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Understanding of the oxide inclusion evolution during the additive manufacturing

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In this research, the evolution of oxide particles during additive manufacturing was simulated using a numerical model to understand their development and identify effective methods to enhance oxide-dispersion strengthening. The model integrated the Kampmann and Wagner numerical model with diffusion considered solidification simulation, and CALPHAD based thermodynamic data. The simulation outputs aligned well with experimental observations from directed-energy deposition and powder-bed fusion process utilizing stainless-steel 316L powder. The findings revealed that the majority of oxide particles undergo explosive nucleation within the oxygen super-saturated melt pool during the solidification process. Oxygen levels in the melt pool momentarily peaked at 0.6 ~ 0.7 wt%. The interfacial tension between Si-Mn-Cr-O oxide and the melt was estimated at 0.4~0.5 N/m. The study also proposed and assessed strategies to optimize the dispersion strengthening effect in additive manufactured materials.