A leading provider of lithography systems for the semiconductor industry uses Plant Simulation to optimize production scenarios.

Innovative consumer and industrial electronics products require state-of-the-art microchips

ASML is one of the world’s leading providers of lithography systems for the semiconductor industry, manufacturing complex machines that are critical to the production of integrated circuits and microchips. These advanced systems help ASML’s customers, the chipmakers, to reduce the size and increase the functionality of microchips within consumer electronics equipment. As a result, ASML helps to create more powerful electronics systems for consumers and industry professionals.

Evolving high-productivity TWINSCAN NXT platform, manufactured by ASML.

ever-shrinking microchips have brought better, more affordable and energy-efficient electronics and services to everyone, improving mobility, connectivity, safety and digital entertainment.

Amid the global financial crisis of 2009, chipmakers sharply reduced capital expenditures. Halfway through the year, the semiconductor industry was among the first to recover, and orders picked up, leading to two subsequent years of record sales for ASML. Sales in 2010 were nearly three times those of 2009, followed by another sales increase in 2011. During this strong rebound, ASML had to ensure that it would continue to deliver its machines on time and in accord with the highest quality standards.

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As demand in the semiconductor industry is cyclical, ASML must continuously adjust its production capacity to meet the requirements of the market. This is a sophisticated process that involves forecasting demand, setting detailed output plans and aligning with a large and complex supply chain. This process also involves the use of the Plant Simulation solution in the Tecnomatix® portfolio.

Bridging the gap between product design and manufacturing

ASML uses several Siemens PLM Software solutions, including Teamcenter® software for digital lifecycle management and NX™ software for product design. Recently, the Industrial Engineering department of ASML began using Plant Simulation, a discrete-event simulation tool.

“Plant Simulation will be part of our engineering decision-making process.”

Andreas Schoenwaldt
Industrial Specification Management Team Manager
ASML

“The Industrial Engineering team functions in between D&E (Development and Engineering) and M&L (Manufacturing and Logistics),” explains Andreas Schoenwaldt, Industrial Specification Management (ISM) team manager at ASML. “The production simulations that we develop using Plant Simulation support building a bridge between these groups. We have to make many decisions regarding the establishment of new production facilities, or improving existing ones. Plant Simulation helps us make these decisions after simulating what-if production scenarios. Our machines have to perform to high standards; they need to print very small features on silicon wafers, printing 30-40 layers exactly on top of each other, and do it extremely fast. Precision is measured in nanometers. A relentless drive to innovate is part of the ASML culture, and has allowed us to meet this challenge. In this context, we had the need for a discrete-event software simulation tool to simulate and optimize our production.”

Results (continued)

Optimized a production line configuration that supports the needed throughput and reduces the investment in production resources for a new EUV machine

Boosted production capacity for a new design by using two positioning module qualification tools

Created library of simulation objects, e.g. an optimization algorithm object that identifies the most efficient sequencing of manufacturing steps

Implemented Plant Simulation as part of the company’s production process approach that enables continuous delivery of the most innovative and cost-effective solution to customers

“Maintaining world leadership is a tough task. You must be innovative and cost-effective. Plant Simulation will be part of our engineering decision-making process. A lot of production scenarios will be simulated virtually using Plant Simulation, before we will actually commission the production line.”

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Industrial Specification Management Team Manager
ASML
Creating a Plant Simulation model for the production phase, with a target of shortening machine lead time

Machine testing is the production phase that requires the longest duration, even significantly longer than the final assembly phase. ASML is constantly striving to shorten lead times, increase production capacity and lower costs in order to increase its appeal as a go-to supplier. In studying these challenges, data analysis showed that one source of delays is the late delivery of processed wafers. Joris Bonsel, an industrial engineer on the Industrial Specification Management (ISM) team at ASML, notes, “These wafers are produced in our process lab, mainly for the purpose of machine testing. We used data from a five-month period of actual wafer orders requested by the test department, combined with the corresponding actual delivery times. We then created a Plant Simulation model that delivered the same results that were collected, reflecting a surprisingly high level of accuracy.

“Once we knew that we had a simulation model that reflected reality, we started to do the industrial engineering analysis. It was clear that adding more manpower in the lab would improve delivery performance, but we were able to simulate the actual production, and proved that there is a clear financial benefit to adding one employee to the process lab, rather than invest, for example, in a new track. Just to prove that this result is not trivial, we simulated and showed that adding a second employee was not cost beneficial. This analysis was previously done based on gut feeling, rather than a simulation, and therefore it was difficult to argue with the simulation recommendation.” Bonsel notes, “This was actually the project we used to pilot Plant Simulation, and we were impressed when we realized that with Plant Simulation, we can build a model that will accurately imitate the performance of a physical production line.”

A new generation of lithography systems

ASML has developed a new generation of lithography systems that uses extreme ultraviolet (EUV) light and will allow chipmakers...
to continue to shrink feature sizes on chips. The first systems intended for volume manufacturing, dubbed NXE:3300B, will ship in 2012, and the engineering teams had to plan production facilities to support the rollout. Maurice Schrooten, an industrial engineer on the ISM team at ASML, explains: “One of the main questions was: ‘Which production resources were needed for manufacturing the MBMM (main body mid module), one of the major modules of this machine?’ Naturally, we were looking for the most cost-effective investment, and therefore we have used Plant Simulation to analyze the implications of three different alternatives on clean room space consumption, throughput variation, and labor and hardware investment. The three alternatives were: 1) cloning the current production line, 2) outsourcing, called HLQB (high-level qualified buy), some of the production and, 3) using a new production line methodology, which splits the assembly work between three different work areas. The simulation showed that the cloning alternative required a higher investment in equipment, so we abandoned it. Out of the other two alternatives, which were largely equal, we selected the one with the lowest risk for ASML. The Plant Simulation result is an optimized production line configuration that supports the needed throughput and reduces the investment in production resources.”

Higher throughput through simulation
One of the key modules of the TWINSCAN NXT:1950i machine is the positioning module (PM). As ASML was considering how to boost production capacity for a new design, the team wanted to know how many qualification tools, that is, positioning module qualification tools (PMQTs) would be needed, and how could the tool utilization be maximized. The team also planned to compare deployment of two parallel workstations with the same tasks versus two serial workstations, each with half of the tasks. Ron Clauwers, an industrial engineer on the ISM team at ASML, notes: “To deliver the highest throughput, four scenarios were compared with each other, and the Plant Simulation results showed that we should use two identical PMQTs in a flexible (not fixed) manner, in other words, each PMQT can accommodate any needed production step, combined with priority rules, and use parallel workstations (rather than serial workstations), in front of the PMQTs.”

Plant Simulation result chart: comparison of investment in three production line alternatives.
Plant Simulation becomes part of the decision-making tool kit

“One of the strengths of Plant Simulation is the ability to create a library of objects with certain logic, and re-use these objects in different models,” says Schrooten. “We worked closely with the Siemens PLM Software deployment partner, cards PLM Solutions B.V., and they have provided us with an initial, useful library of objects. For example, we created the genetic algorithm (GA) optimization object in our object library. When we simulate a manufacturing process, we define a lot of constraints between the manufacturing steps, such as the precedence constraint, which defines which step should be done prior to another step; time constraint, which defines waiting time that is sometimes needed after executing some of the manufacturing steps; and constraints that are related to physical aspects, for instance, two steps that can’t be done simultaneously, as they are done on the same physical area of the machine.

“The GA optimization object uses the genetic algorithm capability of Plant Simulation to recommend a sequence of process steps, taking into account all the constraints, and to assign the steps to the required production personnel.

“Another useful capability of Plant Simulation we are using is the experiment manager. With this, we run simulations of several scenarios, and can very easily compare the results of different alternatives.”

Schoenwaldt concludes, “Maintaining world leadership is a tough task. You must be innovative and cost-effective.” He notes, “Plant Simulation will be part of our engineering decision-making process. A lot of production scenarios will be simulated virtually using Plant Simulation, before we will actually commission the production line.”

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