SWTEST
PROBE TODAY, FOR TOMORROW
2025 CONFERENCE

RF Testing - From Lab to Fab
+224 Gbps Probing

Don Thompson CTO
PTSL

The Growing RF Test Market

- RF test is a growing market with challenging requirements
- Primarily cellphones, including the following types of parts are driving the RF market
  - PA, LNA, envelope tracking, RF switches, antenna tuning switches, FE modules, RF transceivers, and wireless combo chips
- However additional notable applications are also driving the need for high frequency test:
  - AI digital devices: chip to chip SERDES communications
  - Digital compute: High-speed networking, PCIe Gen 6 & 7
  - Automotive radar
- Speeds are always increasing!

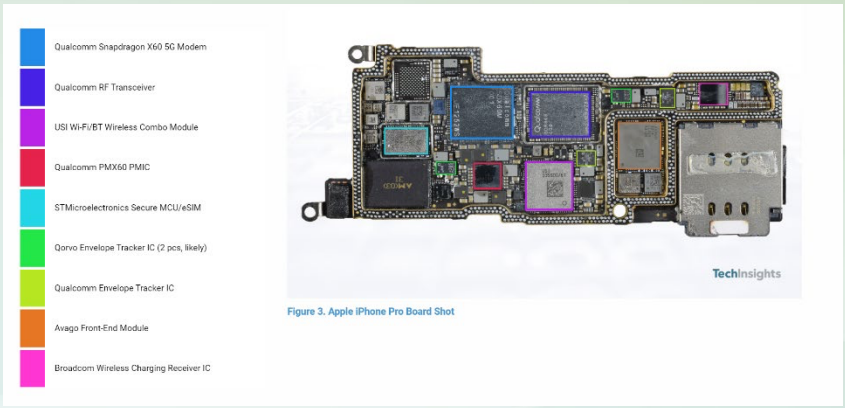
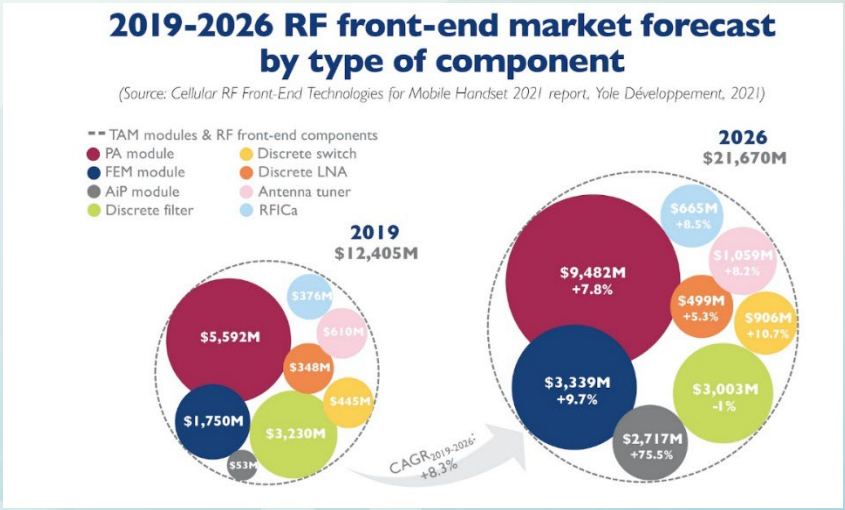
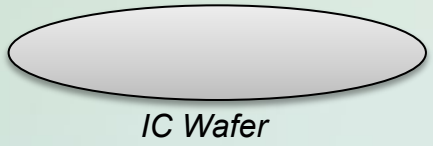


Figure 3. Apple iPhone Pro Board Shot



Moving Through the RF Probe Ecosystem

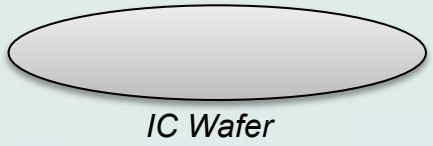
Lab Testing & Characterization



IC Wafer

- Single site
- Low touchdowns
- Highly customizable
- Must be quick
- Low cycle count
- Very high bandwidth
- Finer pitch

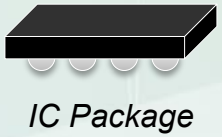
Wafer Sort ATE Testing



IC Wafer

- Multi-site
- Very High volume
- Predictable but fast lead-time
- High cycle count
- Adequate bandwidth
- Finer pitch

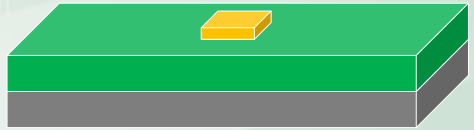
Final Test ATE Testing



IC Package

- Multi-site
- Very High volume
- Predictable but fast lead-time
- High cycle count
- Adequate bandwidth
- Larger pitch

System Characterization



PCB, Circuits, Probes, etc.

- One time measurement
- High bandwidth
- Larger pitch

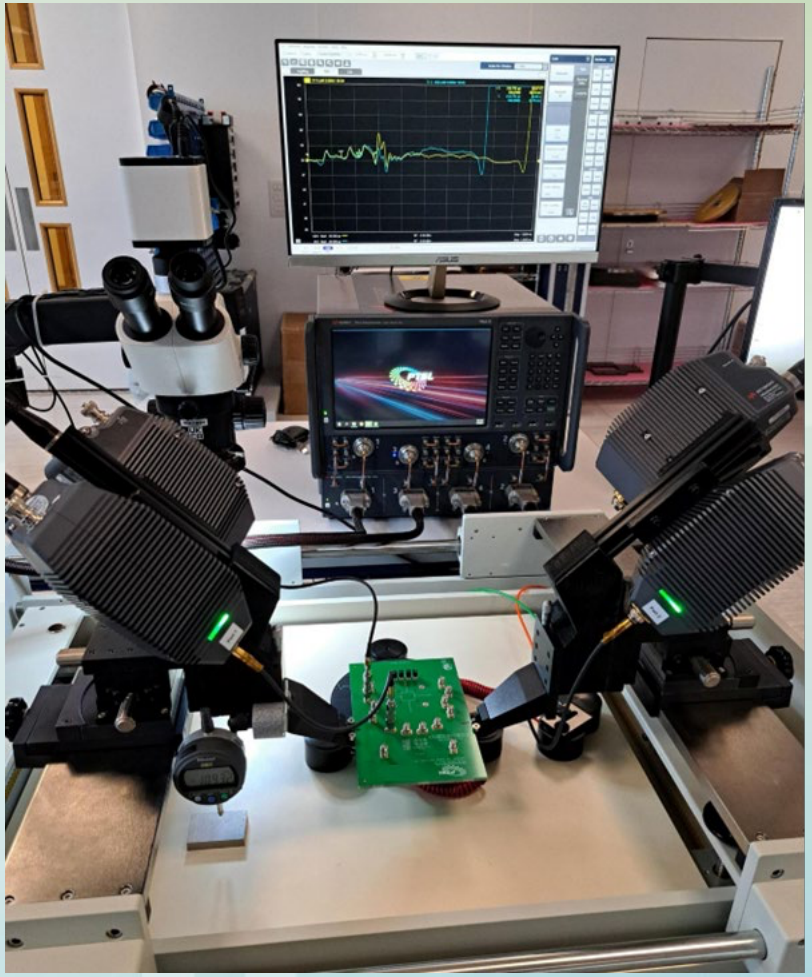
VNA Measurement Setup

VNAs are the primary tool for accurate RF characterization due to their combined calibration, de-embedding, and measurement capabilities.

This is PTSL's setup

- **Our test setup includes:**
  - **110 GHz Keysight VNA**
  - **1 mm Cal kit**
  - **Adapters to 2.92 mm**
  - **Evaluation PCB with 2.92 mm connectors**

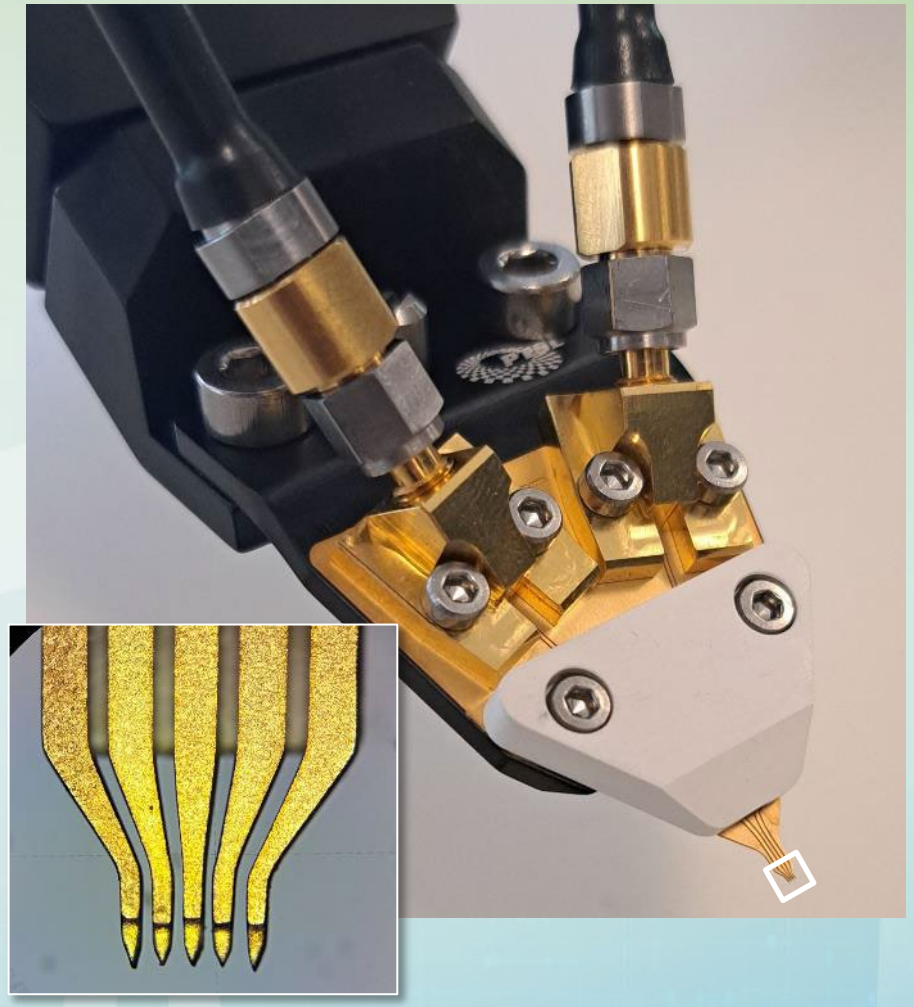
For this presentation, a VNA will be a stand in for all types of RF instrumentation that may be used in specific applications



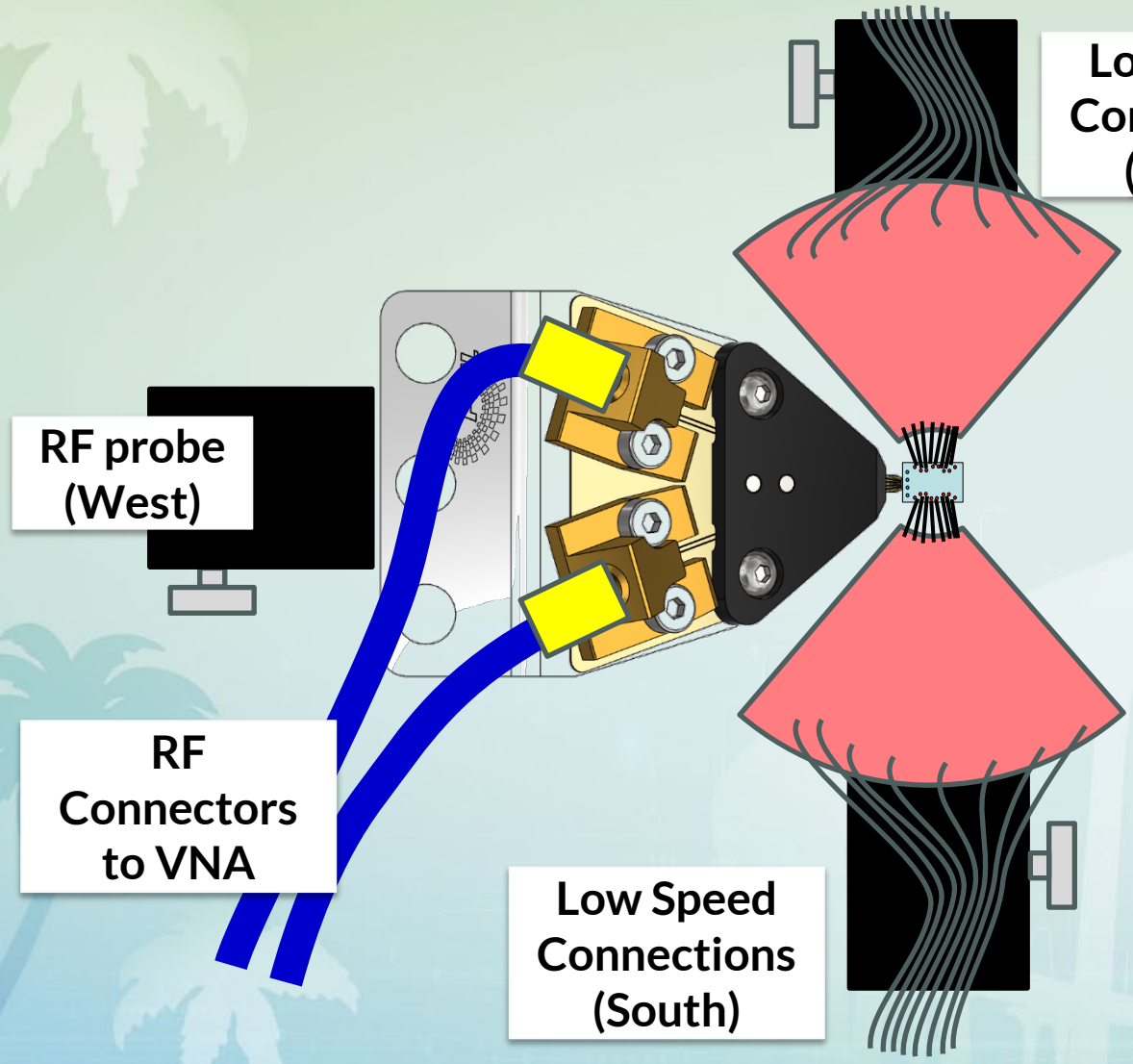
Above is a test Setup measuring a probe head

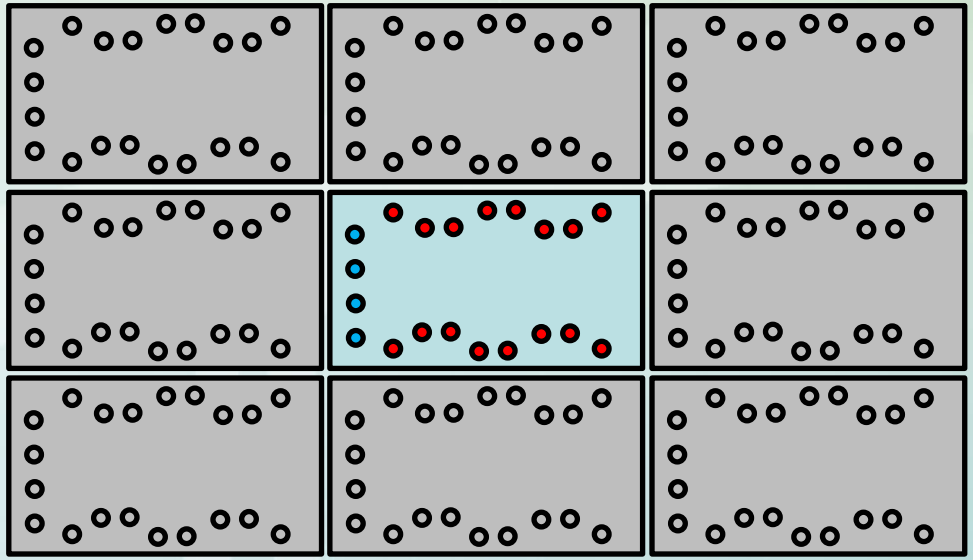
RF Wafer Probe: One Channel at a Time

- Probes individual pads on wafers or PCB
- Standard probe patterns as well as custom configurations. E.G. GSG, GSSG, GSGSG
- Extremely high performance (Highest frequency probes available)
- Used in a lab environment
- Individually aligned using a micro-positioner; typically used on a probe station



RF Wafer Probe Setup

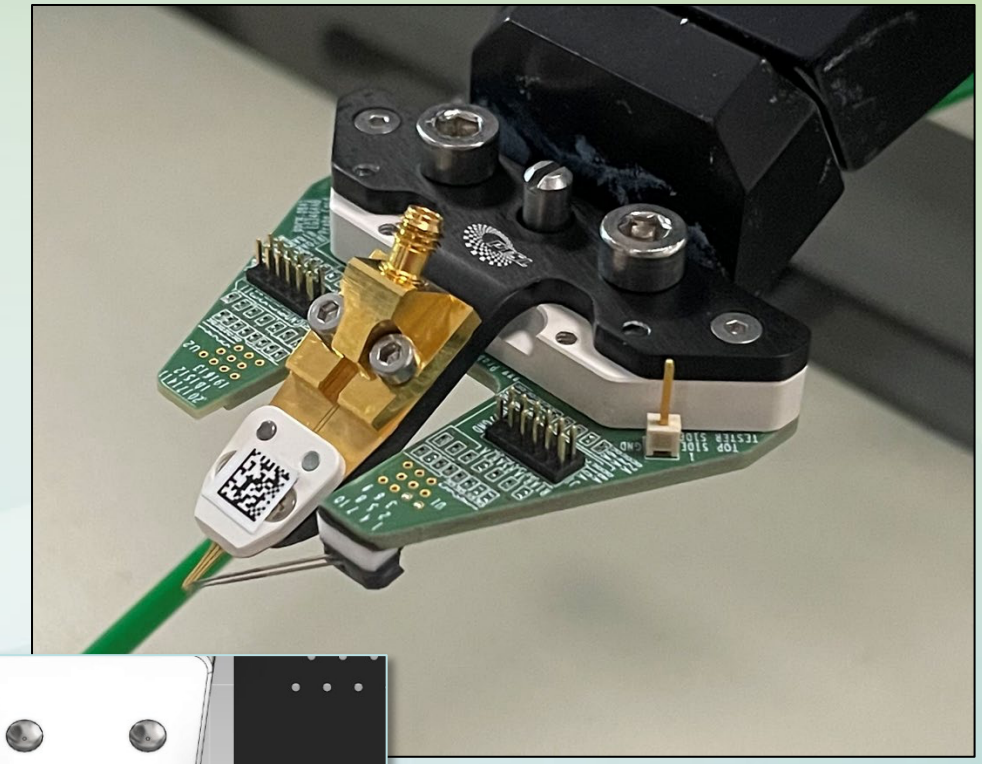


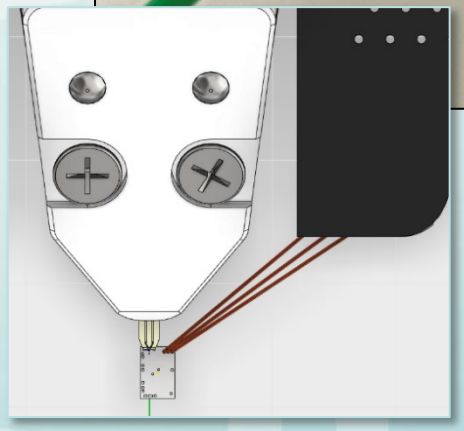


Once configured the probes can be indexed from die to die on a prober for low volume testing

RF Wafer Probe Hybrid

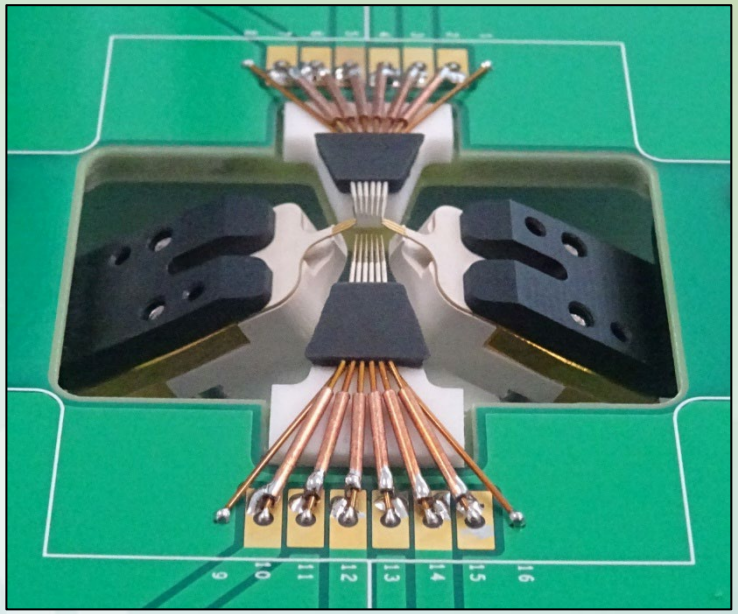
- Combines RF probe with low frequency probes
- Allows for power, ground, and control signals for powering up small devices for RF test
- Quadrant based probing; north/south/east/west
- Quick and easy IC debug and first article evaluation
- Limited in pin count; single site only

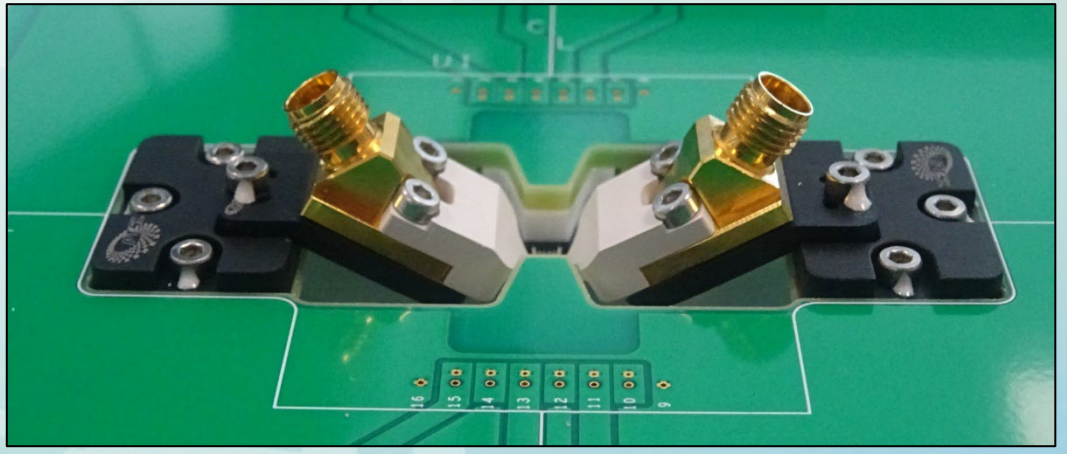




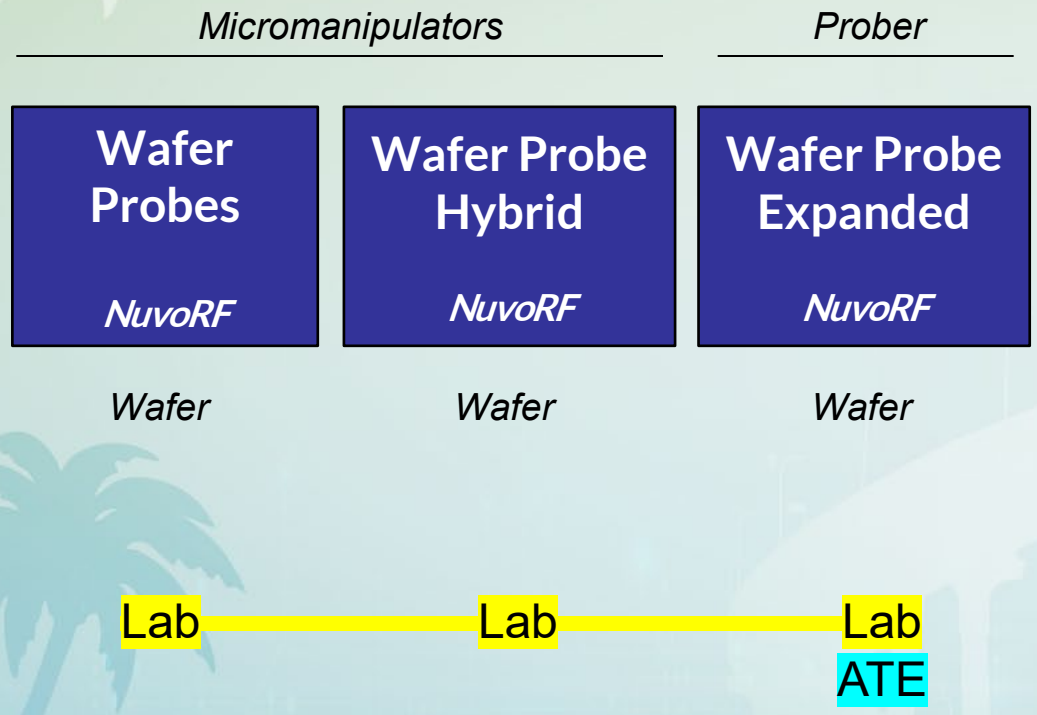
RF Wafer Probe Expanded Solutions

- Combines RF probes with cantilevered or blade technology to allow for PCB integration
- PCB integration enables support circuitry and better integration with probers

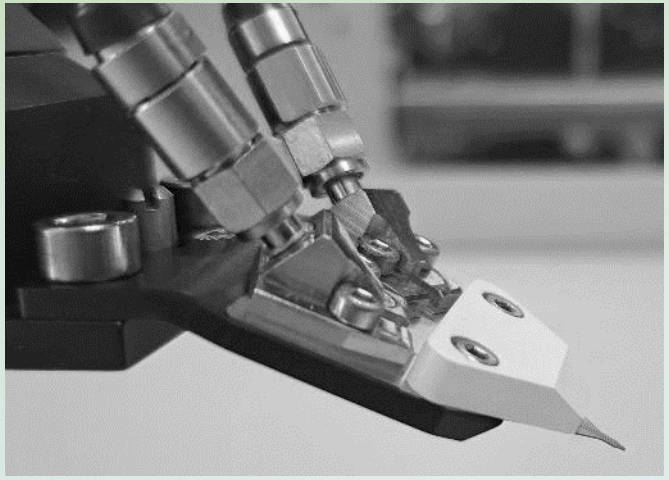




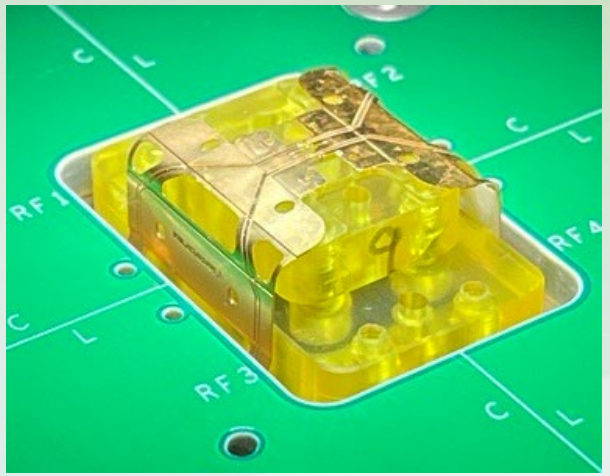
RF Probes; From Lab to Fab



RF Periphery Probe



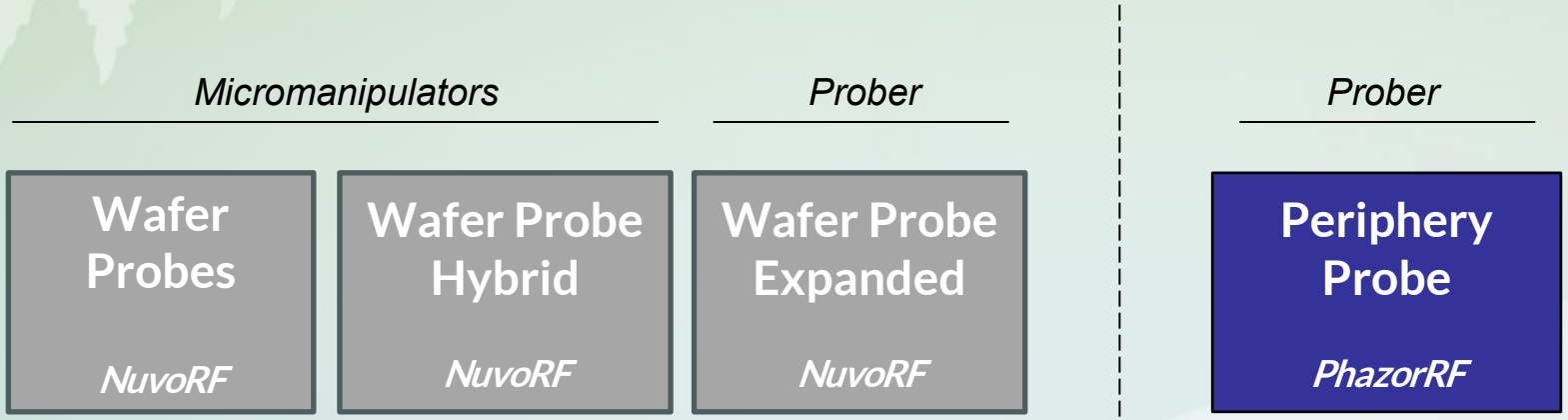
Characterization Probes

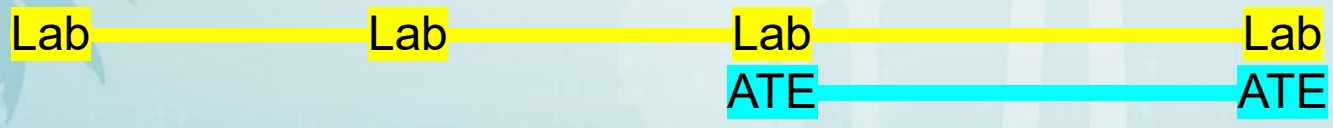


RF Periphery Probe Card

- Periphery probe cards combines wafer probe technology into an ATE solution
- This provides high performance, out-of-the-box alignment, and repeatably stable, single touchdown probe head
- Because RF contacts are limited to periphery of ICs with few routing layers, dense routing is a challenge!
- Spring-loaded coplanar-waveguide transmission lines offer both high-speed routing and touchdown compliance
- Periphery probes are good up and ~90 GHz

RF Probes; From Lab to Fab



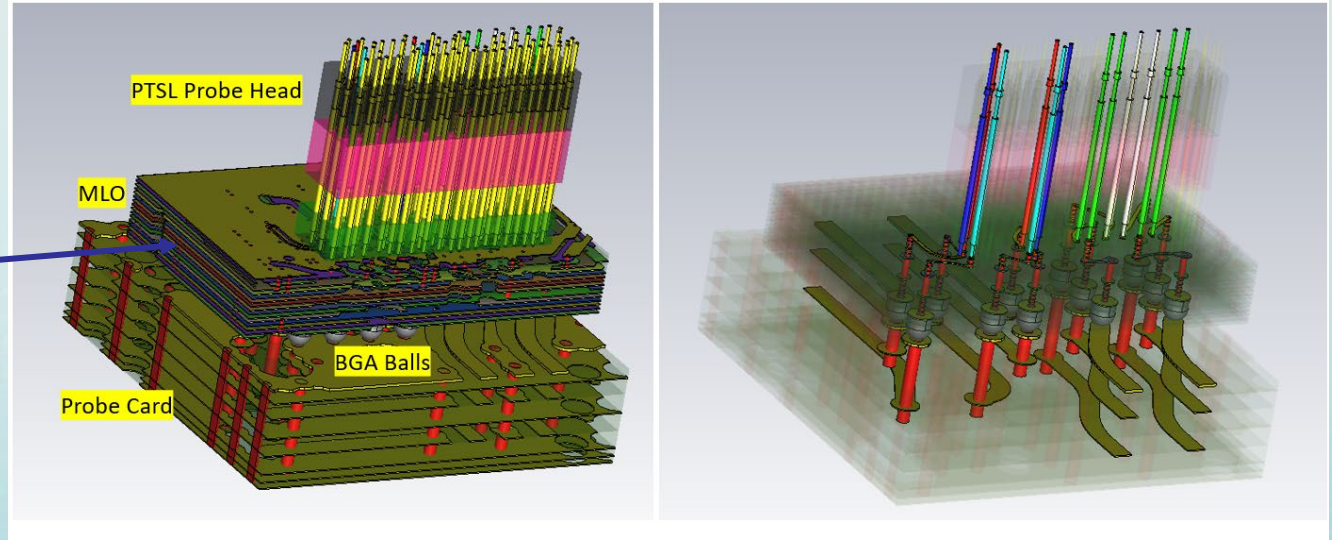


Vertical Probing

- Periphery probing and wafer probing are not good solutions for large devices or high site-count testing
- To achieve maximum density, we must use a vertical probe solutions
- Vertical probe has two major challenges, the first is the probe and the second is the space transformer

MLO / Space Transformer

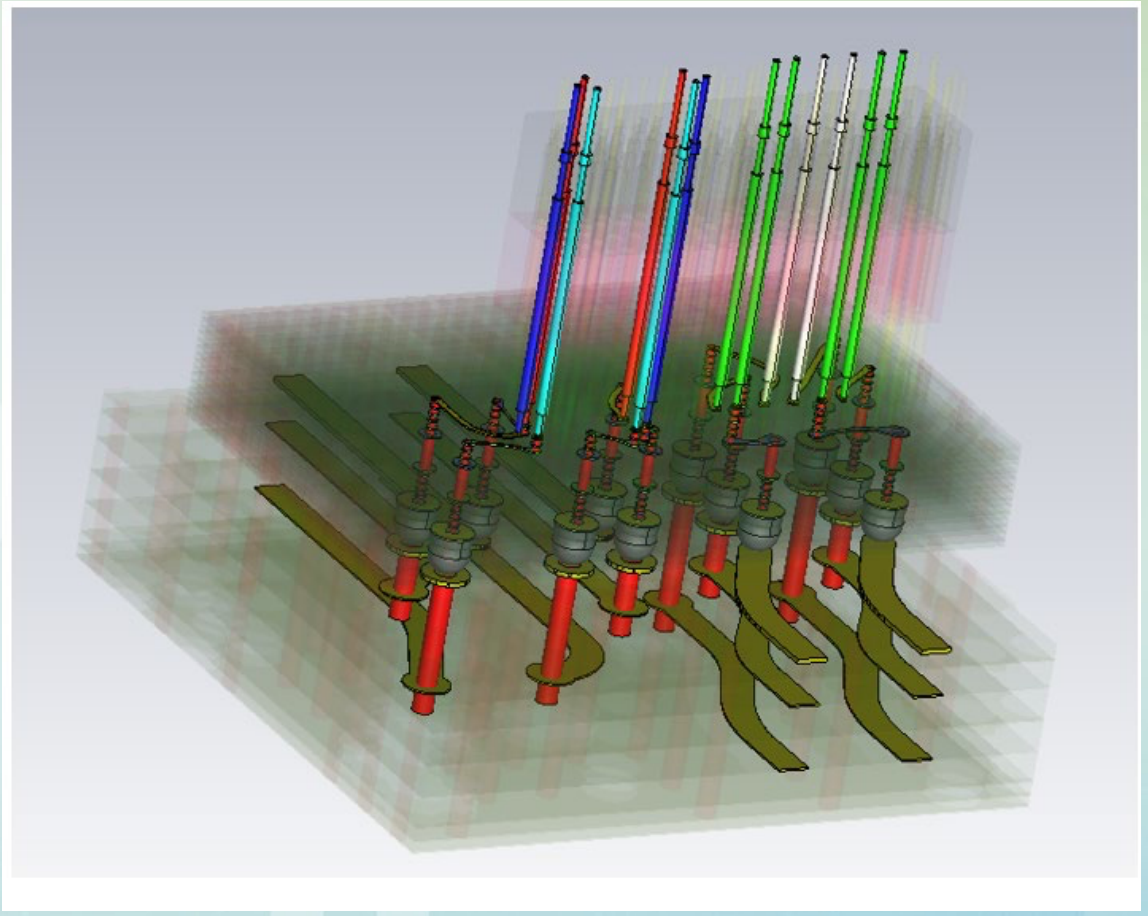
RF signals must be routed out of the Space transformer and probe card



Impedance Controlled (Standard) Probe Heads

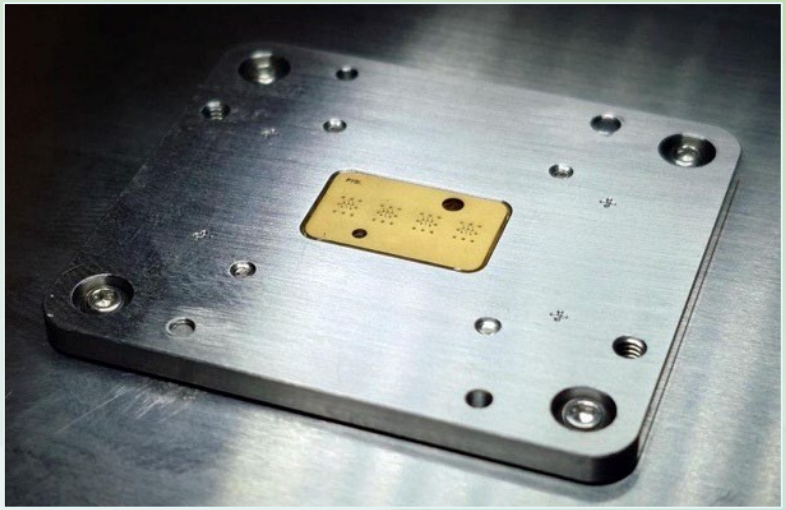
- Unshielded vertical probes can be impedance controlled for improved bandwidth
- Advantages for this are relatively low cost and proven probe solutions
- Unshielded probes will have high crosstalk and noise that will not be suitable for many RF applications
- For these designs, all This high-speed C4 ball outs must be the same or impedance will vary from one channel to the next
- Better for high-speed digital solutions than RF solutions with bandwidth limited to ~30 GHz

- Not good for RF!

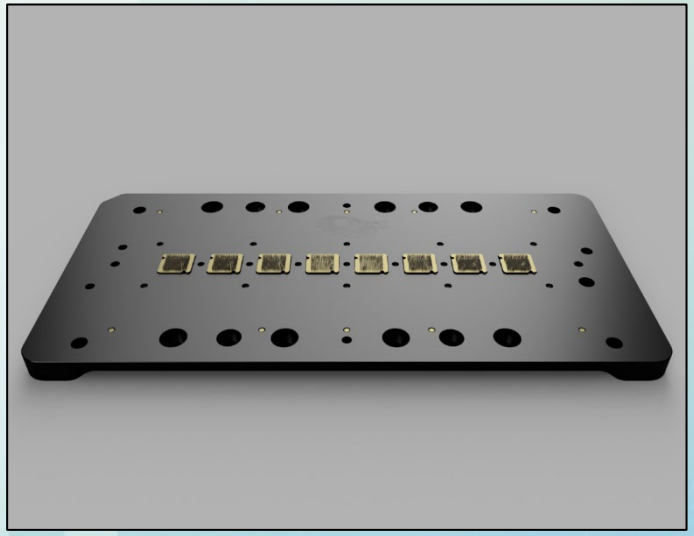


Coax Vertical Probes

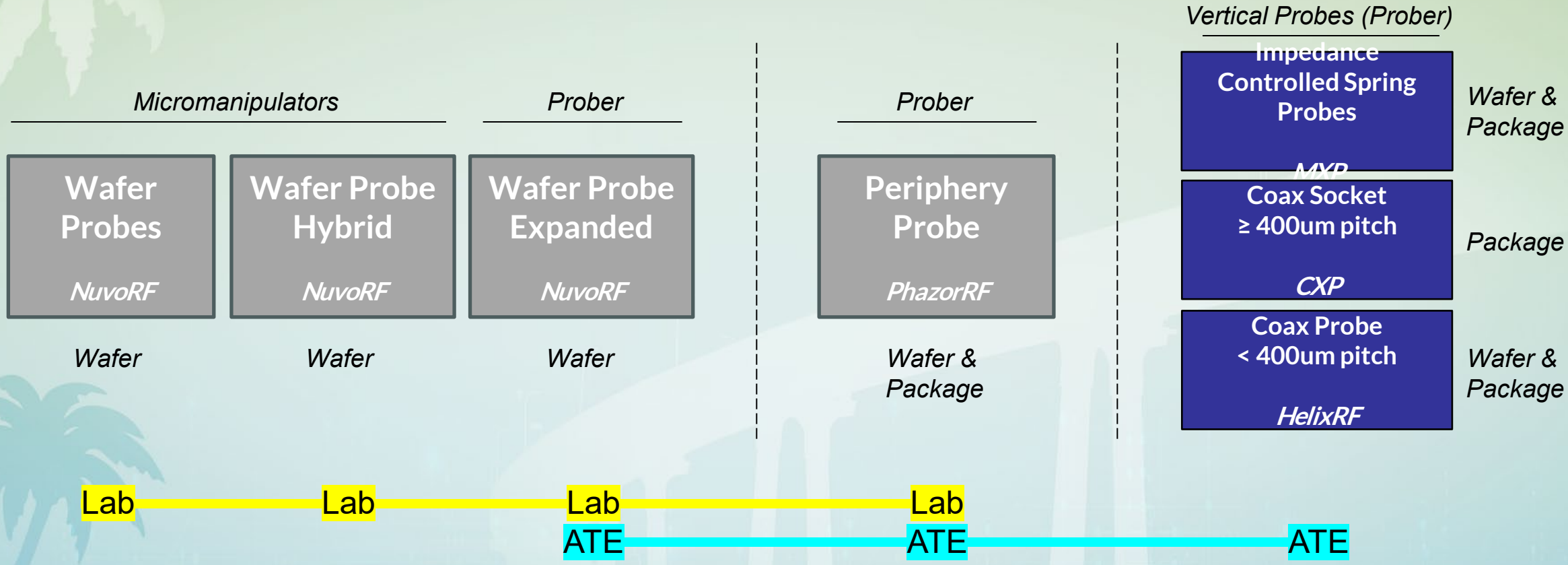
- Coax vertical probes can be designed and built for larger pitch applications
- Good impedance control and low crosstalk
- Probe head can handle nearly any density - density limitation is moved to the space transformer.
- Min pitch is 250um
- Max bandwidth of ~50 GHz



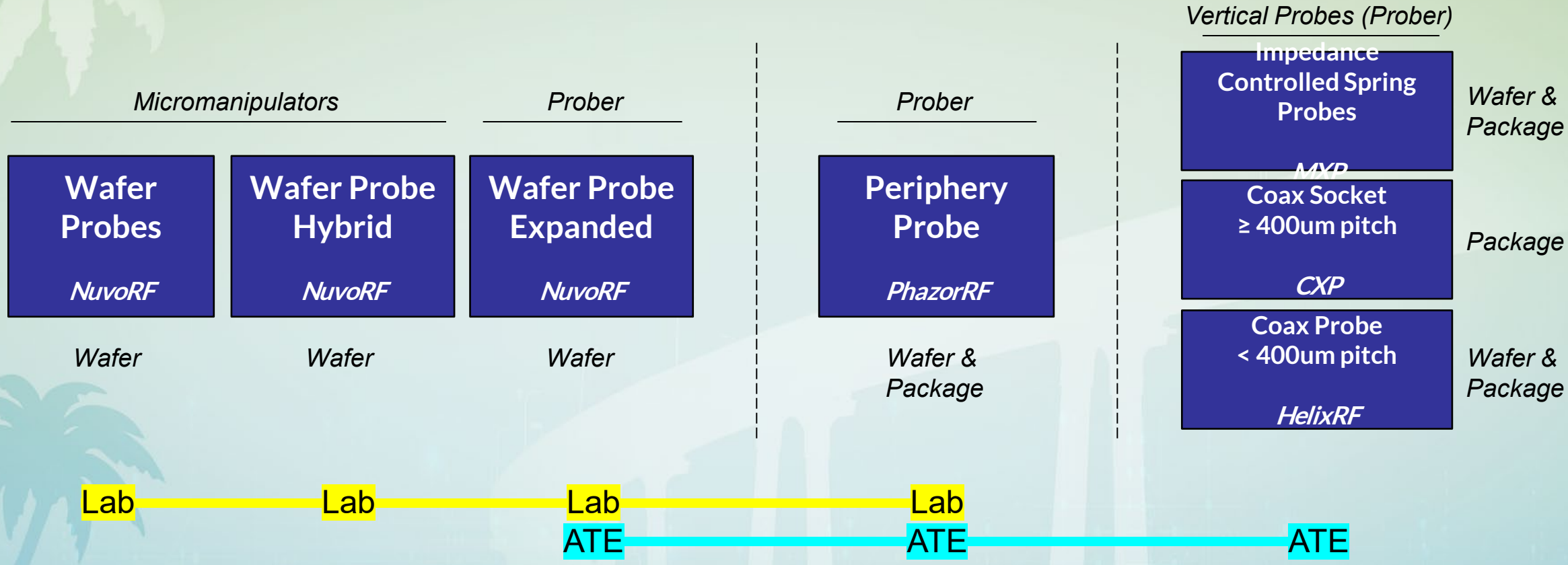
HelixRF



RF Probes; From Lab to Fab



RF Probes; From Lab to Fab



RF & High-Frequency Landscape

Periphery Probe

Vertical Probe

Engineering Wafer & PCB probes

Periphery Probes

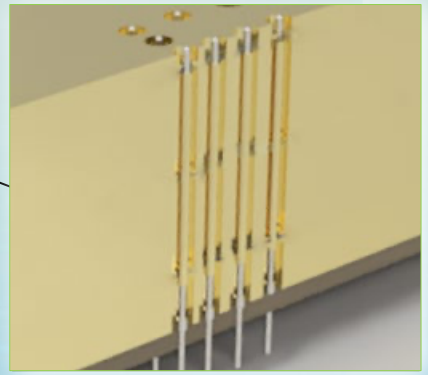
Coax Vertical Head
Shielded Vertical Probes

Impedance Controlled
Vertical Probe Head

224 Gbps

Traditional
vertical probe

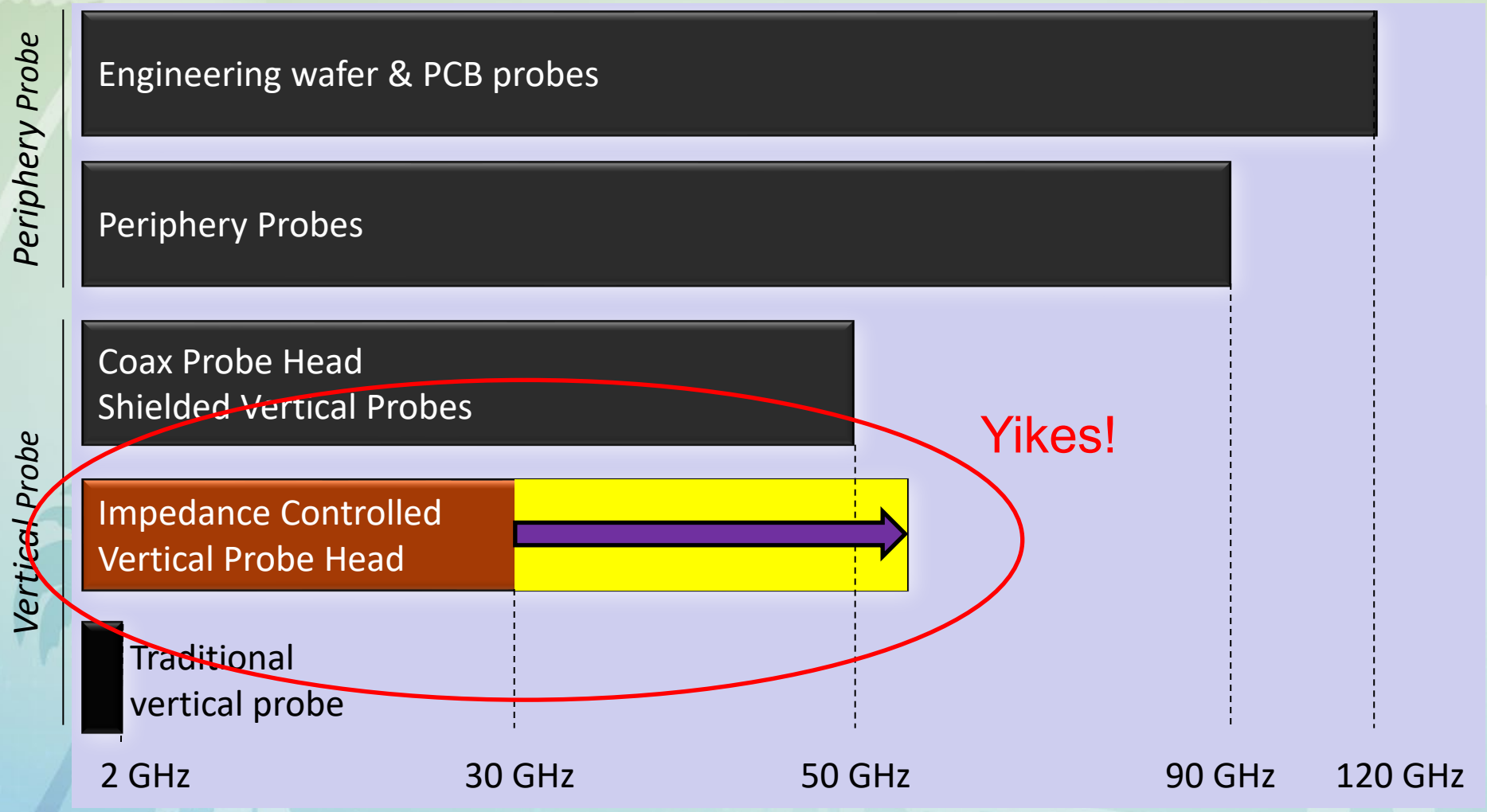
2 GHz | 30 GHz | 50 GHz | 90 GHz | 120 GHz



The New Challenge – 224 Gbps

- Many large IC manufacturers building AI chips need faster and chip to chip interfaces 224 Gbps currently and ***faster in the future***
- Must be tested at probe
- Must use high-density vertical probes!

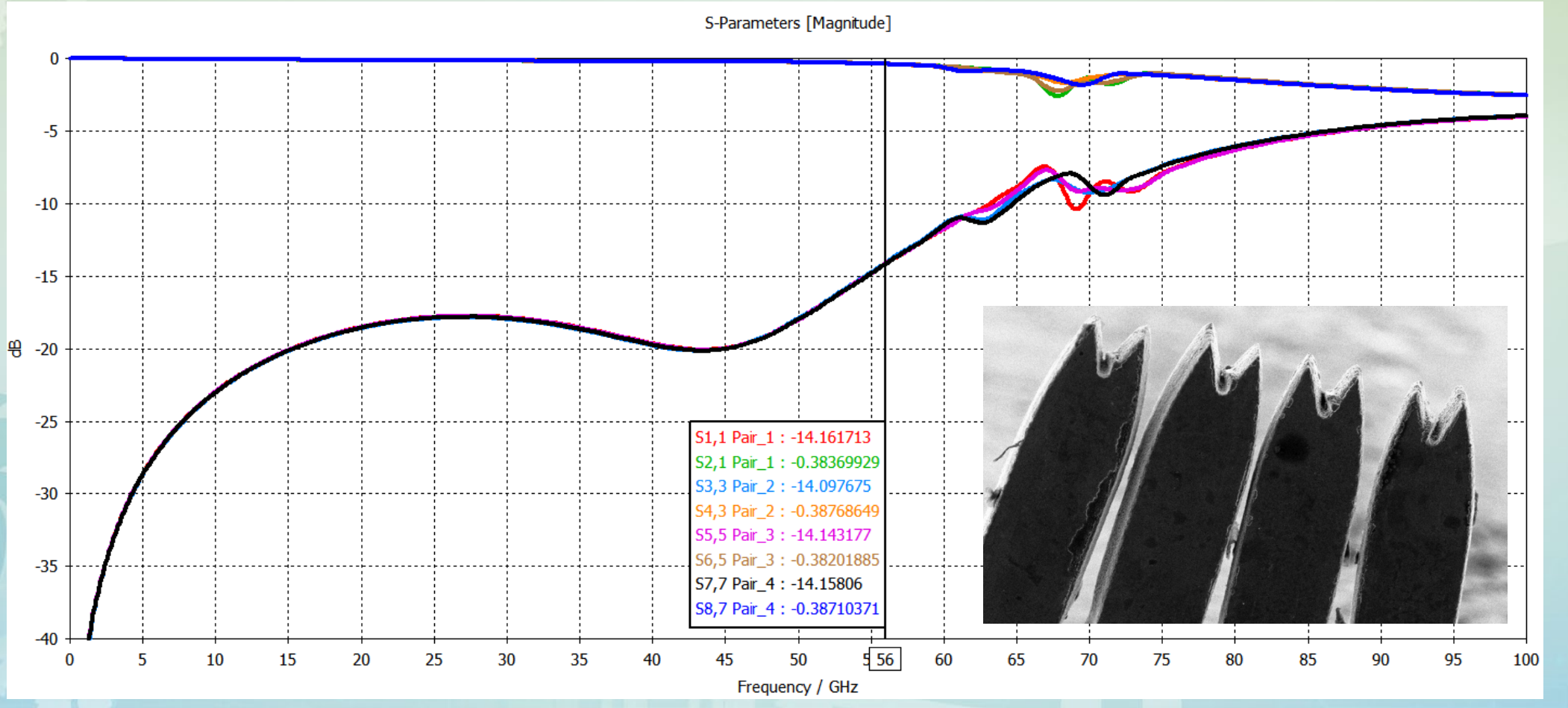
RF & High-Frequency Landscape



The 224 Gbps Solution

- Probe must be short: <1mm
- We must meet 56 GHz (224 Gbps) bandwidth!
- Possible compromises that must be made for bandwidth:
  - Compliance
  - Cycle life
  - Repairability

High-Bandwidth Vertical Probe In Development



Conclusion

- RF probing solutions vary by application, and multiple techniques may be required for a single IC bring-up
- As ATE Test “shifts left” even more challenging requirements are coming to probe
- 224 Gbps is currently beyond vertical probe capability – innovation is required to meet the new challenge!