ATLAS ITk Wire Bonding

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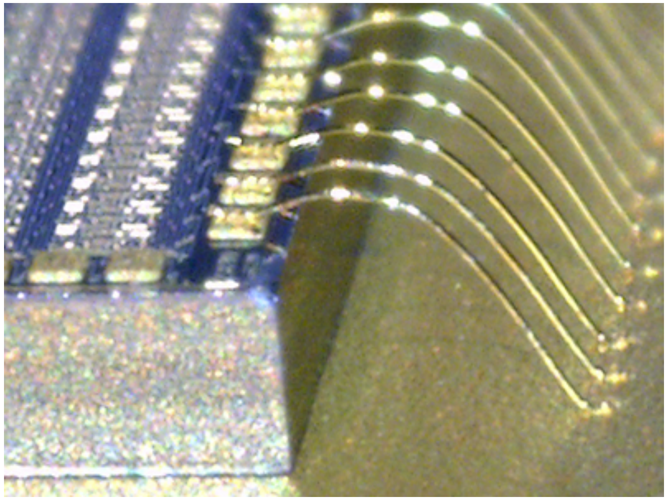
2018-09-21

Outline

- Wire bonding introduction
- ATLAS ITk strip module wire bonding
- Wedge bonding issue
- Wire bonding testing: ABC130
- Improve wire bonding efficiency
- Wire Protection: encapsulation

Wire Bonding

Wire bonding is the method of making interconnections between an integrated circuit (IC), printed circuit board (PCB), electronics or other semiconductor device and its packaging.



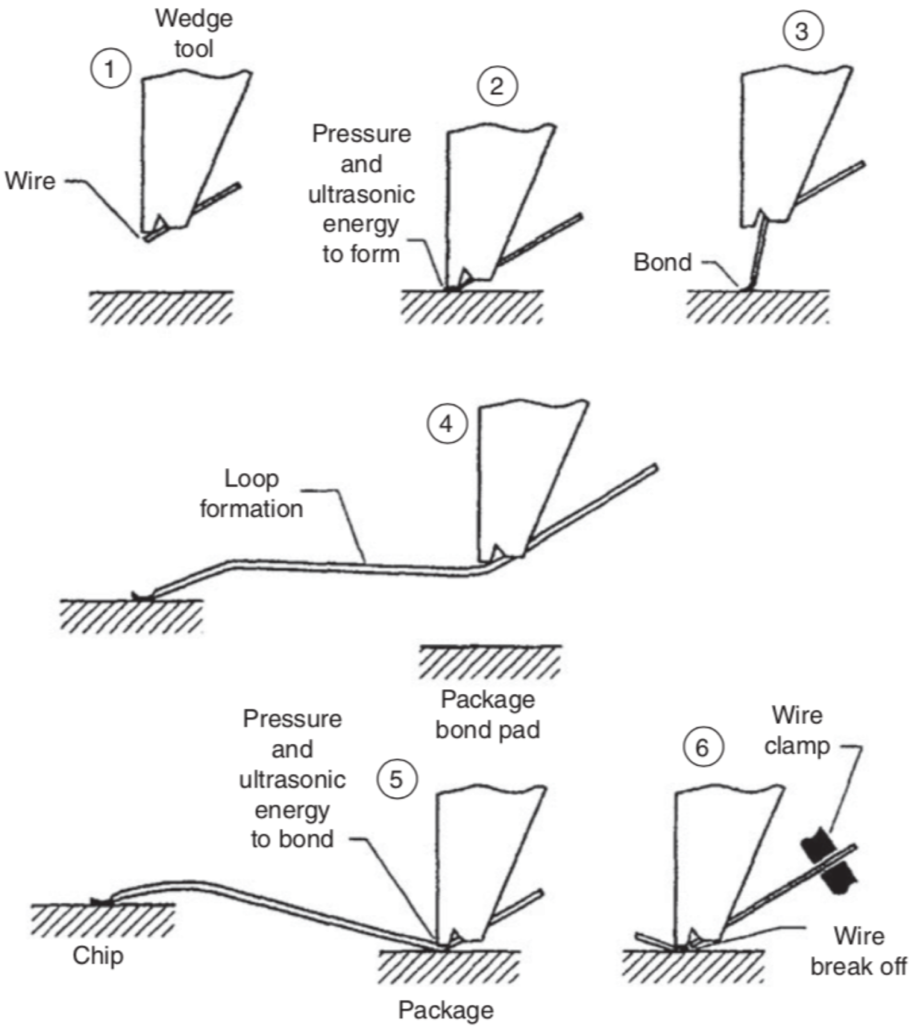
❖ Wire Materials:

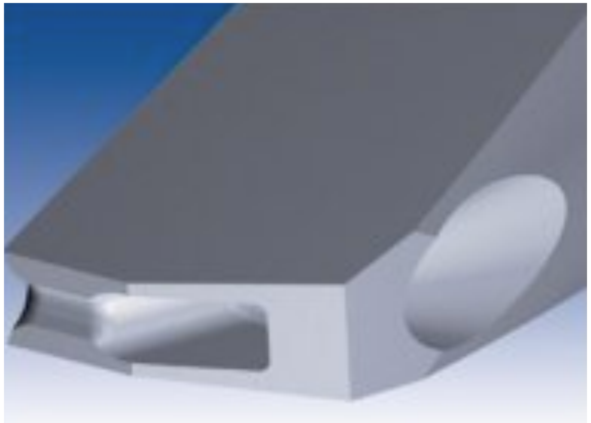
- Aluminum
- Copper
- Silver
- Gold

❖ Main classes of wire bonding:

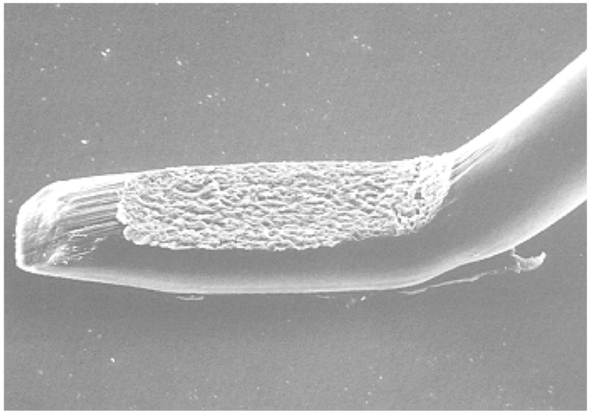
- Ball bonding
- Wedge bonding: round wire, ribbon wire

Wedge Wire Bonding



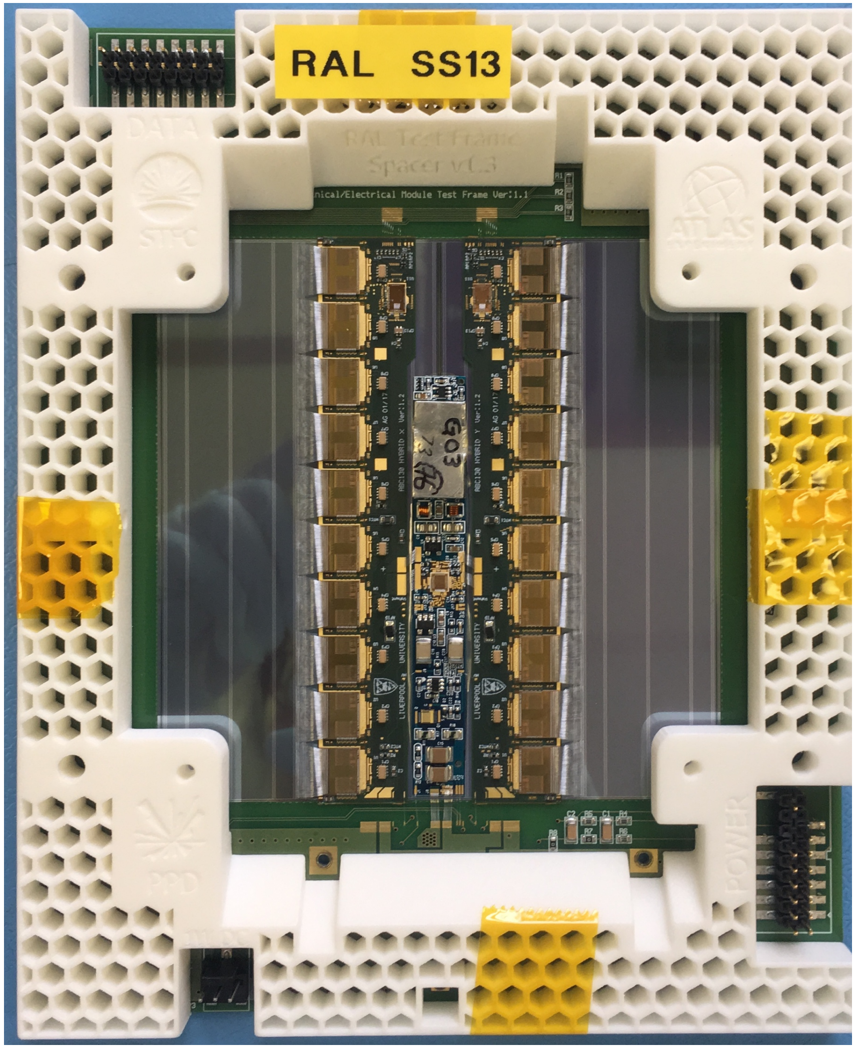


wedge



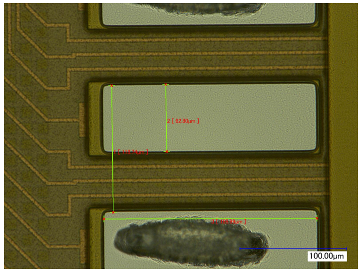
bond

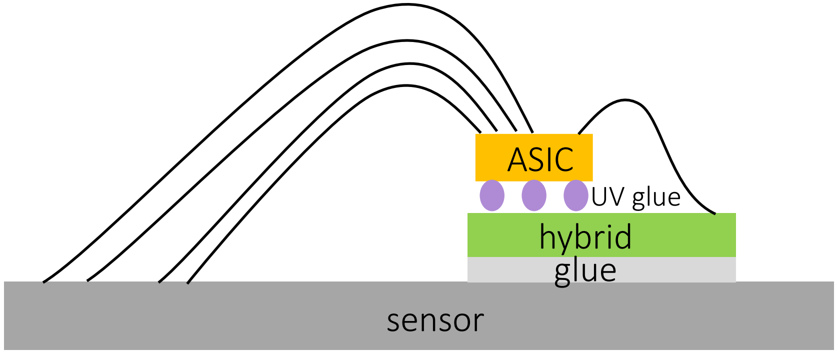
ATLAS ITk module

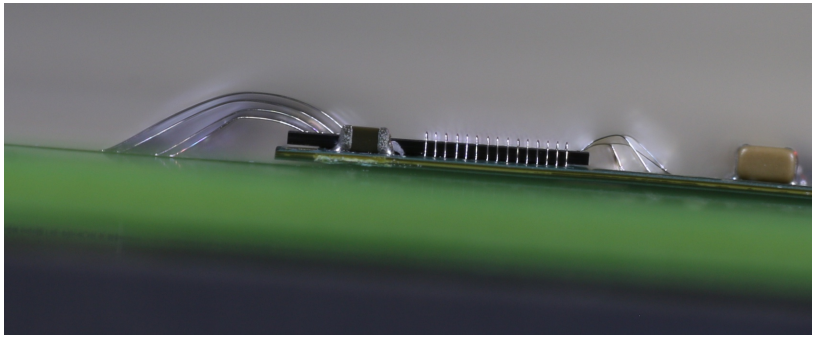


ATLAS ITk module wire bonding

- 25um Aluminum Wire
- ASIC to PCB: hybrid and power board (LS: ~233, SS:~400)
- ASIC to sensor: 4-row wire overlap (LS: 640x4, SS: 640x4x2)
- Bond size of ASIC: 60um x 200um



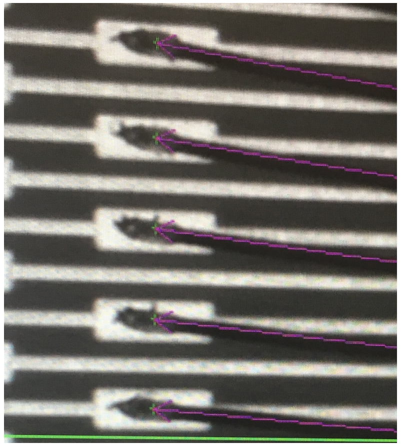


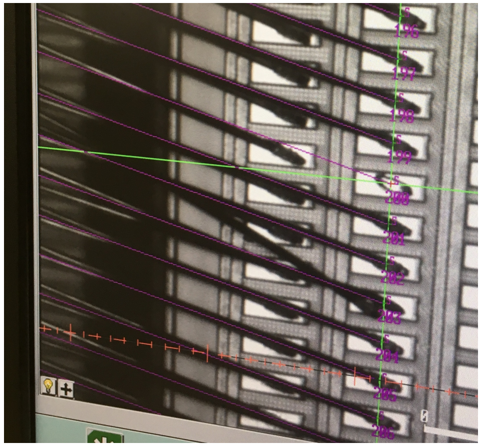


Wedge Wire Bonding Issue

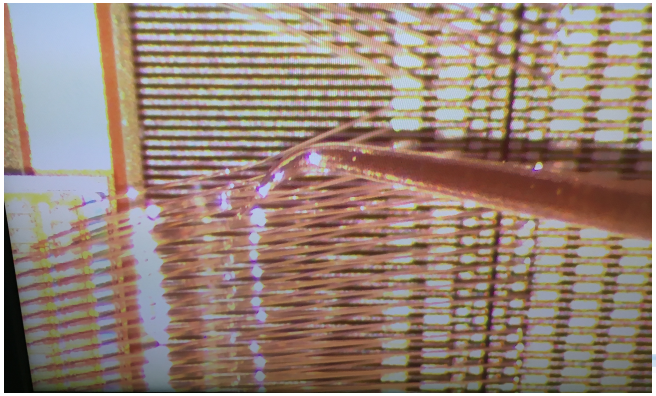
Wire bonding is one of key issue for module production.

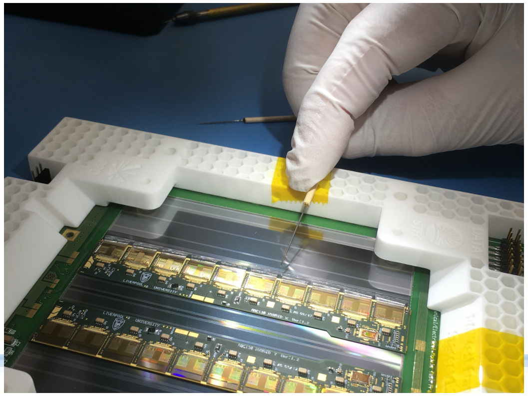
- ❖ Mechanical problem
  - Whiskey
  - Cratering
  - Cracks in the heel
  - bond lift





- ❖ How to rework?

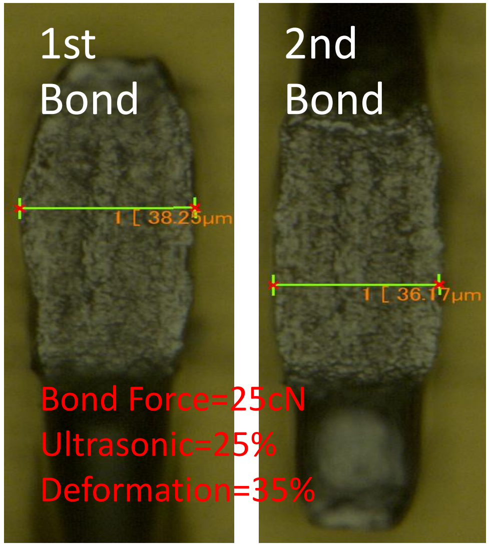




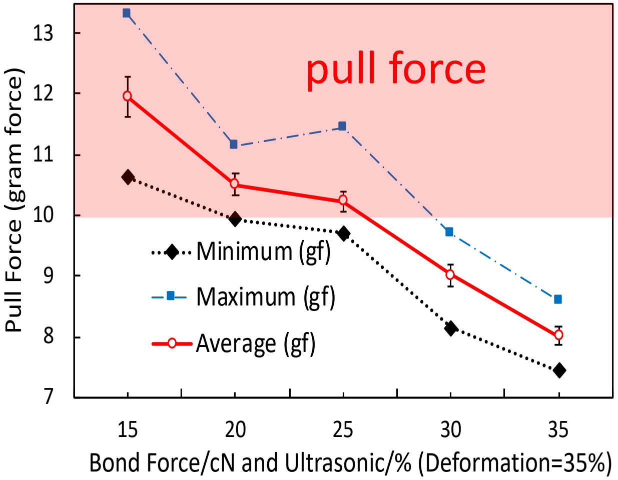
- ❖ Other solution:
  - Optimize parameters
  - clean substrate

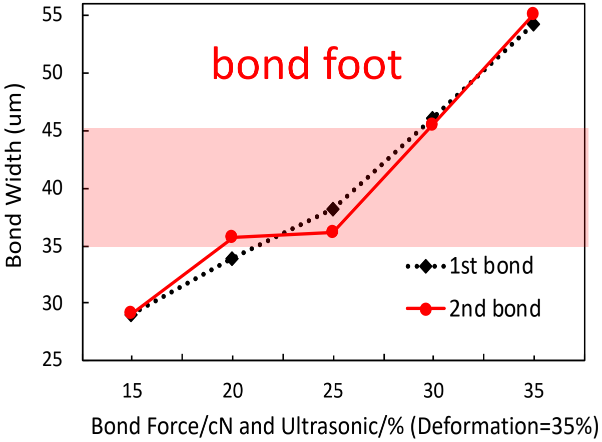
Optimize parameters for wire bonding

- Main parameters:
  - Bond force
  - Ultrasonic
  - deformation
  - tail length
  - loop shape
  - loop height

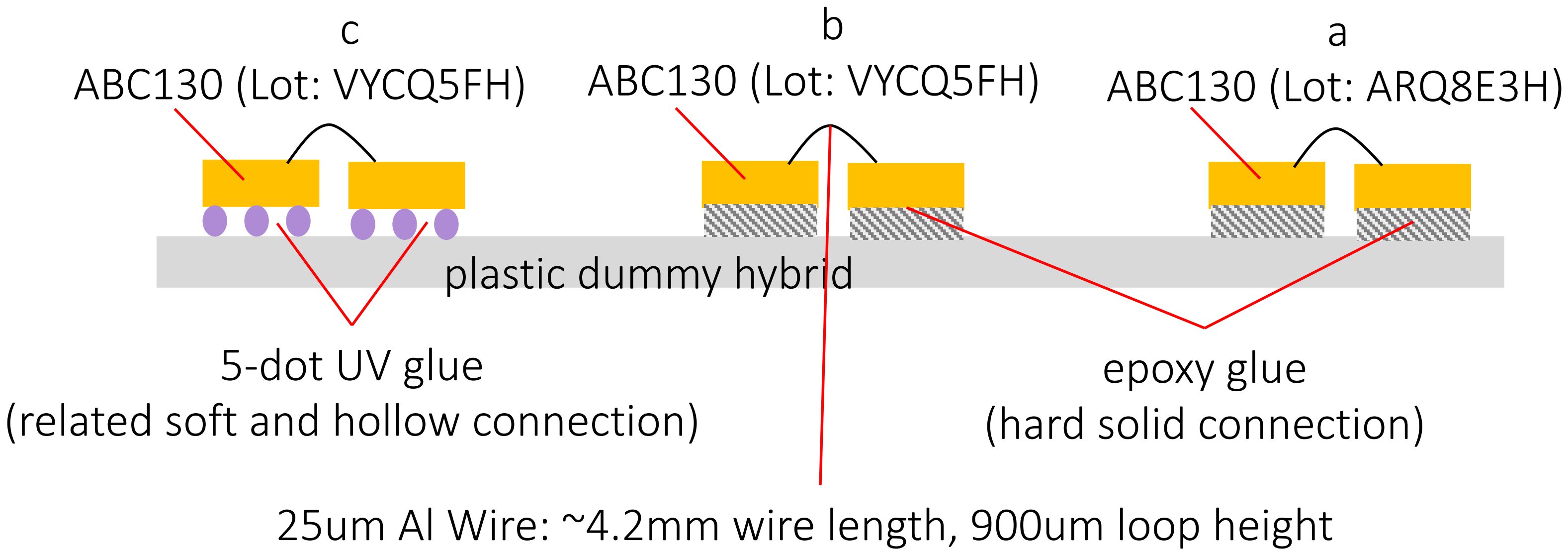


- Wire bond testing: pull test





Wire bonding testing: ABC130



c
ABC130 (Lot: VYCQ5FH)

b
ABC130 (Lot: VYCQ5FH)

a
ABC130 (Lot: ARQ8E3H)

plastic dummy hybrid

5-dot UV glue
(related soft and hollow connection)

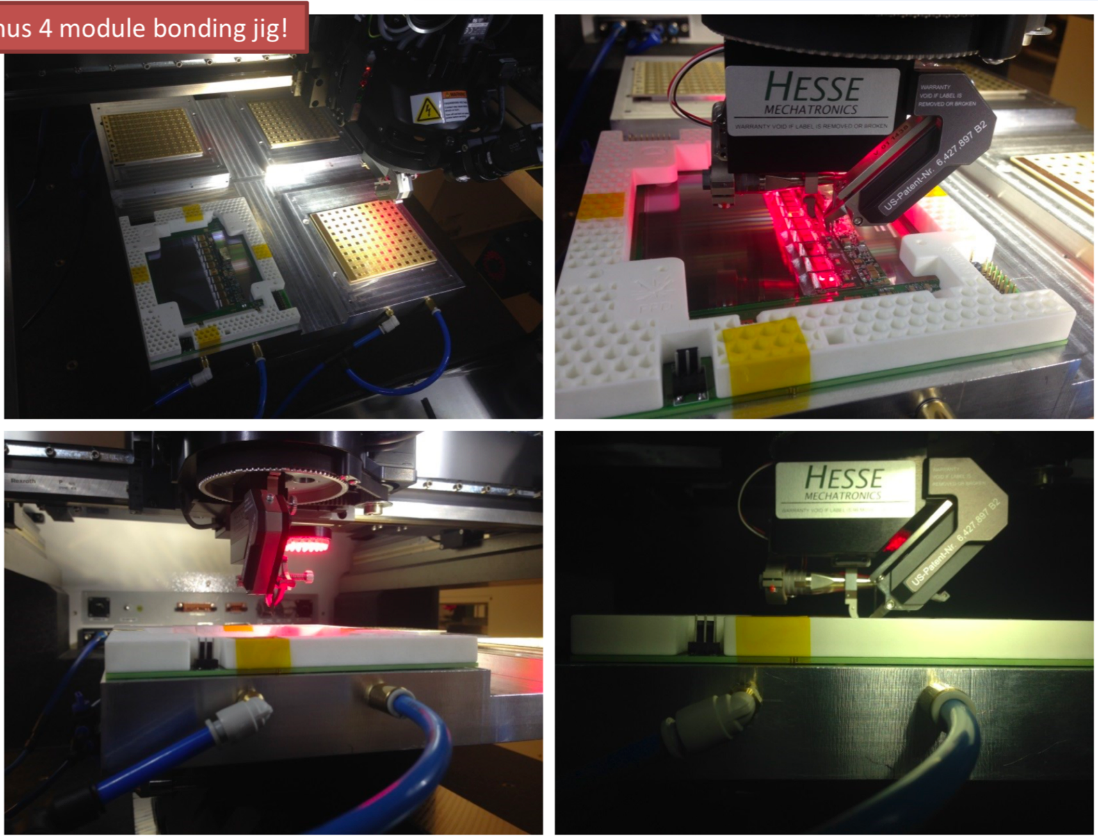
epoxy glue
(hard solid connection)

25um Al Wire: ~4.2mm wire length, 900um loop height

Result is summary on the way.

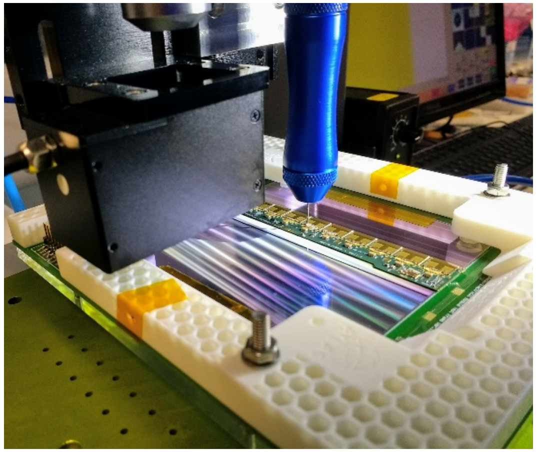
Improve wire bonding efficiency

- Developed 2x2 jig: One module each time->4 module each time
- Optimized bonding program: pattern search works well for each module


Bonus 4 module bonding jig!

Wire protection: encapsulation

- Lesson from IBL pixel detector: wire corrosion
  - Al wire Bond Corrosion due to humidity
  - Humidity control became most important step in quality control
- Another way to protect wire bond: encapsulation (R & D with Oxford)
  - Fully encapsulate ASIC back-end wires (ASIC to hybrid)
  - More tests on going check the performance before and after



Glue dispenser to perform
The encapsulation R & D

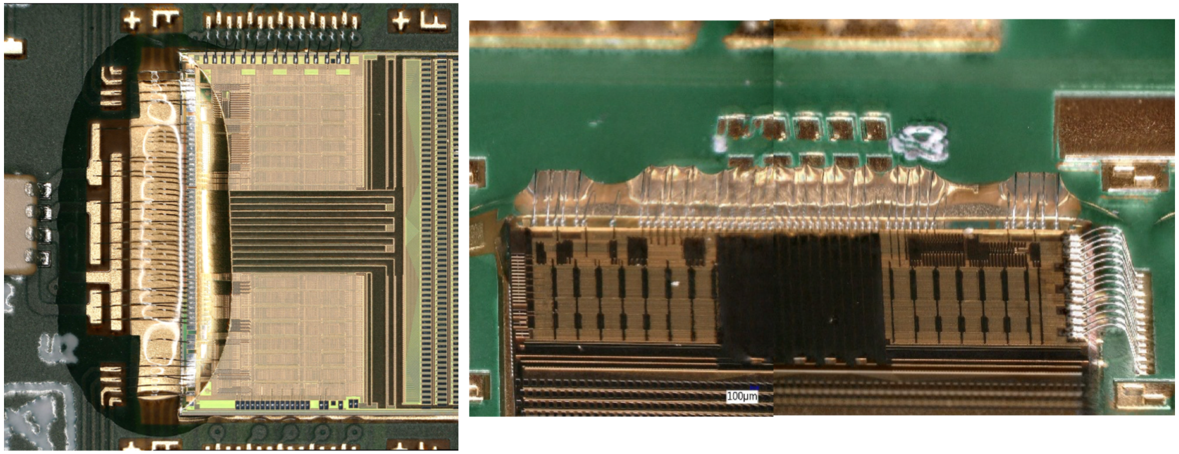


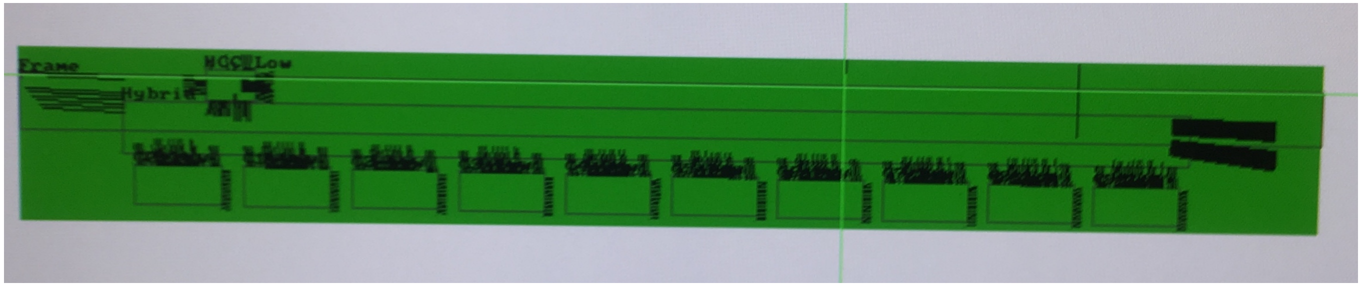
Photo of wire bond encapsulation
(Sylgard 186 Silicone Elastomer)

Conclusion

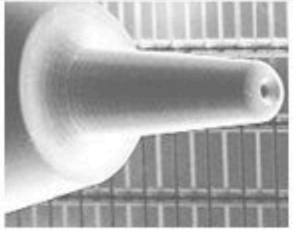
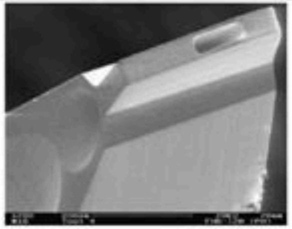
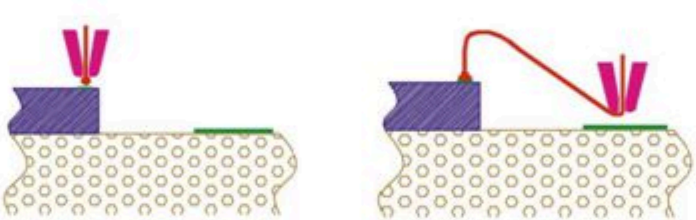
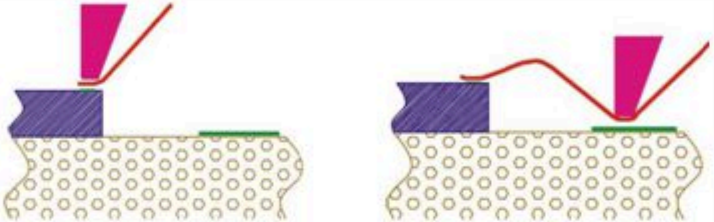
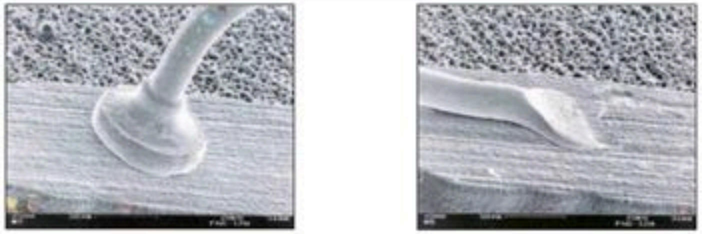
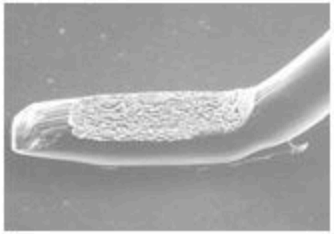
- ATLAS ITk strip module will use Aluminum wedge bonding to connect ASIC, PCB and sensor.
- Wedge bonding issue and rework.
- Pull test on ABC130 to optimize wire bonding parameters.
- 2x2 work holder has been developed to improve wire bonding efficiency.
- Encapsulation is a good way to protect wire.

Back up

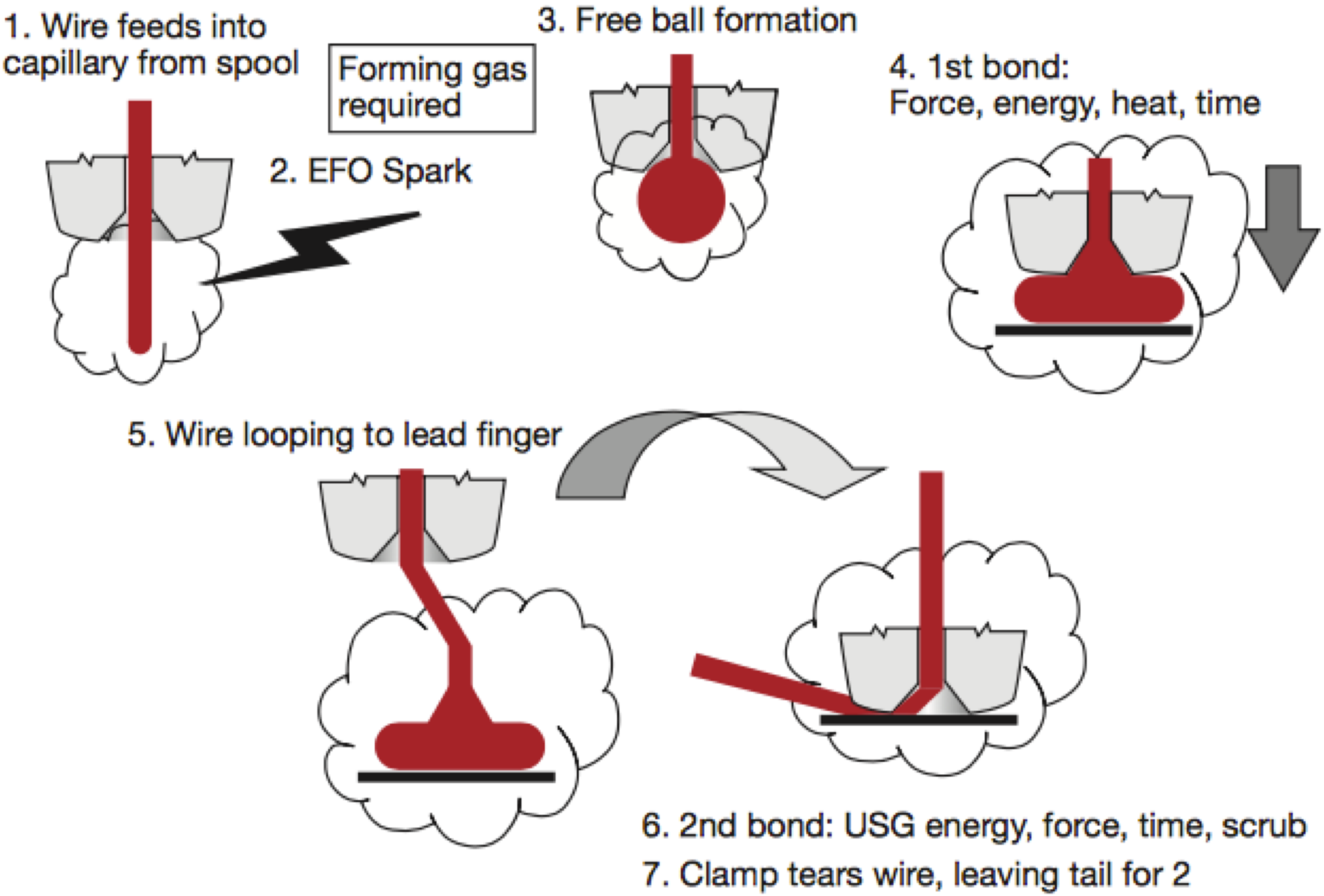
Program diagram



Ball vs. Wedge

Technique	Ball bond	Wedge bond
Process	TC, TS	TS, US
Tool	Capillary 	Wedge 
Bonding		
Bond foot		
Wire	Au	Al, Au
Pad	Al, Au	Al, Au
Speed	<20/s	<4/s

copper (ball) wiring bonding process



1. Wire feeds into capillary from spool

Forming gas required

2. EFO Spark

3. Free ball formation

4. 1st bond: Force, energy, heat, time

5. Wire looping to lead finger

6. 2nd bond: USG energy, force, time, scrub

7. Clamp tears wire, leaving tail for 2