Keith Breinlinger
FormFactor, Inc.

Addressing the Operating Challenges of Full Wafer Contactors

June 7, 2010

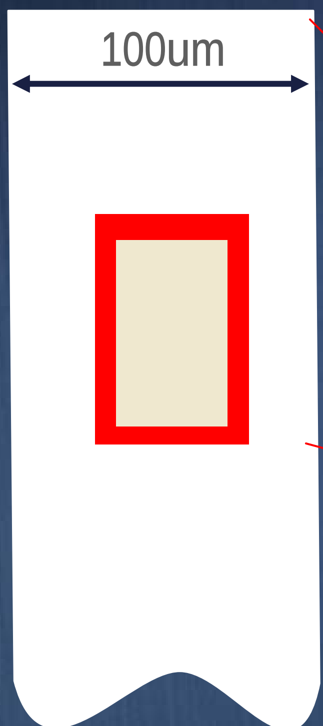
San Diego, CA USA

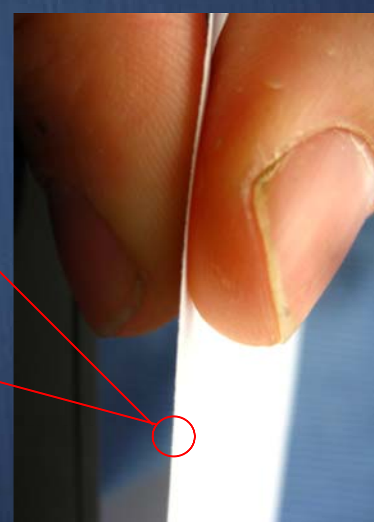
Outline

- Probe cards are really challenging.
- SmartMatrix^{TM} &TouchMatrix^{TM} Architecture Introduction
- 3 really challenging things:
  - Super Bond Pad
  - XY Tip Control
  - Z Tip Control
- Conclusion

Probe cards are really challenging.

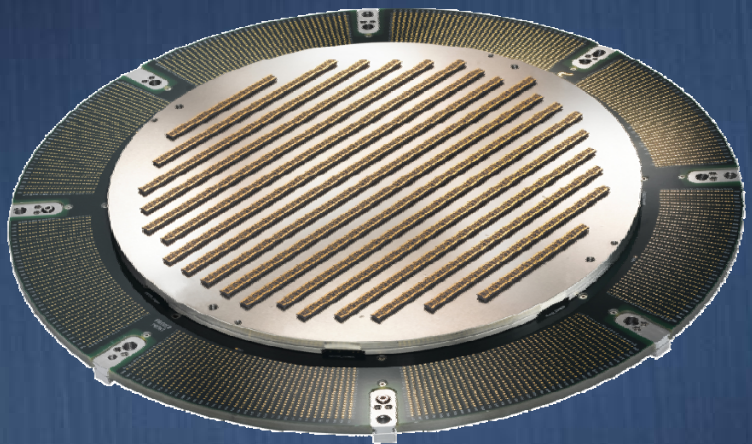
- A typical sheet of paper is ~100um thick.
- A typical ream of papers has 500 sheets.
- Imagine you need to make an electrical connector to contact the edge of every single sheet in the ream.
- Now imagine the you need to make a connector to contact the edge of every sheet in 100 reams of paper = 50,000 contacts!
  - The customer expects to be able to make more than 200,000 cycles on this connector.
    = 10 Million connections!



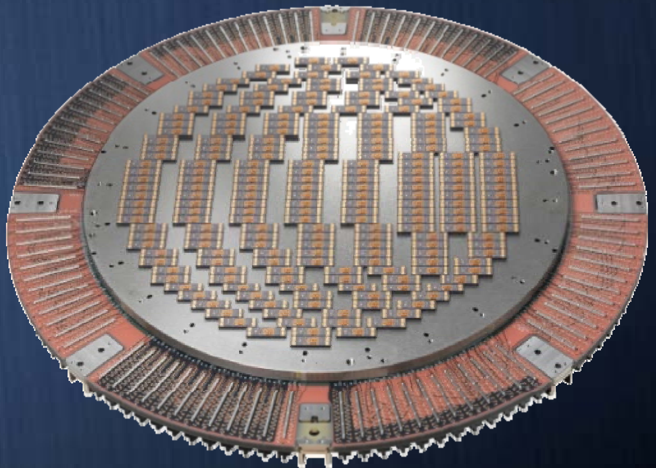


SmartMatrix™ & TouchMatrix™ Architecture

- Smaller Super Bond Pad
- Faster Soak Time
- Faster Installation Time
- Faster Lead Times
- Excellent CRES
- Wide Operating Temperature Range



FLASH platform
TouchMatrix™



DRAM platform
SmartMatrix™

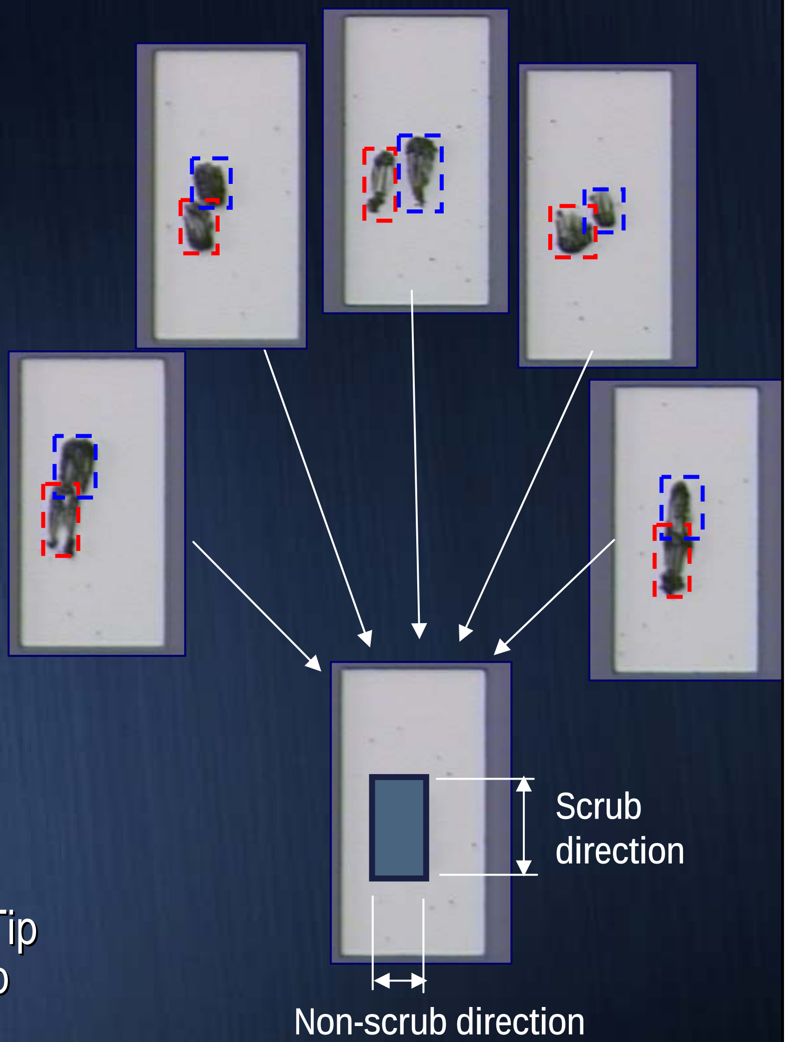
What is a Super Bond Pad?

Step 1) Make a probe card (assume 50,000 probes)

Step 2) Touchdown on a hot wafer and measure bounding box of every single scrub mark (4 measurements: Top, Bottom, Left and Right)

Step 3) Repeat procedure for a cold wafer

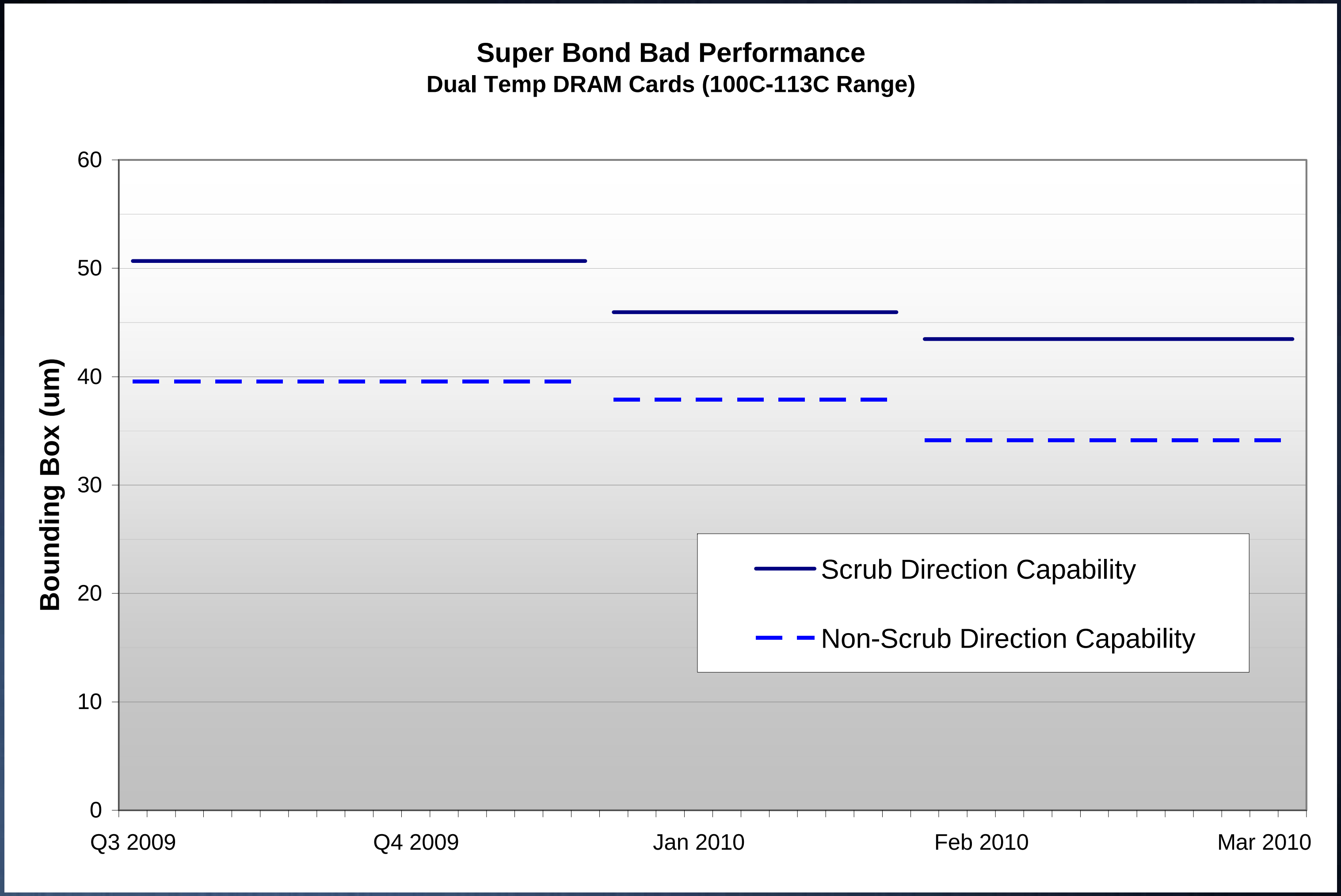
Step 4) Take all 400,000 data points and combine these marks into one "Super Pad". Measure the bounding box. = Super Bond Pad = SBP



SBP Non-Scrub = Tip Width + Tip Width Tolerance + Tip placement accuracy + Scaling Error (Expected Temp x CTE) + Furrow + Prober Alignment

SBP Scrub = Tip Length + Scrub Ratio x Overtravel + Tip Length Tolerance + Tip placement accuracy + Scaling Error (Expected Temp x CTE) + Prow + Prober Alignment

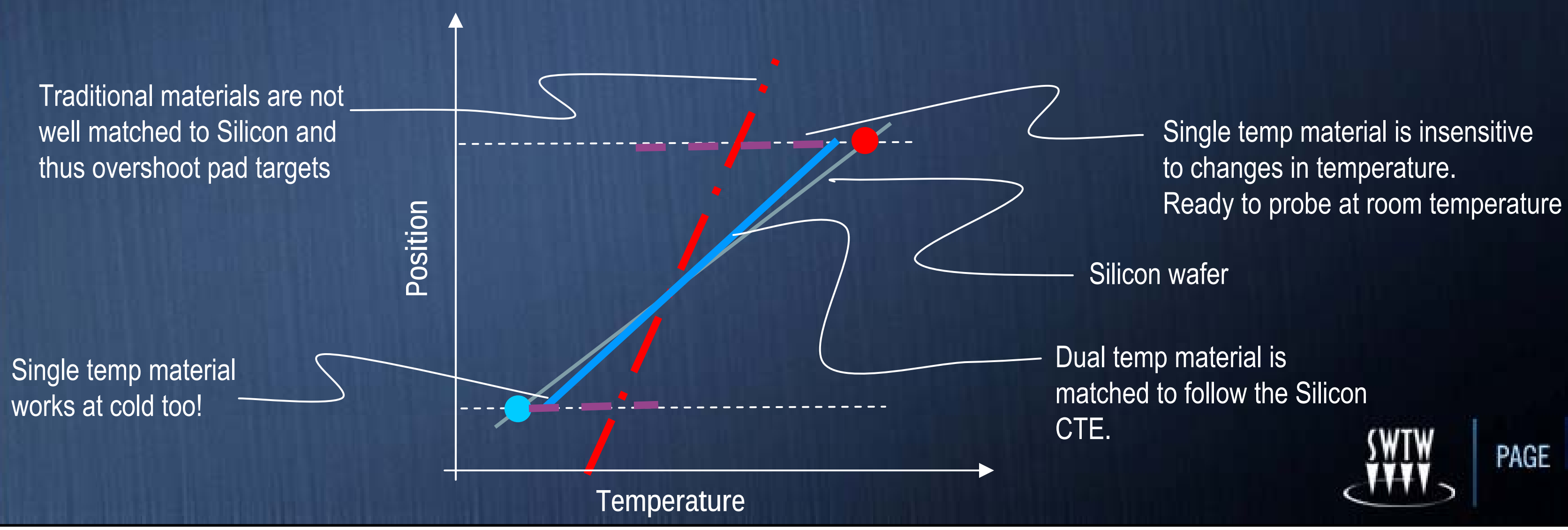
Dual Temp Super Bond Pad Capability



Capable of 34um x 43um today for 100C dual temp range.

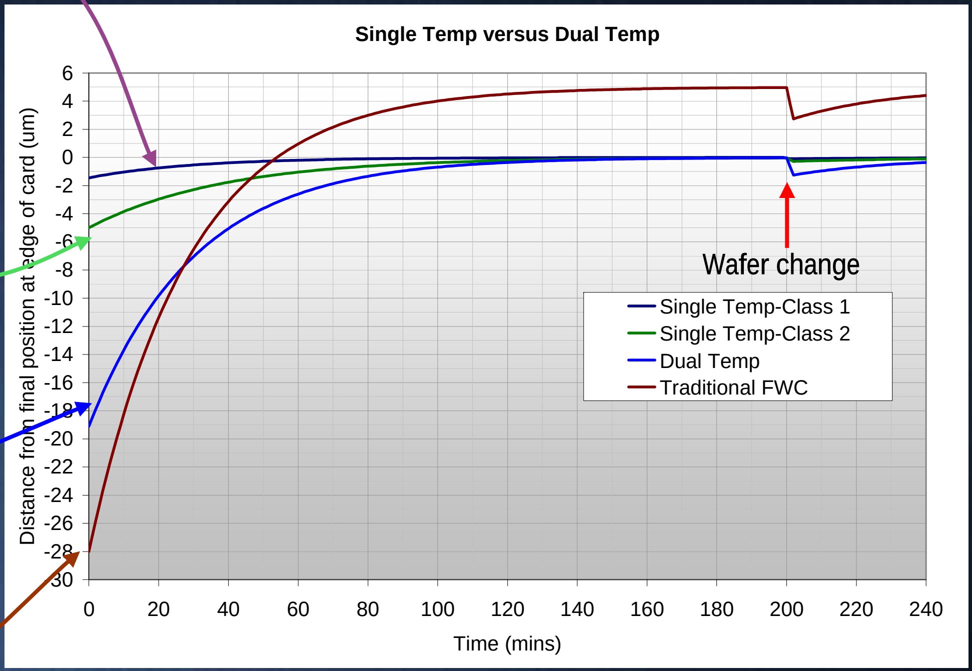
XY Tip position control - Scaling

- Traditional FWC: Probe Card not well matched to silicon wafer
  - Overscaled at hot test
  - Underscaled at cold test
- New Option 1: Dual temperature material
  - Exceptionally well matched to silicon wafer
  - Virtually no hot to cold scaling error.
- New Option 2: Single temperature material
  - True zero soak capability.
  - Ready to probe as soon as the card is loaded



Single and Dual Temperature Options

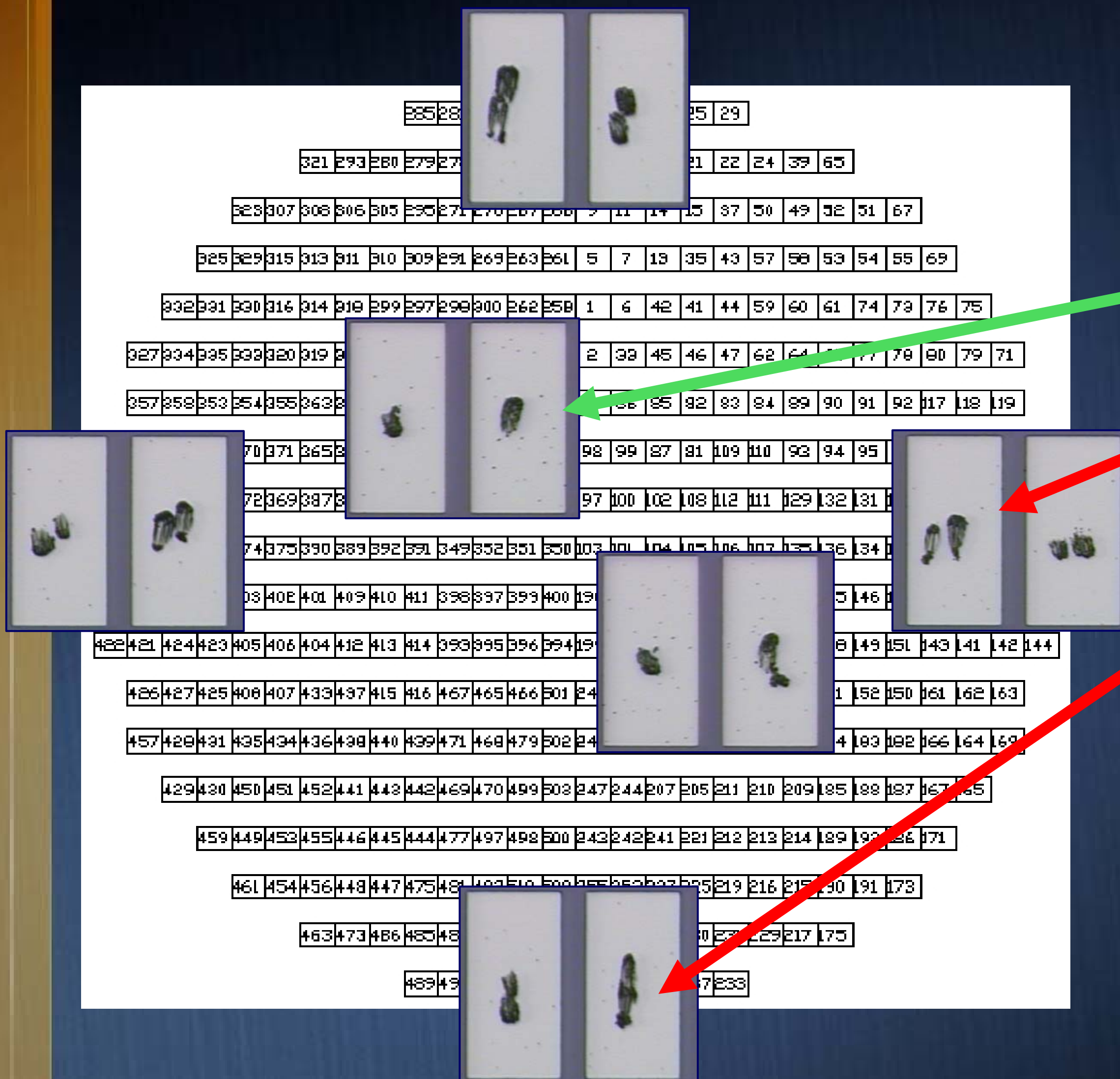
- Single Temp Class I
  - Zero Soak – ready to start testing as soon as the probecard is loaded.
  - Less than 2um of movement at the edge of the wafer from room temperature to fully soaked.
  - Less than 0.5 um of movement at the edge of the wafer during wafer change or lot change
- Single Temp Class II
  - Quick Soak – from 5-30 mins depending on pad size and soak conditions.
  - Typically 5-7um of movement at edge of wafer from room temp to fully soaked depending on test temperature
- Dual Temp
  - Optimized for hot and cold – matched systems results in minimal scaling errors.
  - Good stability during PMI and wafer changes.
- Traditional FWC
  - Non optimized material results in overshoot of center of pad.
  - Lower thermal mass gets to temp quick but more motion of tips occurs during PMI and wafer changes.



Fastest soak & most stable system is Single Temp Class I

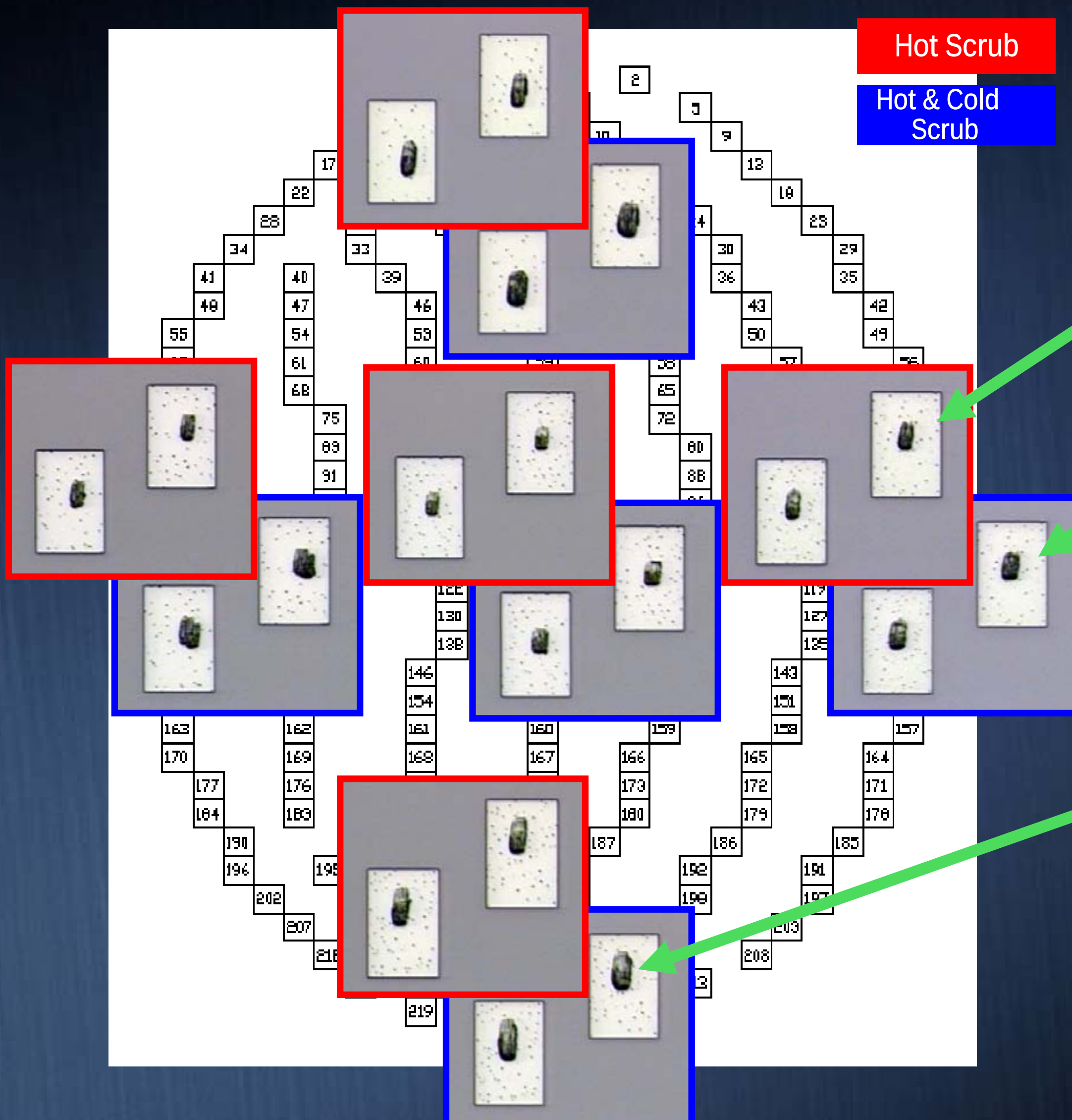
Best matched & widest temp range, is Dual Temp

Traditional FWC Evaluation



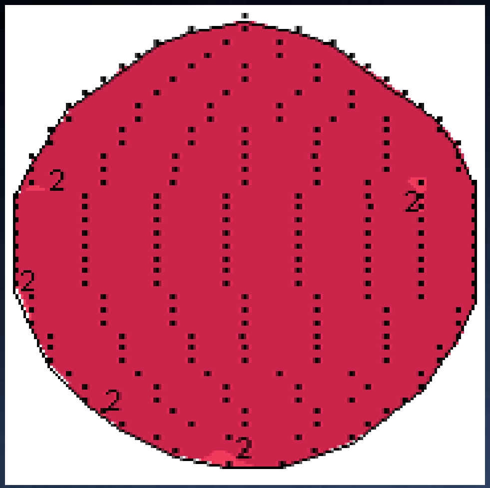
- Hot and cold touchdowns on one wafer.
- Scrub Marks overlap at center.
- Marks diverge as you get further form center of the wafer.
- Pad damage increases as marks diverge.

Dual Temperature Capability

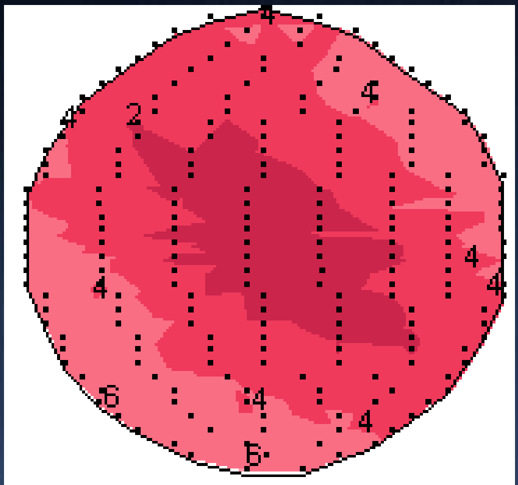


- Dual temperature material provides exceptional scaling control across entire 300mm array.
- Hot touchdown on wafer. Scrub marks are well centered on pads.
- Same wafer cooled to -10C and another touchdown performed. Scrub marks in same position as they were at hot TD.
- Hot and cold marks overlap almost perfectly, minimizing pad damage.

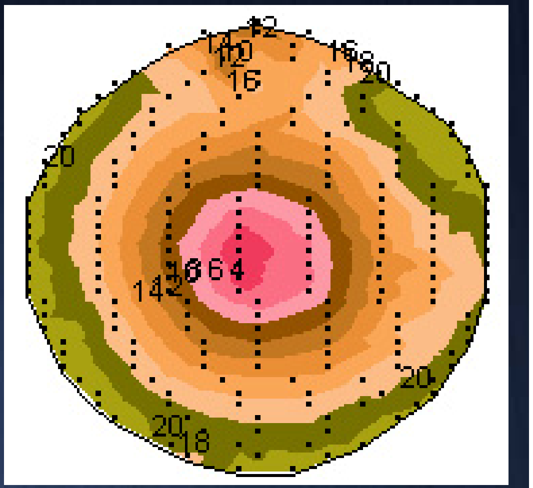
Single and Dual Temp Options - Results



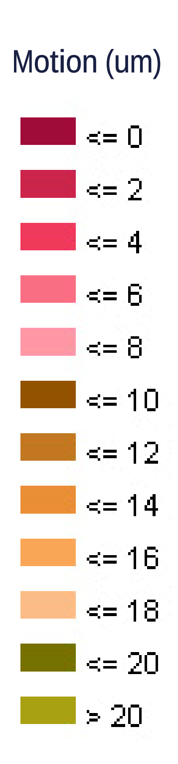
Single Temp – Class I



Single Temp – Class II



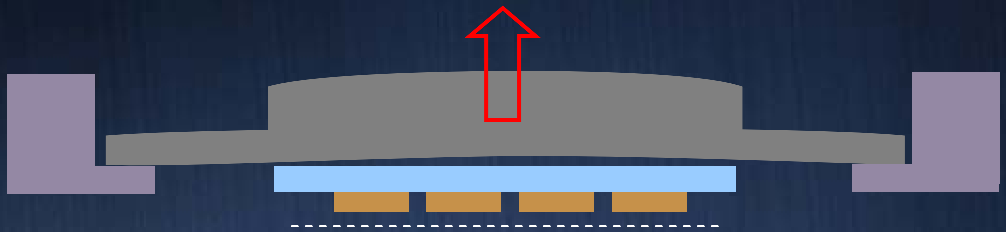
Dual Temp Configuration



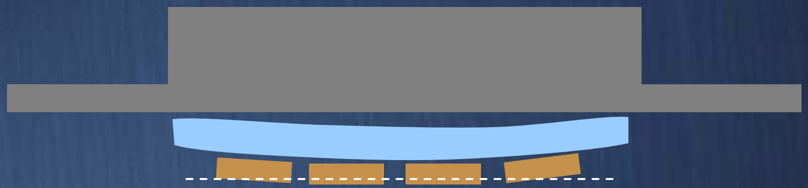
- Step 1) Load a probe card at room temperature into a hot prober.
- Step 2) Make a touchdown immediately (Time 0)
- Step 3) Soak probe card until reaches steady state temperature
- Step 4) Make another touchdown at steady-state
- Step 5) Measure the marks from step 2 and step 4. At each location, calculate the total motion of the probes from time 0 to steady-state.
- Step 6) For each option, plot data as contour plots. Present data at SW Test.

Z tip control

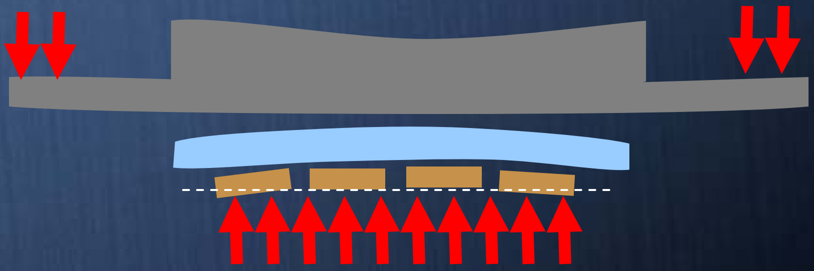
- Translation: When traditional probe cards are heated or cooled they will translate up or down because of the familiar bi-metal effect.



- Bow: The probe array may also be distorted from a perfectly flat plane due to thermal effects

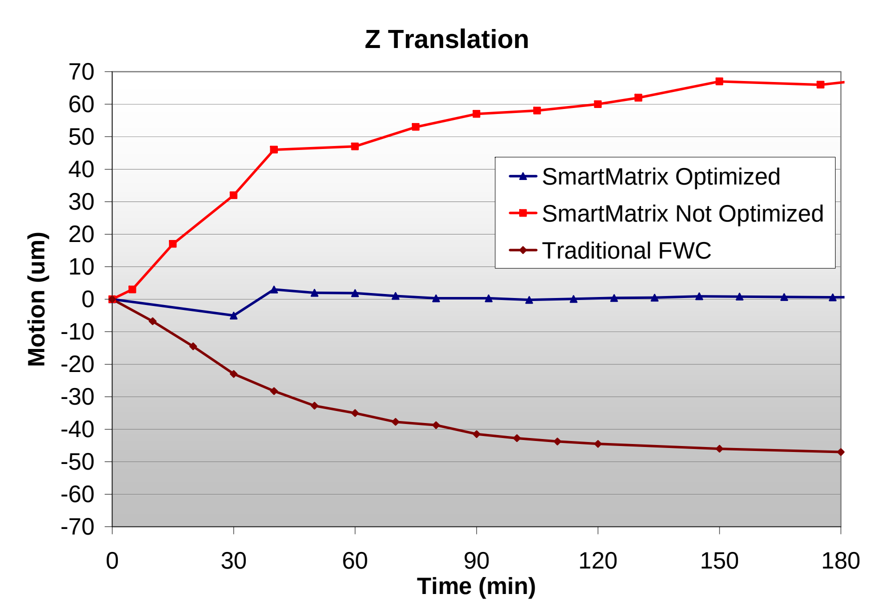


- Bow & Translation: Finally the probe array can be translated & distorted from a perfectly flat plane due to probe forces and forces imparted by the tester connections.

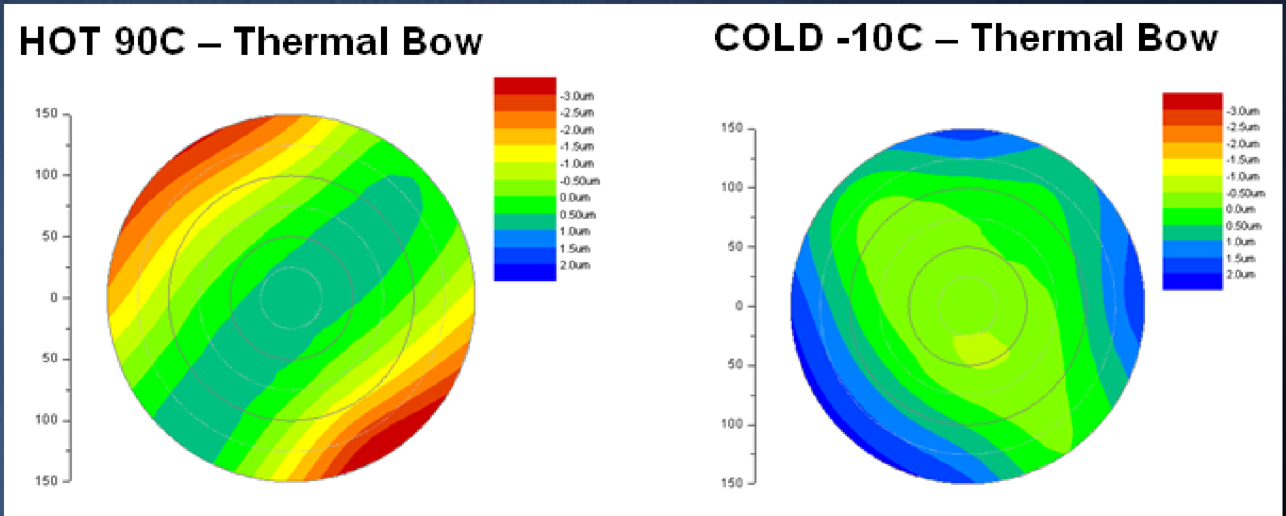


Z tip control

- Z translation of the probe card is optimized for each customer's test cell configuration thru careful design and thermal modeling.



- And we control the bow of the probe array from thermal effects to less than 5 microns.

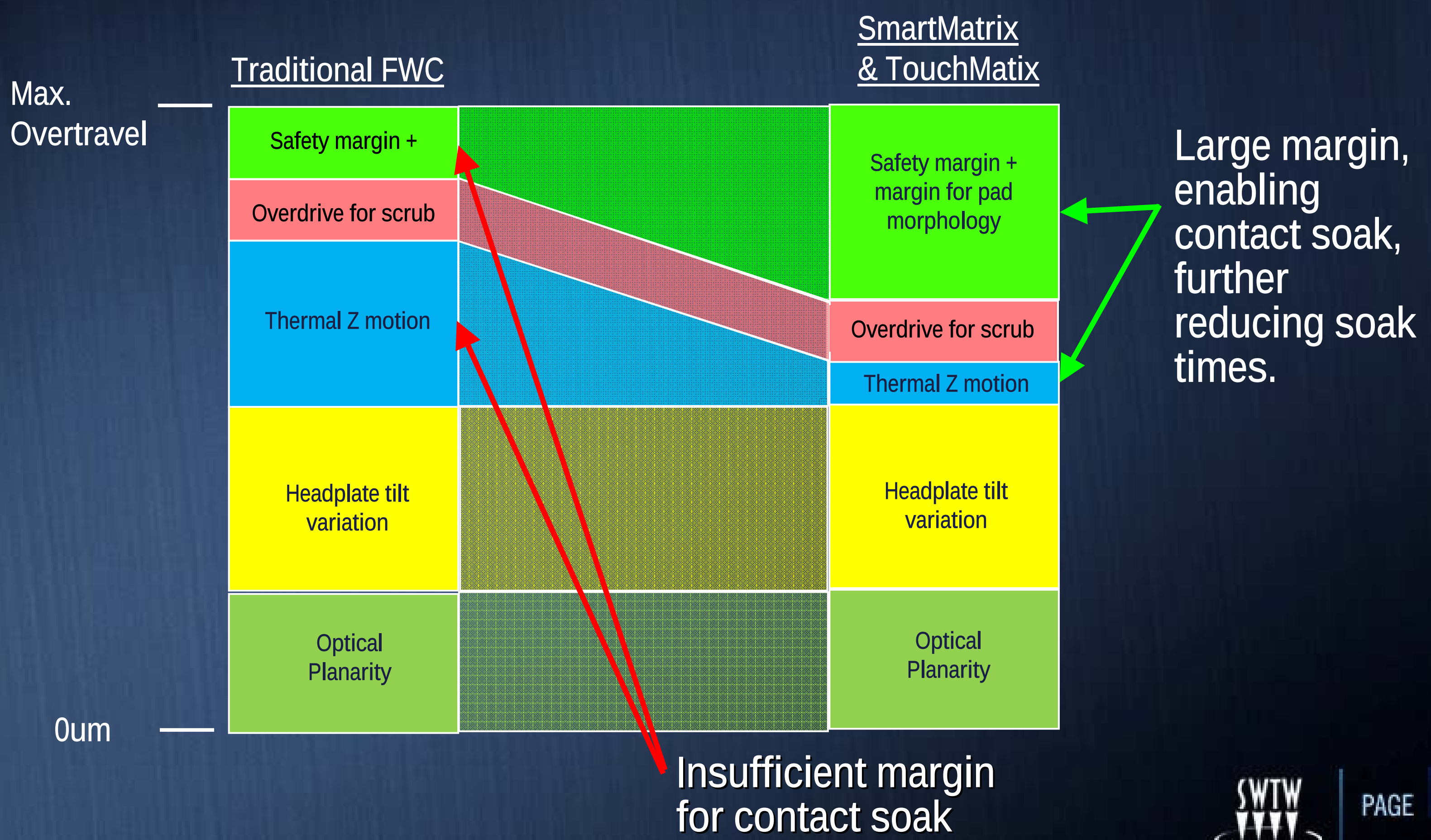


- And we control planarity of all tips to <25 microns even while under load.

So if you choose a single temperature solution – you can start probing immediately!

Z Performance & Benefits

- Minimizing 3 things: Translation, Bow and Planarity results in:
  - More uniform scrub marks, minimized pad damage
  - Faster soak time using closer proximity soak and/or contact soak.



New Architecture Adoption

- Announced in May 2010, we have shipped more than 100 TouchMatrix and SmartMatrix cards.
- Platform qualified or in qualification at all major DRAM and Flash manufacturers
- Multiple re-orders for many high running designs
- Many cards incorporate advanced tester resource extension electronics (A-TRE™) to increase native parallelism of testers.

Conclusion

- The SmartMatrix & TouchMatrix architecture address three really challenging mechanical things:
  - Super Bond Pad
    - Leading edge scrub capability
    - Minimizes pad damage
  - XY Tip Control
    - Scaling matched to silicon wafers (dual temperature)
    - Zero soak time (single temperature)
    - Thermally stable during wafer & lot change
  - Z Tip Control
    - Improved control of Z motion
    - Allows use of contact soak

- There are also really challenging electrical things and MEMS process things that SmartMatrix & TouchMatrix address, but I'll save that for another talk…

Thank You!