Too Hot To Test

February 9 - 11, 2021

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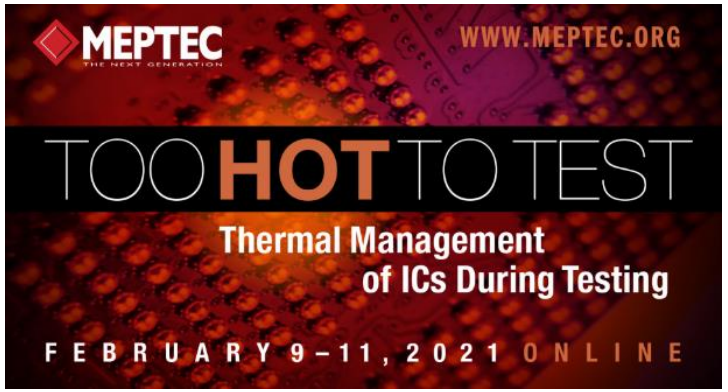


A Revolutionary MEMS RF Hybrid Probe Card

Karan Maniar, Mechanical Engineer

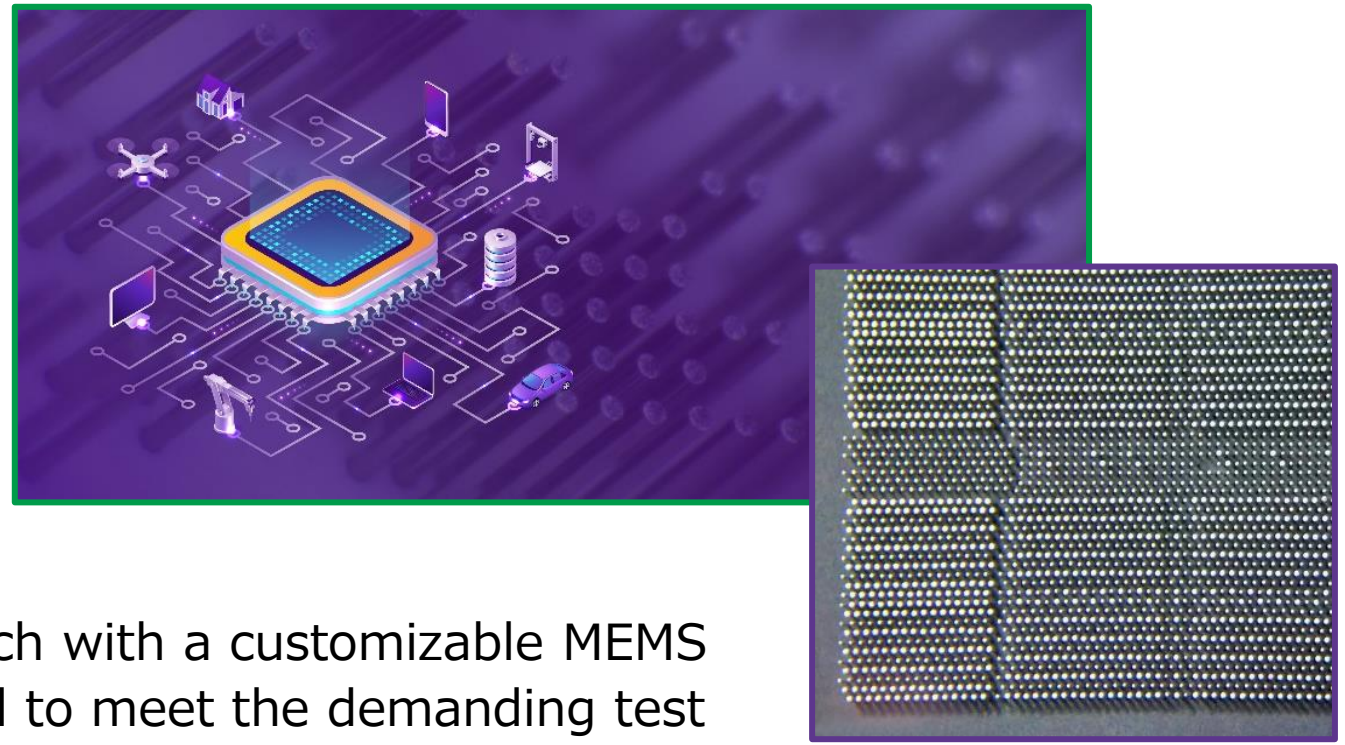
Too Hot to Test Workshop

Organization : SV Probe, Inc.

Date : February 10, 2021

Background & Overview

- ***Test Challenge***: Increasing number of ICs being developed incorporating high frequency & high current, creating tremendous integrated test solution challenges for test coverage & mechanical/electrical complexity requiring:
  - Up to 40 GHz Frequency
  - High Number of Probes
  - Greater Number of RF Ports
  - Increased Power Domains
  - Lower Power Consumption
  - High Temperature Capability

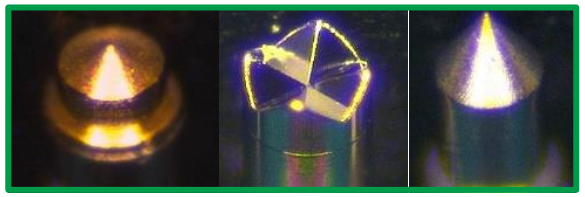


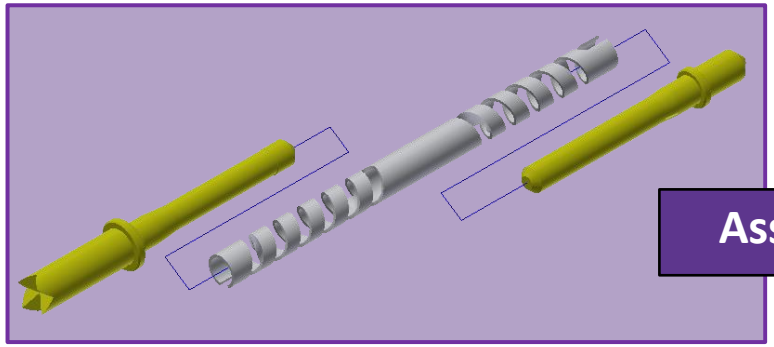
- ***Test Solution:*** A ***unique*** & ***proven*** approach with a customizable MEMS probe-based, hybrid probe head, developed to meet the demanding test conditions of these mmWave, High-Speed, high power ICs.

Note: Multiple Patents Pending

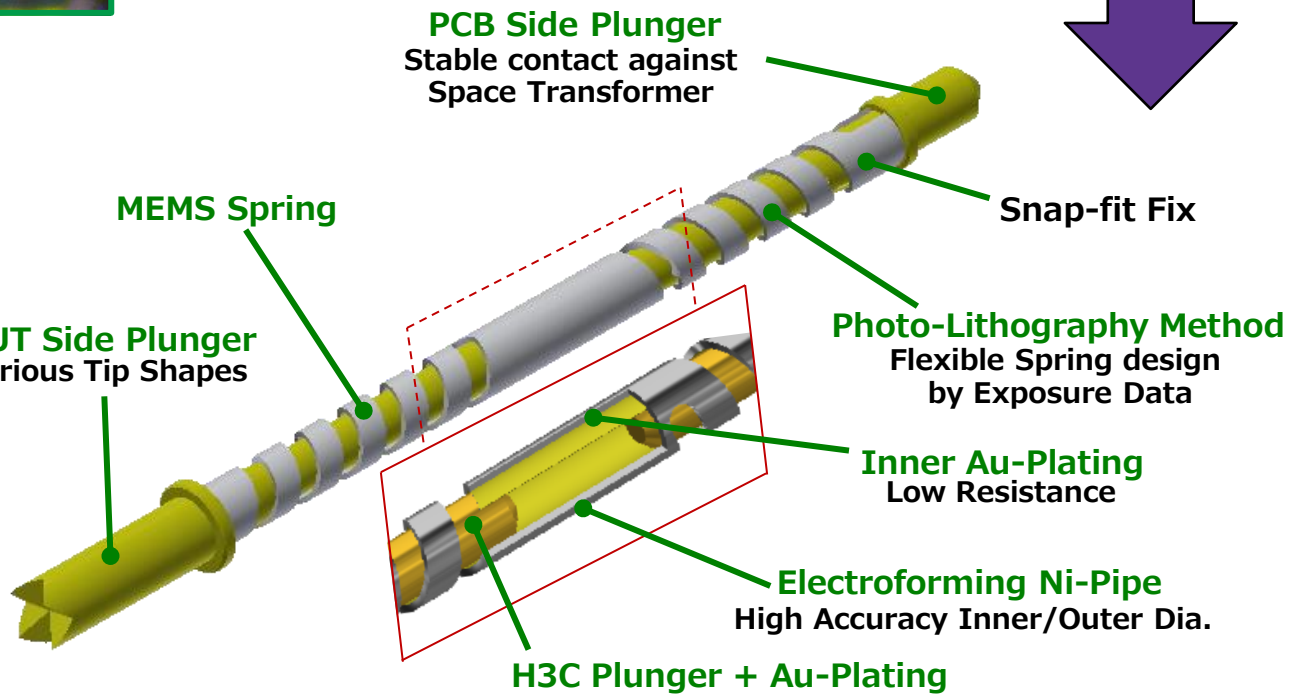
Customizable Probe Design – Assembly Example

- Flexible Pin Design: Force, Overdrive, Length & Tip Style for Application Optimization
- Optional Rotation
- Reduced Probe Length
- Small Probe Pitch
- Consistent Alignment, Planarity, Cres Increases Reliability, 1st Pass Yield
- Single pin replacement capability, reduced downtime of the hardware.
- Automated Assembly
  - Software controlled modifications in probe design versus complex MEMS process deviations





Assembly



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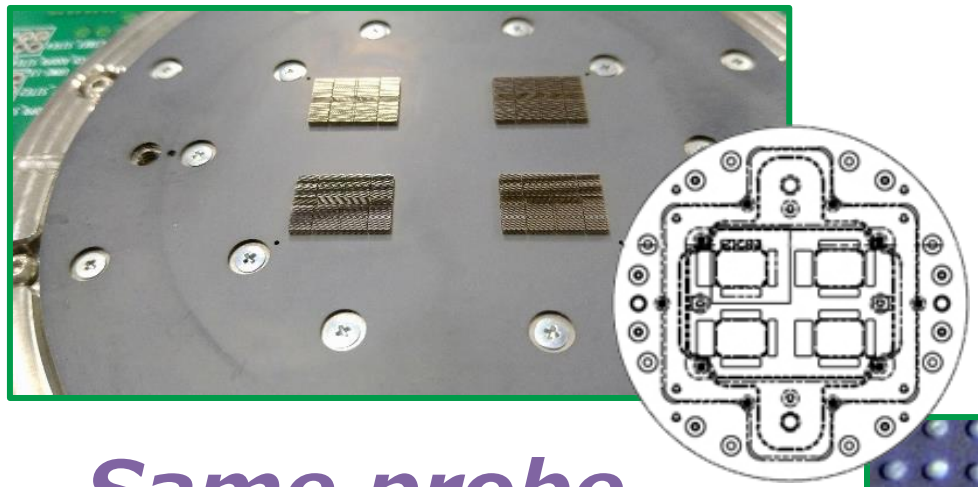
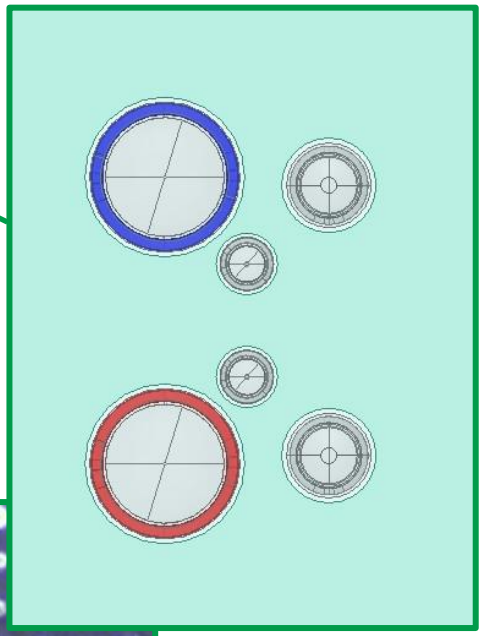
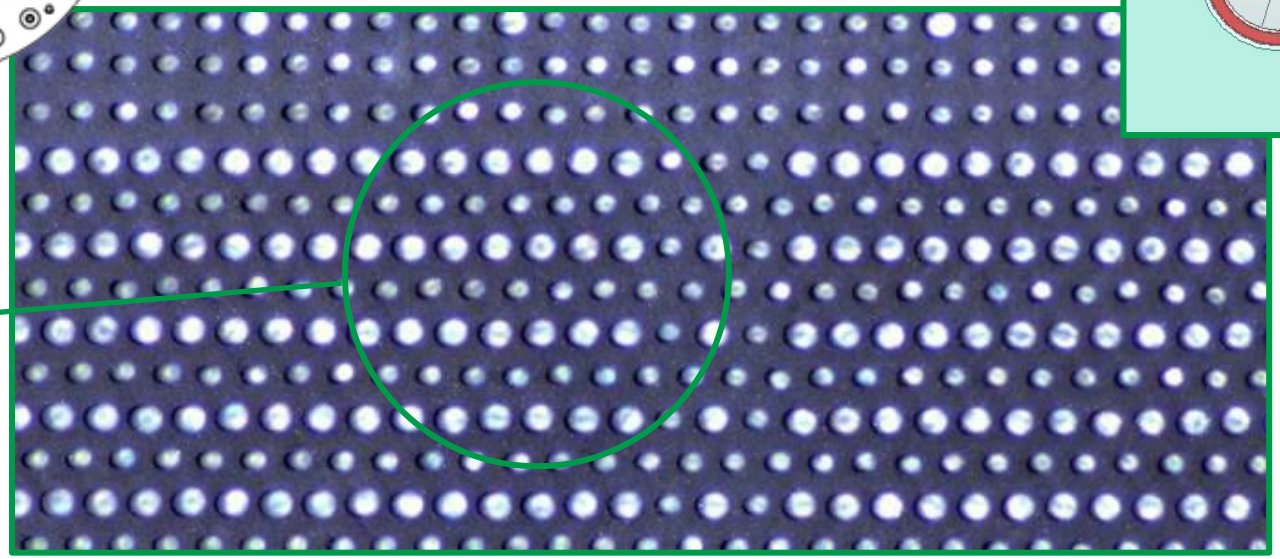
3D MEMS Hybrid Probe Card Design Concept

Flexibility of the probe is key.



Hybrid PH is developed with a combination of larger diameter probes for the signal high current pin & a smaller diameter non-high current pin.





Same probe force, stroke & length, only the diameter increases for higher CCC performance.

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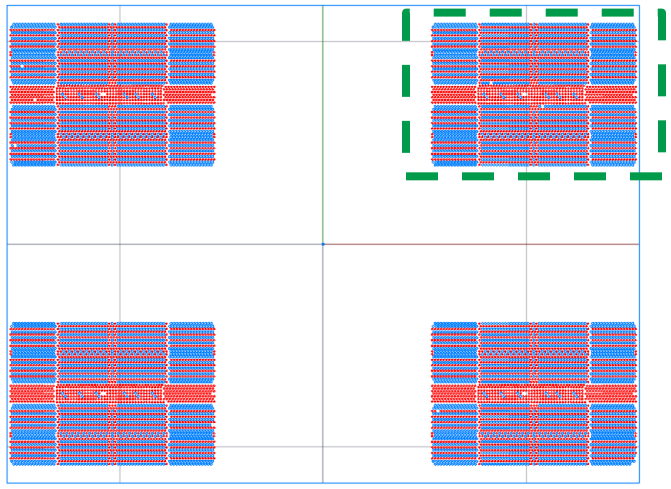
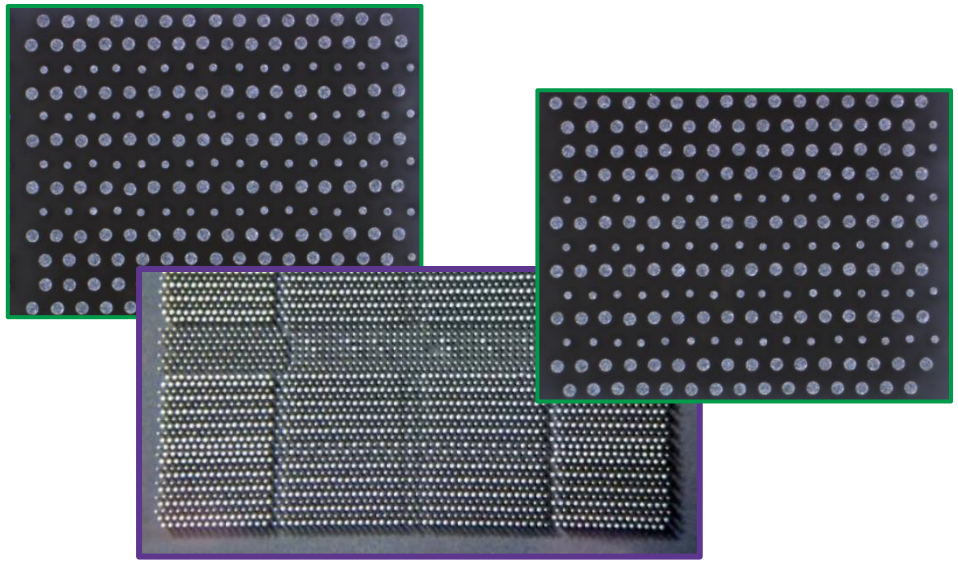
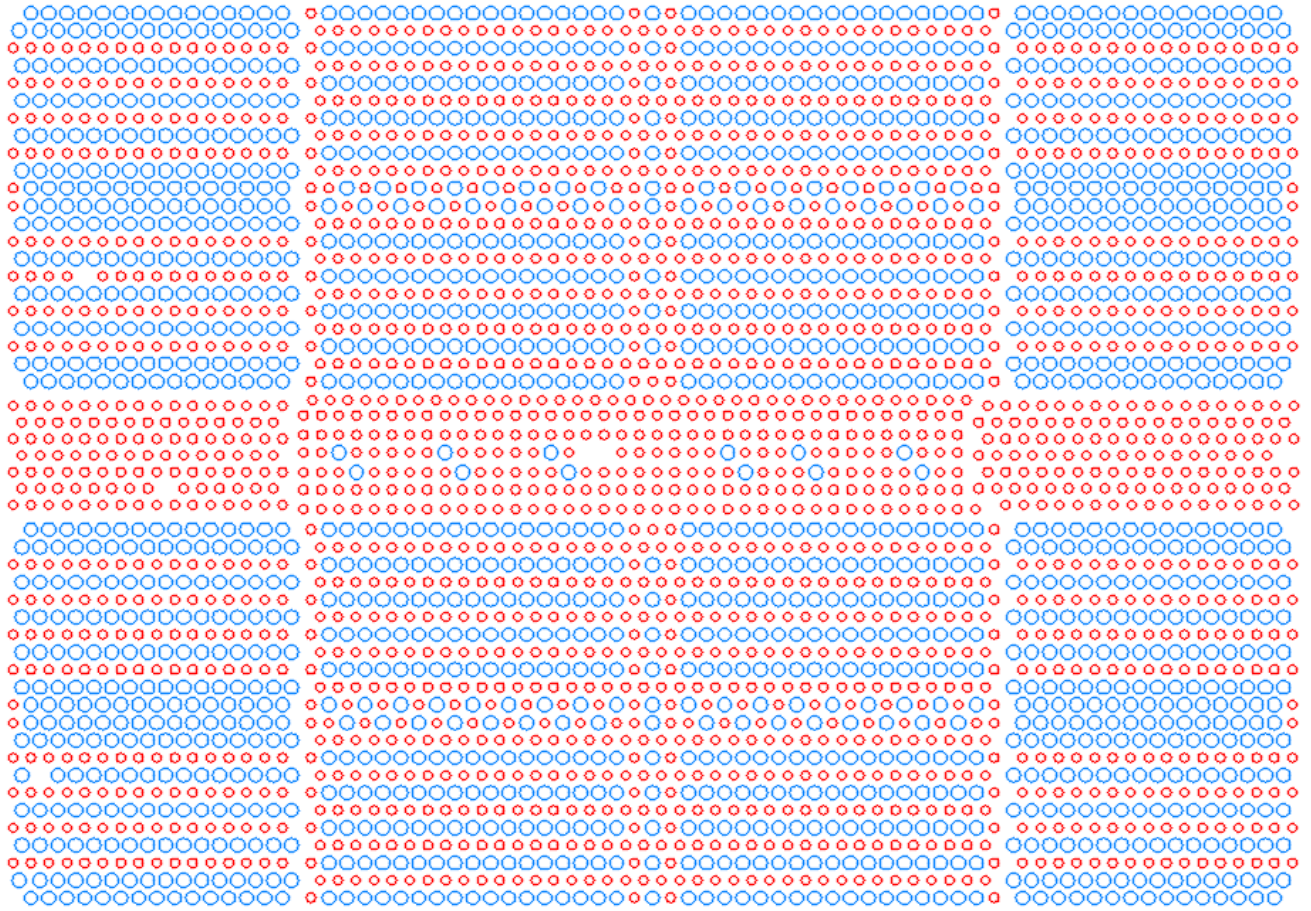
High Current & Non-high Current Pin Location Example







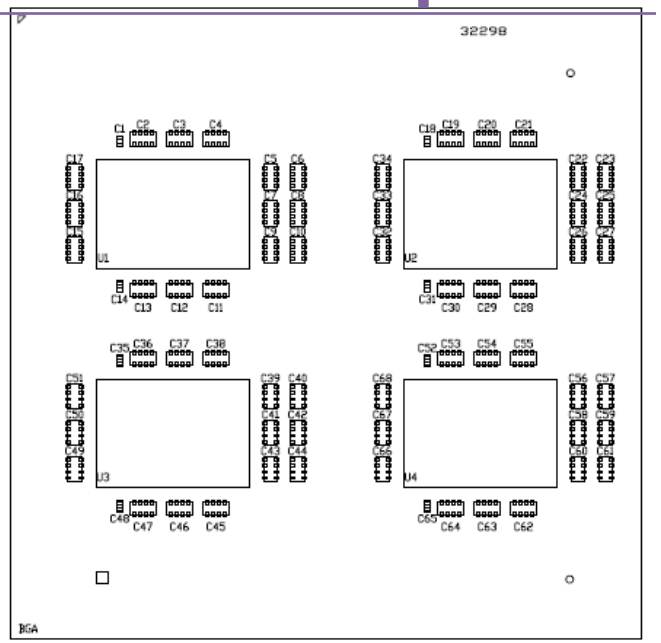
High current pin

Non-high current pin
Lower current supplies & grounds, I/O signals, utilities

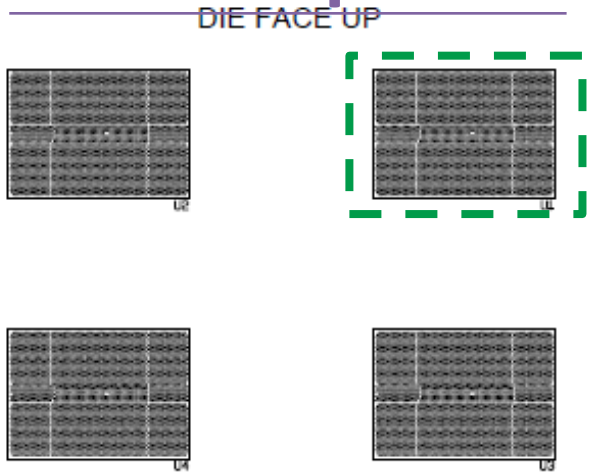
Note: Multiple Patents Pending

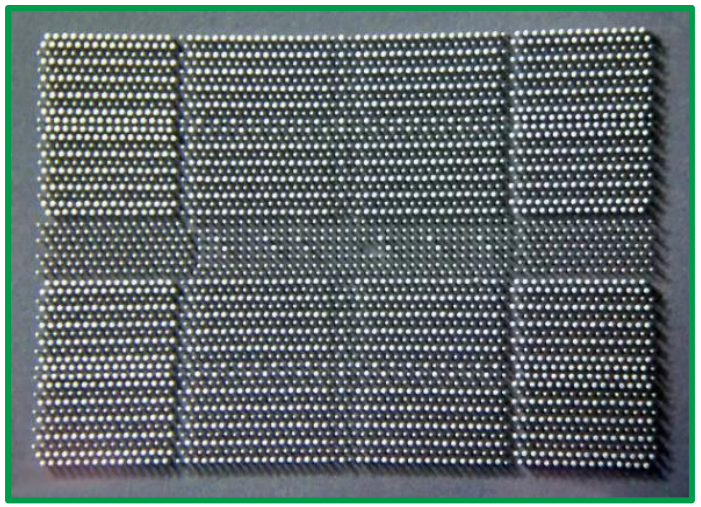
Hybrid Technology with Multi-MLO Design

Substrate Top View

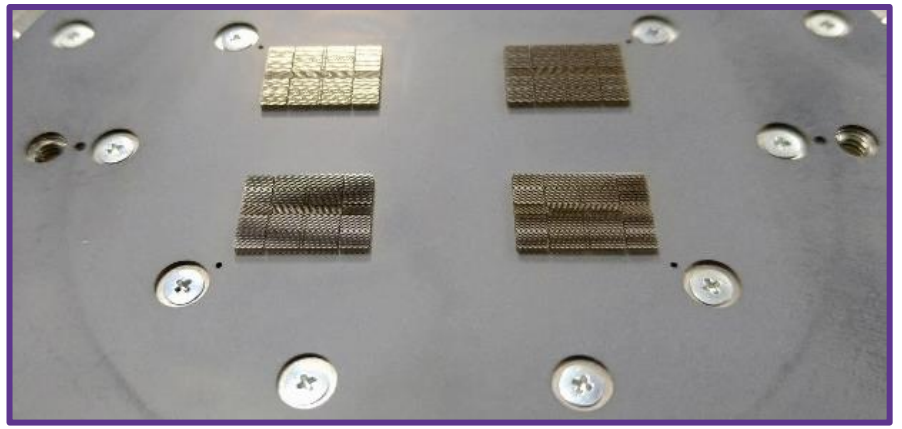


Wafer Top View



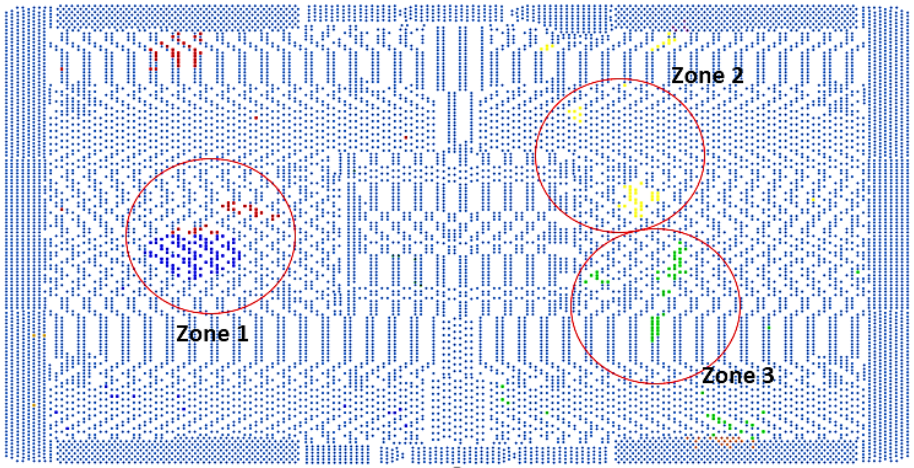


The Hybrid technology demonstrated above is a multi-MLO design that can also use a package substrate with a skip to save on cost.

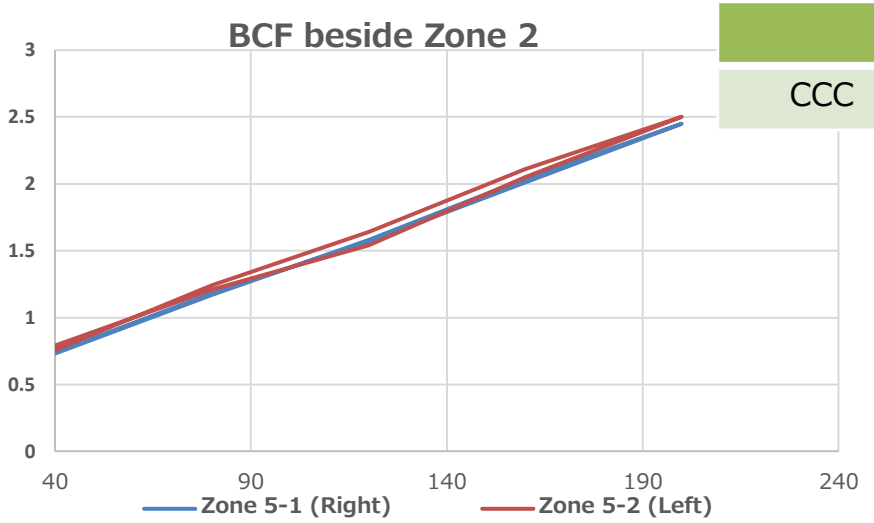


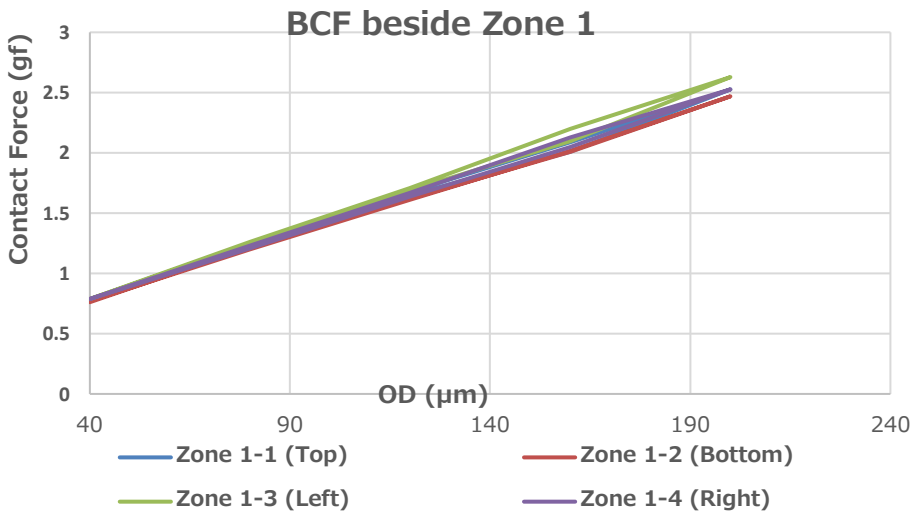
Note: Multiple Patents Pending

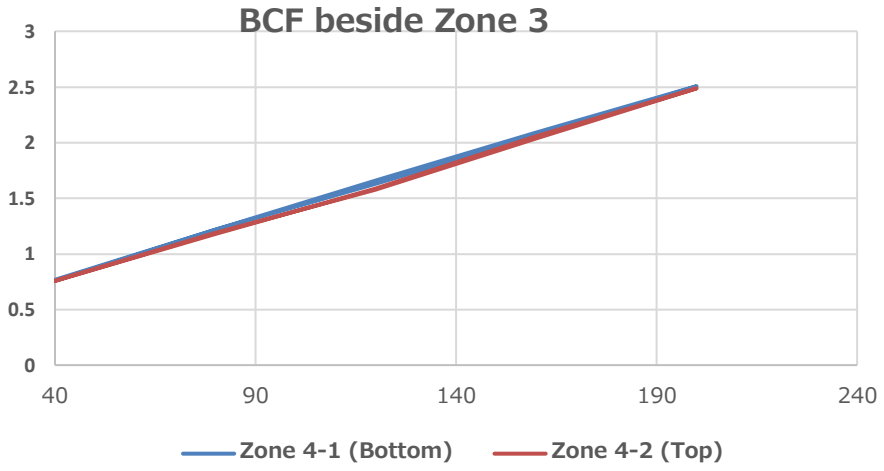
BCF Probe Performance



	P90	P120	P147
CCC	900mA	1200mA	1500mA



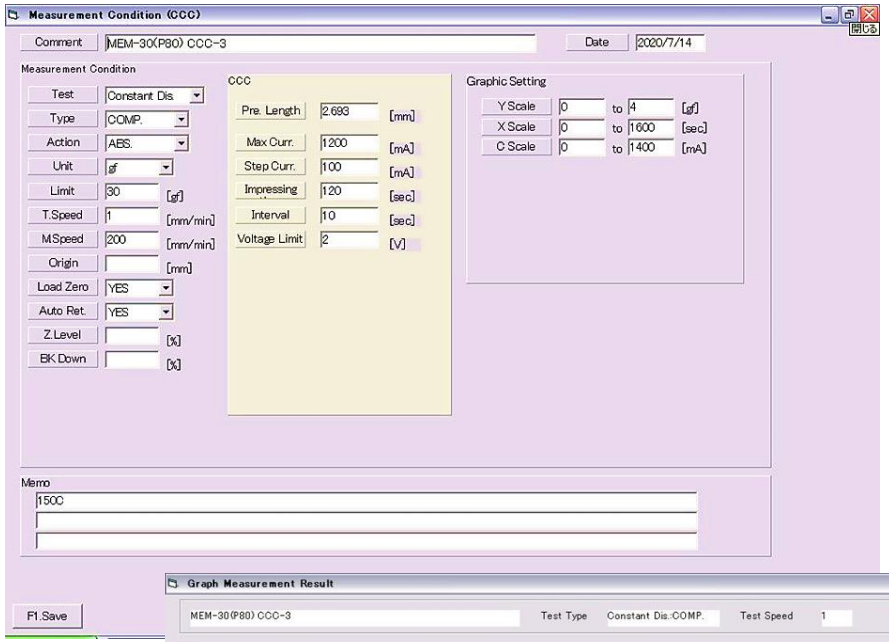


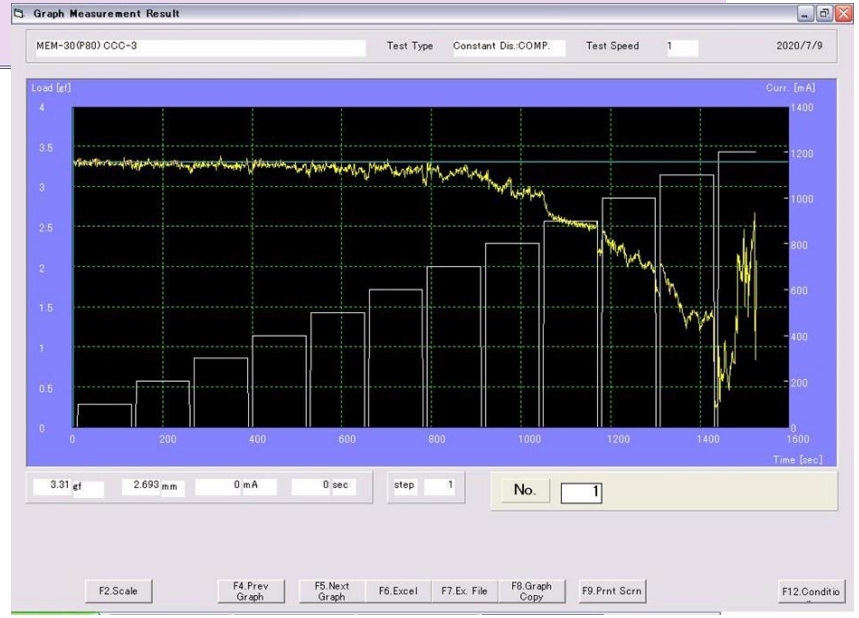


- BCF measurements were performed on different parts of PH with hybrid probes to achieve the CCC requirement.
- All of the probes have consistent force at different OT after population in the PH.

Note: Multiple Patents Pending

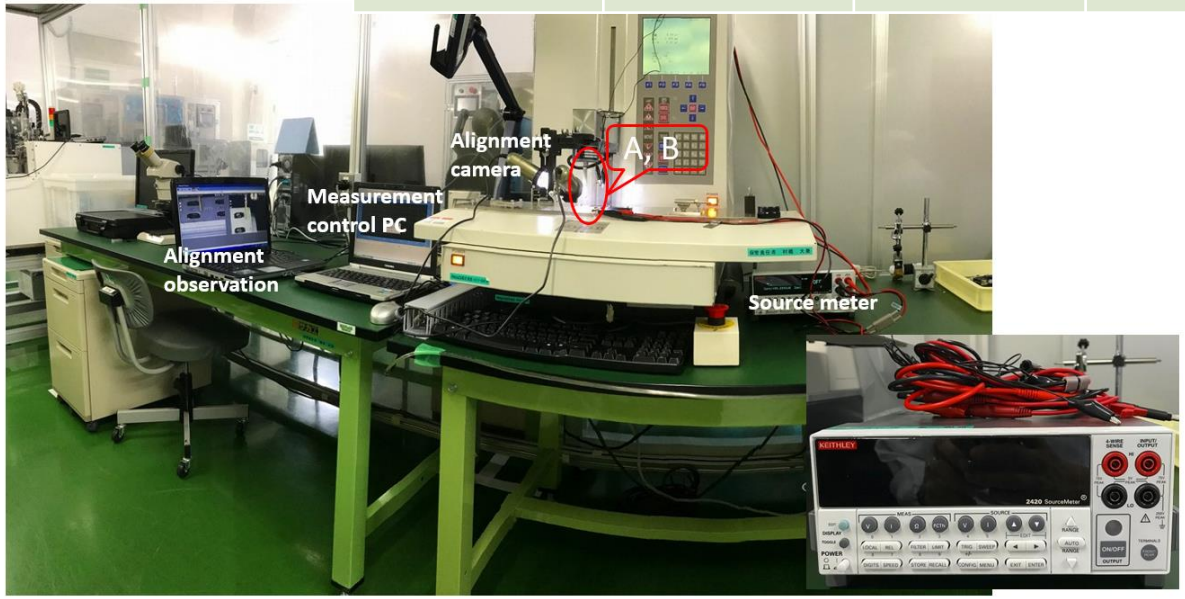
CCC Measurement



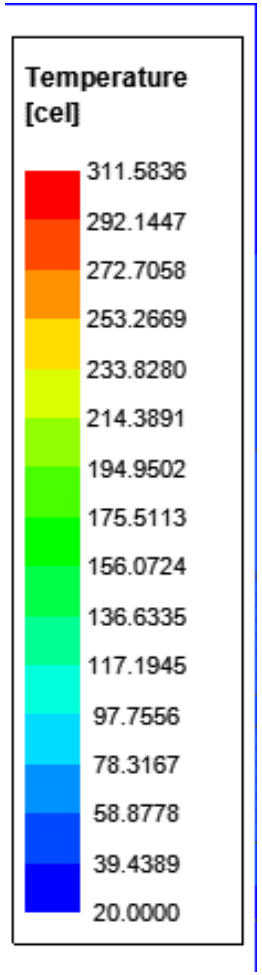


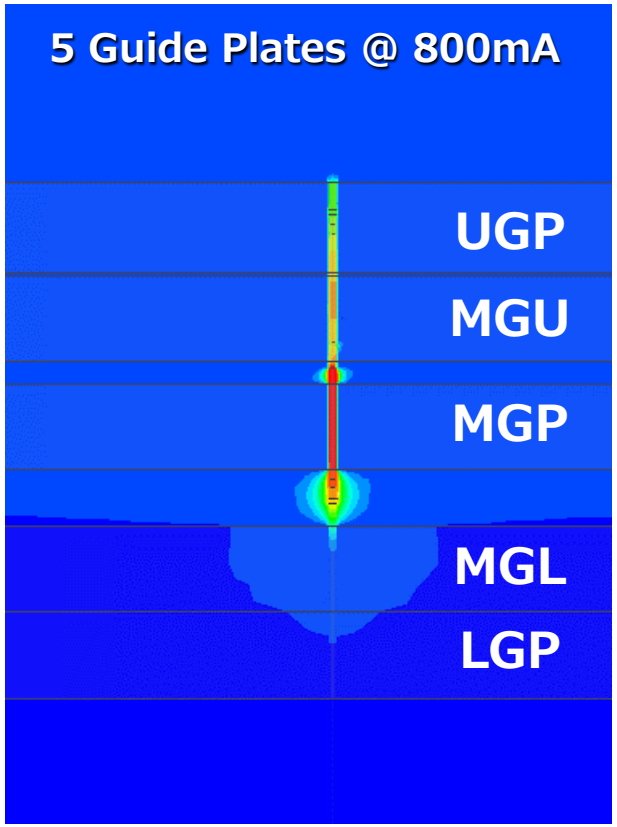
- CCC of the probe is measured as per ISMI standards, with the 20% reduction in force upon exposure to current will be CCC of the probe.
- CCC is measured by passing current for two minutes & then measuring the force after 10 seconds.
- With 20% reduction in force there will be a loss of contact so the probe will lose its robustness.
- As a result, CCC is a useful measure for comparing different technologies but is not recommended for determining maximum current levels when probing wafers.

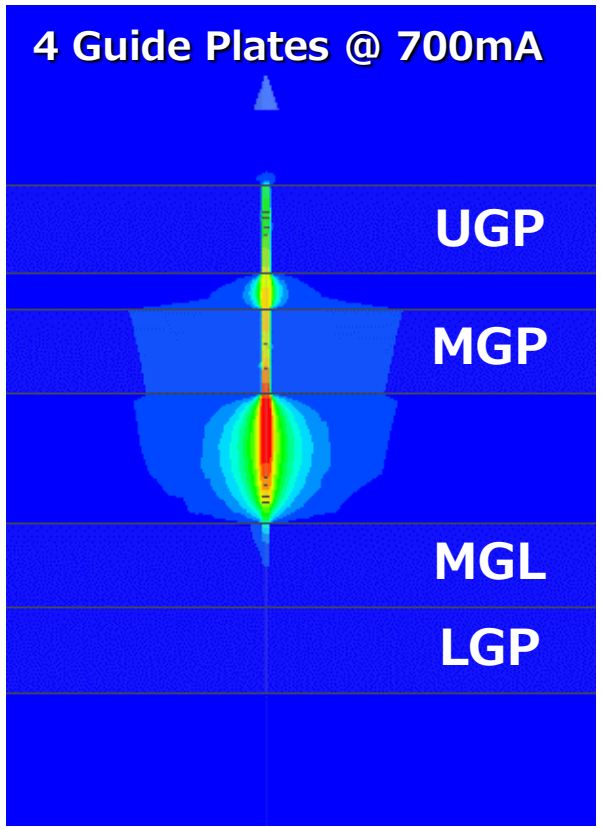
	P90	P120	P147
CCC	900mA	1200mA	1500mA

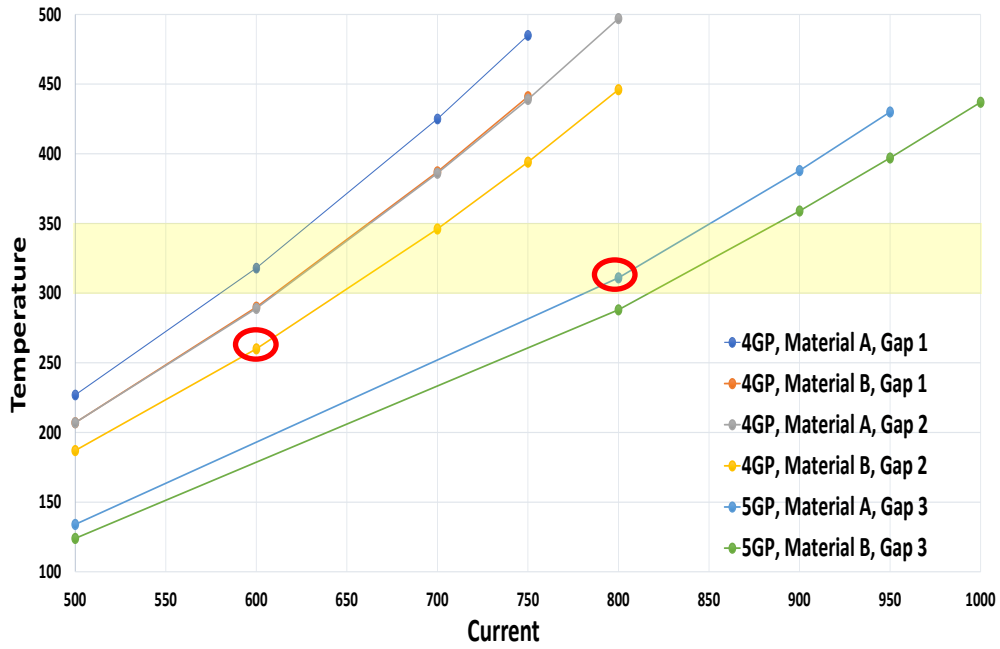


PH Optimization At Temperature









- The PH stack up can be modified depending on the current requirements & the temperature.
- Mechanical thermal simulations were performed to simulate the heat dissipation from the probes at high current.
- Stack up can be optimized to allow for heat dissipation so the probes can pass higher current at high temperatures.

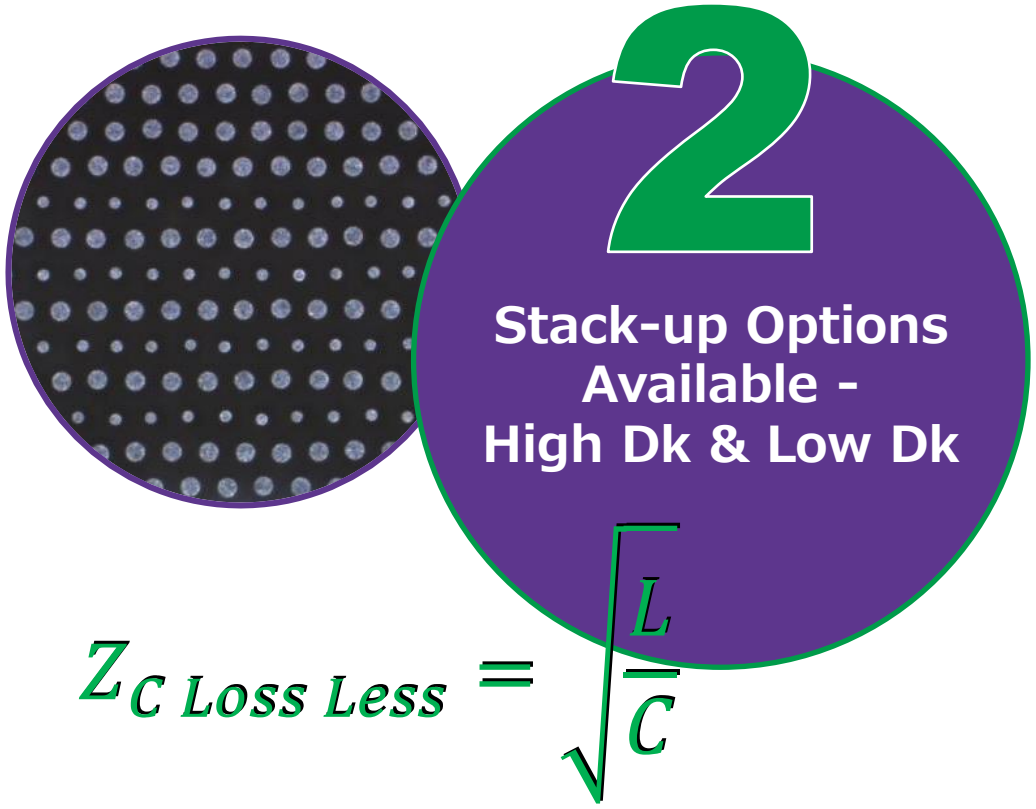
Note: Multiple Patents Pending

Impedance Matching

Demonstration of the optimization of a high-speed probe head design, via impedance matching to achieve a transparent transition between the PCB & wafer. Goal was to determine an optimal Probe Head Structure & Stack-up achieving a Reflection Loss between -20 & -15dB with a transmission loss close to -1dB at the highest frequency requested.

Low-Loss Probe Head Parameters

- Stack-up Optimization
  - Parameter: Dielectric Constant
- Mix Diameter Probes
  - Parameters: Inductance & Capacitance
- Reflection Loss
  - Matching through careful definition of Probe Impedance (Optimizing Probe Head)
- Attenuation/Loss
  - Length of the Probe



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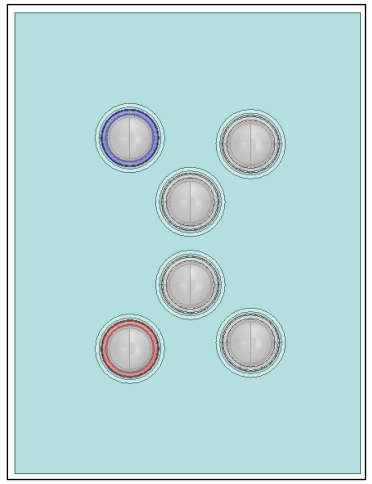
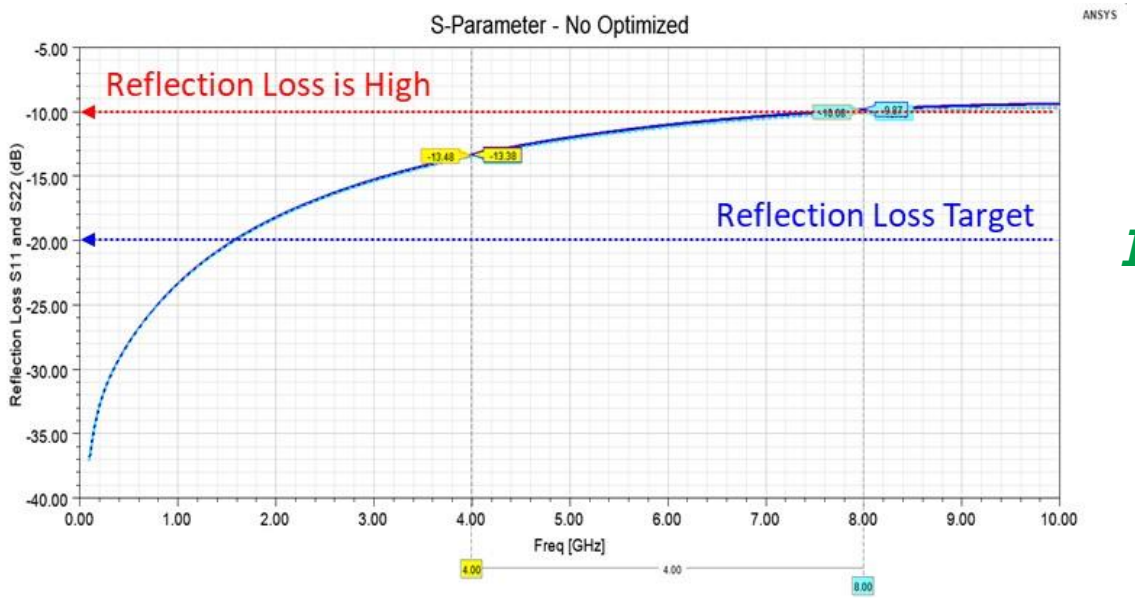
Transparent PH Design Optimization

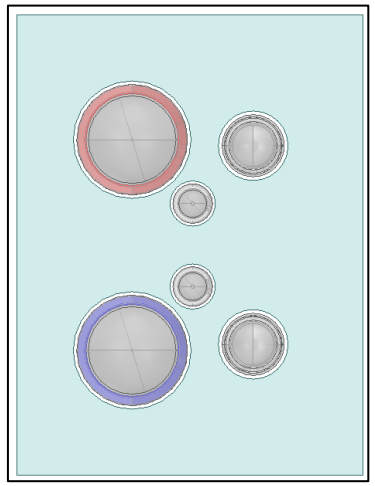
Probe Pitch 180µm

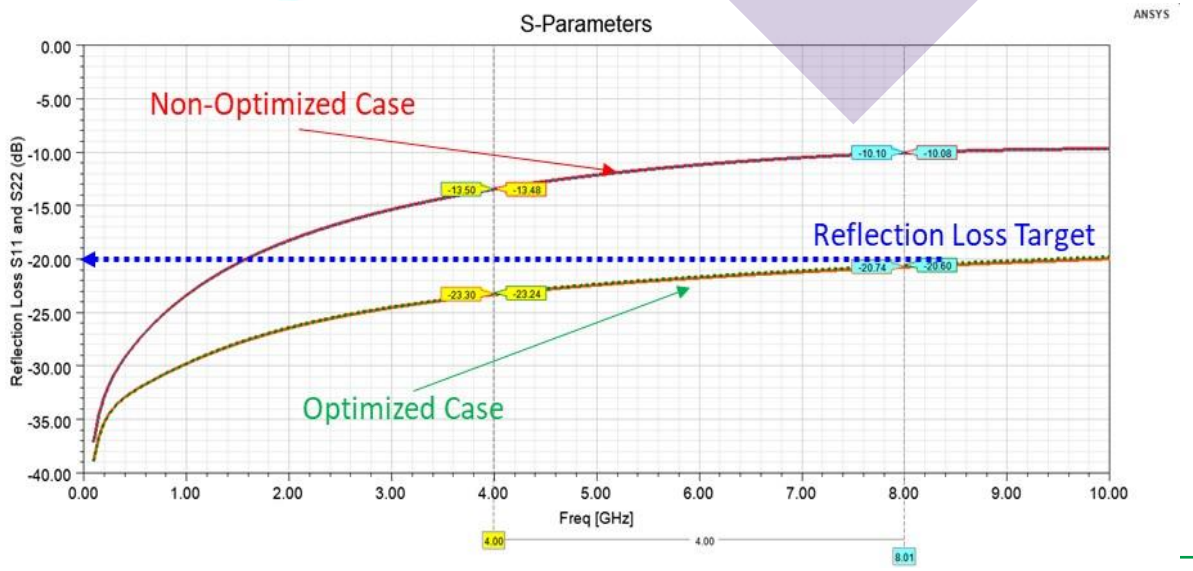




Reflection Loss Improvement from using multiple probe sizes.

Variety of Probe Sizes

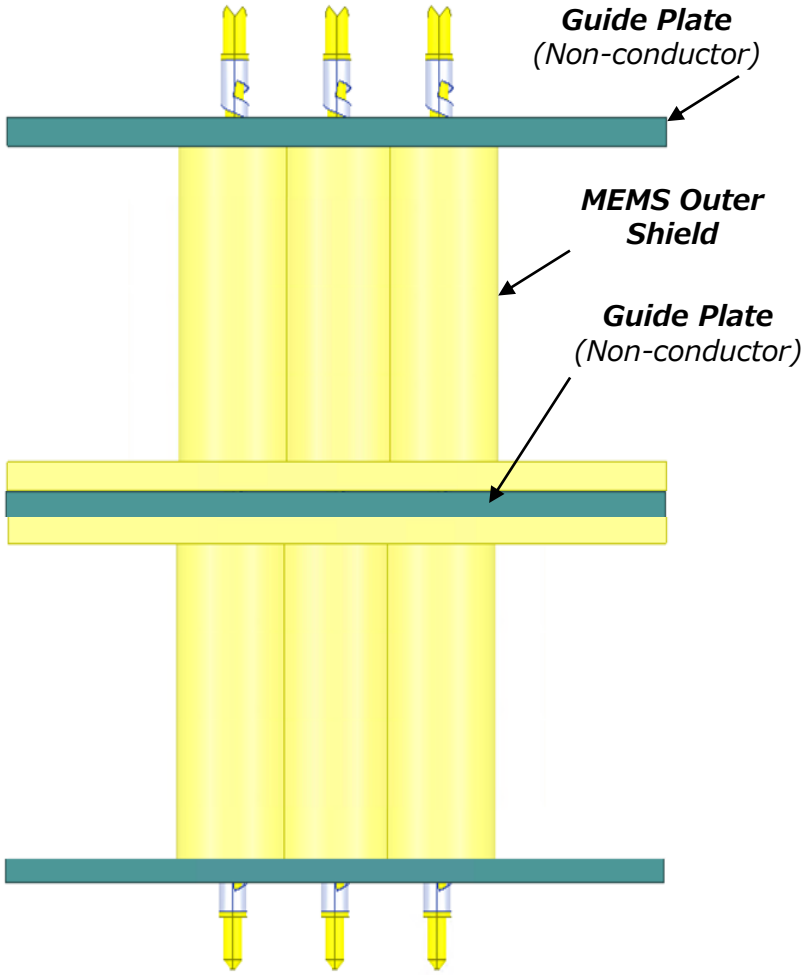




Note: Device used for this experiment only required 10GHz frequency so test results shown simulated to 10GHz. Other Hybrid Probe Cards can go up to 40GHz.

Note: Multiple Patents Pending

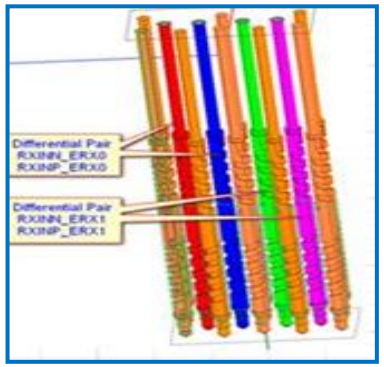
Coax PH with/without Shield for High-Speed RF Applications

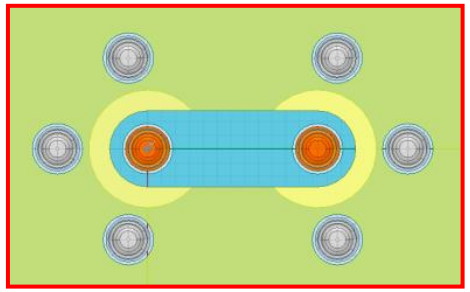


- Coax PH optimizations are performed depending on the speed requirements & pitch.
- Simulations are performed using a larger probe without shields & a smaller probe with shields.
- PH with a smaller probe & shield provides a cleaner transmission loss & achieves the target of reflection loss less than -10db at higher speeds.

Note: Multiple Patents Pending

Coax PH with/without Shield for High-Speed RF Applications

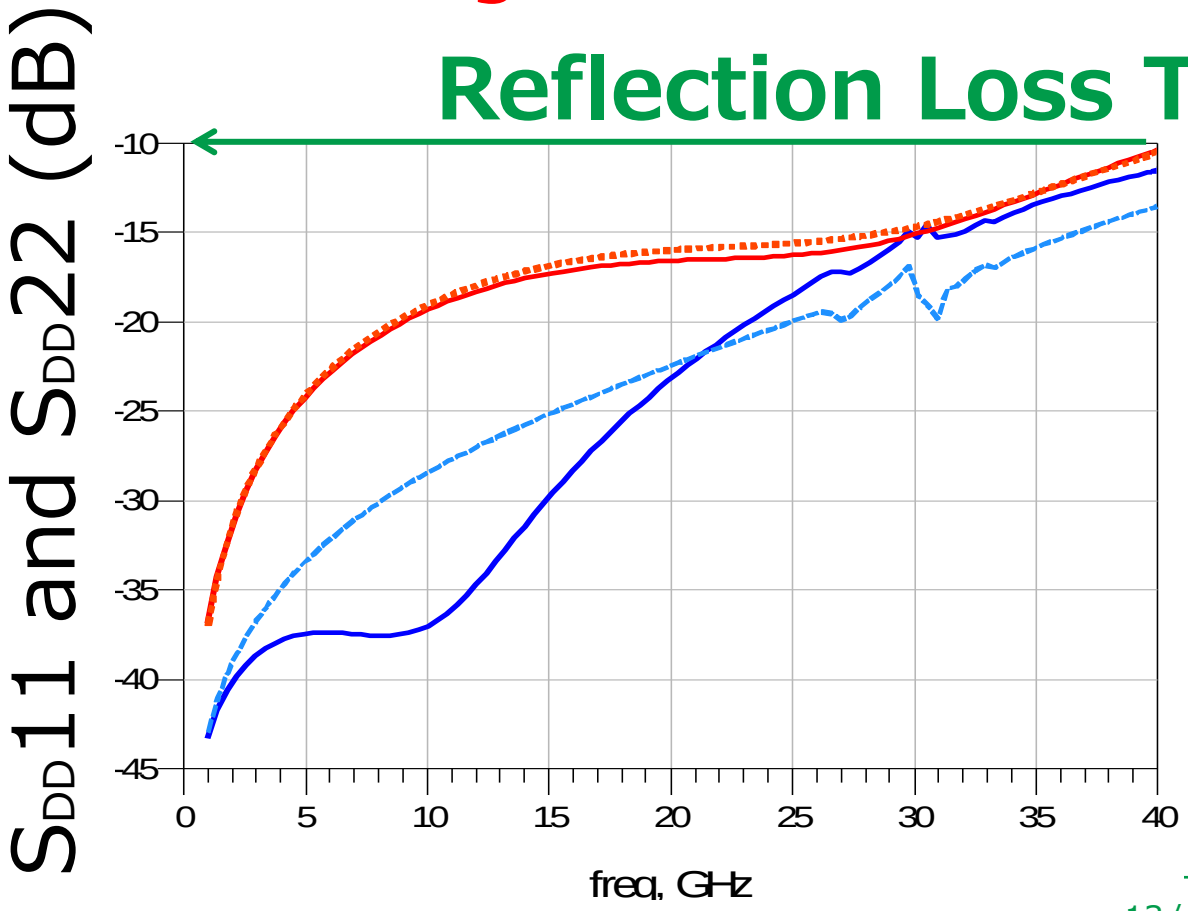




Blue: Design without shield P

Red: Design with shield P90

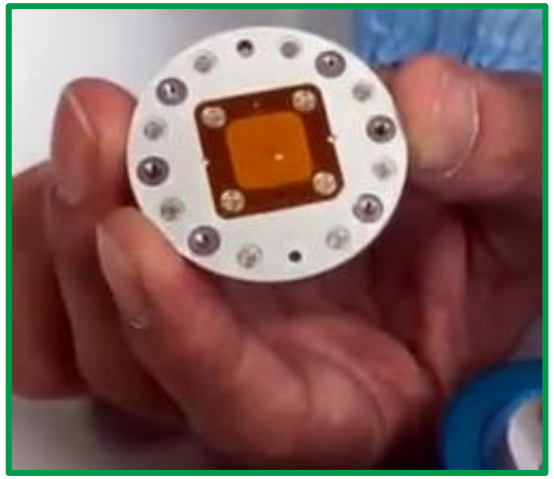
Reflection Loss Targ

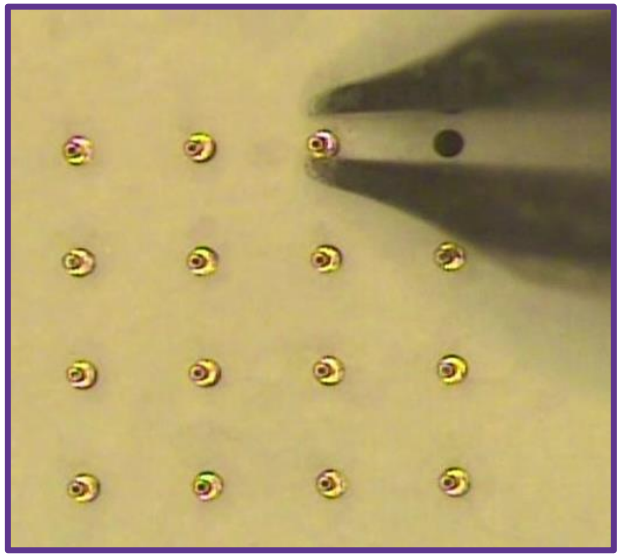


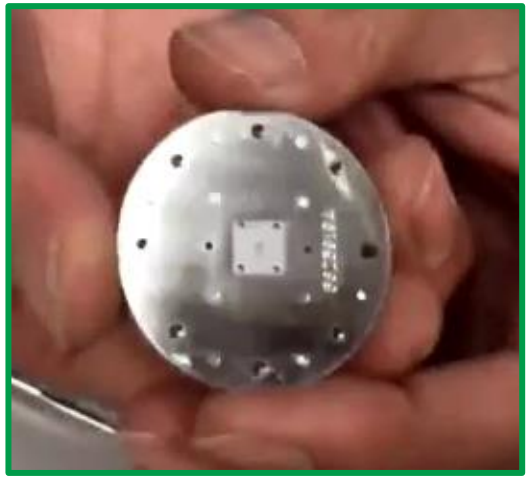
Note: Multiple Patents Pending

MEMS Probe Repair & Replacement

- These MEMS are easily repaired in-house after minimal training.
- Utilizing a probe head repair tool the template can be removed from the probe head.
- Probes can then be removed & replaced with ease.

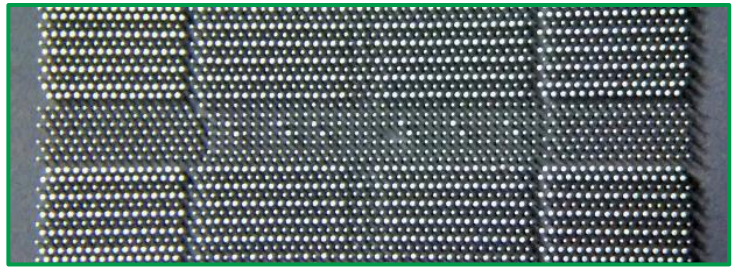






Summary

- Complex Chips & Test Challenges
  - High Frequency
  - High Current
  - High Temperature
  - High Pin Count
- Innovative & Unique Test Solution
  - Customizable, Flexible 3D MEMS Probe with an Efficient Manufacturing process, Easy Replication for Multi-Dut Probing
  - Advanced Hybrid Probe Head with mix of varying probe diameters; Capable of testing at High Current & Non-high Current
  - Easy Single Pin Repair & Simple Cleaning Procedures



Note: Multiple Patents Pending

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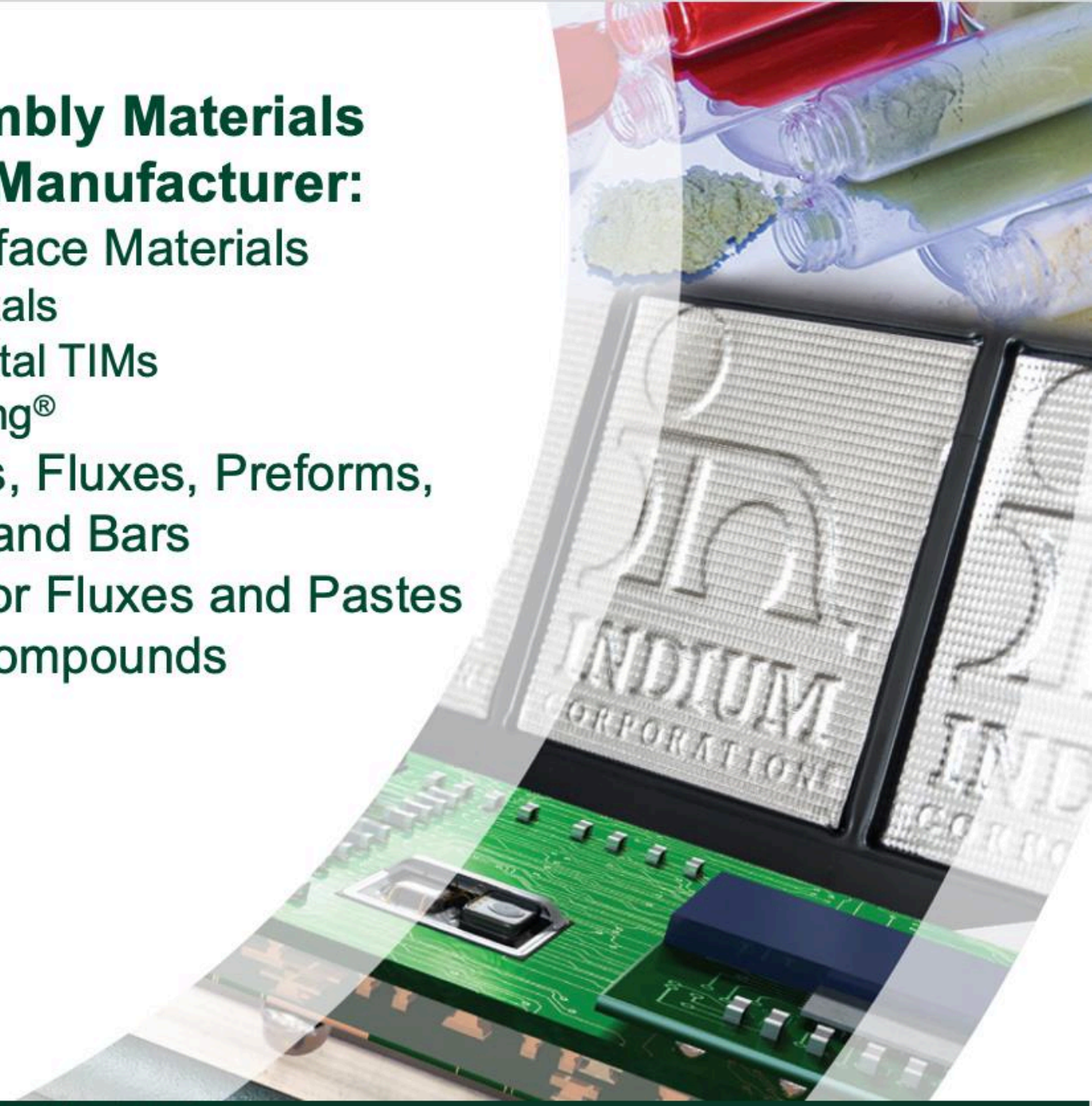

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