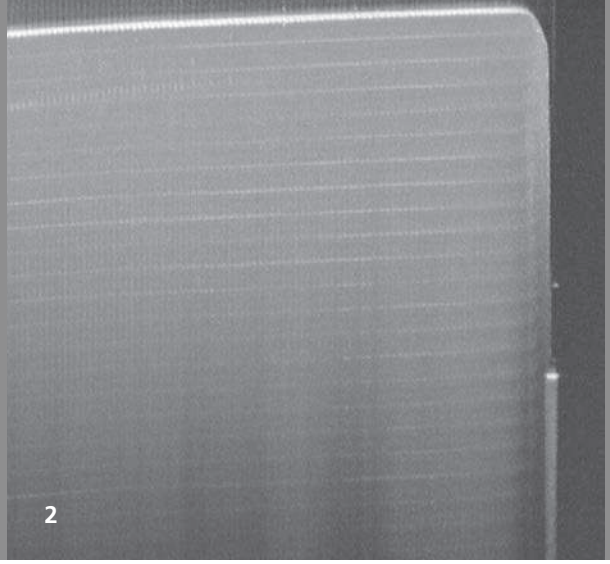

PROCESS MONITORING IN ADDITIVE MANUFACTURING

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Additive manufacturing is becoming an integral element of manufacturing processes for complex components. A shift in scale from prototyping and small batch production to mass production is accompanying this development. The range of materials that can be used with additive technologies is also expanding as new technologies emerge. Besides different polymers and metals, ceramics are now also used in additive manufacturing processes. With the ever-growing role of additive manufacturing systems in industrial production, the need for in-line process monitoring technologies is becoming more pressing. Monitoring systems must meet a myriad of requirements, and the preferred technologies should also have multi-material capabilities.

Established as a medical imaging technique (e.g., in ophthalmology and dermatology), optical coherence tomography (OCT) is now, for the first time ever, to be applied in process monitoring. The focus of research efforts at Fraunhofer IKTS lies mainly on the in-line monitoring of additive manufacturing processes. With OCT, analysis of surfaces as well as internal structures of different materials is possible. In the processing of metals (e.g., laser cladding), OCT is restricted to surface imaging, but for other materials, it is also capable of revealing internal structures and detecting defects, such as delamination or inclusions. Thus, for example, it allows for examining the adhesion of the individual layers in 3D-printed ceramics to be examined. By adding other optical technologies, such as Raman spectroscopy, it is possible to monitor additional process characteristics, such as the degree of cure during the curing process for plastics.

Ultrasonic technology has traditionally been used primarily for non-destructive testing of metal parts, such as hollow shafts, but it can also be used in additive manufacturing. Particularly when water baths are used for 3D printing of ceramic components, application of ultrasonic technologies for reliable detection of pores and delamination is practical. With ultrasonic technology, it is also possible to detect defects in additively manufactured metals.

The different technologies developed and used at Fraunhofer IKTS focus on in-process measurements to allow defects to be detected and segregated, and the necessary process adjustments to be made during the manufacturing process. This makes the Fraunhofer IKTS testing technologies the key to achieving highly efficient certified additive manufacturing systems. Continuous monitoring of different additive manufacturing processes is an important basis for transfer to industrial-scale production and for ensuring consistent product quality.

1 *OCT surface projection of a component formed by additive manufacturing.*
2 *Cross-sectional image of a component formed by additive manufacturing.*

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