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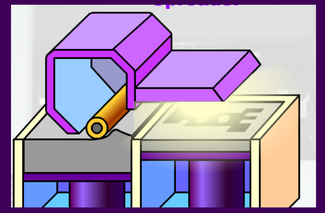
SPONSORS: MSU UNDERGRADUATE RESEARCH CENTER, RASP, EXONE COMPANY

~~3D Printing~~ Additive Manufacturing of Stainless Steel for Engineering Applications

Inject Liquid Adhesive

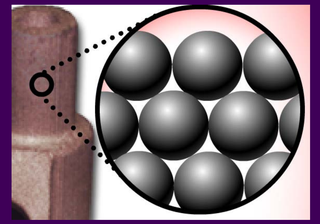
The liquid chemical binder is injected into the active layer of powder and adheres the 30-micron-diameter stainless steel particles together.

Heat Before Rolling Layer



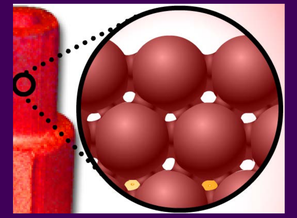
The active layer is then heated to solidify the liquid before rolling the next 50/100/200 micron layer of powder. The process repeats for 1 to 4 hours.

Cure at 200°C - 3 hours



The block of powder is transferred into an oven that burns off 95% of the chemical binder, but makes the part strong enough to remove excess powder.

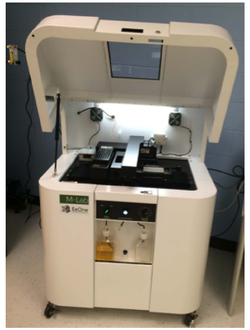
Sinter at 1200°C - 10 hours



The "green" part has remaining binder evaporated in a furnace & melts the particle surfaces into a necked matrix. Pores are infiltrated with bronze.

Tensile Test

The dog bone shaped parts are pulled with a machine that measures the force and elongation. The graph below is based on the machine's data & parts.



Installed Oct 2013

Build Volume
1.5”x2.3”x1.3”
Larger Machine:
15.7”x9.8”x9.8”

ExOne Materials
Sand, Glass, Gold, 316-Stainless Steel, 420-SS + Bronze; Possibly Inconel, Titanium, and more

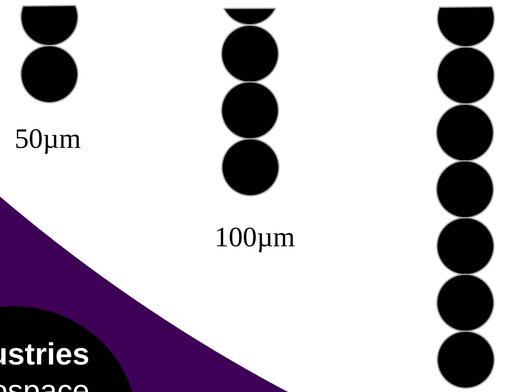
Industries
Aerospace
Oil/Gas
Automotive
Medical

MISSION

To start filling the gap of available information on metal additive manufacturing by publishing the data of these part’s material characteristics, like tensile strength, for this metal chemical binding technology, and the process parameters and procedures involved.

PART ORIENTATION (SIDE VIEW)

LAYER THICKNESS (MICRONS)



FACTORS TESTED

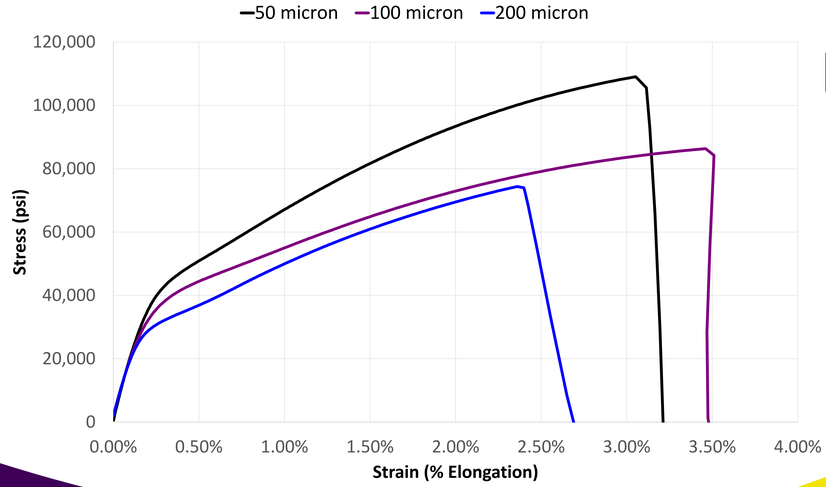
Layer thickness or amount of layers for a given part height
Orientation of part in the block of powder

Layer Thickness (micrometers or meter-millionths)	Linear Slope of Elasticity [Young's Elastic Modulus] (Mega-psi)	Permanent Deformation [Yield] Strength (kilo-psi [ksi])	Maximum [Ultimate Tensile] Strength (ksi)	Change in Length [Strain] (% Elongation)
50	20	33	105	2.8
100	14	30	86	3.3
200	19	28	75	2.3

FACTORS’ SIGNIFICANCE

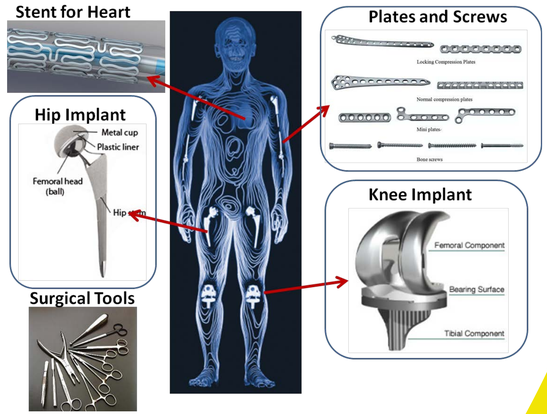
The thinner the layer, the stronger the part
Orientation didn’t give an apparent correlation to tensile strength

Average Tensile Testing of 3 Layer Thicknesses
50% 420-SS + 50% Bronze Parts

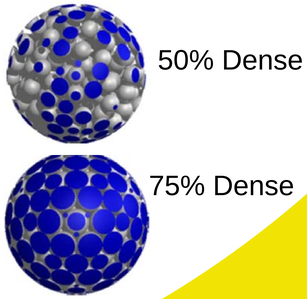


VISION

Increase the 10 year Longevity of Joint Replacements to 20+ years



SPHERE PACKING



Future
Infiltrate Polymers
Gradient Density
More Materials
Gradient Material
Vary Particle Size