

High Strain Rate Signatures of Additively Manufactured High Entropy Alloys

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Background

CoCrFeMnNi High Entropy Alloy (HEA)





Lu, C., et al., Nat Commun 7, 13564 (2016).

B. Gludovatz, et al., Nat Commun 7, 10602 (2016).



Laser Powder Bed Fusion (LPBF)

- EOS M290 has over 100 process parameters to control.
- Power (P), Velocity (V), Hatch Spacing (h) control melt pool geometry.
- Fast cooling rate (10⁶ K/s) creates fine microstructure.



Processing Defects in LPBF





Chia-Ying Lin et al, J. Biomed. Mater. Res. 83 (2007) 272-9.



High Throughput Experiments

- 242 processing conditions explored across power, velocity, and hatch spacing
- Density and hardness measured for each condition
- Low throughput processing regime chosen within bounds of highest density and hardness conditions



High Strain Rate Experiments



Spall

Occurs when shockwaves create a tensile pulse within a material causing voids to form on a spall plane. Spall strength is the resistance of a material to spall fracture and is measured through soft capture plate impact experiments.





Spall Response



An increase in crack density correlates with a decrease in spall strength

Spall Response



No correlation between grain morphology and spall response



Signatures





Cracking

- Microcracking was visible across all samples
- Larger and more numerous cracks evident at higher power and velocity
- Cracks averaged 20-25 µm



Crack Morphology

A) An intragranular crack

B) An intergranular crack



- Crack follows melt pool boundary
- 2. Dendrites within the fracture surface
- Crack initiation at grain boundary



Grain Morphology

• Elongated grains in the build direction consistent with LPBF

Laser Power (W)

 Grain size and aspect ratio decrease less than 20% as VED decreases





V.K. Euser, et. al., (in preparation)

Future Work



Future Studies

- Identify acoustic signatures of processing defects in LPBF.
- Develop techniques to improve printability of CoCrFeMnNi.





Collaborations with ETI

- Prof. Milton Garces: University of Hawai'i In-situ acoustic monitoring and algorithms for data processing
- Dr. Saryu Fensin and Dr. Ginny Euser: Los Alamos National Laboratory High strain rate response of LPBF HEAs
- Prof. Lin Shao: Texas A&M University Radiation response across LPBF processing conditions



Summary

 Seven conditions of LPBF HEA were evaluated using high strain rate experiments

 Pre-existing solidification crack density was found to correlate best with spall response

• Microstructural signatures of LPBF HEA samples were investigated



-aser Power (W)

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Questions?