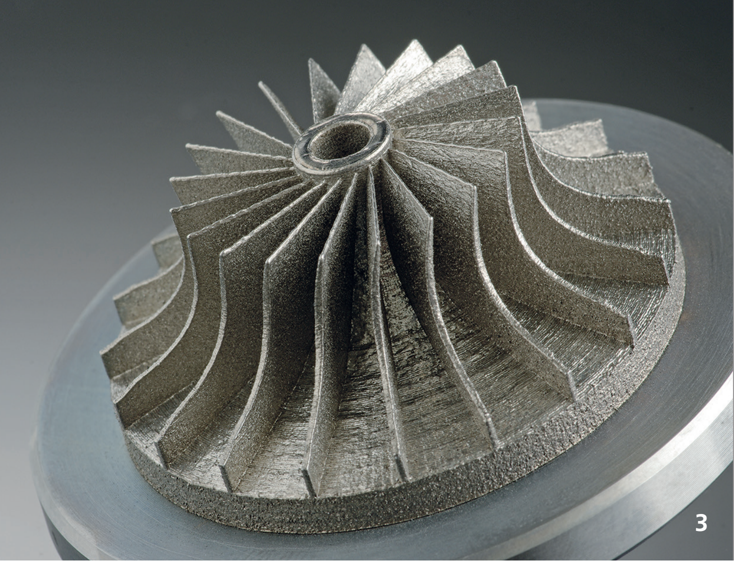

ADDITIVE MANUFACTURING WITH IRON ALUMINIDE ALLOYS

Task

As a material for lightweight construction, iron aluminum alloys are gaining interest and may replace, for example, high-alloy chromium steels in the future. Laser-based additive manufacturing has been used successfully to process binary iron aluminide alloys. Laser Metal Deposition (LMD) and Selective Laser Melting (SLM), however, tend to generate a grain structure solidified in build-up direction, despite high cooling rates. Epitaxy leads to grains that grow over many layers. In addition, binary alloys are not suited for applications running at more than 550 °C due to the Fe_3Al-FeAl phase transformations. Measures specifically developed for alloys can lead to both a grain refinement and to stabilizing the Fe_3Al phase.

Method

Titanium and boron are analyzed as alloying additives. The addition of titanium is used for grain refinement and increase strength by generating a mixed crystal formation. At the grain boundaries, boron forms titanium borides that inhibit grain growth and increase creep resistance.

Result

Defect-free solids having a density greater than 99.5 percent have been made with both SLM and LMD. Due to the larger brittle-ductile transition temperature of Fe-Al-Ti and Al-Fe-Ti-B as compared to binary Fe-Al, a higher preheating temperature is required (400 - 600 °C compared to 100 °C). Thanks to the addition of titanium, a grain size greater than 1 mm could be reduced to about 20 - 50 µm. The addition of boron leads to titanium boride forming at the grain boundaries, thus resulting in a further grain refinement with an average grain size of 3 µm. Current work is identifying the mechanical properties of these alloys.

Applications

Ternary or quaternary Fe-Al alloys can be applied in heavy duty components that have to operate under mechanical, chemical, thermal and corrosive loads. Examples can be found in turbine engines, in aggregates for energy conversion or in the aerospace industry.

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3 Impeller demonstrator out of Fe-Al-Ti-B.

4 EBSD recordings of Fe-Al, Fe-Al-Ti and Fe-Al-Ti-B (from left to right).