Accepted Manuscript

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PII: S0263-4368(18)30109-4
DOI: doi:10.1016/j.ijrmhm.2018.08.016
Reference: RMHM 4782

To appear in: *International Journal of Refractory Metals and Hard Materials*

Received date: 12 February 2018
Revised date: 23 August 2018
Accepted date: 31 August 2018

Please cite this article as: J. Schmelzer, S.-K. Rittinghaus, A. Weisheit, M. Stobik, J. Paulus, K. Gruber, E. Wessel, C. Heinze, M. Krüger , Printability of gas atomized Mo-Si-B powders by laser metal deposition. Rmhm (2018), doi:10.1016/j.ijrmhm.2018.08.016

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Abstract

Mo-Si-B alloys, as a more and more frequently considered high-temperature material, face the challenge of machining complex shapes. In the present work, the feasibility of printing pre-alloyed Mo-Si-B powder materials via laser metal deposition (LMD) process was firstly demonstrated. Mo-Si-B powder was manufactured via gas atomization (GA) process out of solid raw materials meeting the requirements for additive manufacturing (AM) regarding flowability and particle size. Investigations of the powder particles after GA and detailed analyses of the printability and microstructural evolution of the multi-phase Mo_{ss}-Mo_3Si-Mo_5SiB_2 built are presented. As a result, distinct zones resulting from the layer-wise LMD process were observed next to a microstructure of primarily solidified Mo_{ss} phases embedded in fine dispersed eutectic regions. The hardness of the LMD processed material is shown to be comparable with Mo-Si-B alloys produced by ingot metallurgy (IM).

Introduction

Current research on high temperature metallic materials focuses on Mo-Si-B alloys, which are potential candidates for novel turbine materials [1-5]. For structural applications, the most interesting alloy compositions in the ternary Mo-Si-B system are located within the three-phase region between the Mo solid solution phase (Mo_{ss}) and the silicides Mo_5SiB_2 (T2) and Mo_3Si (A15), known as the so-called ''Berczik-triangle'' [2, 6]. Supatarawanich et al. [7] investigated various alloy compositions within the "Berzcik-triangle" and described that the near-eutectic ternary alloy Mo-10Si-14B (all compositions are given in at.%), with a fine distribution of Mo_{ss}, Mo_5SiB_2 and Mo_3Si phases, displayed the best overall oxidation resistance for temperatures between 600 °C and 1300 °C. Furthermore, outstanding creep properties for near-eutectic Mo-Si-B alloys, e.g. Mo-17.5Si-8B, even above temperatures of 1100 °C, were published in [2] and thus indicating the enormous potential of this type of microstructure.

However, ingot processing of this class of materials is challenging due to the high melting point of Mo-Si-B materials being typically > 2000 °C (eutectic Mo_{ss}-Mo_3Si-Mo_5SiB_2 alloy ~ 2000 °C) [1-3, 8]. Due to this reason, different multi-step powder metallurgical processes were typically used in the past to produce dense Mo-Si-B samples under laboratory conditions [4, 9, 10]. The introduction of a one-step process for this type of material via additive manufacturing (AM) or 3D printing represents an important innovation that will allow the production of complex bulk materials with geometries near the foreseen applications (e.g. turbine blades) [8]. Compared to more conventional alloys like steels or titanium alloys that were shown to be satisfactorily