electroglas

Measuring Z-stage accuracy using a force sensor

SWTW

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WAFER PROBERS • TEST HANDLERS • TEST FLOOR MANAGEMENT SOFTWARE

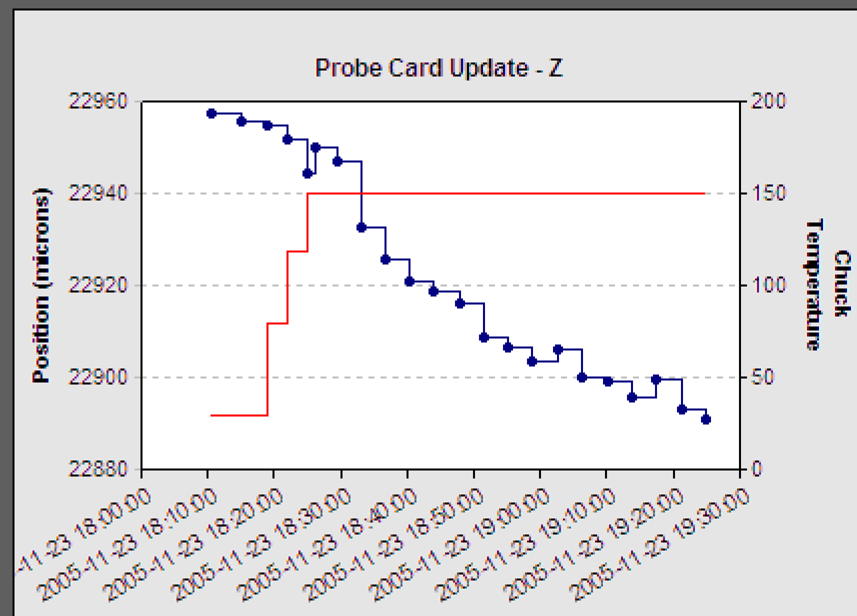
Contents

Z-accuracy requirements are becoming more stringent

- Brittle dielectrics
- Aluminum capped copper
- Circuitry under pads
- When probing at temperatures other than ambient, almost every part of the pin to pad interface moves thermally
    - Probe-card
    - Interface
    - Ring carrier
    - Z-stage?

Exposed Copper

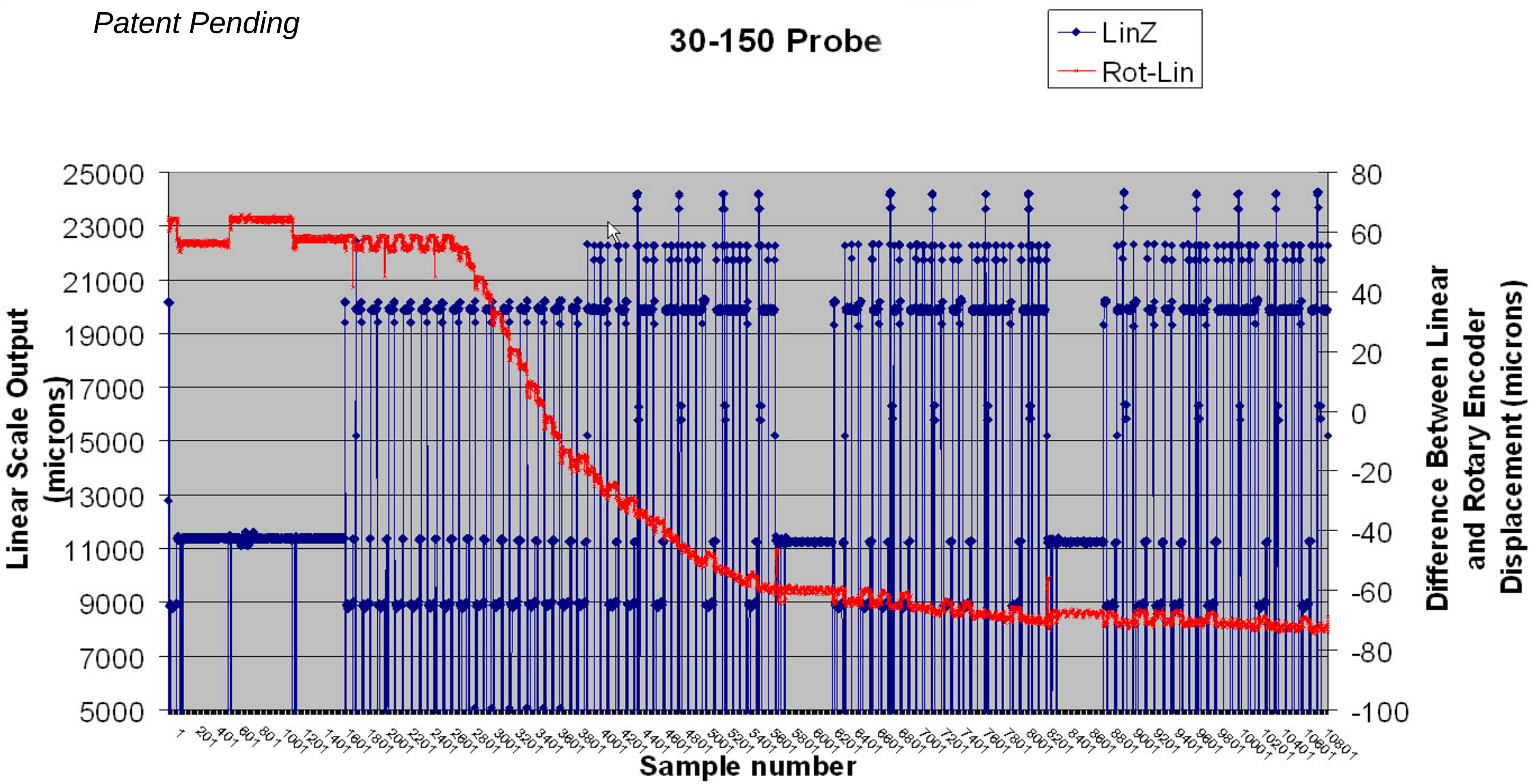
Cracked Die



Probe card Z movement following a chuck temperature change

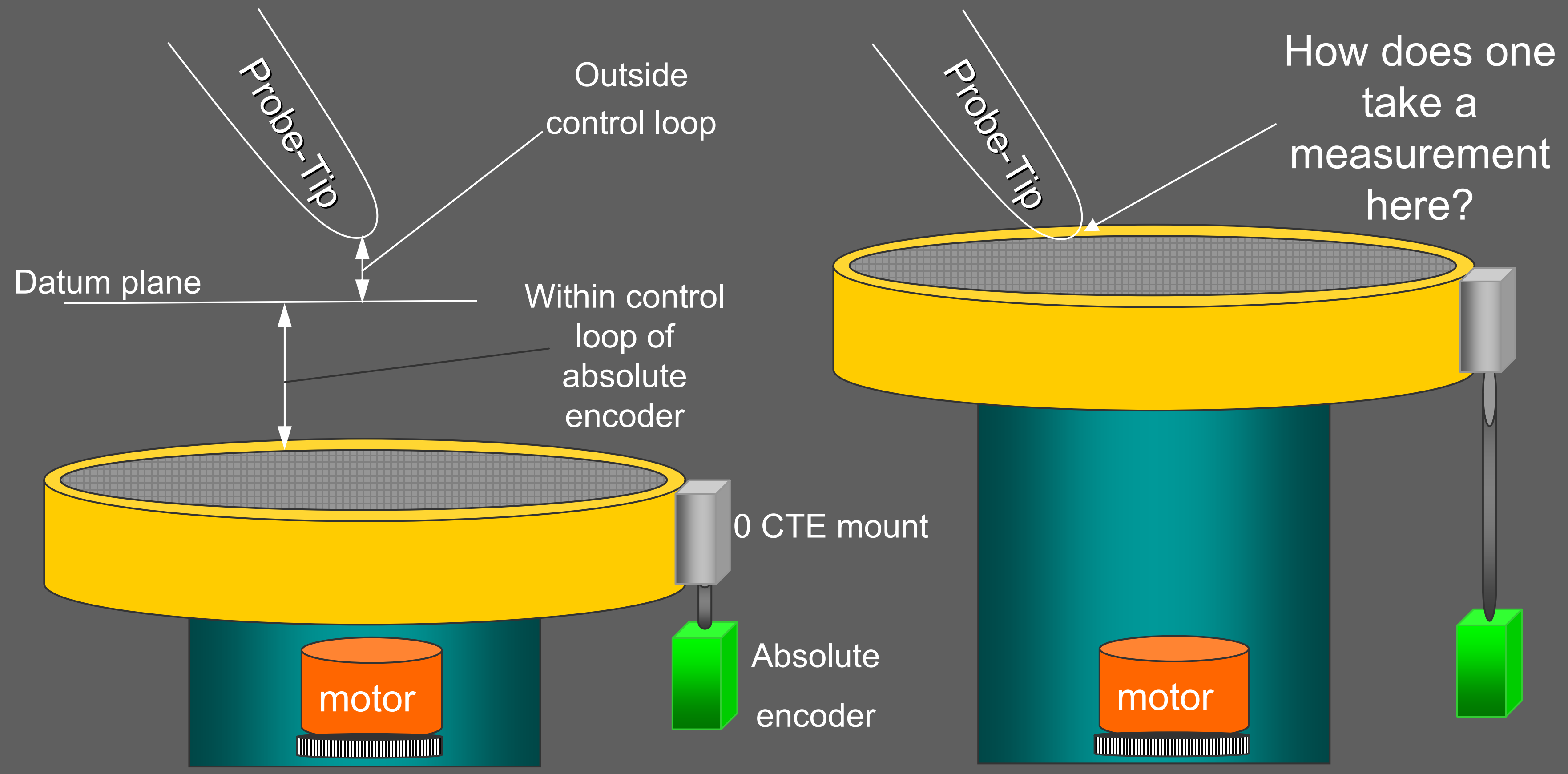
Thermal Effects on Z stage

Patent Pending



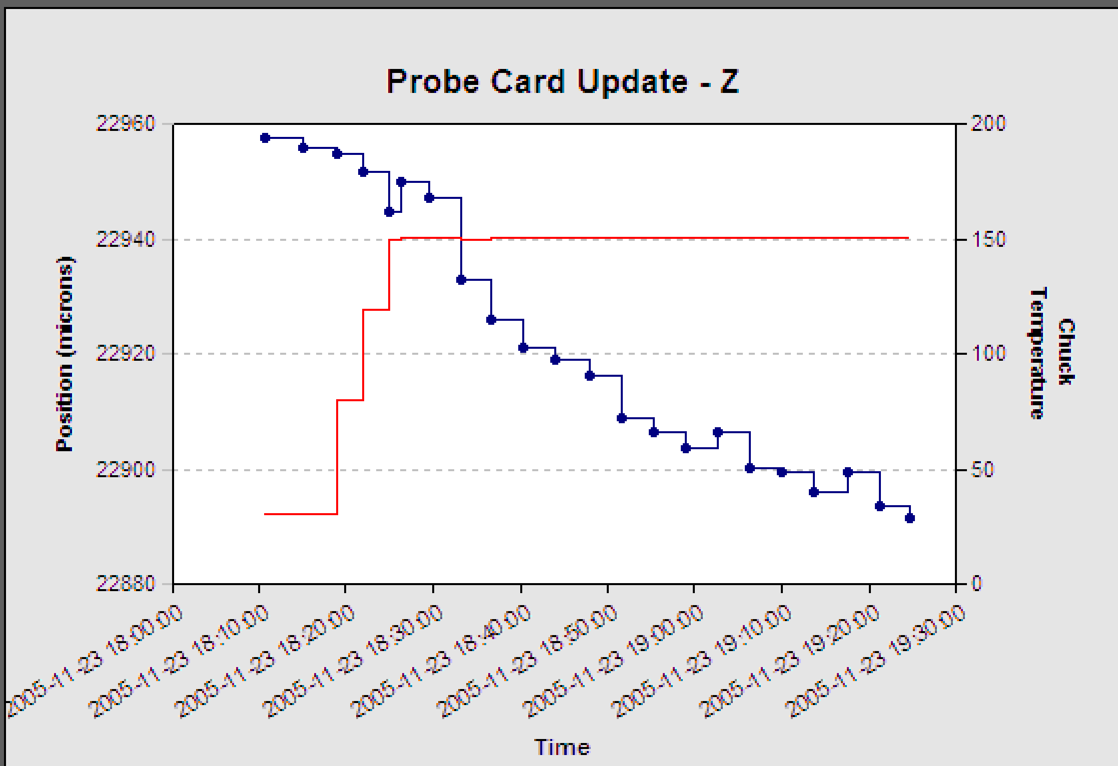
Z-stage vertical movement following a chuck temperature change from 30°C to 150°C

External encoder ensures correct stage position



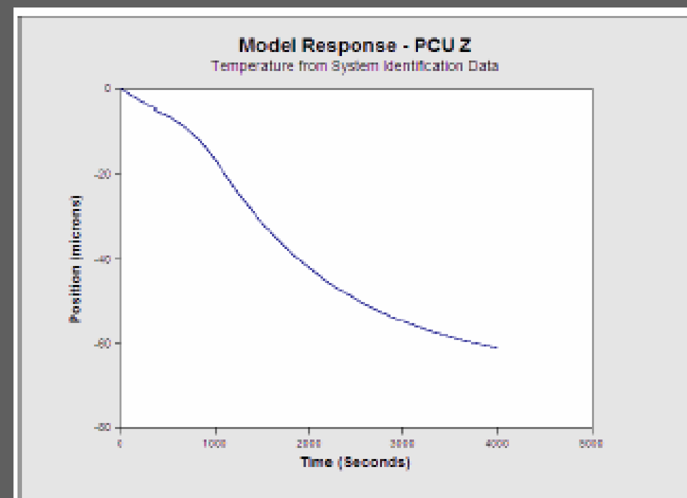
Probe card Z-position over temperature

The movement of the Probe card and the Interface need to be monitored and compensated for



Measured optically

Modeling the probe card behavior reduces the frequency with which "updates" need to be done, thus improving throughput



Modeled from measurements

Are these results correct?

Lets turn to space age technology for a solution

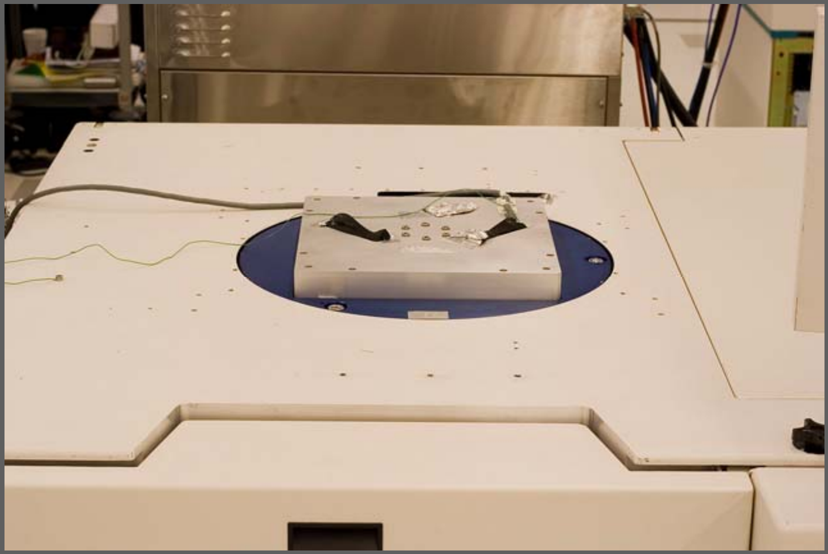
- What we are really interested in is to have consistency in over travel across lots of wafers at all temperatures.

- How do we validate the effectiveness of the dynamic compensation aimed at achieving this?

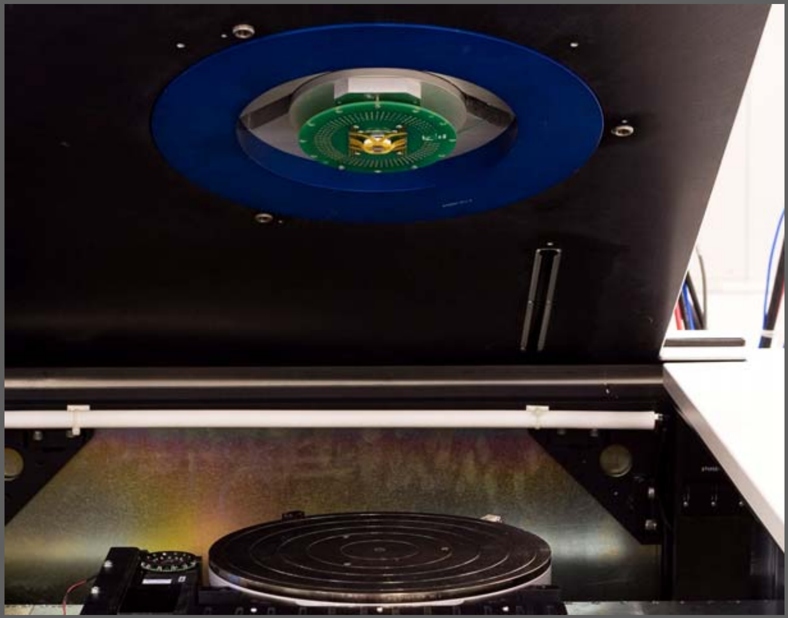
Picture courtesy of JR3

We need a tool that can measure in situ at any temperature within the operating range of the prober and that does so in a scenario that closely mimics probing conditions.

Enter the 6 axis robotic Force sensor

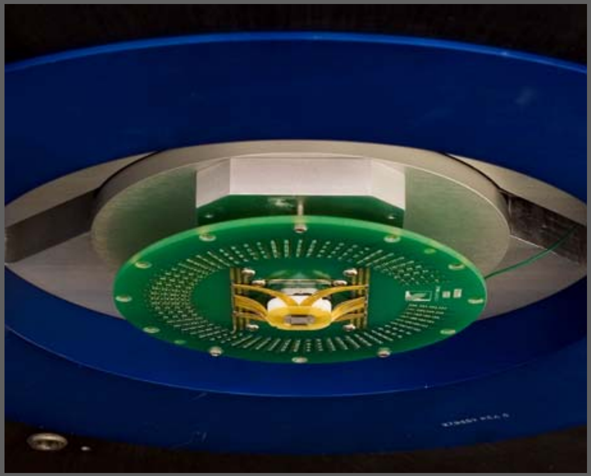


6 axes robotic force sensor installed in prober



***JR3* SENSORS WITH EXTERNAL ELECTRONICS**

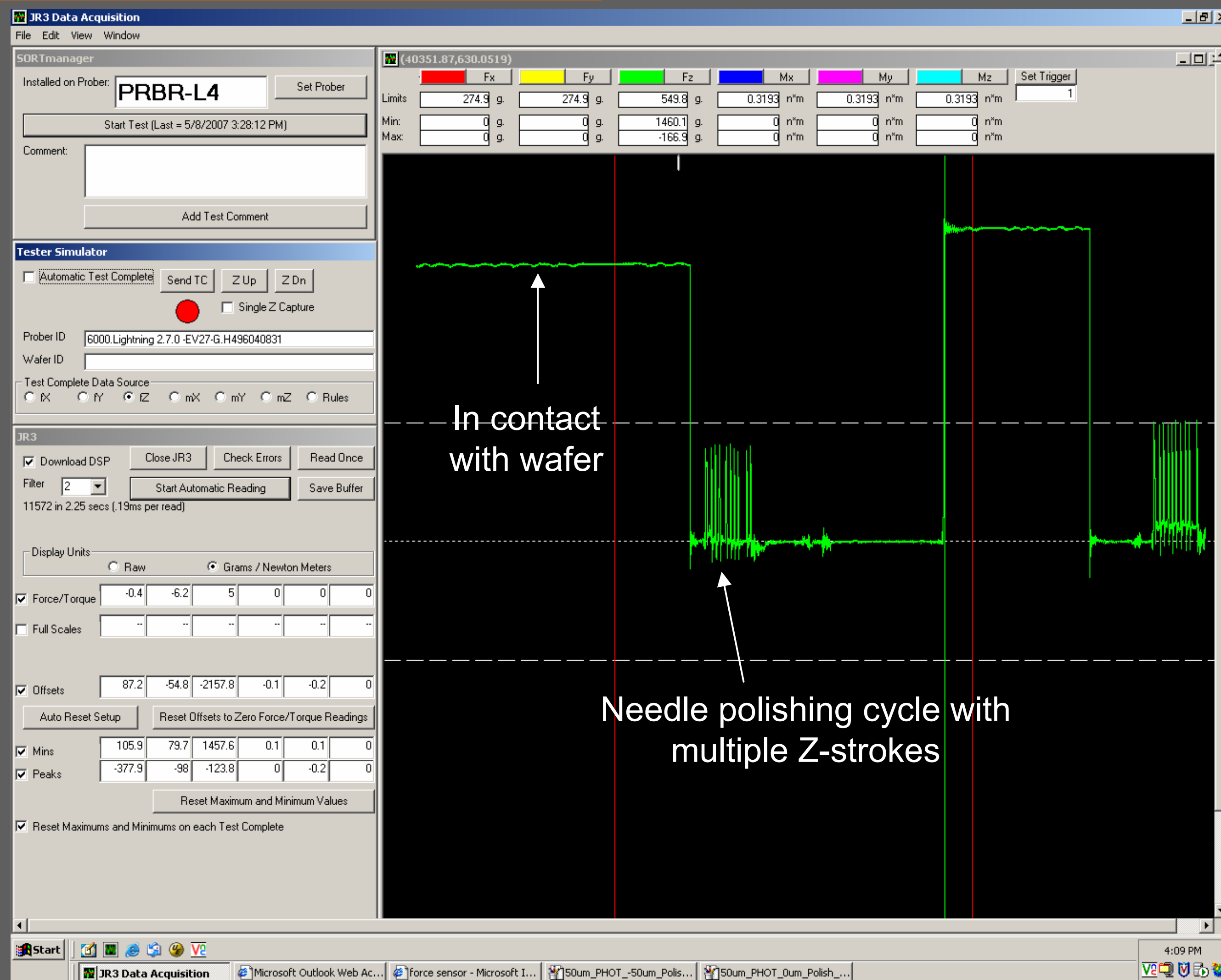
MODEL	DIAMETER	THICKNESS	AVAILABLE LOAD RATINGS
20E12	2.0 in (50.8 mm)	1.25 in (31.8 mm)	10 lb (45 N) to 25 lb (100 N) Up to 65 lb (290 N) in stainless
30E12	3.0 in (76.2 mm)	1.25 in (31.8 mm)	10 lb (45 N) to 50 LB (200 N) Up to 135 lb (600 N) in stainless
35E15	3.50 in (88.9 mm)	1.50 in (38.1 mm)	25 lb (100 N) to 100 lb (400 N) Up to 250 lb (1000 N) in stainless
40E12	4.0 in (102 mm)	1.25 in (31.8 mm)	10 lb (45 N) to 50 lb (200 N) Up to 135 lb (600 N) in stainless
40E15	4.0 in (102 mm)	1.50 in (38.1 mm)	75 lb (315 N) to 150 lb (630 N) Up to 400 lb (1600 N) in stainless
45E15	4.50 in (114 mm)	1.50 in (38.1 mm)	25 LB (100 N) to 100 lb (400 N) Up to 250 lb (1000 N) in stainless
65E20	6.50 in (165 mm)	2.0 in (50.8 mm)	100 lb (400 N) to 500 lb (2200 N) Up to 1350 lb (6000 N) in stainless
75E20	7.50 in (190 mm)	2.00 in (50.8 mm)	100 lb (400 N) to 500 lb (2200 N) Up to 1350 lb (6000 N) in stainless



Probecard mounted on force sensor

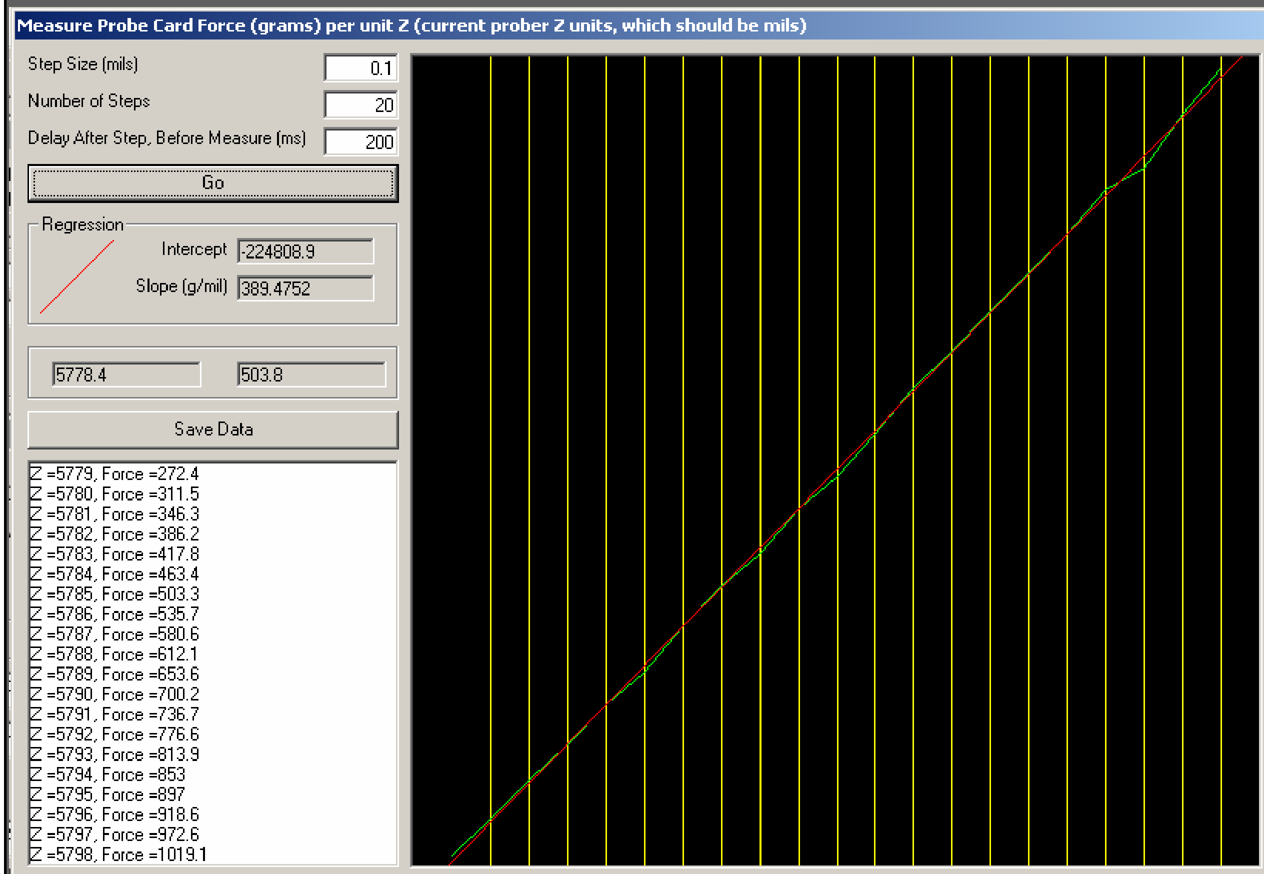
User interface for Force sensor

- 8 kHz sampling rate
- Load rating 30 Lb
- Accuracy ¼ percent of rated load



Custom built EG user interface for force sensor

Establishing the Force/Displacement relation



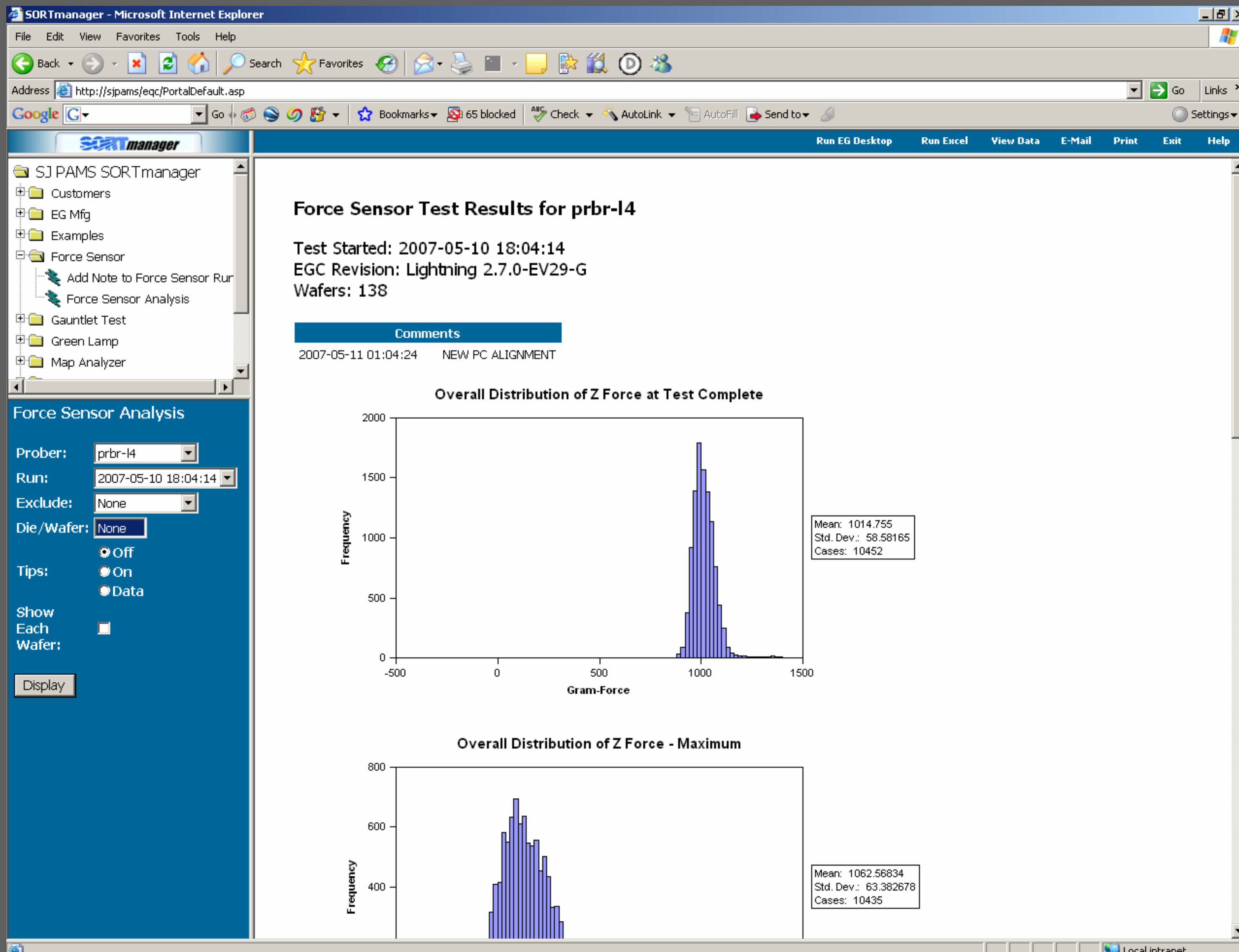
Custom built EG user interface

- Move z-stage up in increments and record the force readings.
- Typically we do not want to calibrate the measurement tool with the tool to be measured. Due to the linear encoder, mounted directly to the chuck this is a valid calibration method.
- Regress the data to create slope and intercept
- Ratio is ~390 g/mil

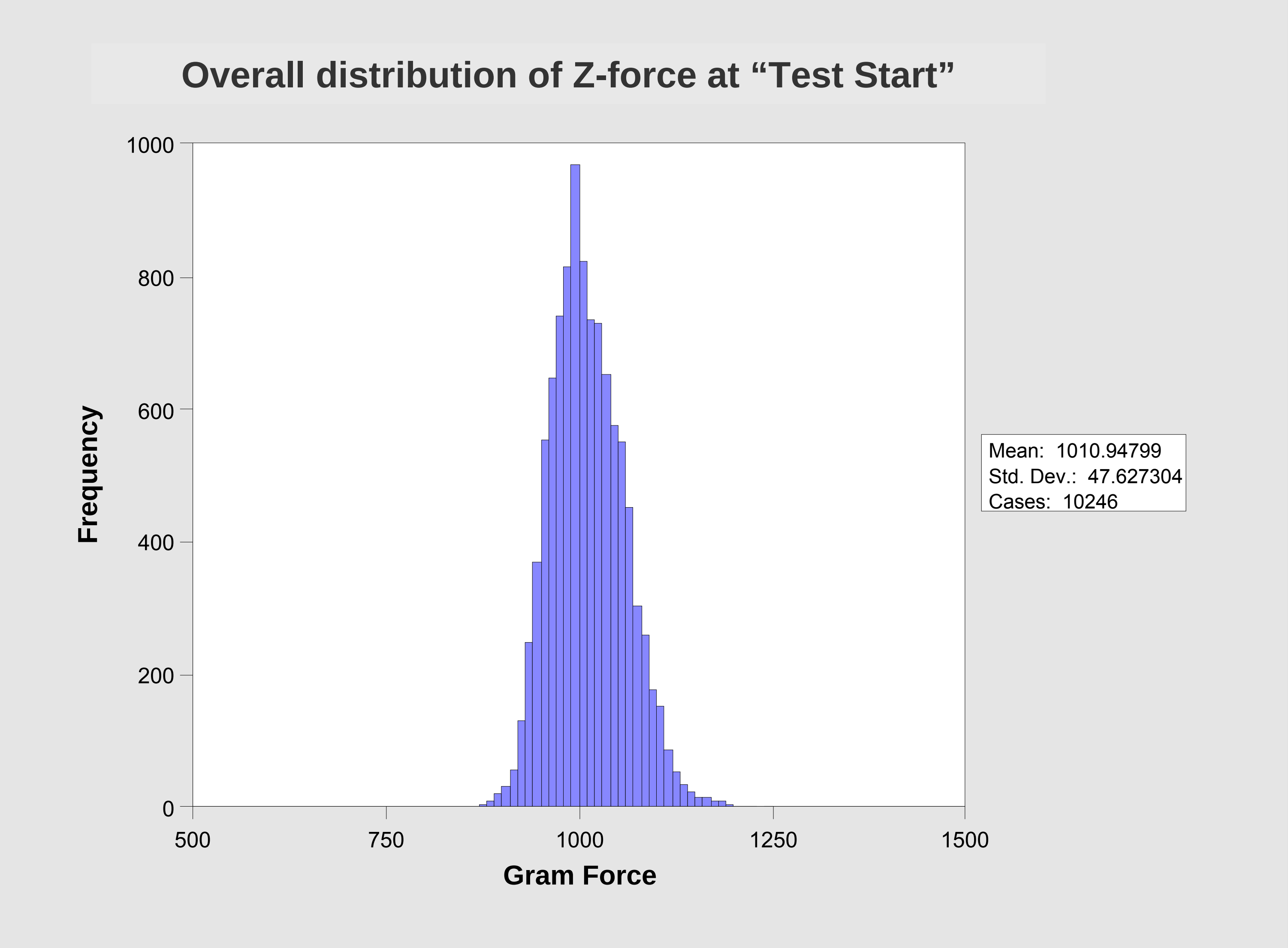
Now we can measure force and translate it into displacement

Long term results using EG SORTmanager™

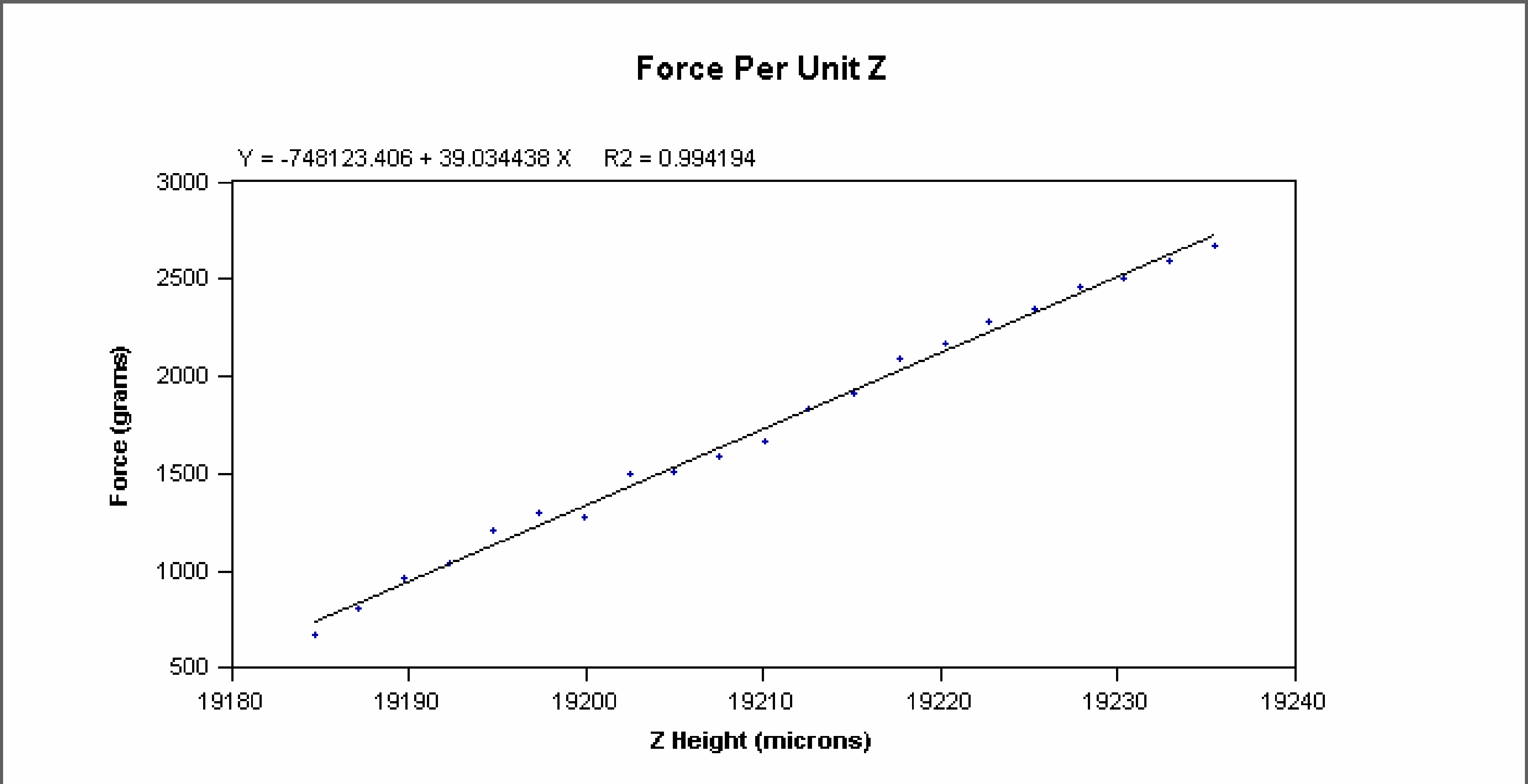
Measurement across 138 wafers with a total of ~10452 die



Z-force on card at Test Start

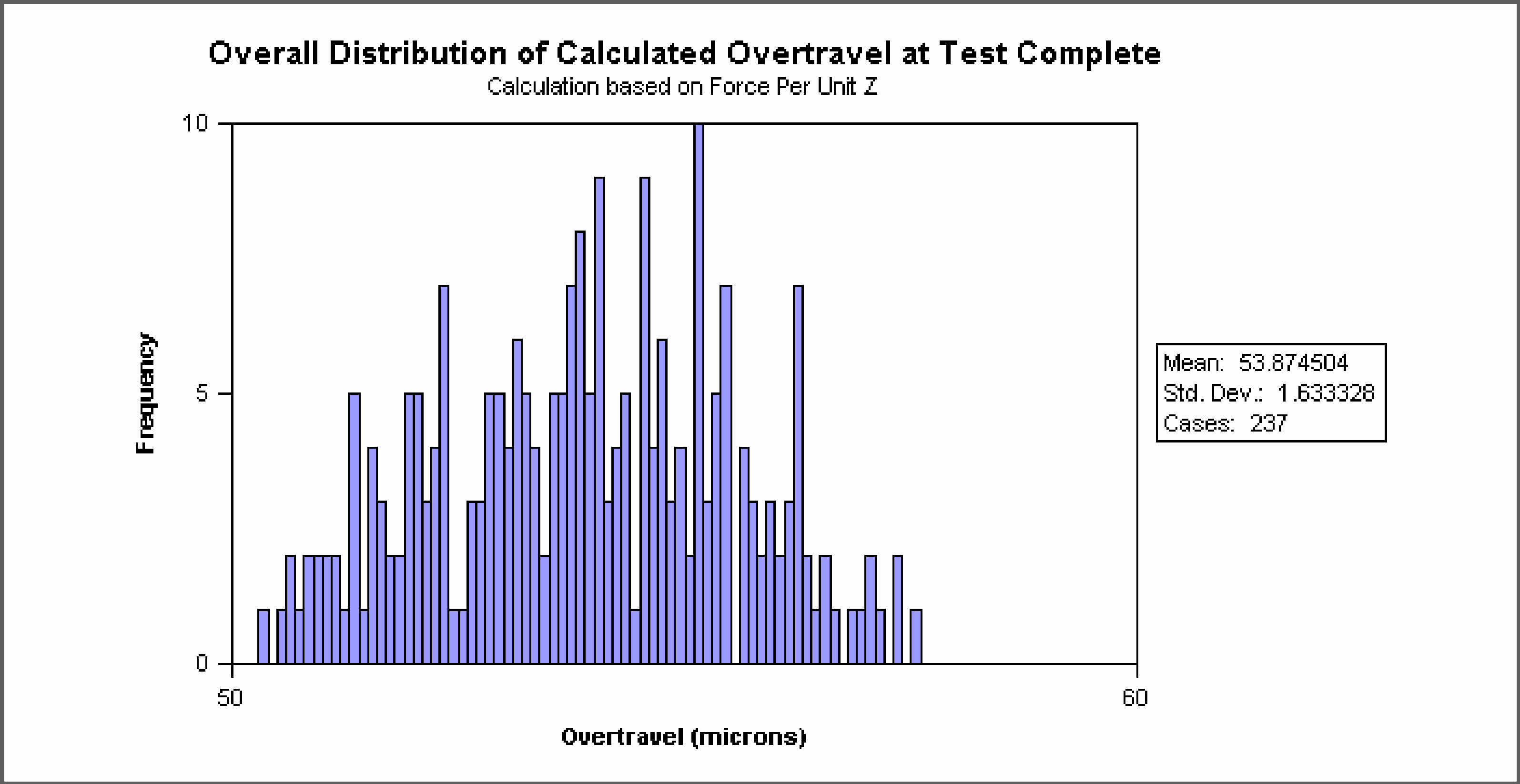


Calibration curve from SORTmanager™ database



Force Distance ratio is 994 grams per mil or 39 grams per micron

Overtravel variation

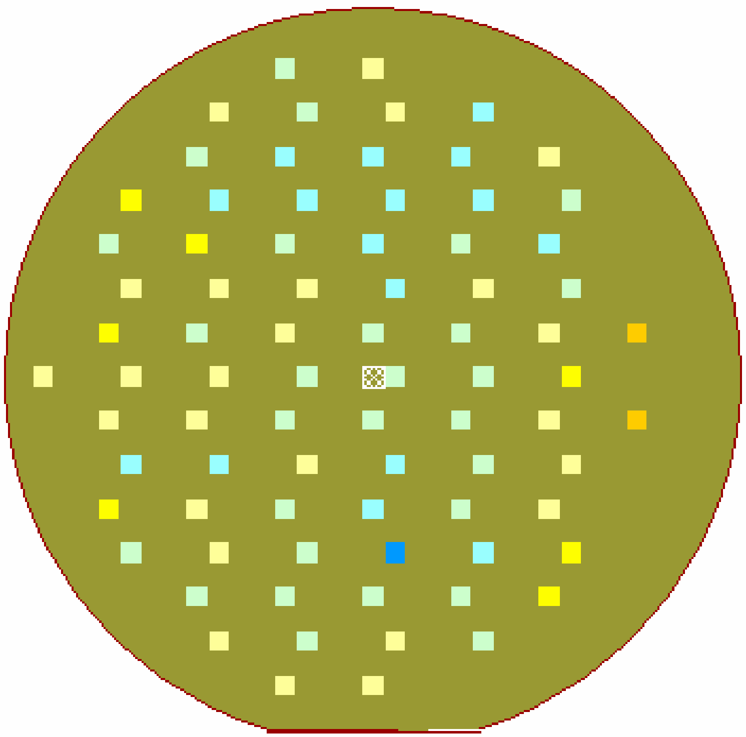


Over-travel variation across 3 wafers ~ 7 µ.

Tested using a 600 pin multi-die Vertical Probe Card

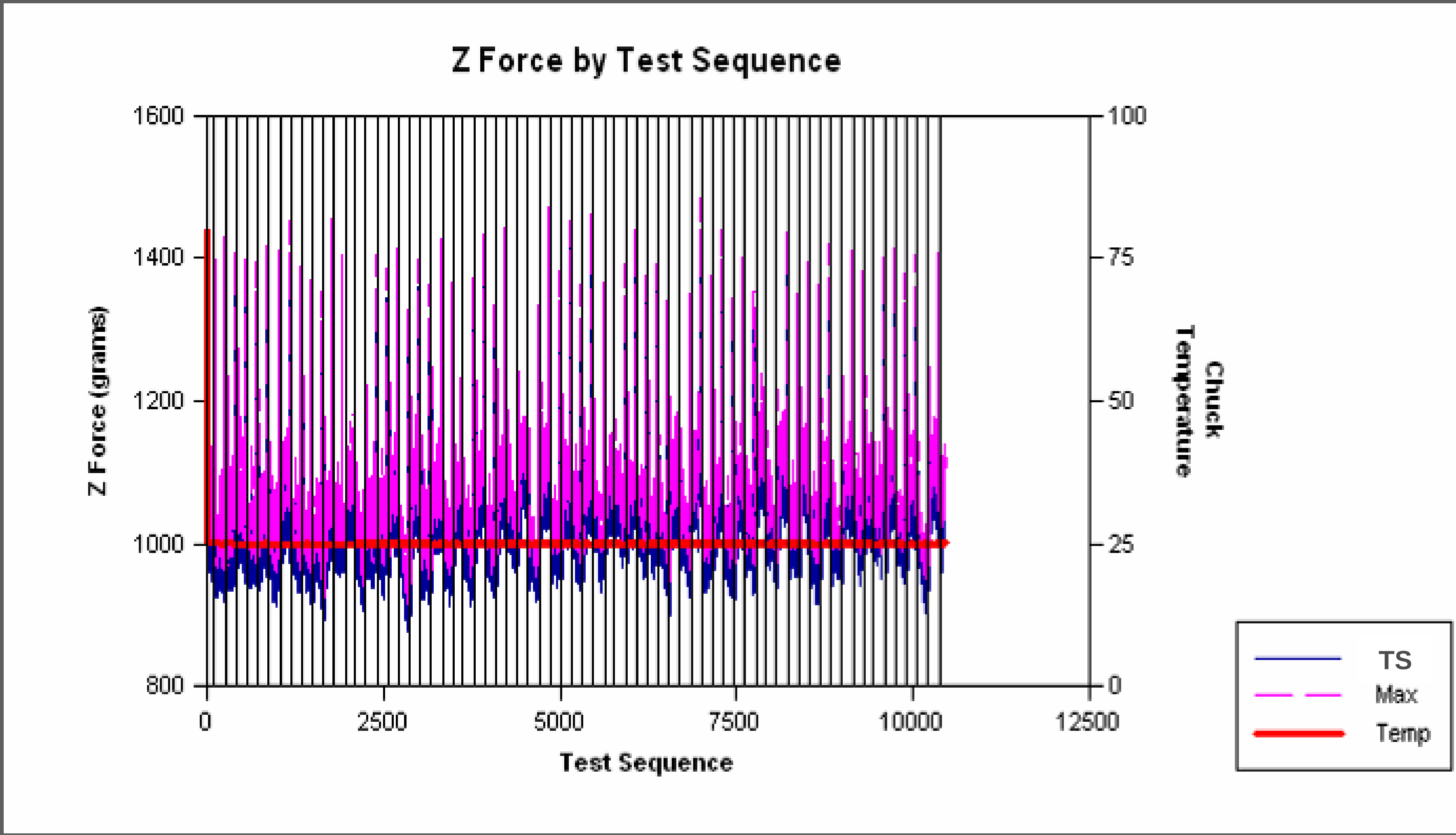
Graphical representation of Z-force by location

Calculated Overtravel
Mean Across 3 Wafers



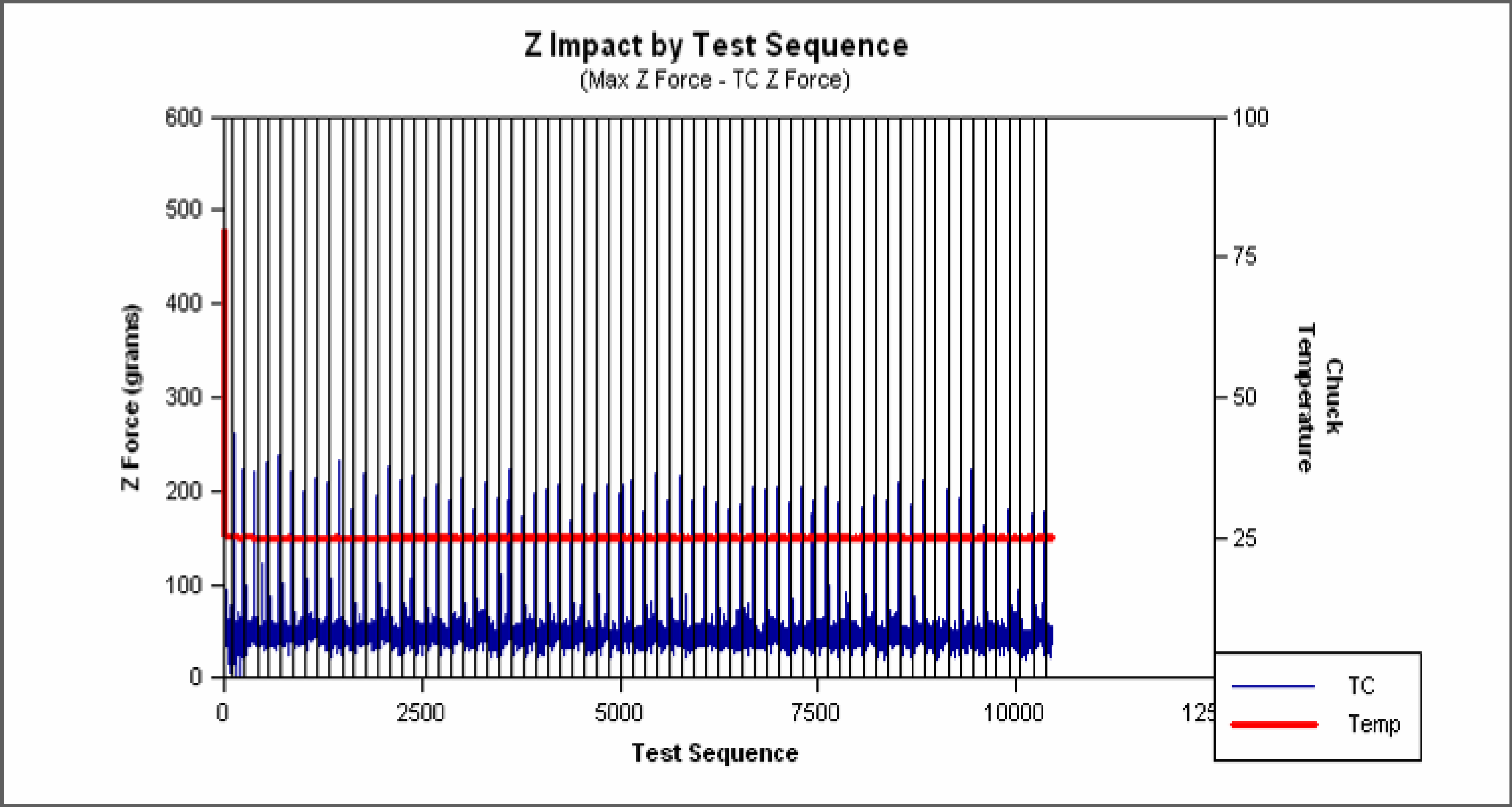
Color	ID	Calculated Overtravel Mean	Count
	1	(57.2, 58]	0:
	2	(56.4, 57.2]	0:
	3	(55.6, 56.4]	2:
	4	(54.8, 55.6]	7:
	5	(54, 54.8]	25:
	6	(53.2, 54]	28:
	7	(52.4, 53.2]	16:
	8	(51.6, 52.4]	1:
	9	(50.8, 51.6]	0:
	10	(50, 50.8]	0:

Min and Maximum Z-force on card by die location



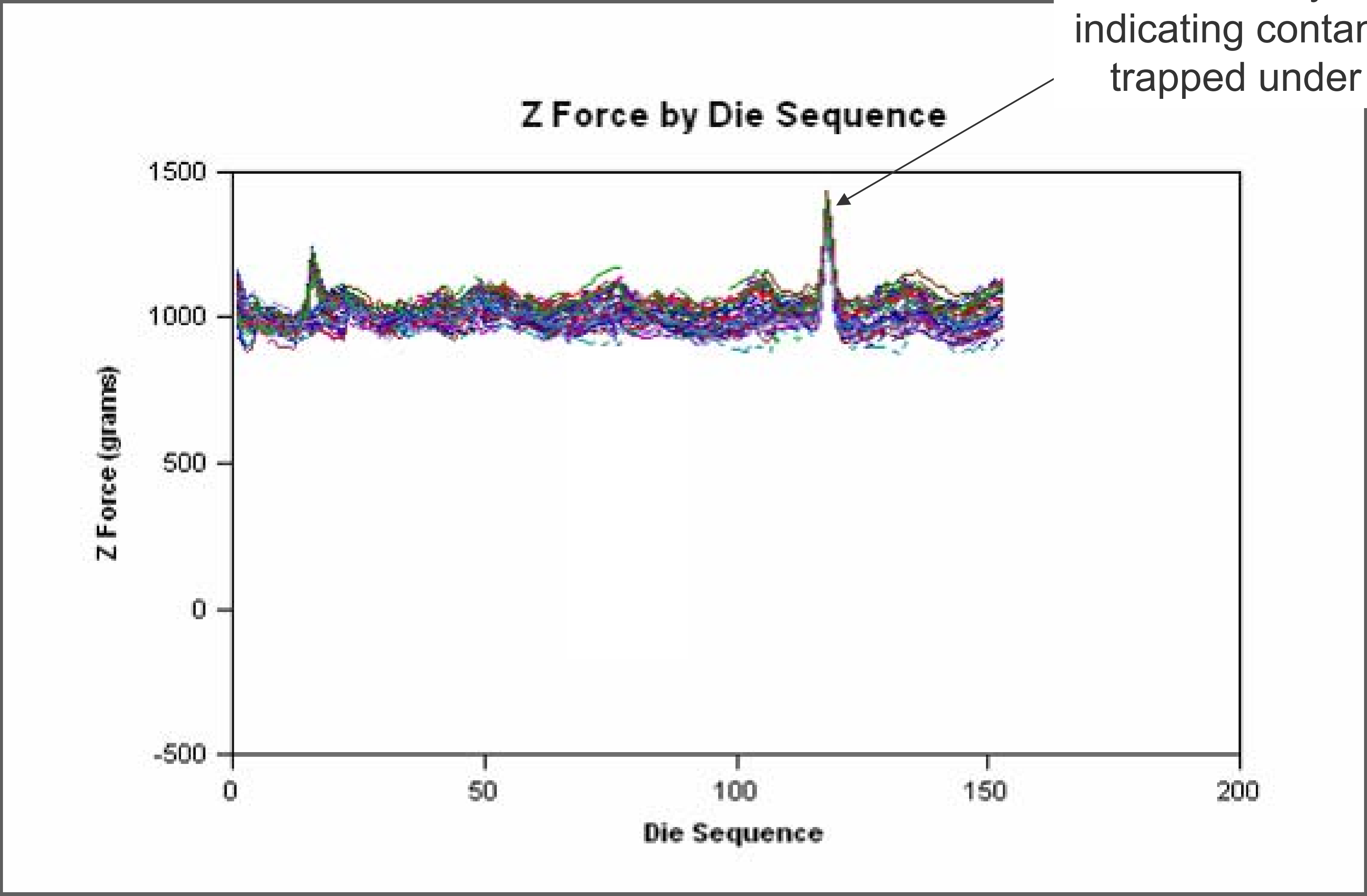
Chuck temperature change from 80C to 25C

Impact force by die location



Z-force range for each die

Z-force on this location consistently higher, indicating contamination trapped under wafer



Conclusions

- A force sensor is a valid measurement tool for measuring Z-accuracy
- Due to the fact that this measurement method replicates a true probing scenario, it will produce results similar to what can be expected in a production environment.
- Prober Z-stages grow significantly when chuck temperature increases. This can be successfully detected and compensated for using an external linear encoder.
- Force sensor can measure accuracy of pins on wafer as well as accuracy of pins on any cleaning or continuity material.
- Due to the high sampling rate of the measurement tool, interesting observations of the impact forces and impact force reduction measures can be made.

Aknowledgements

I would like to thank the following individuals for their cooperation in developing this measurement tool:

- JR3 - John Ramming
- Electroglas
  - Steve Fullerton
  - Steve Martinez
  - Steve Sato