inkbit

Additive Manufacturing

MIT CSAIL

April 2020

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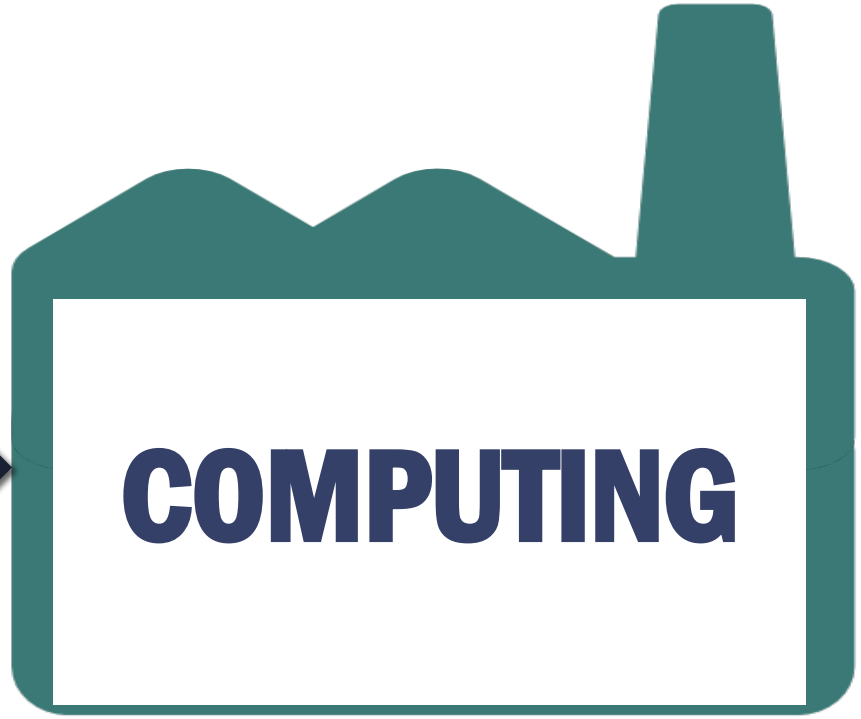
Manufacturing in the near future

Why computing in manufacturing?

Why computing in manufacturing?



Hardware

Hardware

Hardware abstraction and machine code

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26 ;Layer count: 336
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28 M107
29 G0 F9000 X91.800 Y93.520 Z0.300
30 ;TYPE:SKIRT
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Hardware

Machine Code

Hardware abstraction and machine code

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Hardware

Machine Code

Design: shape and materials

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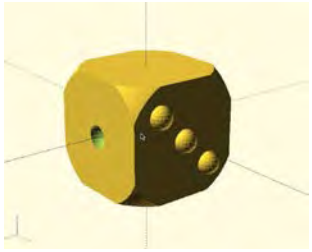

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//cuerpo del dado
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Hardware

Machine Code

Digital Design

From design to machine code

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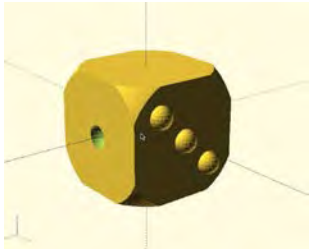

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Hardware

Machine Code

Digital Design

High-level specification: performance

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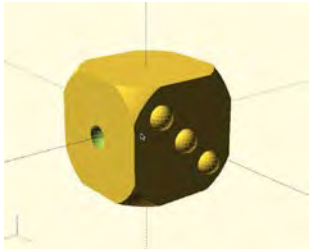

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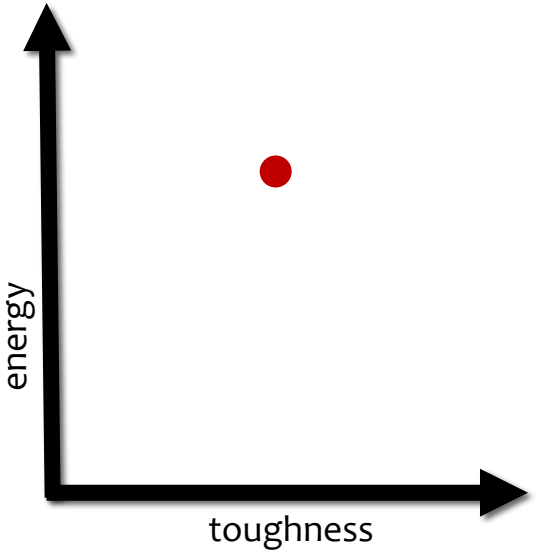

Hardware

Machine Code

Digital Design

Performance Specifications

From design to performance

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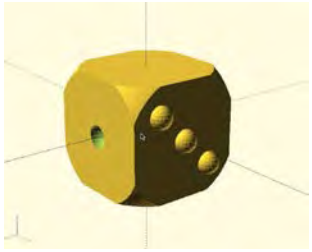

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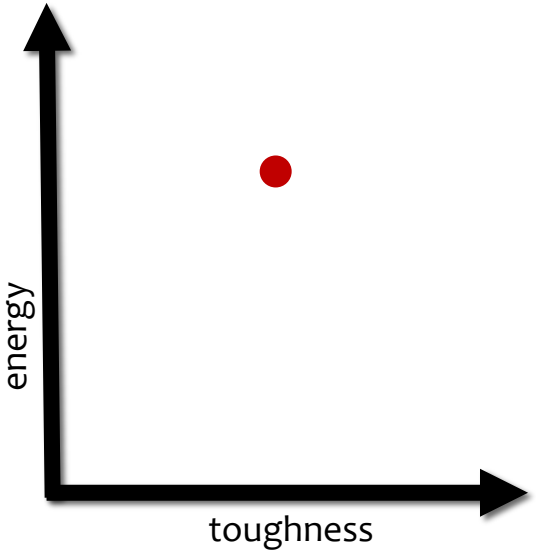

Hardware

Machine Code

Digital Design

Performance Specifications

From performance to design

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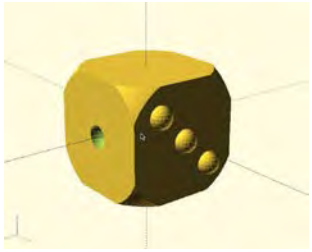

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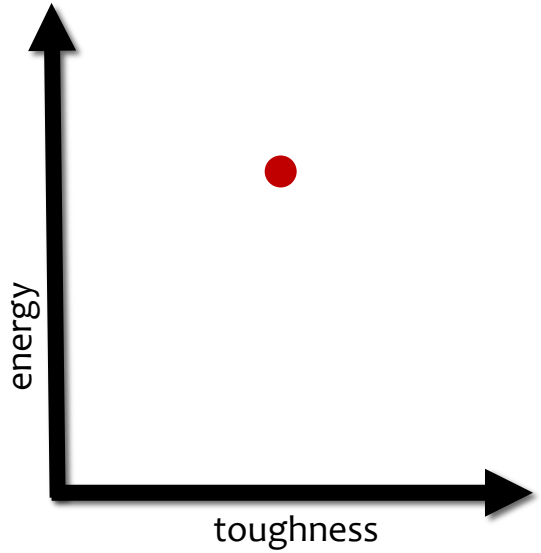


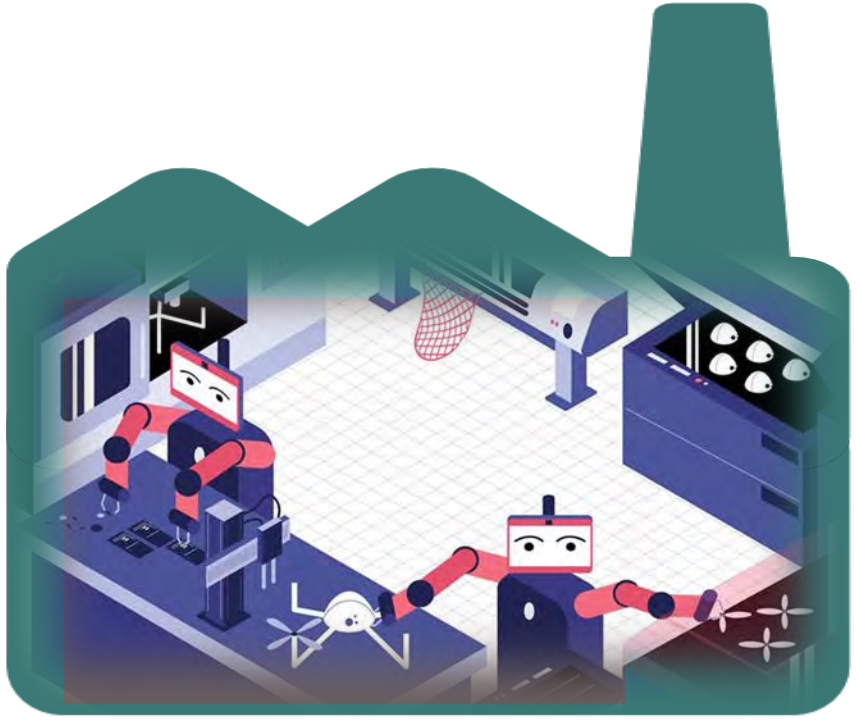
Hardware

Machine Code

Digital Design

Performance Specifications

Operating systems for the future factory



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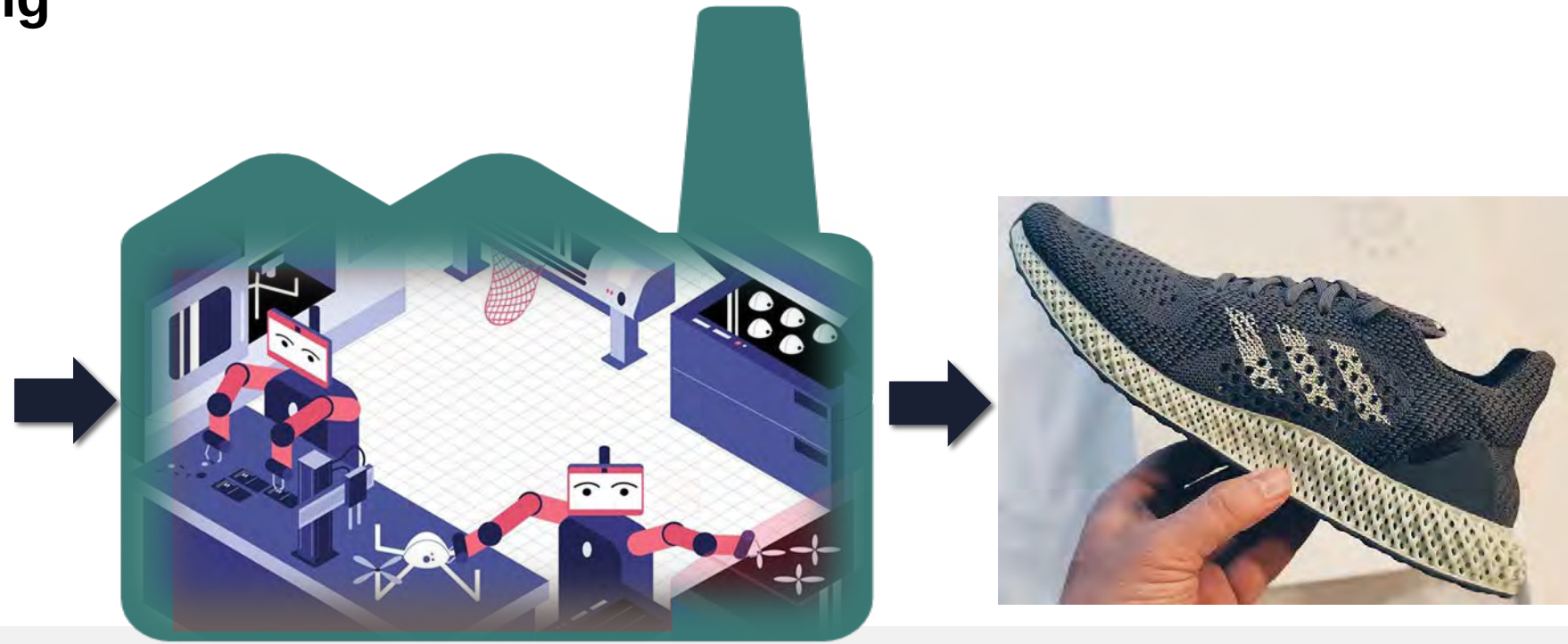
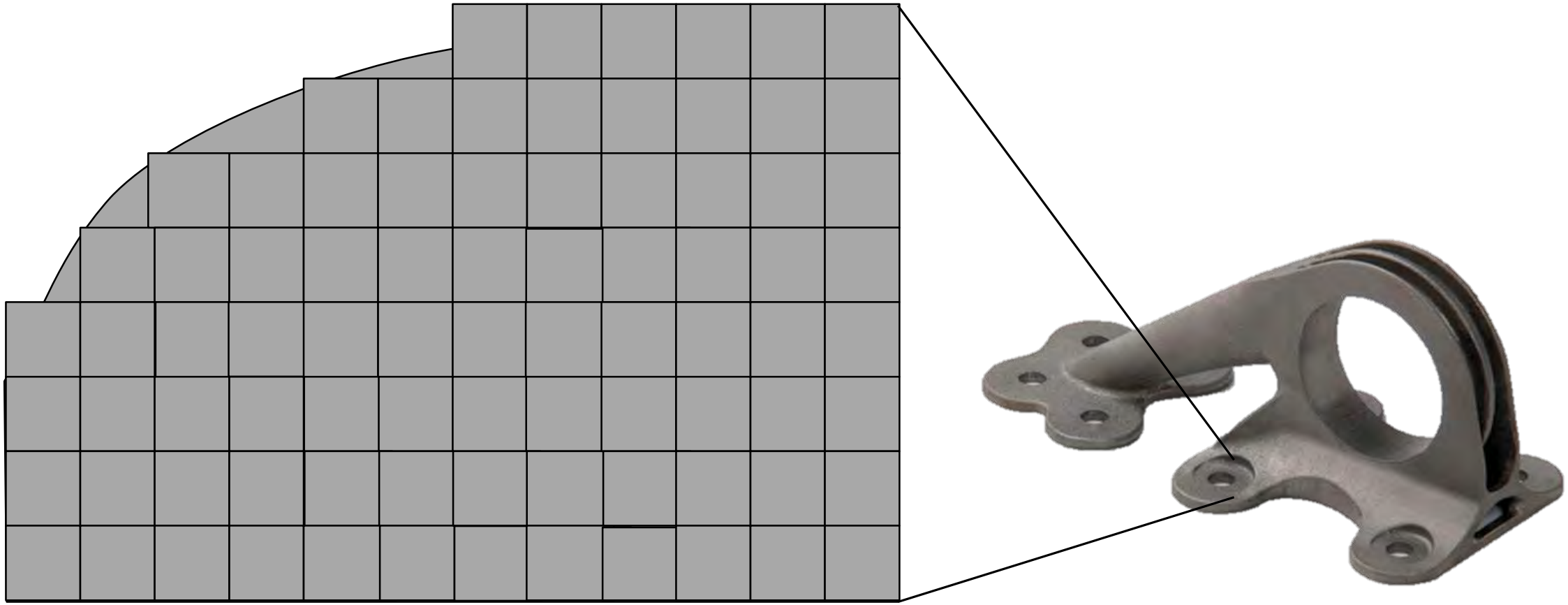
- Multi-tasking
- Distributed systems

Even more computing

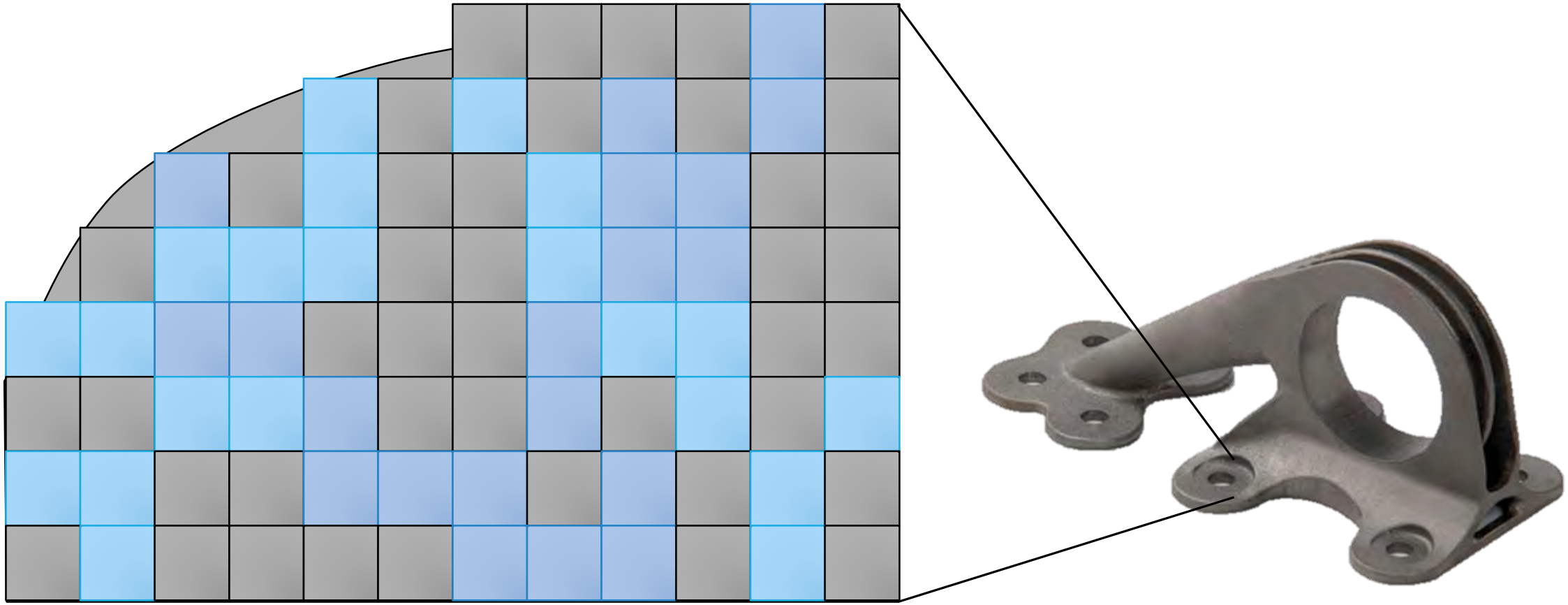
- **HCI**
- **Graphics/Vision**
- **Robotics**
- **AI/Machine Learning**
- **Algorithms**
- **…**



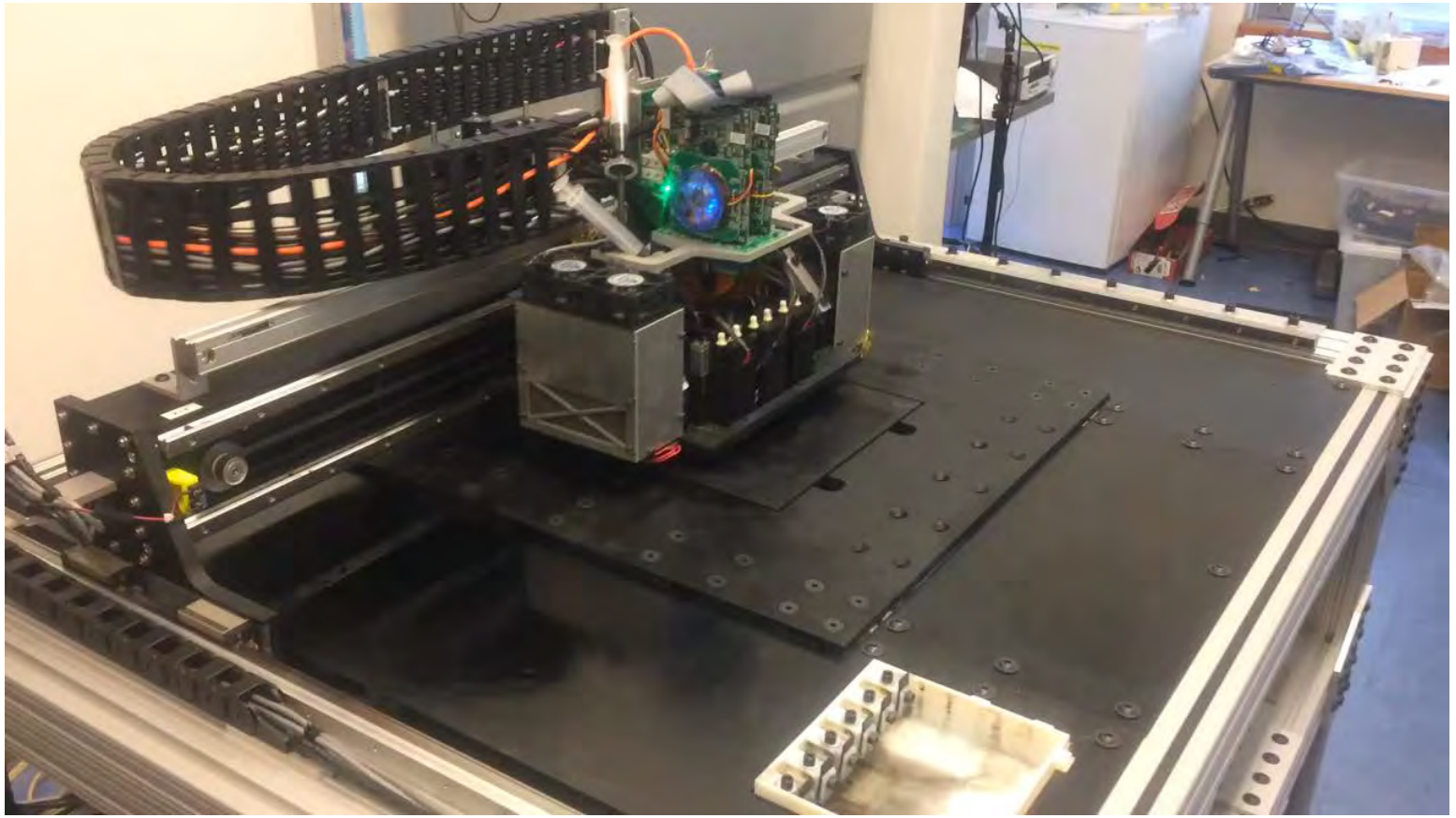
Additive manufacturing

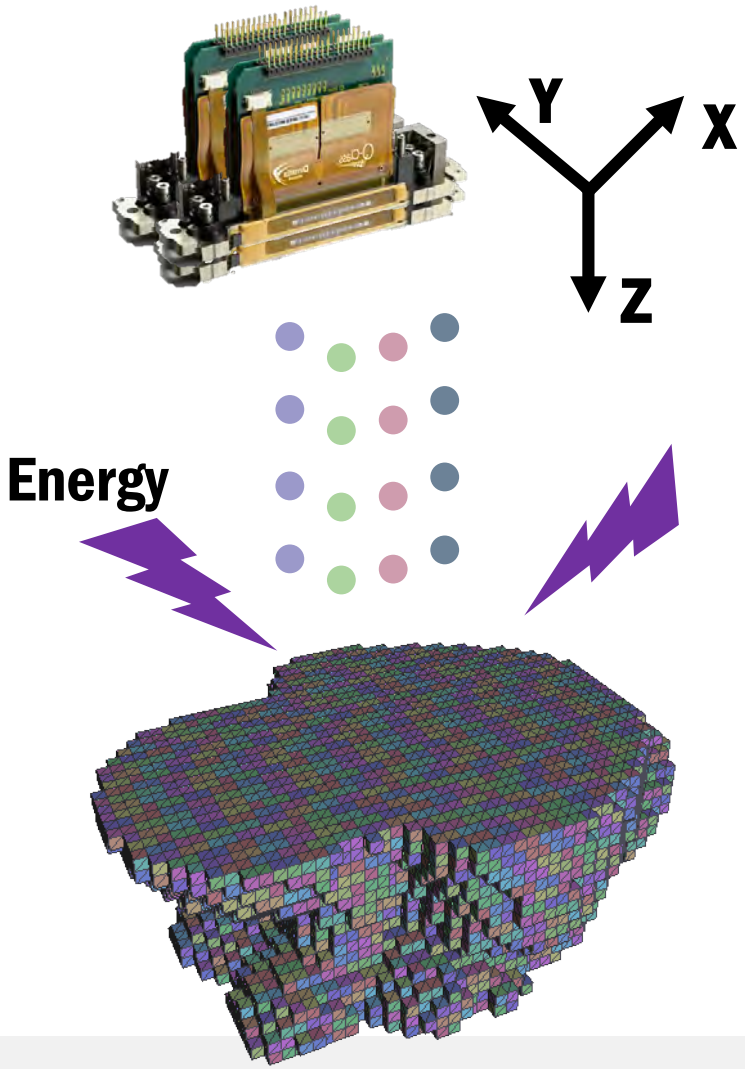


Multi-material additive manufacturing

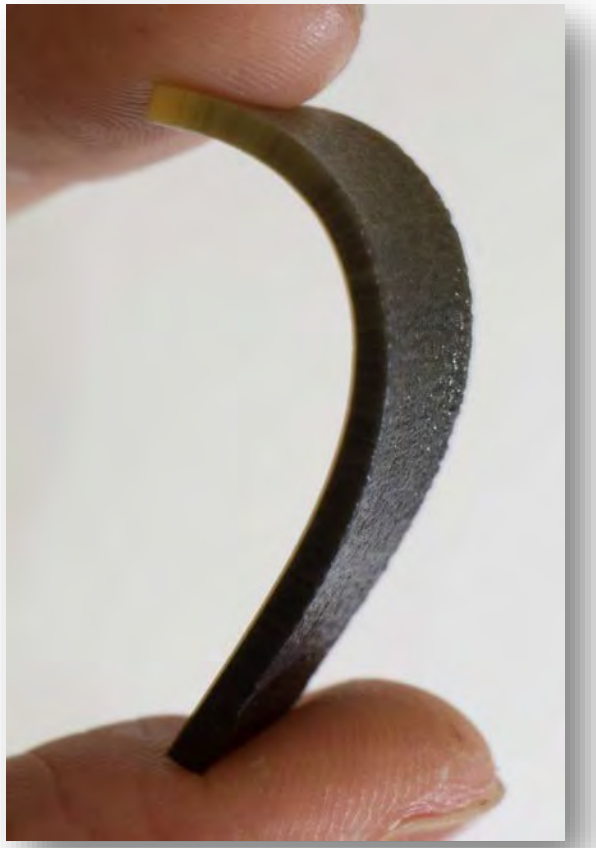


Multi-material additive manufacturing



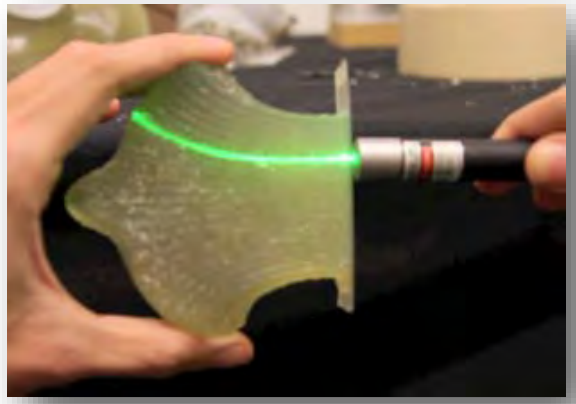


Modulation of material properties



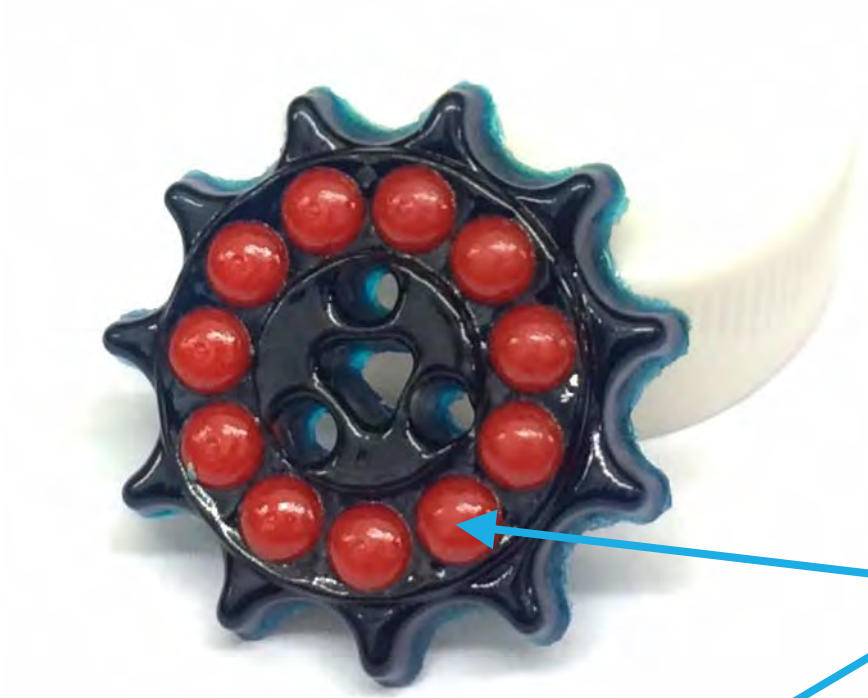
Gradient materials

Continuous lenses



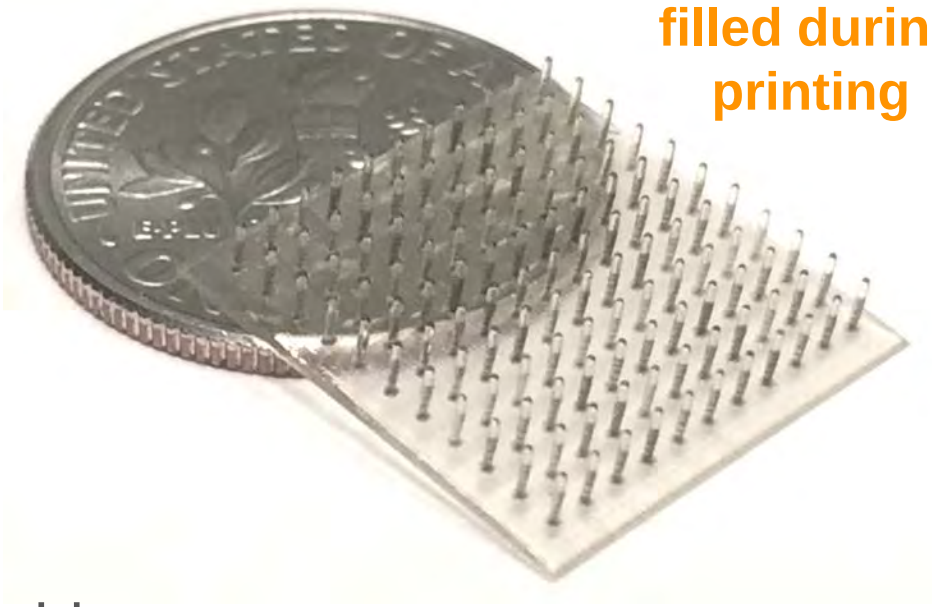
Optical fibers

Integration of fluids and solids

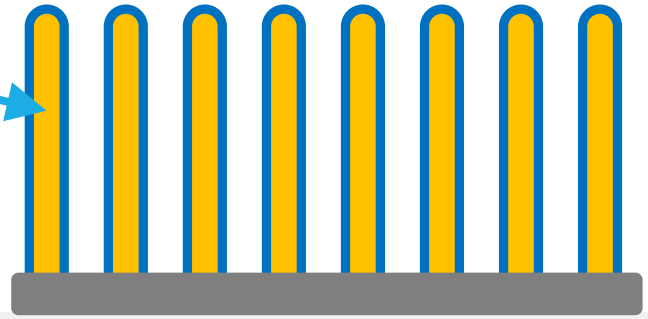


Encapsulated liquid cartridges

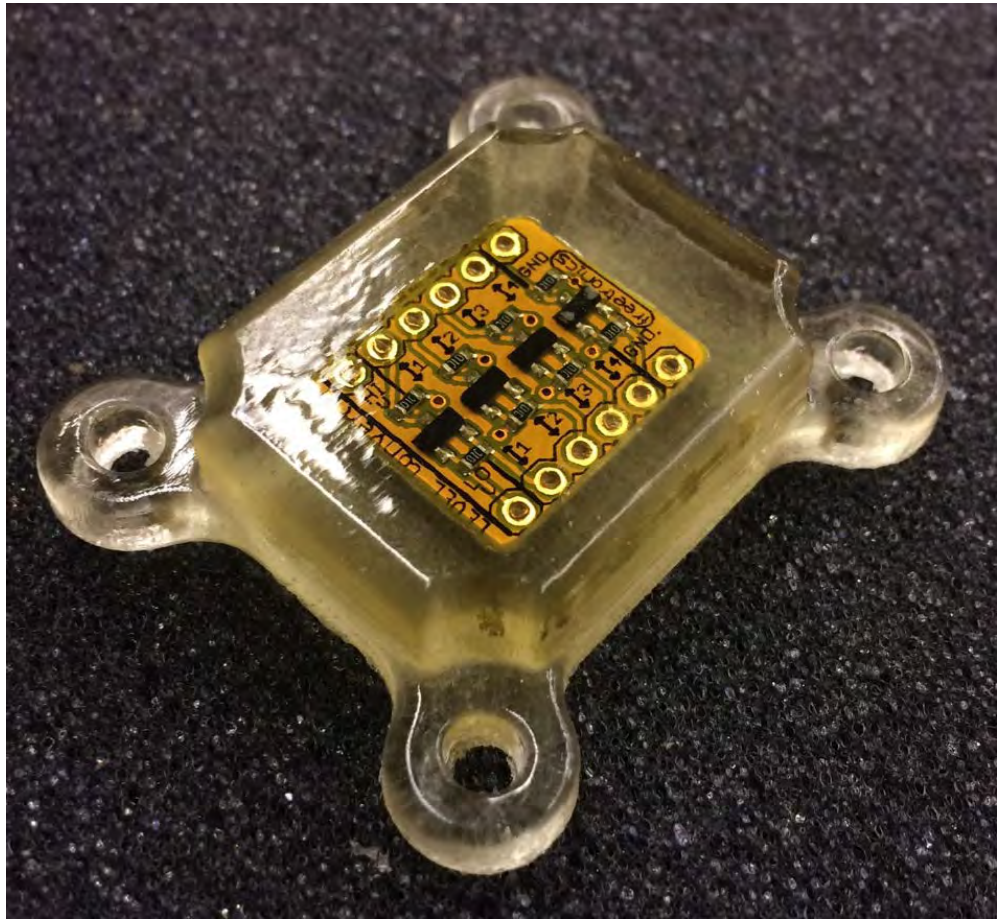
Fluid



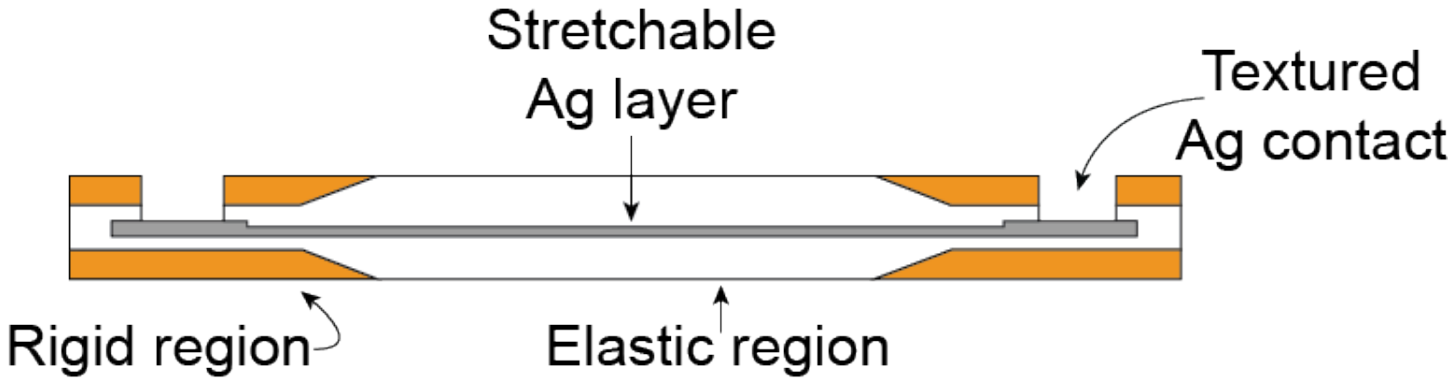
Micro-needles filled during printing

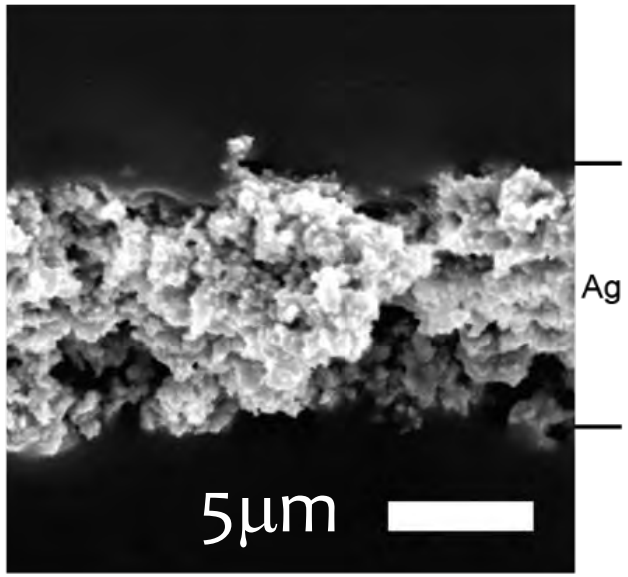


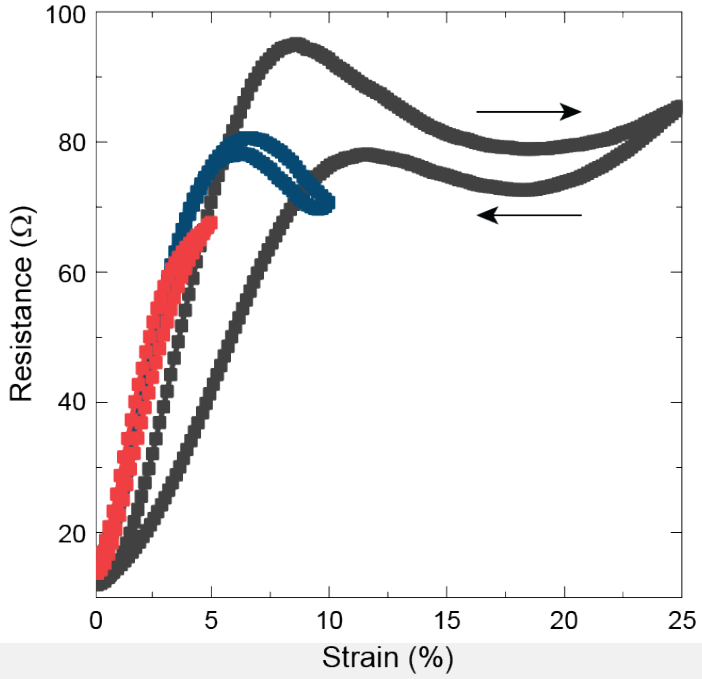
Integrated discrete components



Strain sensors





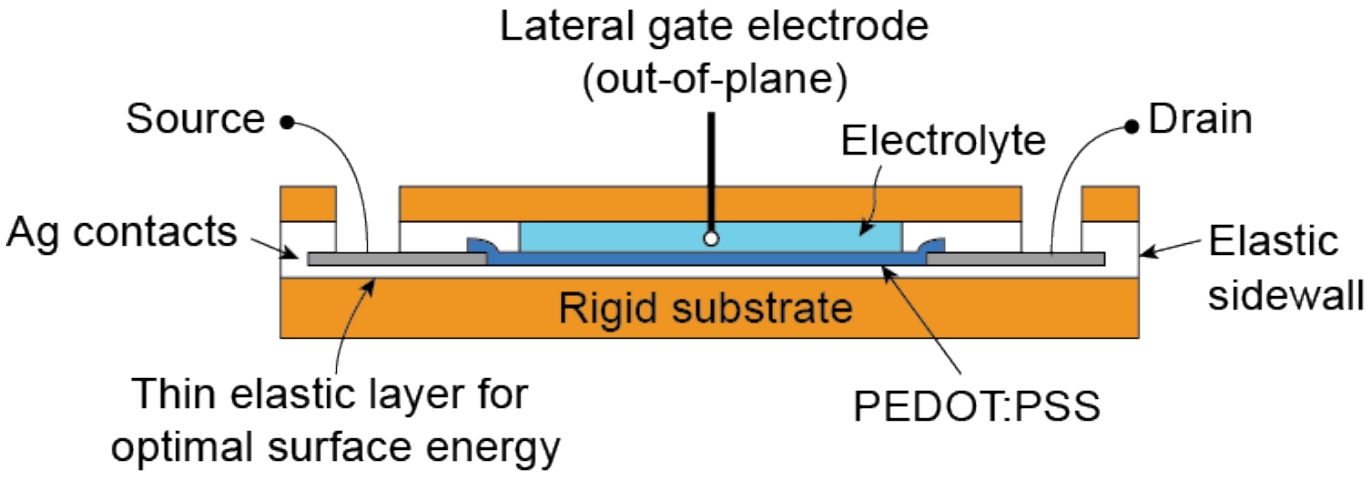


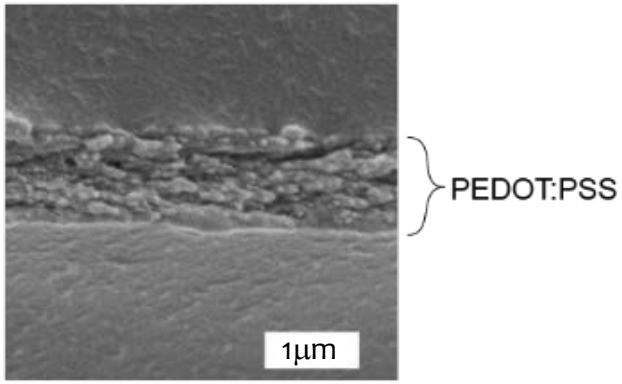
- **Silver in elastic matrix**
- **High ΔR/R**
- **Repeatable, no drift or offset**

Resistance vs. strain

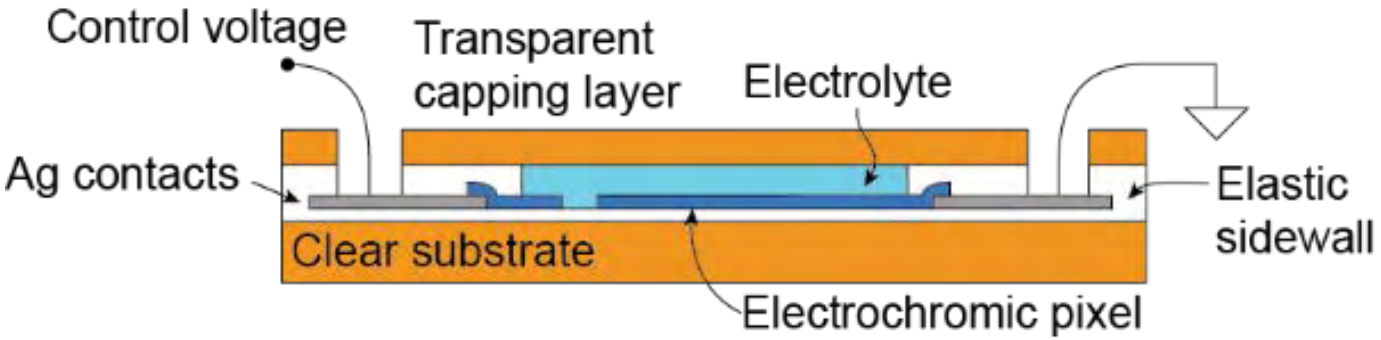
Transistors

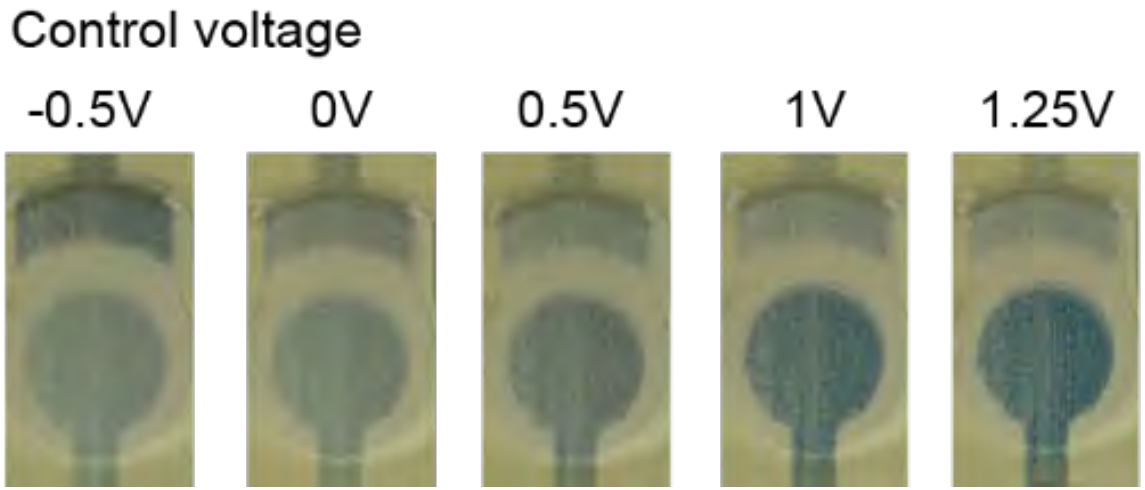
P-TYPE DEPLETION MODE





Pixels

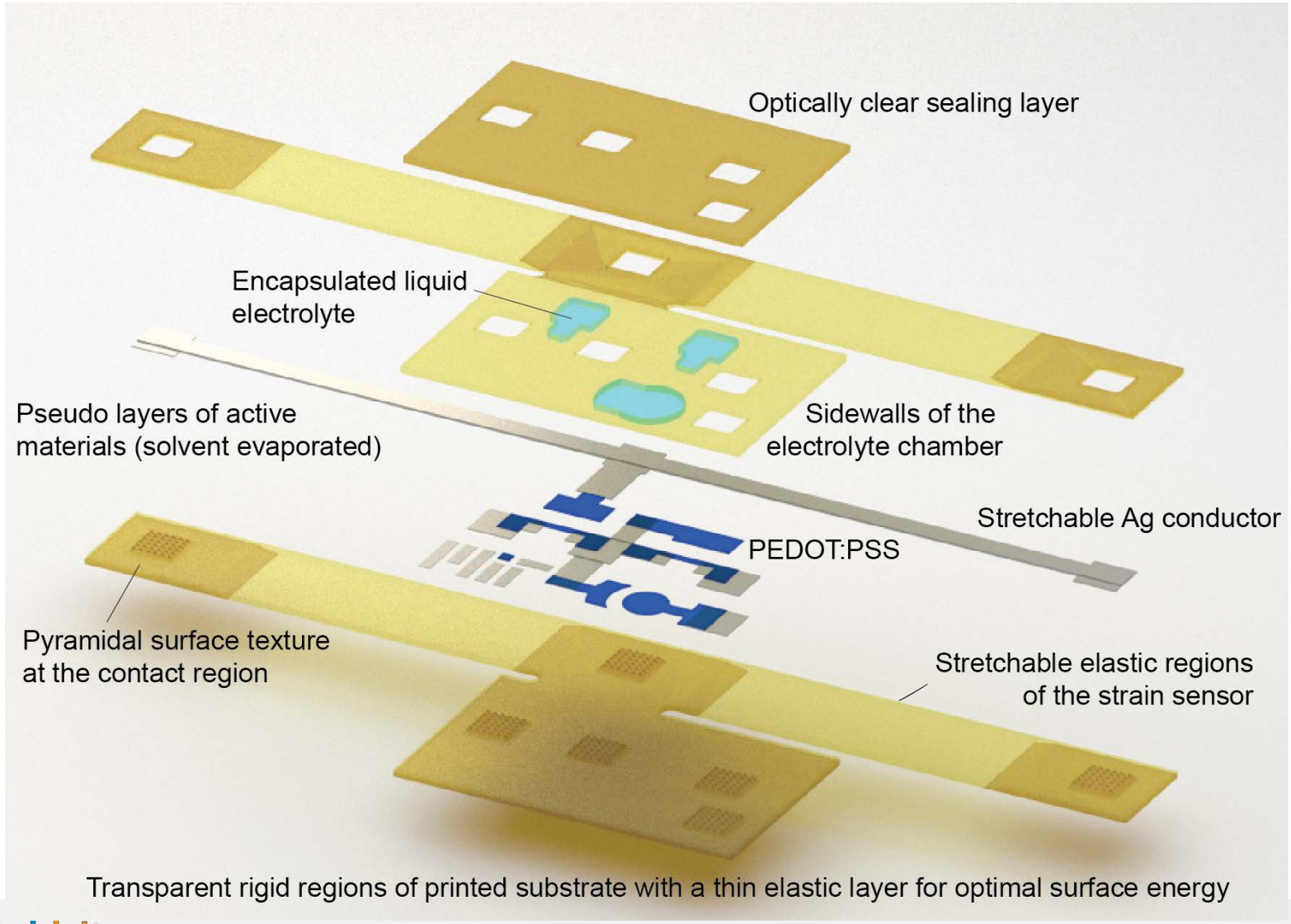


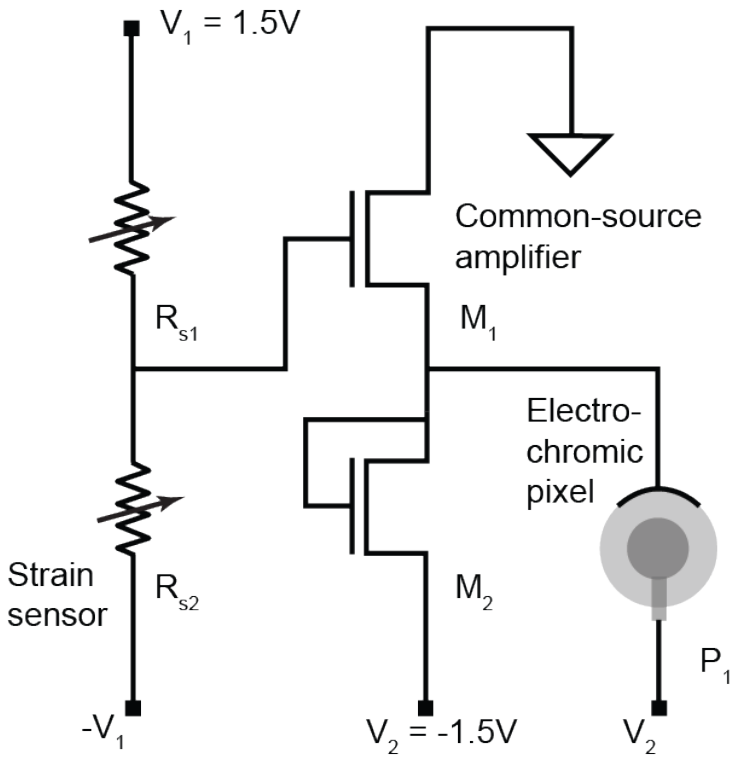


Pixel color - tuning applied control voltage

- 1.5V operation
- Modulate transparency
- Contrast – oxidized/reduced state of PEDOT

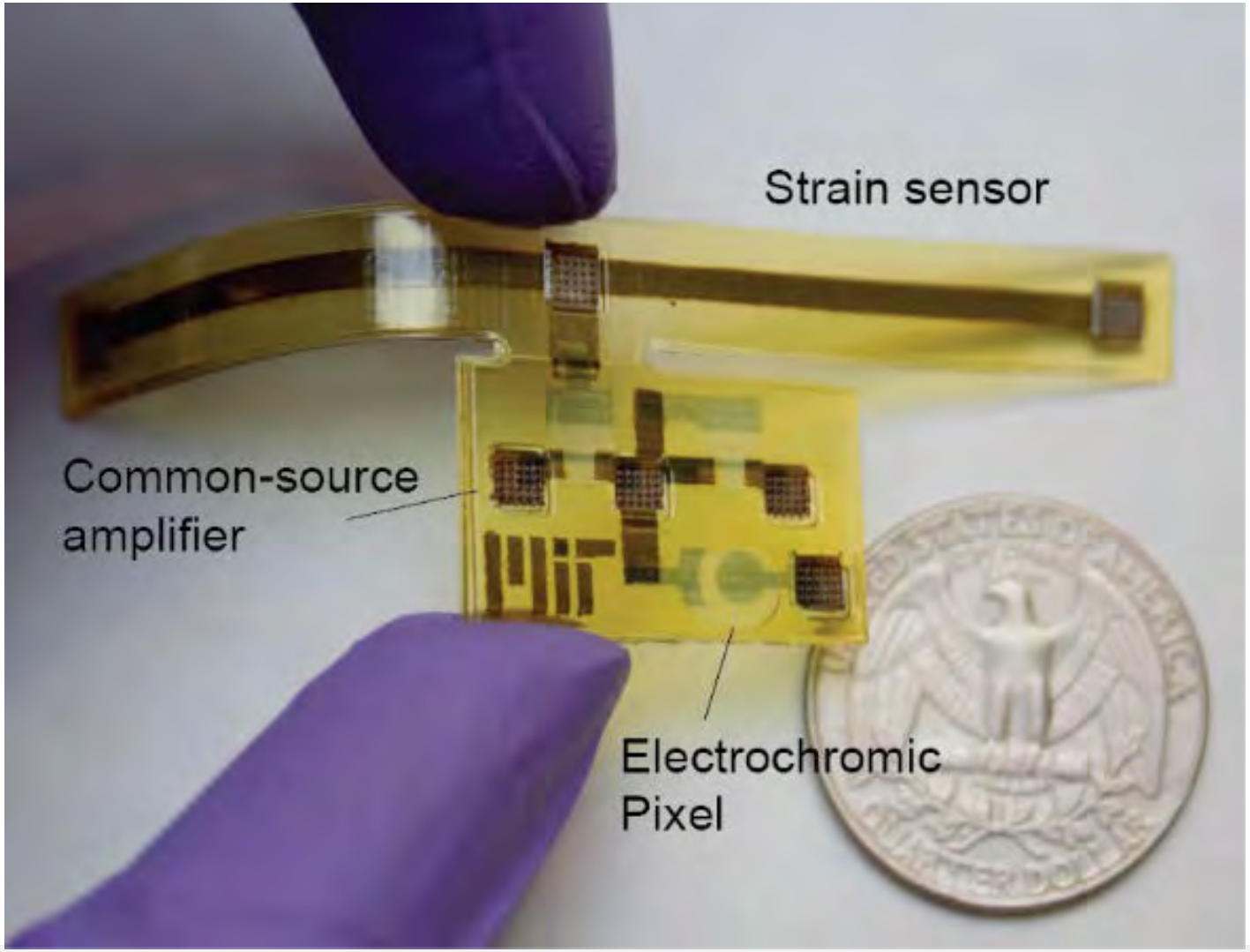
Systems





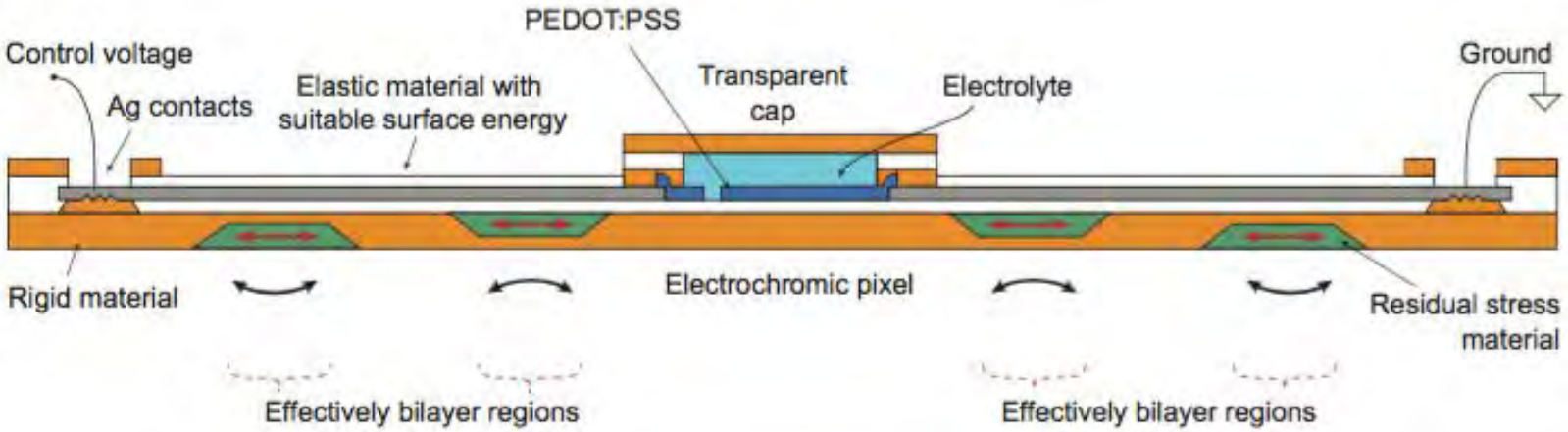
Equivalent circuit

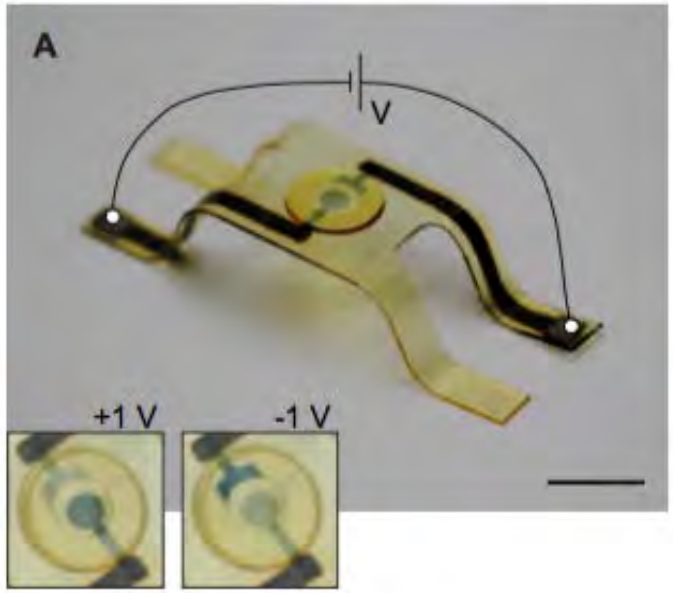
Systems

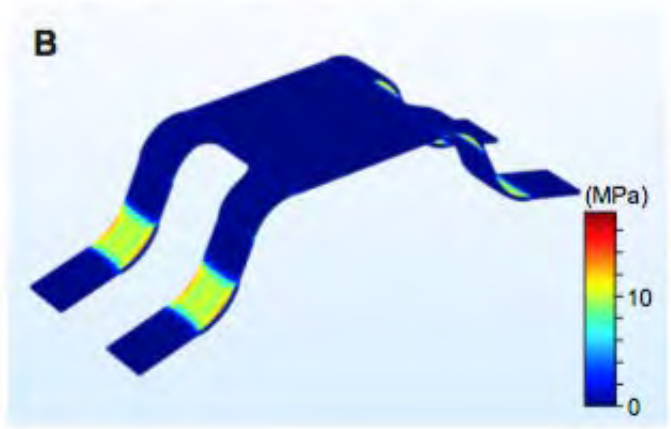


- **Fully printed – 5 materials**
- **Low-temperature process**
- **No post-processing**

Self-folding circuits

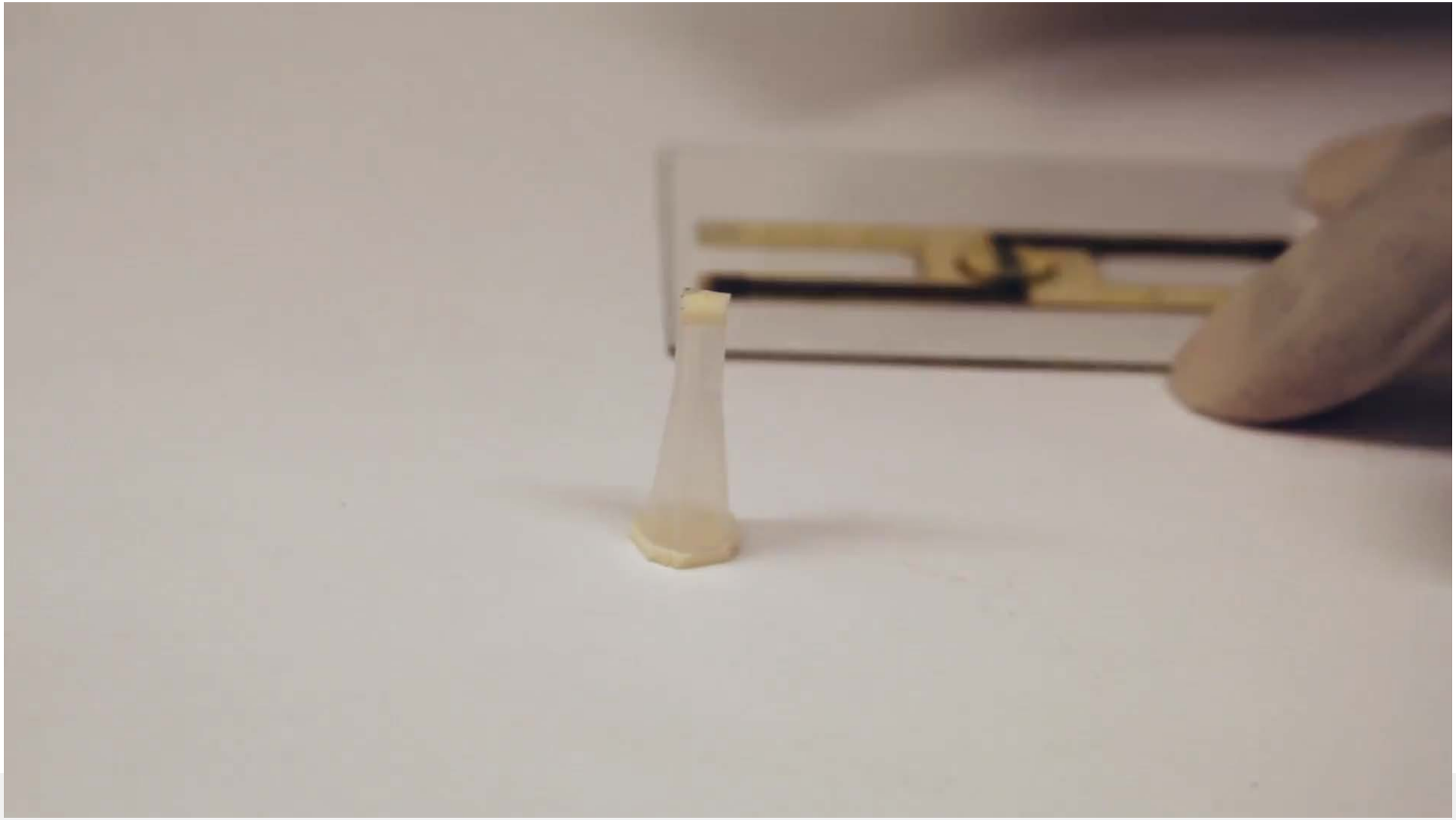






5 min after peeling

Self-folding circuits



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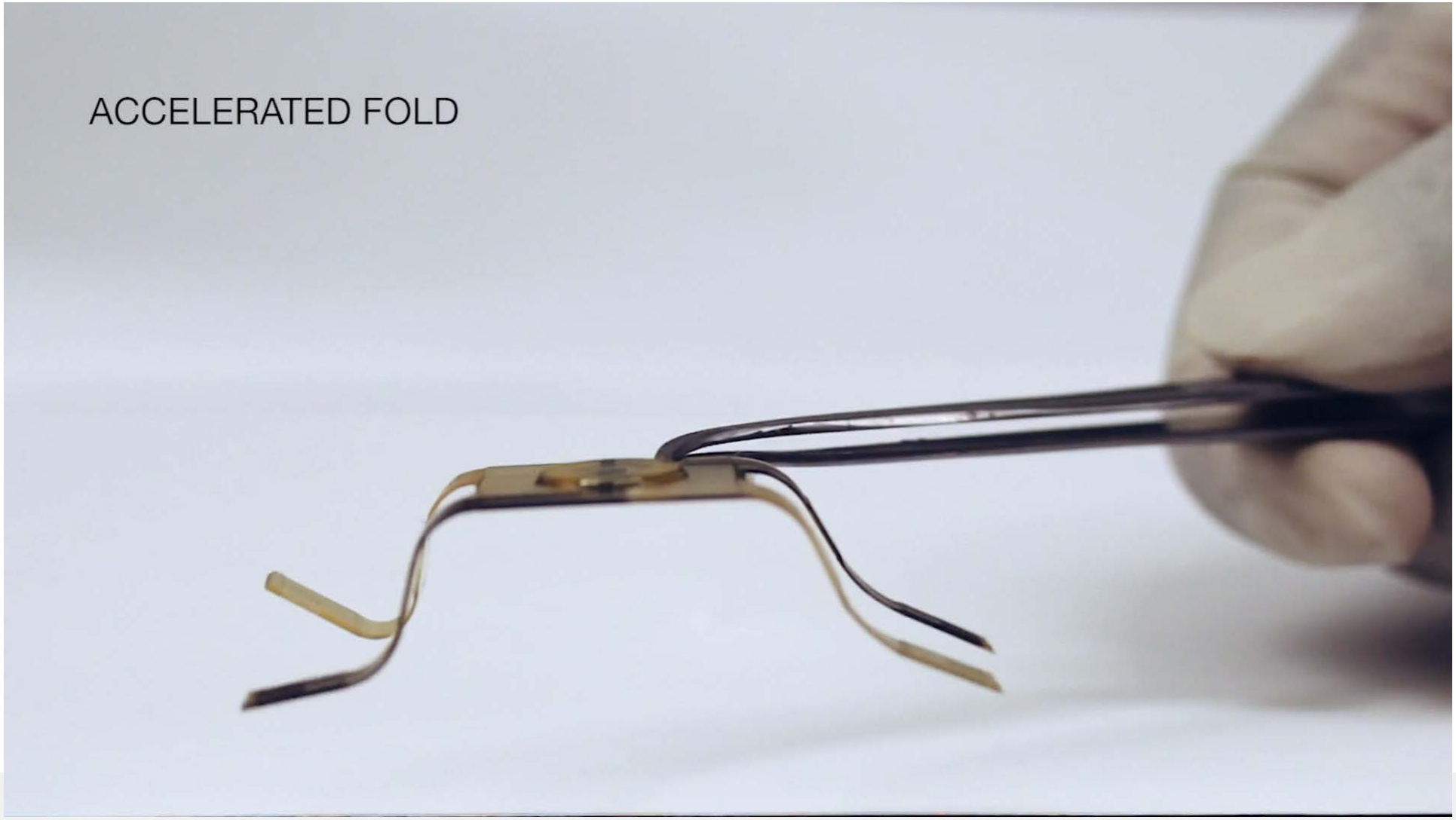

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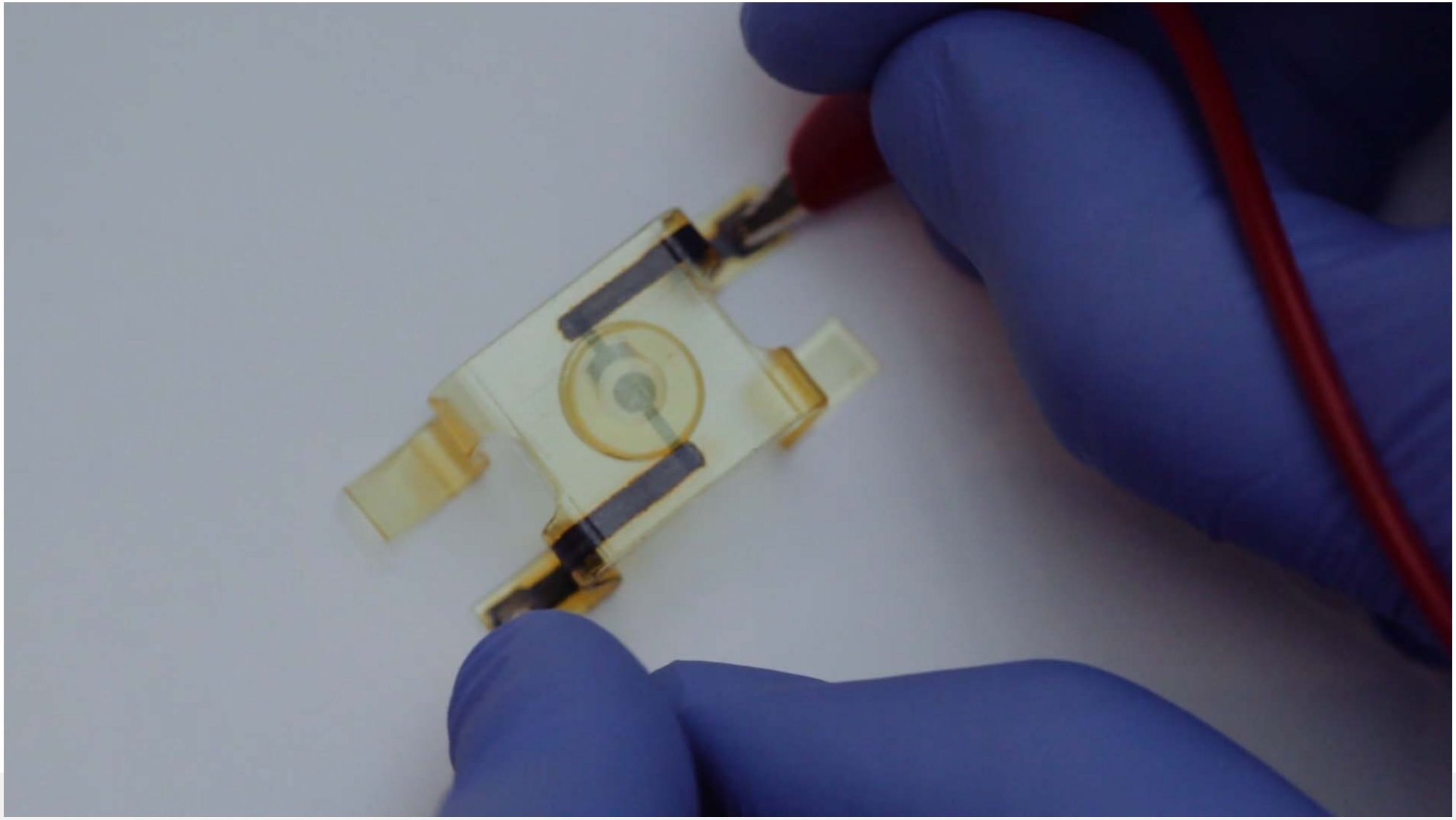


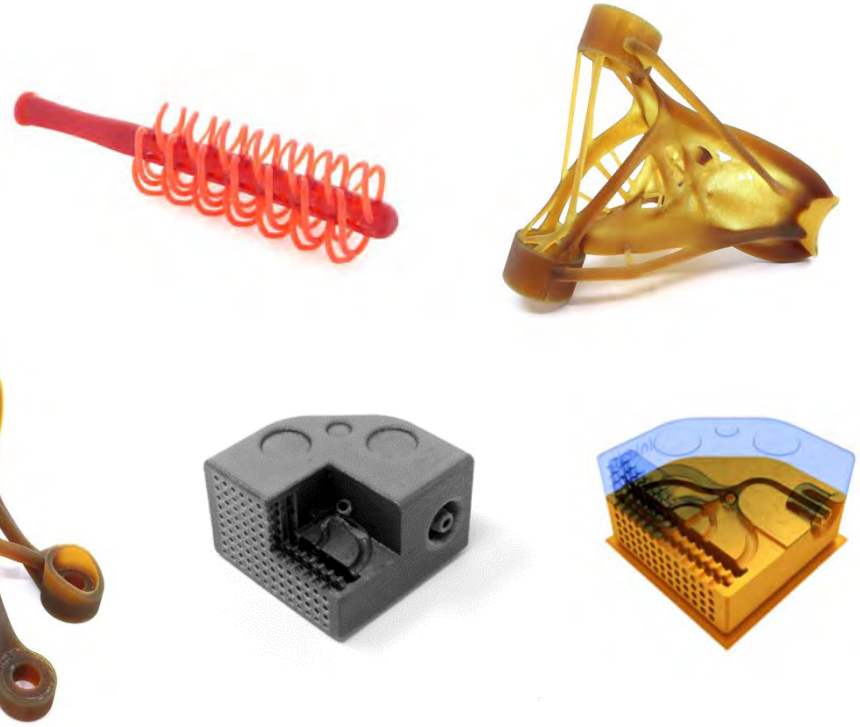
Inkbit: company history

- Founded in 2017
- MIT Spinout – CSAIL
- Located in Medford, MA
- Recently raised our Series A

What is Inkbit?

The first 3D printer powered by machine vision and AI

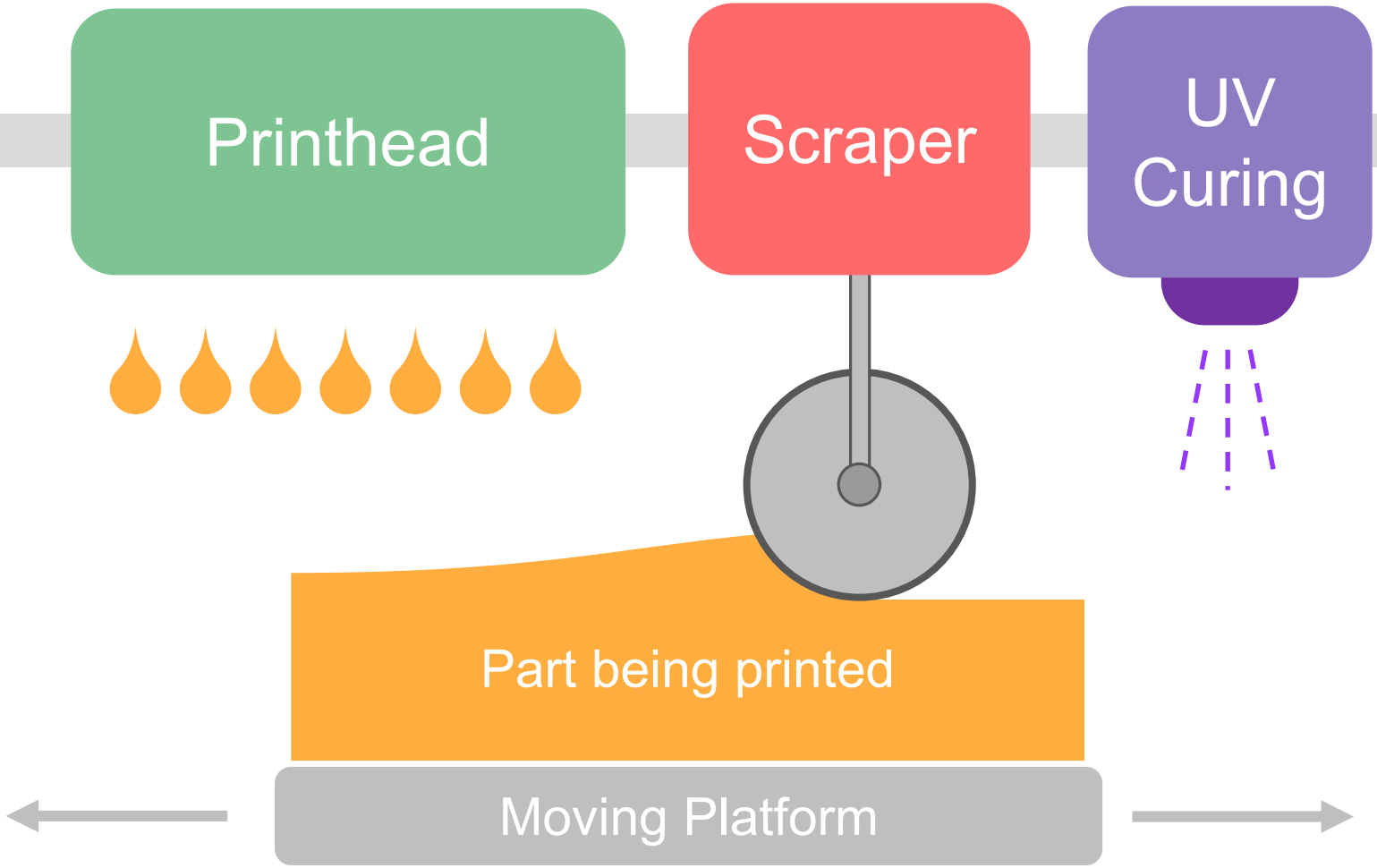
The heart of our technology is printing with vision-based feedback control.



Key Advantages

- Accuracy and repeatability
- High-performance materials
- Integrated quality control

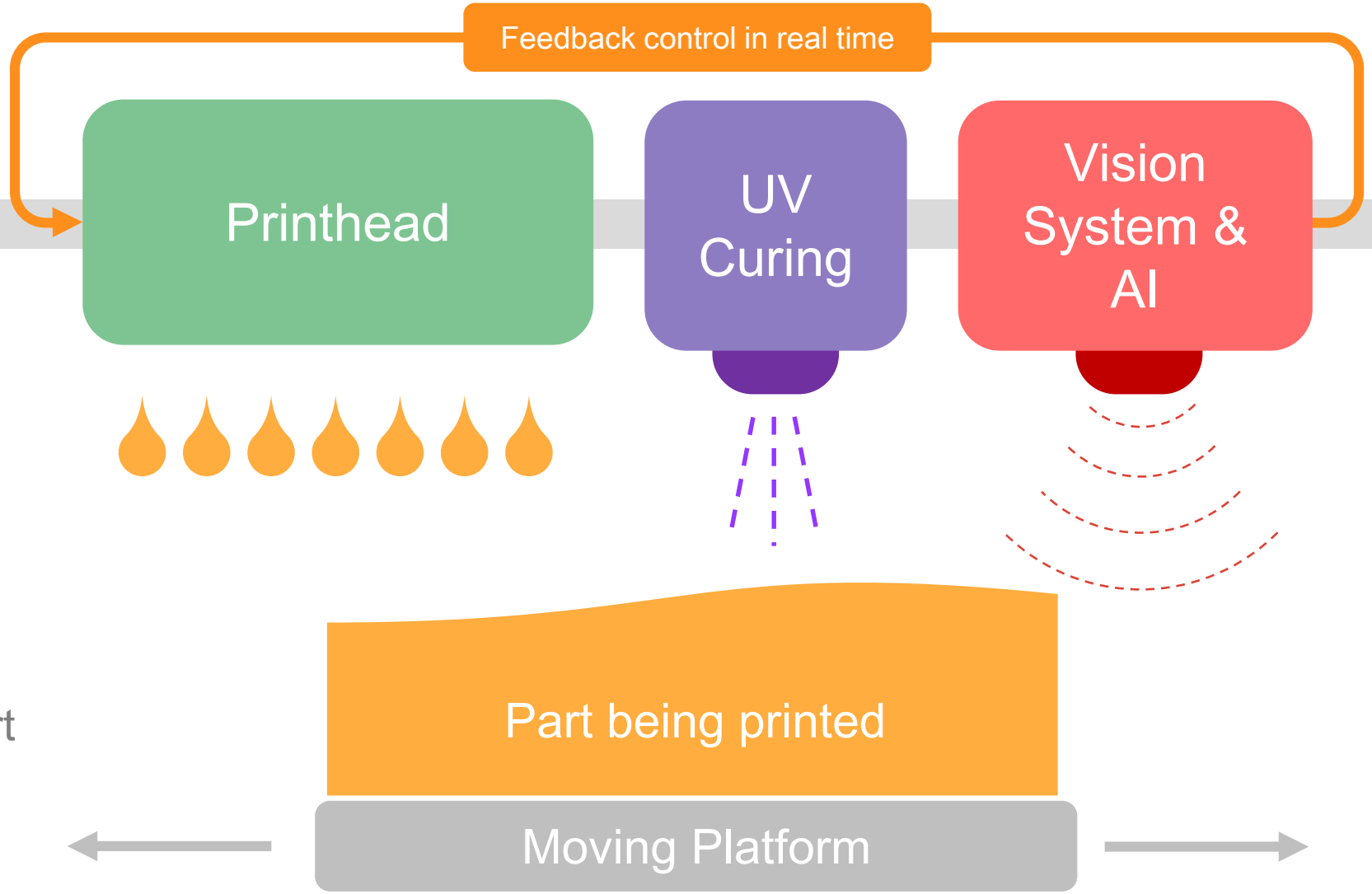
Traditional inkjet relies on mechanical flattening



Disadvantages

- Mechanical smearing
- Limited set of materials
- Poor dimensional control
- Material waste

The first 3D printer powered by machine vision & AI



Advantages

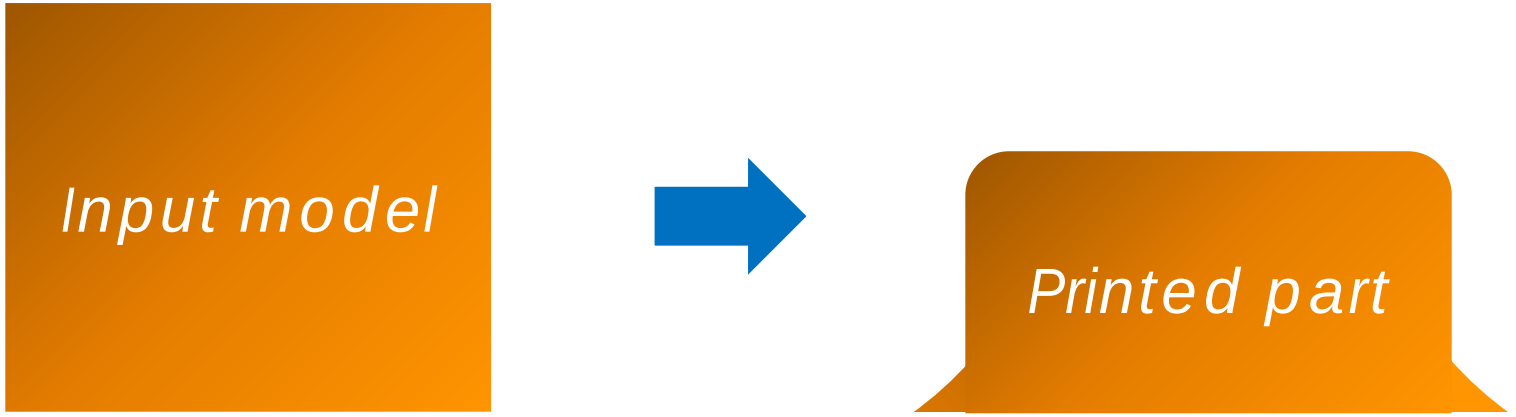
- Speed
- Precision and accuracy
- Better materials
- Digital record for every part
- Zero waste

Sources of imprecision: random and systematic errors

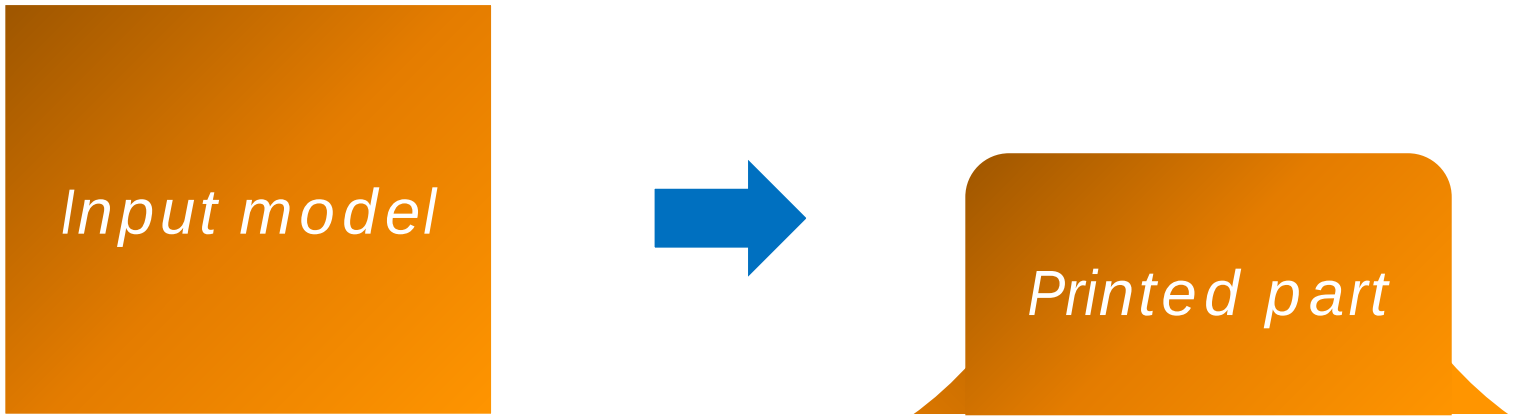
Random errors → *corrected by vision-based feedback control*

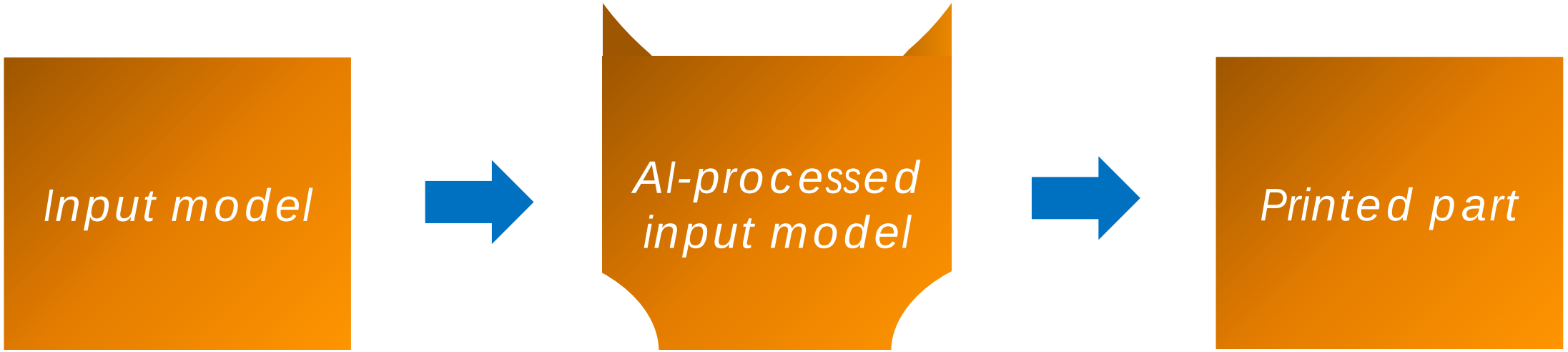
Systematic errors → *preempted by AI-based pre-processing of input model*

Example of a systematic error: a tendency to “flow”



AI to create inverse models of the printing process

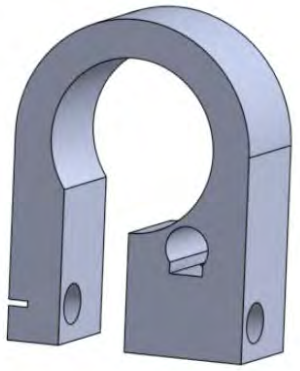




Inkbit Process

System overview

Example part: mount clip



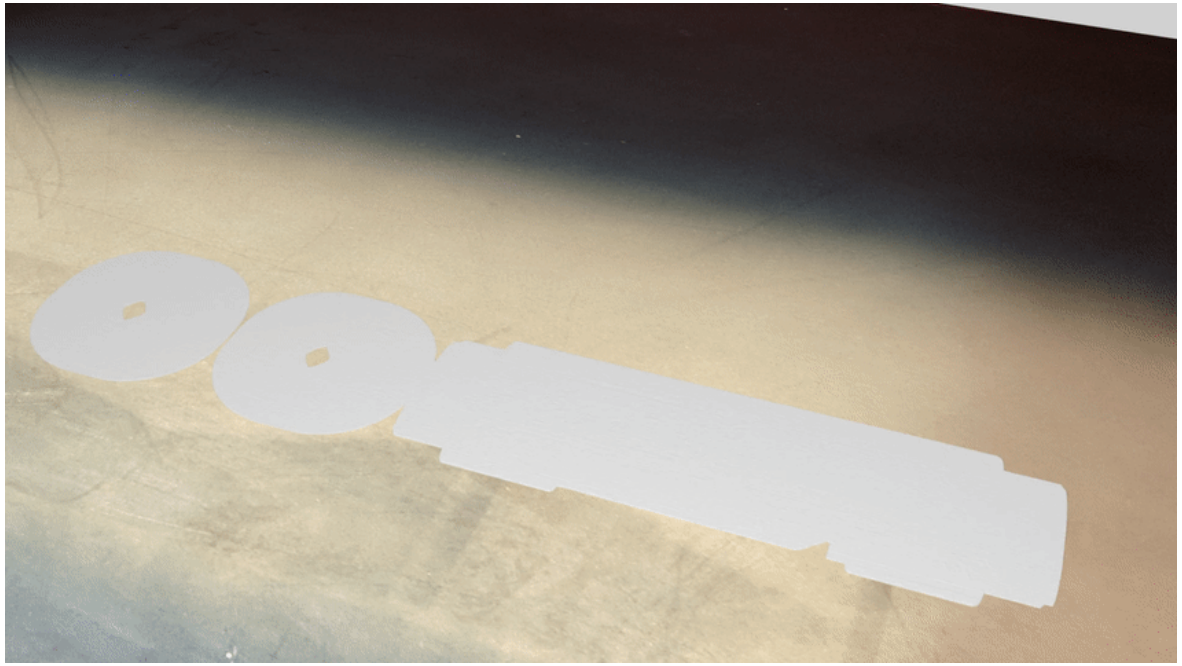
32 mm x 25 mm x 10 mm

Throughput: 6,000 parts/day

System Specs | Production Configuration

System Specifications	
Number of Materials	**3 build + 1 Support**
Material Types	Soft-Touch, Rubber-like[1] Rigid Tough[1] Rigid High-Temp Dissolvable Support
Print Process	Real-time Geometry Control. Fully Non-contact and Adaptive.
Metrology	Real-time, Layer-by-layer part scanning
Scanner Resolution	**X Axis:** 50 µm; **Y Axis:** 50 µm; **Z Axis:** 10 µm
Machine Throughput	Max 40 mm/hour along the **Z Axis** for the full build tray
Build Tray Management	Automated platform loading and unloading
Post-Process Workflow	Warm Water Bath and Mineral Oil Bath
Build Size	500mm x 250mm x 200mm (X, Y, Z)
Resolution	**X Axis:** 800 DPI; **Y Axis:** 400 DPI; **Z Axis:** Adaptive
Power Requirements	5 kW three phase
Machine Footprint	2 meters x 1.2 meters x 1.8 meters (L, W, H)

Our technology enables 100% quality control



Non-toxic support material is quickly removed

5 minutes

Soft and Rigid Materials

High-Performance Biocompatible Elastomer

- Elongation-at-break of over 800%, Soft Touch
- Biocompatible (ISO 10993 5/10/11)
- Compatible with TE-R to produce multi-material parts and match durometers

Typical Applications

- Multi-material dental devices
- Gaskets and seals
- Intricate biocompatible parts

Multi-material Bronchial Tube Model
Elastomer (green), Rigid (red)

Biocompatible Rigid

- Biocompatible (ISO 10993 5/10/11)
- Compatible with TE-E to produce multi-material parts and match durometers

Typical Applications

- Multi-material dental devices
- Complex fluidic components
- Intricate biocompatible parts
- Custom durometer components

High-Temperature Epoxy

inkbit

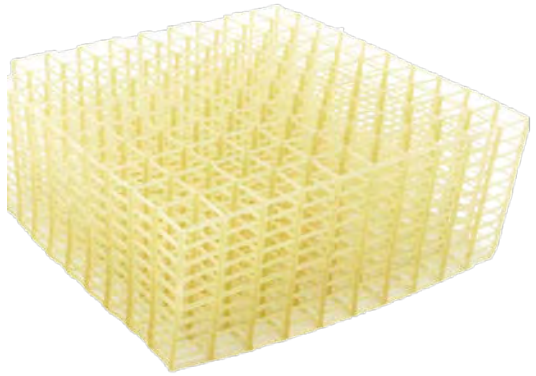
High-Temperature Rigid Epoxy

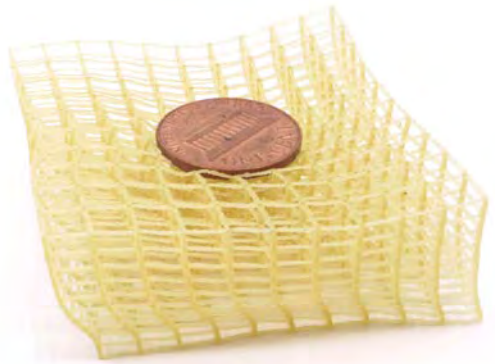
- Stiff and rigid material ideal for high-temperature applications
- Excellent chemical resistance
- Heat deflection temperature of 130 °C

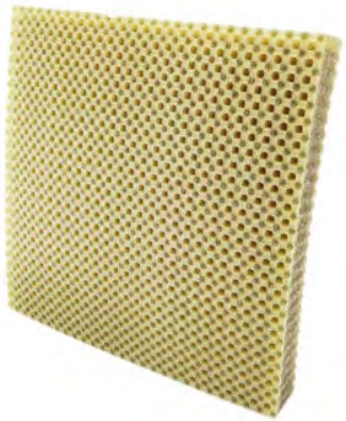
Typical Applications

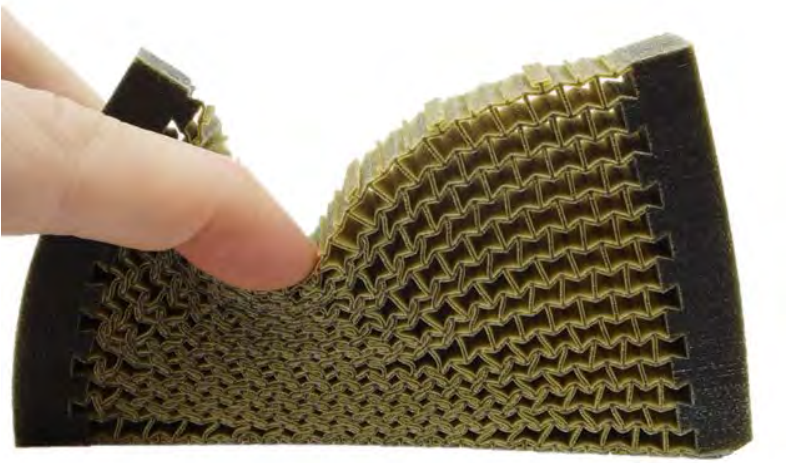
- Intricate fluidic manifolds
- Brackets and mounts
- Chemical handling components

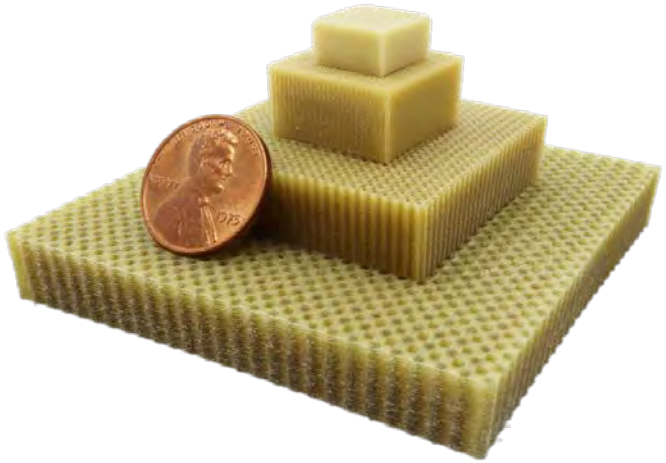
Application: Fine Lattices





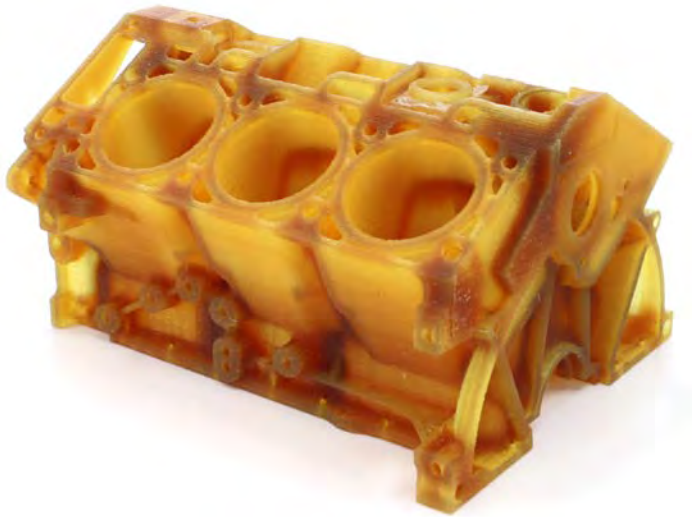




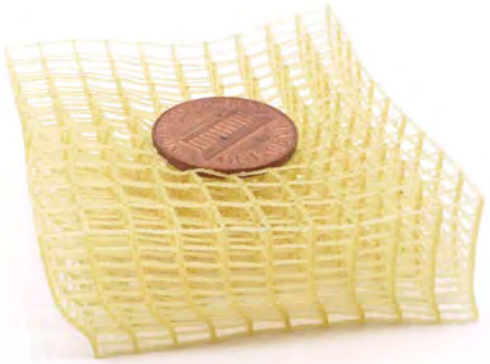


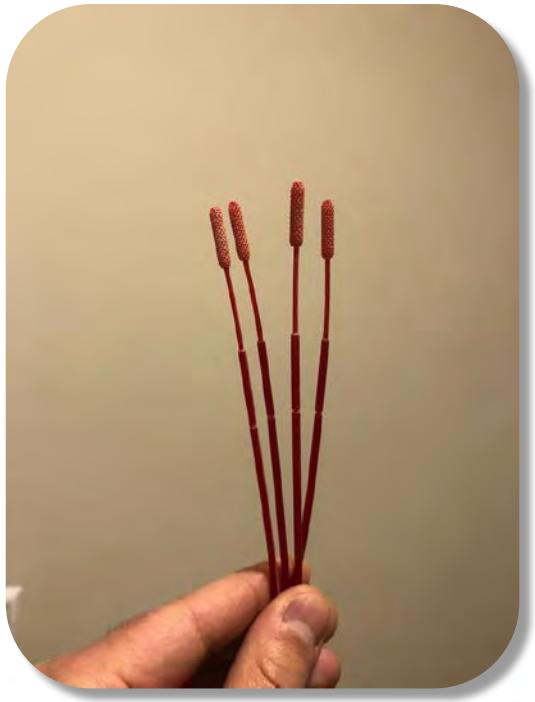
Application: Fluidics

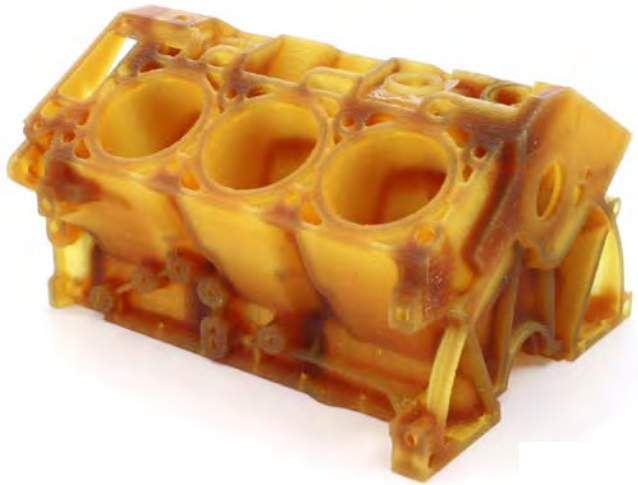
Application: Replacement of Metal Parts

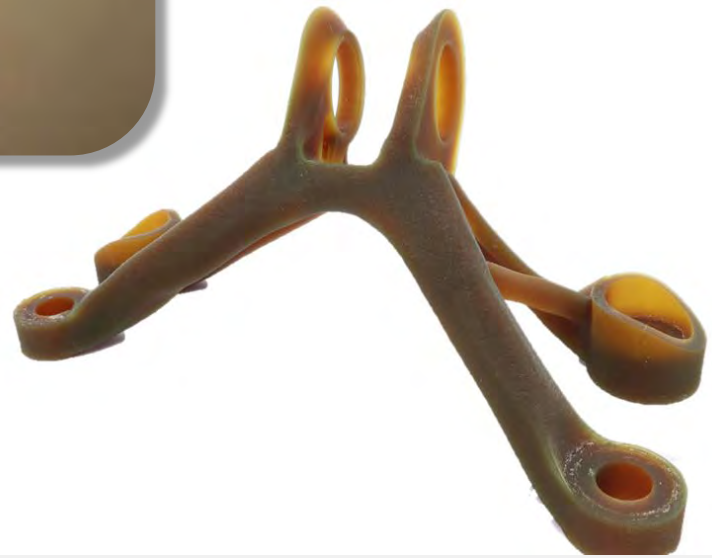


Inkbit enables production of complex parts









Inkbit enables production of complex parts

We are looking for industry partners to develop new applications together

- Bring to us your most challenging parts
- We can develop custom materials for you
- We can help redesign your products for AM

Thank You

info@inkbit3d.com