

Process to Structure Simulation of LENS AM Process, PSED Cluster 2016-2017

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Academic Disciplines:
MECHANICAL ENGINEERING
MATERIALS SCIENCE & ENGINEERING

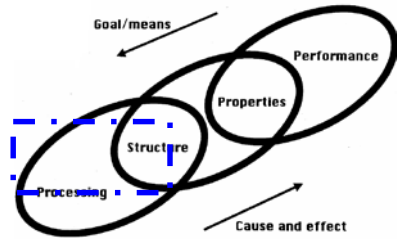
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RESEARCH STATEMENT

Laser engineered net shaping (LENS) is an additive manufacturing process where powder is directly deposited and form to final part geometry. However from process to final structure the microstructure evolution has yet to be fully understood. This project aims to lay down the foundation towards building a process to structure simulation tool for LENS process for a quantitative measurement of microstructure evolution. Two important phenomena are identified: 1) Phase transformation; 2) Grain evolution. Each phenomenon is solved with appropriate computational model and will be coupled together in the future. In the current project, Ti-6Al-4V used as an example in phase transformation study and PH48S used in grain evolution.

COMPUTATIONAL TOOL DEVELOPMENT

Three-link chain model of the central paradigm of materials science and engineering



Phase Transformation Model

Heat Transfer to Solve T

GAMMA Code

Solid-state Phase Transformation Kinetics

•Avrami Equation

$$X_i = F_i(T, t)$$

•K-M Equation

•Fick's Law

As an example of Ti-6Al-4V, four reactions are considered

Cooling: $\beta \rightarrow \alpha$ and $\beta \rightarrow \alpha'$

Heating: $\alpha \rightarrow \beta$ and $\alpha' \rightarrow \alpha + \beta$

Phase fraction evolution is integrated into GAMMA

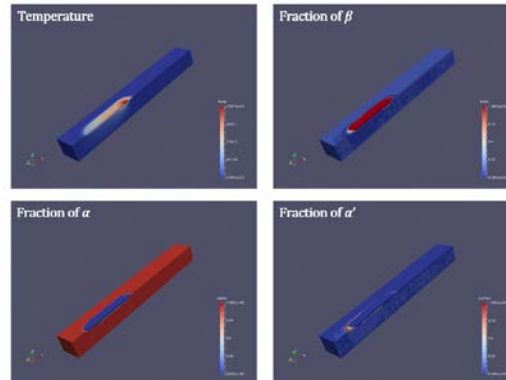
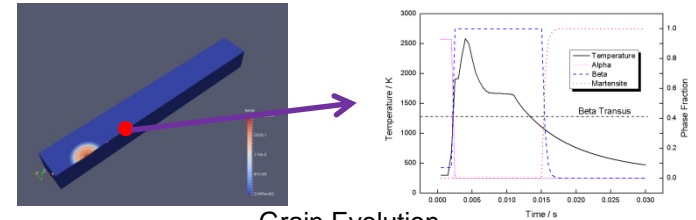


Illustration of Process to Structure Modeling

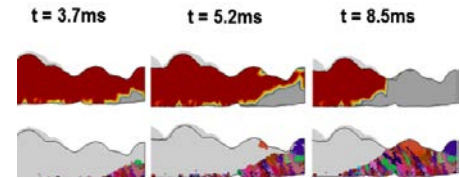
Process Parameter
Laser Power
Scan Velocity
Beam Diameter
Hatch Space
Layer Thickness



Phase Fraction Evolution



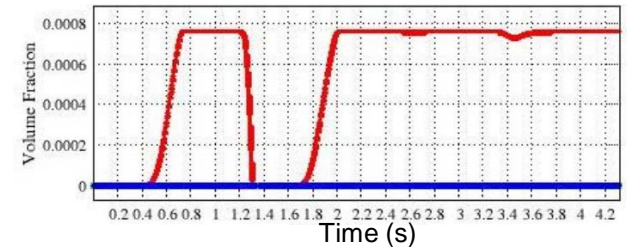
Grain Evolution



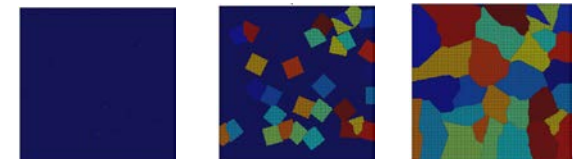
CAFE Model (long term goal)

Grain Evolution

Oxide (serves as nuclei) evolution in time during cooling



Nucleation Based on Oxide Fraction



From initial state to fully developed grain