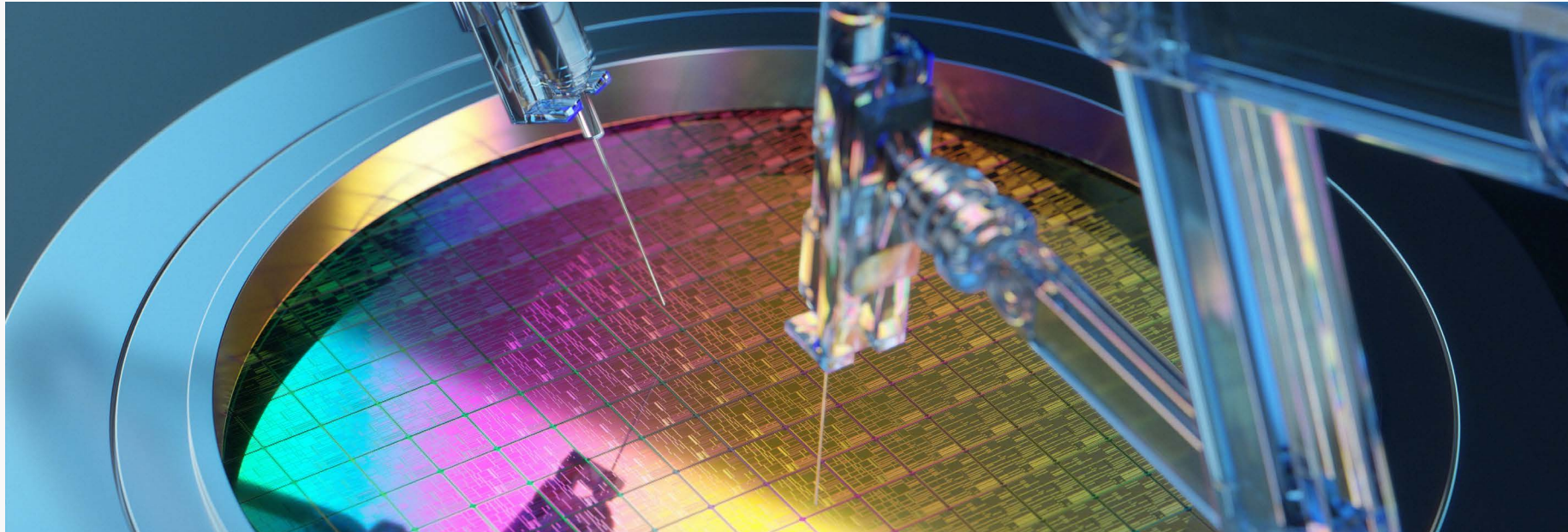# Simulating the future in the *semiconductor industry*

Generative AI is enabling business advantages at a scale that dwarfs other possibilities

Capgemini

Generative AI is enabling business advantages at a scale that dwarfs other possibilities.

Today's semiconductor industry is being rocked by so many waves that it's hard to identify the individual tsunamis. Yet, this still might be the calm before the storm: generative AI has the potential to be the most disruptive innovation of its generation – and companies are only just starting to understand its potential.

Even as industries are enabling GenAI to enhance everything from simple processes like the automation of tasks to complex undertakings such as drug discovery, semiconductor enterprises must prepare for the technology to have a profound impact on their own operations.

Strategies to address these changes are front and center when industry leaders get together to discuss the sector's future. As they prepare to gather at annual events such as *SEMICON West* and the Global Semiconductor Alliance's *Executive Forums,* here are some issues certain to be on everyone's radar.
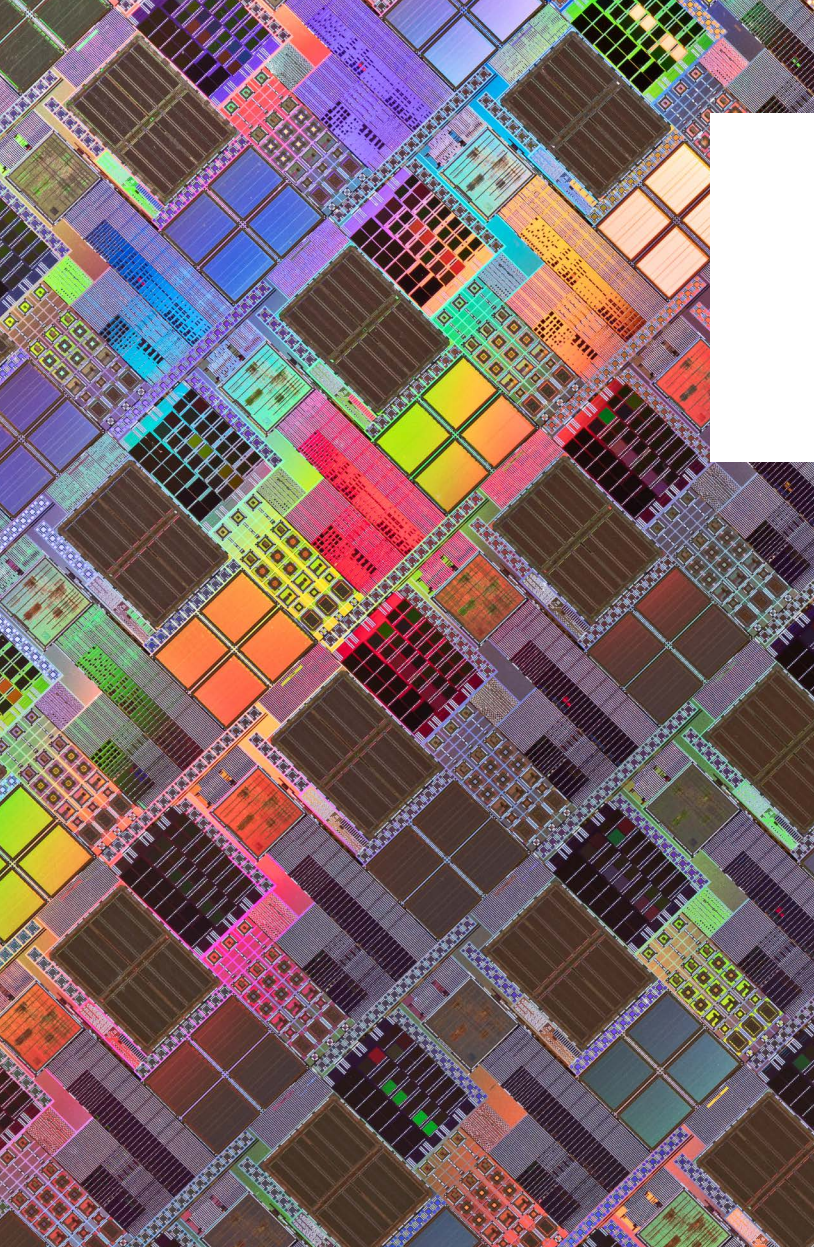
Chip companies central to the GenAI revolution

Companies across all industrial sectors have embraced artificial intelligence to reshape their strategic and operational landscapes. Businesses are keen to leverage GenAI's capabilities to optimize processes, enhance decision-making, and contribute to the development of innovative products and services. As the Capgemini Research Institute reported in *Harnessing the value of generative AI,* 96% of executives surveyed across all industries reported the technology is being discussed in their boardrooms.

In the high-tech sector, that number rose to 100%. This is hardly surprising, given the role the industry plays in the development and deployment of GenAI. What's more, within the high-tech sector, semiconductor companies are at the forefront of this transformation. As companies seek to use GenAI to transform their businesses, the technology will only be as good as the chips on which it operates.

What is certain is that a lot of chips will be required. As Capgemini researchers noted in a companion study, *Why consumers love generative AI,* a majority of people surveyed have interacted with the technology, and satisfaction and trust are both high. This is powering GenAI's explosive growth and will be a major factor in driving demand for chips in the years ahead: Capgemini expects GenAI to be instrumental in pushing the semiconductor industry past *$1 trillion in global revenue by 2030.*

The technology is proving especially useful for predicting trends via its ability to analyze multiple, complex, and data-heavy sources of information for chip-makers. This extends to envisioning several different variations of the end result – a capability Capgemini calls "simulated futures." For the chip industry, this is about to change everything at forward-thinking semiconductor companies. Here are a few examples.
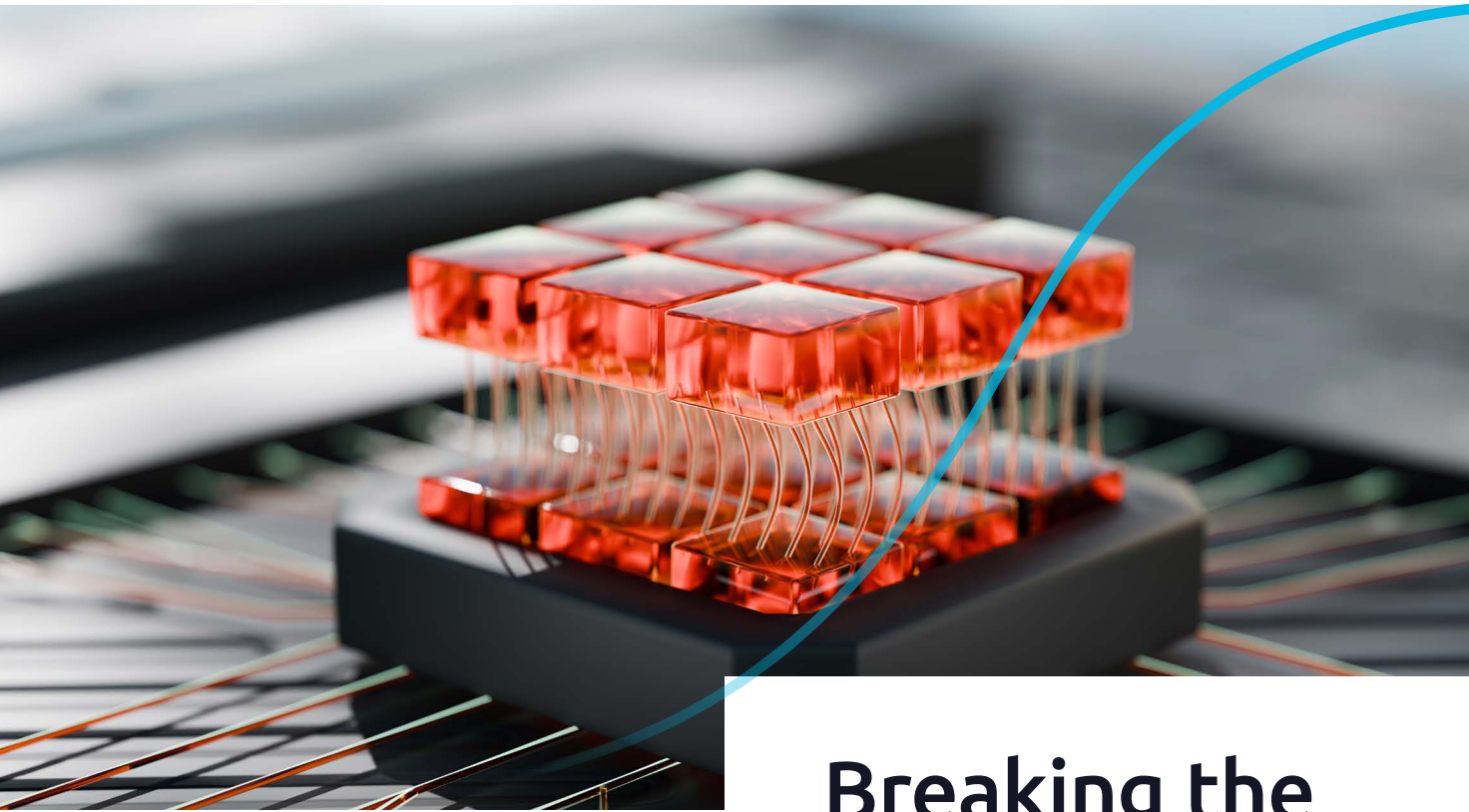
Breaking the iron triangle

Many product developers are familiar with the Iron Triangle: given the goals of speed, cost, and quality, they may choose any two but can rarely accomplish all three. Now, generative AI is enabling semiconductor companies to overcome this limitation and bring to market new, higher-quality products – faster than ever, and at a lower cost. GenAI does this by helping developers shape optimal chip designs. It can then rapidly prototype, test, and validate them.

Developers also benefit when applying generative AI to software engineering. Here, the technology helps improve efficiency and quality across the whole software lifecycle – from design and coding to documentation, testing, deployment, and operations. GenAI can accelerate the time to market for new software, reduce the technical debt of enterprises by facilitating large modernization programs for legacy software, and boost software security by identifying bugs and vulnerabilities and then providing development teams with potential adjustments to address them.

Enhancing the design and operation of semiconductor plants

Big transformations are not limited to development activities. As GenAI-driven applications and use cases proliferate, they are reinventing manufacturing support and prompting massive changes to chip foundries.

Digital twins already enable chip makers to model all aspects of semiconductor production – but enhancing these with generative AI enables such twins to analyze millions of variations, applying reinforcement learning to determine the best-performing model. Digital twin use cases of particular interest include:

• *Device-scale digital twins. These can provide detailed visualization of a device to reduce cycles of silicon learning – enabling more efficient use of resources and reducing waste.*

• *Process-scale digital twins. These can run simulations to streamline process development – reducing the amount of inputs, including chemicals and electricity, required for these activities.*

• *Equipment-scale digital twins. These can identify issues with proposed equipment designs or installations before a production line is built. They can also help production personnel develop equipment expertise faster and more effectively.*

As the factory floor becomes GenAI-enhanced, companies will leverage the technology to

anticipate potential equipment failures and recommend the best approach to predictive maintenance – even at production-line speed. This can solve problems before they occur, preventing a systems failure that might otherwise stop the line and require a team of engineers and hours of research and testing to resolve.

GenAI can also enhance quality assurance by modeling and predicting potential anomalies before they occur, thus improving yield and reducing waste.

Building resilient supply chains

Semiconductors are among the most-traded goods in the world: in 2022, the Observatory of Economic Complexity ranked *semiconductors in third place* with $961 billion in trade. Any disruption in the semiconductor supply chain has potentially significant consequences for the global economy.

Supply chain shortages do more than just reduce sales and profits for chip manufacturers: they also cause considerable financial damage to the industry's customers. The automotive industry learned this painful lesson during the COVID-19 pandemic, when an insufficient supply of chips cost automakers billions of dollars in lost sales and strained the relationship between these two increasingly interconnected industrial sectors.
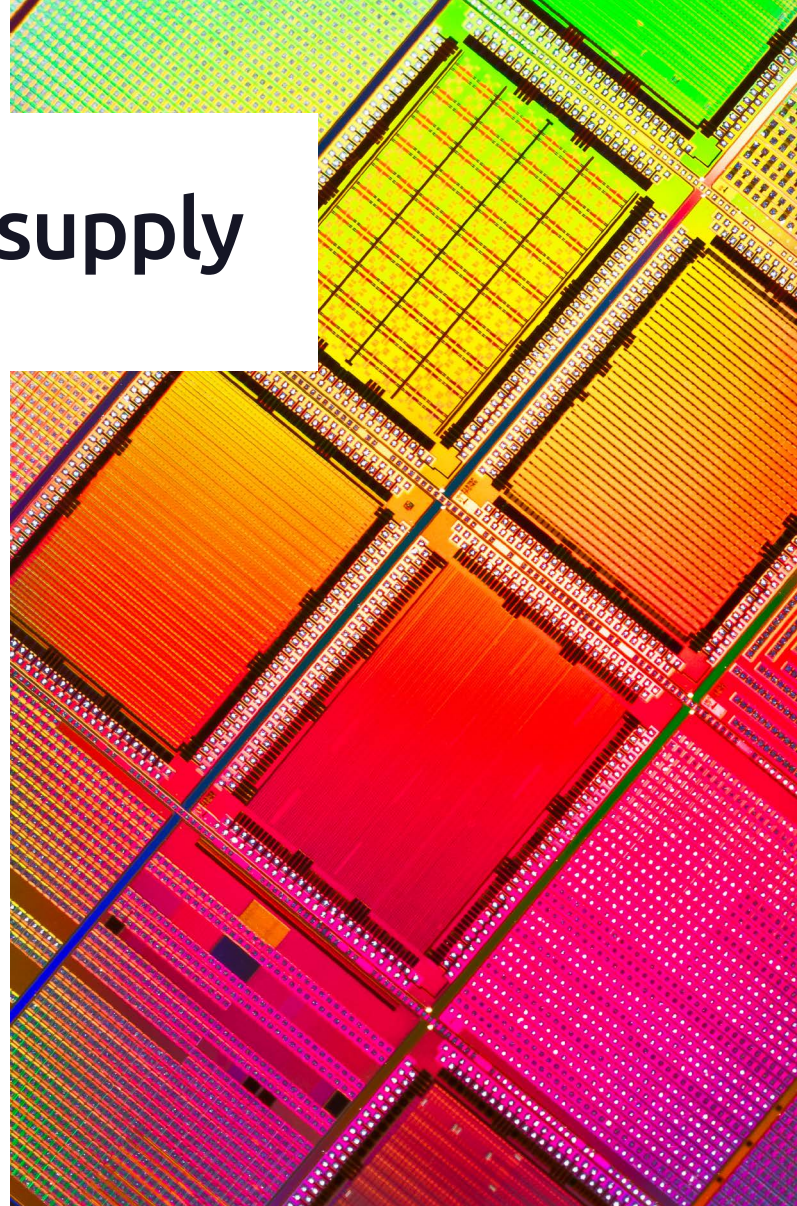
For the semiconductor sector, addressing issues of volatility and ensuring end-to-end transparency are industry priorities – which is why at the 2023 European Executive Forum, members of the Global Semiconductor Alliance discussed inter-industry cooperation and building strategic relationships specifically aimed at establishing more robust supply chains.

Generative AI has an important contribution to make as chip makers build these intelligent supply chains. Through capabilities such as predictive demand and supply chain modeling, the technology can investigate transportation methods, timing, and packaging options and predict what is required from all stakeholders to achieve the delivery of necessary materials and components – at the right time, and at the best price.

Geopolitical tensions rewriting the manufacturing landscape

The *World Population Review* notes that a single enterprise – the Taiwan Semiconductor Manufacturing Company – provides roughly 50% of the world's semiconductors. Given that Taiwan's status as a country is disputed by China, many are concerned TSMC's location puts it in a precarious position.

In response, as chips become increasingly essential drivers of innovation and economic prosperity, the United States and Europe have both launched initiatives to encourage the industry to build semiconductor foundries within their jurisdictions. As Brett Bonthron, Executive Vice President and Global High-Tech Industry Leader at Capgemini notes, "Through the two CHIPS Acts, semiconductor companies see that governments understand the criticality of the industry."

The *US CHIPS and Science Act* commits a minimum of $200 billion in direct funding opportunities as it seeks to build domestic semiconductor capacity in four areas:

Leading-edge logic. The program intends to aid in the establishment of at least two new large-scale clusters of leading-edge logic fabrication sites, where US-based engineers will develop the process technologies underlying the next generation of logic chips.

Memory. The program aims to help set up US-based fabrication facilities that will produce high-volume memory chips on economically competitive terms – plus facilitate domestic R&D for the next-generation memory technologies critical to supercomputing and other advanced applications.

Advanced packaging. This will make the US home to multiple advanced packaging facilities, and help the country become a global leader in commercial-scale advanced packaging technology.

Current generation and mature chips. The program hopes to encourage a strategic increase in domestic production capacity for current-generation and mature chips, so chip makers can respond more nimbly to supply and demand shocks.
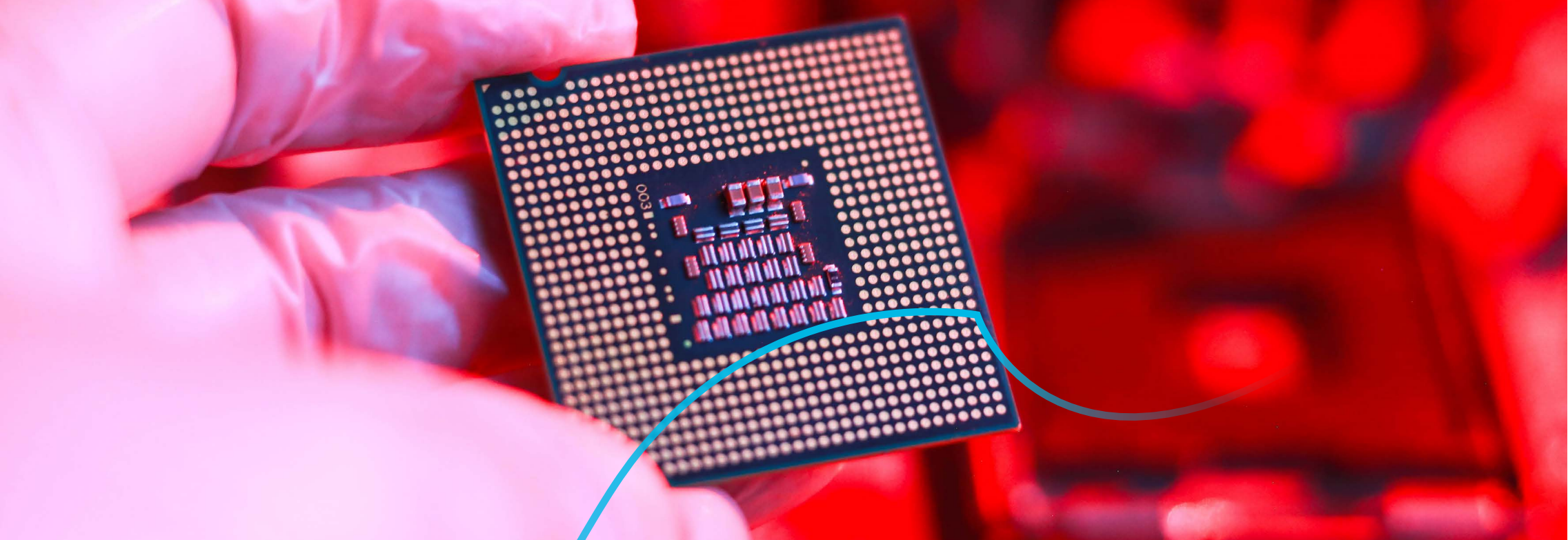
Meantime, the *European Chips Act* is intended to help the European Union address semiconductor shortages and strengthen Europe's technological capabilities. With a budget of 43 billion Euros, this program intends to:

Strengthen Europe's research and technology expertise with a focus on smaller and faster chips	Build and reinforce capacity to innovate in the design, engineering, manufacturing, and packaging of advanced chips
Develop an in-depth understanding of global semiconductor supply chains	Address a skills shortage, attract new talent, and support the emergence of a skilled workforce for the semiconductor sector

Generative AI to bolster the back office

The EU's goal is particularly important for the future of the industry. Diversity, workforce development, and talent are major, industry-wide concerns.

While new chip manufacturing capacity is being built in the US and Europe, many companies are partnering with universities, granting scholarships, and launching apprenticeship programs to ensure they continue to have access to the best possible talent in the years ahead. Generative AI can streamline human resources processes to help chip makers manage workforce needs, as well as rapidly identify, attract, and retain the best candidates based on specific qualifications.

GenAI can improve corporate functions as well. For example, product reference documentation is essential, but companies must manage thousands of pages of precise and detailed technical information. Generative AI can harvest the company's knowledge base about requirements and functional specifications and then produce these documents accurately and instantaneously. GenAI's ability to cross-check the specification versus the implementation improves accuracy and wards off huge downstream costs related to customer support. For documentation teams, this is a game-changer – reducing the time required for this painstaking task from months to moments.

Legal departments can leverage GenAI to help ensure the company complies with all laws and regulations across all jurisdictions. It can help identify and address potential legal risks and compliance issues, and help shield the company against any potential legal vulnerabilities.

Using generative AI to help manage these tasks frees up staff and management to focus on more innovative, value-generating pursuits – from product innovation and development to sustainability.
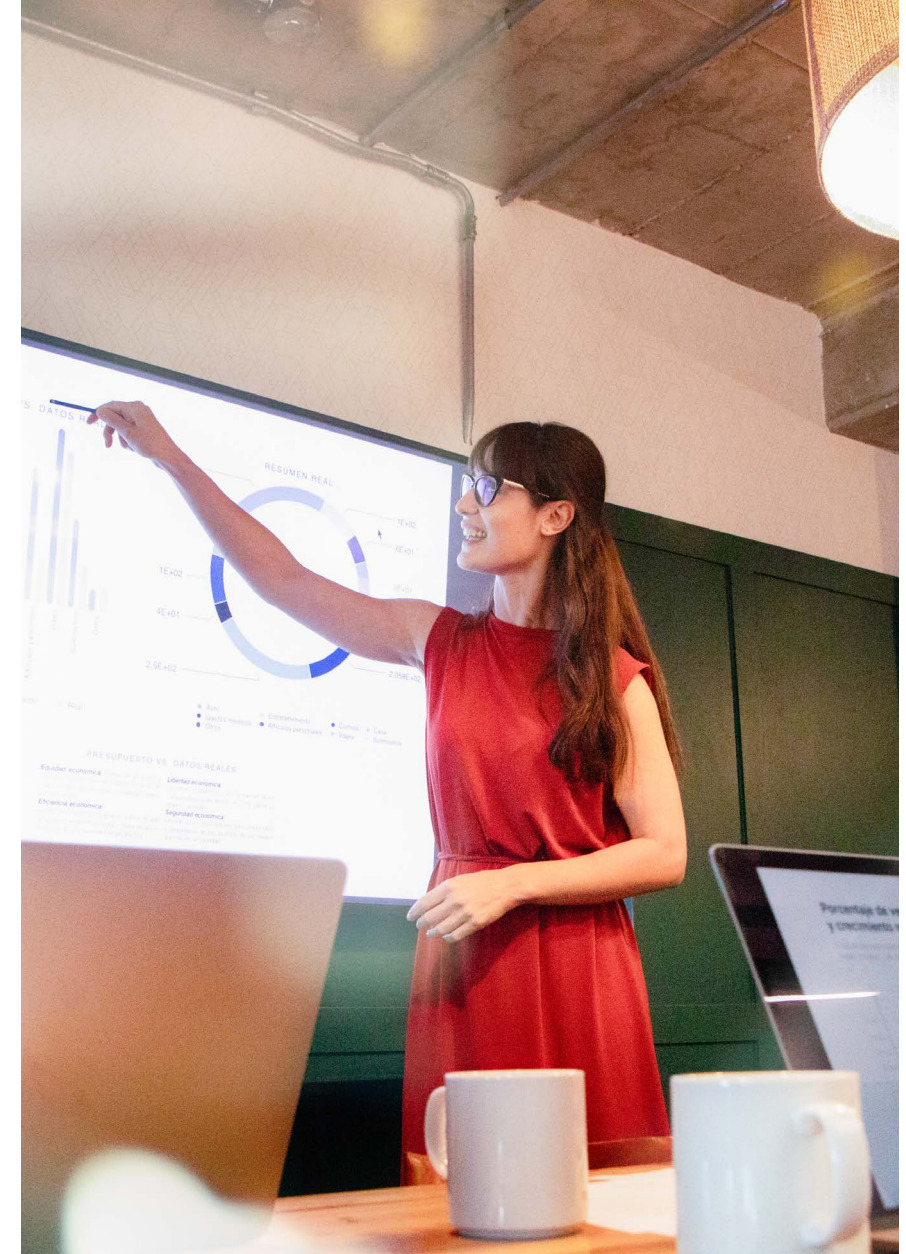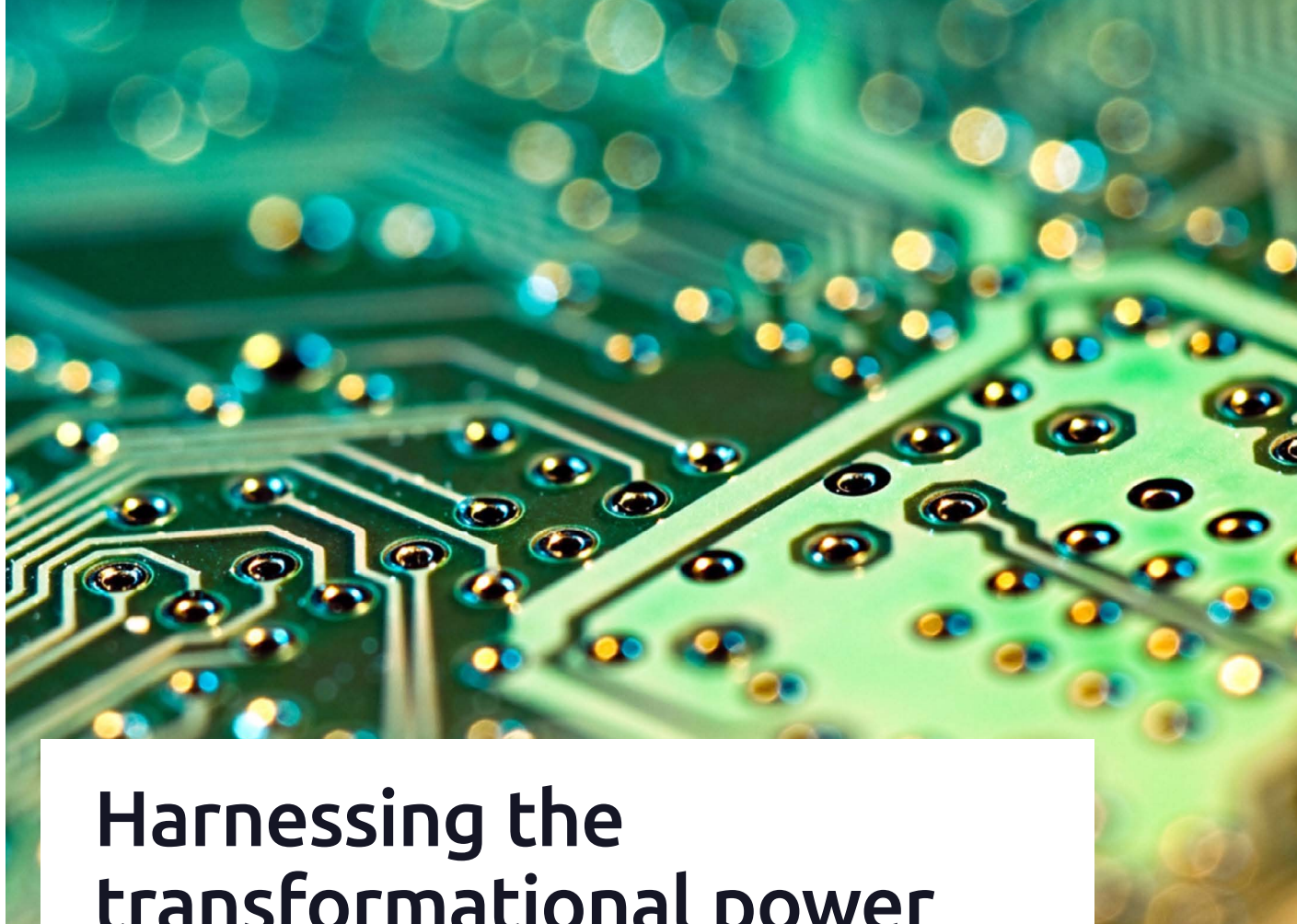
Harnessing the transformational power of sustainability

Sustainability is a huge issue. While the semiconductor industry is expected to double in revenue by 2030, carbon emissions are expected to quadruple over the same period. And unless sustainability is specifically targeted, new technologies will exacerbate the challenge; as noted at the SEMICON West 2023 conference, a search via a generative AI solution such as ChatGPT consumes 13 times more energy than a similar query via a traditional search engine such as Google.

That's obviously a concern that needs to be addressed. As Sanjiv Agarwal, Vice President Global Semiconductor Industry Leader at Capgemini expressed it, "Semiconductor companies need to embrace sustainability and aim to make technology sustainable."

Many leading chip makers are working to improve this through initiatives to produce more sustainable products – including those that use less power or help reduce the carbon footprint of their customers. A key takeaway from SEMICON West 2023 was the need for companies to establish dedicated engineering teams to support sustainability goals – including for equipment, sub-fabs, process recipes, and operations.

Looking ahead

The semiconductor industry is in a state of flux – but as companies tackle the issues they face, they'll do so with abilities never before seen. That's because unlike any previous tool humans have developed, generative AI has the capacity to process and make decisions. Currently, companies are using GenAI in a supporting role, bolstering the skills of their staff. But that divided structure – with people on one side of the building and blinking lights on the other – is about to change. Teams are going to become integrated, with humans and GenAI sharing the decision-making.

How will the tasks be divided? Who will take responsibility for successes – or for failures? Those are some of the questions the industry will need to address.

Meanwhile, generative AI is about to truly elevate the possible through a capability that tests the bounds of credulity: that of predicting the future or, more accurately, simulating a plethora of more or less likely futures.

Today, societies have developed models that can predict bits and pieces of the near future. Weather forecasting is a good example of this. However, generative AI is about to make possible full-fledged business simulations that leaders will use to inform their decisions. These simulations will adapt in real-time and provide decision-makers with practical, probable outcomes.

For a cyclical industry that's simultaneously influenced by multiple, fluctuating, global factors, this ability to greatly increase certainty will be a huge benefit. That said, the accuracy of these simulations will depend upon the data available to them – so this may be a good time for companies that have not yet joined collaborative data networks to get on board.

Getting the future we want

Integrating generative AI across multiple dimensions of the semiconductor industry will unlock transformative advancements. GenAI will equip semiconductor companies to navigate an evolving technological and business landscape with new levels of agility and foresight. This will open the door to opportunities previously unimaginable.

Today, some leading companies are already starting to benefit – and in 10 years, Capgemini predicts there will be two types of semiconductor manufacturers: those that have incorporated GenAI into their operations, and those that exist only in memory.

Successful companies will secure their place at the core of an industry that, fundamentally, creates the technology that will propel civilization forward and create better societies. As a company that believes in leveraging the power of technology to get the future we want for our people, our society, and the planet, Capgemini has developed the GenAI knowledge and vision to help make this a reality. These are exciting times to be active in the semiconductor sector, and we're looking forward to discussing the issues and potential solutions at this year's upcoming industry conferences. To learn more, please contact:

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About Capgemini

Capgemini is a global business and technology transformation partner, helping organizations to accelerate their dual transition to a digital and sustainable world, while creating tangible impact for enterprises and society. It is a responsible and diverse group of 340,000 team members in more than 50 countries. With its strong over 55-year heritage, Capgemini is trusted by its clients to unlock the value of technology to address the entire breadth of their business needs. It delivers end-to-end services and solutions leveraging strengths from strategy and design to engineering, all fueled by its market leading capabilities in AI, cloud and data, combined with its deep industry expertise and partner ecosystem. The Group reported 2023 global revenues of €22.5 billion.

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