SW Test Workshop

Semiconductor Wafer Test Workshop

New Probe Testing Methodology Over-Current Analysis of Probe

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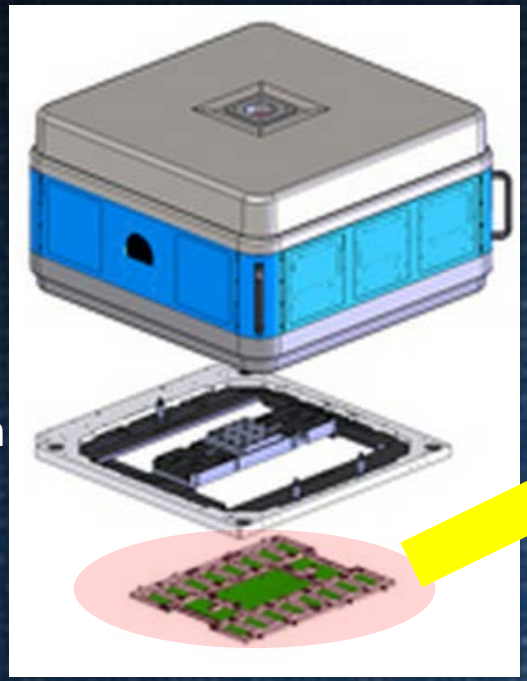
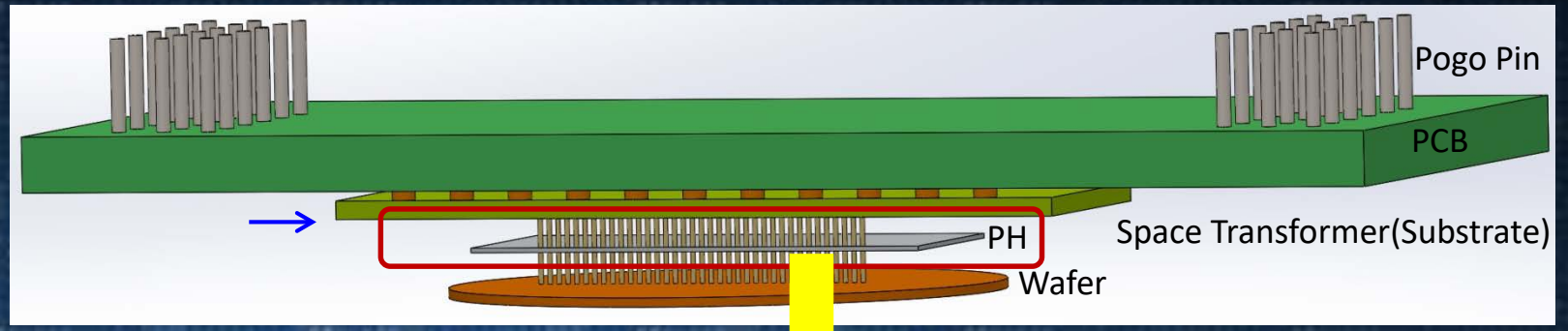
Outline

- ISMI CCC Test and Over Current Operation
- Probe Analysis under Three Current Levels
- Over Current Analysis to Achieve New Safe Current Boundary
- Correlation between Simulation and Measurement
- Conclusion

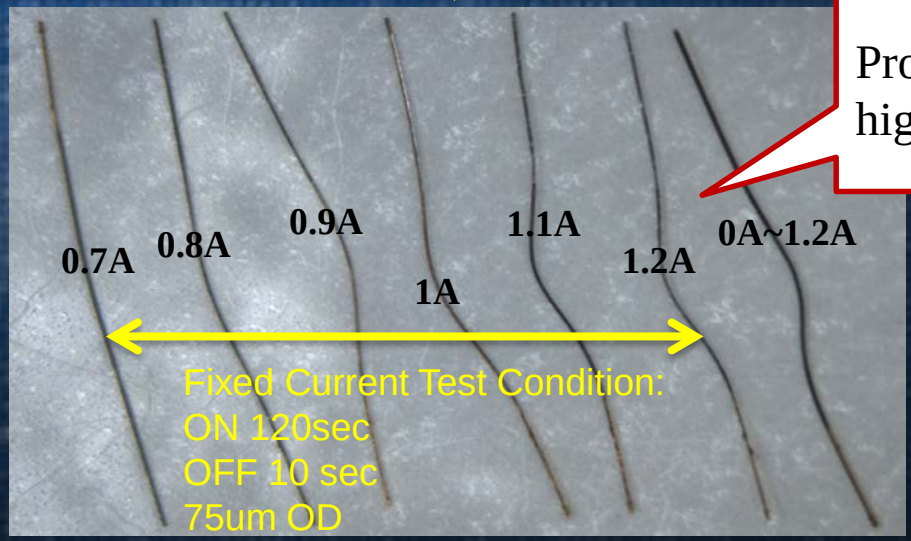
ISMI CCC Test and Over-Current Operation



For VPC test



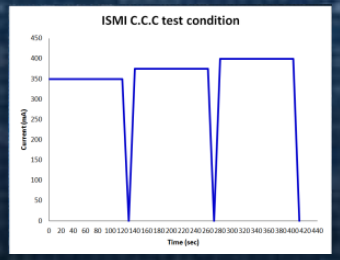
VPC Cross-section View



Probes deform due to higher passing current.

ISMI CCC Test Condition：

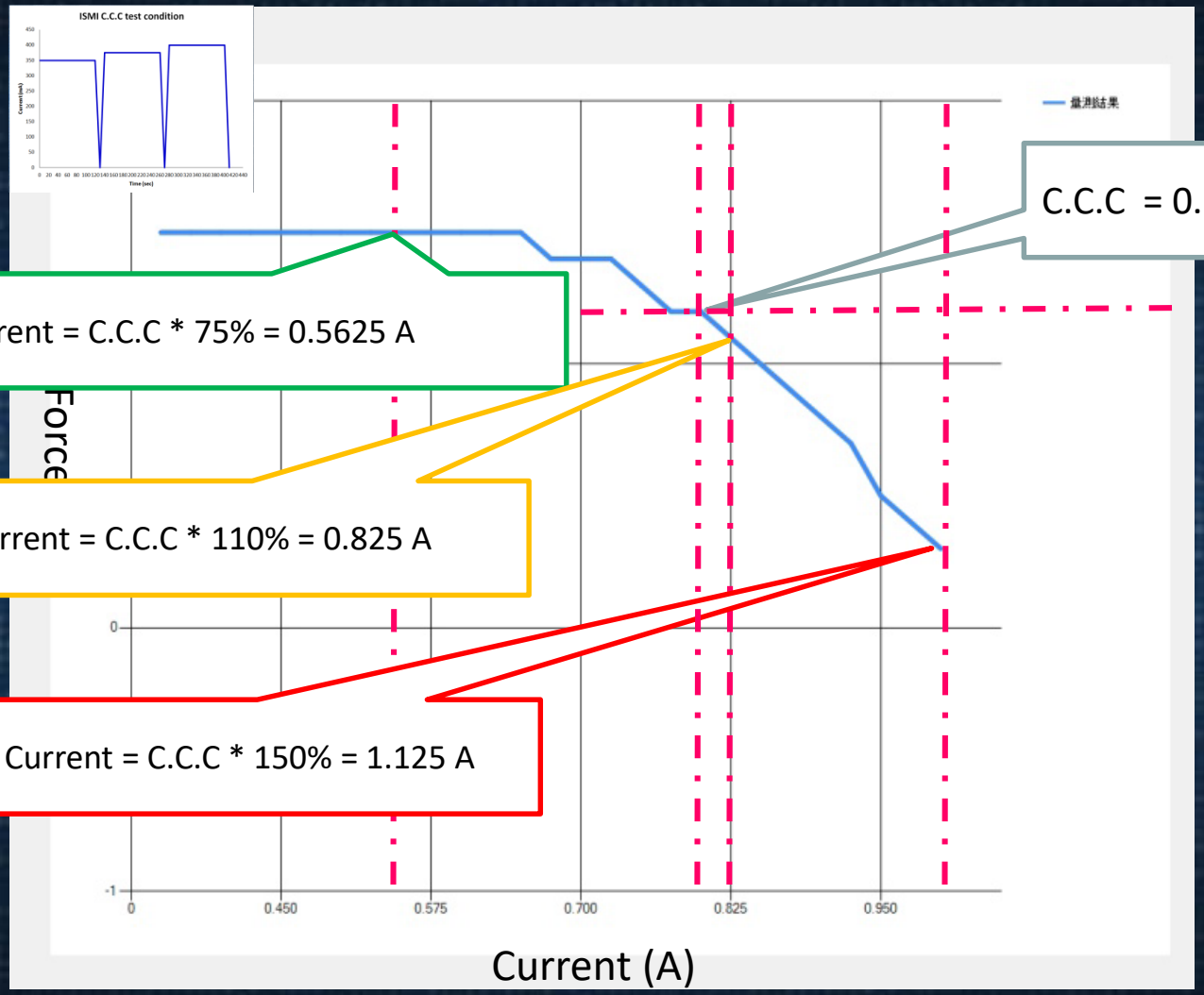
- Supply Current Time： 120 sec
- Cooling Time： 10 sec
- Current Sweep ： 0.7A ~1.2A
- Over Drive： 75um
- α probe CCC (Force Drop 20 %) = 0.75 A



Definition of 3 Different Current Level

α probe diameter = 1.5mils
C.C.C = 0.75A

When current is higher than C.C.C , the probe deform .

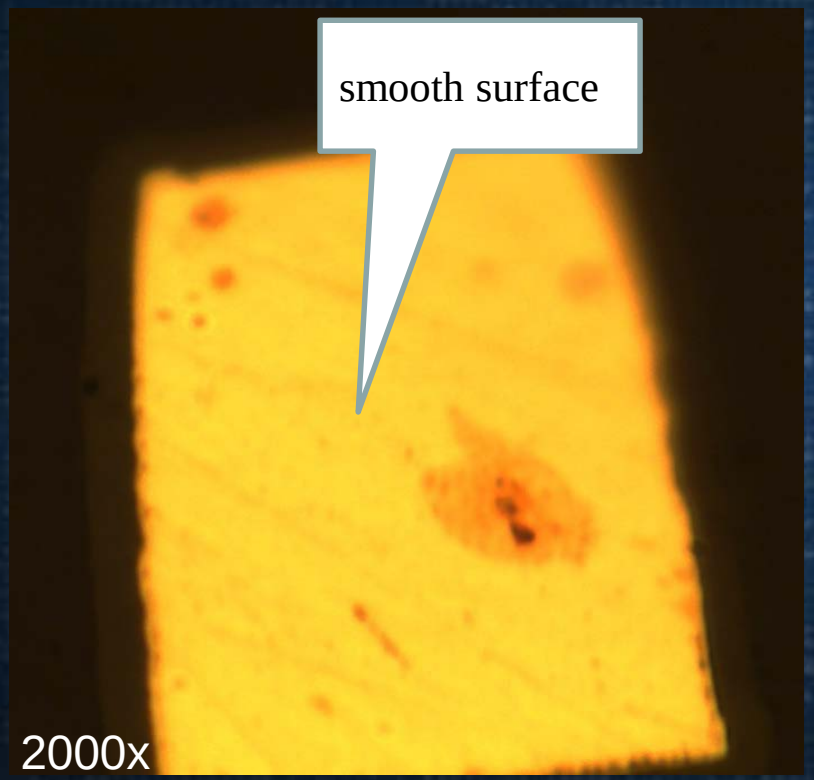


C.C.C measurement

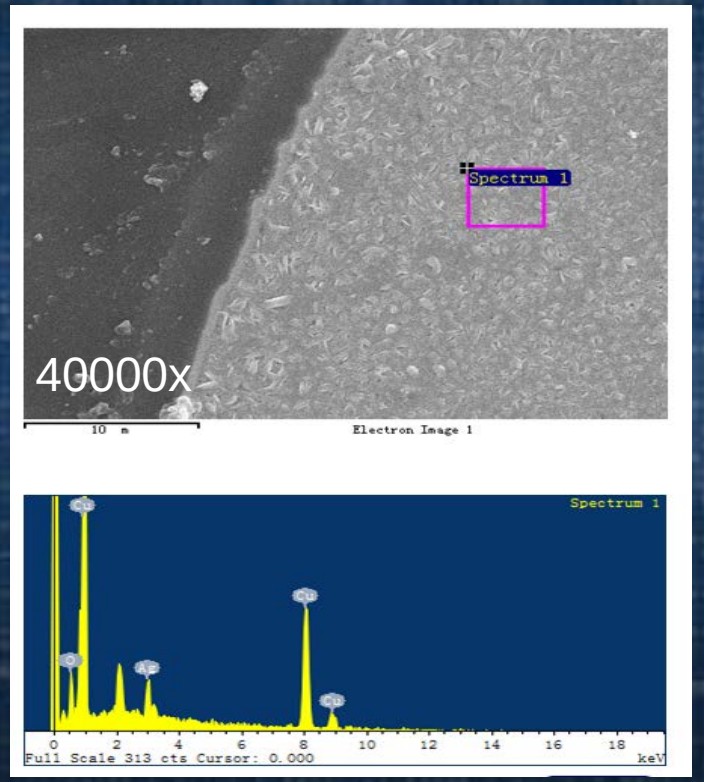
Current (A)	Force (g)
0.35	1.5
0.375	1.5
0.4	1.5
0.425	1.5
0.45	1.5
0.475	1.5
0.5	1.5
0.525	1.5
0.55	1.5
0.575	1.5
0.6	1.5
0.625	1.5
0.65	1.5
0.675	1.4
0.7	1.4
0.725	1.4
0.75	1.3
0.775	1.2
0.8	1.2
0.825	1.1
0.85	1
0.875	0.9
0.9	0.8
0.925	0.7
0.95	0.5
0.975	0.4
1	0.3
1.025	0.3
1.05	0.3
1.075	0.2
1.1	0.2
1.125	0.1

Probe Analysis Under Safe Current

- α Probe : Safe Current (Fixed Current Test Condition)
- Analysis Results Smooth surface No Carbon Element



Cross-sectional View under Optical Microscope



SEM & EDS Analysis

Spectrum processing :

Peak possibly omitted : 2.069 keV

Processing option : All elements analyzed

Number of iterations = 3

Standard :

O SiO2 1-Jun-1999 12:00 A

Cu Cu 1-Jun-1999 12:00 AM

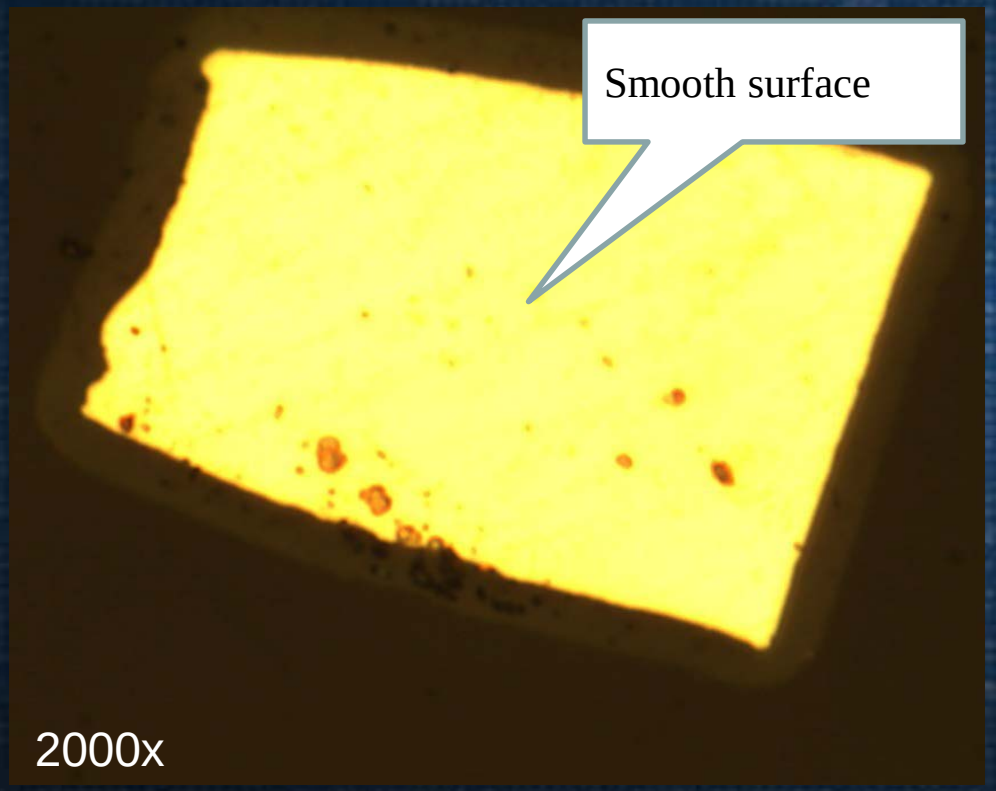
Ag Ag 1-Jun-1999 12:00 AM

No Carbon Element

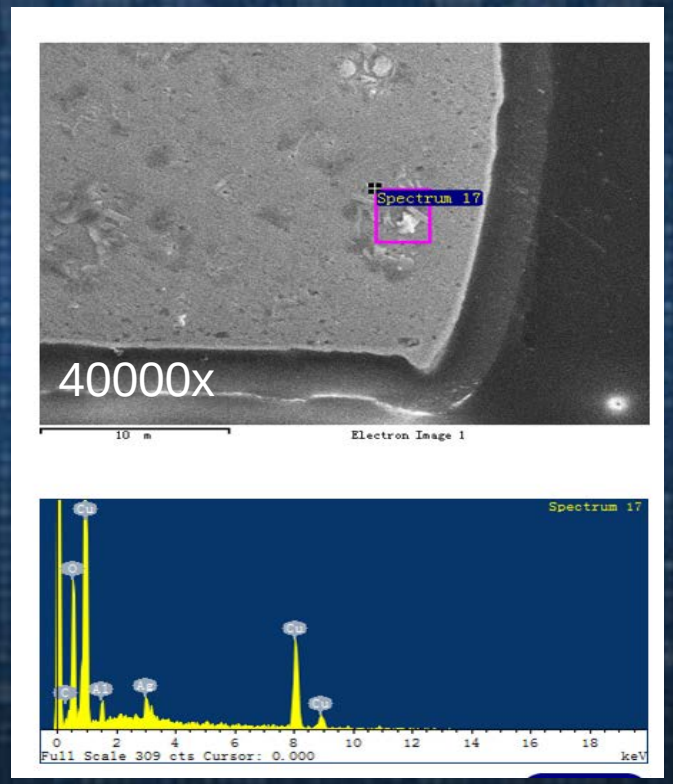
Element	Weight%	Atomic%
O K	0.85	19.80
Cu L	13.04	76.61
Ag L	1.04	3.59
Totals	14.92	

Probe Analysis Under Limit Current

- α Probe : Limit Current (Fixed Current Test Condition)
- Analysis Results Smooth surface, but with Carbon Element



Cross-sectional View under Optical Microscope



SEM & EDS Analysis

Spectrum processing :

No peaks omitted

Processing option : All elements analyzed

Number of iterations = 2

Standard :

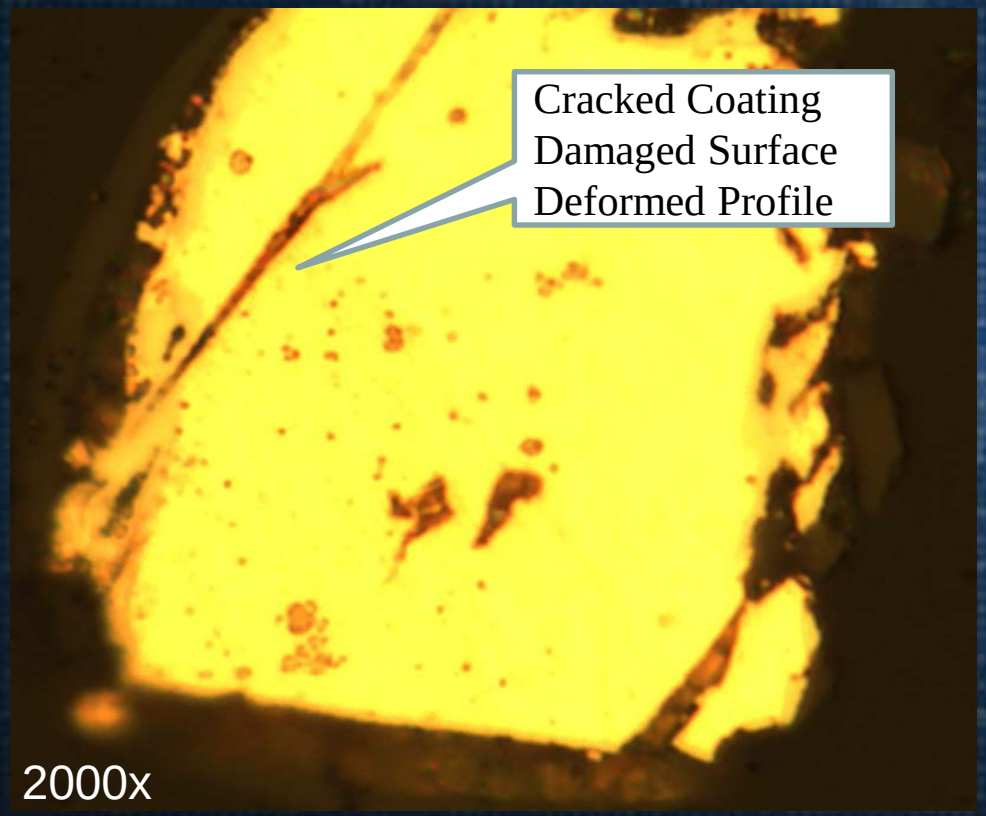
C	CaCO3	1-Jun-1999 12:00 AM
O	SiO2	1-Jun-1999 12:00 AM
Al	Al2O3	1-Jun-1999 12:00 AM
Cu	Cu	1-Jun-1999 12:00 A
Ag	Ag	1-Jun-1999 12:00 A

Carbon Element

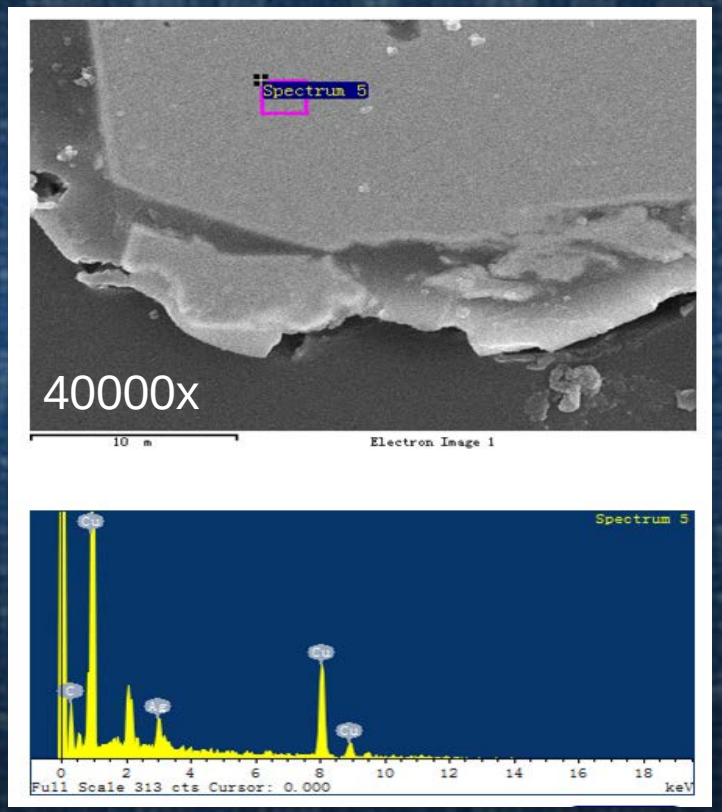
Element	Weight%	Atomic%
C K	0.49	11.70
O K	2.52	44.70
Al K	0.23	2.43
Cu L	8.80	39.36
Ag L	0.69	1.81
Totals	12.73	

Probe Analysis Under Damage Current

- α Probe : Damage Current (Fixed Current Test Condition)
- Analysis Results Serious Damage with Carbon Element



Cross-sectional View under Optical Microscope



SEM & EDS Analysis

Spectrum processing :

Peak possibly omitted : 2.056 keV

Processing option : All elements analyzed

Number of iterations = 3

Standard :

C CaCO3 1-Jun-1999 12:

Cu Cu 1-Jun-1999 12:00

Ag Ag 1-Jun-1999 12:00 AM

Element	Weight%	Atomic
C K	2.17	56.05
Cu L	8.60	42.06
Ag L	0.66	1.89
Totals	11.42	

Carbon Element

Electrical and Mechanical Analysis

Step 1: Fixed Current Test Condition

- One Cycle:

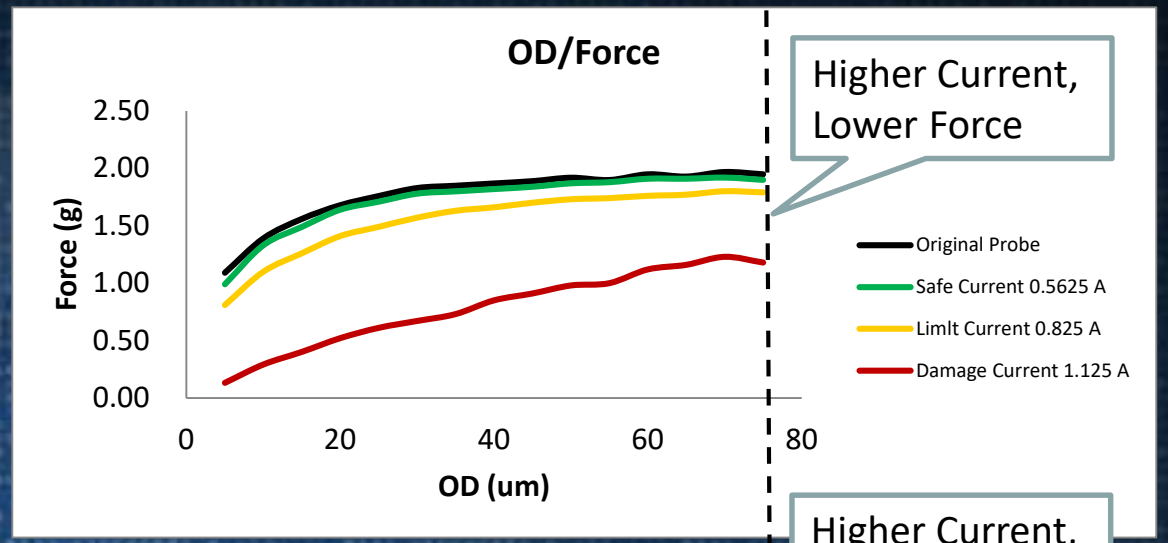
  Supply Current Time： 120 sec
  Cooling Time： 10 sec

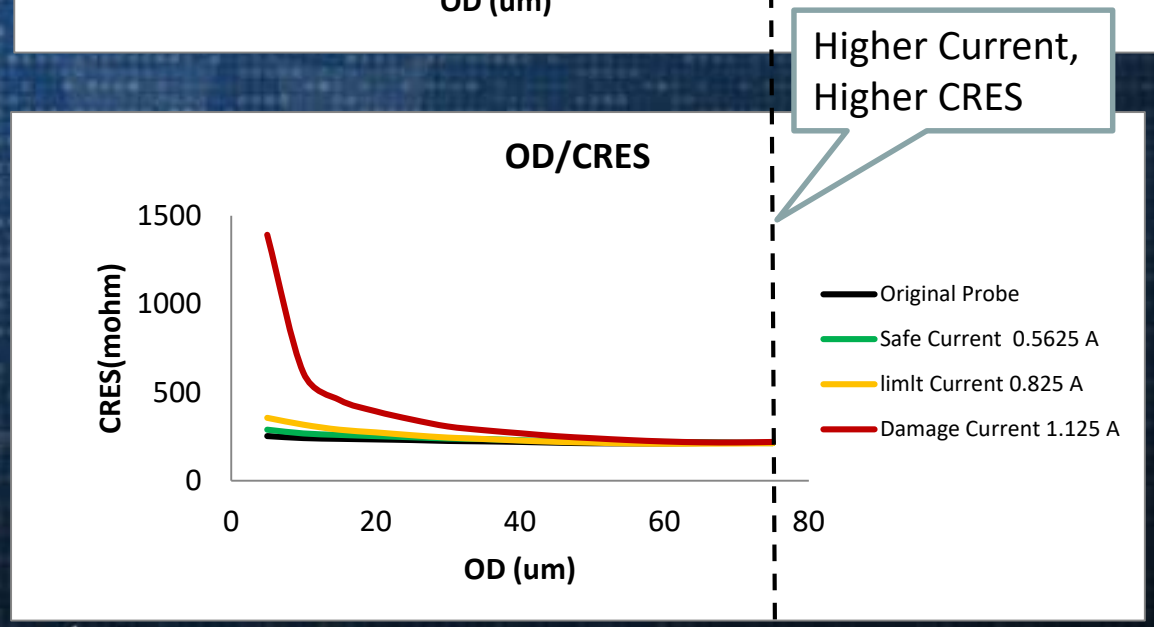
- Fixed Current Levels ：
  None、 0.5625 A 、 0.825 A、 1.125 A

- Over Drive： 75um

Step 2: OD/Force, OD/CRES Curves

- 5um OD increment until 75um for both electrical and mechanical measurements.

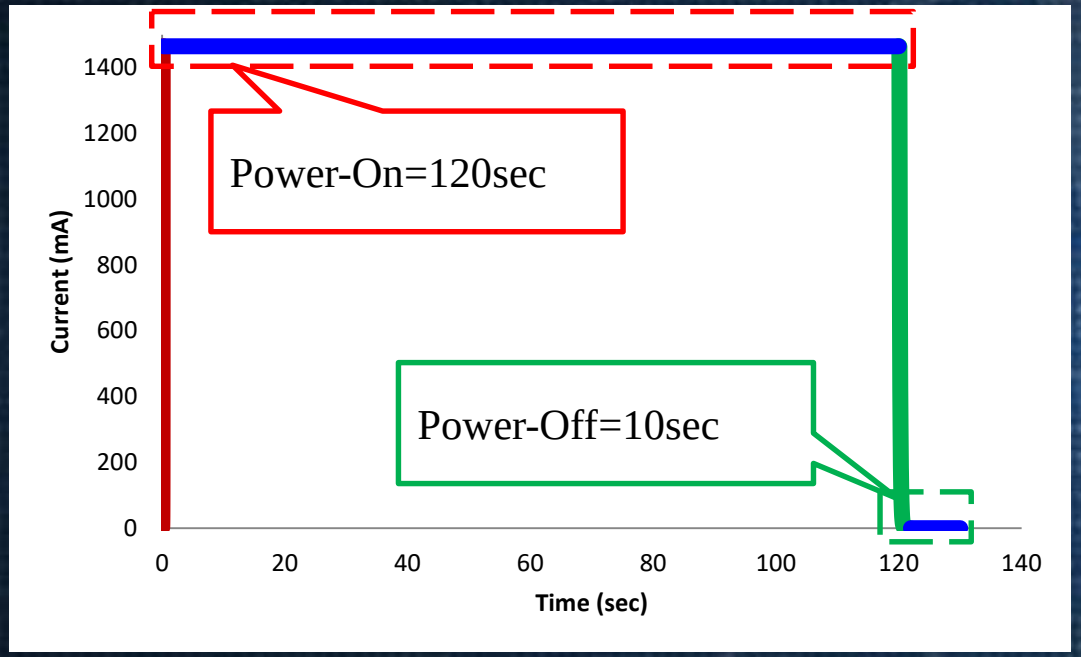




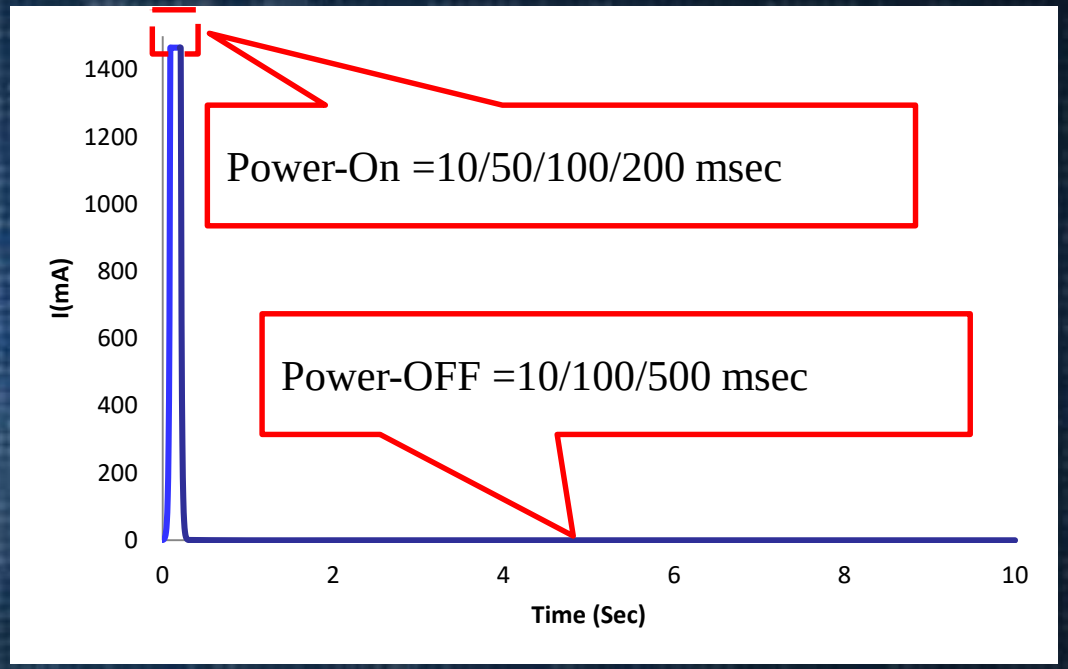
Adjust Current-ON/OFF Time Duration

Probe Temp Rising is proportional to both Current Amplitude and Power-On time duration.

➔ Reduce Power-On time duration can lower the Probe Temp and avoid probe damage.



Time Duration Adjustment



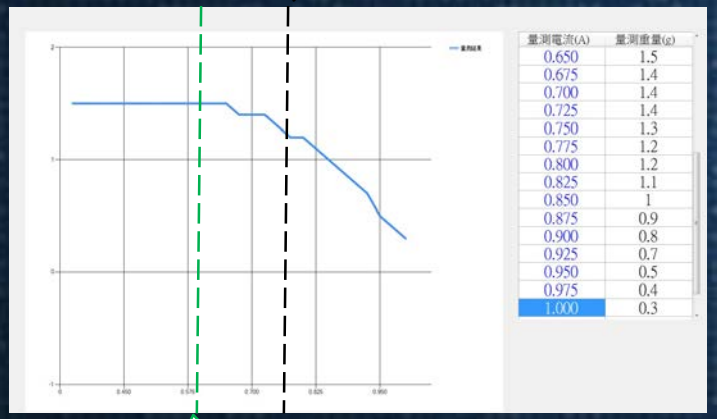
Over-Current Analysis :

– **By adjusting Power-ON/Power-OFF time duration, we can get the new Safe Current boundary.**

Over-Current Analysis : ON 10 msec, OFF 10 sec

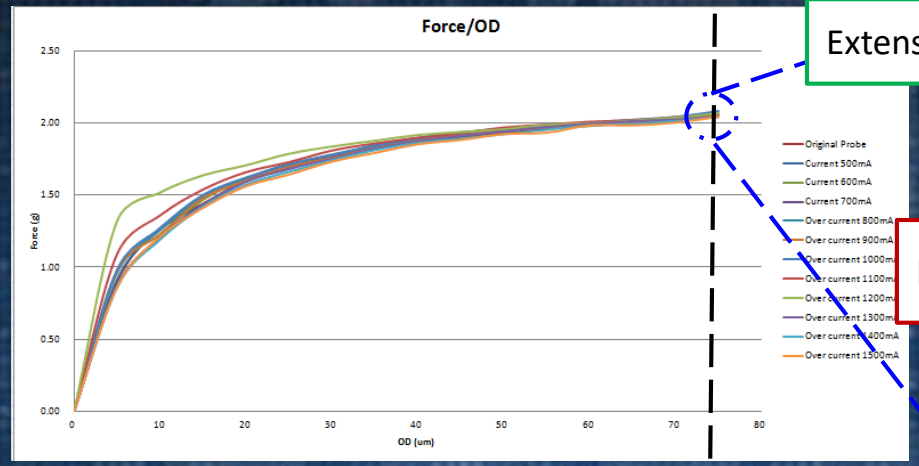
- Fixed Current 500mA~1.5A with 100mA step for each probe (12 probes), OD = 75um
- Power-ON 10 msec ; Power-OFF 10sec

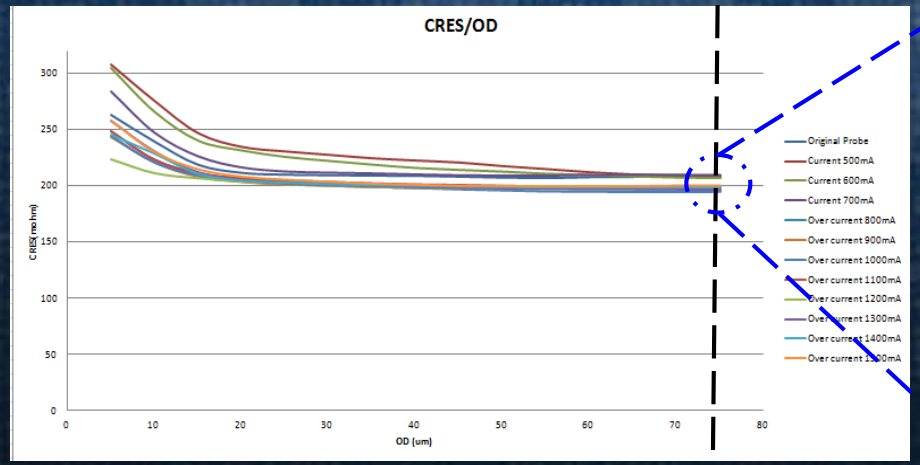
Original C.C.C = 0.75 A



量測電流(A)	量測重量(g)
0.650	1.5
0.675	1.4
0.700	1.4
0.725	1.4
0.750	1.3
0.775	1.2
0.800	1.2
0.825	1.1
0.850	1
0.875	0.9
0.900	0.8
0.925	0.7
0.950	0.5
0.975	0.4
1.000	0.3

Original Safe Current = 0.5625 A



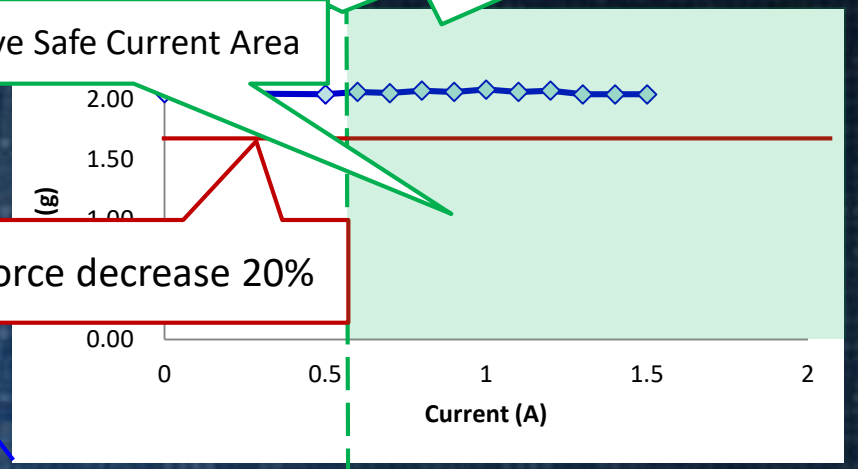


Original Sa

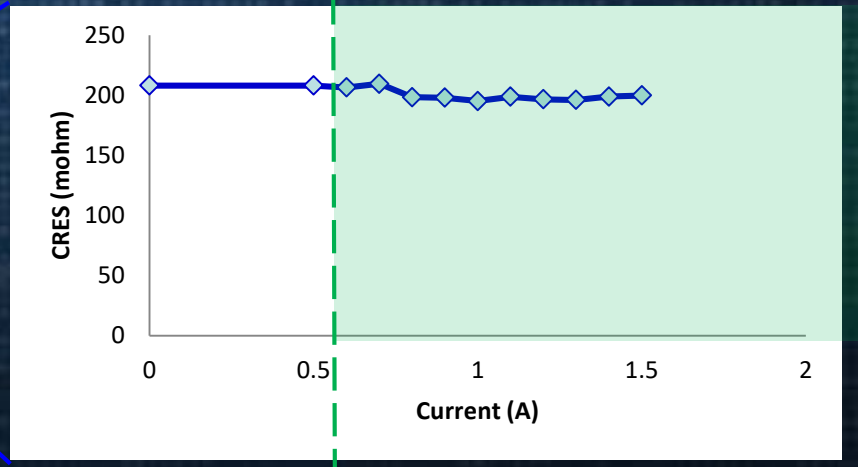
New Safe Current > 1.5A

Extensive Safe Current Area

Force decrease 20%



Force v.s @ OD = 75um

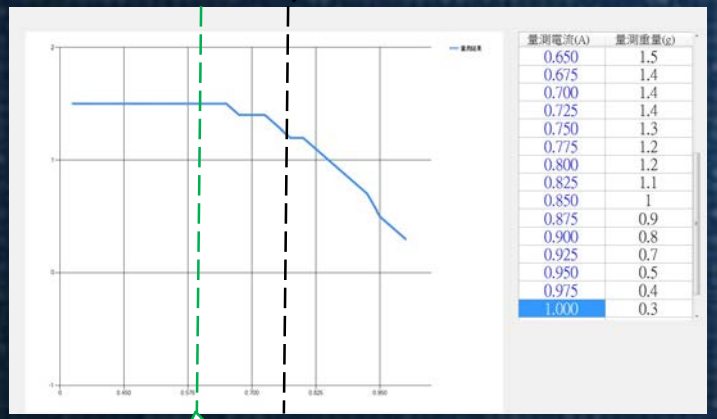


CRES v.s @ OD = 75um

Over-Current Analysis : ON 50 msec, OFF 10 sec

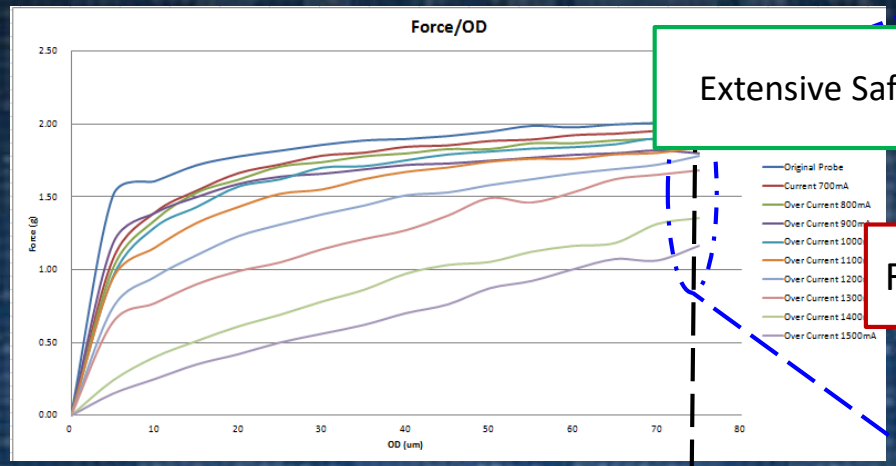
- Fixed Current 700mA~1.5A with 100mA step for each probe (10 probes), OD = 75um
- Power-ON 50 msec ; Power-OFF 10sec

Original C.C.C = 0.75 A



量測電流(A)	量測重量(g)
0.650	1.5
0.675	1.4
0.700	1.4
0.725	1.4
0.750	1.3
0.775	1.2
0.800	1.2
0.825	1.1
0.850	1
0.875	0.9
0.900	0.8
0.925	0.7
0.950	0.5
0.975	0.4
1.000	0.3

Original Safe Current = 0.5625 A

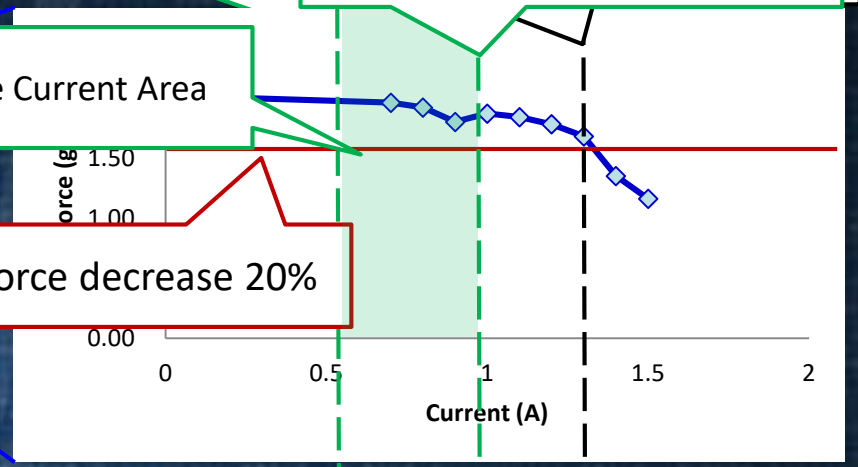


Extensive Safe Current Area

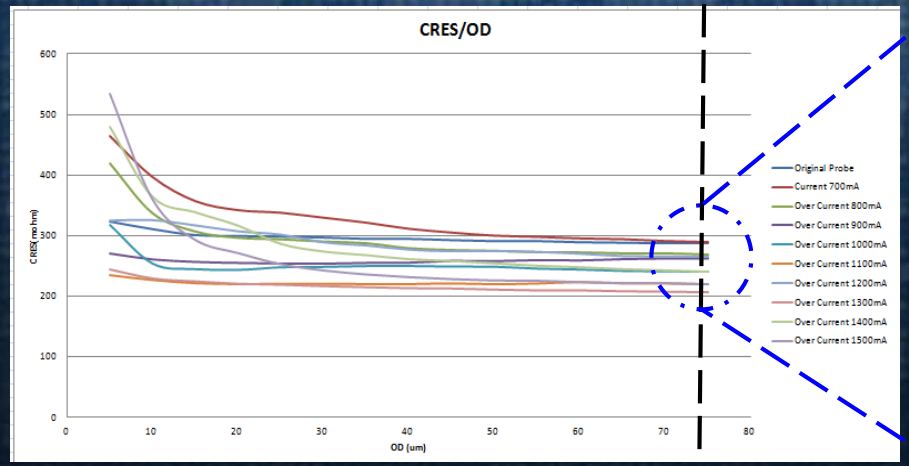
Original Saf

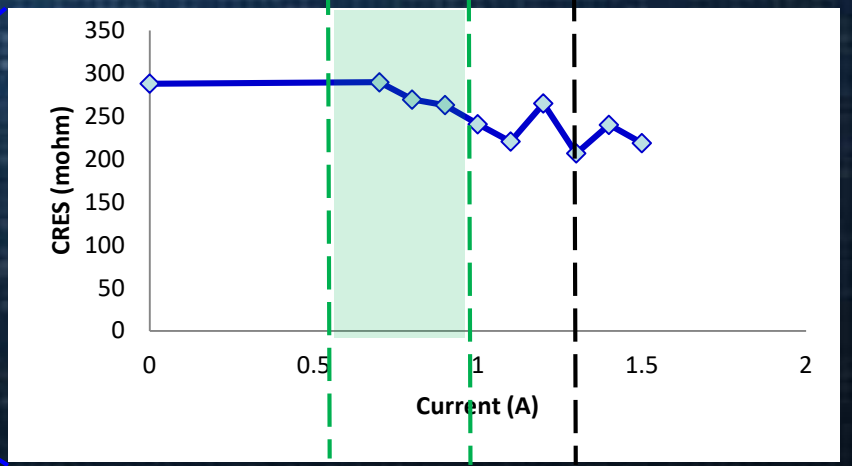
New Safe Current = 0.975A (75% C.C.C)

Force decrease 20%



Force v.s @ OD = 75um



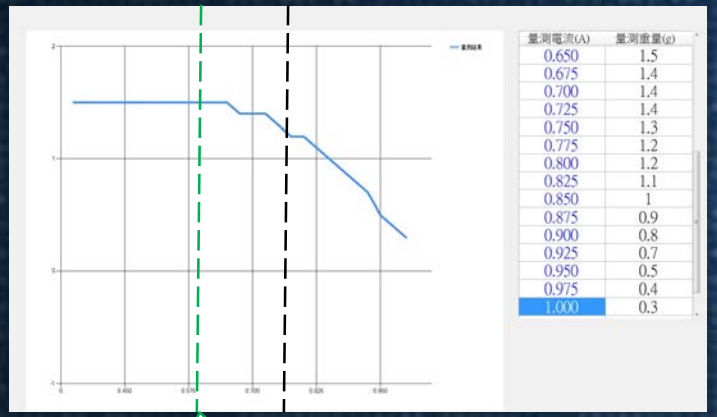


CRES v.s @ OD = 75um

Over-Current Analysis : ON 100 msec, OFF 10 sec

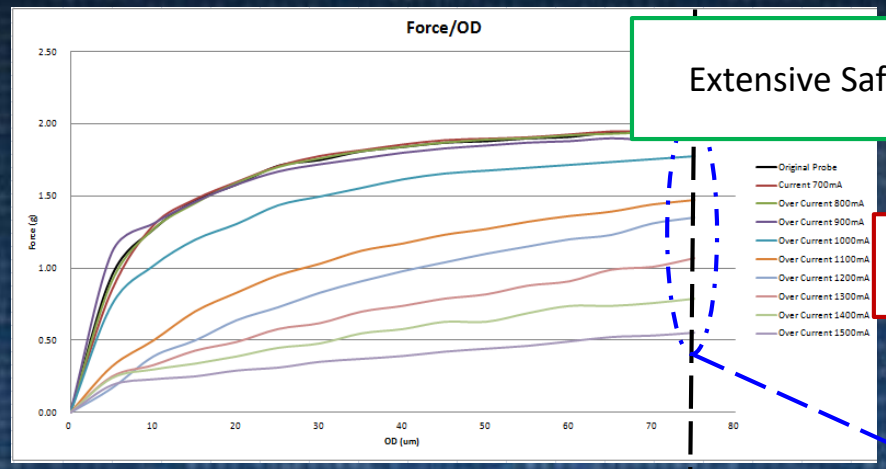
- Fixed Current 700mA~1.5A with 100mA step for each probe (10 probes), OD = 75um
- Power-ON 100 msec ; Power-OFF 10sec

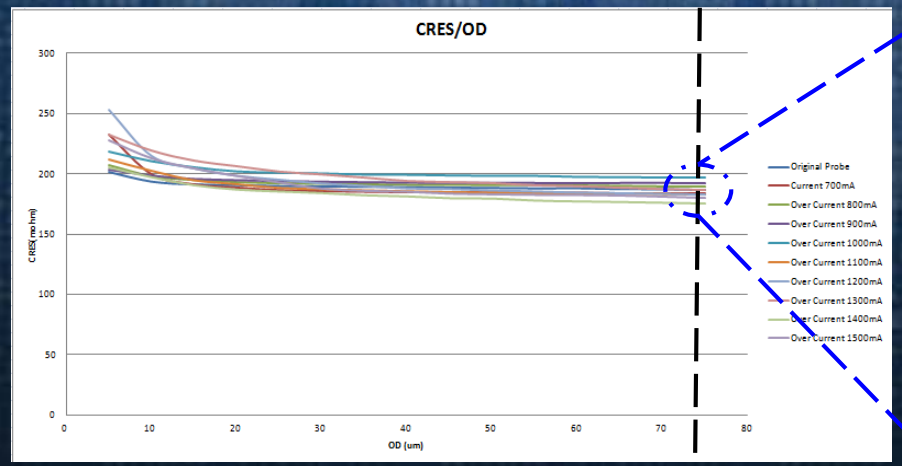
Original C.C.C = 0.75 A



量測電流(A)	量測重量(g)
0.650	1.5
0.675	1.4
0.700	1.4
0.725	1.4
0.750	1.3
0.775	1.2
0.800	1.2
0.825	1.1
0.850	1
0.875	0.9
0.900	0.8
0.925	0.7
0.950	0.5
0.975	0.4
1.000	0.3

Original Safe Current = 0.5625 A



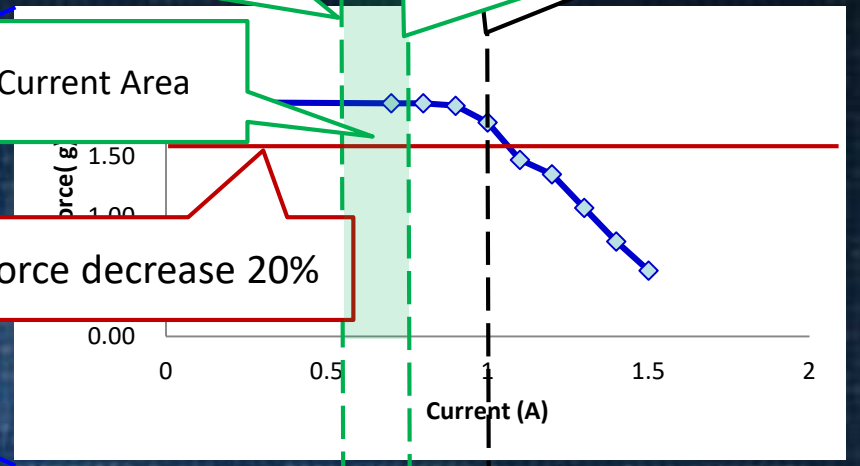


Original Safe Cur

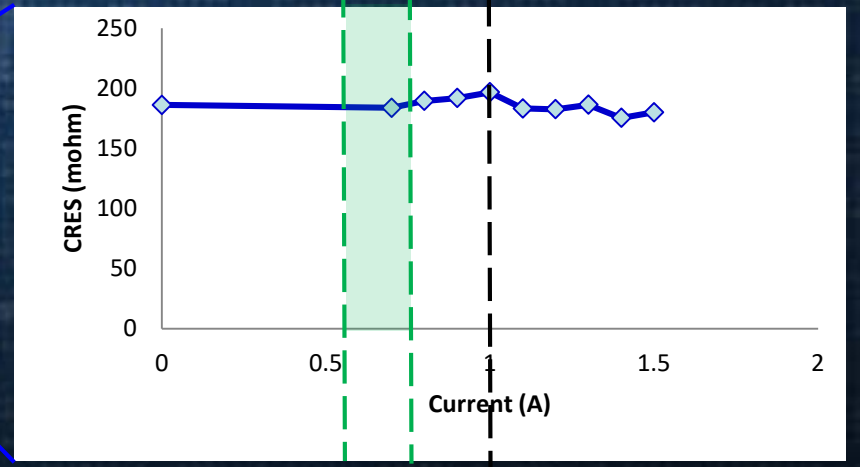
New Safe Current = 0.75A
(75% C.C.C)

Extensive Safe Current Area

Force decrease 20%



Force v.s @ OD = 75um

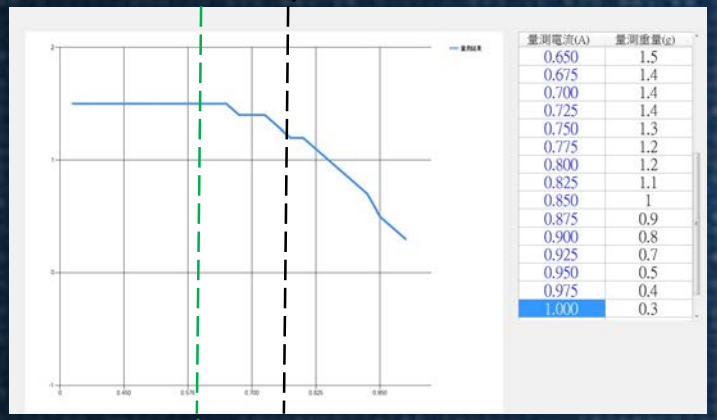


CRES v.s @ OD = 75um

Over-Current Analysis : ON 200 msec, OFF 10 sec

- Fixed Current 500mA~1.3A with 100mA step for each probe (10 probes), OD
- Power-ON 200 msec ; Power-OFF 10sec

Original C.C.C = 0.75 A



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0.650	1.5
0.675	1.4
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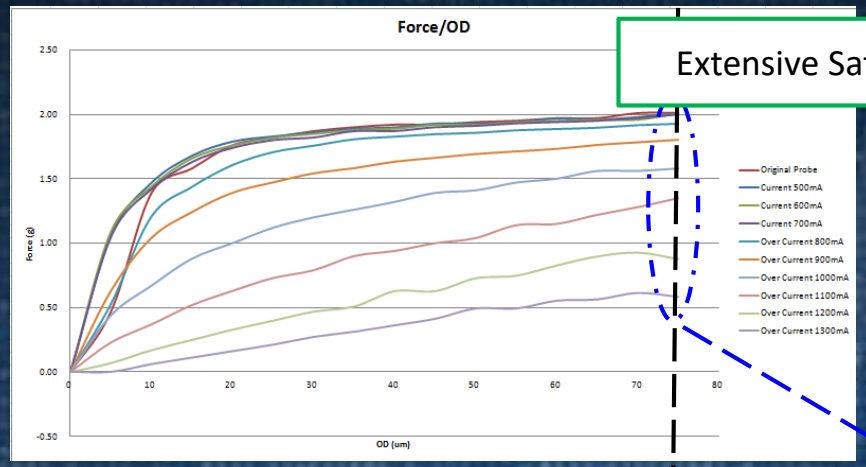
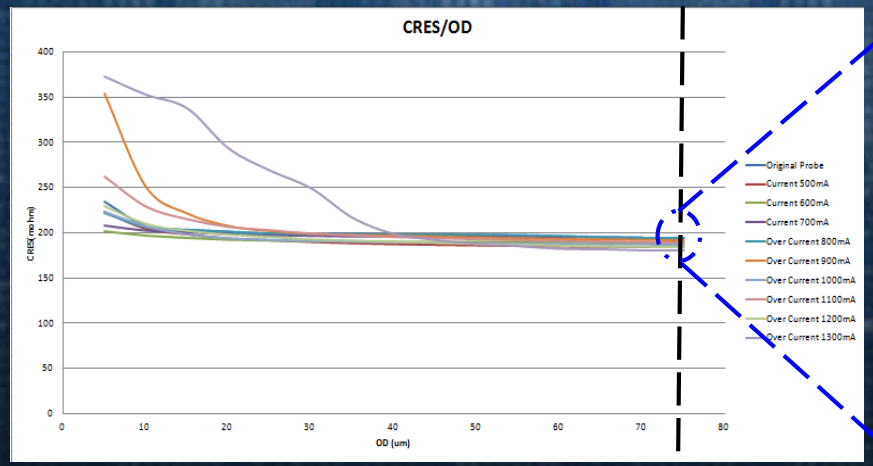
0.725	1.4
0.750	1.3
0.775	1.2
0.800	1.2
0.825	1.1
0.850	1
0.875	0.9
0.900	0.8
0.925	0.7
0.950	0.5
0.975	0.4
1.000	0.3

Original Safe Current = 0.5625 A



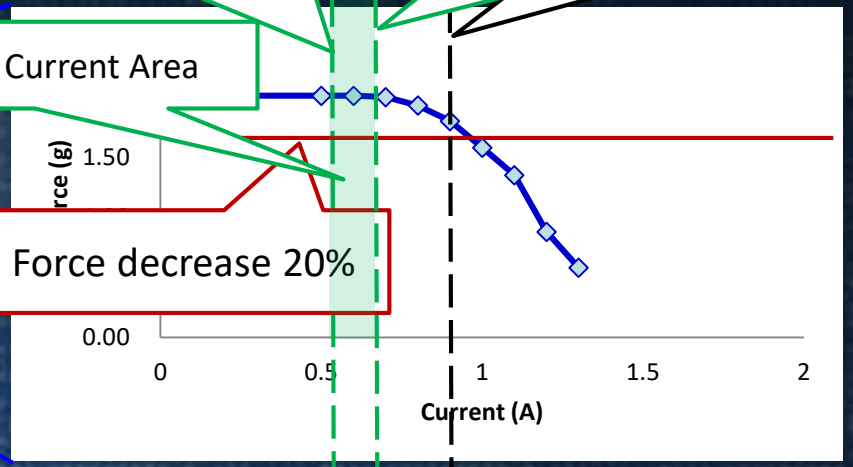


Original Safe Curre

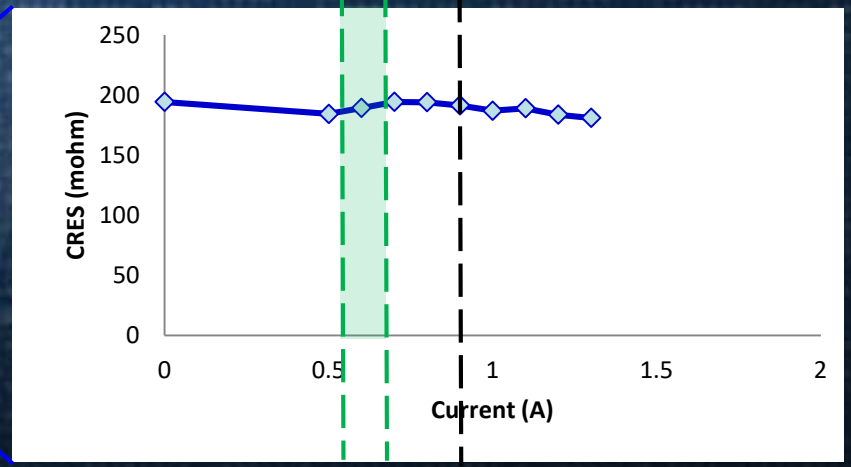
New Safe Current = 0.675A (75% C.C.C)

Extensive Safe Current Area

Force decrease 20%



Force v.s @ OD = 75um

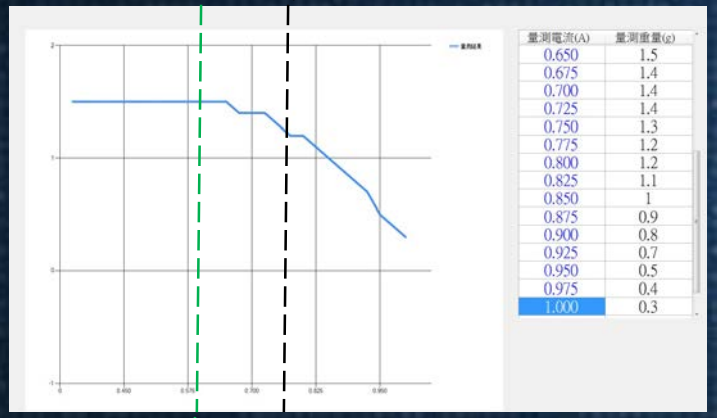


CRES v.s @ OD = 75um

Over-Current Analysis : ON 10 msec, OFF 10 msec

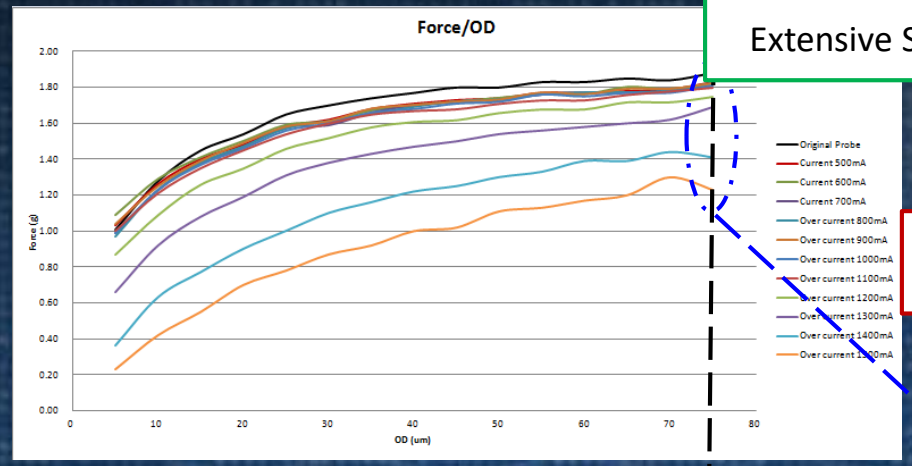
- Fixed Current 500mA~1.5A with 100mA step for each probe (12 probes), OD = 7
- Power-ON 10 msec ; Power-OFF 10 msec

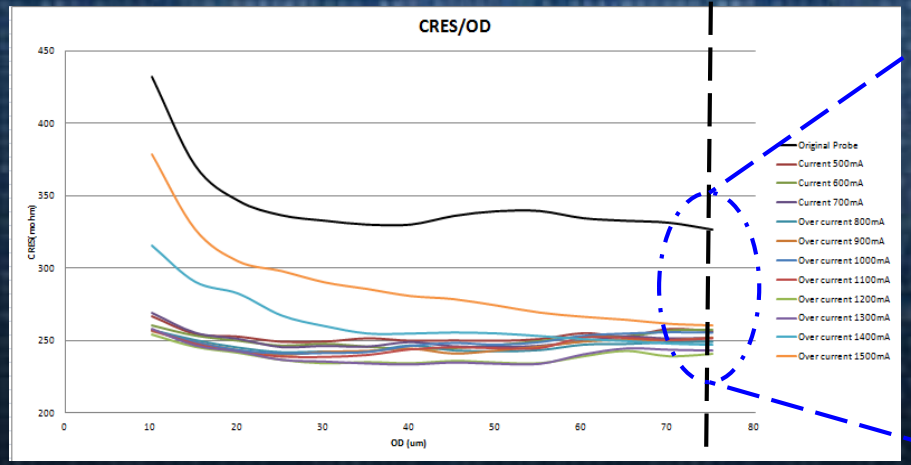
Original C.C.C = 0.75 A



量測電流(A)	量測重量(g)
0.650	1.5
0.675	1.4
0.700	1.4
0.725	1.4
0.750	1.3
0.775	1.2
0.800	1.2
0.825	1.1
0.850	1
0.875	0.9
0.900	0.8
0.925	0.7
0.950	0.5
0.975	0.4
1.000	0.3

Original Safe Current = 0.5625 A



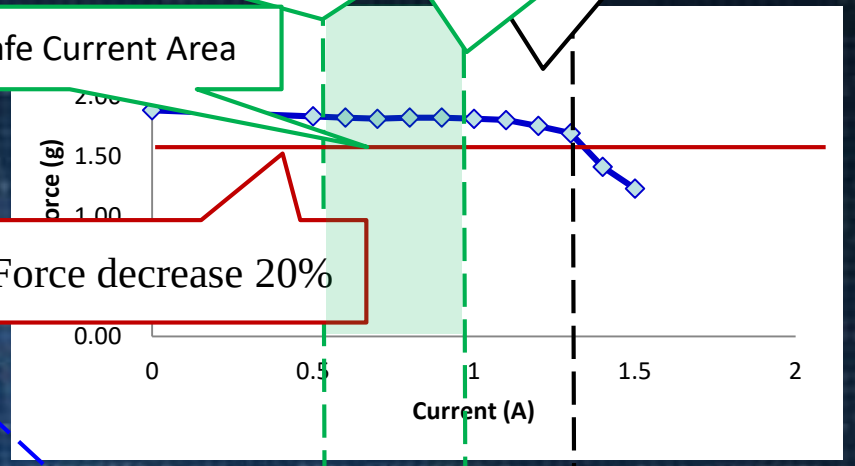


Original Safe C

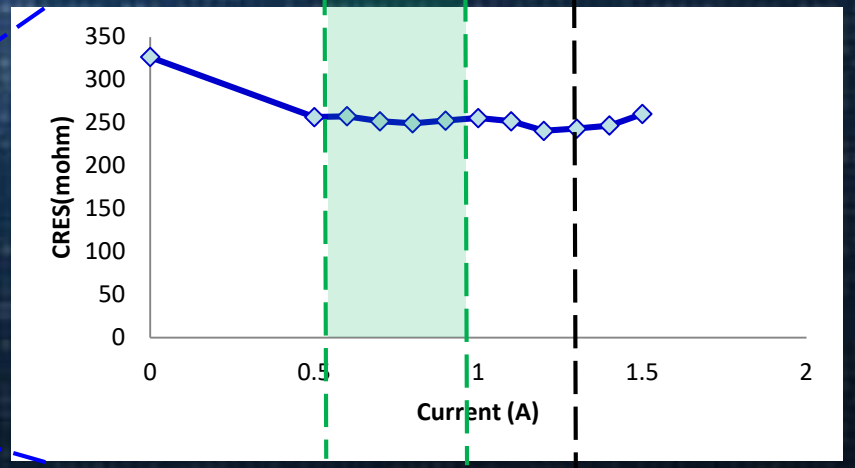
New Safe Current = 0.975A
(75% C.C.C)

Extensive Safe Current Area

Force decrease 20%



Force v.s @ OD = 75um

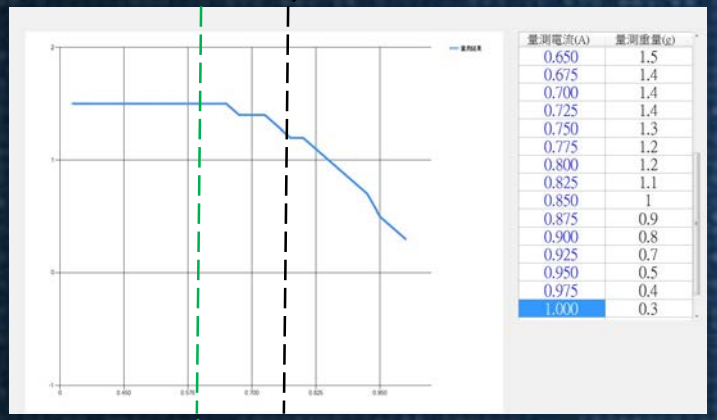


CRES v.s @ OD = 75um

Over-Current Analysis : ON 50 msec, OFF 10 msec

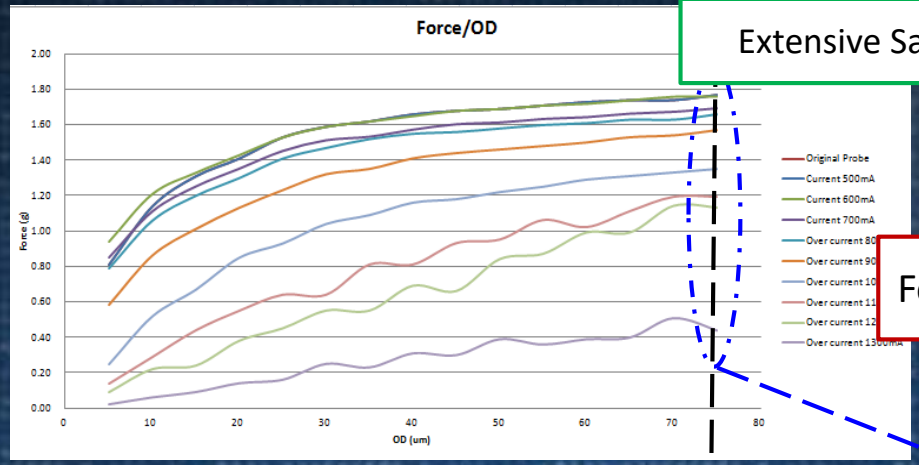
- Fixed Current 500mA~1.5A with 100mA step for each probe (12 probes), OD = 75um
- Power-ON 50 msec ; Power-OFF 10 msec

Original C.C.C = 0.75 A



量測電流(A)	量測重量(g)
0.650	1.5
0.675	1.4
0.700	1.4
0.725	1.4
0.750	1.3
0.775	1.2
0.800	1.2
0.825	1.1
0.850	1
0.875	0.9
0.900	0.8
0.925	0.7
0.950	0.5
0.975	0.4
1.000	0.3

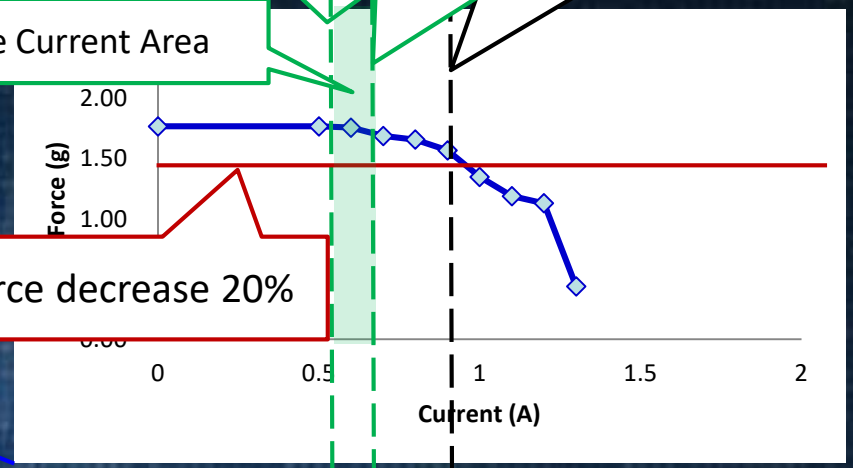
Original Safe Current = 0.5625 A



Extensive Safe Current Area

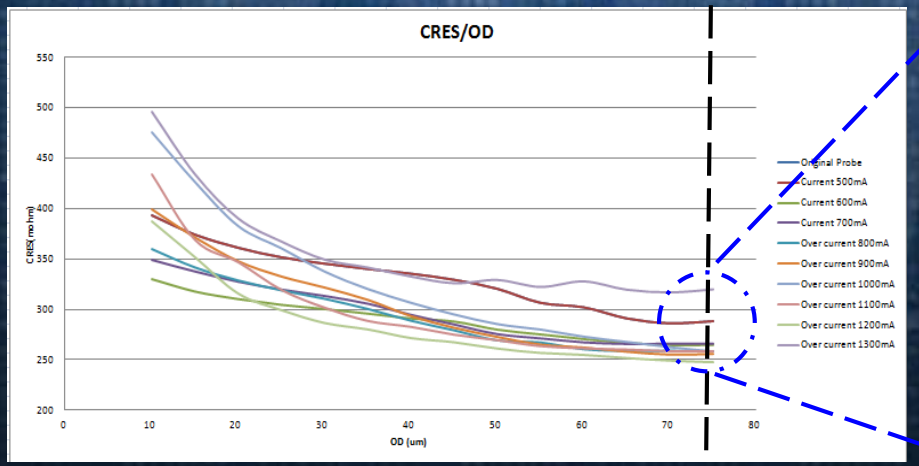
Original

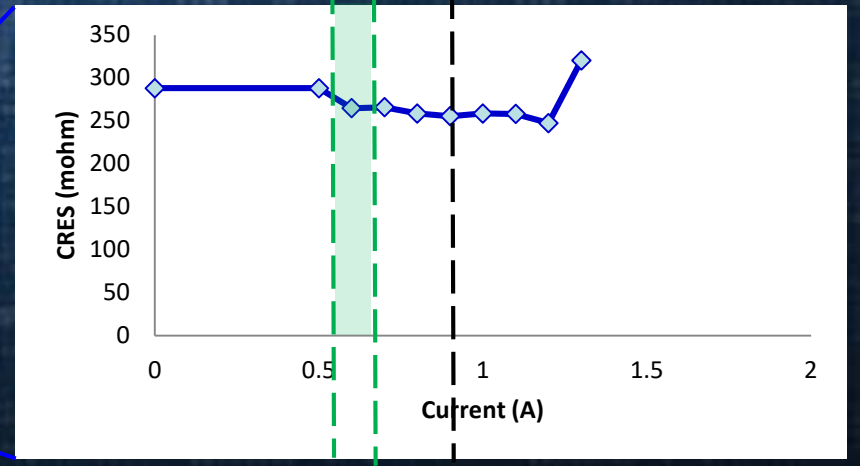
New Safe Current = 0.675A
(75% C.C.C)



Force decrease 20%

Force v.s @ OD = 70um





CRES v.s @ OD = 70um

Analysis Results of Over-Current Operation

Power-On Duration	Power-Off Duration	C.C.C	Safe Current Area	Extensive Safe Current Area (Original Safe Current = 0.5625A)	Extensive % of Safe Current Area
10 msec	10sec (ISMI CCC)	>1.5A	> 1.5A	> 0.9375A	> 166%
	500 msec	>1.5A	> 1.5A	> 0.9375A	> 166%
	100 msec	>1.5A	> 1.5A	> 0.9375A	> 166%
	10 msec	1.3A	0.975 A	0.4125A	73.3%
50 msec	10sec (ISMI CCC)	1.3A	0.975 A	0.4125 A	73.3%
	500 msec	1.2A	0.9 A	0.3375 A	60.0%
	100 msec	1.1A	0.825 A	0.2625A	46.6%
	10 msec	0.9A	0.675 A	0.1125A	20.0%
100 msec	10sec (ISMI CCC)	1.0A	0.75 A	0.1875A	33.33%
	500 msec	0.9A	0.675 A	0.1125A	20.0%
	100 msec	0.9A	0.675 A	0.1125A	20.0%
	10 msec	0.9A	0.675 A	0.1125A	20.0%
200 msec	10sec (ISMI CCC)	0.9A	0.675 A	0.1125A	20.0%
	500 msec	0.9A	0.675 A	0.1125A	20.0%
	100 msec	0.9A	0.675 A	0.1125A	20.0%
	10 msec	0.9A	0.675 A	0.1125A	20.0%

Safe Current > 1.5A

Safe Current =1.5A~0.8 A

Safe Current = 0.8 ~ 0.6A

Safe Current < 0.6A

Analysis Results of Over-Current Operation

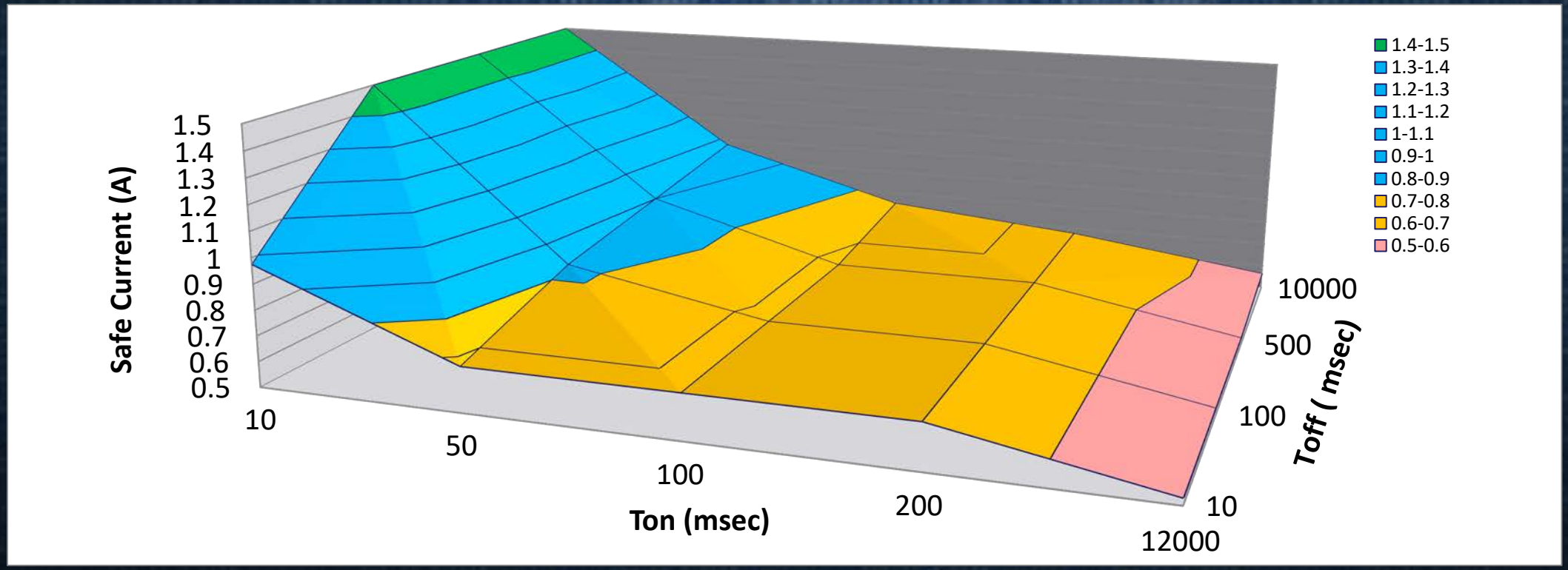
Power-On Duration	Power-Off Duration	C.C.C	Safe Current Area	Extensive Safe Current Area (Original Safe Current = 0.5625A)	Extensive % of Safe Current Area
120 sec	10sec (ISMI CCC)	0.75 A	0.5625 A	0 A	0 %
	500 msec	0.7 A	0.525 A	-0.05 A	-6.6 %
	100 msec	0.7 A	0.525 A	-0.05 A	-6.6 %
	10 msec	0.7 A	0.525 A	-0.05 A	-6.6 %

Safe Current > 1.5A

Safe Current =1.5A~0.8 A

Safe Current = 0.8 ~ 0.6A

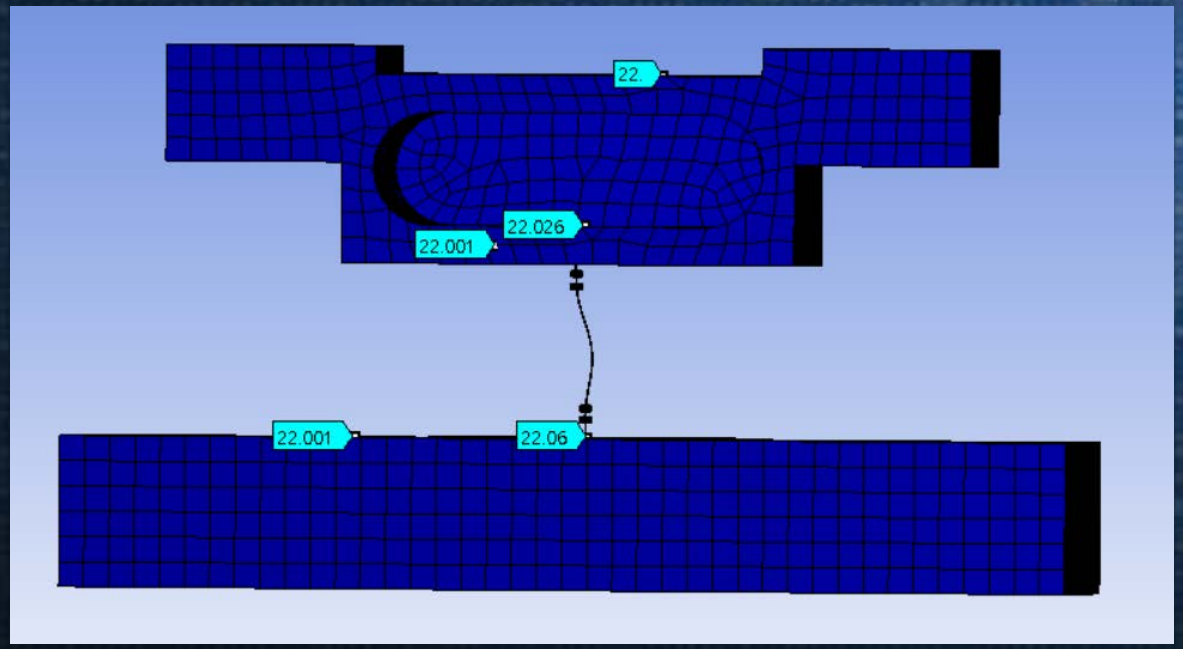
Safe Current < 0.6A



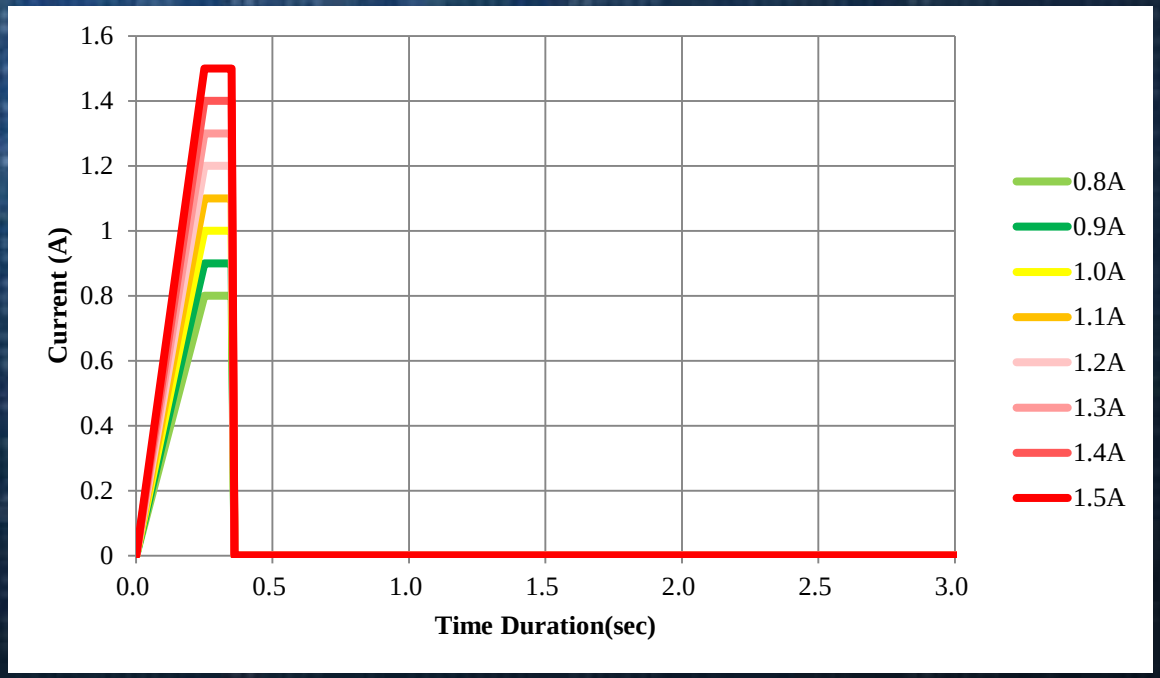
Over-Current Simulation for Probe

- **Simulation Environment Setup**
  - Electrodes of Probe： 22 ℃
  - Power-ON Duration： 100msec ; Power-OFF Duration： 10sec ;
  - Supply Current = 0.8~1.5A

Temperature Boundary Setup

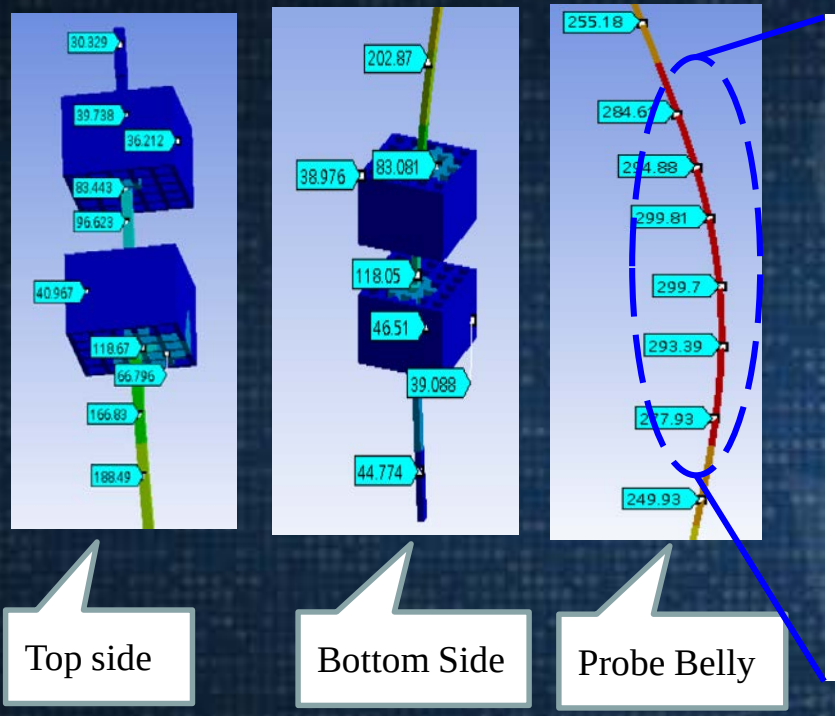


Supply Current Setup

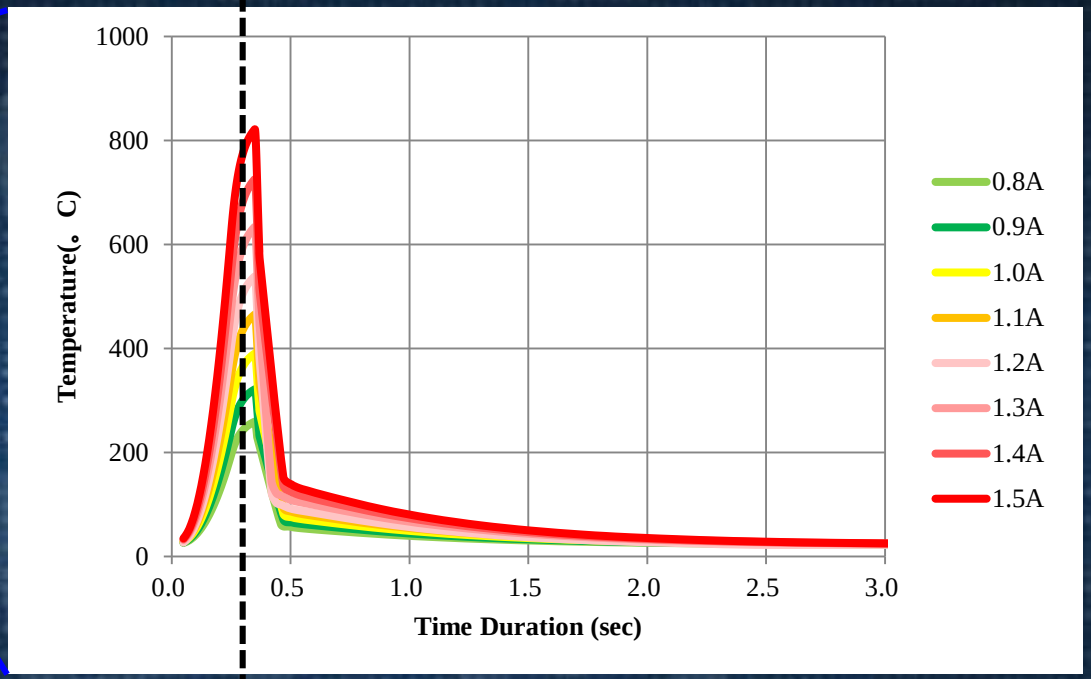


Temperature Simulation Results

Temp. Distribution of Probe



Temp. of Probe Belly vs. Time Duration

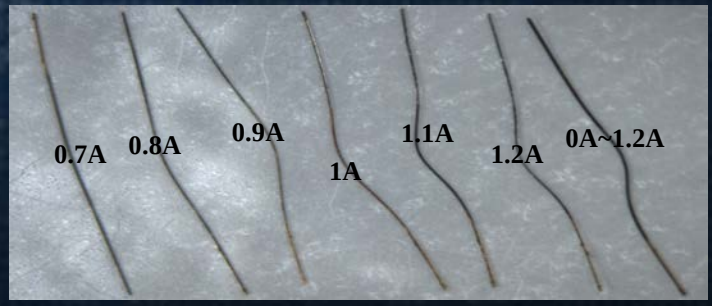


Max. Temp. of Probe

Current	Max. Temp.
0.8A	258.99
0.9A	321.11
1.0A	389.97
1.1A	465.3
1.2A	538.56
1.3A	633.61
1.4A	725.43
1.5A	821.35

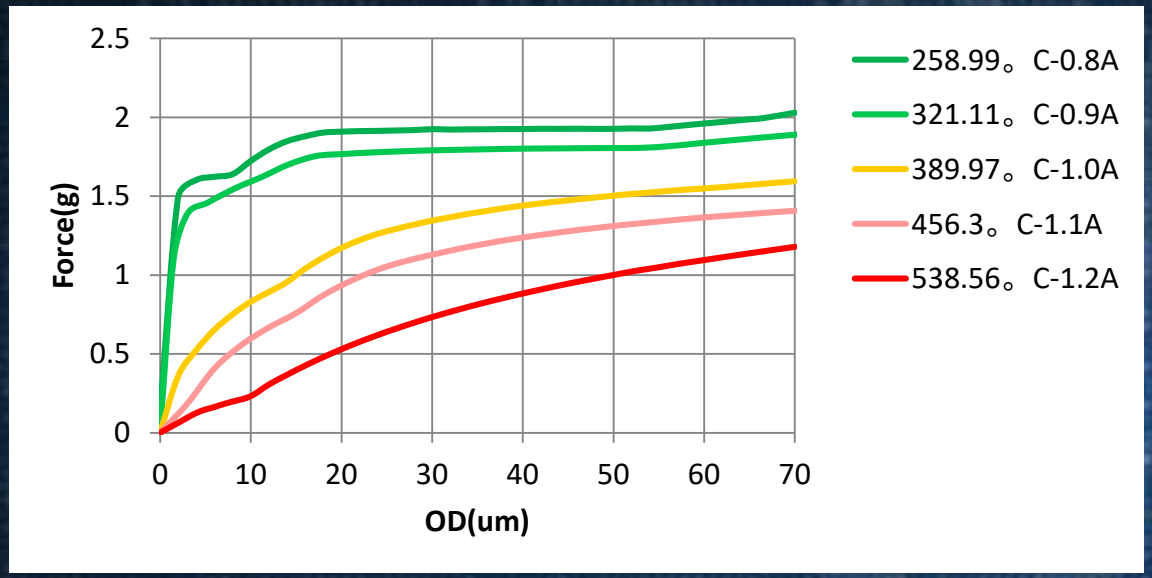
- **The reason why Probes always bend and deform in Probe Belly**

Because the electrodes on probe's both sides can help dissipate the heat, therefore, the Max. Temp. occurs at the Probe Belly. This also explains why the probe always bends and deforms in the belly area.

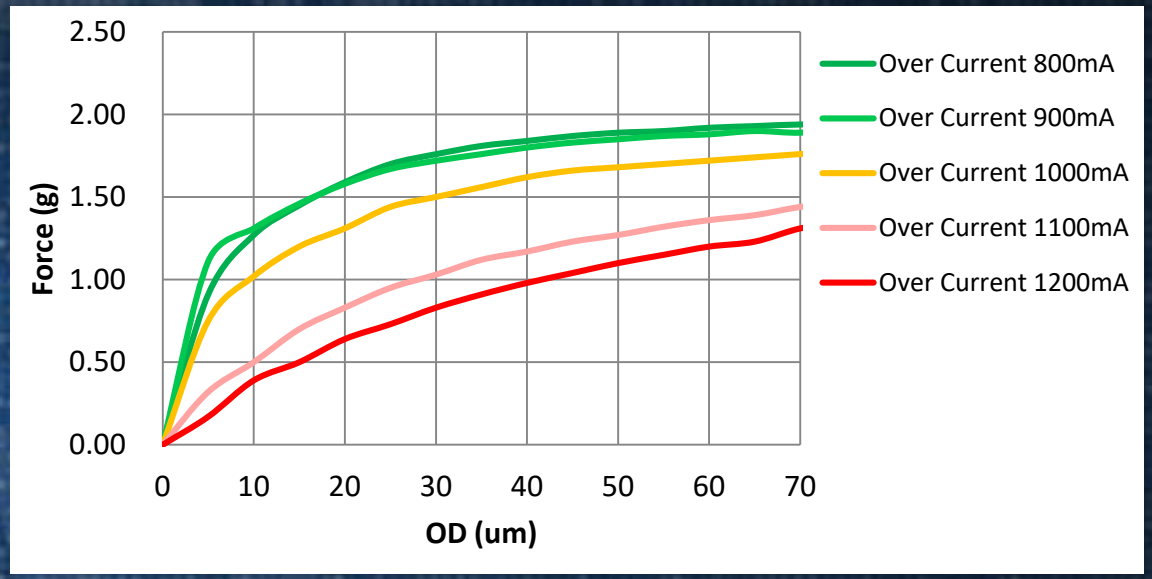


OD vs. Force Correlation

Simulated Temp. v.s Simulated OD/Force



Real Measurement Data: Current v.s OD/Force



Over-Current Operation may causes two effects:

- **Chemical Reaction: Higher Temp. causes probes to generates Carbon element which mixes with metal elements, degrading the Force.**
- **Physical Reaction: Dropping Force also means that Compressed Probe is unable to break the oxidation layer of die pad, causing unstable CRES.**

Conclusion

Definition of 3 Different Current Levels:

- Safe Current (75% CCC) Complete Cross-Sectional View No Carbon Element No Force Dropping
- Limit Current (110% CCC) Complete Cross-Sectional View Carbon Element Force Dropping
- Damage Current (150% CCC) Damaged Cross-Sectional View Carbon Element Seriously Force Dropping

New Safe Current Boundary under Over-Current Analysis:

- Temp. is proportional to both Current Amp. and Power-ON Duration
- Temp. is inversely proportional to Power-OFF Duration
- Over-Current Analysis is to adjust Power-ON and Power-OFF time to reach a new Safe Current Boundary. (Recommendation: Current operates under Probe Vendor's Regulated Limitation.)

Correlation to Provide a Convincing Simulation Report:

- With close correlation, probe Temp. can be predicted.
- With close correlation, simulation report is more efficient and trust-worthy.