IEEE SW Test Workshop

Semiconductor Wafer Test Workshop

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Stud Bump Technology for Space Transformer Lifetime Improvement on Cobra Probe Card

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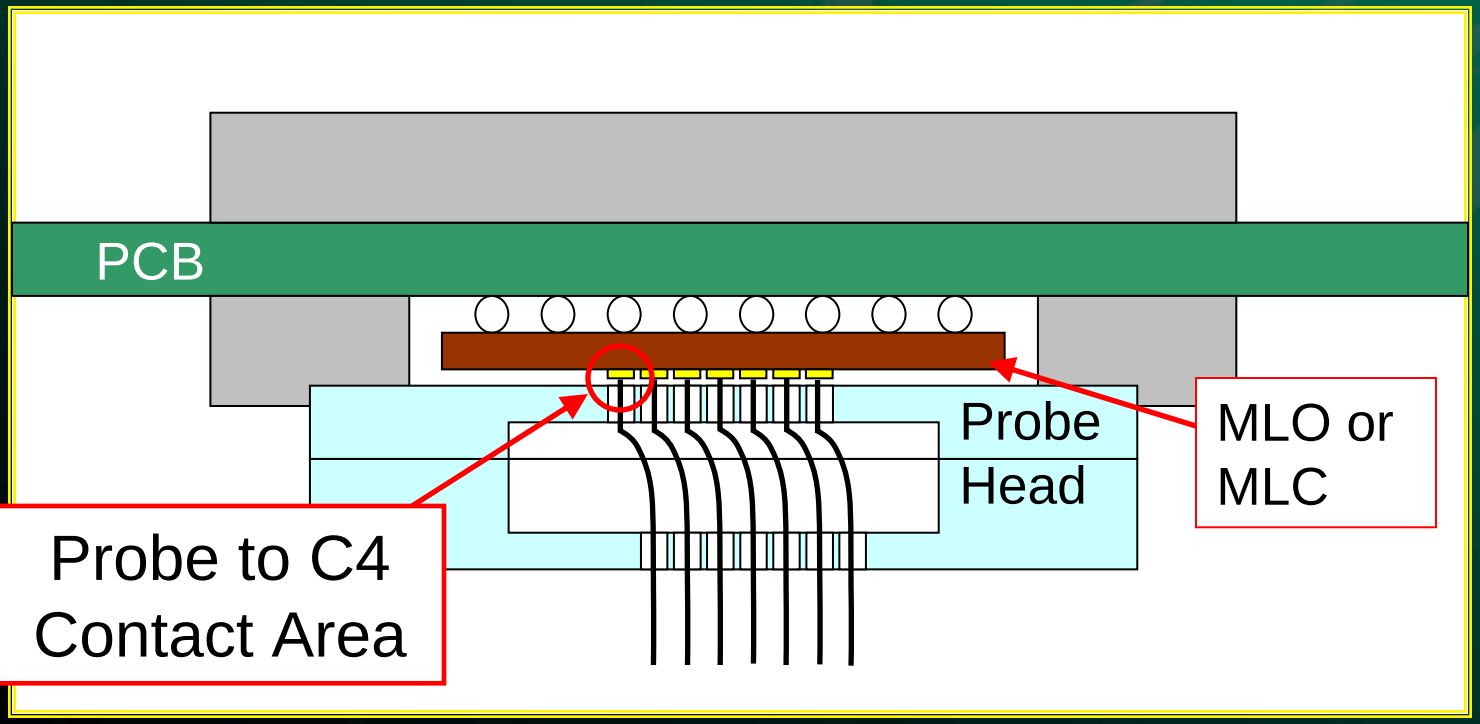
Introduction

- Typically all Vertical Probe Cards have common features such as:
  - Package attached to the PCB
  - Probes aligned to make contact to MLC pads

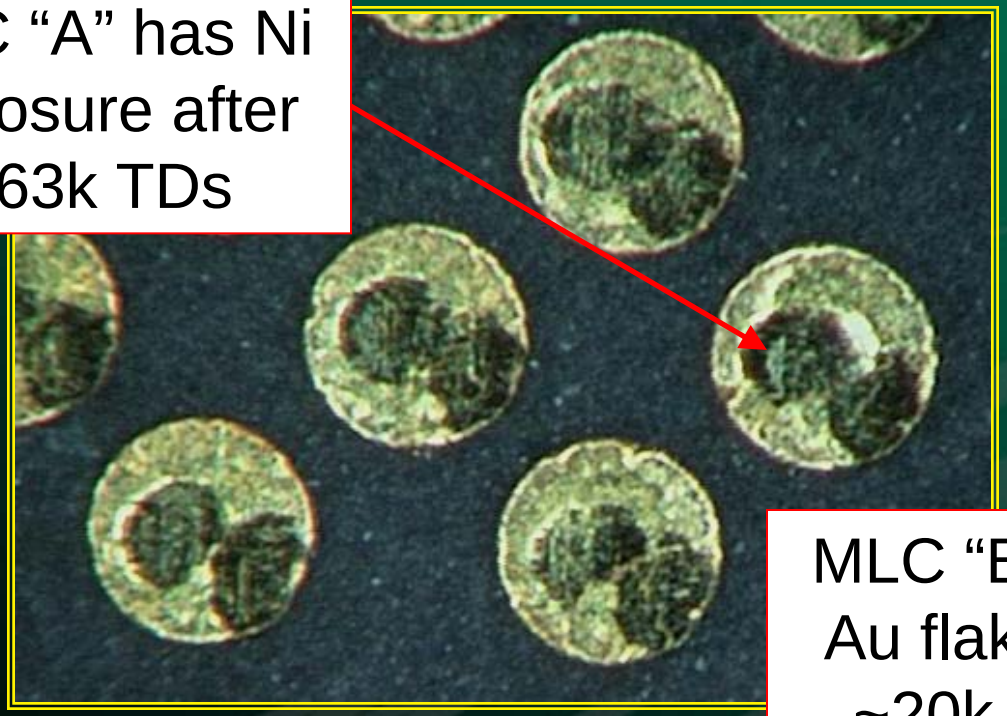


Problem Statement

- The C4 pad is susceptible to aggressive wear by the Cobra Probe during normal operating conditions causing reduced Probe Card life

Worn C4 Contacts

MLC “A” has Ni exposure after ~63k TDs



MLC “B” has Au flakes at ~20k TDs

- Probes contacting the C4 surface can damage the thin gold layer that protects the under-metals from oxidation.

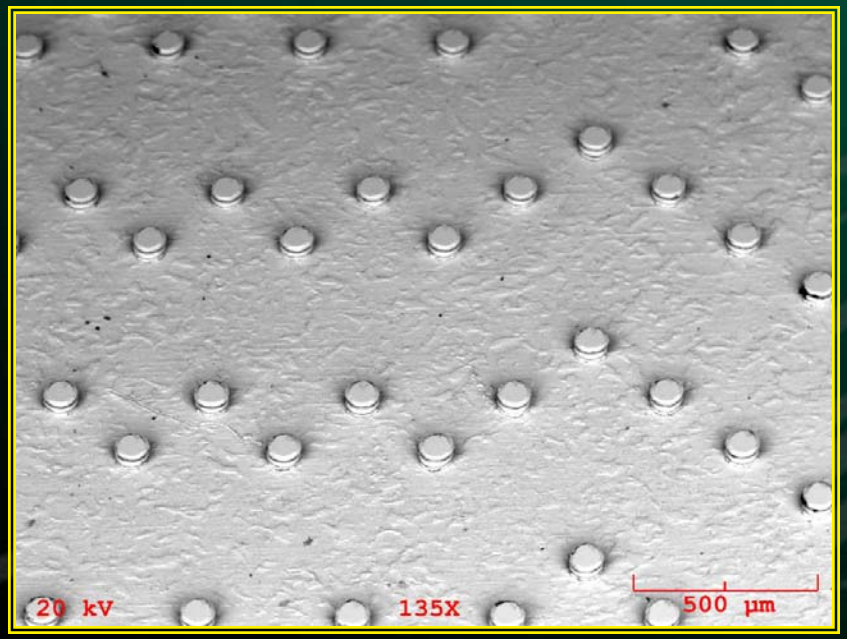
What this Damage Means

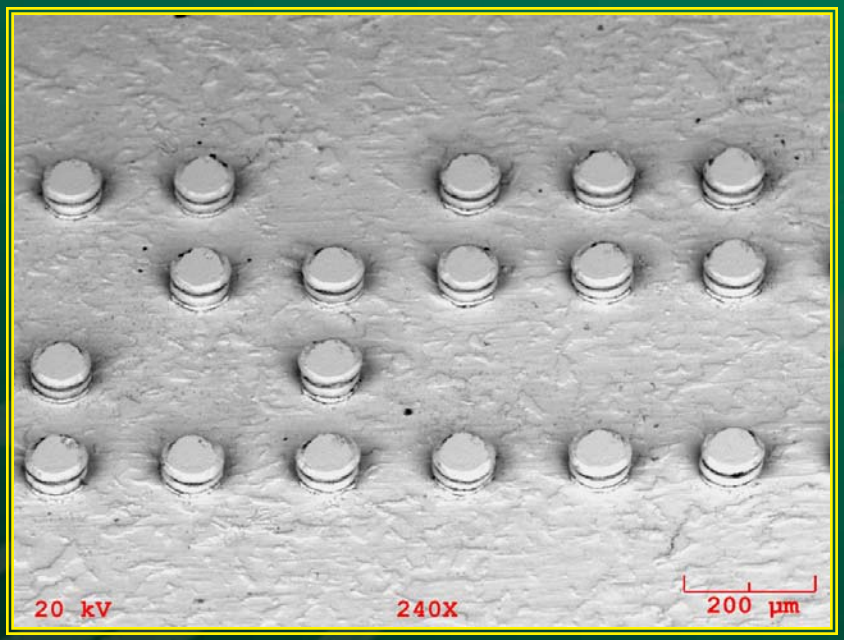
- The pad damage causes:
  - Yield loss due to false failures
    - Shorting
    - High contact resistance
  - Lost time in re-sort
  - Tester down time due to Probe Card repair
    - Removing gold flakes
    - Re-plating of C4 pads

Solution

- Use standard Wire Bond Technology customized to add a Stud Bump to the Probe Contact Surface that is:
  - A non-oxidizing conductive alloy
  - Hard enough to withstand 1M cycles with little wear & no flakes
  - Has no degradation in electrical performance

SEM of Alloy Stud Bumps



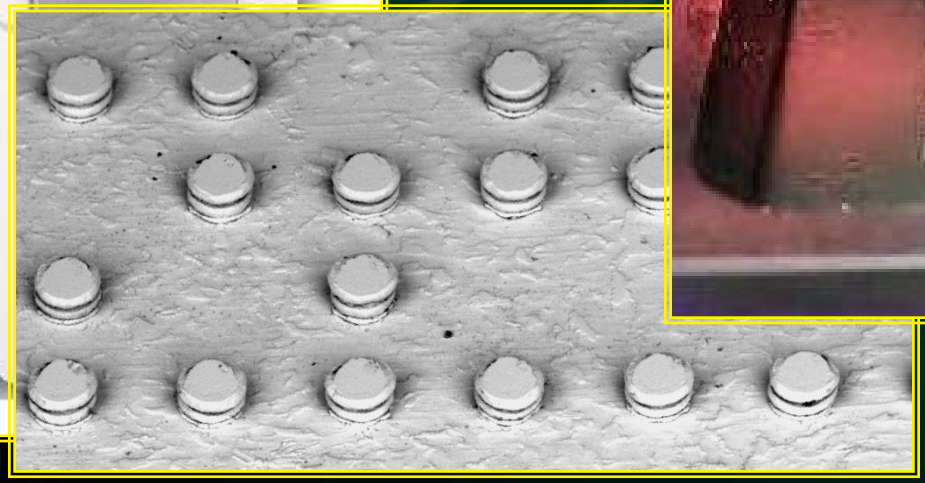


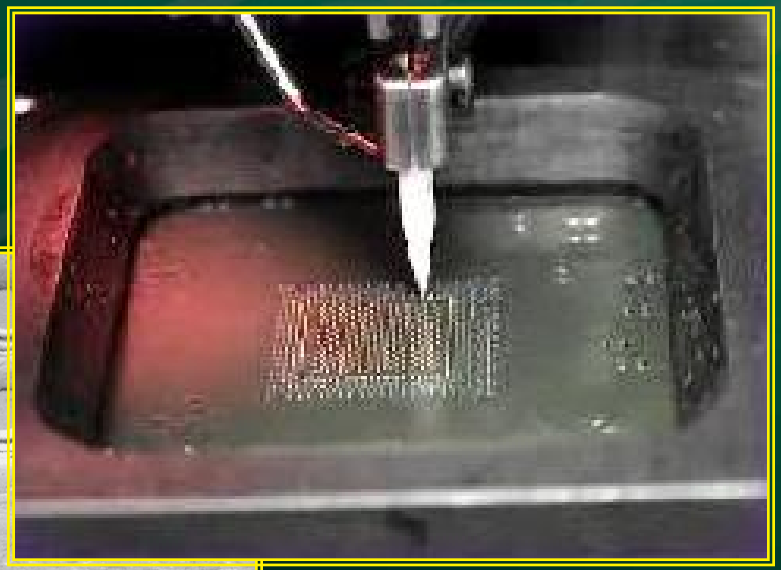
Stud Bump Process

- Proven wirebond technology provides excellent control of the manufacturing process
  - Stud Bump Diameter
  - Stud Bump Height
  - Positional Accuracy
  - Positional Repeatability

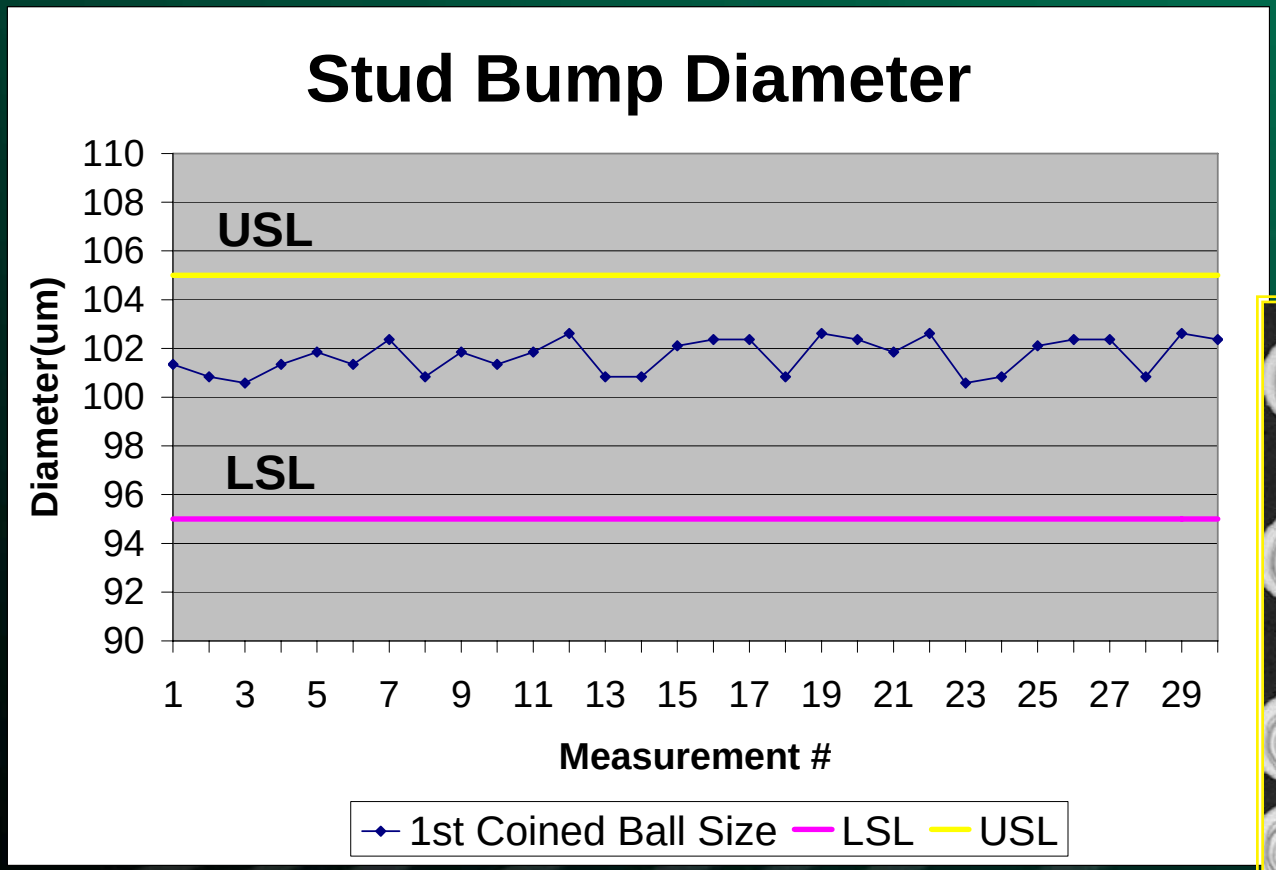
Process

Custom application of the Wire Bond Technology enables an excellent probe contact



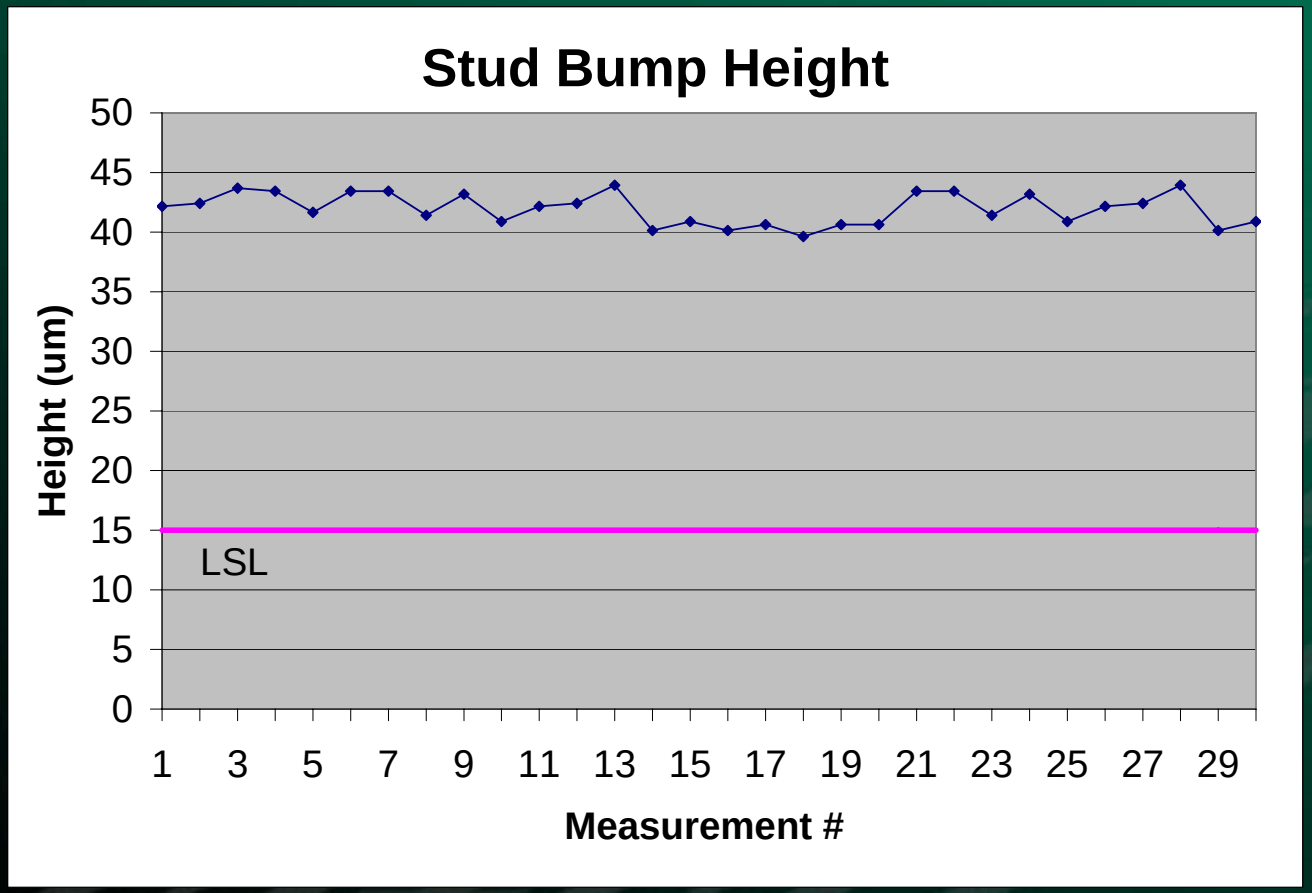


Process: Diameter



- Wire Bond process control allows for consistent Stud Bump diameters which provides the opportunity for tight pitches

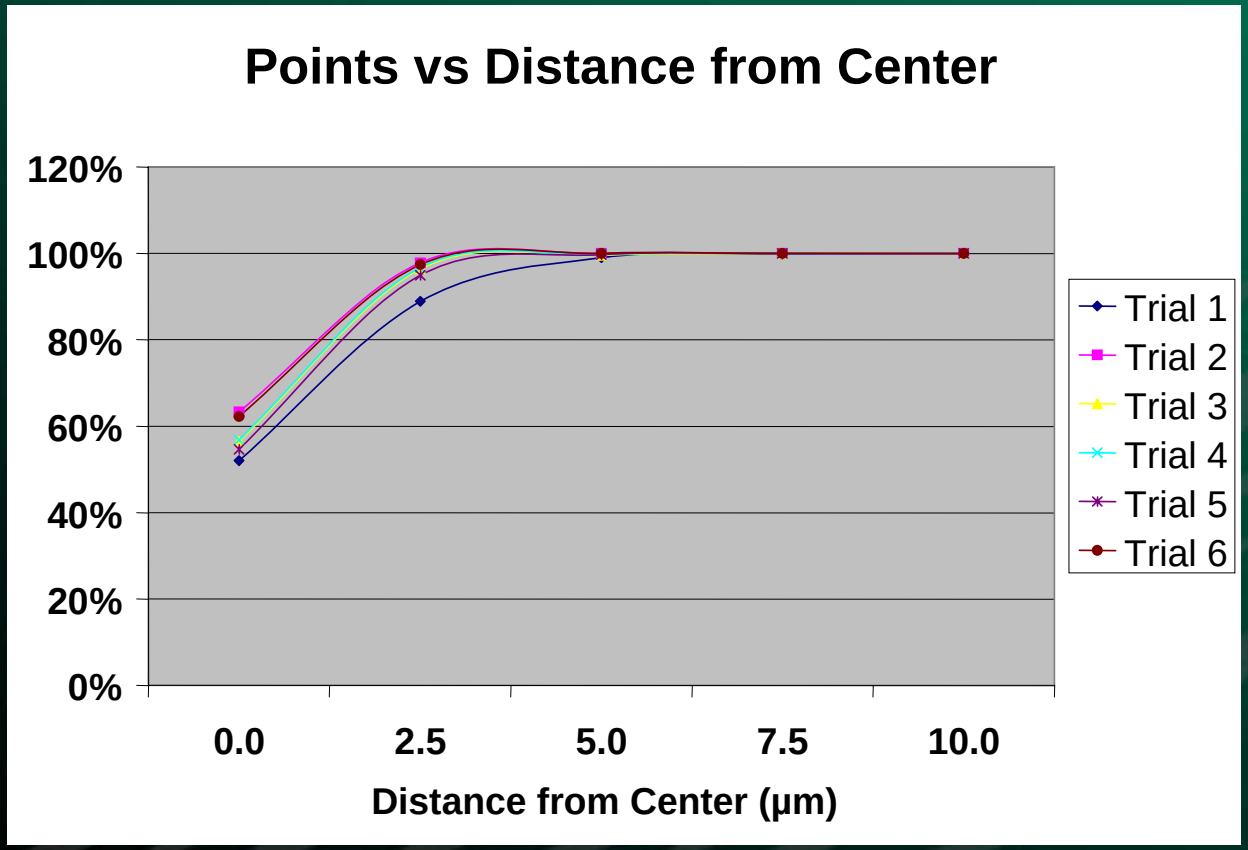
Process: Height



- Variable Heights are Achievable
- Can be Controlled to a Minimum of 15µm high

- Wire Bond Process can provide tightly Controlled Bump Heights

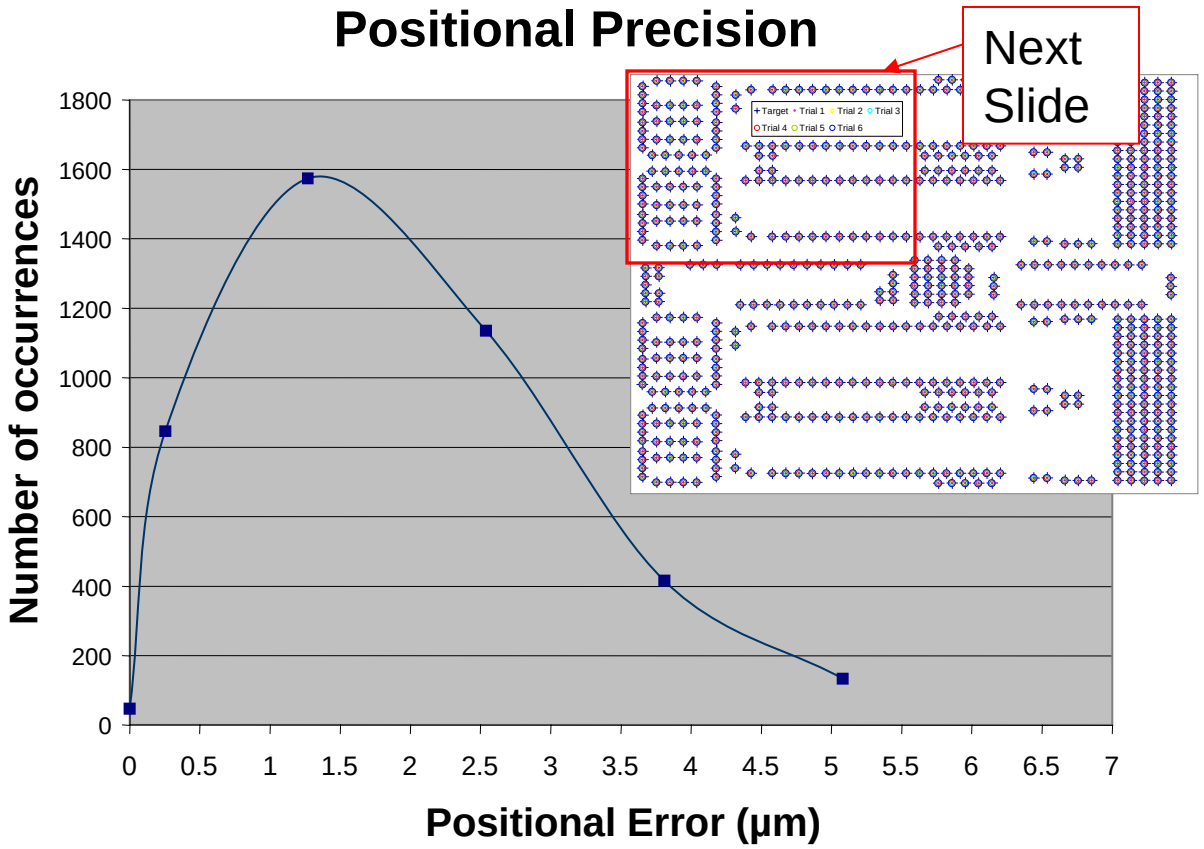
Process: Positional Accuracy



- Six Packages of the Same Pattern Compared for Accuracy
- All Six Trials have Similar Results - 100% of the Points within 7.5 µm

- Pad Find Feature of the Wire Bonder is Accurate to 7.5 µm

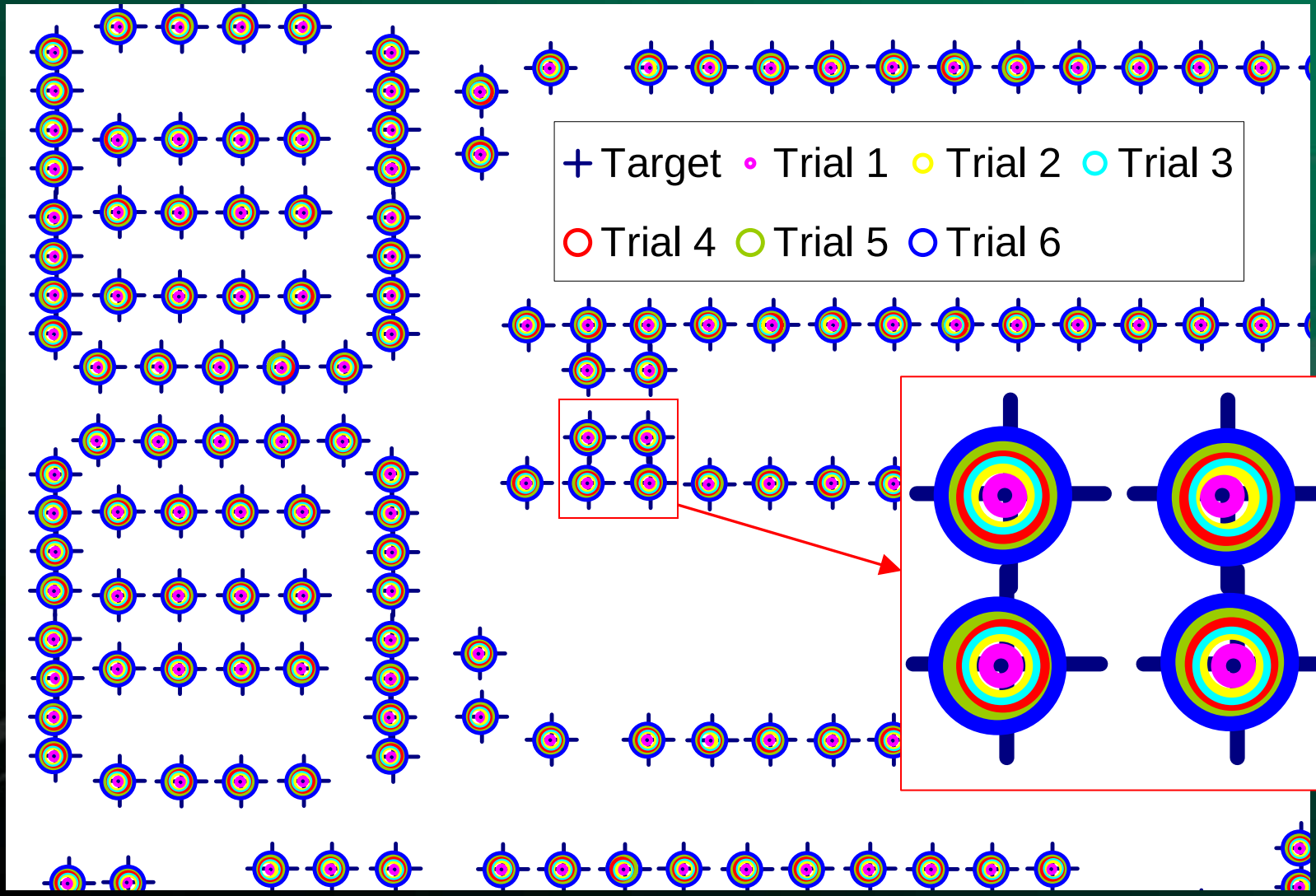
Process: Repeatability



- Small Inlay is a Plot of the Array use in the Study
- 90% Confidence Interval that position will repeat within 2.5 µm

- Plot of how repeatable the Stud Bump position was at each point over the 6 trials

Process: Repeatability



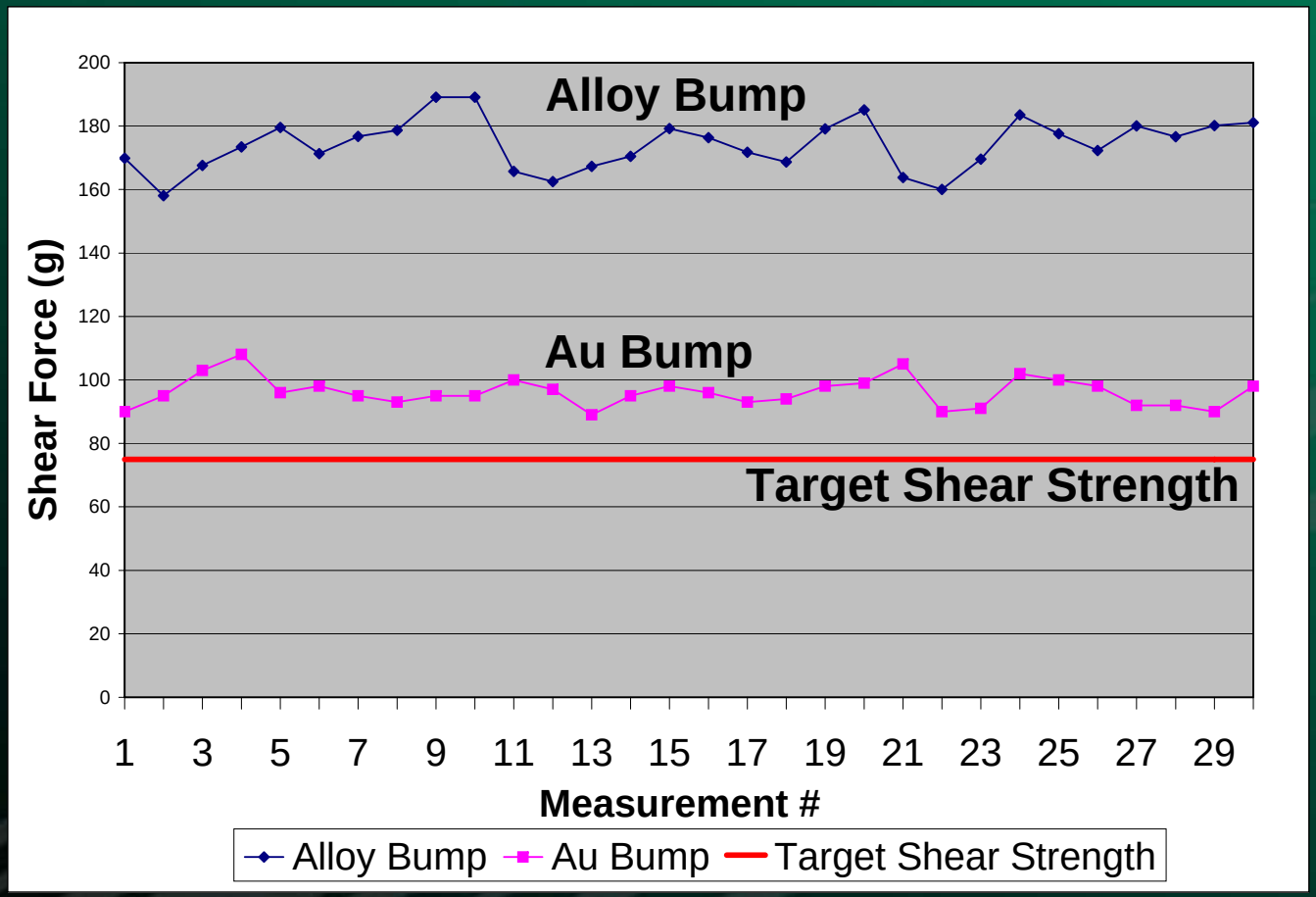
Stud Bump Specifications

- Maximum Diameter: 100 ± 5 µm
- Height: Minimum of 15 µm after Final Planarization
- Positional Accuracy: ± 7.5 µm
- Positional Repeatability: 2.4 µm

Stud Bump Reliability

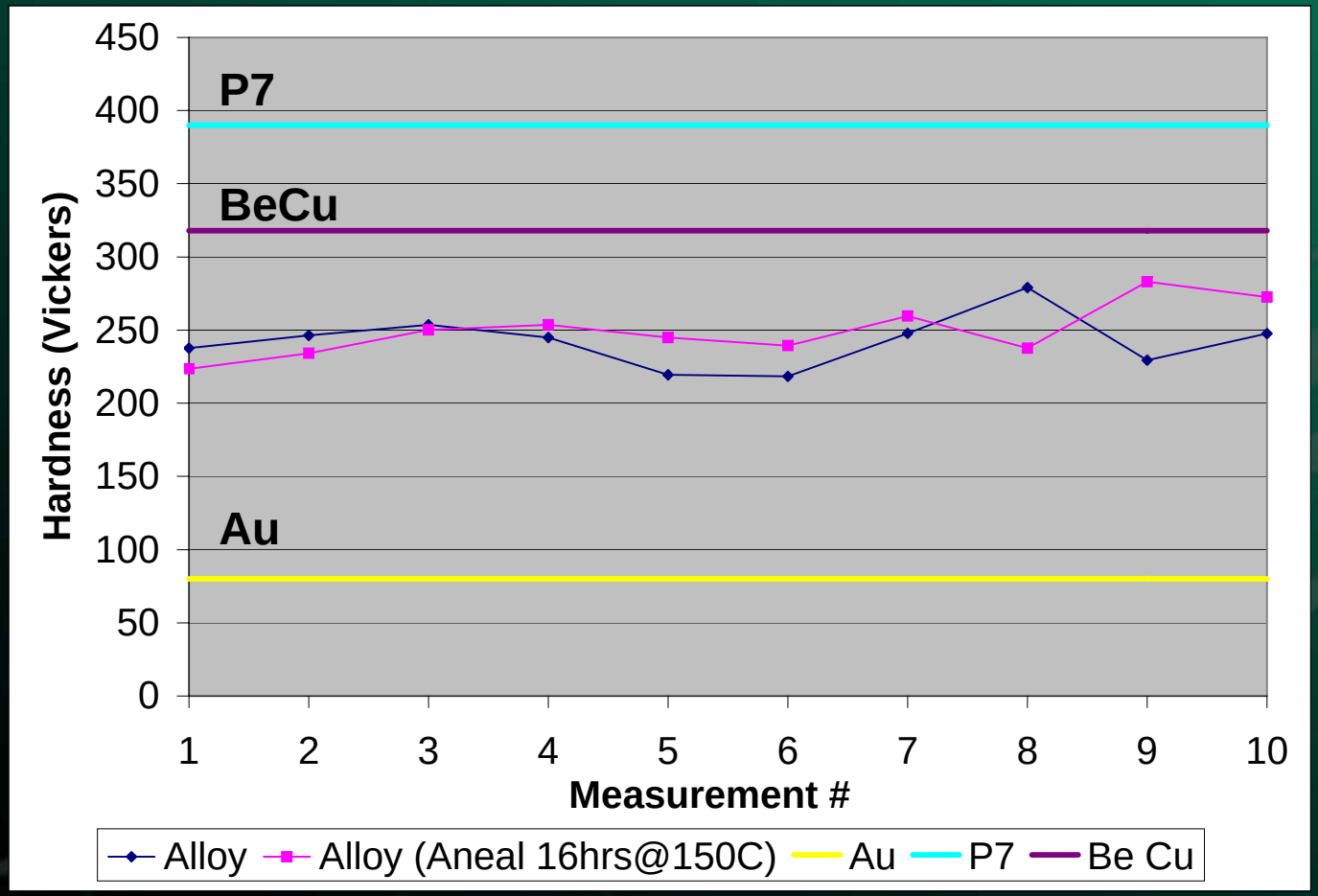
– Extensive internal testing was performed to prove the mechanical robustness of the Stud Bump. The Stud Bump reliability was studied on:
  - Strength – Shear tests are used to determine the Strength of the Stud Bump
  - Hardness – The Stud Bump hardness was studied and compared to other commonly used materials
  - Wear – The Stud Bump was exercised 1M Cycles with a 4 mil Probe

Reliability: Stud Bump Strength



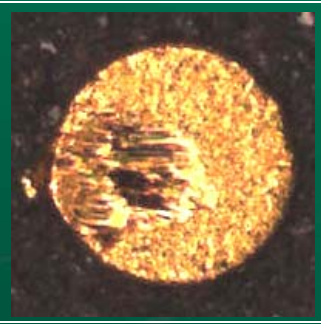
- Stud Bump adhesion exceeds the target shear needed for lifetime

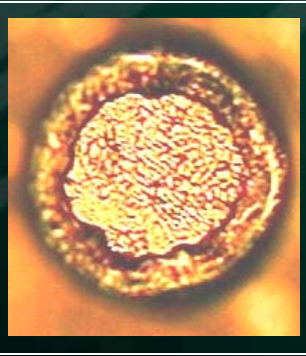
Reliability: Stud Bump Hardness



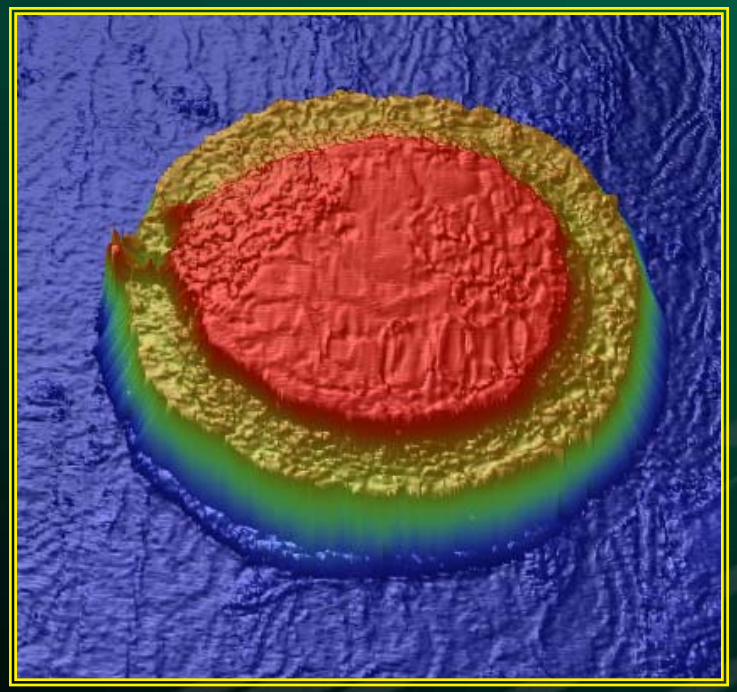
- Alloy is much closer to the probe's hardness
- Alloy hardness is stable at high temp probing applications

Reliability: Wear

4 mil probe ~20k cycles on MLC Gold Pad	

	0 Cycles	1M Cycles
4 mil Probe @ 5 mils OD Coupon 5		
4 mil Probe @ 8 mils OD Coupon 8		

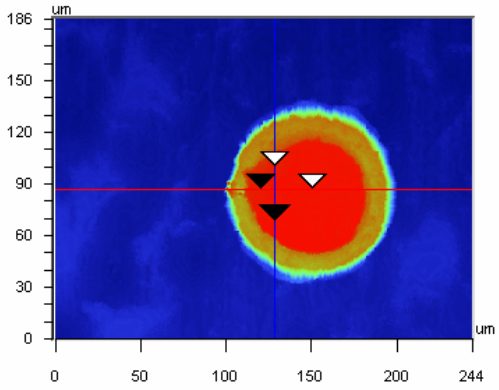
Reliability: Wear

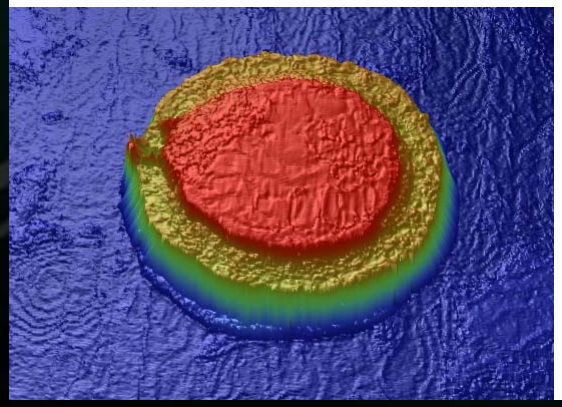


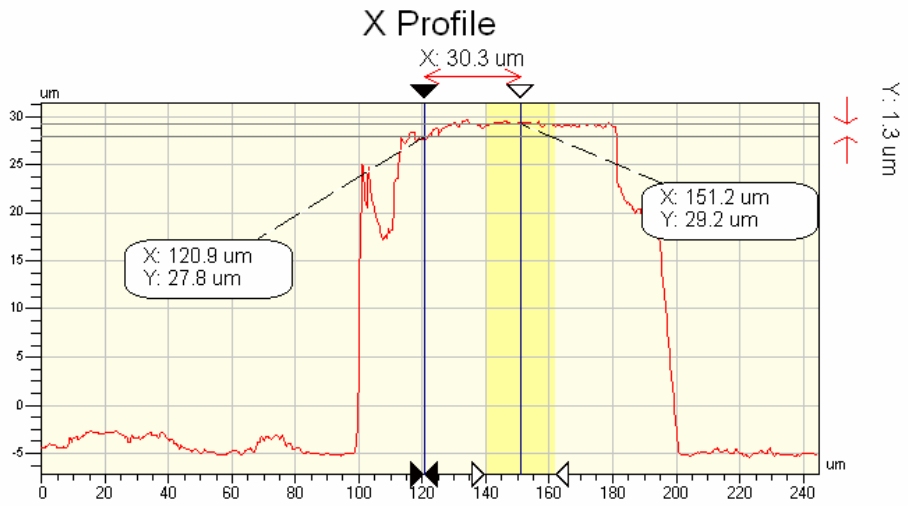
Typical Stud Bump Wear @ 1M Cycles

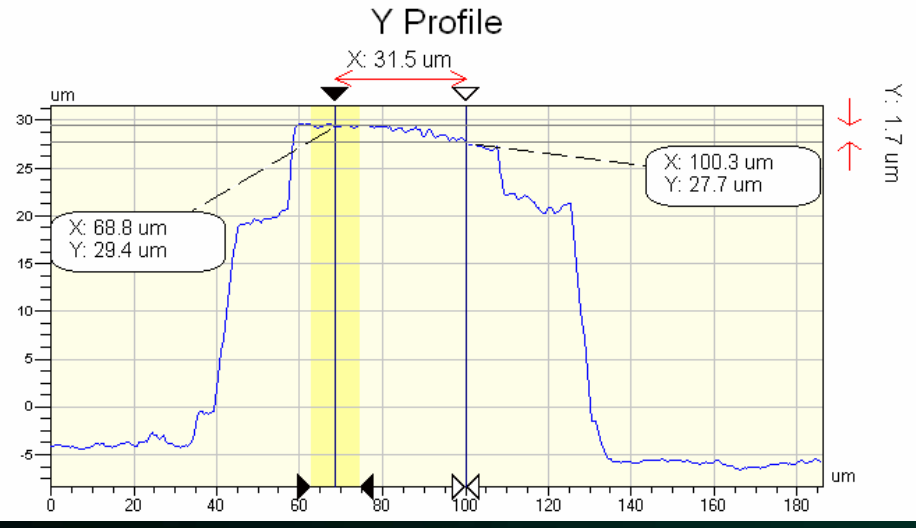
Reliability: Wear

Wear @ 1M Cycles







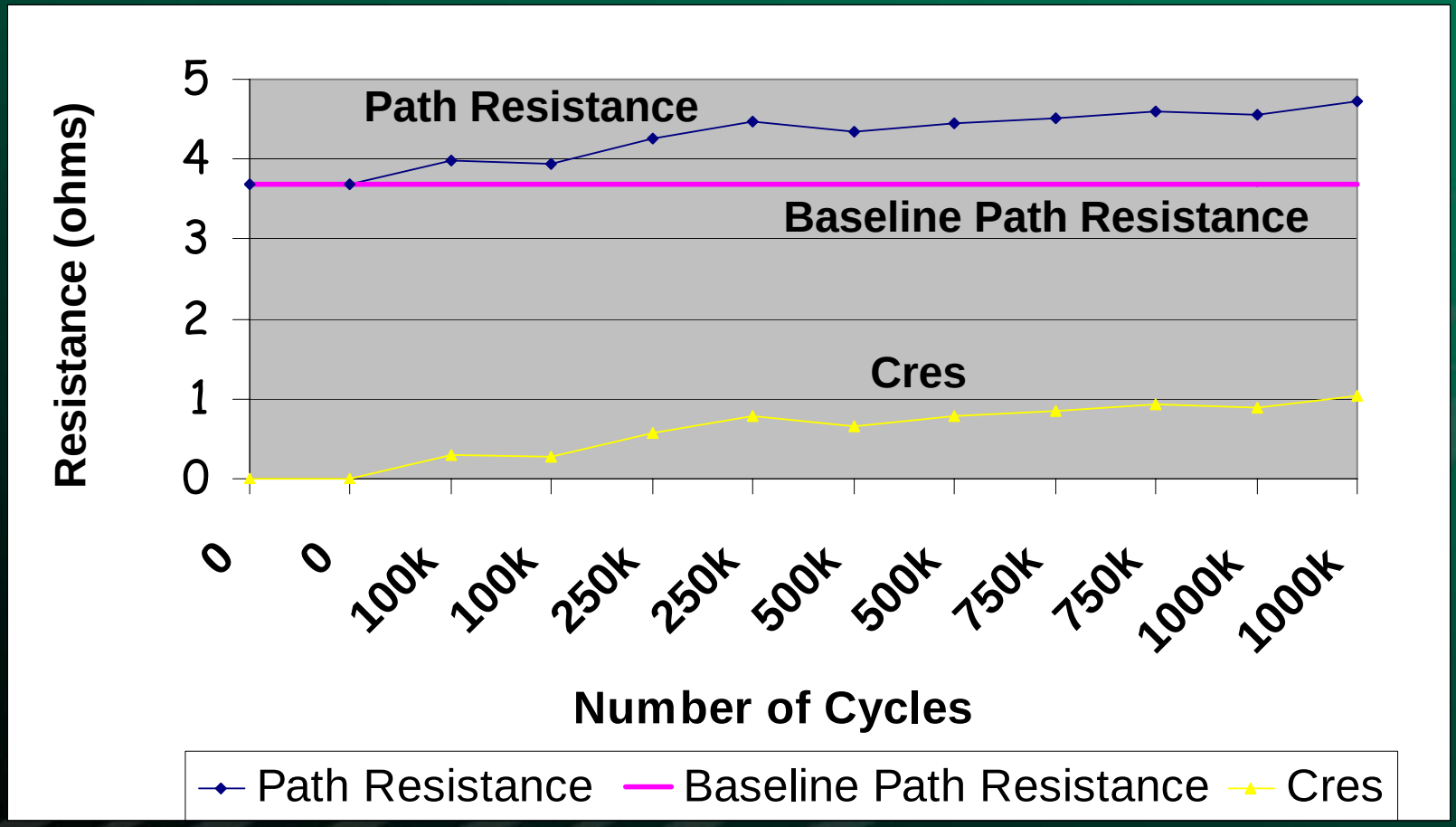


Stud Bump Performance

– The Stud Bump Performance is based in the Results of Lifetime Testing on a Test Vehicle

- Cres – Contact Resistance was measured over 1M cycles on an aluminum wafer
- Octagonal Cleaning – The effects of octagonal cleaning on the probes was studied to see if the cleaning cycle would cause wear

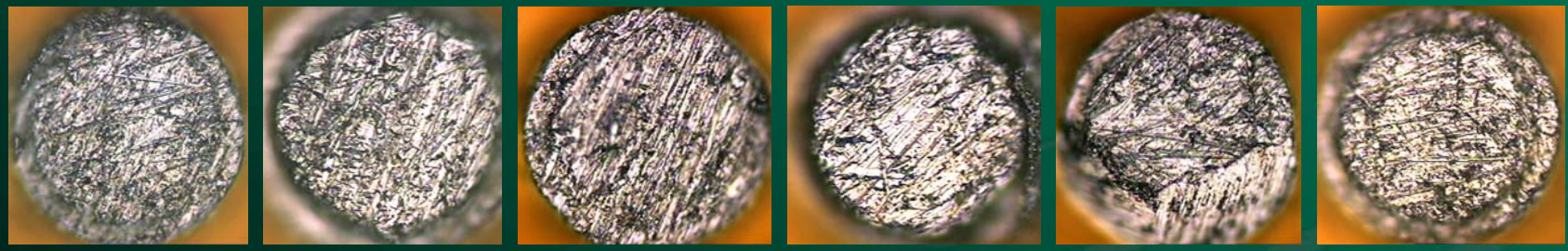
Performance: Electrical



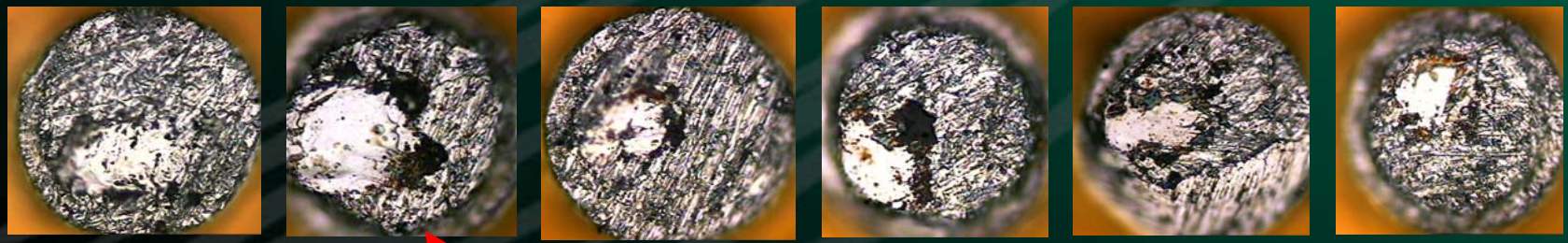
- Cres Changed < 1 Ohm over 1M Cycles with no cleaning

Performance: Octagonal Clean

Alloy Stud Bumps @ 0 Cycles



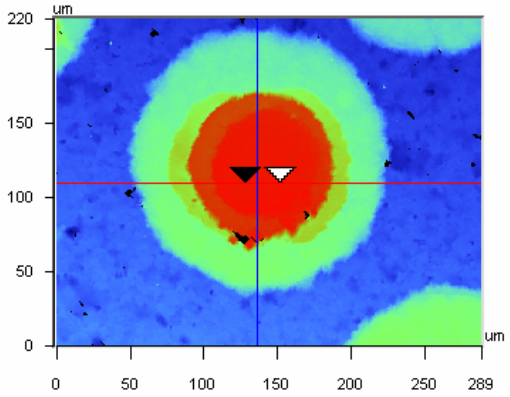
Alloy Stud Bumps @ 1M cycles plus 1000 cycles of octagonal cleaning in 3 µm cleaning film

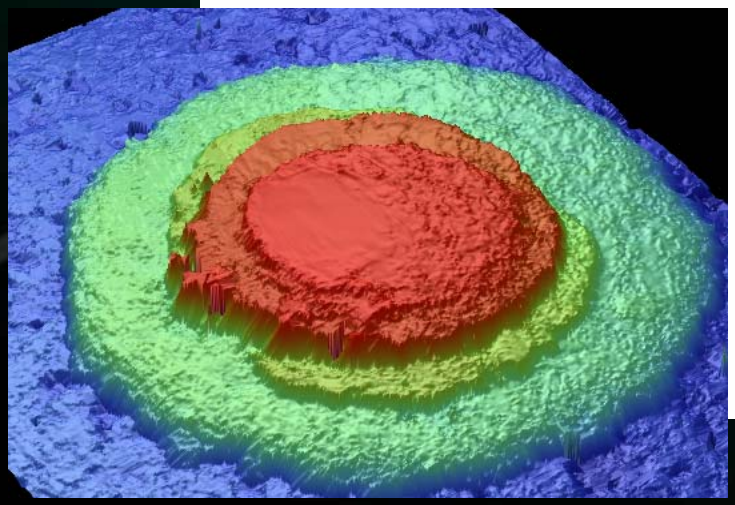


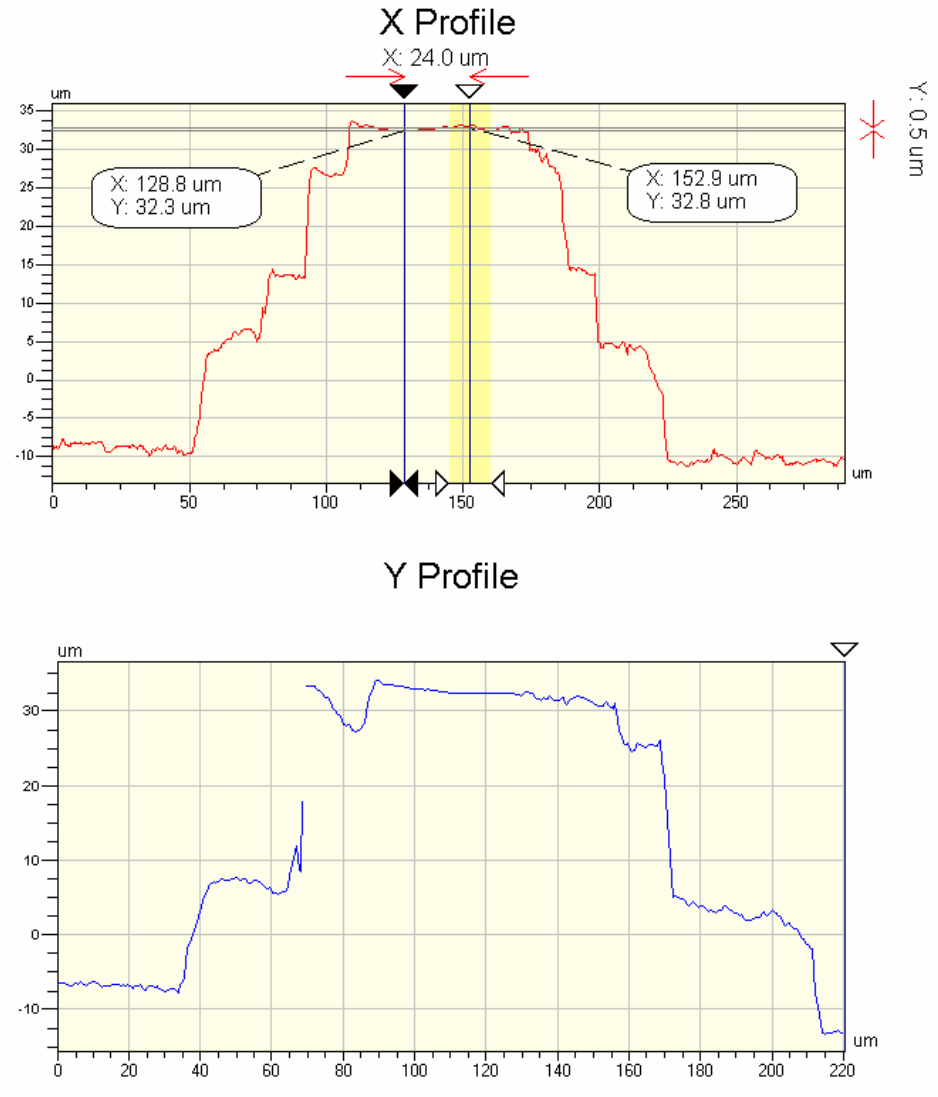
Profile of Wear
Next Slide

Performance: Wear

TV Wear after
1M Cycles and 1k
Octagonal Clean







Strengths

- Can be used on any MLC
- Uses proven bonding technology
- Does not add to build cycle

Weaknesses

- MLO needs engineering evaluation due to varied MLO fabrication processes

Summary

- Stud Bumps Wear ~ 2 µm over 1M Cycles @ 8 mils OD
- Stud Bump Position is Accurate and Precise
- Stud Bump Diameter is Stable over the Life of the Contact
- Stud Bump Height is stable and repeatable
- Stud Bump Hardness is stable at 150°C probing temperature
- Path Resistance remains stable over the life of the Probe Card

Conclusion

- A Stud Bumped Substrate will provide a reliable contact up to 1M Cycles without significant wear or loss in electrical performance thereby reducing the cost of Probe Card ownership

Next Step

- Continue Beta Testing with Infineon
- Continue Process Development on MLOs
- Expand the Stud Bump Process to Wired Space Transformers

Acknowledgements

- Thanks to Christian Degen and Michael Horn of Infineon Technologies AG for partnering with us to perform life time testing.