SWTEST

PROBE TODAY, FOR TOMORROW

WLCSP xWave for high frequency wafer probe applications part 2

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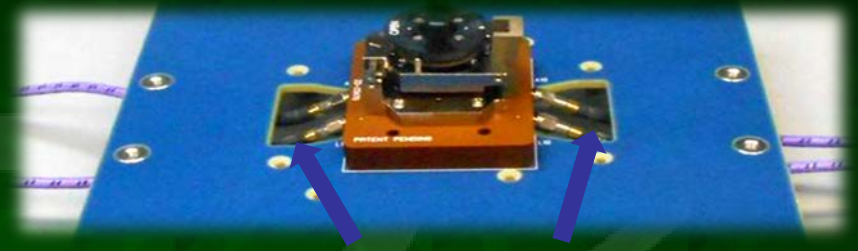
Overview

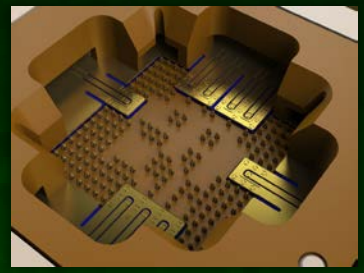
- Objectives / Goals – Move from package test to wafer test
- Methods / Materials / Procedures – design considerations, mechanical simulation, electrical simulation, characterization
- Results / Relevant Findings / Key Data – tip design, force, insertion loss, impedance
- Customer Results/Feedback – 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

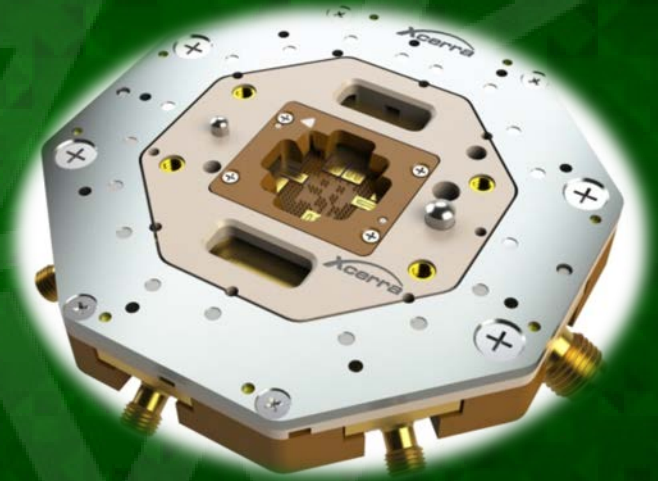
- **Signal Integrity**
  - Short impedance controlled coplanar waveguide (CPW)
  - 1 transition between Tester and DUT (connector to Leadframe)
  - DUT ball contacts CPW
- **Integrated Solution (PCB/Contactor in One)**
  - Includes RF Path from Tester to DUT
  - Pogo pins for Power and control signals
- **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)

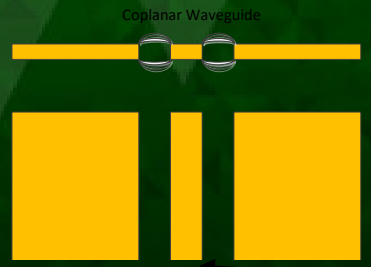


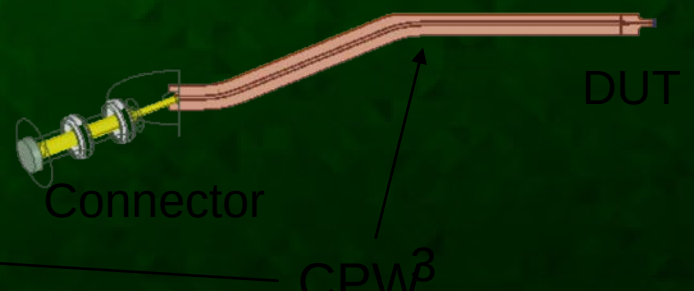
Holes in PCB for cable connections



DUT Pocket



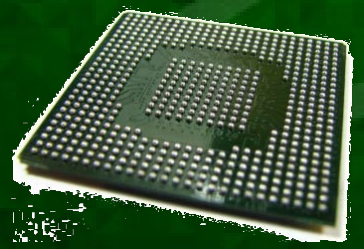


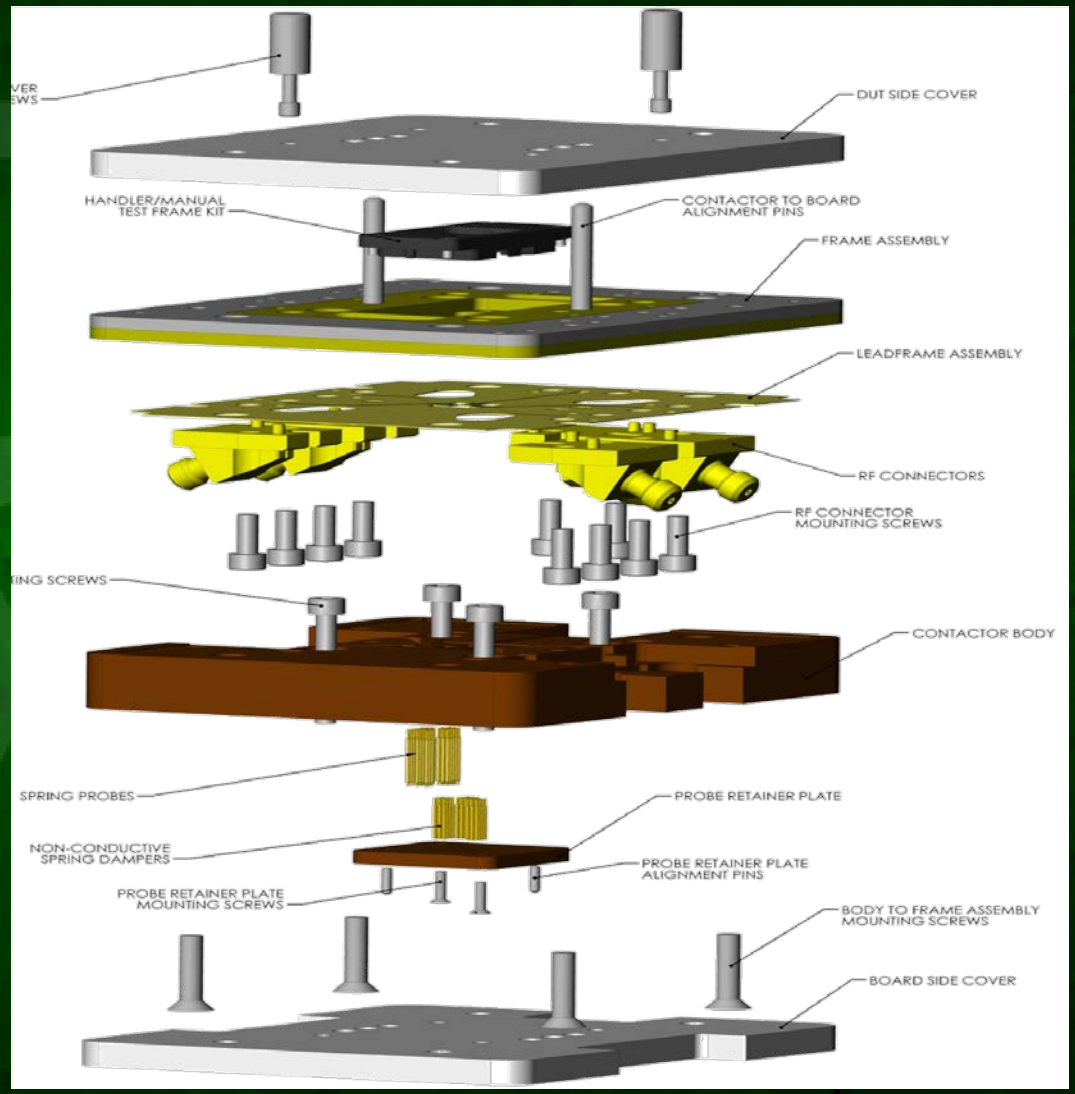


Jason Mroczkowski

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

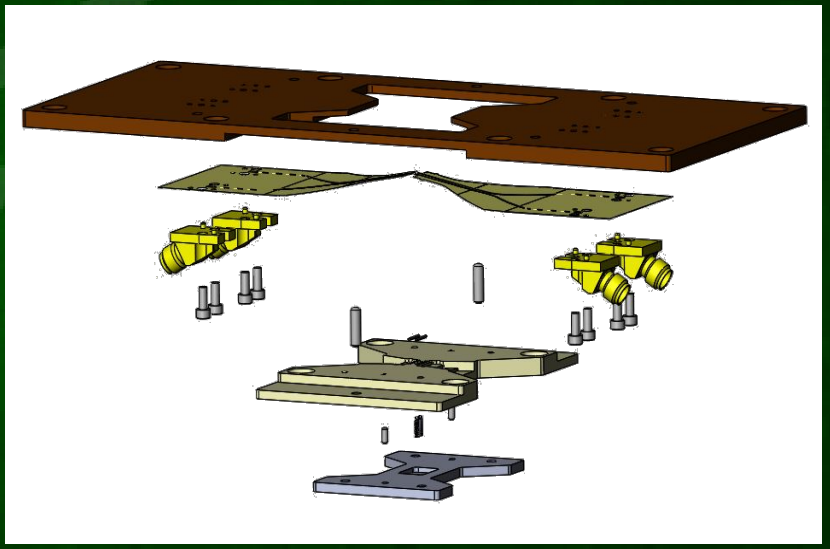




How to make xWave compatible with Wafer Test?

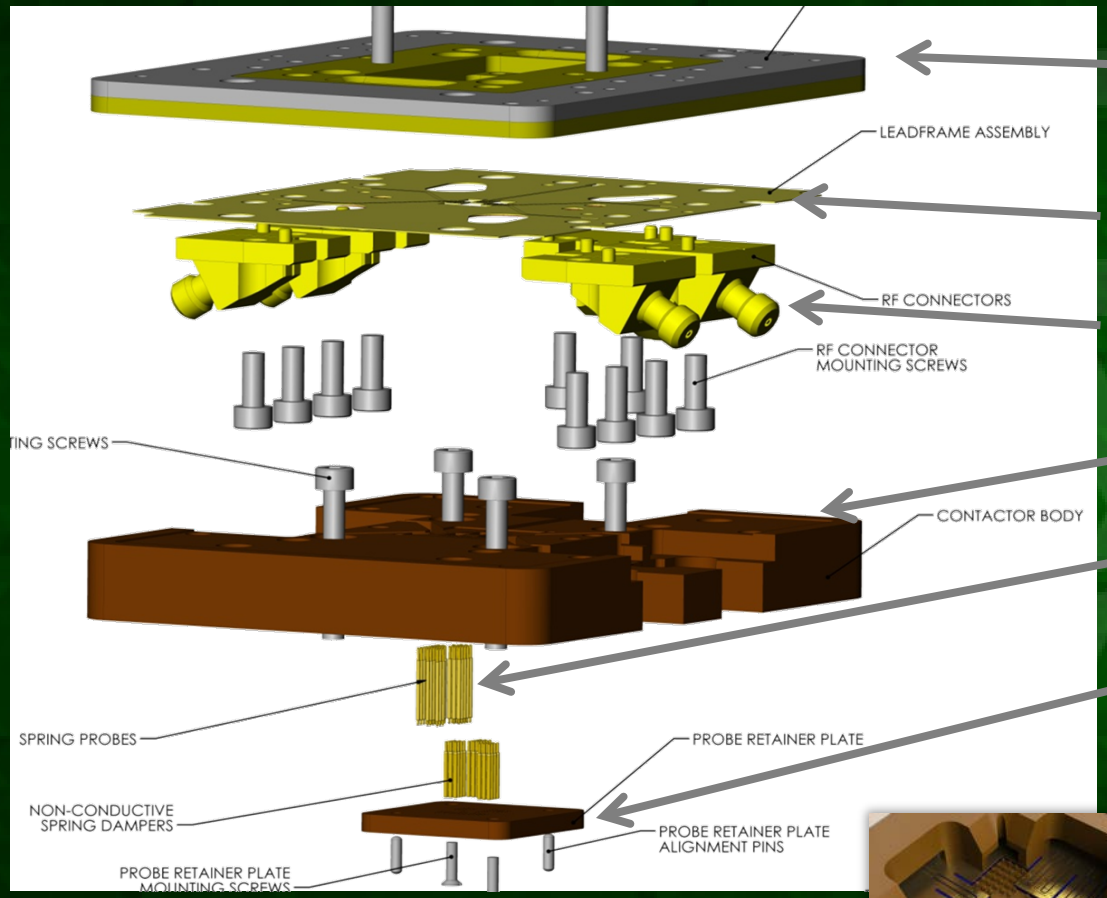
Objectives/Goals

- **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

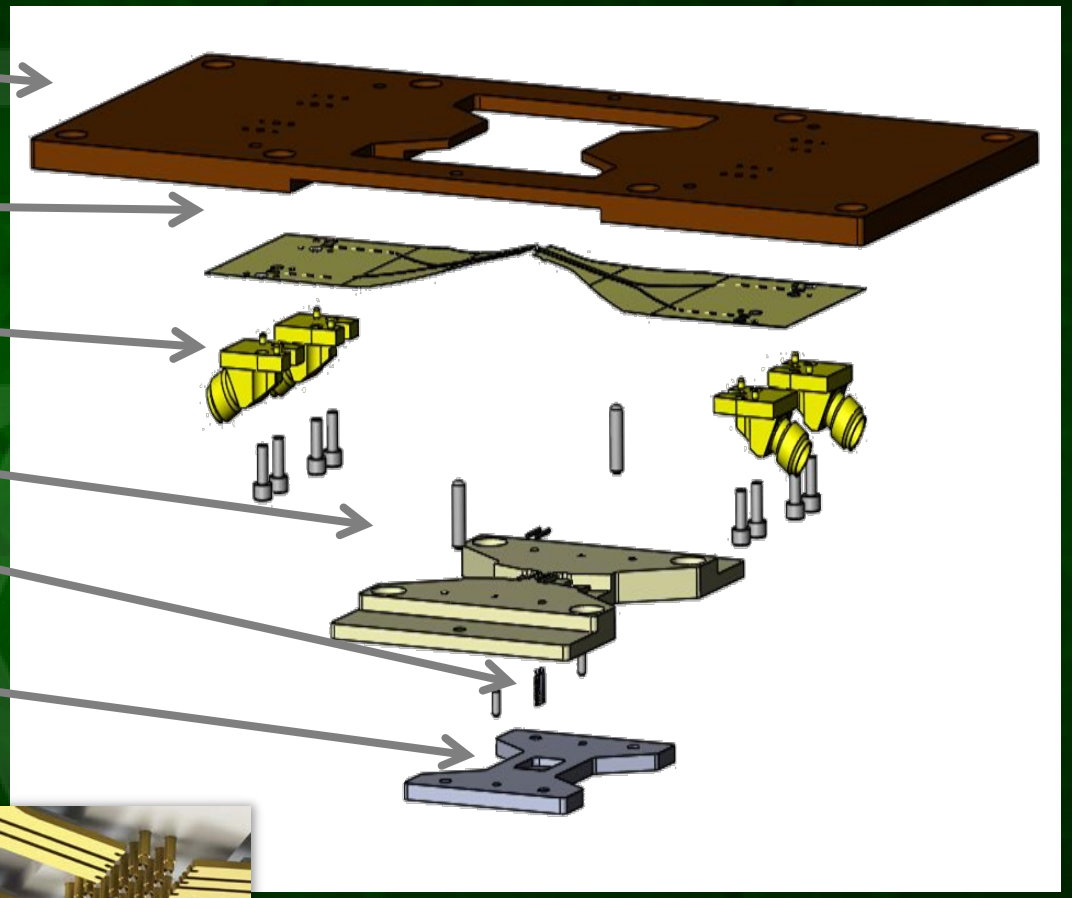


xWave Wafer Level Final Test

Contactor: Package Test



Probe Head: Wafer Test



TopFrame

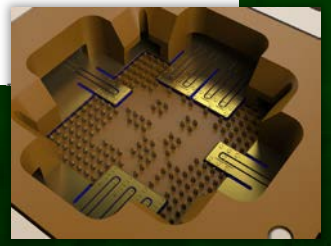
LeadFrame

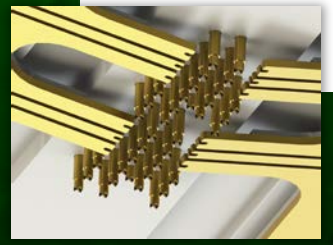
Connectors

Body

Spring Probes

Retainer Plate





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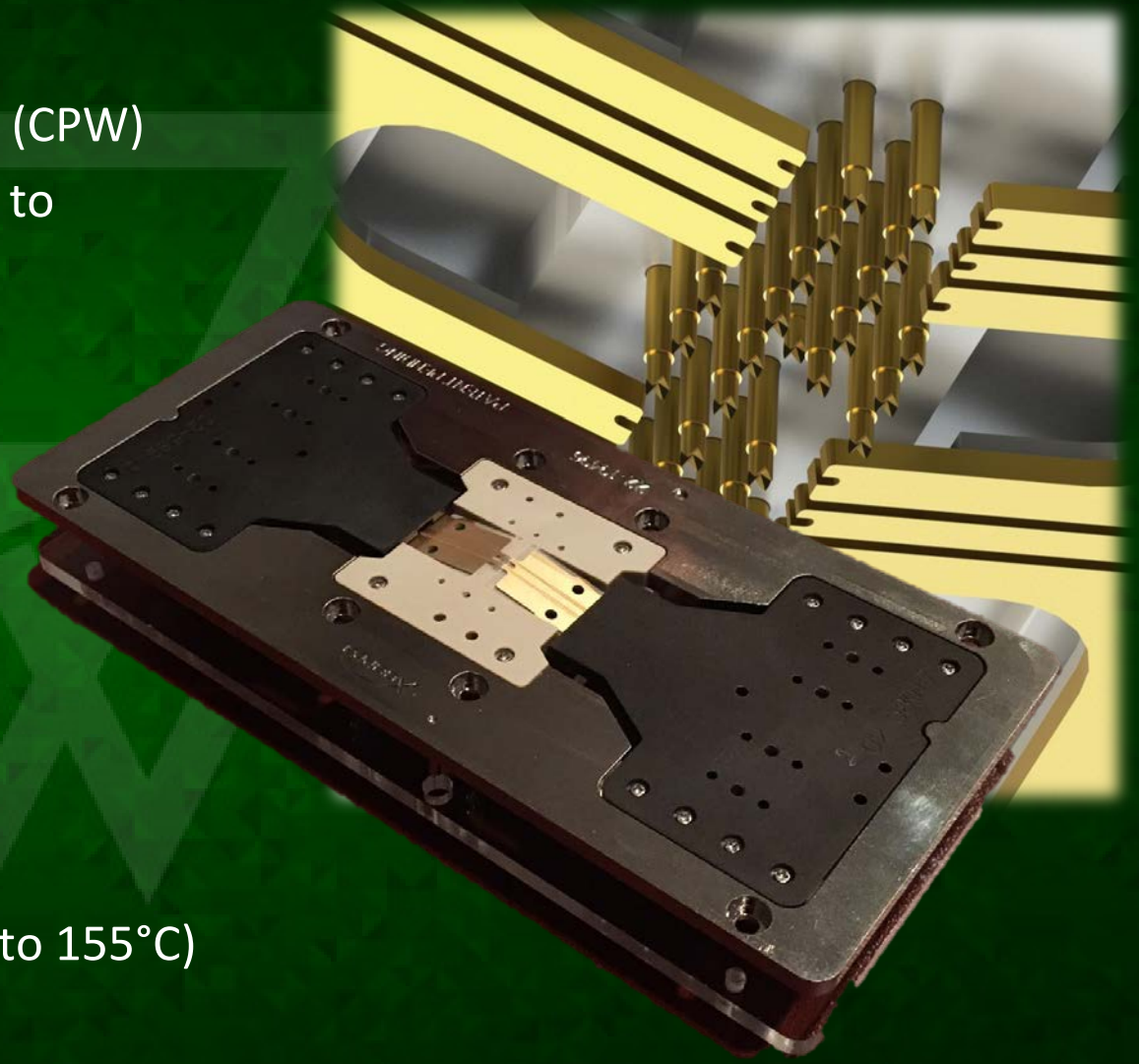
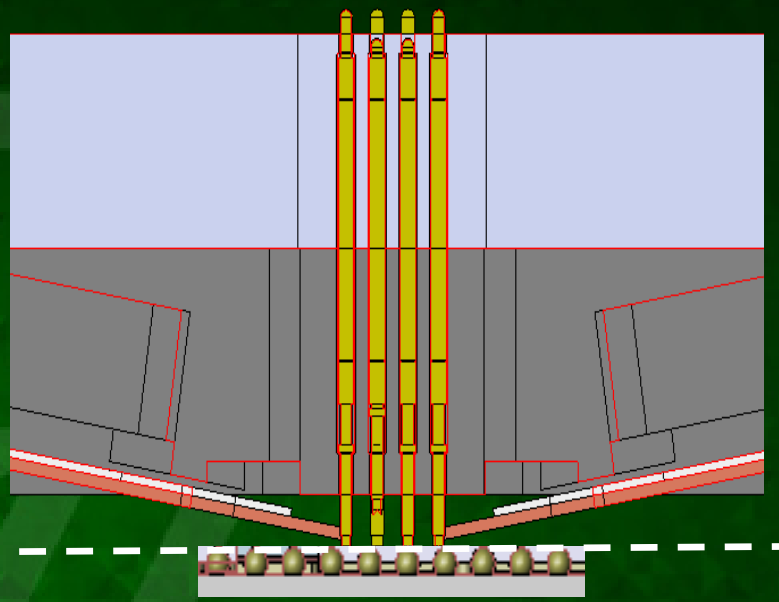
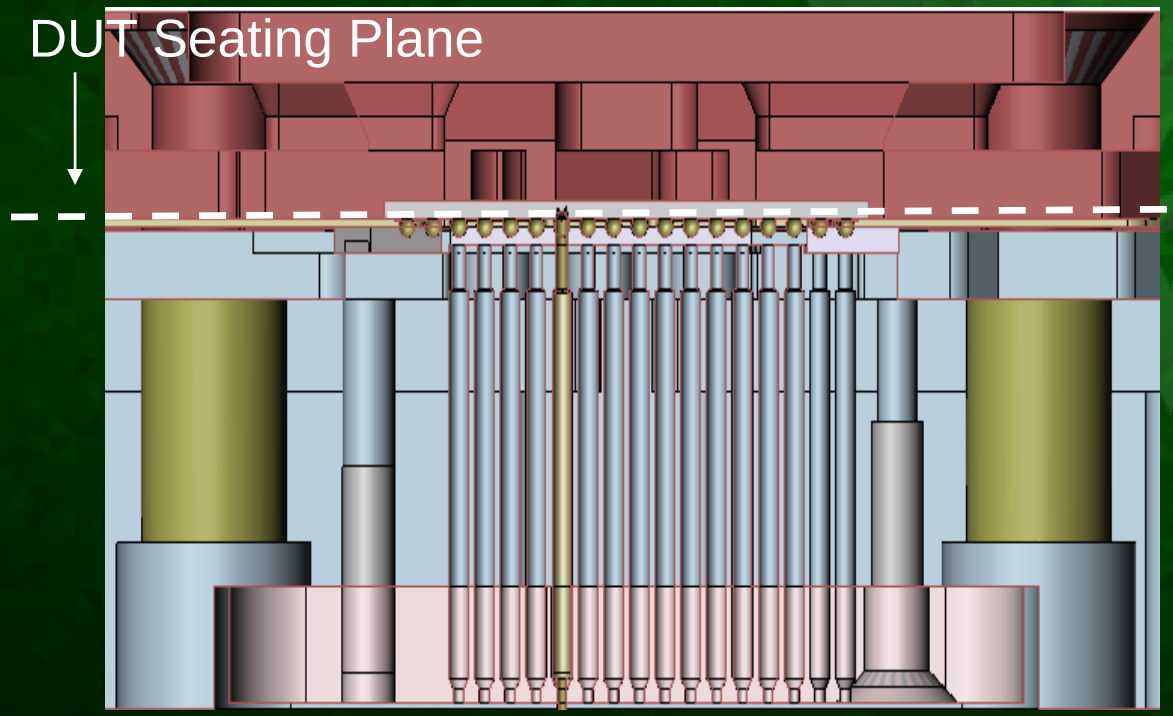


Move contact plane to infinite plane

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





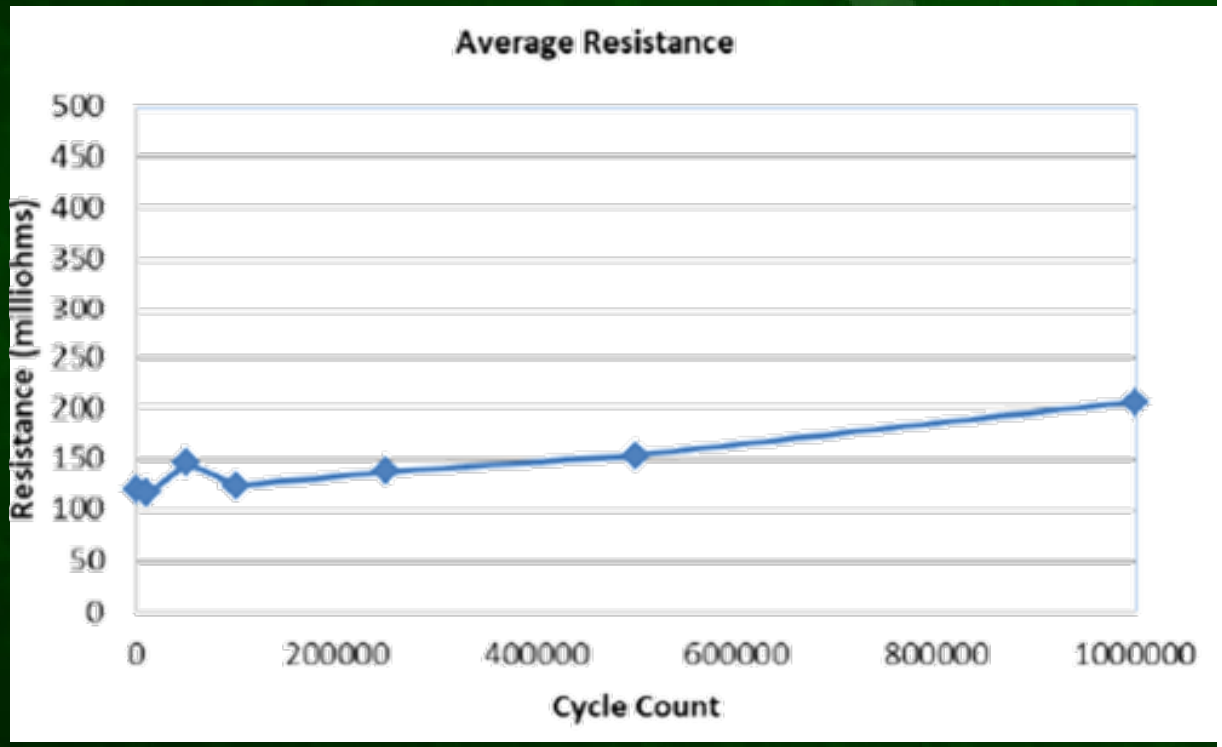
xWave Package Test

xWave Wafer Test

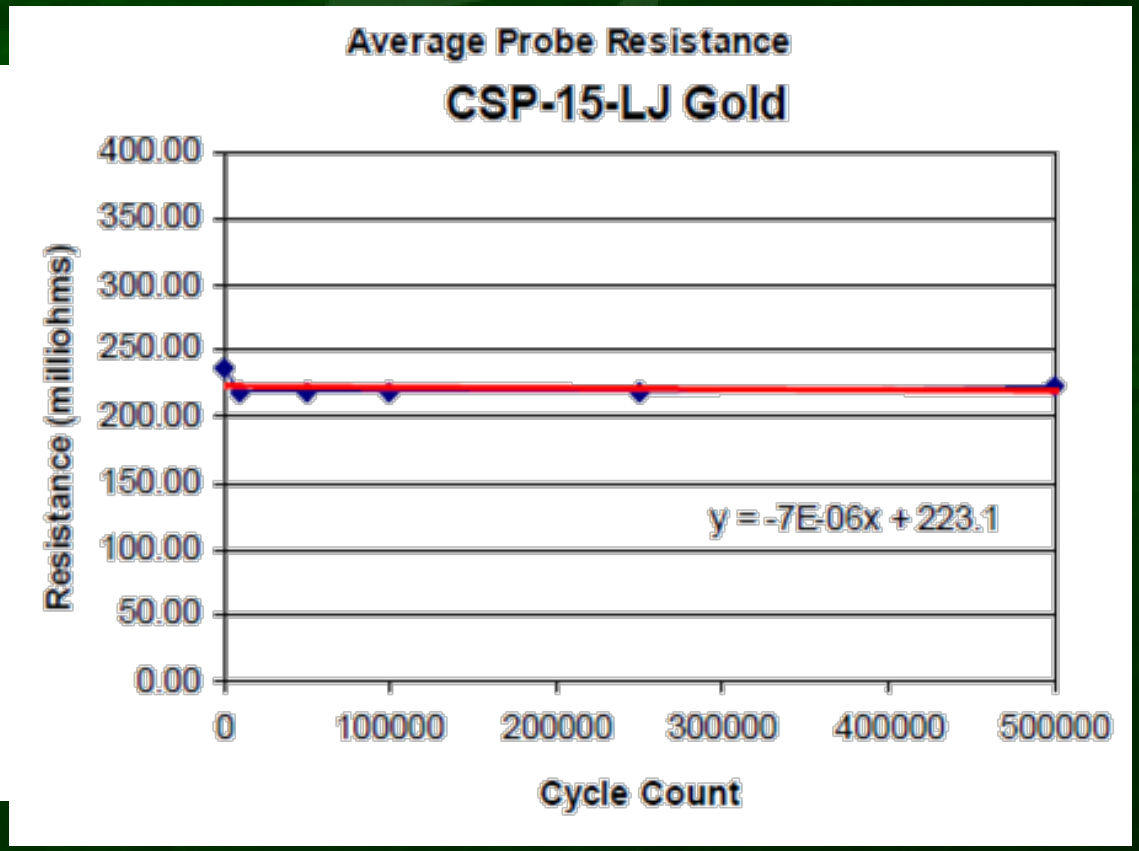
- From 0.5mm probe to 150um probe

Probe comparison

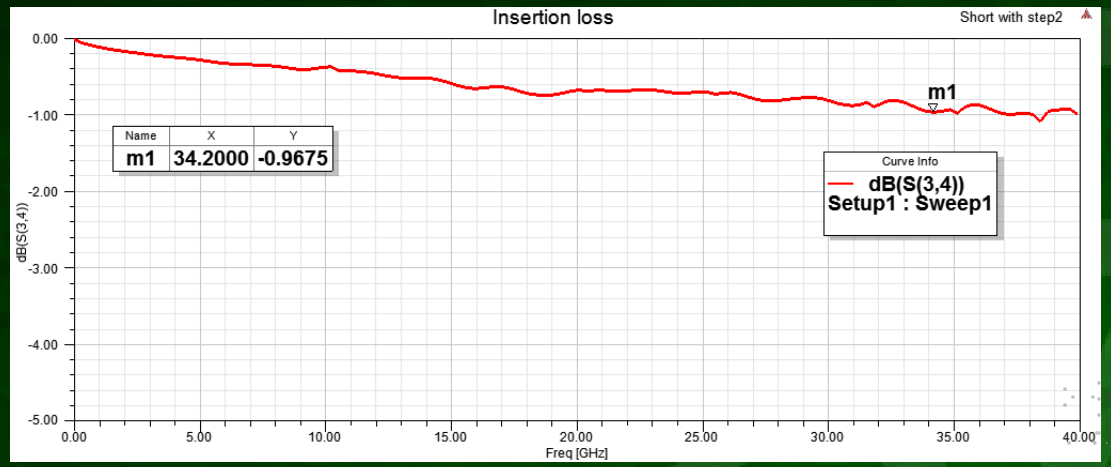
- xWave Contactor Probe

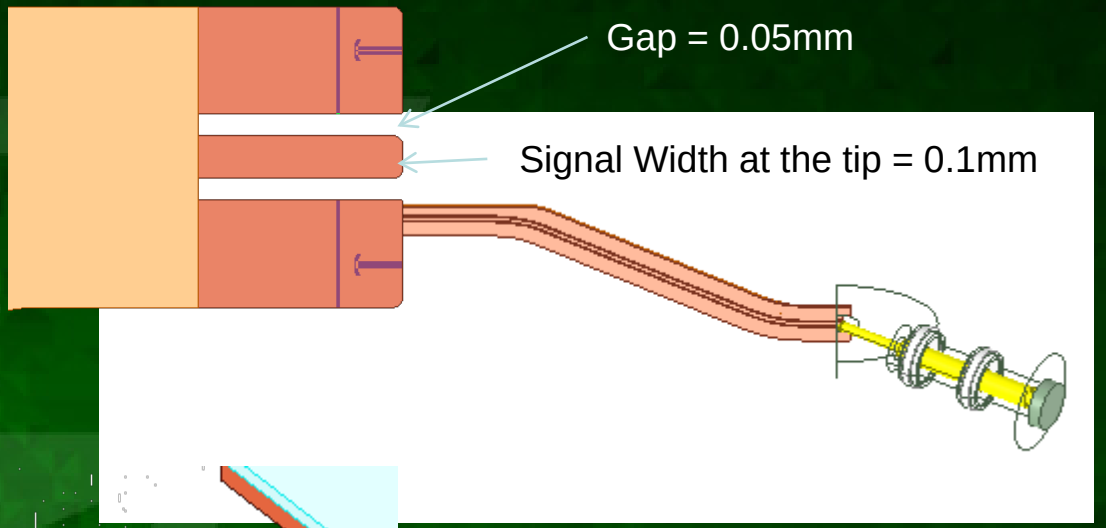


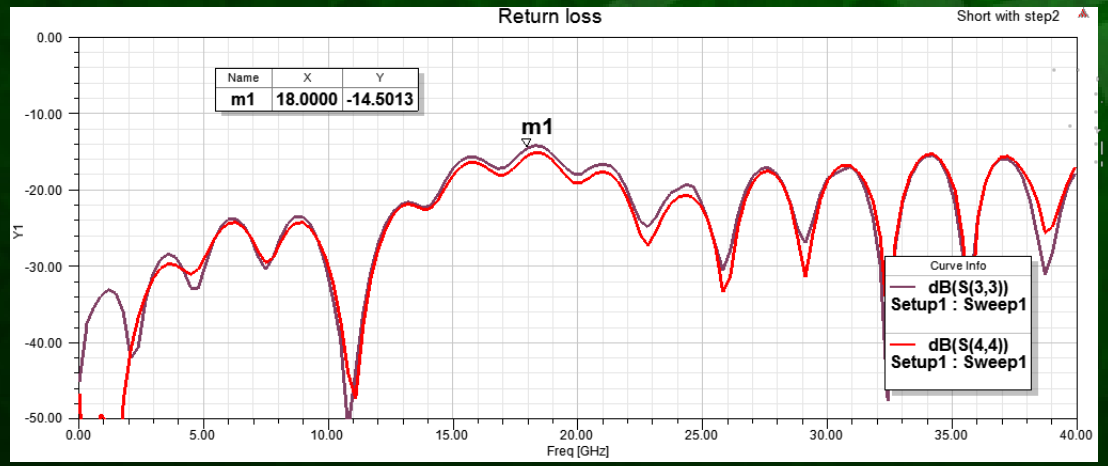
xWave Wafer Probe

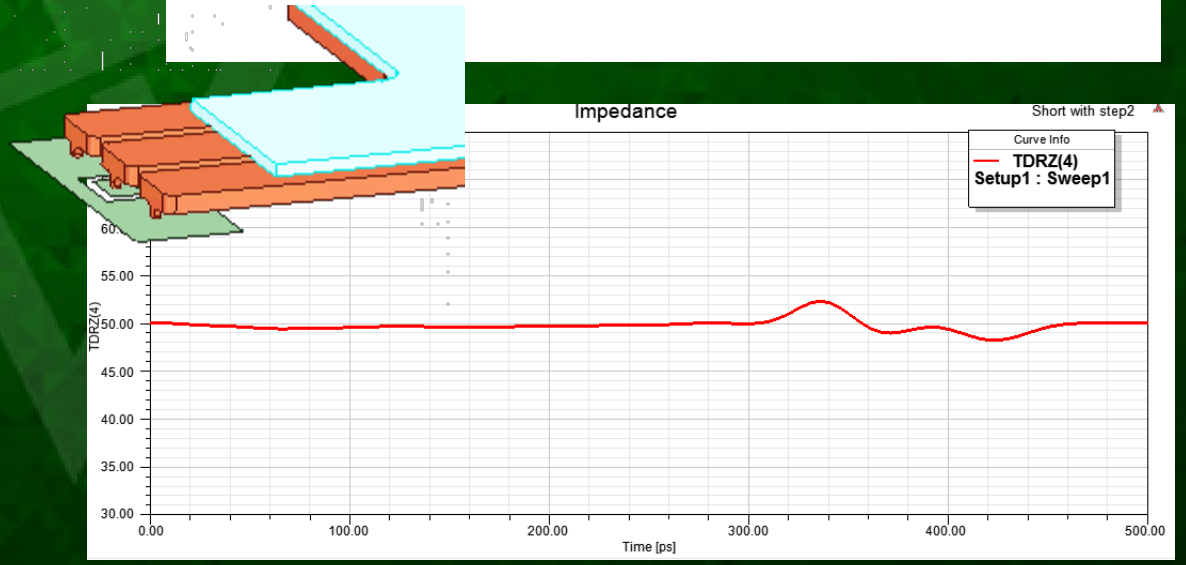


Electromagnetic Simulation

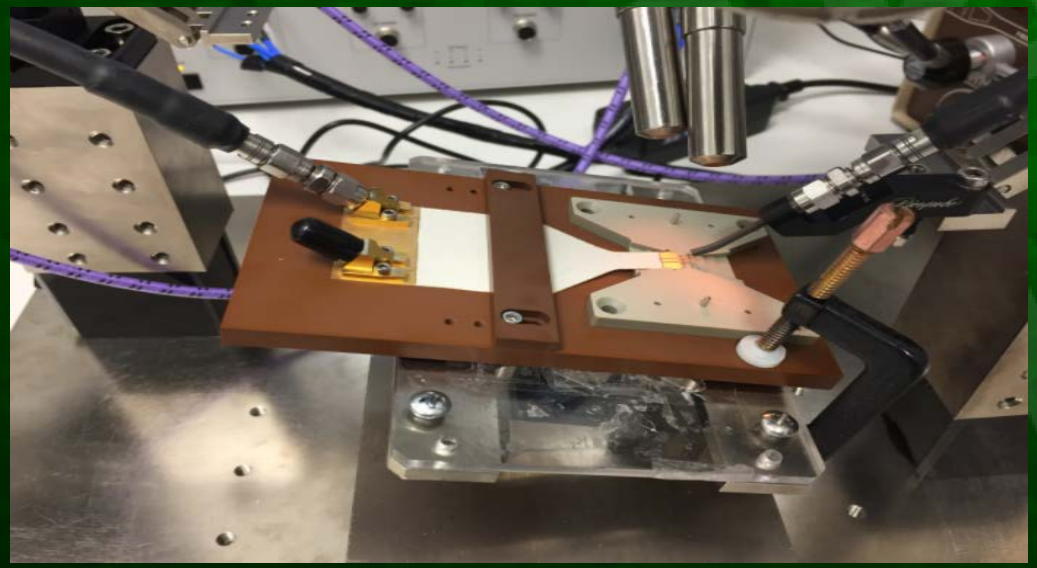


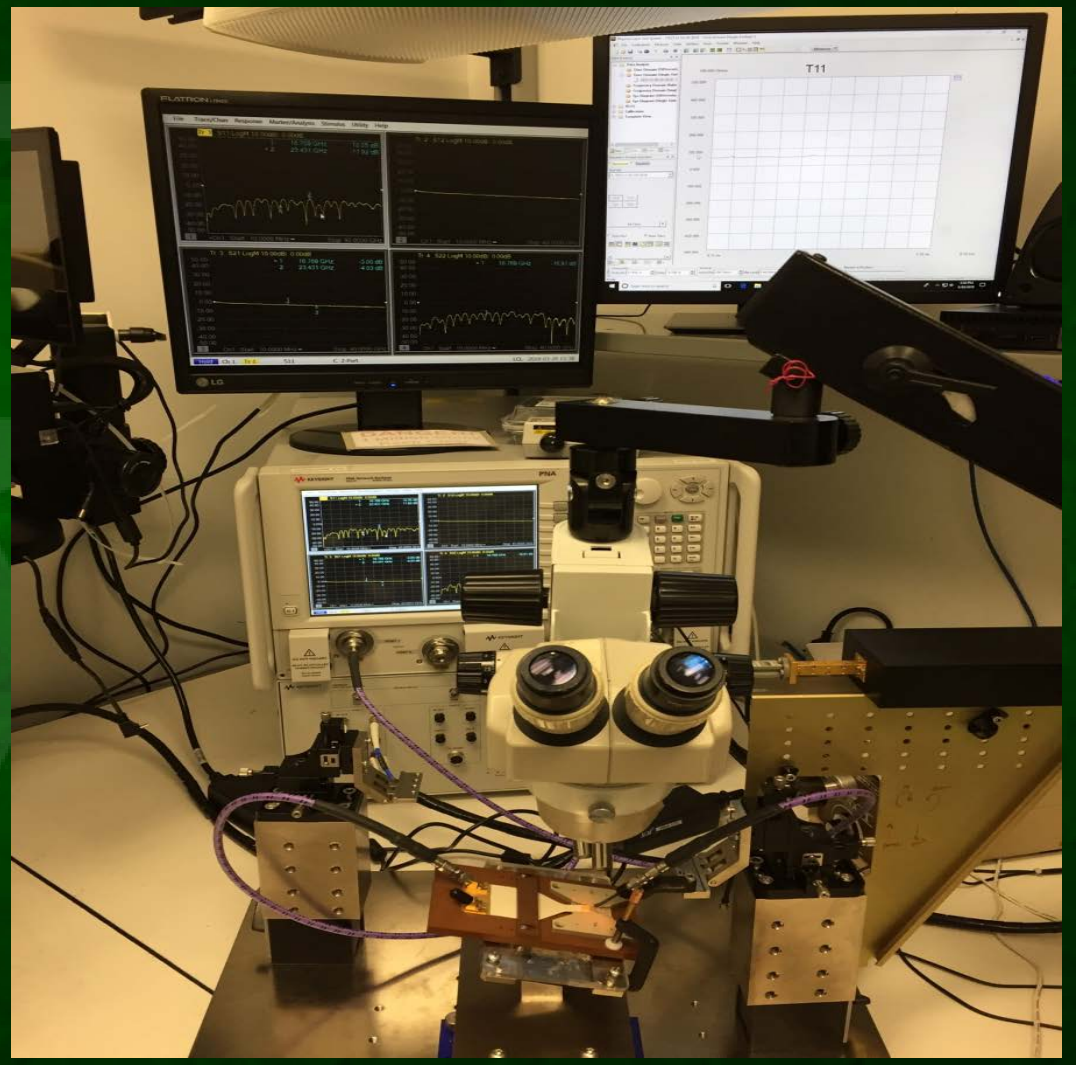






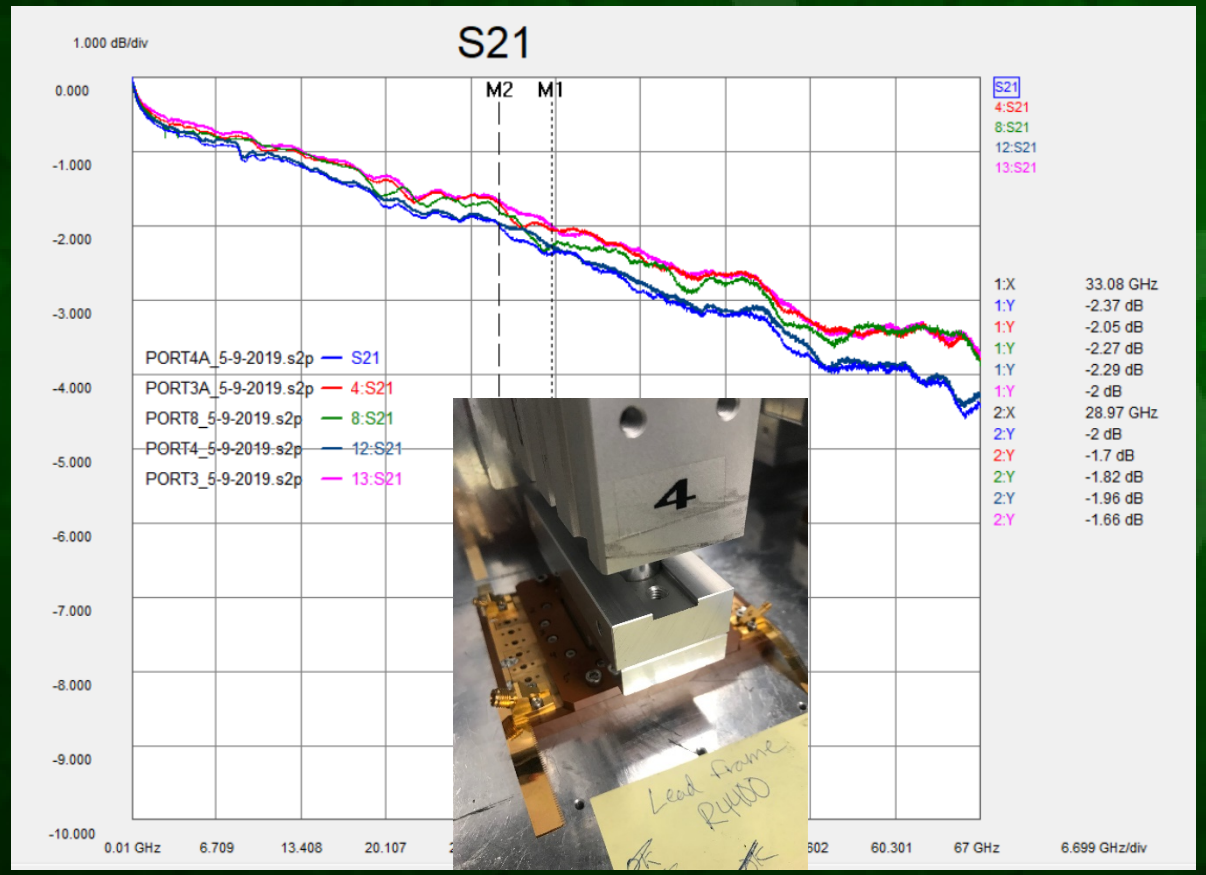
xWave Dual Site Probe Card Prototype RF Lab Measurement

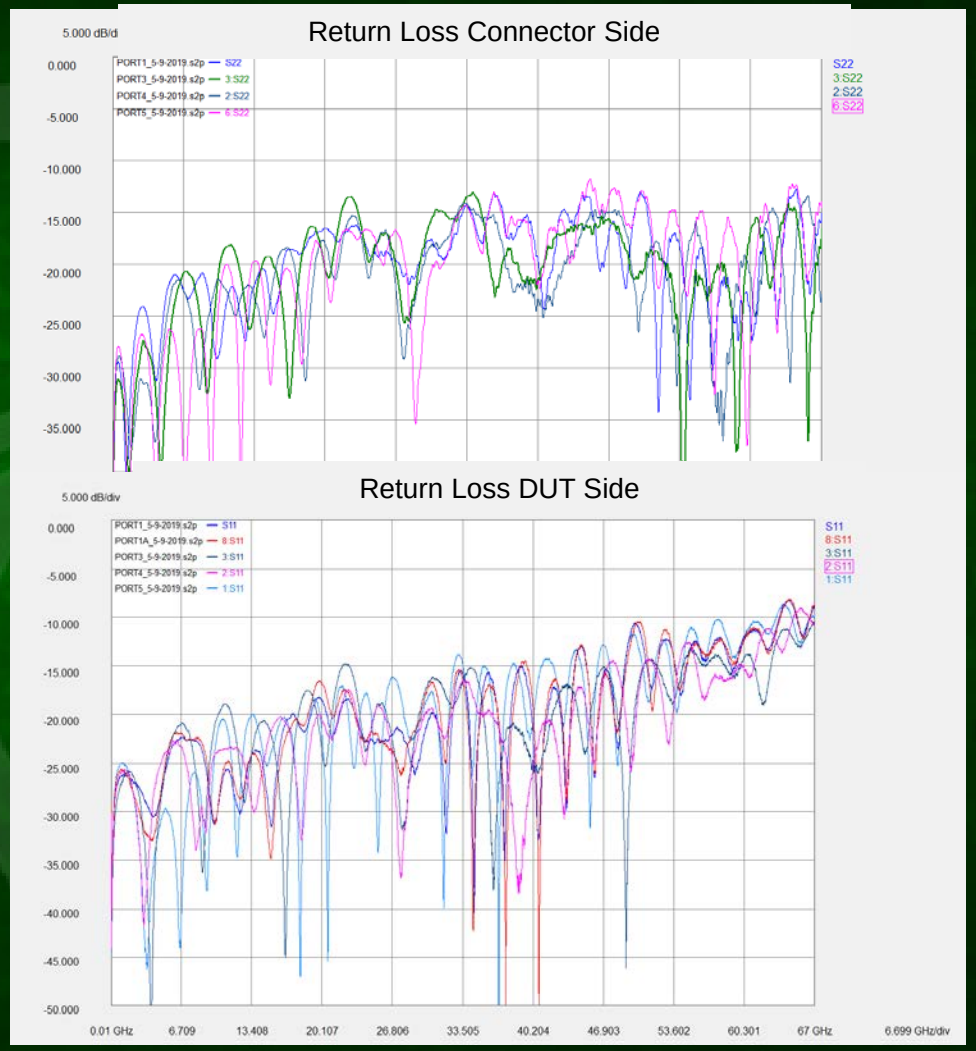




S-parameter 150um xWave Prototype

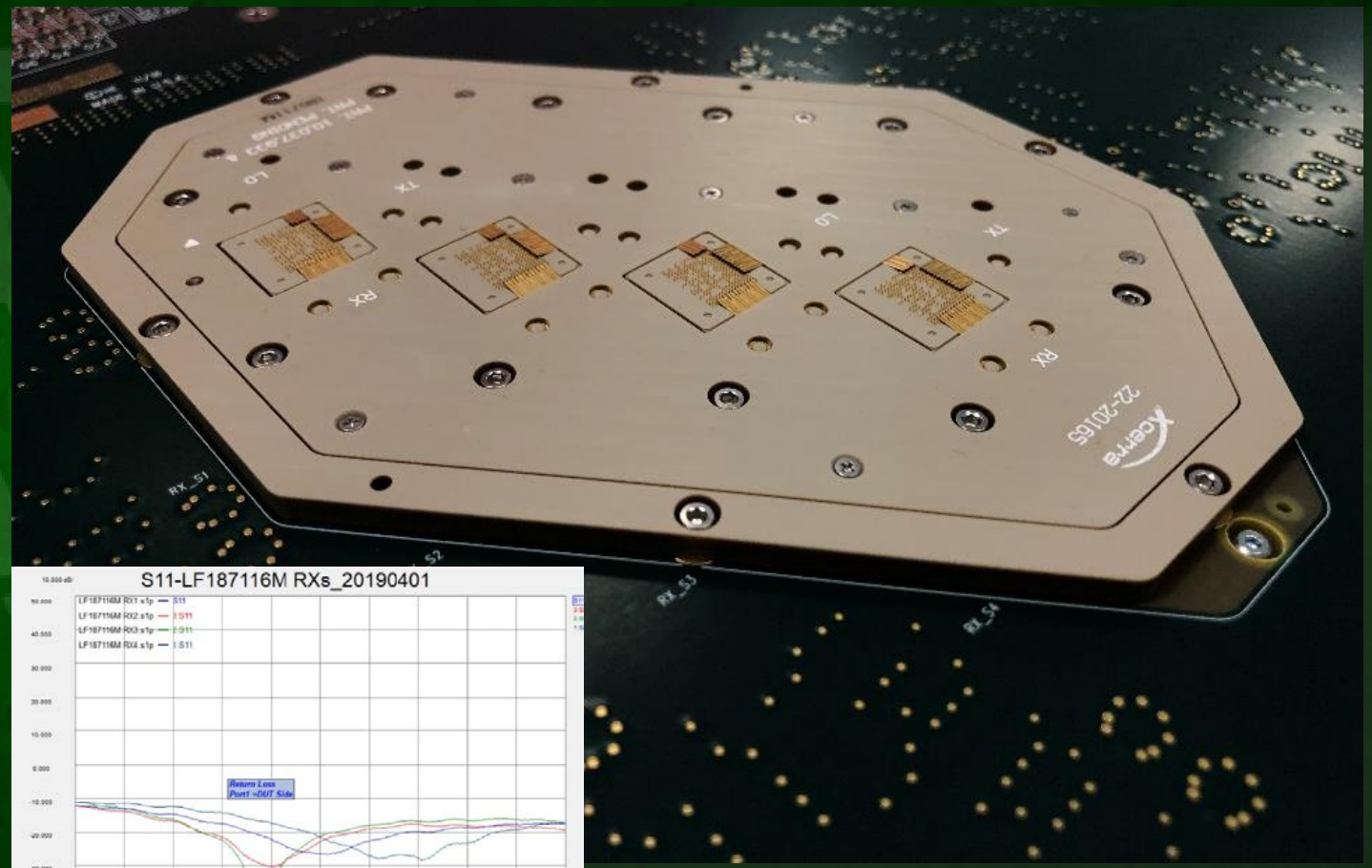
- **Low Linear Insertion Loss and Return Loss below -10dB to 60+GHz (leadframe + connector)**





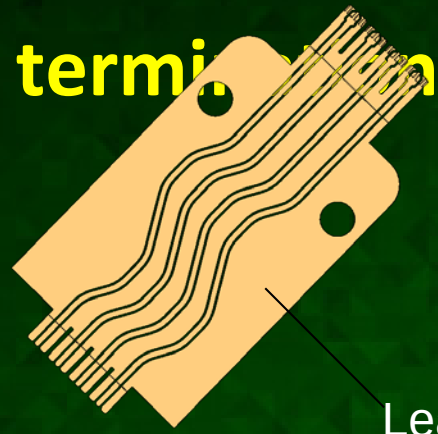
xWave ProbeHead - 80GHz Absorber Termination

- 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)



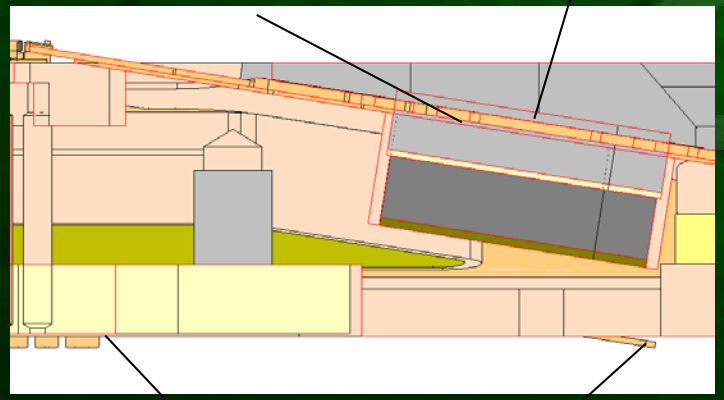
xWave Probe Head - Loadboard Side

- **xWave CPW Loadboard termination**

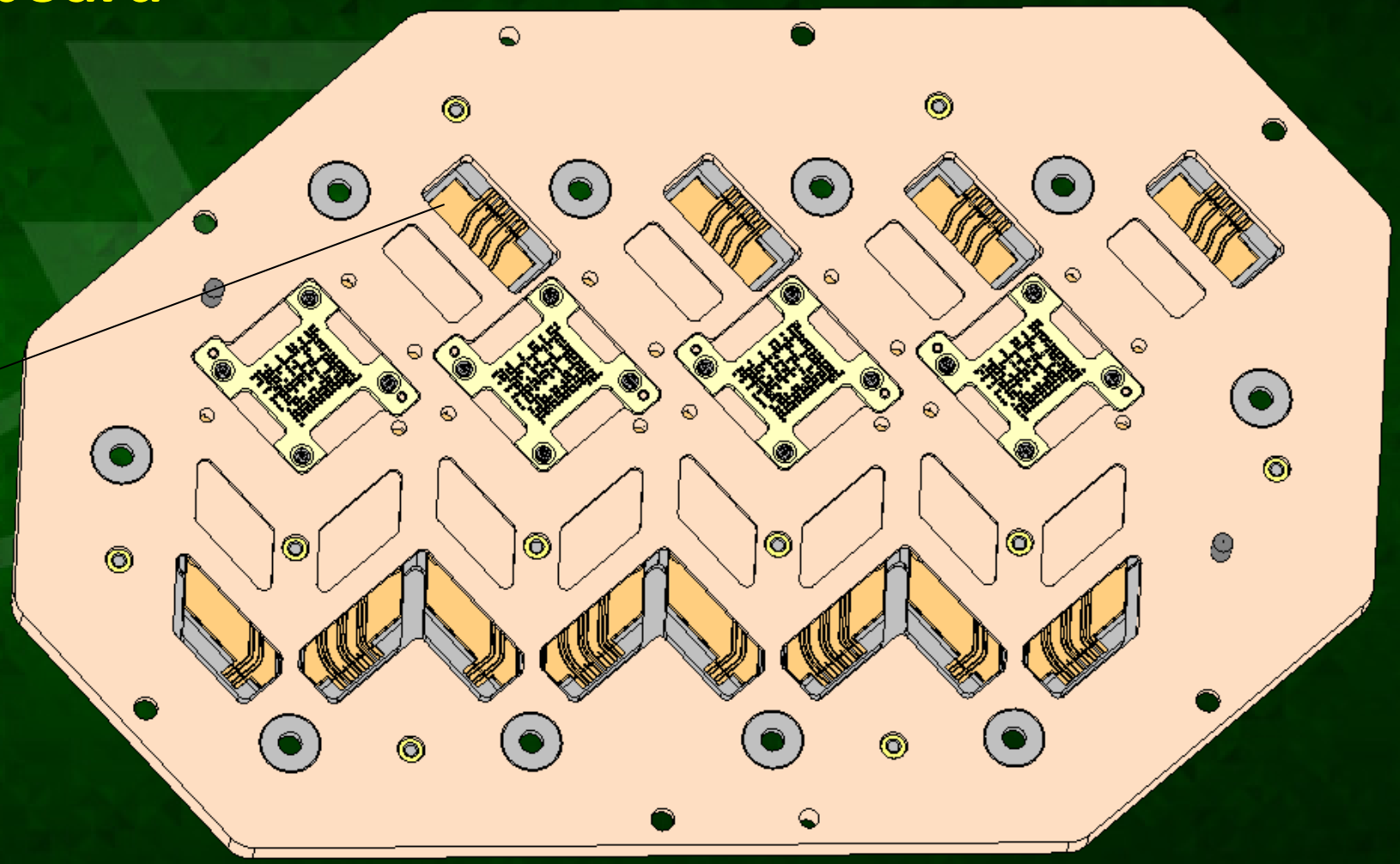


Leadframe

Absorber termination

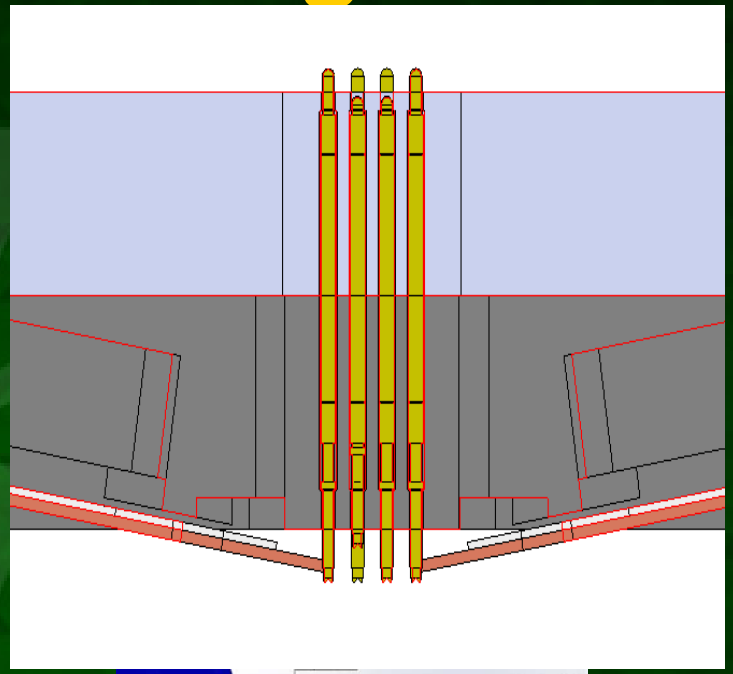


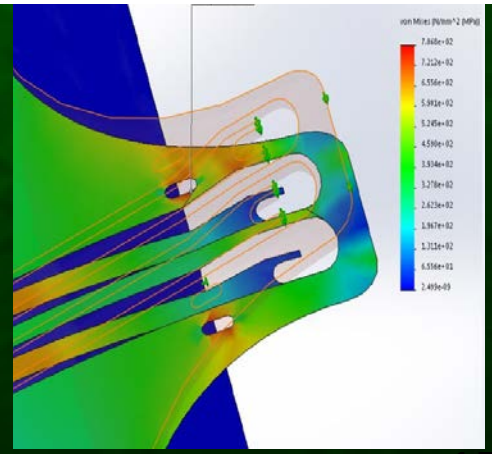
Cantilever CPW PCB termination



WLCSP xWave Mechanical Design

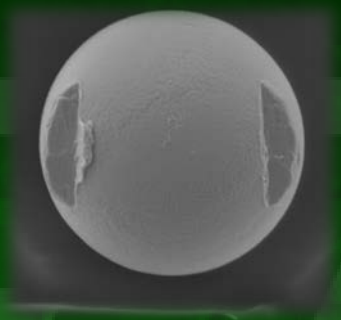
- **Force**
  - Leadframe – 8g @ 150um overdrive
  - 250um leadframe and 300um probe travel
  - Adjustable based on leadframe cross section and cantilever anchor point
  - Sufficient force without spring damper
- **Thermal**
  - Designed for Tri-Temp
  - Same materials as standard xWave
  - All materials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



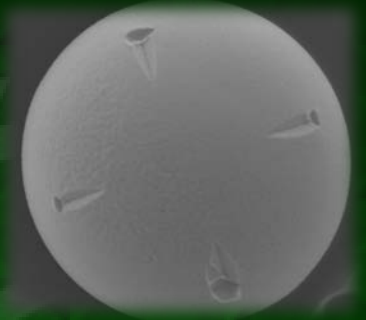


WLCSP xWave Mechanical Design

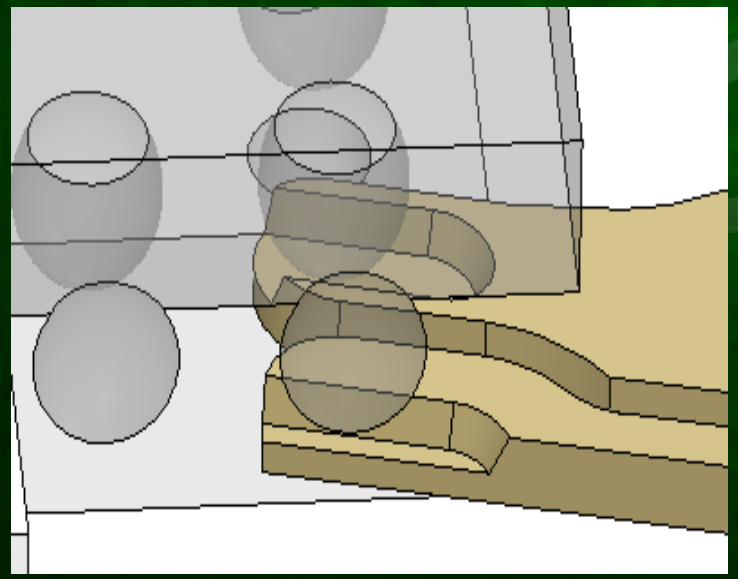
- **BGA Contact feature**
  - Leadframe - U shape edge contact to ball
  - ~10um knife edge scrub
  - Pogo – 4 point crown
  - 250um compliance

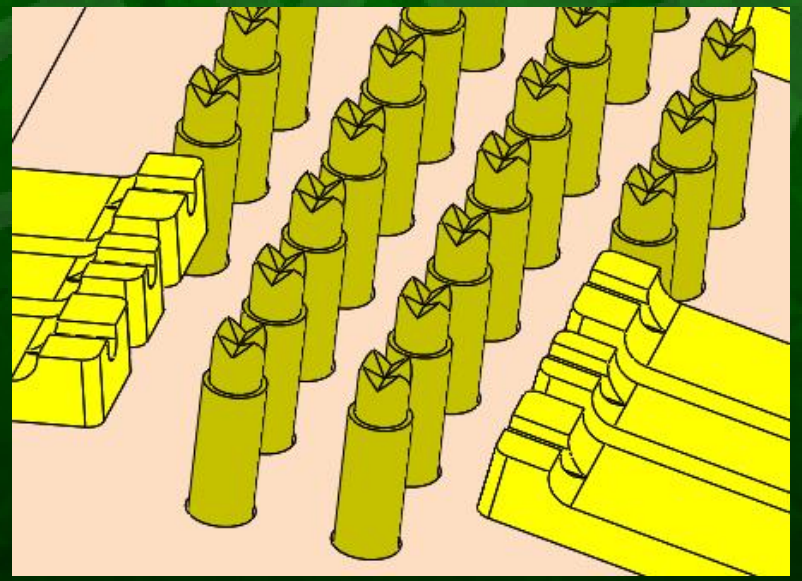


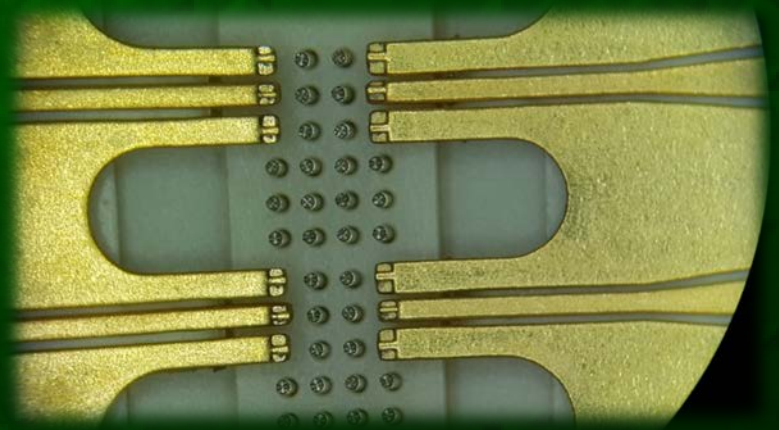
Leadframe



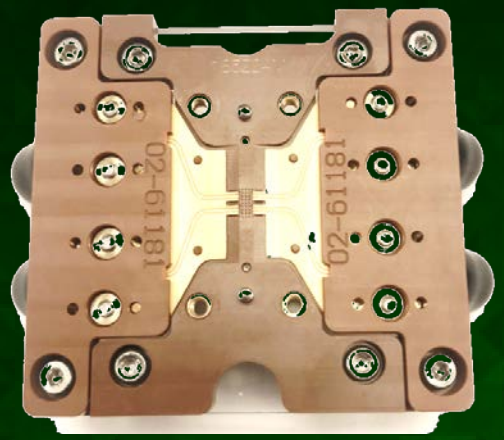
probe

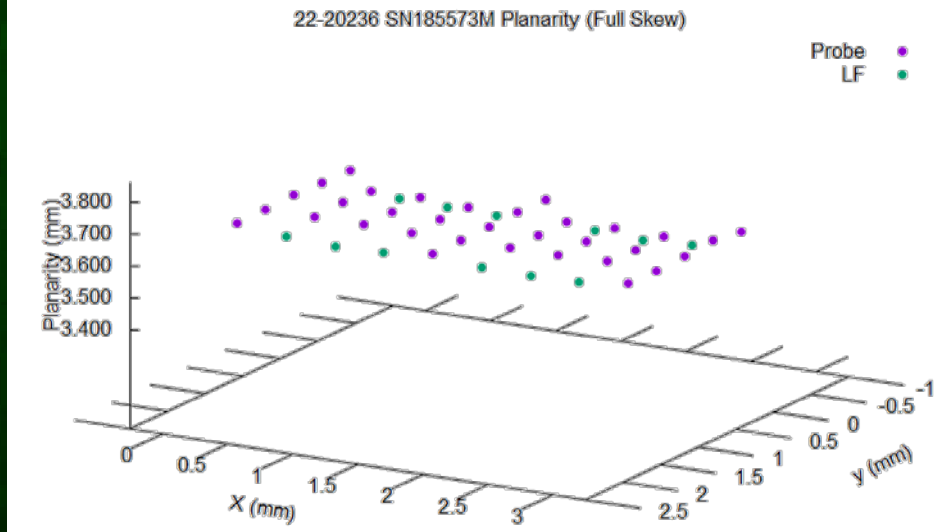






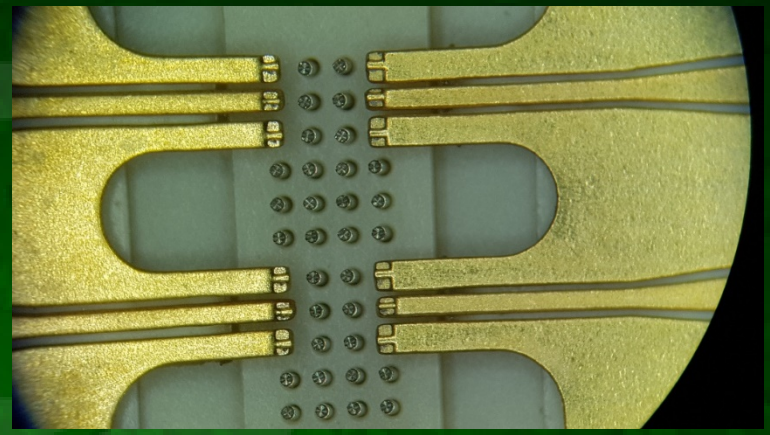
Probe Head Planarity

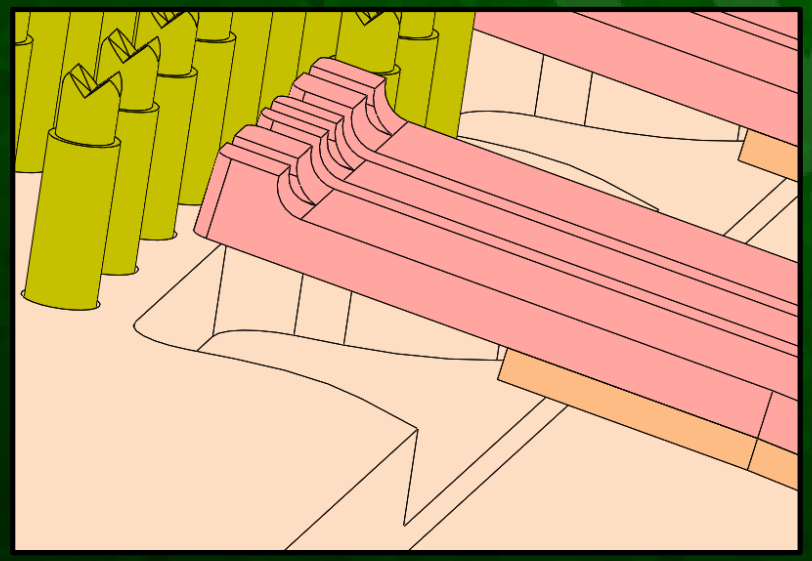




xWave ProbeHead - 30GHz 250um

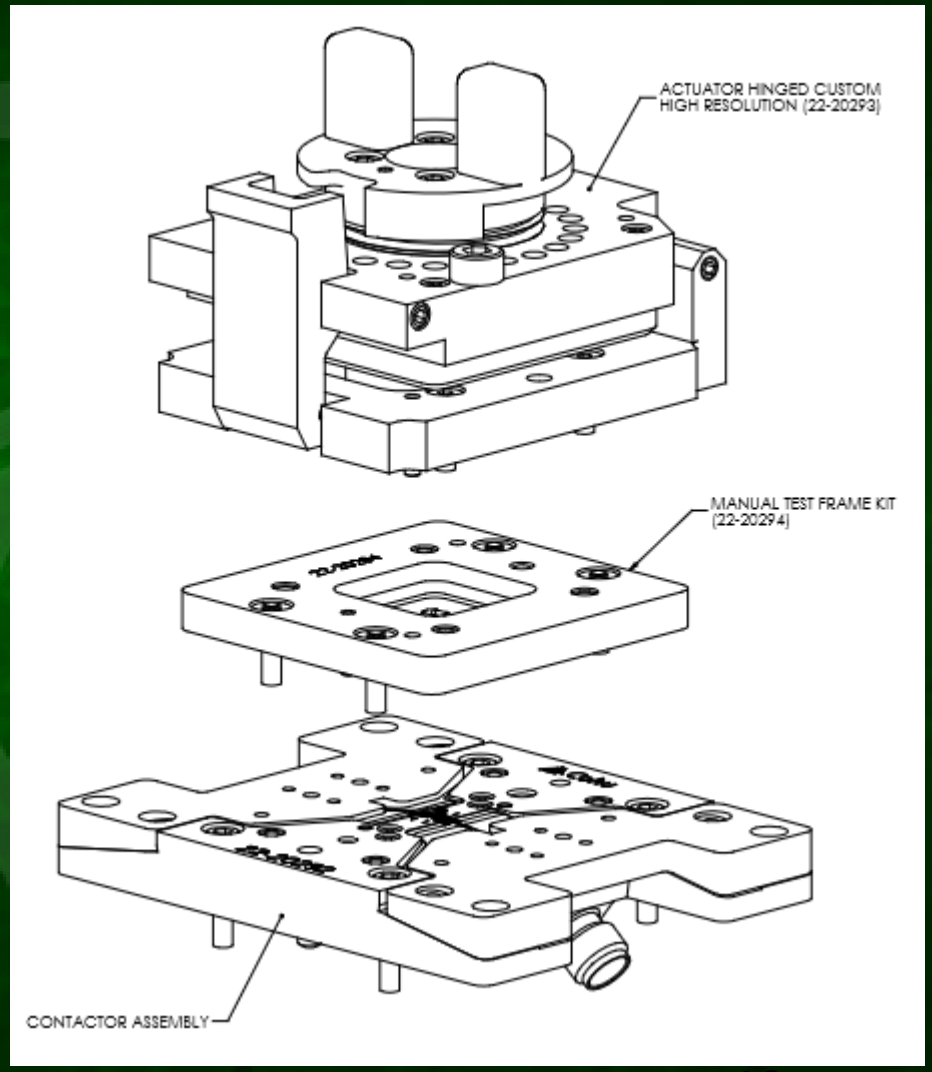
- 30GHz SatComm Dual-Site Probe Head
- 2 RF ports per site on 2 replaceable LeadFrames
- 18 cViper 025 Probes/site



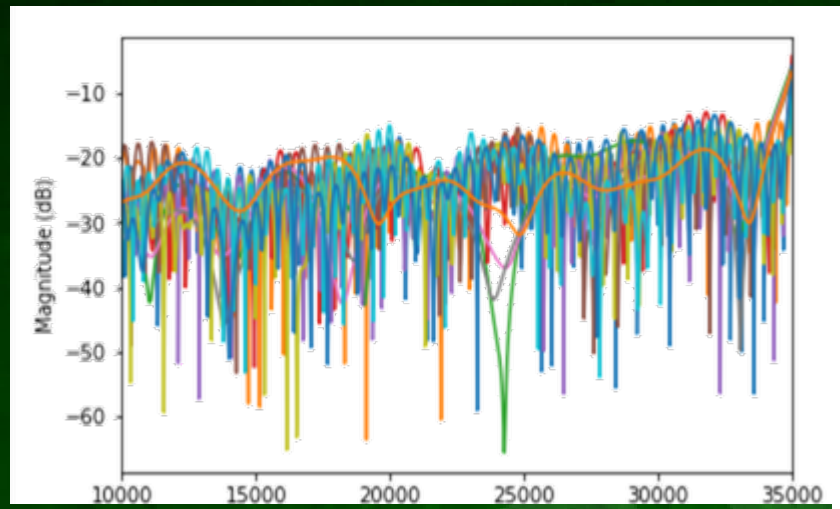


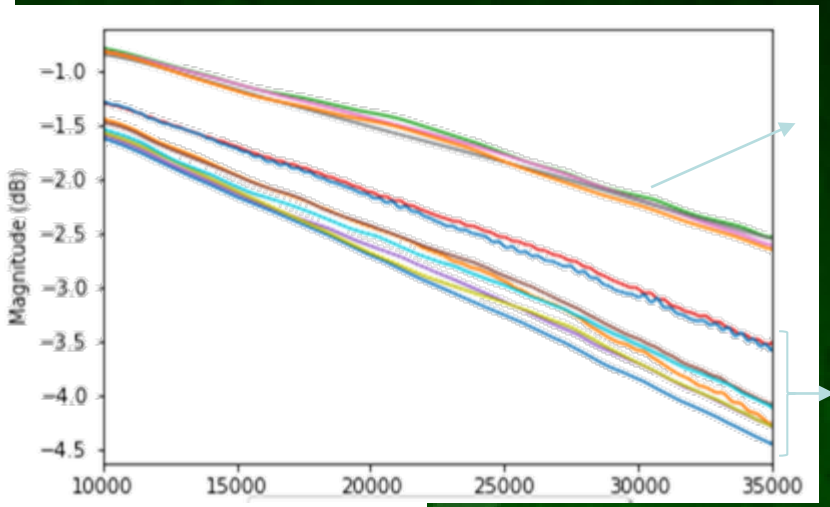
Package Test and Wafer Test in One

- **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



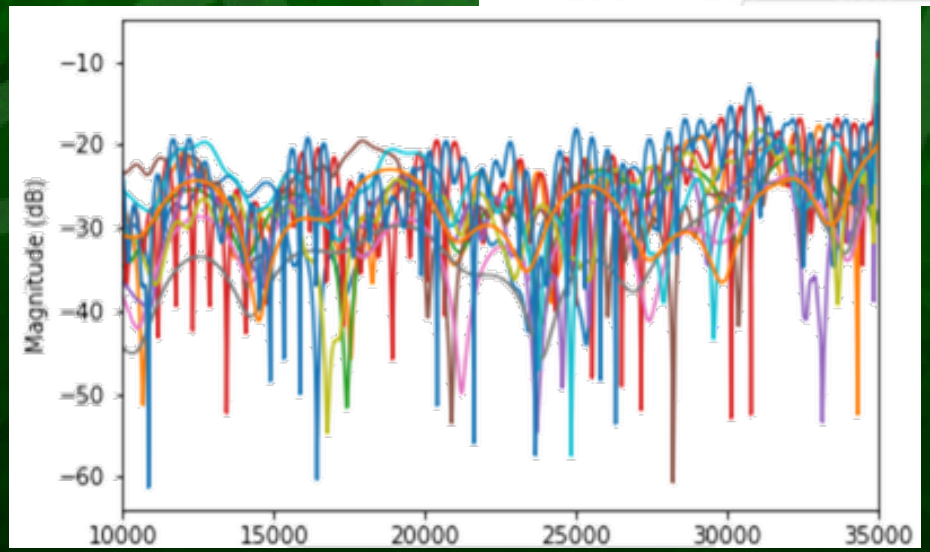
Customer Results: S11, S21 TDR 1 port AFR 0-35GHz





Only probe head, no cabling

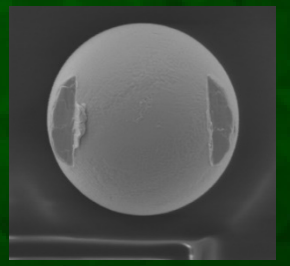
Main difference is cable length

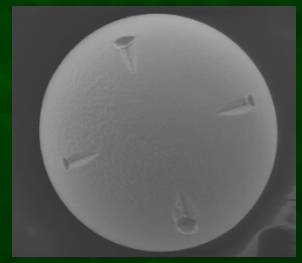


Correlates to Cohu Internal measurements

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)





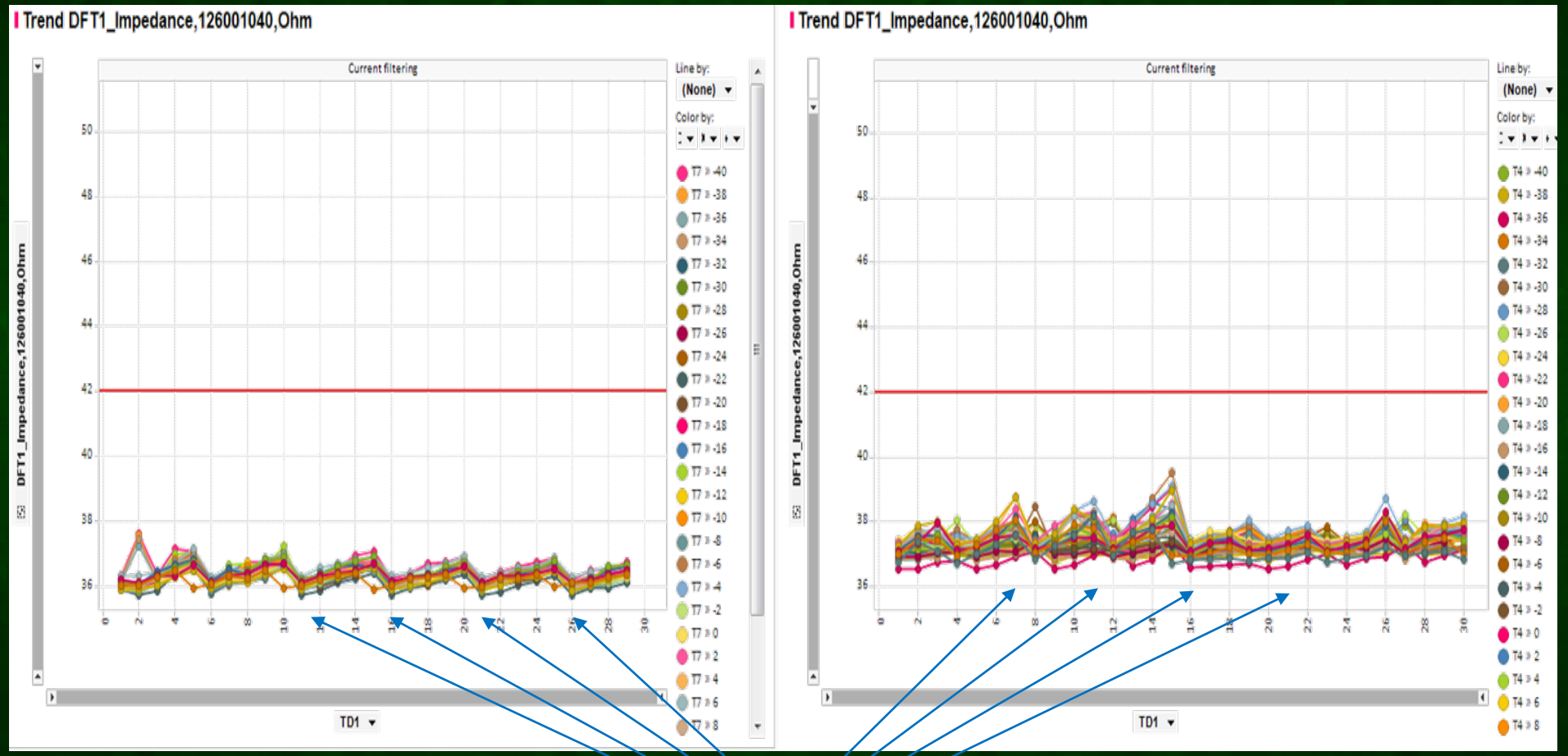
Customer Results DFT1 impedance: Existing vs Cohu

Existing probe card

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

Cohu probe card

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

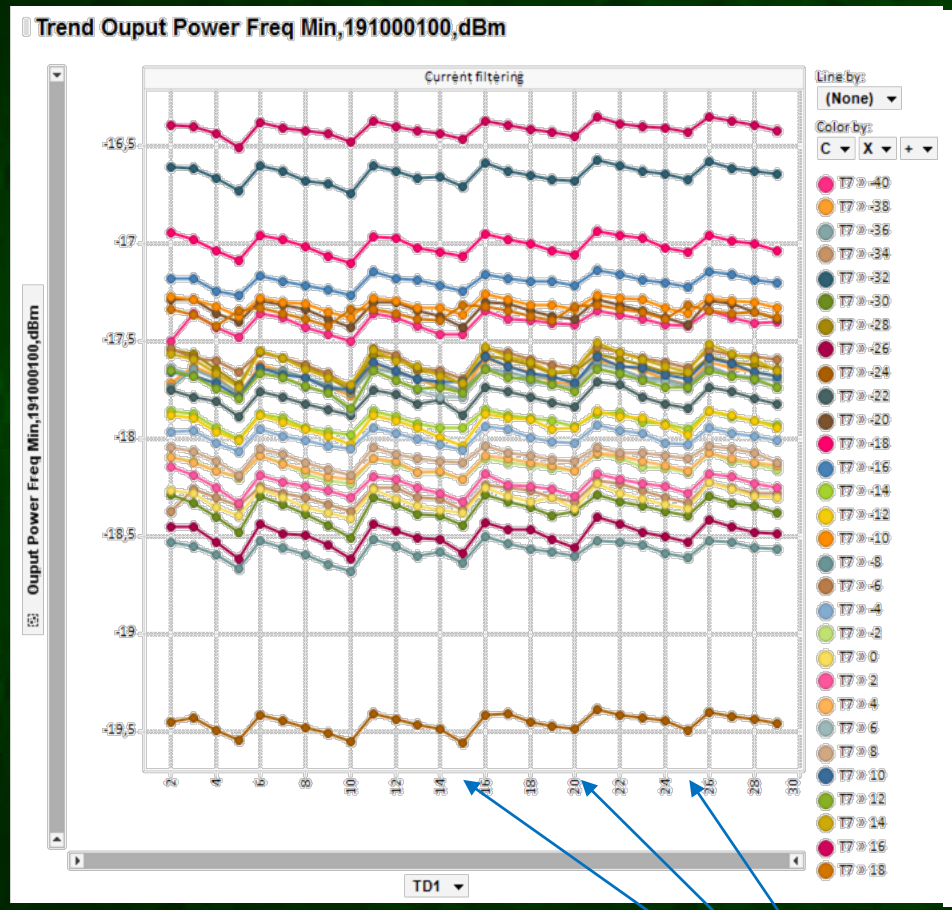


Cleaning every 150 touch down

Customer Results: RF measure: Existing vs Cohu

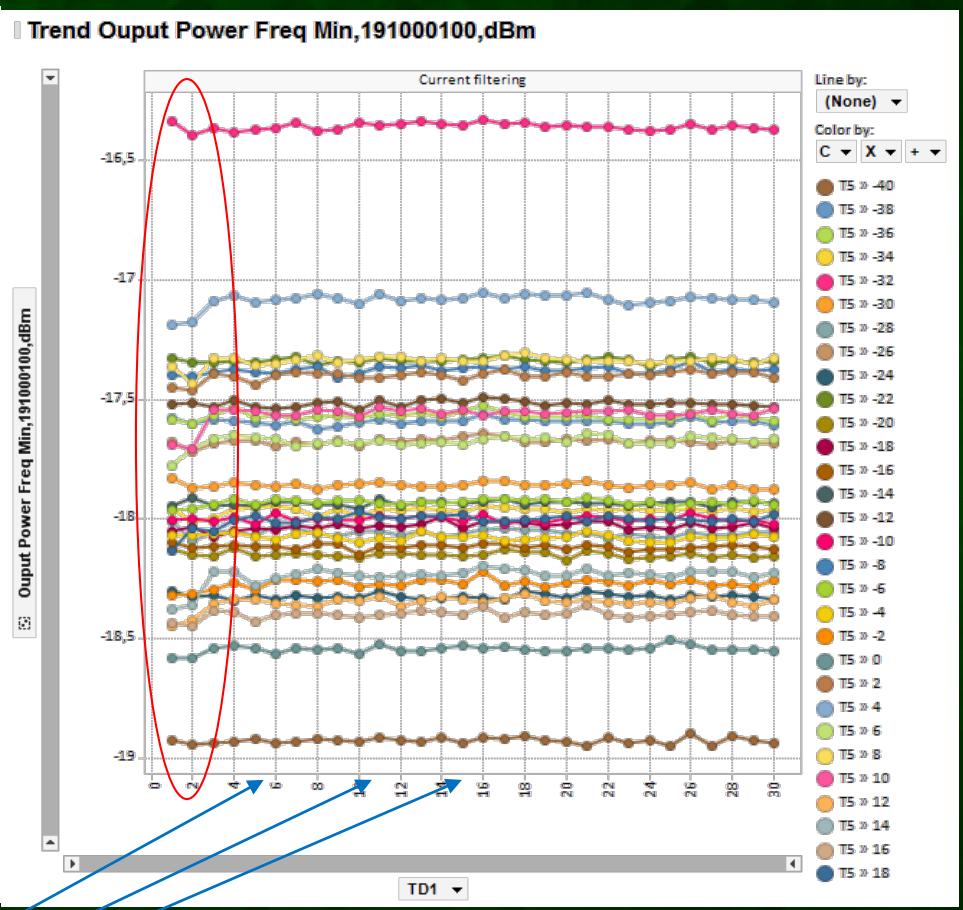
Existing probe card

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

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

Cleaning every 150 touch down

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