Alloying strategies and optimization of powder metallurgically processed Mo-Si-B alloys

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The refractory metal-based Mo-Si-B alloys have long been considered as the most promising candidates for replacing nickel-based superalloys in the aerospace and energy sector, due to their outstanding mechanical properties and good oxidation characteristics of the Mo silicide phases. However, the oxidation behavior of these alloys still remains a critical issue, since catastrophic oxidation failure occurs locally at the Mo solid solution phase, especially at temperatures between 600 and 800°C.

The addition of vanadium leads to a significant density reduction compared to conventional ternary Mo-Si-B alloys, which is even lower than the density of a state-of-the-art nickel-base superalloy CMSX-4. It has been found that the composition Mo-40V-9Si-8B has the best set of properties with respect to normalized mechanical strength and ductility. In this work, a milling study of mechanically alloyed Mo-40V-9Si-8B powder will be carried out first with the aim to optimize the powder metallurgical processing route. In the next step, 2 at. % and 5 at. % titanium will be added, substituting both the molybdenum and the vanadium in all constituents, which improves the stress-strain properties even further. The mechanically alloyed powder obtained from the total of five milling studies will then be characterized as a function of milling time. Due to the high affinity of titanium for oxygen, it is believed that titanium may act as a getter for dissolved oxygen in Mo-V-Si-B alloys and thus contribute to improve ductility as well as to minimize internal oxidation. The analytical methods to determine the milling progress include SEM analysis (microstructure and EDS), XRD analysis (vanadium content of solid solution phases as well as their phase fractions, lattice constant and microstrain), oxygen measurements, microhardness measurements and laser diffraction (particle size). The aim of these studies is to obtain a better understanding of the influence of other alloying elements in powder metallurgically processed Mo-V-Si-B alloys and, based on this, to further optimize the material in terms of mechanical properties and oxidation resistance. Based on the results obtained from the milling studies, the alloy with the best property profile will be selected, which will then represent a new, improved starting material for the subsequent coating experiments.