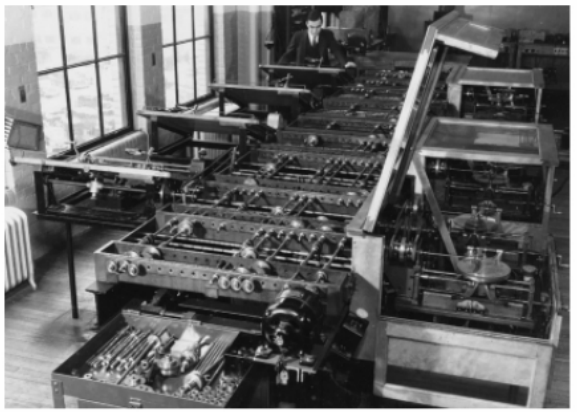
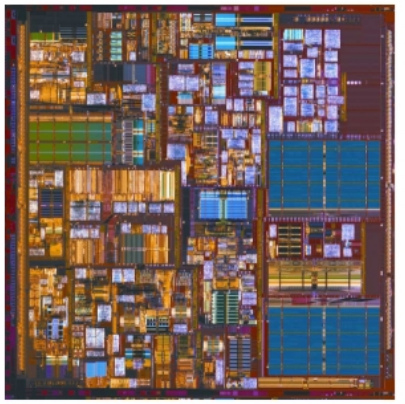
Additive Assembly of Functional Digital Materials

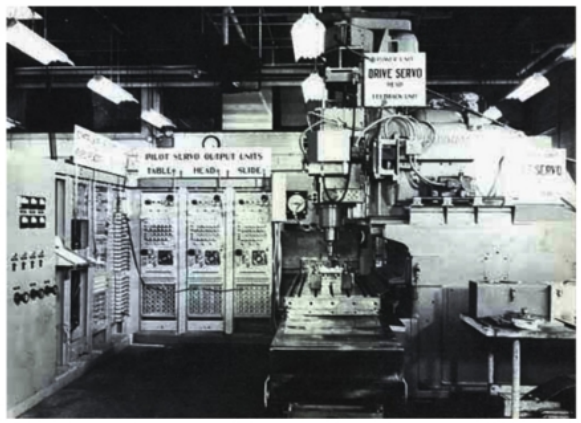
Digital Revolutions

analog → digital communication
~1945

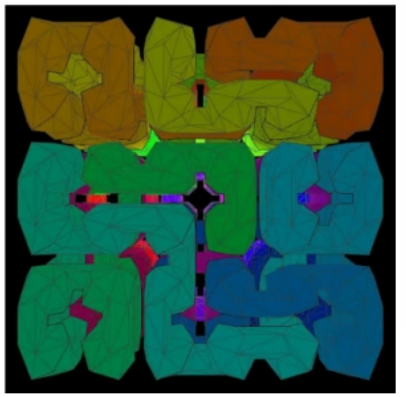


analog → digital computation
~1955





analog → digital fabrication
~2005



THE CENTER FOR BITS AND ATOMS
Massachusetts Institute of Technology

VE RI TAS

OTHERlab

DARPA

BIOLOGY

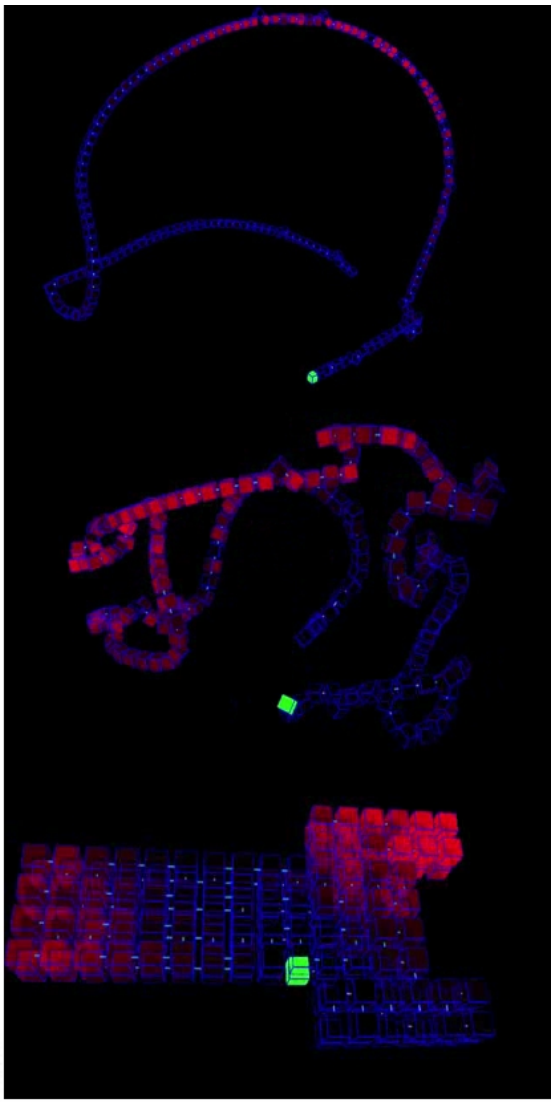
PROGRAMMABLE ASSEMBLY

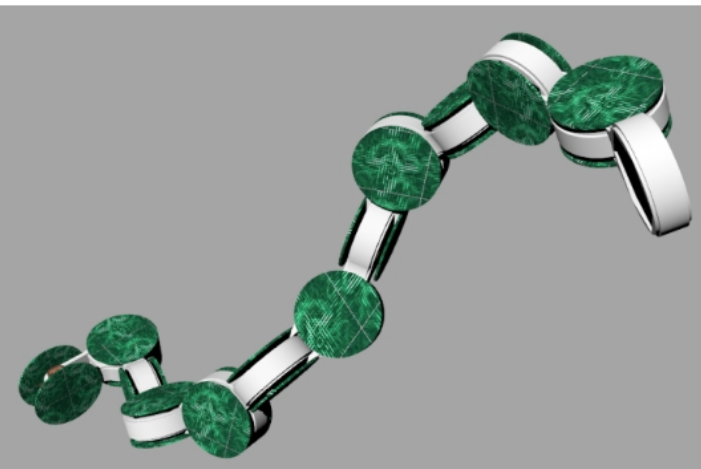
CODED ASSEMBLY

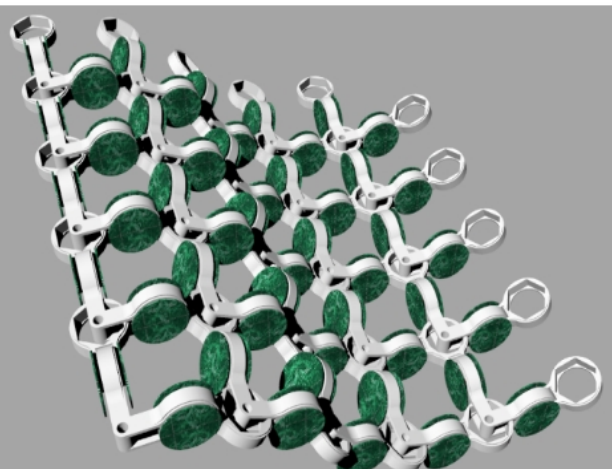
SELF ASSEMBLY

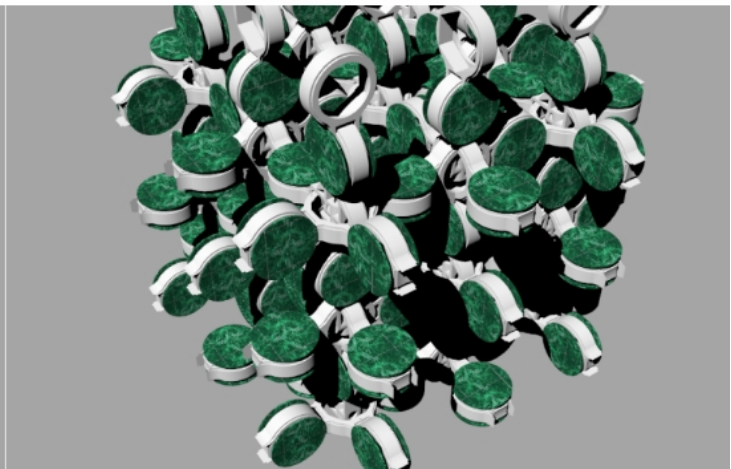
Milli-Biology

nm um mm cm Length scale



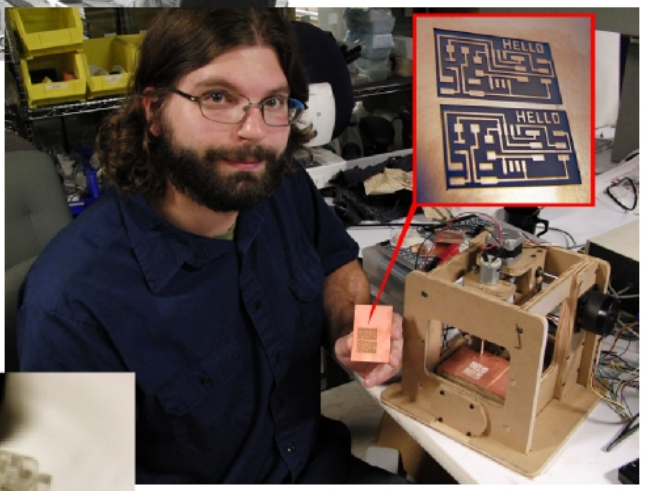




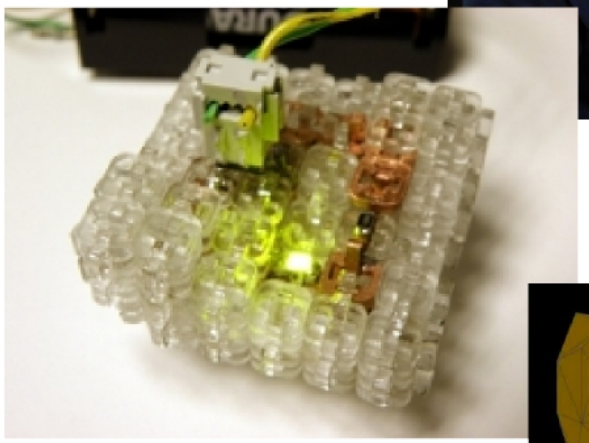


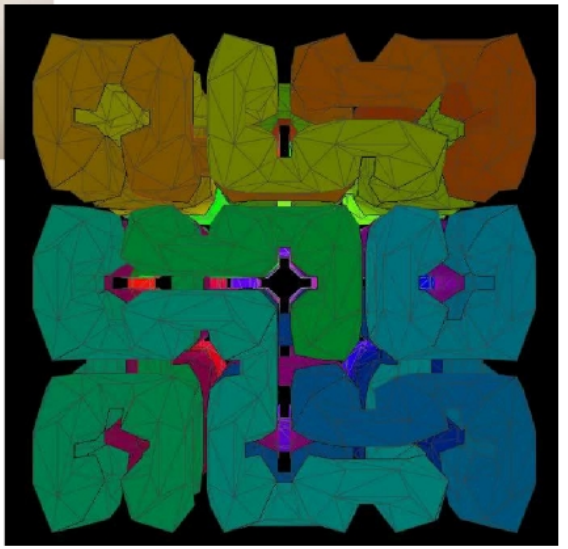
1.0: computers → machines

2.0: machines → machines



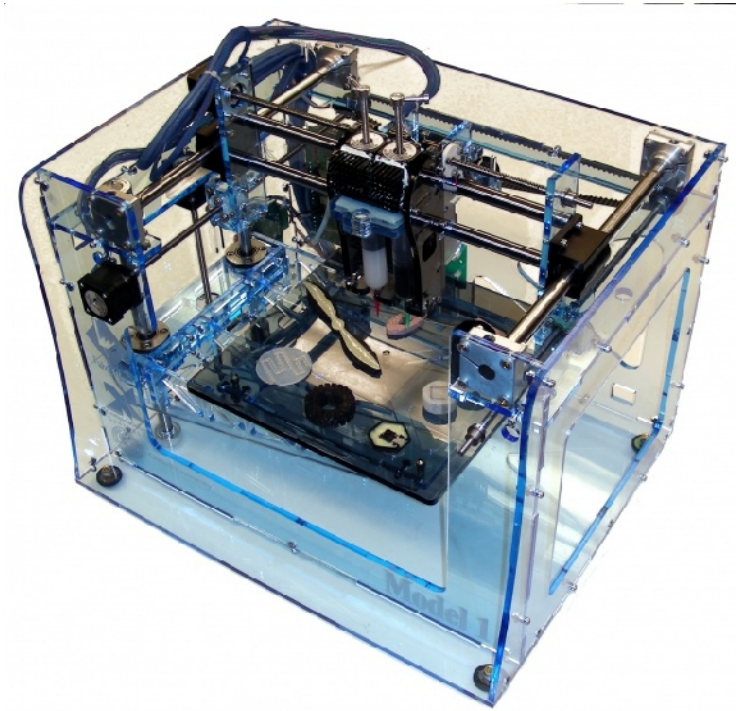
3.0: codes → materials

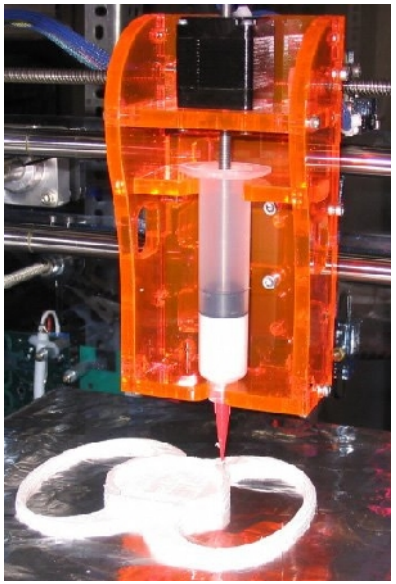




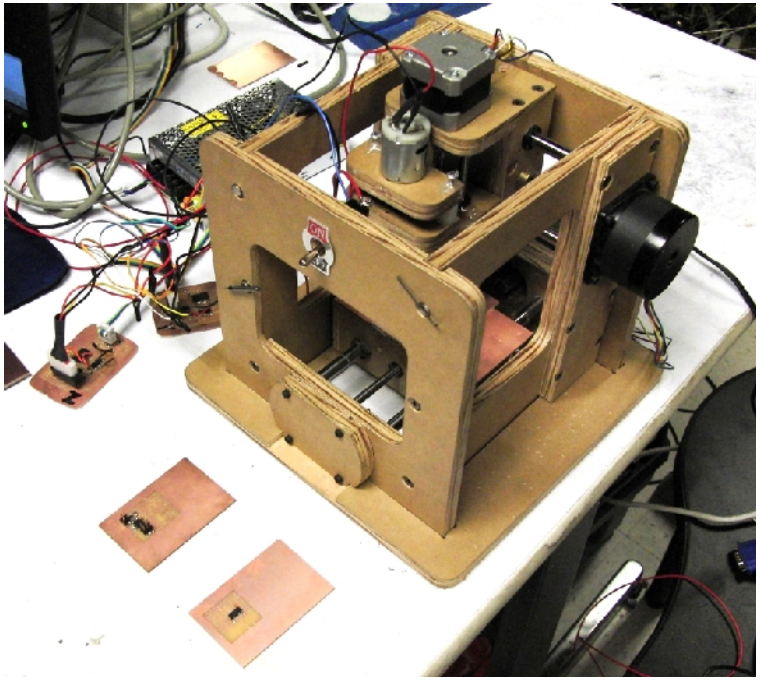
4.0: programs → materials

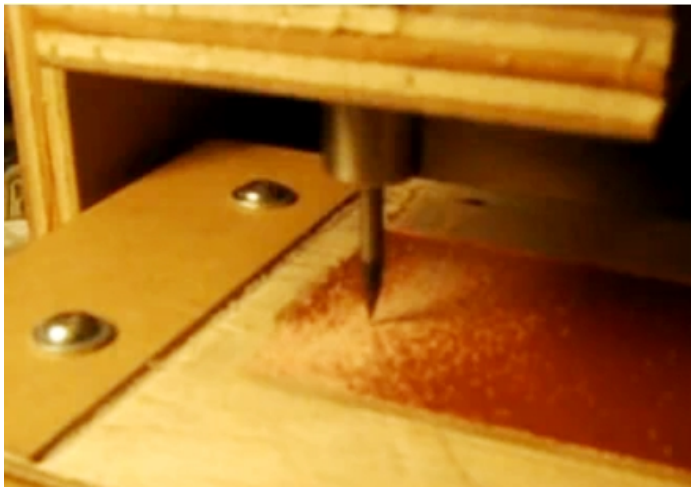
Additive



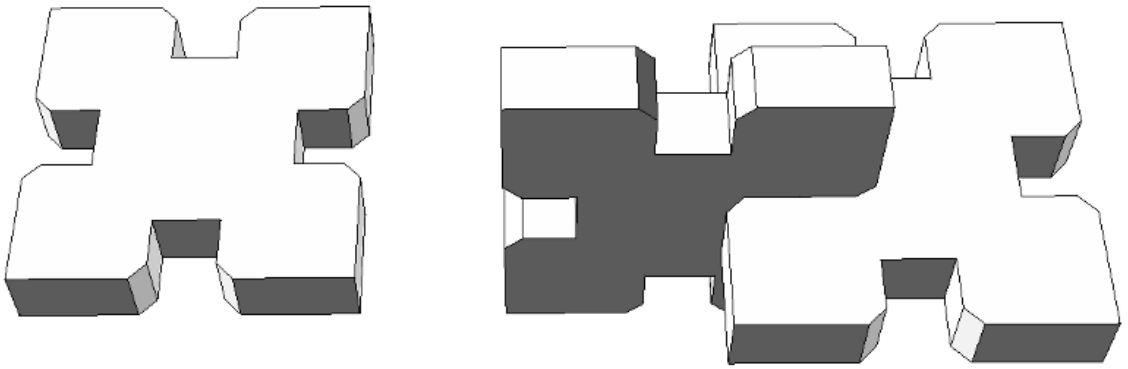


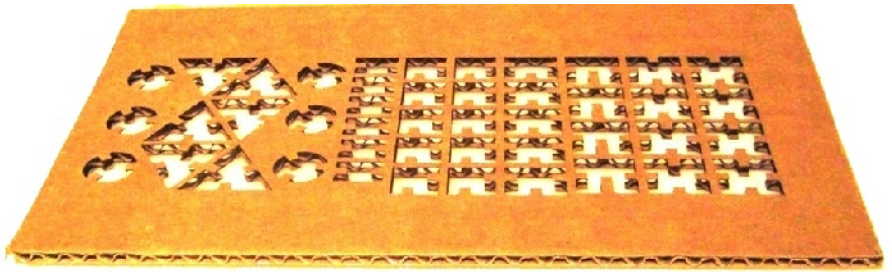
Subtractive

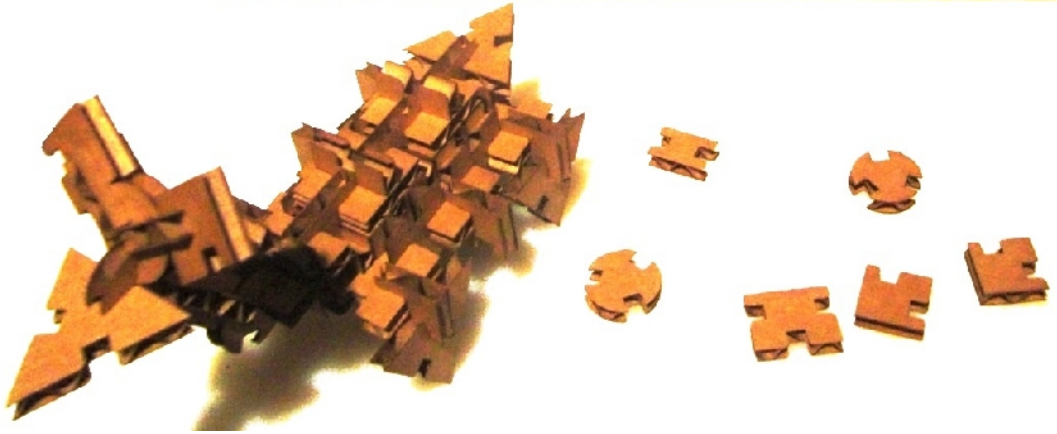




Digital Materials

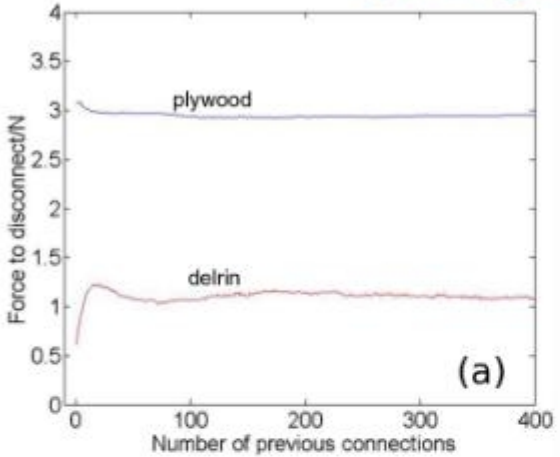


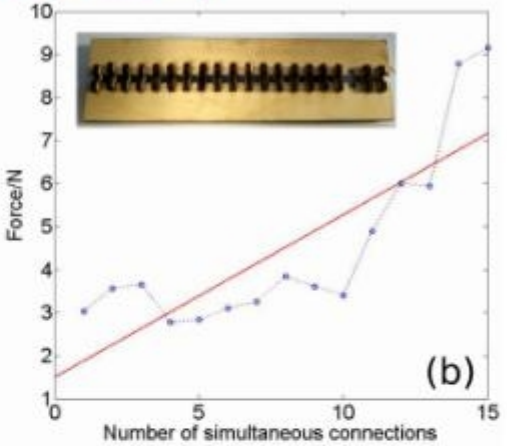


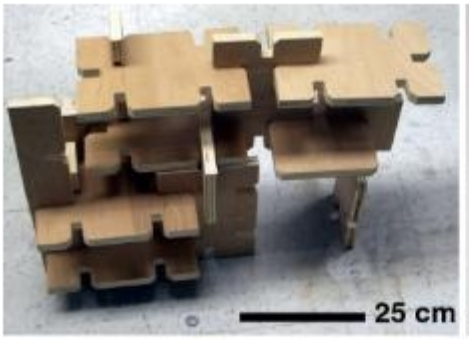


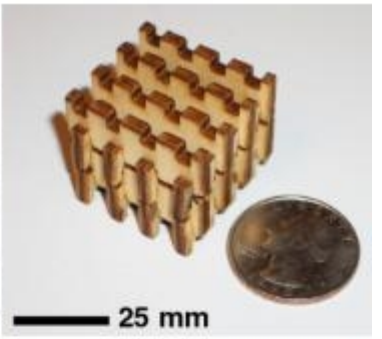
digital materials

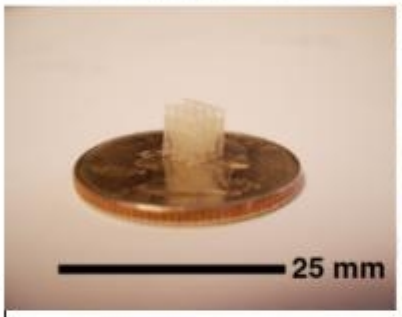
(George Popescu)

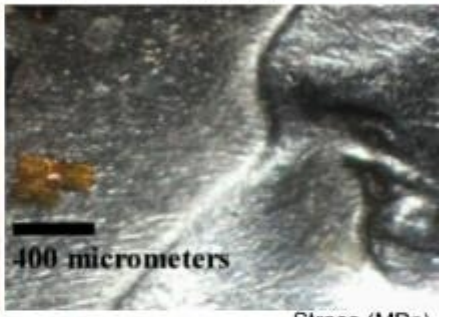


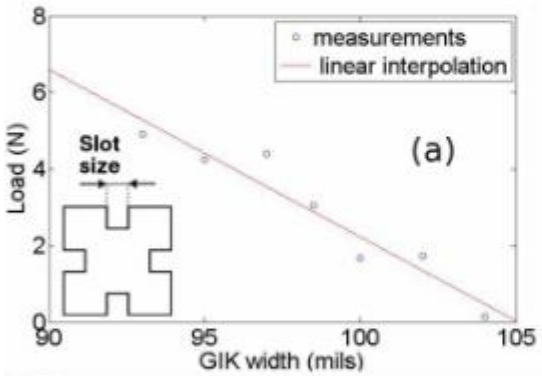


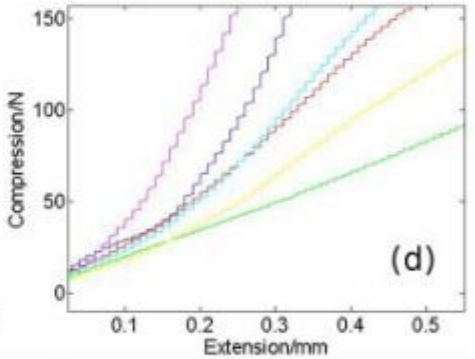


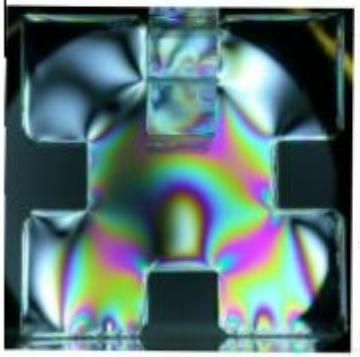


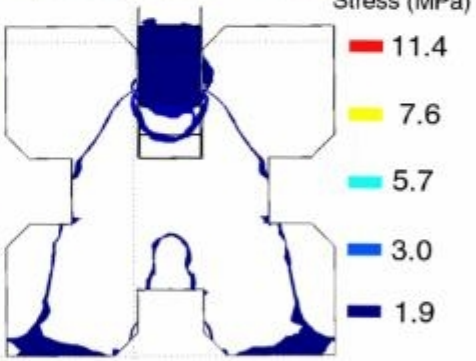


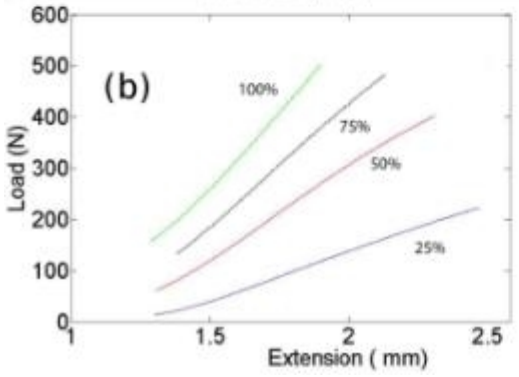


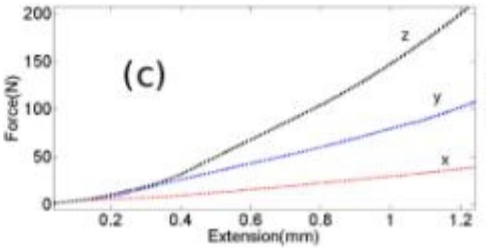


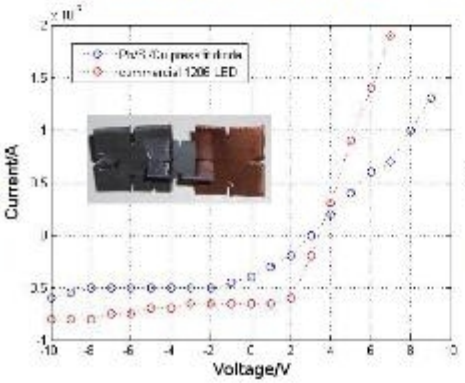


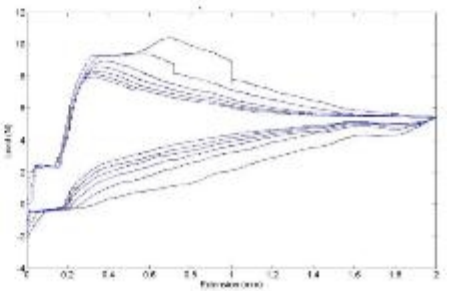


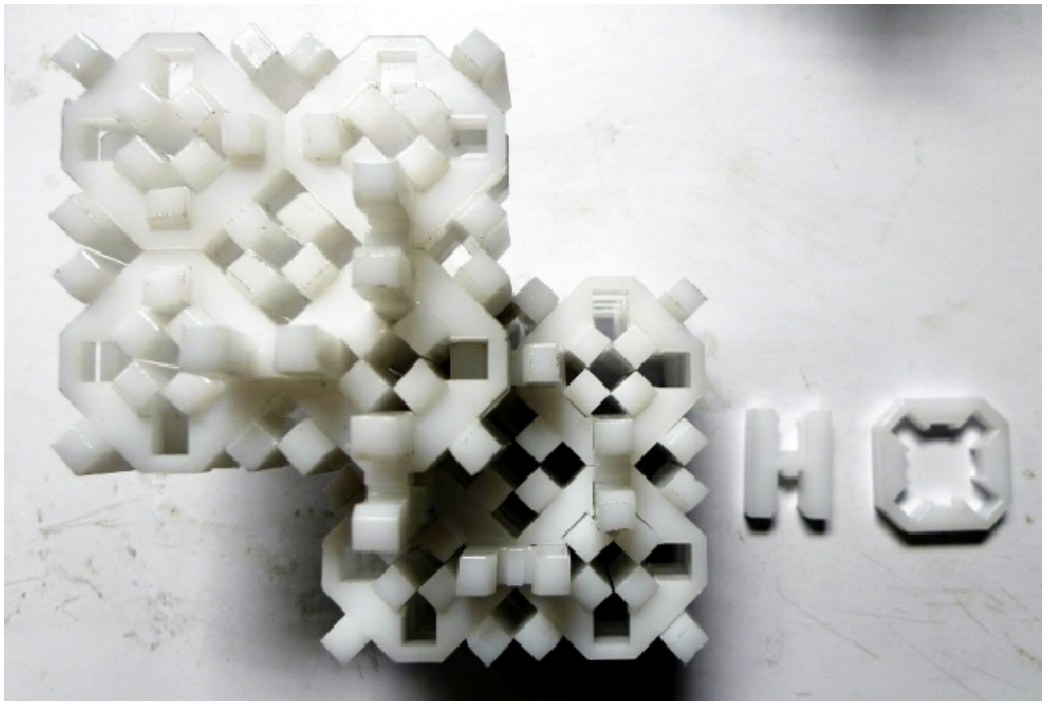


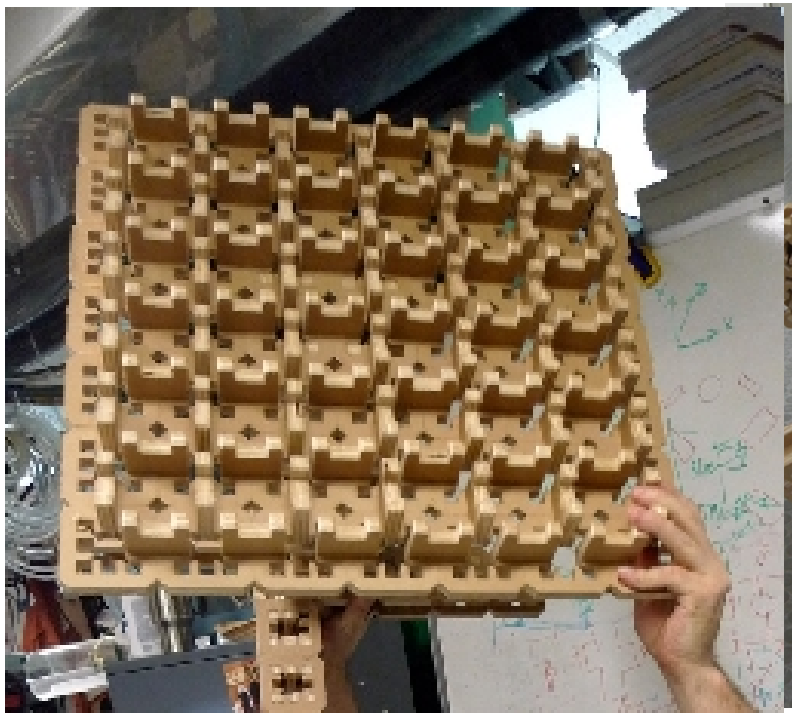


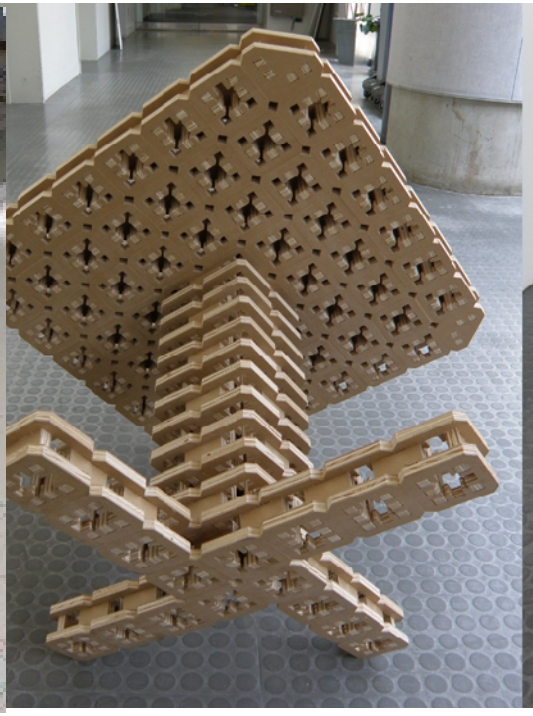


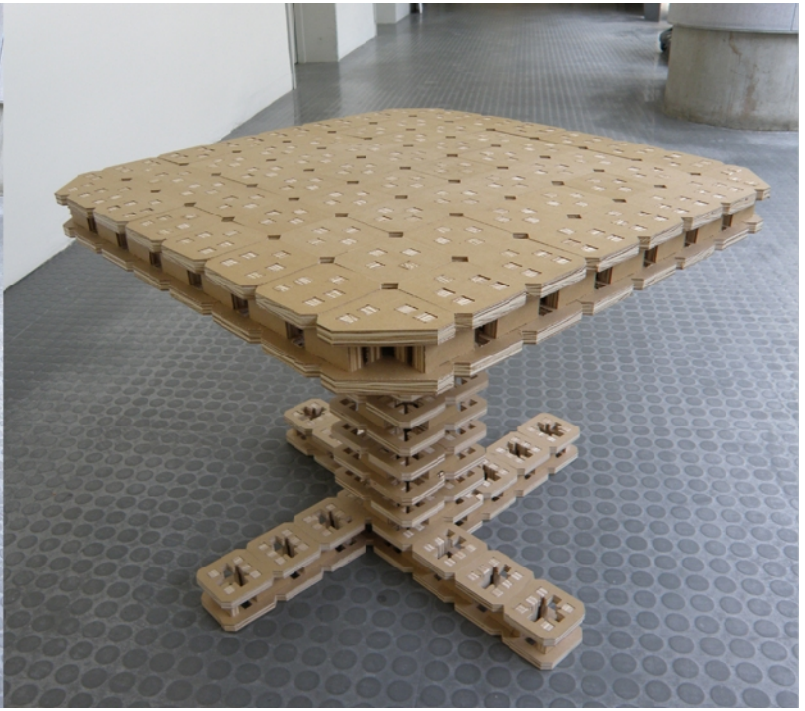


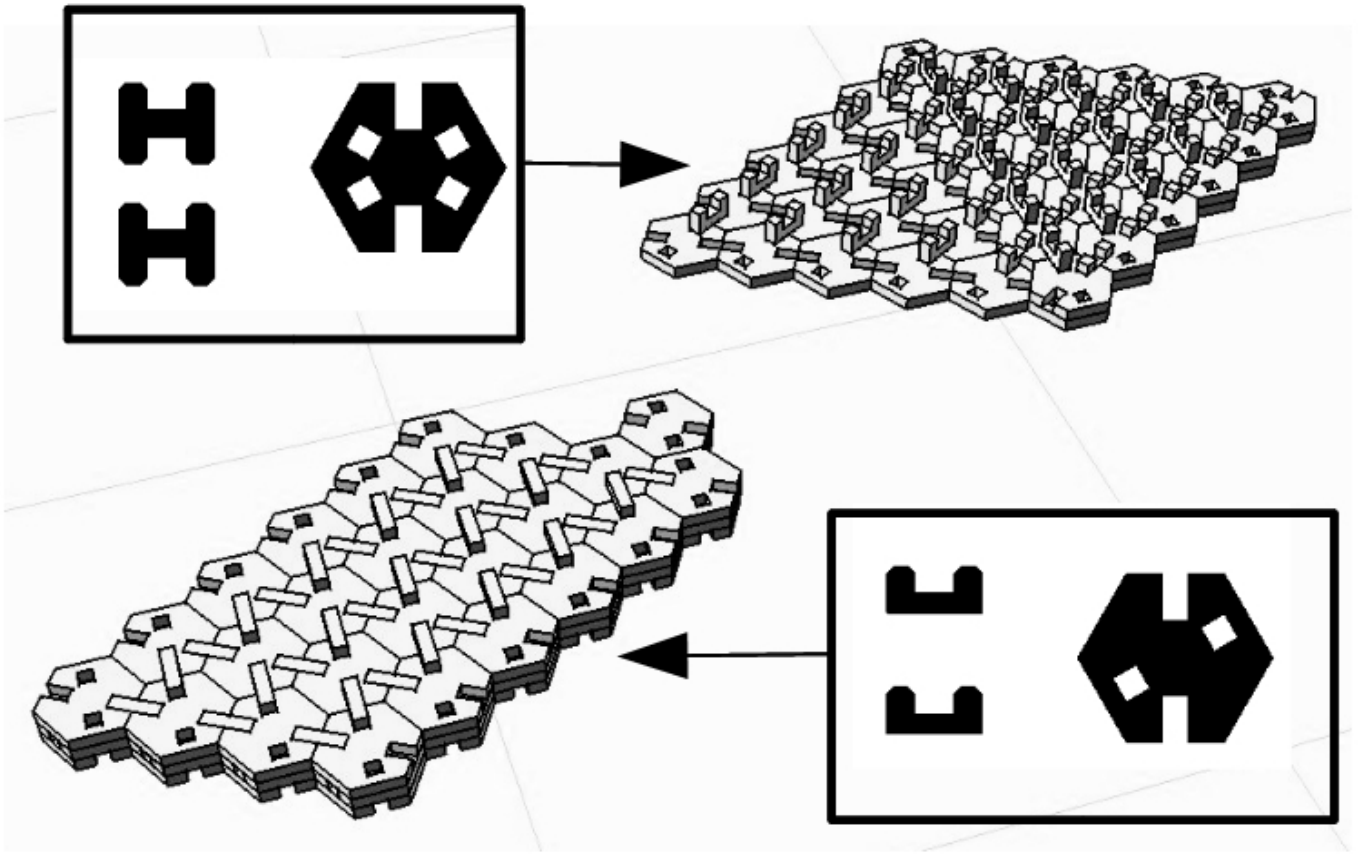


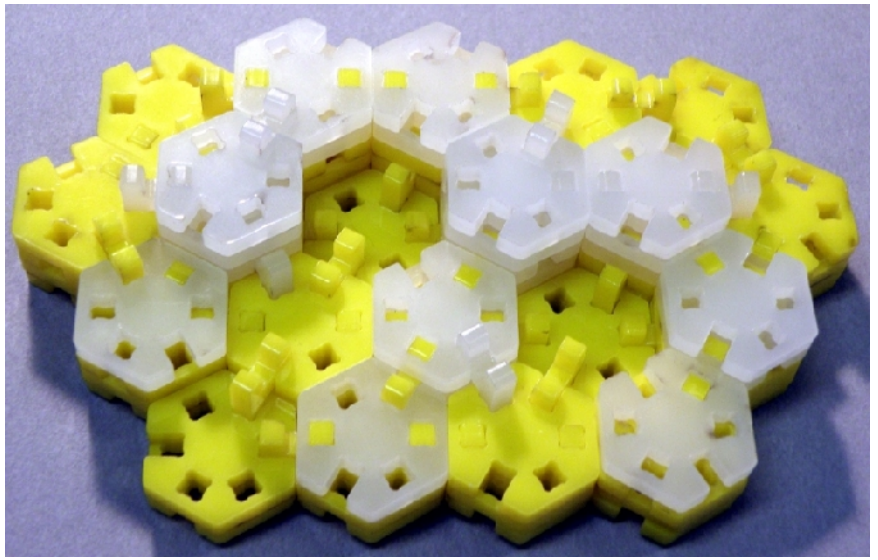


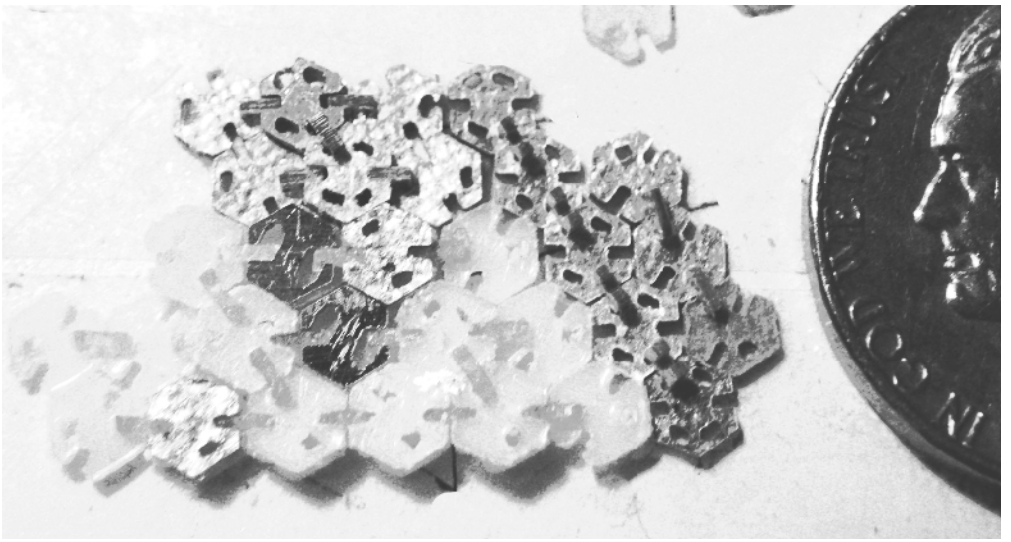


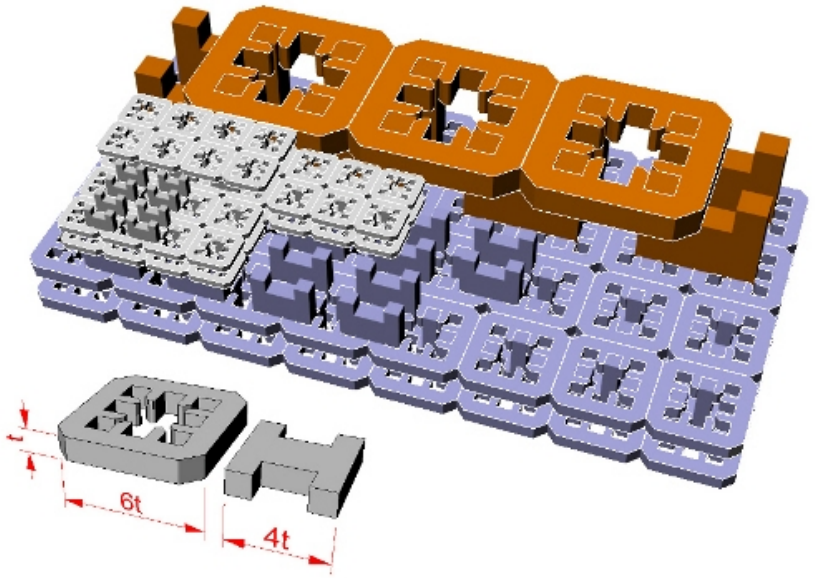








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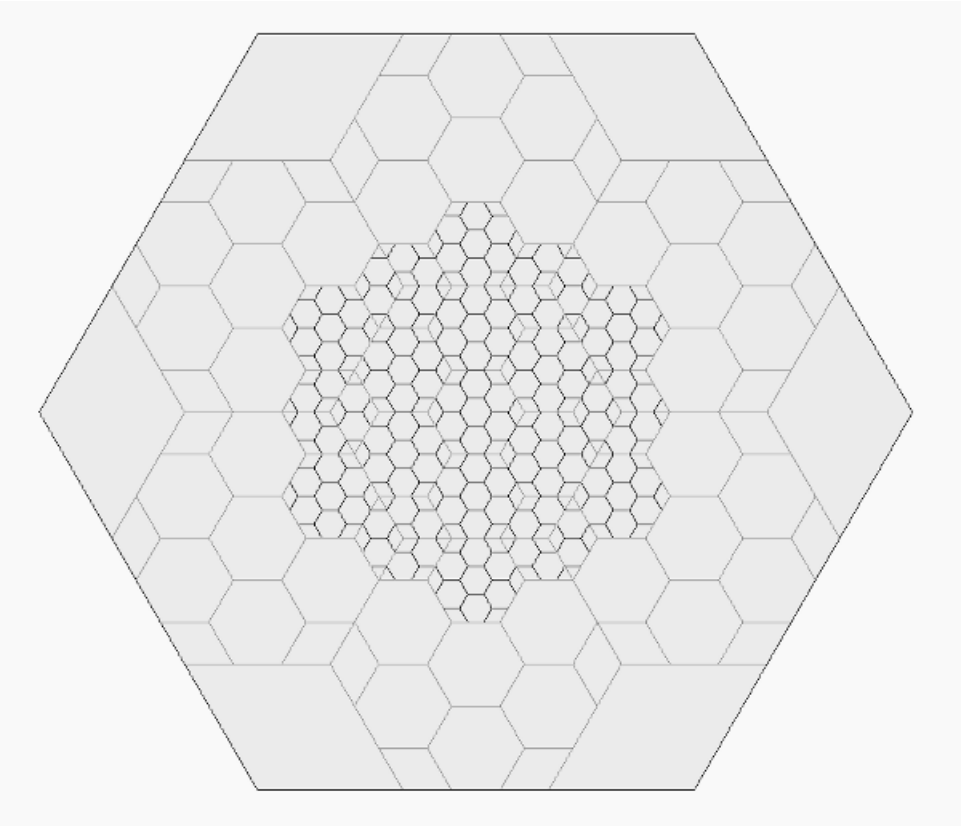
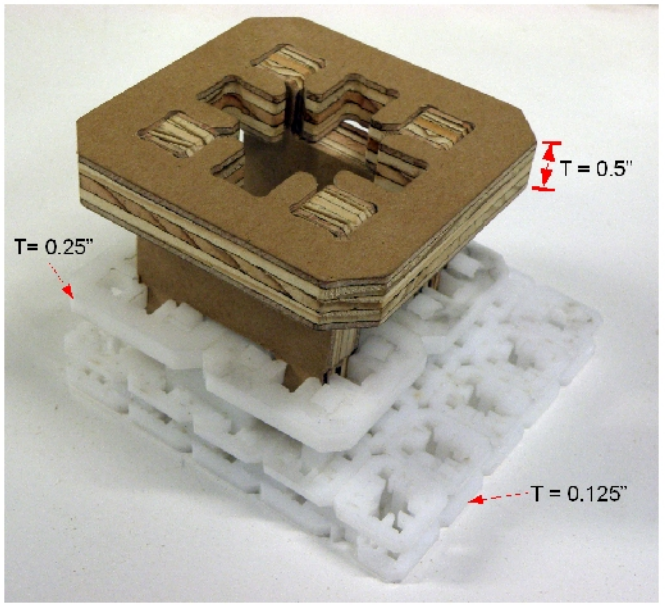
4t

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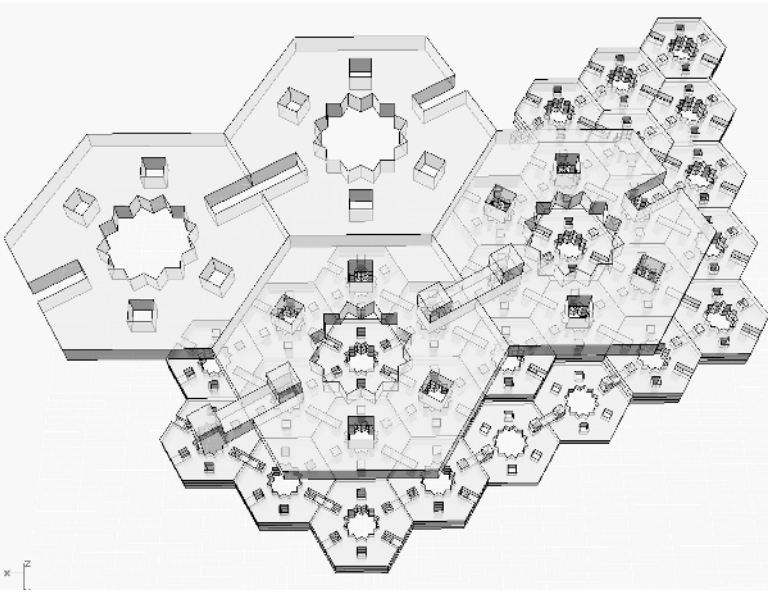

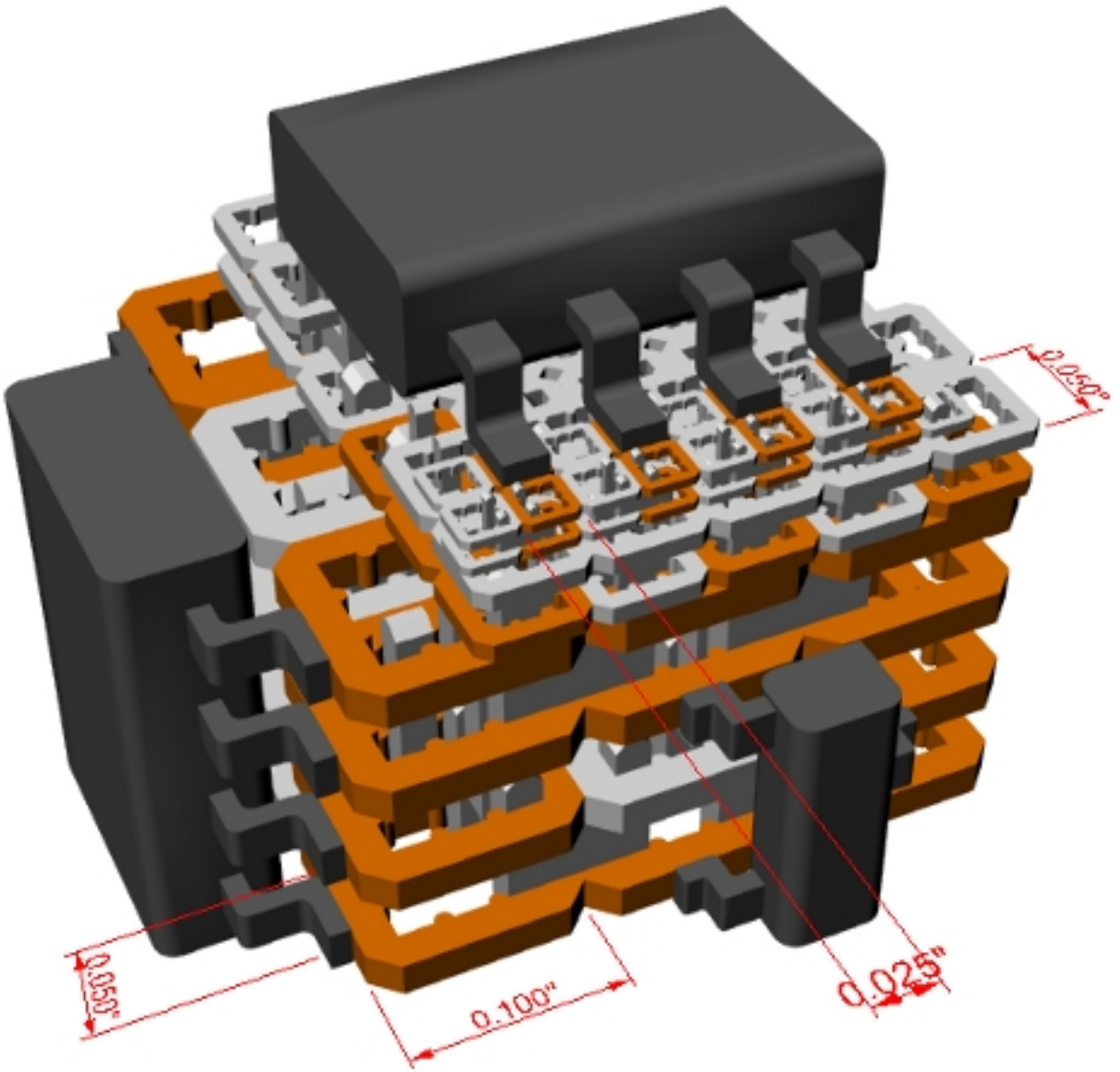
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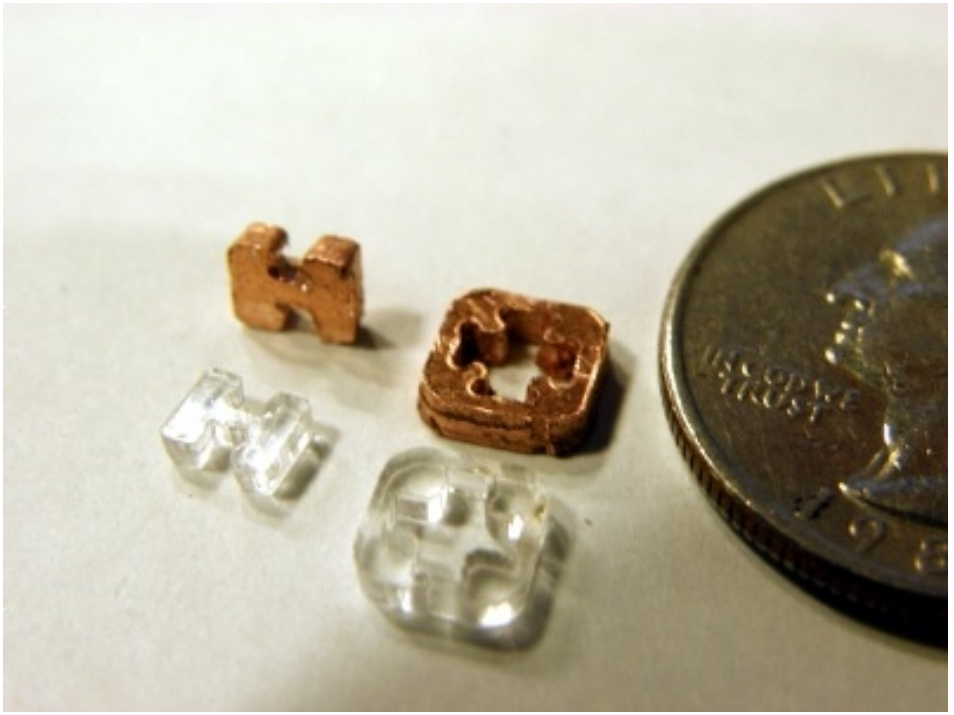
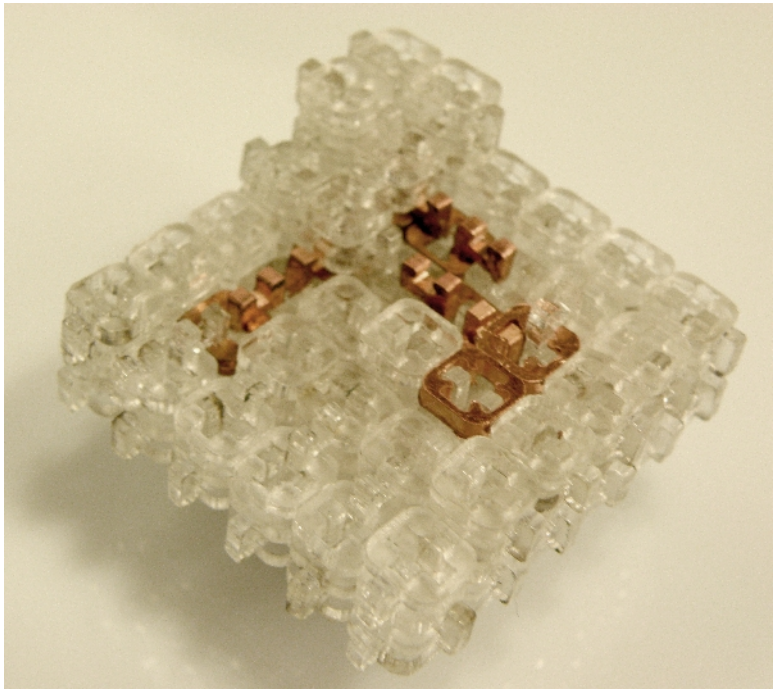
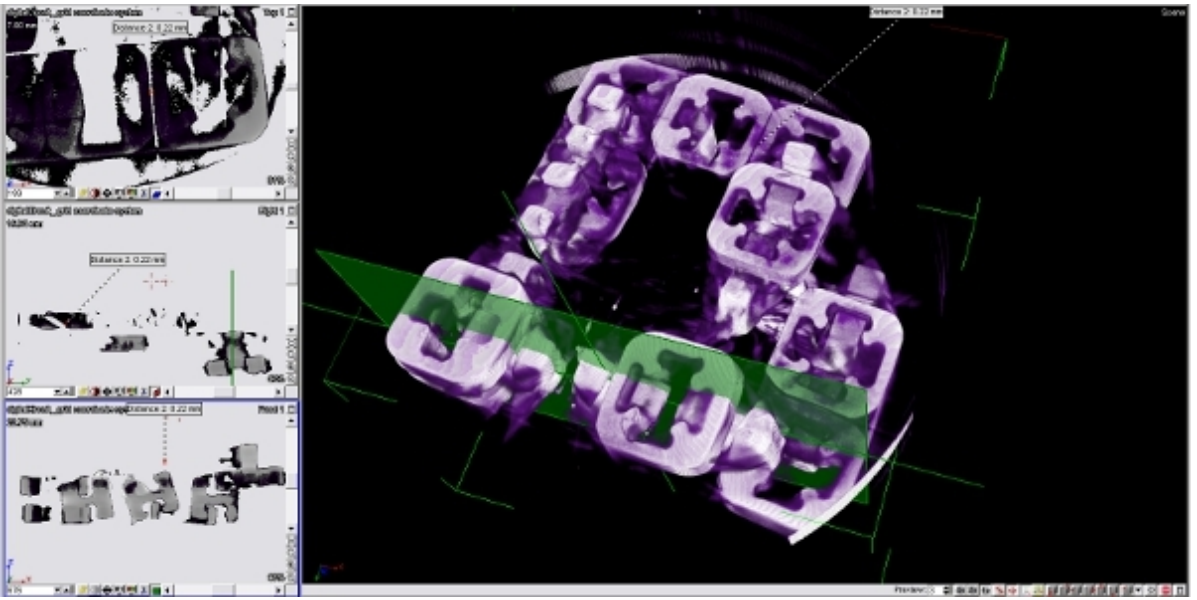
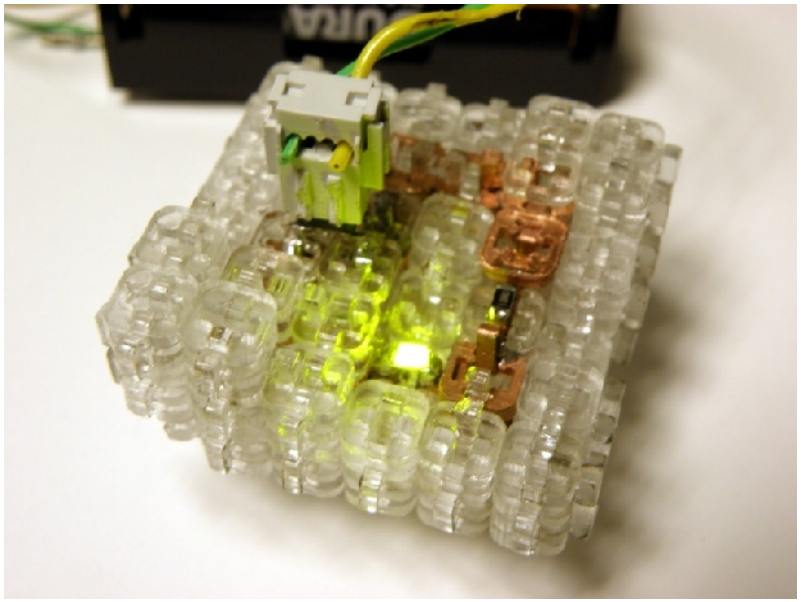
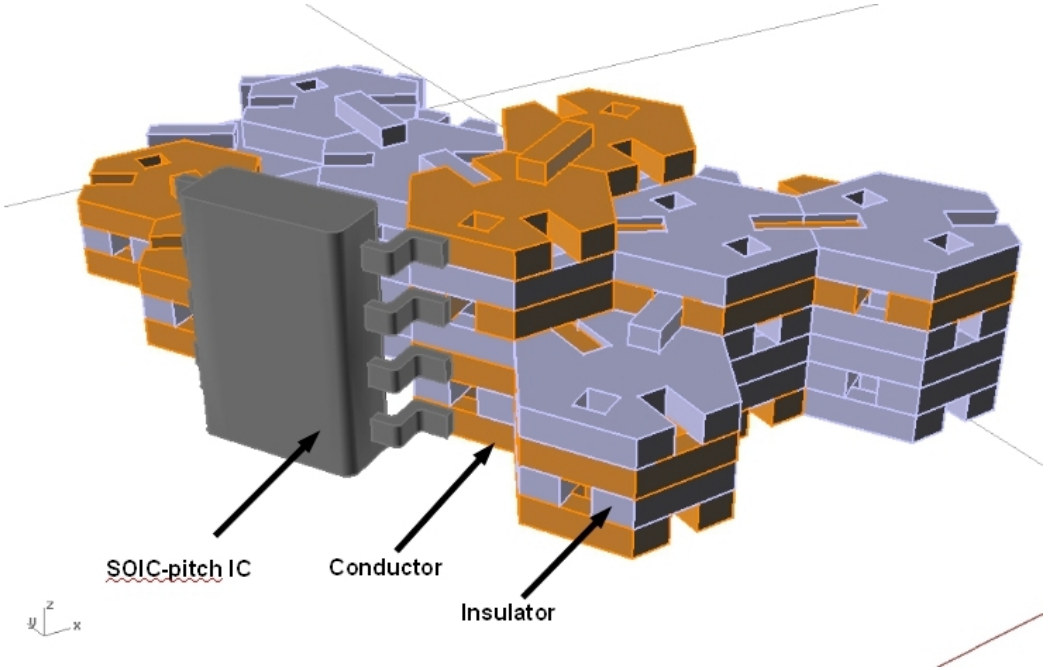
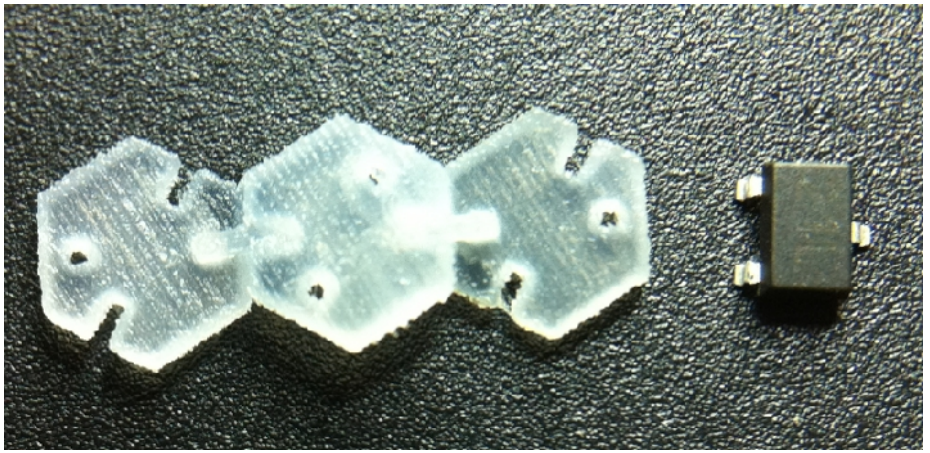


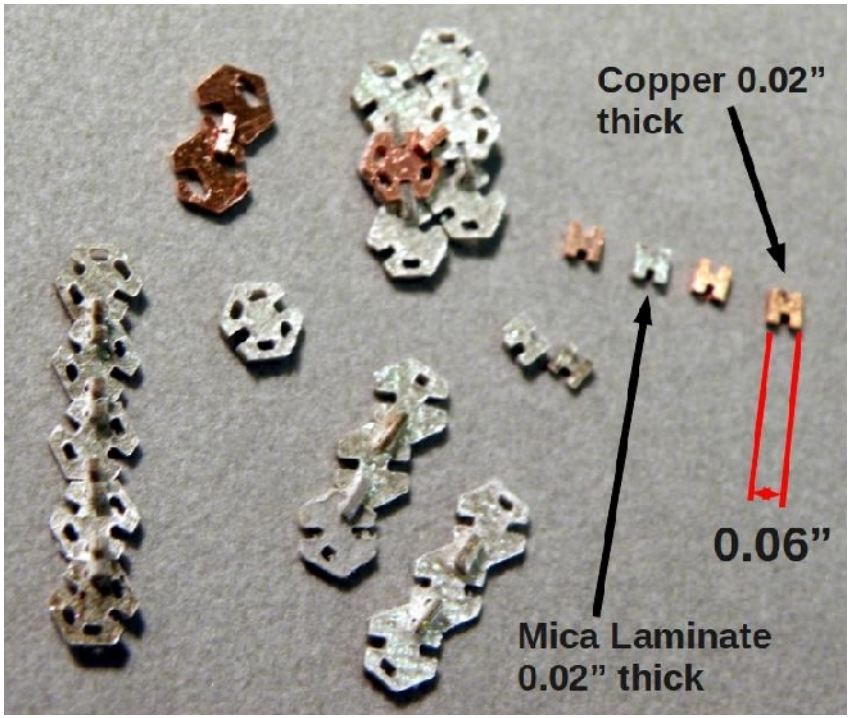


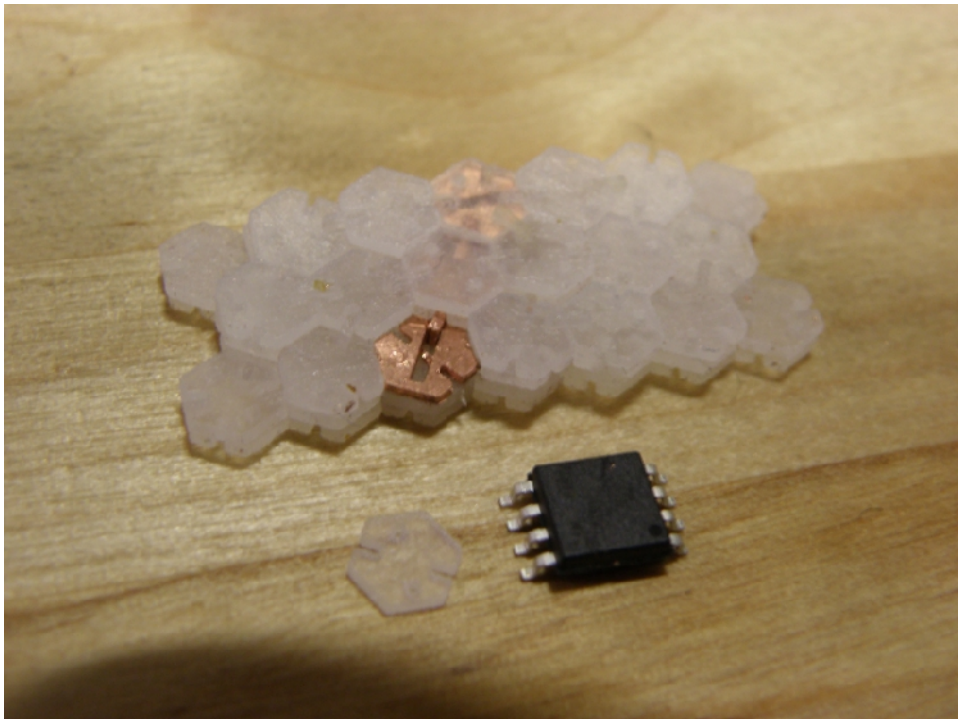


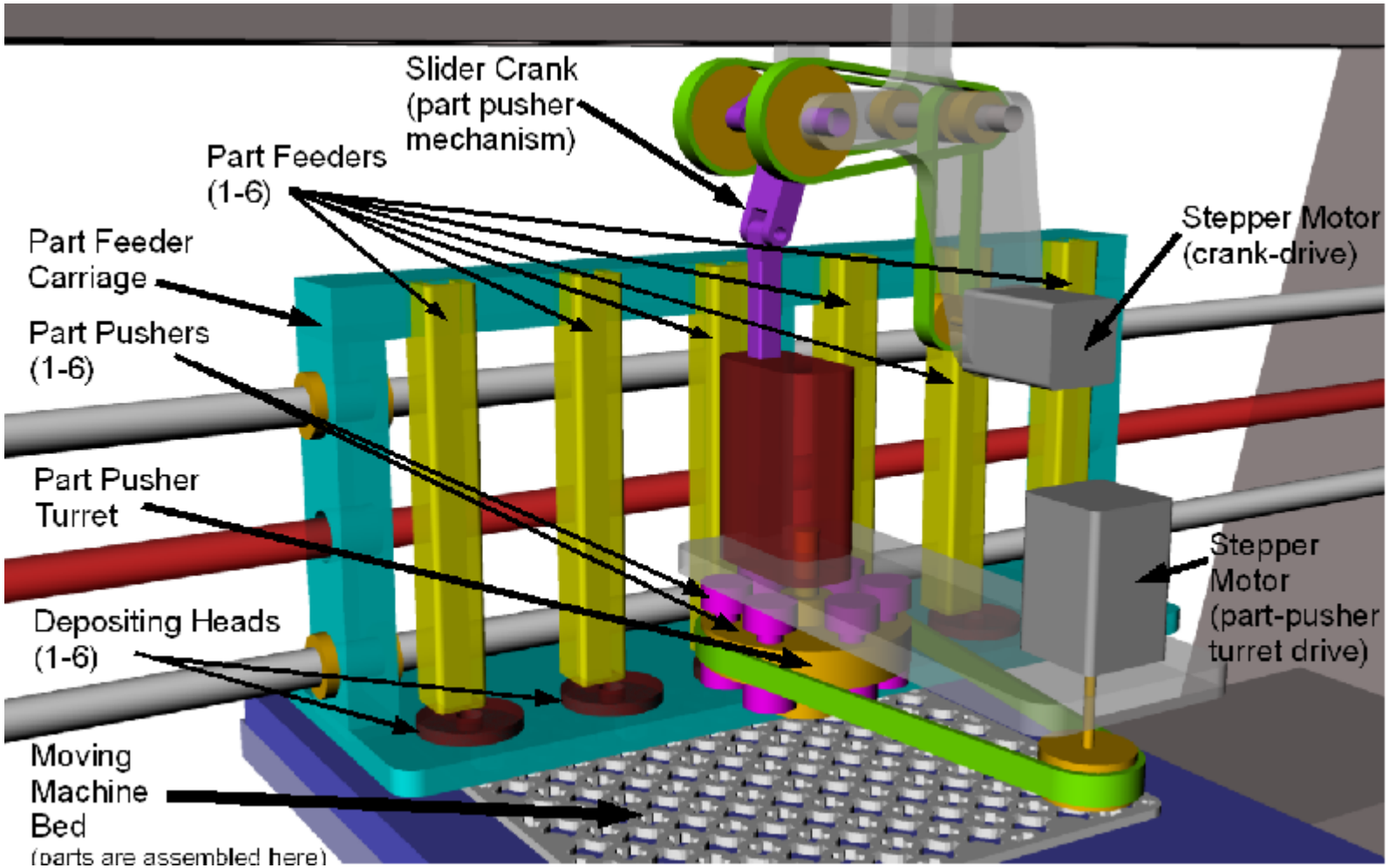


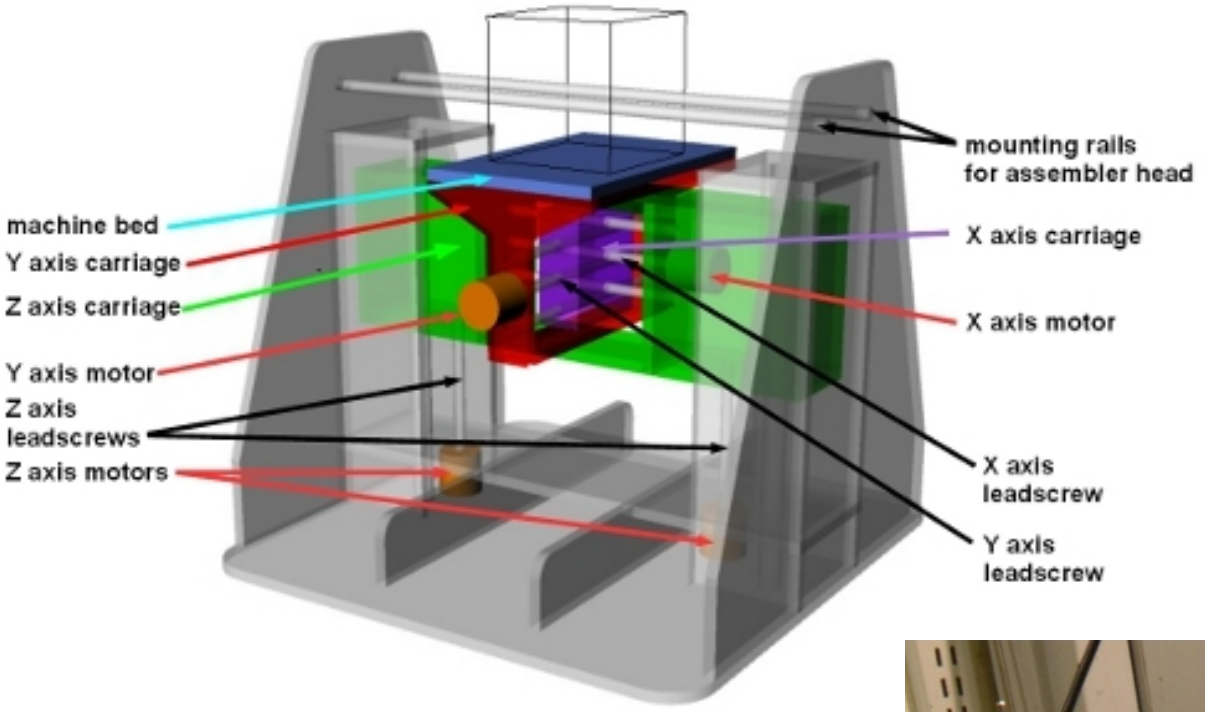

SOIC-pitch IC
Conductor
Insulator

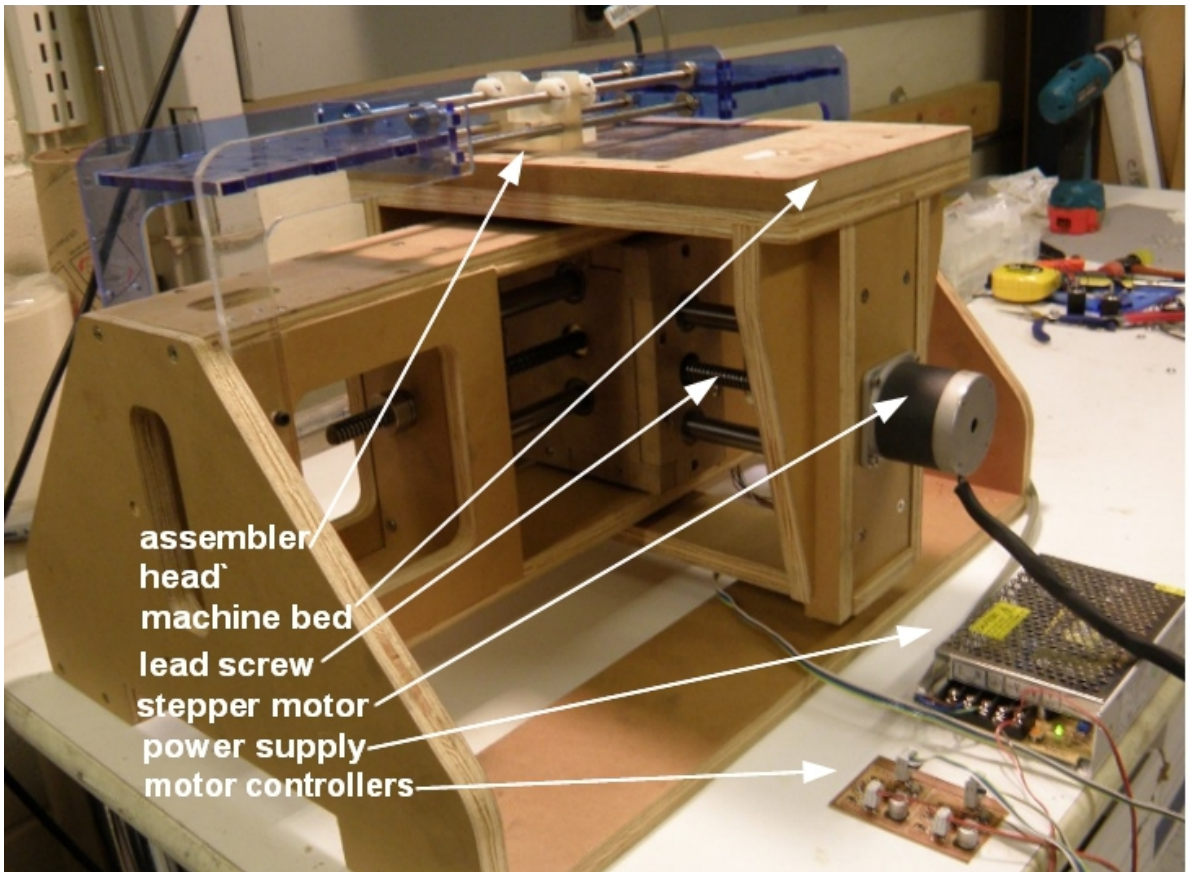


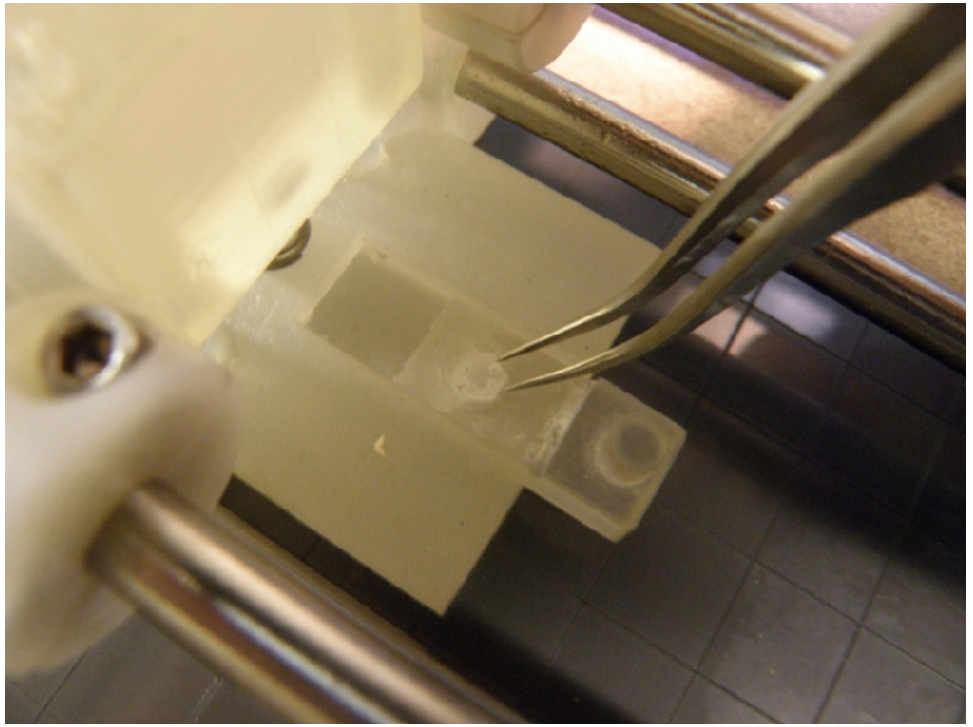

Copper 0.02" thick
0.06"
Mica Laminate 0.02" thick

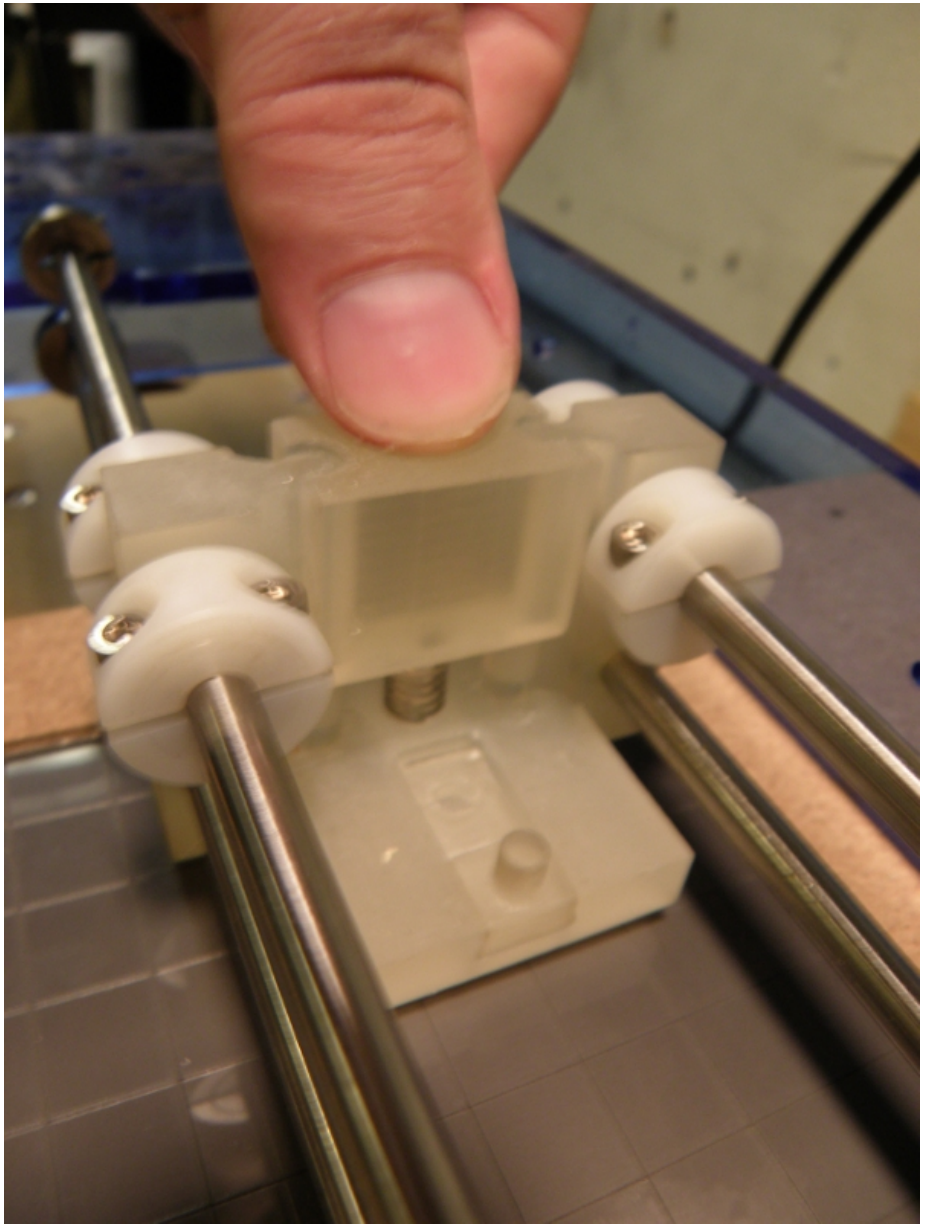


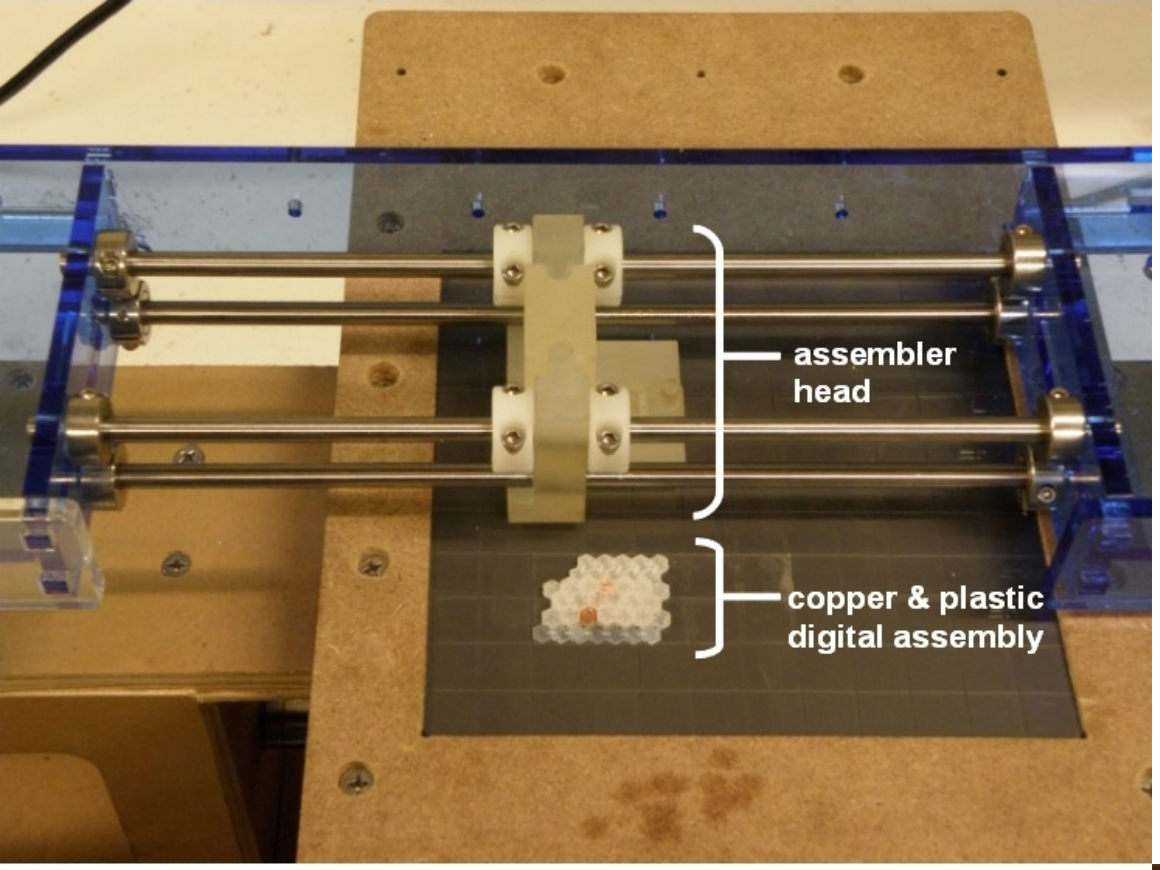

Slider Crank
(part pusher
mechanism)
Part Feeders
(1-6)
Part Feeder
Carriage
Part Pushers
(1-6)
Part Pusher
Turret
Depositing Heads
(1-6)
Moving
Machine
Bed
(parts are assembled here)
Stepper Motor
(crank-drive)
Stepper
Motor
(part-pusher
turret drive)

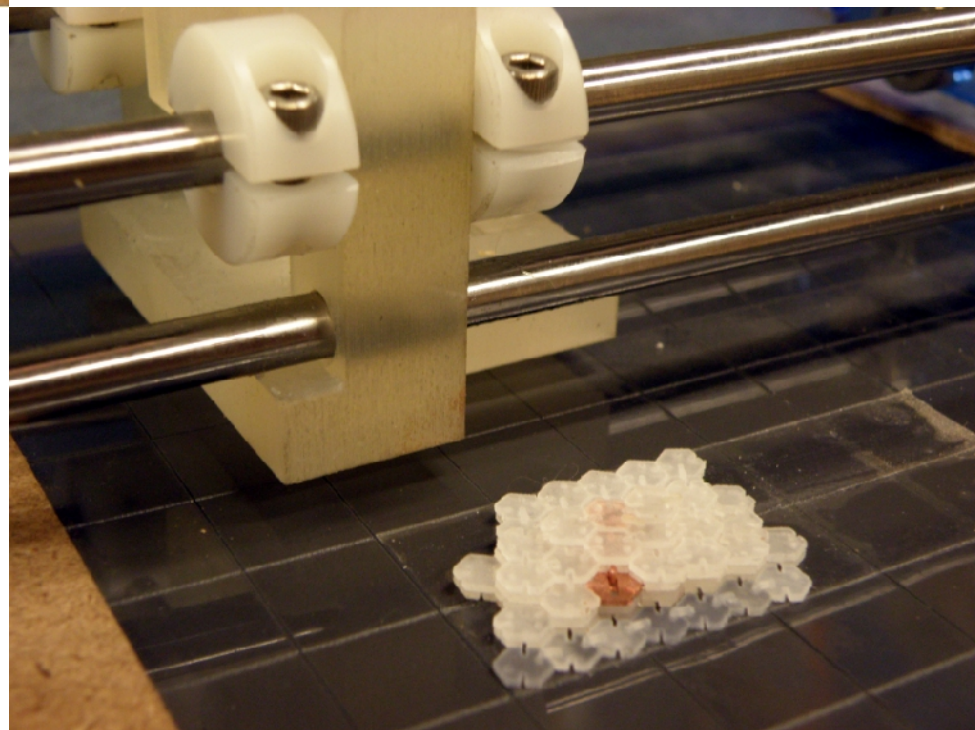
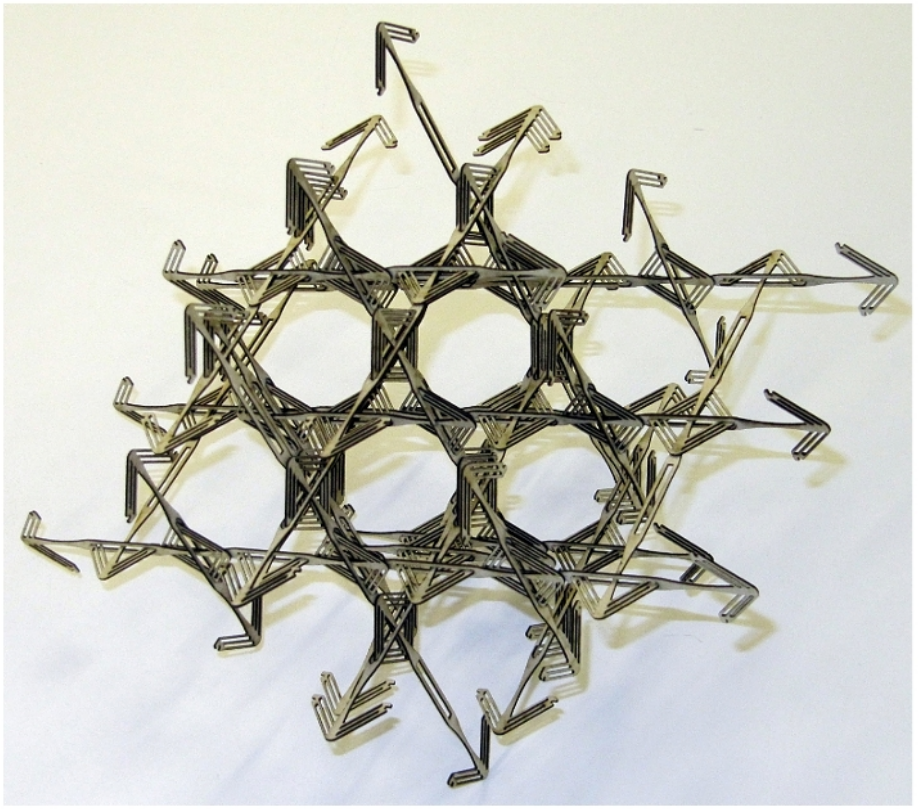
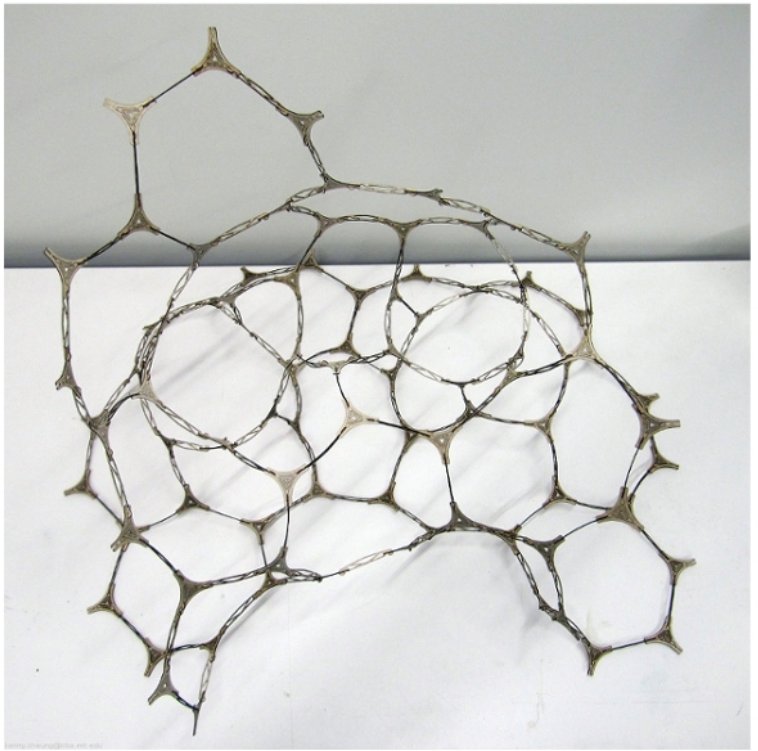
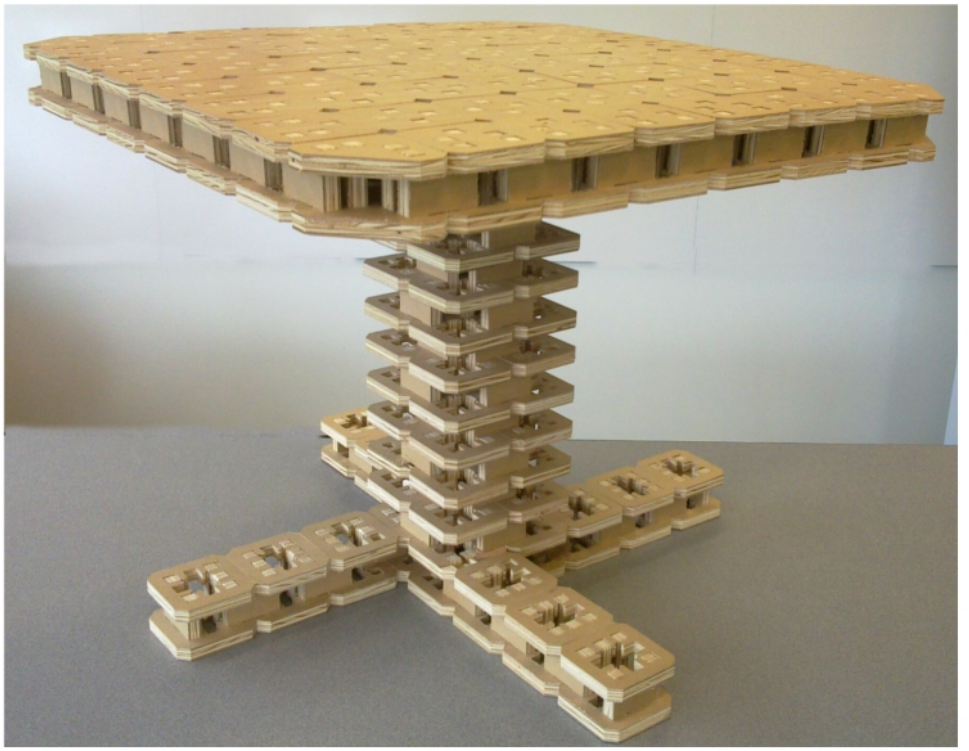
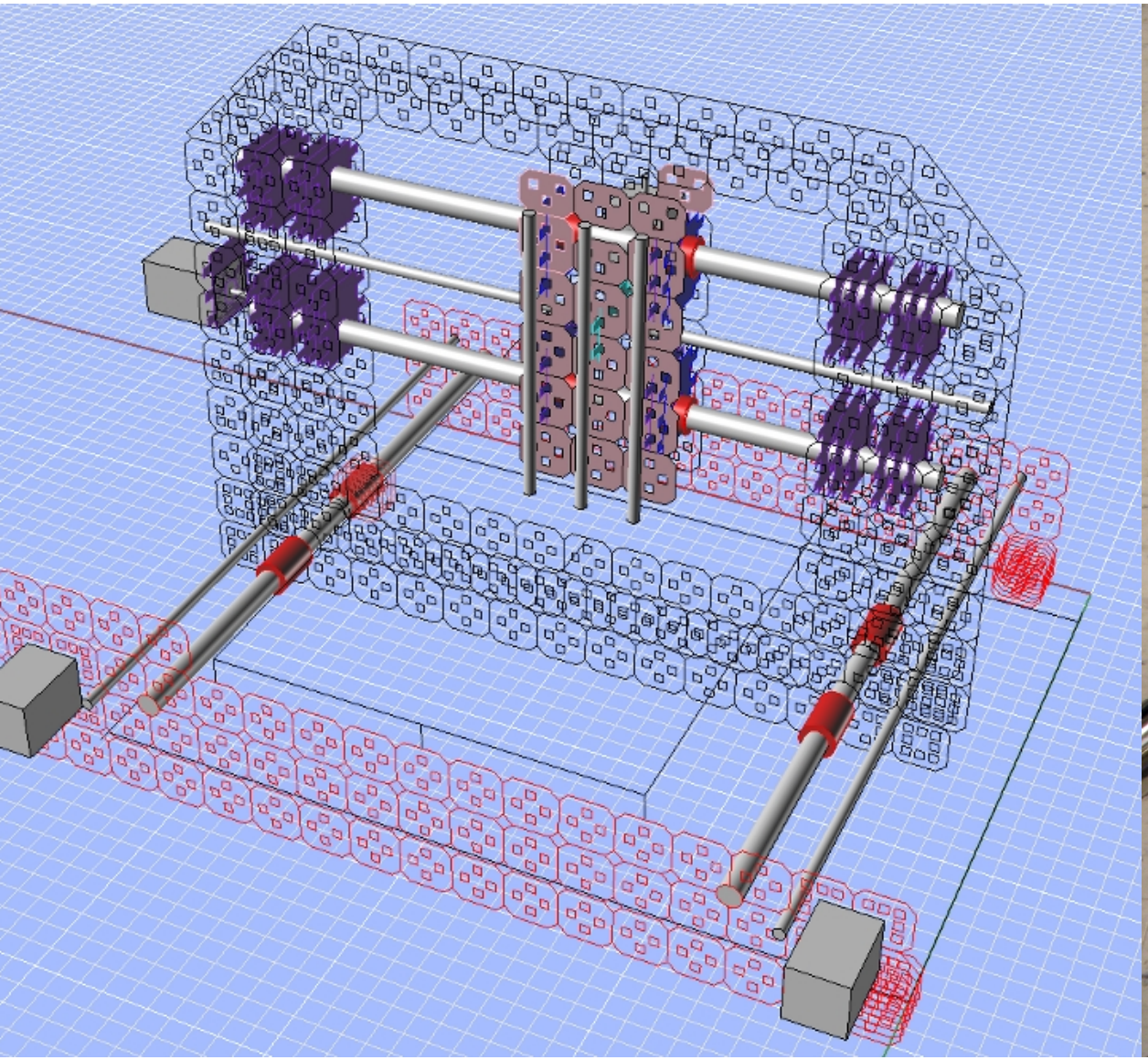
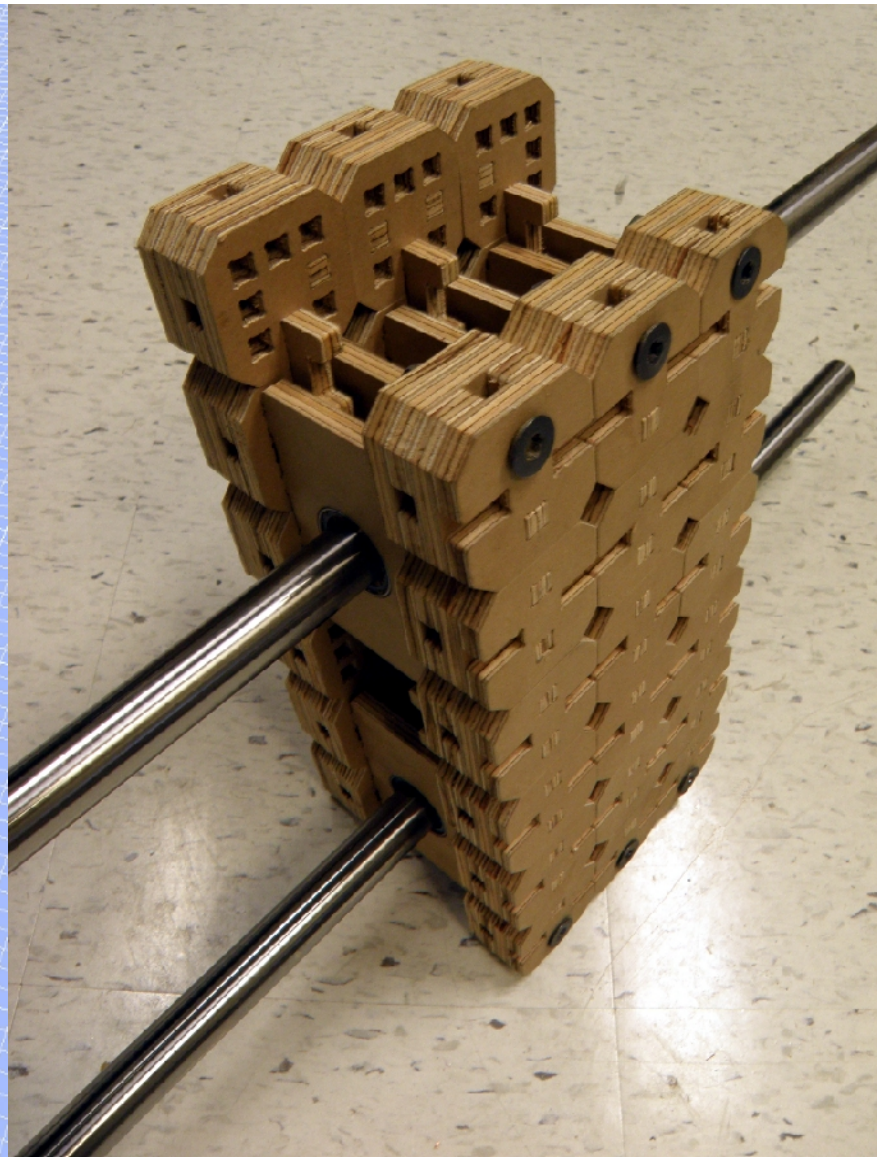

mounting rails
for assembler head
machine bed
Y axis carriage
Z axis carriage
X axis carriage
X axis motor
Y axis motor
Z axis
leadscrews
Z axis motors
X axis
leadscrew
Y axis
leadscrew


assembler
head`
machine bed
lead screw
stepper motor
power supply
motor controllers






assembler
head
copper & plastic
digital assembly



Machine	~Min. Feature Size	~Min. Layer Thickness	~Build Time per 1x1x1” (25.4³ mm)	3D Print Process
Invision XT	0.003” 0.0762 mm)	.00158” (0.40132mm)	~6 hrs	Photopolymer
Dimension Elite	0.007” (0.1778mm)	.007” (0.1778mm)	~1 hr	FDM
Rep Rap Mendel	0.080” (2.032mm)	0.012” (0.3048mm)	~1 hr	Thermoplastic Extrusion
Objet Connex 500	0.001” (25.4 microns)	0.0006” (16 mcrons)	~1 hr	Photopolymer
Digital Assembler	**Part Assembling Rate**	**Voxel Size**	**Build Time per 1³ (25.4³ mm)**	**Number of voxels per 1³ inch**
1.0	1 Hz	0.25” (6.375 mm)	~1 min	64
2.0	15 Hz	0.025” (0.635mm)	~1 hr	64000
3.0	15 kHz	0.0025” (0.0635mm)	~1 hr	64.0E+06
4.0	15 MHz	0.00025” (6.35 microns)	~1 hr	64.0E+09