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Tip Coplanarity Analysis of Spring Probe Vertical Probe Head

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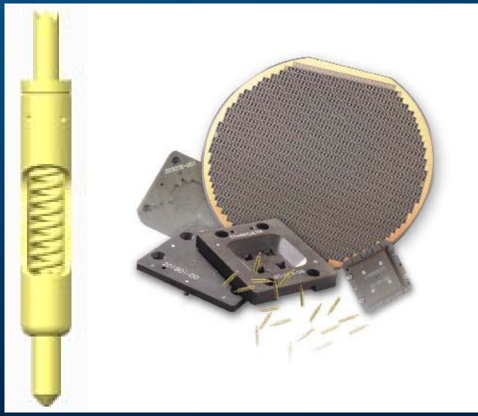
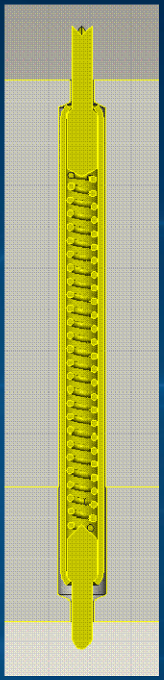
Overview

- Why spring probe in WLCSP probe head
- Probe head structure
- Probe structure & coplanarity
- Coplanarity analysis & example
- Probe head bowing & FEA
- Coplanarity vs. material & structure
- Summary

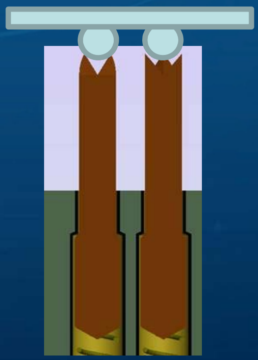


Why Spring Probes?

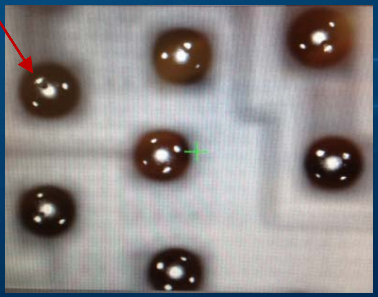
- **Spring contact probe basic structure**
  - Top & bottom plungers, spring, barrel
  - Spring provides compliance of the probe
  - Spring generates force to ensure good contact



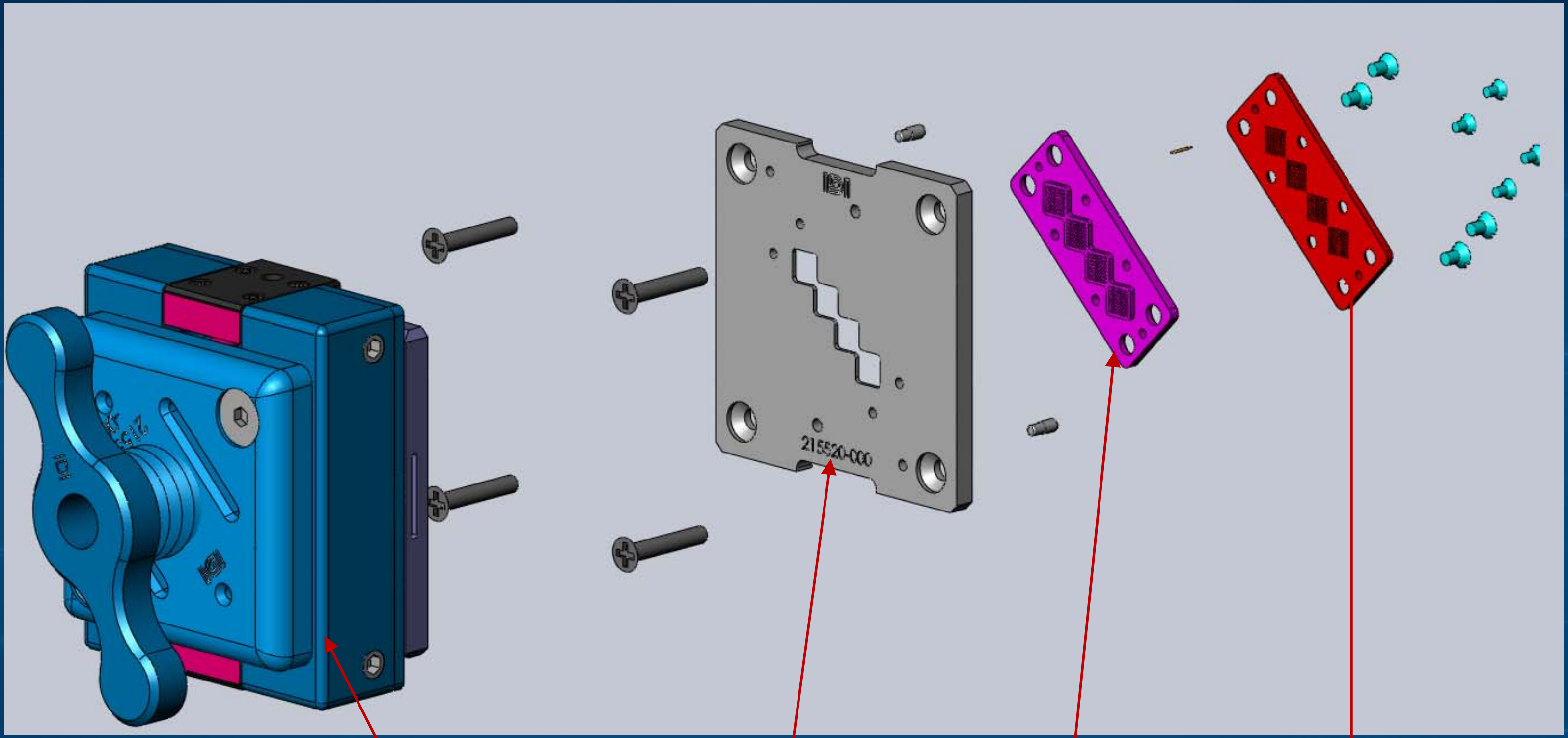
- **Performance advantages**
  - Highly compliant
  - Reliable contact to balls
  - High contact force ensures low C-Res
  - Simplified field serviceability
  - Easy handling



Contact marks



Probe Head with Spring Probes



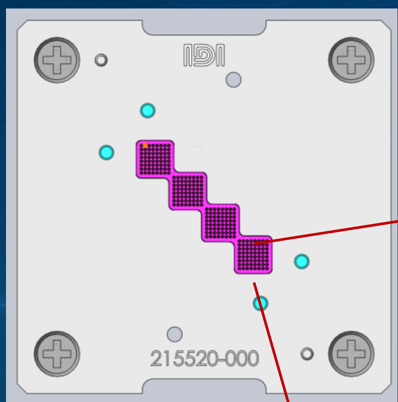
Lid for manual test
Not for auto test

Frame

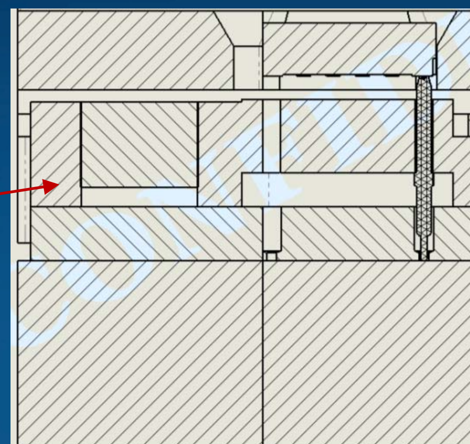
Cartridge body

Cartridge Retainer

Spring Probe & Cavity Structure

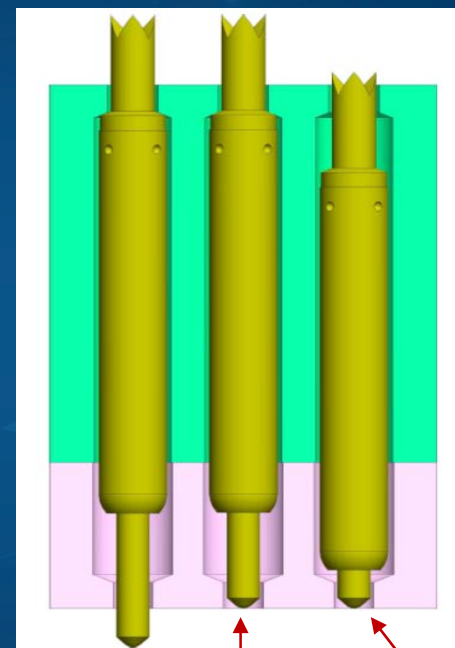


Pin in Cavity



Pin tip array

Probe State



Free Preload Compressed

Probe Head Coplanarity Analysis

- **Coplanarity of spring probe tip array is determined by following formula:**

$$H = \Delta a + \Delta c + \Delta d + \delta$$

- **Where:**

  H – tip coplanarity of whole probe array

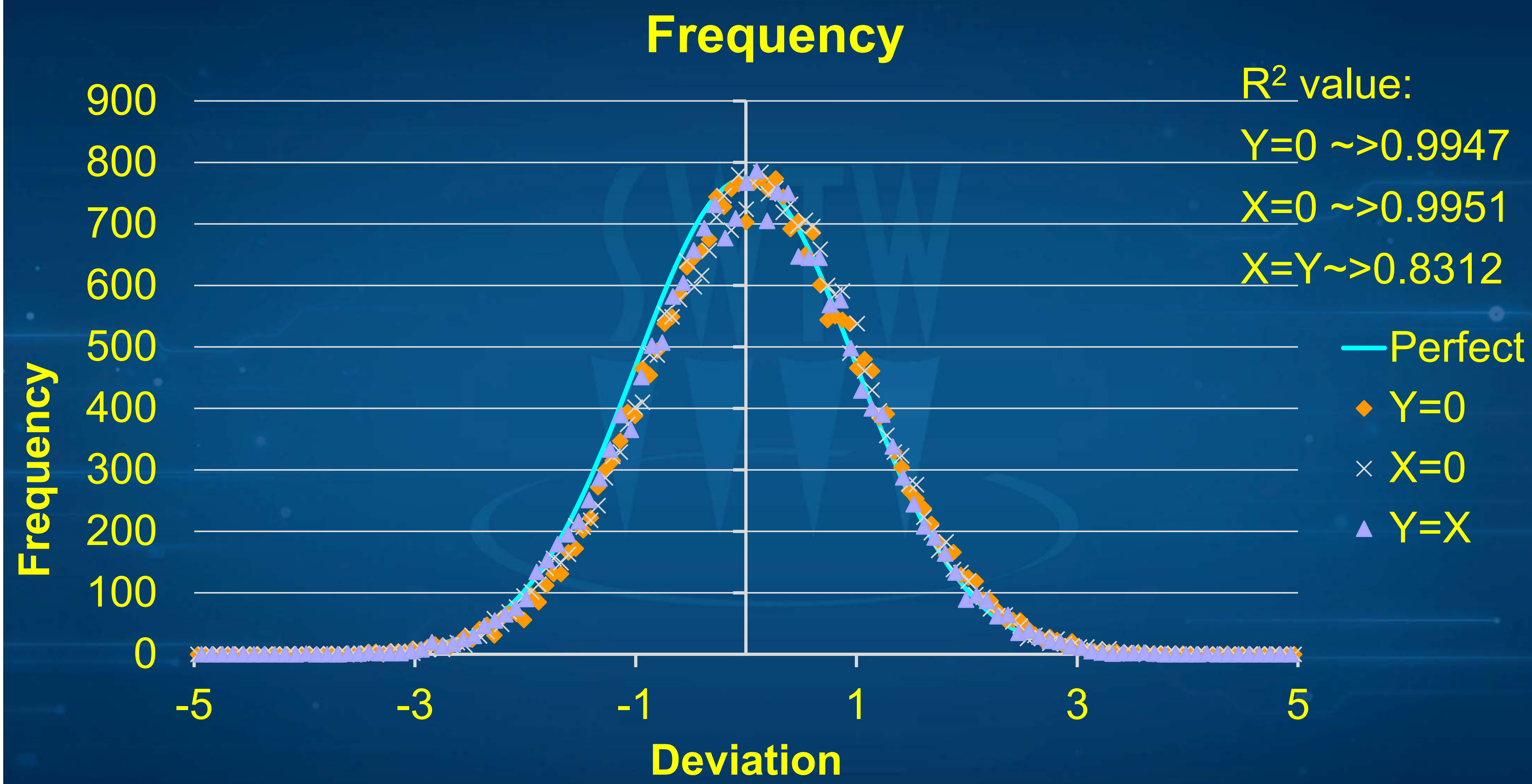
  Δa – top plunger neck tolerance, ~ +/-0.02mm

  Δc – barrel crimping thickness tolerance, negligible

  Δd – counter bore depth tolerance, ~ +/-0.025mm

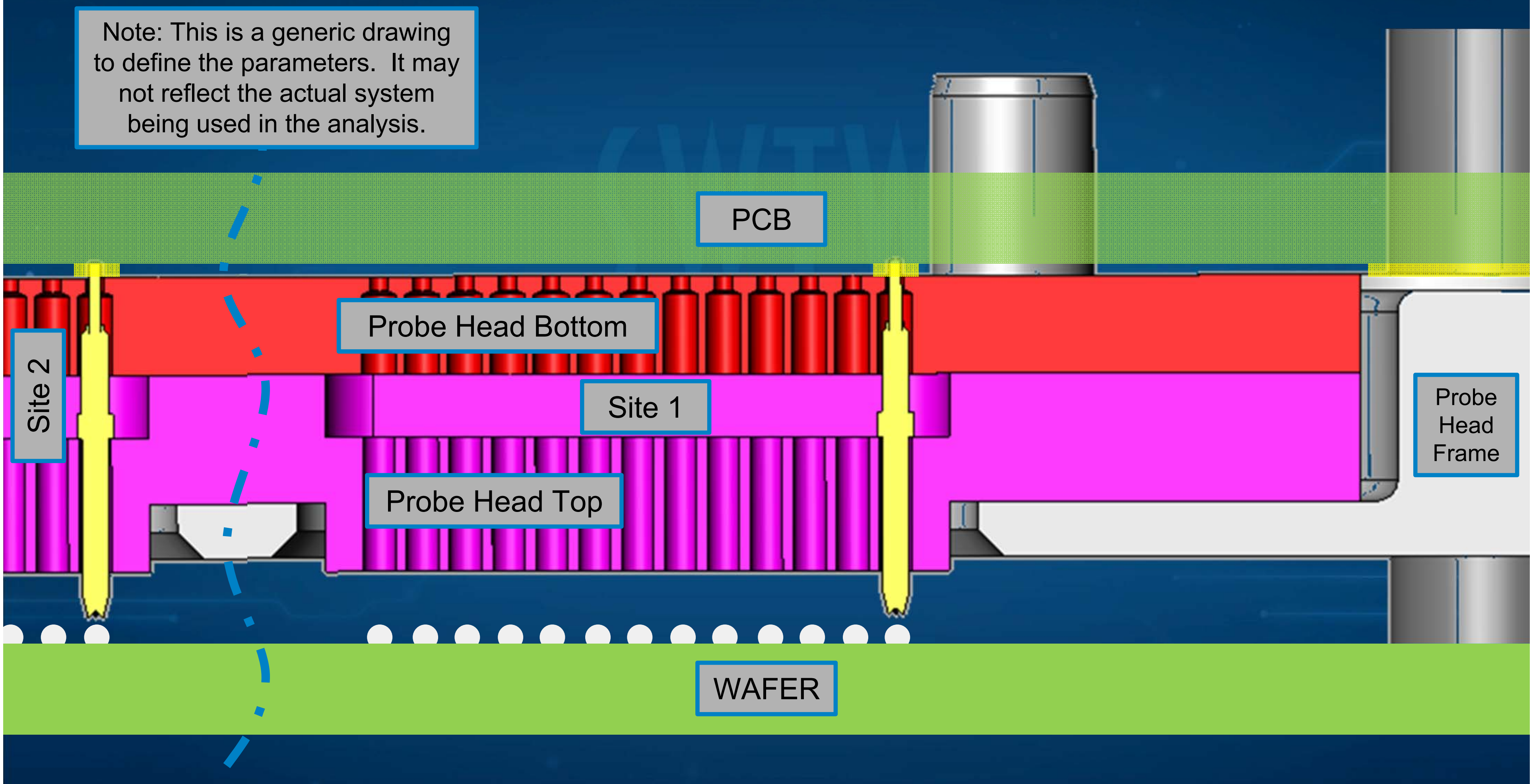
  δ – cartridge bowing due to preload

Monte Carlo Analysis Input Method



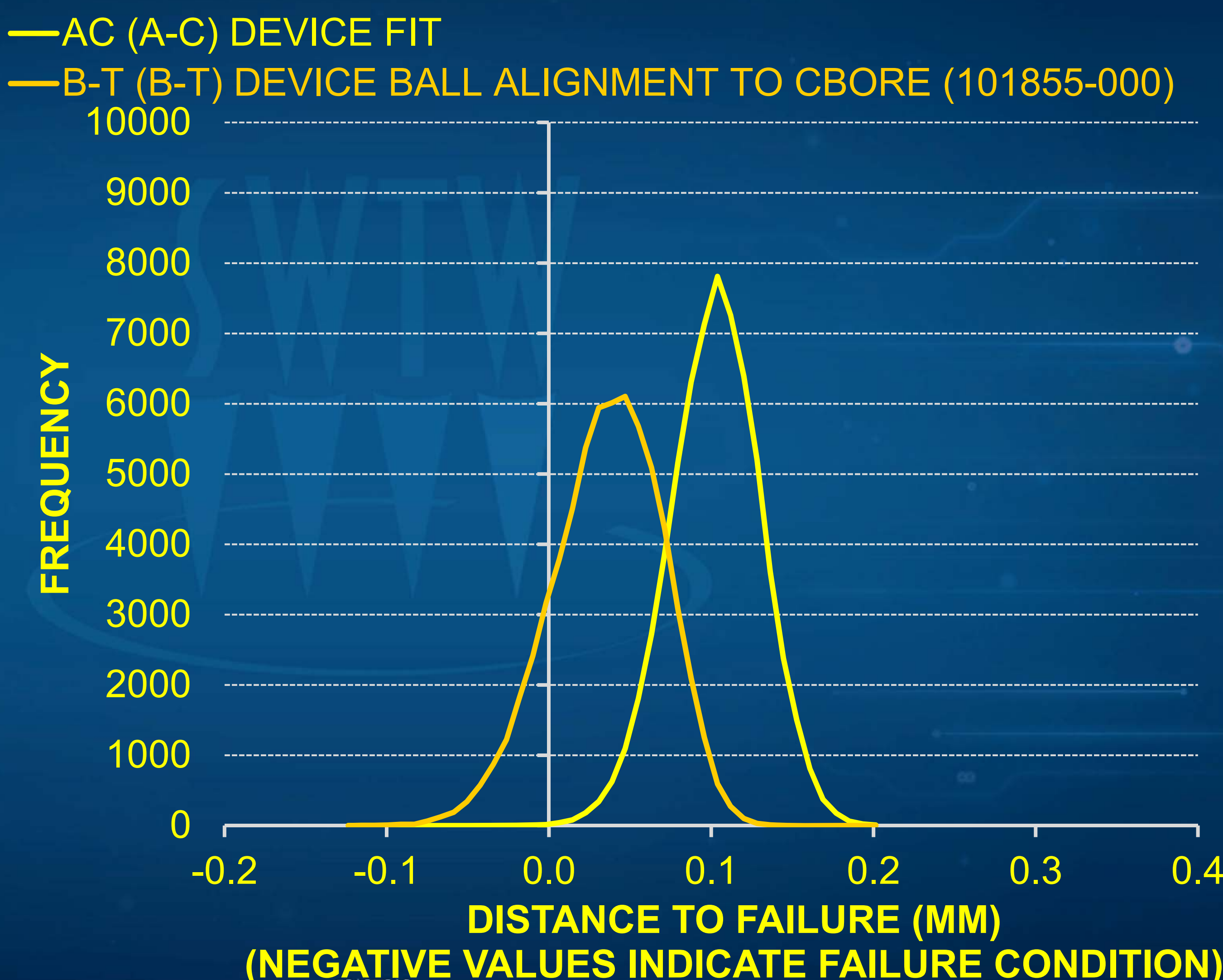
Comparison of normal distribution, Y=0, X=0 and X=Y frequency plots

Monte Carlo Schematic



Monte Carlo Analysis Output Method

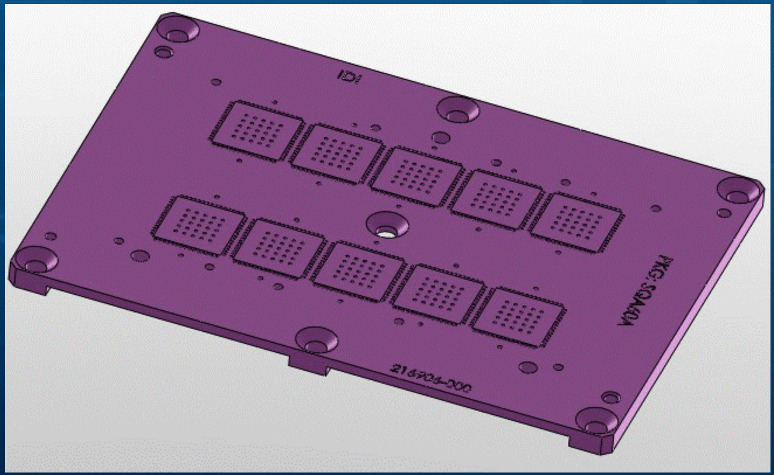
- **Distance to failure allows for use of one sided CpK analysis**
- **Both results are under 4/3 CpK**
- **AC= 1.08 CpK**
- **BT= 0.31 CpK**

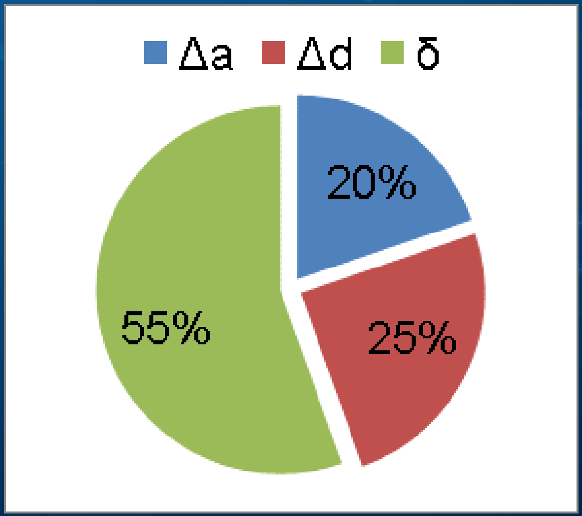


Coplanarity Analysis Example

- Coplanarity of a 10-site WLCSP probe head was analyzed
- The results show cartridge bowing contributes about 50% of total coplanarity.

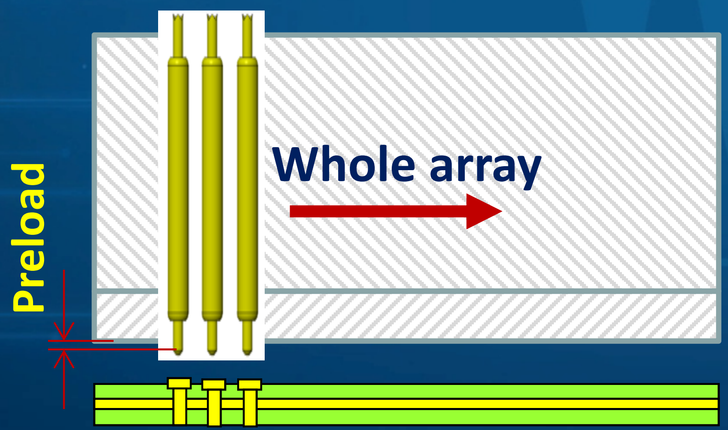
Item	Coplanarity, um
Δa	40
Δd	50
δ	112
H	202



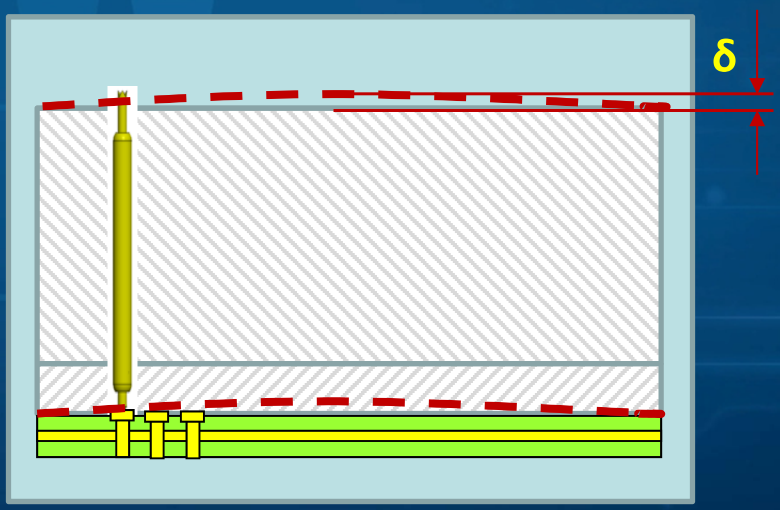


Cartridge Bowing by Preload

- To achieve low and stable Cres of spring probe, bottom plunger of probe is compressed when probe head is mounted on test board
- Cartridge is bent slightly due to spring force by spring probe, “δ”
- The “δ” is determined by total probe force, probe head design and materials



Probe head before amounted on test board

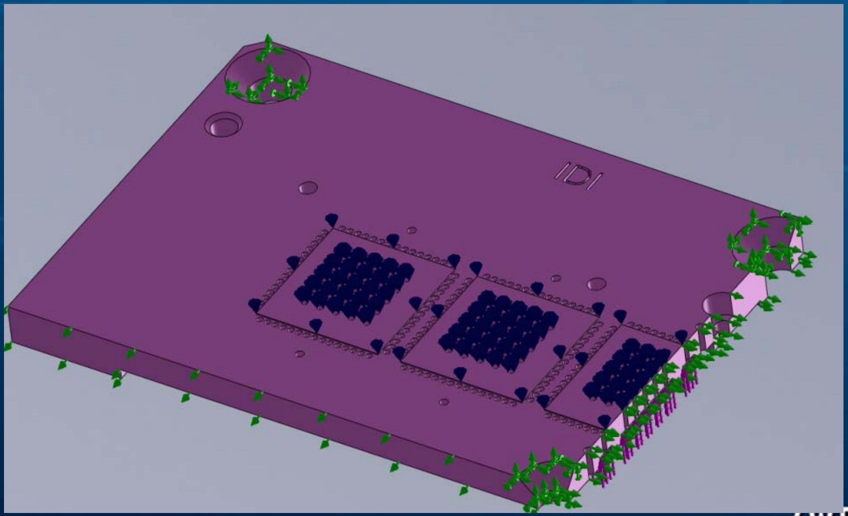


Cartridge bowing by preload on test board

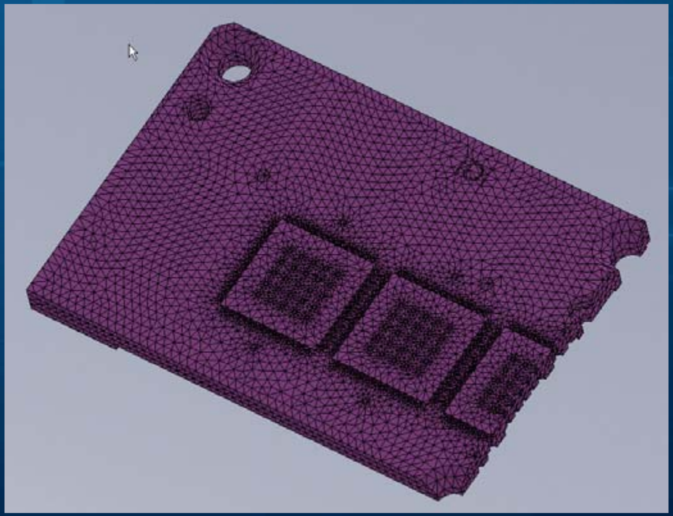
FEA on Probe Head Bowing

- **FEA is commonly applied to predict probe head bowing. For symmetric structures, ½ or ¼ of probe head is used in FEA model.**
- **The basic information required for FEA:**
  - Boundary condition
  - Pin count and pin preload force
  - Material mechanical properties

Example Boundary Condition



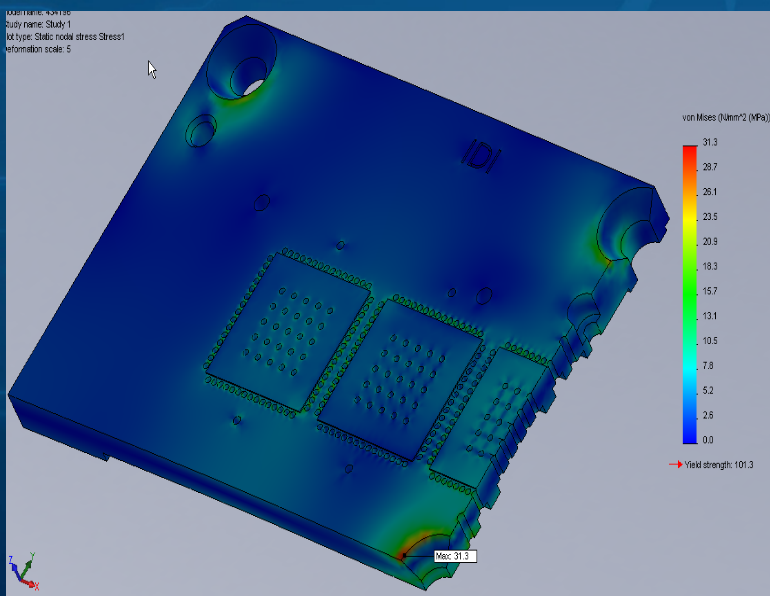
Example Mesh



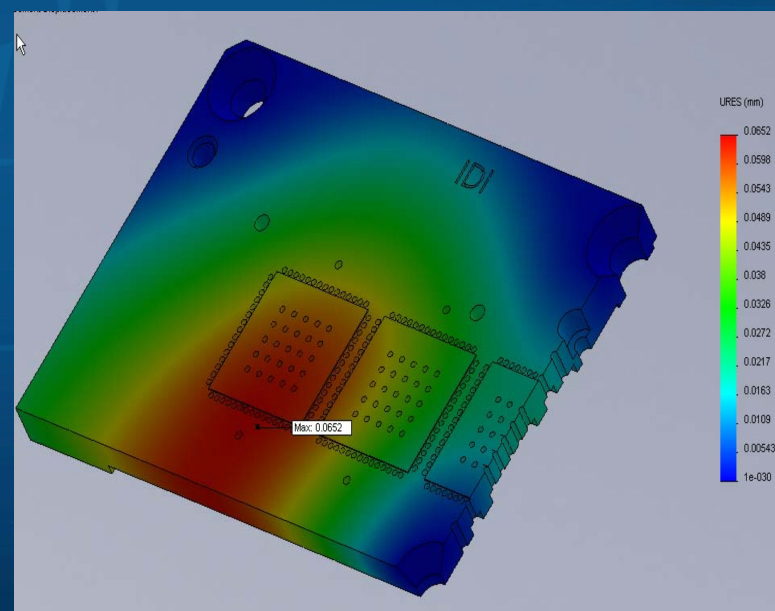
FEA on Probe Head Bowing

- **Analysis results:**
  - Stress distributed throughout the probe head structure
  - Deflection (bowing) of the probe head structure

Stress



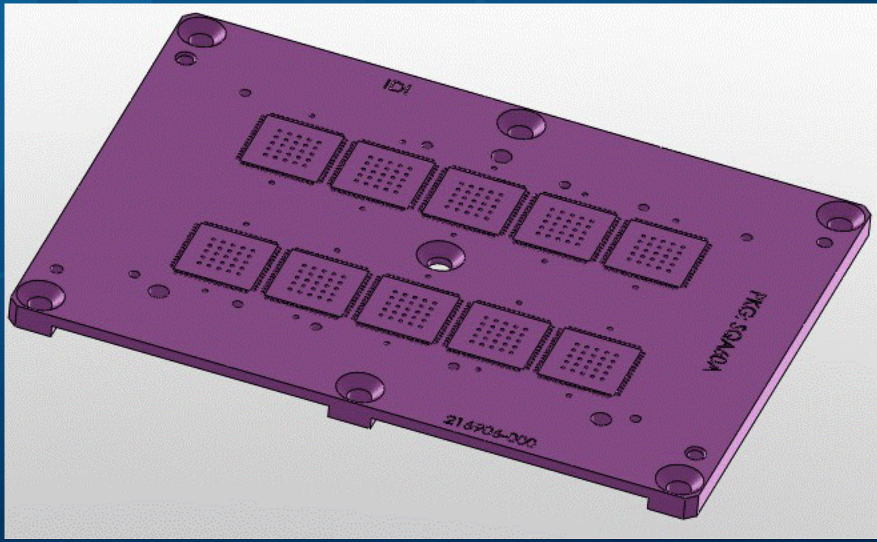
Deflection (Bowing)



Coplanarity vs. Material Selection

- **Material choice makes a significant contribution to improving coplanarity of the probe head**
- **FEA on two materials**
  - Material A is only half of Material B

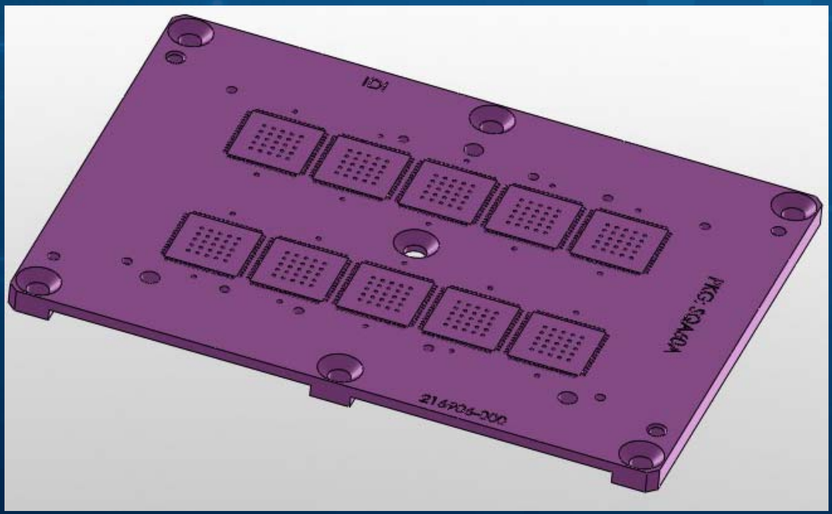
Material	Spring Probe Qty	Max Bowing um
A	850	65
B	850	112



Coplanarity vs. Structure

- **Probe head structure can minimize coplanarity**
  - Structure 1: Single piece high strength plastic composite
  - Structure 2: Stainless steel frame with plastic composite cartridge

Plastic Composite



SS Frame + Plastic Cartridge

Coplanarity vs. Structure

- **SS frame with plastic cartridge can improve coplanarity significantly**
- **The SS frame probe head bowing is reduced over 30% with double the pin count**

Structure	Material	Pin Count	Max Bowing (um)
SS frame + plastic cartridge	A	1568	46
	B	1568	54
Single Plastic Cartridge	A	850	65
	B	850	112

Summary

- Spring probes have more compliance and reliable contact for WLCSP testing.
- Coplanarity of a spring probe based probe head is influenced by tolerances of components and cartridge deflection (bowing).
- The probe head bowing is the largest contributor to coplanarity. It is affected by material, structure and other factors.

Thanks!

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