
SIXTEENTH ANNUAL
BiTS
Burn-in & Test Strategies Workshop
TM
March 15 - 18, 2015
Hilton Phoenix / Mesa Hotel
Mesa, Arizona
Archive – Session 3
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**Session 3**

Valts Treibergs
*Session Chair*

BiTS Workshop 2015 Schedule

# Frontiers Day

Monday March 16 4:30 pm

## Wafer Level Pots of Gold

**"Coplanarity Analysis of WLCSP Spring Probe Head"**

Jiachun (Frank) Zhou , Daniel DelVecchio , & Cody Jacob - Smiths Connectors

**"Pushing the envelope in DFM (Design for Manufacturing) for 0.2 mm Pitch WLCSP Socket"**

Paul Gunn, Muhammad Syafiq, & Takuto Yoshida - Test Tooling Solutions Group

**"Space Transformer PCB For Testing 200 µm WLCSP"**

Khaled Elmadbouly - Smiths Connectors

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# Coplanarity Analysis of WLCSP Spring Probe Head

Dr. Jiachun Zhou (Frank)
Daniel DelVecchio, Cody Jacob
Smiths Connectors

2015 BiTS Workshop
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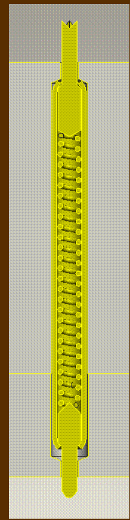
# Contents

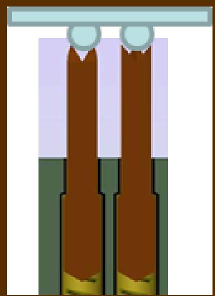
- What learned from spring probe head applications in WLCSP testing
- Spring probe head structure examples
- Probe head coplanarity analysis methods
- Coplanarity analysis & example
- Probe head bowing & FEA
- Coplanarity vs. material & structure
- Summary

# What Learned from WLCSP Testing

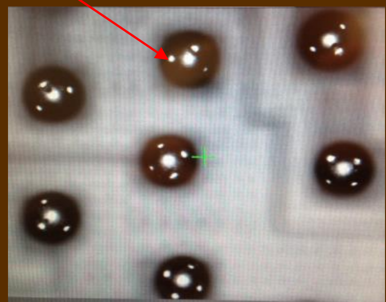
## Spring Probe Head advantages

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





Contact marks

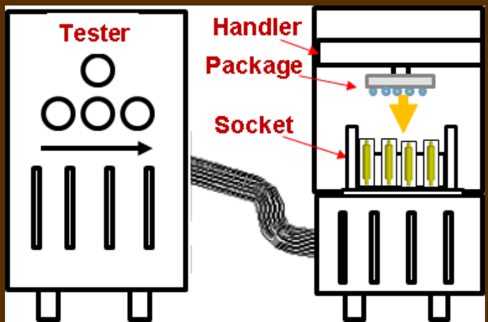


# What Learned from WLCSP Testing

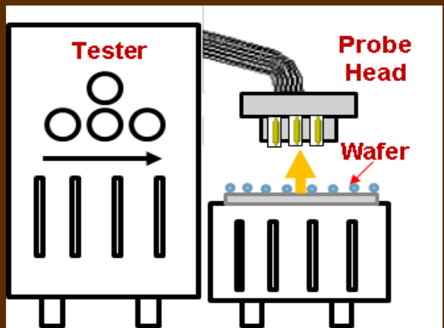
## WLCSP Testing vs. Package Testing

- Set up: handling method; optical alignment in X-Y position
- Ball size: smaller in WLCSP
- Compliance: smaller to avoid penetrate ball and damage wafer
- Tip Coplanarity: very tight control on 1st touch to last touch
- Force: less force in WLCSP testing
- Contamination control

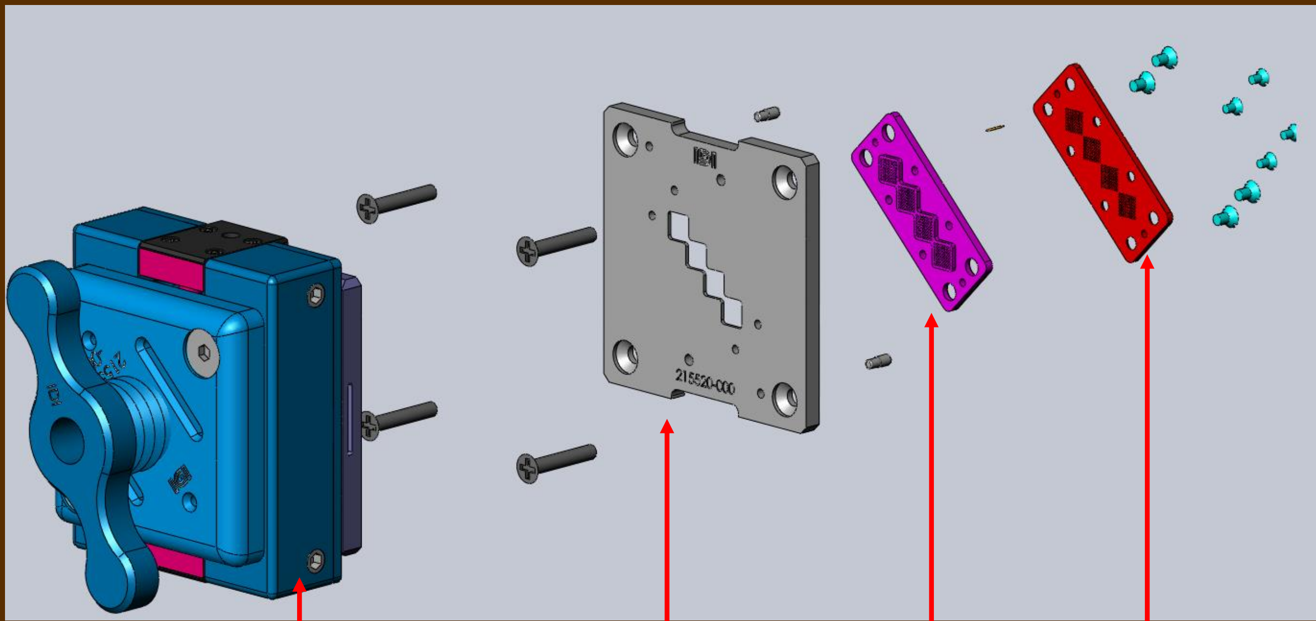
**Package Testing**




**Wafer (WLCSP) Testing**



# Spring Probe Head Example (400um)



**Lid for manual test**
**Not for auto test**

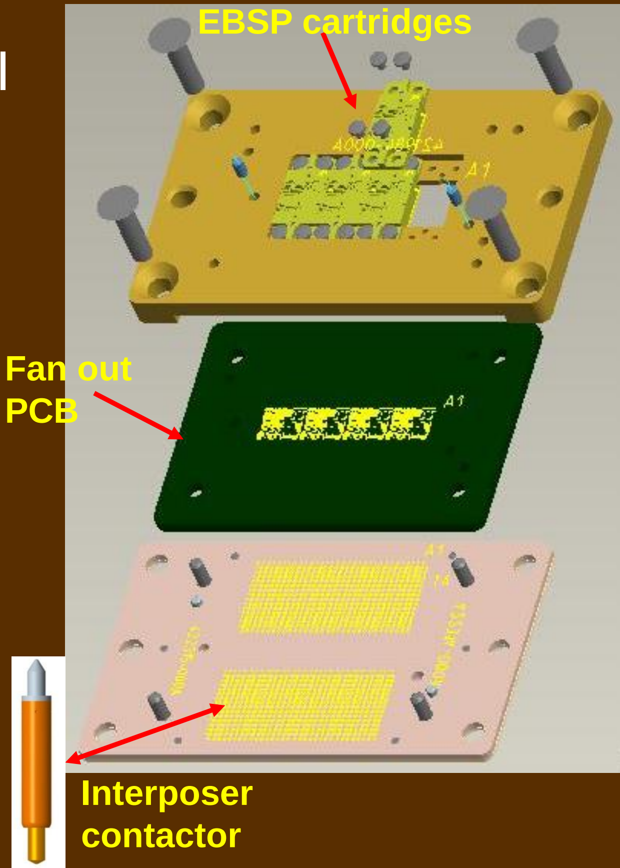
**Frame**

**Cartridge body**

**Cartridge retainer**

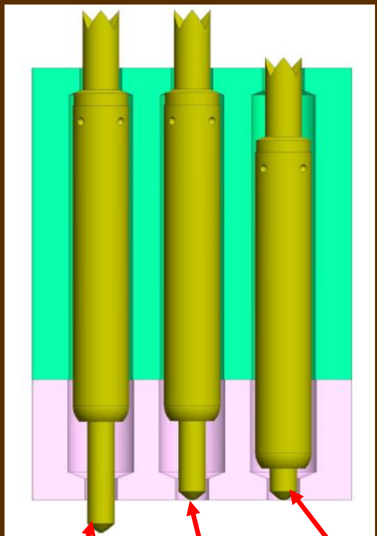
# Spring Probe Head Example (200um)

- New contactor with Embedded Barrel Spring Probe (EBSP) developed for testing wafer, WLCSP, MicroCSP
- Components:
  - EBSP cartridge
  - Fan out PCB
  - Bottom contactor (spring probe, 0.8~1.0mm pitch)

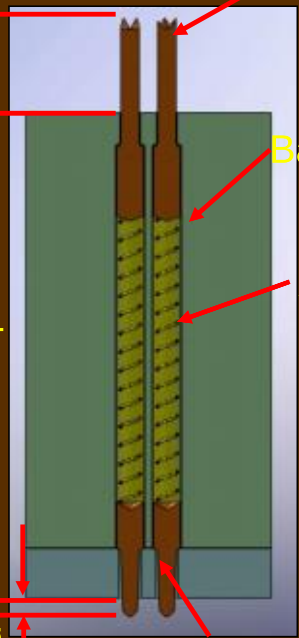


# Spring Probe & Cavity Example

**Probe Status**

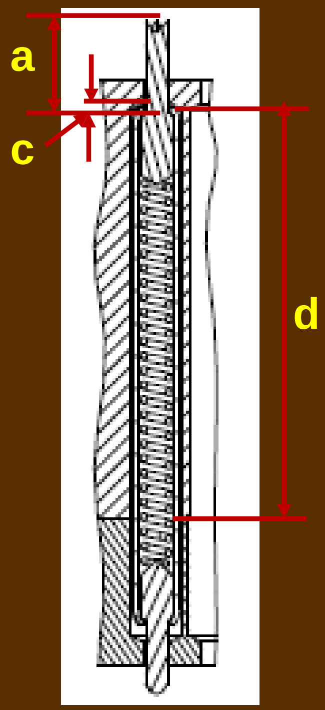



**Pin tip array**




Coplanarity Analysis of WLCSP Spring Probe Head

# Probe Head Coplanarity Analysis (worst case scenery)




- 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

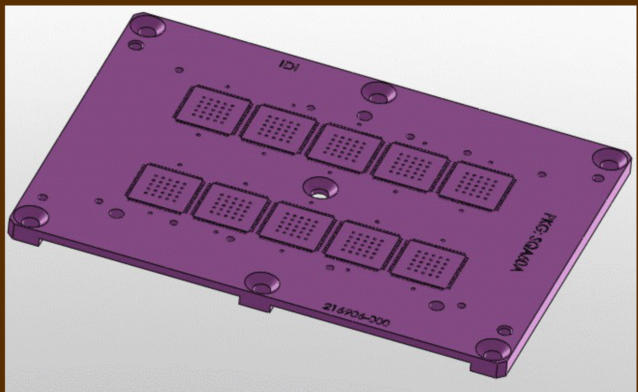
  Δd – counter bore depth tolerance, ~ +/- 0.025mm

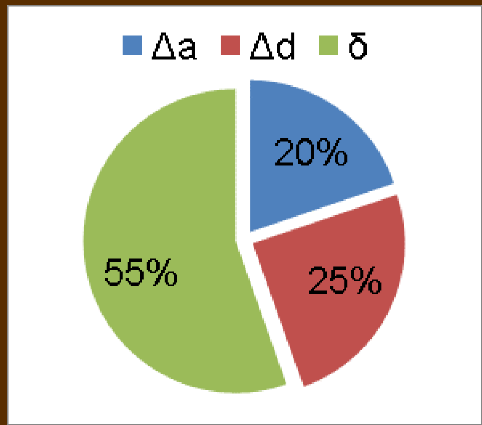
  δ – cartridge bowing due to preload

# Coplanarity Analysis Example

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

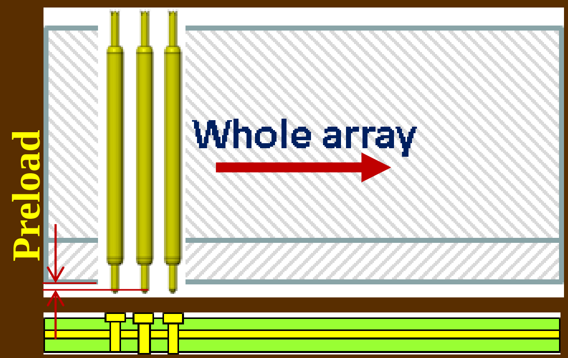
| Item | Coplanarity, um |
|---|---|
| Δa | 40 |
| Δd | 50 |
| δ | 112 |
| H | 202 |



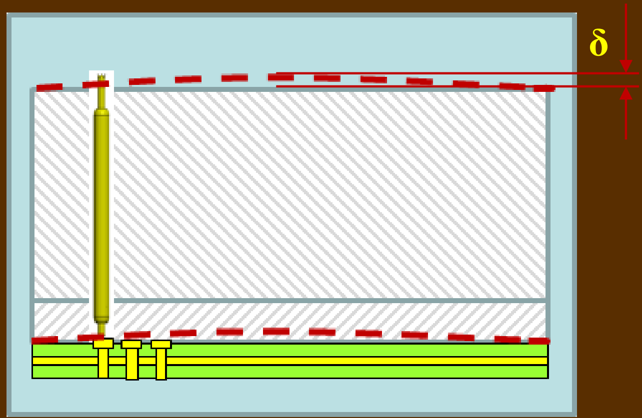


# Cartridge Bowing by Preload

- 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

# Material Stiffness & Bowing

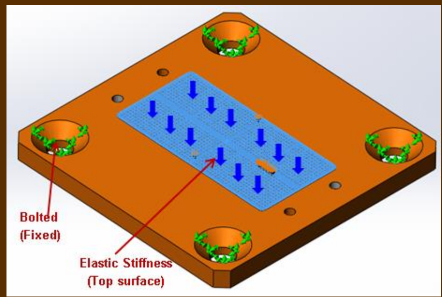
- Spring probe preload & bowing
  - ~ 12gf
  - 20~30% of total spring compliance
  - Bowing: ~ 50% of total tip co-planarity variation
  - Less bowing with higher stiffness material (flexural modulus of elasticity)

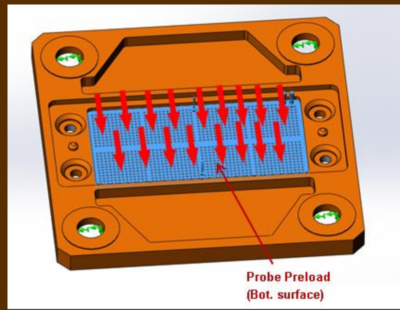
| Material | | Flexural Modulus | |
|---|---|---|---|
| | | English, kPSI | SI, Gpa |
| A | Ceramic Filled PEEK | 650 | 4.482 |
| B | MDS 100 | 1420 | 9.791 |
| C | New Thermoplastic Material | 2465 | 17 |
| D | New Ceramic material | 18853 | 130 |

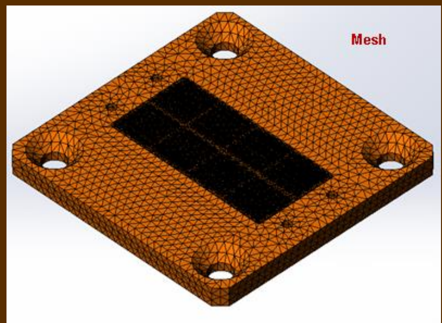
# Bowing FEA - Example

- FEA model & PH dimensions

| | |
|---|---|
| # of sites | 8 |
| Pitch, mm | 0.4 |
| Pin count, per site | 137 |
| Pin count, total | 1096 |
| Preload/pin, gf | 12 |
| Total preload, kgf | 13.15 |



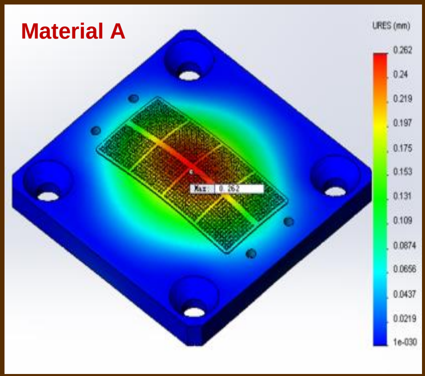



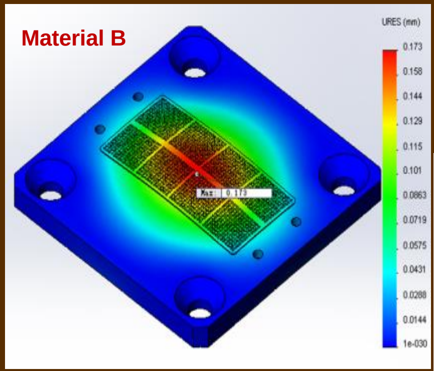



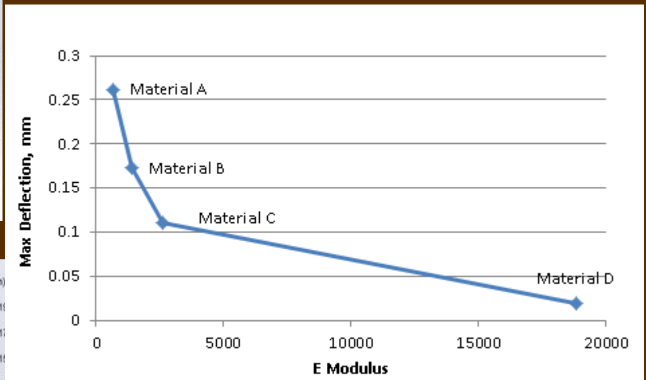

**FEA Model & Boundary conditions**

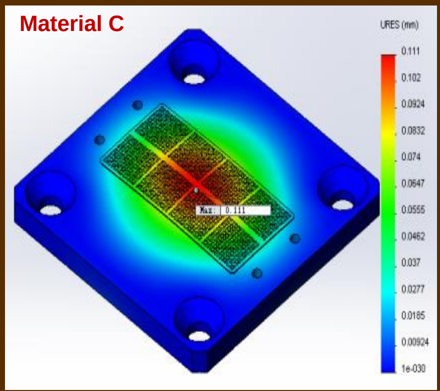
# Bowing FEA - Example

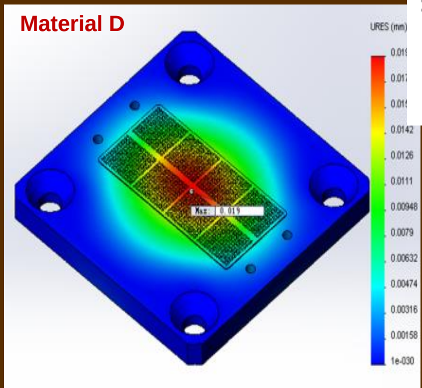
- FEA results for 4 different materials.



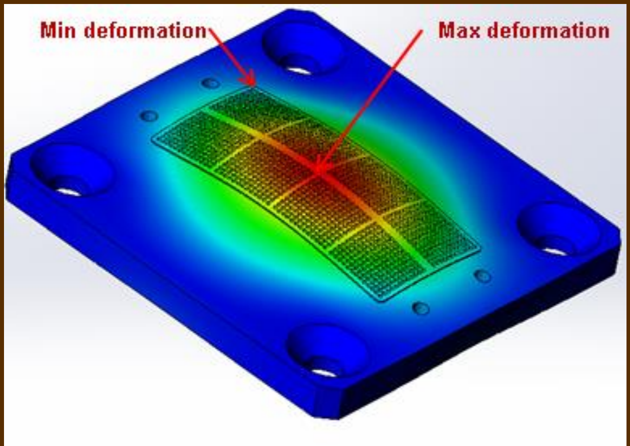



# Bowing & Coplanarity

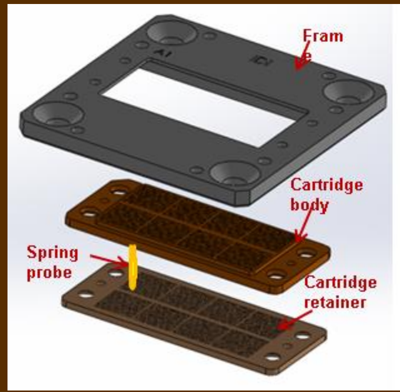
- Tip co-planarity = Max deflection – Min deflection

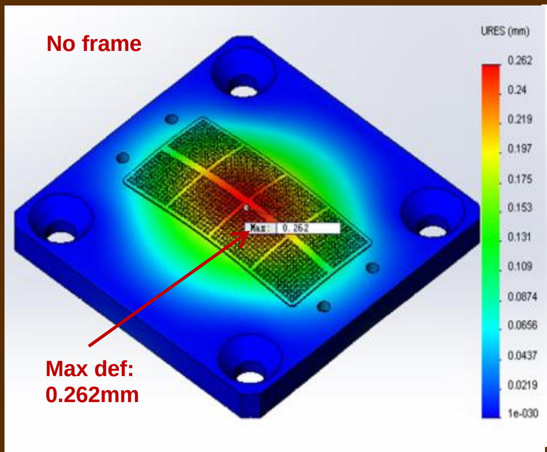


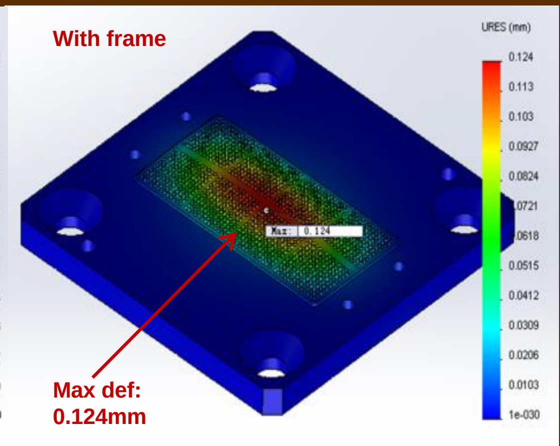

| Material | | PH Bowing, mm | | Co-Planarity mm |
|---|---|---|---|---|
| | | Max | Min | |
| A | Ceramic Filled PEEK | 0.261 | 0.054 | 0.207 |
| B | MDS 100 | 0.172 | 0.033 | 0.139 |
| C | New Thermoplastic Material | 0.110 | 0.020 | 0.090 |
| D | New Ceramic material | 0.019 | 0.016 | 0.003 |

# Coplanarity & Probe Head Structures

- Carrier & frame structure
  - High stiffness frame to reduce bowing
  - Mostly stainless steel used for frame

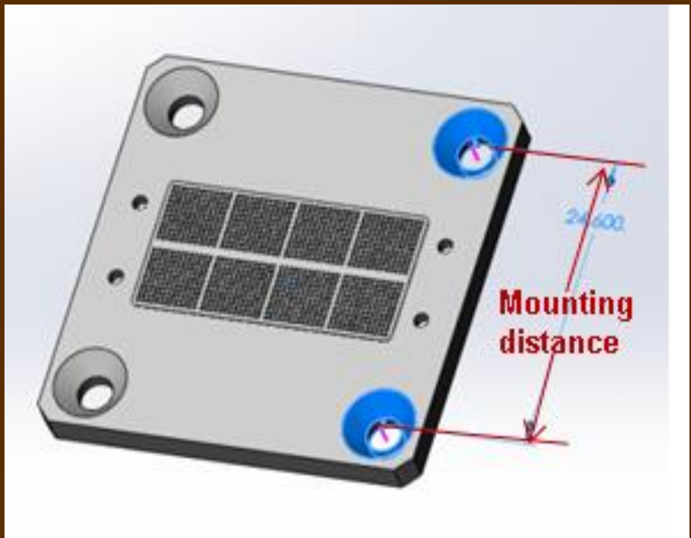


# Coplanarity & Probe Head Structures

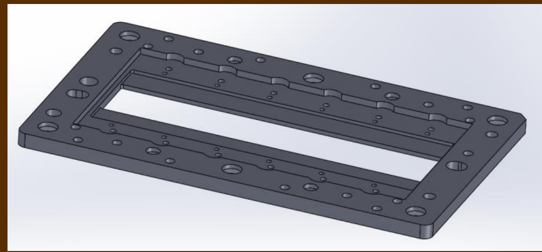
- Mounting structure
  - Less bowing with mounting screws closer to pin array
  - Limitation by electronic components or other features on test board



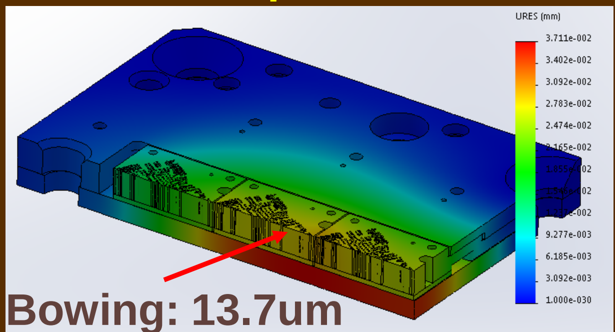

| Mount Distance, mm | Max Deflection, mm |
|---|---|
| 44.6 | 0.329 |
| 39.6 | 0.317 |
| 34.6 | 0.301 |
| 24.6 | 0.262 |

# Optimal Structures for Coplanarity

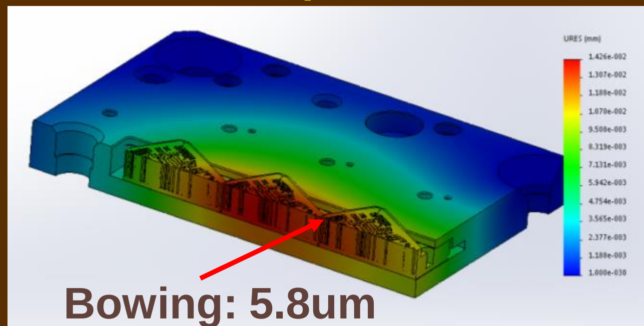
- Optimize structure to improve coplanarity.
  - Before optimization, 13.7um bowing
  - With optimal structure, 5.8um bowing



**Before Optimization**



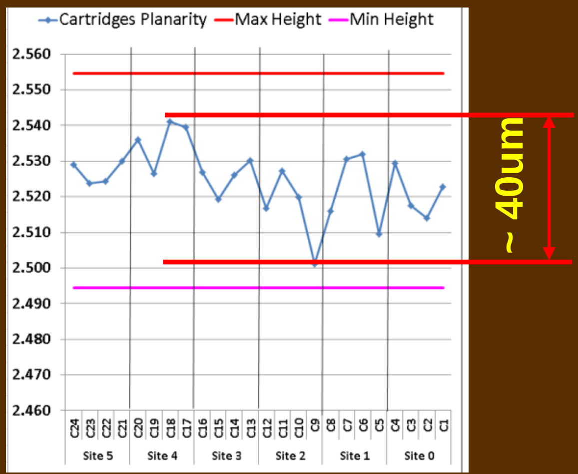

**After Optimization**



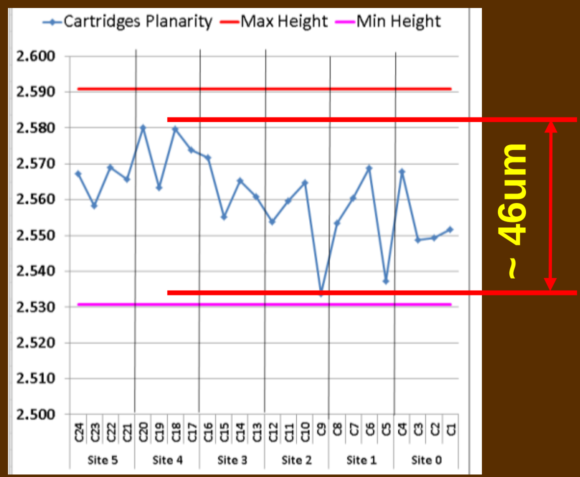
# Coplanarity Example

- Coplanarity example with optimal structure and existing manufacture capability as results below:
  - Six cartridges with SS frame, 200um pitch, ~ 400 pin/site
  - Cartridges surface coplanarity: no preload, ~ 40um; With preload, ~ 46um.
  - Preload contribution: only 6um, mainly by optimal structure.

**No Preload**




**With Preload**



# Summary

- Spring pin preload in WLCSP probe head impacts contactor tip co-planarity significantly.
- Higher stiffness material of PH is preferred to reduce bowing for better co-planarity.
- Optimal mechanical structure of PH can reduce bowing and improve co-planarity.
- With optimal structure and material, spring preload contribution to coplanarity can be reduced significantly to meet spec of wafer/WLCSP testing.