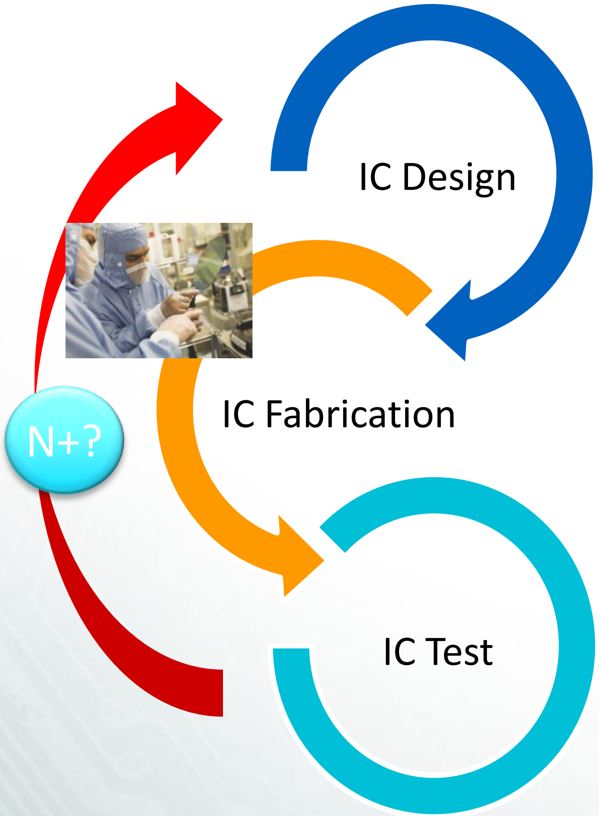
COMPASS

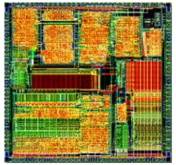
a **FormFactor** users' group conference

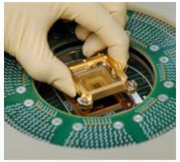
Autonomous RF Measurement assistant

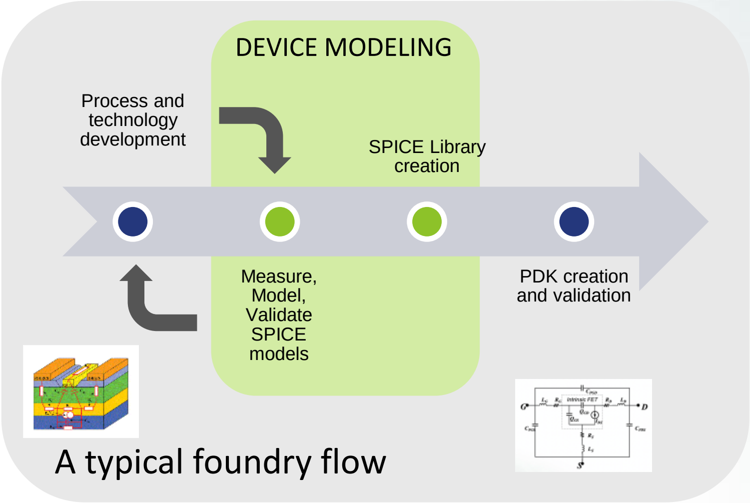
Toru Sugawara– Applications Engineer

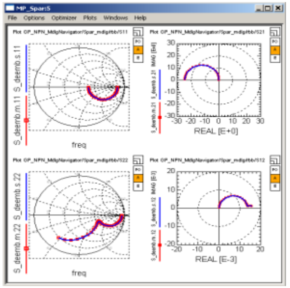
Why is Device Modeling Critical

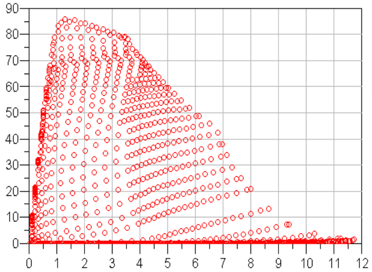




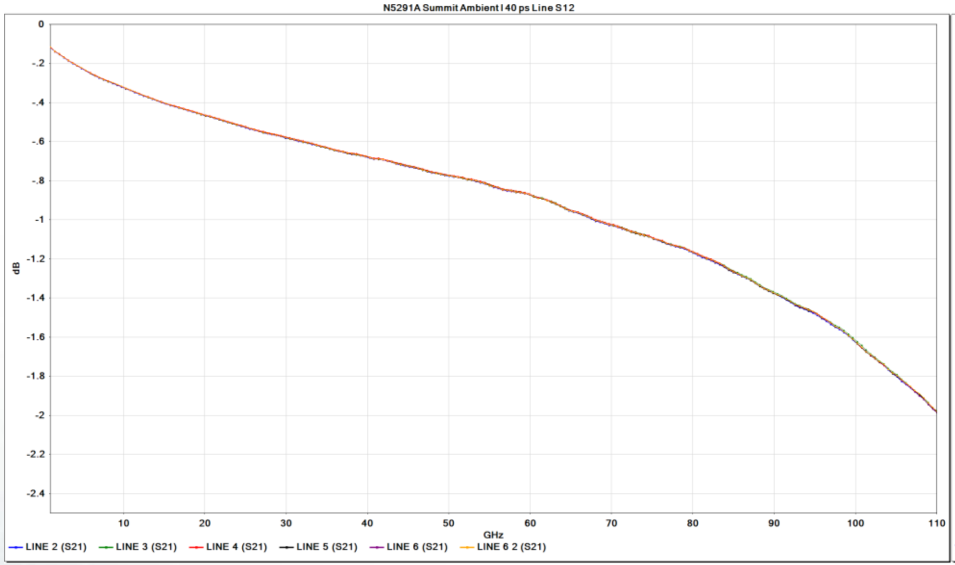


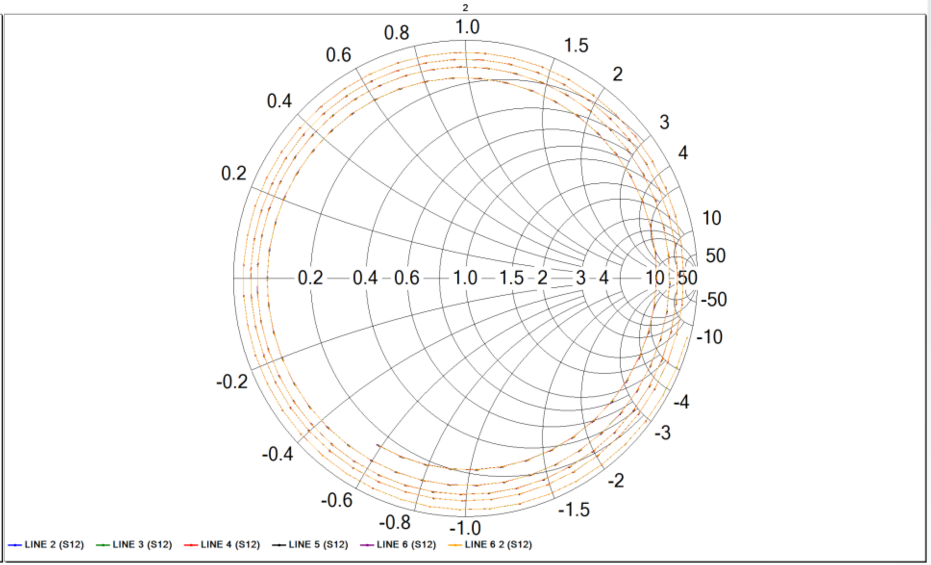






Goal – Accurate Data





More Accurate Data = Better PDK = Faster Time to Market = $$$

COMPASS

FormFactor™

Pain Points – Testing over Temperature

Measurements at ambient can be challenging, but measuring over temperature is much harder

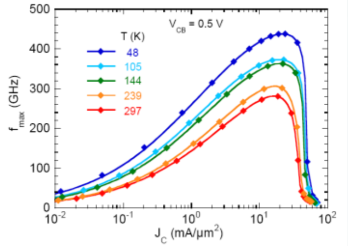
Device modelling for Process Design Kits requires testing from -40degC to +125degC

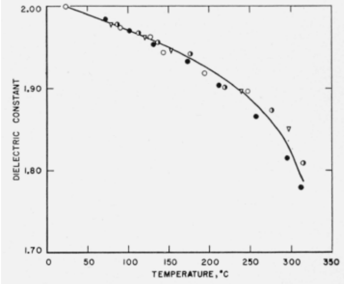
Calibration more prone to drift due to expansion of probes and cables

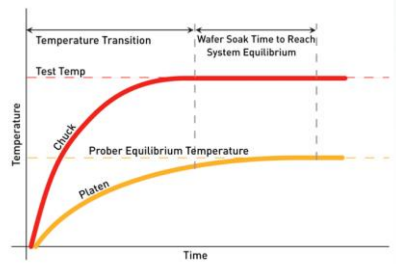
Probe to pad alignment errors due to expansion of chuck, wafer, platen, positioners, probes and more

Problems have become more significant with shrinking pad dimensions

RF Pads typically as small at 50x50um







Mechanical effects of growth

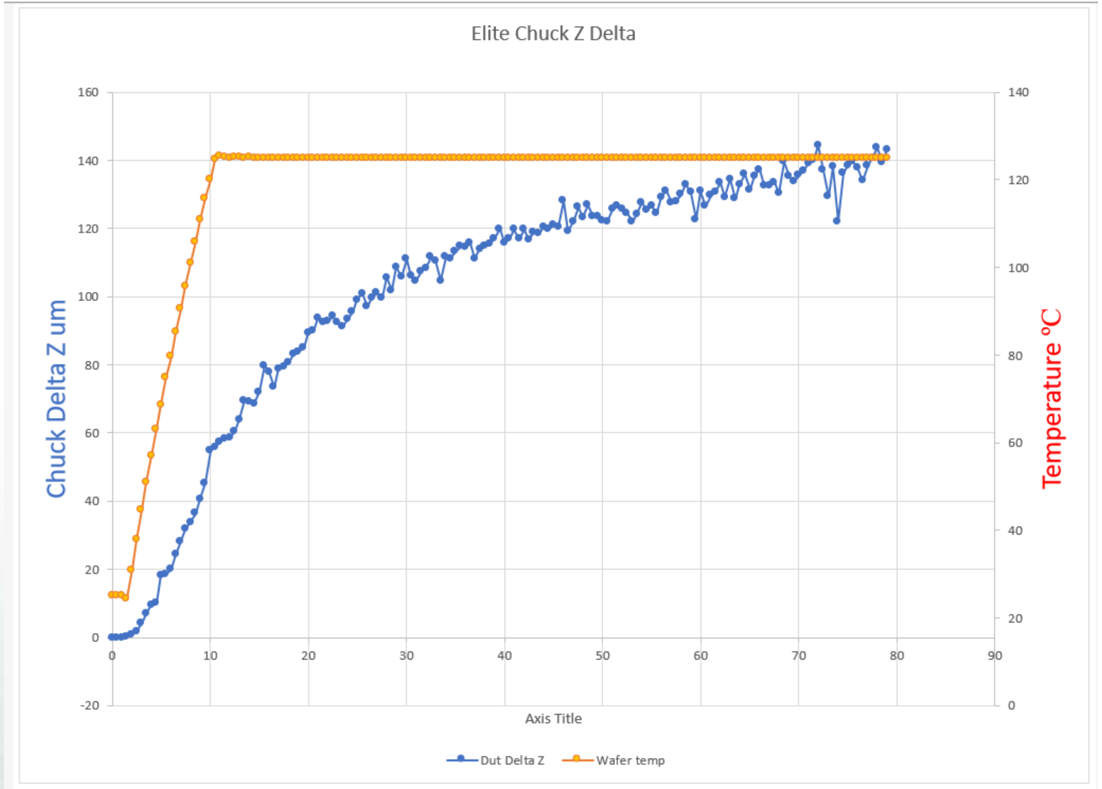
Probes grow / retract with temperature in XZ

Some movement in Y but comparatively minimal

For significant thermal changes evaluate theta also

Chuck grows in XYZ

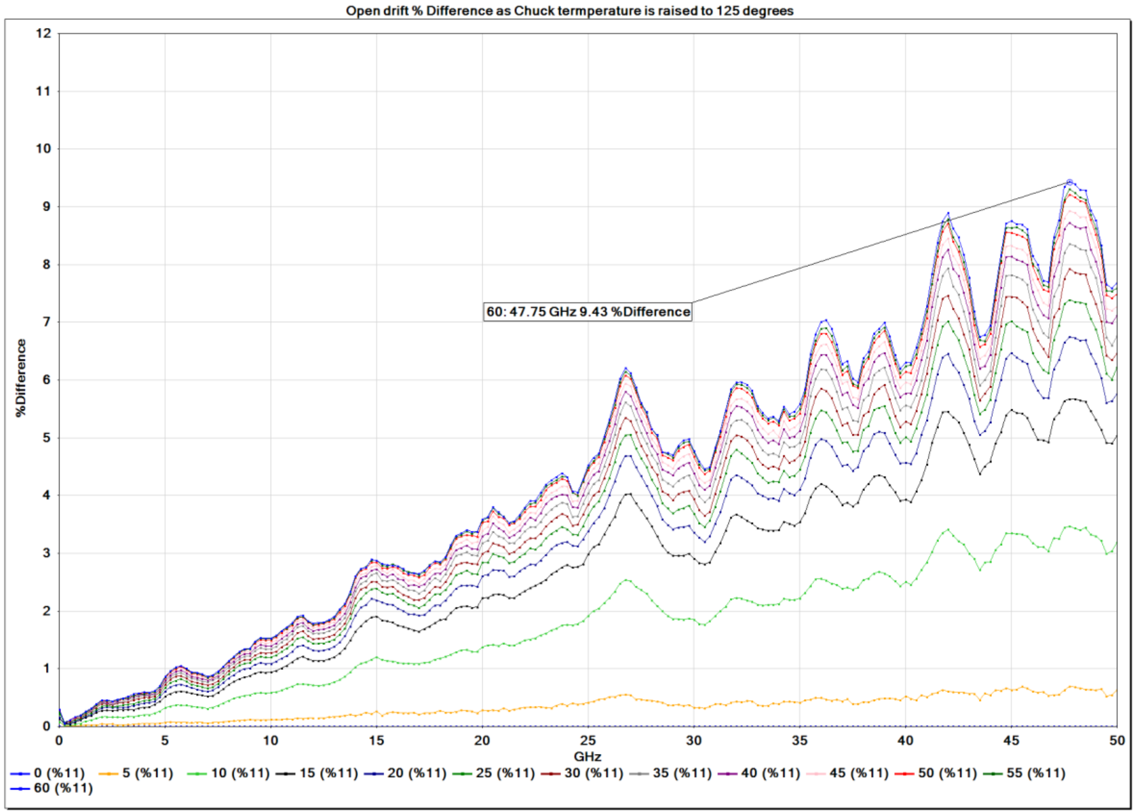
Chuck Z expansion



Chuck to probe geometry change during soak

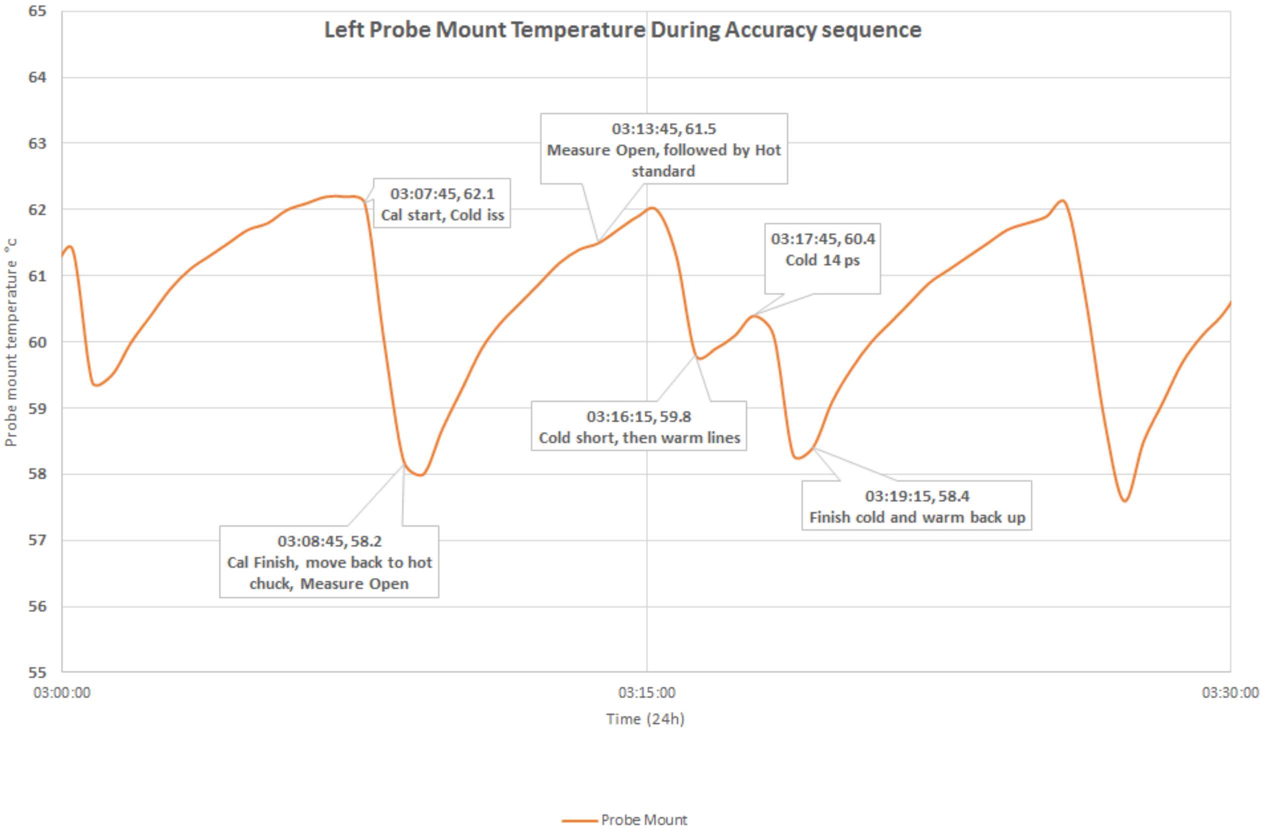
Ideally we would like to probe during growth to save time

S parameter change during probe warm up



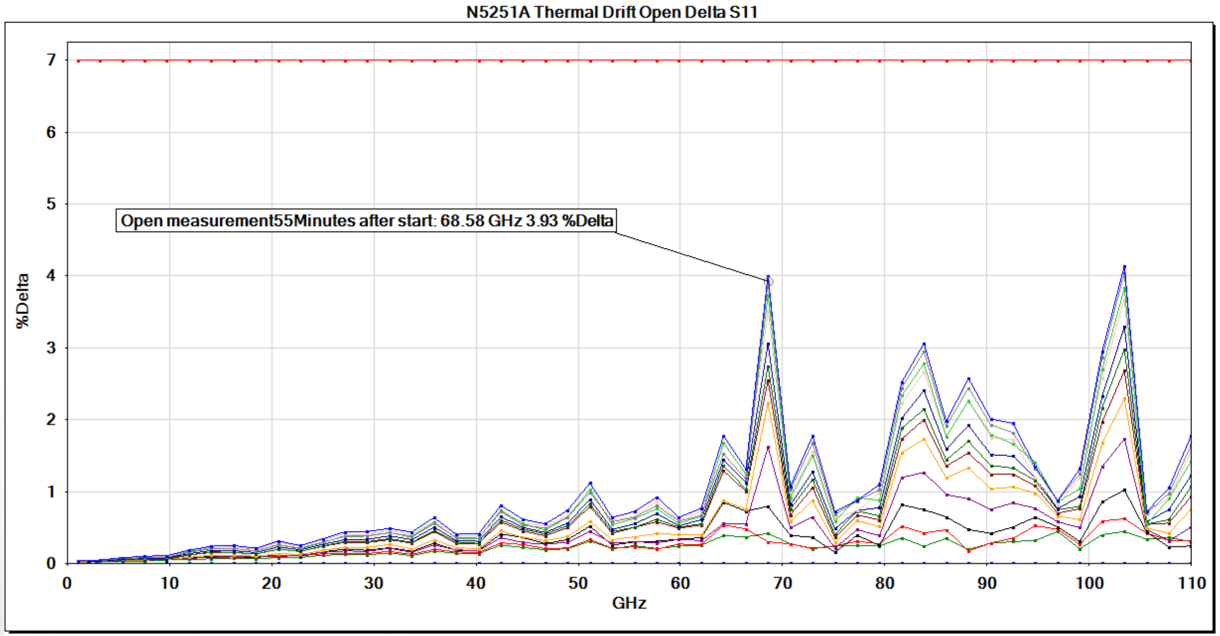
- **This was a 50 GHz example**
- **Reference set at ambient**
- **System was calibrated and probes left above chuck**
- **Chuck temperature raised to 125 degrees**
- **This is the Vector delta * 100 change during warm up without contact to the chuck**
- **Because of these changes we need to calibrate at operating temperature**

Temperature variation during calibration



- **Graph shows the change in temperature of probe base during 1.5 minute calibration cycle**
- **Manually positioning probes on ambient ISS can be inaccurate and time consuming**

Problem – Calibration Drift



- Calibration drifts with time and temperature changes
- Magnitude increases with frequency
- Transitioning chuck temperature invalidates calibration
- Drift has been greatly improved using N5291A system but still a consideration

Pain Points – Calibration Drift

Even a good calibration will drift with time, temperature changes and movement of cables

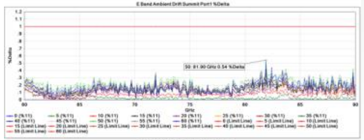
Even small temperature changes in the room, can cause higher frequency calibrations to drift

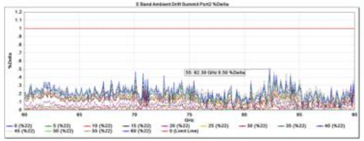
There is no automation of monitoring the magnitude of drift error

Manual checks can be made of the open standard at any time, but automating this requires programming in the test executive

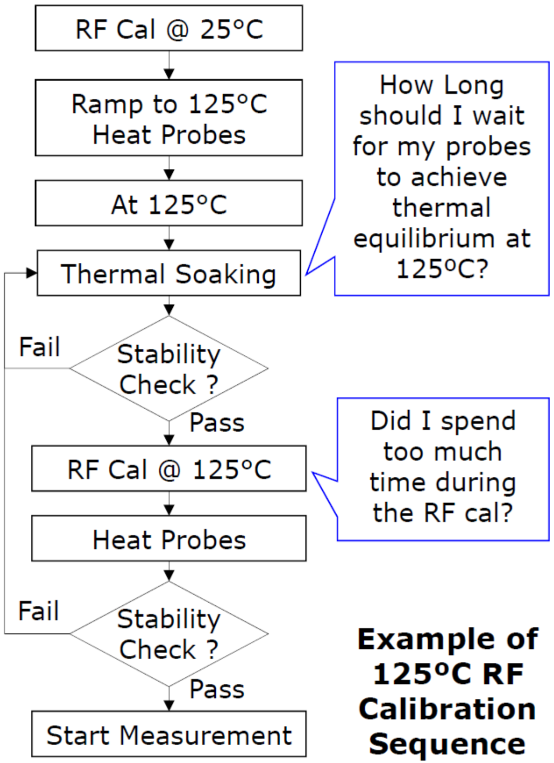
And no autonomous way to re-calibrate once the drift has exceeded a limit

If the calibration is found to be no longer valid, then the user needs to stop the testing and perform the whole calibration again





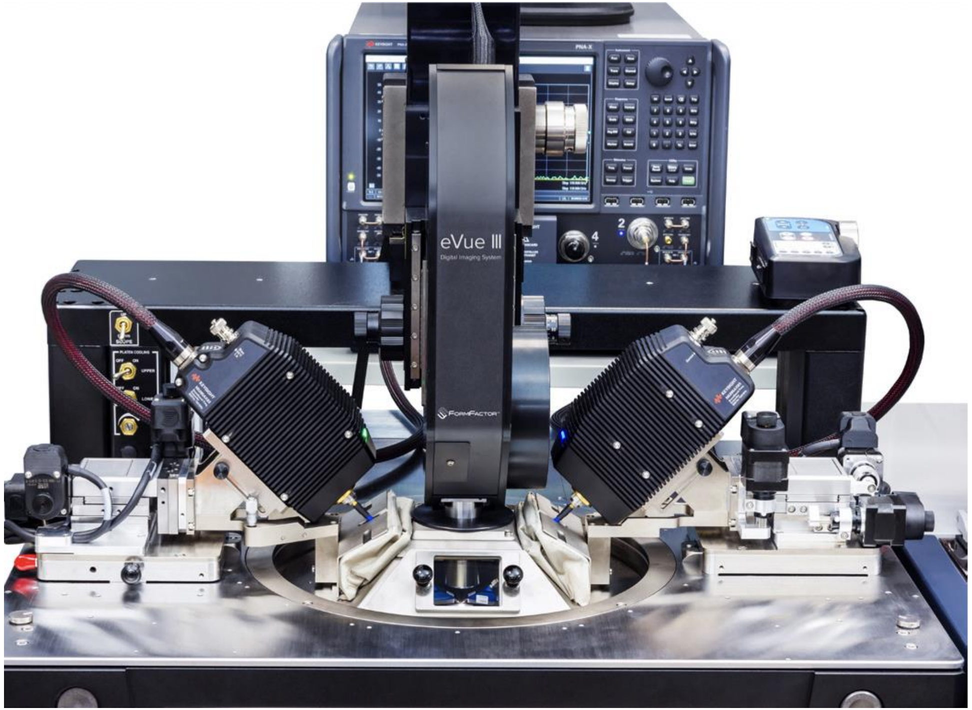
Over temperature calibration general approach



Example of 125°C RF Calibration Sequence

- **Doing all of this takes skill, patience and experience**
- **Doing things without the checks can result in erroneous data**
- **Getting calibration fast enough is very tricky even for experienced users and compromises are often made**
- **Machine must be "nursed"**

Introducing – Autonomous RF Measurement Assistant

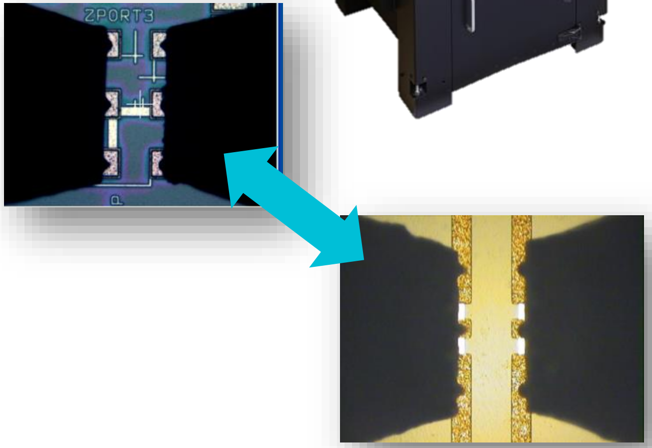


Contact Intelligence™

"Only the Autonomous RF Measurement Assistant, a combination of programmable positioners, a precise digital microscopy system and advanced pattern recognition algorithms, enables fully autonomous, hands-free calibrations and measurements of RF devices over multiple temperatures."

Autonomous RF

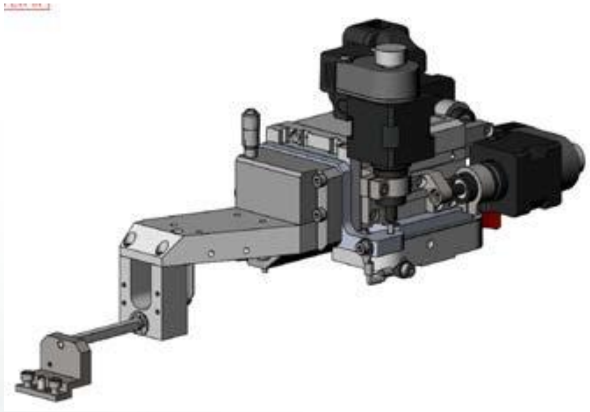
- **True Automatic, hands free calibration**
- **Setup of Calibration requires no expert placement, all automatic**
- **Monitors calibration drift, re-calibrates automatically**
- **Full management of system expansion and RF stability**
- **Full thermal automatic calibration**
- **Save time & increase data accuracy**
- **Corrects “thermally induced” probe electrical errors**



Compact High resolution Programmable Positioner

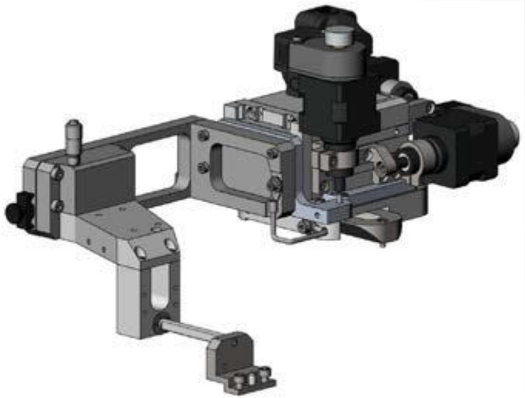
- **Compact positioner allows for multiple motorised positioners on the same prober**
- **Designed from the ground up for best accuracy, repeatability and service life**

New RPP504 Programmable Positioners



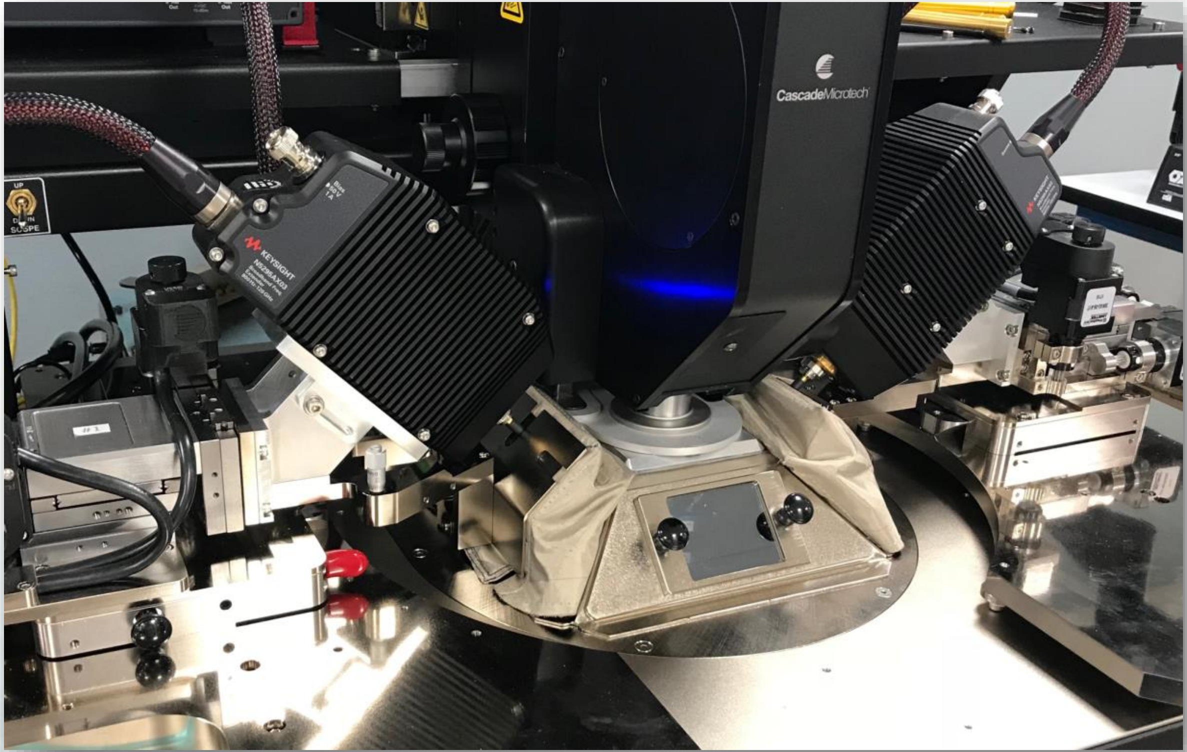
RPP504-EW-67

RPP504-EW-120



RPP504-NS-67

Reduced path length and improved performance



- **Tophat designed to minimise cable lengths and prevent stiction which impacts motorised positioner accuracy**
- **Reducing cable length helps to improve system drift and dynamic range**
- **Autonomous RF currently limited to max 130 GHz and Infinity probes**
- **Can be used with conventional sub 67 GHz coaxial probes**

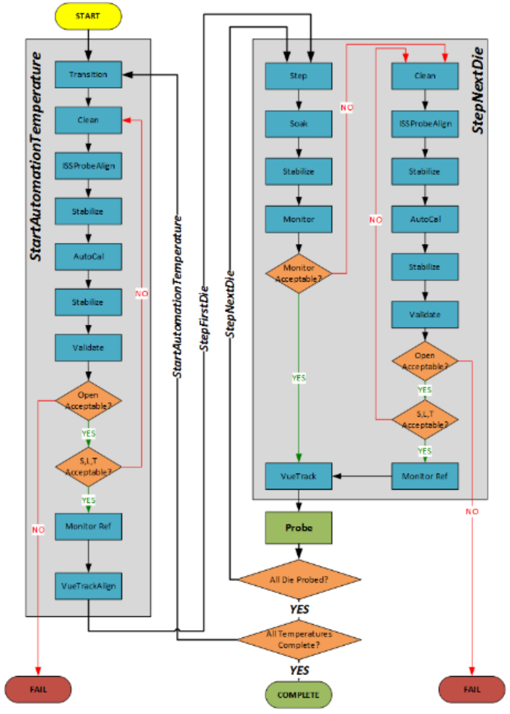
System Photos – Probe Window

- **Clear window designed to ease setup when south positioner is not in use**
- **Quickly sealable using metal cover**
- **Shielded to prevent charge build up**

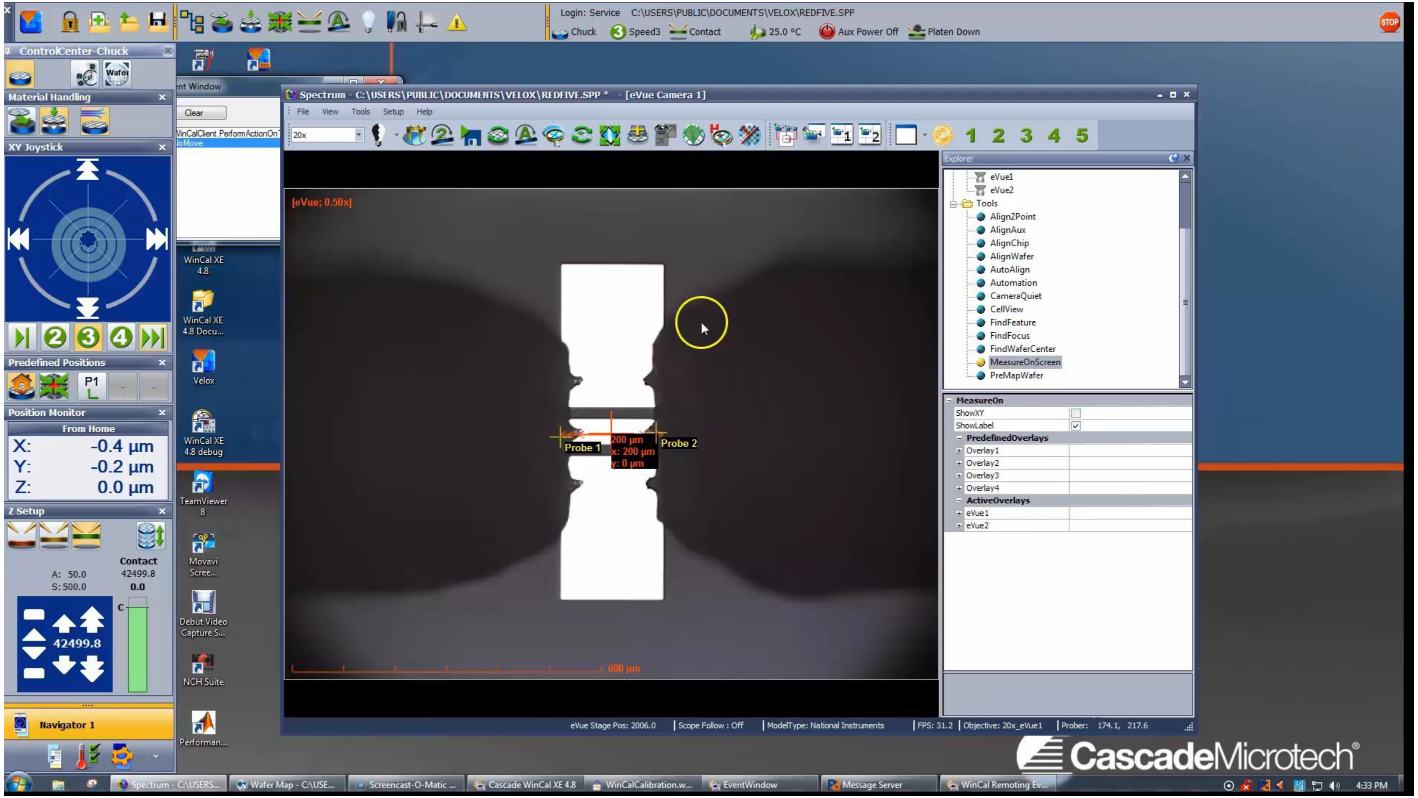
Integrating Automation assistant into test executive

StartAutomationTemperature X does all this…

- Changes temperature and maintains probe to probe, and probe to wafer geometry at Separate
- Die soak at end of transition at align height always maintaining geometry
- Checks using VNA to test for electrical stability
- Moves bias probes out of field of view
- Aligns probes at ISS using defined spacings
- Re-checks stability to ensure probes didn't cool down
- Calibrates system
- Verifies
- Takes monitoring data to check system is stable later on
- Returns probes to wafer Geometry ready for test
- Addition options of this command performs Theta align and sizing



Autonomous RF Measurement Setup video

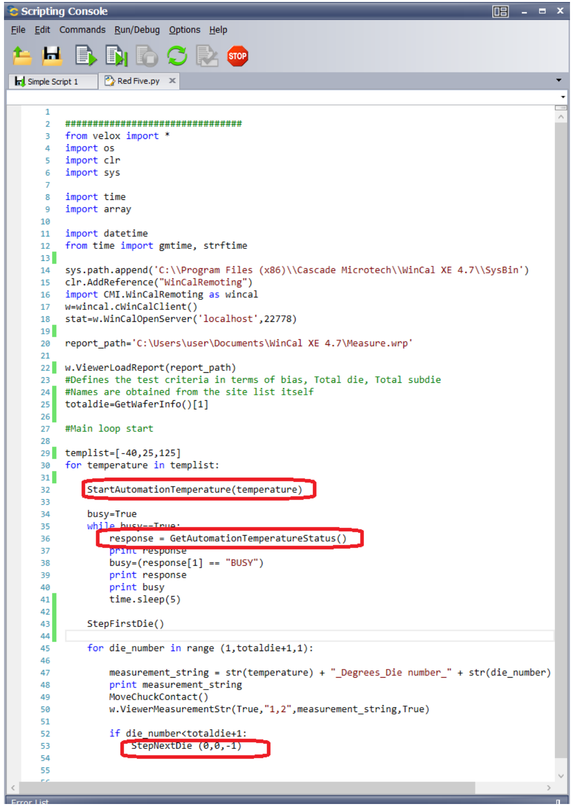


Video

Scripting in Python

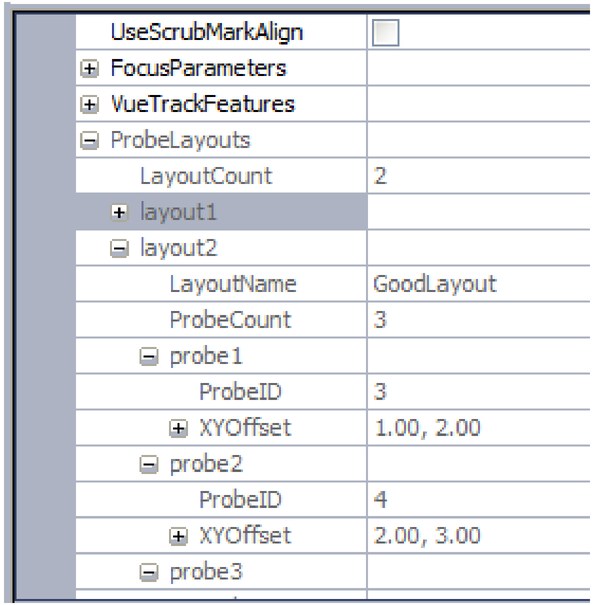
This code is enough to measure all die on a wafer at 3 different temperatures using WinCal

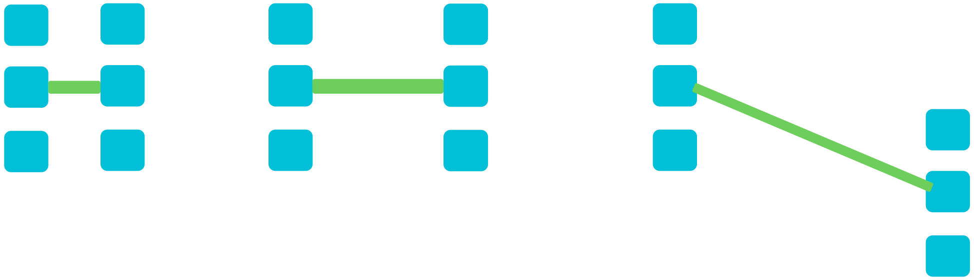
Red Ringed are automation activities



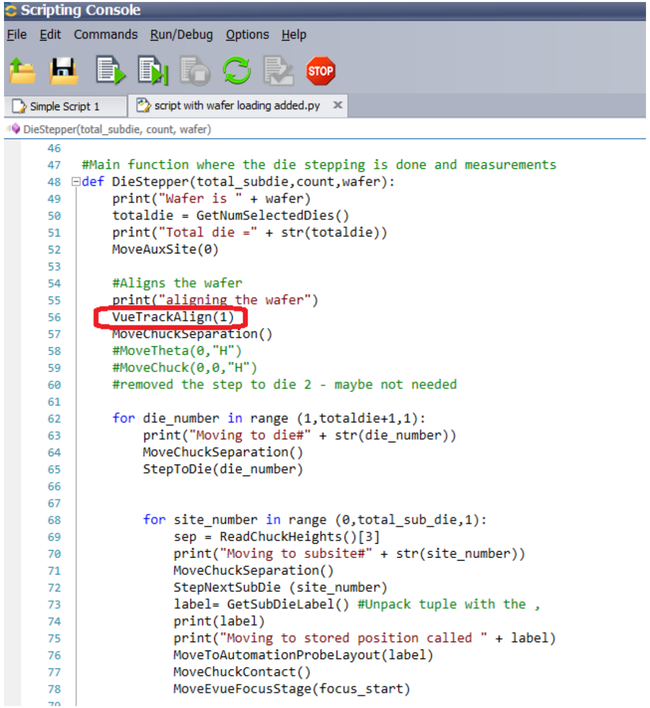
Multiple device layouts

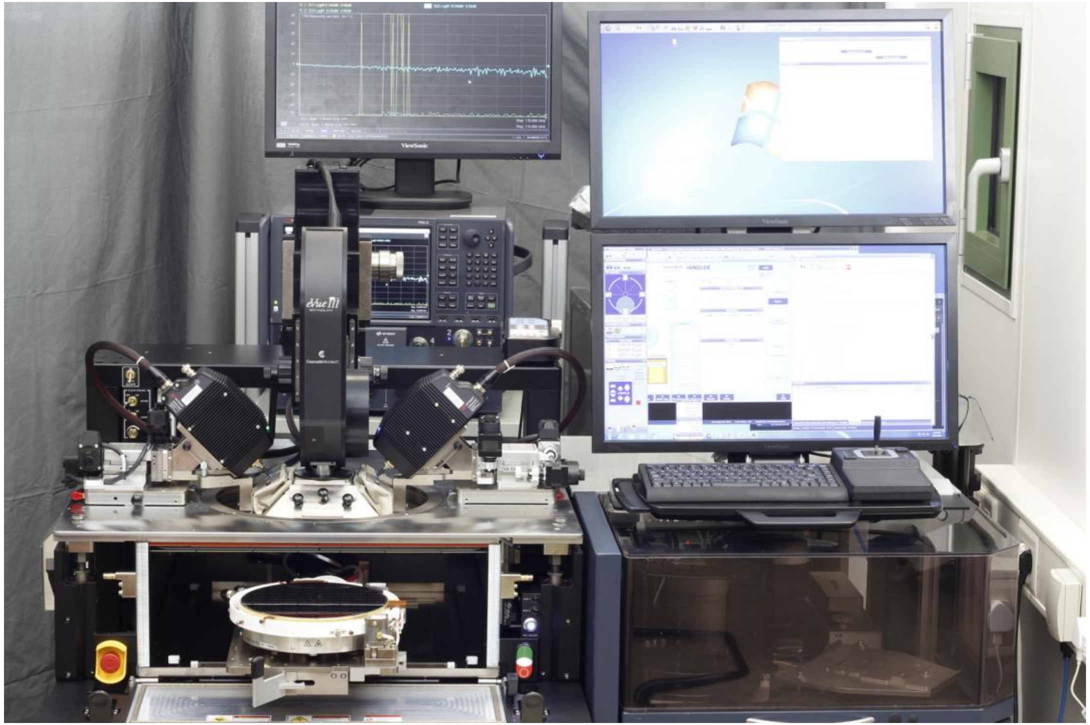
- **Autonomous RF supports different probe spacings for automatic movement to different device topologies**
- **Setup using script commands**
- **Scripting examples supplied to use the wafermap label to dynamically set a probe spacing for a given Subdie**





Using with Robotic loader on Summit 200 or CM300





- **Sample scripts available to show multi wafer, multi die, multi site automatic over temperature automation**

Autonomous RF Key Value Propositions

Ease of use – An inexperienced operator can perform an RF calibration up to 130 GHz by simply pushing a button. This reduces the need of the experienced users full time on each system

Reduced Soak Time – System will re-align the probes to the pads if they drift away from alignment. This reduces the time of test and increases throughput

Unattended Use – Measurements can be left running over night, testing all devices on the wafer, and at different temperatures without the need of the operator.

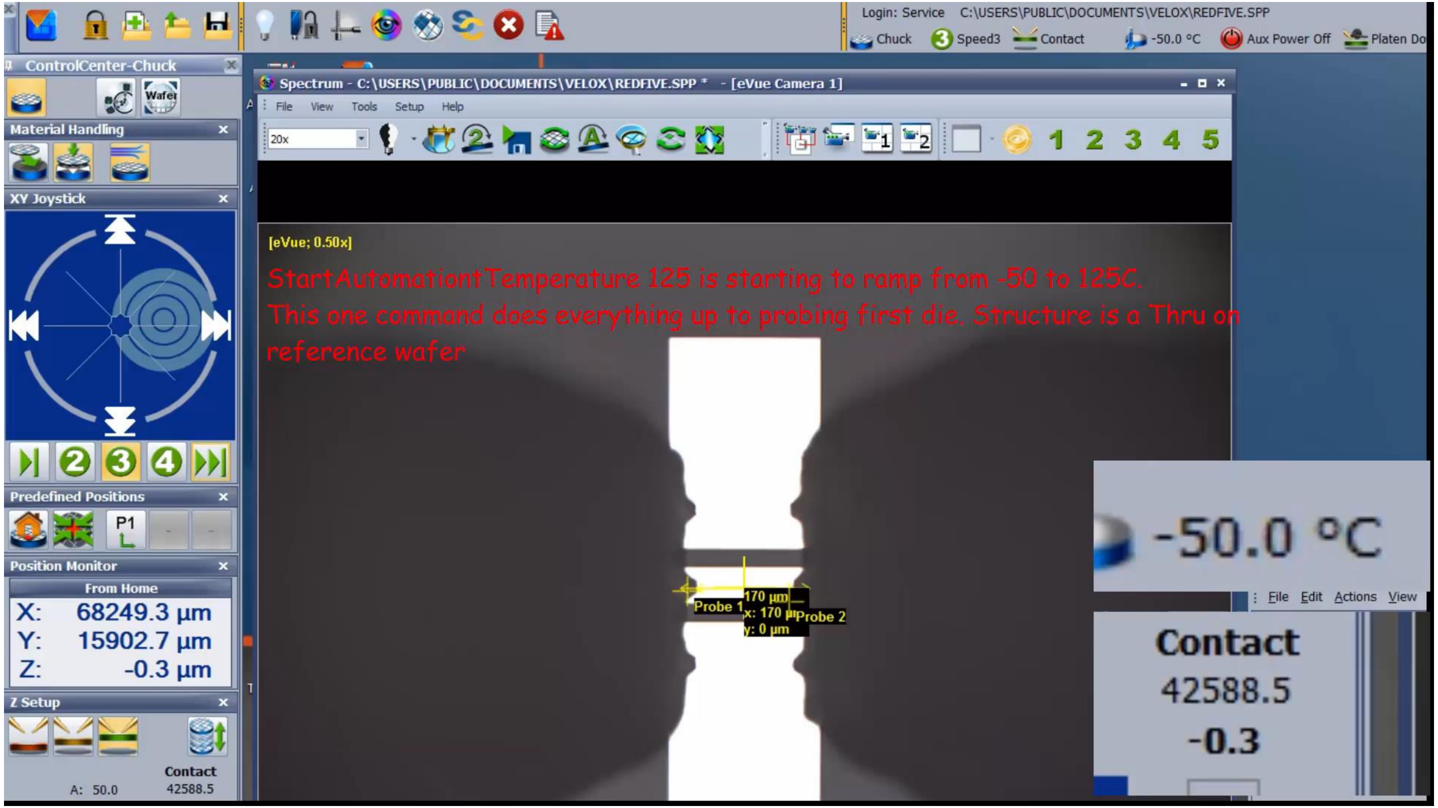
Calibration Monitor and Re-calibration – System will continuously monitor calibration drift, and automatically re-calibrate the system should the drift exceed a pre-defined limit

Data volume – unattended test allows more tool utilisation without additional time and money

Faster Time to Data

Lower Costs of Testing

Video –Temperature transition Run -50C to 125C



Video

Thank You!

For questions, please contact:

Toru Sugawara

FormFactor Japan

Toru.Sugawara@formfactor.com

TEL. 045-338-1286