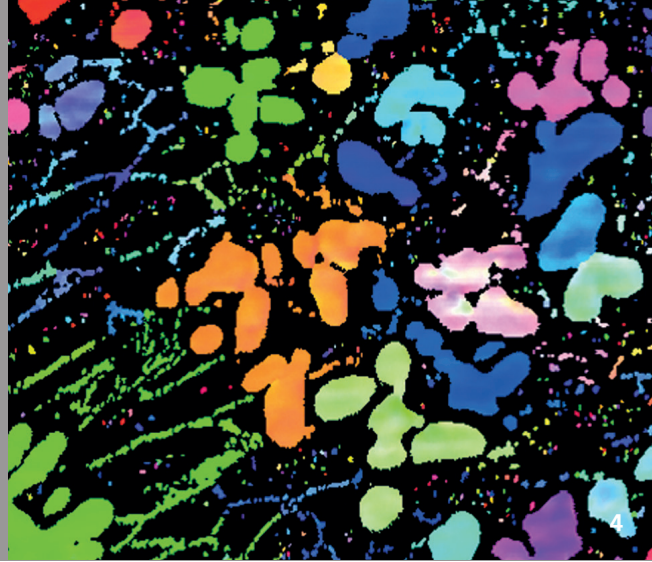
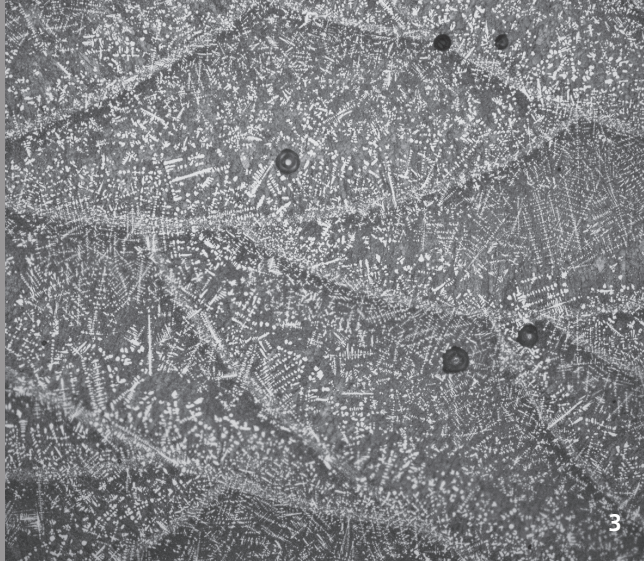




LASER MATERIAL DEPOSITION OF MO-SI-B ALLOYS FOR HIGH-TEMPERATURE APPLICATIONS

Task

By forming intermetallic phases, molybdenum-silicon-boron alloys combine high resistance to thermocyclic stress with great high-temperature strength and oxidation resistance. Therefore, they are interesting materials for increasing the operating temperature of turbines up to 1300 °C (with nickel basis, the maximum is 1100 °C). Processing Mo-Si-B alloys, however, is extremely demanding because of its very high melting temperatures of over 2000 °C and the complex solidification behavior; moreover, to date, it has only been possible in a multi-stage powder metallurgy process. An alternative production route does not yet exist. Laser material deposition (LMD), as an additive manufacturing process, has already been successfully tested for the consolidation of complex intermetallic materials, e.g. Fe-Al or TiAl. The great brittleness of Mo-Si-B poses a particular challenge in the development of this alloy.

Method

As part of »LextrA« (03XP0094), a project for the Federal Ministry of Education and Research (BMBF), the powder- and laser-based additive manufacturing processes laser material deposition (LMD) and selective laser melting (SLM), also known as laser beam melting or Laser Powder Bed Fusion (LPBF), have been in development since the beginning of 2017. Together with partners from the industry (Nanoval, KEG, Siemens) and research (IFKorr, OvGU), Fraunhofer ILT has been using these processes to develop Mo-Si-B alloys.

Fraunhofer ILT is developing the process control of LMD to produce crack-free, dense 3D structures. For this purpose, suitable process parameters were determined in the first step. In the following, the partners will adapt deposition strategies for the production of test specimens and demonstrators.

Results

For the first time, a near-eutectic Mo-Si-B alloy could be processed with the additive manufacturing process LMD and generated crack-free test specimens ($10 \times 1 \times 5 \text{ mm}^3$) at preheating temperatures of min. 900 °C. The microstructure consists of a primary solidified Mo-mixed crystal phase (MoSS), secondary $\text{Mo}_3\text{Si-Mo}_5\text{SiB}_2$ eutectic, and MoSS- $\text{Mo}_3\text{Si-Mo}_5\text{SiB}_2$ ternary regions. Ongoing investigations shall determinate the alloy's mechanical properties.

Applications

The focus is on the development of additive processing technologies of the molybdenum silicide alloy group. Future applications can be found in aerospace as well as in power generation.

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3 Mo-Si-B microstructure after laser material deposition.

4 Electron backscatter diffraction (EBSD) orientation overview of Mo, IPF (source: Dr. Egbert Wessel, Research Center Jülich on behalf of OVGU Magdeburg).