Thomas Swan Scientific decides to install Beckhoff automation system

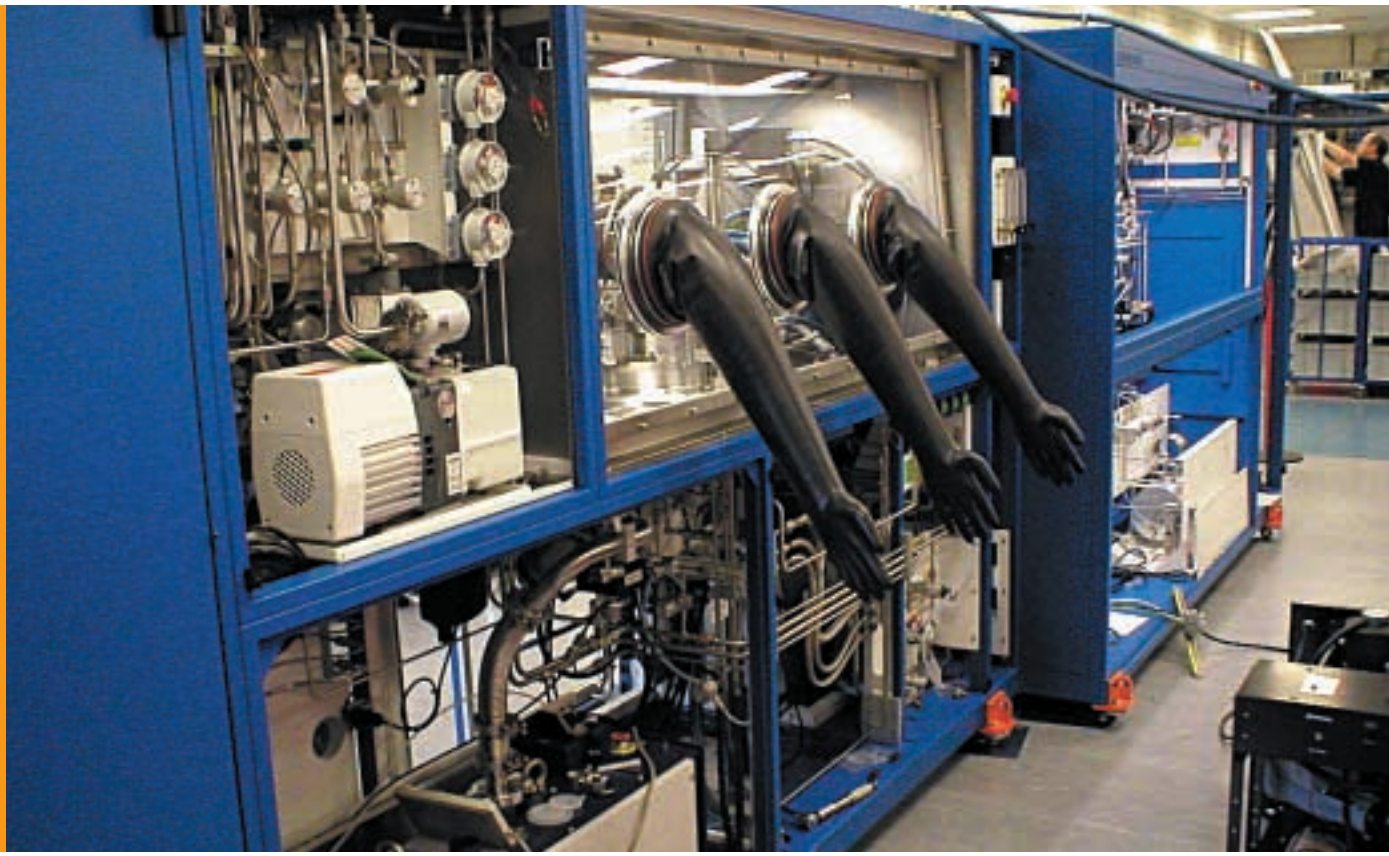
TwinCAT smoothes the way ahead in wafer manufacture

Thomas Swan Scientific, based in Cambridge, England, supplies 40% of the world market for metal-organic chemical vapor deposition (MOCVD) reactors. The market for these machines, which are used in the manufacture of many types of semiconductor, is very competitive, but Thomas Swan is finding that PC-based control systems are providing the key to ensuring that the company retains its market dominance.

While the majority of semiconductor products – for example, processors and memories – are silicon devices, there are now many other products, including light-emitting diodes (LEDs) and microwave components, which make use of other semiconductor materials, such as gallium nitride and indium phosphide. One of the key processes in the manufacture of products using these exotic semiconductor materials is the production of blank wafers which are, in effect, the raw material from which the finished devices are fabricated. The development, manufacture and supply of MOCVD reactors to produce these wafers is the central business of Thomas Swan Scientific, and of its parent company, Aixtron AG, the world's largest supplier of chemical vapor deposition equipment.

The principles behind the MOCVD process are not difficult to understand. For each wafer to be produced, a substrate in the form of a flat disk, usually of sapphire or silicon, is placed in the reactor. Various gasses, some of which contain elements of the required semiconductor material, are then admitted to the reactor chamber. If the temperature and pressure of the gases is precisely controlled, along with the time/temperature profile of the substrate, the result is that a thin layer of ultra-pure semiconductor material is deposited on the substrate, transforming it into the finished blank wafer.

While the principles of the process may be straightforward, however, implementing these ideas in a dependable piece of production equipment is a much more challenging task. Innovative design is part of the answer, and is featured, for example, in Thomas Swan's unique close-coupled showerhead concept. As its name suggests, this looks just like an old-fashioned flat showerhead with an array of holes on its surface. Used as the method of introducing gases into the reactor, this arrangement ensures that they are distributed evenly over the substrate, which is mounted in close proximity to the showerhead. Since it has independent channels for two gases, the showerhead also ensures that, when more than one gas is used, they mix only at the last moment in the reactor. This is essential, as some combinations of gases react to form solid compounds which can block other types of delivery system.



Adaptable control for changing requirements

Innovative process design, however, only addresses part of the challenge of producing a dependable and efficient MOCVD reactor. Accurate, reliable control is also essential and, ideally, the control system adopted must provide an easy path for future developments to take account of changes in the fast-moving semiconductor business.

For many years, Thomas Swan Scientific had used a control system based on a PC, which provided most of the intelligence, linked via a Profibus connection, to a standard PLC, the main task of which was to deal with the system's inputs and outputs. Recently, however, it was decided to upgrade the control system and, in particular, to separate the controls for the gas cabinet, which deals with the supply of gases to the reactor, from the controls for the reactor itself. This arrangement would streamline the manufacture of the machines, as the gas cabinets are largely standardized, and could be built for stock, while the reactors vary considerably according to the type of semiconductor being produced.

At the same time, the Thomas Swan Scientific design team wanted to increase the network capability of the control system so that it could support networked mass-flow controllers, pressure controllers and other intelligent peripherals. While investigating methods of satisfying the new requirements, engineers at Thomas Swan Scientific discovered that simply upgrading the existing PLC-based design would almost double the cost of the control system.

System costs reduced

Clearly, a better solution was needed, and after evaluating various possible solutions, the engineers decided that the optimum approach would be to use PC-based control based on TwinCAT, in conjunction with Beckhoff Bus Terminal products for inputs and outputs. Instead of doubling the cost of the control system, this arrangement reduced it by almost half!

Cost was not the only issue, however. "One of the things which really attracts us to the Beckhoff solution is its flexibility," said Chris Moorhouse, chief software and control engineer at Thomas Swan Scientific. "We can, for example, develop software on a desktop PC, and then move it straight into one of the Beckhoff Industrial PCs, or even one of the tiny new CX1000 embedded PCs." "The freedom that the Beckhoff approach gives us to reconfigure our control systems, without incurring cost penalties," Moorhouse continued, "has unlocked a whole range of possibilities for the future development of our systems."

The first generation of Thomas Swan Scientific MOCVD reactors with control systems based on Beckhoff products feature a single Industrial PC running TwinCAT to implement two virtual PLCs. One of these controls the gas cabinet, and the other controls the reactor itself. Profibus networks are used to communicate with Beckhoff Bus Terminal assemblies, located at various points around the machine, which handle all inputs and outputs.

Reduced cabling effort

"Although our machine is not large – it's roughly five meters end-to-end – it has around 160 analog inputs, 60 digital inputs, and about the same number of each type of output," said Moorhouse. "Simply using the Beckhoff Bus Terminals to provide remote I/O blocks has, therefore, tremendously reduced the amount of wiring needed." "And, an excellent feature of the system is that we can have exactly the combination of input and output types we need in each block," he continued. "We can now, for example, connect PT100 temperature sensors directly to the system without needing to use costly converters, and we can also directly accommodate the RS232 serial connections which are provided by many instruments. Finally, the new networking arrangement is also making it very easy for us to change over to intelligent field devices, as network-ready products that are suited to our requirements become available."

While the new control system arrangements are already delivering substantial benefits, the design team at Thomas Swan Scientific has plans to go much further. The next step will be to provide the gas cabinet with its own CX1000 Embedded PC, and provide another for the reactor. These will be linked to a supervisory PC which will handle operator interfacing, process data logging and diagnostics. This arrangement will achieve the aim of physically separating the gas cabinet and reactor control systems.

Future projects

A further enhancement will be the replacement of the present mimic-panel style operator interface with a Beckhoff Control Panel. "Mimic panels are just too inflexible," said Moorhouse, "even the smallest change means a redesign, and since most of our customers have slightly different requirements, that means a new mimic panel design, with different screen printing, for virtually every job." "With a Beckhoff Control Panel, all that's needed is a simple software change. A further big benefit is that a touch-screen interface looks more modern, is easier to use, and can provide much more detailed information than a mimic panel with just a few lights and gauges."

The final stage in the control system developments which are currently planned is to migrate the machines' safety systems to Profisafe, a step which is again made easy by the new TwinSAFE system. This will further reduce the wiring, and also eliminate a number of costly special-purpose printed circuit boards which are currently used for safety interlocking.

While Thomas Swan Scientific's new control system is very different, in both implementation and capabilities, from its predecessor, the company's development team found that moving from the old system to the new was very straightforward. In fact, less than two weeks of design work was all that was required, including the time taken to modify the control programs to run on their new platform.

Hardware and software from Beckhoff, supplied by the Beckhoff exclusive UK agent, Hayes Control Systems, is providing Thomas Swan Scientific with a versatile control platform for the future development of its market-leading MOCVD reactor systems, at the same time ensuring that the company's current generation of machines maintains and enhances its competitive position in the market place.

Chris Moorhouse has the final word. "Our control system developments using Beckhoff products have met, and in many cases exceeded, all of our requirements and expectations, in terms of performance, versatility and value."

"In fact, the Beckhoff solution is so successful that it is now being closely considered by our parent company, Aixtron in Germany, for adoption on its own equipment. If, as is expected, this development goes ahead, Beckhoff control equipment will be very close to becoming the de-facto world standard for MOCVD reactor systems."

The C6240 Control Cabinet PCs are the hardware platform for the new control concept at Thomas Swan Scientific.

→ Thomas Swan Scientific www.thomasswan.co.uk
→ Aixtron AG www.aixtron.com
→ Hayes Control Systems www.hayescontrols.co.uk