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Real-time reporting and analytics

Gain the power of real-time reporting for smart semiconductor manufacturing decisions

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Leverage real-time production reports and analytics for faster, smarter decision-making

Semiconductor companies know that data is essential. The semiconductor industry is one of the most data intensive industries on the planet today. They also know that data is merely a commodity if it is not the right data. It must be collected in real-time, structured for semiconductor business applications, and displayed in the right context for semiconductor processes and products.

Why is structured data essential? Unstructured data requires filtering through the data lake and needs a data scientist to interpret it. Structured data is prefiltered and is presented in a meaningful context that business staff can readily access to make intelligent, data-driven decisions.

But how do you gain access to this high level of real-time reporting in your fab?

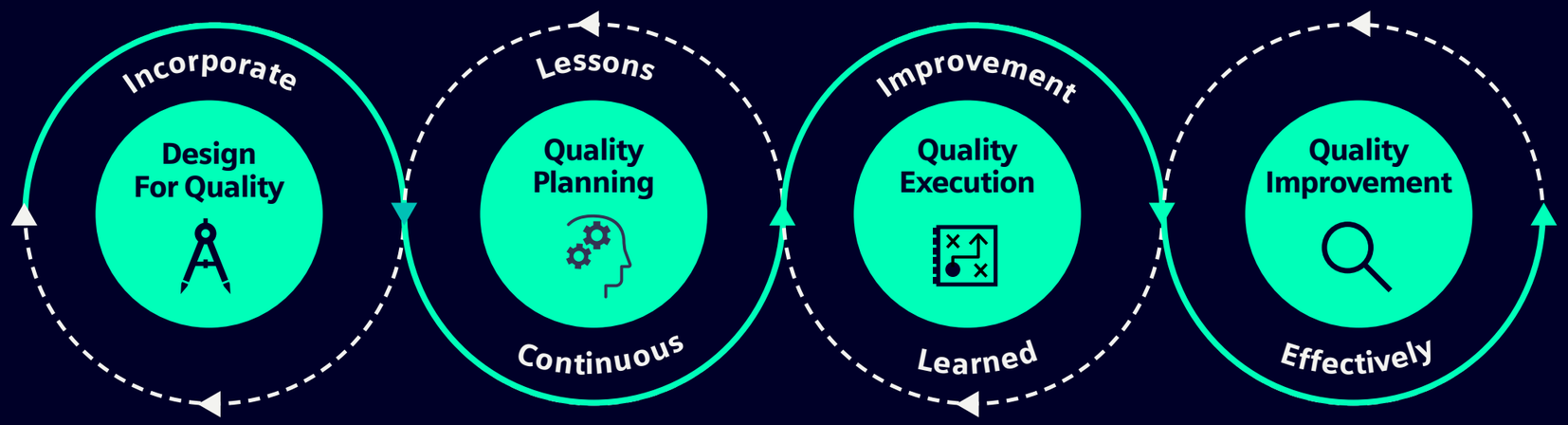
The smart manufacturing environment exponentially changes the power of data

Smart manufacturing provides end-to-end connectivity, so all plant, process, product and design data (customer requirements, original technical specifications, design definitions, production schedules, analysis results, sourcing plans, and quality inspections) are included and tied to critical processes and tasks from requirements to final delivered chip. Which makes it far easier to trace defects, provide verification, resolve issues, leverage analytics, and to replicate proven learnings to drive continuous improvement.

A smart manufacturing environment provides a whole new level of real-time data intelligence, reporting and analytics, with proven industry KPIs, which equips you to manage and execute advanced semiconductor fabrication runs with efficiency and confidence.

"Smart manufacturing is more comprehensively digital, allowing greater and more reliable information flows."[1]

Julie Fraser, Principal, Iyno Advisors Inc.



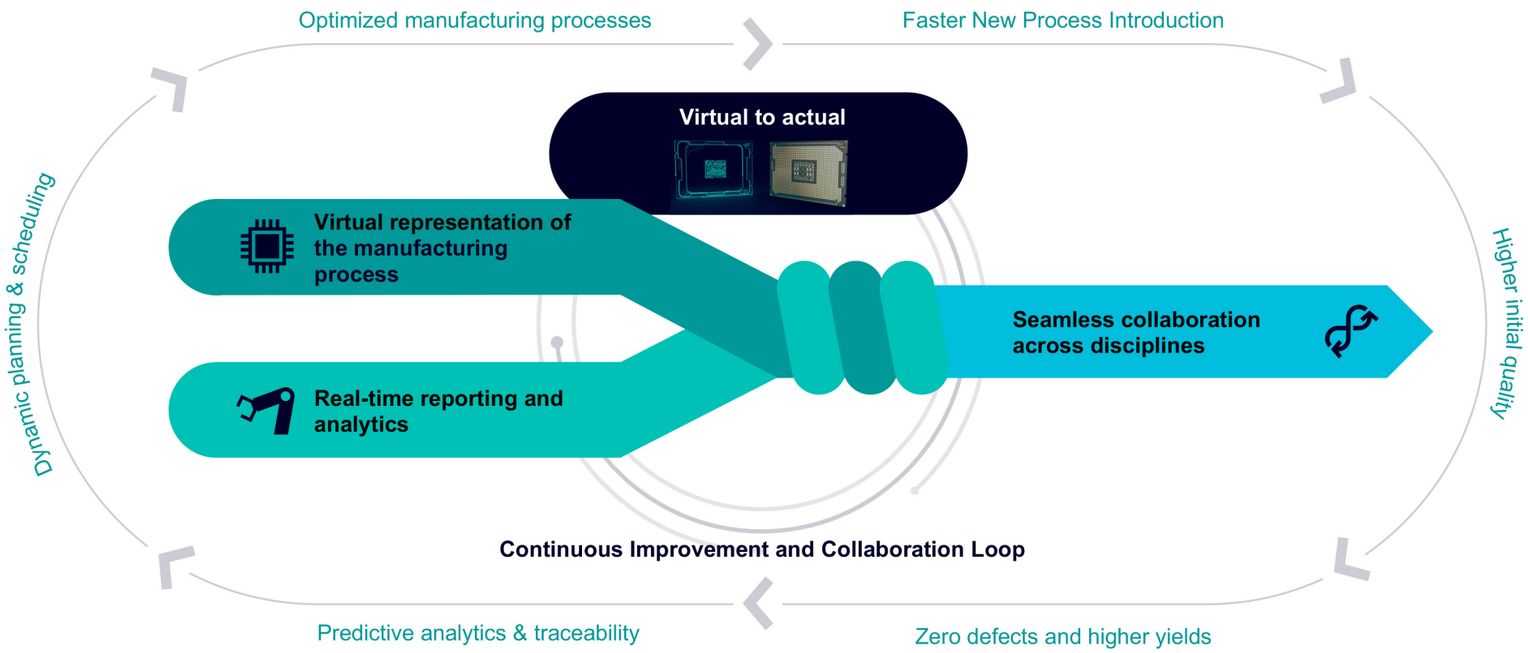
Real-time reporting, analytics and continuous learning make semiconductor manufacturing smarter

- **Smart manufacturing focuses on real-time data.** Smart manufacturing collects and leverages real-time production data to continuously optimize current production for the highest level of initial quality.
- **Smart manufacturing is proactive.** Unlike lean manufacturing that focuses on past data, smart manufacturing uses advanced software solutions and analytics to transform real-time production data into actionable insights to improve current and future performance.
- **Smart manufacturing provides real-time structured reports and analytics**, so you gain the benefit of continuous learning and quality improvement to execute advanced semiconductor fabrication runs with next-gen efficiency.
- **Smart manufacturing updates simulation models in real-time**, so that digital twins and the insights gained from them are always focused on improving current and future manufacturing execution.

Our smart manufacturing solution provides a single source of truth which continuously updates all plant, process, product and design data for seamless collaboration across disciplines. It equips you to plan, execute and optimize your semiconductor enterprise to stay ahead of disruptions so they do not occur, improve NPIs, reduce costs and drive innovation for a traceable, secure, and high yield manufacturing operation.

By leveraging digital twins, you can shift left to predict production issues earlier and to become prescriptive with performance insights about how and where to make operational adjustments to your manufacturing execution system (MES), adopt AI, and become fully preventive to mitigate risk, and build first-time right products.

The critical interaction of real-time data, reporting and analytics in the smart manufacturing model



As the diagram outlines, digital twins are designed for a two-way flow of critical information.

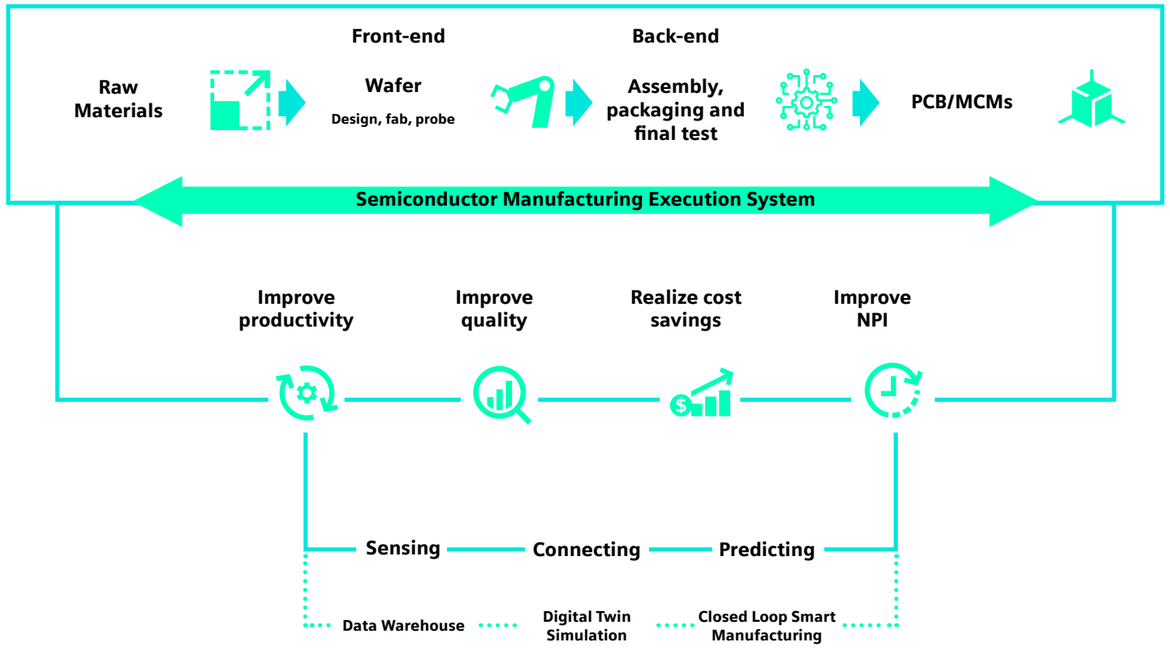
The Inflow. The first flow occurs in the Virtual Representation of the Manufacturing Process when object sensors provide data to the system processor from production systems, plants, machines and processes. This Information flows into the digital twin from actual MES results, including maintenance, testing, and scheduling to 1), create a highly accurate Virtual Representation of the actual Manufacturing Process and operating conditions, and 2), to keep it continuously updated.

With end-to-end connectivity among systems, real-time data is continuously collected directly from the MES to inform semiconductor specific dashboards, including unique semiconductor specific Manufacturing Bill of Process/Bill of Information modules.

The MES for semiconductor manufacturing can leverage a digital twin of production to capture performance data in real-time, including statistical process control (SPC) and any deviations from manufacturing execution, maintenance, testing, and scheduling. Operational data is continuously updated and used to drive quality improvements in the manufacturing process.

The Outflow. The second flow occurs, going the other way, when reports created by and analyzed by the digital twin share insights to suggest where actual performance improvements could be made. This action closes the loop with real-time production data from your MES operating system that creates a multiplier effect with a new level of ability to prescribe adjustments to increase production performance through seamless collaboration across disciplines and domains.

Smart manufacturing connects MES data and the power of digital twins to go from reactive to predictive



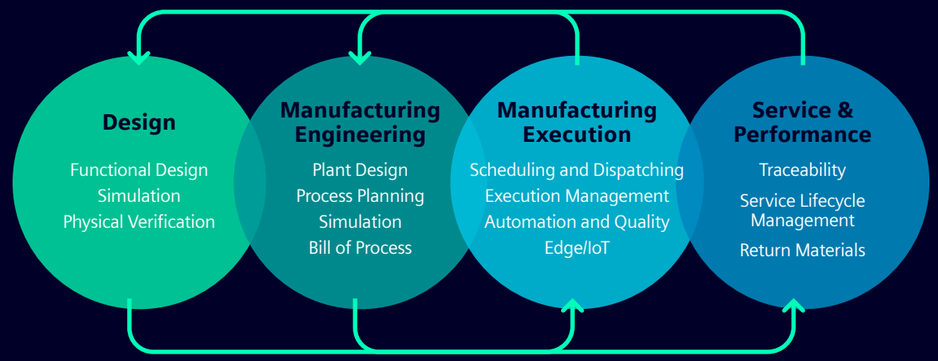
Many traditional IC foundries are reactive, relying on post-incident analysis and corrective steps that often lead to production delays. But the adoption of smart manufacturing, with the digital twin providing accurate simulation of actual production, continuously updated with real-time production data directly from the manufacturing execution system (MES), brings a digital transformation.

Proactive quality management and predictive methodologies

Shifting from the slow pace of reactive problem-solving to the rapid pace of continuous learning, smart manufacturing brings proactive quality management and predictive methodologies to prevent defects for a higher level of semiconductor quality and higher yields.

With the end-to-end connectivity of smart manufacturing, the MES informs semiconductor specific dashboards, including unique semiconductor specific Manufacturing Bill of Process/Bill of Information modules. As outlined in the diagram above, the MES can leverage a digital twin of production to capture performance data in real-time, which is then used to drive improvements in manufacturing quality.

Siemens Digital Enterprise
Enabled by the Digital Twin



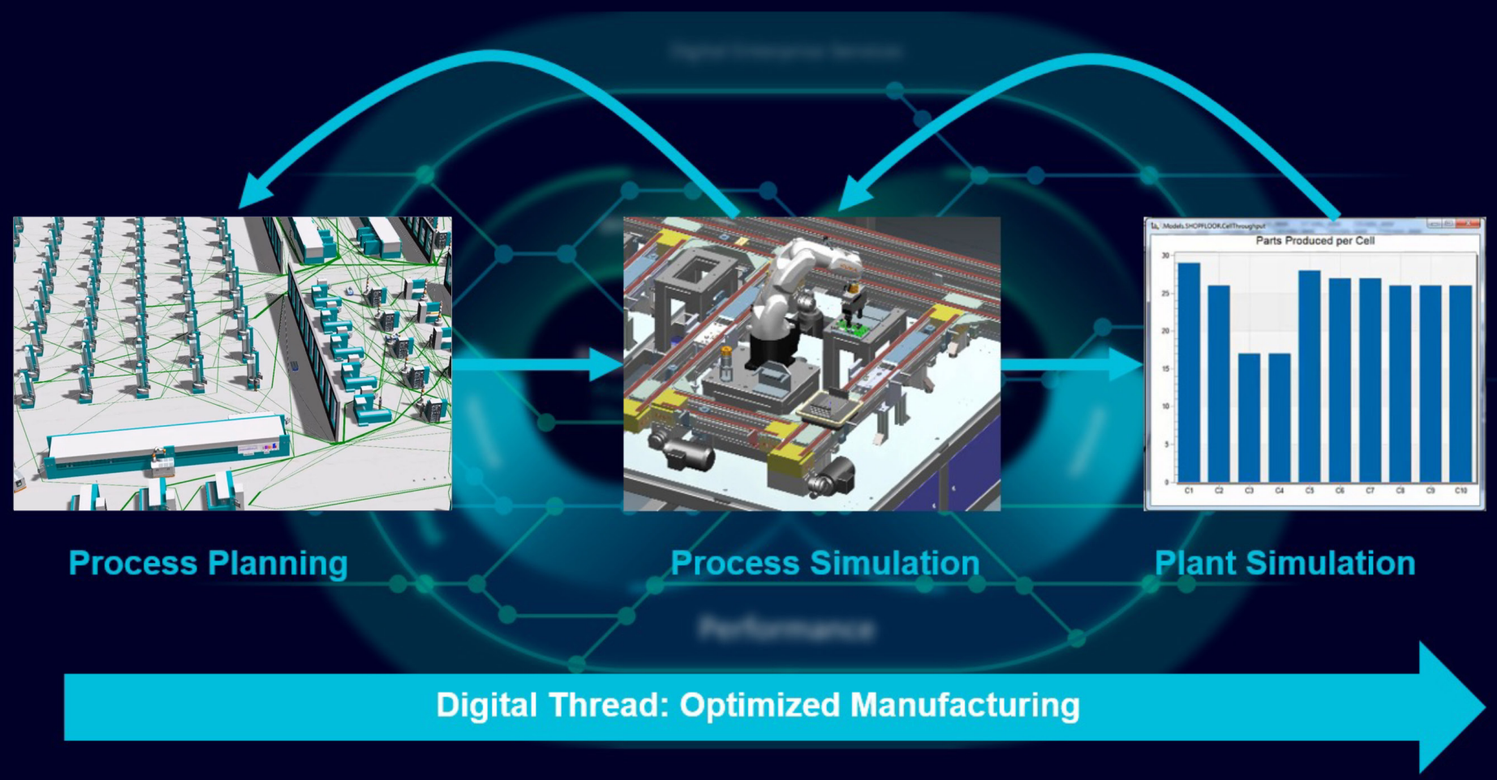
The digital twin takes simulation to the highest level

Continually updated with MES data, a digital twin can study more issues from more vantage points than standard simulations, with greater ultimate potential to improve products and processes. The digital twin provides a highly accurate virtual model that simulates the real-world manufacturing process prior to designing actual manufacturing operations or building a semiconductor product. Connected to the information flows of smart manufacturing, digital twins are always ready to analyze and identify production improvement opportunities.

Real-time data analysis drives continuous learning and quality improvement in semiconductor manufacturing

Smart manufacturing offers management the many benefits of visibility across systems and disciplines, combined with integrated reporting and analytics, including:

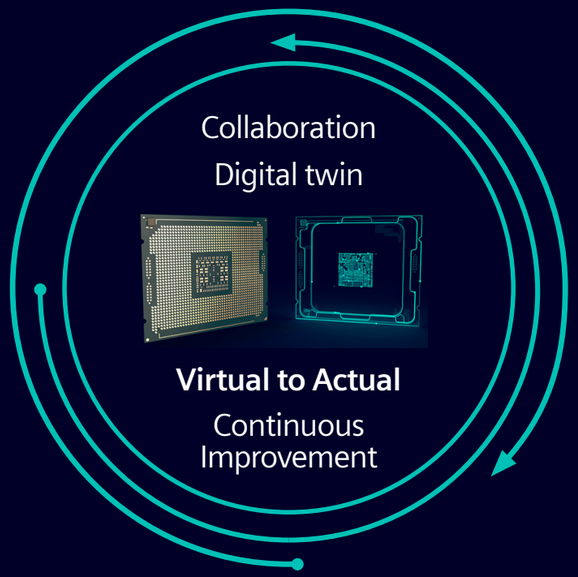
- Use of real-time data to maintain and leverage engineering simulation models to evaluate changes driven by technology or product updates
- Directing process data to run a self-contained digital twin model on the industrial IoT platform for modeling continuous improvement
- Eliminating disruption from changes in product runs – delivering a batch of one with the same efficiency and quality as a batch of 1000
- Integrating regulatory and quality requirements along with synchronized production processes for greater process flexibility and efficiency and optimal supply chain management
- Shifting left to rapidly identify and predict production and quality issues, even before they occur, which increases productivity and reduces cost downstream
- Leveraging advanced analytics that turn high volumes of data into actionable insights
- Accessing cloud and edge analytics to support predictive maintenance



Address factory and line planning needs virtually before implementing actually

Our solution links physical production, operational processes, and facility management with digital technologies to address factory needs. It includes process simulation with line design to increase efficiency and throughput through better designed and optimized lines and cells. Through critical decision-making capabilities such as "what-if" analyses, your team can study multiple production scenarios, check task feasibility and production time, and access robust, out-of-the-box semiconductor solutions based on industry best practices to optimize processes and results.

Why close the loop with real-time data reporting?



A key overall objective in smart manufacturing is to increase efficiency and productivity by exploiting data analytics for continuous process optimizations in production and along the entire value stream.

By creating a complete loop of smart manufacturing information in the fab, semiconductor manufacturers can provide predictive, actionable insights through a constant two-way flow of information, with the benefit of continuous learning and quality improvement, which is a key to consistently producing high-quality products.

Make business, engineering and manufacturing decisions faster to get to market faster

With access to real-time manufacturing data, reporting and analytics, you gain next-gen capabilities:

- Ensuring manufacturing can execute advanced semiconductor fabrication runs efficiently
- Minimizing respins and scrap to improve initial quality
- Leveraging virtual designs, simulations and model-based process definitions to drive innovative designs

The closed loop approach also provides greater process flexibility and efficiency, with complete integration of regulatory and quality requirements along with synchronized production processes for optimal supply chain management that looks ahead to identify issues and ways to mitigate them.

A smart manufacturing environment also offers the advantage of cloud and edge analytics to support predictive maintenance. By using smart manufacturing technologies to monitor equipment health and perform predictive maintenance, fabs can significantly reduce unplanned maintenance downtime.

Operate agile lines and collect real-time data at optimal efficiency

Use data to maintain and leverage engineering simulation models from PLAN to evaluate changes driven by technology or product updates.

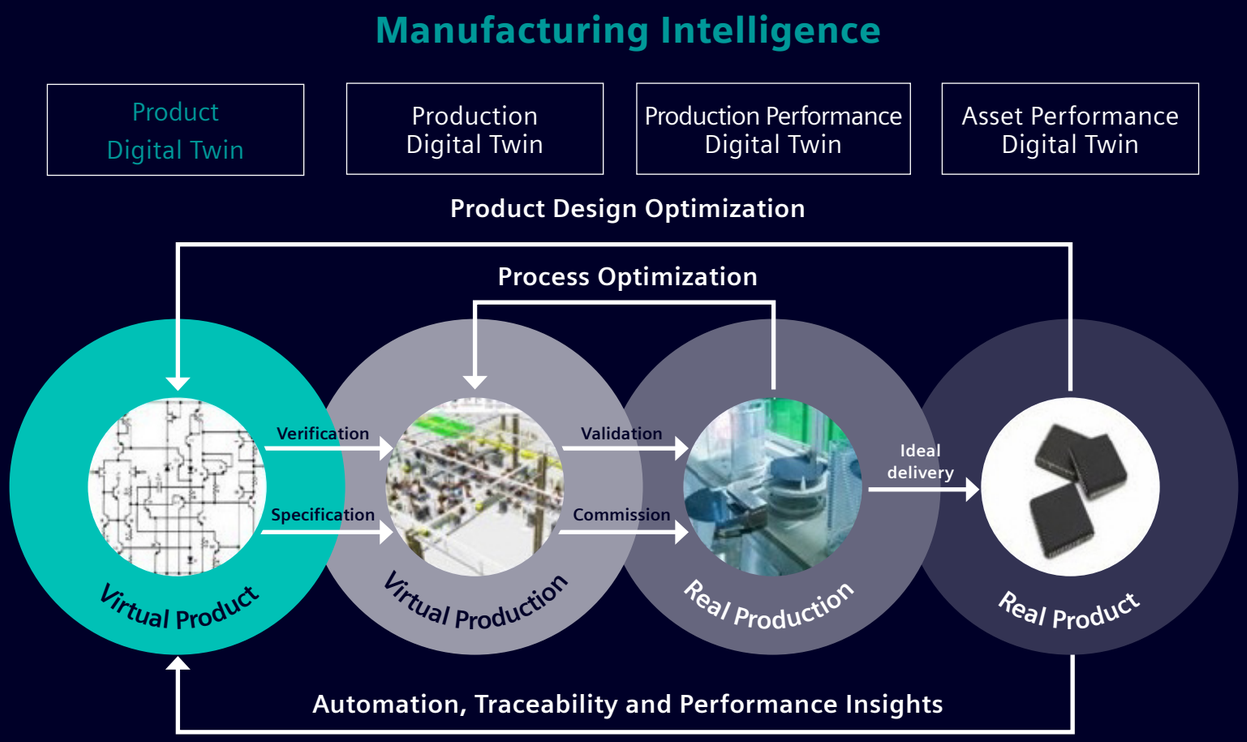
Direct process data to run a self-contained digital twin model on the industrial IoT platform for modeling continuous improvement.

Eliminate disruption from changes in product runs to deliver a batch of one with the same efficiency and quality as a batch of 1000.

Rapidy identify and predict production and quality issues, even before the occur.

Take advantage of advanced analytics that turn high volumes of data into actionable insight.

Real-time reporting makes simulation smarter and more effective



> Digital twins can be of product, production, or performance. Particularly the production and performance elements are key to enabling Smart manufacturing. Ideally these digital twins feed each other for insights and continuous improvement."[2]
>
> *Julie Fraser, Principal, Iyno Advisors Inc.*

By continuously collecting data from real-life manufacturing plants and processes, and feeding that information into collaborative digital twins, manufacturing simulations can be continuously improved, resulting in more efficient manufacturing processes. The virtual model will dynamically inform and optimize the production environment for both detective (monitoring), and predictive (AI) functions.

Simulation with digital twins enables you to continuously perform multiple "what-if" scenarios and analysis from current model updates, with real-time reporting and analytics for exacting accuracy, which can be evaluated virtually at lower cost, without disrupting your actual production. It also provides many opportunities for conducting "what-if" analyses for Research and Development, studying multiple production scenarios, checking task feasibility and production time, capturing and replicating your best practices, and exploring optimization insights.

By leveraging digital twins, you can predict production issues early to become prescriptive with performance insights about how and where to make operational adjustments to your MES, adopt AI, and become fully preventive to mitigate risk, and build first-time right products.

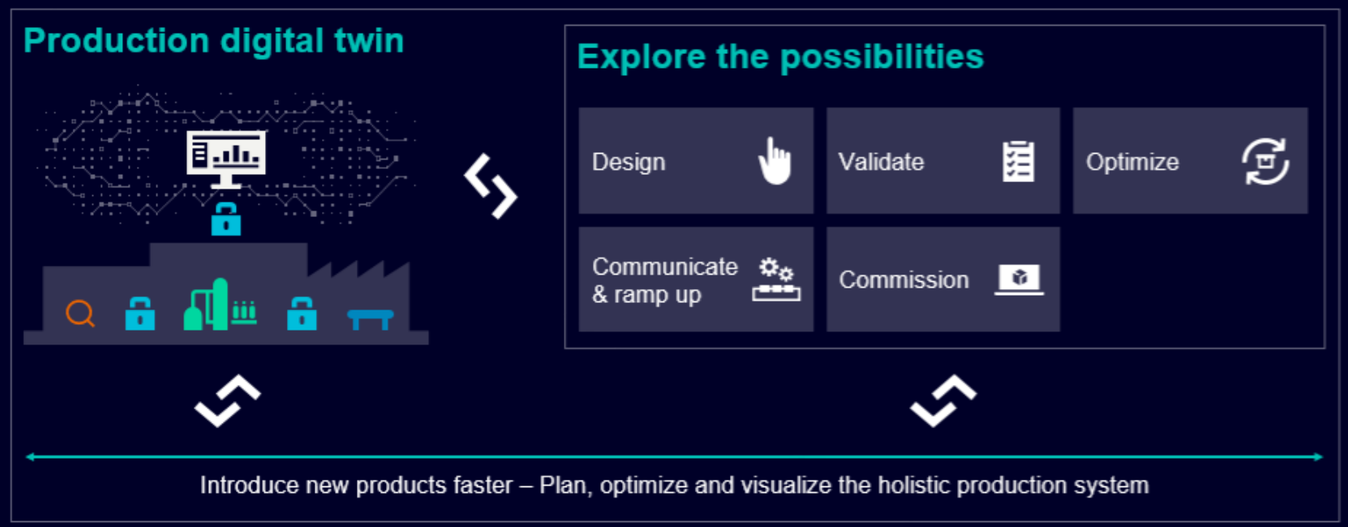
With digital twins, you can feed real-time manufacturing data back into virtual models to:

- Evaluate and optimize manufacturing plant and process layouts
- Explore multiple production scenarios for the best outcomes for time, cost, throughput and quality
- Make forecasting scenarios to ensure capacity for near and long-term orders
- Accurately simulate human interaction with processes and technologies
- Optimize talent, worker allocations, ergonomic environments, productivity, and sustainability
- Capture and replicate your best practices to set a higher quality level than before

"Digital twin models enable you to load forecast data to ensure capacity for near- and long-term orders and to make capital expenditure decisions using historical and forecasted data."[3]

Fram Akiki, President, Joun Technologies

Optimize factory space and maximize capital resource utilization
Validate before building anything



How digital twins enhance manufacturing planning and execution

How can you reduce the cost and risk of issues in the fab to compete in global markets? Digital twins equip you to plan, simulate and optimize manufacturing plants, lines and processes to reach the best operating production scenario, improve quality, ensure manufacturability and flawless replication of your best practices, and more:

- Simulate new production conditions to make reliable changes faster
- Maximize efficiency by eliminating bottlenecks and streamlining production
- Optimize manual and automated processes on the same line to reduce waiting times
- Adapt existing resources to build more products with shorter lead times
- Reduce waste and overhead costs more efficiently
- Measure more data points, such as energy consumption and output, and other sustainability KPIs

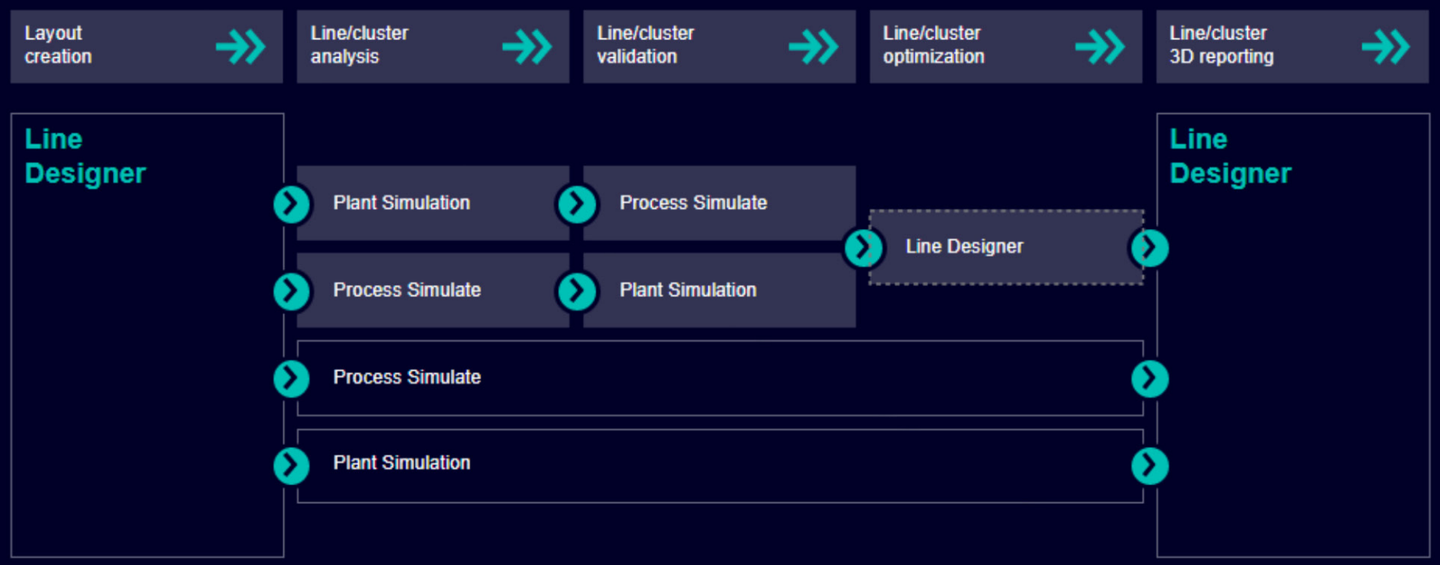
Using digital twins in concert with smart manufacturing equips you to streamline process planning workflows and validate the best plans for making products.

Some of the key digital capabilities include:

- Conduct line planning and material flow analysis to quickly design, visualize in 3D and optimize complete facility and factory layouts
- Perform capacity and “what-if” analysis for the best production scenarios
- Conduct process planning of Design for Manufacturing (DFM), workplace ergonomics and human-centered design, robotics, and planning for automation
- Conduct virtual operations for line balancing, robotic and automated process feasibility and validation
- Validate and virtually commission production lines with the digital twin
- Rapidly pivot to new production when needed

With the right mix of simulation capabilities, you can optimize factory space and maximize your capital resource utilization. You can introduce new equipment faster – by planning, optimizing and visualizing the way the production systems will operate. By using digital twins to analyze the efficiency of production lines, companies can increase throughput, reduce waste, improve quality, and enhance safety and sustainability.

How the cluster and line planning process works



The human factor

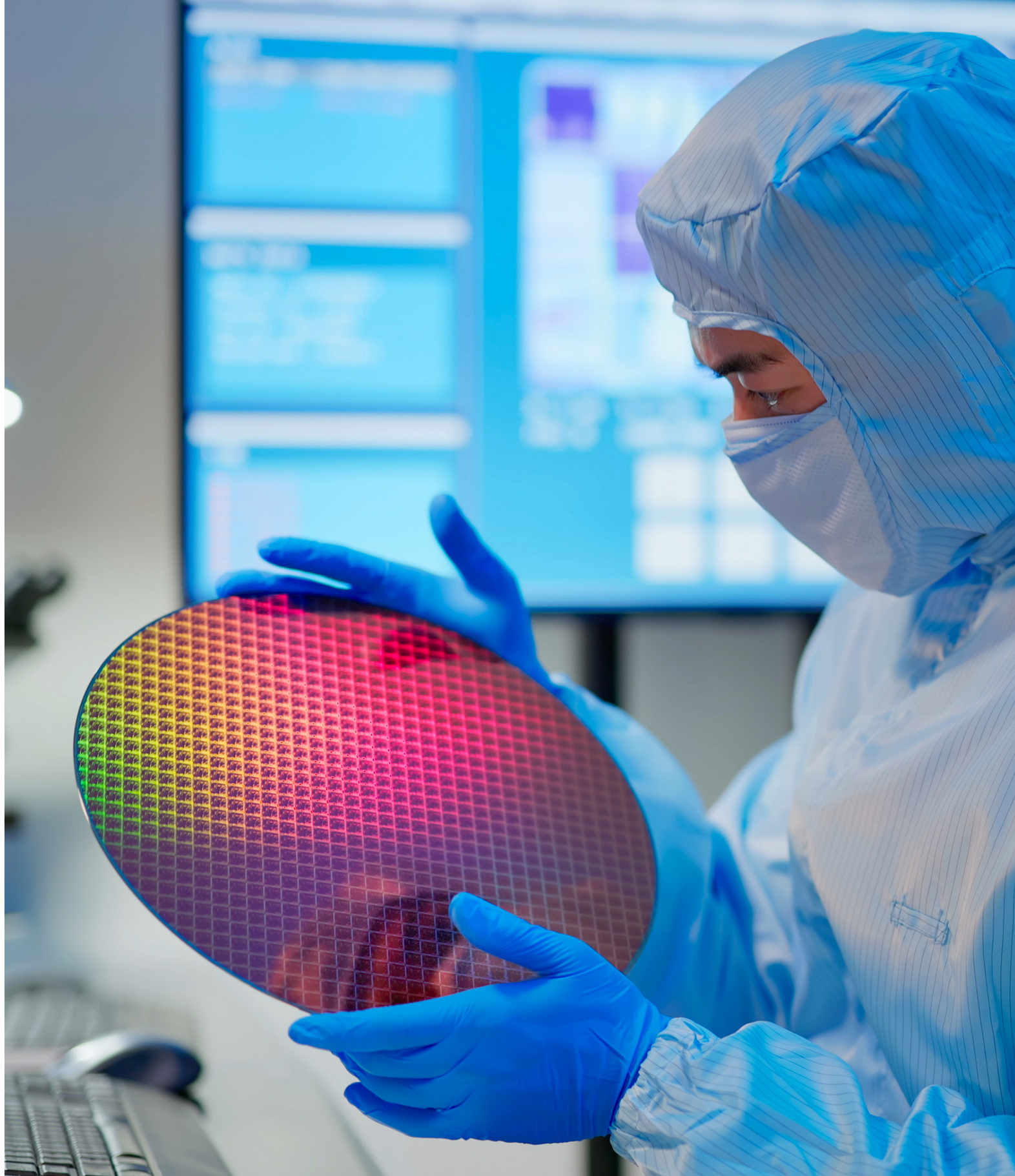
For a truly holistic solution, your digital twin can also be used to simulate human interaction with processes and technologies to optimize talent, worker allocations, ergonomic environments, productivity, and sustainability to ensure continuous business growth. Since a typical large foundry requires several thousand workers with skills in production engineering, production operations, logistics, and support functions, talent optimization is both useful and essential. Design ergonomically valid manual operations, ensure better working conditions for people on the shop floor, while optimizing automated and manual operations, including robotic assistance, for higher efficiency.

How to optimize a Fab selection for NPI with our digital solution:

Challenge: You're introducing a new high-performance semiconductor product, and need to decide which fab to manufacture it in: Fab 1 with line A featuring a tester from vendor A, or Fab 4 with line C featuring a tester from vendor Z. Both fabs have existing capacity, but differ in equipment, layout, and potential process adjustments for the new product.

Solution: Utilize our efficient digital plant and line design, simulation and planning tools to make a data-driven decision

- Chipmakers using conventional tools spend a considerable amount of time (some report up to 75 or 80%) trying to find or exchange data, doing rework to make the data compatible with their current tools or losing time from redundant work done by different teams
- Our integrated solution streamlines the process and promotes data reuse to save time and money. It supports line optimization in remodeling today's layouts and updating line planning quickly. Additional benefits include:
  - Reduced time required to collaborate with other engineering disciplines
  - Increased accuracy by sharing information
  - Eliminated redundant or unnecessary work
  - Reduced cost through the reuse of information



Step-by-step process

1. Plant and Line Design:

- Model both Fab 1 and Fab 4 layouts: Import CAD models or existing layout data to create 3D virtual representations of each fab and its relevant lines (A and C)
- Integrate equipment specifications: Include detailed specifications of both testers (vendor A and vendor Z) within the virtual models, accounting for footprint, power requirements, and process capabilities
- Simulate product flow: Run simulations to visualize and analyze the flow of wafers through each line, considering potential bottlenecks and resource utilization

2. Process Simulate:

- Develop process models: Create digital twins of the manufacturing processes for the new product, accounting for specific requirements and potential adjustments for each tester (A and Z)
- Simulate process variations: Analyze the impact of different process parameters on yield and quality for both testers, considering their capabilities and limitations
- Identify potential issues: Predict potential yield losses or quality defects associated with each tester and its corresponding process adjustments

3. Planning:

- Create production plans: Develop detailed production plans for each fab, including equipment utilization, material requirements, and labor allocation
- Compare cost and time estimates: Analyze the cost and time implications of each production plan, considering factors like equipment setup, process validation, and potential yield variations
- Generate reports: Generate comprehensive reports summarizing the simulations, analyses, and cost/time estimates for each fab, providing a clear basis for decision-making

Benefits:

- Data-driven decision-making: By using simulation and analysis, you can objectively compare the suitability of each fab for the new product, based on factors like yield, quality, cost, and time to market
- Reduced risk and cost: Identifying potential issues early through simulation can help avoid costly production delays and quality problems
- Improved efficiency: Optimizing production plans for the chosen fab can lead to increased throughput, reduced waste, and improved resource utilization

Additional advantages:

- Factor in existing production schedules and capacity constraints in both fabs
- Consider the availability of skilled personnel trained for each specific tester and process
- Evaluate the potential impact of the new product on other ongoing production runs in each fab

By simulating and analyzing different scenarios, you can gain valuable insights and make data-driven choices that optimize your production process and maximize your NPI return on investment.

Capture real-time insights to make your decision-making more effective

Competing at the speed of business today demands the right information at the right place at the right time in the right semiconductor context. With smart manufacturing linking every design, planning and production discipline, you gain the real-time reporting and analytics needed for faster decisions.

With the power of digital twins, informed by closed loop feedback for continuous learning and improvement, you can predict production issues early to become prescriptive with performance insights about how and where to make operational adjustments to your MES, adopt AI, and become fully preventive to mitigate risk, and build first-time right semiconductor devices.

Imagine the transformation:

- Unleash the power of real-time data. With a holistic view of your entire operation, from design to production, make informed decisions based on real-time insights. Catch quality issues early, and ensure flawless product consistency
- Seamlessly collaborate across all disciplines with a robust data management and workflow platform
- Prevent downtime with predictive maintenance capabilities. Analyze sensor data from your equipment. Anticipate potential problems and schedule maintenance before they disrupt production flows
- Extend your virtual design and planning reach into manufacturing execution, engage both quality management and your supply chain
- Leverage rich performance insights to continually feed reporting and analytics back upstream into your engineering improvement decision-makers
- Differentiate your semiconductor enterprise by offering unique value propositions to stay ahead

We understand that successful smart manufacturing requires a holistic approach. It's not just about technology. That's why we offer expert consulting services to guide you through every step of the transformation, from initial planning to implementation and ongoing optimization.

At Siemens, our mission is to ensure that you have a successful business outcome from your smart manufacturing investment as part of the Siemens Xcelerator portfolio.

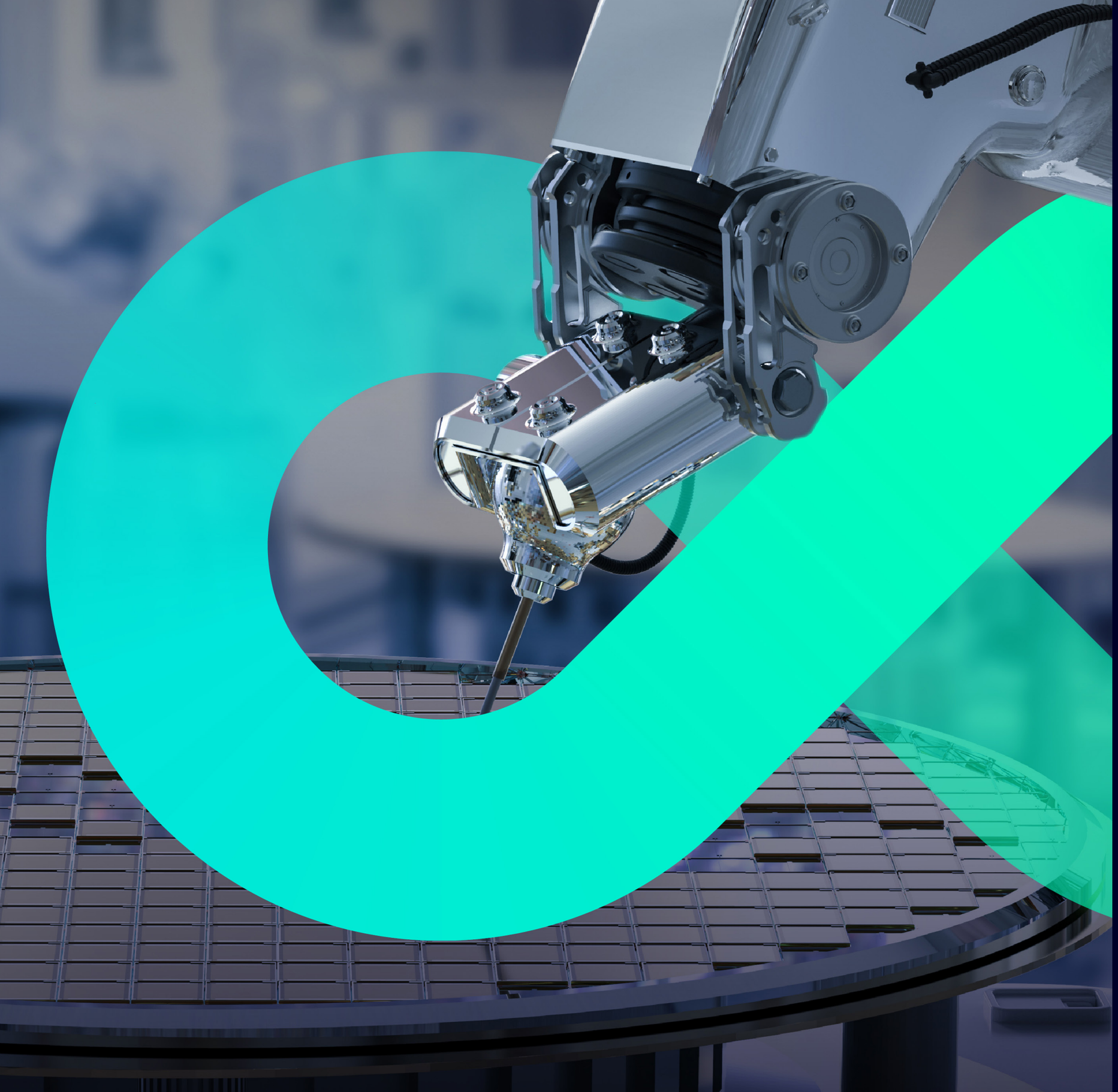
Remember, the future of semiconductor manufacturing is smart. By partnering with Siemens, you can unlock unprecedented efficiency, achieve operational excellence, and sharpen your competitive edge in this ever-evolving industry.

Take the next step. Accelerate your future.

It’s time to leverage the power of real-time reporting and analytics for smarter manufacturing decisions. And smart manufacturing results.

When you’re ready to discover more, we’re ready to show you the next step.

Learn more



References:

1. Siemens Digital Industries Software "Smart manufacturing for semiconductor" White Paper, page 3, Iyno Advisors Inc., Julie Fraser, Principal, 2020
2. Siemens Digital Industries Software "Smart manufacturing for semiconductor" White Paper, page 8, Iyno Advisors Inc., Julie Fraser, Principal, 2020
3. Siemens Digital Industries Software "Digital transformation for smart semiconductor manufacturing" eBook, page 11, Fram Akiki, President, Joun Technologies

About Siemens Digital Industries Software

Siemens Digital Industries Software helps organizations of all sizes digitally transform using software, hardware, and services from the Siemens Xcelerator business platform. Siemens' software and the comprehensive digital twin enable companies to optimize their design, engineering, and manufacturing processes to turn today's ideas into the sustainable products of the future. From chips to entire systems, from product to process, across all industries.

Siemens Digital Industries Software.
Technology to transform the everyday.

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