SIEMENS
Ingenuity for life

Siemens PLM Software

Smart manufacturing for electronics

Providing a fully digitalized strategy that integrates PCB and mechanical flows

Executive summary

This white paper describes a transformative approach to electronics manufacturing made possible by the addition of Mentor Graphics to the Siemens family. It describes a completely digitalized strategy that supports both printed circuit board (PCB) and mechanical design and manufacturing, uniting the entire product lifecycle – from idea and production to customers and back. In a consumer climate that demands new products at an unprecedented rate, this approach can reduce time-to-market by up to 50 percent, shrink development costs by as much as 25 percent and enable you to achieve near perfect product quality.

Contents

Abstract

This white paper describes a product development strategy designed for manufacturers of electronics for consumer and industrial products, home appliances, manufacturing services, automotive and transportation, aerospace and defense and semiconductor equipment.

In each of these industries, companies are struggling to meet customers' demands for faster new product introductions (NPIs), flawless quality, personalized and customized products and internet connectivity. As manufacturers attempt to meet these expectations, they must also manage the complications of global supply chains as well as the increased complexity of today's advanced design and manufacturing practices.

Our strategy for supporting you in this challenging environment is called smart manufacturing for electronics, the centerpiece of which is an integrated platform that encompasses both PCB design and mechanical flows while uniting all of the domains required to engineer, manufacture and deliver today's smart products. It is a digitalized development strategy that encompasses everything from PCB design and factory floor optimization to incorporating customer feedback into new designs.

Smart manufacturing for electronics represents the new manufacturing operating model that Siemens calls the Digital Enterprise, as we have adapted it specifically for your needs. We believe it is the most comprehensive platform currently available, and after seeing it deployed in our own factory, we know it works.

This white paper will explain what smart manufacturing for electronics is, what advantages it offers over conventional product development approaches, and why this strategy from Siemens can help your company succeed.

Today's consumer electronics climate challenges manufacturers

As users of electronic devices, we can all appreciate the excitement of a new smartphone launch, the holiday availability of a new video game platform, or the introduction of a wearable device that promises to enhance our well-being in some way. Breakthrough innovations in electronics come rapidly, and we have come to expect that.

If you look at this development as a consumer, it's positive and exciting. But as someone who manufactures electronics, your view is probably more mixed. Although there is the potential for incredible success in this market, the challenges of competing are daunting.

Not only do your customers expect new devices from you at an ever-accelerating pace; they want to choose a customized version from dozens of options. Eventually they're going to expect their devices to be personalized, if they aren't already. Increasingly, they expect new devices to connect to all of their other devices via the Internet.

Additionally, there is the expectation of flawless quality. In this age of immediate and potentially viral negative product reviews on social media, a minor malfunction or a significant launch delay can doom a product to a premature death.

Practical implications for manufacturers

As electronics manufacturers struggle to meet today's market demands (rapid new product introductions, high expectations for quality, personalization/customization, internet connectivity, etc.), manufacturers must contend with:

Greater product and process complexity

Newer technologies such as 3D printing, knowledge automation/digital assistants, big data/data analytics and advanced robotics have emerged to enhance innovation and accelerate manufacturing processes. Although these offer significant advantages, they also increase the complexity of both products and the processes required to manufacture them.

Cycle-time pressures

Today's short time-to-market makes it difficult to prove in advance that manufacturing processes will work, while the increasing volume of production ramp-up cycles leaves little to no room for error.

Difficulty shifting from mass production to mass customization

The inflexibility of current manufacturing systems prevents them from supporting mass customization.

Strict data and documentation requirements

Proof of compliance is essential for doing business in industries such as automotive and medical, and also for working with strict original equipment manufacturers (OEMs) that require high levels of quality and standardization.

Globalization's effect on labor resources and material replenishment

Decisions about where to manufacture have become more complicated as some low-cost regions have been unable to keep pace with increased product demand and/or cost expectations. Profit margins drop when low-cost labor sites are no longer as cost effective, and also when shipping costs counteract labor-cost savings. Global sourcing offers the potential for cost savings, but also makes it harder to optimize material replenishment.

How the industry has responded so far

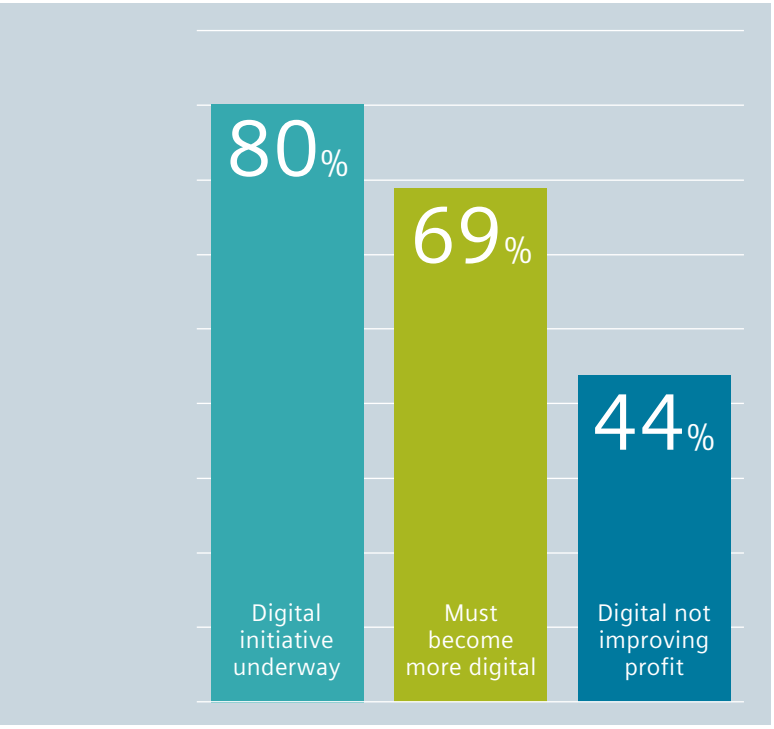
Most electronics manufacturers have applied digitalization[1] to various stages of their product development process. These efforts include one or more of the following solutions:

- Integrated planning and management for PCB assembly and test
- Production ramp-up, virtual design and process verification test management and execution
- Production optimization with integrated layout and simulation
- Model-driven processes for advanced part and mold manufacturing
- Supplier collaboration for PCB contract manufacturing
- Manufacturing execution system (MES) for box build and shop floor connection

Digitalization clearly supports better planning and faster validation of production alternatives, increasing the effectiveness and performance of manufacturing operations. However, research by CEB Global (now Gartner) indicates that so far, digitalization is not having the anticipated bottom-line impact.

In a 2017 survey, the firm found that more than 80 percent of the senior executives they contacted had some sort of digital initiative underway, yet 44 percent also noted that digital investments were not improving net profit.

"Digitalization success depends less on having the most advanced technologies and more on having the right operating systems," Gartner concluded. "Business skills, incentives and operating models have 15 times more impact on the likelihood of success in digitalization than changes in digital technologies."



"Digitalization success depends less on having the most advanced technologies and more on having the right operating systems."

CEB GLOBAL, 2017

What more is needed

Realizing the full potential of digitalization requires a new manufacturing operating model. At Siemens, we call this paradigm the Digital Enterprise, which is an integrated platform that unites all of the domains required to engineer, manufacture and deliver today's smart products.

The foundation of the Digital Enterprise rests on two concepts, the digital thread and the digital twin.

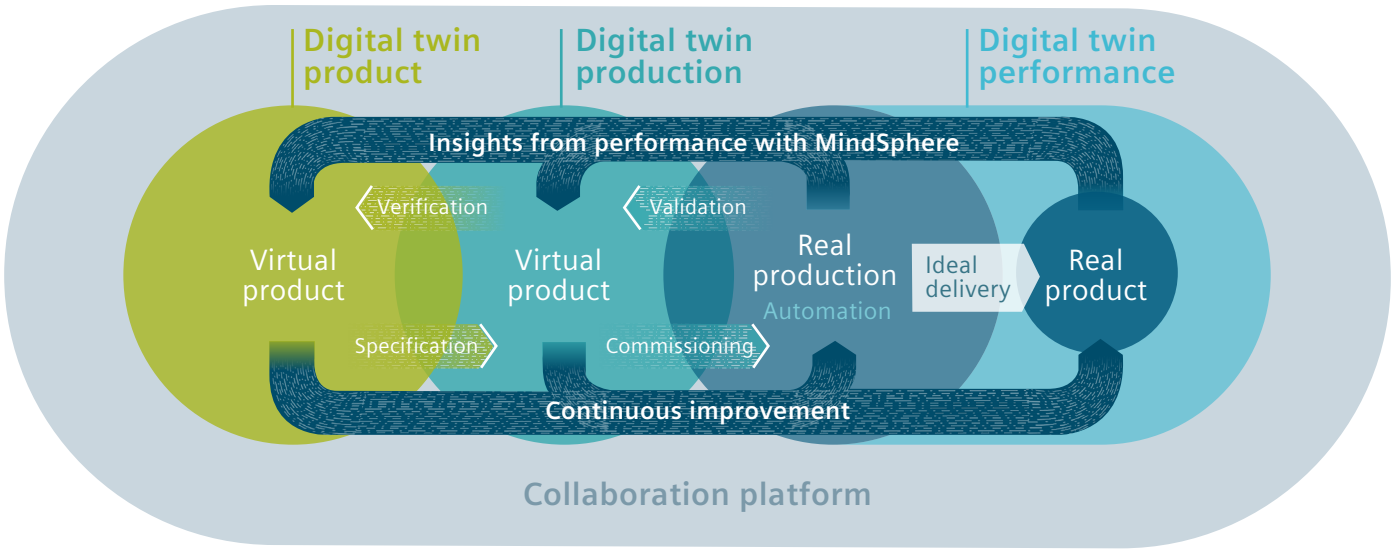
Digital thread

The digital thread is a chain of information that connects all of the participants and information involved in designing, building and supporting the product. A collaboration backbone, such as Teamcenter® software, weaves the digital thread through all of the involved disciplines, applications, tools and systems.

Digital twin

This is a highly accurate virtual model of either the product (the digital product twin) or its manufacturing process (the digital manufacturing twin). These models are used to simulate real-world conditions prior to building a product or designing manufacturing operations, with the goal of optimizing as much as possible in software, in which multiple what-if scenarios can be evaluated relatively inexpensively.

Thanks to information coming from the digital thread, digital twins can be constantly updated for maximum accuracy. For example, customer feedback can be captured to inform the design and testing of future products. Similarly, by collecting information from real-life manufacturing processes, manufacturing simulations can be improved, resulting in more efficient manufacturing processes. Digital twins are also an excellent way to capture and replicate manufacturing best practices.



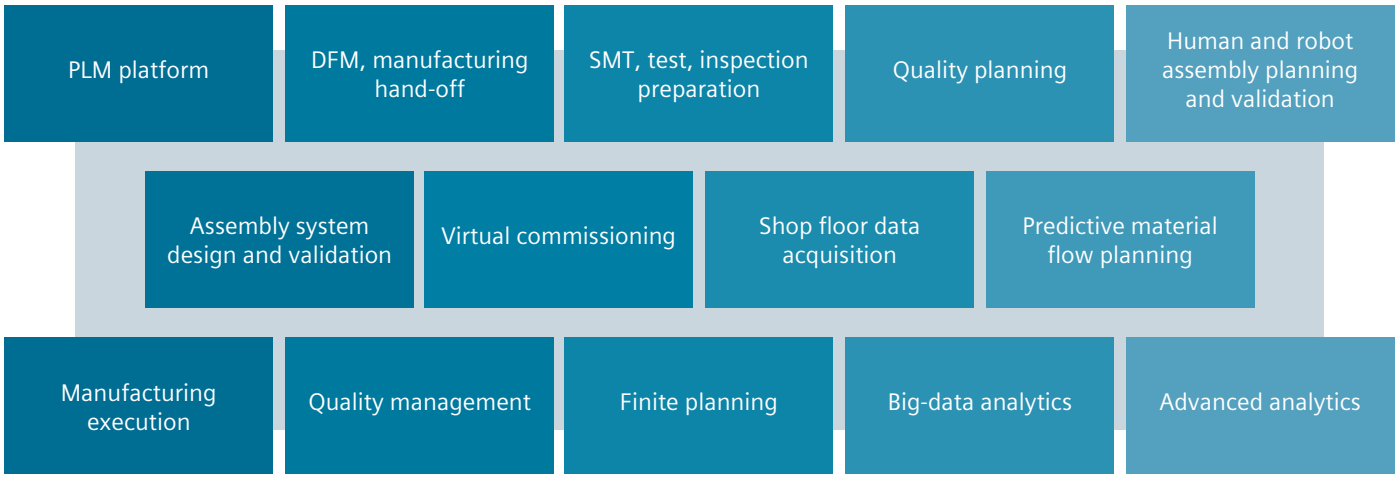
Why smart manufacturing for electronics?

Smart manufacturing for electronics is how Siemens PLM Software has tailored the Digital Enterprise for electronics manufacturers. The smart manufacturing for electronics strategy is the outcome of incorporating Mentor into the Siemens family, and our subsequent efforts to merge the two companies' solutions into a comprehensive, cohesive platform that provides value for you.

Siemens PLM Software has been covering the mechanical flow from end-to-end for many years. Mentor provided solutions for the printed circuit board industry, covering the electronics flow from design to manufacturing.

There are many differences and similarities between the electronic and mechanical flows, but as products in general have become more complex and contain more electronic content, we saw the need for tighter convergence between the flows. This is why we created smart manufacturing for electronics, making us the only company to offer a solution that supports both the electronics (PCB) and the mechanical aspects of product development, all the way from design to manufacturing.

With smart manufacturing for electronics, Siemens is allowing electronics manufacturers to realize greater efficiencies by merging the real and virtual worlds.



The functional foundation

Smart manufacturing for electronics is supported by a number of Siemens PLM Software product suites, including Teamcenter, Active Workspace for Teamcenter software, NX™ software, Teamcenter Manufacturing, the Tecnomatix® portfolio, Camstar™ BoxBuild software, Preactor software, Valor™ Material Management software, Valor Process Preparation software, Valor IoT software and Valor Analytics software.

In terms of functionality, smart manufacturing for electronics provides tools for:

Validating the manufacturability of both PCBs and mechanical design

A PCB design for manufacturing analysis can perform 950 fabrication, assembly, test and reliability checks that assess the digital product twin for issues affecting performance. Mechanical variation analysis simulates and predicts assembly-level quality from part and subassembly geometric dimensioning and tolerancing (GD&Ts), identifying critical product and manufacturing information (PMI).

Virtually designing, simulating and optimizing production processes

PCB assembly process planning creates a digital twin of the production process, enabling a "design anywhere, build everywhere" approach. Box-build planning prepares process plans for NPIs, identifying the impact of design changes on box-build lines and delivering updated work instructions.

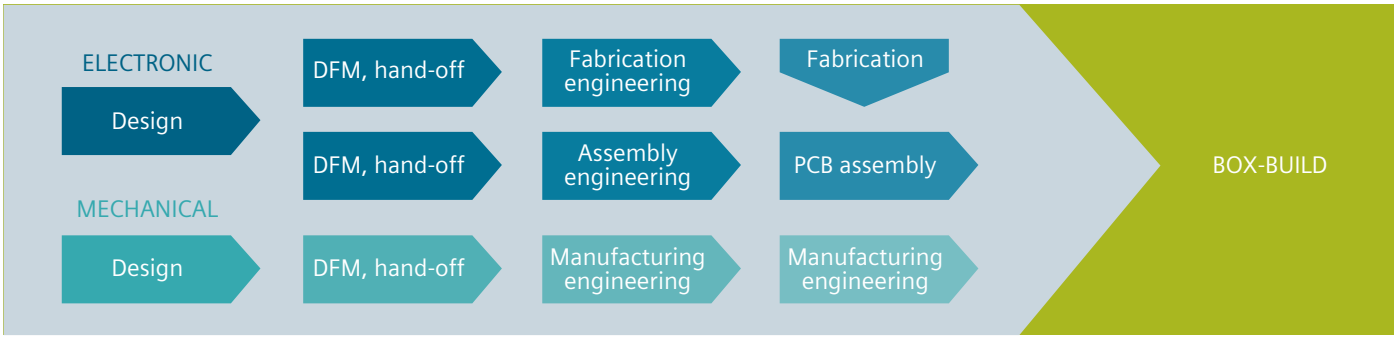
Process validation enables the visualization and analysis of the entire assembly operation to discover issues relating to human, robot and collaborative robotics assembly, and ensure adherence to best practices. Plant throughput and utilization simulation improves the planning of capital investments and prediction of operating expenses, maximizes utilization and reduces per-part costs by optimizing production.

Managing materials and manufacturing operations

Material management tools ensure just-in-time (JIT) deliveries of materials to the line, eliminating excess work-in-process (WIP) and improving inventory turnover. Our Manufacturing Operations Management (MOM) is a comprehensive solution for electronic and mechanical preproduction, production and execution. The solutions manage data from all resources (tools, operators, machines), provide complete as-built traceability, and integrate seamlessly with enterprise resource planning (ERP) and product lifecycle management (PLM) systems.

Collecting and deriving business value from manufacturing data

Internet of Things (IoT) solutions collect all data generated by the manufacturing process (including data about materials consumed, quality and the process flow), creating a digital twin of production and making real-time, normalized manufacturing data available to enterprise applications. Business analytics solutions drive intelligent decision-making based on real-time analysis of manufacturing data, root-cause analysis, and prediction of future performance, quality and cost trends.



Tangible factory floor advantages

Smart manufacturing for electronics eliminates physical prototypes, disconnected systems, paper-based work instructions and silos of information to enable a continuous, integrated flow from design to planning to production.

The difference between this approach, which generates and distributes accurate, validated product and process models across the company, and current piece-meal digitalization strategies, can be seen at every stage of product development. Some key differences include:

- More reliable and manufacturable designs
- Better collaboration among design, engineering and manufacturing departments
- Less data redundancy
- Fewer shop floor planning mistakes
- Less error-prone manual data entry
- Optimized inventory and JIT use of materials
- Enforced manufacturing best practices
- Accurate and up-to-date work instructions
- Plug-and-play data collection and key performance indicators (KPI) monitoring
- Fast time to root-cause identification
- Transition toward higher product mix without loss of factory performance

Competitive advantages and business value

By digitalizing the entire product development process – from design to production – and connecting a digital thread through all the steps in between, the smart manufacturing for electronics strategy lets you know a design can be made, the manufacturing plan is up-to-date and synchronized, and the production system is optimized and performing as you planned it.

This information delivers significant competitive advantages over conventional, partially digitized approaches, including:

Faster time-to-market and more frequent new product introductions

Product development activities that used to take weeks can now be done in hours when connected by a digital thread. Simulations and analyses performed on digital twins ensure right-first-time production. Overall, because a smart manufacturing strategy can reduce time-to-market by as much as 50 percent (see next page), it allows you to succeed in a market that demands frequent innovation.

Quality improvements through left-shift

Left-shift refers to performing tasks that would normally occur later in the design process at an earlier stage. An example in electronics development is PCB design for manufacturing (DFM) analyses, which are performed early and regularly rather than waiting until the design is complete. Each time an analysis is performed, the overall design improves, and the greater the degree of the shift, the greater the benefit.

More responsive manufacturing

With a digital thread linking product design and manufacturing, planning can be performed earlier in development so by the time the design is complete, manufacturing can quickly follow. This opens the door to product customization and personalization.

Smarter decision-making

More informed decisions are made possible by better visibility into manufacturing and the availability of analysis tools that fully exploit manufacturing data.

Cost control

By improving the efficiency of your manufacturing processes and materials – at individual sites as well the global enterprise – the smart manufacturing for electronics strategy can help reduce overall manufacturing costs, ultimately keeping your products affordable for your consumers.

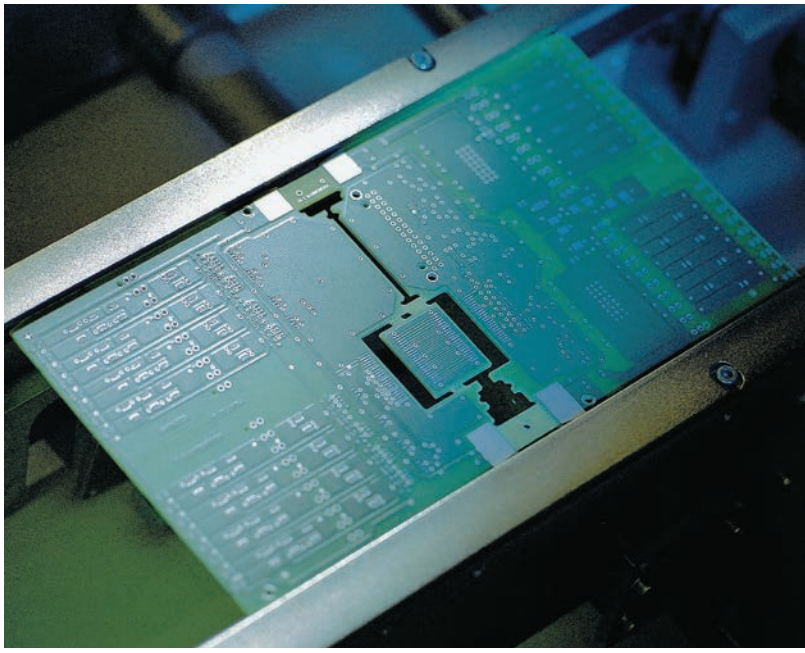
Proof that smart manufacturing for electronics works

Siemens is the world's leading supplier of programmable logic controllers (PLCs) and the Siemens Amberg Electronics Plant (German abbreviation: EWA) is the company's showcase plant for these systems. EWA manufactures 12 million PLCs per year, or one control unit every second, assuming 230 working days per year.

EWA is a highly successful example of Siemens' Digital Enterprise platform in action. Using the smart manufacturing for electronics approach, the plant's real and virtual manufacturing worlds are completely integrated. Product codes tell production machines what requirements they have and which production steps must be taken next. Products and machines determine which items on which production lines should be completed when in order to meet delivery deadlines. Independently operating software agents monitor each step to ensure compliance with regulations.

These practices rapidly turn innovation into products. Between the use of digital prototypes and the ability to simulate and optimize production processes in software, the time it takes for EWA to introduce new products is 50 percent lower than other Siemens PLC factories. Changeover time is half as long as well. New order lead time is 24 hours, with the ability to handle a lot size of one.

Production quality at EWA is 99.99885 percent, and a series of test stations detect the few defects that do occur. This digital enterprise has seen cost savings of up to 25 percent.



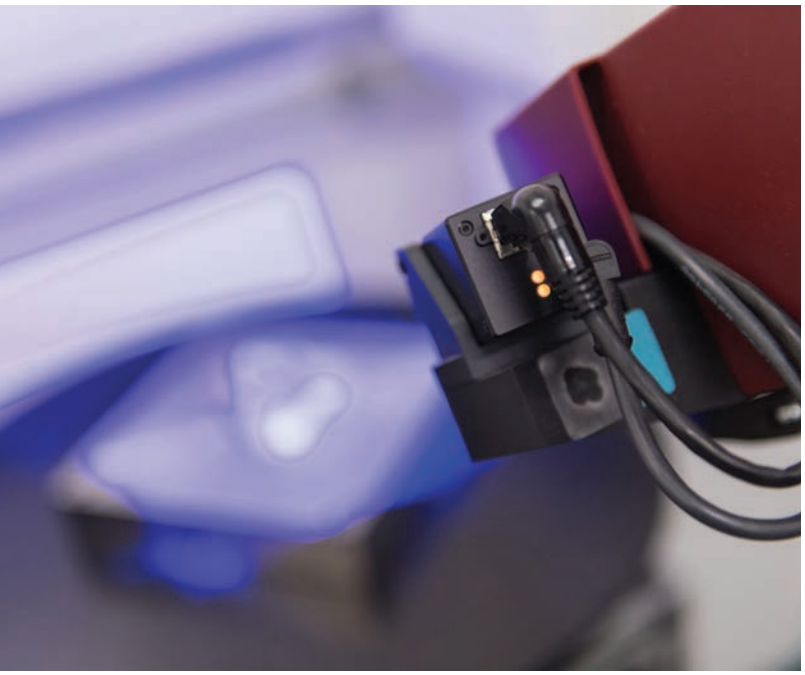
EWA by the numbers

- More than 1,000 product variants were shipped to 60,000 customers worldwide
- 1 million products were manufactured per month
- 50 million process items were entered each day
- The automation level was 75 percent
- There were less than 12 defects per million

Thoughts on the future of electronics manufacturing

Smart manufacturing for electronics is clearly capable of delivering competitive advantages in the current market climate in which fast NPIs, product personalization and high quality requirements are predominant concerns. But what about the future? If history is any indication, unforeseen market forces will pose their own product development challenges.

At Siemens PLM Software, we don't claim to be psychic about market forces driving an industry as fast-changing as electronics. But we do spend time thinking about factories of the future and the technologies that will drive them. In the near- to midterm we see three technologies in particular becoming more important, and we are working to make sure the smart manufacturing for electronics strategy will incorporate them.



Artificial intelligence

There are hundreds of potential use cases for artificial intelligence (AI) in manufacturing, making this one of the most popular technologies amongst the global venture capital community. Capabilities that emanate from AI, called cognitive technologies, include computer vision, natural language processing, speech recognition, robotics, optimization, rules-based systems, planning and scheduling and machine learning (the ability of machines to improve their performance by exposure to data). Siemens' MindSphere is a cloud-based, open IoT operating system that harnesses factory floor IoT data to support machine learning.

Industrial 3D printing

It is estimated that by 2020, 75 percent of manufacturing operations worldwide could be using 3D-printed tools, jigs and fixtures for the production of finished goods. Some analysts predict that automotive and aerospace/defense will be the predominant users of this technology, and electronics manufacturing will also adopt it to some extent. We have efforts underway, including a partnership with HP, to make sure this technology is as beneficial as possible to your manufacturing processes.

Advanced robotics

Robots are now able to perform previously impossible electronics assembly operations. Siemens and partner ArtiMinds Robotics (Karlsruhe, Germany) are enabling a new level of flexible robot use, and are working toward the industrial application of robotic manipulation for smaller lot sizes and processes with significant variance.

Conclusion

When Siemens closed the acquisition of Mentor Graphics in 2017, it was clear that as the number of products with electronics content continues to grow, the concept of the Digital Enterprise would not be complete without tools for electronics design and manufacturing.

Since then, Siemens has spent a lot of time and expertise figuring out how best to help our customers integrate the flows of electronic and mechanical product development. Further, Siemens is working on how best to integrate our solutions so our customers can take an idea and turn it into a product as accurately, quickly and cost effectively as possible.

The result is smart manufacturing for electronics, the strategy described here. With smart manufacturing for electronics, Siemens is delivering a comprehensive portfolio to its customers, with tools that validate the manufacturability of designs; virtually design; simulate and optimize the production process, generate and validate machine programs and work instructions, and optimize the work schedule and resource allocation.

If your company is to succeed in an ever-diversifying market in which personalization and a high frequency of innovation is the rule, you know the importance of flexible, cost-effective and responsive product development. Smart manufacturing for electronics is how you achieve that.

Reference

1. "The use of digital technologies to change a business model and provide new revenue and value-producing opportunities." – Gartner IT Glossary

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About Siemens PLM Software

Siemens PLM Software, a business unit of the Siemens Digital Factory Division, is a leading global provider of software solutions to drive the digital transformation of industry, creating new opportunities for manufacturers to realize innovation. With headquarters in Plano, Texas, and over 140,000 customers worldwide, Siemens PLM Software works with companies of all sizes to transform the way ideas come to life, the way products are realized, and the way products and assets in operation are used and understood. For more information on Siemens PLM Software products and services, visit www.siemens.com/plm.

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