Application Story

Precision Automation for Nanostructures

NYCe4000 semiconductor controller from Rexroth with SERCOS III for SET

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For Immediate Use

Scenario: Nanometer structures are punched into brittle silicon, which is subjected to high pressure metered at tolerances of less than 1 micrometer while the microchips are contacted and packaged using a wide range of elaborate processes. Machine manufacturers such as Smart Equipment Technology (SET) SAS continue to push the envelope of what is technically possible in semiconductor production. With its High Force and High Accuracy Die Bonder FC 300, the company offers a highly flexible machine that can be used to carry out many different production steps. To this end, the NYCe 4000 motion controller from Rexroth regulates the complex operational processes involved as a universal bus via SERCOS III under demanding, real-time conditions.

Microelectronics continue to be available in even smaller sizes. Two years ago, the 100 nanometer structure mark was the benchmark. Today, a few chip manufacturers are already producing modules whose structures measure fewer than 20 nanometers. (A nanometer corresponds to four metal atoms aligned in a row.) Smart Equipment Technology, one of the world's leading providers of process solutions for high-precision bonding and nanoimprint lithography, has developed a machine – the FC300 – which can adapt to a large number of processes for producing microchips and optoelectric components with nanostructures.

It is exactly this flexibility that poses such a challenge for automation. "Our applications for control motion work in an environment where tolerances of under one micrometer are required as well as the capacity to meter several thousand newtons with utmost precision," emphasizes Joseph Macheda, R&D department at SET. Numerous parameters must also be evaluated in real time to ensure process reliability.

The French engineers decided to use the NYCe4000 from Rexroth, a controller optimized for the semiconductor and solar industry, in developing the FC300. The scalable multi-axis control system integrates the complete control and drive hardware in one housing with a smaller footprint than an industrial PC. Its open software architecture provides for extremely high flexibility in automating modules and entire machines. Application-oriented programming for comprehensive functionality reflects the demanding requirements with respect to motor speed and precision (up to ten motors can

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be controlled). With up to 120 digital and analog inputs/outputs, it is now possible to integrate a large number of measuring units so that even very complex process steps can be realized.

"The engineering tools from Rexroth and the end-to-end communication via SERCOS III considerably reduced the time spent during implementation while maintaining maximum flexibility for complex processes," stresses Joseph Macheda. The motion controller in the FC300 regulates linear, piezo, stepper, servo synchronous, and torque motors. The NYCe 4000 directly evaluates the signals of all encoder types, the initial SinCos control signals of high-precision position measuring systems, and the EnDat 2.1, EnDat 2.2, and Hiperface logs to achieve the required contacting accuracy of 0.5 micrometers.

Front- and back-end on a single machine

Integrated circuits are becoming smaller all the time; the machines, however, must still be able to process large workpieces. More and more plants are converting over to the new 300 mm silicon wafers to lower production costs, since considerably more chips will fit on the larger substrates. The FC300 can process these substrates just as it can three-dimensionally integrated circuits and complex, optoelectronic components. Here, the machine applies different front-end and back-end processes that require high forces and/or ultrahigh precision (e.g. nanoimprint lithography). Unlike with photolithography, nanoimprint lithography involves a die that mechanically stamps the structures. The vertical axis of the SET machine produces up to 4,000 N of pressure, which is applied to the brittle silicon wafer in micrometered movements. "Ensuring process reliability is our top priority," affirms Joseph Macheda, "which is why the controller must be able to receive and evaluate many different sensor signals and translate them into motion commands in real time." End-to-end SERCOS III communication provides the bandwidth required for this via a Fast Ethernet infrastructure. SERCOS III also enables short cycle times and high reliability in addition to the proven real-time mechanisms borrowed from the previous version.

The FC 300 likewise incorporates process steps for contacting and packaging the integrated circuits (bonding), whereby the motion controller regulates complex motion sequences and process evaluations at the touch of a button. The FC 300 can handle a wide variety of processes for chip-to-chip and chip-to-wafer production. High forces similar to those of nanoimprint lithography are applied at the vertical axis when multiple chips are bonded to form three-dimensional, integrated circuits. Here, too, the motion controller precisely

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meters the force applied. The operator can also create a vacuum and introduce industrial gases into the process chamber in addition to carrying out these processes under normal atmospheric conditions. Large components (to 100 mm x 100 mm) can be bonded as well.

SET not only makes use of state-of-the-art technology, but relies on a granite structure to ensure lasting precision. "The machine also improves efficiency for smaller batches because of the high reliability with which it is able to apply a host of processes," attests Joseph Macheda. The performance automation solution accommodates the large variance between these processes entirely via software. This, in turn, makes it possible to introduce smaller structures for even higher-performance microelectronics.

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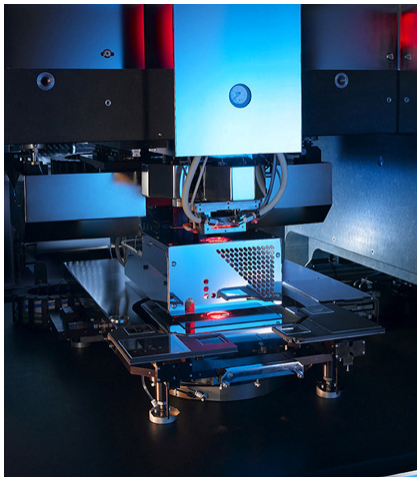

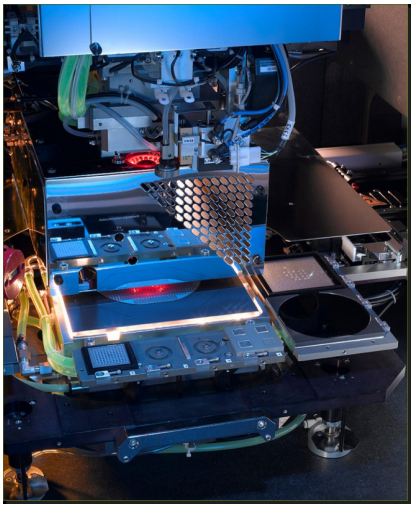

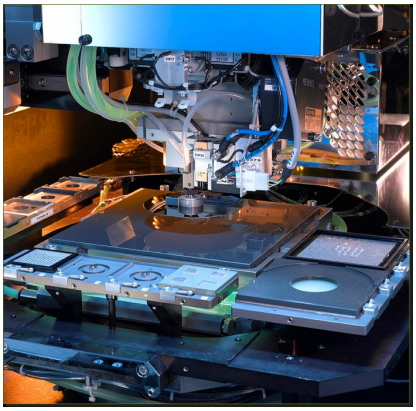

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