Icosahedral short-range order mediated twin formation in laser direct energy deposited 316L stainless steel with silicon

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Abstract

316L stainless steel (316L) with 0.5wt% Si and 2.3wt% Si were fabricated using laser direct energy deposition (LDED). A stark difference is found in the density of $\sum 3$ twins and fine grains in the microstructures of the two materials. 316L with 2.3wt% Si exhibits a remarkably high percentage (23%) of $\sum 3$ twin boundaries whereas 316L with 0.5wt% Si exhibits very low (less than 3%) of these boundaries. In this work, we aim to understand the origin of this difference.

EBSD analysis of 316L with 2.3wt% Si reveals that clusters of twins exhibiting shared $<110>$ five-fold symmetry axes are present in the microstructure, which suggests that they formed via the icosahedral short-range order (ISRO)-mediated nucleation during solidification (1). Additionally, twins form during grain growth due to an ISRO-induced stacking fault mechanism, as evidenced by twin variant analysis showing more than 3 variants, which cannot occur during nucleation from one ISRO motif.

This result is surprising because ISRO-based mechanisms have been mainly reported in face-centered cubic alloys printed via laser-powder bed fusion. In this talk, we will demonstrate why and how these mechanisms can occur in LDED 316L.


Keywords: Stainless steel, Twins, Additive manufacturing, ISRO, Alloying

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