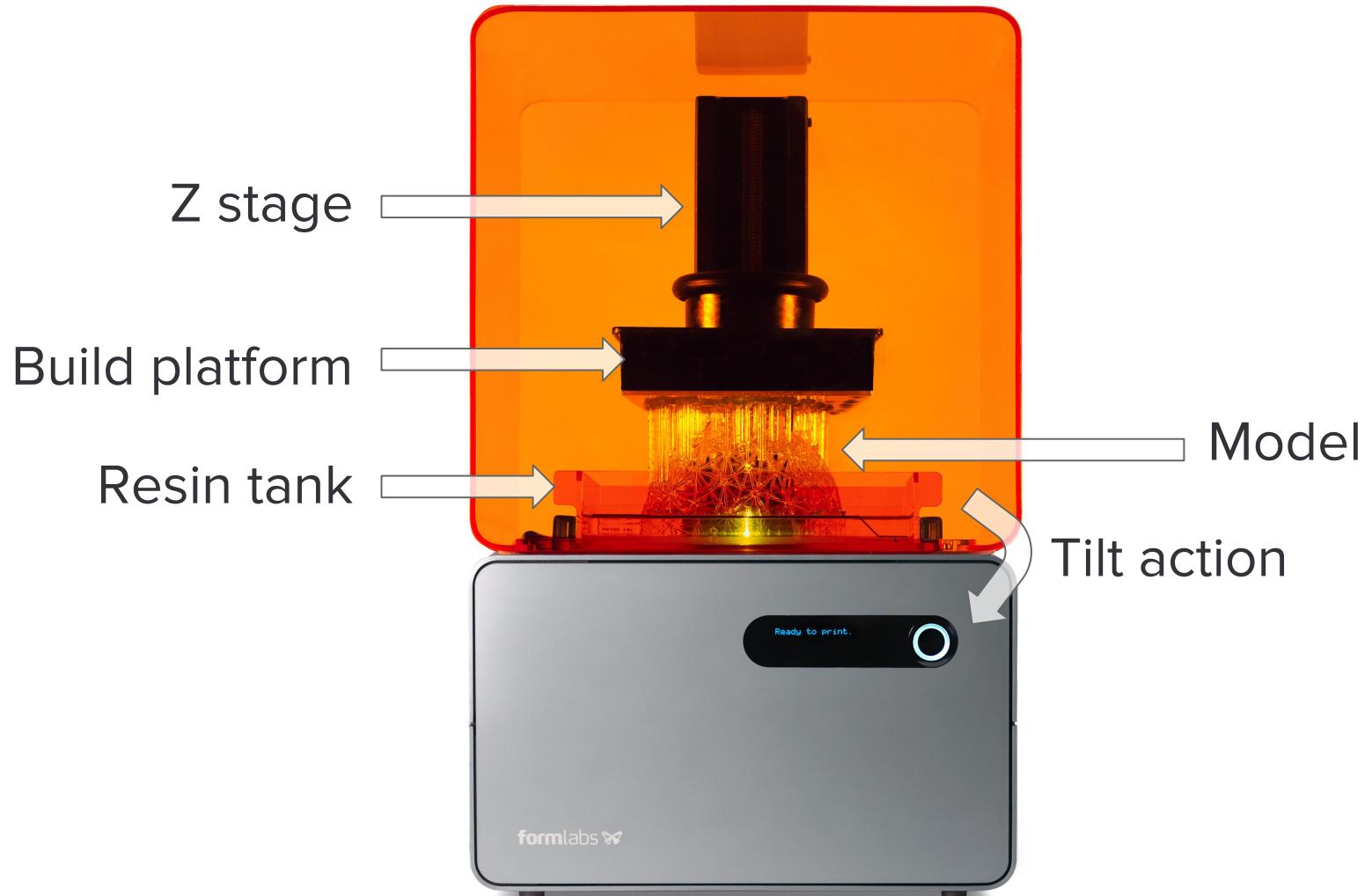


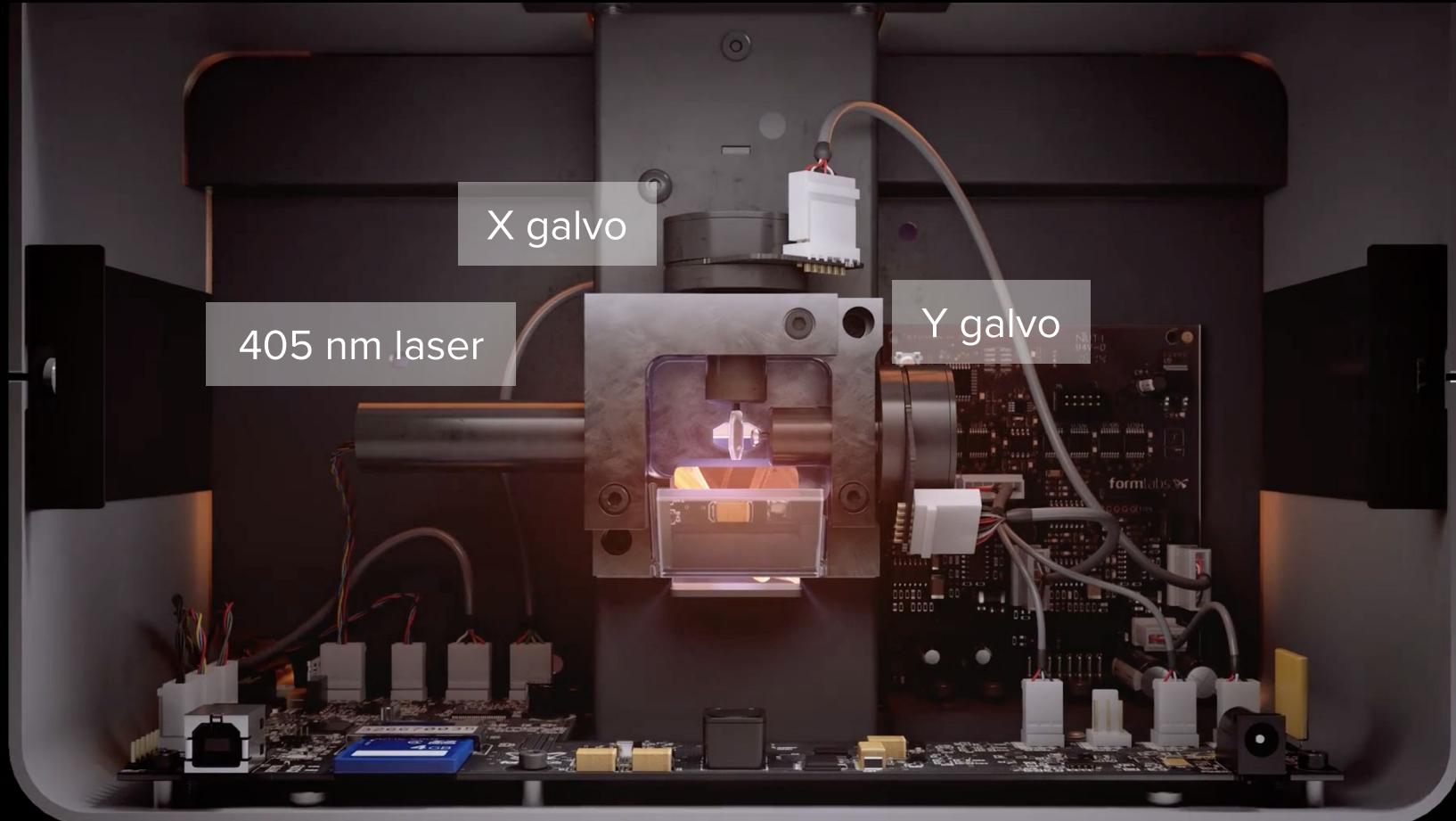
**formlabs** 

# OpenFL: Hacking SL with the Form1+ API

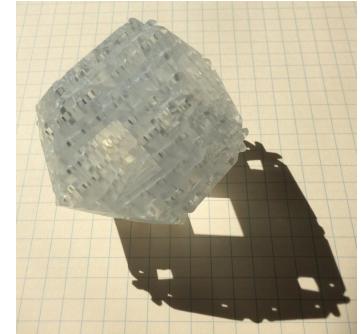
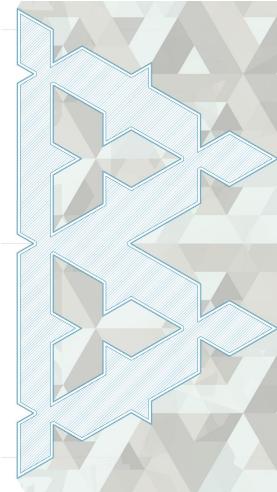
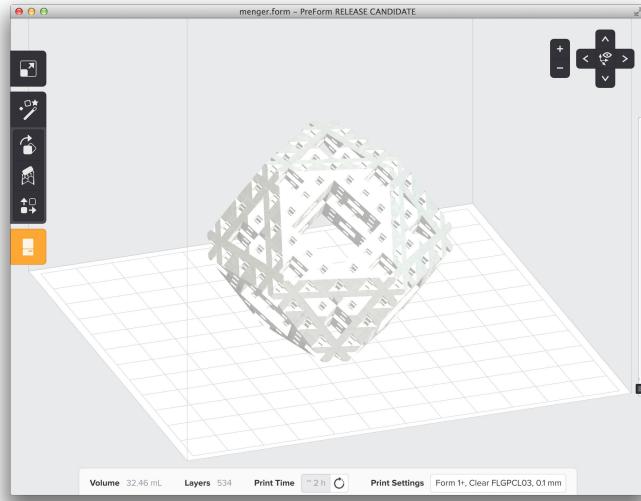
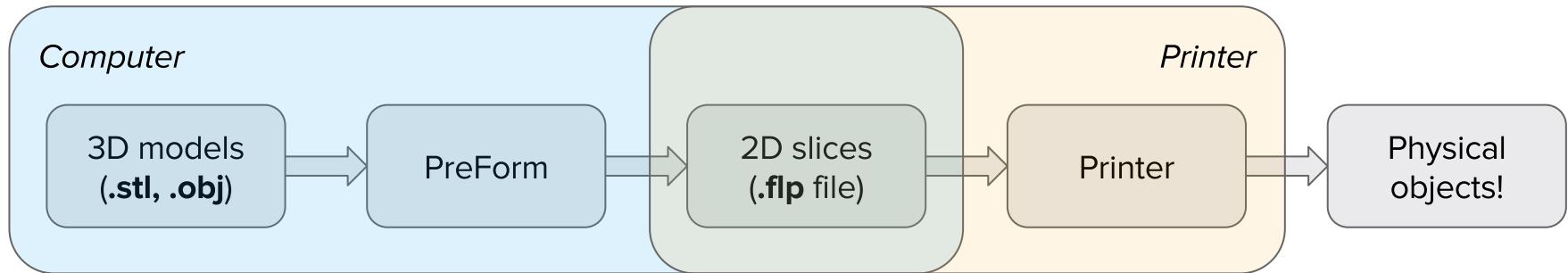
Ben FrantzDale and Matt Keeter  
`{ben, matt}@formlabs.com`







# Print pipeline

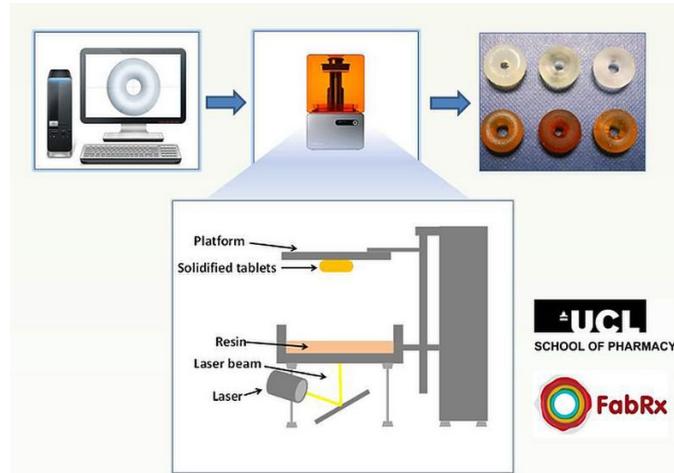


OpenFL is about supporting  
cases that fall outside the usual  
Form 1 / 1+ printing pipeline.



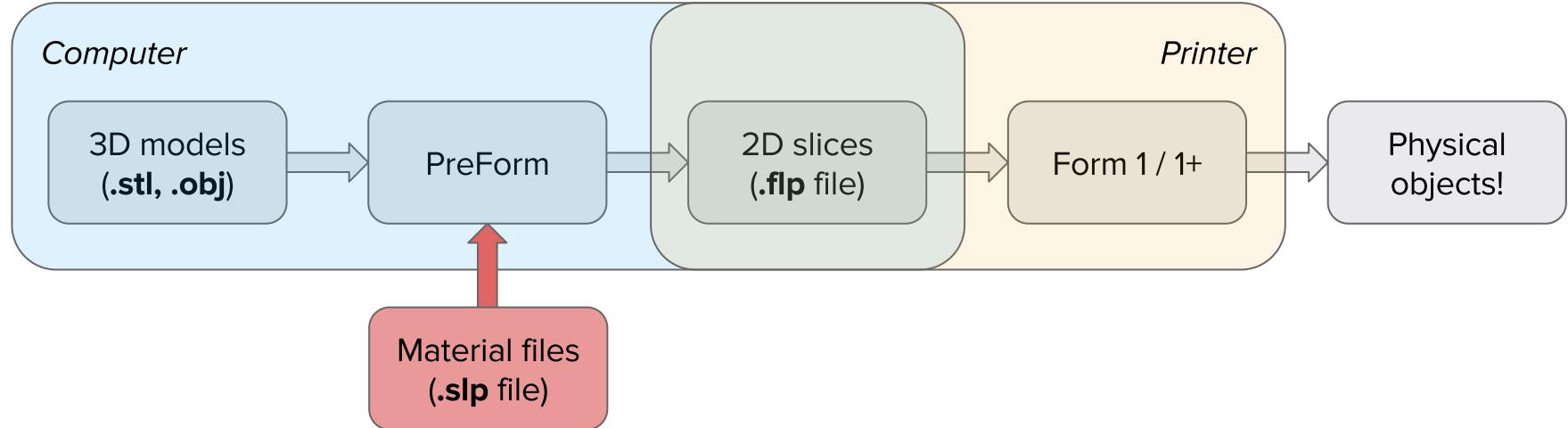
## Stereolithographic (SLA) 3D printing of oral modified-release dosage forms

Jie Wang<sup>a, 1</sup>, Alvaro Goyanes<sup>a, b, 1</sup>, Simon Gaisford<sup>a, b</sup>, Abdul W. Basit<sup>a, b</sup>,  



# Customizing material files on Form 1 and Form 1+

# User-defined material files



# PreForm: Material Hacker Edition\*

Use customized material files with PreForm and your Form 1/1+

```
[PrintSettings]  
OuterBoundaryOffset = 0.03  
InnerBoundaryOffset = 0.12  
ScanlineBoundaryOffset = 0.03  
outlines  
ScanlineSpacing = 0.09  
SliceHeight = 0.025  
OffsetsNum = 3  
Xcorrectionfactor = 1.008  
Ycorrectionfactor = 1.008
```

```
[perimeter]  
modellaserpowermw = 20.7  
modelxyfeedrate = 800 ; mm/s  
supportlaserpowermw = 24.84  
supportxyfeedrate = 800  
baselaserpowermw = 24.84  
basexyfeedrate = 800
```

```
[fill]  
modellaserpowermw = 20.7  
...
```

}

Distance from the model boundary - theoretically is laser's radius  
Distance between any inner boundary offset  
Distance from the innermost boundary offset - defines raster outlines

## Line positioning

The number of outlines  
x shrinkage-correction scale  
y shrinkage-correction scale

}

## Exposure

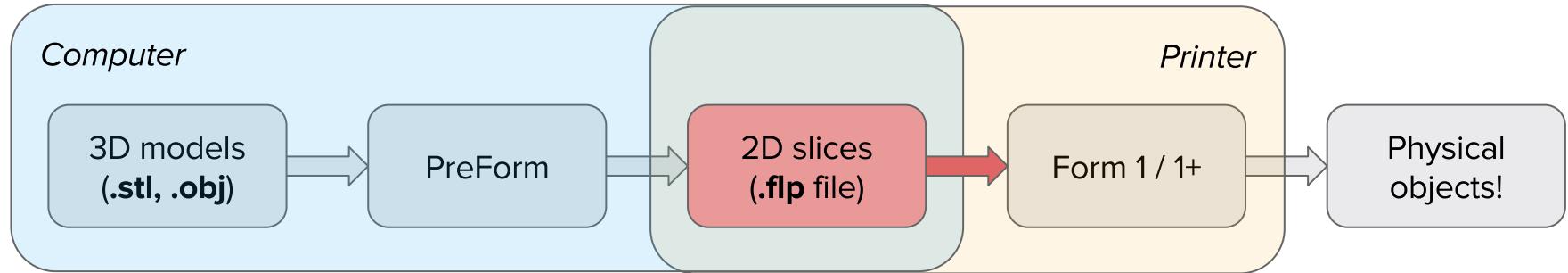


\*name subject to change

Coming next week!

# OpenFL API

# What does it cover?



Two main modules:

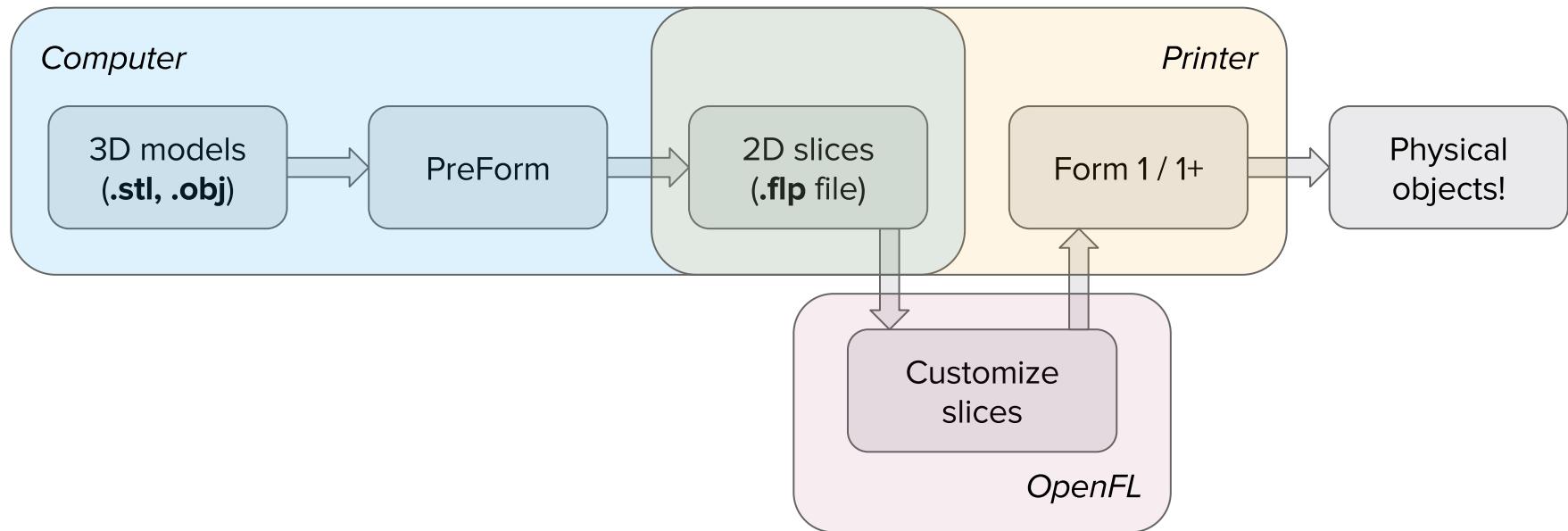
`OpenFL.FLP`  
Read, manipulate,  
and write 2D slice files

`OpenFL.Printer`  
Interface between your  
computer and a Form 1 / 1+

**<https://github.com/Formlabs/OpenFL>**

# Modifying Formlabs Print Files (.FLPs)

# Customizing prints



# What does a print look like?

2D slices  
(.flp file)

```
[<TimeRemaining(1891 s) at 0x10b668470>,
 <XYMoveClockRate(60000 Hz) at 0x10b668890>,
 <ZCurrent(80) at 0x10b6688f0>,
 <TiltCurrent(80) at 0x10b668950>,
 <TiltFeedRate(472 usteps/s) at
 0x10b6689b0>,
 <TiltMove(2362 usteps) at 0x10b668a10>,
 <ZFeedRate(132 usteps/s) at 0x10b668a70>,
 <ZMove(-665 usteps) at 0x10b668ad0>,
 <ZFeedRate(4000 usteps/s) at 0x10b668b30>,
 <WaitForMovesToComplete() at 0x10b668b90>,
 ...
 <LaserPowerLevel(39099) at 0x106e97b90>,
 <XYMove(3 points) at 0x10b667c18>,
 <LaserPowerLevel(0) at 0x106e97bf0>,
 <XYMove(1 points) at 0x10b667c80>,
 <LaserPowerLevel(39099) at 0x106e97c50>,
 <XYMove(2 points) at 0x10b667ce8>,
 <LaserPowerLevel(0) at 0x106e97cb0>,
 ...
]
```

# Laser moves: Power then (x, y, dt) sequence.

```
>>> print laserSequence
[<LaserPowerLevel(39099) at 0x106e97c50>,
 <XYMove(3 points) at 0x10b667c18>,
 <LaserPowerLevel(0) at 0x106e97bf0>]

>>> print laserSequence[1].points
((38352, 32099, 69),
 (38322, 32069, 3),
 (38262, 32166, 8))
```

# Motor Moves

Set current and speed, start moves, wait.

```
[ZCurrent(moving=True),  
 TiltCurrent(moving=True),  
 TiltFeedRate(usteps_per_s=472),  
 ZFeedRate(usteps_per_s=132),  
 TiltMove(usteps=2362),  
 ZMove(usteps=-665),  
 WaitForMovesToComplete(),  
 TiltCurrent(moving=False),  
 ZCurrent(moving=False)]
```

# Embed things in prints.

```
from OpenFL import FLP
from OpenFL import Printer
from examples.insert_material_swaps import insert_pause_before

p = Printer.Printer() # Connect to the printer
layer_i = 8
flp = p.read_block_flp(layer_i)
flp = insert_pause_before(flp, zJog_mm=150.0 - 0.2*i)
# Overexpose the next layer w/ 6 more copies of the laser move:
flp += [laser for laser in flp
        if isinstance(laser, FLP.LaserCommand) ] * 6
p.write_block_flp(layer_i, x) # Send it back to the printer
p.start_printing(0, 16) # Print!
```



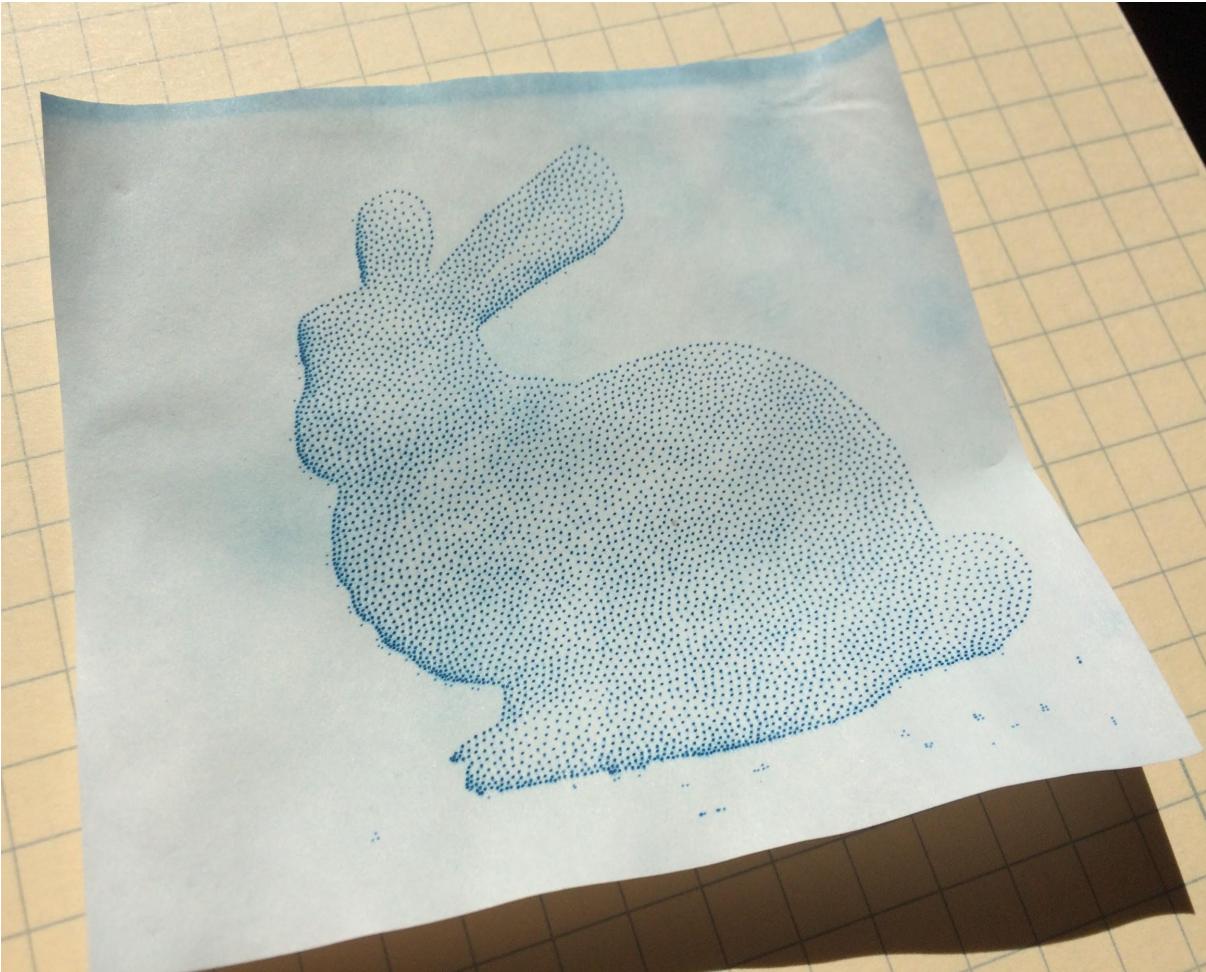
Things... like  
carbon fiber

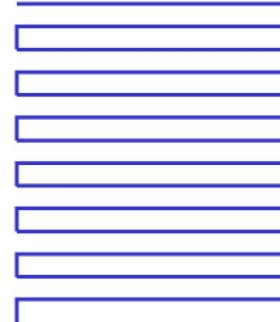
# Creating custom designs



## UV-reactive stippling

Stipple patterns are generated in Python then printed onto UV-sensitive paper, turning the 3D printer back into a 2D printer.



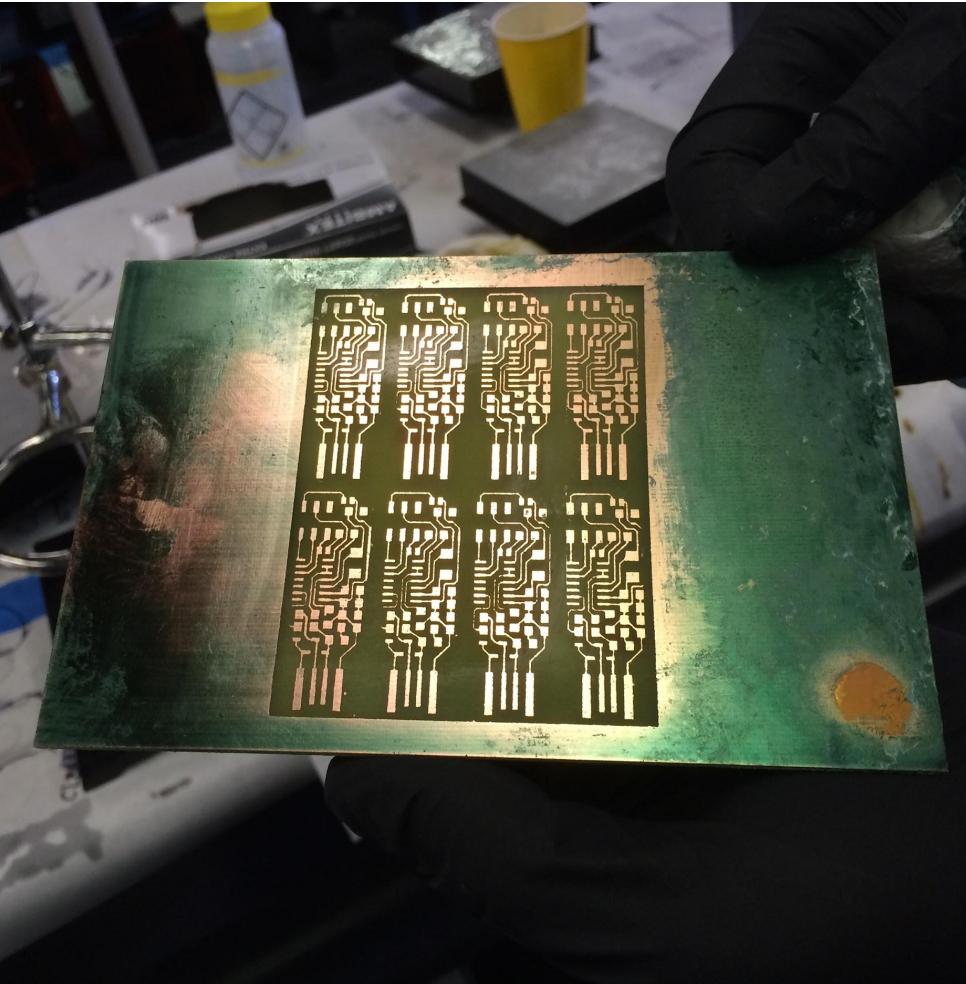


## Single-line lithopane

The laser is scanned across the build platform with continuously changing power

The resin has a log response, so pixel brightness can map directly to laser power.

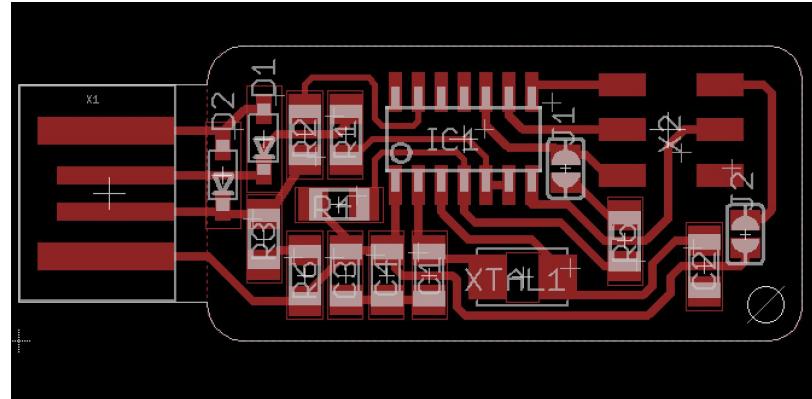
Project by Dima Megretski



## PCB etching

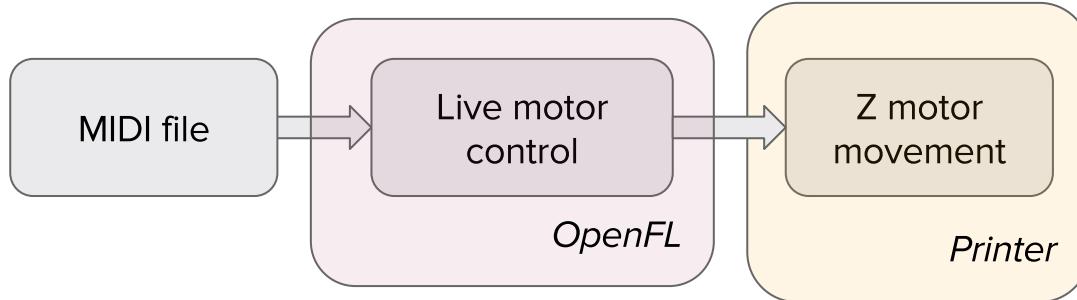
The laser is used to expose a pre-sensitized PCB, which is then etched to make a panel of boards.

fabispkey by Andy Bardagjy



Fun!

# Printers as musical instruments



# Thanks!

**<https://github.com/Formlabs/OpenFL>**

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