SWTEST ASIA
PROBE TODAY, FOR TOMORROW

Probing challenge New MEMS probe design to control probe creep / fatigue for high temp probing

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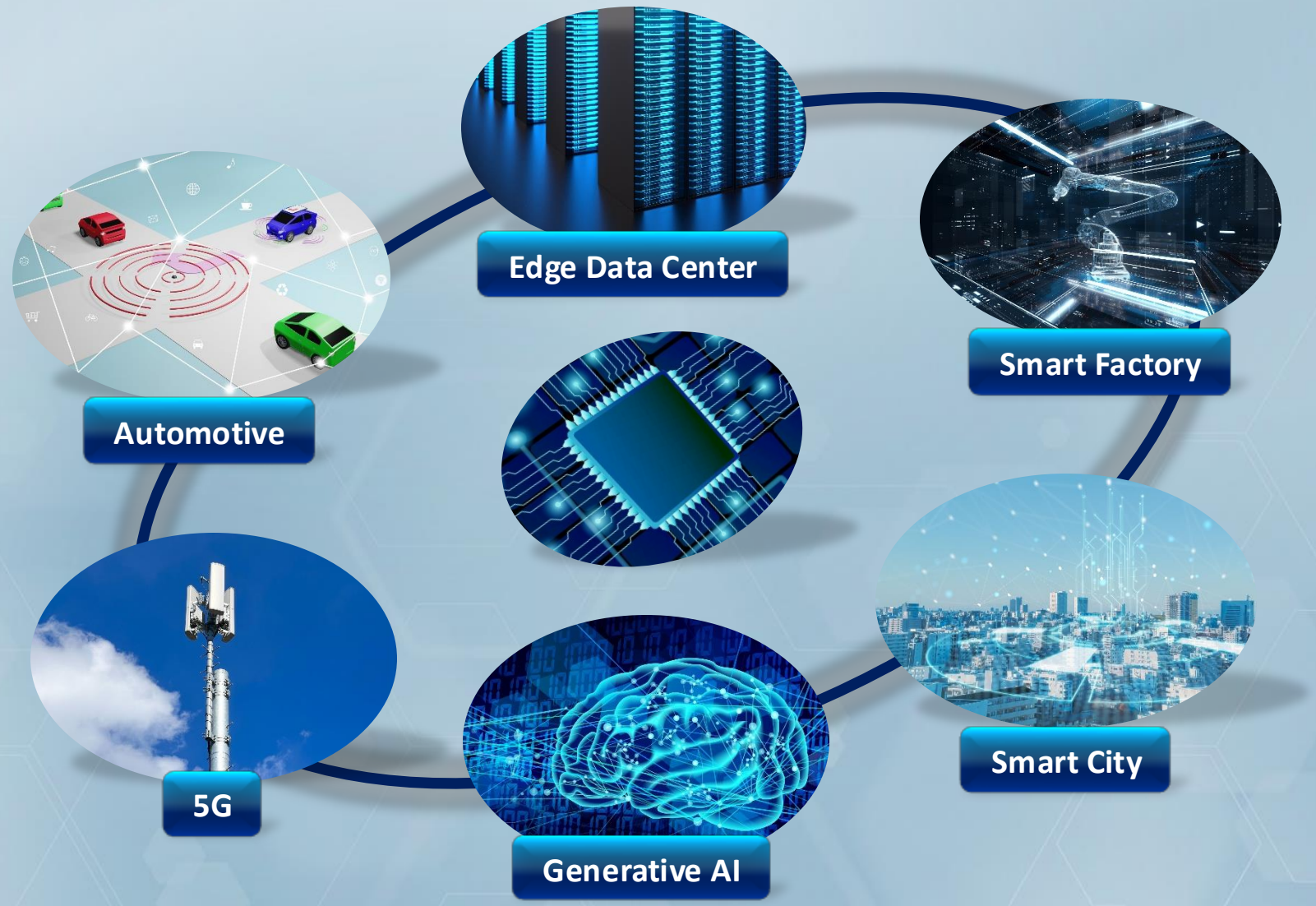
Overview

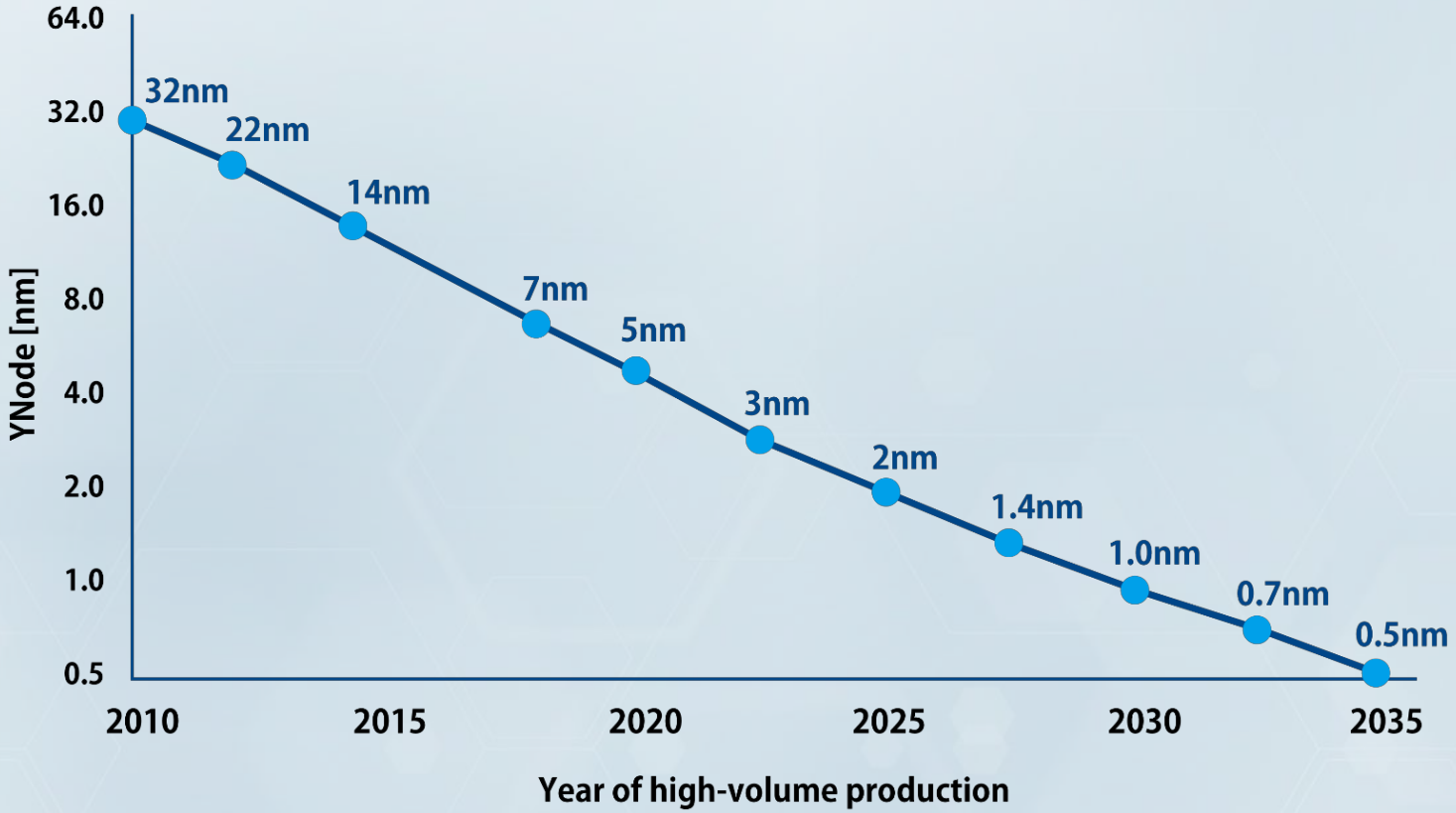
- Market Trend
- Requirements for Wafer Test
- The Challenges of High-Temperature Application
- New Probe/Solder Material Development
- Probe Design Optimization
- Card Level Evaluation
- Conclusion

Market Trend



New and evolving markets are driving demand for high-performance ICs.

Market Trend



To meet these demands, the technology roadmap for semiconductor manufacturing processes is approaching mass production at the 2nm node.

Requirements for Wafer Test

- Temperature
- Speed
- Bandwidth
- Pad Count

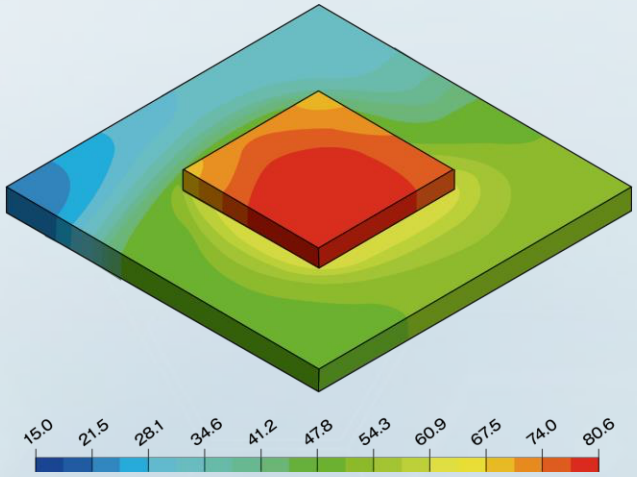
- Chip Size
- Pitch
- Pad Size

High-performance ICs require more complex testing, which increases the load on devices, leading to higher current consumption and heat generation.

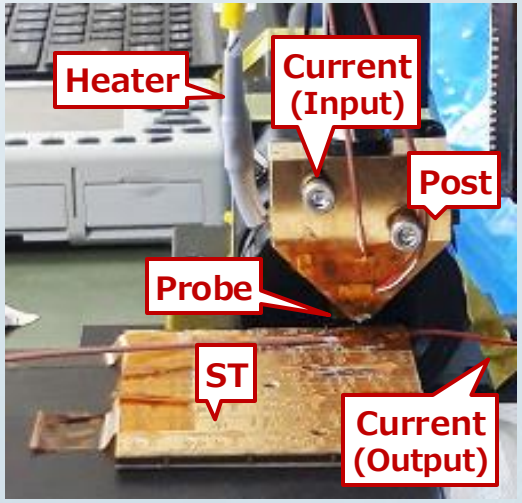
In wafer testing, ensuring reliability requires addressing current capability and heat resistance.

The effects of heat

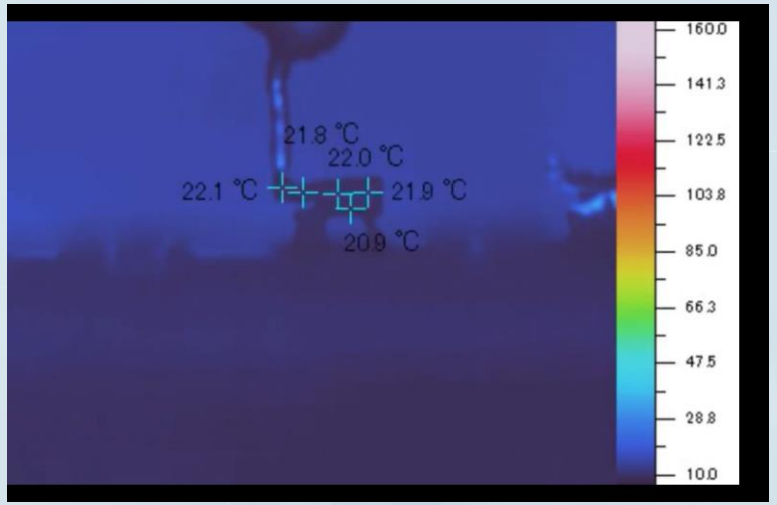
Heat generation of devices



Method of probe temp measurement



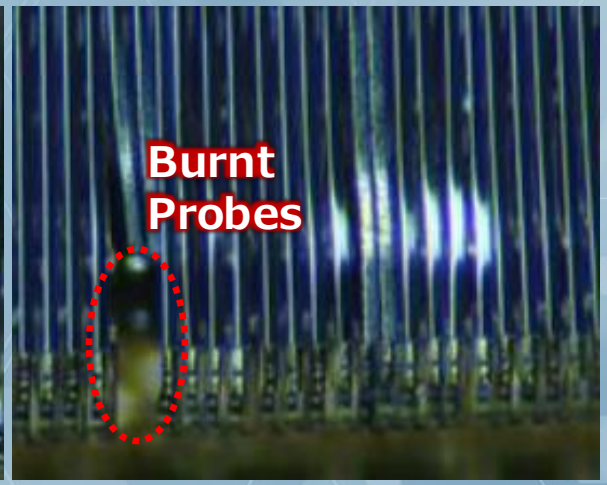
Heat generation of Probe



In high-temperature testing, probes are heated by several sources:

- Joule heating by current in probes
- Heat conduction from device to probes
- Heat convection and radiation from wafer to probes

Probe damage due to heat

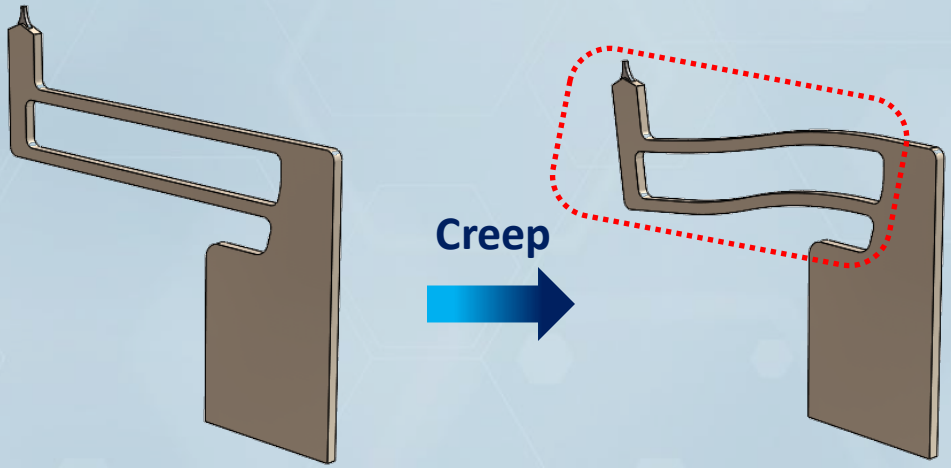


Creep (deformation)

During high-temperature testing, creep begins to occur in the probe material and solder.
This makes it difficult to maintain reliability during long-term high temperature probing.

Probe creeping

In high-temperature environments, the probe will creep and gradually deform due to prolonged stress, which can reduce contact stability.



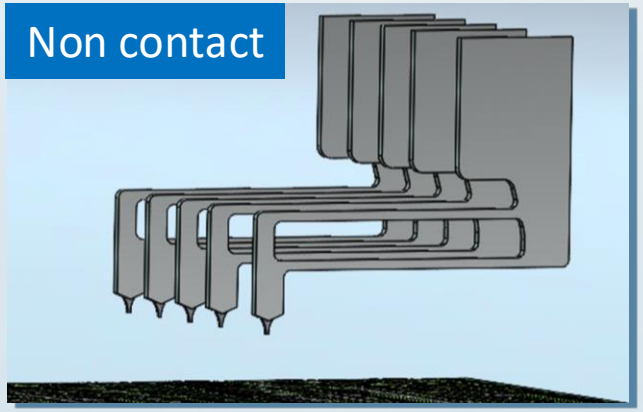
Solder creeping

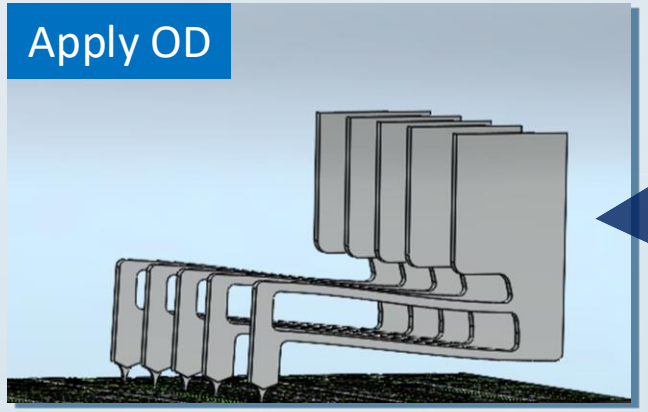
Similarly, solder also begins to creep. This can lead to deterioration of solder joints, resulting in probe position shifts and electrical failures.

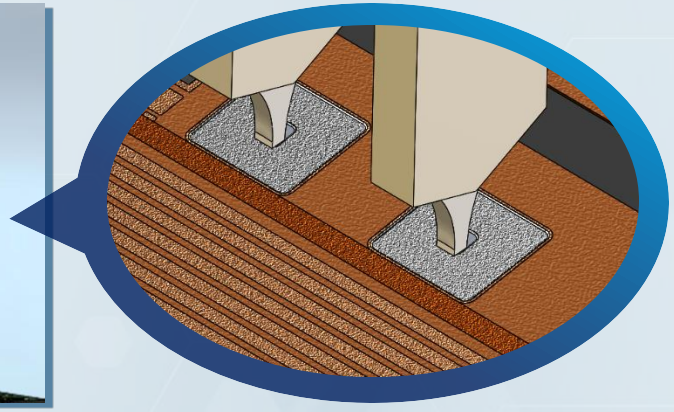
Expected Issues due to creeping

Prolonged use in high-temperature environments leads to creep in the probes.
If the creep are significant, it may cause issues contacting with wafer or poor probe positional accuracy.

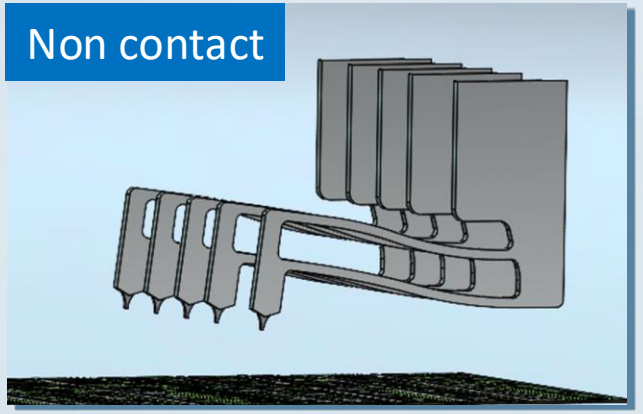
Initial Condition

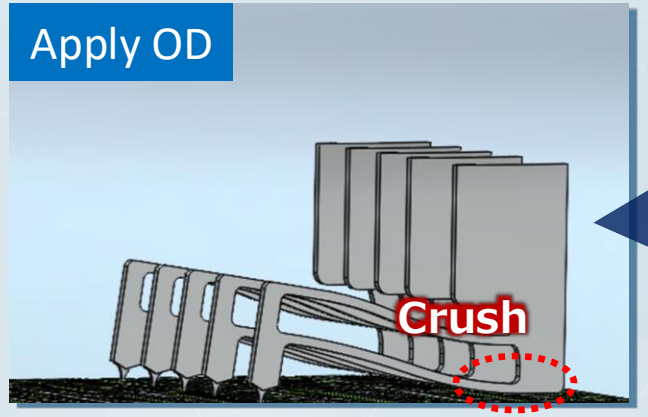


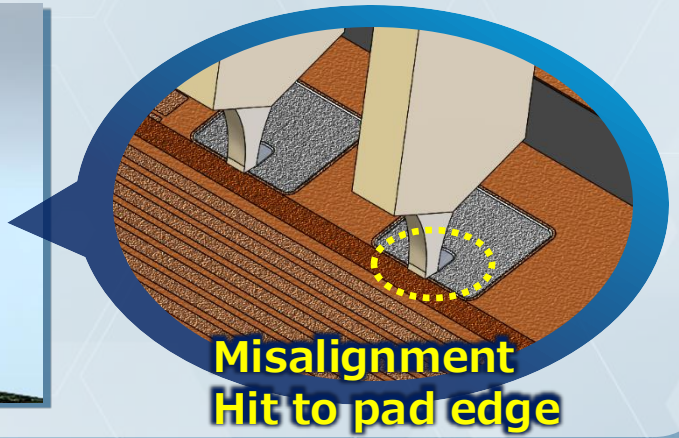




Creep Condition







New Probe Material Development

The production of probes resistant to creep deformation requires a **“Low-stress shape design”** and the **“Selection of materials resistant to creep deformation”**.

When selecting materials, in addition to creep properties, it is also necessary to consider the behavior of the **“Young's modulus”** and **“Fatigue strength”** at high temperatures.

Requirements for probes resistant to creep deformation

Design of shapes with low stress

Selection of materials resistant to creep deformation

Key Points in Material Selection

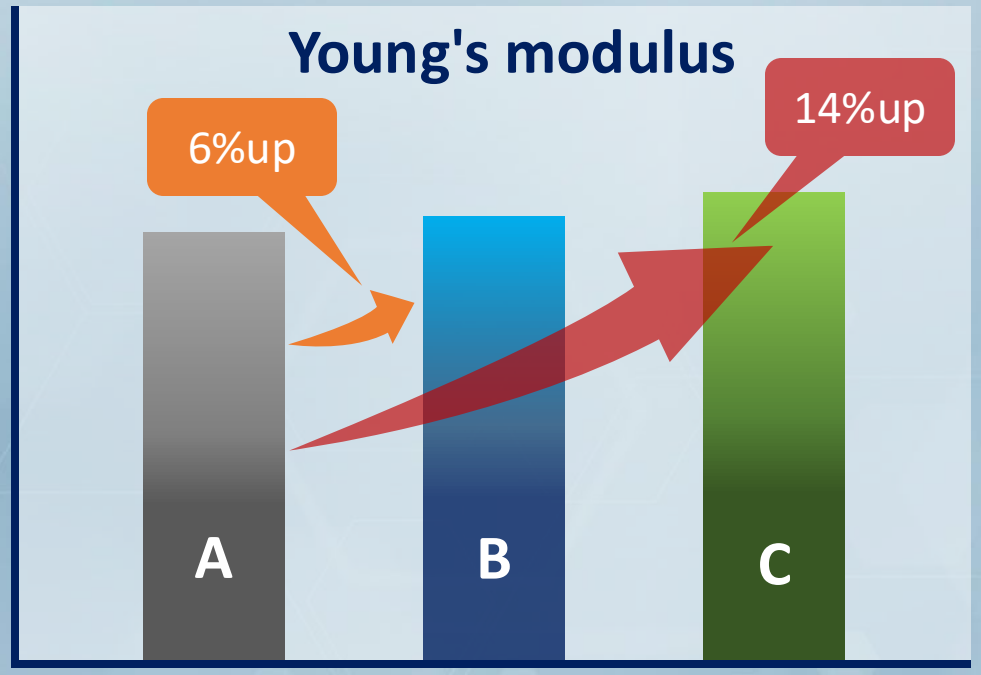
- **Young's modulus**
- **Fatigue strength**

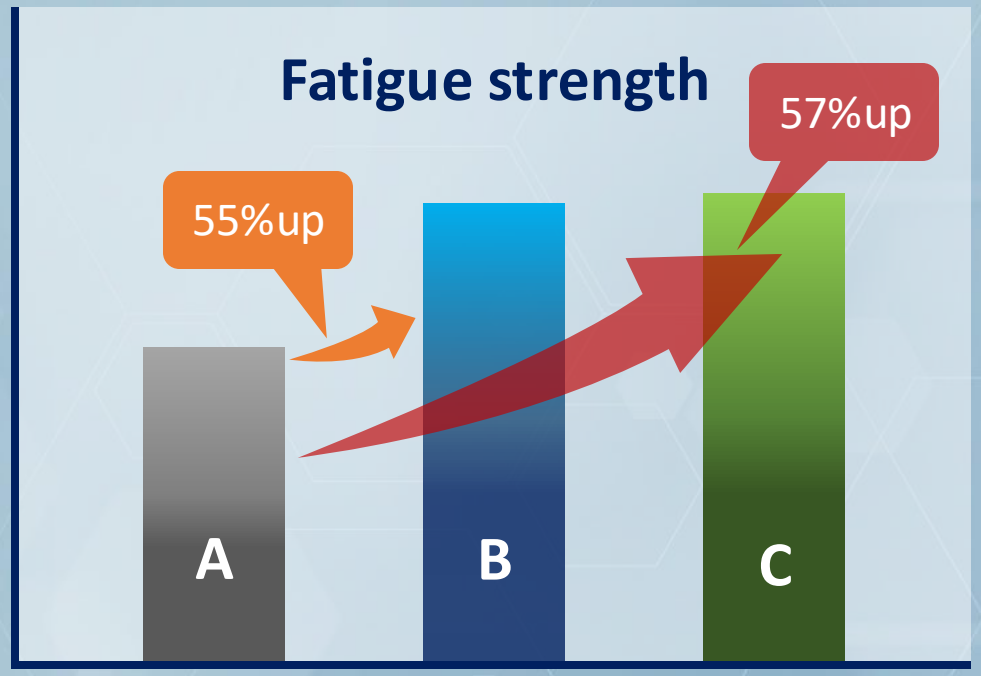
} Behavior at high temperatures should also be confirmed.

- **Creep characteristics**

New Probe Material Development

Two new materials were considered as candidates, and their Young's modulus and fatigue strength were evaluated. Significant improvements over the current materials have been confirmed.





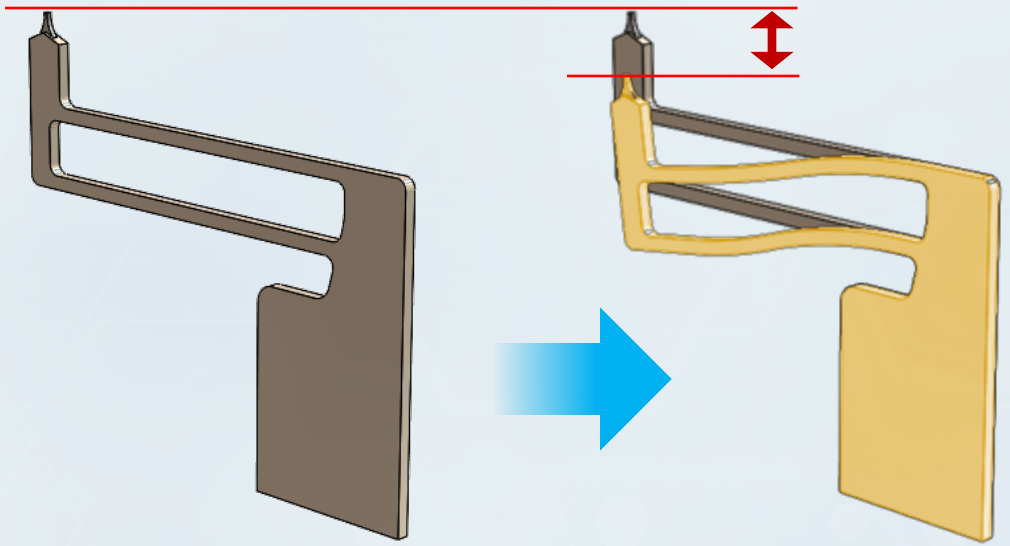
A Material A(Current) B Material B C Material C

Creeping Evaluation Result

The creep rate is calculated from the expected overdrive during operation and the corresponding creep amount.
Improvements in the creep rate have also been observed with the new materials.

Evaluation method

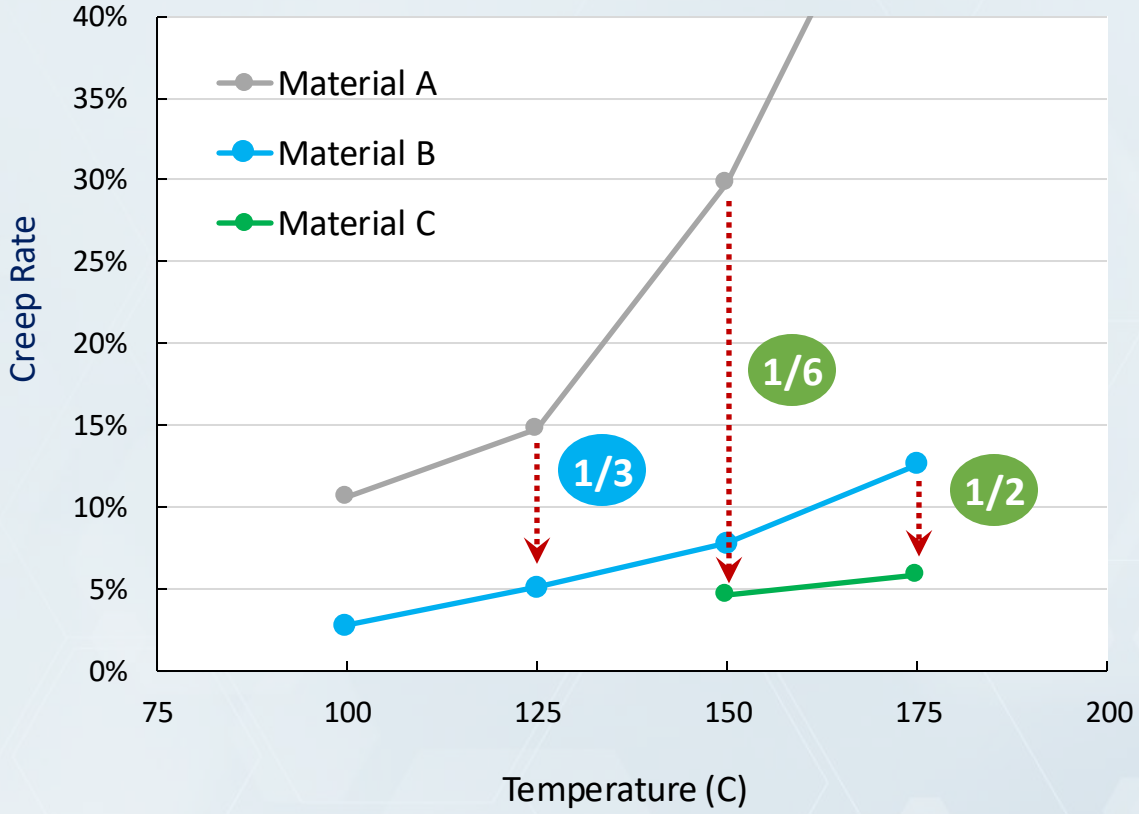
Creep rate = Amount of deformation / Load (OD)



Initial Shape

Creep (deformation)

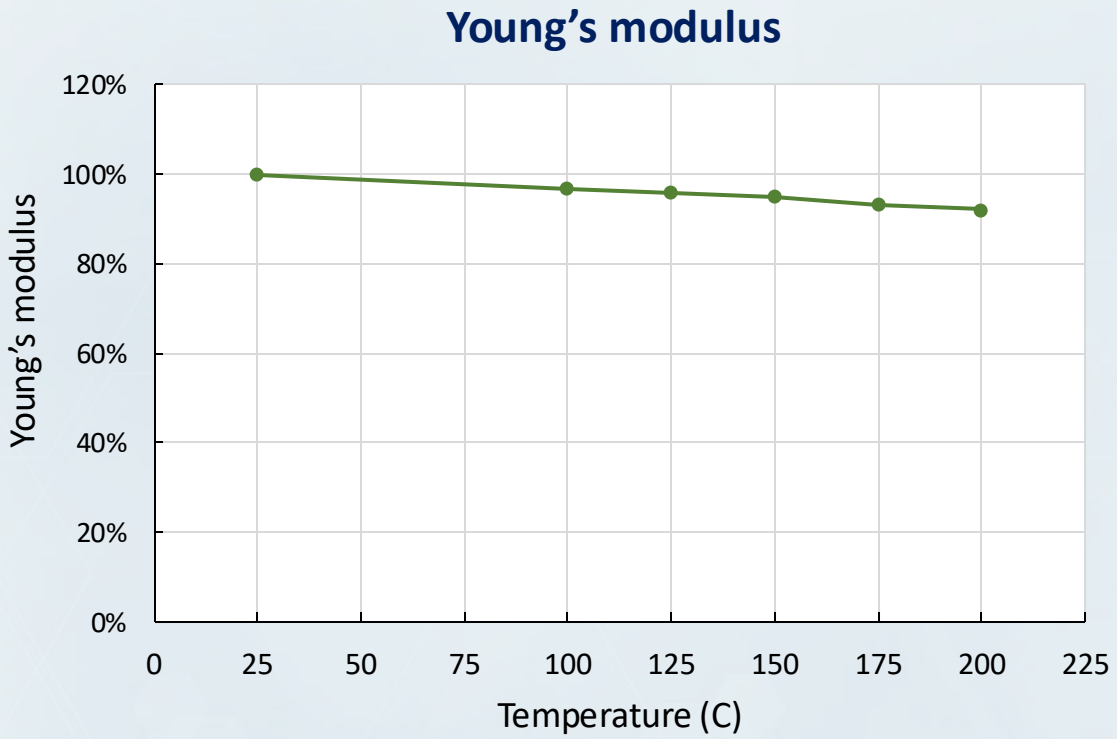
Evaluation results

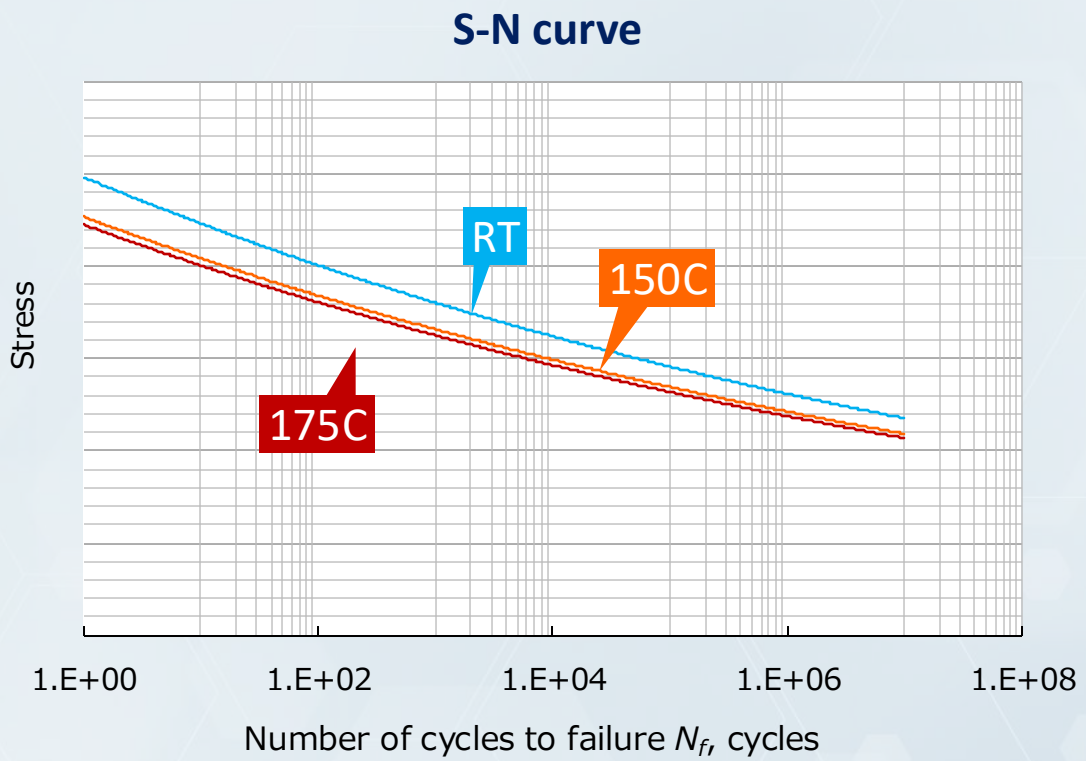


Material C stability

Young's modulus and Fatigue strength were both stable over the full temperature range.

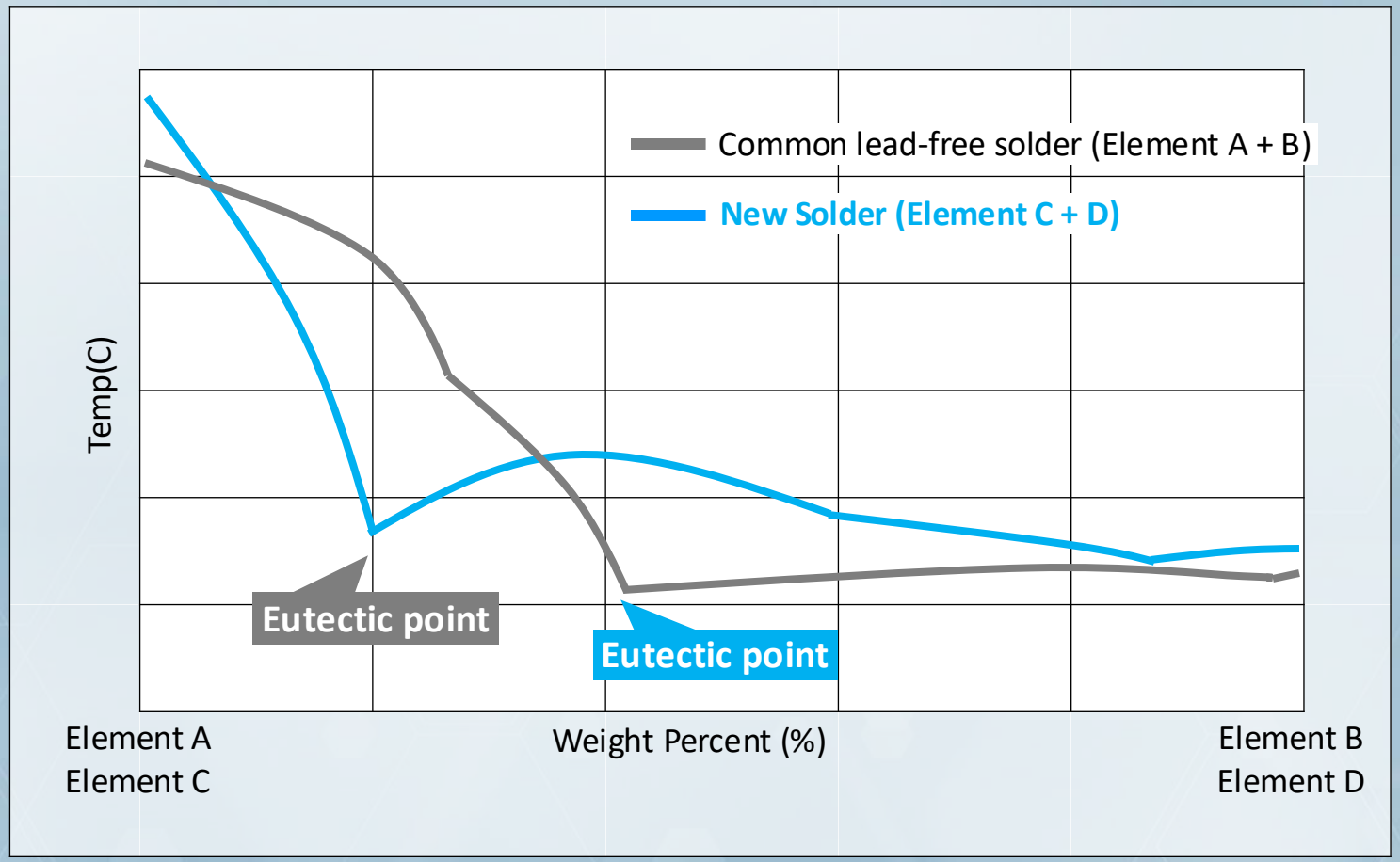
Conclusion: Material C is an excellent probe material for high-temperature applications.





New Solder Material Development

Phase Diagram



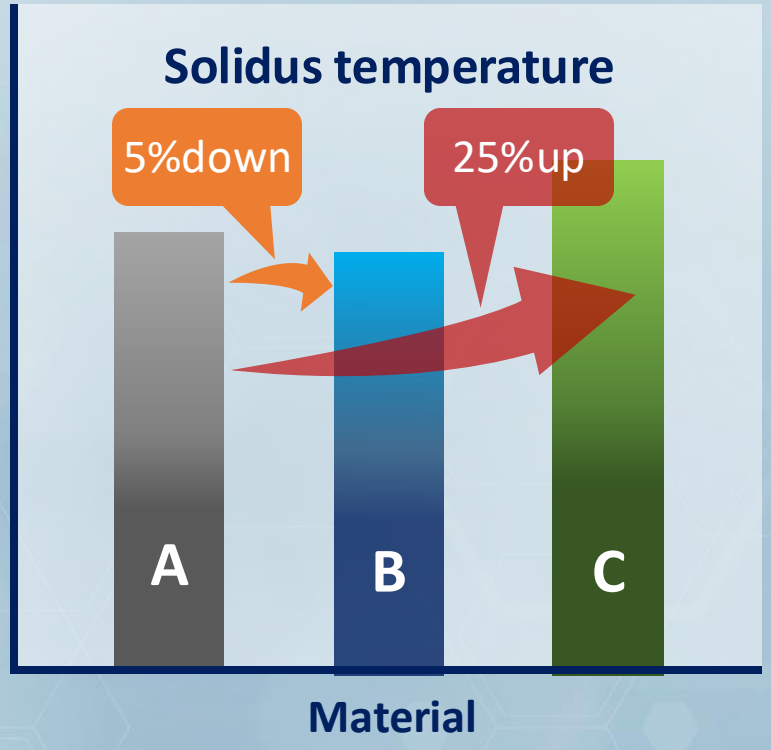
Solder materials are widely known to creep, even in room temperature. Therefore, it is necessary to select materials considering

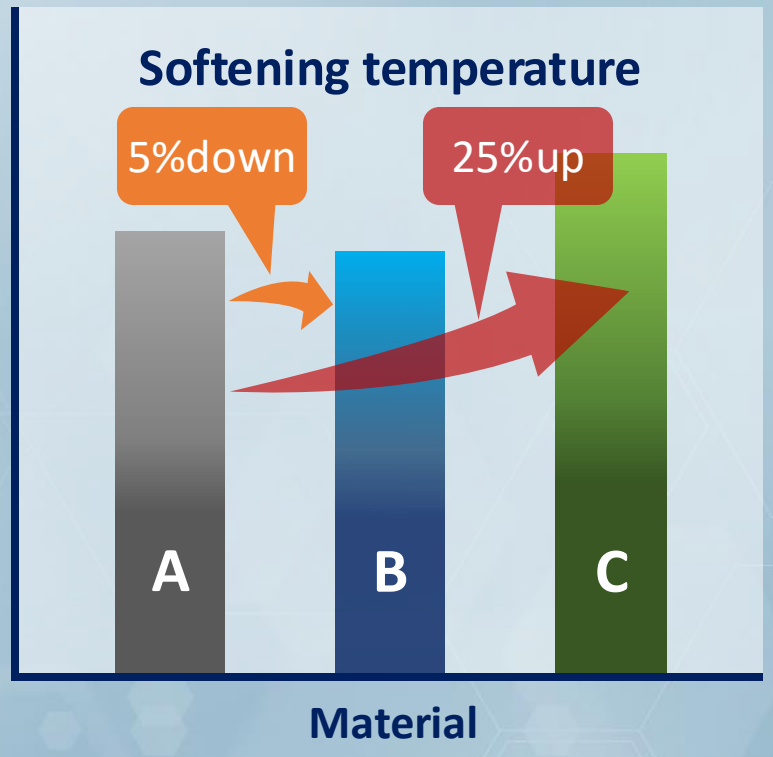
- **High melting points**
- **Creep characteristics**

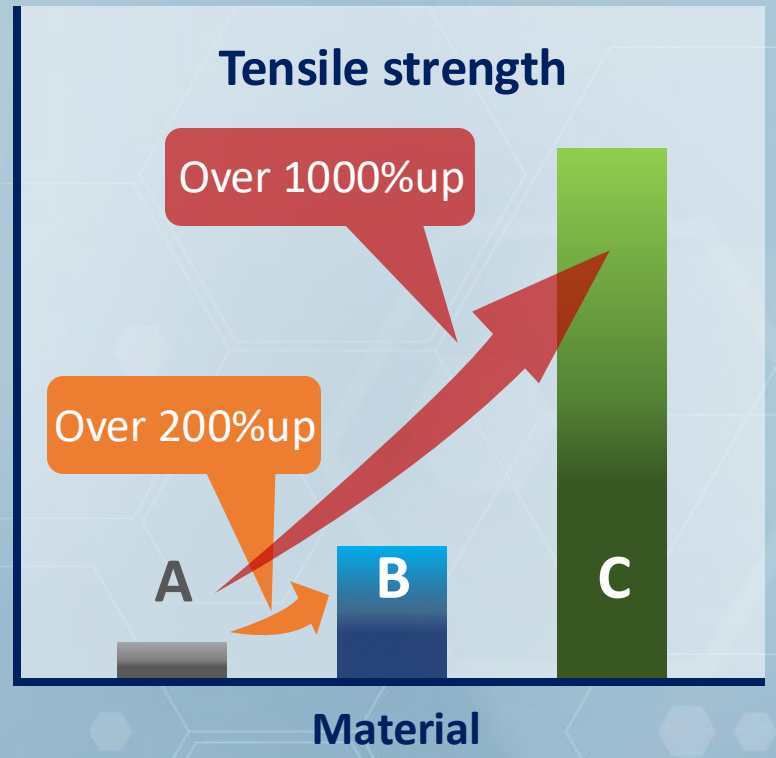
However, if the melting point is too high, it can negatively affect bonding by damaging the base material. It is crucial to choose solder with a high melting point while considering the bonding range of the probe.

New Solder Material Development

Three new materials were evaluated for melting and softening points as well as mechanical robustness.



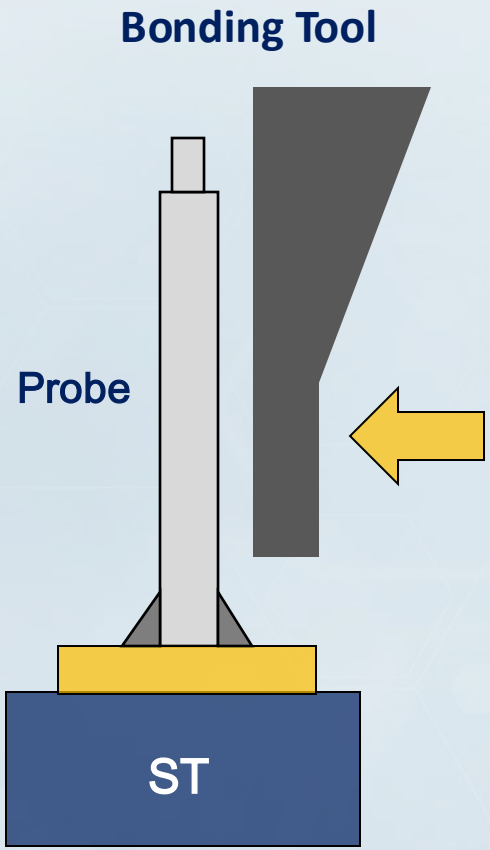


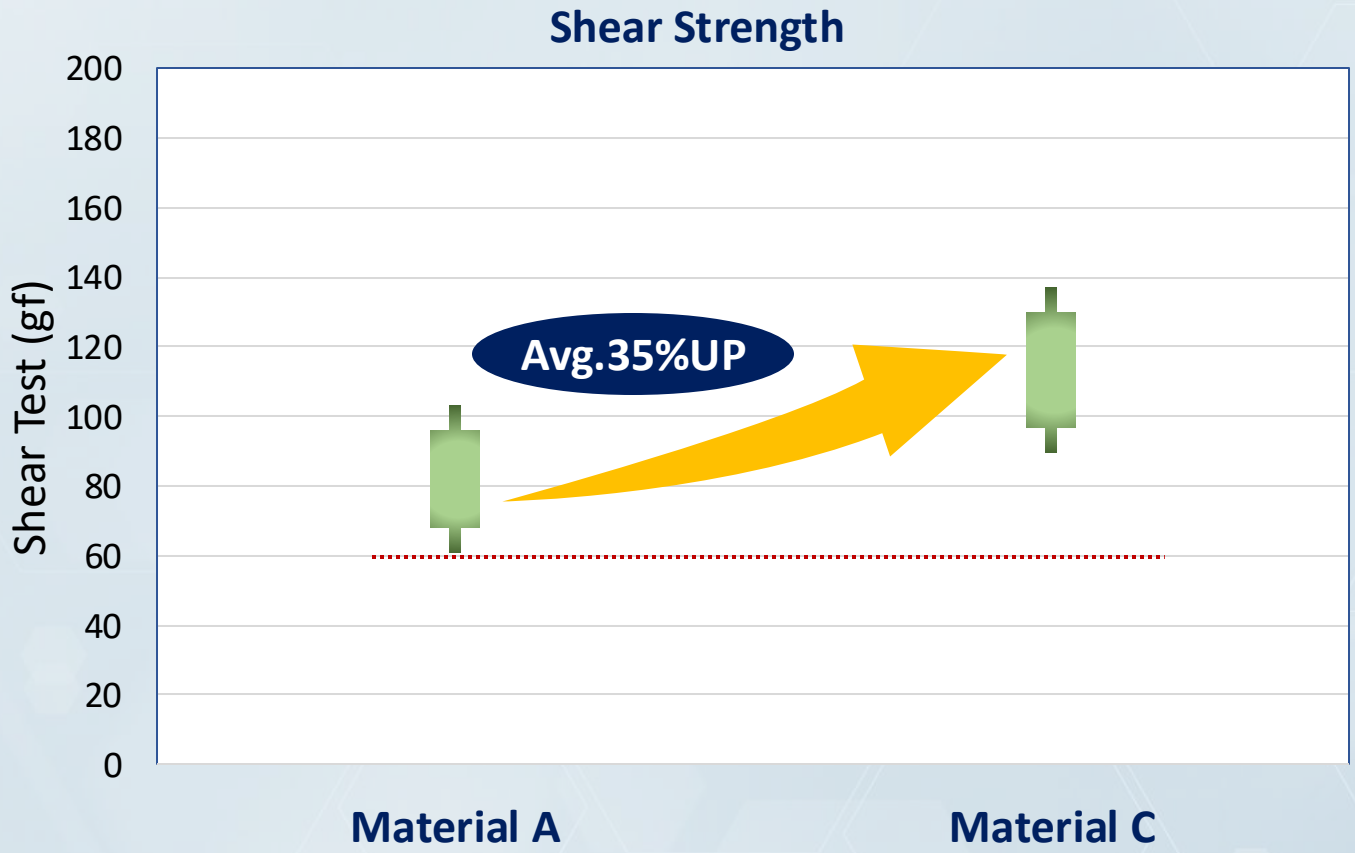


A Material A B Material B C Material C

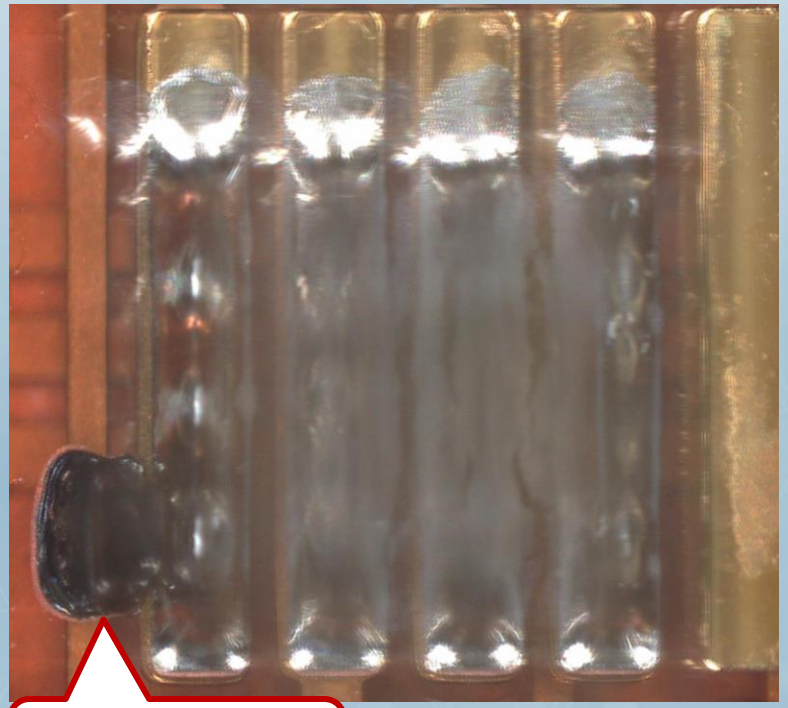
Benefits of new solder material C

Reduced creep + higher tensile and shear strengths
=> Better probe stability at high temperatures

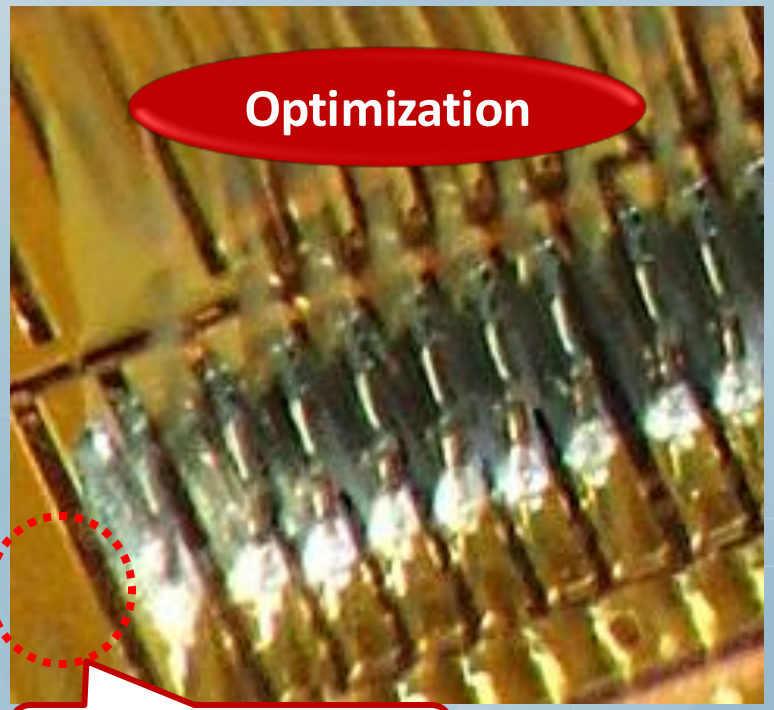




New Solder Material Development



Burnt



No Damage

High melting-point solder requires a high amount of heat during bonding. Therefore, damage to the base material is a critical issue.

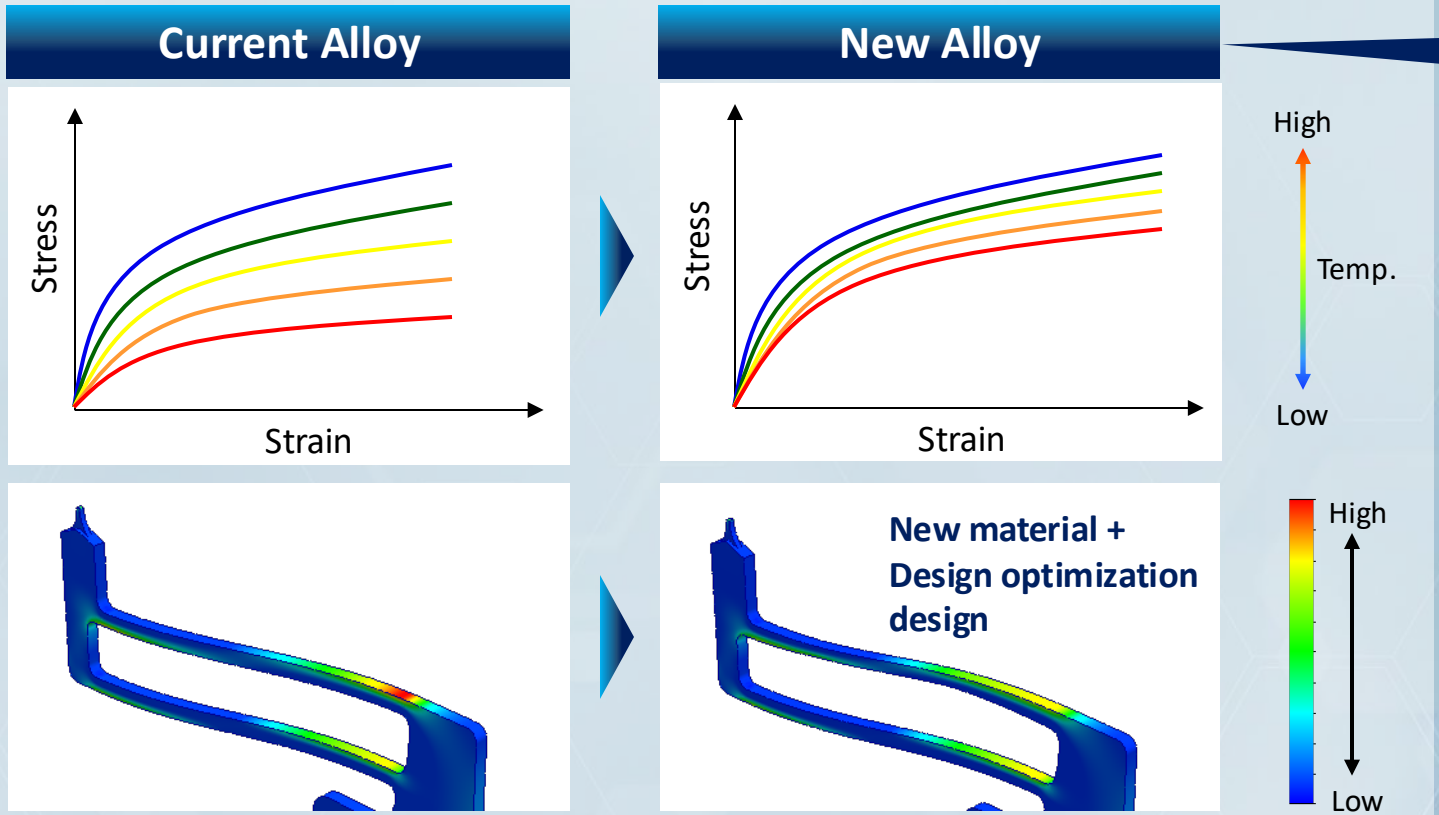
By optimizing conditions such as

- **Laser output**
- **Irradiation time**
- **Laser area**

Robust bonding is achieved.

New Probe Design

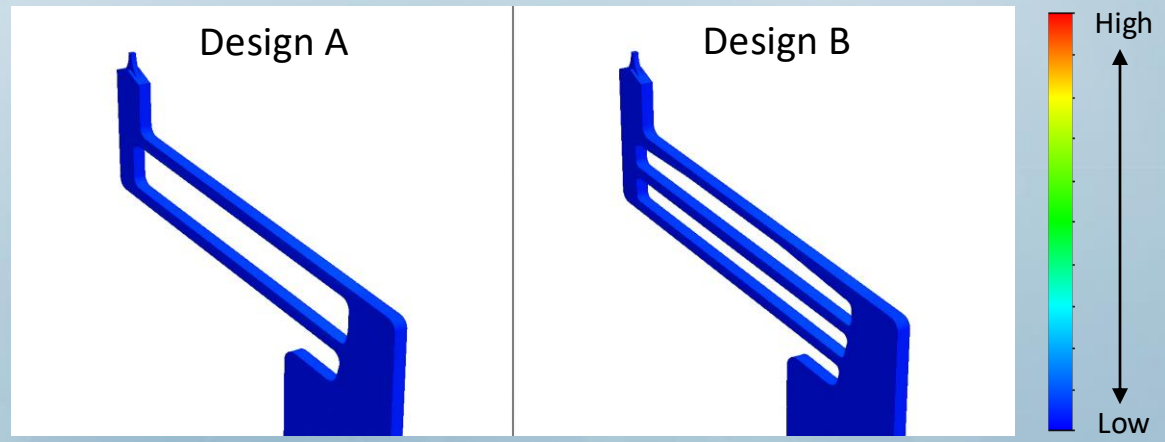
We have designed the probes using new materials for probes and solder.
The new probe material has a higher allowable stress and has improved the flexibility in shape design.
The new solder material reduce changes in strain due to temperature variations which helps to control creep.



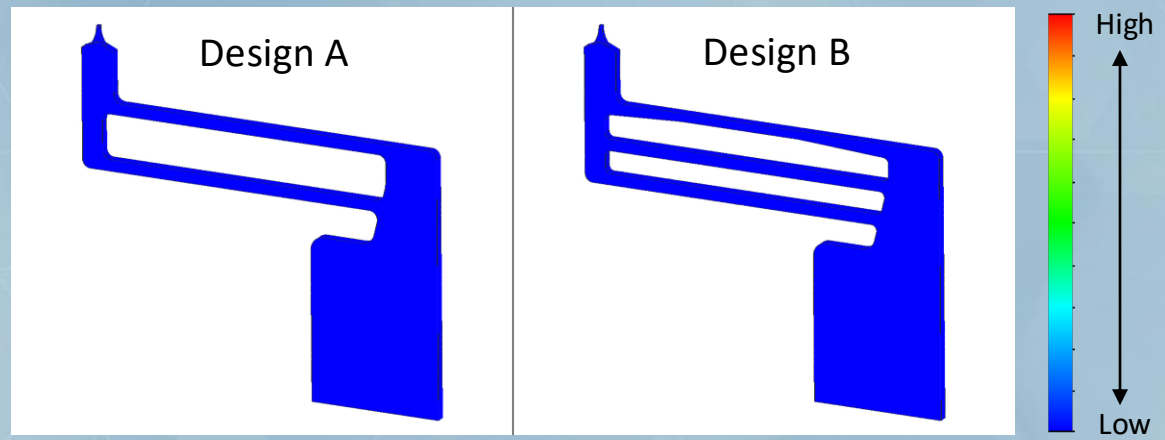
Tip Size	4um x 10um
Probe Force	0.7～0.8gf/mil
Scrub	< 8um
CCC	> 1A
Min Pitch	60um
MAX OD	120um
Stress @100um	< 25%

New Probe Design

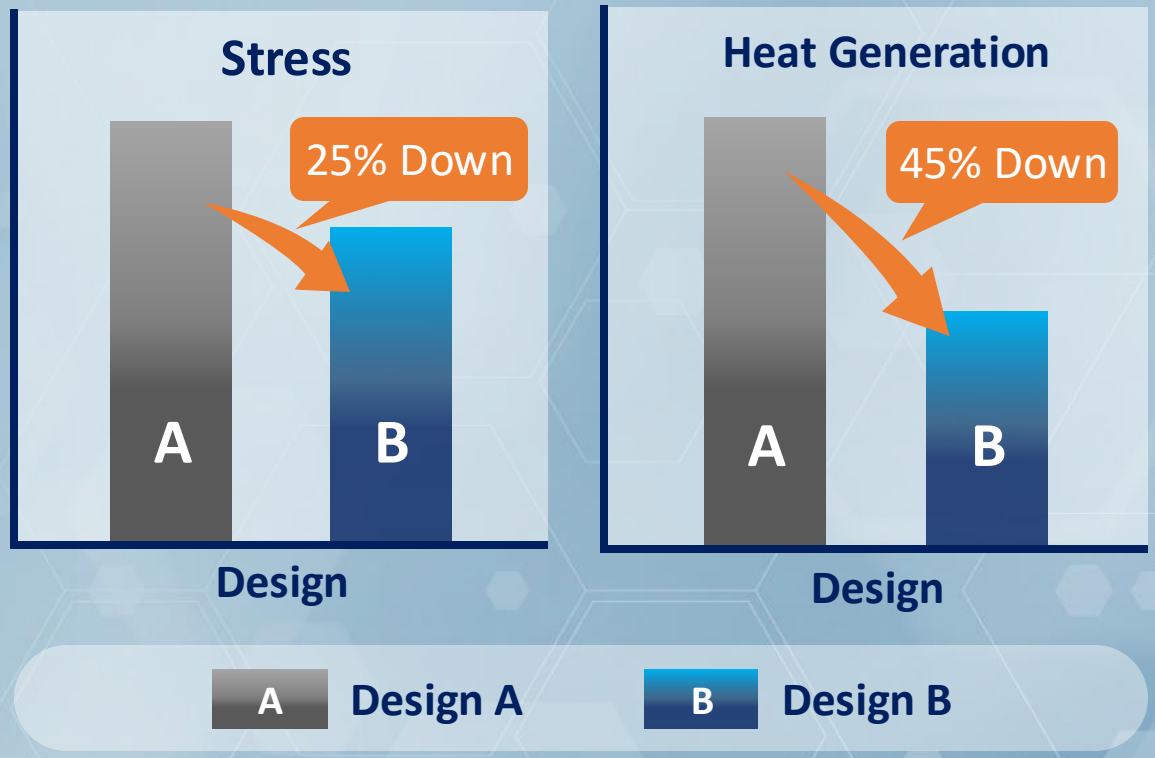
Stress



Heat Generation



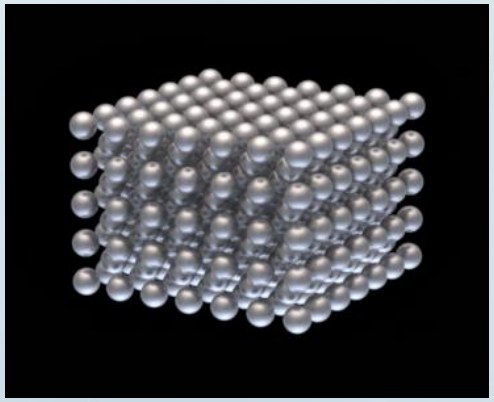
It is possible to improve the stress on the probe and heat generation efficiency by optimizing the probe shape. Analysis results also confirm improvements over conventional products.

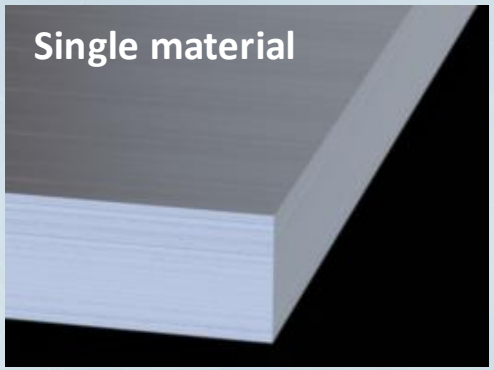


Probe for high temperature

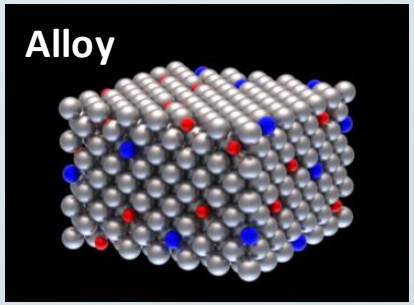
To control creep, it is not important to select only materials with good properties.
It is also necessary to improve in structure and design to reduce stress during contact to ensure long-term reliability.

Material

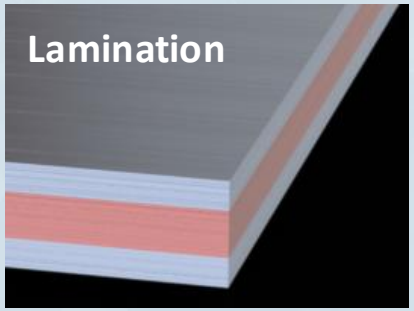




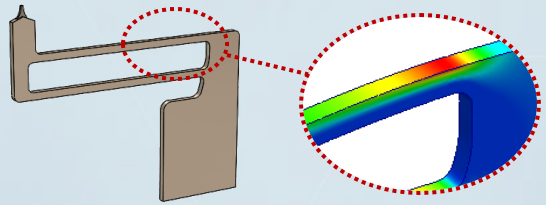
Material/Structure



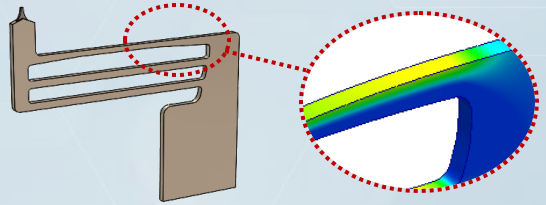
or



Design

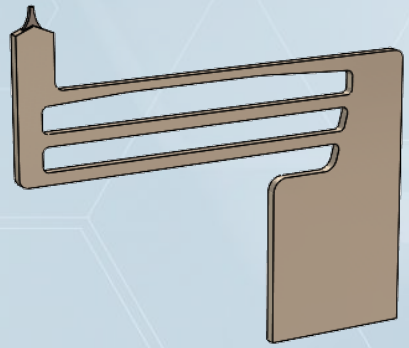


Optimize Stress



High Temp Probe

- Strength at high temperature (fatigue/creep)
- Low stress shape
- Withstand current performance



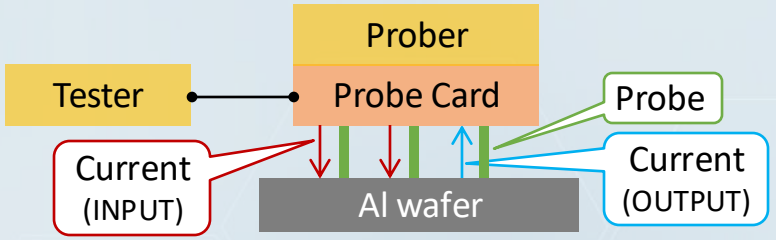
Card-Level Evaluation

Contact Resistance Result

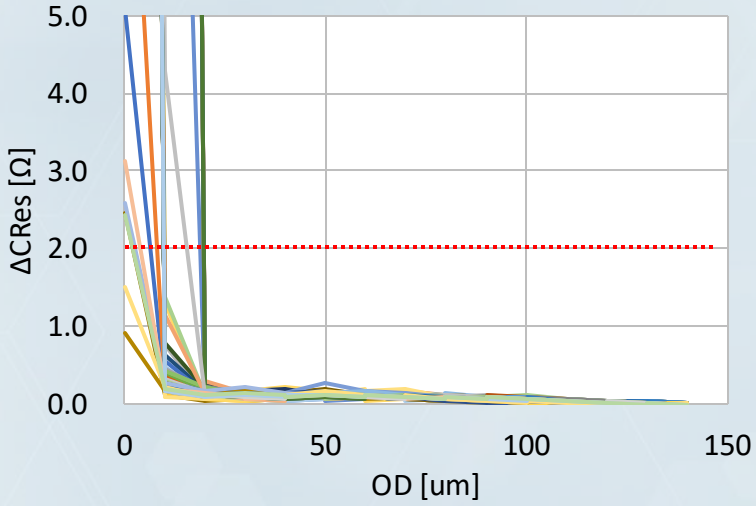
The new probes remain stable even in a 175C environment.
Contact stability is maintained from OD 20um, and consistent contact performance is achieved even with continuous contact.
The needle marks are well-defined, and contact performance is also satisfactory.

[Condition]
Temp : 175C
Contact : 5sec
Input : 10mA

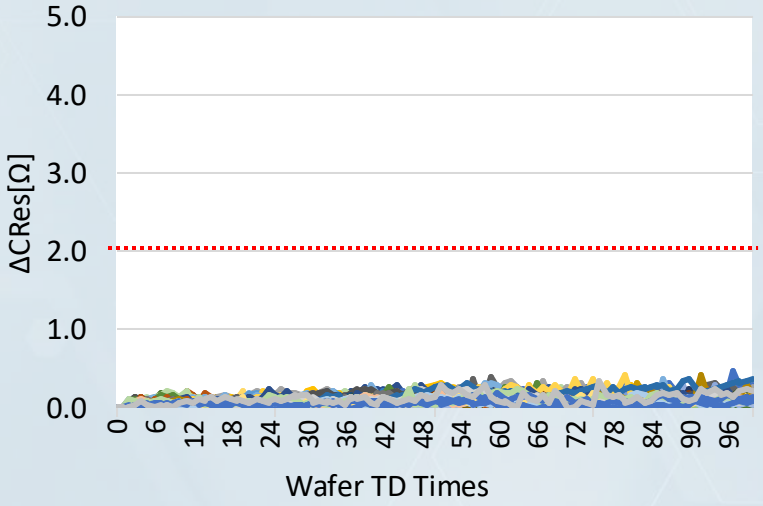
Test image



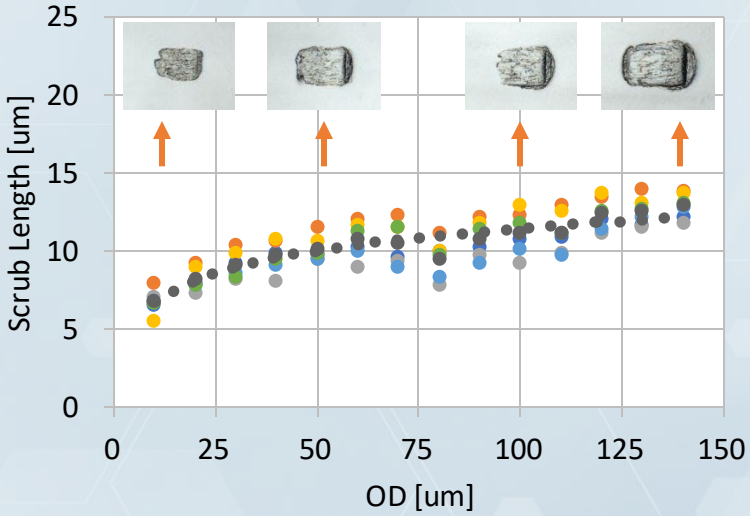
OD vs CRes



TD vs CRes @OD100um



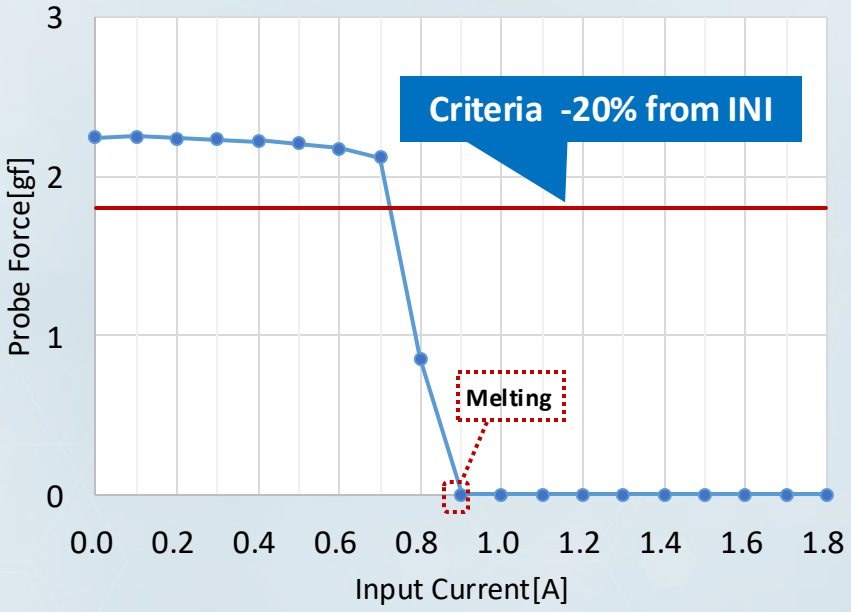
OD vs Scrub Length



CCC Evaluation Result

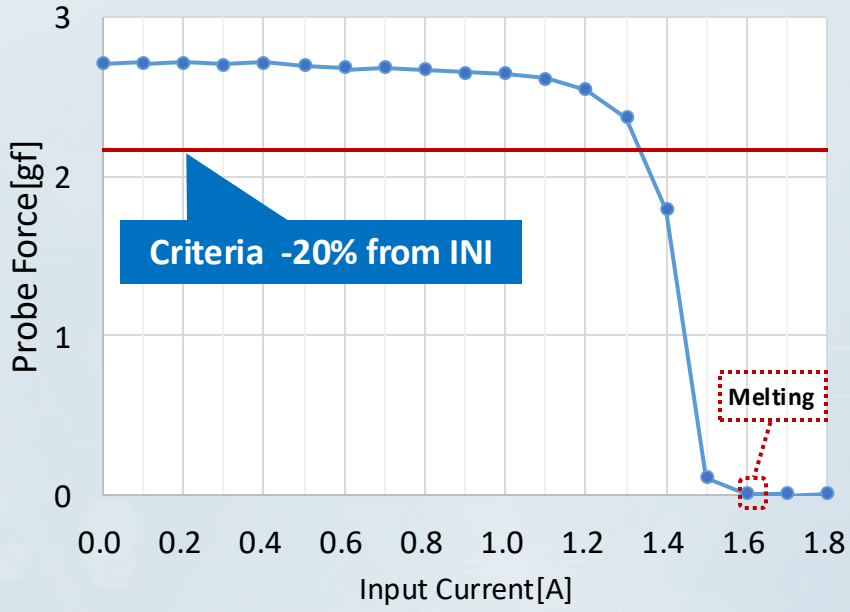
Current is continuously increased by 100mA every minute to verify the current-carrying capacity.
Due to material changes and stress-reducing design improvements, the high-temperature probes have shown a twofold improvement in CCC.

Current Probe



CCC：0.7A / Melting：0.8A

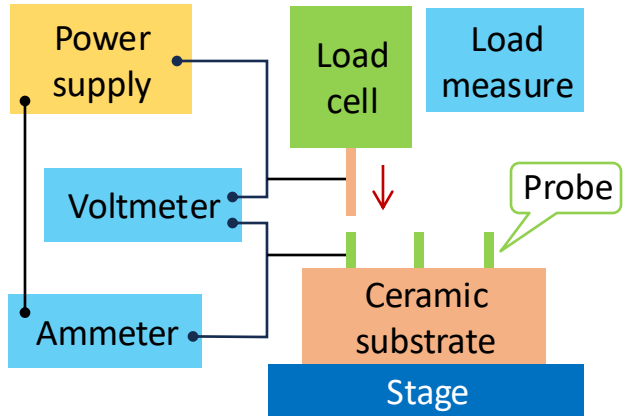
High Temp Probe



CCC：1.3A / Melting：1.6A

[Measurement Condition]
- Mode : Auto Measurement
- OD : 100um
- Input : 100mA 1min/step

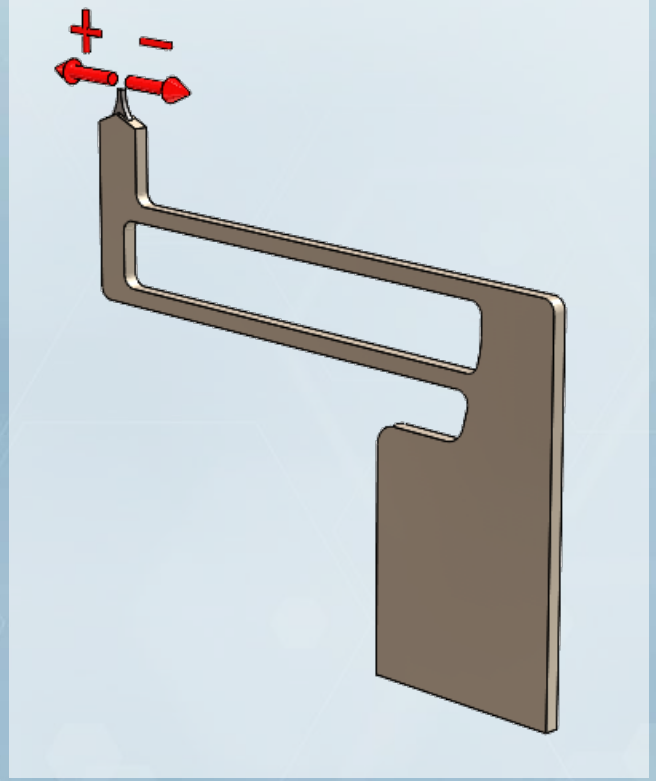
Test image



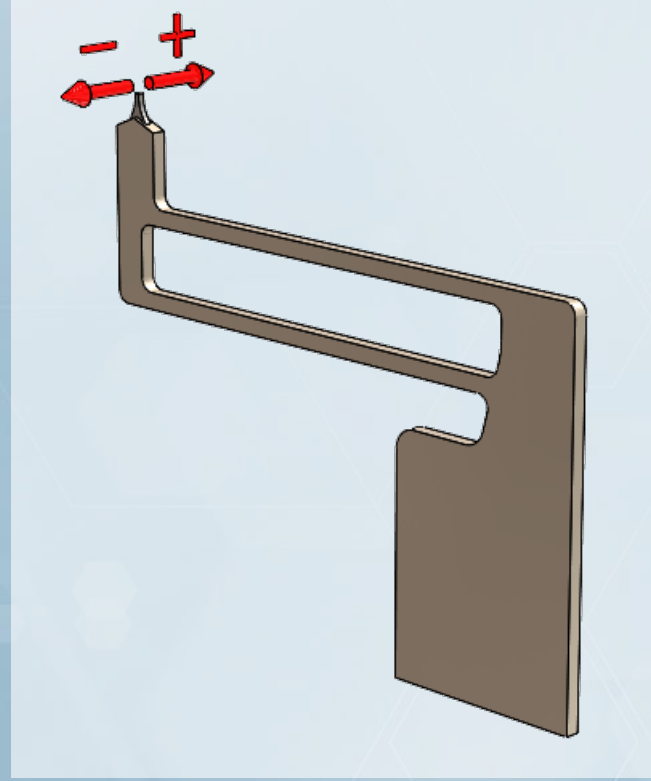
Endurance test TD 1M & Creep Evaluation Result

*Description of displacement direction

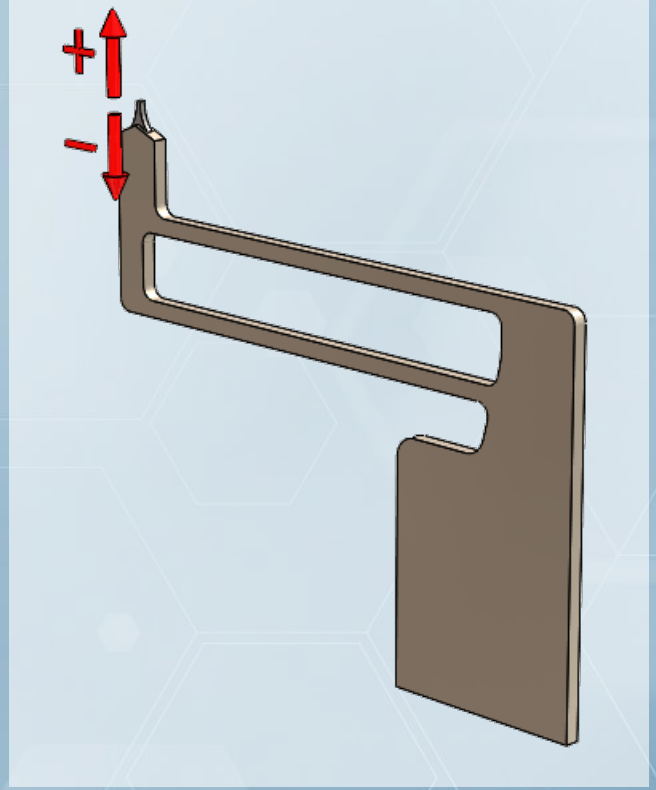
Scrub displacement



Pitch displacement

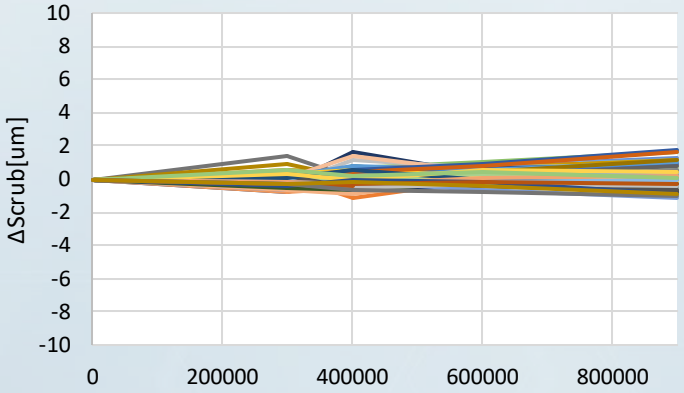
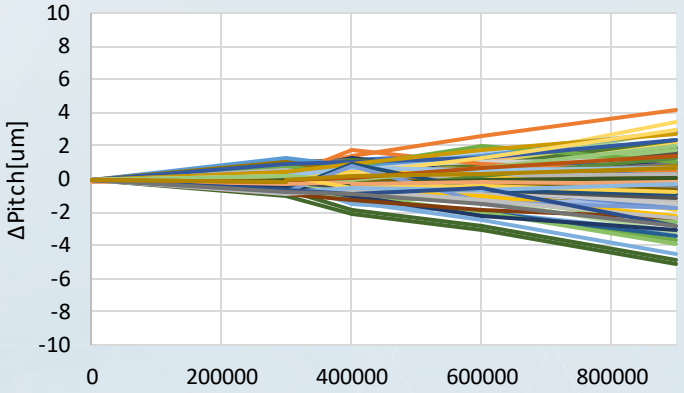
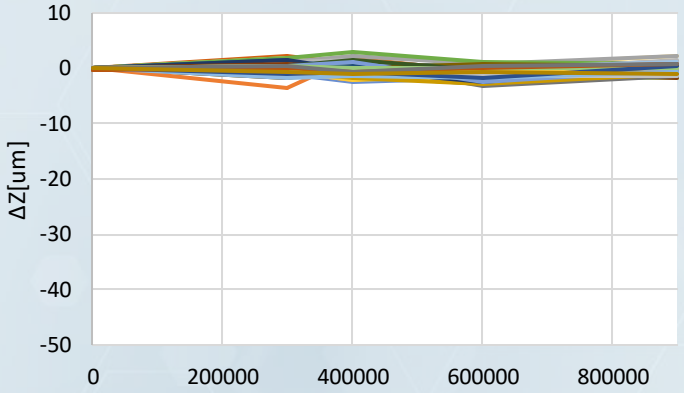
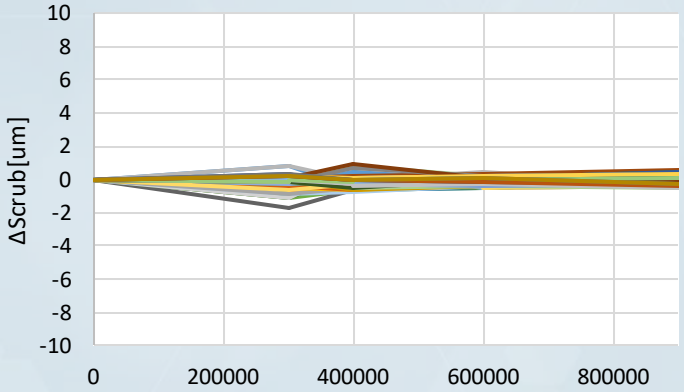
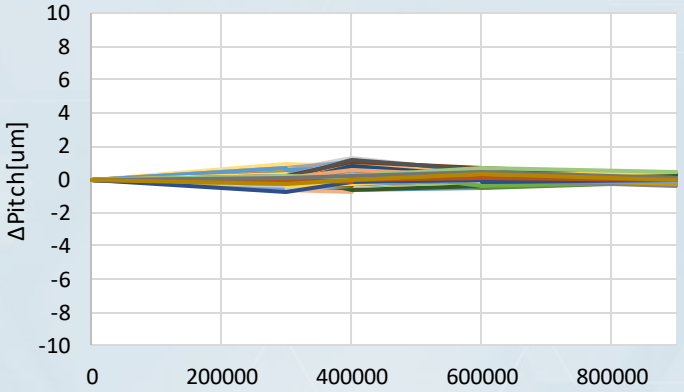
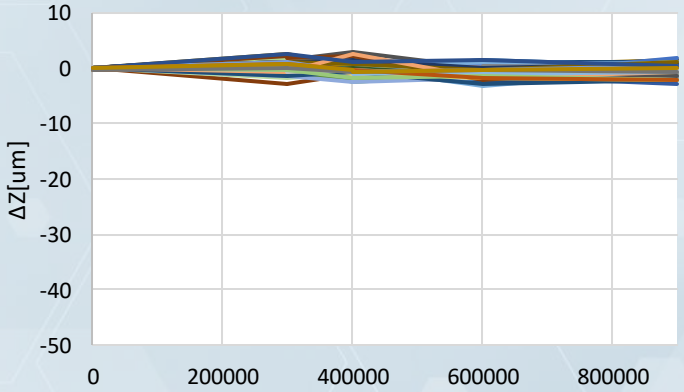


Z displacement



Endurance test TD 1M

This shows the contact endurance test result over 1 million.
The probes developed for high-temperature is well-controlled deformation against existing specifications.

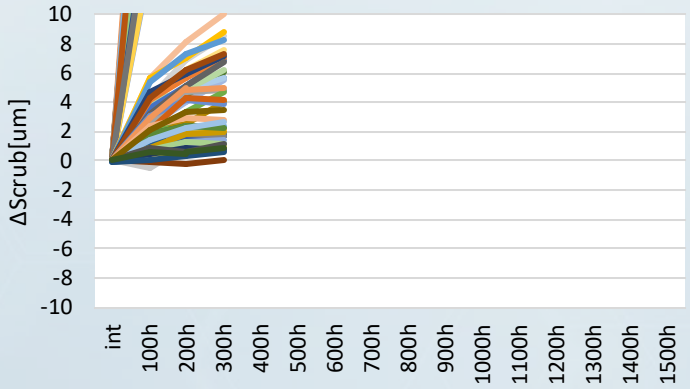
	Scrub displacement	Pitch displacement	Z displacement
Current Probe			
High Temp Probe			

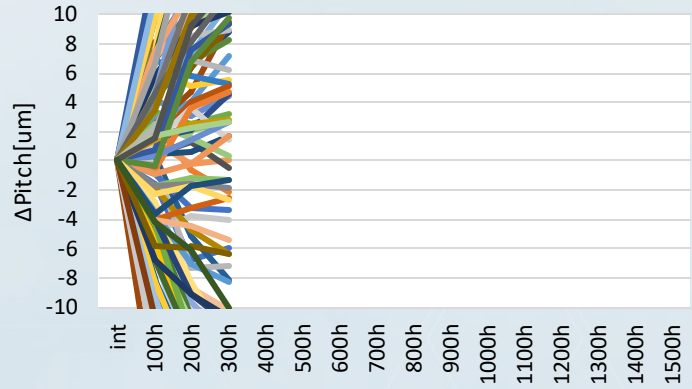
Creep Evaluation Result

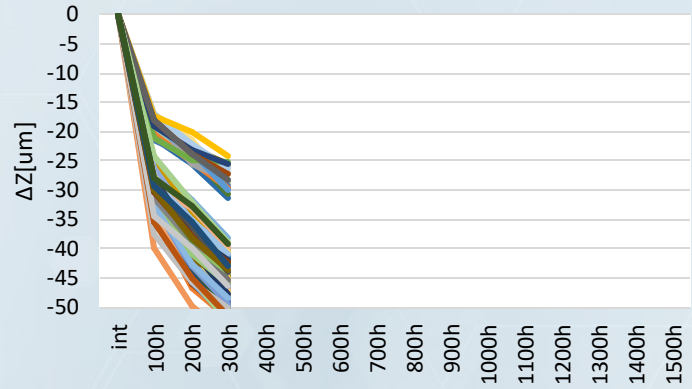
- Current probe has uncontrollable creep.
- High-temperature probe shows significant improvements.

Scrub displacement | **Pitch displacement** | **Z displacement**

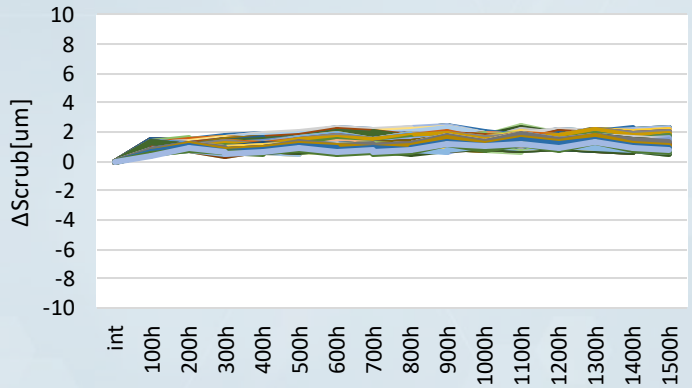
Current Probe

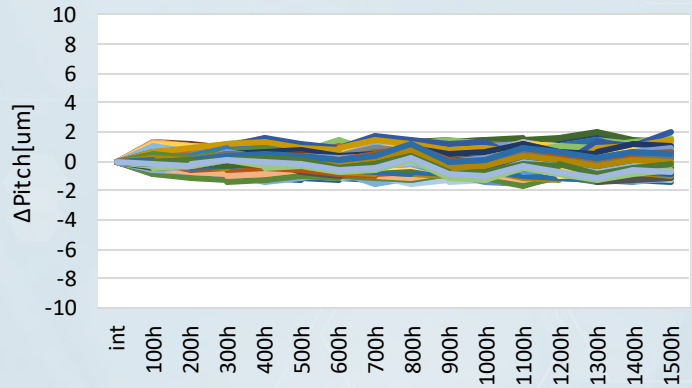


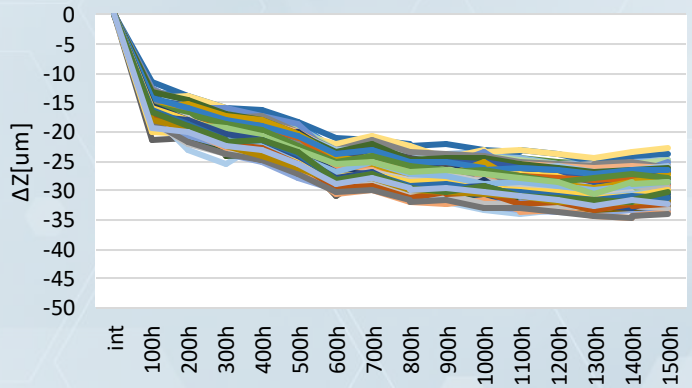




High Temp Probe





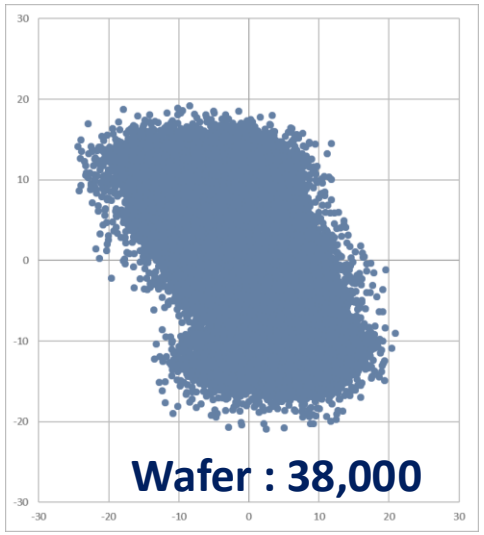


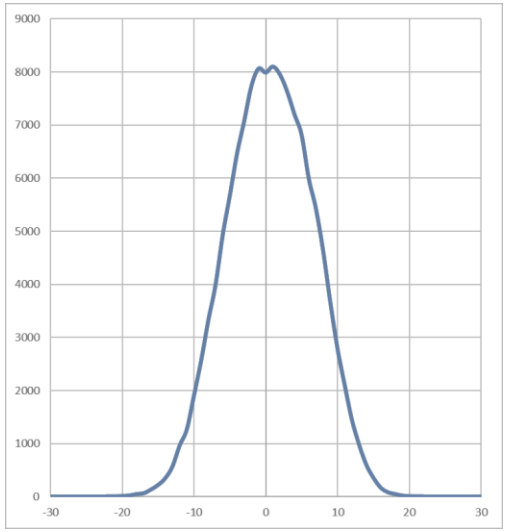
Production Result (Reference Data)

Probe positions measured after many TDs at > 100C

Probes not optimized for high temperatures shows significant probe position variations. In contrast, probes optimized for high temperatures are able to control probe position effectively.

Before Optimization

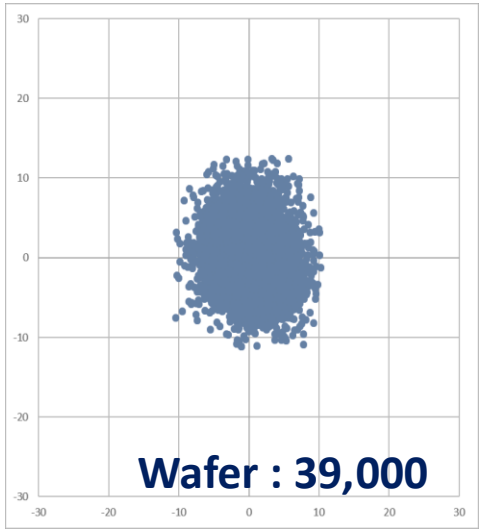


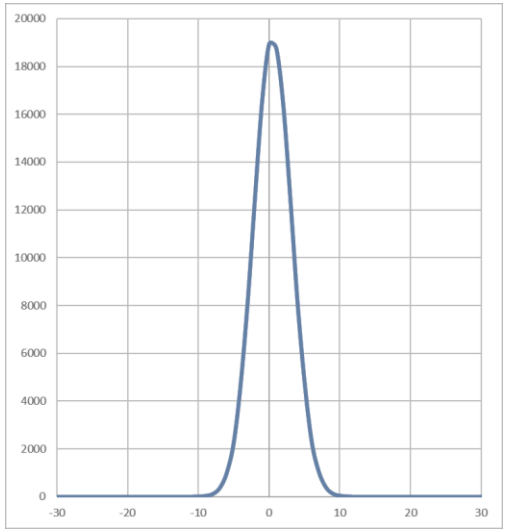


	ΔX (um)	ΔY (um)
3σ	16.3	22.9
Median	0.2	0.4

After Optimization

Test Temp: >100C





	ΔX (um)	ΔY ((um)
3σ	6.0	10.1
Median	0.0	0.2

Conclusion

Requirements for Probe Cards

- Testing high-performance ICs requires careful consideration of thermal effects.
- Probe cards must withstand higher temperatures.
- New probe and solder materials are required to increase CCC, minimize creep, and allow more flexible probe designs.

New probe and solder materials successfully developed

- Creep is well-controlled by using new probe materials and a low-stress design.
- New solder material reduces the probe movement.
- Reliability tests suggest that the new probes are suitable for 175C testing.

Next Step

- Produce engineering samples and proceed to mass production testing in collaboration with customers.

Questions

Thank you!

Acknowledgment

Tomoyuki Takeda / Naoki Arita / Kenji Uchihara / Reisa Nagamatsu

Please visits our booth (403) for discussion in detail

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