NANOCHIP FAB SOLUTIONS
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NEW CONTROLLER EXTENDS LIFE OF 200MM TOOLS

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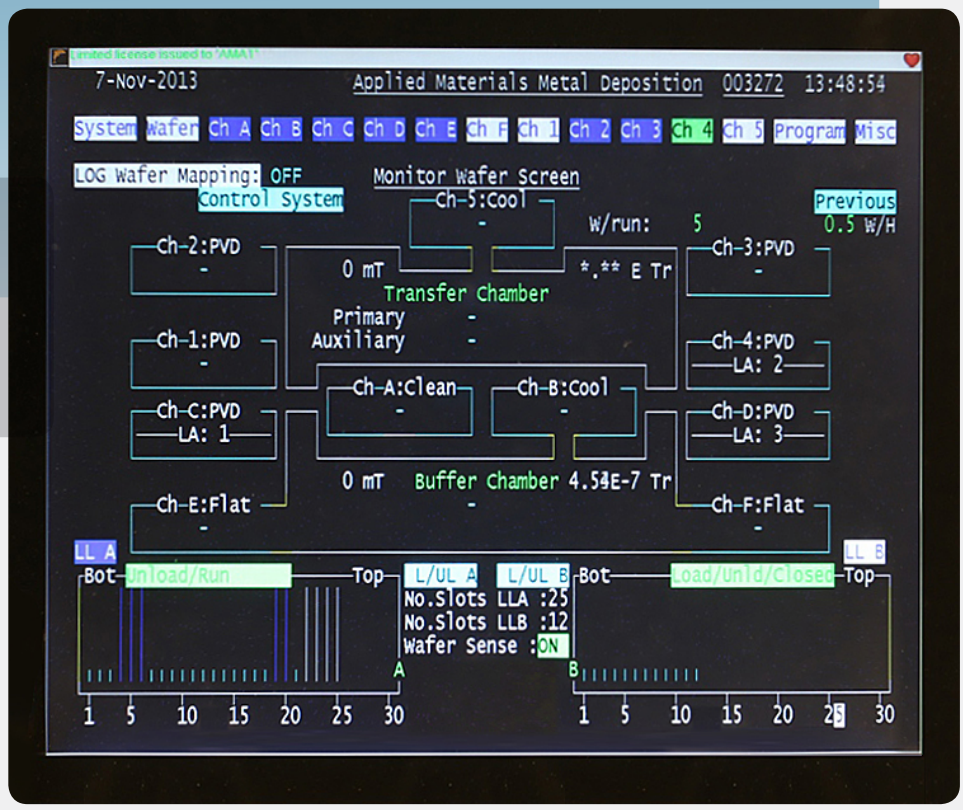

Figure 1. Applied's new controller for legacy 200mm tools makes it possible for customers to develop new materials and processes. It provides fast data-collection capabilities for advanced FDC, high connectivity for remote monitoring/control and scalability, and uses a modern operating system and components to ensure easy parts replacement.

APPLIED MATERIALS®

Legacy 200mm tools are workhorses. Their reliability, economy and performance make them attractive to manufacturers who produce analog, image sensor, MEMS and power products and for whom scaling and migration to larger wafer sizes are not currently high priorities.

However, there are concerns with these older tools regarding continuing productivity, availability and uptime—critical requirements for cost-effective fabrication.

Among these concerns are questions about the continued availability of parts and whether the tools can accommodate modern advanced process control (APC) to enable fault detection and classification (FDC), as well as run-to-run and statistical process control technologies. Applied Materials' new system controller upgrade for its 200mm tools addresses these concerns by replacing the performance-limiting electronics in the original system controller, which is fast becoming obsolete, with a new version (see figure 1). The upgraded controller offers:

- Easy connectivity of legacy tools with modern APC software for higher yields and lower cost production
- Much faster and more robust data collection, enabling the use of FDC analysis tools to help optimize device performance and yield
- Greatly improved system data management, storage and protection
- Full backward compatibility with each tool's existing application software version
- Process- and recipe transparency with the same look and feel for operators and technicians
- Readily available component supplies for future repairs and upgrades

Applied's new controller includes an advanced single-board computer (SBC) with a 2.6 GHz Intel Core CPU and Windows 7 operating system. It is fully and easily compatible with contemporary data communications architectures and technologies, making remote monitoring/control and high-speed host communications possible. New features not available in the legacy design include 4 Ethernet ports for advanced HSMS, with additional data access from 6 USB 2.0 connections, and 16 additional serial ports.

MINIMIZED REQUALIFICATIONS

Significant hardware changes within a fab's qualified production flow can increase manufacturing risk and change control costs by requiring process or product requalification. Applied's new controller is specifically designed to help semiconductor manufacturers minimize the need for tool and process requalification.

The new SBC is designed to be fully backward-compatible with the existing version of software on any tool, as well as process-transparent with existing recipes. Using a proprietary Applied software interpreter layer, the SBC links a user's specific version of legacy application software to the modern electronic architecture, enabling the upgraded system to provide consistent control functionality. Recipes are executed in exactly the same way as before. Operators have a familiar user experience with the same system interface (see figure 1).

To achieve this, Applied conducted extensive in-house testing of the controller upgrade and followed that by collaborating with chip manufacturers for production-validation tests.

PERFORMANCE VALIDATED IN PRODUCTION TESTS

Maintaining the viability of 200mm fabs cost-effectively for another 10-15 years is critical to many customers who believe that supporting an aging installed base requires close cooperation with their equipment manufacturers.

Working together at one customer's fab, the Applied/customer team needed only a single day to swap the controller hardware and restart one of the customer's Applied Endura tools. This work included a complete hard drive backup, which captured tool settings and performance set points. No recalibration was required to achieve the same performance in the tool's material-handling functions, a result similar to a standard tool recovery or restart procedure.

The process transparency of the upgraded Endura tool was evaluated and verified in production during more than three months and over 30,000 wafers. Regular film properties tests of the upgraded tool and, ultimately, end-of-line output were compared with other systems on the line. The electrical tests evaluated four metal layers on five different tools comparing contact resistance, intermetal leakage, sheet resistance and via resistance. The execution of recipes on the tool equipped with the new controller matched that of like tools that still use the original controller, with no need to alter any recipes.

NEW CONTROLLER

EXTENDS LIFE OF 200MM TOOLS

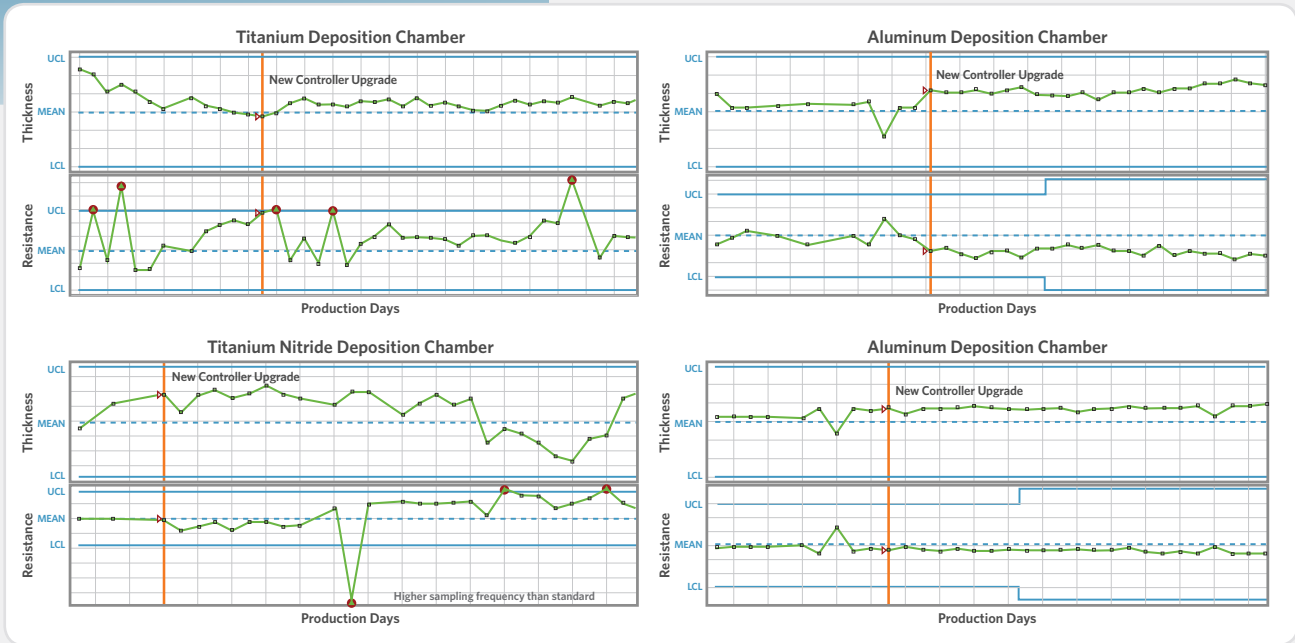

Figure 2. Thickness and resistance performance results for three film types and four chambers demonstrate transparency between the original and new controllers.

Figure 2 provides film control-chart comparison data demonstrating recipe transparency, with excellent repeatability of performance on the test tool before and after the installation of the new controller.

The process transparency was assessed by processing thousands of production wafers and measuring more than 15 electrical structures covering all metal layers, and sampling the contact, via and sheet resistance as well as wire and intermetal leakage. Figure 3 shows a subset of the electrical results, with excellent agreement between the tool running with the new controller and five additional tools running concurrent production on the same device.

The serial communications rate for the original controller is up to 19.2 kHz. A small subset of the installed base, including our beta site, has been upgraded with additional hardware to enable HSMS, which delivers up to 100MHz. The new controller upgrade

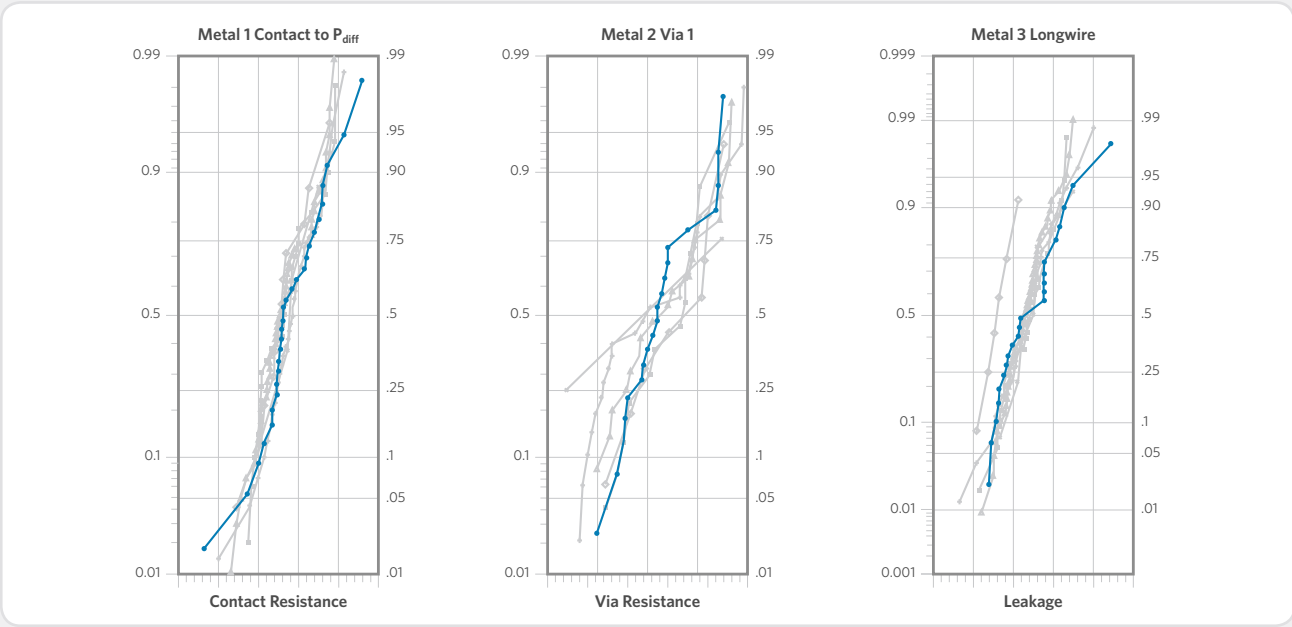

Figure 3. Electrical performance of the new controller (in blue) was in line with five tools running the original hardware. Contact resistance, sheet resistance, via resistance and leakage were comparable for all metal levels of the device.

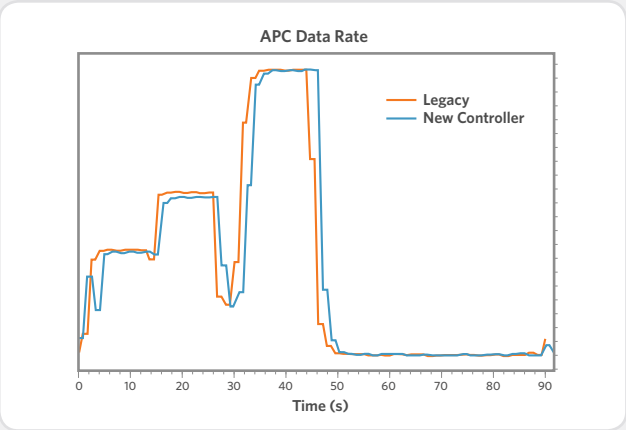

Figure 4. Communications rate matched performance of HSMS-enabled original controller.

design already includes Ethernet HSMS, eliminating the need for this additional hardware.

Figure 4 shows the results of fab-host communications tests where the new controller matched the performance of the HSMS-upgraded communication system on the customer tool. Implementation was accomplished by simply connecting to the fab host to one of the four standard Ethernet ports, with no other modification or optimization required.

BETTER DATA, BETTER RESULTS

The new controller manages interaction within the system much faster and more efficiently than the original controller, eliminating bottlenecks that negatively impact throughput. Internal testing demonstrated an Endura throughput increase of as much as 6% from the optimized interaction between the hard disk drive (HDD) and the CPU (see figure 5).

As file load on the legacy HDD increases, throughput drops. With the new controller this performance loss does not occur; throughput is optimized to full system entitlement. The increase in system throughput depends on many variables, including product line, configuration, recipe time, and system maintenance practices. The

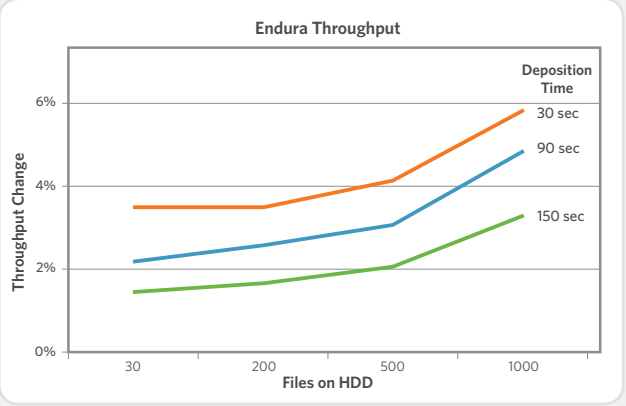

Figure 5. Internal test data demonstrating the impact file volume has on the performance of legacy systems. With the original controller, as file load on the HDD increases throughput drops. With the new controller, this performance loss does not occur; throughput is optimized to full system entitlement.

tests at the customer site showed increases between 1.0% and 2.3%, depending on the application.

Stable high-quality data and higher data transfer rates also enable customers to build viable FDC models that more effectively identify yield excursions, to initiate root cause analyses, and to provide feedback to APC systems to improve yield.

To be most effective in capturing short-duration events of interest, these FDC models require data sampling rates of 10Hz or greater and at least 100 SVIDs (status variable identifier data).

Until now FDC has had limited efficacy with legacy 200mm tools because the data sampling rate was too low. The priority had been placed on the stability of the controller interface with factory automation software, rather than on data collection.

Now, however, the controller upgrade supports up to 10Hz data sampling and for the first time enables the use of viable FDC models with these tools. It also allows the use of sophisticated factory automation software such as Applied's E3 environment.

PUSHBACK ON OBSOLESCENCE

The original design of the SBC used in Applied's Endura and Centura tools is more than 20 years old and is based on the 30 MHz Motorola 68000-type processor. As time marches on for legacy tools, about 3% of parts become obsolete each year. Most of those are electrical parts. Manufacturers began discontinuing production of the SBC's key components in 2007; the remaining stock will soon be depleted. Virtually all of the SBC's building blocks are impacted, including the CPU, memory/memory controllers, PLDs, FGPAs, and I/O controllers.

In addition to the obsolescence problem, many of the critical components of the legacy controller for Applied's Endura and Centura tools have design limitations. These present a major barrier to the use of modern monitoring and control techniques that are proven to increase yields and reduce costs.

Extending the life of mature equipment is a very attractive way to minimize capital expenditures. Applied's new controller for 200mm tools offers customers the opportunity to do just that.

The new controller greatly improves Centura and Endura performance and uses new, readily available components. It offers a low risk, plug-and-play, process-transparent system enhancement on a modern platform with the processing power to add new applications or modules, and to enable effective fault detection and fab automation. By upgrading to the new controller, customers can bring their tried-and-true 200mm production tools into the modern age.

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