SWTEST
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30TH ANNIVERSARY

Fine-Pitch WLCSP Spring Probe Pointing Accuracy and Wobble

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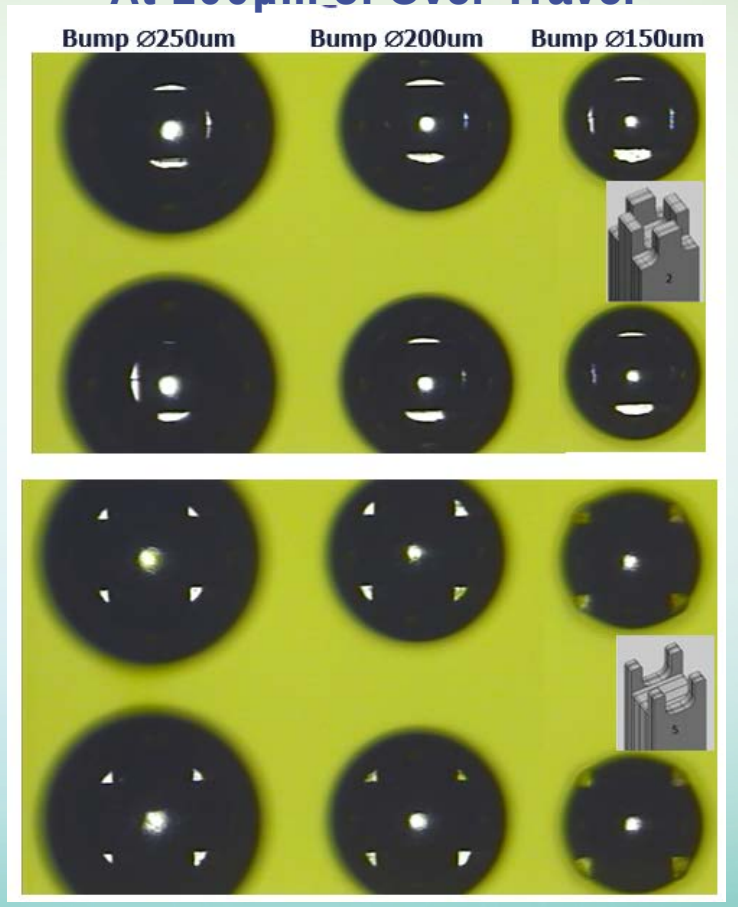
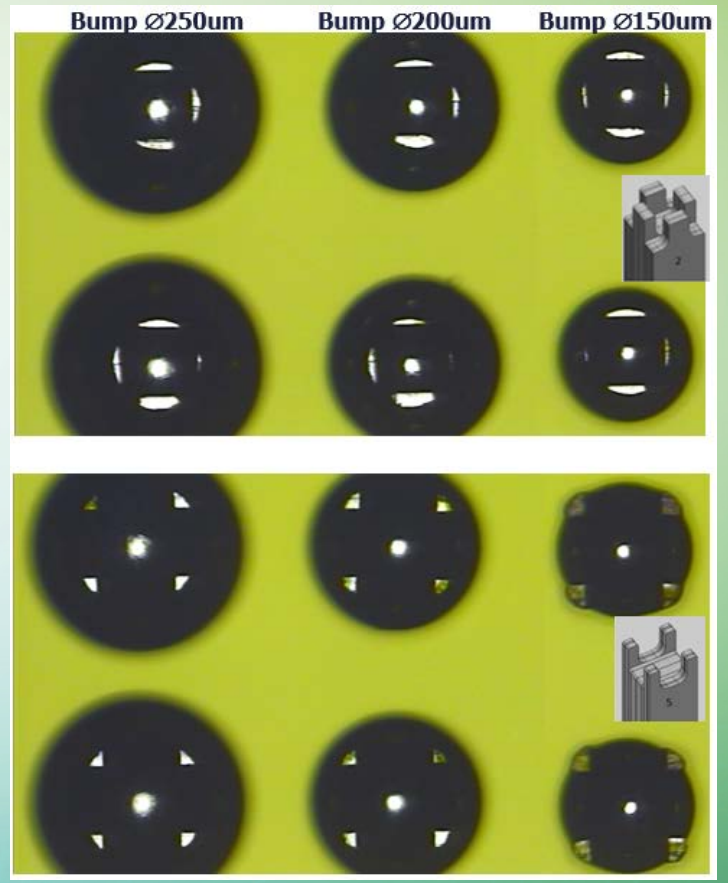
Introduction

- The goal of this paper is to give you the information needed to achieve contacting accuracy and repeatably as achieved with WLCSP MEMS Spring Probes.
- This presentation offers an analysis of tip pointing accuracy and proposes approaches to ensure optimal design and performance of spring probes used in sub 400-micron pitch test applications.

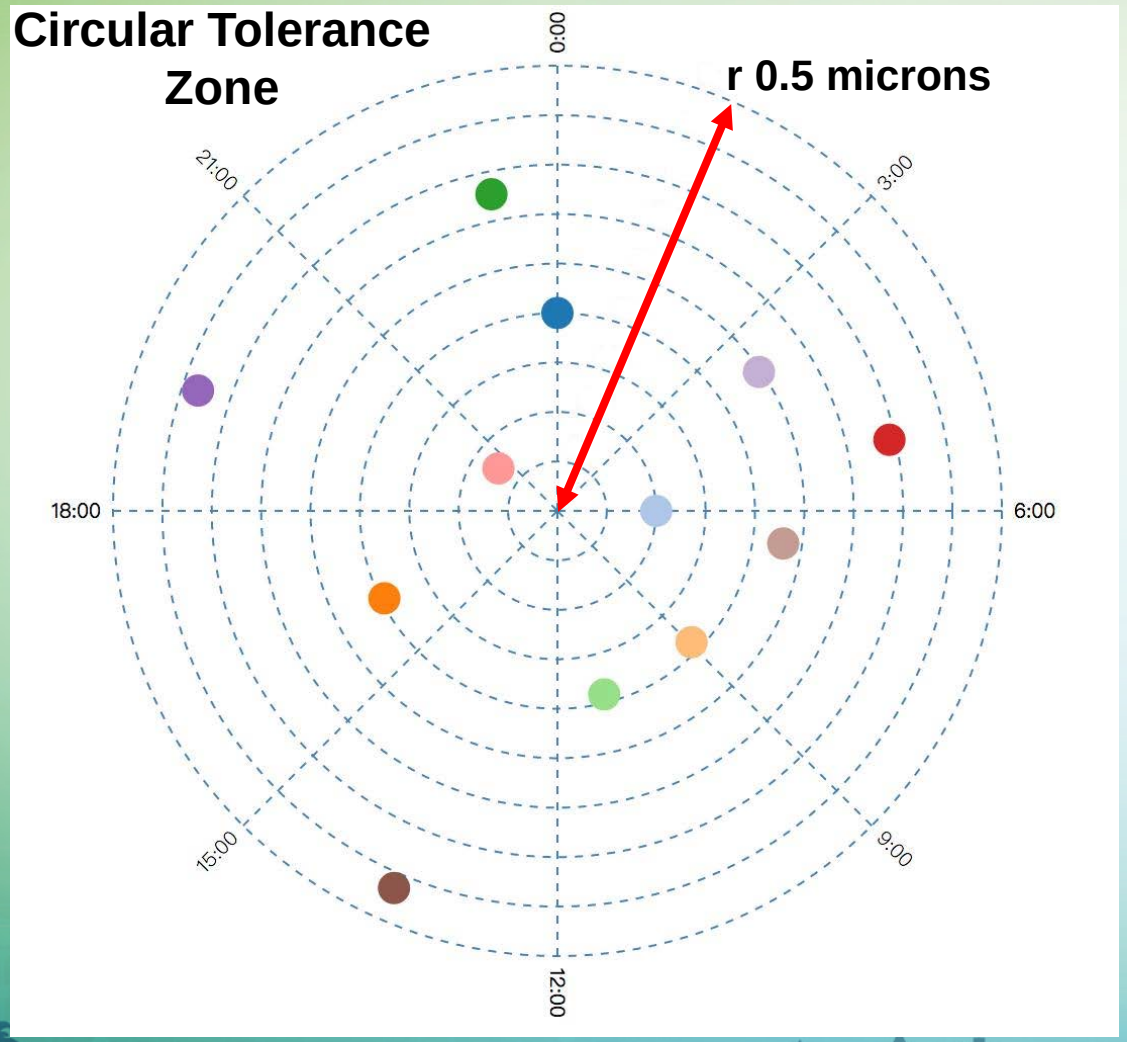
One Touch Down
At 100µm of Over Travel



Five Touch Downs
At 100µm of Over Travel



Spring Probe Pointing Accuracy Considerations

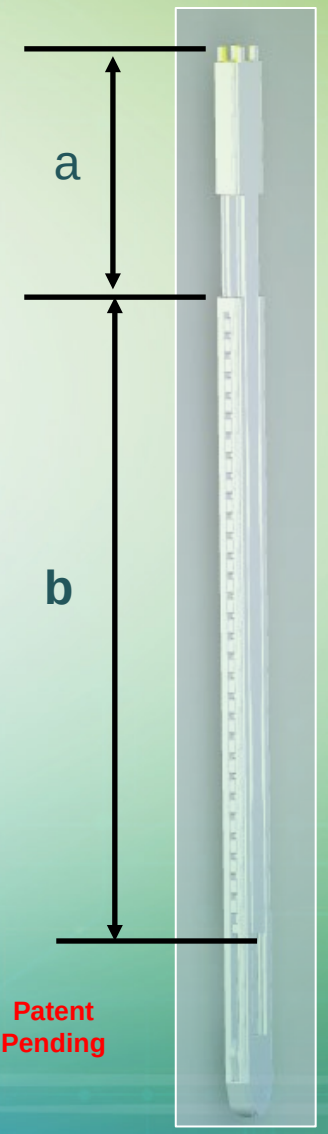


- The three main things to consider about pointing accuracy and wobble.

1. **Fixture Offset:** Fixture Offset relates to spring probe clearance, spring probe location, spring probe straightness, and the tolerance of the manufactured mounting hole in the receptacle also known as the contactor or spring probe probe head body.
2. **Scatter Pattern Offset**: Scatter Pattern Offset is caused by the combined tolerances of the spring probe and manufactured mounting hole in the receptacle. These tolerances are not affected by actuation of the spring probe and therefore remain relatively constant. Items such as tilting of the spring probe in its manufactured hole, plunger bend, and eccentricity of the spring probe tip fall into the category of Scatter Pattern Offset.
3. **Scatter Pattern Diameter:** Scatter Pattern Diameter is the Scatter Pattern Diameter of the spring probe contacting witness marks on the ball, bump, or pad. Scatter Pattern Diameter or Radial target contacting position as shown on the left comes from the clearances within the spring probe assembly and varies from one spring probe actuation to the next, resulting in a roughly circular scatter pattern of the spring probe tip points of contact as illustrated on the last slide of this presentation. This scatter pattern on the left represents the radius true position pointing accuracy of a hypothetical spring probe.

Pointing Accuracy Factors

- The primary factors affecting pointing accuracy are determined by the probe design. These factors include:
  1. The extended length (a) of the plunger from the barrel.
  2. The retained length (b) of the plunger in the barrel.
  3. The working clearance between the plunger and the barrel.
- Other factors that determine pointing accuracy are the straightness of the drilled hole and the clearance between the drilled hole and the probe.
  - These factors will not affect the radial area where the probe can be expected to hit, however, these factors will shift the center point of this area.



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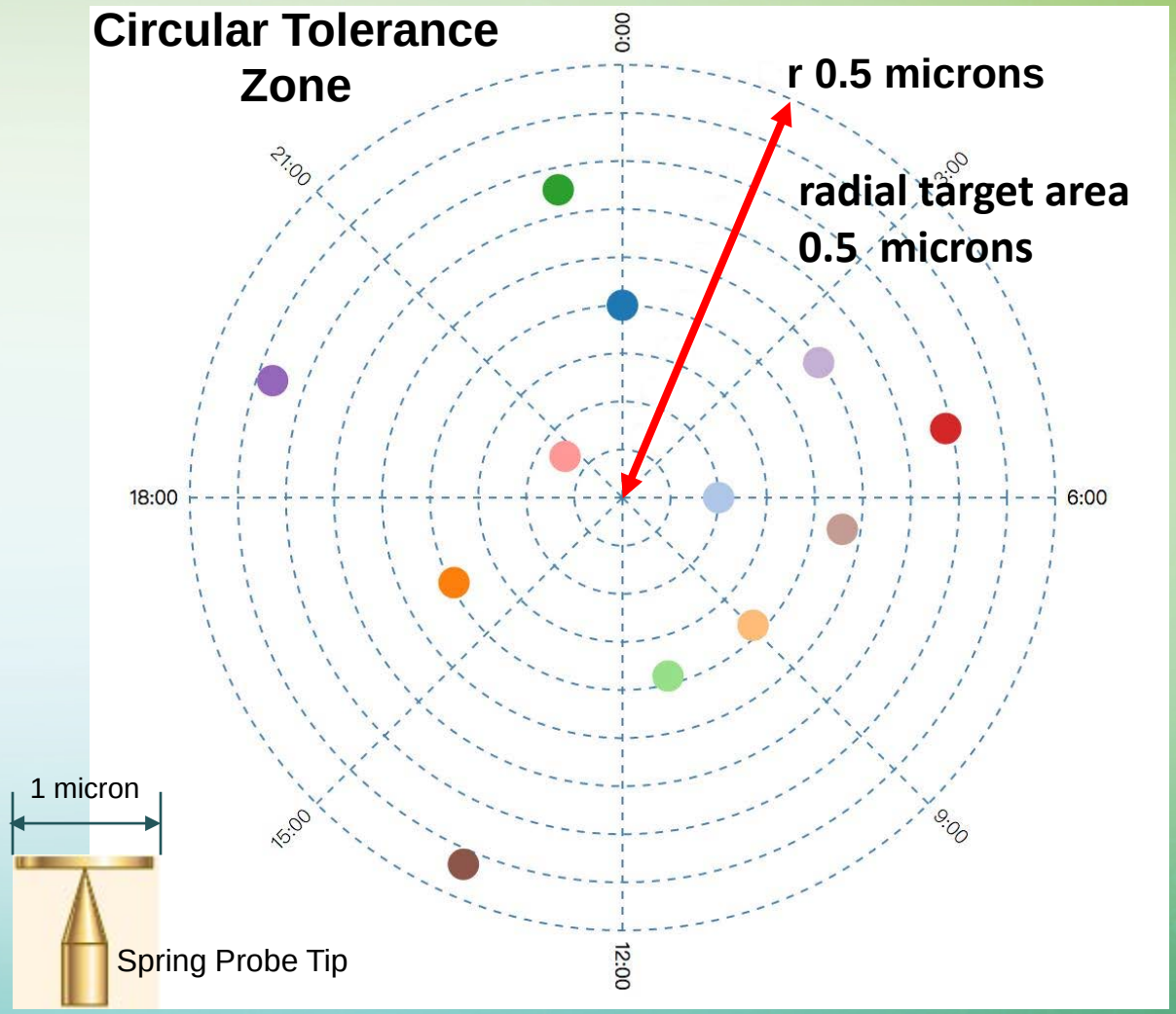
Pointing Accuracy Factors

- Pointing accuracy is defined as the radial target area in which a probe is expected to contact.

- Shown is a hypothetical ball contact area defined with a positional tolerance of 1 micron.
- This defines a circular tolerance zone with a radius of 0.50 microns around the true position.
- Contact with this hypothetical ball axis must lie within this 1-micron diameter circle
- The maximum deviation distance from the intended axis spot is the same in every direction, the radius around the true target position of the bump, ball, or pad.



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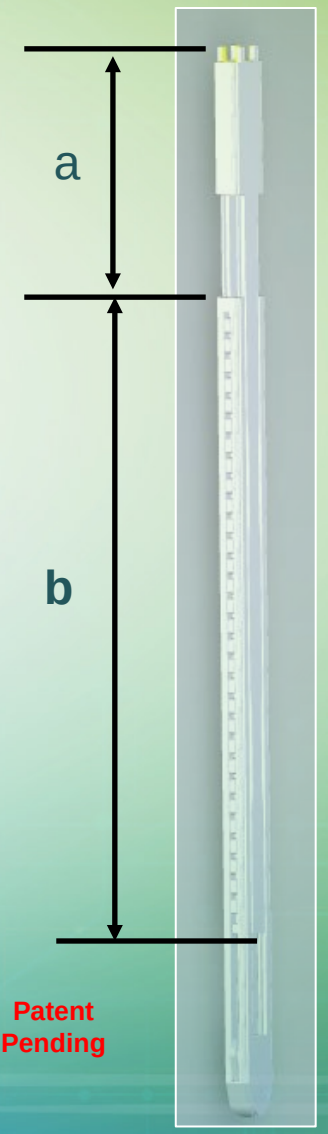
- Other factors that determine pointing accuracy are the straightness of the drilled hole and the clearance between the drilled hole and the probe.
  - These factors will not affect the radial area where the probe can be expected to hit, however, these factors will shift the center point of this area.

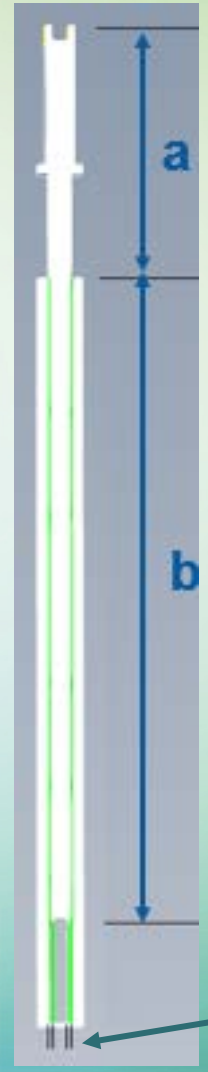


Calculating Pointing Accuracy

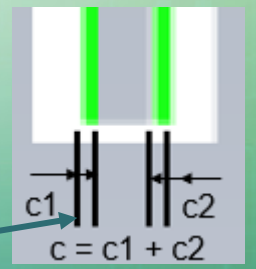
- Point accuracy variables:
  - e = pointing accuracy
    - e is the radial area that the probe tip will hit over multiple cycles.
    - e is determined by the probe design and manufacturing tolerance as describe below:
  - a = extended length of the plunger
  - b = retained length of the plunger
  - c = working clearance between the plunger OD and body ID

- Pointing accuracy for most spring probes is calculated with the following formula:

$$e = \frac{1}{2} c\left(\frac{a}{b} + .05\right)$$



Enlarged View



Calculating Pointing Accuracy

- Pointing accuracy for most spring probes is calculated with the following formula:

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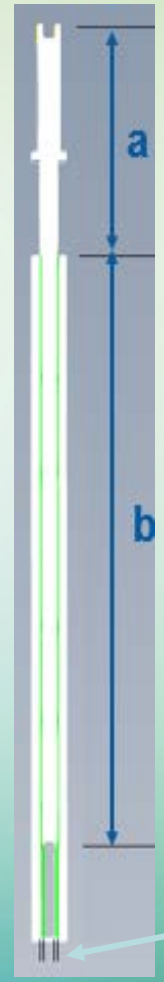
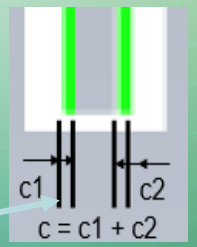
Description	Variable	Value
Pointing Accuracy	e	$\frac{1}{2}c\left(\frac{a}{b} + .05\right)$
Extended Length of Plunger	a	1.5mm
Retained Length of the Plunger	b	2.0mm
Working Clearance	c	0.001mm
Pointing Acracy	e	0.5µm

- The pointing accuracy e =

$$e = \frac{1}{2}(0.001)\left(\frac{1.5}{2.0} + 0.5\right)$$
$$e = 0.0005 * 0.80$$
$$e = 4\mu m$$



Enlarged View



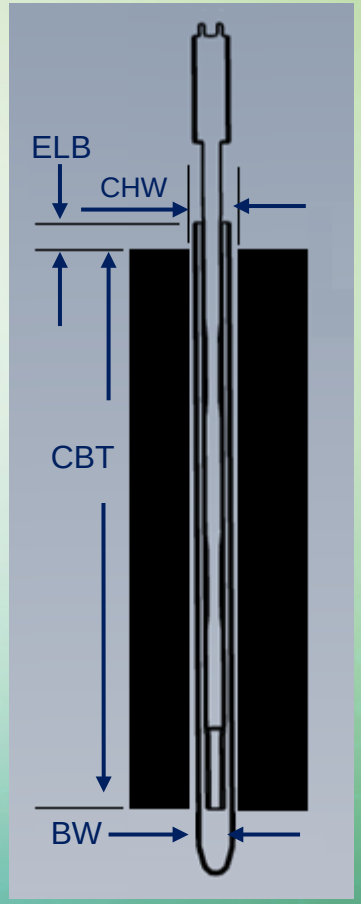
Spring Probe Receptacle Concentricity

- The probe/receptacle concentricity is defined as the offset or angle which occurs when the probe rests inside the body. The factors influencing pointing accuracy include:

  – ELB: Extended Length of the Spring Probe Body
  – CHW: Contactor Hole Width
  – BW: Spring Probe Body/Barrel Width
  – CBT: Contactor Body Thickness

- Spring probe contactor hole width (CHW) clearance typically provides a snug fit for the spring probe allowing spring probes to be freely assembled and disassembled

Side View



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Spring Probe Repeatability and Accuracy
Fixture Offset – Scatter Pattern Offset – Scatter Pattern Diameter

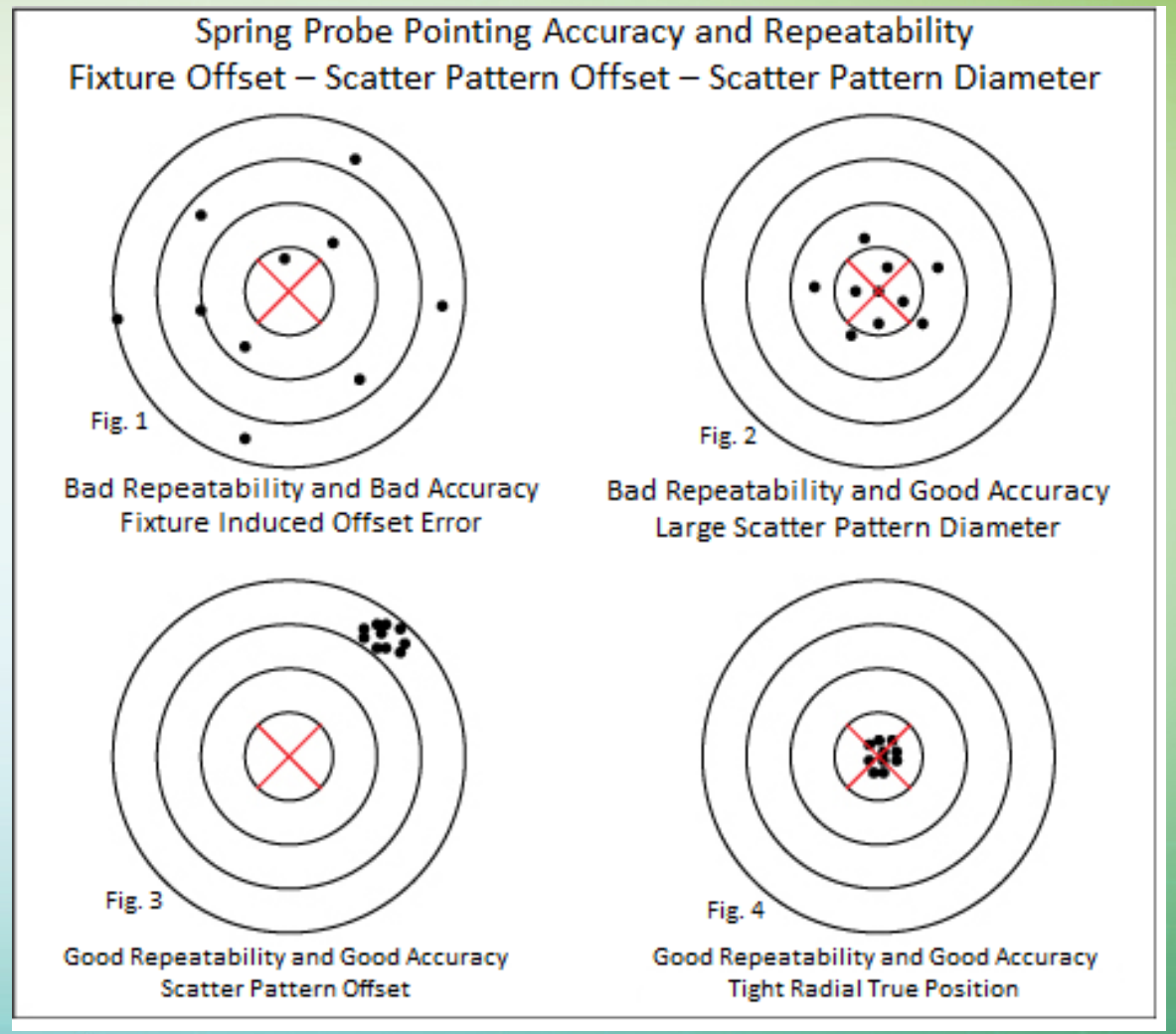
Repeatability is defined as the range of positions attained when the spring probe tip is repeatedly directed to one specific location under identical conditions. Accuracy is defined as to how close a spring probe tip can position to the actual true radius value.

- Figure 1 illustrates Bad Repeatability and Bad Accuracy. For this example, the dots are almost randomly scattered within a large circular window of operation. The cause is sloppy tolerance that are producing the fixture offset error. This relates to the spring probe's internal barrel or body to plunger clearance tolerances, the fit of the spring probe in the manufactured hole in the contactor or spring probe probe head body.

- Figure 2 illustrates Bad Repeatability and Good Accuracy. The larger scatter pattern is most likely caused using large traditional package test spring probes clearance tolerances, or a loose spring probe fit in the manufactured hole in the contactor or spring probe probe head body. Again, the design choice is a locational clearance fit that provides a snug fit for the spring probe while allowing spring probes to be freely assembled and disassembled in the spring probe contactor or spring probe probe head.

- Figure 3 illustrates Good Repeatability and Good Accuracy that did not contribute to hitting the target. This is true scatter pattern offset. Tilting of the spring probe in its manufactured hole, plunger bend, and eccentricity of the spring probe tip are common scatter pattern offset error causes.

- Figure 4 illustrates Good Repeatability and Good Accuracy and tight radial true position. This is the intend goal for contacting balls, bumps, and pads.



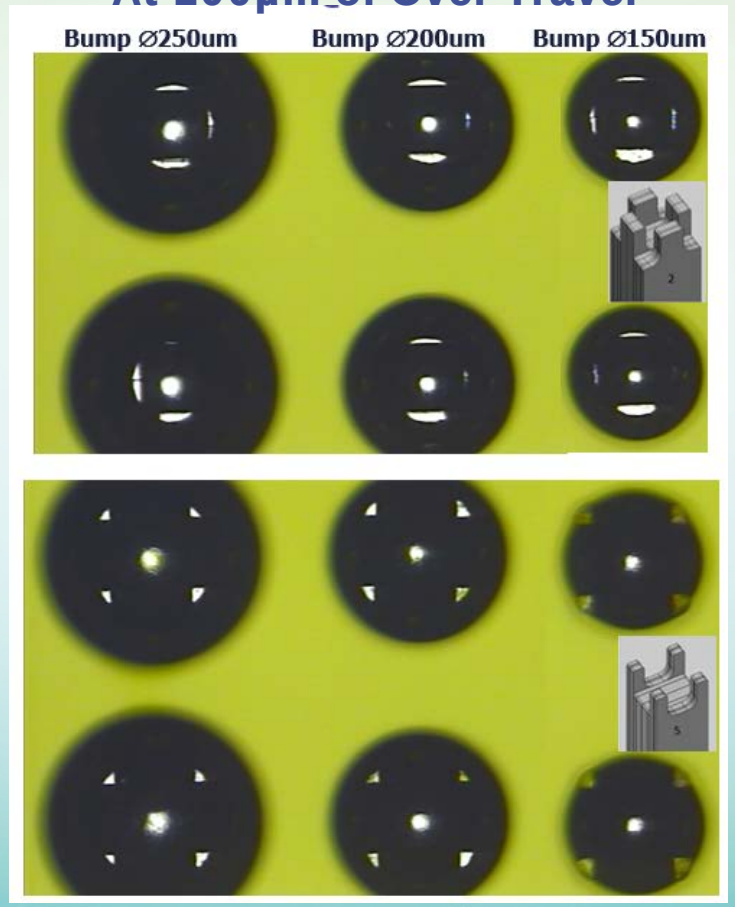
MEMS WLCSP Spring Probe Accuracy and Repeatability

- Shown here are WLSCP Bumps that have been contacted with a MEMS Spring probe. The probe tip style used is shown in the picture next to the contacted bumps.
- **The contacting witness marks on these bumps show a very accurate and repeatable MEMS spring probe contacting pattern.**

- The pictures on the near right
  - One touch down (TD) at 100µm of overtravel
  - The bumps shown on the right were never contacted bumps. The contacting witness marks on these bumps are one time only contacting witness marks.

- The pictures on the far right
  - Five touch downs (TD) at 100µm of overtravel
  - The bumps shown on the far right were contacted five times.

One Touch Down
At 100µm of Over Travel



Five Touch Downs
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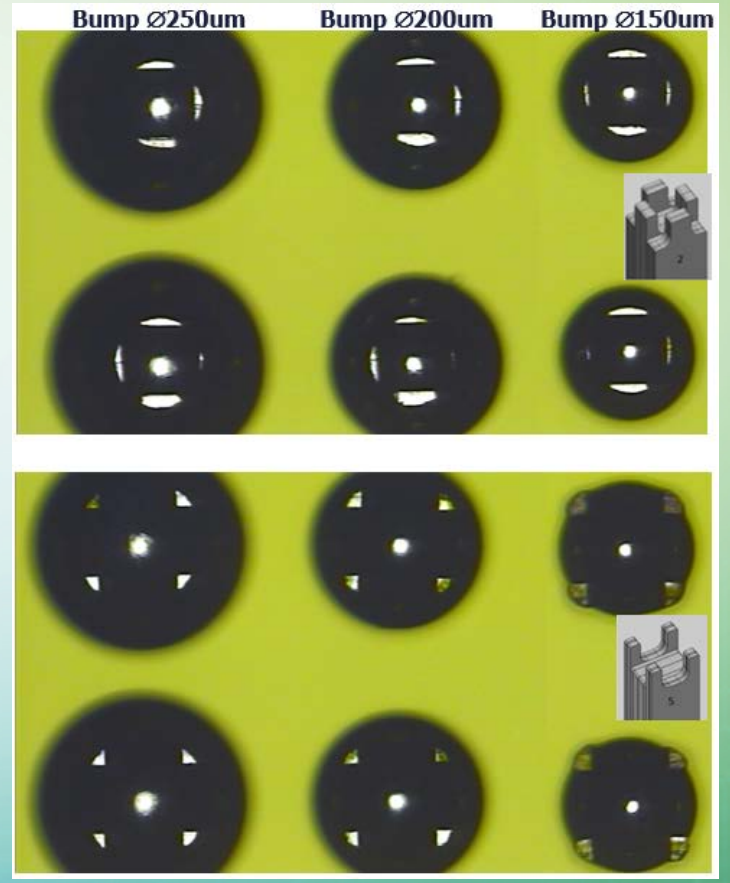
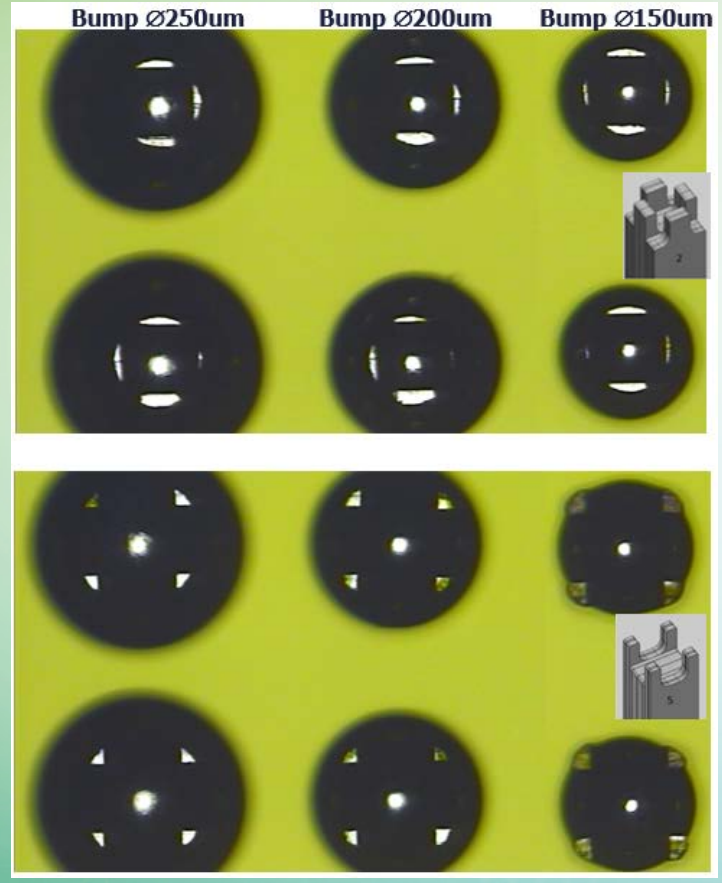


Conclusion

Five Touch Downs
At 100µm of Over Travel



- **Optimum reliability of the spring probe originates with design decisions, is then maintained through application of controlled production processes, is critically dependent on the reliability of each component in the spring probe and must be monitored to assure continuing success.**
- **The spring probe is a system.**
  - The systemic performance of the spring probe is the sum of the interaction of the spring probe components.
- **The spring probe contactor and spring probe probe head are systems consisting of subsystems.**
  - The performance of the WLCSP spring probe contactor and the WLCSP spring probe probe head are the sum of the interaction of the parts, that are the subsystems used make the WLCSP spring probe contactor and or WLCSP spring probe probe head.
- **The structural design and manufacture of the spring probe, the spring probe contactor or spring probe probe head are crucial factor in determining how precisely the spring probe tip will hit its WLSCP device under test target balls, pumps or pads.**

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From Everyone at Technoprobe
Thank You for Watching Our Video

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