Challenges & Resolutions of Spring Probes in WF Test

smiths interconnect

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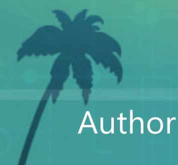
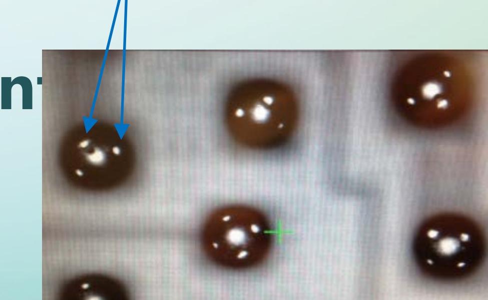
Overview

- **Why Spring Probe in WF Test?**
- **Tip Co-planarity of Spring Probe Card**
- **More Reliable Contact on WLCSP Cu Pillar**
- **Spring Probe Cres with Pro & Con on WF Test**
- **Summary**



Why Spring Probes in WF Test

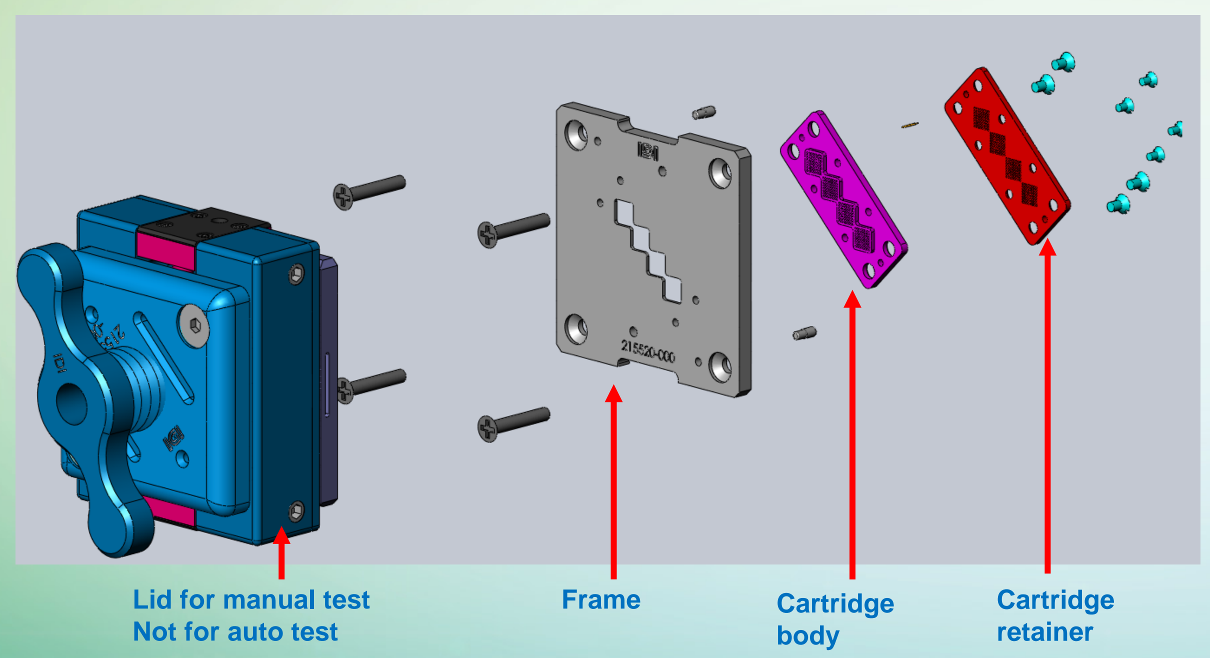
- **More Compliant**
  - Spring probe travels range up to 0.5mm >> other contact technologies in probe cards
- **Reliable contacts on balls or pillars on wafer**
  - Various contact crown features
  - Four points crowns with over 2 contact marks
  - Crown materials varies per performance requirement
- **High contact force to ensure reliable contact**
  - Force from 5 ~ 20gf
- **Easy in field service on cleaning and replacement**
- **Convenience in handling**

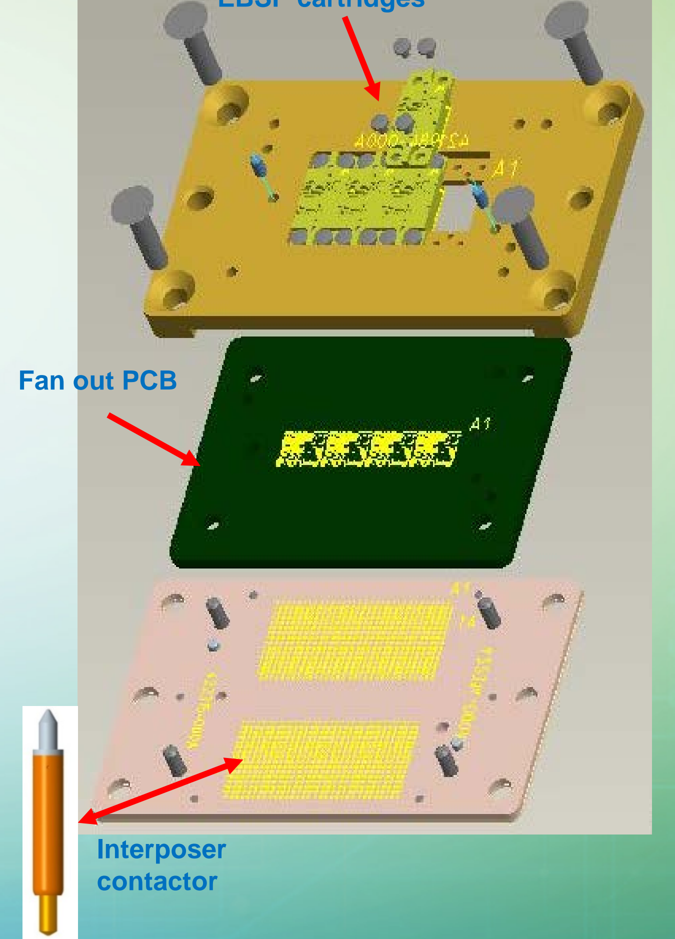


Vertical Contact Probe Head Examples

Fine Pitch (≤0.25mm) Fan-out PCB

Small Pitch (≥0.3mm) No Fan-out PCB





Spring Probe Card Tip Co-planarity Analysis

- **Factors to determine spring probe card tip co-planarity**
  - Top plunger neck tolerance, ~ +/-20um, as “a” in Fig 1.
  - Counter bore depth tolerance, ~ +/- 25um, as “b” in Fig 1.
  - Probe card bowing due to preload of probe as “δ” in table.
- **Calculations on tip co-planarity**
  - Max Co-planarity in 10 sites probe card in table below
  - δ, probe card bowing by preload contribute 50% of co-planarity

Item	Max Co-planarity, um
Δa	40
Δb	50
δ	112
H	202

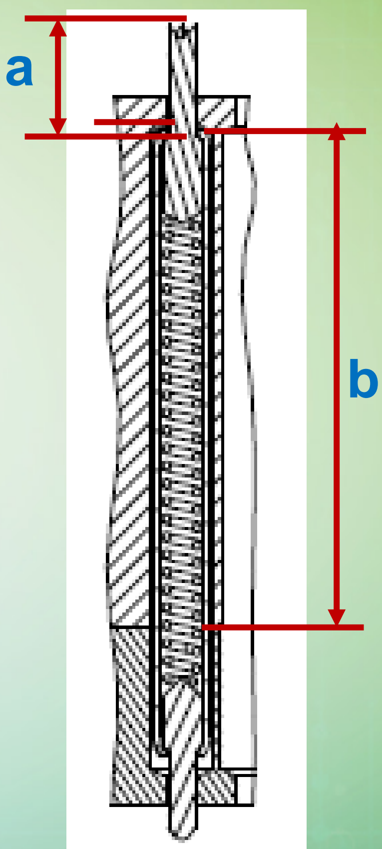


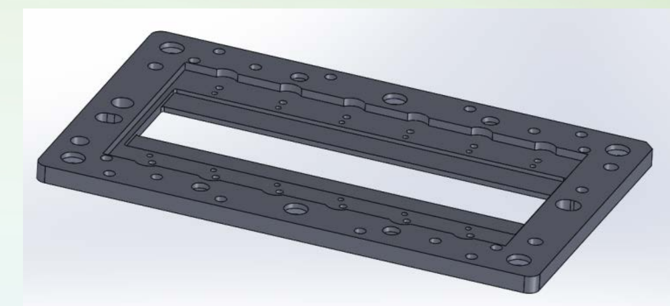
Fig. 1

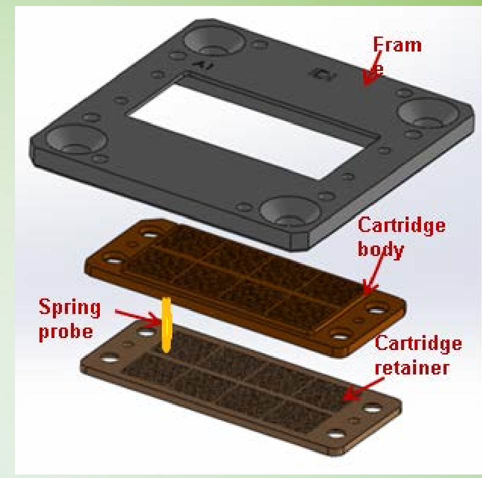
Fig. 2

Coplanarity & Probe Head Optimization

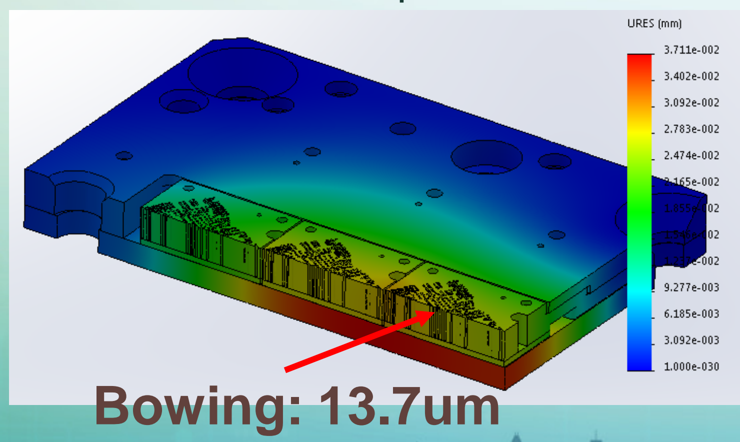
- **Optimization on Frame Structure**
  - High stiffness frame
  - Optimization in frame structure
- **Optimization Example**
  - Before optimization, 13.7um bowing
  - With optimal structure, 5.8um bowing

Probe Card Frame



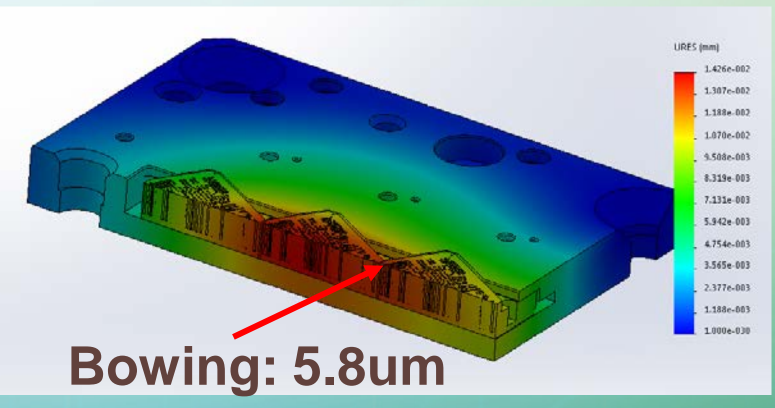


Before Optimization



Bowing: 13.7um

After Optimization

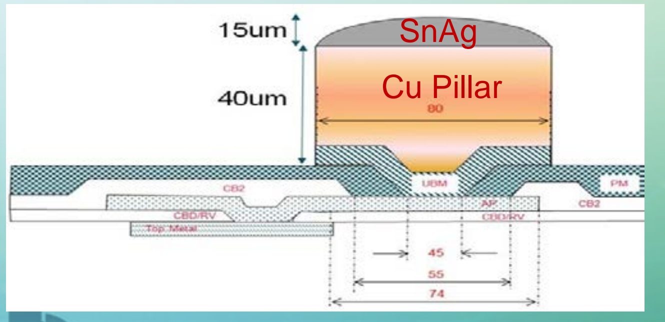


Bowing: 5.8um

Cu Pillar & Test Requirements

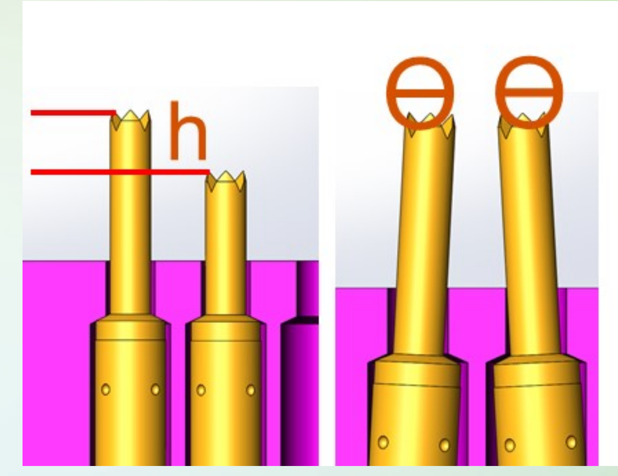
- **Cu Pillar is the next generation bump technology for greater density in smaller pitch**
  - Lower cost
  - Ability to mix smaller more flexible shape with thin SnAg cap in finer pitch
  - Superior electrical and thermal performance than that of conventional solder bumps.
- **Probing on Cu Pillar**
  - Spring Probes need to penetrate thin SnAg Cap for good Cres performance
  - Probes contacts have to avoid oxidation or create voids, as defects may occur in final SMT reflow process
  - Spring force not over stress on Cu Pillar and do not damage UBM (Under Bump Metallurgy) layer

	SnPb C4 Bump	Pb-Free C4 Bump	Cu Pillar + Pb-free Cap	Cu µ-Pillar + Pb-free Cap
Structure		SnAg	SnAg Cu	SnAg Cu
Diameter	75 – 200 µm	75 – 150 µm	50 – 100 µm	10 – 30 µm
	Old Technology	Current Technology		Next-Generation Technology



Probe Head Design & Mfg Challenges

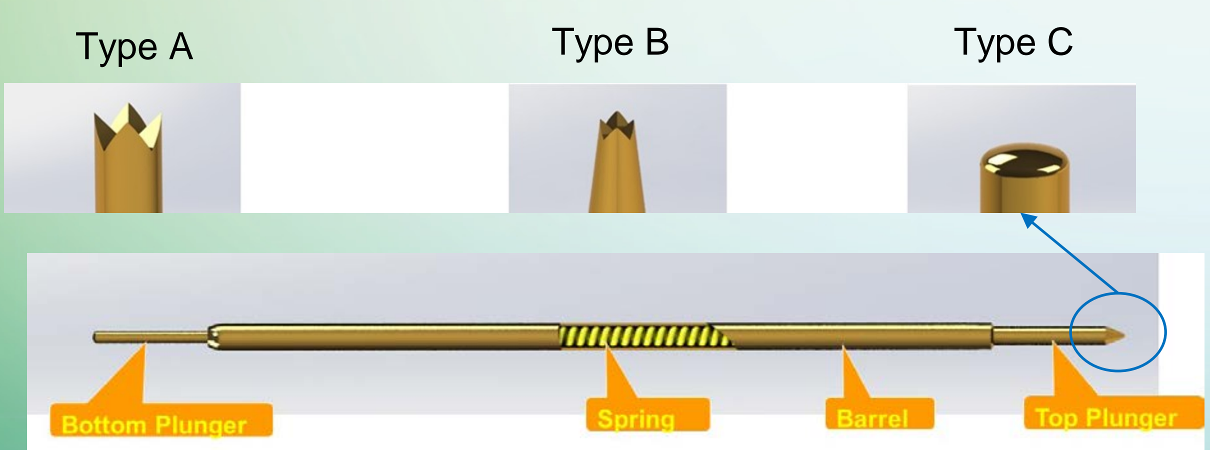
- **Spring Probe Tip Tilting and Tip co-planarity**
- **Spring Probe Tip Material and Geometry**
- **Probe Head Deflection**

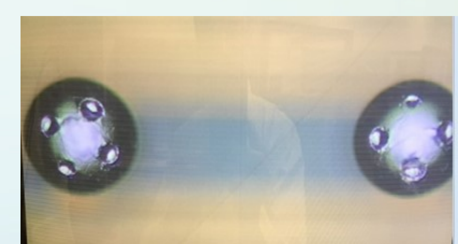


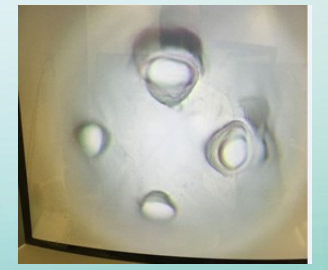
  - Probe Head design needs to tolerate and consider the effective force of 1st to last touch and tip co-planarity due to manufacturing process.
  - Spring Probe Tip material and geometry must optimize to minimize the effect of probe mark on Cu Pillar.

Study on Probe Contact on Cu Pillar

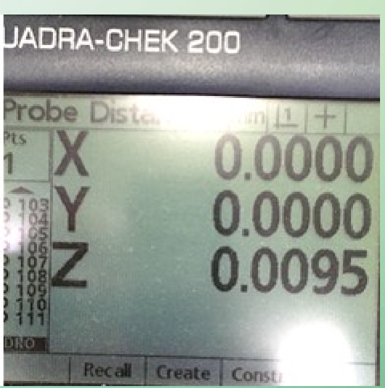
- **Test Methodology**
  - 6 Probe Head with
  - 3 different Plunger tip (A, B and C)
  - 2 different gram force springs on fresh wafer row each time, using Cu Pillar wafer.
  - Analyze Probe Mark size and depth after each 1, 3 and 5 touch down, at 100 to 160um of over drive







Probe Mark Depth

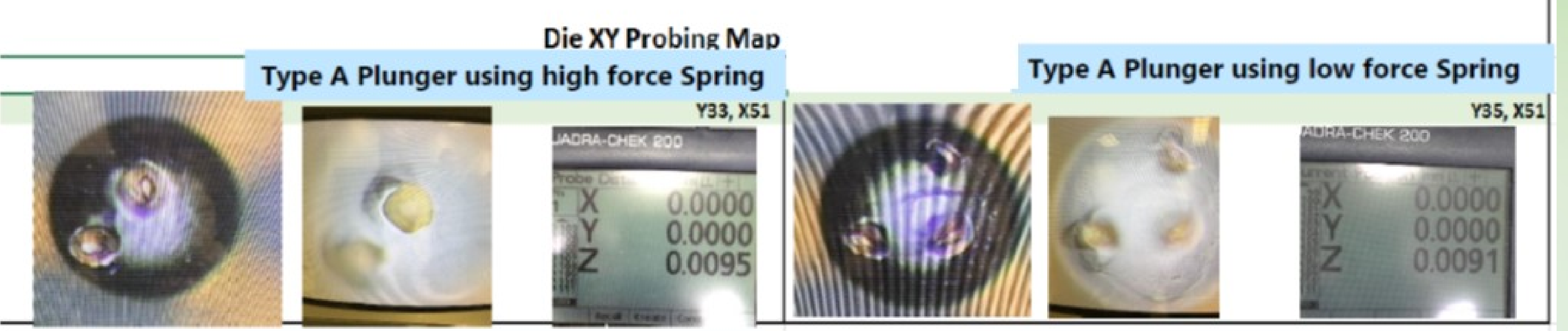


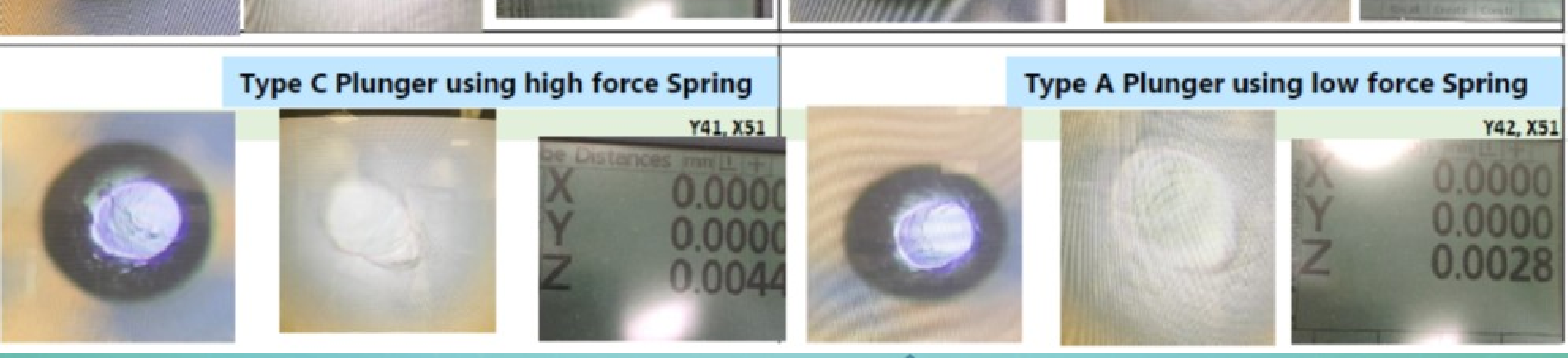
Cu Pillar Prober Test Criteria with Spring Probe

Failed Probe Mark Depth

Heavy Probe Mark

Heavy Probe Mark

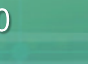




Heavy Probe Mark

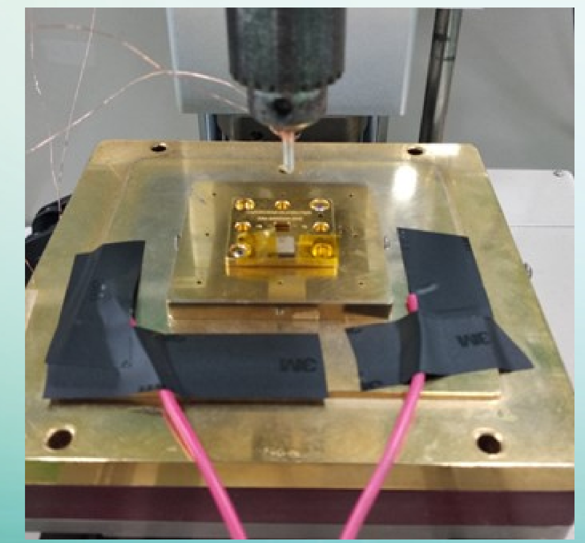
Okay

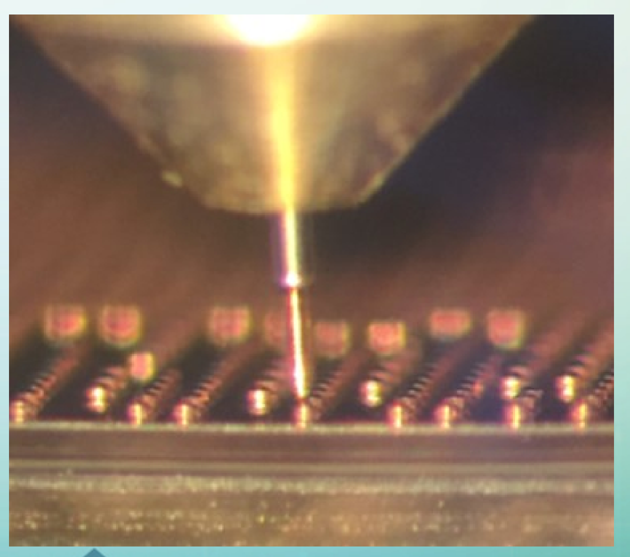
Okay



Cu Pillar Single Die Test with Spring Probes

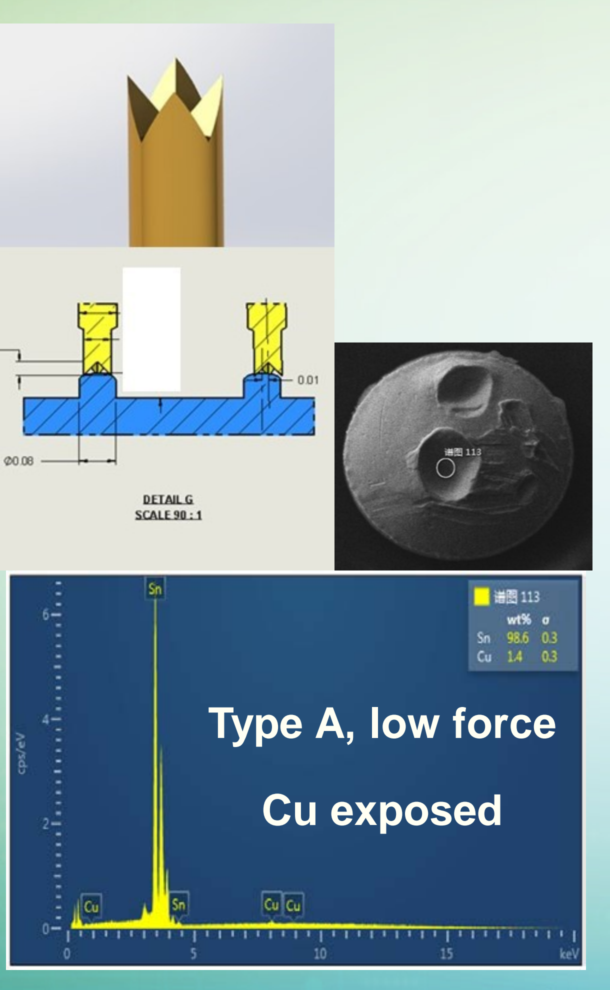
- **Test Setup**
  - A test fixture to align with single die and use FDR Tester and short some Cu Pillar to FDR Tester GND (Sense) Channel.
  - Designed FDR Pin Adapter to hold Spring Probe (in preload condition) and connect the plunger to the FDR Force Channel.
  - Align Cu Pillar with each type of Spring Probe and obtain FDR to highlighted Cu Pillars.
  - Analyze Probe Mark and Cres vs Deflection vs Force for each type of spring probe.



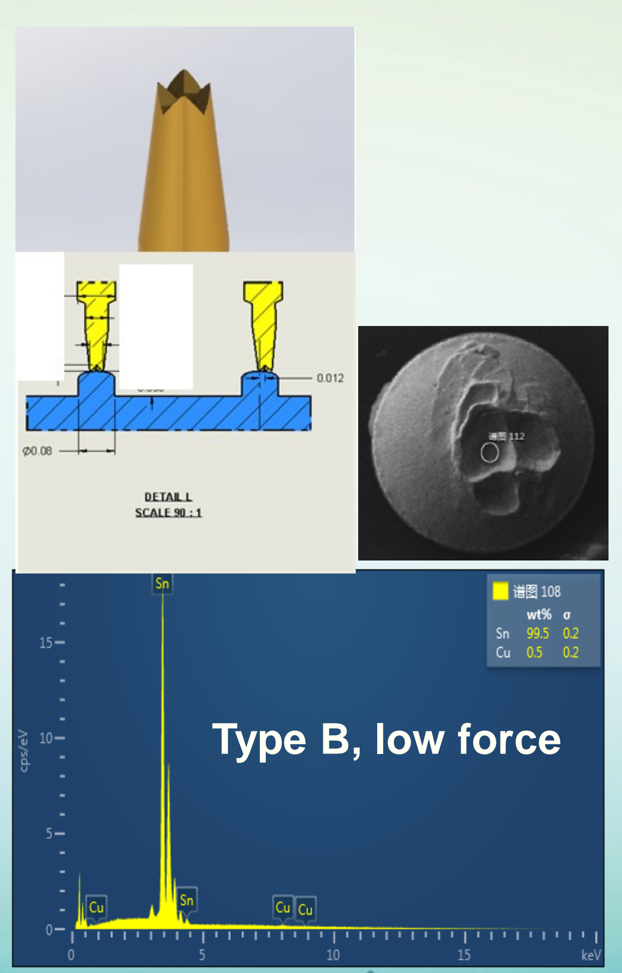


Probe Mark Analysis

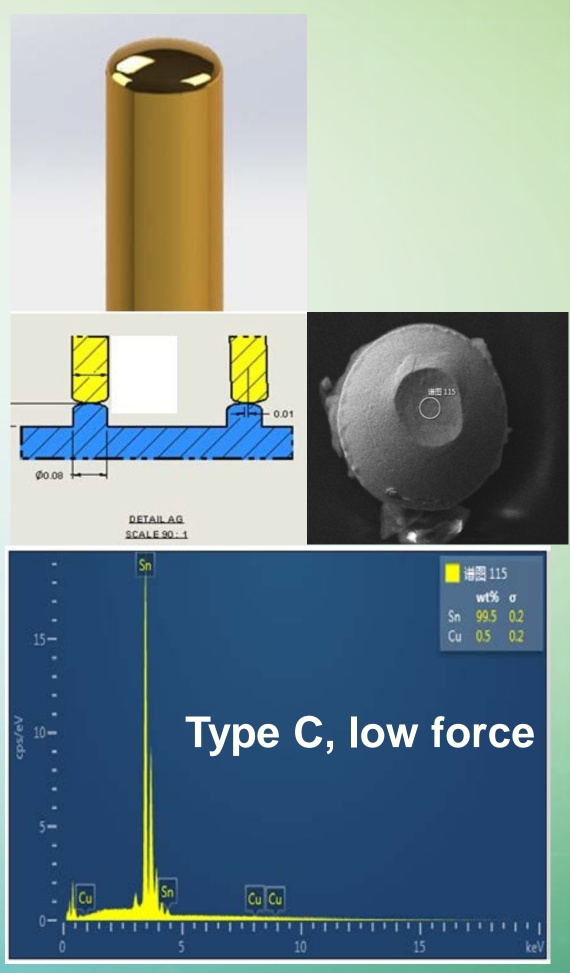
Type A top plunger



Type B top plunger

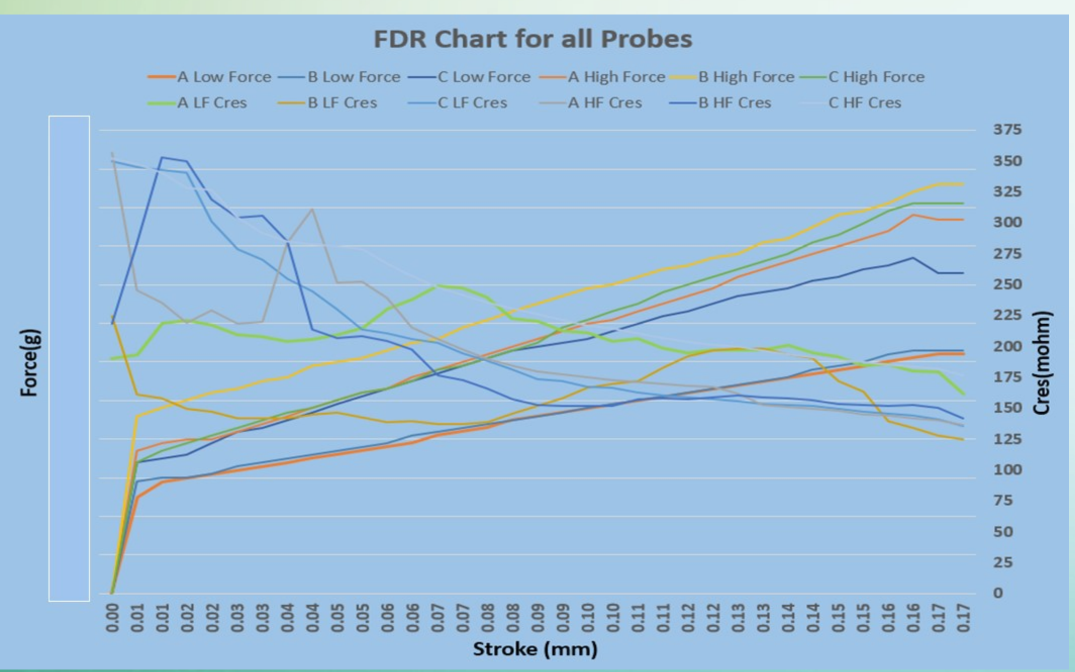


Type C top plunger



Probe Cres vs Force vs Crown Type

- **Factors to affect spring probe Contact Resistance (Cres)**
  - Probe force, structures including contact tips, materials & plating
- **Force & contact tip impacts on Cres**
  - High Force to get low Cres
  - Proper crown tip selected for good Cres



Spring Probe Tip Type		Force	Cres (mOhm)
Type A		Low	179.9
		High	154.8
Type B		Low	152.4
		High	128.4
Type C		Low	183.8
		High	142.4

Summary

- **Spring probes with preload in probe head have significant impacts on tip co-planarity, which requires all probes in preload status.**
- **Higher stiffness material with optimal mechanical structures must be selected to minimize bowing for good tip co-planarity.**
- **To maintain small penetrations to WLCSP bumps for more reliable contacts, probe tip crown must be optimized as examples below:**

Too sharp tip to generate deep mark and expose Cu as contact defects.

Have good Cres with proper force, acceptable probe mark.

Relatively high Cres, acceptable probe mark.

Thanks for your Support !

- **Contact the Smiths Interconnect with any questions …**

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