Additive Manufacturing Process Design, PSED Cluster 2014-2015

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Academic Disciplines: **MECHANICAL ENGINEERING, MATERIALS SCIENCE & ENGINEERING**

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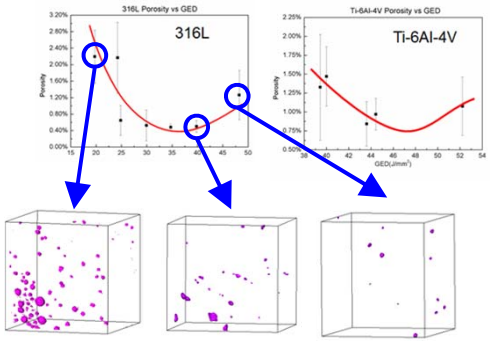
RESEARCH OBJECTIVE The focus of this study is on the directed energy deposition process developed by Sandia National Laboratories named Laser Engineered Net Shaping, or LENS®, one of the additive manufacturing processes. This study aims to understand the physics-based mechanisms that link the process parameters, microstructure and mechanical properties and to develop in-situ metrology tools to understand the influence of process parameters on product performance, which ultimately enables performance prediction and material design.

Process Parameter Design



x -- scanning direction
z -- building direction

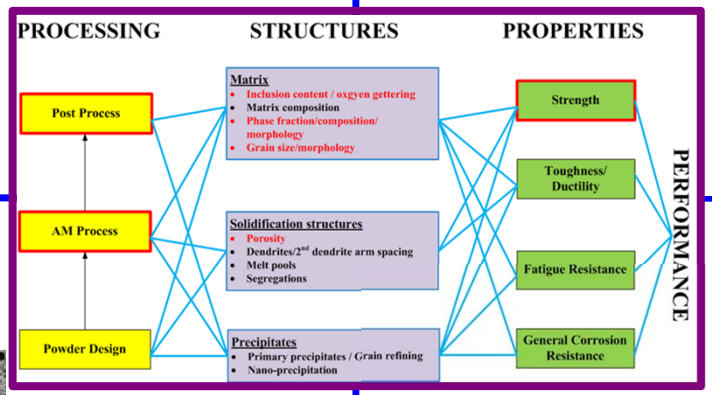
Reconstructed dimension: 5x5x5 μm³
Voxel size: 19.23x19.23x50 μm³

Global Energy Density (GED)

$$E_d = \frac{P}{v \cdot d}\left[\frac{J}{mm^2}\right]$$

P – Laser output power (W)
v – Scan speed (mm/s)
d – Beam diameter (mm)

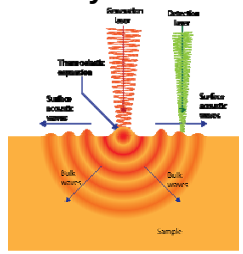
Relationship between porosity and GED

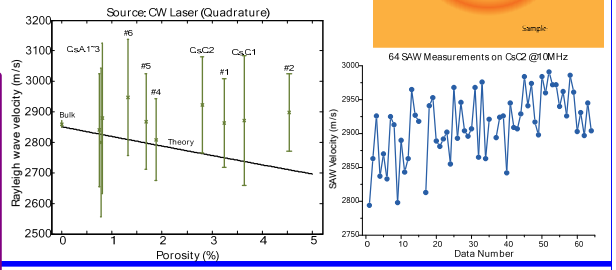


Laser Based Ultrasonics Metrology

Relationship between SAW velocity and porosity

Material's heterogeneous nature affects the reliability of the estimate on porosity from LBU measurements. Based on our study, longer wavelength wave, larger interrogation region, and more measurements are needed to increase the reliability.

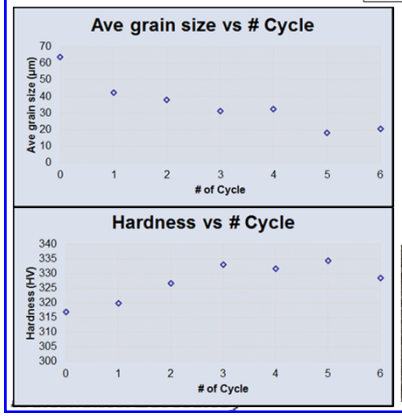




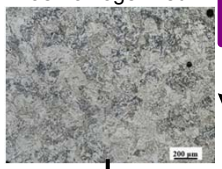
Post-Processing

Problem: columnar grains along the building direction

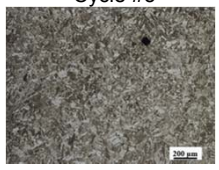
Martensitic transformation ->
Dislocation density ↑ ->
Stored energy ↑ ->
Recrystallization ->
Grain refinement



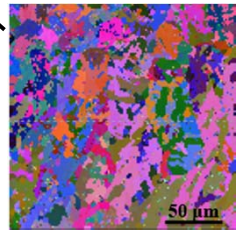
as-homogenized



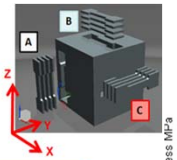
Cycle #5

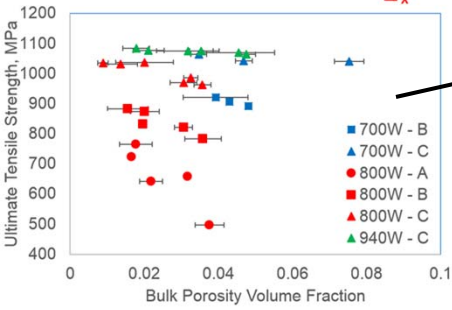


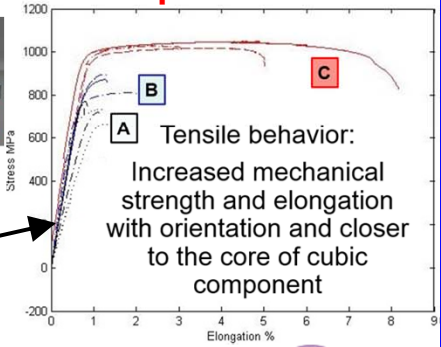
LENS as-built PH48S



Mechanical Properties







Geometry, process parameters, porosity influence properties

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