Foil measurement with Polarization Sensitive Spectral Domain Optical Coherence Tomography

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Theory shows that the improvement in axial resolution in OCT, is inversely proportional to the bandwidth of the laser used. The aim of the thesis is to show that the theory can be applied in practice using a broadband laser. In addition, different polarization states of light are used and show how they interact at different depths of the foil.

Initial situation

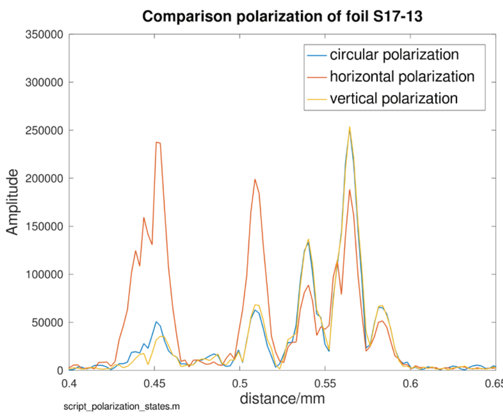
Non-destructive imaging techniques are used as a quality control tool in the production of thin foils to see their internal structure and measure their thickness. For this purpose, a spectral domain OCT is used in combination of a broadband supercontinuum fiber laser. Unfortunately, these lasers are very expensive, so Exalos has developed a new broadband laser.

Goal

OCT is a non-destructive imaging technique based on interference of light. OCT can be used to analyze the surface and the inner structure of foils consisting of multiple layers. Their thickness can be measured with an accuracy of 1 /1000 mm. To reach such a high precision, the axial resolution of the used spectral domain OCT must be improved. One aspect that improves axial resolution is the use of a broadband laser. Supercontinuum fiber lasers do exist but are often very expensive. The company EXALOS is specialized in super luminescent diodes (SLED) and has developed a new laser over the last years.

Method

The quality of the signal can be defined by the signal-to-noise-ratio (SNR) and the axial resolution by the full-width-half-maximum (FWHM) of the peaks.



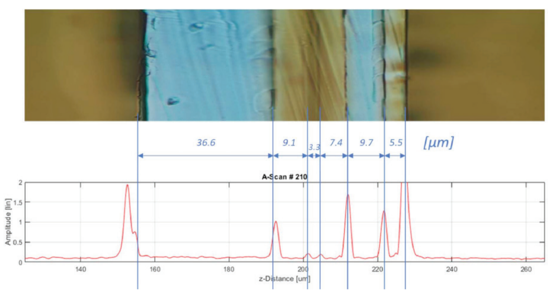
Inner structure of a foil. The peaks represent the layers. The three measurements use different polarization states.

Various scanning techniques can be used to influence the SNR. These techniques include A-scans, which visualize the different layers at one point, and B-scans, which create a slice through the film. Averaging multiple scans also helps to reduce noise and thus increase SNR. FWHM is given by the broadband laser and can be reduced by digital post-processing methods such as windowing, zero padding or spectral shaping.

In addition, the influence of polarization states is analyzed. The idea of using different polarization states is that the light is reflected more intensely at different depths, depending on its polarization state. Combining these states, all layers of the foils would show a similar reflectivity and thus a higher SNR across the entire foil.

Result

For high SNR, the best method is to average the A-scans composing the B-scan. This way the noise cancels out and the peaks get a higher amplitude. Also, using shorter focal lengths increases the SNR and slightly improves the FWHM. Polarization states are actually reflected differently at different layers. If one layer has high reflectivity with horizontal polarization and another layer has vertical polarization, then they can be combined to produce a higher overall signal. This means that the SNR can be reduced and the signal quality improved.



Microscope image of a foil and its inner strucutre. A-scan of the foil. The peak represent the layers.

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