SWTW 2018

SW Test Workshop

Semiconductor Wafer Test Workshop

TPEG™ MEMS RF+ Technology for Vertical Probe Heads

TECHNOPROBE Wafer Probing Technologies

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Outline

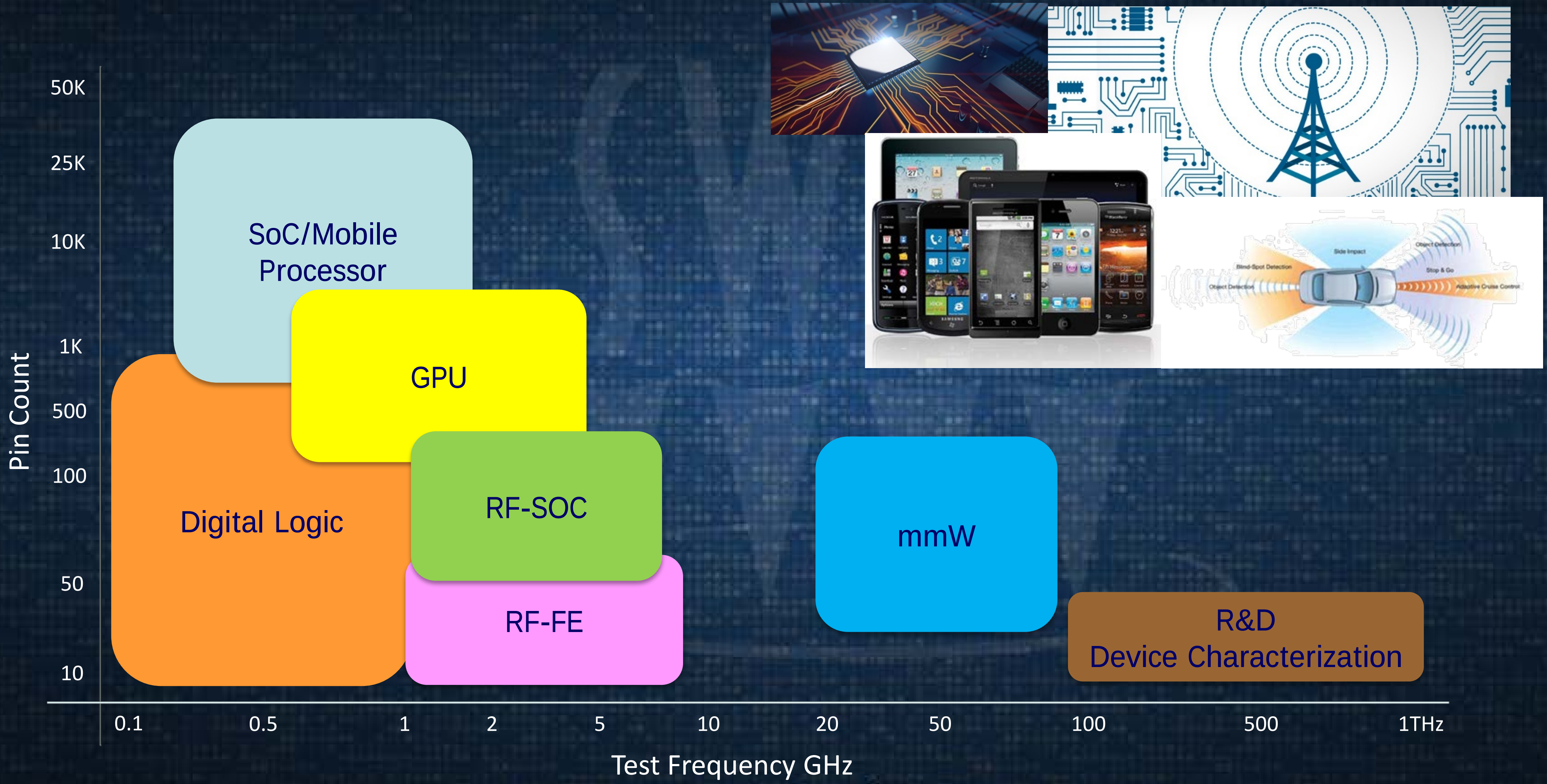
- Introduction
- Technoprobe TPEG™ RF+ architecture
- Production test vehicle
- Modeling data
- Internal experimental validation data
- Conclusions
- Future work

Introduction

- **Standard vertical probe heads do not have satisfactory RF properties.**
  - On the other hand, they offer a series of advantages over other typical RF technologies based on flexible membranes.

- **Technoprobe developed a new PH architecture that provides excellent RF properties based on TPEG™ MEMS vertical PH technology.**
  - This technology improves the return loss (RL), the insertion loss (IL), as well as the other RF related specs…..up to 10 GHz
  - The enhanced RF performances are obtained thanks to additional GND paths inside the PH connected both to the GND of the device and to the space transformer, to control signal impedance

PC Market Segments : High Speed and RF



Probes: High Speed Challenges

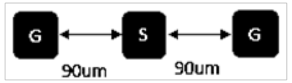
- **Challenges:**
  - Probe cards struggle between having a long needle to optimize the mechanical performance and a short needle to optimize the frequency performances
  - Shorter needles will generate higher forces than ideal
- **Technoprobe Solution: Vertical MEMS Probe Head**
  - Multi-arm needle body allows shorter needles and maintains standard forces

	Standard		Multi-Arm Body(*): Short		Multi-Arm Body(*): eXtra Short		Multi-Arm Body(*): Ultra Short
	T1 XLT	T1	S90 XLT	S90	XS90 XLT	XS90	F90(4*)
CCC [mA]	820	820	1100	1100	1000	1000	1000
Resistance [mΩ]	142	133	59	54	51	46	31
Half Loop Inductance GSG(***) [nH]	1.26	1.18	0.64	0.59	0.39	0.35	0.23

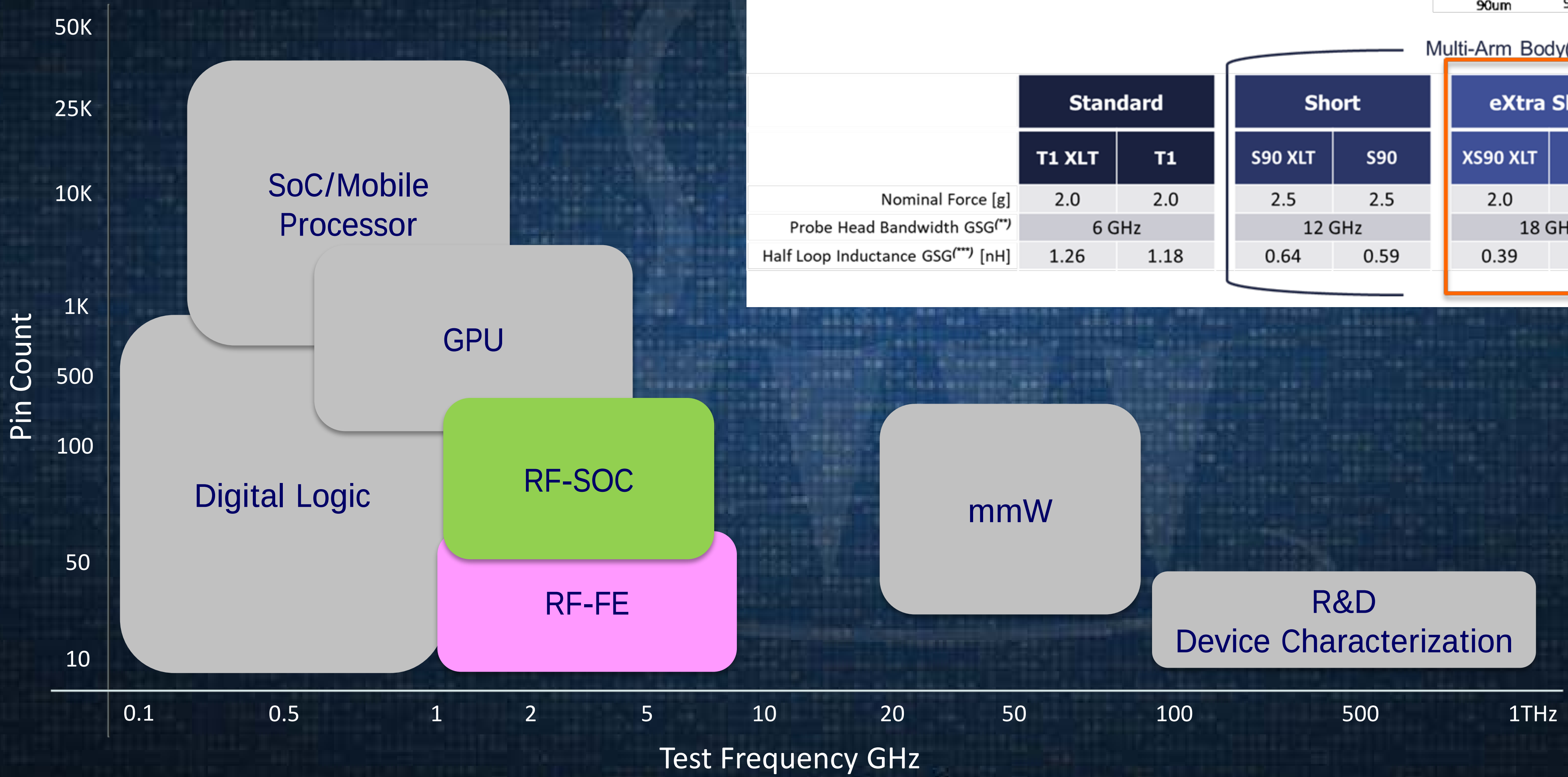
(*) *Technoprobe has licensing rights to use Multi-Arms Patent*

(4*) ***in development***

RF-SOC and RF Front End: Available TP Technology



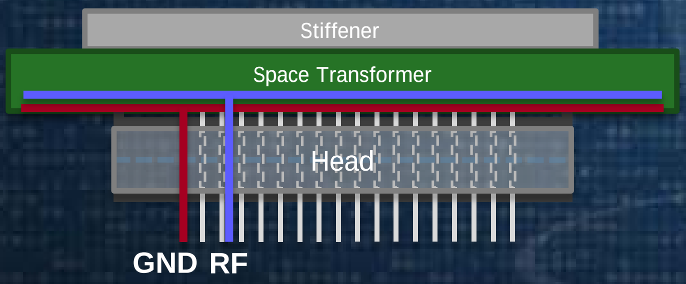
	Standard		Multi-Arm Body(*) Short		Multi-Arm Body(*) eXtra Short		Multi-Arm Body(*) Ultra Short
	T1 XLT	T1	S90 XLT	S90	XS90 XLT	XS90	F90(4*)
Nominal Force [g]	2.0	2.0	2.5	2.5	2.0	2.0	2.0
Probe Head Bandwidth GSG(**)	6 GHz		12 GHz		18 GHz		24 GHz
Half Loop Inductance GSG(***) [nH]	1.26	1.18	0.64	0.59	0.39	0.35	0.23



TPEG™ RF architecture – Patent Pending

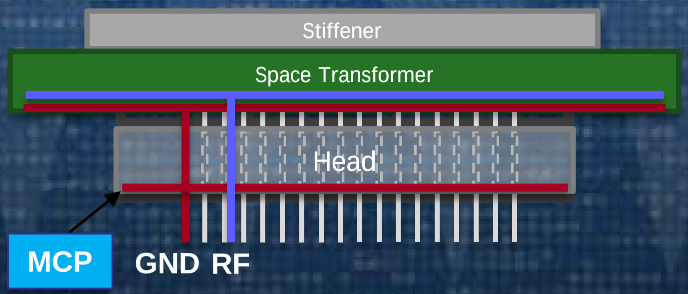
- **Challenge:**
  - RF device layouts are not optimized for RF probing and often short needles are not enough to match RF performance required by customer's application
- **Technoprobe Solution (RF and RF+):**

Standard Architecture



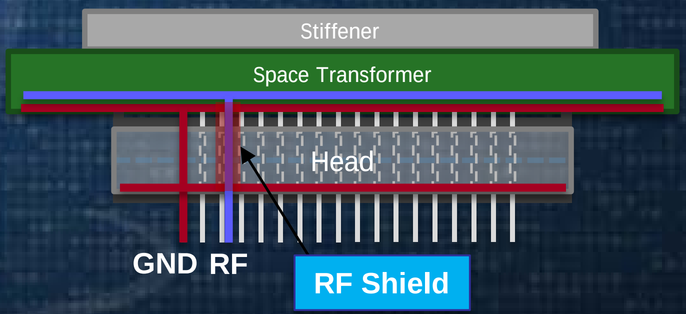
- GND and RF Signals are not matched for all the length of the needles creating not optimized IL, RL and LI (Loop Inductance)

RF Architecture
(Patent pending)



- GND plane is added closer to the DUT thru TP proprietary MCP technology (Multi-Conductive-Plates) optimizing GND noise and LI

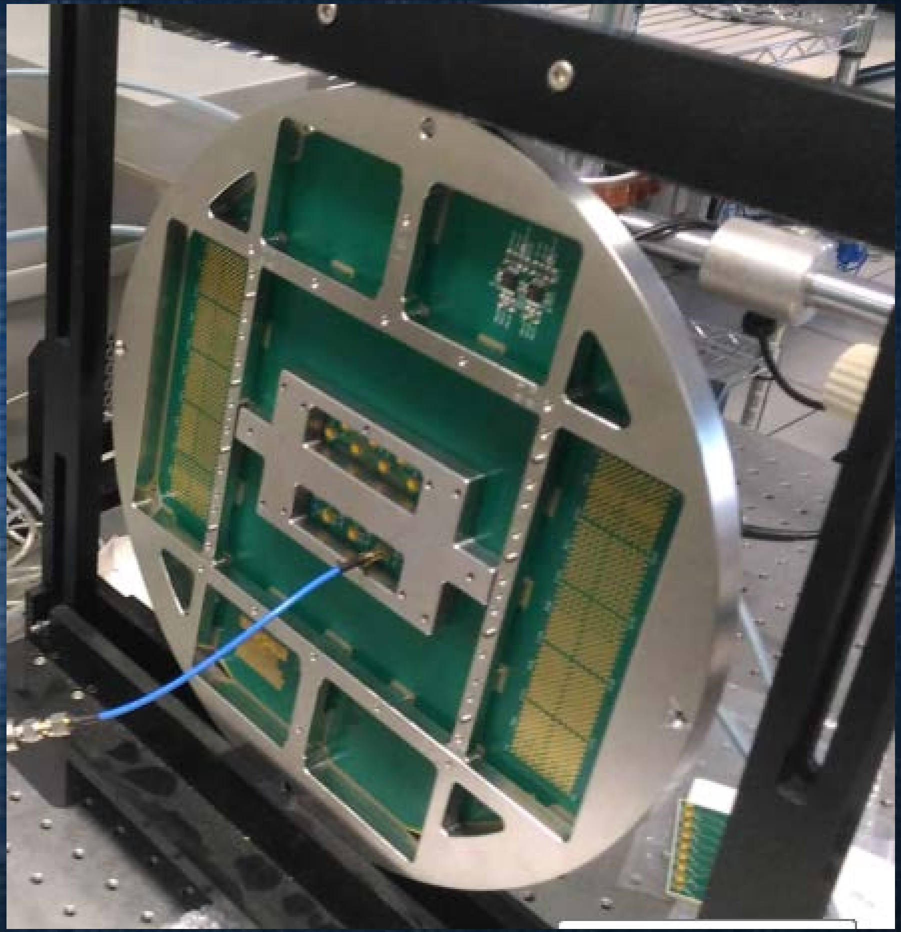
RF+ Architecture
(Patent pending)



- Shield is created around RF signals inside the head using TP proprietary SRF technology (Shield-RF) optimizing IL, RL, LI and GND noise

Production test vehicle

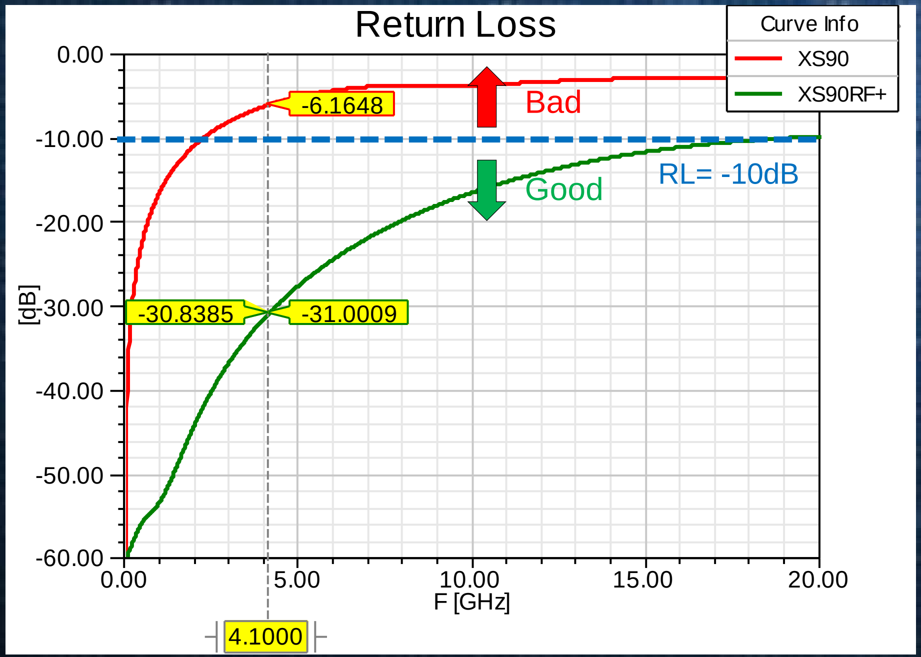
- **Device**
  - SAW filter
  - Pitch is 370 µm and uses minimal grounding
  - 4 pins / DUT: IN, OUT and 2x GND
- **Probe card**
  - Probing x8 diagonal pattern
- **Tester platform**
  - UltraFLEX 300mm with RF interface (LEGO block)
- **RF requirement**
  - Required filter response mask given by customer

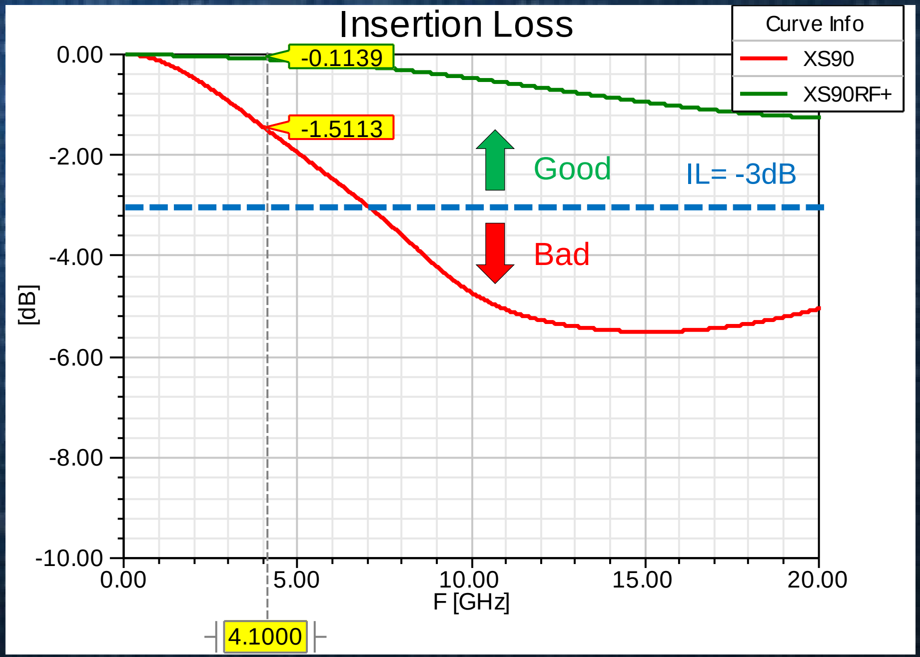


Modeling Data

PH only

- **RF+ architecture based on TPEG™ MEMS XS90 probing technology allows to improve frequency performances**
- **FEM 3D simulation of standalone probe head was performed:**
  - Both return loss and insertion loss show significant improvement
  - Filter response is in spec with respect to customer proprietary filter s-parameter model





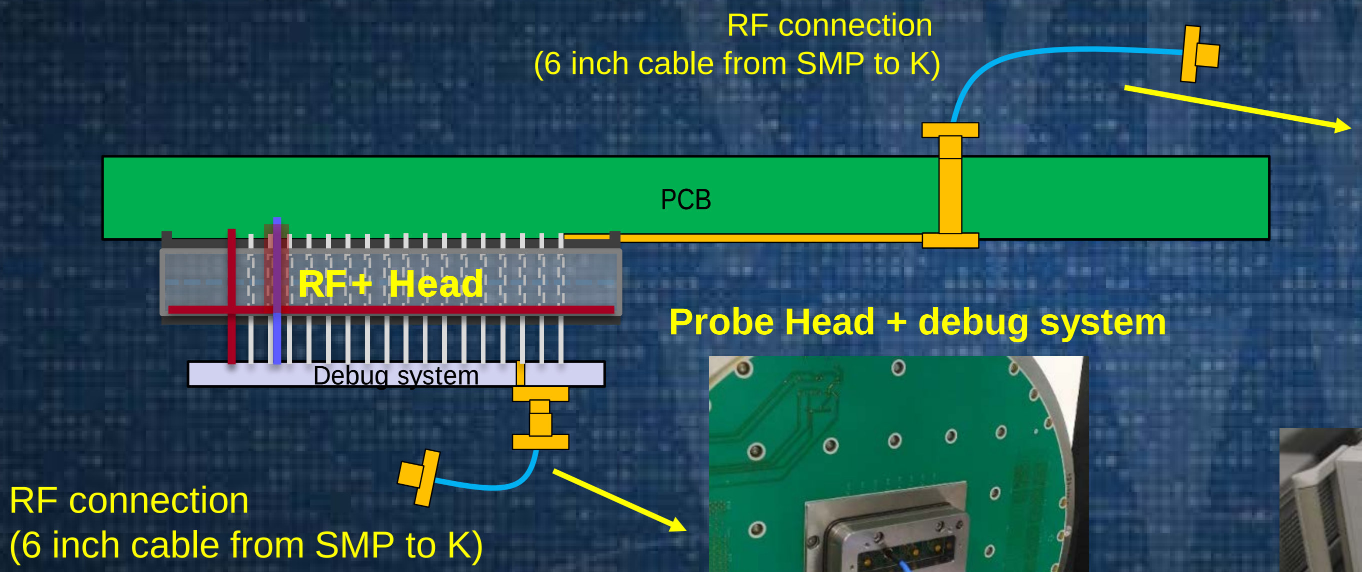
Experimental data

- **Three different experimental setups have been used**
- **RF characterization**
  - RL and IL measured with test fixture and VNA up to 20 GHz
- **DC tests with dedicated wired space transformer**
  - DC continuity test with prober
  - Leakage test on probe card analyser
- **RF tests on prober**
  - Probe card was tested on customer wafer filter (Filter shape under IP no sharable results)

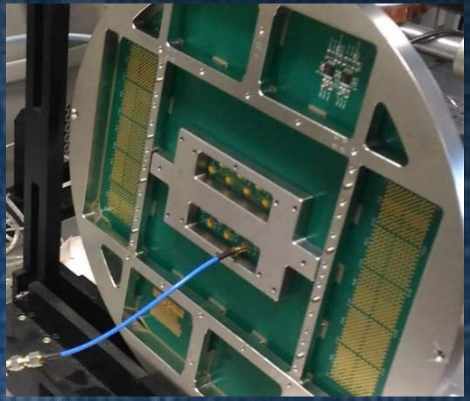
RF Characterization

Experimental setup

- **Measure system fixture for RF+ architecture**

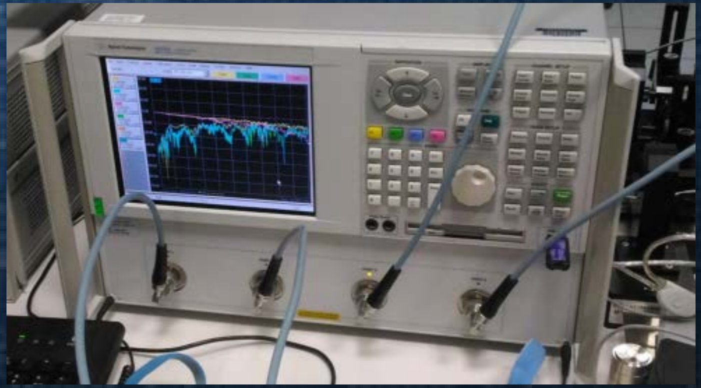


Probe card tester side view



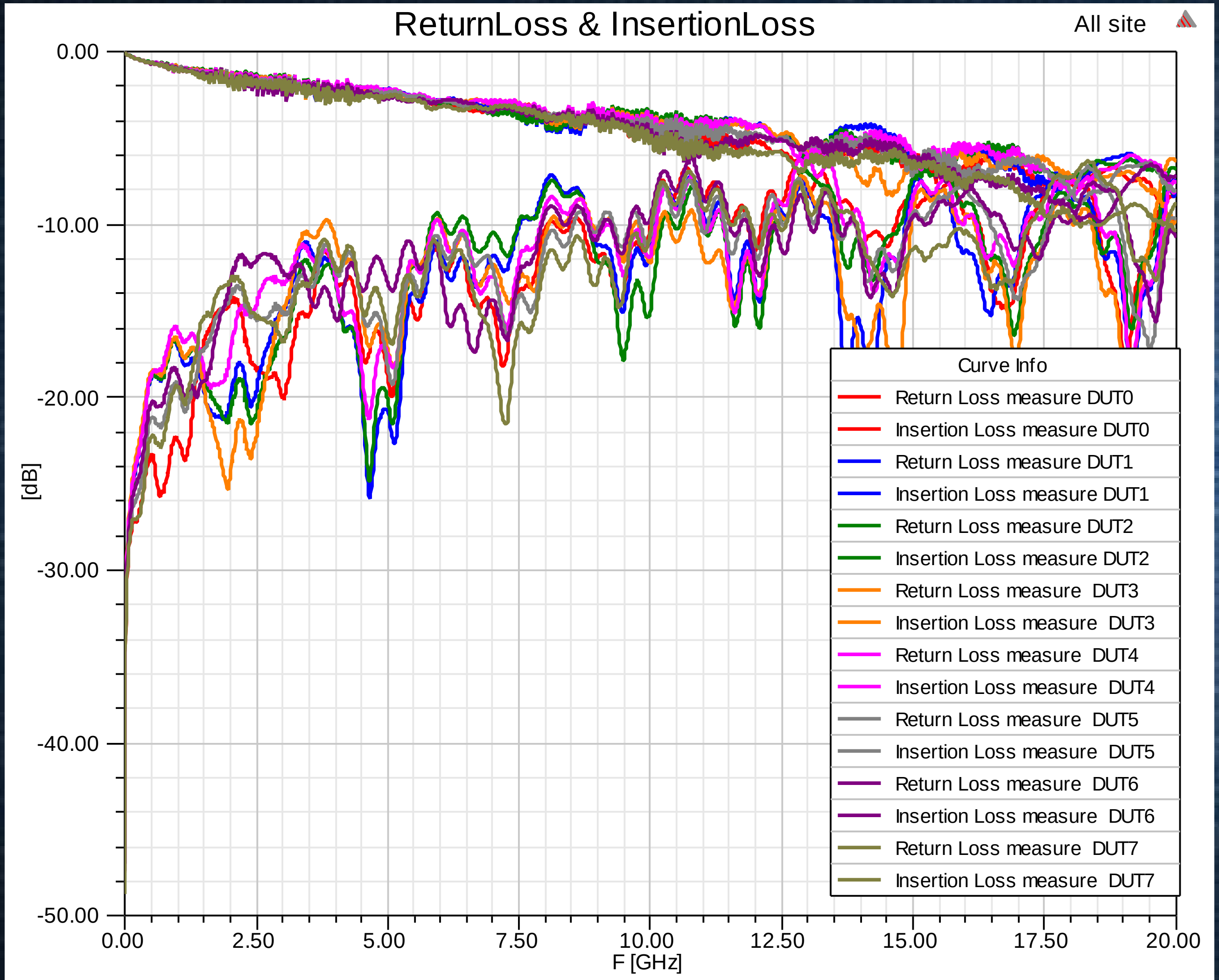
Probe Head + debug system

VNA up to 20 GHz



RF Characterization

Experimental results: RL and IL

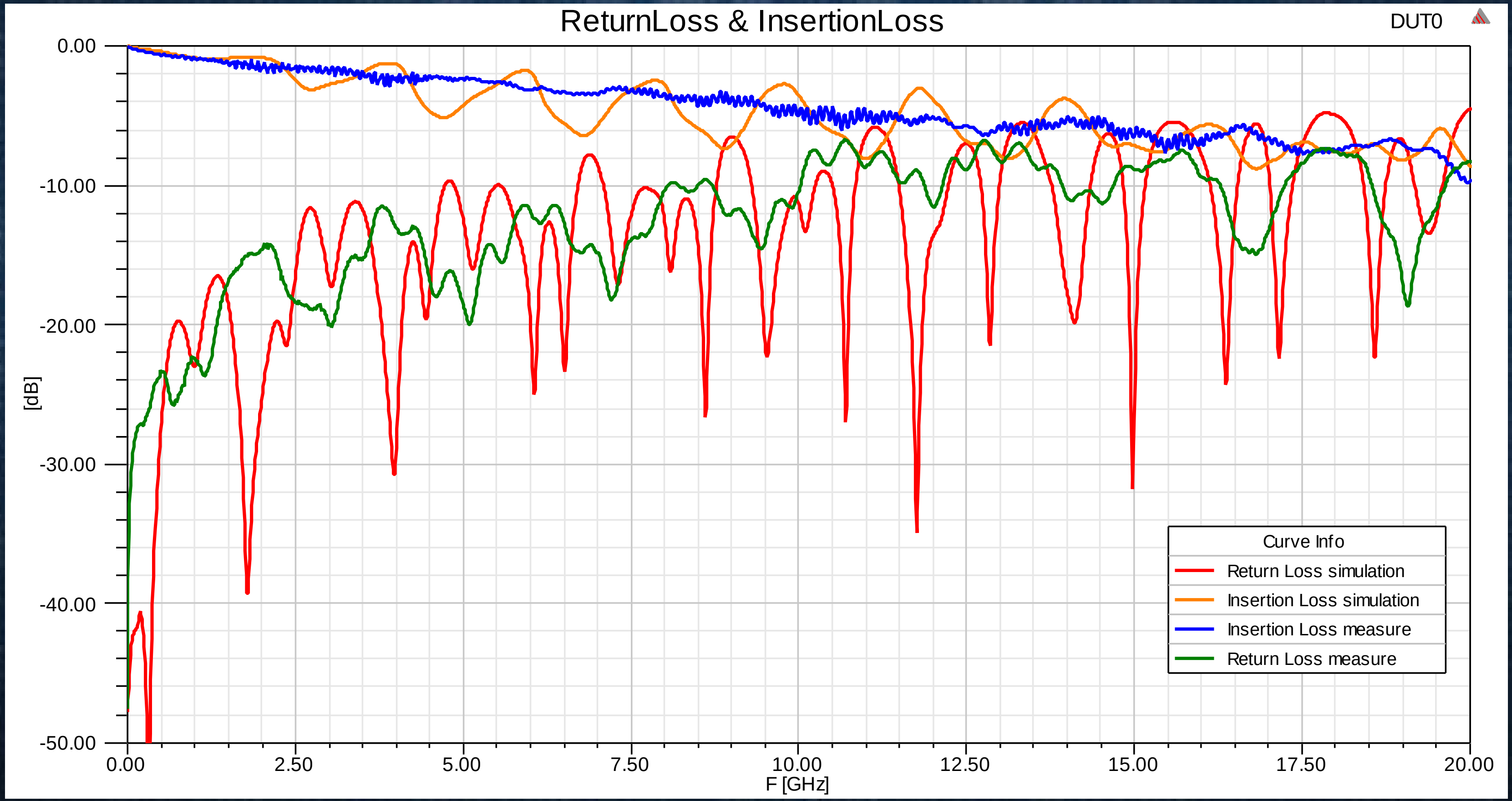


- All 8 sites show similar value of return loss and insertion loss
- Differences are given by PCB design
- Maximum working frequency is 8 GHz because of PCB design: filter device have to work DC to about 5 GHz
- From simulation with higher performance PCB, RF+ architecture is able to work up to 10 GHz (or more)

RF Characterization

Experimental vs. Simulation results

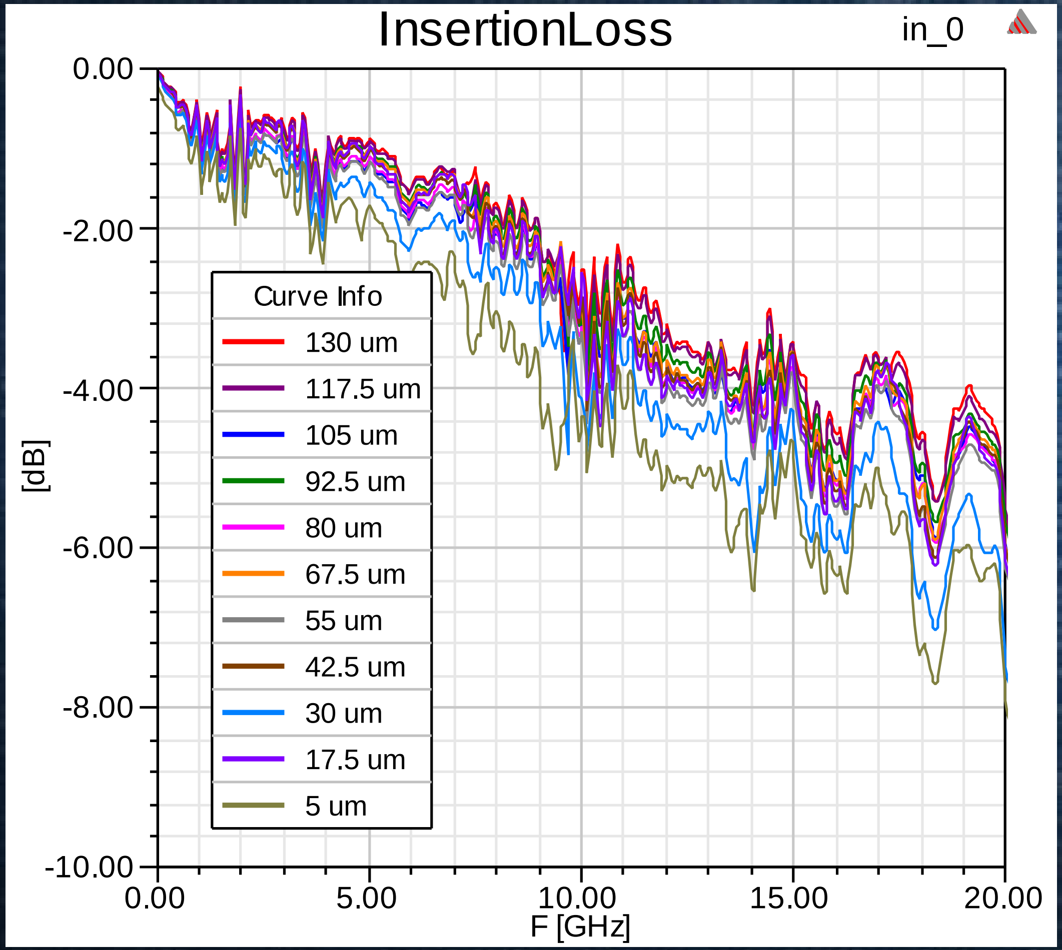
- **Comparison between simulated and measured results allowed to validate the consistency of 3D FEM simulation models**

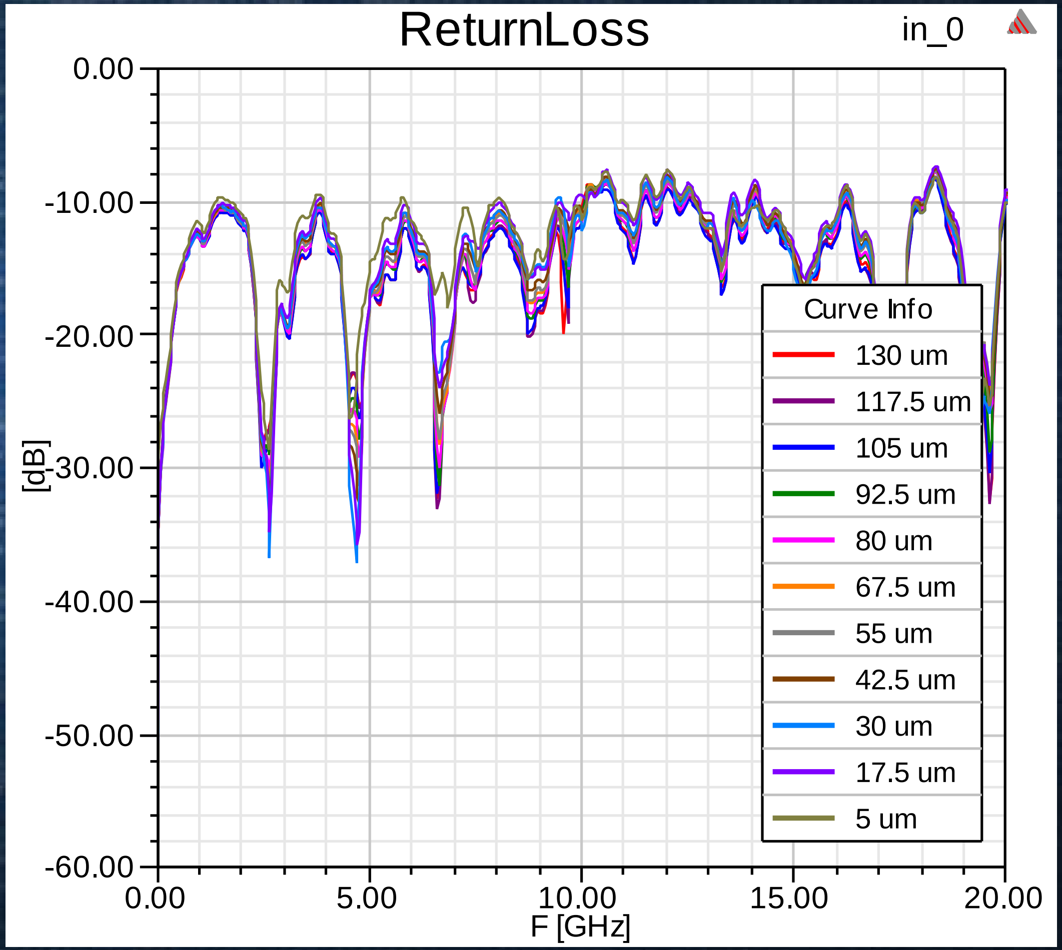


RF characterization

IL and RL varying working overdrive

- **Characterization with different overdrive: technology shows low sensitivity to working OD**





Space Transformer DC Tests

Experimental setup

- Dedicated wired space transformer designed and manufactured
- Probe card loaded on Accretech UF3000EX prober
- Blank wafers used to measure Path Resistance by means of Keithley Kelvin equipment

Space Transformer DC Tests

DC continuity test between GND and shield

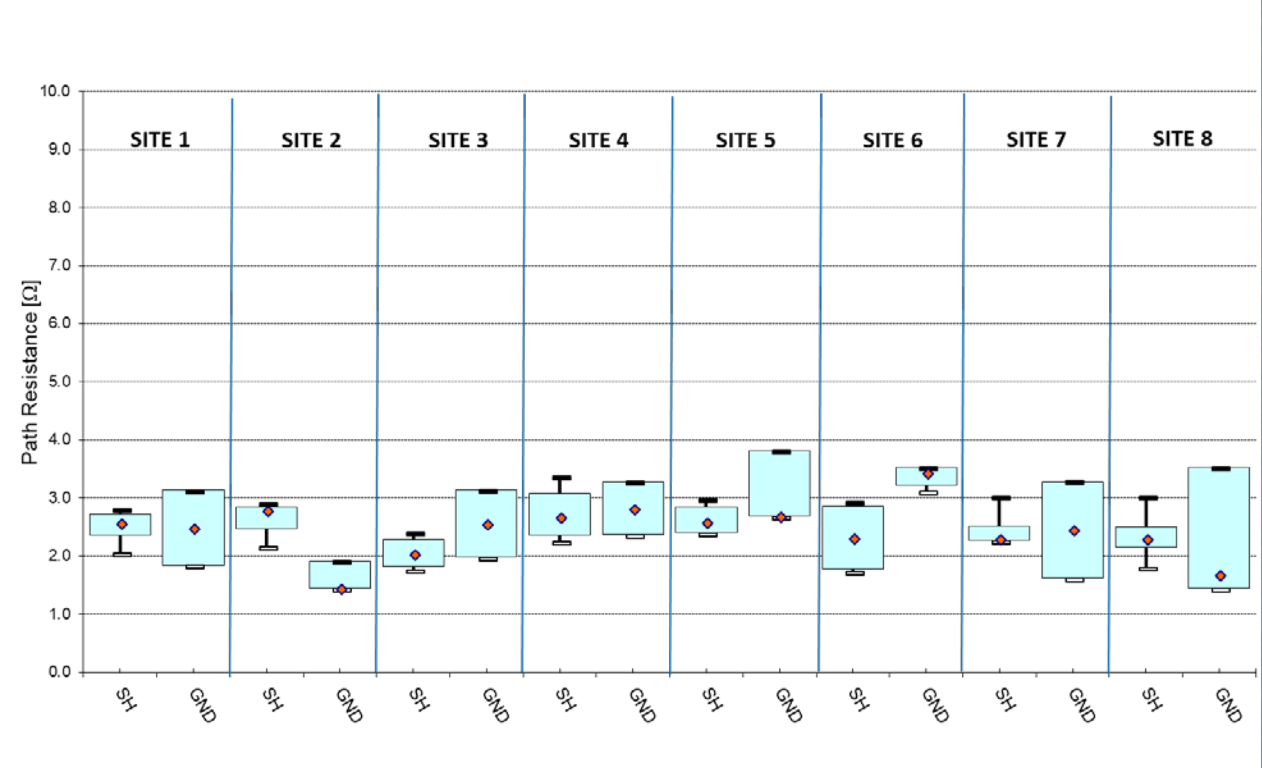
- Path Resistance tests were performed to measure the electrical continuity between GND probes and metallic shield inside the PH while probing on a nonconductive silicon wafer

- Next slides are show Path Resistance test results in function of PH site and of working OD

Space Transformer DC Tests

Path Resistance results in function of PH site

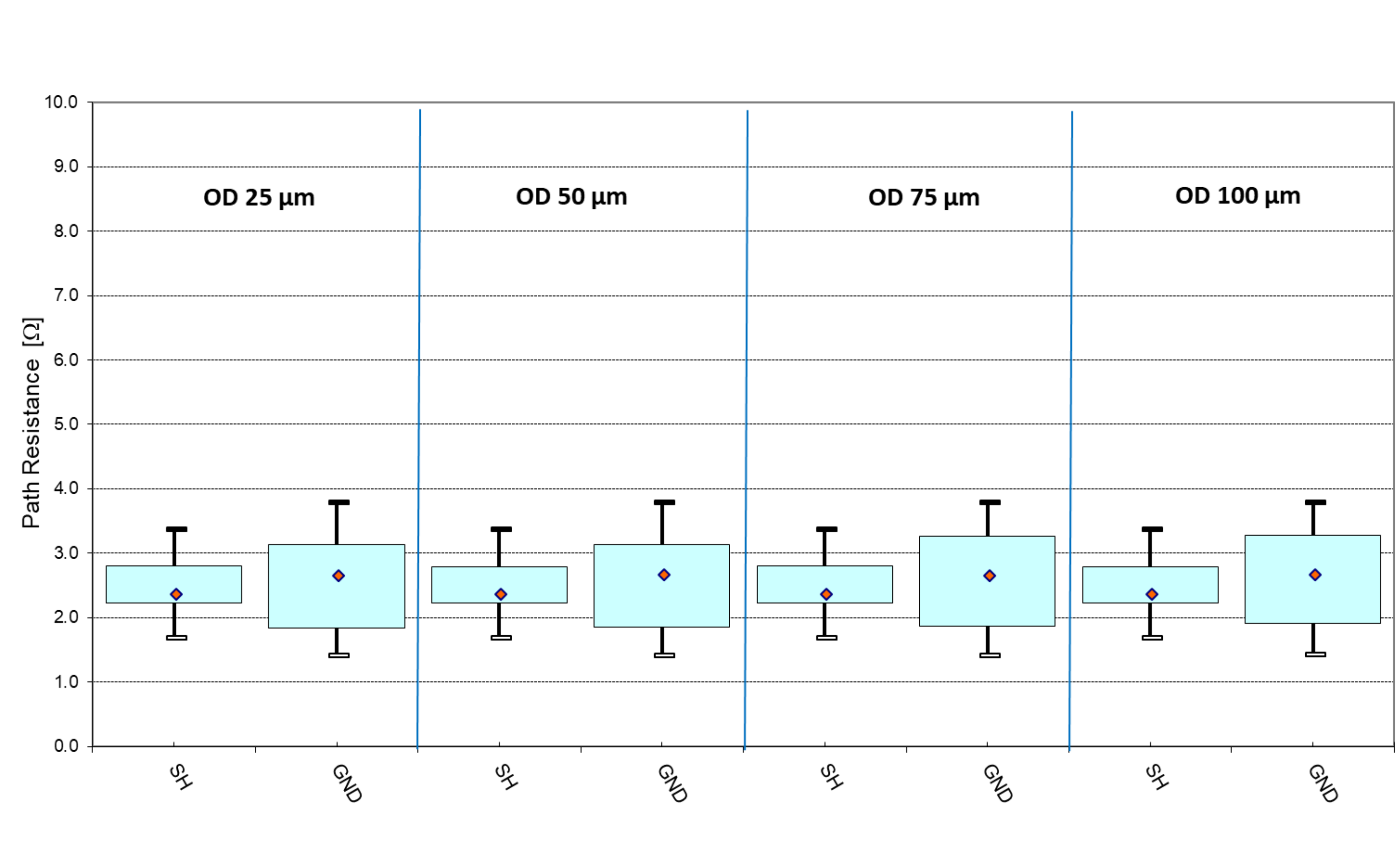
- **Path Resistance tests in function of PH site at a fixed working OD (75 µm)**
  - Results are stable and comparable



Space Transformer DC Tests

Path Resistance results varying working OD

- **Good Path Resistance stability observed in the whole working OD range:**



Space Transformer DC Tests

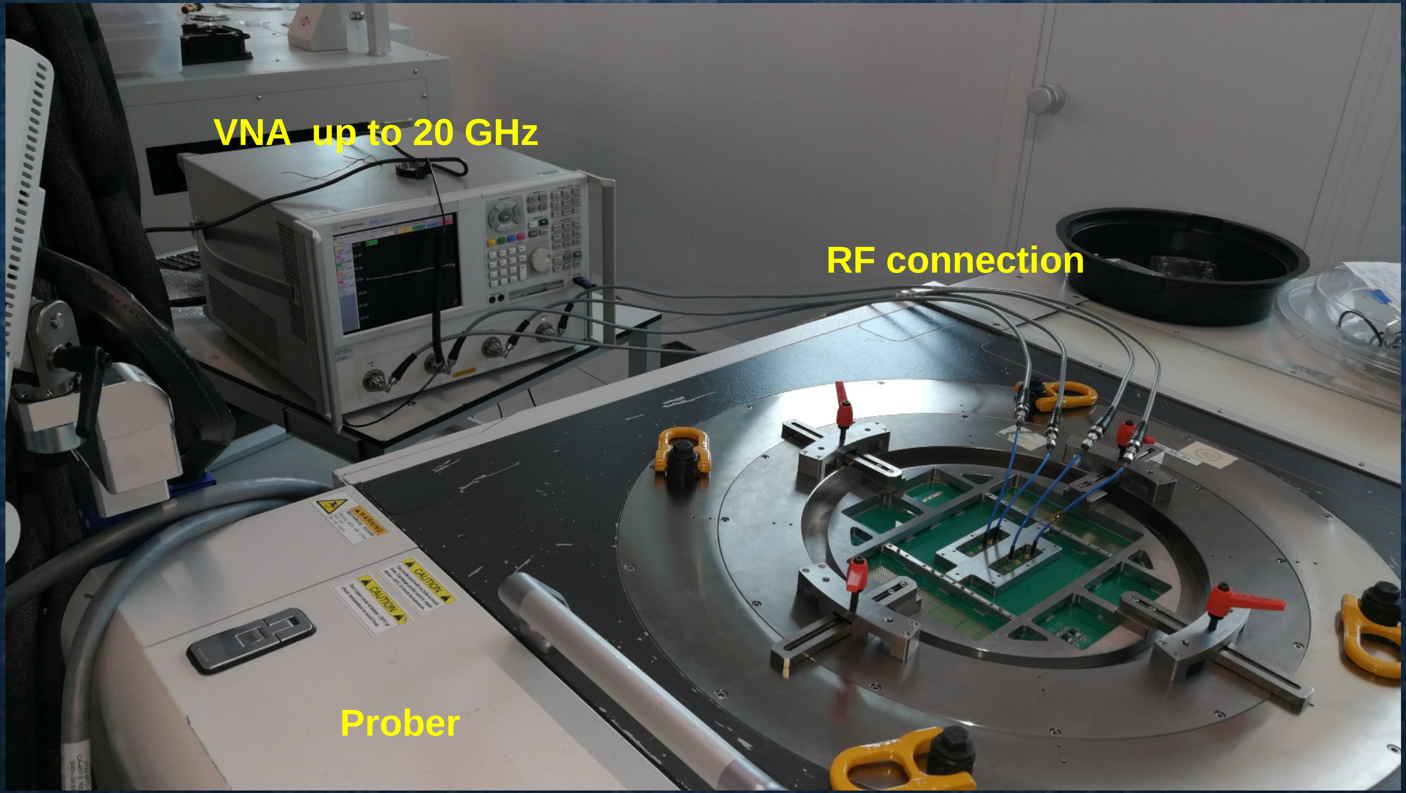
Leakage test on probe card analyzer

- Leakage tests were performed on Rudolph PRVX4 probe card analyzer
- No shorts have been detected in the whole working OD range
- Leakage measurements were below 0.12 nA @ 5 V (vs. 10 nA ref spec)

RF Tests on Prober

Experimental setup

- RF+ architecture has been validated on the prober using customer wafer and VNA up to 20 GHz to measure filter + probe card response



RF Tests on Prober

Experimental results on Customer wafer

- **On all 8 sites, we were able to measure filter shape compliant with required mask at different working OD**

Site Number	Test @50 OD	Test @75 OD	Test @100 OD
Site 1	PASS	PASS	PASS
Site 2	PASS	PASS	PASS
Site 3	PASS	PASS	PASS
Site 4	PASS	PASS	PASS
Site 5	PASS	PASS	PASS
Site 6	PASS	PASS	PASS
Site 7	PASS	PASS	PASS
Site 8	PASS	PASS	PASS

Conclusions

- **RF+ architecture is able to combine good frequency performance with the advantages of TPEG™ MEMS vertical technology**
  - High parallelism
  - Pin to pin onsite reparability
  - Low pad damage
- **RF results aligned with model**
- **Ready for on onsite test**

Future work

- **Evaluate feasibility of:**
  - More complex device
  - Higher parallelism
- **Probe head technology has the same powerful of standard vertical technology into manage device complexity… Need to understand space transformer capability into deal with high number of RF pins**

Thanks for your Support !

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