4D Metrology of grinded surface based on short coherent interferometry

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During the manufacturing process of glass lenses, especially the grinding step, it is important to control the important parameters such as shape or sub-surface damage (SSD) with high accuracy. For example, SSD is the driver for the duration and costs of the subsequent polishing process. Typically used methods measure the parameters only separately and suffer from limited resolution. In order to detect these parameters simultaneously, an optical coherence tomography set-up is build and tested.

1 Introduction

The grinding step of the manufacturing process of lenses is very essential for overall achievable accuracy of the final optical surface. Surface deviations introduced by a deficient grinding process can be hardly corrected in the subsequent polishing step. That is why, to make the whole process cheaper and faster, grinding should be well optimized to bring the lens as close as possible to final specification.

Therefore, there is a need for a measurement device to monitor the surface parameters determined by the grinding process.

First of all shape of the grinded surface should be monitored. Tactile measuring machines [6] are the most common method for shape measurements. They deliver sufficient precision regarding shape measurements but suffer from limited lateral resolution.

Another important parameter is the sub-surface damages (SSD) of the glass which modify the glass substrate in third dimension and have to be removed by subsequent polishing. There are destructive [2]-[3] and non-destructive [4]-[5] techniques which are able to measure the surface micro-cracks with necessary resolution. The disadvantages of these methods are that they are time consuming and modify the surface under test irreversibly.

Therefore, a nondestructive measurement method of SSD is a challenge for the metrology of grinding surfaces.

We have investigated and tested [1] optical coherence tomography (OCT) as an interesting alternative to existing methods. It is a nondestructive three dimensional optical imaging technique with high dynamic range based on short coherence interferometry. With precision of the depth measurements of 0.25 µm, lateral positioning accuracy of 2µm and lateral resolution of 4µm.

2 Measurement method

In principle, OCT is a Michelson interferometer Fig.1. The light is emitted from the broadband, low-coherence (or "white" in our case SLD with λ=670 nm) light source. Then it's split into two arms – reference and measurement. The reference wave front is reflected back by a cyclically scanned mirror (travel range of 1.8 mm, scanner rate of 68Hz). The measurement wave front is focused onto the sample, hits it, being also reflected (or, better, scattered) back by it. These two wave fronts are joined, and forwarded to detector. If the path length difference of these two wave fronts is small (within coherence length of the source), the detector will see the interference, otherwise, they will not interfere and the detector will just see the mean value of intensity. The computer unit controls the scanner mirror movement and records the incoming signal from the detector as a function of mirror position. The oscillating detector signal is demodulated to receive the envelope of the signal. The task is to find the maximum of the interference function which corresponds to the position of the scanned mirror where path length between this mirror and the reflecting sample layer are the same. This is how the A-scan (depth scan) is accomplished. Then the computer translates the sample laterally relative to the focused probe beam and makes another A-scan at a different point on the sample. A series of these A-scans form a B-Scan (lateral scan). Combining those B-Scans at various cross-sections a full 3D surface scan can be accomplished.

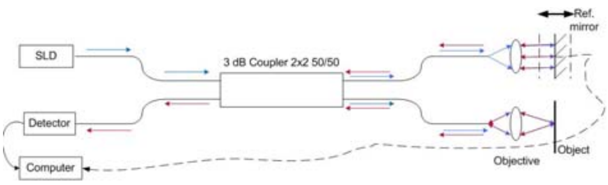

Fig. 1 *OCT principle scheme.*

3 Results and Discussions

3.1 Measurements of the sub-surface damages

For the grinding process of glass surfaces, there exist the “rule of thumb” (“COM summer school, Funkenbusch, 1997”) that predict that the SSD for grinded lenses is approximately of the size of the diamond rain size of the grinding tool. We used an “ALG 200 Schneider grinding machine“ with 3 diamond tools with grain size of 20µm, 45µm and 91µm diamonds to produced 3 samples (glass S-BSL7) with introduced SSD of different sizes (see the results on Fig.2)

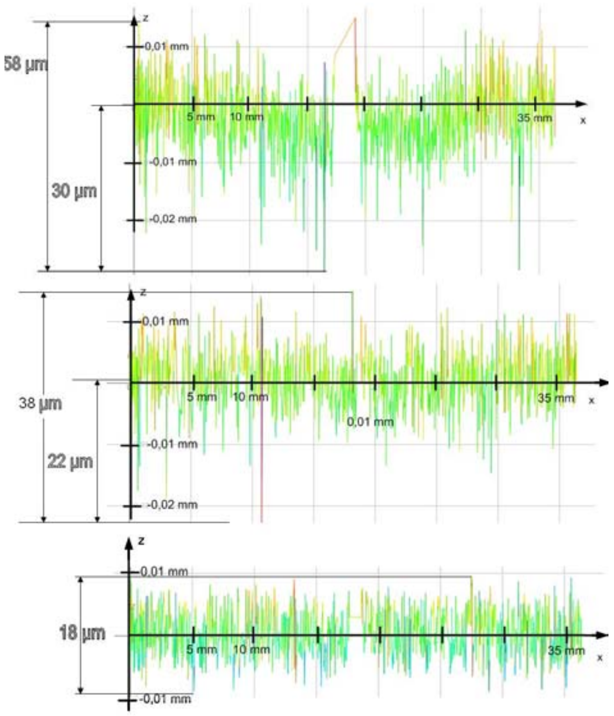

***Fig 2**: a) D91, b) D46, c) D20: The lens was scanned across the center with the sampling of 1µm; the unmachined part in the middle is masked.*

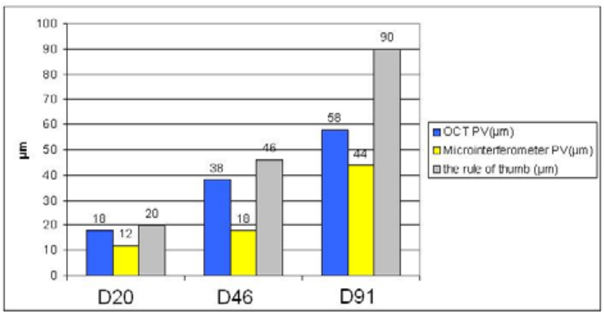

***Fig 3**: Comparison of the results obtained using OCT and Zygo Microinterferometer with the rule of thumb.*

The results in Fig.3 obtained using OCT show a good agreement with expected values for the grinding process. Furthermore, we compared the results with existing metrology, like the Zygo NewView 200 [7]. For the white light interferometer the deeper material layers have insufficient reflection which results in lost points. While the OCT gets the signal back from all points and therefore deliver the complete information about SSD of rough grinded surfaces.

3.2 Form measurements

To test the form measurements we measured a test glass plate of $\lambda/4$ flatness (Fig.4), which is polished on both sides. OCT can distinguish between front and rear surface. The form deviation was found to be of ± 1µm, depending on the stage accuracy.

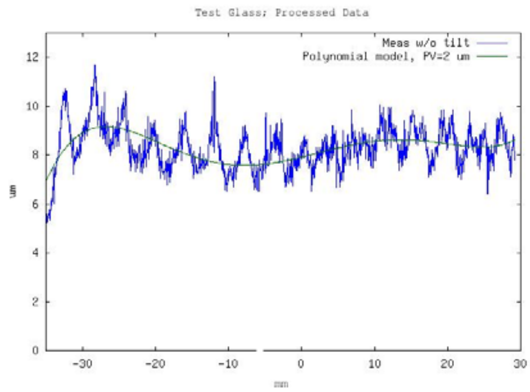

***Fig 4**: The measured line and fitted polynomial curve. Shape deviation is caused by the non linearity and instability of the translational stage.*

4 Conclusion

The measurement results show that the optical coherence tomography is a promising technique to monitor the most relevant parameters of a grinding process such as SSD and shape.

5 Acknowledgement

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