Decisive factors guide motion control solutions for semiconductor manufacturing

Enhancing control in multiple high-performance applications

Now that the semiconductor industry has transitioned from "laboratory"-style manufacture to industrial-scale production, improving machine motion control offers opportunities for competitive differentiation and controlling the high cost of ownership — particularly for high-performance, multi-axis, high-throughput machines.

Several OEMs and system integrators are leveraging the inherent advantages of advanced motion control systems to enhance the performance and market value of their offerings, across multiple high-performance applications.

The Bosch Rexroth NYCe 4000 is a motion control platform that is highly modular, compact, and is an example of the kind of "off-the-shelf" platform with algorithms and control loops optimized for high-performance semiconductor applications.

Benefit of lessons learned

Current semiconductor business conditions are offering a slight lull in the perennial boom-or-bust market cycles; in addition, these cycles are becoming more predictable than in the past.

Business owners, plant operators and machine builders are taking the opportunity to step back, look at current systems and future machine plans, and make strategic decisions. They are finding ways to improve total cost of ownership, speed return on machine investment, and better condition plant and machine performance and productivity for industrial level manufacturing.

Lessons learned in other industries with demanding throughput, precision, and quality control requirements — such as electronics, pharmaceutical, medical devices, etc. — offer useful guidance for semiconductors. These industries have had to solve parallel business issues and production concerns:

- OEMs need flexible, easy-to-implement interfaces and modular hardware and software architectures for faster time-to-market;
- Operators want easy-to-use PC-based menus and much more flexible control over machine functions and day-to-day operations;
- Service people and system commissioning personnel need access to failure analysis and improved hardware serviceability;
- Business owners seek zero downtime, less maintenance, best possible cost, and faster return on investment.

In machine applications where speed, accuracy, high numbers of axes to be managed, and low cost and faster time to market are essential, motion control factors can have a decisive impact on these goals. These include modularity, ease of use and integration, and performance.

Modularity—solutions "out of the box"

More and more, modularity is becoming a key requirement for motion

control platforms in semiconductor tool design. Cost pressures and tight design schedules are driving machine designers and systems integrators to concentrate valuable engineering resources on the semiconductor technologies that provide their clear strategic advantage.

In turn, they are choosing turnkey, "out-of-box" motion control platforms, created by expert suppliers in this field. To be truly useful, these platforms need a scalable structure for easy adaptation to the required level of machine complexity.

Modularity is particularly significant when considering motion control hardware factors. Space is always at a premium in semiconductor tools; controlling footprint and fitting more functionality into less space remains a constant imperative.

Technology that simplifies and condenses functionality—by combining high-speed motion control, drive, and I/O into a compact, easily maintained package, for example—offers several advantages:

- Reduced cabling and component interfaces, improving reliability and a reduction in potential physical failure points
- Simplified assembly and faster startup testing
- Opportunity to take advantage of distributed intelligence architectures
- Improved scalability, when machines need to be upgraded and/or changed to respond to fast-moving market conditions
- Serviceability—an important aspect of long-term machine value on the production floor

One major supplier of automated semiconductor packaging platforms recently took advantage of a modular motion control platform to help turbo-charge the performance of a new generation of high-speed IC inspection and packaging machines.

The new ST 868 Handling System from IPT/Systemation of New Berlin, Wisconsin, sets a new throughput record for integrated inspection/packaging machines: up to 15,000 units per hour (UPH).

In effect, one ST 868 machine can deliver the same production as two previous-generation machines. This represents a 50% increase of UPH per square foot of plant floor space—a dramatic productivity increase. It can provide this throughput in part because IPT incorporated a highly efficient and robust motion control solution, built around a distributed architecture that supports up to 20 axes per machine, including real-time visual inspection functions.

Plus, the ST 868 system supports both JEDEC tray and tape and reel processing. For fabs needing this kind of packaging flexibility, a modular motion control architecture means processing changeovers are faster and easier, minimizing machine downtime and maximizing throughput.

Ease of use and integration: speeding ROI

The sooner a machine or fab line is fully up and running, the faster it begins paying off the investment you've made. A motion control platform with the right features and capabilities can help make that payoff date arrive much sooner.

One major trend is the introduction of systems with extensive C and C++ motion control libraries as part of a total motion control package. This can save precious development time; designers can quickly configure

The Systemation ST 868 is a High Speed Semiconductor Inspection and Packaging system capable of processing up to 15,000 chips per hour (four per second).

complex control sequences using pre-defined control blocks, freeing machine designers to spend more time developing powerful control loops and setting up and testing complex mechanical systems.

Functionality such as single-axis and multi-axis synchronization, camming, gearing, spline functionality, and safety features on-board should be included. In addition, integration will be speeded if the software package includes such features as real-time tuning data logging and display from one system, and machine simulation options.

The advantages are clear: instead of building motion control from the ground up, much of the work is already done. The more robust and user-friendly these packages are (including their user interfaces and testing procedures), the more time you will save.

This is particularly important in those highly complex, multi-axis applications unique to the semiconductor industry. A recent example of this is a new tool custom-created by Oregon-based Automation Tooling Systems (ATS).

The company, dedicated to designing and manufacturing advanced factory automation systems and custom automation equipment, developed a new Wafer Cleaning system. It's a complex tool used to clean the surfaces of substrates for IC, displays, and disk drives.

The tool has very demanding motion control requirements: Four axes of motion for the wafer chuck (X, Y, Z, theta) as well as an independently moving nozzle and visual inspection components. Reliable, repeatable motion at an extreme level of precision, factory-level throughput production, without sacrificing a micron of quality—altogether, quite a motion control challenge.

ATS chose a flexible motion control platform with an extensive software library on-board; in addition, the company's existing motion control software packages for the previous generation of this application were easily ported into the new platform.

Flexibility and ease of integration were key reasons ATS chose to use an "out-of-box" motion control platform, rather than develop one on their own, as they had done previously. They experienced significant savings in development and commissioning time, and were able to concentrate valuable programming resources on issues specific to the Wafer Cleaning application.

Ease of integration on a physical level is also an important motion control consideration. High-performance semiconductor tools combine multiple electronic and electromechanical technologies; a truly high-end motion control platform will have built-in connection points so specialized machine components—sensors, powering, visual systems, etc.—can be swiftly integrated, and not require external connector panels.

An open communications bus architecture is also advisable; use of robust, reliable industry-standard backbones such as FireWire have the throughput necessary for large machines with multiple axes, while assuring flexibility over the life of the machine as new components or functions are added.

Performance – controlling complexity

Complexity has always been a given in semiconductor machine tool performance. Sophisticated applications, nanometer-levels of precision, and stability requirements almost no other industry calls for—these are the everyday demands for semiconductor manufacturing.

Add to this the need for more throughput, more wafers per hour processed, faster return on extremely expensive tool investments, and lower machine costs, and the definition of high-performance becomes extreme.

Motion control platforms need to be both rugged and sophisticated enough to support this production environment, with reliable, repeatable, virtually error-free processing.

Leading motion control platform suppliers—those with in-depth experience

Extremes in motion control performance—extreme throughput, extreme stability—are represented by this image of the FEI Company's logo carved into a human hair (diameter ≈ 50 μm) with an ion beam and captured by FEI's Nova NanoLab 600 scanning electron microscope.

automating motion control in other industries — are offering solutions designed to meet this need. These are proven, off-the-shelf systems offering:

- 32 KHz standard control loops and options for user-defined control loop algorithms
- Support for 10+ axes of motion per unit
- Networking of multiple units, potentially up to 600+ axes in a network
- High bandwidth buses implementing IEEE 1394b — with support for 800 Mb up to 3.2 Gb
- Seamless integration and support for new features such as vision, without excess customization
- Industry-specific functionality, such as ultra-low-speed motion — moving a stage at the speed human hair grows, for example

ATS has been developing a tool for the optoelectronics industry featuring performance and motion control requirements similar to those of semiconductor manufacturing.

This Optical Fiber Connecting machine takes a single strand of optical fiber — a thickness of 50 microns — applies an epoxy sealant, connects the fiber to a laser-emitting diode, and then exposes the joined fixture to a UV source for 3.5-7 seconds to cure the fiber-diode bond.

Consider the control requirements inherent in this operation:

- EXTREME Precision — 50 micron fiber inserted into a tiny laser diode
- EXTREME Stability — holding a non-rigid optical fiber still for 3.5-7 secs for UV curing of epoxy
- EXTREME Throughput — industrial level production to match the ever-expanding market demand

In certain applications, the machine's functionality steps up one more level of complexity: it can be configured to insert up to 40 single fiber optic strands into one multi-interface diode. That means the same operation described above, times forty!

Even though the requirements for this application are unique and quite strenuous, ATS plans to use the same motion control platform it has implemented in other machines it is building, rather than develop their own motion control from scratch.

The platform meets the machine's requirements for fast multi-axis movement, synchronization, repeatable precision, and highly stable dwells. In addition, the motion control platform's modularity helps conserve valuable floor space, and its software architecture and library of motion control tools will make integration faster and easier to accomplish.

High performance requires high levels of control

The fundamental driving force of any successful manufacturing enterprise is productivity: constantly finding ways to generate more throughput and earnings from the existing plant investment.

For the semiconductor industry, this is leading to the development of much faster, more complex machines designed for high-performance industrial level production. Although these systems are quite sophisticated, there are constant pressures to control costs and do more with less — particularly for machine designers and system integrators.

Better motion control can make a decisive difference in achieving these goals. Across multiple machine applications, the right motion control solution can help a machine or fab production line deliver more value from startup and over the long term.

Several OEMs have found that the subsystems approach, with a single vendor, has long-term strategic value, in terms of engineering support, ease of specification, and faster completion of machine design and commissioning.

By working with experts in the field of motion control, you take advantage of their depth of knowledge and past experience, and are able to devote engineering resources to the aspects of machine design that provide the highest levels of competitive advantage in your business.

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