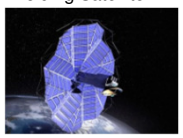
Title: All-Printed Morphing Electronics

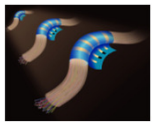
PRESENTER:
Jack Messerli-Wallace

WHY?

Applications in
- Telecommunications
- Space Technology
- Medicine

Folding Satellite



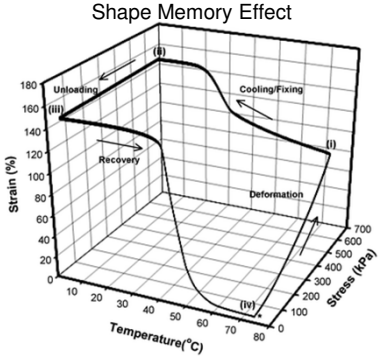


Morphing Tissue Stimulators

INTRODUCTION

Shape Memory Polymers (SMPs): Polymers that have a memorized shape in which they return to after deformation and subsequent heating.

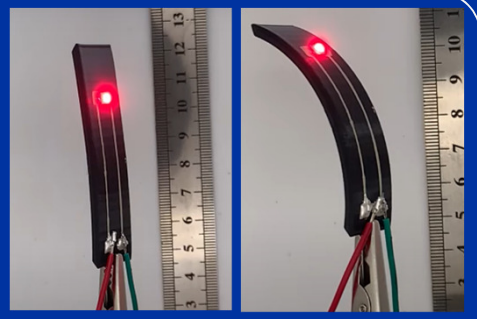
Shape Memory Effect



Objective: Use Hyrel Multi-head 3D printing to fabricate a SMP and an activating conductive paste in one print.

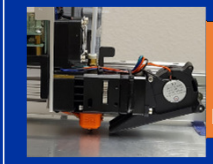
- Polylactic acid (PLA) and thermoplastic polyurethane (TPU) are low cost, common 3D-printing polymers.
- A PLA/TPU mix has a strong shape memory effect and adequate rigidity.
- Conductive paste is printed directly on the SMP via syringe deposition.
- Electricity is sent through the cured paste, generating heat to activate the shape memory effect.
- A carbon-based paste (Dupont 7082) and a silver-based paste (Dupont 5029) have been tested.

We have fabricated **morphing electronics** through **shape memory polymers** and **conductive paste heating**.



25°C at the start | 70°C after 1 minute

Fabrication:

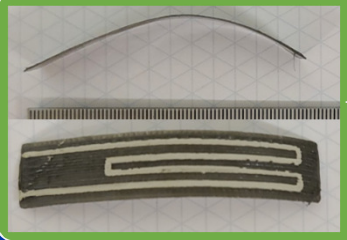


PLA/TPU Base Layer Extrusion

Paste Deposition

Let Paste Dry (4hr)*

Heat to 70°C



Bend into temporary shape

Scan to see the sample being printed!

Open Silver Sample in Permanent Form

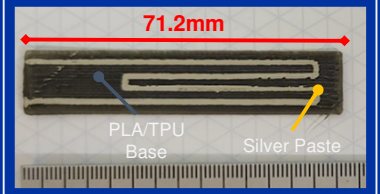
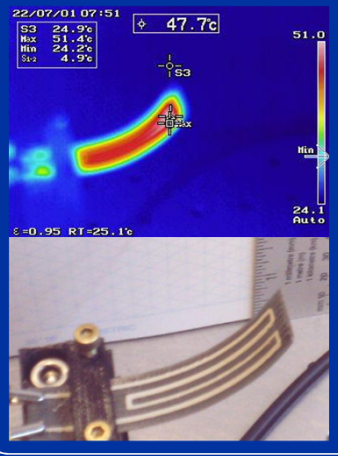


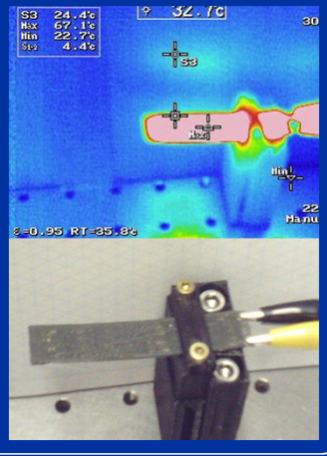
*Photo taken after silver is dried

Testing:

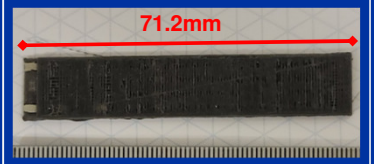
Open sample heated with 1.6 amps for three minutes



Closed sample heated with 1.2 amps for three minutes



Closed Silver Sample in Permanent Form



Silver Paste is encapsulated in the PLA/TPU SMP
- Improves thermal isolation
  - Lowers required current
- Prevents silver from cracking

Scan to see the sample transform!

Takeaways

Carbon Paste Printing Results:

Print Speed (mm/s)	Extrusion Multiplier (1=100%)	Resistivity (kΩ)
5	1.0	71.05
15	1.0	151.2
30	0.6	242.4

Carbon paste resistivity is always too high for low-current applications, but could be used for sunlight activation.

Silver Paste Printing Results:

- Printed at 10mm/s, 1.0 extrusion multiplier
- Resistance of circuit is about 1Ω, suitable for the application.
- Open silver-SMP samples exhibit SMP effect under 1.2-2.0 amps.
- Open circuit continuity breaks as the sample straightens.
- Closed silver-SMP samples exhibit SMP effect under 1.0-1.6 amps.
- Closed circuit continuity has not been broken over three testing cycles.

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