SWTEST

PROBE TODAY, FOR TOMORROW

2024 CONFERENCE

Risk Mitigation Strategies for mmWave Production Test Environments

FormFactor™

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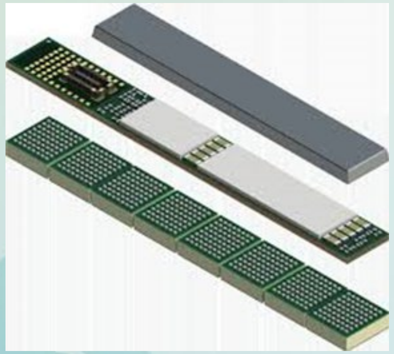
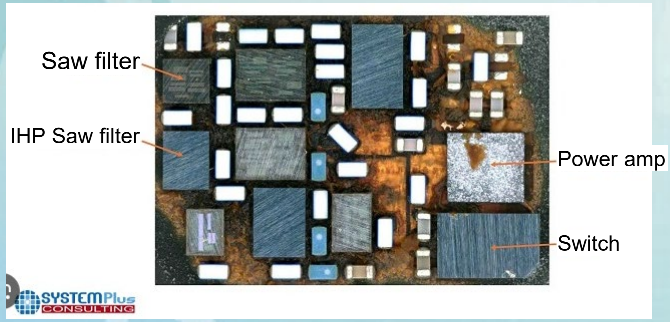
Drivers for RF Wafer Level Test

5G/6G mmWave Mobile

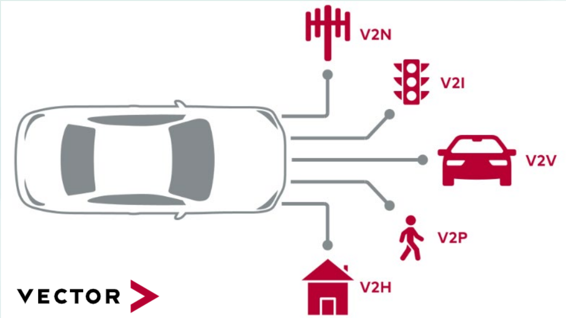
- Antenna in Package (AiP)
- RFFE Modules including LNA, switch, tuner and filter devices

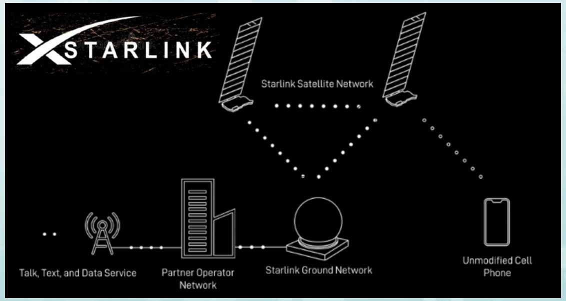




New Communications

- Between vehicles (V2V) and between vehicles and infrastructure (V2I)
- Satellite internet and direct to mobile





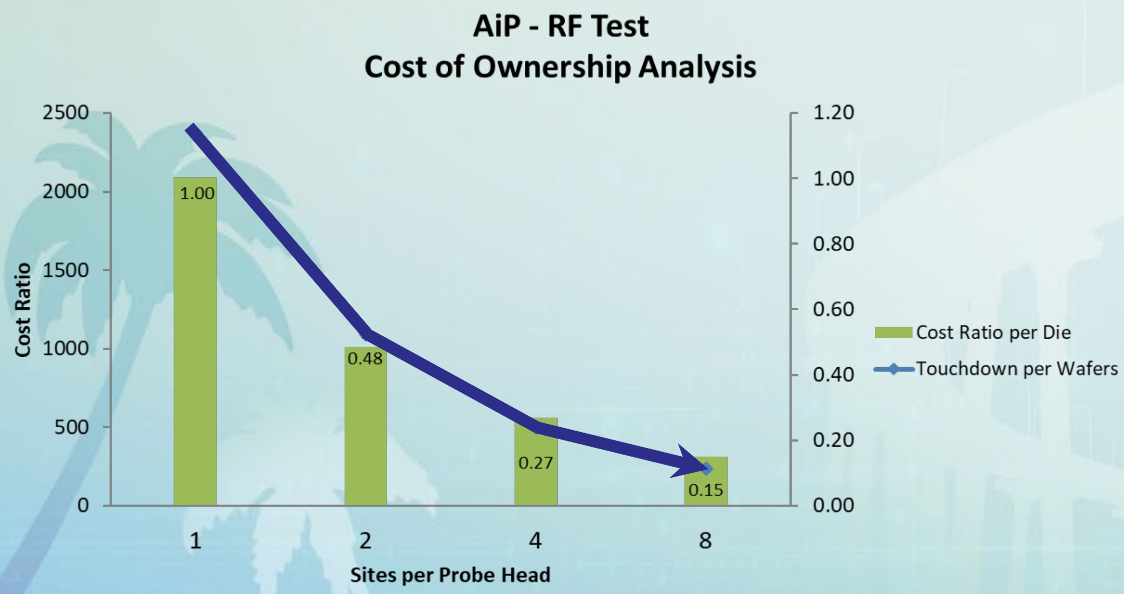
IoT and Wearables

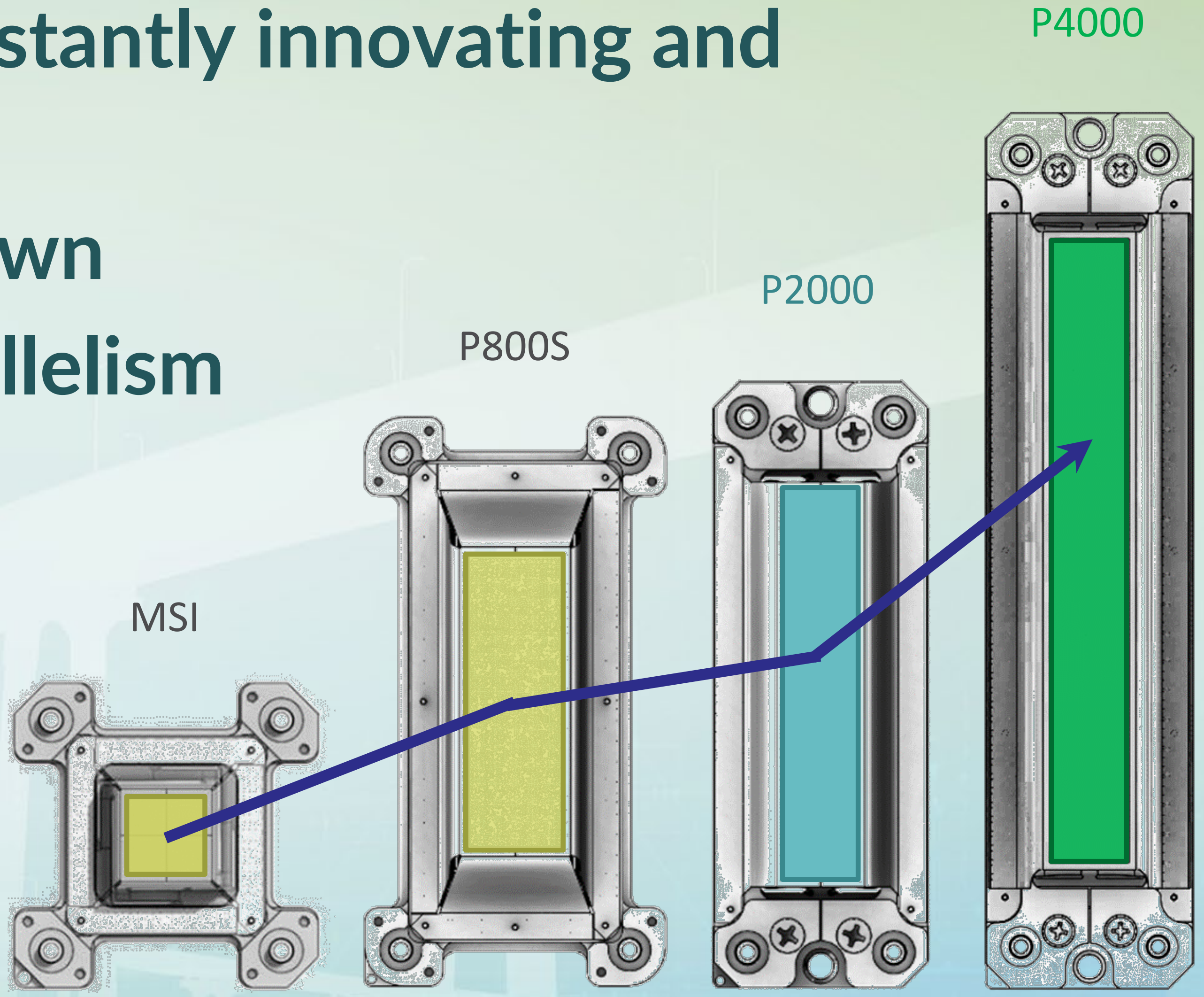
- AR/VR
- Smart TVs
- Watches
- Etc…

EE Times ASIA

Raising the Bar

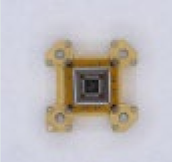
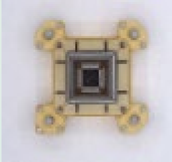
- RF device technology is constantly innovating and ramping-up volumes
- Costs-of-test must come down
- Ergo, we must increase parallelism





(Approx. to scale)

A new challenge was also raised

						
Metric	**Unit**	**RFC**	**MSI**	**P800s**	**P2000s**	**P4000s**
Typical pin count	**#**	20	50	1200	2500	5000

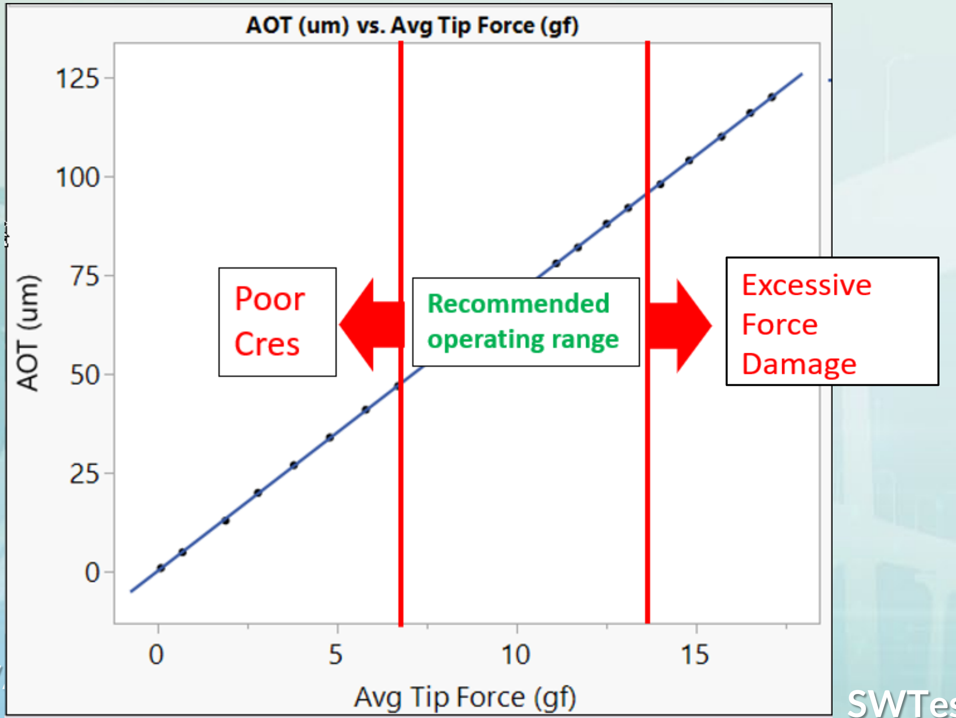
- **Larger probe heads with more probes create high system forces**
- **Resulting deflections need characterization to ensure optimal contact and durability**
- **A novel method was used to precisely characterize relative deflections**
- **Bonus: Real world deployment revealed some unexpected transient responses**

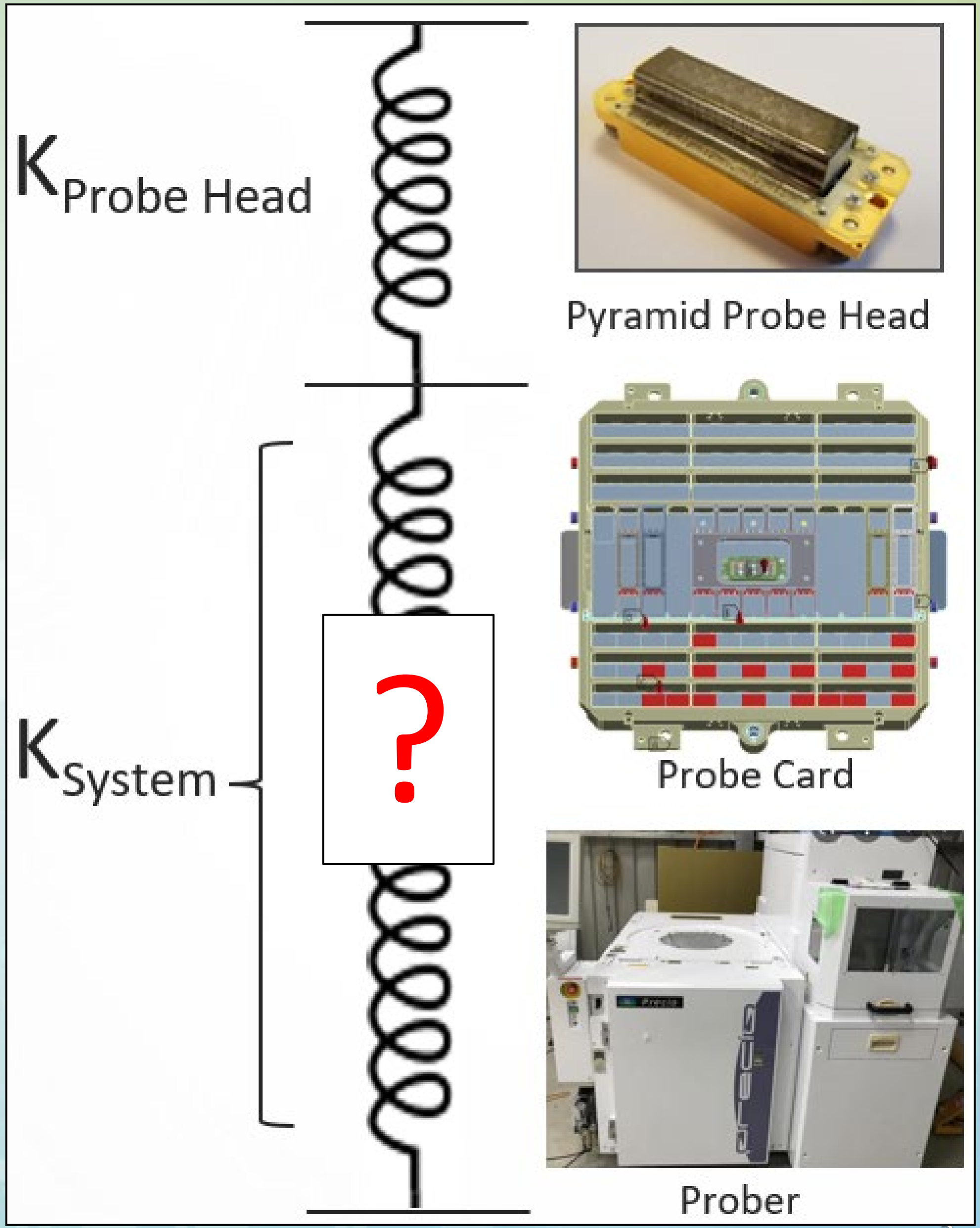
The Need

- With high pin count FFI Pyramid probe heads, a significant portion of the prober overtravel (POT) is deflecting the system, not the probe head spring (AOT).

- A method is needed to measure the probe head spring deflection (AOT).

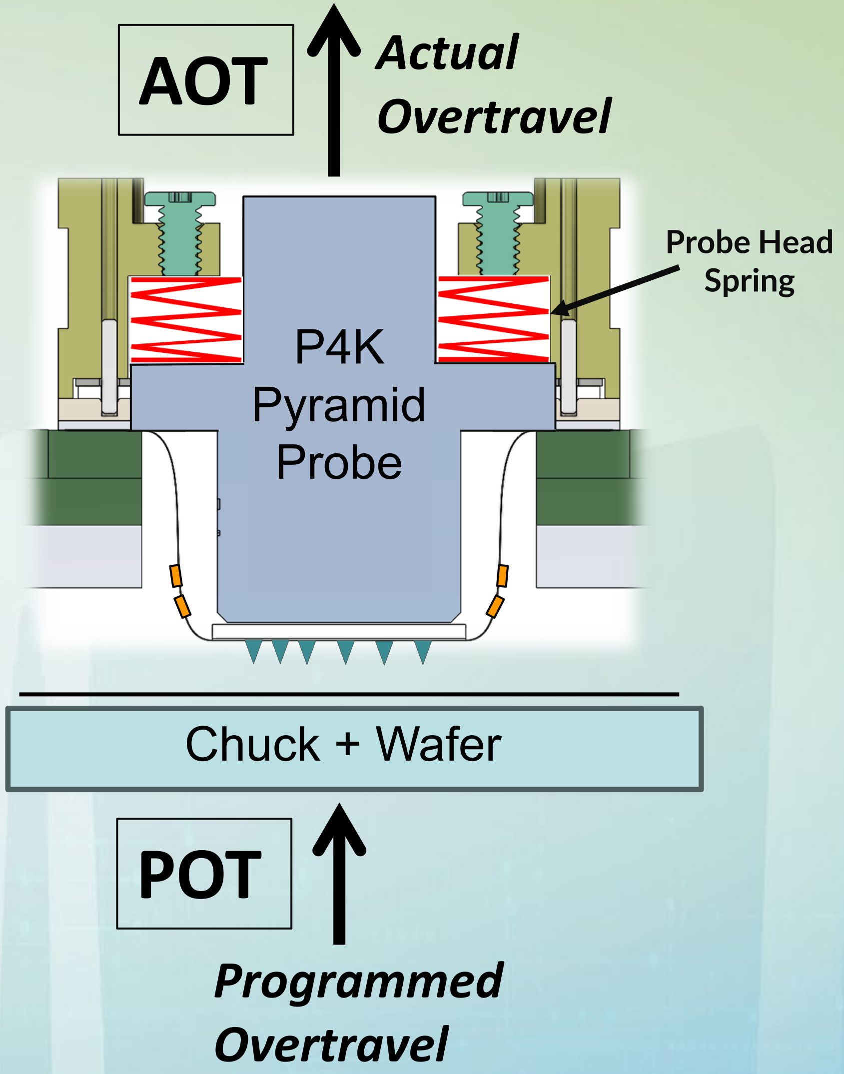
- Deflection measurements will enable FFI to recommend customer operating parameters (POT)





Definitions

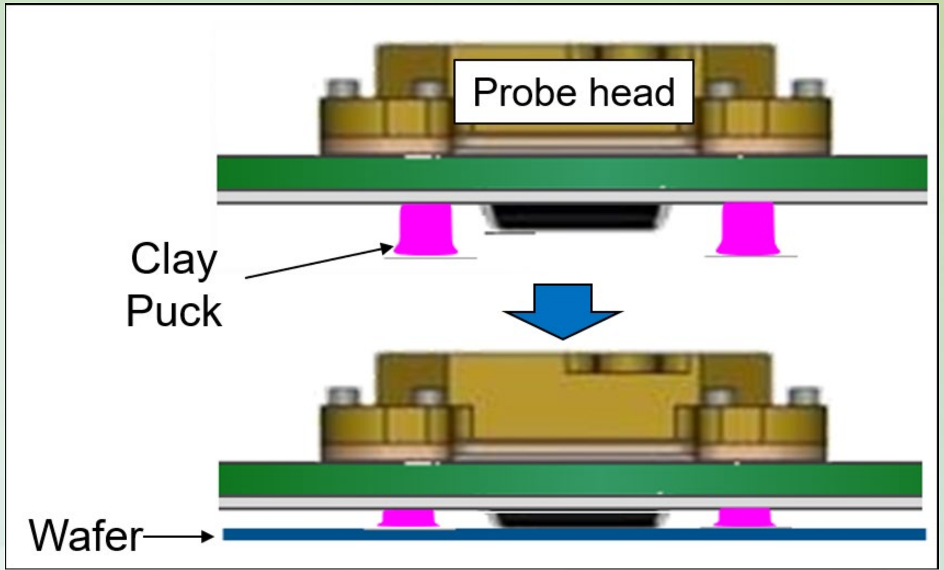
- **AOT=Actual Overtravel of probe head spring**
  - AOT has a direct relationship with probe force
- **POT=Programmed Overtravel of Prober Chuck**



Existing Methods to measure AOT/POT

1. Clay Puck Method

Process: Clay puck is compressed during overtravel. Changed height of clay puck is measured using prober camera.



Downsides: Accuracy less than desired

2. Push Pin Method

Process: Pin is pushed into stiffener during overtravel and then measured with prober camera.

Pin partially inserted before AOT/POT test

Pin pushed into receptacle after AOT/POT test

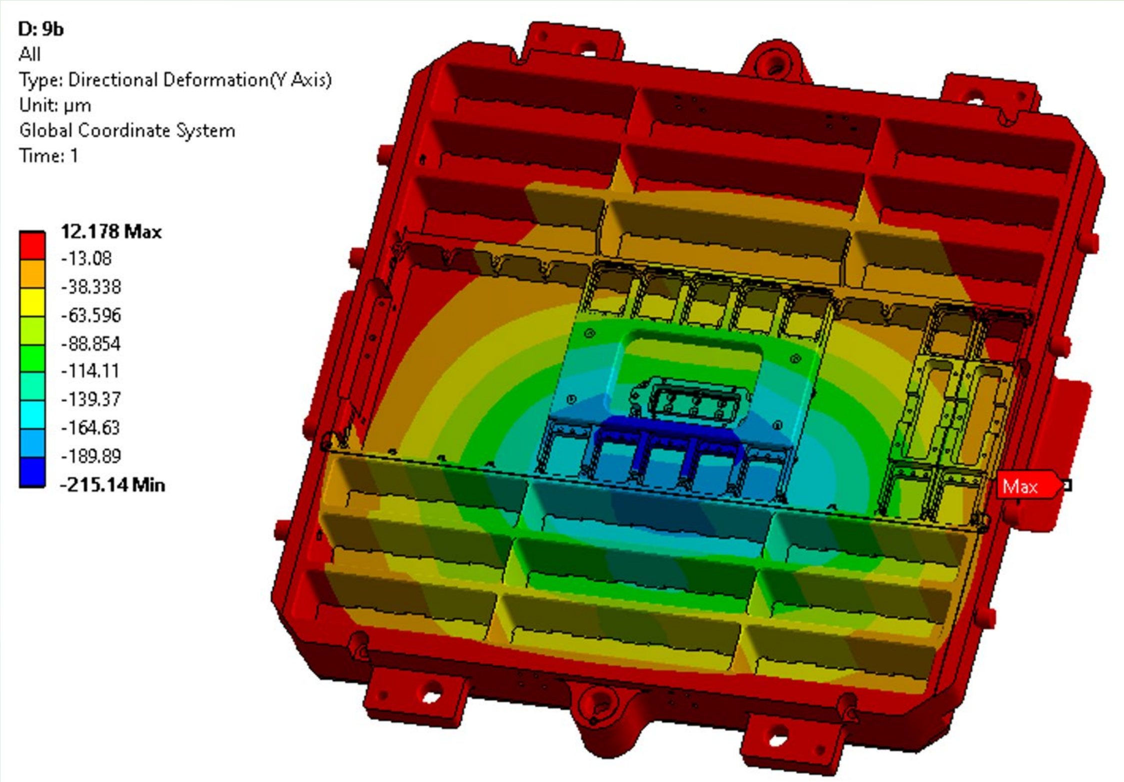
Downsides: Unable to use for FFI Pyramid

Simulation

- **FEA Simulations of the probecard have also been used to estimate AOT/POT.**

- **Downside: Modeling of AOT/POT is complex as the probecard, tester docking system, prober head plate, and chuck need to be modeled.**

- **A method for direct measurement of AOT/POT is preferred over simulation**



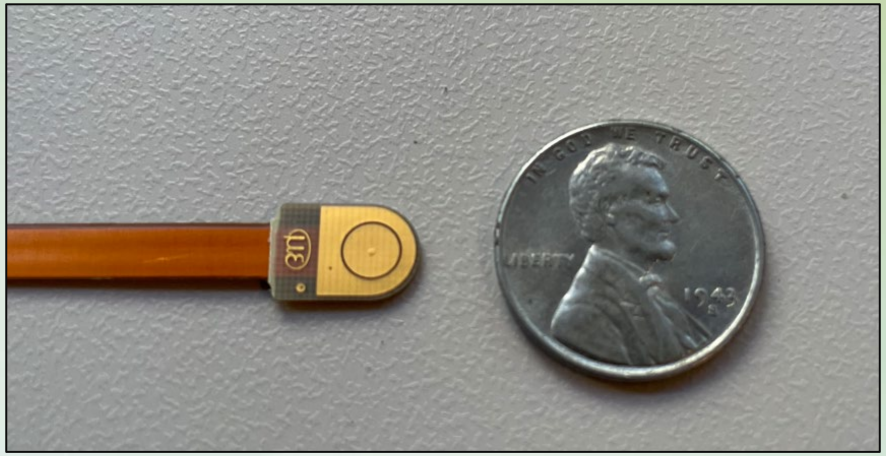
FEA Simulation of P2K and UltraFLEX Probe Card

A new method to measure AOT/POT

New Method: Flex circuit capacitive sensor

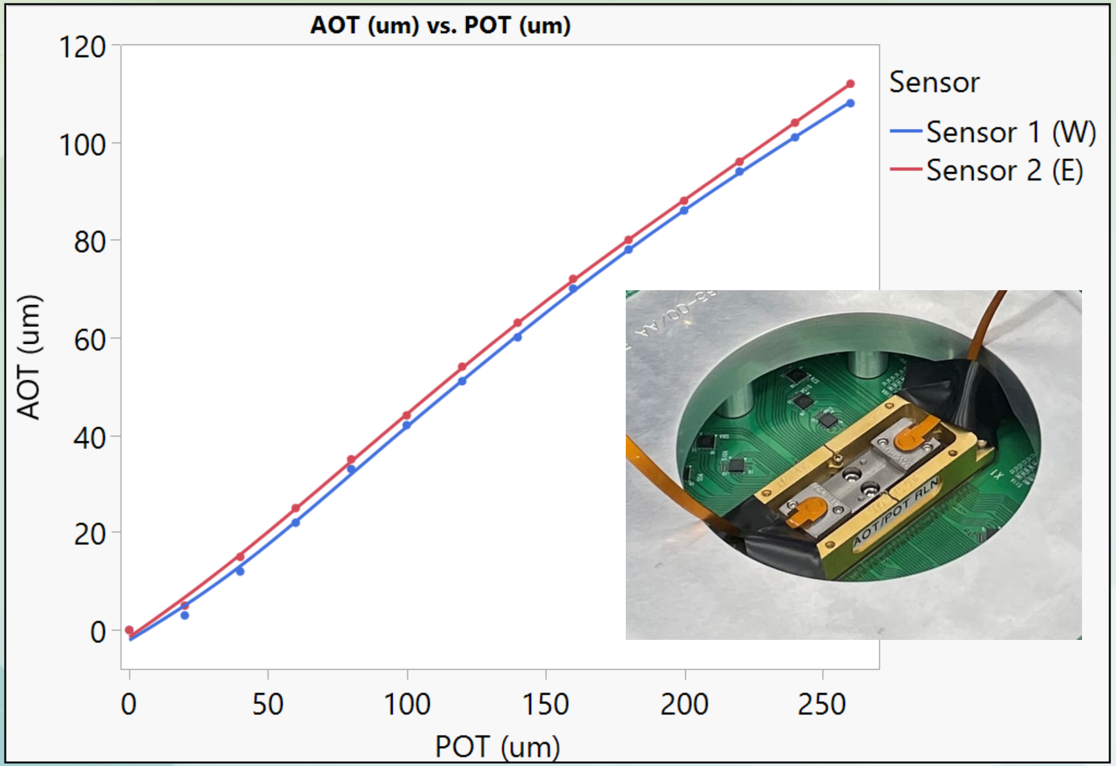
Highlights:
- <1µm resolution
- 4 data points per millisecond (4 KHz)
- 500µm range

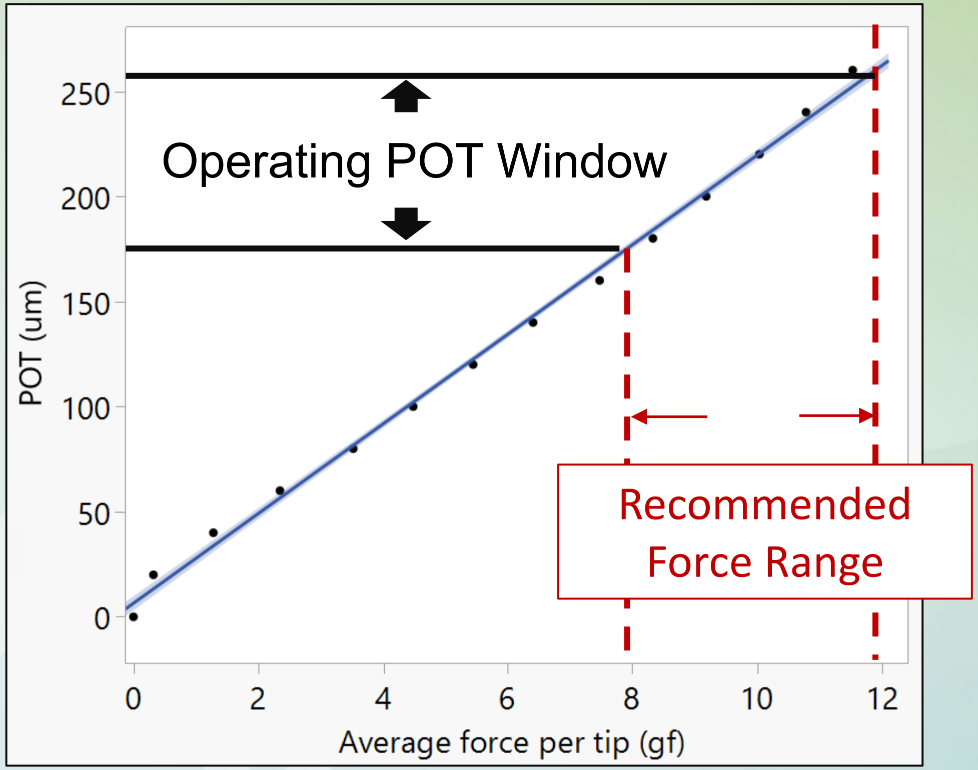
Lowlights:
- Cables must be routed out of prober/tester


Cap sensor next to Mr. Lincoln


P4K Probe with 2 cap sensors attached

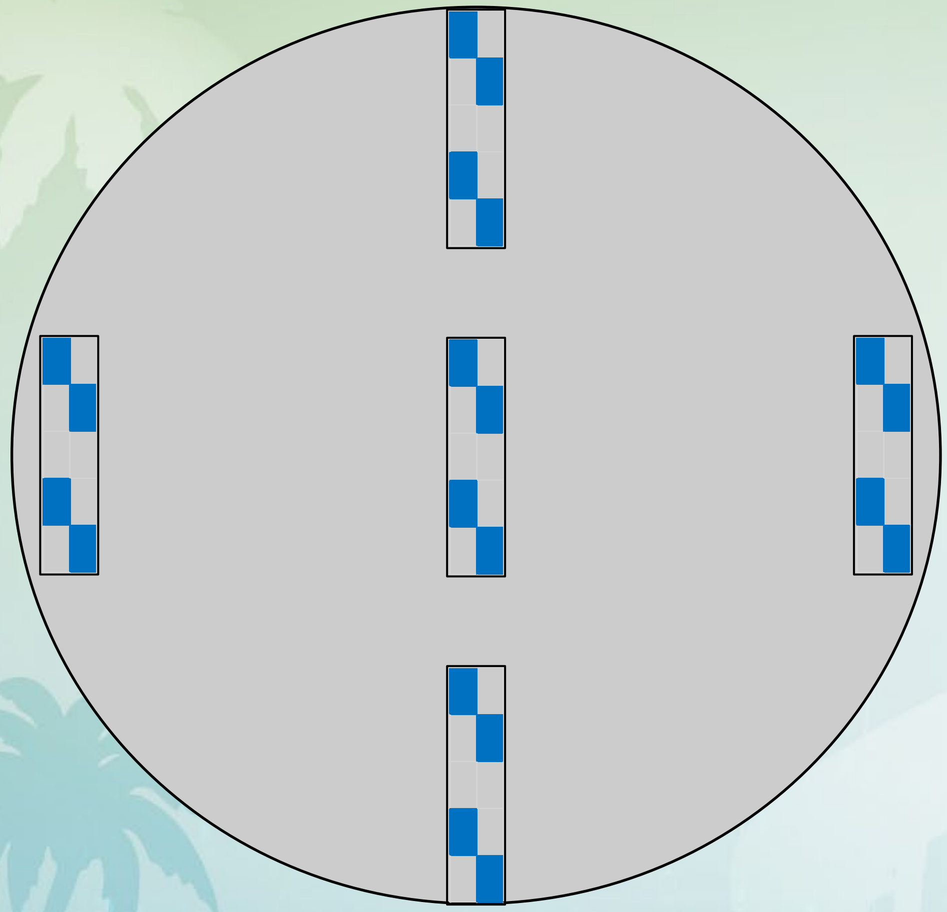
AOT/POT Results



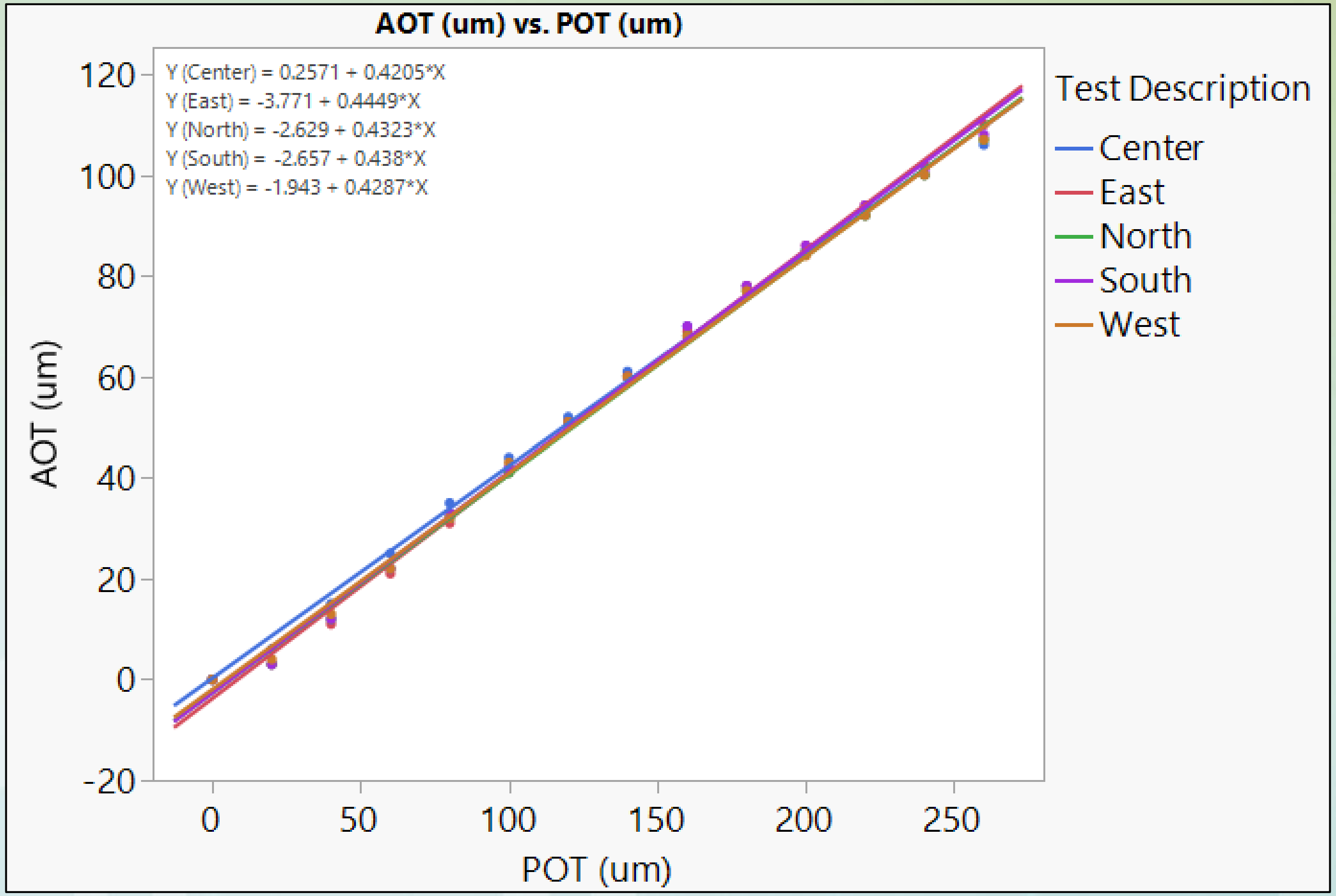


- Good correlation between both cap sensors (No significant core tilt)
- AOT/POT enables Operating POT window recommendation

AOT/POT By Wafer Location



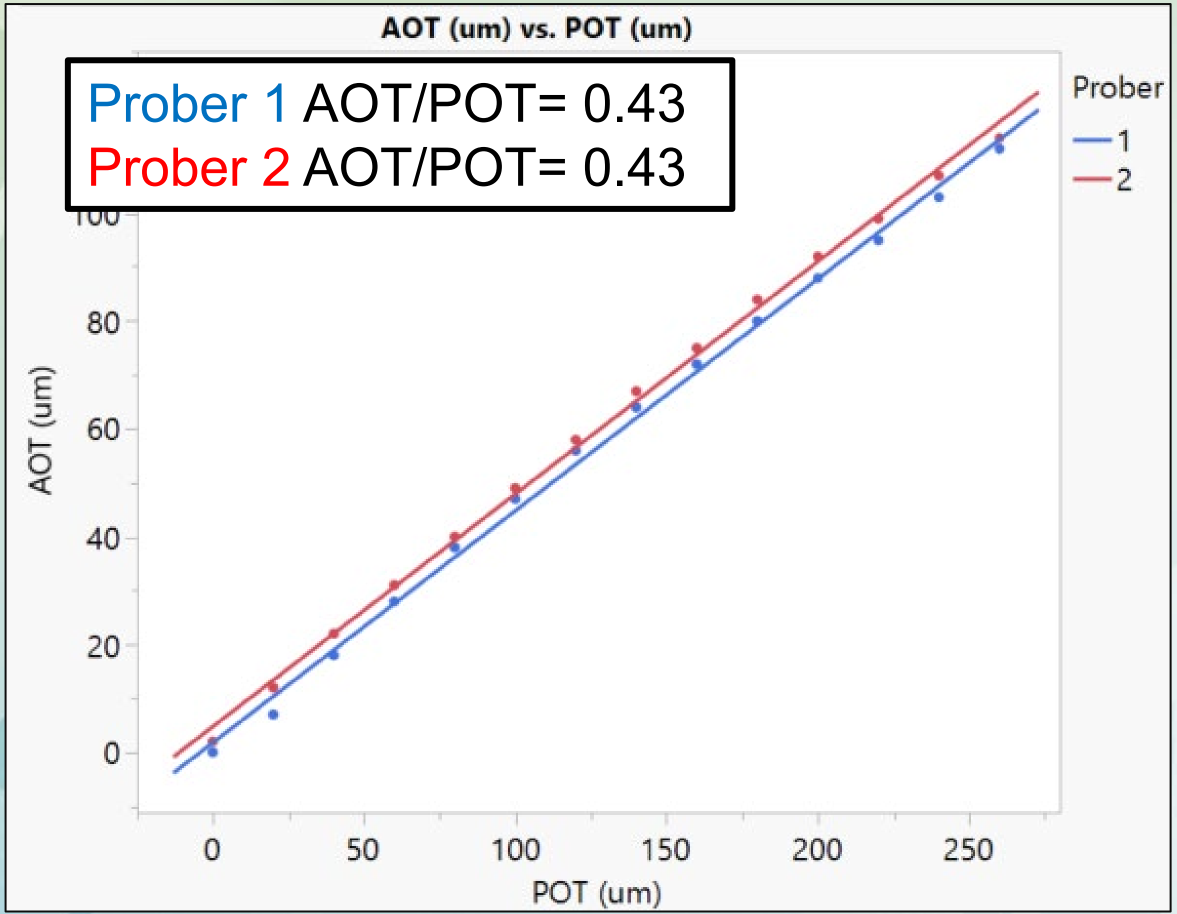
Wafer Probing Locations



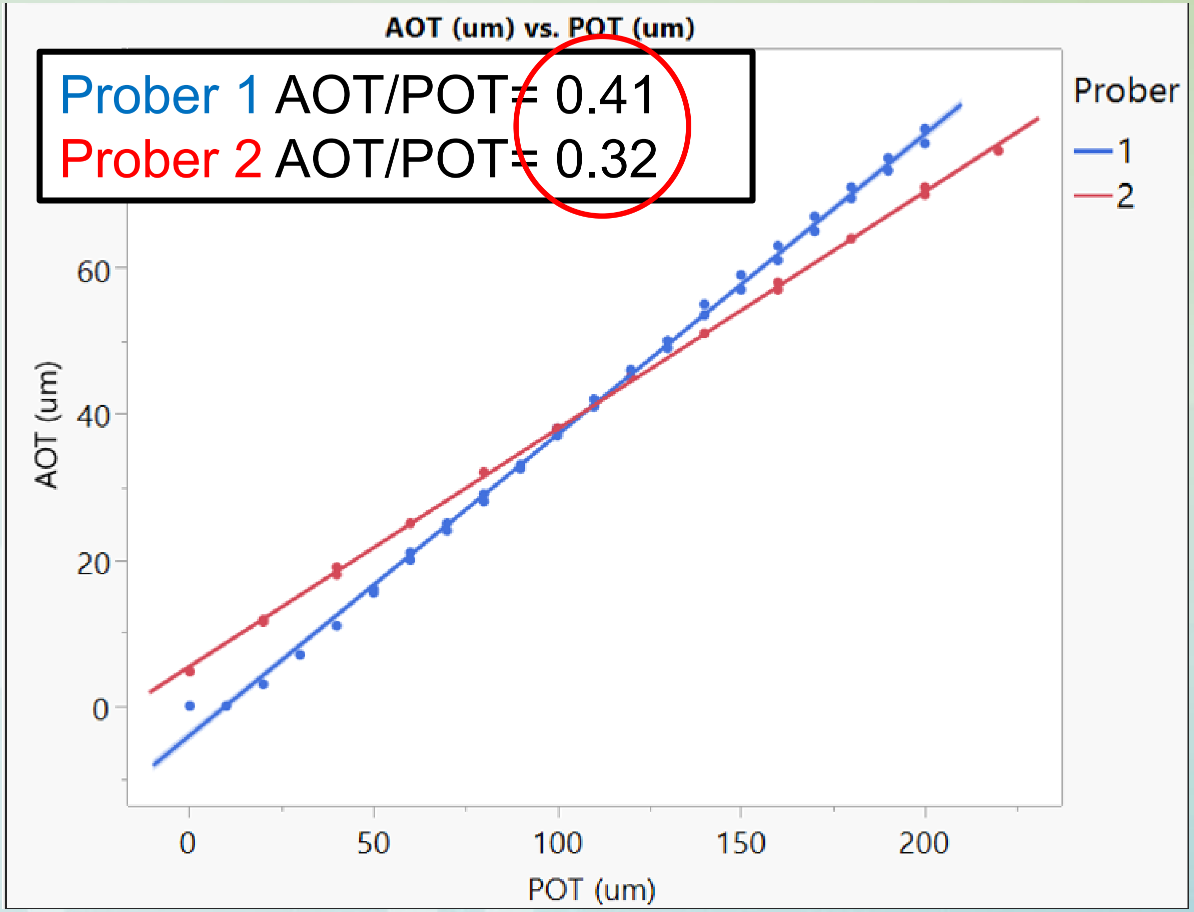
- AOT/POT Ratio of ~0.43
- No significant difference in AOT/POT by wafer location (No evidence of chuck tilt)

AOT/POT Variation by Prober

Customer #1



Customer #2



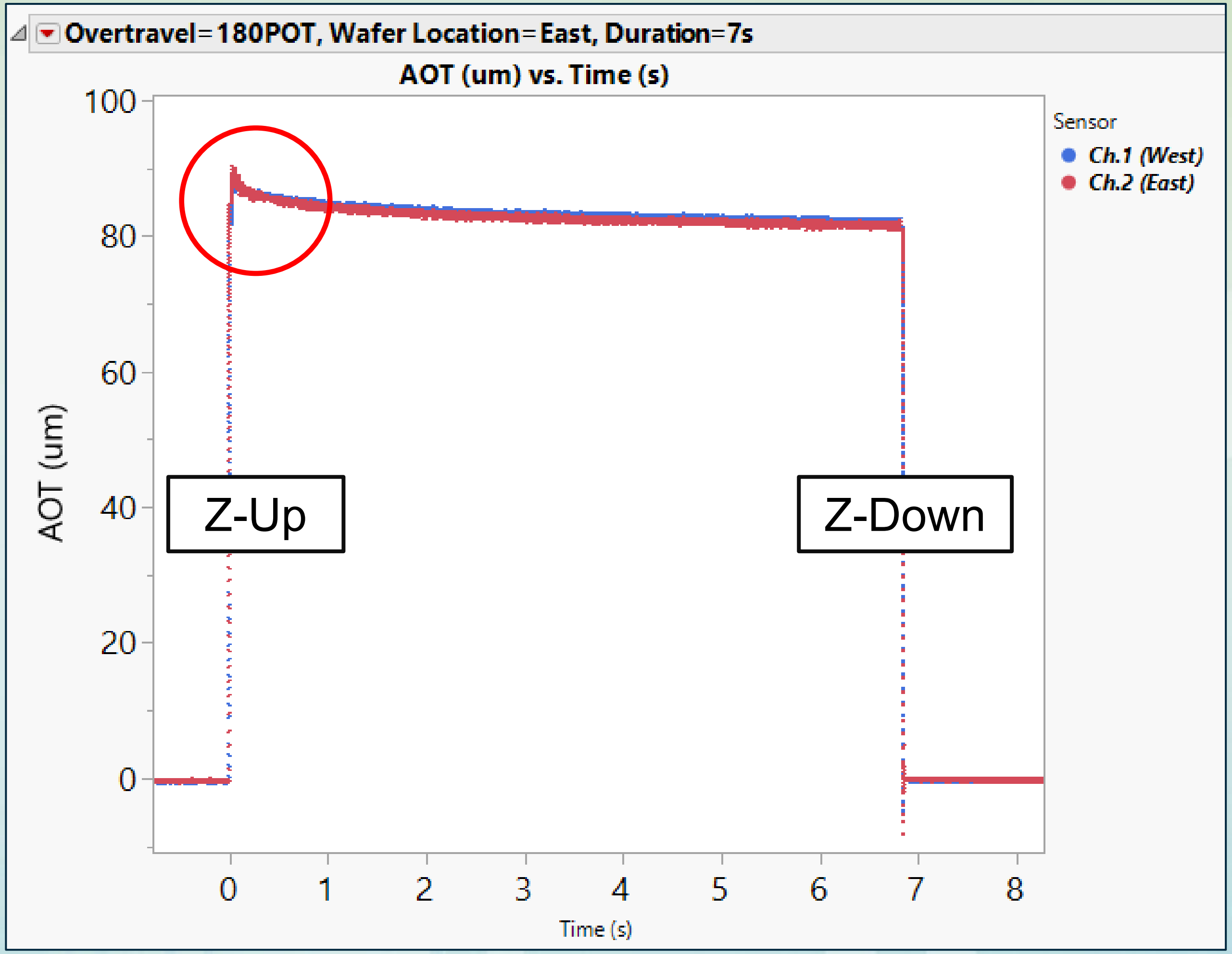
- ~20% difference in AOT/POT between probers at customer #2

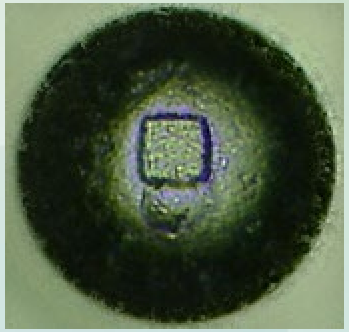
Bonus: Transient Response Testing

- AOT vs Time on Solder Bumps
- Prober Bounce
- Z-up Mystery
- Cleaning Concerns

AOT vs Time on Solder Bump

- Reduction in AOT after prober Zup is due to probe tips penetrating into solder bump.
- Sensor data helps to quantify transient response of tip penetration into solder

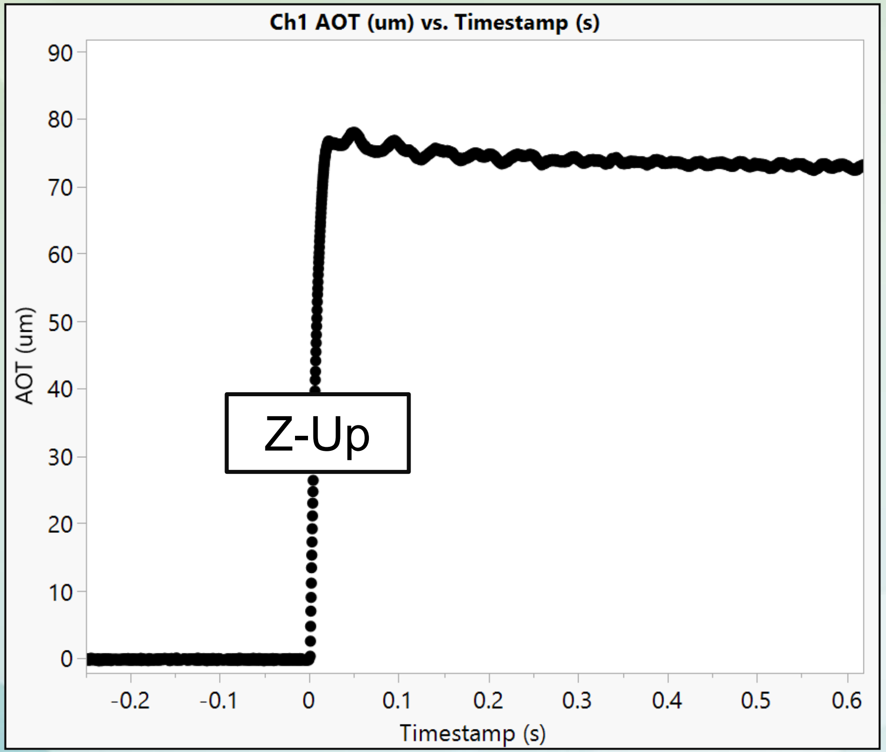




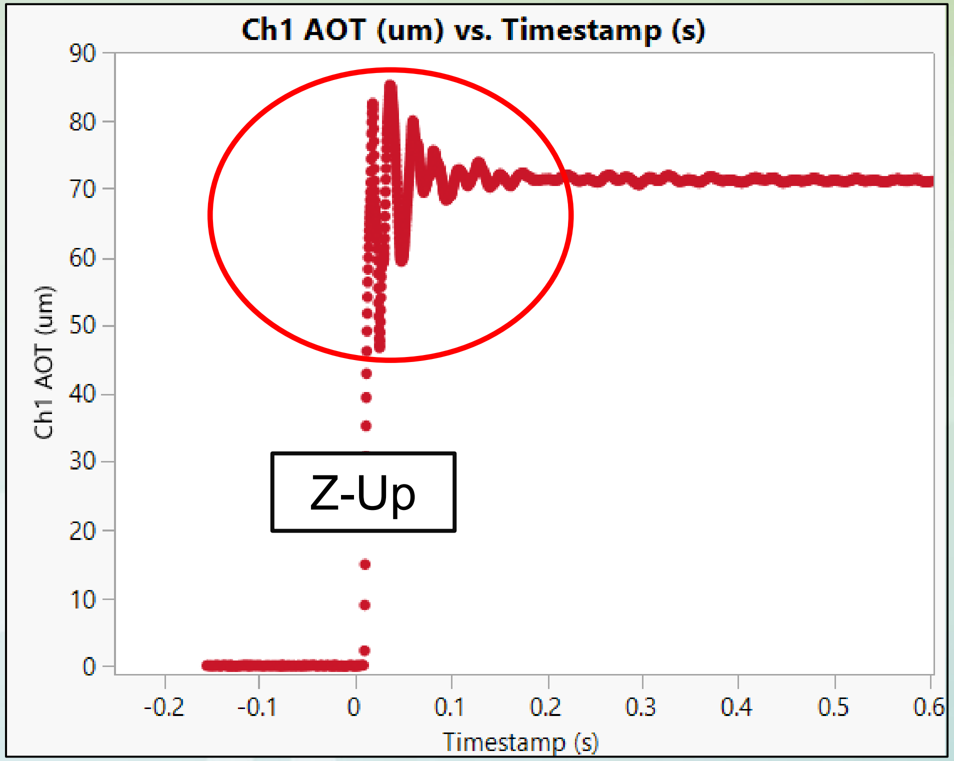
Probe mark in solder bump

Prober Bounce

Customer #1

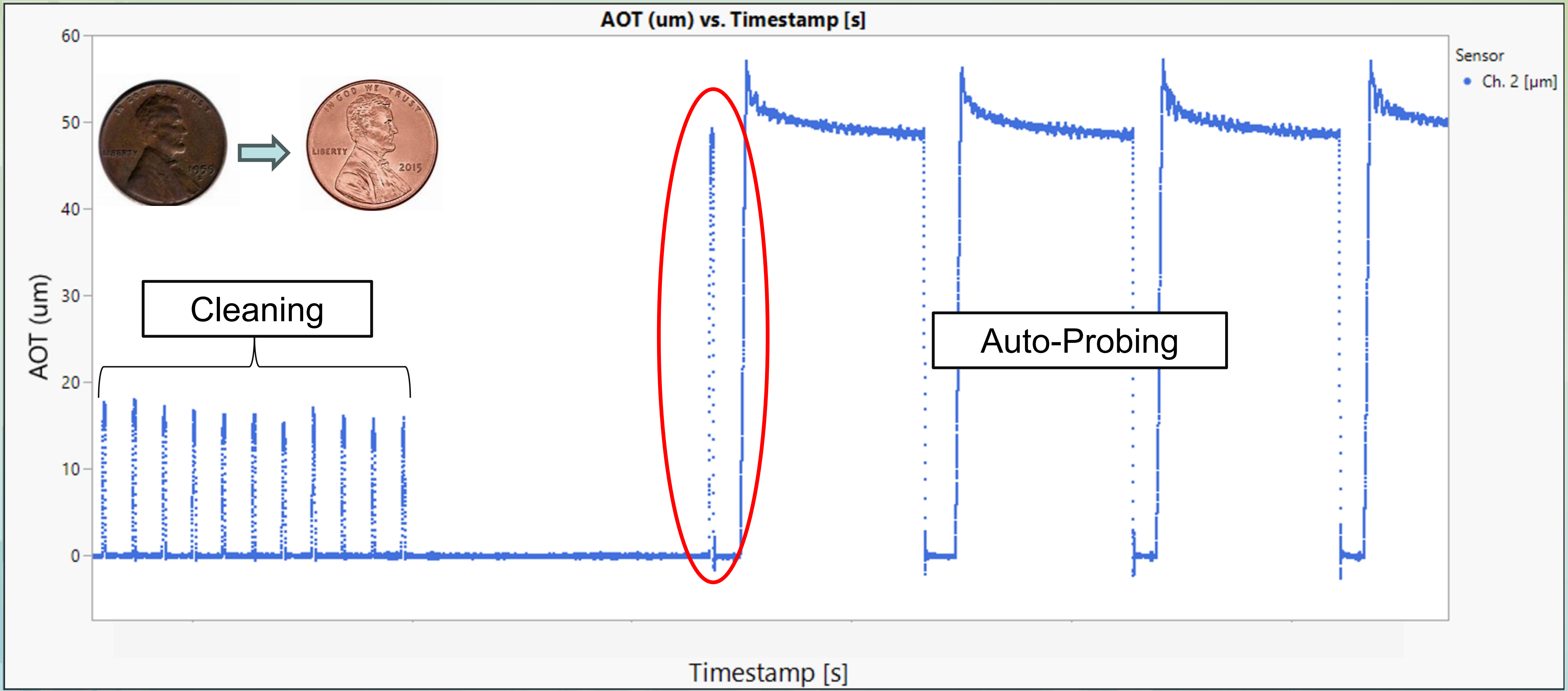


Customer #2



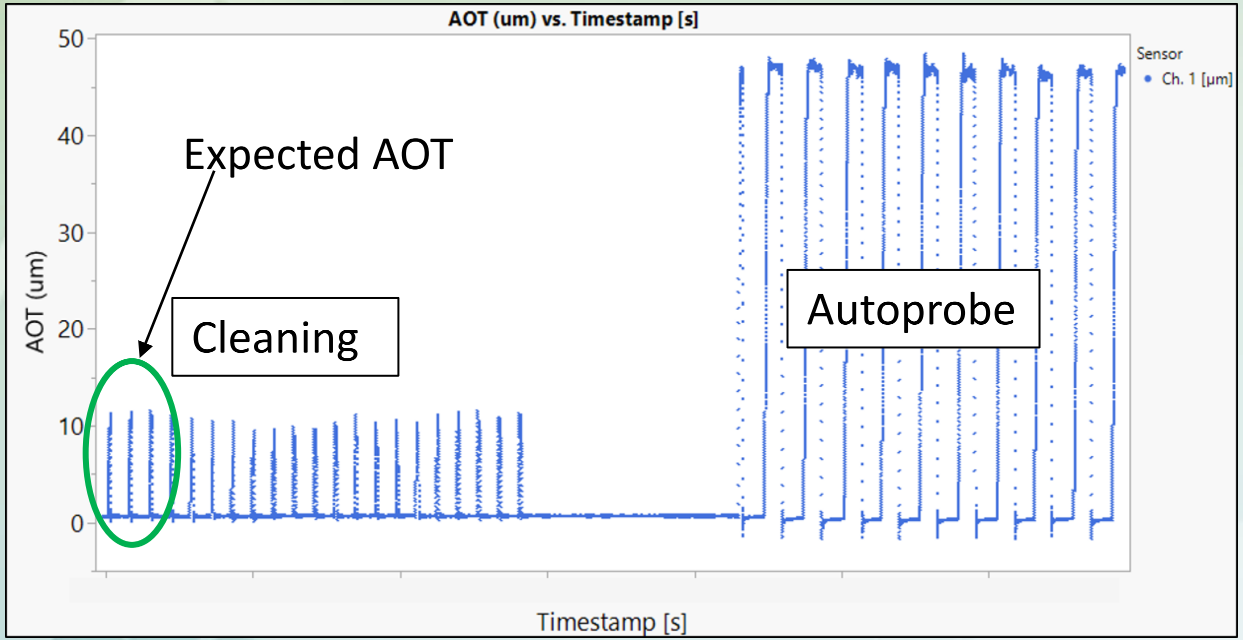
- **Undesirable transient oscillation observed at Customer #2**
- **Root cause was due to incorrect deceleration settings on prober**
  - Customer delighted issue was discovered and resolved

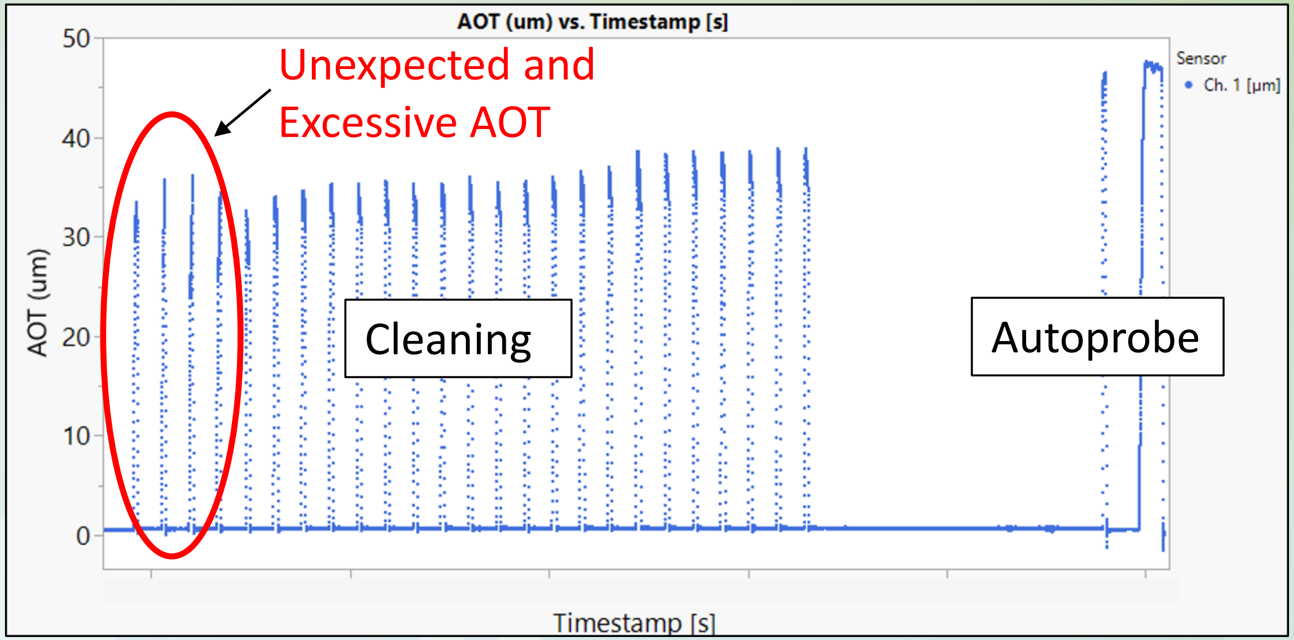
Z-up Mystery



- Strange short duration Z-up observed after cleaning
- Root Cause: Prober setting →Return to previous position after cleaning
  - Undesirable setting as 1st TD after cleaning is made on a previously probed die.
- Prober setting changed to→ Go to next die after cleaning

Cleaning Concerns





- **Unexpected shift in cleaning AOT measured at customer site.**
  - Both events captured during <u>one continuous test</u>
- **At a minimum, excessive cleaning AOT observed will reduce lifetime**
- **Leading suspect is cleaning plate not parallel to headplate**

Summary

- **Capacitive sensor method presented can:**
  - Precisely characterize AOT/POT, enabling recommended operating conditions for high probe count Pyramid cores
  - Measure transient mechanical response, ensuring test cell is properly setup
- **Demonstrated to be effective at multiple OSATs**
- **Eager to collaborate with more customers to characterize and optimize test deflection of new devices!**