SW Test Workshop
Semiconductor Wafer Test Workshop

Automated Thermal Drift Correction of Discrete Probes on Motorized Positioners for Device Characterization

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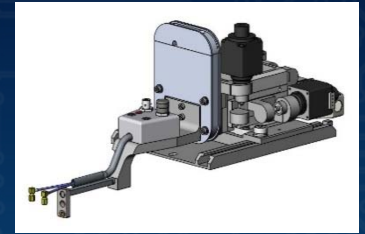
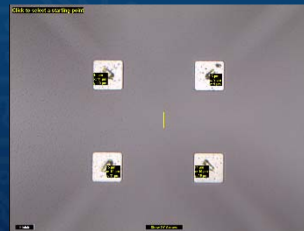
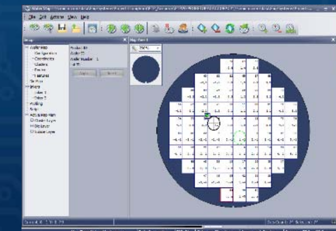
Introduction



- **<u>Problem</u>: As pad sizes shrink from 40um to 30um and smaller, fixed DC probes can no longer make reliable contact over temperature**
- **<u>Approach</u>: Motorize positioners and add controls to enable Unattended Testing at Multiple Temperatures (UT@MT) on Cascade CM300 Probe Stations**
  - Perform probe-to-pad realignment automatically when changing temperature, loading wafer, or stepping to new die
  - Develop fully autonomous operation





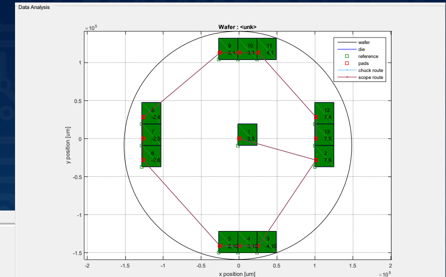
Motorized Positioner Hardware

DPP-504 Motorized Positioners
- 3 axis stepper drives
- 10mm range of travel
- 60nm resolution

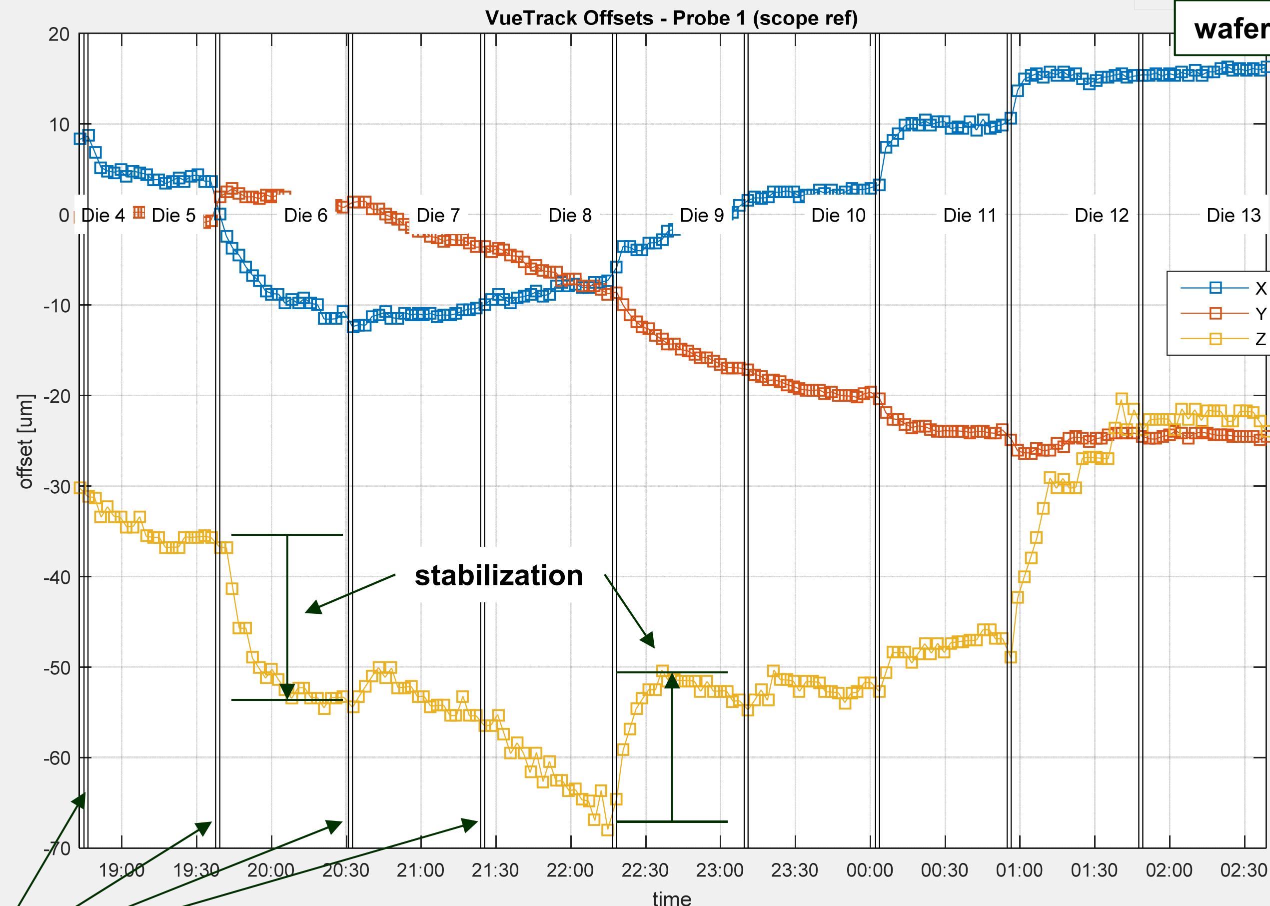
Cloth boot replaces top hat sliders:
- Low friction
- Thermal isolation
- EMI shielding (conductive)
- Light tight

MPX positioner controller installs in back of probe station

Stabilization Time



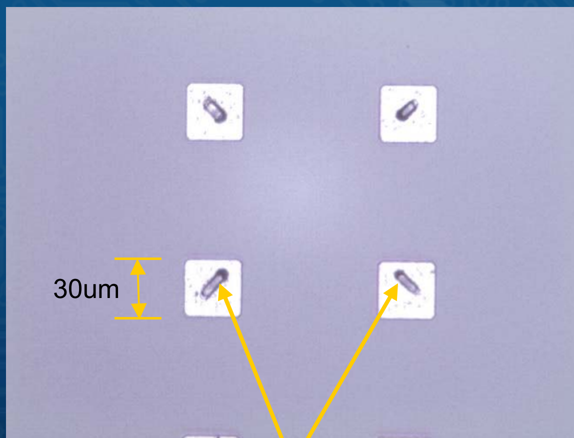
wafer map & chuck route

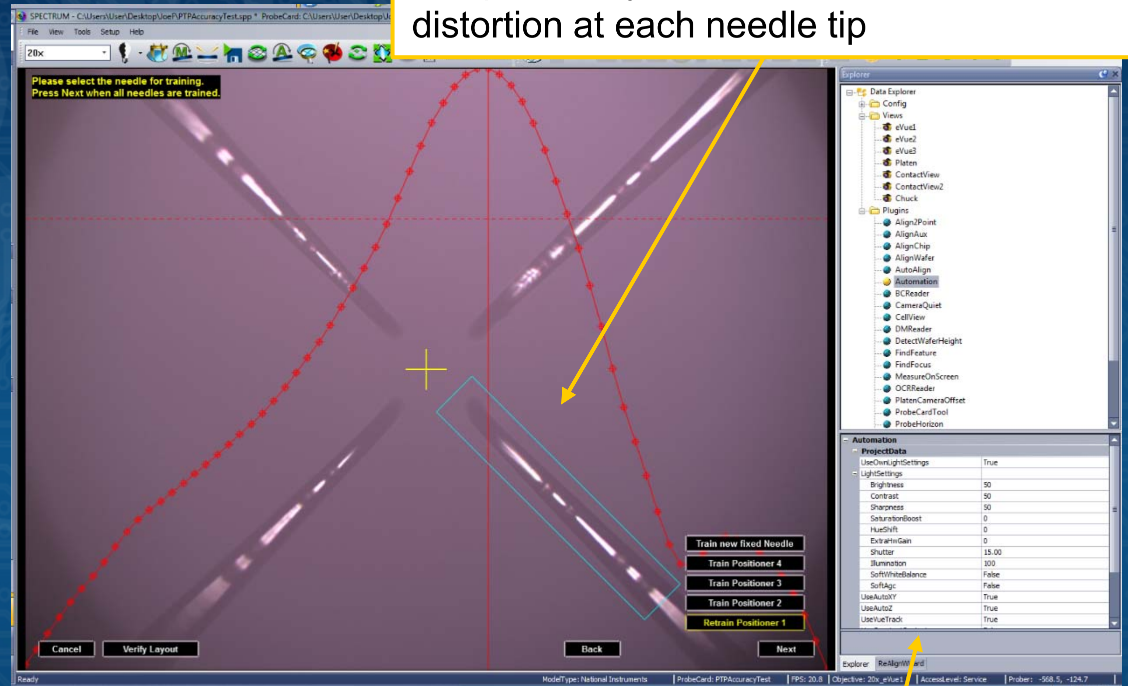


die stepping

Uncorrected probe-to-pad motion due to die stepping at temperature exhibits well behaved 1st order response, and can be used to optimize die soak time

VueTrackPro Software





Vision-based position feedback independently corrects for thermal distortion at each needle tip

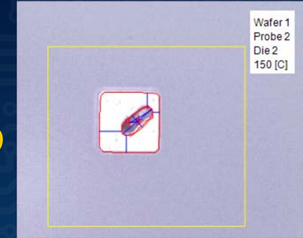
New capabilities with VueTrack Automation (*VueTrackPro*) to control motorized positioners

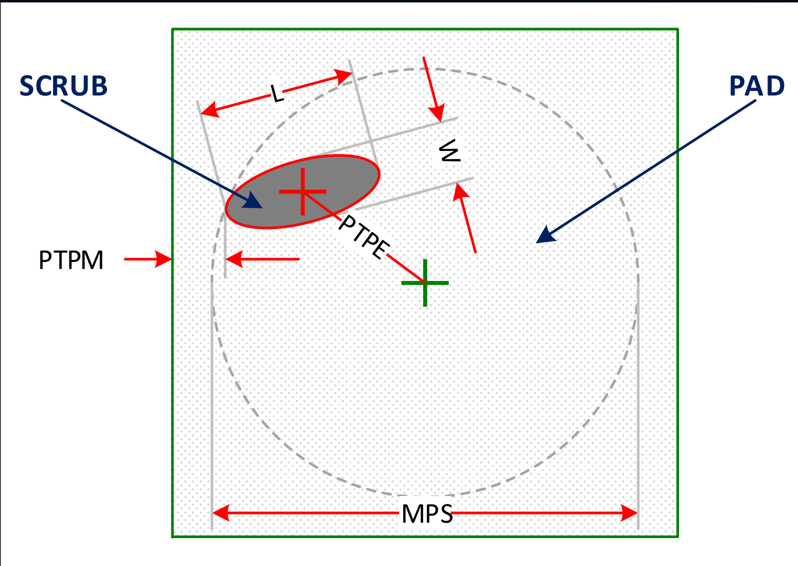
Unattended performance demonstrated over temperature on 30um pads

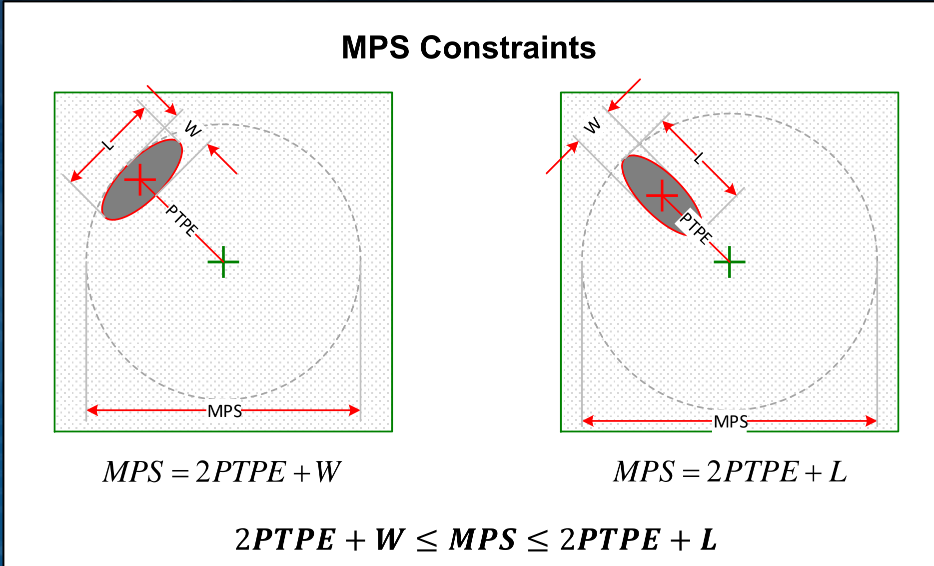
Verification Use Case Parameters

Parameter	Specification
Probe Station	CM300
Probes	DCP-HTR w/fiducial marks
Tip diameter	10 μm
eVue Objective	20X
Scrub Length	15-25 um
Contact Resistance	$< 2\ \Omega$
Temperature Range	-60C to +200C
Wafer Soak Time	3 hrs
Die Soak Time	10 min

Probe-to-Pad Accuracy Metrics



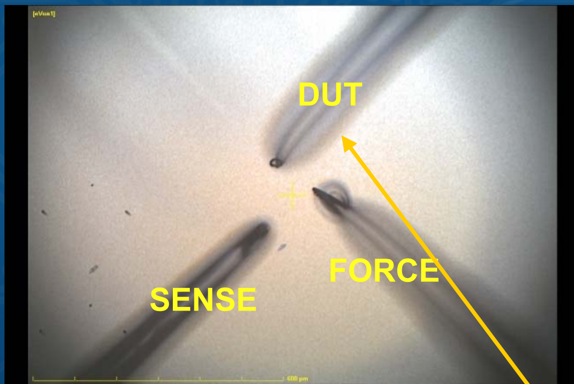


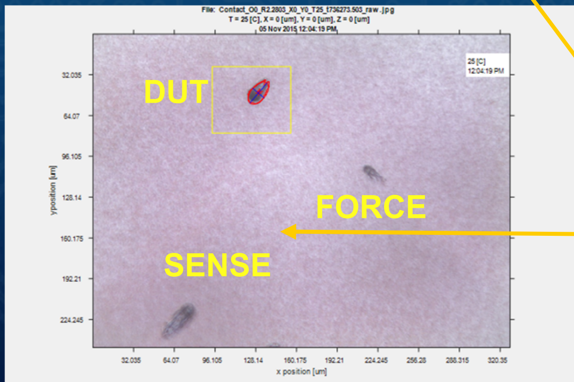


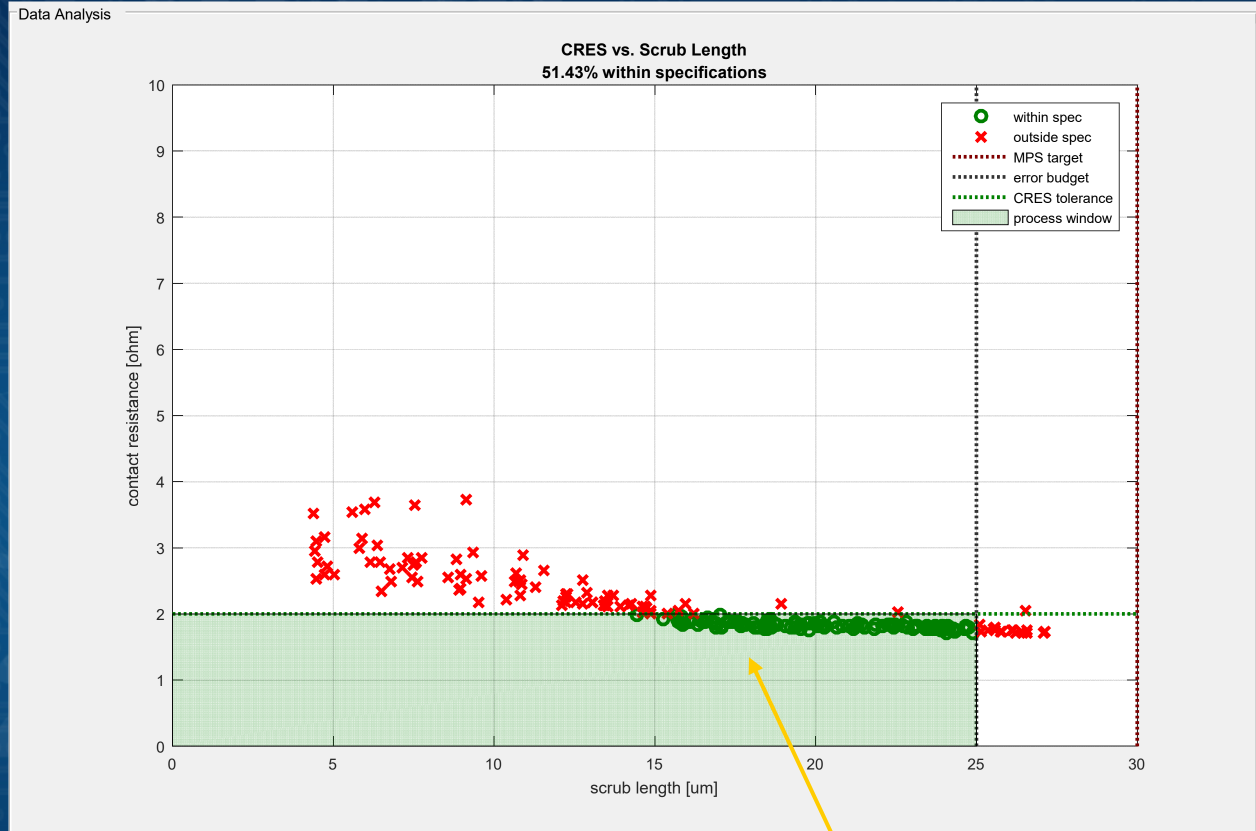
Terminology	Unit	Definition
Minimum Pad Size (MPS)	μm	radial distance from center of pad to furthest point on scrub mark
Effective Pad Size (EPS)	μm	EPS = MPS – Tip Diameter
Probe-to-Pad Error (PTPE)	μm	radial distance from center of pad to center of scrub mark
Probe-to-Pad Margin (PTPM)	μm	shortest distance from scrub mark to edge of pad
Scrub Length (L)	μm	length of long axis of scrub mark
Scrub Width (W)	μm	length of short axis of scrub mark
Contact Resistance (CRES)	Ω	Resistance between probe tip and wafer as obtained by Kelvin measurement with B1505A

Data File:
CRES003

CRES vs. Scrub Length Characterization



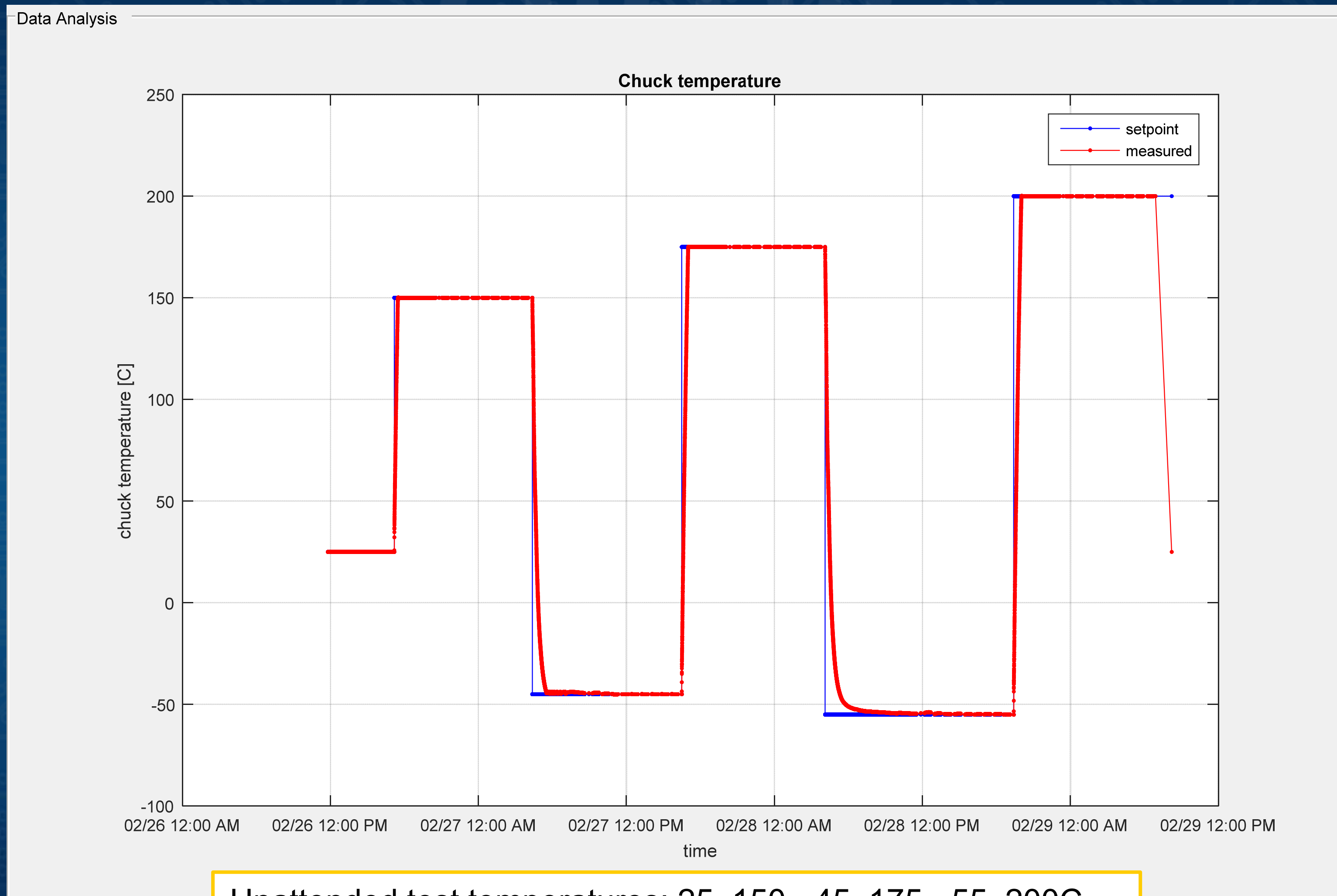




- Contact resistance measured with Keysight B1505A in Kelvin configuration
- Scrub length measured with automated image processing

→ ***Data indicates process window of CRES < 2ohm for scrub length >15um*** *on Cascade test wafer*

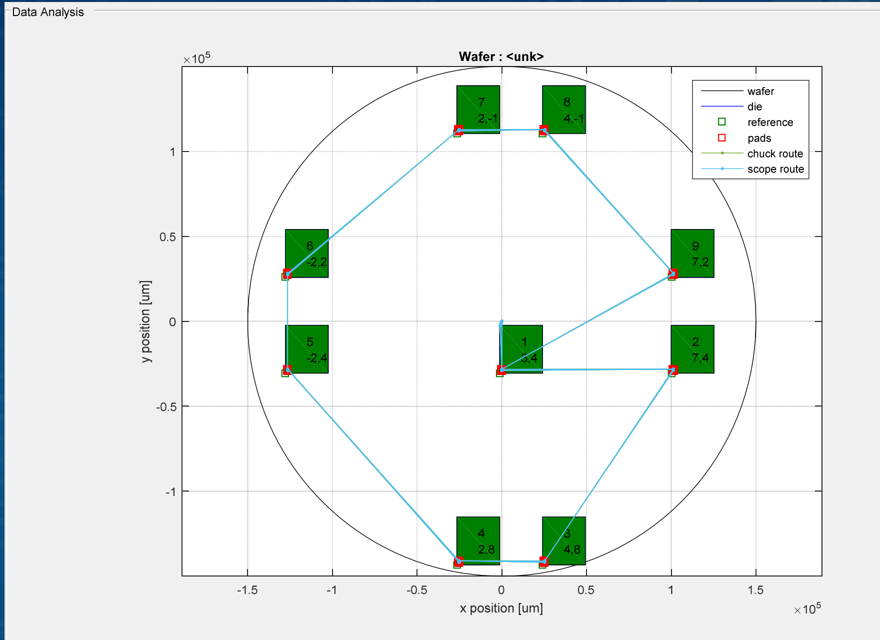
Chuck Temperature vs. Time

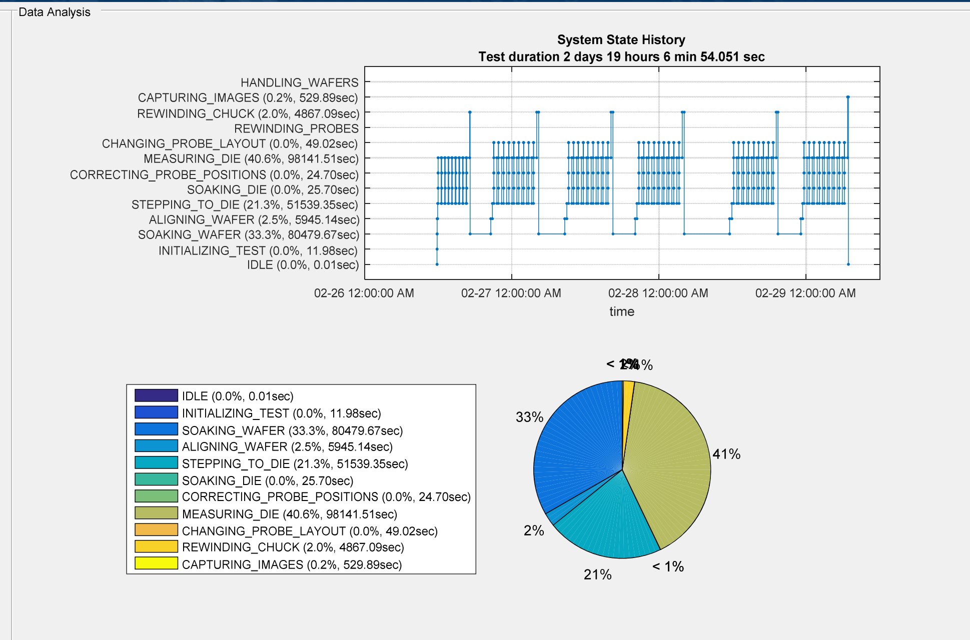


Unattended test temperatures: 25, 150, -45, 175, -55, 200C

Data File:
PTP127

Wafer Map & System State





Wafer map illustrates selected die and chuck motion route vs. XY

System state chart illustrates thermal transitions, wafer stepping, and probing over multiple temperatures vs. time, as well as breakdown of system utilization

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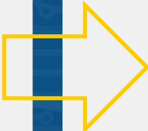
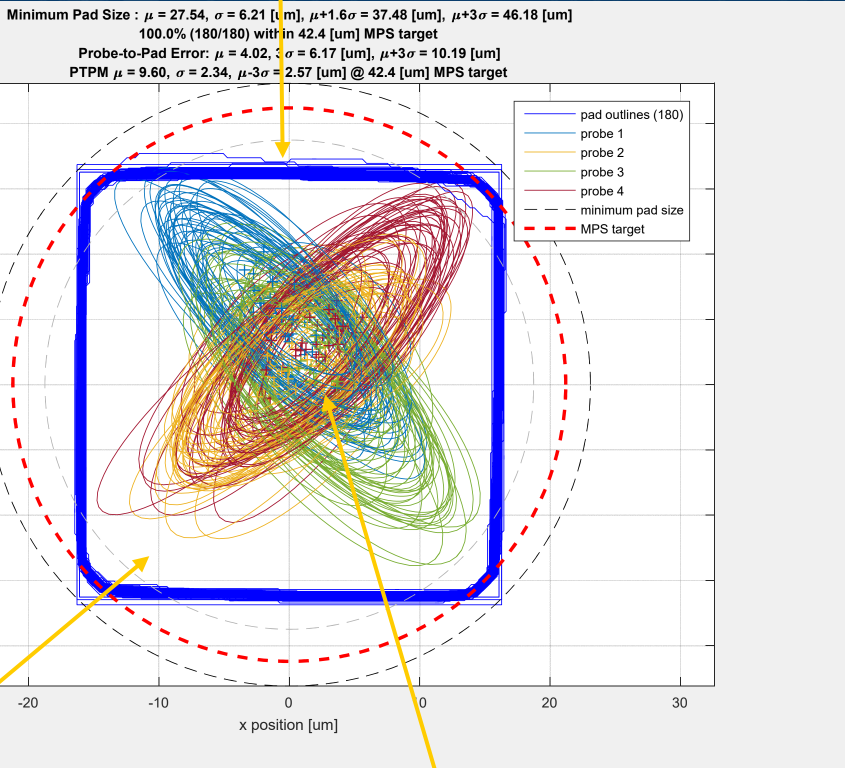
Probe-to-Pad Accuracy - Spatial



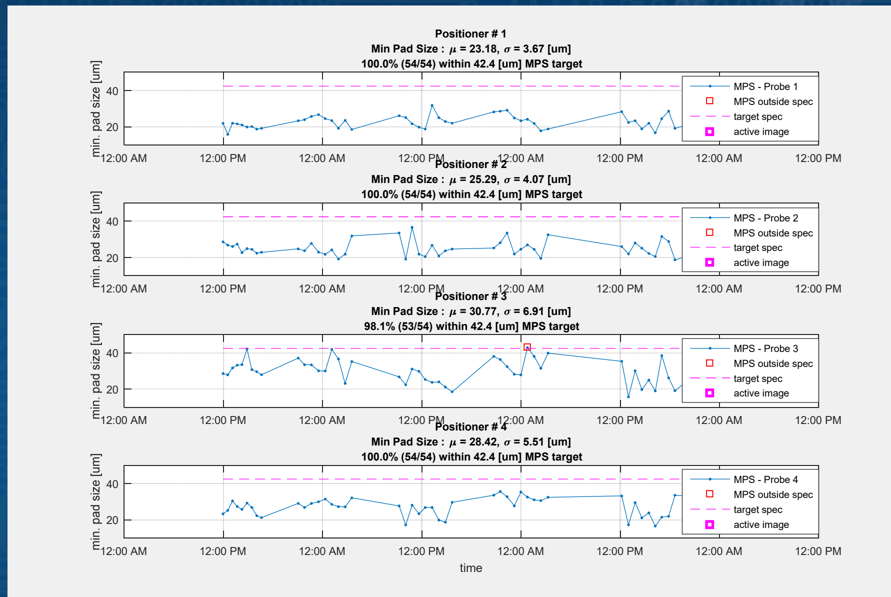
Unattended test temperatures: 25, -55, -40, 150, 175C



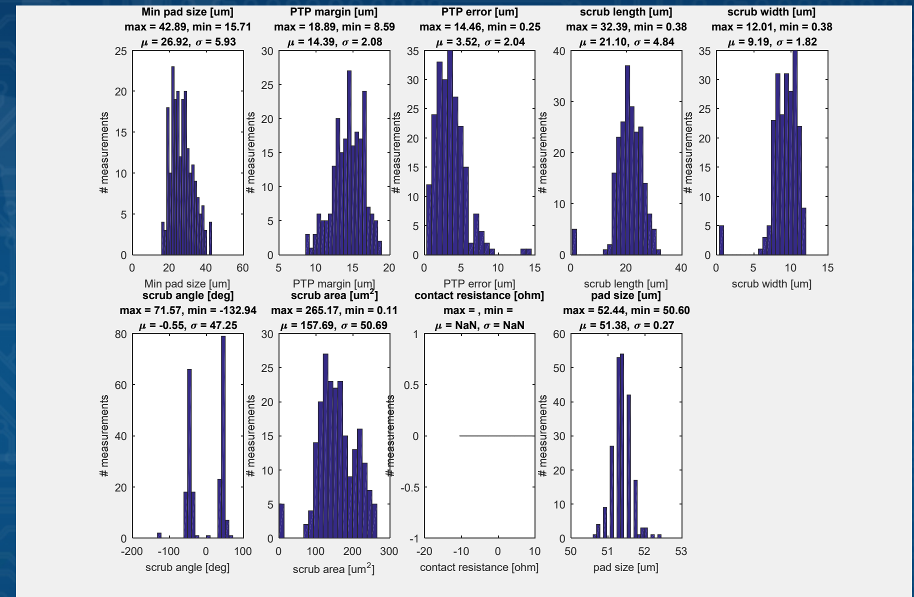
30um pads

Scrub mark measurements
All 180 marks within 30um pads in this example

Probe-to-Pad Accuracy – Temporal & Statistical



Minimum pad size vs. time by probe



Accuracy metric distributions

Looking at data from different perspectives provides insights into probing performance and enables troubleshooting

Data File:
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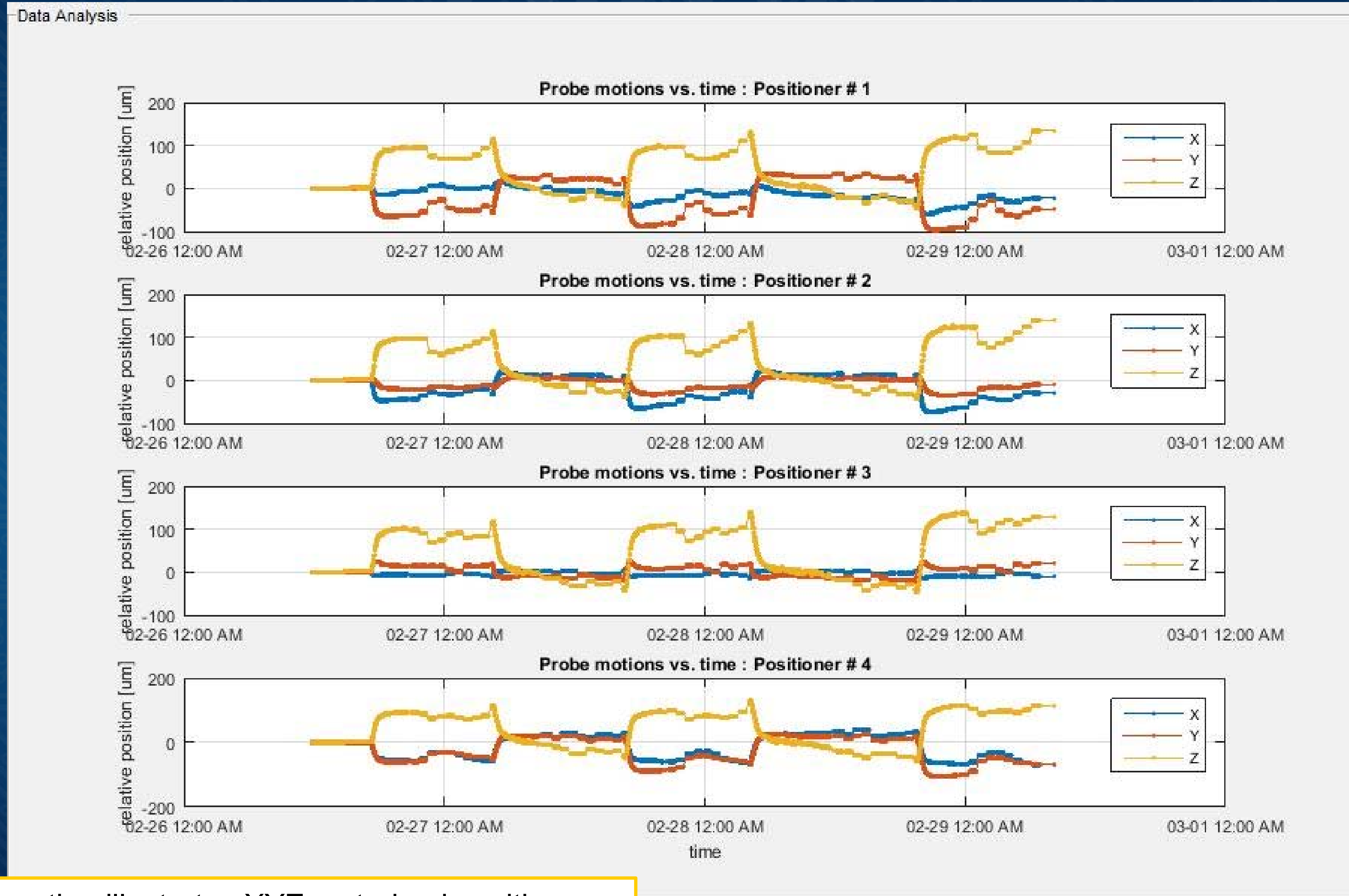
Probe Motion vs. Time

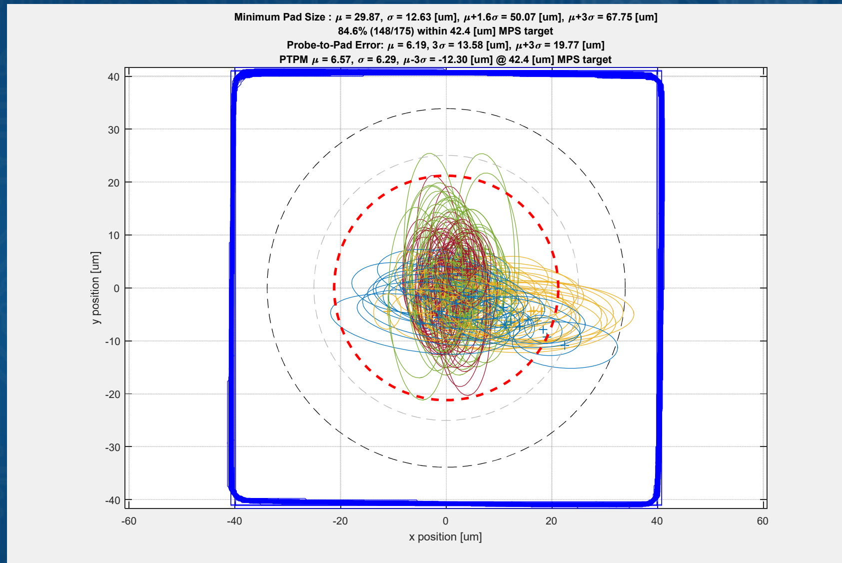


Probe motion illustrates XYZ motorized positioner correction at each die step and thermal transition

Motorized vs. Non-Motorized

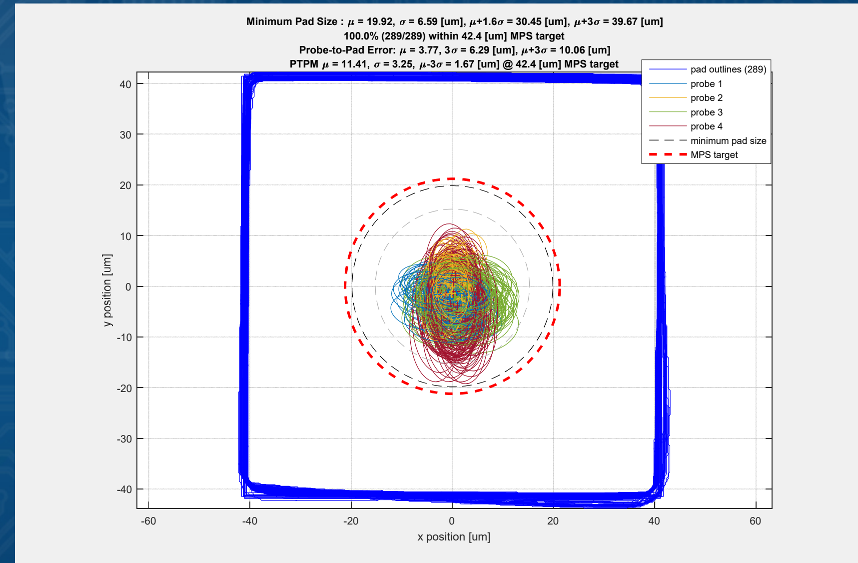
Non-Motorized, Uncorrected

MPS 67.75 um (3σ)



Motorized, Corrected

MPS 39.67um (3σ)



Minimum Pad Size (MPS) metric reduced by motorized correction when stepping and probing at temperature relative to uncorrected case

Conclusions

- **Vision-based alignment with laser etched tips enables correction of thermal distortion anywhere in the probe-to-pad kinematic loop after stabilization**
- **Autonomous probing of 30um pads over temperature has been demonstrated at Cascade Microtech in Germany and the US**
- **Autonomous probing of 30um pads over temperature has also been demonstrated at a key customer site**

Data File: PTP126

UT@MT Probing Animation