SWTW 2-0-1-8

SW Test Workshop

Semiconductor Wafer Test Workshop

Probe Card Stability during High Temperature Testing

Nidec SV TCL

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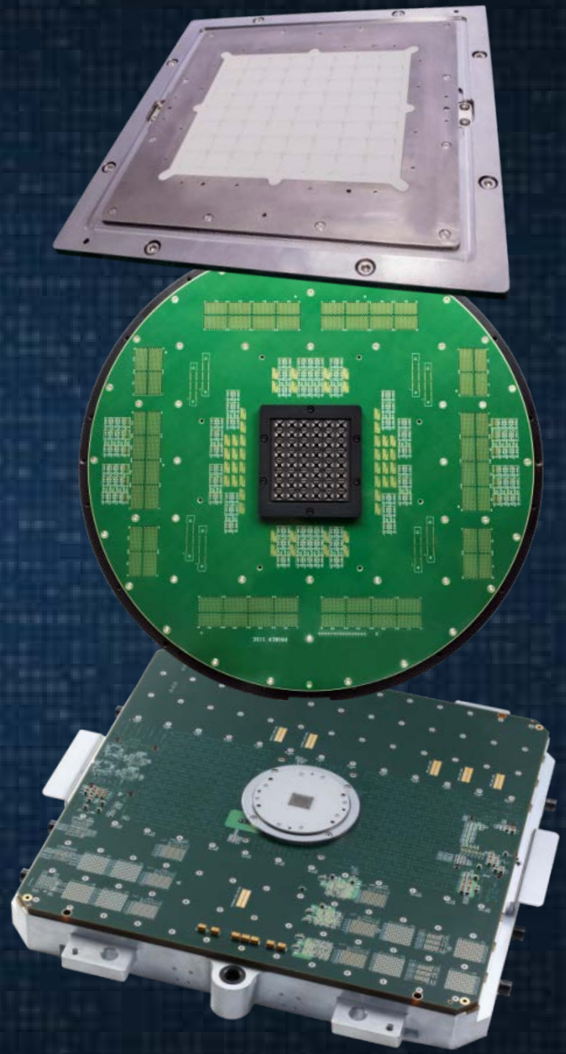
June 3-6, 2018

Overview

- Overview of Nidec SV TCL
- Introduction on High Temp Probing Challenges
- Motivation
- Approaches for Experiment & Simulation
- Experimental & Simulation Results
- Conclusions
- Future Work

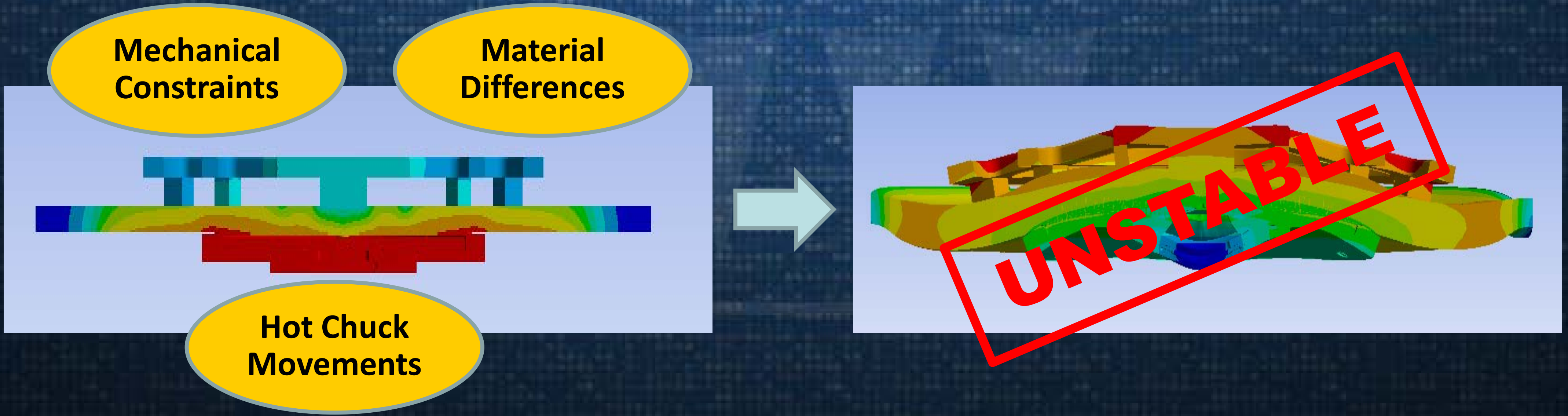
Overview of Nidec SV TCL

- Established in 1994 as a US-based probe card supplier offering cantilever product.
- Acquired by Nidec-Read Corp. October 31, 2017
- Products to enable technology roadmaps in the high growth Mobile, Networking/Data, Automotive & Internet of Things “IoT” markets
- Strength through diverse product portfolio, turnkey solutions, global presence with manufacturing, sales & service centers worldwide



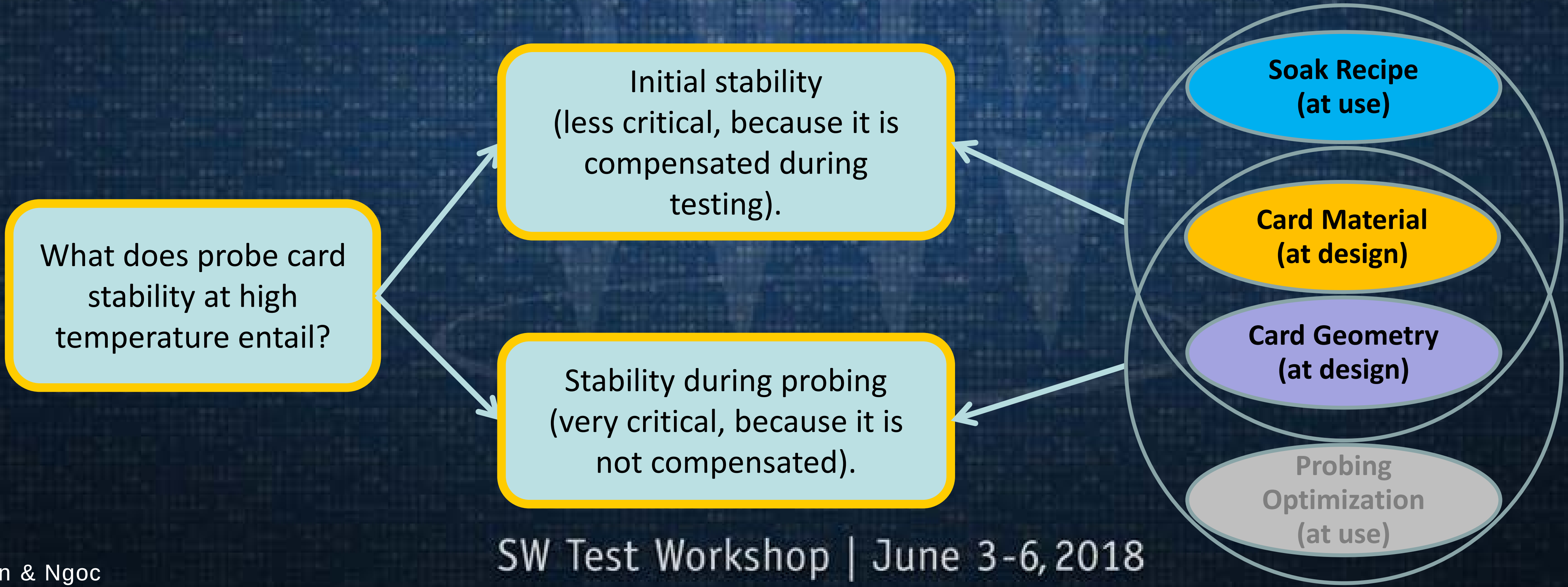
Introduction

- **High temperature probing introduces extra failure modes that are not present at room temperature.**
- **Probe card stability at high temperature is a major issue & causes various failures.**



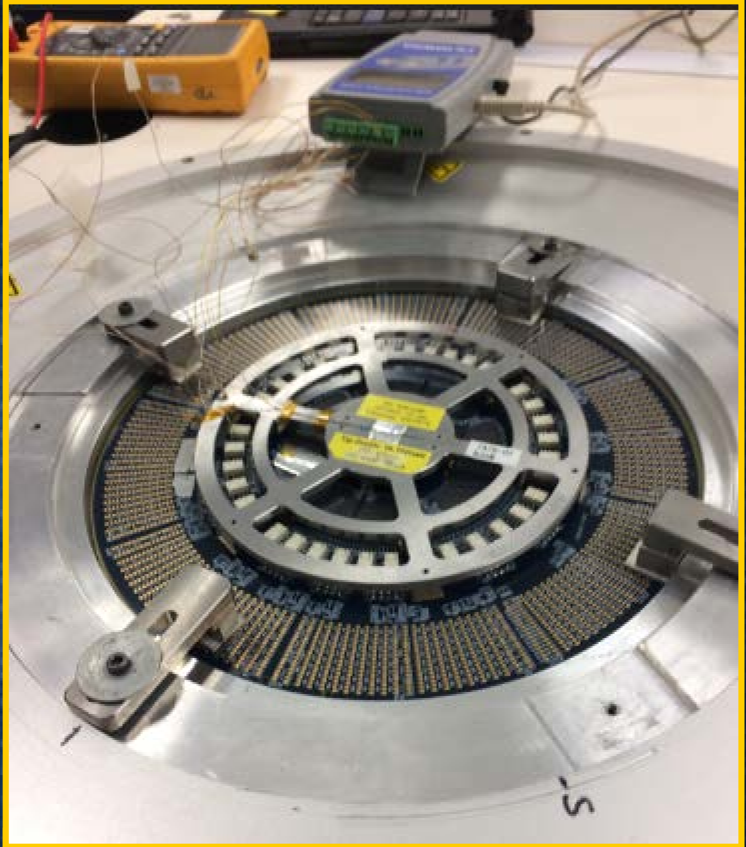
Motivation

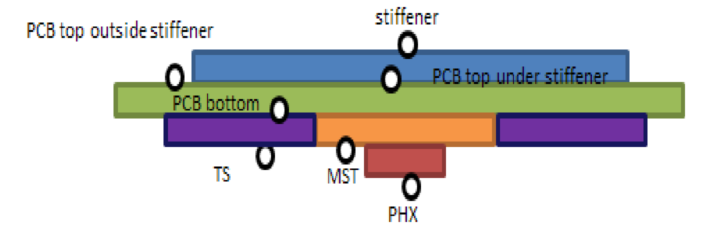
- **Establish high temperature stability evaluation method.**
- **Develop FEA models to capture high temperature behavior.**
- **Counter measures to minimize stability issues.**



Approaches – Experiment

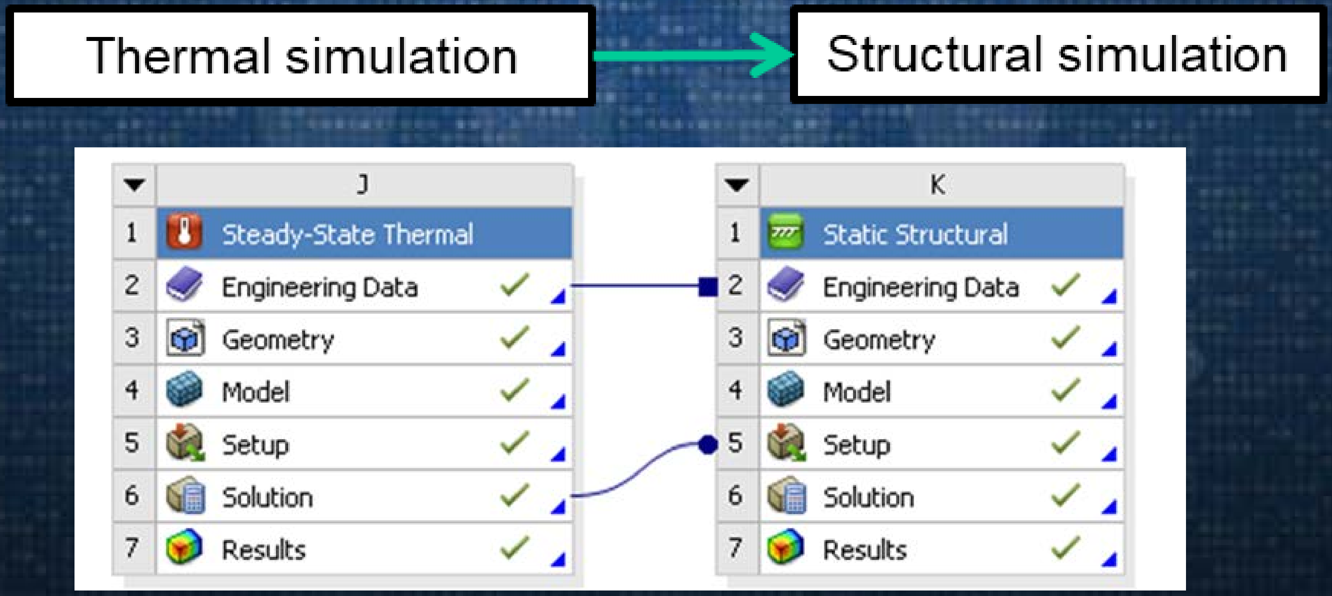
- **Setup**
  - J750 Platform Sample Card
  - Test Floor Operations
  - Simultaneous Deflection Measurement & Temperature Mapping
- **Experiments**
  - Soak Study
  - Component Level Study
  - Improvement Concept Study



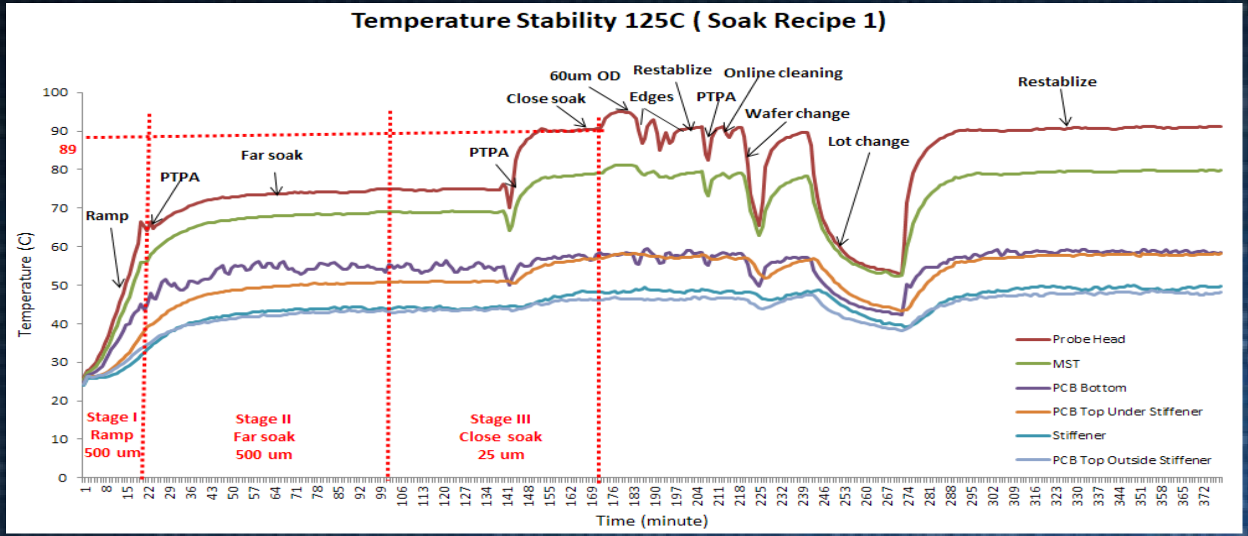


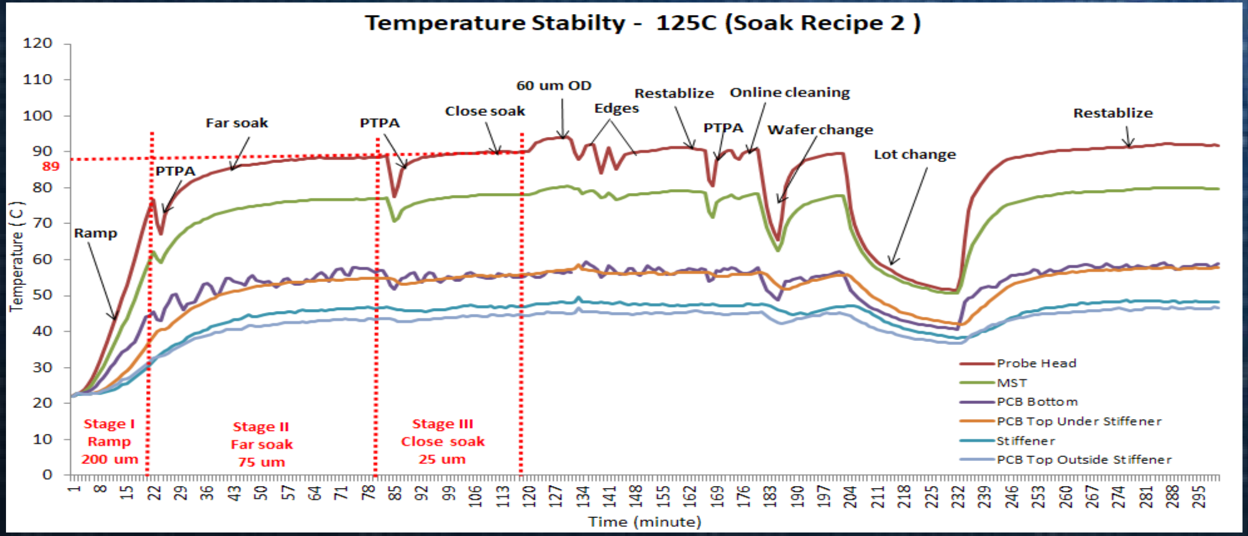
Approaches – Simulation

- **Setup**
  - Thermal Simulation Module
  - Input Thermal Results to Structural Module
  - Predict Deflection from Structural Module

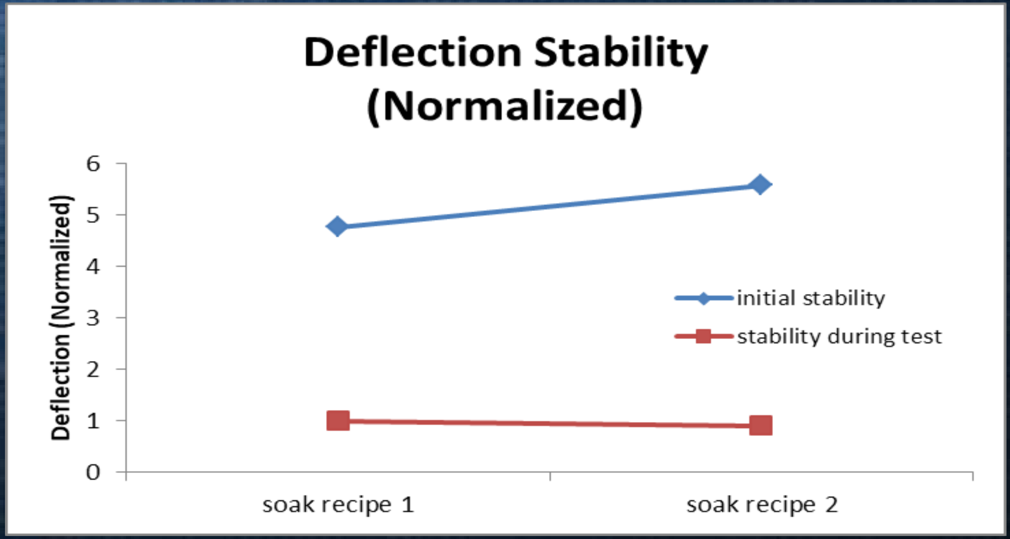


Results – Soak Study



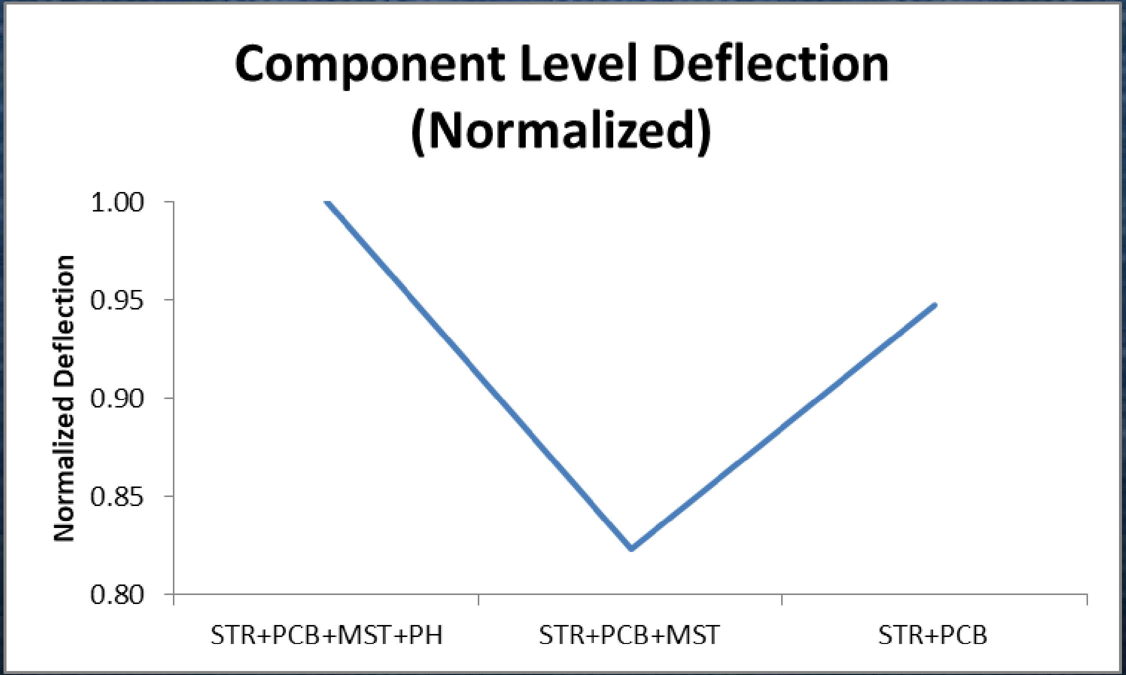


- Every probe card has one unique stability state.
- There are different paths to reach the stability state & some take less time.



Results – Component Level Study

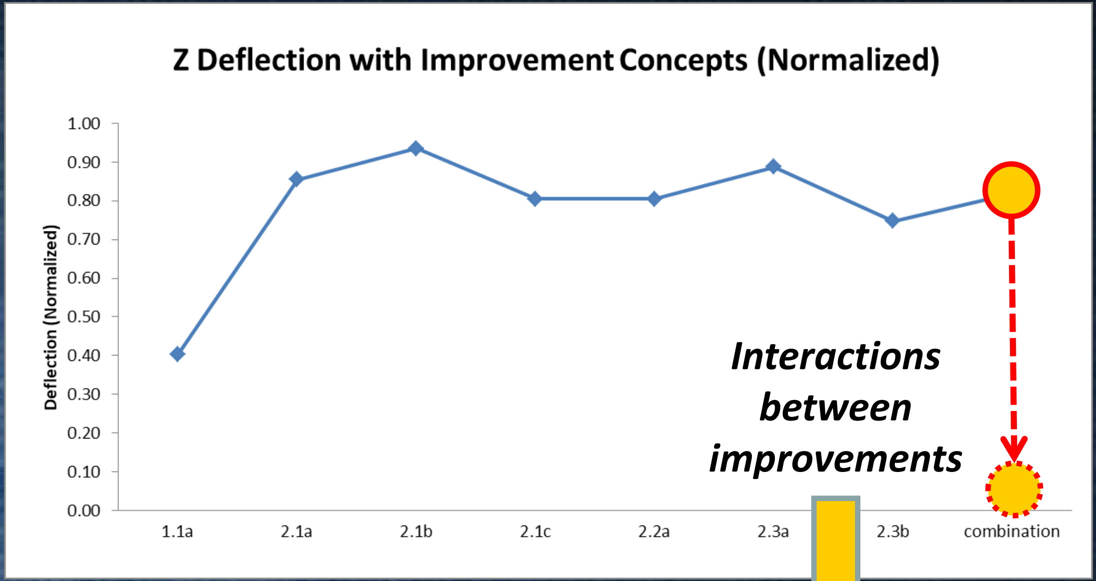
- PCB is the most unstable component in the probe card assembly, making up for 80% to 90% of total deflection.
- Improvement concepts should focus on isolating PCB from the assembly.



Results – Improvement Concept Study

- **Material Change**
- **Design Change to Isolate PCB**
- Soak Recipe Optimization

#	Category	Concept
1	1.1a	Change component material
2	2.1a	Add thermal control component design 1
3	2.1b	Add thermal control component design 2
4	2.1c	Add thermal control component design 3
5	2.2a	Isolate PCB from system design 1
6	2.2b	Isolate PCB from system design 2
7	2.3a	Modify stiffener design 1
8	2.3b	Change mounting mechanism within components



Interaction Map

	1.1a	2.1c	2.2b	2.3b
1.1a				
2.1c				
2.2b				
2.3b				

Interaction Count

	No Interaction	Weak Interaction	Strong Interaction
1.1a	1	1	1
2.1c	0	0	3
2.2b	2	1	0
2.3b	1	0	2

Results – Improvements Combination

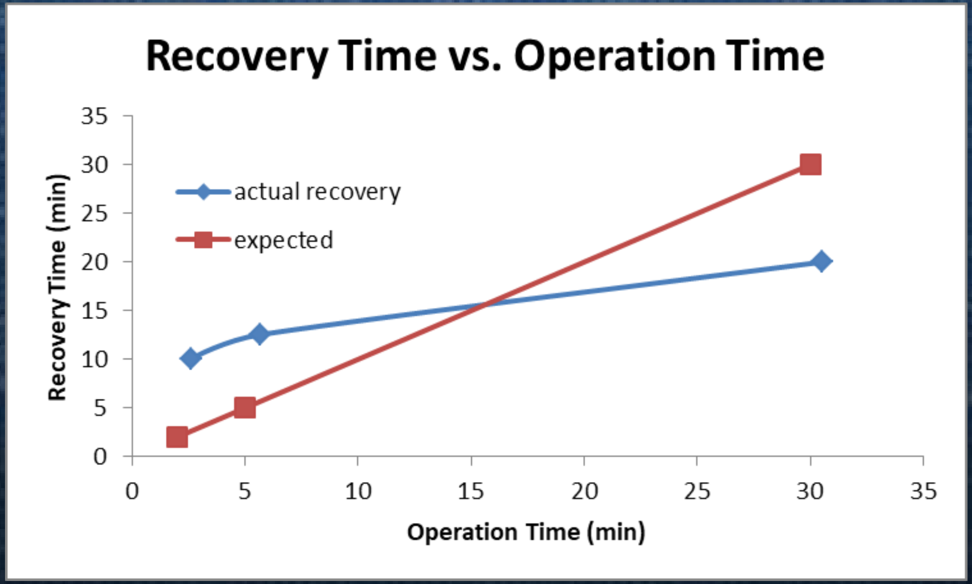
Improvement Concept Combination DOE								
					Initial stability	Stability during probing		Overall stability
Run#	2.3b	1.1a	2.1c	2.2b	Normalized Z due to ramp	Normalized Z due to soak	Normalized Z due to close soak	Normalized total Z
1	+	+	+	+	0.80	0.78	0.98	0.82
2	+	+	+	-	0.80	0.36	0.67	0.72
3	+	+	-	+	0.64	0.16	0.31	0.53
4	+	+	-	-	0.70	0.02	0.40	0.58
5	+	-	+	+	1.07	1.00	1.14	1.07
6	+	-	+	-	1.08	0.78	0.95	1.03
7	+	-	-	+	0.80	0.07	0.31	0.64
8	+	-	-	-	0.86	0.40	0.45	0.75
9	-	+	+	+	1.01	0.84	0.76	0.96
10	-	+	+	-	1.02	0.60	0.98	0.96
11	-	+	-	+	0.55	0.07	0.26	0.45
12	-	+	-	-	0.58	0.27	0.05	0.40
13	-	-	+	+	1.04	1.22	1.12	1.10
14	-	-	+	-	0.80	0.71	0.93	0.80
15	-	-	-	+	0.79	0.76	0.93	0.80
default	-	-	-	-	1.00	1.00	1.00	1.00

High Pin & High Temperature Solution
- 20% initial stability improvement.
- 81% stability during probing improvement.
- Stable within Stage I soak, approximately 30 minutes.

Low Pin & High Temperature Solution
- 42% initial stability improvement.
- 84% stability during probing improvement.
- Stable within Stage I soak, approximately 30 minutes.

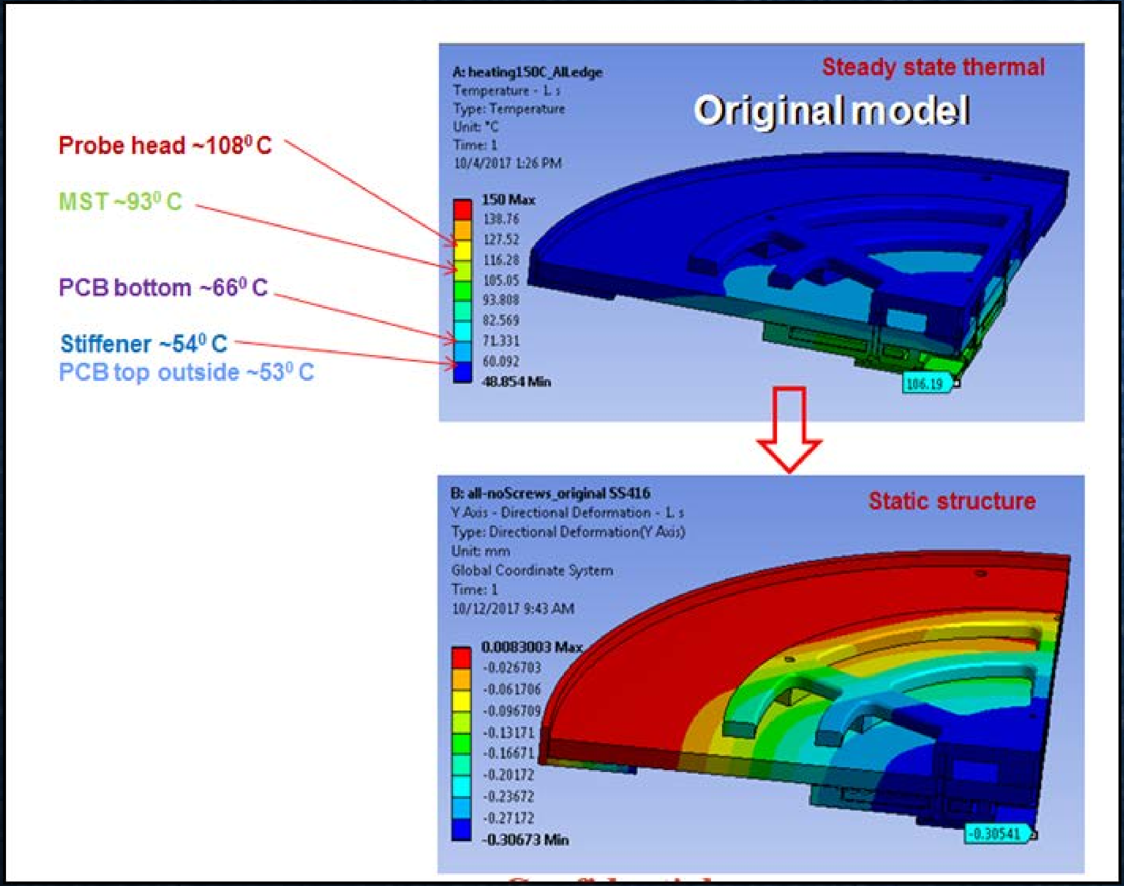
Results – the Unexpected

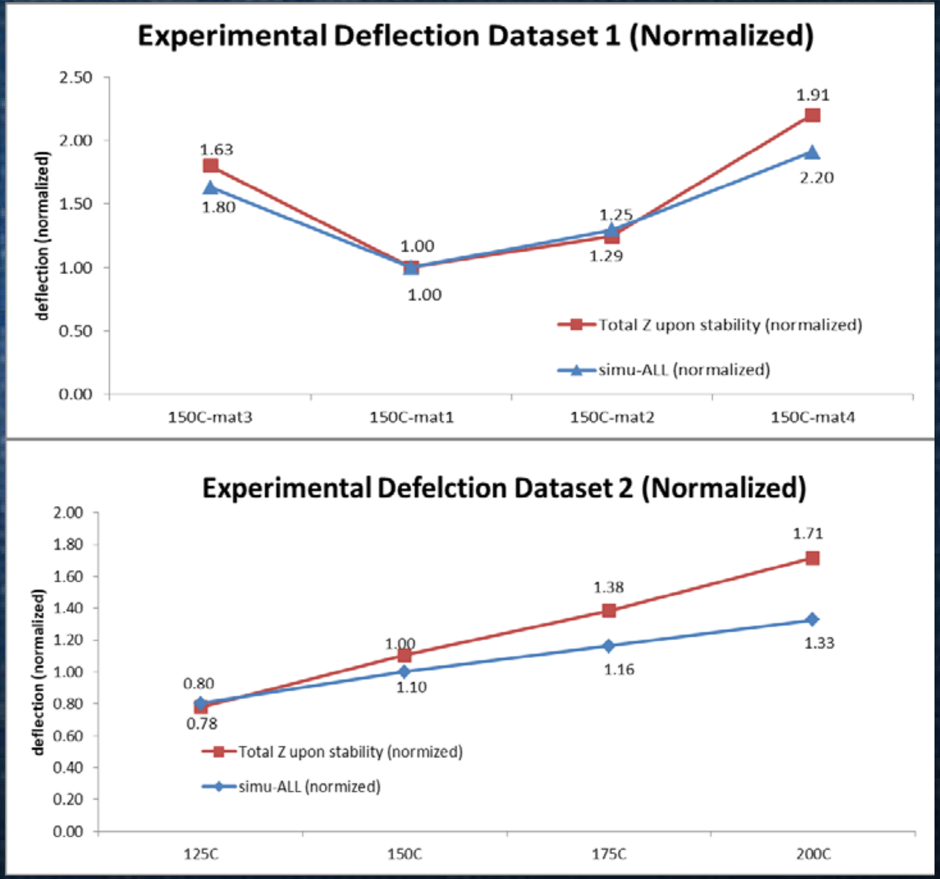
1. Typical soak recipes assume equal operation time & recovery time, but on the sample card, it is found that short operations take a long time to recover.
2. Recovery vs. operation time is very likely platform dependent.



Simulation – Correlation to Experimental Data

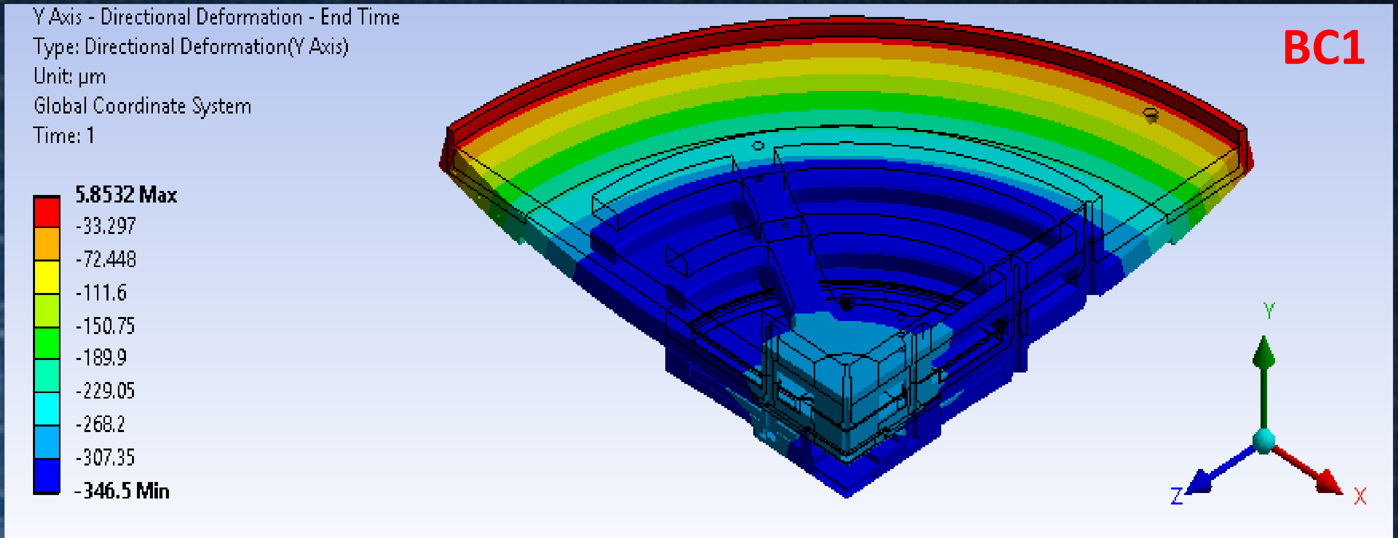
- **FEA model showed good temperature & deflection correlation to experimental data.**

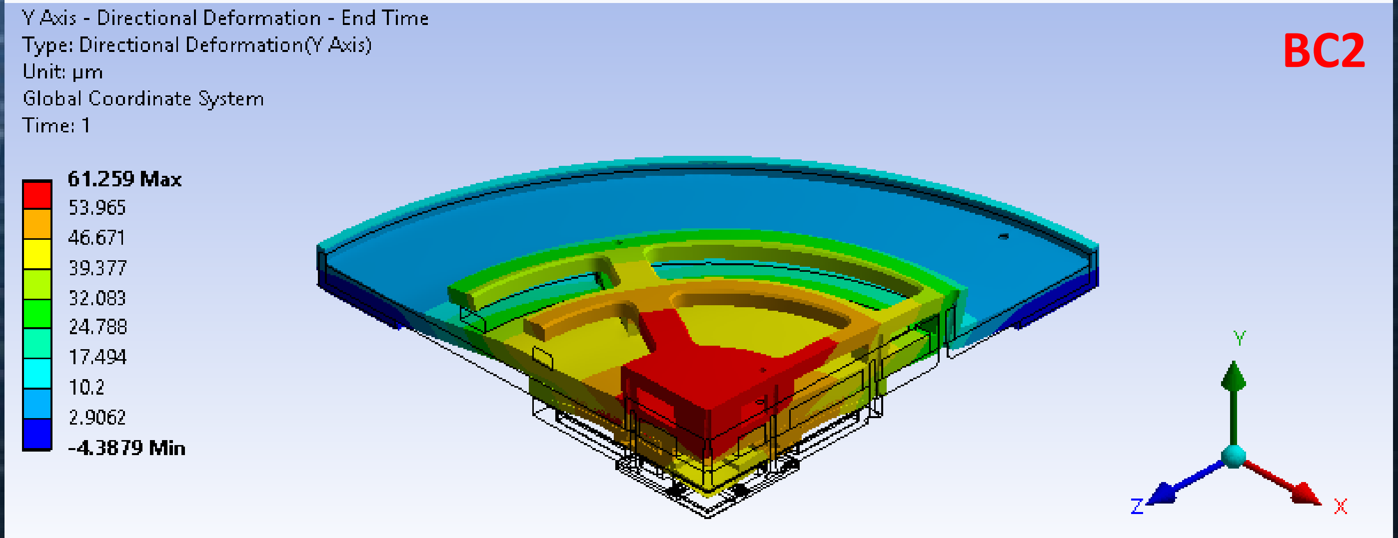




Simulation – Boundary & Contact Effects

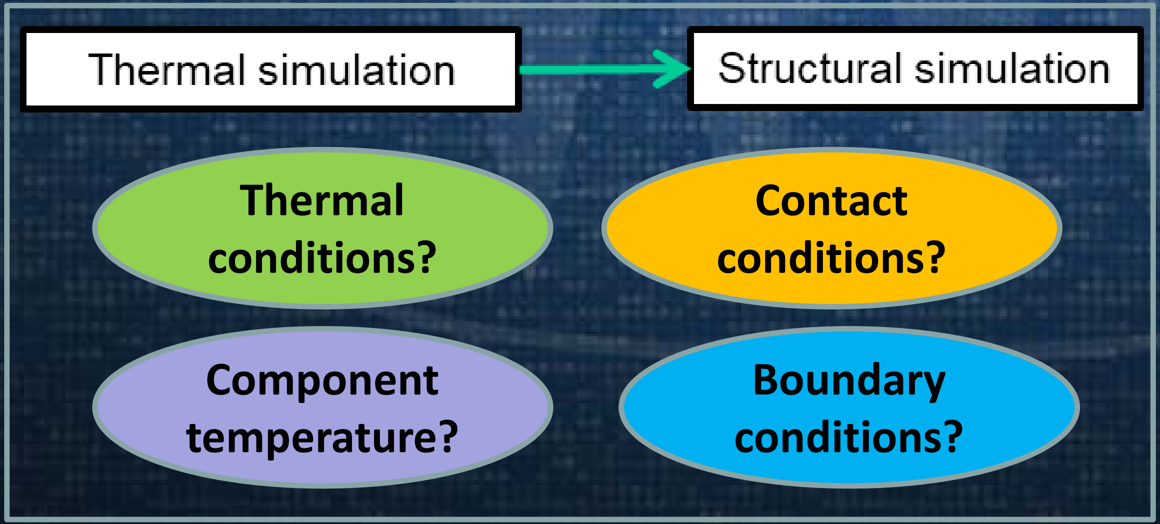
- **High temperature simulations are much more sensitive to boundary & contact conditions than room temperature setups.**
- **Great care must be taken in modeling & results interpretation.**





Simulation – Capabilities & Limitations

- Although capable of predicting general probe card high temperature behavior, the demonstrated model also has limitations in capturing subtle contact changes in real life cases.
- This type of model requires large amount of calibration data from experiment.



Need lots of experimental data to answer.

Conclusions – In General

- Probe card high temperature stability includes initial stability & stability during probing.
- Every probe card has one unique stability state, as a function of card construction & material composition.
- By adjusting soak procedures, the path to reach stability state can change & certain paths require shorter time.
- Improvements made to change card construction or material composition may interact & their application needs to be determined case by case.
- Every card has as its own recovery time vs. operation time characteristics, likely dependent of platform.
- High temperature simulation models are highly sensitive to BC & contact setups.

Conclusions – J750 Type Specific

- The PCB is the most unstable component in the probe card assembly.
- Short operations such as cleaning and wafer change take a long time to recover.
- Our high temperature solutions are applicable to other platforms similar to J750 with stiffeners only in contact with PCB.

High Temperature Solutions for J750 & Similar Platforms	
Time to Initial Stability	Stability during Probing
< 30 minutes	< 20 µm

Future Work

- Platform variation study
- Low temperature study, which is suspected to be a close reverse of high temperature, but not exact.

Acknowledgements

- **Special thanks to the high temperature project team at Nidec SV TCL for their hard work & dedication in preparing data used in this paper:**
  - Steven Pham
  - Alan Truong
  - Diane Rook
  - Thai Nguyen
  - Steve Tran
  - Khuong Van Duong
  - Phu Cong Phan
  - Binh Kim Tran
  - Stephane Denarnaud
- **Special thanks to management at Nidec SV TCL for their invaluable inputs regarding topic selection & review of this paper:**
  - Pete Rogan
  - Kyle Cotner
  - Robert Stampahar
  - JB Hollstein

Thank you!

Questions?