M-Scan OCT for Dosimetry Control during Retinal Laser Therapy

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Retinal photocoagulation is a well-established laser application in ophthal- 1
mology. Today's therapies use short pulse lasers to decrease thermal damage in the surrounding tissue. Studies have shown that the necessary dose is reached before effects are visually recognisable.
By using OCT, the therapy can be monitored. During this thesis, an OCT-System was set up and measurements in technical samples were taken. The physical processes were analysed and deduced theoretically.

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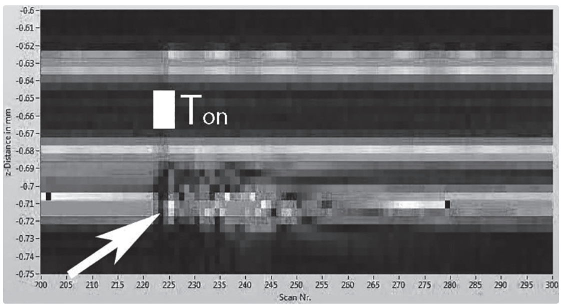
Motivation

Retinal diseases, such as age related macula degeneration or diabetic retinopathy, play an increasing role in modern society. In both of these cases, the retinal pigment epithelium (RPE) is affected and this can lead to blindness if not treated. In contrast to the conventional laser photocoagulation, selective retinal therapy (SRT) causes minimal local damage to the RPE and this provokes an enhanced natural healing and recovery of its function. To keep the induced damage as small as possible, the energy deposited must be dosed very carefully. In this thesis the physical processes during the application of SRT are examined and explained on technical samples.

Methods

The OptoLab built optical coherence tomography (OCT)-System was put into operation and the software and the signal processing were extended which allowed the registering of stationary, time resolved M-scans (sequence of A-scans at the same position). In order to trigger the treatment laser, an appropriate signal needed to be provided. This was achieved by downsampling the A-scan trigger by a certain factor. The operator could select a pulse rate of 50, 200 or 500Hz whilst the A-scan rate is constantly at 50 kHz. The first measurements on the technical samples produced good results and was based on the presumption that the observed effects of signal loss are induced by thermal expansion. A M-scan OCT-System was then simulated to verify this theory. Thermodynamic calculations showed that local warming can be big enough to cause a significant movement of the sample's surface. This theoretical model will be proven by advanced experiments on technical and biological samples.
A signal loss, caused by optoacustic effects, was also taken into account however it showed that the treatment pulses were not short enough to cause such a pressure wave. Moreover, the signal integration time at 50 kHz is greater than the propagation time of sound within the sample.



Signal loss in M-scan OCT during the treatment pulse (Ton, arrow) on black photopaper covered with stickytape.

Results

At first the existing OCT-System was converted to register M-scans as desired. Then the OCT-software was extended to provide a trigger to the treatment laser and from this a good understanding of OCT signal acquisition and processing was obtained and a theory about the cause of this signal loss was proposed and proved by simulation and experiments. It was shown that the signal loss was generated by a rapidly moving surface or layer of scatterers which was caused by fast thermal expansion and therefore can not be avoided. In collaboration with a bachelor student, the existing treatment hand-piece was extended with the optics required to register collinear M-scans.

Conclusion

Avoiding signal washout is not possible as it results from the very basic operating mode of OCT however, this effect is in no way dangerous or even harmful. As the effect takes place at an assigned time, it does not disturb the overall signal quality. Using smart image processing, this effect can even be useful to check if the treatment laserpulse was fired as designated.