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Development of μ-Bump and Pad Contactor Technology for Next-Generation HBM Testing

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- Semiconductor Testing Outline
- HBM Test Solution
- Test Socket Evolution
- μ-Bump Contactor Technology
- D/A Pad Contactor Technology
- Summary

Memory Manufacturing and Testing Process

DDR5

Wafer – EDS TEST → PKG Ass'y → PKG Burn-In → PKG TEST(L/MF) → PKG TEST(HF) → Module TEST(MF) → QA Monitoring – Shipping

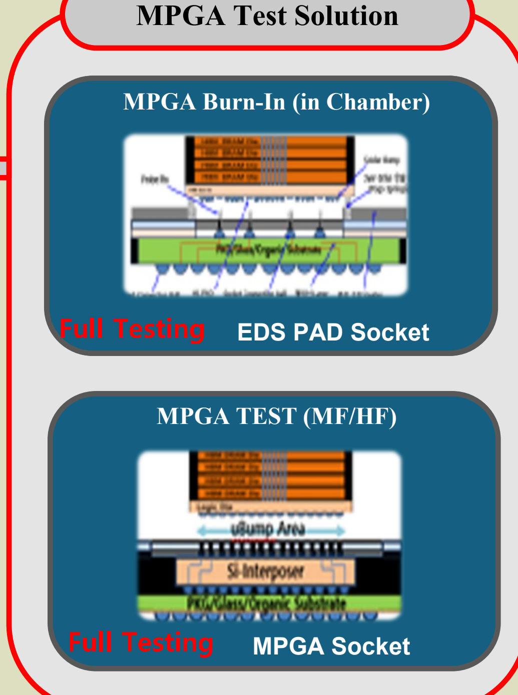
Full Testing | Full Testing | Full Testing | Full Testing

HBM

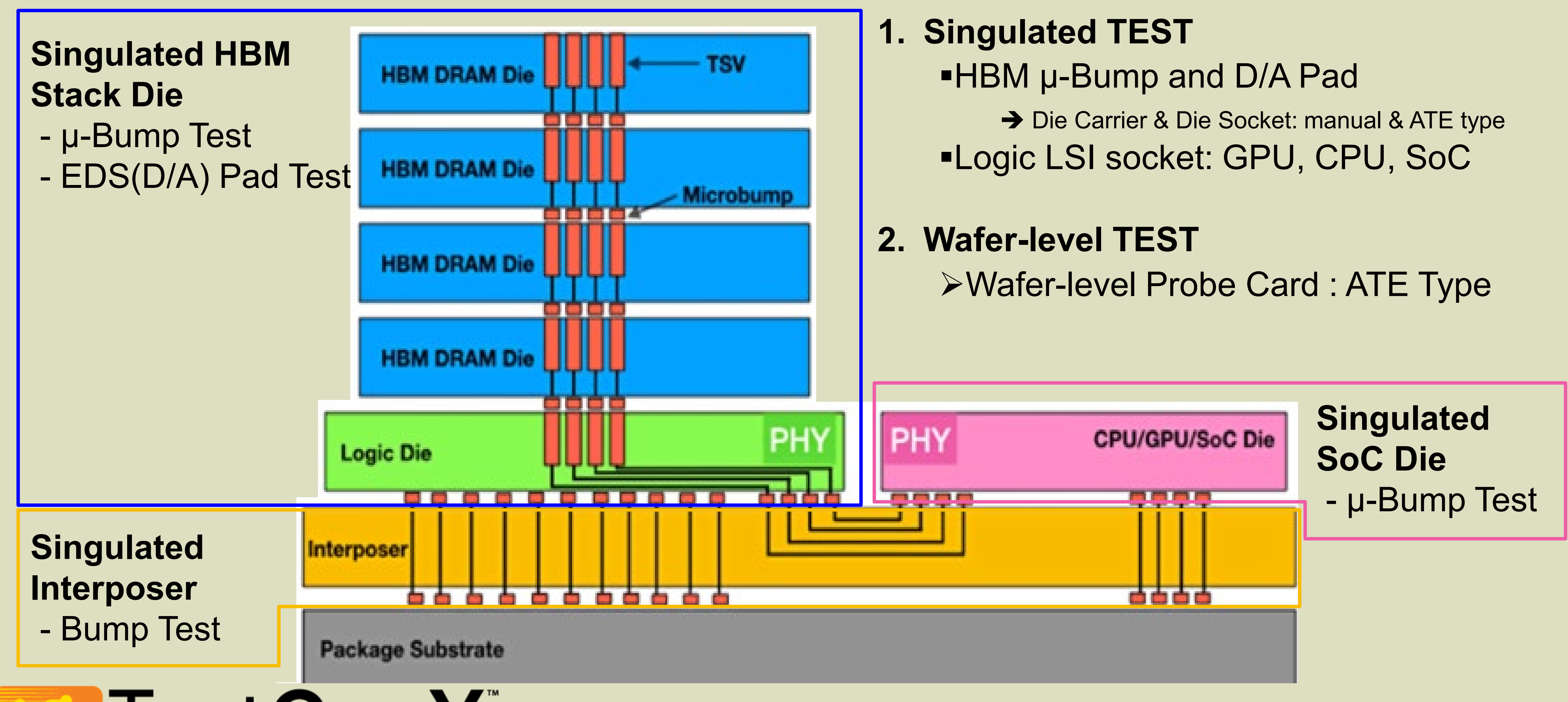
Core Die – EDS TEST → Base Die, Stack – CoW Ass'y → ATE, Probe-Card EDS Pad Probing Test – CoW TEST → CoW, Dicing Shipment – Dicing → HBM, Logic Die – PKG Ass'y → QA Monitoring – Shipping

Full Testing | No Full Testing

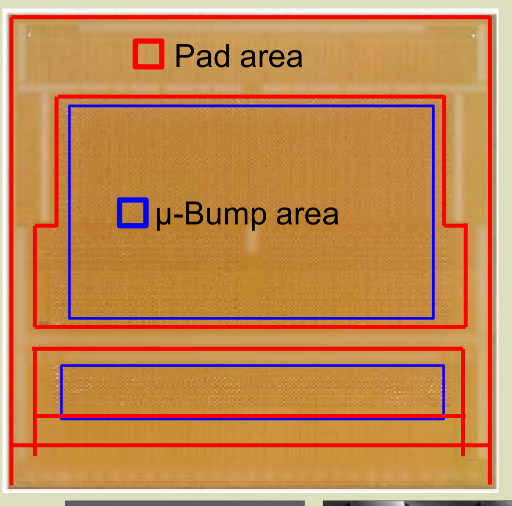
- MPGA: Micro Pin Grid Array (HBM μ-Bump Array)

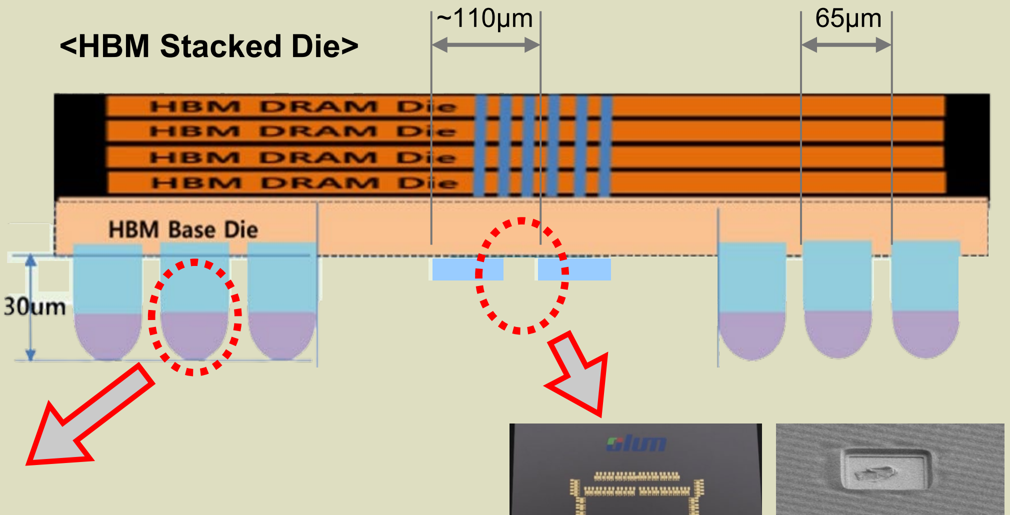


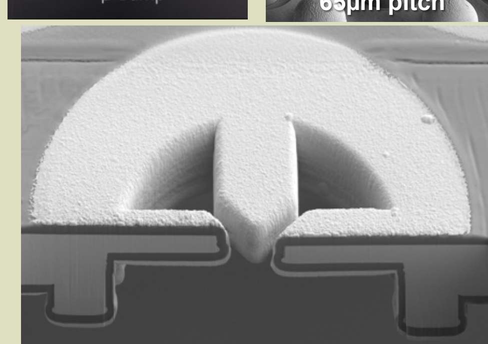
HBM Testing and Scope



HBM Test Solution







Pad

~350ea Pad
~110μm pitch

μ-Bump contactor

μ-Bump
~16,000ea, 65μm pitch

D/A Pad contactor

D/A Pad
~350ea, ~110μm pitch

Horizontal Cantilever

HBM Test Solution: μ-Bump & D/A Pad

μ-Bump
HBM
Pad

<μ-Bump Contactor>

<D/A Pad Contactor>

HBM
Die Socket
Contactor
Si (RDL)
Interposer
Substrate

HBM
Substrate

HBM
Die Socket
Substrate

HBM
Substrate

Test Socket Evolution

- The bump pitch reduces continuously.

> 0.5

0.2~0.3

< 0.15

Space Width

Pitch

Areas of Cantilever pin

Package

Pogo pin socket

Load board

Pogo Pin

Rubber Pin

μ-Bump

Olum "Canta" Pin

Market Share

CPU/GPU/ AP PKG

LPDDR5 PKG

HBM, LPDDR6 SoC Die

0.8 0.6 0.5 0.3 0.2 0.1 0.05

Pitch (mm)

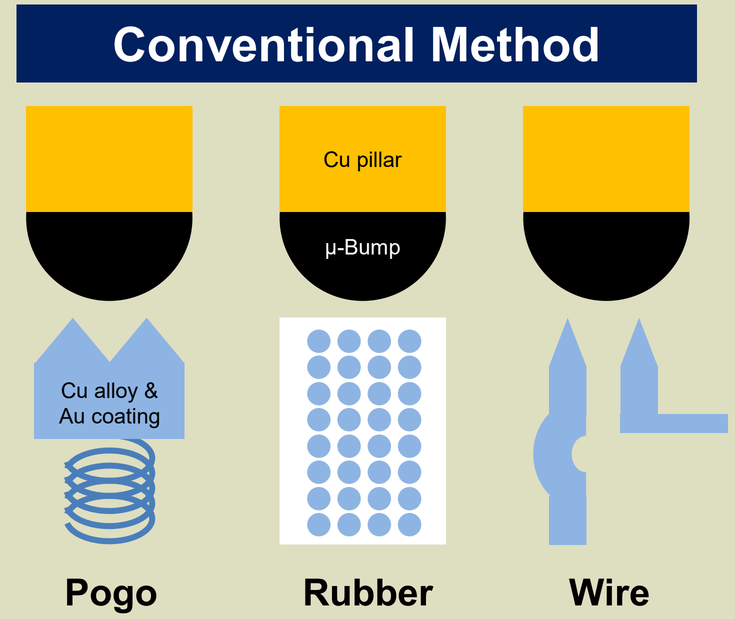
Test Socket Evolution

- Full HBM testing is possible for the first time.

Category	Pogo Pin	Rubber Pin	Olum Cantilever Pin
Image	Package / Pogo pin socket / Load board	Packaged IC / Package Ball / Metal Powder / Dielectric / Main Test PCB / 0.3 mm / 1.2 mm	μ-Bump
Advantage	Longer lifespan High mix, low volume production specialized	No ball damage Cost competitiveness Low-mix, high volume specialized	**Fine pitch solution** Low-mix, high volume specialized High frequency compatible
Disadvantage	Limited high-frequency performance **No fine-pitch solution** Ball damage	Shorter life span **No high temperature capability** Poor position accuracy	Requires long-term reliability verification
Pitch	**500~1,000μm**	**250~500μm**	**<250μm**
Position Accuracy	**±30μm**	**±50μm**	**±1.0μm**
Full HBM Testing	**Impossible**	**Impossible**	**Possible**
Supplier	Leeno, Yokow, Winway, Cohu, Smith Interconnect, etc.	ISC, TSE, TFE, etc.	**Olum**

Test Socket Evolution

- Horizontal Cantilever
  - Short current path, metal backbone, high position accuracy



Cantilever Method

1~20㎛ thick

<±1.0㎛ accuracy

Metal

Horizontal Cantilever
(Spring-board effect)

[Key Advantages]

① Short current path (contactor thickness <30μm)
➔ High bandwidth - dominant performance

② Metal backbone: extreme low CTE
➔ High temperature operation - outstanding

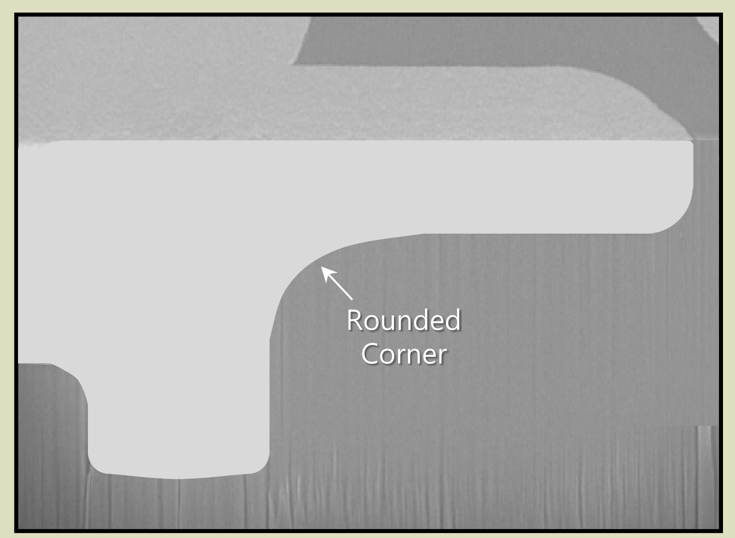
③ Precise position accuracy ≤ ±1.0μm
➔ Testing operation margin and speed up

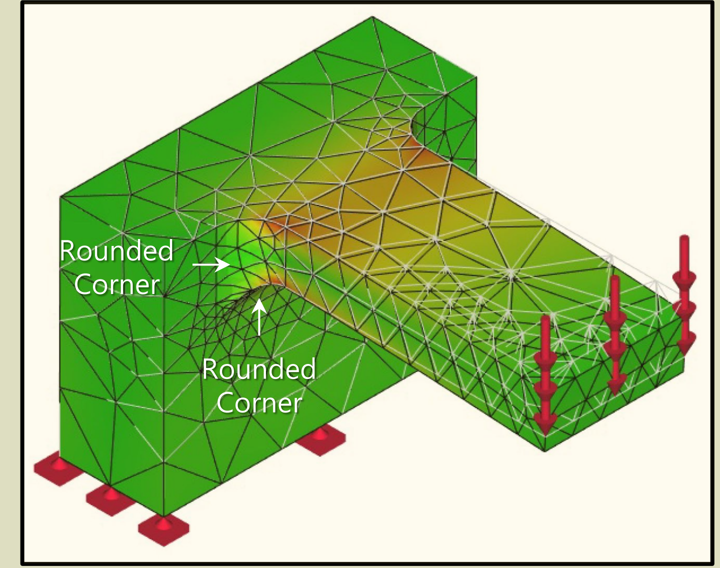
Test Socket Evolution: Horizontal Cantilever

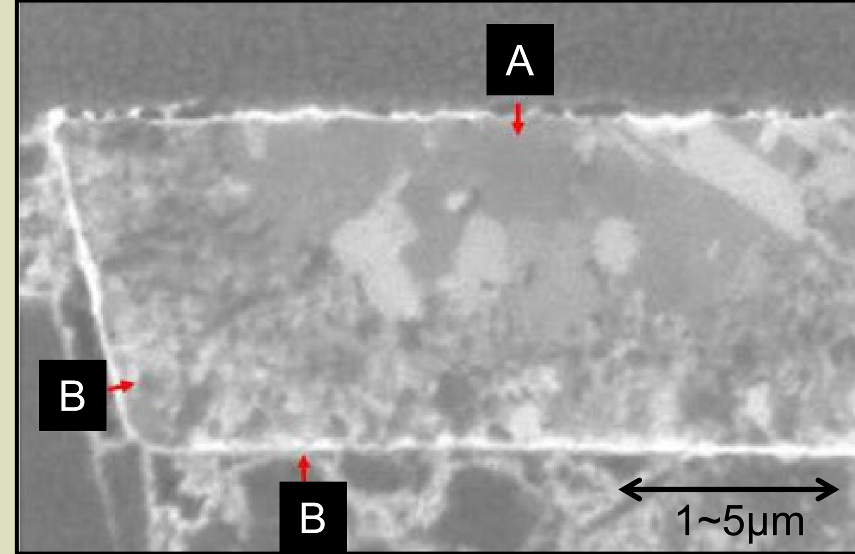
- Design and Microstructure optimization
  - Reduced stress concentration (>50%)
  - Increased lifespan (>200%)

Region	E	σ_Y	UTS
A	~100GPa	~900MPa	~1,000MPa
B	~130GPa	~1,000MPa	~1,100MPa

Patents: (KR) PD24-6562, 10-2025-0004351
(KR) PD25-6710, 10-2025-0099224
(US) PO25-1011-US







μ-Bump Contactor

- FDR
  - Force: 0.3gf @5μm
  - Resistance: 300mΩ

Force (gf)

2.0
1.5
1.0
0.5
0.0

Resistance (mΩ)

4000
3000
2000
1000
0

1㎛ 2㎛ 3㎛ 4㎛ 5㎛ 6㎛ 7㎛

#1 Fc #2 Fc #3 Fc #4 Fc #5 Fc
#1 Rc #2 Rc #3 Rc #4 Rc #5 Rc

μ-Bump Contactor

- Lifespan
  - >5,000 @10μm

0.7
0.6
0.5
0.4
0.3
0.2
0.1
0

Force (gf)

0.6 gf

0.4 gf

0
2,000
4,000
6,000

Counts

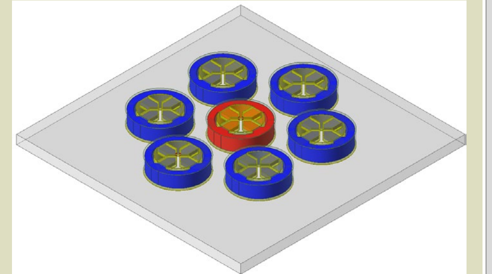
μ-Bump Contactor

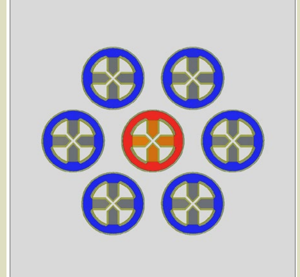
- Ball-mark
  - Area <10%

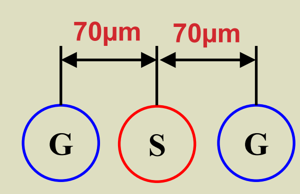
Category	Ball-mark	
	HBM μ-Bump	LPDDR5 BGA
Image		
Condition	1. μ-Bump size: 30μm 2. Stroke: 7μm 3. Contact force: 1gf	1. BGA ball size: 150μm 2. Stroke: 100μm 3. Contact force: 5gf

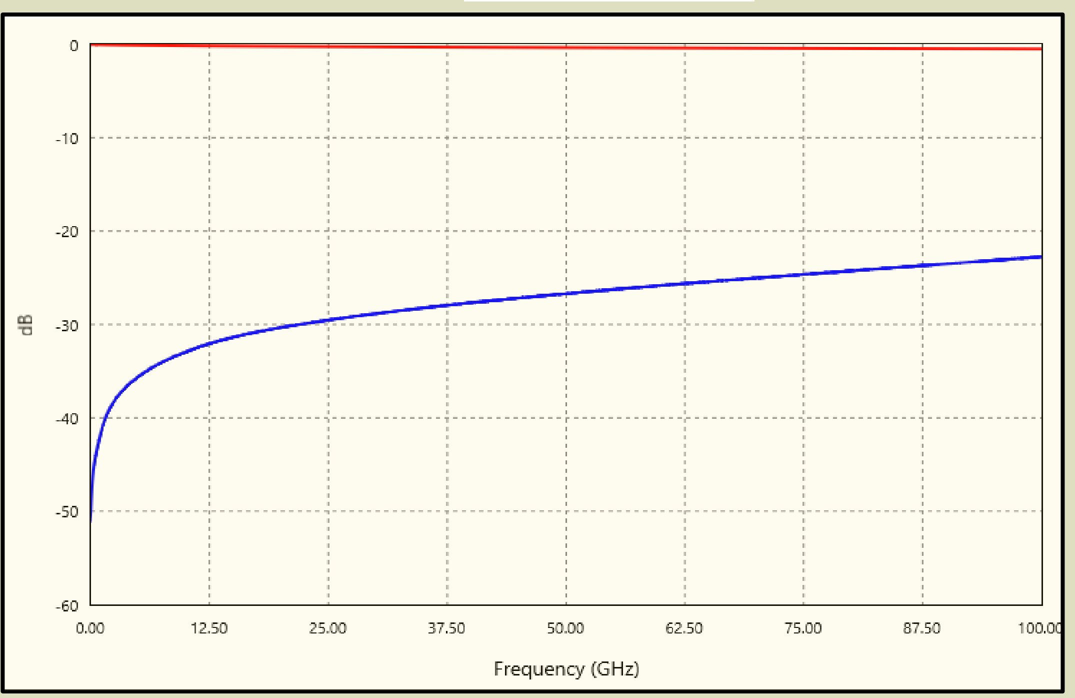
µ-Bump Contactor

- Electrical performance
  - Insertion loss: -0.5dB @100GHz
  - Return loss: -20.0dB @100GHz







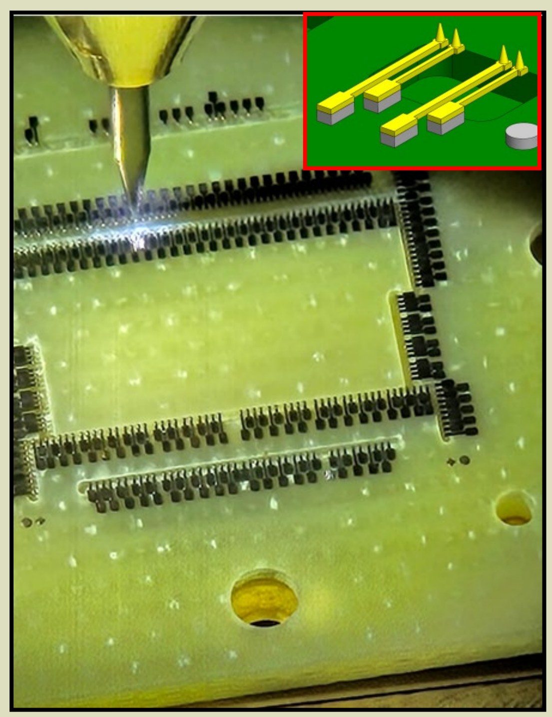


- **Simulation Results**
  - Characteristic impedance: 49.5Ω
  - Insertion loss: 100GHz >-0.5dB
  - Return loss: 100GHz >-20.0dB
  - Self inductance: 0.025nH
  - Capacitance: 0.010pF
  - Current rating: 0.200A

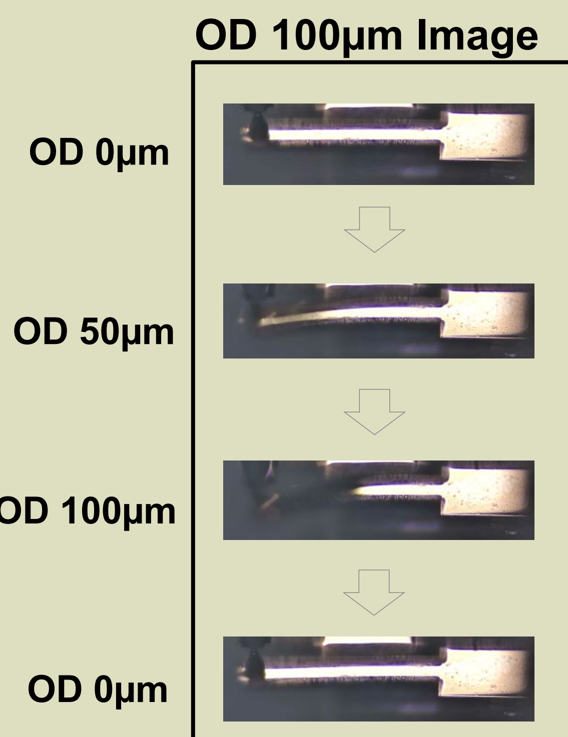
D/A Pad Contactor

- Overdrive
  - 100μm

Die Socket



OD 100μm Image



D/A Pad Contactor

- FDR
  - Force: 2gf @100μm
  - Resistance: 200mΩ

Force (gf)
5.0
4.0
3.0
2.0
1.0
0.0

Resistance (mΩ)
1000
800
600
400
200
0

5μm 10μm 15μm 20μm 25μm 30μm 35μm 40μm 45μm 50μm 55μm 60μm 65μm 70μm 75μm 80μm 85μm 90μm 95μm 100μm

Distance (μm)

Force Rc

D/A Pad Contactor

- Lifespan
  - Test conditions: Pushing material (glass) and cleaning cycle (one time)
  - >1,020k @50μm

Force (gf): 2.0, 1.6, 1.2, 0.8, 0.4, 0.0

Resistance (mΩ): 5000, 4000, 3000, 2000, 1000, 0

Replace the upper measuring tip before measuring

Clean with a nylon brush before measuring

Touch (# of times)	Force	Rc
0k	1.00	328
10k	0.99	239
20k	0.98	199
30k	0.87	127
40k	0.86	201
50k	1.00	187
60k	0.97	154
70k	1.03	162
80k	1.00	220
90k	0.93	269
100k	0.99	244
110k	0.99	150
120k	1.00	220
220k	1.00	273
320k	0.93	126
420k	0.85	134
520k	0.80	142
620k	1.01	190
720k	0.94	509
820k	0.91	560
920k	0.86	325
1020k	0.94	224

Force — Rc

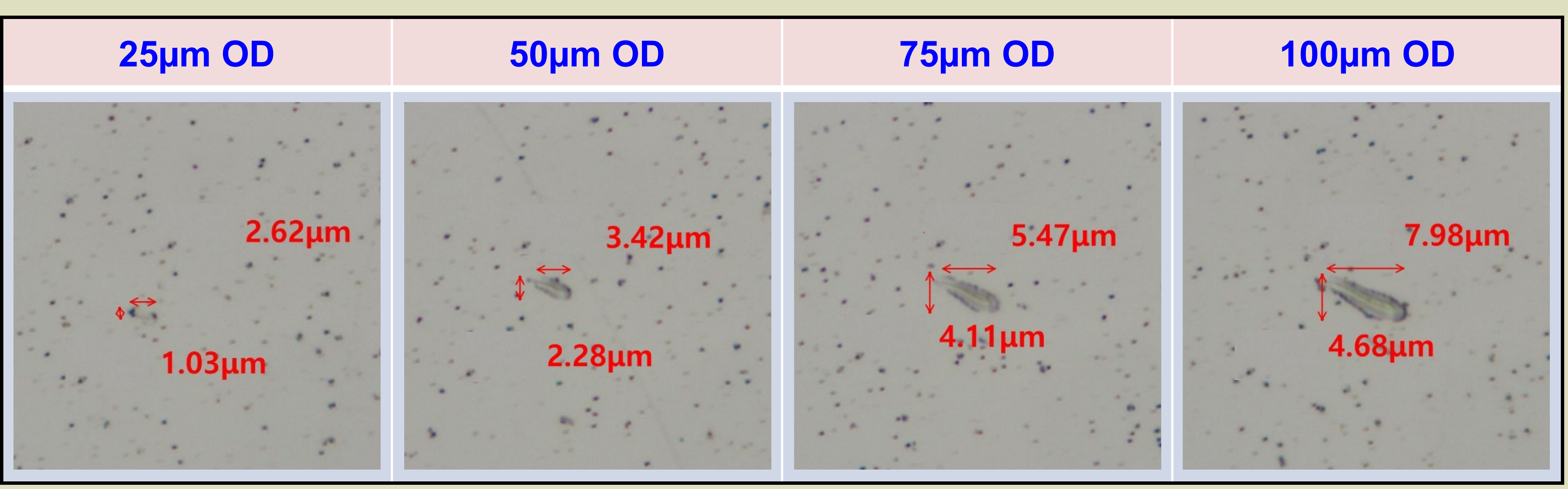
D/A Pad Contactor

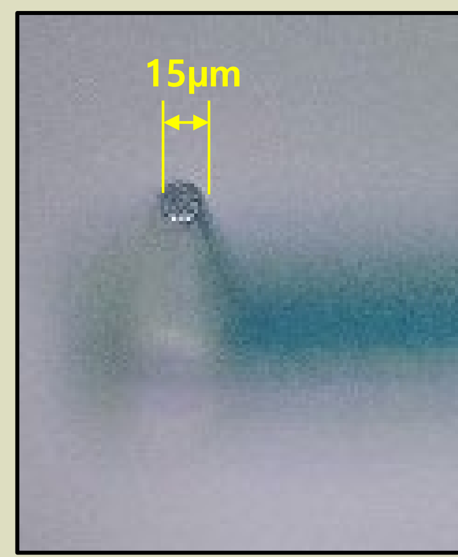
- Tip wear evaluation
  - No probe deformation @1M cycle

Step	Tip Condition	Step	Tip Condition
0k			
50k		620k	
100k		720k	
220k		820k	
320k		920k	
520k		1,020k	

D/A Pad Contactor

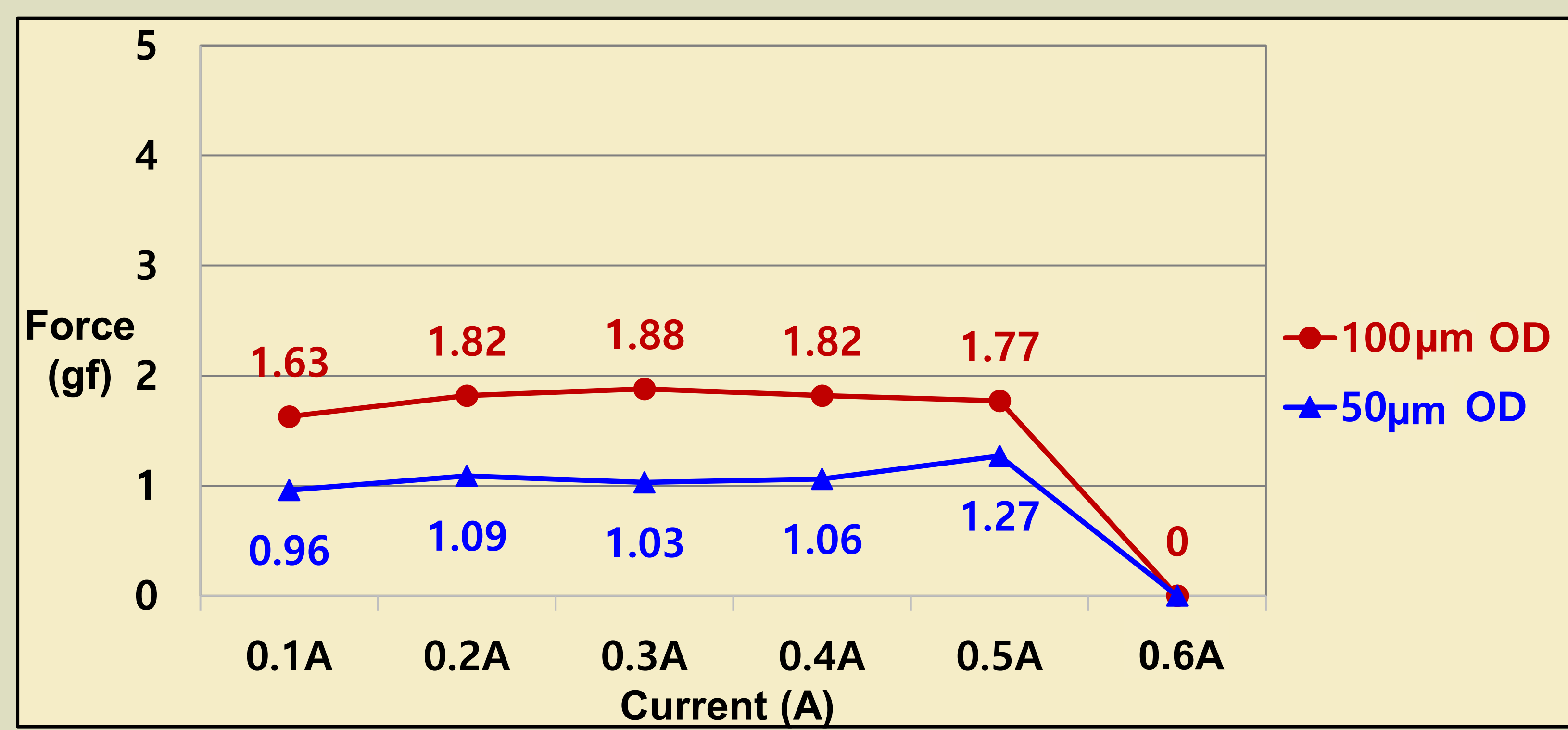
- Scrub mark
  - <10μm @100μm
    - Aluminum pad on wafer

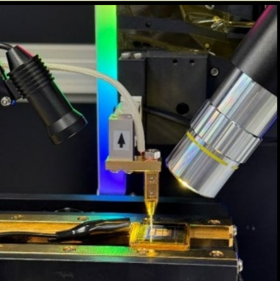


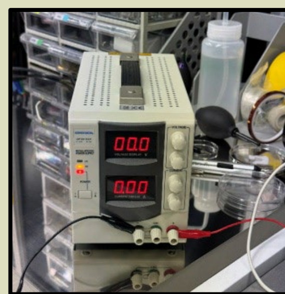


D/A Pad Contactor

- Electrical performance
  - Current spec: 500mA/pin
  - No current degradation with increasing OD







D/A Pad Contactor

- Electrical test conditions
  - OD 50μm & 100μm / 180s continuous / current applied

CCC Test @50μm

[A]	Force[gf]		Rc[mΩ]		[V]	Side View
	B	A	B	A		
0.1	1.09	0.96	645	447	0.08	
0.2	1.10	1.09	417	392	0.14	
0.3	1.04	1.03	432	462	0.23	
0.4	1.09	1.06	393	392	0.31	
0.5	1.63	1.27	388	438	0.43	
0.6	1.07	-	446	-	0.55	

CCC Test @100μm

[A]	Force[gf]		Rc[mΩ]		[V]	Side View
	B	A	B	A		
0.1	1.71	1.63	397	374	0.06	
0.2	1.86	1.82	405	423	0.12	
0.3	1.98	1.88	488	500	0.22	
0.4	1.88	1.82	372	362	0.28	
0.5	1.97	1.77	405	421	0.37	
0.6	1.76	-	440	-	0.54	

Summary

- Challenges for Next-Generation HBM Testing
  - μ-Bump increases from 16,000ea to >30,000ea (pitch 65➔<50um?)
  - D/A pad also increases from 300ea to >600ea (pitch ~100➔<60um?)
  - HBM testing requires high-frequency compatibility, minimized μ-Bump damage, long mechanical lifespan, and high temperature reliability
- **Solutions for Next-Generation HBM Testing**
  - **Development completed with proprietary electroforming technology with 3D isolated electrode process**
  - **We have proved short transmission path, controlled impedance, elastic horizontal deflection, minimized μ-Bump damage, and enhanced signal integrity at high bandwidths**
  - **The Technology has been successfully applied to Die Sockets for HBM μ-Bump and D/A pad**
  - **The Technology can be further expanded to HBM Probe Card and finer-pitch test sockets for advanced 3D packages**

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