



SWTEST

PROBE TODAY, FOR TOMORROW

2023 CONFERENCE

Advanced MEMS Probe Cards for Inline Process Control Monitoring (PCM) & End-of-Line Wafer Acceptance Tests (WAT)



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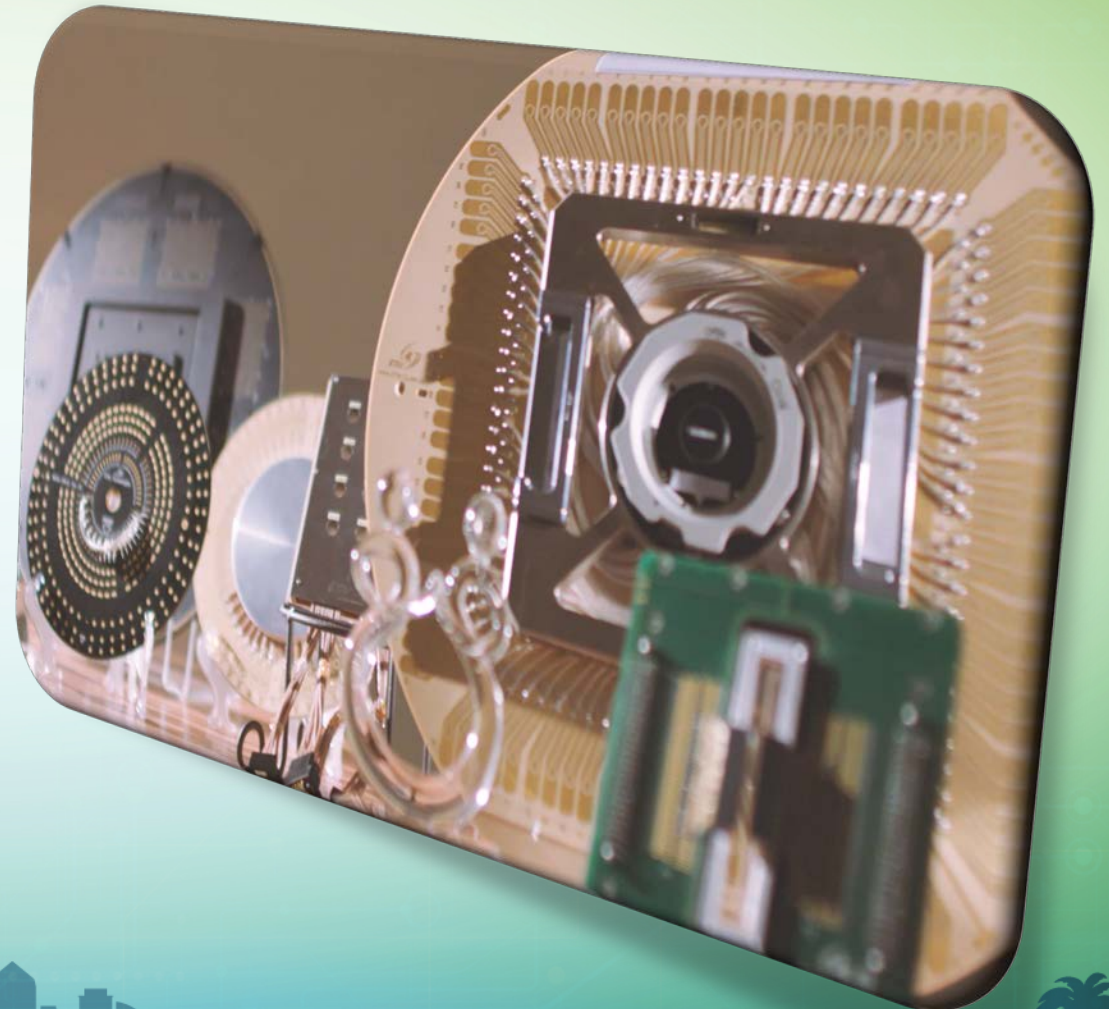
Ting TSENG

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June 5 - 7, 2023

Outline

- Introduction / Background
- Objectives / Goals
- PCM/WAT MEMS Probes & Probe Cards
- Prima MEMS Probe Card Specifications
- Prima-LM PCM MEMS Probe Card Metrology & Performance
- Prima-EM WAT MEMS Probe Card Electrical Tests & Lifetime
- Conclusion → STAr Frontiers



Introduction / Background

- **Advanced CMOS technology nodes down to 3nm & beyond**
 - Increasingly complex processes
 - Extreme process control needs
 - Intertwining yield impact factors
 - Ultra-high wafer cost
- **Escalating demands for advanced PCM & WAT probe cards**
 - “ZERO” variations from pin-to-pin and card-to-card
 - “NO” yield impact after inline process control monitoring tests
 - Maximum throughput and lifetime for wafer-acceptance-tests

Objectives / Goals

● Objectives

- New generation MEMS probes for inline PCM & end-of-line WAT/WLR (wafer-level reliability)
 - Very stable and consistent low contact resistance
 - Very stable and minimal pin-to-pin parasitic capacitance
 - Extremely low pad damage

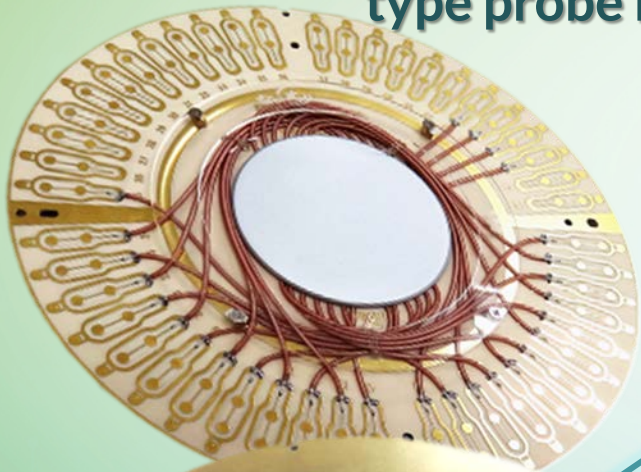
● Goals / Targets

- Minimum pitch of 40um or smaller and pad size at 25um.sq
- Low-CRES with low contact force and small probe overdrive
- Low and consistent parasitic resistance and capacitance (possibly with new probe configuration or test methodologies)

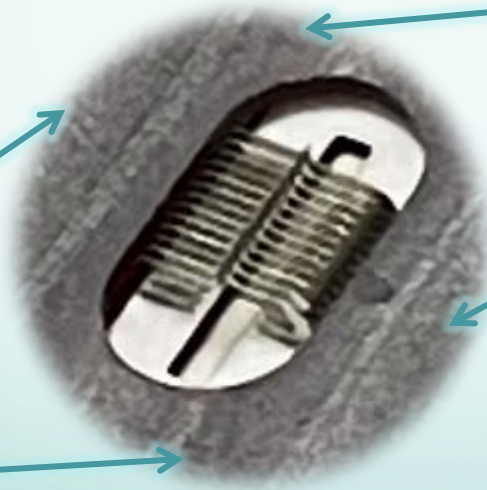
PCM/WAT MEMS Probe & Probe Card

- Keysight 4080 series tester
WAT probe card with fixed
type probe head

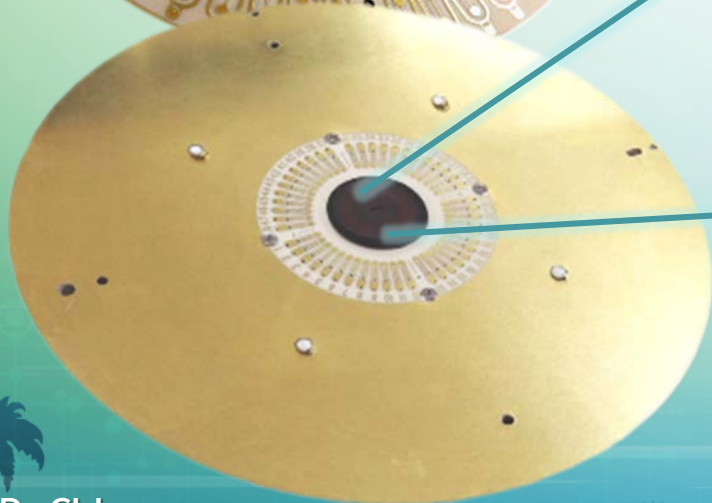
- Keysight P9000 / Advantest 93K WAT
probe card with replaceable probe
head



VIRGO-PRIMA



**MEMS Probe Head
(micro-cantilever)**



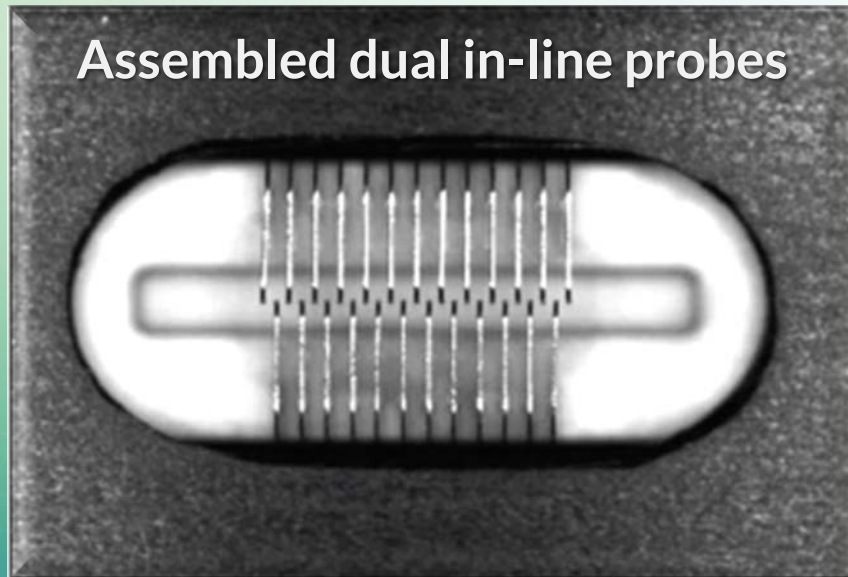
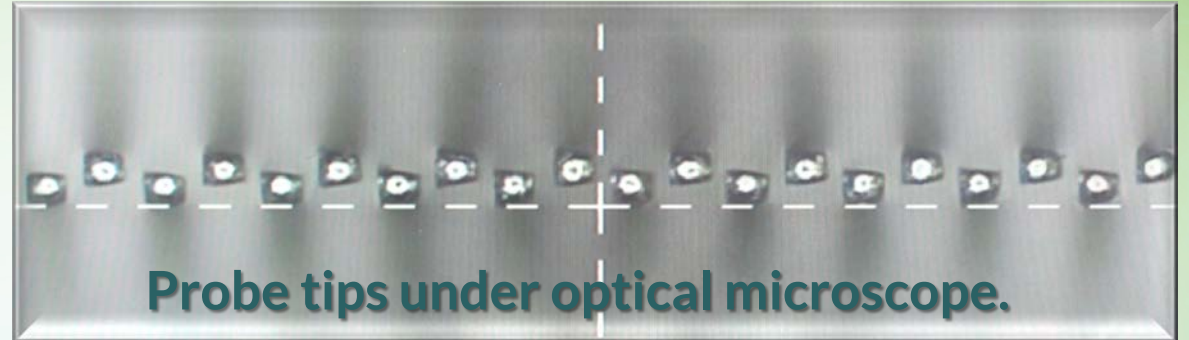
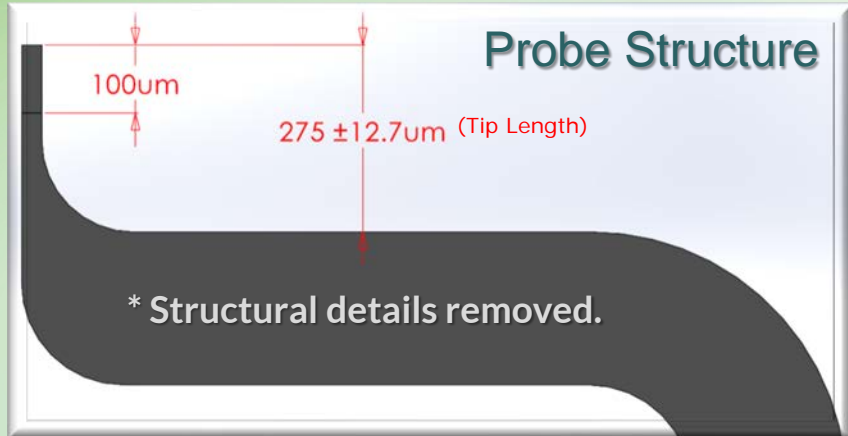
Virgo-Prima MEMS Probe Card Specifications

	type EM (WAT)	type LM (PCM)
Probe Material	CuG-Rh super-alloy	Pd-Pt-Cu super-alloy
Probe Thickness	28um	30um
Force (ref.)	1.0gf/mil \pm 10% @ rec. OD	0.65gf/mil \pm 20% @ rec. OD
Overdrive	rec.: >25um rng.: 15um ~ 75um max.: 100 um	rec.: >35um rng.: 25um ~ 50um max.: 75 um
Pad Pitch (min.)	In-line: 45um Dual In-line: 38um	In-line: 50um Dual In-line: 40um
Pad Size (min.)	25um.sq	25um.sq
Alignment	std.: \pm 5um / min.: \pm 2um	std.: \pm 5um / min.: \pm 2um
Planarity	std.: < 10um / min.: < 5um	std.: < 10um / min.: < 5um
Contact Resistance	< 100m Ω	< 300m Ω
Leakage Current	std.: < 1.0pA @ 10V (100fA/V) opt-LL: < 0.3pA @ 10V (30fA/V)	std.: < 1.0pA @ 10V (100fA/V) opt-LL: < 0.3pA @ 10V (30fA/V)
Parasitic Capacitance	< 0.5pF (probe-to-probe)	< 0.5pF (probe-to-probe)
Operation Temperature	std.: ambient ~ 100°C opt.-HT: -40°C ~ 150°C opt.-UT: -40°C ~ 200°C	std.: ambient ~ 100°C opt.-HT: -40°C ~ 150°C

- **type EM (WAT)**
 - Copper-Graphene + Rhodium super-alloy sandwiched probes
 - Long Lifetime
- **type LM (PCM)**
 - Palladium-based super-alloy
 - Soft contact with Low contact force

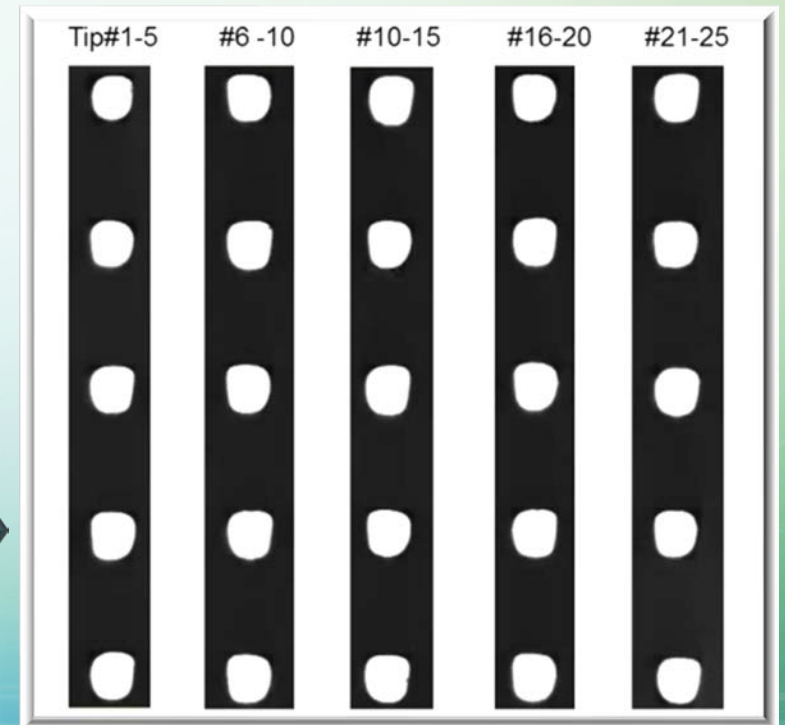
* Subject to change without notice

Prima-LM PCM MEMS Probe Metrology



Clear probe image viewed & identified by probe station microscope.

→ Easy & accurate alignment.



Prima-LM PCM MEMS Probe Evaluation

OD	0um	25um	50um	75um	100um	125um
Scrub Mark						
Scrub Profile						
X (um)	10	10	10.1	10.1	10.2	10.3
Y (um)	5.48	9.53	15.24	20.06	20.8	22.5
H (um)	0.188	0.38	0.724	1.49	1.98	2.97
D (um)	0.094	0.287	0.404	0.515	0.728	1.072

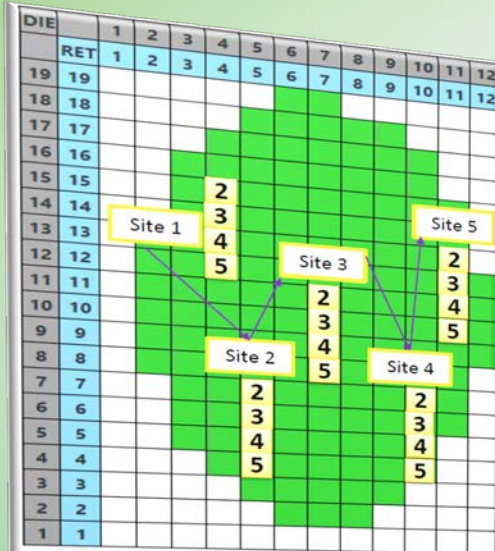
- **Well controlled probe marks with predictable topography**

- Good, stable and repeatable data at low overdrive (Cres with extremely low variations)
- Low overdrive probing → less cleaning → longer lifetime 😊

PS: Contact on Aluminum pad wafer

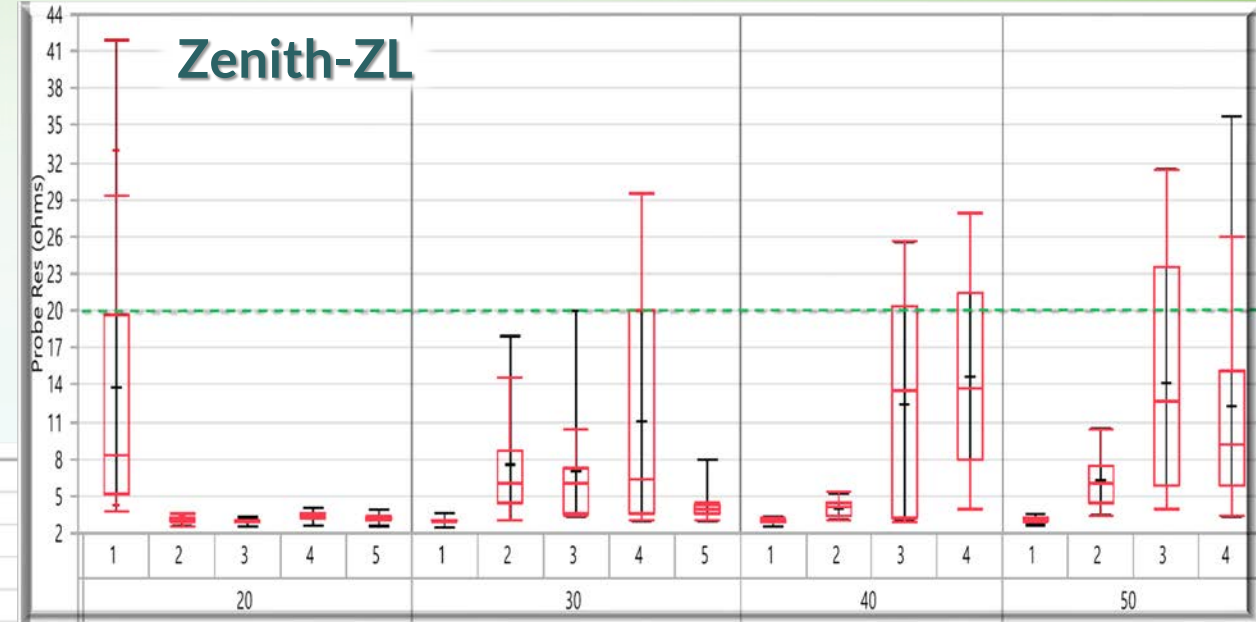
Prima-LM PCM E-tests (Res.) Qualification

Wafer Site Test Map

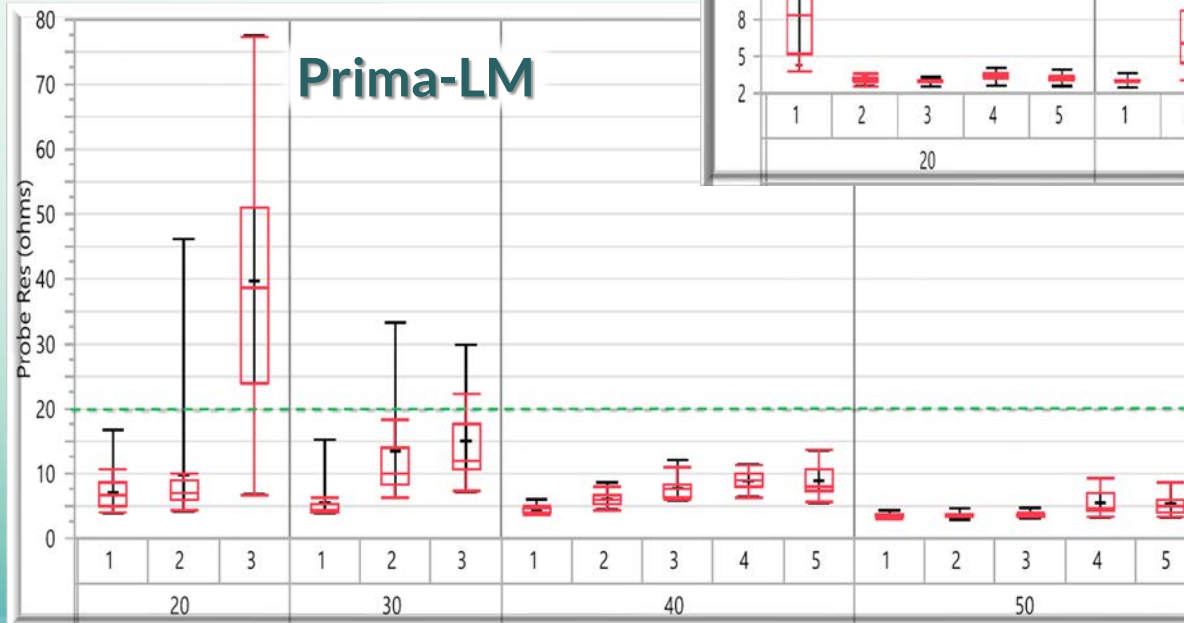


Zenith-ZL

- Vertical probe cards with no scrub, contaminations on tip after first contact.
- Unstable contact over time for Cres at PCM test. → probe card cleaning.



Prima-LM



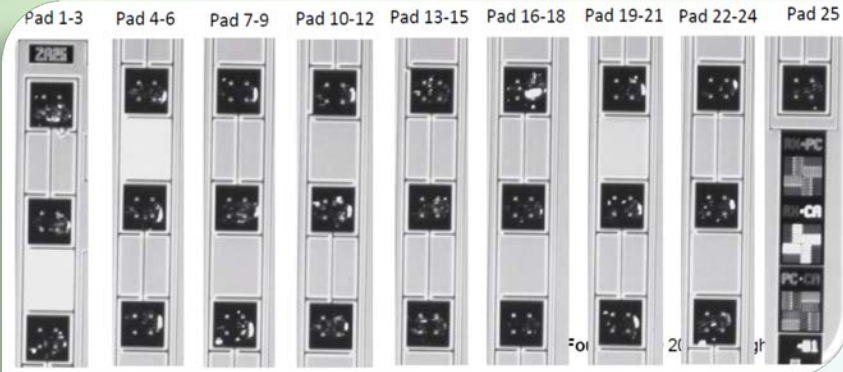
Prima-LM

- Contact resistance with good results from 40um.
- Very low scrub mark resulting in good data consistency.
- Less cleaning required.

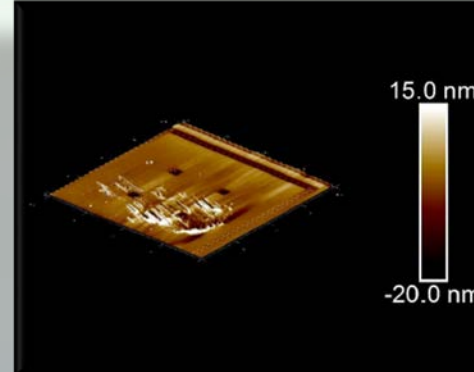
PCM MEMS Probe Tests Pad Damages

Zenith-ZL
Vertical Probes

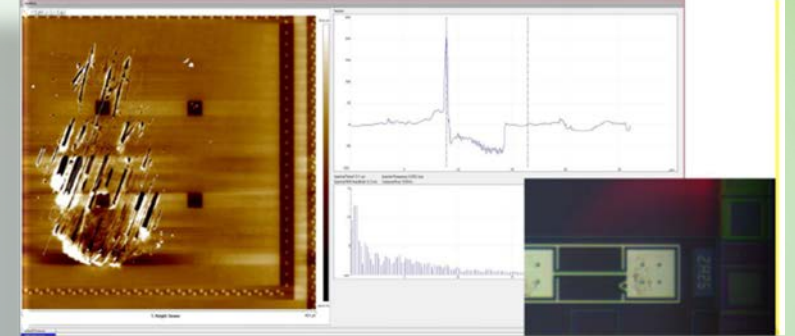
Prober Dark-Field View



3D-Scan View



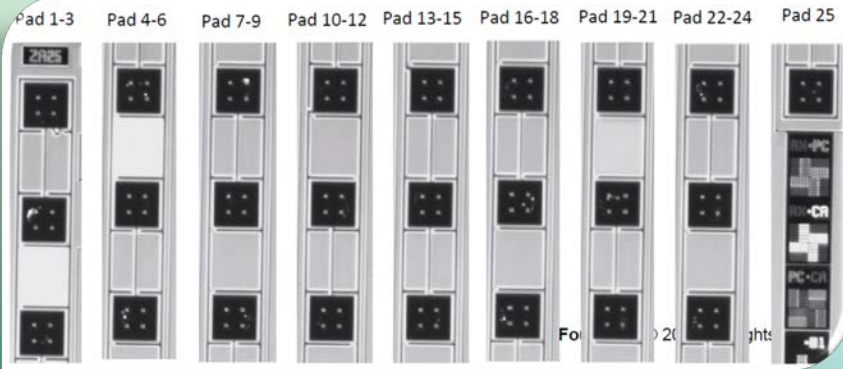
Probe-Mark Profile



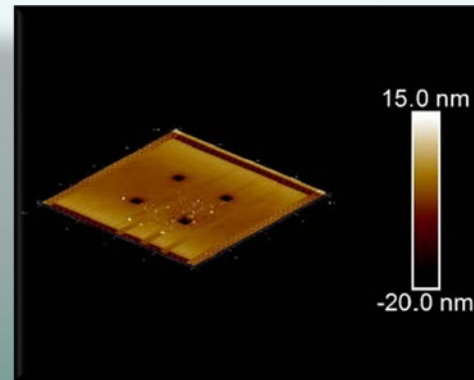
Height: 208nm Depth: 69nm

Prima-LM
MEMS Probes

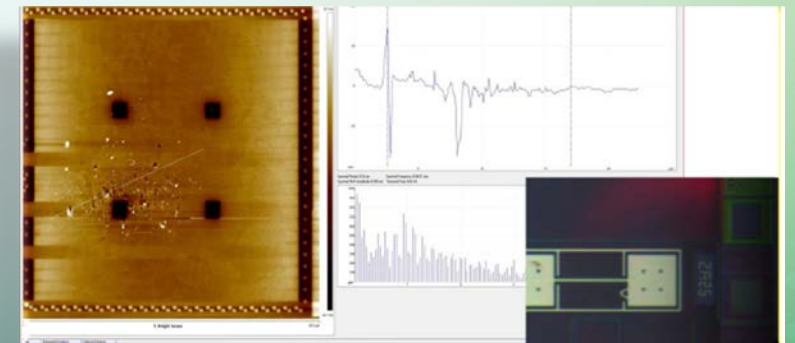
Prober Dark-Field View



3D-Scan View



Probe-Mark Profile

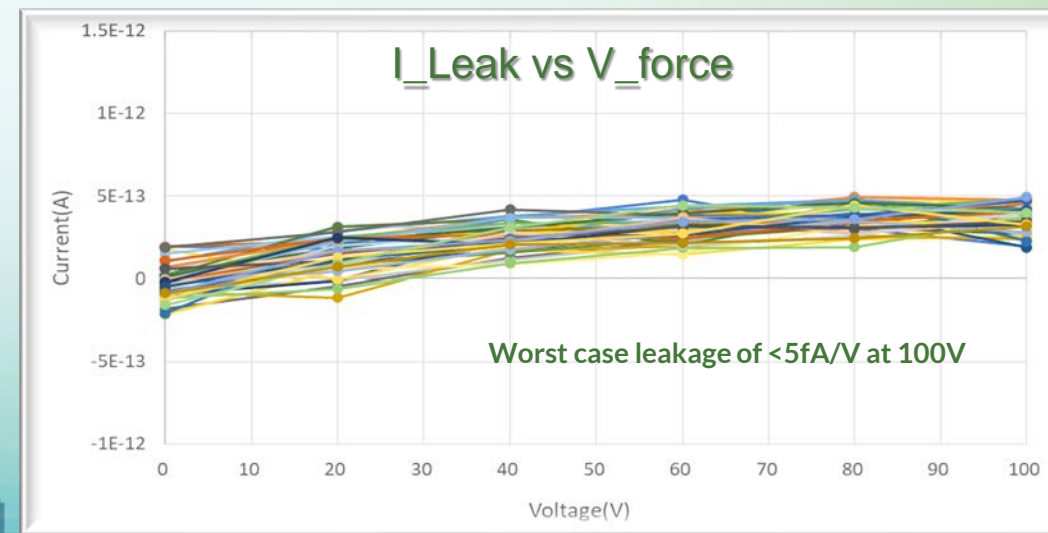
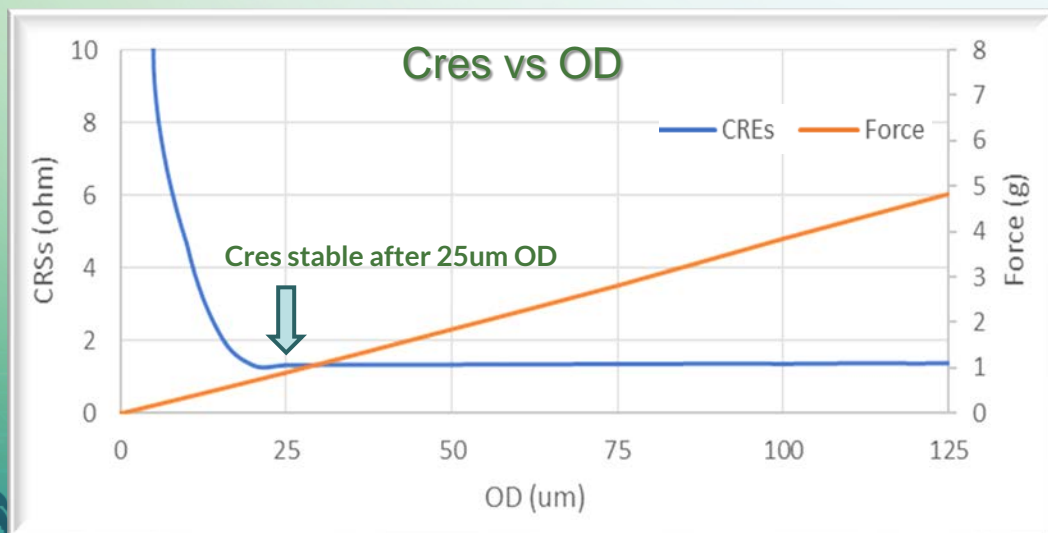
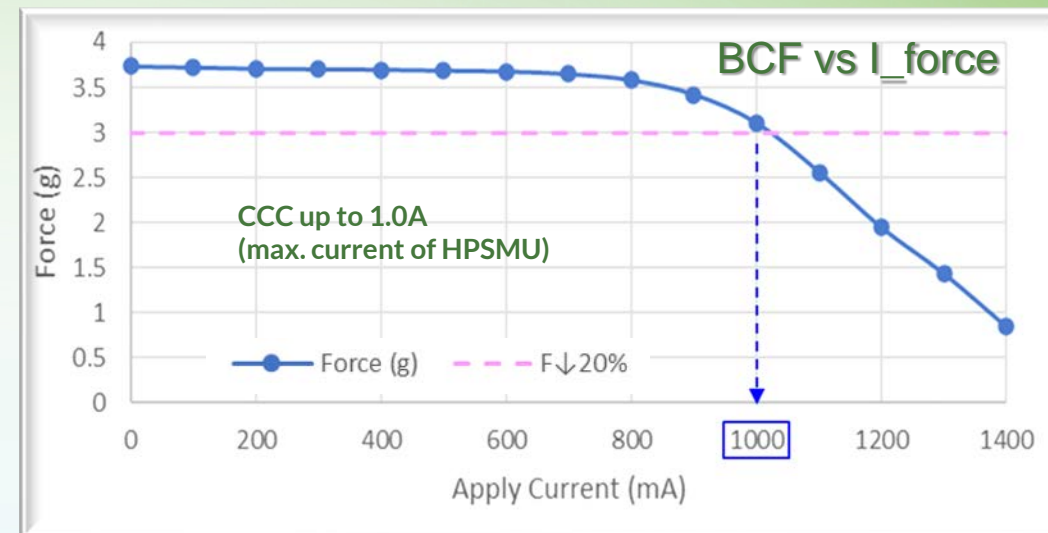
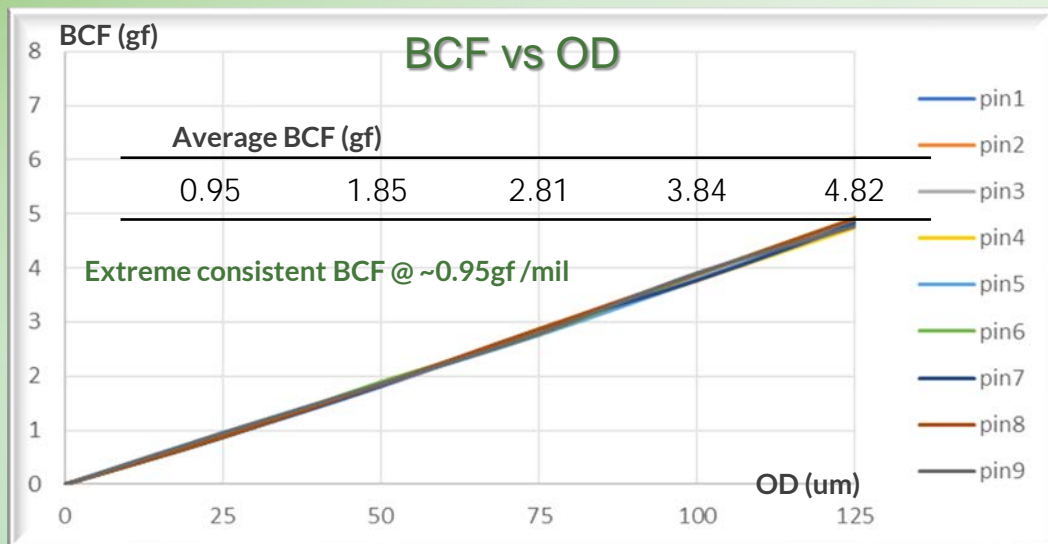


Height: 39nm Depth: 17nm

PS: Contact on Copper pad wafer

Spec: Height <100nm

Prima-EM WAT MEMS Probe Qualification



Prima-EM WAT E-tests (Cap.) Qualification

Probe Tip Alignment $\leq \pm 2\mu\text{m}$

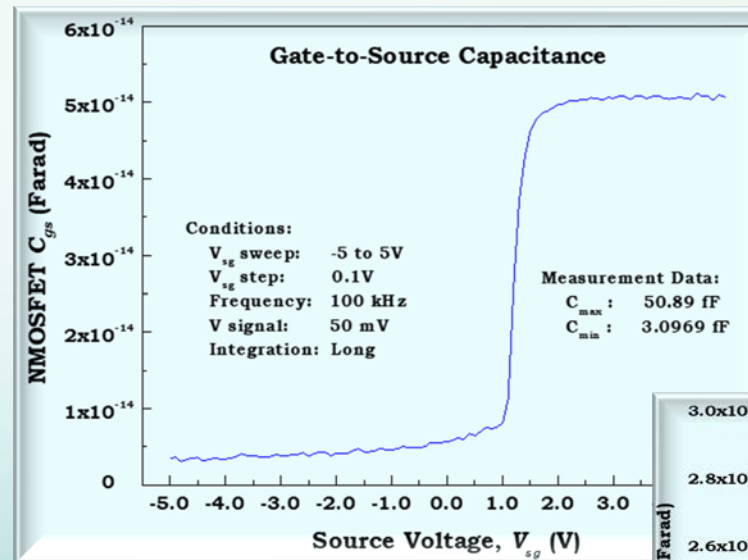
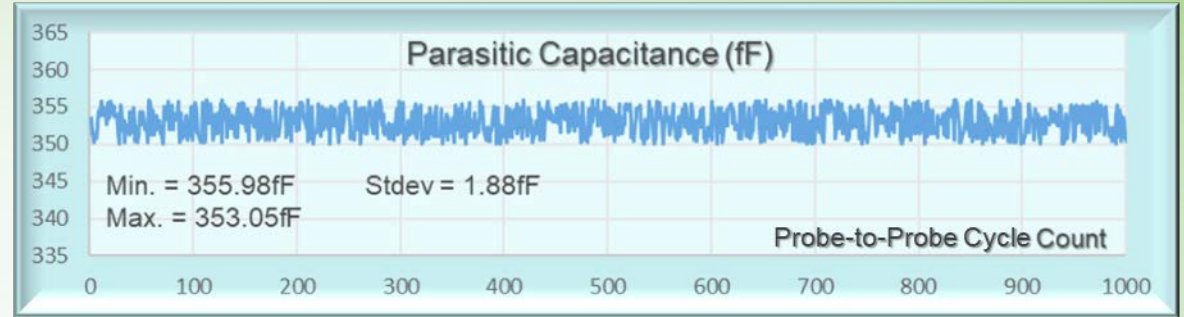
X-ray imaging



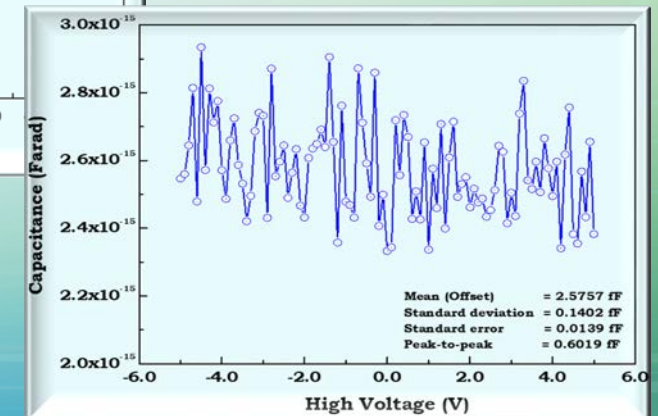
Inconsistent probe body spacing.



Precise spacing:
Variation $\leq \pm 2\mu\text{m}$



- Minimal probe-to-probe parasitic capacitance variations (max.-min. = 2.93fF)
- High-frequency CV measurements down-to femto-farad level



Prima-EM WAT Probe Card Lifetime

● Experiment:

- System:

- Prober: UF3000
- Tester: Keysight 4082
- Temp.: 25degC

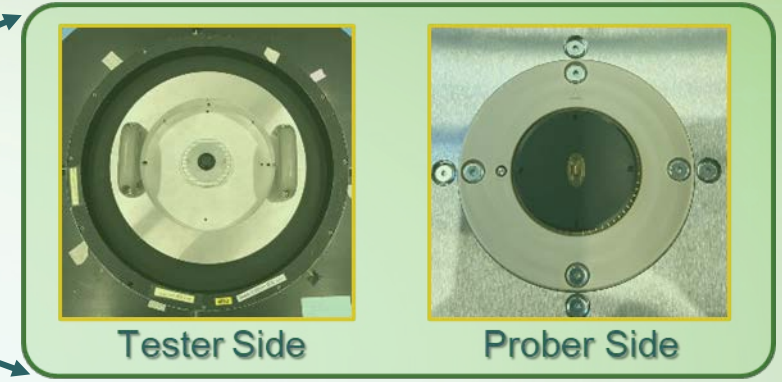
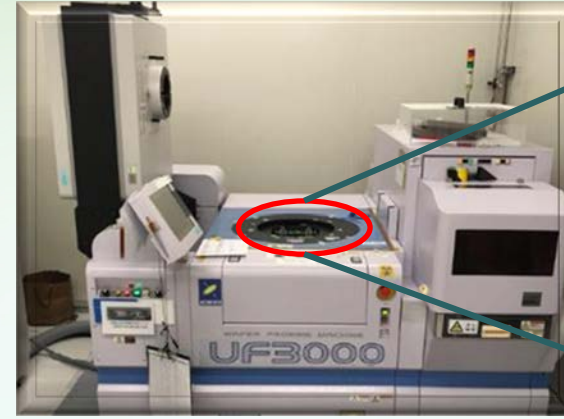
- Test:

- OD: 50um
- Pad: Al.
- Iforce: 100mA
- Rmeas: $10\Omega \pm < 0.3\%$

- Clean Recipe:

- OD: 35um
- Step: diag. 1000um
- TD: 10/1K TDs

● Lifetime >3M TDs



Conclusion

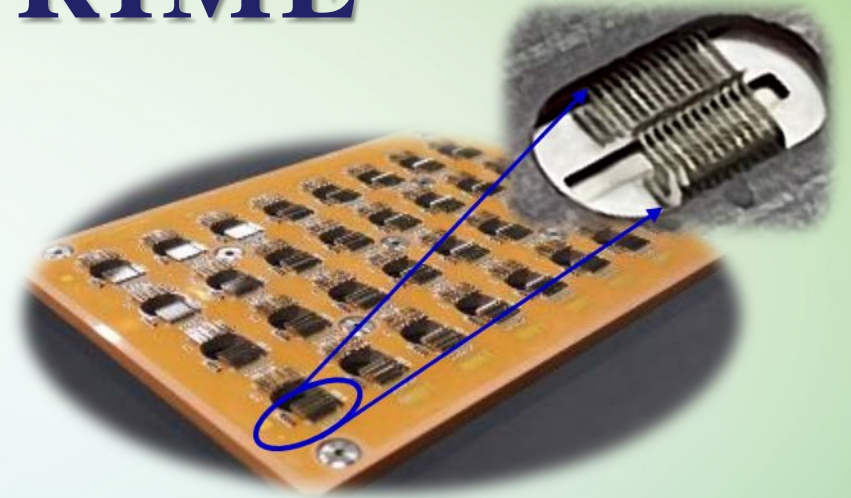
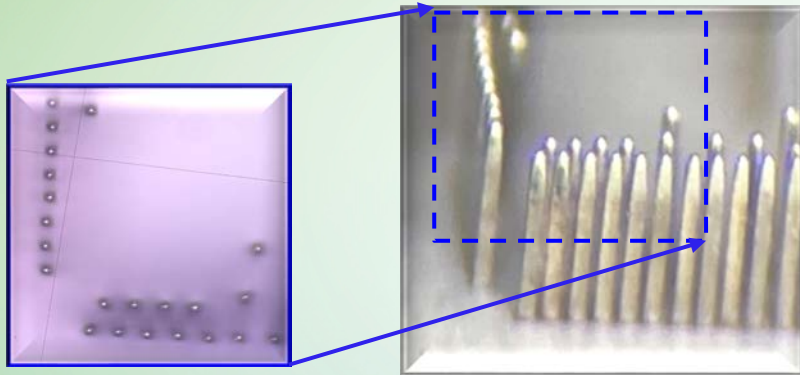
- STAr's Virgo-PRIMA MEMS micro-cantilever probe cards can meet the new PCM/WAT/WLR tests of semiconductor technology nodes 3nm and beyond
- Excellent Performance:
 - Electrical: Low-leakage current, Low contact resistance
Low parasitic capacitance, high repeatability (high GR&R)
 - Mechanical: Small scrub mark, less pad damage, replaceable probe head
 - COO: Long lifetime, Higher yield, Less finger-pointing
- Global teams: USA / Taiwan / Japan / China / South Korea
/ Singapore-SAP / EU (coming soon ...)
- STAr's research and development expertise with hundreds of patented technologies ensure best-in-class probe cards and test services.



STAr Frontiers ...

OPTIMUS

PRIME



• STAr **OPTIMA** MEMS

Vertical Probe Card

- SP45PS: Pitch 45um, MAC 500mA
- SP65PS: Pitch 65um, MAC 1200mA
- SP90CG: Pitch 90um, MAC 2500mA

• STAr **PRIMA** MEMS

micro-Cantilever Probe Card

- LM: Pitch 40um, BCF 0.65gf
- EM: Pitch 38um, BCF 1.00gf
- In-house customizable

Thanks for your Support !

● Contact the STAR team with any questions ...

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