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# How To Buckle Under Pressure

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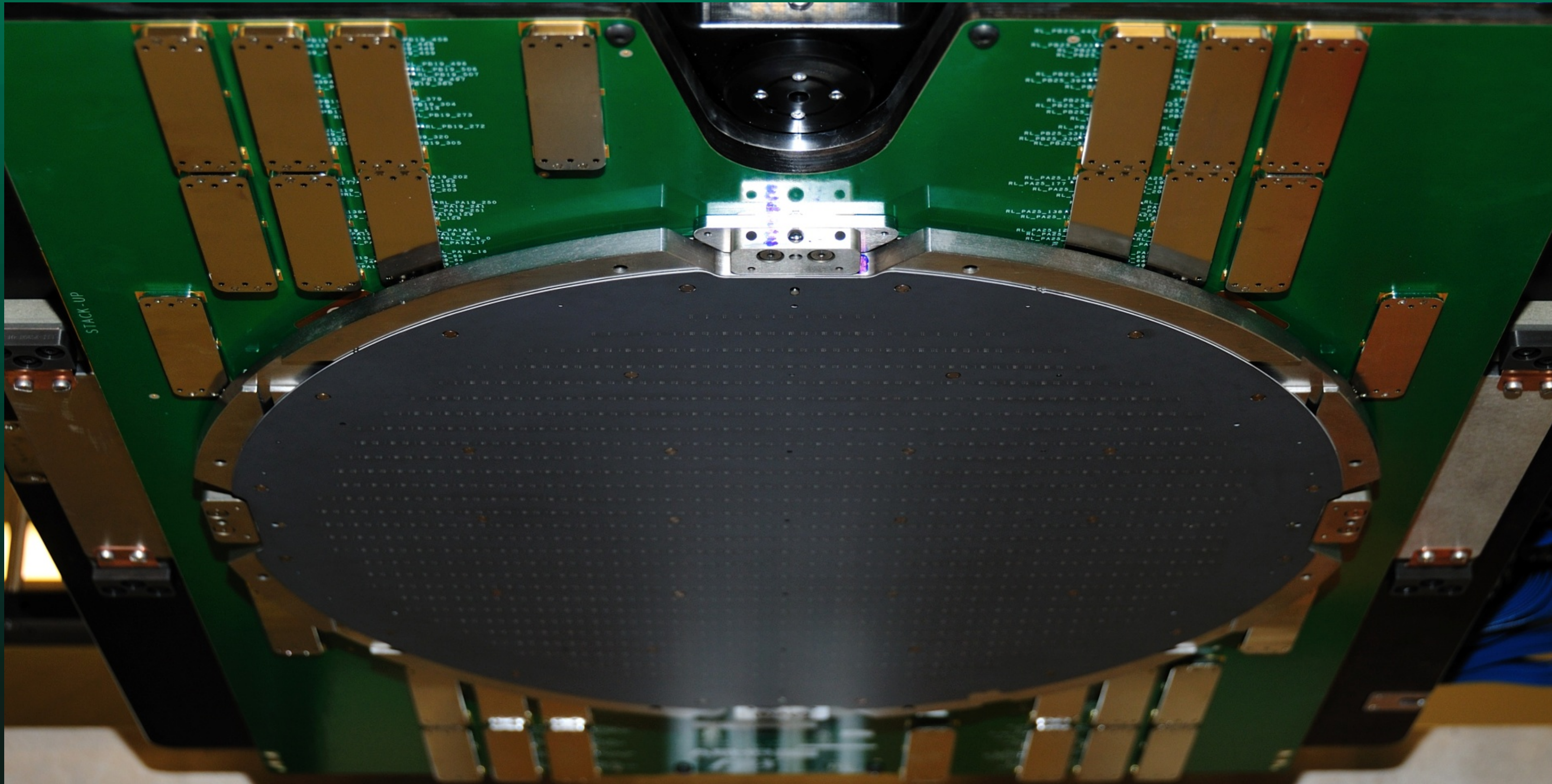
# Overview

- **Introduction**
  - Force Based Probing
  - Buckling Beam Technology
- **Challenges of Full Wafer Probing**
- **Probe Characterization**
- **Force Characterization**
- **Electrical Characterization**
  - Resistance Data
  - Functional Data
- **Summary / Conclusion**

# Benefits of Full 300mm Probing

- **High Throughput and Capability**
  - All devices tested in parallel.
  - Total probe card change time <15 minutes
- **Single Touchdown Full-Wafer Test:**
  - Dramatically reduces test time
  - Up to 12,000 power channels (6000 Amps/wafer)
  - Up to 3500 I/O channels
    - Nearly 200,000 device I/O lines using parallel test technology
  - Electronics optimized for BIST/DFT testing
- **Production Proven :**
  - Protects wafers and probe cards with individual power channel over-current protection
  - Standard cassette/FOUP automation
  - Dozens of systems in production

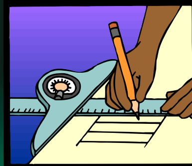
# 300mm Full Wafer Contactor



# Force vs. Displacement

## Displacement Based

- **Leveling step required to planarize probe card**
- **Prober chuck presents wafer and supplies prescribed "overdrive"**
- **With larger pin numbers programmed overdrive does not equal actual overdrive**
- **Actual overdrive is never really known**
- **Relies on Z strength of prober chuck (Legacy probers are <= 200kg)**
- **Susceptible to chuck and adapter plate deflection**
- **Requires deformation to be symmetric to maintain uniform contact**



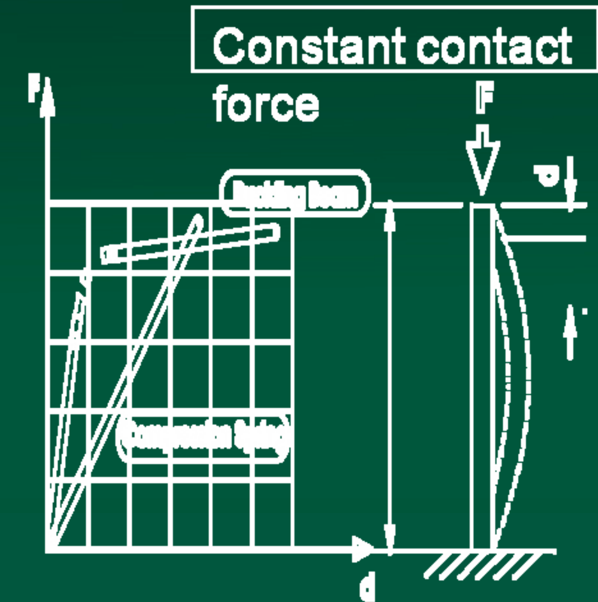
## Force Based

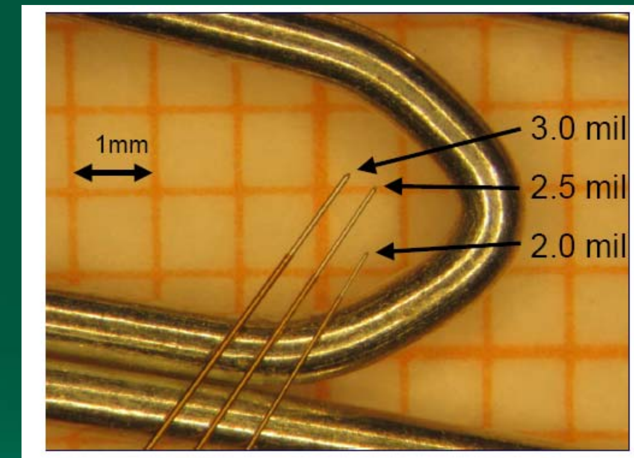
- **Prober chuck presents wafer to pins (small under-drive, little or no force)**
- **Air pressure provides desired pin stroke**
  - Inherently self-leveling
  - Not dependent on chuck deflection
  - Not dependent on adapter plate deflection
  - Can supply more force than prober alone (we've tested over 400kg on a 200kg rated chuck)
- **Allows much more Z movement and Z tolerance**

# ViProbe® Based WaferPak™ Concept

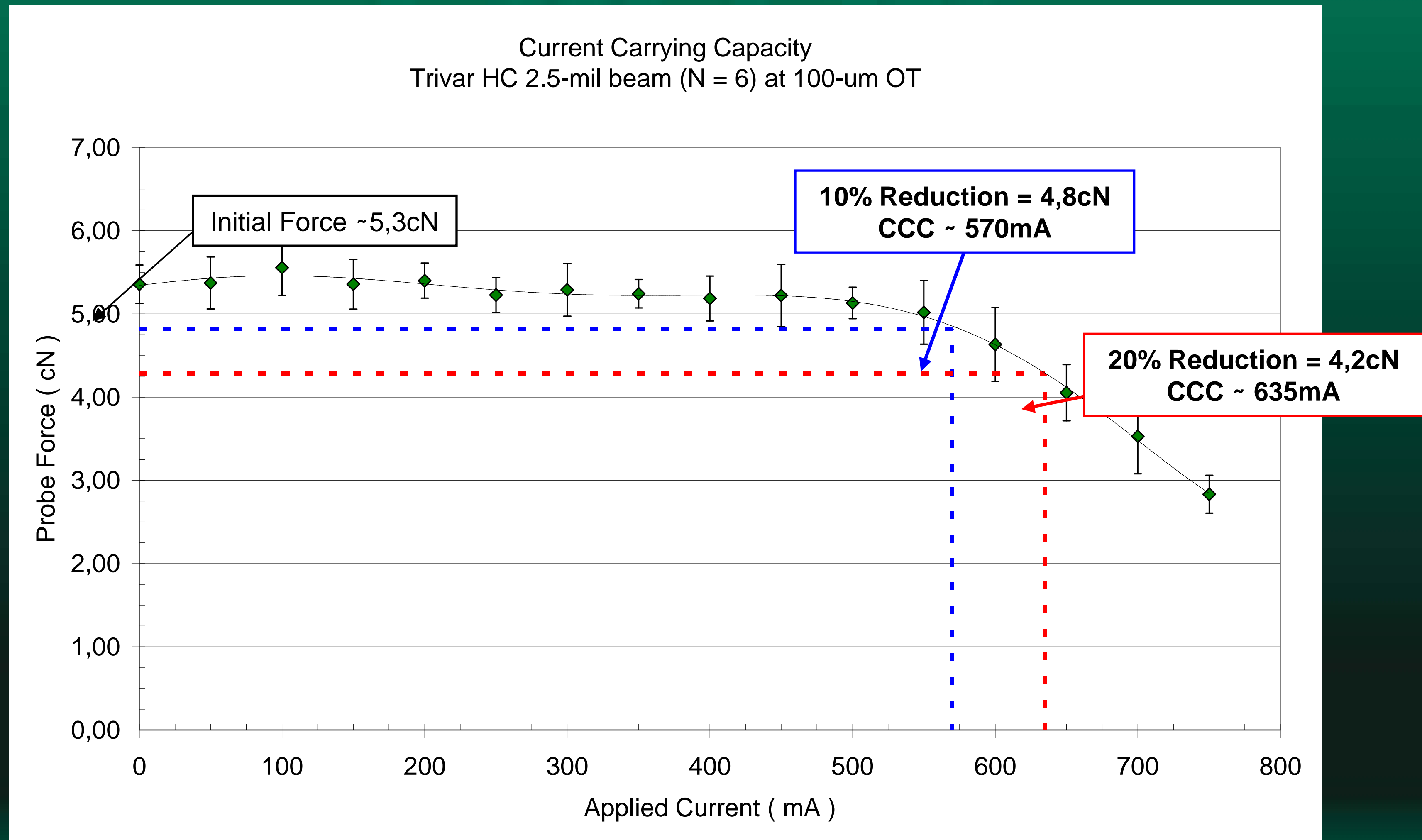
# Feinmetall ViProbe® Contactor

- Beam diameter: 2.5mil
- Maximum current: 500mA
- Force at 150µm over-travel is 6.5cN
- Pointed tip shape
- Beam temperature capability: -40°C to 180°C
- Very robust design => easy handling

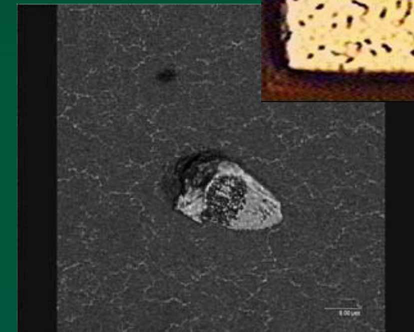


# 2.5 mil Beam CCC



# Contactor Design Parameters



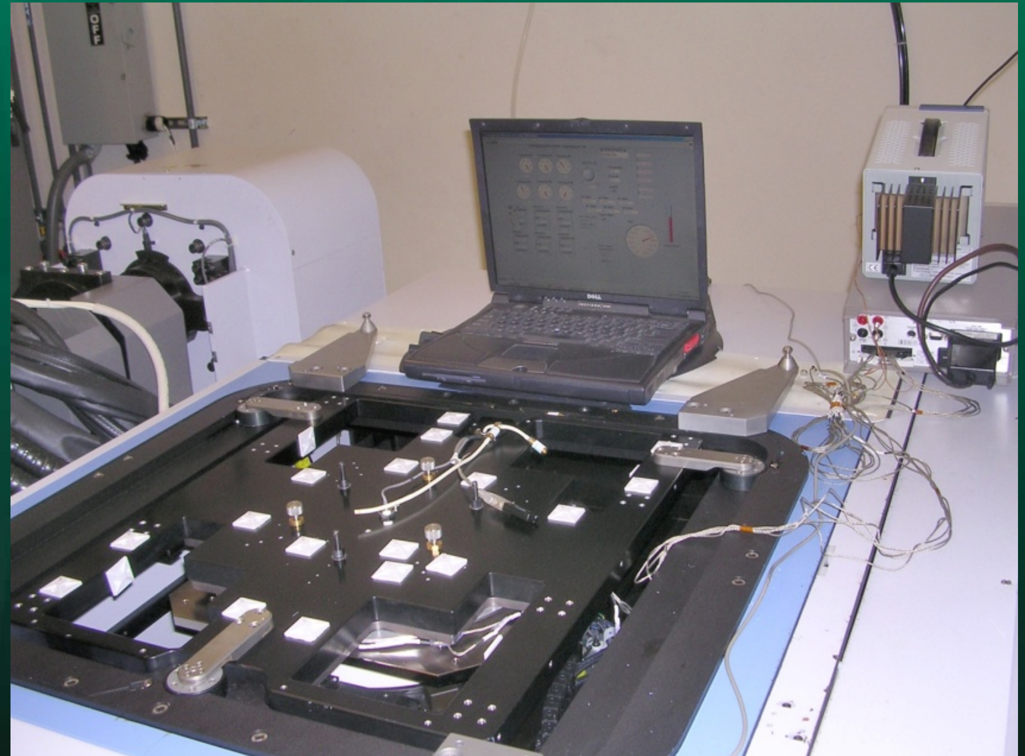
- Probe Mark
  - Small impact compared to cantilever probe cards
  - Probing over active structures possible nearly independent of overdrive
  - Contact mark stays within the pad even with high overdrive
- WaferPak probe card designed to work over large temperature range
- Contactor can be quickly removed in field for pin replacement
- Cleaning done using ITS Probe Polish™ cleaning wafer

# Meeting Challenges in Full Wafer Probing at Temperature

- **Mechanical**
  - Forced Based probing enables “self leveling” across 300mm
  - Z expansion during thermal cycling compensated by linear force-displacement capability
  - No danger of overdriving probes
  - Capability of providing up to 400kg force
- **Electrical**
  - Individual power supplies (no power plane) to avoid hostage fails, contactor damage or wafer damage
  - All power supplies have separate sense lines to allow fine voltage control
  - Signals isolated to obviate hostage fails.
- **Thermal**
  - Dual Temperature
  - -40 to 150°C
  - Wafer and WaferPak probe card thermal expansion management

# Force Measurement Experiments

- **Five force "button" transducers**
  - 50 lb range
  - 500 lb range
- **LabVIEW monitoring**
  - Force, chuck displacement, temperature and pressure
  - Displacement sensors monitoring piston movement



# Force Independent of Chuck Position

Uniform force range of greater than 1400um!

Force (kg)

250
200
150
100
50
0

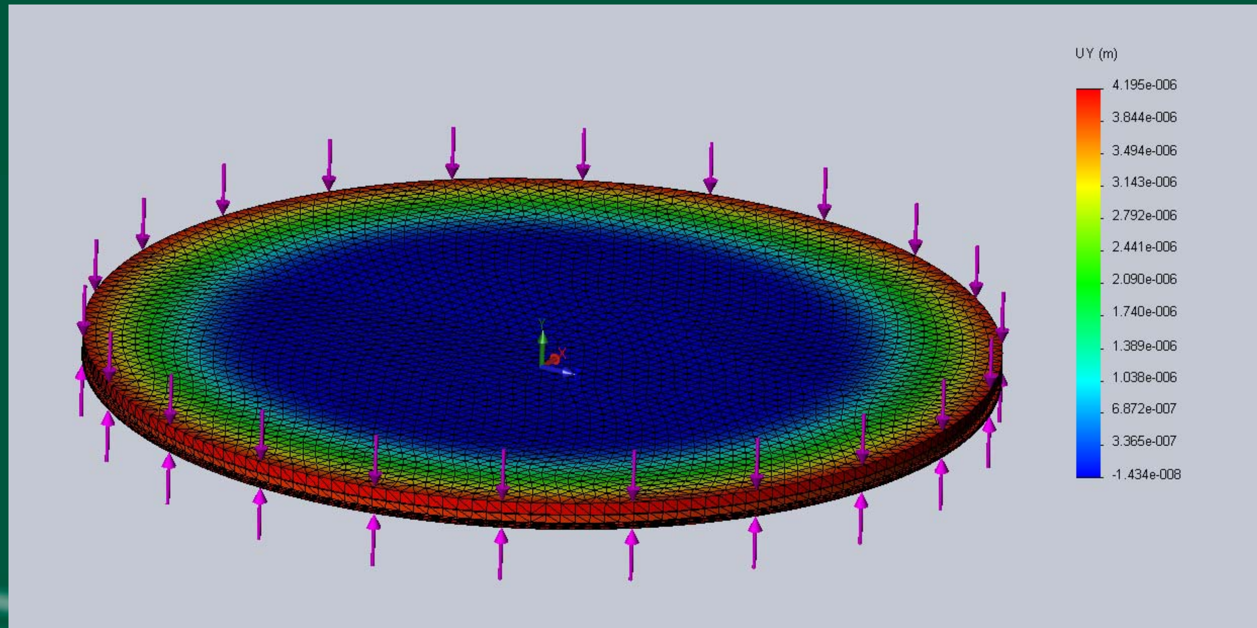
70
75
80
85
90
95

Chuck Location (mmX10)

ForceTotal
Theoretical Force

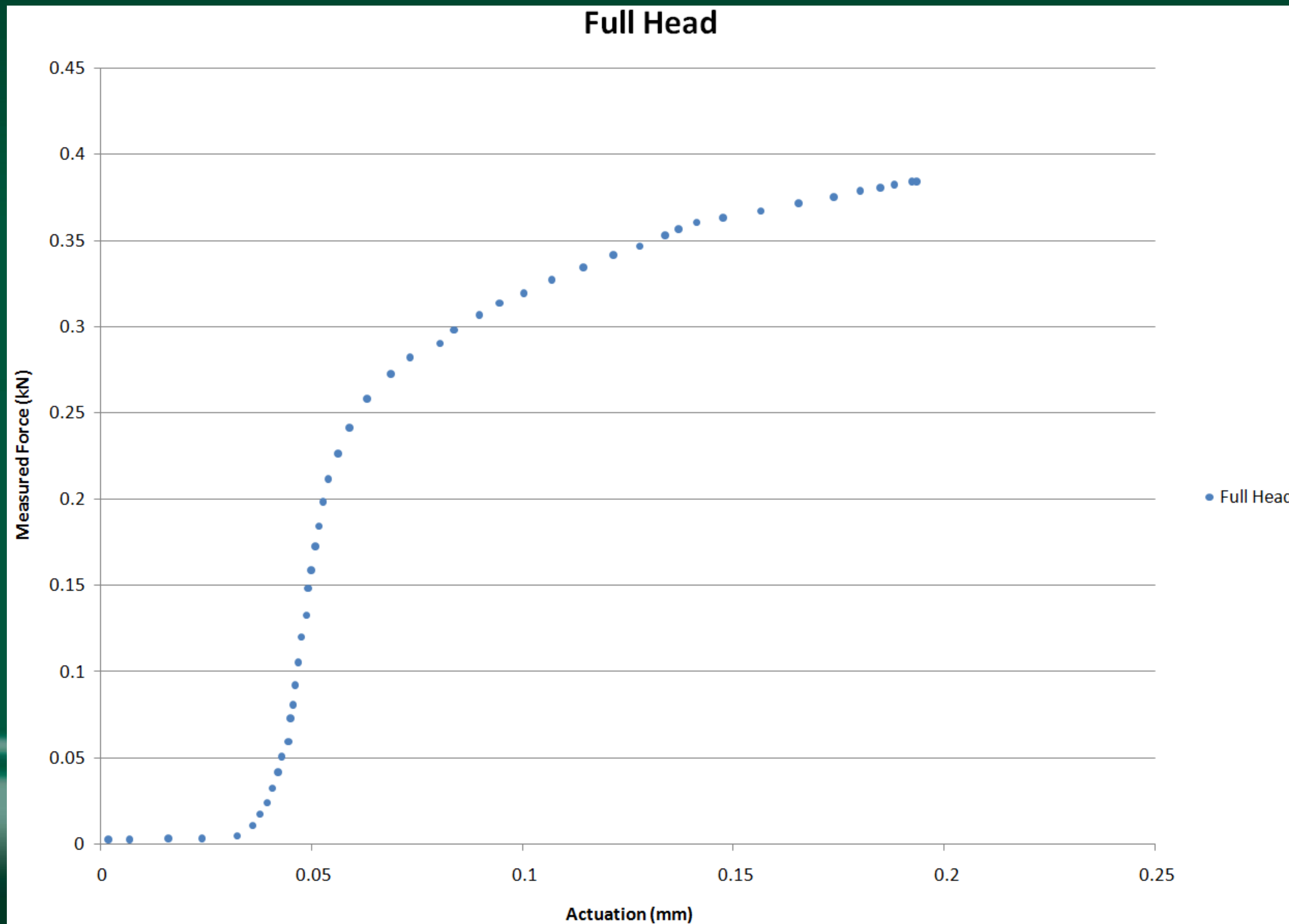
# 800 Pound Gorilla

- 800lbs Applied Force (~60K probes)
  - < 5 microns of Stiffener deflection



# Force Deflection Curve

## Full Head



# Thermal Z Movement Of Contactor

**Average Contactor Z Height During Thermal Soak Experiment**

# Summary of Force Based Buckling

- **Avoids pitfalls of displacement based probing**
  - Unwanted and unknown deflections
  - Limitations of overall force
- **Avoids damage due to thermal expansion**
- **Faster heat-up and cool-down times**
- **Buckling beam enables a more consistent force over a small displacement range.**
- **Force control enables global control over a large displacement range**
- **=➔ This results in uniform average force/pin**

# Probe Location Characterization

- XY Pin Tip Uniformity
- XY Scrub Mark Uniformity
- Scrub Length
- Z Pin Height Uniformity

# Typical Probing Challenges

- **XY Position**
  - PTPA
  - Guide hole location
  - Pin scrub
  - Thermal effects
- **Z-Force Uniformity**
  - Probe design
  - Pin height control
  - Pin force control
  - WaferPak probe card stack-up

# ProbeWoRx® XY Scatter

**Bivariate Fit of Y Error ( µm ) By X Error ( µm )**

# ProbeWoRx® Z Histogram

Histogram

Frequency

500
450
400
350
300
250
200
150
100
50
0

120.00%
100.00%
80.00%
60.00%
40.00%
20.00%
0.00%

-35 -32 -29 -26 -23 -20 -17 -14 -11 -8 -5 -2 1 4 7 10 13 16 19 22 25 28 31 34

Bin

Frequency
Cumulative %

# DC Resistance Testing

- Blanket Aluminum wafers (0.5% Cu)
- Keithley 707 Scanner
- LabVIEW based instrument control
- Production use conditions simulated

# DC Resistance Histogram

Single and Dual Pin Combined Histogram

Frequency: 160, 140, 120, 100, 80, 60, 40, 20, 0

120.00%, 100.00%, 80.00%, 60.00%, 40.00%, 20.00%, 0.00%

0, 0.05, 0.1, 0.15, 0.2, 0.25, 0.3, 0.35, 0.4, 0.45, 0.5, 0.55, 0.6, 0.65, 0.7, 0.75, 0.8, 0.85, 0.9, 0.95, 1

Resistance

Frequency
Cumulative %

# BIST Functionality Map

- **Test results from end product wafer on Aehr FOX-1 full-wafer test system**
- **Layout independent device programming**
- **Pressure, prober and tester control integrated into Linux based local controller**

# Conclusions

- Pressure based probing systems enable self leveling and compensation for chuck, head-plate and asymmetric deflections during full wafer probing
- The non-linear buckling beam force-deflection curve enables short distance Z variances to have minimal effect on individual probe force
- The combination of these technologies allows fine pitch, high pin count full wafer probing to be a reality

# Acknowledgements

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