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Multimodal OCT Imaging

Bettina Heise[1] and Ivan Zorin[1] and Guenther Hannesschlaeger, and Markus Brandstaetter[1]

RECENDT- Research Center for Non-Destructive Testing GmbH
Altenberger Str 69, 4020 Linz, Austria

Abstract We demonstrate OCT as an inspection tool for monitoring and validating 3d printed AM specimens. We will discuss the potential and challenges in this applications. Furthermore, we illustrate extensions like spectroscopy and speckle imaging.

Keywords Optical Coherence Tomography, imaging, multimodal, speckles, quality inspection, reliability, additive manufacturing

1 Introduction

Multimodal imaging has emerged in recent years. Its advantage is the agglomeration of information through image and data fusion, which allows deeper insights into structural, functional or chemical information of samples. In addition, different spatial or temporal scales can be combined. Here, we mainly limit ourselves to imaging by optical coherence tomography (OCT) to extract structural information from samples and to enable optical characterization in a non-destructive and not hazardous way. The combination of OCT with spectroscopic information is a valuable tool, as it provides insights into the chemical and structural composition. Furthermore, with the advent of novel light sources, such as supercontinuum sources; covering spectral ranges from the visible to the near and mid infrared, this range can be facilitated in a very comprehensive way [1]. Additionally, also combinations of spectral probing range of OCT in near infrared and THz imaging are exploitable for advanced material characterization. OCT imaging itself also allows the use of different contrast mechanisms partly based on statistical optics approaches [2]. Therefore, the almost ubiquitous speckles in OCT imaging are not only noise but can also serve as a source of information. Their variance, higher order moments or local autocorrelation can provide information about the dynamics inherent in the sample under investigation [3]. We will present our latest results with a multimodal OCT system combining structural and spectroscopic material characterization. In addition, statistical optics/speckles based characterization for scattering samples with dynamics on different time scales will be presented.

2 Methods

OCT imaging is currently mainly realized in Fourier Domain OCT (FD-OCT) configurations due to its increased sensitivity. Both versions, Spectral Domain OCT (SD-OCT) and Swept Source OCT (SS-OCT) are the most predominant versions nowadays. However, to extend these FD-OCT setting to other spectral ranges is challenging. However such extension offer promising combinations and multi-modal imaging approaches, especially such as spectroscopy or speckle (variance) imaging. We will demonstrate comparatively particular features of FD-OCT in NIR and MIR spectral range. Thereby we can cover a spectral range covering from about 2 to 5 µm currently, beyond the conventional NIR range of 0.8 to 1.5 µm.

3 Results

In particular the inspecting and monitoring additive manufacturing (AM) products and processes already during manufacturing or in intermediate states by OCT seems very promising currently to introduce it with ab industrial background. The 3d printing of layers in micron scales represents a feasible approach for OCT imaging. The 3d printed materials hereby comprehends on one hand polymeric substances, on the other hand also the wide range of ceramics 3D printed specimens is of interest. OCT can enable to monitor in future such printing, or allows to inspect the green parts. That give valuable insights on micro-defects already before e.g. sintering processes start. We will demonstrate different OCT settings and results for visualization and inspection of different 3d printed materials exhibiting micro-defects. However, one has also to know the specific features of OCT imaging, where pigments and fillers can modify appearance of cross-sectional images. This can result that defects are mitigated or suppressed in their visibility by scattering sites. It is essential therefore to consider the scattering features of specimens under test to define and select suitable wavelength and probing ranges for OCT imaging and sensing.

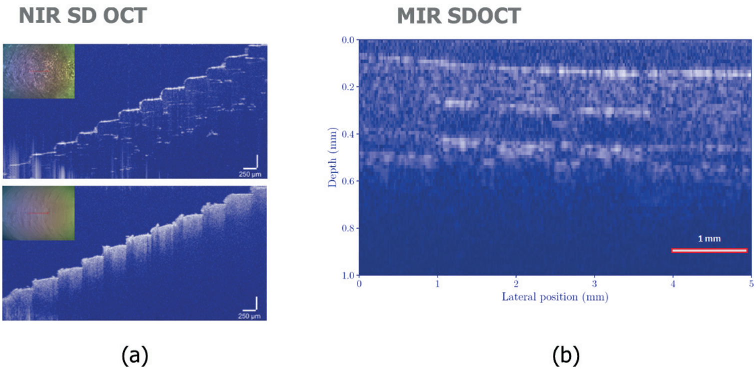

Figure 3.1: OCT cross-sectional images (B-scans), captured from 3d printed specimens. They represent examples both for (a) 3d filament printed polymer samples and (b) lithographically AM ceramics.

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