# Interferometric Asphere Testing without CGH

Markus Bosse, Thomas Blümel

*FISBA OPTIK GmbH, Schwarzschildstr. 12, 12489 Berlin, Germany*

mailto:markus.bosse@fisba.de

A method for interferometric measuring of aspheres without CGHs with spherical wave fronts is presented. A sample measurement demonstrates that the precision is comparable to conventional CGH based measurements.

## 1 Introduction

Aspheres allow to reduce the number of lenses in optical systems without loss of optical performance. In some cases it can even be improved. This allows the fabrication of more compact, lighter and „simpler“ systems. Due to the improved possibilities in fabrication of high quality molded optics aspheres are found more and more in consumer products like mobile phones, single use cameras etc.. But it does not mean that the requirements to aspheres are less compared to classical spherical lenses. Therefore an easy and cheap technology for testing aspheres is a key value for the quality of the whole optical system.

The advantages and disadvantages of different asphere testing methods are listed in the following table:

| interferometric | scanning | Stitching |
|---|---|---|
| + non-contact<br>+ area testing<br>+ fast | + flexible<br>+ independent of surface quality<br>+ high dynamic | + non-contact<br>+ area testing<br>+ high dynamic |
| - expensive (special optics, e.g. CGH)<br>- need of optical surface quality | - long measurement time<br>- often with contact<br>- only profile slices | - more inaccurate due to addition of errors from different measurement<br>- need for optical surface quality |

**Tab. 1** *Comparison of different asphere testing methods*

## 2 General aspheric description

$$z(h) = \frac{h^2 r}{1+\sqrt{1-e(hr)^2}} + \sum_{n=2} a_{2n} h^{2n} \qquad (1)$$

with:

$z(h)$, sagitta value

$R_0 = 1/r$, radius of basic sphere

$e = (1+k)$, conic constant

$a_{2n}$, aspheric coefficients

## 3 Description of the new method

The asphere is measured like a conventional sphere in a spherical setup (Fig. 1). Therefore each spherical interferometer for surface testing can be used. But this introduces a setup related systematic error in addition to the aspheric shape error. The systematic error is caused by the difference between the asphere and the reference sphere. The difficulty is, that the reference sphere depends also from the test aperture. Furthermore the asphere description is mostly given in cartesian and not in polar coordinates.

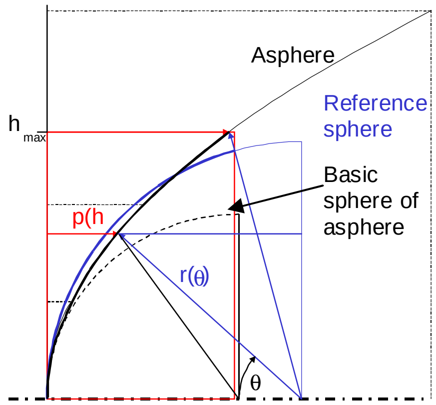


**Fig. 1** *The reference-sphere is closed approximation to the asphere and also depends from test aperture*

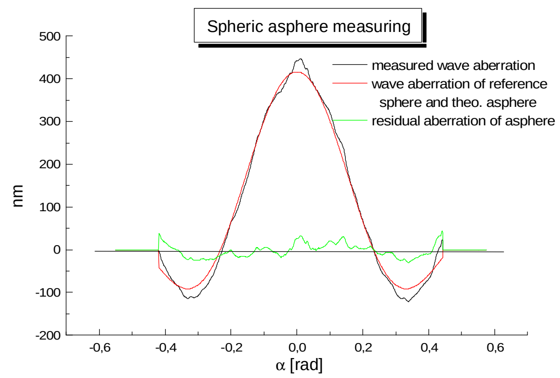


**Fig. 2** *Fit (red) of best fit reference sphere to measurement data (black). Residual shape error of asphere (green)*

The parameter of the reference sphere can be calculated from the measurement data when knowing the interferometric setup. The setup related systematic error can then be subtracted like the calibration error from the measurement data. The residual data show the deviation of the asphere from the theoretical shape and correspond to the results given by an interferometric measurement with an aspheric wave front (Fig. 2).

## 4 Software implementation

This algorithm is implemented into the interferometry software package µShape™ developed by FISBA. In addition to the functionality explained above the software supports the user to find the optimal measurement position. From the known data of the used objective, the asphere description and the specified test aperture the test position of the asphere related to focus of the spherical test wave front is calculated and displayed. If the asphere is moved to this position the residual aberrations on the test aperture will be minimized (in least square sense).

Is the measured aperture smaller than specified (e.g. due to too high fringe density at the aperture rim) the reference sphere will be calculated to the smaller measured aperture. The resulting aberrations show the deviation of the actual asphere from the theoretical description on the analysed aperture.

## 5 Measurement example hyperboloid

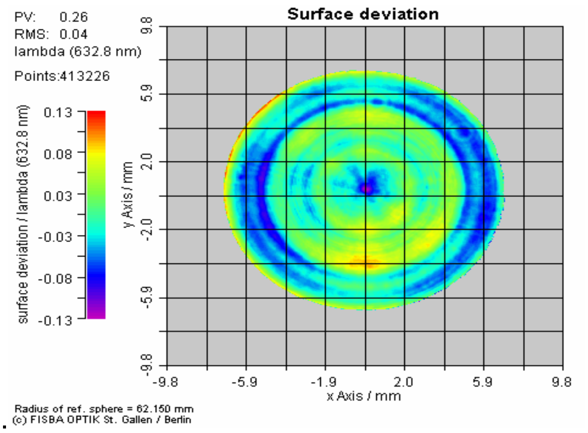


**Fig. 3** *Residual error of a convex hyperbola measured in spherical setup (test aperture 12 mm)*

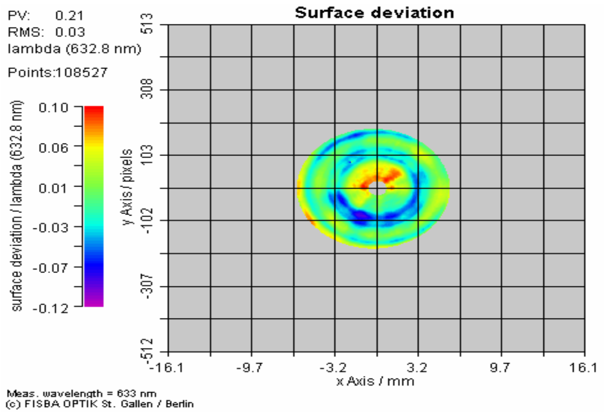


**Fig. 4** *Residual error of the hyperbola measured with adapted wave front generated by a CGH (test aperture 12 mm)*

Fig. 3 shows the measurement of a hyperbola in a spherical setup. The same aperture, measured traditional with an adapted aspheric wave front, generated by a CGH, is shown in Fig. 4.

A good correspondence of PV value and topography can be seen in both measurements.

## 6 Conclusion and prospects

A new method for interferometric measuring and analysis of aspheres was demonstrated. The advantage lies in using a spherical setup for asphere testing. No wave shaping elements like CGHs are required. So a variety of different aspheres can be measured with the same spherical setup. The disadvantage is the limitation to weak aspheres (small deviations from sphere). The concrete limits whether an asphere can be measured depend on the resolution (fringe density) of the used interferometer.

First investigations show the proper function of the used algorithm. The achieved precision has to be determined by further theoretical and practical investigations.

Due to the setup related systematic error the proper adjustment of the measured asphere is essential. The software gives helpful advices in advance to reduce this error to a minimum.

Based on the implemented algorithm a tool is developed to get an answer to the question how large for a given asphere the systematic error will be and which µPhase® setup is recommended to measure this asphere.