Multi-Channel Spectrometer for Optical Coherence Tomography and Low Coherence Interferometry

Subject: Optics and Photonics
Thesis advisor: Prof. Meier Christoph
Expert: Dr. Boris Považay

Low coherence imaging techniques are well-established in biomedical and industrial applications for depth resolved characterisation of transparent as well as scattering samples. Some of these applications necessitate simultaneous acquisition of multiple channels. In scope of this thesis, a multi-channel spectrometer was developed. Its capabilities are demonstrated in polarization sensitive optical coherence tomography as well as in an industrial positioning application.

Motivation

For optical coherence tomography (OCT) and low coherence interferometry (LCI) multiple signal enhancing methods have been demonstrated. Some applications e.g. polarization sensitive OCT and speckle noise reducing OCT necessitate multiple acquisition channels. Former implementations suffer from increased system alignment complexity and high system costs, since optical components are needed multiple times. The goal of this thesis is to realize a competitive and cost-efficient multi-channel OCT/LCI solution for multidimensional optical imaging and ranging.

Multi-Channel Spectrometer

The design features a holographic grating as dispersive element, a collimation and an objective lens to image the light entering the device onto the two-dimensional photodetector-array. The multi-channel capability is implemented by means of a V-groove fibre mount, which holds eight single-mode fibres precisely aligned in the vertical plane. The spatially separated spectra of all channels are acquired by the camera individually (cf. Fig. 1). This design offers comparatively simple alignment and the opportunity to expand the number of parallel channels to up to 32 without significantly increasing system complexity. The spectrometer exhibits a sensitivity of 90dB (300µW @ sample) and signal roll-off of 15dB over the 4.8mm detection range for each channel. Both values are close to the theoretical limit and enable biomedical imaging.

Applications

The multi-channel spectrometer was integrated with a number of probes and specially developed detection algorithms. It was successfully tested for imaging biomedical and technical specimen, by measuring polarization changing structures in the anterior segment of a pig eye «in vitro» as well as by measuring spatially resolved stress distribution in a plastic moulded part (cf. Fig. 2). Furthermore a positioning application using simultaneous acquisition of multiple sites with sub-µm placement precision is demonstrated.

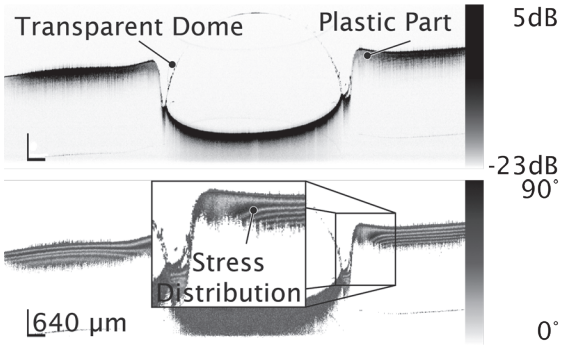

Fig. 2: Measured cross-section of a plastic moulded part.
Top: Intensity image / Bottom: Retardation image

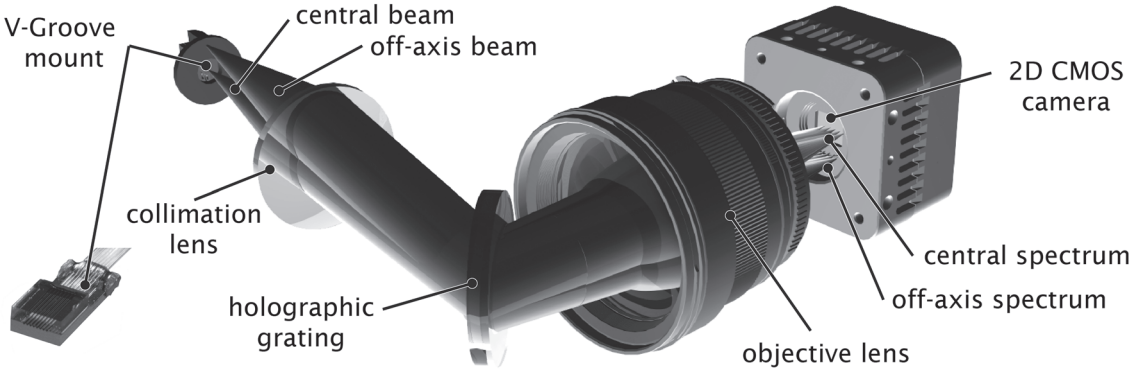

Fig. 1: Three dimensional scheme of the spectrometer. Inset shows the actually implemented V-Groove mount.

Dominic Ernst
dominic.ernst@gmail.ch