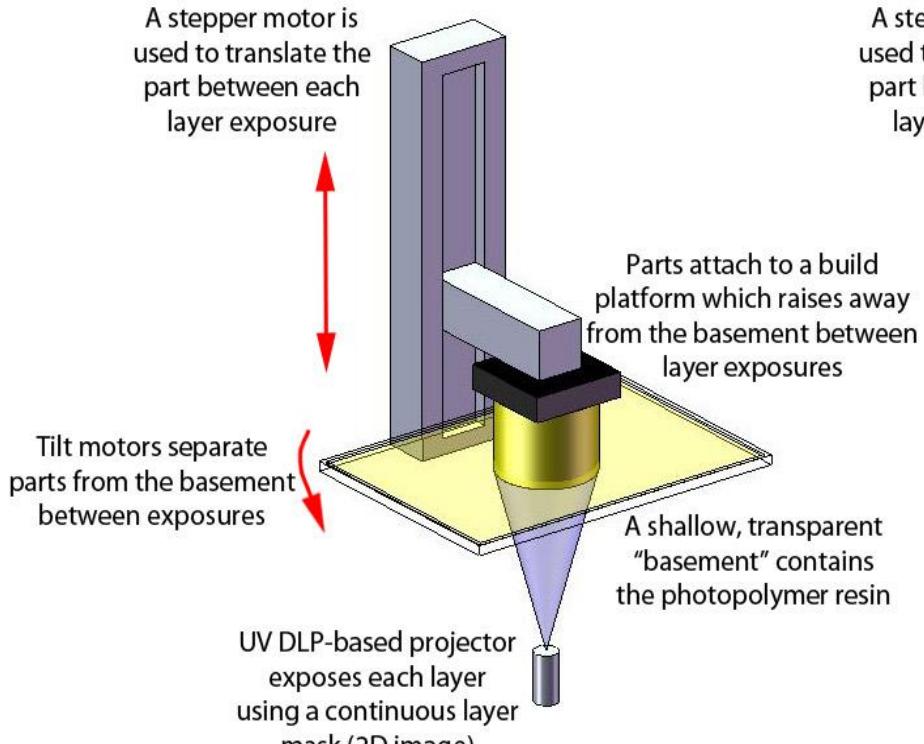
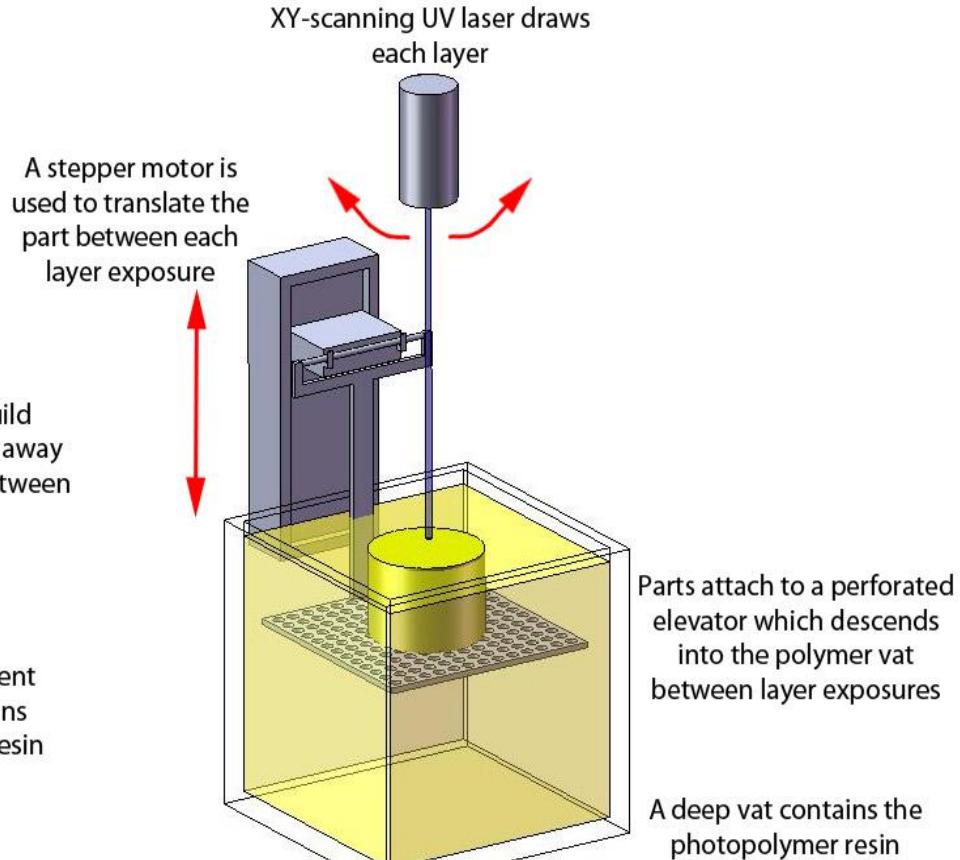


On 3D printing PPF for bone tissue engineering.

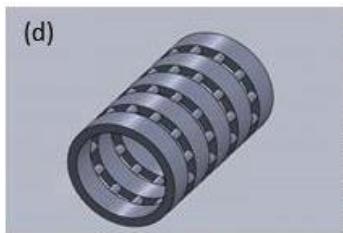
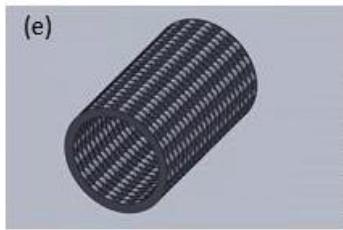
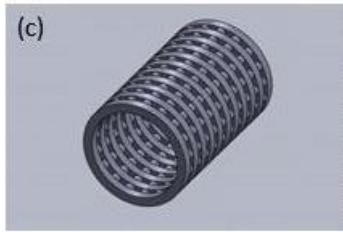


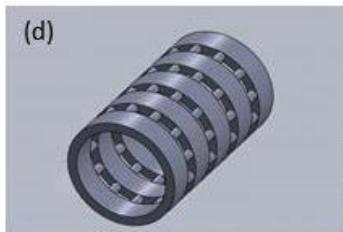
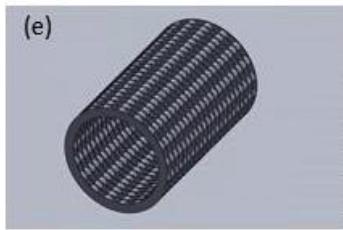
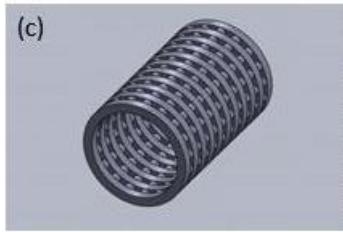


cDLP

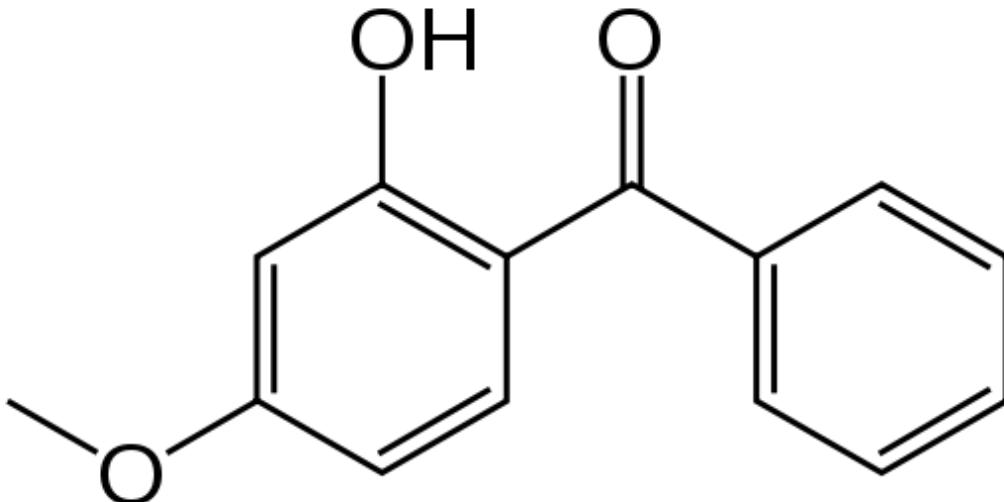


SLA

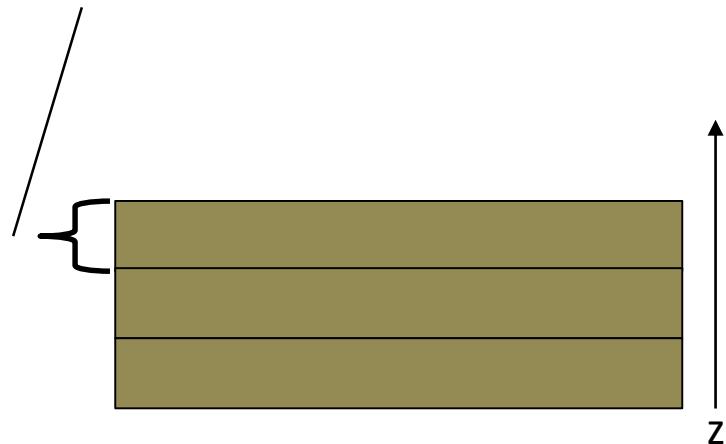




oxybenzone



Layer-thickness (z-resolution)

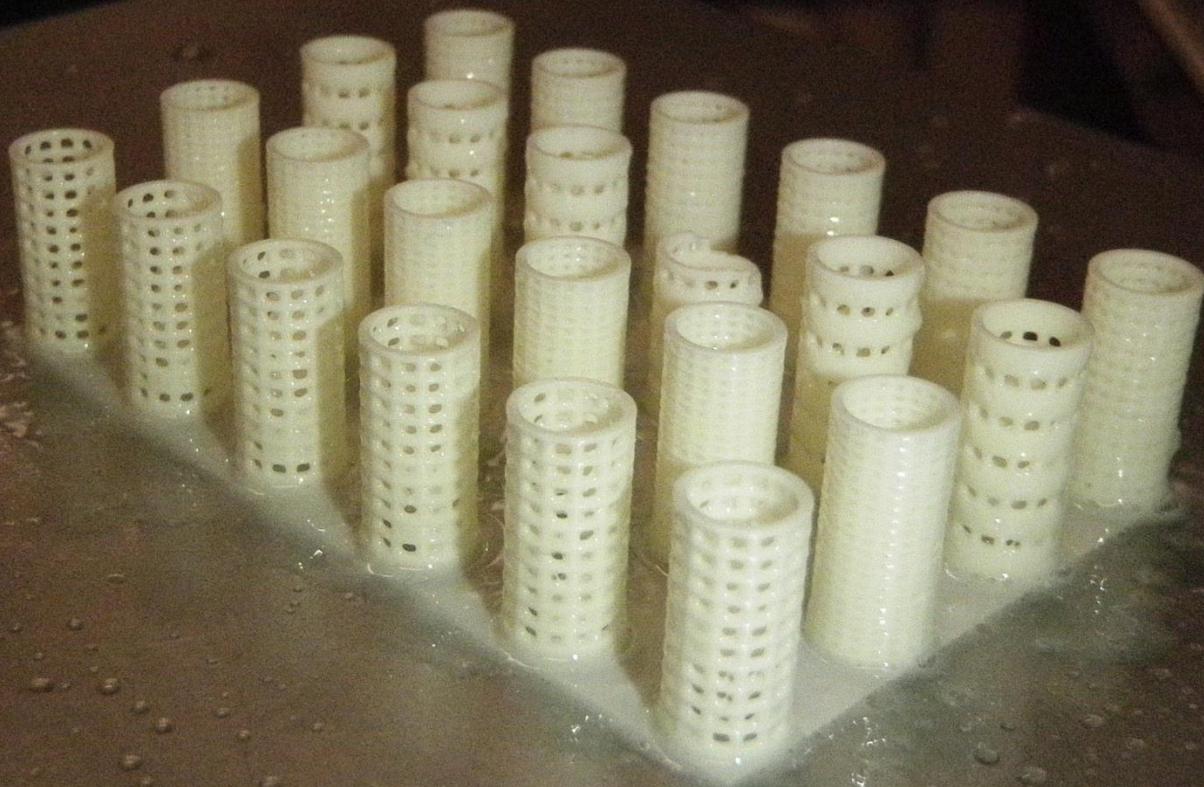


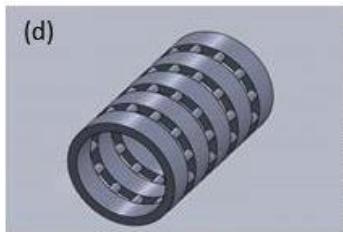
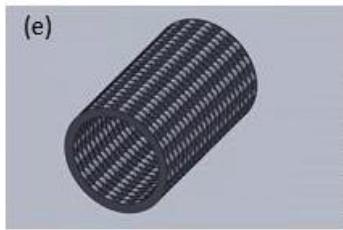
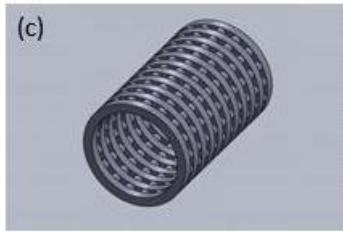
Over 33% needed as opposed to 3%-4% TiO₂ to achieve same layer thickness.

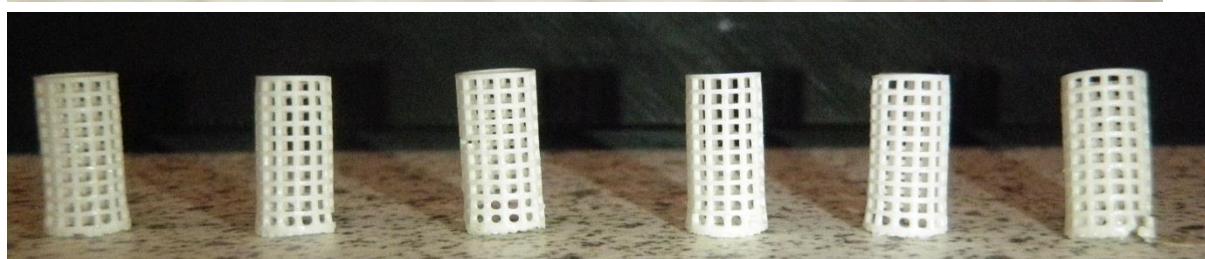
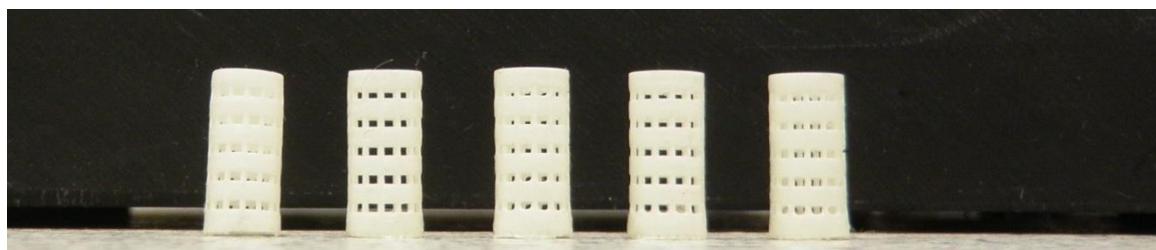
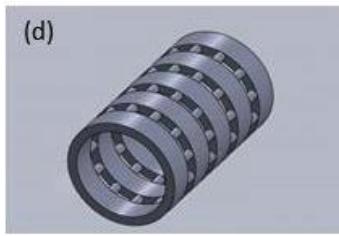
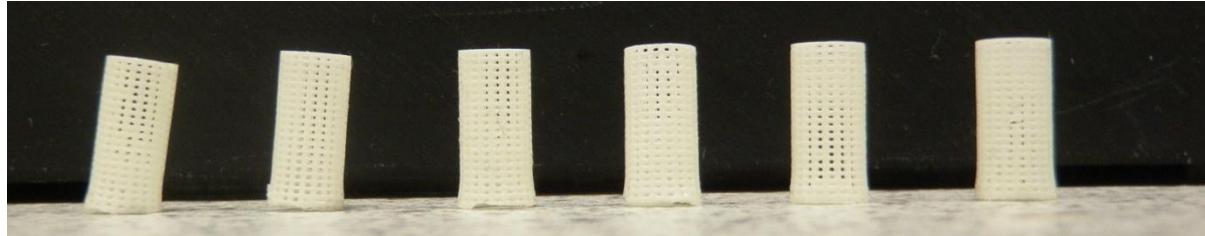
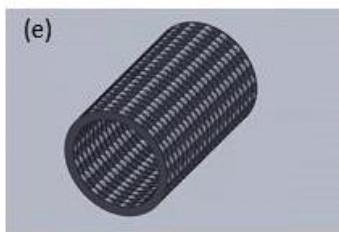
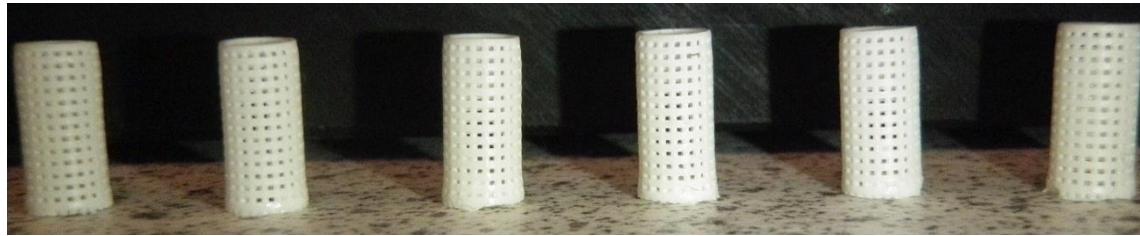
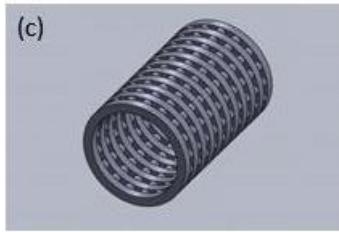




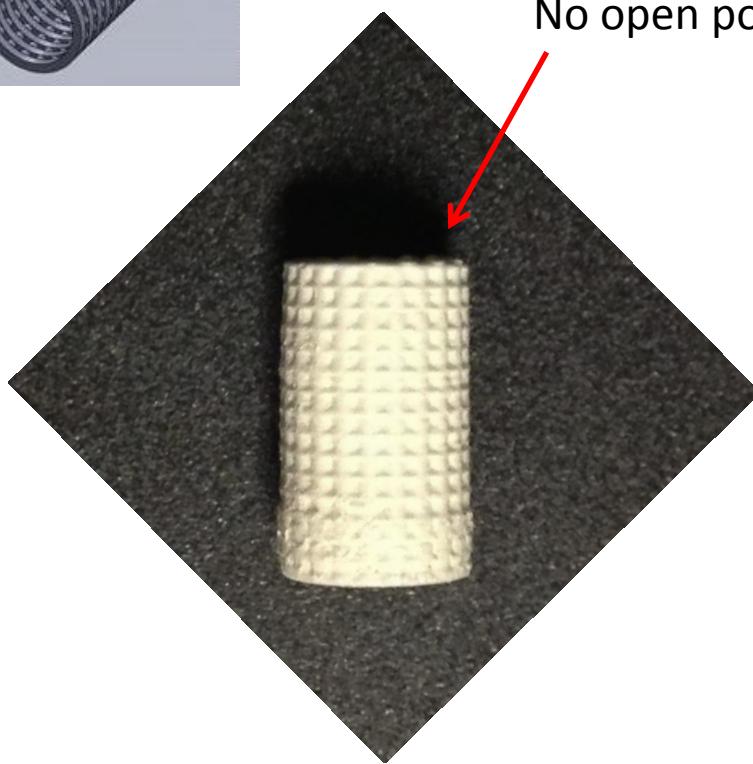
?
SPF
SUNSCREEN



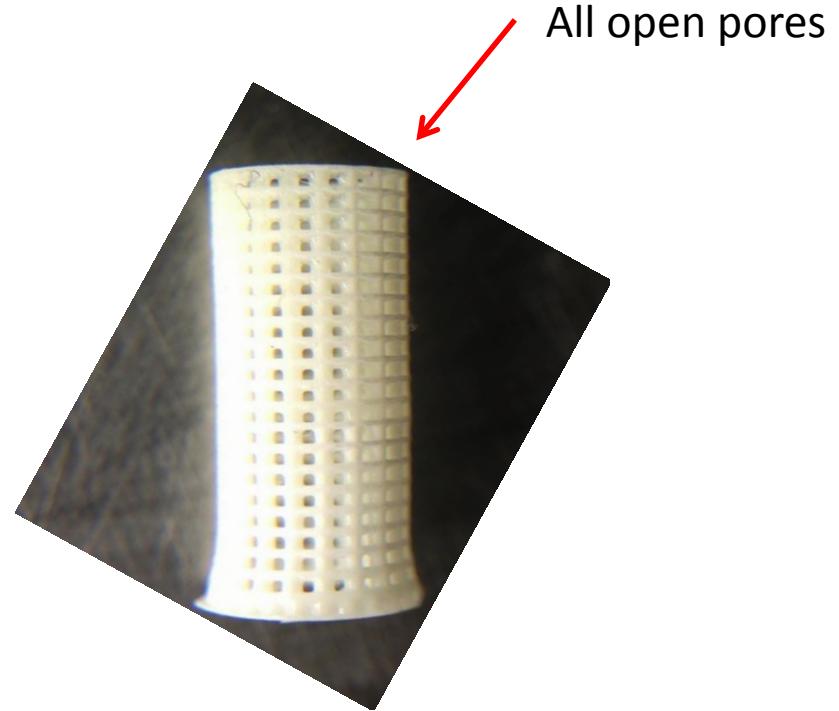




Increase in Resolution



Just TiO₂



TiO₂ and Oxybenzone

“dark cure”



TiO_2 alone

“dark cure”

No “dark cure”

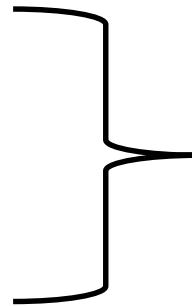


TiO_2 alone

$\text{TiO}_2 + \text{Oxybenzone}$

The Magic Potion

- 1:1 PPF:DEF
- 1% Irgacure 819
- 1% TiO_2
- 28% Oxybenzone

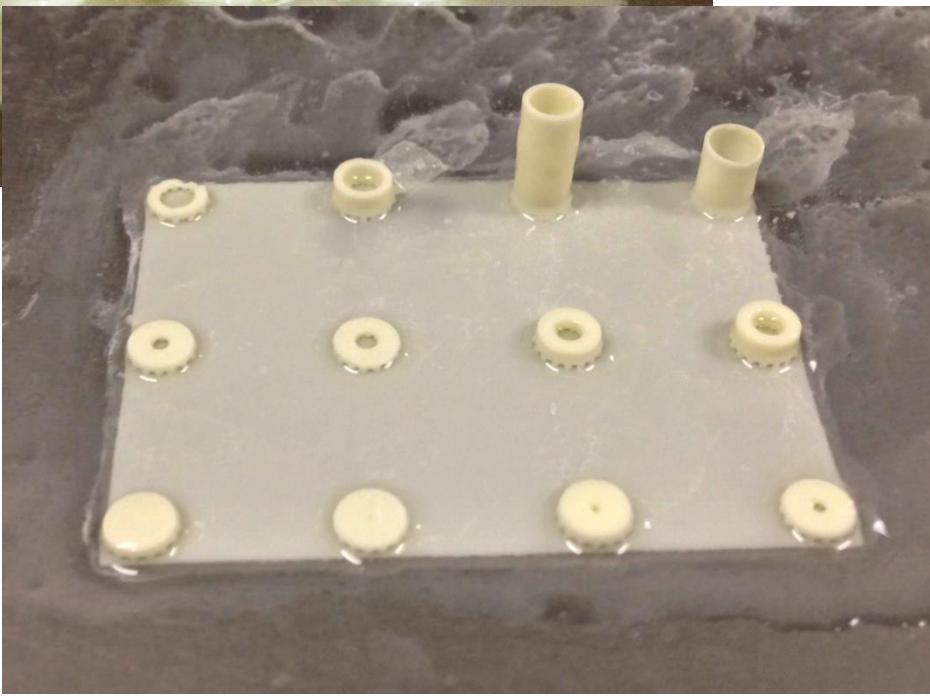
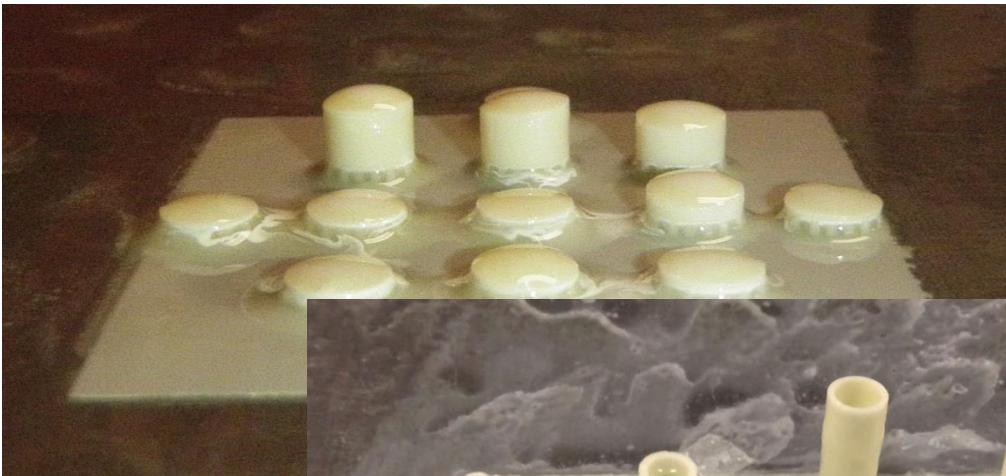


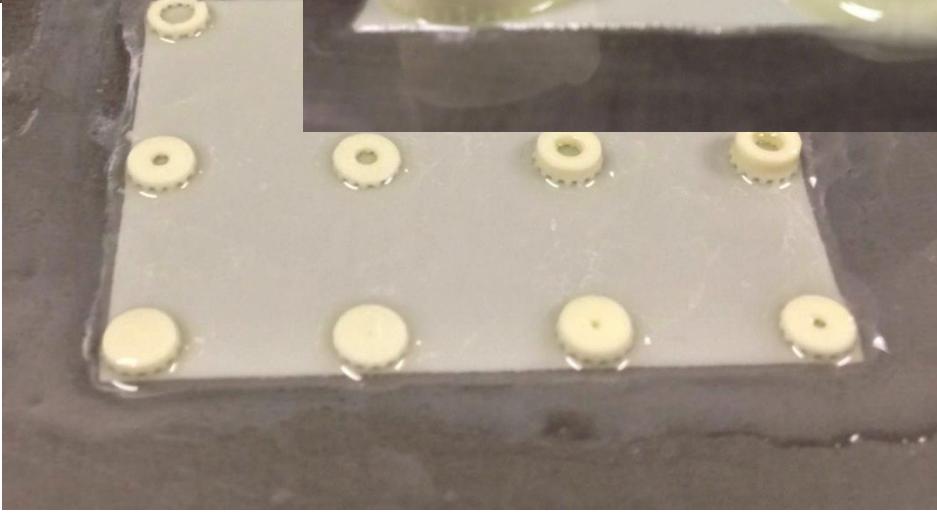
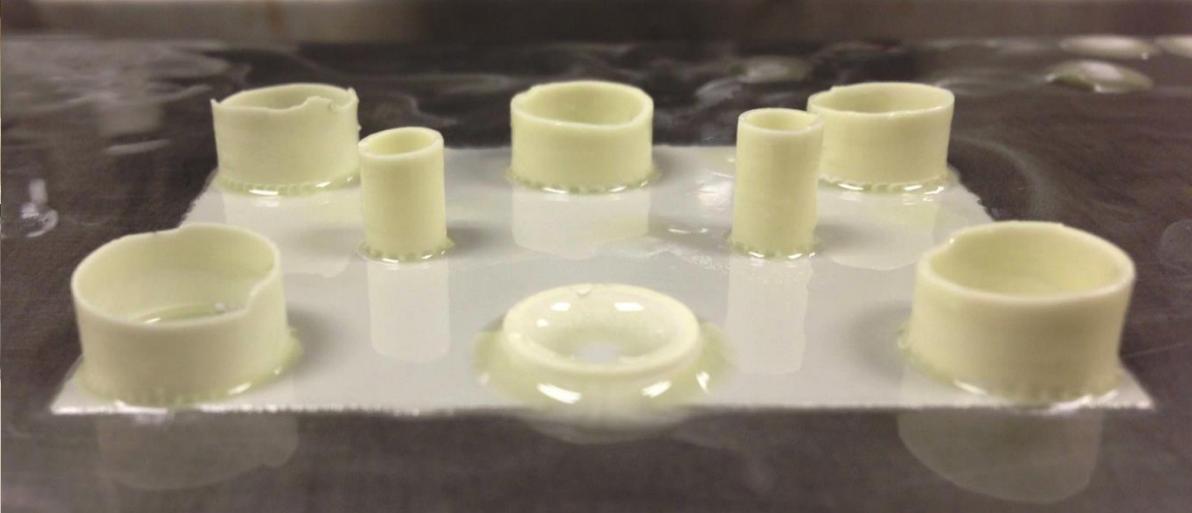
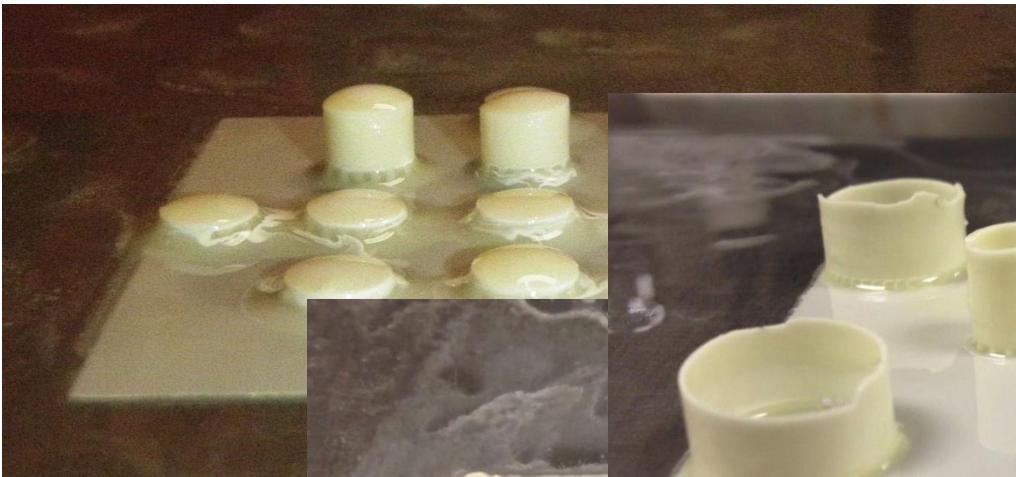
With respect to mass of
PPF & DEF

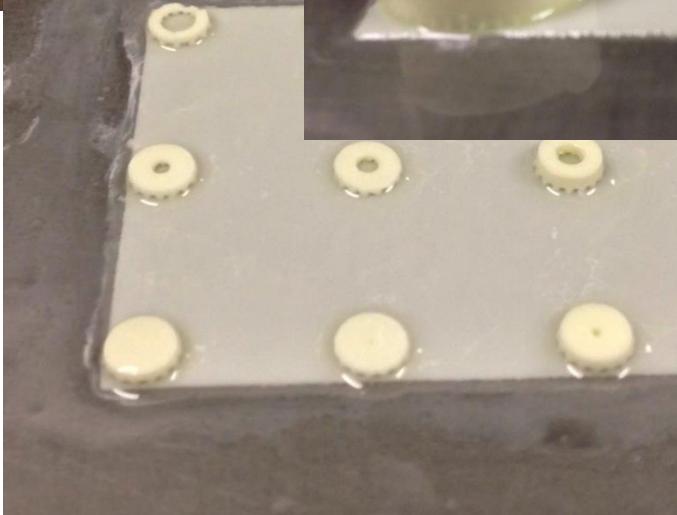
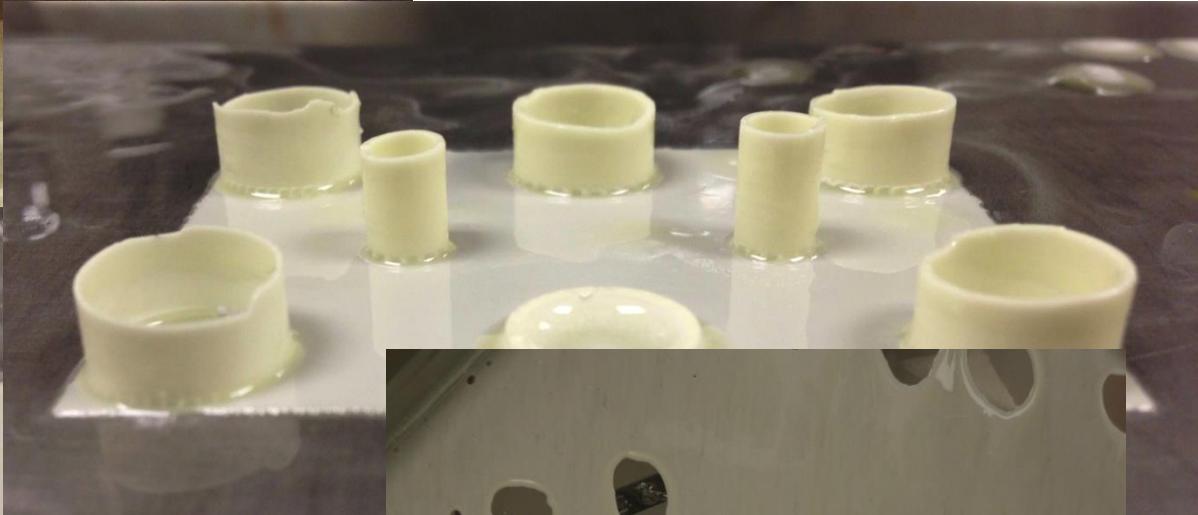
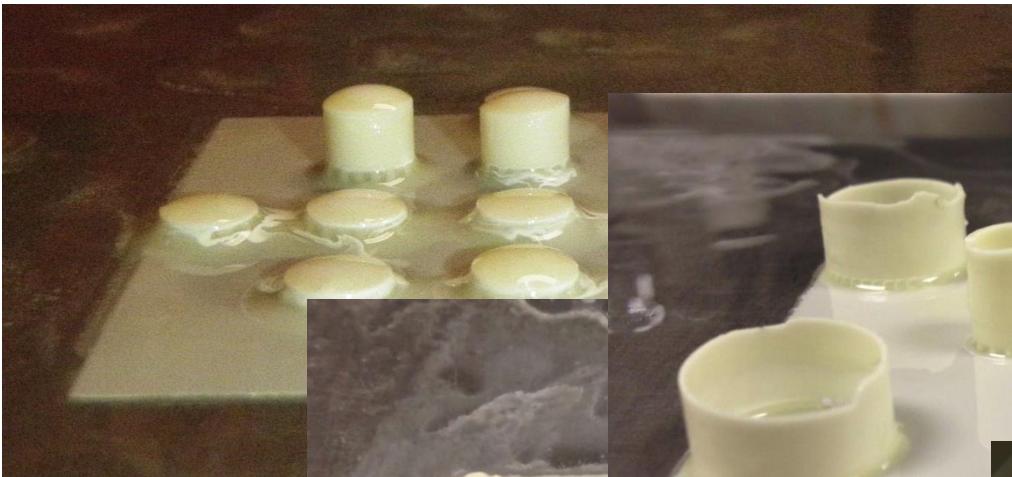
PPF Parameters:

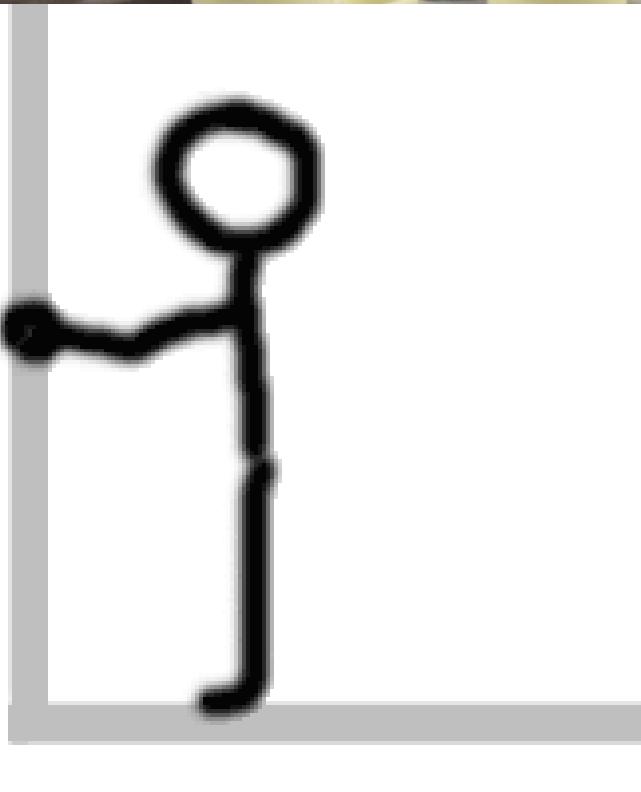
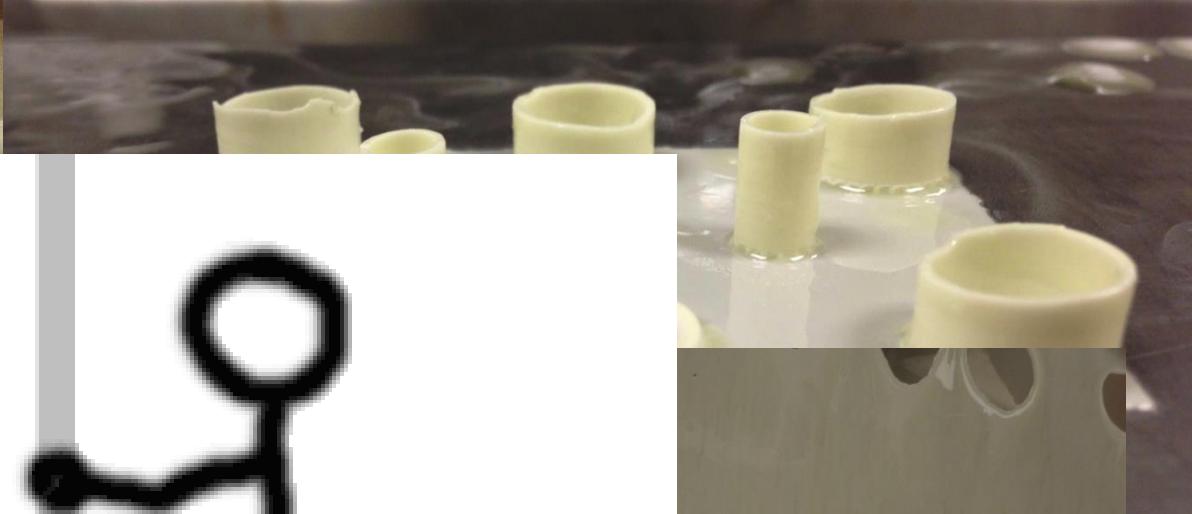
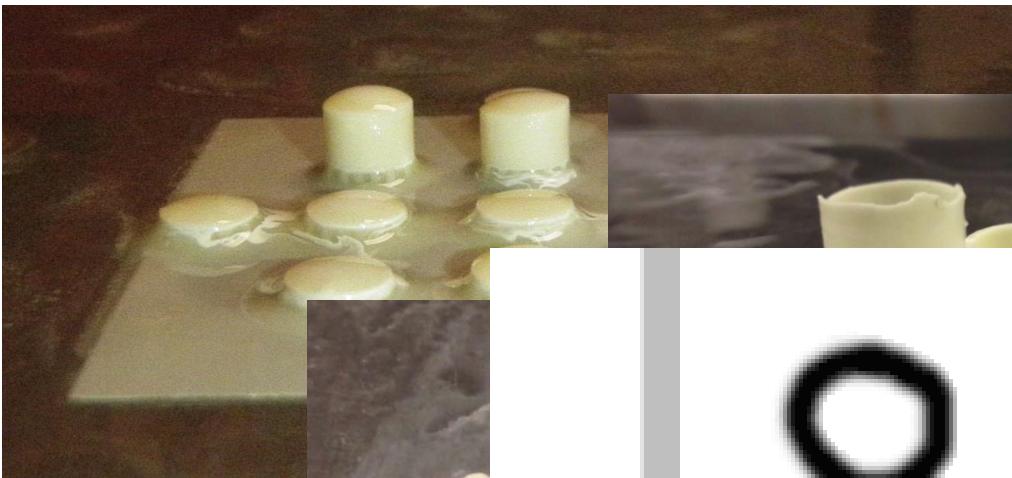
- M_n : 866 da
- PDI: 1.3















Time Out!!

Potential Fixes:

- Increase the light intensity
- Tighten up the bandwidth



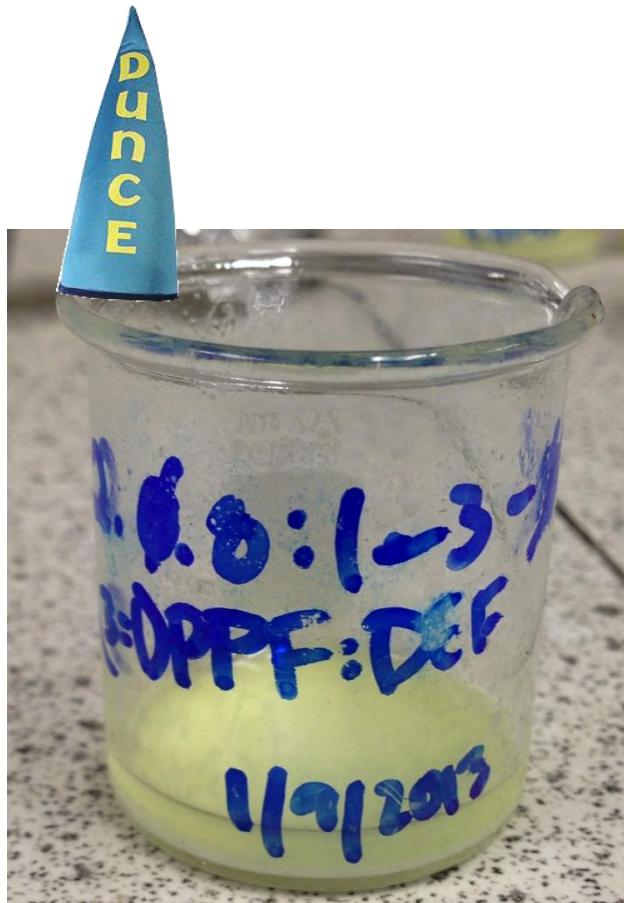
The Perfactory Micro^{beta}

Key Benefits:

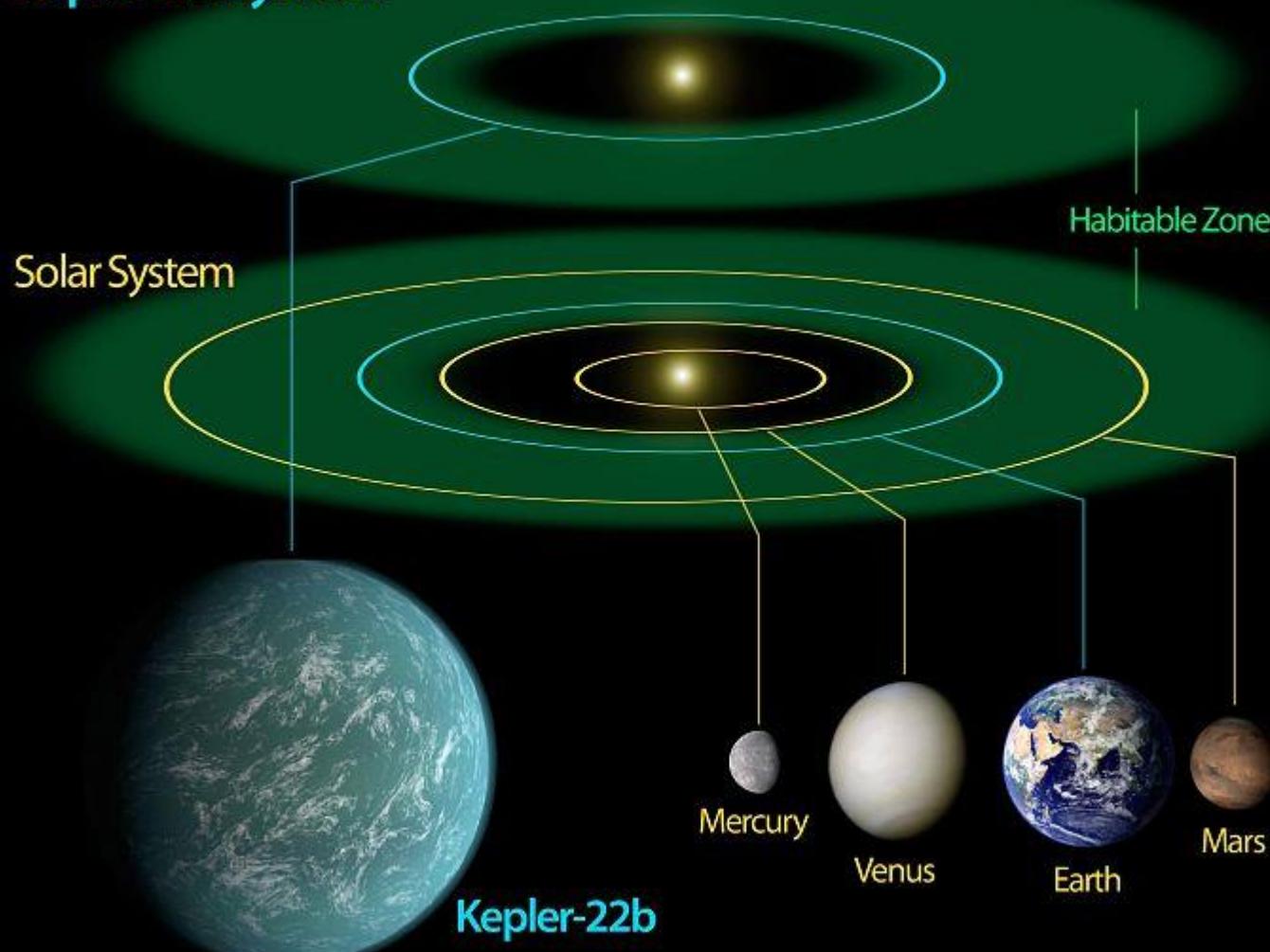
	Micro	P3
Lamp warm up time:	0 min	30 min
Calibration required:	None	Yes
Calibration time:	0 min	Up to 2 hours
User control of build-style:	Full	Very limited
Control of Job-file:	Full	Limited
Resin required:	40 ml	200 ml
GUI via computer:	Yes	No

80% less material required to run it!



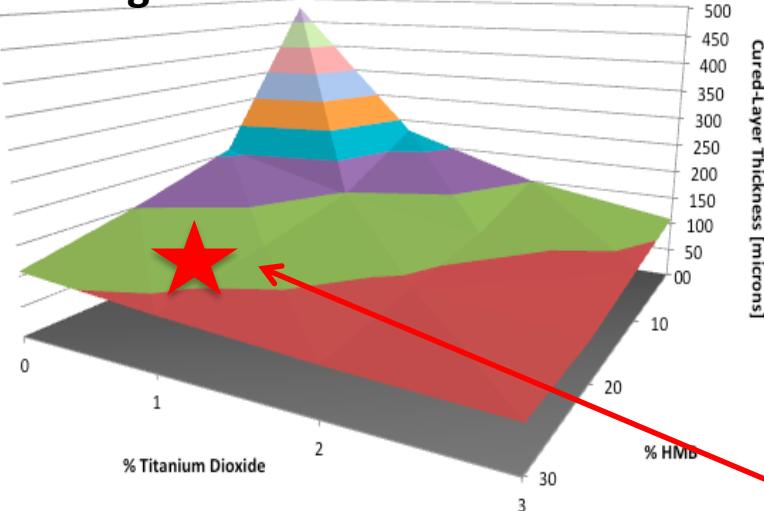


Kepler-22 System

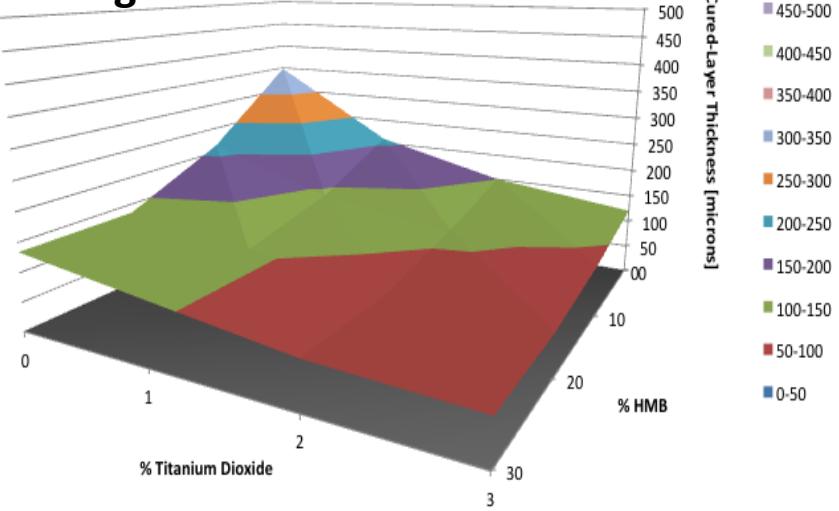


Planets and orbits to scale

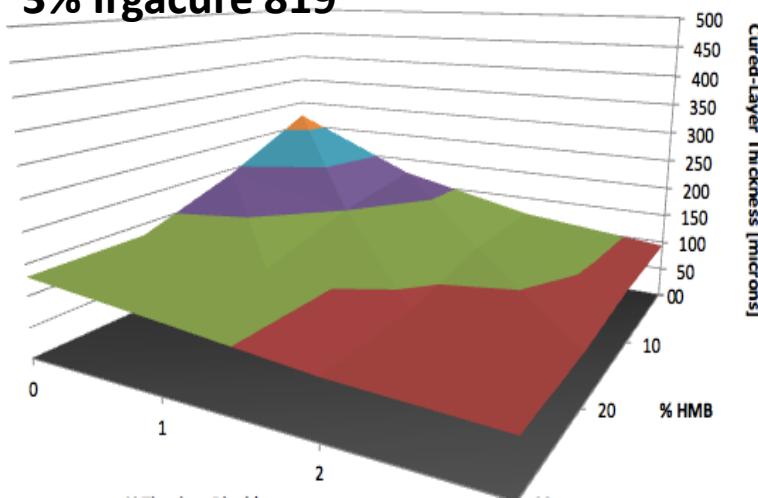
1% Irgacure 819



2% Irgacure 819



3% Irgacure 819



You are here

“The Goldilocks zone.”

Material Variables:

- Polymer kind
- Polymer concentration
- Polymer molecular weight [da]
- Polymer polydispersity [unit-less]
- Diluent/Solvent kind
- Diluent/Solvent concentration
- Photoinitiator kinds
- Photoinitiator concentrations
- Dyes (kinds and concentrations)
- Pigments (kinds and concentrations)
- Origin date

Post Processing Variables:

- Post cure time
- Wash method

Printer Variables:

- Light intensity [mW/dm^2]
- Light wavelengths [nm]
- Burn-in range [μm]
- Burn-in range exposure time [s]
- Standard range [μm]
- Standard range exposure time [s]
- z-step size [μm]
- Base plate height [μm]
- Peel velocity [$\mu\text{m}/\text{s}$]
- Separation velocity [$\mu\text{m}/\text{s}$]
- Residence time before exposure [s]
- Residence time after exposure [s]
- Basement type [material]

Material Variables:

- Polymer kind
- Polymer concentration
- Polymer molecular weight [da]
- Polymer polydispersity [unit-less]
- Diluent/Solvent kind
- Diluent/Solvent concentration
- **Photoinitiator kinds**
- Photoinitiator concentrations
- Dyes (kinds and concentrations)
- Pigments (kinds and concentrations)
- Origin date

Post Processing Variables:

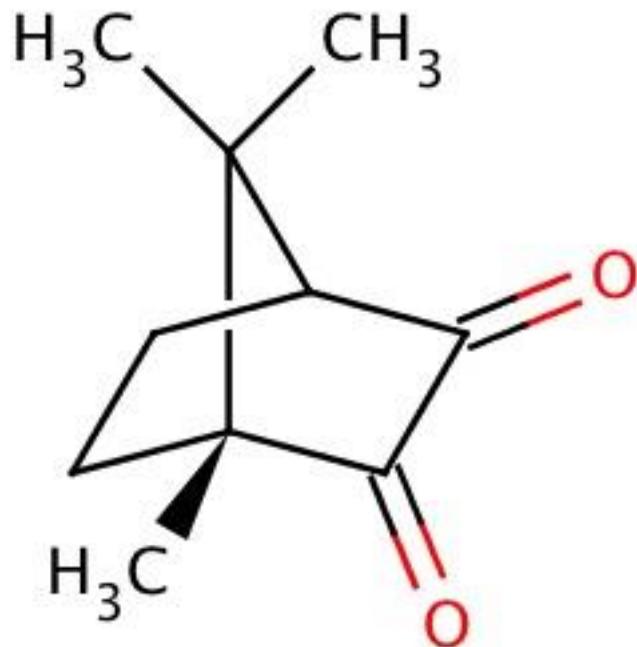
- Post cure time
- Wash method

Printer Variables:

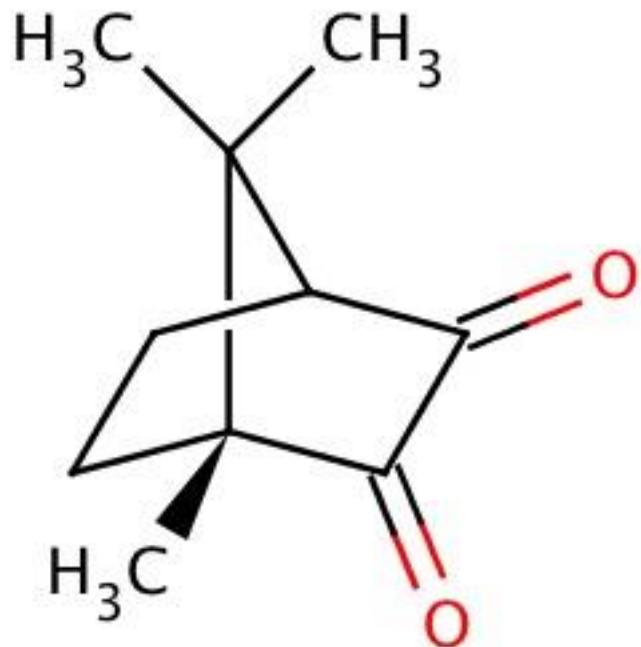
- Light intensity [mW/dm^2]
- Light wavelengths [nm]
- Burn-in range [μm]
- Burn-in range exposure time [s]
- Standard range [μm]
- Standard range exposure time [s]
- z-step size [μm]
- Base plate height [μm]
- Peel velocity [$\mu\text{m}/\text{s}$]
- Separation velocity [$\mu\text{m}/\text{s}$]
- Residence time before exposure [s]
- Residence time after exposure [s]
- Basement type [material]



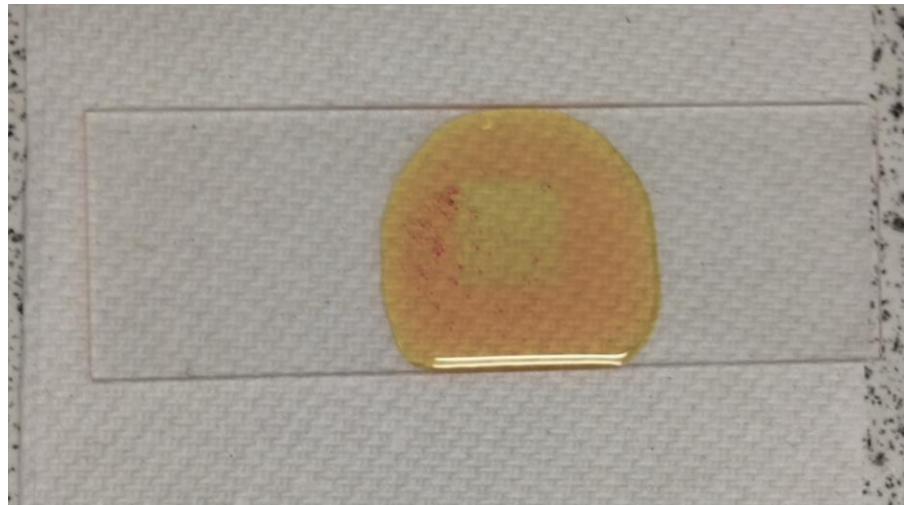
Camphorquinone



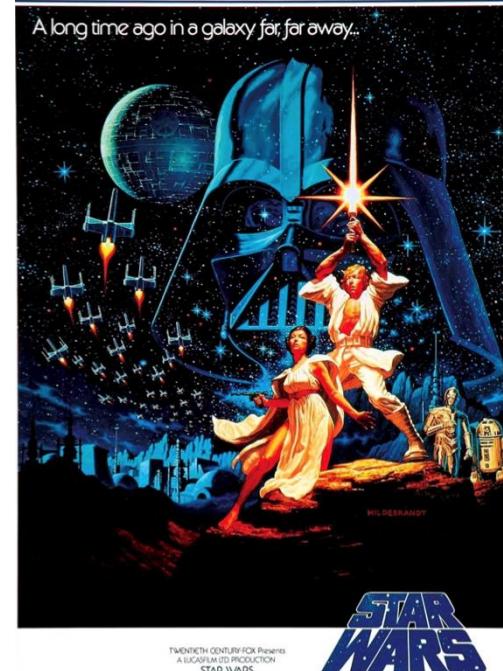
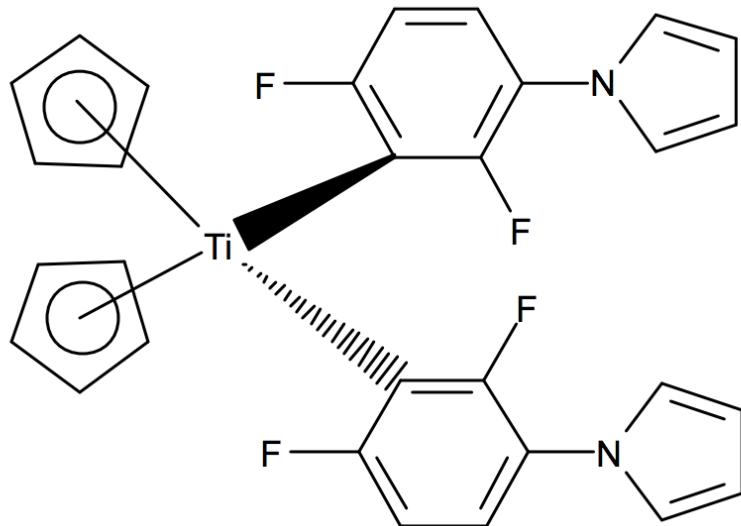
Camphorquinone



Result: A polymer puddle



Irgacure 784

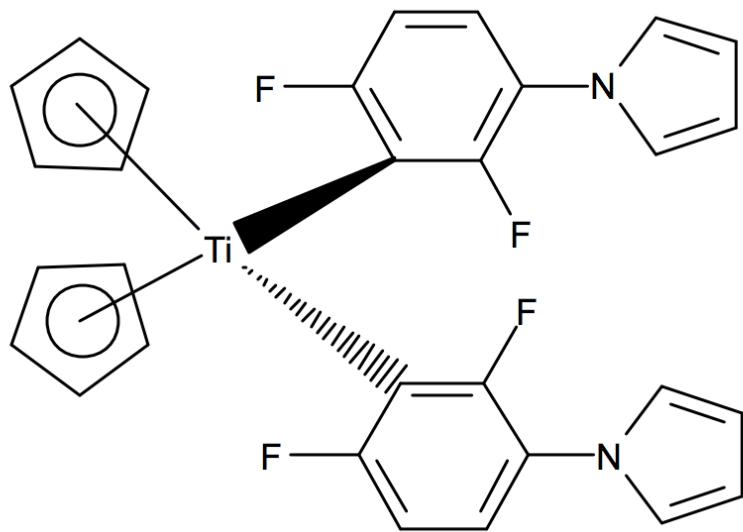


A NEW HOPE

- Biocompatible¹
- Favorable absorption profile²

1. Zhang. Et al. (2011). Development of Photocrosslinkable Urethane-Doped Polyester Elastomers for Soft Tissue Engineering
2. Ciba Specialty Chemicals Inc. Edition: 2.4.98, Basle

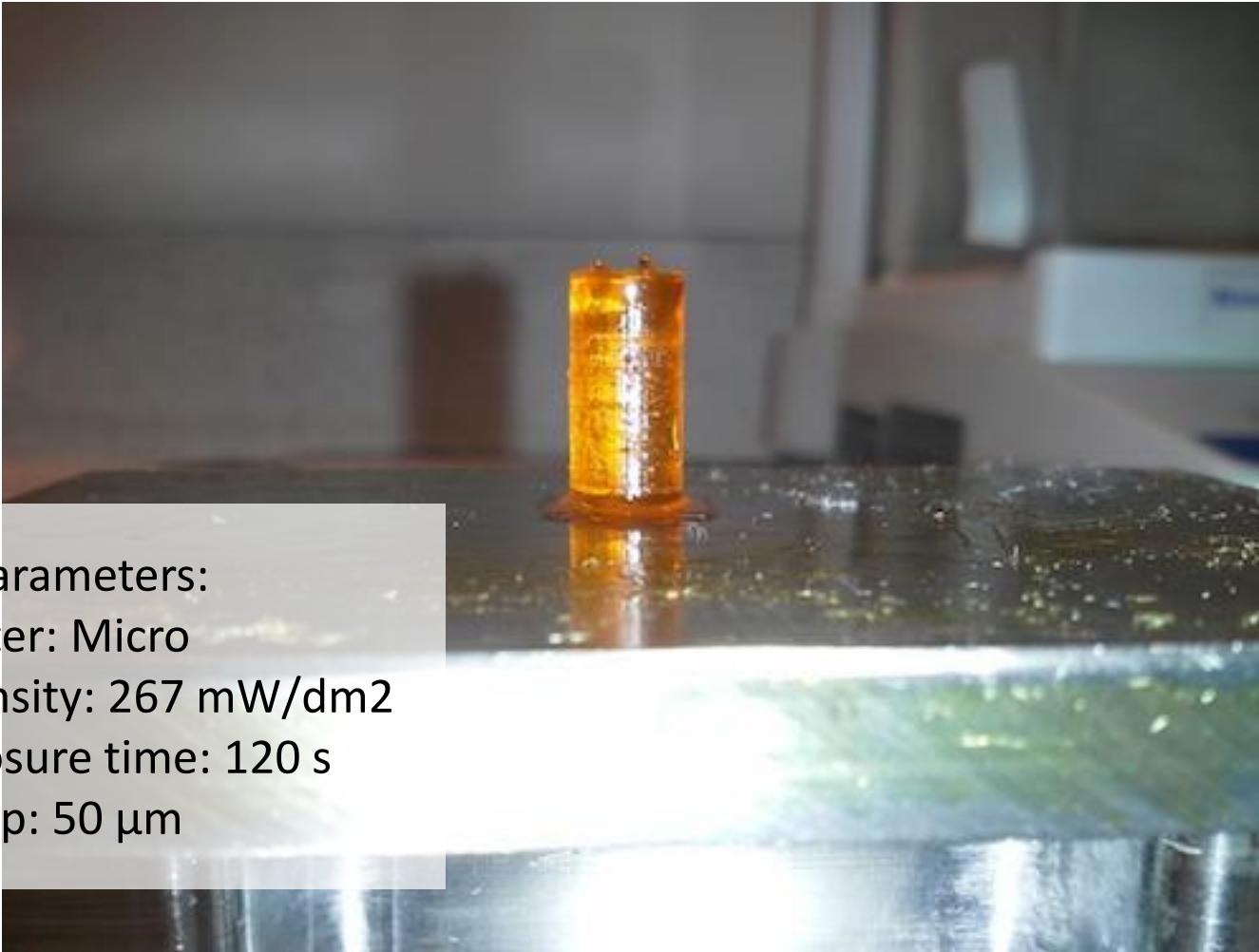
Irgacure 784



Result: A polymer puddle



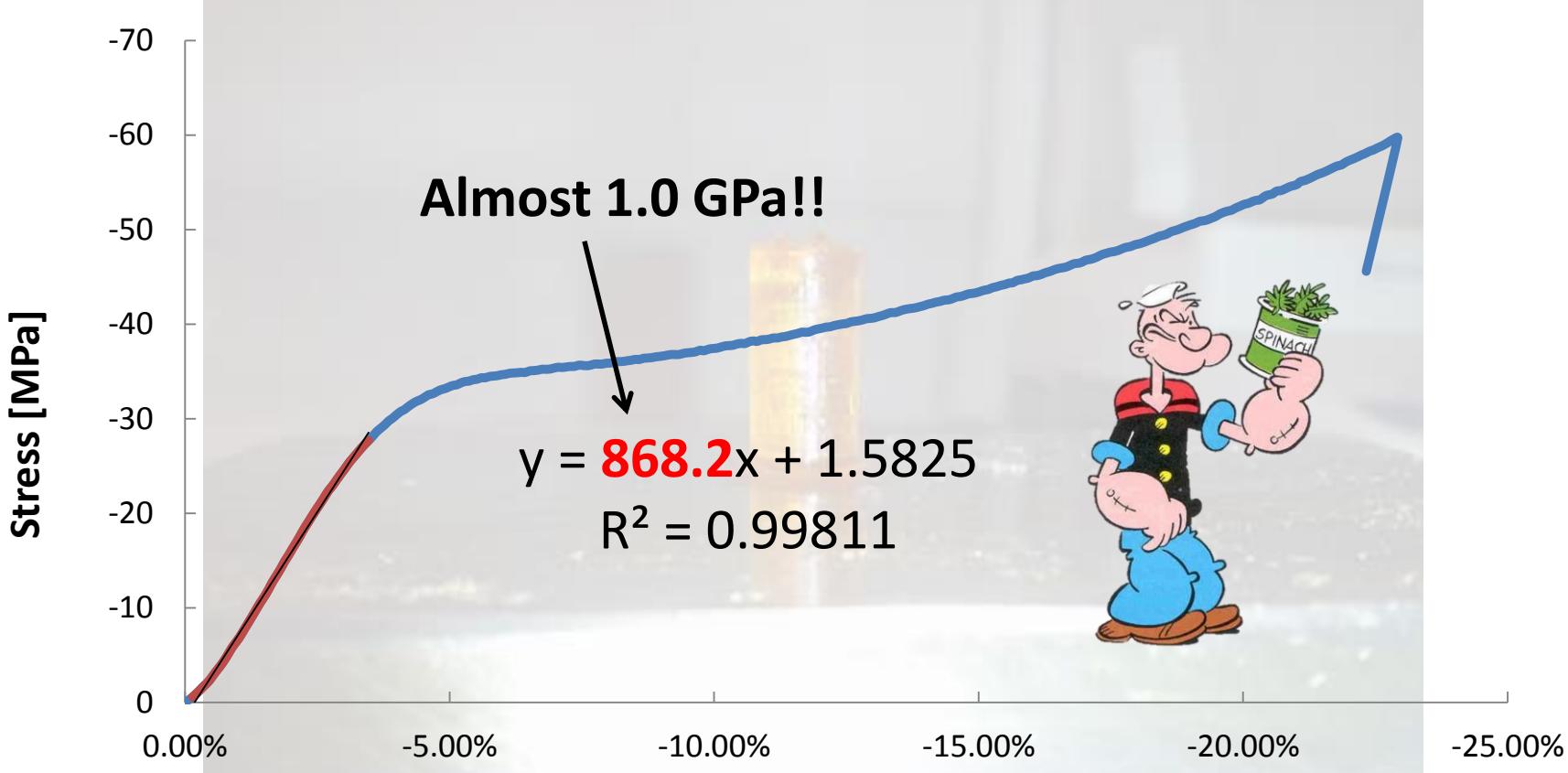
6 mm x 12 mm Solid Cylinder (1.5:1 PPF:DEF, 3% BAPO, 3% 784)



Build Parameters:

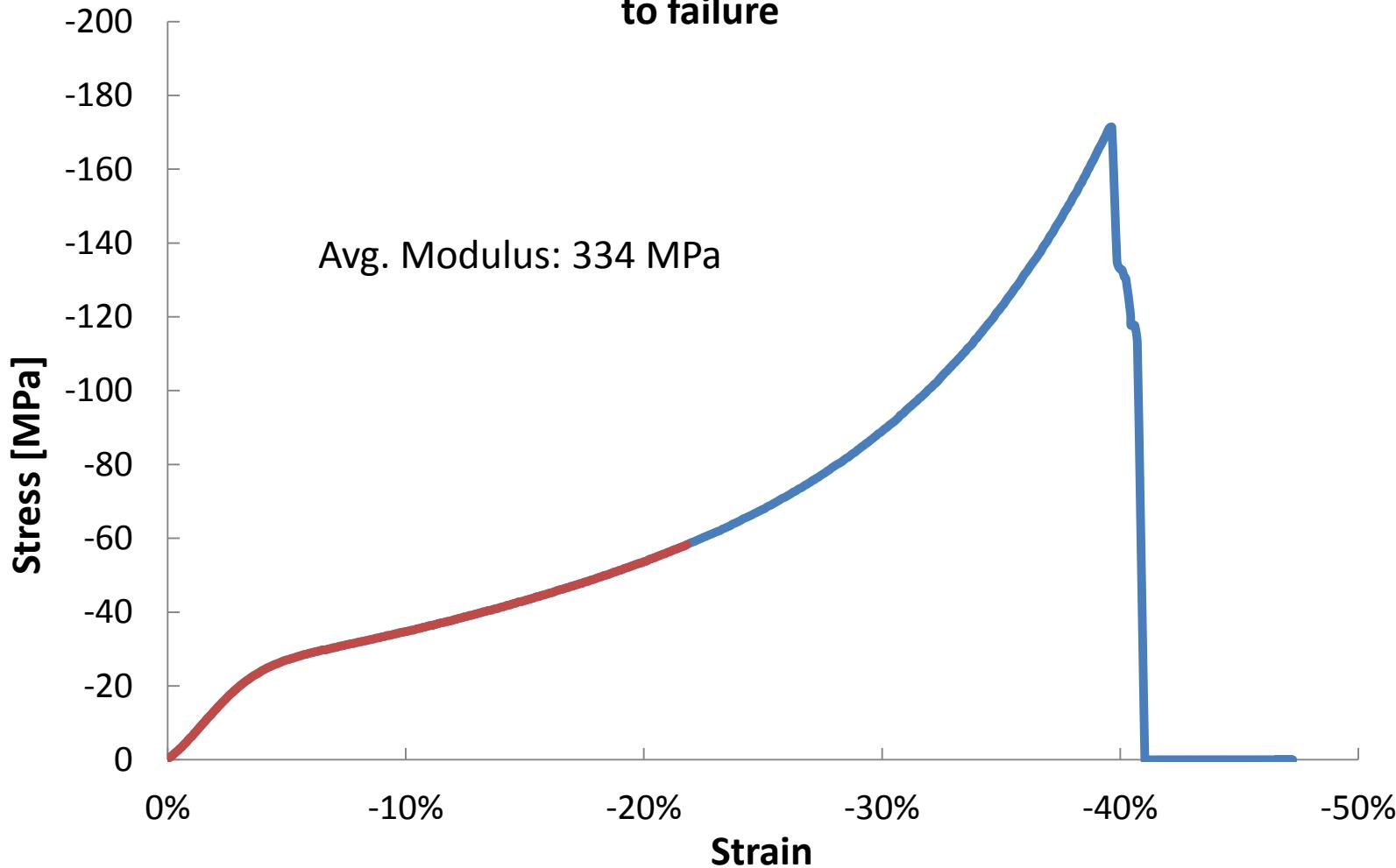
- Printer: Micro
- Intensity: 267 mW/dm²
- Exposure time: 120 s
- z-step: 50 µm

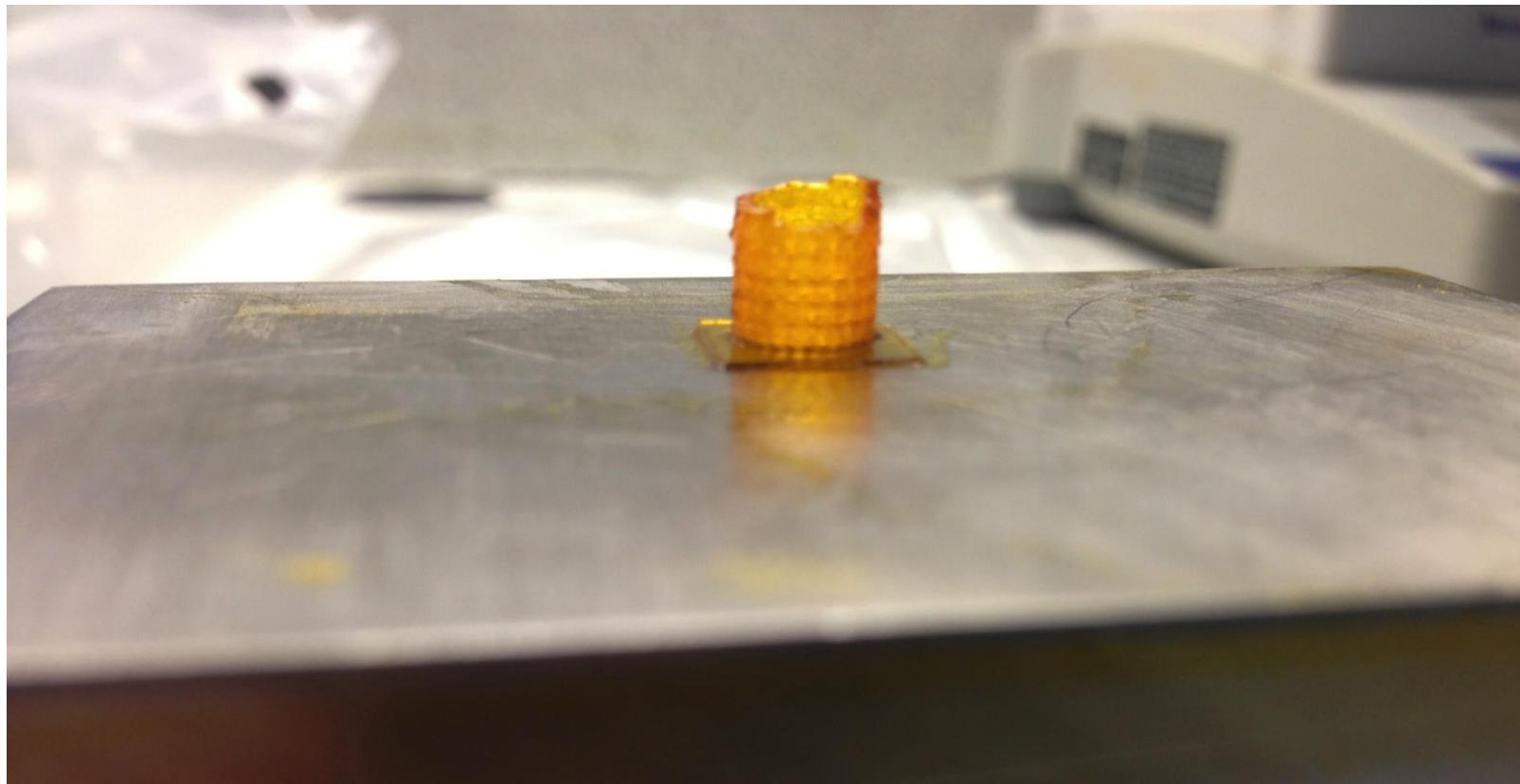
6 mm x 12 mm Solid Cylinder (1.5:1 PPF:DEF, 3% BAPO, 3% 784)

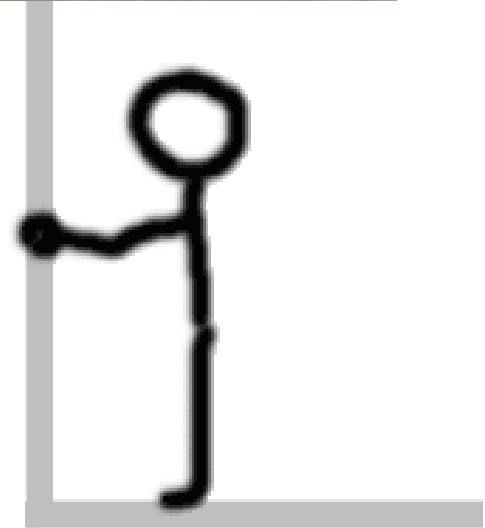
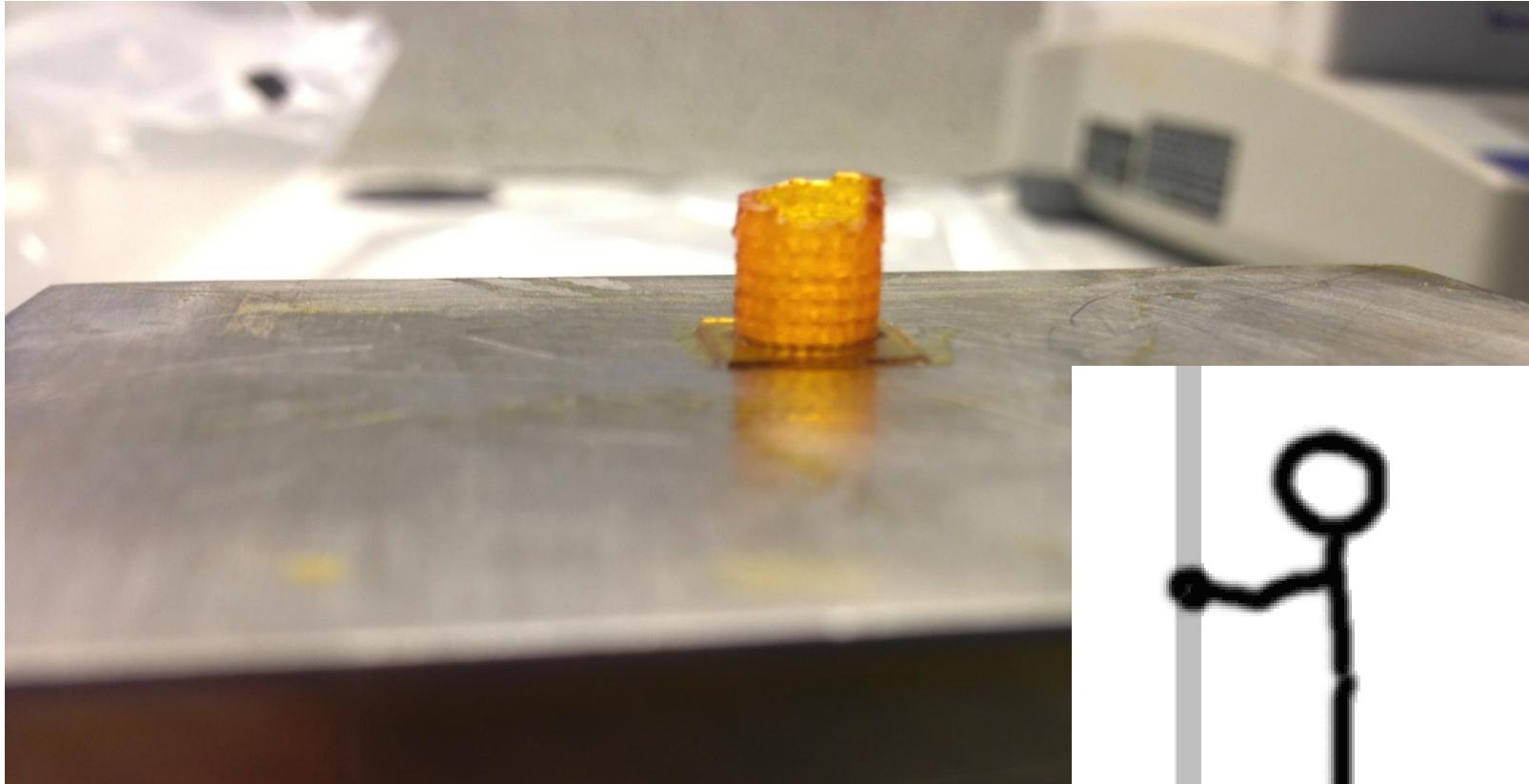


Previous studies showed maximum PPF modulus as: 195.3 +/- 17.5 MPa.

6 mm x 12 mm Solid Cylinder (1.5:1 PPF:DEF, 3% BAPO, 3% 784)
to failure



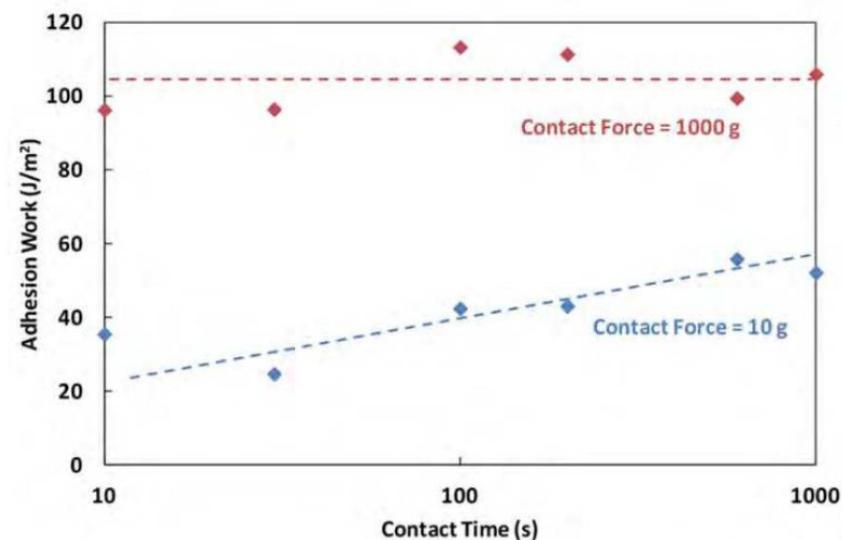
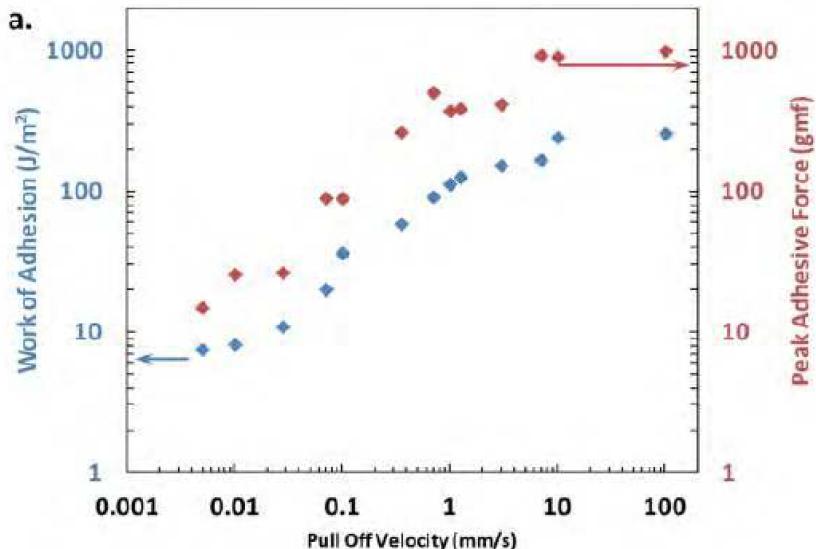




Hypothesis:

- Adhesion to the basement is a serious factor.
- Shear forces due to PSA basement during build may be resulting in failure at extended time points.

What we know about adhesion:



Grillet et al. (2012). Polymer Gel Rheology and Adhesion.

The answer!



Return of the Perfactory

Benefits:

- Higher intensity than Micro
- Peel mechanism
- PSA not required

The build

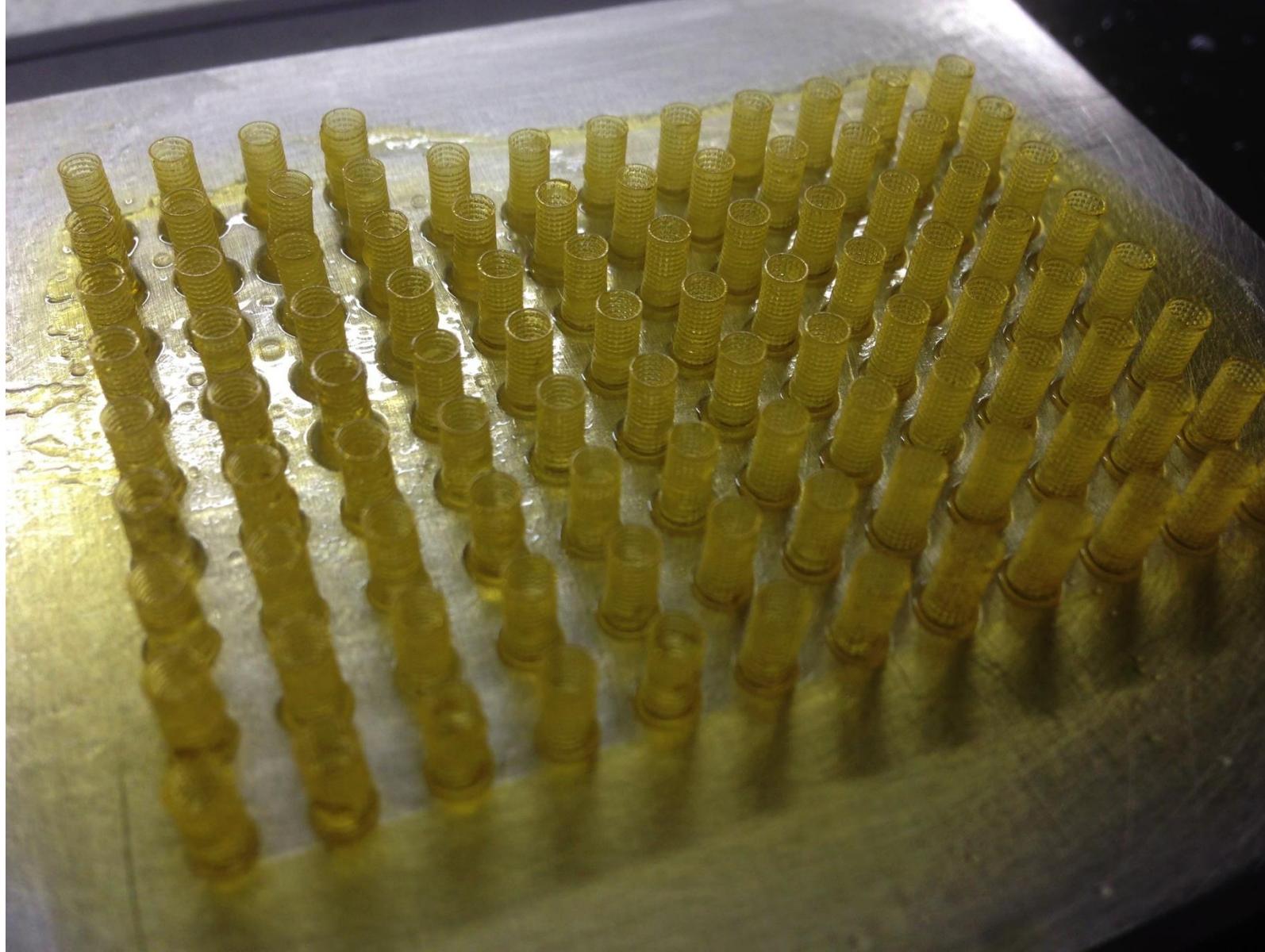


Resin:

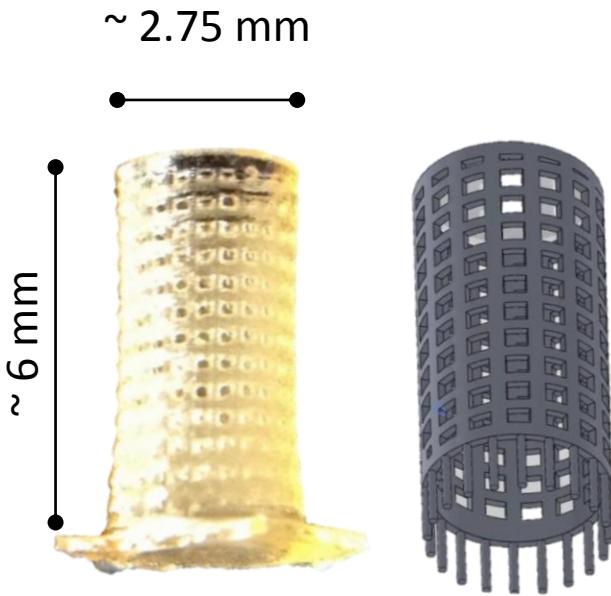
- Name: BY
- 1:1 PPF:DEF
- M_n : 933 da
- Polydispersity: 1.9
- 3% Irgacure 819
- 0.5% Irgacure 784

Build parameters:

- Printer: Perfactory P3
- Intensity: 350 mW/dm²
- Exposure time: 30 s
- Slow peel



Compression Testing



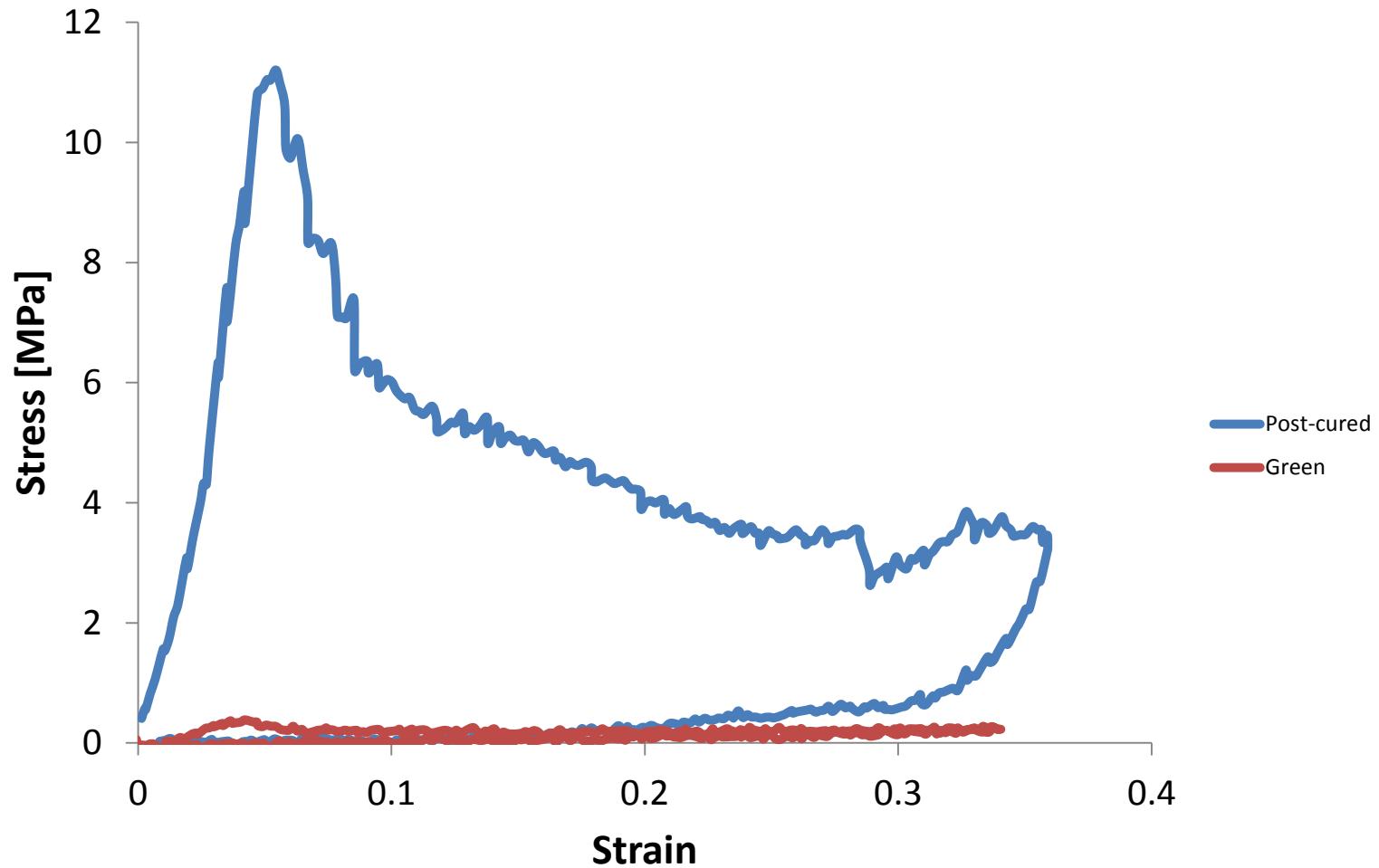
Compression Test Parameters:

- Instron
- Load Cell: 100 lb_f (444 N)
- Strain Rate: 0.1 mm/s
- Max Strain: 2 mm

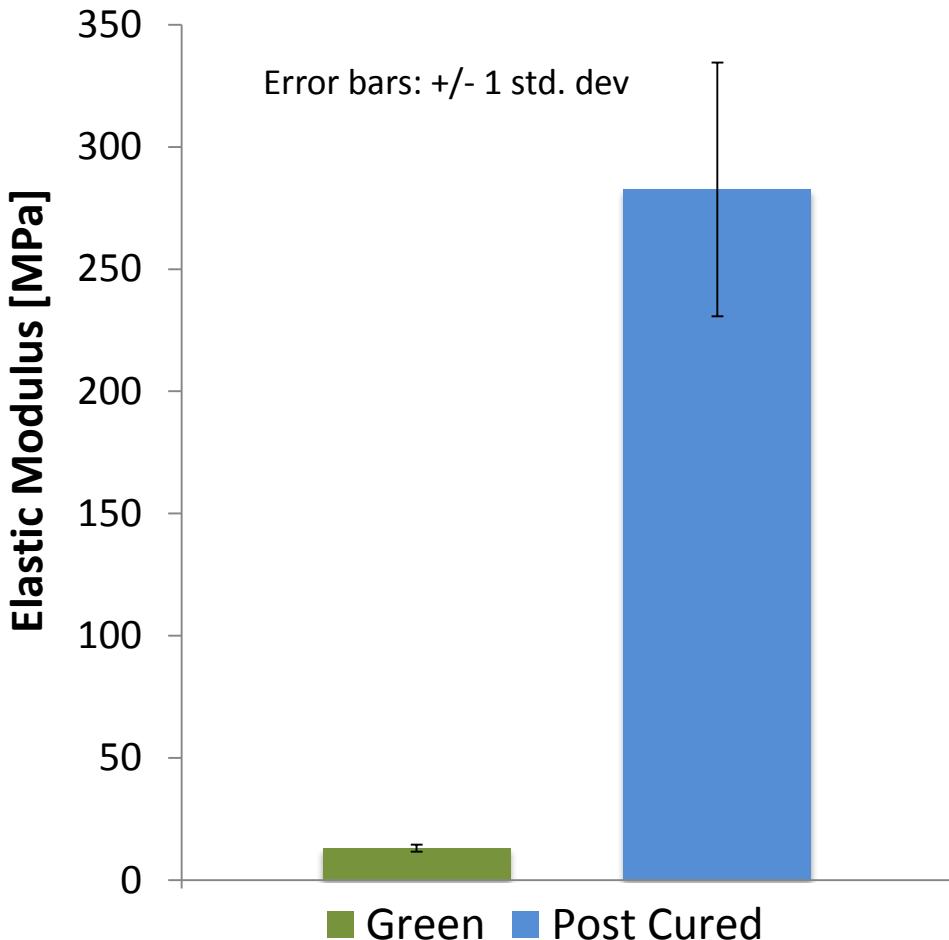
Nominal Part parameters:

- Height: 6 mm
- Outer diameter: 2.75 mm
- Wall thickness: 125 μm
- Pore size: 350 μm

Green vs. Post-Cured



Elastic Modulus



Resin:

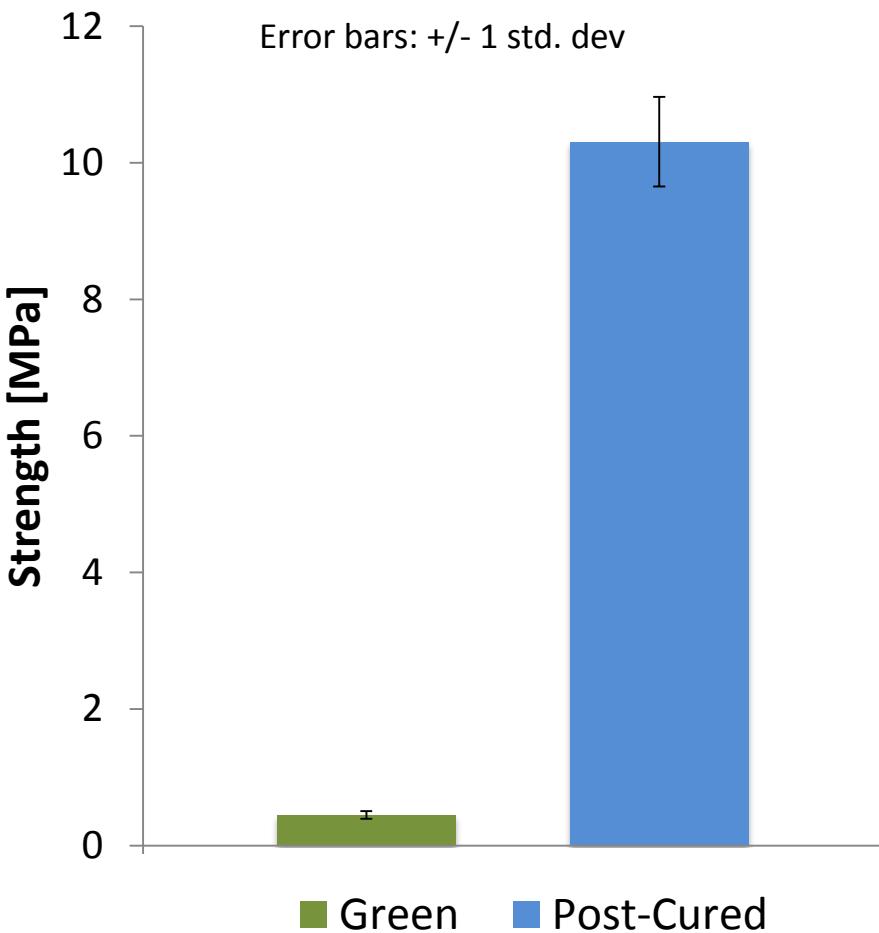
- 1:1 PPF:DEF
- 3% Irgacure 819
- 0.5% Irgacure 784

Post Cure Time: 480 min

Result:

- 1800% increase in modulus with post-curing.

Max Compressive Strength



Resin:

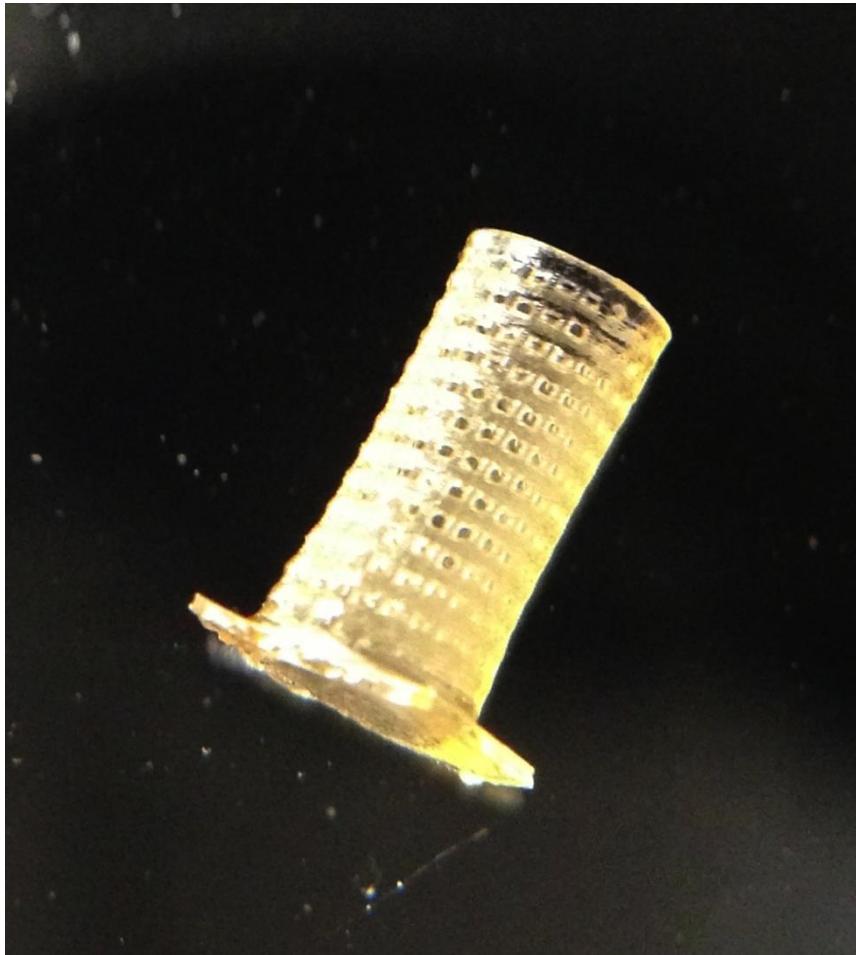
- 1:1 PPF:DEF
- 3% Irgacure 819
- 0.5% Irgacure 784

Post Cure Time: 480 min

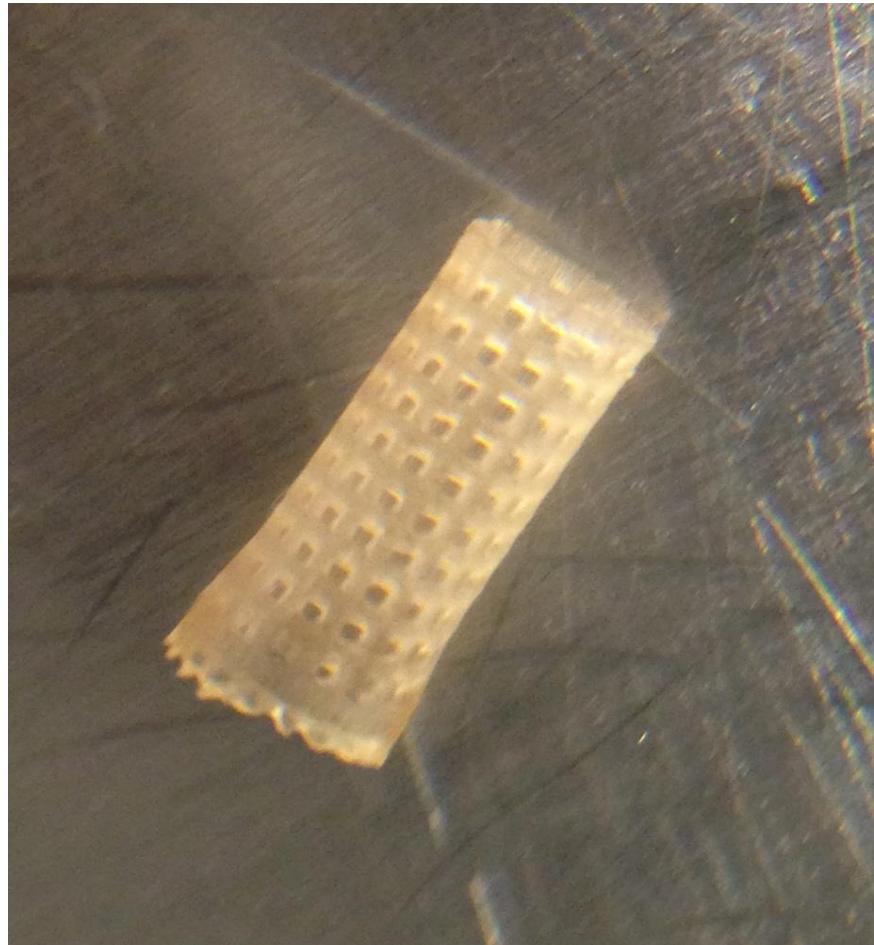
Result:

- 2200% increase in compressive strength with post-curing.

1:1 PPF:DEF, 3% Irgacure 819, 0.5% Irgacure 784

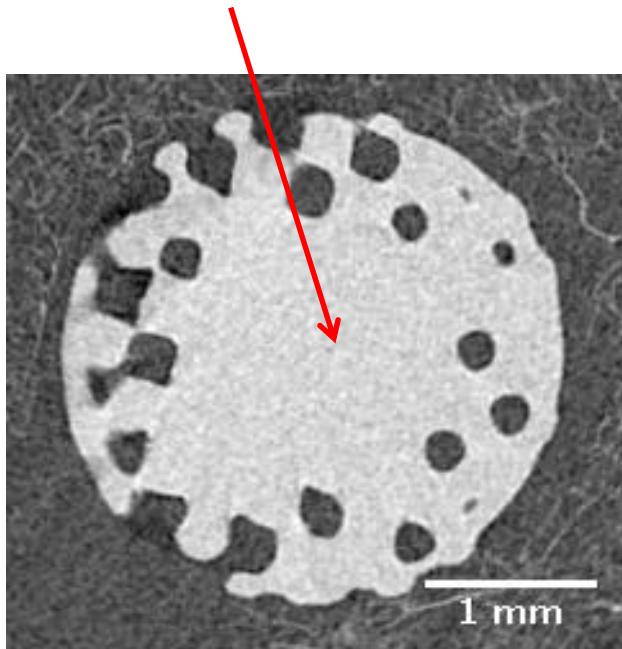


1:1 PPF:DEF, 3% Irgacure 819, 0.4% Irgacure 784,
0.3% Oxybenzone



The Importance of Post Processing Techniques

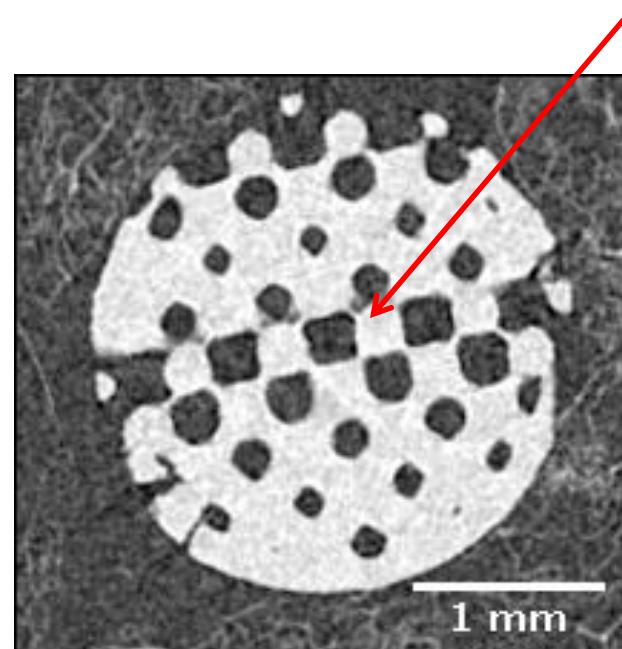
core area pores are not cleared



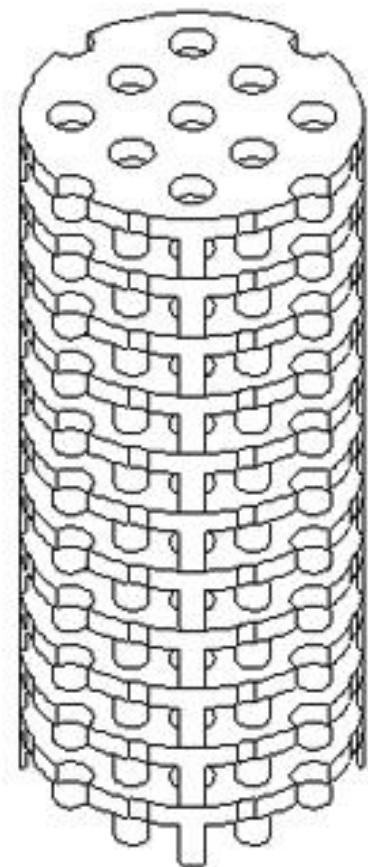
Post cured with no post-processing.

Both of these are the same build with different post-processing handling.
Resin: BY-Full (1:1 PPF:DEF, 3% BAPO, 0.5% I784)

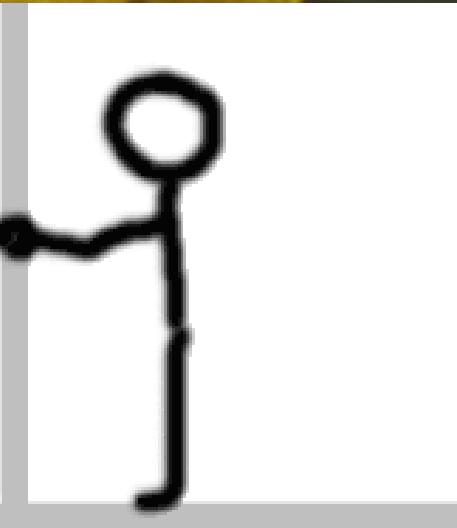
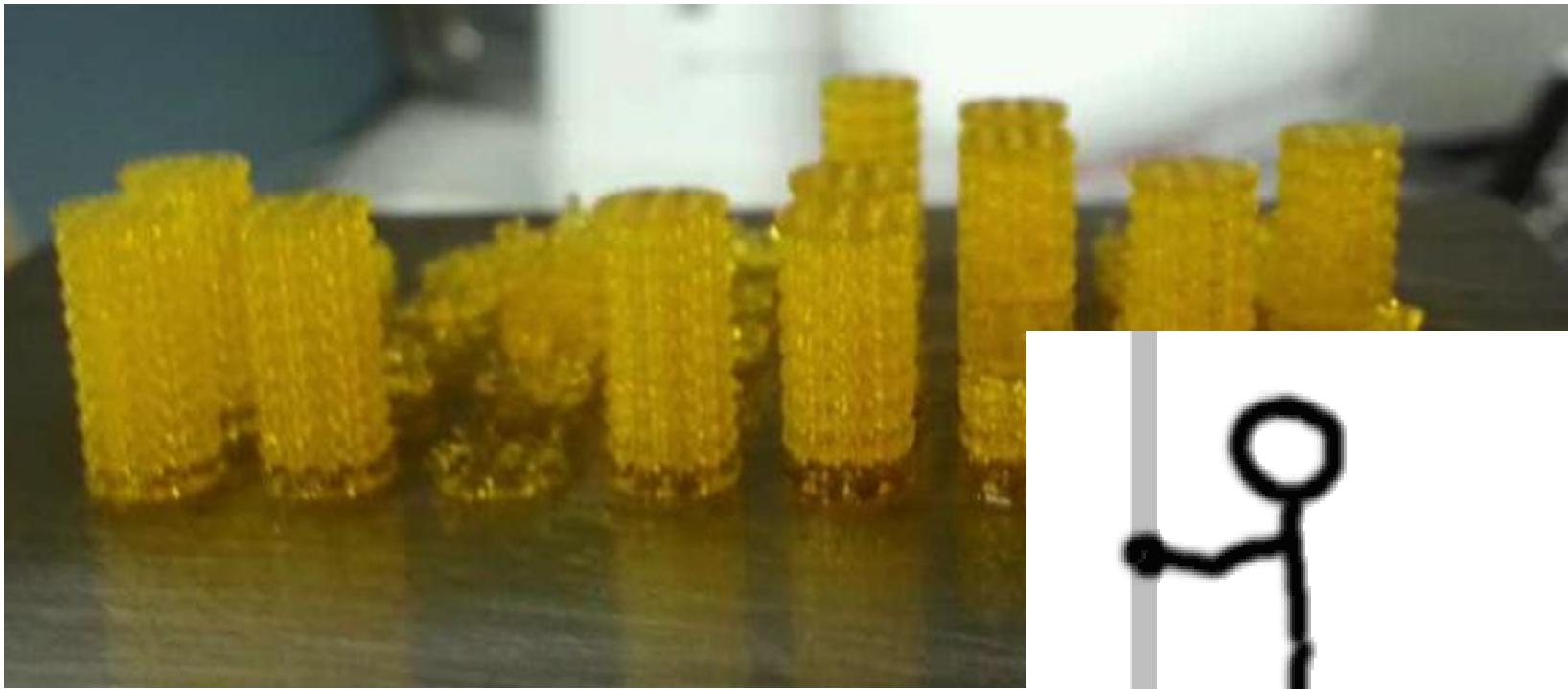
core area pores are open



Post cured after post-processing (100% acetone over night).









THANK YOU



{ The Team }