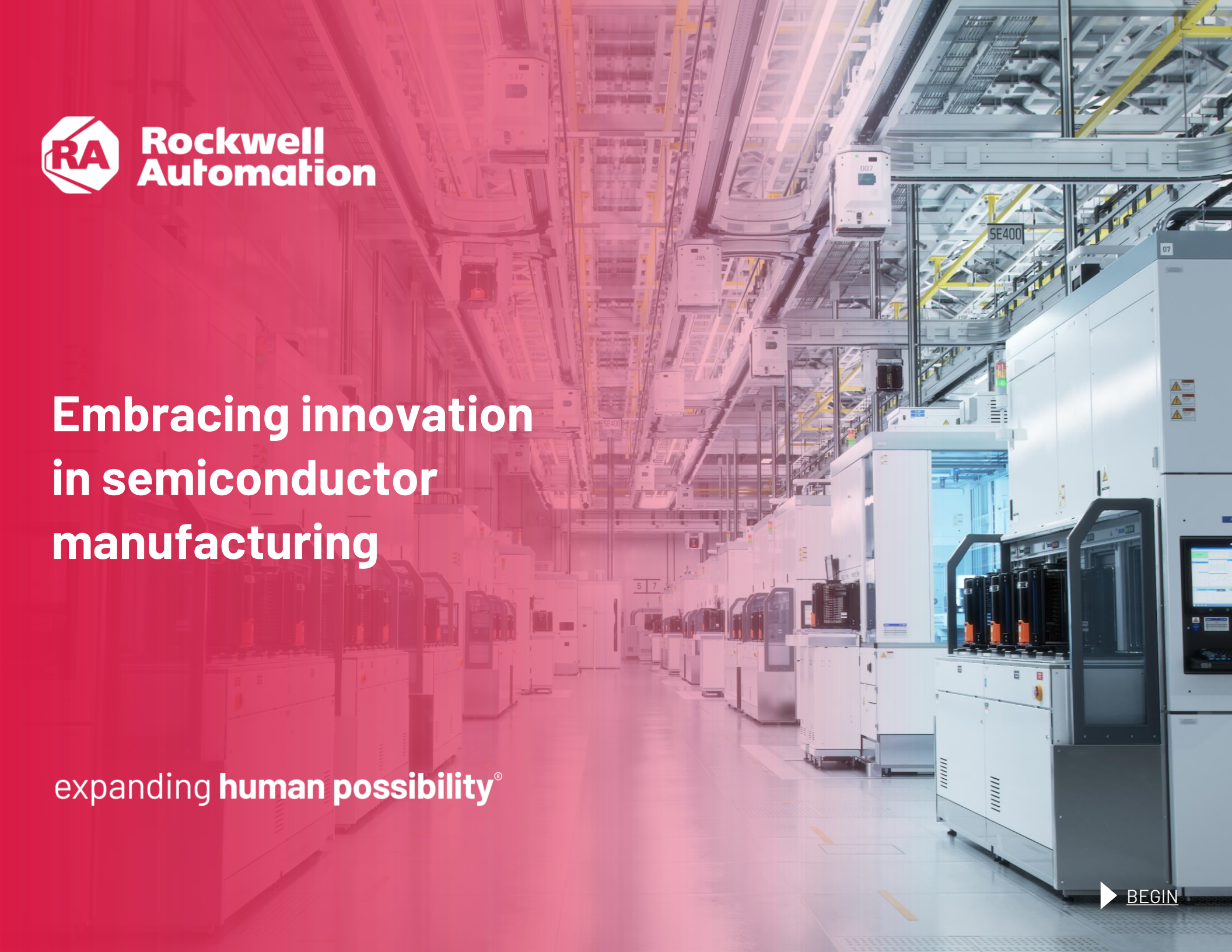
Rockwell Automation

Embracing innovation in semiconductor manufacturing

expanding **human possibility**®

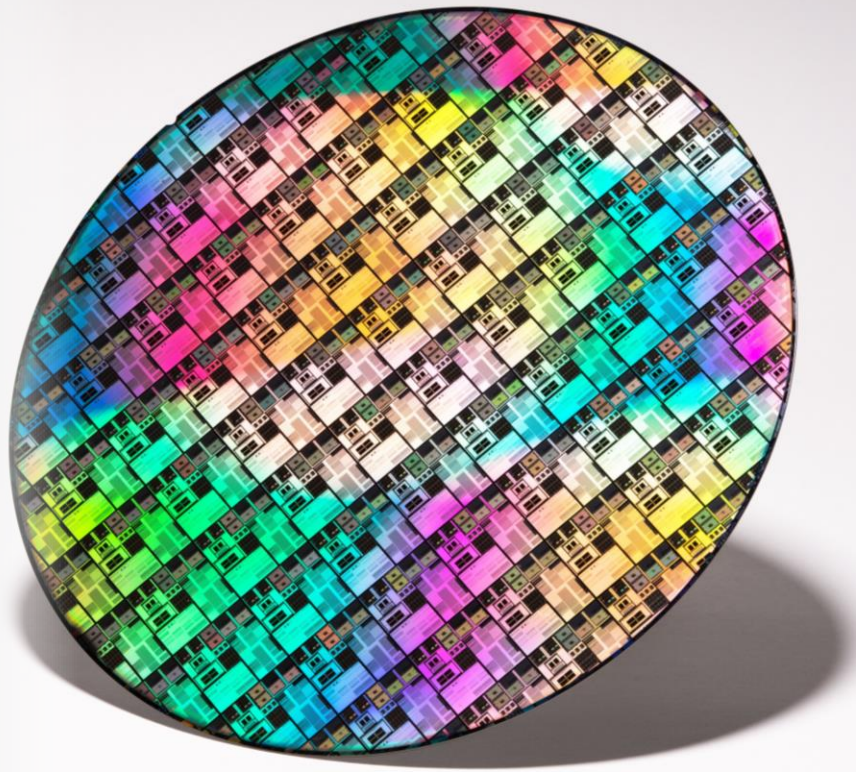


BEGIN

Digital transformation is accelerating, and demand for semiconductors is rising

As technology continues to reshape the world, the semiconductor industry is evolving. In the past, the growth of the semiconductor industry was closely tied to consumer electronics like PCs and mobile phones. This resulted in boom-and-bust cycles of demand as smaller, cheaper components powered more and more advanced computing machines. While the computing and semiconductor industries remain linked, digital transformation is accelerating across every industry, unlocking a new era of sustained—rather than cyclical—growth.

Advanced technologies like the Internet of Things (IoT) and artificial intelligence (AI) are leading to continual innovation in industries as diverse as automotive, healthcare and finance—which impacts the way these technologies evolve. Demand for semiconductors will become more sustained as a result of these broader trends, leading to more stable growth. Organizations that can innovate today will be well-positioned to reap these benefits in the years to come.



The global semiconductor industry is projected to become a trillion-dollar industry by 2030[1]

1. "The semiconductor decade: A trillion-dollar industry." McKinsey, 2022.

Forces shaping the future of the semiconductor industry

Staying one step ahead in this evolving industry requires keeping an eye on the future. The industry is on pace to change dramatically in the next five to ten years as digital transformation occurs. There are many forces shaping the future of the semiconductor industry, including the push for sustainability, the expansion of the internet, and increased government involvement.

Semiconductor materials will evolve as the world strives for a more sustainable future

While silicon chips will continue to be the standard for semiconductors, we can expect **new materials innovations** in the future. Gallium nitride and silicon carbide semiconductors have already gained traction thanks to their use in battery electric vehicles and solar panels. Growth in these types of chips— power compound semiconductors—is expected to accelerate to close to 60% in 2024.[1]

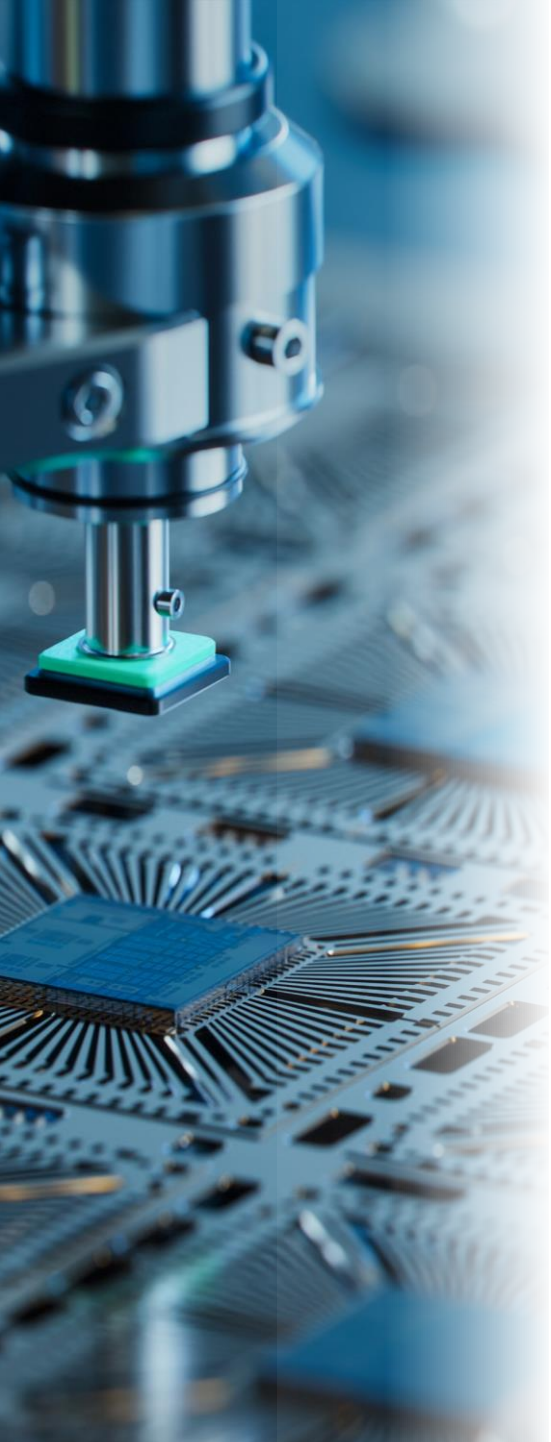
As the Internet of Everything expands, applications will demand higher volumes of data and higher communication performance

The proliferation of the internet is only going to accelerate, with the rate of communication traffic expected to nearly double each year through 2030.[2] **Semiconductor chip technology must advance** to meet the IoT device requirements needed to communicate with the internet and deliver information to the cloud and within the cloud.

Government support will boost regionalized investment to create a more resilient supply chain

As demand increases, organizations around the world will continue to invest in global semiconductor manufacturing—**strengthening supply chain resilience**. The US CHIPS Act has already incentivized companies to invest over $200B USD in dozens of new US-based semiconductor ecosystem projects,[3] and the EU is currently planning their own European Chips Act.[4] Mainland China, India, Japan, South Korea and Taiwan have also adopted similar policies.[5] Economic incentives such as these will likely lay the groundwork for sustained innovation in the future.

1. "Supercharged semiconductors: Chips made of newer materials surge ahead..." Deloitte, 2022.
2. The International Roadmap for Devices and Systems: 2022 Edition Executive Summary. IEEE, 2022. p. 16.
3. "2023 State of the U.S. Semiconductor Industry." Semiconductor Industry Association, 2023.
4. "Global semiconductor industry outlook for 2023." KPMG, 2023.
5. "Why semiconductors could be the comeback kings of 2023." J.P.Morgan, 2023.



As demand grows, so will the operational challenges

Increased demand will give rise to new operational challenges and exacerbate perennial ones. To position semiconductor fabrication plants ("fabs") for future success, it's important to have a strategy in place to tackle potential obstacles such as:

Meeting production KPI targets

Increased demand can result in fabs struggling to keep up with key performance indicators (KPIs) around cycle times, throughput, and yield—ultimately leading to decreased profitability.

Enabling IT/OT convergence

IT and OT systems have always been separated, leading to a fractured view of operational data. This problem only gets worse as organizations adopt new technologies that don't integrate with legacy systems. Disparate systems and a lack of connection results in siloed data, hindering visibility and future process improvements.

Mitigating threats to IP and operations

As semiconductor fabs have grown increasingly complex, the cyberattack surface has expanded, creating vulnerabilities across production operations. These gaps can leave critical technology IP and production operations exposed, which could result in catastrophic financial loss.

Navigating workforce and skills shortages

Manufacturers may not always find the skillsets needed to successfully open fabs and foundries, leading to delayed opening timelines. And when fabs do open, a lack of skilled workers needed to staff new fabs could lead to costly delays to wafer starts.

Developing more sustainable practices

Semiconductor manufacturing is a highly resource-intensive and energy-intensive process that generates large amounts of greenhouse gas (GHG) emissions, water consumption, and waste. Without a comprehensive view of operational data, fabs will struggle to put current and future environmental initiatives into practice to reduce emissions and water and energy consumption.

Embrace innovation with a focus on four key business outcomes

Now is the time to re-evaluate your semiconductor manufacturing operations and look for opportunities to innovate. With the right tools and approach, your fabs will be well-equipped to succeed, no matter what the future holds. Making the right investments around four key business outcomes can help you set your fabs apart from the competition:

Maximize yield: Adopt and embrace digital transformation technologies that maximize yield.

Build resilience: Manage risk to help protect technology IP and semiconductor production operations and avoid disruption.

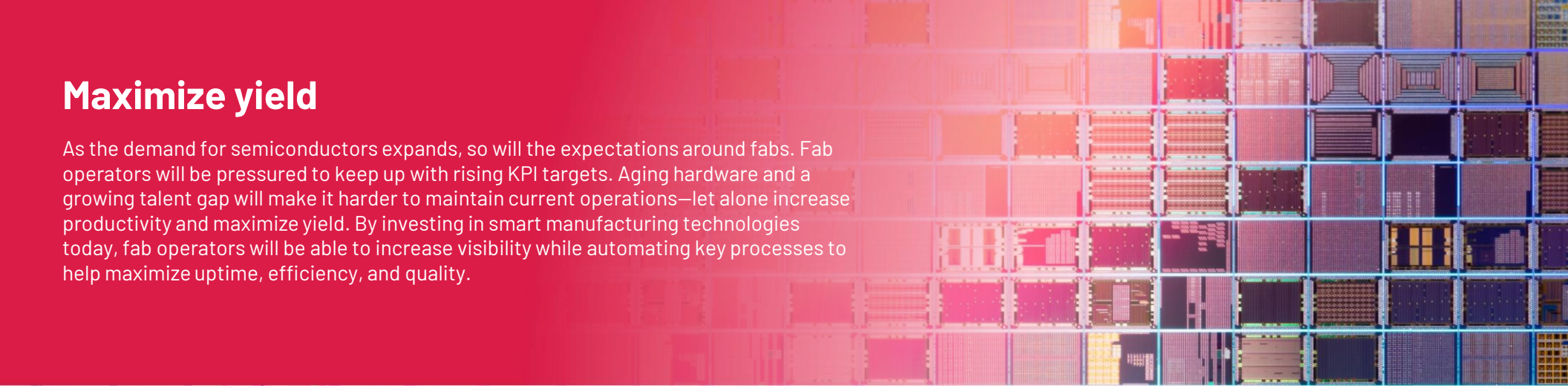
Empower people: Build the next generation of the semiconductor workforce with a comprehensive approach to training and technology.

Drive sustainability: Achieve ESG imperatives and meet high-visibility commitments.

Read on to learn more about the best practices and technologies that can help you optimize fab operations going forward.

Maximize yield

As the demand for semiconductors expands, so will the expectations around fabs. Fab operators will be pressured to keep up with rising KPI targets. Aging hardware and a growing talent gap will make it harder to maintain current operations—let alone increase productivity and maximize yield. By investing in smart manufacturing technologies today, fab operators will be able to increase visibility while automating key processes to help maximize uptime, efficiency, and quality.



Maintain high uptime by eliminating production disruptions and improving scheduling

Semiconductor manufacturing is a complex process with many steps, and outages anywhere in the fab can have a catastrophic effect on yield.

By building on a resilient architecture and monitoring assets through predictive and prescriptive analytics, fab operators will be able to reduce the likelihood of outages and catch issues before they impact uptime.

Smart scheduling systems backed by AI and ML will also help optimize material flows between process tools to ensure the right materials are available where and when they're needed.

Increase efficiency through automation and improved resource management

Modernizing key systems and assets can also help improve operational efficiency and resource management with strategic, modular investments. For example, technologies such as Independent Cart Technology (ICT) can be used to automate wafer handling. ICT provides a more flexible and modular conveyor system to help transfer materials in a more efficient, effective way.

Additionally, AI-based scheduling systems will help optimize workflows to enhance worker productivity and accelerate cycle times. These workers will also benefit from automated reporting and improved displays that make it easy to find critical information and focus on more meaningful operational work.

Finally, for manufacturers building new fabs, smart objects and pre-tested code libraries will make it easier to bring new fabs online quickly and accelerate time to market—all with limited on-site labor.

Enhance product quality by identifying and addressing issues before they impact production

Of course, increasing yield can't come at the expense of quality. Ensuring product quality while increasing production will require fabs to run efficiently and in accordance with standard processes.

Smart technologies like quality management systems and predictive and prescriptive analytics will help keep fabs running and quickly catch production anomalies before they impact yield.

Build resilience

While it's impossible to know what the future holds, managing risk is essential to building operational resilience. For semiconductor manufacturers, risk takes many forms. With increased nationalization and scrutiny on the industry, semiconductor manufacturers face mounting cybersecurity risks and complex supply chain challenges. Additionally, as fabs look for new ways to deal with the growing talent crunch, ensuring effective change management and document control will be critical to keeping fabs running safely and efficiently. The right technologies will help fabs stay ahead of risk without impacting productivity.

Strengthen compliance and adherence to best practices

New government regulations point to security concerns around semiconductor manufacturing, and a growing skills gap will make it difficult to efficiently transfer knowledge and maintain seamless operations.

Smart systems with role-based permissions and interfaces will make it easier to secure operations and help protect sensitive IP. These systems also help enforce adherence to standard processes, maximizing product quality and supporting employee training and skills development.

Ensure fab productivity and uptime through employee safety

Security threats are only one aspect of risk—above all, manufacturers must protect their workers' health and safety. Building redundancy and intelligent controls into operational systems helps fabs run safely and securely while also improving productivity.

And should an incident occur, greater operational visibility enables fab operators to pinpoint root causes with greater precision and mitigate similar issues in the future.

Minimize project risk by consolidating cross-organizational logistics on a single platform

The semiconductor industry has already faced major logistical challenges due to skyrocketing demand during the COVID-19 pandemic. As new regulations establish boundaries along national lines, the situation will only become more complex.

Adopting a centralized digital hub can provide manufacturers with end-to-end logistical visibility across procurement, production, and sales, which will make it easier to plan and communicate across the organization and keep production aligned to demand.

This approach also provides greater visibility over prefabricated greenfield sites to ensure high-quality production with limited on-site labor.

Empower people

As the industry shifts to meet more complex demands, today's skills gap is only going to expand. In fact, by 2030, the semiconductor industry will require more than one million additional skilled workers to meet demand.[1] Not only is it difficult to find new talent to fill openings, but even the most experienced workers often don't have the skills necessary to keep up with changing technology and complex demands.
Building the next generation of the workforce requires a nuanced approach: bridging the skills gap with industry-specific training; giving employees the innovative tools they need to do their jobs at the highest level; and enabling skilled workers to focus their attention on the highest value tasks by automating manual processes.

Bridge the skills gap with training and a focus on education

Skilling should be thought about holistically: It's about providing the current workforce with the world-class training and education programs they need to keep their skills on the cutting edge. Bridging the skills gap also means looking towards the future.

To ensure current and future students can become the skilled engineers and technicians the industry needs, the industry needs to develop academic consortiums. Building ties with universities and academic programs is critical to successfully training the next generation of workers.

Augment capabilities with innovative technology

Empowering the workforce also means giving employees the tools they need to succeed today. Fortunately, innovative technology like augmented and virtual reality make hands-on training easier and more intuitive than ever before. Rather than reading dense documents, employees can engage with immersive, interactive experiences that are tactical and proven to stick.

Augmented reality solutions can also capture experts' knowledge through graphical overlays and video and audio recordings, which can be used to scale knowledge to other employees in an unprecedented way.

Optimize operations

Freeing up time so experts can focus on highest value tasks is critical for every fab. Automating processes can help fab operators reduce the labor intensity of more manual, routine work such as quality control, material handling and transportation. This has a noteworthy side effect: helping improve safety and product quality within those processes.

By digitizing and automating these processes, you can even implement digital twins—digital simulations that provide powerful, data-driven insights—to optimize processes in real time.

By 2030, more than one million additional skilled workers will be needed to meet demand in the semiconductor industry.[1]

1. "The global semiconductor talent shortage." Deloitte, 2022.

GlobalFoundries case study

GlobalFoundries™

ptc

Challenge

GlobalFoundries wanted to improve their manufacturing process, boost productivity and transform their employee training.

Solution

GlobalFoundries partnered with Rockwell Automation and PTC. Together, they deployed AR solutions to improve manufacturing processes, and reduced the burden on workers by digitizing training manuals, implementing remote expert assistance, and constructing digital twins for powering AI engines.

Result

After the revamp, GlobalFoundries saw **a 50% reduction** in training time—including time spent onboarding new technicians, training existing technicians, and capturing expert knowledge from retiring workers.

Partnership Spotlight: Rockwell Automation is empowering the future workforce

Inspiring the next generation

Rockwell is focused on supporting the next generation of the semiconductor workforce and bridging the skills gap, but questions remain. How do we take the existing expertise from fabs and extend it to the next generation—and more broadly, how do we motivate the next generation to join the semiconductor workforce?

We believe the answer lies in creating rich learning experiences that both inspire students to pursue careers in the semiconductor industry and provide a strong foundation for starting in entry-level positions. Working with partners in the industry, we've taken a close look at the next generation to tailor curriculum around what they like and how they learn—including on-site training, e-learning, and virtual classrooms. By equipping educational settings with leading technologies such as augmented reality, virtual reality, and digital twins, we're creating immersive forward-thinking experiences to prepare students for the future of the semiconductor industry.

Rockwell's programs and partnerships

Rockwell is engaged with universities in North America and around the globe to expand and train tomorrow's workforce. Since 1998, our University Partnership Program has enabled us to grow a healthy pipeline for ourselves, our partners, and our customers across manufacturing industries. One example of these efforts is our collaboration with University of Wisconsin-Milwaukee (UWM) to equip the Connected Systems Institute, a state-of-the-art lab facility providing training for the next generation of manufacturers. Working with universities like Arizona State University, Cleveland State University, The State University of New York (SUNY) and Texas A&M, we're helping overcome the skills gap by preparing students through our intensive training and industry-recognized certificate programs.

Rockwell also works with students from non-traditional pathways. Our Academy of Advanced Manufacturing is a joint initiative with ManpowerGroup that provides U.S. military veterans with the skills they need to succeed in advanced manufacturing roles, including those in the semiconductor industry. We're working directly with the workforce of the future to provide them with the connections, experience and skills they need to make an impact in the semiconductor industry of tomorrow.

Drive sustainability

With new environmental regulations bringing increased scrutiny from governments and investors, a fab's success depends on its ability to meet ESG goals while continuing to maximize yield. However, this is often easier said than done. Semiconductor manufacturing is very resource-intensive, requiring large amounts of energy and freshwater withdrawal to operate. Waste-related greenhouse gas (GHG) emissions are an additional concern. And as semiconductor fabs expand and develop new manufacturing methods to maximize yield and meet demand, so do their environmental footprints.

Enabling sustainable semiconductor manufacturing is more than just a social responsibility—it's now mission-critical. By leveraging data from new or existing automation technologies with advanced AI and ML solutions, semiconductor manufacturers can pinpoint opportunities to reduce energy use, optimize water processes and minimize waste-related emissions.

Increase energy efficiency and reduce energy consumption

Overall semiconductor energy use in chip production has doubled every three years since 2010,[1] making reducing energy consumption increasingly urgent.

By automating core processes and leveraging operational energy data, organizations can make data-driven decisions to drive energy savings, lower costs, and meet regulatory requirements.

Applying analytics and AI technology on top of this automation layer enables companies to pinpoint energy inefficiencies and adjust operating parameters in real-time for tighter control.

Conserve and use water more intelligently

Since water and energy consumption are intrinsically connected, water conservation and reuse are essential to enabling sustainable semiconductor manufacturing.

By leveraging existing automation systems to gather data, companies can construct a digital twin of key water processes. This enables organizations to evaluate progress toward current and future water usage targets and implement innovations that reduce water and energy consumption, such as water-cooled chiller systems.

Reduce waste and minimize emissions

Although most chemicals used in semiconductor manufacturing are not harmful to the environment when adequately treated, their production, transport and management require significant energy, producing CO_2 emissions as a result.

A holistic approach is needed to ensure optimal usage of chemicals in both semiconductor facility systems and tools.

Leveraging data from automation technology allows companies to pinpoint opportunities to reduce energy usage and reduce waste by making water purification and treatment systems more energy efficient and sustainable.

1. "The Pulse of the semiconductor industry." Accenture, 2023.

A trusted partner can help you navigate changes in the industry

Preparing for the future of the semiconductor industry means taking action today. Fortunately, it's never been easier to implement new technologies in a smart, intentional way. Scalable, modular technologies can help you manage costs and drive improvements through smaller, incremental investments. Experienced industry partners help you get the most from these investments, meeting you where you are with personalized services to help you meet your unique business goals and needs without having to build out in-house expertise.

At Rockwell Automation, we combine decades of industry experience with a vast partner ecosystem to provide end-to-end solutions that drive real business value—no matter where you are in the world. Whether you're looking to maximize efficiency and yield through control and automation systems or focused on enabling the next generation of smart fabs, we can help you realize your vision.

Prepare for the future of semiconductors with Rockwell Automation

The semiconductor industry is changing rapidly, but the right technologies and partners can help you keep up and take advantage of a new era of innovation. Companies that make smart investments today stand to drive the industry forward by maximizing efficiency and yield, building resilience, empowering people, and driving sustainable operations.

We can support you in a changing industry

Rockwell Automation is here to support you in the evolving semiconductor industry, from modernizing existing assets to maximize yield, to using data and insights to optimize operations and empower people while minimizing risk and downtime.

Learn more by visiting us at our Semiconductor web page.

IT'S TIME TO REIMAGINE WHAT'S POSSIBLE

Connect with us.

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