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Submission

F02: High Performance Materials for Sustainable Energy Applications (F: Functional Materials, Surfaces and Devices)

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$Al_4Co_{15.2}Cr_7Fe_{5.4}Ni_{64.4}Ti_4$ High Entropy Super Alloy development, laser printability and high temperature tensile assessment.

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Short abstract

High Entropy Super Alloys (HEAs) are outstanding alloys with promising high temperature properties intended to compete with commercial Ni superalloys. The precipitation of γ' phase gives these alloys a high temperature resistance, higher as the Ti and Al contents is increased in the chemical composition. However, as it is known in welding, larger quantities of hardening elements are related with hot cracking susceptibility due to the solidification range. During laser additive manufacturing (AM), the extreme thermal cycling and cooling rates lead to different as-built microstructures. Understanding the cracking mechanism and how it is associated to a certain chemical composition and AM conditions is an important requisite to design new alloy grades to reach an equilibrium between high temperature behaviour and manufacturability.

In this work, thermodynamics modelling has been used to design a new HESA, $Al_4Co_{15.2}Cr_7Fe_{5.4}Ni_{64.4}Ti_4$, by modifying the chemical composition of an alloy from literature. The composition has been optimized balancing the Al and Ti contents to maximize the γ' formation while remaining in safe zone in relation to the strain-age cracking risk. For that, the brittle range and the solidification crack index (SCI) have been calculated for 0.9-0.99 solid fraction using the modified Scheil's model available in Thermo-calc for rapid solidification (TCHEA5 and TCNI9 databases).

Powders of the starting alloy, $Al_{11}Co_{14.8}Cr_{6.6}Fe_{2.8}Ni_{60.6}Ti_{4.2}$, and the new designed one were gas-atomized and printed using directed energy deposition laser beam (DED-LB). A range of laser parameters and manufacturing strategies were evaluated. The starting alloy presented severe cracks in almost all conditions meanwhile coupons free of cracks were printed with the new alloy. For this last, microstructure and tensile performance were evaluated at room and high temperature (800ºC). As-built samples were compared to heat treated samples for which the γ' precipitation was maximized.