OBJECTIVE: The Defense Logistics Agency (DLA) seeks technologies and processes in Additive Manufacturing (AM) design and engineering procedures that can predetermine the microstructure of AM parts with "tailored" grain boundaries to produce predictable mechanical properties including mode of failure.

DESCRIPTION: Department of Defense (DoD) demand for out-of-production parts to maintain mission readiness of various weapons system platforms is an ongoing challenge. DLA’s strategic objective is to enable a flexible supply chain that can accelerate repairs and part replacements utilizing AM. However, AM technology is relatively new to manufacturing and has many hurdles to overcome before universal adoption as a replacement to traditional manufacturing. Variability in the mechanical properties of additively manufactured metal parts is a key concern for DoD Engineers. Understanding the microstructure development and evolution during the AM process of metallic alloys is an important precondition for the optimization of the parameters to achieve desired mechanical properties of the AM builds. DLA is looking to leverage this evolving technology to enable a supply chain that is flexible, scalable, and capable of producing parts that are more reliable.

Metallurgical alloys consist of individual crystallites commonly referred to as grains. The individual grain connections (grain boundaries) formed through recrystallization during metal part fabrication and heat treatment. A grain boundary is the interface between two grains, or crystallites. Grain boundaries influence the mechanical properties of the metal; hence, certain grain boundaries are preferred over others. For example, grain boundaries such as coincidence site lattice (CSL) grain boundaries and low angle grain boundaries exhibit improved properties as compared to equiaxed grain boundaries. The improved properties exhibited by the CSL grain boundaries and low angle grain boundaries may include increased resistance to stress, corrosion, and cracking. The performance of grain boundary engineering may attempt to create CSL grain boundaries and/or low angle grain boundaries. It is now recognized, that improved grain boundary engineering techniques are desirable and may be a viable technology to provide DoD with more reliable parts.

In subtractive manufacturing, the grain boundaries are predetermined in the net-shaped parts. In AM, it would be possible to design the grain size and grain boundaries of the net-shaped parts by altering the process parameters or by adding nano/micro particles in a specific localized region during the AM process.

PHASE I: Demonstrate the feasibility of "engineered" grain boundary in metal AM technologies and processes.

PHASE II: Develop a TRL 6 prototype demonstrating the technologies and processes of Grain Boundary Engineering in AM in a DLA environment.

PHASE III DUAL-USE APPLICATIONS: At this point, no specific funding is associated with Phase III. Progress made in PHASE I and PHASE II should result in a functional Open Source System which can transition into the Government or the commercial markets.

COMMERCIALIZATION: Expand and enable Grain Boundary Engineering in AM technologies and processes to produce parts with predictable mechanical properties including mode of failure.

REFERENCES:


KEYWORDS: Additive Manufacturing; Grain Boundary; Engineering