



ATTACHING MICRODEVICES TO FIBERS FOR FLOW THROUGH ELECTRONICS

VIOLET TICE- UNIVERSITY OF UTAH

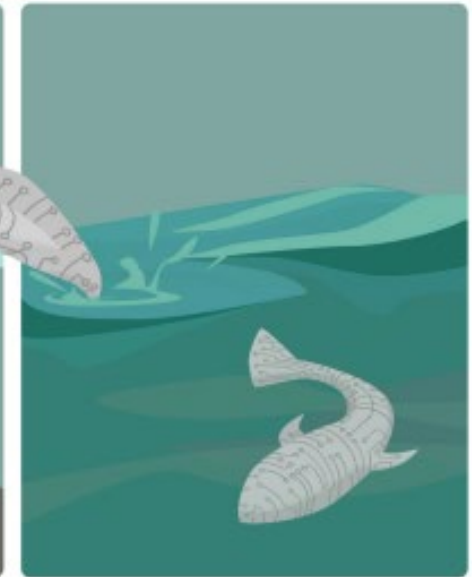
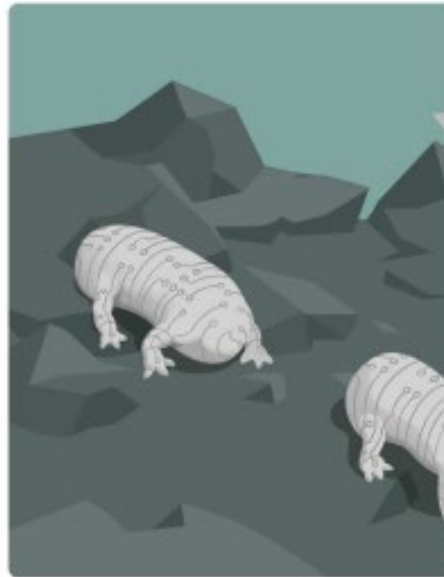
DR. HARNETT- UNIVERSITY OF LOUISVILLE



INTRODUCTION

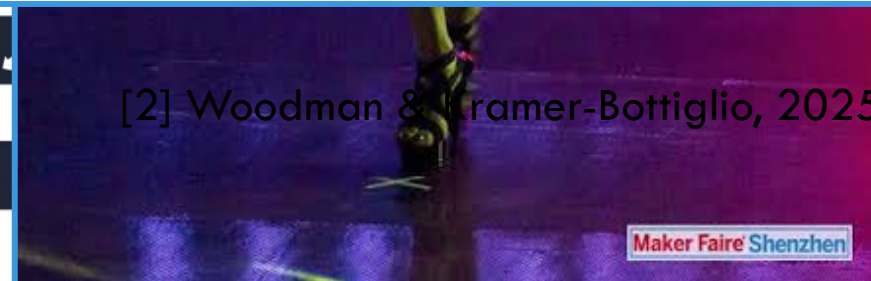
- **Wearable electronics:**
combining electronic components with textiles to create large scale circuits
- **How?**
 - Not sewing a wire onto a shirt
 - Integrating electronics into the textile structure without interfering with its properties
- **Why?**
 - Monitoring health
 - Art
 - Shape changing robotics

[1] Choudry et al., 2021



3-Axis
Accelerometer

Skin
Temperature



3-Lead ECG
HRV, QRS, RR Intervals

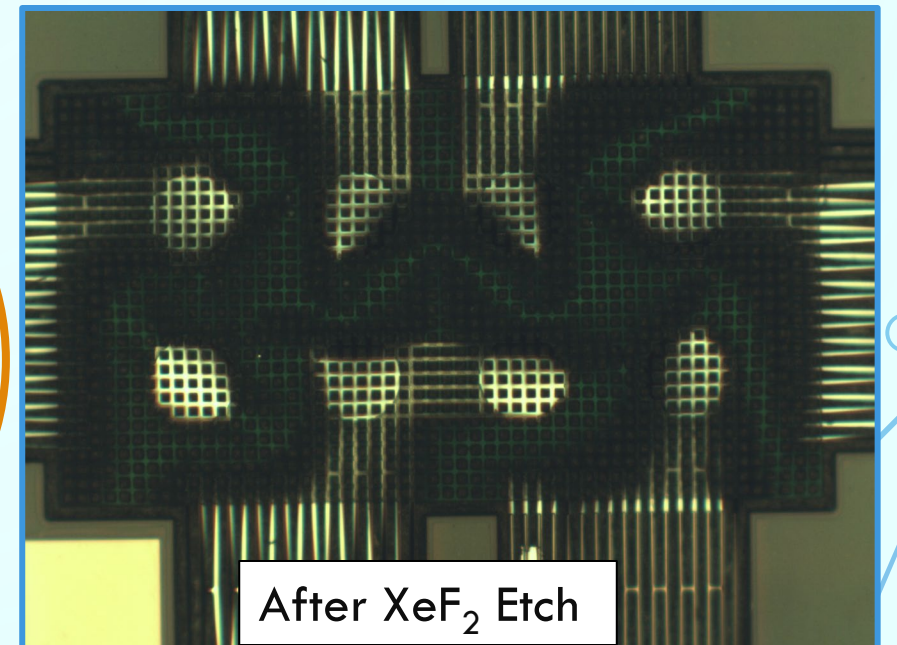
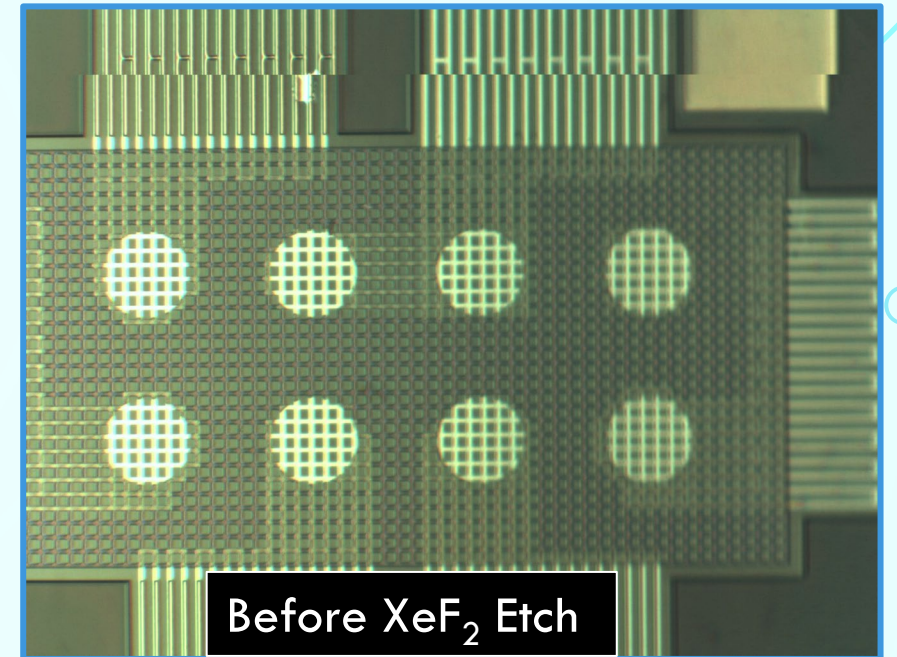
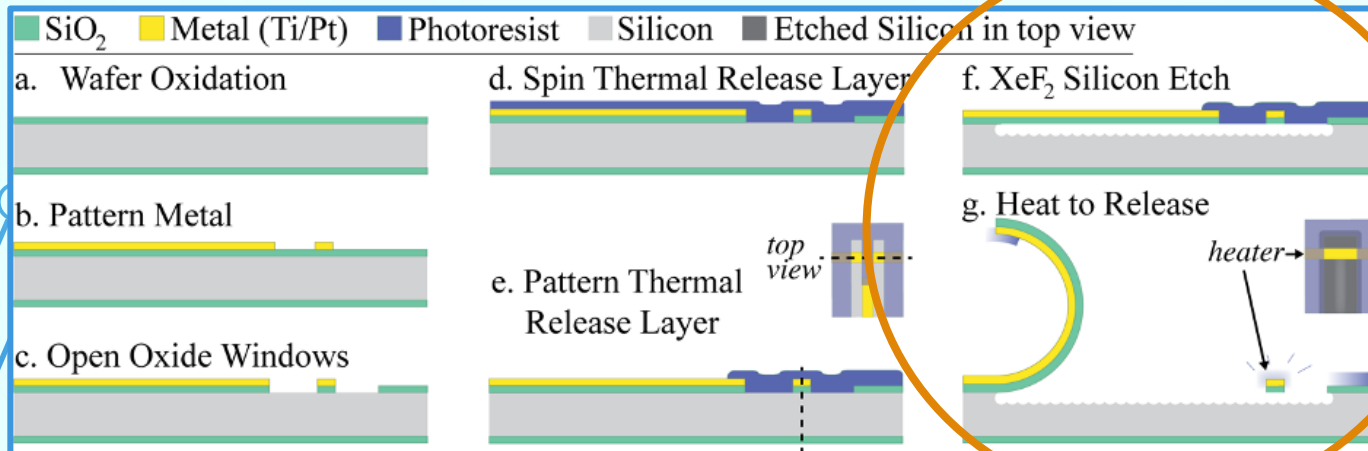
Breathing Rate
& Volume (RIP)

Maker Faire Shenzhen

<http://www.makefashion.ca/>

MEMS DEVICES

- Applied current results in cantilevers gripping onto fibers
- Cantilevers are made of platinum & titanium
- Fabrication method:



THE CHIPS

Chips are used to communicate to the MEMS

- Measure magnetic field, take temperature, etc.
- Solder balls attached to chip

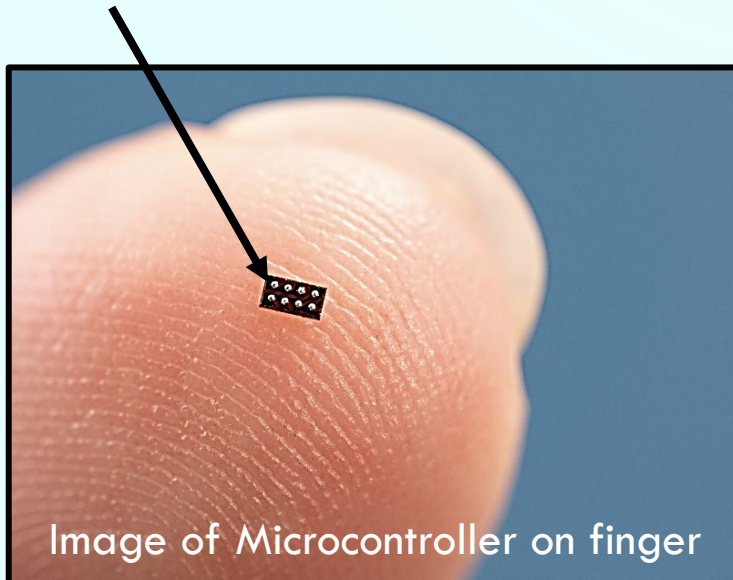
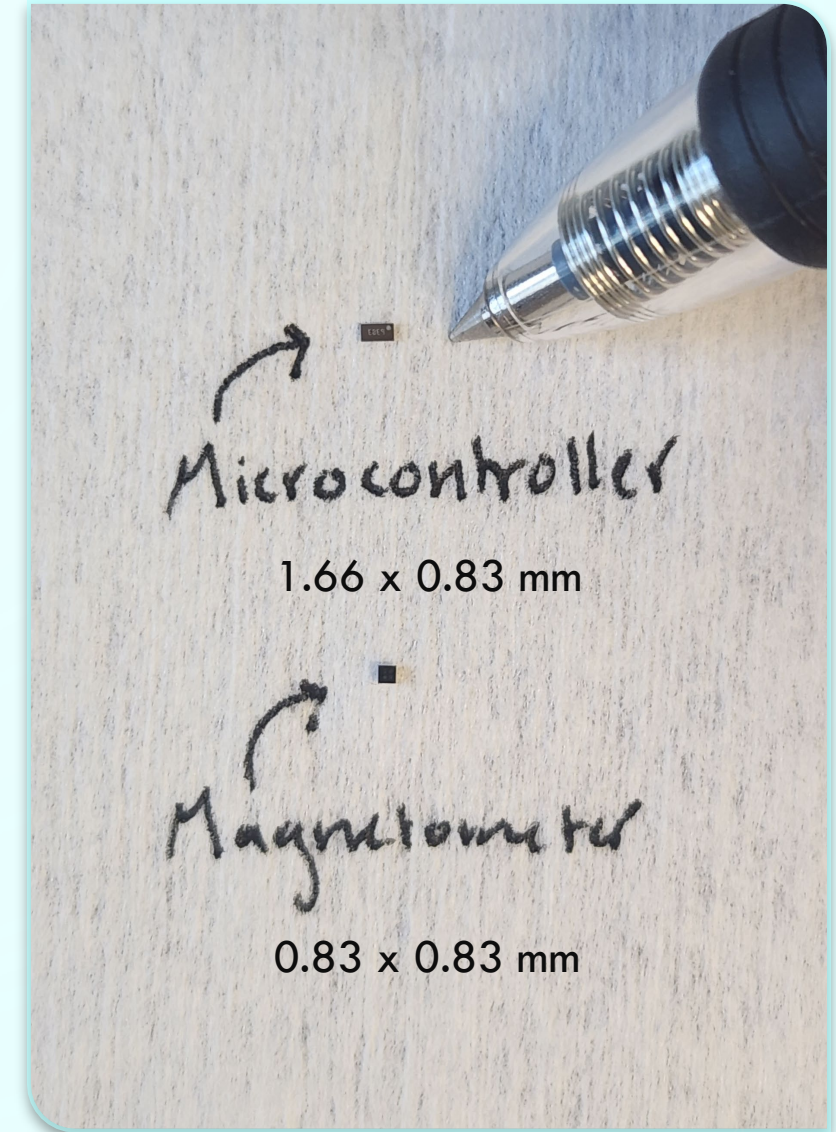


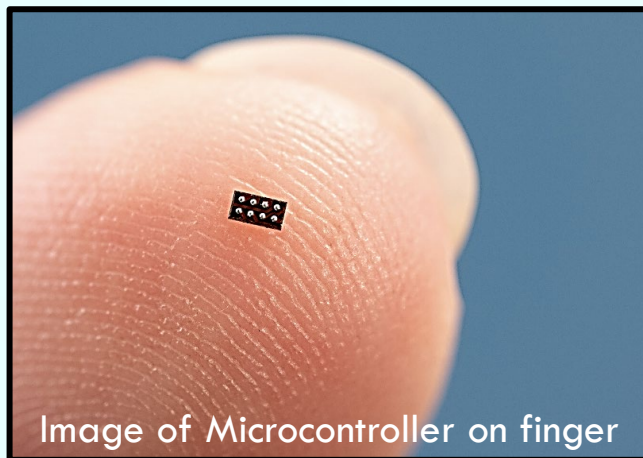
Image of Microcontroller on finger



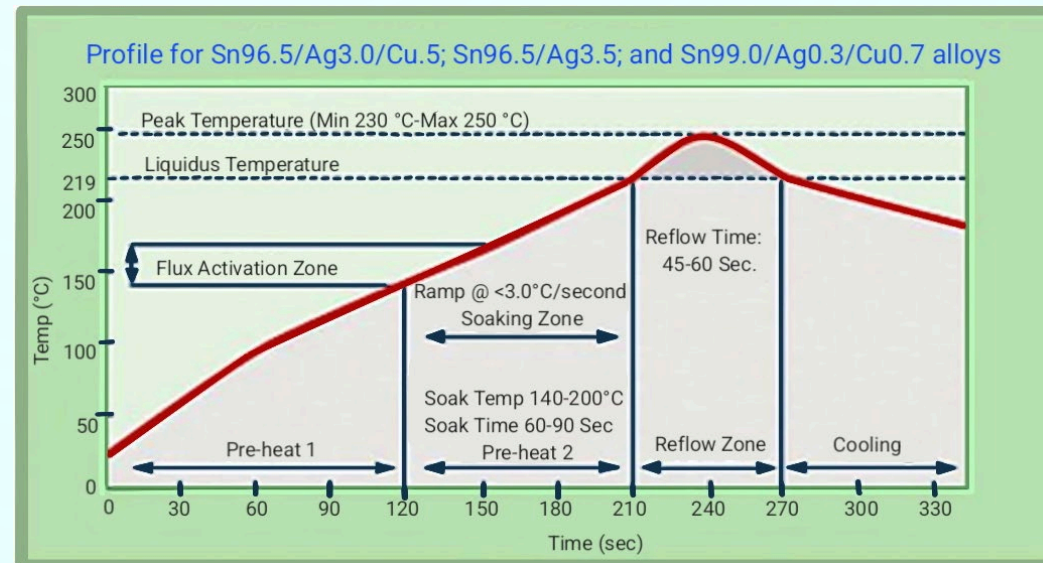
SOLDERING

Reflow soldering: gradual heating of solder until it melts

- Works best on small chips
- Soak at 170 °C
- Reflow at 230 °C



[3] Wakeel et al., 2021

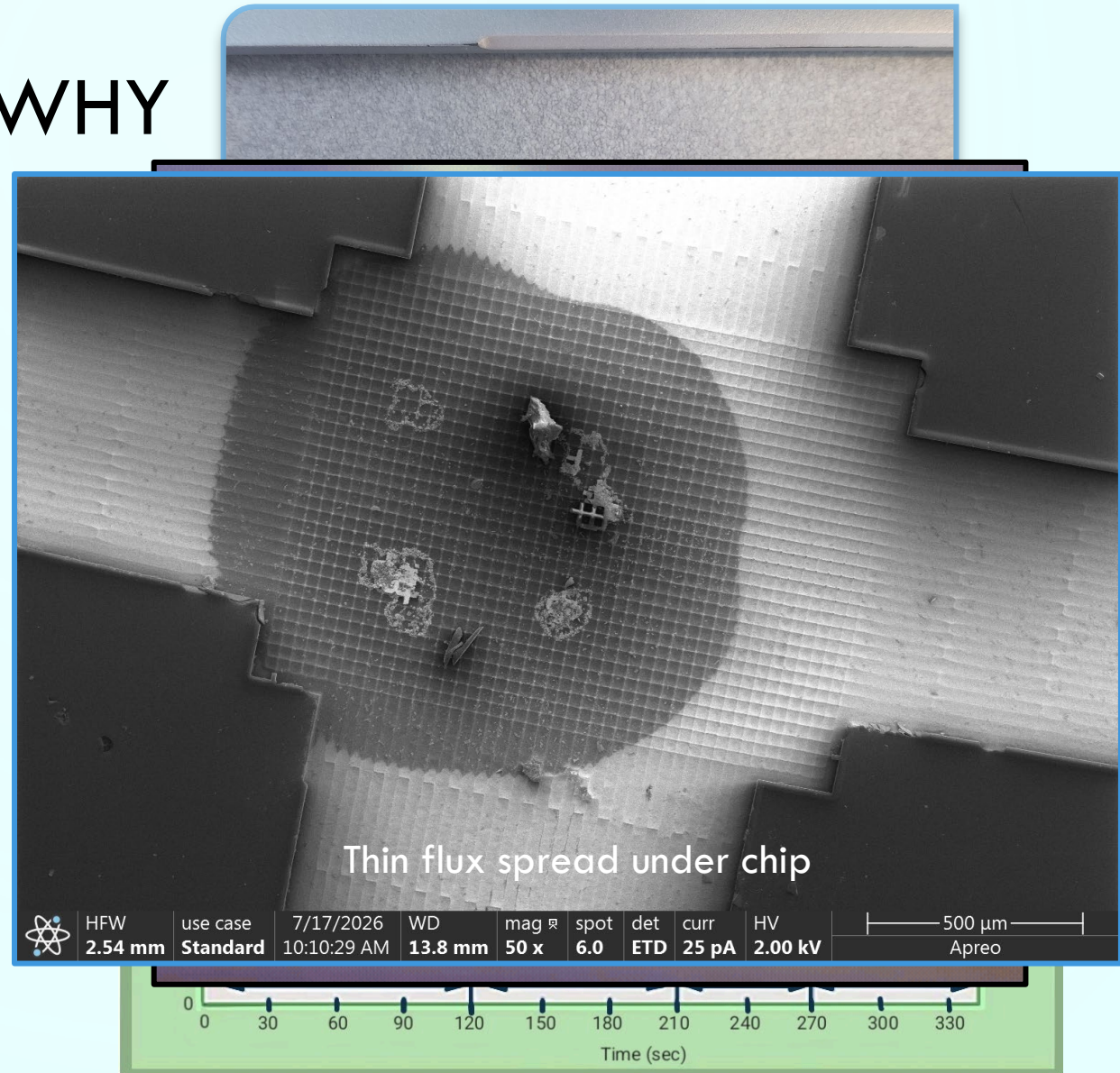


Tube of flux and Reflow Diagram [6]

TACKY FLUX: HOW & WHY

- Flux removes oxides while improving device longevity
- No Clean Flux: excess evaporates
- Guides sensors into the correct place
- Viscosity plays an important role
 - Too thin of flux will glue down cantilevers

[3] Wakeel et al., 2021



Tube of tacky flux & Reflow Diagram [4]

PROBLEMS:

1. Chips are too small for traditional soldering methods
2. Without flux, chips won't move into place and device lifespan decreases
3. If our flux is too thin, then it will glue down cantilevers and the device will fail
4. If our flux is too thick, then it won't fully evaporate and the cantilevers will be glued down

GOAL: IMPROVE SUCCESS RATE OF ATTACHING CHIPS TO MEMS

Find an optimal tacky flux depth & apply a uniform layer to minimize spread

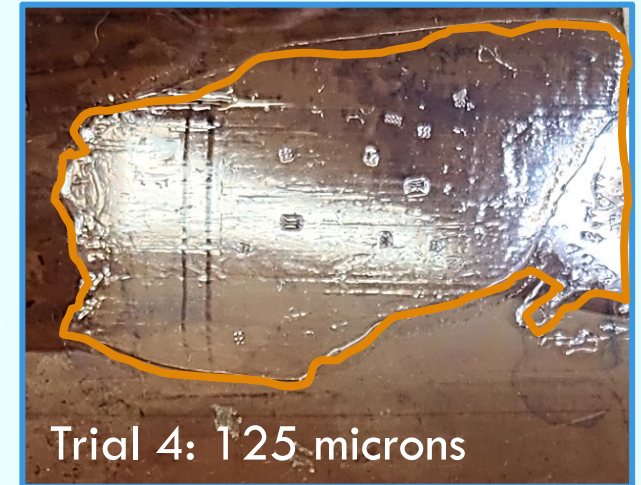
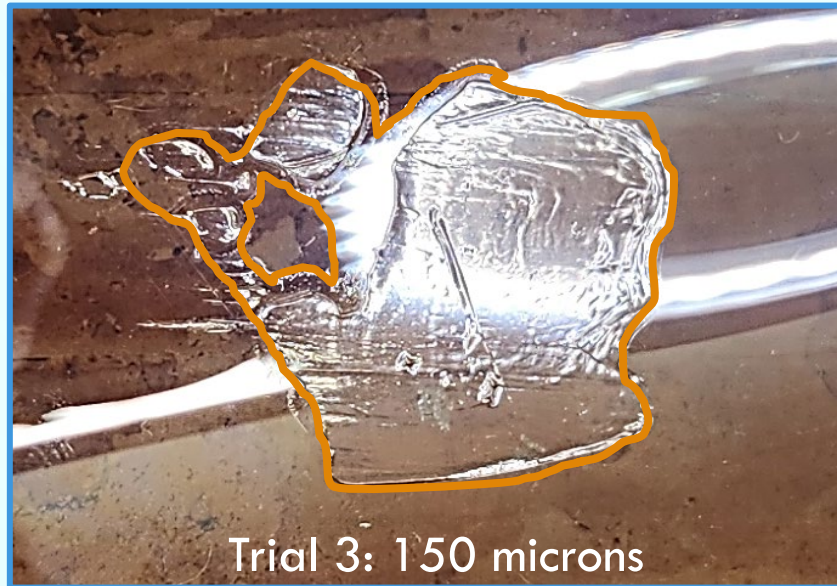
STEP 1: FILM APPLICATOR

- Spreads a thin, uniform layer of flux by pushing bar across a Mylar sheet

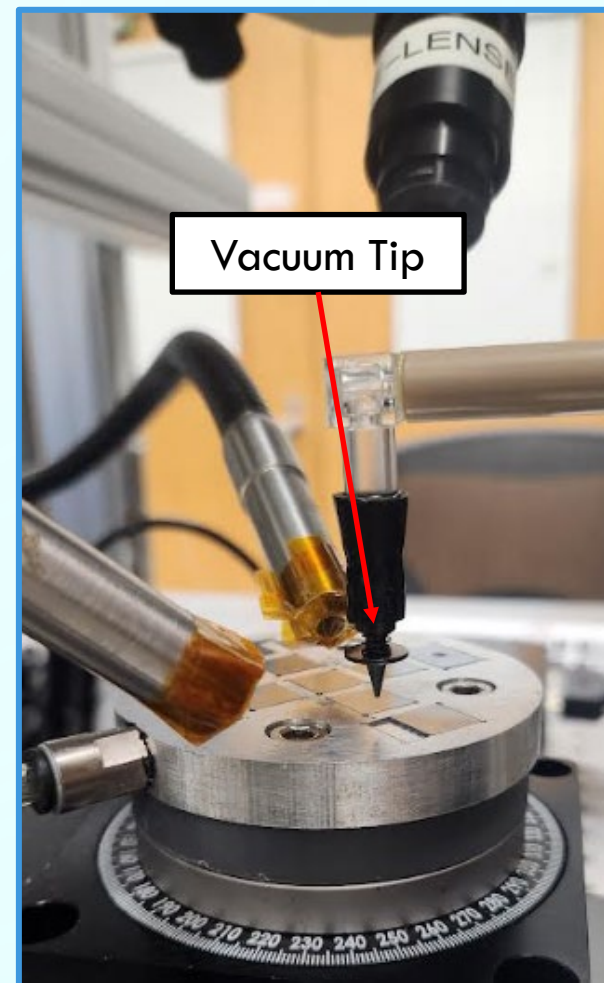
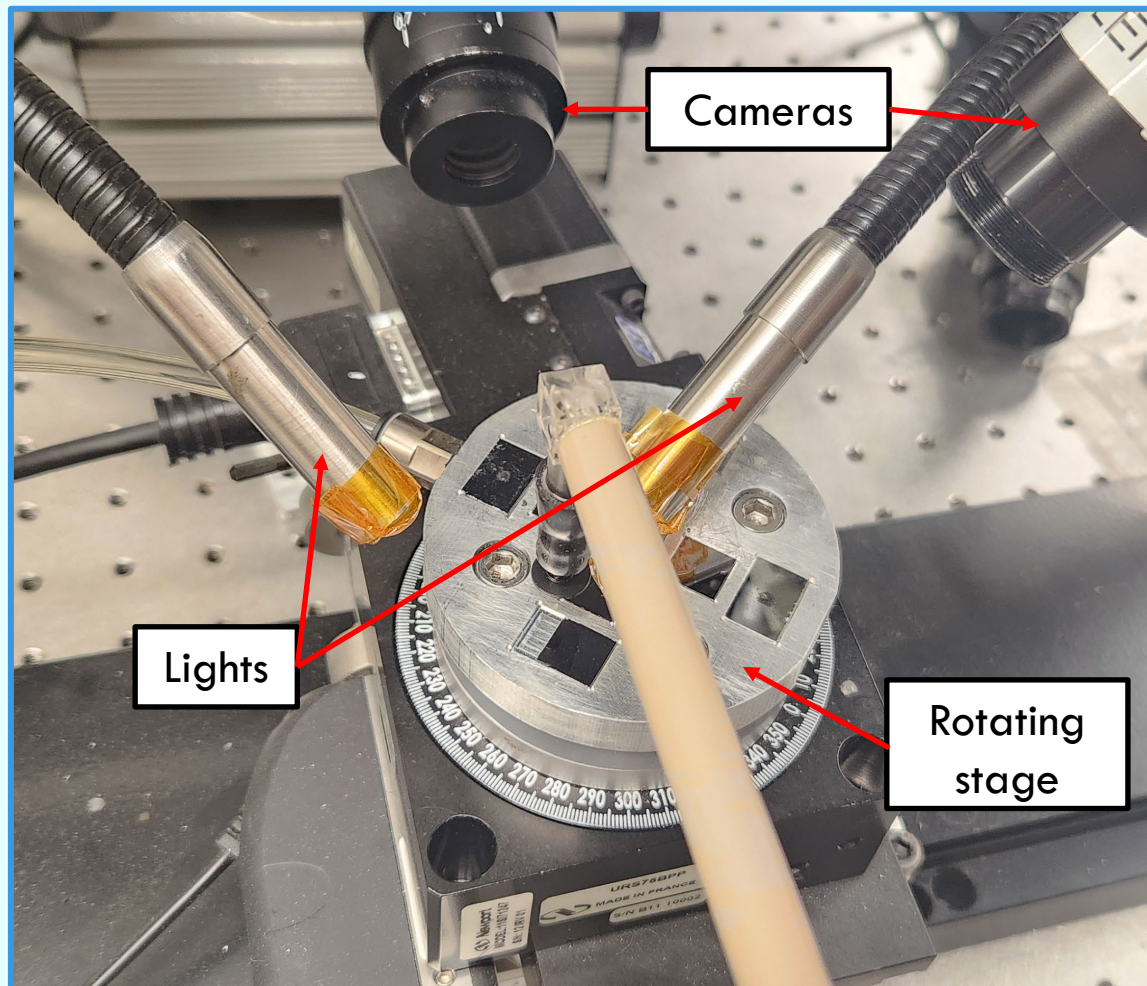




FIVE DIFFERENT FLUX DEPTHS

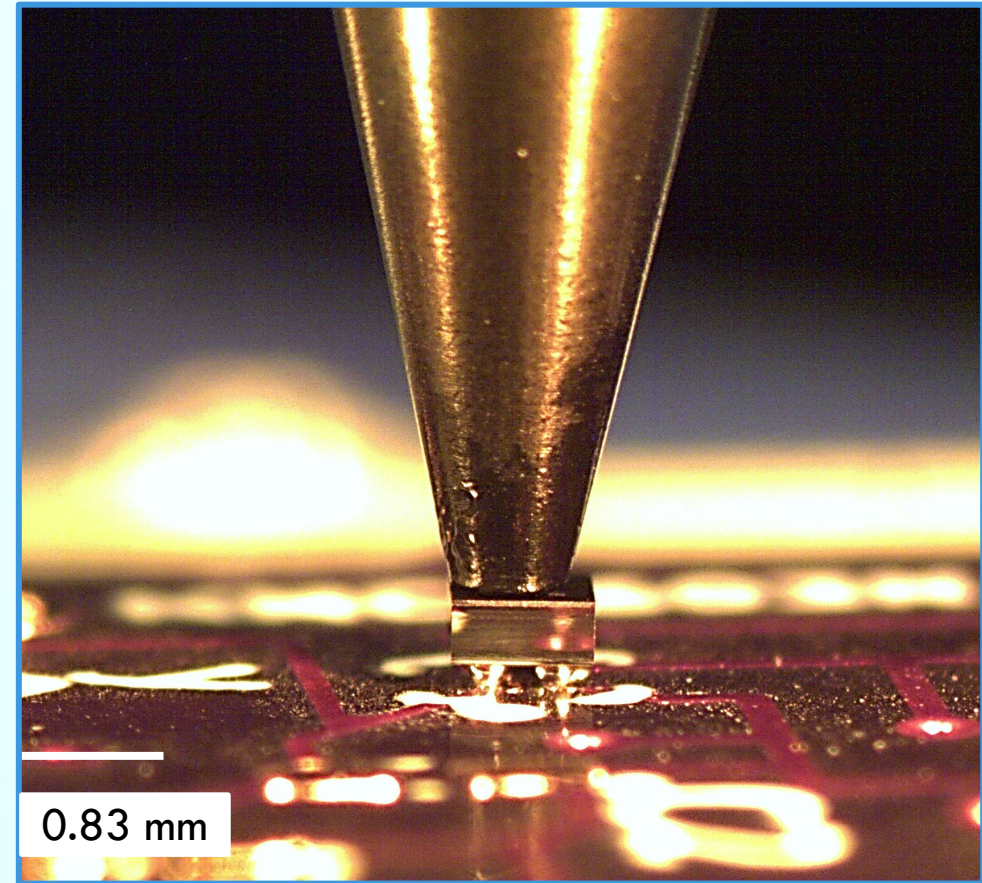
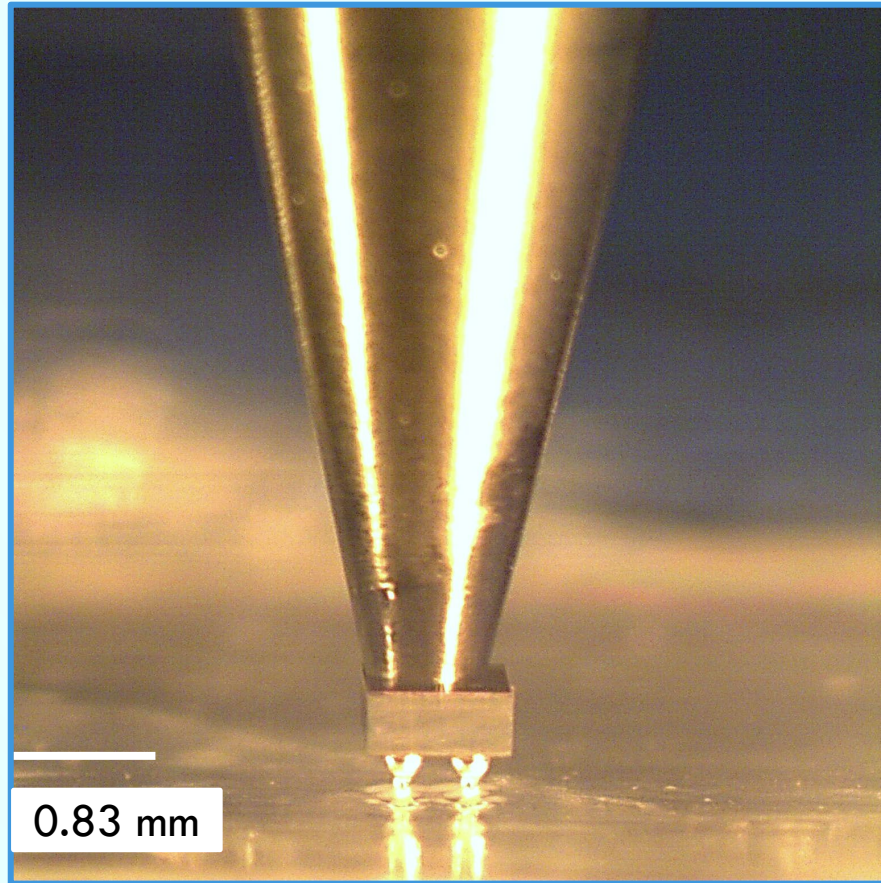


STEP 2: MICRO ASSEMBLY STATION



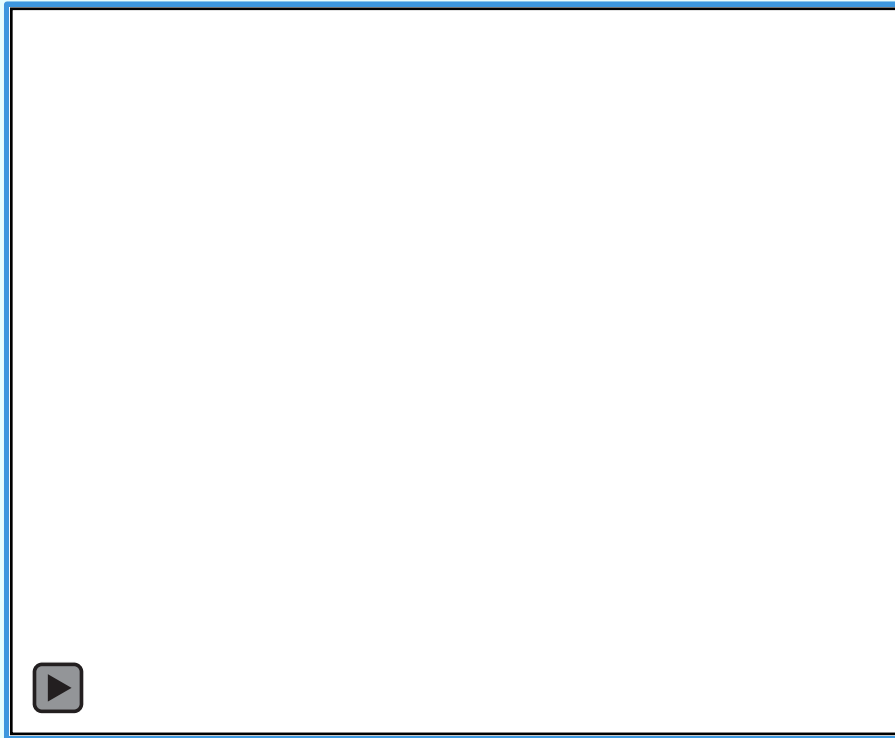
Overview of the micro assembly station

STEP 3A: ATTACH TO PCB



A sensor being dipped in tacky flux & attached to PCB

RESULTS & TAKEAWAY- UNIFORM LAYER ON PCB



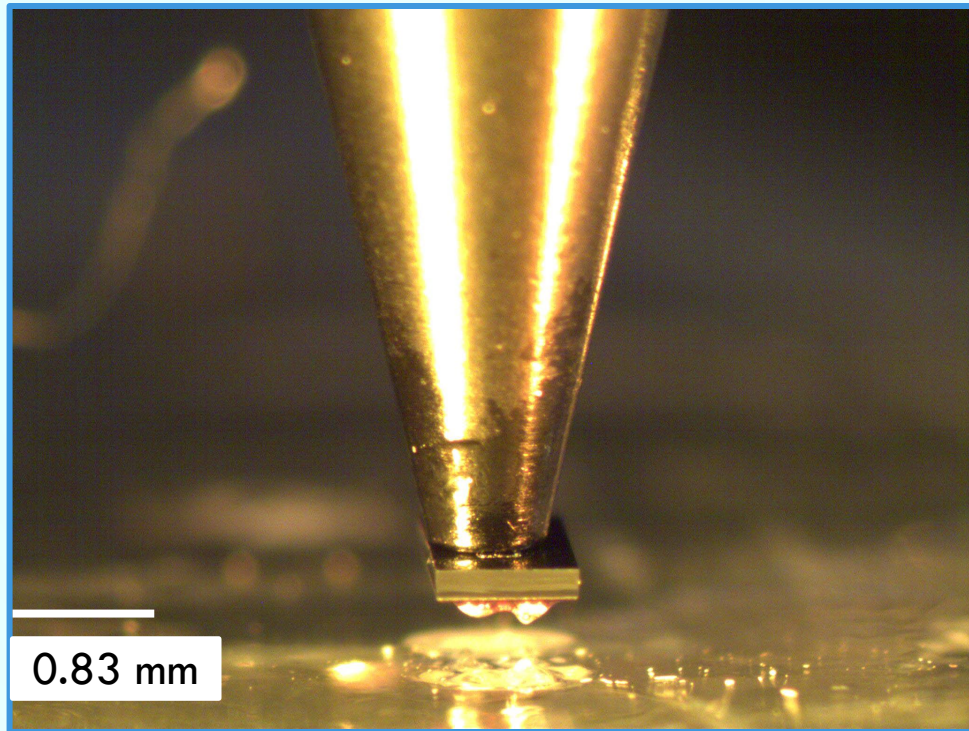
50 μm thick layer of flux soldered:
Poor connection between PCB and
chip

*Chips are 0.83 x 0.83 mm

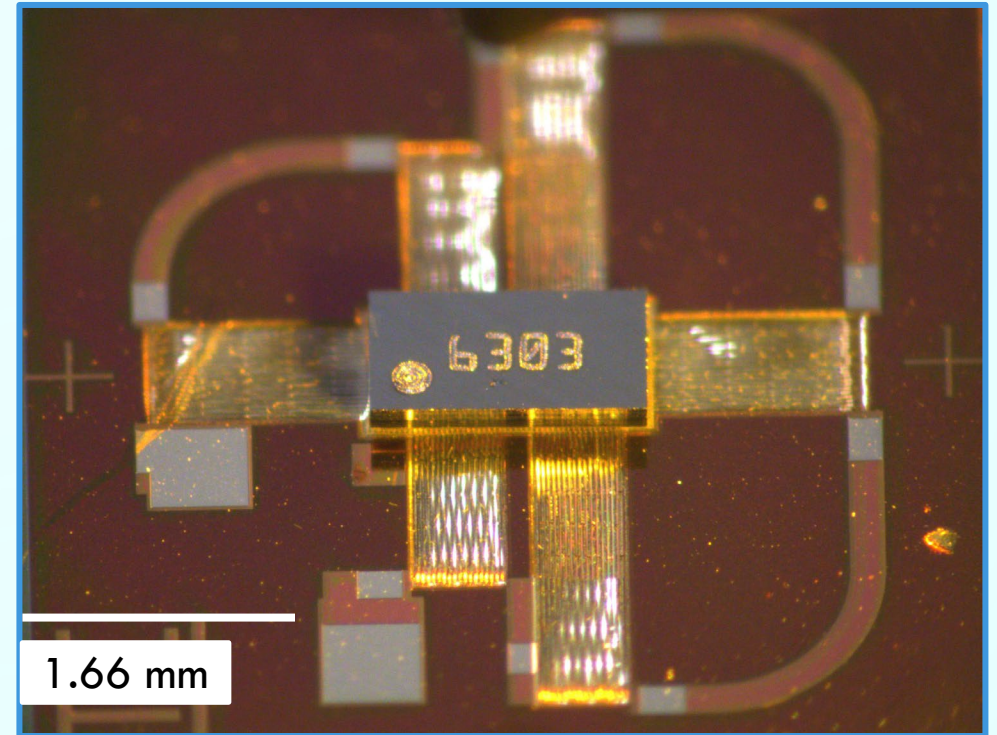


150 μm thick layer of flux soldered:
Chip slides into place, excess flux is
evaporated, good connection

STEP 3B: ATTACH TO MEMS

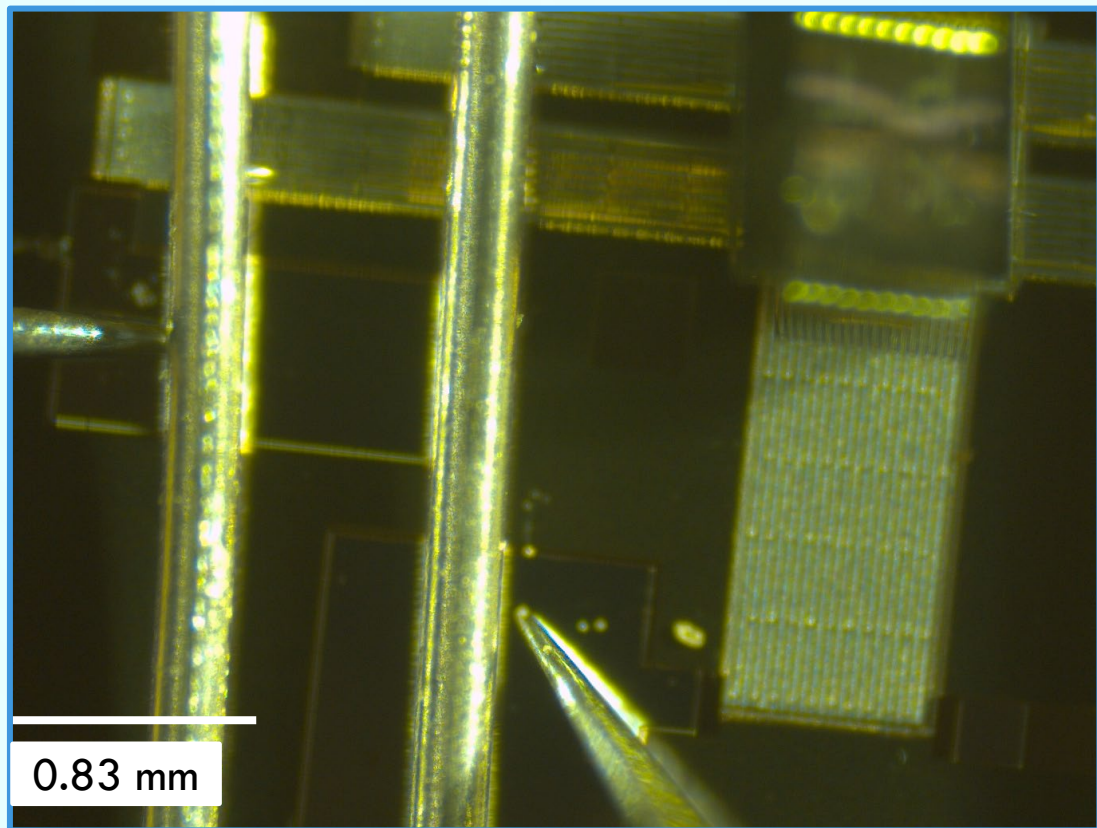


Microcontroller being dipped in 150 μm thick layer of tacky flux

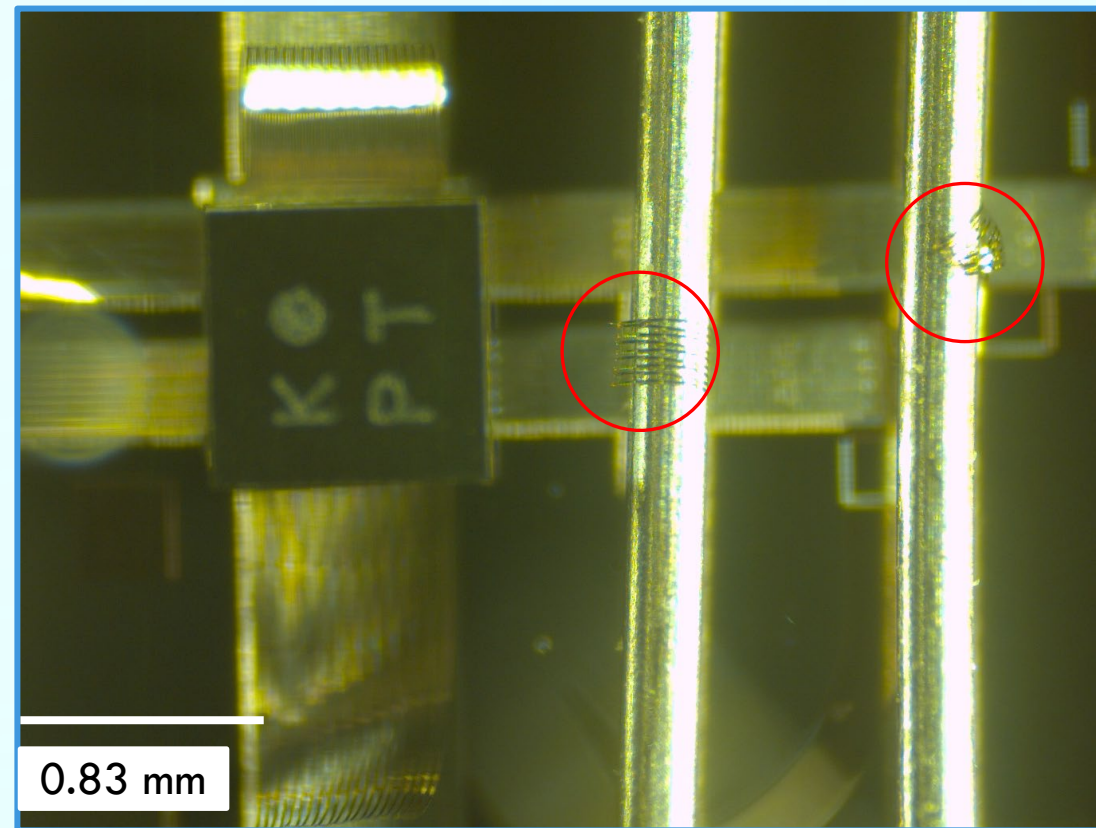


Microcontroller placed on the MEMS device

STEP 4: ATTACH TO WIRES

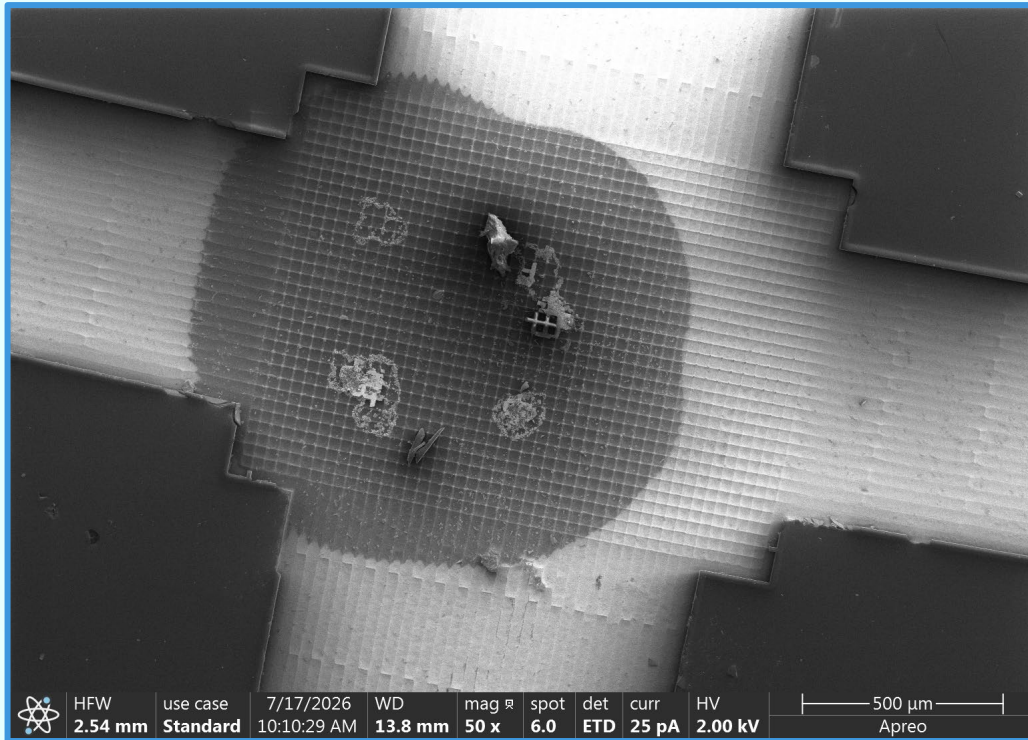


Before MEMS gripped onto wire

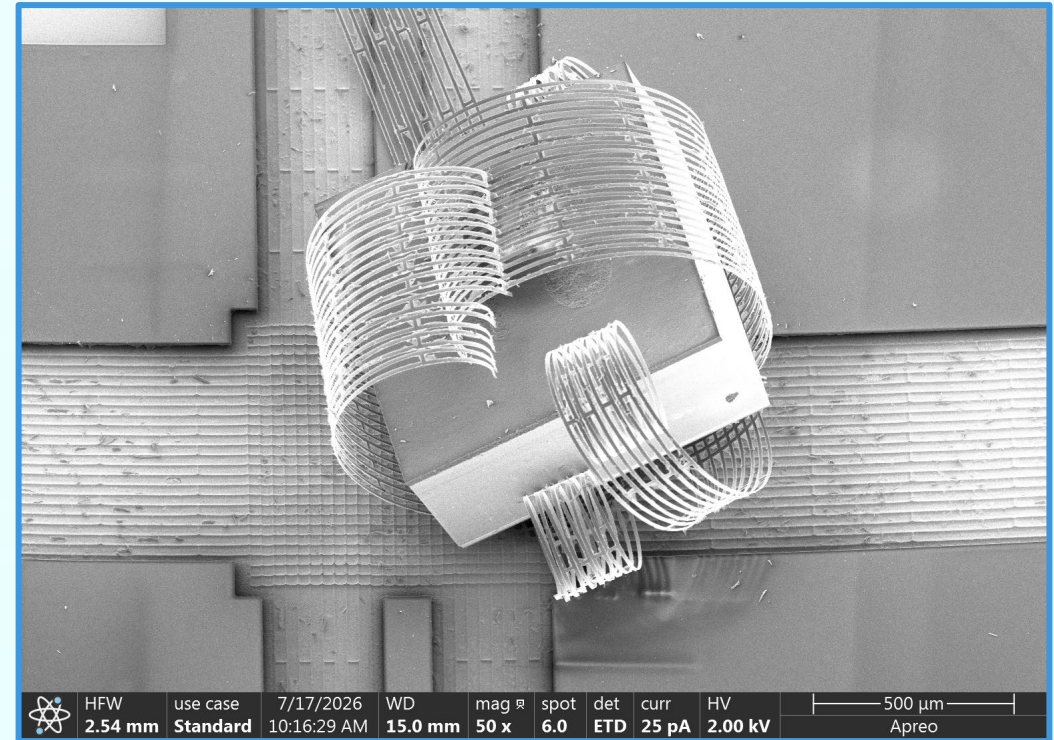


After MEMS gripped onto wire

RESULTS & TAKEAWAY

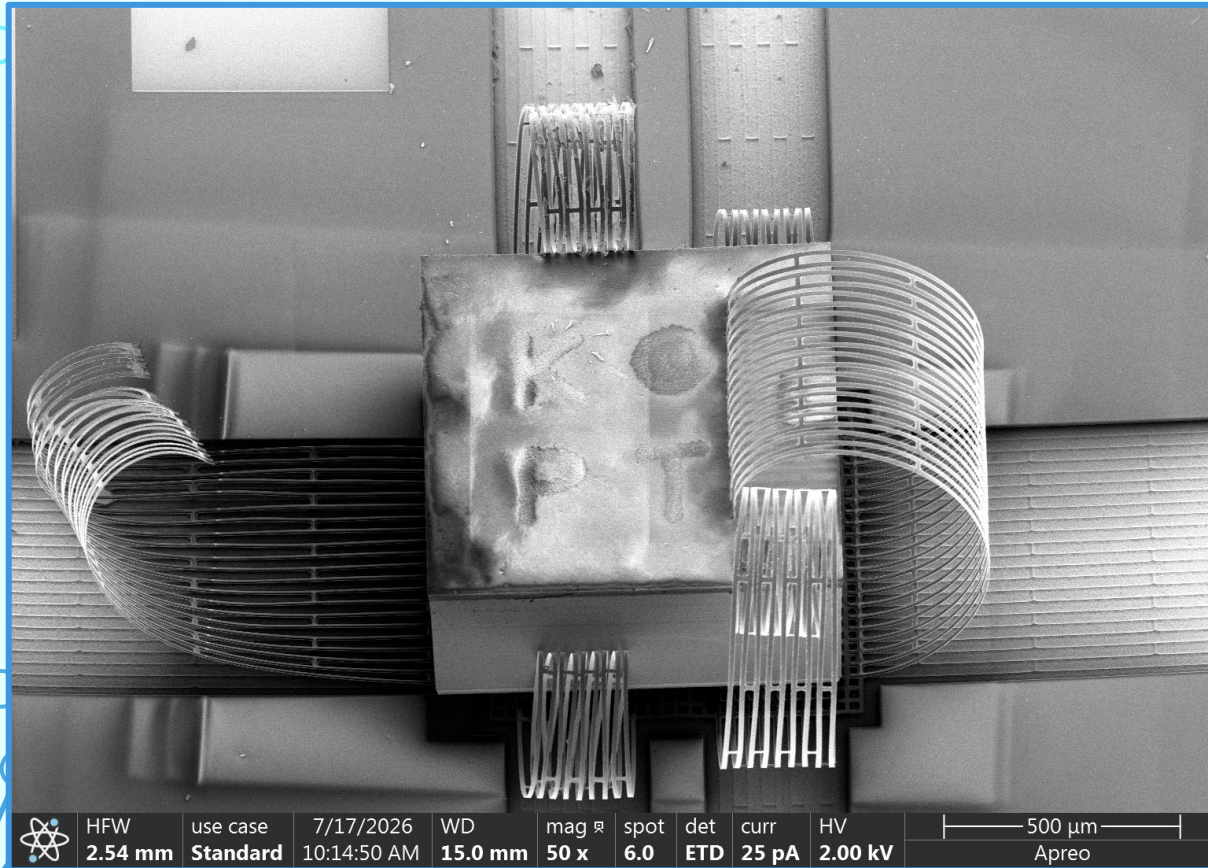


Before: A thin, wet tacky flux residue glues down cantilevers resulting in unsuccessful grappling



After: A uniform 150 μm thick layer of tacky flux leaves no residue, leaving wires free to grapple

CONCLUSION



Tacky flux stayed on chip and MEMS, instead of gluing onto the wafer. This suggests uniform depths of 125 microns are optimal for improving MEMS success

REFERENCES

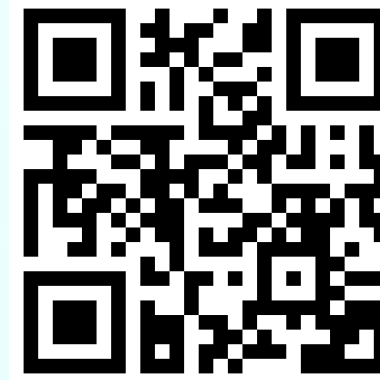
- [1] Choudhry, N. A., Arnold, L., Rasheed, A., Khan, I. A., & Wang, L. (2021). Textronics—A Review of Textile-Based Wearable Electronics. *Advanced Engineering Materials*, 23(12), 2100469. <https://doi.org/10.1002/adem.202100469>
- [2] Stephanie J. Woodman, Rebecca Kramer-Bottiglio. 2025. Stretchable Shape Sensing and Computation for General Shape-Changing Robots. *Annual Review Control, Robotics, and Autonomous Systems*. 8:1-23. <https://doi.org/10.1146/annurev-control-030123-013355>
- [3] Wakeel, S., Haseeb, A. S. M. A., Afifi, M. A., Bingol, S., & Hoon, K. L. (2021). Constituents and performance of no-clean flux for electronic solder. *Microelectronics Reliability*, 123, 114177. <https://doi.org/10.1016/j.microrel.2021.114177>
- [4] <https://fctsolder.com/no-clean-solder-paste/>
- [5] <https://www.nordson.com/en/products/efd-products/pico-pulse-jetting-valves>
- [6] <https://www.inventec.dehon.com/wp-content/uploads/2025/04/TDS-NC-559-V2-TF.pdf>



THANK YOU!



QUESTIONS?



Linked 

ACKNOWLEDGEMENTS

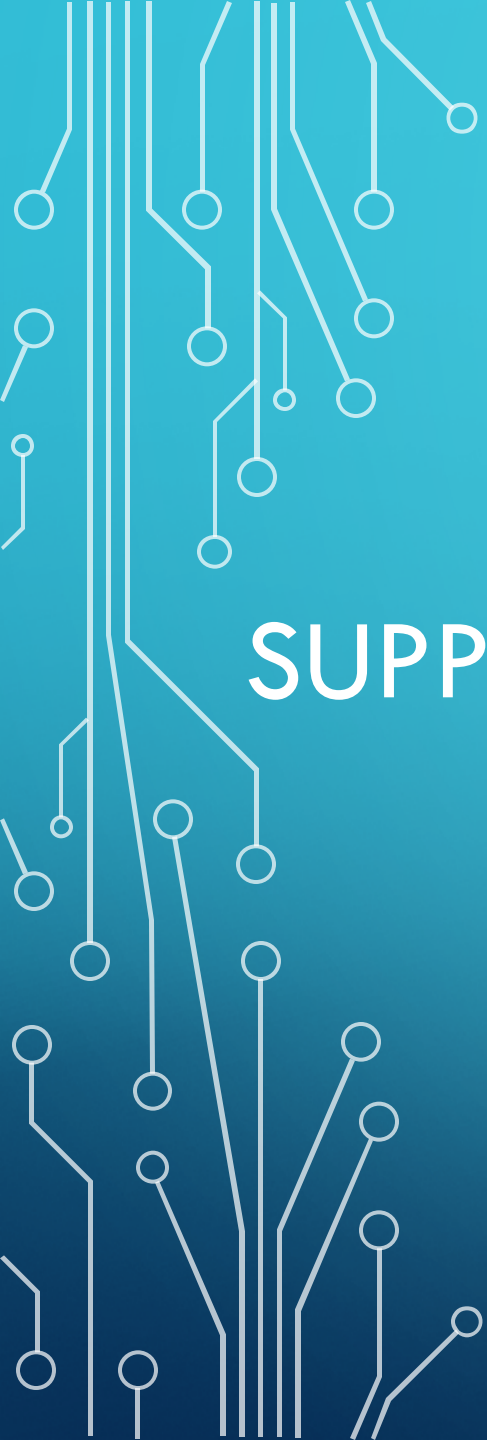
Supported by the NSF REU Award ID #2348869 and NSF NNCI Award ID #2025075.

Thank you MNTC for fabricating the devices and the NEXUS Micro Assembly Station at the University of Louisville, supported by NSF MRI award #18283555

Thank you, Dr. Harnett, for your support

Thank you, Ana Sanchez Galiano, for your hard work



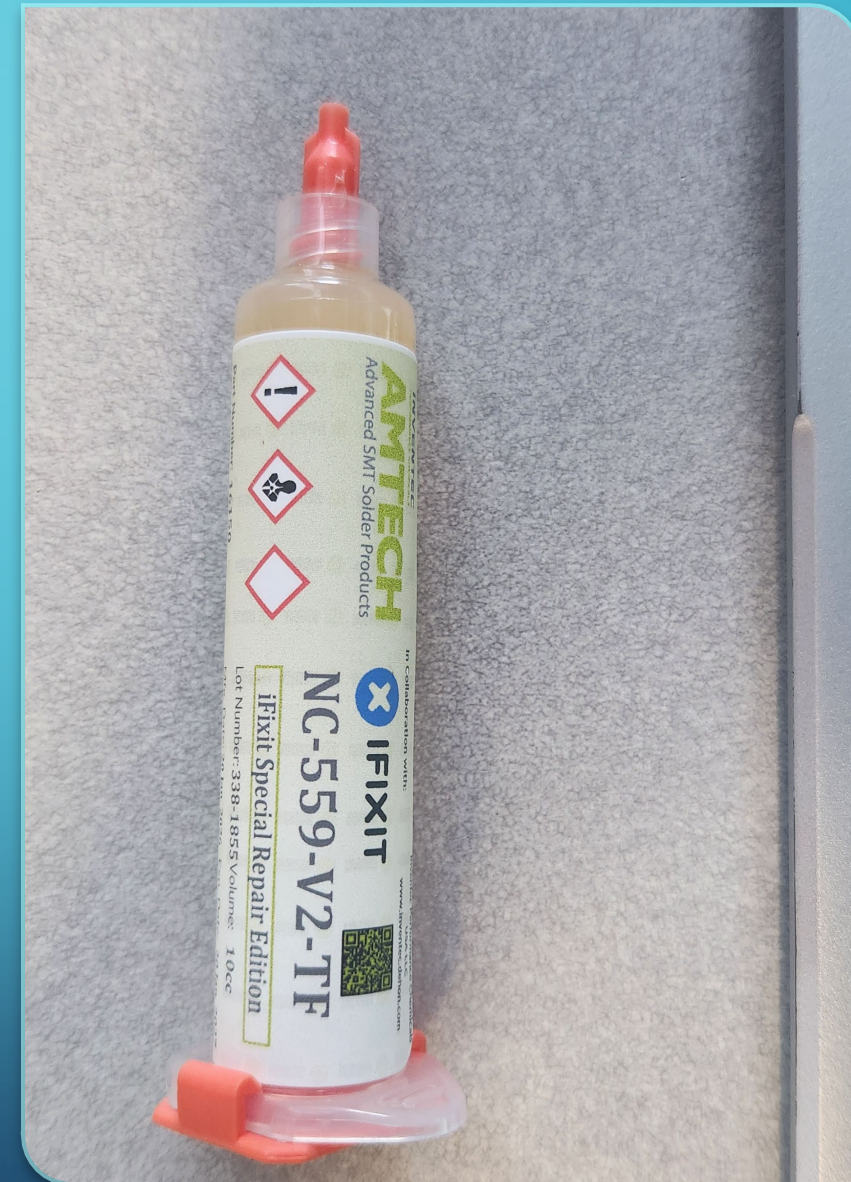
A series of white, stylized circuit lines and nodes on the left side of the slide, extending from the top to the bottom. The lines are of varying thickness and connect to small white circles, creating a complex, branching pattern.

SUPPLEMENTARY SLIDES

FLUX

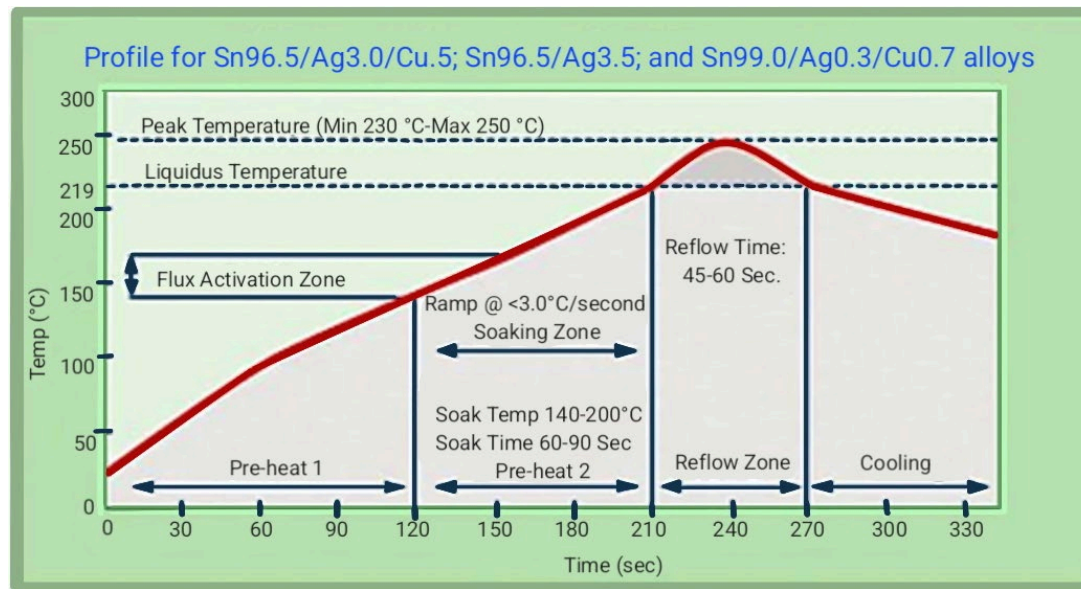
- Flux: cleaning agent that increases component longevity and improves flow
- No Clean Flux (NCF): components evaporate while soldering
- Four components:
 - Activators: remove metal oxides
 - Surfactants: create tackiness & improve wetting; dissolves reaction products
 - Additives: remove oxides & inhibits corrosion
 - Solvents: adjusts viscosity; creates uniform mixture
- Rosin NCF: prevents reoxidation of surface but residue left behind

[3] Wakeel et al., 2021



Flux used on chips

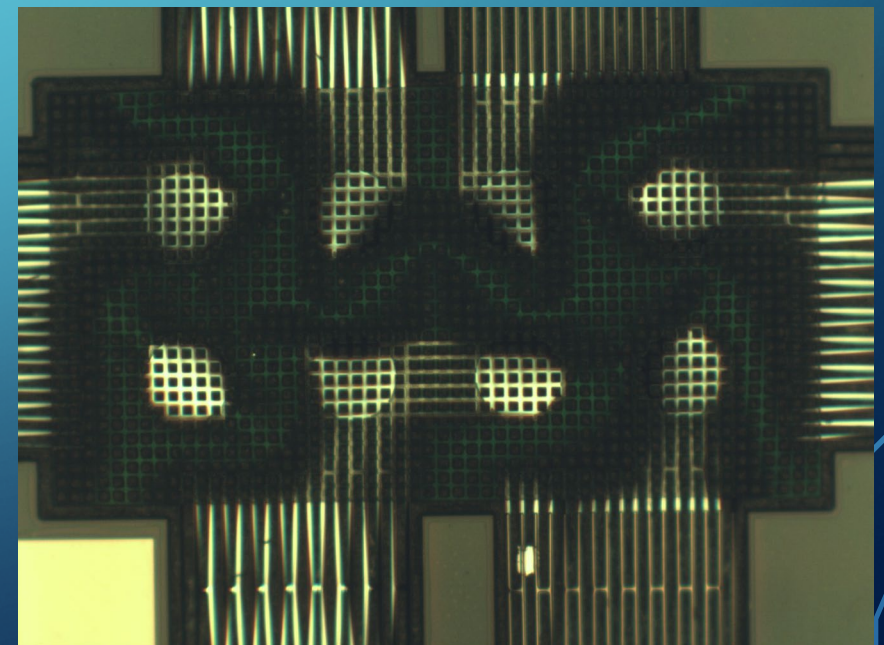
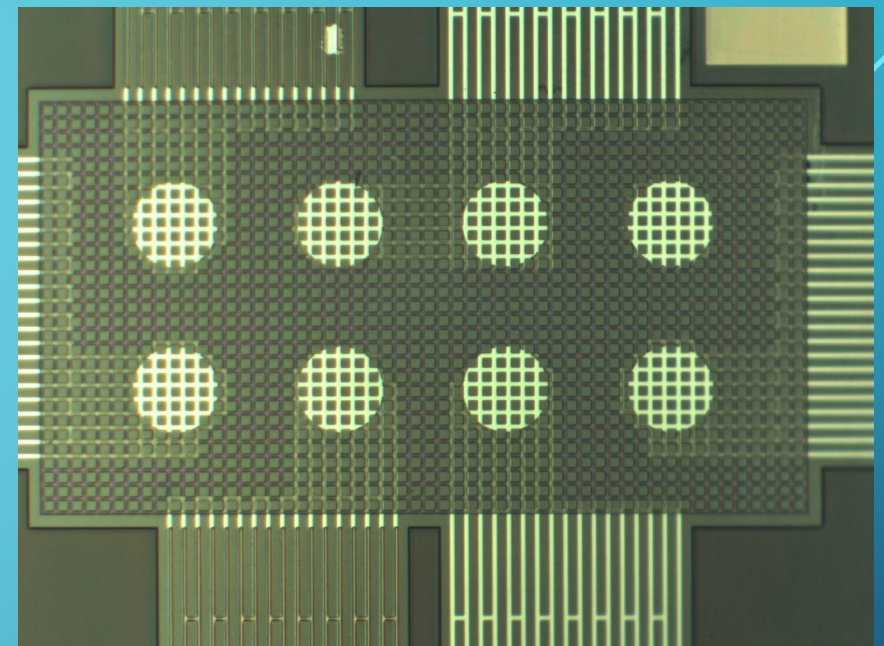
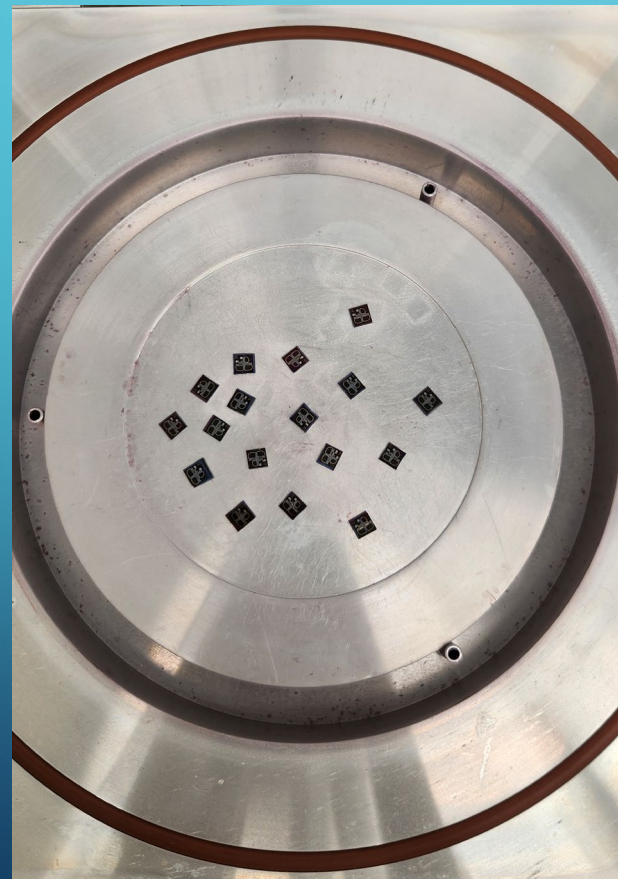
SOLVENTS



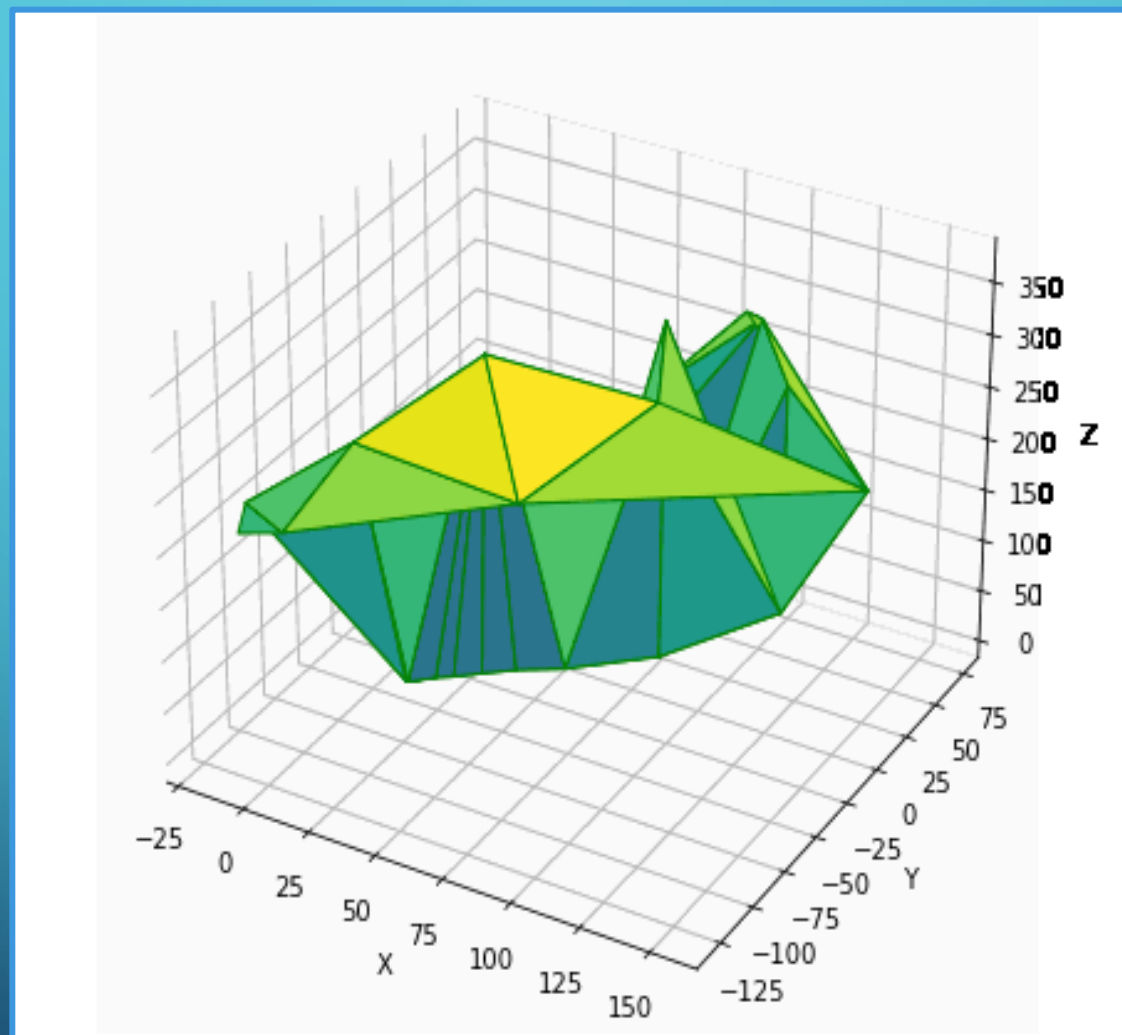
Typical Reflow Profile [6]

- NCF viscosity determined by solvent viscosity
- Viscosity:
 - Too high and flux will not completely evaporate
 - Too low and bridging may occur (not necessarily an issue here)
- Needs to have a low boiling point
- Needs to be thermally stable at high temperatures

XENON DIFLUORIDE ETCH

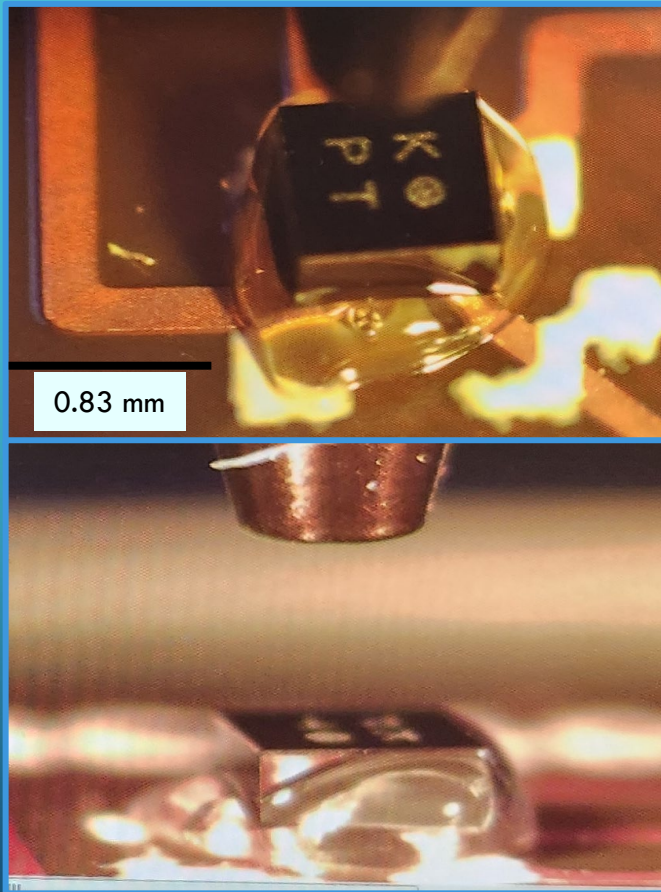


GRAPH

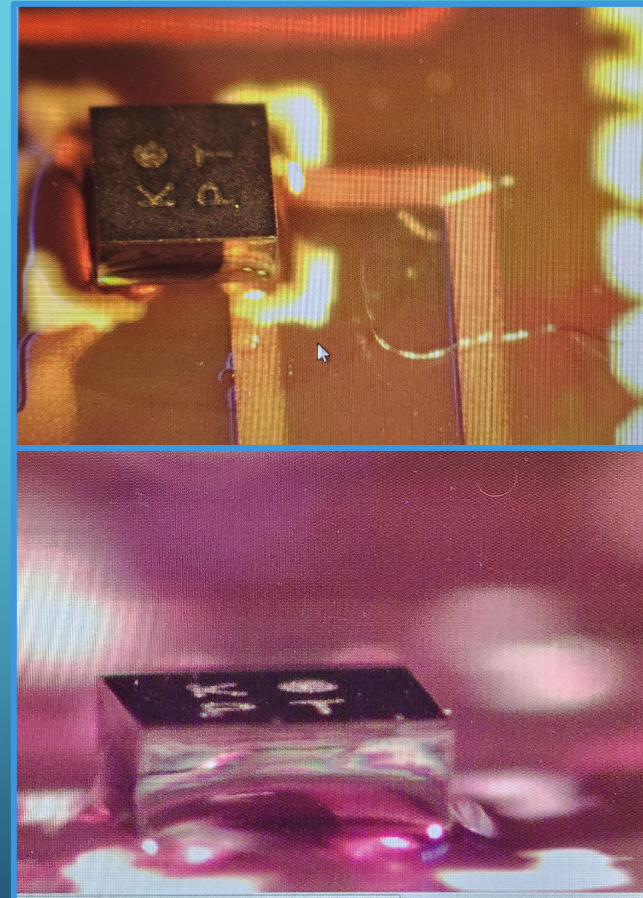


Sensor Response to
Applied Magnet

WEEK 1 SOLDER RESULTS:

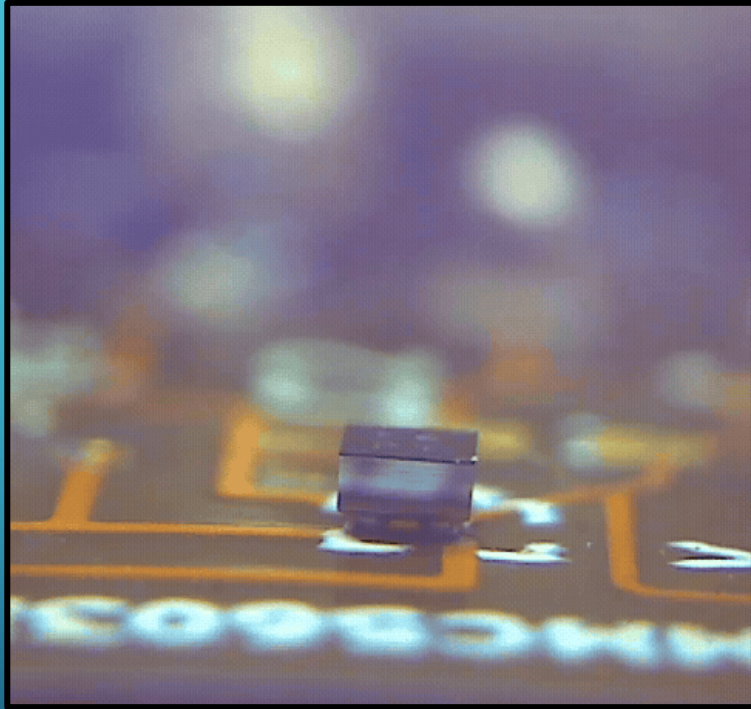


Before soldering

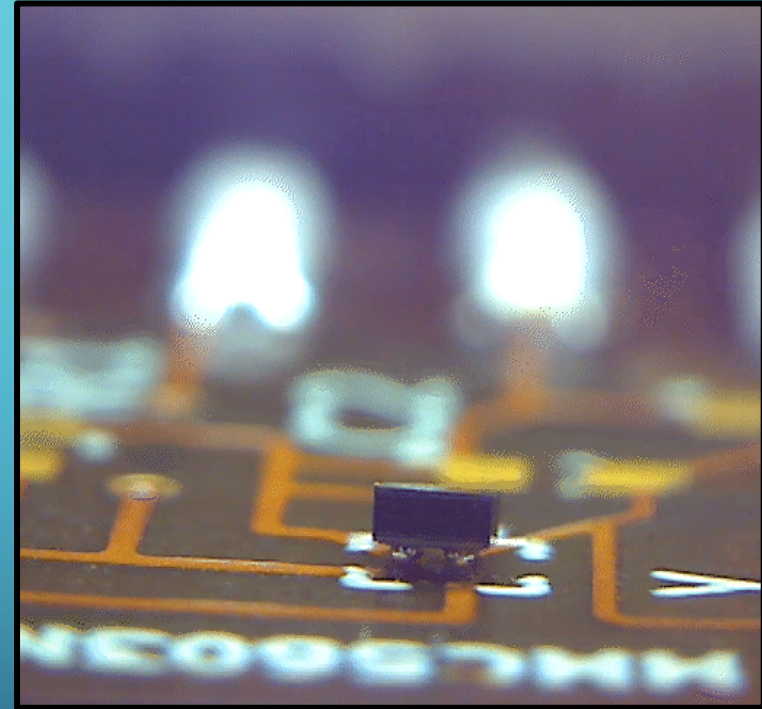


After soldering

SOLDER RESULTS



Solder with excess flux



Solder with minimal flux

SOLDER SETUP

