

AM at SNL



PRESENTED BY

Bradley Jared, Michael Heiden

Materials Engineering and Manufacturing S&T

2 Sandia National Laboratories

A National Security Science & Engineering Laboratory

- “Exceptional service in the national interest”

Nuclear Weapons

Defense Systems & Assessments

Energy & Climate

International, Homeland, & Nuclear Security



3 SNL's Additive Interests

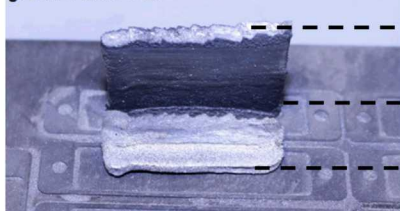
Reduce risk, accelerate development

- simplify assembly & processing
- prototypes, test hardware, tooling & fixturing

Add value

- design & optimize for performance, not mfg
 - complex freeforms, internal structures, integration
- engineered materials
 - gradient compositions
 - microstructure optimization & control
 - multi-material integration
 - “print everything inside the box, not just the box”

CoCrFeMnNi-Ta
graded thin wall



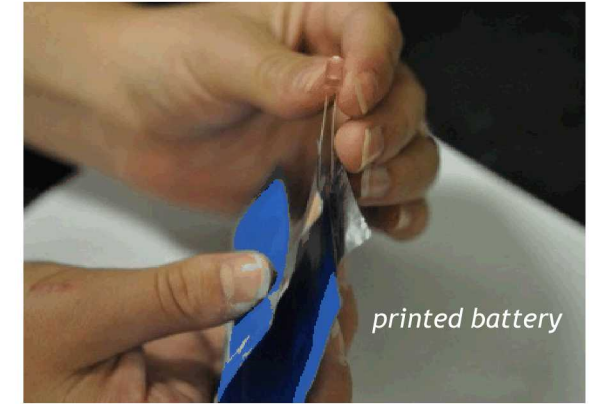
A particular graded composition that was brittle and fractured during processing....

• 100% CoCrFeMnNi

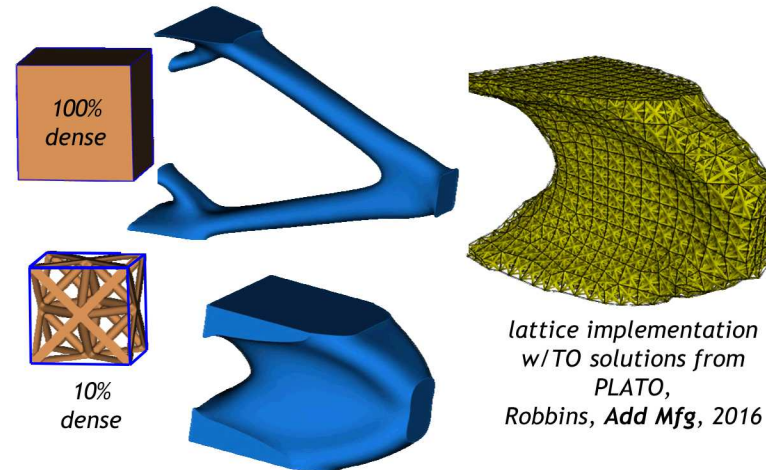
• 100% Tantalum



Sandia
telescope



printed battery



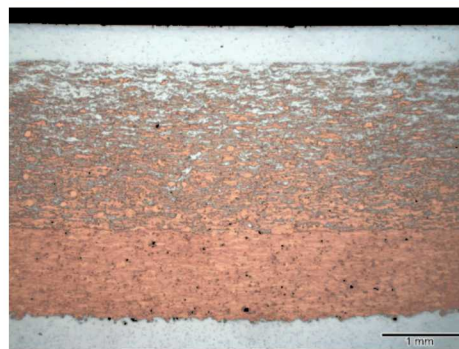
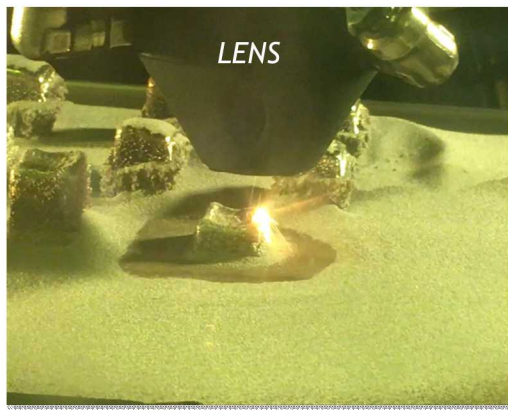
full scale additive
weapon mock-up



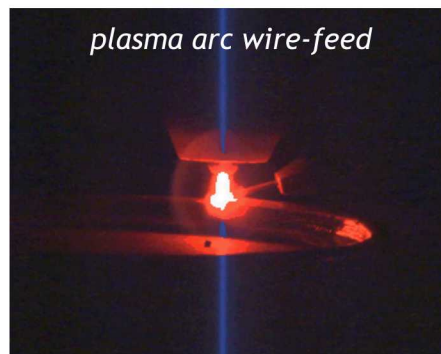
HOT SHOT sounding
rocket lifts off from the
Kauai Test Facility, Hi

Sandia Processes

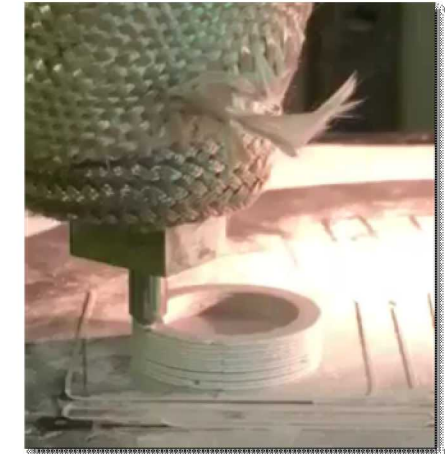
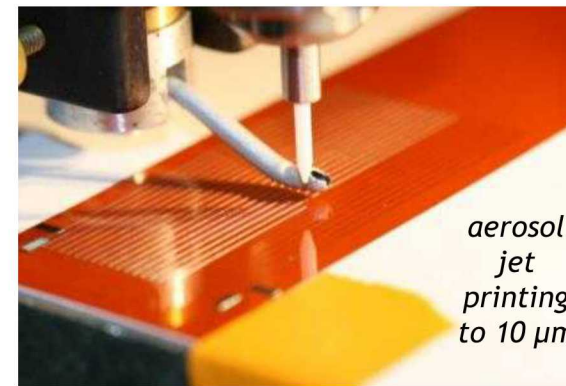
Metal



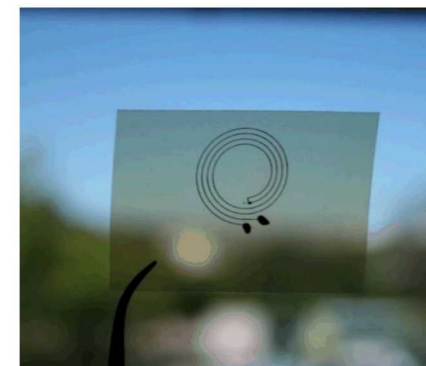
Cu-Al plasma sprayed graded density coating



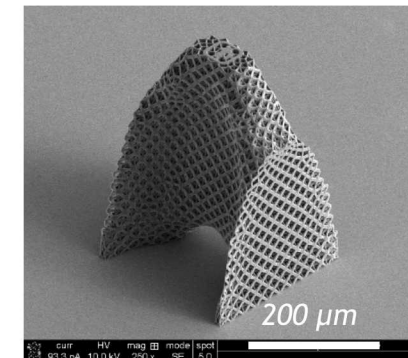
Direct Write



ceramic-thermoplastic 3D (CT3D) printing alumina



room temperature cure of conductive traces on polymer film



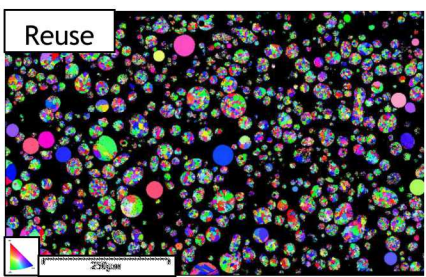
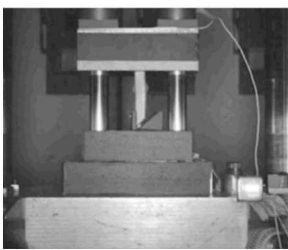
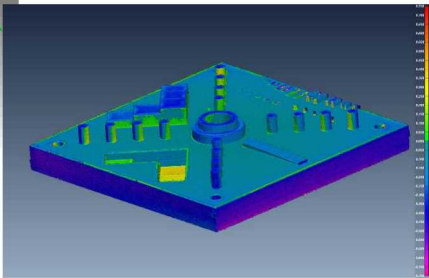
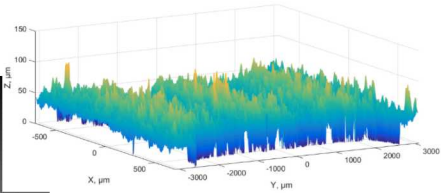
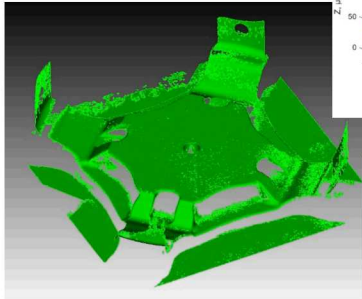
Nanoscribe two-photon lithography



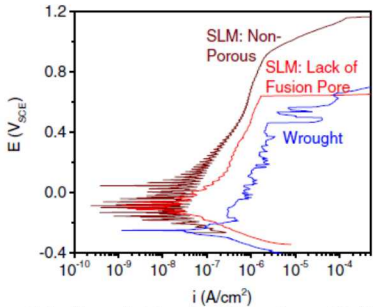
energetics



5 Qualification Foundations

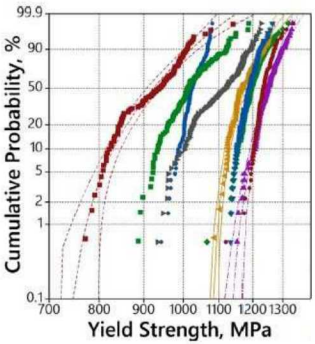


Heiden, Add. Mfg., 2019

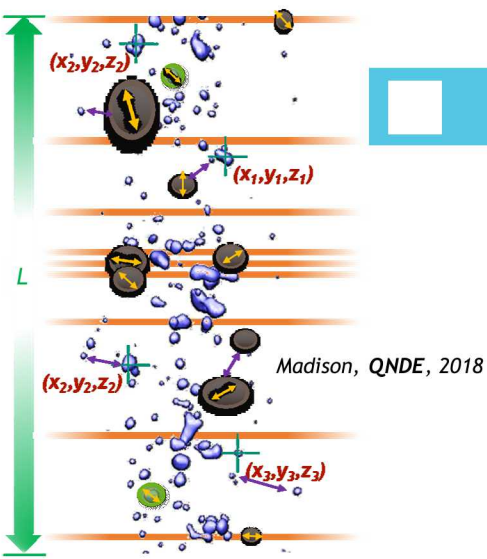
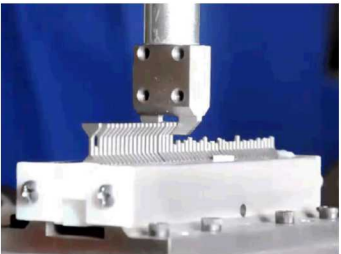


Schaller, J. Electrochem Soc., 2018

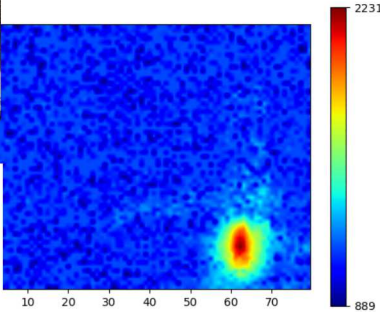
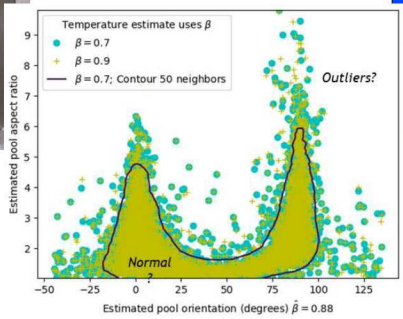
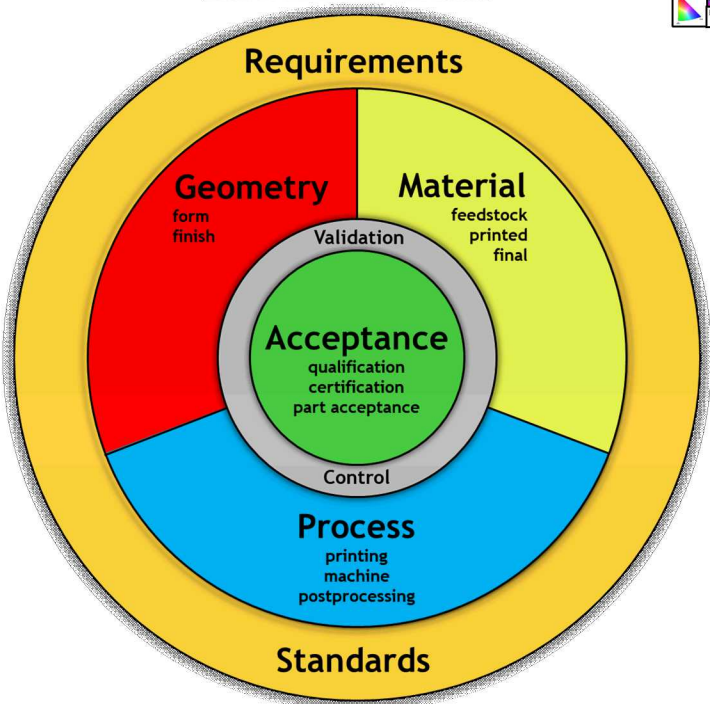
Boyce, Adv. Eng. Mat., 2017



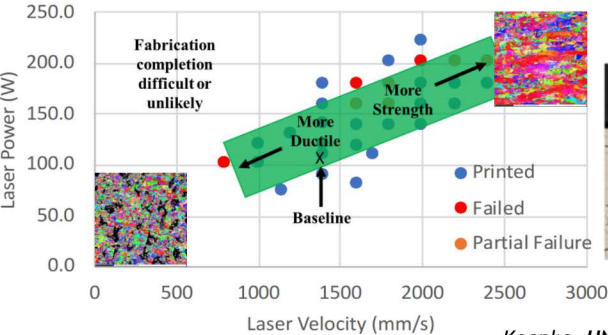
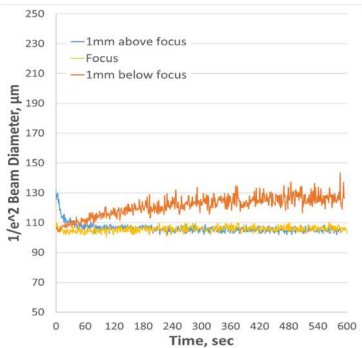
Heckman, Mat. Sci. Eng. A, submitted



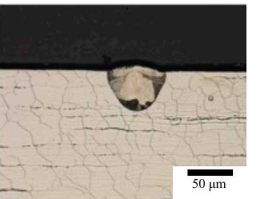
Madison, QNDE, 2018

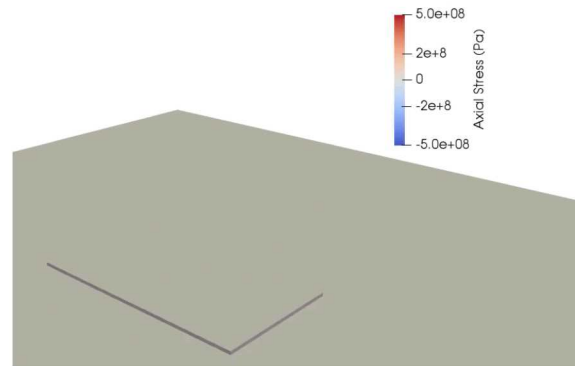
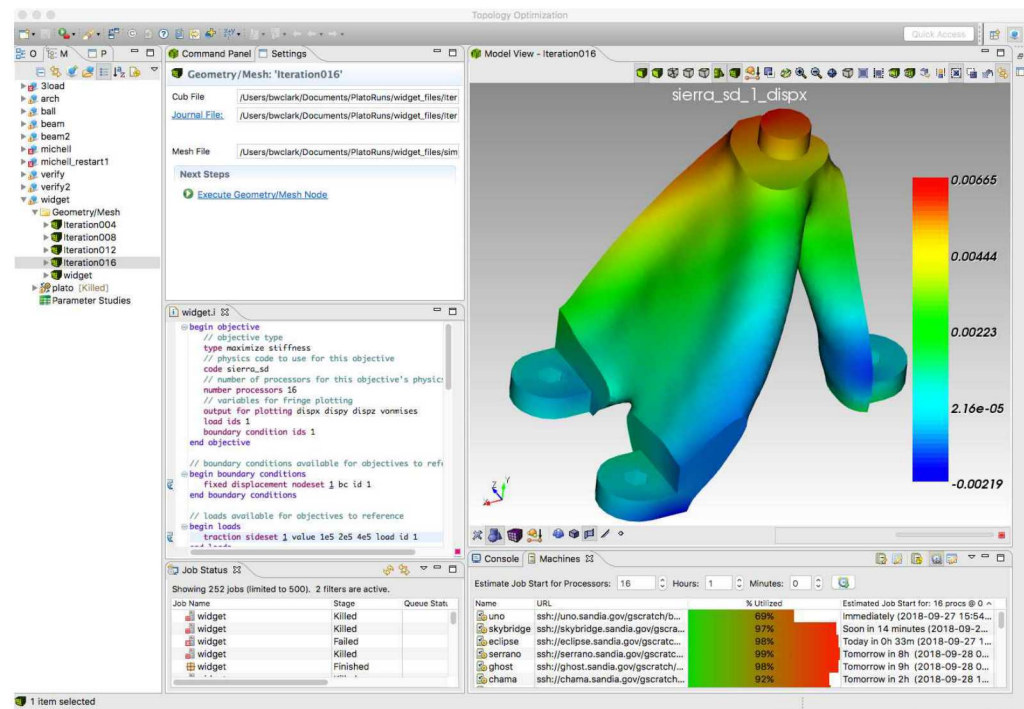
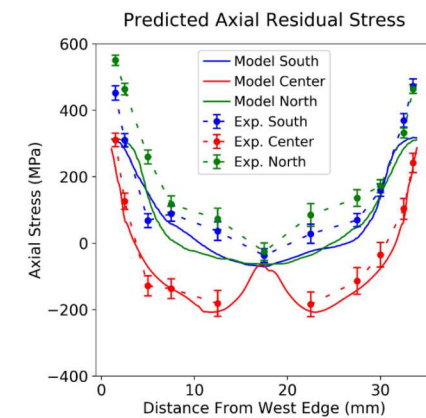
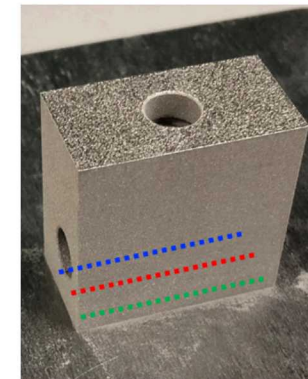


Mitchell, in progress

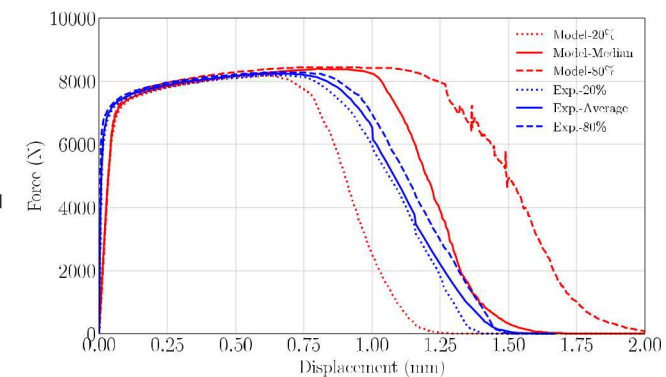
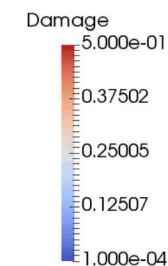
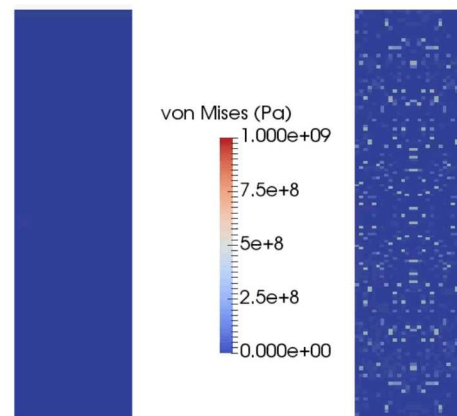
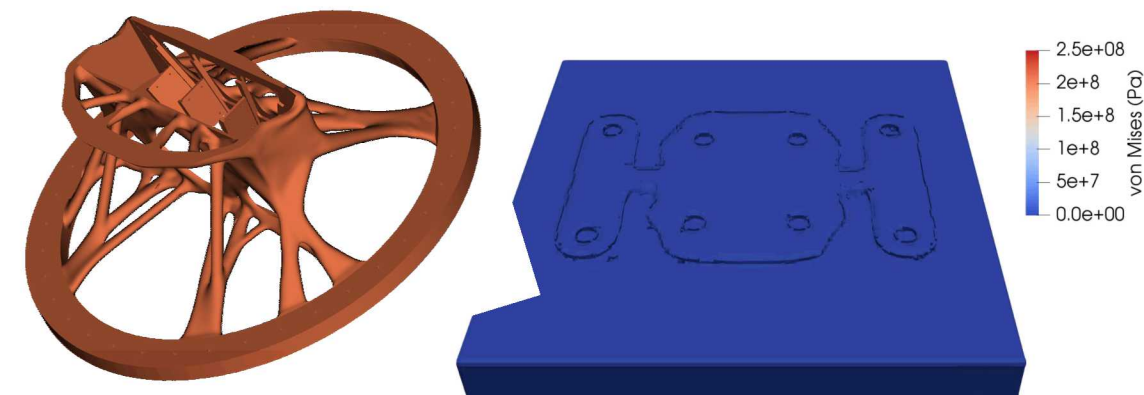


Koepke, UNM Thesis, 2019

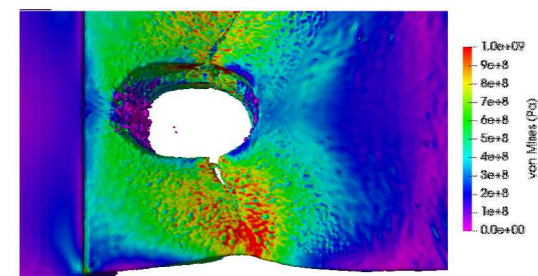


PLATOPerformance Simulations

mechanical inherent strain reduced order model, 60 cpus, 30 min run time



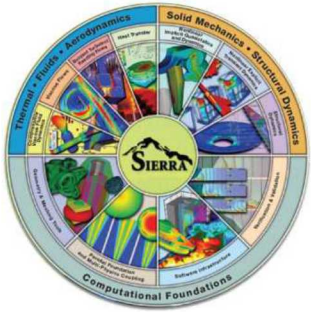
prediction for Sandia Fracture Challenge



representing porosity as initial damage

material response w/voids & surface roughness

Models Bridging Length Scales



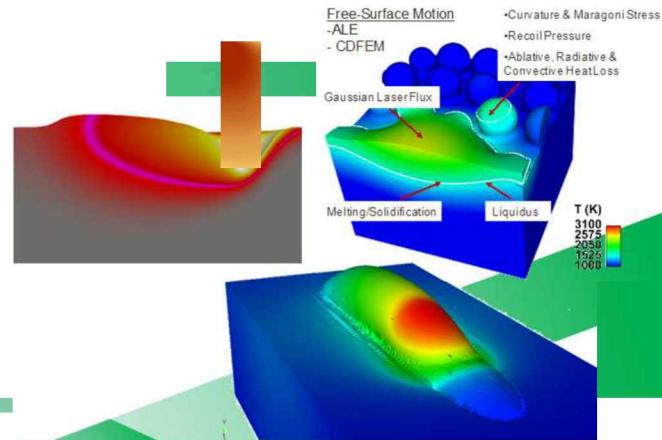
LAMMPS

ARIA

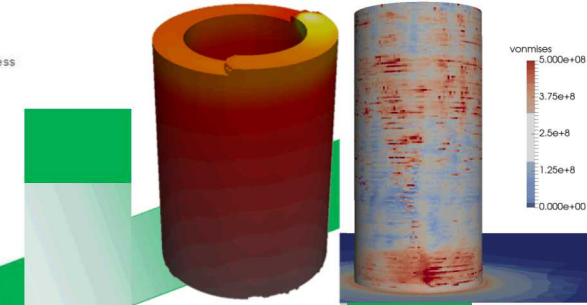
ADAGIO

SPPARKS

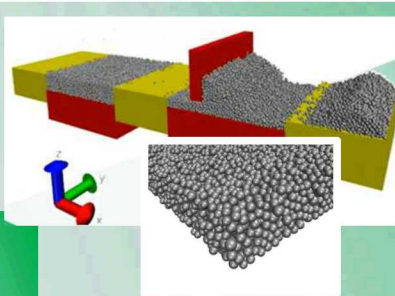
Solidification Scale Thermal
M. Martinez, B. Trembacki, D. Moser



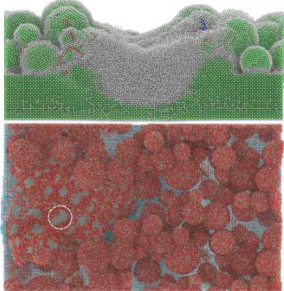
Build Scale Thermal + Mechanics
K. Johnson, K. Ford, L. Beghini, M. Stender & J. Bishop



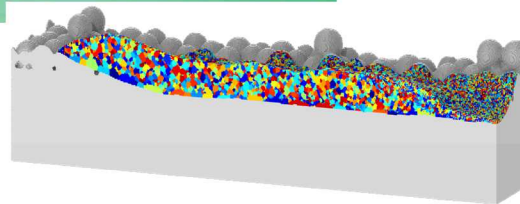
Powder Spreading
D. Bolintineanu



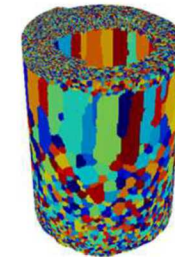
Powder Behavior
M. Wilson



Mesoscale Texture/Solid Mechanics
T. Rodgers, J. Brown, K. Ford



Build Scale Microstructure
T. Rodgers, J. Madison



10^{-6}

10^{-3}

1

Length Scale (m)



Questions?

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“Changing the Engineering Design & Qualification Paradigm”

- leverage AM, in-process metrology & HPC to revolutionize product realization
- accelerating design to production

