Production Wafer Probe of 77-81 GHz Automotive Radar Applications

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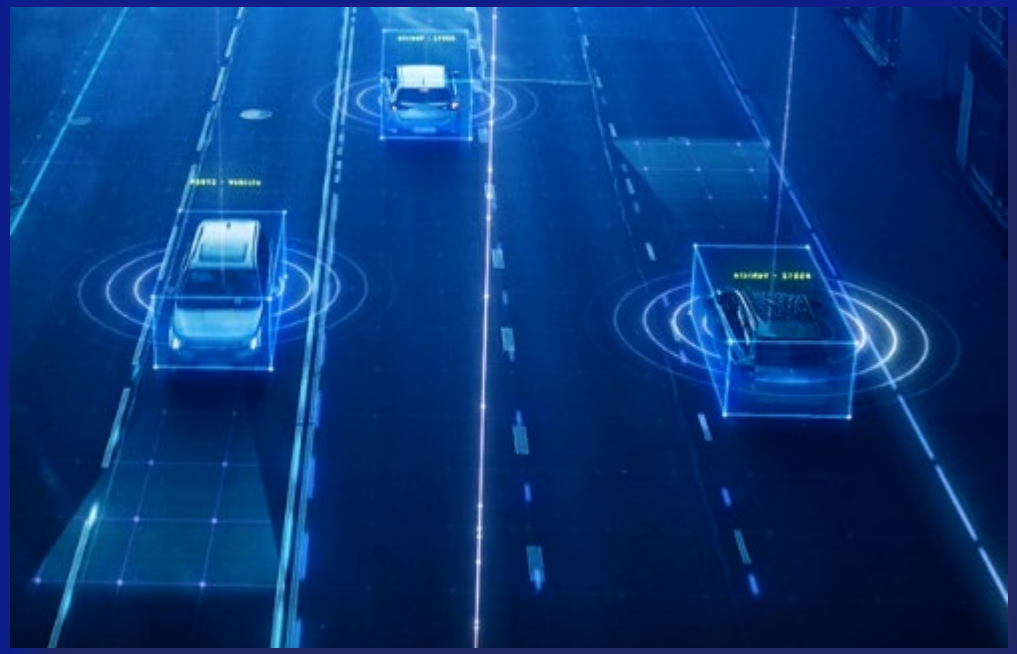
Outline

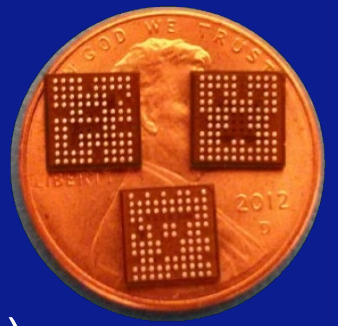
- **Introduction**
  - **Automotive Radar device and testing trend**
- **Benefits and challenges in testing the new generation of devices**
- **Testing requirements and options**
  - Pogo with PCB Stealth (patent pending)
  - xWave with Stealth (patent pending)
    - Advantages
    - Modification to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

Introduction

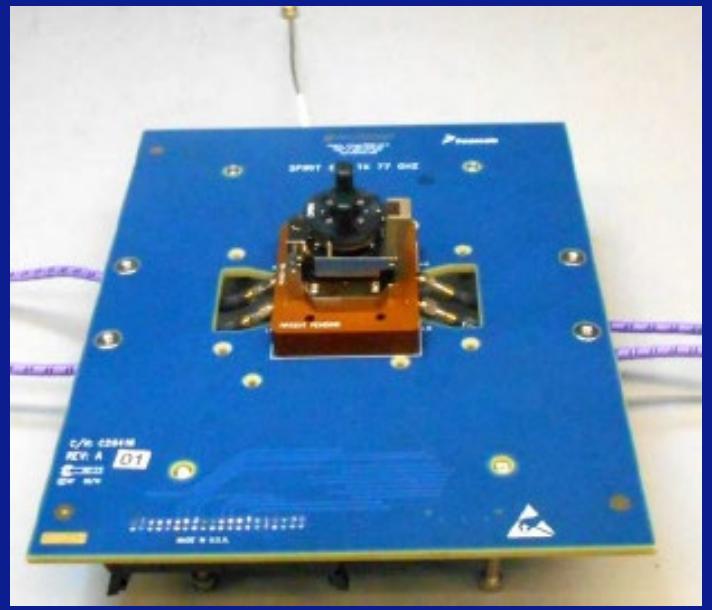
- **Automotive Radar has been used since 2007**
  - First generation (Approximately 2007 – 2013)
    - 28 GHz
    - Short range
    - Limited functionality
  - Second generation (Approximately 2014 – 2018)
    - 80 GHz – improved resolution
    - Longer range
    - Increased functionality
- **Now entering 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!*

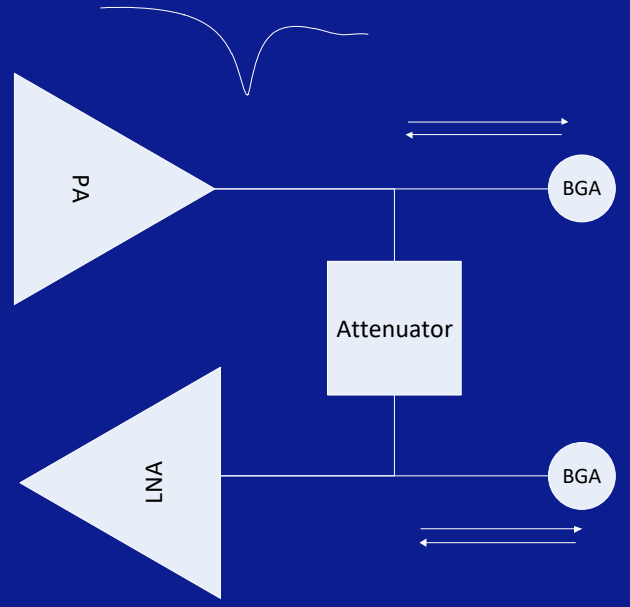


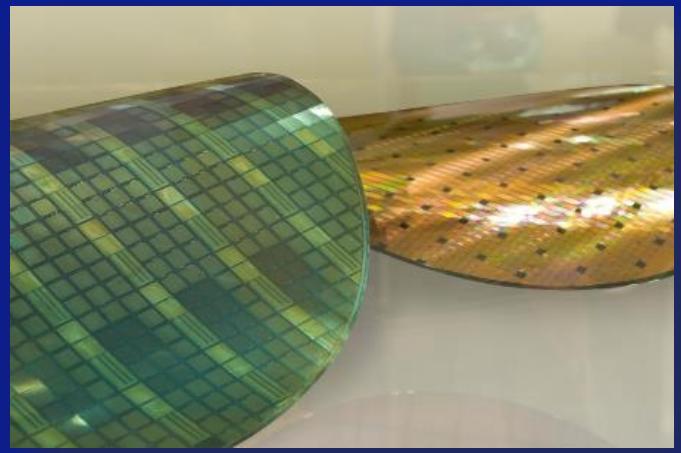
Benefits in Testing the New Generation

- **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

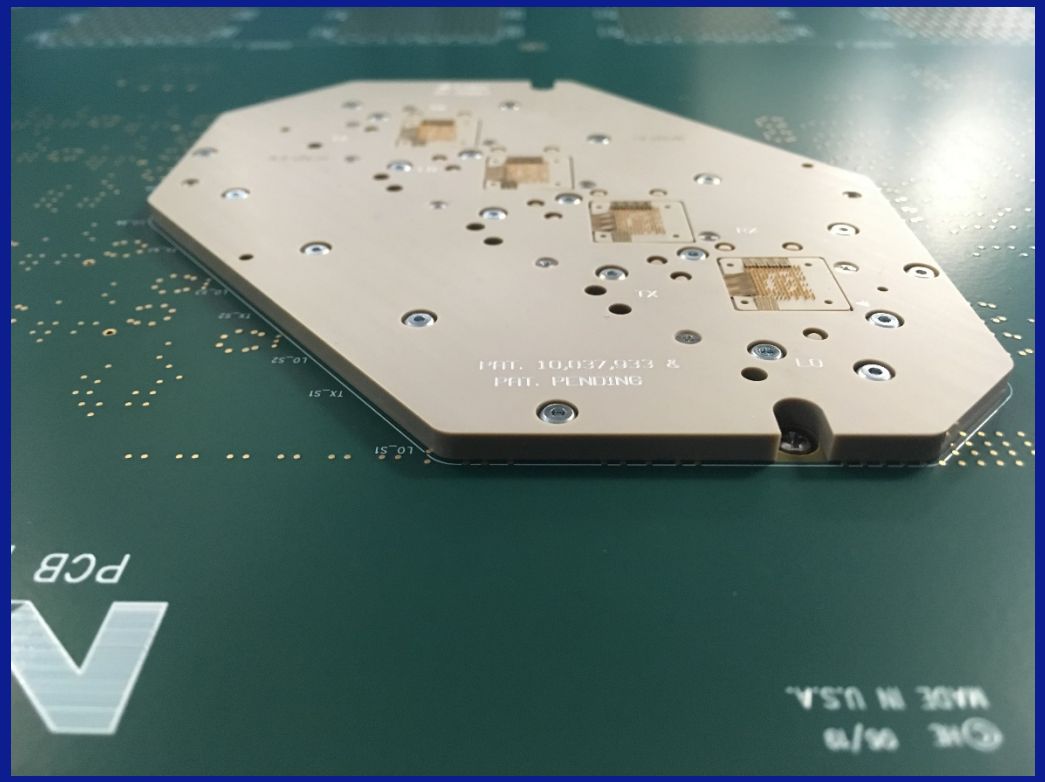
- **Built-in Self Test (BIST)**
  - Requires the I/O for the high frequency signals to be properly terminated while still providing a path for sourcing a DC voltage to the DUT.
  - New functionality in the test hardware/probehead
  - Dual frequency ranges to optimize with differing absorption requirements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



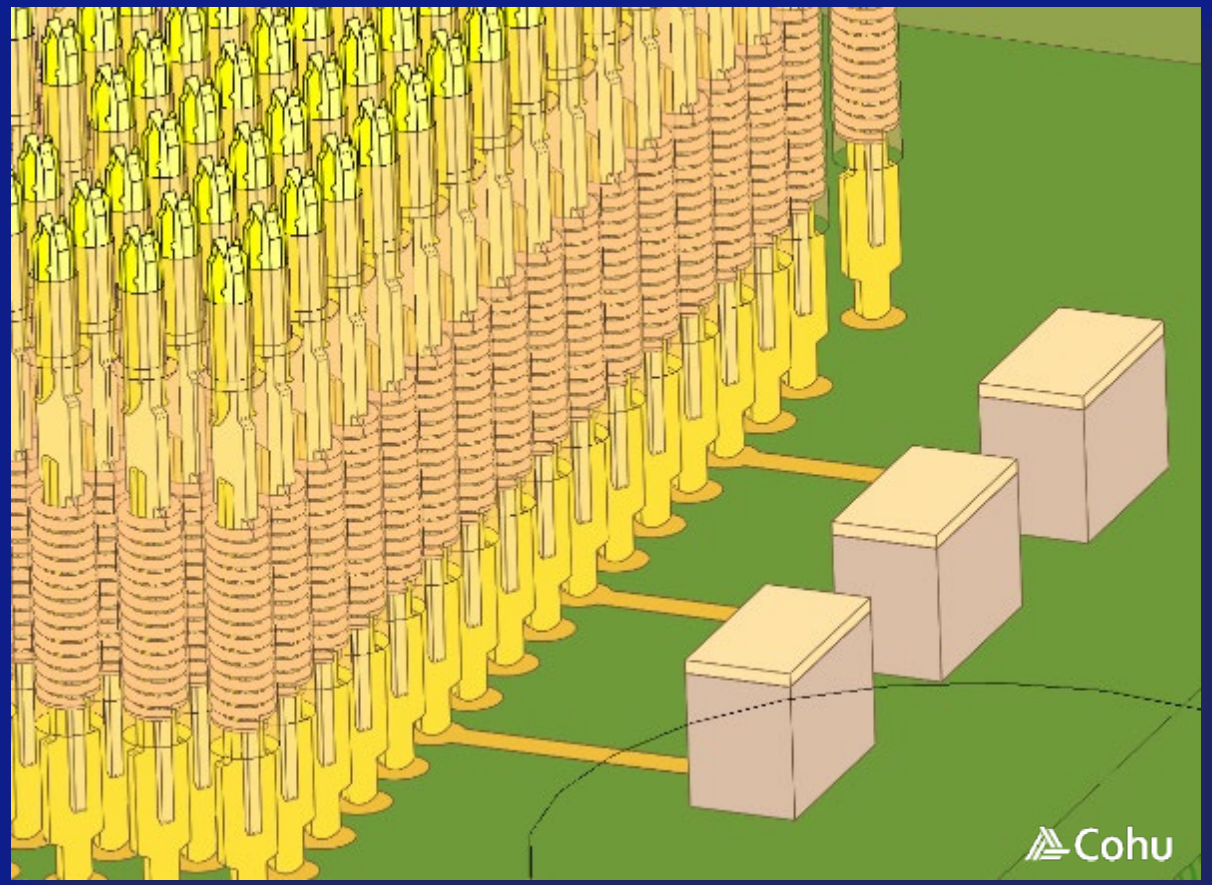


Challenges in Testing the New Generation (cont.)

- **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**

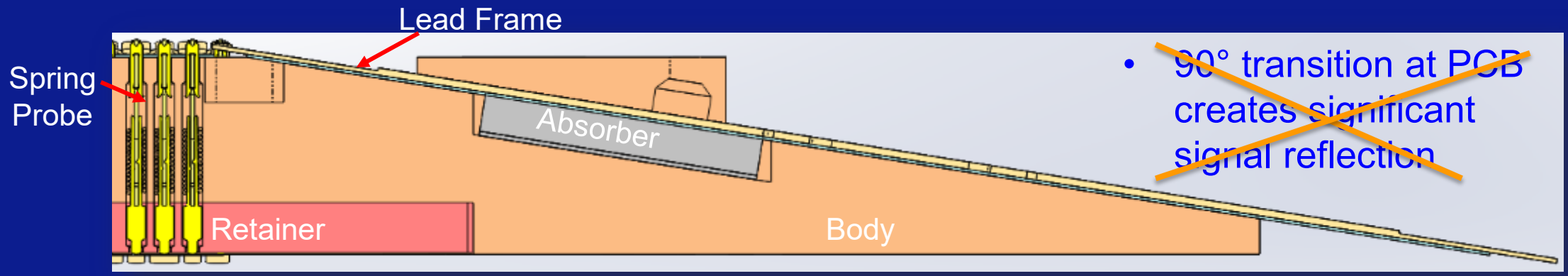


Test Solutions – Absorber on PCB



- 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



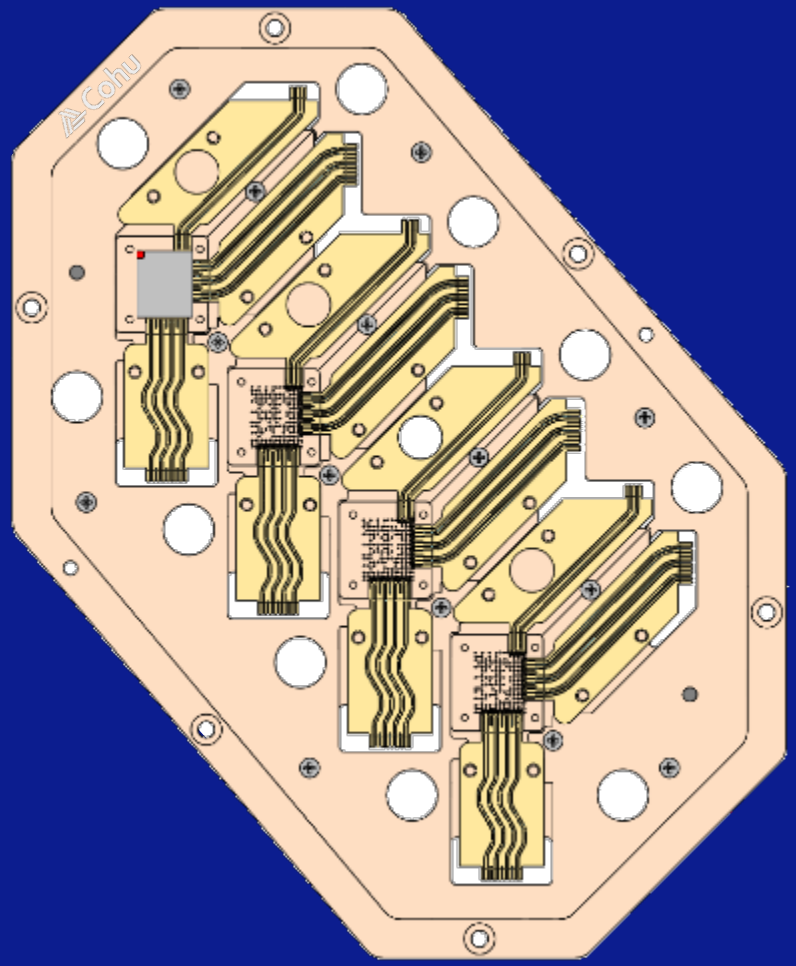
Issues Solved

- 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

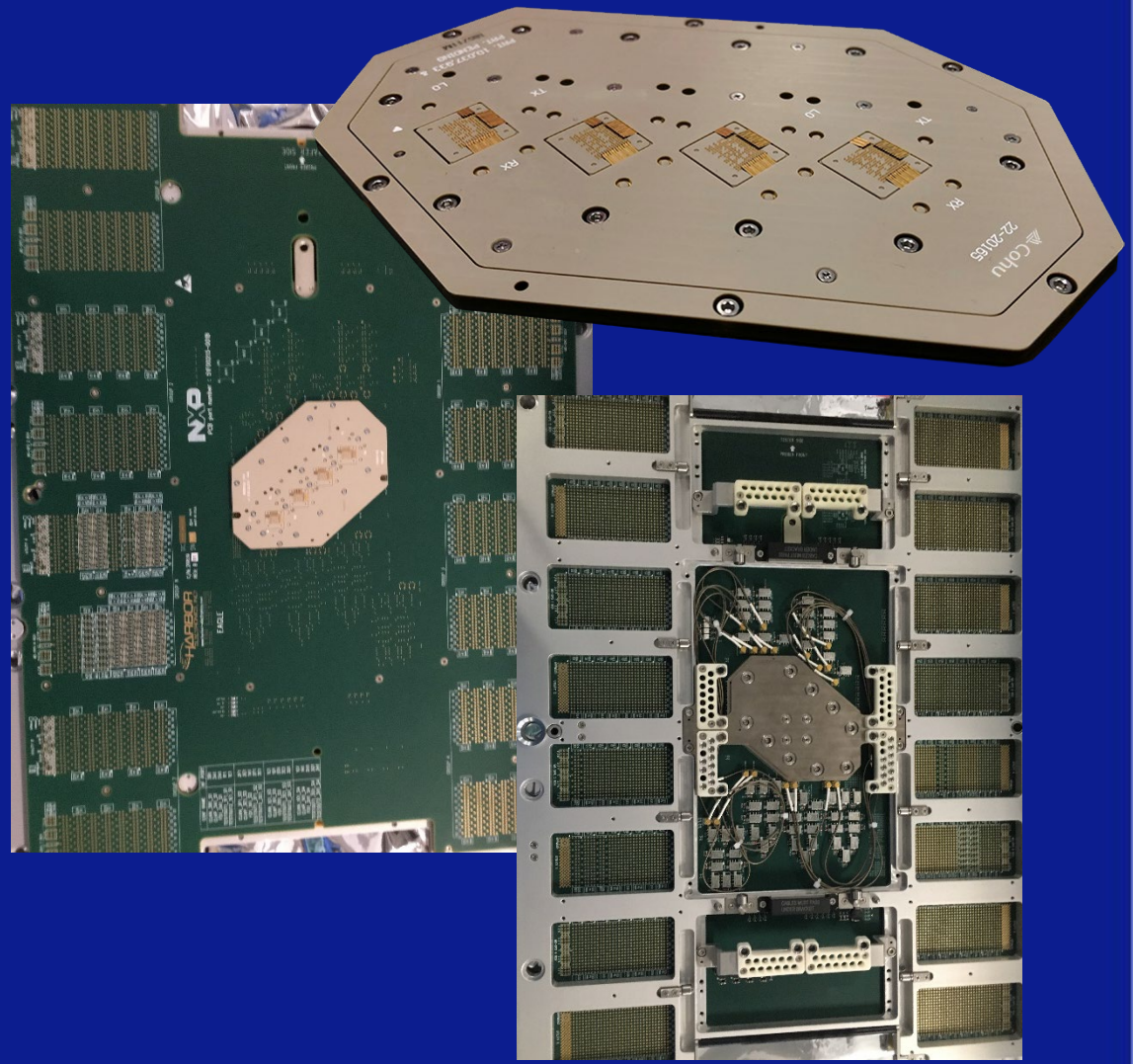
Test Solutions – Prototype Build
Leadframe with PCB Connection – Multi-site



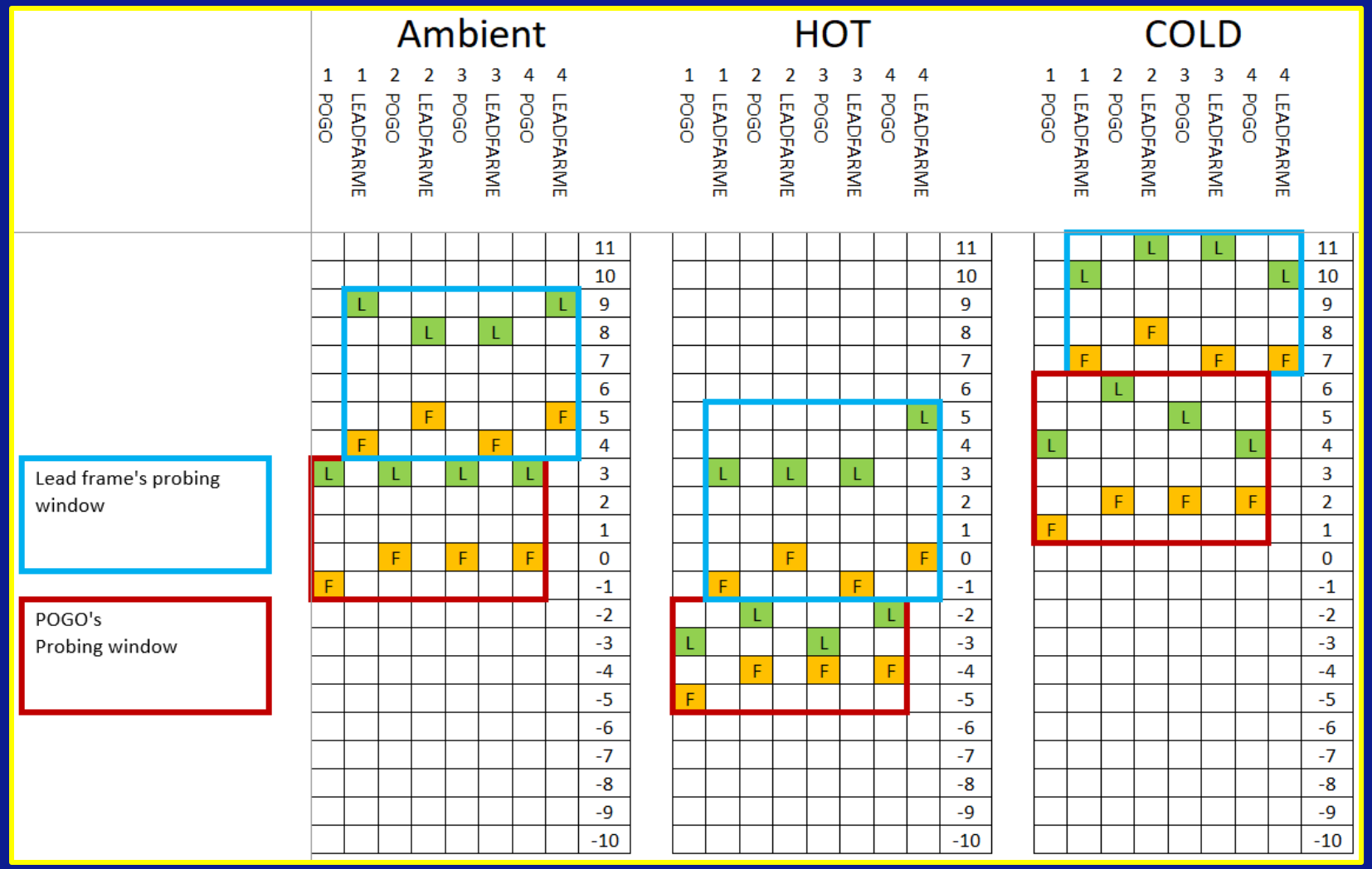
- Multi-site required some new thinking with leadframes fanning out at 45° from three sides
- Quad-site Diagonal skipped die
- Angled 25mm leadframes

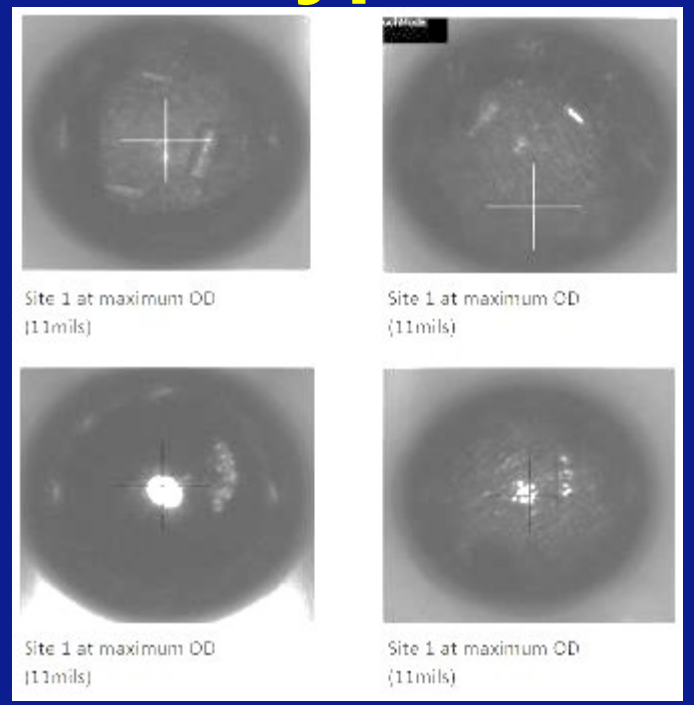
Challenges in Prototype Build

- **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

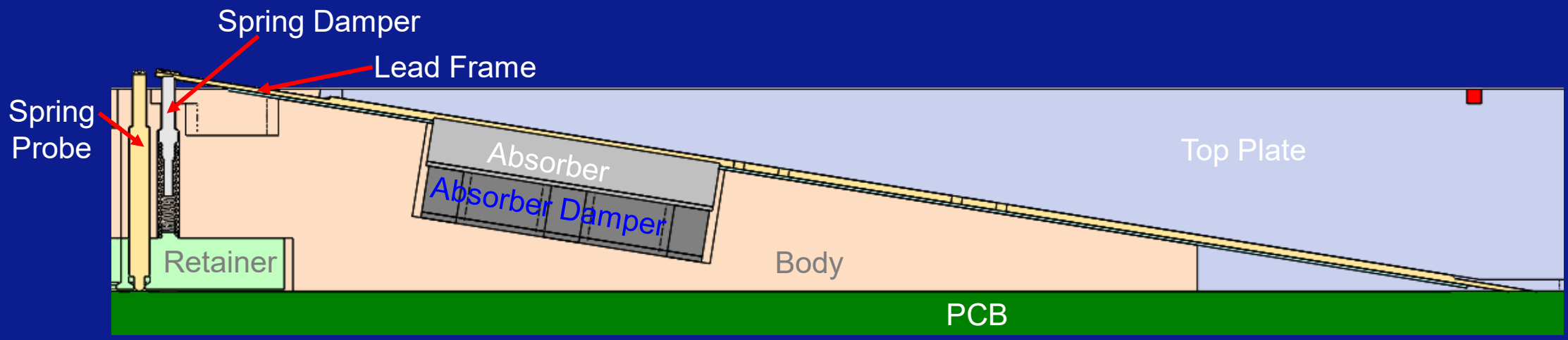




Total overdrive of about 11 mils to achieve continuity

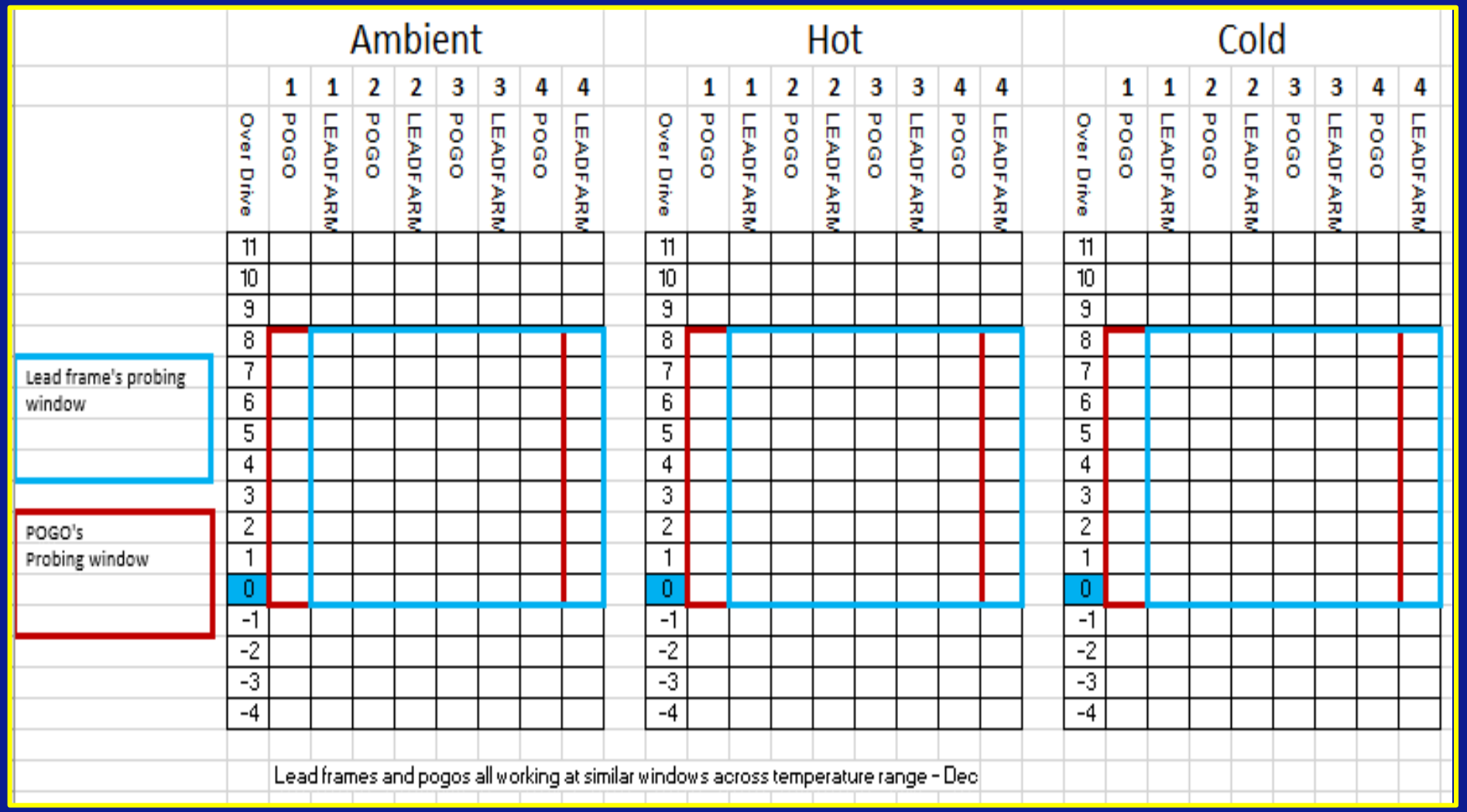
Successful but window was limited and production team wanted improvements

Test Solutions – Production Build



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

Field Results – Improved Production



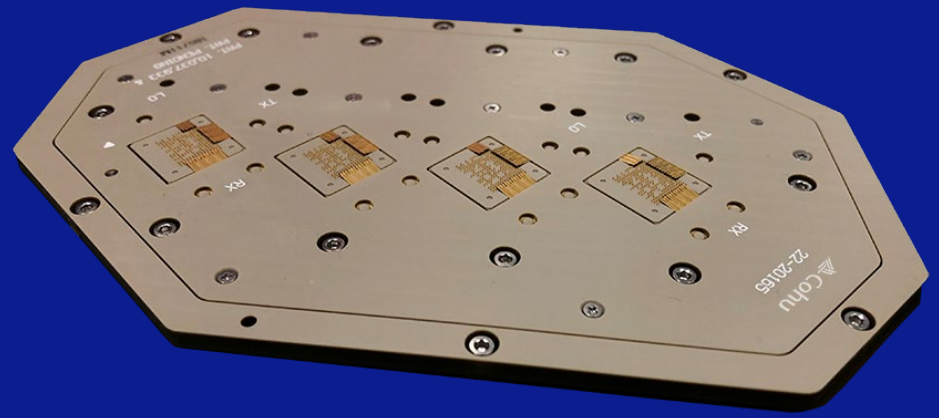
- Full continuity at all temps at 8 mils of overdrive
- Max overdrive of 13 mils allowed
- 5 mil working window
- Production team approved for release

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

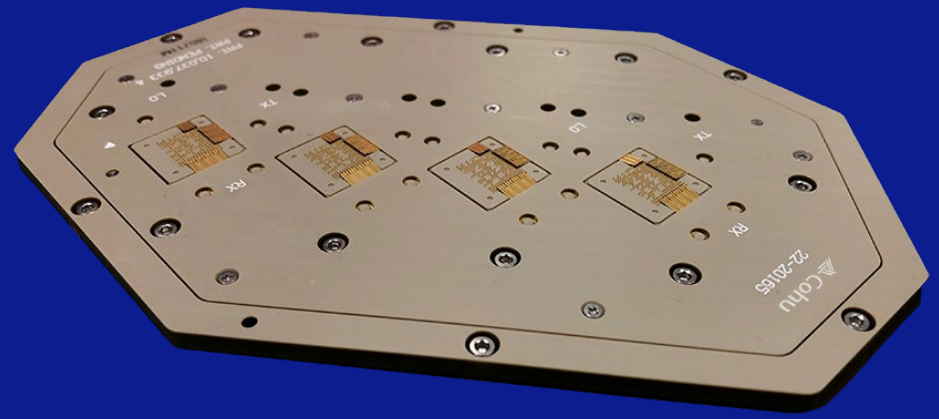
Strengths

- 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 wafter test applications with BIST
- Thank you to NXP for the opportunity and collaboration to make it happen!