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Influence of processing factors on the physical metallurgy of LENS deposited 316L stainless steel

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Directed energy deposition (DED) is a type of additive manufacturing (AM) process; Laser Engineered Net Shaping (LENS) is a commercial DED process. We are developing LENS technology for printing 316L stainless steel components for structural applications. It is widely known that material properties of AM components are process dependent, attributed to different molten metal incorporation and thermal transport mechanisms. This investigation focuses on process-structure-property relationships for LENS deposits for enabling the process development and optimization to control material property.

We observed interactions among powder melting, directional molten metal flow, and the molten metal solidification. The resultant LENS induced microstructure found to be dictated by the process-related characteristics, i.e., interpass boundaries from multi-layer deposition, molten metal flow lines, and solidification dendrite cells. Each characteristic bears the signature of the unique localized thermal history during deposition. Correlation observed between localized thermal transport, resultant microstructure, and its subsequent impact on the mechanical behavior of the current 316L is discussed. We also discuss how the structures of interpass boundaries are susceptible to localized recrystallization, grain growth and/or defect formation, and therefore, heterogeneous mechanical properties due to the adverse presence of unmelted powder inclusions.

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