Multiaxial OCT Scan Head

Degree programme: BSc in Micro- and Medical Technology | Specialisation: Optics and Photonics
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Optical Coherence Tomography is a useful tool in medical and industrial applications to acquire intensity-based cross-sectional images of various samples using light. The developed multiaxial OCT scan head allows to acquire cross-sectional images from several axis which are further post-processed into a single optimized image of higher accuracy.

Initial Situation

At the present time, no inline inspection system to control the production of semi-transparent complex structured tubes of polymerized material with sufficient geometrical accuracy exists. The goal of the global project is to develop such a system using optical coherence tomography (OCT) with measurements from different orientation relative to the samples. In this thesis, the focus was to design a proof of concept of a multiaxial OCT scan head, analyze its characteristics and limitations as well as implement a multiaxial cross-sectional image reconstruction software.

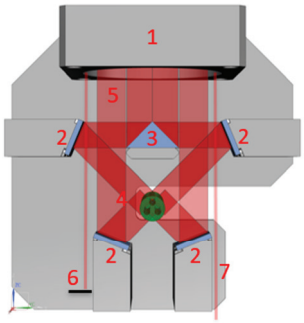
Material & Methods

The multiaxial scan head is mounted on a swept source OCT system. The system uses a galvo scanner to redirect the laser onto a telecentric optic allowing to acquire B-scans . The mirror system of the scan head subdivides this B-scan by redirecting the laser beam to scan the sample from different orientations. As the laser beam is focused, the optical path length must be equal in each axis to guarantee that the measured sample is in focus and contained in the depth of field.

The development started with an implementation of a script to calculate the optical path length of each scan axis and optimize the positions of the mirror and prism to guarantee the minimal optical path length according to the required system specifications. After the computation of the scan head's geometrical constraints, two scan head prototypes have been designed for different measuring field sizes. Once mounted, a square calibration target has been scanned which was used to create a calibration script for the final image reconstruction. Finally, a basic image reconstruction algorithm was designed allowing to reconstruct cross-sectional images for samples of different shapes and geometries.

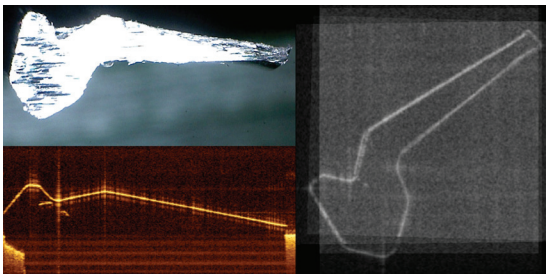
Results

A functional proof of concept has been elaborated and used for the cross-sectional image reconstruction of samples with different shapes. It has been demonstrated that the calibration process is crucial to achieve sufficient reconstruction quality for the further measurement processes. Moreover, due to refraction of light in the sample, a more advanced algorithm may be implemented to obtain an accurate reconstruction of the internal structures of samples.



1: Telecentric optic
2: Flat mirror
3: Prism mirror 90°
4: Sample
5: Laser paths
6: Reference surface for temperature dilatation
7: Background reference

CAD 4 axis OCT scan head



Top left: Metal profile sample, bottom left: single view OCT B-scan, right: Multiaxial reconstructed B-scan

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