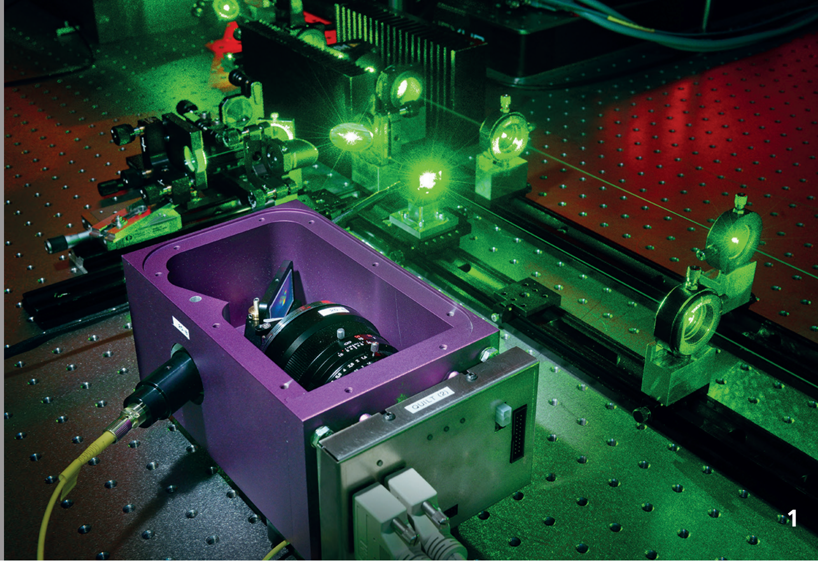

QUANTUM OCT

Task

Optical coherence tomography (OCT) is a powerful and widely used method for the non-destructive 3D imaging of layered systems. While previous OCT systems work in the visible or near-infrared range, the penetration depth in scattering materials can be significantly increased if the system uses light with longer wavelengths – in the mid-infrared (MIR). At the same time, however, the complexity and cost of appropriate detectors and light sources increase, which is why such MIR OCT systems have not yet been commercially implemented. This circumstance can be circumvented if the sample measurement and the detection are examined at different wavelengths, using a so-called measurement of undetected photons.

Method

In a quantum OCT, entangled photon pairs are used in which the wavelength of one photon is in the visible or near-infrared range and the second in the MIR range. While measurements are made in the MIR, detection in the visible or near-infrared wavelength range is done with low-cost and low-noise silicon detectors. The Fourier transform of the interference signal is used to evaluate the depth information of the sample. The Fraunhofer ILT is developing an adapted spectrometer as well as a nonlinear interferometer. The latter is essentially a Michelson interferometer, whereby the entangled photon pairs are generated in a nonlinear crystal (here, a periodically poled lithium niobate: PPLN), which is located in the input and output of the interferometer. A commercially available laser at 532 nm is used as pump source.

1 Nonlinear interferometer (background) and spectrometer (foreground).

Results

Fraunhofer ILT built and tested the nonlinear interferometer in a laboratory setup. The principle function was first demonstrated at a measurement wavelength in the near infrared at 1485 nm and a detection wavelength of 829 nm. Furthermore, the setup was converted for MIR measurement wavelengths, which could be adjusted between 4 and 5.7 µm, a range that is within the limit of what the PPLN crystal can transmit. Detection is performed accordingly between 586 nm and 613 nm. The recorded interference signals also show that the quantum OCT principle works. Depending on the wavelength selected, the spectral width allows axial resolutions in the range of 10 µm.

Applications

One application is the 3D investigation of ceramic functional components and coatings. In the future, the quantum OCT system will be able to detect pores, cracks and fluctuations in coating thicknesses during the production cycle and be used to increase component quality and control manufacturing processes.

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