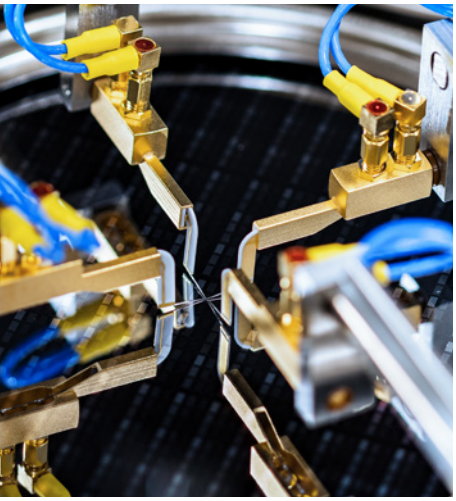


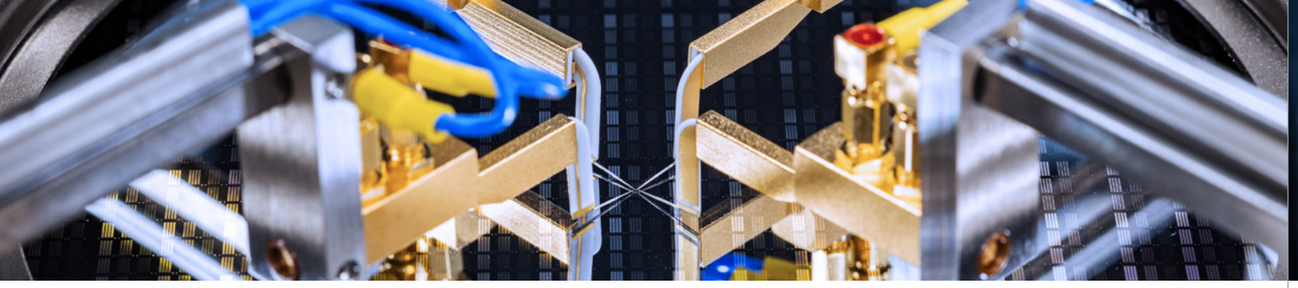
Cascade

Autonomous DC Measurement Assistant

Contact Intelligence™

Improving Accuracy and Accelerating Time to Market

FormFactor™



Achieving High Throughput DC Parametric Measurements

For todays DC parametric probing of devices with small pads for over-temperature device characterization and modelling, manual probe-to-pad alignment can be very time-consuming. Temperature transitions make frequent readjustment of the probes necessary to avoid needle collision, pad damage and invalid data due to thermal system drift. To increase accuracy, lower cost of test, and significantly increase on-wafer test throughput, automation can be added to a test setup using four different methods:

1. Automatic wafer loading
2. Motorized probe positioners for small pad touchdown optimization
3. Automatic thermal transitions with probe-to-pad-alignment
4. Multi-DUT layout automation

Lower cost of test

Increased on-wafer test throughput

Consistent low contact resistance probing

FormFactor's CM300xi-ULN Probe Station with Auto DC Measurement Assistant. The solution is also available for the CM300xi, SUMMIT200, Summit 12000 and Elite.

Autonomous DC Wafer Probing featuring Contact Intelligence™

FormFactor's Autonomous DC Measurement Assistant creates a paradigm shift for engineers and lab managers. It is now possible to setup a high throughput test cell, for both semi- or fully-automatic systems, offering complete hands-free 24/7 operation.

The Autonomous DC Measurement Assistant combines motorized probe positioners with state-of-the-art image processing to achieve highly-reliable measurement data at any time. It enables small pad touchdown optimization, automatic testing over multiple different temperatures, and automatic probe layout spacing for testing sub die.

Both single-DUT probe layouts and multi-DUT layouts can be easily called by measurement software for complete automation. The Autonomous DC Measurement Assistant takes care of all the complex management of thermal transitions, and thermal soak time optimization of probe-to-pad-alignment (PTPA). The result is optimized and reliable low contact resistance probing on small pads down to 30 µm for device characterization and modelling at extended temperatures (-55 to 200°C), over all dies on a wafer, and all wafers.

"The Autonomous DC Measurement Assistant combines motorized positioners with state-of-the-art image processing to achieve hands-free 24/7 operation."

24/7

Autonomous 24/7 Operation
Up to 4x faster DC parametric thermal testing on 30 µm pads

≥ 30 µm

Small Pad Probing
Accurate contact of small pads down to 30 µm

R_c Optimized

Optimized Contact Resistance
Improved test data with dynamic control of each probe touchdown

Multi-DUT Layout Testing
Enhanced test flexibility and increased throughput

-55 to 200°C

Measurements Over Temperature
TopHat:
EMI-shielded, dark and frost-free

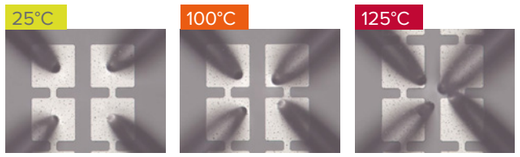
Contact Intelligence™

Small Pad Probing down to 30 µm – at Multiple Temperatures

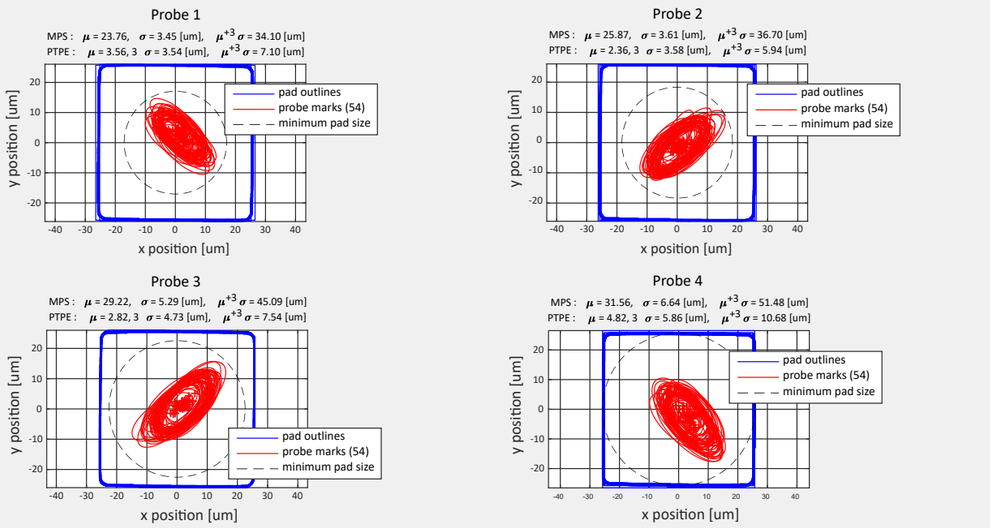
"Autonomous DC constantly monitors the probes and will automatically readjust if necessary."

On-wafer measurements are particularly challenging when probing on small pads and at multiple temperatures. Temperature transitions will lead to mechanical expansion/contraction of the probes, the chuck, and the wafer itself in X, Y and Z. If not monitored properly, there is a high risk that the probes hit one another as they change in X and Y, or damage the pads significantly as they expand in Z. To maintain good contact, readjustment of the probes to the pads is necessary after each temperature change.

Auto DC **constantly monitors the probes and will automatically readjust** if necessary. It ensures accurate contact of small pads down to 30 µm at any time and over the full temperature range*, resulting in faster time to measurement, increased productivity and higher contact accuracy compared to manual adjustment. Finally, it protects your valuable equipment from unintended crashes.



Temperature transition without readjustment: The probes have been aligned to the pads at 25°C. After temperature transistion to 100°C and 125°C, the probes need to be readjusted in order to make good contact. This is done automatically using Auto DC.



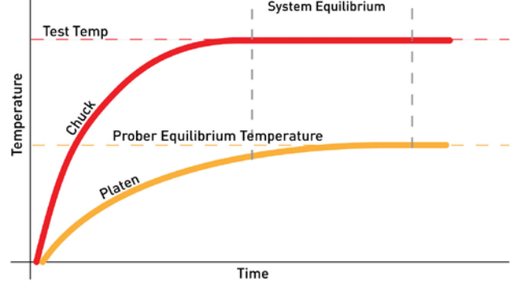
Measured data: 54 sets of die touchdowns / probe scrub marks, at multiple locations across 300 mm wafer, with accurate touchdown of 4 motorized probes on 30 µm pads, at 6 different temperatures (25, 150, -45, 175, -55, 200°C). Conditions include wafer soak 3 hr, die soak: 10 min, and 30 min contact test time.

Optimized Soak Times

Temperature transition soak time

When a wafer prober transitions to a new temperature, the chuck reaches the target temperature, while the prober structure (platen) has a time lag to reach thermal equilibrium. A prober must reach thermal equilibrium before probes can contact the pads, otherwise probes would drift off the pads after touchdown.

Autonomous DC automates the adjustment process by applying pre-defined soak conditions before it automatically readjusts the probes and starts the measurements.

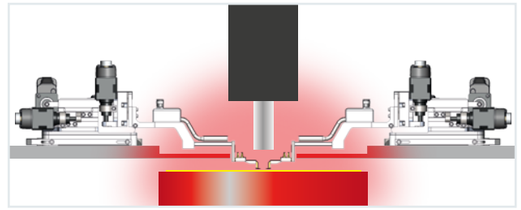


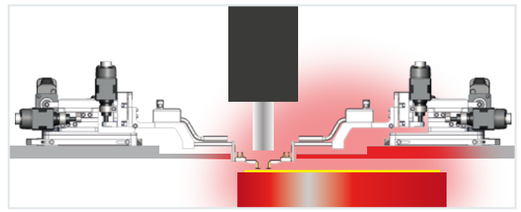
The time required for the prober to reach thermal equilibrium before probes can contact the pads is referred to as transition soak time or thermal soak time.

Die soak time

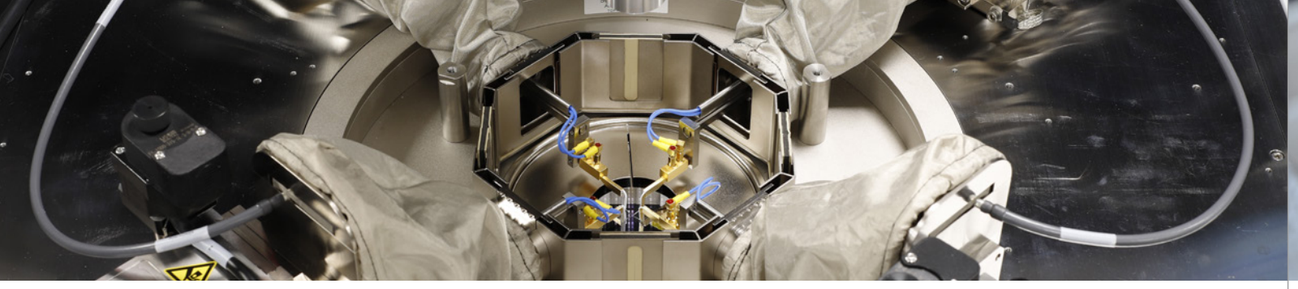
When the chuck is moved to a new test site a thermal imbalance in the prober is created. This imbalance is caused by an old hot spot cooling down and a new hot spot heating up. The time required for the prober to reach equilibrium under this condition is die soak time. Without adequate die soak time, probes can drift off the pads after contact is made, invalidating the data and possibly causing damage. This is especially the case when making large movements of the chuck to test only a few dies across the wafer or to reach a cleaning pad.

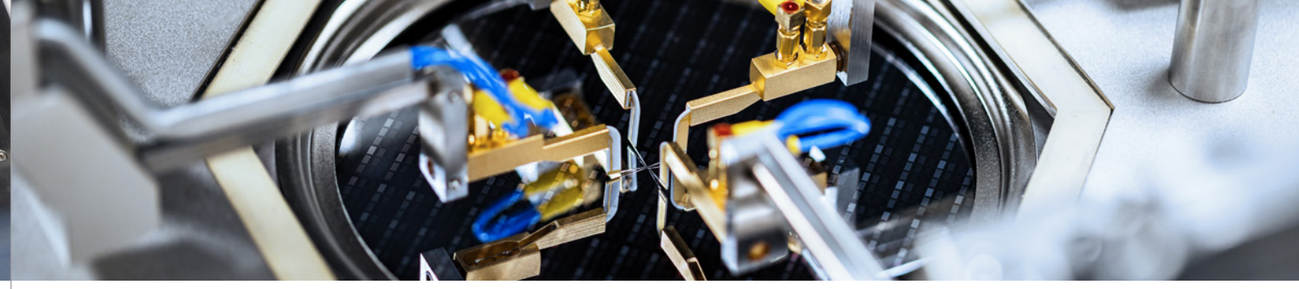
Autonomous DC manages die soak times and automatically readjusts the probes before continuing with the measurements.





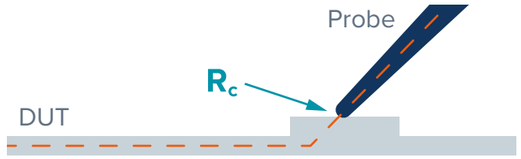
When the hot chuck is moved, a thermal imbalance in the prober is created.





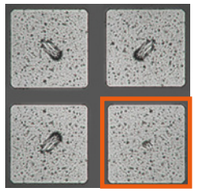
Optimized Contact Resistance

A low and consistent contact resistance (R_c) between the probe tip and the pad is an essential precondition for accurate measurement data. A good contact resistance is achieved by applying an appropriate force and overdrive to the probes. This is especially challenging when contacting small pads as the contact space is limited to a minimum.

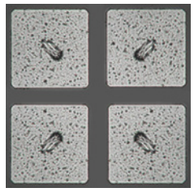


Auto DC provides **dynamic control of each probe touchdown** (Z overdrive) by analyzing probe marks and transition-related movements. The system will initiate corrective adjustments whenever necessary, resulting in consistent contact resistance for each probe, not only on the DUT but on the whole wafer.

The following example shows different probe marks on pads that indicate good and bad contact.



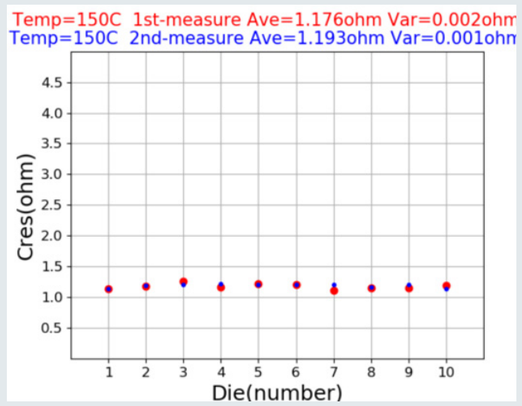
Probe marks after contacting four pads. The probe contacting the lower right pad did not make good contact.

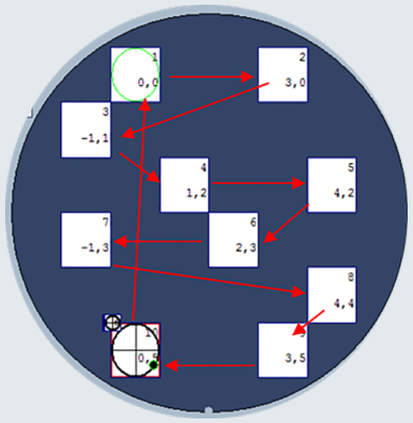


With Auto DC all four probes made good and consistent contact.

Automatic Probe Cleaning

In addition to monitoring contact resistance, Auto DC will perform regular probe cleanings to ensure highest contact quality.



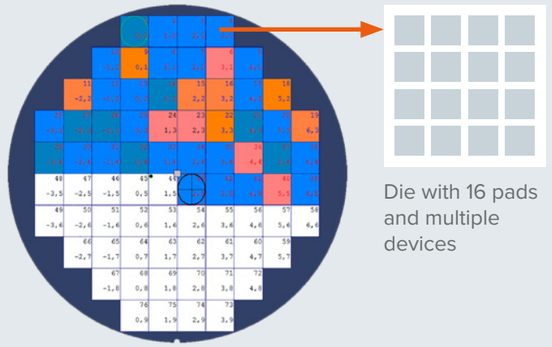


Consistent and low contact resistance measured on 10 dies across a wafer at 150°C. Average contact resistance is measured at 1.176 Ω with a variance of 0.002 Ω (first measurement) and 1.193 Ω with a variance of 0.001 Ω (second measurement).

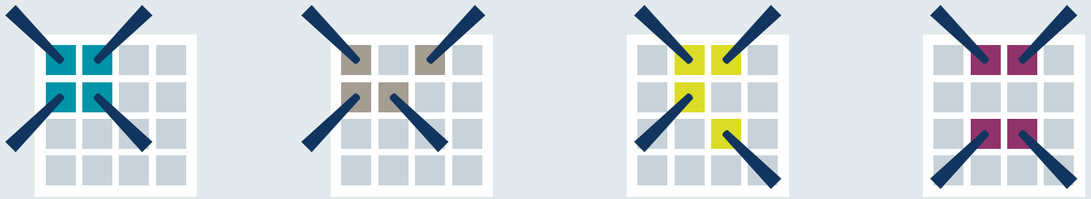
Automated Multi-DUT Layout Testing

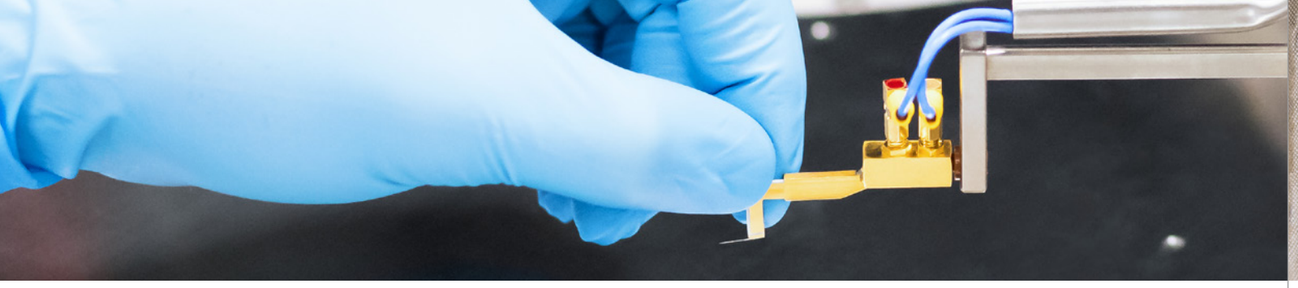
Testing multiple devices with different probe layouts in each die location can be very time consuming. Traditionally, a single layout is tested on all dies of the wafer, before setting up the needles for the next probe layout and testing each die again. Testing at different temperatures increases the duration even further due to additional transition, soak and adjustment times.

Auto DC automates multi-DUT layout testing by changing probe layouts automatically for each die. Multiple devices can be tested automatically in each die location before stepping to the next die. This enhances test flexibility and increases throughput.



Die with 16 pads and multiple devices



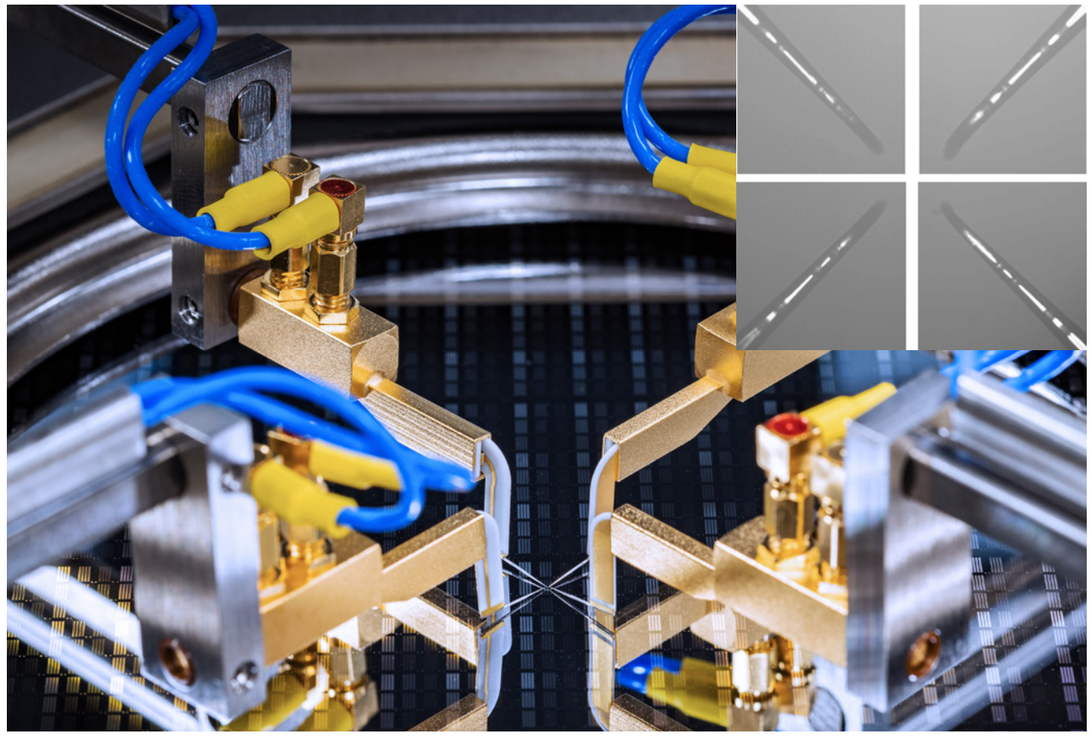


Industry-Leading High-Performance Probes

The DCP-HTR probe delivers fA-level measurement capability from -65 °C to 300 °C for advanced characterization and reliability testing. Its unique design offers superior guarding and shielding over-temperature, overcoming the high-temperature performance limitations of standard coaxial needles. The optional probe tips with small diameter are ideal for probing pads as small as 30 x 30 µm.

For advanced accuracy and better vision system recognition, Autonomous DC uses special laser-marked DCP-HTR probe needles.

- / Ultra-low, fA-level current and fF-level capacitance measurements from -65 °C to + 300 °C
- / Guarantees fully-guarded measurements to fA and fF levels
- / Individual connectors provide force-sense connection for quasi-Kelvin and CV measurements



Advanced laser-marked probe needles enable highest accuracy for small pad probing down to 30 µm.

Motorized Positioners

Perfected Probe Positioning with Highest Accuracy and Repeatability

Uniquely Developed Motorized Positioners

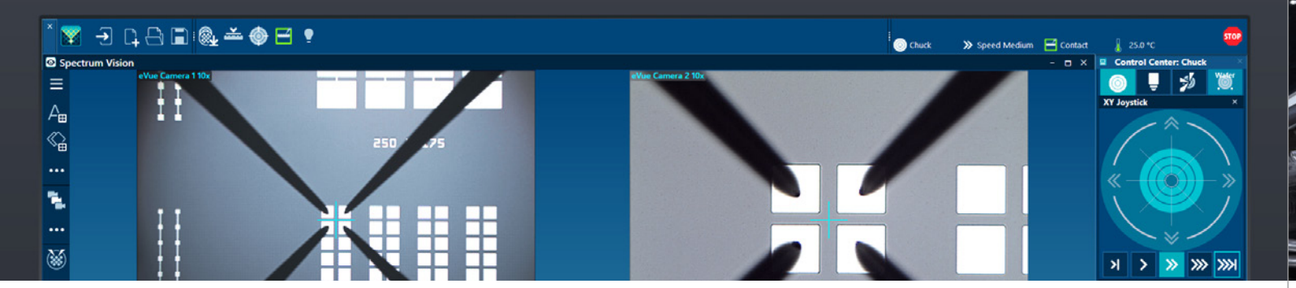
- Submicron positioning accuracy
- Additional manual controls and encoders
- Most accurate and repeatable probe positioning
- Up to six motorized positioners can be used with Auto DC

Only Available PRECISE From FormFactor

Newly designed programmable positioners have been developed specifically for this application, to give the highest positioning resolution for the most accurate and repeatable probe positioning and measurement performance. With 0.3 µm resolutions even the smallest errors can be recognized and corrected.

And with manual controls and encoders the user can set the system up like a manual DC positioner and the system never loses track of the probe location.

Up to six motorized positioners can be used with the Auto DC Measurement Assistant.



VueTrack™

Simplified Test Management Enables the Ultimate Test Experience

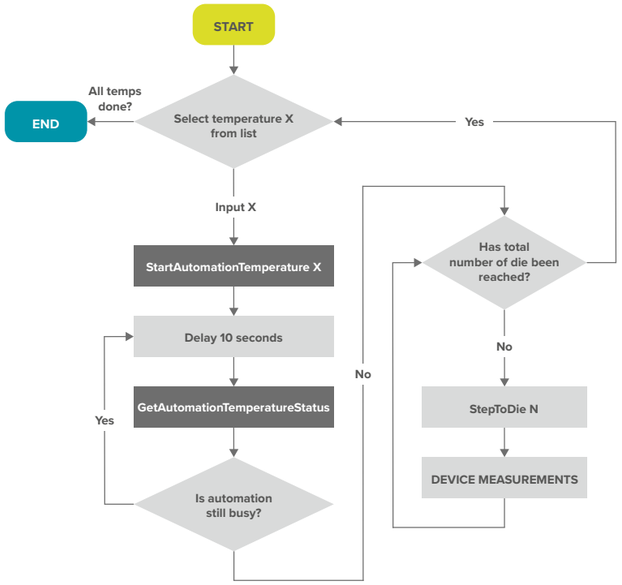
Exclusive Automation

- Simplified test sequences
- Minimized training needs
- Dynamic die soak times
- Higher productivity

Only Available SIMPLIFIED From FormFactor

The test sequencing has been vastly simplified, such that each temperature change only requires a simple line of command that will transition the temperature, soak, align the probes and report once ready to test – no operator intervention is required.

Once ready to test, the test controller software makes the desired measurement and moves to next die. Before contact is made, checks are performed to ensure the probes make precise contact to the pads, and only then the test of the next die is performed. All the thermal transitions, soaks, moving and probing is controlled by Velox and the VueTrack software.



All Manual Steps are Automated

- / Moves the probes to a save location during thermal transistion
- / Transitioning to next test temperature
- / Dynamic soak time to thermal equilibrium
- / Aligns the probes to first device ready to test

Full Thermal Range in a Shielded Environment

Exclusive TopHat with FlexShield

Exclusive TopHat

- Dark, shielded and frost-free
- Minimized system drift
- FlexShield for resistance-free probing
- Advanced accuracy

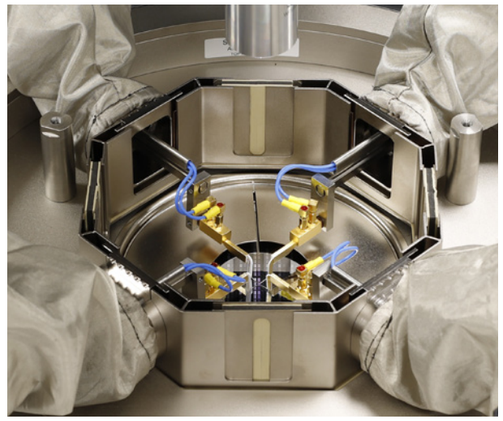
Only Available EXCLUSIVE From FormFactor

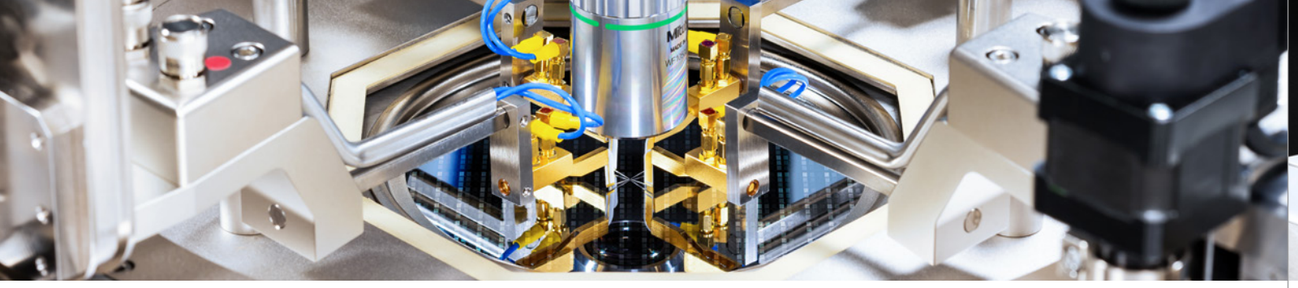
The Auto DC Measurement Assistant has been designed to integrate seamlessly with FormFactor's exclusive TopHat. In combination with the patented FlexShields the solution maintains a dark, shielded and frost-free measurement environment and prevents friction which impacts motorized positioner accuracy.

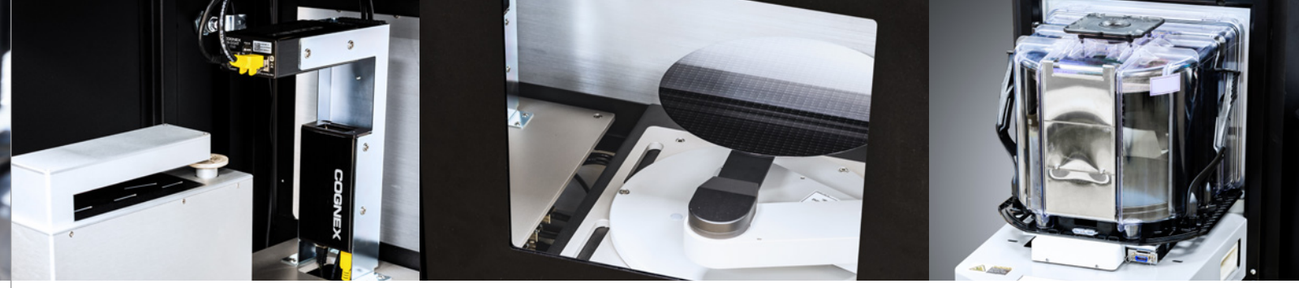
The Auto DC Measurement Assistant enables measurements from -55°C to +200°C.

FlexShield

- Resistance-free and highly accurate probe positioning
- Dark, shielded and frost-free







High Resolution Microscope System

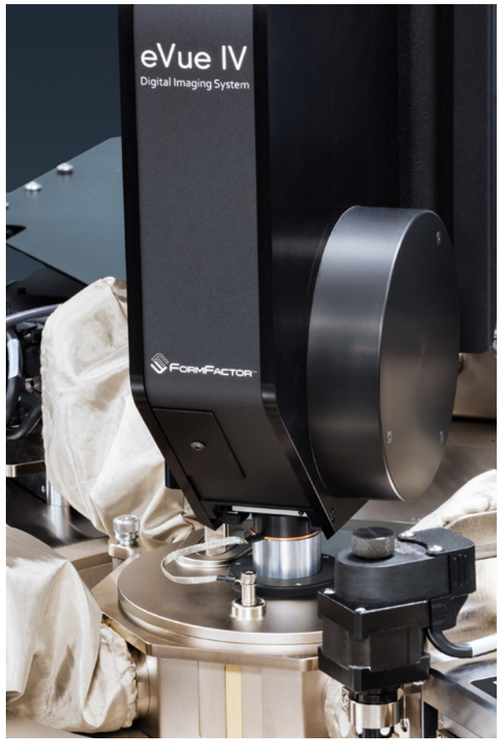
Smaller pad geometries come with several advantages like saving valuable wafer space and reduced pad parasitics. Many devices today have pads as small as 30 µm. To properly see those pads and probe them accurately, a high-resolution microscope system is essential.

FormFactor's Auto DC Measurement Assistant integrates the eVue high-resolution microscope, enabling highest visibility of contact pads as small as 30 µm with micron level accuracy.

Safety Features

eVue Crash Protection

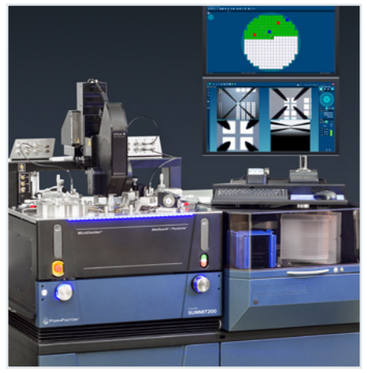
FormFactor's patent-pending eVue Crash Detection protects your valuable equipment from expensive damage, even when probes are in contact.
When accidently hitting the tuner or probes, the microscope will instantly stop all movements and retract the objective.



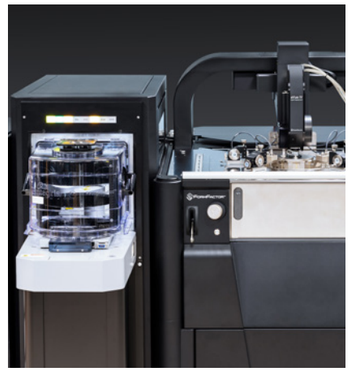
FormFactor's eVue Digital Microscope comes with a high power objective, enabling easy visibility of contact pads as small as 30 µm with micron level accuracy. FormFactor's patented eVue Crash Detection protects your valuable equipment.

Full Automation with Optional Wafer Handling Unit

With the optional loader that is available for the SUMMIT200 and CM300xi, the system enables true 24/7 testing with zero idle time even when measuring over temperature. This results in more devices tested in a shorter amount of time. The loader can handle up to fifty wafers provided in SEMI-standard wafer cassettes.



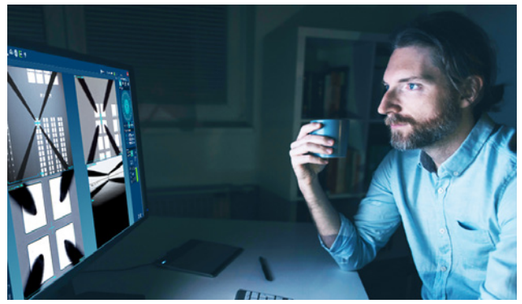
SUMMIT200 with Loader: SEMI-compliant handling of up to 50 different wafers



CM300xi with MHU301 (left) and MHU300 (right): SEMI-compliant handling of up to 50 different wafers

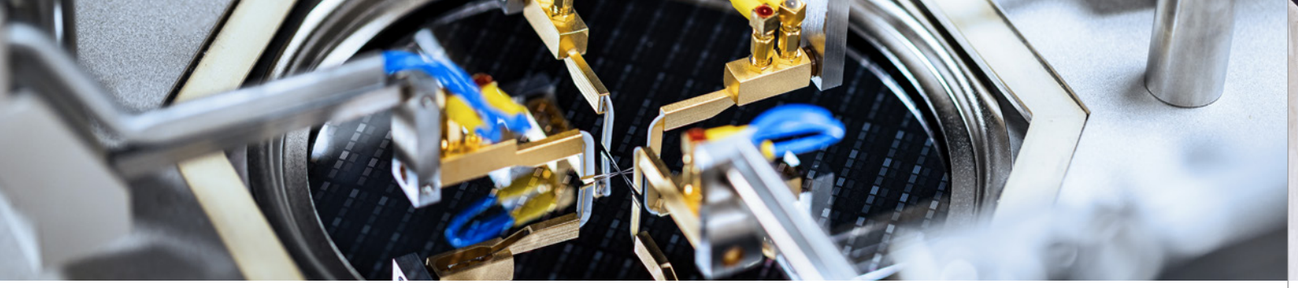
Remote Probing Over the Internet

Auto DC enables remote probe station management from home or anywhere in the world.



Remote probing:

- Safely and easily place probes down in contact with the test pads
- Safely move the wafer to different test sites
- View and manage live microscope viewing of the probes and the wafer
- View Wafer Map test plans
- Initiate remote test programs to gather and analyze test data



High Throughput – Lower Cost of Test – Minimizes Idle Times

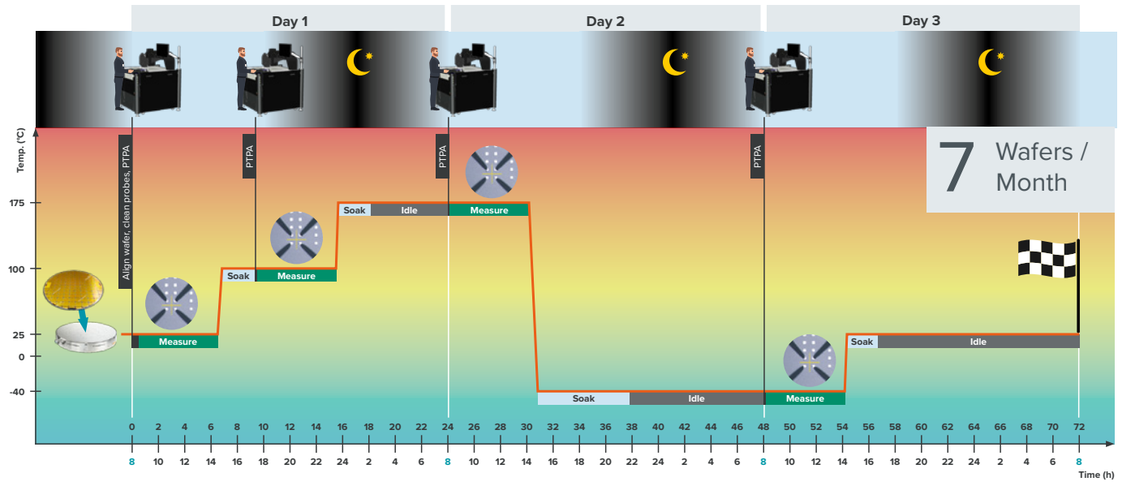


*Figure 5: Probe station with manual probe-to-pad alignment. The system is idle at night and the weekends.**

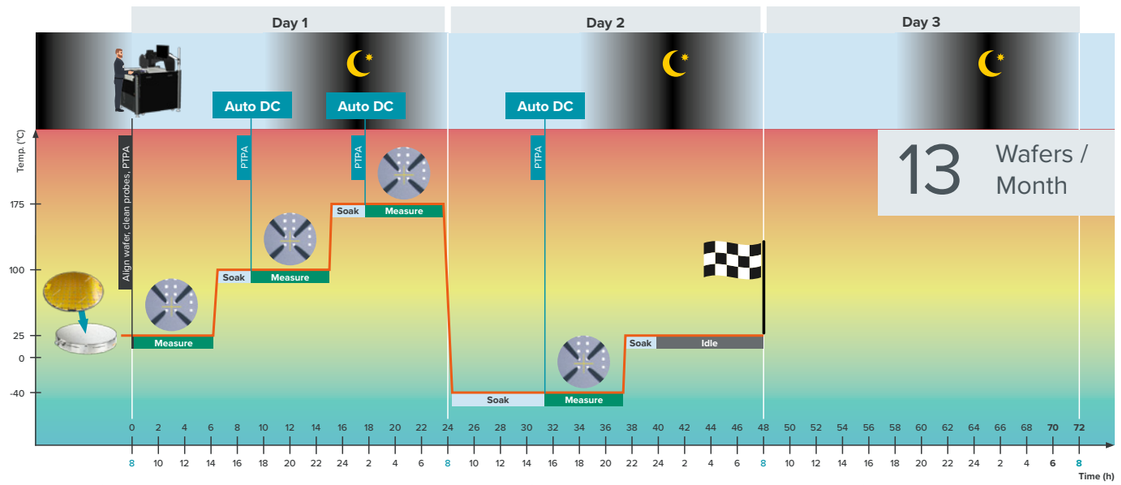


*Figure 6: A FormFactor probe station with Autonomous DC Measurement Assistant achieves a 1.8X increased wafer throughput and requires 75% less test engineers time than Figure 5.**

Contact Intelligence™

Improved DC parametric data accuracy and increased test throughput add up to significant time and cost savings for semiconductor companies needing to improve Cost of Test (CoT). Figures 6 and 7 show an example of the real-world savings potential with the Autonomous DC Measurement Assistant and wafer loader.

*Test conditions	
Test Time / Die (min)	30
# Dies to Test on Wafer	12
Test Time / Wafer (min)	360
# Temperatures (°C)	+25 / +100 / +175 / -40

Using a CM300xi or SUMMIT200 semi-auto prober with manual probe positioning as the baseline condition (Figure 5), a 1.8X increased wafer throughput is achieved with the Autonomous DC Measurement Assistant (Figure 6). And using a CM300xi or SUMMIT200 with wafer loader and the Autonomous DC Measurement Assistant, a huge 4.1X increase wafer throughput is gained (Figure 7).

Implementing these new automation solutions allows reduced capital equipment costs, and reduced operator/staffing costs resulting in cost savings of up to US$815,000 per year for 3 years.

In the same typical testing seen in figure 5, three additional full thermal semi-auto probers (~US$1.35 M) would be needed to reach the test capability of the single full-auto prober with the Autonomous DC Measurement Assistant. And three additional test engineers (~US$30k / month) would be needed (1 per shift x3 for 24/7 operation) to operate all 4 probers continuously.

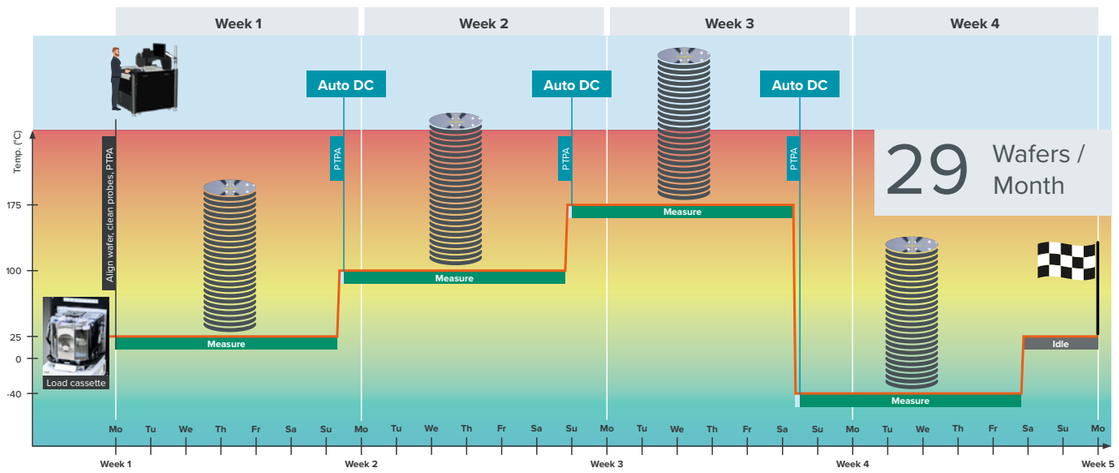
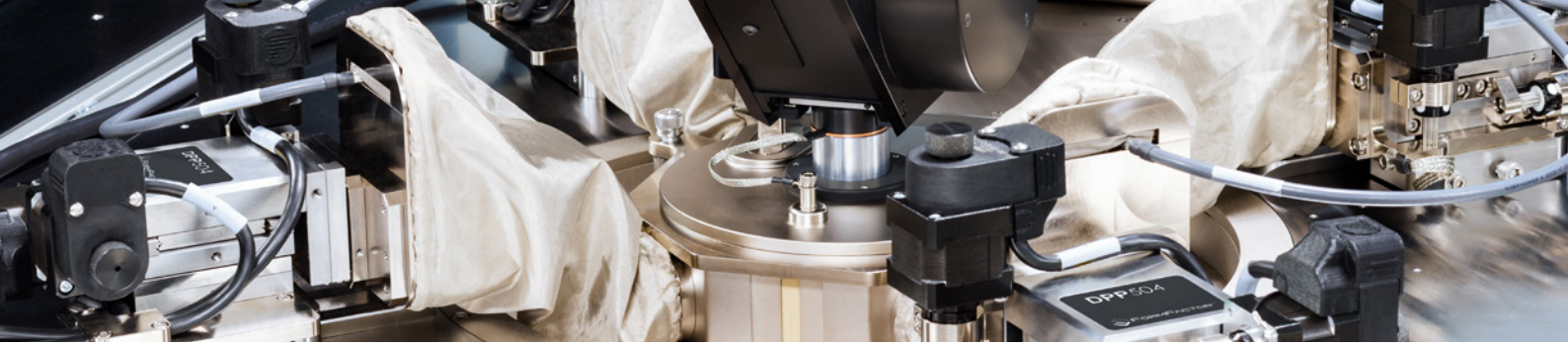
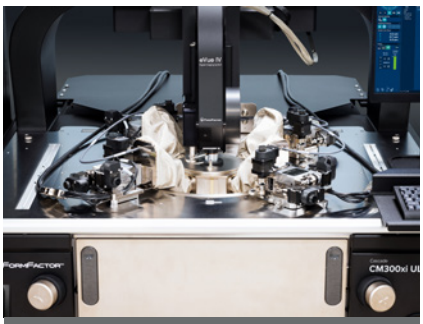


*Figure 7: CM300xi and SUMMIT200 with Wafer Loader and Autonomous DC Measurement Assistant achieves 4.1X increased wafer throughput and requires 92% less test engineers time than Figure 5.**

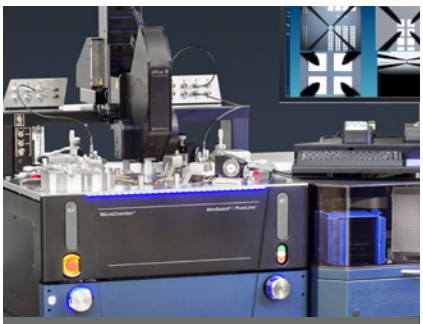


Compatibility

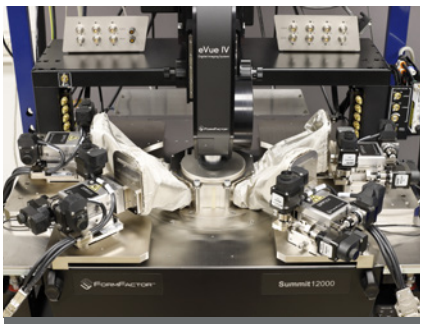
The solution is available for the CM300xi, CM300xi-ULN, SUMMIT200, Summit 12000 and Elite.



CM300xi



SUMMIT200



Summit 12000

Manufactured with Green Energy

BR-AUTODC-0322