SW Test Workshop

Semiconductor Wafer Test Workshop

MEMS process on RF Probe Cards

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MPI CORPORATION

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Overview

- Objectives
- Introduction
- Application
- Summary

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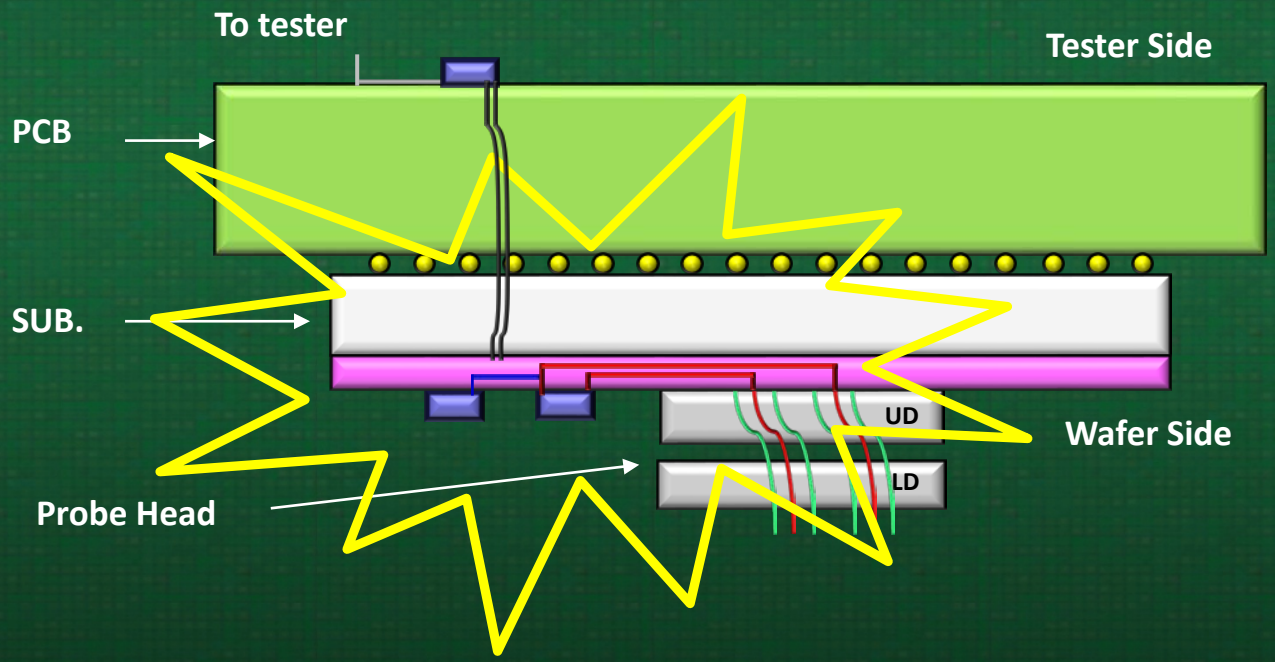
Objectives

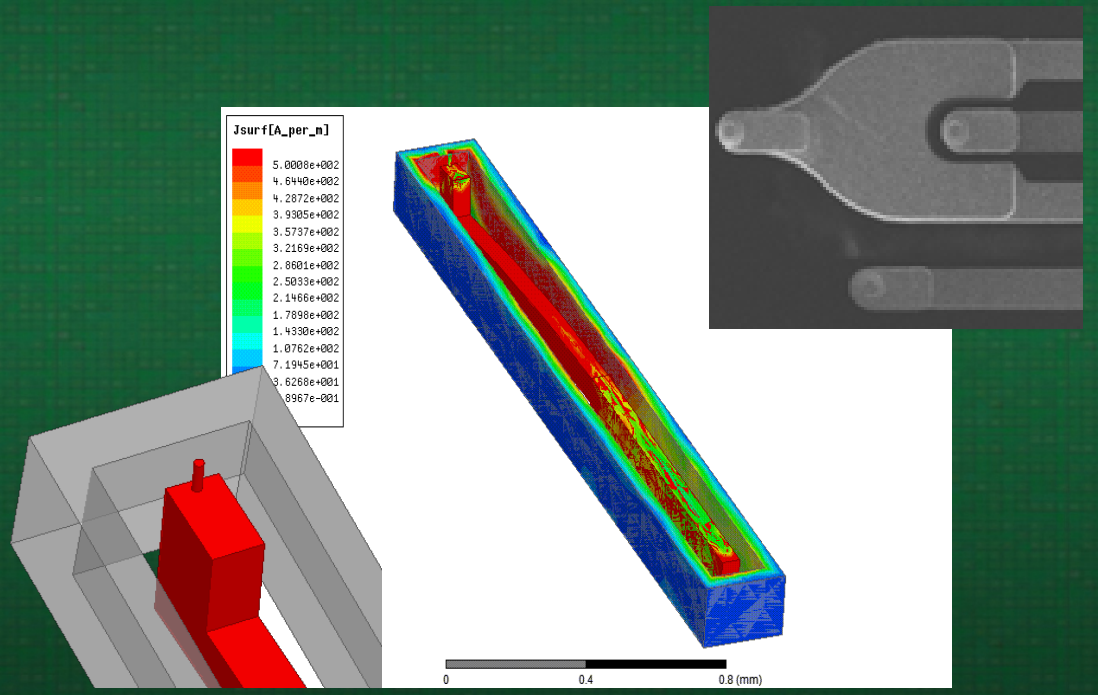
High Speed solution on substrate:

Super Eye (2015 SWTW, 2016 SWTW)



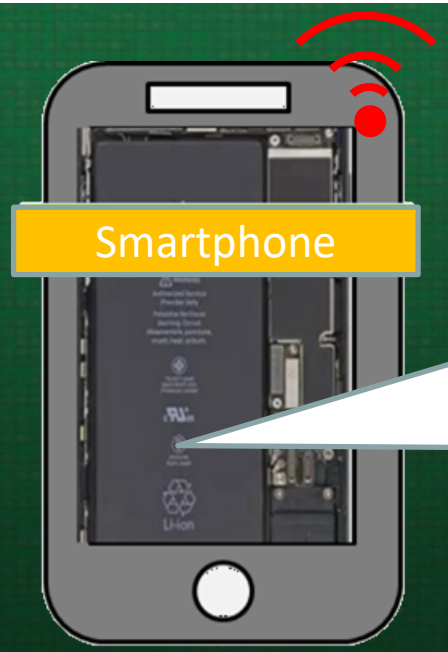
RF solution on needle:

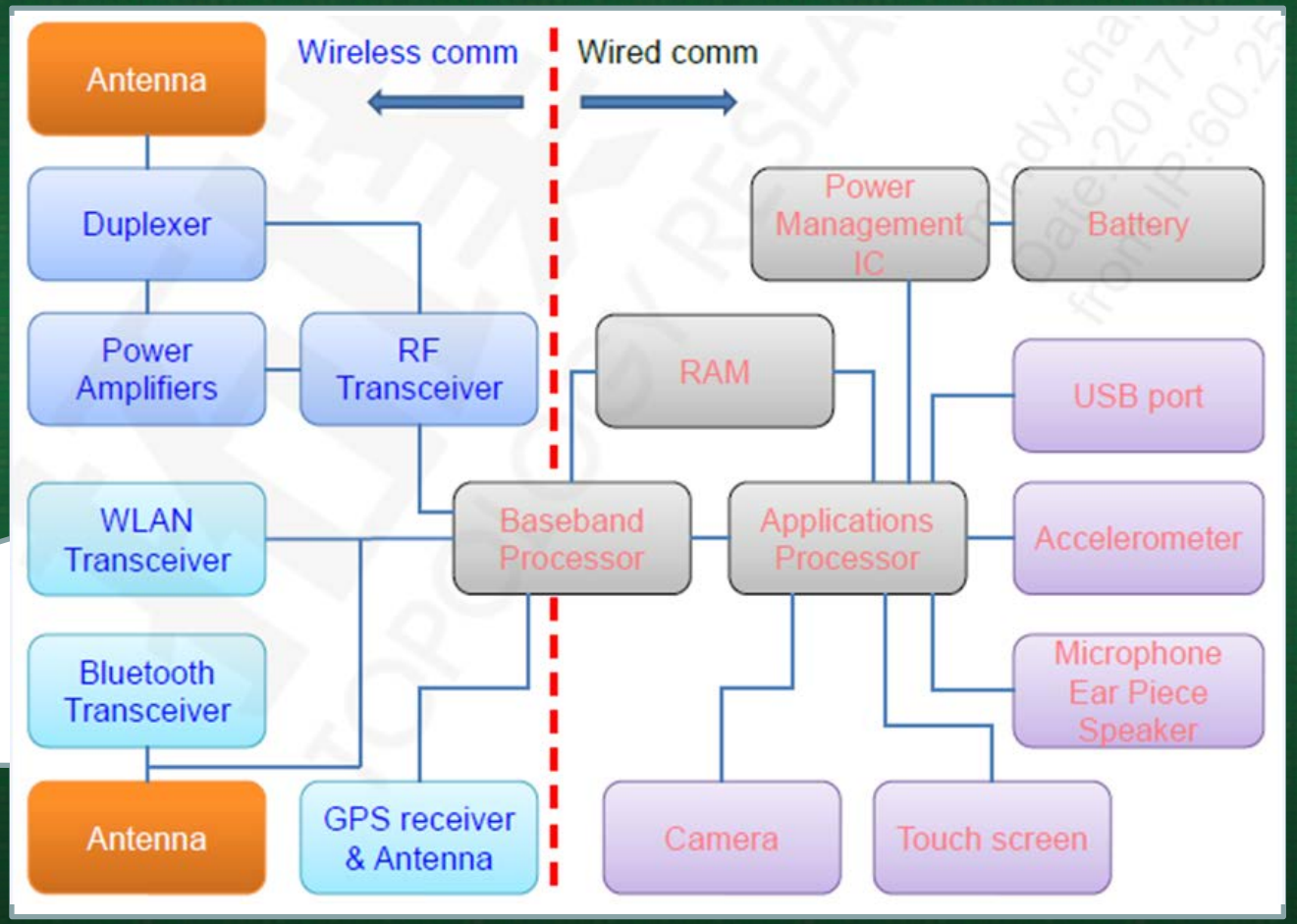
Gt-X (2017 SWTW)



Objectives

With the advances in science and technology, IC applications are used in many fields.
e.g. different types of IC's in one smartphone

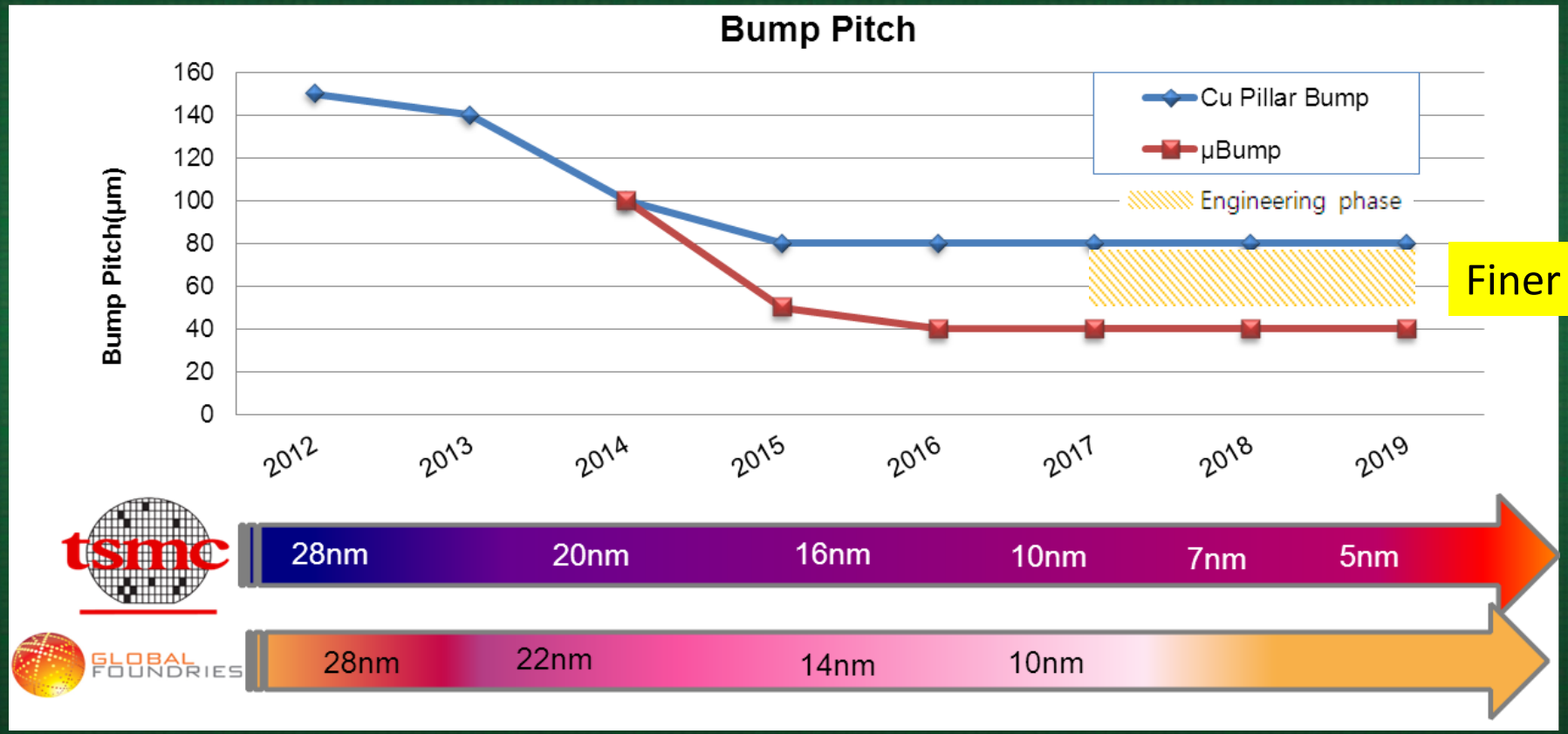




Source: TRI (03/2017)

Objectives

More functions lead to higher pin counts requiring smaller pad sizes and tighter pitches



Source：TSMC and GlobalFoundries Company Data； SWTW (June 2015); Organized by MPI.

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Introduction

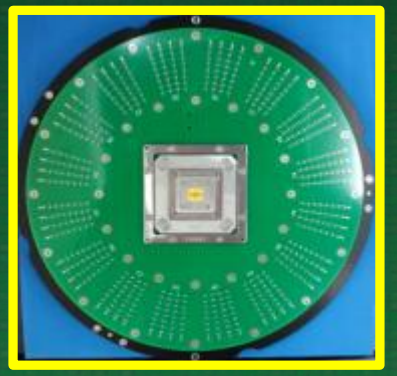
Why MPI's Gt-X Technology?

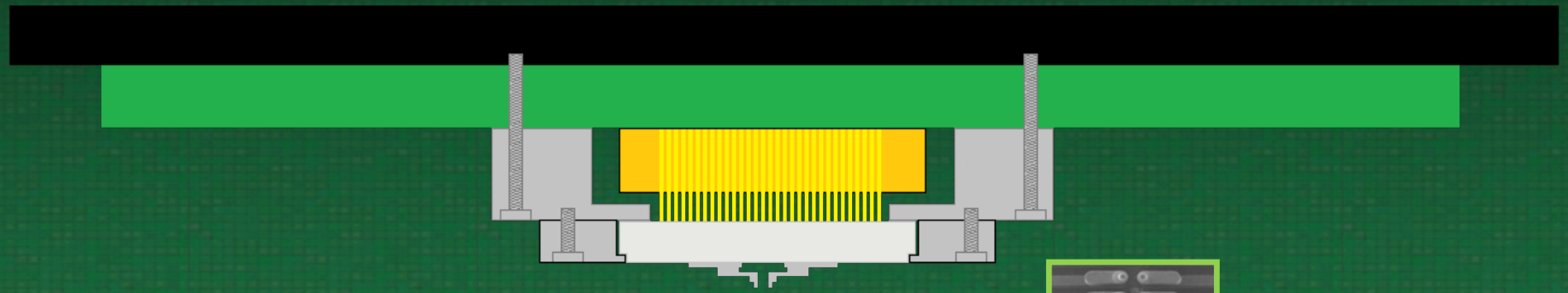
- *Finer Pitches*
- *Probe Mark & Alignment Control*
- *Improved Life Time*
- *Better Force Control*
- *Replaceable PH*
- *Multiple Applications*

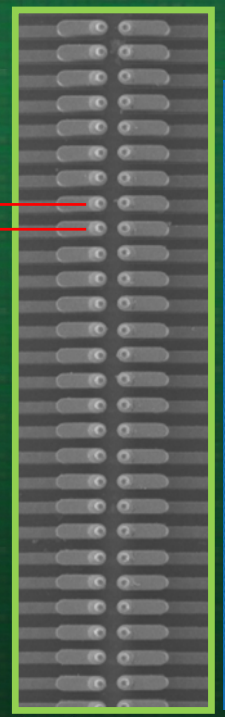
Introduction - Gt-X

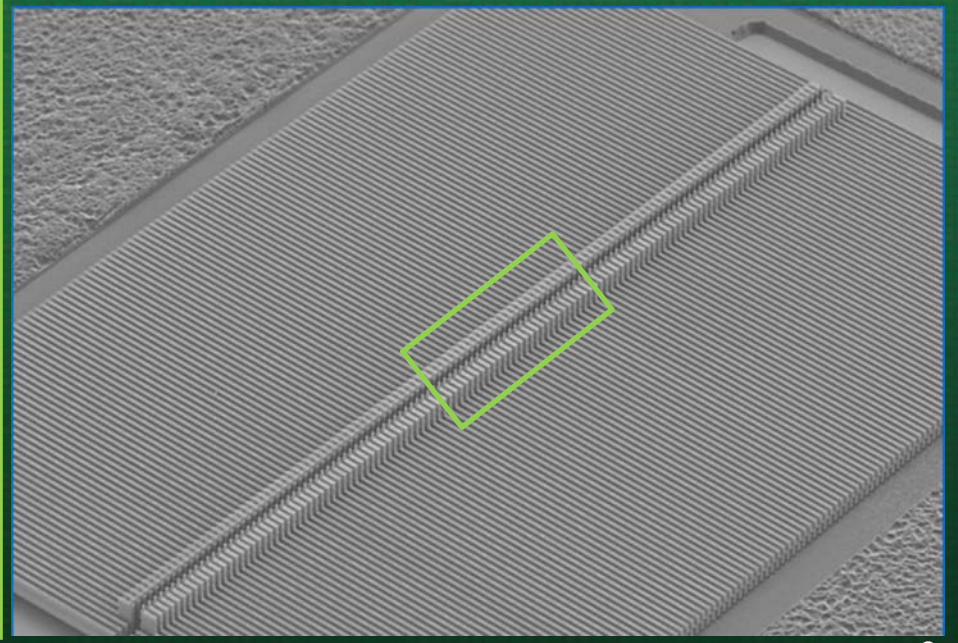
Pitch below 50 um when using MEMS process.

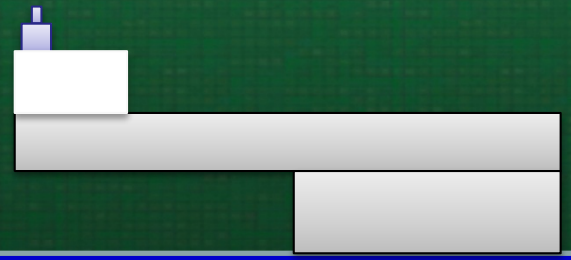
Gt-X Probe Card









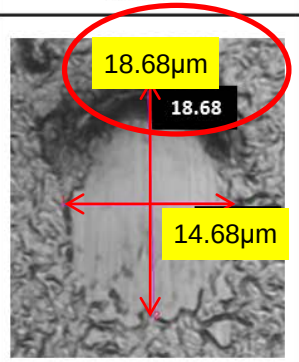
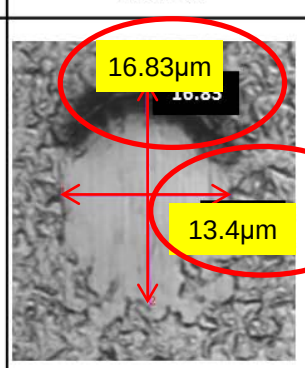
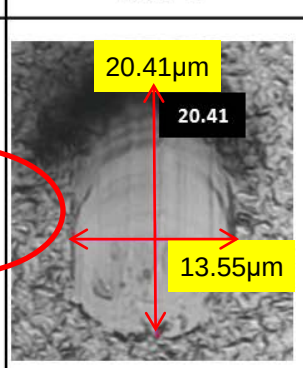
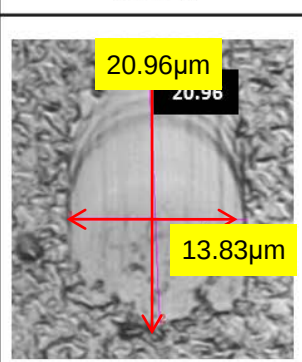
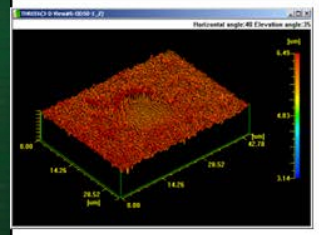
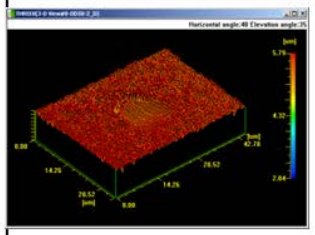
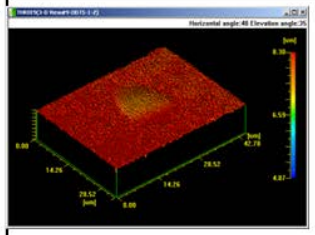
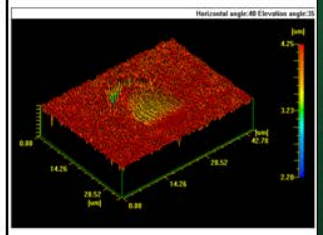


50 um

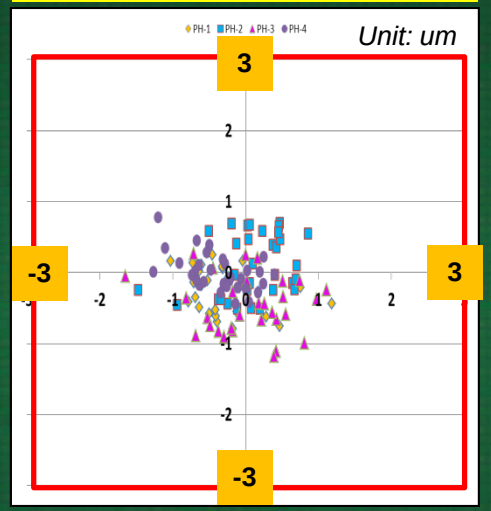
MLC Substrate

Introduction

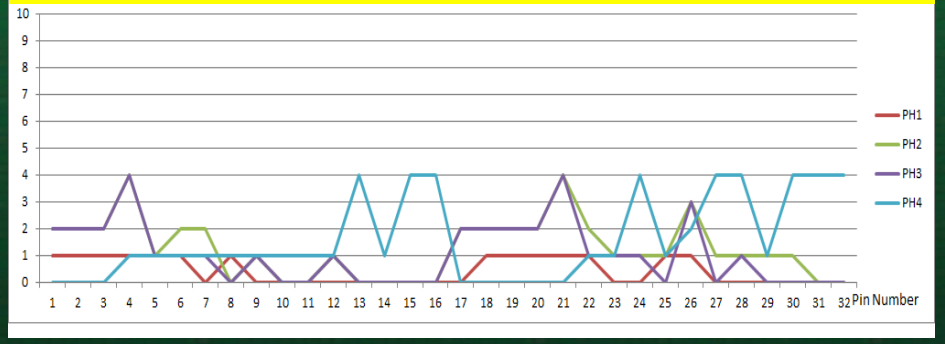
Less Probe Mark Damage, More Accurate Tip Alignment & Tighter Planarity Capabilities

OD 2mil		OD 3mil	
Pin 1	Pin 2	Pin 1	Pin 2
			
Depth			
0.537 um	0.510 um	0.974 um	0.836 um
			

Alignment: < +/- 3 um

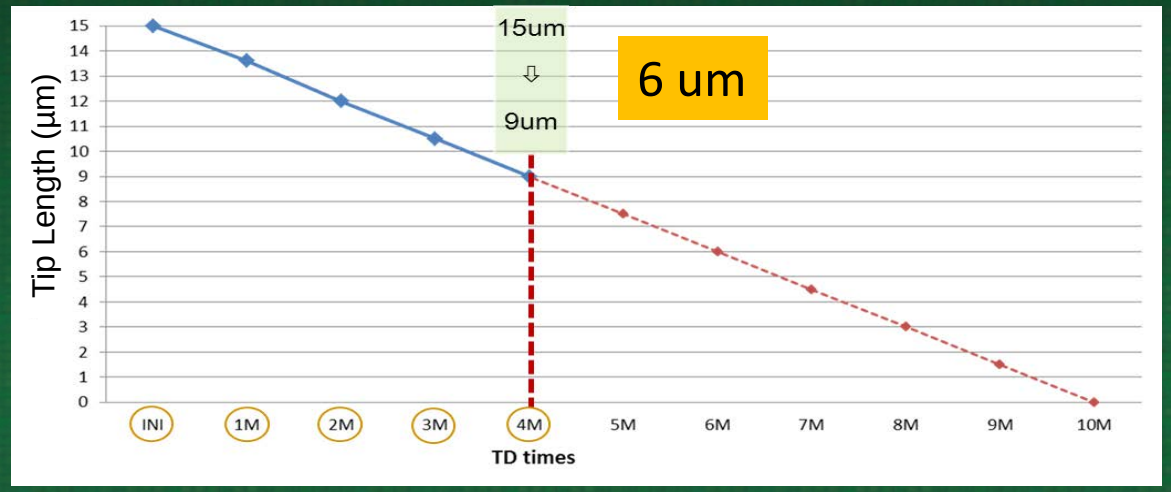


um **Planarity: < 5 um** *Unit: um*



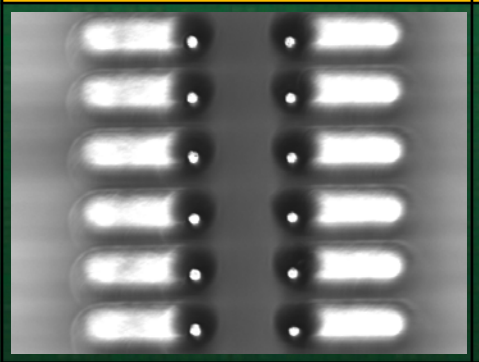
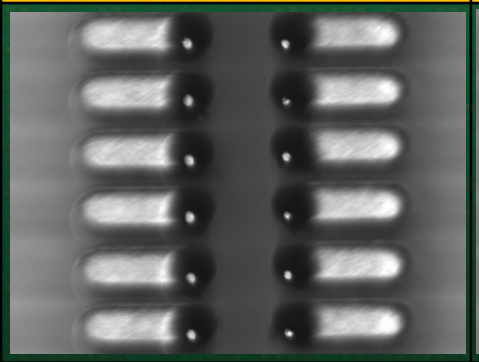
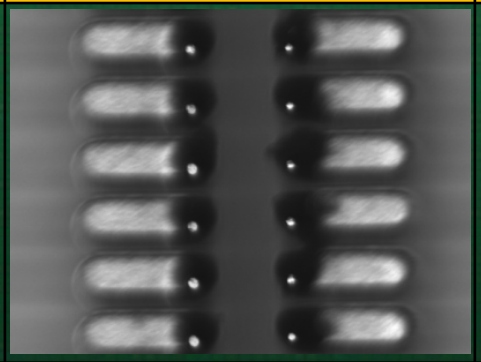
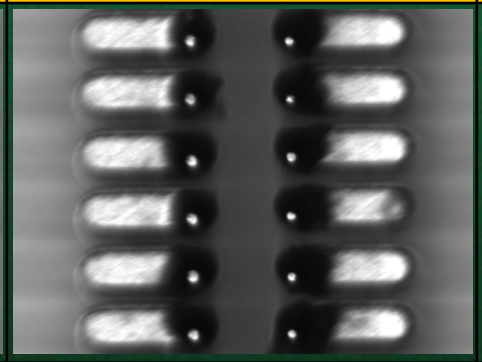
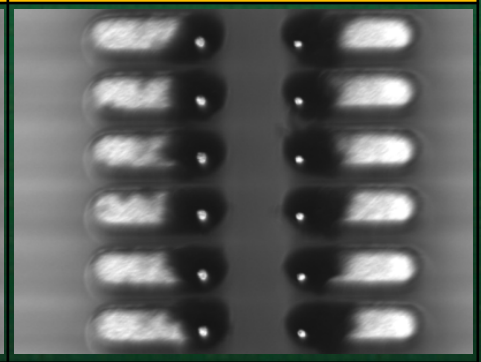
Introduction

Significantly Reduced Tip Wear: Only 6µm tip wear at 4 million T/D on Al wafer



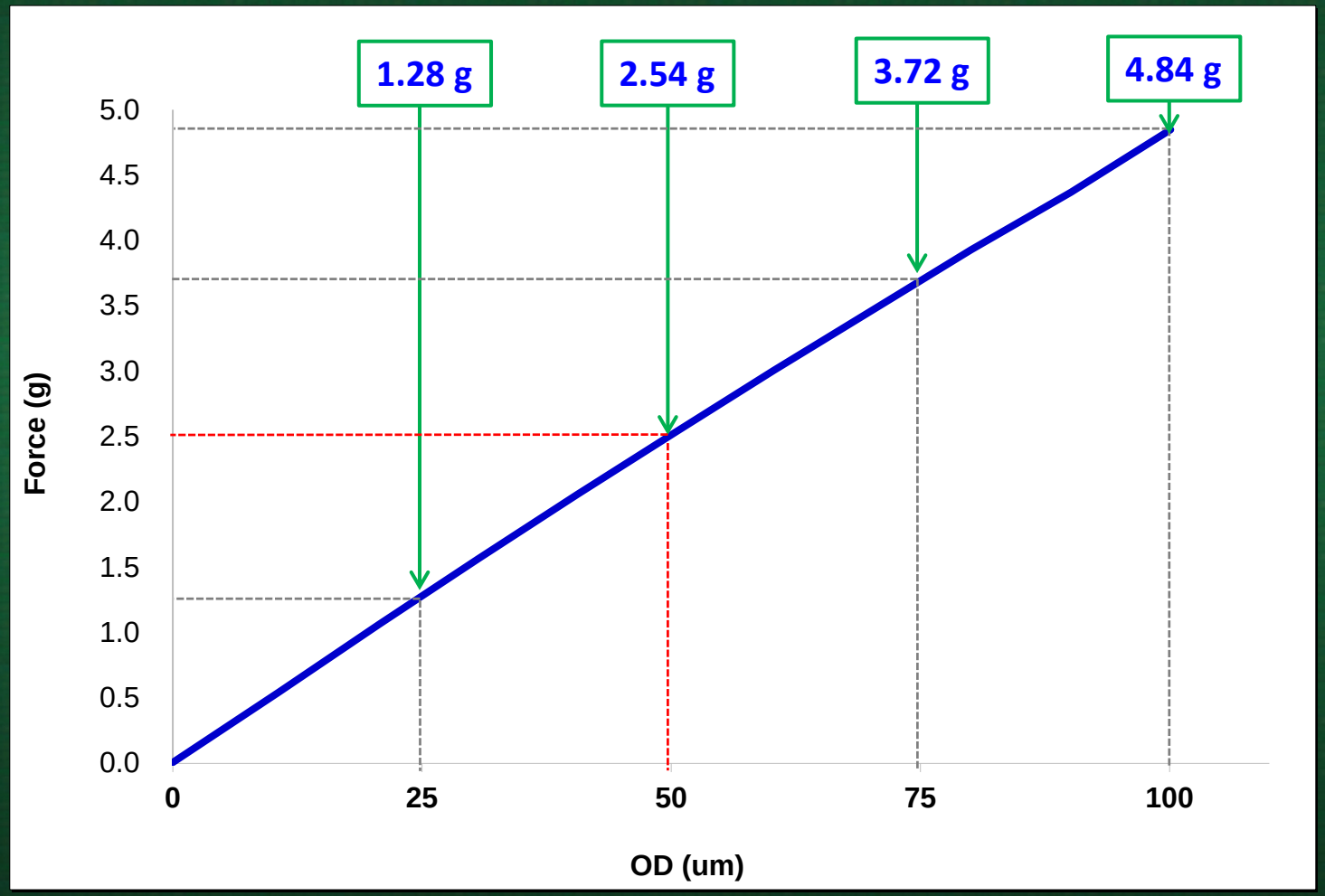
On MPI Al wafer

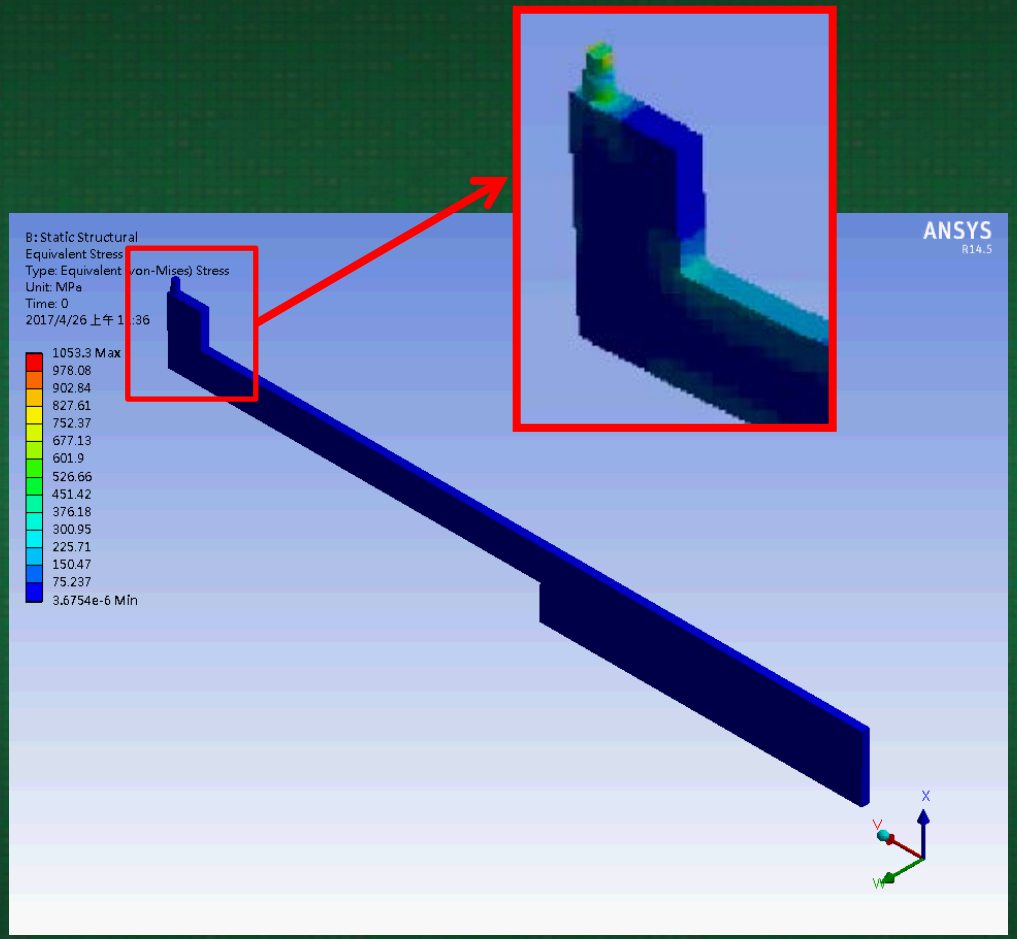
- Clean Material: ITS cleaning sheet
- Setting
  - Overdrive: 50µm (from first contact)
  - Z Up/Down Count: 20
  - Same Position Contact Count: 1
  - Polish Pattern: Up-Down
  - Intervals: 600 TDs

Initial	1M	2M	3M	4M
				

Introduction

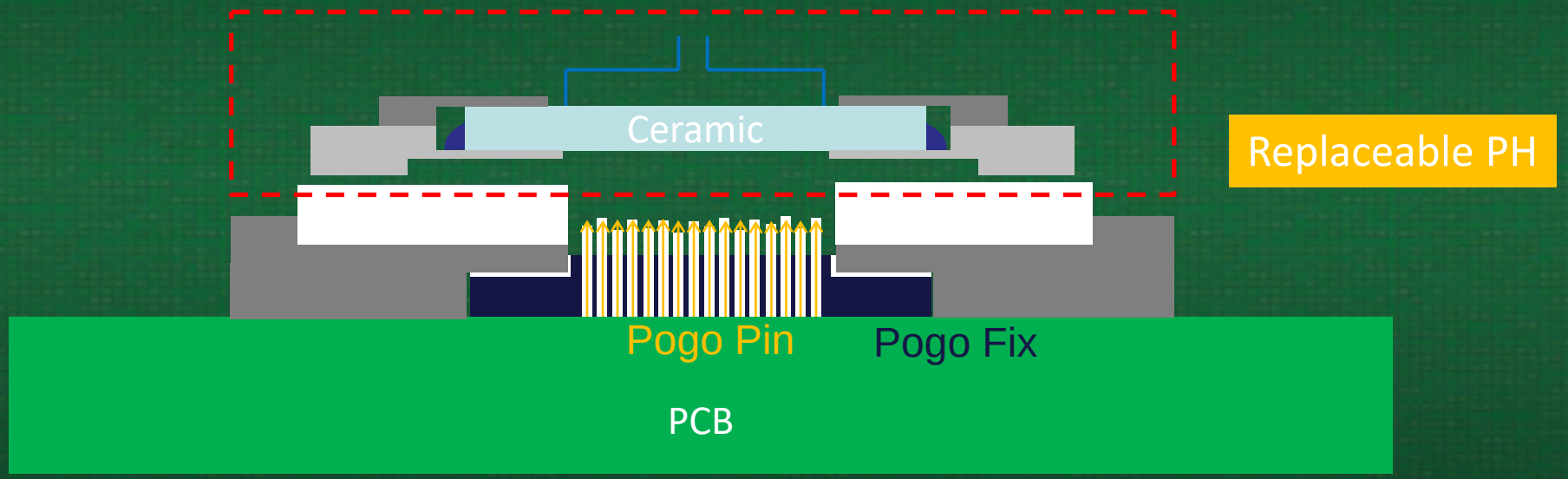
Force 2.54 g @ 50µm OD





Introduction – Replaceable PH

Damaged Probe Tips? Simply replace PH for faster repair



Introduction – Gt-X

Comparing Cantilever probe card vs. MEMS probe card (Gt-X) as shown in table below
The advantage of MEMS technology includes both Mechanical and Electrical performance enhancements

Item	Cantilever	MEMS
Fine pitch	o	o
Mechanical performance	Δ	o
Electrical performance	Δ	o
Maintenance	Replace Needle	Replace PH

o: Higher Comparable Performance
Δ: Lower Comparable Performance

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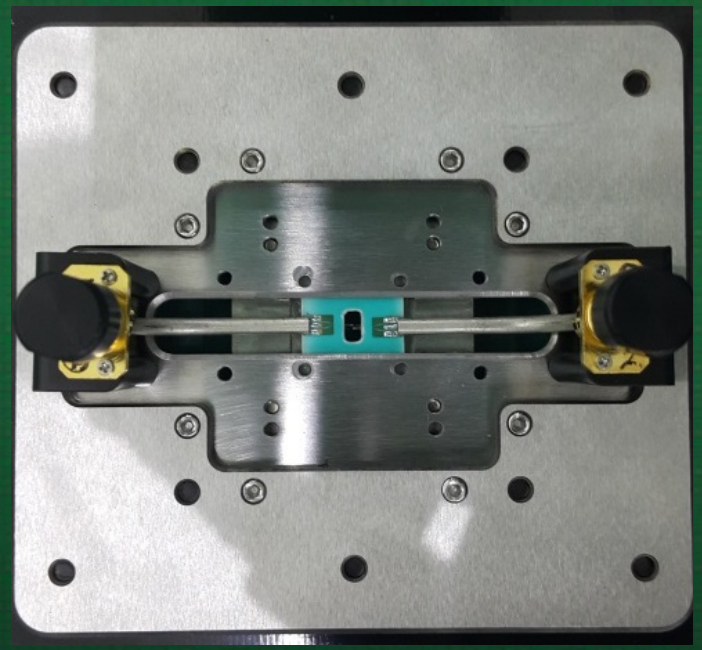
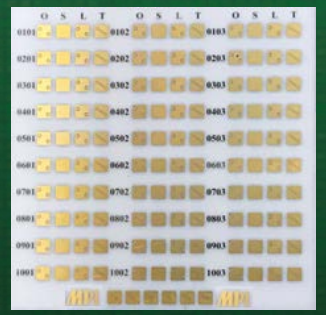
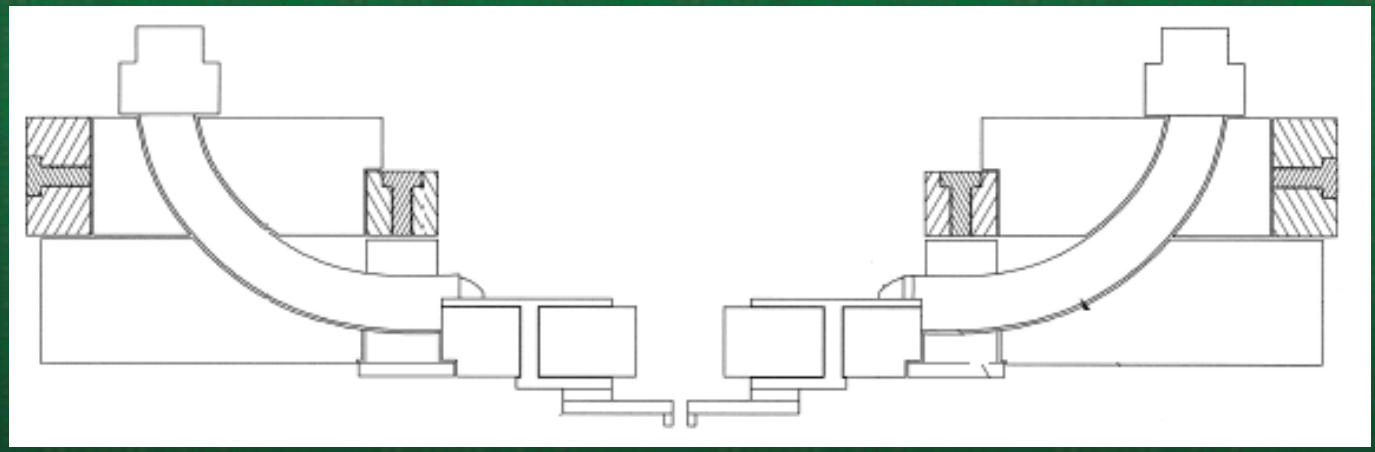
Application

De-imbedding for a more accurate understanding of the DUT performance. Transmission path issues enter errors into the measurement data. In order to resolve the issue, we provide a calibration substrate and methodology to understand the errors and remove them from the measurement results



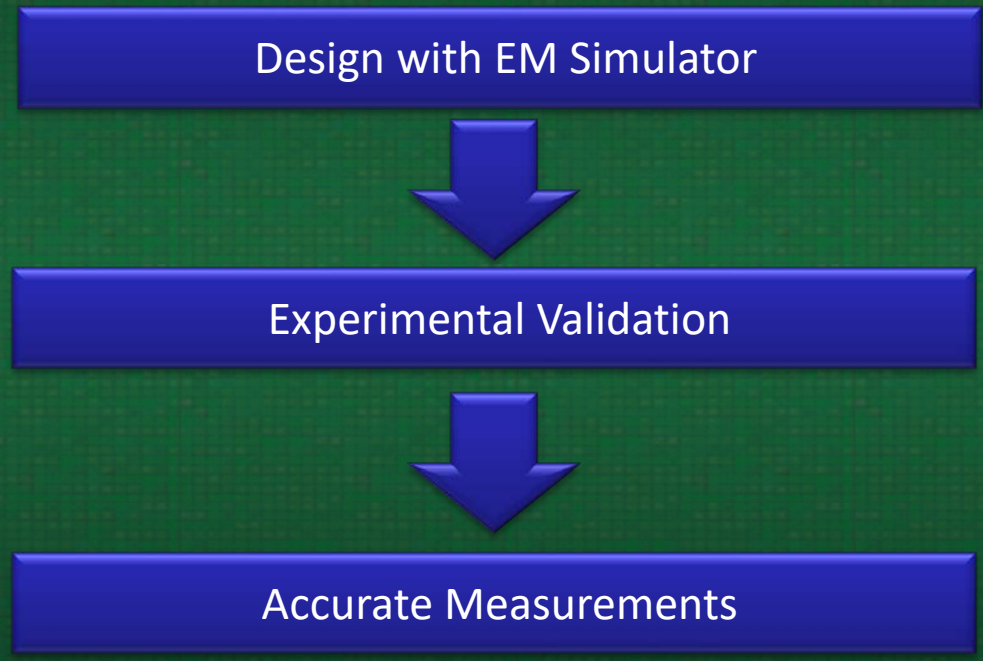




Application

Before discussing the details, let us review the design process

- Previous methodologies used simple trial and error in the development process
- This increased costs and was very time consuming



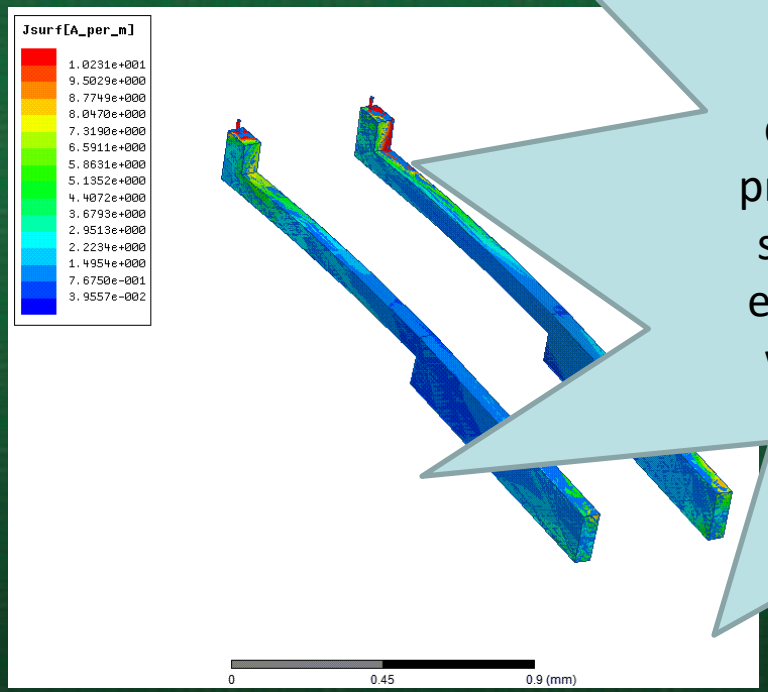
To improve the design process

We used a 3D-EM simulator at the beginning of development
and a two-tier calibration process for validation

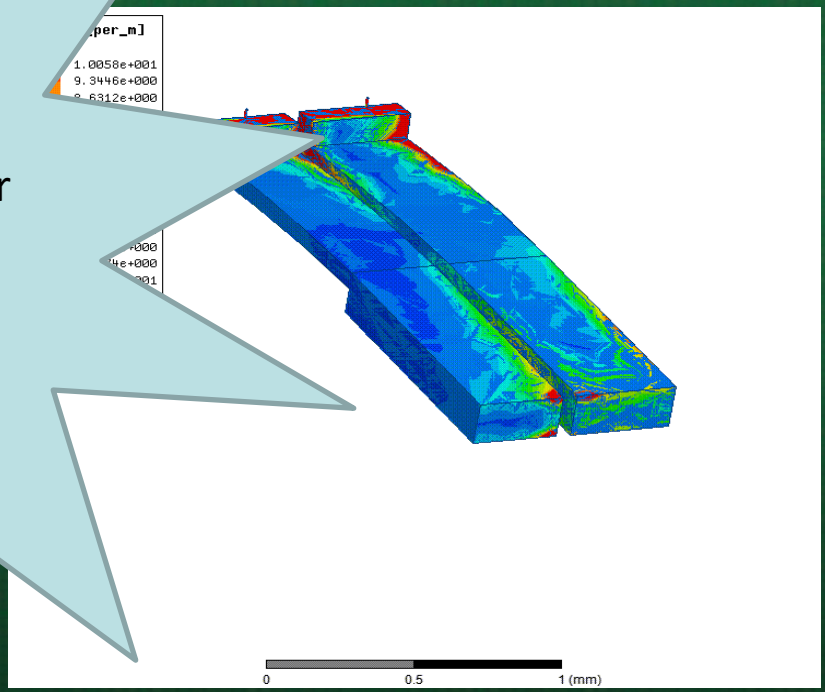
Application

Ground-Signal (GS) and Signal-Ground (SG) contacts are usually used in RF measurement. Matching impedance to 50 ohm is accomplished by adjusting the g[illegible]s. However, it is not good enough to effectively reduce crosstalk.

Original type:
Without Impedance Matching



Enhanced 1:
Im[illegible]nce Match Design via adjustment to gap



Note: Impedance match via gap design is critical. Widening of the probe shaft is simply an exercise for supporting the gap of this specific experiment's pitch. This, of course, would have a significant negative impact on probe mark control.

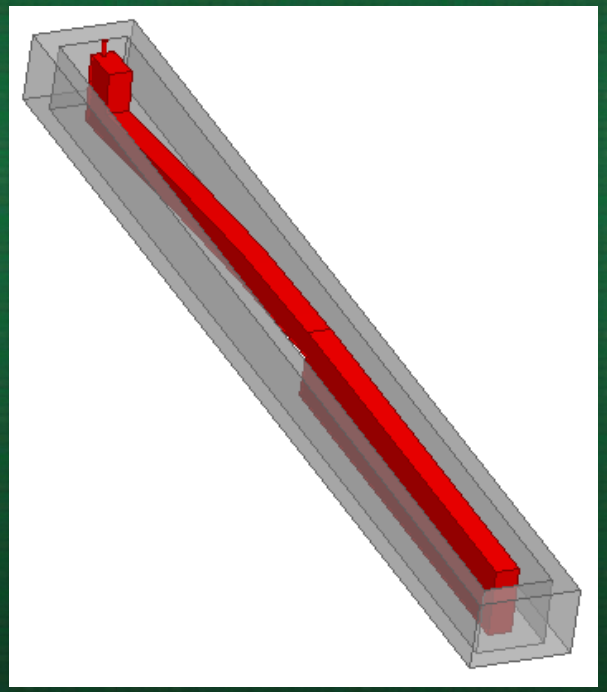
$$k_1' = \sqrt{\bar{p}}$$

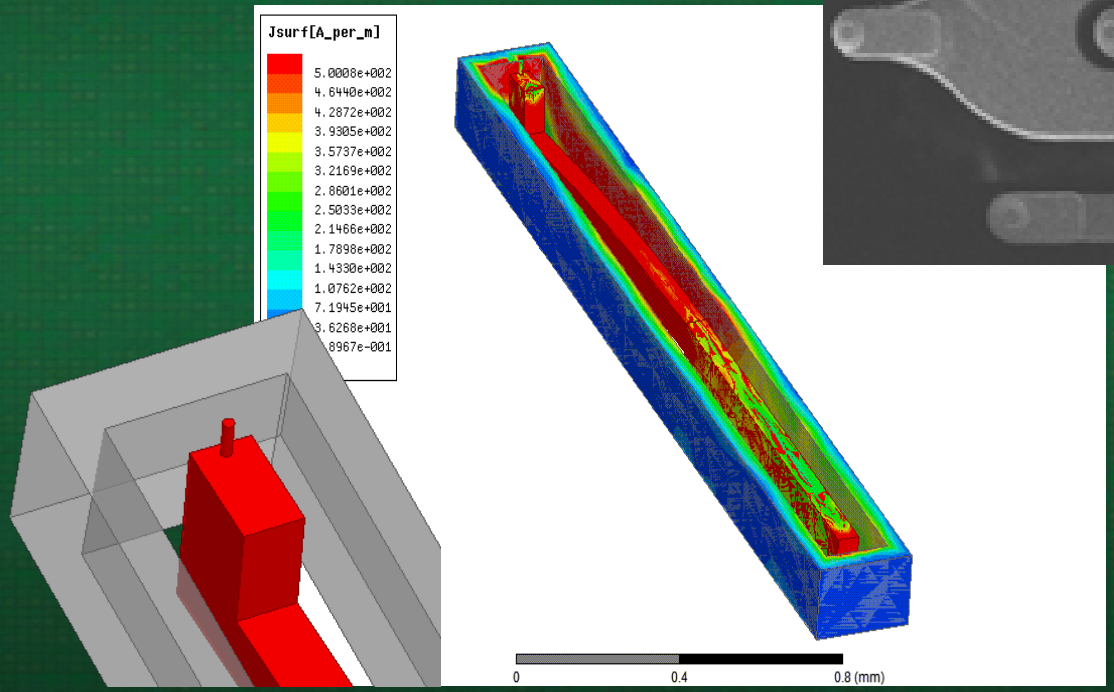
Application

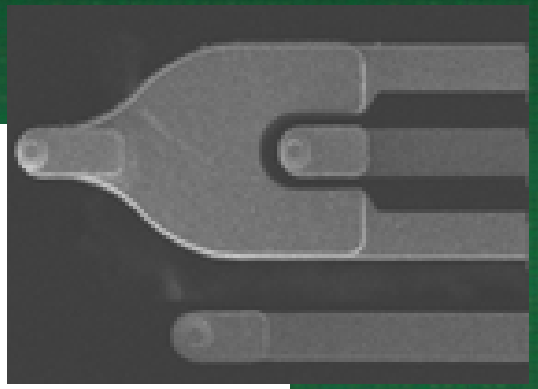
Advantages are realized when using ground-loop designs

- Reduction in crosstalk with simultaneous impedance matching
- Easy to manufacture

Enhance 2:
Use of Ground-Loop around signal line

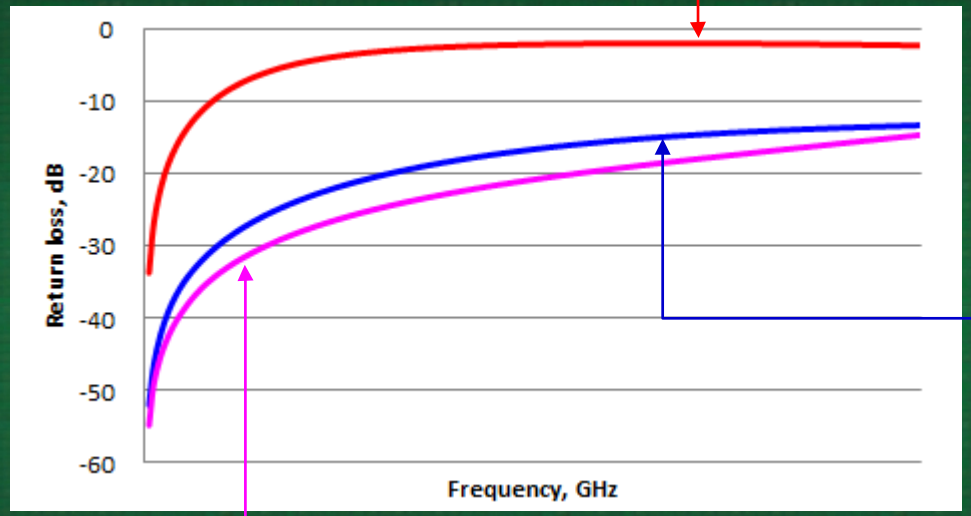


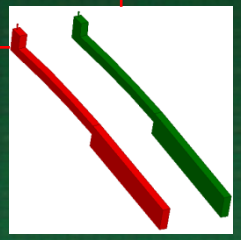




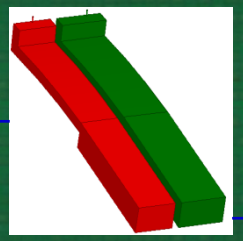
Application

Return Loss

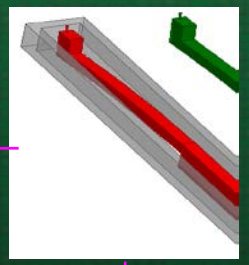




Original Model
No Impedance Matching



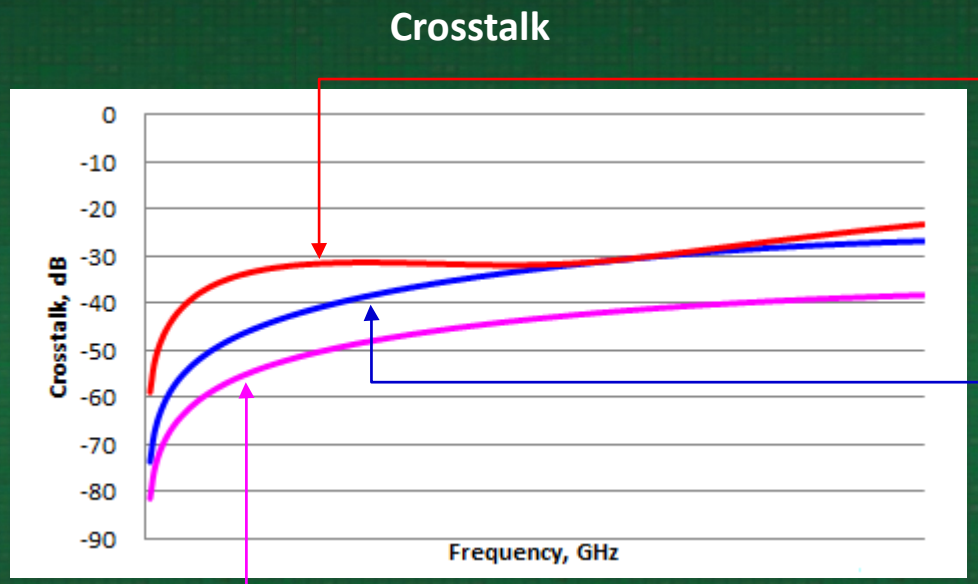
Enhance-1
Impedance Matching using gap and width

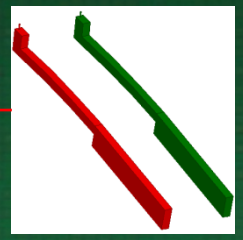


Enhance-2
Impedance Matching with Ground-Loop design

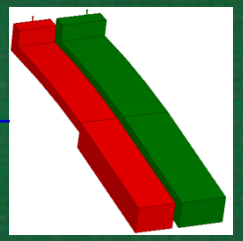
Insertion Loss

Application

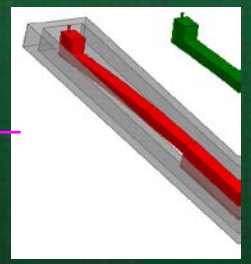




Original Model
No Impedance Matching



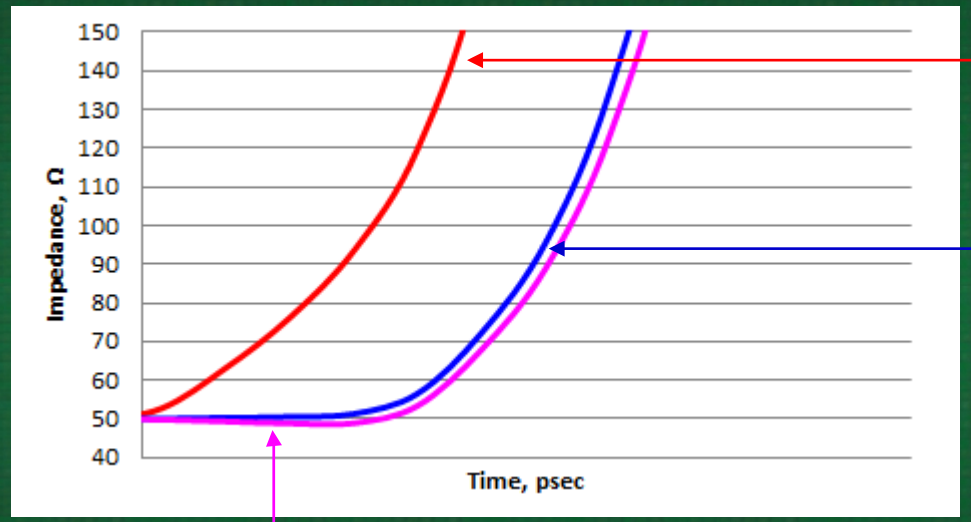
Enhanced 1
Designed gap to get good matching. It is effective to reduce crosstalk caused by electromagnetic radiation

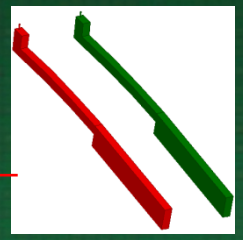


Enhanced 2
Best crosstalk suppression in all of three models. This design is able to reduce Magnetic and Electrical Fields between signal and ground

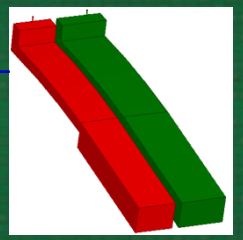
Application

Impedance in time domain

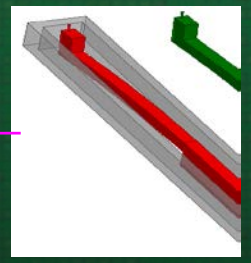




Original Model
High Impedance without matching



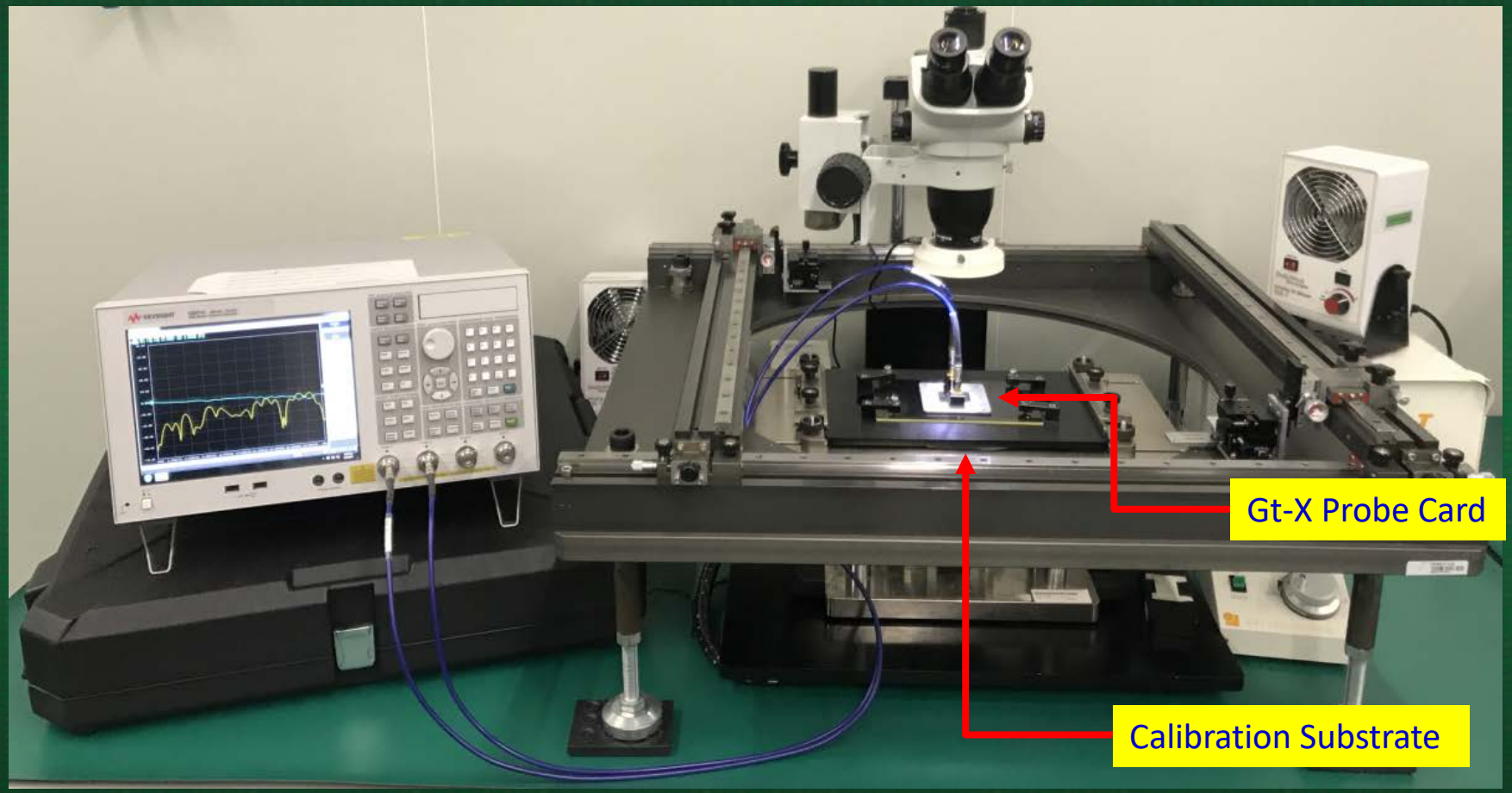
Enhanced 1
Designed for 50 ohm



Enhanced 2
Optimum Impedance Matching via Ground-Loop design

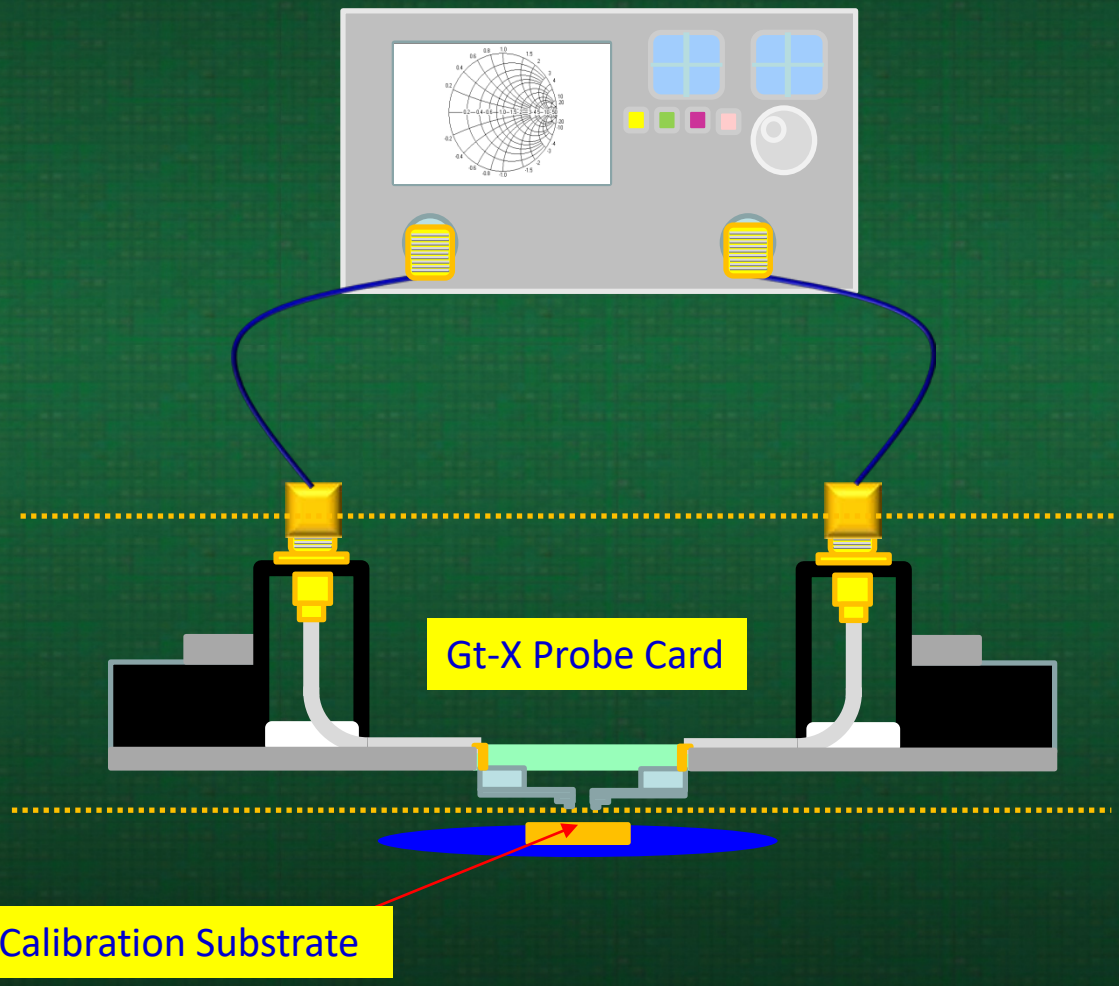
Application

The Measurement Setup



Application

Using a two-tier calibration for corrections of coefficients
on calibration substrate and probe card parameters

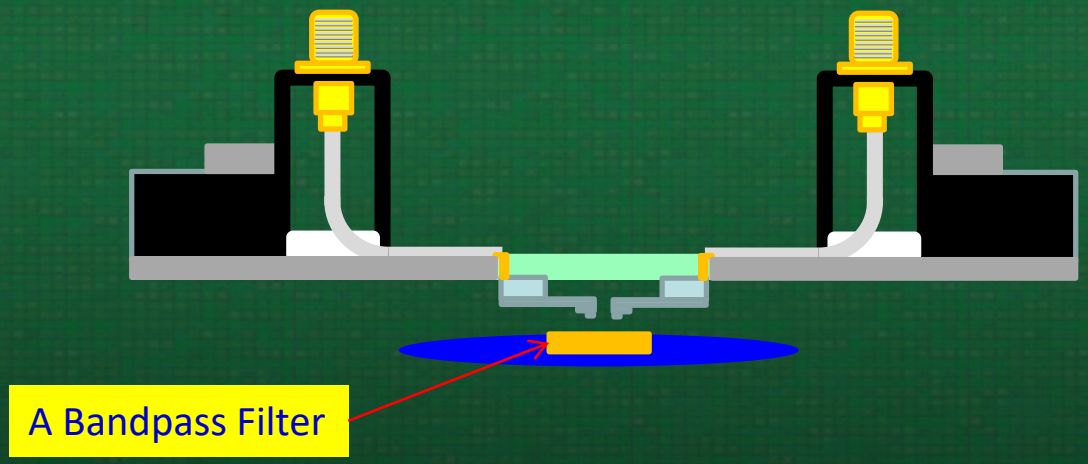


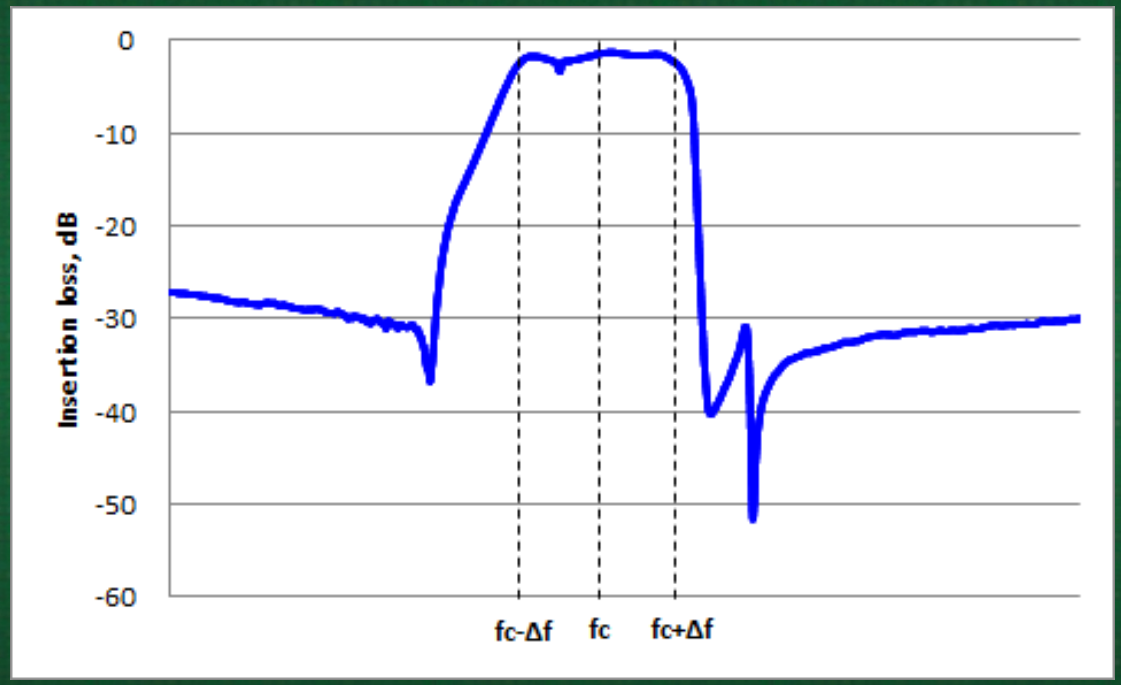
1st tier calibration to move reference plane to cable end

2nd tier calibration to move reference plane to probe tips. Then, extract both correction coefficient of standards on cal substrate and parameter of probe card

Application

Measurement performance of a Bandpass Filter



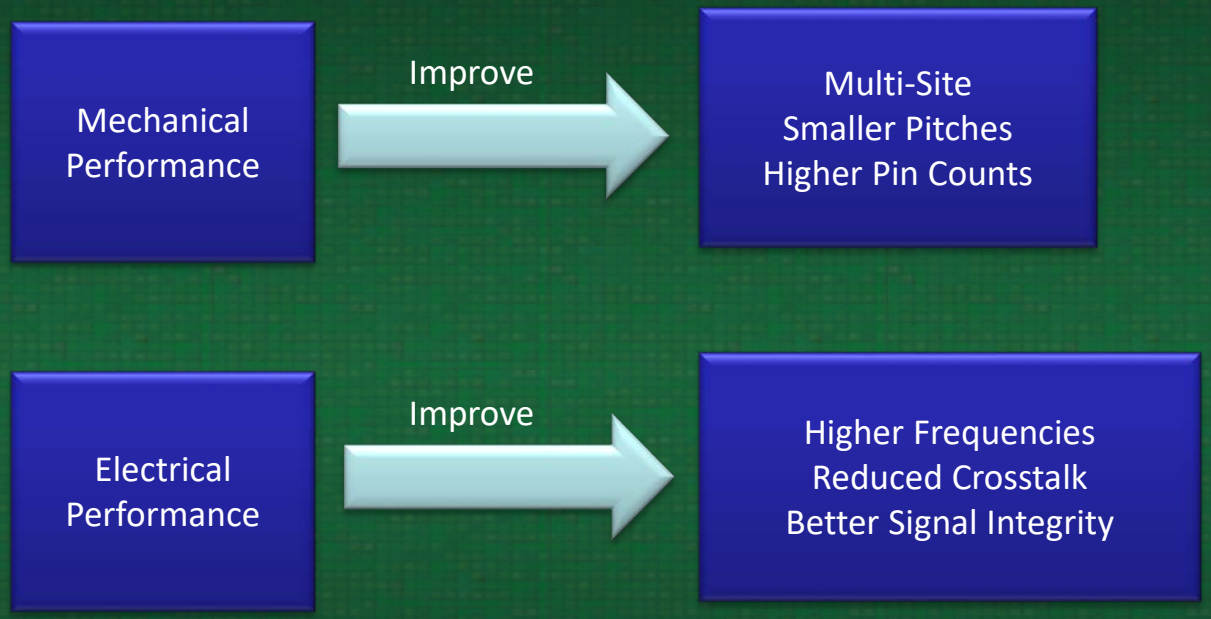


Overview

- Objectives
- Introduction
- Application
- Summary

Summary

- MEMS process was successfully implemented on RF probe card and with good performance
  - ✓ Fine pitch (below 50 µm)
  - ✓ Better Probe Mark Uniformity
  - ✓ Planarity
  - ✓ Alignment
  - ✓ Long Life Time Performance



- Future work:
  - ✓ Develop multi-site, smaller pitch and higher pin counts (Mechanical Performance)
  - ✓ Improve application for higher frequencies, reduced crosstalk, and better signal integrity (Electrical Performance)

Summary

- As mentioned above, the Super Eye is used on specific customers/applications for production in Asia. After that, this RF MEMS probe card will be advanced into development and ultimately production release in the coming years.

Stage\Year	2015	2016	2017	2018	2019 …
Research	Super Eye		RF MEMS		
Development		Super Eye		RF MEMS	
Released			Super Eye	Super Eye	RF MEMS Super Eye

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