Investigation of in-situ alloying of cobalt-free compositional complex alloys by means of laser metal deposition

Authors
Irina Shakhverdova[1], Jörg Kaspar[1], Peter Grün[1], Holger Hillig[1], Clément Vary[2], Pascal Aubry[2], Filofteia-Laura Toma[1]
1) Fraunhofer-Institut für Werkstoff- und Strahltechnik IWS, Winterbergstr. 28, 01277 Dresden, Germany
2) SRMA, CEA, Université Paris-Saclay, France

Contact: irina.shakhverdova@iws.fraunhofer.de; Phone +49 (351) 83391-3245, Fax +49 (351) 83391-3300, www.iws.fraunhofer.de

Abstract
Compositional Complex Alloys (CCAs) are a new class of metallic alloys with huge potential for being the next generation of high-temperature materials. One of the major challenges on the way to apply the CCAs is the extensive design, selection efforts due to the high variety in possible compositions resulting in different material properties, as well as cost-intensive fabrication of these materials.
In this work the development of in-situ alloying of Co-free CCAs by means of laser cladding was investigated. Laser cladding is a well-known process for its robustness and versatility. The deposition of the compositional complex coatings demands the development of smart system technology for process monitoring and control. For the proposed compositional complex materials, the possibility of in-situ alloying of elemental powders or binary and ternary powder mixtures saves a huge amount of costly material and time-consuming alloy development by the common melting and casting route.
In current work, titanium (Ti), aluminum (Al) and molybdenum (Mo) were added to a CrFeNi base system in order to improve mechanical performance and wear resistance. The question here was whether cobalt could be completely eliminated in order to achieve the desired target properties. $Al_xTi_yMo_z$-CrFeNi samples were produced with a coaxial laser head and a 4-kW diode laser. During deposition, different powder streams at given feed rates were simultaneously injected into the coaxial laser nozzle enabling the in-situ alloying. The samples were submitted to a heat treatment (HT) at 1150°C for 24 h for homogenization. The microstructure and the chemical composition of samples (as-built and after HT) were characterization by means of SEM/EDX analysis. Dense and relatively fine-grained microstructure with mainly bcc B2 phase on the grain boundaries, could be identified in the Co-free as-built samples. After HT very fine and regular structures with some nitrides and oxides were identified in the homogenized samples. The structures are composed of sigma-phase, bcc B2 phase and some minor amount of fcc A1 phase. For all in-situ compositions high hardness values (> 750 HV0,3) were measured showing the potential to fabricated Co-free hardfacing alloys by laser cladding processing. The investigation of the corrosion and sliding wear properties is ongoing.
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