Non-contact measurement of aspherical and free-form optics with a new confocal tracking profiler

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Summary

We introduce a new non-contact technique for the measurement of aspherical and free-form optics. This technology, called confocal tracking, is based on confocal imaging and consists on tracking the focus on the sample while it is moved along the horizontal axis. It can be considered the optical equivalent of a contact profiler.

Introduction

Manufacturing technologies for optics have evolved rapidly in the latest years due to a demand for ever-complex optical surfaces to be machined. In parallel, requirements for the metrology for such parts have also tightened.

Desirable features for such metrology systems are: non-contact, high accuracy and fast measurement speed. The technology we introduce in this contribution fulfils them all.

Confocal Tracking

Confocal tracking consists on tracking the focus on the sample to be measured while it is moved along the horizontal, x-axis. Slit confocal technology together with high numerical aperture objectives are used to determine focus to a high degree of accuracy [1]. Once the sample is in focus, a closed-loop PID based control algorithm that drives the z-stage keeps the focus at the center of the field of view while the sample is moved along the x-axis.

As seen on Figure 1, initially the sample is focussed at the desired measurement initial position. Then the sample is moved along the x-axis using a high-accuracy air-bearing stage and the closed-loop system moves the sensorhead in a coordinated move in such a way that focus is kept all the way at the center of the field of view until the desired measurement length is reached. High quality position encoders are used to determine both the x and z position (10 nm repeatability, 100 nm accuracy, 1 nm noise). The sample profile is reconstructed from the moves executed by the x and z stages. In order to improve the repeatability and accuracy of the measured shapes, residual tracking errors are compensated by shifting the x value of each measured point to that corresponding to the actual position along the slit where confocal focus is found [2].

This technology provides an accuracy of less than 100 nm and can achieve measurement speeds of 1 mm/s typically or even larger. Depending on sample geometry a measurement objective that can reach slopes up to 65º can be used.

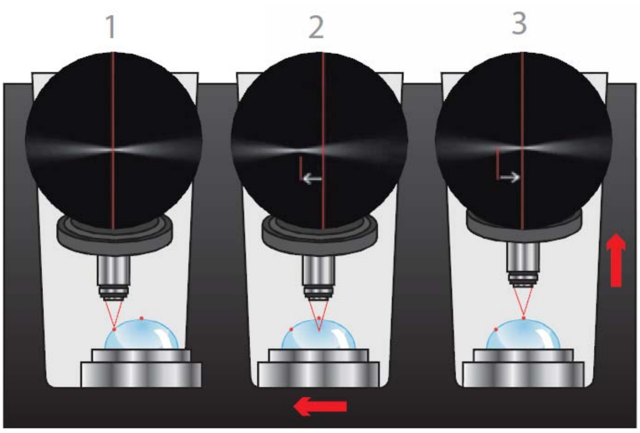

Fig. 1. Sequence of movements of the confocal tracking technique

For this technology to reach sub-100 nm accuracy high-quality components have to be used: an air-bearing for the x-axis and a crossed-roller bearing linear stage for the z-axis as any departure from ideal move, say flatness and straightness errors, will be superimposed to measured data.

A unique feature that this technology provides is the fact that the system can determine the center of the lens automatically without the need to carry out a measurement [2]. It takes advantage of the fact that it is not a single-point technique, but an image based technology.

Conclusions

We have presented a new non-contact technique for the measurement of aspherical and free-form optics that can reach sub-100 nm accuracy and measurement speeds up to 1 mm/s typical. It is fulfilling a need that existed in the optics metrology market.

References

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R. Artigas, F. Laguarta, and C. Cadevall, SPIE Proceedings, **5447**, 166, 2004
[2] Sensofar proprietary technology, patent pending