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Semiconductor Manufacturing:

Think globally, build locally

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Executive Summary

Many high tech companies are racing to build and/or augment onshore semiconductor fabrication plants ("fabs"). With the pandemic-driven chip shortage still top of mind and now-declining demand expected to rebound sharply in coming years, they want to be ready.

But the semiconductor business is complex and challenges that range from addressing talent shortages to navigating the nuances of long-term, strategic planning processes represent considerable hurdles. Four steps can better their chances of clearing these hurdles and ensuring that the changing face of the industry is prepared for whatever the future holds. This report discusses these steps in detail, sharing executive insights and case studies that illuminate both challenges and leading practices.

Evolution of the semiconductor manufacturing landscape

Current investments in new or expanded semiconductor fabs represent a massive bet on the industry's future.

Consider: There are more than 60 (at the time of publication) announced new or expanded facilities across the United States, 11 of which are new or expanded fabs.[1] Each facility represents up to $10 billion in Capex and government support and they target to be online within the next three years.[2] For perspective, the United States' $52 billion commitment represents just a small portion of the almost half a trillion dollars in government funding for new fabs globally.[3] Business and government leaders share an overarching goal: eliminate the risks associated with having most of the world's semiconductor chips produced in very few locations by onshoring and friendshoring these operations. Based on Accenture's recent interviews with a range of industry leaders, companies are highly optimistic about their prospects (see About the Research for details) and expect to be ready for the anticipated rebound in demand for chips in 2024 (See Figure 1).
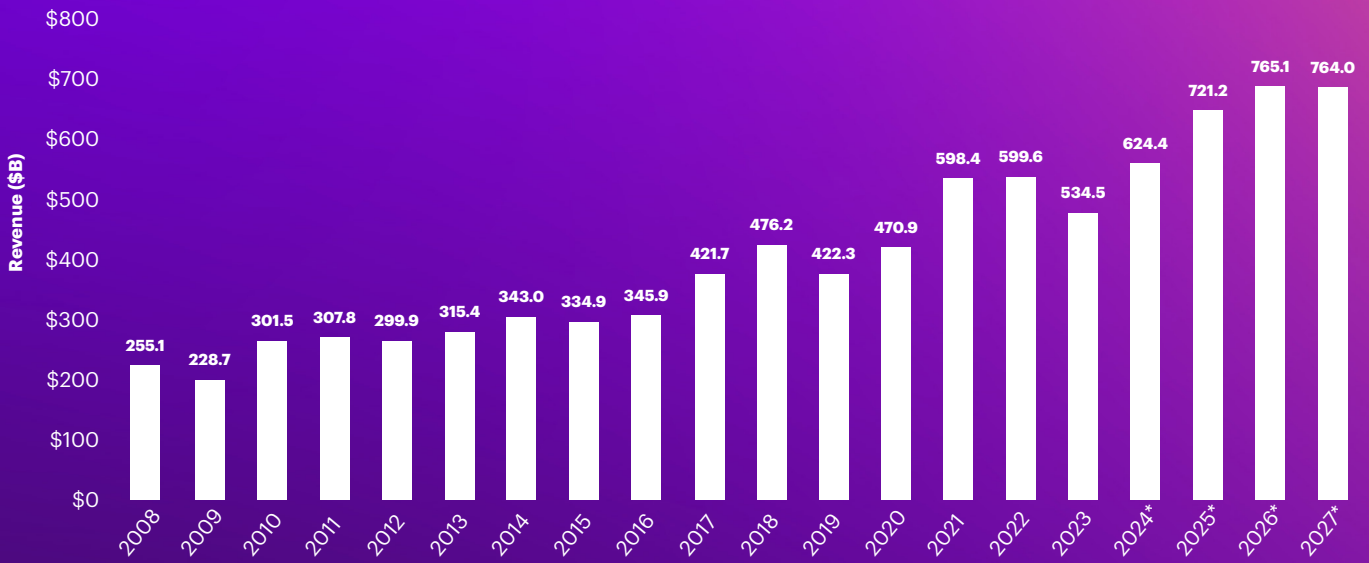
Nonetheless, executives are acutely aware that they face considerable challenges on the path to success. They know they're shouldering an agenda that, for most, means moving well outside their strategic comfort zones. And they know they're trying to accomplish something in short order that the industry had naturally developed to its current state over decades. This isn't organic growth.

Executives are worried about stabilizing supply chains and operations, handling unanticipated challenges and enhancing national security. They're worried about developing strong capital allocation strategies—balancing short-term and long-term needs they're worried about identifying and developing talent amid an ongoing shortage. And they're worried about tracking and meeting evolving government funding requirements.

> *"I do have fears in the United States about a lot of the overhead in building new factories with environmental and some other restrictions that are just non-existent in some places in Asia. [That's] a cost disadvantage, and it's a hard one to overcome."*
>
> **Amkor Technology Executive**

Figure 1: Industry Revenue

Bar chart — Revenue ($B) by year:

| Year	Revenue ($B)
2008	255.1
2009	228.7
2010	301.5
2011	307.8
2012	299.9
2013	315.4
2014	343.0
2015	334.9
2016	345.9
2017	421.7
2018	476.2
2019	422.3
2020	470.9
2021	598.4
2022	599.6
2023	534.5
2024*	624.4
2025*	721.2
2026*	765.1
2027*	764.0

Charts/graphics created by Accenture based on Gartner research. Gartner®, Source: Market Share: Semiconductors by End Market, Worldwide from 2011 to 2022 and Semiconductors and Electronics Forecast Database, Worldwide, 3Q23 Update for Forecast Numbers (2023 to 2027). Figures are global and include all industry subsegments. Revenue is sourced from each forecast and plotted as needed.

Figure 1:

Historically, semiconductor revenues have been closely linked to market-driven events, such the Dot.com Bubble, the Great Recession and Covid-19 pandemic. Specifically, our analysis of industry revenue shows a revenue decline when these kinds of events occur, followed by a rebound the following year. While revenue is forecasted to decline in 2023 in light of uncertain economic conditions, it is expected to grow 18.5% in 2024 (at the time of publication).[4]
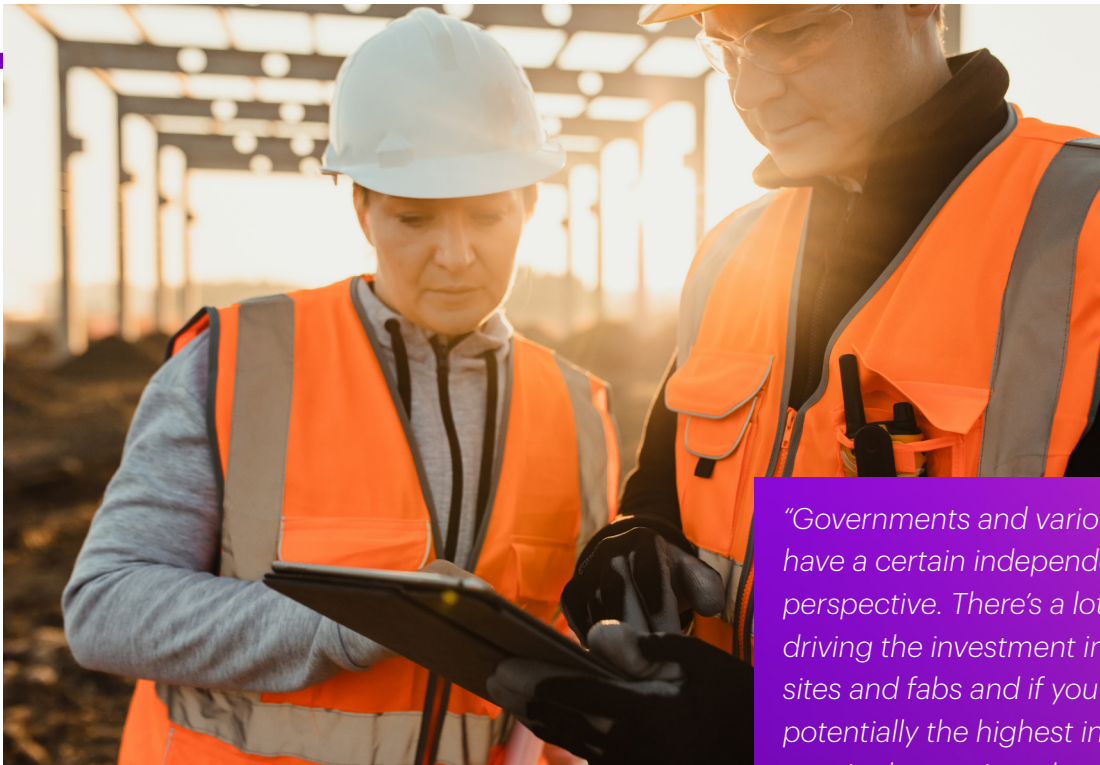
"Governments and various regions try to have a certain independence from a global perspective. There's a lot of public money driving the investment into manufacturing sites and fabs and if you sum it up, there is potentially the highest investment into fabs ever in the semiconductor industry."

Industry Executive

Four steps to navigate the current landscape.

These concerns are valid. In July 2023, TSMC announced a delay in starting the production of 4nm chips at its Phoenix facility, which they began constructing in 2021. The fab, which was expected to come online in 2024, is now scheduled to open in 2025 due to a lack of skilled workers with the necessary expertise to install the equipment correctly.

As of this writing, TSMC had responded rapidly to the challenge with plans to bring more than 500 workers from Taiwan to train local employees.[5]

The good news is that the outlines of leading practice are emerging. Based on input from the executives we interviewed, our client experiences, industry expertise and ongoing quantitative research, Accenture has identified four steps that companies can take to better their chances of success as they accelerate their efforts to build and operate onshore fabs.

4 steps to navigate the current landscape:

1. Create an internal capability to engage in public-private partnerships (PPP)
2. Rethink talent strategies
3. Become radically proactive about security and emerging technologies
4. Re-assess ROI expectations.

The rest of this report focuses on each step in turn.

Steps to accelerate successful fab build and operations

Create an internal capability to engage in PPP

Rethink talent strategies

Become radically proactive about security and emerging technologies

Re-asses ROI expectations

Globally, as noted, governments are emerging as prolific and engaged investors in onshore chip manufacturing. As one industry executive put it: *"It's in the interest of the government [to invest heavily] because a lot of the activity that takes place, not just from a commerce point of view, but also from the defense point of view, is going to be highly dependent on the semiconductor capabilities of the country."*

The challenge for company leaders is how to secure some of this government funding. Reduced to its essentials, this is a race—albeit a race with guardrails—for funding. An Analog Devices Director of Product Marketing noted: *"It's hard to invest in the manufacturing space. But since the government is covering a lot of the expenses, it's like money on the table. If you don't take it now, you will never take it. You won't have a chance. Other competitors will take it before you do."*

They also need to be able to deploy the funding they receive. All of our respondents observed the federal government's role in fab development.

Our recent research found that 45% of global high tech executives said incentives from a government program were a factor in their reshoring/relocation plans, though it wasn't the deciding factor.[6] Regardless, high tech companies are prioritizing investment in the United States and Canada at 34%, and 28% are secondarily prioritizing investments in the same region over the next three years. We also found 35% are prioritizing investments in India and 30% are prioritizing investments in Western Europe during this time period.[7]

Beyond the federal government, states are acutely aware of environmental implications for their regions, the nature of the jobs created, the type of education needed and the associated and (preferably integrated opportunities) for community improvement and advancement. They're tailoring their own requirements based on factors like environmental standards, investments and job availability.

As a result, an industry expert told us, *"The state does [play the most important role in development] because they're most invested in securing that capability for their region."*

How to create an internal capability to engage in PPPs

Be proactive about engaging with local and federal government officials, with an eye toward ensuring that the company's understanding of the regulations and requirements is up to date. Take the lead in scheduling these meetings and setting their agendas.

Prepare the processes and policies in advance to pursue and manage the grant process. The idea is to create a structure that enables speed. If a company has to form a team and teach them the necessary rules for creating a grant proposal, they'll start at a disadvantage. If the rules change later and they lack a strong foundation, they'll struggle. On the flip side, if team members are confident in their understanding of the requirements and have the necessary experience, they'll adapt more effectively.

Articulate and socialize clear roles for stakeholders and beneficiaries. Elevate ecosystem partnerships by highlighting the unique role each plays in developing new fabs and fostering deeper engagement with stakeholders. For example, with new messaging and engagement, a company can help their government partners (state and local) evolve from simply being financing providers, to becoming stewards of the sector. Companies can highlight their role in national security with these projects. Together, the ecosystem can move forward with purpose and mission highlighted from the outset.

Conduct ongoing research and analysis on leading practices for PPPs. Develop an understanding of holisitc and social infrastructure (e.g., childcare, jobs, educational pathways) designed to keep organizations well-staffed with people who have the expertise needed in the moment and can meet rapidly unfolding deadlines and handle requests.

Foster new partnerships to create cross-industry consortiums. Leverage existing infrastructure and ongoing R&D efforts (e.g., NASA, NIST) and commit to engaging with a cross-industry consortium to improve collaboration and foster innovation.

Industry Example

The Texas Institute for Electronics (TIE) is a PPP sponsored by the University of Texas at Austin. This partnership convenes public entities, semiconductor companies, defense electronics companies, national labs and academic institutions to strengthen the nation's leadership in advanced packaging. One of its primary missions is to lead the industry stakeholders in rethinking the talent strategy and STEM education. Additionally, TIE is collaborating with its partners to develop and implement semiconductor workforce development strategies. Recently, The University of Texas at Austin has been awarded $440M in funding from state of Texas to build fabs.[8]
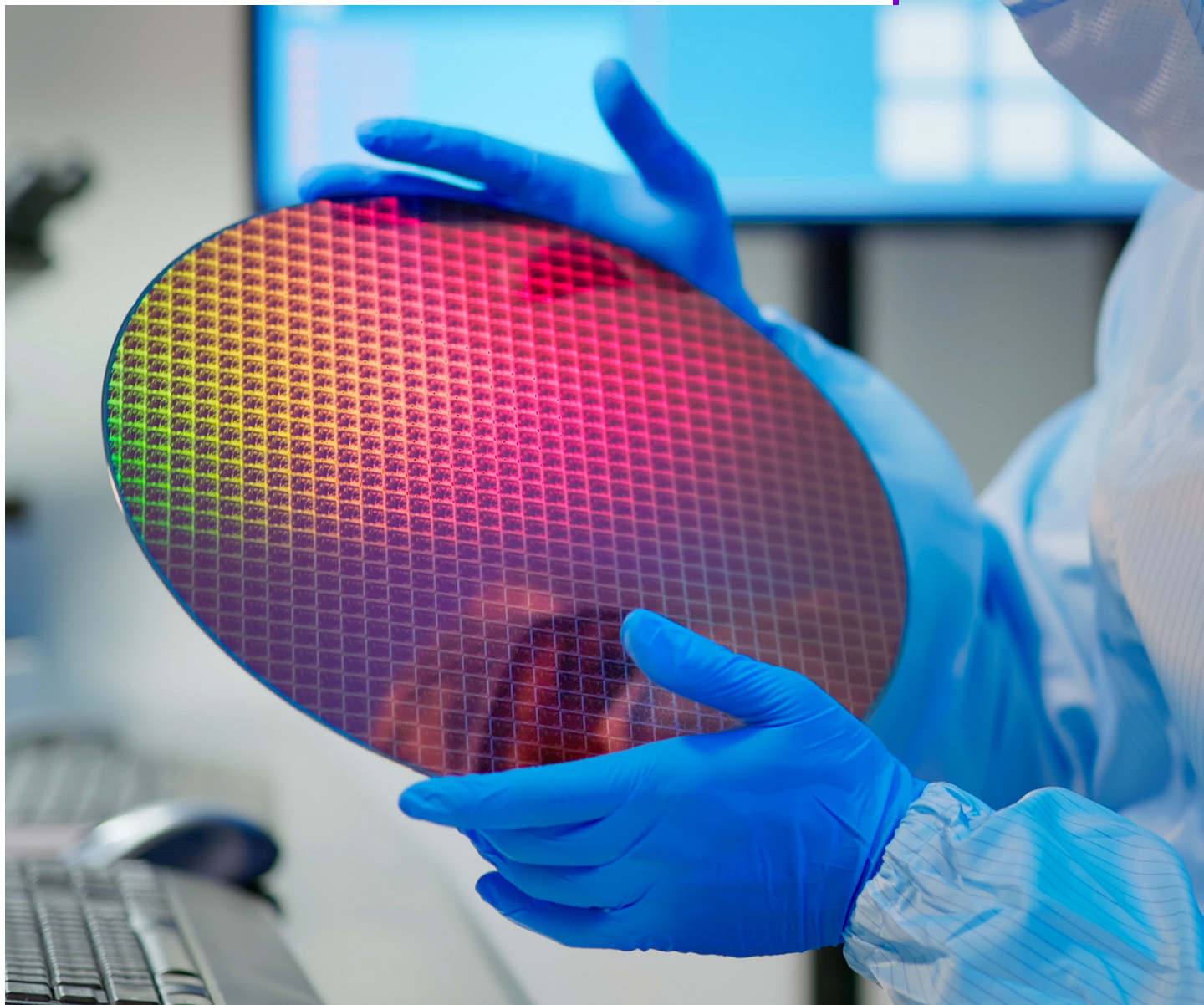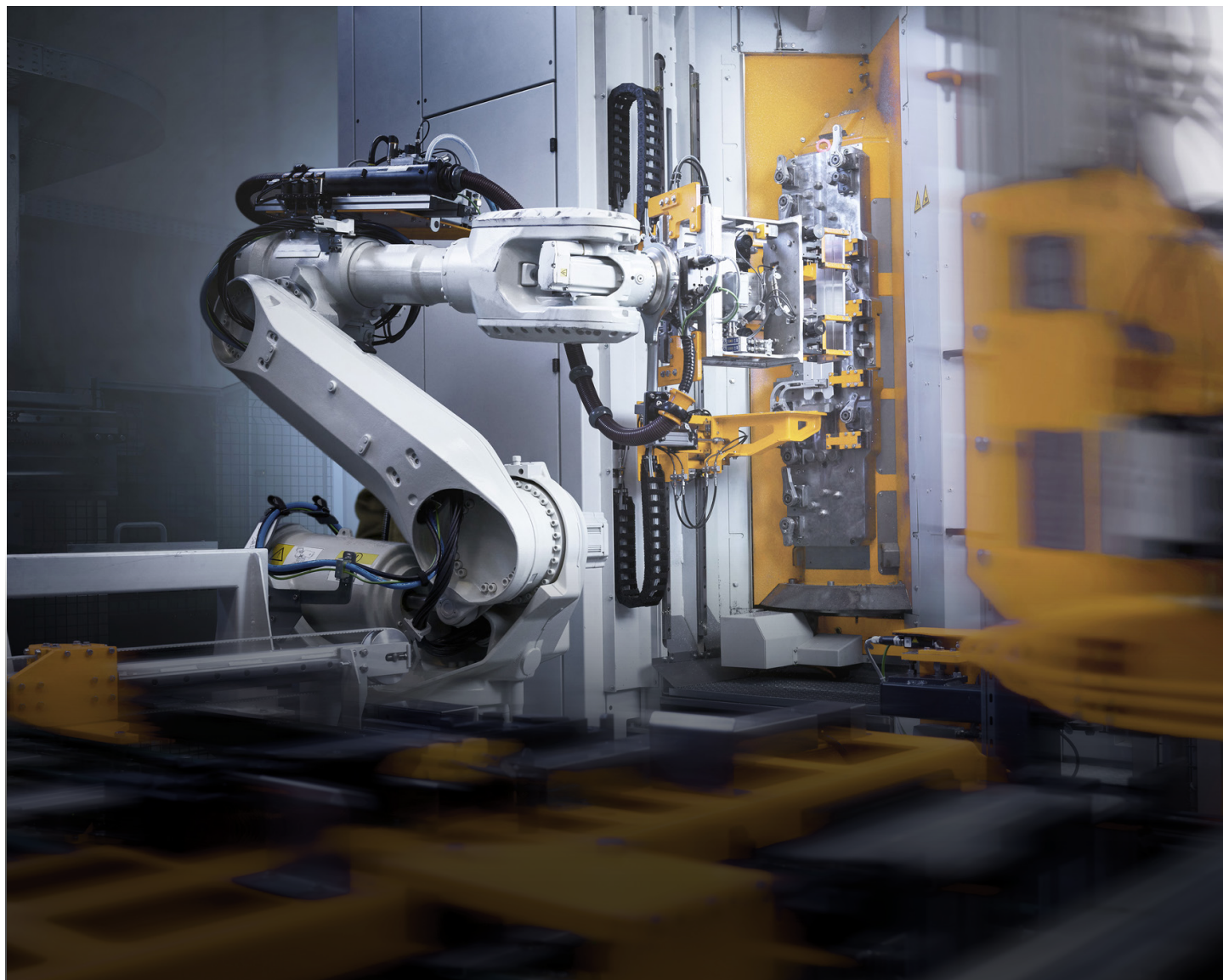
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In the US in 2019, less than a third (28%) of STEM-educated workers were working in a STEM job.[9]

A meaningful increase in the number of employed STEM workers could be plugged into the semiconductor workforce. Yet this industry, like many others, faces a significant talent shortage.

Our interviews indicate that companies believe their organizations will find and attract the individuals they need within this talent pool— people who are prepared and willing to handle the specialized tasks associated with chip manufacturing. Making it happen, though, requires intervention by the industry.

Specifically, hiring managers need to think boldly to create a compelling value proposition and act urgently—engaging leaders from within and beyond the company—to deliver.

In part, this means promoting the industry anew to raise awareness of onshore growth. Companies must intensify their efforts to highlight semiconductor career pathways to other engineering sectors. They need to think more broadly about what the "right" talent profile is and how and where to attract and develop talent. The "right" profile historically looked for STEM talent only. Today, the industry is more welcoming for high school graduates, apprentices and non-STEM graduates to fill gaps with proper training. Bottom line, it means reinventing the industry's talent strategy, company by company.

How to rethink talent strategies

Identify and offer steps for building new skills or growing skills. Allow existing employees to develop skills that are in demand and enable them to move across functions. Only 34% of workers are very confident that their skills will be of use and value 3-5 years from now, so leaders should help employees understand why it matters and convince them that the effort is worth it.[10] There is a high likelihood of transferability between engineering talent and connected technologies which can uncover missed talent pools and close skill gaps.

Embrace emerging technologies including AI. Automate tasks where possible and focus on filling more strategic and time-insensitive roles. Our recent high tech executive survey found that 56% of respondents are planning to invest in artificial intelligence and machine learning-based manufacturing for digital technologies.[11] The strategy entails more than automating to create operational efficiencies. It's also focused on attracting the right talent to leverage emerging technologies to run fabs as efficiently as possible.

Increase efforts to attract, include, develop and retain a varied workforce. Develop formal outreach programs from urban to rural regions. The recruiting processes need to be increasingly accessible and inclusive to raise awareness of the industry beyond traditional talent sources and attract employees from different backgrounds, locations, races and genders—and disciplines beyond electrical engineering. Improving diversity and representation in leadership is key to this effort as well. They should leverage federal funds and activate PPPs to extend into the workforce and support efforts to recruit, retain and identify various talent as government agencies place a renewed focus on this effort.[12]

> *"Now I think a lot of people are not only looking into technological challenges, they are also looking for purpose, and to work in an environment that makes sense to them… you're competing with software companies that allow work from home flexibility, but you need control testers and people to operate different types of machines. You need to offer long-term incentive plans and define roles as developing for the future."*
>
> **Industry Executive**

Industry Example

Intel's ambitions to create a "Silicon Heartland" in Ohio include more than its planned cutting-edge fabs. The company pledged $50 million to support 80 higher-education institutions to train tomorrow's workforce and provide internships, guidance and research opportunities. It has also positioned itself as a primary driver, partner and resource to collaborate with the higher education system to refine its offerings to produce the workforce it needs in the state. For example, Intel asked universities to provide hands-on clean-room experience to community college students to gain the skills they need to support the industry's growth.[13] The company also awarded Ohio University a grant to lead a multi-university effort aimed at growing a STEM-focused workforce to fuel the advanced manufacturing sector in Ohio.[14]
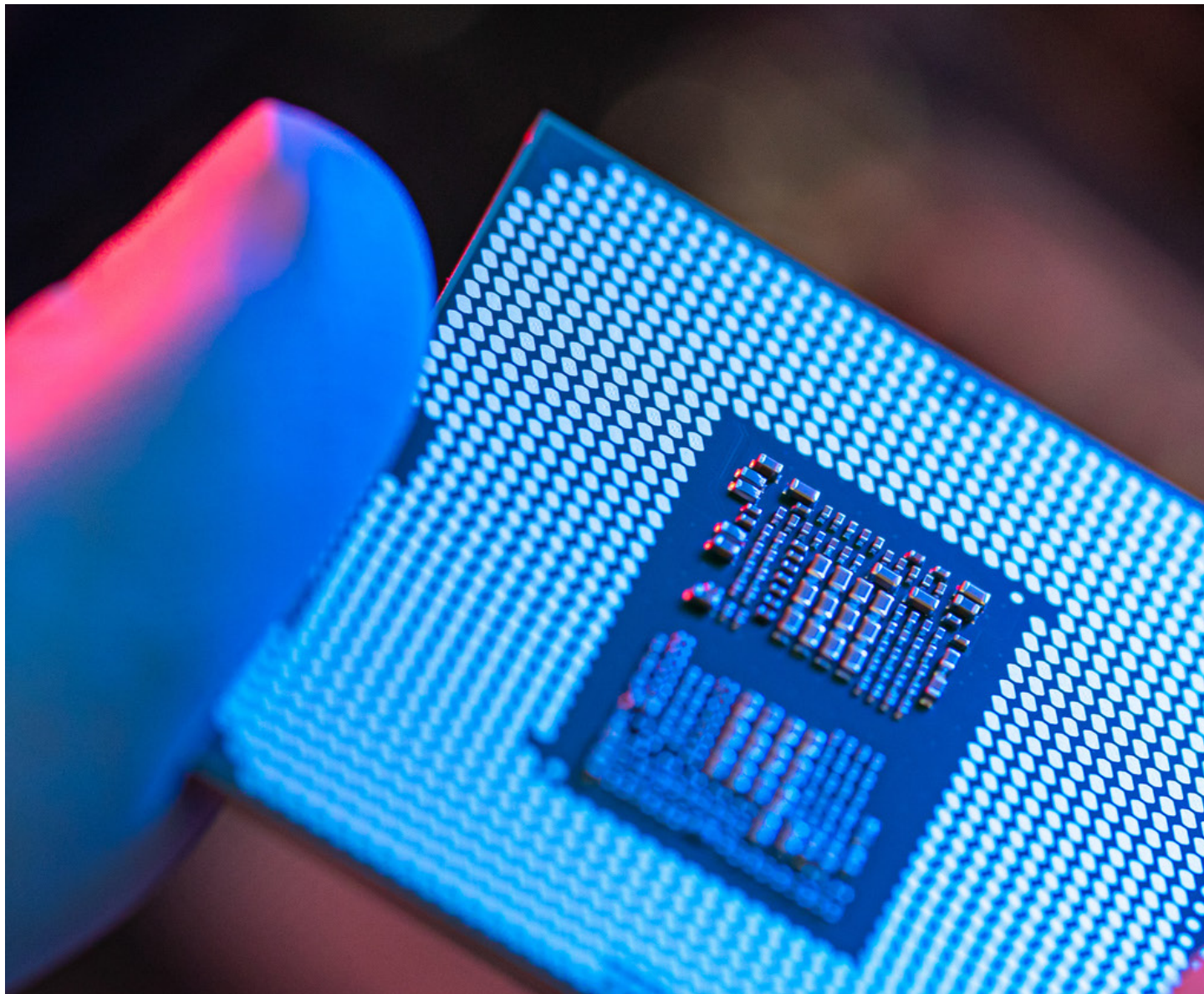
Industry example

GlobalFoundries offers "returnships" to help experienced women and veterans return to the workforce and has a Manufacturing Technician Apprenticeship Program to build a workforce pipeline.[15] The company is part of the STEM Reentry Task Force, an alliance geared toward technical or engineering professional women who are seeking to resume their careers.[16] Another goal is to support and reskill the number of technical women across various fields. Accenture has partnered with the Global Semiconductor Alliance to study this topic in depth and offer solutions.[17]
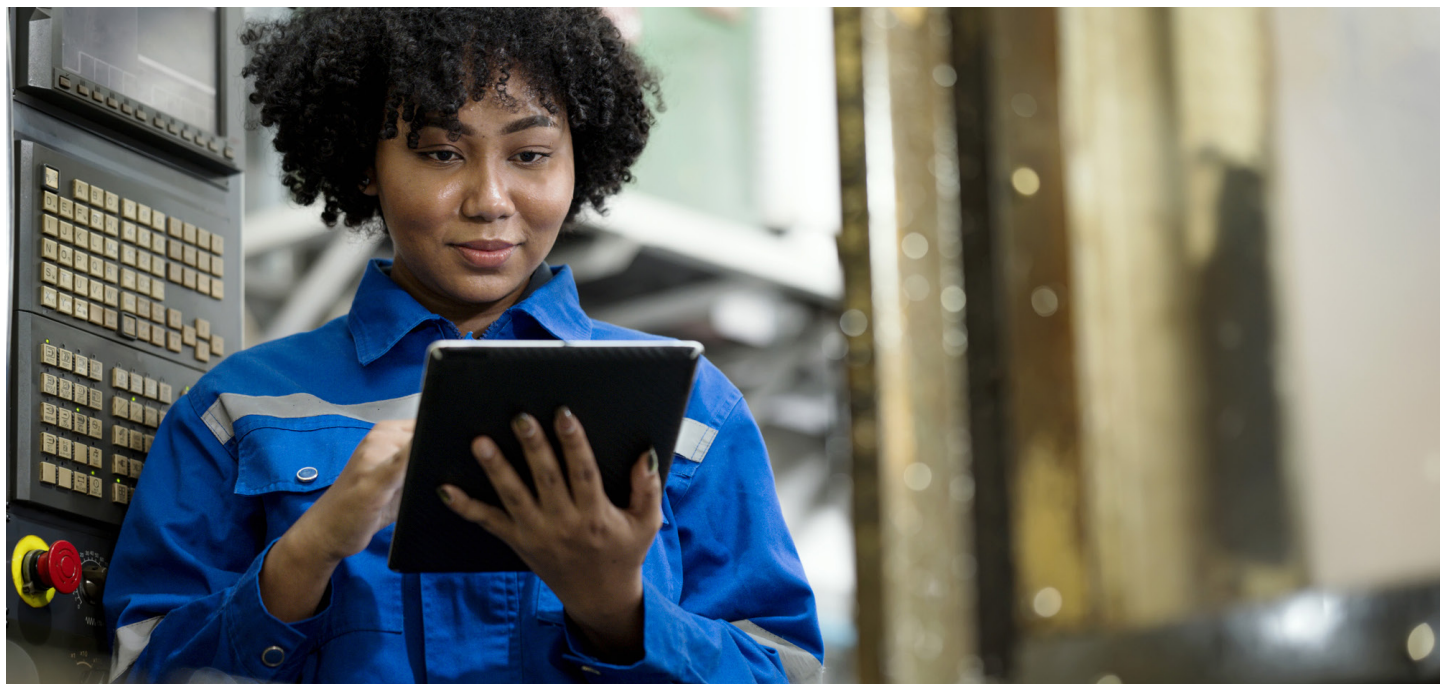
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Concepts such as security—specifically data security as it relates to emerging technologies and supply chain protection—were consistent themes we heard, with good reason. As an industry executive told us: *"On a scale of 1 to 10, the importance of security is a 10. Maybe even 11! It's about design houses securing the IP, facilities securing the manufacturing process and securing the software to avoid threats that can potentially shut down a fab."* This security element becomes increasingly important as the ecosystem expands and as the number of players involved in bringing a semiconductor solution to market increases. Each connection, new customer, supplier and source of data becomes a new security vector. While security is of the utmost importance for a facility, emerging technologies (metaverse, AI, GenAI, etc.) can improve the efficiency of high tech manufacturing operations and make life easier for the employees.

We also noted an emphasis on learning about and adopting advanced technologies and capabilities in the semiconductor industry to improve inputs (such as the clean room) and outputs (such as the yield). Most of the executives we spoke with were particularly focused on the metaverse and potential for the technologies to improve operations exponentially, to the point of transformation. However, with new emerging technologies, the potential surface area for security attacks also increases.

As one industry executive said, *"Artificial intelligence is one of those accelerators, if you understand how to run an AI system, you can gain a system understanding in a very fast time. That enables you to provide world class systems without having all this history of system understanding."*

Brandon Goodyear, Vice President, CFO Accelerated Computing and Graphics at Intel said: *"Thanks to the virtual reality capabilities within our fab, our employees can monitor fab operations from the Remote Operations Center (ROC), rather than from within the fab. This helps Intel minimize disruption in manufacturing and sustain critical operations throughout our global network of fabs. Having remote operations capabilities is not a nice to have— it's a requirement. Not only does it ensure business continuity, it increases operational efficiency and allows us to mitigate quality risk (e.g., reducing number of contaminants)."*

How to become radically proactive about security and emerging technologies

Ensure that the company's approach to security permeates the entire organization. Codify the company's approach to security. Articulate and formalize roles and responsibilities pertaining to security. Establish formal, required, regular training for people at all levels of the company, with no exceptions.

Design and build fabs with security in mind. Identify the tools and technologies needed to secure data, technology infrastructure and architecture as early as possible. The United States State Department's International Technology Security and Innovation Fund allocates $500 million to explore and secure semiconductor manufacturing. One of its goals is to provide cybersecurity tools and services to bolster industry partners' cybersecurity defense capabilities.[18]

Develop and hone the ability to operate remotely by leveraging the Metaverse. The United States and Indian governments recently established a strategic partnership as part of the initiative on Critical and Emerging Technology.[19] Lam Research's Semiverse™ Solutions portfolio is a critical component in this effort, training up to 60,000 engineering students in some of the most advanced nanotechnologies and experimenting with volatile chemistries. The Semiverse™ Solutions portfolio has already benefited users in the United States with the hope of replicating the same in India.[20]

> *"Metaverse is making an impact on the innovation side. If you look at artificial intelligence and metaverse it's becoming a required technology to cut the cost and speed up design cycles. These are essential demands for the future and metaverse is the key to it."*
>
> **Industry Executive**

> *"Security of all types, from access to data to data-sharing is a top priority for us, our partners and our customers. So as we think about increasing global reality (e.g., metaverse), so increases the requirement for robust security."*
>
> **Intel Executive**

Industry Example

Demonstrating effective security practices is difficult; the "proof" of solid security is the lack of a breach. Therefore, it's difficult to showcase an example of leading practices. What we do know is that security matters enormously, not only as it pertains to protecting the company from external threats, but also from attacks on its partners. TSMC's security was put to the test and excelled against a cybersecurity attack, as reported in June 2023, that stemmed from one of its IT hardware suppliers but did not compromise their business operations or customer information.[21]

Based on our experience with companies in the semiconductor industry and beyond, we can point to practices that we believe give companies an advantage in securing operations. For example, some companies have been leveraging metaverse technologies to plan in 3D environments, experimenting with specific layout requirements to avoid costly and sometimes irreversible planning errors. They also use metaverse technologies to animate manufacturing operations; a digital twin of the entire facility built in the multiverse enables easy access from remote locations. Accenture uses a layout planning platform that provides different use cases including virtual collaboration, detailed validation of workflows and the ability to create learning modules for plant training.
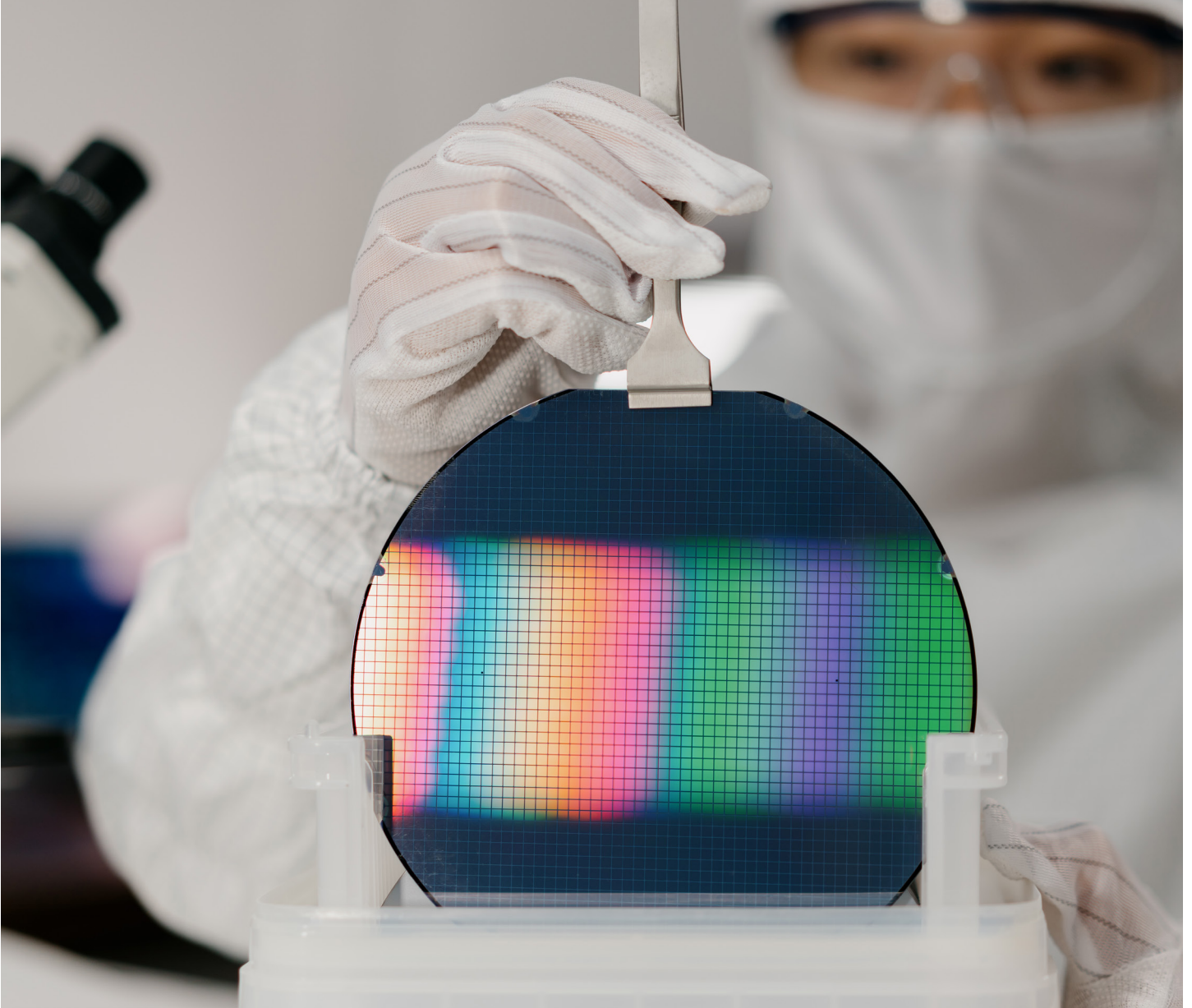
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Re-assess ROI expectations

The timeframe from planning to launch continues to tighten as new talent, change management and new partners add project complexity. These factors decrease available time, increase projected costs and impact projected ROI.

Managing costs while optimizing profitability emerged as recurring themes in our interviews with industry executives. In this context, they cited the industry's shift toward increasing the number of application-specific products and a greater product mix that a typical fab has. They also noted rising labor costs and the increased complexities associated with supplier partnerships. As the General Manager of the Corporate Strategy Office at a Japanese electronic parts manufacturer shared: *"Short-term profitability depends on whether the investment plan and business plan of five years ago have progressed."*

"Regardless of the application, each semiconductor company has its own project. And in some cases, it is the years of data collection that is the investment. It depends on the company and which kind of parameters they prioritize."

Resonac Executive

How to re-assess ROI expectations

Monitor developments in real-time and act accordingly. In our experience, this can include boosting asset utilization by 5% to 15% and yield by 15% to 25%; improving worker productivity by 30% to 40%; reducing inventory holding costs by 20% to 30% and reducing time-to-market by 30% to 50%.[22]

Share information and use financial incentives to strengthen industry ecosystems. Prompt the local supply chain to adapt and players to take on new roles. Fabless players, for example, can engage with partners in new ways by sharing customer insights with players further down the value chain with the aim of improving efficiency, supply and demand predictability. They can also consider new financial arrangements with OEMs and suppliers to decrease risk and increase bargaining power. As the General Manager of the Corporate Strategy Office at a Japanese electronic parts manufacturer explained: "We are making efforts such as requesting investment from our customers, forming a capital tie up or setting up customer-owned processes in-house."
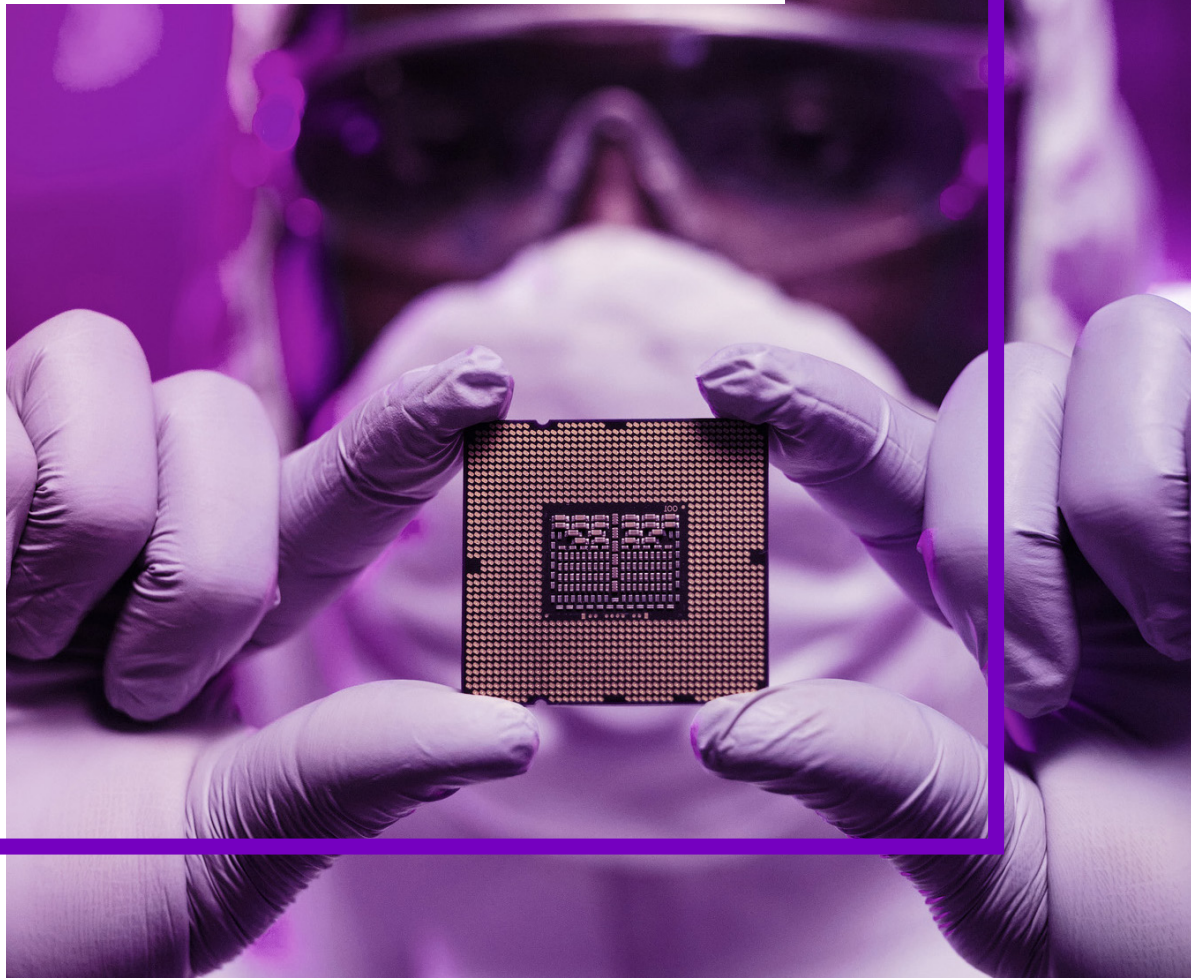
How to re-assess ROI expectations (cont.)
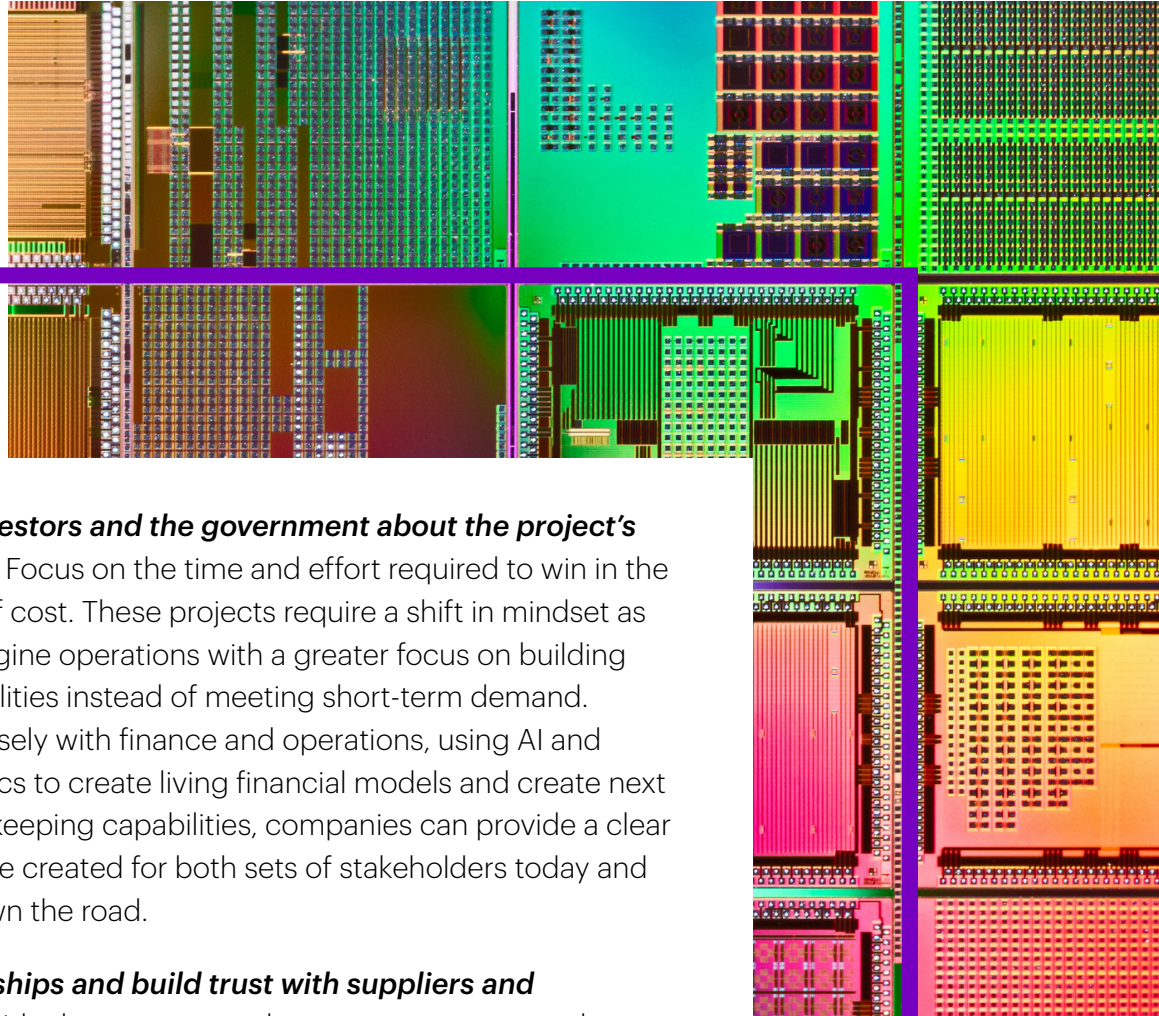
Be clear with investors and the government about the project's long-term value. Focus on the time and effort required to win in the market outside of cost. These projects require a shift in mindset as executives reimagine operations with a greater focus on building long-term capabilities instead of meeting short-term demand. By partnering closely with finance and operations, using AI and predictive analytics to create living financial models and create next generation bookkeeping capabilities, companies can provide a clear guidance on value created for both sets of stakeholders today and several years down the road.

Deepen relationships and build trust with suppliers and customers. Consider long-term supply agreements to smooth market fluctuations. Forge information-sharing agreements with the suppliers and customers in your ecosystem to better understand the complexities they face and add predictability into production. Such transparency helps all parties balance their needs with their partners' needs. In doing so, it enables companies to offer other stakeholders, including investors, better information to manage their expectations.

Adopt a holistic value assessment mechanism. Continually reflect on the state of the company to help shareholders appreciate the complexity of the organization's business operation and how today's expenses result in tomorrow's value. Having a real-time and data-driven view of construction progress, evolving talent model and technology application will improve planning and reduce investment risk.
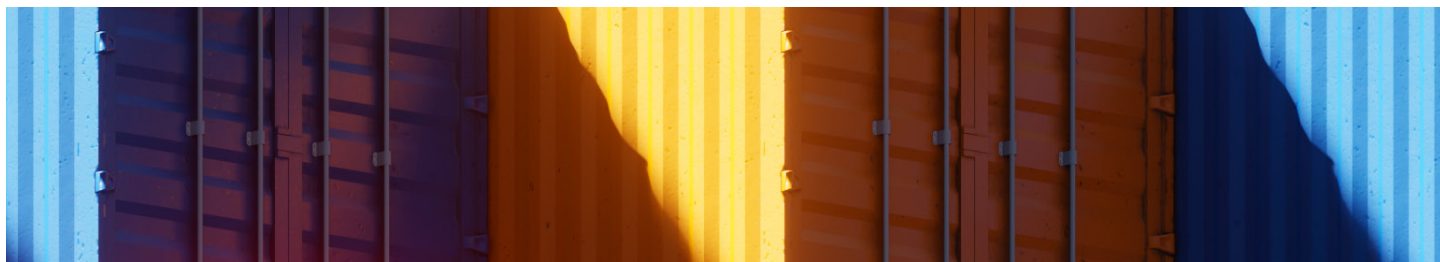
Industry example

Agreements between manufacturers and customers can add a layer of transparency and planning to balance the needs of both companies. As operations begin to onshore in the United States, sourcing local partners becomes even more critical in the supply chain: 85% of manufacturers said they want their incoming material sources to be within the same hemisphere as their factories and 78% want their factories to be within four time zones of the customer.[23] We've seen non-binding deals focused on strategic collaboration as R&D efforts move from proof-of-concept to delivery. General Motors recently inked a deal with GlobalFoundries to establish dedicated semiconductor production capacity exclusively in the United States.

The automaker will benefit from supply predictability and better quality—ultimately passing these benefits to its end customers.[24]

Conclusion

High Stakes, High Potential

The semiconductor industry's journey down the path of manufacturing reinvention will be long and complex.

The stakes are high, the vision is ambitious and the scrutiny is intense. The chances of success rise when company leaders address their strategy with a longer-term horizon than their business traditionally dictated. They will accomplish this by aligning success criteria with all relevant players: their people, the public at large and their ecosystem partners. Now is the time to turn shovel-ready projects into significant onshore assets.

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Research

About the Research

Accenture interviewed 14 global semiconductor executives to learn more about the status of semiconductor fabrication manufacturing facilities. We reviewed the transcripts to identify key insights that supported or challenged hypotheses that formed the interview questionnaire. Then NLP and sentiment analysis were conducted on the interview transcripts to identify key themes and related findings. We also visualized the results by theme in various word clouds. The interviews took place between April and June 2023.

About Accenture

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