Additive manufacturing of multi-phase V-Si-B alloys for high temperature application

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For improving thermodynamic efficiency of gas turbines it is necessary to develop new high-temperature materials beyond the capability of Ni-based superalloys. Next to a high melting point the reduction of the weight is also an important issue to achieve the target of increased thermodynamic efficiency. V points out as an interesting candidate, since it offers the lowest density (ρ = 6.11 g/cm3) in comparison to other high-melting metals. Moreover, alloyed with Si and B a multi-phase microstructure, consisting of a V solid solution (Vss) phase next to the intermetallic phases V3Si and V5SiB2 [1,2] forms, which offers a low ductile-brittle-transition as well as enhanced high temperature strength and creep resistance next to an improved oxidation resistance [1].
However, ingot processing of this class of materials is challenging due to the high melting points and different multi-step powder metallurgical processes were typically used in the past to produce dense samples out of these high melting elements. This work presents the first study on additive manufacturing of a high melting point near-eutectic V-based alloys via Laser - Direct Energy Deposition and Laser – Powder Bed Fusion. Tailored V-9Si-5B powder material was produced by means of a gas atomization process. A novel setup for the DED experiments was developed and an overview of the production parameters for manufacturing of crack-free specimens is given. The microstructural evolution of the three-phase V-9Si-5B alloy is described by means of SEM, EBSD and STEM analyses during the entire process chain, i.e. the gas atomization of the powder material, the consolidation via DED and the heat treatment of the compacts. First mechanical tests demonstrate the high hardness and the competitive creep resistance of the AM V-9Si-5B material in comparison to other three-phase V-based alloys.

References

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