SW Test Workshop
Semiconductor Wafer Test Workshop

Advances in MEMS Spring Probe Technology for Wafer Test Applications

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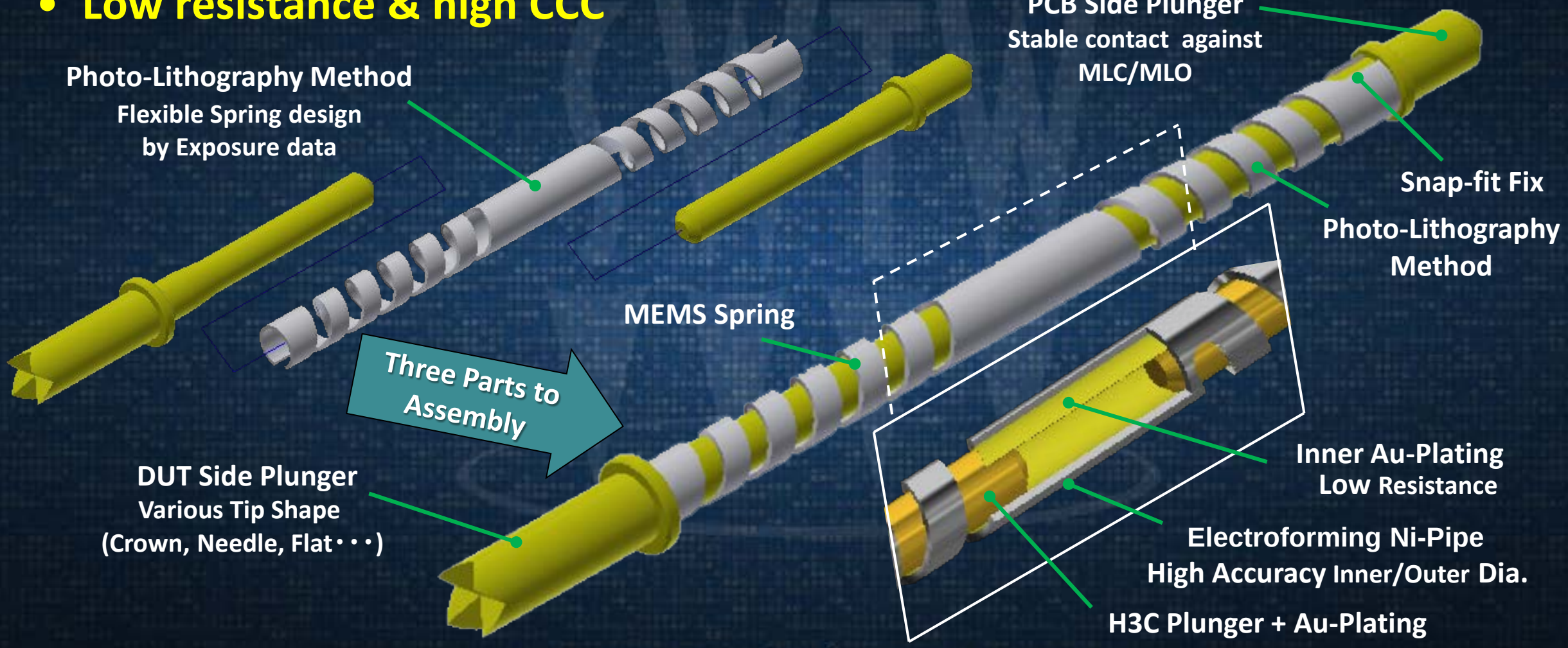
Overview

- Why is it called “MEMS” Spring Probe
- MEMS Spring Probe Card
- Design Feasibility/Customization
- Specification
- Road Map
- Summary

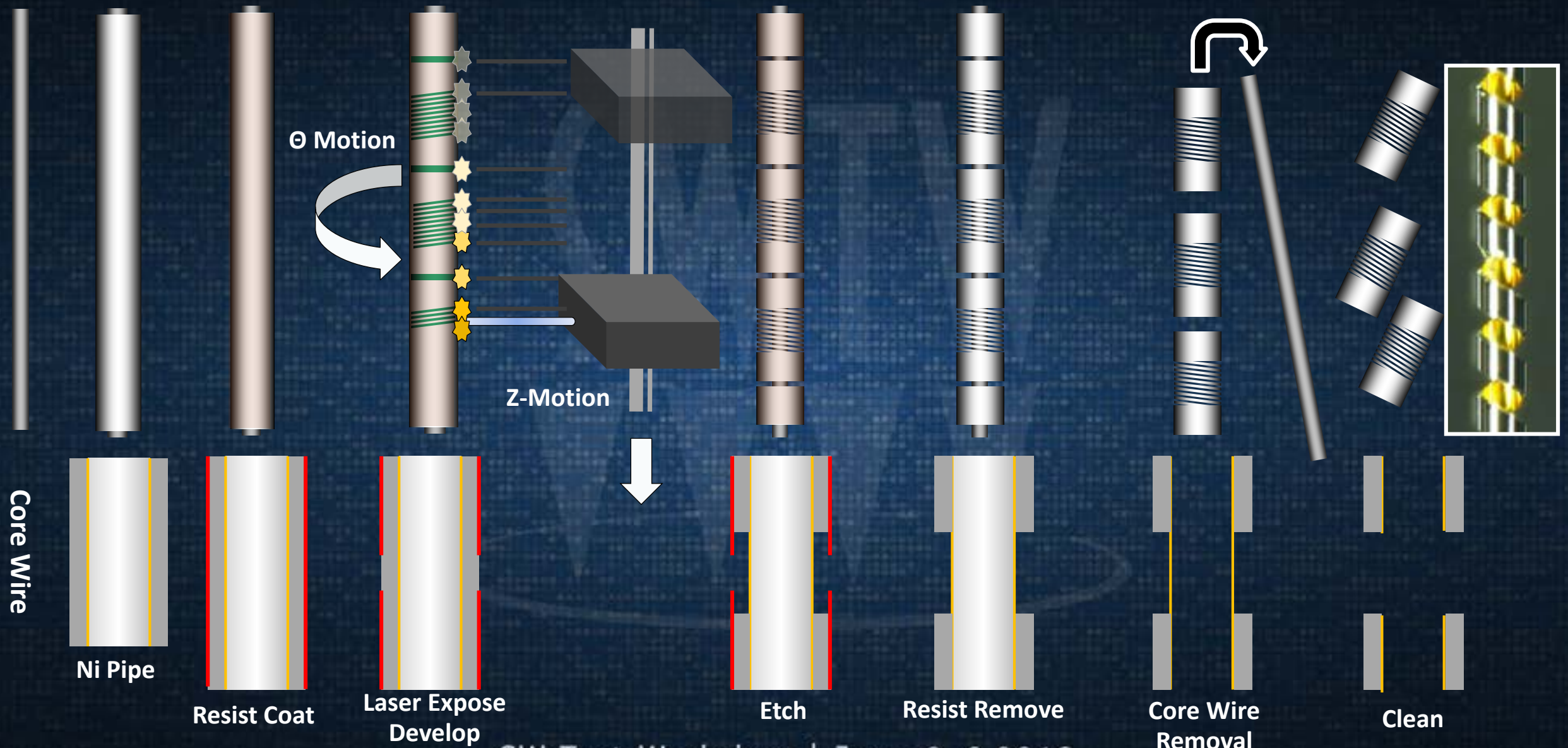
Why is it called "MEMS" Spring Probe?

MEMS Spring Pin Probe Definition

- Simple structure with spring & two snap-fixed plungers
- Low resistance & high CCC



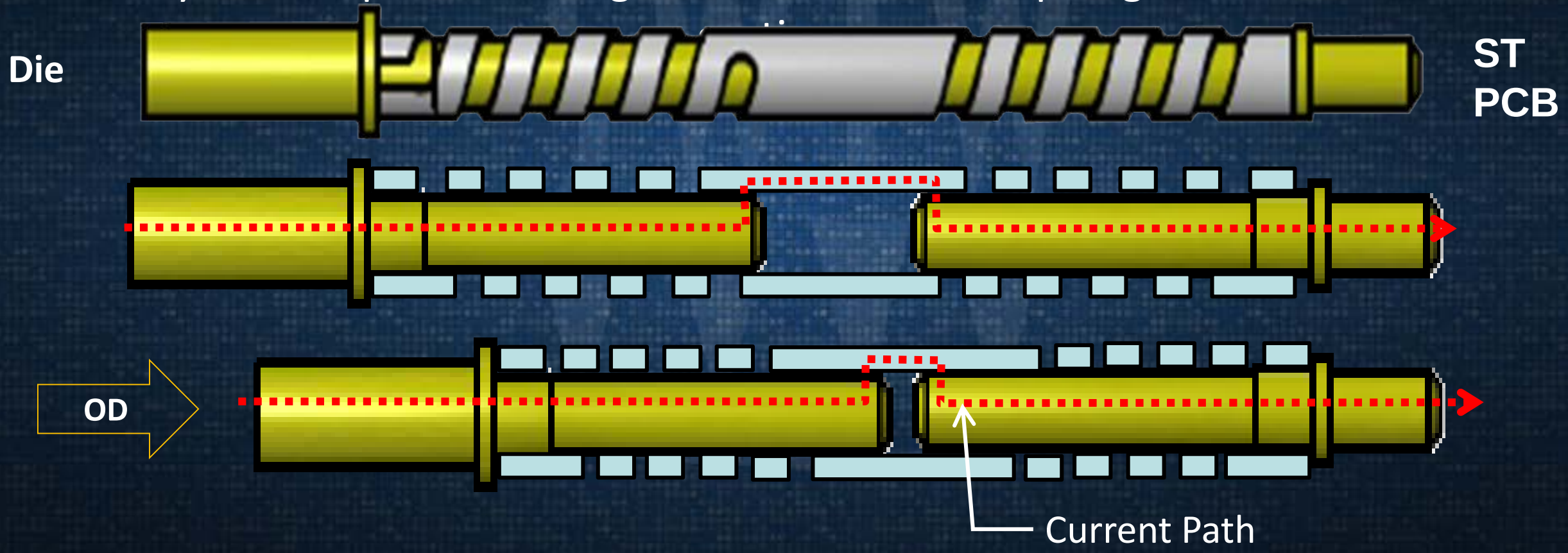
Manufacturing Process – Photolithography



Advanced Features

- **Current Path ･･･ Low Resistance & High CCC**

Primary current path is through the low-resistance plunger & center barrel.



MEMS Spring Probe Card

MEMS Spring Probe
MEMS Spring Probe Card

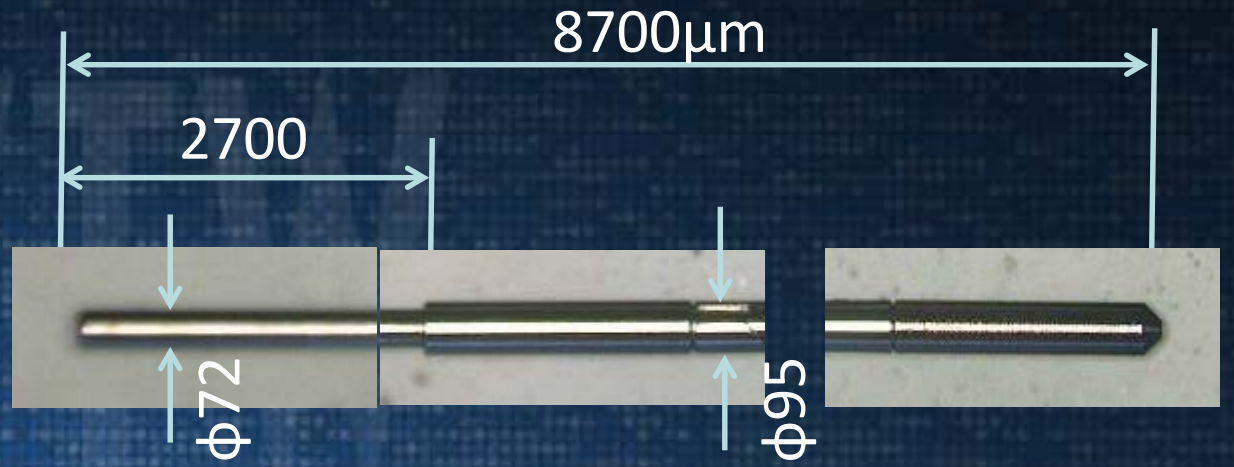
Introduce P147 MEMS Spring Probe

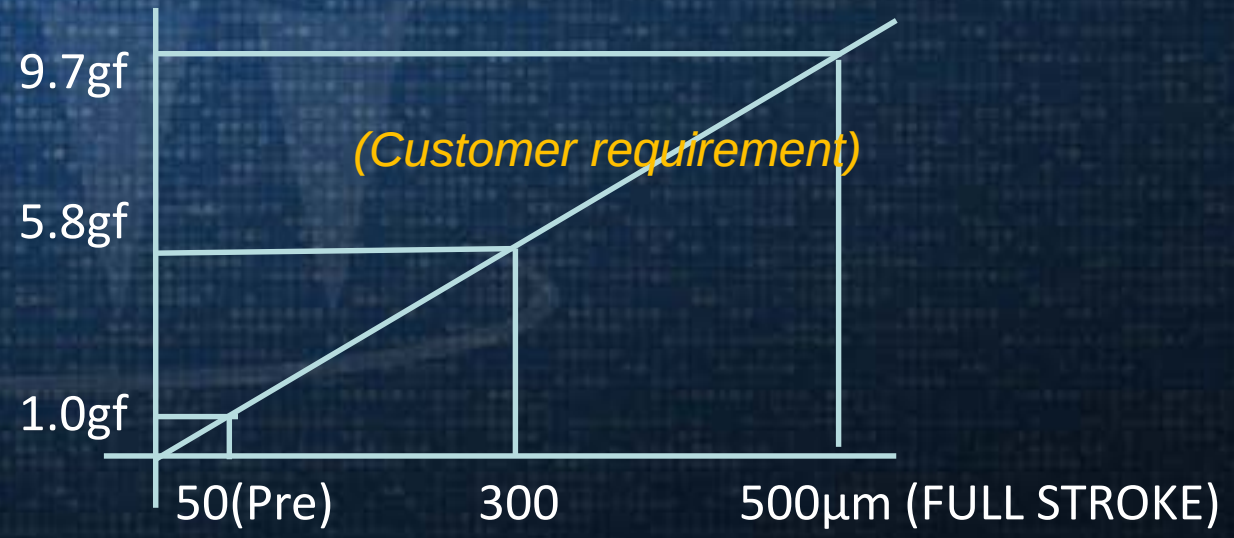
P147 MEMS Spring Probe Specifications

(Customer requirement)

Pitch	147µm
Probe Diameter	ϕ72µm
Probe tip	Flat
Contact Force	5.8gf@300µm OD
Preload	1gf
Max OP OD	350µm *
Max OD	450µm *

* Wider OD range than Conventional Spring probe





P147 MEMS Spring Probe Performance - Contact Force/OD

Graph Indicates

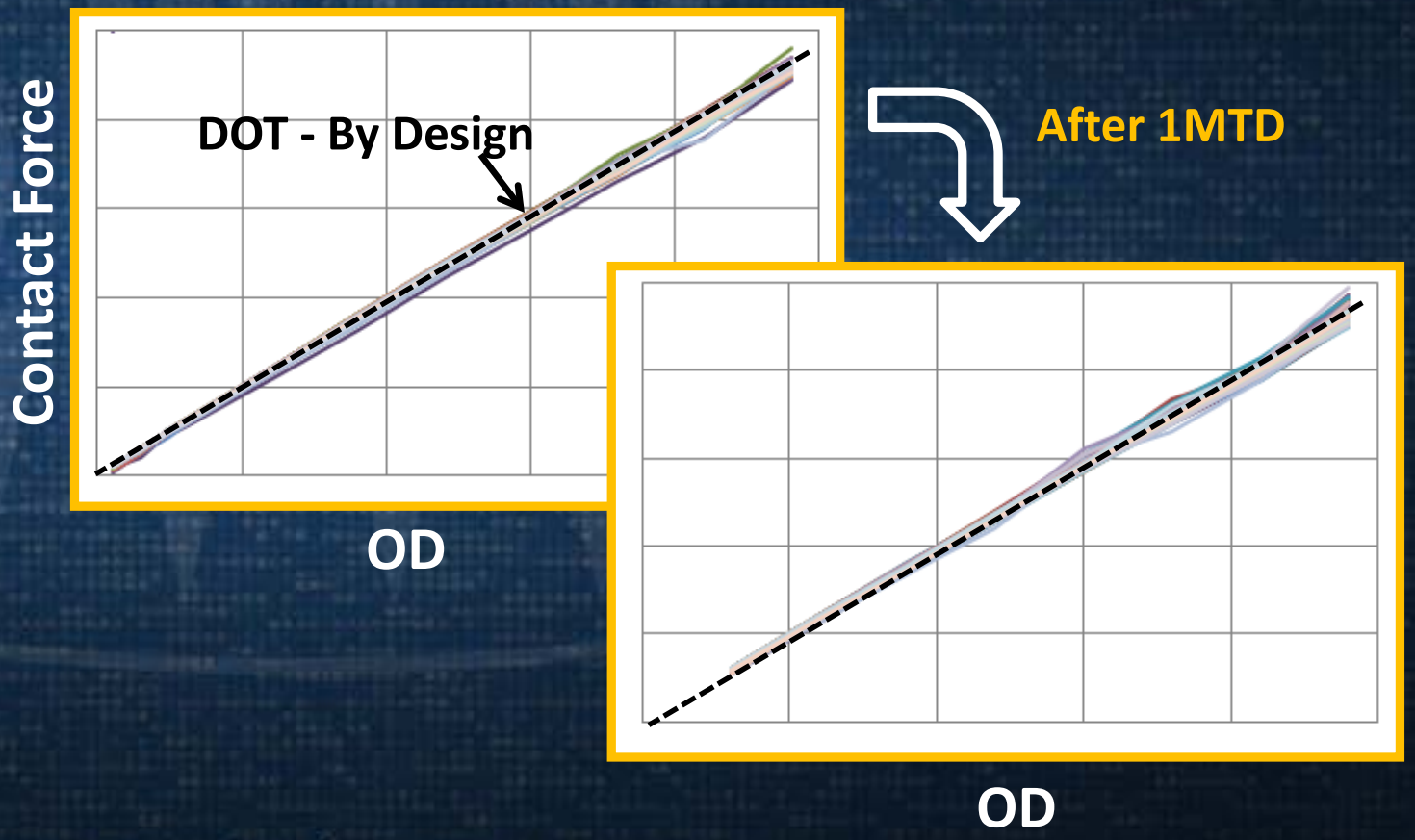
1. Contact Force/OD

Test Condition

- Before/after 1MTD (HT +125℃)
- Change OD from ZERO to 400µm
- N=100
- Room temp

Result

a. Very little Contact Force Variation
b. Right on Design SPEC
c. No Degradation after 1MTD



Additional Sample

P200 MEMS Spring Probe vs. Conventional

Graph Indicates

1. MEMS Spring Probe CF/OD
2. Conventional Spring Probe CF/OD

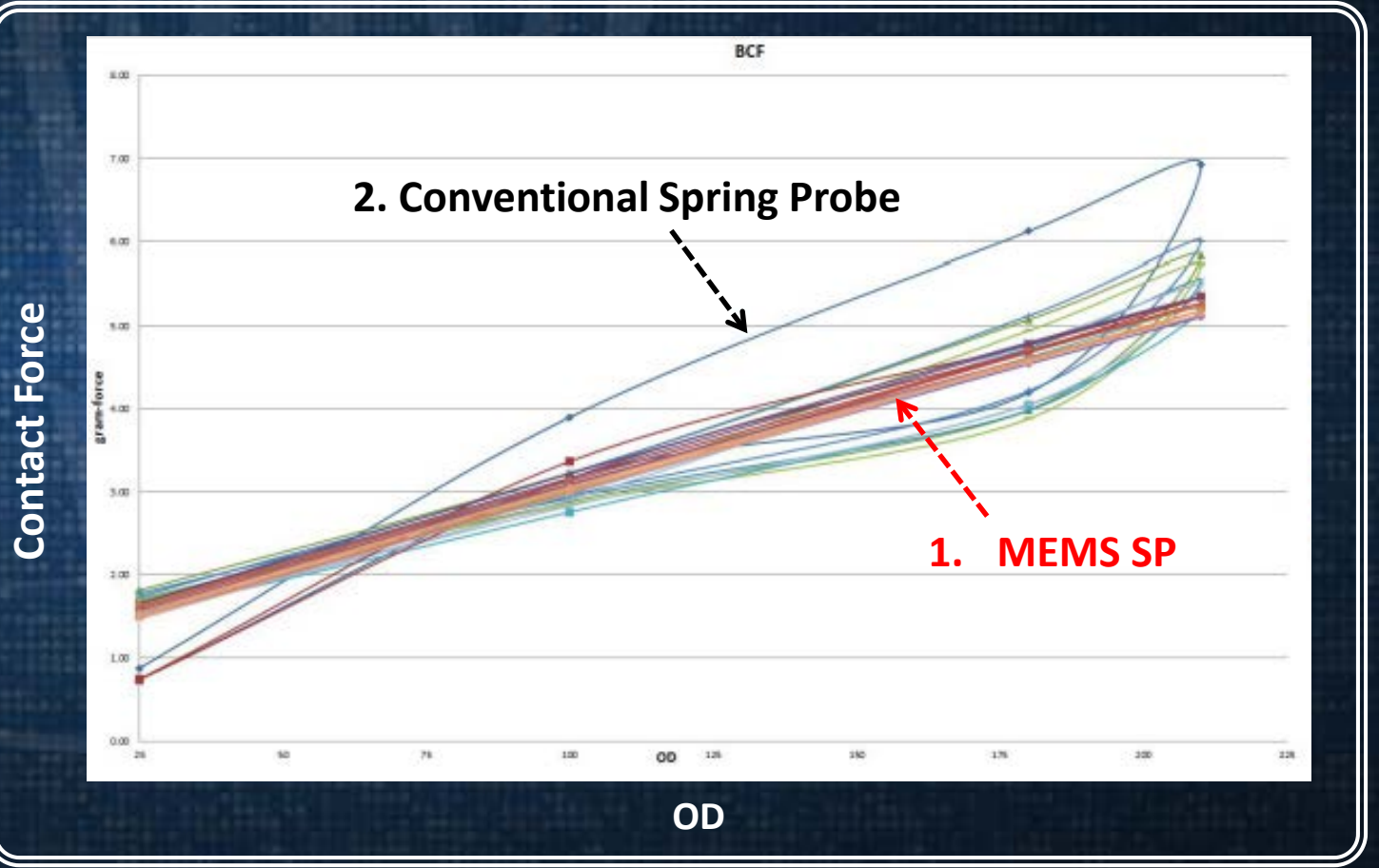
Test Condition

- Change OD from ZERO to 400µm
- Then back to ZERO
- N=7
- Room temp

Result

a. MEMS Spring Probe CF right on design & no variation (even after 130°C24Hrs)

b. Conventional Spring Probe CF more variation



P147 MEMS Spring Probe Performance - CCC

Graph Indicates

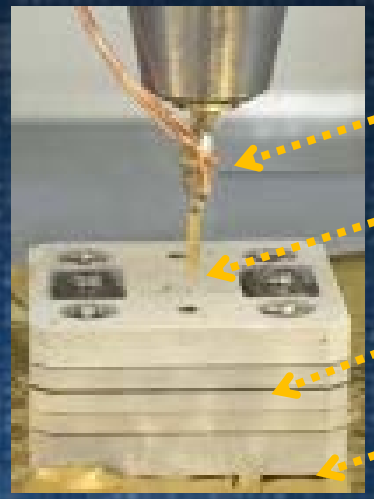
1. Contact Force(%)/Current (mA)

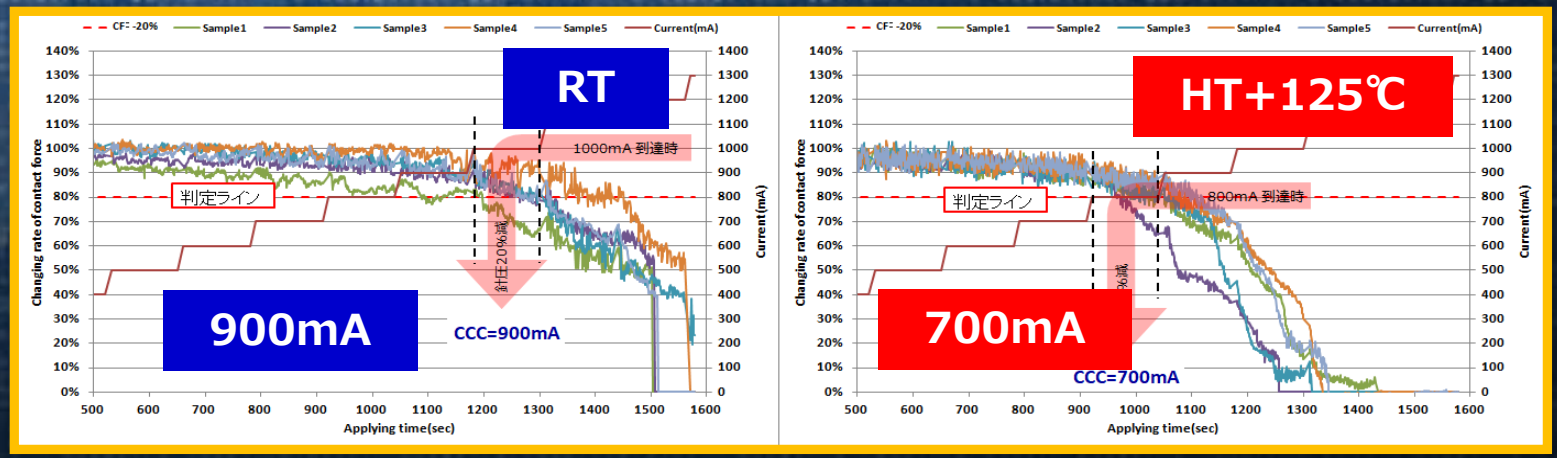
Test Condition

- ISMI STD
- N=5
- Same PH design of probe card
- OD400µm
- RT & HT +125℃

Result

a. Took the worst of five samples
b. RT 900mA
c. HT +125℃ 700mA



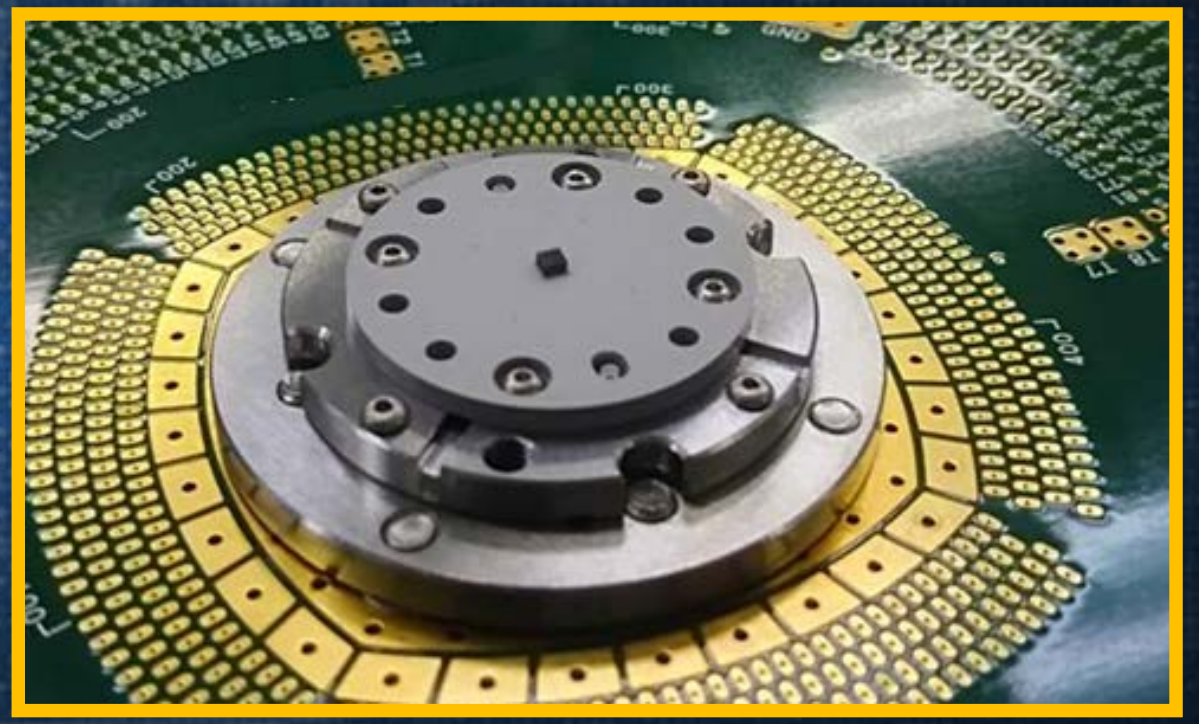


MEMS Spring Probe Card Test Vehicle + P147 MEMS Spring Probe

Test Vehicle Specifications

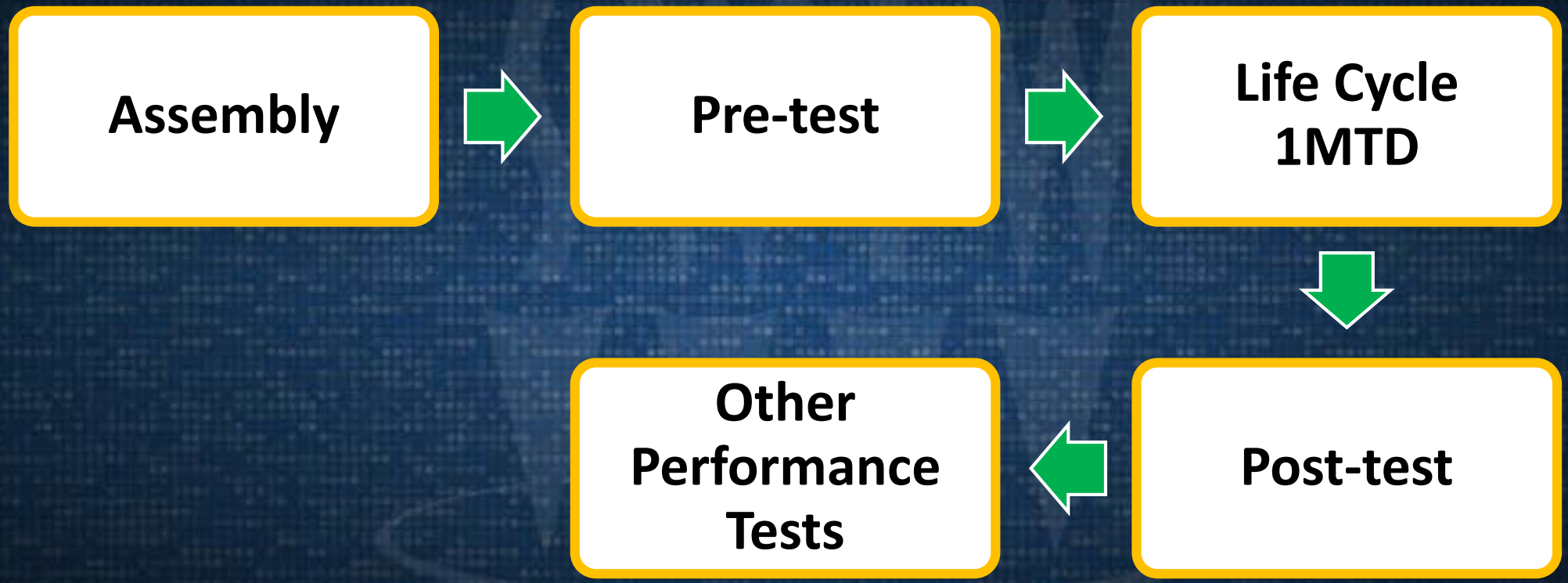
(To evaluate the card performance under Customer requirement)

Pitch	147µm
Probe Diameter	ϕ72µm
Probe tip	Flat
Contact Force	6.8gf@300µm OD
Preload	1gf
Max OP OD	350µm *
Max OD	450µm *
# of Probes	100



* Wider OD range than Conventional Spring probe

MEMS Spring Probe Card Evaluation Flow



MEMS Spring Probe Card Evaluation Parameter

		Key Parameter	Evaluation Parameter	Result
MEMS Spring Probe Card	Pre/Post 1MTD Life Cycle	Probe Position	XY Accuracy	GOOD
			Planarity	GOOD
		Contact Resistance (Single-TD)	CRES/OD	GOOD
			CRES/500TD	GOOD
		Contact Resistance (Multi-TD)	CRES/Multi-TD	GOOD
		Probe Mark	Mark on Bump	GOOD
		Deformation	Tip Length, Barrel Length	GOOD
		Frequency, S21	Probe Only, Probe Card	GOOD
		Inductance	WLCSP 2.78mm long	GOOD

MEMS Spring Probe Card Test Vehicle Performance – XY Position Accuracy

Graph Indicates

1. XY Position [After 1MTD Life cycle]
2. RT

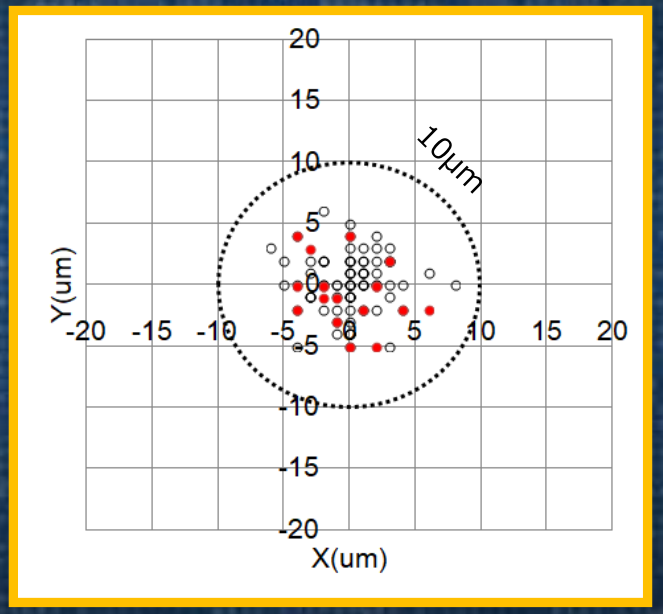
Test Condition

- Target < ±10µm
- N=100
- OD300µm
- IF = 50mA during 1MTD Life (N=20)
- Before/After 1MTD. Show only after 1MTD

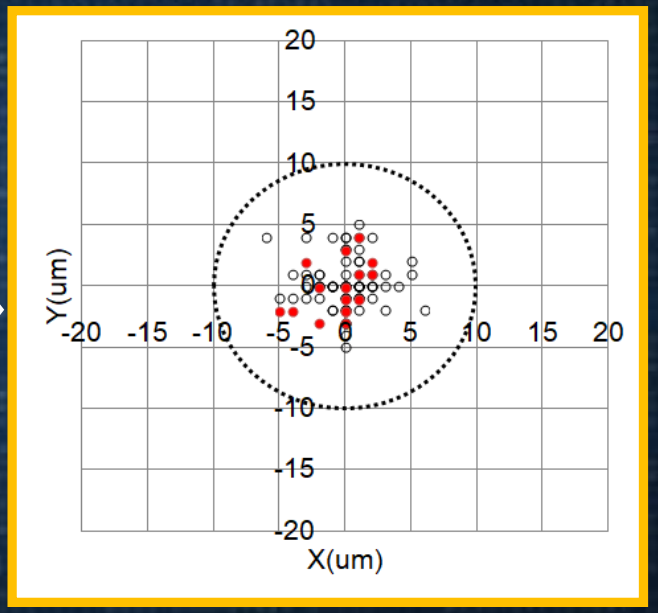
Result

a. Below the target
b. No degradation after 1MTD
c. No difference with IF=50mA

Pre-test



Post-test (1MTD)



● : IF=50mA during Life Cycle

○ : No force current

MEMS Spring Probe Card Test Vehicle Performance – Planarity

Graph Indicates

1. XY Position [After 1MTD Life cycle]
2. RT

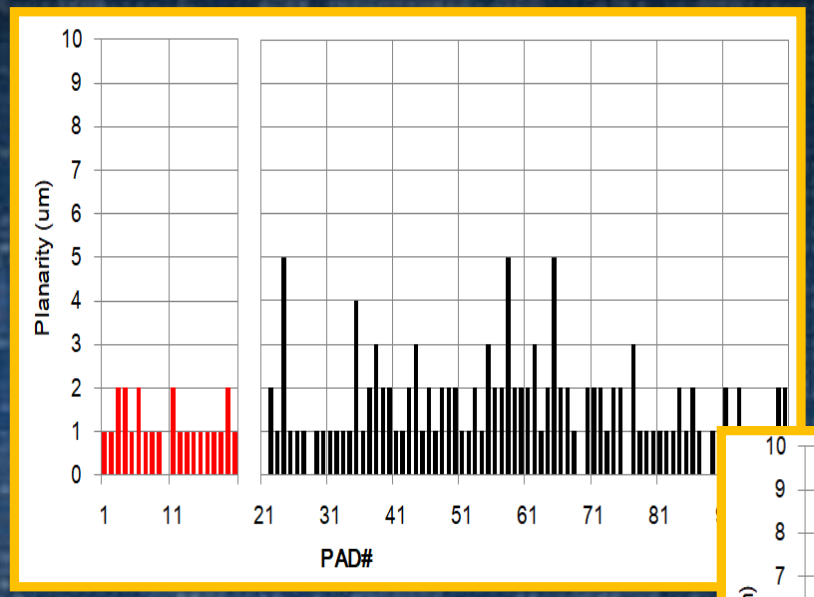
Test Condition

- Target < 20µm
- N=100
- OD300µm
- IF = 50mA during 1MTD Life (N=20)
- Before/After 1MTD. Show only after 1MTD

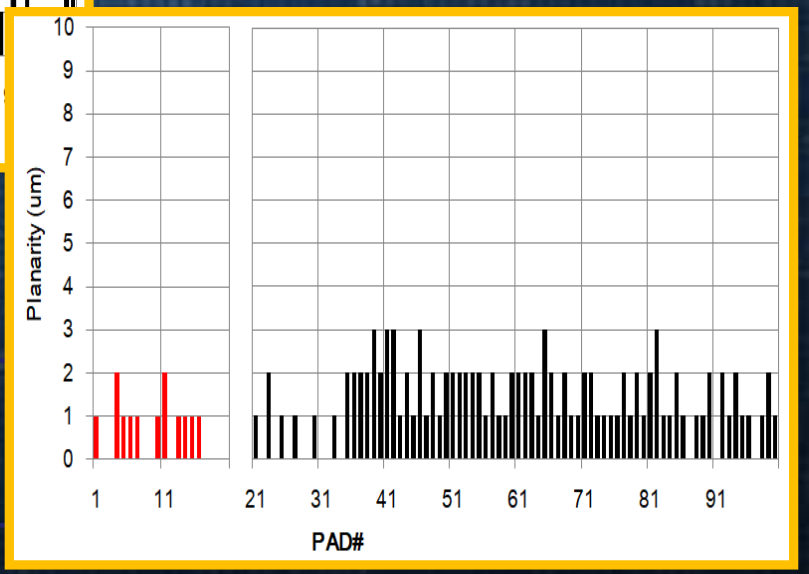
Result

a. Below the Target
b. No Degradation after 1MTD
c. No Difference with IF=50mA

Pre-test



Post-test (1MTD)



● : IF=50mA during Life Cycle

○ : No Force Current

MEMS Spring Probe Card Test Vehicle Performance – CRES Bump Contact/OD

Graph indicates

1. CRES/OD [After 1MTD Life cycle]
2. Tri-Temp (RT, LT -40℃, HT +125℃)

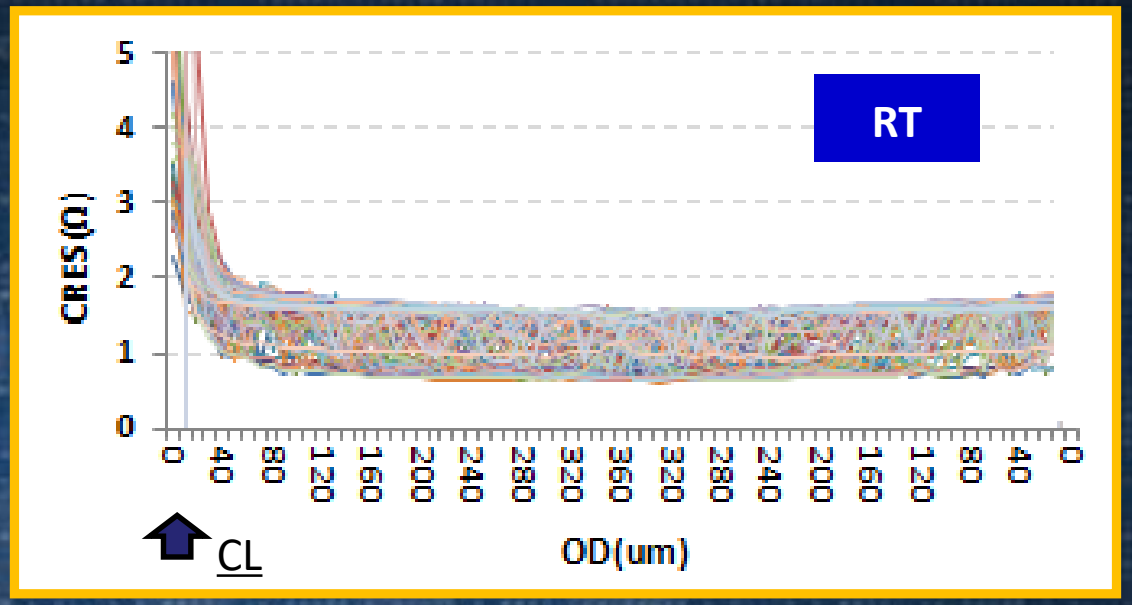
Test Condition

- Target CRES < 2 Ohms
- N=70
- Online Cleaning only before START
- IF = 50mA
- Before/After 1MTD. Show only after 1MTD

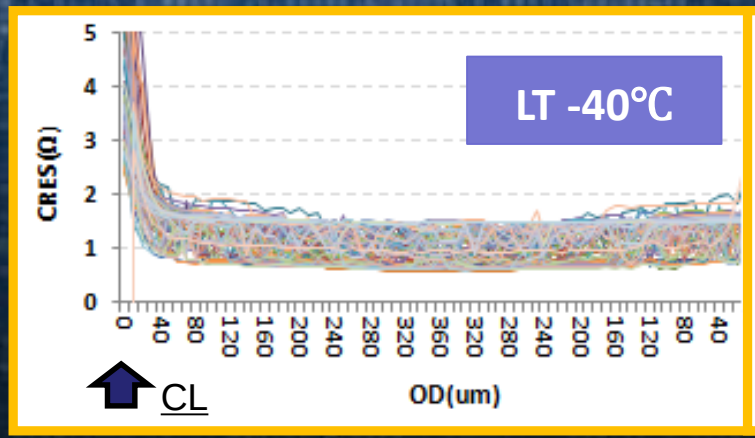
Result

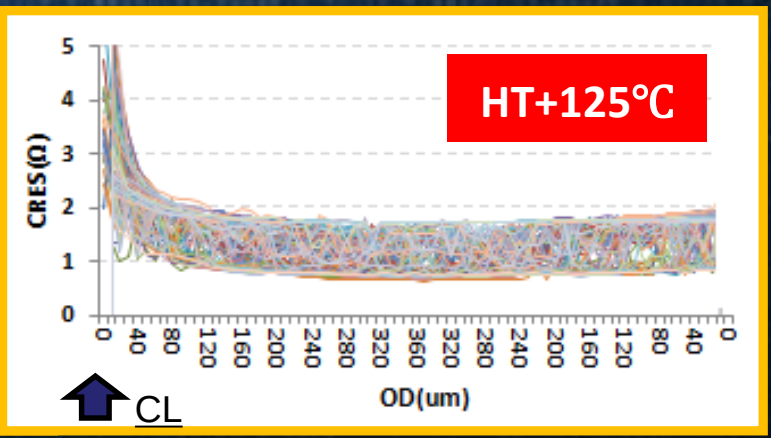
a. Below the target CRES @OD80µm

b. No degradation after 1MTD



Show "after 1MTD" Only





MEMS Spring Probe Card Test Vehicle Performance – CRES Bump Contact/500TD

Graph Indicates

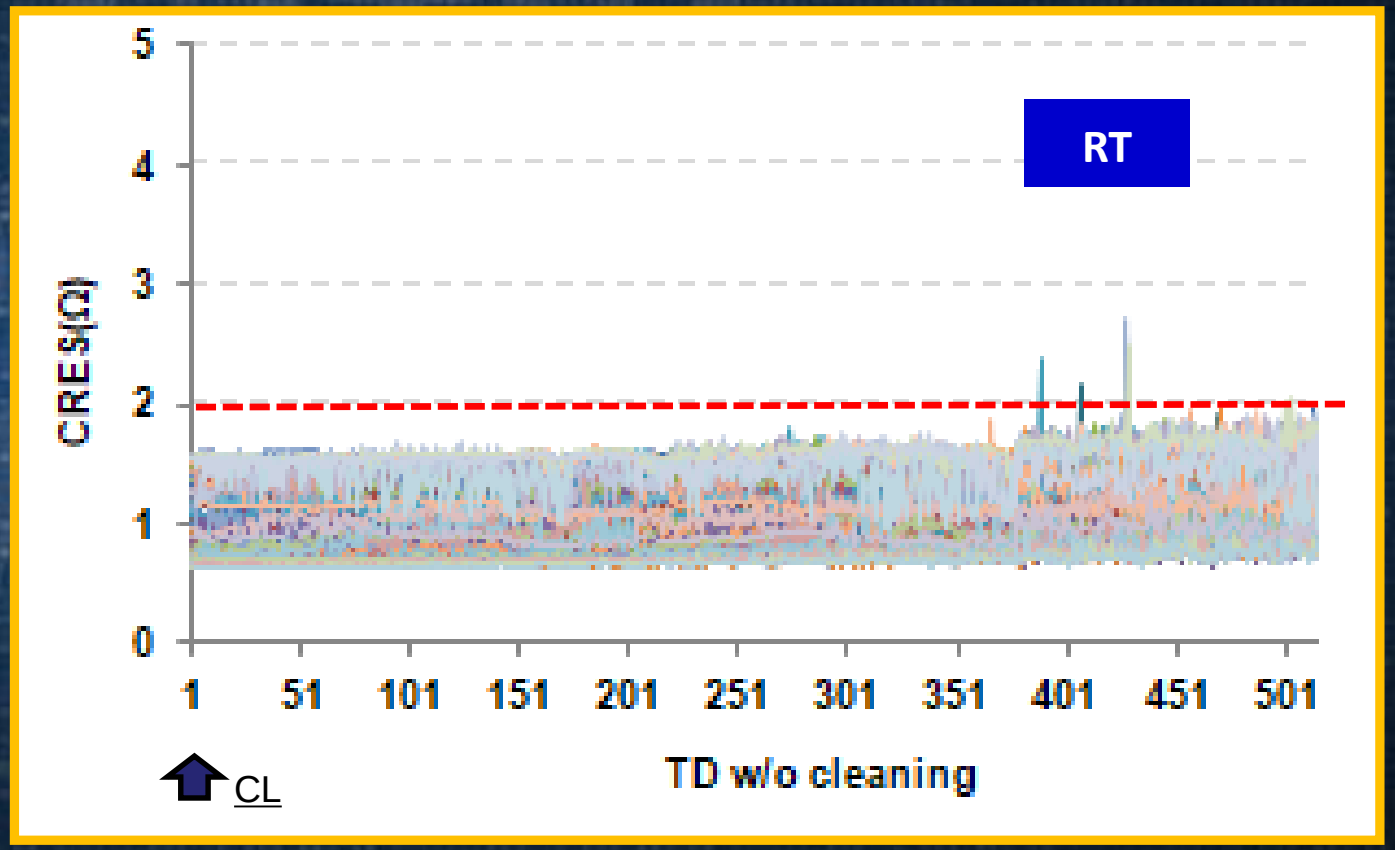
1. CRES/500TD [After 1MTD Life cycle]
2. RT

Test Condition

- Target CRES < 2 Ohms
- N=70
- Online Cleaning only before START
- OD300µm
- IF = 50mA
- Before/After 1MTD. Show only after 1MTD

Result

a. Below the target above 350TD@RT



Show "after 1MTD" Only

MEMS Spring Probe Card Test Vehicle Performance – CRES Bump Contact/500TD

Graph Indicates

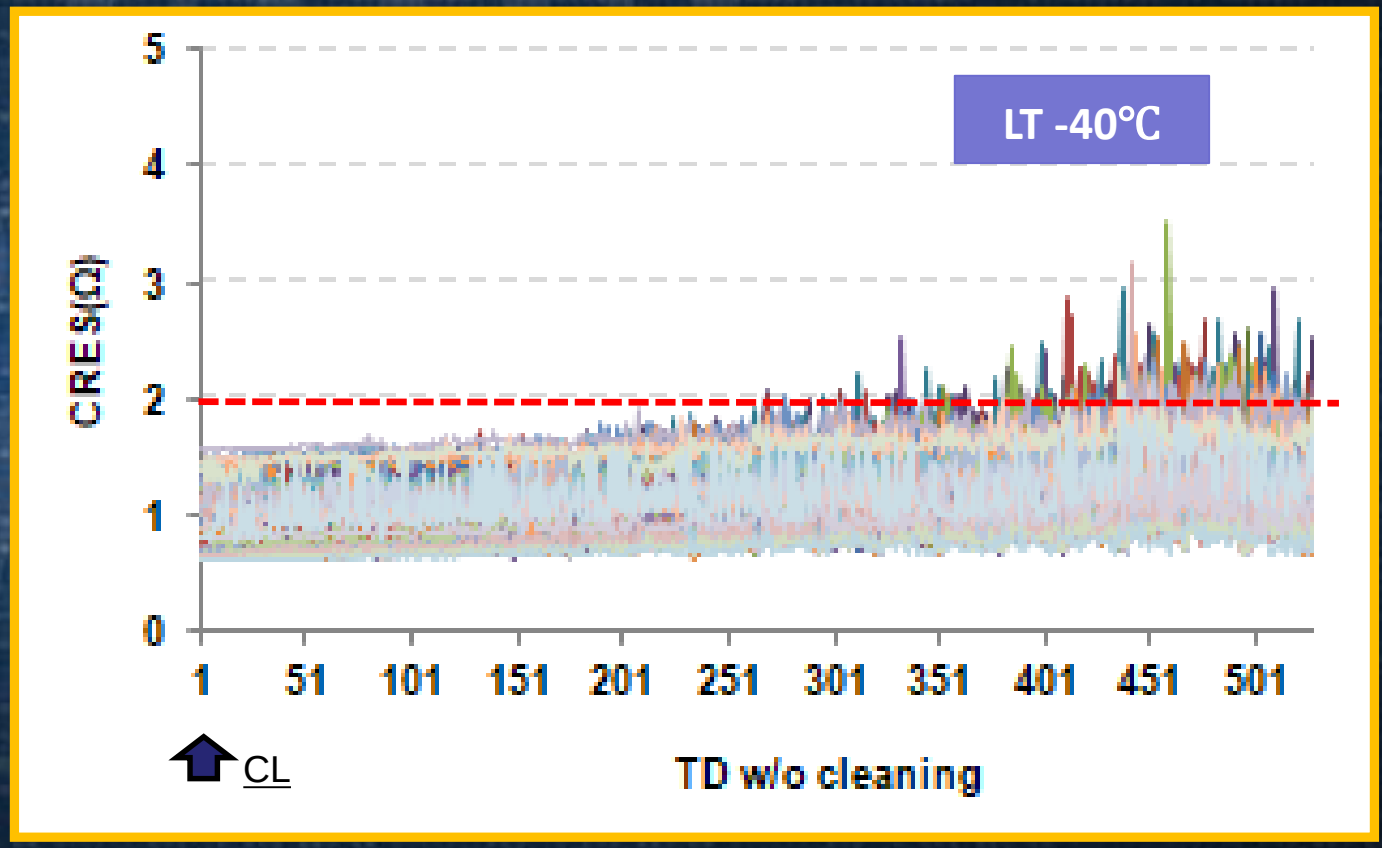
1. CRES/500TD [After 1MTD Life Cycle]
2. LT -40°C

Test Condition

- Target CRES < 2 Ohms
- N=70
- Online Cleaning only before START
- OD300µm
- IF = 50mA
- Before/After 1MTD. Show only after 1MTD

Result

a. Below the target until 300TD@LT



Show "after 1MTD" Only

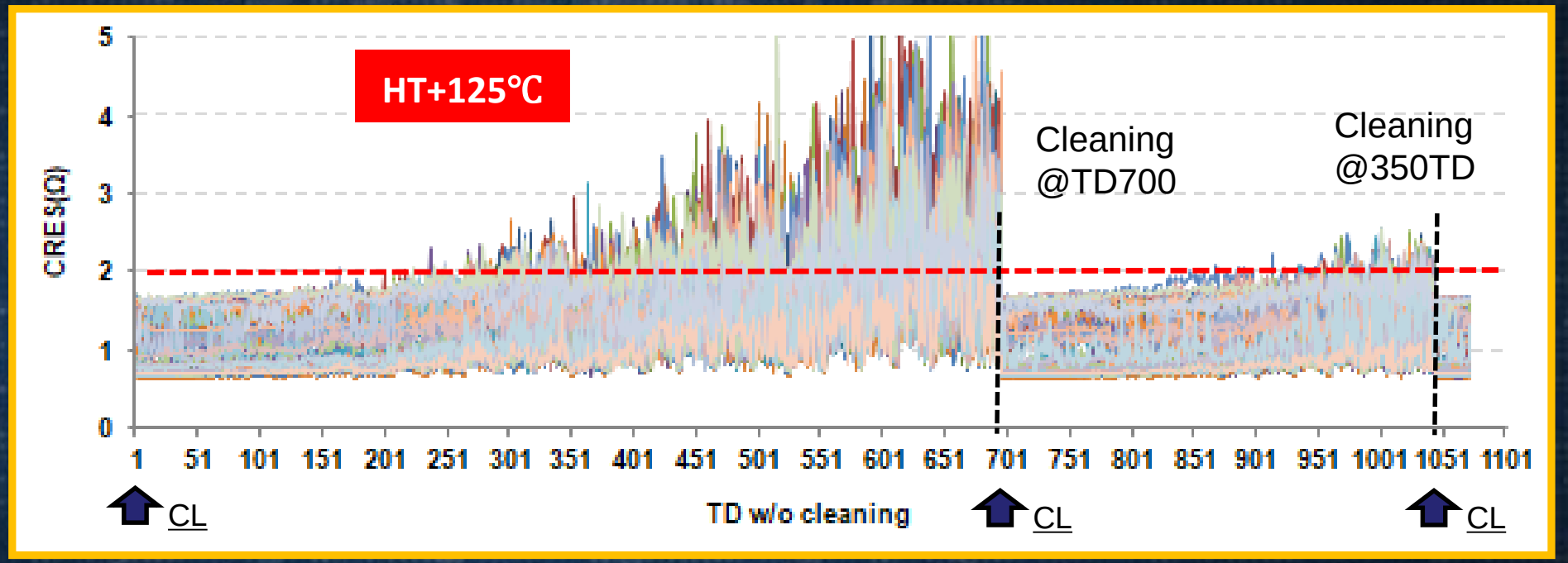
MEMS Spring Probe Card Test Vehicle Performance – CRES Bump Contact/500TD

Graph Indicates

1. CRES/1000TD [After 1MTD Life cycle]
2. HT +125℃

Test Condition

- Target CRES < 2 Ohms
- N=70
- Online Cleaning only before START
- OD300µm
- IF = 50mA
- Before/After 1MTD. Show only after 1MTD



Result

a. Below the target until 200TD@HT
b. CRES performance stabilizes after Cleaning

Show "after 1MTD" Only

MEMS Spring Probe Card Test Vehicle Performance – CRES Bump Contact/Multi-TD

Graph Indicates

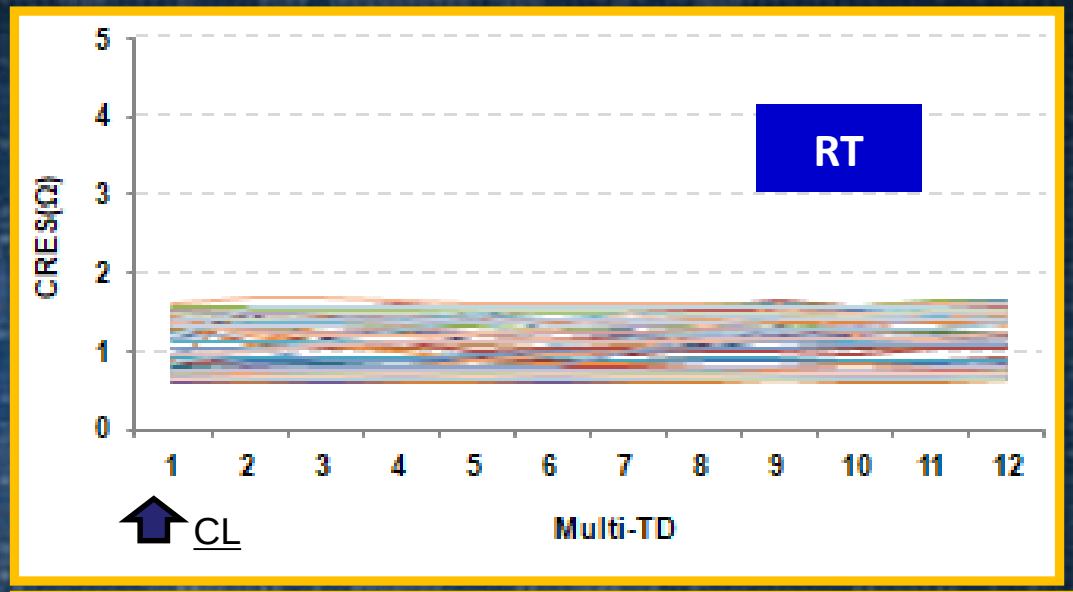
1. CRES/12TD on Same Bump
2. Tri-Temp

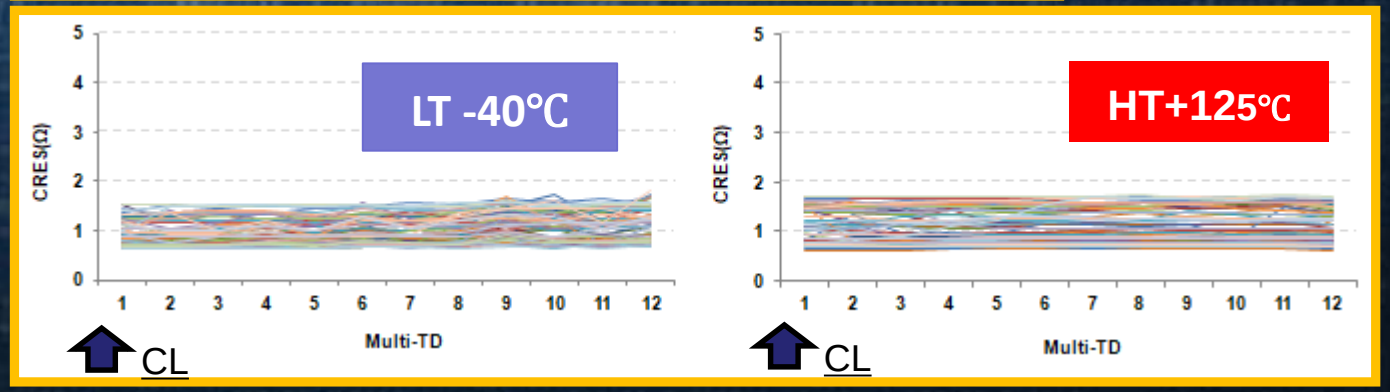
Test Condition

- Target CRES < 2 Ohms
- N=70
- Online Cleaning only before START
- OD300µm
- IF = 50mA

Result

a. CRES performance is stable below 2 Ohms even 12th TD





MEMS Spring Probe Card Test Vehicle
Performance – Probe Mark/Single -TD

Picture Indicates

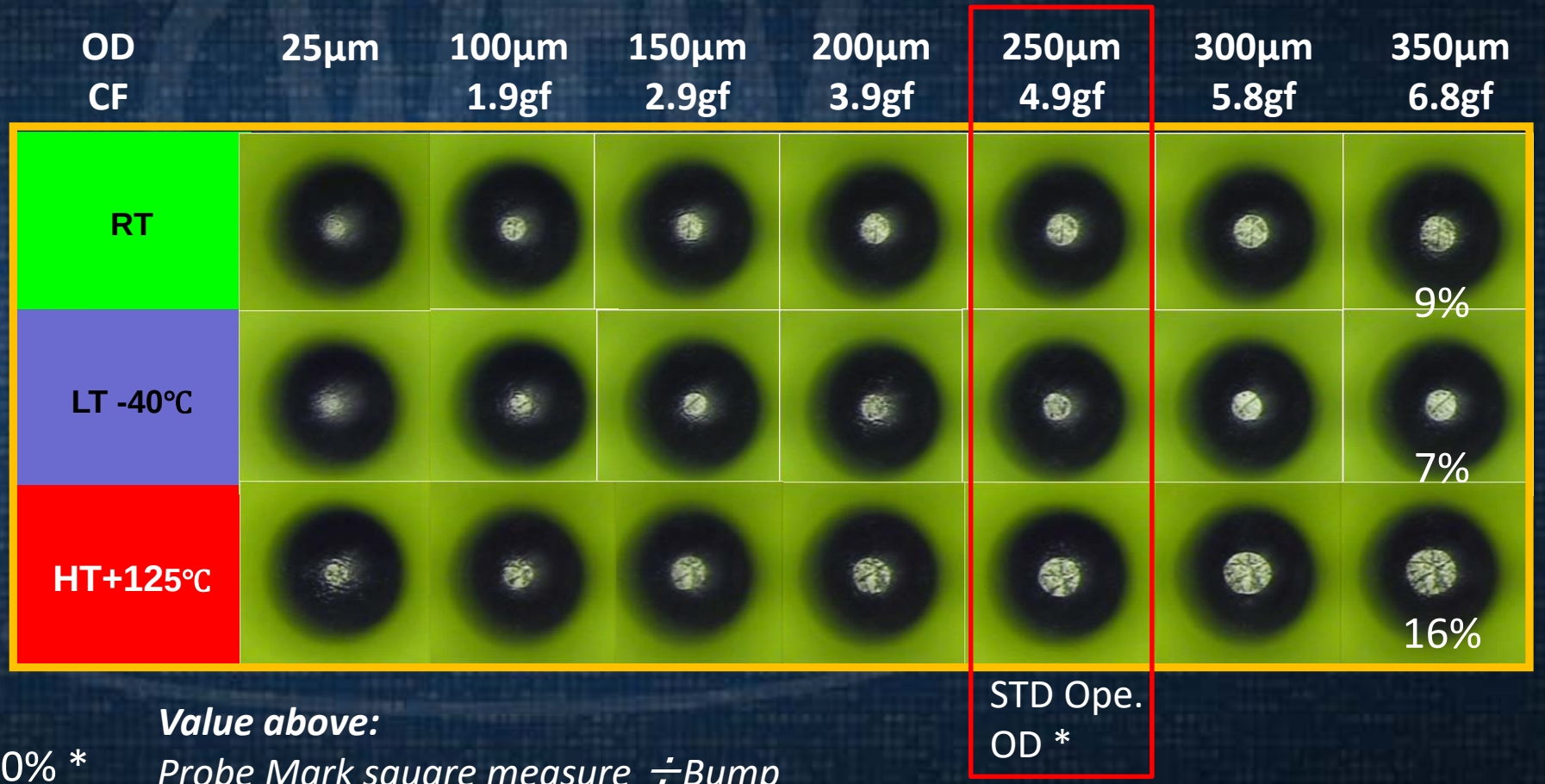
1. Probe Mark on Bump
2. Tri-Temp

Test Condition

- Target below 50% of Bump square size*
- Average values from N=5
- Single TD

Result

1. HT +125℃ showed worst
2. Even HT, Probe Mark 16% < 50% *
   (* Customer specification)



Value above:
Probe Mark square measure ÷Bump

MEMS Spring Probe Card Test Vehicle Performance – Probe Mark/Multi-TD

Picture Indicates

1. Probe Mark on Bump
2. Tri-Temp

Test Condition

- Target below 50% of Bump square size*
- Average values from N=5
- Multi-TD

Result

1. HT +125℃ showed worst
2. Even HT & TD 12 times, Probe Mark 18% < 50% *

(* Customer specification)

Value above:
Probe Mark square measure ÷Bump

MEMS Spring Probe Card Test Vehicle Performance – 1MTD Life Cycle, Barrel Spring Length

Test Condition

- 1MTD Life cycle (HT +125℃, OD 350µm)
- W/O Online Cleaning
- Average values from N=5

Result

1. Barrel length ▲13µm. Deformation per 1MTD under HT.
   Less than 2% of Barrel length. No impact to neither Contact force nor CRES performance (showed previous pages)

MEMS Spring Probe Card Test Vehicle
Performance – Frequency

Picture Indicates

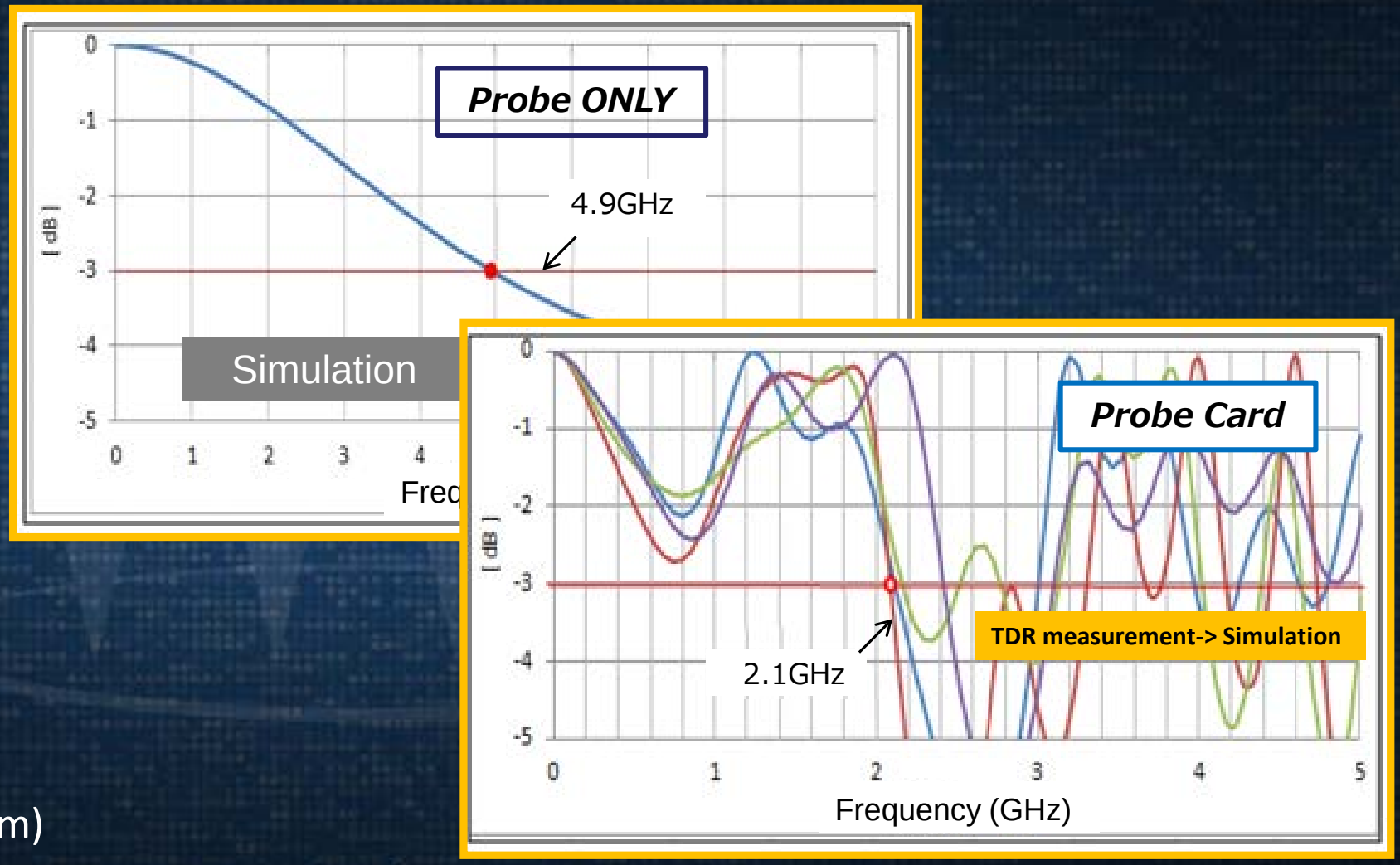
1. S21 Probe Only [Simulation]
2. S21 Probe Card/Wired type [Simulation based on TDR measurement]

Test Condition

- N=1 (Probe Only)
- N=4 (Probe Card)
- Read @-3db. 1/3 to convert to rectangle wave form,

Result

1. 1.6GHz, Probe Only
2. 700MHz, Probe Card (Wire 41mm)



Additional Sample
WLCSP Probe, Measure Inductance

Graph Indicates

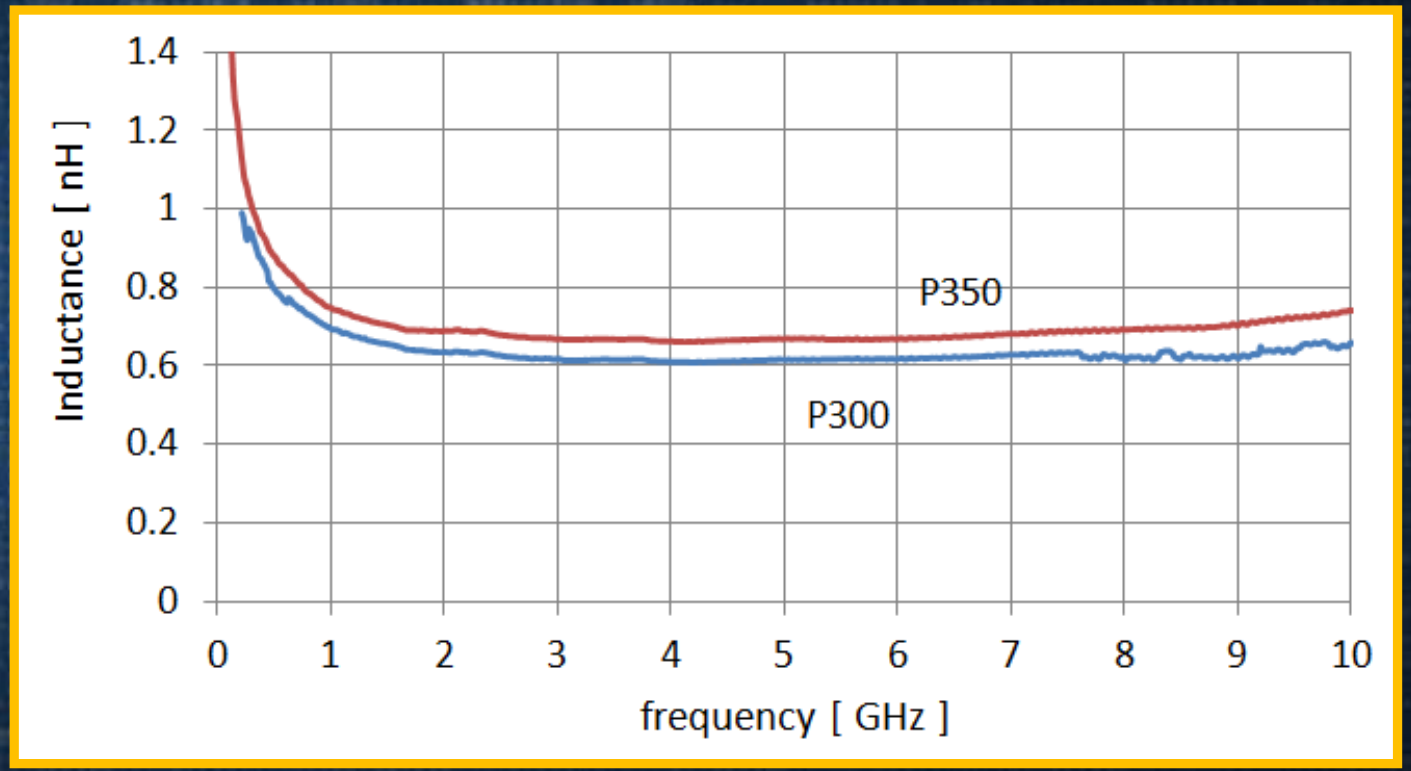
1. WLCSP Probe Inductance
   Φ235µm
   L =2.78mm

Test Condition

- G-S Measurement
- Pitch = 350µm, 300µm

Result

a. Inductance Measurement
   0.6nH/P300
   0.67nH/P350



achieve the required

MEMS Spring Probe Card Evaluation Result

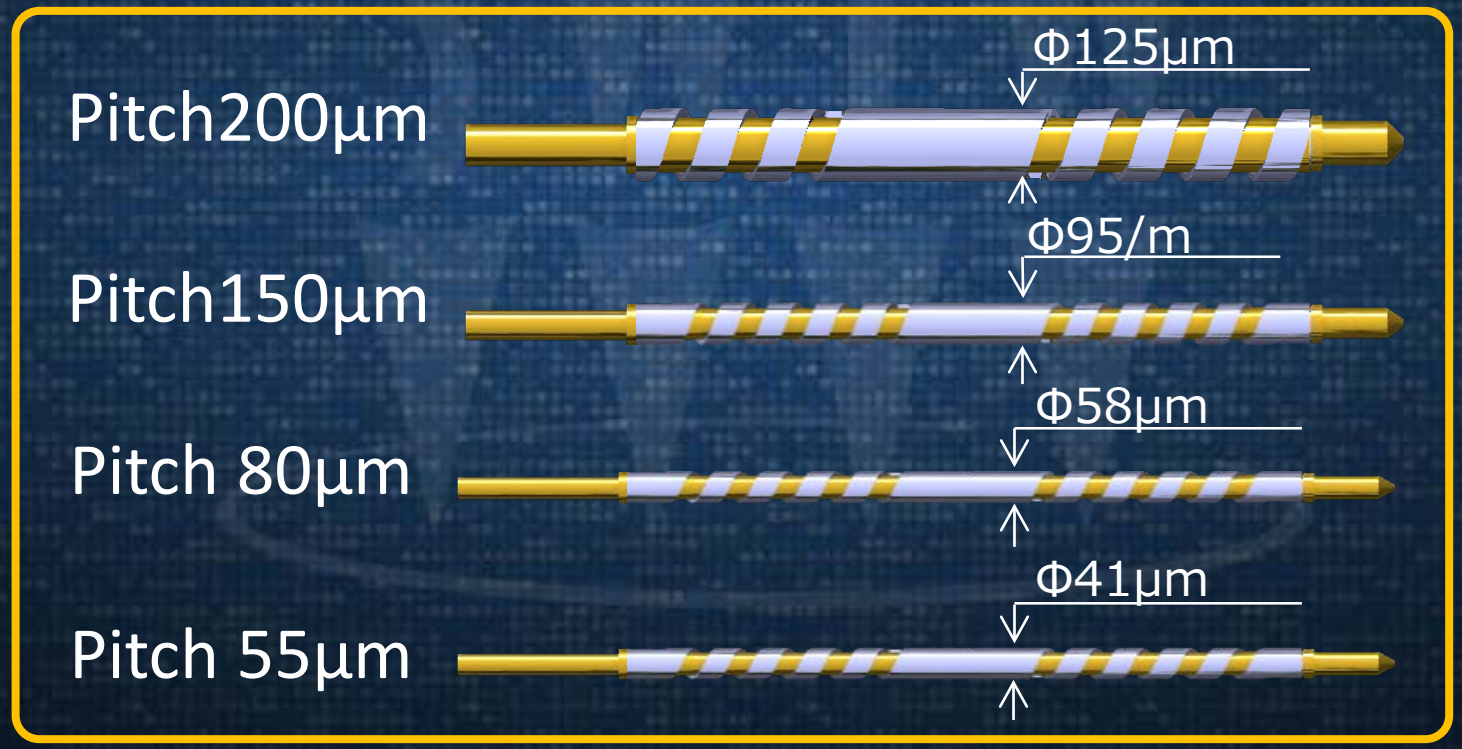
		Key Parameter	Evaluation Parameter	Result
MEMS Spring Probe Card	Pre/Post 1MTD Life Cycle	Probe Position	XY Accuracy	<±10µm, GOOD
			Planarity	<5µm, GOOD
		Contact Resistance (Single-TD)	CRES/OD	<2 Ohms, GOOD
			CRES/500TD	200TD@HT, GOOD
		Contact Resistance (Multi-TD)	CRES/Multi-TD	<2 Ohms@HT, GOOD
		Probe Mark	Mark on Bump	<18% (12TDs,HT), GOOD
		Deformation	Tip Length, Barrel Length	▲13µm Barrel L, GOOD
		Frequency, S21	Probe Only, Probe Card	Wired 700MHz , GOOD MLO/MLC TBD
		Inductance	WLCSP 2.5mm Probe	0.6nH L2.78mm, GOOD
MEMS Spring Probe		CCC	CCC RT/HT+125℃	900/700mA, GOOD
		Contact Force	Contact Force/OD	On Design, little variation

Confirmed to be able to achieve the customer requirement

Design Feasibility

Design Feasibility
Highly Scalable MEMS Technology

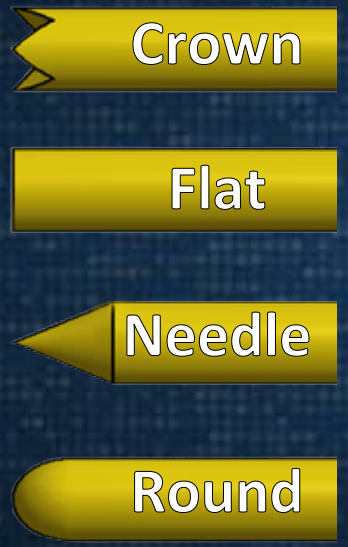
General probe diameter & parts size. It is easy to adapt design from wide pitch to narrow pitch.



Design Feasibility
Highly Scalable MEMS Technology

Four design factors can be used to achieve Design flexibility

(1) Probe Tip



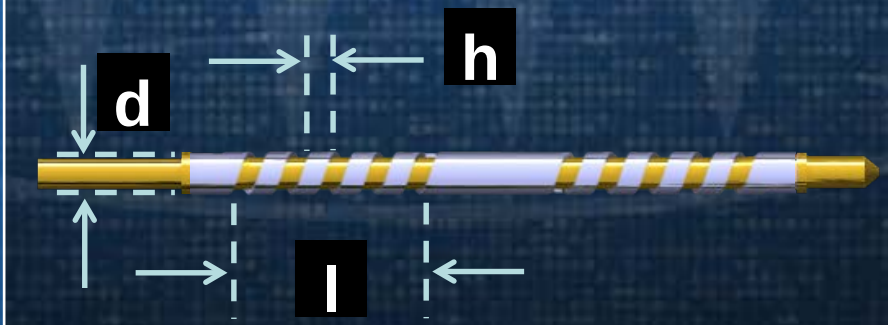
Bump, Pillar, AL, Au

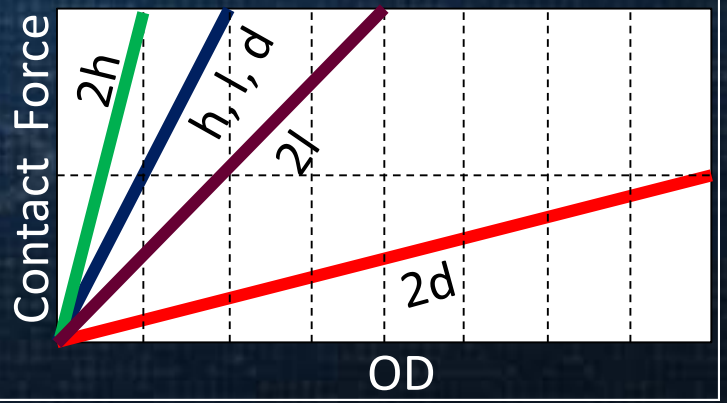
(2) Self Rotation

Rotation

No-Rotation

(3) Probe Force

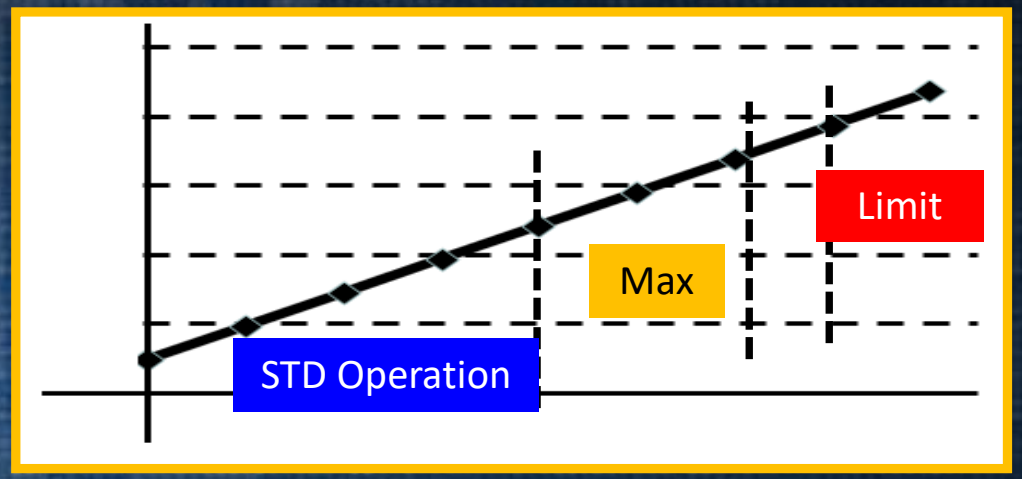


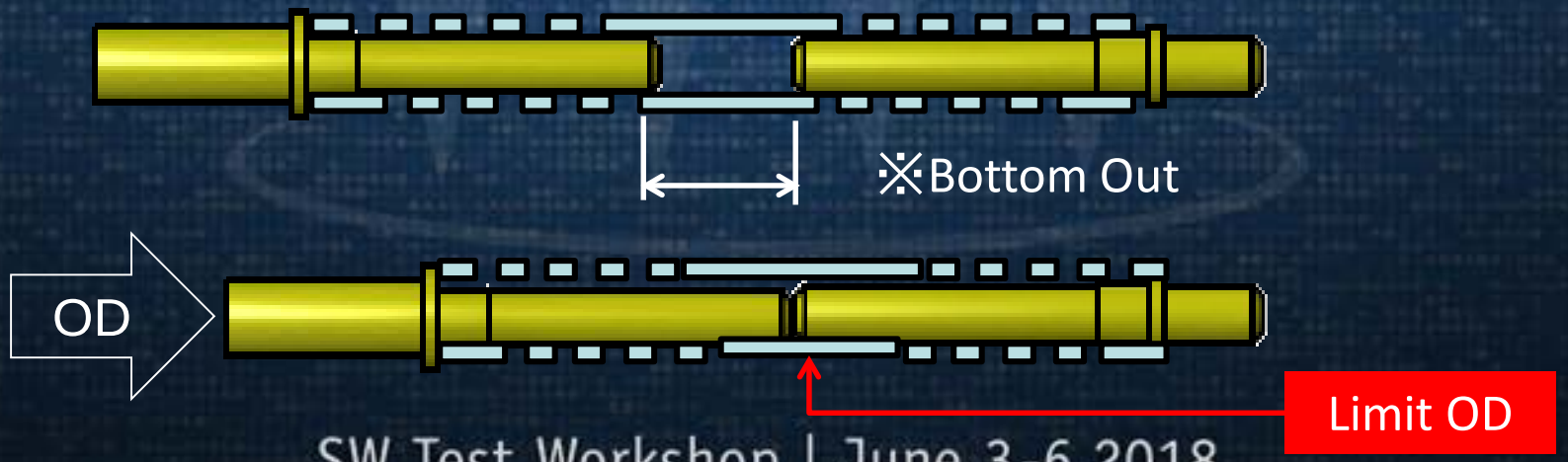


Design Feasibility
Highly Scalable MEMS Technology

(4) Operation OD margin

- Pre-load
- STD Operation OD
- Max Operation OD (=Bottom Out - Margin)
- Limit OD (=Bottom Out)



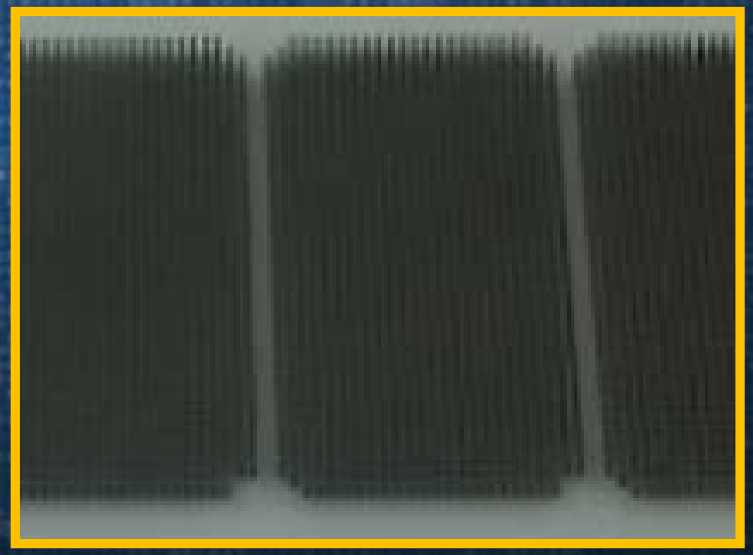


MEMS Probe Card General Specifications

MEMS Probe Card General Specifications

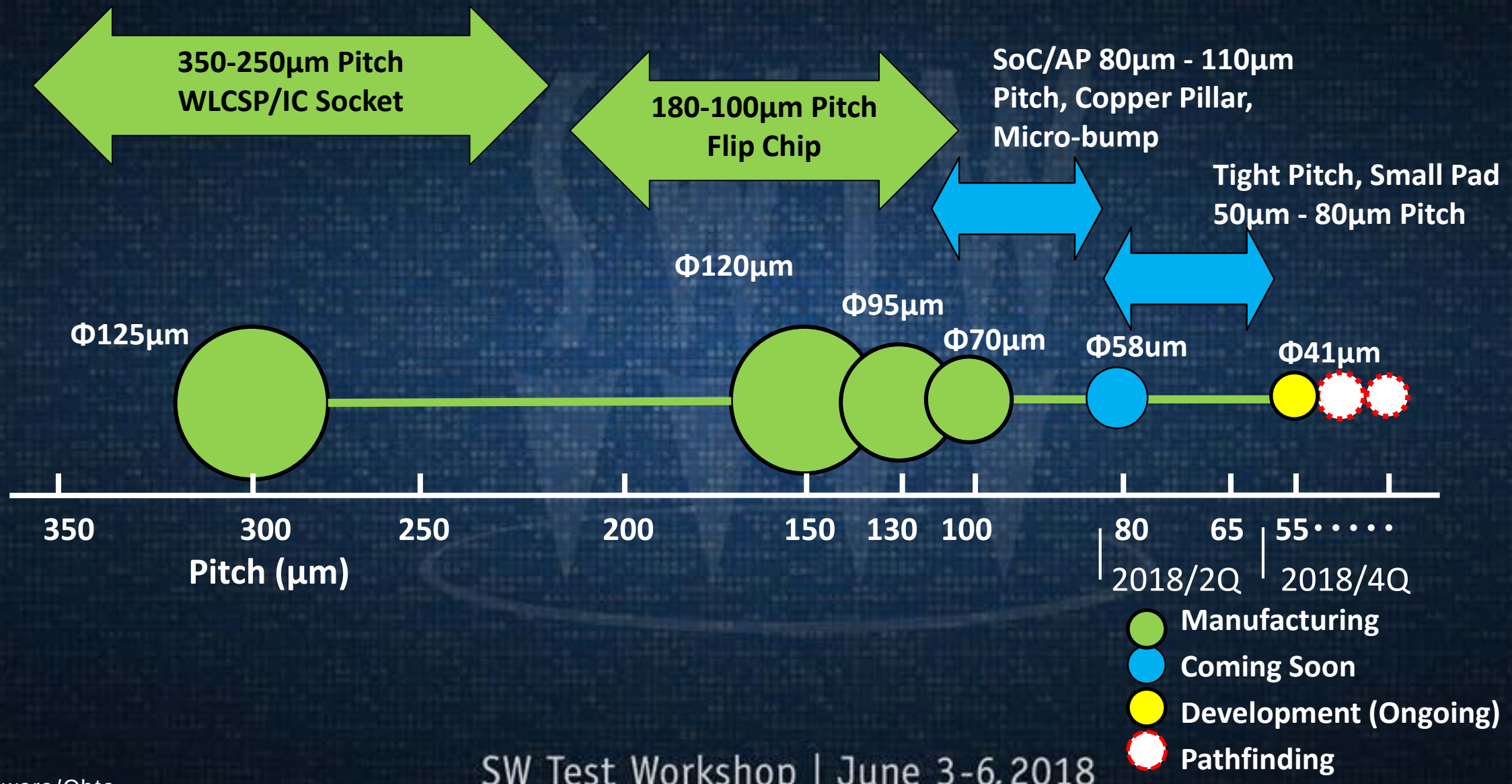
Parameter	SPEC
Pitch	Min 80µm
Planarity	< 10µm
XY Position	< ±10µm
Contact Force	Max 10gf
CRES	< 3Ω
CCC (RT)	P250(Φ125µm) – 1400mA P80(Φ50µm) – 600mA
Temp	-40℃～+180℃
Max OD (Example)	P250 - Max 250µm P150 - Max 400µm P80 – Max 180µm

Tip Motion	Self Rotating or Non-Self Rotating
Tip Shape	Point, Round, Flat, Crown
Material	W+Au, H3C, Rh



Roadmap

Technology Road Map



Future Study

- MAC
  - High temp +180℃
    - MLO/MLC frequency
      - 80um pitch
        - Auto probe insertion machine
          - High volume MFG capacity

Conclusions

- The MEMS SPRING PROBE technology can easily provide small diameter probes that cannot be realized with conventional coil springs.
- Simple structure realizes high CCC & low CRES which is stable over life & temperature.
- Minimize Bump damage by Rotation control & free tip shape.
- Positive performance CRES/OD, CRES/TD at Tri-temp.
- No degradation after 1MTD.
- Roadmap to 55µm pitch.
- Wide variety of pin specs achievable using common manufacturing process & no hard tooling.

Acknowledgements

- End User Test Engineering Team
- MEMS Spring Probe Engineering Team (Nidec-Read & LuzCom)
- SV TCL Engineering Team

Thank you