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Optical Coherence Tomography (OCT) in the mid-Infrared (mid-IR) to detect hidden material defects

Mid-IR OCT: an effective tool to inspect high-scattering objects

Optical coherence tomography (OCT) is a high-sensitivity, high-resolution non-destructive testing technique to obtain 3D structural images of samples with complex shape and structures at micron-scale. Recently emerged mid-infrared (mid-IR / MIR) OCT helps to overcome the common problems when inspecting opaque and turbid industrial materials and samples. Mid-IR OCT offers increased penetration depth and more detailed sub-surface information for highly scattering materials such as ceramics, paints, and polymers.

The functional window of standard OCT lies in the shortwave region namely visible and near-infrared (near-IR) spectral ranges. Such OCT systems are well-developed (provide high imaging speed, sensitivity, and resolution) and highly suitable for effective use in the main field of application – biomedicine. In practice, however, the effective probing

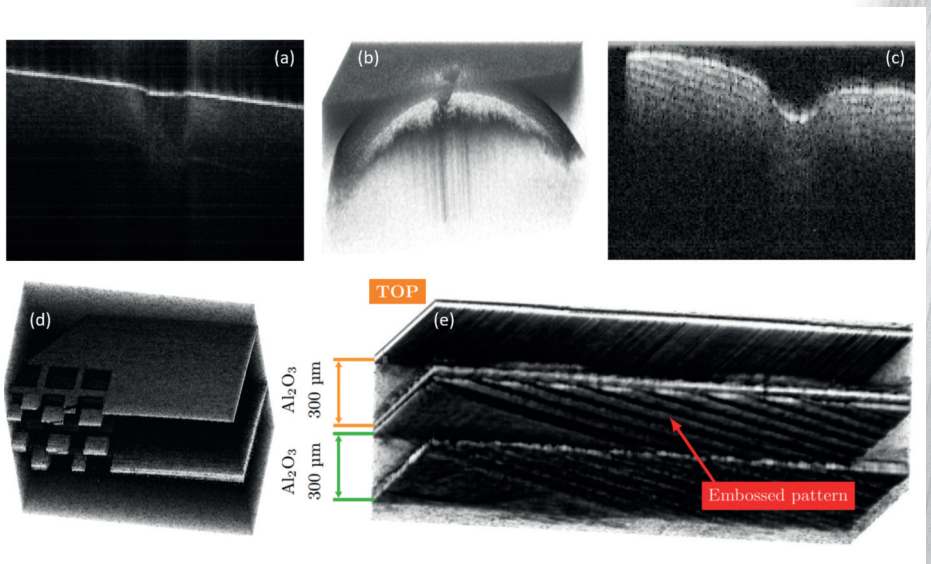

Figure 1: OCT scans of various high-scattering samples: (a) sintered lithography-based manufactured bulk ceramic part with a sub-surface porosity inhomogeneous defect; (b) tablet coating; (c) additive manufactured ceramics with detected layers (around 30 µm thick each); (d) micro-structured part (650 µm thick) composed by ceramic particles embedded in a polymer matrix; (e) standard sintered industrial ceramics with laser-embossed patterns. Ceramics samples (a, c, d) were provided courtesy of Lithoz GmbH Vienna within the framework of the FFG project DIQACAM.

Facts/Key-Values/ Features & Benefits

- Non-destructive and contact-free
- High-resolution structural imaging
- Resolution: 8 µm axial, 35 µm lateral
- Increased probing depth for high-scattering industrial materials
- 3D imaging and visualization

Potential Users & Fields of Application

- Quality inspection and process monitoring
- Ceramics, polymers, and paints industries
- Additive manufacturing industry
- Material research

Status – what do we offer?

- Feasibility studies, measurements
- R&D for probing and sensor configuration
- Consulting for your specific measurement and testing tasks
- Development of customized measurement solutions

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depth of near-IR OCT becomes severely limited, e.g., in the case of industrial imaging scenarios and NDT, because materials here are often turbid and thus exhibit strong light scattering.
As shown first in theoretical predictions and simulations, the probing depth can be considerably increased by shifting to longer wavelengths, since the magnitude of scattering is inversely proportional to the wavelength. These predictions have been recently confirmed by RECENDT researchers as several realizations of the first mid-IR OCT systems were demonstrated; the enhanced imaging probing depth and high suitability for NDT applications were confirmed. The systems showed high application capability for inspecting industrial ceramics, polymers, paints, and composite materials (see examples in Fig. 1).

References, Publications

1. Ivan Zorin, Paul Gattinger, Andrii Prylepa, and Bettina Heise, "Time-encoded mid-infrared Fourier-domain optical coherence tomography," Opt. Lett. 46, 4108-4111 (2021)

2. Ivan Zorin, Paul Gattinger, Markus Brandstetter, and Bettina Heise, "Dual-band infrared optical coherence tomography using a single super-continuum source," Opt. Express 28, 7858-7874 (2020)

3. Ivan Zorin, Rong Su, Andrii Prylepa, Jakob Kilgus, Markus Brandstetter, and Bettina Heise, "Mid-infrared Fourier-domain optical coherence tomography with a pyroelectric linear array," Opt. Express 26, 33428-33439 (2018)

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