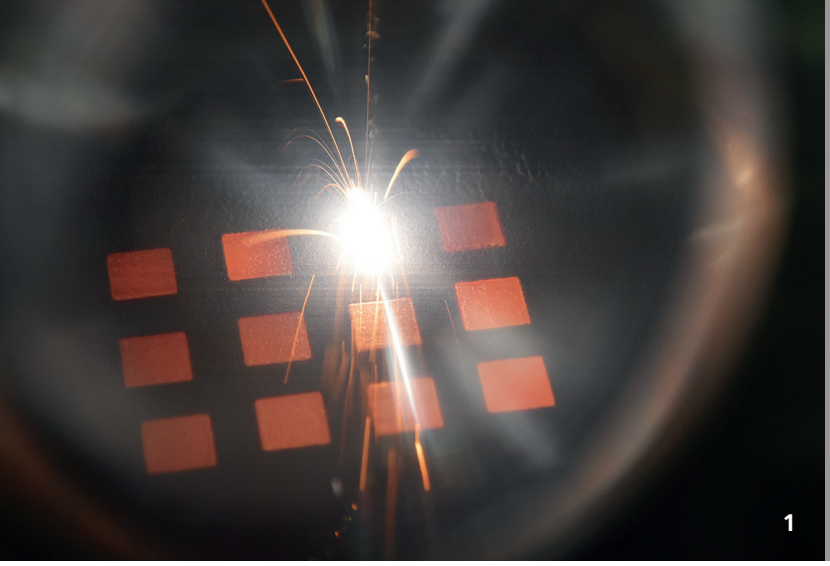

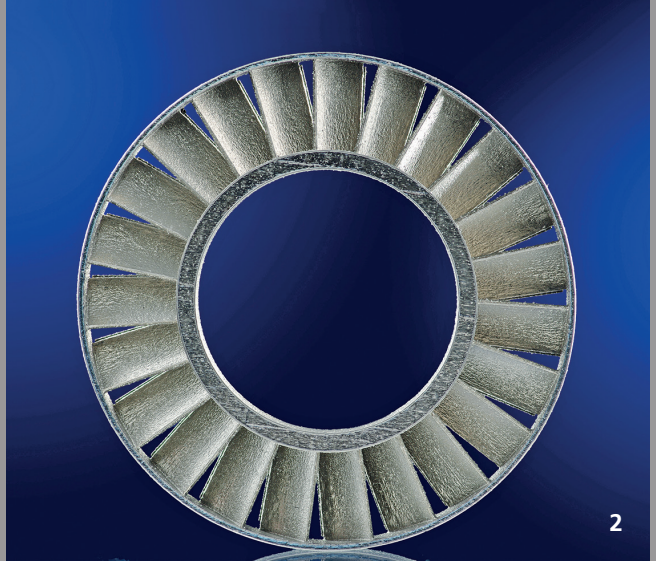

PROCESSING OF TITANIUM ALUMINIDES (TIAL) WITH HIGH-TEMPERATURE SELECTIVE LASER MELTING (HT-SLM)

Task

Lightweight structures and materials are increasingly being used to reduce the emission of pollutants from mobile turbomachinery. The intermetallic lightweight material titanium aluminide (TiAl) has great potential for such purposes because it combines high material strength with low weight and high thermal resistance. However, since it is highly brittle and has mechanical characteristics significantly dependent on the oxygen concentration in the component, it is difficult to process TiAl with conventional production processes. As a powder-based additive manufacturing process, Selective Laser Melting (SLM) basically makes it possible to manufacture complex metallic structures without tools and with a near net shape. Therefore, this project aims to develop suitable process control for the processing of TiAl with SLM. Components are considered suitable when they are crack-free with a density > 99.5 % and with mechanical properties which are in the range of cast TiAl.

Method

Owing to the localized melting during SLM, large thermal gradients are created, which can lead to crack formation in the component structure, especially in the case of brittle intermetallic materials. For the crack-free processing of TiAl with SLM, the components are, therefore, preheated over the brittle-ductile temperature during the process. For this purpose, an SLM laboratory machine is used with an induction heating system which reaches preheating temperatures of > 1000 °C. So that the mechanical characteristic values »elongation« and »tensile strength« can be determined, tensile specimens are built and heat-treated by hot isostatic pressing (HIP) before they are subjected to tensile tests at room temperature. Finally, a guide vane ring is manufactured and its dimensional accuracy checked with the aid of a 3D scanner.

Results

Pre-heating over the brittle-ductile temperature makes it possible for SLM to process TiAl free of defects, with densities > 99.95 percent and a micro-duplex structure. The tensile strength of 917 ± 97 MPa at room temperature is comparable to the tensile strength of cast tensile specimens made of TiAl. However, the breaking elongation is smaller compared to cast samples. This can be caused by an increase in the oxygen concentration from the process chain. If a shrinkage that occurs during cooling is taken into account as an oversize in the CAD file, a dimensional accuracy of < 80 µm can be achieved.

Applications

Possible applications for TiAl components manufactured by SLM are in turbomachinery, as well as in the automotive and aerospace sectors.

The SME-innovative project underlying this report has been carried out on behalf of the Federal Ministry of Education and Research (BMBF) under grant number 033RKo35C.

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1 Exposure of SLM specimens out of TiAl at a preheating temperature > 800 °C.

2 Guide vane ring made of TiAl with HT-SLM.