WLCSP xWave for high frequency wafer probe applications part 2

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Abstract:

Today cmWave(3-30 GHz) and mmWave (30-300 GHz) applications have become mainstream. Packaging has become obsolete and wafers are becoming the new final test package. Testing automotive radar on wafer at 80 GHz and 150 degC was previously a fantasy, but is now a reality. With high power simulation tools and 110 GHz VNA's it's possible to design and fabricate hardware for these extremely high frequency, high temperature applications.

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SWTEST
PROBE TODAY, FOR TOMORROW

WLCSP xWave for high frequency wafer probe applications part 2

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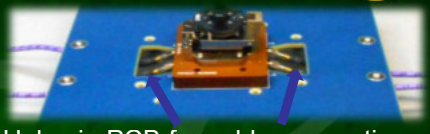
Overview

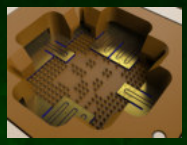
- **Objectives / Goals – Move from package test to wafer test**
- **Methods / Materials / Procedures – design considerations, mechanical simulation, electrical simulation, characterization**
- **Results / Relevant Findings / Key Data – tip design, force, insertion loss, impedance**
- **Customer Results/Feedback – Initial DC and RF test results**
- **Summary / Conclusion - viable cmWave and mmWave wafer level test solution**
- **Follow-On Work – Beta sites feedback**

xWave Platform for mmWave Package Test

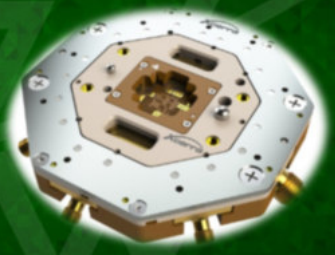
- **Signal Integrity**
  - Short impedance controlled coplanar waveguide (CPW)
  - 1 transition between Tester and DUT (connector to Leadframe)
  - DUT ball contacts CPW
- **Integrated Solution (PCB/Contactor in One)**
  - Includes RF Path from Tester to DUT
  - Pogo pins for Power and control signals
- **Production Package Test Solution**
  - Robust Leadframe lasts Millions of cycles
  - Mechanical assembly fully field maintainable
  - Includes calibration kit (s-parameters)
  - CTE matched materials for Tri Temp testing (-55 to 155°C)

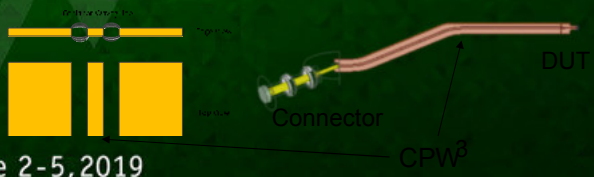


Holes in PCB for cable connections



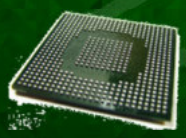
DUT Pocket



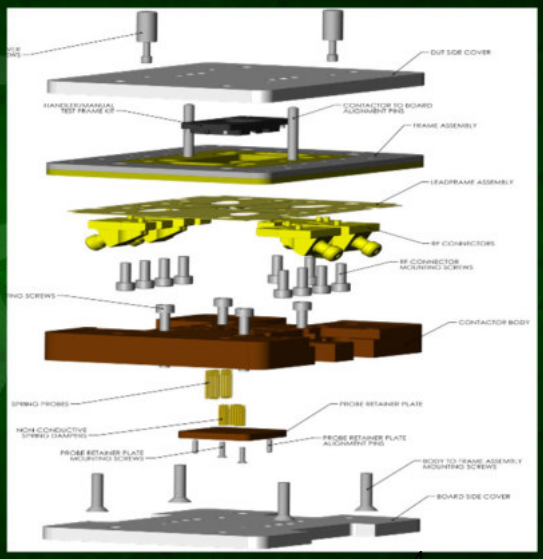


xWave Limitations for Wafer Test

- **Frame limits xWave solution to Package test**
  - Leadframe sandwiched between top frame and connectors
  - Top frame violates wafer infinite plane
  - Flat leadframe shorts adjacent sites

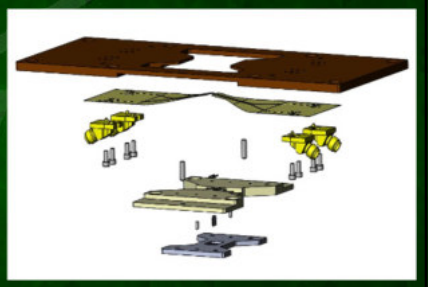


How to make xWave compatible with Wafer Test?

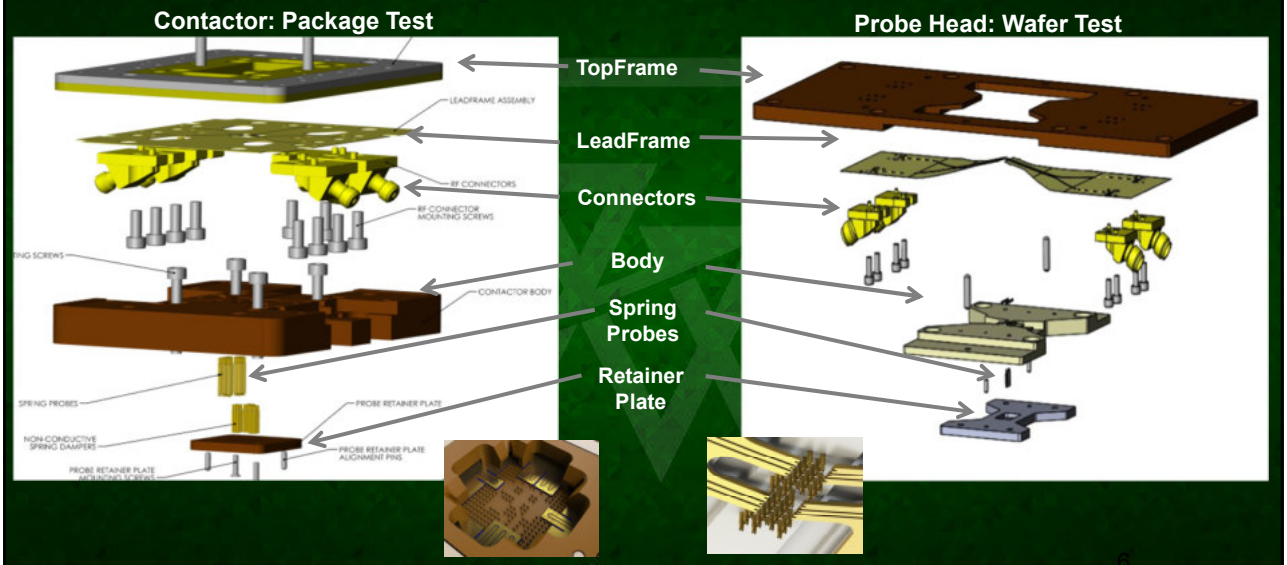


Objectives/Goals

- **Move xWave Technology from package test to wafer probe**
  - Move contact point of leadframe to infinite plane
  - Combine leadframe with fine pitch pogo technology
  - Reduce leadframe features to match bump pitch
  - Reduce leadframe force to limit contact marking on wafer bumps
  - Limit scrub to ensure no ball shear



xWave Wafer Level Final Test



xWave: Wafer Level Final Test

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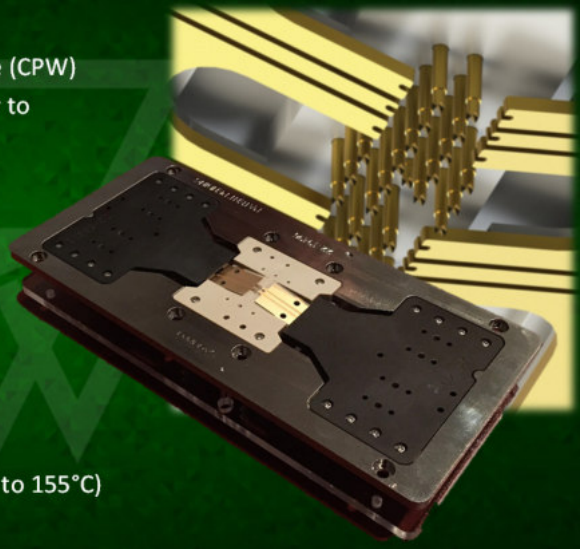
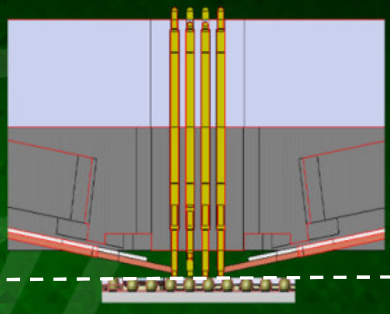
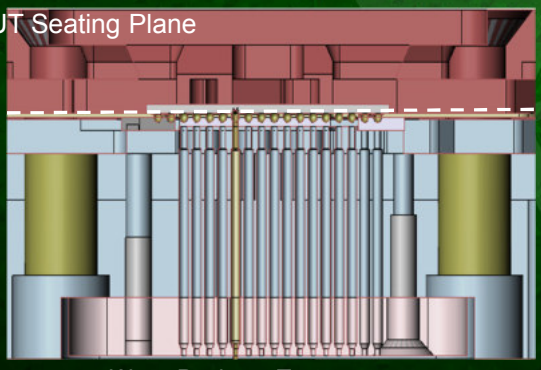


Move contact plane to infinite plane

- From Flat leadframe in DUT pocket to Angled leadframe at infinite plane



xWave Wafer Test

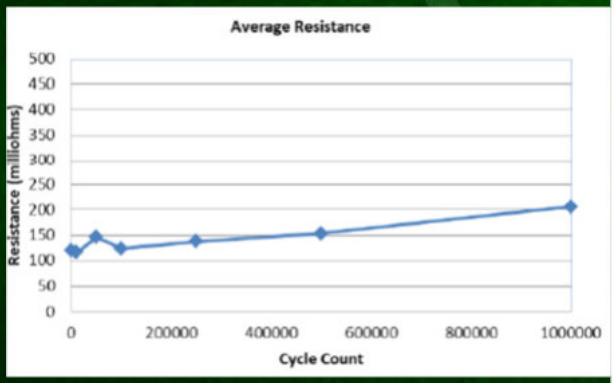


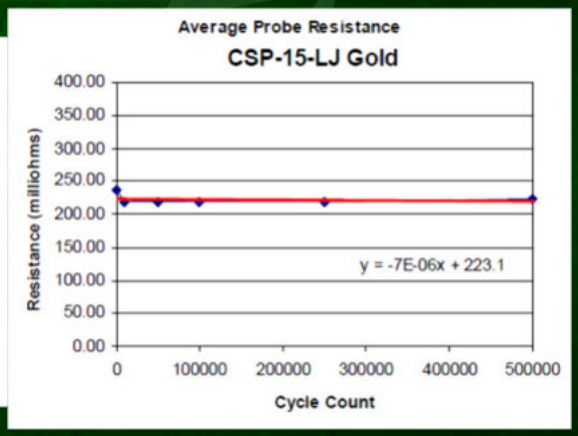
xWave Package Test

- From 0.5mm probe to 150um probe

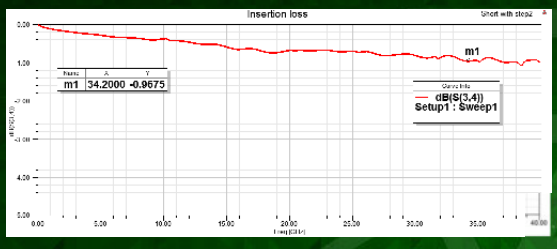
Probe comparison

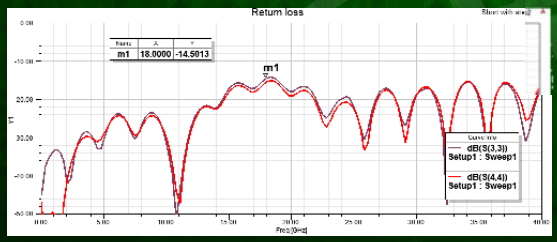
- xWave Contactor Probe xWave Wafer Probe

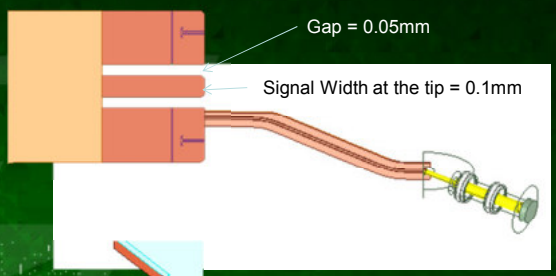


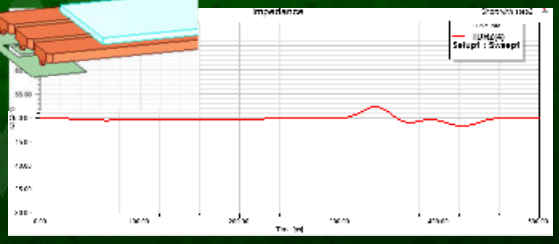


Electromagnetic Simulation









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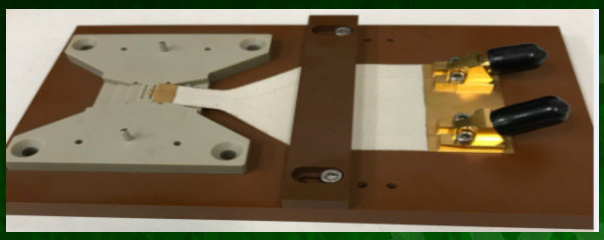
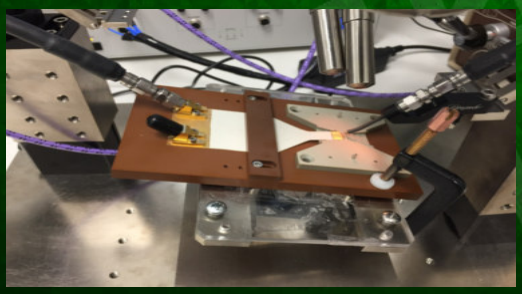
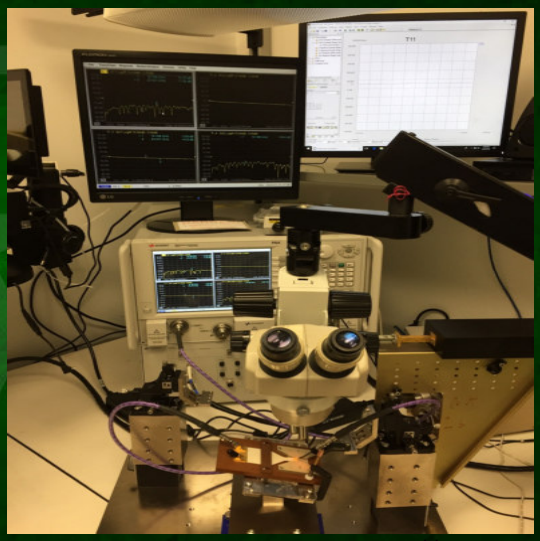
xWave Dual Site Probe Card Prototype RF Lab Measurement

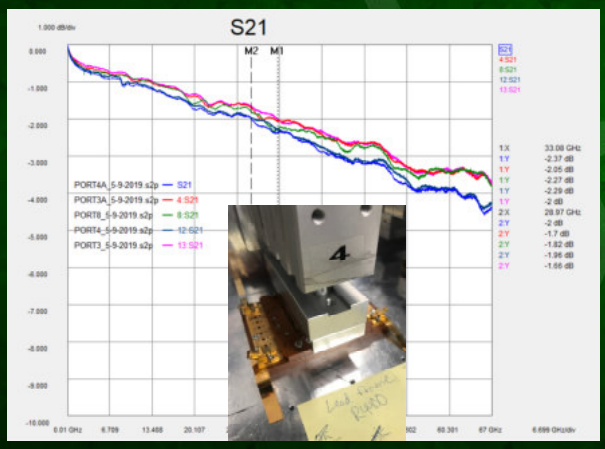






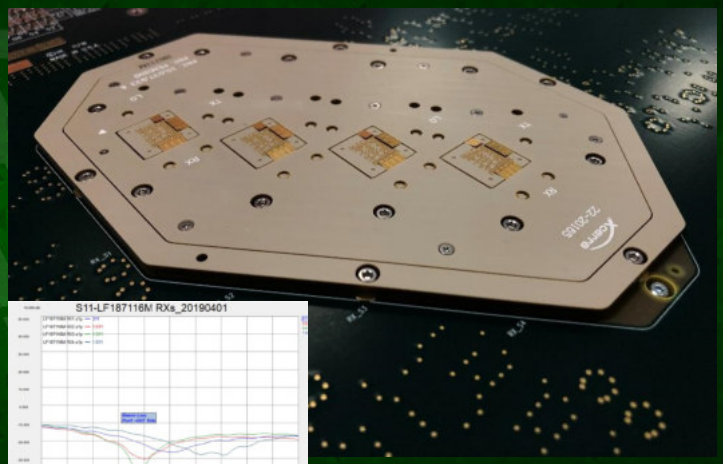
S-parameter 150um xWave Prototype

- **Low Linear Insertion Loss and Return Loss below -10dB to 60+GHz (leadframe + connector)**



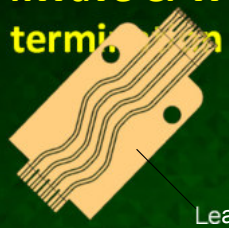
xWave ProbeHead - 80GHz Absorber Termination

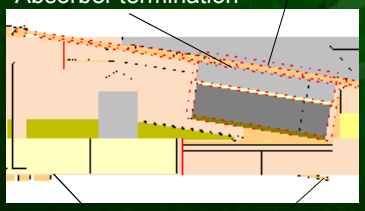
- 80GHz ADAS Quad Site Probe Head
- xWave Hybrid Coplanar waveguide and spring probe design
- 12 Absorber Terminated Leadframes (48 channels)
- No coax connectors
- PCB leadframe launch
- Turnkey Probe Head/ Probe Card
- Impedance controlled Leadframes (<10dB return loss 76GHz-81GHz)

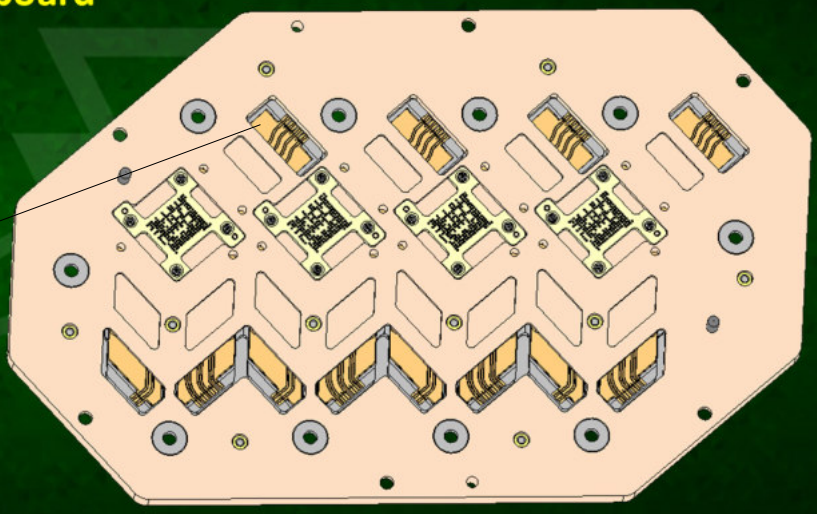


xWave Probe Head - Loadboard Side

- xWave CPW Loadboard termination

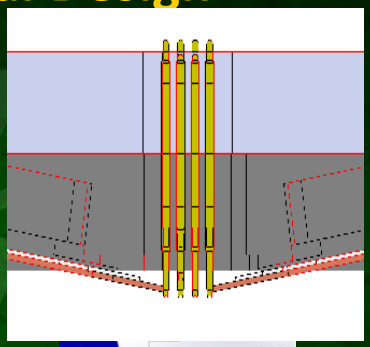


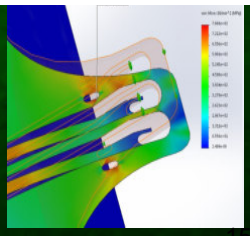




WLCSP xWave Mechanical Design

- **Force**
  - Leadframe – 8g @ 150um overdrive
  - 250um leadframe and 300um probe travel
  - Adjustable based on leadframe cross section and cantilever anchor point
  - Sufficient force without spring damper
- **Thermal**
  - Designed for Tri-Temp
  - Same materials as standard xWave
  - All materials are matched coefficient of thermal expansion (CTE)

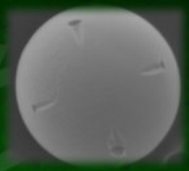




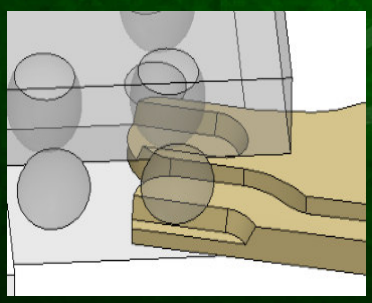
WLCSP xWave Mechanical Design

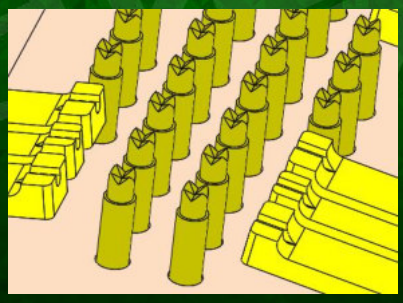
- **BGA Contact feature**
  - Leadframe - U shape edge contact to ball
  - ~10um knife edge scrub
  - Pogo – 4 point crown
  - 250um compliance

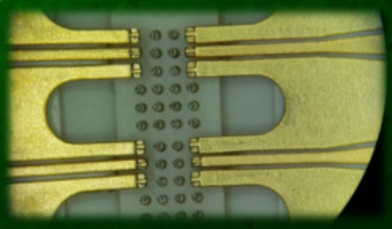
Leadframe



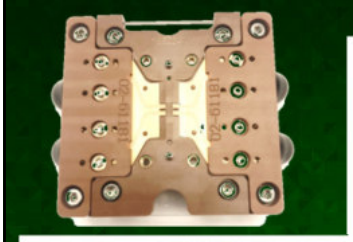
probe





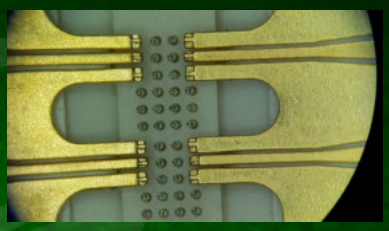


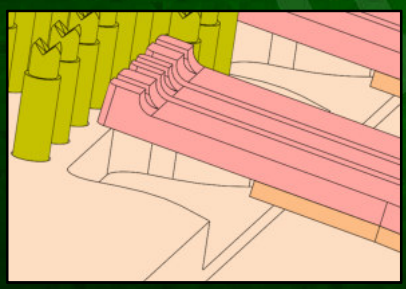
Probe Head Planarity



xWave ProbeHead - 30GHz 250um

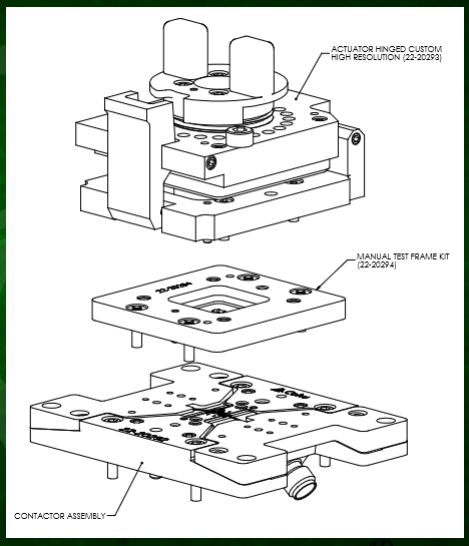
- **30GHz SatComm Dual-Site Probe Head**
- **2 RF ports per site on 2 replaceable LeadFrames**
- **18 cViper 025 Probes/site**



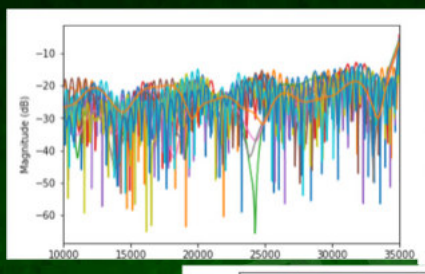


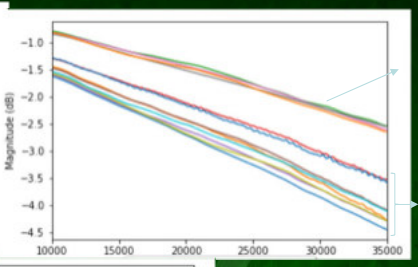
Package Test and Wafer Test in One

- **Same hardware can be used for both packaged test and wafer test**
  - Manual Alignment Frame (MAF) attaches to Probe head to convert to final test
  - Manual Actuator (MA) attaches to MAF
  - Simple change over from Wafer to Packaged parts for QA or RMA's



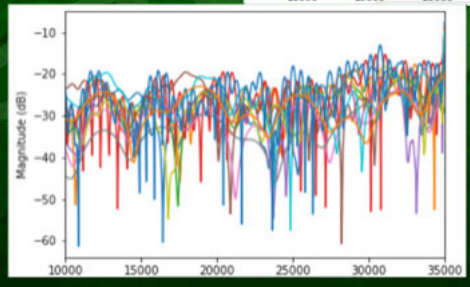
Customer Results: S11, S21 TDR 1 port AFR 0-35GHz





Only probe head, no cabling

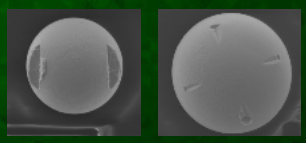
Main difference is cable length



Correlates to Cohu Internal measurements

Customer Results: First trials

- **Day 1**
  - Prober setup OK(single only)
    - Site and bump pitch/location is OK
  - DC trials: both sites OK
    - No overdrive needed to get contact
    - DC measures analysis on going for different overdrive steps
    - No obvious DC probe mark on bump, or very slight (prober camera)
  - RF trials : site 1 OK
    - Requires ~100um overdrive to get RF contact
      - Prober measured 55um difference height DC vs RF
      - Cohu expecting 60um overdrive RF vs DC for contact. Nominal 150um would be ok for most cases.
    - No obvious RF probe mark on bump, or very slight (prober camera)



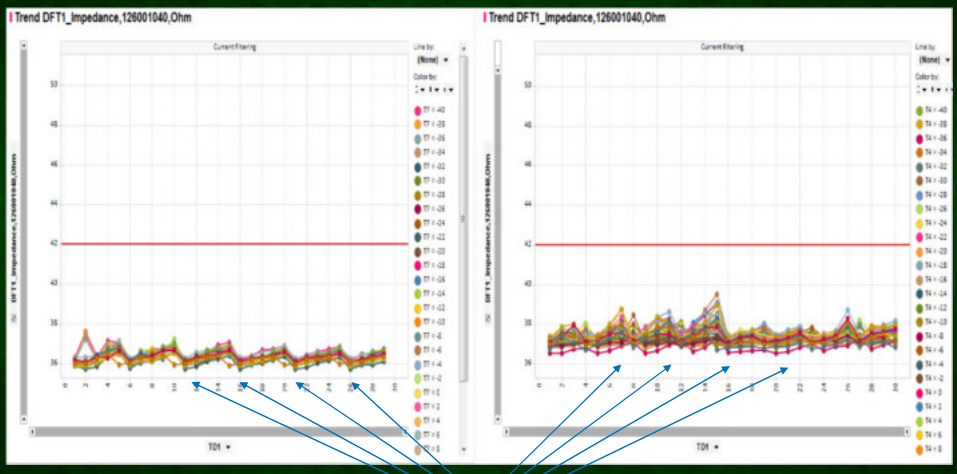
Customer Results DFT1 impedance: Existing vs Cohu

Existing probe card

Pos Y=-26, cleaning, 30 Run, OD=200

Cohu probe card

Pos Y=-98, cleaning, 30 Run, OD=190



Cleaning every 150 touch down

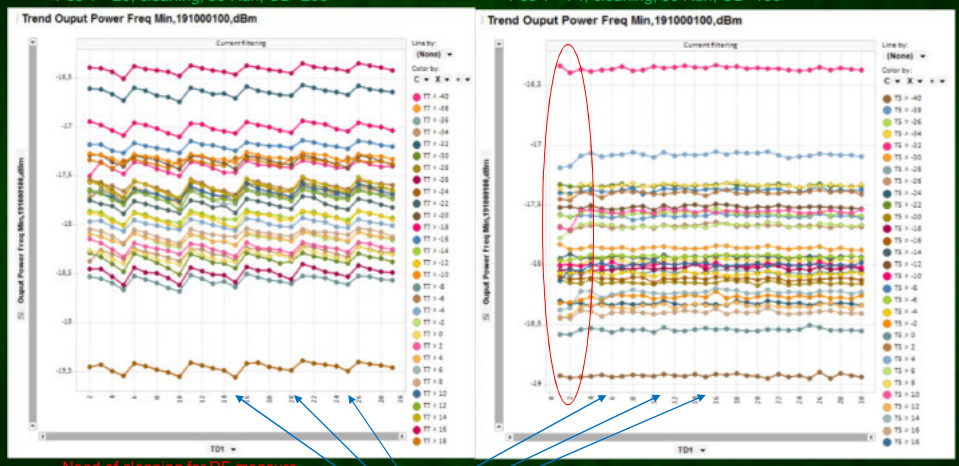
Customer Results: RF measure: Existing vs Cohu

Existing probe card

Pos Y=-26, cleaning, 30 Run, OD=200

Cohu probe card

Pos Y=-74, cleaning, 30 Run, OD=150



Need of cleaning for RF measure

Cleaning every 150 touch down

- No impact of cleaning on RF
- Small drift seen on first runs (to be checked)

Customer Results: Wrap-Up / X-Wave Pros & Cons

- Excellent Insertion Loss and Return Loss performance.
  - IL < 4dB @ 30GHz (including cable),
  - RL < 15dB @ 30GHz,
  - X-Wave design up to 110GHz.
- X-Wave is designed to reduce probe mark.
  - Avoid hitting center of ball,
  - May remove need for ball re-flow.
- Fully repairable on Field at low cost.
  - Part maintenance has been demo'ed.
- Good RF Repeatability
  - < 0.05dB over 30 program loops.
- Good RF Repeatability on multiple touch-down
  - About 0.2dB variation observed on 30 cycles.
- Capability to perform manual retest of singulated die.
  - Need microscope to insert the tiny device,
  - Good unit at first test.

- Probe core is more expensive than current solution.
- Lead-frame alignment is made manually (few tens of um).
  - Need to assess stability during prober operation,
  - Need to understand what it means for production.
- During trial a larger drift has been observed on DFT1 Impedance test.
  - When pogo hits multiple times at same place, the electrical contact is degraded,
  - Behavior seems no more true when prober steps or when pogo hit more the center of the ball.
  - Need more investigation.

Summary/Conclusion

- Overcame infinite plane and force profile to take the mmWave technology from final test applications to wafer test.
- WLCSP test data shows same electrical and mechanical performance as package test data
- Customer trials shows positive results

Next Steps

- Improve contrast on Calibration Substrate for better prober visibility
- Move leadframe first contact to same plane as pogo contact
- Standardize on pogo pin length
- Standardize on Leadframe geometry
- Develop internal array contact capability
- Standardize leadframe for lower COT