SAND2018-7889C

Sandia National Laboratories

Microstructural Effects on Localization Behavior in Finite Deformation Solid Mechanics

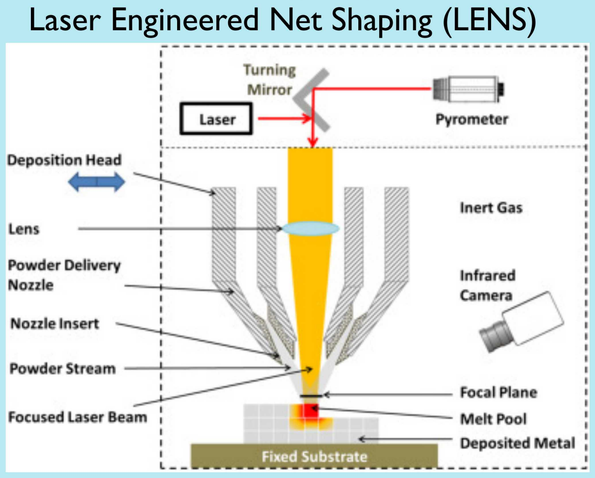
Shanna Hays, University of California, Berkeley, Ph.D. Mechanical Engineering
Coleman Alleman, Sandia National Laboratories, Mechanics of Materials (8343)

Objective

Develop a fundamental understanding of yield and localization in Additive Manufactured (AM) structural alloys.

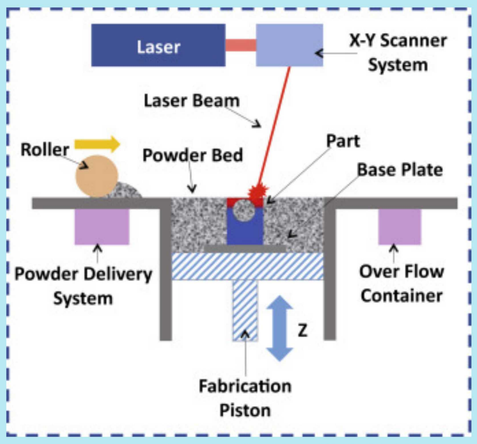
Motivation

Directed Energy Deposition
Laser Engineered Net Shaping (LENS)



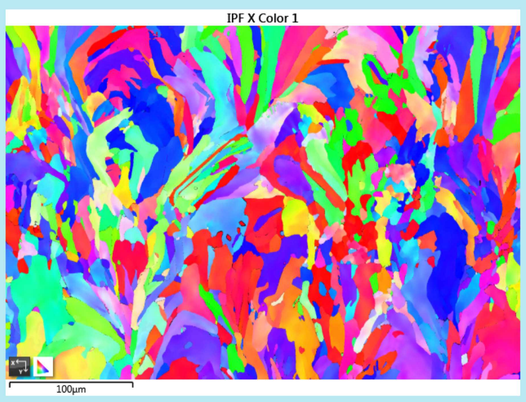
https://doi.org/10.1016/j.addma.2015.07.001

Selective Laser Melting
Powder Bed Fusion

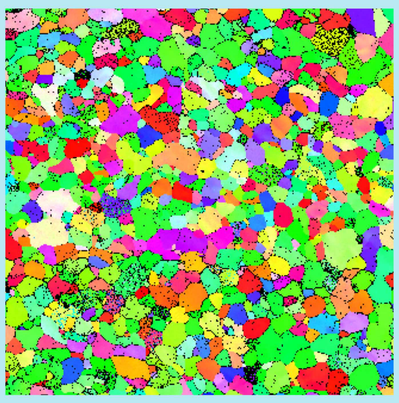


https://doi.org/10.1016/j.addma.2015.07.001

- Parts produced through AM demonstrate anisotropic material behavior
- This behavior stems from nonuniformities in the microstructure resulting from the manufacturing process
  - Fusion of material in a point-by-point manner
  - Deposition of a new layer onto a previous layer



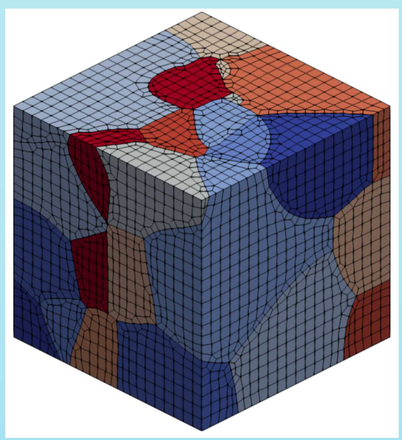
Microstructure of a part produced through powder bed fusion (selective laser melting).
J. Sugar, 2017



Microstructure of a part produced through traditional manufacturing.
J. Sugar, 2016

Methodology

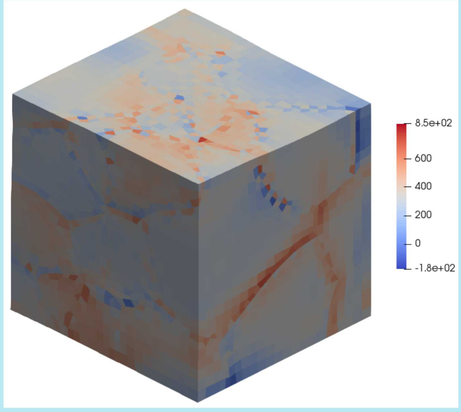
- Modeling
  - Investigating effects of microstructural physics
  - Incorporating effects of process
  - Structure-microstructure coupling

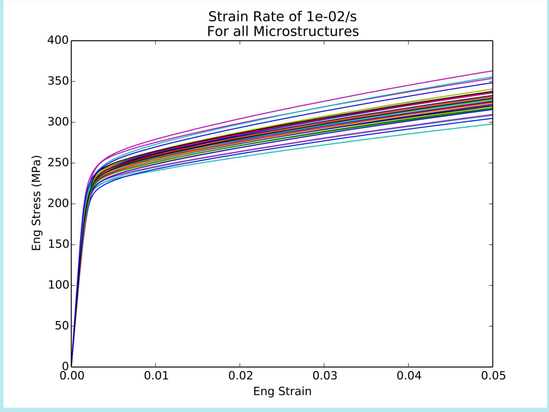


- Coupling to characterization and mechanical testing
  - Realistic microstructure
  - Rate and temperature dependence
  - Identify/discovering mechanisms of deformation

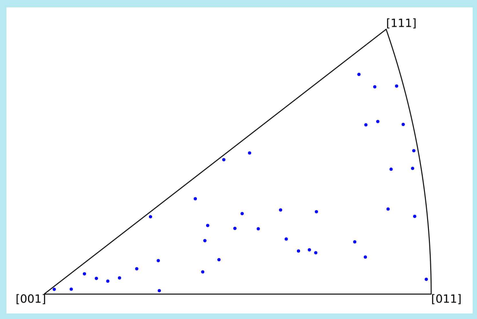
Microstructure with 40 grains created using DREAM.3D and SCULPT.

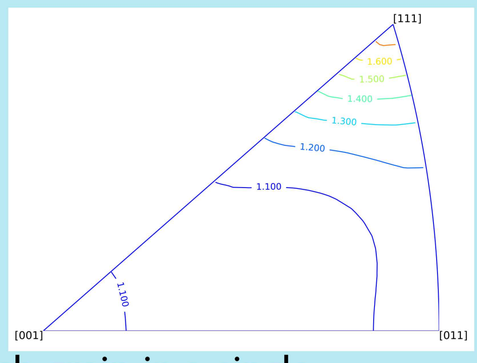
Results



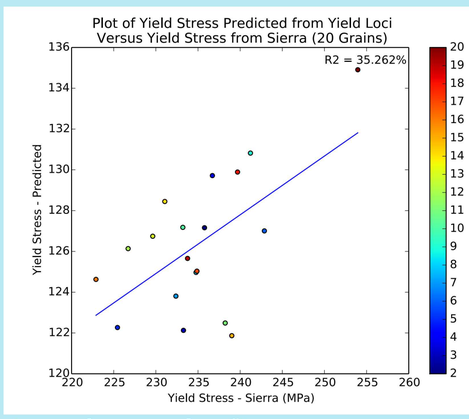


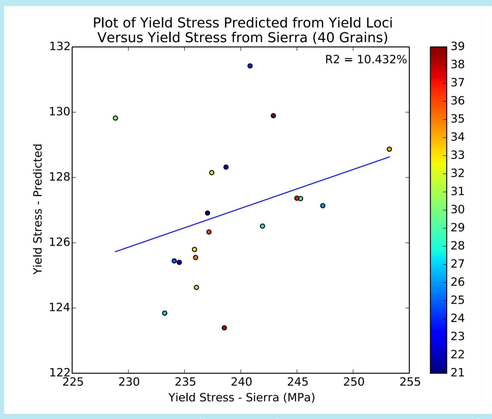
(Left) Stress corresponding to loading direction at a strain of 0.05 produced calculated by SIERRA SM crystal plasticity model. (Right) Plot corresponding to the volume averaged stress and deformation gradient at each time step to produce a stress-strain curve.





(Left) Map the crystal orientation for each grain in a single microstructure onto a pole figure. (Right) Contour plot of the analytical yield stress on the same pole figure.

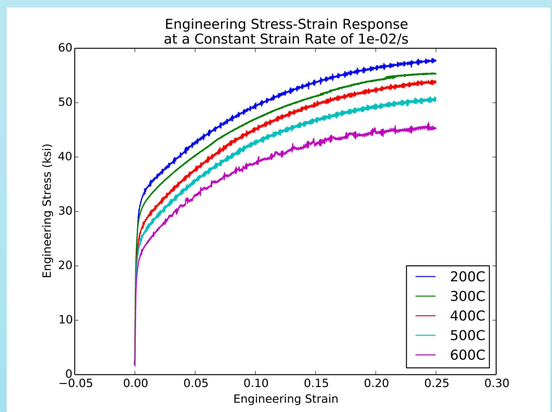


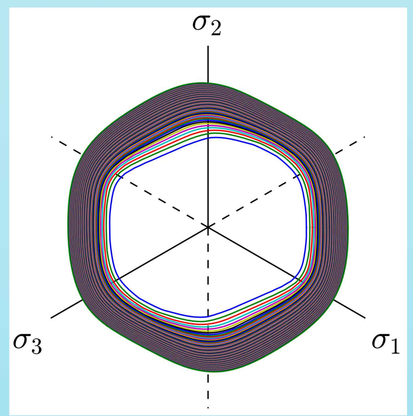


Using the pole figure mappings and the grain size of each grain predict the yield stress.

Future Work

- Select an representative volume element (RVE) and fit material parameters to experimental stress-strain data
- Generate yield loci and fit a yield criterion
- Implement yield criterion in macroscale model and couple structure-microstructure problems





Sandia National Laboratories is a multimission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.
SAND No. _____

Sandia National Laboratories