New probe design and development for high current capacity using bi-furcated structure

Joonyeon Kim, Yugyeom Kim
Samsung Electronics

Taegyun Kim, Yongho Cho
Microfriend Inc.

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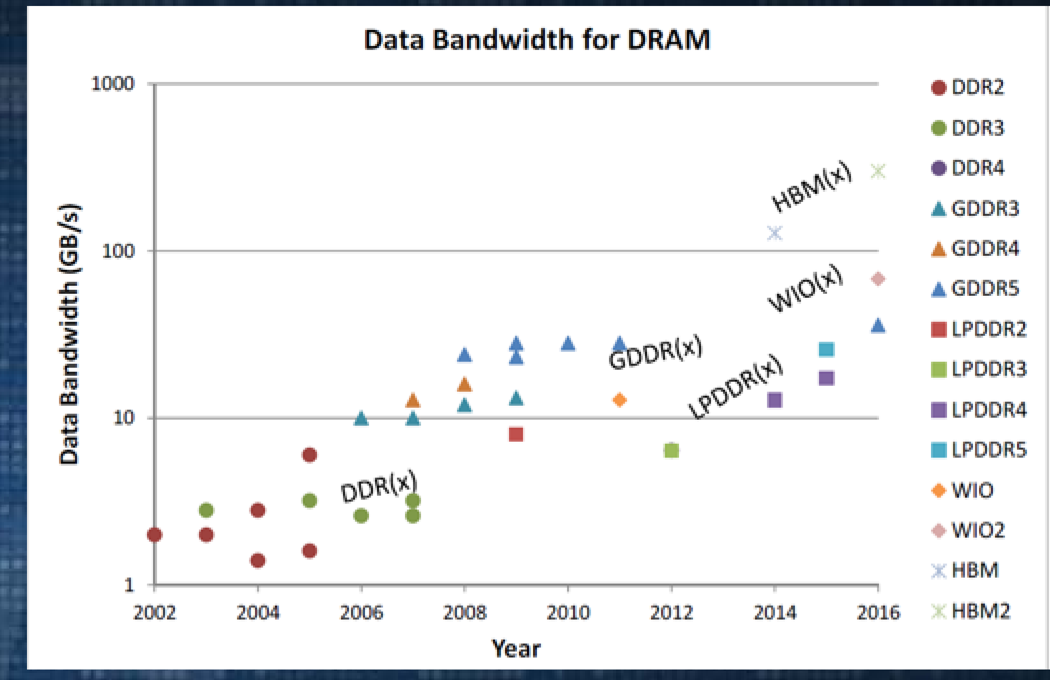
Overview

- Device Trend and Challenge
- Goal of study
- Design and realization for high current capacity
- Experiment and result in manufacturing field
- Summary

DRAM Device Trend

- **Higher performance device**
  - EDP : DDR3 → DDR4 → DDR5
  - Graphic : GDDR4 → GDDR5 → GDDR6
  - Mobile : LPDDR3 → LPDDR4 → LPDDR5
  - Density : 6G → 8G → 16G
- **Higher current consumption**
  - GDDR 6, High Bandwidth Memory (HBM)
  - Requiring high current test INFRA
- **Lower pin per DUT for maximum parallelism**
  - As test parallelism increases, number of pins for DUT decreases
  - It is connected a number of PWR/GND pins

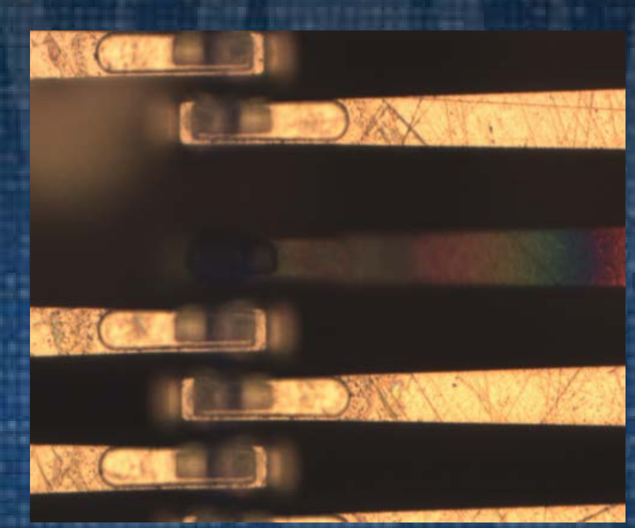


What is probe burnt ?

- **Over current causes probe burnt**
  - Energies resulting from high current may result in high temperatures at probe
  - Probe burnt causes tip burnt and beam depress
- **Burning of the tip can be prevented by cleaning solutions**
  - Cleaning method
  - Cleaning period
  - Needle polishing materials
- **How to prevent probe beam depress?**
  - Current? / Voltage?
  - Device makers don’t want to change device test condition

Side effects of beam depress

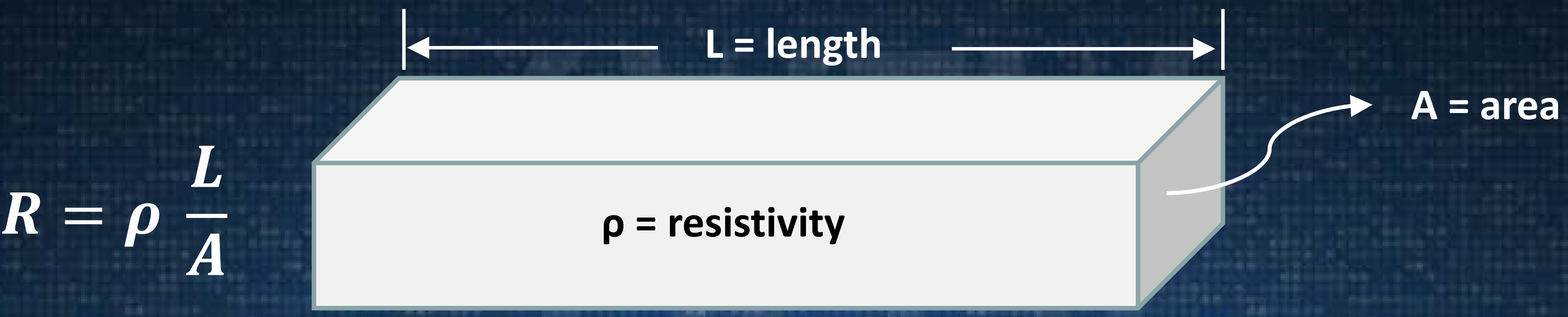
- Current ↑
- Temperature ↑
- Strength Yield point ↓
- Plastic Deformation



- **Depressed probes cause**
  - High contact resistance
  - Malposition of scrub marks
  - Yield loss

Current carrying capacity & Resistance

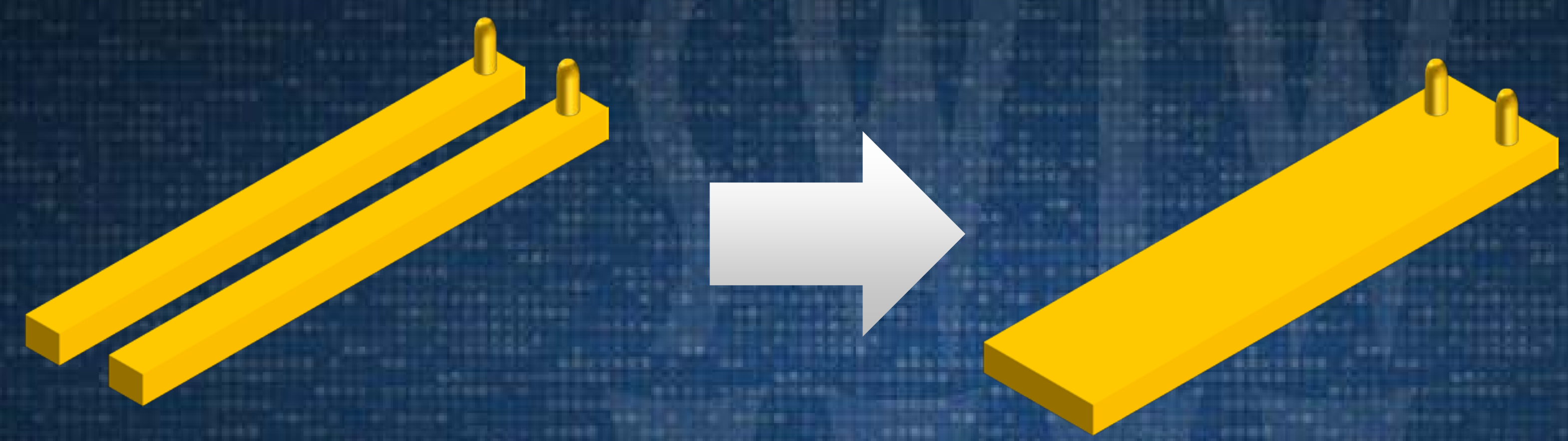
$$R = \rho \frac{L}{A}$$



- **For increasing C.C.C of probe**
  - Decreasing resistance of probe
- **For reducing resistance**
  - Low resistivity material → It requires material of probe is changed
  - Enlargement of A (Cross section)
  - Shorten length

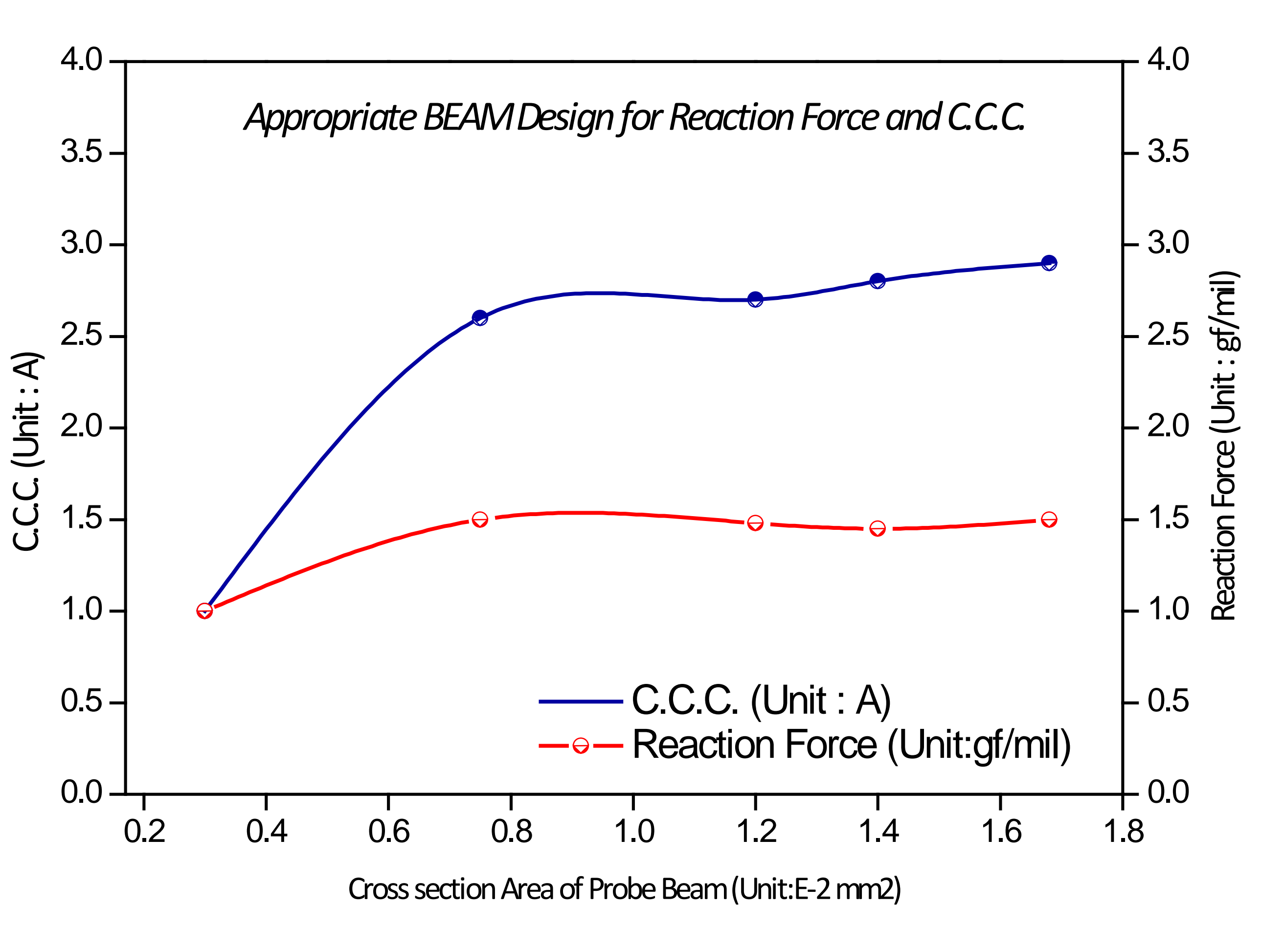
Bi-furcated structure

- **C.C.C Maximized Structure**

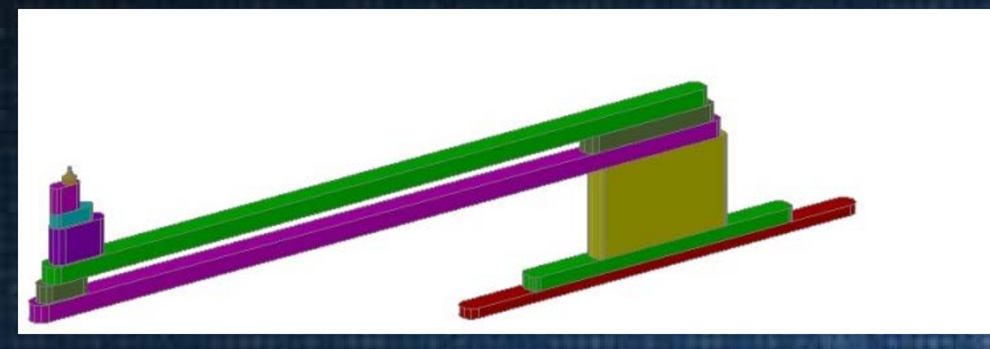


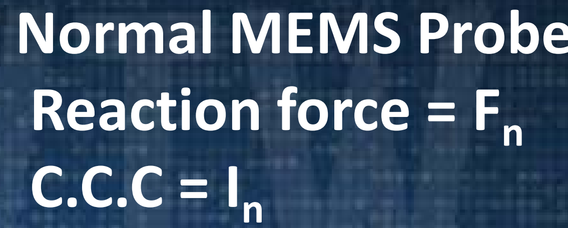
  - As section area widened, C.C.C increases
  - **But, it has side effects of increased reaction force**
- **Requirement**
  - **Correlation between C.C.C and reaction force**
  - ***In order to balance other probes, we have to adjust reaction force of the probe.***
  - ***When Pad lay out is designed, power pads must be designed to be adjacent.***

Correlation between C.C.C and Reaction force



Design & simulation probes

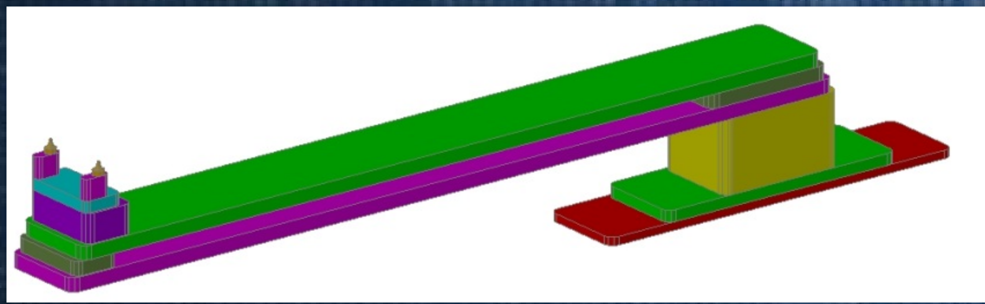




Normal MEMS Probe

Reaction force = F_n

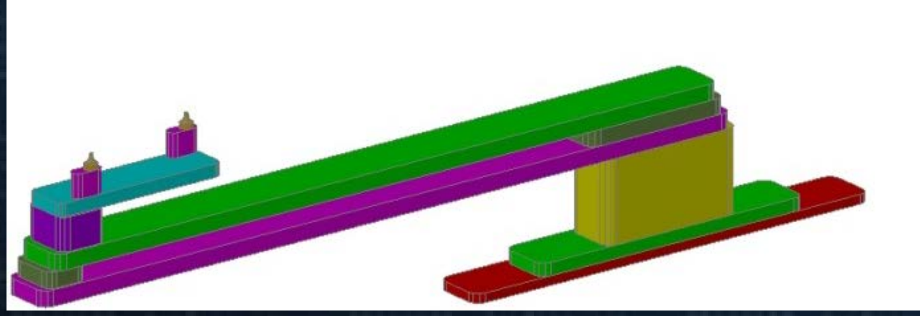
C.C.C = I_n



Bi-furcated MEMS Probe 1

Reaction force = $F_{b1} \times 3.6$

C.C.C = $I_n \times 3.3$



Bi-furcated MEMS Probe 2

Reaction force = $F_{b2} \times 2.6$

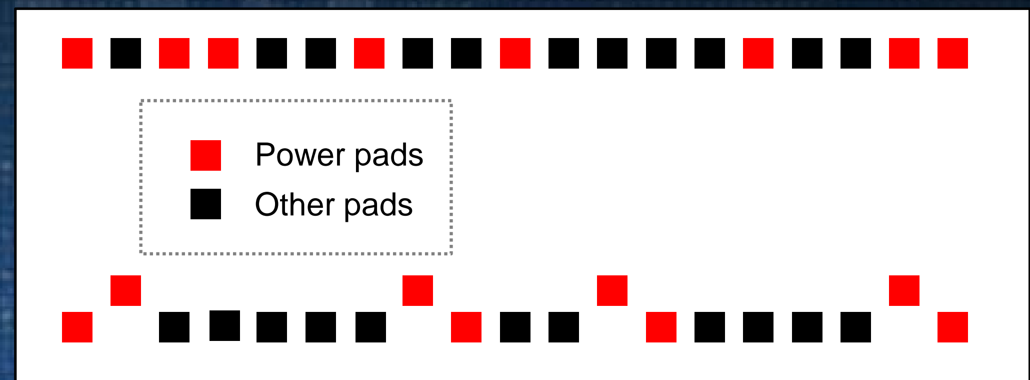
C.C.C = $I_n \times 2.67$

Design & simulation probes

	No.	Shape	Side View (실제 Image)	Top View (실제 Image)	BEAM Length (㎛)	BEAM Width (㎛)	Force (Sim)
Single PROBE	1				1961㎛	60㎛	1.08gf/mil
Bifurcated PROBE Type 1	2				2117㎛	240㎛	3.34gf/mil
	3				2370㎛	240㎛	2.13gf/mil
	4				2470㎛	280㎛	2.13gf/mil
	5				2590㎛	336㎛	2.13gf/mil
	6				2265㎛	240㎛	2.13gf/mil
2열 Bifurcated PROBE₩ Type 2	7				2117㎛	150㎛	2.15gf/mil
	8				2117㎛	150㎛	2.1gf/mil

Design pads lay-out

- **Power pads rearrange**
  - Rearrange power pads which require high current
    - One of power pad next to another power pad
  - Matching the number of top/bottom power pads



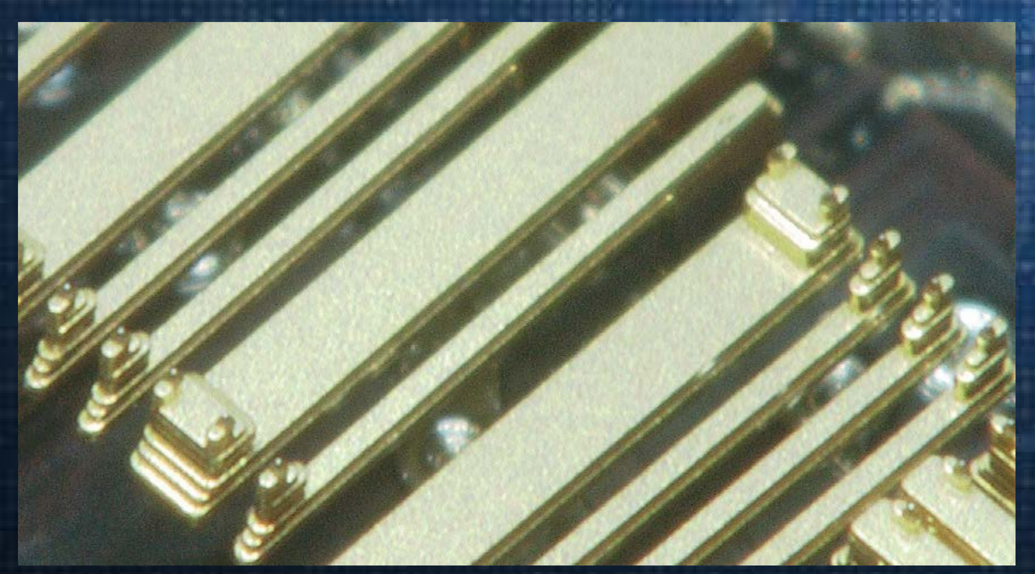
- **Total probe force balance**

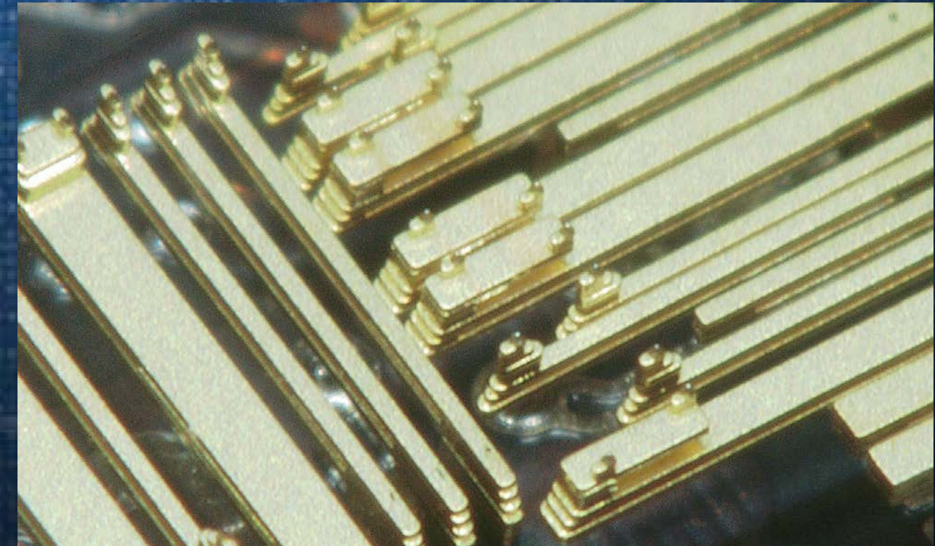
Σ Force of upward direction probes

Σ Force of downward direction probes

Probe fabrication

- **Bi furcated probe array realization using 3-D MEMS process**
  - Probe array realization for DRAM device
  - 31,000 pins per probe card
  - 3 types of bi furcated probes are mixed in 1 DUT



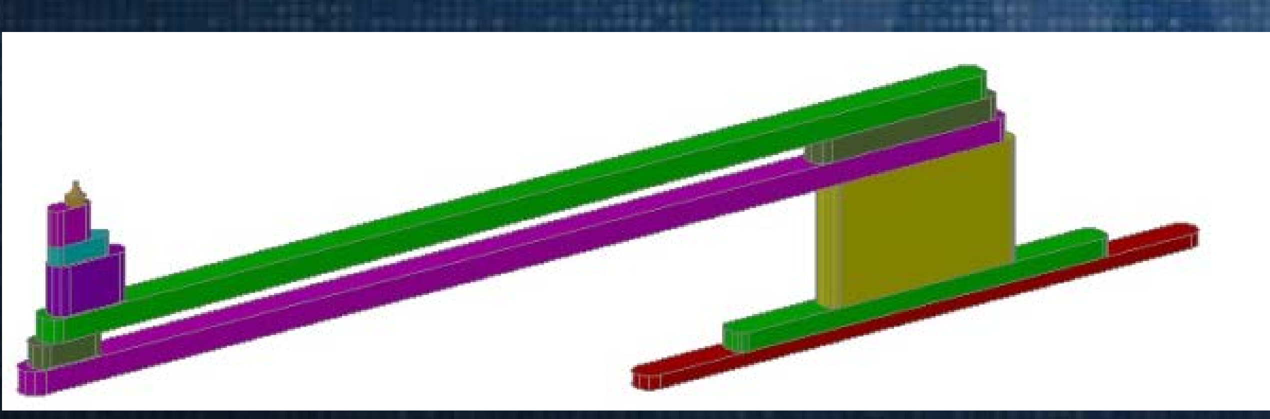


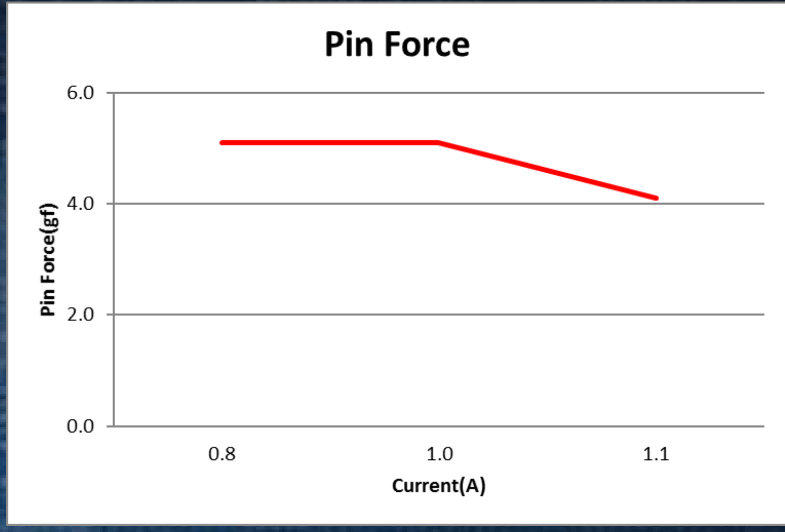
Performance evaluation

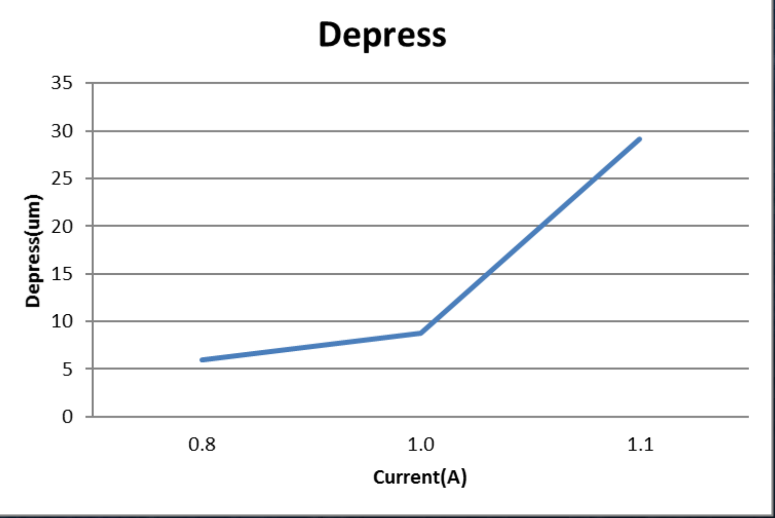
- **Measurement parameter**
  - C.C.C of probe
  - Reaction force of probe
  - Depress (㎛)
- **Test condition**
  - Temperature : 100 ℃
  - Current applied for 1 hour at contact condition
  - Increase the current by 200mA every 1 hour
  - Measure depress & reaction force
- **Failure condition**
  - When the probe depress over 25㎛
  - When reaction force is reduced more than 15%

Evaluation (Normal Probe)

Current	Depress	Pin Force(gf)		Reduction rate
		Before applying current	After applying current	
0.8	6	5.2	5.1	2%
1.0	9	5.2	5.1	2%
1.1	**29**	**5.2**	**4.1**	**21%**

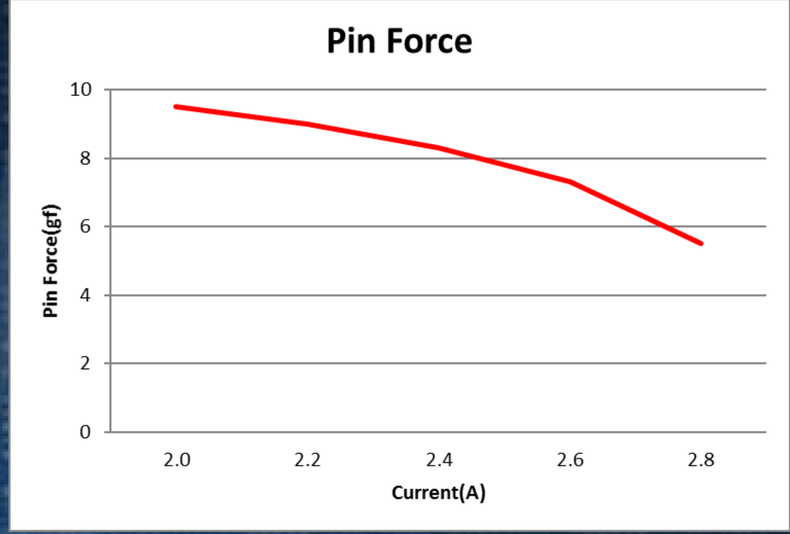


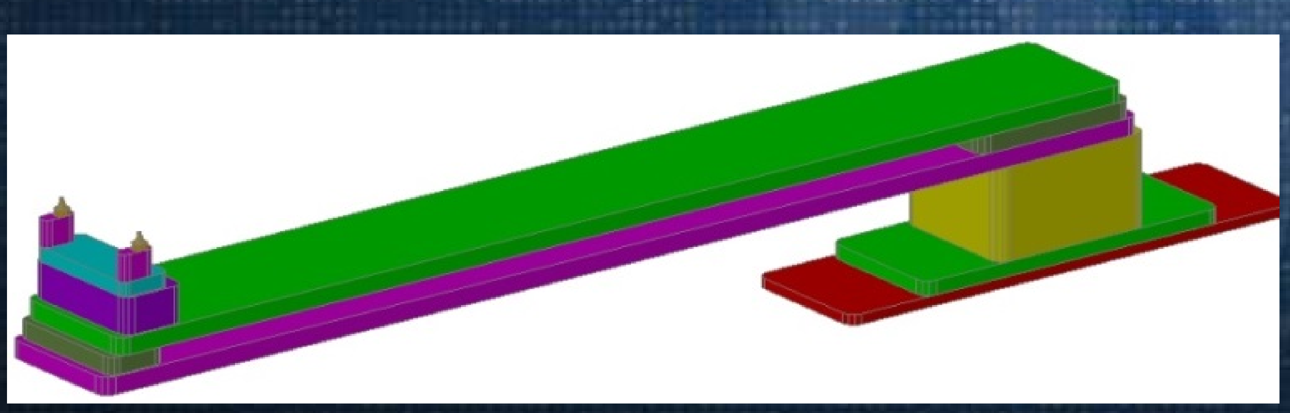


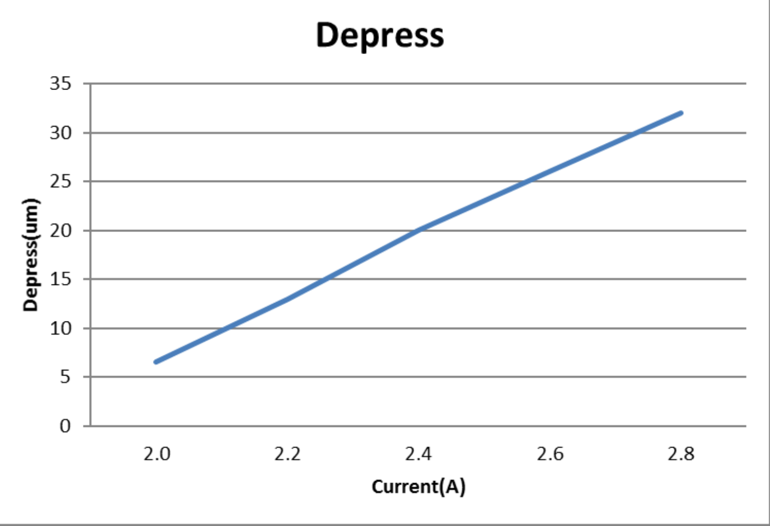


Evaluation (type 1)

Current	Depress	Pin Force(gf)		Reduction rate
		Before applying current	After applying current	
2.0	6.5	10	9.5	5%
2.2	13	10	9	10%
2.4	**20**	**10**	**8.3**	**17%**
2.6	26	10	7.3	27%
2.8	32	10	5.5	45%

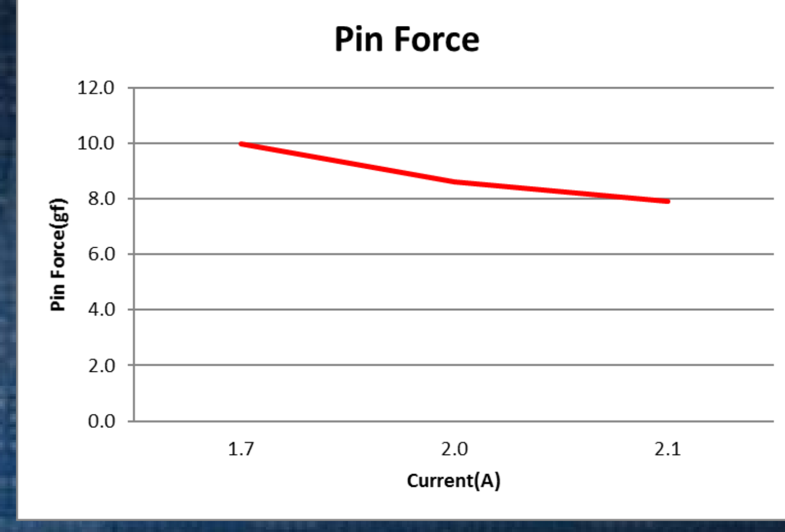


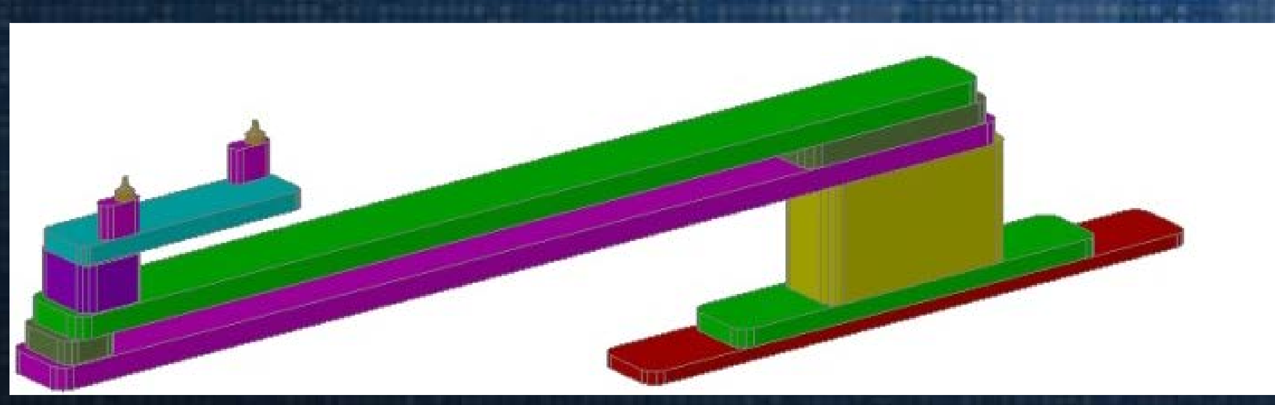


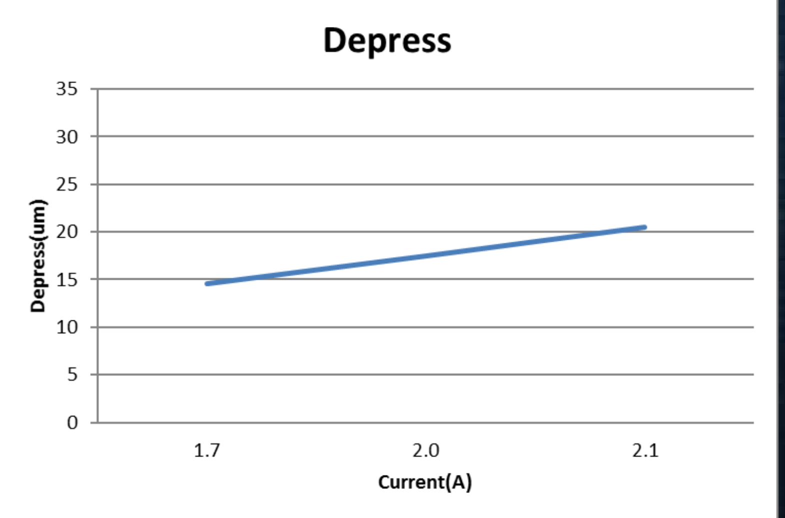


Evaluation (type 2)

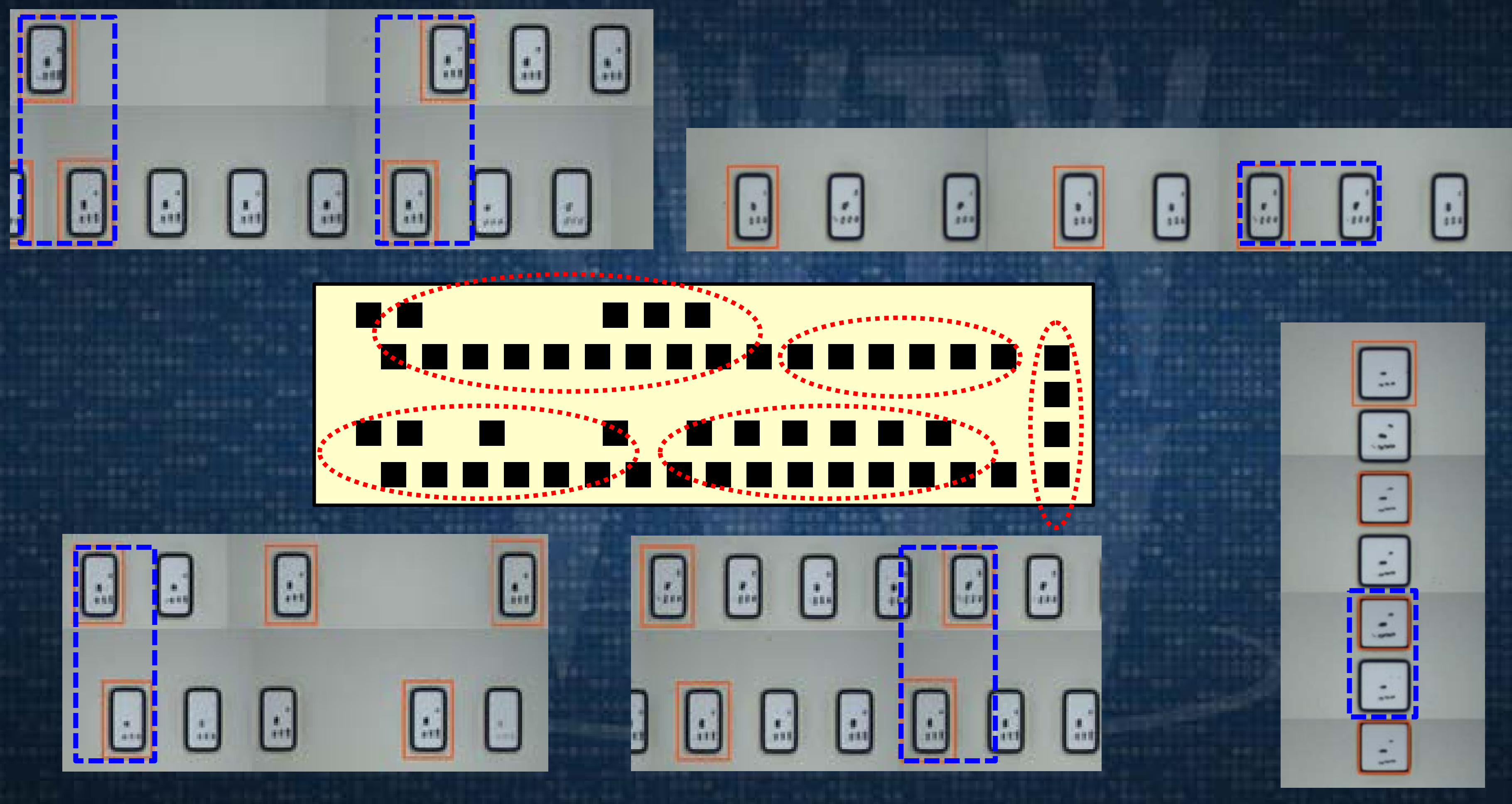
Current	Depress	Pin Force(gf)		Reduction rate
		Before applying current	After applying current	
1.7	15	10	10.0	0%
2.0	18	10	8.6	14%
2.1	**21**	**10**	**7.9**	**21%**



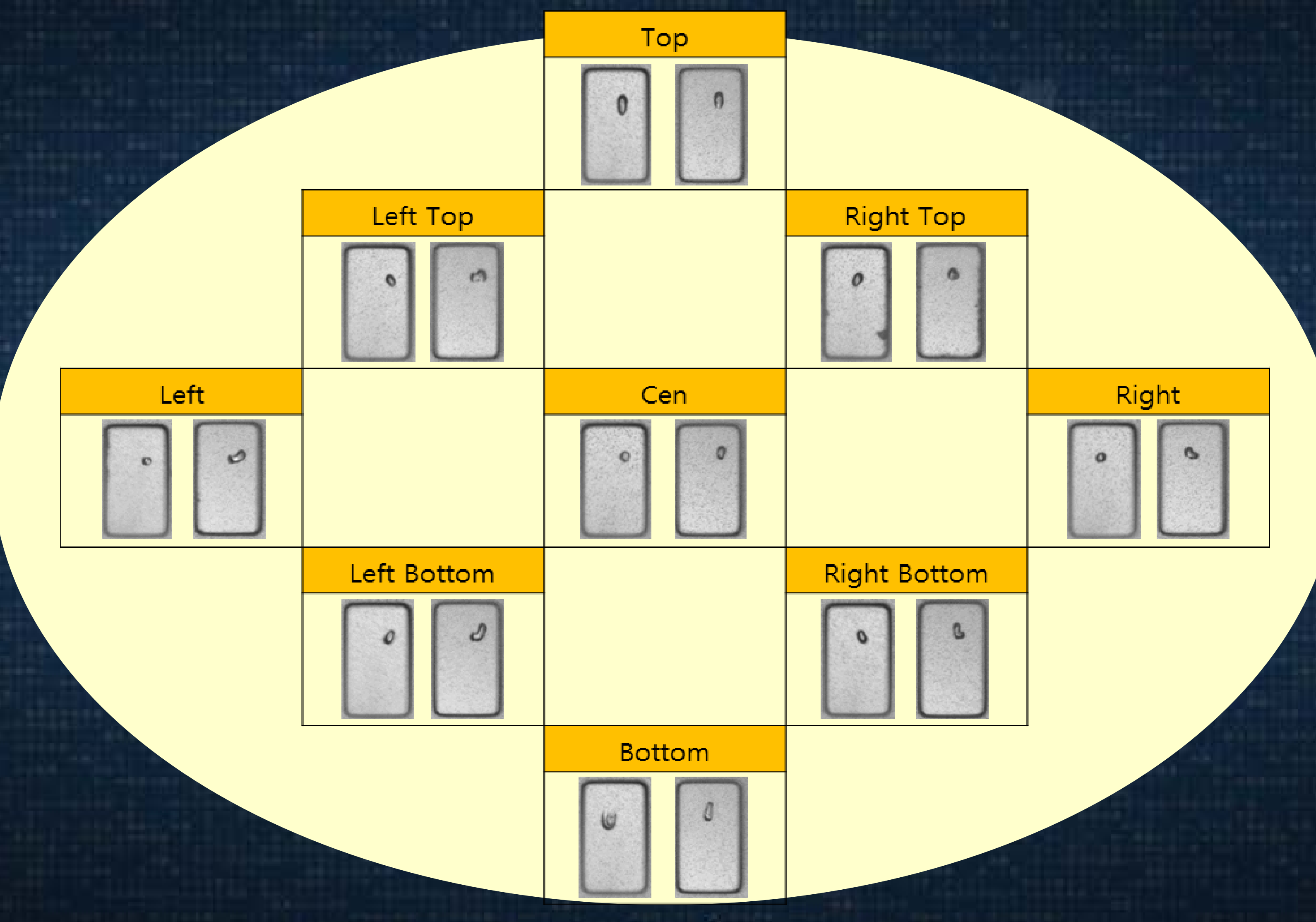




Field test (DUT)



Field test (Wafer)



Summary

- **Memory devices require high current INFRA for wafer testing**

- **New probe using bi furcated structure improves its C.C.C**

- **To balance contact force, it needs to optimize pad lay-out**
  (including pads position and number)

- **It is available to apply new probe for mass production line**

Thanks for your Support !

- Je-Young Park
- Sang-Kyu Yoo
- Yu-Gyeom Kim

- Yong-Ho Cho
- Tae-Kyun Kim