BUMP TEST SEMINAR
and
FUTURE µBUMP DEMAND RESEARCH

VPC Team

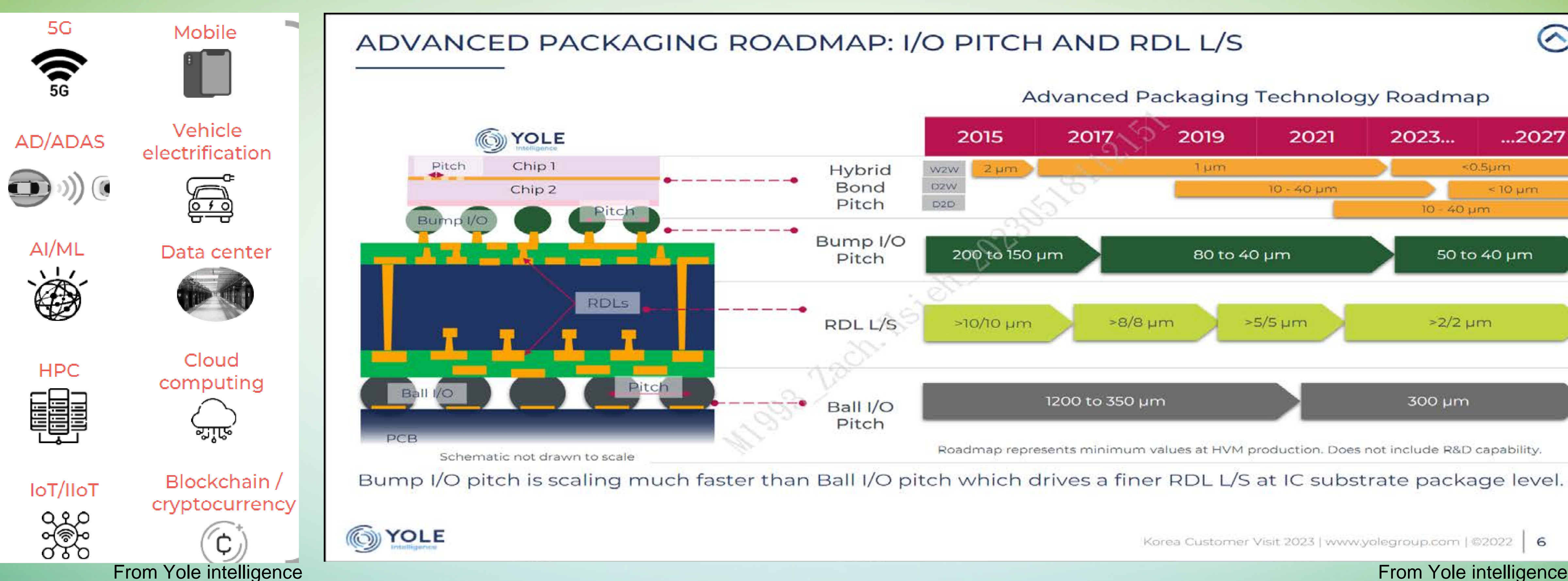
Zach

June 5 - 7, 2023

Overview

- **Why needle force is such IMPORTANT for testing**
- **How we do**
  - ANASYS Bump simulation
  - Bump Analysis System
- **What we do**
  - Bump 80
  - Bump 40x70
  - Bump 60
- **Comparison between Bumps**
- **Summary 2023**

New tech Application Evolution

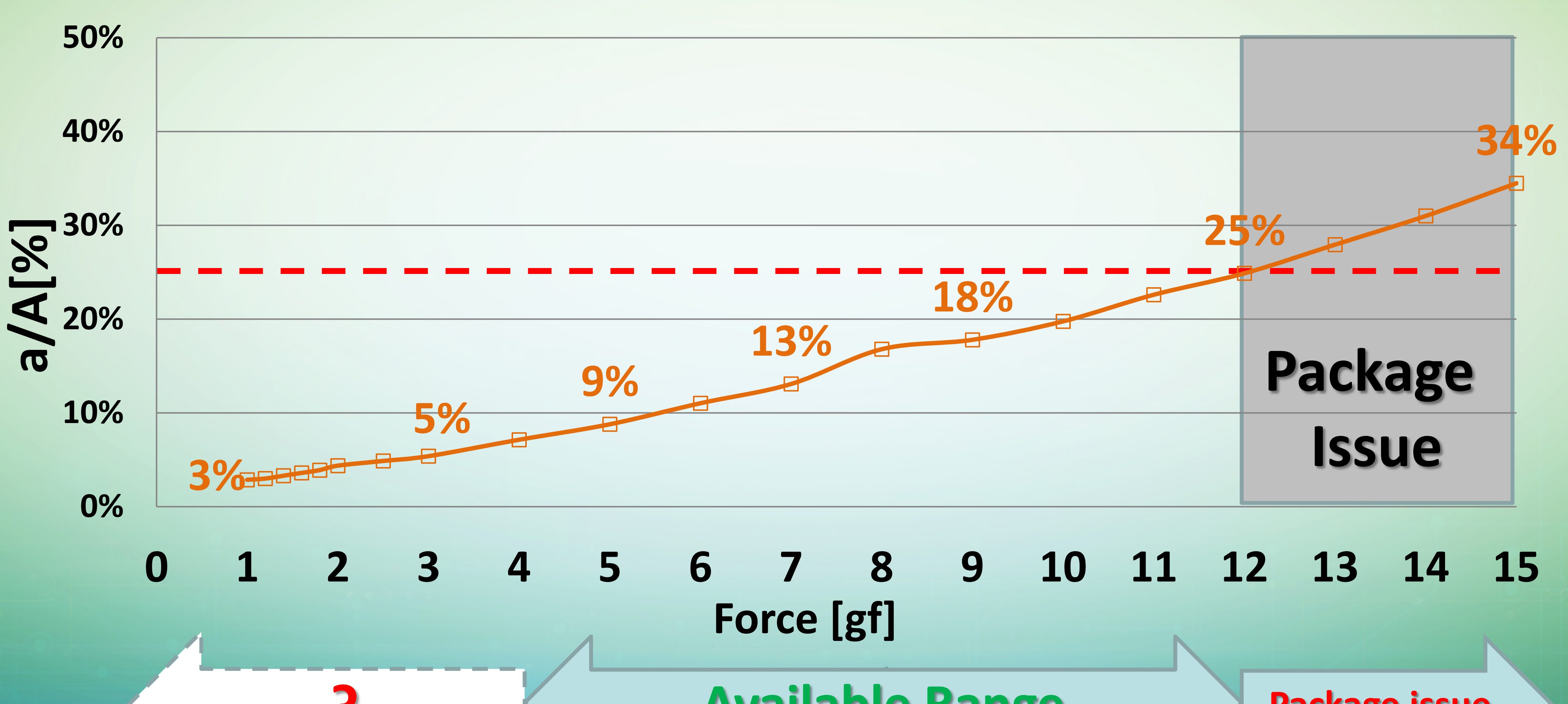


From Yole intelligence

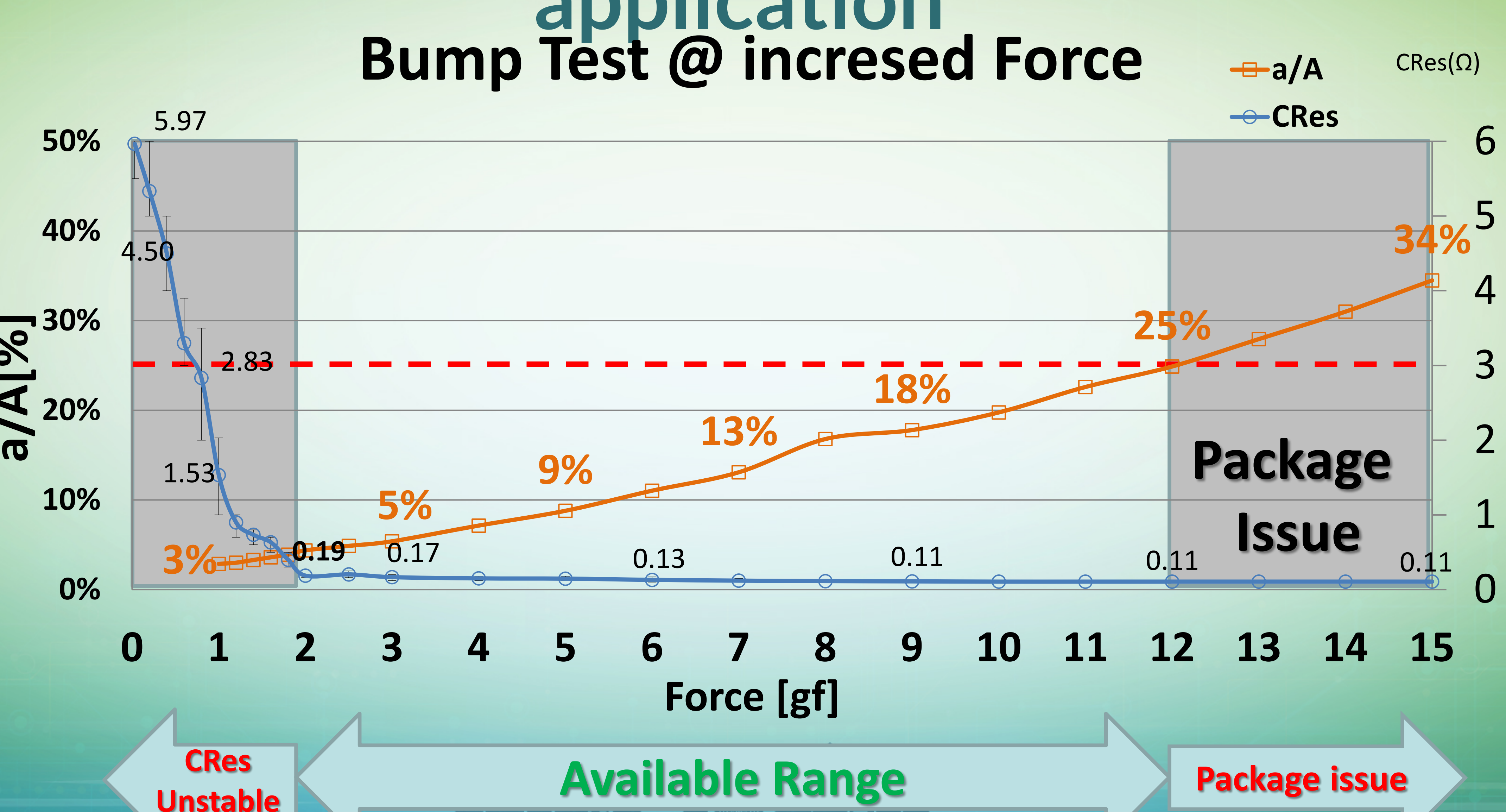
From Yole intelligence

Bump sizes had decreased to around 100 microns, and today they can be as small as 30 microns or less.

How to define the force range with application



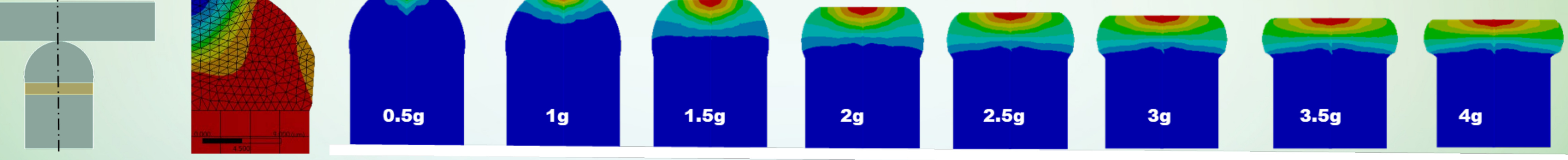
How to define the force range with application



How to know the force range

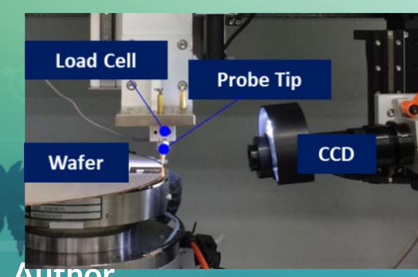
• ANASYS bump simulation

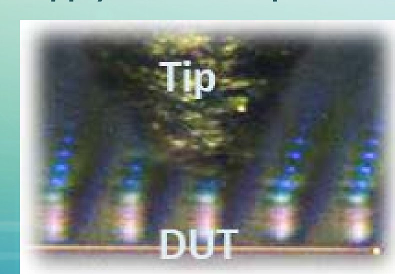
- In mechanical analysis, the wafer bump itself is an elastic material and the external force it receives comes from the contact force provided by the elastic probe. Under the interaction of the two, the spring constants of the wafer bump and probe form a series-connected system of springs. Therefore, different combinations of wafer bump and probe of different materials or sizes will produce different equivalent spring constants. In this study, we use equipment measurement, mathematical modeling, and finite element analysis (FEA) simulation to observe the probe mark on the wafer bump. We simultaneously compare the factors that affect the difference in probe marks under various strengths of external force and establish a comprehensive and precise definition of the probe mark. We also provide clear rules for designing the contact force of the probe.

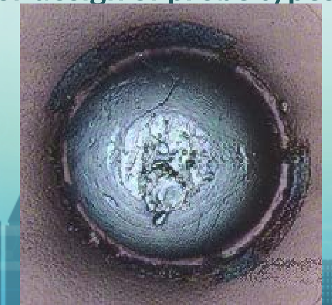


• Real Bump Test

- At MPI, we use the Probe Analysis System (PAS) and Prober testing equipment to perform probe mark testing on single probes and complete probe cards. Through precise alignment of the equipment, researcher inspections, and large-scale data collection, as well as analysis software to summarize the test results, we obtain sufficient data feedback and apply it to the improvement or design of probe types in actual cases



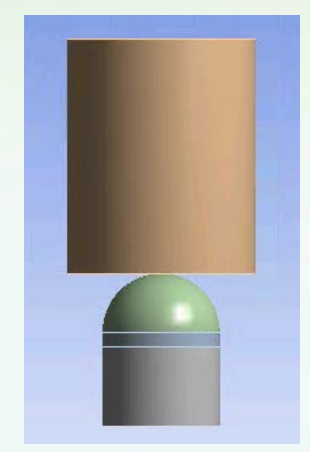


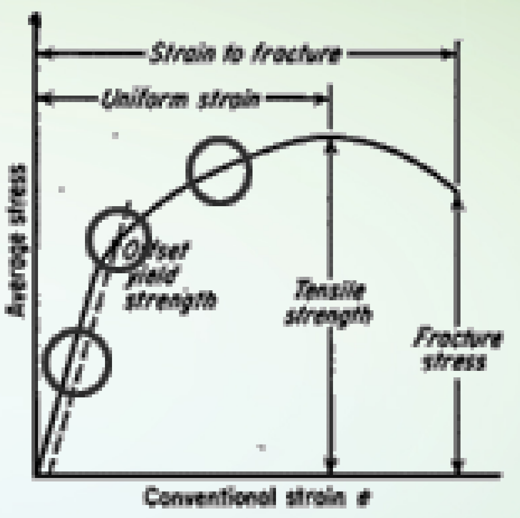


Bump stimulation by AnSYS

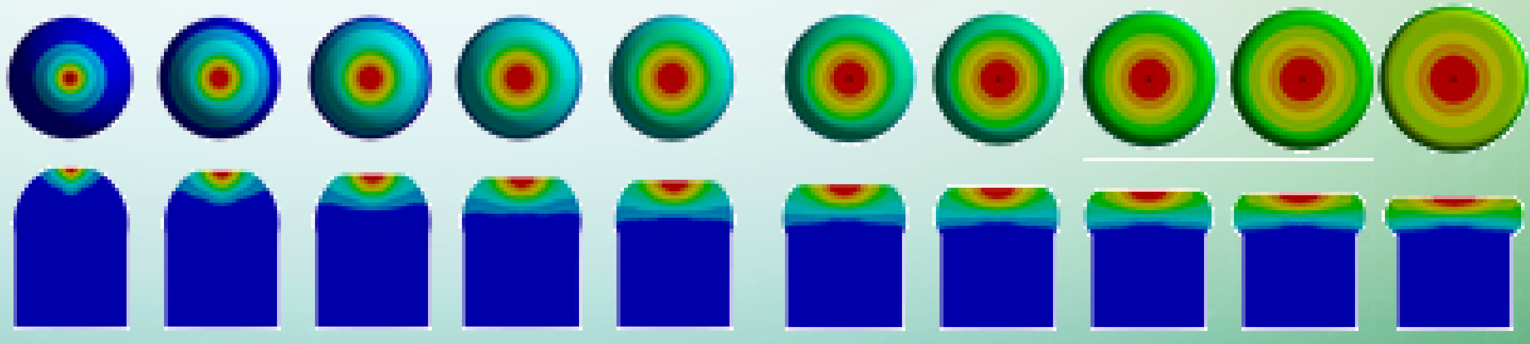
- ANSYS bump simulation
  - Geometry
    - Dimensions
    - 3D model vs. 2D model
  - Material Properties
    - *Young's Modulus*
    - *Yield Strength*
    - Tangent Modulus
  - Meshes
    - Generally vs. Adaptively
    - Optimization
  - Boundary Conditions
    - Fixed Support
    - Force

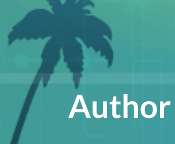
Solve : Bump Deformation
(x, y, z - direction)





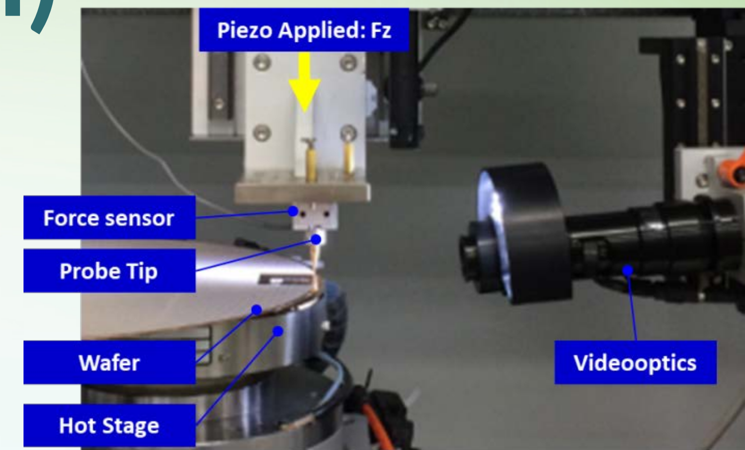
Young's Modulus
Yield Strength
Tangent Modulus

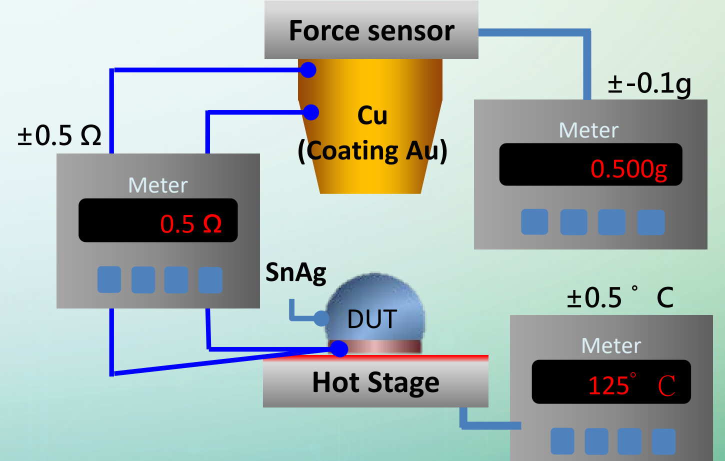




Real Bump Test by PAS (Probe Analysis System)

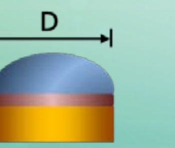
- **Experimental conditions**
  - Instrument : **Probe Analysis System**
  - Contact force by Bump Size ≧60um ： **1 ~ 15 gf (increase by 1 gf.)**
  - Contact force by Bump Size <60um ： **1 ~ 5 gf (increase by 0.5 gf.)**
  - Contact Time(sec): **1sec**
  - Touch Down Time ： **1 time**
  - Temperature ： **25℃、125 ℃ (Pre heat time ： 90min)**
  - Samples ： **10 valid PM result each condition**

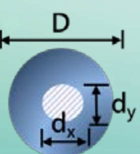




- **Experimental Result**
  - PM Surface figure (valid PM result)
  - Force vs. Bump a/A ratio

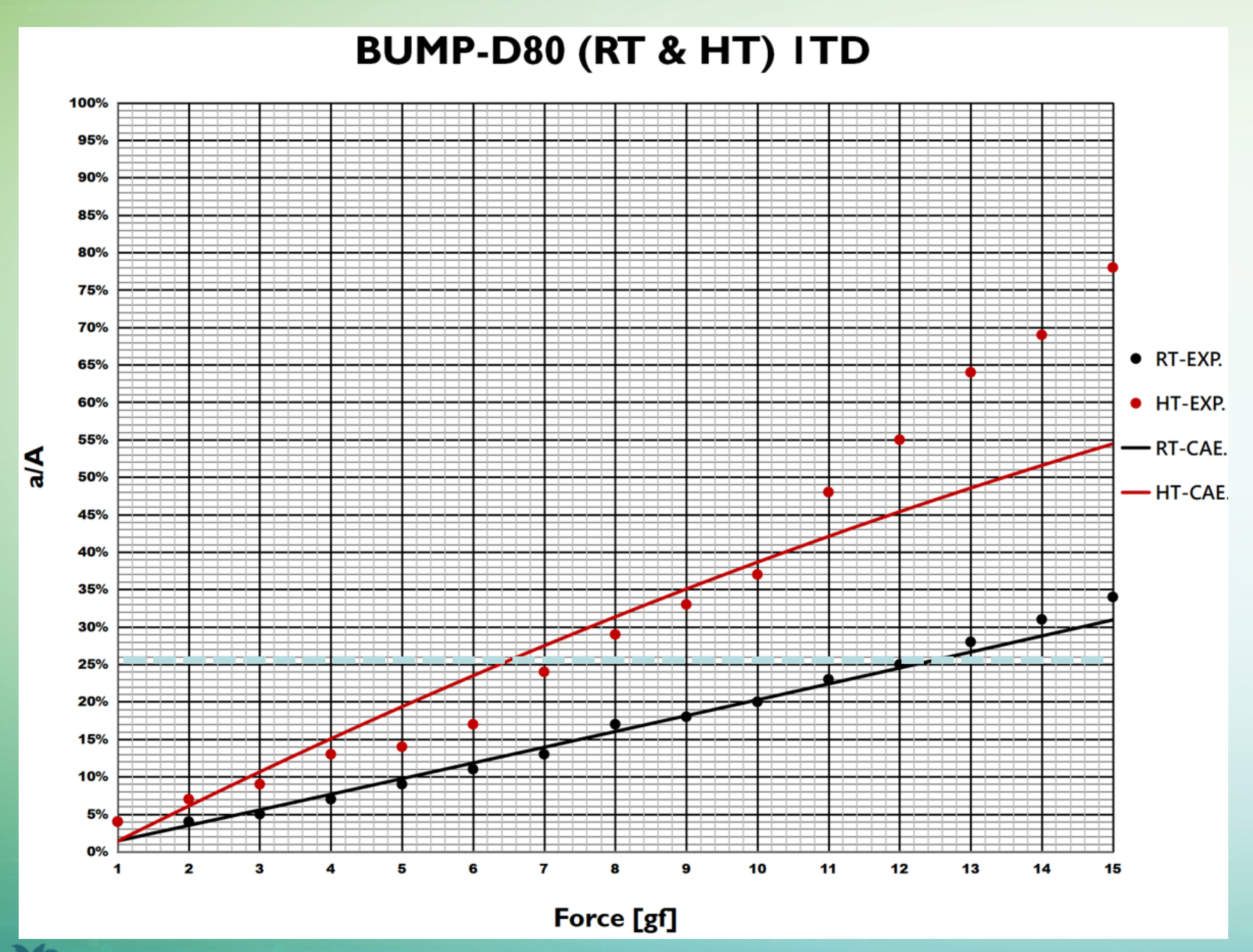
PM Area：





$Max(dx, dy) = d$; $A = \frac{\pi D^2}{4}$; $a = \frac{\pi d^2}{4}$; Ratio= $\frac{a}{A}$x100%

Bump 80_ Stimulation & Bump test



finite element analysis (FEA) simulation to observe the probe mark on the wafer bump. We simultaneously compare the factors that affect the difference in probe marks under various strengths of external force and establish a comprehensive and precise definition of the probe mark. We also provide clear rules for designing the contact force of the probe.

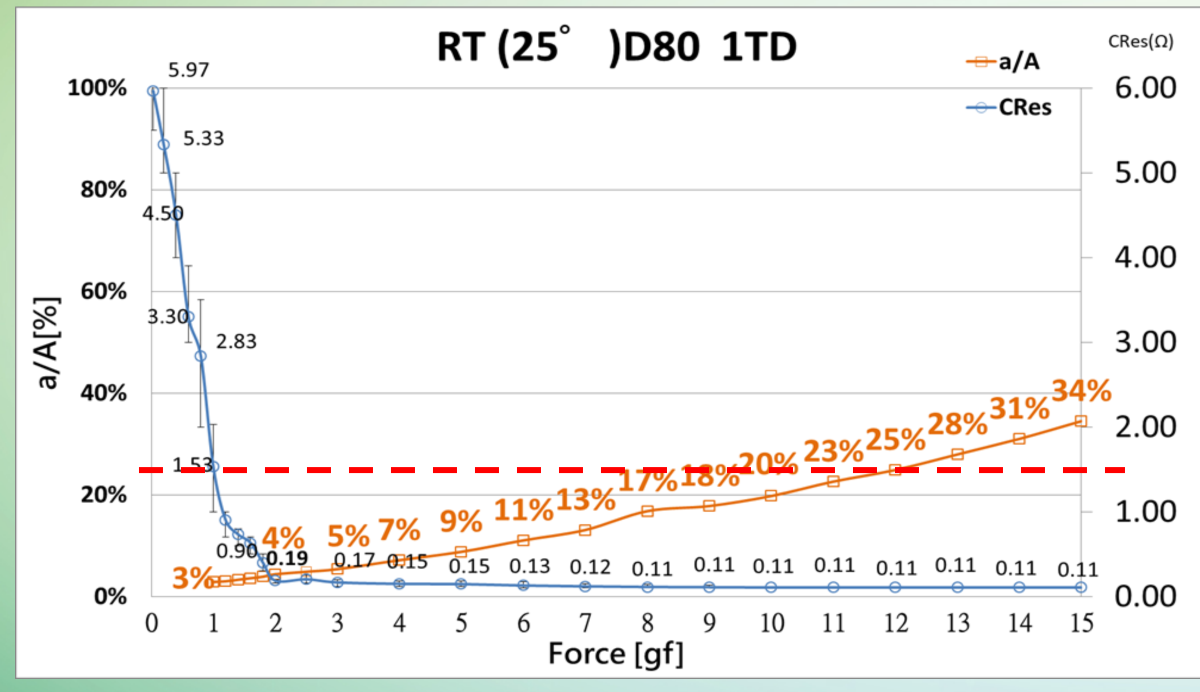
Suggest Force Range @ Different a/A Condition:

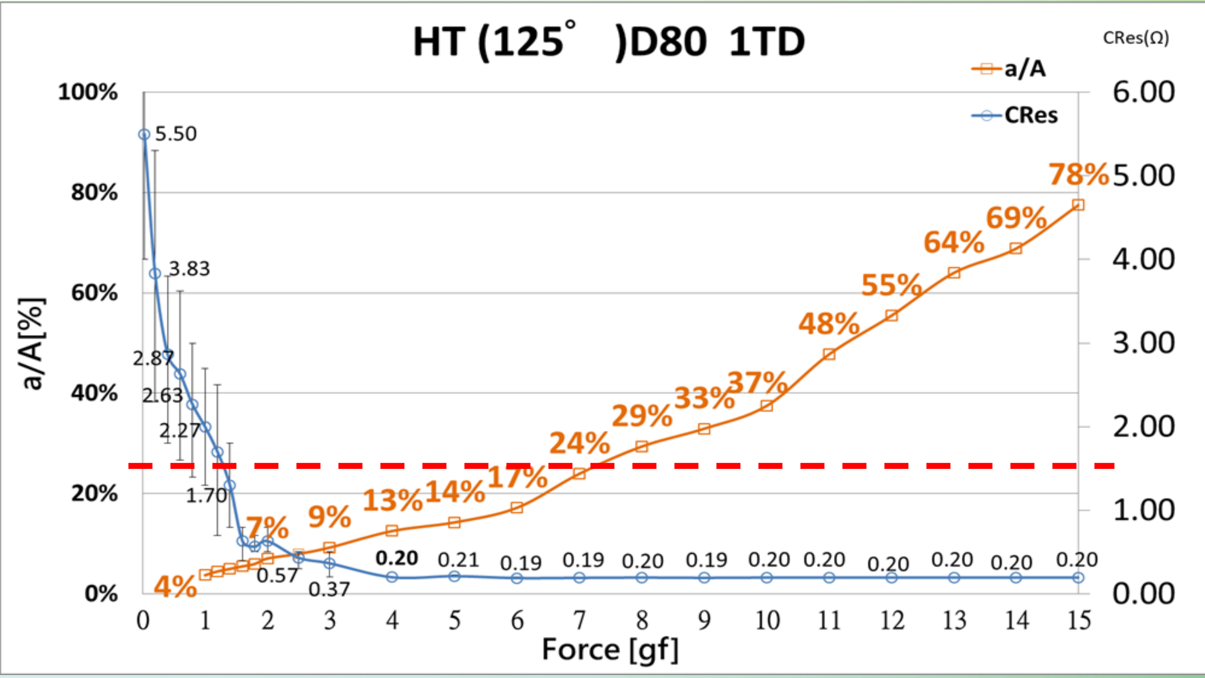
Bump size@ Condition	Force @ 25% a/A	
	Stimulation	ENG Test
Bump 80@25℃	< 12 gf	< 12.1 gf
Bump 80@125℃	<6.7 gf	<7 gf

Bump 80_ Stimulation & Bump test

Test Parameter:

- Applied Force range: <15 gf
- Test Temperature: 25℃/125℃
- CR data collect ：Contact Time(1 sec)
- Sample count : 10 pcs/each condition





Bump size@ Condition	Suggested Force Range		
	by stable CRes	By 25% a/A	Stimulation@ 25% a/A
Bump 80@25℃	2 gf <	< 12.1gf	< 12 gf
Bump 80@125℃	4 gf <	< 7.0 gf	<6.7 gf

Bump 80_ Bump Real test Data

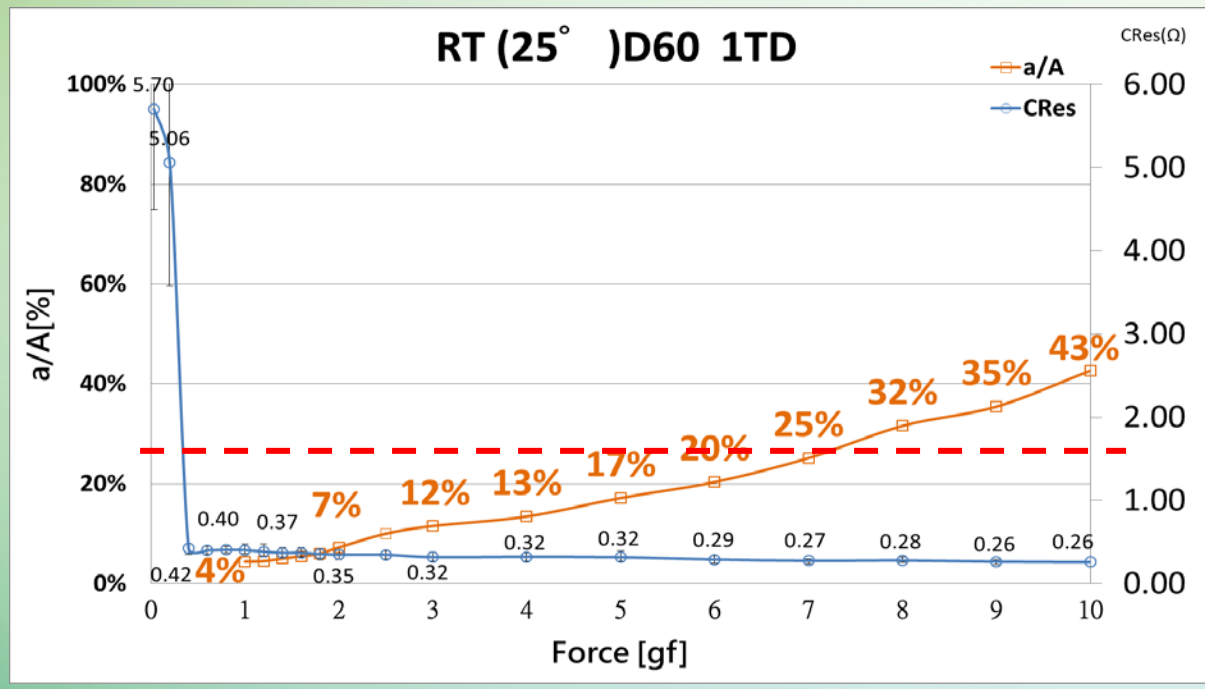
- a/A %
- Instrument : KEYANCE VKX250 Software : MultiFile Analyzer

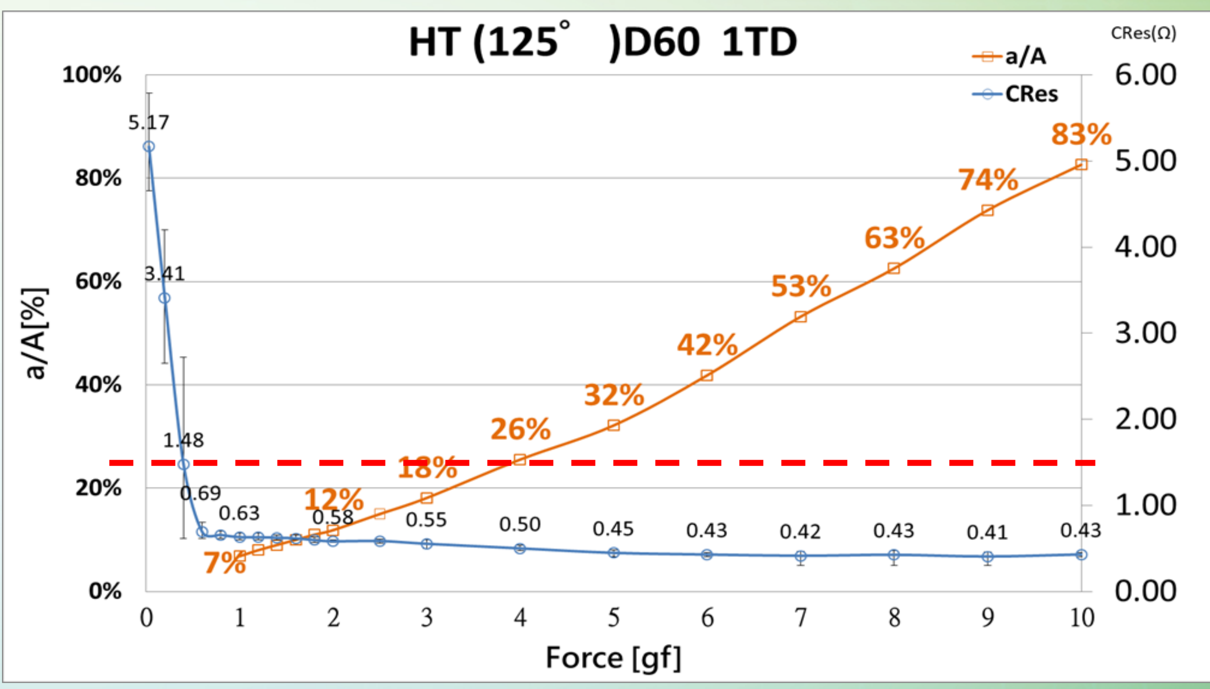
a/A[%]	1g	2g	3g	4g	5g	6g	7g	8g	9g	10g	11g	12g	13g	14g	15g
Laser Pic															
RT-1st	2.0%	4.1%	5.1%	7.7%	8.5%	11.3%	14.3%	15.5%	16.7%	19.5%	24.0%	27.4%	29.8%	29.2%	36.8%
Laser Pic															
RT-2nd	2.4%	4.2%	5.3%	6.8%	8.7%	12.0%	13.1%	16.1%	18.5%	21.7%	22.1%	24.8%	24.2%	32.3%	35.9%
Laser Pic															
RT-3rd	3.0%	4.7%	5.5%	7.3%	9.7%	11.3%	13.4%	18.9%	18.0%	19.4%	22.1%	26.4%	30.5%	31.9%	33.1%
Laser Pic															
RT-4th	4.1%	4.2%	5.6%	6.6%	8.2%	10.9%	12.3%	16.7%	18.6%	19.2%	23.1%	24.1%	26.6%	30.2%	32.3%
Laser Pic															
RT-5th	2.9%	4.7%	5.4%	7.3%	8.8%	9.6%	12.4%	16.8%	17.1%	18.9%	21.7%	21.7%	28.6%	31.4%	34.3%
MAX	4.1%	4.7%	5.6%	7.7%	9.7%	12.0%	14.3%	18.9%	18.6%	21.7%	24.0%	27.4%	30.5%	32.3%	36.8%
Ave.	2.9%	4.4%	5.4%	7.1%	8.8%	11.0%	13.1%	16.8%	17.8%	19.8%	22.6%	24.9%	27.9%	31.0%	34.5%
Min	2.0%	4.1%	5.1%	6.6%	8.2%	9.6%	12.3%	15.5%	16.7%	18.9%	21.7%	21.7%	24.2%	29.2%	32.3%
Stdev.	0.008	0.003	0.002	0.004	0.005	0.009	0.008	0.013	0.009	0.011	0.010	0.022	0.025	0.013	0.019

Bump 60_ Stimulation & Bump test

Test Parameter:

- Applied Force range: <10 gf
- Test Temperature: 25℃/125℃
- CR data collect : Contact Time(1 sec)
- Sample count : 10 pcs/each condition



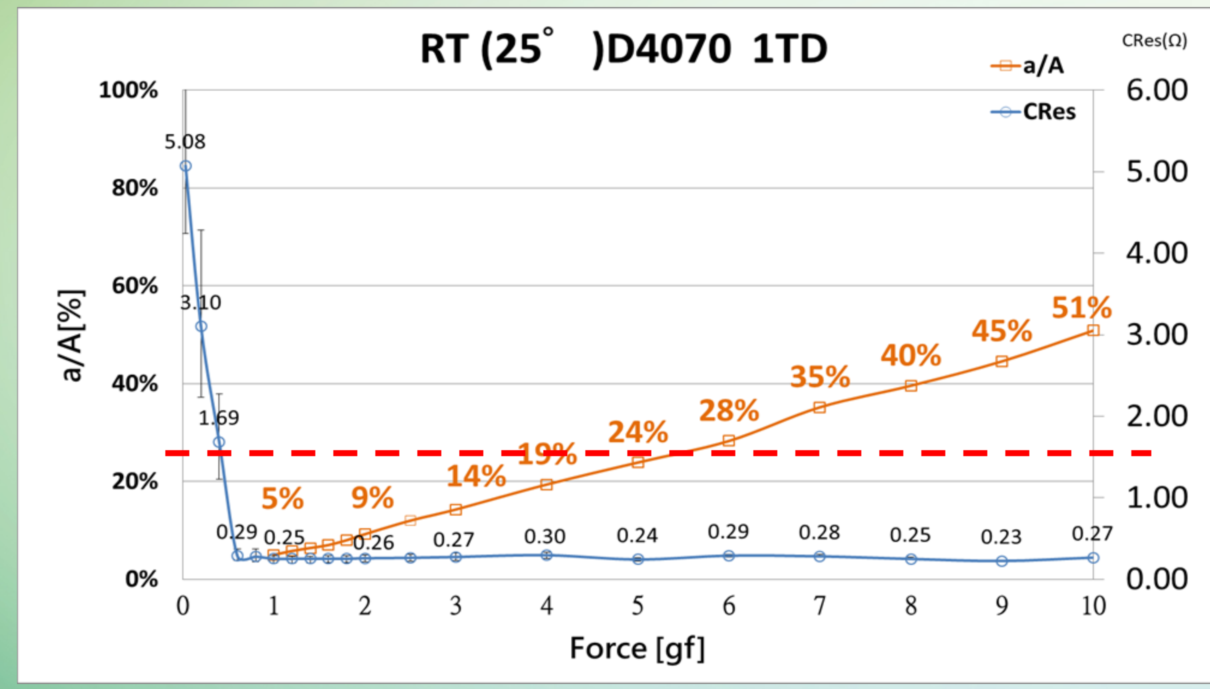


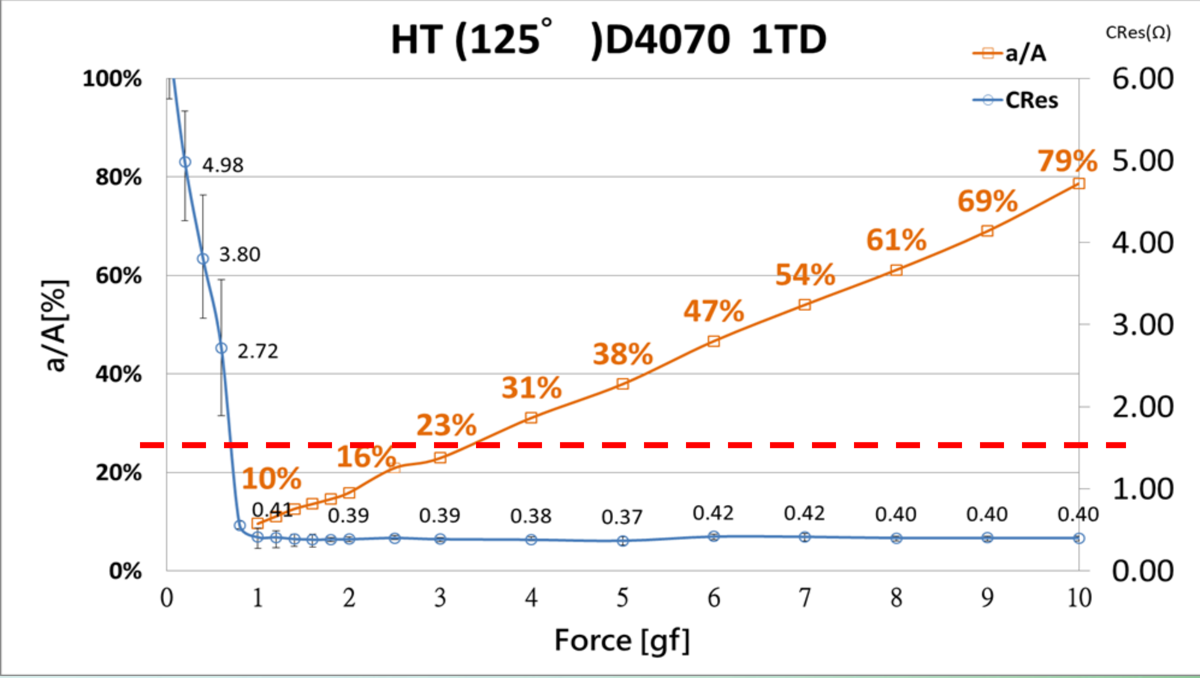
Bump size@ Condition	Suggested Force Range		
	by stable CRes	By 25% a/A	Stimulation@ 25% a/A
Bump 80@25℃	0.4 gf <	< 7.0gf	<7.2 gf
Bump 80@125℃	0.8 gf <	< 3.8gf	<3.8 gf

Bump 40x70_ Stimulation & Bump test

Test Parameter:

- Applied Force range: <10 gf
- Test Temperature: 25℃/125℃
- CR data collect ：Contact Time(1 sec)
- Sample count : 10 pcs/each condition





Bump size@ Condition	Suggested Force Range		
	by stable CRes	By 25% a/A	Stimulation@ 25% a/A
Bump 80@25℃	0.6gf <	< 5.0gf	< 5.5gf
Bump 80@125℃	1.0gf <	< 3.2gf	< 2.9gf

Sub-Summary Different Bump Size

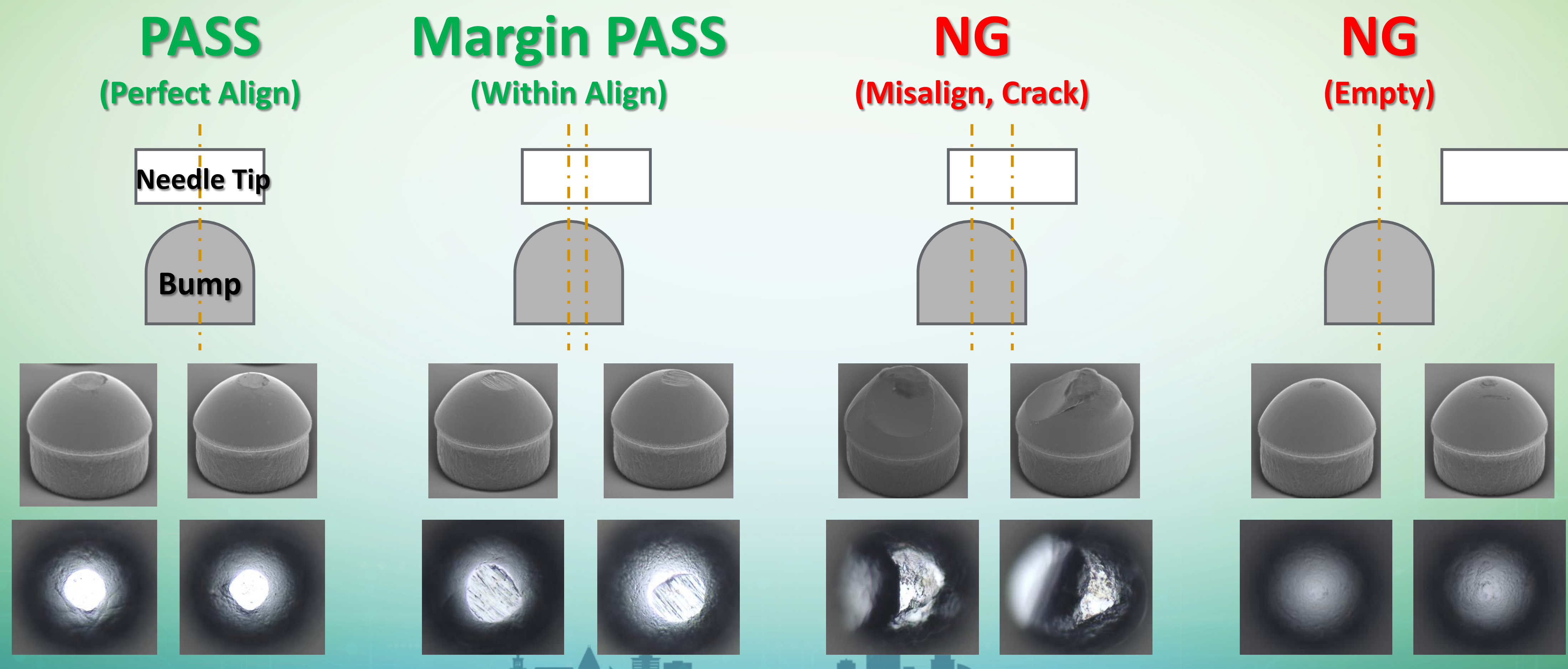
As our experiment, Force suggestion by different bump

Bump Size	Available Force Range	
	@25℃	@125℃
Bump 80 um	2.0 ~12.1 gf	4.0~7.0 gf
Bump 60 um	0.4~7.0 gf	0.8~3.8 gf
Bump 40x70 um	0.6~5.0 gf	1.0~3.2 gf

- Applied force must be redesigned when bump size is different.
- Bump with larger size would have more wider force range could be applied on without fail testing.

What is the challenge on µBump test

What is a good Bump test:

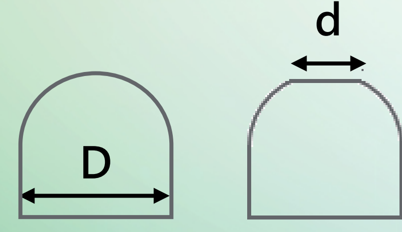


What is the challenge on μBump test

How many the max alignment is:

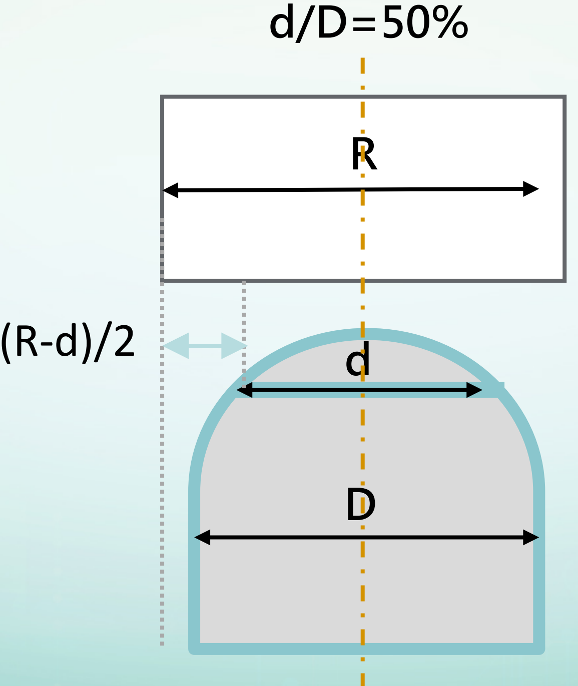
“PASS” Probe Mark

- ✓ Within Bump Force range(CF)
- ✓ a/A ratio (< 25%)
- – Needle Tip Alignment (A)
- – Appearance

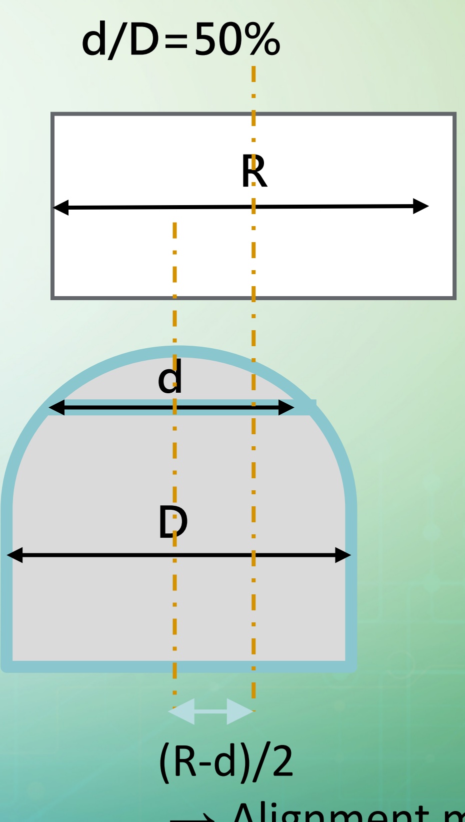


A = Alignment between bump and needle tip
D = Diameter of Bump Size
d = Probe Mark Size
R = Diameter of Needle Tip
CF = Contact Force of a Needle

Perfect Align

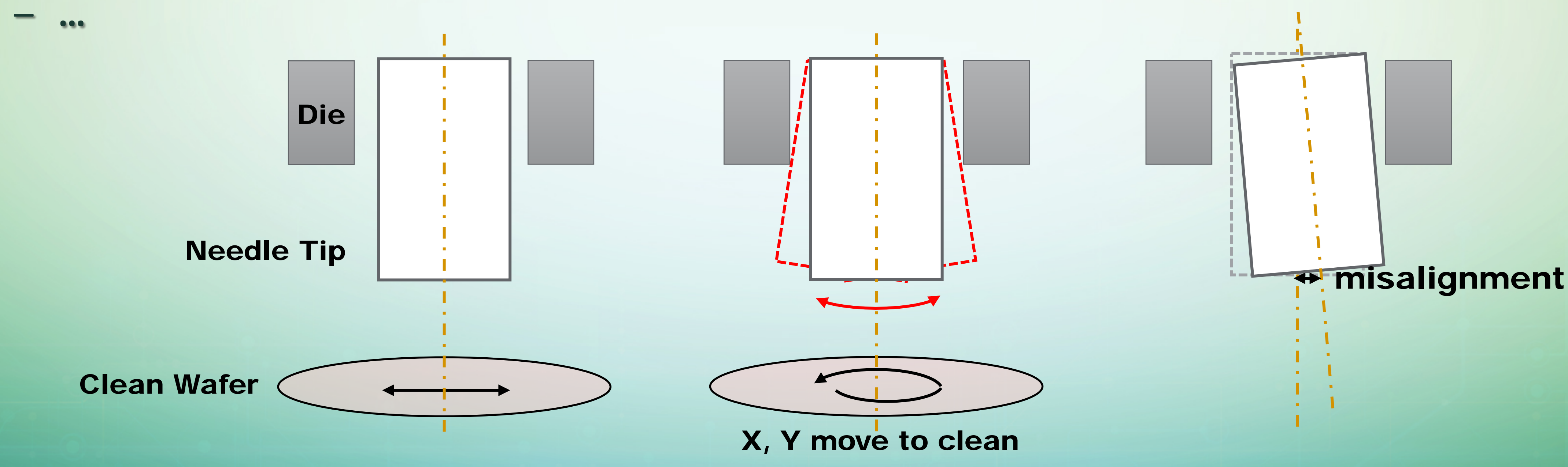


Margin Align



What is the challenge on μBump test

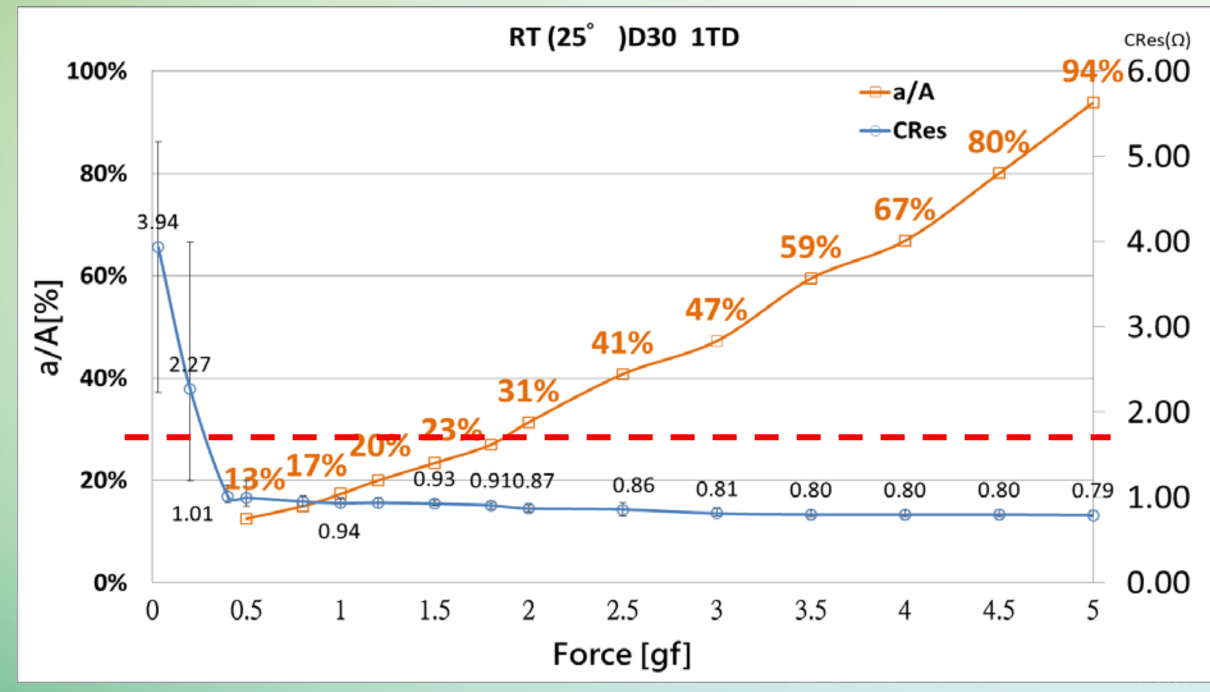
- **Cause of Misalignment**
  - Needle Offset
  - Needle Tip Cleaning
  - Wafer Bump tolerance
  - …

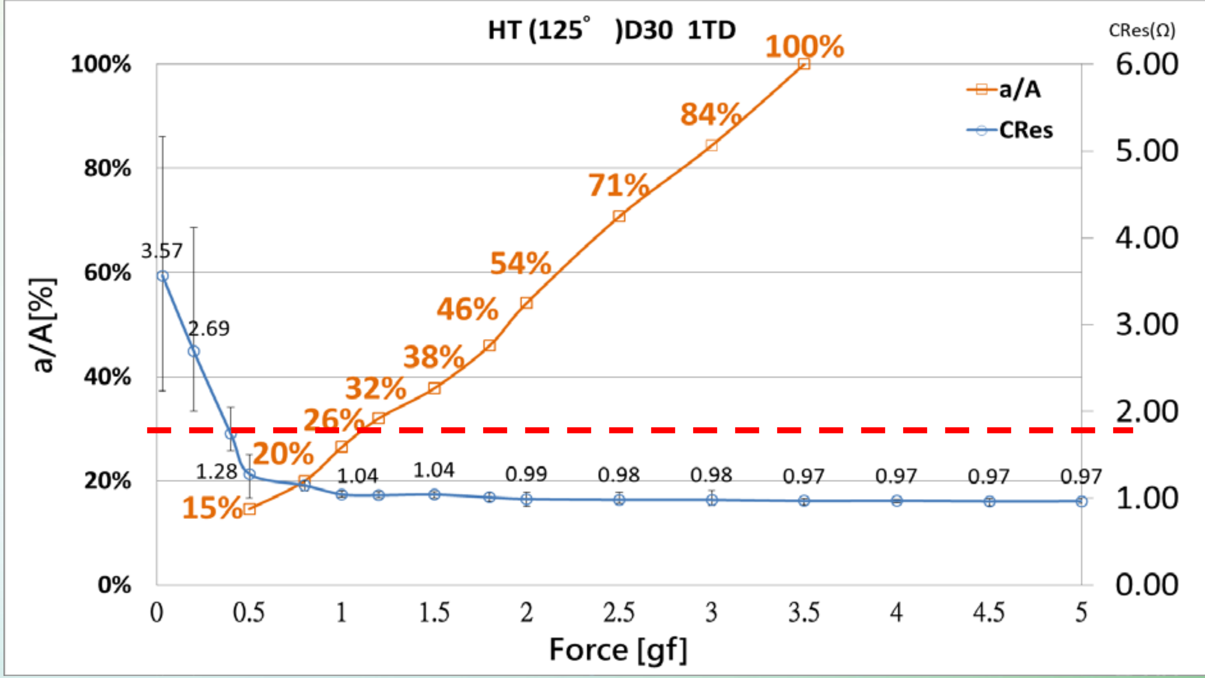


What force range μBump D30 should be at

Test Parameter:

- Applied Force range: <5 gf
- Test Temperature: 25℃/125℃
- CR data collect ：Contact Time(1 sec)
- Sample count : 10 pcs/each condition



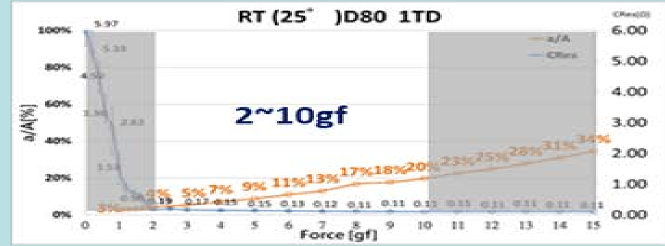
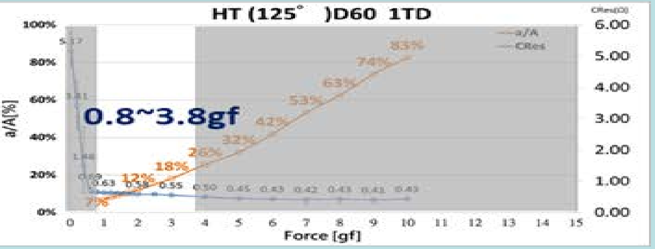
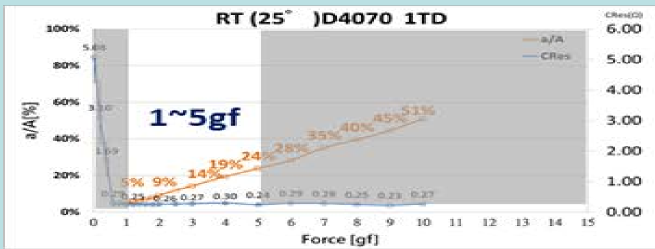
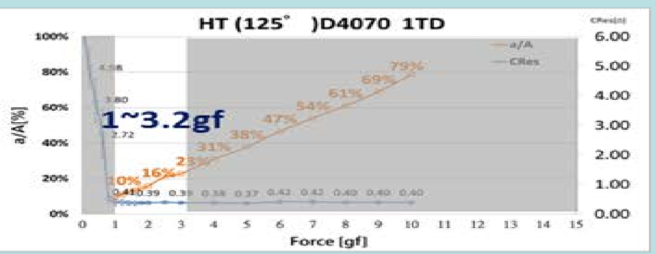
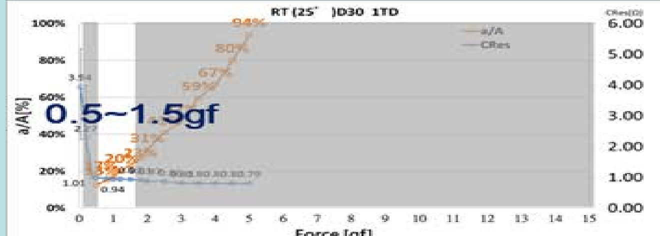


Bump size@ Condition	Suggested Force Range		
	by stable CRes	By 25% a/A	Stimulation@ 25% a/A
Bump 80@25℃	0.4 gf<	< 1.6gf	<1.8gf
Bump 80@125℃	0.8 gf<	<1.0gf	<1.0gf

Summary

- **Again!!!!**

Applied force must be redesigned when bump size is different.

	P/M Test@25℃	P/M Test@125℃
Bump80		
Bump60		
Bump4070		
Bump30		

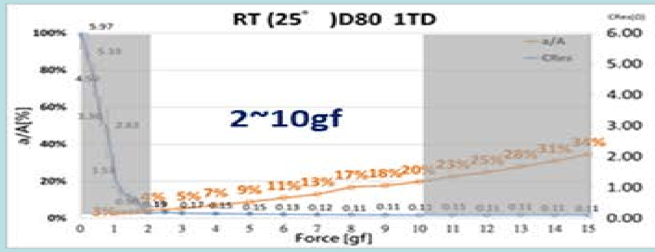
Summary

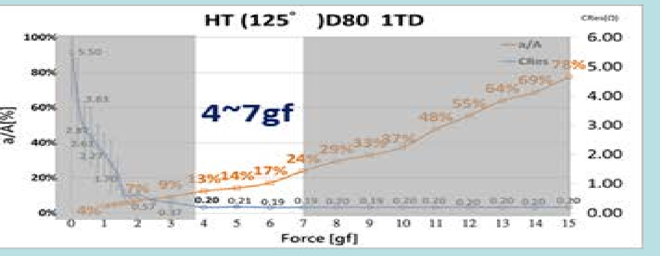
- It must be extremely narrow range when bump size is smaller than 50um, such as our 30um bump case.

P/M Test@25℃

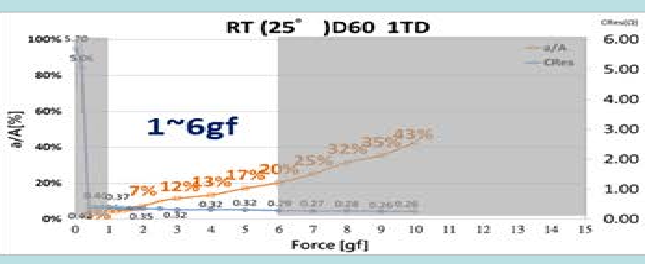
P/M Test@125℃

Bump80

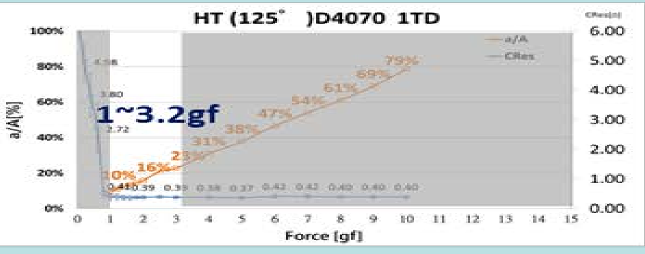




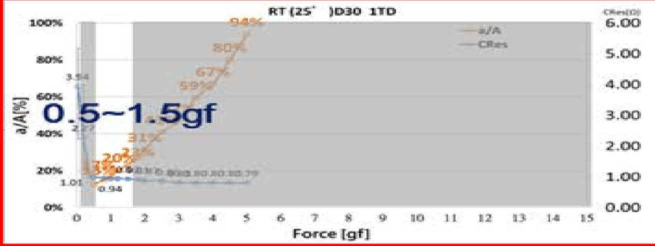
Bump60



Bump4070

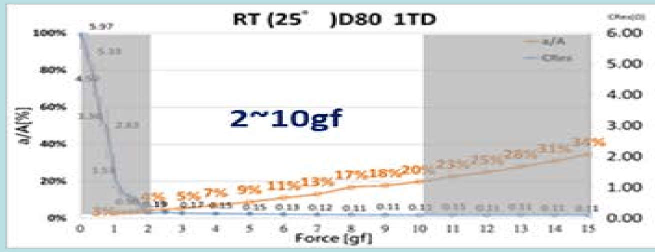
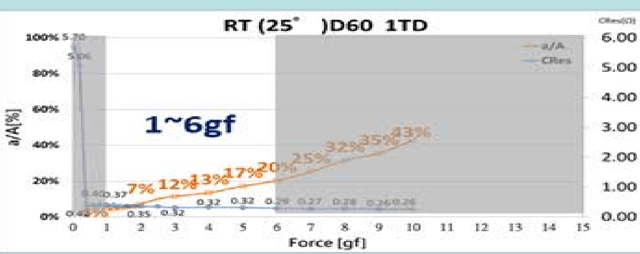
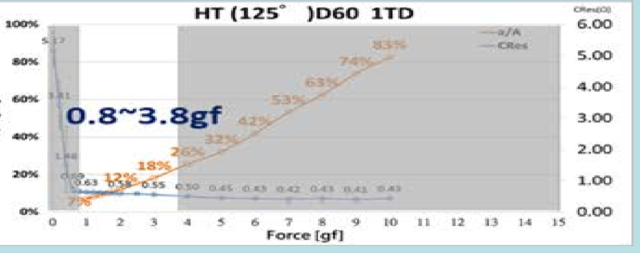
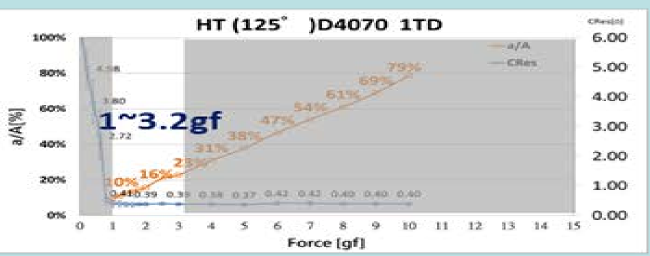
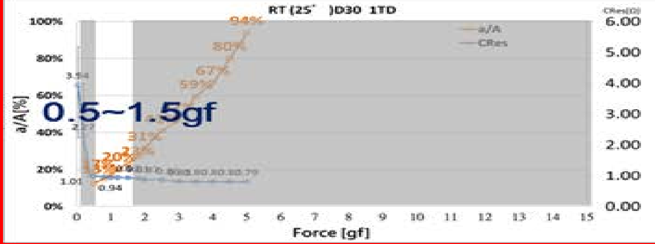


Bump30



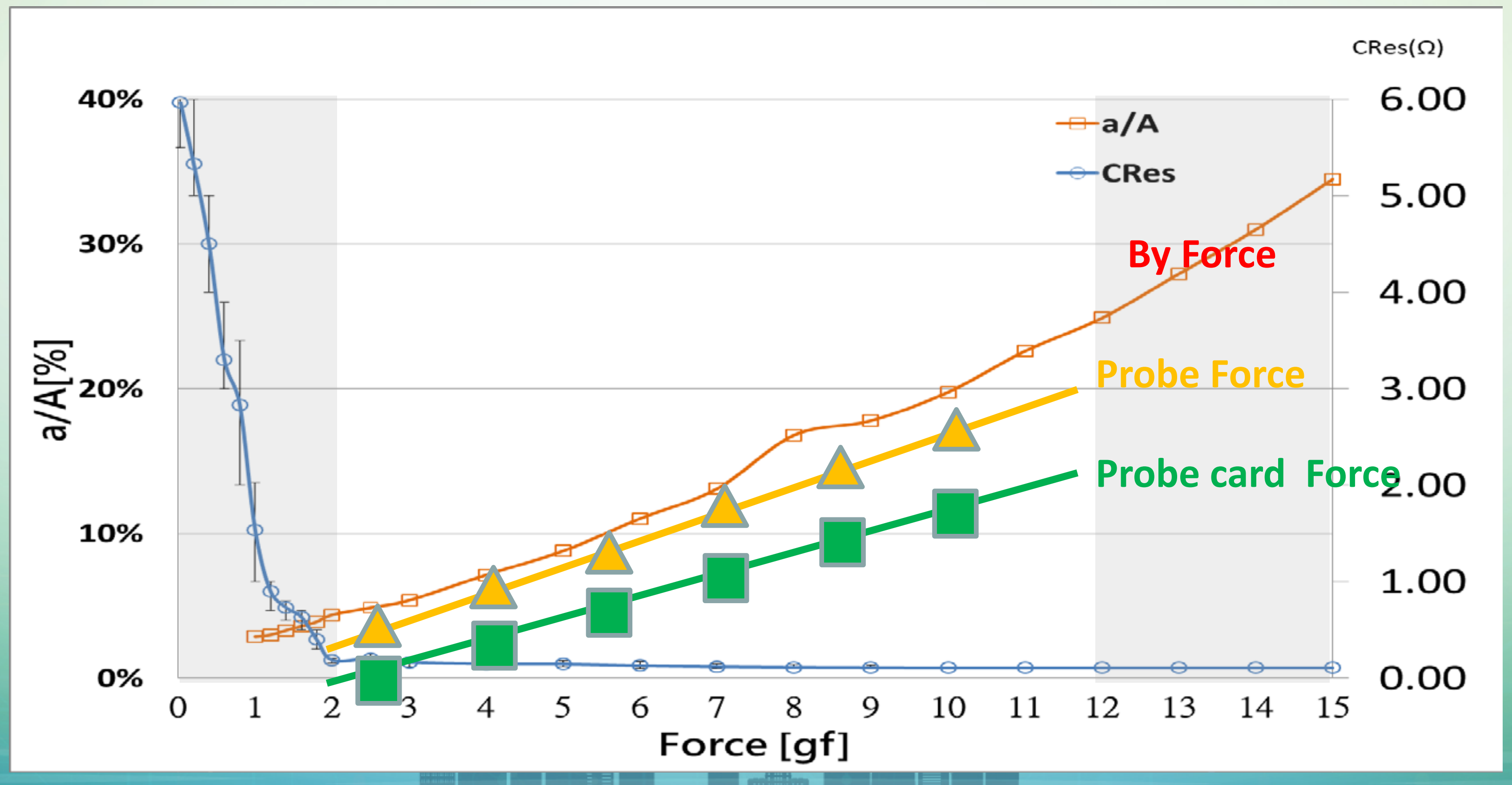
Summary

- When bump size goes down to 30um, the available force range should be tested, it would be affected by material, bump shape, manufacture process etc.

	P/M Test@25℃	P/M Test@125℃
Bump80		
Bump60		
Bump4070		
Bump30		

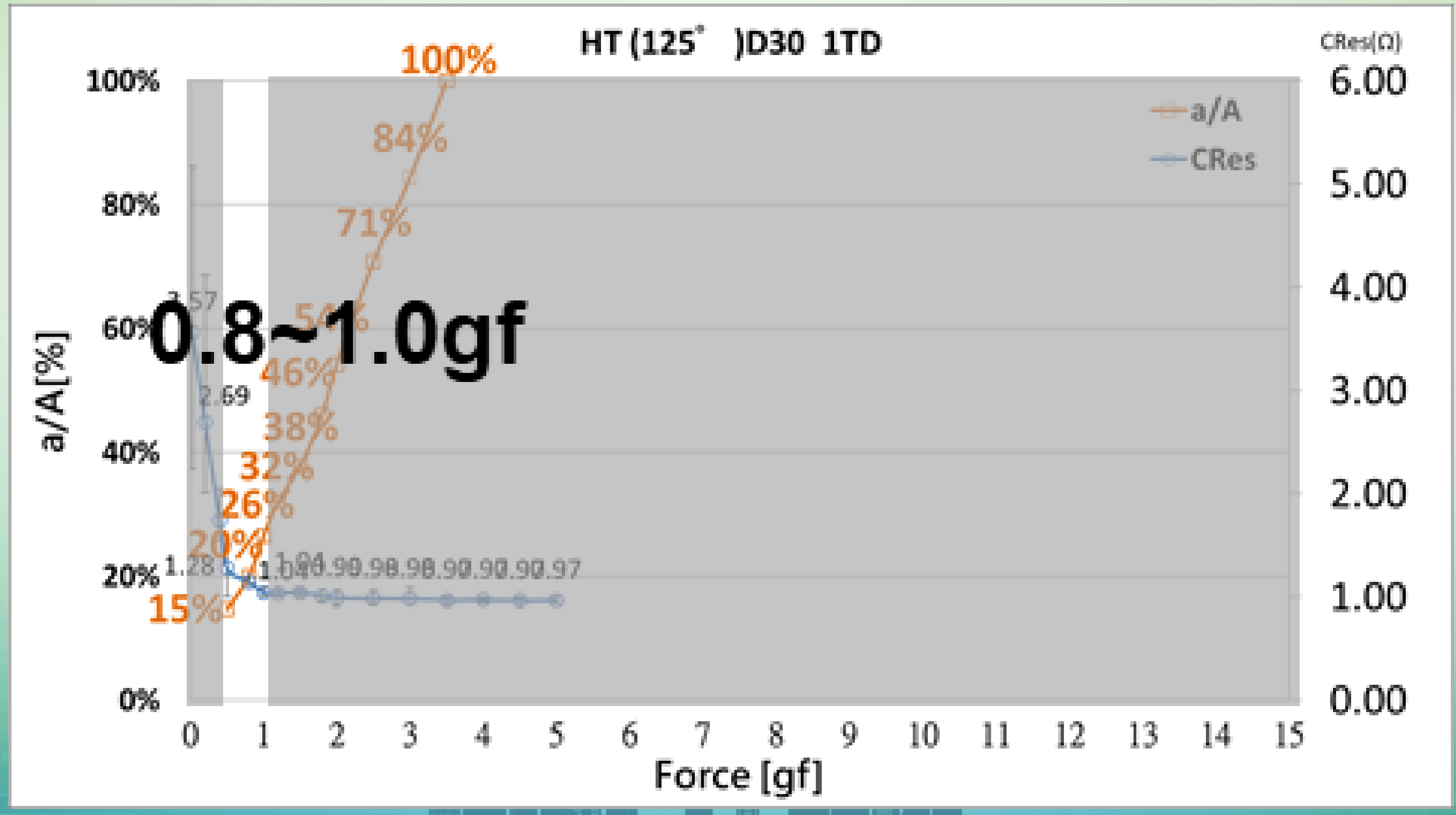
Work in future

- Base on those date, we've already known how to define applied force by pure force test.
- In future, we'll share more about probe mark distribution when we apply the data we have on probe card designing. Does it make any difference?



Work in future

- Where is the upper limitation of ubump?



Thank for your listening