COMPASS

a **FormFactor** users' group conference

FormFactor™

Autonomous RF/mmW Measurement and Calibration to Accelerate 5G Time-to-Data

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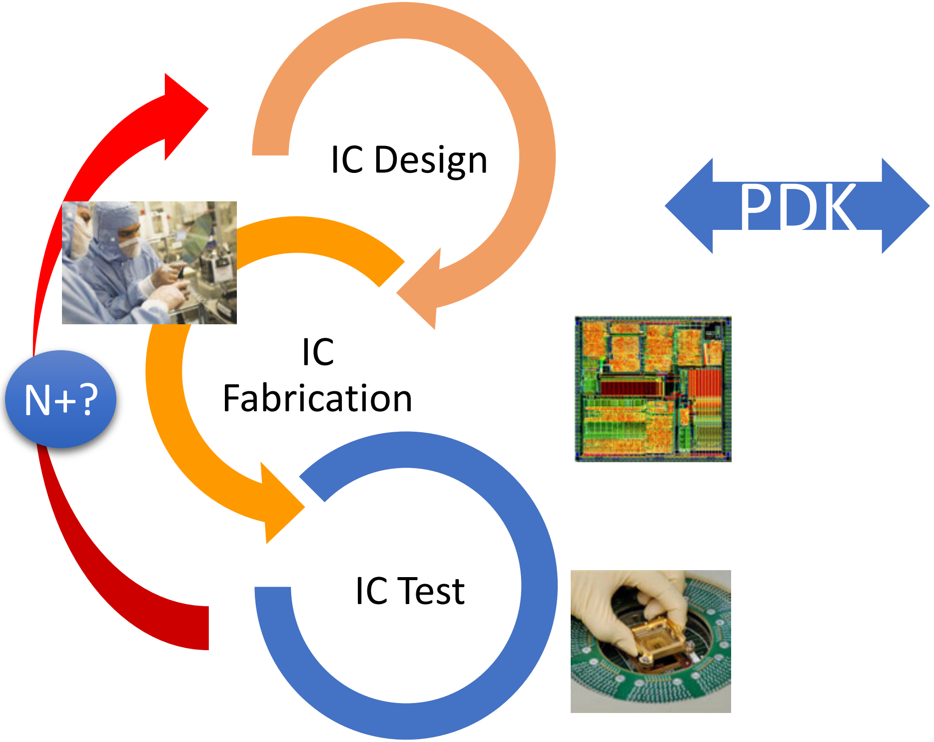
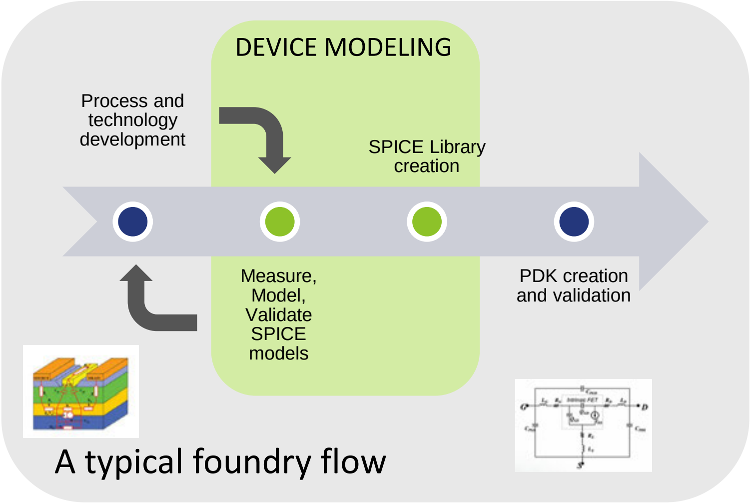
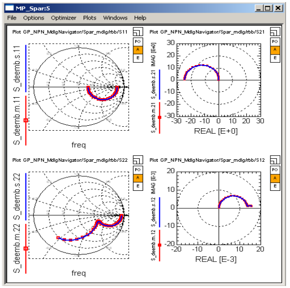
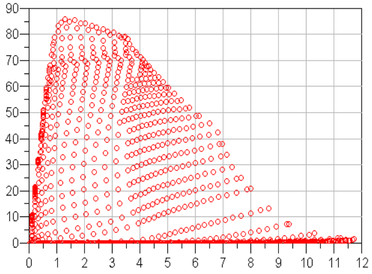
FormFactor

Why is device modeling critical?



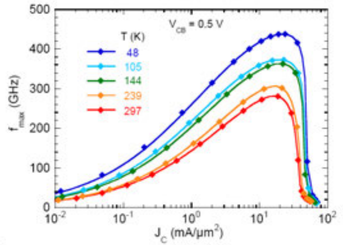


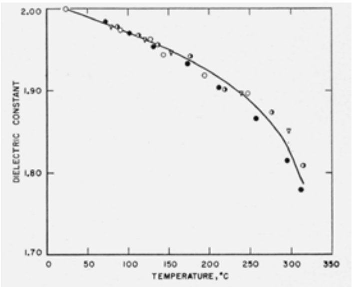


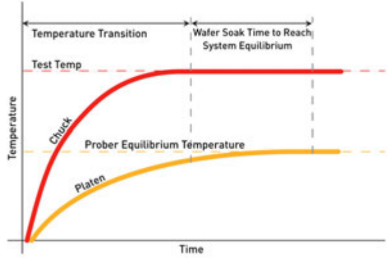


Pain points – testing over temperature

- 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





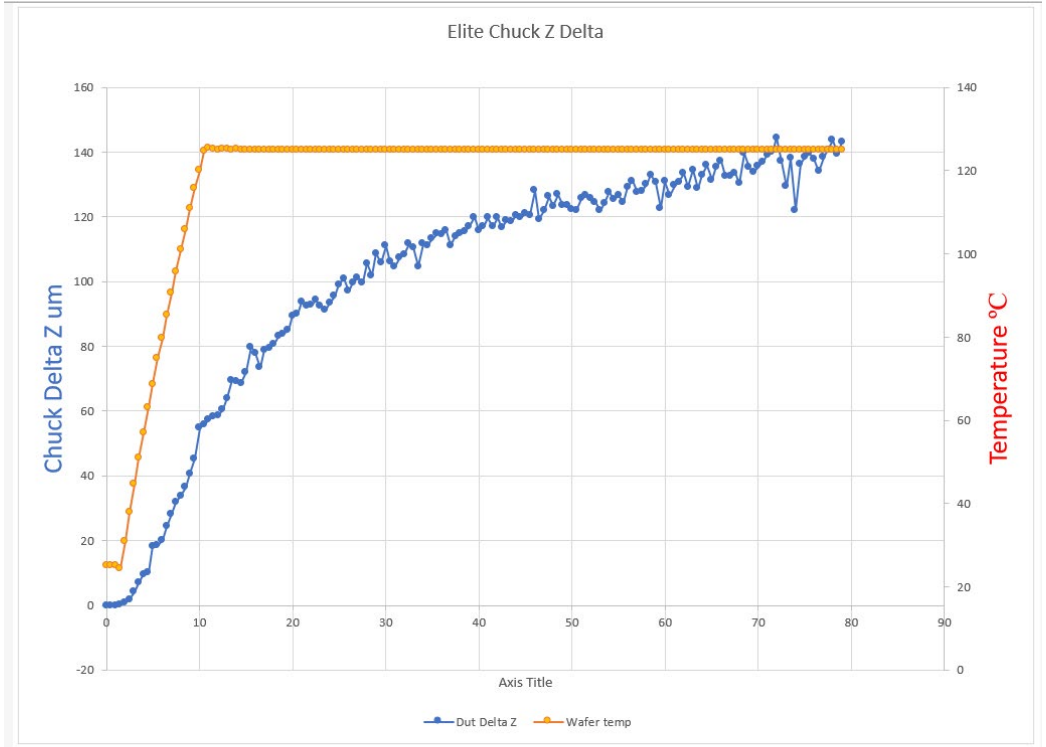


Mechanical effects of growth

- 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

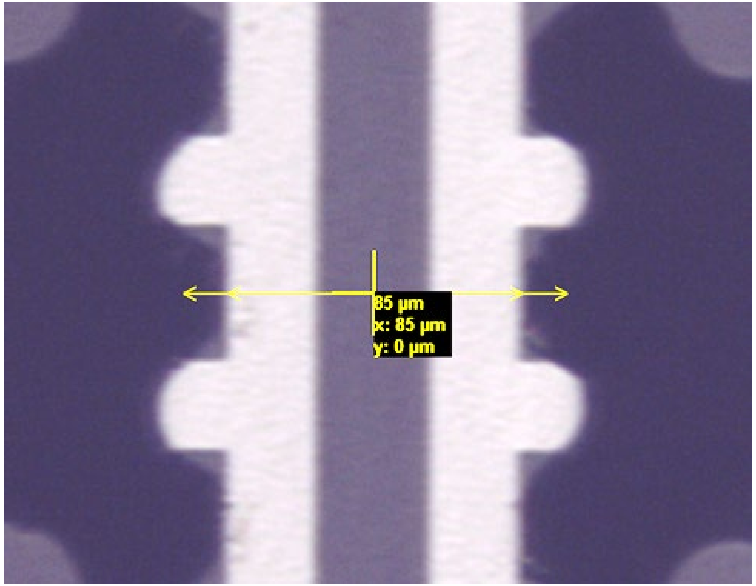
25oC>>125C>>25C

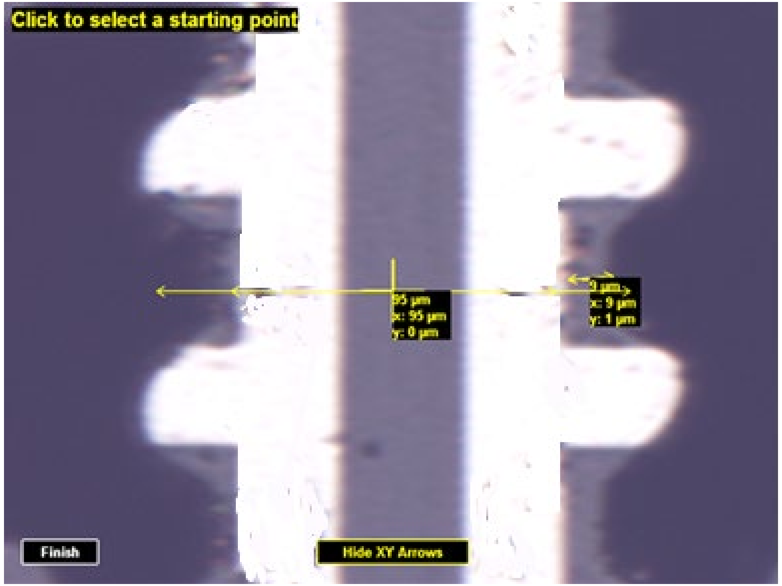
Chuck Z expansion



- Chuck to probe geometry change during soak
- Ideally we would like to probe during growth to save time

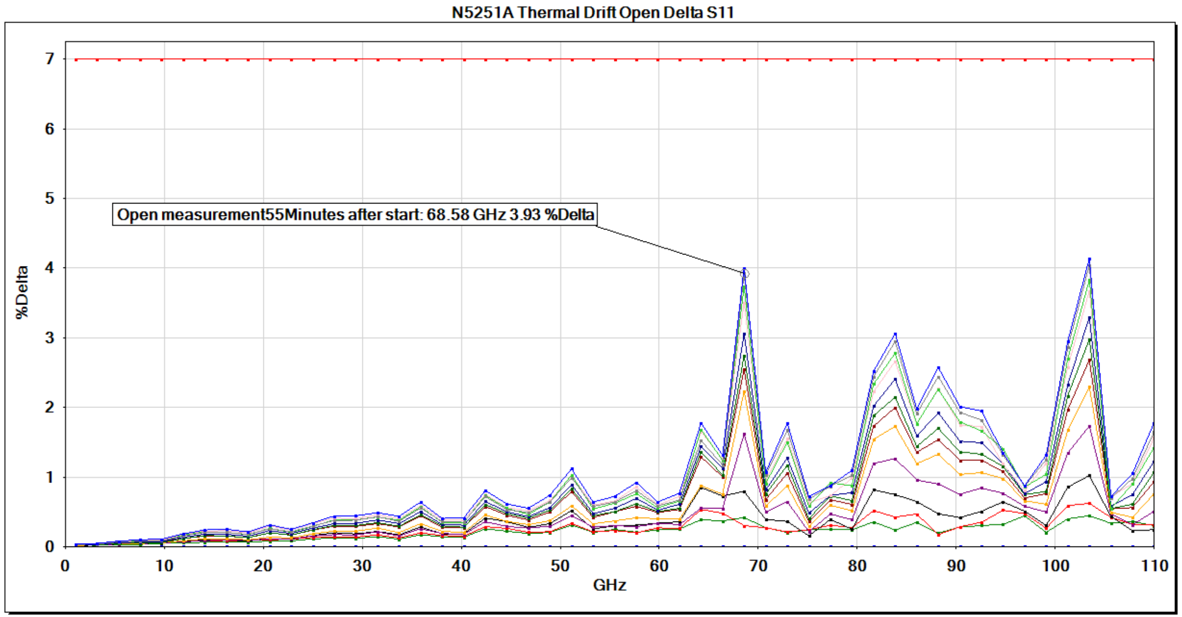
Mechanical effects during calibration itself





- Probe shrinkage during 1 minute LRRM calibration
- East probe further from hot chuck has 9 um delta in contact position
- Critical line measurement is measured first in calibration

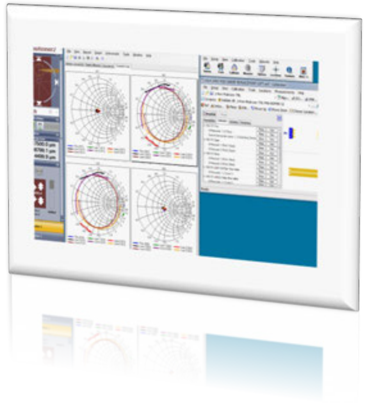
Problem – calibration drift

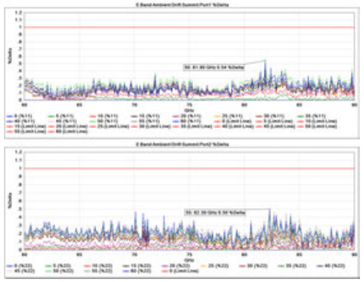


- Calibration drifts with time and temperature changes
- Magnitude increases with frequency
- Transitioning chuck temperature invalidates calibration
- Drift has been greatly improved using N5291A system but still a consideration

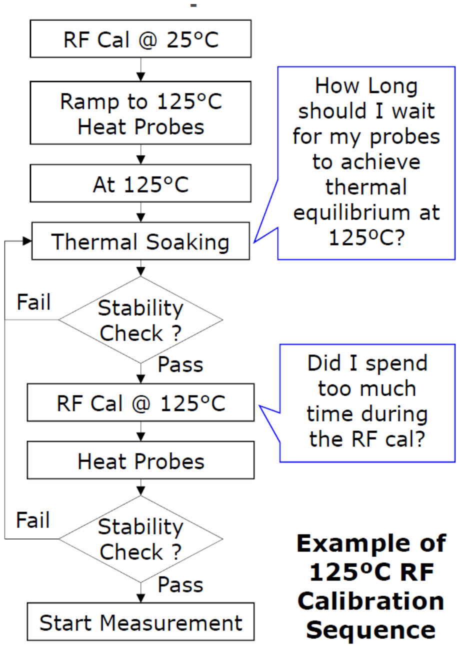
Pain points – calibration drift

- 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 me 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

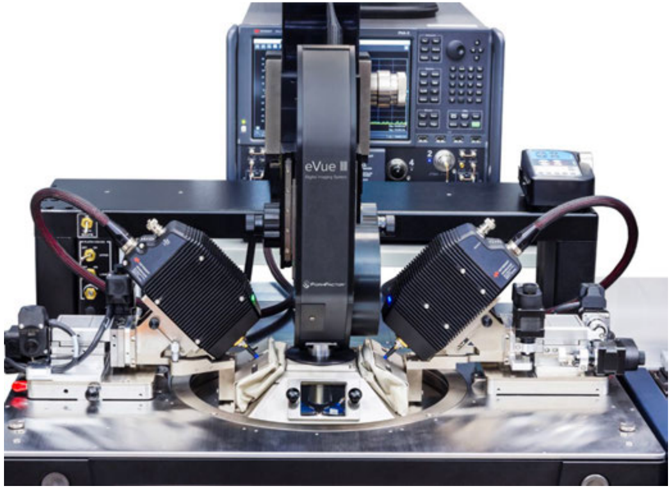


Example of 125ºC RF Calibration Sequence

- 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”

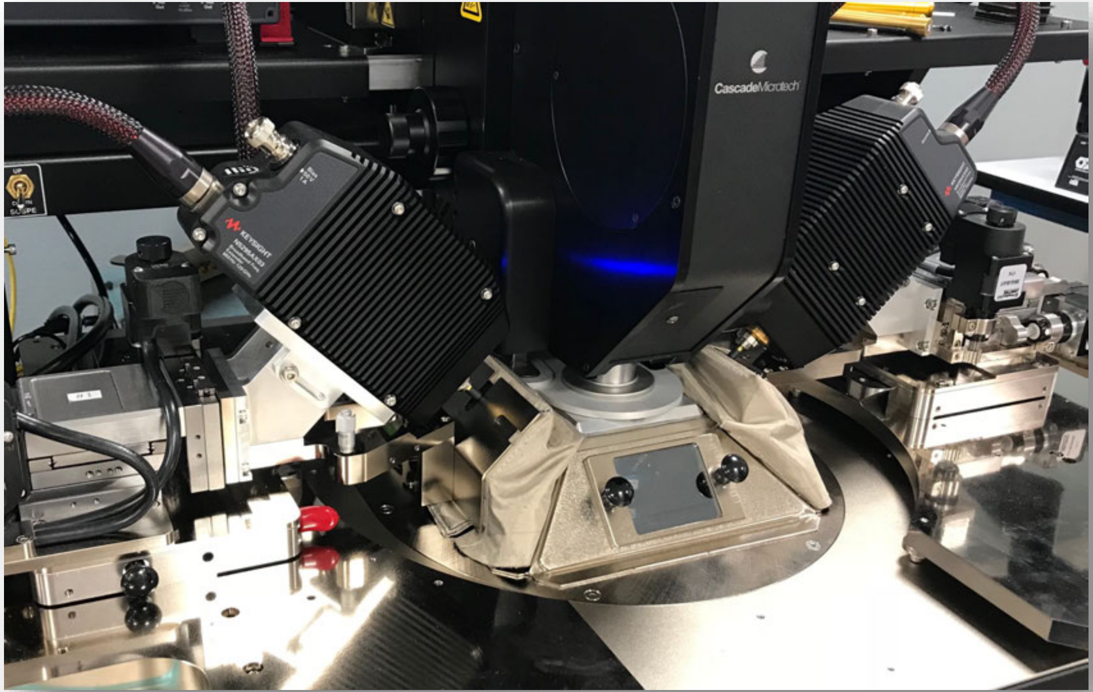
Introducing – Autonomous RF Measurement Assistant

- 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



Contact Intelligence™

Reduced path length and improved performance

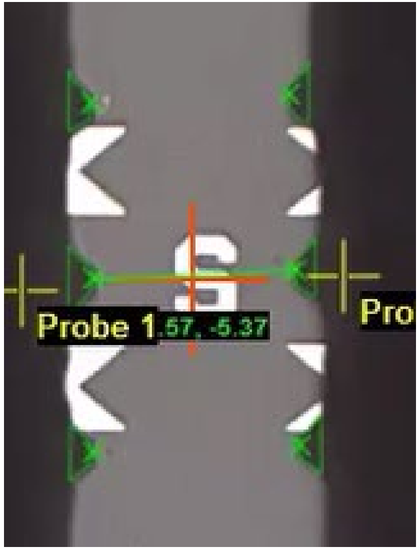


- Compact high resolution programmable positioner
- Tophat designed to minimise cable lengths and prevent stiction which impacts motorised positioner accuracy
- Reducing cable length helps to improve system drift and dynamic range
- Autonomous RF currently limited to max 130 GHz and Infinity probes

Integrating automation assistant into test executive

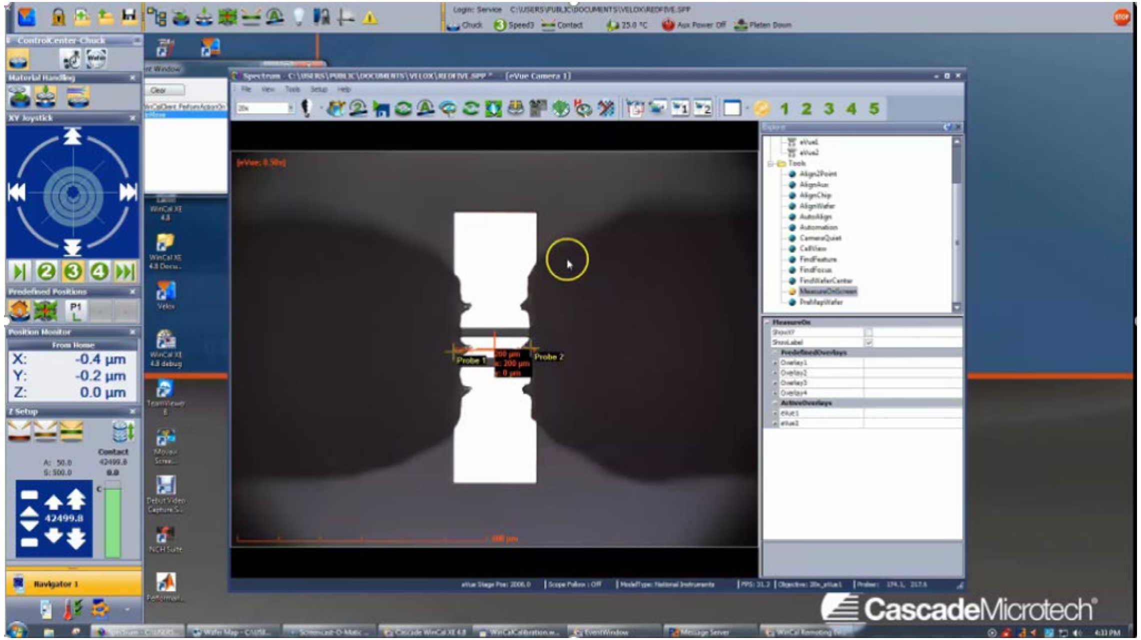
- Yellow Coloured processes are the two new commands StartAutomationTemperature GetAutomationTemperature Status
- Test exec never needs to ask system to calibrate, monitor or soak. Its all automatic
- Only needs to send temperature automation, wait till complete and then step to numbered die as normal
- Next die commands will check for drift, recalibrate if needed and automate probe on die placement
- supports different probe spacings for automatic movement to different device topologies

Training Autonomous RF – tip finding



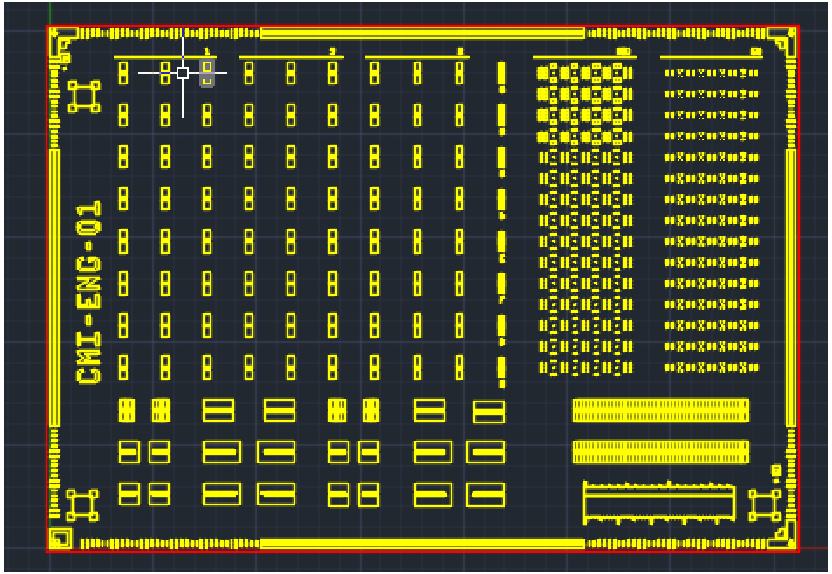
- Auto RF tip location and iteration is at the heart of the process
- Required for Autonomous calibration

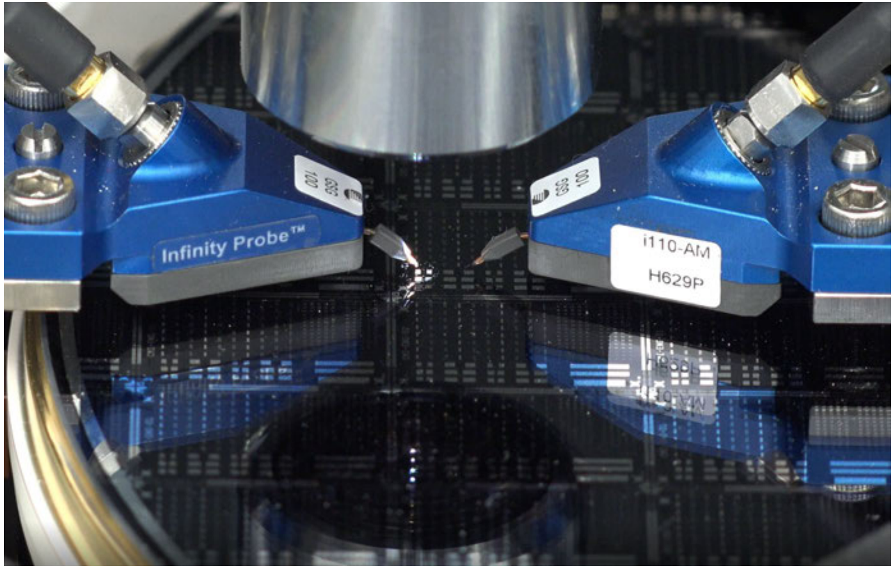
Autonomous RF measurement setup video



Video

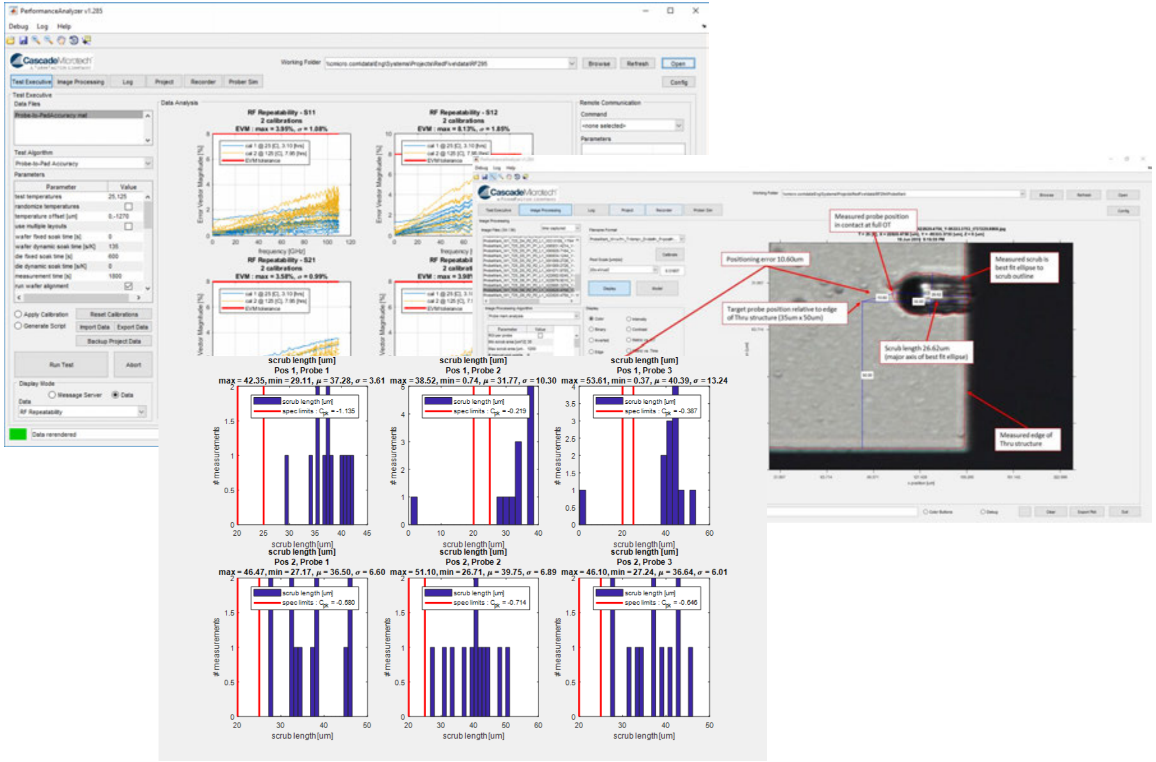
Custom validation wafer for performance evaluation





- Aluminium on glass Wafer contains array of validation lines and offset shorts and other open structures
- 200 and 300 mm versions
- Used for factory and field performance evaluation

Performance analyser



- FormFactor internal reference tool used to benchmark automation performance automatically
- Gives measurement deltas of standard across the wafer
- Statistical measurements are given from optical mark inspection to evaluate positioning error

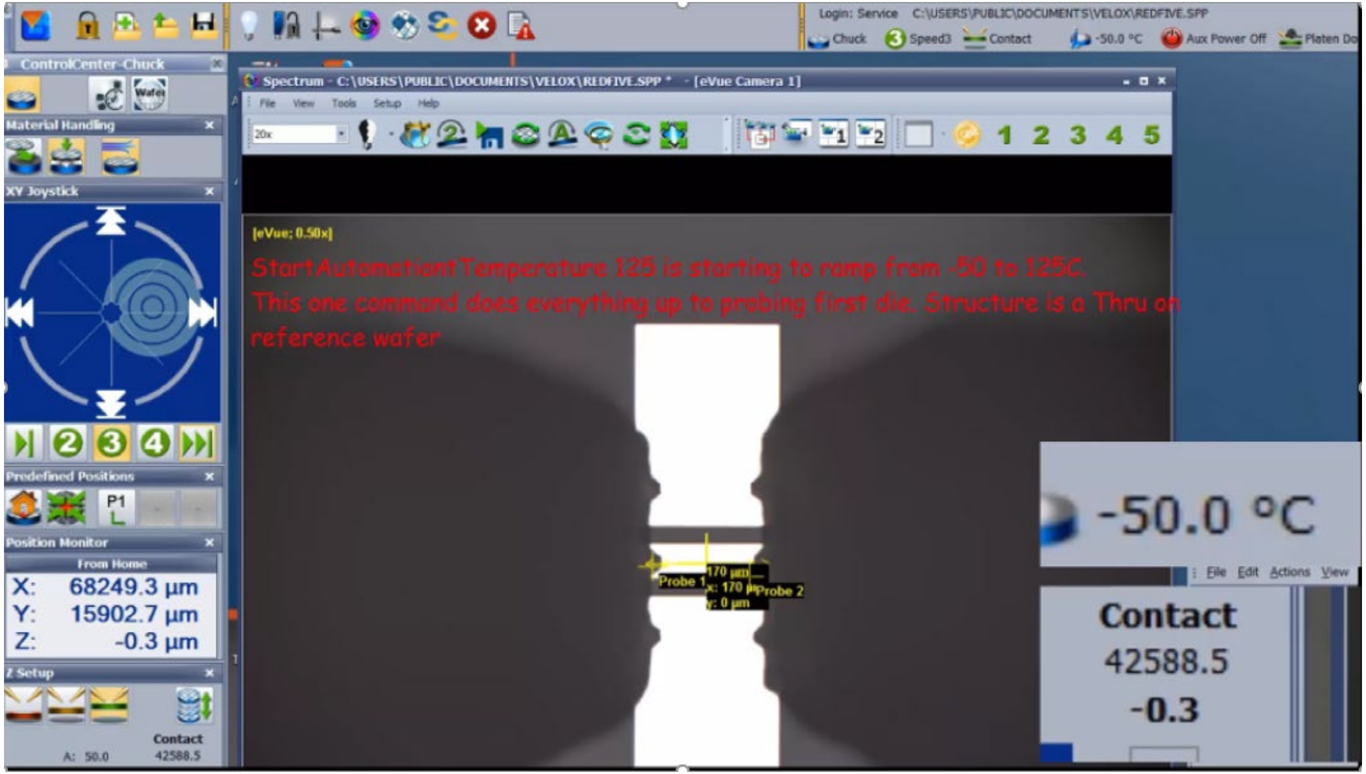
Autonomous RF Key Value Propositions

- **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

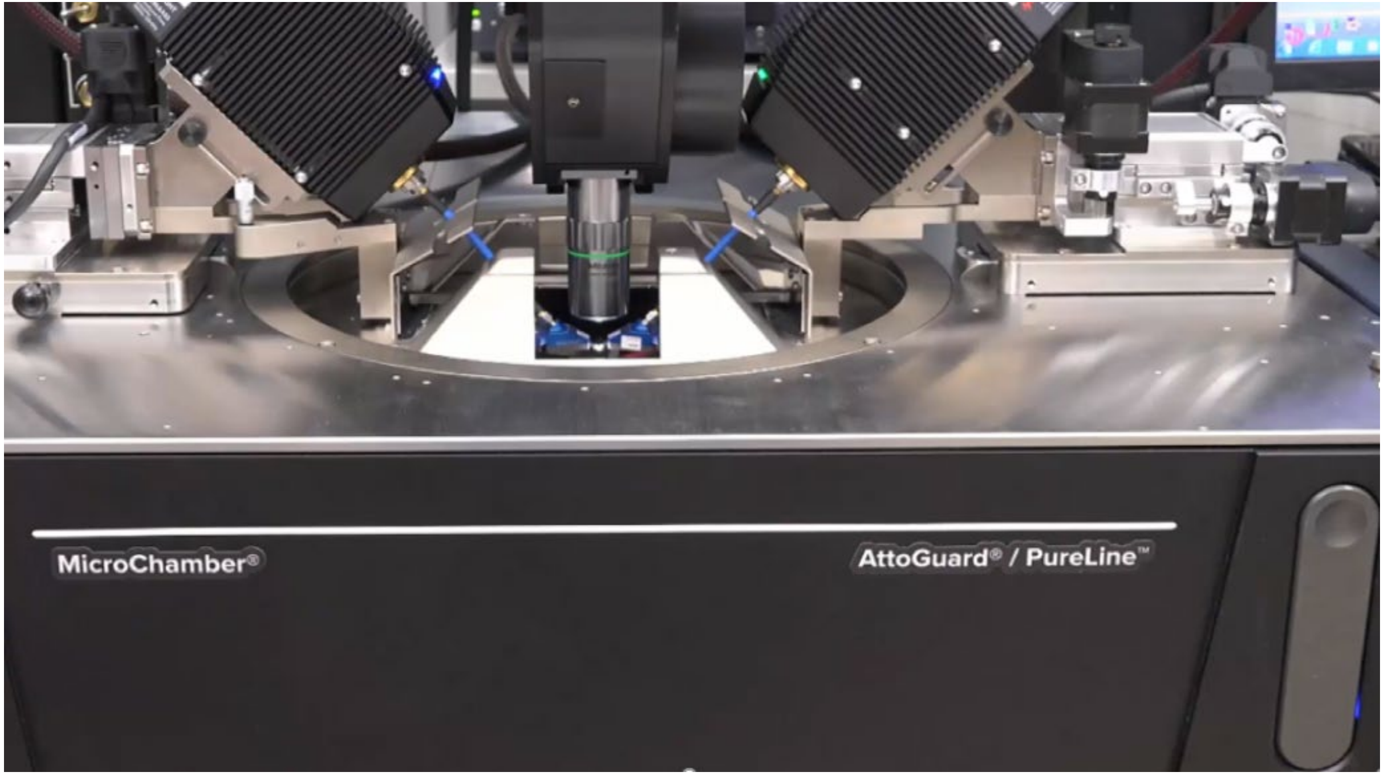
Lower Cost of Testing

Video – temperature transition run -50C to 125C



Video

Video – SUMMIT200



Video