SW Test Workshop

Semiconductor Wafer Test Workshop

Micro burn-in techniques at wafer-level test to implement cost effective solutions

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June 3-6, 2018

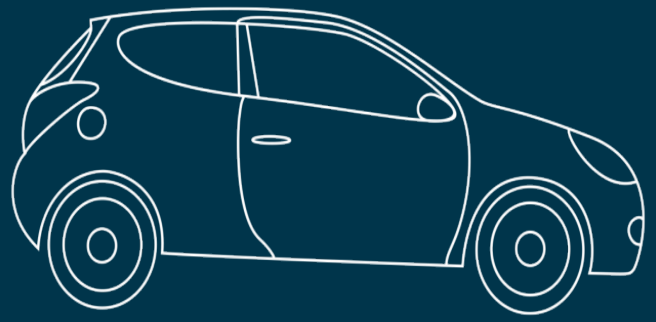
Agenda

1. Melexis Company Overview
2. Automotive Safety Requirements & Burn In
3. Wafer Level micro Burn In (WLµBI) Concept
4. TPEG(TM) MEMS T1 LCR2 Vertical Probe Head
5. Characterization, Simulation & System Setup
6. Evaluation Criteria & Achievements
7. Conclusions & Future Work

Melexis supplies worldwide > 1.3 billion ICs with an average of 10 ICs / car

Sense & Drive

- Position
- Latch & Switch
- Current
- Speed
- BLDC/DC Motor Drivers
- Fan Drivers
- Gate Drivers



Sense & Light

- Pressure / TPMS
- Temperature / FIR
- Light / Rain-Light
- Gesture / Active Light / 3D ToF
- Sensors Interface IC
- LIN RGB Drivers

Melexis Facilities & Locations

Sales & Applications
Belgium – Tessenderlo
Greater China – Shanghai, Shenzhen, Taipei
France – Paris
Germany – Erfurt
Italy
Japan – Yokohama
South Korea – Seoul
USA – Detroit

Manufacturing
Belgium – Ieper
Bulgaria - Sofia
France – Corbeil-Essonnes
Germany – Erfurt
Malaysia – Kuching

Research & Development
Belgium – Ieper, Tessenderlo
Bulgaria – Sofia
France – Grasse, Paris
Germany – Erfurt, Dresden
Philippines – Manila
Switzerland - Bevaix
Ukraine – Kiev
USA – Nashua

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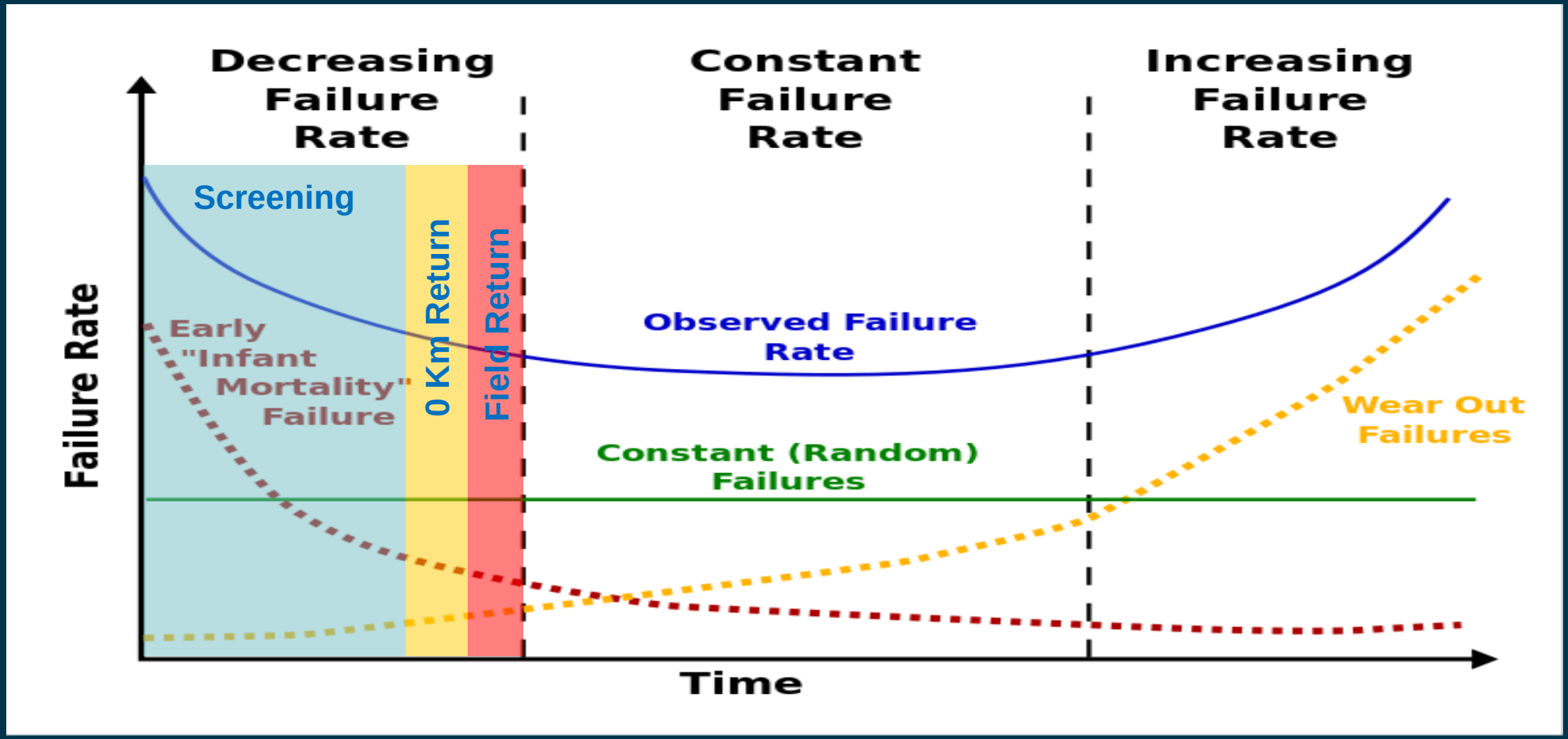
Automotive Safety Requirements

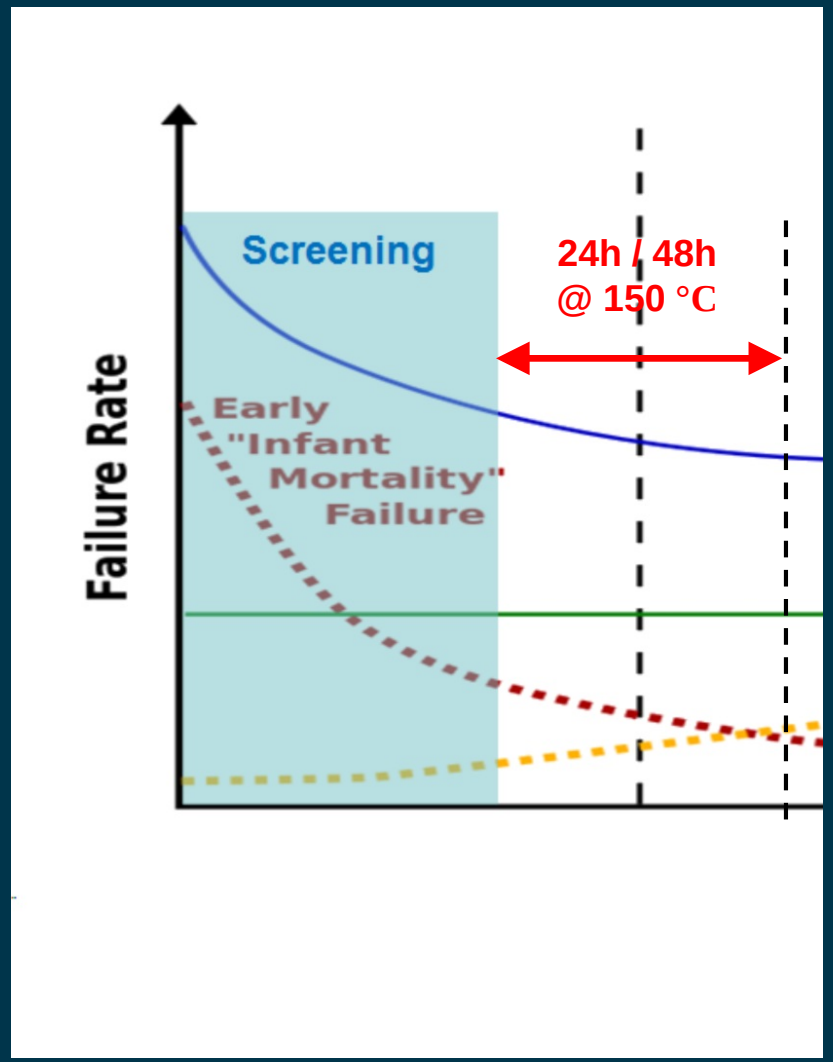
- Prevent 75% of early life failure at customer side
- Focus on digital failures without redesign
- Low impact on supply chain lead-time

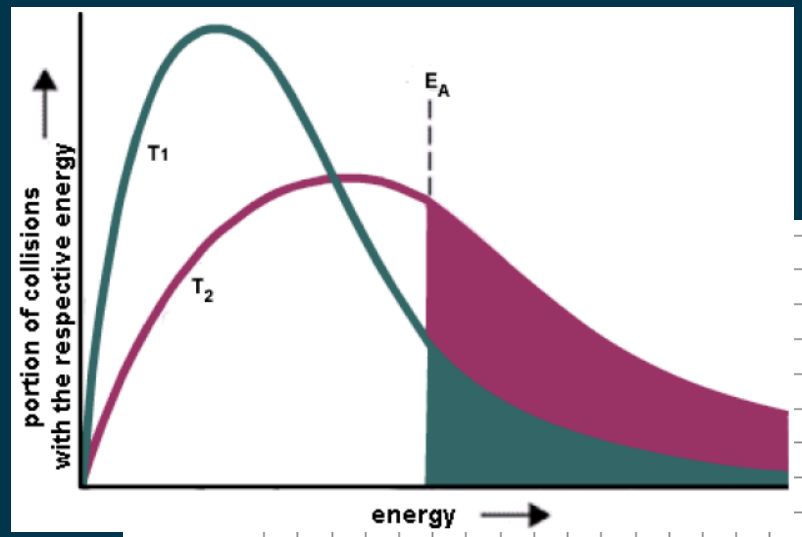
→ Only available solution: ***“Burn-In”***

Burn In Concept



Burn In Concept





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Wafer Level *micro* Burn In (WLµBI)

Test requirements:

- Stress all devices with enhanced test capability
- Multi-site testing at the wafer level (for efficient throughput)
- Tests at high temperature

  → High temperature capability and materials (chuck, prober, probe card with stiffener)

Challenges:

- Stability of the prober and probe card (test-cell) for high temperature

  → Stable Cres, probe-to-pad alignment and minimal pad damage
- Limit effect on supply chain lead time

Wafer Level *micro* Burn In (WLµBI)

Acceleration factor = exp (Ea/kT1) / exp (Ea/kT2)
Practical use temperature (T1) = 55°C = 328.15 K
Accelerated test temperature (T2) = **175 °C** = 448.15 K
Activation energy (Ea) = 0.7 eV
Boltzmann constant (k) = 8.6171 * 10^-5 eV/K
Acceleration factor = 756.43

	28	27	22	21	16	15	10	9	4	3
	29	26	23	20	17	14	11	8	5	2
	30	25	24	19	18	13	12	7	6	1
	31	32	33	34	35	86	87	88	89	90
	40	39	38	37	36	85	84	83	82	81
	41	42	43	44	45	76	77	78	79	80
	50	49	48	47	46	75	74	73	72	71
	51	52	53	54	55	66	67	68	69	70
	60	59	58	57	56	65	64	63	62	61
	93	94	99	100	105	106	111	112	117	118
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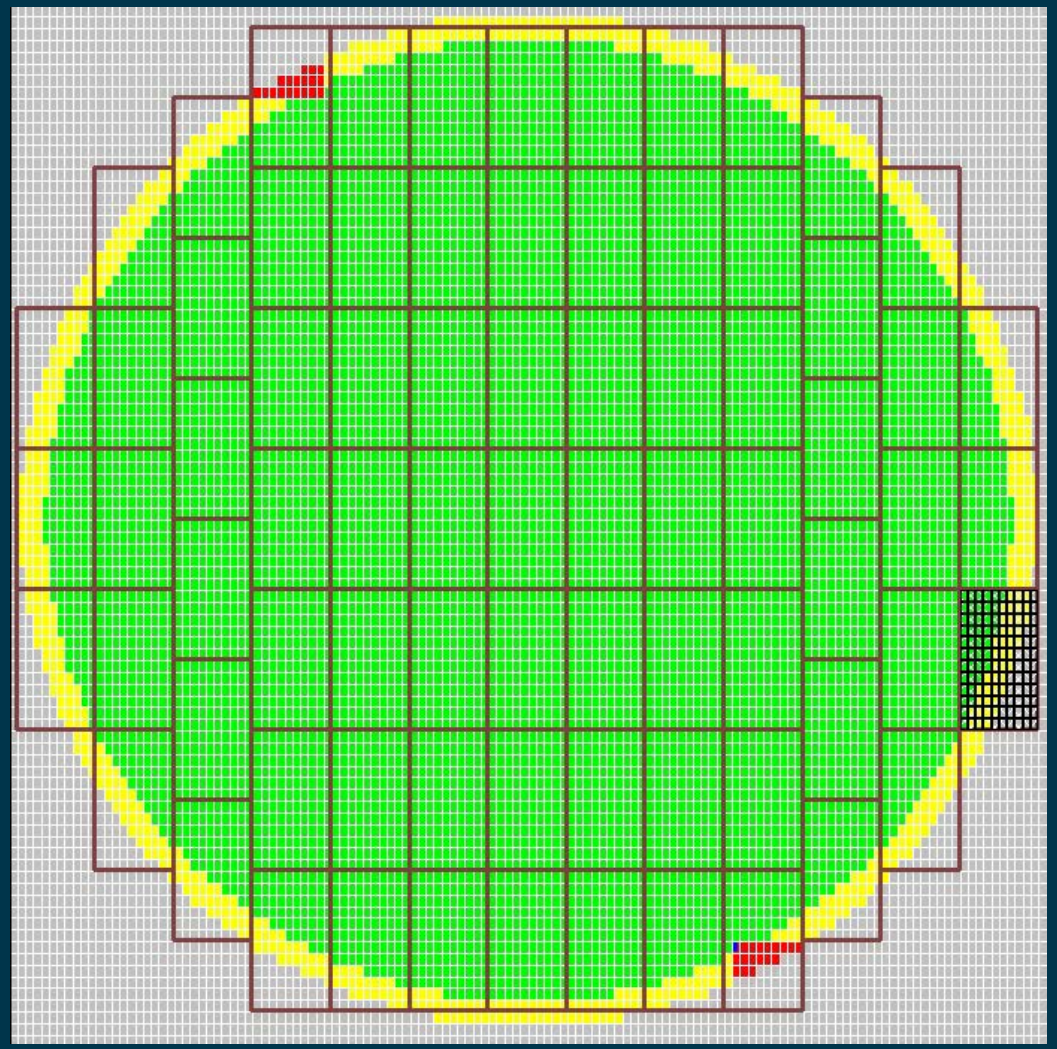
	91	96	97	102	103	108	109	114	115	120



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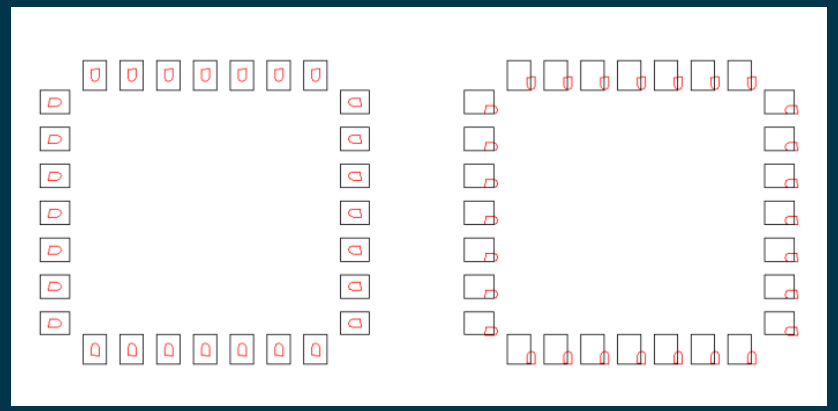
Wafer Probing @ Very High Temperature Background

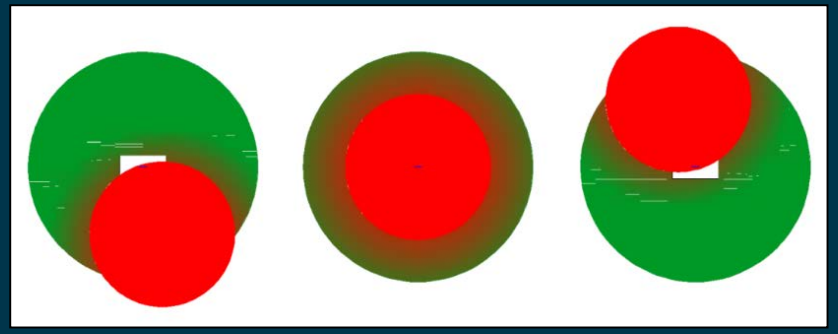
Challenges of probing in temperature:

- CTE mismatch
- Prober constraints
- PCB thermal gradient

Issues:

- XY misalignment
- Probe head Z displacement





In red the hot chuck
In green the PCB

Concept

Probe card design needs to consider all materials/mechanical constraints at high temperature trying to mitigate:

- CTE mismatches
- Thermal gradients

Probe card for hot temp test needs:

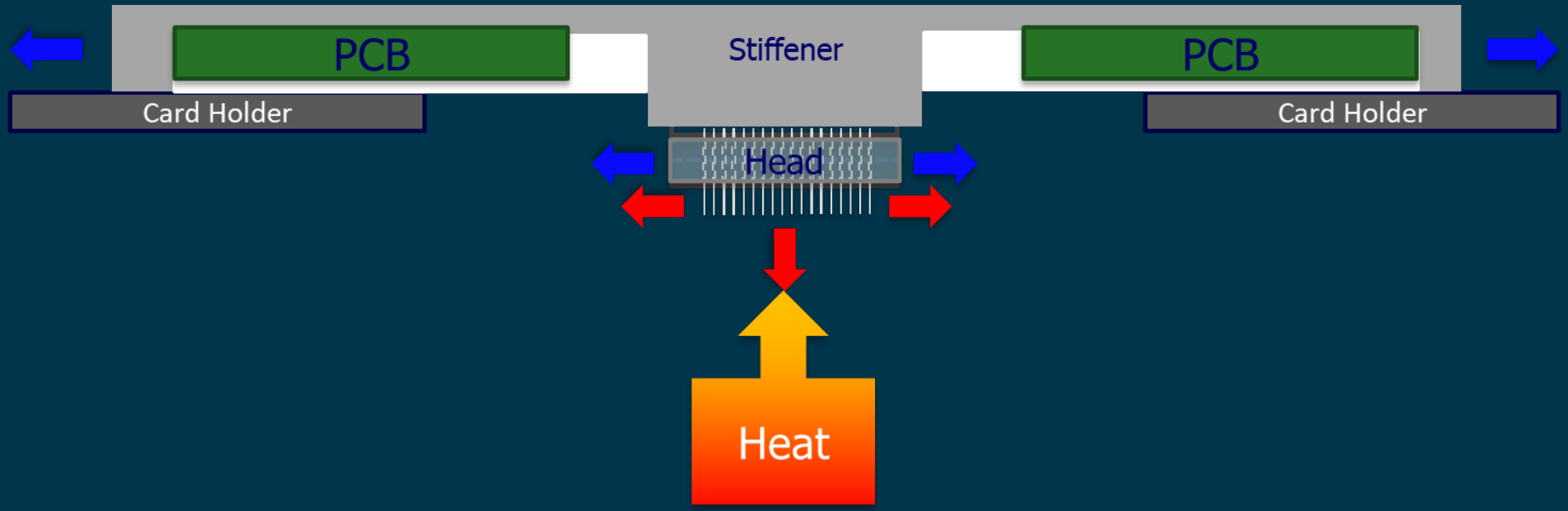
- Enhanced mechanical structure to test at high temperature
- Dedicated probing technologies to address stable contact

Characterization data on proofed concept hardware

Enhanced Mechanical Structure

Enhanced mechanical structure to test at high temperature:

- Large stiffener: best configuration is when PC stiffener is larger than PCB and it lands directly on prober PC holder
- High probe depth to increase PCB distance from heat source (chuck)

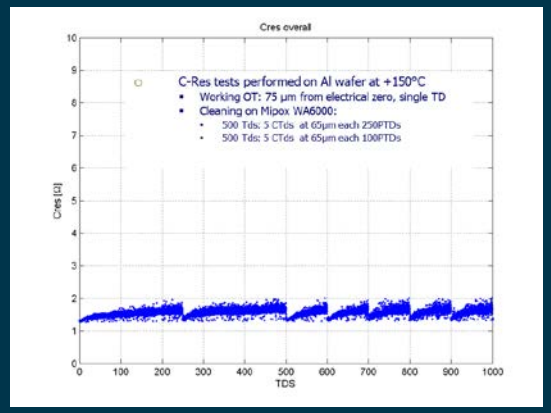


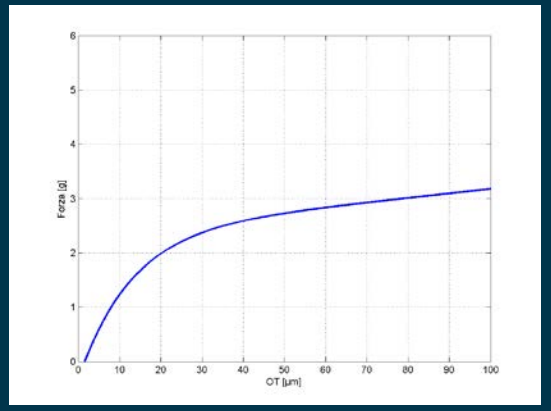
Dedicated Probing Technologies

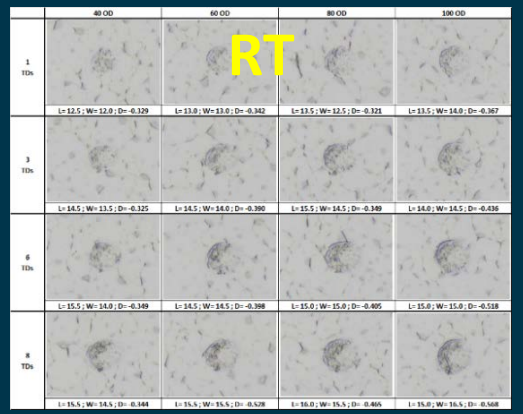
TPEG(™) MEMS T1 LCR2 Vertical Probe Head:

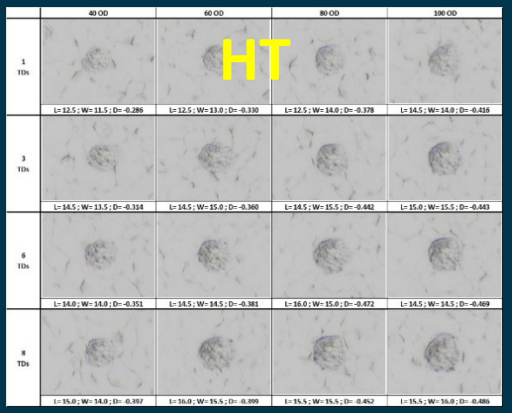
- Has been characterized for high temperature
  !! Test up to 200 ° C !!
- Stable Cres over time at high temperature
- Stable force over high temperature
- Stable probe marks over high temperature

PARAMETER	TPEG™ MEMS T1
Needle diameter	Less than 1,5 mils equivalent
Max pin count	> 20.000 pins
X, Y alignment accuracy and Z planarity	X,Y: ± 8 µm; Z plan: Δ 20 µm
Min pitch and configuration	55 µm linear configuration
Pin Current (CCC @RT)	410 mA
Force (at 3 mils OT)	3 g









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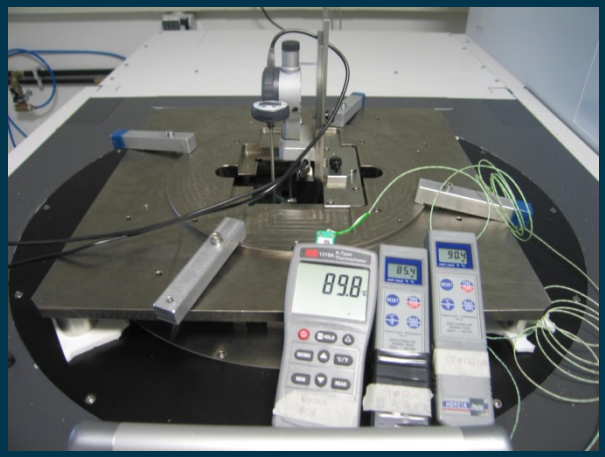
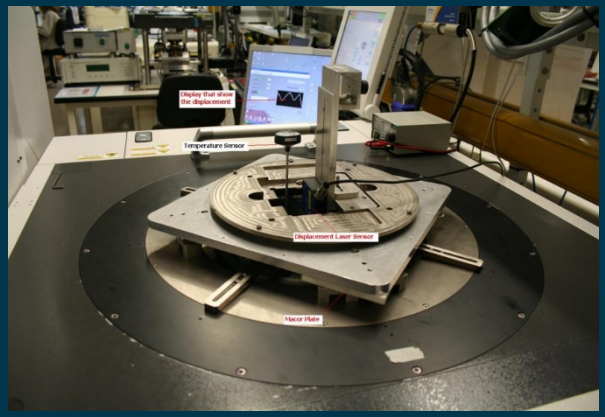
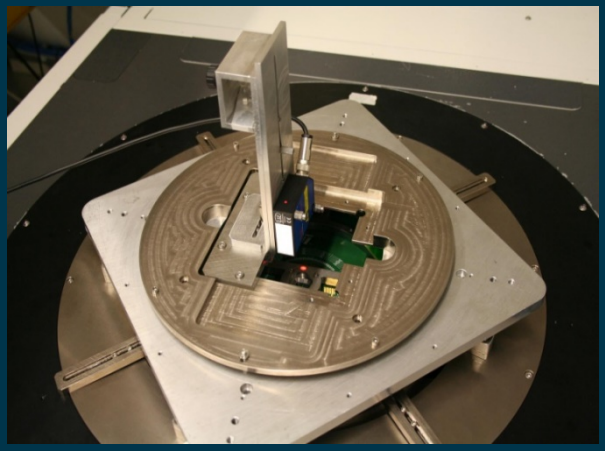
Characterization

Technoprobe's ultra high temperature solution:

- Characterization tests up to +200° C
- Mechanical testing setup
  - Card fixed on the prober
  - Tests performed without pogo pins pressure
  - Laser sensor measures the vertical movement during a full wafer test
  - No sensors in contact with the card
  - Thermal sensors to detect card temperatures
  - Standard card and enhanced HW card both tested on Al blank wafer as well as customer wafer (Al pad)



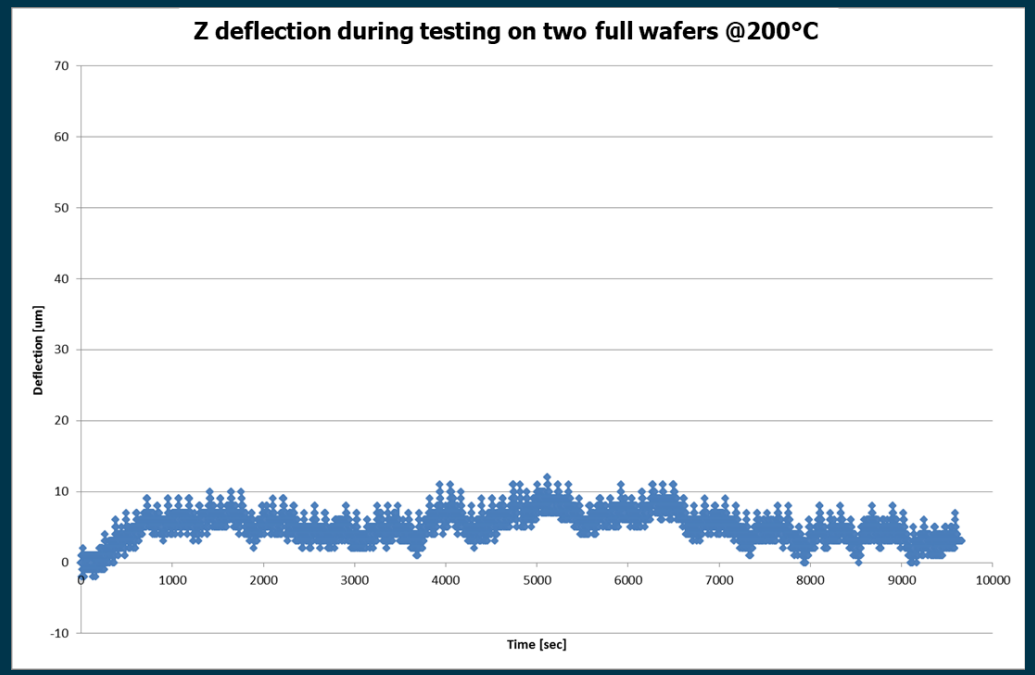


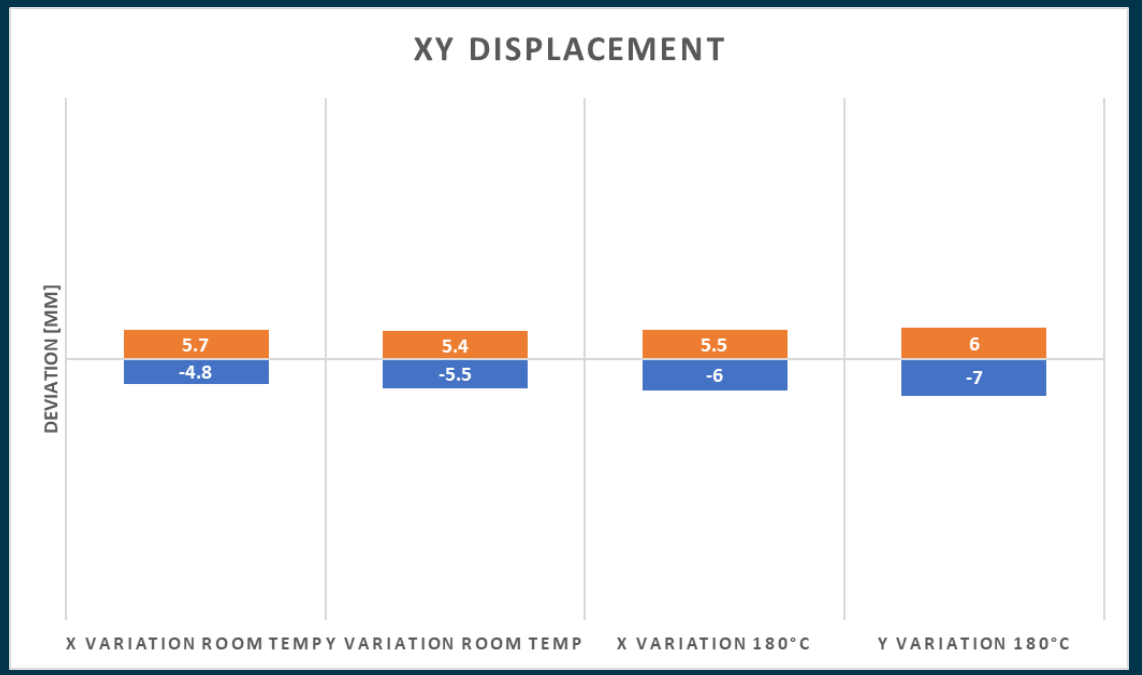


Z Deflection @ High Temperature: "Enhanced Mechanical Probe Card"

Characterization collected data on AL blank wafer at +200 ° C shows low XYZ variation vs. room temperature:

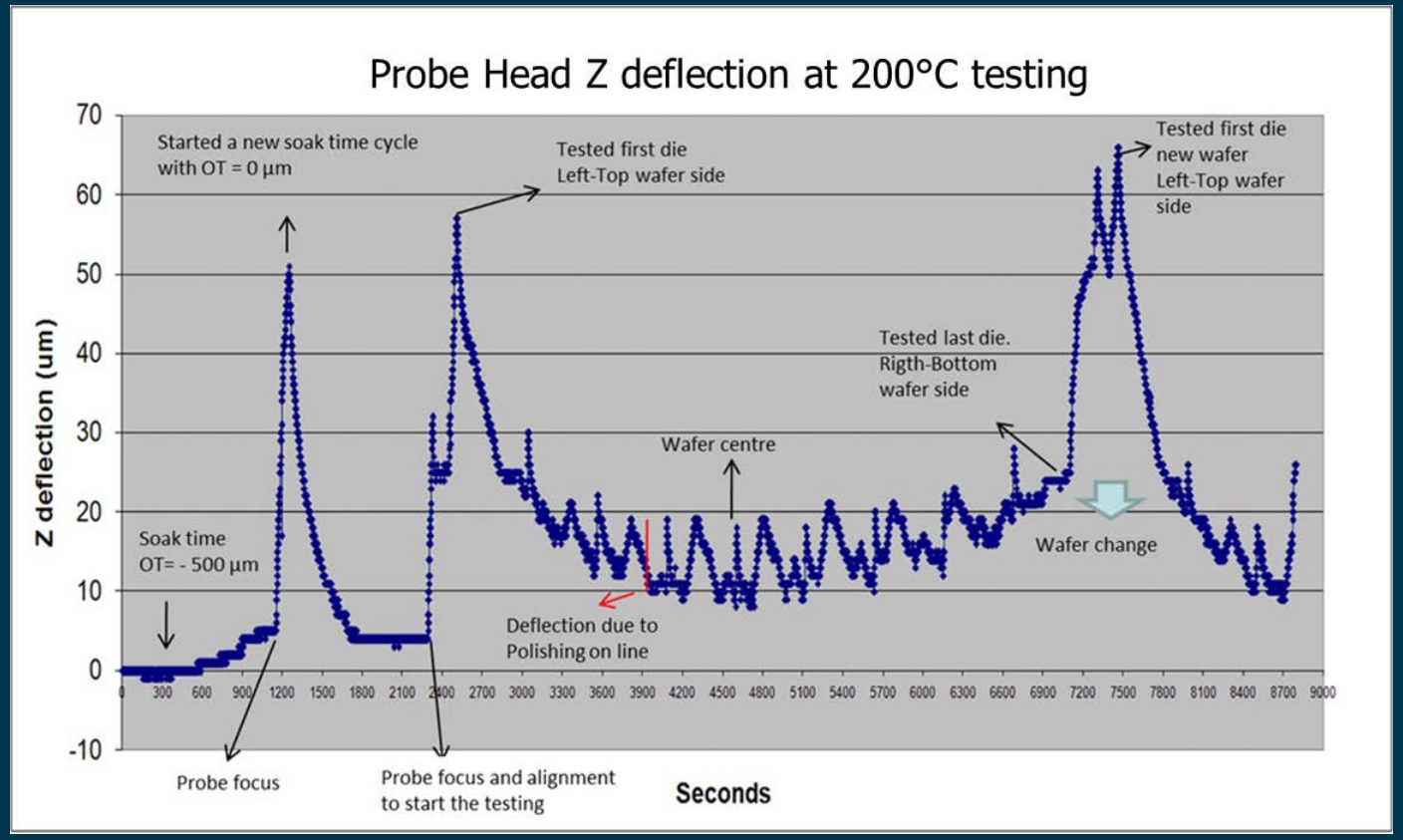
- Z deflection less than 20 µm
- XY displacement variation less than 10 µm





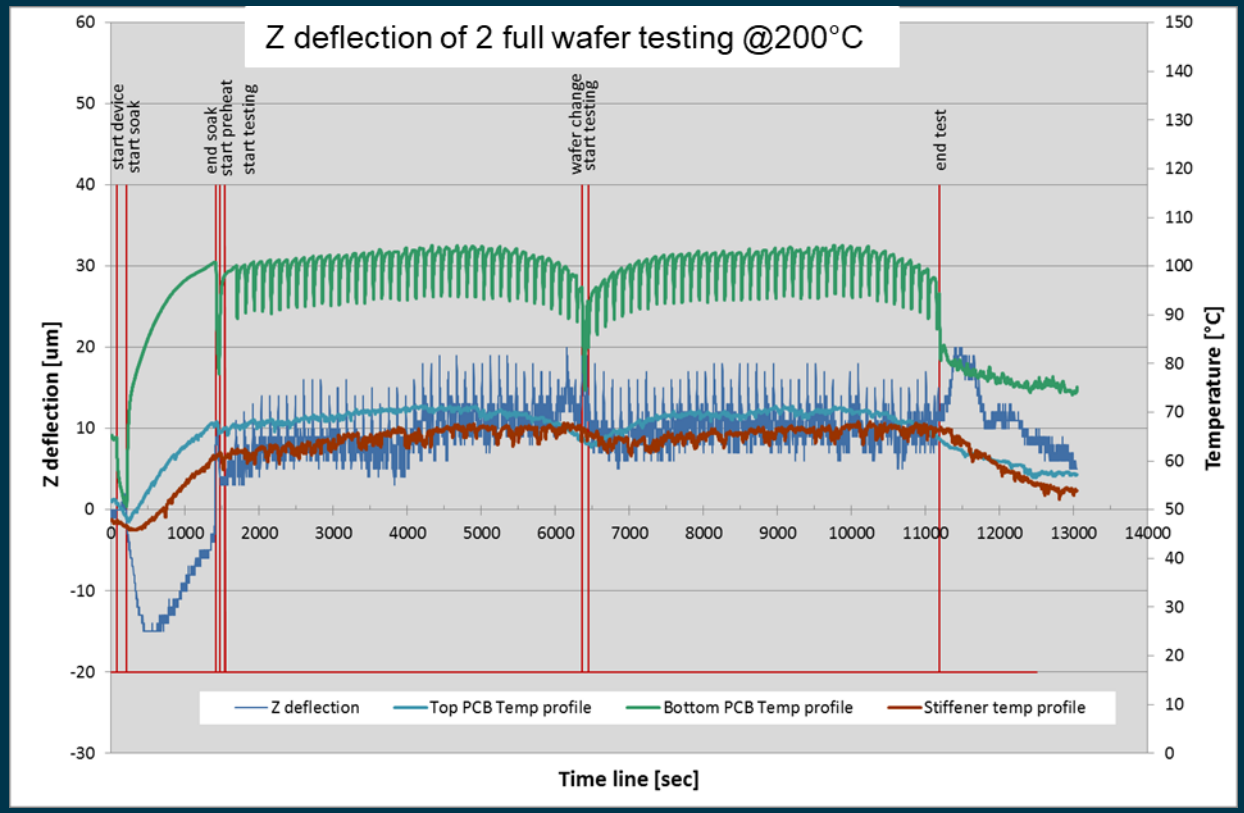
Z Deflection @ High Temperature: "Standard Probe Card"

Characterization data on Customer wafer @200° C : Without enhanced high temperature hardware the characterization results showed large Z deflection

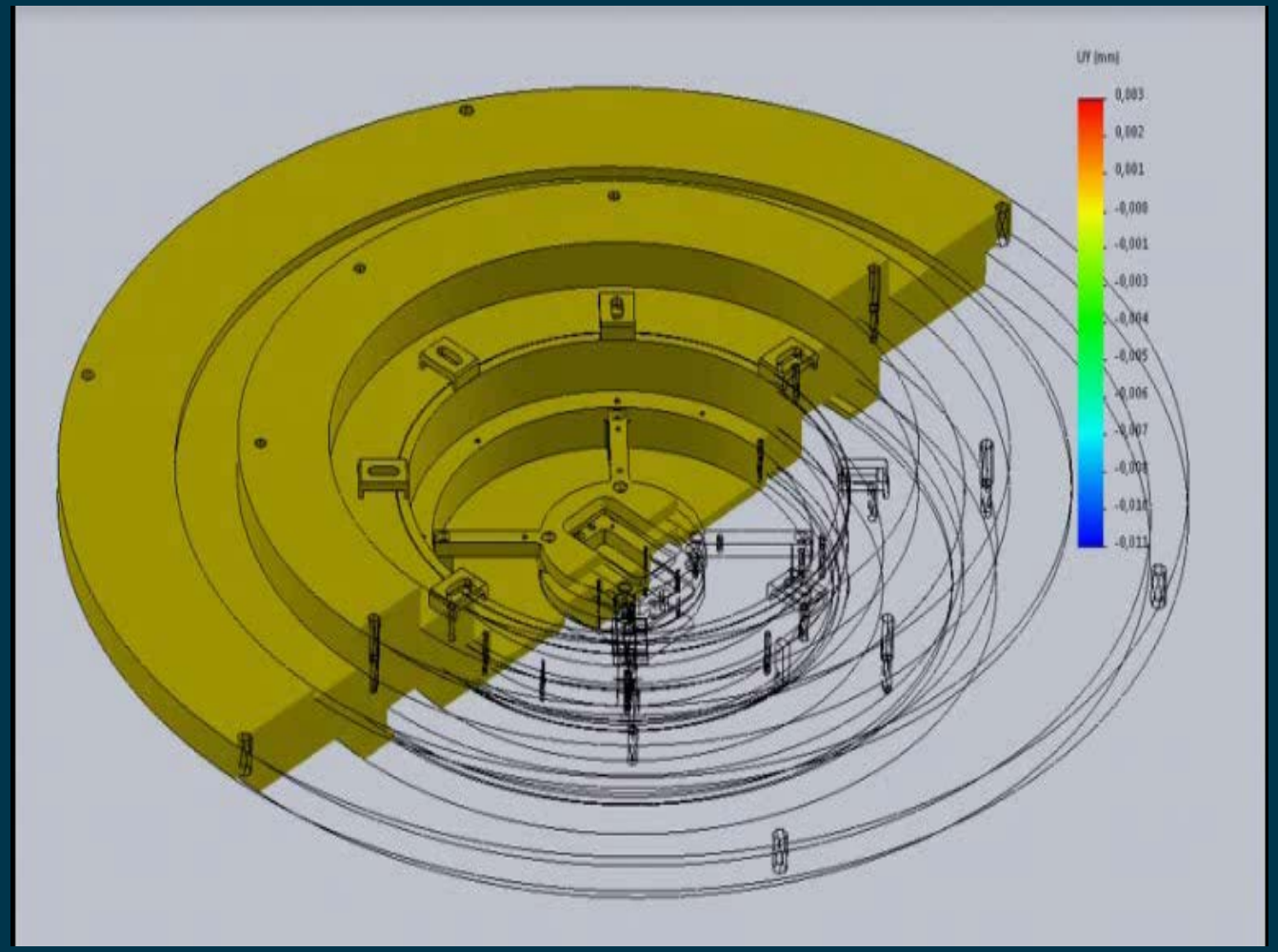


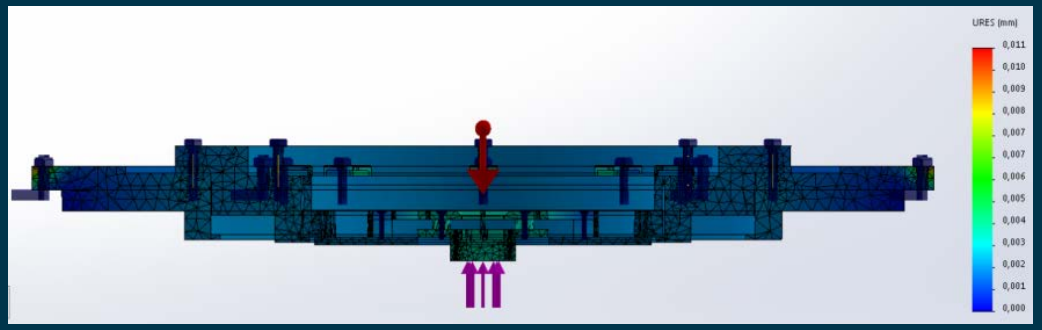
Z Deflection @ High Temperature: "Enhanced Mechanical Probe Card"

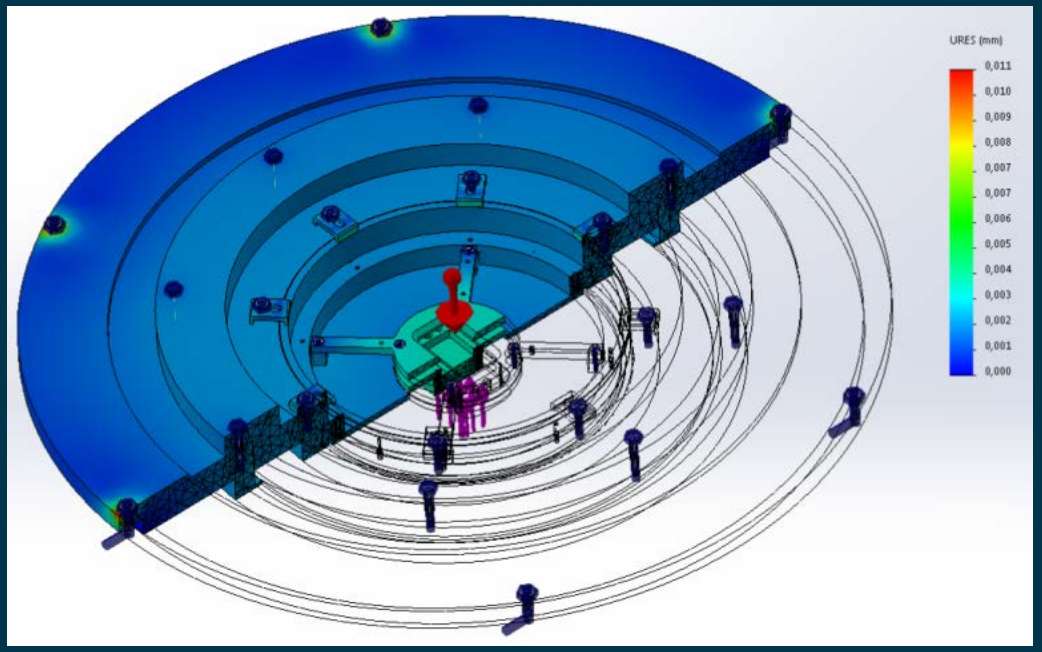
Characterization data on Customer wafer @200˚C: Enhanced mechanical structure for high temperature testing provides the required Z stability as probe head Z deflection follows stiffener (mechanical structure)



WLµBI System Simulation



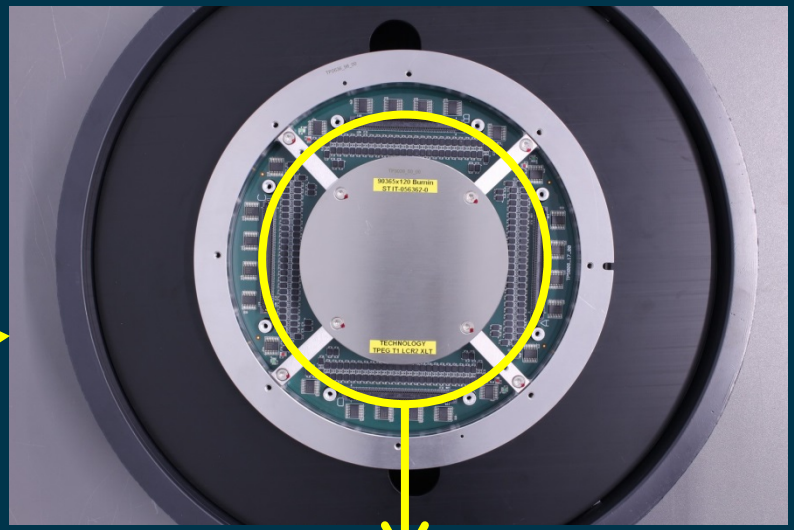


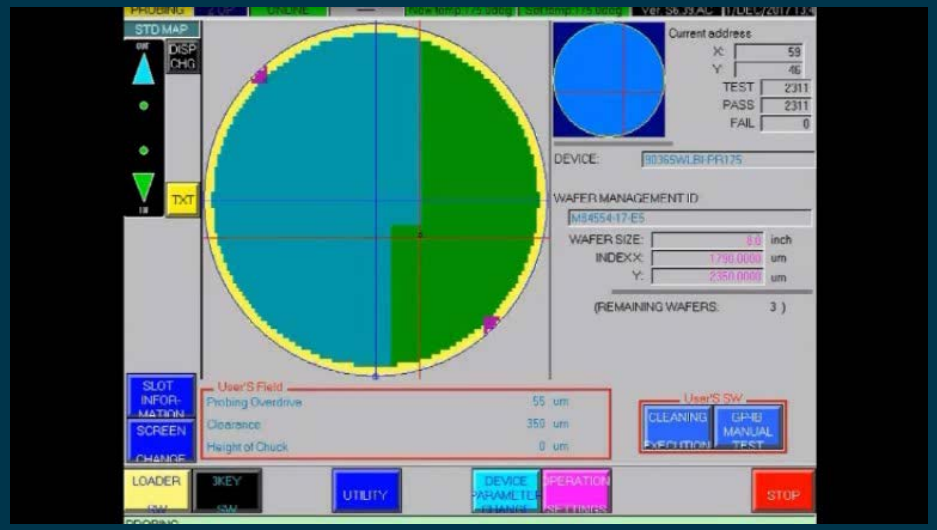


WLµBI System Setup

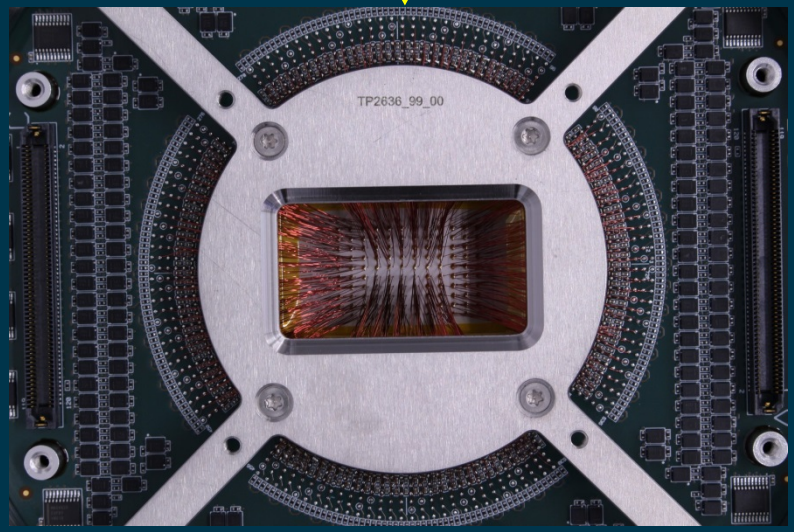
TSK UF2000 – ATT high temp. chuck

Technoprobe MEMS T1





Probing action



Tester side – space transformer

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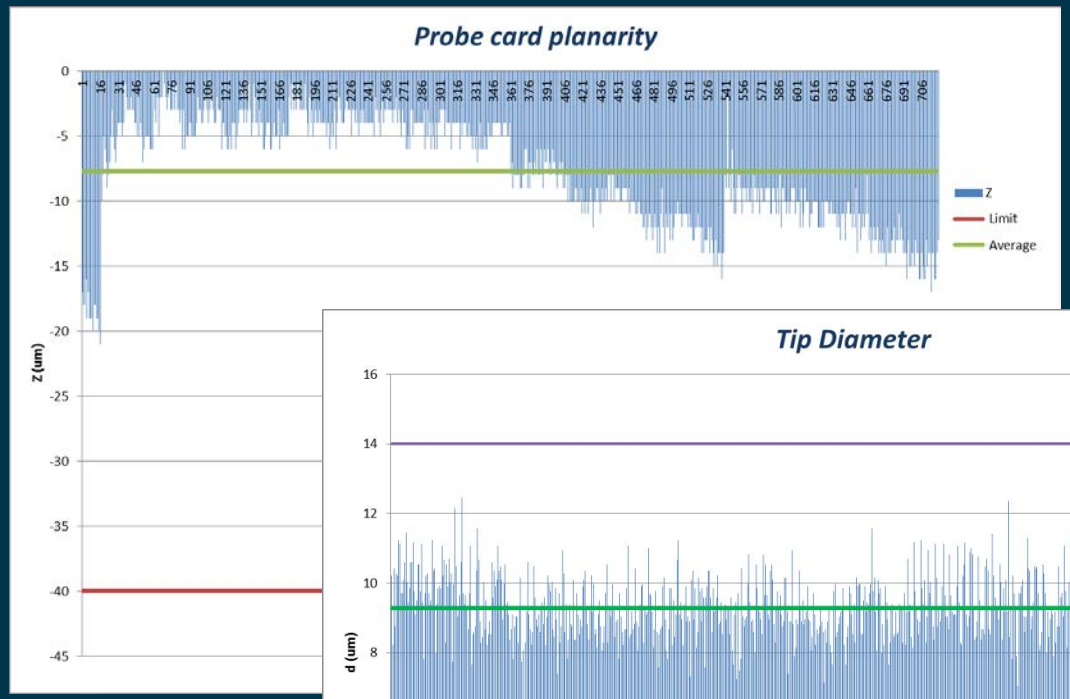
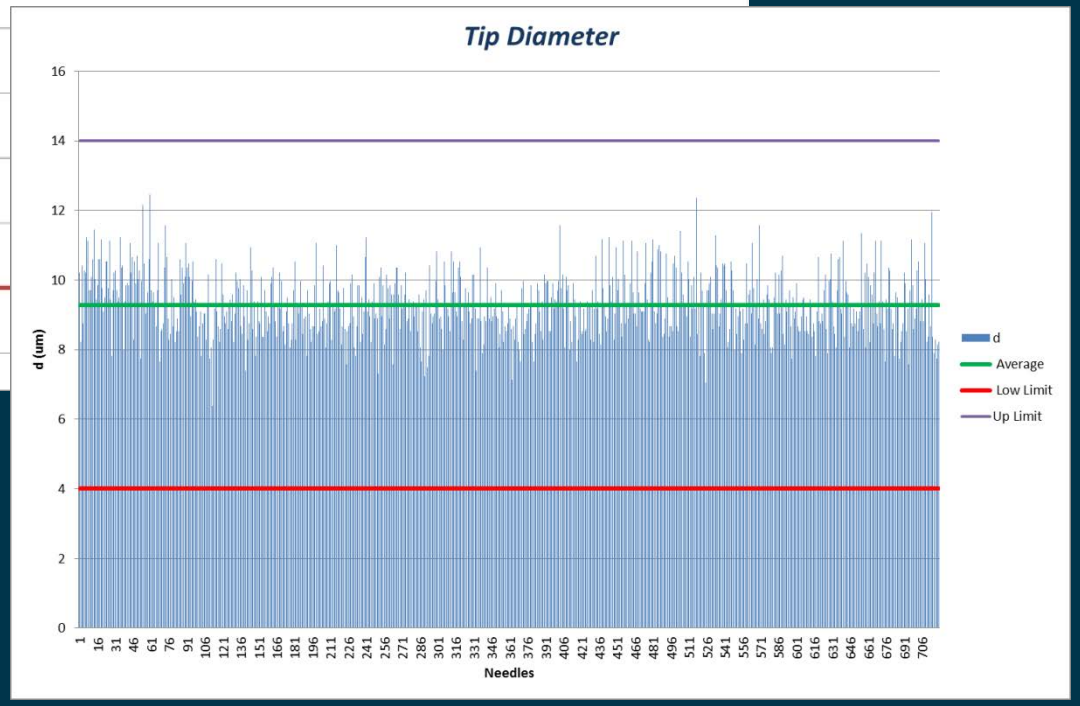
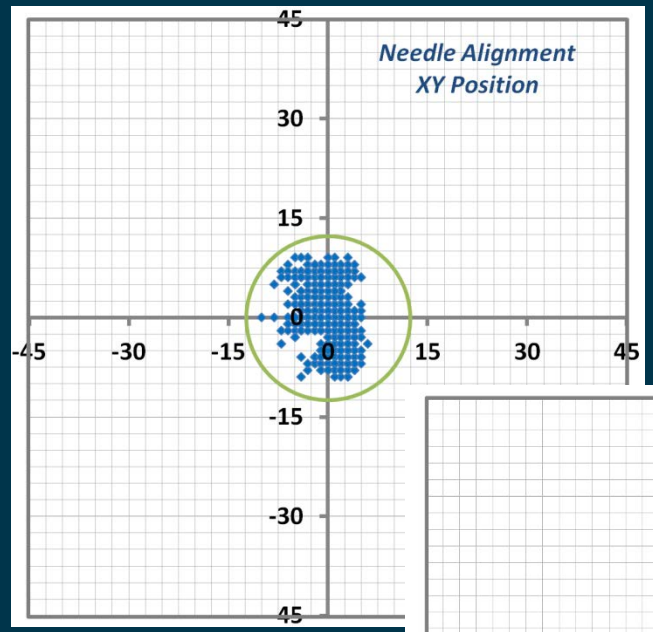
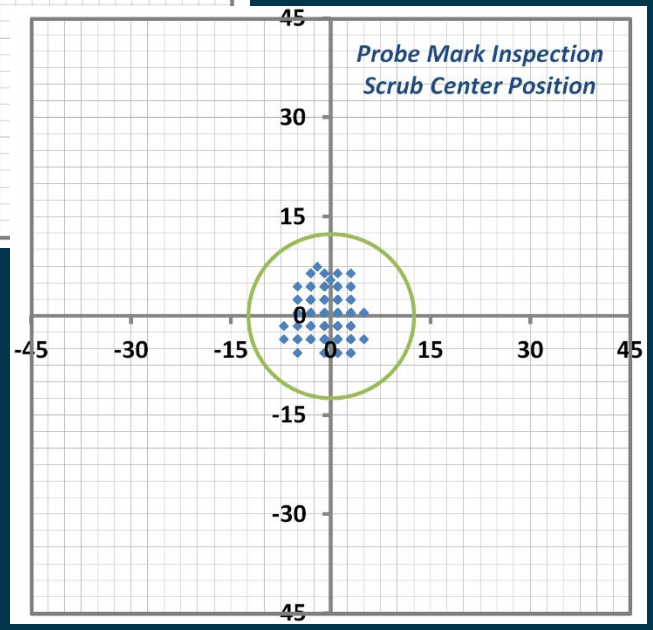
WLμBI Validation Results









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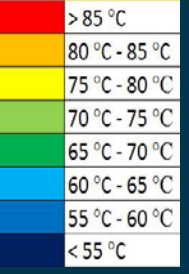
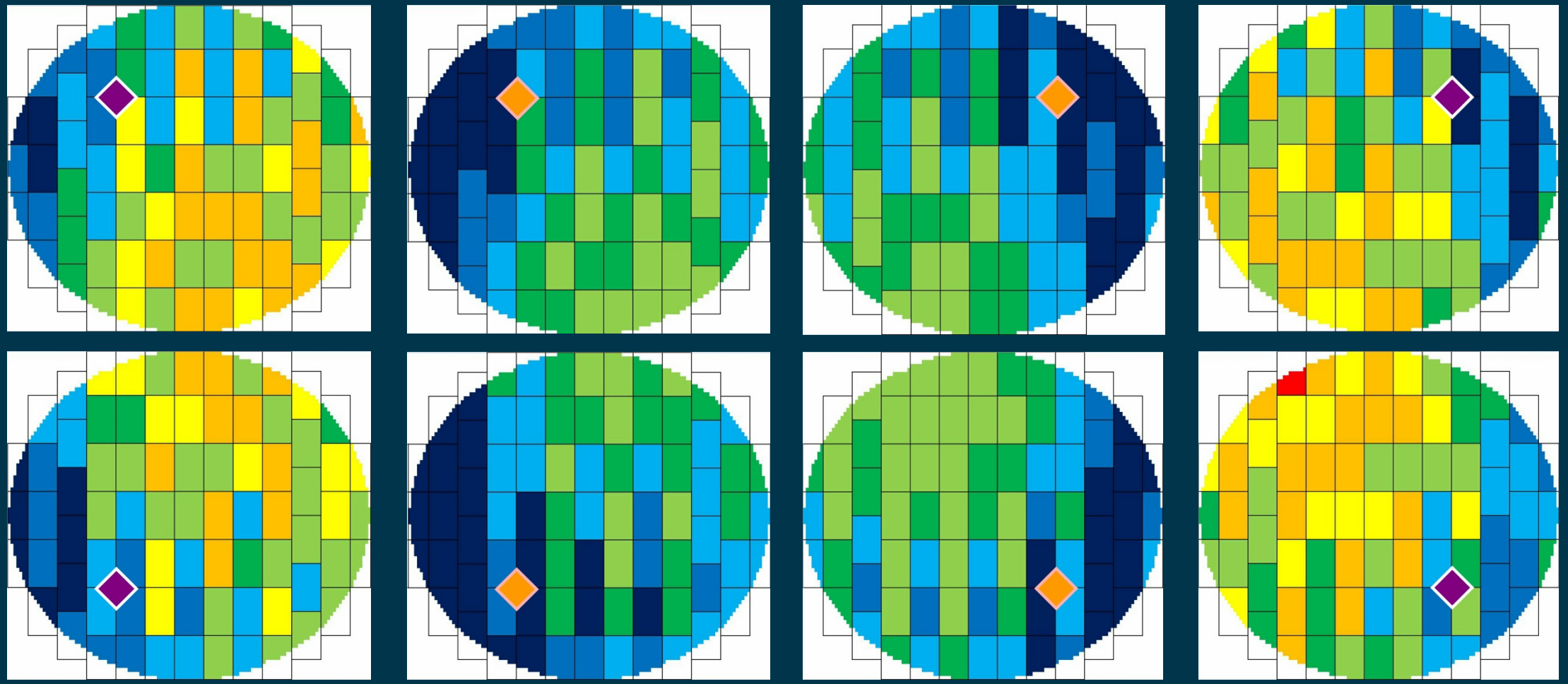


Wafer side Tester side Tester side Wafer side



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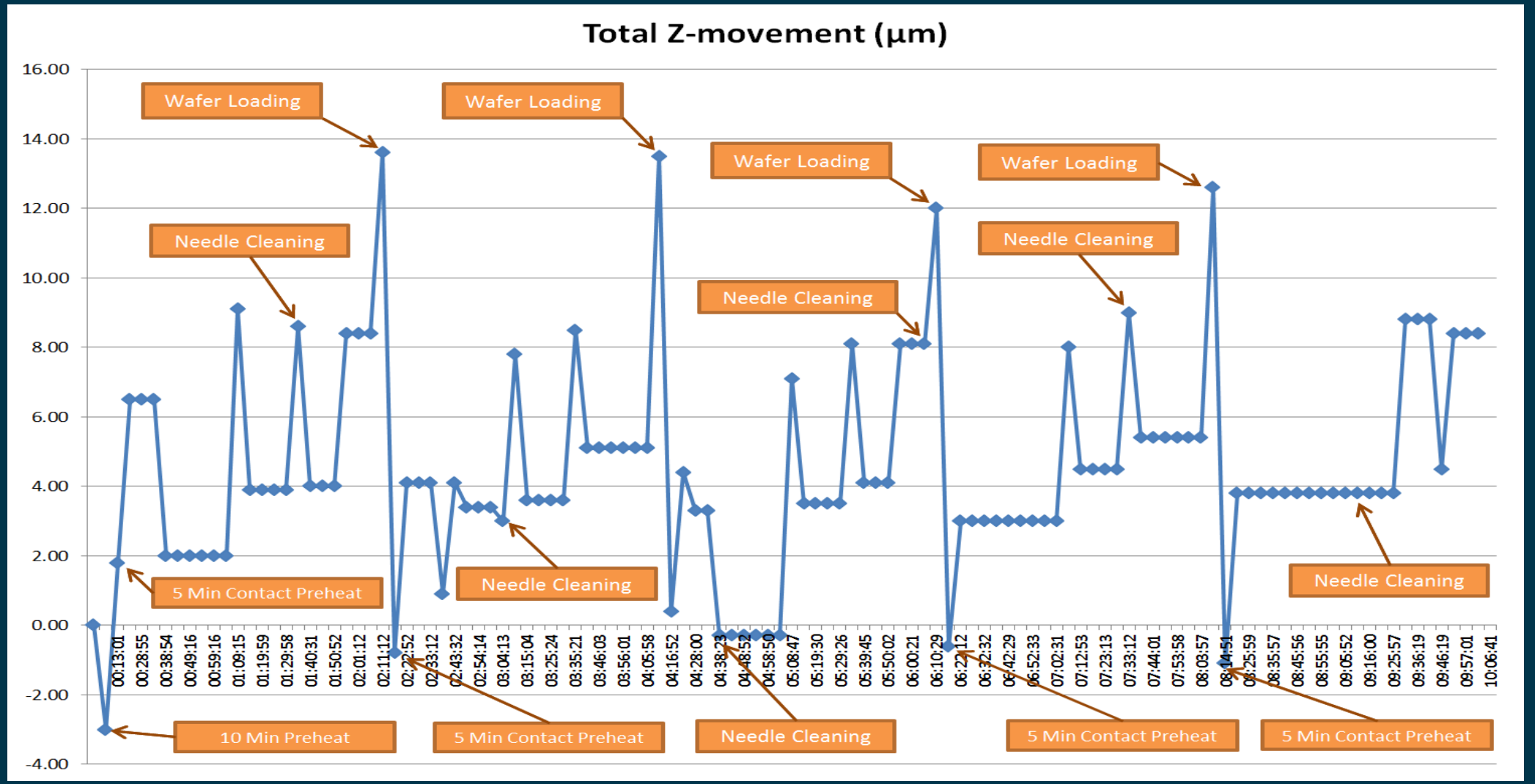

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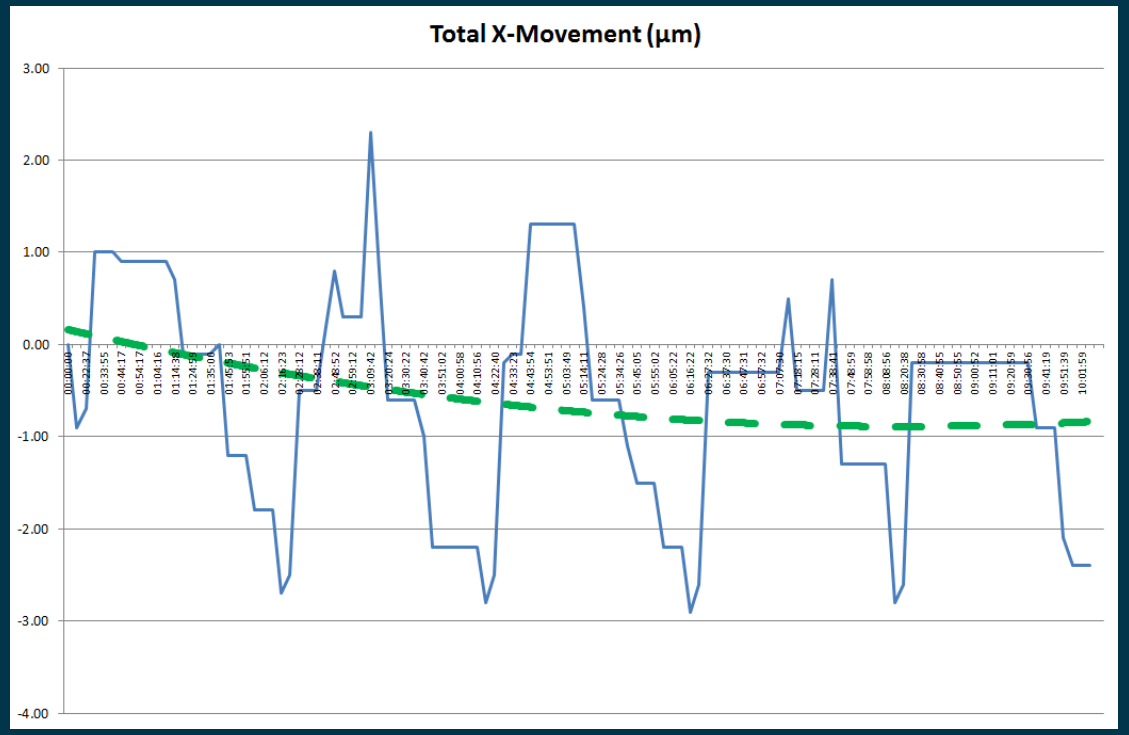
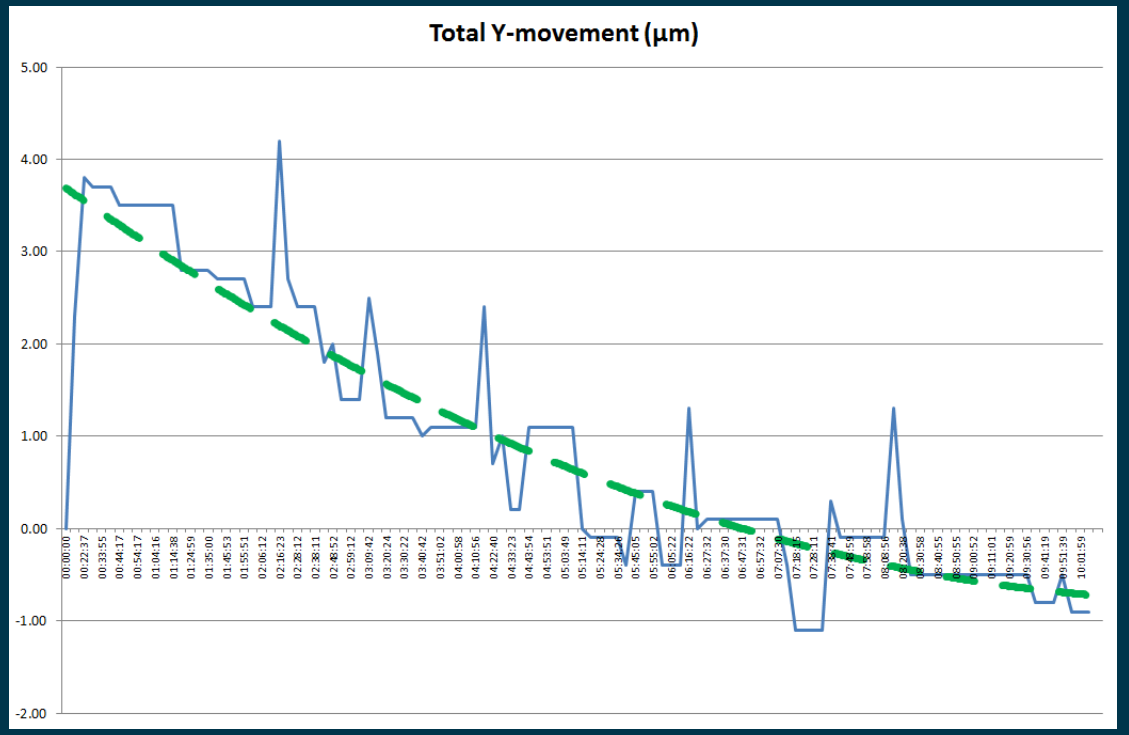
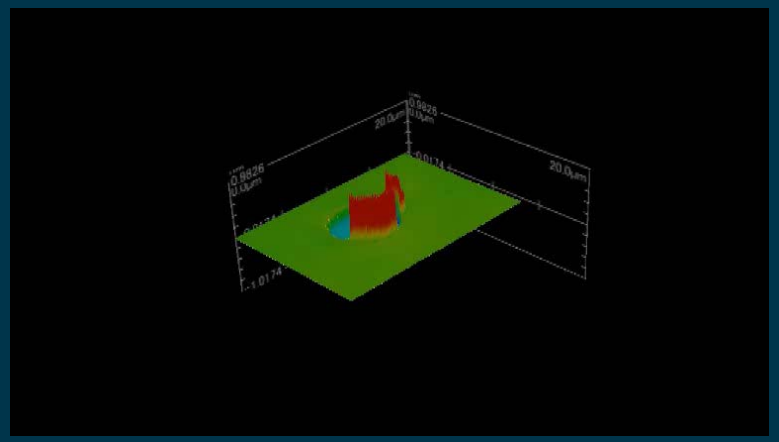


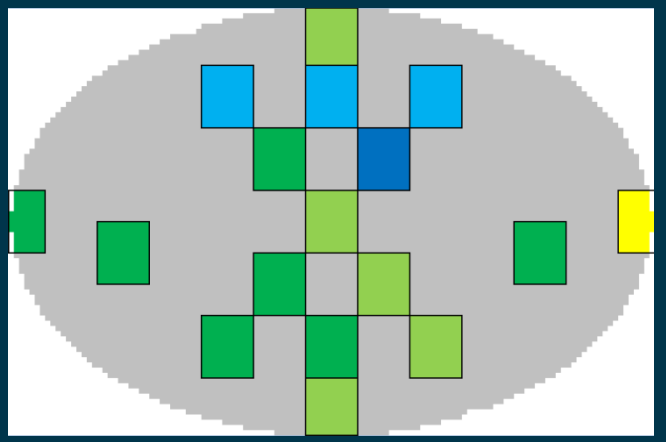


Scrub Profile & 3D @ 175 °C (55 µm OD)

MEMS T1

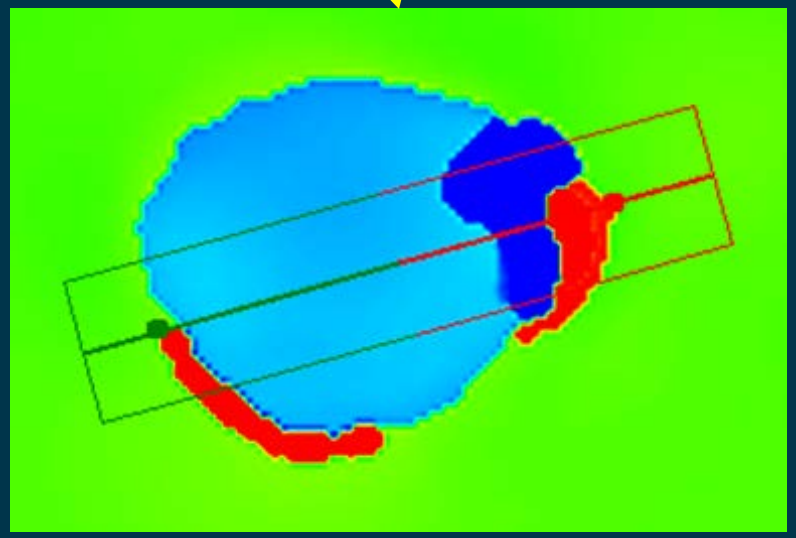
Cantilever



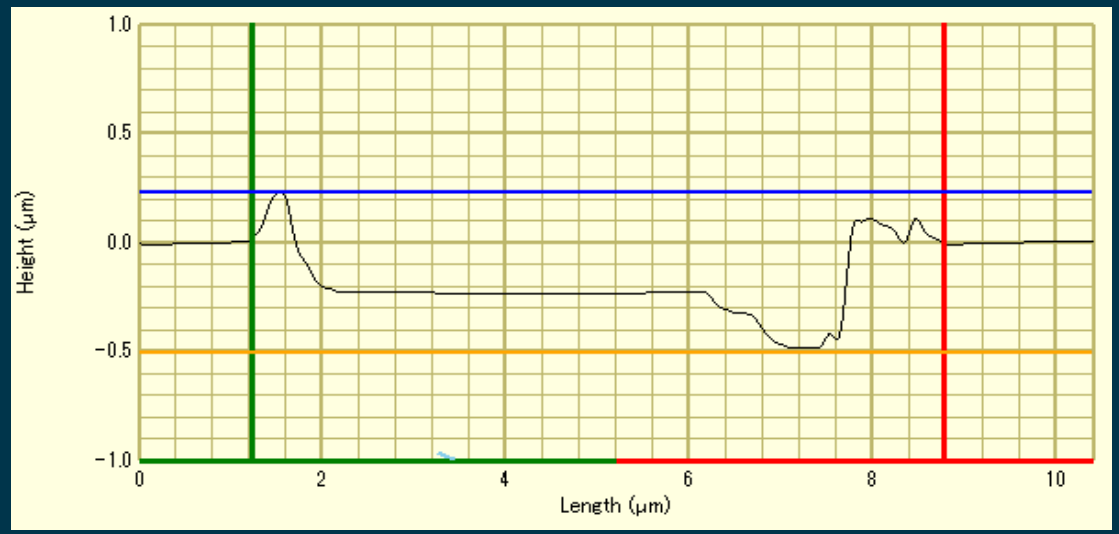


Scrub depth variation

> 400	
375 - 400	
350 - 375	
325 - 350	
300 - 325	
275 - 300	
250 - 275	
225 - 250	

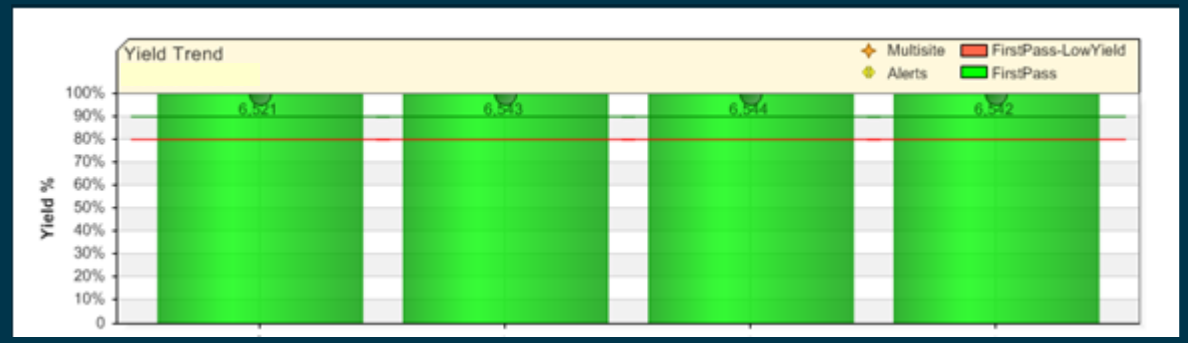


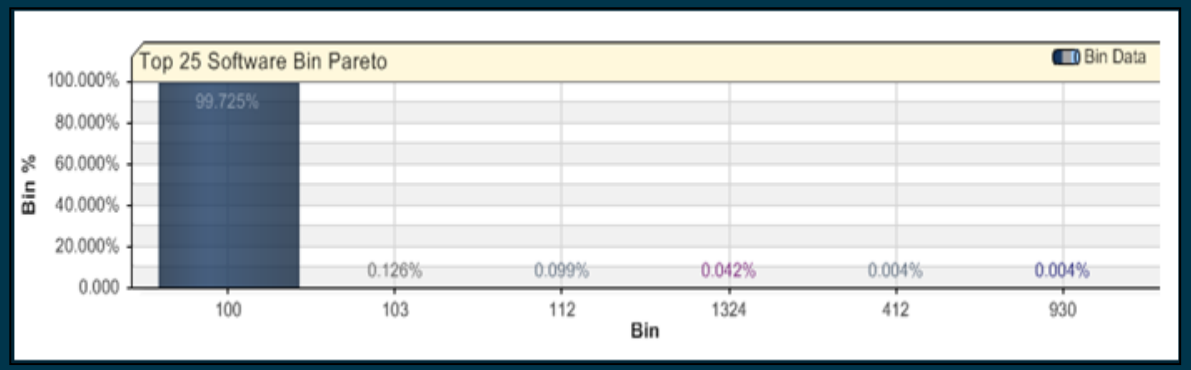
Scrub profiling

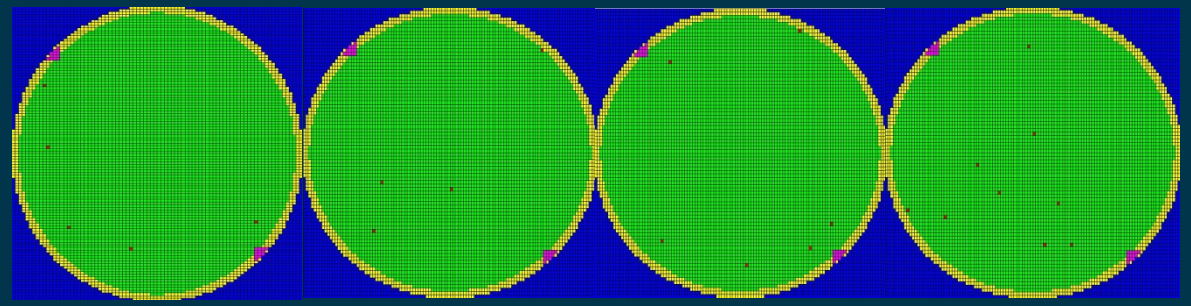


Initial Functional Test Results

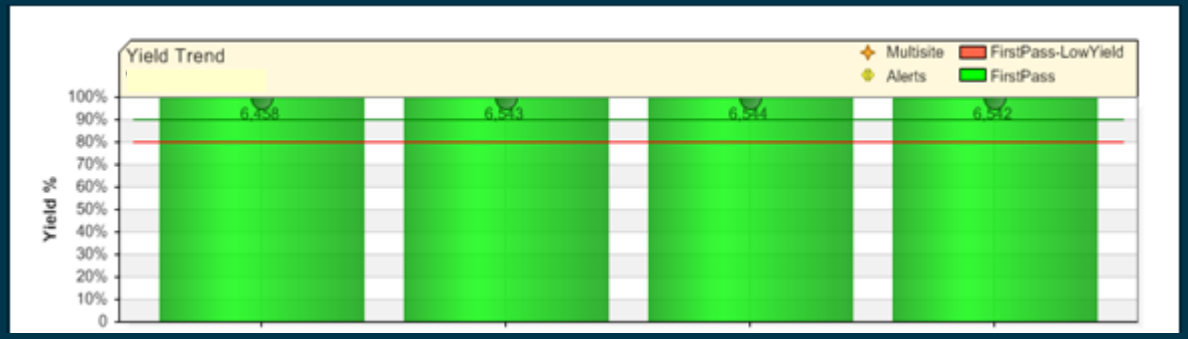
WITHOUT WLμBI

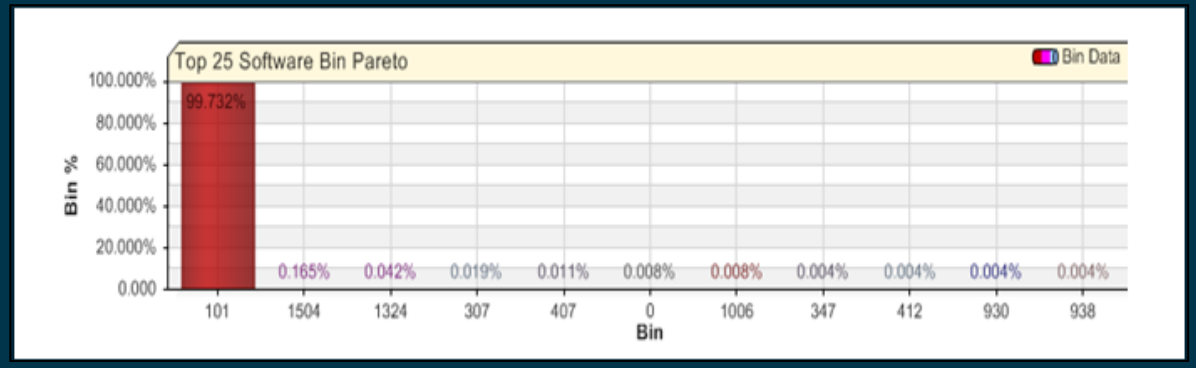


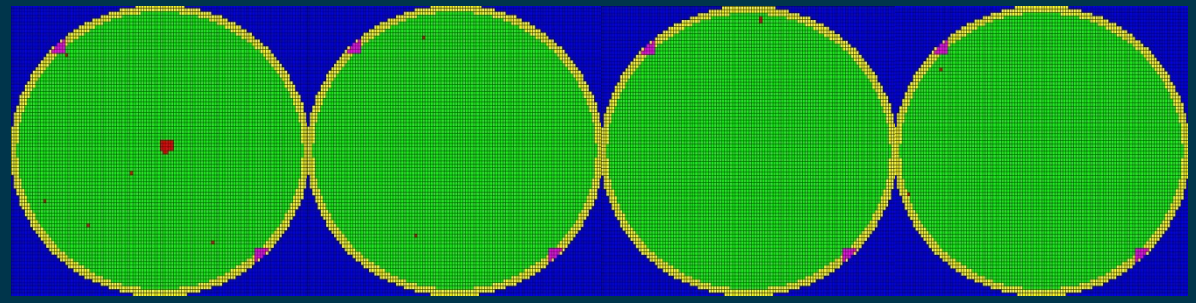




WITH WLμBI







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Conclusions

- **WLµBI system-level approach at 175 °C shows good performance in terms of yield with limited effect on supply chain lead time**
- **Wafers processed with WLµBI have normal results in next probing step**
- **Parametric analysis highlighted no impact from WLµBI**
- **Concept qualified for future products**

Future Work

- Observe the effect of probe card aging (in progress)
- Increase the temperature to reduce the test time
- Stepping optimization
- Probe card temperature control

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Thank You


Wafer Level µ Burn In is not the Holy Grail.
It is a solution to extend test coverage when no other solution can be implemented.