



SW Test Workshop
Semiconductor Wafer Test Workshop

High and Low Temperature Wafer Probing Challenges



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Overview

- **Motivation**
- **Probing challenges at high/low temperatures**
- **Production probing issues with reference probe card**
- **Prober setup optimization**
- **Technoprobe solution introduction and results**
- **Conclusions**

Motivation: Automotive Applications

Power
Management

Connectivity

Sensors

Safety



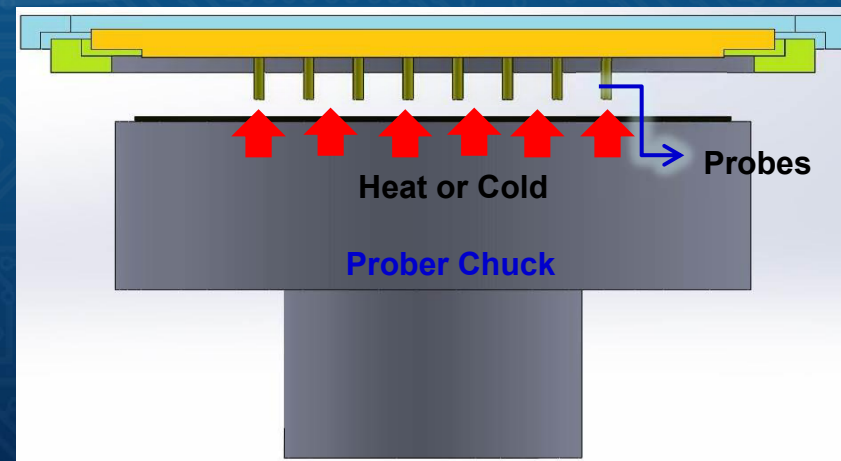
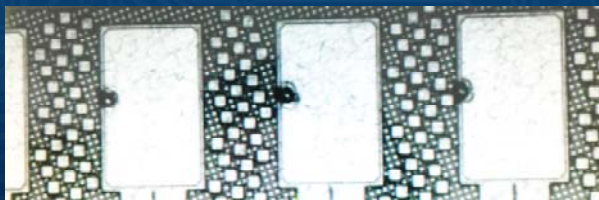
Security

Probing Challenges At High/Low Temperature

- **Temperature variation makes everything dynamic, requiring the stabilization of thermal deformation of mechanical setup**
 - Thermal contraction and expansion of probes
 - Planarity of prober chuck
 - Optimization of chuck movement
 - Condensation and icing
 - Probe card design and technology

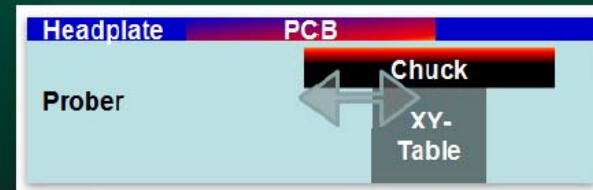
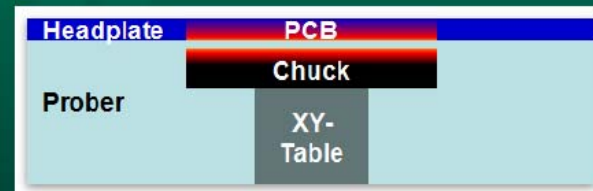
Mechanical Setup Stabilization – Thermal Deformation

- Chuck temperature affects probe card + prober deformation → x,y,z displacement of tips.
- Uneven expansion and contraction causes:
 - Uneven contact between different probes
 - Incorrect overdrive
 - Pad damage
 - OD out of control (z)
 - Incorrect alignment (x,y)

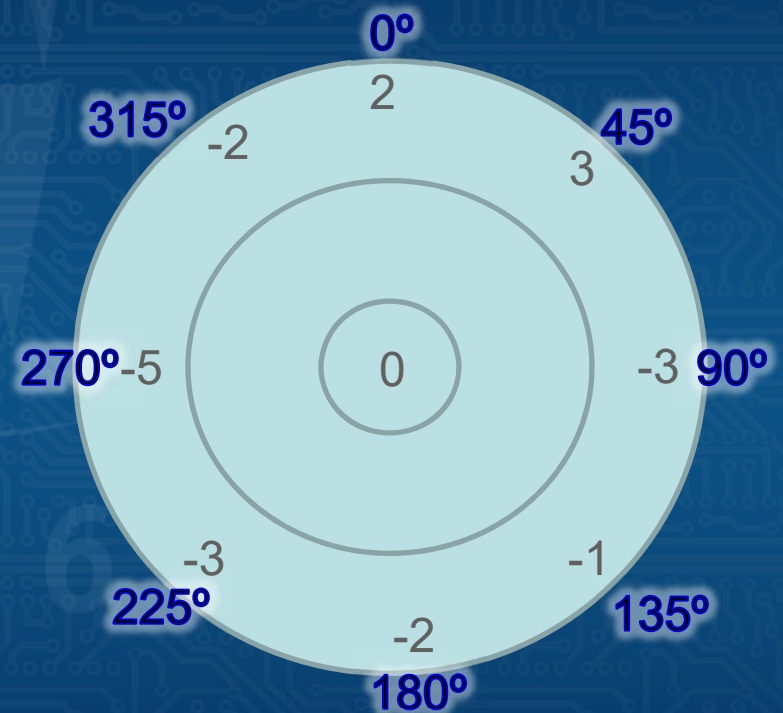
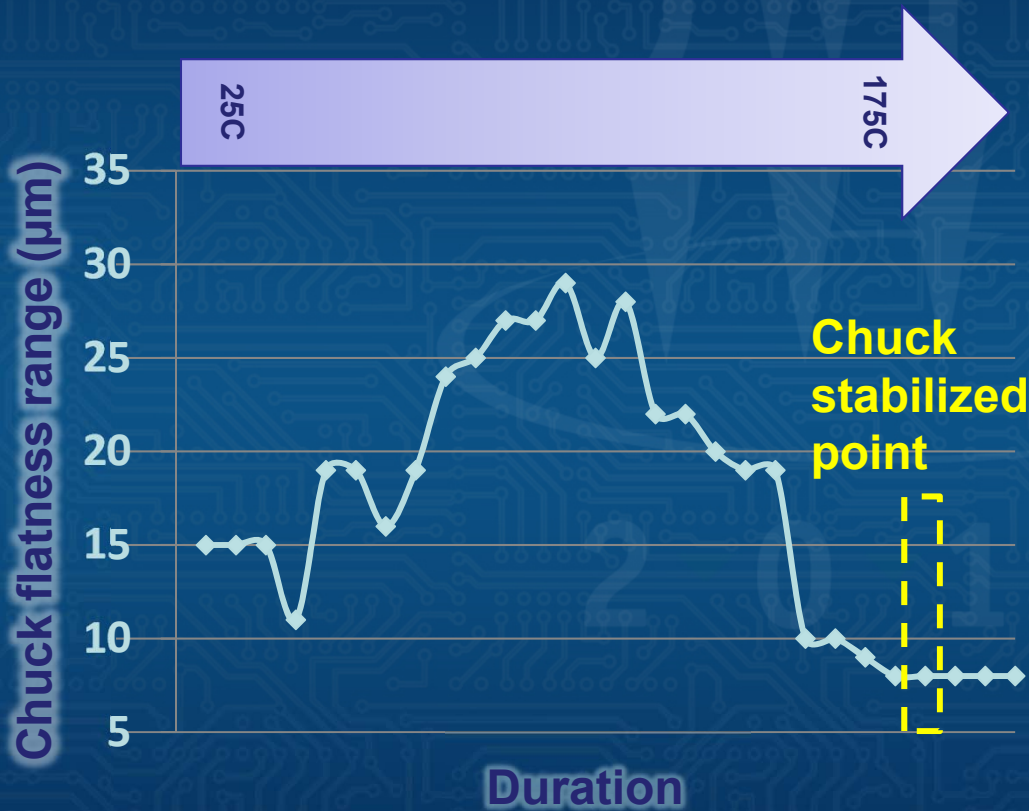


Continuous thermal stress by moving chuck

- **Wafer start up**
 - Fast heating of PCB
 - Head plate slow temp. change
- **Moving chuck**
 - Change of thermal gradient in PCB
 - Depends on size and thickness
- **Long term status**
 - Headplate warms up
 - Continuous change of thermal gradient in PCB

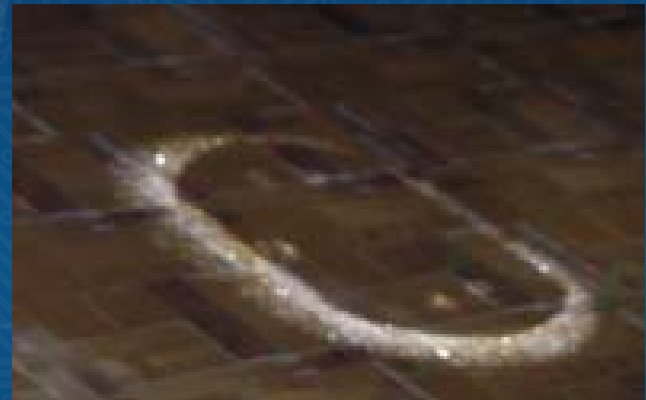


Chuck Flatness Stability Over Time



Condensation

- **Environment temperature cause condensation**
 - Condensation inside prober and on the probe card
- **Preventive Measures**
 1. Probe card sealing
 - PCB thru hole
 - Probe head
 2. Dry air purge of probe card
 - Dry air displaces humidity around the probe card to prevent condensation during low temperature probing



Device Description

- **Tester platform is Teradyne J750, Aurora tower**
 - PCB is directly in contact with the card holder
 - External stiffener cannot be implemented
- **Probe card details**
 - Pin count: 159
 - Pad layout: peripheral, 2 rows
 - Array size: 3 mm x 3 mm
 - Min pitch: 100 μm
 - Min pad opening: 60 x 90 μm
 - Pad metallurgy: Al pads

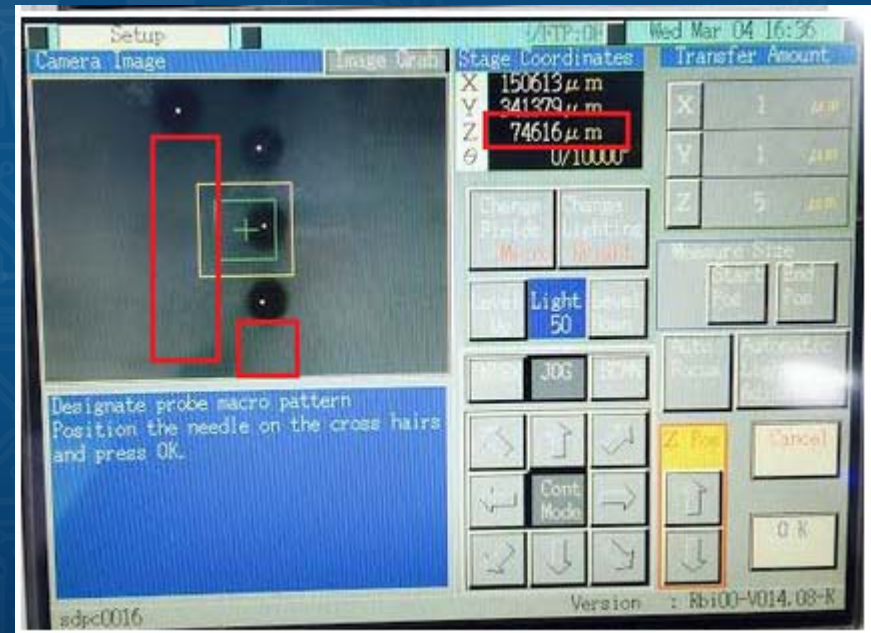
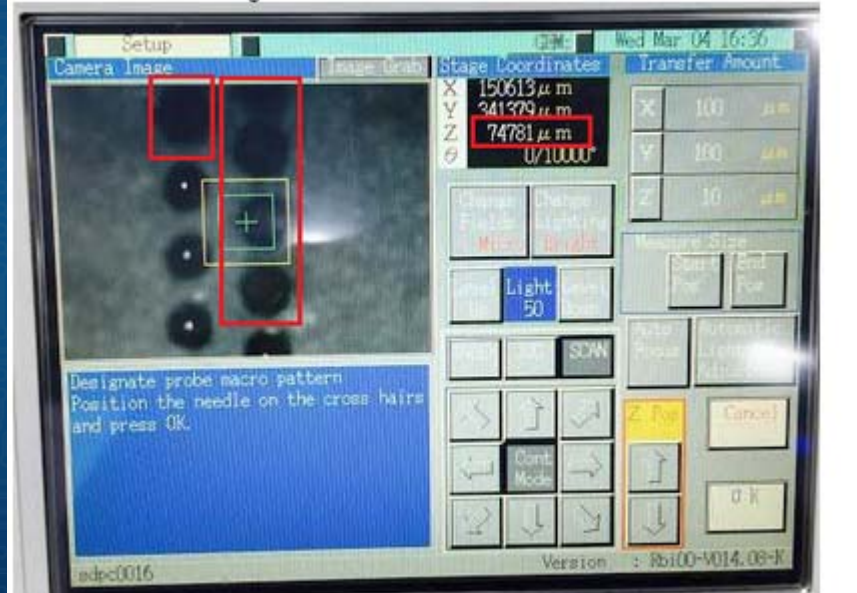
Production Probing Issues

- **Issues encountered with existing probe card**
 - Frequent floating needle issues observed during extreme high and low temperature testing.
 - Constant probe realignment requirement for high temperature testing.
 - Continuity and yield issues
 - High cost Polisher material to maintain probe's contact resistance during high temperature testing.

Production Probing Issues

- **Excessive pin floating: PH mechanical issue**
 - Floating issue higher than 150um < happen frequently during high/low temperature testing and exit maximum spec 50um.

Around 165um Z height different



Production Probing Issues

- Z height variations at high Temperature

Uneven probe height causing prober misalignment is magnified at high temperature

Uneven height still present after probe re-seating

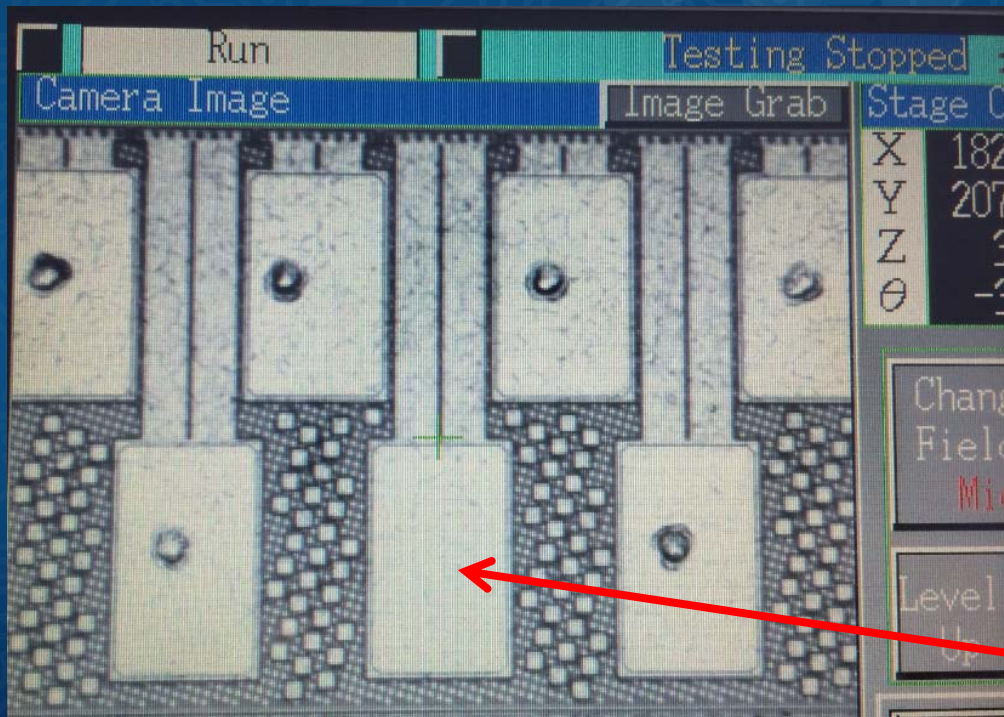


250uM height different

Production Probing Issues

- **Missing probe marks**

- Additional probe alignment required every 5mins to avoid probe mark shift

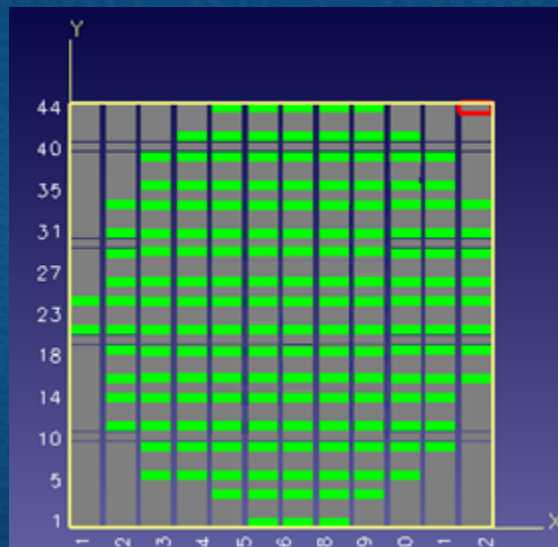


Probe mark with OD 65um

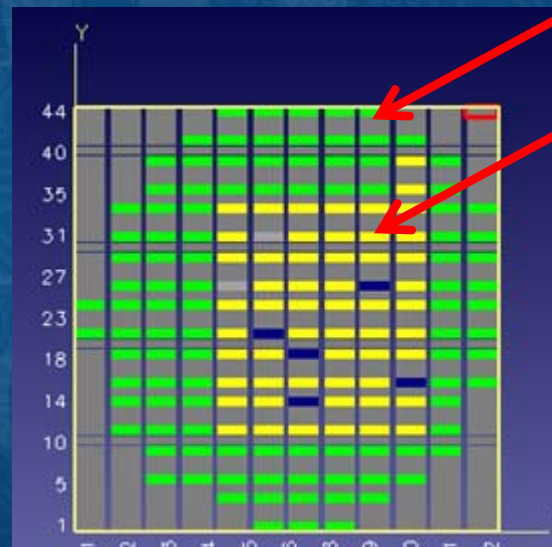
Missing
Probe mark

Production Probing Issues

- Observed continuity issue at wafer center from 2nd wafer onwards



First wafer



Next wafer

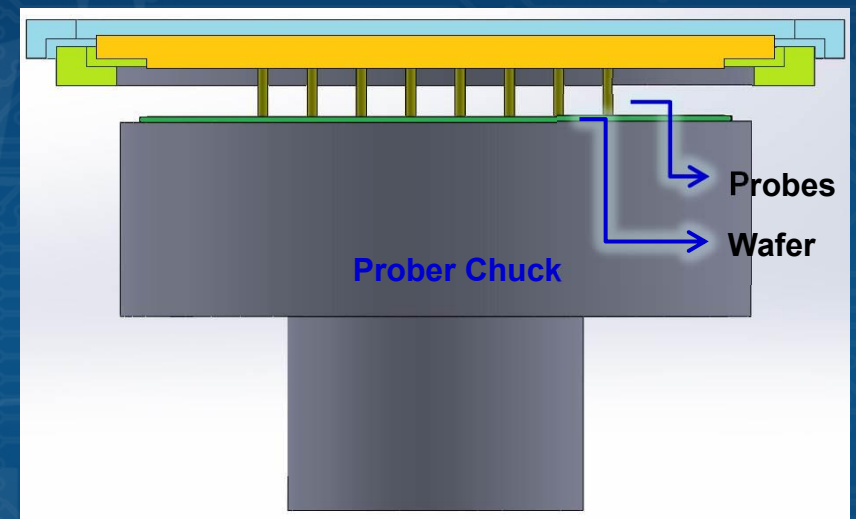
Good probemarks

Issue probemarks

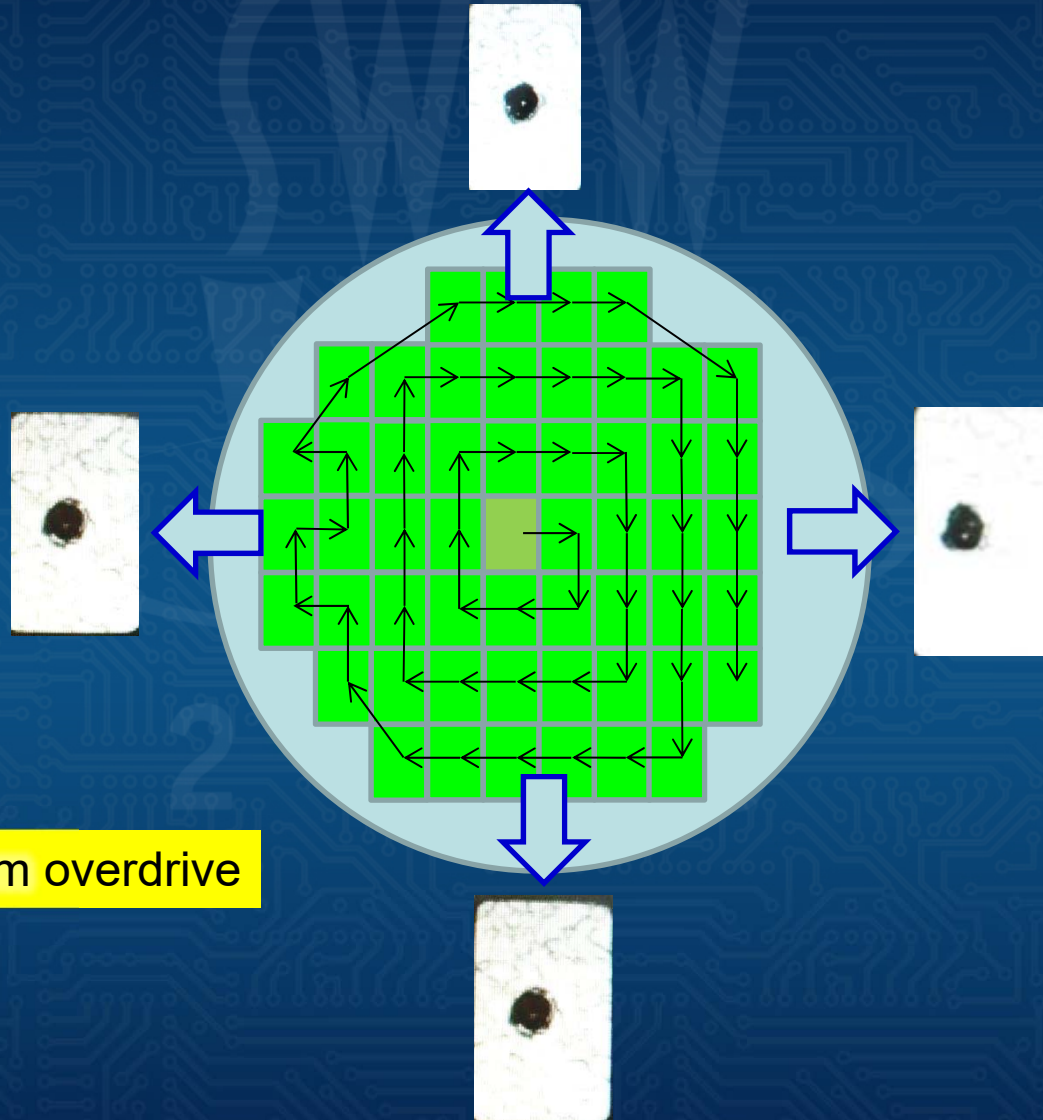
Yellow color =
continuity failure
bin

Soaking Requirement During Probing

- **Stability during test**
 - Preheat first die with contact
 - Require additional soaking for long pauses
 - Realignment after preheat

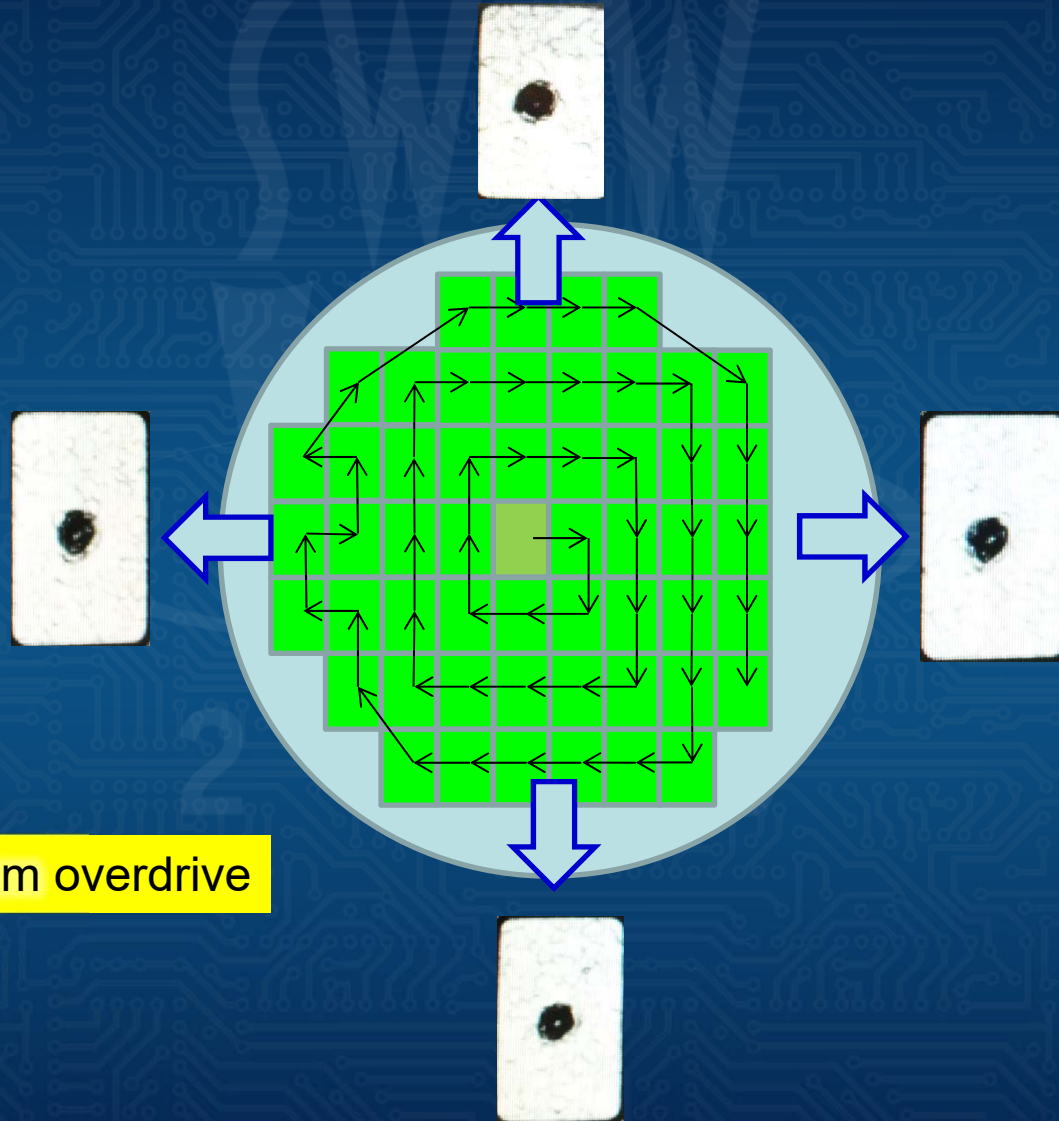


Probe Mark Profile at 175°C



Probing with 50µm overdrive

Probe Mark Profile at -40°C



Probing with $50\mu\text{m}$ overdrive

Test Results

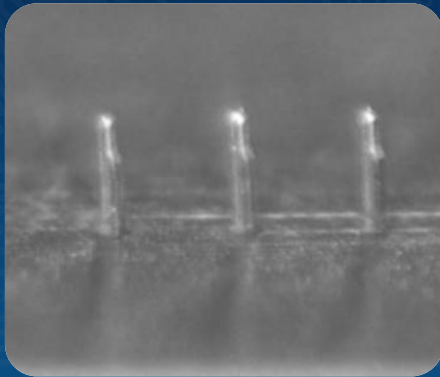
Continuity failure bin



Technoprobe Probe Card Introduction

- **Developed a dedicated design, to achieve a weak mechanical interaction between PH mechanics and PCB**
- **Sealing is applied to isolate prober interior from external environment and prevent condensation during low temperature testing**
- **PH technology is based on TPEG™ MEMS T1, developed to address probing of Al pads and POAA from -55°C up to + 200°C**

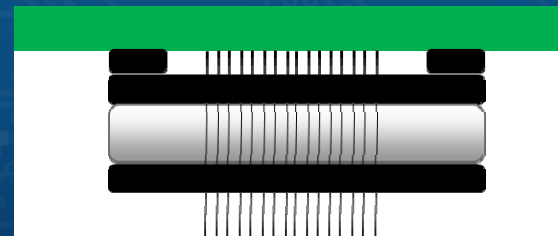
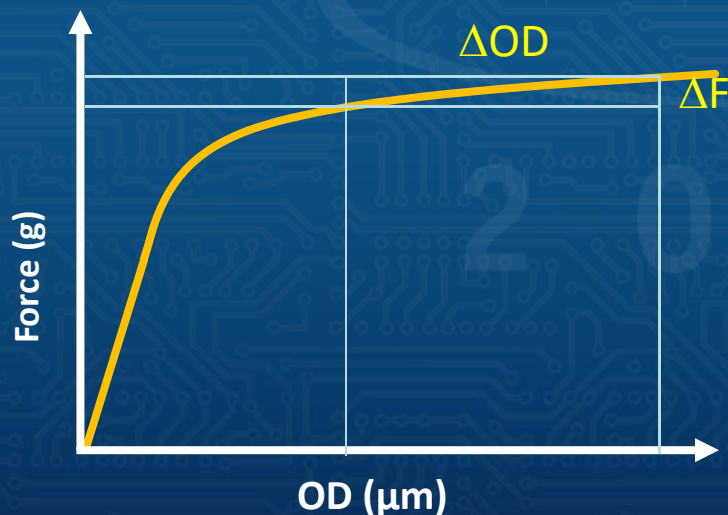
TPEG™ MEMS T1 Main Features



PARAMETER	TPEG™ MEMS T1
Needle diameter	1,5 mils equivalent
Max pin count	> 20.000 pins
X, Y alignment accuracy and Z planarity	X,Y: $\pm 8 \mu\text{m}$; Z plan: $\Delta 20 \mu\text{m}$
Min pitch and configuration	55 μm linear configuration
Pin Current (CCC)	410 mA
Force (at 3 mils OT)	3 g

Buckling Beam Concept

- Technoprobe PH mechanics exploits buckling beam: small force variation (ΔF) vs large OD variation (ΔOD)
- Buckling starts to occur at about 25 μm of actual OD
- Force is almost constant in the working OD range



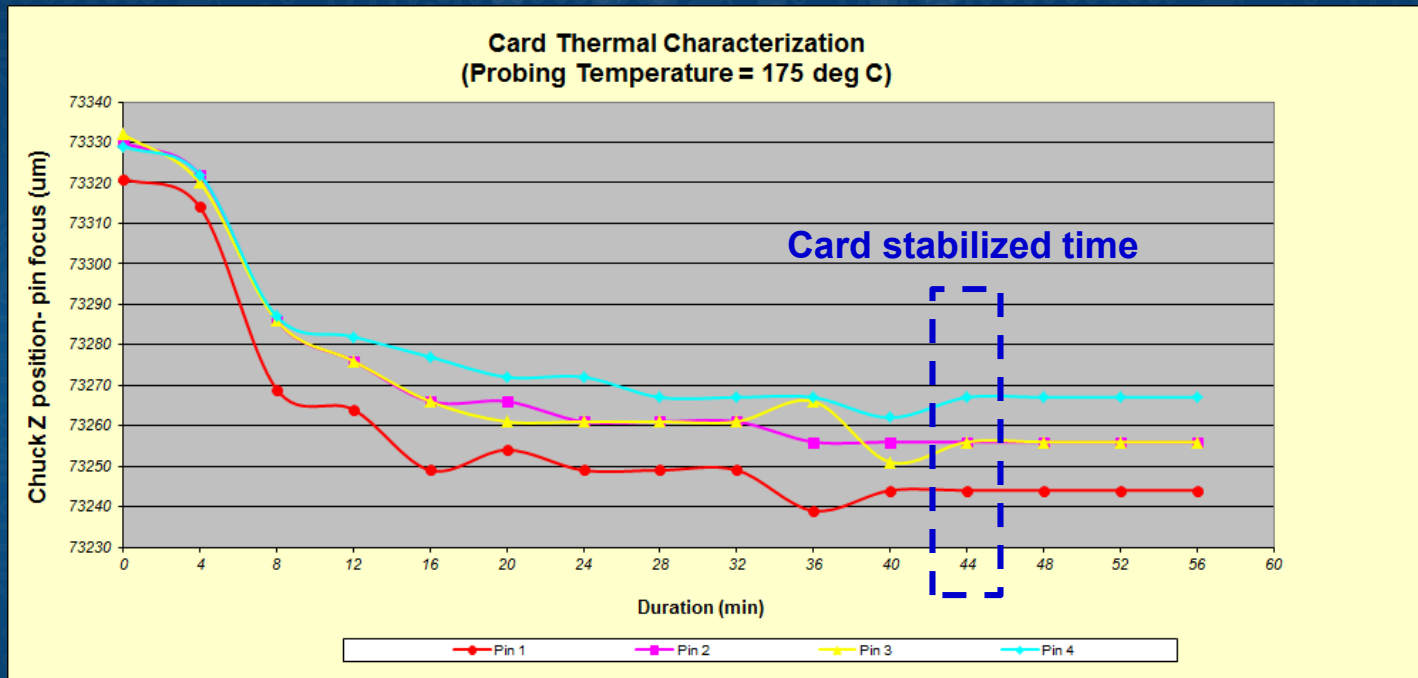
PH Technology Comparison

- Following table is showing a comparison between Reference Probe card and TP TPEG™ MEMS T1 probing solution

Parameter	Reference probe card	Technoprobe TPEG™ MEMS T1
Needle diameter	2 mils	1.5 mils equivalent
Min Pitch Array	75 um	80 um full array (55 um linear)
X,Y alignment	±12 um	± 8 um
Z Planarity	20 um	20 um
Force (3 mil OD)	4,5cN with 100um OD	3g
Probe Length	8.5 mm	6.3 mm

Stabilization at 175 °C

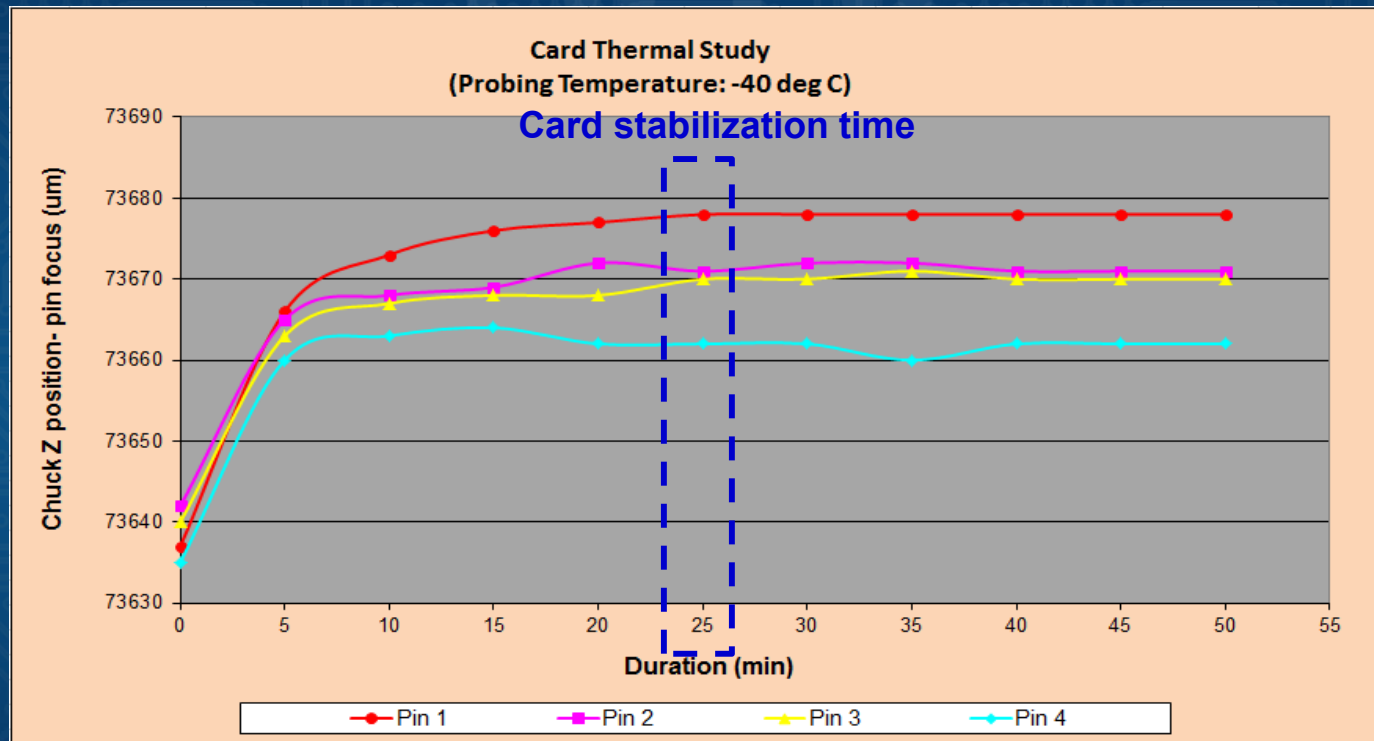
- Card preheating at 200 μm over the chuck



Duration(Min)		0	4	8	12	16	20	24	28	32	36	40	44	48	52	56
Reference Pins (μm)	Pin 1	73321	73314	73269	73264	73249	73254	73249	73249	73249	73239	73244	73244	73244	73244	73244
	Pin 2	73330	73322	73286	73276	73266	73266	73261	73261	73261	73256	73256	73256	73256	73256	73256
	Pin 3	73332	73320	73286	73276	73266	73261	73261	73261	73261	73261	73266	73251	73256	73256	73256
	Pin 4	73329	73322	73287	73282	73277	73272	73272	73272	73267	73267	73267	73262	73267	73267	73267

Stabilization at -40 °C

- Card precooling at 200 μm over the chuck



Duration (min)	0	5	10	15	20	25	30	35	40	45	50
Reference pins (um)	Pin 1	73637	73666	73673	73676	73677	73678	73678	73678	73678	73678
	Pin 2	73642	73665	73668	73669	73672	73671	73672	73672	73671	73671
	Pin 3	73640	73663	73667	73668	73668	73670	73670	73671	73670	73670
	Pin 4	73635	73660	73663	73664	73662	73662	73662	73660	73662	73662

Benchmark Summary

- Following table is showing the prober and cleaning setup comparing today reference probe card with respect to Technoprobe probing solution

Category	Reference Probe card	Technoprobe
Prober Type	TEL P12	TEL P12
Probing OD	70~80 um (max125um)	50 um (max 100 um)
Soaking Time, if any	2 hours	2 hours
Preheat Setting, if any	30 mins	45 mins - HT 25 mins - cold
Cleaning settings:		
Cleaning Media	ITS PP99	Mipox WA6000
Cleaning OD	70~80 um	50 um
Cleaning Frequency	20 index	100 index
Auto Alignment, if any	Every 5 mins	None

Conclusions

Solutions to extreme temperature probing:

- Fine tuning soaking recipe
- Optimize probing sequence
- Avoiding condensation
- Additional soaking requirements
- Technoprobe probe card design and probe technology demonstrated to be a production worthy solution

Acknowledgements

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