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.
(1) M. Rappaz, Ph. Jarry, G. Kurtuldu, J. Zollinger, Metall. Mater. Trans. A 51 (2020) 2651–2664.

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