Application note:

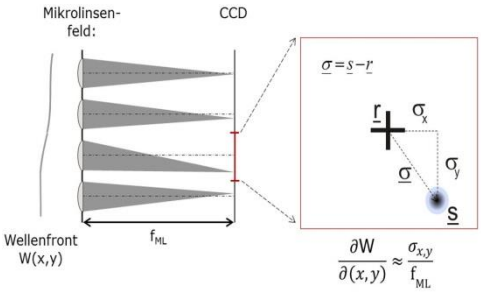
SHSInspect for multi-functional optics testing

1 Introduction

The Shack-Hartmann wave-front sensor SHSLab is a powerful tool for testing all kinds of optics. Especially, mobile phone optics, microscope objectives, vision objectives, photographic lenses, laser optics, etc., but also optical elements such as filters etc. can be tested in a great number of different measurement processes and modalities.

2 The Shack-Hartmann wave-front sensor SHSLab

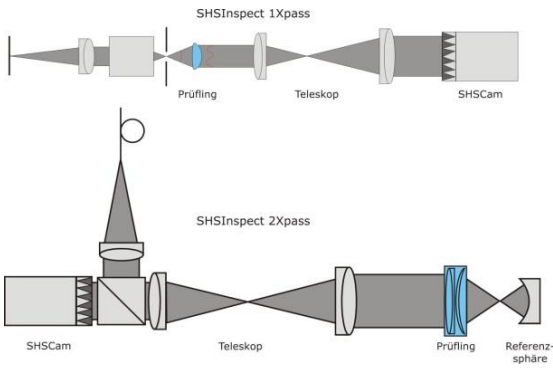
A wave-front sensor consists of a 2D array of micro-lenses and a detector, a sort of CCD camera. After passing through the micro-lens field, a flat wave front generates a regular point matrix on the detector whose spots have the same separation distance as the micro-lenses. If the wave-front is curved, the spots generated by the micro-lenses migrate correspondingly far from the optical axis. From this spot displacement, the wave-front can be reconstructed.



SHSLab still reliably assigns the spots to their reference points in case they have moved outside their subaperture. The process requires only a single camera image and is thus very fast and simple in application. The local radius of curvature of a wave-front on the micro-lens array can be as small as 5 mm, so that wave-fronts with extreme curvatures can also be measured. SHSLab sensors are available with up to 240 x 160 spots, as well as sensors with an evaluation rate of up to 1000 Hz. By means of the associated software SHSWorks, a great number of optical measurement variables can be tested, e.g. wave-front aberrations, imaging quality (Strehl, MTF etc.), focal length and laser quality.

3 Test systems SHSInspect

One of the complete measurement systems which make use of SHSLab is SHSInspect. There are two configurations: with SHSInspect 1Xpass the measurement beam is transmitted through the test specimens only once while with SHSInspect 2Xpass the light is reflected back after the first transmission by a mirror and passes through the sample twice.



Top: typical 1Xpass configuration.
Bottom: typical 2Xpass configuration

One strength of 2Xpass is that the effect of the test specimen on the wave-front is doubled. So the measurement sensitivity is increased and extremely precise measurements are possible. As a result of the optical layout, the whole measurement configuration can be calibrated simply by means of a plane mirror and a reference sphere.

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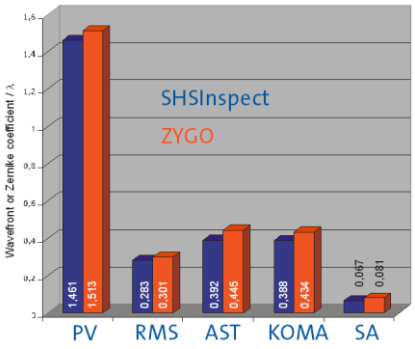
4 Integration into R&D and the production environment

SHSInspect can easily be integrated into an automated production environment and measures in real time concerning the production cycle. The systems 1Xpass and 2Xpass, according to sensor size, reach frame rates between 1 and 50 Hz – in special applications even up to 1000 Hz. Ultimately, the time required for the insertion of the test specimen into the measuring equipment determines the measuring rate.

SHSInspect systems can achieve very high accuracy and sensitivity even under rough conditions. The pure sensor head already achieves a typical base accuracy of (uncalibrated) λ/15 PV (SHSCam HR). According to the optical structure of the test system, an even higher precision can be achieved by suitable calibration measures. In case of the 2Xpass, the value λ/20 PV has been proven in direct comparison to a Fizeau interferometer.



Comparison of SHSInspect 2Xpass and Fizeau interferometer using the example of the measurement of a microscope objective.

5 Multi-functional systems

SHSInspect can be considered as a platform which can optimally be adapted to the requirements of the customer. The system is flexible and works more cost-efficiently than any interferometer, and furthermore covers a wide functional range. Currently, on-axis and off-axis measurements with field angles up to 50° are available. Larger angles are feasible. As a result of the combination of mechanical and optical measurement variables, both the BFL (Back Focal Length) as well as the EFL (Effective Focal Length) can be measured.

For testing chromatic effects of optics, it is of great advantage that SHSLab can be used for light sources with different wavelengths, and also sources with low spatial and temporal coherence. In this way, LEDs can be used which are available for a large wavelength range.

Many objective lenses comprise an adjustable lens which can be displaced, and/or tilted, to compensate shape and position faults of the other fixed-assembled lenses. With the SHSInspect 2Xpass, the adjustment of such adjustable lenses in microscope objectives is very fast and easy. This is made possible by the motorized centering function of the return sphere which is automatically adjusted to the ideal position, so that the operator can concentrate on the adjustments of the test specimen.

In production, the measurement process can be implemented in a semi or fully automated way. In the semi-automatic case, the test specimen is inserted manually into the measuring system but SHSInspect carries out the measurement process automatically. However, this loading and unloading can also be implemented by means of a robot. As a result of their flexibility and versatility, SHSInspect 1Xpass and 2Xpass can be used both in research and development and in production, and can be adapted flexibly to the respective measurement task.