

Production Wafer Probe of 77-81 GHz Automotive Radar Applications

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Virtual Event • May 3 - 7, 2021



Outline

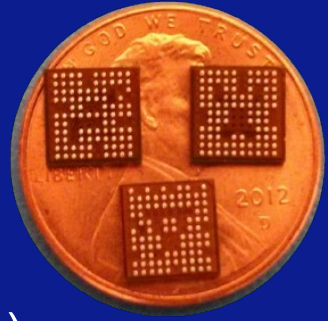
- **Introduction**
 - Automotive Radar device and testing trend
- **Benefits and challenges in testing the new generation of devices**
- **Testing requirements and options**
 - Pogo with PCB Stealth (patent pending)
 - xWave with Stealth (patent pending)
 - Advantages
 - Modification to the standard xWave
- **Test results**
 - Initial and current
- **Improvements along the way**
- **Next and ongoing steps**
- **Summary/Conclusion**

Introduction

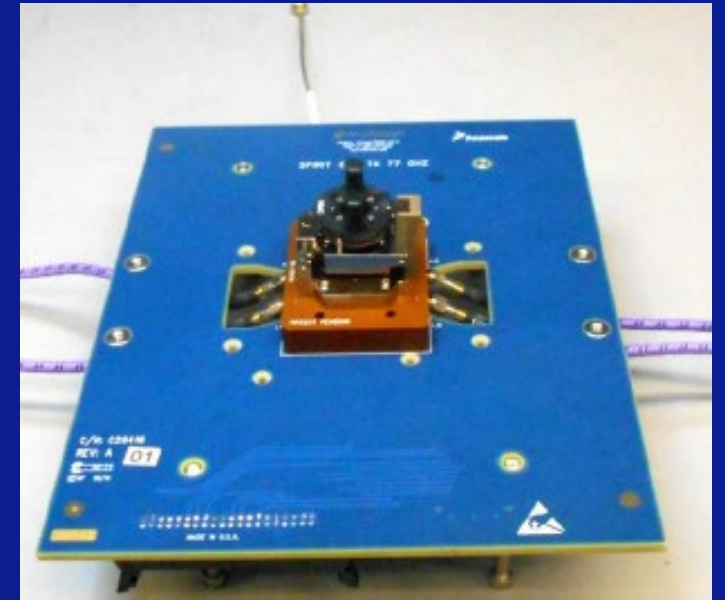
- **Automotive Radar has been used since 2007**
 - First generation (Approximately 2007 – 2013)
 - 28 GHz
 - Short range
 - Limited functionality
 - Second generation (Approximately 2014 – 2018)
 - 80 GHz – improved resolution
 - Longer range
 - Increased functionality
- **Now entering a third generation (2019-TBD)**
 - 80 GHz
 - Longest range
 - Increased performance and functionality
 - Lower cost
 - New testing challenges



Challenges with the Second Generation

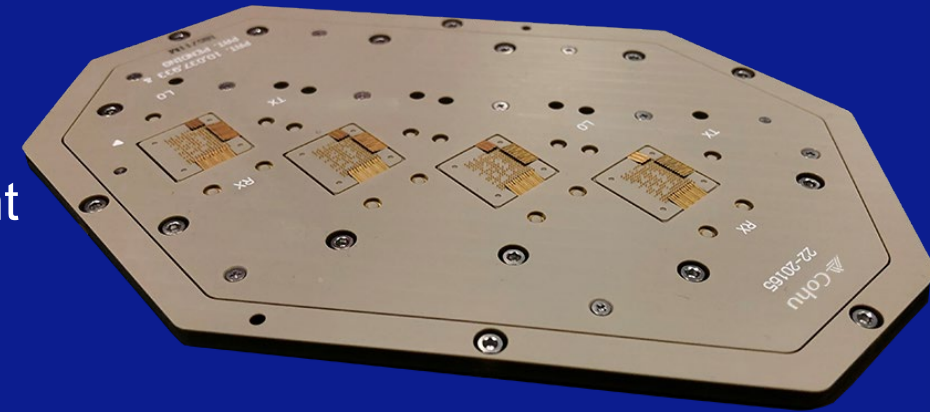


- **Second generation (Presented by Brian Nakai at BiTS 2017)**
 - Devices packaged in traditional formats (i.e. BGA, QFN, etc.)
 - Multiple packages for receiver (RX), transmitter (TX) and voltage controller (VCO)
 - Packages combined into module
 - Testing required at multiple levels (wafer, film frame, package, transceiver module)
 - About 15 tests, many of them repetitive
 - mmWave Automated Test Equipment (ATE)
 - Expensive new
 - Difficult to get repeatable results due to sensitivity
 - Extensive set-up due to calibration
 - *Basically, need an RF Lab on your test floor with RF engineers to keep it going!*



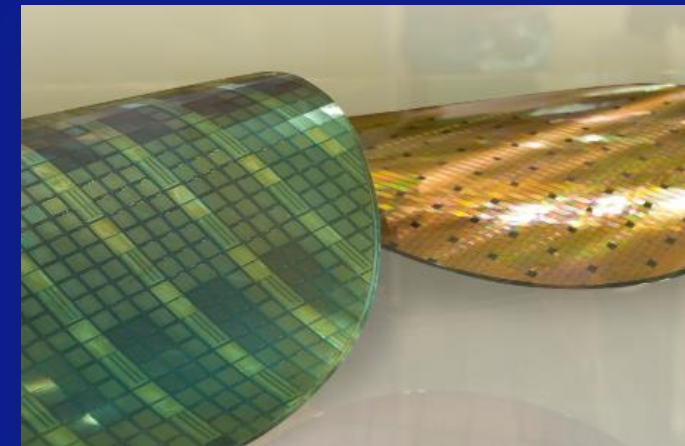
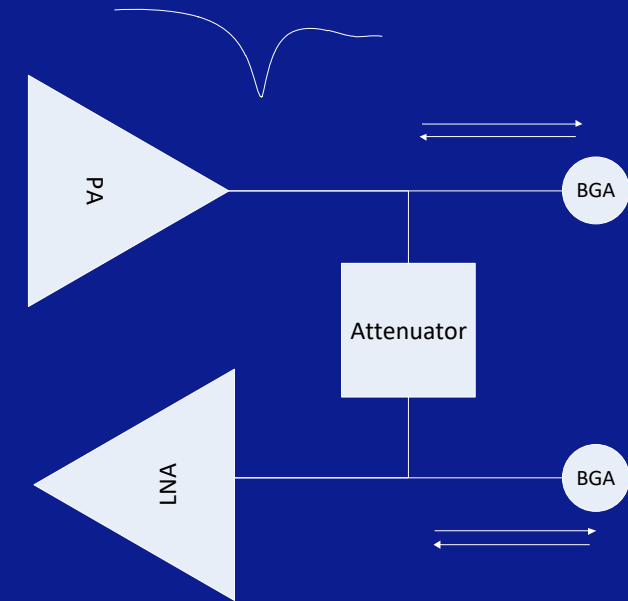
Benefits in Testing the New Generation

- **Third generation**
 - Die level integration of receiver (RX), transmitter (TX) and voltage controller (VCO)
 - Packages no longer required
 - Testing required at wafer with fine pitch without RF and redistributed wafer test at speed WLCSP
 - Ambient, hot, cold, fewer total tests and less repetition (4 total)
- **Built-in Self Test (BIST)**
 - BIST allows die to do internal testing
 - Eliminates need for expensive mmWave test equipment
 - Better fit with standard wafer test environment
- **Multi-site testing**
 - Higher throughput



Challenges in Testing the New Generation

- **Built-in Self Test (BIST)**
 - Requires the I/O for the high frequency signals to be properly terminated while still providing a path for sourcing a DC voltage to the DUT.
 - New functionality in the test hardware/probehead
 - Dual frequency ranges to optimize with differing absorption requirements
- **Wafer/WLCSP testing**
 - Smaller target
 - More sensitive to coplanarity
 - Temperature sensitivity
- **Integration of the three devices into one die**
 - More complex test program

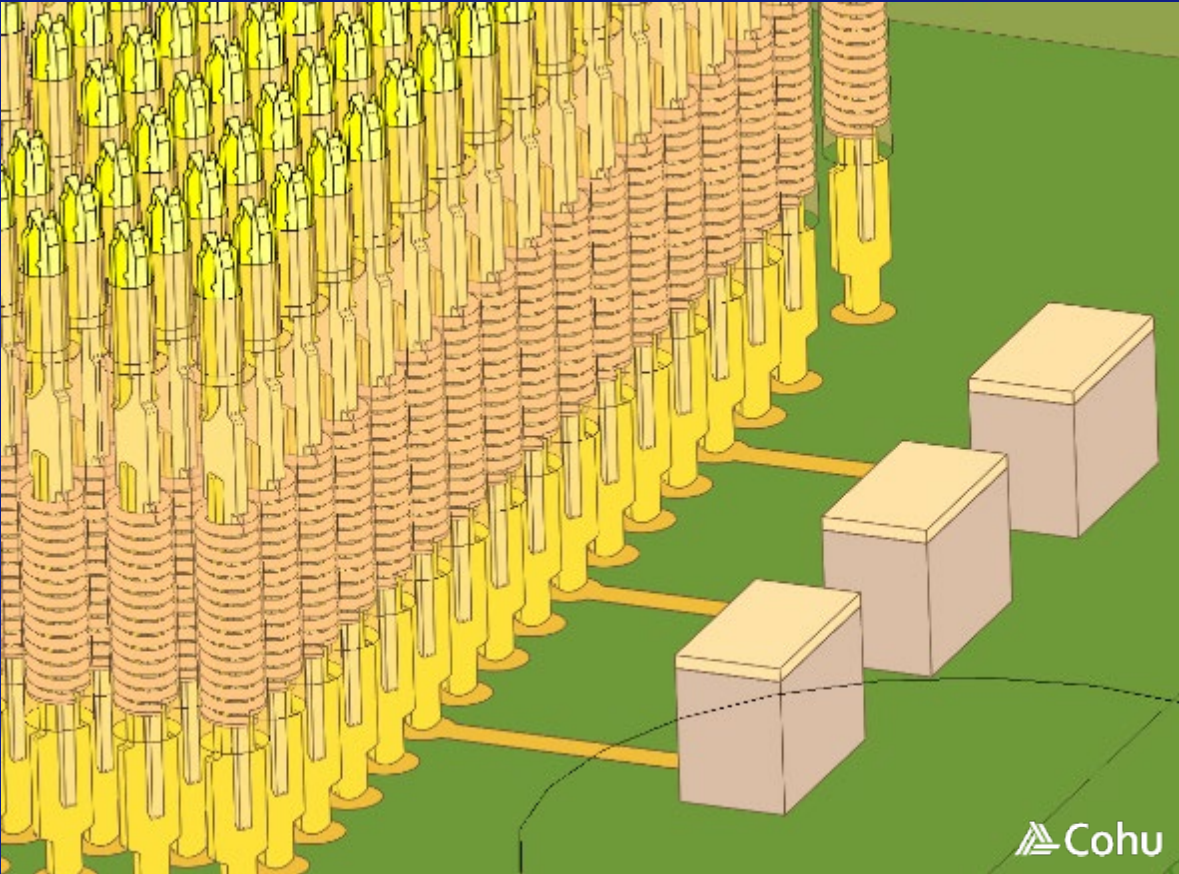


Challenges in Testing the New Generation (cont.)

- **Multi Site Testing**
 - Coplanarity challenges
 - Reduction of forces
 - Adding support for PCB (Bridge Beam)
 - Site to site alignment
 - Site to site variation
 - CTE
- **Contact Technology – Dual**
 - Spring Probes for standard signals
 - Leadframe for RF frequency signals
- **Production Worthy Solution**

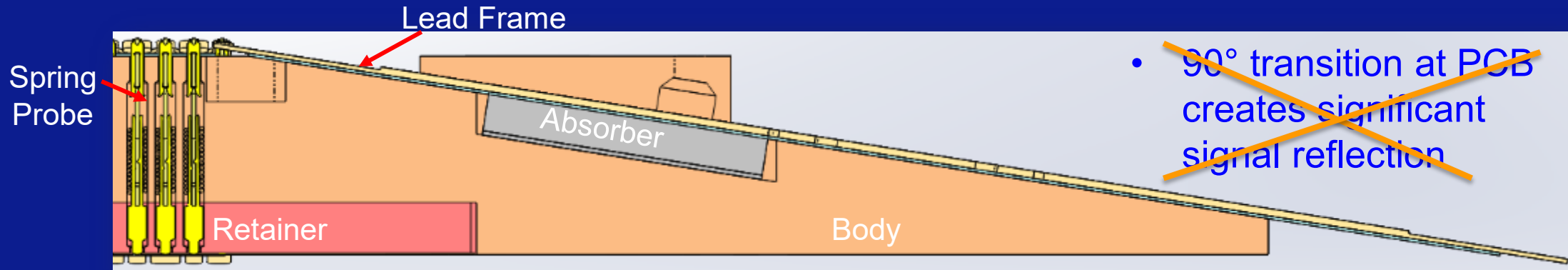


Test Solutions – Absorber on PCB



- Initially considered Solution
- Pogo Pins with Trace to termination on PCB (SMT resistor or absorber)
- 90° transition at PCB creates significant signal reflection before termination

Test Solutions – Prototype Build Leadframe with PCB Connection



Issues Solved

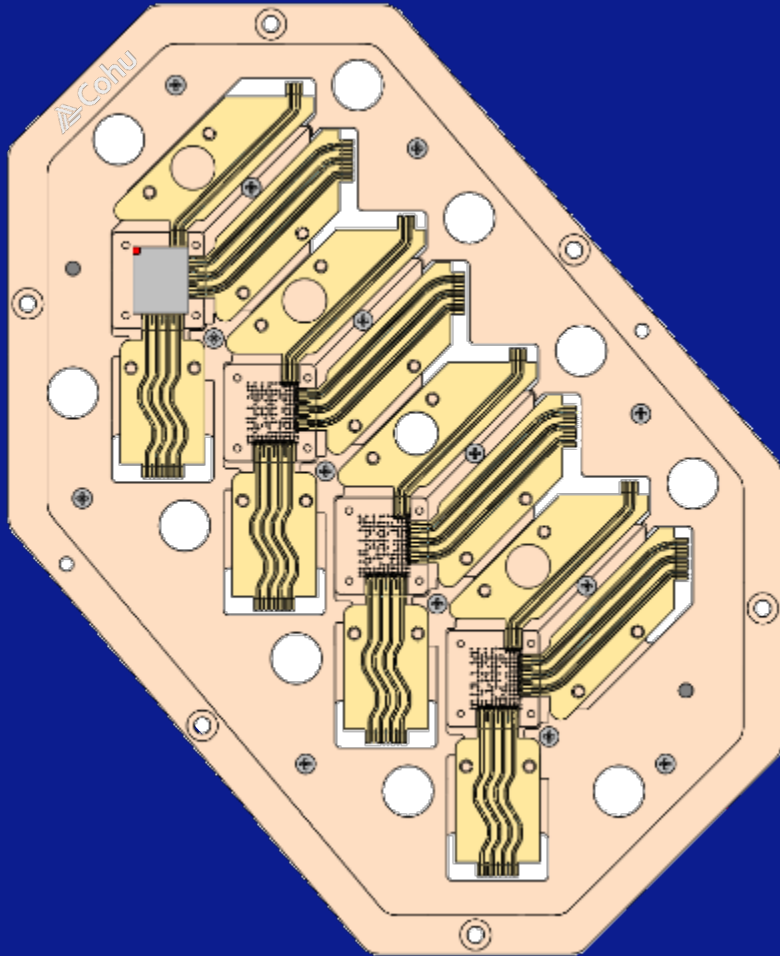
- Straight leadframe with shallow angle connection to PCB reduces reflections
- Absorber attenuates signal

New Issues

- Tolerances of absorber create mechanical bowing issues
- Initial leadframe mechanics require larger than planned overdrive

Test Solutions – Prototype Build

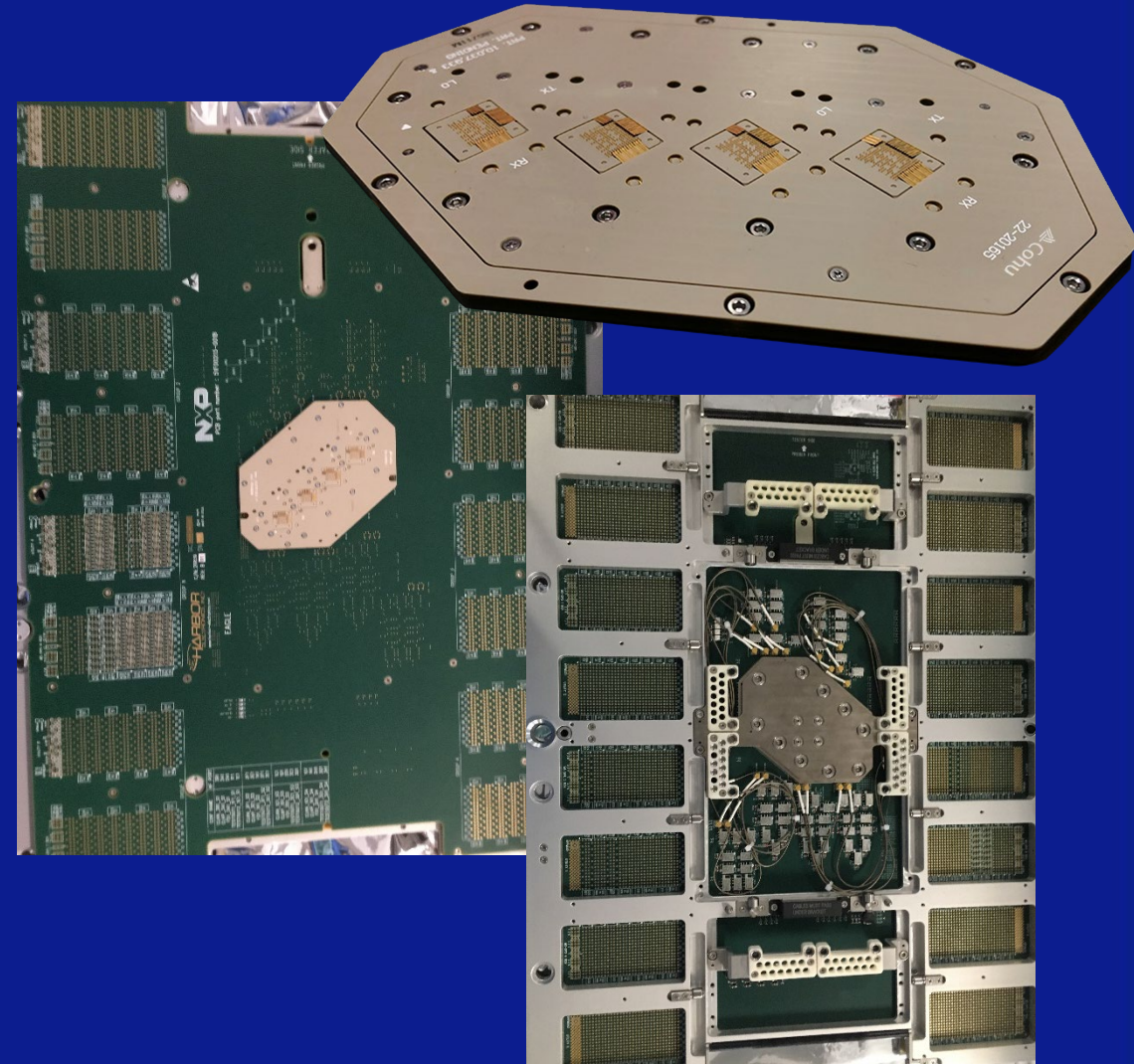
Leadframe with PCB Connection – Multi-site



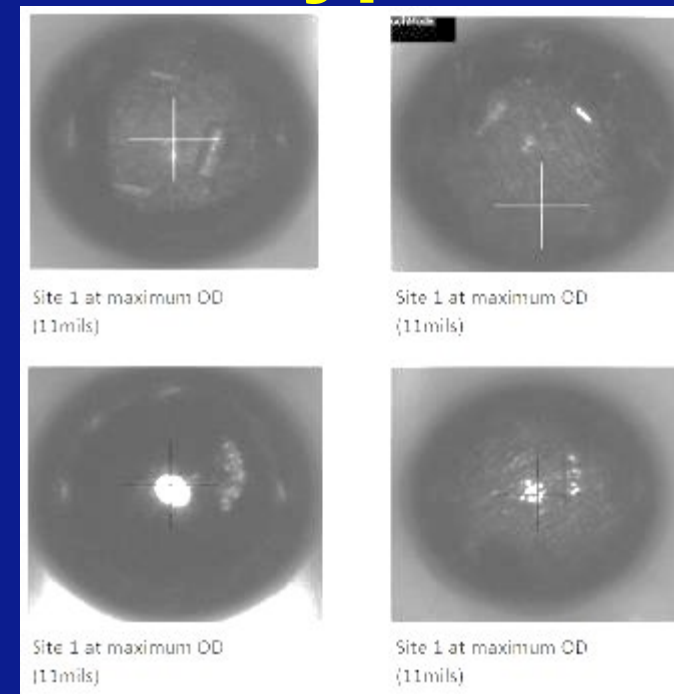
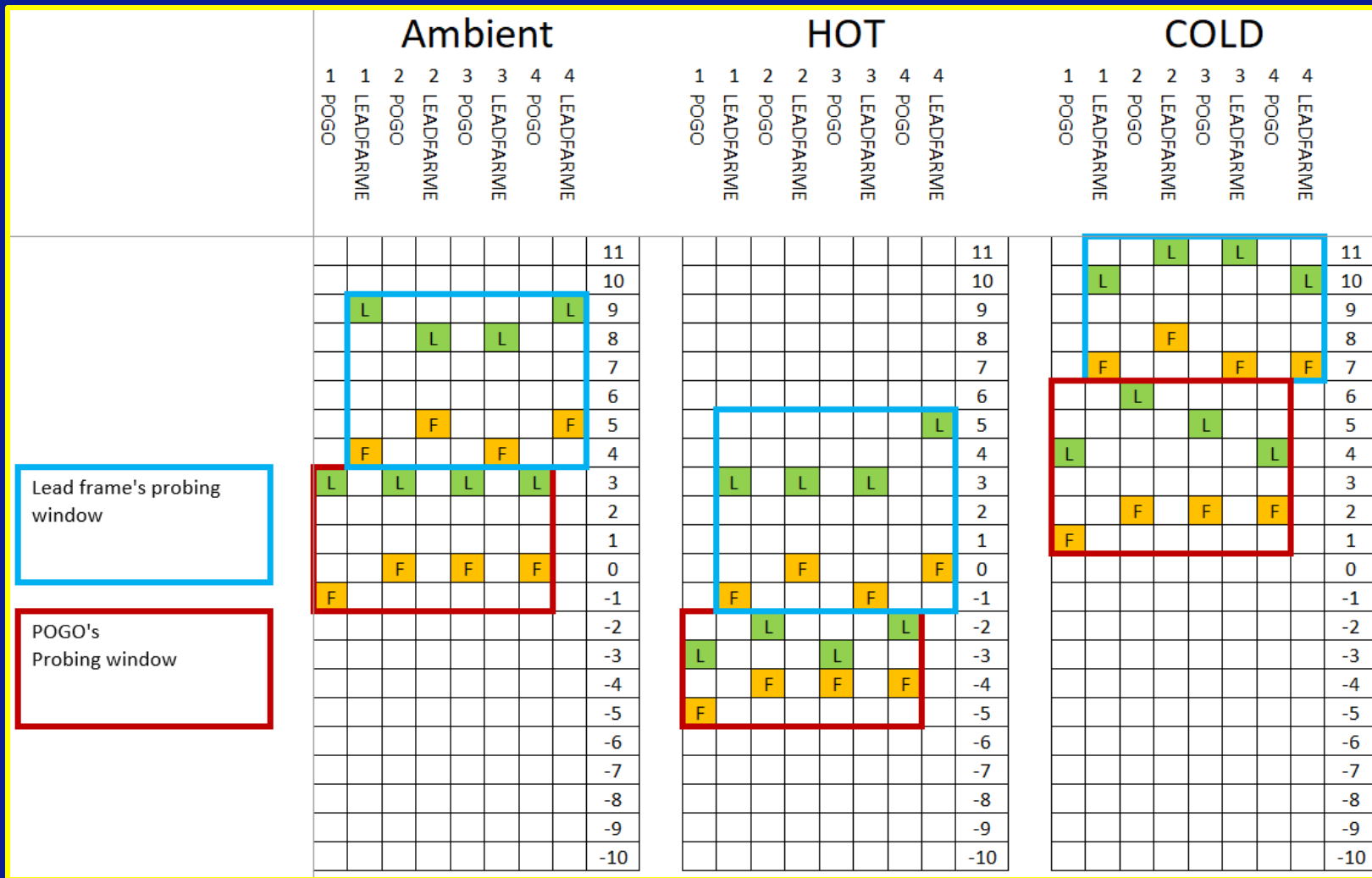
- Multi-site required some new thinking with leadframes fanning out at 45° from three sides
- Quad-site Diagonal skipped die
- Angled 25mm leadframes

Challenges in Prototype Build

- **Bowing of probehead**
 - Additional mounting locations required
 - Reduction of force applied by absorbers – more compliant second layer
 - Redesign of components to add rigidity
- **Coplanarity of PCB**
 - Stiffener in original design
 - Added adjustable support beam to coplanarize
- **Logistics across engineering and production sites**
 - Probe Card Stiffener compatibility
 - Good yield and contact in original engineering site
 - Inconsistencies once installed in production site



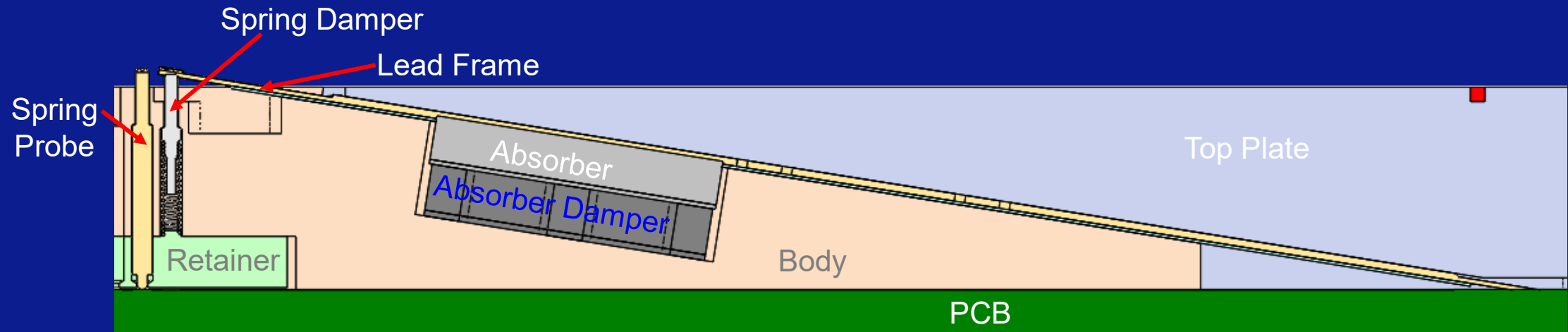
Field Results - Initial Production with Prototype Build



Total overdrive of about 11
mils to achieve continuity

Successful but window was limited and production team wanted improvements

Test Solutions – Production Build



- Spring damper to better support leadframes
- Absorber damper to add compliance/reduce bowing of top plate

Field Results – Improved Production

Ambient										Hot										Cold									
		1	1	2	2	3	3	4	4			1	1	2	2	3	3	4	4			1	1	2	2	3	3	4	4
	Over Drive	POGO	LEADFARM	POGO	LEADFARM	POGO	LEADFARM	POGO	LEADFARM		Over Drive	POGO	LEADFARM	POGO	LEADFARM	POGO	LEADFARM	POGO	LEADFARM		Over Drive	POGO	LEADFARM	POGO	LEADFARM	POGO	LEADFARM	POGO	LEADFARM
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Lead frame's probing window

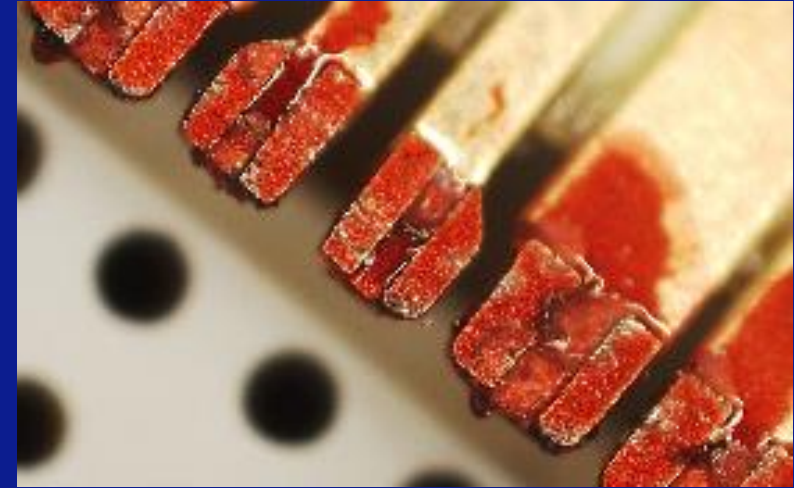
POGO's Probing window

Lead frames and pogos all working at similar windows across temperature range - Dec

- Full continuity at all temps at 8 mils of overdrive
- Max overdrive of 13 mils allowed
- 5 mil working window
- Production team approved for release

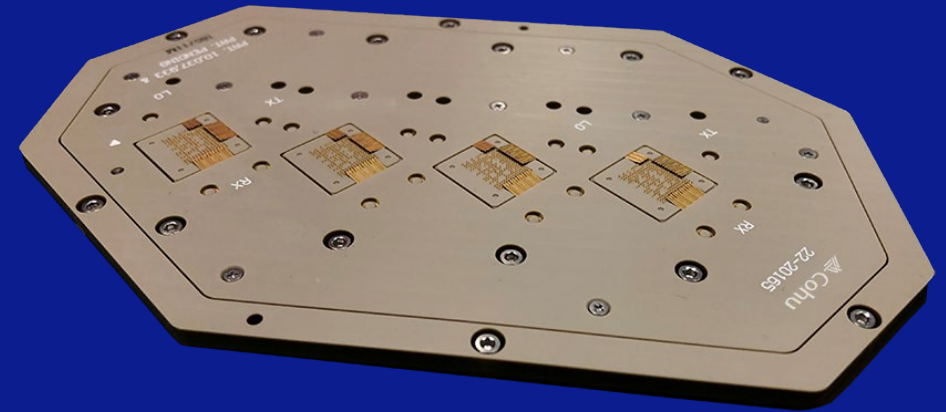
Field Results – Ongoing Concerns

- Over 250,000 insertions on the first probe head
- In-Situ cleaning as angled leadframes are more difficult to clean than pogo pins or flat leadframes – reviewing new cleaning media
- Absorber system may degrade over time and require repair/improvement



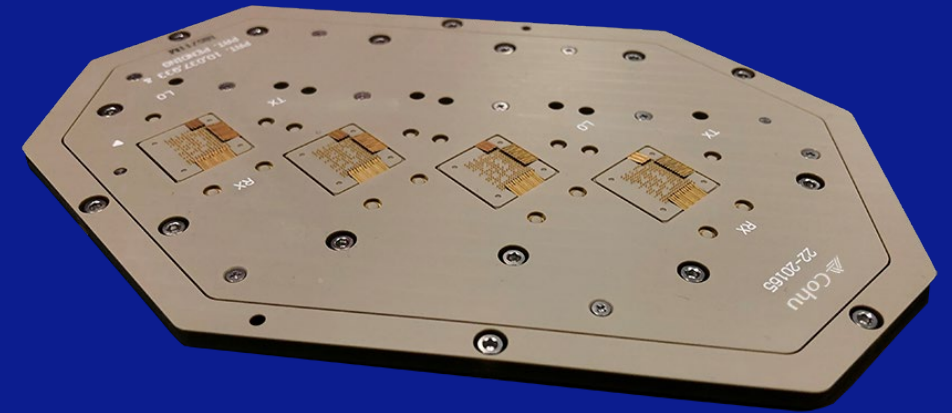
Strengths

- Excellent RF performance over a broad range of frequencies
- Long life
- Individual probe / lead frame replacement
- Multi-site capability (material CTE Match)
- Large compliance window



Weakness

- Complex to balance multiple contact technologies on one DUT
- Some limits on the number and location of RF signals
- In-situ cleaning is difficult
- May need maintenance on absorption system over time



Next Steps

- Project has moved to production and additional test cells are being deployed to meet end user demand! (13 probe heads shipped to date)
- Testing in-situ cleaning media and methods under investigation
- Testing life performance of absorption system (resolved)
- Better control of force on leadframes with modifications to support system (future projects)
- Have improved tolerance capabilities and geometries on leadframes
- Have implemented better PCB pad compatible geometries

Summary/Conclusion

- Advances in IC design architectures and contacting methods make high volume test of automotive radar RF devices production capable with test resources already available on production floors.
- Demonstrated Production worthy quad-site tri-temp Probecard solution for 77GHz automotive radar wafer test applications with BIST
- Thank you to NXP for the opportunity and collaboration to make it happen!