New options for finding defects on and below the surface using structured laser thermography

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In infrared thermography, the interaction of the heat flow with the internal geometry or inhomogeneities in a sample and their effect on the transient temperature distribution is used, e.g., to detect defects non-destructively. An equivalent way of describing this is the propagation of thermal waves inside the sample. Although thermography is suitable for a wide range of inhomogeneities and materials, the fundamental limitation is the diffuse nature of thermal waves and the need to measure their effect radiometrically at the sample surface only. The crucial difference between diffuse thermal waves and propagating waves, as they occur, e.g., in ultrasound, is the rapid degradation of spatial resolution with increasing defect depth. This degradation usually limits the applicability of thermography for finding small defects on and below the surface. A promising approach to improve the spatial resolution and thus the detection sensitivity and reconstruction quality of the thermographic technique lies in the shaping of these diffuse thermal wave fields using structured laser thermography. Some examples are: • Narrow crack-like defects below the surface can be detected with high sensitivity by superimposing several interfering thermal wave fields, • Defects very close to each other can be separated by multiple measurements with varying heating structures, • Defects at different depths can be distinguished by an optimized temporal shaping of the thermal excitation function, • Narrow cracks on the surface can be found by robotic scanning with focused laser spots. We present the latest results of this technology obtained with high-power laser systems and modern numerical methods.