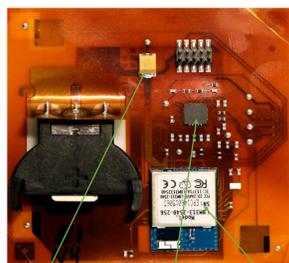
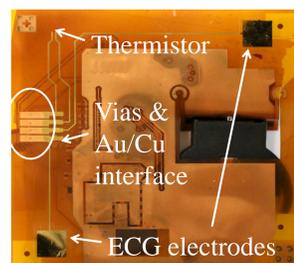


Wearable Sensor Patch:

Component Side



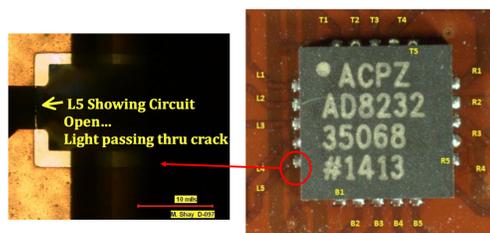
Sensor Side



Power cap AD8232 CC2540
sig. cond. SoC, 12 bit & gain 8 channels

Phase I device assembly

- Substrate: 2" X 2", 50 μm thick Kapton[®] polyimide (PI).
- Electrical circuit: 2 μm thick Cu.
- Solder: Sn63Pb (reflow temp: 205 $^{\circ}\text{C}$).
- ECG electrodes: Printed Au nanoparticle ink.



Cu trace cracking

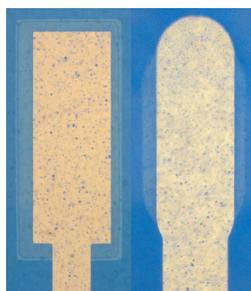
Test Vehicles (TV) for Bend Testing:

Device ID	Cu thickness (μm)	PI thickness (μm)	Solder used
M5 A2	6	50	Sn63Pb
M5 B2	6	50	Sn63Pb
M6 A1	6	50	Sn42Bi
M6 B1	6	50	Sn42Bi
M9 A2	2	125	Sn63Pb
M9 B2	2	125	Sn63Pb
M10 A1	2	125	Sn42Bi
M10 B1	2	125	Sn42Bi
Phase 1	2	50	Sn63Pb

Set 1 TV configurations

Set 2 TVs

- Substrate: 50 μm thick Kapton[®] PI.
- Electrical circuit: 2 μm thick Cu.
- Solder: Sn63Pb (reflow temp: 205 $^{\circ}\text{C}$) or Sn42Bi (reflow temp: 175 $^{\circ}\text{C}$).
- Improved solder pad design.



Original (left) and improved (right) solder pad design

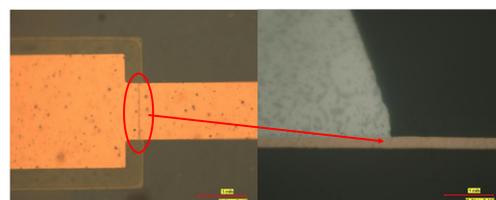
Bend Testing Procedure:

1. Microscopy and imaging of 20 solder joint locations of AD8232 chip to documents manufacturing defects.
2. 1000 bend cycles on 4" – 0.5" radius mandrels.
3. Microscopy and imaging after each stage to study and document new defects/failures.

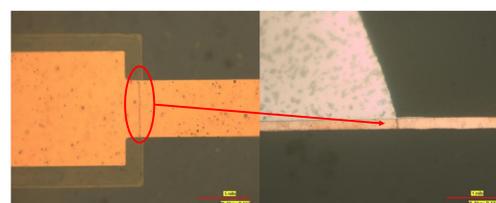


Mandrel pushing against sensor side

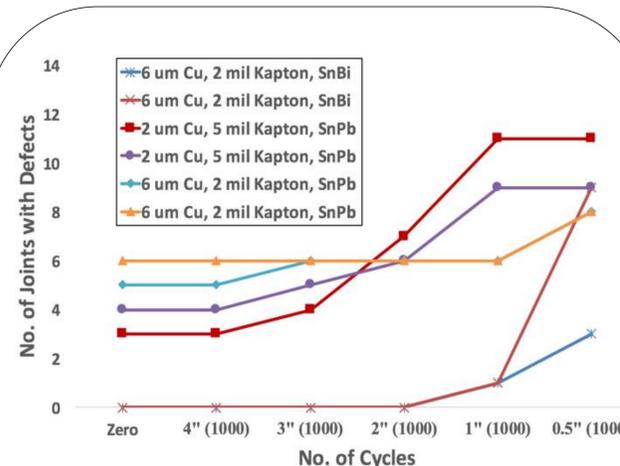
Results:



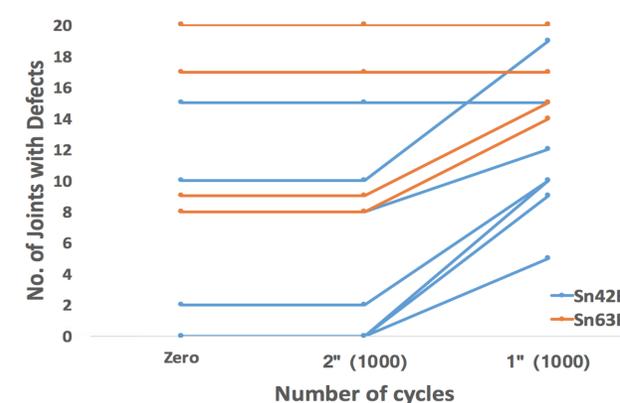
Defect due to crack initiation/local delamination



Crack through Cu trace

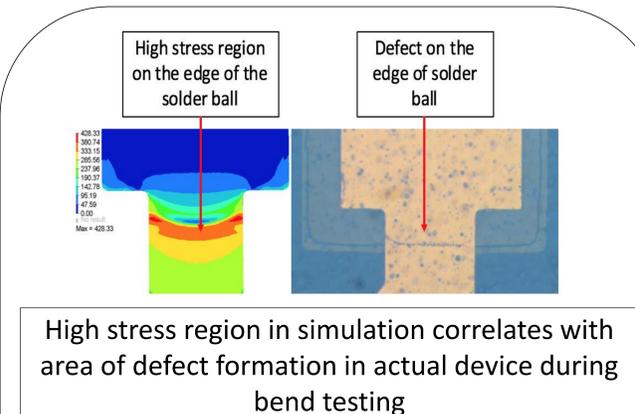
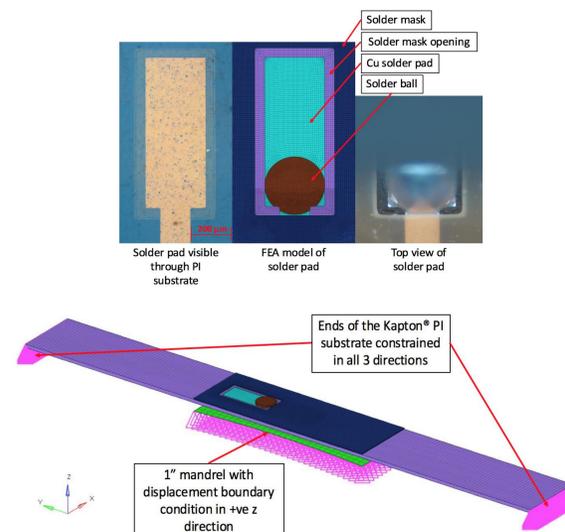


Set 1 TV bend testing results

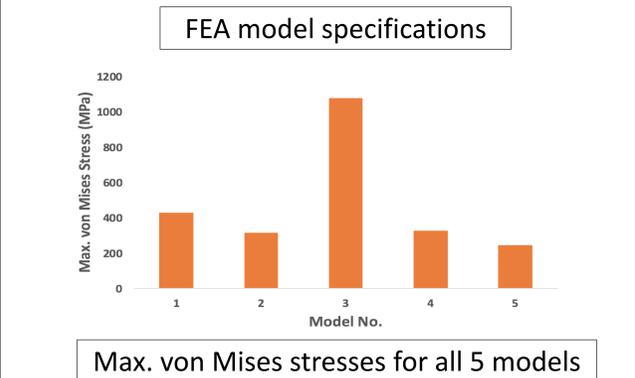


Set 2 TV bend testing results

Finite Element Analysis:



Model No.	Solder Pad Design	Cu Thickness (μm)	PI Thickness (μm)
1	Original	2	50
2	Original	6	50
3	Original	2	125
4	Improved	2	50
5	Improved	6	50



Conclusions:

1. Most robust configuration: 6 μm Cu, 50 μm PI, Sn42Bi solder. Only configuration with zero defects after fabrication.
2. Sn42Bi solder reduces stresses due to CTE mismatch.
3. Improved solder pad design increases robustness.
4. FEA results correlated closely with experimental results.

Reference:

Poliks, Mark, James Turner, Kanad Ghose, Zhanpeng Jin, Mohit Garg, Qiong Gui, Ana Arias, Yasser Kahn, Mark Schadt, and Frank Egitto. "A Wearable Flexible Hybrid Electronics ECG Monitor." Proceedings of the 2016 IEEE 66th Electronic Components and Technology Conference (ECTC), Las Vegas, Nevada, May 31 – June 3, pp. 1623-1631, 2016.