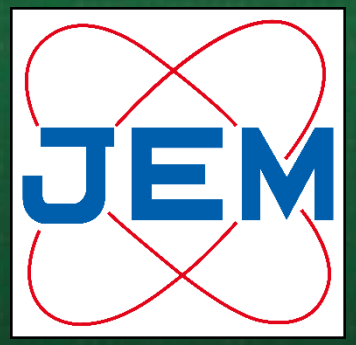
SW Test Workshop

Semiconductor Wafer Test Workshop

Probing Challenges with Cu Pillar



Phill Mai, JEM America

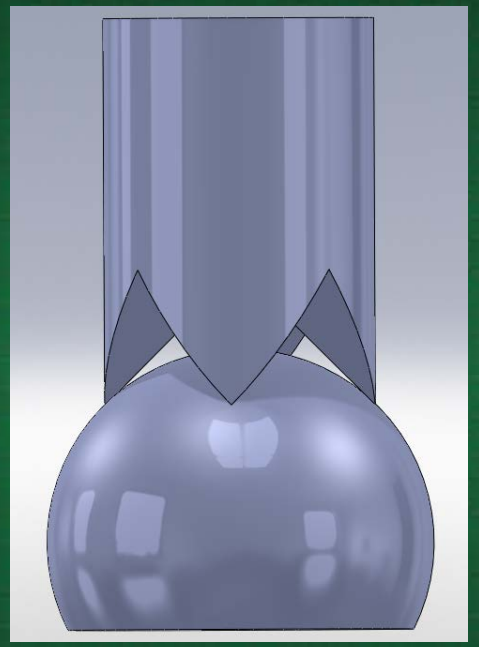
Joe Mai, JEM Europe

June 4-7, 2017

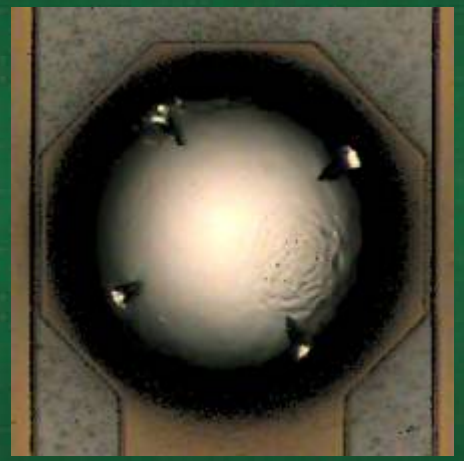
Overview

- Crown-tip probe limitations
- MEMS probe with flat tip
- Summary
- Future work

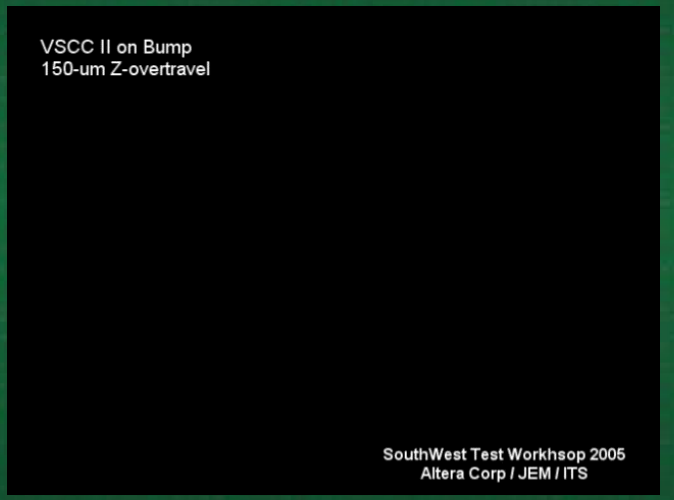
Crown-to-bump contact



Piercing Contact

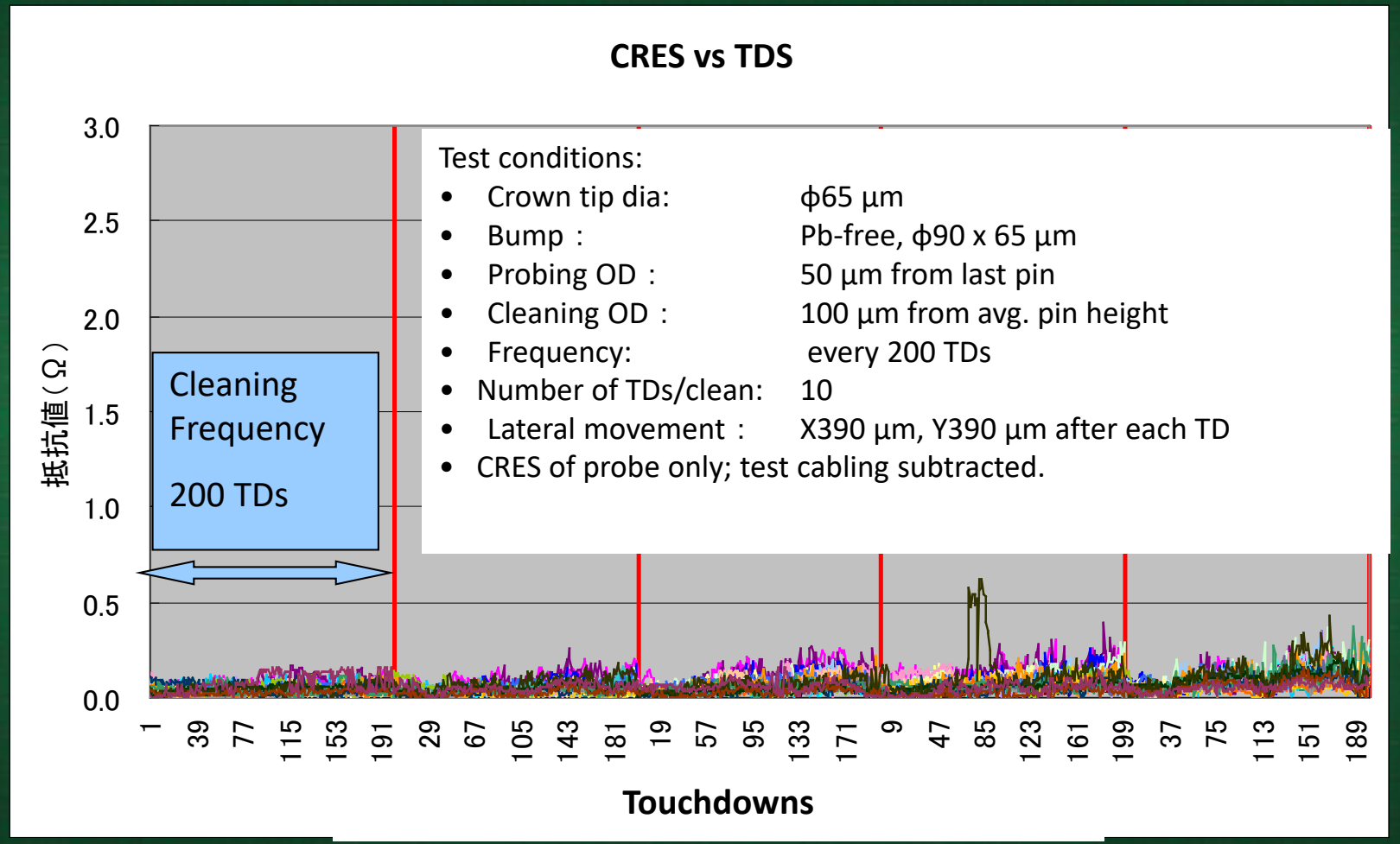


Probe mark

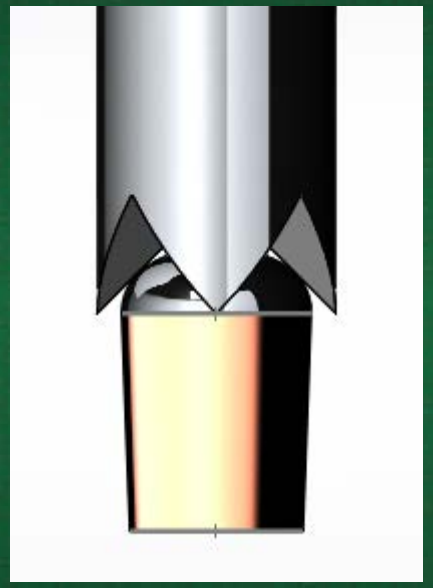


Abrasive/Gel Cleaning

Crown-to-bump CRES stability

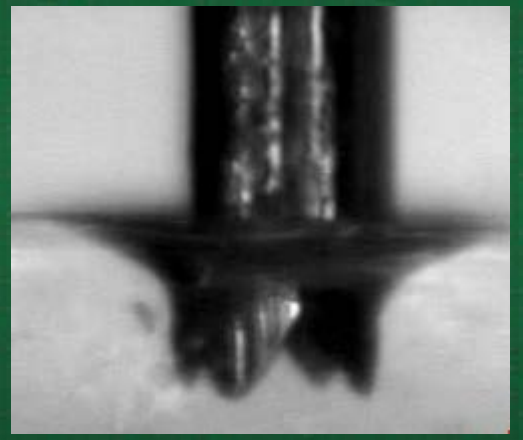


Crown-to-Cu pillar contact



Slicing Contact

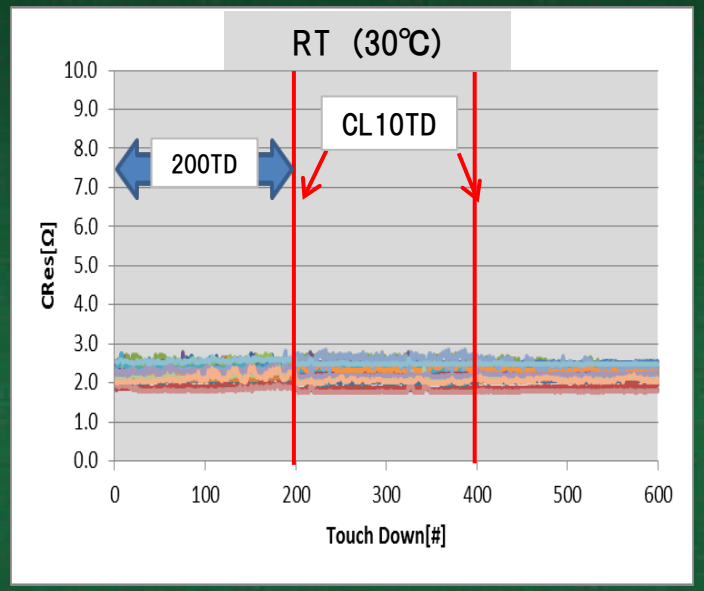
Probe mark

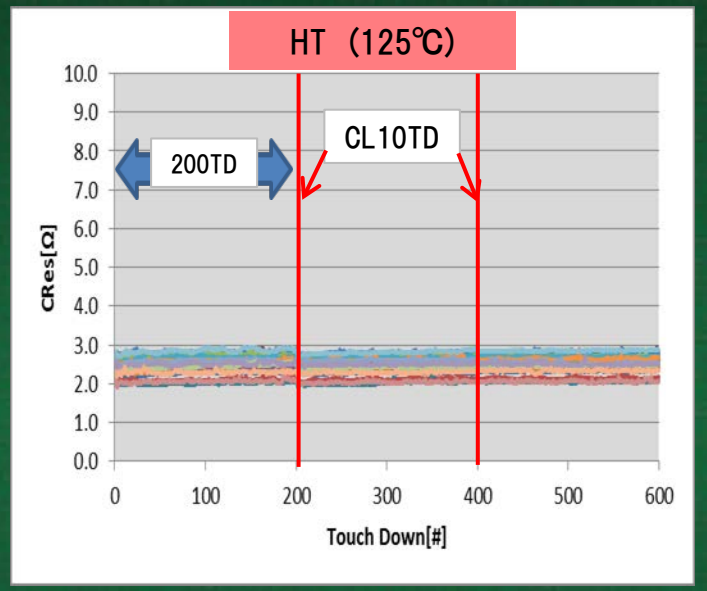


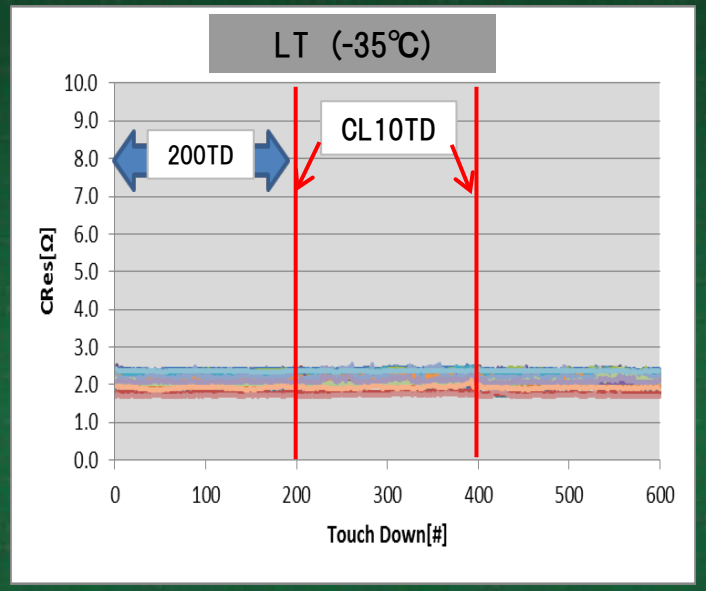
Abrasive/Gel Cleaning not so effective in the long term

Initial Crown-to-Cu pillar CRES stability

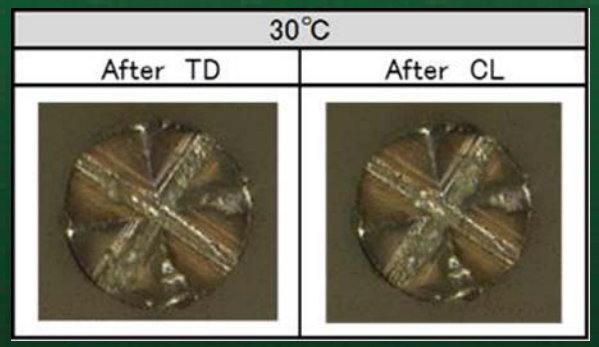
・Current: 50mA

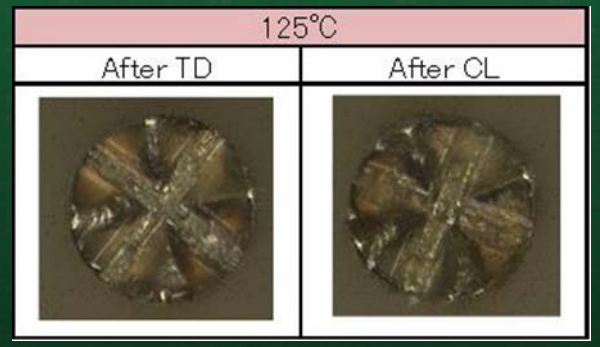


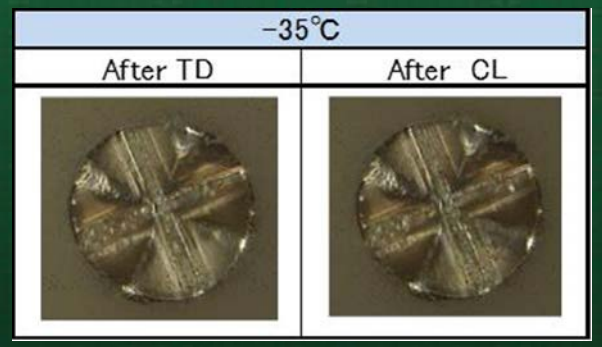




*CRES includes about 2 ohms of resistance due to PCB, Space transformer, Interposer, and probe body.

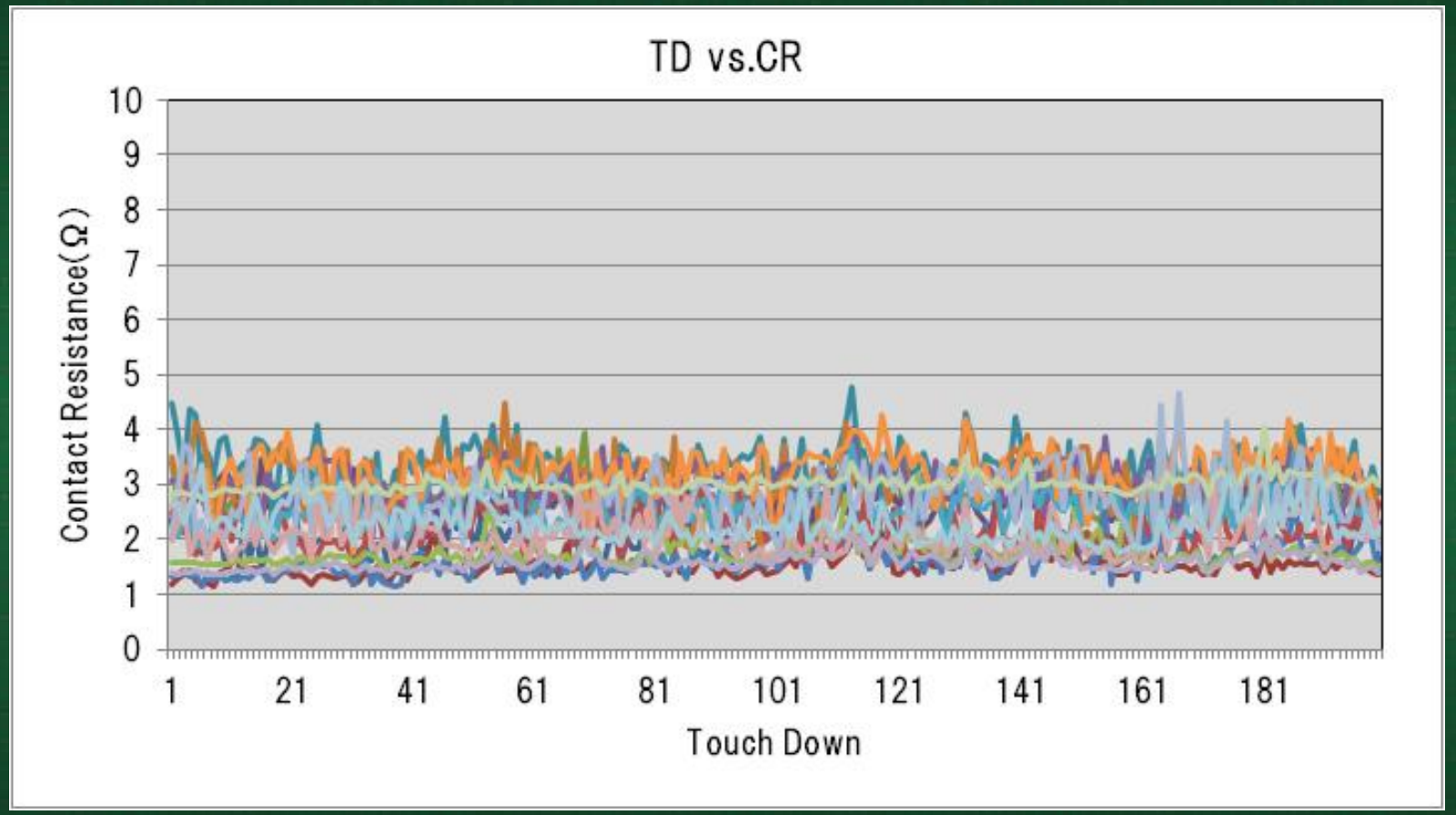




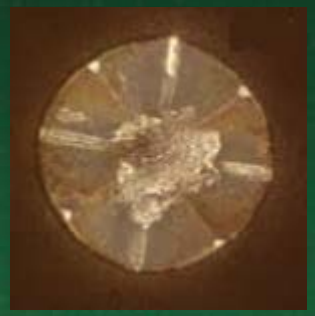


Long term Crown-to-Cu pillar CRES stability

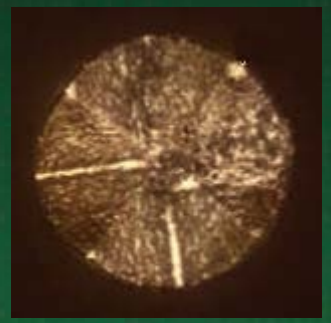
Adhesion of SnAg causes CRES instability after 50K TDs



Crown Tip Contamination with eutectic solder



Before laser

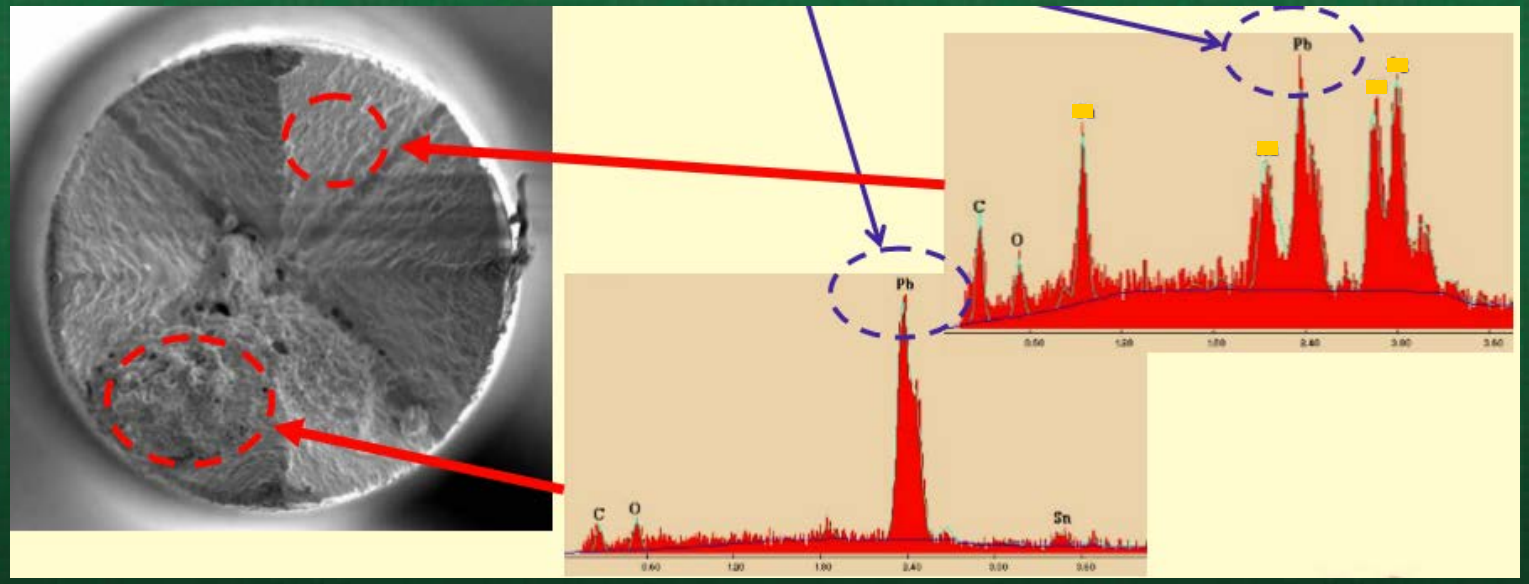


After laser

In 2007…

Laser: IMT800MV
Beam dia.: ~3 mm

Pb debris remains



Crown Tip Contamination with Pb-free solder

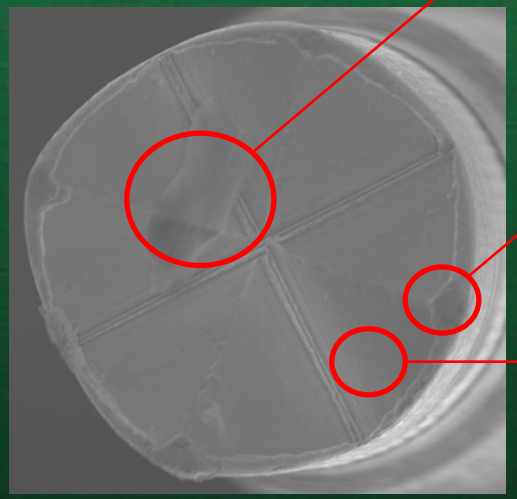
REF: “Probe Card Cleaning by Laser”, J.M. Lee et.al., SWTW 2010

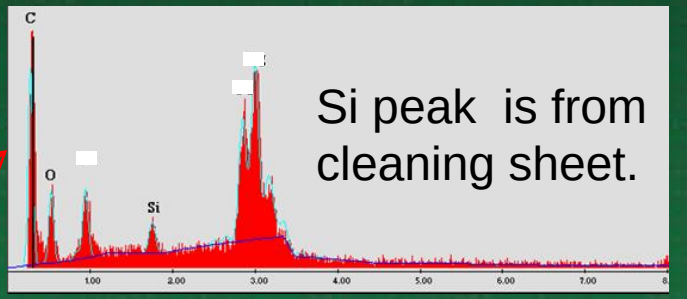
Before laser

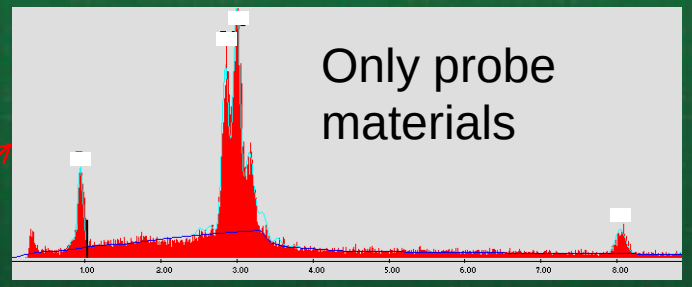
After laser

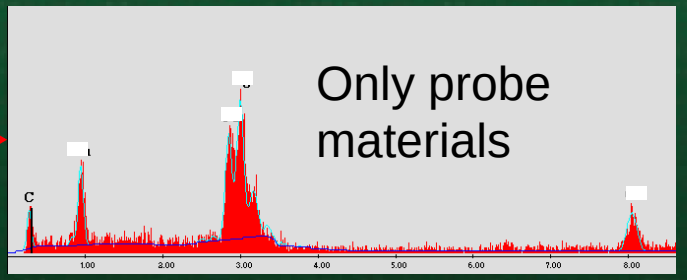
In 2016…

Laser: IMT400P
Beam dia.: ~3 mm

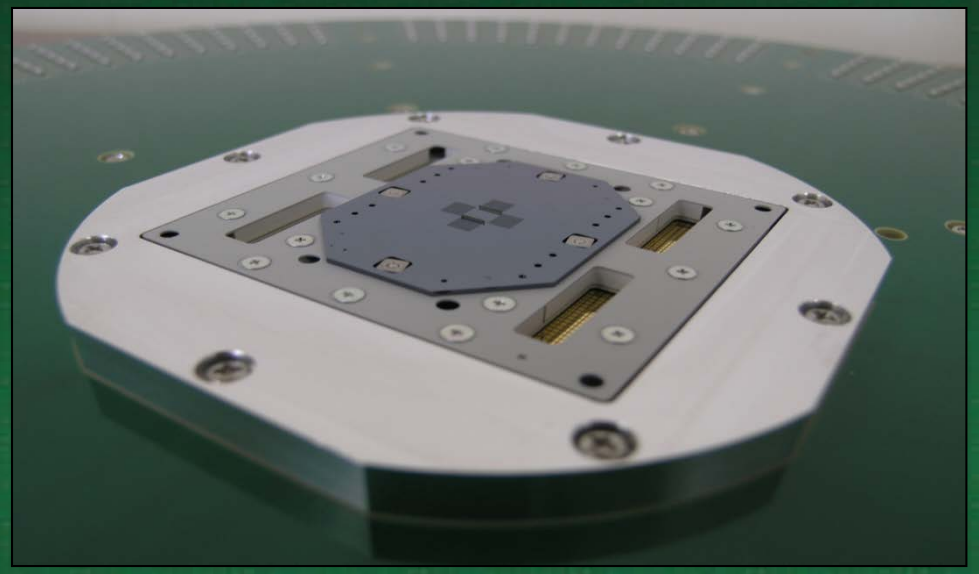


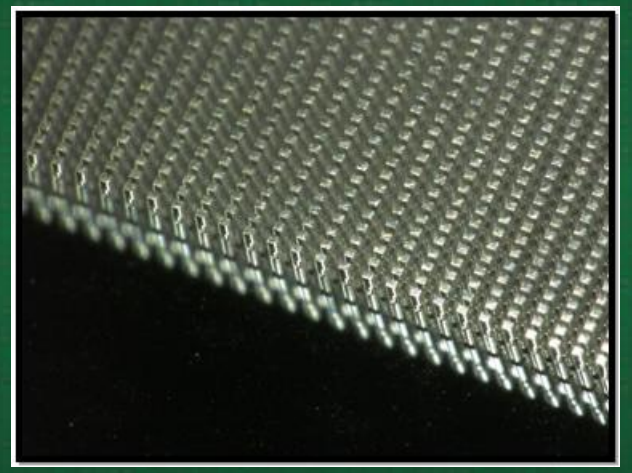


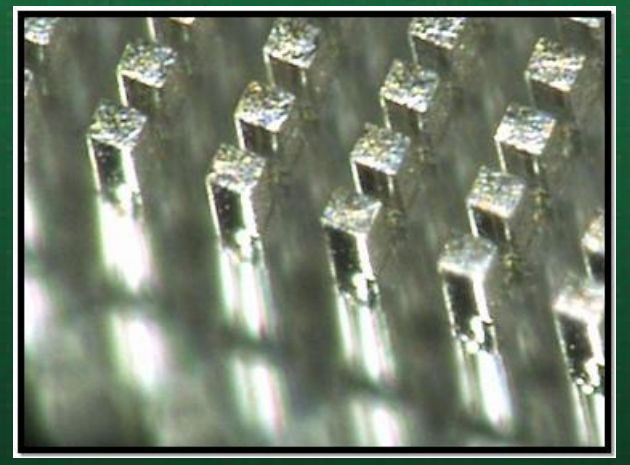




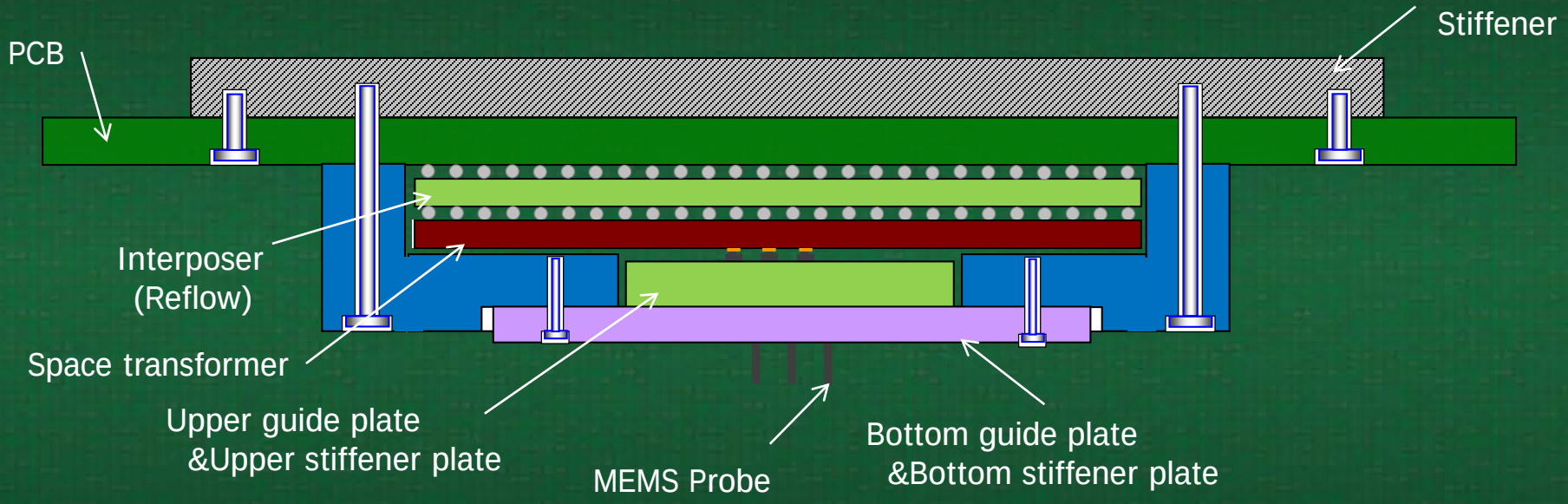
MEMS Technology (MT) as an Alternative







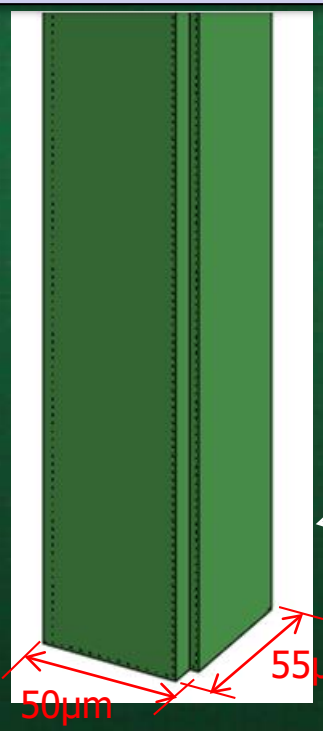
MT Probe Card Structure

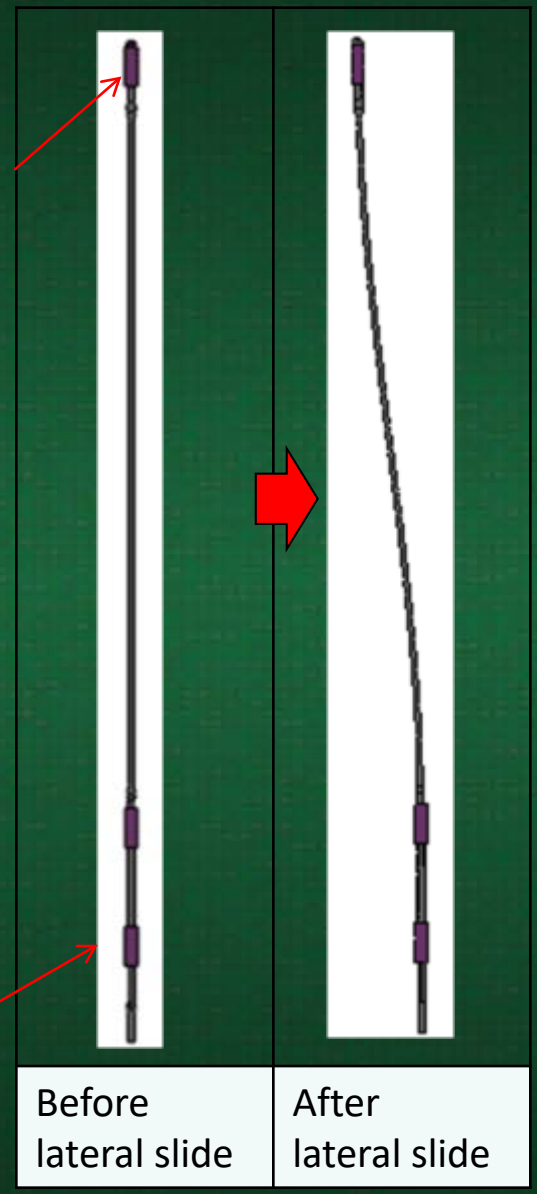


MT Probe

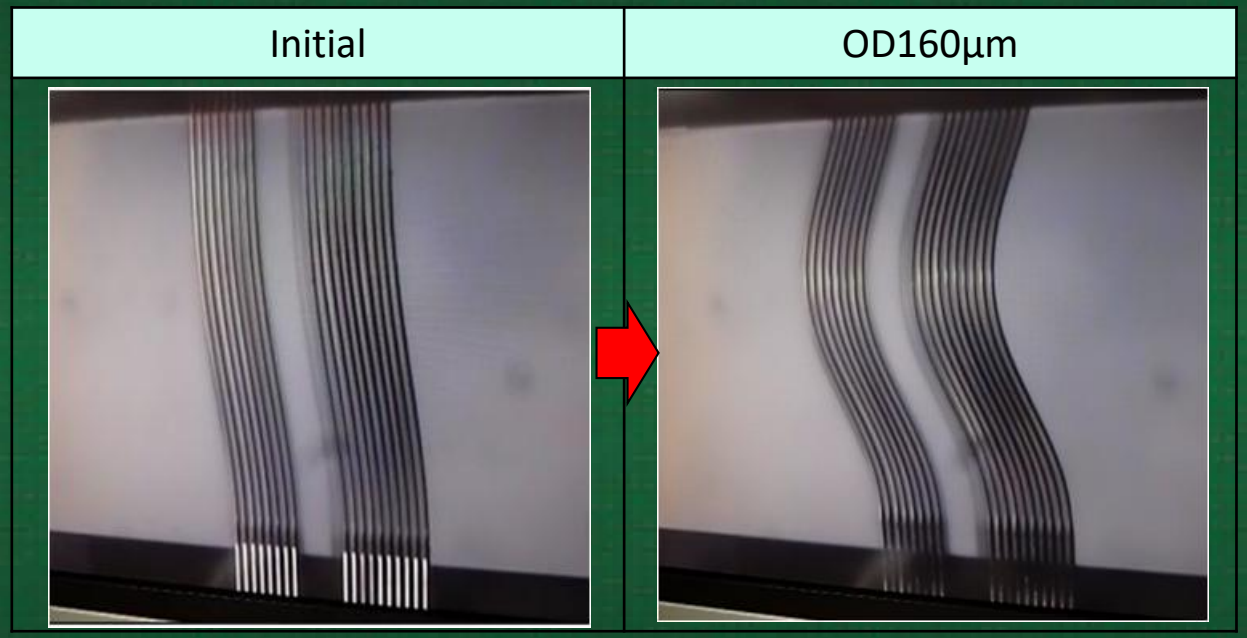
MT Probe characteristics

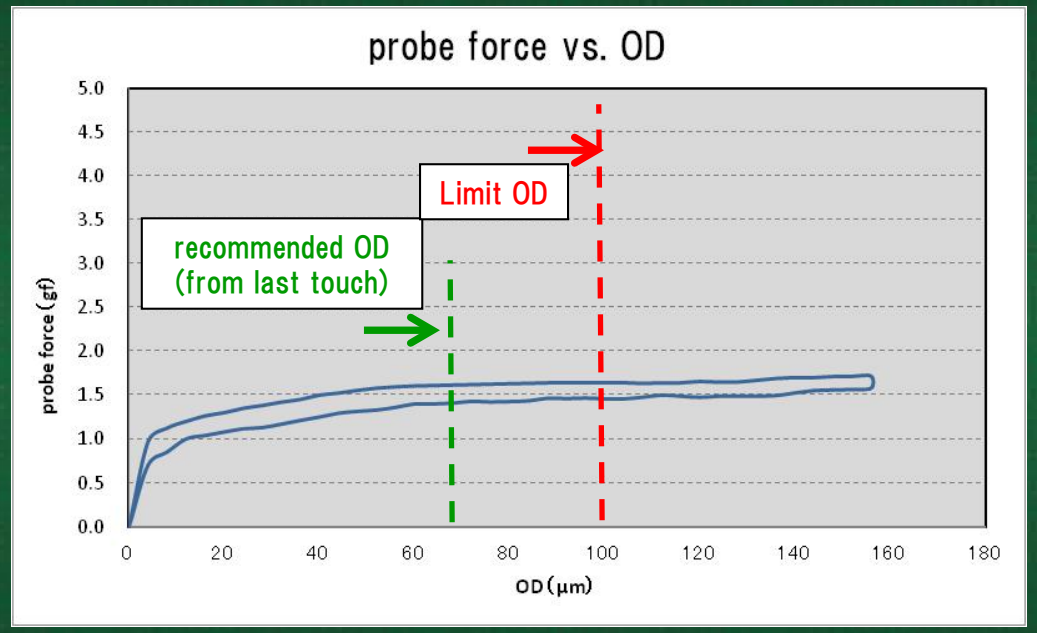
- Straight probe allows easy assembly and maintenance
- Composite (multi-layer) structure optimizes mechanical and electrical properties, and reduces probe wear.
- Tip material: Pd alloy



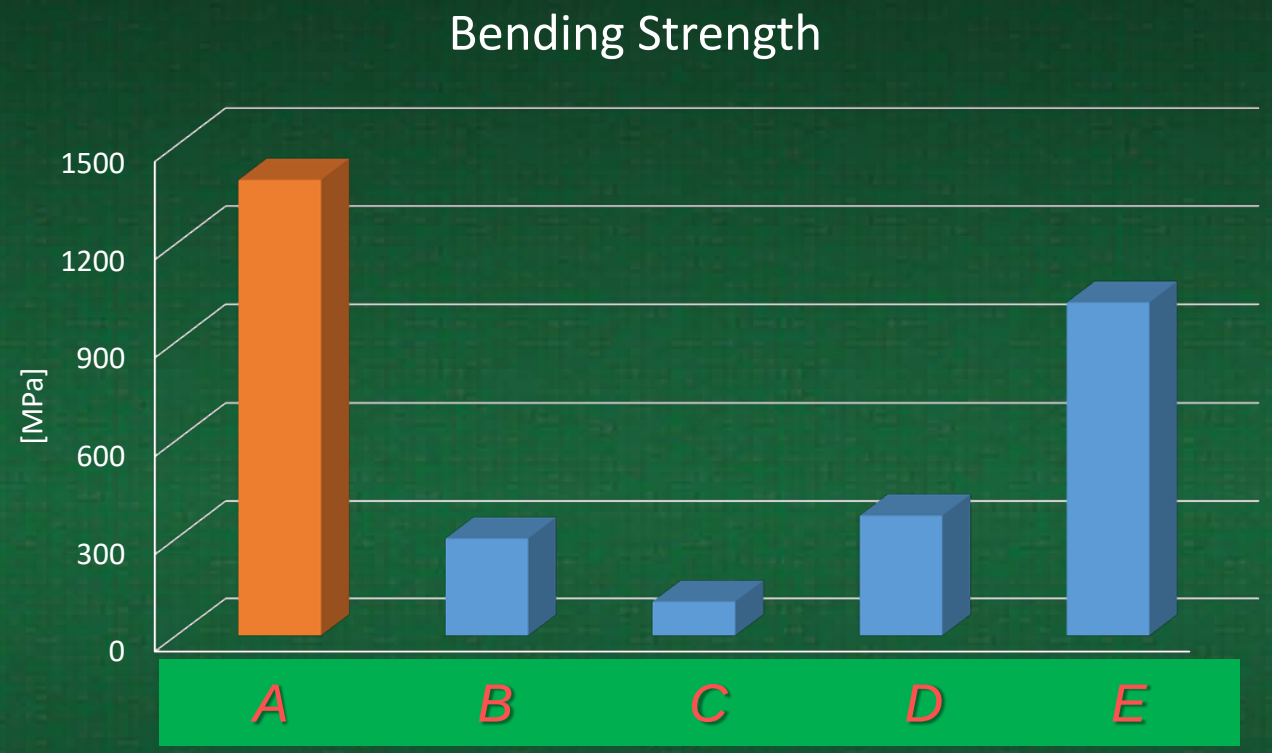


MT PROBE MECHANICS

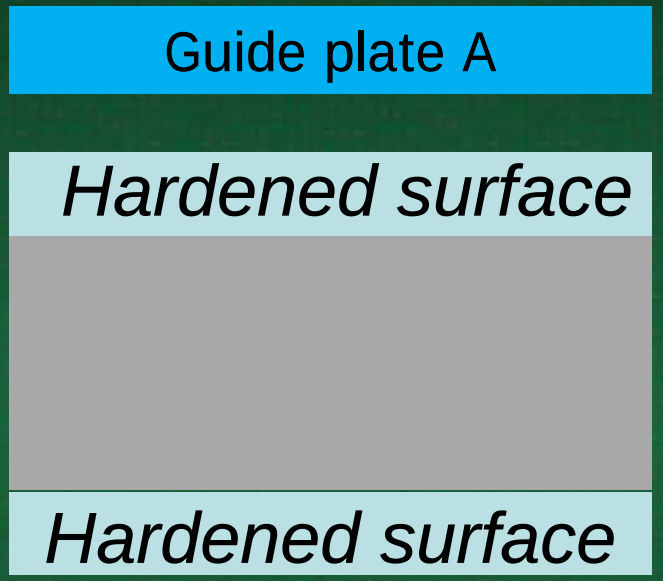




Guide Plate Selection



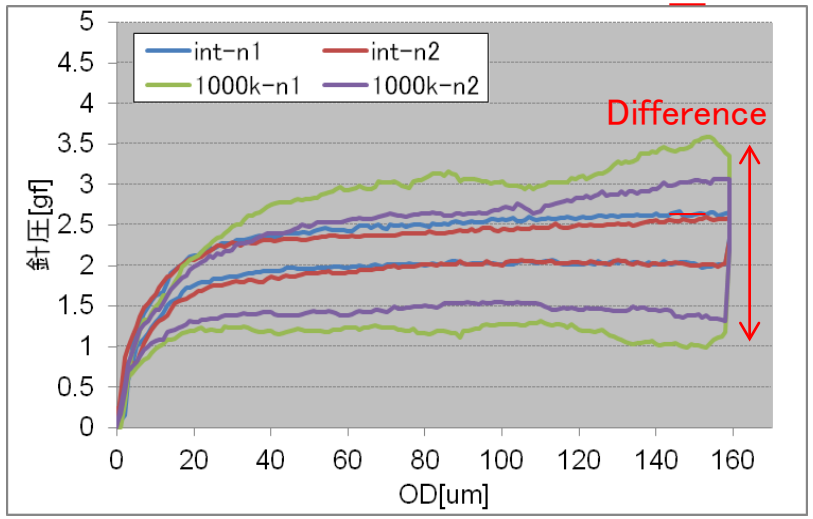
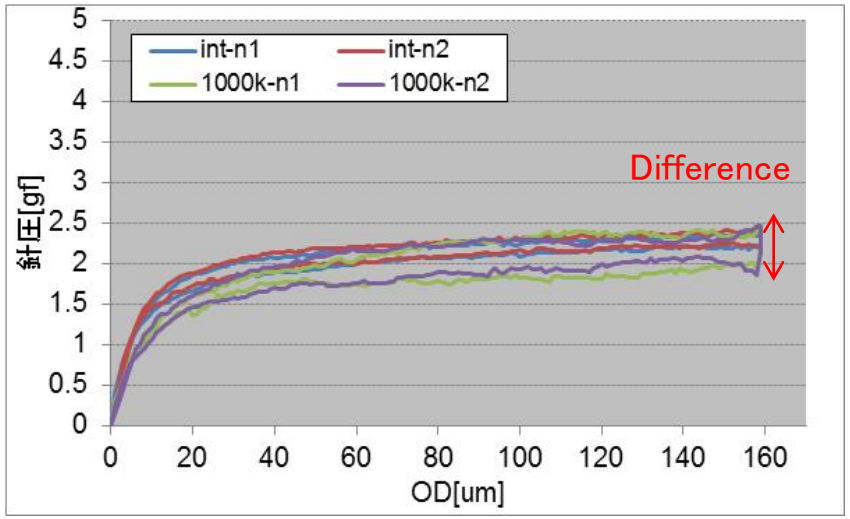
Guide plate materials



Guide plate A has high bending strength and low friction.

Probe Force Hysteresis

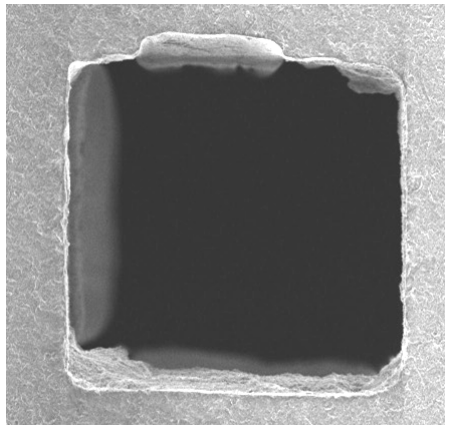
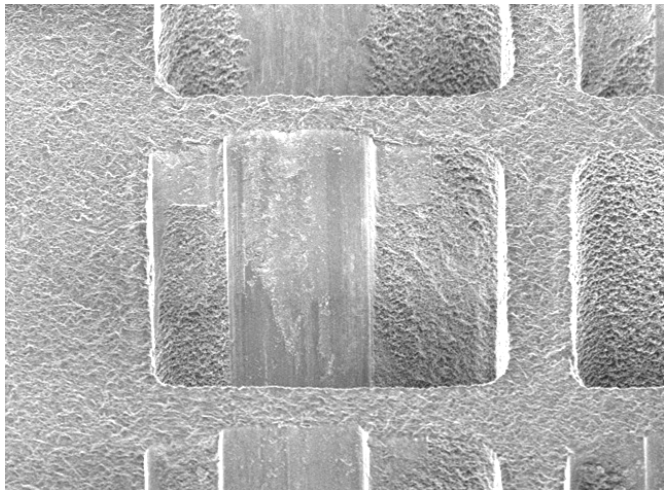
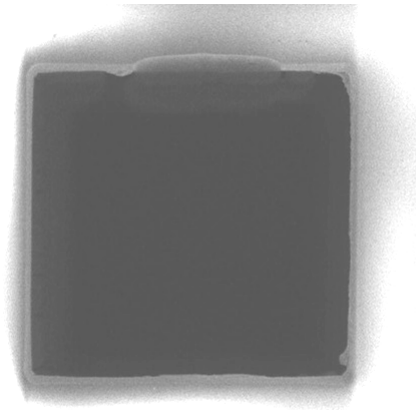
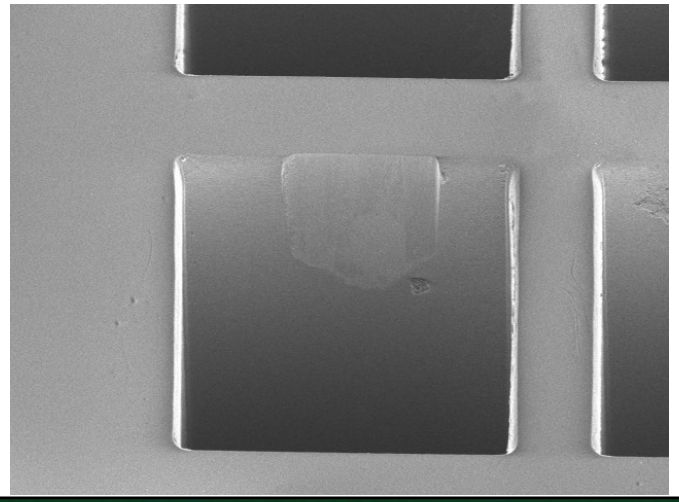
Probe : 2.5g Contact force version

	Initial Guide Plate	Optimized Guide Plate
Probe force hysteresis		
Difference		

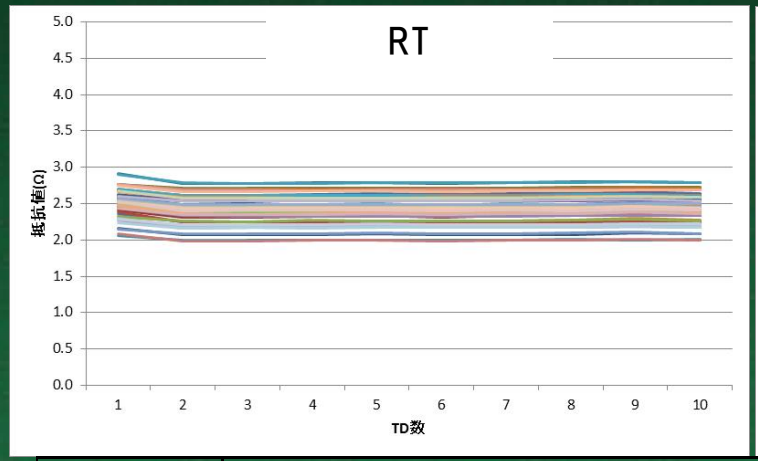
Sample	Difference	
	int	1M
N1	0.65gf	2.28gf
N2	0.57gf	1.72gf
Ave.	0.61gf	2.00gf

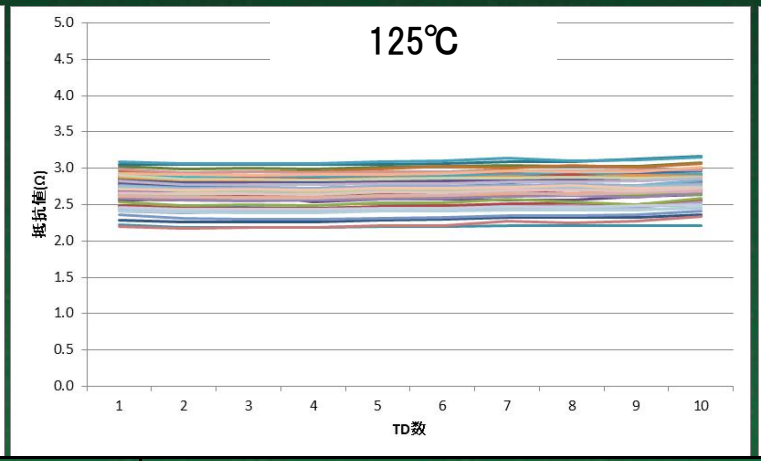
Sample	Difference	
	int	1M
N1	0.13gf	0.44gf
N2	0.18gf	0.56gf
Ave.	0.16gf	0.50gf

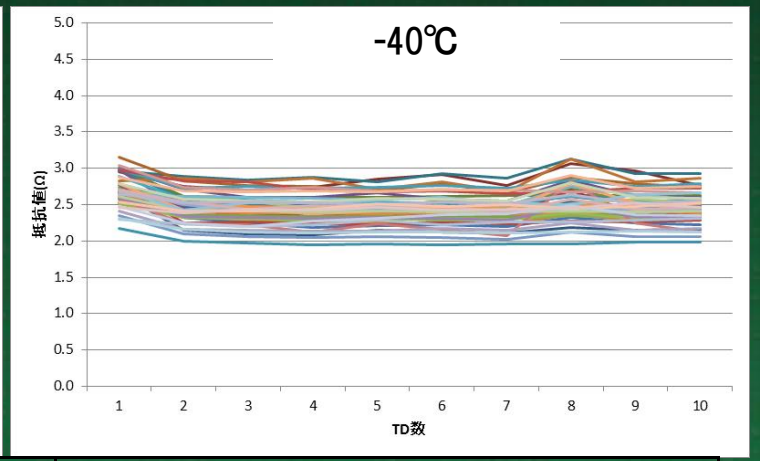
Guide-plate Wear

View:	Top of the Guide Plate	Oblique Angle View
Initial Guide Plate	 Wear ：4.4～5.5 μm（n=5）	
Optimized Guide Plate	 Wear ：2.1～3.1 μm（n=4）	

MT-to-Cu Pillar Probe Mark (multiple contacts)



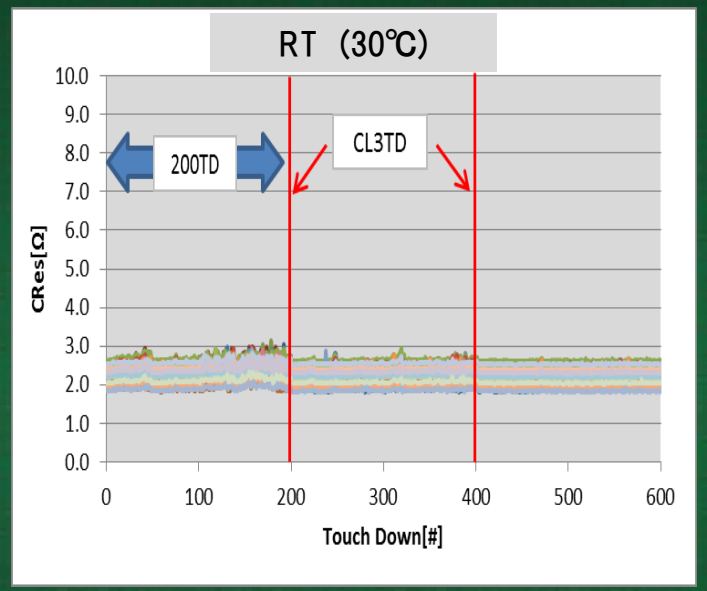


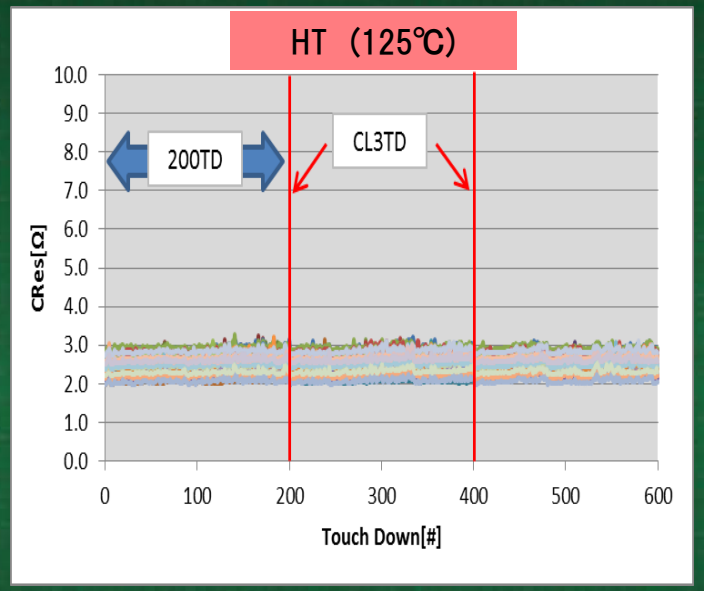


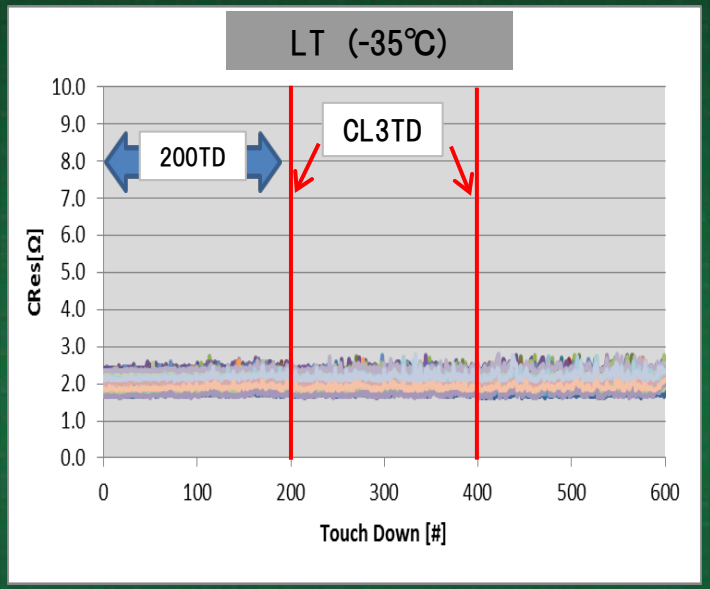
Temp.	30℃			125℃			-40℃		
TD counts	1st	2nd	5th	1st	2nd	5th	1st	2nd	5th
Contact Mark									
Percentage of flat-to-initial diameter	34%	36%	38%	49%	54%	60%	27%	28%	30%
Contact Mark Diameter (μm)	12	13	13	17	19	21	10	10	10
Contact Mark Depression (μm)	0.8	0.9	1.5	2.0	2.5	3.4	0.6	0.6	0.8

Flat-to-Cu pillar CRES Stability

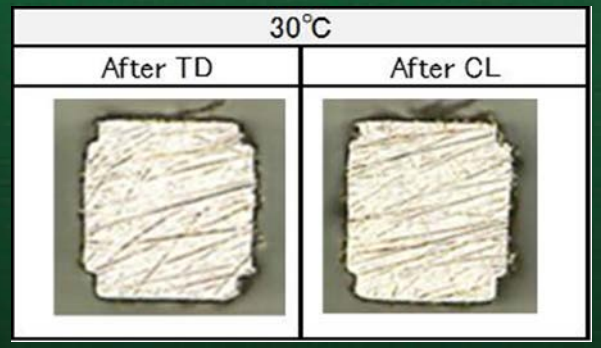
- Current: 50 mA
- OD: 70µm (from last pin)
- Cleaning Sheet: WA6000 lapping paper
- Cleaning Sheet OD: 70µm (from last pin)

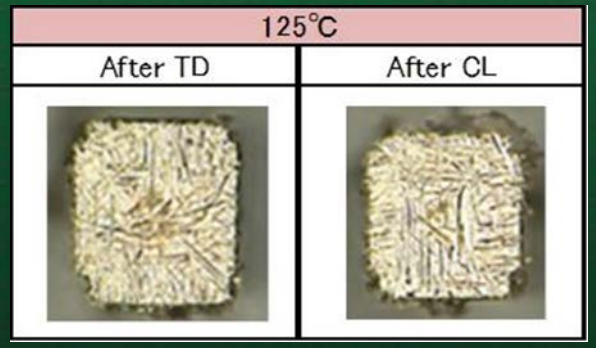


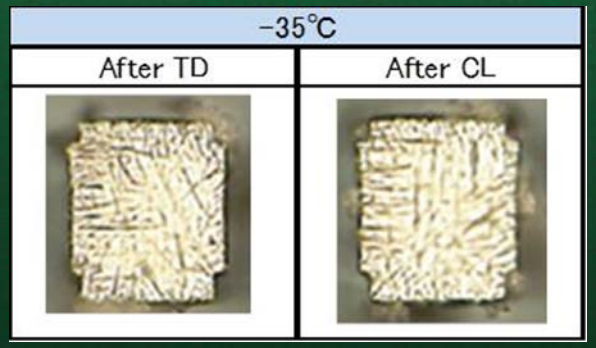




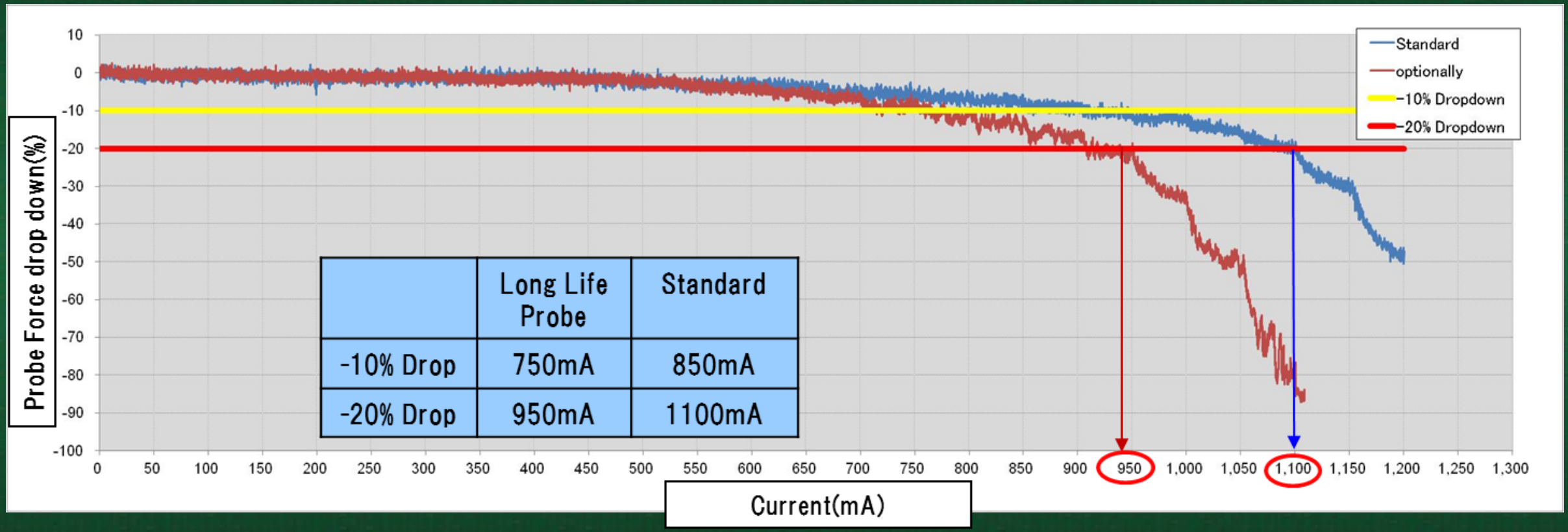
***CRes includes ~2 ohms of resistance due to PCB, Space transformer, Interposer, and probe body.**







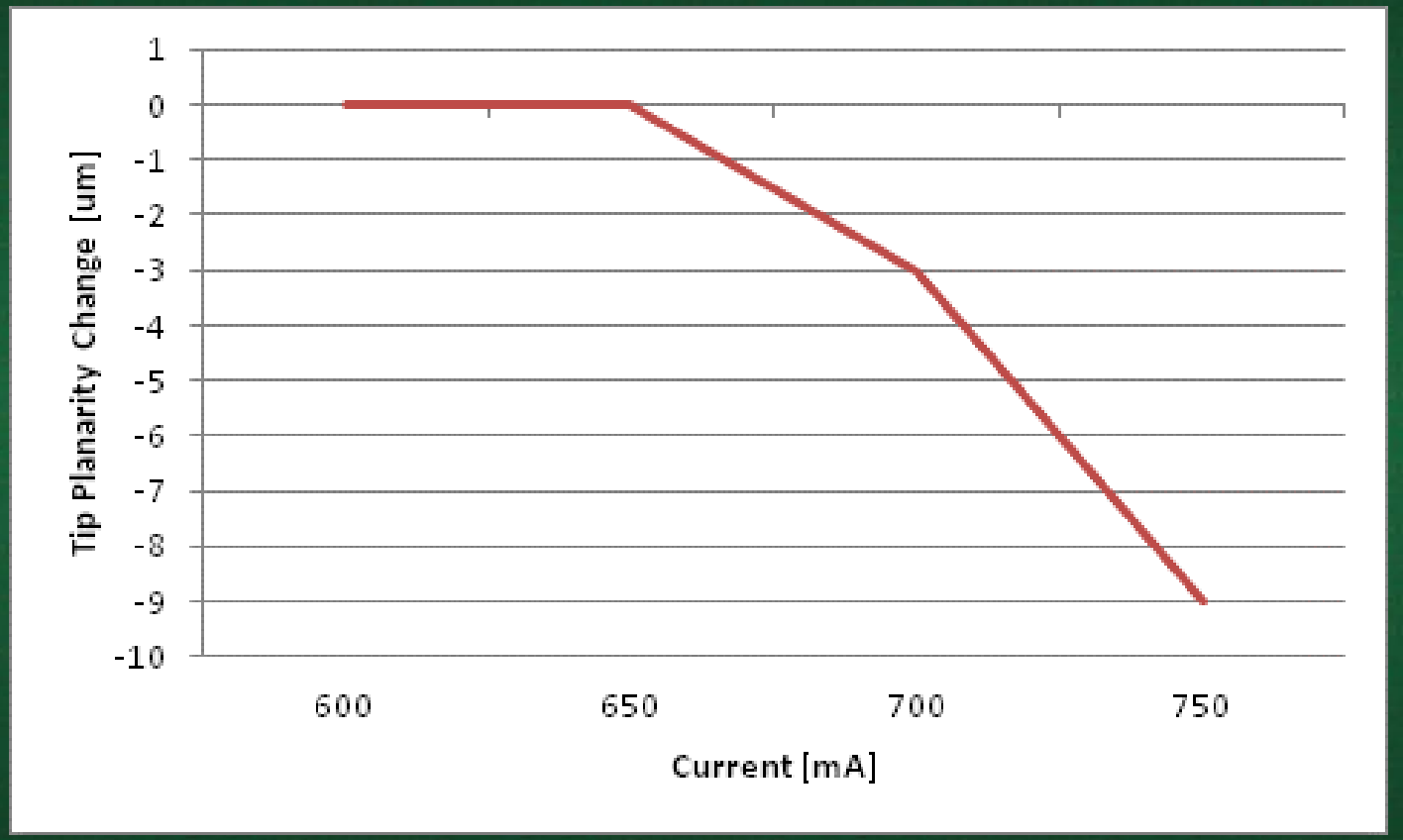
Current-Carrying Capacity (CCC)



	Long Life Probe	Standard
-10% Drop	750mA	850mA
-20% Drop	950mA	1100mA

Maximum Allowable Current (MAC)

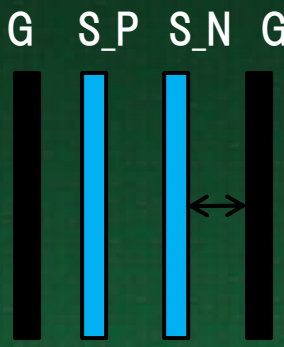
- MT probe for 80 um pitch
- Contact OD:MT 70μm / VS 100μm
- Pulse:10Pulses @ 1 min-on/1 sec- off
- Current: 600, 650, 700, 750mA
- Number of Pins: 3 pins for MT and VS



MAC: ~650mA

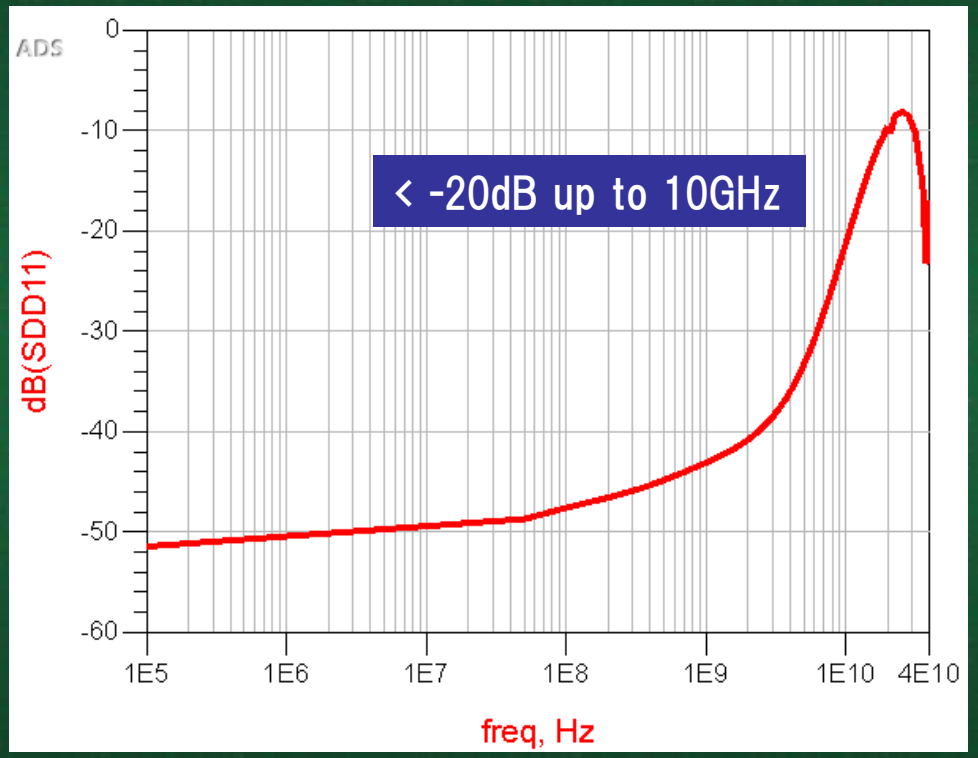
Bandwidth

■ Sparameter Model

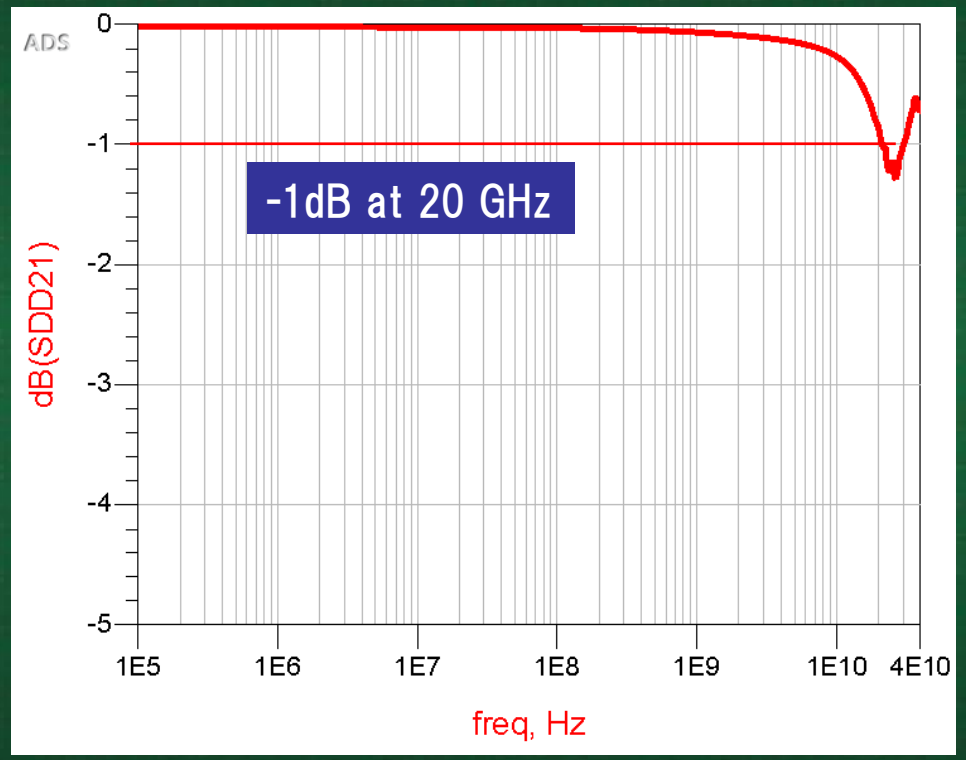


Pitch:80 μ m
Length:7.23mm

MT80 - Differential S11



MT80 - Differential S21

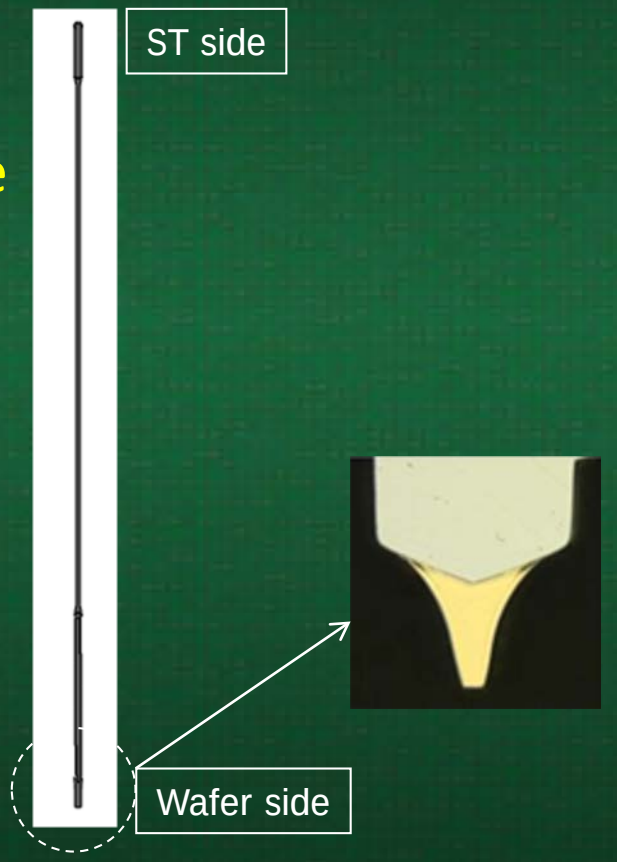


Summary

- Probing Cu pillars with minimal bump damage and stable CRES is challenging.
- Crown tips can be used, but tip cleaning is difficult and requires offline laser cleaning.
- Flat-tip MT probes are effective for probing 35 μm dia. Cu pillars if low-friction guide plates and low probe forces are used.
- MT probes have high CCC and MAC even with small probe cross-sections.

Future Work

- Develop 40um pitch MT probe.
- Increase CCC of 60-um-pitch probe to at least 500 mA.
- Develop pointed tips for Al pad contact.
- Optimize overdrive vs. temperature to minimize bump damage
- Increase max. temperature to 175 °C.



Acknowledgements

- Atsushi Mine, JEM Japan
- ITS