Outer Tracker R&D at UC Davis

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Brown OT Workshop
Jun. 18, 2015

UC Davis Phase 2 activities

Thermal conductance testing

- Rod support structure
- PS module heat transport

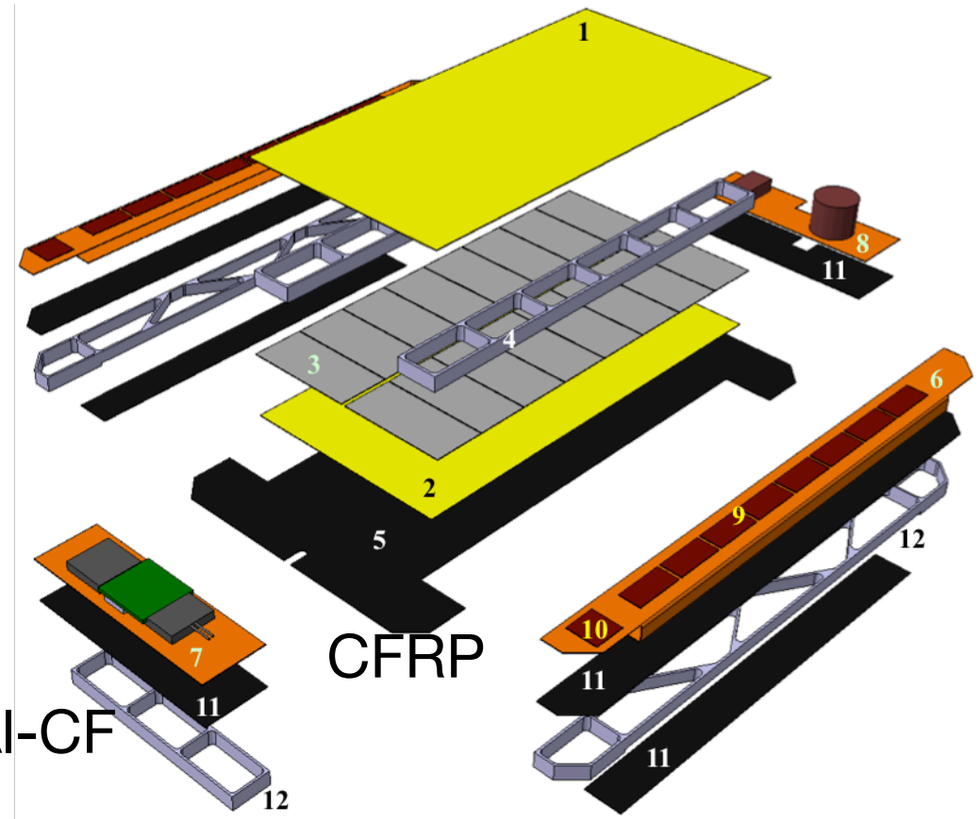
PS Module development

- Assembly of dummy modules
- MaPSA bond yield

Thermal conductance testing

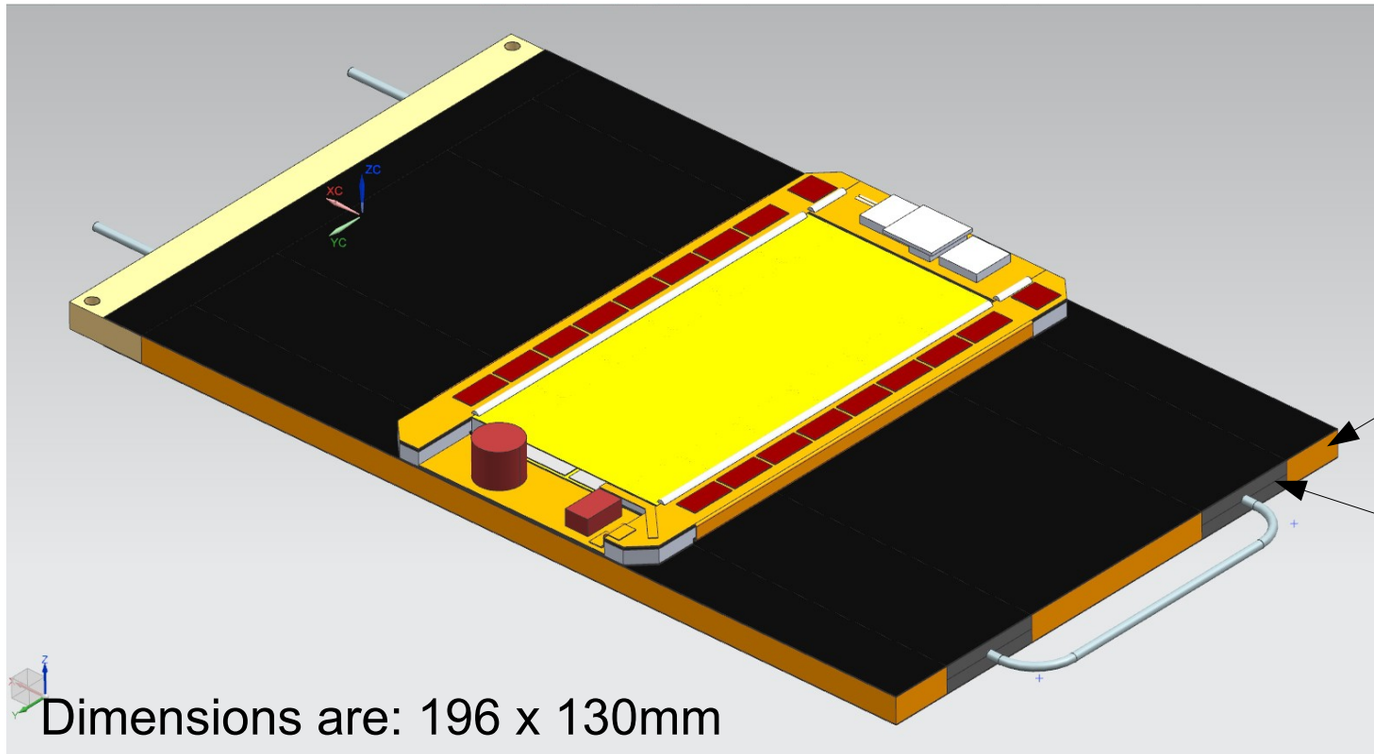
OT mechanical structures

Pixel-Strip Module



Cooling from below, thin Al-CF structures - sufficient?

Support Rod

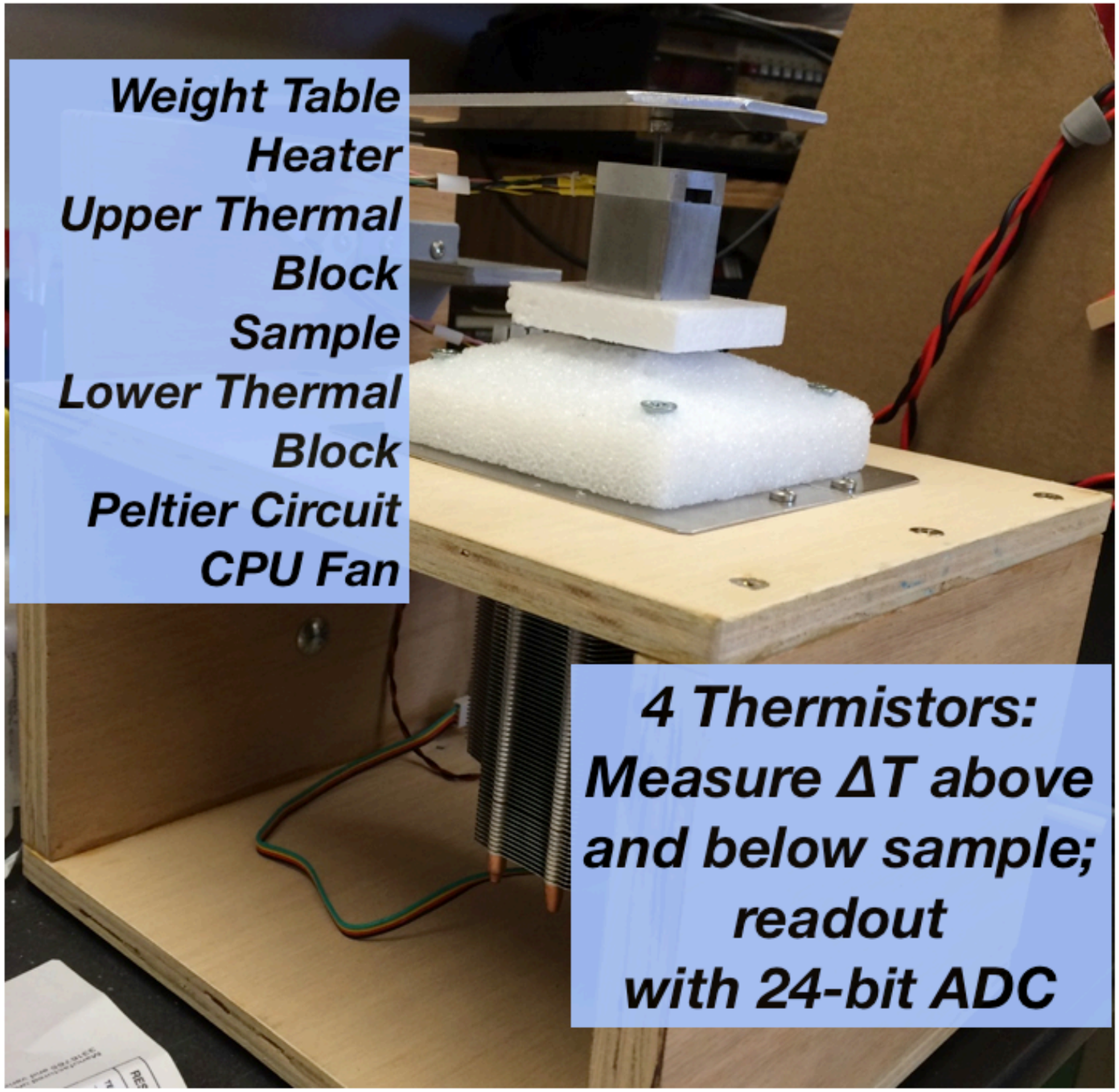


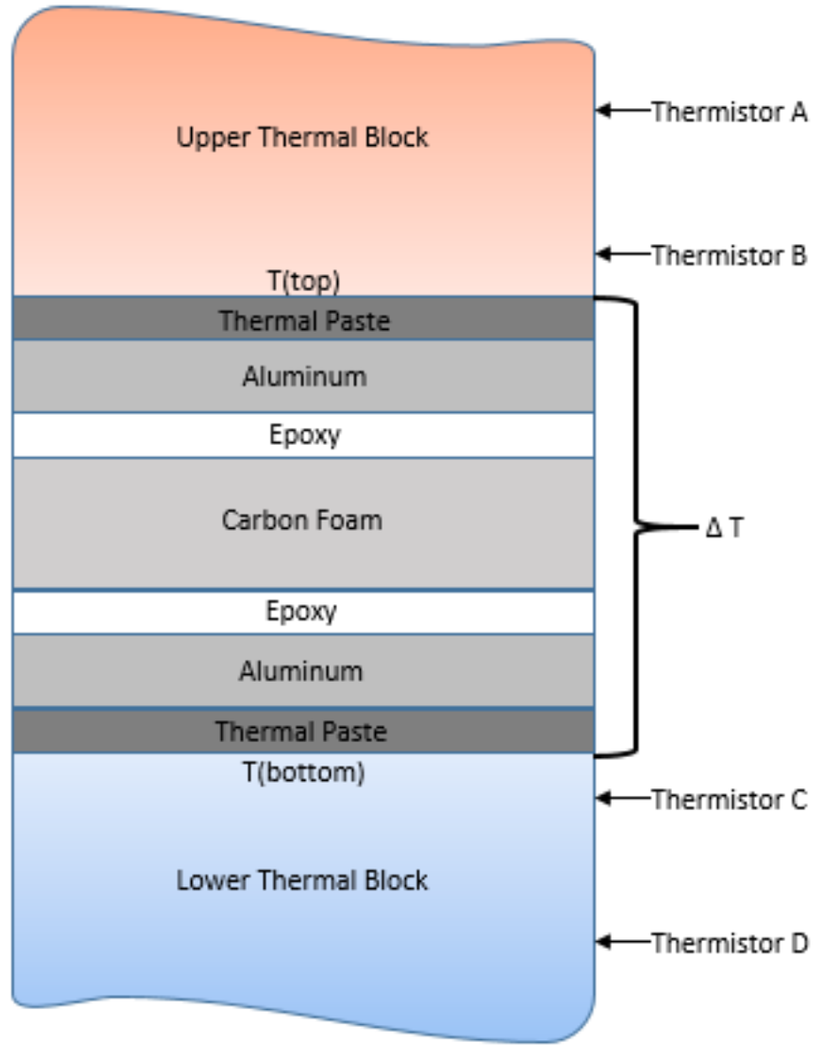
CFiber, CFoam, rohacell (not rad hard)

pipe diameter

PS module mounted with Laird film

Thermal tester

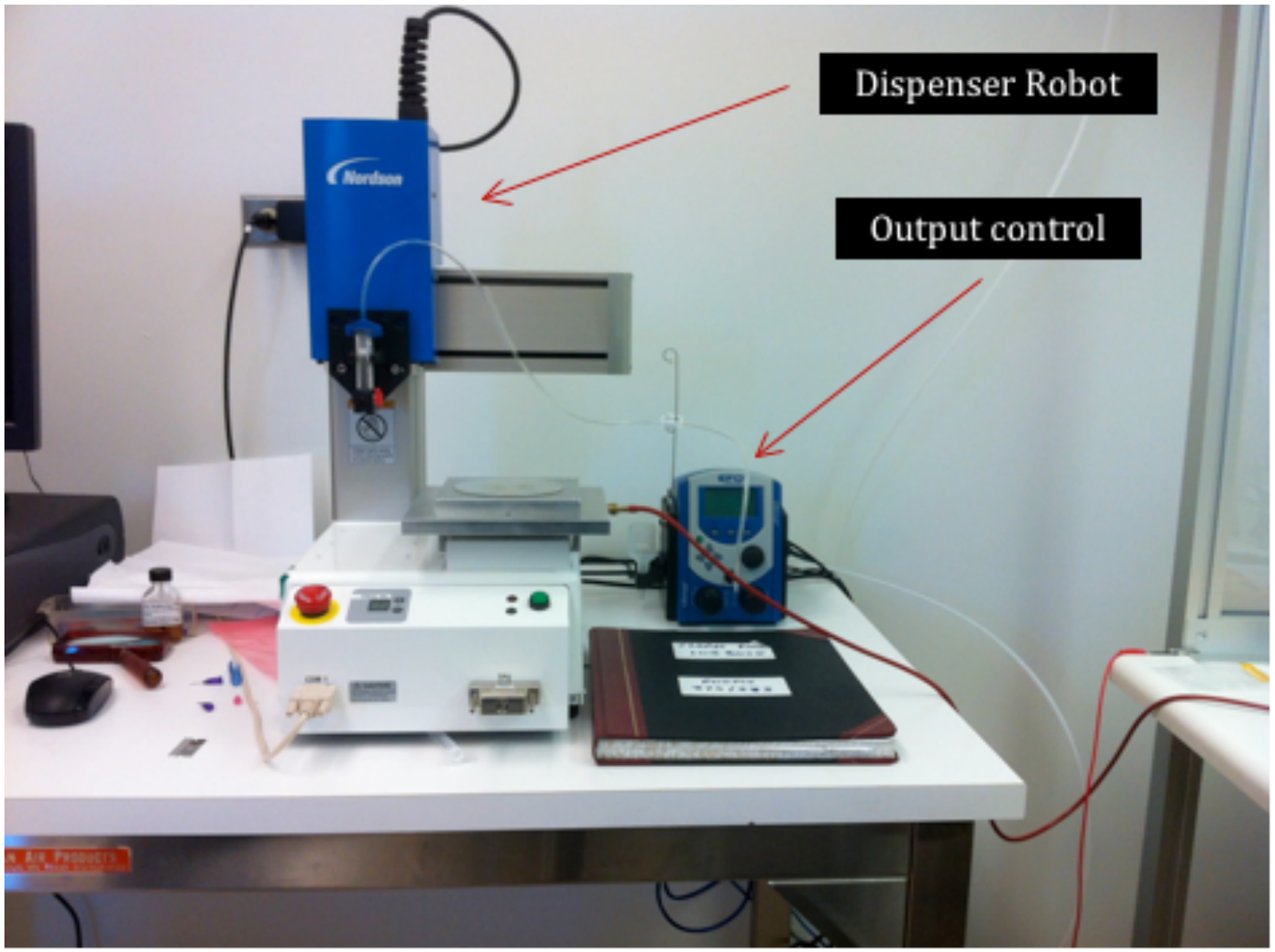




Heat is introduced at the top of the system and removed from the bottom

Measures thermal resistance of a sample by calculating the temperature drop across the interface

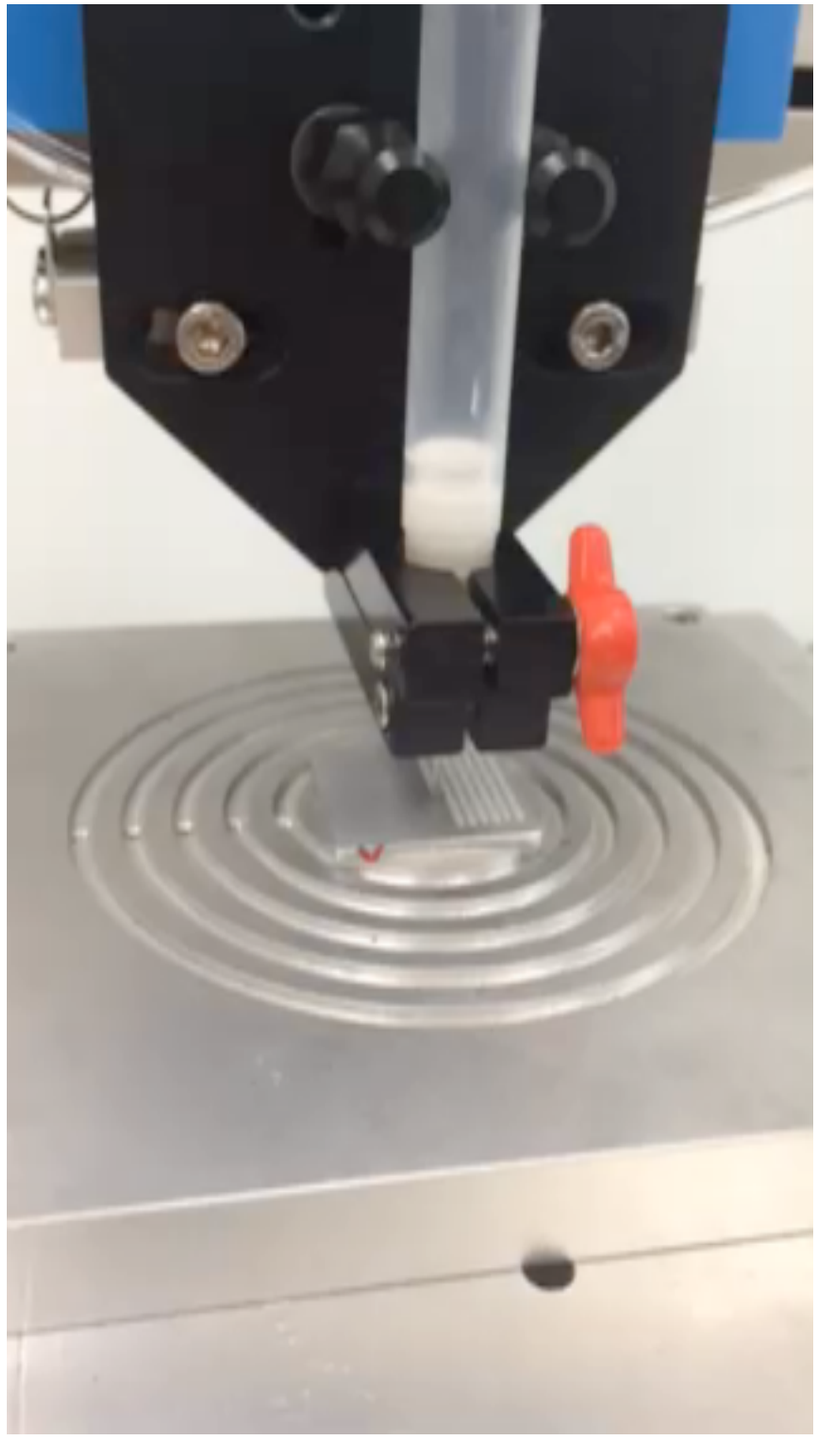
Robotic dispenser:



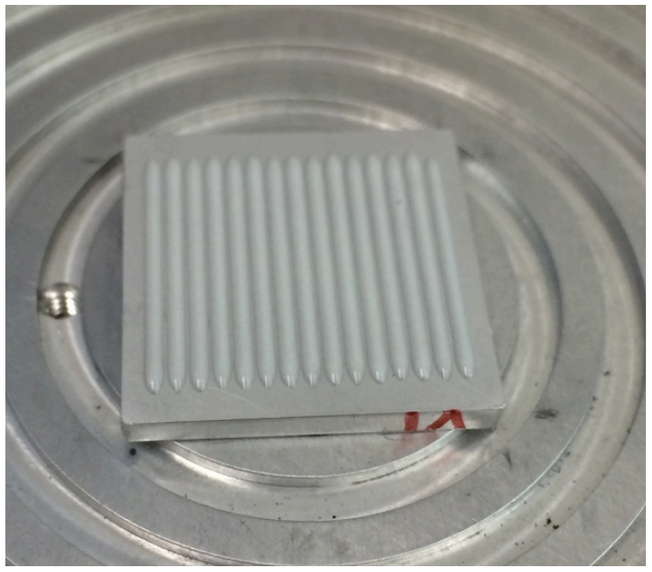
Automated epoxy dispenser

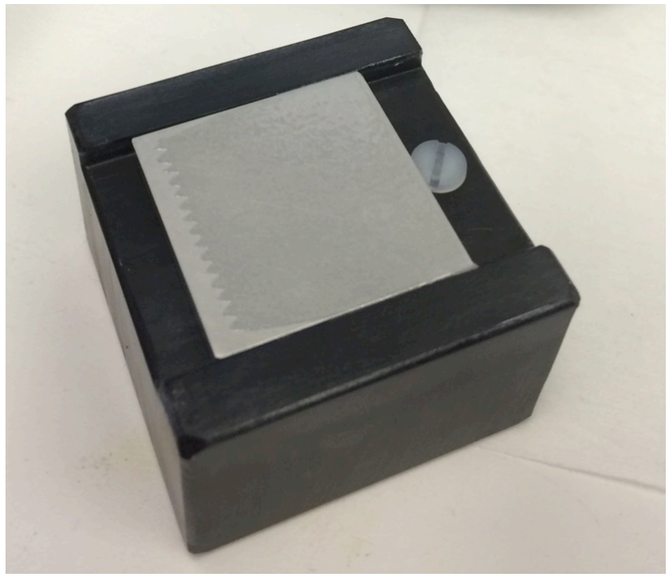
Used to build sample stacks for thermal testing

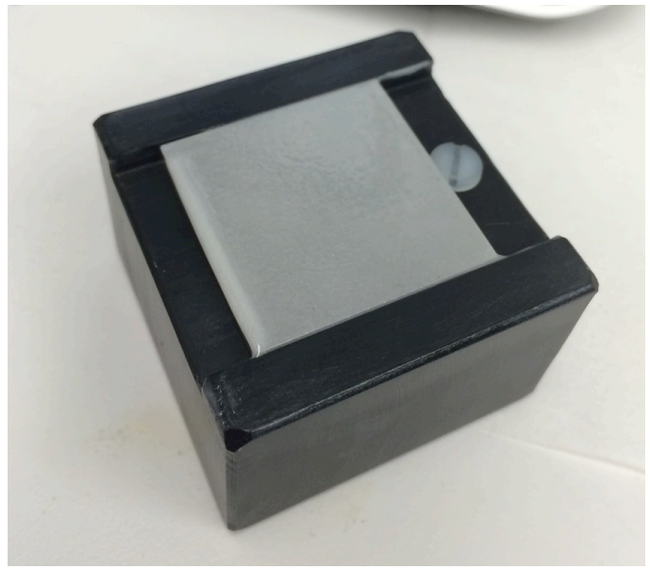
Dispenser in action

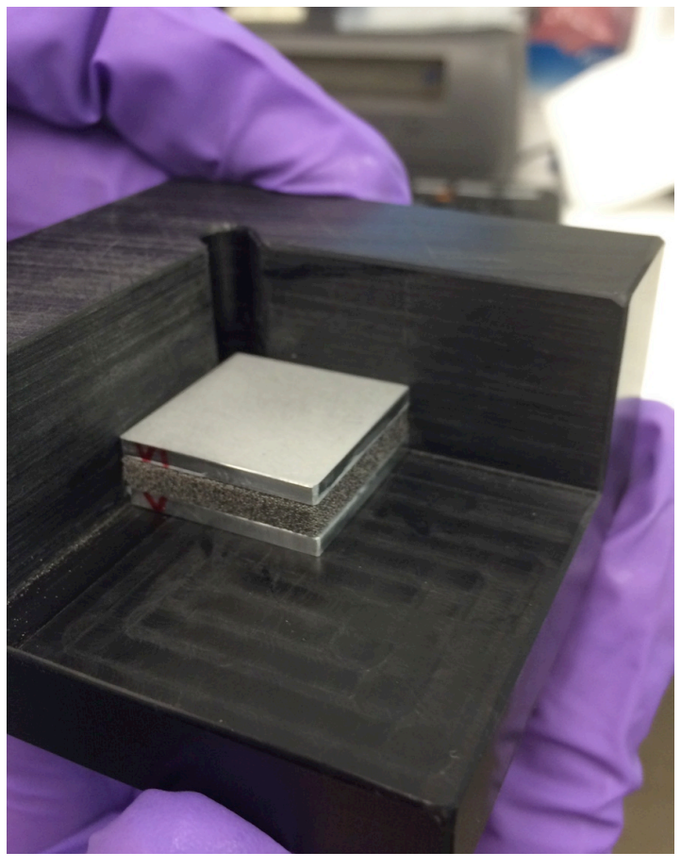


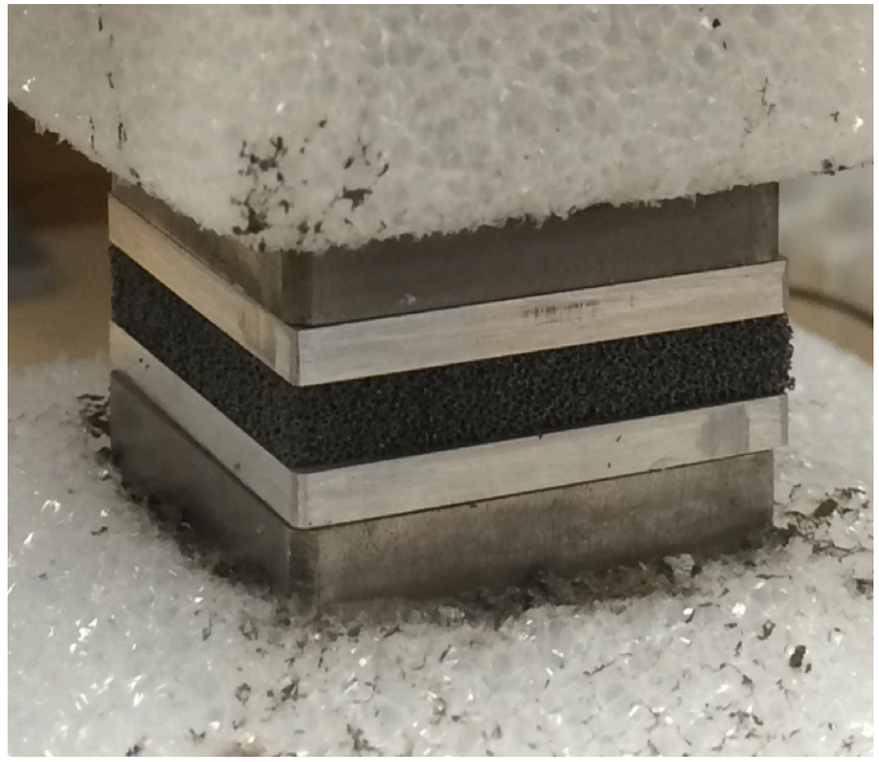
Recent BN samples



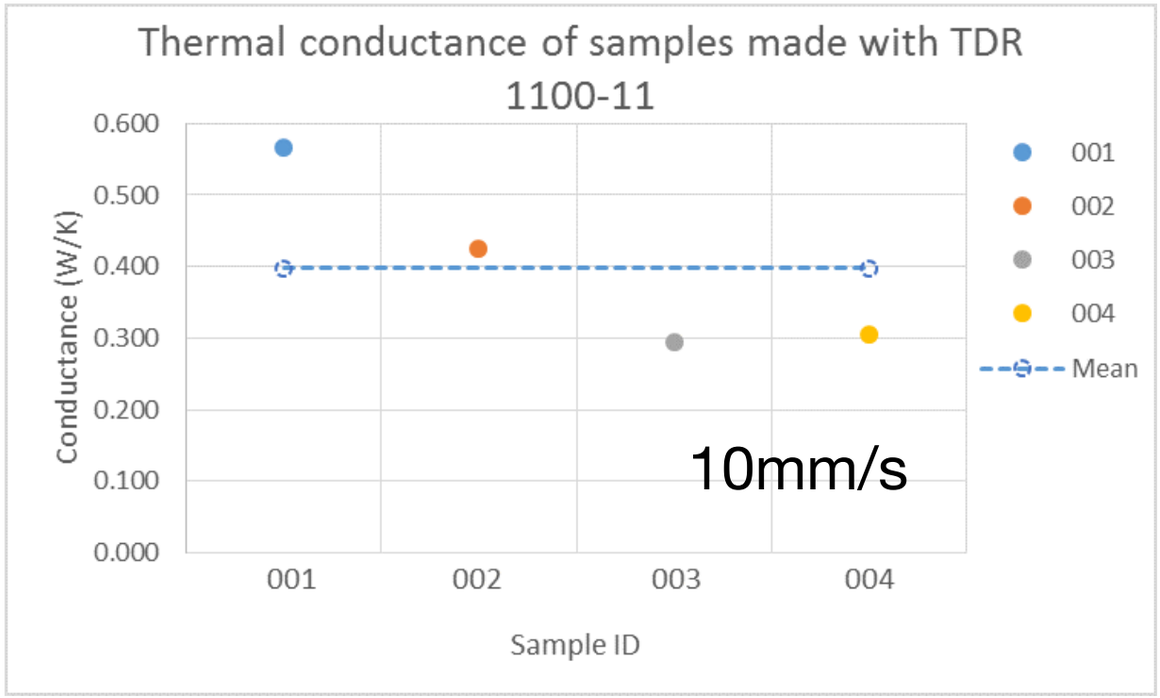


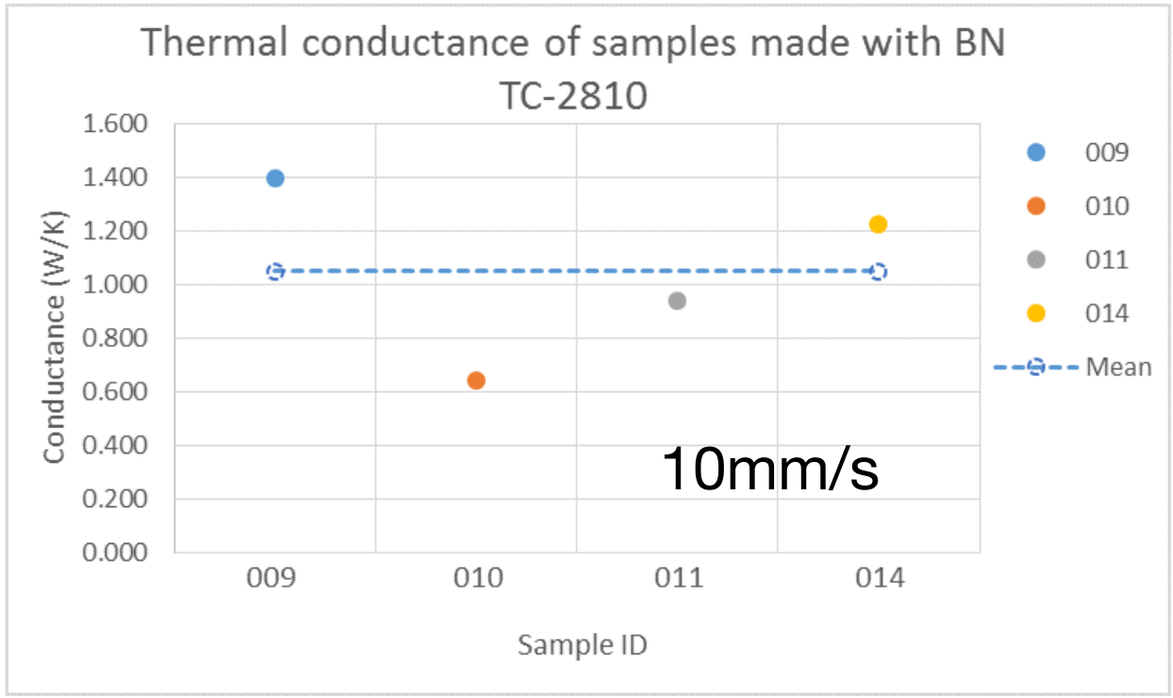


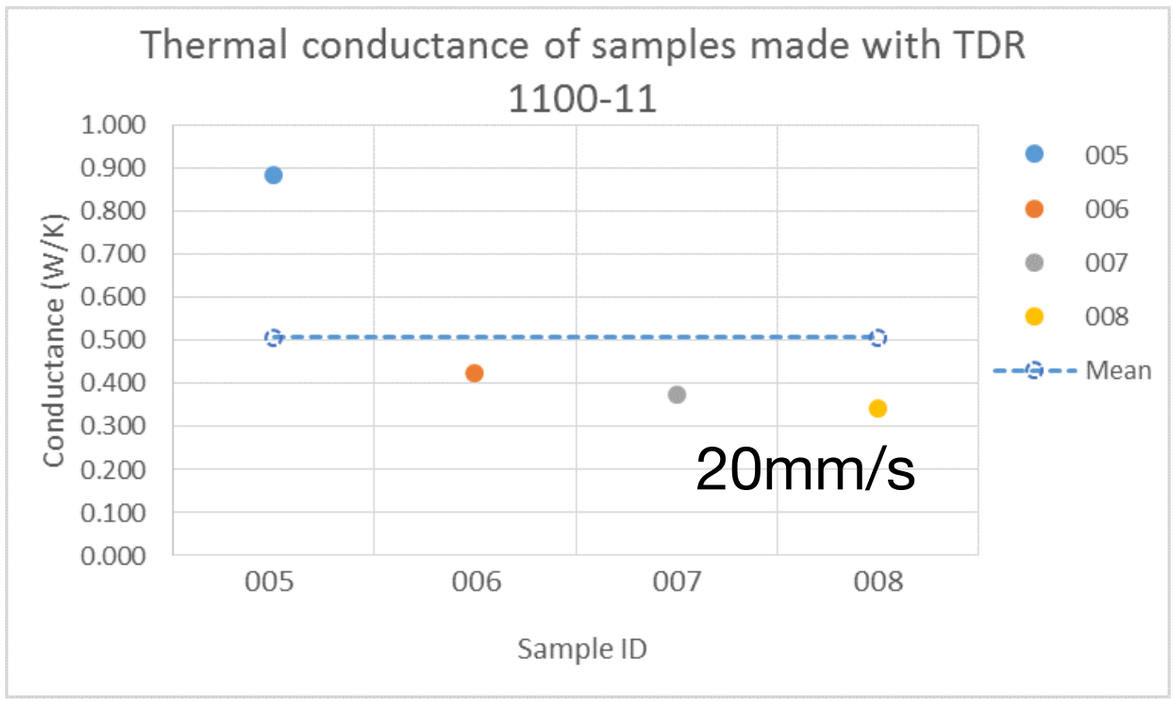


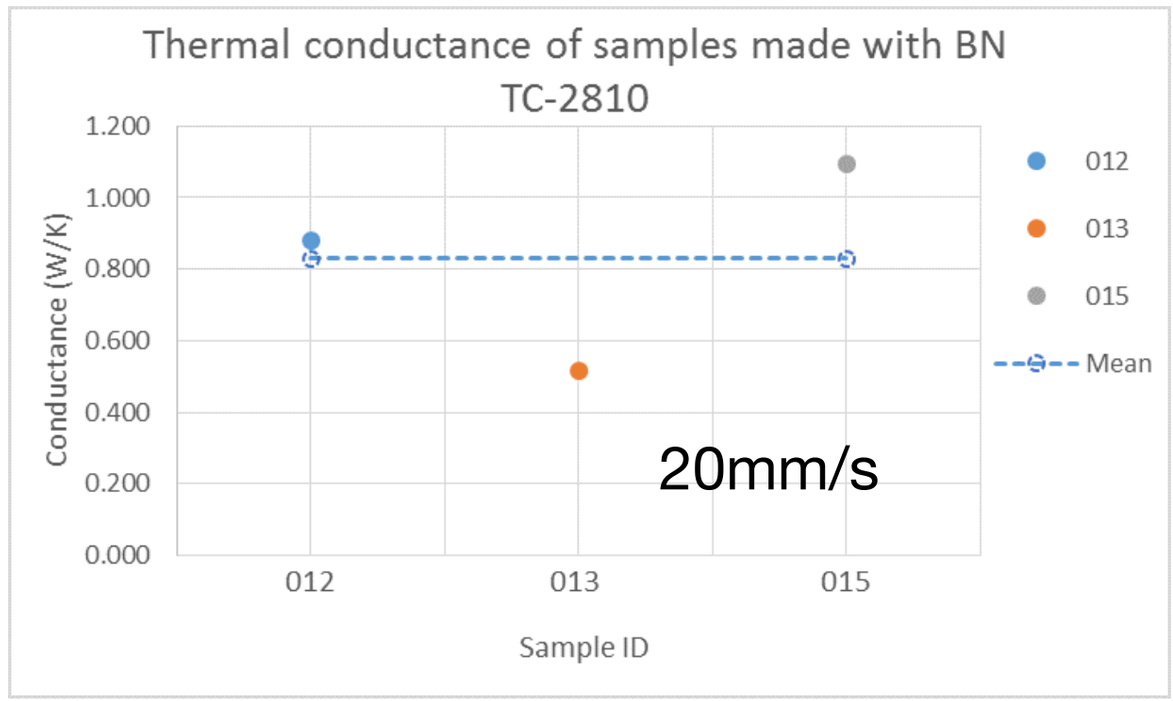


TC results:

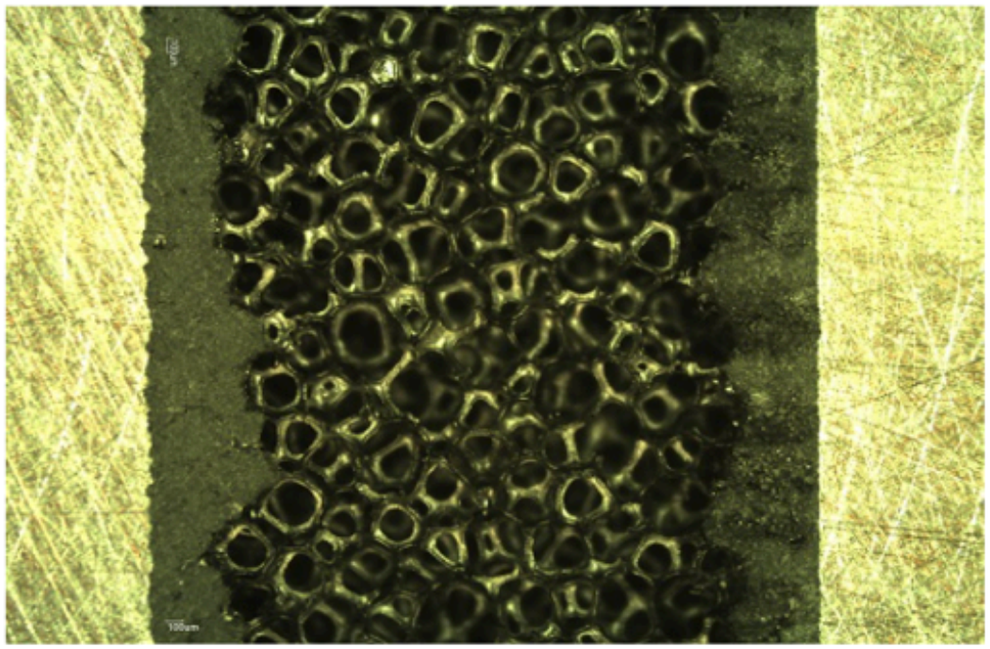

Thermal conductance of samples made with TDR
1100-11
Conductance (W/K)
0.600
0.500
0.400
0.300
0.200
0.100
0.000
001
002
003
004
Mean
10mm/s
Sample ID


Thermal conductance of samples made with BN
TC-2810
Conductance (W/K)
1.600
1.400
1.200
1.000
0.800
0.600
0.400
0.200
0.000
009
010
011
014
Mean
10mm/s
Sample ID

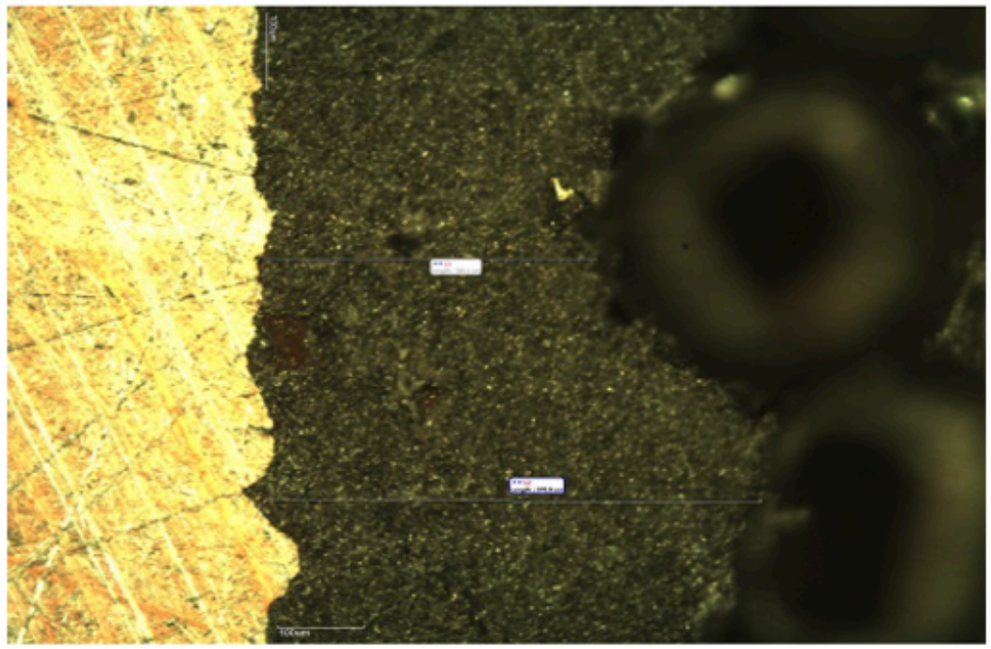

Thermal conductance of samples made with TDR
1100-11
Conductance (W/K)
1.000
0.900
0.800
0.700
0.600
0.500
0.400
0.300
0.200
0.100
0.000
005
006
007
008
Mean
20mm/s
Sample ID


Thermal conductance of samples made with BN
TC-2810
Conductance (W/K)
1.200
1.000
0.800
0.600
0.400
0.200
0.000
012
013
015
Mean
20mm/s
Sample ID

Sample Cross Sections:

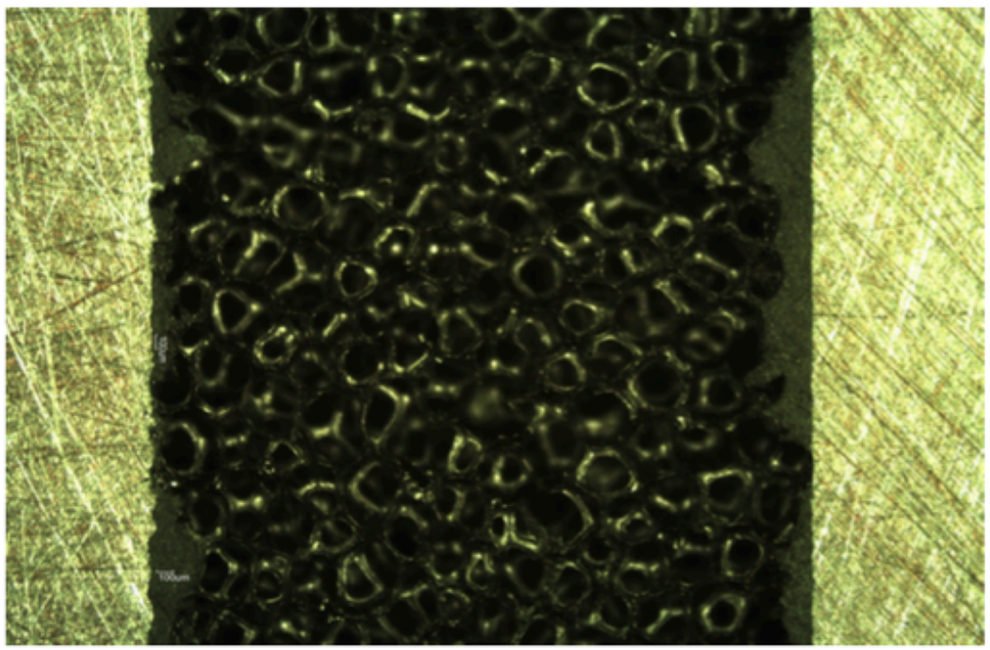


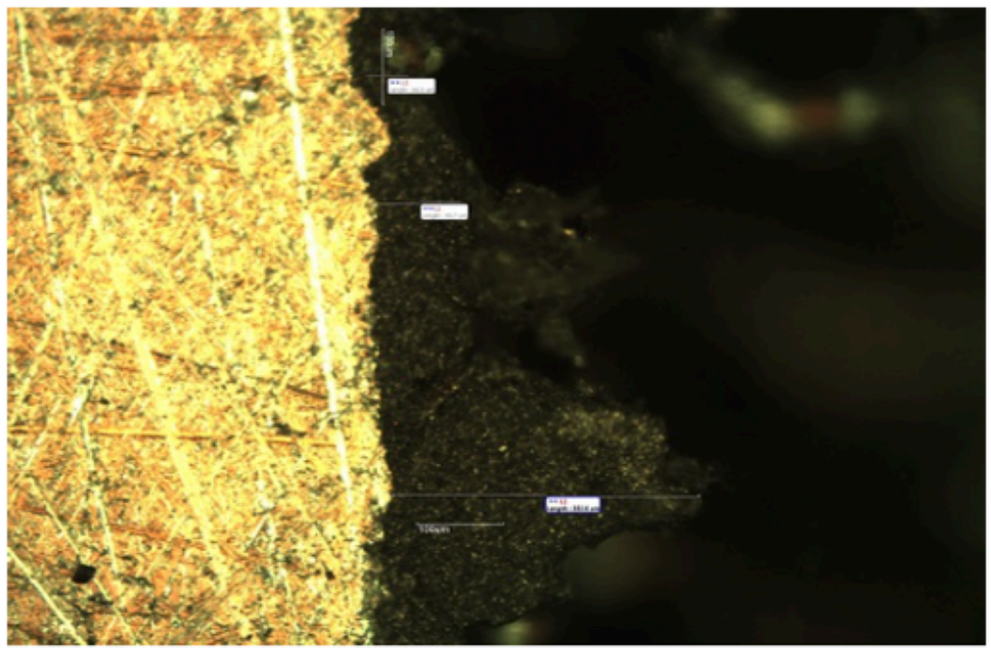
Low Magnification



High Magnification

Robotic epoxy dispenser set to 10 mm/sec





Robotic epoxy dispenser set to 20 mm/sec

These samples were not squeegeed

Status

BN studies ongoing

TC ~ 2X compared to previous epoxy

Weight of epoxy does not scale linearly with dispenser speed

Some scatter, ~ 20-30% among samples

- **Stick to lower speed, use squeegee, ultrasonic bath to remove bubbles, timed steps**

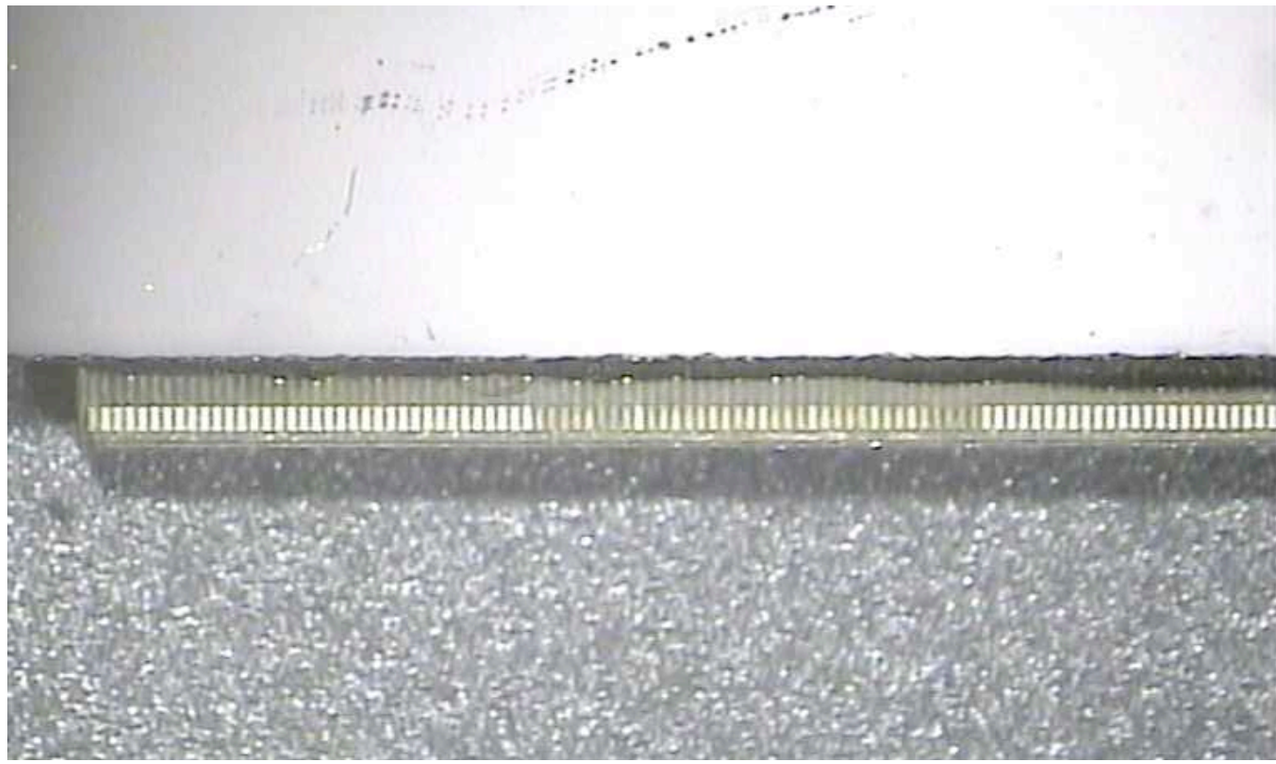
Next

- **Reservoir idea from Frank Meier**
- **Measure TC vs. epoxy layer thickness**
- **Testing of more complex structures, e.g., Al-CF spacers**
- **Further comparison with FEA**
- **Reactive bonding alternative**

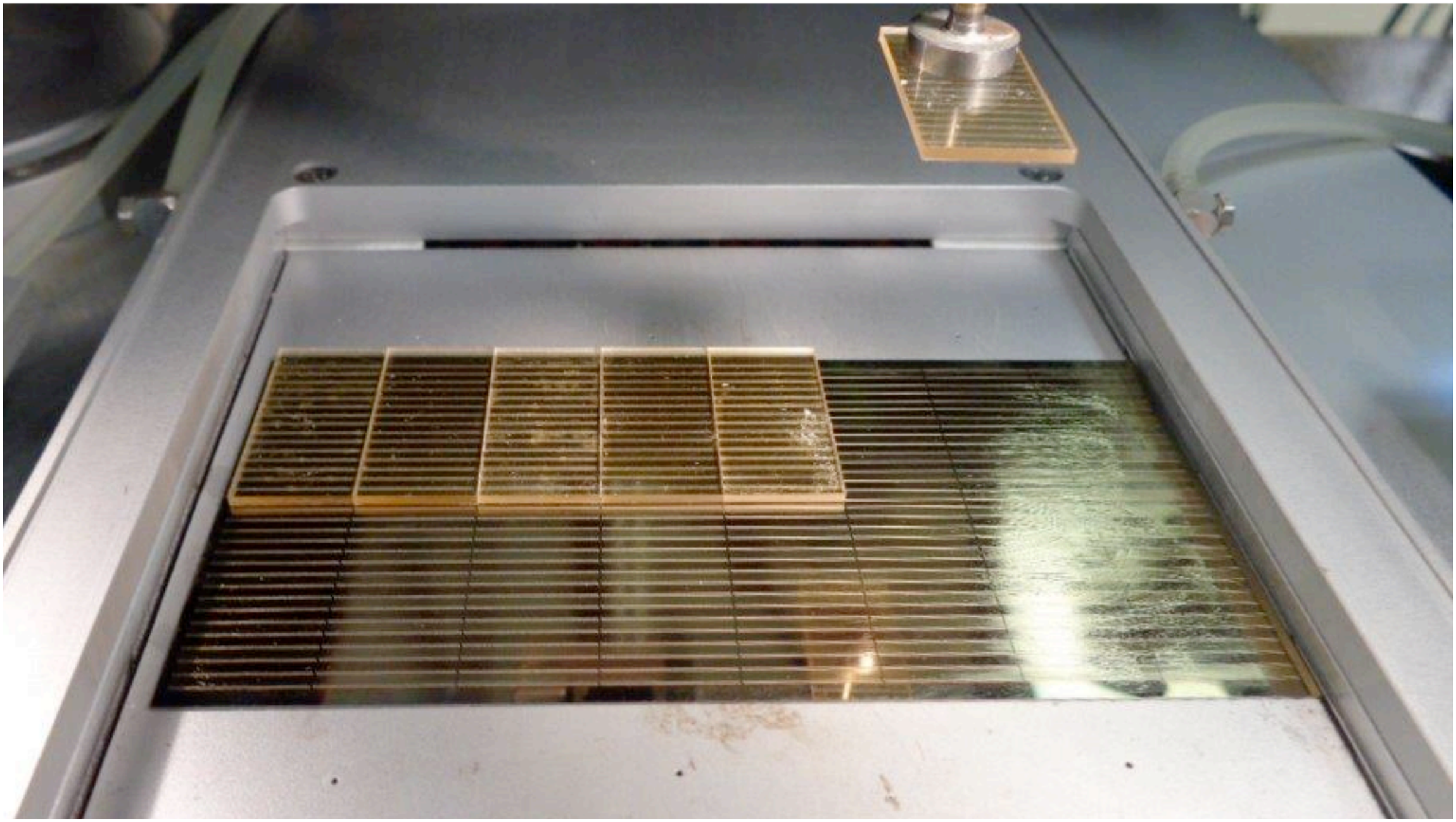
MaPSA assembly and bond yield testing

Goals for Dummy MaPSA Modules

- Align and accurately bond 16 dummy ROIC chips to a larger sensor wafer. Requires a high bond yield to be usable
  - (99%)^16 ~= 85%
  - (90%)^16 ~= 19%
- Daisy-chained bump-bonds and overhanging pads on dummy ROIC's used for probing.

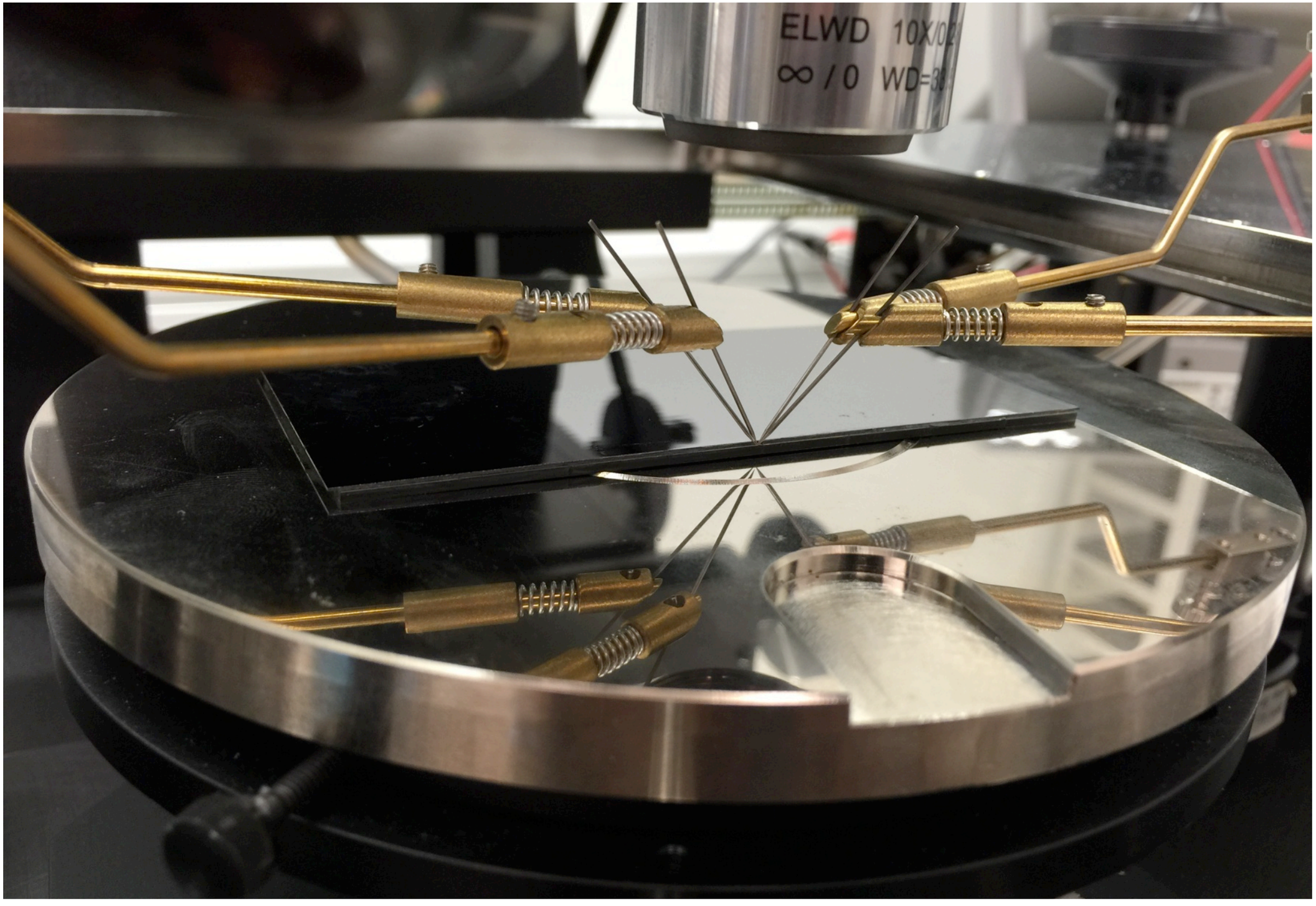


- Once bonding is complete, test the daisy chained bonds for conductivity and determine yield of successful connections
- Design was completed at UC Davis
- Fabrication was carried out by CVI
- Under test at UC Davis



ROICs being aligned and placed onto sensor wafer at CVI

Completed Assembly with 16 bonded ROICs and underfill



Assembly being tested for bond connectivity using a four point probe station at UC Davis

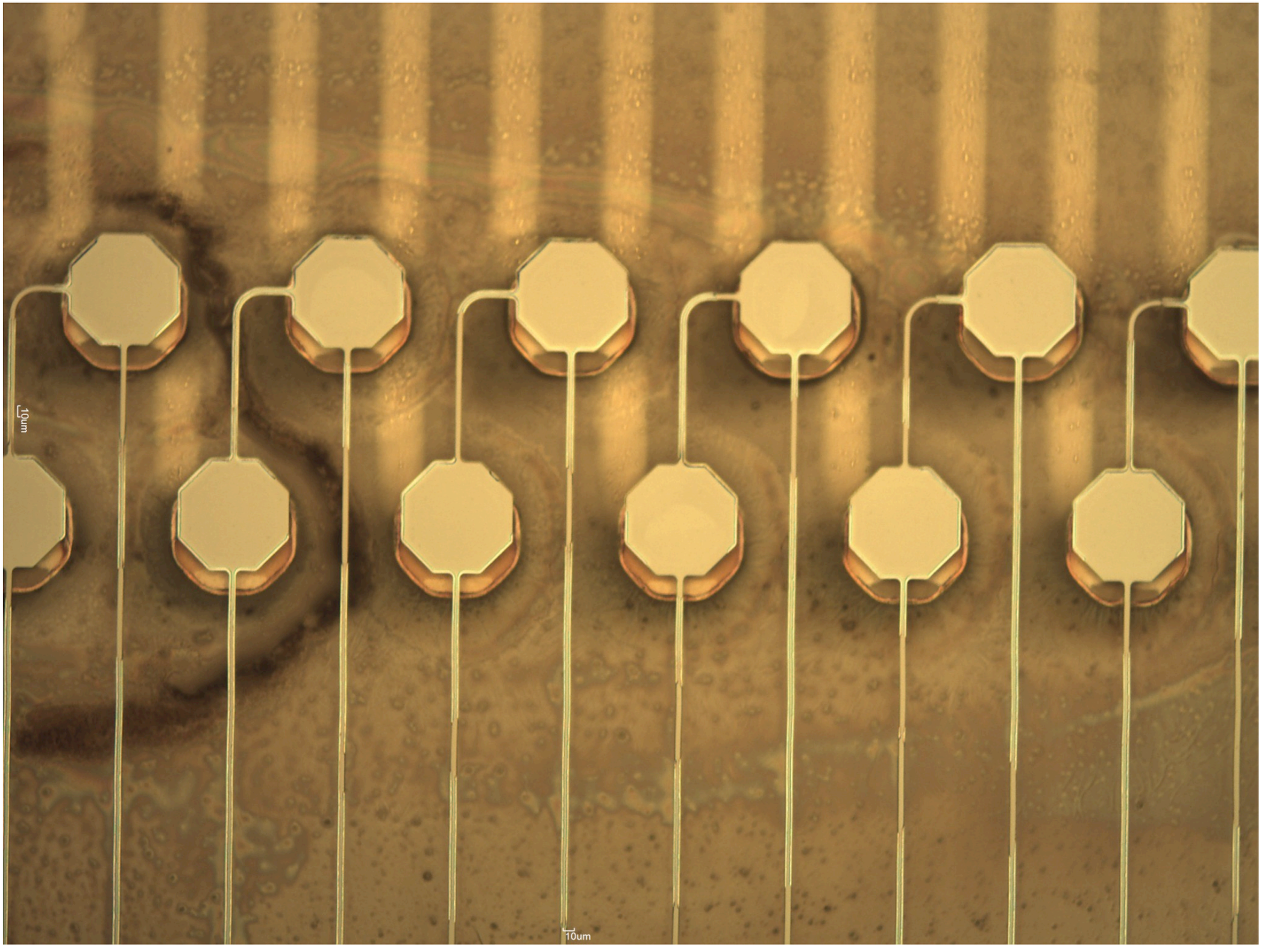
Challenges

Assembly of 16 ROIC on to one large sensor is done by first aligning and “tacking” the ROICs and re-flowing all 16 at once. This procedure has certain challenges:

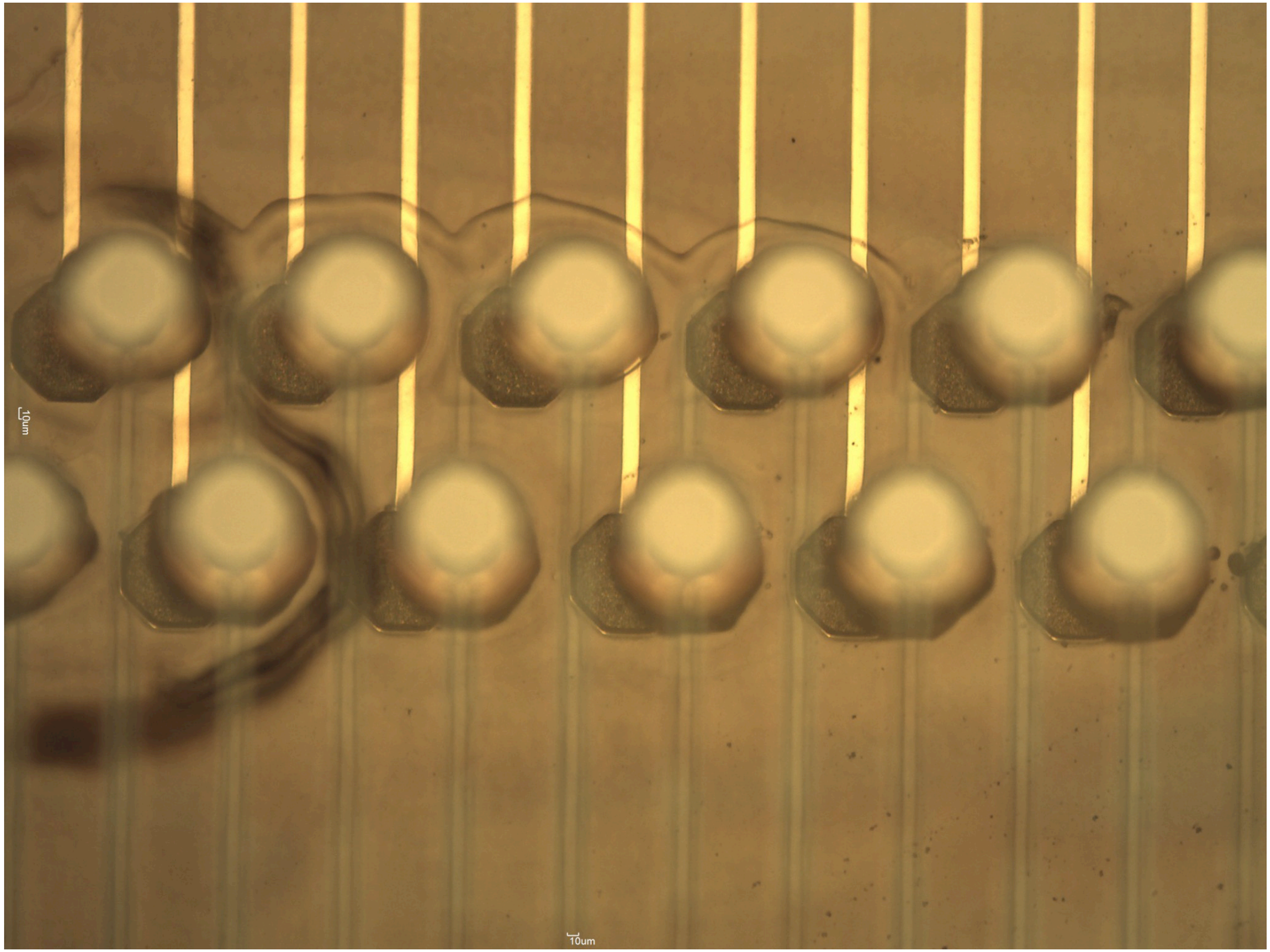
•Reducing the native oxide on solder bumps: If we use flux, it leaves a residue which is difficult to clean. If we use forming gas (10%H2, 90%N2) it may not penetrate to the bumps farthest from the edges. More work needs to be done to determine the yield for good solder bonds.

•Maintaining alignment during Re-flow: Temperature gradients may develop across the assembly resulting in some relative movements among the ROIC’s, leading to misalignment.

•Mechanical Strength: Typically, some underfill material is wicked in between the ROIC and sensor. This can create problems if the underfill ends up covering bond pads. For such a large number of bump-bonds, there may not be a need for underfill. This needs to be studied as well.



- Misaligned pads – backside of ROIC pads in focus



- Misaligned pads – sensor pads in focus

Steps Moving Forward

- This first attempt points to necessary improvements in process.
  - More care needs to be taken to avoid disturbing alignment during reflow step.
  - While flux poses long term challenges, we should attempt a bond using flux to ensure adequate oxide removal from all solder balls during bonding.
- Mechanical Strength tests of samples with no underfill need to be taken
  - Would simplify the bonding process tremendously