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Laser Powder Bed Fusion of Mixed Powders

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Laser powder bed fusion (LPBF) of metals is a popular mode of additive manufacturing (AM) that has the advantage of producing complex shapes with little or no additional processing. However, an important limitation is that the metallic microstructures obtained are usually relatively simple solidification structures and there are few means available to enrich this without subjecting the components to subsequent thermal processing routines, which has its own difficulties due to dimensional control. This limits the microstructural complexity that can be achieved in components fabricated by LPBF and hence the properties obtainable.

In this work, we present and validate a physically-based model to predict the chemical distribution resulting from LPBF of physically mixed powders of different compositions. We demonstrate that mixing of powders with different compositions can be used to generate a deliberately controlled, mesoscale chemical heterogeneity in LPBF that allows the formation of multiphase microstructures and delivers new microstructural complexity to LPBF. A duplex stainless steel, consisting of equal fractions of ferrite and austenite in the as-built state is used as a demonstration of the approach.

The model describing the chemical distribution in the consolidated build can be extended to describe remelting effects and exploited for the design of spatially varying microstructures. This provides a path towards generating architecture materials from random mixes of initial powders. Examples of using spatially controlled remelting to generate architecture materials for random powder mixtures will be shown.

This opens up an interesting path for delivering microstructural complexity to LPBF of metals.