Advanced Materials for the Additive Manufacturing of Machines

ORL : Organic Robotics Laboratory

Robert Shepherd

Major market segmentation (2015)

11.0%
Consumers

38.7%
Manufacturing companies

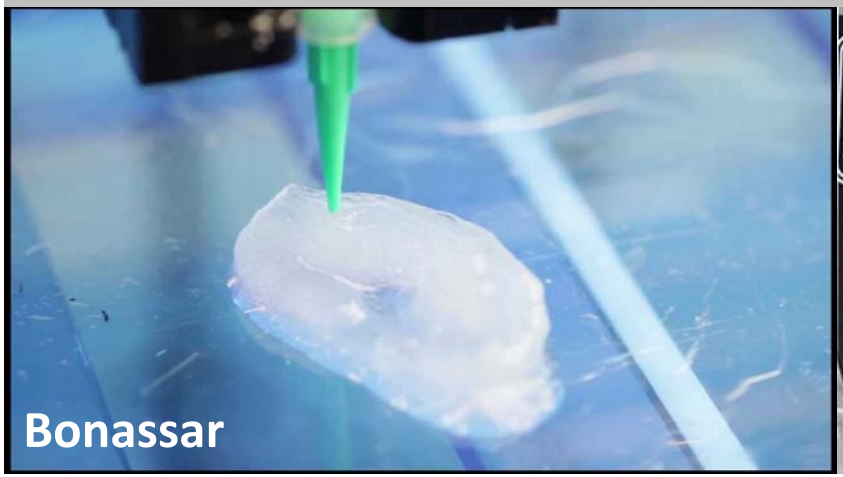
23.4%
Medical companies

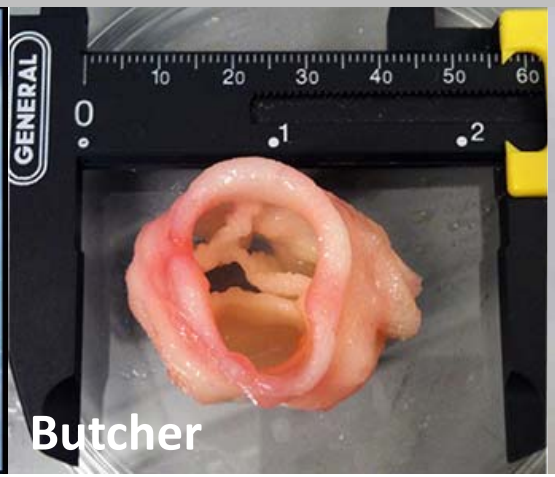
26.9%
Construction and architecture companies

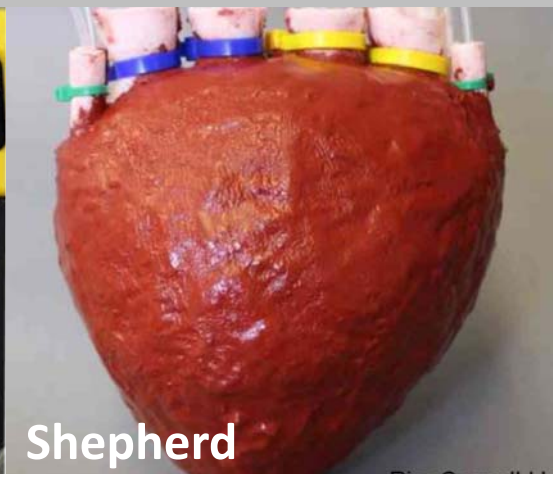
Total $492.4m

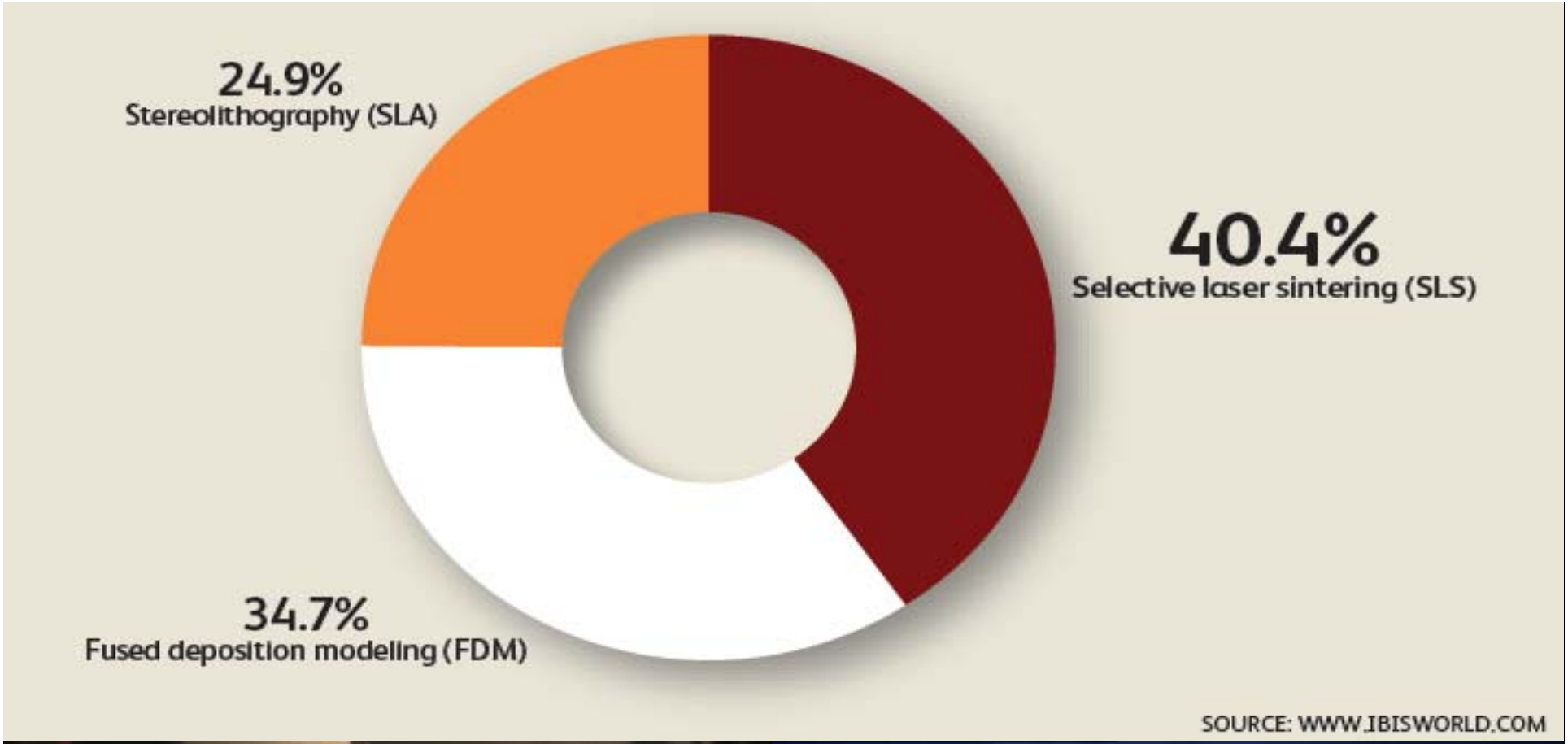
SOURCE: WWW.IBISWORLD.COM

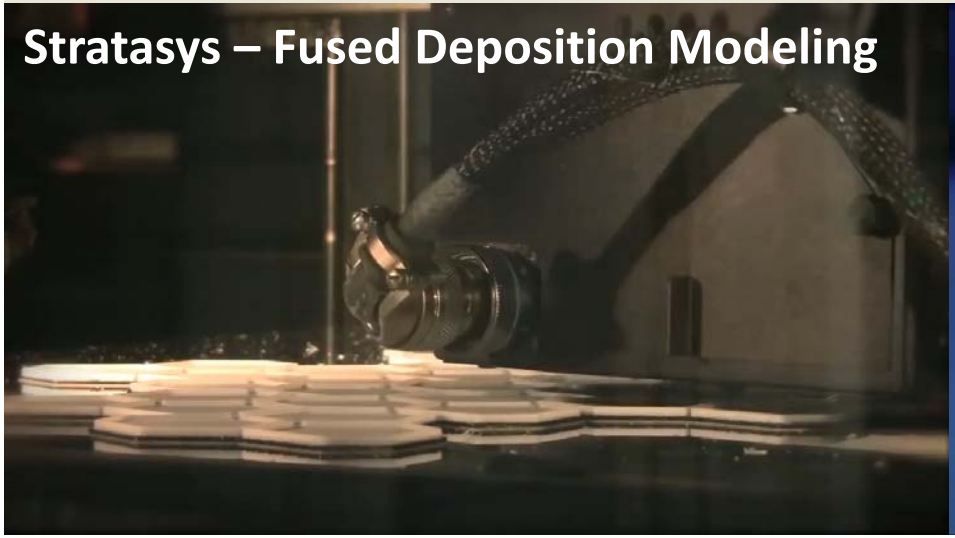
Biomedical Device Printing @ Cornell

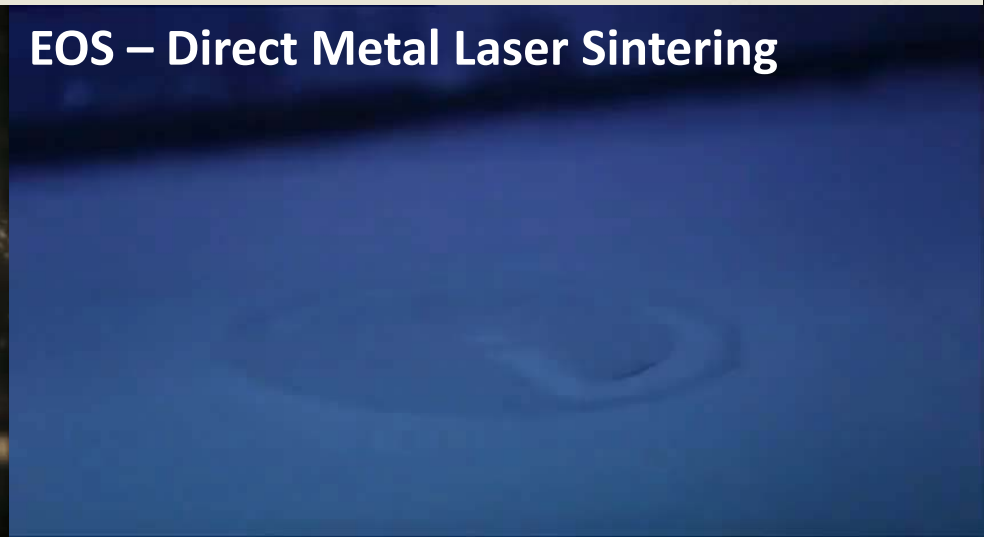







24.9%
Stereolithography (SLA)
40.4%
Selective laser sintering (SLS)
34.7%
Fused deposition modeling (FDM)
SOURCE: WWW.IBISWORLD.COM

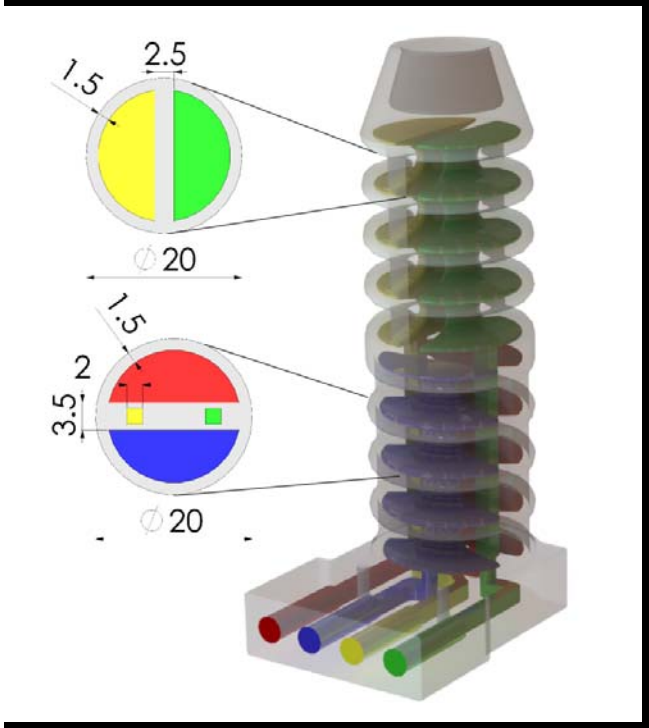

Stratasys – Fused Deposition Modeling

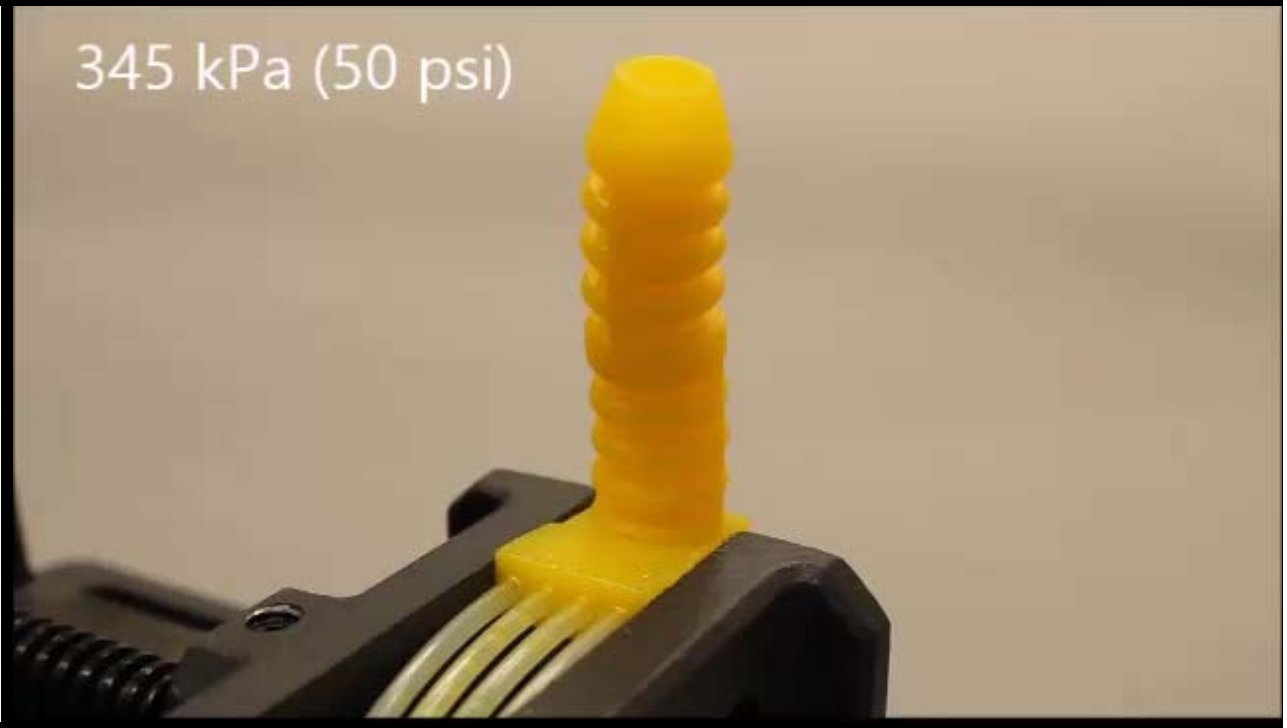

EOS – Direct Metal Laser Sintering

Stereolithography

- 3D printing via chemistry
- Fastest 3D printer
- No layering effect – monolithic part production

3D Printing Machines



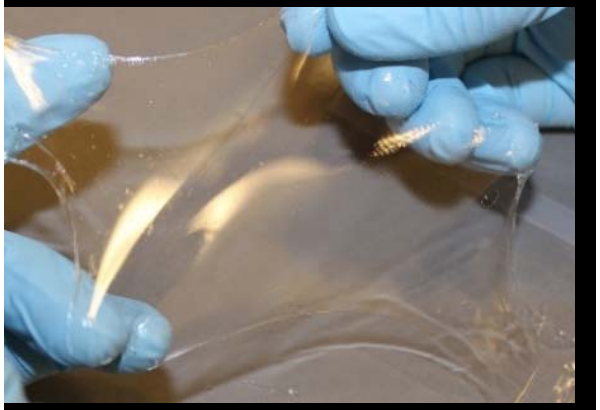


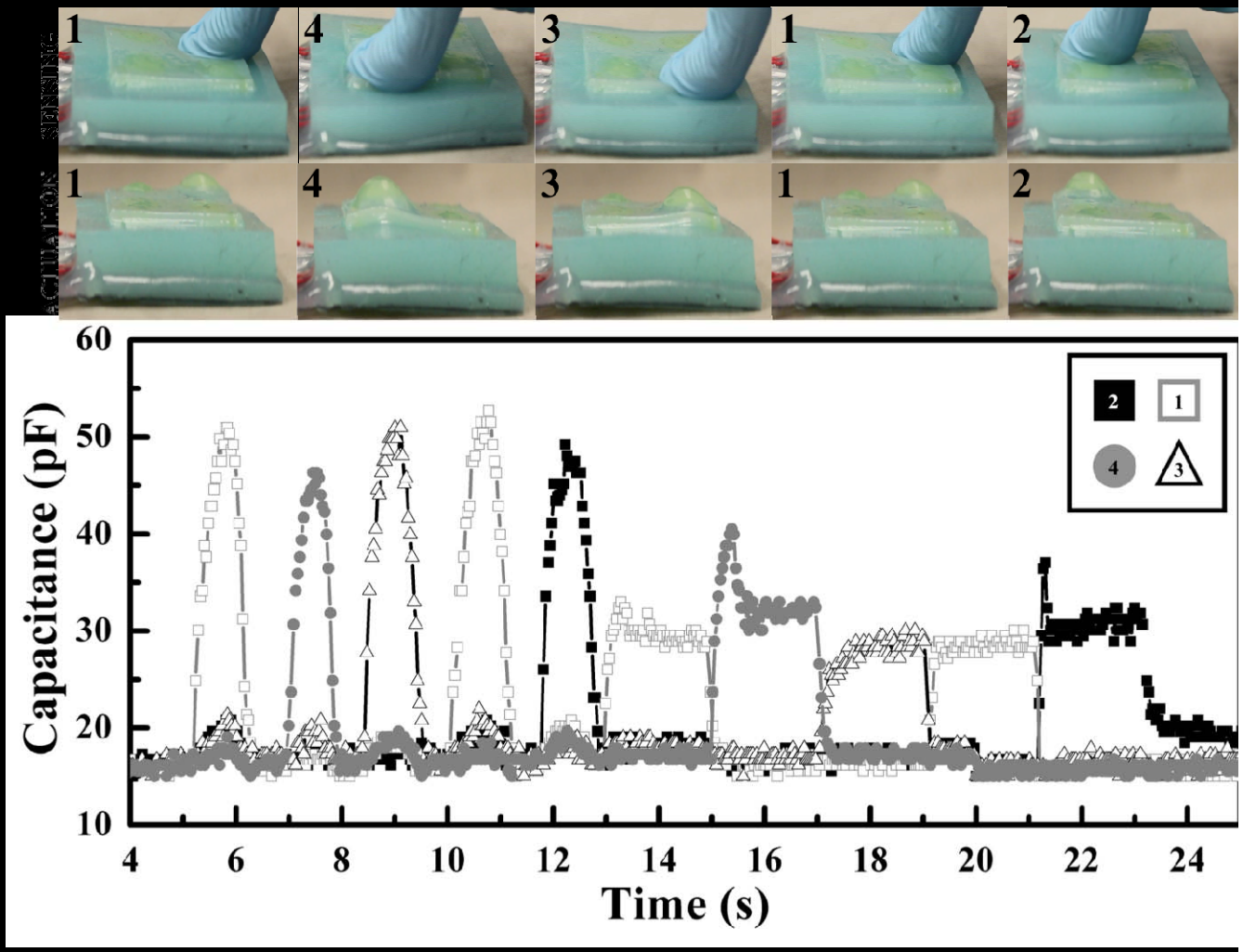
*Peele, et al. Bioinspiration & Biomimetics (2015)

3D Printing Sensors

Transparent, Insulating Rubber

Transparent, Conductive Rubber





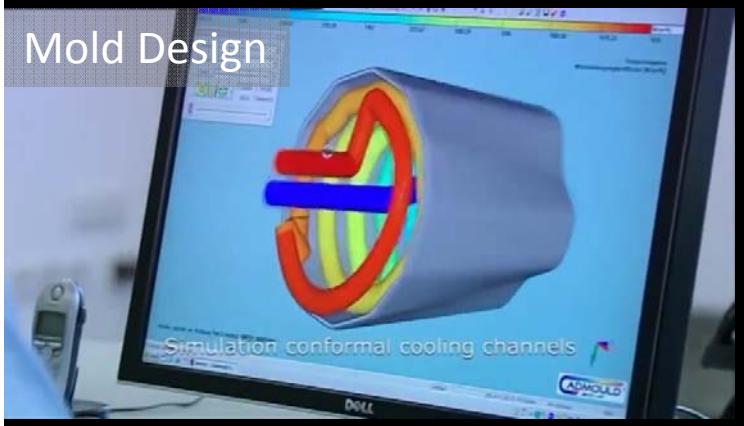
*Robinson, et al. Extreme Mechanics Letters (2015)

3D Printing Sensors Onto Actuators

*Robinson, et al. Extreme Mechanics Letters (2015)

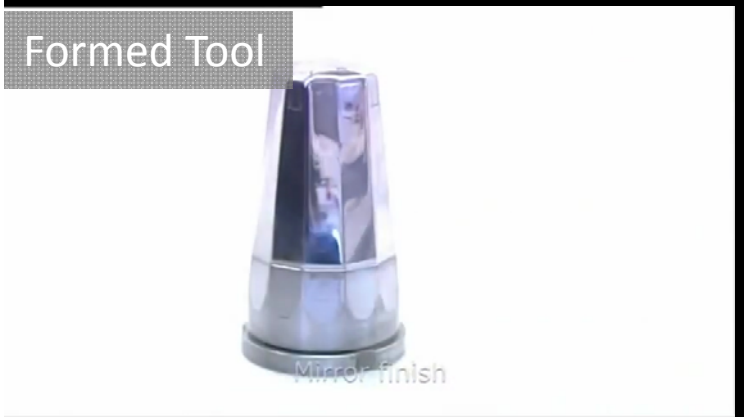
3D Printing Tooling for A.M.

Mold Design



Printing

Formed Tool



- Use 3D printing to form molds for additive manufacturing
- Tool formed using EOS metal sintering, for an injection molding machine – 40% faster cycle time, lower tooling production cost
- Opportunity to replace metal molds

Cornell's Role in Injection Molding

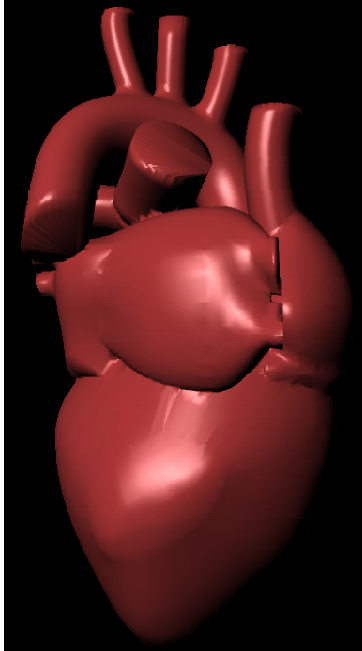
- 1970: K.K. Wang, PI of project; H. McManus, Dept. Head; R. Shepherd, Director of Sibley School; E. Cranch, Dean of Engineering
- Eastman Kodak – needs a tool to injection mold a $10 re-usable camera and wanted a scientific method for mold design
- K.K. Wang turned market need into research opportunity and developed C-Mold software, now owned by Autodesk, Inc.

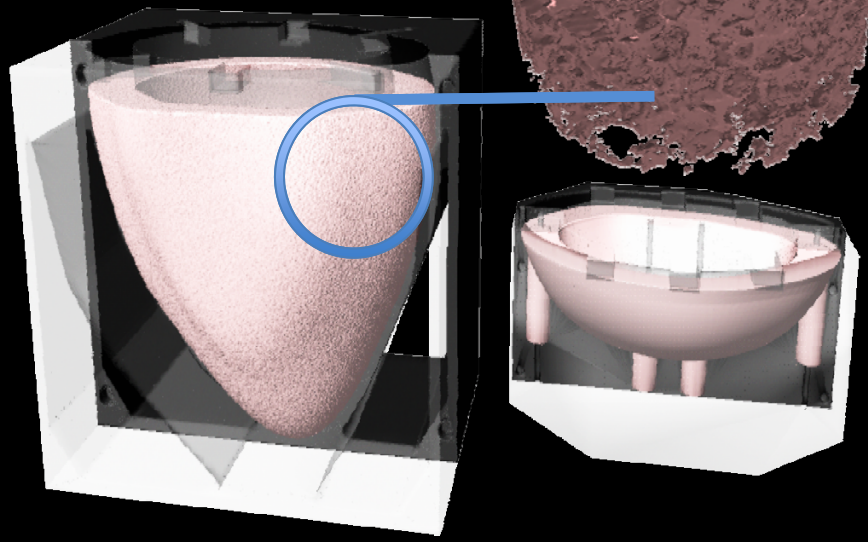
- Simulation tools to predict mold design
- Rapid manufacturing of tooling
- New era in thermoforming

Molding foam hearts

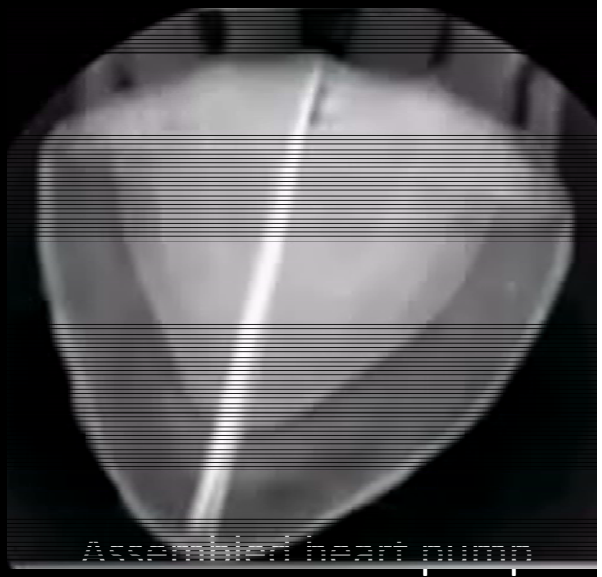
CT scan of foamed silicone

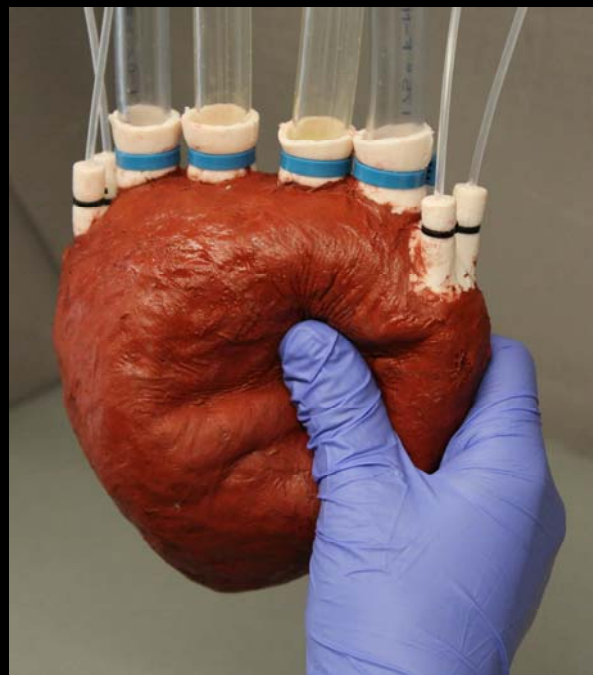
Digital heart model



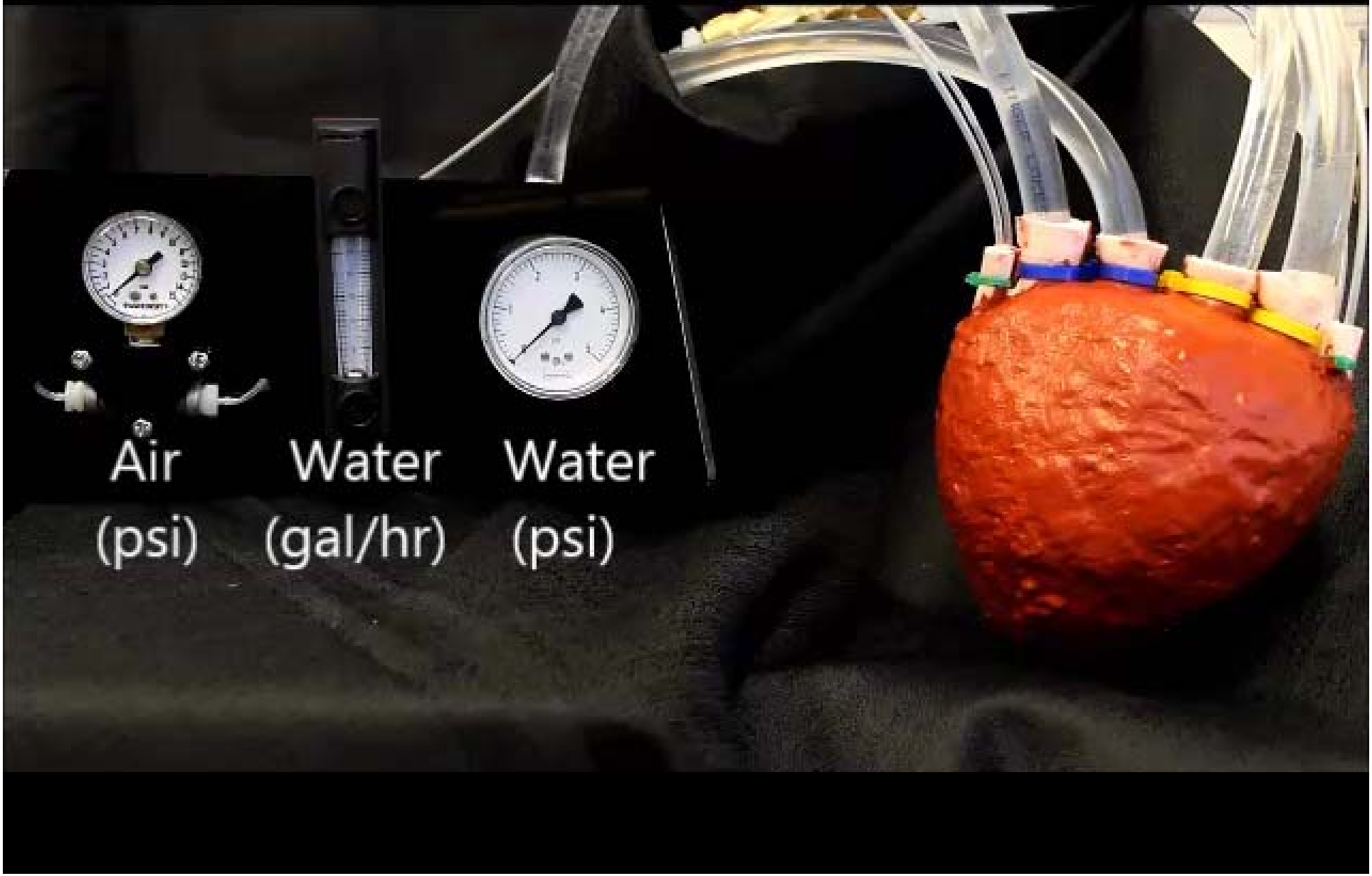


3D Printed mold of heart and foam casting

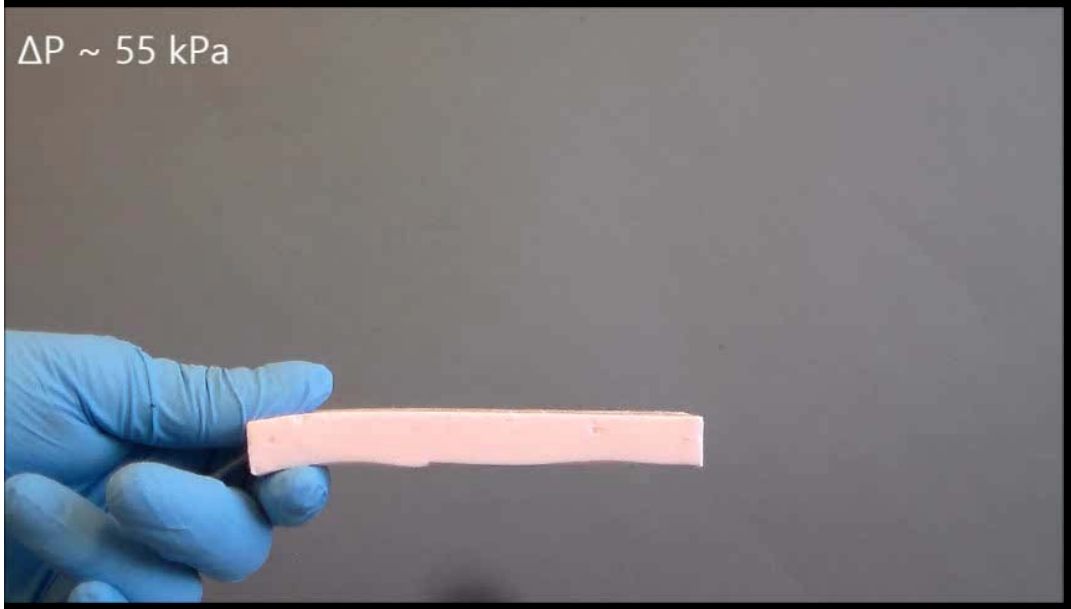


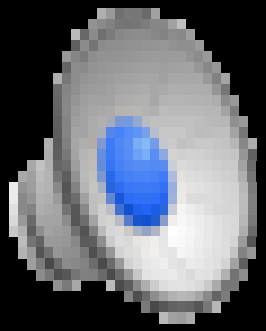


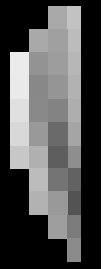
3D printing synthetic biomedical machines



Casting foams for soft machines







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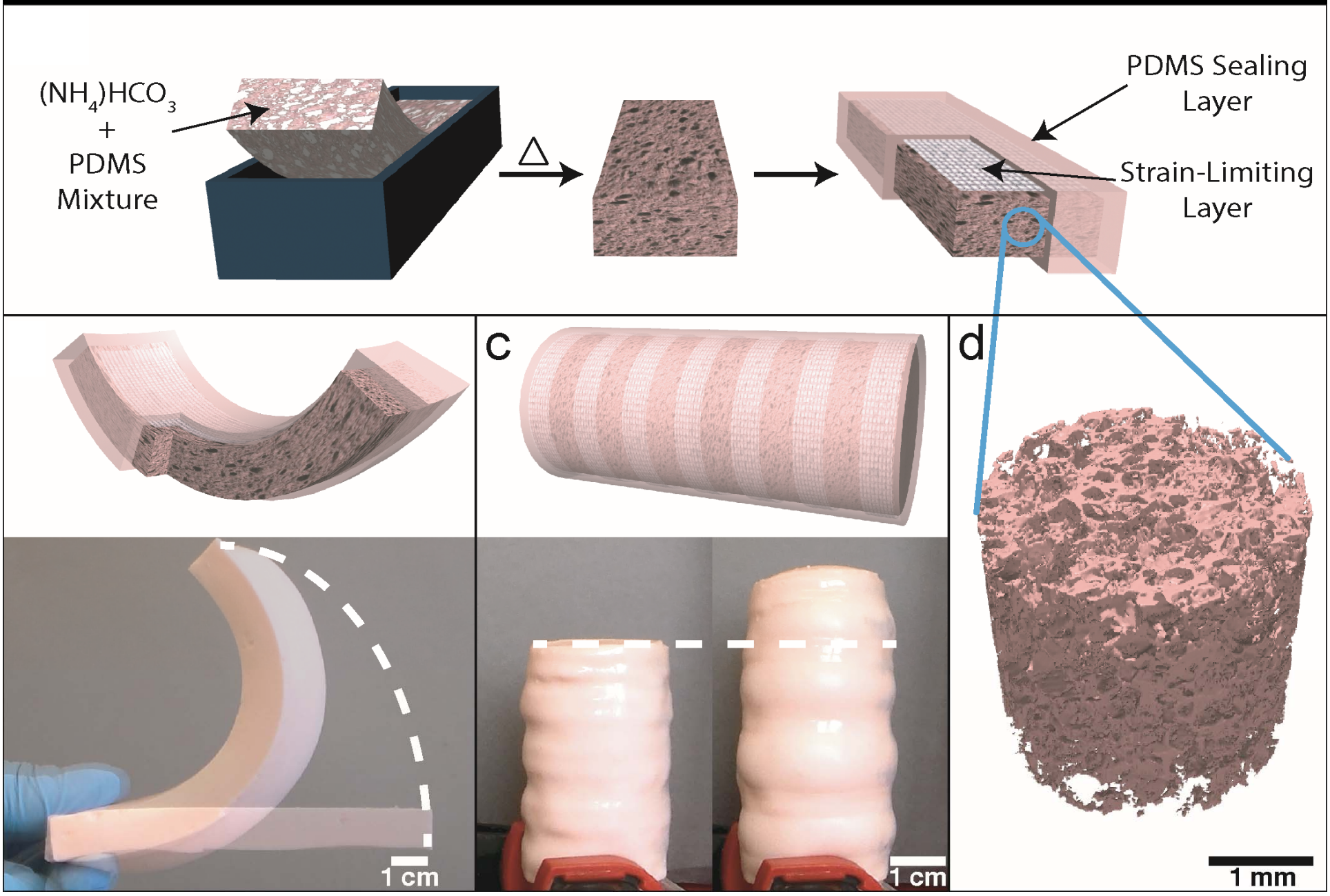

Acknowledgements