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

- Global Energy Density (GED)
  \[ E_d = \frac{P}{v \cdot d} \left( \text{J/mm}^2 \right) \]
  - P – Laser output power (W)
  - v – Scan speed (mm/s)
  - d – Beam diameter (mm)

Post-Processing

- Problem: columnar grains along the building direction
- Material: transformation \( \rightarrow \) Dislocation density \( \rightarrow \) Stored energy \( \rightarrow \) Recrystallization \( \rightarrow \) Grain refinement
- Ave grain size vs # Cycle
- Hardness vs # Cycle
- LENS as-built PH48S
- Cycle #5

Laser Based Ultrasions 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.

Mechanical Properties

Increased mechanical strength and elongation with orientation and closer to the core of cubic component

Geometry, process parameters, porosity influence properties