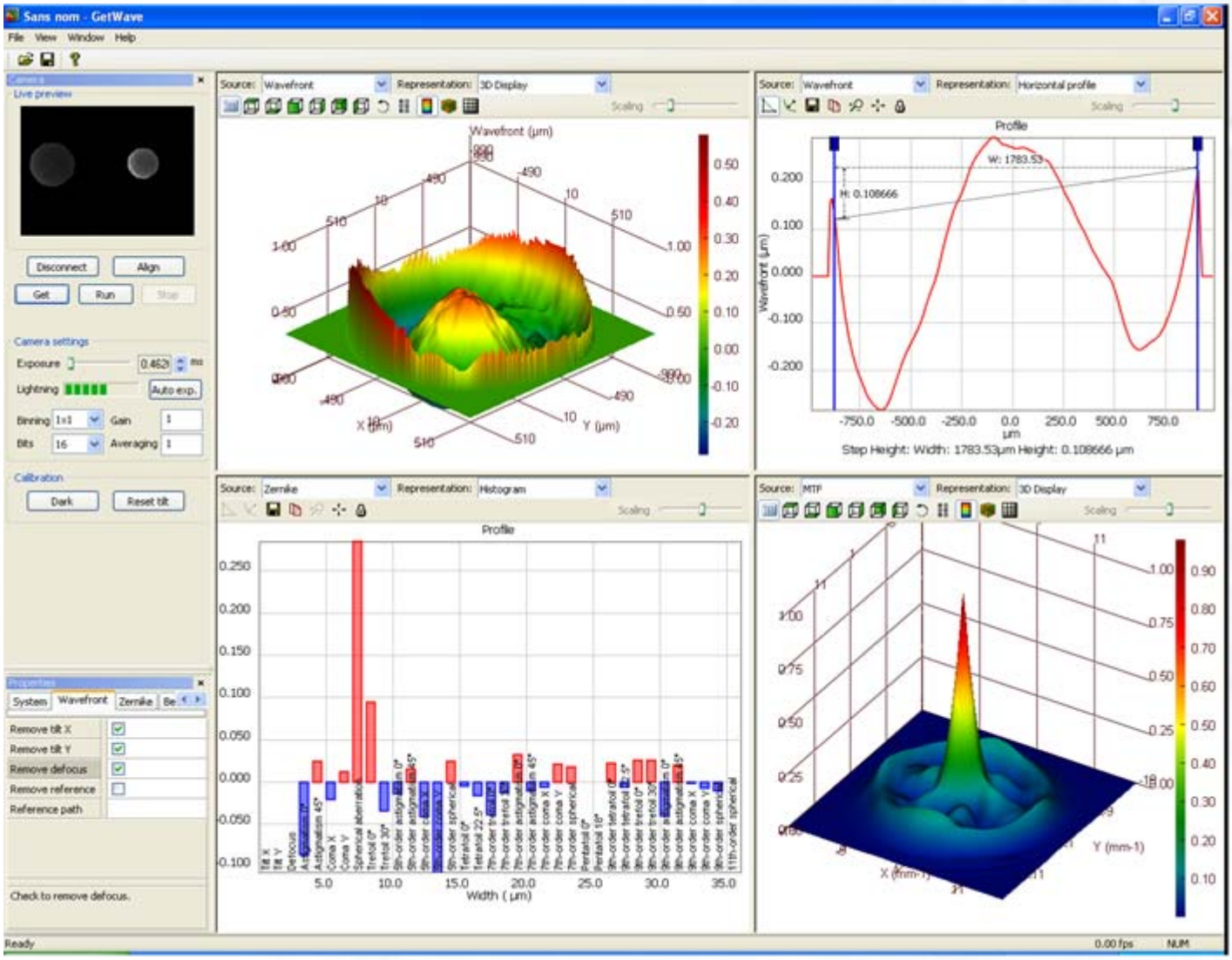


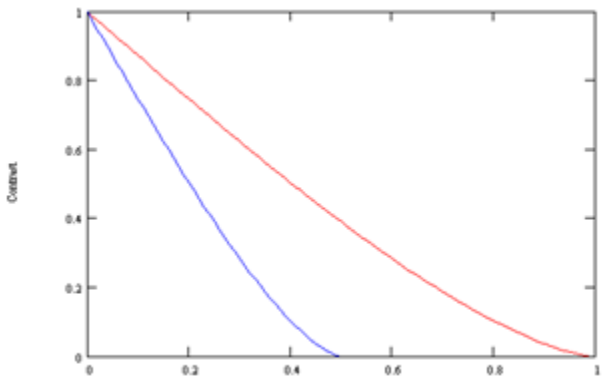
Characterization of the optics with **WaveGauge®** is based on the simultaneous measurement of the high-resolution images of intensity and wavefront by **Digital Wavefront Camera® (DWC®)**. The wavefront is computed starting from two slightly defocused beam intensity images acquired on a CCD camera inside DWC® by mathematical computations involving the two images and the difference between them.

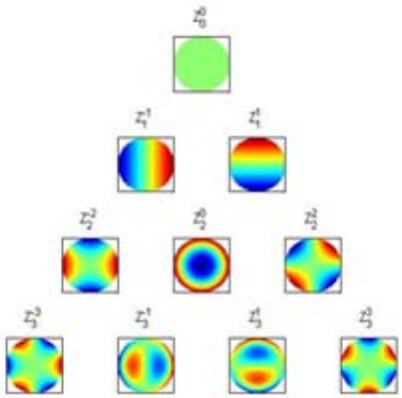
From the reconstructed wavefront and measured intensity, typical optical characteristics such as lens aberrations, Zernike polynomial terms, point spread function (PSF), modulation transfer function (MTF) and Effective Focal Length (EFL) are obtained by straightforward but intensive computations.



Measurement principle of the Digital Wavefront Camera®





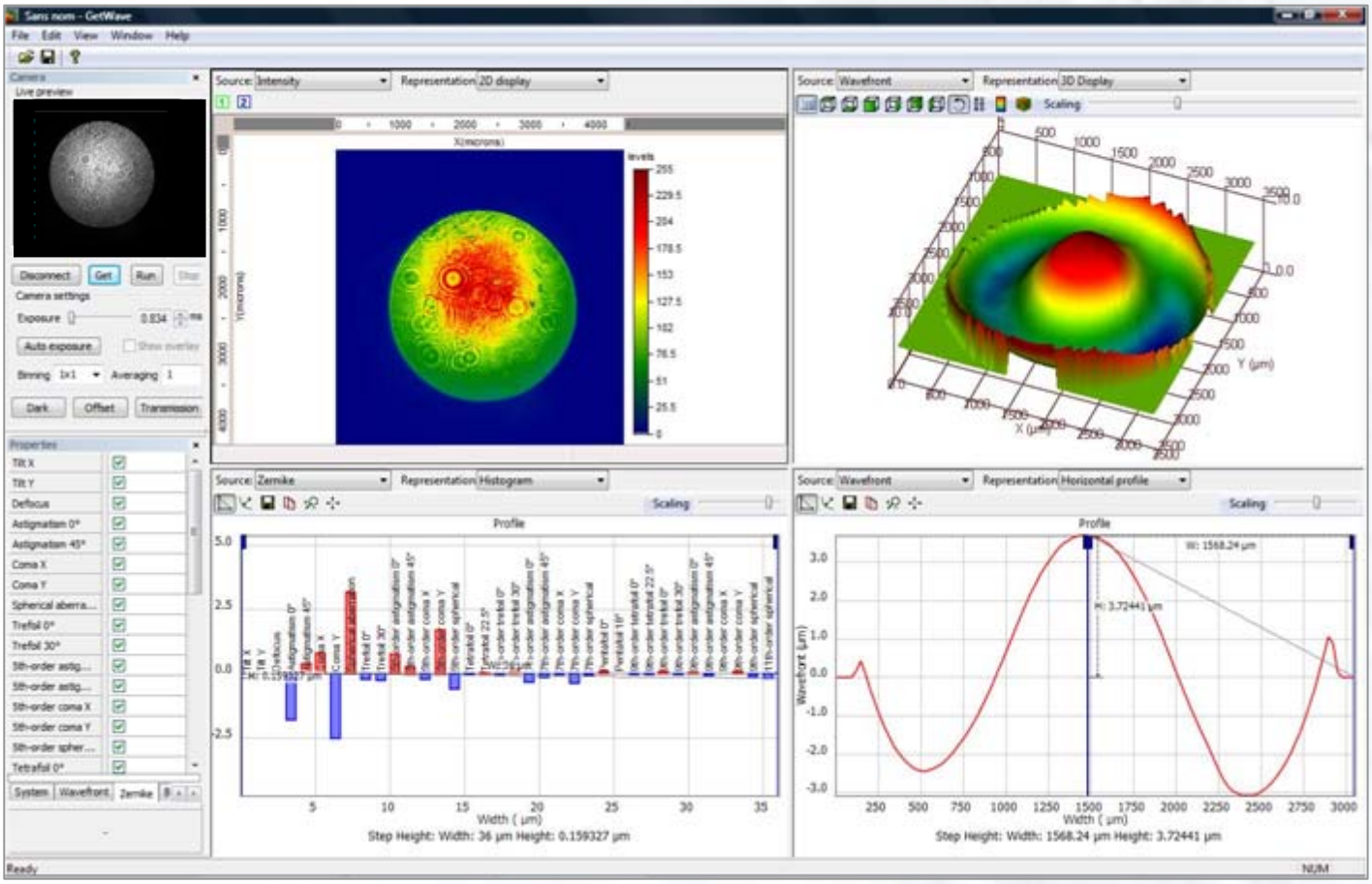


PSF and MTF

The Modulation Transfer Function (MTF) and Point Spread Function (PSF) are critical parameters for true assessment of optical imaging systems performance. The MTF curve describes the capability of an optical system to transfer the details of an object to the image in terms of contrast. The point spread function (PSF) describes the response of an imaging system to a point object.

Lens aberrations

The measured wavefront can be decomposed into Zernike polynomials -or the Seidel series which represent the effects of various types of lens aberrations e.g. coma and astigmatism or spherical aberrations. Both lower and higher order lens aberrations can be measured or compared.



Operator Level

The live light intensity image from the lens is displayed to check measurement conditions (illumination, alignment). Operator can enter information about lens being measured, its material and measurement mode (in air or in situ).

When wavefront map is computed, operator can select radius for analysis, by entering value or by clicking on the wavefront map. For the selected radius, measurements of the axis, dioptric power, resolution efficiency and MTF are displayed. Zernike aberration coefficients (values and histogram) are also displayed.

Supervisor Level

Full features and measurement analysis are accessible including:

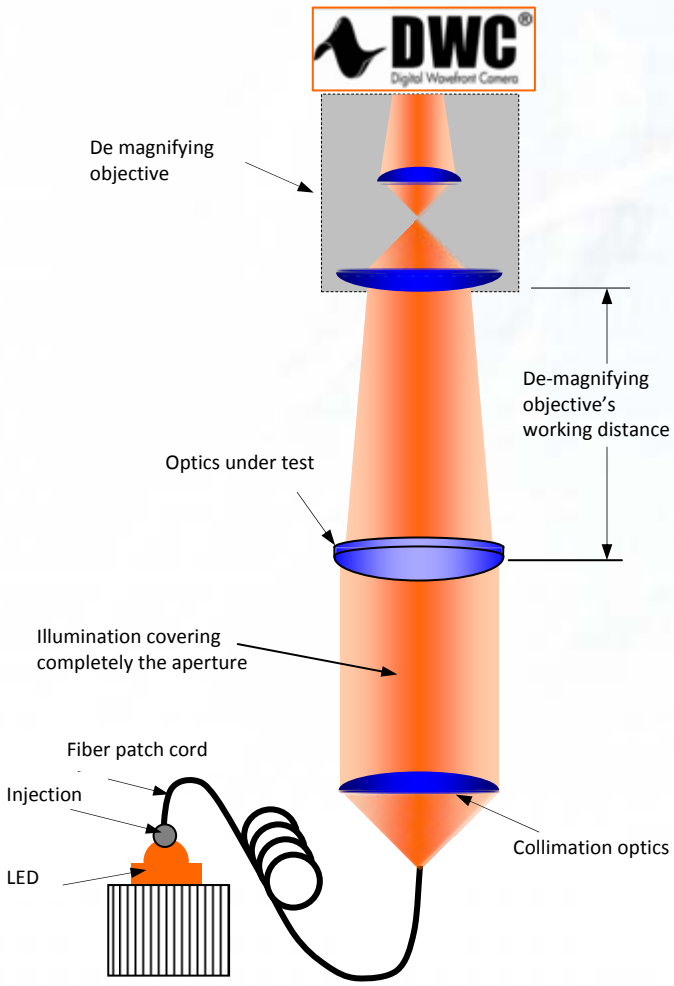
- Histogram of the power distribution within the tested area;
- A graph of the radial profile of the power along the lens;
- A quality number providing the information of the uniformity of the lens.

In addition, saving files with measured parameters and wavefront for the future reference, printing and exporting files are also available.

WaveGauge® - Setup & Configurations

WaveGauge® system contains specially designed light source, customizable lens manipulation stage, focalization optics and PhaseView's **Digital Wavefront Camera® (DWC®)**, a modern wavefront sensor having the same resolution as the pixel inter space of the digital CCD camera, thus allowing simultaneous real-time capture of both intensity and wavefront.

The pupil of the lens holder is visualized in the analysis (reconstruction) plane of the DWC®. In order to produce a clean plane wavefront (for an ideal lens), the measured lens is placed in focal plane-infinity configuration, producing a beam from a monochromatic point source. The pupil plane is imaged inside DWC®.



Set up of the wavefront measurement system

Light source

The point light source consists of a stabilized 5W green LED (not coherent) injected into a fiber cord and collimated onto the sample. It is available at 530, 505, 470 and 455nm wavelengths.

Measured Parameters

- Diopter power and power maps
- Lens aberrations to an arbitrary order
- Point Spread Function (PSF)
- Modulation Transfer Function (MTF)
- Effective Focal Length (EFL)

These parameters can be measured both in air and in situ, due to the capability of the software for changing the refractive index of substrate material and as well as of the medium. WaveGauge® has the capability of measuring lens dioptric power at different diameters, especially for multifocal IOL's. MTF is measured at different diameters of the IOL.

WaveGauge IOL

Optimized for intraocular lenses measurement in situ or in air including specific lens holder and pass / fail analysis software.

WaveGauge Contact Lens

Ideally suits R&D needs and production line environment constraints for all type of contact lenses.

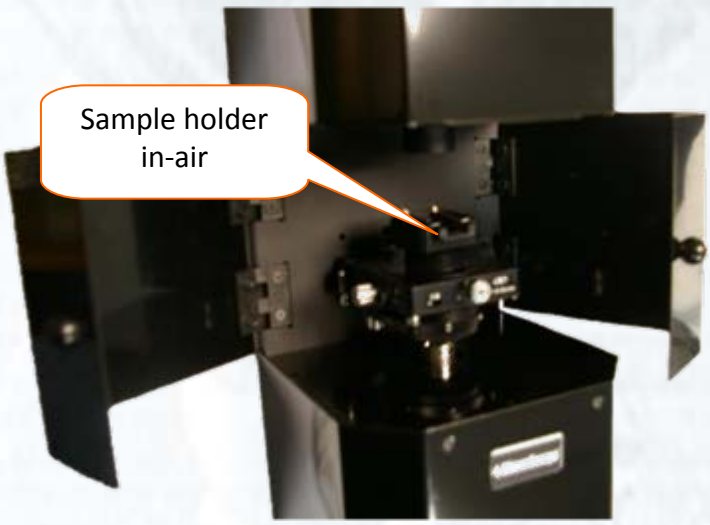
WaveGauge Aspherics

Fulfills quality assurance requirements of various type of aspherics and performs ultimate measurement of the latest aspherics shape.

Taking advantage of its high accuracy, repeatability and fast measurement speed, WaveGauge® is an ideal tool for testing intraocular lenses for R&D as well as in a production environment. The wavefront is measured in real time and provides lens power map, PSF, MTF, lower and higher order lens aberrations, as well as EFL and average diopter power. A specific user interface allows pass/fail analysis on the basis of theoretical values.

Sample Holder

The sample holder is adapted for single IOL measurement with a precision XYZ mount. It has been specially designed to avoid tedious alignment adjustments and to ease rapid lens handling for higher throughput.

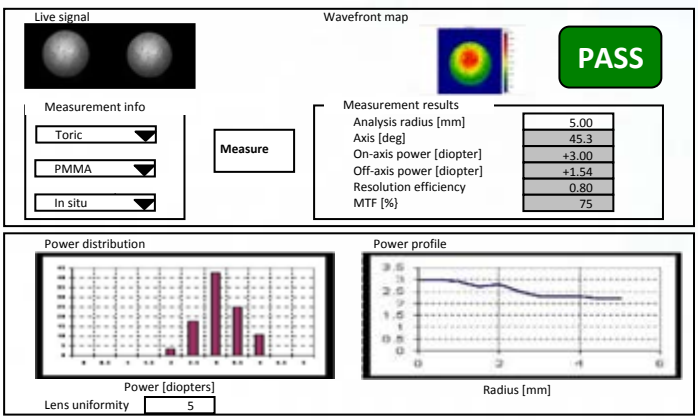


The WaveGauge® with sample holder for in-air measurements

In-air measurement
IOL in-air measurement is performed with WaveGauge® IOL by placing the lens in the jig which is then inserted into the lens holder.

In-situ measurement
When in-situ measurements are required, an IOL is placed in a saline solution (a model eye). The Model Eye has been designed as defined in the ISO 11979 standard to simulate the effect of the real human eye during measurements of IOL's.

Pass / Fail Analysis



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For the selected radius, measurements of the axis, dioptric power, resolution efficiency and MTF are displayed. Zernike aberration coefficients (values and histogram) are also displayed.

Report for exporting or printing of pass/fail analysis is provided for quality assurance follow-up.

Software Functionalities

Wavefront Acquisition and Display

- Absolute or relative measurement
- Subtraction of background illumination
- Real time display of 2D- and 3D-wavefront
- Peak-to-Valley and Root-Mean square values
- Intensity
- Slope, curvature data
- Best fit sphere data
- Raw camera image
- Real time correction of sample misalignment (tilt and defocus)
- Available units: µm or λ

Lens Specific Measurements

- Diopter power and power map
- Real time calculation and 2D- and 3D display
- Customized zonal display of power map
- EFL measurement and display
- MTF and PSF in 1D, 2D and 3D
- Real time calculation and 2D- and 3D- display
- Real time numerical and graphical (2D and 3D) display
- Lower and higher lens aberration (Zernike and Seidel)
- Real time aberration analysis
- Real time numerical and graphical (2D and 3D) display of aberration coefficients
- Pass/Fail classification according to user defined criteria
- Real time comparison of measurement results with design data

Data Saving and Documentation

- Measurement certificate showing graphical and numerical display of all measurement results
- Measurement conditions and sample related information
- Results can be saved in various formats to allow for further analysis with external software
- Detailed measurement settings can be saved into separate files and reloaded

Compatibility

- XP
- Vista
- Windows 7

Recommended Configuration

- nVidia GPU Graphics Processor Unit

Performance

Wavefront Sensor DWC	
Sensor	CCD
Resolution	1392x1040
Frame Rate	15Hz
Optical Format	2/3”
Pixel Dimensions, um	6.45x6.45
Pixel Bit Depth	12
Camera Dynamic Range, dB	66
Wavelength Range, nm	350 - 1100
Wavefront Measurement Points	500x500
Lens Measurement Capabilities	
Aperture diameter	0.5 to 6 mm (20mm with adaptor)
Power Range	-20 to +20 D
Power absolute accuracy	0.1 to 0.3 %
Power resolution	0.01 D
Power map lateral resolution	6.45 µm
MTF absolute accuracy	2% MTF
Wavefront measurement absolute (relative) accuracy rms	<λ/20 (λ /50)
Light Source Wavelength	535 nm ± 15 nm
Measurement time for 1 lens including Power, MTF and aberrations	1 sec
Mechanical & Electrical Specs	
Computer Interface	USB 2.0
Power	110 / 220 VAC
Dimensions, cm	67.5 x 18.5 x 15.5
Weight, kg	6

PhaseView® The Digital Wavefront Company

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