Thermal Challenges in the Fine Pitch Testing Solutions

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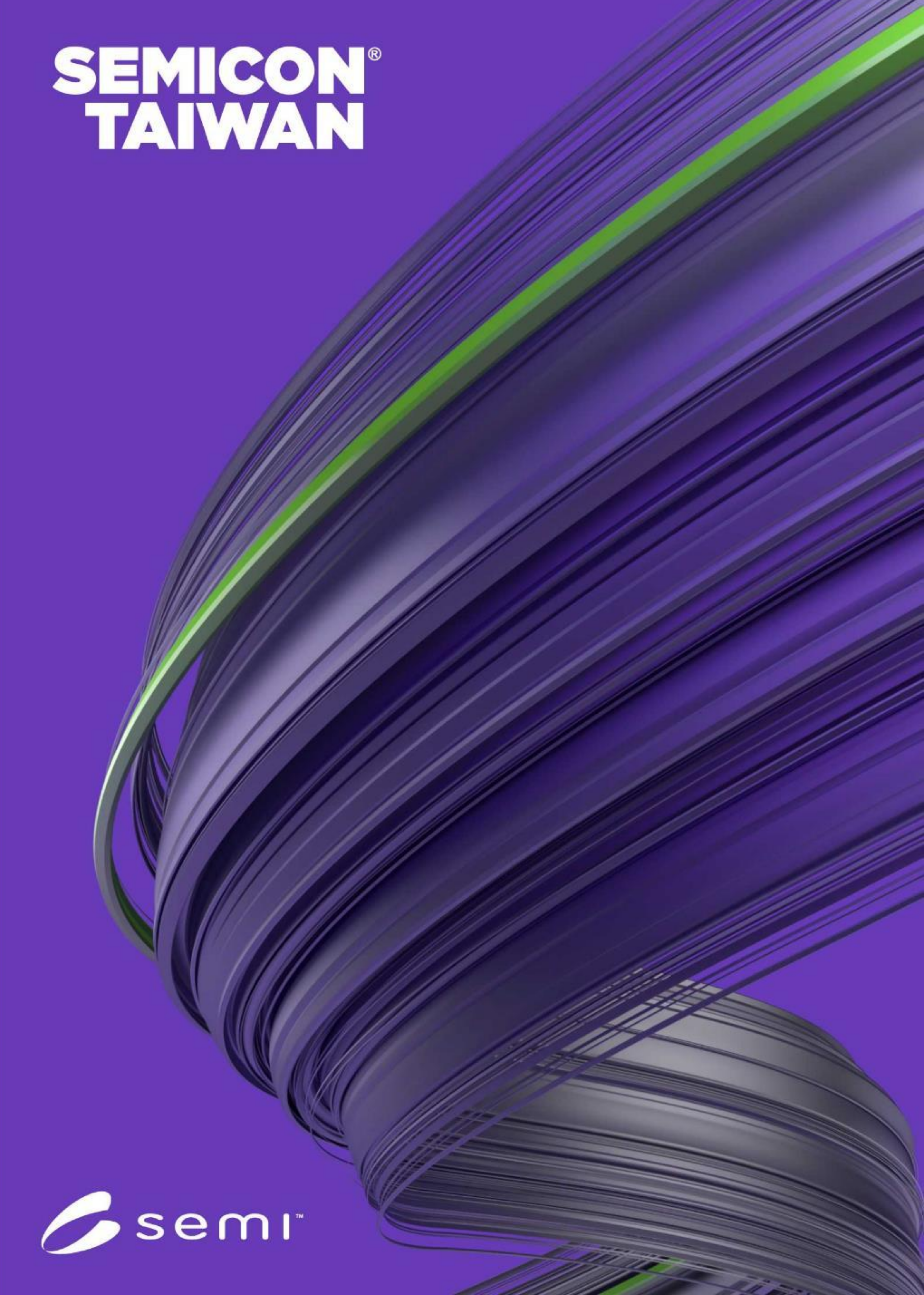
CHPT

Advanced Testing Forum

Contents

- Probe cards & advanced packaging market
- Thermal challenges of probe card
- CHPT fine pitch solutions for high & low temperature
- Summary



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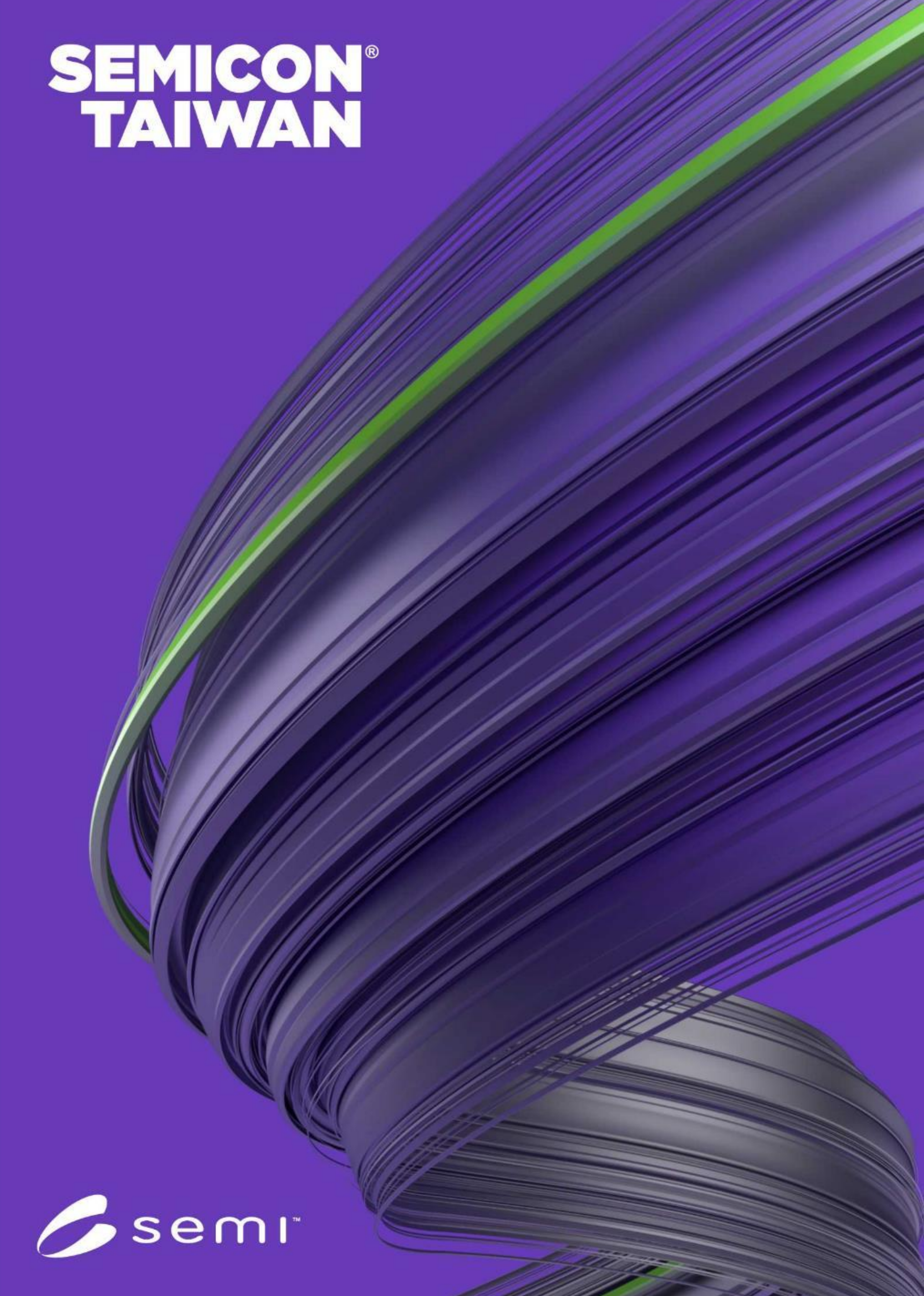


Probe cards & advanced packaging market

US $ Million (left axis: Probe Card Market; right axis: Advanced Packaging Market)

Year	Probe Card Market	Advanced Packaging Market
2021	2,573	32,117
2022	2,856	36,704
2023	3,108	40,154
2024	3,077	43,966
2025	3,281	47,149
2026	3,519	52,200
2027	3,783	57,247

Advanced Packaging Market 2021-2027 CAGR **+10.11%**

Probe Card Market 2021-2027 CAGR **+6.63%**

Source: Yole Développement 2022/5；CHPT

* CHPT's technology has been patented or patent pending.

Development of advanced packaging

	SnPb C4 Bump	Pb-Free C4 Bump	Cu Pillar+ Pb-free Cap	Cu μ-Pillar+ Pb-free Cap
Structure		SnAg	SnAg Cu	SnAg Cu
Diameter	75-200μm	75-150μm	50-100μm	10-30μm

Traditional Technology → Current Technology → Next-Generation Technology

Source: Dow Chemicals

* CHPT's technology has been patented or patent pending.

CHPT all in house

PCB assembly with probe head

PCB manufacturing and assembly

ALL IN HOUSE

01 R&D

02 Design

03 PCB

04 P/C Assembly

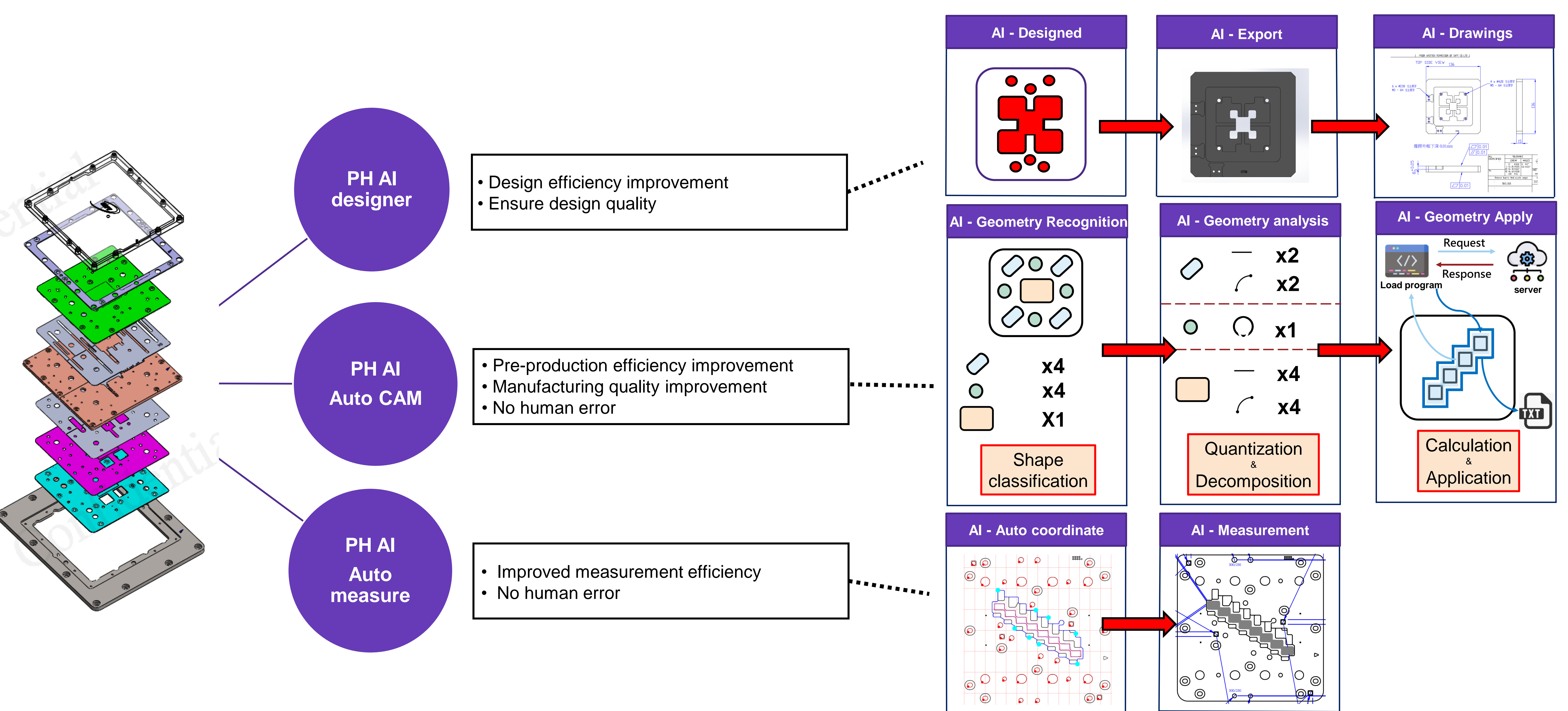
05 Service

Probe mechanics simulation

Signal path design optimization

* CHPT's technology has been patented or patent pending.

CHPT probe head AI design



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CHPT's solutions

Probe Card by Applications

Applications	IC	CHPT needle	Features
HPC	APU , CPU, GPU, ASIC, Network	BR, SR, BK	Bandwidth & High Current
Mobile	AP, PMIC, RF, CIS, Modem	NS, BR, MJ	High Pin-count & High Current
AIoT	MCU, WiFi, ASIC, CIS	NS, BR, BK	Bandwidth & Mixed Pitch
Display	TV Controller, TDDI, LCD Driver	NS, MJ	Fine pitch
Memory	HBM, Flash, DRAM, Flash Controller	NS, MJ	Fine pitch

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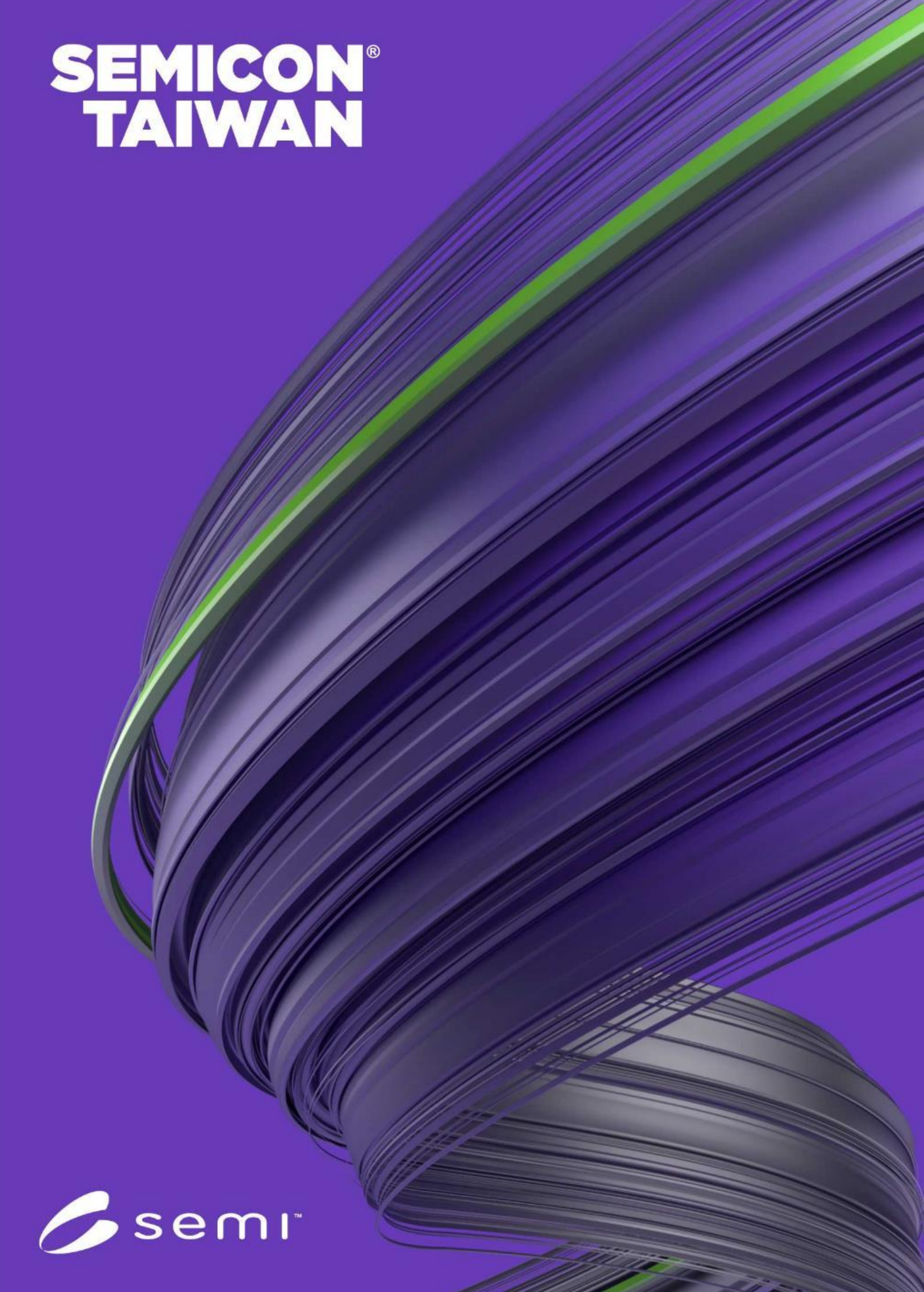
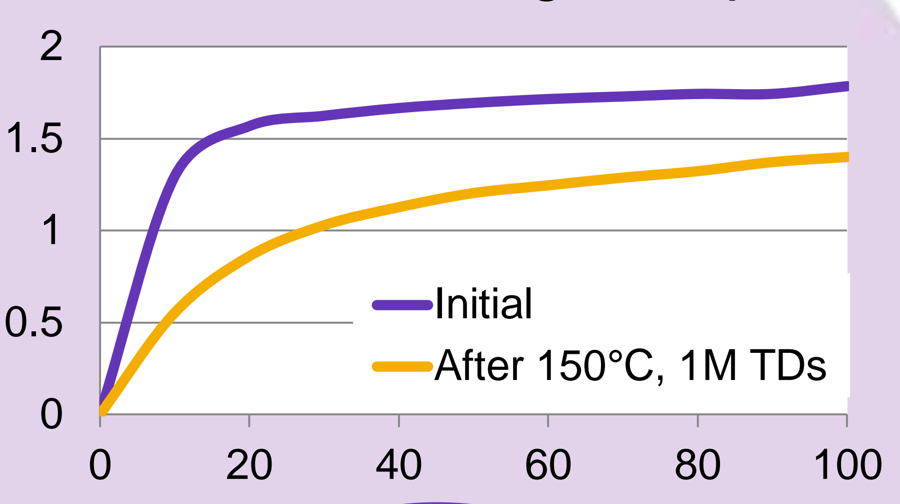


Fine pitch challenges of probe card

The components of the probe card will cause decay and distortion due to heat, especially when the pitch is getting smaller and smaller.

Probe

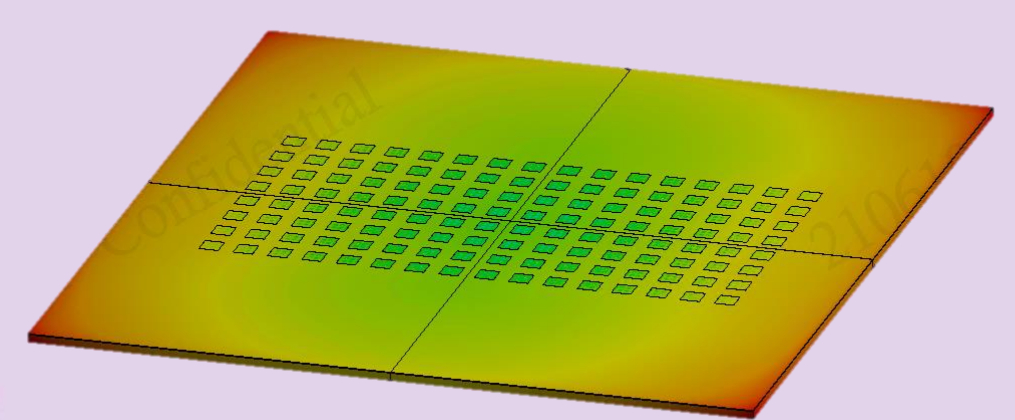
Force decay after 1M touchdown at high temp.



Thermal

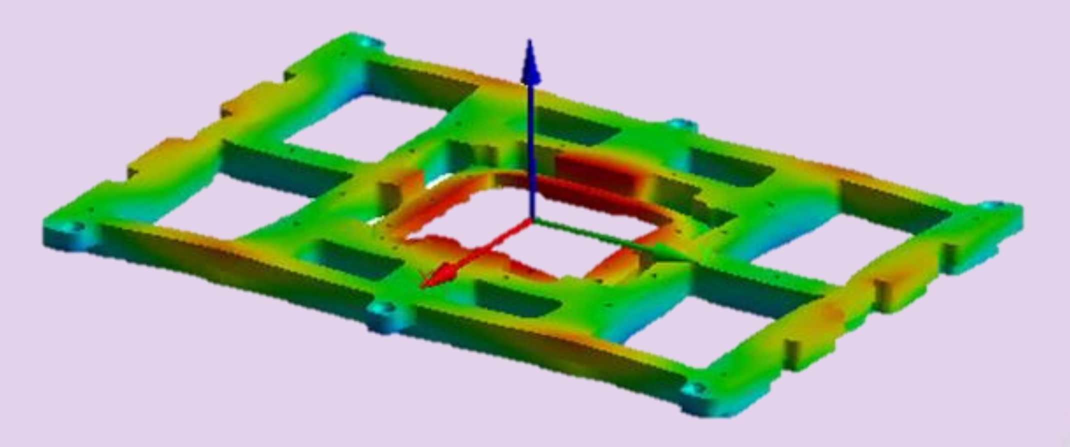
Substrate

CTE mismatch and distortion at high & low temp.



Mechanical Parts

Inlay distortion at high & low temp.



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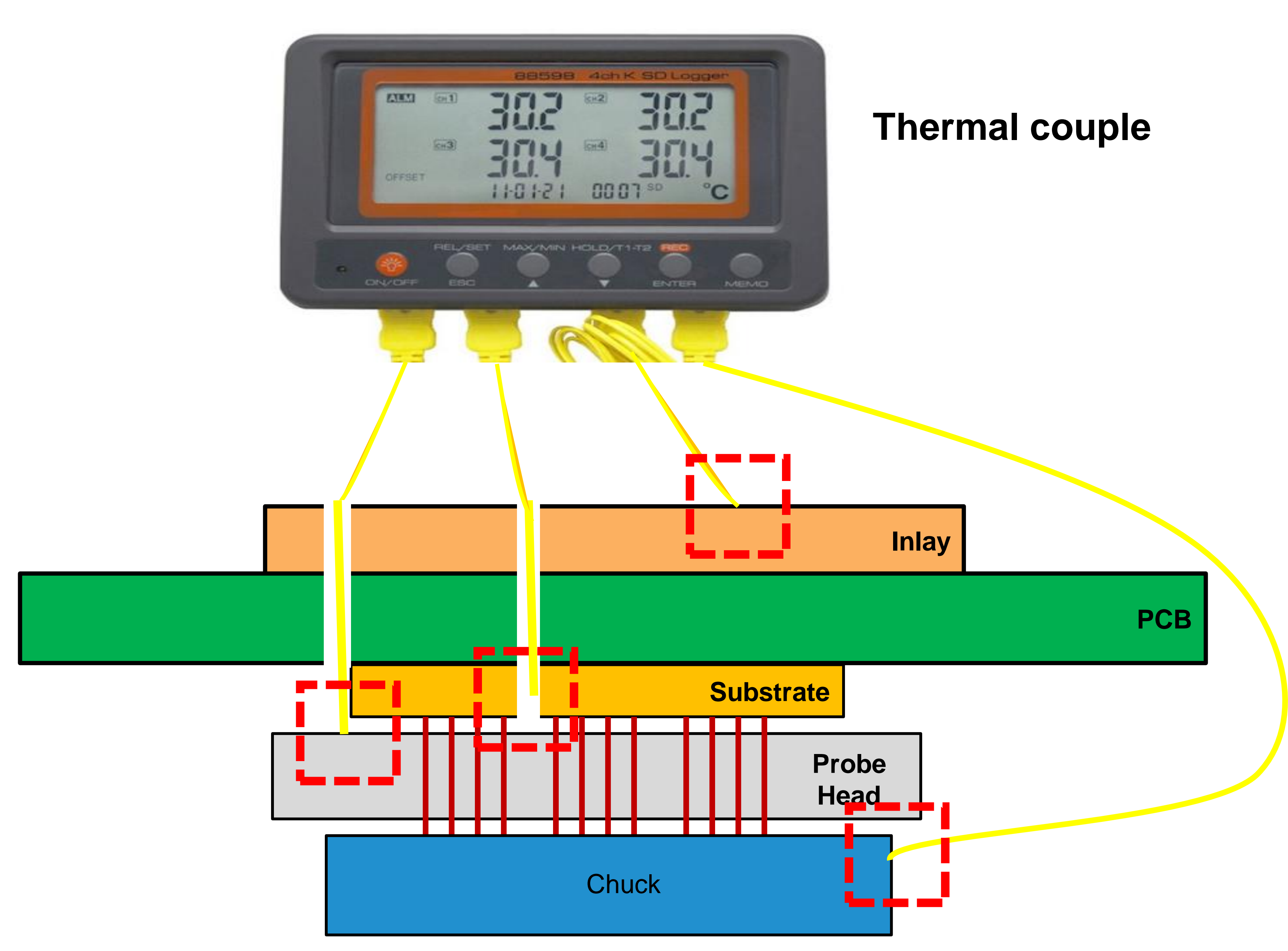
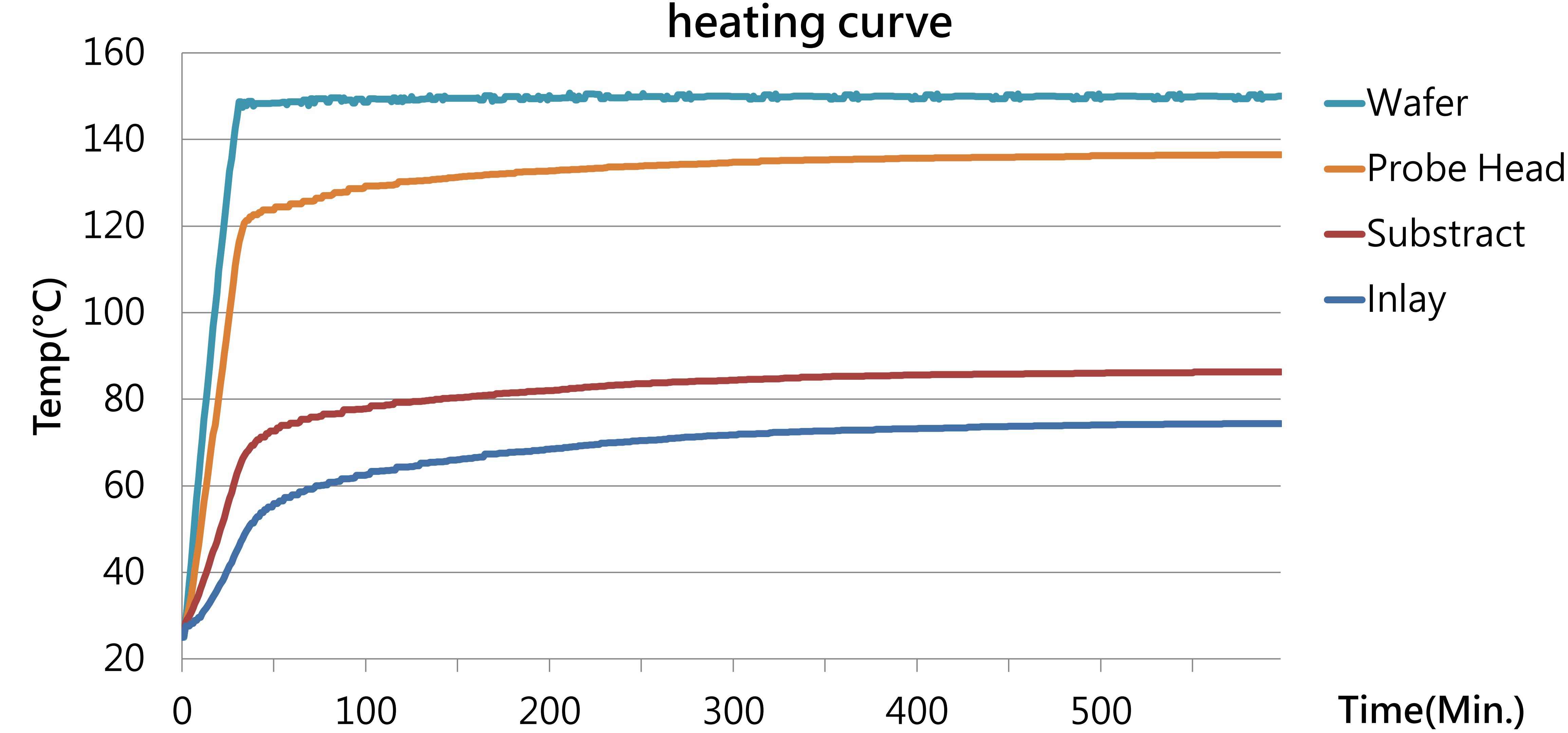
Testing error due to CTE mismatch

Under the influence of temperature changes, the contact points of various components are shifted, which leads to poor measurement.



Probe card architecture



Item	Wafer	Probe Head	Substrate	Inlay
High Temp.	150°C	136°C	86°C	74°C
CTE[1] (ppm/°C)	2.3~2.6	2.6~3.0	14~18	10~18

CTE property and actual temperature of different materials
[1] : Coefficient of Thermal Expansion

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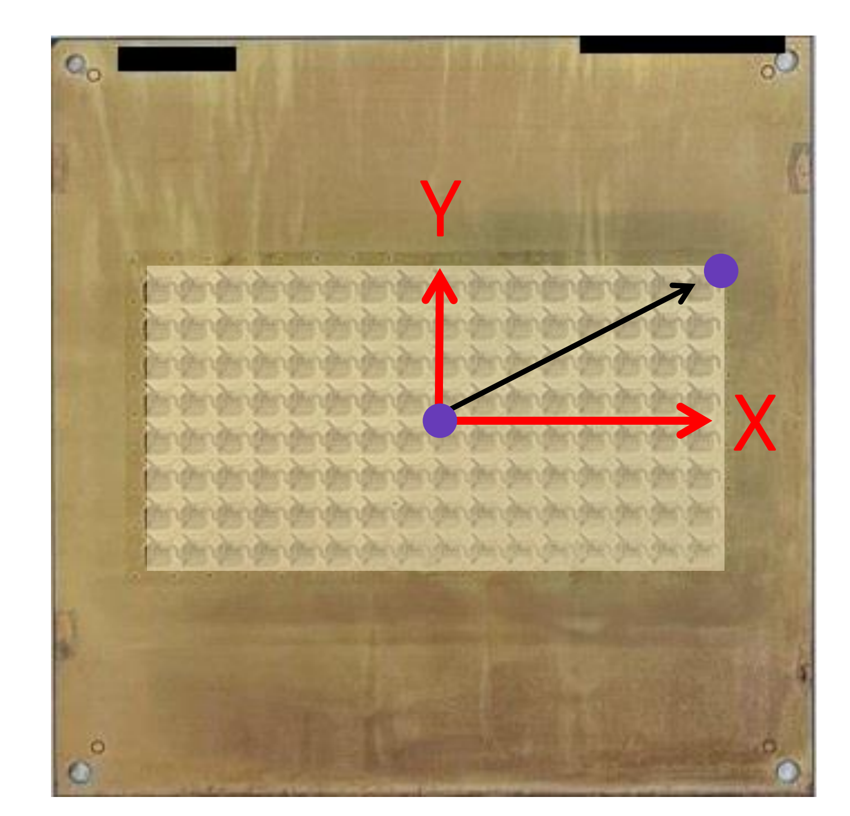
Substrate material improvement

By suppressing the expansion and contraction caused by different temperature, making probe contact with C4 pad more stable.



Simulation of thermal expansion at high temperature		
	MLO	**New Substrate**
Pattern simulation		
Maximum deformation	25 ~ 40 um	< 5 um

Actual measurement of thermal expansion at high temperature				
Materials	MLO	MLO	**New**	**New**
Axial	X	Y	X	Y
Chuck Temp: -40°C	-20um	-12um	-2m	-1um
Chuck Temp: 25°C (Original point)	0	0	0	0
Chuck Temp: 150°C	29um	15um	2um	1um

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By suppressing the expansion and contraction in the Z direction, the planarity of the probe card at different temperatures can be improved.

Simulation of thermal expansion at high temperature		
	Current Material	**New Material**
Pattern simulation		
Z-axis deformation	40.8 um	8.2 um

* CHPT's technology has been patented or patent pending.

Probe material improvement

The new material showed good mechanical properties after being tested at high temperature.

Actual measurement of 1 million touchdown force decay at high temperature		
	Current Material	**New Material**
Pattern simulation		
Force drop	1.8g > 1.4g, -22%	1.8g > 1.76g, -2%

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Choose suitable probe material

We have several materials with different properties, to match customer needs.

CHPT materials

	Material A	Material B	Material C	Material D
Contact force	△	△	◎	◎
C.C.C.	◎	◎	△	○
Probe resistance	◎	○	△	○
Temperature range	○ -40 ~ 150°C	◎ -40 ~ 200°C	◎ -40 ~ 200°C	○ -40 ~ 150°C
Life time	◎	◎	◎	◎

◎ : very good. ○ : good. △ : need to be improved.

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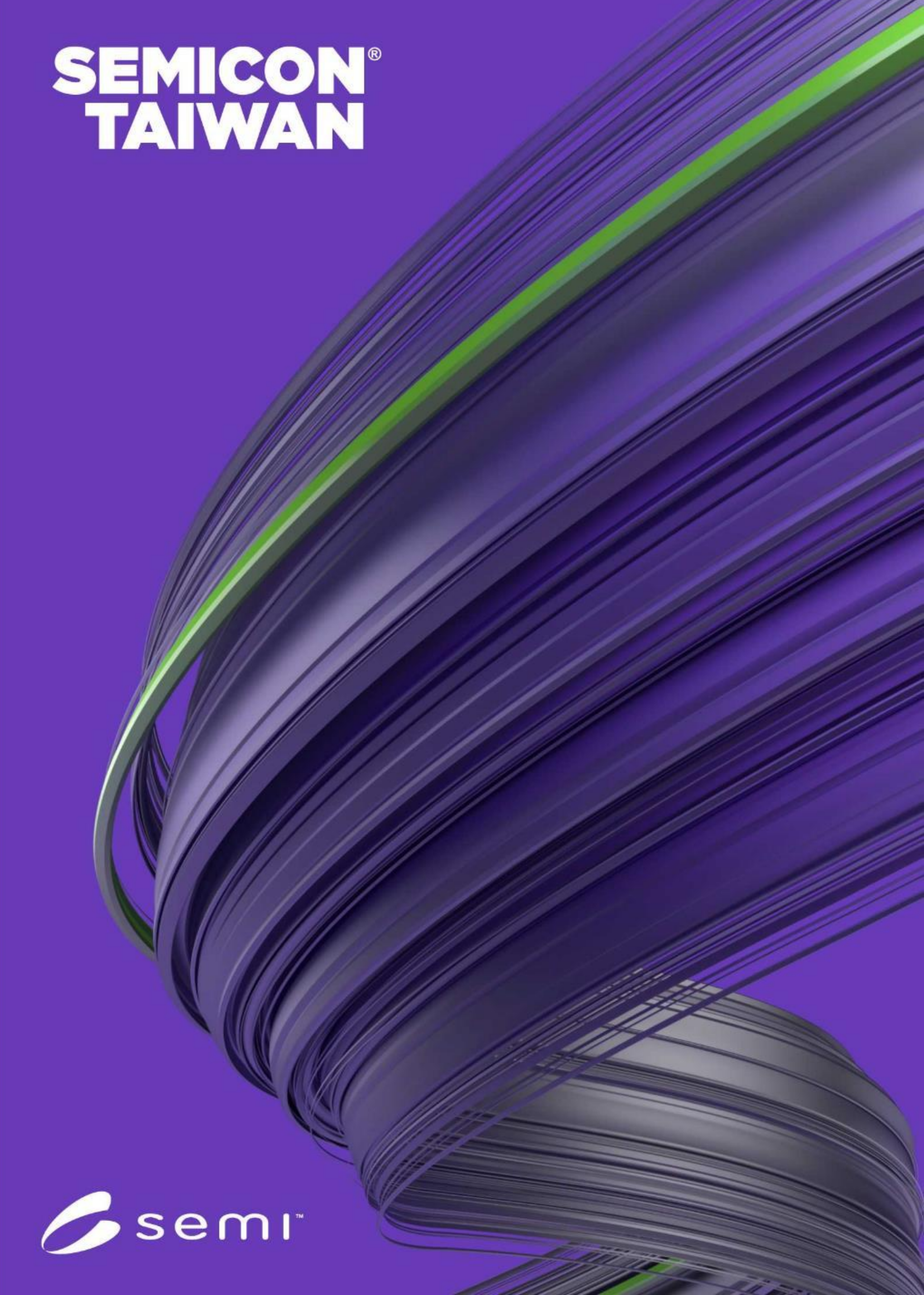
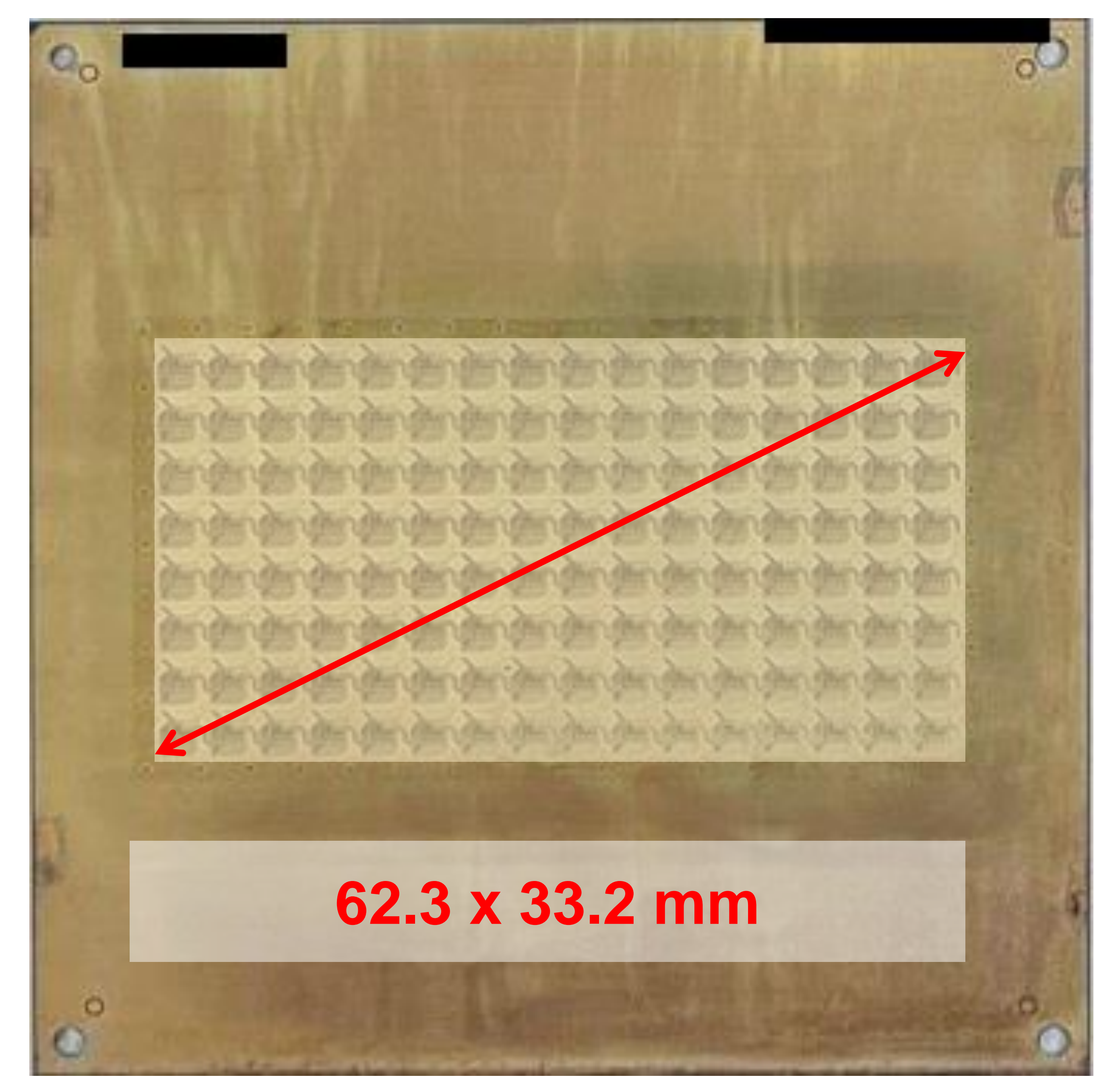


Real case

	Customer Criteria
Pitch	52 um
Temperature	-40°C, 25°C, 150°C
Probe mark depth	< 1.4 um
Alignment XY	< 10 um
Tip diameter	6 ~ 10 um
Planarity Z	< 40 um

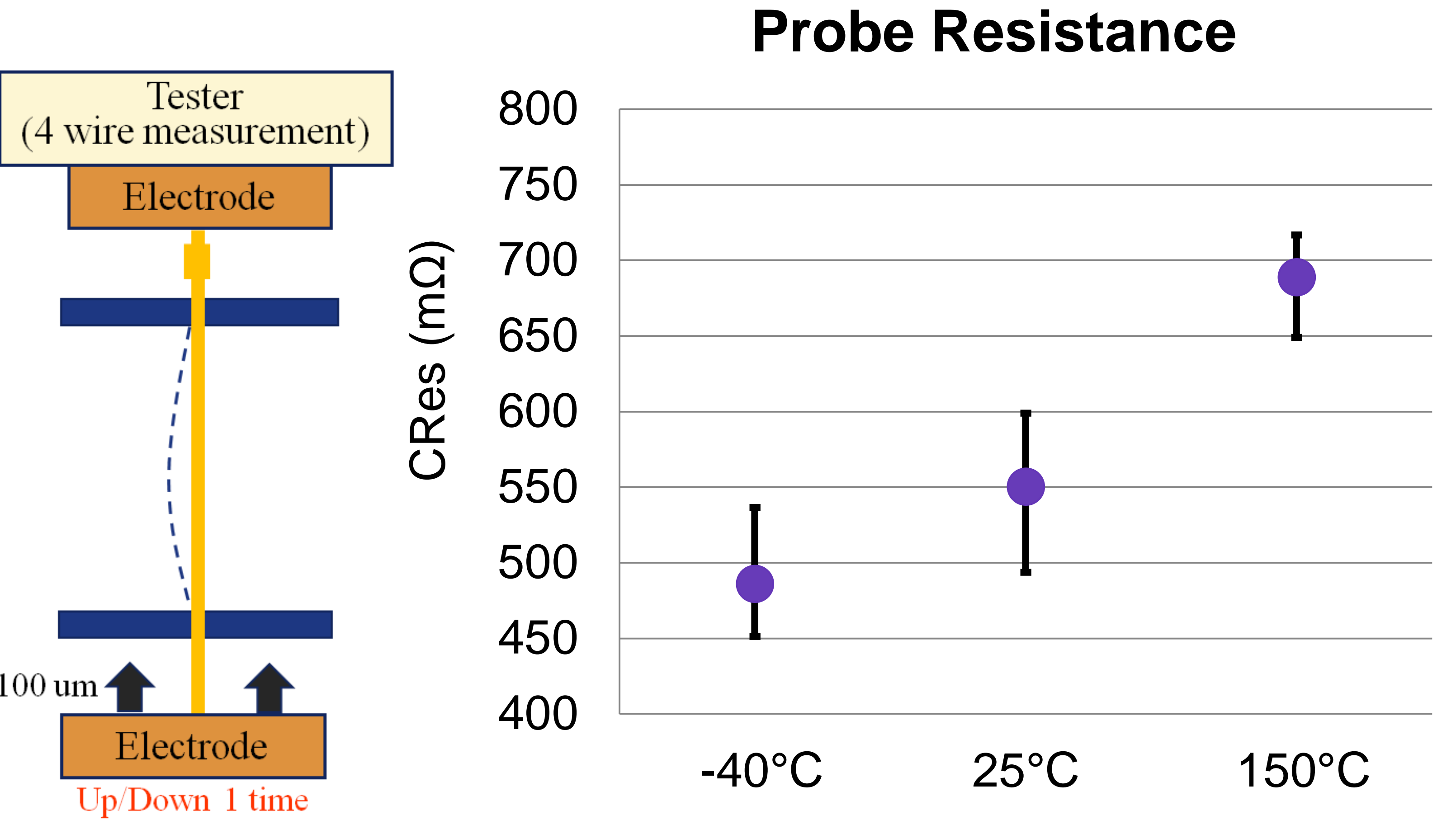


Probing Area

* CHPT's technology has been patented or patent pending.

NS45 solution has excellent design, stable probe resistance, consistent contact force and excellent current carrying capacity, and has excellent performance in the full temperature range from -40 to 150 degrees.

Parameter	NS45
Pitch minimum	45 um
Tip shape	Point (Option : Flat)
Temperature	-40~150°C
Contact force	1.8 g
Probe resistance	600 mΩ
CCC	450 mA
Alignment XY	< 8 um
Planarity Z	Δ 25 um



Probe resistance at different temperature

Contact Force

Forc e(g)

2.10, 1.80, 1.50, 1.20, 0.90, 0.60, 0.30, 0.00

0, 20, 40, 60, 80, 100 OD(um)

25°C
-40°C
150°C

Contact force at different temperature

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Probe mark stability

After 10 repeated test under 150 degrees, the NS45 probe only causes scratches with a depth of <0.9um, which is lower than the customer's requirement of <1.4um.

	100um		
	-40°C	25℃	150℃
1st	size 11 x 10 um Depth 0.39 um	size 12 x 12 um Depth 0.50 um	size 13 x 14 um Depth 0.57 um
5 times	size 13 x 12 um Depth 0.65 um	size 14 x 13 um Depth 0.53 um	size 14 x 14 um Depth 0.78 um
10 times	size 15 x 12 um Depth 0.74 um	size 14 x 13 um Depth 0.69 um	size 16 x 14 um Depth 0.89 um

Probe mark depth at different temperature and touchdown

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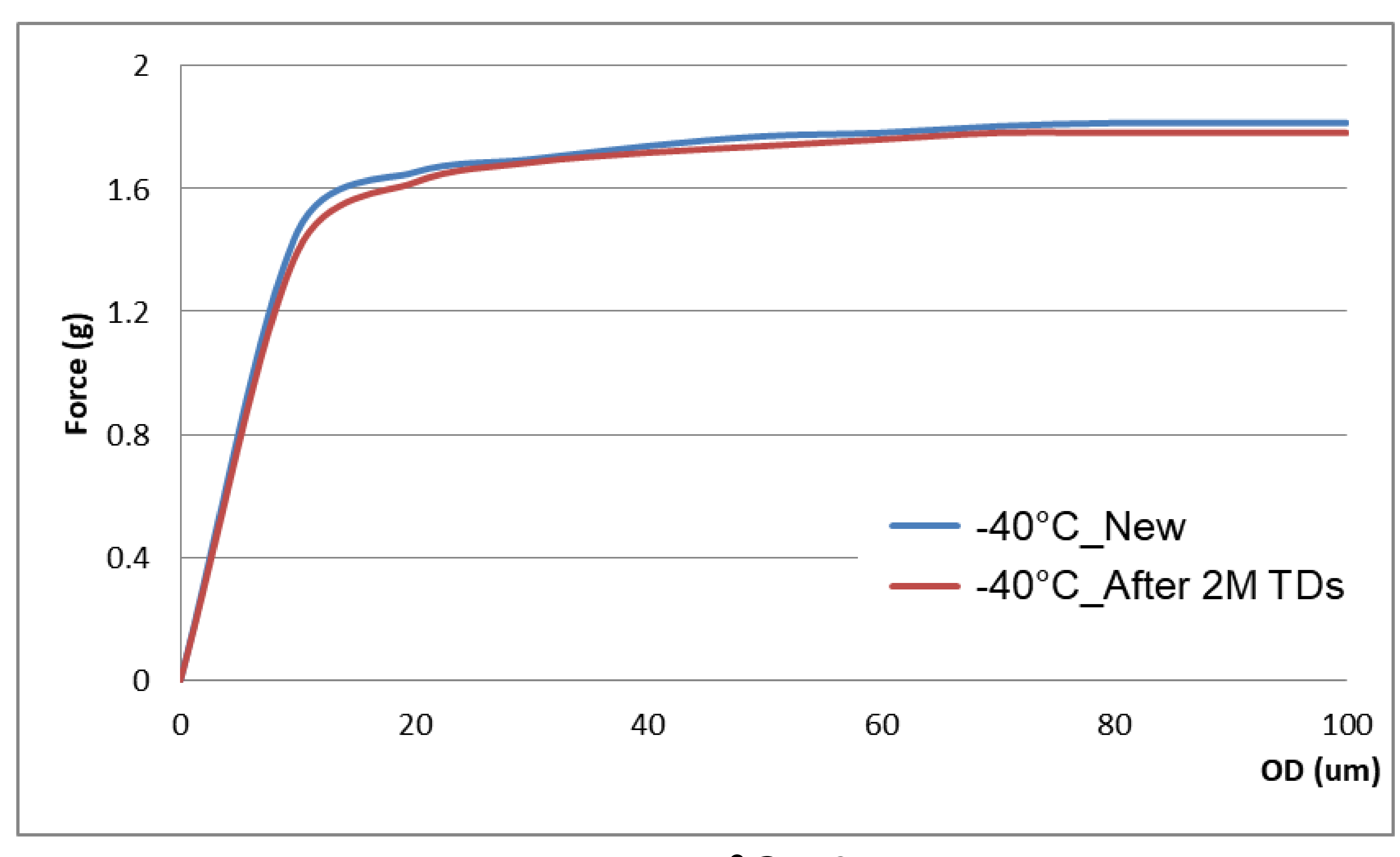
Probe reliability

After 2 million touchdowns, the mechanical properties of NS45 remained almost unchanged.



Force decay at -40°C after 2M TDs

Force decay at 150°C after 2M TDs

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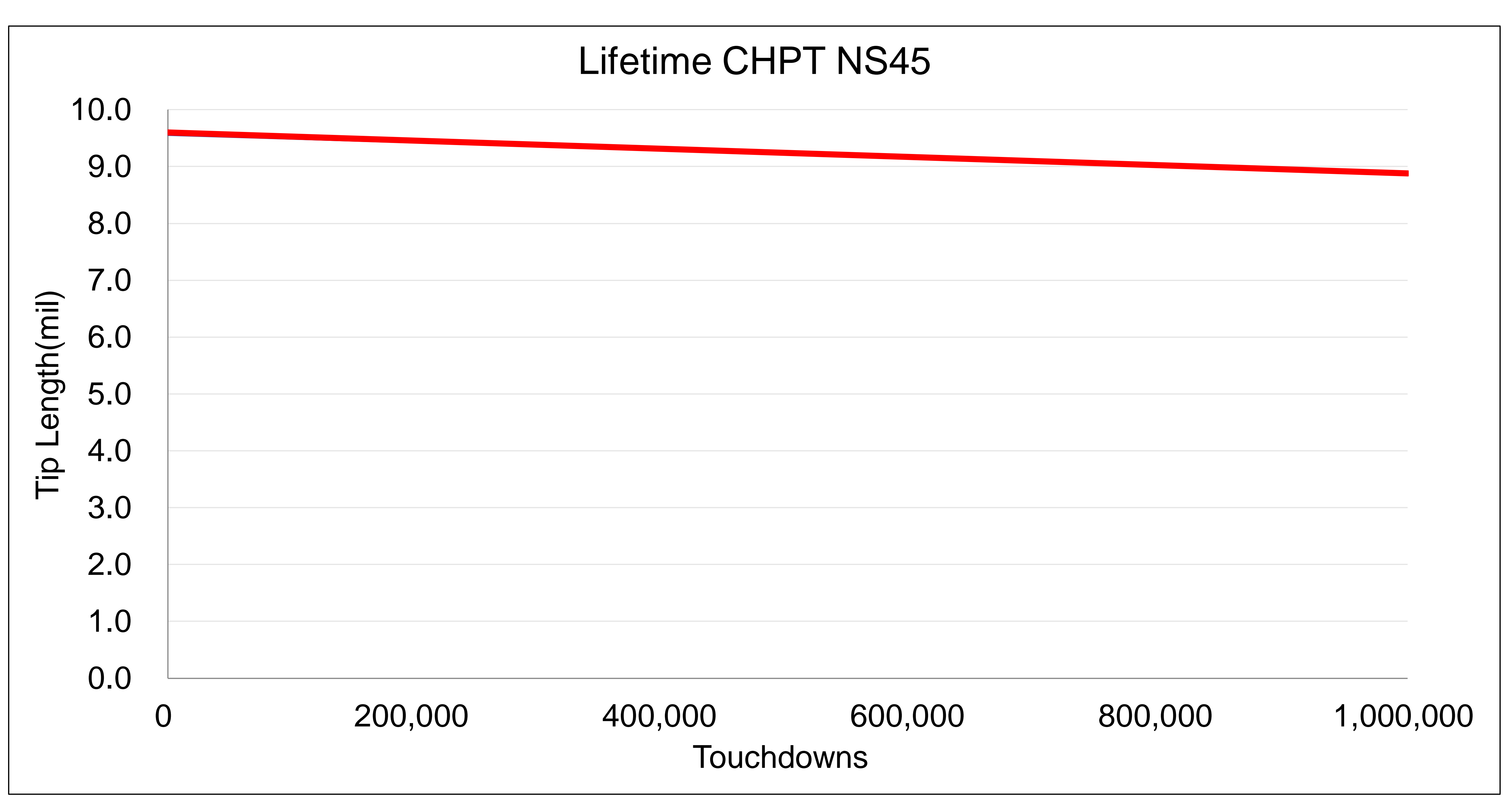
Probe card life time

We guarantee NS45 for more than 1 million touchdowns, with stable test results throughout its life cycle.



OD	70um
Temp.	25°C
Sanding paper	WA6000 lapping sheet
Clean method	X-Y movement (X= 0um / Y= 0um)
Z up/down count *1	2 times
Clean OD	+0~40um(from OD2)
Frequency *2	Every 100 TDs

Projected life time exceeds 1.0 MTDs.

***1** : Depends on the wafer and device characteristics, it could be optimized and adjusted by User.
***2** : At the begging of the probe card life we recommend usage of LOWE Substrate frequency prescribed.

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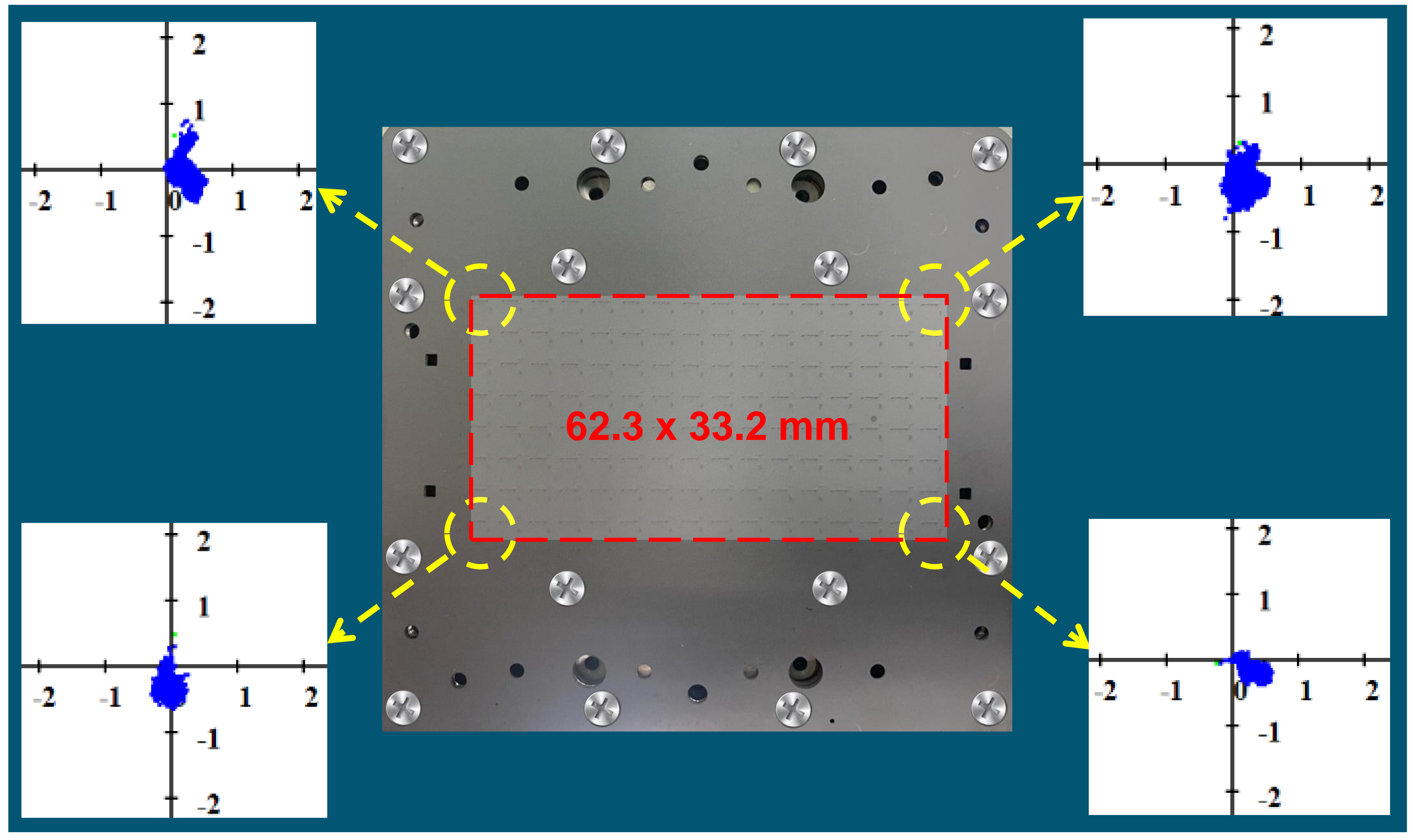
Alignment stability

Probe marks are all distributed within 2um.



OD 3mil, 150°C, touchdown 200K

* CHPT's technology has been patented or patent pending.

Customer verification results

CHPT's NS45 solution has been verified by customers and proved that it has good alignment under high temperature, which meets customer test requirements.

Position / Temp.	Top Left	Top Right	Bottom Left	Bottom Right
25°C	4.0 um	4.5 um	3.4 um	3.9 um
150°C	5.0 um	5.4 um	6.5 um	6.8 um

probe mark actually tested by the customer

* CHPT's technology has been patented or patent pending.

Customer verification results

CHPT's NS45 solution meets the stringent testing conditions, and has been in mass production.

	Customer Criteria	NS45 Solution	
Temperature	-40°C, 25°C, 150°C	-40°C, 25°C, 150°C	PASS
Probe mark depth	< 1.4 um	< 0.9um (150°C, 10 TD)	PASS
Alignment XY	< 10 um	< 8 um	PASS
Tip diameter	6 ~ 10 um	9 um	PASS
Planarity Z	< 40 um	< 25 um	PASS

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Advantages of CHPT solution

Compared with peers, CHPT's NS45 solution has the following absolute advantages.

	Peers	CHPT NS45 solution
Pitch minimum	50 um	45 um
MAX pin count	6,000	10,000 ✓
Contact force	1.5~2.0 g	1.5~2.0 g
CCC	375 mA	450 mA ✓
Probe resistance	1000 mΩ	550 mΩ ✓
Temperature range	-40 to 120°C	-40 to 150°C ✓
Life time	0.2M TD	1M TD ✓

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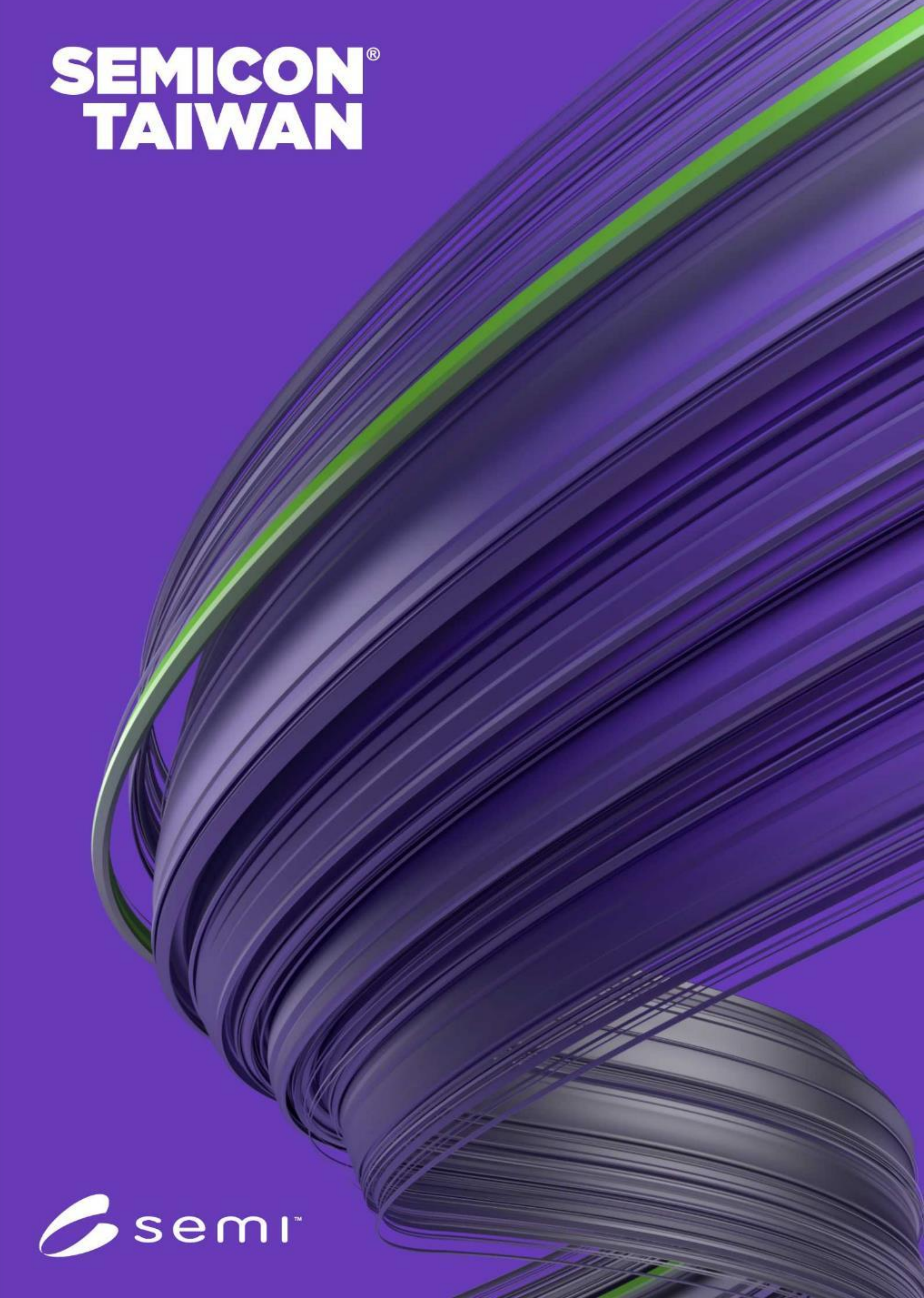

Summary

1. With the continuous evolution of the process, the compound annual growth rate of advanced packaging to 2027 can reach 10.1%, and the bump size will also continue to shrink.
2. Through improved materials and AI-assisted design, CHPT has successfully developed NS45 probe card products with a minimum pitch of 45um, and deeply optimized the test stability of the probe card.
3. The self-developed probe material is used to achieve a balance between electrical properties, mechanical properties and high and low temperature stability. It is suitable for -40°C to 150°C and provides customers with the best test quality.
4. The solutions has been verified by customers and is in mass production.

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Q & A