2D MEMS Probe to Parametric Testing and Other Probe Technology

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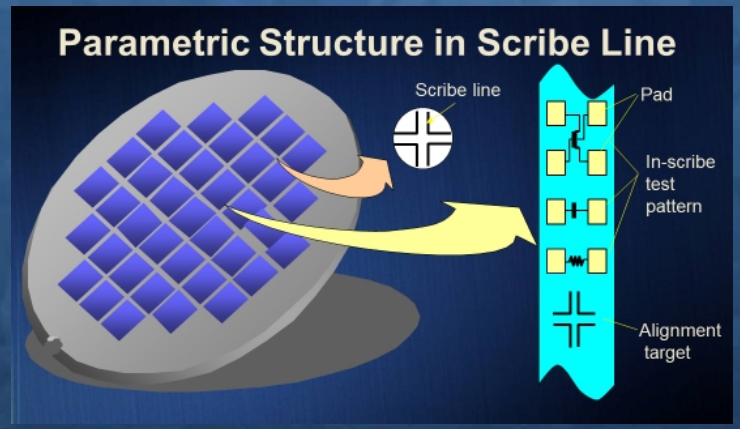
Overview

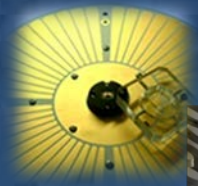
- Introduction
- History of Parametric Probe Card
- Objective
- 2D MEMS Probe to Parametric Test
- Customer Evaluation Results
- Probe Technology Comparison for Parametric Testing
- Summary

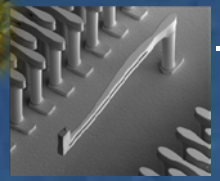
Introduction

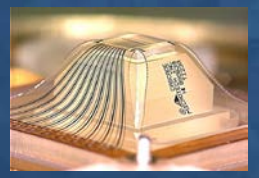
- **Parametric Testing(WAT; Wafer Acceptance Test) is unique application for probe card suppliers**
  - Basically similar and simple probe layout – 1 or 2 lines, 10 – 100 probes
  - NO device type specific test – DRAM, NAND, SoC, Logic, CIS
  - Each semiconductor company has each special requirement
  - Circuit, Test condition, Pad size, material and treatment, Sample size and etc
  - Many different Probe technologies are available by each probe card supplier
- **Formfactor also providing many probe technology**
- **Added 1 more probe technology to Parametric card – 2D-MEMS, T18**

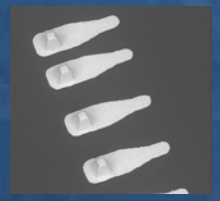


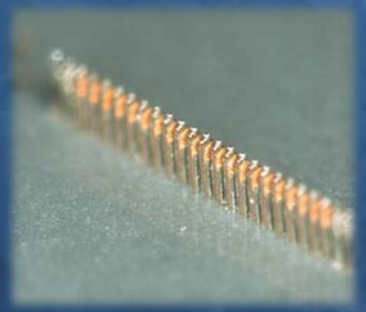
History of Parametric Probe Card

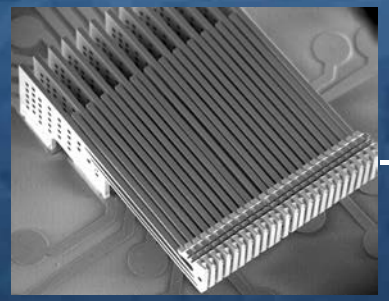












2000 2005 2010 2015 2020

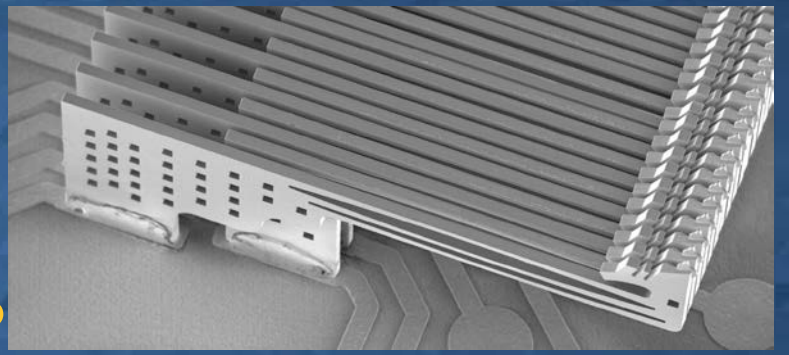
- Cantilever Needle
- 3D MEMS(Takumi T3, T11)
- Pyramid Membrane
- Vertical MEMS
- 2D MEMS – Takumi-CL

Objective

- Introducing T18, 2D-MEM Cantilever type spring under evaluation by A Semiconductor company.
- Evaluation is showing some difference from 3D-MEMS type probe
- Hopefully this presentation will be one of guidance for probe technology choice for Semiconductor company

T18, 2D-MEMS Probe to Parametric

- **Formfactor T18, 2D-MEMS Cantilever type spring was originally developed for NAND Flash probe card**
  - Take advantage from Cantilever type and Vertical type
  - Low Scrub Ratio; 4% OD with saturating
  - Less Particle generation
  - Excess Over Travel capability; 250um Max OD

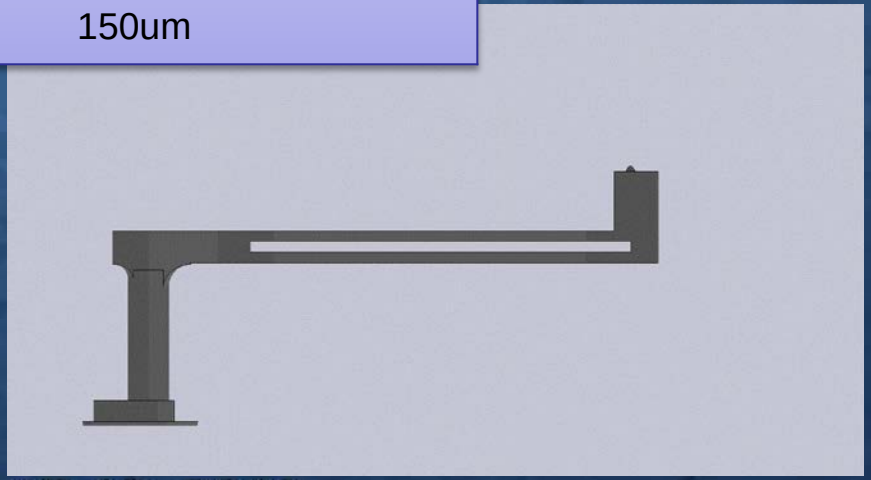


- **Potentially good for Parametric Probe Card !?**
  - Low Scrub Ratio → Stay in Small pad(<30um) with ease of use
  - Less Particle generation → Good for everybody
  - Excess OD capability → Absorb thermal Z movement with ease of use

2D-MEMS and 3D-MEMS Difference

- **2D and 3D Comparison for some important factors**

T18, 2D-MEMS	Item	T11.2, 3D-MEMS
Square Pole (10x10x >20um)	Probe Tip Shape/Size	Truncated Pyramid (6x6 ~ 25x25um)
+/-5um	Tip Placement Accuracy	+/-5um
Fixed - 35-50um	Spring Body - Width	Tapered – More Robust
PA-II	Tip Material	PA-II
4% Saturating - Smaller	Scrub Ratio	10% Linear
250um - Larger	Maximum Over Travel	150um



T18, 2D-MEMS Probe Tip

- **2D-MEMS Tip Shape maintains same tip size for life**
  - Polishing probe tips by Abrasive cleaning will not change the tip X&Y size

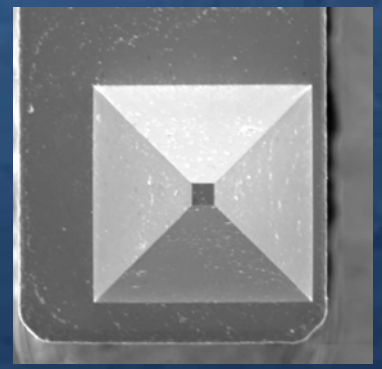
Angled View
- T18, 2D

Side View
-T18, 2D

- **T11, 3D-MEMS Pyramid Shape**
  - 6x6um tip size increases by tip wear and abrasive cleaning
  - Scrub mark size also increases
  - # Recent ITS Waffle cleaning maintains tip size small

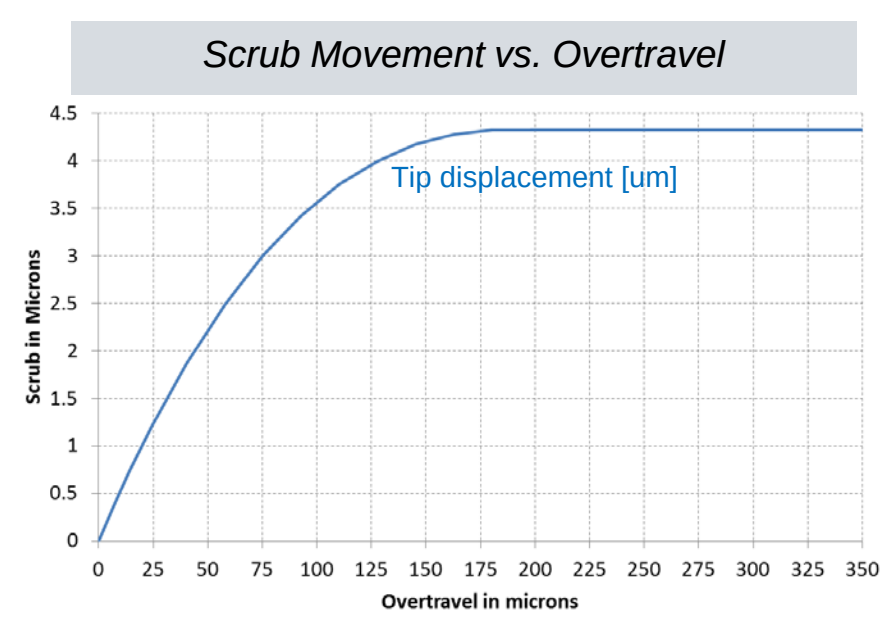
by aggressive cleaning and rounding tip

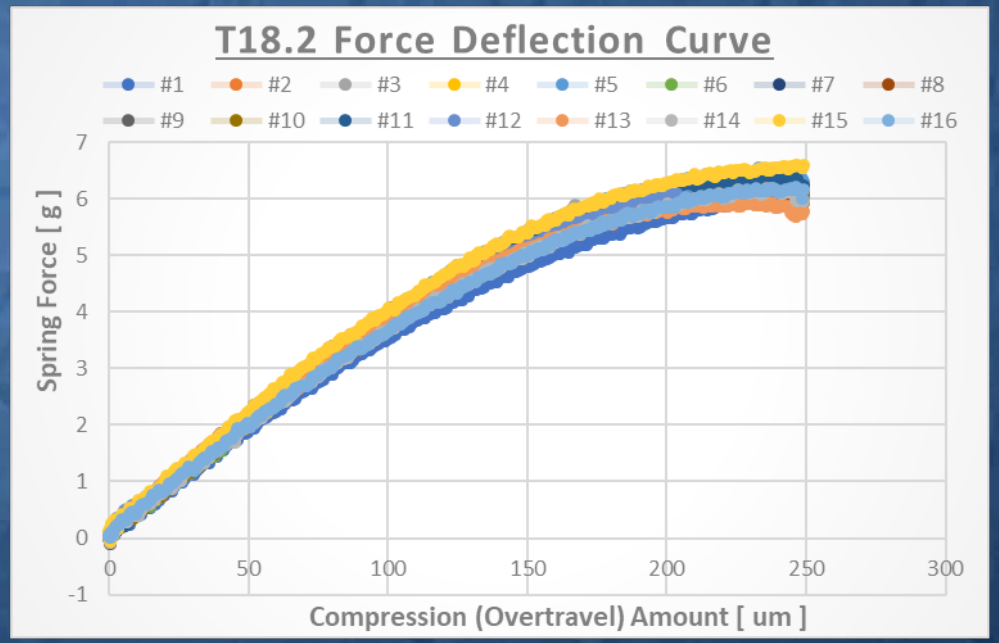
Top View
– T11, 3D



T18, 2D-MEMS Scrub Ratio and Force

- **Scrub Ratio; ~4% with decreasing at high OD**
- **Spring constant(K-value); 0.6 – 0.8[g/mil] decreasing at high OD**



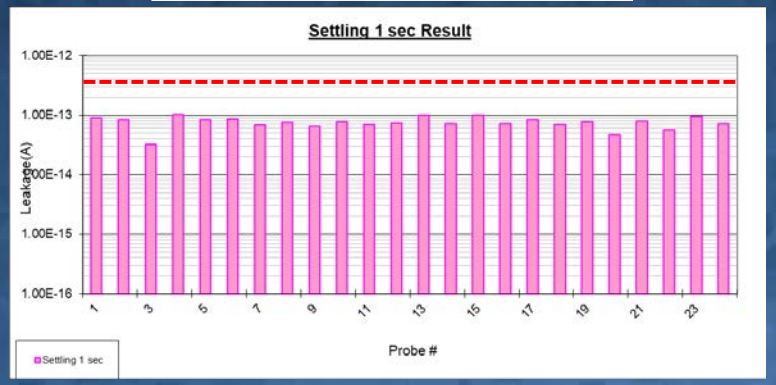


T18, 2D-MEMS – Low Electrical Leakage

Experimental Procedure

Tester; Agilent 4156C
Measured voltage: 10V (100V)
Temperature: 23+/-5C
Humidity: 50+/-10%
Measurement pin count: 48 ch
Measurement setting time: 1sec, 10sec

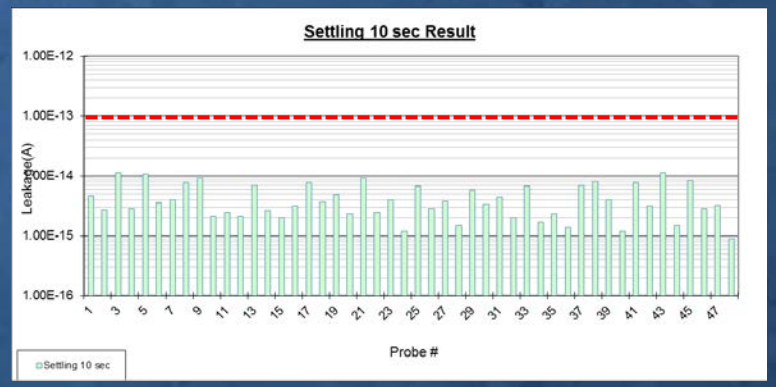
3D-MEMS, T11 - Takumi



<250fA @ 1 sec settling

<100fA @ 10 sec settling

2D-MEMS, T18 - Takumi-CL

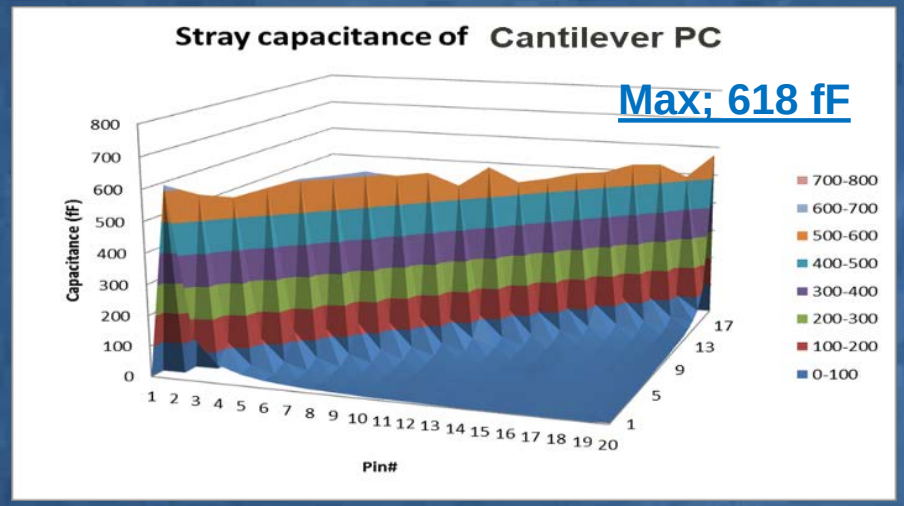


- **2D-MEMS & 3D-MEMS probe card both showed equivalent low electrical leakage performance**
- **MEMS type leakage performance rely on substrate and PCB, which requires experienced design and material selection**

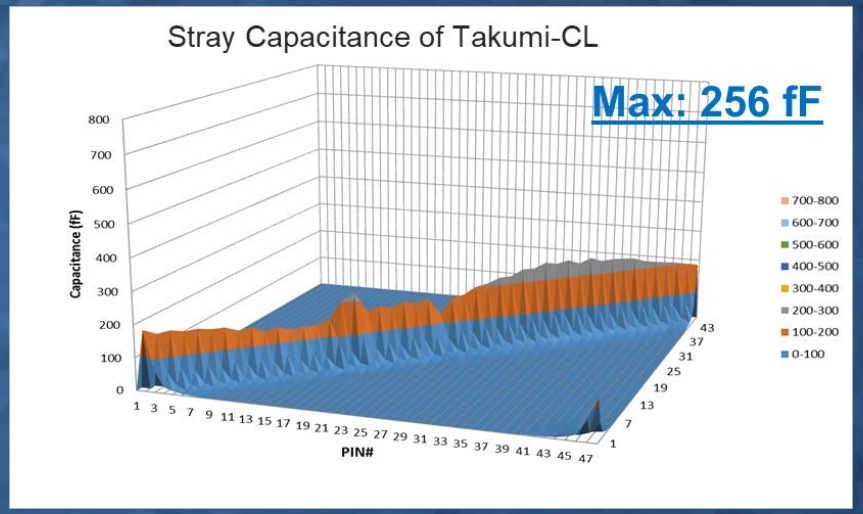
T18, 2D-MEMS – Low Parasitic(Stray) Capacitance

Tester; Agilent E4980A
Measured voltage: 1V
Measurement frequency: 1MHz
Temperature: 23+/-5C
Humidity: 50+/-10%
Measurement pin count: 48 ch

Typical Cantilever Probe Card



2D-MEMS, T18
Takumi-CL



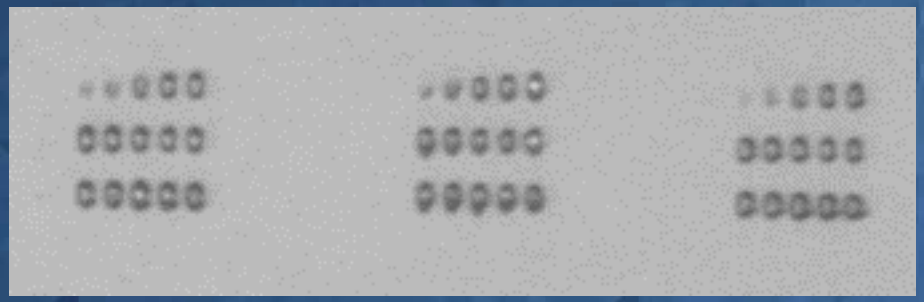
- **2D-MEMS probe card showed low stray capacitance equivalent with 3D-MEMS type**
- **Careful Substrate design and material selection are important to utilize MEMS stable mechanical performance and realize consistent electrical performance.**

Customer Evaluation Results

- A semiconductor company has been evaluating T18 probe card with actual wafers
- Important to evaluate the actual Scrub mark size and Electrical Contact performance with actual wafer, which varies with pad metallization condition

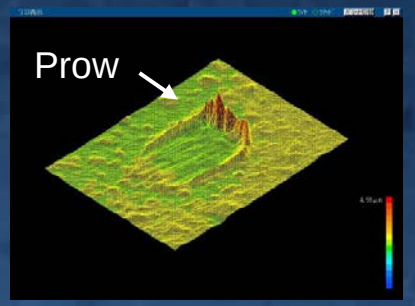
Customer Evaluation Results
– Scrub Mark Size, T18, 2D-MEMS

- **Scrub Mark Size saturated on actual customer wafer also**
  - Saturated Scrub Mark Size; 8 x 13um (NSxS direction)



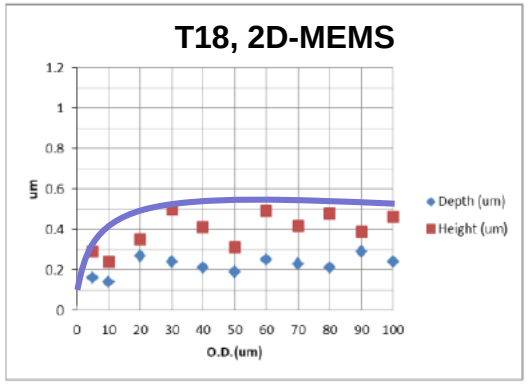
OD (um)				
10	20	30	40	50
100	90	80	70	60
110	120	130	140	150

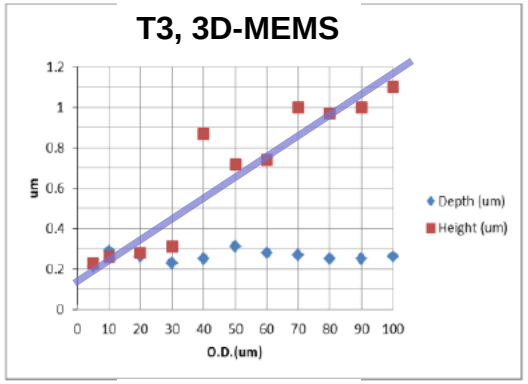
Customer Evaluation Results – Scrub Mark – Depth & Prow Height

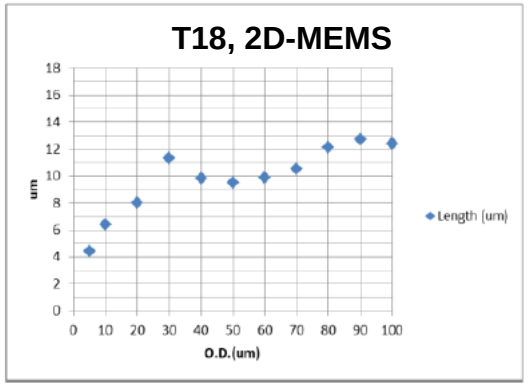


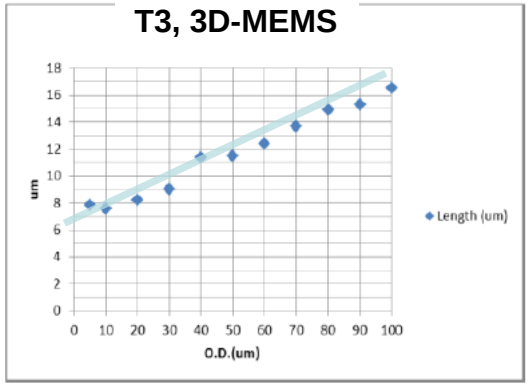
- **Customer Special Requirement: Prow Height**

Needle mark









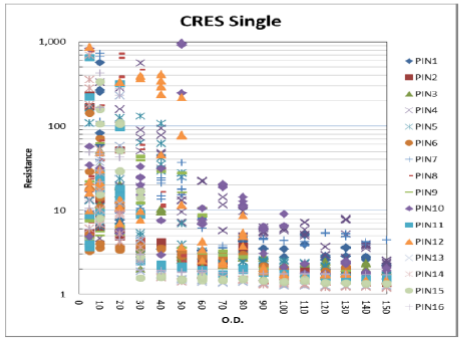
- **Due to following process, Prow height limitation required**
  - T3 type 3D-MEMS showing proportional increase
  - T18 type, 2D-MEMS showing saturated prow height and passed customer criteria

Customer Evaluation Results
– CRES vs. OD Performance

- **Production Overtravel amount was set with 100um with margin**
- **Evaluation continues**

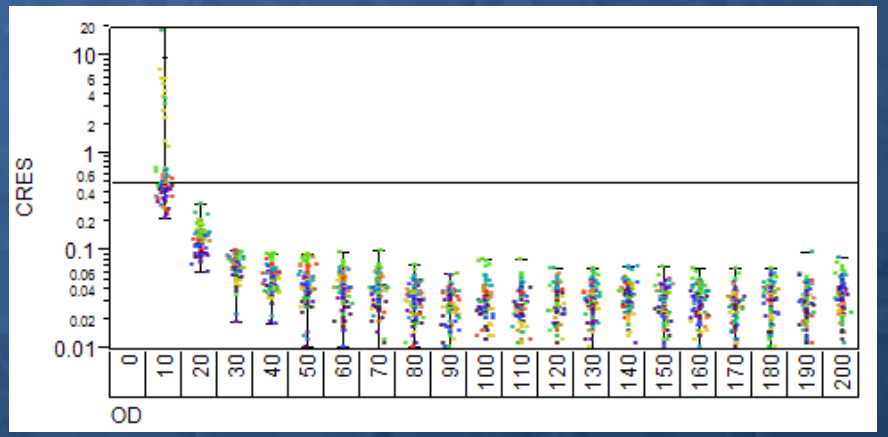
Customer Data

CRES



Takumi-A option3 O.D. spited C-res data.

- Stable C-res looks stable above 90um O.D. in this evaluation.
- We choice 100um O.D. temporary standard.
- Spring force will increase 2.2g to 3.8g (about 40%)



CRES[Ohms] vs. OD[um]
Stable after 90um Overtravel
CRES + Path Registance

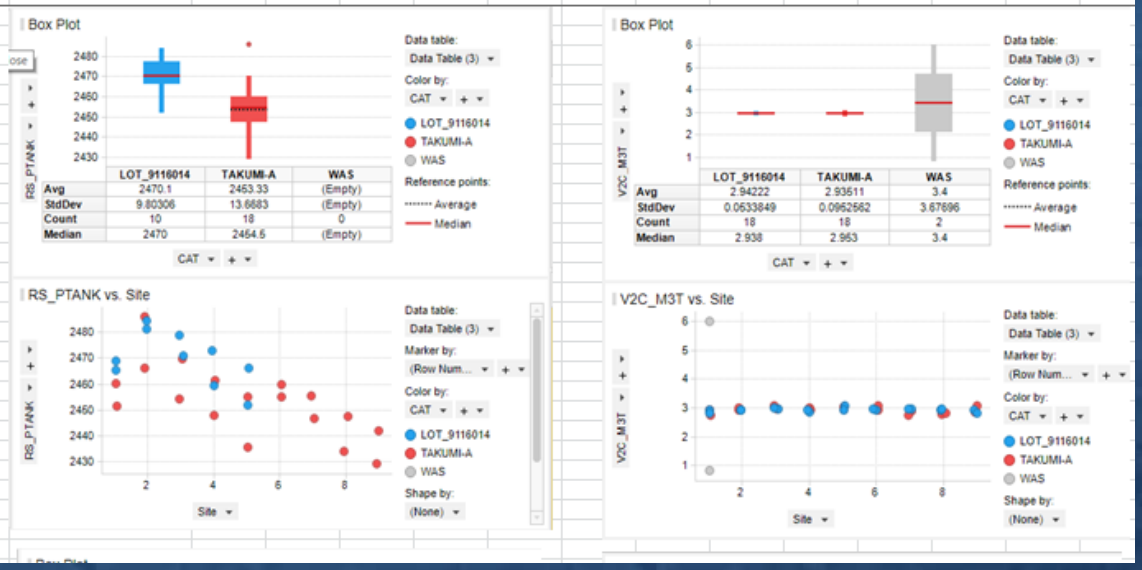
CRES[Ohms] vs. OD[um]
FFI Internal Measurement

Customer Evaluation Results
– Electrical Data Correlation #1

- **Data Correlation between Cantilever card and T18 card performed with +/-2.5% difference specification on 110 items**

Parameter Name			Sameness1	Summary
Example A	Link to SFC	Green	94	94
Example B		Yellow	8	8
Example C		Red	8	8

Parameter Nar	Baseline Mea	Baseline Std	Split Mean	Split Std	Sameness		ABS(DEL%)
37P_VTLS	-0.7	0.01	-0.7	0.01	100.03%	0	0.0%
X12N_VTL	0.57	0.01	0.57	0.01	100.03%	0	0.0%
X20P_VTL	-0.65	0.01	-0.65	0.01	100.03%	0	0.0%
X29N_VTL	0.59	0.01	0.59	0.01	100.03%	0	0.0%
X30P_VTL	-0.55	0.01	-0.55	0.01	100.03%	0	0.0%
X33N_VTL	1.51	0.01	1.51	0.01	100.03%	0	0.0%
X40P_VTL	-0.55	0.01	-0.55	0.01	100.03%	0	0.0%
JZEN_BV	6.34	0.01	6.34	0.01	100.03%	0	0.0%
RS_NBL	49.92	1.72	50.39	1.64	100.06%	0	0.9%
NV_BVBSS	-21.95	0.16	-21.82	0.12	100.12%	0	0.6%
RS_M23RP	92.55	1.97	93.25	1.76	100.14%	1	0.8%
RS_PTHSR	304.83	0.62	304.94	0.57	100.17%	0	0.0%
S3P_BVDW	-8.1	0.11	-8.12	0.1	100.18%	#	0.2%
S7PABVDS	-13.1	0.11	-13.12	0.1	100.18%	#	0.2%
V2K_M3T	2.72	0.17	2.67	0.15	100.18%	#	1.9%
EP_IDET	39.08	1.33	38.88	1.21	100.19%	#	0.5%
S3NIBIDS	20.76	0.24	20.63	0.19	100.21%	#	0.6%
OC_PMOAT	10.44	0.45	10.54	0.39	100.22%	0	0.9%
NV_HFE_M	61.91	1.81	61.61	1.58	100.23%	#	0.5%
NV_BVEBO	17.15	0.07	17.1	0.05	100.23%	#	0.3%
NV_BVGEO	10.28	0.16	10.3	0.14	100.23%	0	0.2%
S7PAIONS	-238.05	1.79	-237.35	1.42	100.25%	1	0.3%
NV_BVECS	17.13	0.06	17.12	0.05	100.26%	#	0.1%
GC_NMOAT	10.49	0.29	10.47	0.24	100.27%	#	0.2%
V1K_NOM	4.08	0.16	4.1	0.13	100.27%	0	0.5%
X20N_ION	338.85	0.91	339.46	0.6	100.28%	1	0.2%
PS_HFE_M	21.08	0.52	21.03	0.41	100.29%	#	0.2%
X39N_ION	282.36	5.83	282.25	4.37	100.29%	#	0.0%



Customer Evaluation Results
– Electrical Data Correlation #2

- 16/110 items showed >2.5% spec. And customer confirmed all of 16 items are caused by other testing root causes.
- And passed the correlation test.

Takumi-A electrical part update

Result

-Compared the CRES between released cards.
Slightly shift between Cantilever and Takumi/Takumi-A.
The cause is as a shift from the difference in contact area.
Cantilever : 0.26 ~ 0.28 Ω
Takumi : 1.03 ~1.30 Ω
Takumi-A : 1.11 ~ 1,35 Ω

-Compared the sameness by totally 110 items.(*WAS only)
Did not found abnormal matter by Card issue. @R/Y color.

	Sameness1	Summary
Green	94	94
Yellow	8	8
Red	8	8

3

- "CRES" this case means "(CRES)+(Path Resistance)x2Ch value

Parametric Probe Card Comparison

		Cantilever Needle	3D MEMS - T11	Pyramid Memblene	Vertical MEMS	2D-MEMS, T18
Mechanical Characteristics	Pad Pitch	>50um	>50um	>50um	>74um	>70um
	Layout Capability - 2 Row	40um	60um	60um	74um	70um
	Probe Tip Size	10x10	4x4	8x8um	10x10um	10x10um
	Tip size growth by tip wear	Yes	Yes	Yes	No	No
	Probe Tip Placement Accuracy - X & Y	+/-5um	+/-5um	+/-5um	+/8.5um	+/-5um
	Scrub Ratio (% to OD)	Long	Midium	Short	Short	Short
	Accuracy durability	+/-10um	+/-5um	+/-5um	+/-8.5um	+/-5um
	Pad Size - Production level	>50x50um	>25x25um	>30x30um	>30x30um	>30x30um
Electrical Characteristics	Leakage Performance	Moderate - Low	Low	Moderate	Moderate	Low
	Path Resistance	Low	Midium	Middium	Midium	Midium
	Contact Stability	Moderate	High	High	Moderate	High
Special Require ment	RF	Moderate	Moderate	-3dB@40GHz	Moderate	Moderate
	Bump wafer parametric	Capable	Height Limit	NA	Capable	Height Limit
Utilization	Life Time	Moderte	Long	Moderate	Moderate	Moderate
	Probe Insert Replaceable	Some	Yes	Yes	Yes	Option
	Unit Cost	Low	Moderate	Moderate	Moderate	Moderate
	NRE Cost	None	Moderate	Moderate	Moderate	Moderate
	New desgin Lead Time	Short	Moderate	Moderate	Moderate	Moderate

- **Each Probe Technology has each strength and weakness**

Consideration and Next Step

- T18, 2D-MEMS evaluation with A Customer showed a special benefit, Low prow height
- Continuing customer qualification to optimize the utilization and look for other benefits for customer satisfaction
- Depends on priority, one of characteristics will fit on all Semiconductor company.
- Will accumulate the experience to find out the fastest way