

A Scalable Additive Manufacturing Technology for Large Area Printed Circuit Boards

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Outline

- Overview of UHV Technologies/nanoRANCH
 - History and Core Competencies
- DOE NP Phase II SBIR Project for LARGE AREA PCBS
 - Confined Electro-Deposition (CED)
 - Preliminary Data and Results
- Parallel Programs:
 - DOE Office of Science SBIR Project for small SIZE 3D Chips
 - NASA SBIR Project for Alloy Deposition

UHV Technologies, Inc. (aka nanoRANCH)

- **25 year old high tech company with facilities in Lexington, KY and Fort Worth, TX**
 1. New headquarters in Lexington, KY opened in 2016
 2. Over 30,000 sq. ft. combined Manu. & R&D Space
 3. Active collaboration with 10+ Universities
- **3-Prong business strategy**
 1. R&D in Advanced Thin Films, Diamond, Nano-Materials & Devices, X-Rays, Artificial Intelligence and Deep Learning, & Optical Fiber Coatings
 2. In-House Small Scale Manufacturing
 3. Commercialization through Subsidiaries and Alliances
 4. Various spin-offs including 1 IPO (NASDAQ) and > 22 million in Venture Capital
- **Current Status**
 1. 20+ employees
 2. \$2.5M expected in 2019
 3. Raised \$2M in Series A Venture Capital in July 2020
 4. Multiple R&D contracts and products



R&D Facilities



Core Competencies

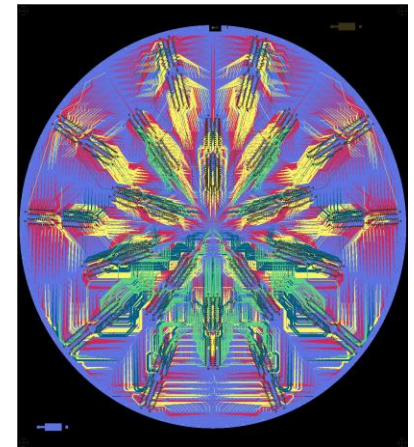
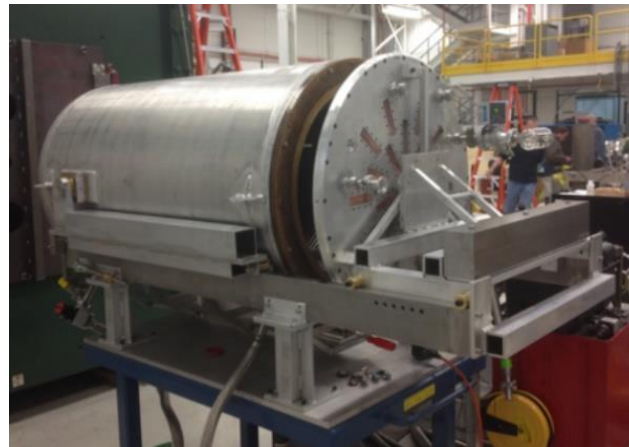
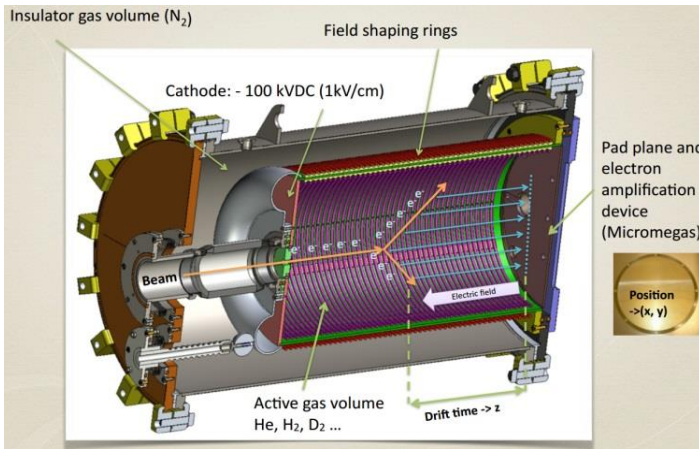
- 1. Advanced Materials R&D including Diamond, CNT and Semiconductor Films**
- 2. Advanced Device/Instrumentation/System Design and Manufacturing including**
 - Vacuum Deposition Systems
 - X-ray CT Systems
 - Metal scrap Sorting Systems
- 3. Software Development for Industrial Applications using Artificial Intelligence**
- 4. Equipment Manufacturing with In-House Manufacturing Capability**
- 5. AI and XRF Sensor Sorting Technology for Metal, Plastics and Bio-mass recycling**

UHV Product Photos



A Scalable Additive Manufacturing Technology for Large Area Printed Circuit Boards

- **US-DOE NP Phase 1 SBIR** awarded in Feb. 2017
- **Collaboration with UT-Dallas and NSCL-MSU**
- **Goal:** To develop a scalable additive manufacturing technology for large area, multiple layer printed circuit boards (15 ft x 15 ft)

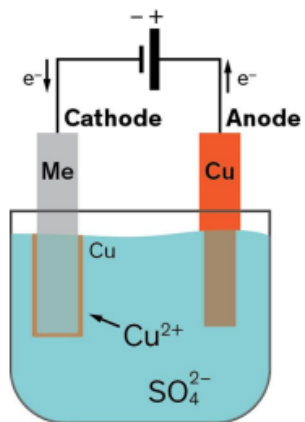


NP Phase II SBIR

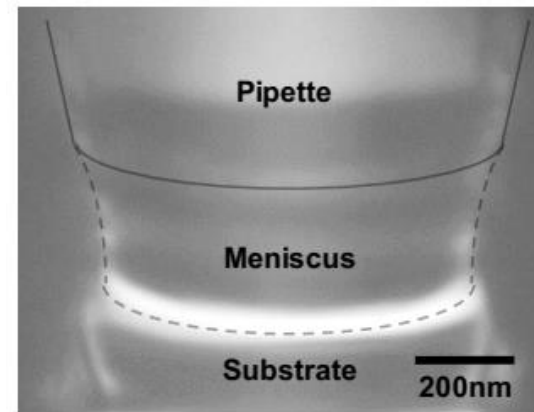
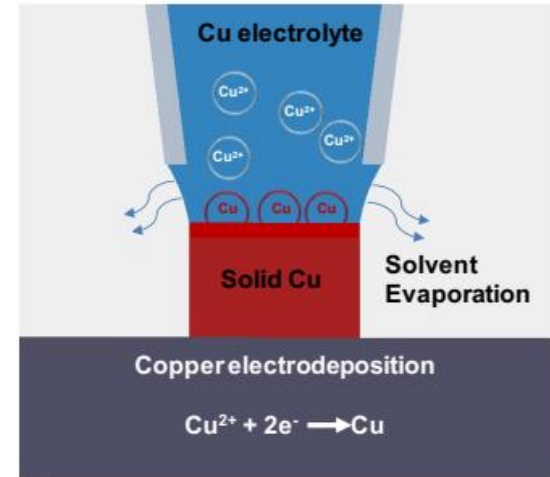
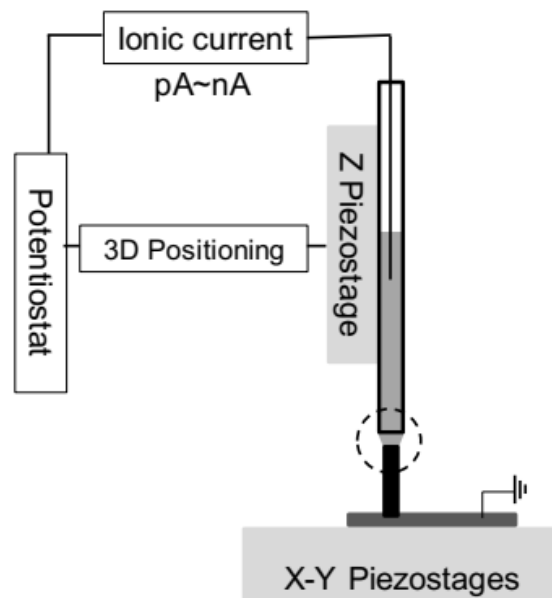
Scalable 3D Printed PCBs

- **Team:** UHV, UTD and NSCL/MSU
- **Objectives:**
 1. **Develop, build and demonstrate a large area multi-layer PCB Printer for detector instrumentation used in nuclear facilities**
 2. **Develop and demonstrate innovative novel micro-pattern gaseous detector (MPGD) architectures for higher performance gas detectors**
- **Key Technical Concept:** Confined Electro-Deposition (CED)
- **Enabling Technologies:**
 - ~Bulk conductivity copper feature fabrication at room temperatures
 - Both horizontal and vertical metallic features of 1-3,000 microns.
 - Computer controlled process optimization of multiple print heads
 - AI based path optimization for higher throughput
 - Other metals and alloys can be fabricated

Confined Electrodeposition (CED)



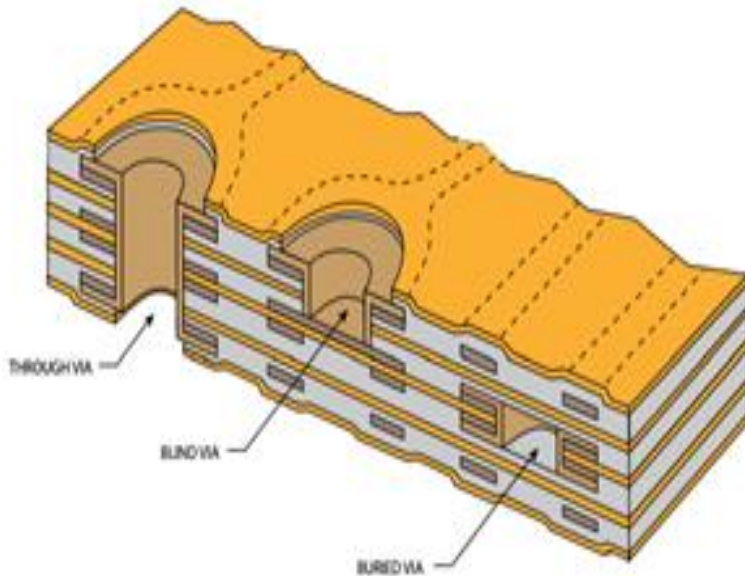
Electroplating of Cu



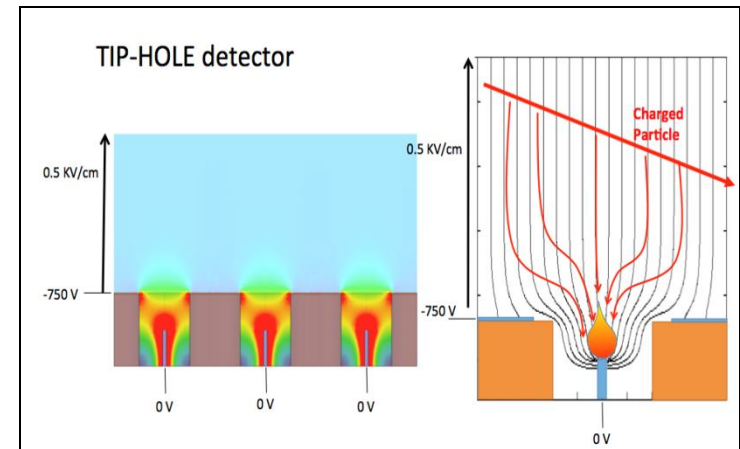
Phase II Goals

**Very Large Area PCBs for
NP Detectors**

**Develop Novel NP Devices enabled
by Low Temperature 3D Metal Printing**

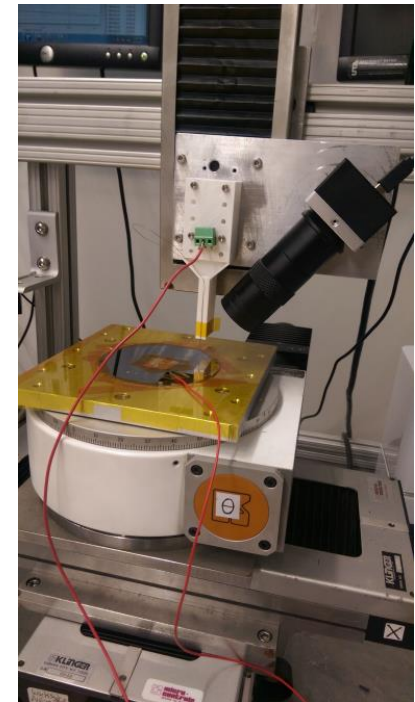
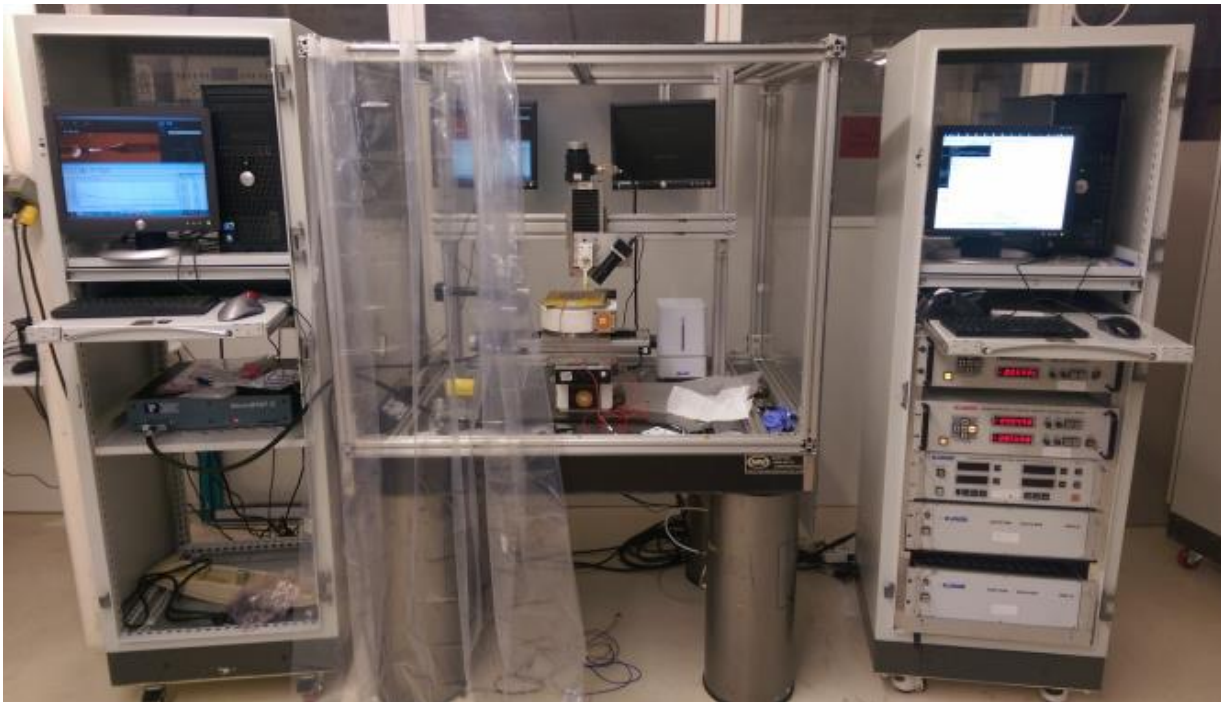


TIP-HOLE DETECTOR



Cortesi and Mittig, NSCL

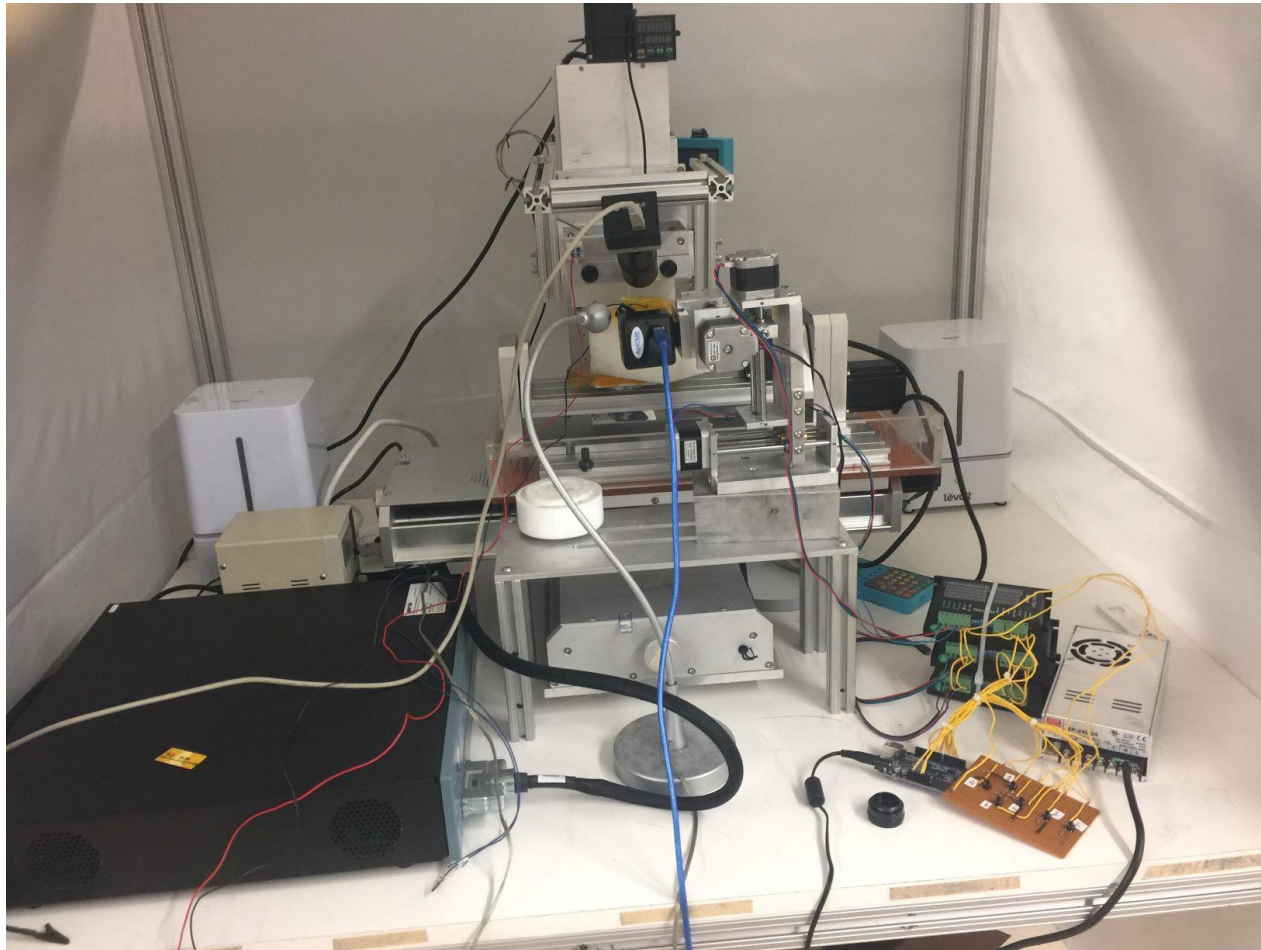
UHV's Phase I Computer Controlled 3D Printer



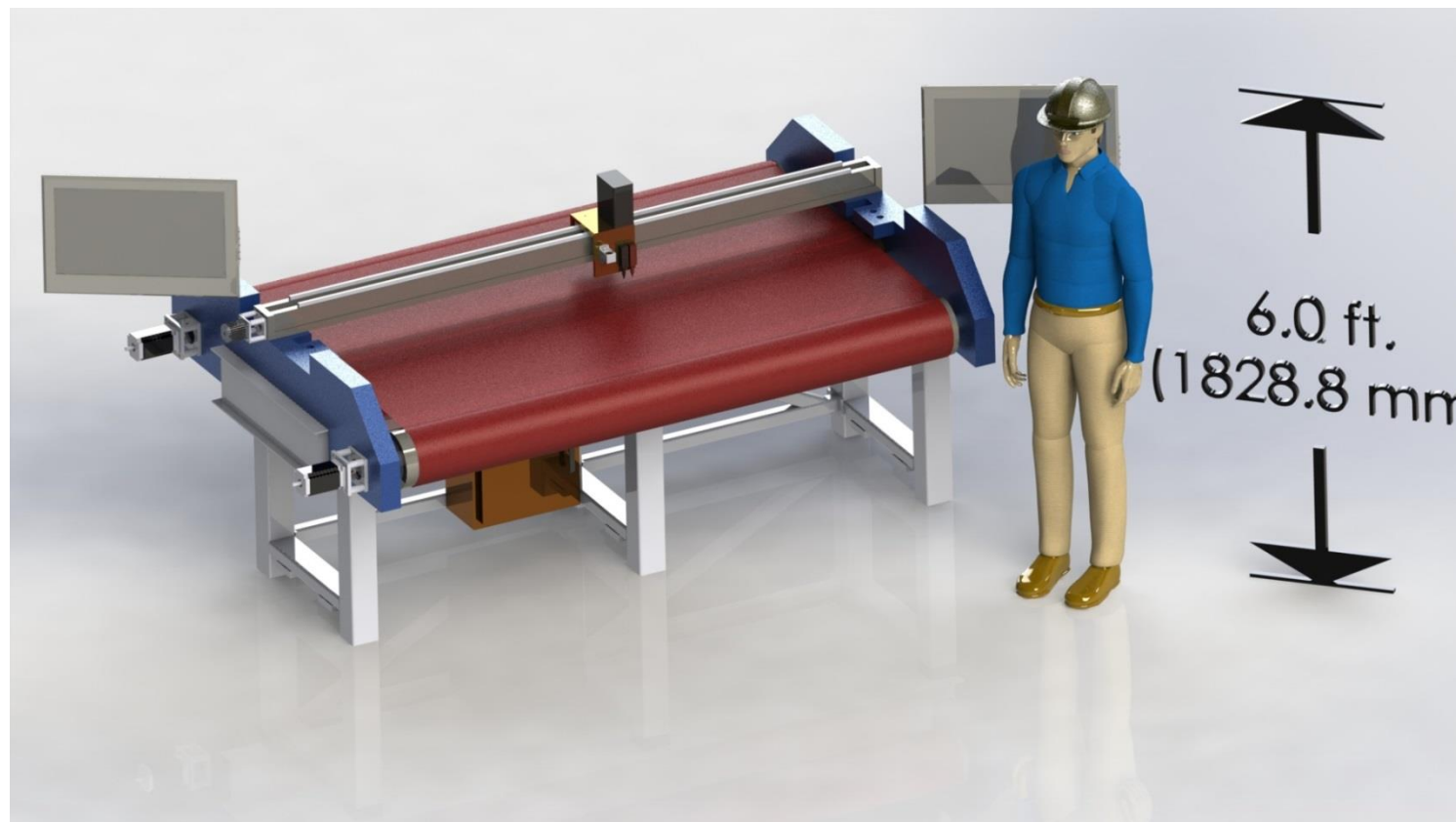
UHV's 3D Printer R&D Lab



6 Axis R&D Printer



Phase II 3D Printer Under Development at UHV

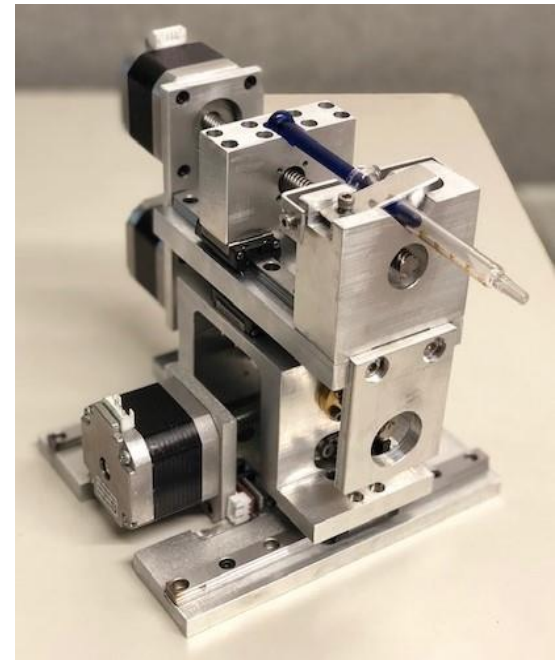
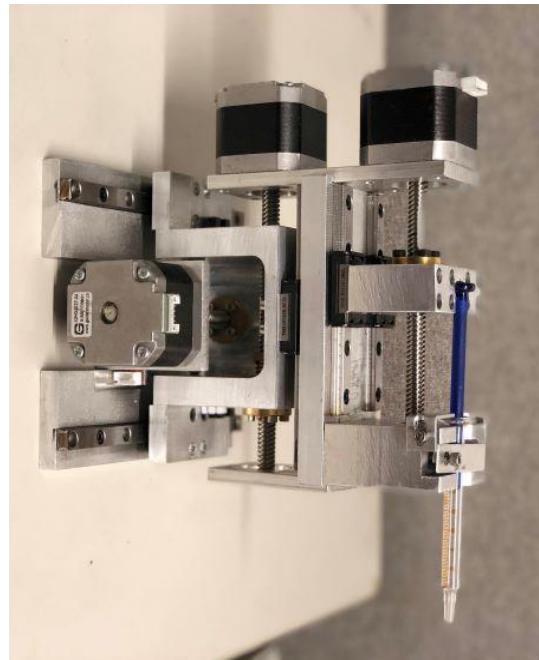
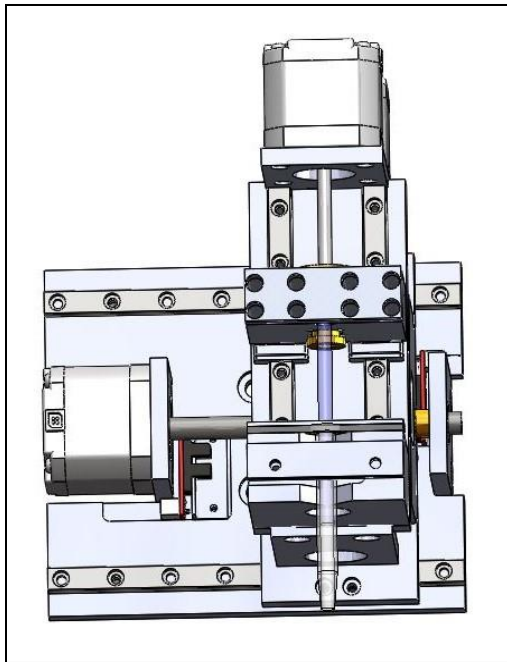


Large Area 3D Printer designed for 2 meter PCBs

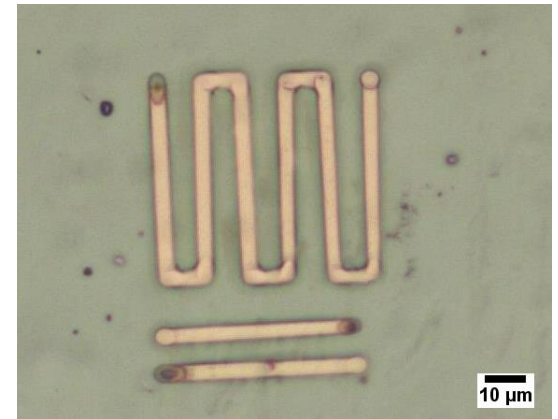
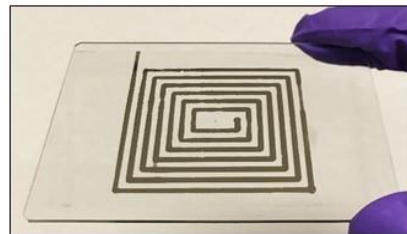
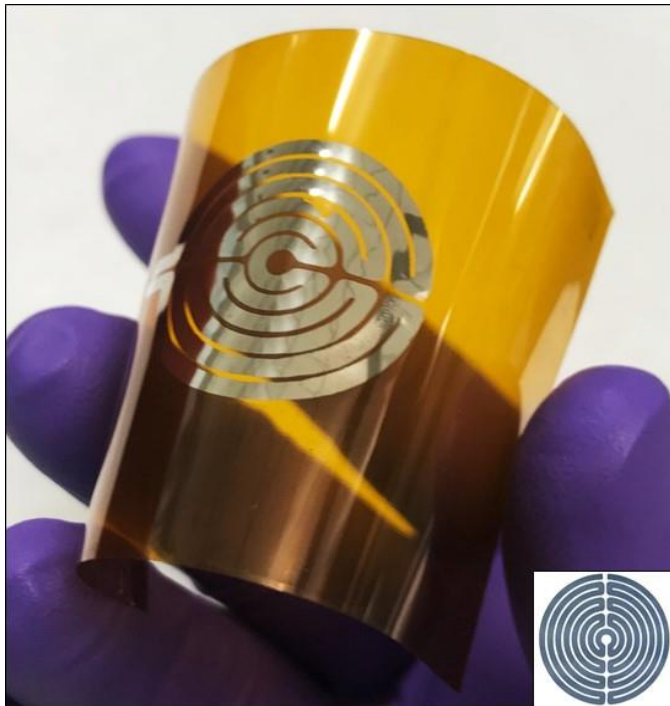
2 Meter PCB Printer



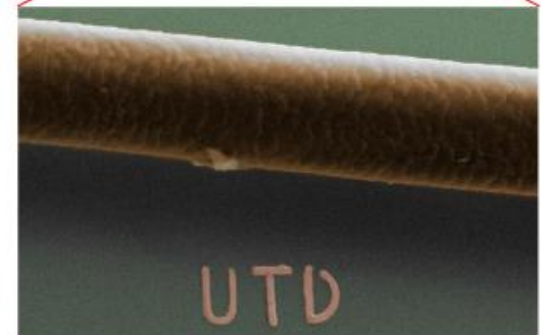
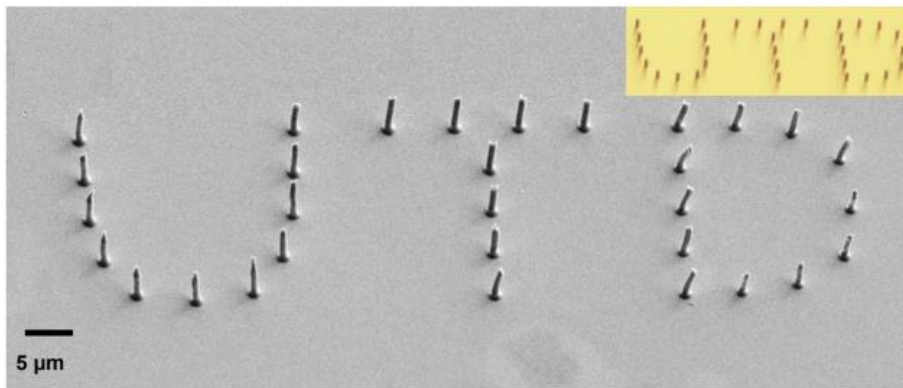
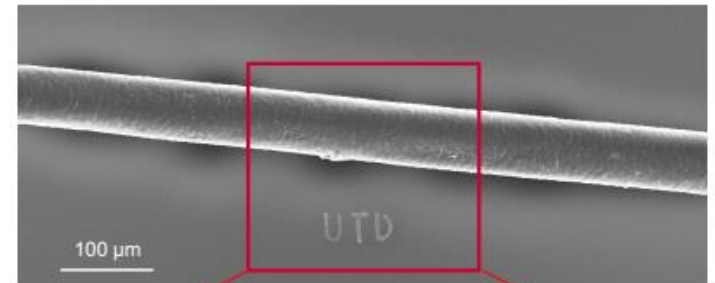
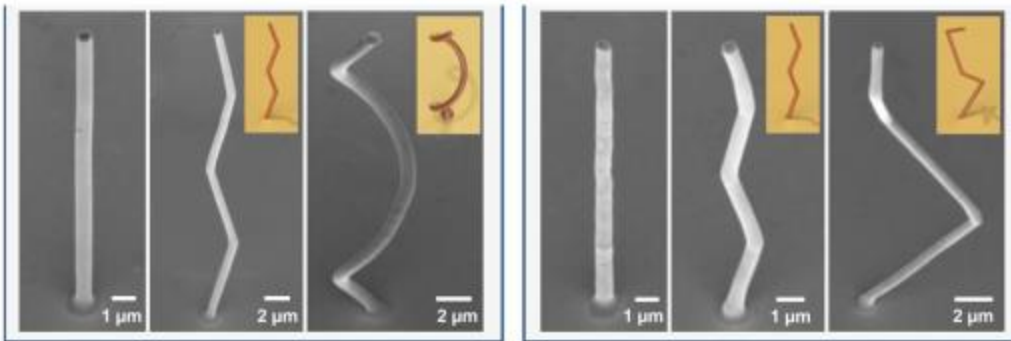
Progress: New Print Heads



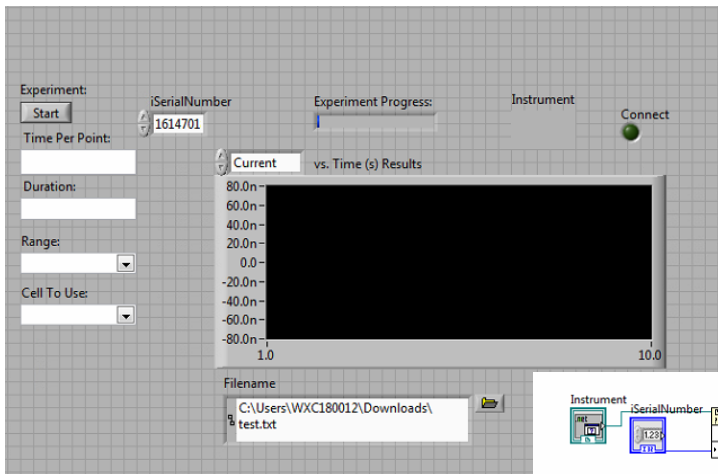
Ni and Cu patterns



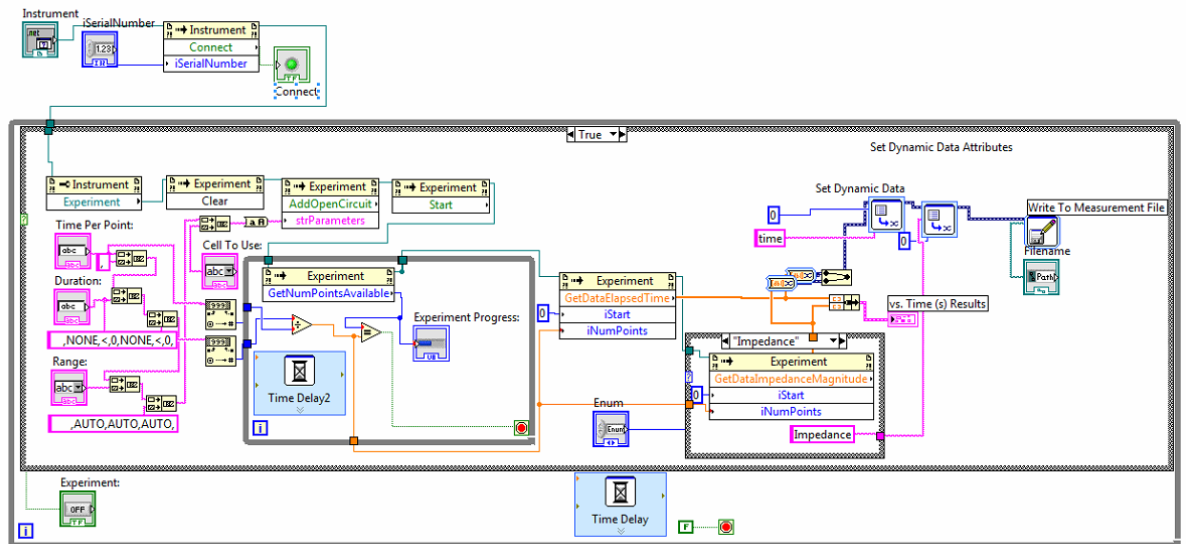
Fabricated structures



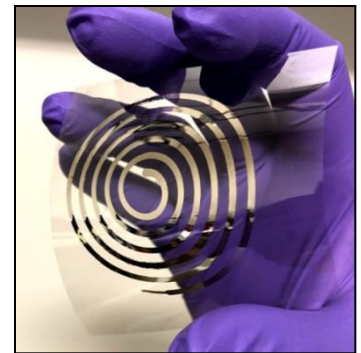
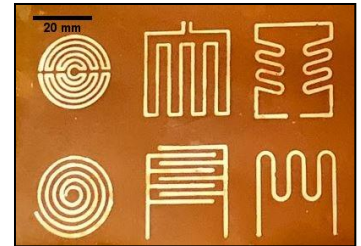
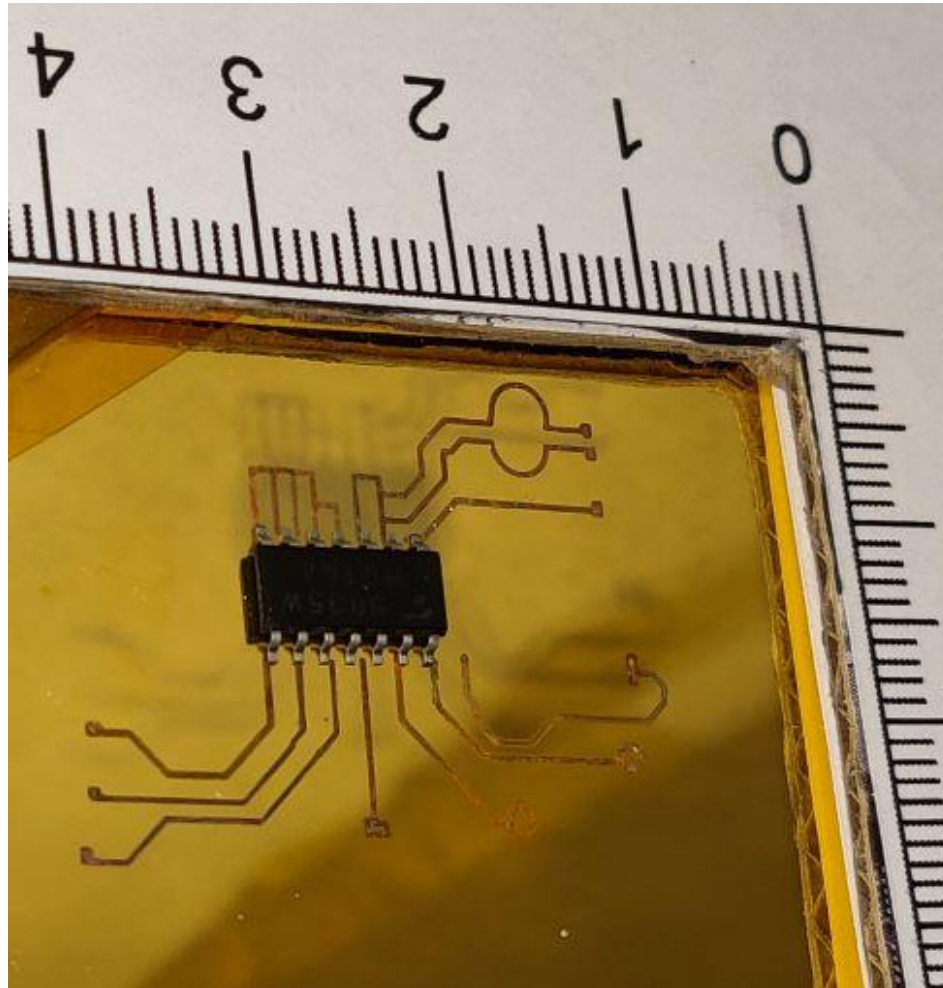
Progress: Real Time Machine Interface



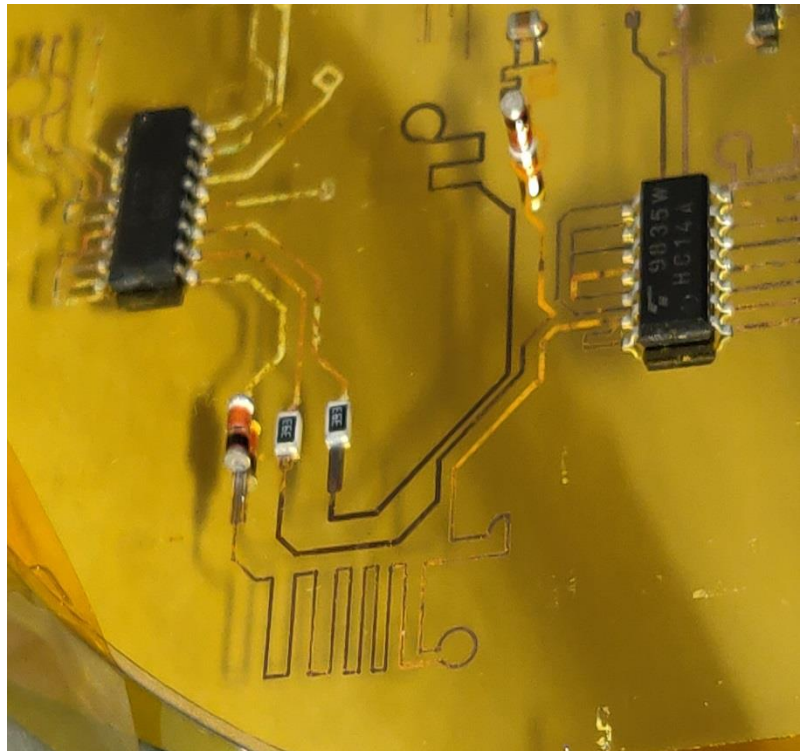
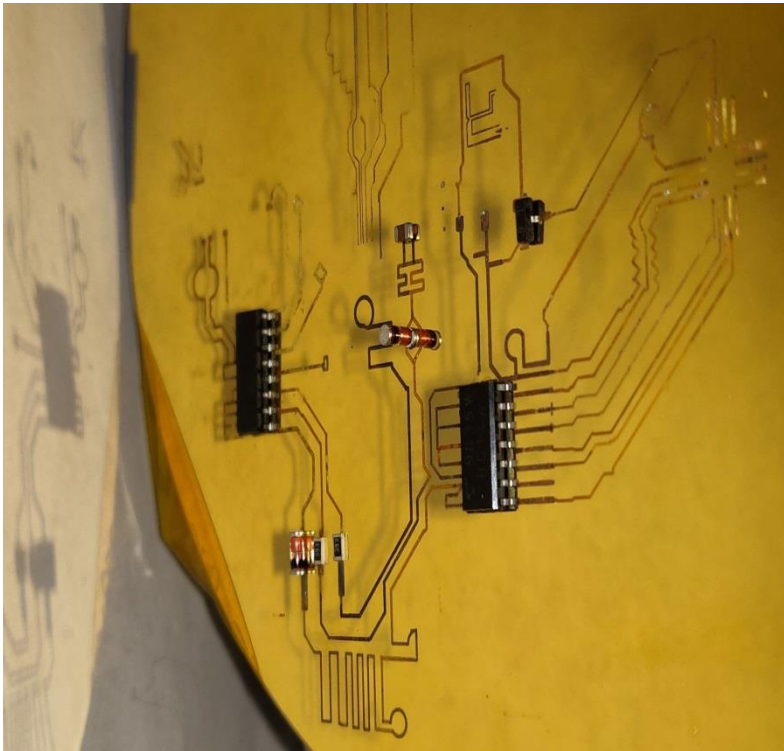
- Establish LabVIEW Interface with VersaSTAT
- Exports measurement data (voltage, current, time)
- all commands are text based, and need to be sent once



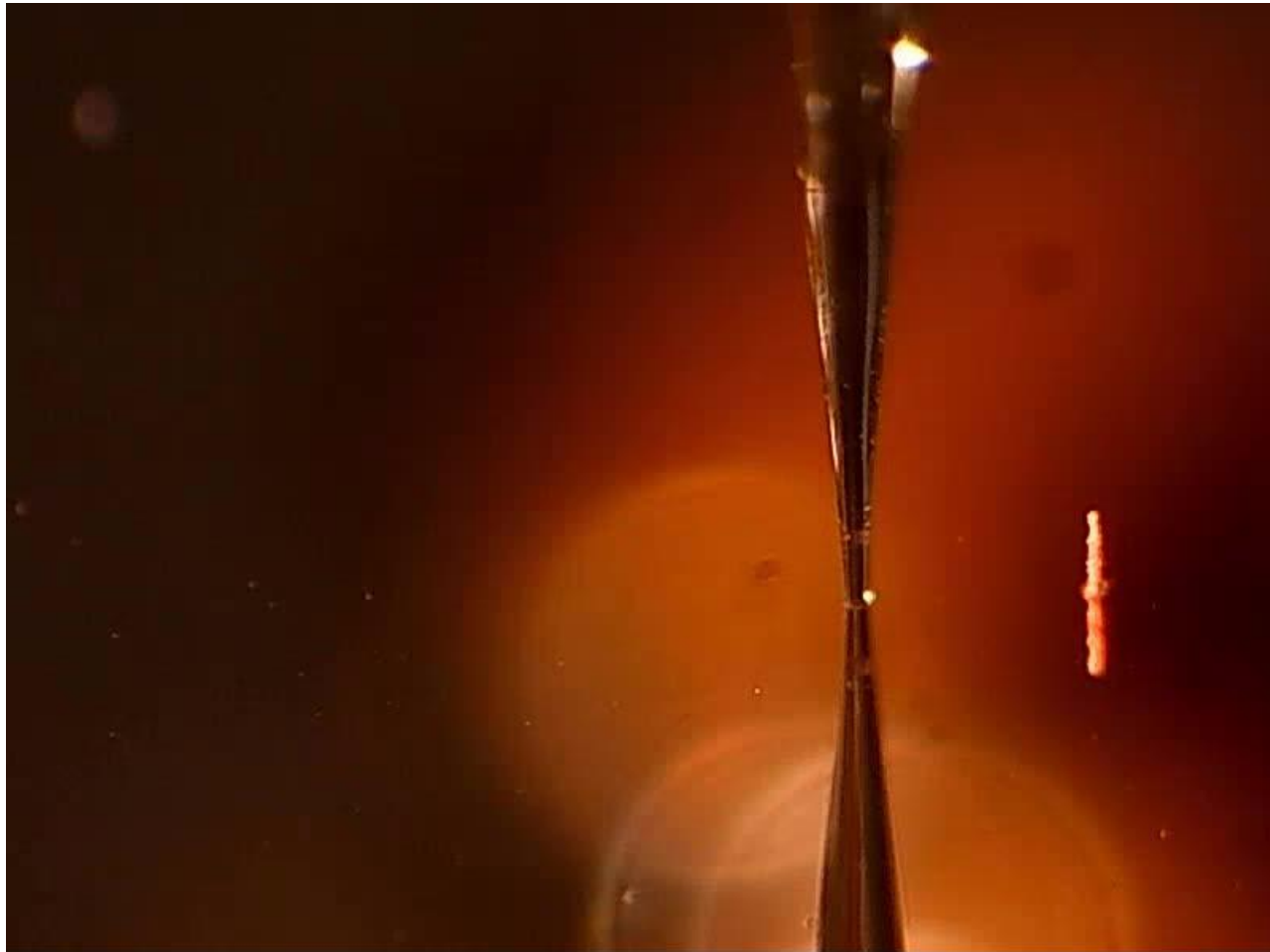
Progress: PCB Fabrication by CED



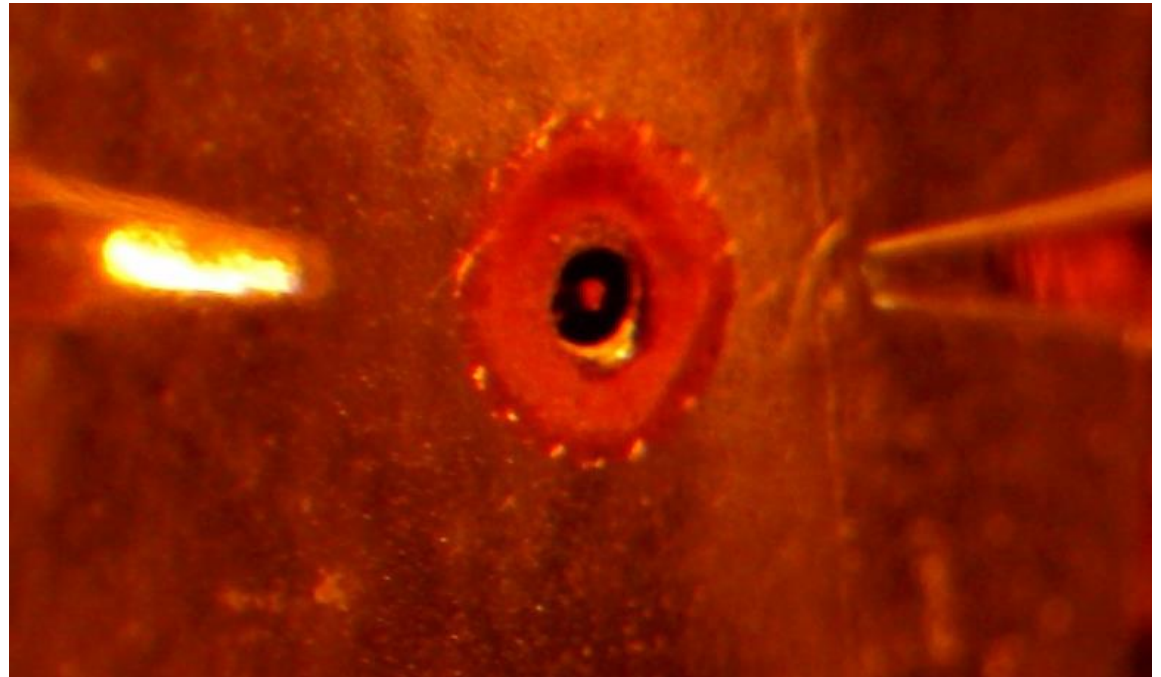
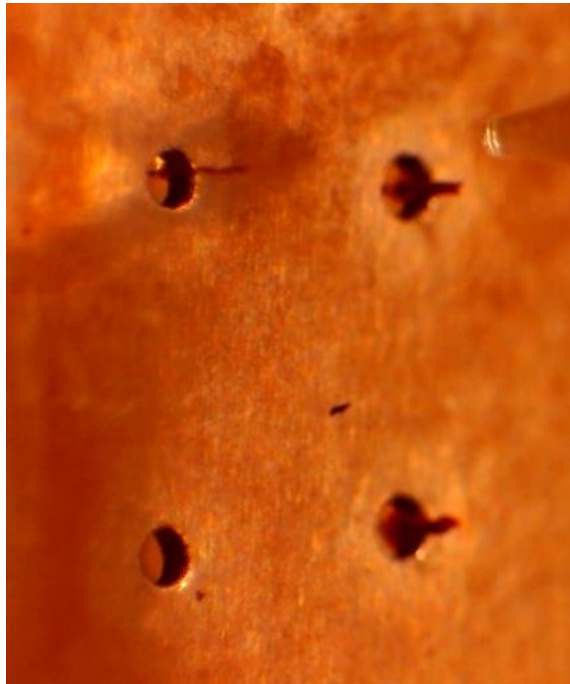
Progress: PCBs Fabrication by CED



Video of 80 Micron Pillars



Tip-Hole Detector Photographs

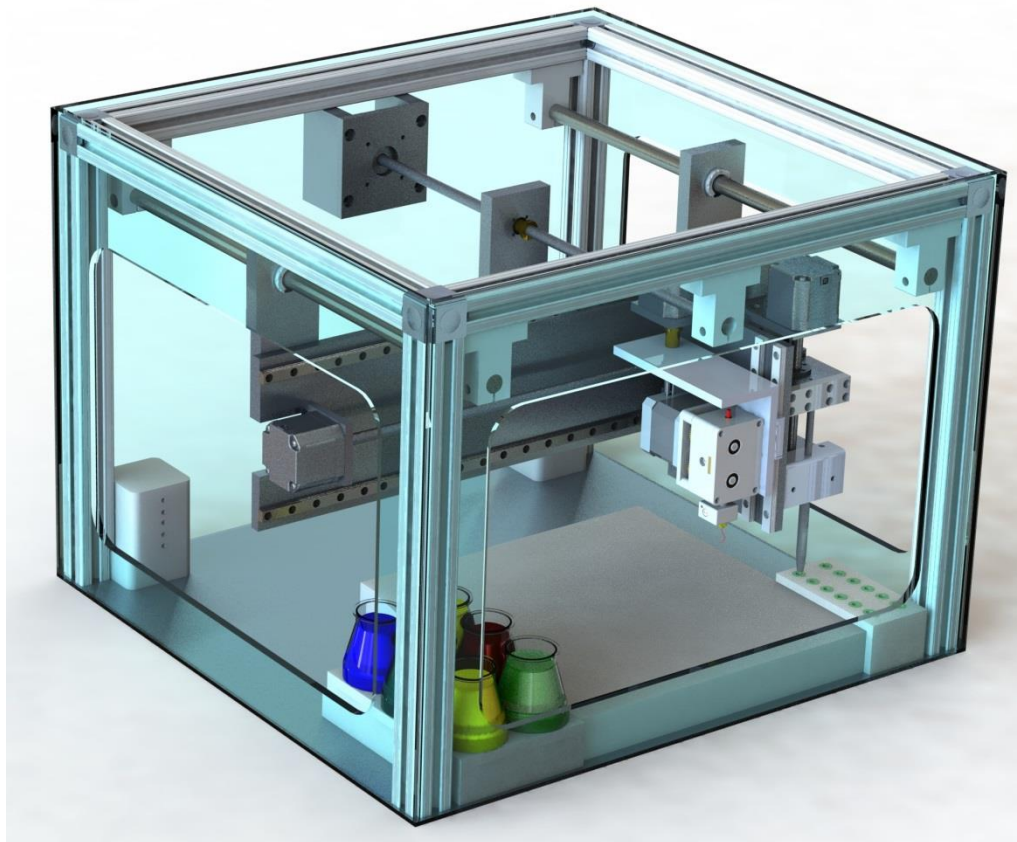


Commercialization: Potential Applications

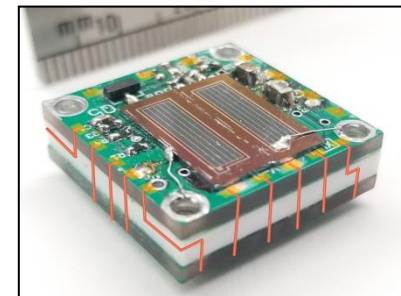
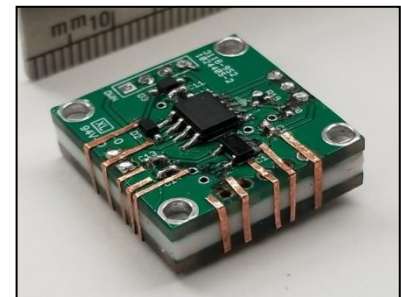
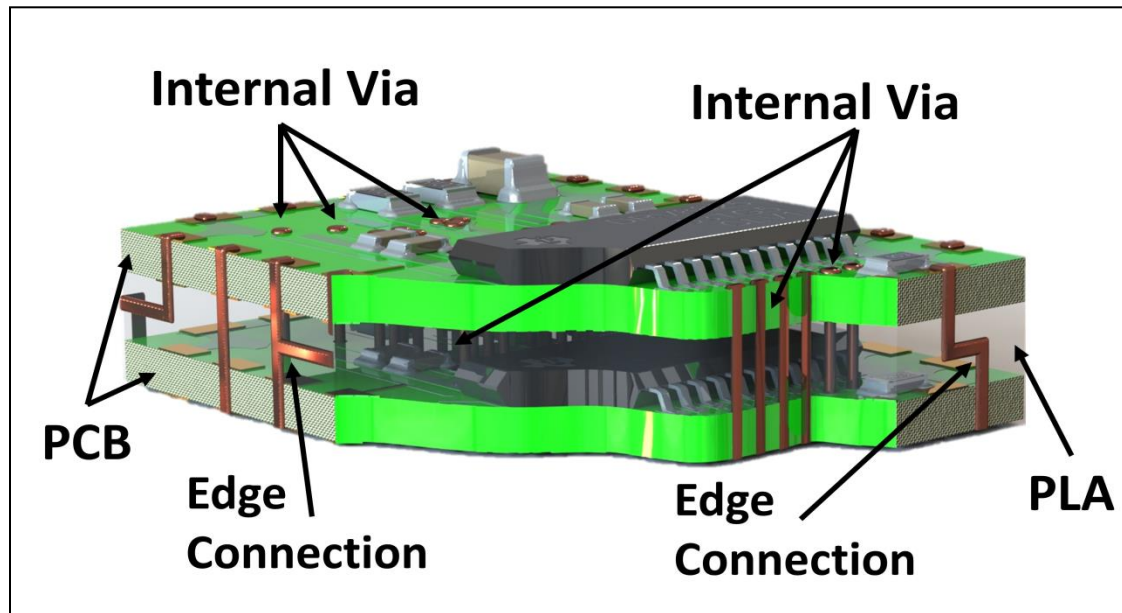
- 1. Large Area Custom PCBs**
- 2. Single Chip and Multi-Chip Packages**
- 3. 3D integrated Circuits**
- 4. Solder Bumps and Interconnects**
- 5. Conformal Antennas**
- 6. Micro-fluidic Devices**
- 7. Environment and bio-medical sensors and Electronics**
- 8. Space On-Board Electronics Manufacturing**
- 9. Military Munitions**

Low Cost Metal 3D Printer

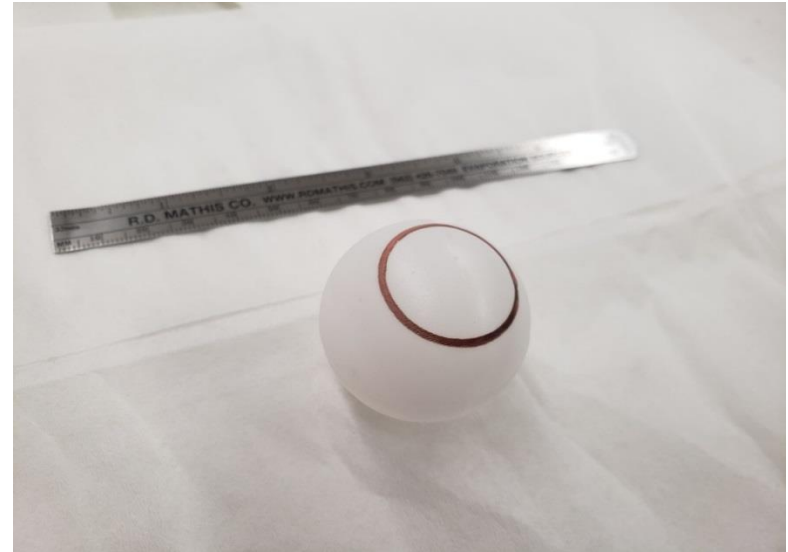
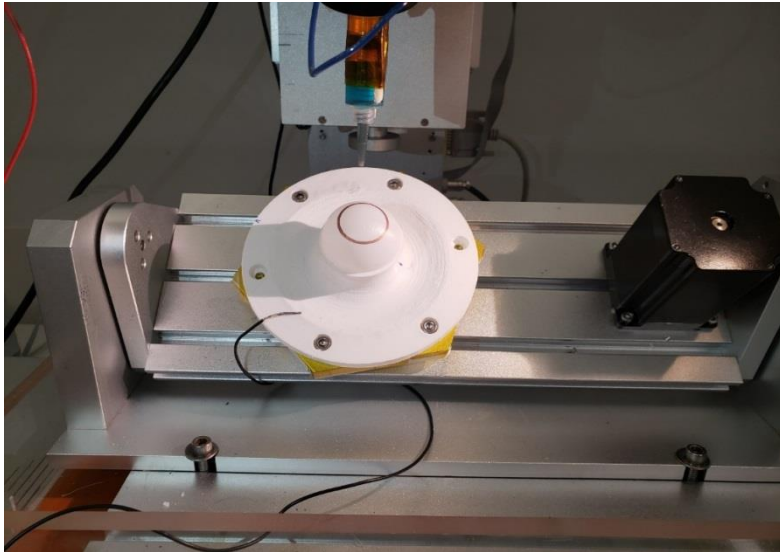
A tabletop 3D Printer capable of fabricating both plastic and metal features



Future: Advanced 3D Instrumentation



Conformal Printing with 6-axis 3D Printer



High Speed (RF) PCB Interconnects

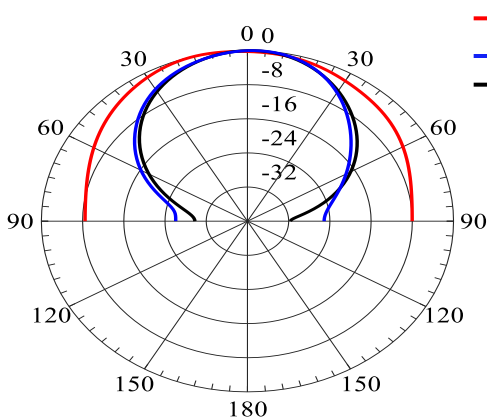
Annular Ring Antenna: Baseline Array Feeding Network



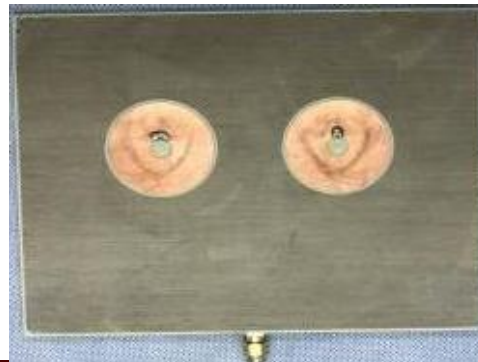
High Speed (RF) PCB Interconnects

Preliminary Results

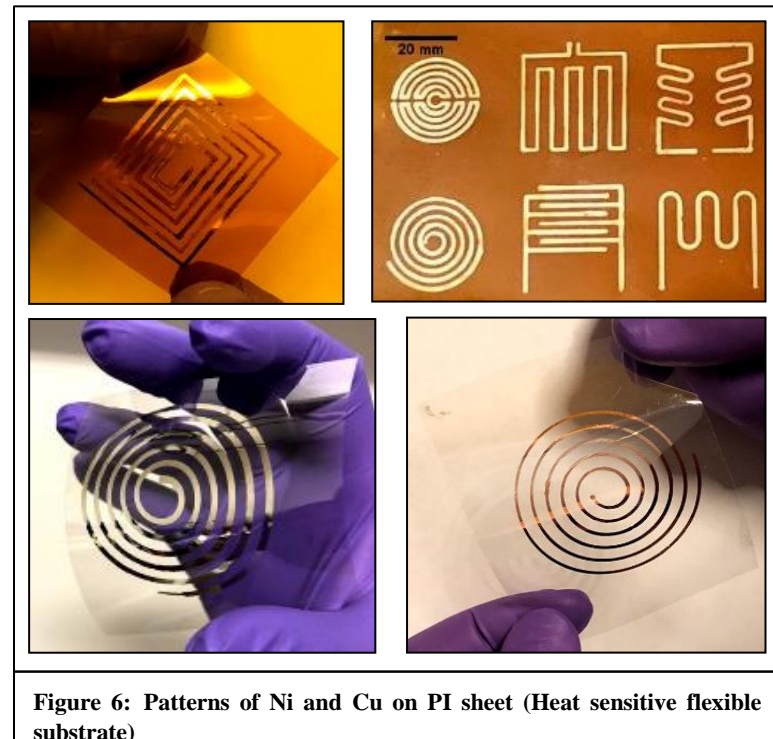
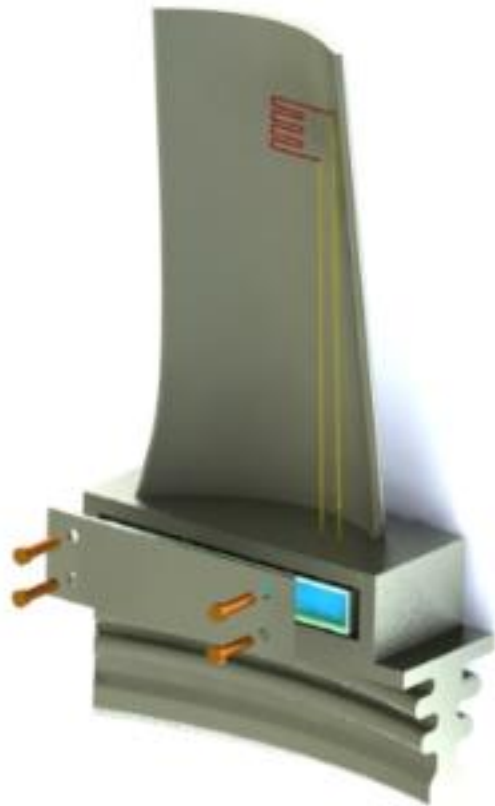
ARA	Probe Feeding		Feeding Network RT/Duroid			
Type	Single		2x1		2x2	
Parameters	Sim.	Meas.	Sim.	Meas.	Sim.	Meas.
F(GHz)	2.3	2.3	2.3	2.3	2.3	2.3
RL(dB)	17.5	11.1	14.6	14	27	12
Gain(dBi)	5	2.15	7.4	6.2	9.8	7.8



— Meas. Single
— Meas. 2x1
— Meas. 2x2

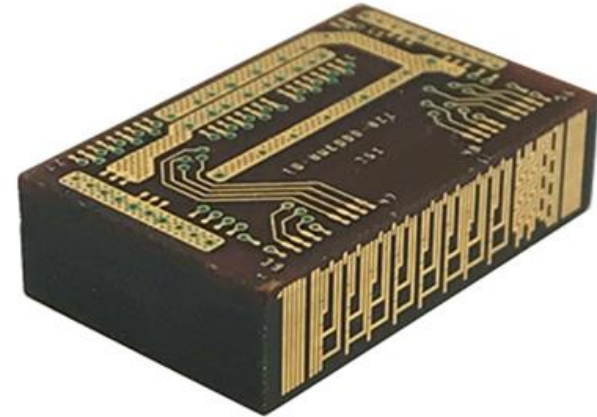
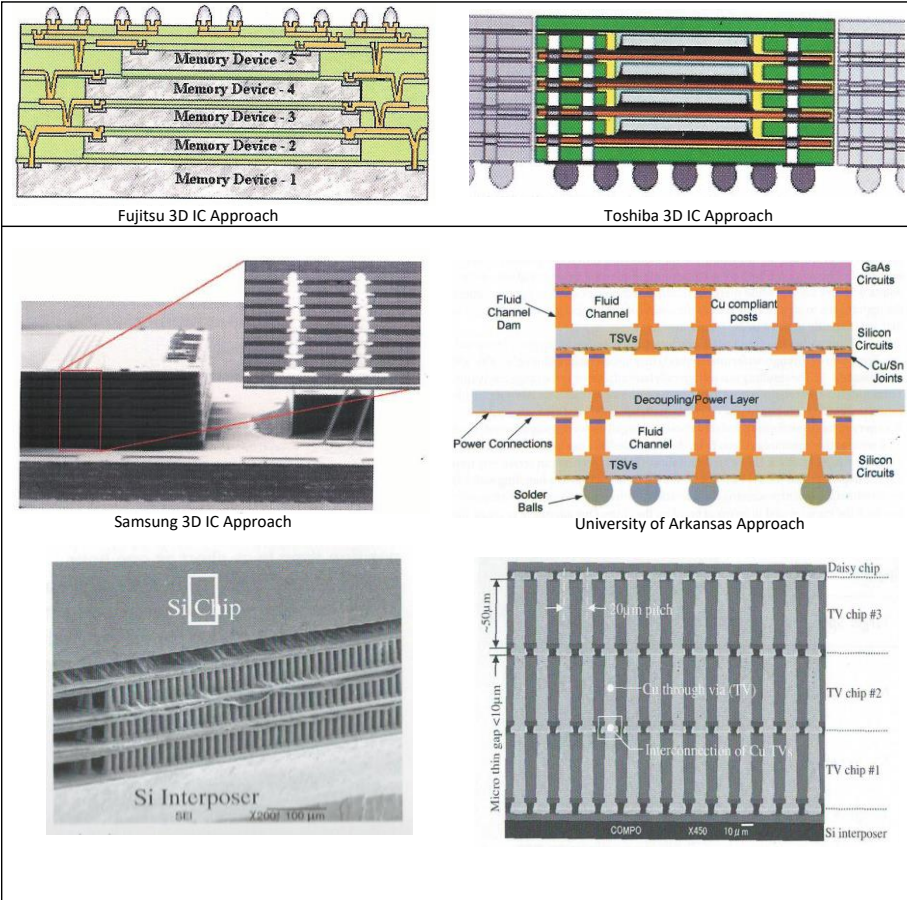


High Temp Sensors for Gas Turbines



DOE Office of Science Funded SBIR

3D-Chips



Photos of High Density Interconnects

