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# Tailoring Hierarchical Material Performance Through Process Manipulation

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*3D Systems ProX 200 powder bed fusion machine*

*North Star X3000 µCT*


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## Motivation

- hierarchical materials introduce a compelling design space
  - material & structural performance regimes inaccessible in bulk, homogenous materials
- exploring the impact of process inputs from laser-powder bed fusion
  - geometrical constructs for tuning properties already widely researched

## Process-Property Relationships

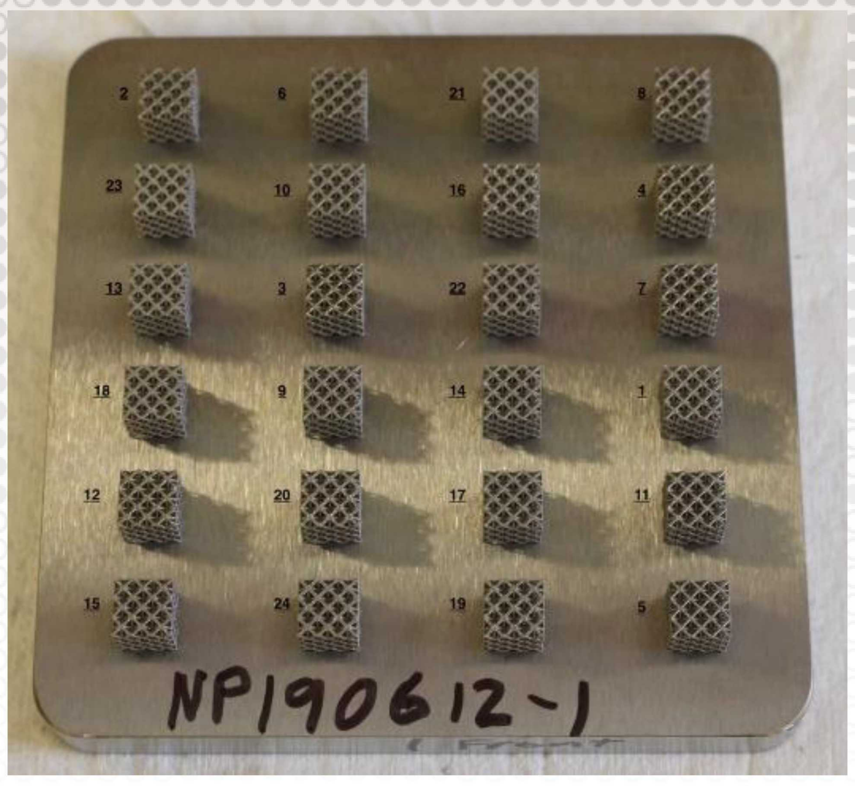
- 316L stainless steel
- 10.5mm octet truss lattice
  - 20% fill, 3x3x3 unit cells
- varied laser power & velocity @ 48 settings
- explored resultant strut geometry & structure performance

## Inspection

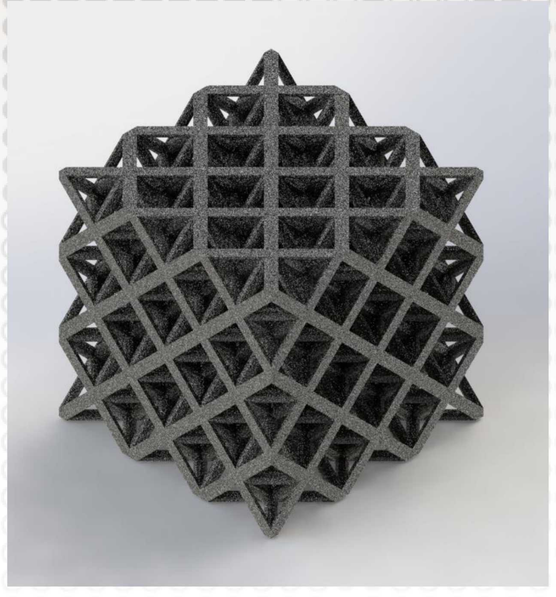
- Keyence VR-3100 fringe projection microscopy
  - feature based metric is challenging
  - form / finish work well for "conventional" geometries, but not lattices
  - strut diameter "fit" using top surface area ratios
- computed tomography
  - North Star X3000 CT system
    - ~220Kv, ~15W, w/copper filters
  - measuring lattice surface / structure, not porosity
  - 10-15min scans
- quasi-static compression loading
  - 5 mm controlled displacement
  - metrics: elastic modulus, yield strength, compression energy (area under load displacement curve)

## Summary

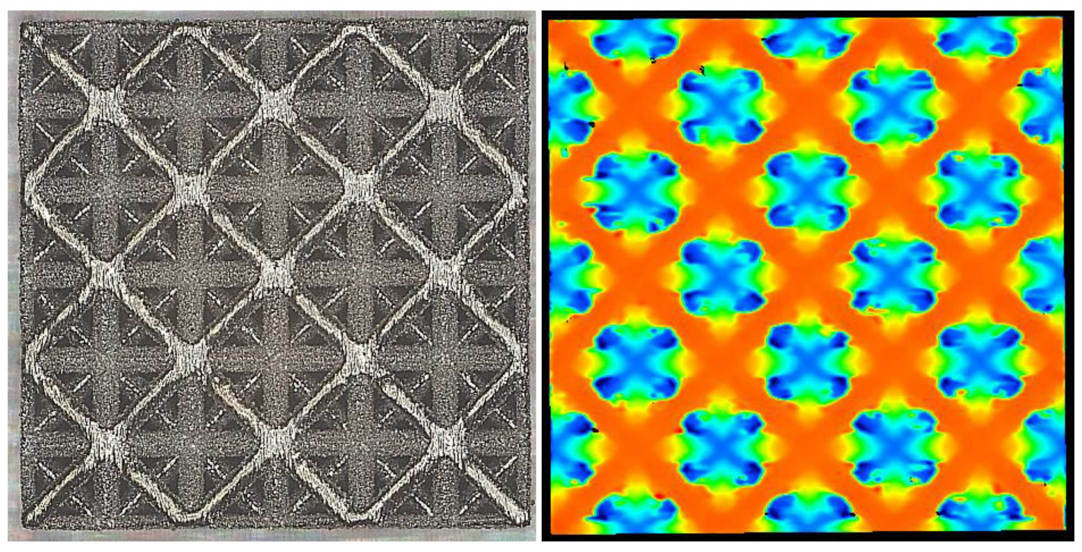
- process inputs provide an additional degree of freedom in the design & fabrication of hierarchical materials
- strut diameter is predominant indicator of properties
  - strut diameter is proportional to process volumetric energy density
- process was more robust than anticipated
  - no failures across selected parameter space



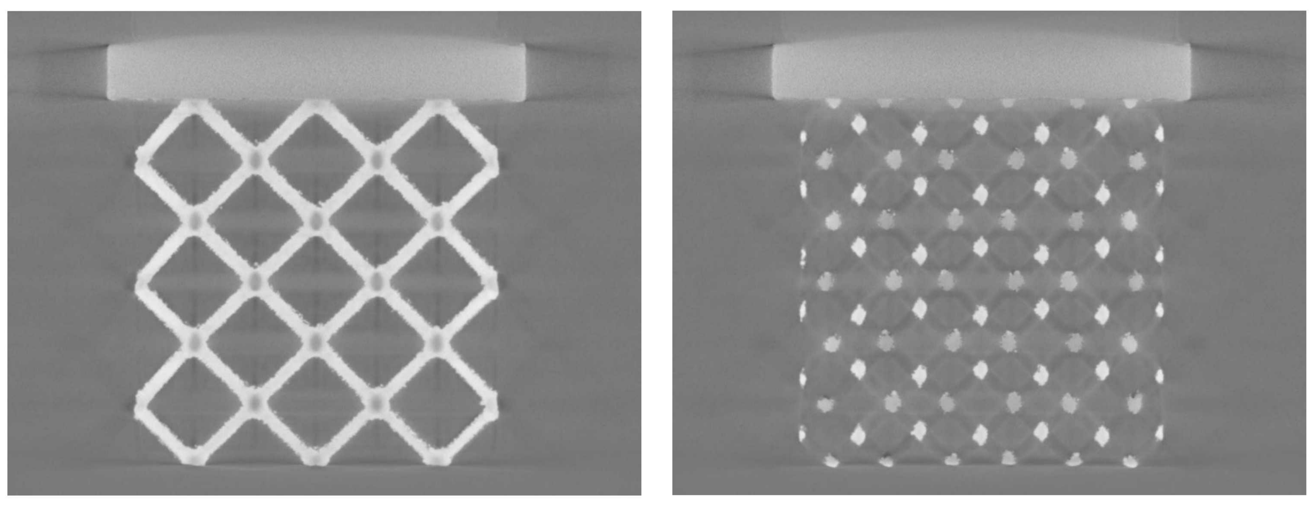

*$1cm^3$ octet structures build plate, 24 structures per plate*



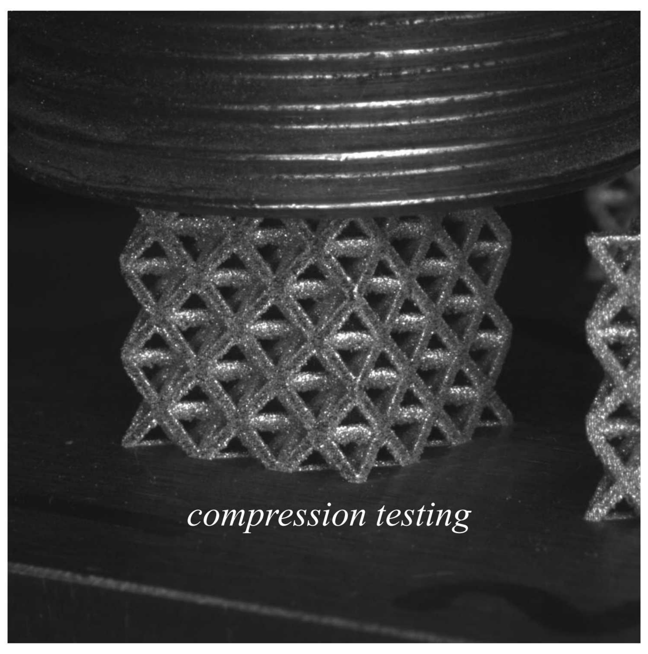
*solid model of single octet truss structure*



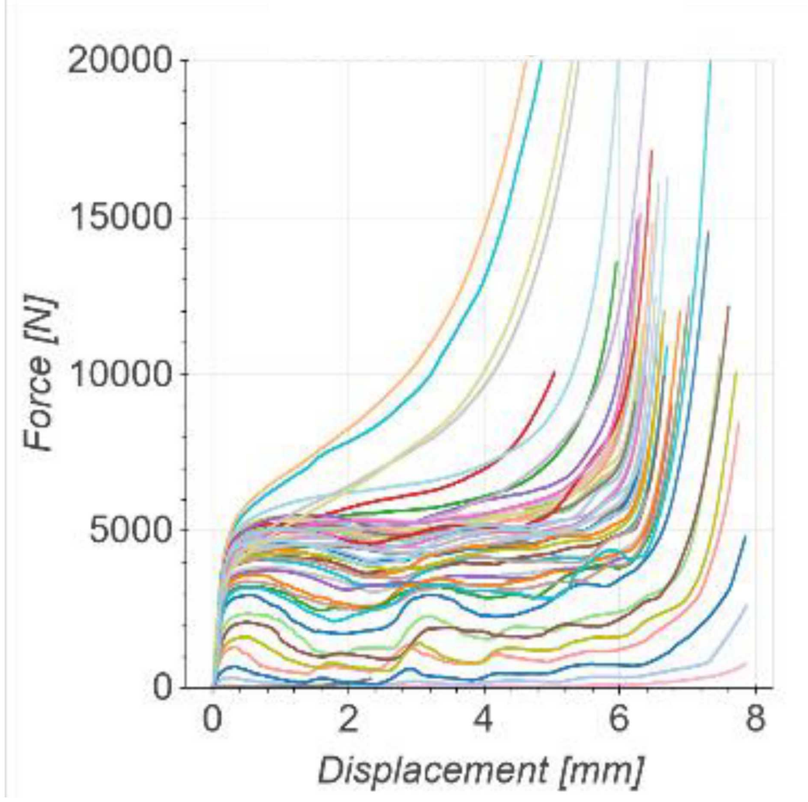
*top surface image (left) and topography (right) from fringe projection microscopy*



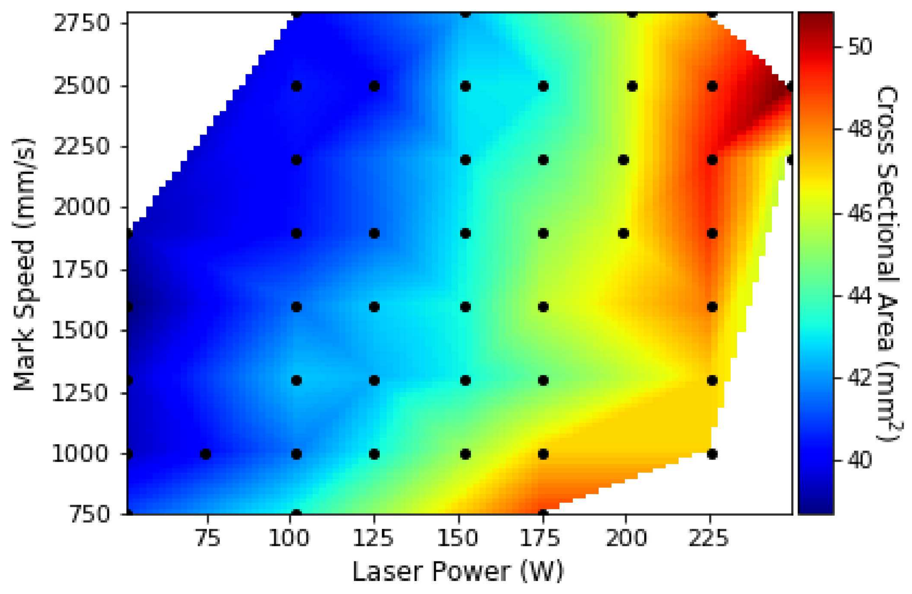
*computed tomography images from 10min scan of octet with struts (left) & nodes (right)*

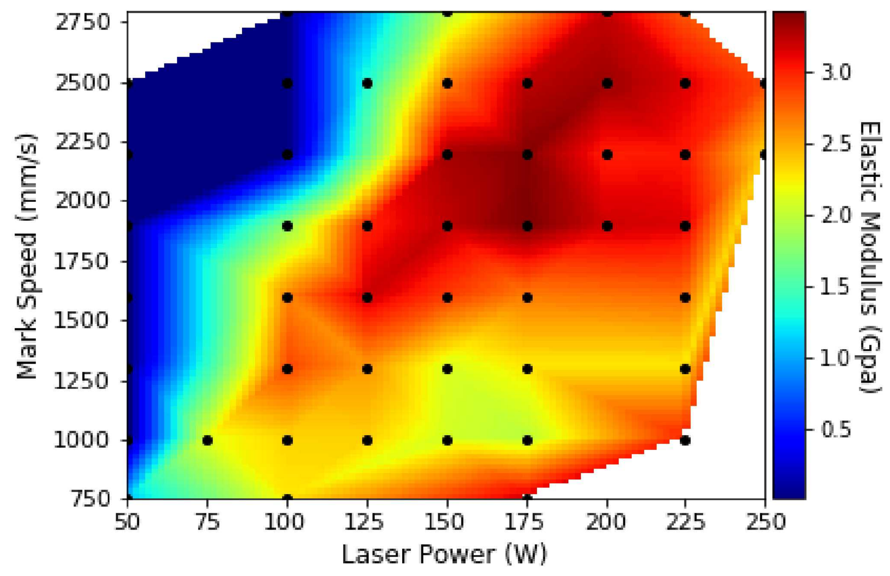


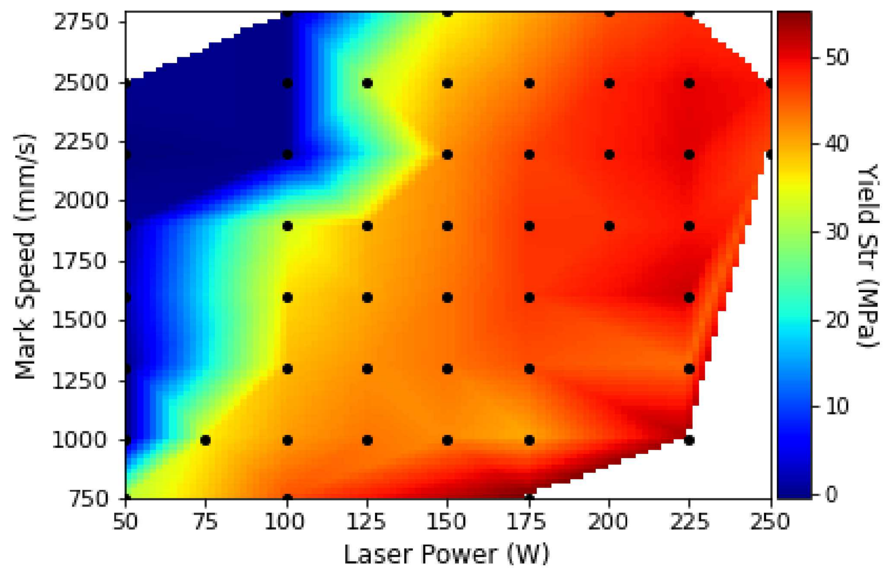
*compression testing*

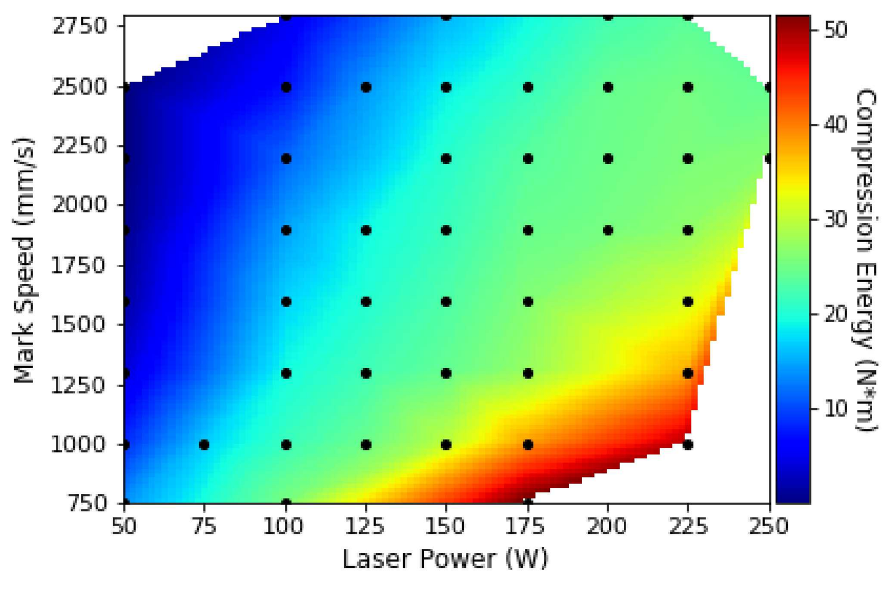


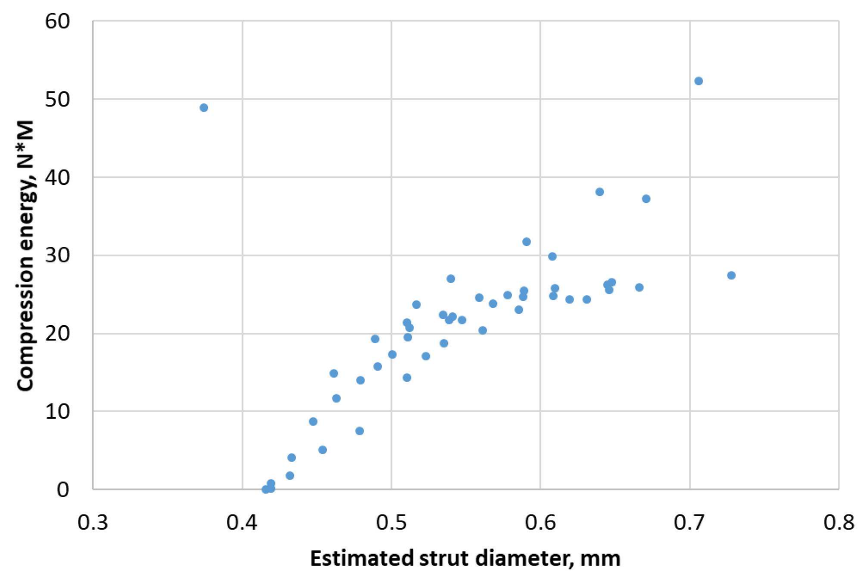

*force-displacement curve for all 48 octet structures*

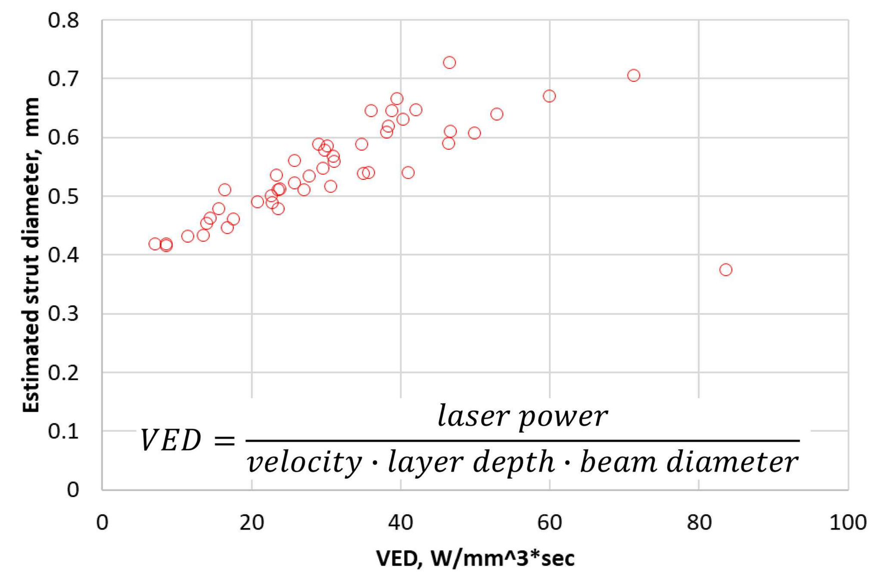
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