VueTrack™ technology for unattended testing over multiple temperatures increases wafer test productivity

The demands to reduce time-to-market, shrink device geometry, and increase reliability are relentless in the semi-conductor development environment. That is why it is becoming even more critical to increase wafer test productivity and reduce overall test cost.

Most test plans call for gathering wafer test data over a series of temperatures, but alignment errors between probes and pads induced by thermal drift must be corrected at each new temperature to maintain reliable electrical contact. Autoprobers in the production test environment are equipped with traditional Probe-to-Pad Alignment (PTPA) technologies to automatically correct alignment errors. In general, analytical probers used in test labs or fabless facilities are not equipped with automatic PTPA technologies. PTPA errors must be corrected manually, adding unnecessary delay to obtain the desired test data and limit test productivity.

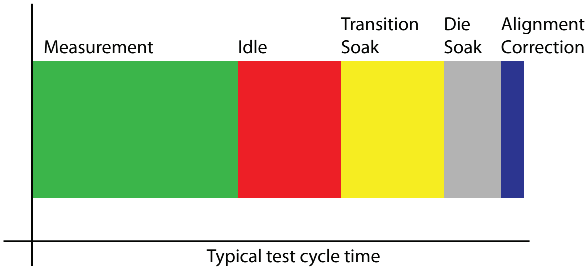


Figure 1. With a manual PTPA error correction approach, the test productivity decreases due to test time segments probers are not making measurements.

This technical brief summarizes the major sources of productivity loss in multiple-temperature measurements, and showcases a new on-site PTPA error correction approach. This new on-site PTPA approach significantly improves the productivity of test labs by reducing time segments during which probers are not making measurements (Figure 1). It is a foundation technology that will keep pace with advanced roadmaps in a very cost-effective manner.

Factors Impacting Test Productivity

PTPA errors and non-productive time segments

Due to PTPA errors induced by thermal drift during over-temperature testing, wafer probers are unable to make measurements and collect data during idle time, transition soak time, die soak time and alignment correction time, negatively impacting on the overall test productivity.

Idle time

Without a capability to automatically correct PTPA errors caused by thermal drift, it is impossible to run a wafer prober over multiple temperature set-points without an operator. Either an operator must manually correct PTPA errors after each temperature change, or a prober will be idle until the correction is made. Tasking operators to come in after hours to make the corrections, or running multiple shifts, or reducing the number of temperatures for a protocol could have an adverse impact on the cost of test, or could compromise the data gathered. For test plans that span several days, it is very possible that idle time constitutes a 25-50% productivity loss for the prober.

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 (Figure 2). A prober must reach thermal equilibrium before probes can contact the pads, otherwise probes would drift off the pads after touchdown. Transition soak time can consume hours between each temperature change, contributing a major source of productivity loss.

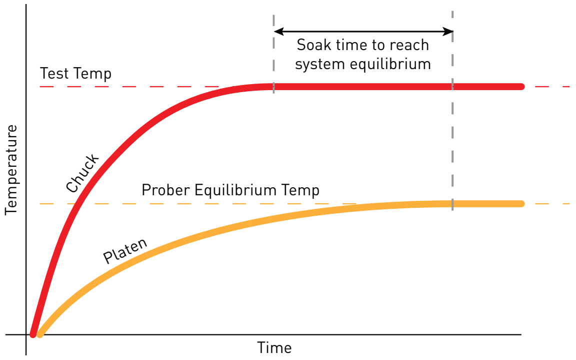


Figure 2. The time required for the prober to reach thermal equilibrium before probes can contact the pads is referred to as transition soak time or thermal soak time.

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 above the chuck cooling down and a new hot spot heating up (Figure 3). The time required for the prober to reach equilibrium under this condition is die soak time. Die soak must be accounted for when the time required to recover from the imbalance is long relative to the test time, allowing the prober to reach a thermo-mechanically stable equilibrium before touchdown (Figure 4). Without adequate die soak time, probes can drift off the pads after contact is made, invalidating the data and possibly causing damage. The amount of productivity lost to die soak times is a function of the number of test sites per wafer and the extent of the chuck move required to reach them. Testing every small die on a wafer may not require much soak time at all, while only testing a few die across the full diameter of a 300 mm wafer could consume hours over the course of a complete test plan.

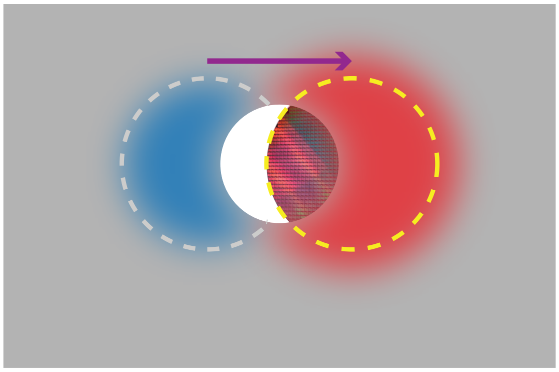


Figure 3. When the chuck is moved to test a new die, the old hot spot cools and a new hot spot is formed on the platen.

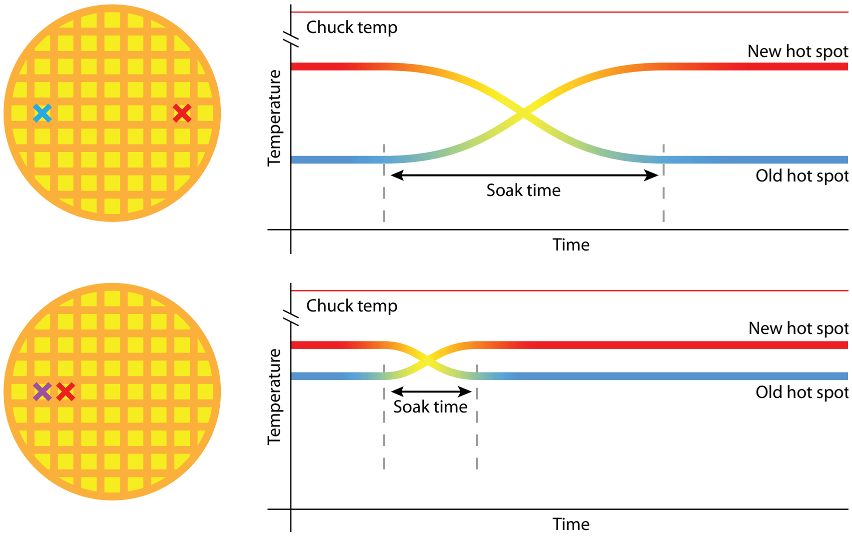


Figure 4. When die-to-die moves are relatively large, it causes a thermal imbalance across the platen (top), while small die moves result a negligible thermal imbalance (bottom).

Alignment correction time

Without automatic PTPA correction, alignment errors must be manually adjusted between temperature changes, which can be very time consuming when probe arrays are large or pad sizes are very small. This is particularly true for positioner-based probes. When automatic PTPA is employed, the corrections are inherently fast. Overall, this is the smallest wafer test time segment to cause productivity loss.

New On-Site PTPA Approach

The new on-site PTPA approach utilizes a single downward-looking microscope to measure the probe tips and wafer locations with the chuck in the same position that the electrical measurement (or probe contact) will be made (Figure 5). On-site probe tip and wafer location measurements enable the best possible alignment to be maintained throughout a wafer test plan.

The on-site PTPA method operates in two distinct modes:
Probe tip training mode – used during setup to allow a user to define proper PTPA and then train on a user-selected set of probe tips and wafer fiducial.
Probe tip tracking mode – used during run time to rapidly measure the probes and wafer at every test site.

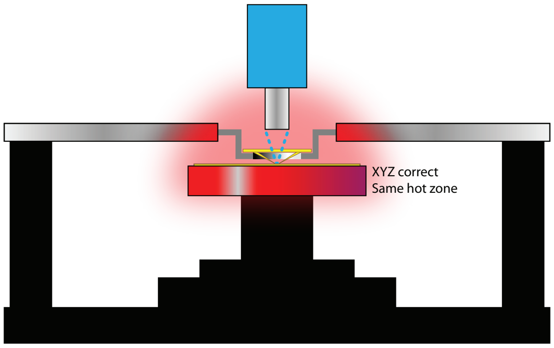


Figure 5. The new on-site PTPA approach utilizes a single downward-looking microscope, eliminating the thermal imbalance traditional off-axis PTPA methods would impose.

Unattended Testing Over Multiple Temperatures

Technical Brief

I. Productivity benefits of on-site PTPA approach

The VueTrack technology, a new on-site PTPA correction approach, improves every test segment previously discussed that impacts productivity. Idle time between two temperature steps is eliminated, and the only idle time remaining is when a test plan is complete and the prober is waiting for a manual wafer change. Transition and die soak times for short test durations can be decreased when the touchdown duration is short. Alignment correction times are likewise improved with an automatic approach (Figure 6). For greater productivity gains, a High-Thermal Stability (HTS) hardware option is also available for Cascade Microtech probe stations.

II. How on-site PTPA works

The on-site PTPA technique utilizes a coordinated sequence of small Z movements in the wafer stage and the internal fine focus stage of an eVue™ Digital Imaging System (Appendix 1). By eliminating the need for XY chuck movements and making only very small Z movements of the thermal chuck, alignment errors can be determined and corrected in thermal conditions identical to the electrical test.

By keeping the thermal chuck on-site during the probe tip and wafer tracking mode, it does not induce any thermal imbalance to the prober and can reduce or eliminate the need for soak times in most test scenarios. It is even possible to make numerous corrections per site if the electrical test allows for probe separation. This is a powerful advantage of the new on-axis technique, since it can virtually eliminate transition and die soak times for short duration measurements.

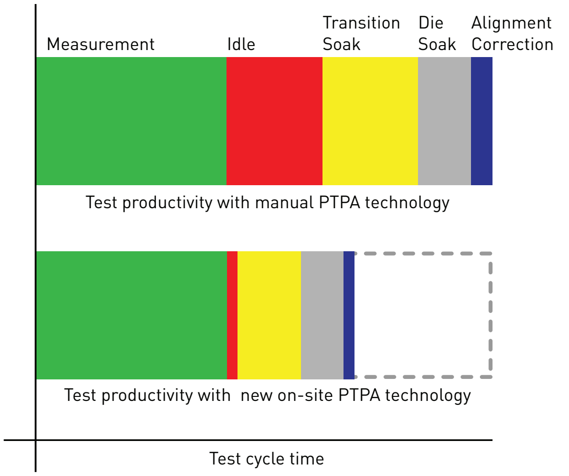


Figure 6. With a manual PTPA error correction approach, the test productivity decreases due to test time segments probers are not making measurements.

III. How to implement on-site PTPA

The new on-site PTPA approach is enabled by Cascade Microtech's VueTrack technology. The VueTrack is a very cost-effective technology to implement, since it does not rely on any additional cameras or specialized mechanisms and uses a standard compact wafer stage.

The VueTrack technology can be purchased with any new Cascade Microtech probe station, and is compatible with Cascade Microtech's ELITE300™ and Summit™ 12000B probe stations. Even S300 and Summit 12000 probe stations that have been in service for years can be upgraded to perform unattended multiple-temperature tests. The basic requirements for the VueTrack are the eVue PRO Digital Imaging System and Nucleus™ 4.0 Prober Control Software. An upgrade to High-Thermal Stability (HTS) hardware may be required as well, to ensure the over-temperature performance of some probe stations. The "PRO" version of the eVue Digital Imaging System is ideally suited to the task of rapidly determining alignment errors with its high-speed imaging capability and long travel, high-resolution focus drive.

The combination of VueTrack, eVue and Nucleus 4.0 offers additional capabilities to ensure consistency from test to test and increased productivity. The 'NextWafer' load feature of Nucleus 4.0 allows a wafer to be automatically aligned after manual loading. The setup parameters for any wafer and probe card combination can be saved to a user file. When changing between different test setups, these user files can be recalled to avoid repeating many of the setup steps and the wafer can again be automatically aligned after loading.

Several default Wizards are included to allow an operator to use VueTrack in a very intuitive manner. Additionally, new Wizards can be created from scratch or modified from existing ones with custom text and images for operator training on unique setups.

Conclusion

The fundamental task of a wafer prober is to make repeatable electrical contact between the probes and device pads, and enable the collection of reliable test data. Whenever the probes are not in contact properly, no data is being taken, and productivity suffers. The main sources of productivity loss in multiple-temperature testing are idle times, transition and die soak times, as well as PTPA error correction times.

Cascade Microtech’s new on-site PTPA error correction method dramatically increases the productivity of analytical probers in test labs, by enhancing contact reliability and automating PTPA error correction. The new on-site PTPA approach utilizes a single downward-looking microscope to measure the probe tips and wafer locations with the chuck in the same position that the electrical measurement (or probe contact) will be made. On-site probe tip and wafer location measurements enable the best possible alignment to be maintained throughout a wafer test plan.

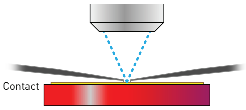
One of the greatest benefits of VueTrack is the ability to inexpensively upgrade an existing probe station to have automatic on-site PTPA capability. Upgradeability extends the original investment in the prober to meet roadmap requirements beyond those it was originally intended to meet.

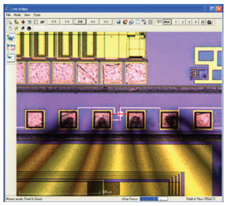
By implementing VueTrack technology on either new or installed Cascade Microtech probe stations, analytical probers in test labs can be leveraged to make unattended testing over multiple temperatures, resulting in higher productivity to meet the market demands of semiconductor development.

Appendix

1 The new on-axis PTPA approach utilizes a single downward-looking microscope. Alignment errors can be detected and corrected by utilizing a special sequence of small Z movements in the wafer stage and internal fine focus stage of a microscope, without moving the chuck and changing the thermal conditions.

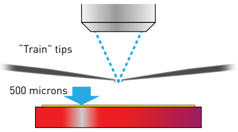
1-1 At setup, the wafer is aligned to the chuck and the probes are aligned to their proper test structures.

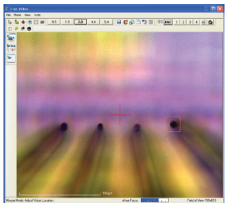




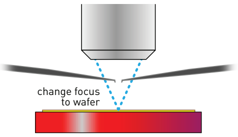
1-2 To train or track the probe tips, the wafer is first lowered in Z to “de-focus” the wafer surface features, allowing a clear representation of the probe tips. This move is only about 2.5 times greater than the “separate” position.

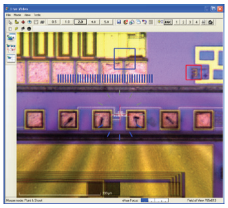
During probe tip tracking, the microscope is scanned in Z to find the best match for the probe tip location trained on during the set-up. From this information, the X, Y and Z locations are determined.



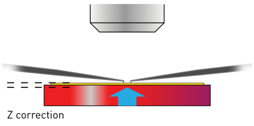


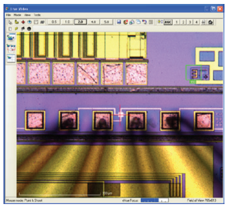
1-3 The microscope is focused on the wafer surface, de-focusing the probe tips, allowing a clear view of the wafer. An autofocus routine finds the Z height of the wafer using the fine focus drive in the microscope. The wafer target location is then found automatically in X and Y using a pattern matching routine.





1-4 A corrective move is made to the wafer in X and Y to compensate for position error. The wafer is then moved into the contact position with a correction for the Z error to maintain proper overdrive while the microscope follows the movement of the wafer allowing a focused image of the probe tips and wafer.





2. Ordering Information

2.1 VueTrack Technology

Description		ELITE300	Summit 12000B	S300
VueTrack technology*		151-359	151-359	151-359
eVue-III PRO microscope	40X or 10X or upgrade for any non-PRO model	151-551	151-552	151-552
		151-531	151-532	151-532
		131-964	131-964	131-964
Nucleus 4.0 upgrade**		125-812	125-812	125-812
VueTrack upgrade bundle: VueTrack eVue-II 40X PRO Nucleus 4.0 Software		151-242	151-360	151-360

*Nucleus 4.0 or later and eVue PRO model required

**ELITE300 and Summit 12000B probe stations ordered or installed after March 31, 2010 are equipped with Nucleus 4.0

2.2 HTS Enhancements

Description	Probe	ELITE300	Summit 12000B	S300
Thermally-isolated platen***	All	Standard*	151-337	151-338
Thermally-stable probe card holder	Probe cards	151-293		
Thermally-stable probe arms for probes	DCP or DCP-HTR	151-288 (for DCM positioners, coax)**		
		151-287 (for DCM positioners, triax)**		
		151-286 (for MS-1 positioners,triax)**		
	PTT needles	151-289 (for DCM positioners)		
		151-290 (for MS-1 positioners)		
HTS probe tips for DCP-HTR	DCP-HTR	151-291 (18 µm radius tip/9 µm mark)		
		151-292 (12 µm radius tip/6 µm mark)		
		151-341 (7 µm radius tip/4 µm mark)		

*Elite300 stations ordered before March 31, 2010 require HTS Platen Retrofit Kit p/n 151-284

**DCP-HTR probe holders must be ordered separately.

Cascade Microtech, Inc.
Corporate Headquarters
toll free: +1-800-550-3279
phone: +1-503-601-1000
email: cmi_sales@cmicro.com

Germany
phone: +49-89-9090195-0
email: cmg_sales@cmicro.com

Japan
phone: +81-3-5615-5150
email: cmj_sales@cmicro.com

China
phone: +86-21-3330-3188
email: cmc_sales@cmicro.com

Singapore
phone: +65-6873-7482
email: cms_sales@cmicro.com

Taiwan
phone: +886-3-5722810
email: cmt_sales@cmicro.com

CascadeMicrotech®