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**Best part Award 2005**

# Ultraligth weight construction

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## The process and materials

Direct laser forming will be presented as a new generative manufacturing process for metallic parts. Laser melting is a layer by layer process, which generates 3 dimensional parts out of standard material powders achieving a part density of approx . 100%.

In comparison to other powder bed based generative metal processes two major differences can be pointed out.

On the one hand, the material used is a single component metal powder like stainless steel X2CrNiMo17 13 2, tool steel X38CrMoV 5 1, Titanium GdII or TiAl6V4, or Aluminum alloys (AlSi10Mg for example).

On the other hand, the physical process is a complete melting of the powder layer with a metallurgical bonding between the layers yielding densities of approx. 100% in one step. These characteristics enlarge the field of application for this technology from Rapid Prototyping to the Rapid manufacturing of functional parts and serial tool.

## Presentation of the Ultralight weight part and industrial potential

Due to the layer by layer manufacturing laser melting enable a high degree in design freedom and does not comply the user to geometric limitations given by conventional manufacturing methods. The most known examples of application are the conformational cooling channels for injection molding tools. Nevertheless design features like internal hollow structures, which cannot be manufactured by conventional methods, can be realized.

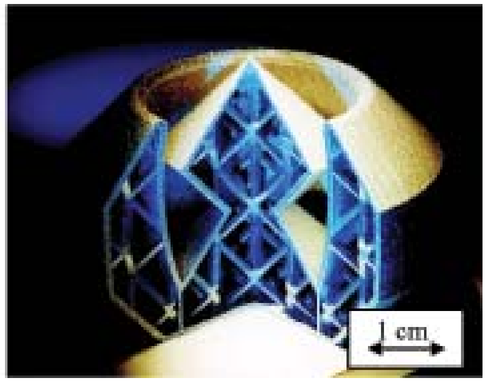
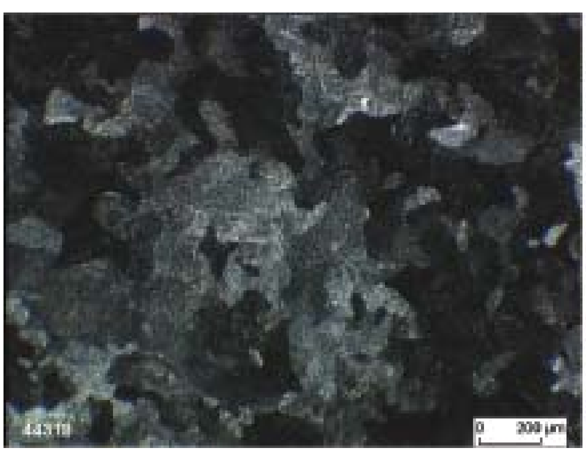



Figure 1 : CAD picture Figure 2 : laser melting part (TiAl6V4 or AlSi10Mg)

This advantage can be used for parts with load optimized internal structures like the demonstration part in the figure bellow. The lightweight design has also advantages for dynamically loaded parts. In combination with a lightweight material such as titanium or aluminum alloys ultralight structures for example for aerospace (which uses 80% of the world wide consumed Ti) and automotive racing applications can be produced.

## Properties of parts : microstructure, chemical composition and mechanical properties of laser melting samples out of TiAl6V4

Cross section of parts out of Ti6Al6V4, which are etched and analyze using polarized light, show size of the former β-solid solution (Figure 3). Due to the high cooling rates (up to $7.10^6$ K/s) during the laser melting process the martensitic α'-phase was formed out of the b-solid solution. Using light microscopy the typical needle-type structure of α'- martensite can be observed (Figure 4).



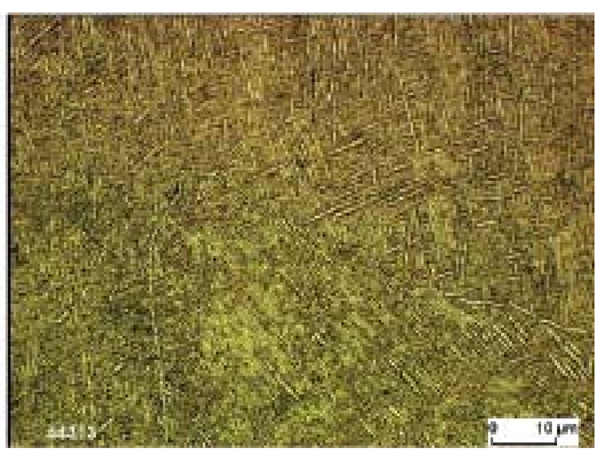
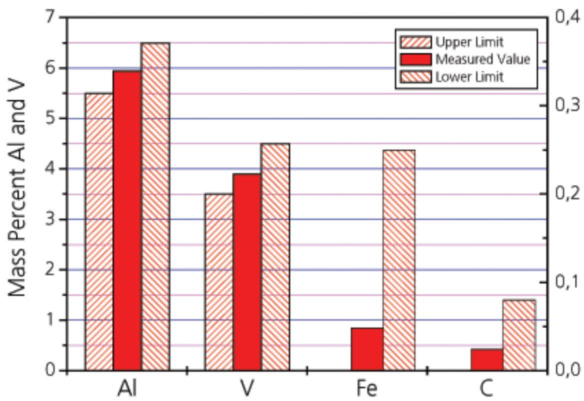




Figure 3 and 4 : Cross section of TiAl6V4 samples using respectively polarized and reflected light microscope.

The loss of alloying elements and the amount of interstitial elements such as oxygen and nitrogen are crucial points. A spark discharge emission spectroscopy shows, that the alloying elements are within respectively lower than allowed limits (Figure 5). An analysis using hot carrier gas extraction exhibits, that the oxygen content of laser melting parts is higher than the content in the powder but still lower than the accepted limit. Looking at the nitrogen content there is even a decrease from powder to part (Figure 6).



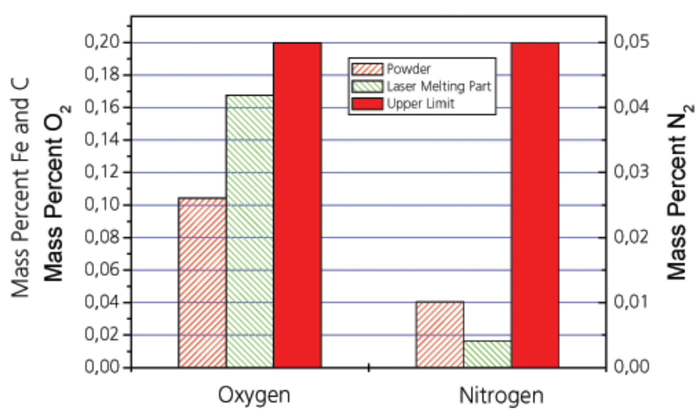




Figure 5 and 6 : Respectively analysis of content of alloying and interstitial element in TiAl6V4 laser melting parts

Due to the high density resulting from the laser process the samples exhibit good mechanical characteristics. Tensile test specimen according to DIN 50125 Form E were tested (Figure 7).

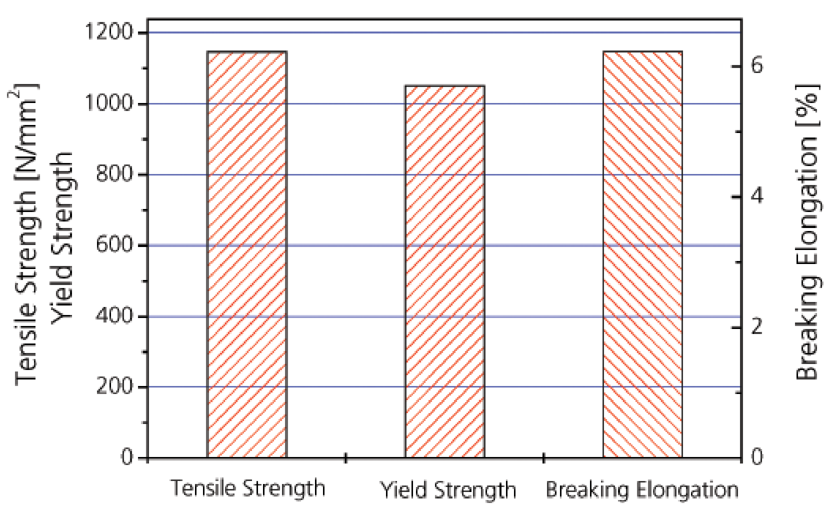



Figure 7 : Tensile strength, yield strength and breaking elongation of laser melting parts out of TiAl6V4.

Tensile strength, yield strength and breaking elongation proved to be above the value for cast specimen out of TiAl6V4, which exhibit a similar microstructure. Especially the breaking elongation of approx. 6% indicates, that despite the increase in oxygen content during the laser melting process the samples do not exhibit brittle characteristics.

## Conclusion

The presented example demonstrate the potential offered by the laser melting process. Especially the use of serial materials like TiAl6V4 or aluminum alloys offers nex possibilities in the direct generative manufacturing of parts. In addition the realization of new geometric features represents a supplementation of conventional manufacturing in various different fields of applications like aerospace  and motor sport applications.