Production Wafer Probe of 77-81 GHz Automotive Radar Applications

Jason Mroczkowski (Cohu)
Marty Cavegn (Cohu)
Jory Twitchell (NXP)
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
    • 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

---

Production Wafer Probe of 77-81 GHz Automotive Radar Applications
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**

<table>
<thead>
<tr>
<th>Leadframe</th>
<th>Ambient</th>
<th>HOT</th>
<th>COLD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 POGO</td>
<td>L</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>2 POGO</td>
<td>L</td>
<td>F</td>
<td>F</td>
</tr>
<tr>
<td>3 POGO</td>
<td>L</td>
<td>F</td>
<td>F</td>
</tr>
<tr>
<td>4 POGO</td>
<td>L</td>
<td>F</td>
<td>F</td>
</tr>
<tr>
<td>5 POGO</td>
<td>L</td>
<td>F</td>
<td>F</td>
</tr>
<tr>
<td>6 POGO</td>
<td>L</td>
<td>F</td>
<td>F</td>
</tr>
<tr>
<td>7 POGO</td>
<td>L</td>
<td>F</td>
<td>F</td>
</tr>
<tr>
<td>8 POGO</td>
<td>L</td>
<td>F</td>
<td>F</td>
</tr>
<tr>
<td>9 POGO</td>
<td>L</td>
<td>F</td>
<td>F</td>
</tr>
<tr>
<td>10 POGO</td>
<td>L</td>
<td>F</td>
<td>F</td>
</tr>
<tr>
<td>11 POGO</td>
<td>L</td>
<td>F</td>
<td>F</td>
</tr>
</tbody>
</table>

**Total overdrive of about 11 mils to achieve continuity**

Successful but window was limited and production team wanted improvements.
• 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

**Table:**

<table>
<thead>
<tr>
<th>Ambient</th>
<th>Hot</th>
<th>Cold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Over Drive</td>
<td>Over Drive</td>
<td>Over Drive</td>
</tr>
<tr>
<td>POGO</td>
<td>LEADFARM</td>
<td>POGO</td>
</tr>
<tr>
<td>LEADFARM</td>
<td>LEADFARM</td>
<td>LEADFARM</td>
</tr>
<tr>
<td>LEADFARM</td>
<td>LEADFARM</td>
<td>LEADFARM</td>
</tr>
<tr>
<td>LEADFARM</td>
<td>LEADFARM</td>
<td>LEADFARM</td>
</tr>
<tr>
<td>LEADFARM</td>
<td>LEADFARM</td>
<td>LEADFARM</td>
</tr>
<tr>
<td>LEADFARM</td>
<td>LEADFARM</td>
<td>LEADFARM</td>
</tr>
</tbody>
</table>

*Lead frames and pogs all working at similar windows across temperature range – Dec.*

**Diagram:**

- Lead frame's probing window
- POGO's Probing window

---

*TestConX™*

Production Wafer Probe of 77-81 GHz Automotive Radar Applications
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!
With Thanks to Our Sponsors!

Premier

Cohu

Emeritus

Johnstech®

Honored

ISC

WIN SOLUTION

TSE
With Thanks to Our Sponsors!

Distinguished

![Backer Hotwatt](image)

![Innovative Circuits Engineering](image)

![JMT](image)

![Nidec SV TCL](image)

![R&D Altanova](image)

![UI Green](image)

Exhibitor

![ELES](image)

![MJC](image)

![Phoenix Test Arrays](image)

![Smiths Interconnect](image)
With Thanks to Our Sponsors!

Industry Partners

- MEPTEC
- SWTEST

Publication Sponsor

- Chip Scale Review

TestConX™

Welcome - Virtual Event 2021
The Market Leader in Test Interface Solutions for the Most Challenging Applications
ELASTOMET SOCKET & INTERPOSERS
• High performance and competitive price
• High speed & RF device capability
• Various customized design to meet challenge requirement

POGO SOCKET SOLUTIONS
• Excellent gap control & long lifespan
• High bandwidth & low contact resistance

THERMAL CONTROL UNIT
• Extreme active temperature control
• Safety auto shut-down temperature monitoring of the device & thermal control unit
• Full FEA analysis & Price competitiveness

BURN-IN SOLUTIONS
• Direct inserting on the board without soldering
• Higher performance BIB solution
Spring probe by stamping

- Free Length (mm)
  0.15 ~ 0.25: 7.0
  0.25 ~ 0.35: 6.5
  0.35 ~ 0.45: 6.0
  0.45 ~ 0.55: 5.5
  0.55 ~ 0.65: 5.0

- Patented:
  Pitch (mm) | Free Length (mm) | Current Capacity (Ampere)
  0.15/0.25/0.35 | 2.17~ | 6.5~
  0.3 | 1.5~ | 1.5~
  0.35/0.45/0.55 | 2.08~ | 1.8~
  0.4 | 0.8~ | 2.0~
  0.45/0.55 | 1.6~ | 3.0~
  0.5 | 1.13~ | 4.0~
  0.55/0.65 | 3.14~ | 3.5~

- 250 kinds of spring probe pin
- 300 kinds of test socket (44,000 Pin count socket possible)
- One piece spring probe
- Three piece spring probe
- High speed product -> 0.63mm free length
- Spring probe pin available
- Finest Pitch -> 0.15mm Pitch

Spring probe pins for High speed

Automation
Pin assembly and Quality control

- Extremely short spring probes by stamping

Socket and Lid

- Design approach

Pin assembly (Fully automated machines)

- Stamped parts are attached to a reel and fed into the assembly machine
- Assembled pins can be attached to a reel, ready for socket assembly

Copyright ©2021 IWIN Co., Ltd all right reserved
Homepage. www.iwinsn.com Tel. +82-10-6417-7580 E-mail. aj@iwinsn.com

High Performance Probe solution