High-Temperature Stability of PBF-LB/M Processed AISI 316L ODS Steel with Micrometre-Sized Y_2O_3 Additions

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Oxide dispersion-strengthened (ODS) steels are a class of ferritic or austenitic alloys distinguished by a homogeneous distribution of thermally stable oxide particles—most commonly yttrium oxide (Y_2O_3)—within the metallic matrix. The presence of these finely dispersed oxides enhances structural stability and mechanical strength at elevated temperatures. The outstanding high-temperature performance of ODS steels primarily arises from two strengthening mechanisms: (i) Orowan strengthening, which limits dislocation motion through the interaction with non-deformable oxide particles, and (ii) Zener pinning, where the dispersed oxides hinder grain boundary migration by acting as stable anchoring sites.

In this work, commercially available AISI 316L stainless steel powder was blended with micrometre-scale Y_2O_3 particles using a Turbula mixer and subsequently processed via laser powder bed fusion (PBF-LB/M) under optimised parameters. The selected processing conditions enabled partial dissolution of Y_2O_3 particles and their uniform reprecipitation within the austenitic matrix, producing a thermally stable microstructure. This finding is supported by detailed microstructural examinations and further corroborated by mechanical, corrosion, and tribological tests, which collectively demonstrate the improved high-temperature stability and performance of the modified alloy.