



# Measuring instruments for optical parameters

Lens Testing Equipment  
Camera Testing Equipment  
IIT Testing Equipment  
Automated Lens Assembly  
Lens Testing Services



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## MTF Measuring Systems for industrial applications and research

OEG GmbH was founded in 1991 and works since that time in the field of MTF testing. Based on that long experience OEG GmbH provides a comprehensive product line for the computer-controlled fully automatic measurement of the modulation transfer function (MTF) for quality assurance in the optics manufacturing and research. Depending on specimen parameter, there are different setups available.

MTF, Effective Focal Length (EFL), Back Focal Length (BFL), Flange Focal Length (FFL), Distortion, Field Curvature, Chromatic Aberrations (axial, lateral), Astigmatism, Depth of focus, Rotation Symmetry and Relative Illumination.

### Reasons for MTF measurement

Despite the presence of sophisticated design and manufacturing

their characterisation by help of the Modulation Transfer Function (MTF) as the premier parameter for objectively evaluating is more and more used. Another feature of an MTF measuring instrument is, that it allows system testing in situations similar to actual applications. Field angle positions, spectral ranges, distances between object- and image plane can be replicated or simulated in the test of an optical system.

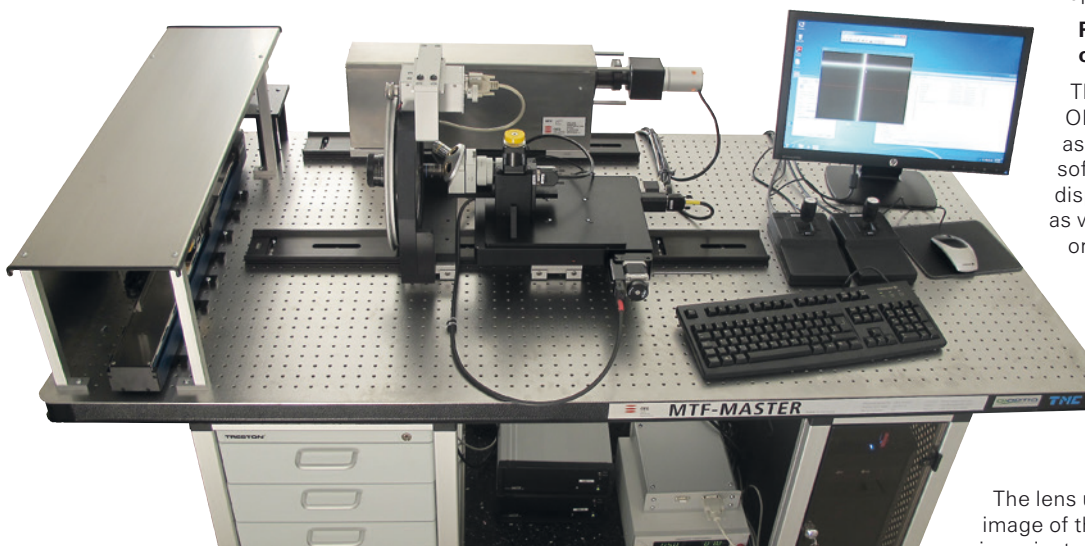
### Real time MTF-measurement offers new possibilities

The MTF test benches from OEG are using a CCD-camera as sensor. An image processing software allows the real time display of the test chart image as well as parameters like line- or edge spread function, grey value distribution and MTF.

Additionally CCD-cameras provide the advantage, that both directions of MTF (sagittal, tangential) can be measured nearly at the same time.

### Measuring principle

The lens under test provides an image of the test chart. This image is projected by the image analyzer optics on the CCD camera. The MTF evaluation software calculates the MTF and other parameters from the detected grey value distribution. A meaningful MTF measurement needs both the measurement on the optical axes and in the image field. A powerful software for



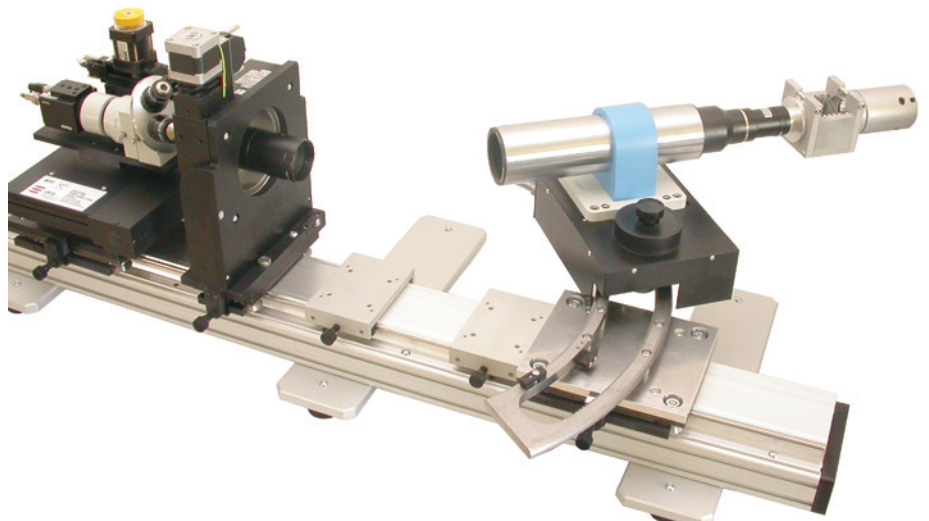
### A new standard of MTF-measurement

MTF test benches from OEG provide the fully automatic characterization of the imaging quality on the axis and in the image field for any azimuths and types of object / image conjugates by measurement of the modulation transfer function. The operational area covers a wide range of optics from VIS to NIR, up to 250 mm free aperture and 900 mm specimen-EFL.

### Technical background

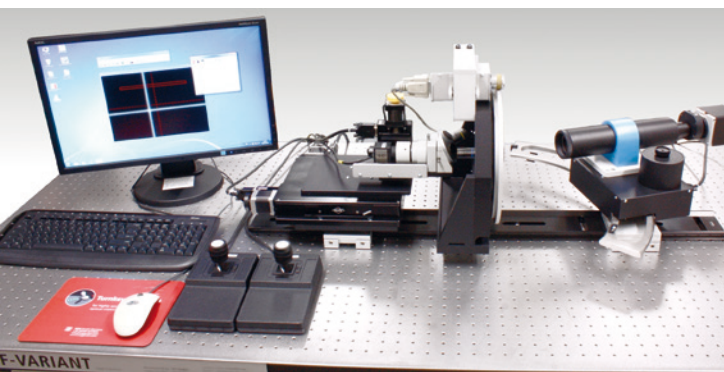
The modulation transfer function (MTF) is a recognized control criterion for the optical imaging quality. It characterizes the resolution of optical systems on the axis and in the image field. The MTF describes how the image contrast varies with spatial frequencies. Spatial frequency is expressed in terms of line pairs per millimeter (lp/mm). The MTF combines image resolution and contrast into a common representation. Beside the MTF also other optical parameters can be measured, like Through-Focus

techniques, lenses can still vary considerably in imaging quality because of manufacturing errors. Because of the growing demands in imaging performance of lenses

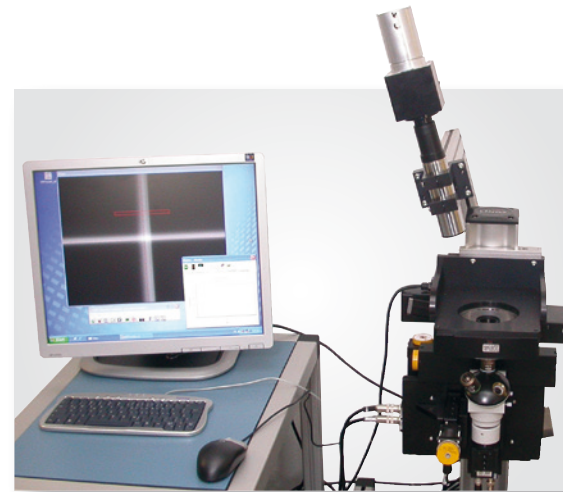




the control of an automatic measuring sequence is at least of equal importance like the MTF calculation algorithms. Additionally, the optical components of the MTF test bench and the mechanical components must meet high quality demands. MTF test benches from OEG guarantee the compliance with the demands of a high accurate MTF measurement!



- fully automatic, software controlled measuring sequence for up to 7 automatic axes;
- alternatively manual or automatic azimuth-dependent measurement
- automatic, software controlled symmetry measurement;
- operation and control of the hardware by Joystick, mouse and PC keyboard
- graphic and numeric representation of the measured values;
- automatic production of meaningful metrology records (quick report);
- diagram of the focus curve (contrast for given spatial frequency)
- software controlled or manual focusing;
- automatic focusing with a user selected spatial frequency;



### Special requirements require special solutions

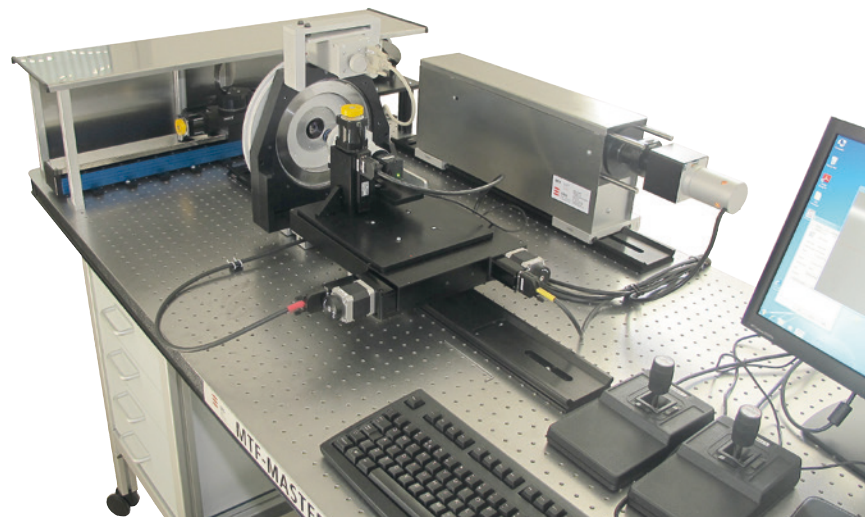
Experience has shown that MTF test benches often have to be customized. Therefore, a close cooperation of supplier and customer is necessary, to adapt the MTF bench to the existing measuring demands. Parameters, which must be adapted to the specimen are e.g. the free aperture, measuring wavelength, object-/image- conjugates, image field size, object field angle and EFL of specimen.

### On a view

MTF test benches from OEG provide among others the following features:

- real time representation of MTF, ESF (edge spread function) and LSF (line spread function) on the PC screen;
- fast switching between tangential and sagittal MTF measurement;
- comparison with freely selectable desired MTF-values in the diagram;
- simple change between different measuring wavelengths;
- automatic, software controlled measurement of colour aberrations;
- fast change between measurement on the axis and in the image field

- measuring procedure very easily programmable by operator;
- measurement of focal length (infinity / finite) or magnification (finite / finite);
- evaluation of distortion, image field curvature and astigmatism;
- objective data base;
- measuring template data base assigned to the according objective;





## MTF-PENTATEST

The increase of camera technology in devices like webcams, automotive applications like driver assistance systems and cell phones has created a need for real time optical test equipment that is capable of qualifying the alignment and focus of a lens to a camera in a very short time.

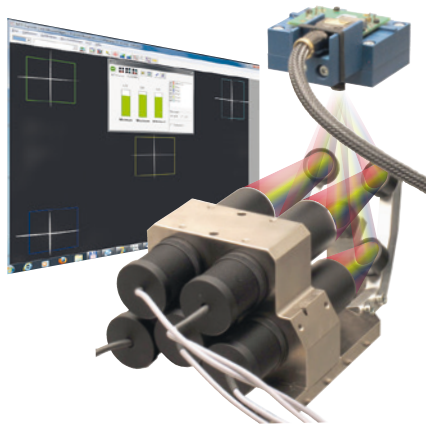
This requirement necessarily means that all relevant field points within the image must be presented to the unit under test simultaneously.

### An innovative Approach

OEG has developed the **MTF-PENTATEST** product line to meet the new needs in optics and sensor manufacture. **MTF-PENTATEST** offers a complete new approach to the fast and accurate camera testing. **MTF-PENTATEST** is an easy to adapt and cost effective tool for In-line-MTF-Testing. The concept of **MTF-PENTATEST** is the use of a multiple target generator (usually collimators) to generate an object in infinite distance under multiple object angles at the same time. The **MTF-PENTATEST** software evaluates the images of the according objects in real time and gives the MTF values as

criterion for good / bad decision or for final adjustments.

The **MTF-PENTATEST** system is already successfully integrated in robot based



optics assembly lines, where the PENTATEST software controls the robot.

### Customized design fits special testing requirements

Since optics is always adapted to special requirements, also the target

generator needs to be adapted to the according optics, in particular to the demands on the object angles to be realized. OEG provides this special testing requirements according customer demands.

### MTF-PENTATEST Object Generator

The **MTF-PENTATEST** Target Generator consists of 5 collimators, which are mounted in a collimator block. 5 deflecting mirrors provide objects under 5 different object angles. The object angles must be adapted to the field of view of the lens under test, so that they cover the optical axis and the 4 corners of the camera chip. Each collimator has an own LED illumination with brightness control. The wavelength can be in the visible range (white or monochromatic) or in the near IR range according customer demands.

OEG GmbH can provide either the **MTF-PENTATEST** system according customer demands. In cooperation with partner companies we can supply robot-based optics- and sensor-assembly lines.

## MTF MASTER IIT – MTF Test System for Image Intensifier Tubes

The **MTF MASTER IIT** was specially designed to classify the quality of image intensifier tubes by MTF measurement. The **MTF MASTER IIT** was specially developed for this measuring task. The main building groups are the illumination unit, the test chart projection unit, the IIT power supply unit, the IIT mounting unit and the image analyzer unit.

The projection unit has a hair cross test chart with 2 micron slit width and a high resolution projection optics. The test chart is illuminated with exactly defined illuminance and projected onto the photocathode of the IIT. The IIT provides an image of the test chart on the IIT screen. This image on the IIT screen is evaluated by the high resolution microscope of the image analyzer unit.

The light source contains a Tungsten Halogen Lamp 20W with color temperature of  $2856 \pm 50$  K.

The lowest light level is  $10^{-3}$  Lux. The light intensity is regulated continuously

and software controlled.

The IIT can be positioned relatively to the object generator in 3 axes. The image analyzer unit can be moved relatively to the IIT screen in 3 axes. All axes are motorized and have a high positioning accuracy (resolution 1 micron). The complete measuring sequence runs automatic and software controlled.

The MTF is measured both tangential and sagittal with an accuracy of  $\pm 4\%$ .

The IIT control unit provides DC power to the IIT (low and high voltage).





## Optics Test Stations for single lenses and optical systems

The Optics Test Stations are an indispensable tool for control of incoming goods and quality assurance in optics production! **OTS 200** and **OTS 500** featuring the objective, motorized and software controlled measurement of optical parameters of single lenses and optical systems like:

- Effective Focal Length (EFL), positive and negative
- Back Focal Length (BFL)
- Radius of Curvature (R), positive and negative
- Flange Focal Length (FFL)
- Modulation Transfer function (MTF), on axis, tangential and sagittal
- Centering error
- Lens center thickness
- wedge angle / parallelism of plano optics, 90°-angle of prisms

The standard system is the **OTS 200**, which has a measuring range up to  $\pm 600$  mm for EFL, FFL, BFL and Radius.

The **OTS 500** was developed in particular for the measurement of long focal length optics. It is equipped with

an air bearing z-stage and has a measuring range up to  $\pm 1200$  mm for EFL, BFL, FFL and Radius. The advantages of the OTS Optics Test Stations from OEG are:

- objective, fast and high accurate measurement by electronic image evaluation;
- autofocus function avoid influence of operator on measurements;
- motorized, software controlled movement of the measuring head;
- optional control of measuring head by joystick;
- motorized reticle changer (the collimator-reticle, which is necessary for the measurement, is positioned software controlled);

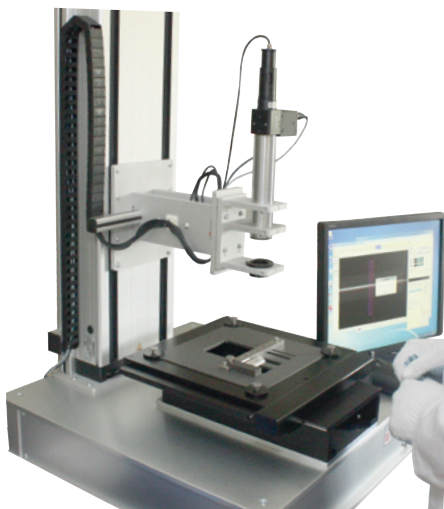


- direct connection to Windows computer for creation of protocols and data storage;
- live video image of the measuring signal on the PC screen;
- easy operability by intuitive software interface;
- proven solution, worldwide used;
- unique concept to prove measuring accuracy

### Remark

The **OTS 200** can be supplied as Focometer for testing only positive and negative focal length. The Focometer has a downgraded hard- and software, which is specialized to the focal length measurement. Therefore the Focometer is a very cost effective solution, which is less expensive than the complete **OTS 200**. An upgrade of the Focometer to the complete OTS functionality is afterwards not possible.

## OTS-Z – Optics Test Station for cylindrical lenses



**OTS-Z** features the objective, motorized and software controlled measurement of optical and geometrical parameters of cylindrical lenses. **OTS-Z** is capable for most practical measuring tasks

and provides fast and reproducible measurement results with automatic protocol generation. The following parameters of cylindrical lenses are supported to measure:

- effective focal length (EFL)
- back focal length (BFL)
- radius of curvature (R, concave/convex)
- flange focal length (FFL)
- deviation of cylinder axis in relation to mechanical centering line (centering error)
- Twist between cylinder axis and mechanical reference

The standard measuring range for EFL, Radius, BFL and FFL is  $\pm 500$  mm.

Depending on the mechanical dimensions of the specimen, an according x/y stage must be used. Centering error and Twist can be measured with a reproducibility of  $\pm 5$  micron. The advantages of the **OTS-Z** Optics Test Stations for cylindrical lenses are from OEG are:

- objective, fast and high accurate measurement by electronic image evaluation;
- autofocus function avoid influence of operator on measurements;
- motorized, software controlled movement of the measuring head and the specimen;
- optional control of measuring head and x/y-stage by joystick;
- direct connection to Windows computer for creation of protocols and data storage;
- live video image of the measuring signal on the PC screen;
- easy operability by intuitive software interface;
- proven solution, worldwide used;
- unique concept to prove measuring accuracy



## FLATSCAN

**FLATSCAN** is an optical, noncontact surface profilometer.

It was specially developed for large specimen sizes. **FLATSCAN** features the measurement of 2D and 3D surface form, radius of curvature and slope. An additional software module provides the calculation of thin film stress (wafer stress) for applications in semiconductor technology. The basic principle is based on deflectometry. Therefore the **FLATSCAN** can be used for all kind of polished surfaces like wafers, mirrors and polished glass.

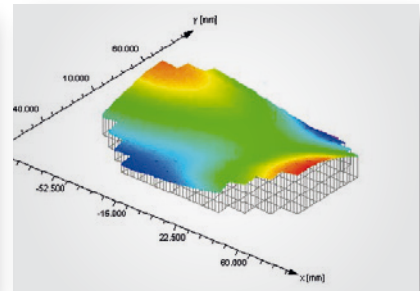
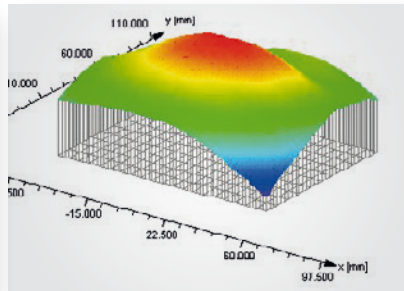
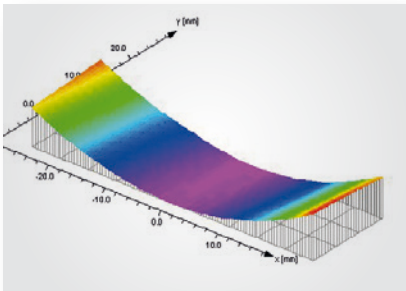
One of the essential features of the **FLATSCAN** is the large radius-(slope-) measuring range. Therefore the **FLATSCAN** can measure objects with strong curvatures, which can no more measured by interferometers. Nevertheless, the measuring accuracy is in the same range like fringe interferometers.

The **FLATSCAN** is a proven solution for measurement of wafer flatness and thin film stress. It can also be used for glass wafers.

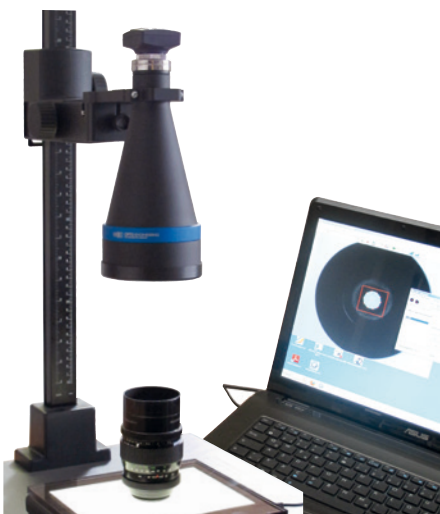
**FLATSCAN** is in particular for the measurement of x-ray mirrors the perfect solution, since they have a very strong curvature and some of them have large sizes.

Beside the large curvature measuring range, there are large measuring field (large specimen size) and high

measuring accuracy the important advantages of the **FLATSCAN** system.



## F-Number Measuring system



### Definition

The f-number of a camera objective is defined as the ratio of focal length  $f'$  and the diameter of the effective entrance pupil.

### Application

The f-number measuring system serves for the automatic, software controlled measurement of the f-number of optical systems.

### Setup and function

The setup consists of a stand with CCD camera and measuring optics. The specimen is positioned on a back light illumination. The measuring lens takes an image from the free aperture of the specimen. The image processing software shows the image of the

specimen in real time on the PC monitor. The software is calibrated and measures the diameter of the free aperture with high accuracy automatically. The f-number is calculated from the measured diameter.

### Advantages

- Connection to computer by USB cable
- Objectively, highly accurate measurement by image processing
- Creation of measuring Protocol, saving of images
- Easy service and operation
- Price competitive solution
- Easy adaption to different specimen types



## CROSSDETECT – Windows image processing software for autocollimators and collimating telescopes

**CROSSDETECT** is an image processing software, which was specially developed for use in connection with autocollimators. **CROSSDETECT** is suited perfectly for all applications, where autocollimators can be used, like:

- Measurement of small angles
- Ultra precision angular adjustment and calibration
- Wedge- and prism angle measurement
- Angle position monitoring

The software can be used either for the upgrade of visual autocollimators with an objectively, electronic data acquisition or the complete solution consisting of software, camera and autocollimator can be supplied by OEG GmbH. Since autocollimators are often already in use, **CROSSDETECT** is a very cost effective solution to upgrade a visual autocollimator to an electronic autocollimator. By help of **CROSSDETECT** and a CCD camera, the accuracy can be increased by factor 10 compared to visual evaluation. Other advantages are the objective, user independent measurement and the possibility to automate measurements. If an autocollimator or telescope is used in connection with a CCD camera, the crosshair image, which represents the measuring signal, results onto the CCD-chip of the camera.

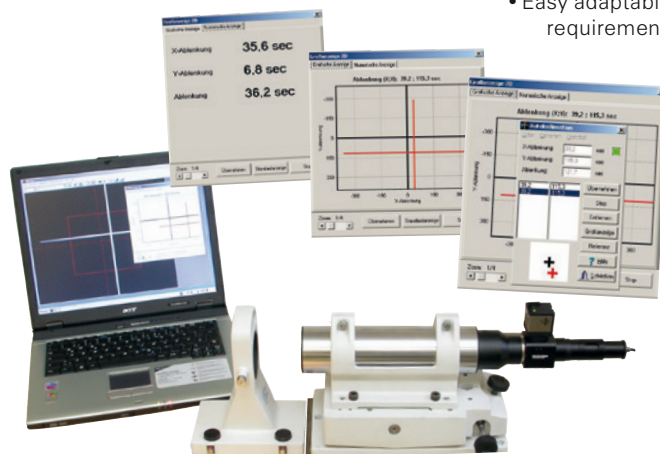
**CROSSDETECT** recognizes the crosshair position or the position of several crosshairs with extremely high accuracy, using subpixel algorithms.

Beside the general functions of hair cross detection, **CROSSDETECT** has numerous additional measuring functions like:

- wedge angle measurement in reflection and transmission
- centering error measurement
- wedge angle by double cross
- measurement of deflection
- manual and automatic distance measurements

### Main Features of **CROSSDETECT**

- Use of standard USB cameras
- Connection to computer by USB cable
- Objectively, highly accurate measurement by image processing
- Creation of measuring Protocol, saving of images
- Multiple hair cross detection / evaluation
- Interface via TCP/IP-protocol
- Fast and easy measurement of small angles with high accuracy
- Easy service and operation
- Price competitive solution
- Easy adaptable to special requirements



## Electronic Autocollimator

Electronic Autocollimators from OEG are equipped with a CCD camera and an image processing software, specialized to this application. Any Laptop can be used to run the software and perform high accurate angle measurements. Beside the standard function as autocollimator the software provides additional helpful functions. The software is easy adaptable to special measuring requirements.

### Short list of features

- data acquisition with digital USB 2.0-camera
- 1,3 megapixel resolution, higher resolution is possible
- resolution of angle measurement  $< 0.1$  arcsec (depending from the focal length and free aperture)
- focal length range of autocollimator from 90mm to 1100mm



- free apertures of 28mm or 50mm
- display of the measuring signal as live video on the laptop monitor
  - additional display of graphical hair crosses (e.g. reference point and current hair cross position)
- Representation of the measuring signal as angle value in different units
- Production and print out of freely configurable metrology records
- TCP/IP interface
- display of tolerance fields
- multi cross detection
- many hardware accessories available (mounting plates, basis mirror, stands)



## Wedge Angle Measuring System

The wedge angle measuring system serves specially for the measurement of the wedge angle or parallelism of optical windows, filters and glass plates.

It works in double transmission with a reference mirror, which is placed under the specimen table. The acquisition of measuring values is performed by an autocollimator, equipped with CCD-camera and the image processing software **CROSSDETECT**.

**CROSSDETECT** is an image processing software, which was specially developed for use in connection with autocollimators. **CROSSDETECT** is suited perfectly for all applications, where autocollimators can be used, like:

- Measurement of small angles
- Ultra precision angular adjustment and calibration
- Wedge- and prism angle measurement
- Angle position monitoring

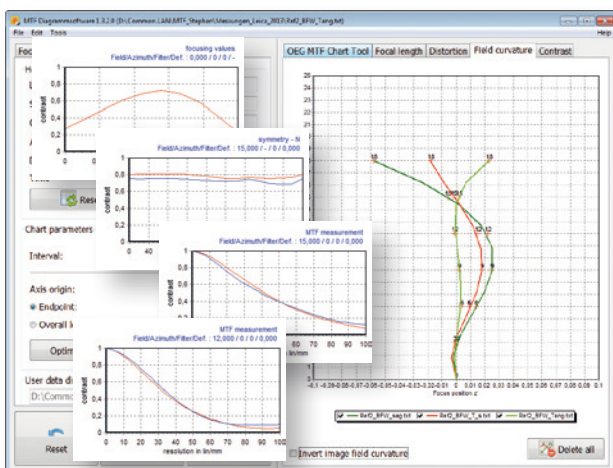
### Advantages

- Connection to computer by USB cable
- Objectively, highly accurate measurement by image processing
- Creation of measuring Protocol, saving of images
- Multiple hair cross evaluation



- Interface to other devices or software applications
- Fast and easy measurement of small angles with high accuracy
- Several special measuring functions
- Easy service and operation
- Price competitive solution
- Objective pipes from 90 mm to 500 mm focal lengths are available and allow the adaption to the special measuring task

## Testing Service



Since 1991 OEG GmbH develops and produces highly accurate optical measuring systems for industry and research. Our experience in optical metrology for many years guarantees reliable, and customer-oriented execution of the measuring task.

OEG GmbH maintains testing capabilities for many optical parameters. We offer comprehensive modulation transfer function lens testing and testing services for other parameters. Many of our metrology products are available for contract metrology work.

To put OEG to work for you, call us or fill out the Optical Lens Testing Services questionnaire, which you can find on our website [www.oeggmbh.com](http://www.oeggmbh.com).

### Scope of supply and services:

- consulting
- measuring services
- special developments on customer request
- development and manufacturing of turn-key measuring instruments