NEW VITA CONTROLLER DEMONSTRATES PERFORMANCE ON >1 MILLION WAFERS

BY JEFFREY DIETZ AND FLORENT DUCROT
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Integrates analytical and control capabilities used in 300mm equipment.

While many of the world’s semiconductor manufacturers fight it out on the frontiers of bleeding-edge IC technology with state-of-the-art production tools, tried-and-true 200mm and 300mm legacy tools continue to work harder than ever.

Nearly half of silicon production today takes place on 200mm tools. That trend is expected to continue in order to meet the demand for devices and sensors needed for mobility, healthcare, automotive, security and Internet of Things applications, where predictions are for exponential growth.

This means older fabs must continuously evolve to operate flexibly and at peak yield and efficiency to stay competitive and profitable. To help customers achieve those goals, Applied Materials is developing advanced technology and service options that not only extend the lifetime of cost-effective legacy equipment, but rejuvenate them with innovative, contemporary technology.

One such option is Applied Materials’ recently introduced Vita controller for its 200mm Centura and Endura tools. The result of substantial ongoing R&D investments in legacy tool improvements, this sophisticated controller upgrades aging systems. But more importantly, it delivers modern analytical and control capabilities, such as run-to-run control, chamber matching and virtual metrology—all derived from advanced 300mm equipment—to help legacy fabs achieve critical productivity goals.

Since its introduction less than one year ago, the Applied Vita controller has demonstrated the power of its performance on more than one million production wafers at IDM and foundry customers around the world. To date, scores of Applied Vita controllers have been committed, ordered or shipped for ≤200mm Applied Centura and Endura tools running processes such as:

- PVD (Al slab and fill, MOCVD liner barrier)
- Etch (aluminum, polysilicon, dielectric)
- CVD (HDP, SiH₄, TEOS)
- Thermal (poly, epi, RTP, LPCVD)

These installations include upgrades to customers’ existing tools and to refurbished systems from Applied’s manufacturing facility in Austin, Texas.

When combined with Applied’s growing portfolio of advanced, technology-enabled service options, the Applied Vita controller enables customers to tap the flood of process- and equipment-related data flowing from the tool. With that data, processes can be optimized, overall cost of ownership can be reduced, and device performance and yields can be increased.

POWERING THE FUTURE OF 200MM TOOLS

The Applied Vita controller is fully compatible with the existing version of software used on 200mm Applied Centura and Endura tools, and is process-transparent with existing recipes. A proprietary software interpreter layer links a user’s specific version of legacy application software to the controller’s modern electronic architecture so that recipes are executed exactly as before, and operators have a familiar user experience with the same system interface.

The Applied Vita controller features a Windows 7 operating system; 2.6 GHz Intel Core CPU; multiple high-speed Ethernet ports for advanced HSMS; 6 USB connections and 16 additional serial ports; and robust data management and storage capabilities.

These features enable legacy users to take advantage of contemporary technologies offered through Applied service agreements, including remote monitoring/control, high-speed communications with the fab host, and integration with sophisticated factory automation software such as Applied’s E3 environment.

In addition, the new controller supports data sampling at up to 10Hz, which is critical to capturing short-duration events of interest. It allows for effective use of fault detection and classification (FDC) models.
DEMONSTRATING OPTIMIZED TOOL PERFORMANCE

The Vita single-board computer design, with its powerful CPU, ensures that recipe task execution as prescribed in the software is performed at maximum efficiency. This optimizes tool productivity to its design entitlement. Figure 1 shows three models that schematically illustrate how communication impacts this provides to recipe execution, on-wafer performance and overall system throughput.

In this case, a customer was running a high-density plasma CVD (HDP-CVD) process on an Applied 200mm Centura tool to fabricate an intermetal dielectric (IMD). Precise control of all the steps that occur during HDP-CVD is critical. Execution delays, however, result in small differences in the performance of software-controlled tasks and variation in results from wafer to wafer. In some cases thickness measurements exceed upper and lower control limits, which can lead to unplanned equipment checks or downtime, and may require a hold for disposition of substandard lots. In this instance, the Applied Vita controller executed the functions precisely as required, eliminating response delays. Figure 2 shows the improved film thickness stability, with no points outside control limits after installation of the Applied Vita controller. Figure 3 shows improved consistency in the deposition time for the two deposition steps, and figure 4 shows the increased stability of the delivered RF power, as measured by the required compensation.

The improved task execution consistency for the HDP-CVD IMD recipes also delivered an increase in the throughput of the tool of 2.0–3.8%. This performance is summarized in table 1. Included here is a second result from a customer running a PVD aluminum deposition process on an Applied Endura tool, which realized increased system throughput of up to 2.3%.

DATA COLLECTION RATES MATCH 300MM SYSTEMS

The key to enabling effective FDC modeling is the ability of the systems to transmit data at a very high rate with high fidelity. The Applied Vita controller high-speed messaging system can share data with an FDC system...
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Figure 2. With the Applied Vita controller running an HDP-CVD process on an Applied 200mm Centura tool, thickness stability improved by 2% and all measurements were within control limits. The greater process control led to improved CpK.

Figure 3. The Applied Vita controller led to improved consistency in deposition time.

Figure 4. The Applied Vita controller led to a 1% improvement in the stability of RF power bias.

Table 1. Examples of throughput improvements realized with the Applied Vita controller from improved task execution. These throughput improvements enabled realization of the systems’ design entitlement.

<table>
<thead>
<tr>
<th>THROUGHPUT (WPH)</th>
<th>ORIGINAL</th>
<th>VITA</th>
<th>IMPACT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Centura</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IMD Recipe A</td>
<td>38.7</td>
<td>40.3</td>
<td>+1.6</td>
</tr>
<tr>
<td>IMD Recipe B</td>
<td>37.3</td>
<td>38.1</td>
<td>+0.8</td>
</tr>
<tr>
<td>Endura</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cold Al stack</td>
<td>40.0</td>
<td>40.9</td>
<td>+0.9</td>
</tr>
<tr>
<td>Via Liner</td>
<td>38.3</td>
<td>38.7</td>
<td>+0.4</td>
</tr>
<tr>
<td>Hot Al stack</td>
<td>18.9</td>
<td>19.2</td>
<td>+0.3</td>
</tr>
</tbody>
</table>

at the same rates as 300mm systems.

In the example shown in figure 5, data from an Applied Centura etch system is analyzed with the Applied E3 fabwide automation and equipment engineering platform to determine if there is DC bias variation, which can lead to performance drift. Legacy RS232 data collection is slow (~1Hz) and is known to have data gaps of up to 1500ms. With so much variation it is nearly impossible to determine performance trends.

The Applied Vita controller, with a 5Hz sampling rate and a data gap <30ms, allows users to easily determine a trend around the mean. In effect, engineers are no longer modeling noise, and this high sampling rate makes it possible to evaluate extremely short duration events like those that occur in RF processes. For example, a rate of 16 samples per second enables a transition spike to be captured. Such a spike would be missed by legacy RS232 data collection because it would provide fewer than 3 samples during the same 1-second period (see figures 5 and 6).

Using the new Vita controller, Applied customer engineers can now see these excursions and quickly take effective corrective actions, enabling a predictive maintenance approach.
OLD BUT NEW

The top priority of Applied Global Services is helping customers succeed by helping them stay ahead of changing market and technology trends with hardware, software and service options that resolve their most difficult production challenges.

Legacy tools are more essential than ever, and the new Vita controller is but one example of Applied Materials’ commitment to extending the equipment lifecycle and bringing innovative capabilities to this older—but definitely not forgotten—production equipment.

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Joseph Farah had a rare first-hand opportunity to experience the benefits of the Applied Vita controller during beta-site testing. He was responsible for the service needs of some 20 customers, and had more than 30 AGS customer engineers reporting to him.

"Basically, my life was to keep customers’ tools up and running," he said, "and I can tell you for a fact that my customers started to see significant benefits from the Applied Vita controller from day one."

Farah’s beta-site customers included a number of manufacturers using 200mm tools to supply products such as power semiconductors for LED lighting and other vehicle systems.

“They wanted to enhance their 200mm tools both to serve their customers better and to operate the tools at the lowest possible overall cost,” Farah said. “The Applied Vita controller gave them a number of ways to do just that.”

These included much faster and easier data backups; increased responsiveness of the tools’ moving parts, which led to higher throughput and quality; less susceptibility to power interruptions; and the ability to leverage tool and factory data to optimize tool performance.

“Let’s take just one simple task: data backups,” Farah said. “With the old system controller, it could take up to eight hours to back up these tools, and that’s about 1,000–2,000 files. But suppose there’s a system crash or power outage during backup. You might have to restore all of the tool’s calibrations and settings, and that could take a week or more. But with the Applied Vita controller, backup takes all of about a minute and then you have all the files on a USB drive. In fact, some of my customers began to do backups weekly instead of monthly because it became so much easier.”

Farah noted the mechanical performance of his customers’ tools became much crisper with the Applied Vita controller, which increased both quality and throughput. “With the old controller, there was an unavoidable delay of a second or more from when a command was issued and components such as the robot, chamber lift, valves and so forth actually responded. Now it’s almost instantaneous, so the chambers operate much better and faster,” he said.

“In fact, some of my customers running Applied Endura tools saw throughput increase by as much as 5% because of this. One of them actually told me the benefit from the Applied Vita controller was so significant it was almost like adding another chamber, although such a dramatic improvement isn’t something every single user would experience. It depends on many variables, such as the specific recipe, for example.”

Unlike the old system controller, the Applied Vita controller comes with its own uninterruptible power supply (UPS), and that helps with both fast power glitches or flickers, and with lengthier power interruptions, “Because of the responsiveness of the UPS, fast glitches in the power supply are invisible to the Applied Vita controller, whereas before you could lose data each time and if there were enough glitches you’d maybe have to scrap some in-process wafers,” Farah said.

“In addition, the Applied Vita controller and its UPS protect you in the case of total power loss by idling the electronics and putting the entire tool through a soft shutdown, both to prevent equipment damage and so that when power returns you can see clearly where things stopped during processing and recover quickly.”

According to Farah, it is hard to overstate how important his customers found the ability to leverage data to optimize performance. “With data collection taking place 10 times faster than before, my customers were able to use FDC to troubleshoot and monitor tool components such as the gas flow controller and power supplies in ways they just couldn’t do before. This enabled them to avoid downs and run in more of a predictive maintenance mode of operation,” he said.

“Imagine that—200mm legacy tools running in a predictive mode. Now that makes all of our lives easier.”

Farah is currently product line manager for Applied’s dielectric systems and modules (DSM) business unit. *