UV-Deflectometry: No parasitic reflections

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Deflectometry is a meanwhile well established tool to measure smooth surfaces, such as aspheric eye glasses. Deflectometry fails, however, if there are parasitic reflections from the rear side of the specimen. We present a new tool, where back side reflections are suppressed: “UV-Deflectometry” (UV-D).

1 Introduction

Phase Measuring Deflectometry (PMD) is a meanwhile established method to measure specular free form surfaces [1]. The principle is depicted in Fig. 2, left.

A sinusoidal pattern at a remote screen is observed via the specimen. From the distorted fringe images, the local slope of the specimen surface can be acquired.

However, as shown in the left part of Fig. 1, for transparent objects like lenses, the observed signal is a superposition of contributions from the front and the rear side of the specimen, which leads to a failure of the evaluation. Therefore until now transparent objects are prepared by roughening or blackening their rear side to absorb the parasitic signal. New solutions without altering the specimen are necessary. One possibility (for an overview see [2]) is ultraviolet illumination. As most mineral and organic glasses are not transparent for radiation below 330nm, only the front side reflection remains (right part of Fig. 1).

A straight forward solution would be to build a “UV-fringe projector”. However, this would entail severe technical difficulties and high costs. Moreover, deep UV projection, as necessary for several eye glass materials, would be impossible to achieve for reasonable costs. We use a different approach which is simple and less expensive.

Therefore we substitute the projector and the screen by a proper UV source with a slit mask (right part of Fig. 2). Instead of the phase shift algorithm with a sinus pattern we move the slit mask by a mechanical slide across the virtual screen.

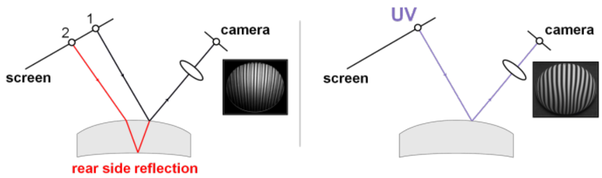

Fig. 1 *Left: Superposition of front- and rear side signal* *Right: Elimination of the rear side reflection by using ultraviolet radiation*

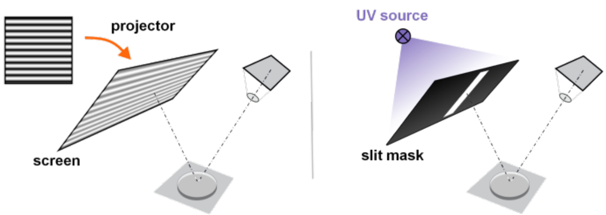

Fig. 2 *Differences between the “Standard”-PMD (left) and the UV-Deflectometry (UV-D) (right) setup*

2 Measurement principle

The measurement procedure is shown in Fig. 3. The pixel P at the camera observes the point Q on the virtual screen (x and y axis in Fig. 3) via the reflecting object. First, the mask is moved in the x direction and one detects the intensity distribution over time in pixel P. Because the slide position is known, the peak of this intensity signal yields the x component Q_x of point Q.

For the y component Q_y the mask has to be rotated 90° in the virtual screen plane and then moved along the y direction. Analogous to Q_x, from the intensity peak we acquire the y component Q_y and eventually the virtual screen position observed by camera pixel P is known.

However, for a precise 90° mask rotation a complex handling would be necessary. We implemented a much more simple sensor by a new concept: First, we replace the simple slit mask by a V-shaped slit mask as displayed in Fig. 4. Now, translation only in one direction is necessary to acquire the positions Q_y and Q_x.

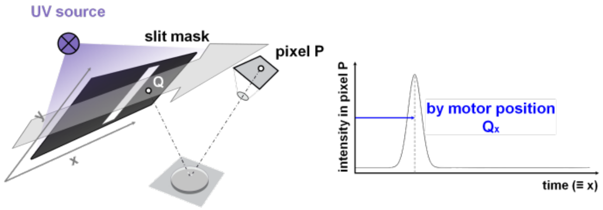

Fig. 3 *Determination of the x component of point Q during an UV-D measurement procedure with a slit mask*

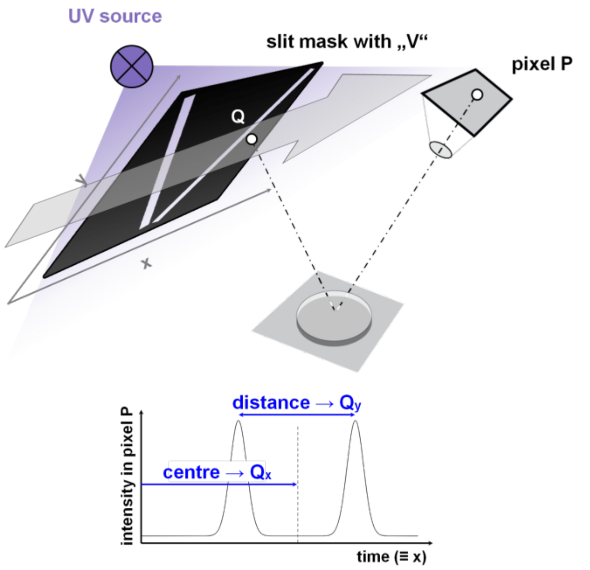

Fig. 4 *UV-D measurement procedure with a V-Slit mask*

3 The mask

Using this approach, the final translation range and therefore the measurement time can be optimized by adapting the layout of the mask. The result of this optimization process is shown in Fig. 5.

The depicted “fishbone-like” structures ensure a shorter translation range (because of the periodic arrangement) and also the detection of the x and y component. The same angle for every line guarantees a balanced error, too. In order to avoid sample artifacts every line is build by a dithered Gaussian structure (left part of Fig. 5).

There are other structures that enable a unique indexing for every fishbone element.

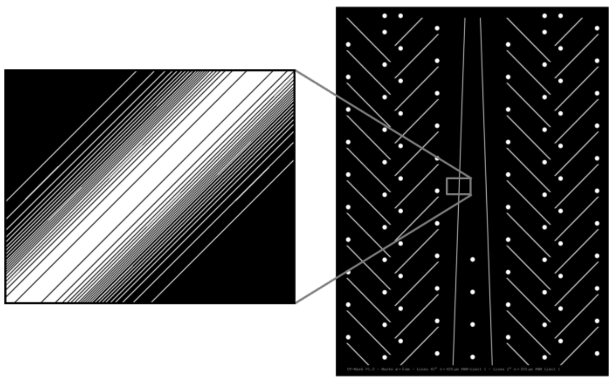

Fig. 5 *Current mask layout in the UV-D setup*

4 Setup and results

The experimental setup is shown in Fig. 6 and the first calibrated measurement result of an unprepared lens is displayed in Fig. 7. The accumulated exposure time is 150 s and the parasitic waviness is about 0.05 dpt.

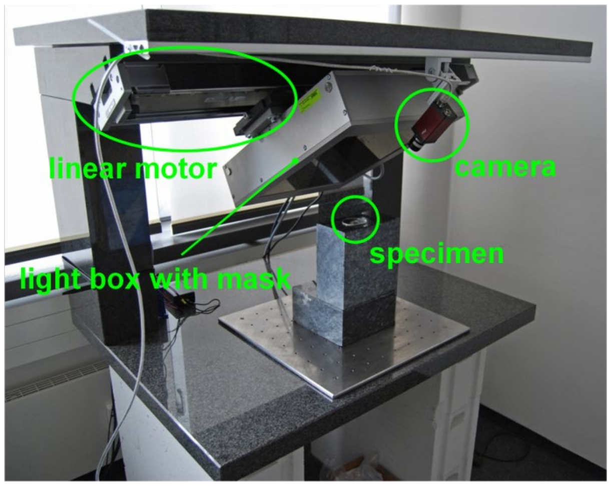

Fig. 6 *Experimental setup*

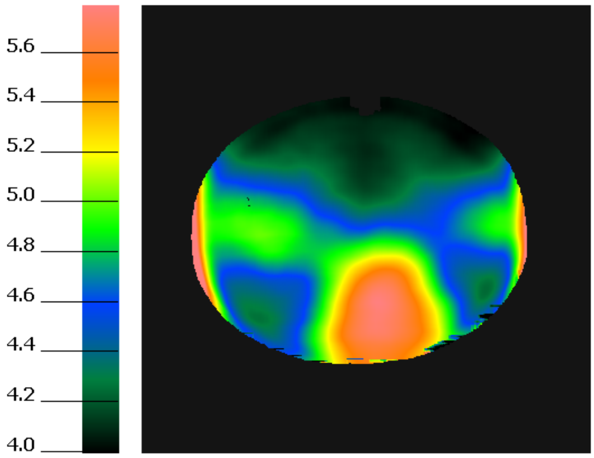

Fig. 7 *UV-D measurement of the mean curvature of an organic unprepared lens*

5 Summary and outlook

With the newly implemented UV-D setup, first successful measurements have been presented. The next step will be the enhancement of the measurement time to achieve the industrial requirement.

References

[1] M.C. Knauer, J. Kaminski, and G. Häusler, “Phase-Measuring Deflectometry: a new approach to measurespecular free-form surfaces”, Proc. SPIE 5457, pp. 366–376 (2004).

[2] C. Faber, M. C. Knauer and G. Häusler: „Can Deflectometry Work in Presence of Parasitic Reflections? “, DGaO Proceedings 2009

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