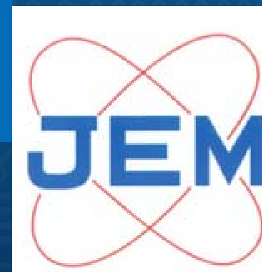
SW Test Workshop
Semiconductor Wafer Test Workshop

Multi-site probing of magnetic sensors at 175 deg C



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Joe Mai, JEM

June 5-8, 2016

Agenda

- Melexis company overview
- Basics: triaxis®
- Test requirements, challenges & test cell considerations
- Concept & system setup
- Flowchart probe card evaluation
- Evaluation criteria & achievements
- Future work

Melexis supplies worldwide average 7 ICs / car

Sensing
- Speed
- Position
- Current
- Pressure
- Temperature
- Light
- Image

Driving
- BLDC/DC Motor Drivers
- Smart Drivers

Communicating
- Wired SW CAN, SENT and LIN
- Wireless RF & RFID/NFC

Combining into Systems

Facilities and locations

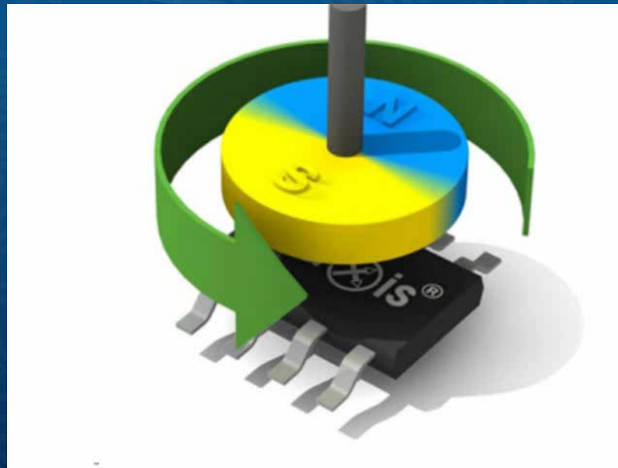
Basics: triaxis® technology

Triaxis® principle:

- 3 axis magnetic field measurement from a single sensor

Triaxis® types:

- Position sensor – rotational, linear, 3D displacement
- Current sensor mounted on a bus bar



Triaxis® characteristics:

- Small size
- High temperature
- Contactless
- Robustness
- Self-diagnostic
- High resolution
- High linearity
- High accuracy

Test requirements and challenges

Test requirements:

- Rotating magnetic stimulation during electrical test
- Multi-site testing at the wafer level (for efficient throughput)
- Tests at several temperatures from 35 to 175 ^{o} C
- Robust and uniform magnetic fields across all the sites

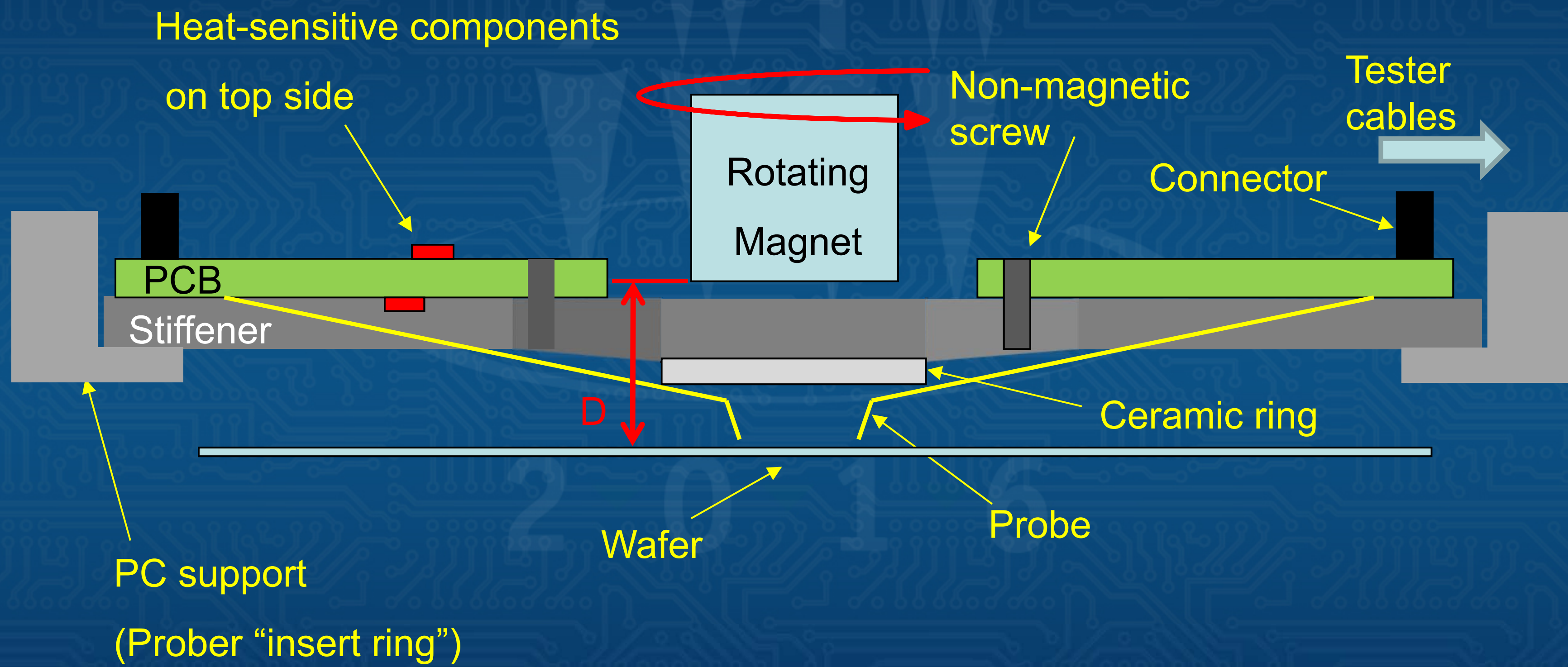
Challenges:

- Stability of the probe card (and test-cell) over the full temperature range
  → Stable probe-to-pad alignment and minimal pad damage
- Magnetic source as close as possible to the wafer - but the probe card is in the way!
- Minimal magnetic interference from test cell (probe card, prober chuck, etc.)

Test-cell considerations

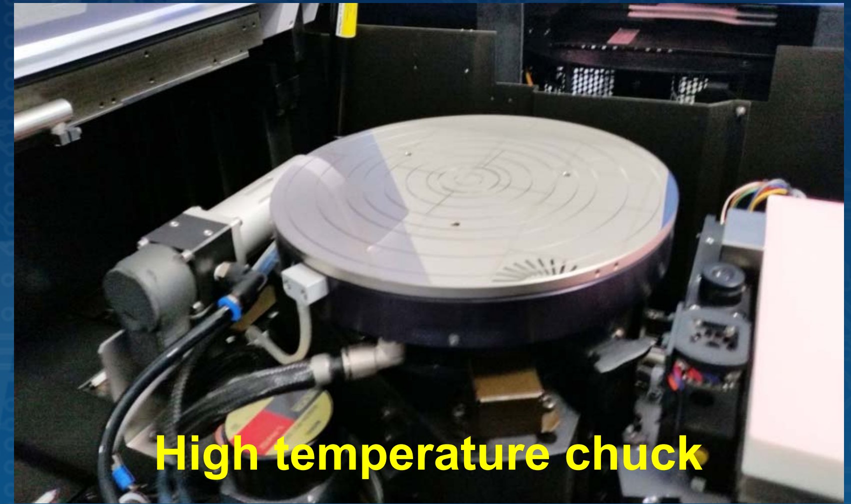
- **Wafer chuck:**
  - High temperature capability with minimal magnetic noise
- **Prober:**
  - High-temperature software options required to ensure good probe-to-pad alignment
  - Modified insert ring for mechanical stability at high temperatures
- **Probe card:**
  - Minimize non-magnetic materials
  - High-temperature materials
  - Stiffener required on bottom (wafer) side
- **Magnetic test head:**
  - Designed for rotation and installation on wafer prober

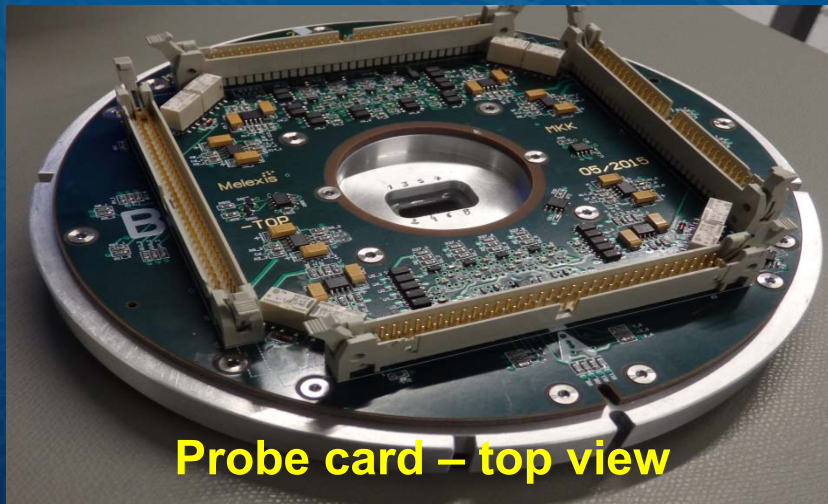
Concept



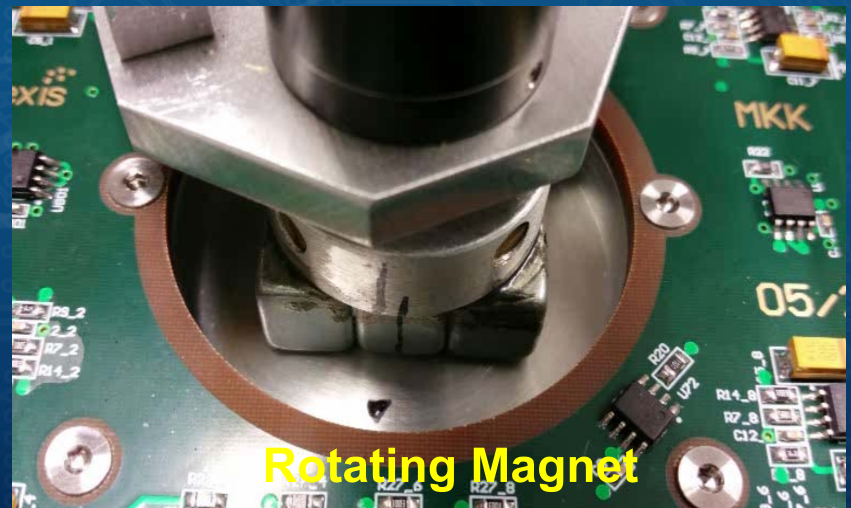
System setup

Test head & prober


High temperature chuck

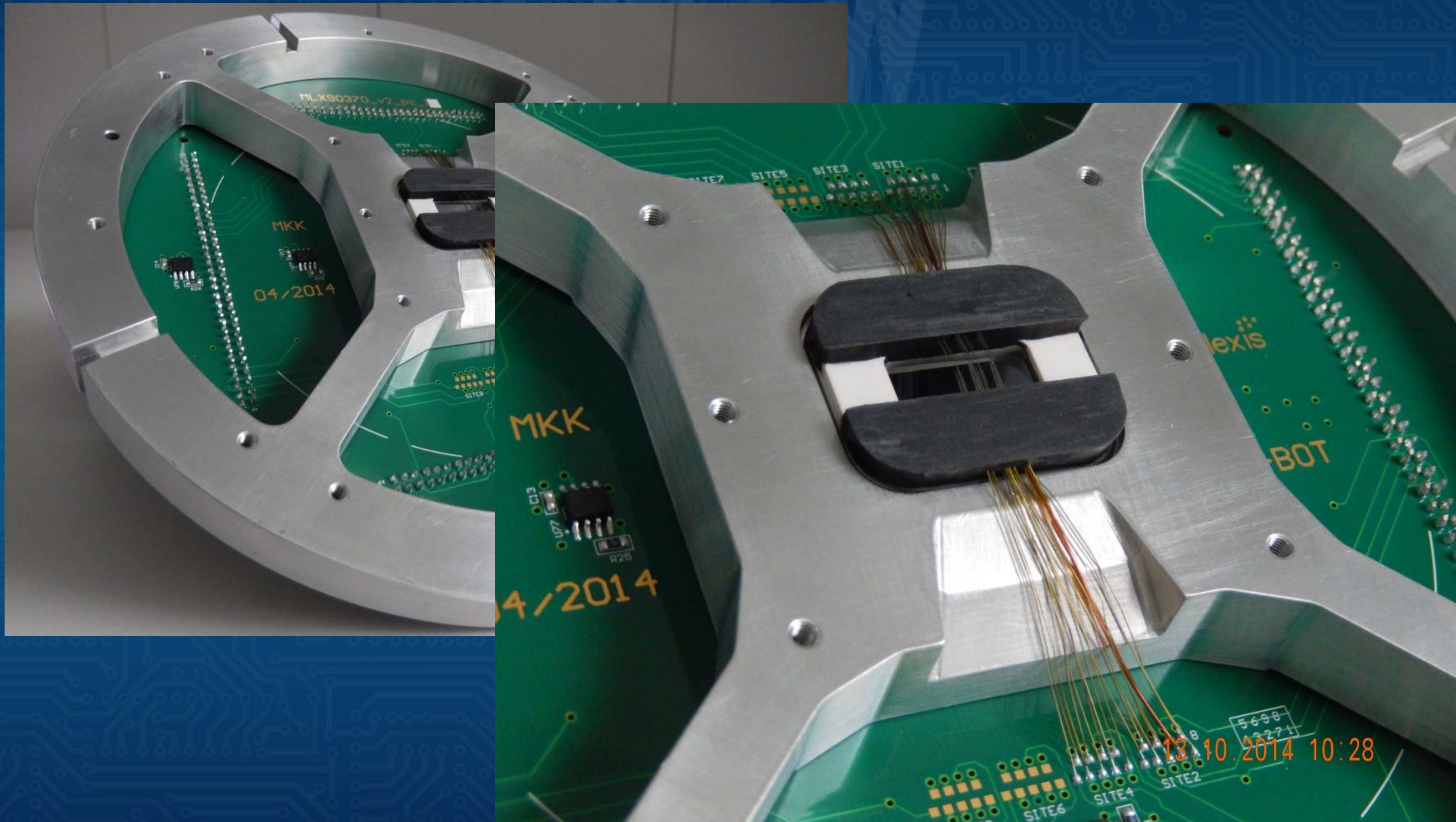


Probe card – top view



Rotating Magnet

High-temperature probe card (PCB & stiffener)

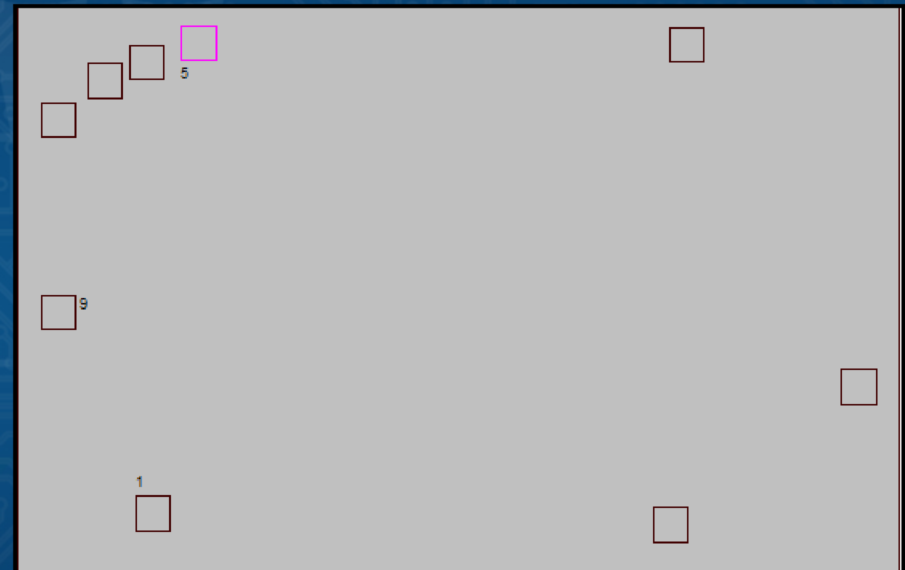


Material selection

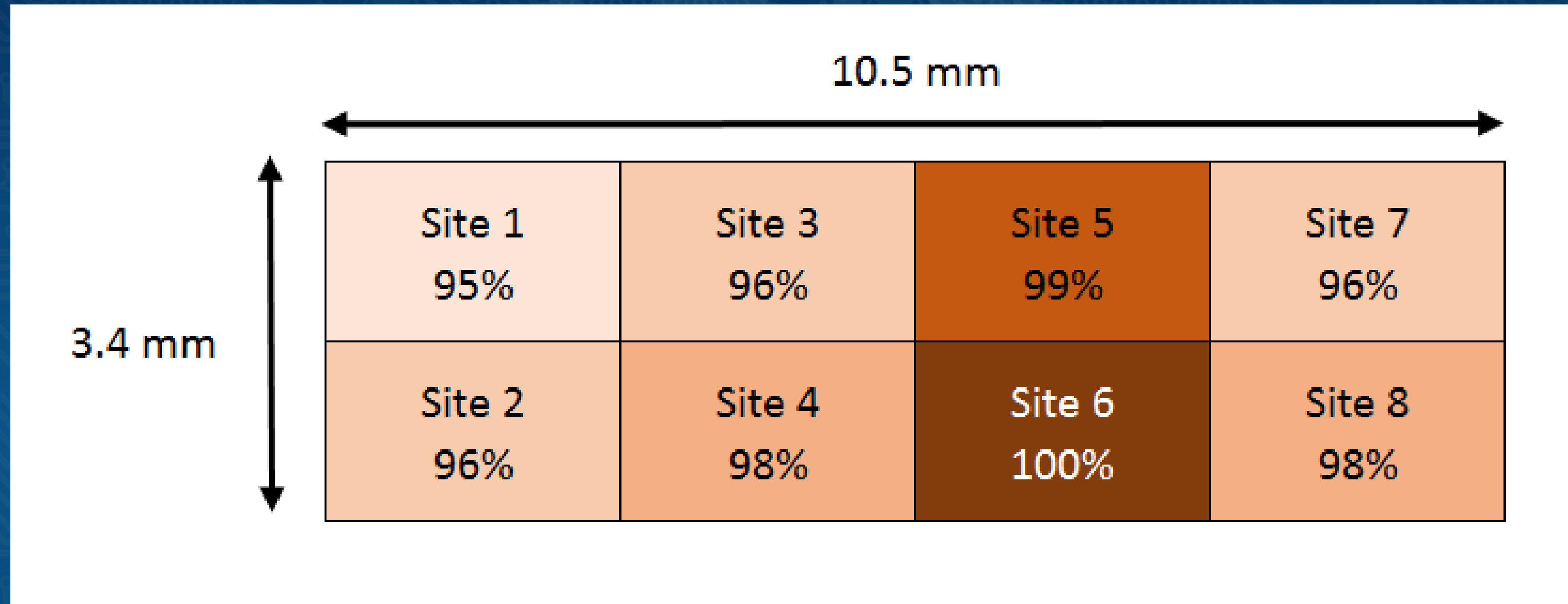
Test cell item	Material	Stiffness (Shear modulus) Gpa	Thermal expansion (CTE) um/m-°C	Thermal conductivity W/(m K)	Magnetic susceptibility	Selection result
PC stiffener + PC support (Prober insert ring)	Low-CTE steels	56	2	14	High	✗
	Stainless steels	77	14	16	Med	✗
	Aluminum alloy	27	23	205	Low	✓
PCB	High-Tg epoxy-glass Cu/Ni/Au plating	Variable	15 (XY plane) 60 (Z-axis)	Low	Low	Weak point
Probe ring	Ceramic	360	5	18	Low	✓
Probe-ring epoxy	High-temp. epoxy	15	10	Low	Low	✓
	Standard Epoxy	Poor	50	Low	Low	✗
Probes	Tungsten-Rhenium	161	4	174	Low	✓
Wafer	Silicon		3			

Probing conditions

Stepping X (μm) = 2615
Stepping Y (μm) = 1680
Pad Opening (μm) = 101 * 101
Recommended OD (μm) = 60
Alignment Tolerance (μm) = ± 7
Planarity Tolerance (μm) = ± 7
Operating Temperature (°C) = 35 .. 175
Minimum Pad Pitch (μm) = 133.2
Probe Material = ReW
Tip Diameter (μm) = 25 ± 5
Tip Shape = Semi Radius
Probe Force (g@ODtarget) = 6 ± 20%



Magnetic field uniformity



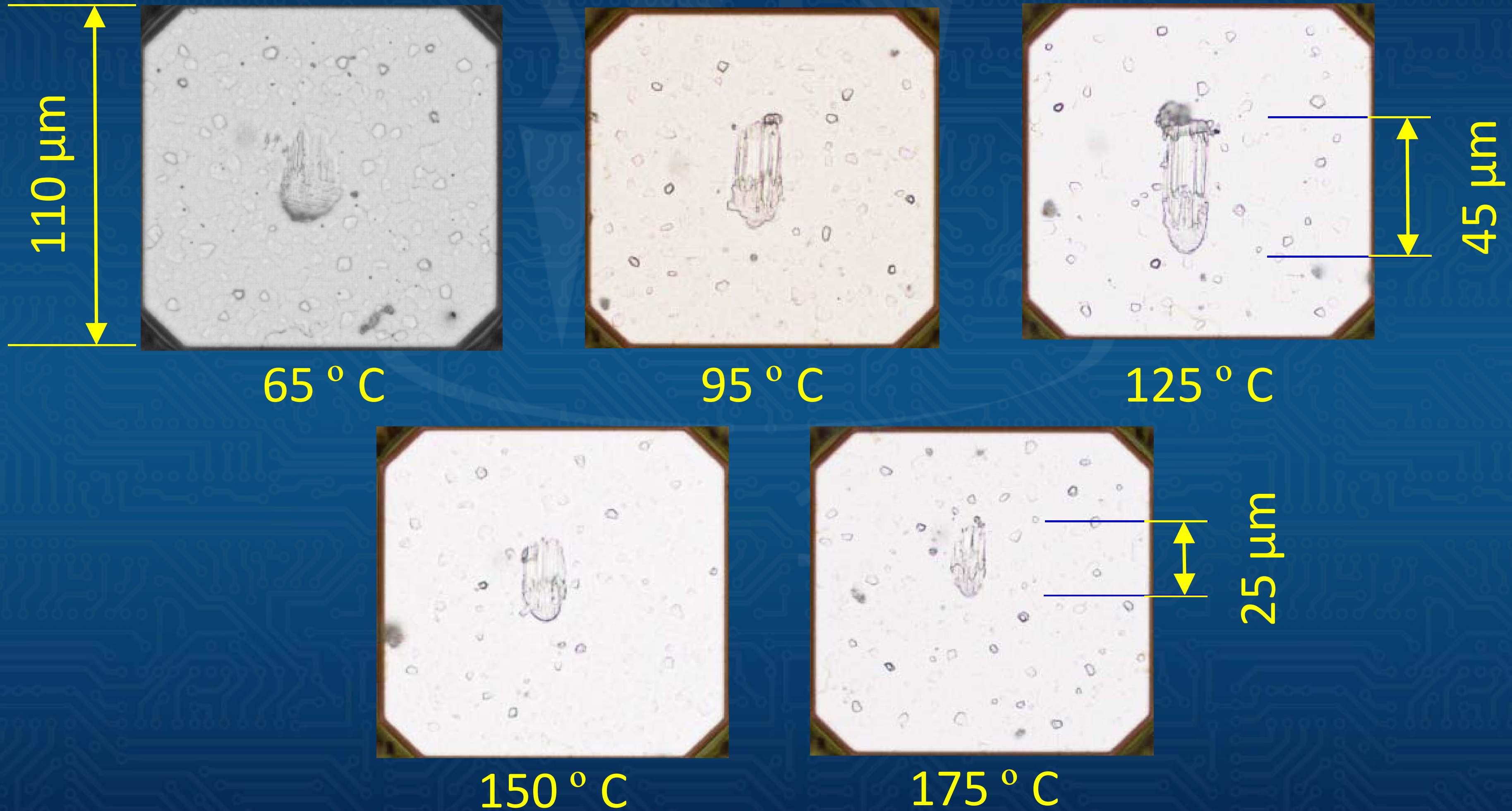
Center of magnetic field slightly shifted towards site 6

Field uniformity OK (5% variation across all sites)

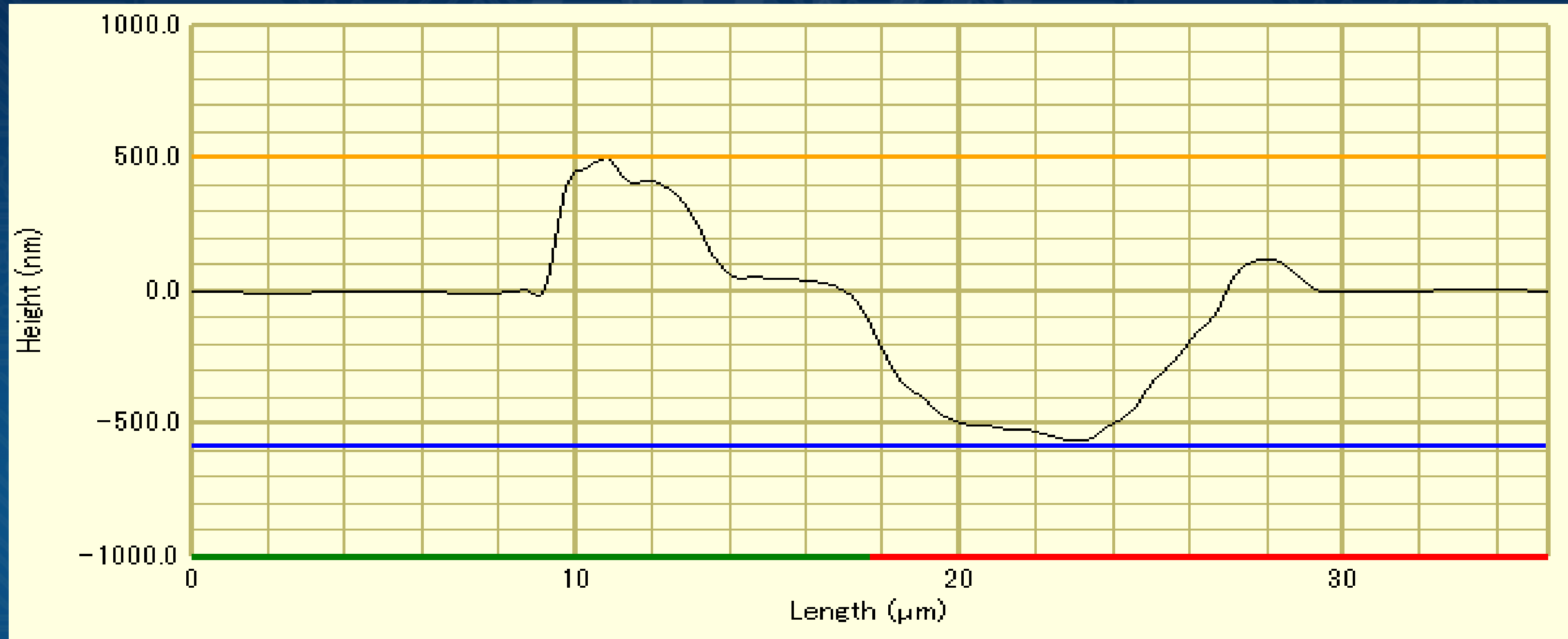
Evaluation criteria - summary

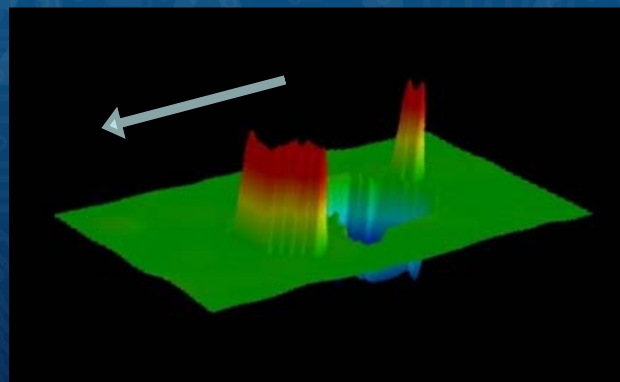
Criteria	Specification	Measured	Assessment
Stable PTPA (probe to pad alignment)			
Alignment tolerance over full temperature range	± 7 µm		
Planarity tolerance over full temperature range	± 7 µm		
Tip diameter (25 µm)	± 5 µm		
Acceptable probe card (system) deflection			
Uniform and stable pad damage (scrub marks)			
Scrub area in specification			
Scrub depth in specification			
Maximum scrub depth not to exceed material thickness			
Stable functionality over operating temperature	35 .. 175 °C		
Stable contact at recommended OD			
Repeatable yields at all temperatures			
Test results uniform among all sites			
Magnetic field uniform among all sites	5% field variation		
Probe card information			
Probe card cost	Low cost		
Probe card technology	Cantilever		
Tip Shape	Semi Radius		
Probe Force (g@ODtarget)	6 g ± 20%		

Scrub mark size versus temperature @ 60 μm OD

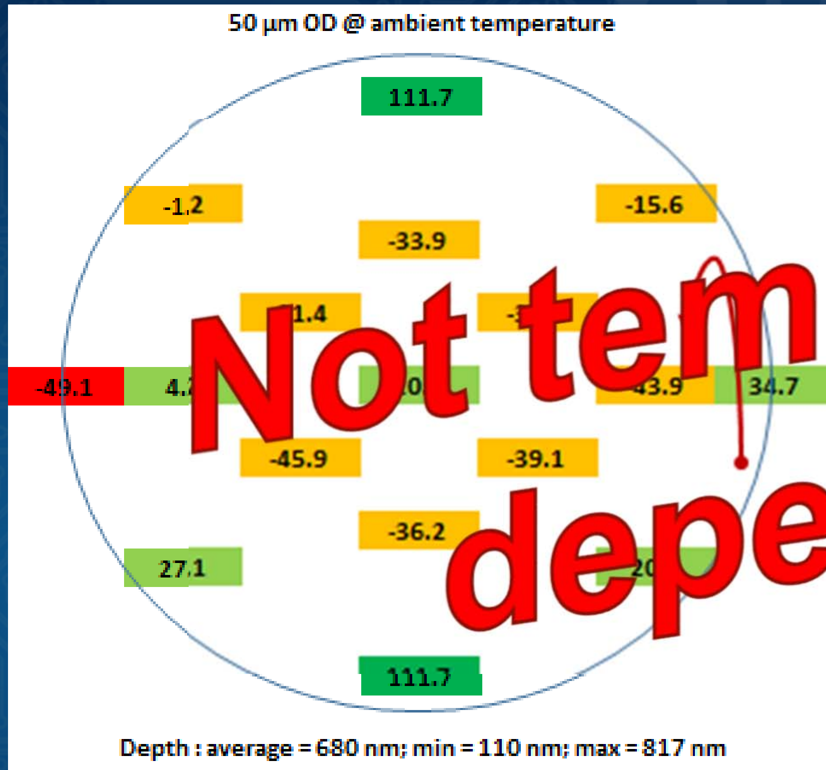


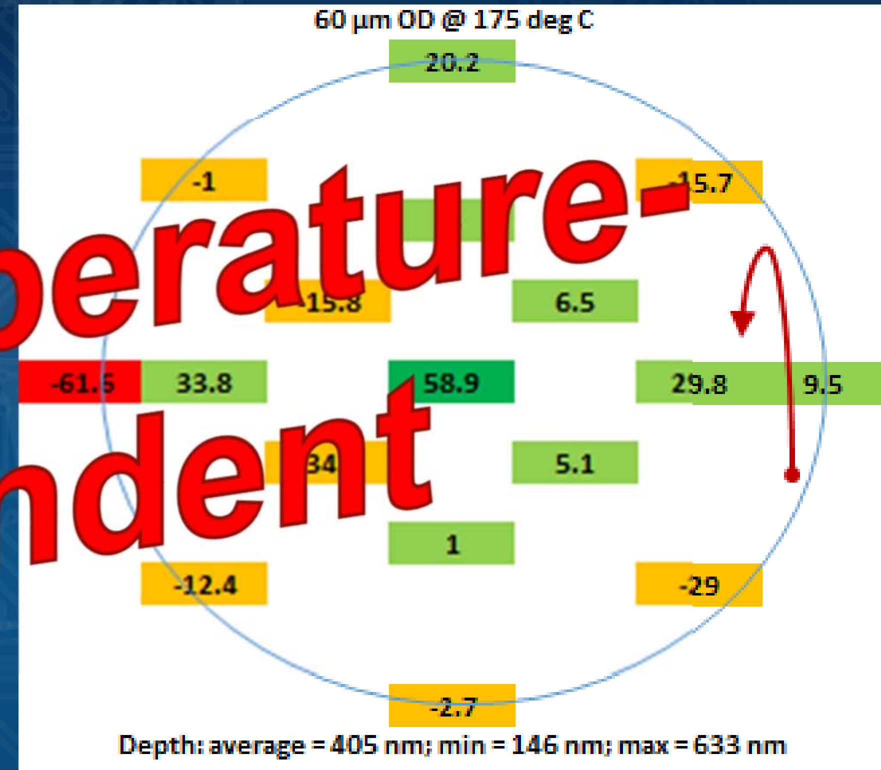
3D & profile @ 175 º C (60 μm OD)





Scrub profile depth variation





Highest point	
> Average	
< Average	
Deepest point	

Melexis Microelectronic Integrated Systems

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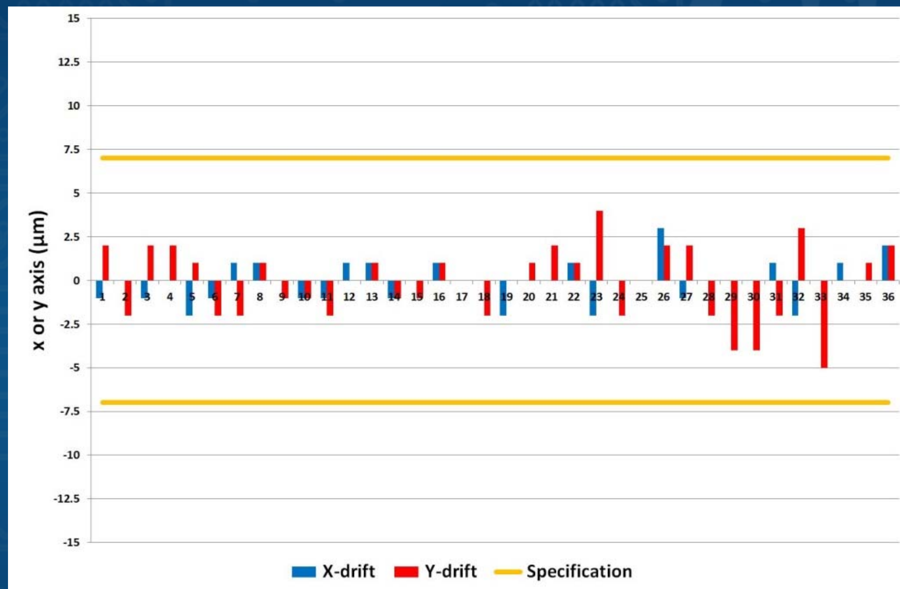
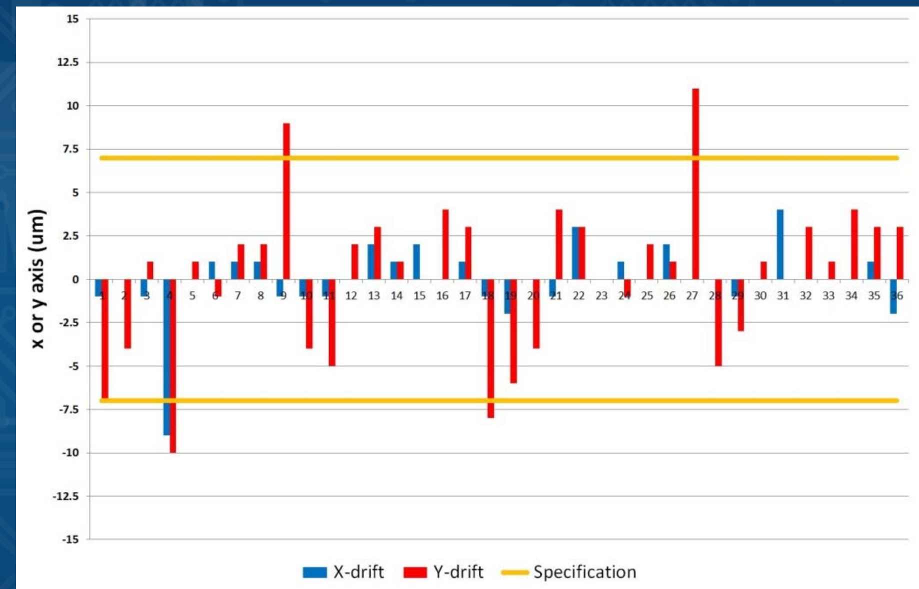
JEM

Needle alignment drift

Ambient



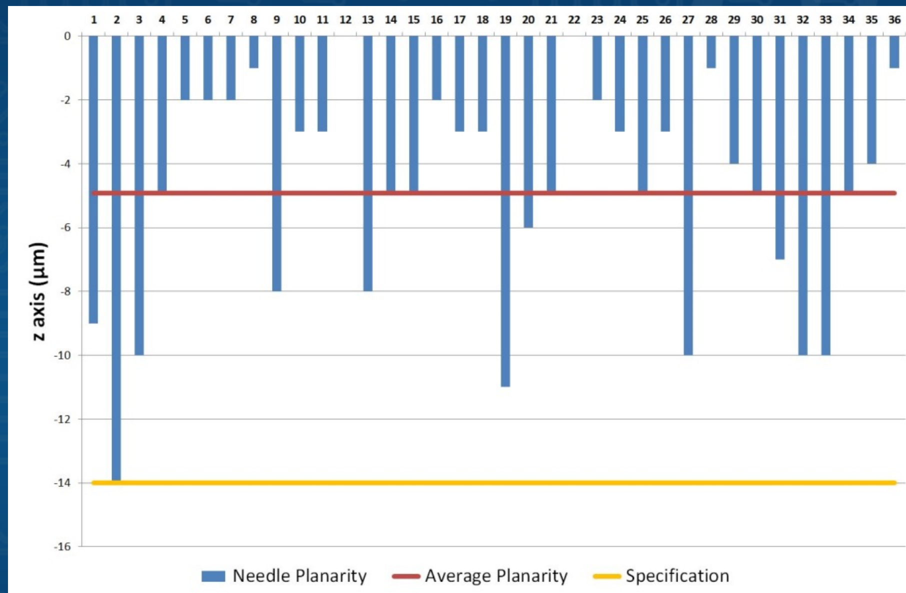
175 deg C



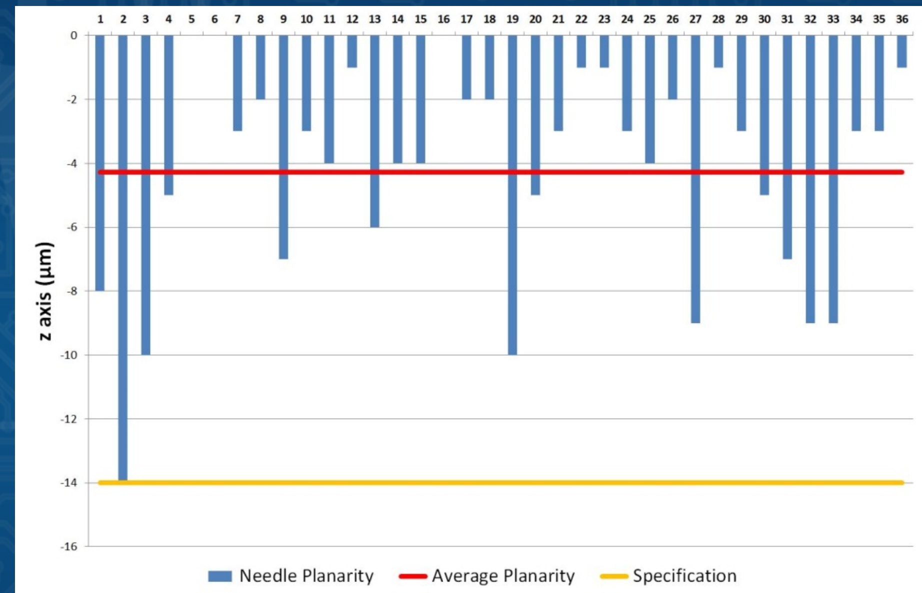
Drift is relative to tip position @ 0 TD.

Probe card planarity

Ambient



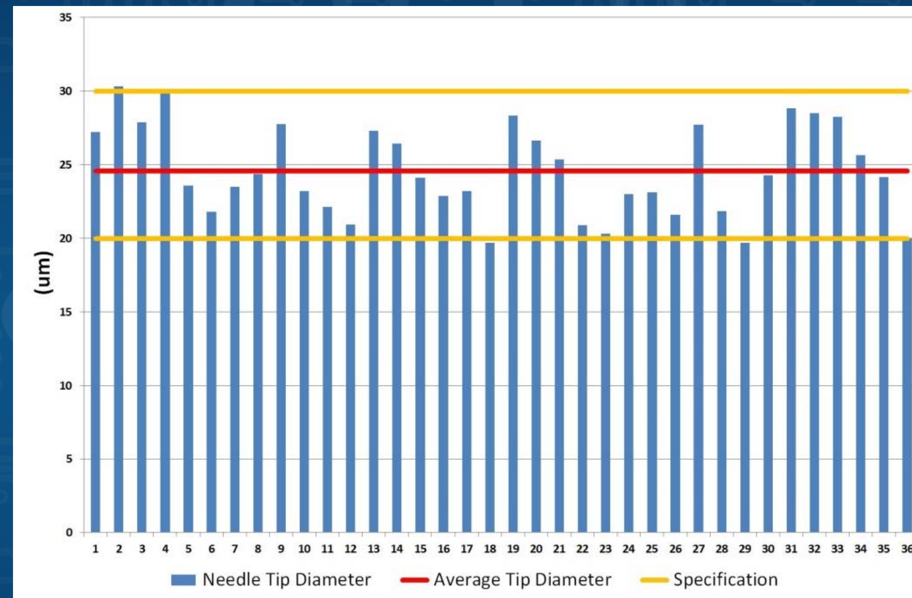
175 deg C



Planarity is relative to tip planarity @ 0 TD.

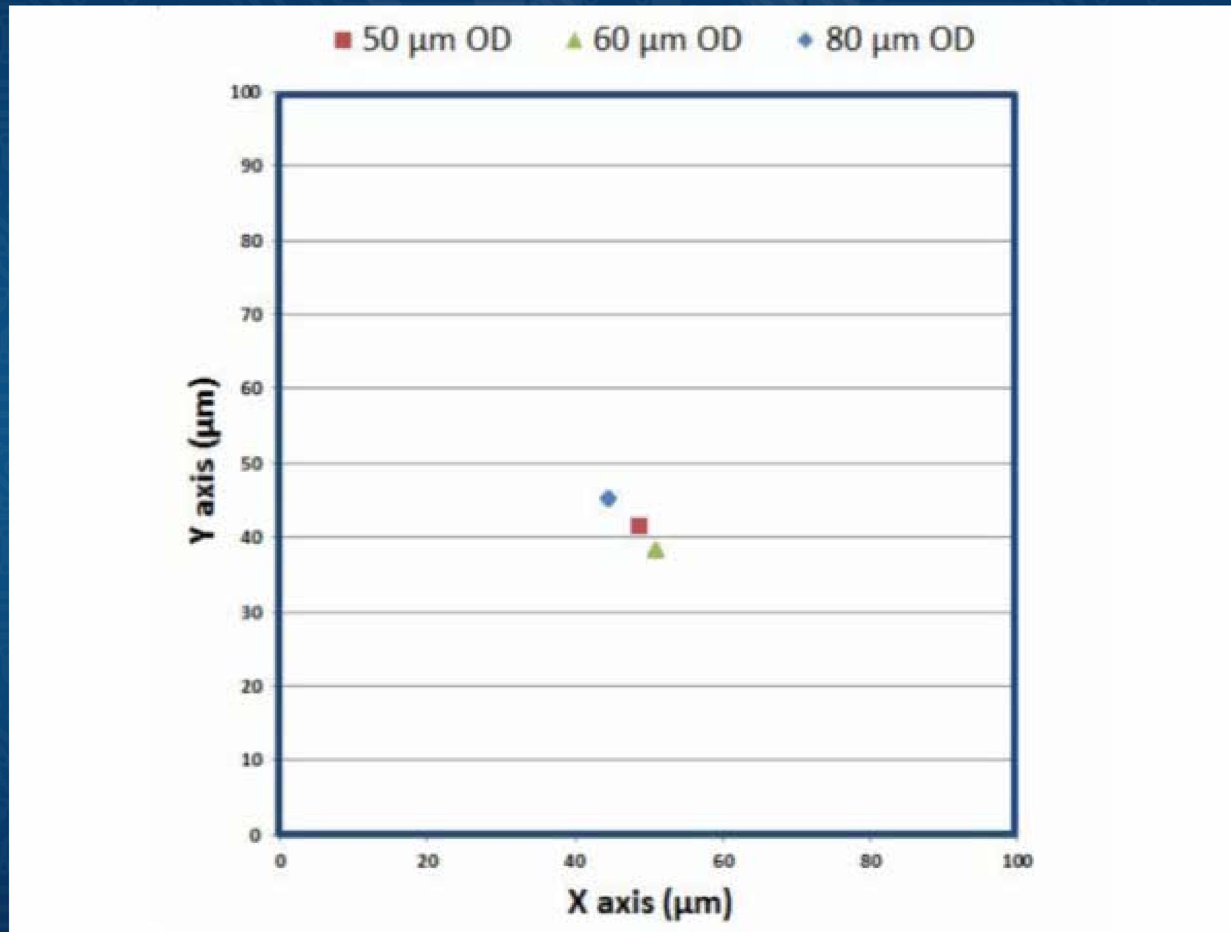
Tip diameter

Ambient

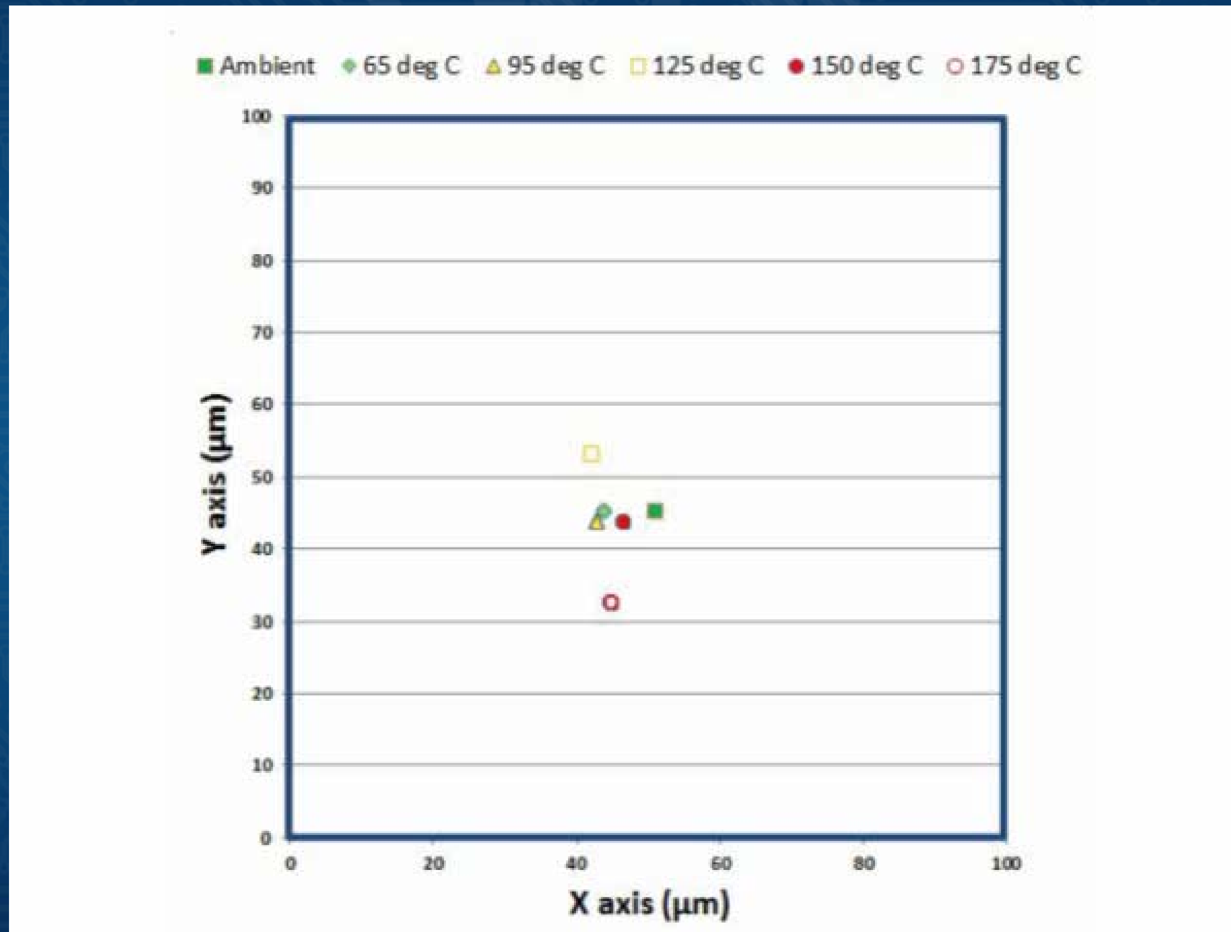


Not temperature-dependent.

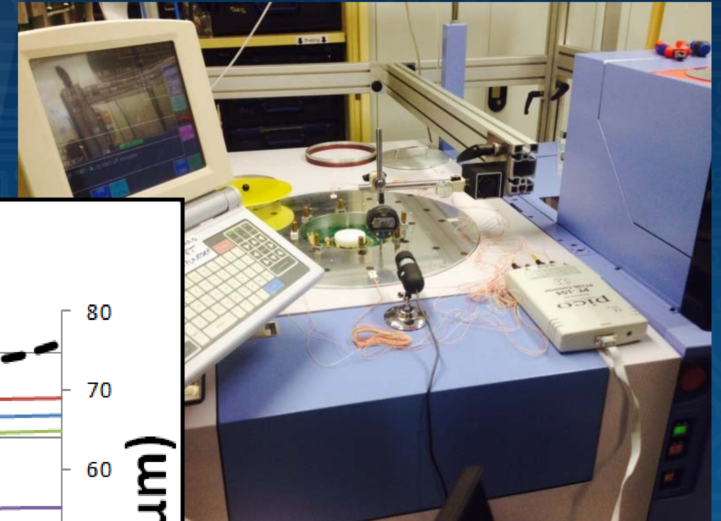
Probe-mark position @ ambient

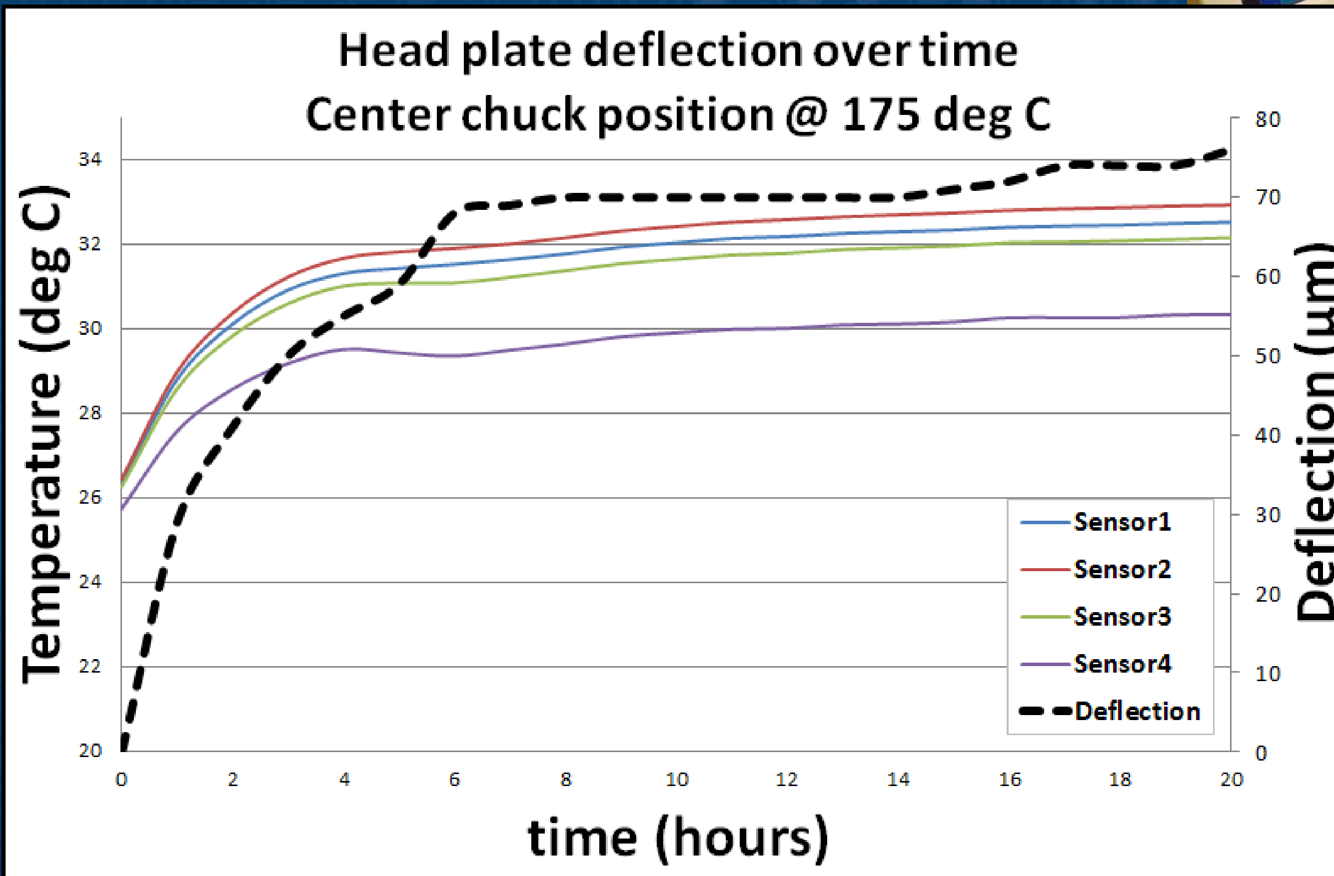


Probe-mark position versus temperature

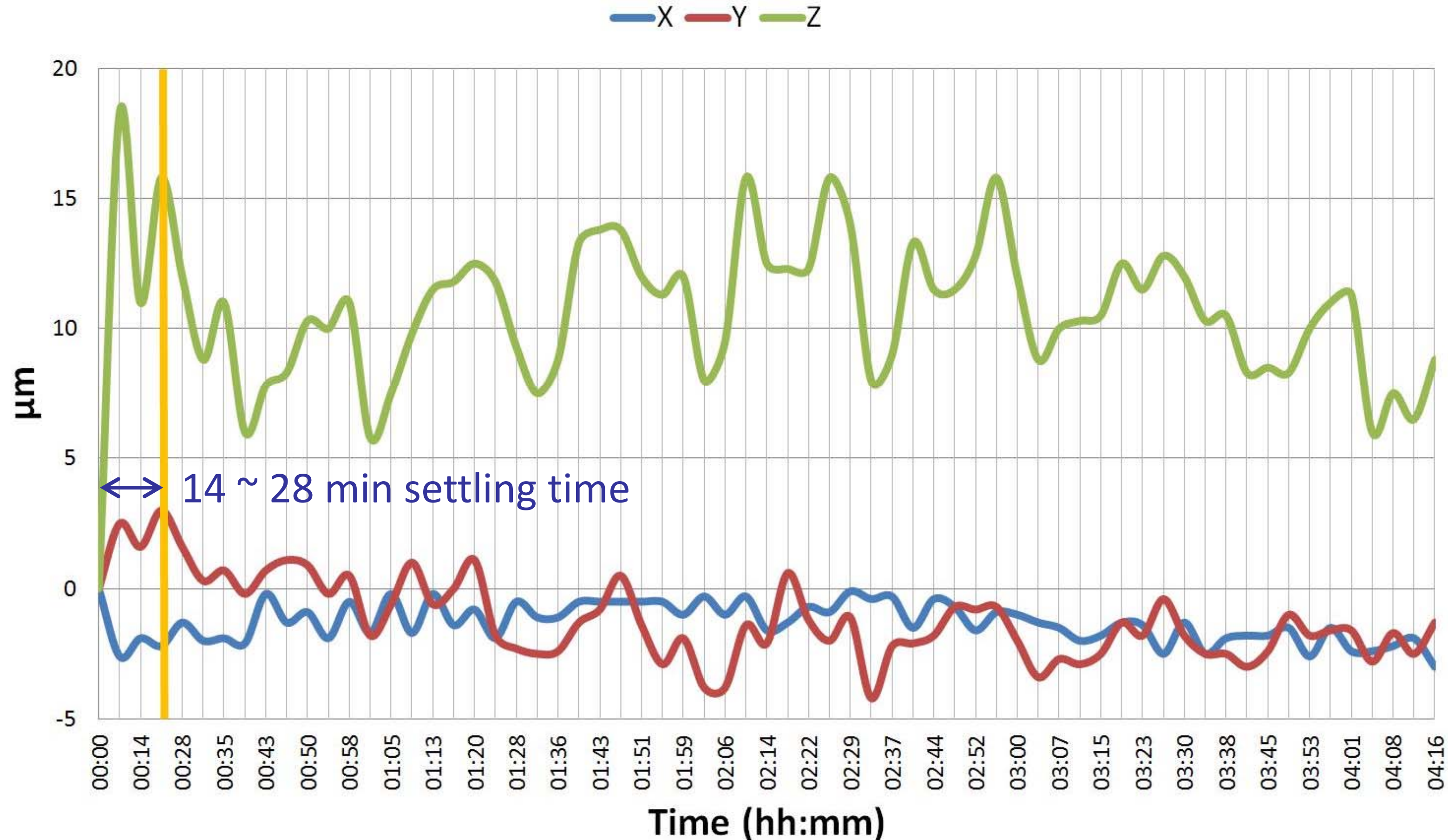


Temperature effects

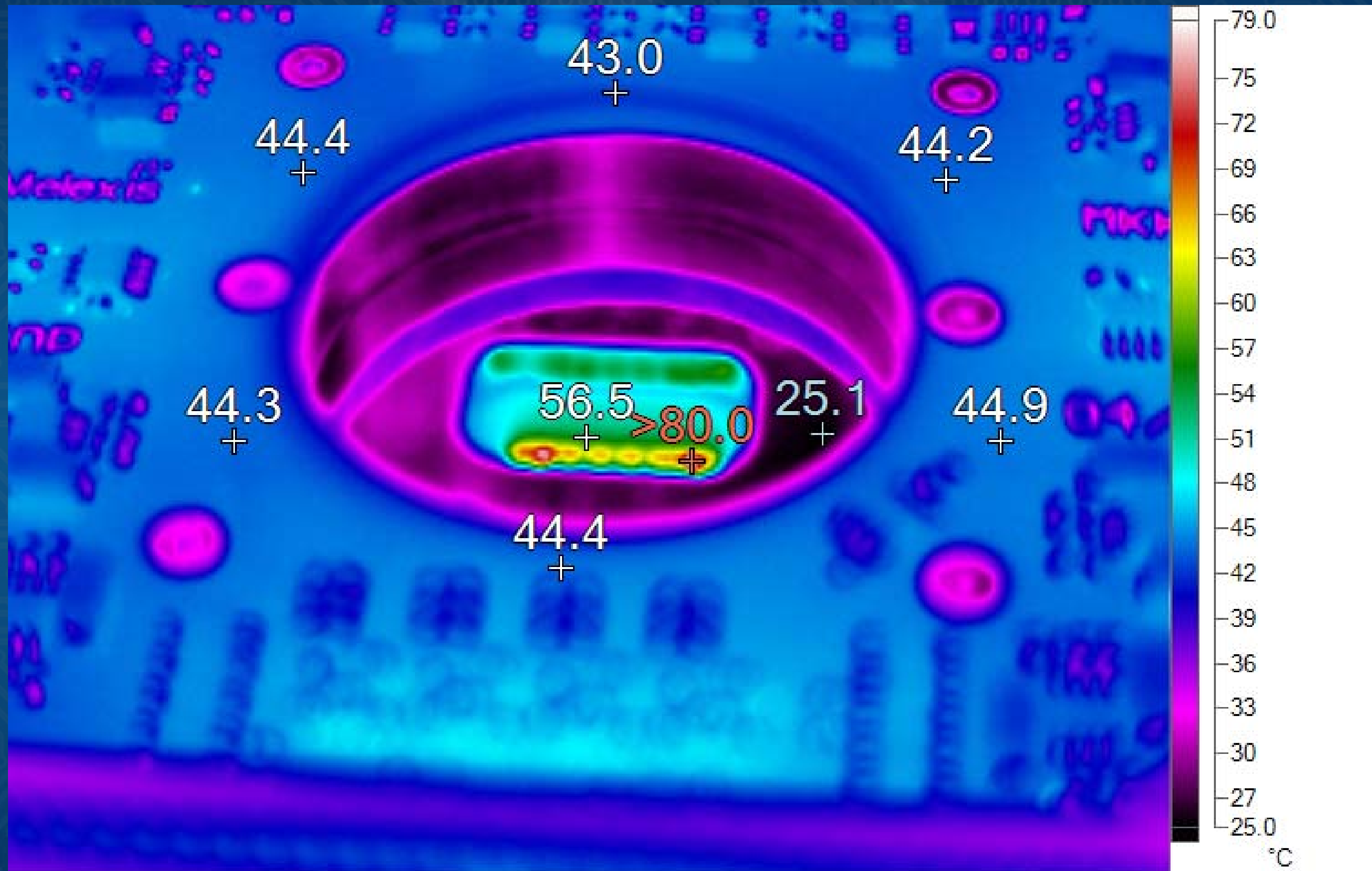




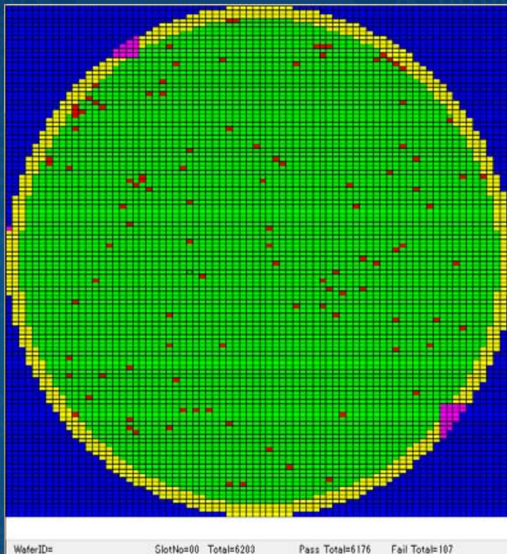
Probe card settling time



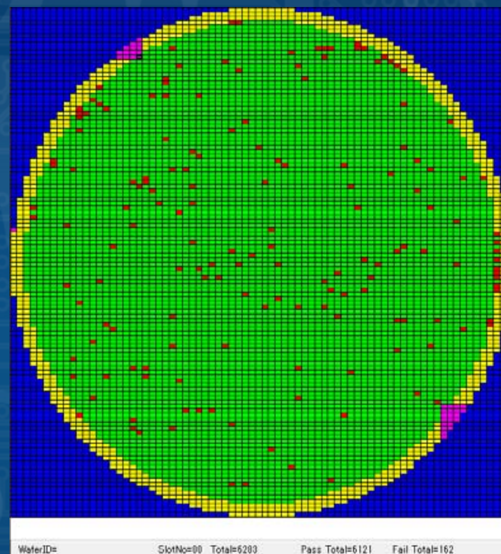
Temperature effects



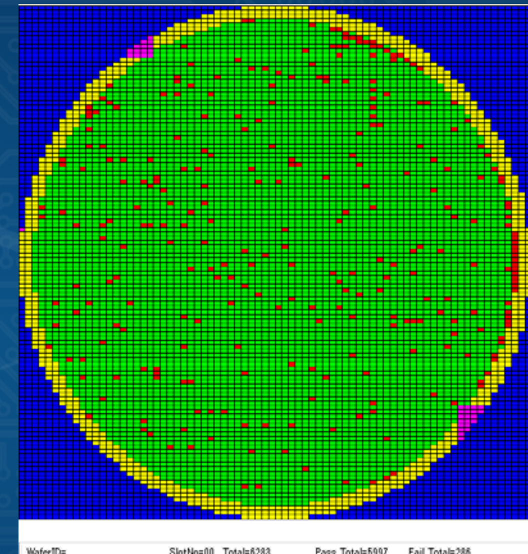
Initial functional test results



35 º C

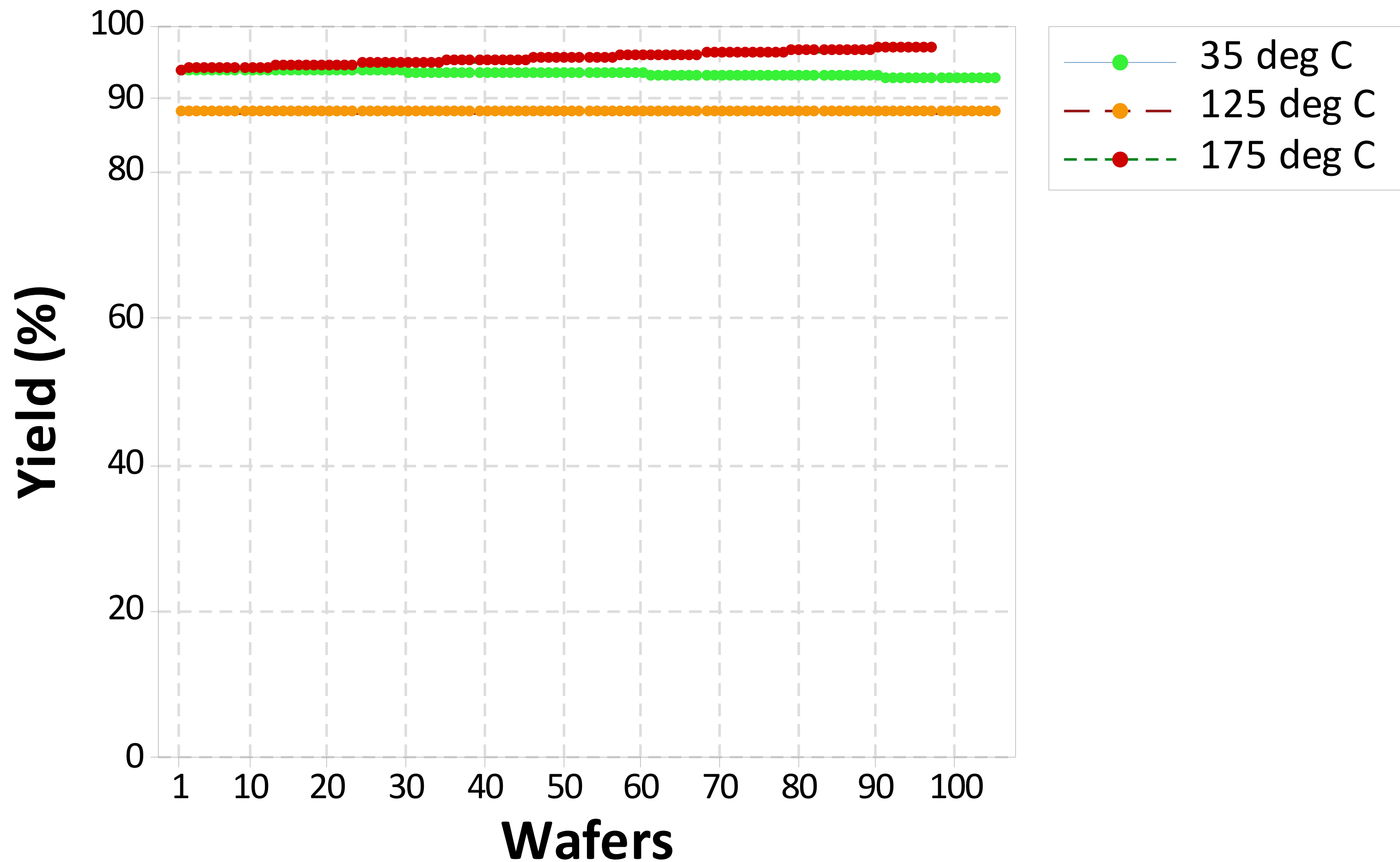


125 º C



175 º C

Yield versus number of wafers



Evaluation criteria - results

Criteria	Specification	Measured	Assessment
Stable PTPA (probe to pad alignment)			✓
Alignment tolerance over full temperature range	± 7 µm	+ 4 µm -10 µm	✓
Planarity tolerance over full temperature range	± 7 µm	- 14 µm	✓
Tip diameter (25 µm)	± 5 µm	min 18 µm- max 32 µm	*Acceptable*
Acceptable probe card (system) deflection			✓
Uniform and stable pad damage (scrub marks)			✓
Scrub area in specification		~1200 µm² (Ambient) ~400 µm² (175 °C)	✓
Scrub depth in specification		~680 nm (Ambient) ~405 nm (175 °C)	✓
Maximum scrub depth not to exceed material thickness		817 nm (Ambient) 633 nm (175 °C)	✓
Stable functionality over operating temperature	35 .. 175 °C		✓
Stable contact at recommended OD			✓
Repeatable yields at all temperatures			✓
Test results uniform among all sites			✓
Magnetic field uniform among all sites	5% field variation	5.5% in X-direction < 1% in Y-direction	*Acceptable*
Probe card information			✓
Probe card cost	Low cost		✓
Probe card technology	Cantilever		✓
Tip Shape	Semi Radius		✓
Probe Force (g@ODtarget)	6 g ± 20%		✓

Conclusions

- System-level approach successful for high-temp and multi-site testing of magnetic devices
- Entire test cell needs to be considered
- Low-cost cantilever probecard is acceptable
- Concept qualified for future products

Future work

- Observe the effect of probe card aging (in progress)
- Optimize first-pass yields for each temperature
- Evaluate low-force probe material to reduce scrub size and depth
- Evaluate the concept over wider temperature range (from -40 ^{o} C to 200 ^{o} C)
- Increase tests parallelism (possibly with vertical probe card)
- Improve positioning of magnetic sensor (in X Y Z)

Acknowledgements

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Frederic Plancke	Melexis
Julien Throckmorton	Melexis
Lindsey Ameele	Melexis
Olivier Dubrulle	Melexis
Peter Schops	Melexis
Vincent Hiligsmann	Melexis
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Thank you. Questions ?