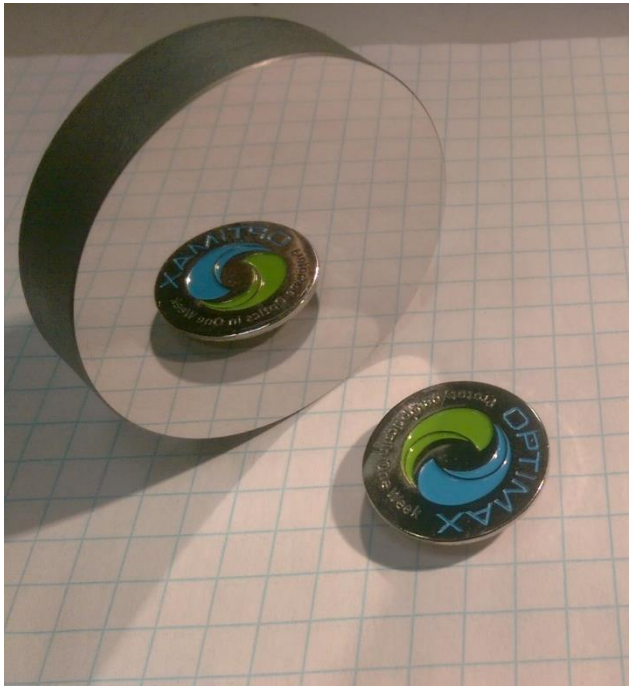


OPTIMAX

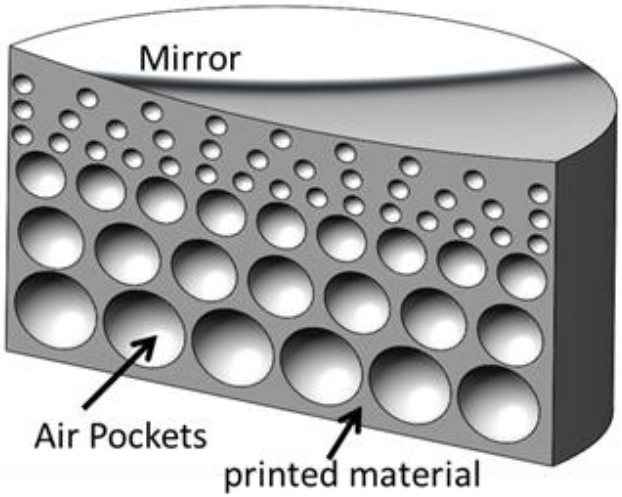
Additive Manufacturing for Lightweight Mirrors

Presented By:

Matt Brunelle, Kate Medicus,
Jessica DeGroote Nelson

Project Goals

How can additive manufacturing be best utilized for lightweight mirrors?

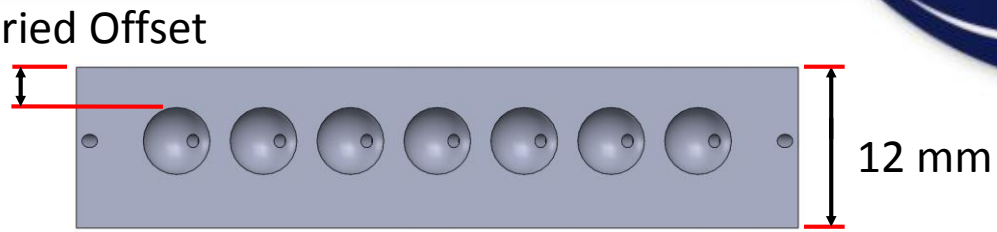


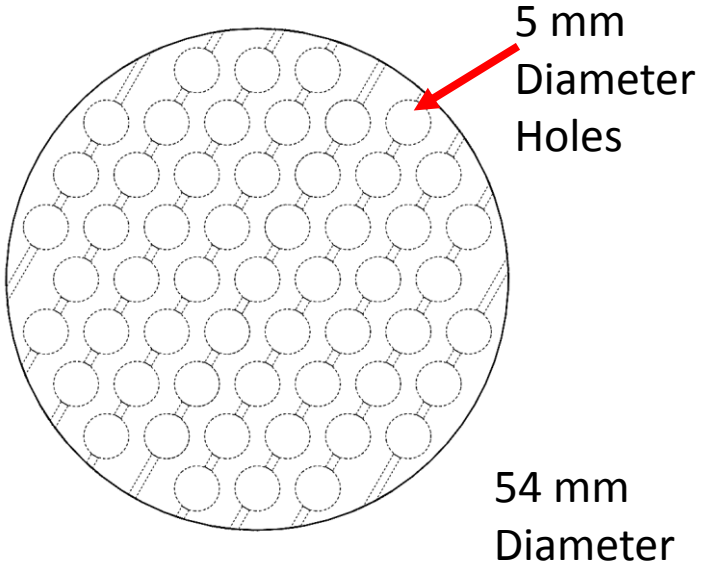
- Can structures like this be printed?
- Will they hold up to polishing?
- How should they be optimized for load, temperature, etc?

Coupons for Testing

Testing for:

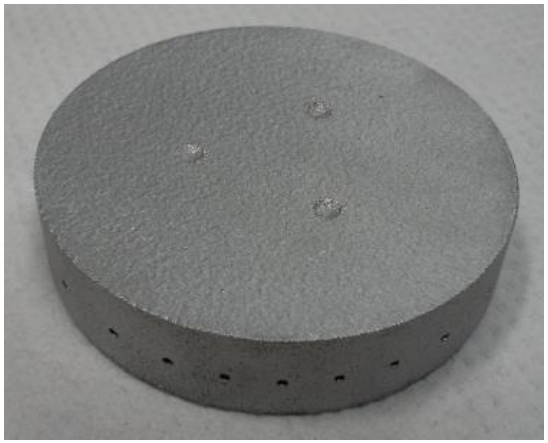
- Possibilities for internal features
- Material studies - polishing
- Print through





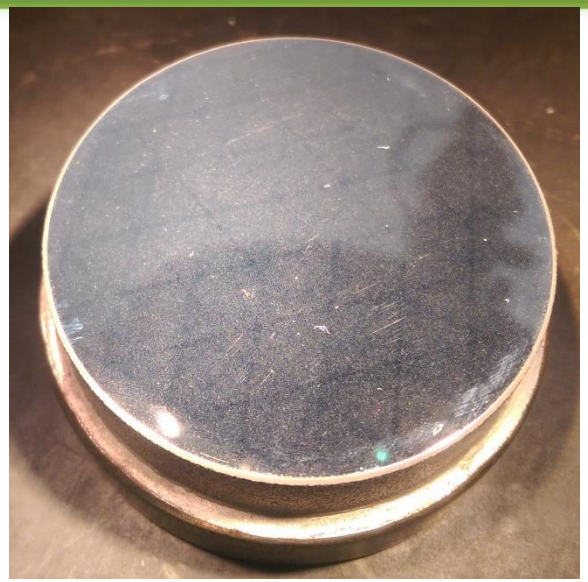
- EOS M270
- Direct metal laser sintering
- Powder (50 µm – 80 µm) bed

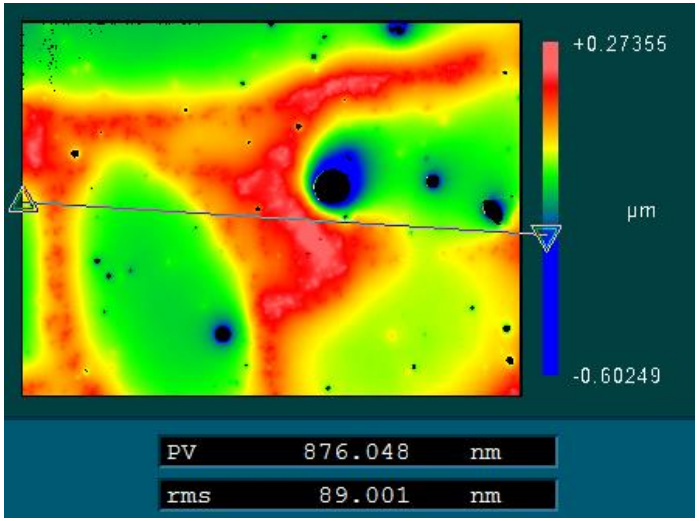
- $AlSi_{10}Mg$
- 17-4 Stainless Steel



Polishing the Aluminum Alloy was not Promising

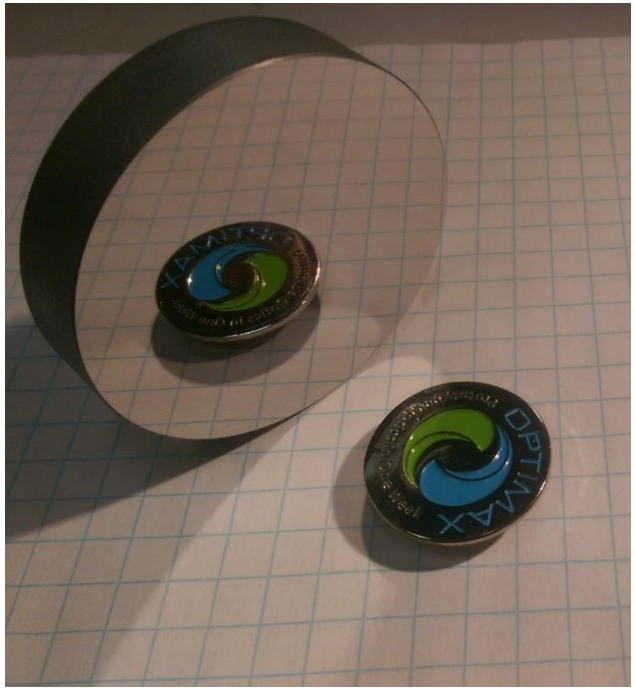
- AlSi10Mg polishing
- Solid coupon
- Triangular pattern
- Surface “Rippling”
- Significant voids
- Poor surface roughness

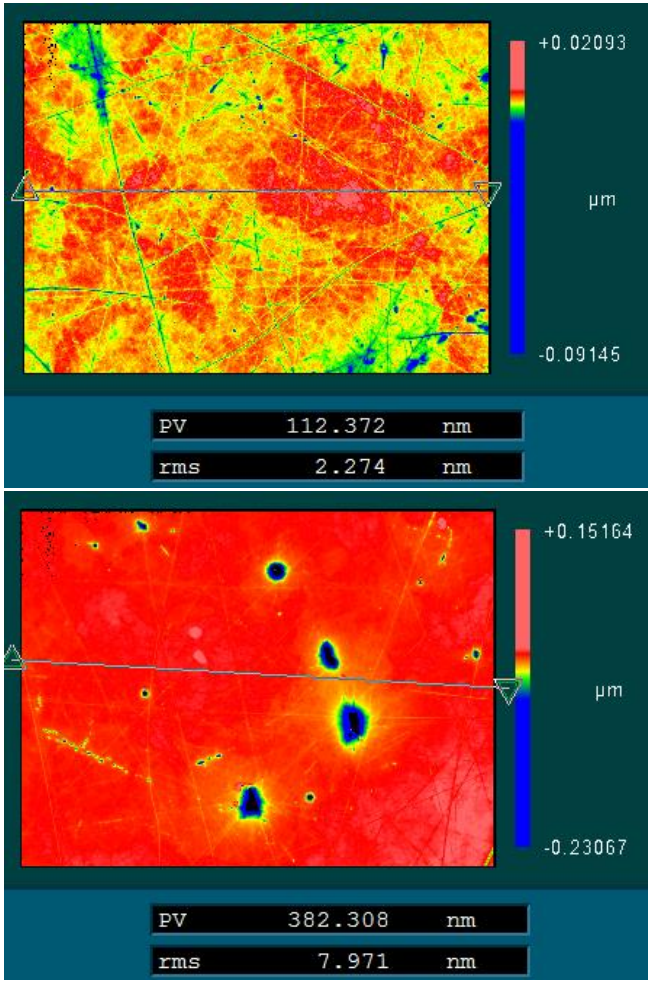




Polishing the Stainless Steel went well

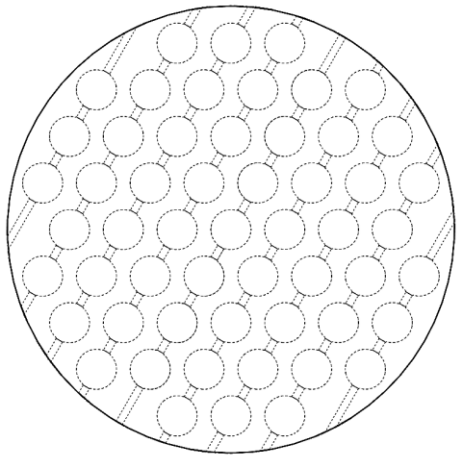
- 17-4 SS SR at 2.2 nm rms
- Some 30 µm diameter voids





Internal Light Weighting Holes Were Printed

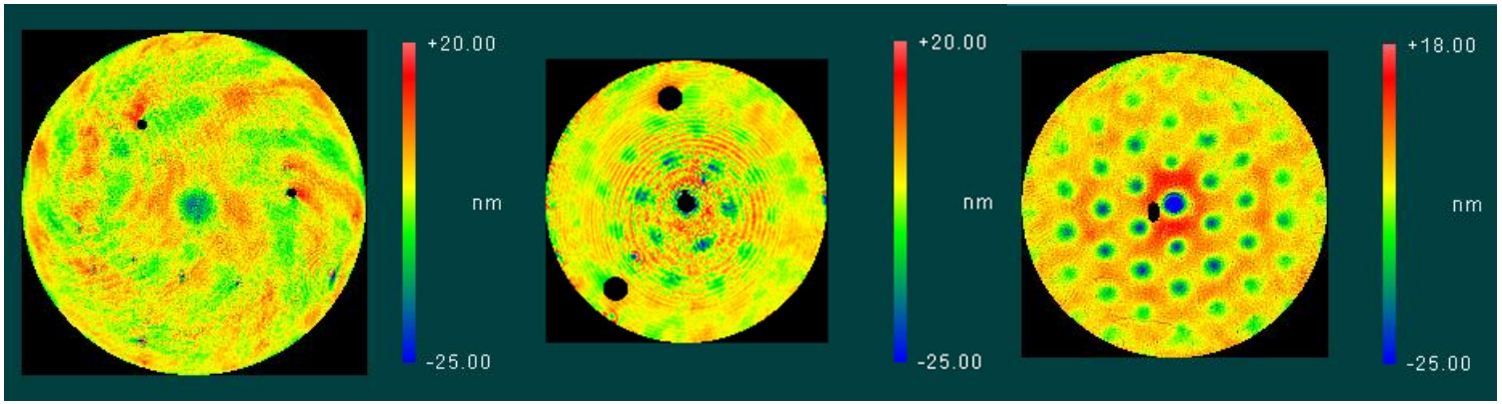
- 5 mm diameter spherical holes
- 1 mm diameter channels printed for draining powder
- No collapsing was observed
- Leads to possibility of designing internal features for lightweighting of larger substrates – how big and how dense can we go?



OPTIMAX

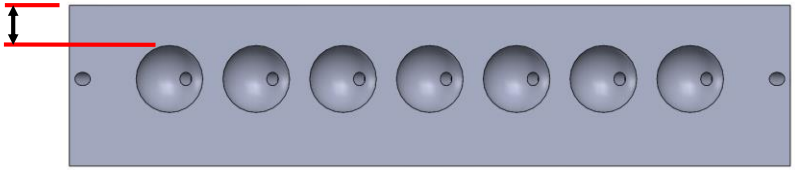
Print Through Observed at <0.5 mm Face Thickness

- Purposefully varied the offset to determine when print through occured
- Measured with interferometer
- Zernike residual shown (remove low order errors to see print through)



1 mm 0.5 mm 0.25 mm

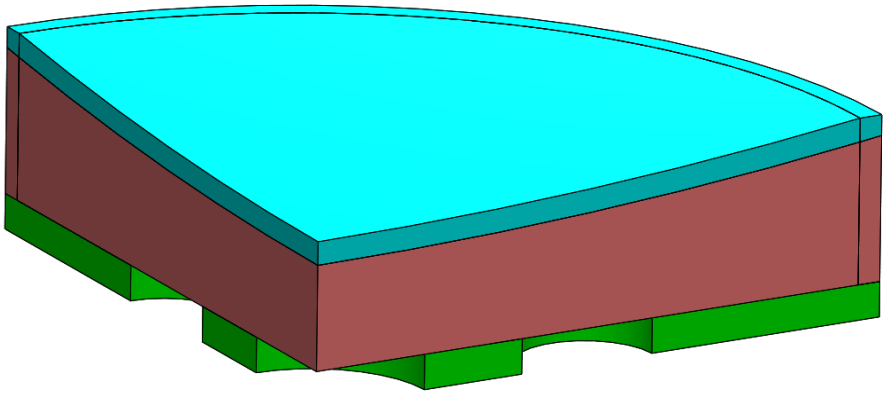
Varied Offset

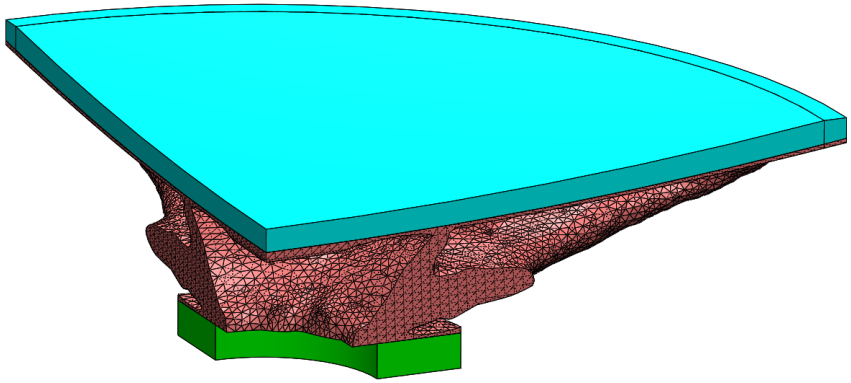


New Tools are Available for Shape and Structure Optimization

Topology Optimization

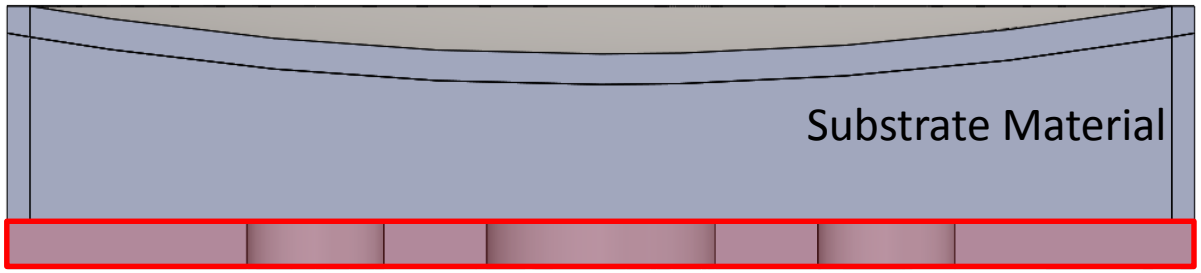
- Start with a basic shape – 100 diameter, 400 mm radius concave mirror, 14 mm center thickness
- Set external conditions – mounting conditions, gravity load, temperature change
- Set desired outcomes – minimal mass, deformation less than XX
- Allow software to run
- Software divides the mass into elements and starts removing them in an attempt to meet the outcomes



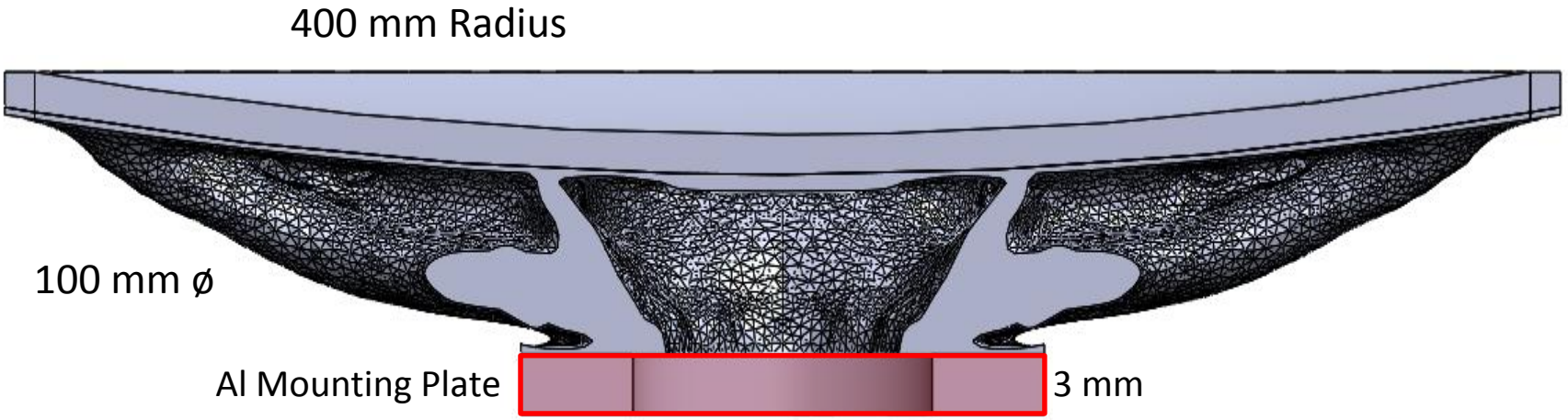


About the Material

- Our initial studies were done with Invar 36 as the substrate material
  - Currently not available as a commercial 3D printed material, but we are working with partners on this
  - Will be printing test pieces in stainless steel
- Also have done some simulation using a different material as a base material
  - Bimetallic structure to minimize bending
  - Aluminum is a good candidate here
  - Options exist for printing onto base plates of a different material



Optimized Design for 40 degree Temperature change and Gravity Load

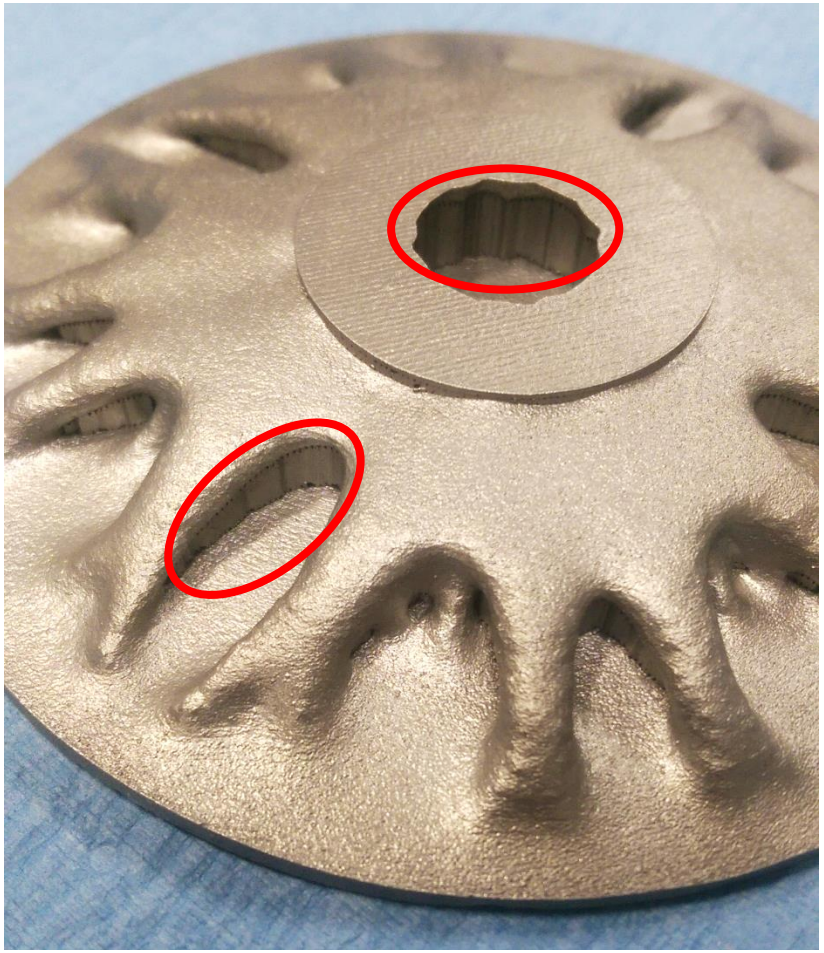


- Organic structure seen
- Software shows performance improvements with optimized design
- How feasible is the printing of this structure?

OPTIMAX

Mirror Printed from Stainless Steel

Support structure is not optimized

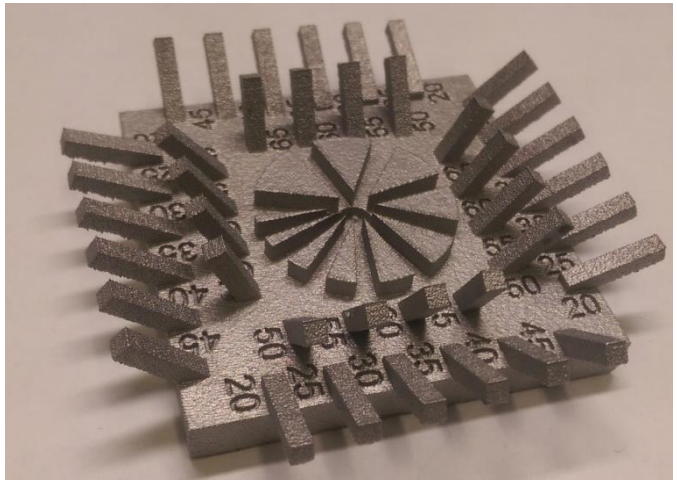


Support Structures

- Required to mechanically support overhanging features
- Helps to dissipate heat resulting in better surface finish

Our plans moving forward

- Design without the need for support structures
- Work with the supports – design our structure to have the needed support as an inherent part of the component
- Investigate more of the hole and teardrop shapes that don't seem to need the supports.



Upcoming

- Working with, not against the support structures
- Invar 36
- Full mirror designs with holes