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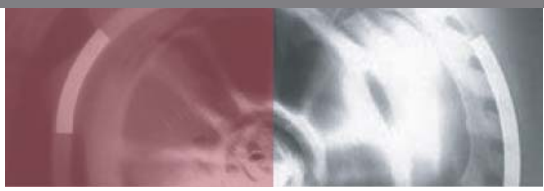
White Paper

Case Study



Semiconductor Metrology Stage

August 2007

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Challenge

How do you **double the throughput**, decrease wafer pre-alignment time five fold (to 600 ms), increase performance five fold in positional repeatability (to 5 nm), while at the same time reducing the cost and increasing the reliability?

The competitive nature of the semiconductor industry places increasing importance on performance characteristics and integration ease for today's motion controllers. New processes demand finer position resolutions, better repeatability while also delivering higher throughput. At the same time increasing process complexities require more integration flexibility of the motion control components chosen for new machine projects.

Micro Precision Automation [MPA] has developed a new metrology stage that addresses these trends in the market. Agile Systems' microMAX *R* distributed motion control delivers key ingredients to achieve the new stage's performance characteristics.

Solution

Agile System's third generation microMAX *R* advanced motion controller offers innovative solutions for semiconductor-tool manufacturing facing the challenges of this dynamic market. The microMAX *R* product is a fully integrated motion controller, servo amplifier and high-speed network for a single axis of motion. The high-speed network transforms multiple axes of motion into a full featured, high-performance, multi-axis motion-control system.

Benefits

Higher Precision

To satisfy the demand for ever higher precision, microMAX *R* allowed MPA to employ Heidenhain analogue encoders. Analogue encoders provide sinusoidal, 1 Volt peak-to-peak (Figure 1), output signal on both A and B channels instead of the conventional 5 Volt TTL square wave signal. The signal of an analogue encoder can be electronically interpolated, in order to obtain resolutions substantially larger than can be obtained from conventional square-wave encoders.

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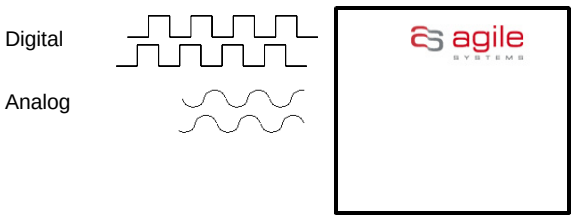

Figure 1 - Digital vs. Analogue Encoder

Yet, the higher encoder resolution by no means guarantees a higher positioning accuracy of the same degree. The reason for this can be found in the current control resolution of the servo amplifiers. The servo amplifier's output current determines the torque the connected servomotor generates. High current produces high motor torque or force; low current produces proportionally lower motor torque or force. The servo system controls the motion of the servomotor shaft or linear motor by regulating the motor's torque or force by varying the current. In order to take advantage of higher resolutions, the servo systems has to be able to move the servomotor shaft or motor in increments as fine as the higher encoder resolution. This requires a much higher effective current resolution than is available from conventional systems. The amplifier designer has to solve two problems to achieve the needed current resolution. The first problem has an easy solution and simply means hardware that provides more bits of analogue-to-digital conversion. The second problem is proper filtering to be able to separate the actual current signal from background noise.

Agile Systems' microMAX R motion controllers provide effective current resolution of 14 bits. It achieves positioning resolutions of a few nanometers when applied to an appropriately designed mechanism.

Previous generations of semiconductor metrology tools achieved positioning repeatability of 25 nm. MPA's new stage features position repeatability of 5 nm with double the throughput.

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Higher Throughput

The pre-align process takes up a considerable portion of the total tool cycle time. The pre-align process finds the center of the 300 mm wafer and locates the reference notch on its periphery. In most tools, the notch is found during a high speed rotation and precisely located during a precision rescan. It typically takes up to 3 seconds in conventional motion-control configurations.

MPA was able to utilize the features of Agile Systems' microMax *R* controller enables the reduction of pre-align time to 0.6 second through careful collection of a laser based pre-alignment signal. The system was designed using three microMax *R* controllers on a single backplane board which allowed drastically improved signals over a conventional design. A high speed Firewire B network connects the microMAX *R* controllers with each other and the central process controller for the metrology tool. Real-time axis position from axis encoders as well as digitized analog and digital signals can pass directly to the central process control through the high-speed network. This allowed MPA to collect clean high speed pre-alignment data, which was used to eliminate the precision, rescan step of pre-alignment.

Tight Integration

Conventional motion-control configurations in *Figure 2* require relative large electrical enclosures to house separate motion control components consisting of power supplies, servo amplifiers, motion controllers and signal converters. Since metrology tools will be tightly integrated with other semiconductor processing equipment, it is desirable to mount the motion-control hardware within the tool itself and eliminate the separate electrical enclosure typical for conventional systems.

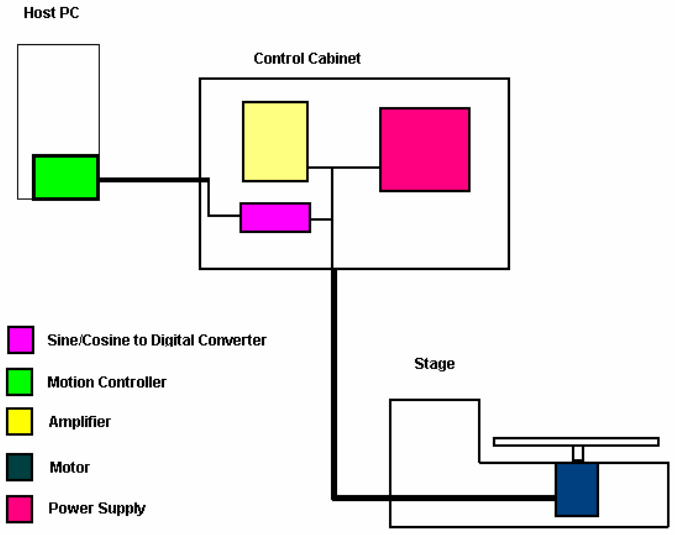

Figure 2 - Conventional Motion-control configuration

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But as *Photo 1* illustrates available mounting space within the tool is limited and restricted. Trying to fit conventional control configurations inside the tool would prove extremely difficult, if not impossible.

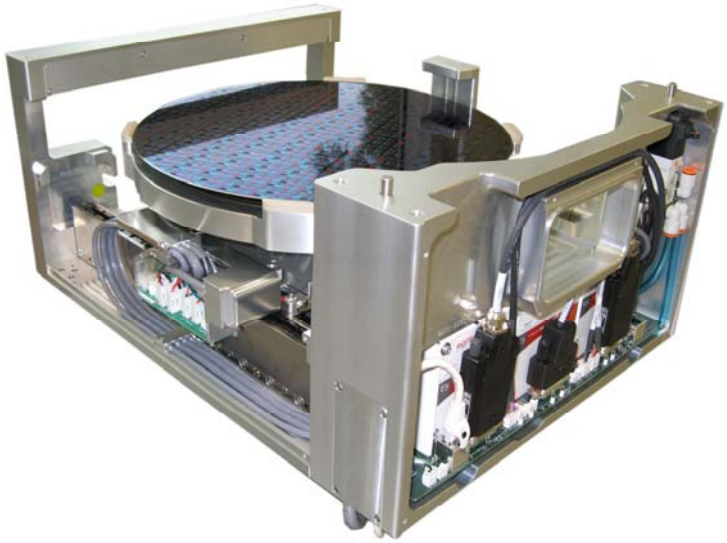

Photo 1 - Metrology Tool

Agile Systems' microMAX *R* motion controller *Figure 3* combines motion controller, servo amplifier, signal conversion and high-speed network in a single compact package.

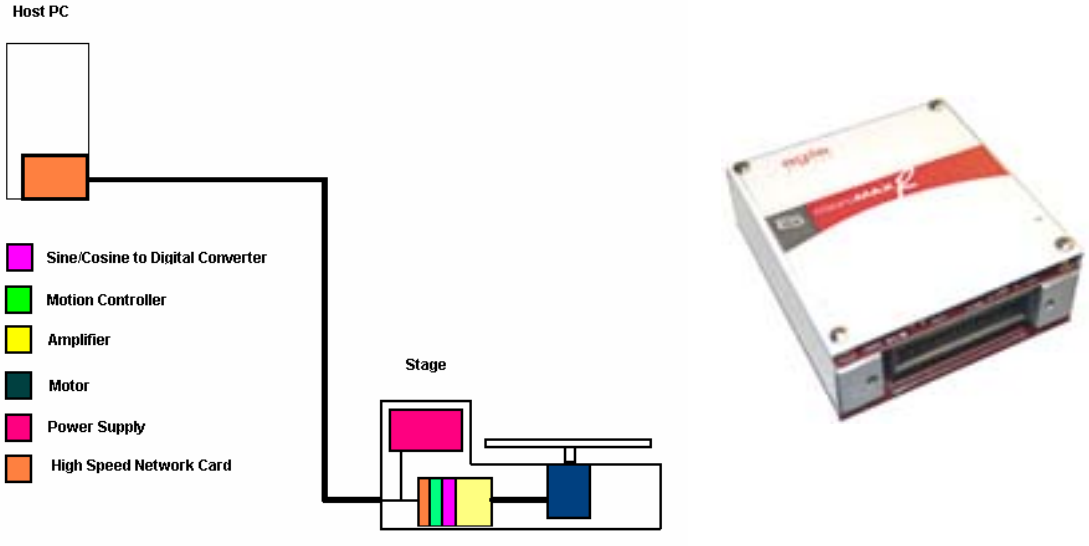

Figure 3 - Integrted Motion Control

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The approximate overall dimensions of the microMAX *R* controller are 3 inches long, 3 ¼" wide and 1 ¼" high. Reduction in wiring is another key ingredient to support tight integration of motion control components and semiconductor tools. The microMAX *R* controller eliminates a substantial amount of system wiring by combining motion controller and servo amplifier in a single, fully integrated package.

The controller provides further reduction in cabling and wiring due to its unique construction. All signal and interface connections are brought out to a backplane. *Figure 4* with 2 compact interface connectors.

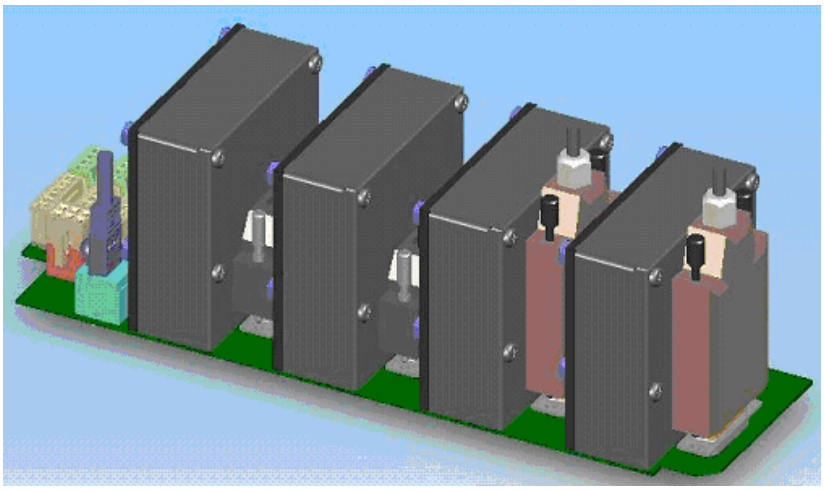

Figure 4 – Typical Backplane Controller Configuration

This 'Lego Concept' allows the tool designer ultimate flexibility in laying out the motion control installation scheme. The machine designer can create his own PCB board, which contains the required interface signal connections to the motion controllers. A custom PCB board layout in a shape most appropriate for a given tool configuration can be easily created.

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Conclusion

Technological innovations in motion control technology included in Agile Systems microMAX *R* motion controller enabled Micro Precision Automation to successfully address competitive challenges facing today's manufacturers of semiconductor production equipment in several key areas – throughput, performance, cost, reliability, and integration time .

More precise and finer motor current control is a pre-requisite for designing a tool with higher positional accuracies and repeatability. High-speed network facility reductions in wafer pre-align times translate into improved productivity for the tool user. Compact construction and space saving backplane designs ease integration complexities.

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