Design and Assembly Studies for Track Trigger Modules

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R&D aimed at studying assembly issues

- Architectures being considered typically involve several sensors/IC's in a complex assembly.
- Pixel detectors present in most designs, so bump bonding needed.
- Information transfer between layers - from the bottom sensor to the top (or vice-versa).
- Interconnections are required between chips to define overlapping regions/sectors. Z information must cross between chips or incur dead regions.
- Material budget is always an issue.
- Efficient cooling requires that the assembly should have minimum thermal impedance.
- CTE differences need to be minimized.

UCD Facility for Interconnect Technology

UCD Facility for Interconnect Technology

- Equipment purchased using ARRA funds. Operations funded by DOE Generic R&D grant
- Mission is to support detector R&D projects

Electronics Shop

Britt Holbrook & Ray Gerhard

Christian Neher
Technician.

Mask design. Bump bonding. Wet chem.

Machine Shop

John Thomson & Dave Hemer

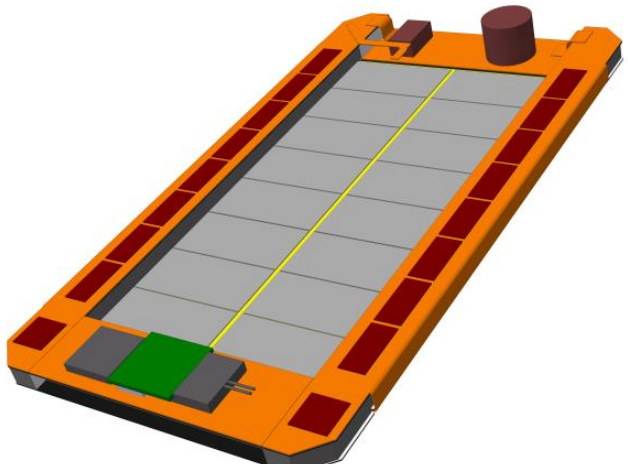
CMS Example: MAPSA-Light

See talk by D. Ceresa

MPA-Light with wirebond and flip chip pads, diced, unbumped, Al surface finish.

Sensor-Light: on wafer or diced, Al surface finish pads.

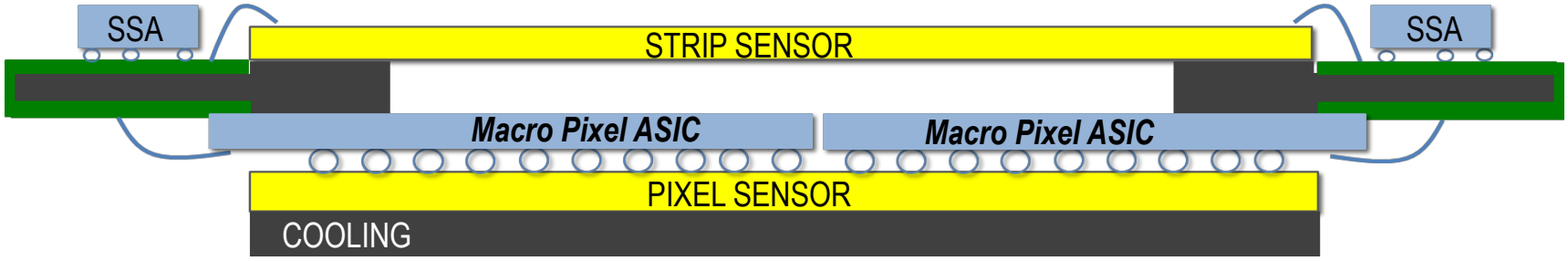
No TSV on first MAPSA-Light assembly.



From G. Blanchot

Assembly process flow:

- UBM metallurgy on both sensor and MPA light parts.
- Bump deposition on diced MPA-Light chip.
- Bump bonding of MPA-Light on Sensor Light.



From R. Lipton

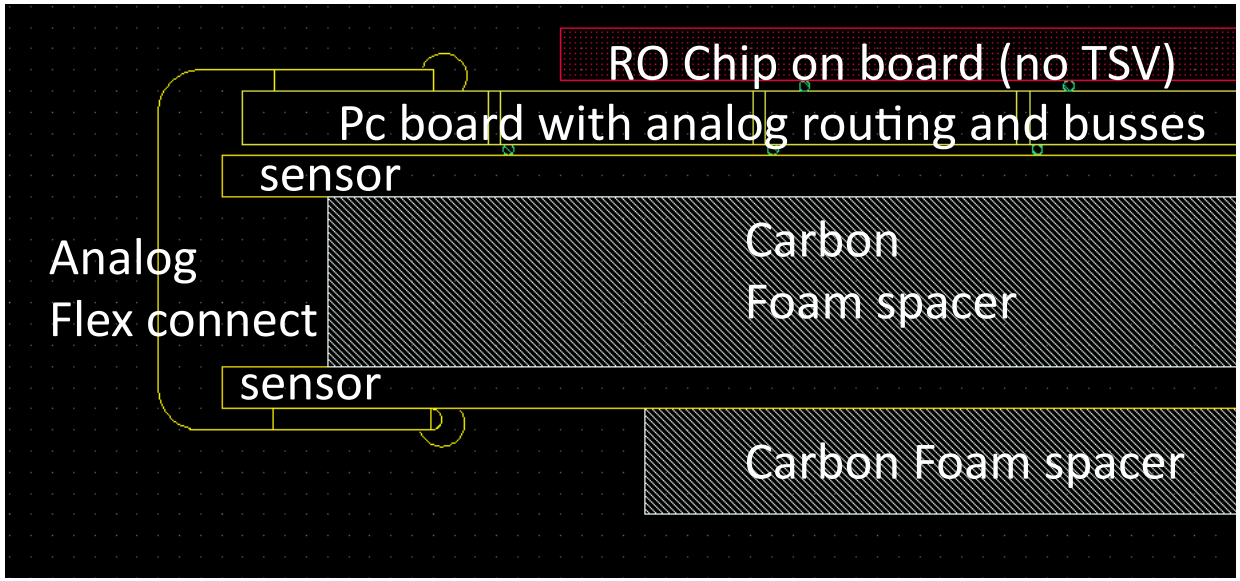
Initial Design Concepts

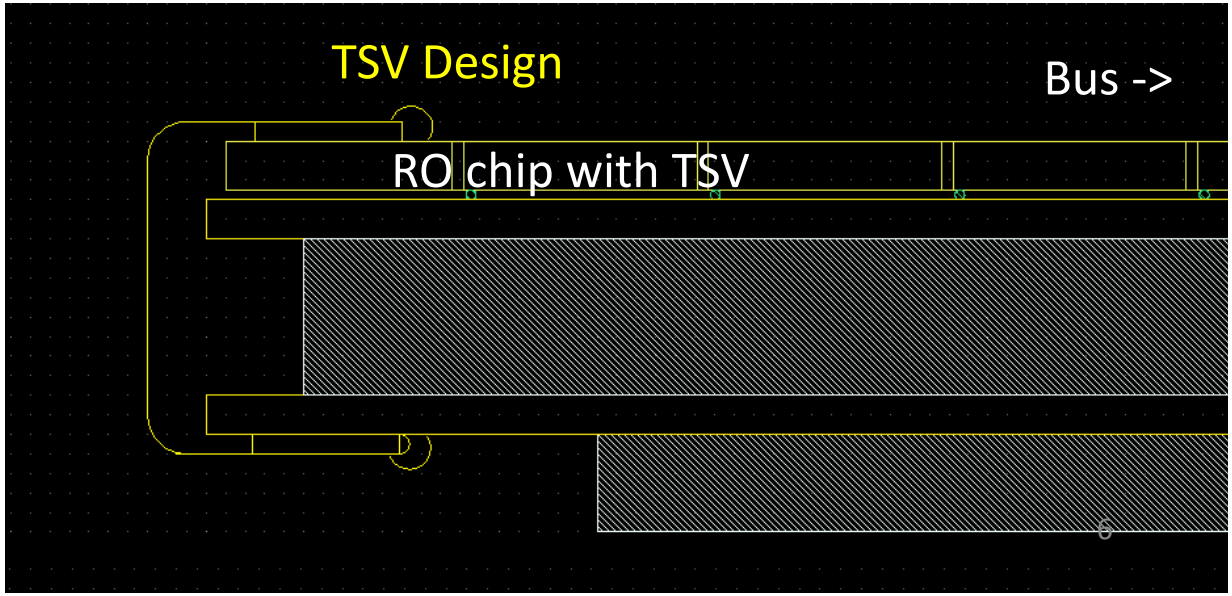
All designs are based around carbon foam spacers that provide requisite radial lever arm between sensors.

The top sensor communicates with the ROC through a PCB, which also houses analog traces and digital busses.

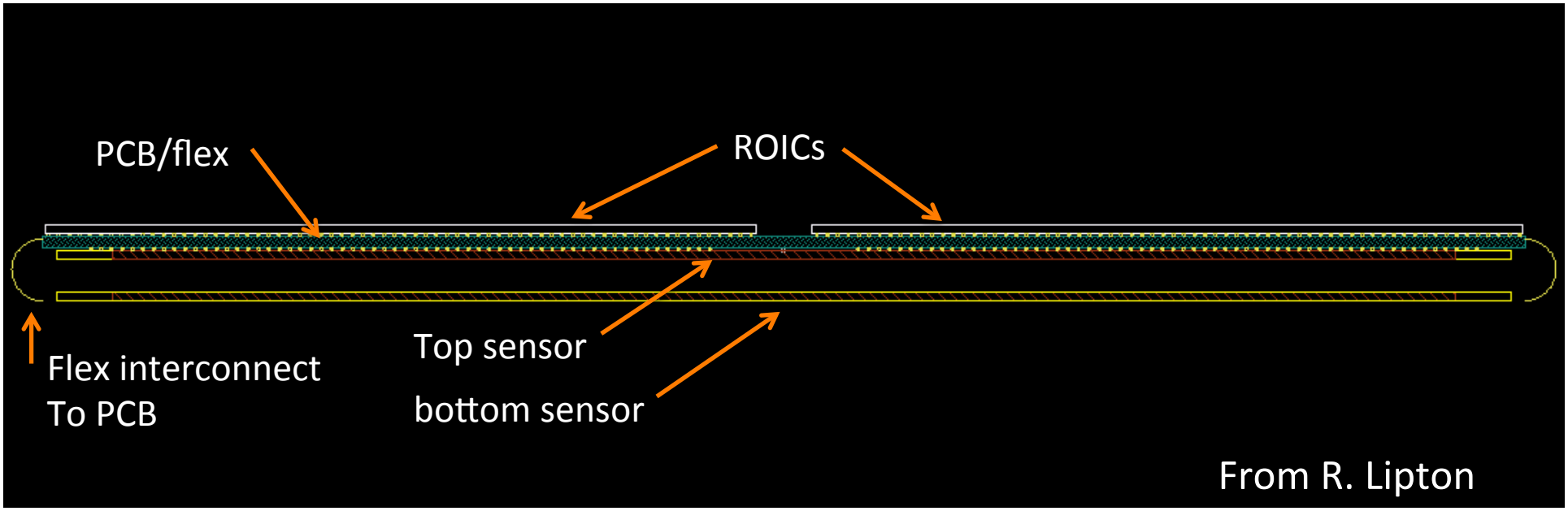
A flex cable is used to communicate with the bottom sensor.

In an alternative design through silicon vias (TSV) are used to connect the ROC with the top sensor.





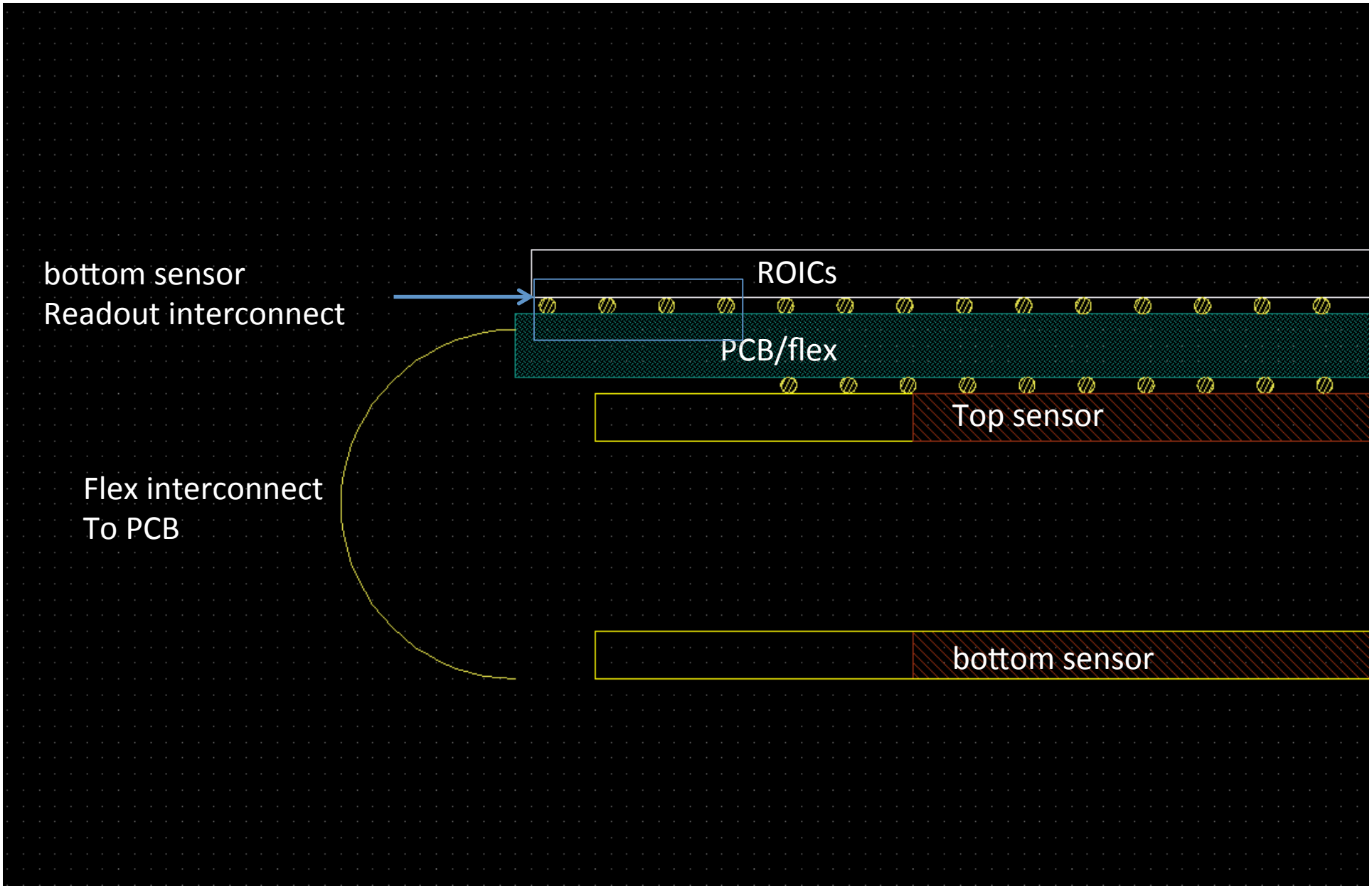
Example: Proposed Structure



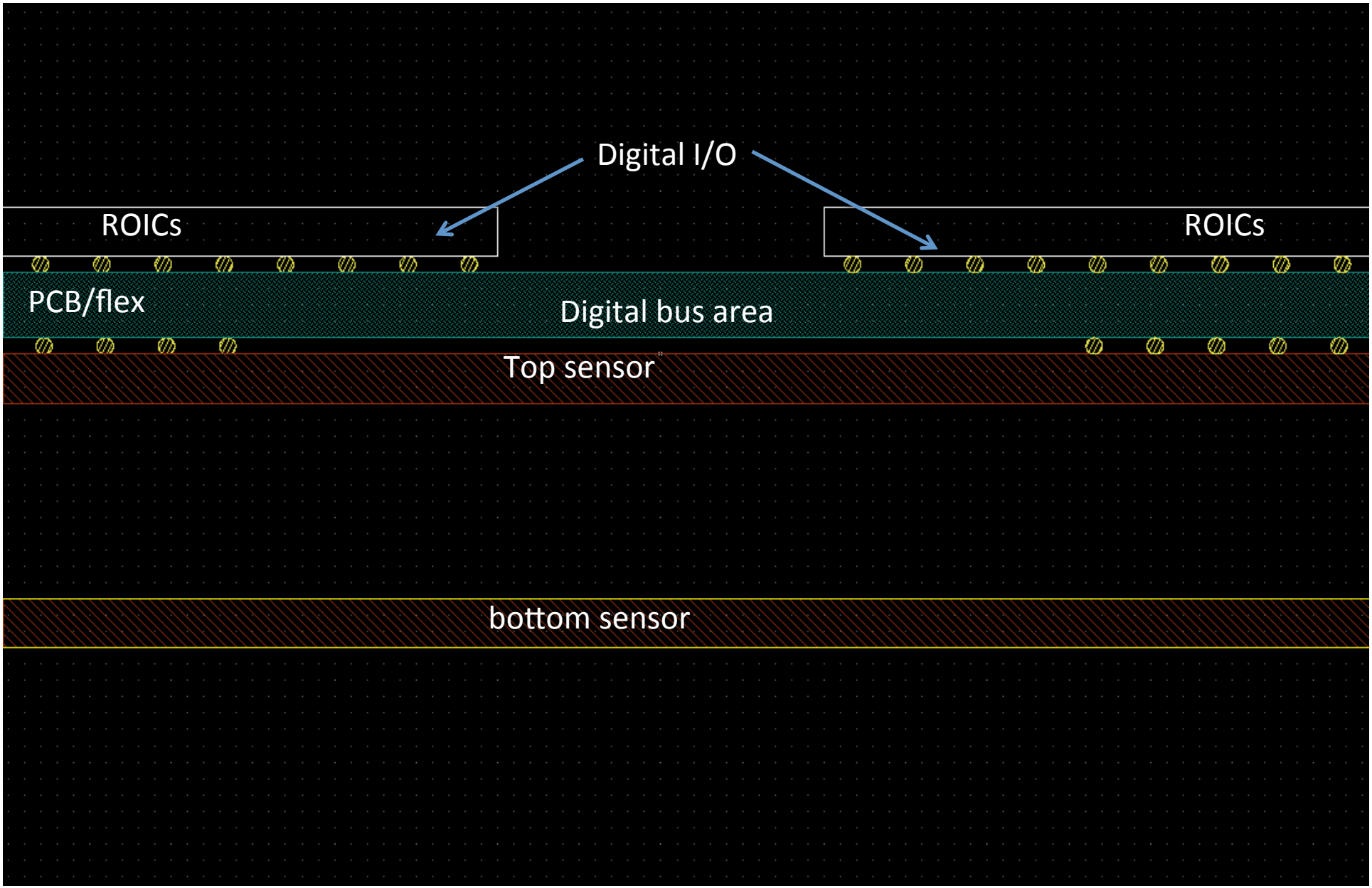
Do away with the PC board and place the RO chip directly on the flex.

- Explore PCB-based interposer design using flex circuit
- Understand requirements (via size, line width, layers) for successful layout
- Understand bump-bonding and CTE issues

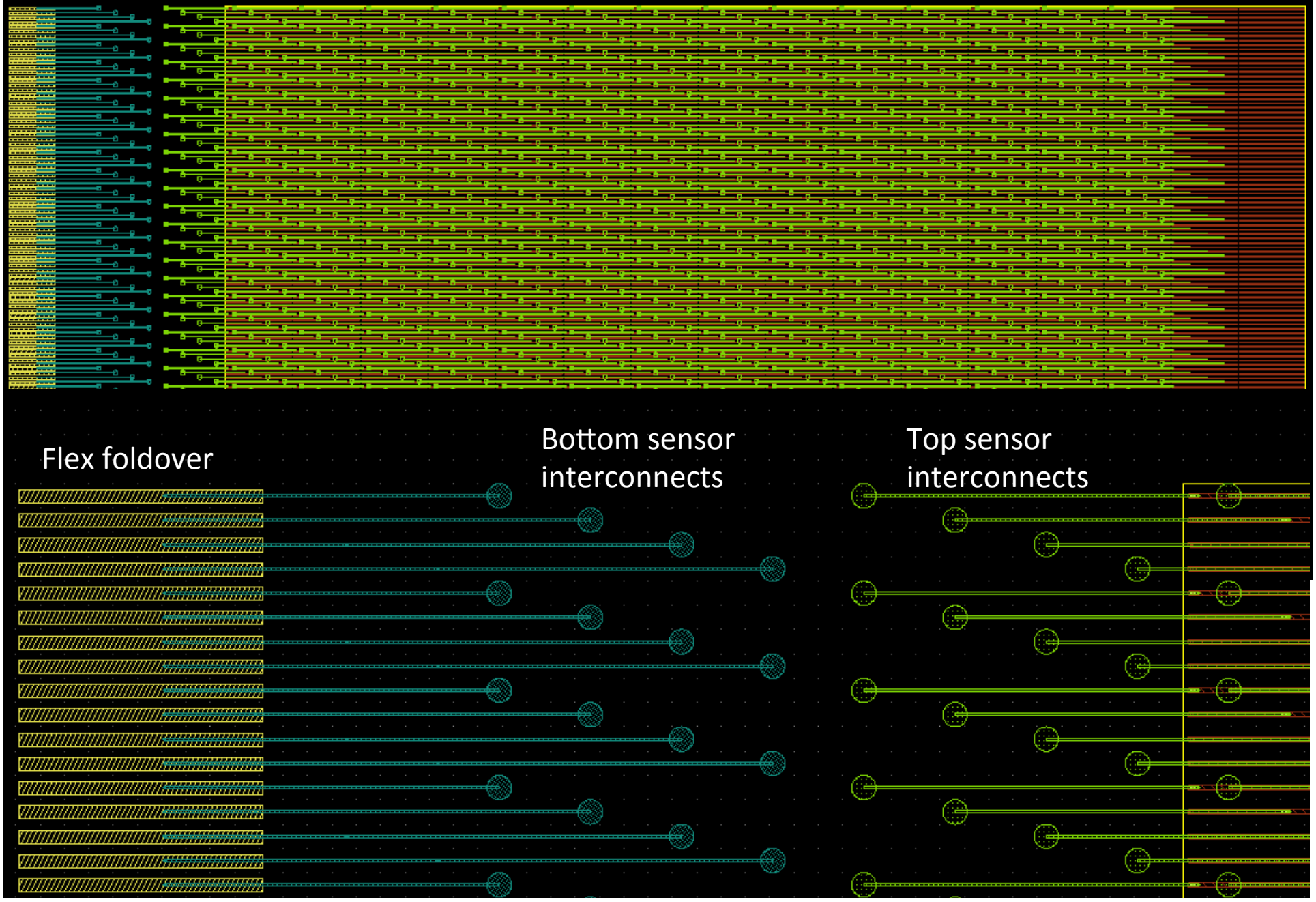
Proposed Structure: Details - I



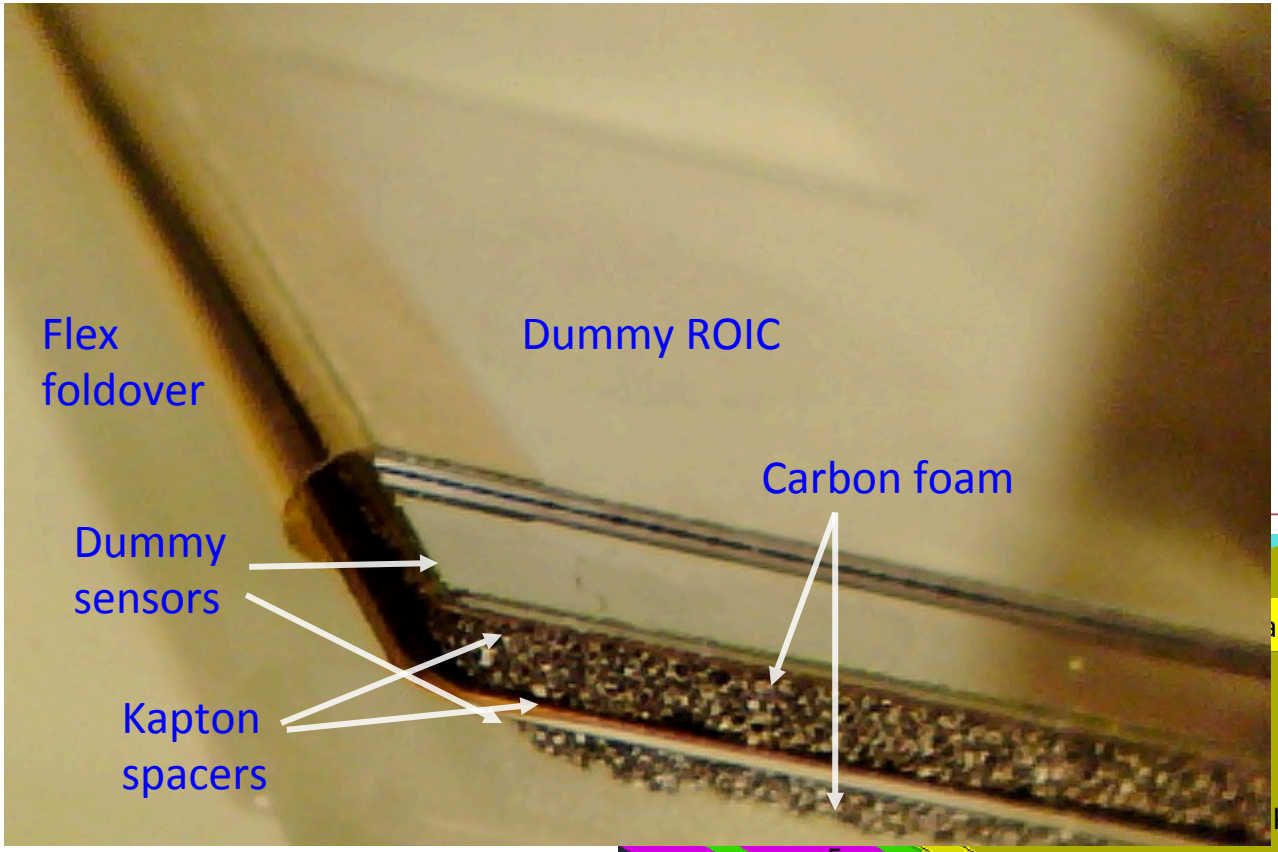
Proposed Structure: Details - II

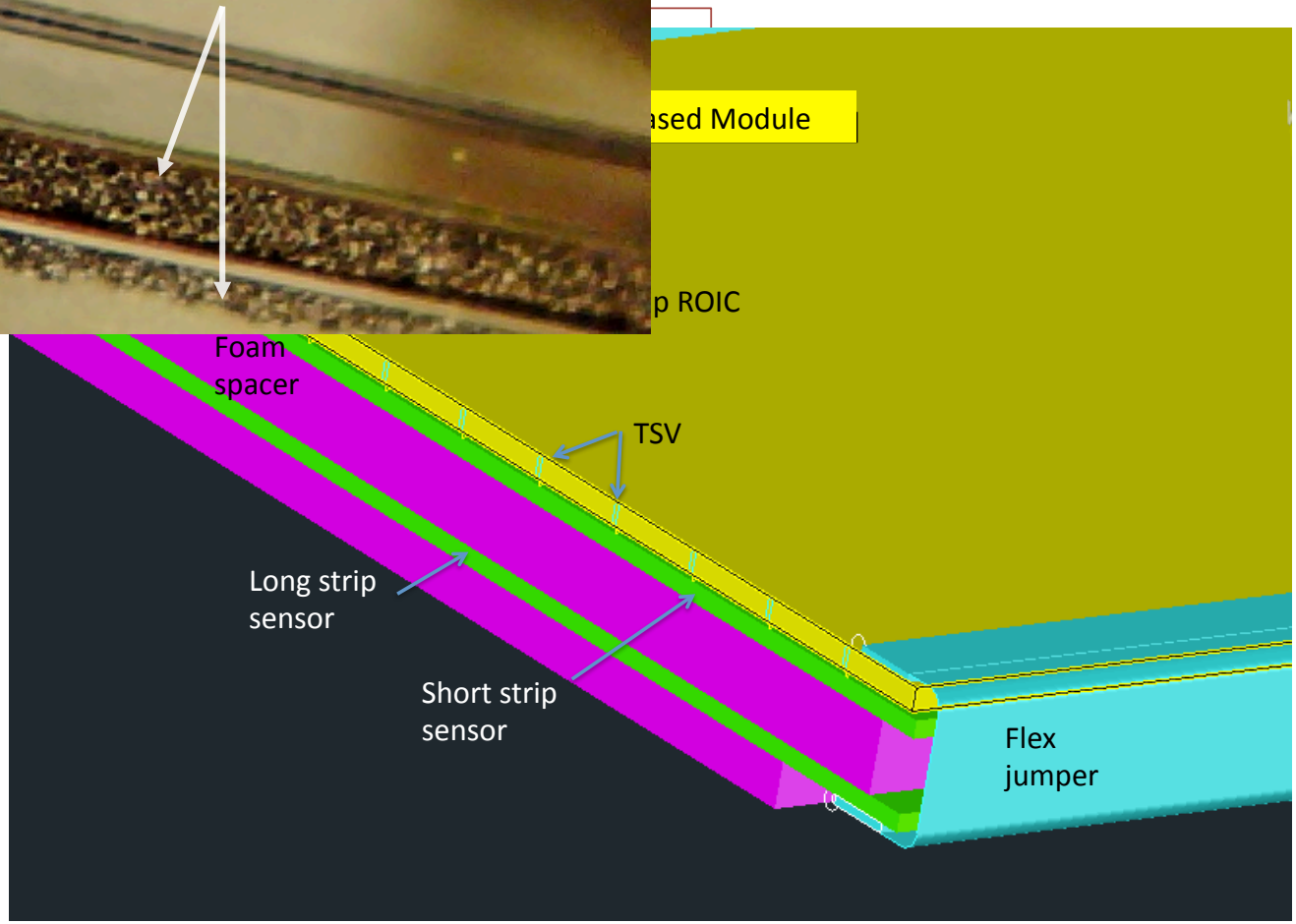


Details - III


Bottom sensor interconnects
Top sensor interconnects
Flex foldover
Bottom sensor interconnects
Top sensor interconnects

Carbon foam/flex based design

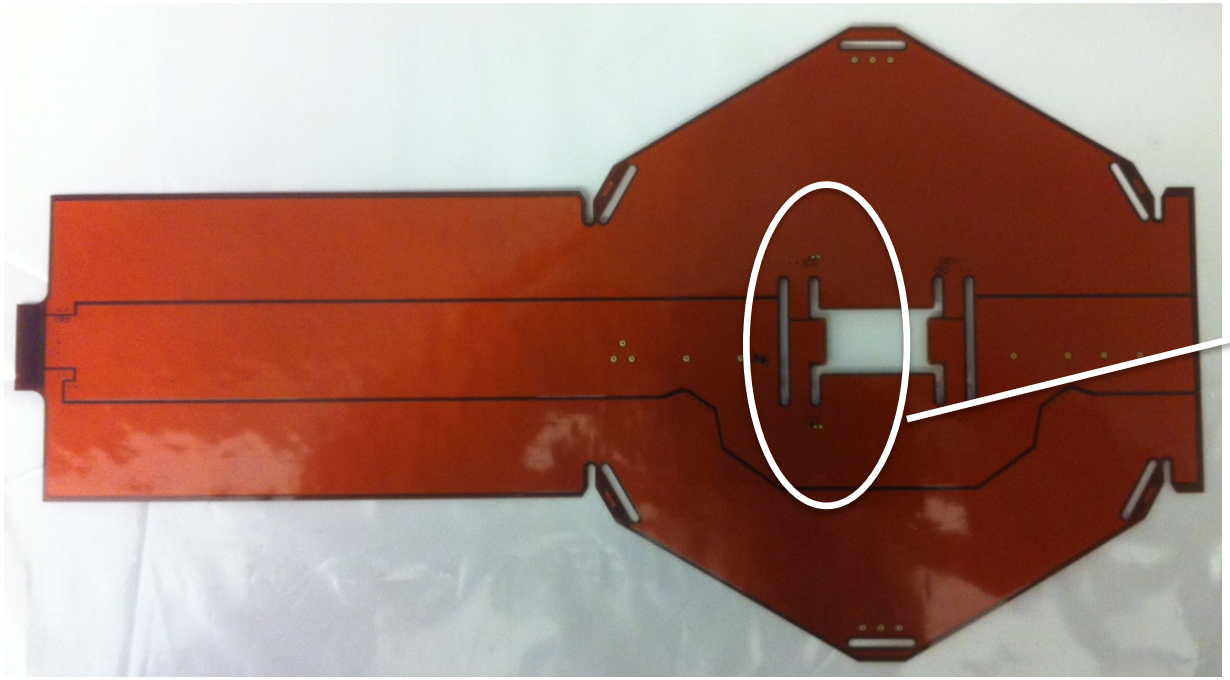


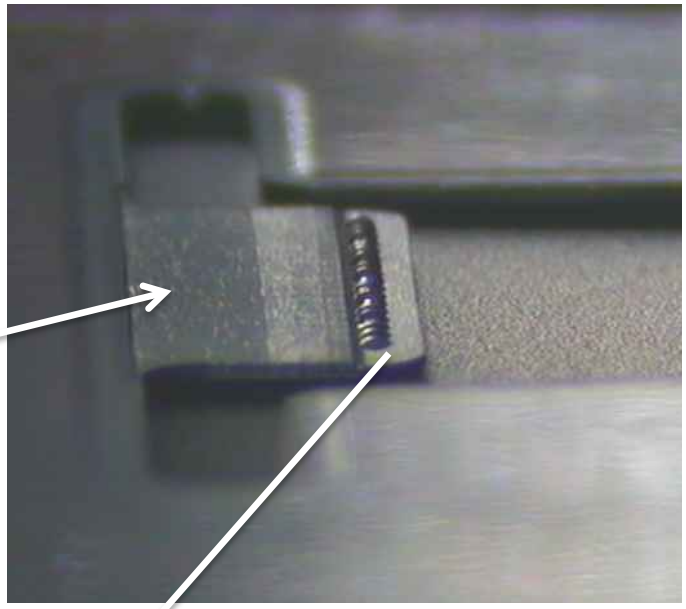


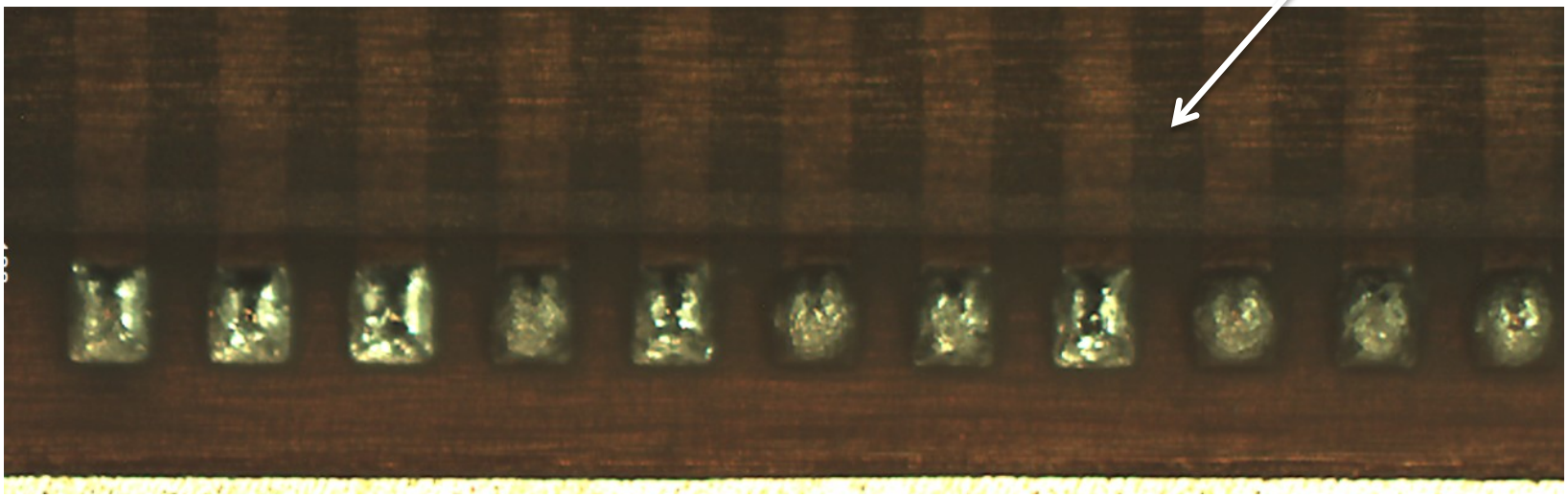
Studies Being Done

- Flex cable attachment
- Solder bump formation
- Gold stud bump bonding
- Chip stacking via interposers
- Glue dispensing
- Thermal conductivity measurements

Studies of Flex Cable Attachment





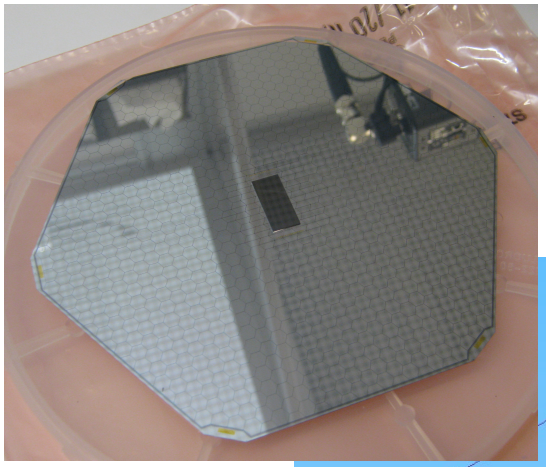


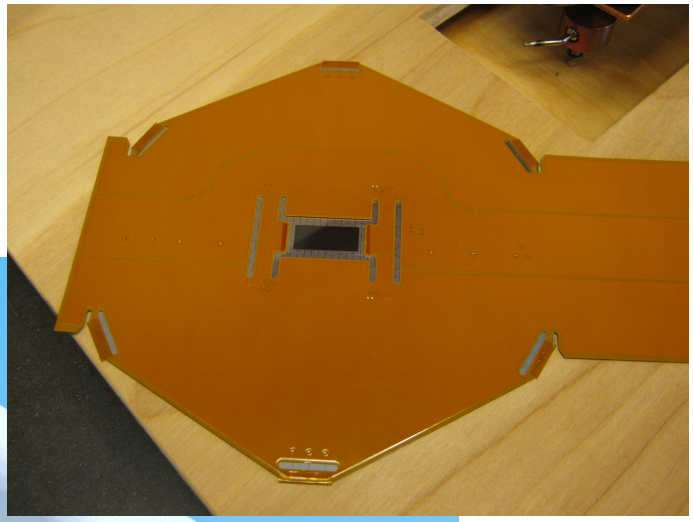
Main Issues with Flex Cable

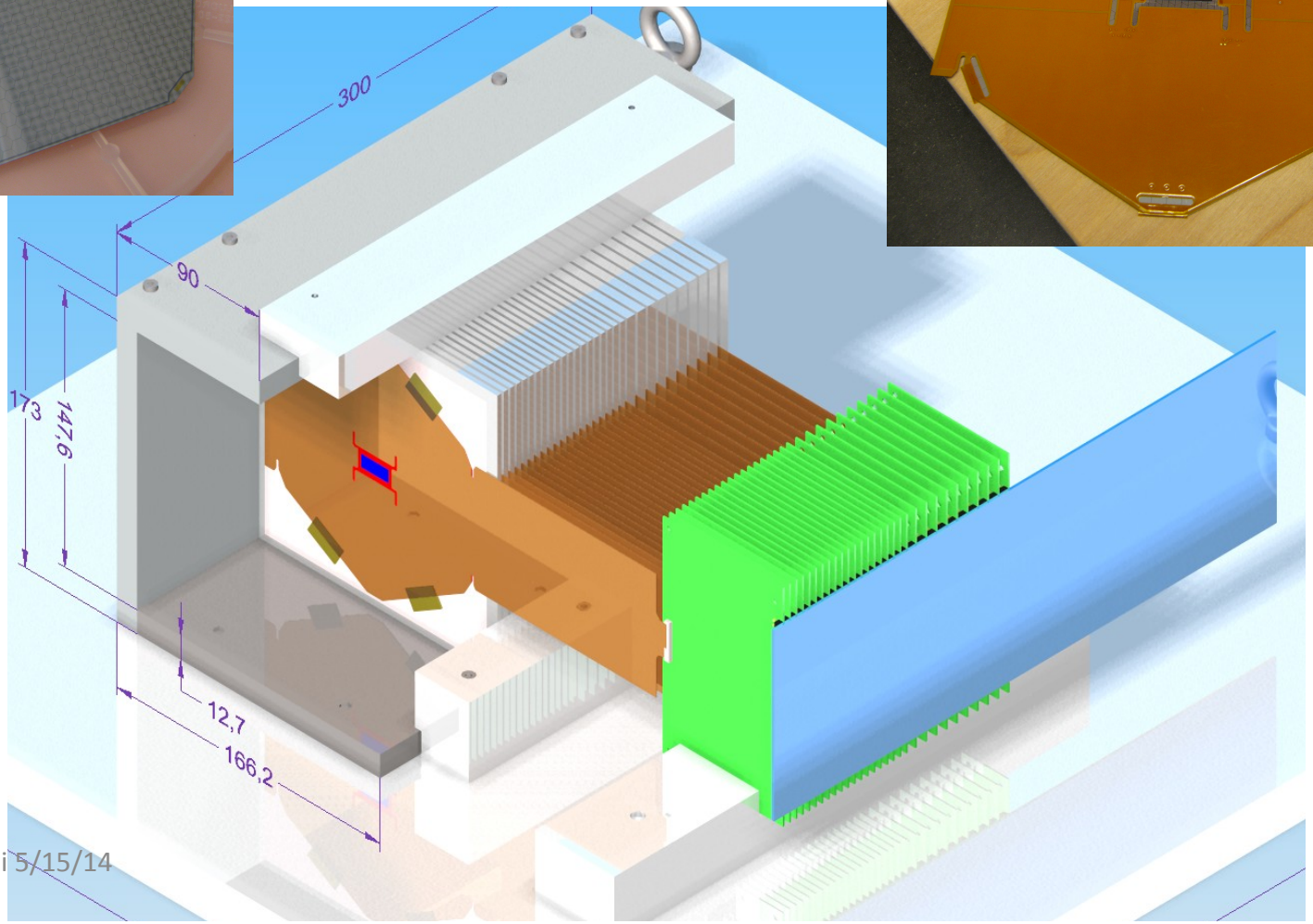
- For large cables, CTE mismatch between kapton and silicon is an issue - Strain relief slots were cut into the cable.
- The pads needed a good solder dam for uniform height
- Alignment windows with matching targets on wafer.
- The flip-chip assembly already had been solder bonded (using Pb/Sn eutectic). Hence, the reflow had to occur at a lower temp – Used In/Ag solder – other options exist.
- The heating had to be uniform in order to avoid warping of the kapton cable.
- Mechanical strength of bond not enough – Add epoxy.

Si-W Calorimeter

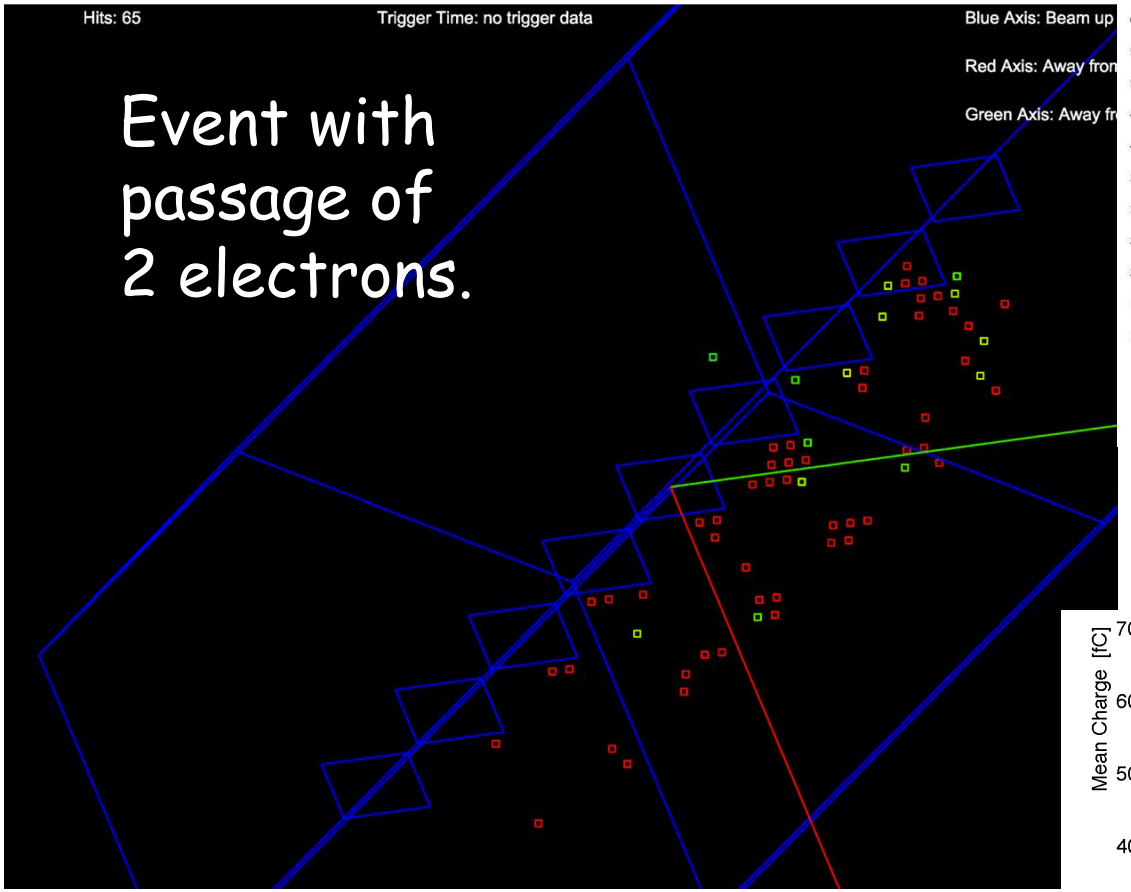
Beam test with 9 layer calorimeter at SLAC End Station A



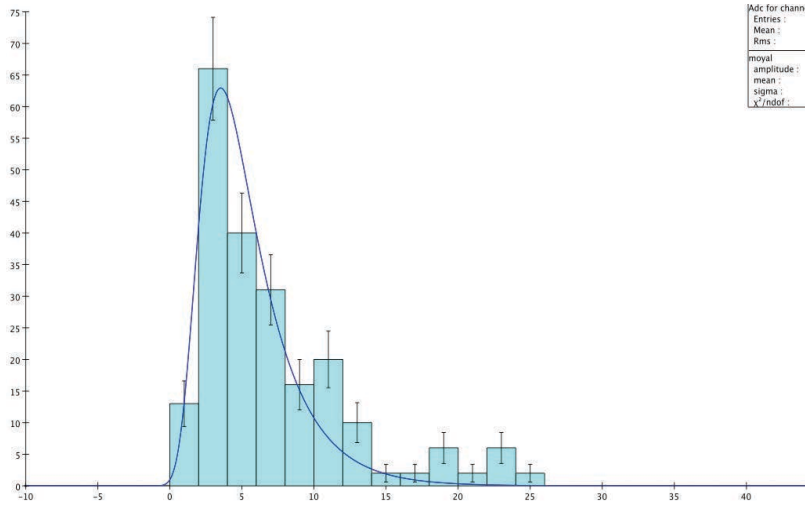


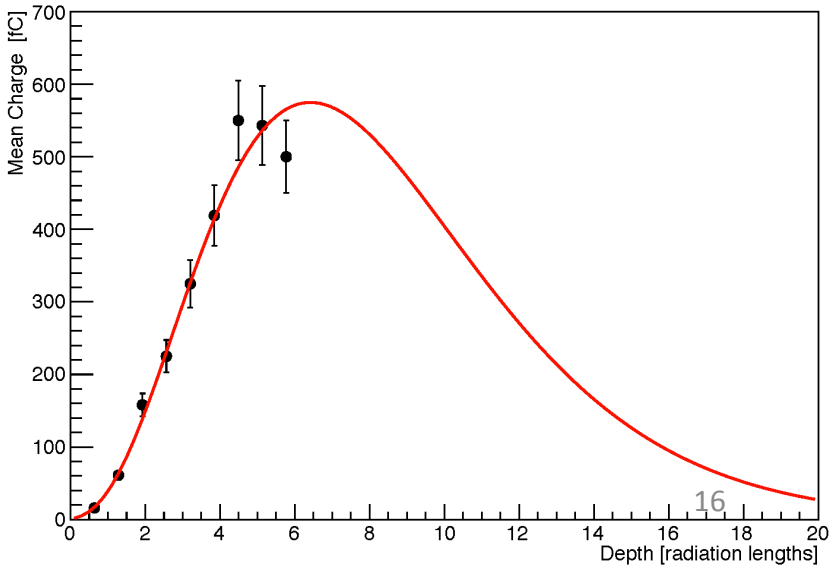


Si-W Calorimeter

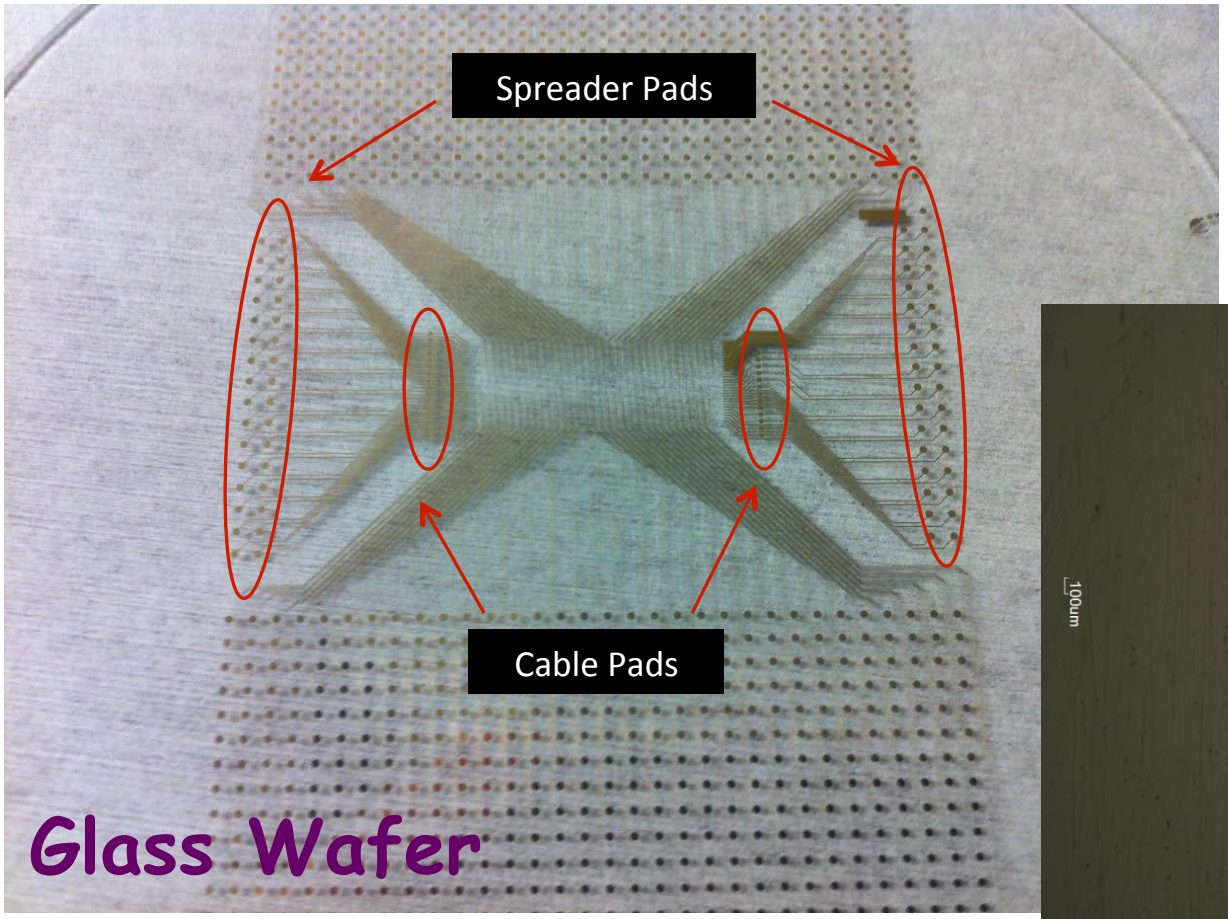


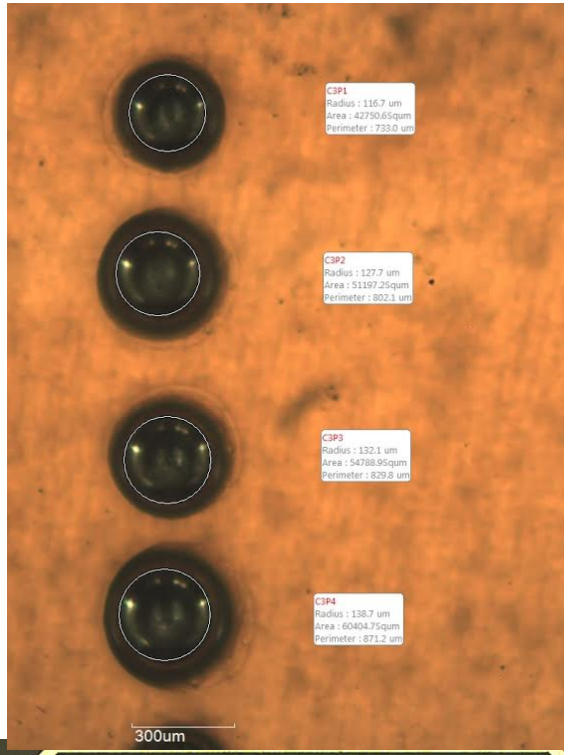
Event with passage of 2 electrons.

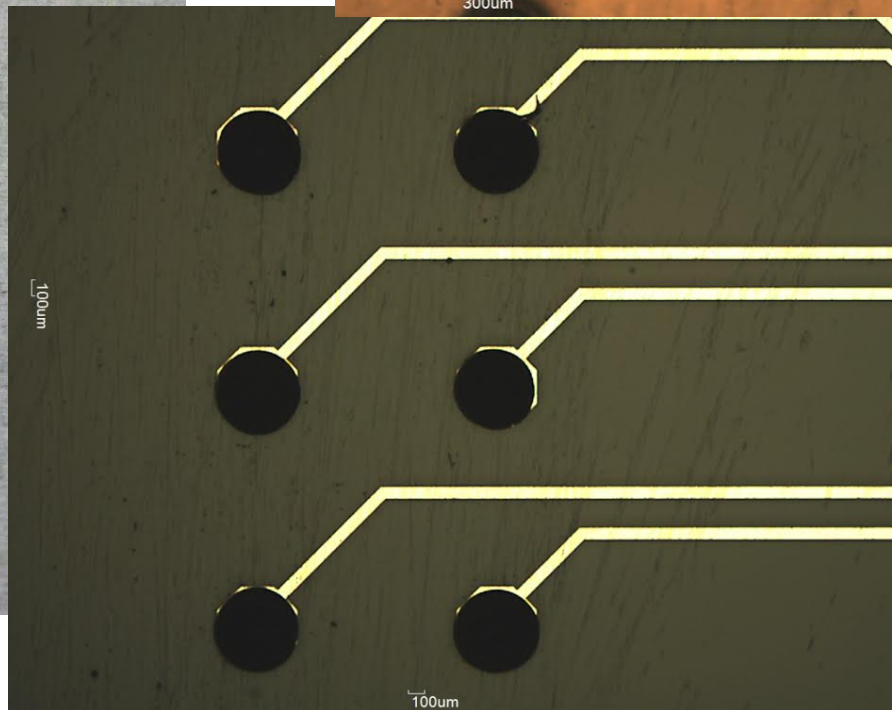


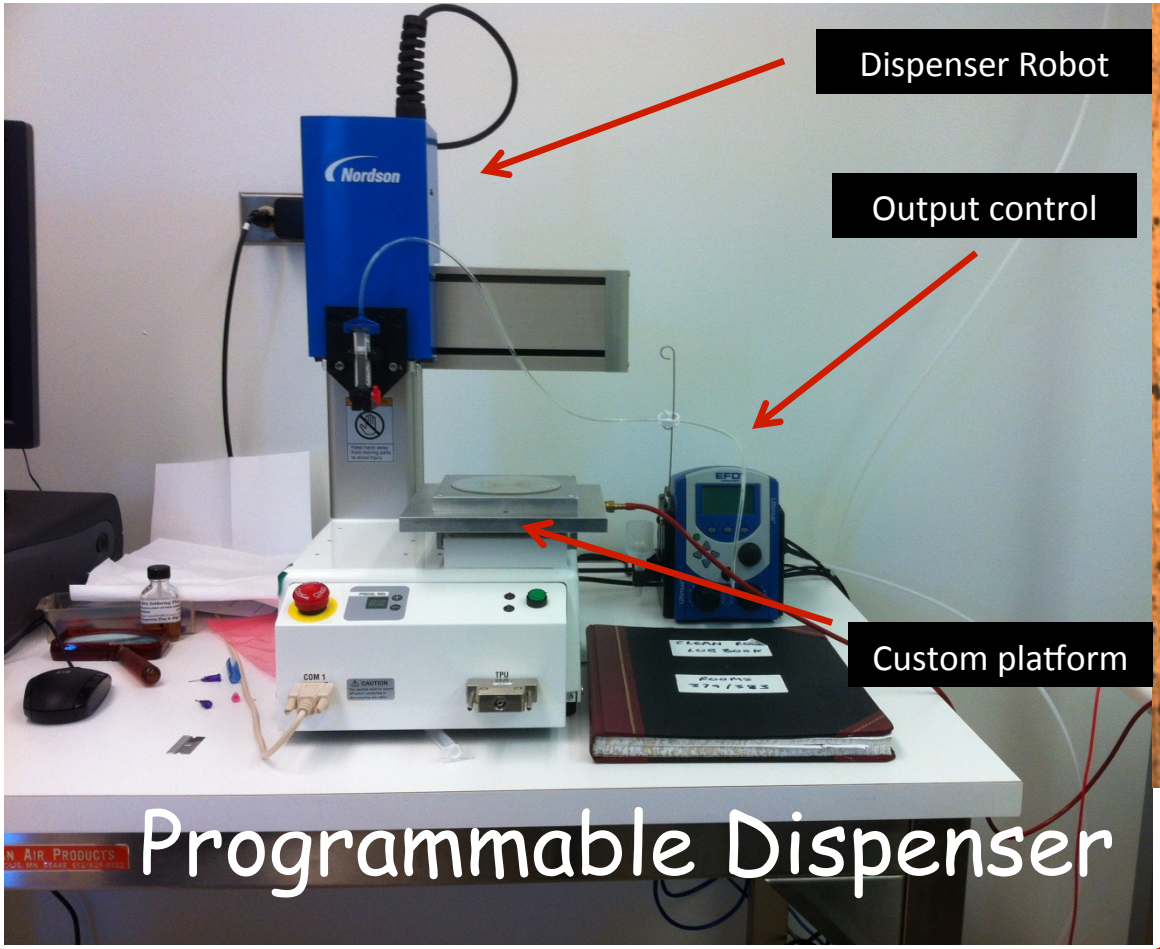


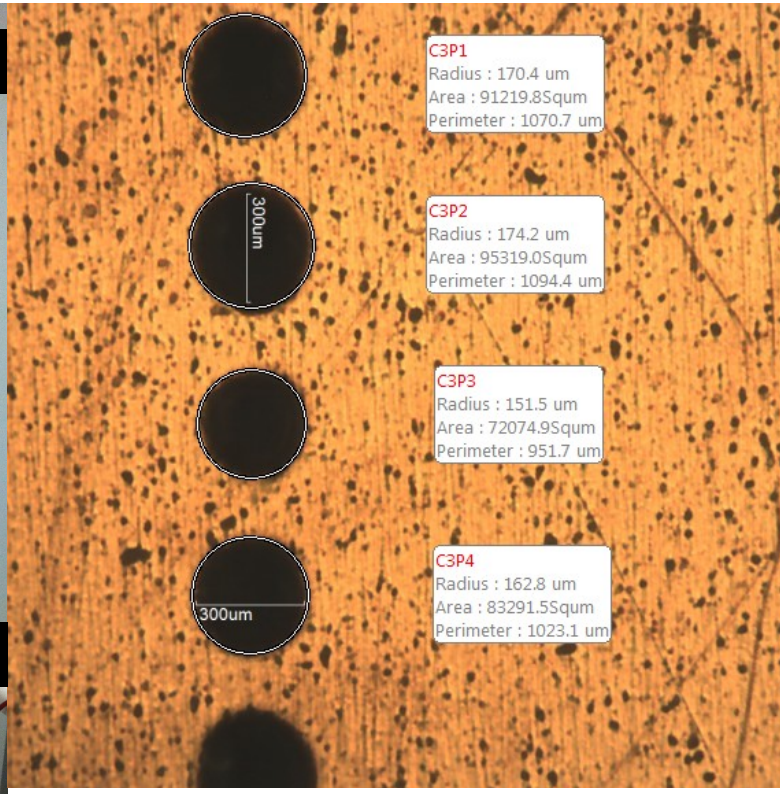
Studies of Solder Dispensing











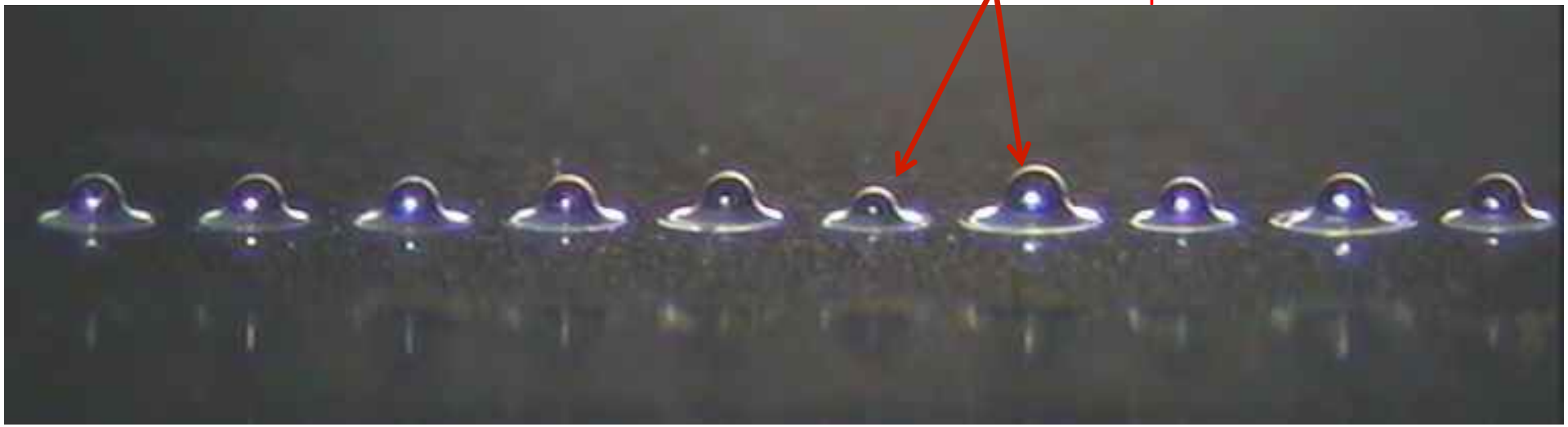
This bump had less material

This got the left over material

After Reflow

- Heating plate for reflow - MP + 20C for 60 seconds.

- Corrected most of the size inconsistencies. Manual intervention possible for prototypes

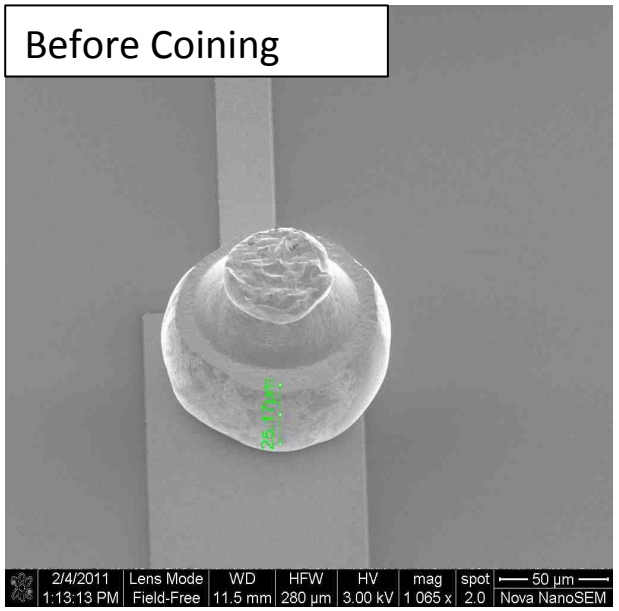


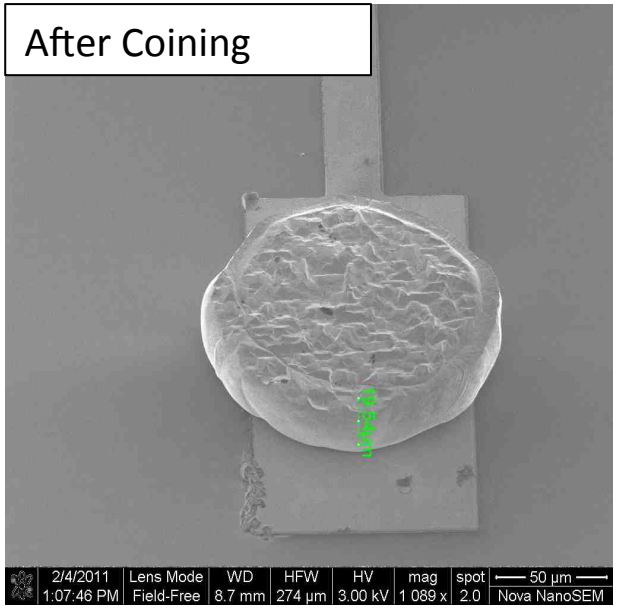
- Distance from syringe tip to substrate important - Larger distance resulted in larger bumps

- Current size ~300 um - Move to smaller tip for forming smaller bumps.

Double gold-stud bonding

- Useful for devices with Al pads – no need for UBM.
- Gold ball placed on both devices to be bonded
- Studs are flattened (coining)'
- Standard alignment with flip-chip bonder
- Bonded with thermocompression





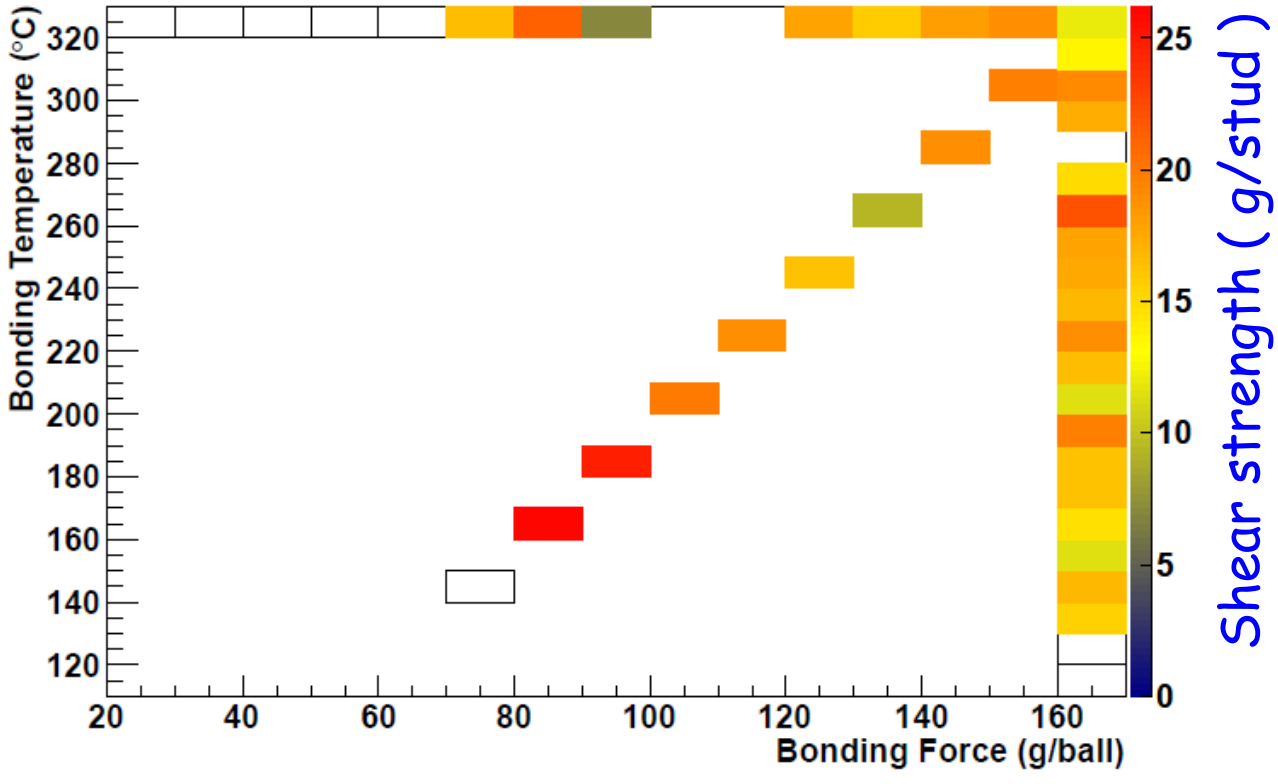
Process requires lower T and P

- Pressure Dependence at 320 °C: 100% yield with 70 g/stud or more
- Temperature Dependence at 160 g/stud: 100% yield with 130 °C and above

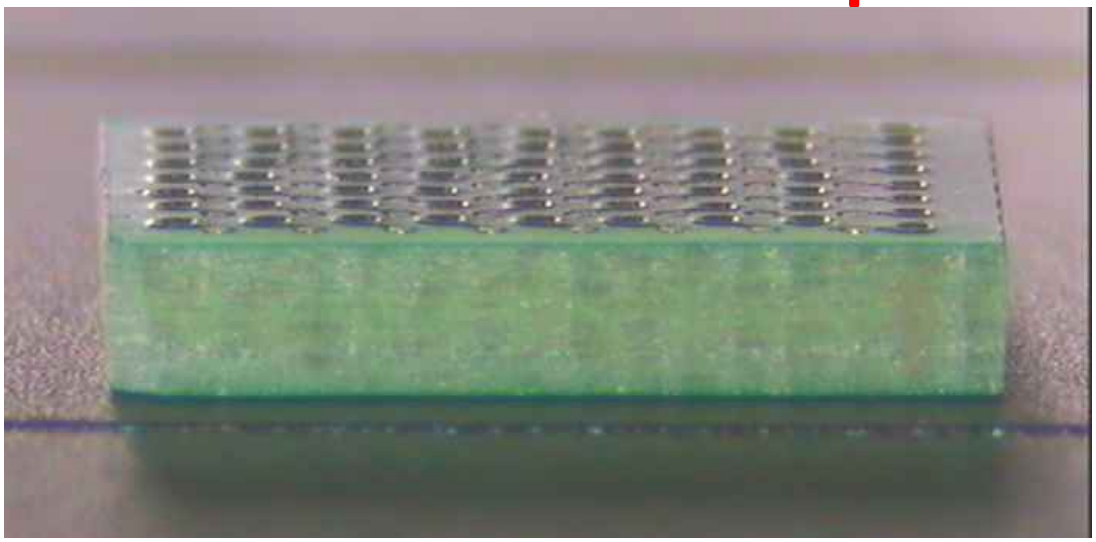
Dual Variable Trials

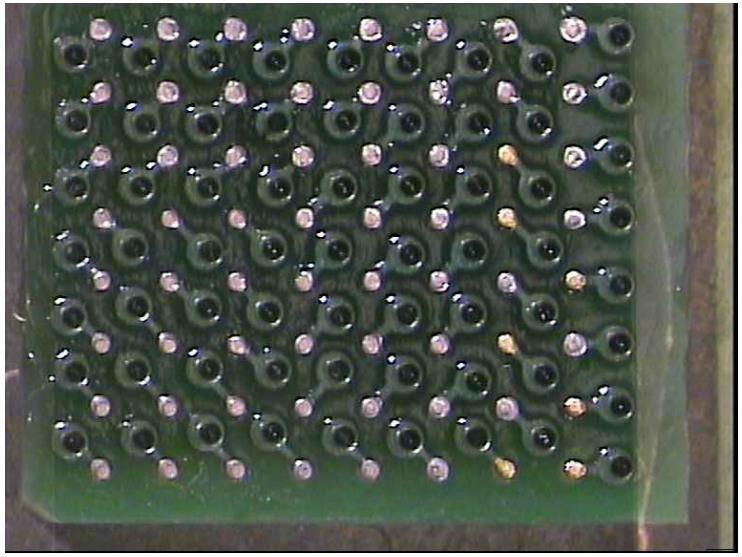
- 80 g/stud and 160 °C yielded 100%
- Combinations above this successful

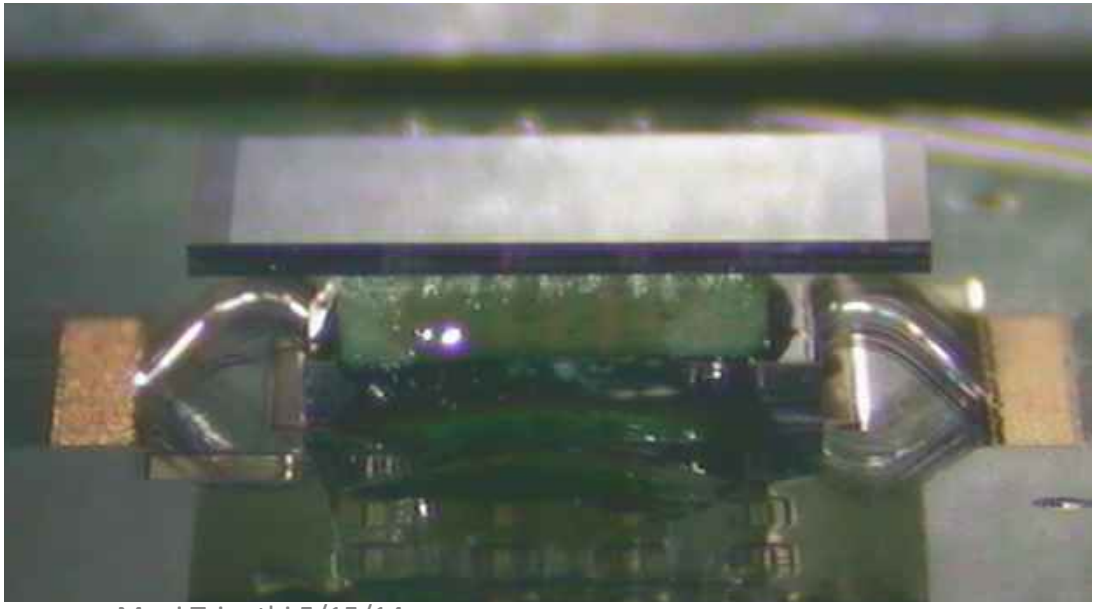
Bond Yield vs. T and P (for bonds < 2 mΩ)

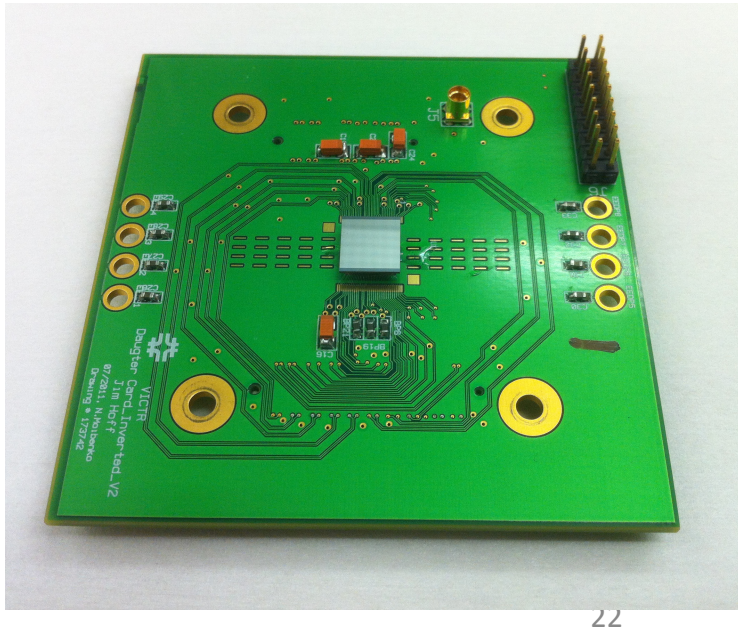


Sensor-Interposer-ROIC Stack









Gluing Studies

- We are putting together practice assemblies using dummy MaPSA ROIC, sensors and carbon foam.
- Will also be used in thermal tests.

- We are experimenting with dispensing the epoxy in a dot matrix.
- The initial trials are with glass wafers so that the spreading of the glue can be observed.

Summary

- Solder dispensing is a promising avenue for bumping.
- Double gold-studs are excellent tool for prototyping on devices with Al pads.
- Procedures for flex cable attachments are being developed.
- Dummy assemblies with epoxy attachments to carbon foam layers are ebing prepared.
- A jig for thermal conductivity measurements is being constructed.

Extra