



Not Just Chips

April 4-6, 2023



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Liquid WireTM
MADE TO MOVE

Metal GelTM conductor offers increased durability for hard to soft interfaces in Flexible Hybrid Electronics (FHE)

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- Wearable sensors are becoming widespread in every walk of life
- Reliable sample collection is limited with conventional wearables as they lack body movement compliance



Sports



Healthcare



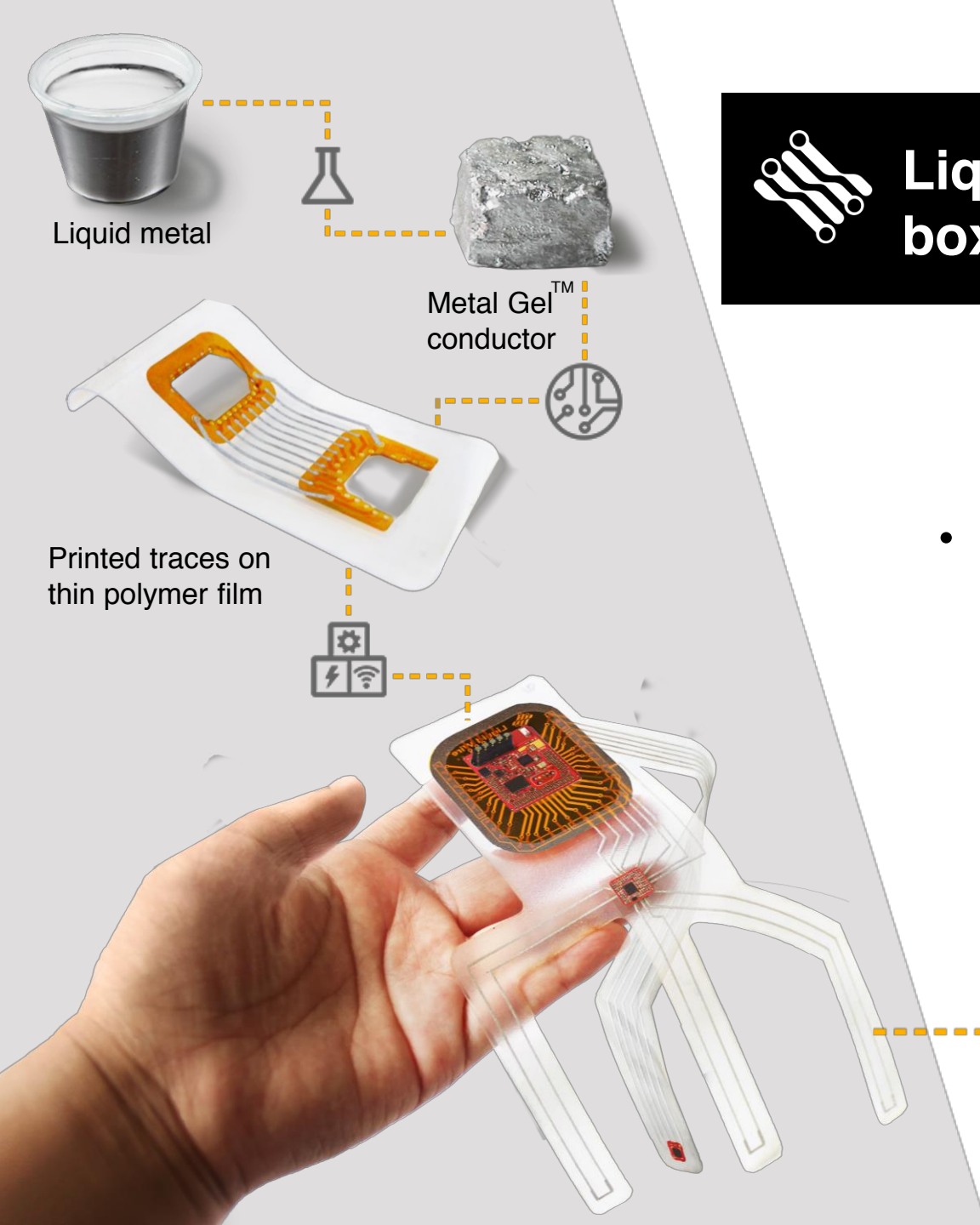
Gaming



Fitness



Industry

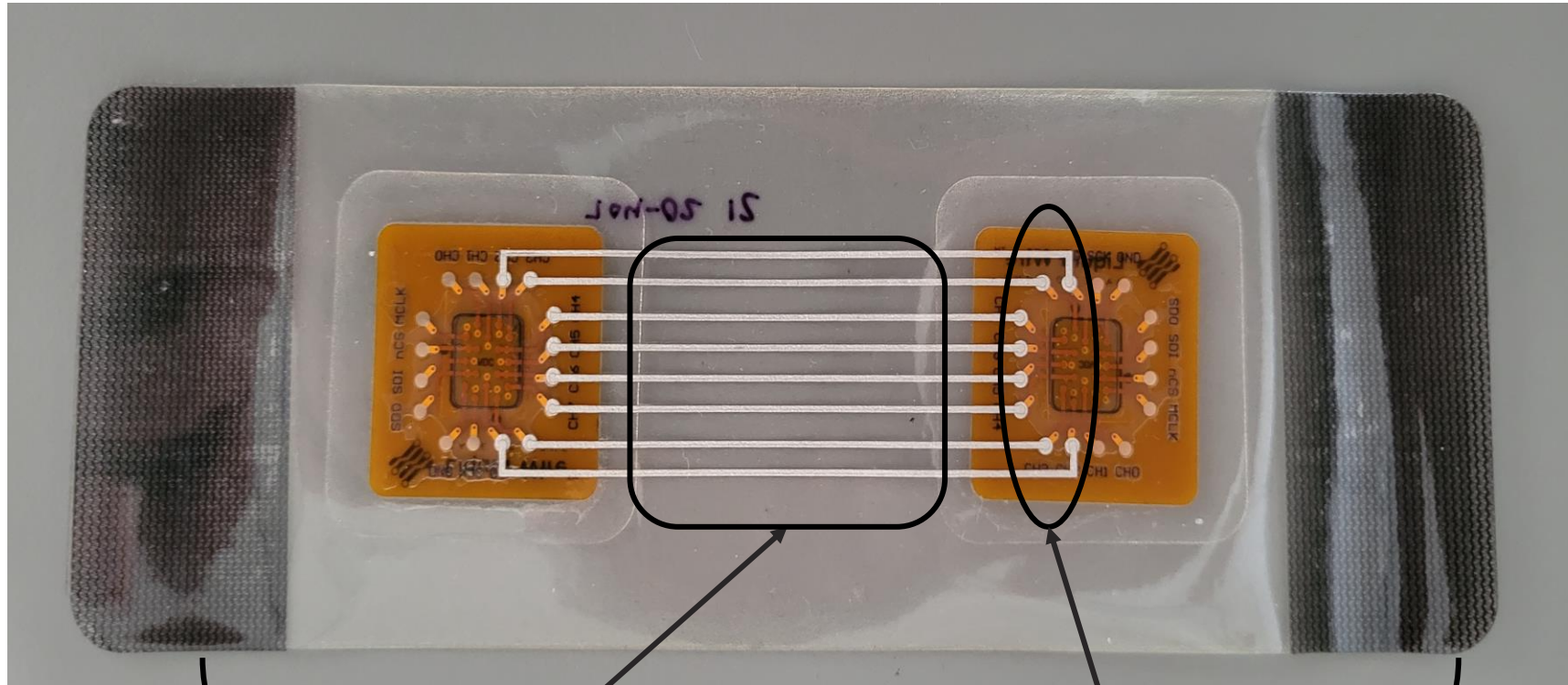


Liquid Wire frees electronics from their rigid boxes to let circuits and sensors move fluidly

- ROHS compliant liquid metals enhanced through a proprietary gelling process, Liquid Wire creates circuitry that can move, bend, stretch and twist



Key elements of Liquid Wire flexible hybrid electronics



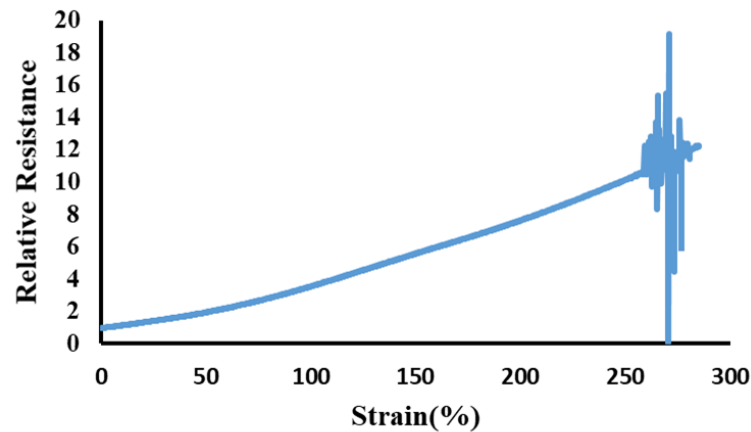
Stretchable conductor

Hard-to-soft transition

Both maintain electrical conductivity, and mechanical integrity under high tensile strain amplitudes and repeated cyclic deformations

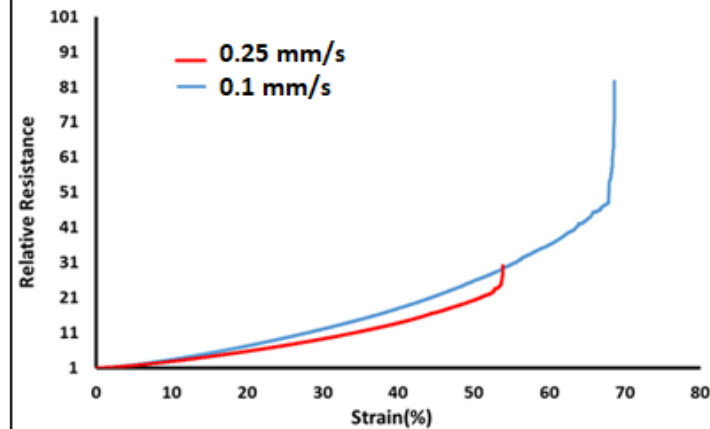
Metal Gel™ vs commercially available silver and carbon paste

**10 times original
resistance at 250%
strain**

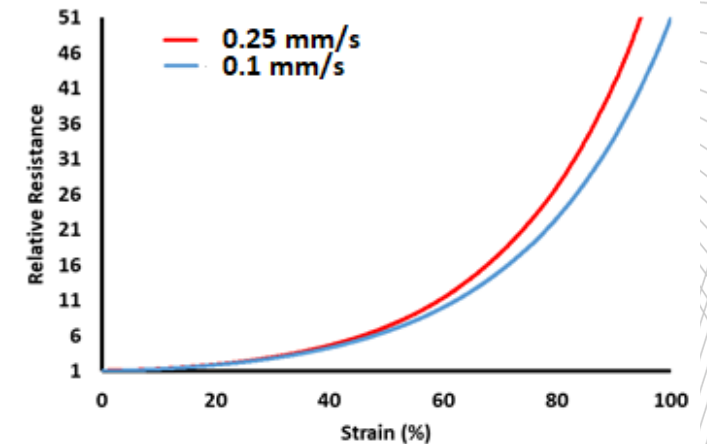


Substrate: TPU (Lubrizol)
Conductor: Metal Gel™

**10 times original resistance only at
20% and 70% strain**



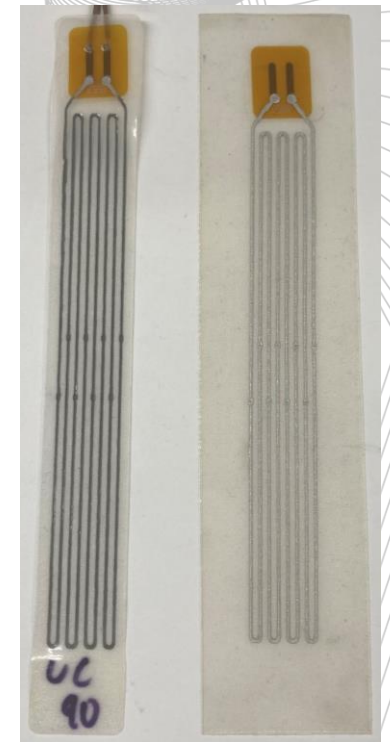
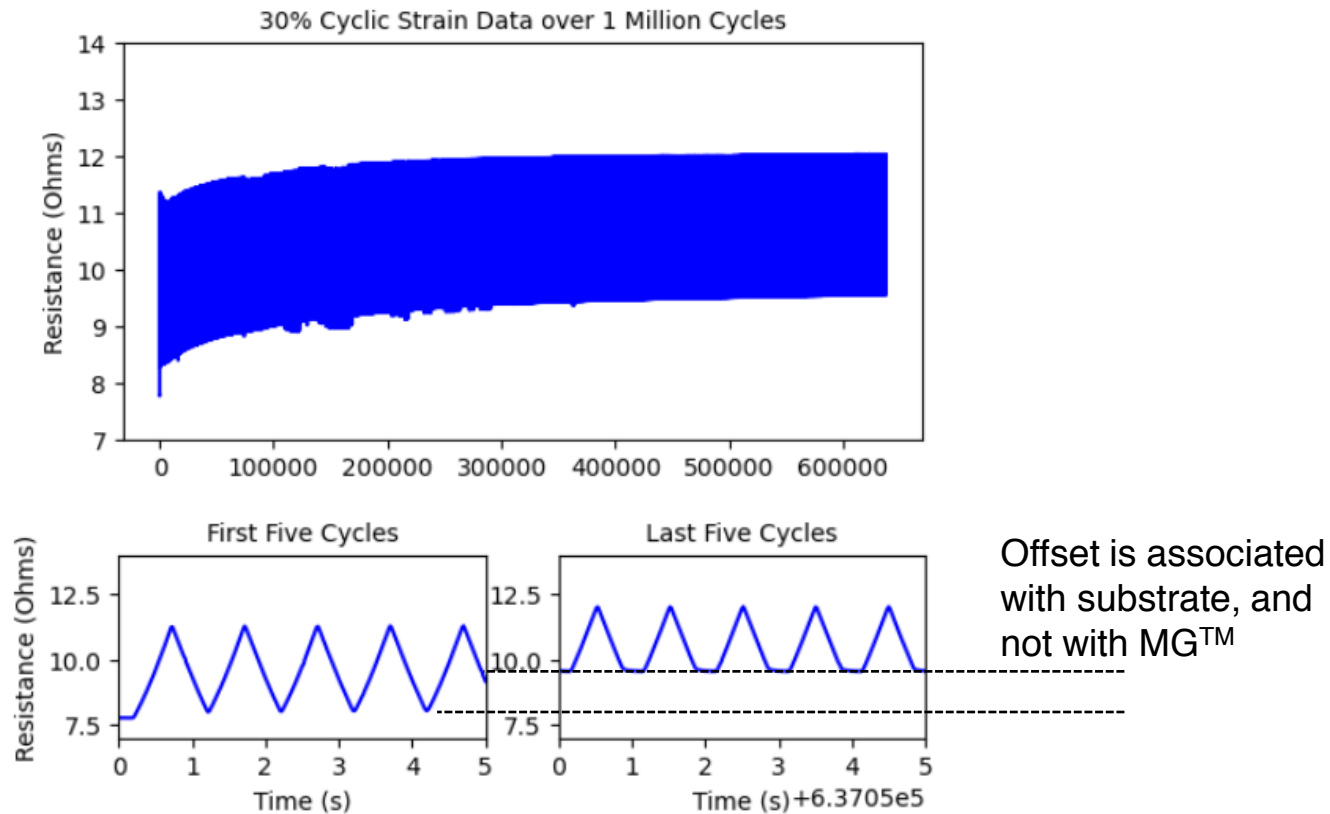
Substrate: TPU (Covestro)
Conductor: Silver Paste



Substrate: TPU (Covestro)
Paste: Carbon Paste

Fatigue cycling of stretchable conductor

- Liquid Wire stretchable conductor has ability to retain mechanical and electrical integrity over 1 million 30% cyclic tensile strain cycles

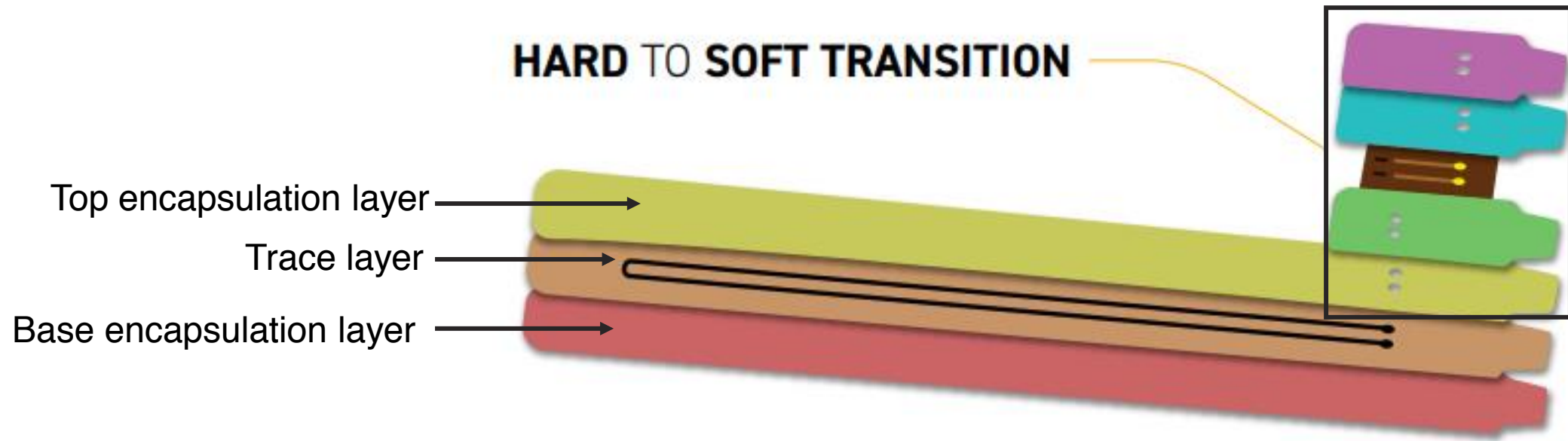


Tested specimen

Untested specimen

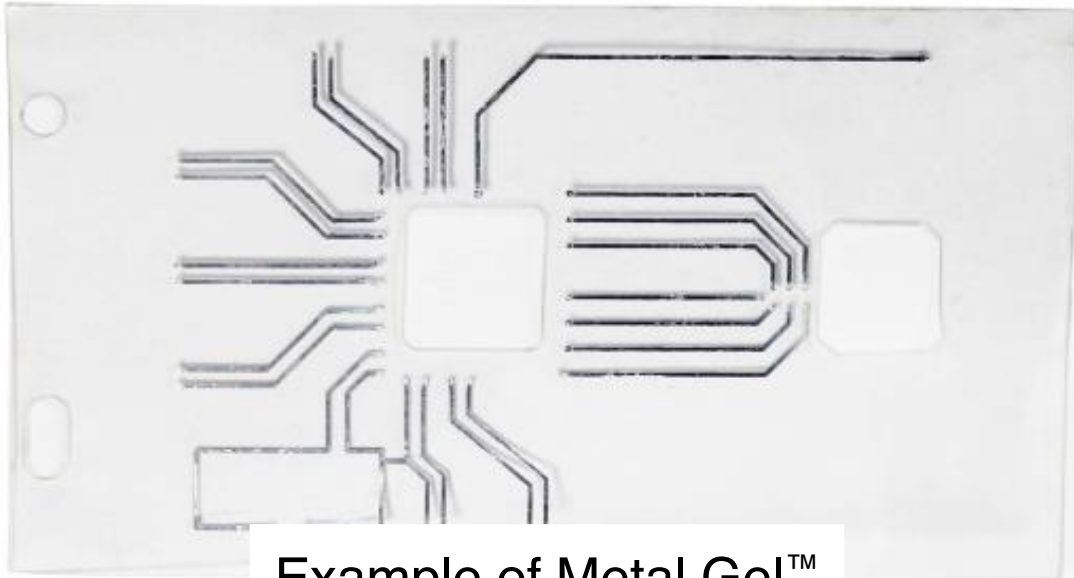
Hard-to-soft transition

- The Metal Gel™ conductor flows into itself and makes ohmic contact with metals it flows against. This feature is called Self-Solder™

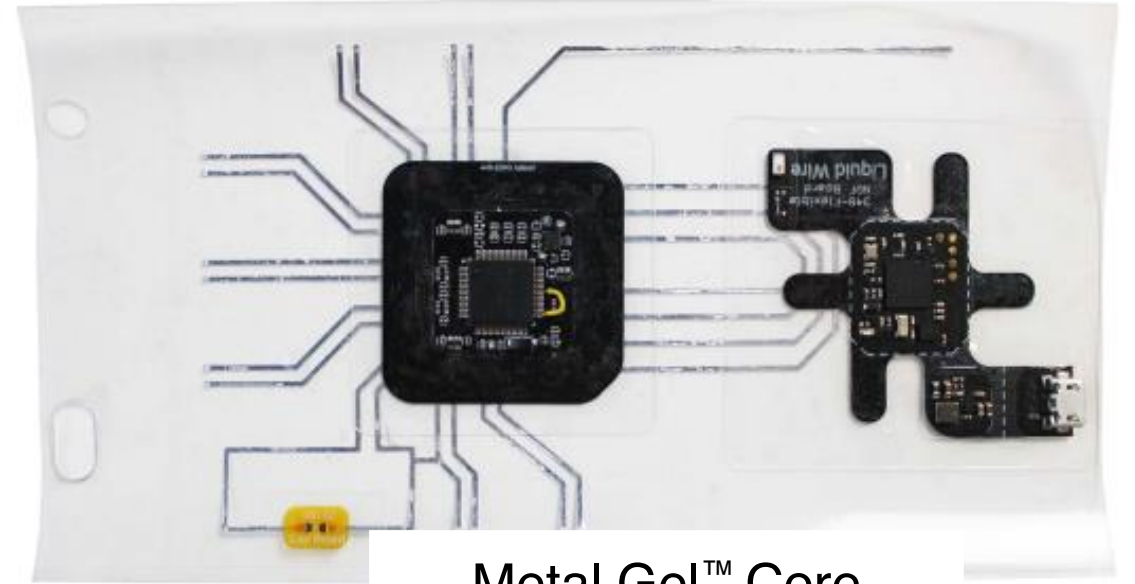


Liquid Wire island architecture

- Bond “Islands” into gel phase circuitry that allows mechanical movement



Example of Metal Gel™
Core



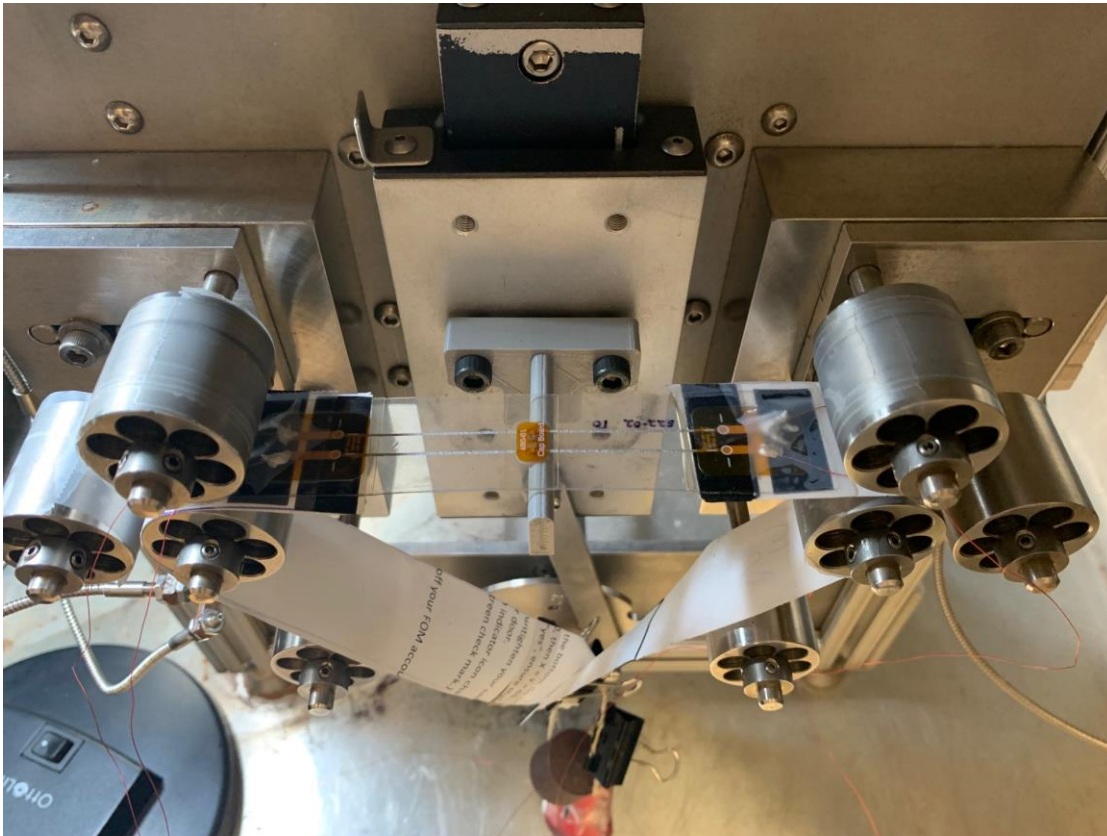
Metal Gel™ Core
Populated with Islands

Modulus mismatch

- From literature review it has been observed that modulus mismatch between inherent hard islands and stretchable substrates is key reason of failure
- With manufacturing processes and materials developed at Liquid Wire, a far more reliable and robust interconnection mechanism for hard-to-soft transition is now possible

Bend radius testing at Binghamton University

Relaxed State

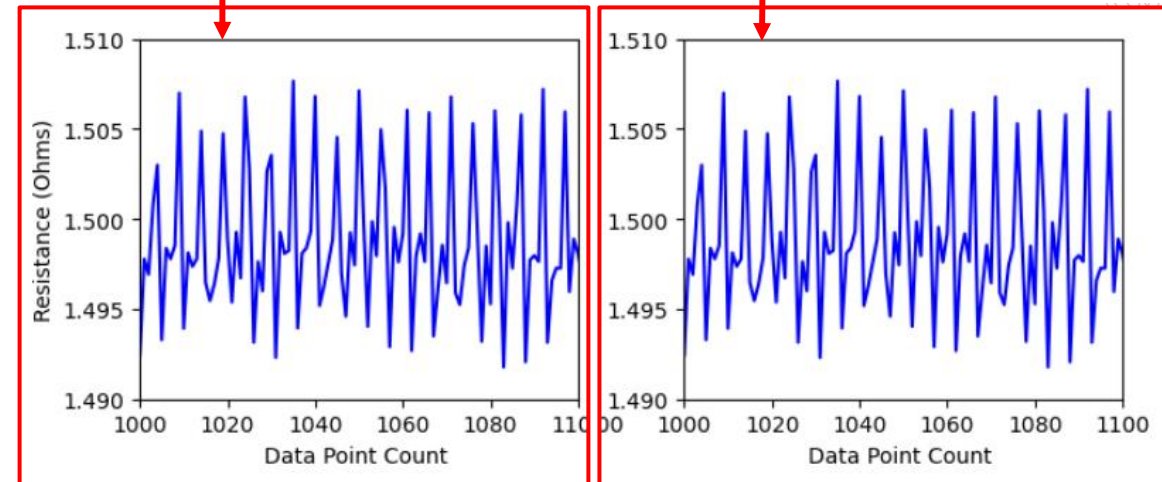
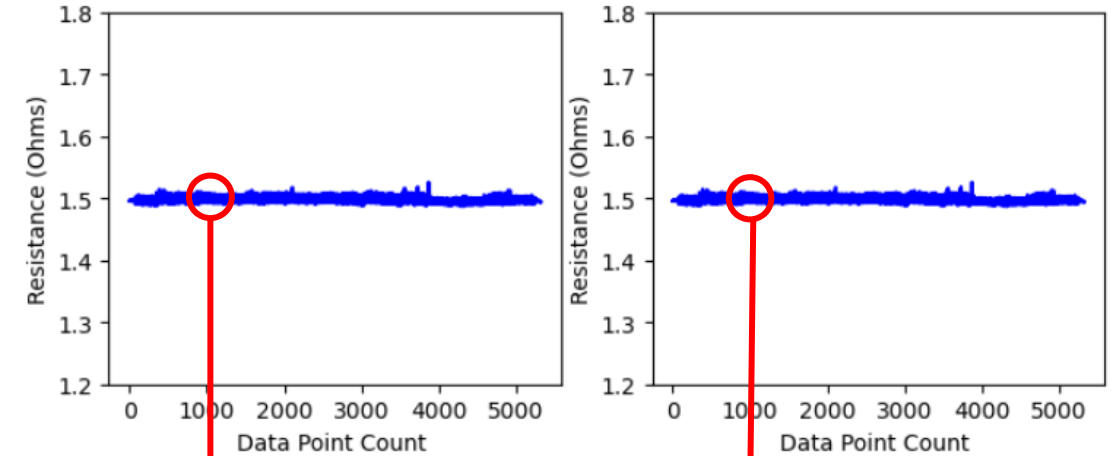
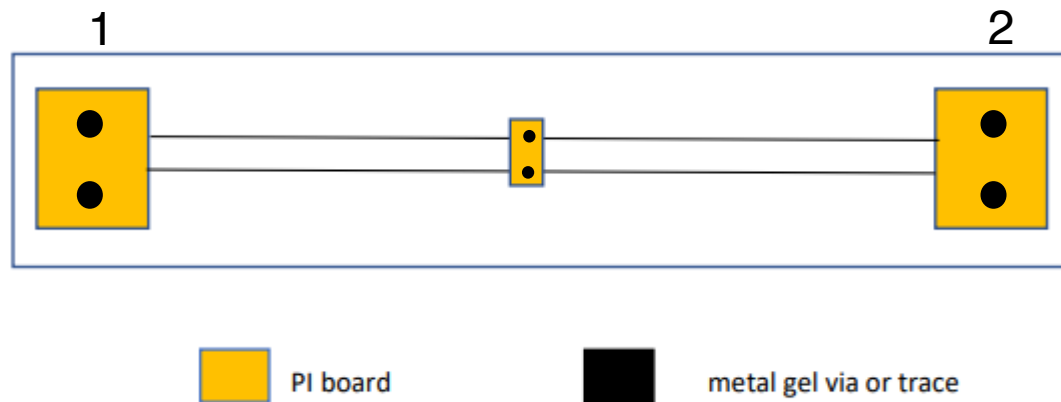


Bent State



Bend Radius Testing [Cont.]

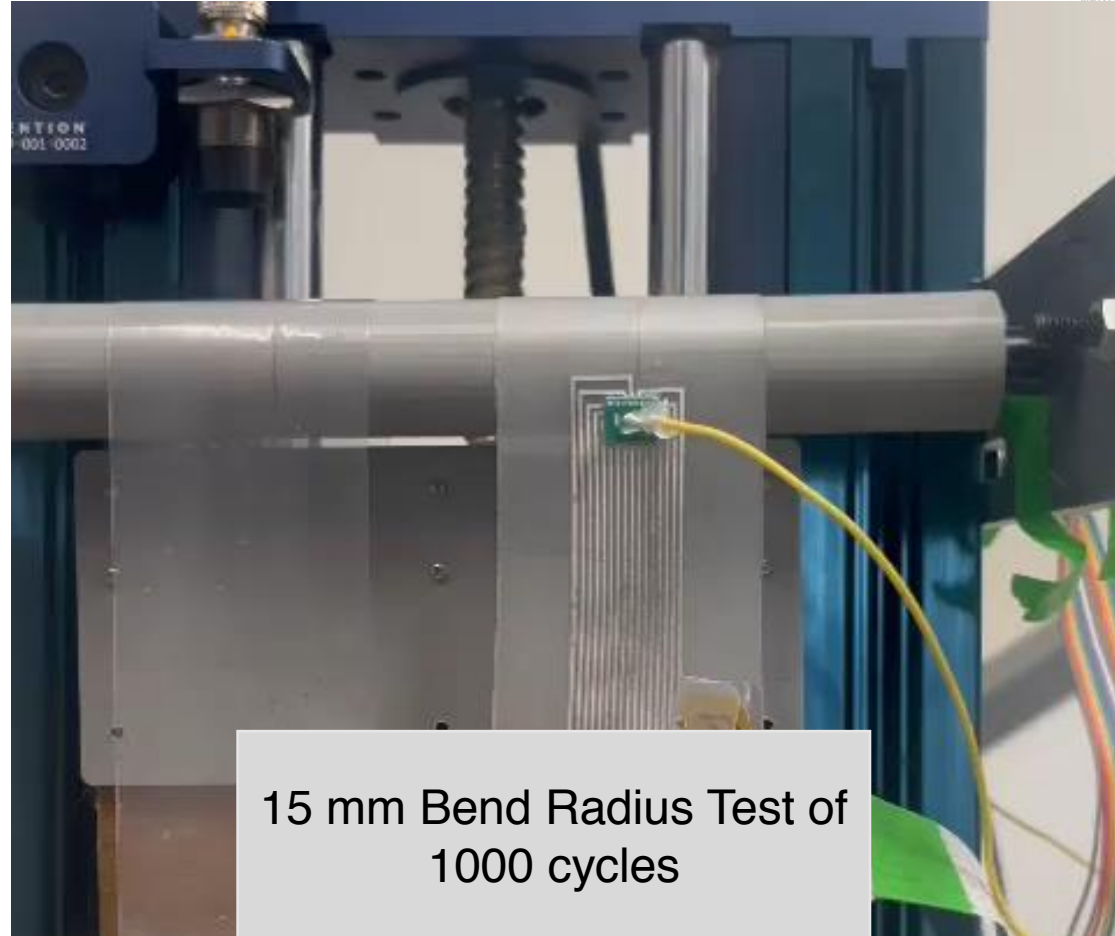
- Resistance between point 1 and 2 is continuously measured
- Noise arising from bending action is < 0.02 ohms



Bend Radius Testing at Liquid Wire



Specimen with more traces
and tight pitch spacing



15 mm Bend Radius Test of
1000 cycles

Conclusions

- Stretchable conductor made using Metal Gel™ showed ability to withstand cycle strains over 1 million cycles
- Metal Gel™ Self-Solder™ capability, and stability enables direct attachment of components without concern
- Liquid Wire hard-to-soft transitions were put through extreme bend radius testing and hot wash and dry testing and showed 100% success



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